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EGOPSv52

Software User Manual

Reference Manual

Software User Manual, Part 2 of 3, Doc. No. WegCIGAMUG/ESA-EGOPSv52/SUM-REF
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1 Introduction

1.1 Scope

This document (EGOPSv52_SUM-REF.pdf) is Part 2 of the Software User Manual for the End-to-end Generic Occultation Performance Simulator, Version 5 [E52SUM], termed Software User Manual – Reference Manual [E52SUM-REF], which gives the detailed description of the various EGOPS functions, tasks and system operations. The operations are listed according to the EGOPS logical work-flow.

Part 1 of the Software User Manual for the End-to-end Generic Occultation Performance Simulator, Version 5 (EGOPSv52_SUM-OV.pdf) is the Software User Manual – Overview Manual [E52SUM-OV], which provides an overview description of the EGOPS simulator and its capabilities.

Part 3 of the Software User Manual for the End-to-end Generic Occultation Performance Simulator, Version 5 (EGOPSv52_SUM-FF.pdf) is the Software User Manual – File Format Manual [E52SUM-FF], which gives the detailed description of the various data files used by EGOPS.

1.2 Abbreviations and Acronyms

AD	Architectural Design
ADD	Architectural Design Document
ATPRO	Atmospheric Profiling
CIRA	COSPAR International Reference Atmosphere
COSPAR	Committee on Space Research
CRI	Computer Resources International A/S
DDD	Detailed Design Document
DMI	Danish Meteorological Institute
ECHAM(4)	Atmosphere/Climate model developed at MPI Hamburg (Version 4)
ECMWF	European Centre for Medium-Range Weather Forecasts
EGOPS®	End-to-end Generic Occultation Performance Simulator (generic)
EGOPS5	End-to-end Generic Occultation Performance Simulator, Version 5
ESA	European Space Agency
ESTEC	European Space Agency Technology Center
FoMod	Forward Modeling
GLONASS	(Russian) Global navigation satellite system
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRIB	Gridded Binary (file format for meteorological data)
HOOD	Hierarchical Object Oriented Design
IAP	Institute for Atmospheric Physics, Moscow
IDL	Interactive Data Language
IEP	Institute for Environmental Physics, Bremen
IEEE	Institute of Electrical and Electronics Engineer
IGAM/UG (*)	Institute for Geophysics, Astrophysics, and Meteorology/University of Graz
IMG/UoG	Institute for Meteorology and Geophysics/University of Graz
InRet	Inversion/Retrieval
LEO	Low Earth Orbit
MAnPl	Mission Analysis/Planning
MPI	Max-Planck Institute (for Meteorology, Hamburg)
MPS	Multiple Phase Screen
MSISE90	Global atmospheric model MSISE90 ([HEDIN91])
MSIS90_DMI	MSISE90 variant (modifications by DMI)
NeUoG	Global ionospheric model NeUoG
OSMod	Observation System Modeling
ReFlexPortEx	Reliability, Flexibility, Portability, Extendibility
RO	Radio Occultation(s)
RR	Radio Reflection(s)
ROSAP	Radio Occultation Simulation for Atmospheric Profiling
SA	Selective Availability
SPD	Space Division
SRD	Software Requirements Document
TBD	To Be Defined
TEC	Total Electron Content
TERMA	TERMA Elektronik AS
URD	User Requirements Document

(*) Note: As of December 3, 1999, IGAM/UG is the legal successor of IMG/UoG.

1.3 Terms and Definitions

Project — A group of simulation and visualization/validation activities whose output is separated from that of other projects. A project is identified by its user specified Project-id.

Task — A simulation activity within a project. Four Tasks are generically available in EGOPS. Mission Analysis/Planning, Forward Modeling, Observation System Modeling, and Occultation Data Inversion/Retrieval. A specific task is identified by its user-specified Task-id.

Toolkit — A group of software tools with related purposes.

2 Document References

2.1 Applicable Documents

The documents which are applicable for this document are:

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[PSS-05] ESA Software Engineering Standards, Doc. PSS-05-0, Issue 1, February 1991.

[IEEE-610.12] IEEE Standard Glossary of Software Engineering Terminology, Doc. ANSI/IEEE Std. 610.12-1990, 1990.

2.2 Reference Documents

The documents, except for the applicable documents, which are referenced in this document are:

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[E52ATR] G. Kirchengast and J. Fritzer, EGOPSv52 Acceptence Test Report, *WegCenter&IGAM/UniGraz Report for ESA/ESTEC No. 6/2007*, Doc. No. WegCIGAMUG/ESA-EGOPSv52/ATR, Issue 1, April 2007.

[E52URDSRD] G. Kirchengast and J. Fritzer, EGOPSv52 User Requirements Document/Software Requirements Document, *WegCenter&IGAM/UniGraz Report for ESA/ESTEC No. 2/2007*, Doc. No. WegCIGAMUG/ESA-EGOPSv52/URD-SRD, Issue 1, January 2007.

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[E52SUM-FF] G. Kirchengast, S. Schweitzer, J. Ramsauer and J. Fritzer, EGOPSv52 Software User Manual – File Format Manual, *WegCenter&IGAM/UniGraz Report for ESA/ESTEC No. 4/2007*, Doc. No. WegCIGAMUG/ESA-EGOPSv52/SUM-FF, Issue 1, January 2007

3 About the Manual

3.1 Intended Readership

The users of the software are expected to be scientists and/or engineers with the following potential expectations and reasons for using the software:

- Scientists with specialist knowledge of the Radio Occultation (RO) technique who wish to have software which can serve as a technique-related research support tool and a data processing tool.

- Scientists with basic knowledge of the RO technique who wish to have a software to learn about the technique by performing simulation runs and with data processing capability to get auxiliary data for their own work or techniques where they are specialists.

- Engineers, who in general may have basic occultation knowledge and who wish to have a software for supporting mission/constellation planning and performance evaluation of the entire system with particular interest in technical/instrumental effects as involved in the RO technique.

The reader of this manual is thus expected to come from the scientific/technical community, to have at least a small basic knowledge of the RO technique, and to be familiar with the use of software in a UNIX environment.

3.2 Applicability Statement

This is Part 2 of the EGOPS version 5.2 Software User Manual [SUM], i.e. Software User Manual – Reference Manual [SUM-REF]. It contains information about all options within the EGOPS software, including allowable ranges for input data, algorithms and techniques invoked when choosing different options, how to include user supplied data files etc. The reference manual is organized according to the logical work-flow when working with EGOPS. Each section corresponds to a main-level menu option. Each sub-section corresponds to one of the sub-options available.

For a detailed statement on the hardware and software requirements of EGOPS, please see the Section on “Installation Prerequisites” in Chapter 5.1, “EGOPS Installation Guidelines” of the EGOPS Software User Manual – Overview Manual [SUM-OV] (EGOPS5_SUM-OV.pdf).

4 Common Dialogs

4.1 Quit and Save

4.1.1 OK

The 'OK' button causes all values, droplist settings, text field entries etc. to be accepted as the current input status and the input window to be closed 'Cancel' means to drop the changes just made in this input window.

4.1.2 Quit

The 'Quit' button causes all input (values, droplist and button entries etc.) to be lost and the currently open input window to be closed (immediate reopening of the input window will only show the last saved- or the default settings of the window).

SPECIAL NOTES/HINTS

- No warning will be issued in case you attempt to quit an input window.

4.1.3 Compute

The 'Compute' button causes two actions.
1) All input (values, droplist and button entries, etc.) will be saved under the chosen Task-id, i.e., in a file named <Task-id>.inp (an overview of the current input state can be seen anytime via the 'View Input' button).
2) After saving, EGOPS starts the numerical calculation by employing the corresponding computational system (e.g. the Mission Analysis/Planning System [MAnPlSystem], which corresponds to a software package written in FORTRAN 90, located in the /prog/FORprog directory of EGOPS). It performs all necessary computations based on to the current input and produces all the needed result files for subsequent processing and visualization. (To learn more about the file structure behind EGOPS, consult the "EGOPS explained..." Help entry of the main-level Help menu.)
After starting a computation, an 'Information Window' pops up with a short hint about the expected computation time, followed by a second 'Information Window' when the computations are finished.

SPECIAL NOTES/HINTS

- A warning will be issued in case you attempt to save the input with an already existing Task-id. You can then decide to either supersede (and loose) the existing information or to rename your Task.
- Be careful in selecting your simulation input parameters in order not to waste computation time and disk space for results not really exploited. Note that some input combinations (very long simulation time ranges together with dozens of satellites and fiducial sites, etc.) can of result in extremely long computation times.
- The estimated calculation time is only a rough estimation of the real value, based on a so called 'Whetstone' test. However, you will always be provided with a posterior information on how long a computation really took.
- The 'Compute' button always starts EGOPS jobs online (the EGOPS user interface is blocked during the whole time of the calculation). Therefore, for longer and more time consuming EGOPS calculations, the EGOPS 'Batch...' button offers to start the same job in the background so the EGOPS user interface can be utilized for other activities.
- If a file required is missing or incorrect (e.g., due to inappropriate direct

manipulation by the user), the program may abnormally terminate with a message of varying information content saved in the log file. Note that an abnormal termination of the FORTRAN System will not inflict the User I/F in any way. Thus, after correcting a problem, you can proceed as usual. (To learn more about Error Handling related to EGOPS, consult the appropriate sections of the User Manual.)

4.1.4 Save Input

The 'Save Input' button causes all input (values, droplist and button entries, etc.) to be saved with the present Task-id, i.e., in a file named <Task-id>.inp (an overview of the current input state can be seen anytime by clicking the 'Input Summary' button).

SPECIAL NOTES/HINTS

- A warning will be issued in case you attempt to save the input with an already existing Task-id. You may then decide to either supersede (and loose) the existing information or to rename your Task.

4.2 Reset Defaults

The 'Reset Defaults' button causes all input (values, droplist and button entries, displayed plots etc.) to be lost and all values and settings will be reset to its defaults. Reset to defaults has the same effect as entering an EGOPS input window for the first time (i.e. the default Task-id settings are loaded).

SPECIAL NOTES/HINTS

- No warning will be issued in case you attempt to press the reset to defaults button of an EGOPS input window.

4.3 View Input

The 'View Input' button opens a pop-up window containing full information on the current state of the input to the current Task (the information exactly resembles the contents and format of the <Task-id>.inp file). This enables to easily check the input. Via the 'Print to PS file' button, the input can be saved to a PostScript file in the /PSFiles subdirectory of the current Project directory (for subsequent print-out).

4.4 View Log

The 'View Log' button opens a pop-up window showing the log file of the current task. Via the 'Print to PS file' button, the input can be saved to a PostScript file in the /PSFiles subdirectory of the current Project directory (for subsequent print-out).
Within the log-file, the computation of the respective EGOPS task is documented. In case of an abort of the computation, also the related error message(s) will be recorded in the log file which is stored in the respective Project directory.

4.5 Batch Jobs

4.5.1 Batch...

The 'Batch...' button opens a pop-up window for saving and computing the

currently open task offline in EGOPS batch mode. Especially for longer runs, computing in EGOPS batch mode enables to save time because one can do further online work within EGOPS while the computer does the rest autonomously in the background (without blocking the graphical EGOPS interface in the mean time as it would be the case during an EGOPS online calculation). The batch job processing pop-up window allows to select the start time of the EGOPS Batch-Job and offers the possibility to show further batch job status information via an extra pop-up window.

4.5.1.1 Batch Processing

This input window allows to specify the start time of an EGOPS batch job. The current batch-jobs status can be displayed via the "Jobs..." button. "OK" causes all text field entries and droplist settings to be accepted as the current input, whereas "Cancel" closes the input window without any action done.

1) === Start time ===

Specification of the start time of an EGOPS batch job.

"DROPLIST for Batch Job Start Time"
- Selection of three predefined Batch Job start times or an user defined start time: 'Now' (the job will start at the next available full minute), 'Noon' (the job will start at 12h), 'Midnight' (the job will start at 00h), 'User Input' (renders the input fields for user-defined start time sensitive).

"INPUT FIELDS for Arbitrary Start Time Definition"
- Selection of an arbitrary batch job start time by directly specifying the desired day, hours and minutes.
- Only integers are allowed.
- As input for the day, the absolute date (e.g. 27 for the 27th of this month) must be supplied. The values may range from today (default) up to eight days in the future.
- Available only, if the droplist for start time is set to 'User Input'.

2) === Jobs... ===

- The 'Jobs...' button opens a pop-up window showing all batch job status information (no input is possible). It allows to monitor and change the status of all active or pending Batch-Jobs.

4.5.2 Batch Info...

The 'Batch Info...' button opens a pop-up window containing information on the batch job status - such as the job-id, project-id, task-id, start time, status, and the PID number of all EGOPS batch jobs listed. It's also possible to remove finished tasks, terminate running tasks or to restart tasks from the EGOPS batch job list.

SPECIAL NOTES/HINTS

- For a better overview, it is recommended to remove all finished tasks from time to time from the list to keep the batch job status information list as short as possible.

4.5.2.1 Batch Processing Information

This pop-up window shows status information on all internal EGOPS batch jobs. It is also possible to terminate running tasks, remove tasks or restart former tasks. 'Quit' closes the window.

SPECIAL NOTES/HINTS

- The Batch Processing Information window is only for information purposes (no direct input is possible). Nevertheless, it is possible to interact with the window content via the 'Terminate Task', 'Remove Task' or the 'Restart Task' buttons.

INPUT PARAMETER(S)

1) === LIST for showing important Batch Processing Information ===

- This list allows to monitor the status of all finished/aborted, active or pending EGOPS Batch Jobs. It includes the following parameters: 'Job-Id', 'Project_Id', 'Task-Id', 'Start Time', 'Status', 'PID'.
- 'Job-Id' is the Job-Id of the Batch Job.
  'Project_Id' names the project from where the Batch Job was started.
  'Task-Id' is the individual name of the Batch Job Task.
  'Start Time' shows the actual Batch Job Start Time.
  (Format: yyyymmdd.hhmm - yyyy is the year, mm (1st) the month, dd the day, hh the hour, mm (2nd) the minutes).
  'Status' is either 'pending' or 'running' or 'finished' or 'error'.
  'PID' (Process Identifier) is the Batch Job Process Identification number.

2) === View Job's Log ===

- This button opens a pop-up window showing the log output of finished batch jobs.
- Only active after selection of a finished batch job (with or without errors).

3) === Refresh ===

- The 'Refresh' pull-down button offers different refresh rates of the content of the Batch Processing Information window: immediate (now), high (all 2 secs), medium (all 10 secs) and long refresh rates (all 60 secs).

4) === Terminate Task ===

- This button allows to terminate a running batch job.
- The button is only active, if the user selects a running batch job with the left mouse button previously.

5) === Restart Task ===

- This button allows to restart batch jobs which have terminated with an error status.
- The button is only active, if the user selects a crashed batch job with the left mouse button previously.

6) === Remove Task ===

- This button allows to remove pending or finished (status 'finished' or 'error') batch jobs from the Batch Processing Information list.
- The button is only active, if the user selects a pending or finished batch job with the left mouse button previously.

7) === Remove finished Tasks ===

- This button allows to remove all regularly finished (status 'finished') batch job entries from the Batch Processing Information list.
- The button is only active, if at least one finished job is indicated in the Batch Processing Information list.

4.6 Pickfile/Pickdirectory

This file selection widget lets you pick a file. The files are shown in the field to the right. You can select a file by clicking on it with the mouse or by typing the filename directly into the Selection field. 'OK' causes to accept the choice, whereas 'Cancel' closes the window without any action done.

SPECIAL NOTES/HINTS

- 'Path' and 'Filter' are non editable. Their only purpose is to show the user, in which directory the displayed files are located and through which filter they have been pre-selected. The 'Subdirectories' field is ignored within EGOPS (always set insensitive).
- The fastest way to select a file from the list is by double-clicking on it. This makes the choice immediately accepted and closes the window without additionally pressing 'OK'.

INPUT PARAMETER(S)

1) === Path ===

   - Shows the full directory path for the selected files. Actually no input, just for display.

2) === Filter ===

   - The filter is automatically set to the file type appropriate in the given context. Actually no input, just for display.

3) === Files List ===

   - Shows the whole list of existing files for the selected file type. Allows to select one file by clicking on the filenames in the list, which is then placed into the 'Selection' field below.
   - Only available if at least one file of the required file type was found (which is, based on the basic EGOPS installation, always true).

4) === Selection ===

   - Allows file selection by direct keyboard input of the filename or shows the file selection done by mouse-click in the 'Files List', respectively.

4.7 Atmosphere Data Path/File Selection Input

4.7.1 GCM3D Atmosphere Data Path/GRIB File Selection

This input group allows to specify a GRIB Data File by selecting the GRIB Data File Path and the GRIB Data File Name.

SPECIAL NOTES/HINTS

- All GRIB data files have standardized file names of the form: <filenameYYYYMMDDHHL.grb>.
  YYYYMMDDHHL are digits and stand for the year (YYYY), the month (MM), the day (DD), the hour (HH) and the level of designation (L).
  For L = 1, HH is free between 00 and 24, whereas for L = 2, 4, or 8, HH is fixed and set to 00. Level L = 2 means two time layers (00 and 12h), L = 4 means four time layers (00, 06, 12, and 18h), and level 8 denotes eight different time layers (00, 03, 06, 09, 12, 15, 18, and 21h).

INPUT PARAMETER(S)

1) === GRIB Data File Path ===

- Specification of the GRIB Data File Path either by keyboard input or by selection via a pop-up window (pick-file widget).
- Each existing GRIB file with a standardized name can be selected.

2) === GRIB Data File Name... ===

- Selection of a GRIB Data File via a pop-up window (pick-file widget). The chosen file will be displayed in the text field on the right of the button.
- Each GRIB file (with a standardized name) available in the list can be selected.

4.7.2 HiVRes Atmosphere Data Path/RAOB File Selection

This input group allows to specify a RAOB Data File by selecting the RAOB Data File Path and the RAOB Data File Name.

SPECIAL NOTES/HINTS

- All RAOB data files have standardized file names of the form: <filenameLaLaHnsLoLoLoHewYYYYMMDDhhmm.raob>. 'LaLa' are the two digits for the latitude, 'Hns' is one digit for the hemisphere [N for northern or S for southern hemisphere], 'LoLoLo' are three digits for the longitude, 'Hew' describes the eastern- or western hemisphere [E for the eastern- or W for the western hemisphere], 'YYYY' are four digits for the year, 'MM' and 'DD' are month and day, respectively, and 'hh' and 'mm' are hours and minutes, respectively.

INPUT PARAMETER(S)

1) === RAOB Data File Path ===

- Specification of the RAOB Data File Path either by keyboard input or by selection via a pop-up window (pick-file widget).
- Each existing RAOB file with a standardized name can be selected.

2) === RAOB Data File Name... ===

- Selection of a RAOB Data File via a pop-up window (pick-file widget). The chosen file will be displayed in the text field on the right of the button.
- Each RAOB file (with a standardized name) available in the list can be selected.

4.8 PS File Output

The PS File Output pop-up widget allows to manipulate several output parameters for individual storing of the plot window content. The resulting output PSfiles are written into the directory ../EGOPS/genPSfiles for Visualize Geographic Maps plots and Visualize Volume Data plots or into the PSfiles-subdirectory of the currently open project (../EGOPS/<Projectname>/PSfiles) for Visualize MAnPl Statistics and Visualize Validate Profiles plots.
'OK' activates PS-File printing with the chosen options and closes the pop-up window, whereas 'Cancel' closes the pop-up window without action.

SPECIAL NOTES/HINTS

- It is not possible to manually change the file path for the resulting PS

output file.

INPUT PARAMETER(S)

1) === INPUT FIELD for showing or changing the PS Filename ===

- Shows the default ps-filename and allows to change it.
- All alphanumeric strings of up to 34 characters length are allowed.

2) === Exclusive BUTTONS ===

- Choice of Format (DIN-A4 or Letter Format), PS File Type (Standard or Encapsulated) and Frame (with or without Frame) of the ps-plot.

5 Project Menu

5.1 Common Dialogs

5.1.1 Text Editor

The text editor opens files for their editing. 'Save & Quit' writes the text file with its current contents back to the disk and forces the editor to close and return. 'Print to PS file' saves the content of the opened file and creates a PS file (<textfilename>.ps) with the same content in the subdirectory /PSfiles of the current Project. 'Cancel' closes the text editor without saving any modifications.

INPUT PARAMETER(S)

1) === INPUT FIELD for editing a text file ===

- Allows to edit the content of text files.
- The Up-Down, Left-Right, Backspace, etc., navigation is similar as with "typical" text editors.

2) === Find Text ===

- Allows to search for an arbitrary string within the text displayed.
- Type the search string in the input field and click 'Find' to find any occurrence of the string in the text (the editor's text field moves to the text block and highlights the string found). If the string do not occur, you will get a not found message.
- Repeated use of the 'Find' button searches for all occurrences from the present cursor position downwards (cycling through the text file).

5.2 Launch New EGOPS Project

For creation of a new EGOPS Project, assign it an unique, not yet existing, identifier. The length of this "Project-id" of the new EGOPS Project is limited to a maximum of 25 characters (minimum length is one char).
'OK' confirms the new EGOPS/Project-id and closes the input window. 'Cancel' causes to return without action.

SPECIAL NOTES/HINTS

- Assign to your new EGOPS Project a "smart" Project-id which conveys some hint to you on what this Project is about.

INPUT PARAMETER(S)

1) === EGOPS/Project-id ===

- Input of the name (Project-id) of a new EGOPS project. The Project-id will be the key name throughout the entire EGOPS system for identifying your current Project.
- Supply an arbitrary alphanumeric string of up to 25 characters which may also contain hyphen or underline characters. Longer strings, intermediate blanks, or use of other characters are not allowed.
- You will be warned in case you choose an EGOPS/Project-id which already exists from prior work or by default.

2) === Edit <Project-id>.txt ===

- Allows to take some notes on the new EGOPS Project via a Text Editor (pop-up window).
- Available as soon as a valid new EGOPS/Project-id was specified.

3) === OK ===

- Available only, if a valid new EGOPS/Project-id was specified.

5.3 Open EGOPS Project

Window for selecting an already existing EGOPS/Project-id. Selection may be done by directly typing the EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing EGOPS/Project-ids..." button). 'OK' confirms the chosen EGOPS/Project-id and closes the input window, 'Cancel causes to return without action.

SPECIAL NOTES/HINTS

- It is not possible to assign a new EGOPS Project-id via "Open ...", use the "Project - Launch new..." function for this purpose.

INPUT PARAMETER(S)

1) === EGOPS/Project-id ===

- Allows to select an existing EGOPS/Project-id by keyboard input.

2) === Existing EGOPS/Project-id ===

- This button opens a pop-up window which allows to select an existing EGOPS/Project-id from a list. Confirm your selection with 'OK' or choose 'Cancel' to return without action.

3) === Edit <Project-id>.txt ===

- Allows to take some notes on the chosen EGOPS Project via a Text Editor (pop-up window).
- Available after an existing EGOPS/Project-id was selected.

4) === OK ===

- Available after an existing EGOPS/Project-id was selected.

5.4 Close EGOPS Project

Window for closing the currently open EGOPS Project. 'Ok' confirms the closing and 'Cancel' causes to return without action.

SPECIAL NOTES/HINTS

- Only the currently open EGOPS Project can be closed.

INPUT PARAMETER(S)

1) === FIELD showing the currently open EGOPS Project ===

- The field shows the currently open EGOPS Project. Not editable.

2) === Edit <Project-id>.txt ===

- Allows to take notes on the currently open EGOPS Project via a Text Editor (pop-up window).

5.5 Rename EGOPS Project

Window for renaming an already existing (old) EGOPS/Project-id to a (new) EGOPS/Project-id.
Selection of the existing (old) EGOPS/Project-id can be done by directly typing the old EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing EGOPS/Project-ids..." button). The new EGOPS/Project-id needs to be typed into the right input field. The format conventions for EGOPS/Project-id strings apply also to new EGOPS/Project-ids assigned here (cf. help on "Launch new...").'OK' confirms the new EGOPS/Project-id and closes the input window, whereas 'Cancel' causes to return without action.

SPECIAL NOTES/HINTS

- Assign your new EGOPS Project a Project-id which conveys some hint to you on what this Project is about.
- If an EGOPS Project is currently open, its (old) EGOPS/Project-id is shown by default in the left input field.
- The "old" Project-id is renamed to the new one everywhere in the project-related file structure (project directory name, Project-id entries in the existing task input files, etc.). The exception is that it is not changed within the input file location info string in the header of the "old" task output data files.
- The EGOPS-internal project "EGOPSProject" can not be renamed.

INPUT PARAMETER(S)

1) === Old EGOPS/Project-id and New EGOPS/Project-id ===

- Specification of the Old and New EGOPS/Project-id by keyboard input.
- The new EGOPS/Project-id must be an alphanumeric string of up to 25 characters which may also contain hyphen or underline characters. Longer strings, intermediate blanks, or use of other characters are not allowed.

2) === Existing User-defined EGOPS/Project-ids... ===

- This button opens a pop-up window which allows to select an existing user-defined EGOPS/Project-id from a list. Confirm your selection with 'OK' or choose 'Cancel' to return without action.

3) === Edit <new-project-id>.txt... ===

- Allows to take some notes on the renamed (new) EGOPS Project via a Text Editor (pop-up window). Note that the old Project's <Project-id>.txt will be carried over to the new <Project-id>.txt file. Therefore the "old" notices on the Project are also present in the "new" <Project-id>.txt file.
- Available as soon as a valid new EGOPS/Project-id was specified.

4) === OK ===

- Available, as soon as a valid new EGOPS/Project-id was specified.

5.6 Delete EGOPS Project

Window for deleting an already existing EGOPS Project. The deletion can be done

by directly typing the EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing EGOPS/Project-ids..." button). Pressing 'OK' displays a "Warning" message which informs you that *Every Information on this Project will be lost!*. If this is o.k., confirm with the 'OK' button on the "Warning" message, otherwise press 'Cancel' to return to the "Delete"-window again.

SPECIAL NOTES/HINTS

- Be careful in using this function, since deletion of a project means that in fact every information (input/output data of all simulations performed within the project) including the project's directory structure is cleared from the disk.
- Trying to choose a non-existing EGOPS Project by direct keyboard input leads to an error message.
- The EGOPS-internal basic project "EGOPSProject" is protected from deletion.

INPUT PARAMETER(S)

1) === INPUT FIELD for deleting an existing EGOPS Project ===

   - Type the Project-id of a project, which shall be deleted.

2) === Existing User-defined EGOPS/Project-ids... ===

   - This button opens a pop-up window which allows to select an existing user-defined EGOPS/Project-id (for deletion) from a list. Confirm your selection with 'OK' or choose 'Cancel' to return without action.

3) === OK ===

   - Available only, if an existing EGOPS Project was selected.

5.7 Shelve EGOPS Project

Window for selecting an already existing EGOPS/Project-id for archiving. Selection can be done by directly typing the EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing EGOPS/Project-ids..." button). 'OK' causes that all data generated by EGOPS in relation to the selected project will be stored automatically in compressed form as ../EGOPS/projshelf/<Project-id>.tar.gz file and closes the input window. 'Cancel' causes to return without action.

SPECIAL NOTES/HINTS

- It is not allowed to choose a new EGOPS Project-id or to select the EGOPS default project (EGOPSProject) for archiving by direct keyboard input.

INPUT PARAMETER(S)

1) === EGOPS/Project-id ===

   - Input field for selection of an existing EGOPS/Project-id for archiving.

2) === Existing EGOPS/Project-ids... ===

   - This button opens a pop-up window which allows to select an existing EGOPS/Project-id (for archiving) from a list. Confirm your selection with 'OK' or choose 'Cancel' to return without action.

3) === Edit <Project-id>.txt ===

```
    - Allows to take some notes on the chosen EGOPS Project via a Text Editor
      (pop-up window).
    - Available after an existing EGOPS/Project-id was selected.


 4) === OK  ===

    - Available after an existing EGOPS/Project-id was selected.
```

5.8 Restore EGOPS Project

```
Window for selecting an already archived EGOPS/Project-id for restoring.
Selection can be done by directly typing the EGOPS/Project-id name into the
foreseen input field or by means of the button/select-list window ("Existing
EGOPS/Project-ids..." button). 'OK' causes that all data generated by EGOPS in
relation to the selected project will be restored automatically in the
../EGOPS/<Project-id> directory and closes the input window. 'Cancel' causes to
return without action.


SPECIAL NOTES/HINTS

 - It is not possible to change the EGOPS Project-id when restoring a project.


INPUT PARAMETER(S)

 1) === INPUT FIELD for assigning an Archived EGOPS/Project-id ===

    - Allows to select an archived EGOPS/Project-id for restoring.


 2) === Existing User-defined EGOPS/Project-ids... ===

    - This button opens a pop-up window which allows to select an archived
      EGOPS/Project-id (for restoring) from a list. Confirm your selection with
      'OK' or choose 'Cancel' to return without action.


 3) === OK BUTTON (& Cancel button) ===

    - Only available after an existing archived EGOPS/Project-id was selected.
```

5.8.1 Restore EGOPS Project Warning

```
This Information Window gives a warning if you try to restore a project which
has the same EGOPS/Project-id as an project already existing in the /projects
directory of EGOPS. To avoid any losses of data it is necessary to rename the
already existing project, otherwise (at least) parts of the existing will be
overwritten. To avoid overwriting, close the warning window with 'Cancel' and
perform the appropriate steps before restoring this EGOPS/Project-id again.
Otherwise, you can choose between deleting the existing project and restoring
the archived one ('Delete & Restore') or overwriting the existing project with
the content of the stored EGOPS/Project-id (Update & Restore).
```

5.9 BatchJobs Info

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.5.2.1, titled "Batch Processing Information" .

6 Task Menu

6.1 Common Dialogs

6.1.1 Task-id

A Task-id (Task identifier) within EGOPS denotes generally the User's name and identification of a specific Task. (Consult the "Help on Task - About Tasks" entry at the menu level in case you need to learn what an EGOPS "Task" is.)

The Task-id is the name and identification of the MAnPl-, FoMod-, OSMod-, InRet-Task you are currently supplying the input for. It is the key identification means for EGOPS to separate all files relating to your current simulation activity (which will actually start when you go for Save&Compute in the bottom button row) from others with different inputs (which you will assign different Task-ids). In fact all files relating to the current Task will contain the Task-id as leading part of the file name. Specifically, all information relating to the e.g., Mission/Analysis Planning will be saved in the /MAnPl subdirectory of the /<Project-id> directory of your current Project. (Consult the "Help on Project/About Projects" entry at the menu level in case you need to learn what an EGOPS "Project" and "Project-id" are.)

SPECIAL NOTES/HINTS

- Assign your Task a "smart" Task-id which conveys some hint to you on what this Task is about. (Among other things, this is very helpful during the visualization/validation of your results, when your primary selector will be just the Task-id assigned here.)

INPUT PARAMETER(S)

1) === INPUT FIELD for assigning a Task-id ===

- This input field allows to assign a Task-id of the current Task.
- Supply an arbitrary alphanumeric string of up to 25 characters which may also contain hyphen or underline characters. Longer strings, intermediate blanks, or use of other characters are not allowed.
- You will be properly warned in case you choose a Task-id which already exists from prior work or by default.
- Remember that the Task-id will be the key name throughout the entire EGOPS system for identifying your current Task.

2) === Existing Tasks... ===

- This button opens a pop-up window for selection of an existing Task-id from a list.
- Available only if more than one Task already exists (otherwise the only existing Task-id - Default - is autom. set and the button/select-list window is insensitive).

3) === Delete Tasks... ===========

- This button opens a pop-up window for selection of one (or more) existing Task-id (s) out of all existing ones for deleting (only the Default Task-id cannot be deleted). Specifically, e.g., all information relating to the chosen Forward Modeling Task-id (s) will be deleted in the /FoMod subdirectory of the /<Project-id> directory of the currently open Project.
- Available only, if more than one Task already exists (otherwise the only existing Task-id - Default - is not allowed to delete and the delete

window button is set insensitive).

6.1.1.1 Delete Tasks Input

The Delete Task-ids pop-up widget allows to remove outdated Task-ids from the currently open project. This tool can be used to delete obsolete MAnPl-, FoMod-, OSMod-, and InRet-Task-ids by activating the delete procedure in the MAnPl-, FoMod-, etc. window. All files belonging to the deleted Task-id will be completely removed and cannot be recovered later, therefore a warning appears so the user has a last chance to reverse his action before actually destroying the whole content of the task.

SPECIAL NOTES/HINTS

- Default Task-ids are not shown in the list of existing Tasks because it is not allowed to delete the default EGOPS Task-ids.

INPUT PARAMETER(S)

1) === Existing Tasks ===

   - List widget which allows to select by mouse-click one (or more) existing Task-id(s) from a list of available entries for deleting.

2) === Tasks to delete ===

   - This list widget shows all Task-Id's selected for deletion.

3) === BUTTONS for moving Task-ids between the two task listings ===

   - Bitmap buttons which allow to move the selected Task-id(s) between the two list widgets (existing tasks and tasks to delete).
   - Available only, if a task was highlighted by mouse click.

4) === Delete ===

   - Button which allows to delete all Task-id(s) listed in the Tasks field 'Tasks to delete' at once. Before actually deleting the content of the list, a warning pops up so the user could also abandon his decision at the last moment or can press 'OK' for deleting the selected (group of) task(s).
   - Available only, if there is at least one Task-id in the 'Tasks to delete' list (otherwise the delete button is insensitive).

6.2 Mission Analysis/Planning

Mission Analysis/Planning (MAnPl) is considered to include the analysis and planning of single LEO satellites as well as LEO constellations carrying GNSS and LEO occultation receivers, including antennae field-of-view planning and analysis, and visibility analysis with respect to ground stations for assessing, investigating and optimizing occultation event coverage and related relevant statistics. Further included are reflection data calculation scenarios which enable to analyze the reflection geometry between Transmitter (Tx) satellite, water surface (normally the ocean or several huge lakes which act as a big mirror reflecting the Tx radio signals to the Rx) and Receiver (Rx) satellite.

Such analysis requires a considerable number of "free input parameters" in a simulation tool in order to allow for (realistic) MAnPl simulations of widely arbitrary GNSS/LEO-LEO occultation missions. (See the section "MAnPl INPUT PARAMETERS" below for an overview on the respective functionality furnished by EGOPS. Details are found in the On-line Help within the "MAnPl Input" interface window available via the "Task" menu.)

Furthermore, it is necessary to have available convenient tools for visualization of the simulation results in order to carry out simulation studies efficiently and in order to effectively comprehend and interpret the results. (See the section "MAnPl VISUALIZATION" below for a crude overview on the respective functionality furnished by EGOPS. A refined overview is given under the "Help on Visualize/Val. - Help on Visualize MAnPl Statistics, Help on Visualize Geographic Maps" entries of the "Help" menu. Details are found in the On-line Help within the "Visualize Mission Analysis/Planning Statistics" and "Visualize Geographic Maps" interface windows available via the "Visualize/Validate" menu.)

MAnPl INPUT PARAMETERS

EGOPS allows to compute Mission Analysis/Planning tasks taking into account the set of "free input parameters" outlined below, which all together provide considerable flexibility and potential for Mission Analysis/Planning. All these parameters can be - within their range of validity - freely set by the User just as desired for a specific MAnPl task.

The "MAnPl Input" window, which is available via the "Mission Analysis/Planning" entry of the "Task" menu, is the convenient interface EGOPS provides for the supply of all of these parameters (including the supply of a few input file names, providing for access to some more lengthy parameter lists required, e.g., satellite orbit elements).

- Data type:
The selection between GNSS-LEO and LEO-LEO occultation- and reflection data is possible.

- Simulation time:
Start date and time, and the total time range for a simulation.

- Height levels of interest:
For each of such height levels (and for each occultation in the time range) the corresponding occultation geometry is computed, interpreting the height levels as those tangent point heights of an occultation event for which the geometric information is sought just at the instant when the levels are crossed. The essential geometric information is the corresponding geographic coordinates of the tangent point together with the corresponding positions of the Tx and Rx satellites involved in the occultation event. Height levels are only used for calculation of occultation data.

- Time step:
Choose an integer divide of the simulation time range for the reflection data time step. Time steps are only used for reflection data calculation.

- Geographic area of interest:
Global, hemispheric or any regional area for which the coverage by occultation events is sought.

- Earth Figure model:
Spherical (R = 6371 km) or Ellipsoidal (WGS-84) Earth.

- Tx-to-Rx/Reflection ray treatment:
Straight-line approximation of rays or rays with quasi-realistic bending caused by the neutral atmosphere.

- Active space segment (Tx satellites):
Number, orbit constellation (i.e., orbit elements) and signal properties of the GNSS and LEO transmitters. The different transmitter systems (GPS, GALILEO, GLONASS, LEO) can be selected in arbitrary combinations or alone. This information is supplied by the Tx-*.tle and Tx-*.spd files in the /orbitelem and /signalprop directory of EGOPS, respectively, which are selected within the "MAnPl Input" window.

- Tx orbit propagator:
Spherical orbit approximation, Keplerian orbit or "Simplified General Perturbation (SGP)" orbit (the latter including short and long period perturbations and parameterized radiation/star drag).

- Tx antenna specifications:
Antennae pointing and characteristics including boresight direction and field-of-view width and shape for "anti-velocity" looking and forward-looking antenna.

- Spaceborne receiver segment (Rx satellites):
Number and orbit constellation (i.e., orbit elements) of receiver platforms in LEO. This information is supplied by the Rx*.tle files in the /orbitelem directory, one of which is always selected within the "MAnPl Input" window. [Please see the Software User Manual - File Format Manual (SUM-FF) for a description of the *.tle file format.]

- Rx orbit propagator:
Spherical orbit approximation, Keplerian orbit or "Simplified General Perturbation (SGP)" orbit (the latter including short and long period perturbations and parameterized atmospheric drag).

- Rx antenna specifications:
Antennae pointing and characteristics including boresight direction and field-of-view width and shape for "anti-velocity" looking and forward-looking antenna. Furthermore information on the Rx's zenith-antenna field-of-view.

- Ground segment (Fiducial and Tracking sites):
The number, location and antenna field-of-view of auxiliary GNSS/LEO receiver sites for aiding the usual single- or double-difference processing of occultation data (fiducial sites), and the number, location and antenna field-of-view of ground stations for telemetry/telecommand (tracking sites). This information is supplied by fid*.gst and trk*.gst files, respectively, in the /groundst directory of EGOPS, which are selected within the "MAnPl input" window. [Please see the Software User Manual - File Format Manual (SUM-FF) for a description of the *.gst file format.]
Satellite visibility information is then computed for the fiducial and tracking stations, as necessary for assessing the visibility conditions for single- and/or double-differencing and tracking for a given scenario.

MAnPl VISUALIZATION

EGOPS provides for the visualization of results of Mission Analysis/Planning tasks by its "Visualize MAnPl Statistics" and "Visualize Geographic Maps" window interfaces, both available through the "Visualize/Validate" menu.

The "MAnpl Statistics" interface allows to compute, visualize and print-out 1D and 2D occultation coverage statistics as function of variables like latitude, local time, duration of occultation events, etc.
Furthermore, it allows to compute, visualize and print-out visibility statistics for fiducial and tracking sites, e.g., no. of occultation events for which successful single- or double-differencing is possible by each of a given sample of fiducial sites, or no. of orbits seen for a certain time range per orbit by each of a couple of tracking sites.
[See "Help on Visualize/Val. - Help on Visualize MAnPl Statistics" for more information.]

The "Geographic Maps" interface allows to compute, visualize and print-out latitude-longitude maps (different map projections available) of occultation event coverage for arbitrary geographic areas and including information such as on the geometrical shape and time of each event.
Furthermore, it allows to compute, visualize (stand-alone or as overplot to occultation event coverage maps) and print-out geographic maps of a series of atmospheric/ionospheric variables (e.g., temperature and electron density) from all atmospheric/ionospheric models available within EGOPS. These may either slice the atmospheric/ionospheric field at a certain height or be vertically integrated quantities (e.g., total precipitable water).
[See "Help on Visualize/Val. - Help on Visualize Geographic Maps" for more information.]

6.3 Mission Analysis/Planning Input

6.3.1 Data Type Selection

The data type selection droplist allows to specify one of four different available Data Types for Mission Analysis/Planning. These types are GNSS-LEO Occultation Data, LEO-LEO Occultation Data, GNSS-LEO Reflection Data and LEO-LEO Reflection Data.

SPECIAL NOTES/HINTS

- GNSS is the generic acronym for the Global Navigation Satellite System (comprising GPS, GALILEO and GLONASS).
- LEO is the acronym for Low Earth Orbit.
- The Reflection Data modes only use reflections from large water areas like big lakes or the ocean.

6.3.2 UT Range

This input group allows to specify start date/time and simulation time range of the simulations. The time range added to the start date/time gives the time of the end of the simulation.

SPECIAL NOTES/HINTS

- "Only" dates between 1990 and 2089 are supported.
- Minimum simulation time is 0000h 01min 00sec, i.e., 1 minute.
  Beware of further exploiting any MAnPl computation results in case of a short simulation time range, leading to no occultation events; in this case, re-run the simulation with a sufficiently long time range.
- Maximum simulation time is 999h 59min 59sec (about 6 weeks).
- A warning will be issued, if the orbital elements (i.e., the epoch) in the selected *.tle file are older than 6 months with respect to the simulation date. Prediction of LEO with the "SGP (Impr. Kepler)" propagator might be significantly degraded, if the orbital elements are too old.
  For very low LEOs and long simulation time ranges, the satellite could even decay from orbit within the simulation time range. So, beware of being too far off from *.tle epoch times for accurate orbit prediction employing the SGP propagator.
  In case of "strange" abnormal termination of MAnPl computations (with a start date far off from the TLE-epoch), the reason could be that a satellite apparently has decayed. To confirm this assumption, rerun the task for a date close to the TLE-epoch. If the MAnPl computations then operate smoothly, the assumption is verified.
- Visibility Information on Differencing and Tracking is only available for a simulation time range longer than 2 hours.

INPUT PARAMETER(S)

1) === Start Date/Time ===

   - Specification of the simulation start date and start time.
   - Input Format: [yymmdd.hhmmss]
     'yy' are the last two numbers of the chosen year, 'mm' (1st) is the month, 'dd' is the day, 'hh' are the hours, 'mm' (2nd) the minutes and 'ss' the seconds.
   - In each case two digits are necessary for correct input. Intermediate blanks are not allowed. Pay attention to the dot's position.
   - The values for the year can range between 90,...,99,00,01,...,89 (that means from 1990 till 2089).

2) === Simulation Time Range ===

   - Specification of the Simulation Time Range.

- Input Format: [hhhmmss]
  'hhh' are the hours, 'mm' the minutes and 'ss' the seconds.
- Only integers are allowed. Intermediate blanks are not allowed.
- The hours can range from 000 to 999.

6.3.3 Height Levels

This input field allows to specify the height levels [km] for "Occultation Data" simulations. If the tangent point of an occultation event passes a specified height level, corresponding information on the instantaneous geometry of the occultation event (time, geographic location, satellite positions) will be computed and saved in the *.sgd output file.
Up to 4 different height level ranges can be chosen by directly specifying the desired height level values.

- Input Format: [Hlo1 Hhi1 Hstep1 dh1, Hlo2 Hhi2 Hstep2 dh2, ...]
  Each height level range is specified by four numbers (allowing for one post-comma digit) which are separated by a blank: 'Hlo' is the lower boundary of the height range, 'Hhi' is the upper boundary, 'Hstep' is the step size and 'dh' specifies the height accuracy for the simulation (all units are in [km]).
  Different height level ranges are separated by a comma and a blank.
  Hstep must be an integral multiple of the height range, i.e., the Hlo-Hhi bounds need to be matched.

- Range of Values:
  For later atmospheric calculations with FoMod and InRet, Hlo can take values from 0.0 (earth surface) to 30.0 km, and Hhi from 70.0 to 120.0 km.
  For later ionospheric calculations with FoMod and InRet, Hlo can be chosen between 0.0 and 200.0 km, and Hhi can go up to the perigee of the lowest Rx-satellite contained in the current Rx-*.tle file.
  If only geometrical aspects are of interest (pure MAnPl simulations), Hlo can be set between 0.0 km and Hhi, and Hhi can be chosen from Hlo up to the perigee of the lowest Rx-satellite contained in the current Rx-*.tle file (if Hlo = Hhi, Hstep has to be set to 0.0 km, i.e. there is only one single height level).
  The minimum step size is 0.1 km, the maximum height accuracy may be 0.05 km. The maximum number of height levels is 100.

SPECIAL NOTES/HINTS

- An overlap of different height level ranges is not allowed.
- If two adjacent ranges are chosen with different accuracy but common boundary (e.g., Hhi1=Hlo2), the common boundary computations will use the more accurate dh value (e.g., MIN(dh1,dh2)).
- Only available for data type "Occultation Data".

6.3.4 Time Step

Specification of the length of the Time Step [min] used for a MAnPl 'Reflection Data' calculation. Reflection events are searched at each Time Step within the specified Simulation Time Range. If one ore more reflection events belonging to a time step are found, corresponding geometric information on the reflection events (time, satellite positions, reflection point) will be computed and saved in the *.srd output file.

- Input of the Time Step.
- The minimum value is 0.1 min. The maximum value allowed is half the length of the chosen Simulation Time Range.
- The Time Step must always be an integer divide of the chosen Simulation Time Range.
- Only available for Data Type "Reflection Data".

6.3.5 Geographic Area of Interest for Occultation/Reflection Events

This input group allows to specify the geographic area for which occultation/reflection events shall be computed within the time range specified in the "UT Range" input group. For occultation events, only those events are accounted for in the MAnPl computations, whose tangent point (precisely speaking, the tangent point of the lowest height level specified in the "Height Levels" input) lies within the specified latitude-longitude region. Reflection events are computed for reflections from the surface of big lakes or from the oceans, but not from land areas.

SPECIAL NOTES/HINTS

- Specifying areas crossing the date line (+/-180 deg) is no problem: Always observe that the minimum longitude (LoMin) is the westward longitude and the max. longitude (LoMax) is the eastward one. For example, LoMin = 160 and LoMax = -150 corresponds to a 50 deg wide longitude range crossing the date line.

INPUT PARAMETER(S)

1) === DROPLIST for Predefined Area Choice ===

- Selection of predefined geographic areas ('Global', 'Northern Hemisphere', 'Southern Hemisphere') or of an arbitrary user-defined area ('Regional...').
- 'Regional...' renders the input field for Arbitrary Area Definition sensitive (see input parameter 2 below).

2) === Area ===

- Selection of an arbitrary geographic area by directly specifying the desired latitude-longitude region.
- Input Format: (LaMin LaMax LoMin LoMax)
  'LaMin' and 'LaMax' are the minimum and maximum latitude of the area [deg], and 'LoMin' and 'LoMax' stand for the minimum and maximum longitude [deg], respectively.
  Supply numerical values with a maximum of one post-comma digit. Separation of the values with a blank.
- Range of Values:
  -90.0 <= LaMin, LaMax <= 90.0, with LaMax-LaMin >= 1.0 [deg]
  -180.0 <= LoMin, LoMax <= 180.0, with LoMax-LoMin >= 1.0 [deg]
- Available only, if the droplist for predefined area choice is set to 'Regional...' (cf. input parameter 1 above).

6.3.6 Earth Figure Model

In case of "Occultation Data", this droplist allows to specify one of two different Earth Figure Models. The 'Spherical' Earth model assumes the Earth to be a sphere with constant mean radius 6371.0 km (the radius of a sphere with the same volume as the actual body of the Earth). The 'Ellipsoidal' Earth model follows the widely used WGS84 definition. This ellipsoid deviates from the mean-sea-level reference surface, the Geoid, by a maximum of no more than about 100 m. For "Reflection Data" only the 'Spherical' Earth model is available.

SPECIAL NOTES/HINTS

- WGS84 is the acronym for World Geodetic System 1984.
- For a more rough approximation, you will typically choose the Spherical Earth model; when aiming for high absolute accuracy, the Ellipsoidal Earth model (WGS84) should be selected.

6.3.7 Tx-to-Rx/Reflection Ray Treatment

In case of "Occultation Data", this droplist allows to specify two different ways of Tx-Rx Ray Treatment. The first one is an approximate computation

assuming quasi-vacuum conditions, termed 'Straight Line Rays' approximation. The second one is a more precise calculation, the 'Bended Rays' approach. The straight-line treatment determines the geometry of the occultation event for the desired height levels by assuming straight-line visibility between Tx and Rx (i.e., vacuum or thin atmosphere). The bended-rays treatment uses an exponential atmosphere model (very close to the RefAtm_UoG refractivity field included within EGOPS) and takes refractivity-field compliant bended-ray visibility into account.
For "Reflection Data", only the 'Straight Line Ray' approximation is available.

SPECIAL NOTES/HINTS

- Tx-Rx are acronyms for Transmitter - Receiver.
- For quasi-realistic tropospheric geometry, the use of the bended-ray treatment is mandatory.

6.3.8 Tx System Specifications

This input group allows to define the generic transmitter (Tx) satellite system(s) used for the occultation/reflection event calculation. Detailed specifications of the generic satellite systems are defined via Tx Orbit Element File(s) (Tx-*.tle) and Tx Signal Property File(s) (Tx-*.spd).
Furthermore, the modeling mode of the Tx satellite orbits can be chosen via the "Tx Orbit Model" droplist.

SPECIAL NOTES/HINTS

- GNSS is the generic acronym for the Global Navigation Satellite System (comprising GPS, GALILEO and GLONASS).
- GPS is the US Global Positioning System.
- GALILEO is the European Satellite Navigation System.
- GLONASS is the Russian GLObal NAvigation Satellite System.
- SGP is the name of the "SGP" satellite orbit propagator which is one of the official propagators to propagate the NORAD/NASA two-line orbital elements (*.tle files).
  [Kelso (1988), Models for Propagation of NORAD Element Sets (F.R. Hoots and R.L. Roehrlich/1980), Package by T.S. Kelso, Spacetrack Report No. 3, Dep. of Commerce/Nat'l Tech Information Service, Springfield VA.]

INPUT PARAMETER(S)

1) === Tx Satellite System(s) ===

   - Up to three droplists allow to choose different Satellite Systems supplying the Tx satellites for the occultation/reflection event calculation. At least one system must be used.
   - In case of GNSS-LEO Occultation/Reflection events, the GPS, GALILEO('GAL') and GLONASS ('GLO') satellite systems are available.
   - In case of LEO-LEO Occultation/Reflection events, 'ACE' is the only system available at the moment.

2) === Tx Orbit Element File(s) ===

   - The 'Tx-*.tle...' button opens a pop-up window for the selection of an Orbit Element file (Tx-*.tle) from the /orbitelem subdirectory of EGOPS.
   - Tx-*.tle files contain the orbit elements (epoch, etc.) of the Tx-satellites used. To learn more what Tx-*.tle files are and how to supply your own Tx-*.tle files consult the Software User Manual - File Format Manual (SUM-FF).
   - This button is available for activated Satellite Systems only.

3) === Tx Signal Property File(s) ===

   - The 'Tx-*.spd...' button opens a pop-up window for the selection of a Signal Property file (Tx-*.spd) from the /signalprop subdirectory of

```
      EGOPS.
    - Tx-*.spd files contain information on the used frequency chains. To learn
      more what Tx-*.spd files are and how to supply your own Tx-*.spd files
      consult the Software User Manual - File Format Manual (SUM-FF).
    - This button is available for activated Satellite Systems only.


 4) === Tx Orbit Model ===

    - Specification of the modeling mode of the Tx satellite orbits. Following
      options are available:
      'Circular Orbits': Simplest but fastest model. The eccentricity in the
          Tx-*.tle files is ignored
      'Keplerian Orbits': Allows to calculate elliptic Tx orbits, secular
          changes of the Kepler ellipse due to Earth's ellipsoidal mass
          distribution are included. More accurate than the circular model.
      'SGP Orbits (Improved Kepler)': Based on a Keplerian Orbit model,
          including higher order perturbations of the Kepler ellipse and a
          parametric treatment of atmospheric drag or star drag. The most
          accurate and realistic, but slowest model available.
```

6.3.8.1 Selection of a Orbital Element (*.tle) and a Signal Property (*.spd) File

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.6, titled "Pickfile/Pickdirectory" .

6.3.9 Tx Antenna Specifications

```
Specification of technical characteristics of the transmitter antennae via
pop-up windows. Boresight direction, Antenna Field of View (FOV) and
Threshold-Power Beam Width (TPBW) can be appointed to reasonable values.

    - The usage or non-usage of -V Tx and +V Tx antennae for the simulation is
      controlled by the check-box on the left of the "+/-V Tx Antenna" buttons.
      At least one of the antennae must be activated.
    - The "+/-V Tx Antenna" button allows to manipulate technical antenna
      characteristics (Boresight direction, Antenna FOV, TPBW) via a pop-up
      window.
    - Only available for data type "LEO-LEO Occultation Data". In each other
      case, the Tx antenna specifications are predefined internally.


SPECIAL NOTES/HINTS

 - "-V Tx antenna" denotes an antenna pointing towards the anti-velocity
   direction half-space of a satellite (backward viewing). Enables the
   simulation of setting occultation events.
 - "+V Tx antenna" denotes pointing towards the velocity-direction half-space
   (forward viewing). Enables the simulation of rising occultation events.
 - "Threshold-Power Beam Width (TPBW)" denotes the beamwidth around the
   boresight within which the antenna is defined to have sufficient power for
   enabling an occultation event. It is advisable to use the Half-Power Beam
   Width (HBPW) of an antenna as the TPBW (i.e., applying the antenna's -3dB
   point as threshold).
```

6.3.9.1 Tx/Rx Antenna Input

```
This input window allows to specify technical antenna characteristics. In
particular, boresight direction of the antenna, antenna Field of View (FOV), and
Threshold-Power Beam With (TPBW) can be adjusted to reasonable values. "OK"
causes all text field entries and droplist settings to be accepted as the
current input, whereas "Cancel" closes the input window without any action done.


INPUT PARAMETER(S)
```

```
1) === Boresight ===

   - Specification of Elevation and Azimuth [deg] of a Tx/Rx antenna mounted on
     a LEO satellite relative to the antenna coordinate system.
     The antenna coordinate system is a s/c (spacecraft) fixed cartesian system
     having its Z axis pointing towards nadir, its X axis perpendicular to this
     Z axis in the plane spanned by the s/c velocity vector and the Z axis, and
     the Y axis completing a right-handed coordinate system.
   - Range of Values:
     Elevation, 0.0 to 60.0 deg (default 27.0 deg, approx. towards Earth limb
                for a typical LEO near 800 km).
     Azimuth, 90.0 to 270.0 deg for the '-V antenna' (default 0.0 deg),
              -90.0 to 90.0 deg for the '+V antenna' (default 180.0 deg).
   - An elevation of 0.0 deg denotes an antenna boresight in the X-Y plane of
     the antenna coordinates. The elevation increases towards nadir.
   - An azimuth of 0.0 deg means a forward-looking, an azimuth of 180.0 deg a
     backward-looking antenna, the azimuth increasing from X over Y.


2) === Antenna FOV ===

   - Droplist for selection among different Antenna field-of-views (FOVs):
     'Conical FOV': Any power pattern isocontour of the antenna main lobe
         corresponds to a circle so the FOV defined by this isocontour is a
         cone with constant opening angle at all lobe azimuths.
     'Elliptical FOV/horiz. Cartesian': The lobe's isocontours are (regular)
         ellipses corresponding to an elliptical lobe shape with different
         opening angles in the horizontal and vertical.
     'Elliptical FOV/horiz. Earth shaped': The lobe's isocontours are quasi
         ellipses with the horizontal axis curved (banana-shaped) to follow the
         shape of the Earth's surface as seen from the LEO satellite.
   - The Elliptical FOV/horizontally Earth shaped antenna FOV is not available
     for FoMod reflection data calculations.


3) === Threshold-Power Beam Width ===

   - Specification of the Horizontal and Vertical Threshold-Power Beam Width
     (TPBW) [deg] of a Tx/Rx antenna mounted on a LEO. The TPBW defines the
     beamwidth in horizontal (H-) and vertical (V-) direction within which
     sufficient power/gain is available for enabling occultation measurements.
     Beyond, no occultation events can be found.
     Usually, the half-power beamwidth (HPBW, the "-3dB point") of an antenna
     is an adequate measure for the TPBW settings.
   - Range of Values:
     For 'Conical FOV', H-TPBW and V-TPBW from 1.0 to 180.0 deg.
     For 'Ellip. FOV/hor. Cartesian', H-TPBW from 1.0 to 180.0 deg, V-TPBW from
         1.0 to 90.0 deg.
     For 'Ellip. FOV/hor. Earth shaped', H-TPBW from 1.0 to 180.0 deg, the
         maximum V-TPBW is confined to half of the chosen H-TPBW. The minimum
         V-TPBW depends linear on the H-TPBW (i.e. 1 deg for a H-TPBW of 1 deg,
         10 deg for a H-TPBW of 90 deg, and 30 deg for a H-TPBW of 180 deg;
         between (from H-HPBW 1 - 90 deg and 90 - 180 deg) two linear functions
         with different derivatives).
   - The values define the full width of the beam (e.g., 90 deg = +-45 deg
     around boresight).
   - In the case of 'Conical FOV', the input field for the vertical TPBW is
     insensitive (since in this case, horizontal TPBW = vertical TPBW).
```

6.3.10 Rx System Specifications

```
This input group allows to define the receiver (Rx) satellite system and its
orbit specifications used for the occultation/reflection event calculation.
Furthermore, the modeling mode of the Rx satellite orbits can be chosen via the
"Rx Orbit Model" droplist.


SPECIAL NOTES/HINTS
```

- SGP is the name of the "SGP" satellite orbit propagator which is one of the official propagators to propagate the NORAD/NASA two-line orbital elements (*.tle files).

  [Kelso (1988), Models for Propagation of NORAD Element Sets (F.R. Hoots and R.L. Roehrlich/1980), Package by T.S. Kelso, Spacetrack Report No. 3, Dep. of Commerce/Nat'l Tech Information Service, Springfield VA.]

INPUT PARAMETER(S)

1) === Rx Satellite System ===

   - The Rx Satellite System used is automatically defined via the selected Rx Orbit Element File (Rx-*.tle) (see 'Rx Orbit Element File').

2) === Rx Orbit Element File ===

   - The 'Rx-*.tle...' button opens a Pop-up Window for the selection of an Orbit Element file (Rx-*.tle) from the /orbitelem subdirectory of EGOPS.
   - Rx-*.tle files contain the orbit elements (epoch, etc.) of the Rx-satellites used. For more details consult the Software User Manual - File Format Manual (SUM-FF).

3) === Rx Orbit Model ===

   - Specification of the modeling mode of the Rx satellite orbits. Following options are available:
     'Circular Orbits': Simplest but fastest model. The eccentricity in the Rx-*.tle files is ignored
     'Keplerian Orbits': Allows to calculate elliptic Rx orbits, secular changes of the Kepler ellipse due to Earth's ellipsoidal mass distribution are included. More accurate than the circular model.
     'SGP Orbits (Improved Kepler)': Based on a Keplerian Orbit model, including higher order perturbations of the Kepler ellipse and a parametric treatment of atmospheric drag or star drag. The most accurate and realistic, but slowest model available.

6.3.11 Rx Antenna Specifications

This input group allows to define technical characteristics of the receiver antennae. Boresight direction, Antenna Field of View (FOV), and Threshold-Power Beam Width (TPBW) can be appointed to reasonable values. Furthermore, the elevation limit of a zenith antenna which is necessary for double differencing can be controlled.

SPECIAL NOTES/HINTS

- "-V Rx antenna" denotes an antenna pointing towards the anti-velocity direction half-space of a satellite (backward viewing). Enables the simulation of setting occultation events.
- "+V Rx antenna" denotes pointing towards the velocity-direction half-space (forward viewing). Enables the simulation of rising occultation events.
- "Threshold-Power Beam Width (TPBW)" denotes the beamwidth around the boresight within which the antenna is defined to have sufficient gain for acquiring an occultation event. It is advisable to use the Half-Power Beam Width (HBPW) of an antenna as the TPBW (i.e., applying the antenna's -3dB point as threshold).

INPUT PARAMETER(S)

1) === Rx Antenna Specifications ===

   - The usage or non-usage of -V Rx and +V Rx antennae for the simulation is controlled by the check-box on the left of the '+/-V Rx Antenna' buttons. At least one antenna must be activated.

```
    - The '+/-V Rx Antenna' button allows to manipulate technical antenna
      characteristics (Boresight direction,  Antenna FOV, TPBW) via a pop-up
      window.


 2) === Rx Zenith Antenna Elevation Limit ===

    - The Zenith Antenna is necessary in order to enable Double Differencing
      and Space-based Single Differencing.
    - The Elevation Limit [deg] defines the angle above the horizontal of the
      actual orbital position of the receiver within which no other satellites
      can be seen.
    - Range of Values:
      From 0.1 - 89.9 deg. 0.1 deg means that virtually the whole hemisphere
      above the satellite's height is visible. 89.9 deg means that only
      satellites directly above the receiver can be seen.
```

6.3.11.1 Tx/Rx Antenna Input

The information on this topic is provided in the chapter on "Common Dialogs" - Section 6.3.9.1, titled "Tx/Rx Antenna Input" .

6.3.12 Visibility Information

```
This input group allows to get information on the visibility of Rx satellites
from Tracking Stations, as well as of Tx satellites from Fiducial Sites and
additional Rx satellites not involved into the occultation. This knowledge
can then be statistically analyzed which yields information on the need for
Tracking Stations and the possibility of differencing, for example.


SPECIAL NOTES/HINTS

 - This input group is only available for "Occultation Data" if the simulation
   time range is longer than 2 hours.
 - In order to learn more about how to specify your own tracking stations
   (trk*.gst files), fiducial sites (fid*.gst files) and additional Rx satellite
   systems (Rx-*.tle files), consult the Software User Manual - File Format
   Manual (SUM-FF).
 - Don't use this function if it is not relevant for the current task or if you
   are not well-versed in this topic. This would save computational time and
   disk space.


INPUT PARAMETER(S)

 1) === Visibility Information on Differencing ===

    - Enables to calculate the visibility of Tx satellites from Fiducial Sites
      and additional Rx satellites. From this information you can later on
      derive statistics on how well your fiducial sites will be able to help in
      "Ground-based Single/Double Differencing" processing of your occultation
      data, and how well the additional Rx satellites will be able to help in
      "Spacebased Single Differencing".
    - Setting the droplist to 'Differencing Vis. Info...' allows to select among
      different Differencing Visibility Choices, Fiducial Sites and additional
      Rx satellite systems via a pop-up window. To deactivate the visibility
      calculation, set the droplist to 'No Differencing Vis. Info'.


 2) === Visibility Information on Tracking ===

    - Enables to calculate the visibility of Rx-satellites from Tracking
      stations. From this information you can later on derive statistics on how
      many orbits of the simulated Rx-satellites have been seen by the selected
      tracking sites. This is done within the "Visualize MAnPl Statistics" menu
      item of the "Visualize/Validate" menu.
```

```
    - Setting the droplist to 'Tracking Vis. Info...' allows to select between
      different Tracking Station(s) via a pop-up window. To deactivate this
      function, set the droplist to 'No Tracking Vis. Info'.
```

6.3.12.1 Differencing Visibility Informations Input

```
This input window allows to define the settings for the calculation of
Differencing Visibility Information. This information may be later on evaluated
with the Differencing Visibility Statistics option of the "Visualize/Validate ->
MAnPl Statistics" tool. "OK" causes all text field entries and droplist settings
to be accepted as the current input, whereas "Cancel" closes the input window
without any action done.


INPUT PARAMETER(S)

 1) === Differencing Visibility Choices ===

    - Selection of the Differencing mode(s) on which visibility information is
      desired: 'Ground-based Double-Differencing', 'Ground-based
      Single-Differencing' and/or 'Spacebased Single-Differencing'.
    - Selection of a mode via the check-box the left of the respective entry.
    - At least one of the three offered Differencing treatments has to be
      selected. Otherwise dismiss the window and choose 'No Differencing Vis.
      Info'.


 2) === Fiducial Sites fid*.gst file ===

    - Button for selection of a Fiducial Sites file (fid*.gst) from the
      /groundst subdirectory of EGOPS via a pop-up window.
    - fid*.gst files contain information on geographic location and antenna
      specifics of Fiducial Stations. For more details consult the Software User
      Manual - File Format Manual (SUM-FF).
    - Only available if information on Ground-based Double-Differencing or
      Ground-based Single-Differencing is desired.


 3) === Additional Rx*.tle file ===

    - Button for selection of an additional Rx orbit element file (Rx-*.tle)
      from the /orbitelem subdirectory of EGOPS via a pop-up window.
    - Rx-*.tle files contain information on the orbits of the Rx-satellites
      used. For more details consult the Software User Manual - File Format
      Manual (SUM-FF).
    - Only available if information on Space-based Single Differencing is
      desired.
```

6.3.12.1.1 Selection of a Fiducial Sites (fid*.gst) and an Additional Rx*.tle File

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.6, titled "Pickfile/Pickdirectory" .

6.3.12.2 Tracking Visibility Information Input

```
This input window allows to define the settings for the calculation of Tracking
Visibility Information. This information may be later on evaluated with the
Differencing Visibility Statistics option of the "Visualize/Validate -> MAnPl
Statistics" tool. "OK" causes all text field entries and droplist settings to be
accepted as the current input, whereas "Cancel" closes the input window without
any action done.


INPUT PARAMETER(S)
```

```
 1) === Tracking Visibility Choices ===

    - Selection of the Tracking mode(s) on which visibility information is
      desired. 'Ground to Rx Tracking Info' is currently the single fixed
      option. (So no actual choice is available but the input is designed to be
      readily expandable for add-on choices).


 2) === Tracking Station(s) trk*.gst file ===

    - Button for selection of a Tracking Station file (trk*.gst) from the
      /groundst subdirectory of EGOPS via a pop-up window.
    - trk*.gst files contain information on geographic location and antenna
      specifics of Tracking Stations. For more details consult the Software User
      Manual - File Format Manual (SUM-FF).
```

6.3.12.2.1 Input for the Selection of a Tracking Station

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.6, titled "Pickfile/Pickdirectory" .

6.4 Forward Modeling

```
Forward Modeling (FoMod), together with subsequent Observation System Modeling
(OSMod), performs quasi-realistic simulation of observables and related required
variables of the GNSS and LEO radio occultation technique. The main observables
are time-tagged phase and amplitude measurements, obtained in real world by
tracking occulted Transmitter signals with a LEO platform-mounted receiver for
atmospheric sounding during their set/rise through the atmosphere imposed by the
relative orbital motion of the Transmitter (Tx) and Receiver (Rx) satellites.

Forward Modeling itself denotes the simulation of the propagation of transmitted
signals through the atmosphere/ionosphere system given the orbital motions of
the Tx and Rx satellites. It results in "ideal" signals which contain the
effects of the atmosphere/ionosphere media only. - "Ideal" in the sense that it
is the state of the signal right before it enters the receiving antenna and
before any degradations by the receiving system are incurred. Thus FoMod results
allow to inspect the environmental influence alone. In addition to spaceborne
radio occultations (GNSS-LEO, LEO-LEO) EGOPS allows also to simulate airborne
occultations (GNSS-Airplane, LEO-Airplane) where the signal receiver is placed
onboard an aircraft instead of a LEO satellite. Satellite to groundstation
events can be computed, too.

Furthermore, it is quite useful in terms of computational performance to
separate FoMod, involving CPU-expensive propagation simulation (i.e., ray
tracing) from OSMod, since the latter can be treated very efficiently as
superposition of "observation system" effects on the "ideal" signal. Thus
studies of different receiving system effects can be efficiently carried out
using one and the same CPU-expensive FoMod result as baseline. [See "Help on
Task - Help on Observation System Modeling" for more information on OSMod.]

In case of interest in observation simulations, Forward Modeling is the natural
stage in EGOPS following some planning and preparation of occultation events
with desired properties within "Mission Analysis/Planning (MAnPl)" (e.g., events
occurring in a geographic region of interest, etc.). In fact the geometric
properties (i.e., Rx and Tx orbital arcs) of an occultation event being "forward
modeled" can be, in case simulations are desired for realistic geometry,
directly taken from the results of a User- selected MAnPl task (typically
prepared before). For a realistic airborne occultation the mission analysis and
planning part will be additionally done together with the rest of the pure
forward modelling tasks in FoMod.

Such forward modelling requires a considerable number of "free input parameters"
in a simulation tool in order to allow for a (realistic) FoMod simulation of
widely arbitrary GNSS and LEO occultation missions. (See the section "FoMod
INPUT PARAMETERS" below for an overview on the respective functionality
furnished by EGOPS. Details are found in the On-line Help within the "FoMod
```

Input" interface window available via the "Task" menu.)

Furthermore, it is necessary to have convenient tools for visualization and validation of the simulation results available in order to carry out simulation studies efficiently and in order to effectively comprehend and interpret the results. (See the section "FoMod VISUALIZATION" below for a crude overview on the respective functionality furnished by EGOPS. A refined overview is given under the "Help on Visualize/Val. - Help on Visualize/Val. Profiles" entry of the "Help" menu. Details are found in the On-line Help within the "Visualize/Validate Profiles" interface window available via the "Visualize/Validate" menu.)

FoMod INPUT PARAMETERS

EGOPS allows to compute Forward Modeling tasks taking into account the set of "free input parameters" outlined below, which all together provide considerable flexibility and potential for Forward Modeling. Nomen est omen all these parameters can be - within their range of validity - freely set by the User just as desired for a specific FoMod task.
The "FoMod Input" window, available via the "Forward Modeling" entry of the "Task" menu, is the convenient interface EGOPS provides for the supply of all of these parameters (including the supply of a "Reference MAnPl Task-id" in case simulations are desired for realistic geometry, providing for access to the input conditions and results of a prior MAnPl task).

- Type of occultation event to be simulated:
For spaceborne radio occultations a single event or a whole sample of events can be "forward modeled", whereby single events can be simulated either for an ideal geometry (assuming co-planar Tx and Rx orbits and, correspondingly, virtually-vertical tangent point trajectory) or for a realistic geometry (based on the geometry data obtained for a result event of a prior MAnPl task). Sample-of-event simulations always require event samples from a prior MAnPl task. Approximately the same is true for airborne radio occultations (only sample of realistic airborne occultation events cannot be processed).

  - Specifications for modelling a single event with ideal geometry:
  Tangent point location, azimuth of occultation plane (containing Tx, Rx, and the Earth's center), start date and time, height range over which the occultation event shall be "forward modeled", Tx and Rx orbital heights, the used Tx satellite system and the Tx signal properties. In case of an ideal geometry airborne occultation all Rx specifications are substituted by their corresponding aircraft specifications (additionally also the speed of the airplane is needed as input parameter).

  - Specifications for modeling with realistic geometry:
  Reference MAnPl Task-id (to be selected from the list of suitable MAnPl tasks existing within the current Project), event number of desired event within the MAnPl results (if single event) or event number range within the MAnPl results (if sample of events), height range over which the event(s) shall be "forward modeled", and the used Tx satellite system. In case of an airborne occultation with realistic geometry the coordinates of the start and end location, the start date and time, the occultation event height range, the airplane height and speed, the used Tx satellite system, the Tx orbit element and signal property file and the occultation event number are the key input parameters.

  - Specifications for a satellite to groundstation event:
  Reference MAnPl Task-id (to be selected from the list of suitable MAnPl tasks existing within the current Project), satellite and groundstation Id, time range over which the event shall be "forward modeled", and the used Tx satellite system.

- Choice of atmospheric and ionospheric models:

  - Climatological atmospheric model: No atmosphere, or simple dry or moist (bi-)exponential atmosphere, or dry or moist 2D atmosphere, or dry 3D atmosphere, or the GSM 3D Atmosphere, or the HiVRes Atmosphere, or a user-supplied atmosphere (default for the latter: the bi-exponential atmosphere). [If you have a source code version of EGOPS read the file usratm.SampleFile in the /prog/FORprog subdirectory of EGOPS in case you want

to learn more about how to supply your own user-supplied atmosphere.]

- Atmospheric disturbance model: In the case of a GNSS transmitter, following options are available but only in dry air: no disturbance, or gravity wave superposed, or frontal system gradient superposed, or tropopause fold superposed, or atmospheric inversion superposed. In the case of a LEO transmitter turbulence/scintillations can be superposed.

- Climatological ionospheric model: No ionosphere, or simple double-Chapman ionosphere, or full 3D ionosphere.

- Ionospheric disturbance model: No disturbance, or travelling ionospheric disturbance (TID) superposed, or ionospheric gradient superposed, or ionospheric trough superposed, or ionospheric storm effect superposed.

- Sampling rates for forward modeling:
1000 Hz, 500 Hz, or 250 Hz, or 100 Hz, or 50 Hz, or 25 Hz, or 10 Hz, or 5 Hz, or 1 Hz, or 0.2 Hz for all frequencies (if the upper limit of the occultation event height is larger than 90 km the sampling rates are limited to a maximum of 50 Hz, for airborne occultations the maximum sampling rate is 5 Hz, for satellite to groundstation events it is only 1 Hz).

- Signal propagation simulator:
Quasi-3D ray tracing (considering, in terms of refractivity gradients, the radial gradient only), full-3D ray tracing (accounting for the full-3D refractivity gradient field), or wave optics propagator (for a more realistic computation dealing with diffraction and multipath effects). Accuracy of ray-tracing from Tx to Rx can be set to be <~ 1 mm, or <~ 1 cm, or <~ 10 cm (less demanding accuracy allowing faster computations but yielding more inaccurate simulated phase observables) for the first two signal propagation simulators whereas the ray tracer accuracy for the wave optics propagator can be set to be "High", "Medium", or "Low".

FoMod VISUALIZATION

EGOPS provides for the visualization of results of Forward Modeling tasks by its "Visualize/Validate Profiles" window interface available via the "Visualize/Validate" menu.

The "Visualize/Validate Profiles" window interface allows, for FoMod tasks, to post-process, visualize, customize, compare, and print-out simulated phase and amplitude data (in terms of "atmospheric(/ionospheric) excess phase" and "atmospheric(/ionospheric) power loss") as function of occultation event time. The excess phase data at the transmitted frequencies as well as the linearly corrected (LC) data (neutral atmosphere only after linear ionospheric combination of F1/F2 phases) and LI data (ionosphere only at L1) are all available for visualization and inspection, stand-alone or in combinations.

The post-processing includes functionality to compute absolute and relative difference profiles between profiles of different FoMod tasks or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events.

Customization includes, among other features, functionality to fit an exponential or polynomial of user-specified order to a selected range of a profile or to compute the time average value over a selected range of a profile (and to visualize this information by overplot on the original profile). [See "Help on Visualize/Val. - Help on Visualize/Val. Profiles" for more information.]

6.5 Forward Modeling Input

6.5.1 Occultation Event Simulation Type

This droplist allows to specify one of six different Occultation Event Simulation Types. For every simulation type, the corresponding input window

will be mapped in the framed section below the droplist. For spaceborne cases, it is possible to choose amongst "Single Event/Ideal Geometry", "Single Event/Realistic Geometry" and "Sample of Events/Realistic Geometry".
In case of airborne events "Airborne Occultation - Ideal Event" and "Airborne Occultation - Realistic Event" are possible selections.
"Satellite to Groundstation Events" can also be computed.

SPECIAL NOTES/HINTS

- If the droplist is set to Sample of Events/Realistic Geometry, the "Ionosphere Disturbance Model" choice is disabled. If, additionally, GNSS-LEO occultations are selected, atmospheric disturbances can not be superposed either.

6.5.2 Single Event/Ideal Geometry Specifications

This input group allows to set various specifications needed for a "Single Event/Ideal Geometry" occultation. Ideal Geometry means that straight lines are used as connection between the Tx- and Rx-Satellite.

SPECIAL NOTES/HINTS

- Minimum/maximum Satellite Heights are between 150 km and 100000 km.
- The "Speed of Airplane" input field has no meaning in this case and is insensitive (it's only sensitive in case of an "Airborne Occultation - Ideal Event").

INPUT PARAMETER(S)

1) === Tangent Point Location ===

- Input field for the Tangent Point Location (Latitude and Longitude) of the occultation event.
- Input Format: (Lat Lon)
  Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical values with a maximum of one post-comma digit. The values must be separated by at least one blank.
- Range of Values:
  Latitude from -89.0 to 89.0 deg (note that the geographic poles of the earth are not allowed), Longitude from -180.0 to 180.0 deg.

2) === Azimuth Occultation Plane ===

- Specification of the orientation of the Azimuth Occultation Plane [deg].
- Input Format:
  Only integers are allowed. North is 0 deg, West is 90 deg and so on.
- Range of Values: From 0 to 360 deg.

3) === Occultation Event Start Date/Time ===

- Input of Start Date and Start Time of the occultation event.
- Input Format: (yymmdd.hhmmss)
  'yy' are the last two numbers of the chosen year, 'mm' (1st) is the month, 'dd' is the day, 'hh' are the hours, 'mm' (2nd) the minutes and 'ss' the seconds.
  In each case two digits are necessary for correct input. Intermediate blanks are not allowed. Pay attention to the dot's position.
- Range of Values:
  The values for the year can range between 90,...,99,00,01,...,89 (that means from 1990 till 2089).

4) === Occultation Event Height Range ===

- Input field for the Height Range of the occultation event.

- Input Format: (Hlo Hhi)
  'Hlo' is the lower limit of the Occultation Event Height Range and 'Hhi' is the upper limit [km]. The limits must be specified by numerical values with a maximum of one post-comma digit. The values must be separated by at least one blank.
- Range of Values:
  For later atmospheric calculations with InRet, Hlo can be set between 0.0 km (earth surface) and 30.0 km, and Hhi can be set between 70.0 km and 120.0 km. For later ionospheric calculations with InRet (possible only in case of GNSS-LEO occultations), Hlo can be chosen between 0.0 km and 200.0 km, and Hhi can go from 500.0 km up to the perigee of the lowest Rx-satellite contained in the current Rx-*.tle file.
  For later InRet simulations, if the lowest used FoMod Sampling Rate at relevant Tx frequencies is higher or equal 5 Hz, the allowed limits for Hlo are set from 0.0 to Hhi-8 km, and for Hhi are set from Hlo+8 km to 120.0 km in an atmospheric case (for ionospheres the limits specified before are unchanged). Default values are 0.0 km for Hlo and 80.0 km for Hhi.

5) === Rx Tx Satellite Heights ===

- Specification of the orbital heights of Tx and Rx satellite.
- Input Format: (HRx HTx)
  'HRx' is the height of the receiver satellite and 'HTx' is the height of the transmitter satellite [km]. Only integers are allowed. The values must be separated by at least one blank.
- Range of Values:
  In the case of GNSS-LEO, the Rx satellite height can vary from 200 - 5000 km, the Tx satellite height from 1501 - 50000 km.
  In the case of LEO-LEO, Rx as well as Tx satellite height can take values between 200 and 1500 km.

6) === Tx Sat System Choice ===

- Input field for the specification of the Tx Satellite System. Either 'GNSS' or 'LEO' can be chosen.

7) === Tx Signal Property File ===

- Depending on the selected Tx Satellite System, this input allows to select an appropriate signal property file (Tx-GNSS*.spd or Tx-LEO*.spd) from the /signalprop subdirectory of EGOPS via a pop-up window.
- Tx-*.spd files contain information on the used frequency chains. For more details consult the Software User Manual - File Format Manual (SUM-FF).

6.5.3 Single Event/Realistic Geometry Specifications

This input group allows to set various specifications needed for a "Single Event/Realistic Geometry" occultation. Realistic Geometry means that also bended lines as connection between the Tx- and Rx-Satellite are allowed.

INPUT PARAMETER(S)

1) === Reference MAnPl/Task-id... ===

- This button opens a pop-up window for selection of an already computed MAnPl Task. From this task, one occultation event can be later on selected whose geometry data serve as baseline for the FoMod simulation.

2) === Infos on Task in ===

- This button opens a pop-up window showing all entries of the Reference MAnPl/Task-id input.

3) === Occultation Event Number ===

- Input field for selection of an occultation event from the chosen MAnPl Task which shall be forward modeled.
- Only integers are allowed.
- The range of valus depends on the occultation event numbers in the corresponding MAnPl/MAnPl/Task-id.sgd-file. These numbers will be always shown in the explanation label right of the input field.

5) === Occultation Event Height Range ===

- Specification of the Height Range of the occultation event.
- Input Format: (Hlo Hhi)
  'Hlo' is the lower limit of the Occultation Event Height Range and 'Hhi' is the upper limit [km]. The limits must be specified by numerical values with a maximum of one post-comma digit. The values must be separated by at least one blank.
- The range of values is controlled by the height-resolution of the respective MAnPl occultation event which is listed in the explanation label on the right of the input field. Only values which are multiples of the step size (refer to "Reference MAnPl/Task-id...") will be accepted.

6) === Tx Sat System Choice ===

- Displays the used transmitter satellite system, which is automatically defined by the selected MAnPl Task. Not for input.

6.5.4 Sample of Events/Realistic Geometry Specifications

This input group allows to set various specifications needed for a "Sample of Events/Realistic Geometry" occultation. Realistic Geometry means that also bended lines as connection between the Tx- and Rx-Satellite are allowed.

INPUT PARAMETER(S)

1) === Reference MAnPl/Task-id... ===

- This button opens a pop-up window for selection of an already computed MAnPl Task. From this task, a sample of occultation events can be later on selected whose geometry data serve as baseline for the FoMod simulation.

2) === Infos on Task in ===

- This button opens a pop-up window showing all entries of the Reference MAnPl/Task-id input.

3) === Occultation Number Range ===

- Selection of a sample of occultation events from the chosen MAnPl Task which shall be forward modeled.
- Input Format: (lo hi step)
  'lo' is the lowest occultation number of the range, 'hi' the highest one, and 'step' denotes the stepsize defining the used events between 'lo' and 'hi'. 'step' must be an integral multiple of the Occultation Number Range. All three values must be separated by at least one blank.
- Only integers are allowed.
- The range of values depends on the occultation event numbers in the corresponding MAnPl/MAnPl/Task-id.sgd-file. These numbers will be always shown in the explanation label right of the input field.

4) === Occultation Event Height Range ===

- Specification of the Height Range of the occultation event.
- Input Format: (Hlo Hhi)
  'Hlo' is the lower limit of the Occultation Event Height Range and 'Hhi' is the upper limit [km]. The limits must be specified by numerical values

with a maximum of one post-comma digit. The values must be separated by at least one blank.
- The range of values is controlled by the height-resolution of the respective MAnPl occultation event which is listed in the explanation label on the right of the input field. Only values which are multiples of the step size (refer to "Reference MAnPl/Task-id...") will be accepted.

5) === Tx Sat System Choice ===

- Displays the used transmitter satellite system, which is automatically defined by the selected MAnPl Task. Not for input.

6.5.5 Airborne Occultation - Ideal Event

This input group allows to set various specifications needed for an Airborne Occultation Event with Ideal Geometry. Ideal Geometry means that only straight lines as connection between the Transmitter (Tx) and the Airplane are allowed.

INPUT PARAMETER(S)

1) === Tangent Point Location ===

- Input of the Tangent Point Location (Latitude and Longitude) of the airborne occultation event.
- Input Format: (Lat Lon)
  Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical values with a maximum of one post-comma digit. The values must be separated by at least one blank.
- Range of values:
  Latitude from -89.0 to 89.0 deg (note that the geographic poles of the earth are not allowed), Longitude from -180.0 to 180.0 deg.

2) === Azimuth Occultation Plane ===

- Specification of the orientation of the Azimuth Occultation Plane [deg].
- Input Format:
  Only integers are allowed. North is 0 deg, West is 90 deg and so on.
- Range of Values: From 0 to 360 deg.

3) === Occultation Event Start Date/Time ===

- Input of Start Date and Start Time of the airborne occultation event.
- Input Format: (yymmdd.hhmmss)
  'yy' are the last two numbers of the chosen year, 'mm' (1st) is the month, 'dd' is the day, 'hh' are the hours, 'mm' (2nd) the minutes and 'ss' the seconds.
- In each case two digits are necessary for correct input. Intermediate blanks are not allowed. Pay attention to the dot's position.
- Range of Values:
  The values for the year can range between 90,...,99,00,01,...,89 (that means from 1990 till 2089).

4) === Occultation Event Height Range ===

- Input field for the Height Range of the airborne occultation event.
- Input Format: (Hlo Hhi)
  'Hlo' is the lower limit of the Occultation Event Height Range and 'Hhi' is the upper limit [km]. The limits must be specified by numerical values with a maximum of one post-comma digit. The values must be separated by at least one blank.
- Range of Values:
  Hlo from 0.0 to 3.0 km and Hhi from 8.0 to 16.0 km. Default values are 0.0 km for Hlo and 10.0 km for Hhi.

```
 5) === Airplane/Tx Sat Height ===

    - Input of the Airplane Trajectory Height and the Tx Satellite Height.
    - Input Format: (HAPT HTx)
      'HAPT' is the height of the  receiver satellite and 'HTx' is the height of
      the transmitter satellite [km]. Only integers are allowed. The values must
      be separated by at least one blank.
    - Range of Values:
      If the transmitter is a GNSS satellite, HTx can vary from 1501 - 50000 km.
      In the case of a LEO transmitter, HTx from 200 - 1500 km. HAPT can take
      values from 8 - 16 km in each case.


 6) === Speed of Airplane ===

    - Input of the speed of the airplane [km/h]. Only integers are allowed.
    - Range of values: From 300 - 3000 km/h.


 7) === Tx Sat System Choice ===

    - Input field for the specification of the Tx Satellite System. Either
      'GNSS' or 'LEO' can be chosen.


 8) === Tx Signal Property File ===

    - Depending on the selected Tx Satellite System, this input allows to select
      an appropriate signal property file (Tx-GNSS*.spd or  Tx-LEO*.spd) from
      the /signalprop subdirectory of EGOPS via a pop-up window.
    - Tx-*.spd files contain information on the used frequency chains. For more
      details consult the Software User Manual - File Format Manual (SUM-FF).
```

6.5.6 Airborne Occultation - Realistic Event

```
This input group allows to set various specifications needed for an Airborne
Occultation Event with Realistic Geometry. Realistic Geometry means that also
bended lines as connection between the Transmitter (Tx) and the Airplane are
allowed.


INPUT PARAMETER(S)

 1) === Start/End Location... ===

    - Specification of start and end location of the AirPlane Trajectory (APT).
      This can be done either via a pop-up window ("Start/End Location..."
      button) or by direct keyboard input of latitude and longitude of the
      desired start and end locations.
    - Selection via the pop-up window:
      Three different ways for selection. Either by direct input of location
      names (cities with airport) or by choosing the location from a list of
      available entries or by direct mouse click on a world map.
    - Selection by direct keyboard input:
      The first input field right of the "Start/End Location..." button includes
      the coordinates of the start location, the second one that of the end
      location.
      Input format: (Lat Lon)
      Latitude (Lat) and longitude (Lon) [deg] of the start/end location must be
      specified by numerical values with a maximum of two post-comma digits. The
      values must be separated by at least one blank.
      Range of Values:
      Lat from -89.00 to 89.00 deg and Lon from -180.00 to 180.00 deg.


 2) === Start Date/Time APT ===

    - Input of Start Date and Start Time of the airborne occultation event.
    - Input Format: (yymmdd.hhmmss)
      'yy' are the last two numbers of the chosen year, 'mm' (1st) is the month,
```

'dd' is the day, 'hh' are the hours, 'mm' (2nd) the minutes and 'ss' the seconds.
In each case two digits are necessary for correct input. Intermediate blanks are not allowed. Pay attention to the dot's position.
- Range of Values:
The values for the year can range between 90,...,99,00,01,...,89 (that means from 1990 till 2089).

3) === Occultation Event Height Range ===

- Input field for the Height Range of the airborne occultation event.
- Input Format: (Hlo Hhi)
'Hlo' is the lower limit of the Occultation Event Height Range and 'Hhi' is the upper limit [km]. The limits must be specified by numerical values with a maximum of one post-comma digit. The values must be separated by at least one blank.
- Range of Values:
Hlo from 0.0 to 3.0 km and Hhi from 8.0 to 16.0 km. Default values are 0.0 km for Hlo and 10.0 km for Hhi.

4) === Height APT ===

- Input of the height od the airplane trajectory [km]. Only numerical values with a maximum of one post-comma digit are allowed.
- Range of Values: From 8.0 - 16.0 km.

5) === Speed APT ===

- Input of the speed of the airplane [km/h]. Only integers are allowed.
- Range of values: From 568 - 3000 km/h.

6) === Tx Sat System Choice ===

- Input field for the specification of the Tx Satellite System. Either 'GPS' or 'GAL' or 'GLO' or 'ACE' can be chosen.

7) === Tx Orbit Element File ===

- Depending on the selected Tx Satellite System, this input allows to select an appropriate orbit element file (Tx-GPS*.tle, Tx-GAL*.tle, Tx-GLO*.tle, Tx-ACE*.tle) from the /orbitelem subdirectory of EGOPS via a pop-up window.
- Tx-*.tle files contain information on the orbits of the Tx-satellites used. For more details consult the Software User Manual - File Format Manual (SUM-FF).

8) === Tx Signal Property File ===

- Depending on the selected Tx Satellite System, this input allows to select an appropriate signal property file (Tx-GPS*.spd, Tx-GAL*.spd, Tx-GLO*.spd, Tx-ACE*.spd) from the /signalprop subdirectory of EGOPS via a pop-up window.
- Tx-*.spd files contain information on the used frequency chains. For more details consult the Software User Manual - File Format Manual (SUM-FF).

9) === Select Event... ===

- Selection of the number of an airborne occultation event, which shall be forward modeled.
- Via the "Select Event..." button, a pop-up window opens up and geometry data of the airborne events - resulting from the inputs above - are calculated simultaneously.
- One of the just calculated occultation events can be selected for forward modeling. This can be done via the pop-up window or by keyboard input:
- Selection via the pop-up window:

```
      Either by direct mouse click on the desired event on the shown map or by
      keyboard input.
    - Selection by direct keyboard input:
      Specification of the desired occultation number in the input field right
      of the "Select Event..." button. Only integers are allowed.
      The range of values depends on the occultation events found and is shown
      in the explanation label right of the input field.
      This input field is only available, if the number of occultation events
      was calculated before by means of the 'Select Event...' pop-up tool.
```

6.5.6.1 Start and End Location selection for Airborne Occultations

```
Selection of start and end location of the AirPlane Trajectory (APT) for
airborne occultations. This can be done either via keyboard input or by
selection from the city list or by direct mouse click on the map. "Quit" causes
all selected values to be accepted as the current ATP Begin and End Location
input. "Cancel" means to drop the changes just made in this input window.


INPUT PARAMETER(S)

 1) === Select Start Location ===

    - Selection of the APT Start Location either by keyboard input (put in the
      name of the desired city into the input field), by direct selection from
      the city-list or by direct mouse click on the map. In the latter case, you
      must activate the "Select from Map by Mouse" button before selection.
    - Selection via the input field only allows for strings contained in the
      city list.
    - If you select the desired Start Location via the map, corresponding
      coordinates (Latitude, Longitude) will be written into the bottom line of
      the Select Start Location window.


 2) === Select End Location ===

    - Selection of the APT End Location. This can be done in the same three ways
      as the selection of the Start Location (see point 1).


 3) === World Map ===

    - The map graphically shows the chosen APT and allows to select the APT
      Start/End Location via mouse click.
```

6.5.6.1.1 Selection of a Two Line Element (*.tle) and a Signal Property (*.spd) File

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.6, titled "Pickfile/Pickdirectory" .

6.5.6.2 Occultation Event Selection for Realistic Airborne Occultations

```
This input group allows to select an airborne occultation event from the whole
set of events shown on the map. The selection can be done directly via keyboard
input or by selecting the desired occultation event per mouse-click from the
map. "Quit" causes the selected Occultation Event Number to be accepted as
input. "Cancel" means to drop the changes just made in this input window.


SPECIAL NOTES/HINTS

 - After initially opening this pop-up window (the 'Select Event...' button is
   dark blue colored and the Occultation Event number window aside is
   insensitive), all Occultation Events along the AirPlane Trajectory (APT) are
   calculated 'online'. Therefore, it takes some time before the pop-up window
```

```
   is ready for user inputs.


INPUT PARAMETER(S)

 1) === Selection of Occultation Event ===

    - Specification of the number of the Occultation Event which shall be
      forward modeled. This can be done either by direct keyboard input (only
      integers are allowed) or by selecting the desired event via mouse click
      from the map.
    - The actual range of possible values is shown in the information label on
      the right side of the input window.


 2) === Information on the Selected Occultation Event ===

    - Displays important information on the selected occultation event
      (occultation event type and time; Tx satellite Id; positions of tangent
      point, Tx satellite and airplane).


 3) === Graphics Window Settings ===

    - The Geographic Area droplist allows to alter the view of the map.
      "Global", "Northern Hemisphere","Southern Hemisphere" or "Zoom Region" can
      be selected.
    - "Zoom Region" enables to mark a rectangular zoom region on the map
      pressing the left mouse button. Clicking the right mouse button afterwards
      enlarges the marked region.
    - The lower line within this box aids with finding a specific occultation
      event on the map since the occultation event number is displayed if the
      pointer is near an event.


 4) === Show rays ===

    - If the check-box is activated, a part of the radio signal track near the
      tangent point between Tx-satellite and the airplane is visualized on the
      map. In particular, two rays - one at the beginning and the other at the
      end of the occultation event - are shown.


 5) === Print to PS file... ===

    - Enables to print the whole content of the plot window into a PS-file for
      permanent storage via a pop-up window. Name of the file, size of the plot
      (DIN-A4 or letter format) and kind of the PS plot file (standard or
      encapsulated PS) can be selected.
```

6.5.6.2.1 PS File Output

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.8, titled "PS File Output" .

6.5.7 Satellite to Groundstation Geometry Specifications

```
This input group allows to set various specifications needed for a "Satellite to
Groundstation Event" (Tx-GS event).


SPECIAL NOTES/HINTS

 - GS is the acronym for GroundStation.
 - Tx is the acronym for Transmitter.
```

INPUT PARAMETER(S)

1) === Reference MAnPl/Task-id... ===

- This button opens a pop-up window for selection of an already computed MAnPl Task which yields the geometry data for the FoMod simulation.
- Only Reference MAnPl/Task-ids with simulated Groundbased Single Differencing Visibility Information included are valid for Tx to Groundstation calculations. Furthermore, the simulation time interval is limited (max. 24 h in case of a GNSS transmitter, max. 6 h in case of a LEO transmitter) in order to avoid multiple occurrence of the same Tx-GS event. If such a case occurs anyhow, only the first event will be used and automatically displayed in the UT Range input field.

2) === Infos on Task in ===

- This button opens a pop-up window showing all entries of the Reference MAnPl/Task-id input.

3) === Choose Sat- and GrdSt-Id ===

- Input of the Identification Numbers of a Tx-GS pair able to perform a Tx-GS event.
- Input Format: (Sat-Id GrdSt-Id)
  'Sat-Id' and 'GrdSt-Id' are the identification numbers of the transmitter satellite and the groundstation, respectively. Only integers are allowed. The values must be separated by at least one blank.
- All valid Id-number pairs can be found by scanning the corresponding MAnPl/Task-id.vis-file. If a wrong combination is typed, the input field values will be automatically set back to the last valid Tx- and GS-Id pair.

4) === Select UT Range ===

- Allows to manipulate the shown UT range for shortening the simulation time interval.
- Input Format: [yymmdd.hhmmss,hhmmss]
  The input before the comma is the Simulation Start Date and Time of the current Tx-GS event, and the Simulation Time Range stands after the comma. 'yy' are the last two numbers of the chosen year, 'mm' (1st) is the month, 'dd' is the day, 'hh' are the hours, 'mm' (2nd & 3rd) the minutes and 'ss' the seconds. In each case two digits are necessary for correct input. Intermediate blanks are not allowed. Pay attention to the dot's and comma's position.
- Range of Values:
  All values which are fitting inside the given default (maximum) simulation time interval.
- Be aware that increasing the simulation start time must be compensated by reducing the simulation time length of at least the same amount - if not this will automatically be done by EGOPS.

5) === Tx Sat System Choice ===

- Displays the transmitter satellite system involved in the Tx-GS event, which is automatically determined by the selected Satellite Id.

6.5.8 Atmosphere Climatology Model & Atmosphere Disturbance Model

This input group allows to specify the atmospheric conditions underlying to the FoMod simulations. The basic atmosphere climatology model, water vapor content, clouds and rain as well as the atmospheric structure can be defined via droplists. Furthermore, atmospheric disturbances can be superposed.

INPUT PARAMETER(S)

1) === DROPLIST for Atmosphere Climatology Model ===

- Selection of the basic atmosphere model underlying to the FoMod simulations. Besides 'No Atmosphere', following models are available: 'Bi-Exponential Atmosphere (RefAtm_UoG)', 'HLat 2D Atmosphere (CIRA86aQ_UoG)', '3D Atmosphere dry (MSIS90_DMI)', 'GCM 3D Atmosphere (GCM3DAtm)', 'HiVRes Atmosphere (HiVResAtm)' and a 'User-supplied atmosphere (RefAtm_UoG)'.
- In the "No Atmosphere" case, obviously, the other droplists of this box as well as the "Atmosphere Disturbance Model" are insensitive.

2) === DROPLIST for Humidity ===

- Selection between 'No Humidity included' and 'Humidity included'.
- Only available, if the chosen Atmosphere Climatology Model allows to include humidity. Otherwise, "No humidity included" is automatically set and the droplist button is insensitive.

3) === DROPLIST for Clouds and Rain ===

- Selection between 'No Clouds and Rain' and various cloud and rain settings superimposed to the basic Atmosphere Climatology Model:

  'Simple Clouds and Rain...': Allows to model clouds of different types (Cumulus, Altostratus, Cirrus, etc.) with user-defined liquid- and ice-water content, height and thickness via a pop-up window.
  'GCM 3D Clouds LWC', 'GCM 3D Clouds IWC', 'GCM 3D Clouds LWC+IWC': Selection of one of these entries causes, that 3D liquid-water (IWC) and/or 3D ice-water (IWC) fields will be included in addition to the basic atmospheric conditions (pressure, temperature, humidity). Only available in the case of GCM 3D Atmosphere (GCM3DAtm).

- Only available if the transmitter is a LEO satellite and if humidity is included. Not available in the case of "Sample of Events/Realistic Geometry" and "Satellite to Groundstation Event".

4) === DROPLIST for Atmosphere Structure Model ===

- Allows the selection between the Atmosphere Model Structure as is and a Spherical Symmetric Atmosphere Model Structure (a structure with no horizontal variations).

5) === Atmosphere Disturbance Model ===

- Allows to superpose atmospheric disturbances on the basic atmosphere settings. Depending on the used transmitter system, various disturbance models are available.

- If the transmitter is a GNSS satellite, following settings are possible: 'No Atmospheric Disturbance superposed', "Gravity Wave superposed...', 'Frontal System Gradient superposed...', "Tropopause Fold superposed...', and 'Atmospheric Inversion superposed...'.
  Specific inputs needed for the calculation of the different disturbances are defined via pop-up windows.
  If "No Atmosphere" or an Atmosphere Climatology Model with humidity included is used, it is not possible to choose any of these Atmosphere Disturbance Models (corresponding droplist will be set insensitive). These models are not available in the case of "Sample of Events/Realistic Geometry", too.

- If the transmitter is a LEO satellite, following entries are possible: 'No Atmospheric Disturbance superposed' and 'Turbulence/Scintillations superposed'.
  Specific inputs needed for the calculation of turbulence/scintillations are defined via a pop-up window.

6.5.8.1 GCM3D Atmosphere Data Path/GRIB File Selection

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.7.1, titled "GCM3D Atmosphere Data Path/GRIB File Selection" .

6.5.8.2 HIVRes Atmosphere Data Path/RAOB File Selection

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.7.2, titled "HiVRes Atmosphere Data Path/RAOB File Selection" .

6.5.8.3 Simple Clouds and Rain Model

```
The Simple Clouds and Rain Model allows to simulate clouds as simple
(horizontally-limited) layers of a given thickness around a given cloud height
with constant liquid water and/or ice water content. The inputs needed for the
calculation are defined within this pop-up window. "OK" causes all text field
entries and droplist settings to be accepted as the current input, whereas
"Cancel" closes the input window without any action done.


SPECIAL NOTES/HINTS

 - LWC is the acronym for Liquid Water Cloud.
 - IWC is the acronym for Ice Water Cloud.


INPUT PARAMETER(S)

 1) === Clouds and Rain Type ===

    - Specification of the cloud type via selection from two droplists.
    - The left droplist allows to specify, whether the cloud shall be simulated
      as horizontally-unlimited (1D) or as horizontally-limited layer (3D).
    - The right droplist allows to specify the cloud type. Following entries are
      available: 'Cu-Cumulus (LWC)', 'As-Altostratus (LWC)', 'Ci-Cirrus (IWC)',
      'Cb-Cumulonimbus (IWC+LWC)', 'Cp-Cumulonimbus precipitation
      (IWC+LWC+Rain)', and 'Ns-Nimbostratus (LWC+Rain)'.


 2) === Clouds and Rain Parameters ===

    Specification of various cloud properties, such as liquid and/or ice water
    content of the cloud, height and thickness of the LWC and/or IWC, rain top
    height and rain rate.
    It depends on the chosen cloud type, which specifications are needed. The
    input fields for the required specifications will be highlighted, all other
    entries will be insensitive.

    "LW Cloud Water Content"
        - Specification of the liquid water content of a cloud.
        - Numerical value between 0.01 and 5.00 [g/m^3]. Default is

    "LW Cloud Height Thickness"
        - Input Format: (hei thi)
          'hei' is the height of the liquid water cloud [km] and 'thi' the
          thickness [km]. Both are specified by a numerical value with a maximum
          of one post-comma digit. The values must be separated by at least one
          blank.
        - Range of Values:
          Height from  2.0 - 5.0 km, thickness from 0.1 - 3.0 km.
    "IW Cloud Water Content"
        - Numerical value between 0.01 and 0.05 [g/m^3].
    "IW Cloud Height Thickness"
        - Input Format: (hei thi)
          'hei' is the center height of the ice water cloud [km] and 'thi' the
          thickness [km]. Both are specified by a numerical value with a maximum
```

```
          of one post-comma digit. The values must be separated by at least one
          blank.
        - Range of Values:
          Height from 6.0 - 12.0 km, thickness from 0.1 - 3.0 km.
    "Rain Top Height"
        - Numerical value between 1.0 and 3.0 [km].
    "Rain Rate"
        - Numerical value between 0.01 and 50.00 [mm/h].


 3) === Clouds and Rain Location ===

    Definition of location and horizontal extend of the (rain)cloud. Only
    available, if "3D" cloud is selcted.

    "Reference Location Center":
        - Definition of the geographic location of the center of the cloud.
        - Input Format: (Lat Lon)
          Latitude (Lat) and Longitude (Lon) [deg] must be specified by
          numerical values with a maximum of two post-comma digits. The values
          must be separated by at least one blank.
        - Range of Values:
          'Lat' from -90 to 90 deg, 'Lon' from -180 to 180 deg.
          In order to facilitate the choice of the center of the cloud, the
          location of the tangent point of the respective occultation event is
          shown in the line below the input field.

    "Cloud LatWidth LonWidth":
        - Specification of latitudinal and longitudinal extend of the cloud
          around the cloud center.
        - Input Format: (LaWi LoWi)
          Latitudinal width (LaWi) and longitudinal width (LoWi) [km] must be
          specified by numerical values with a maximum of one post-comma digit.
          The values must be separated by at least one blank.
        - Range of Values:
          'LaWi' and 'LoWi' from 5.0 to 2000.0 km.
```

6.5.8.4 Gravity Wave superposed Superposition Input

```
Specification of the input parameters needed for the simulation of gravity waves
disturbing the atmosphere. "Ok" causes all text field entries and droplist
settings to be accepted as the current input, whereas "Cancel" closes the input
window without any action done.


INPUT PARAMETER(S)

 1) === Geographic Domain of Gravity Wave superposed Disturbance ===

    - Specification of the geographic domain of the disturbance.
    - The "Disturbed Area" always comprises the full ray. The appropriate
      droplist is insensitive.
    - "Disturbance Reference Location/Center":
      Input of the geographic location of the center of the disturbance.
      Input Format: (Lat, Lon)
      Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical
      values with a maximum of one post-comma digit. The values must be
      separated by at least one blank.
      Range of Values:
      'Lat' from -90.0 to 90.0 deg, 'Lon' from -180.0 to 180.0 deg.
      In order to facilitate the choice of the center of the disturbance, the
      tangent point location of the respective occultation event is shown in the
      line below the input field.


 2) === Gravity Wave superposed Specifications ===

    - Specification of the characteristics of the gravity wave.
    - "Meridional Wavelength (positive southward)":
      Values from 0.0 or 10.0 (depends on the zonal wavelength) to 3000.0 km.
```

```
      Default is 500.0 km.
    - "Zonal Wavelength (positive eastward)":
      Values from 0.0 or 10.0 (depends on the meridional wavelength) to
      3000.0 km. Default is 0.0 km.
    - "Maximum Relative Gravity Wave Amplitude (breaking level)":
      Values from 0.0 to 5.0 %. Default is 2.0 %.
    - It is not possible to use 0 km as Meridional Wavelength and 0 km as Zonal
      Wavelength at the same time.
```

6.5.8.5 Frontal System Gradient superposed Superposition Input

```
Specification of the input parameters needed for the simulation of a frontal
system disturbing the atmosphere. "Ok" causes all text field entries and
droplist settings to be accepted as the current input, whereas "Cancel" closes
the input window without any action done.


INPUT PARAMETER(S)

 1) === Geographic Domain of Frontal System Gradient superposed Disturbance ===

    - Specification of the geographic domain of the disturbance.
    - The "Disturbed Area" always comprises the full ray. The appropriate
      droplist is insensitive.
    - "Disturbance Reference Location/Center":
      Input of the geographic location of the center of the disturbance.
      Input Format: (Lat, Lon)
      Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical
      values with a maximum of one post-comma digit. The values must be
      separated by at least one blank.
      Range of Values:
      'Lat' from -90.0 to 90.0 deg, 'Lon' from -180.0 to 180.0 deg.
      In order to facilitate the choice of the center of the disturbance, the
      tangent point location of the respective occultation event is shown in the
      line below the input field.


 2) === Frontal System Gradient superposed Specifications ===

    - Specification of the characteristics of the Frontal System Gradient.
    - "Meridional Temperature Gradient (positive southward)":
      The meridional temperature gradient can take values from 0.0 to
      10.0 K/100 km. Default is 5 K/100 km.
    - "Zonal Temperature Gradient (positive eastward)":
      The zonal temperature gradient can take values from 0.0 to
      10.0 K/100 km. Default is 5 K/100 km.
    - "Slope of Front (Vertical/Horizontal)":
      The slope of the front is constrained from 0.0 to 10.0 %. Default is
      5.0 %.
```

6.5.8.6 Tropopause Fold superposed Superposition Input

```
Specification of the input parameters needed for the simulation of a tropopause
fold disturbing the atmosphere. "Ok" causes all text field entries and droplist
settings to be accepted as the current input, whereas "Cancel" closes the input
window without any action done.


INPUT PARAMETER(S)

 1) === Geographic Domain of Tropopause Fold superposed Disturbance ===

    - Specification of the geographic domain of the disturbance.
    - The "Disturbed Area" always comprises the full ray. The appropriate
      droplist is insensitive.
    - "Disturbance Reference Location/Center":
      Input of the geographic location of the center of the disturbance.
      Input Format: (Lat, Lon)
```

```
      Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical
      values with a maximum of one post-comma digit. The values must be
      separated by at least one blank.
      Range of Values:
      'Lat' from -90.0 to 90.0 deg, 'Lon' from -180.0 to 180.0 deg.
      In order to facilitate the choice of the center of the disturbance, the
      tangent point location of the respective occultation event is shown in the
      line below the input field.


 2) === Tropopause Fold superposed Specifications ===

    - Specification of the characteristics of the Tropopause Fold.
    - "Center Height of Fold":
      The center height of the tropopause fault is constrained between 3.0 and
      25.0 km. Default is 12.0 km.
    - "Vertical Width of Fold":
      The vertical width of the tropopause fault is constrained between 100.0
      and 5000.0 m. Default is 2000.0 m.
    - "Relative Density Amplitude of Fold":
      The relative density amplitude of the tropopause fault is constrained
      between 0.0 and 4.0 %. Default is 2.0 %.
```

6.5.8.7 Atmospheric Inversion superposed Superposition Input

```
Specification of the input parameters needed for the simulation of an
atmospheric inversion disturbing the atmosphere. "Ok" causes all text field
entries and droplist settings to be accepted as the current input, whereas
"Cancel" closes the input window without any action done.


INPUT PARAMETER(S)

 1) === Geographic Domain of Atmospheric Inversion superposed Disturbance ===

    - Specification of the geographic domain of the disturbance.
    - The "Disturbed Area" always comprises the full ray. The appropriate
      droplist is insensitive.
    - "Disturbance Reference Location/Center":
      Input of the geographic location of the center of the disturbance.
      Input Format: (Lat, Lon)
      Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical
      values with a maximum of one post-comma digit. The values must be
      separated by at least one blank.
      Range of Values:
      'Lat' from -90.0 to 90.0 deg, 'Lon' from -180.0 to 180.0 deg.
      In order to facilitate the choice of the center of the disturbance, the
      tangent point location of the respective occultation event is shown in the
      line below the input field.


 2) ===  Atmospheric Inversion superposed Specifications ===

    - Specification of the characteristics of the Atmospheric Inversion.
    - "Center Height of Inversion":
      The center height of the inversion is constrained from 1.0 to 7.0 km.
      Default is 5.0 km.
    - "Vertical Width of Inversion":
      The vertical width of the inversion is constrained from 100.0 to
      5000.0 km. Default is 2000.0 km.
    - "Relative Density Gradient due to Inversion":
      The density gradient due to the inversion is constrained from 0.0 to
      4.0 %/km. Default is 2 %/km.
```

6.5.8.8 Turbulence/Scintillations Model

```
The Turbulence/Scintillation Model allows to simulate fluctuations of the
amplitude (atmospheric loss) caused by atmospheric turbulence. This effect is
```

called "scintillation". The inputs needed for the calculation are defined within this pop-up window. "OK" causes all text field entries and droplist settings to be accepted as the current input, whereas "Cancel" closes the input window without any action done.

SPECIAL NOTES/HINTS

- Cn2 is the refractivity structure constant in turbulence.

INPUT PARAMETER(S)

1) === Turbulence/Scintillation Model Type ===

   - Two different model types are available. The "Standard" model uses a user-defined Cn2 value for all events of a FoMod simulation. The "Cn2-model", however, uses predefined Cn2 values which vary dependent on the latitude of the event (reasonable average values which have been derived from empirical results).

2) === Turbulence Reference Height ===

   - Specification of a reference height of the turbulence [km]. Starting from this height, the vertical structure of Cn2 will be defined.
   - Values can range from 0.0 - 4.0 km. Default is 0.0 km.

3) === Turbulence Cn2 at Reference Height ===

   - Specification of the Cn2 value [m^(-2/3)] at the reference height.
   - Values can range from 1.00E-18 to 1.00E-12 m^(-2/3). Default is 1.30E-15 m^(-2/3).
   - Only available in the case of "Standard" model.

4) === Turbulence Vertical Structure ===

   - Specification of the vertical structure of the turbulence. "Exponential" and "Gaussian" are presently available.

5) === Turbulence Vertical Scale ===

   - Specification of the scale height of the turbulent domain [km].
   - Values can range from 1.0 to 8.0 km. Default is 2.0 km.
   - Only available in the case of "Standard" model.

6) === Turbulence Horizontal Extend ===

   - Specification of the horizontal extend (correlation distance) of the turbulent area [km].
   - Values can range from 1.0 to 300.0 km. Default is 300.0 km.

6.5.9 Ionosphere Climatology Model & Ionosphere Disturbance Model

This input group allows to specify the ionospheric conditions underlying to the FoMod simulations. The basic ionosphere climatology model, the solar activity as well as the ionospheric structure can be defined. Furthermore, ionospheric disturbances can be superposed.

INPUT PARAMETER(S)

1) === DROPLIST for Ionosphere Climatology Model ===

   - Selection of the basic ionosphere model underlying to the FoMod simulations. Besides "No Ionosphere", following models are available:

"Double-Chapman Ionosphere (RefIon_UoG)" and "3D Ionosphere (Iono3D_UoG)".
- In the "No Ionosphere" case, obviously, the other entries of this box as well as the "Ionosphere Disturbance Model" are insensitive.

2) === Solar Activity/F10.7 Index ===

- Specification of the Solar Activity Index. EGOPS uses the so called "F10.7 Index".
- The values can range from 60 to 220. Only integers are allowed..

3) === DROPLIST for Ionosphere Structure Model ===

- Allows the selection between the Ionosphere Model Structure as is and a Spherical Symmetric Ionosphere Model Structure (a structure with no horizontal variations).

4) === Ionosphere Disturbance Model ===

- Allows to superpose ionospheric disturbances on the basic ionosphere settings.
- Following settings are possible: "No Ionospheric Disturbance superposed", TID Event superposed...", "Ionospheric Gradient superposed...", "Ionospheric Trough superposed...", and "Ionospheric Storm Effect superposed...".
- Specific inputs needed for the calculation of the different disturbances are defined via pop-up windows.
- In the case of "Sample of Events/Realistic Geometry" or "No Ionosphere" it is not possible to choose any of these Ionosphere Disturbance Models (corresponding droplist will be set insensitive).

6.5.9.1 TID Event superposed Superposition Input

Specification of the input parameters needed for the simulation of Travelling Ionospheric Disturbances (TID). "Ok" causes all text field entries and droplist settings to be accepted as the current input, whereas "Cancel" closes the input window without any action done.

INPUT PARAMETER(S)

1) === Geographic Domain of TID Event superposed Disturbance ===

- Specification of the geographic domain of the disturbance.
- "Disturbed Area":
  Definition, which part of the ray will be comprised by the disturbance. The full ray, the inbound ray (Tx-to-Tangent Point) or the outbound ray (Tangent Point to Rx) can be selected.
  Only available, if the projection of the line of sight between the Tx and Rx satellites never reaches latitudes higher than +-80 deg.
- "Disturbance Reference Location/Center":
  Specification of the geographic location of the center of the disturbance.
  Input Format: (Lat, Lon)
  Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical values with a maximum of one post-comma digit. The values must be separated by at least one blank.
  Range of Values:
  'Lat' from -90.0 to 90.0 deg, 'Lon' from -180.0 to 180.0 deg.
  In order to facilitate the choice of the center of the disturbance, the tangent point location of the respective occultation event is shown in the line below the input field.

2) === TID Event superposed Specifications ===

- Specification of the characteristics of the TID.
- "Meridional Wavelength (positive southward)":
  Values from 0.0 or 100.0 (depends on the zonal wavelength) to 3000.0 km.

```
      Default is 1000.0 km.
    - "Zonal Wavelength (positive eastward)":
      Values from 0.0 or 100.0 (depends on the meridional wavelength) to
      3000.0 km. Default is 0.0 km.
    - "Maximum Relative TID Amplitude":
      Values from 0.0 to 30.0 %. Default is 10.0 %.
    - It is not possible to use 0 km as Meridional Wavelength and 0 km as Zonal
      Wavelength at the same time.
```

6.5.9.2 Ionospheric Gradient superposed Superposition Input

```
Specification of the input parameters needed for the simulation of gradients
disturbing the ionosphere. "Ok" causes all text field entries and droplist
settings to be accepted as the current input, whereas "Cancel" closes the input
window without any action done.


INPUT PARAMETER(S)

 1) === Geographic Domain of Ionosphere Gradient superposed Disturbance ===

    - Specification of the geographic domain of the disturbance.
    - "Disturbed Area":
      Definition, which part of the ray will be comprised by the disturbance.
      The full ray, the inbound ray (Tx-to-Tangent Point) or the outbound ray
      (Tangent Point to Rx) can be selected.
      Only available, if the projection of the line of sight between the Tx and
      Rx satellites never reaches latitudes higher than +-80 deg.
    - "Disturbance Reference Location/Center":
      Specification of the geographic location of the center of the disturbance.
      Input Format: (Lat, Lon)
      Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical
      values with a maximum of one post-comma digit. The values must be
      separated by at least one blank.
      Range of Values:
      'Lat' from -90.0 to 90.0 deg, 'Lon' from -180.0 to 180.0 deg.
      In order to facilitate the choice of the center of the disturbance, the
      tangent point location of the respective occultation event is shown in the
      line below the input field.


 2) === Ionosphere Gradient Specifications ===

    - Specification of the characteristics of the ionospheric gradient.
    - "Meridional Gradient (positive southward)":
      Values from 0.0 to 100.0 [%/10 deg]. Default is 10.0 %/10 deg.
    - "Zonal Gradient (positive eastward)":
      Values from 0.0 to 100.0 [%/10 deg]. Default is 0.0 %/10 deg.
    - "Relative Disturbance of Mean":
      Values between -50.0 and 100.0 %. Default is 0 %.
```

6.5.9.3 Ionospheric Trough superposed Superposition Input

```
Specification of the input parameters needed for the simulation of an
ionospheric trough disturbing the ionosphere. "Ok" causes all text field entries
and droplist settings to be accepted as the current input, whereas "Cancel"
closes the input window without any action done.


INPUT PARAMETER(S)

 1) === Geographic Domain of Ionosphere Trough superposed Disturbance ===

    - Specification of the geographic domain of the disturbance.
    - "Disturbed Area":
      Definition, which part of the ray will be comprised by the disturbance.
      The full ray, the inbound ray (Tx-to-Tangent Point) or the outbound ray
      (Tangent Point to Rx) can be selected.
```

```
      Only available, if the projection of the line of sight between the Tx and
      Rx satellites never reaches latitudes higher than +-80 deg.
    - "Disturbance Reference Location/Center":
      Specification of the geographic location of the center of the disturbance.
      Input Format: (Lat, Lon)
      Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical
      values with a maximum of one post-comma digit. The values must be
      separated by at least one blank.
      Range of Values:
      'Lat' from -90.0 to 90.0 deg, 'Lon' from -180.0 to 180.0 deg.
      In order to facilitate the choice of the center of the disturbance, the
      tangent point location of the respective occultation event is shown in the
      line below the input field.


 2) === Ionospheric Trough superposed Specifications ===

    - Specification of the characteristics of the ionospheric trough.
    - "Latitudinal Full Width":
      Values constrained between 1.0 and 90.0 deg. Default is 5.0 deg.
    - "Longitudinal Full Width":
      Values constrained between 1.0 and 90.0 deg. Default is 45.0 deg.
    - "Relative Depth of Trough Center":
      Values constrained between -300.0 and 99.0 %. Default is 90 %.
```

6.5.9.4 Ionospheric Storm Effect superposed Superposition Input

```
Specification of the input parameters needed for the simulation of ionospheric
storm effects disturbing the ionosphere. "Ok" causes all text field entries
and droplist settings to be accepted as the current input, whereas "Cancel"
closes the input window without any action done.


INPUT PARAMETER(S)

 1) === Geographic Domain of Ionosphere Storm Effect superposed Disturbance ===

    - Specification of the geographic domain of the disturbance.
    - "Disturbed Area":
      Definition, which part of the ray will be comprised by the disturbance.
      The full ray, the inbound ray (Tx-to-Tangent Point) or the outbound ray
      (Tangent Point to Rx) can be selected.
      Only available, if the projection of the line of sight between the Tx and
      Rx satellites never reaches latitudes higher than +-80 deg.
    - "Disturbance Reference Location/Center":
      Specification of the geographic location of the center of the disturbance.
      Input Format: (Lat, Lon)
      Latitude (Lat) and Longitude (Lon) [deg] must be specified by numerical
      values with a maximum of one post-comma digit. The values must be
      separated by at least one blank.
      Range of Values:
      'Lat' from -90.0 to 90.0 deg, 'Lon' from -180.0 to 180.0 deg.
      In order to facilitate the choice of the center of the disturbance, the
      tangent point location of the respective occultation event is shown in the
      line below the input field.


 2) === Ionospheric Storm Effect superposed Specifications ===

    - Specification of the Amplitude of the Storm Effect.
    - Values are constrained between -75.0 and 300.0 %. Default is 50.0 %.
```

6.5.10 Forward Modeling Sampling Rate

```
Specification of the Receiver Sampling Rate at the relevant transmitter
frequencies via a droplist. The sampling rate will be the same for all
frequencies used during a FoMod simulation.
```

- Range of Values:
  In the case of Satellite based Occultation Events, ten values between 0.2 and 1000 Hz can be selected. If "Hhi" of the Occultation Event Height Range is 90.1 km or more, only six values between 0.2 and 50 Hz are available.
  In the case of Airborne Occultation Events, three values between 0.2 and 5 Hz can be selected.
  In the case of a Satellite to Groundstation Event, 0.2 or 1 Hz are available.

SPECIAL NOTES/HINTS

- The wave optics propagator can only be used, if the sampling rate is set to at least 10 Hz.
- In the case of a GNSS transmitter, InRet atmosphere processing needs a minimum sampling rate of 1 Hz, the maximum sampling rate is 50 Hz.
- In the case of a LEO transmitter, InRet atmosphere processing needs a sampling rate of 10 Hz if the Advanced Geometric Optics Bending Angle Retrieval will be used, and a sampling rate of 1000 Hz if the Advanced Wave Optics Bending Angle Retrieval will be used.

6.5.11 Signal Propagation Simulator Specification

This input group allows to specify the ray tracer type and its accuracy. Furthermore, extended data output can be requested.

INPUT PARAMETER(S)

1) === Simulator Type ===

- Selection of the simulator type via a droplist.
- "Quasi-3D Ray Tracer": Accounts for the radial refractivity gradient only. Is the fastest simulator.
- "Full-3D Ray Tracer": Accounts for the full-3D refractivity gradient field. Little slower but more precise than the Quasi-3D Ray Tracer.
- "Wave Optics Propagator": More realistic computation dealing with diffraction and multipath effects. Is the slowest, but most precise ray tracer.
- In case of an Airborne Occultation, the Wave Optics Propagator is not available. In case of a Satellite to Groundstation Event, whether the Wave Optics Propagator nor the Quasi-3D Ray Tracer can be selected.
- The Wave Optics Propagator can only be used, if the sampling rate is set to at least 10 Hz. Furthermore, ionosphere models are not allowed in this case.

2) === Simulator Accuracy ===

- Specification of the accuracy of the ray tracer via a droplist.
- In the case of Quasi-3D or Full-3D Ray Tracer, the accuracy can be smaller than 1mm, 1cm or 10 cm.
  In the case of the wave optics propagator, "Highest", "Advanced", and "Basic" can be selected.

2) === Dopp-Tran-Bend-pLC1 Data ===

- If the check-box is activated, besides excess phases and atmospheric losses also doppler shifts, transmissions, bending angles, impact parameters and the linearly corrected phase for frequency F1 are stored within the *.ssd output file.

6.6 Observation System Modeling

Observation System Modeling (OSMod), together with prior Forward Modeling

(FoMod), performs quasi-realistic simulation of observables, and related required variables, of the GNSS and LEO radio occultation technique. The main observables are time-tagged phase and amplitude measurements, obtained in real world by tracking occulted Transmitter signals with a LEO platform-mounted receiver for atmospheric sounding during their set/rise through the atmosphere imposed by the relative orbital motion of the Transmitter (Tx) and Receiver (Rx) satellites.

Observation System Modeling itself denotes the superposition of all sorts of relevant physical and technical influences of the observation system (antenna, receiver, platform, fiducial sites) on the "ideal" signal (phase and amplitude data) arriving at the receiving antenna, and on the "ideal" orbit data (Tx and Rx positions and velocities). In fact these "ideal" data are the output of Forward Modeling, a necessary prerequisite to be performed before Observation System Modeling can be done. [See "Help on Task - Help on Forward Modeling" for more information on FoMod.]

Many of the effects of the observation system correspond to the "classical" sort of instrumental errors (e.g., receiver noise), others are intrinsic natural parts of the receiving system (e.g., effect of the antenna gain pattern on the signal amplitude finally available). The most relevant observation system effects to be modeled include precise orbit determination (POD) errors, the antennae gain pattern, receiver noise, local multipath (due to the platform structure in the vicinity of the antenna), and differencing treatment/clocks precision. For the Realistic Receiving System Simulator (RRSS), e.g., it is now possible to include Open-Loop (OL) tracking.

Observation system modeling requires a considerable number of "free input parameters" in a simulation tool in order to allow for a (realistic) OSMod simulation of widely arbitrary GNSS occultation missions. (See the section "OSMod INPUT PARAMETERS" below for an overview on the respective functionality furnished by EGOPS. Details are found in the On-line Help within the "OSMod Input" interface window available via the "Task" menu.)

Furthermore, it is necessary to have convenient tools for visualization and validation of the simulation results available in order to carry out simulation studies efficiently and in order to effectively comprehend and interpret the results. (See the section "OSMod VISUALIZATION" below for a crude overview on the respective functionality furnished by EGOPS. A refined overview is given under the "Help on Visualize/Val. - Help on Visualize/Val. Profiles" entry of the "Help" menu. Details are found in the On-line Help within the "Visualize/Validate Profiles" interface window available via the "Visualize/Validate" menu.)

OSMod INPUT PARAMETERS

EGOPS allows to compute Observation System Modeling tasks taking into account the set of "free input parameters" outlined below, which all together provide considerable flexibility and potential for Observation System Modeling. All these parameters can be - within their range of validity - freely set by the User just as desired for a specific OSMod task.

The "OSMod Input" window, available via the "Observation System Modeling" entry of the "Task" menu, is the convenient interface EGOPS provides for the supply of all of these parameters (including the supply of a "Reference FoMod Task-id", providing for access to the input conditions and results of a prior FoMod task).

- Forward modeling occultation event(s) selection:
The Reference FoMod Task-id can be selected from the list of suitable FoMod tasks existing within the current Project. In the case that a sample of events is available for the selected Reference FoMod task, also the event number range (or individual event number) of desired event(s) within the available FoMod events are selectable.

- OsMod sampling rate:
Default is the FoMod sampling rate (one of 1000 Hz, 500 Hz, 250 Hz, 100 Hz, 50 Hz, 25 Hz, 10 Hz, 5 Hz, 1 Hz, 0.2 Hz). In the case of a GNSS transmitter, a task with sampling rate greater than 50 Hz will not be available in the Inversion Retrieval (InRet) System later. In the case of a LEO transmitter, only tasks with a sampling rate of 10 Hz or 1000 Hz will presently be available in InRet. For the Realistic Receiving System Simulator the minimum sampling frequency is

10 Hz.

- POD error modeling:
No POD errors, or use of a "kinematic" POD error model is provided. (The latter model mimics POD position errors mainly by considering radial Tx and Rx position errors, POD velocity errors by considering along-ray velocity bias and drift errors (superposed to the "ideal" Rx velocity), and POD-induced excess phase errors by considering along-ray excess phase drift and acceleration errors incurred by along-ray velocity bias and drift errors.)

- Receiving system simulator type:
Between a parameterized- or a realistic receiving system simulator can be selected, with the following specifications (first for the parameterized- and second for realistic receiving system simulator):

For the parameterized receiver system simulator:

- Tx/Rx antennae specifications:
Antennae pointing and pattern characteristics, including boresight direction, field-of-view width and shape, and antenna gain at boresight (at 1 GHz), for "anti-velocity" looking and forward-looking antenna. The availability of the specific antennae depends on the type of occultation event(s) baselined via the selection of the Reference FoMod task (e.g., if a single setting occultation event was baselined, only the "anti-velocity" antennae will be available. Furthermore, the Tx antenna specifications are only sensitive in the case of a LEO-Tx antenna).

- Receiver performance/noise modeling specifications:
In the case of a GNSS-LEO event, No GNSS-LEO thermal noise, or Gaussian phase noise, or GNSS-LEO thermal noise can be selected, with the following specifications of the latter two:

  - Gaussian phase noise model:
  RMS (root-mean-square) value of the Gaussian phase noise (thermal noise).

  - Realistic performance/noise model:
  Loop bandwidth (single-sided), Rx antenna noise temperature, and the number of quantization levels in A/D conversion.

In the case of a LEO-LEO event, Rx thermal noise, or polynomial amplitude drifts, or 1/f amplitude noise, or sinusoidal amplitude drifts can be superimposed.

- Local multipath modeling specifications:
No local multipath, or sinusoidal local multipath, or realistic local multipath can be selected, with the following specifications of the latter two:

  - Sinusoidal multipath model:
  Period of the phase error, amplitude of the phase error, and (initialization) amplitude of the phase error at the topmost height of the occultation event.

  - Realistic multipath model:
  Ratio of multipath signal to direct signal, and source location (i.e., reflection point) of the multipath signal in (spherical) antenna coordinates.

- Differencing treatment and clocks modeling specifications:
Perfect clocks (no differencing), or real clocks (no differencing), or double differencing, or ground-based single differencing, or spacebased single differencing, with the following specifications of the latter four:

  - Real clocks (no differencing):
  Relative stability of the Tx clock (assumed for the worst clock in case of no differencing with real clocks involved).

  - Double differencing:
  Relative stability of ground clock (assumed for the worst clock in case of double differencing), and atmospheric noise per ground-to-satellite link involved in the differencing (this noise considered as clock-like noise).

- Ground-based single differencing:
Relative stability of the Rx clock (assumed for the worst clock in case of ground-based single differencing), and atmospheric noise per ground-to-satellite link involved in the differencing.

- Spacebased single differencing:
Relative stability of the Rx clock (assumed for the worst clock in case of space-based single differencing).

In the case of a LEO transmitter, only perfect clocks (no differencing) and real clocks (no differencing) are available.

For the realistic receiving system simulator:

- GRAS antenna specifications - antenna pattern files:
The select button allows to choose between two different antenna pattern files. These antenna pattern characteristic files are valid for the "anti-velocity" looking antenna (only setting GPS events can be processed because the realistic receiving system simulator is a pure GPS receiver).

- Random number seed:
The integer value of the random number seed can be set between 0 and 100, whereas 0 denotes the system clock.

- Technical specifications:
Several different features are connected together under this formal name. The system noise temperature, the number of interfering GPS satellites, the implementation loss, the antenna internal loss and the interference misalign loss.

- Loop specifications:
For open-loop tracking two different atmosphere models are available (the Bi-exponential- or a SAE-Fit atmosphere model). But it is also possible to turn the open-loop tracking off. Also adjustable are the loop period values and the start time of the 2nd value.

- FLL specifications:
It allows to specify the stop time and the filter order for the Frequency-Locked Loop (FLL) of the realistic receiving system simulator.

- Filter Specifications:
Adjustment of the L1- and CA filter specification allows for each filter the selection of the filter type and order, of the bandwidth values and the start time of the 2nd value can be modified.

OSMod VISUALIZATION:

EGOPS provides for the visualization of results of Observation System Modeling tasks by its "Visualize/Validate Profiles" window interface available via the "Visualize/Validate" menu.

The "Visualize/Validate Profiles" window interface allows, for OSMod tasks, to post-process, visualize, customize, compare, and print-out simulated phase and amplitude data (in terms of "observed excess phase" and "observed power", "observed" here in the sense of end-to-end simulated observables) as function of occultation event time.
The excess phase data at the transmitted frequencies as well as the linearly corrected (LC) data (neutral atmosphere only after linear ionospheric combination of F1/F2 phases)and LI data (ionosphere only at L1) are all available for visualization and inspection, stand-alone or in combinations.

The post-processing includes functionality to compute absolute and relative difference profiles between profiles of different OSMod tasks or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events.

Customization includes, among other features, functionality to fit an exponential or polynomial of user-specified order to a selected range of a profile or to compute the time average value over a selected range of a profile (and to visualize this information by overplot on the original profile).

[See "Help on Visualize/Val. - Help on Visualize/Val. Profiles" for more information.]

6.7 Observation System Modeling Input

6.7.1 Forward Modeling Occultation Event Selection

This input group allows to select a single or a sample of occultation events from a Reference FoMod Task, on which observation system errors shall be superimposed.

INPUT PARAMETER(S)

1) === Reference FoMod/Task-id ===

- This button opens a pop-up window for selection of an already computed FoMod Task. From this task, a single or a sample of occultation events can be later on selected whose simulated signal data serve as baseline for the OsMod simulation.
- Note that InRet atmosphere processing needs 1 Hz as minimum sampling rate in the case of a GNSS-Tx based occultation and 10 or 1000 Hz in the case of a LEO-Tx based occultation. No special sampling frequency constraint exists for ionosphere processing.

2) === Infos on Task in ===

- This button opens a pop-up window showing all entries of the Reference FoMod/Task-id input.

3) === Occultation Number Range ===

- Selection of a single or a sample of occultation events from the chosen FoMod Task on which observation system errors shall be superimposed.
- Input Format: (lo hi step)
  'lo' is the lowest occultation number of the range, 'hi' the highest one, and 'step' denotes the stepsize defining the used events between 'lo' and 'hi'. 'step' must be an integral multiple of the Occultation Number Range. All three values must be separated by at least one blank.
- Only integers are allowed.
- The range of values depends on the occultation event numbers in the corresponding FoMod/FoMod/Task-id.sgd-file. These numbers will be always shown in the explanation label right of the input field.

4) === Tx Sat System Choice ===

- Displays the used transmitter satellite system, which is automatically defined by the selected FoMod Task. Not for input.

6.7.2 OSMod Sampling Rate

Specification of the receiver sampling rate at the relevant transmitter frequencies via a droplist.

- Range of Values:
  The maximum value corresponds to the sampling rate of the selected Reference FoMod Task. If desired, this sampling rate can be reduced to the values available in the droplist.

SPECIAL NOTES/HINTS

- Note that InRet atmosphere processing needs 1 Hz as minimum sampling rate in the case of a GNSS-Tx based occultation, and 10 Hz or 1000 Hz in the case of a LEO-Tx based occultation. No special sampling frequency constraint exists for ionosphere processing.

6.7.3 POD Errors Modeling

This droplist provides a choice of "No POD Errors Modeling" or of a "Kinematic POD Error Model". Selecting the "Kinematic POD Error Model" opens a pop-up window that allows to specify the Error Specs Type, the Radial Position Errors, and the Along-Ray Errors.

SPECIAL NOTES/HINTS

- POD is the acronym for "Precise Orbit Determination".
- If an Airborne Occultation or a Satellite to Groundstation Event was selected as FoMod Occultation Event Simulation Type, POD error modeling is not possible.

6.7.3.1 Kineamtic POD Error Model Specifications

This input group allows to specify the properties of the orbital position errors. "OK" causes all text field entries and droplist settings to be accepted as the current input, whereas "Cancel" closes the input window without any action done.

INPUT PARAMETER(S)

1) === Error Specs Type ===

- Selection of the manner, how the error specifications will be applied.
- The droplist includes the following options: "Apply Error Specs as specified" and "Apply Error Specs randomly (as rms)".
- Only available, if Sample of Events/Realistic Geometry was selected as FoMod Occultation Event Simulation Type. In each other case, the droplist is fixed to Apply Error Specs as specified.

2) === Radial Position Errors ===

- Specification of the radial position errors of Tx and Rx satellite [m].
- Numerical values with a maximum of two post-comma digits are allowed.
- Range of Values: Depends on the chosen Error Specs Type.
  From -50 to 50 m for "Apply Error Specs as specified" or from 0 to 50 m for "Apply Error Specs randomly (as rms)". Default is 0.25 m.

3) === Along-Ray Errors (applied to Tx) ===

- Specification of the Along-Ray Velocity Error [mm/s] and the Along-Ray Acceleration Error [micrometer/s^2].
- Numerical values with a maximum of two post-comma digits are allowed.
- Range of Values: Depends on the chosen Error Specs Type.
  "Along-Ray Velocity Error"
  From -5 to 5 mm/s for "Apply Error Specs as specified" or from 0 to 5 mm/s for "Apply Error Specs randomly (as rms)". Default is 0.05 mm/s.
  "Along-Ray Acceleration Error"
  From -10 to 10 um/s2 for "Apply Error Specs as specified" or from 0 to 10 um/s2 for "Apply Error Specs randomly (as rms)". Default is 0.05 um/s2.

6.7.4 Receiving System Simulator Type

This droplist allows to select among two different receiving system simulator types: the 'Parameterized Receiving System Simulator' (a theoretical receiver

model) or the 'Realistic Receiving System Simulator', which models the exact behavior of the Austrian Aerospace GPS-Receiver (GALILEO, GLONASS or LEO-Tx signals cannot be received with this receiver).

SPECIAL NOTES/HINTS

- The Realistic Receiving System Simulator is only available, if the sampling rate is a least 10 Hz and if the selected FoMod-occultation is a setting event with a GPS transmitter.

6.7.5 Parameterized Receiving System Simulator

The "Parameterized Receiving System Simulator" simulates the receiving system applying a theoretical receiver model.

SPECIAL NOTES/HINTS

- The receiving system simulator type can be selected via the "Receiving System Simulator Type" droplist. Besides the Parameterized Receiving System Simulator, a Realistic Receiving System Simulator (modeling the behavior of the Austrian Aerospace GPS-Receiver) can be selected too.
- The Realistic Receiving System Simulator is only available, if the sampling rate is a least 10 Hz and if the selected FoMod-occultation is a setting event with a GPS transmitter.

INPUT PARAMETER(S)

1) === Output also C/N0 and Antenna Data ===

   If the check-box is activated, besides excess phases and signal amplitudes also carrier-to-noise spectral densities, Rx and Tx antenna gains, Rx ray incidence angle and Tx ray exitance angle are stored within the *.ssd output file.

2) === Tx/Rx Antennae Specifications ===

   Manipulation of technical characteristics of the Tx and Rx antennae via pop-up windows. Boresight direction, Antenna Field of View (FOV), Half-Power Beam Width (HPBW), and Antenna Gain can be appointed to reasonable values.

   "Tx Antenna Specifications"
   - '-V Tx antenna' and '+V Tx antenna' can be manipulated.
   - Only active in the case of LEO-Tx based occultation events. In the case of a GNSS transmitter, the Tx antenna specifications are predefined internally.

   "Rx Antenna Specifications"
   - '-V Rx antenna' and '+V Rx antenna' can be manipulated.
   - The -V Rx antenna is only active if the selected occultation event(s) is/include a setting event. The +V Rx antenna is only active if the selected occultation event(s) is/include a rising event.

   SPECIAL NOTES/HINTS
   - "-V antenna" denotes an antenna pointing towards the anti-velocity direction half-space of a satellite (backward viewing), "+V antenna" denotes pointing towards the velocity-direction half-space (forward viewing).
   - "Half-Power Beam Width (HPBW)" denotes a beamwidth within which the antenna has a -3dB gain for acquiring an occultation event.

3) === Receiver Performance Modeling ===

   Specifications needed for the receiver performance modeling. Depending on the Tx satellite system (GNSS or LEO), different options are available.

GNSS Transmitter

Besides no noise, a Gaussian Phase Noise Model and a GNSS-LEO Thermal Noise Model are available requiring different input.

"Rx Performance Modeling"
- Specification of the receiver noise model.
- 'No GNSS-LEO Thermal Noise' denotes an ideal perfect noiseless receiver, 'Gaussian Phase Noise Model' implements Gaussian receiver noise characteristics and 'GNSS-LEO Thermal Noise Model' simulates a more realistic receiver noise distribution.

"Gaussian Phase Noise (rms)"
- Specification of the Gaussian Phase Noise [mm].
- Numerical value from 0.1 to 50.0 mm. Default is 1.0 mm.
- Only available, if the Gaussian Phase Noise Model is selected.

"Loop Bandwidth (single-side)"
- Specification of the Loop Bandwidth [Hz].
- Numerical value from 1.0 to 50.0 Hz. Default is 10.0 Hz.
- Only available, if the GNSS-LEO Thermal Noise Model is selected.

"LEO Antenna Noise Temperature"
- Specification of the LEO Antenna Noise Temperature [K].
- Numerical value from 10.0 to 500.0 K. Default is 200.0 K.
- Only available, if the GNSS-LEO Thermal Noise Model is selected.

"Quantization Levels/A-D Conversion"
- Specification of the Quantization Level. This is a measure for the quantization loss which is caused by the Analog-to-Digital Conversion.
- The following values are possible: 2,3,4,8,16. Default value is 4.
- Only available, if the GNSS-LEO Thermal Noise Model is selected.

LEO Transmitter

There are four models for different noise and drift sources, which can be applied altogether, alone or none.

"Rx Thermal Noise Modeling"
- If desired, thermal noise can be modeled. The input parameters needed for this are defined via a pop-up window.

"Rx Polynomial Amplitude Drifts Modeling"
- If desired, polynomial (linear, quadratic and 3rd order) amplitude drifts can be modeled. The input parameters needed for this are defined via a pop-up window.

"Rx 1/f Amplitude Noise Modeling"
- If desired, 1/f noise can be modeled. The input parameters needed for this are defined via a pop-up window.

"Rx Sinusoidal Amplitude Drifts Modeling"
- If desired, sinusoidal amplitude drifts can be modeled. The input paramters needed for this are defined via a pop-up window.

4) === Local Multipath Modeling ===

If desired, local multipath effects in the receiver can be modeled either using a sinusoidal multipath model or a realistic multipath model.

"Local Multipath Modeling"
- Selection of a local multipath model.
- 'No Local Multipath' denotes an ideal perfect "straight-line" receiver, 'Sinusoidal Multipath Model...' implements a multipath model with sinusoidal behavior, and 'Realistic Multipath Model' simulates a more realistic receiver multipath mode.
- The parameters required for the Sinusoidal Multipath Model are defined via a pop-up window.
- The 'No Local Multipath' choice is only recommendable for quick

```
          overview OSMod calculations.

    "Multipath to Direct Signal Ratio"
        - Specification of the ratio of multipath to direct signal [%].
        - Numerical value from 0.1 to 10.0 %. Default is 1.0 %.
        - Only available, if the Realistic Multipath Model is selected.

    "Multipath Source"
        - Specification of the relative position of the dominant multipath
          source on the receiver with respect to the antenna position in
          spherical coordinates.
        - Input Format: (r theta phi)
          'r' is the radial distance [m], 'theta' the zenith angle [deg] and
          'phi' the azimuthal angle [deg].
          Numerical values with a maximum of one post-comma digit are allowed.
          The values must be separated by at least one blank.
        - Range of Values:
          'r' from 0.0 - 12.0 m, 'theta' from -90 to 90 deg and 'phi' from 0 to
          360 deg. Default values are 1.5 80.0 210.0 [m deg deg].
        - Only available, if Realistic Multipath Model is selected.


 5) ===  Differencing Treatment & Clock Modeling ===

    Specification of the Differencing Treatment and Clock Modeling. Various
    choices are available which require different input parameters.

    "Differencing Treatment & Clock Modeling"
        - Selection of the basic treatment. In case of a GNSS transmitter, the
          following 5 options are available: 'Perfect Clocks (No Differencing)',
          'Real Clocks (No Differencing)', 'Double Differencing', 'Groundbased
          Single Differencing', and 'Spacebased Single Differencing'.
          In case of a LEO transmitter, only the former two options are
          available.

    "Relative Stability/GNSS Clock (1sAllan)"
        - Specification of the relative stability of the GNSS clock [1E-13].
        - Numerical value between 0.01 and 50 [1E-13]. Default is 30 [1E-13].
        - Only available, if Real Clocks (No Differencing) is selected and if
          the transmitter is a GNSS satellite.

    "Relative Stability/Ground Clock (1sAllan)"
        - Specification of the relative stability of the ground clock [1E-13].
        - Numerical value between 0.01 and 50 [1E-13]. Default is 0.01 [1E-13].
        - Only available, if Double Differencing was selected.

    "Atmospheric Noise/Ground Link (1sAllan)"
        - Specification of the atmospheric noise along the ground link.
        - Numerical value between 0.01 and 50 [1E-13]. Default is 1.0 [1E-13].
        - Only available, if Double Differencing or Groundbased Single
          Differencing is selected.

    "Relative Stability/LEO Clock (1sAllan)"
        - Specification of the relative stability of the LEO clock [1E-13].
        - Numerical value between 0.01 and 50 [1E-13]. Default is 1.0 [1E-13].
        - Only available in case of Groundbased Single Differencing or
          Spacebased Single Differencing. Also in case of Real Clocks (No
          Differencing), if the transmitter is a LEO satellite.

    SPECIAL NOTES/HINTS
    - 1secAllan is a measure for the (atomic) clock stability.
```

6.7.5.1 Tx/Rx Antenna Input

This input window allows to specify antenna characteristics. In particular, Boresight direction of the antenna, Antenna Field of View (FOV), Half-Power Beam With and Antenna Gain can be adjusted to reasonable values. "OK" causes all text field entries and droplist settings to be accepted as the current input status, whereas "Cancel" closes the input window without any action done.

INPUT PARAMETER(S)

1) === Boresight ===

- Elevation and Azimuth [deg] of a Tx/Rx antenna mounted on a LEO satellite relative to the antenna coordinate system can be defined. The antenna coordinate system is a s/c (spacecraft) fixed cartesian system, having its Z axis pointing towards nadir, its X axis perpendicular to this Z axis in the plane spanned by the s/c velocity vector and the Z axis, and the Y axis completing a right-handed coordinate system.
- Input Format:
  Numerical values with a maximum of one post-comma digit.
- Range of Values:
  Elevation, 0.0 to 60.0 deg (default 27.0 deg, approx. towards Earth limb for a typical LEO near 800 km).
  Azimuth, 90.0 to 270.0 deg for the "-V antenna" (default 0.0 deg), -90.0 to 90.0 deg for the "+V antenna" (default 180.0 deg).
- An Elevation of 0.0 deg denotes an antenna boresight in the X-Y plane of the antenna coordinates. The elevation increases towards nadir.
- An Azimuth of 0.0 deg means a forward-looking, an Azimuth of 180.0 deg a backward-looking antenna, the azimuth increasing from X over Y.

2) === Antenna FOV ===

- Droplist for selection among different Antenna field-of-views (FOVs):
  "Conical FOV": Any power pattern isocontour of the antenna main lobe corresponds to a circle so the FOV defined by this isocontour is a cone with constant opening angle at all lobe azimuths.
  "Elliptical FOV/horiz. Cartesian": The lobe's isocontours are (regular) ellipses corresponding to an elliptical lobe shape with different opening angles in the horizontal and vertical.
  "Elliptical FOV/horiz. Earth shaped": The lobe's isocontours are quasi ellipses with the horizontal axis curved (banana-shaped) to follow the shape of the Earth's surface as seen from the LEO satellite.

3) === Half-Power Beam Width (HPBW) ===

- Specification of the Horizontal and Vertical Half-Power Beam Width (HPBW) [deg] of a Tx/Rx antenna mounted on a LEO. The Horizontal/Vertical HPBW of an antenna is the region corresponding to a -3dB threshold of the normalized power pattern in the Horizontal/Vertical antenna direction.
- Input Format:
  Numerical values with a maximum of one post-comma digit.
- Range of Values:
  For "Conical FOV", H-HPBW and V-HPBW from 1.0 to 180.0 deg.
  For "Ellip. FOV/hor. Cartesian", H-HPBW from 1.0 to 180.0 deg, V-HPBW from 1.0 to 90.0 deg.
  For "Ellip. FOV/hor. Earth shaped", H-HPBW from 1.0 to 180.0 deg, the maximum V-HPBW is confined to half of the chosen H-HPBW. The minimum V-HPBW depends linear on the H-HPBW (i.e. 1 deg for a H-HPBW of 1 deg, 10 deg for a H-HPBW of 90 deg, and 30 deg for a H-HPBW of 180 deg; between (from H-HPBW 1 - 90 deg and 90 - 180 deg) two linear functions with different derivatives).
- The values define the full width of the beam (e.g., 90 deg = +-45 deg around boresight).
- In the case of "Conical FOV", the input field for the vertical HPBW is insensitive (since in this case, horizontal HPBW = vertical HPBW).

4) === Antenna Gain/boresight ===

- Specification of the antenna gain [dB] in boresight direction. The antenna gain denotes the antenna amplification for the received radio signal.
- The antenna gain input is related to a signal frequency of 1 GHz. Thus, e.g., if you have a transmitter frequency of 10 GHz and you like to have a gain of 30 dB, you have to type 20 dB (valid at 1 GHz, leading to 30 dB at 10 GHz).
- Numerical values with a maximum of one post-comma digit are allowed.
- The range of values depends on the antenna FOV and the HPBW (mainly

```
       inverse-linear on the HPBW, i.e., narrower beam = higher gain)
    - The decibel [dB] scale is a logarithmic notation for the Antenna Gain.


 5) === Antenna boresight Tracking ===

    - If the check-box is activated, the antenna gain is assumed to be
      the boresight gain at all times throughout an occultation event
      (i.e., the signal is assumed to be continuously received in
      boresight, at maximum gain).
```

6.7.5.2 LEO-LEO Thermal Noise modeling

```
This input window allows to adjust the signal to noise ratio at each frequency
channel and to specify antenna and receiver noise temperature for the thermal
noise modeling. "OK" causes all text field entries to be accepted as the current
input status, whereas "Cancel" closes the input window without any action done.


INPUT PARAMETER(S)

 1) === Channels C/N0 Adjustment ===

    - Adjustment of the signal-to-noise ratio (C/N0) [dBHz] at each frequency
      channel.
    - Input Format: (C/N0_1 C/N0_2 ... C/N0_i)
      C/N0_1 is the signal-to-noise ratio for frequency channel F1, C/N0_2 is
      that for frequency channel F2, and so on.
      Numerical values with a maximum of two post-comma digits are allowed. The
      values must be separated by at least one blank.
    - Range of Values:
      From -10 to 10 dBHz for each frequency channel.


 2) === Antenna Noise Temperature (at 10 GHz) ===

    - The antenna noise temperature [K] is related to a signal frequency of
      10 GHz.
    - Values from 10.0 to 500.0 K are allowed. Default is 80.0 K.


 3) === Receiver Noise Temperature (at 10 GHz) ===

    - The receiver noise temperature [K] is related to a signal frequency of
      10 GHz.
    - Values from 10.0 to 500.0 K are allowed. Default is 160.0 K.

In the receiver simulator, the given Antenna Noise Temperature and Receiver
Noise Temperature are summed up to the System Noise Temperature at 10 GHz.
For relating this System Noise Temperature to other frequencies than
10 GHz it is linearly adjusted with a noise rate of 2 dBK per 10 GHz.
Thus, for example, at 23 GHz the noise temperature is set to be 2.3 dBK
higher than its 10 GHz value.
```

6.7.5.3 Polynomial Amplitude Drift Error Model Specifications

```
This input window allows to specify the properties of the amplitude drift. The
amplitude drifts can be modeled up to an order of 3. "OK" causes all droplist
settings and text field entries to be accepted as the current input status,
whereas "Cancel" closes the input window without any action done.


INPUT PARAMETER(S)

 1) === Drift Application Type ===

    - Selection of the manner, how the drift specifications will be applied.
    - The droplist includes the following options: "Apply drifts as specified"
```

```
      and "Apply drifts randomly (as rms)".
    - Only available, if Sample of Events/Realistic Geometry was selected as
      FoMod Occultation Event Simulation Type. In each other case, the droplist
      is fixed to Apply Error Specs as specified.


 2) === Reference Height ===

    - The reference height [km] is the height at which the drift starts to be
      superposed; all heights below are drift-perturbed, all heights above are
      not.
    - Numerical value between 15.0 and 30.0 km. Default is 25.0 km.


 3) === Drifts ===

    Specification of the order of the polynomial drift.

    "Linear Drift Slope"
        - Definition of the slope (1st order) of the drift drift [dB/min].
        - Numerical value between 0.000 and 0.500 dB/min. Default is
          0.040 dB/min.

    "Quadratic Drift Curvature"
        - Definition of the curvature (2nd order) of the drift [dB/min^2].
        - Numerical value between 0.0000 and 0.0500 dB/min^2. Default is
          0.0000 dB/min^2.

    "3rd Order Drift Curve Change"
        - Definition of the curve change (3rd order) of the drift [dB/min^3].
        - Numerical value between 0.00000 and 0.00500 dB/min^3. Default is
          0.00000 dB/min^3.
```

6.7.5.4 1/f Amplitude Noise Modeling

```
This input window allows to specify model type and appropriate parameters of the
1/f amplitude noise. "OK" causes all droplist settings and text field entries to
be accepted as the current input status, whereas "Cancel" closes the input
window without any action done.


INPUT PARAMETER(S)

 1) === Rx 1/f Noise Model Type ===

    - Either a theoretical model ("1/f Amplitude Noise") or a empirical model
      (1/f Amplitude Noise from file") can be selected from a droplist.
    - The empirical model uses a data file ("flicker noise model") supplied by
      ESTEC (P. Silvestrin and N. Floury, ESA/ESTEC, Noordwijk, Netherlands,
      pers. communications, 2004).


 2) === Reference Height ===

    - The reference height [km] is the height at which the noise starts to be
      superposed; all heights below are noise-perturbed, all heights above are
      not.
    - Numerical value between 15.0 and 30.0 km. Default is 25.0 km.


 3) ===  1/f Amplitude Noise Modeling ===

    Specification of the error slope within a user-defined period.

    "Period Interval TMin TMax"
        - Specification of the interval of periods T of sine waves, within which
          all periods T = 1/f are spectral components of the 1/f noise (spectral
          components with periods smaller or larger are not part of the noise)
        - Input Format: (TMin TMax)
          'TMin' and 'TMax' are the lower and upper boundary of the time period
```

```
          [sec], respectively.
          Numerical values with a maximum of two post-comma digits are allowed.
          The values must be separated by at least one blank.
        - Range of Values:
          'TMin' from 1.00 to 3.00 sec, 'TMax' from 10.00 to 30.00 sec. Default
          values are TMin = 1.00 sec and TMax = 20.00 sec.

    "Error Slope Period Domain"
        - Specification of the error slope [dB/min] within the period domain.
        - Numerical value between 0.001 and 0.100 dB/min. Default is
          0.025 dB/min.

    SPECIAL NOTES/HINTS
     - This input group is only available if the '1/f Amplitude Noise' model has
       been selected.
```

6.7.5.5 Sinusoidal Amplitude Drifts Model Specifiacations

```
This input window allows to specify the properties of the sinusoidal amplitude
drift. "OK" causes all droplist settings and text field entries to be accepted
as the current input status, whereas "Cancel" closes the input window without
any action done.


INPUT PARAMETER(S)

 1) === Reference Height ===

    - The reference height [km] is the height at which the sinusoidal drift
      starts to be superposed; all heights below are drift-perturbed, all
      heights above are not.
    - Numerical value between 15.0 and 30.0 km. Default is 25.0 km.


 2) === Multiple Sines ===

    Specification of period and amplitude of the sinusoidal amplitude drift. Up
    to 4 individual sines (Sine #1 - Sine #4) can be chosen.

The Multiple Sines Model first calculates the start time for each drift sine
curve and then sums up the drift values of the individual sines. For calculation
the input of the Sine Drift Period, the Sine Drift Amplitude, and the Sine Drift
Amplitude at Reference Height is necessary.

    "Sine Drift Period"
        - Allows to set the sine drift period [sec] for the individual sines.
        - Numerical values from 0.0 - 5000.0 sec are allowed. At least one sine
          drift period must be 1 sec or more.

    "Sine Drift Amplitude"
        - Specification of the sine drift amplitudes [dB] for the individual
          sines.
        - Numerical values from 0.001 - 0.100 dB are allowed. Default is
          0.020 dB.

    "Sine Drift Amplitude/Reference Height"
        - Specification of the sine drift amplitudes at the reference height
          [dB] for the individual sines.
        - The values can range from -Ampl to +Ampl, where 'Ampl' is the value of
          the corresponding 'Sine Drift Amplitude'. The numerical values can
          have at maximum three post-comma digits. Default is 0.000 dB.
```

6.7.5.6 Multiple Sines Multipath Model Specifications

```
This input group allows to specify up to four individual sines for the Multiple
Sines Multipath Modeling. The Multiple Sines Multipath Model first calculates
the start time for each phase error sinus curve and then sums up the phase error
values of the individual sines. For calculation the input of the Phase Error
```

Period, the Phase Error Amplitude, and the Phase Error Amplitude/Topmost Ray is necessary.

SPECIAL NOTES/HINTS

- One to four individual sines can be chosen.

INPUT PARAMETER(S)

1) === Phase Error Period ===

- Allows to set the phase error periods [sec] for the individual sines.
- Numerical values from 0.0 - 5000.0 sec are allowed. At least one phase error period must be 1 sec or more.

2) === Phase Error Amplitude ===

- Specification of the phase error amplitudes [mm] for the individual sines.
- Numerical values from 0.1 - 50.0 mm are allowed. Default is 2.0 mm.

3) === Phase Error Amplitude/Topmost Ray ===

- Specification of the phase error amplitudes at the topmost rays [mm] for the individual sines.
- The values can range from -Ampl to +Ampl, where 'Ampl' is the value of the corresponding 'Phase Error Amplitude'. The numerical values can have at maximum one post-comma digit. Default is 0.0 mm.

6.7.6 Realistic Receiving System Simulator

The "Realistic Receiving System Simulator" models the behavior of the Austrian Aerospace GPS-Receiver (GALILEO, GLONASS or LEO-Tx signals cannot be received with this receiver).

SPECIAL NOTES/HINTS

- The receiving system simulator type can be selected via the "Receiving System Simulator Type" droplist. Besides the Realistic Receiving System Simulator, a Parameterized Receiving System Simulator (theoretical receiver model) can be selected too.
- The Realistic Receiving System Simulator is only available, if the sampling rate amounts to at least 10 Hz and if the selected FoMod-occultation is a setting event with a GPS transmitter.
- "Output also C/N0 and Antenna Data" is only available for the Parameterized Receiving System Simulator.

INPUT PARAMETER(S)

1) === GRAS Antenna Specifications ===

This input group allows to specify the GRAS antenna specifications which are stored in an Antenna Pattern File.

"Antenna Pattern Files"
- Selection of an antenna pattern file (GRAS-AVA*.apd) via a pop-up window.

"Random Number Seed"
- Specification of the random number seed value [1] (initializes the random number generator)
- Integer between 0 and 100.

SPECIAL NOTES/HINTS
- GRAS is the acronym for "GNSS Receiver for Atmospheric Sounding".

```
     - GRAS-AVA means the GRAS Anti-Velocity Antenna.
     - APD is the acronym for Antenna Pattern Data.


2) === Technical Specifications ===

   This input group allows to specify several technical parameters of the
   Realistic Receiving System Simulator.

   "System Noise Temperature"
       - Specification of the system noise temperature [K].
       - Integer values between 0 and 500 K are allowed. Default is 310 K.

   " Number of interfering GPS Sats"
       - Specification of the number of interfering GPS satellites.
       - Integer values between 0 and 12 are allowed. Default is 3.

   "Implementation Loss"
       - Specification of the implementation loss [dB].
       - Values between 0.0 and 10.0 dB are allowed. Default is 2.0 dB.

   "Antenna Internal Loss"
       - Specification of the internal loss of the antenna [dB].
       - Values between 0.0 and 10.0 dB are allowed. Default is 1.0 dB.

   "Interference Misalign Loss"
       - Specification of the interference misalign loss.
       - Values between 0.0 and 10.0 dB are allowed. Default is 0.0 dB.


3) === Loop Specifications ===

   This input group allows to adjust different loop specifications of the
   Realistic Receiving System Simulator. For open-loop tracking, two different
   atmosphere models are available.

   "Loop Period Values"
       - Specification of the loop period values [msec].
       - Input Format: (lp1 lp2)
         The both loop period values (lp1 and lp2) must be specified by
         integers. The values must be separated by at least one blank.
       - Range of Values:
         The loop period values can be 1, 10, or 100 msec.

   "Start Time of 2nd Value"
       - Specification of the start time [sec] of the 2nd value of the loop
         period values.
       - Numerical value between 0.0 and 1000.0 sec. Default is 2.0 sec.

   "Open-Loop (OL) Tracking"
       - If the "Include OL Tracking" check-box is activated, the droplist for
         the choice of an atmosphere model is available.
       - Via the atmosphere model choice droplist, two different atmosphere
         models can be selected: a 'Bi-exponential Atmosphere Model', or a
         'SAE-Fit Atmosphere Model' (the former is a model from IGAM, Univ. of
         Graz, implemented by Austrian Aerospace, Vienna, the latter from Saab
         Ericsson Space, Gothenburg, Sweden).


3) === FLL Specifications ===

   This input group allows to specify stop time and filter order of the
   Frequency-Locked Loop (FLL) of the Realistic Receiving System Simulator.

   "Stop Time"
       - Specification of the FLL stop time [msec].
       - Integer value between 0 and 200 msec is allowed. Default is 100 msec.

   "Filter Order"
       - Selection among three different FLL Filter Orders via a droplist.
         First (1), second (2) and third (3) order can be chosen.
```

```
 4) === Filter Specifications ===

    Two different Filters (L1 Filter and CA Filter) are used for the Realistic
    Receiving System Simulator. The specific technical filter characteristics
    (filter type, filter order, bandwidth values, start time of the 2nd value)
    can be modified via pop-up windows.


 5) === Extended Data Output ===

    If the check-box is activated, a *.ssd-IQ file will be generated
    (additionally to the standard Simulated Signal Data File(s)), wherein the
    I-Signal and Q-Signal data are stored.
```

6.7.6.1 L1/CA Filter Specifications

```
This pop-up window allows to manipulate several technical Filter characteristics
for the Realistic Receiving System Simulator (RRSS). Filter type, filter order,
bandwidth values, and start time of the 2nd value can be adjusted. OK" causes
all droplist settings and text field entries to be accepted as the current input
status, whereas "Cancel" closes the input window without any action done.


INPUT PARAMETER(S)

 1) === Filter Type ===

   - Selection between two different filter types: the 'JPL-SCD' or the
     'JPL-SUD' filter.
   - SCD is the acronym for "Super Critically Damped".
   - SUD is the acronym for "Standard Under Damped".


 2) === Filter Order ===

    - Selection between three different filter orders: first (1), second (2) or
      third (3).


 3) === Bandwidth Values ===

   - Specification of the RRSS filter bandwidth values [Hz].
   - Input Format: (b1 b2)
     The both bandwidth values (b1 and b2) must be specified by numerical values
     with a maximum of two post-comma digits. The values must be separated by at
     least one blank.
   - Range of Values:
     From 0.05 to 200.00 Hz. Default values are b1 = 100.00 Hz, b2 = 5.00 Hz.


 4) === Start Time of 2nd Value ===

    - Specification of the start time [sec] of the 2nd Value of the loop period
      values.
    - Numerical value between 0.0 and 1.0 sec. Default is 1.0 sec.
```

6.8 Occultation Data Inversion/Retrieval

```
Inversion/Retrieval of occultation data denotes the processing of simulated or
observed phase and amplitude data (supplemented by the necessary geometrical
information) typically via Doppler shifts, bending angles and transmissions down
to quasi-vertical atmospheric profiles of refractivity, density, pressure,
temperature, humidity, and liquid water.

This processing chain typically requires, sequentially, tools for ionospheric
correction and conversion of the "raw" excess phase observables to
neutral-atmospheric bending angle profiles, for conversion of the signal
```

amplitudes to transmission profiles, for inversion of bending angle and transmission profiles into (complex) refractivity profiles ("Inverse Abel Transform"), and for finally retrieving the atmospheric variables (e.g., temperature) from (complex) refractivity. The air (in the troposphere) may be considered either dry or moist or cloudy in the last stage of this processing chain.

Necessary prerequisites for inversion/retrieval are either simulated observables, obtained by Observation System Modeling (OSMod) within EGOPS, or genuine observed phase and amplitude data (e.g. from the GPS/MET experiment). [See "Help on Task - Help on Observation System Modeling" for more information on OSMod, and see, e.g., the WWW site "http://pocc.gpsmet.ucar.edu" for more information on the GPS/MET experiment and the data obtained.]

Such occultation data inversion/retrieval requires a considerable number of "free input parameters" in a simulation tool in order to allow for flexible data processing of widely arbitrary simulated GNSS occultation missions as well as for observed data. (See the section "InRet INPUT PARAMETERS" below for an overview on the respective functionality furnished by EGOPS. Details are found in the On-line Help within the "InRet Input" interface window available via the "Task" menu.)

Furthermore, it is necessary to have convenient tools for visualization and validation of the simulation results available in order to carry out simulation studies efficiently and in order to effectively comprehend and interpret the results. (See the section "InRet VISUALIZATION" below for a crude overview on the respective functionality furnished by EGOPS. A refined overview is given under the "Help on Visualize/Val. - Help on Visualize/Val. Profiles" entry of the "Help" menu. Details are found in the On-line Help within the "Visualize/Validate Profiles" interface window available via the "Visualize/Validate" menu.)

InRet INPUT PARAMETERS

EGOPS allows to compute Occ. Data Inversion/Retrieval tasks taking into account the set of "free input parameters" outlined below, which all together provide considerable flexibility and potential for Occultation Data Inversion/Retrieval. All these parameters can be - within their range of validity - freely set by the User just as desired for a specific InRet task.

The "InRet Input" window, available via the "Occ. Data Inv./Retrieval" entry of the "Task" menu, is the convenient interface EGOPS provides for the supply of all of these parameters (including either the supply of a "Reference OSMod Task-id", providing for access to the input conditions and results of a prior OSMod task, or, alternatively, including the supply of a "GPS/MET" or "CHAMP/GPS" data path, providing for access to User-prepared GPS/MET or CHAMP/GPS data files.)

- Type of occultation data to be processed:
Simulated data (prepared by prior OSMod tasks run within EGOPS), or Observed data (prepared by the User in a directory to which at least read-access exists from the EGOPS installation; presently, GPS/MET data in the "UCAR Level 2 data" file format as well as CHAMP/GPS Level 2 data can be processed).

  - Occultation event(s) selection in case of simulated data:
  Reference OSMod Task-id (to be selected from the list of suitable OSMod tasks existing within the current Project).
  Also, in the case that a sample of events is available for the selected Reference OSMod task, event number range (or individual event number) of desired event(s) within the available OSMod events.

  - Occultation event(s) selection in case of observed data:
  GPS/MET or CHAMP/GPS data path (full directory path of the directory where the desired data reside, e.g., /home/<usr>/gpsmet/level2/occ/95.294/). Also, in the case that a sample of events is available within the selected data directory, event number range (or individual event number) of desired event(s) within the available GPS/MET or CHAMP/GPS events.

- Choice of Retrieval Processing Specifications:
"Atmospheric Processing" for the retrieval of atmospheric profiles, or "Ionosphere Processing" for the retrieval of ionospheric profiles. These

processing modes allow for the following further choices:

- Choice of Bending Angle and Transmission Retrieval Specifications:

  - Choice of Bending Angle Retrieval Tool:
  Dependent on the used Tx satellite system and the selected retrieval processing, different bending angle tools are available:

    - Tools in case of Atmosphere Processing of GNSS-Tx based occultation data: "Advanced Geometric Optics Bending Angle Retrieval", "Advanced GNSS-LEO Wave Optics Bending Angle Retrieval", "Basic Geom. Optics/Statistical Optimization Bending Angle Retrieval", or "Basic Geometric Optics/No Optimization Bending Angle Retrieval".
    - Tools in case of Atmosphere Processing of LEO-Tx based occultation data: "Advanced Geometric Optics Bending Angle Retrieval" (if sampling rate = 10 Hz), or "Advanced LEO-LEO Wave Optics Bending Angle Retrieval" (if sampling rate = 1000 Hz).
    - Tools in case of Ionosphere Processing: "Standard Ionospheric Bending Angle Retrieval".

  For Advanced GNSS-LEO Wave Optics Bend. Angle Retrieval, "Canonical Transform" is possible for the Diff. Correction Type (for Advanced LEO-LEO Wave Optics Bend. Angle Retrieval, the Diff. Correction Type is insensitive). For Advanced Geometric Optics Bending Angle Retrieval and Basic Geom. Optics/Statistical Optimization Bending Angle Retrieval, the Ion. Correction Type can be varied between "Phase Correction" and "Bend. Angle Correction", whereas the Stat. Optimization Type can be chosen among "No Stat. Optimization", "Optimize invoking MSIS90_DMI", "Optimize invoking CIRA86aQ_UoG" in the first case and amongst "No Stat. Optimization", "Optimize using m+z BenA Search", and "Optimize using glob. BenA Search" in the latter case (for Basic Geometric Optics/No Optimization Bending Angle Retrieval both the Ion. Correction Type and the Stat. Optimization Type are insensitive).
  For Standard Ionospheric Bending Angle Retrieval, the Ion. Correction Type is fixed to "Phase Correction" and the Stat. Optimization Type os fixed to "No Stat. Optimization".

  - Choice of Transmission Retrieval Tool:
  The transmission retrieval tool is only available in the case of atmosphere processing of LEO-Tx based occultation data. "Standard Channel Transmission Retrieval" (only if Advanced Geom. Optics Bending Angle Retrieval is used) and "Advanced Wave Optics Transmission Retrieval" (only if Advanced LEO-LEO Wave Optics Bend. Angle Retrieval is used) can be selected.

- Refractivity Profiles Retrieval Specifications:
For the Refractivity Profiles Retrieval/Inversion Tool, various options are possible dependent on the used Tx satellite system and the selected retrieval processing:

  - Tools in case of Atmosphere Processing of GNSS-Tx based occultation data: "No Atmos. Refractivity Profiles Retrieval" or "Abel Transform Real Refr. Profiles Retrieval".
  - Tools in case of Atmosphere Processing of LEO-Tx based occultation data: "No Atmos. Refractivity Profiles Retrieval" or "Abel Transform Complex Refr. Profiles Retrieval".
  - Tools in case of Ionosphere Processing: "No Ionos. Refractivity Profiles Retrieval" or "Abel Transform Ionos. Refr. Profiles Retrieval".

- Choice of Atmospheric Profiles Retrieval Specifications:

  - For the type of Atmospheric Profiles Retrieval Tool:
  "No Atmospheric Profiles Retrieval", "Real Refractivity Based Dry Air Profiles" retrieval, or "Real Refractivity Based Moist Air Profiles" retrieval. In the case of LEO-Tx based occultations, also "Complex Refr. Based Atmos. Profiles" retrieval.
  The Real Refractivity Based Moist Air Profiles retrieval allows the following further choices:

    - For the type of moist air retrieval:
    "q,e,p,rho w. T prescribed (It)", or "q,e,p,rho w. T prescribed (In)", "q,e,rho with p,T prescribed", or "T,e,p,rho w. q prescribed (In)", or "T,e,rho with p,q prescribed", or "T,q,e,p,rho by Opt.Estimation...".

The last one opens a pop-up window for the input of the Observation + Forward Modeling error covariance matrix specifications and the background (T,q) error covariance matrix specifications.

- Atmospheric model used for prescribed parameters:
"FoMod atmosphere" (default in case of simulated data, meaning the atmosphere used in the "forward modeling" of the simulated observables), or "Bi-Exponential atmosphere", or "HLat 2D Atmosphere (CIRA86aQ_UoG)" (default in case of GPS/MET data), or the "GCM 3D Atmosphere (GCM3DAtm)", or the "HiVRes Atmosphere (HiVResAtm)...", or a "(Moist) User-supplied Atmosphere" (if moist air included in this atmosphere). [If you have a source-code version of EGOPS read the file usratm.SampleFile in the /prog/FORprog subdirectory of EGOPS in case you want to learn more about how to supply your own user supplied atmosphere.]

The Complex Refr. Based Atmos. Profiles retrieval allows the following further choice:

- Complex Refractivity Inversion Type
'T,q,e,p,rho,w by Optimal Inverse Estimation' is the single type available presently.

- Choice of Ionospheric Profiles Retrieval Specifications (only possible in case of Ionosphere Processing):

- For the Ionospheric Profile Retrieval Tool:
"No Ionospheric Profiles Retrieval", or "Electron Density Profiles Retrieval" are possible for selection.

InRet VISUALIZATION

EGOPS provides for the visualization of results of Occ. Data Inversion/Retrieval tasks by its "Visualize/Validate Profiles" window interface available via the "Visualize/Validate" menu.

The "Visualize/Validate Profiles" window interface allows, for InRet tasks, to post-process, validate against reference data, visualize, customize, compare, and print-out simulated or observed Doppler shift profiles (as function of occ. event time), bending angle profiles (as function of impact parameter), and refractivity, density, pressure, geopotential height, temperature, water vapor, specific humidity and liquid water profiles (as function of height). Also, in case of observed data, the original phase and amplitude data can be visualized (as function of occ. event time). The GPS/MET or CHAMP/GPS excess phase data at the L1 and L2 frequencies as well as the LC data (neutral atmosphere only after linear ionospheric combination of L1/L2 phases) and LI data (ionosphere only at L1) are all available for visualization and inspection, stand-alone or in combinations.

The post-processing includes functionality to compute absolute and relative difference profiles between profiles of different InRet tasks or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events.
Furthermore, reference "ground-truth" profiles of refractivity, density, pressure, geopotential height, temperature, water vapor, specific humidity, and liquid water can be prepared with any available atmospheric model within EGOPS, at the tangent point locations of the retrievals. Absolute and relative difference profiles w.r.t. these reference profiles can then be computed, as well as difference profiles statistics (mean difference to "ground-truth" and standard deviations compared to "ground-truth") for samples of events.

Customization includes, among other features, functionality to fit an exponential or polynomial of user-specified order to a selected range of a profile or to compute the time average value over a selected range of a profile (and to visualize this information by overplot on the original profile).
[See "Help on Visualize/Val. - Help on Visualize/Val. Profiles" for more information.]

6.9 Occultation Data Inversion/Retrieval Input

6.9.1 Occultation Data Type

This droplist allows to select among two different occultation data types: 'Simulated Data' and 'Observed Data'. For each simulation type, the corresponding input window will be mapped in the framed section below the droplist.
The text on the right side of the droplist displays the type of the current occultation event (GNSS-LEO, LEO-LEO, GPS/MET, or CHAMP/GPS) which is determined either by the selected reference OSMod task (in case of Simulated Data) or by the selected data source (in case of Observed data).

6.9.2 Simulated Data - OSMod Occultation Data Selection

This input group allows to select a single or a sample of occultation events from a Reference OSMod Task, whose excess-phase and amplitude data shall be exploited for the retrieval of atmospheric or ionospheric profiles.

INPUT PARAMETER(S)

1) === Reference OSMod/Task-id ===

- This button opens a pop-up window for selection of an already computed OSMod task. From this task, a single or a sample of occultation events can be later on selected whose simulated signal data serve as baseline for the InRet simulation.
- Depending on the selected OSMod task, the text on the right of the Occultation Data Type droplist displays the type of the current occultation event (GNSS-LEO or LEO-LEO).
- Only OSMod/Task-ids which fulfill the height range limits for atmospheric (ionospheric) calculations (Hlo between 0 and 30 km (0 and 200 km), Hhi between 70 to 120 km (500 km up to the perigee of the lowest Rx-satellite)) are shown in the list.
- Note that InRet atmosphere processing needs 1 Hz as minimum sampling rate in the case of a GNSS-Tx based occultation and 10 or 1000 Hz in the case of a LEO-Tx based occultation. No special sampling frequency constraint exists for ionosphere processing.

2) === Infos on Task in ===

- This button opens a pop-up window showing all entries of the Reference OSMod/Task-id input.

3) === Occultation Number Range ===

- Selection of a single or a sample of occultation events from the chosen OSMod Task which shall be evaluated.
- Input Format: (lo hi step)
  'lo' is the lowest occultation number of the range, 'hi' the highest one, and 'step' denotes the stepsize defining the used events between 'lo' and 'hi'. 'step' must be an integral multiple of the Occultation Number Range. All three values must be separated by at least one blank.
- Only integers are allowed.
- The range of values depends on the occultation event numbers in the corresponding OSMod/OSMod/Task-id.sgd-file. These numbers will be always shown in the explanation label right of the input field.

4) === Tx Sat System Choice ===

- Displays the used transmitter satellite system, which is automatically defined by the selected OSMod Task. Not for input.

6.9.3 GPS/MET Occultation Data Selection

This input group allows to select a single or a sample of occultation events from a GPS/MET or a CHAMP/GPS Data file, whose excess-phase and amplitude data shall be exploited for the retrieval of atmospheric or ionospheric profiles.

SPECIAL NOTES/HINTS

- Mandatory file format of GPS/MET data: the "UCAR Level 2 data" format.
- Mandatory file format of CHAMP/GPS data: "Level 2 data".

INPUT PARAMETER(S)

1) === Data Source Selection ===

   - Specification of the source of the observed occultation data. Presently, 'GPS/MET Data' or 'CHAMP-GPS Data' (Level2 data) can be selected.

2) === Tx Signal Property File ===

   - This input allows to select a GPS signal property file (Tx-GPS*.spd) from the /signalprop subdirectory of EGOPS via a pop-up window.
   - Tx-*.spd files contain information on the frequency chains used. For more details consult the Software User Manual - File Format Manual (SUM-FF).

3) === GPS/MET or CHAMP/GPS Data Path ===

   - Specification of the GPS/MET or CHAMP/GPS Data Path either by keyboard input or by selection via a pop-up window.
   - The default GPS/MET or CHAMP/GPS Data Path is set to the user's home directory.

4) === Occultation Number Range ===

   - Specification of the range of occultation events which shall be evaluated.
   - Input Format: (lo hi)
     'lo' is the lowest occultation number of the range and 'hi' the highest one. Only integers are allowed. The values must be separated by at least one blank.
   - The range of values depends on the occultation event numbers in the corresponding GPS/MET or CHAMP/GPS data files. These numbers will be always shown in the explanation label right of the input field.
   - Each occultation event comprised by the occultation number range will be evaluated. There is no harm if some events within the specified range are missing.

6.9.4 Retrieval Processing Specifications

Selection of the general retrieval mode via exclusive buttons: 'Atmosphere Processing' or 'Ionosphere Processing'. Depending on this choice, different Bending Angle and Transmission Retrieval options, Refractivity Profiles Retrieval options and Atmospheric/Ionospheric Profiles Retrieval options are available.

SPECIAL NOTES/HINTS

- Note that InRet atmosphere processing needs 1 Hz as minimum sampling rate in the case of a GNSS-Tx based occultation and 10 or 1000 Hz in the case of a LEO-Tx based occultation. No special sampling frequency constraint exists for ionosphere processing.
- Atmosphere or Ionosphere processing is only available if the height range limits in the selected reference OSMod Task were set within the allowed limits for atmospheric calculations (Hlo between 0 and 30 km and Hhi between

70 and 120 km) or ionospheric calculations (Hlo between 0 and 200 km and Hhi between 500 km and the perigee of the lowest Rx-satellite).

6.9.5 Bending Angle retrieval Specifications

Dependent on the Tx Satellite System and the selected Retrieval Processing, this input group allows to select among different Bending Angle Retrieval Tools. Dependent on the selected tool, either an ionospheric correction or a difference correction can be applied. There are also different tools for the optimization of the retrieved bending angle profiles.

INPUT PARAMETER(S)

1) === Bending Angle Retrieval Tool ===

- Selection of the tool which shall be used for the bending angle retrieval. Dependent on the used Tx Satellite System and the selected Retrieval Processing, different options are available.
- In the case of Atmosphere Processing of GNSS-Tx based occultation data, following settings are possible:
  'Advanced Geometric Optics Bending Angle Retrieval',
  'Advanced GNSS-LEO Wave Optics Bending Angle Retrieval',
  'Basic Geom. Optics/Statistical Optimization Bending Angle Retrieval',
  'Basic Geometric Optics/No Optimization Bending Angle Retrieval'.
- In the case of Atmosphere Processing of LEO-Tx based occultation data, following settings are possible:
  'Advanced Geometric Optics Bending Angle Retrieval' (if sampling rate = 10 Hz), or 'Advanced LEO-LEO Wave Optics Bending Angle Retrieval' (if samplig rate = 1000 Hz).
- In the case of ionosphere processing, the 'Standard Ionospheric Bending Angle Retrieval' can be applied.

2) === Ionosphere Correction Type ===

- Specification, if the ionospheric correction shall be applied on phases ('Phase Correction') or on bending angles ('Bending Angle Correction').
- For the 'Standard Ionospheric Bend. Angle Retrieval' the droplist is fixed to 'Phase Correction'.
- The droplist is not available for 'Basic Geom. Optics/No Opt. Bend. Angle Retrieval', 'Advanced GNSS-LEO Wave Optics Bend. Angle Retrieval', and 'Advanced LEO-LEO Wave Optics Bend. Angle Retrieval'.

3) === Statistical Optimization Type ===

- Selection among different Statistical Optimization Types. It depends on the chosen Bending Angle Retrieval Tool which options are available.
- For the Advanced Geom. Optics Bend. Angle Retrieval, following settings are possible:
  'No Statistical Optimization', 'Optimize invoking MSIS90_DMI', and 'Optimize invoking MSIS90_DMI'.
- For the Basic Geom. Optics/Stat. Opt. Bending Angle Retrieval, following settings are possible:
  'No Statistical Optimization', 'Optimize using m+z Bending Angle Search', and 'Optimize using global Bending Angle Search'.
- For the 'Standard Ionospheric Bending Angle Retrieval' the droplist is fixed to 'No Stat. Optimization'.
- The droplist is not available for 'Basic Geom.Optics/No Opt. Bend.Angle Retrieval', 'Advanced GNSS-LEO Wave Optics Bend. Angle Retrieval' and 'Advanced LEO-LEO Wave Optics Bend. Angle Retrieval'.

4) === Difference Correction Type ===

- Specification which difference correction shall be applied. 'Canonical Transform' is the single entry presently available.
- The droplist is only available for the Advanced GNSS-LEO Wave Optics Bend. Angle Retrieval.

```
 5) === Initialization Profile ===

    - Specification of the initialization profile, which is used as
      background profile for statistical optimization. The following options
      are available: 'MSIS90 Profile', 'GCM 3D Atmosphere Profile...' (selection
      of a GRIB data file via a pop-up window), or 'User-supplied Profile...'
      (selection of your own atmosphere data file).
    - The droplist is only available for the Advanced GNSS-LEO Wave Optics Bend.
      Angle Retrieval.
```

6.9.5.1 GCM3D Atmosphere Data Path/GRIB File Selection

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.7.1, titled "GCM3D Atmosphere Data Path/GRIB File Selection" .

6.9.5.2 User-supplied Profile File Selection

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.6, titled "Pickfile/Pickdirectory" .

6.9.6 Transmission Retrieval Specifications

```
This input group allows to select a Transmission Retrieval Tool and to specify
the appropriate input parameters.


SPECIAL NOTES/HINTS

 - Only available in the case of Atmosphere Processing of LEO-Tx based
   occultation data.


INPUT PARAMETER(S)

 1) === Transmission Retrieval Tool ===

    - Selection of the tool which shall be used for the transmission retrieval.
      Following options are available: 'Standard Channel Transmission Retrieval'
      (only if Advanced Geom. Optics Bending Angle Retrieval is used) and
      'Advanced Wave Optics Transmission Retrieval' (only if Advanced LEO-LEO
      Wave Optics Bend. Angle Retrieval is used).


 2) === I/I0 Reference Heights ===

    - Specification of a reference height [km], where the signal intensity will
      be computed which is then utilized to normalize the transmission
      (intrinsic self calibration). Especially, a mean value of the signal
      intensity averaged within an interval (see point 3) around this reference
      height will be used for the normalization.
    - The reference height must be so high, that virtually no signal absorption
      occurs above, i.e. the signal intensity is not attenuated at this height.
    - Input Format: (hF1 hF2 ....)
      One reference height 'hF*' for each frequency channel. Numerical values
      with a maximum of one post-comma digit are allowed. The values must be
      separated by at least one blank.
    - Range of Values:
      From 15.0 to 30.0 km for each frequency channel. Default is 25.0 km (for
      each channel).
    - Only available for Standard Channel Transmission Retrieval.


 3) === IO Value Averaging Height Interval ===
```

- Specification of a height interval [km] around the reference height, within which the signal intensity will be averaged.
- Numerical value from 1.0 to 10.0 km. Default is 4.0 km.

6.9.7 Refractivity Profiles Retrieval Specifications

Selection of the Refractivity Profiles Retrieval/Inversion Tool. Dependent on the Tx Satellite System and the selected Retrieval Processing various options are available:

- In the case of Atmosphere Processing of GNSS-Tx based occultation data, 'No Atmos. Refractivity Profiles Retrieval' or 'Abel Transform Real Refr. Profiles Retrieval' can be selected.
- In the case of Atmosphere Processing of LEO-Tx based occultation data, 'No Atmos. Refractivity Profiles Retrieval' or 'Abel Transform Complex Refr. Profiles Retrieval' can be selected.
- In the case of Ionosphere Processing, 'No Ionos. Refractivity Profiles Retrieval' or 'Abel Transform Ionos. Refr. Profiles Retrieval' are available.

6.9.8 Atmospheric/Ionospheric Profiles Retrieval Specifications

This input group allows to select the specifications for the retrieval of atmospheric or ionospheric profiles. Dependent on the Tx Satellite System and the selected Retrieval Processing various Retrieval Tools are available which require different additional information.

INPUT PARAMETER(S)

1) === Atmospheric/Ionospheric Profiles Retrieval Tool ===

- Selection of the Atmospheric/Ionospheric Profiles Retrieval Tool via a droplist. Dependent on the Tx Satellite System and the selected Retrieval Processing various Retrieval Tools are available:
- In the case of Atmosphere Processing of GNSS-Tx based occultation data, following tools are possible:
  'No Atmospheric Profiles Retrieval',
  'Real Refractivity Based Dry Air Profiles' retrieval, or
  'Real Refractivity Based Moist Air Profiles' retrieval.
- In the case of Atmosphere Processing of LEO-Tx based occultation data, a 'Complex Refr. Based Atmos. Profiles' retrieval is available in addition to the options mentioned above.
- In the case of Ionosphere Processing, 'No Ionospheric Profiles Retrieval' or 'Electron Density Profiles Retrieval' is possible.

2) === Moist Air Retrieval Type ===

- Selection of the detailed retrieval type in case of moist air retrieval. One of the following 6 types can be chosen:
  'q,e,p,rho with T prescribed (It)',
  'q,e,p,rho with T prescribed (In)',
  'q,e,rho with p,T prescribed',
  'T,e,p,rho with q prescribed (In)',
  'T,e,rho with p,q prescribed'
  'T,q,e,p,rho by Opt.Estimation...'.
- The last type (T,q,e,p,rho by Opt.Estimation...) requires additional input, which can be specified via a pop-up window.
- 'q' describes the specific humidity, 'e' the water vapor pressure, 'p' the pressure, 'rho' the air density and 'T' the temperature. 'It' and 'In' describe an algorithm based on iteration and based on integration, respectively.
- Only available for the Real Refr. Based Moist Air Profiles retrieval tool.

3) === Atmospheric Model for prescribed parameters ===

```
    - Selection of the atmospheric model yielding a-priori information on
      atmospheric parameters (either temperature (T), pressure (p) or water
      vapor (q)) required for the moist air retrieval.
    - The following models can be selected:
          'FoMod Atmosphere (Atm-Name)',
          'Bi-Exponential Atm. (RefAtm_UoG)',
          'HLat 2D Atmosphere (CIRA86aQ_UoG)',
          'GCM 3D Atmosphere (GCM3DAtm)...',
          'HiVRes Atmosphere (HiVResAtm)...',
          'User-supplied Atm. (Atm-Name)'.
      FoMod Atmosphere means the atmosphere used in the used in the forward
      modeling of the simulated observables.
      "Atm-Name" for a FoMod- or User-supplied Atmosphere is only a symbolic
      name here, because the real name of the chosen atmosphere depends on the
      user and therefore is not known in advance.
    - Only available for the Real Refr. Based Moist Air Profiles retrieval tool.


 4) === Complex Refractivity Inversion Type ===

    - Selection of the detailed inversion type in case of Complex Refractivity
      Based Atmospheric Profiles retrieval.
    - 'T,q,e,p,rho,w by Optimal Inverse Estimation' is the single type
      available presently. This type requires additional input which can be
      specified via a pop-up window.
    - Only available for the Complex Refr. Based Atmos. Profiles retrieval tool.
```

6.9.8.1 Optimal Estimation Retrieval Input

```
The Optimal Estimation (OE) retrieval tool enables to derive atmospheric
temperature and humidity profiles from refractivity profiles in an optimal
manner in the sense of statistical estimation theory. The optimal estimation
algorithm uses the Observation and Forward Modeling Error Covariance Matrix and
the Background error Covariance Matrix, whose specifications can be supplied via
this input window. ("OK" causes all text field entries to be accepted as the
current input, whereas "Cancel" closes the input window without any action
done.)


INPUT PARAMETER(S)

 1) === Observation + Forward Modeling Error Covariance Matrix Specs ===

    This input group allows to supply the specifications needed for the
    calculation of the Observation + Forward Modeling Error Covariance Matrix:
    the refractivity rms uncertainty (at 0 and 15 km height) and the vertical
    correlation length of refractivity errors.

    "Refractivity RMS Uncertainty"
        - Specification of the Refractivity RMS Uncertainty [%] at 0 km and at
          15 km height.
        - Input Format: (dN_0km dN_15km)
          dN_0km and dN_15km are the refractivity uncertainties at 0 km and
          15 km, respectively. Numerical values with a maximum of one post-comma
          digit are allowed. The values must be separated by at least one blank.
        - Range of Values:
          From 0.1 to 10.0 % for both values. Default values are dN_0km = 1.0 %
          and dN_15km = 0.2 %.

    "Vertical Correlation Length of Refractivity Errors"
        - Specification of the Vertical Correlation Length of Refractivity
          Errors [km].
        - Numerical value between 0.0 and 10.0 km is allowed. Default is 3.0 km.


 2) === Background (T,q) Error Covariance Matrix Specifications ===

    This input group allows to supply the specifications needed for the
    calculation of the Background (T,q) Error Covariance Matrix: The temperature
```

```
and humidity rms uncertainties and their corresponding vertical correlation
lengths.

"Temperature RMS Uncertainty"
    - Specification of the Temperature RMS Uncertainty [K] at 0 km and at
      15 km height.
    - Input Format: (dT_0km dT_15km)
      dT_0km and dT_15km are the temperature uncertainties at 0 km and
      15 km, respectively. Numerical values with a maximum of one post-comma
      digit are allowed. The values must be separated by at least one blank.
    - Range of Values:
      From 0.1 to 20.0 K for both values. Default is 2.0 K for both values.

"Vertical Correlation Length of Temperature Errors"
    - Specification of the Vertical Correlation Length of Temperature
      Errors [km].
    - Numerical value between 0.0 and 50.0 km is allowed. Default is 6.0 km.

"Humidity RMS Uncertainty"
    - Specification of the Humidity RMS Uncertainty [%] at 0 km and at 10 km
      height.
    - Input Format: (dq_0km dq_10km)
      dq_0km and dq_10km are the humidity uncertainties at 0 km and 10 km,
      respectively. Numerical values with a maximum of one post-comma
      digit are allowed. The values must be separated by at least one blank.
    - Range of Values:
      From 0.1 to 200.0 % for both values. Default values are
      dq_0km = 20.0 % and dq_10km = 40.0 %.

"Vertical Correlation Length of Humidity Errors"
    - Specification of the Vertical Correlation Length of Humidity
      Errors [km].
    - Numerical value between 0.0 and 50.0 km is allowed. Default is 3.0 km.
```

6.9.8.2 T, q, e, p, rho, w by Optimal Inverse Estimation Input

```
The Optimal Inverse Estimation (OIE) retrieval tool enables to derive
atmospheric temperature and humidity profiles from complex refractivity profiles
in an optimal manner in the sense of statistical inverse estimation theory. The
optimal inverse estimation algorithm needs information about the errors of real
and imaginary refractivity profiles, which can be specified by this input
window. ("OK" causes all text field entries and droplist settings to be accepted
as the current input, whereas "Cancel" closes the input window without any
action done.)


INPUT PARAMETER(S)


 1) === Real Refractivity Profiles Error Specifications ===

    This input group allows to specify the vertical behavior of the real
    refractivity error.

    "Real Refractivity Error Model"
        - Selection of the Real Refractivity Error Model via a droplist.
        - 'Constant Fractional Errors' or the '1/z (<zRef) + exp(z) (>zRef)
          Errors' model are available.

    "Real Refractivity RMS Error at zRef = 15 km"
        - Specification of the Real Refractivity RMS error [%] at a reference
          height of 15 km.
        - Numerical value between 0.01 and 10.00 %. Default is 0.10 %.


 2) === Imaginary Refractivity Profiles Error Specifications ===

    This input group allows to specify the vertical behavior of the imaginary
    refractivity error.
```

```
   "Imaginary Refractivity Error Model"
       - Selection of the Imaginary Refractivity Error Model via a droplist.
       - 'Constant Absolute Errors' or the 'fac*dNi(z0)*W(z) SNR-based Errors'
         model are available.

   "Imaginary Refractivity Absolute RMS Error"
       - Specification of the absolute RMS error of the imaginary refractivity
         [100*N-units].
       - Numerical value between 0.01 and 10.00. Default is 1.00 [100*N-units].
       - Only available for the Constant Absolute Errors model.


   "Imaginary Refractivity RMS Errors scale factor"
       - Specification of the scale factor (fac) of the imaginary refractivity
         RMS error [1].
       - Numerical value between 0.10 and 5.00. Default is 0.50 [1].
       - Only available for the fac*dNi(z0)*W(z) SNR-based Errors model.


3) === Atmospheric Profiles Retrieval Mode Specification ===

   This input group allows to select the mode of the atmospheric profiles
   retrieval.

   "Retrieval Mode"
       - Selection of the generic atmospheric profiles retrieval mode.
       - 'p+T (dry air) Retrieval', 'p+T+q (moist air) Retrieval' and 'p+T+q+w
         (cloudy air) Retrieval' are available.

   "Atmospheric Background Mode"
       - Selection, if atmospheric background shall be used in order to
         stabilize the retrieval in case of severe turbulence and heavy clouds
         or not.
       - 'No Background' or the 'Best-fit T at z < zBestfitTop' background mode
         are available. The latter mode causes, that a-priori temperature
         information will be used in heights, where the retrieval is strongly
         affected by severe turbulence and/or heavy clouds.
       - Not available for the p+T (dry air) Retrieval mode.

   "Atmospheric Model for Best Fit"
       - Selection of the atmosphere model which will be scanned for an
         appropriate background profile (if needed). Available models are:
         'FoMod Atmosphere (RefAtm_UoG)',
         'Bi-Exponential Atm. (RefAtm_UoG)',
         'HLat 2D Atmosphere (CIRA86aQ_UoG)',
         'GCM 3D Atmosphere (GCM3DAtm)...',
         'HiVRes Atmosphere (HiVResAtm)...',
         'User-supplied Atm. (RefAtm_UoG)'.'
         FoMod Atmosphere means the atmosphere used in the used in the forward
         modeling of the simulated observables.
       - Only available for the Best-fit T at z < zBestfitTop background mode.
```

6.9.8.3 GCM 3D Atmosphere Data Path/GRIB File Selection

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.7.1, titled "GCM3D Atmosphere Data Path/GRIB File Selection" .

6.9.8.4 HiVRes Atmosphere Data Path/RAOB File Selection

The information on this topic is provided in the chapter on "Common Dialogs" - Section 4.7.2, titled "HiVRes Atmosphere Data Path/RAOB File Selection" .

7 Visualize/Validate Menu

7.1 Common Dialogs

7.1.1 Reset Defaults

The 'Reset Defaults' button causes all input (values, droplist and button entries, displayed plots etc.) to be lost and all values and settings will be reset to its defaults. Reset to defaults has the same effect as entering an EGOPS input window for the first time (i.e. the default Task-id settings are loaded).

SPECIAL NOTES/HINTS

- No warning will be issued in case you attempt to press the reset to defaults button of an EGOPS input window.

7.1.2 Color Adjustments

7.1.2.1 Plot Colors - Tables

Plot Colors is a widget based utility for the interactive manipulation of color tables. It may be used with any EGOPS plot application. The color table maps the data values written to the screen to different colors and intensities. Its operation is similar to that of a photographic wedge. The slope and position of the wedge are manipulated to best display a particular data set.

SPECIAL NOTES/HINTS

- "Plot Colors" is a modified version of the "XLoadCT" widget tool contained in the IDL software package.
- The current color table is always shown in the draw window above the first button row.

INPUT PARAMETER(S)

1) === Exclusive BUTTON for Tables [and Options and Function] ===

   - Activates widget sliders for Stretch Bottom, Stretch Top, Gamma Correction, and the Color Tables list.
   - "Tables" is the default setting of this exclusive button. The other settings are "Options" and "Functions".

2) === Stretch Bottom and Stretch Top ===

   - These sliders control the "contrast" of the color tables, and are expressed in percentages of full intensity. The color table wedge is "stretched" so that values equal to or less than "Stretch Bottom" are set to the lowest color table entry, which is usually black.
     Values equal to or greater than "Stretch Top" are set to the last entry in the color table, usually white or some other bright color. Values between the bottom and top are linearly scaled to the color table. Making "Stretch Bottom" higher than "Stretch Top" inverts the color table.
   - Range of Values:
     From 0 to 100 (percent). Default is 0 for Stretch Bottom and 100 for

```
      Stretch Top.
    - Always available, if "Tables" or "Options" is activated.


 3) === Gamma Correction ===

    - This slider can be used to compensate for the characteristics of your
      monitor. Values larger than 1.0 have a steeper contrast curve at the top
      end of the ramp, while values less than 1.0 have a steeper contrast curve
      at the bottom end of the ramp.  A value of 1.0 results in a linear ramp.
    - Range of Values:
      From 0.1 to 10. Default is 1.0.
    - Always available, if "Tables" or "Options" button is activated.


 4) === Color Tables LIST ===

    - This list shows the whole Color Table List available within IDL. Allows to
      select one Color Table from the list.
    - The default color table of EGOPS is '16 LEVEL'.
      (Browse through the available color tables while you have on-screen an
      image plot, e.g., a "Volume Data" plot, for learning how the different
      color tables look like.)
    - Always available, if "Tables" button is activated.
```

7.1.2.2 Plot Colors - Options

```
Plot Colors is a widget based utility for the interactive manipulation of color
tables. It may be used with any EGOPS plot applications. The color table maps
the data values written to the screen to different colors and intensities. Its
operation is similar to that of a photographic wedge. The slope and position of
the wedge are manipulated to best display a particular data set.


SPECIAL NOTES/HINTS

 - "Plot Colors" is a modified version of the "XLoadCT" widget tool
   contained in the IDL software package.
 - The current color table is always shown in the draw window above the
   first button row.


INPUT PARAMETER(S)

 1) === Exclusive BUTTON for Options [and Tables and Function] ===

    - Activates widget sliders for Stretch Bottom, Stretch Top, Gamma
      Correction, exclusive buttons for manipulating Sliders, Top, Stretch, and
      buttons for Reverse Table, Replace Original Table, and Restore Original
      Table.


 2) === Stretch Bottom and Strech Top ===

    - These sliders control the "contrast" of the color tables, and are
      expressed in percentages of full intensity. The color table wedge is
      "stretched" so that values equal to or less than "Stretch Bottom" are set
      to the lowest color table entry, which is usually black.
      Values equal to or greater than "Stretch Top" are set to the last entry in
      the color table, usually white or some other bright color. Values between
      the bottom and top are linearly scaled to the color table. Making "Stretch
      Bottom" higher than "Stretch Top" inverts the color table.
    - Range of Values:
      From 0 to 100 (percent). Default is 0 for Stretch Bottom and 100 for
      Stretch Top.
    - Always available, if "Options" or "Tables" button is activated.


 3) === Gamma Correction ===
```

- This slider can be used to compensate for the characteristics of your monitor. Values larger than 1.0 have a steeper contrast curve at the top end of the ramp, while values less than 1.0 have a steeper contrast curve at the bottom end of the ramp. A value of 1.0 results in a linear ramp.
- Range of Values:
  From 0.1 to 10. Default is 1.0.
- Always available, if "Options" or "Tables" button is activated.

4) === Exclusive BUTTONS for Sliders ===

- "Gang" Sliders connects the "Stretch Bottom" and "Stretch Top". Moving one slider moves the other. With the sliders ganged, movement of a slider causes the other slider to track keeping the width of the wedge constant, while moving it across the range of data values. Normally, the sliders are independent. The width of the wedge is fixed when this button is pressed. "Independent" Sliders removes the connection.
- Default is "Independent".
- Always available, if "Options" button is activated.

5) === Exclusive BUTTONS for Top ===

- When set to "Clip", values larger than "Stretch Top" are set to the largest color index. If set to "Chop", values larger than "Stretch Top" are set to color index 0.
- Default is "Clip".
- Always available if "Options" button is activated.

6) === Exclusive BUTTONS for Stretch ===

- When "Stretch" is set to the default "Indices", manipulations effect the mapping between color indices and color table triples. When set to "Intensity", the mapping individually controls the intensity of each color table entry. This is useful when displaying quantized images, where the pixel value is arbitrary and does not represent an intensity. In this mode, the hue and saturation remain relatively constant for a given color index.
- Default is "Indices".
- Always available if "Options" button is activated.

7) === Reverse Table, Replace-, Restore Original Table ===

- These three buttons are pre-defined Color Table buttons. Pressing one of these buttons loads the selected pre-defined color table. The settings of the other controls are not affected.
- "Reverse Table" reverses the current color table.
  "Replace Original Table" replaces the original color table.
  "Restore Original Table" restores the original color table.
- Always available if "Options" button is activated.

7.1.2.3 Plot Colors - Functions

Plot Colors is a widget based utility for the interactive manipulation of color tables. It may be used with any EGOPS plot applications. The color table maps the data values written to the screen to different colors and intensities. Its operation is similar to that of a photographic wedge. The slope and position of the wedge are manipulated to best display a particular data set.

SPECIAL NOTES/HINTS

- "Plot Colors" is a modified version of the "XLoadCT" widget tool contained in the IDL software package.
- The current color table is always shown in the draw window above the first button row.

INPUT PARAMETER(S)

1) === Exclusive BUTTON for Function [and Tables and Options] ===

- Activates Transfer Function widgets for Reset Transfer Function, Add Control Point, Remove Control Point, and display the corresponding Draw Window.

2) === BUTTONS for Reset Transfer Function, Add-, Remove Control Point ===

- These three non-exclusive buttons allow interactive editing of the Transfer Function (mapping of color table values to color indices) by dragging control points on a plot of the transfer function. (Select and move control points by clicking and dragging them in the draw window - see below.)
- "Reset Transfer Function" restores a linear one-to-one transfer function.
  "Add Control Point" adds a control point in the largest interval containing no control point.
  "Remove Control Point" removes the central control point in the smallest interval containing three control points.
- Always available if "Function" button is activated.

5) === DRAW WINDOW for interactive editing of color table values ===

- This window allows interactive modification of the transfer function by dragging control points on a plot of the transfer function. Select and move a control point by clicking and dragging on its symbol. The first and last control points may only be moved in the vertical direction. Other control points may be moved anywhere within the plot as long as they are to the right of their predecessors and to the left of the following control points.
- Always available, if "Function" button is activated.

7.2 Visualize Mission Analysis/Planning Statistics

7.2.1 Visualize MAnPl Statistics

The "Visualize Mission Analysis/Planning Statistics" window interface is called via the "MAnPl Statistics..." entry of the "Visualize/Validate" menu.

The basic data visualized by the interface are the result data from MAnPl tasks computed under the "Mission Analysis/Planning" entry of the "Task" menu previously. The User selects specific MAnPl result data, out of all MAnPl data available within the current project, by first assigning within the interface the Task-id of a desired MAnPl task.

Having assigned an "Occultation" MAnPl/Task-id, information on the main input parameters of the current task is displayed at the top of the window, including UT range, height level range (for "Reflection" MAnPl/Task-ids the time step is shown instead of the undefined height level ranges in this case), and the geographic area covered. In addition, full information on the input of the current task can be displayed (and printed out if desired) by one mouse click, at any time during the visualization.

The post-processing computations possible for the result data of the current task are occultation (reflection) coverage statistics computations and visibility statistics for fiducial and tracking sites. [See, e.g., the "Help on Task - Help on Mission Analysis/Planning" function to learn what fiducial and tracking sites are.] These computations are performed within post-processing pop-up windows of the interface, which are accessed via the "Compute Occ. Statistics..." or "Compute Refl. Statistics..." and "Compute Vis. Statistics..." buttons.

Occultation (reflection) coverage statistics computations yield 1D and 2D statistics data in form of histogram data (discrete event distribution functions

over a 1D or 2D domain). Options available for 1D statistics include the number of events taking place in bins of user-specified width over latitude, or longitude, or Local Time, or duration of events, or obliquity of tangent-point trajectories (w.r.t. to a vertical set or rise of the tangent point). Options available for 2D statistics include the number of events taking place in boxes of user-specified size over longitude-latitude maps, or Local Time-latitude maps, or event duration-latitude maps, or event obliquity-latitude maps. It is also possible to calculate statistical measures for occultation (reflection) tasks. Different options for statistical measures are Number of Events per unit area, mean Distances, rms of Distances, mean Time Separation, and rms of Time Separation.

Visibility statistics computations yield, for each of a given set of LEO receivers involved in the current MAnPl task, the number of occultation events for which successful ground- or spacebased single differencing or double-differencing is possible by each of a given sample of fiducial ground sites (and by all sites together) or additional LEO-satellites, and the number of orbits seen for a given time range per orbit by each of a couple of tracking ground stations (and by all stations together).

The post-processing result data are saved in "display files" which are named with the Task-id of the current task and which indicate through their file extension the type of processing (and, for a given type, the version). For instance "MAnPltest1.Lat02" contains, for a current task named "MAnPltest1", the results of the 2nd post-processing run ("02") for 1D histogram data versus latitude ("Lat").

All "display files" computed so far for the current task are basically available to be visualized. For visualizing a specific result, the User needs to first select the type desired (for 2D histogram data also whether these shall be plotted as 2D histograms or 2D contours) and then the version desired (i.e., the actual "display file" among all versions available for the selected type).

Having selected a "display file", immediate on-screen plotting is possible into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, and the axes ranges (and viewing angle in case of 2D histogram plots). However, these plot settings can also be adjusted by the User before plotting. In addition, the User can decide whether to plot the data directly as they appear in the "display files" (as numbers of events), or "equal area-weighted" (in case occ. statistics data include a dependence on latitude), or "as percentages" (in case of visibility statistics data).

The standardized graphics output window can be used in one-panel, two-panel (stacked vertically), or four-panel mode (for statistical measures data the four-panel mode is not foreseen), and "plot", "overplot", and "erase last" or "erase all" functions can be quite arbitrarily employed. In addition, a "colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately affect the current graphics allowing for efficient color optimization.

A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file. A color PostScript file is generated (always in the /<Project-id>/PSfiles subdirectory of EGOPS) so that either a color printer may be employed to get the full colored graphics on paper or a standard b/w printer to get the grayscale/black/white analog of the on-screen plot on paper.

[Detailed help on each function of the "Visualize Mission Analysis/Planning Statistics" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Prepare some MAnPl tasks, then pop-up this interface and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no

problem for you.

7.3 Visualize Mission Analysis/Planning Statistics Input

7.3.1 MAnPl/Task-ids

A Task-id (Task identifier) within EGOPS denotes generally the User's name and identification of a specific Task. (Consult the "Help on Task/About Tasks" entry at the menu level in case you need to learn what an EGOPS "Task" is.)
The MAnPl/Task-id for Visualize Mission Analysis/Planning Statistics is the name and identification of the Mission Analysis/Planning (MAnPl) Task whose results are to be visualized. In fact, all files relating to the current Task will contain the Task-id as leading part of the file name. Specifically, all information relating to Mission/Analysis Planning is saved in the /MAnPl subdirectory of the /<Project-id> directory of your current Project.

SPECIAL NOTES/HINTS

- Default MAnPl/Task-id is the last used MAnPl/Task-id.

INPUT PARAMETER(S)

1) === MAnPl/Task-id ===

- This text field (non editable) shows the currently selected MAnPl/Task-id.
- Remember that the Task-id will be the key name throughout the entire EGOPS system for identifying your current Task.

2) === Existing MAnPl/Task-ids... ===

- This button opens a pop-up window which allows to select an existing Task-id from a list. Confirm your selection with "Ok" or choose "Cancel" to return without action.
- Available only, if a project is open and more than one Task already exists (otherwise the only existing Task-id - MAnPldefault - is selected by default and the button/select-list window is insensitive).

7.3.2 Properties of the selected ManPl task

This input group displays starting date/time, simulation time range, height levels and geographic area of the selected MAnPl simulation.

SPECIAL NOTES/HINTS

- Only available if an Occultation Task was selected.
- It is not possible to modify the given values.

INPUT PARAMETER(S)

1) === UT Range ===

- This label shows starting date/time of the selected MAnPl simulation and simulation time range. Thus, the time range added to the start date/time gives the time of the end of the simulation.

2) === Height Levels/Time Steps ===

- In the case that an occultation task was selected, the height levels of the corresponding MAnPl/Task-id will be shown. Maximum the first two

height levels (up to 4 height levels might be defined) can be shown. If a reflection task is selected, instead of the height levels the used time steps are shown.

3) === Geographic area ===

- Shows the geographic area for which occultation (reflection) events were computed within the time range specified in the "UT Range" input group.
- Only events are accounted for in the MAnPl computations, for which the tangent (reflection) point (precisely speaking, in case of an occultation task, the tangent point of the lowest height level specified in the "Height Levels" input) lies within the latitude-longitude region specified.

7.3.3 Occultation/Reflection Statistics

This input group allows to choose between 1D/2D Histogram, 2D Contours, and Statistical Measures for plotting of the resulting Occultation (Reflection) Statistics Computations data files. The first step in this is to prepare the statistics data within the Occultation (Reflection) Statistics Computations window and to compute the occultation (reflection) numbers (No. of Events).

INPUT PARAMETER(S)

1) === Display Occultation/Reflection Statistics ===

This input group allows to choose between 1D/2D Histogram, 2D Contours, and Statistical Measures for plotting of the resulting Occultation (Reflection) Statistics Computations data files.

"Display Occultation/Reflection Statistics"
- Activating this check box activates the exclusive buttons for 1D/2D Histogram, 2D Contours, or Statistical Measures plot as well as the associated droplist.

"1D/2D Histogram, 2D Contours, or Statistical Measures"
- These exclusive buttons allow to select the plot mode.
- Selecting a specific plot mode activates the respective droplist for selection of the parameters for the second (and third in case of 2D plots) plot axis.
- Only available, if 'Display Occ./Refl. Statistics' is activated.

"DROPLIST for 1D Histogram X-Axis Labelling"
- For occultation events, selection between No. of Events versus Latitude, vs. Longitude, vs. Universal- or Local Time, vs. Obliquity Angle, vs. Event Duration, or Number of Occultating Satellites versus Universal Time.
- For reflection events, the last three items are superseded with No. of Events versus Reflection Angle.
- Only available if 1D Histogram was selected.

"DROPLIST for Statistical Measures Plot Parameter"
- Allows to select among No. of Events, mean- or rms of Distances, and mean-or rms of Time Separation.
- Only available if Stat. Measures was selected.

"DROPLIST for 2D Histogram/Contours XY-Axis Labelling"
- For occultation events, selection among No. of Events versus Longitude and Latitude, vs. Universal- or Local Time and Latitude, vs. Obliquity Angle and Latitude, and versus Event Duration and Latitude.
- For reflection data, the last two items are superseded with No. of Events versus Reflection Angle and Latitude.
- Only available if 2D Histogram or 2D Contours is selected.

2) === Compute Occultation/Reflection Statistics ===

- This button opens a pop-up window that allows to select the statistics type, to specify the statistics computation input and to compute the resulting occultation (reflection) file.

7.3.3.1 Occultation/Reflection Statistics Computations

This input window allows to select type and related input for the computation of occultation/reflection statistics data. These data may be graphically displayed later on.

INPUT PARAMETER(S)

1) === Statistics Type ===

This input group allows to choose the occultation/reflection statistics type among 1D/2D Statistics, Sum/Difference Data, Statistical Measures, and Sum- or Difference of Measures Data.

"1D/2D Statistics or Sum/Diff. Data"
- These exclusive buttons allow to select among the first three possible different occultation/reflection statistics types (1D Statistics, 2D Statistics or Sum/Diff. Statistics Data Type).
- Activating a specific type activates the respective droplist for selection of the parameters for the second (and third in case of 2D plots) plot axis.

"DROPLIST for 1D Statistics X-Axis Labelling"
- For occultation statistics, selection among No. of Events versus Latitude, vs. Longitude, vs. Universal- or Local Time, vs. Obliquity Angle, vs. Event Duration, or No. OccSats versus UT.
- For reflection statistics, the last three items are superseded with No. of Events versus Reflection Angle.
- Only available if 1D Statistics was selected.

"DROPLIST for 2D Statistics XY-Axis Labelling"
- For occultation statistics selection among No. of Events versus Longitude and Latitude, vs. Universal- or Local Time and Latitude, vs. Obliquity Angle and Latitude, and versus Event Duration and Latitude.
- For reflection statistics, the last two items are superseded with No. of Events versus Reflection Angle and Latitude.
- Only available if 2D Statistics was selected.

"DROPLIST for Sum/Difference Statistics Data"
- Allows the selection between sum of statistics data or difference of statistics data for occultation/reflection statistics data.
- Only available if Sum/Diff. Data was selected.

"Statistical Measures or Sum- or Difference of Measure Data"
- These exclusive buttons allow to select amongst three further different occultation/reflection statistics types.

2) === Statistics Computation Input ===

This input group allows to select UT Range, <Parameter> Ranges and Binsizes, Height Range (if necessary), Occultation/Reflection Event and Tx Type as the occultation/reflection statistics computation input (for Statistical Measures computation only UT Range, Occultation/Reflection Event and Tx Type inputs are necessary).
- For Sum/Difference Data selection, a separate input window will be mapped instead of the statistics computation input window.
- The range defaults of all shown statistics computation input values are their maximum ranges. Inputted values which are out of range will be automatically adjusted.

"UT Range"
- This input field allows to modify (shorten) the shown UT range.

"<Parameter> Ranges & Binsizes"
- These input fields allow to change the shown <parameter> range & binsize.
- For 1D statistics only one <parameter> range & binsize input field is necessary; for 2D statistics computation, two <parameter> range & binsize input fields are available.
- Input Format: (Min MAx d)
  'Min' and 'Max' are the minimum and maximum value of the range of the parameter, respectively. 'd' is the stepsize. Only numbers are allowed. The range must be an integral multiple of the stepsize.

"Height Range"

- This input field allows to modify the shown height range.
- The height range must be compatible with the settings of the respective MAnPl task (are shown below the input field).
- Input Format: (Hlo Hhi)
  'Hlo' and 'Hhi' are the lower and upper boundary of the height range [km], respectively. Only numbers are allowed
- Only available if 1D (2D) statistics will be computed versus obliquity angle (vs. obliquity angle and lat.) or versus event duration (vs. event duration and lat.).

"Occultation Event Type"
- This droplist allows to choose among all occultation events, setting events and rising events
- Only active in case that rising and setting events are found. If only rising (setting) events are found, the droplist will be fixed to 'Rising Events' ('Setting Events').

"Tx Type"
- This droplist allows to select among all possible combinations of Tx satellites (GPS, GAL, GLO, ACE) used during the respective MAnPl computation.
- Only active if more than one Tx satellite system was used in the corresponding MAnPl/Task-id geometry simulation. Otherwise, the droplist will be fixed to the single used Tx system.

3) === Sum/Difference Data Computation Input ===

This input group allows to select the Sum/Difference Statistics Type. Furthermore, the primary and reference data files can be selected from a respective pick-file window (in case of primary data file) or from the respective file select list (in case of reference data file). For Sum, the file content of the primary and reference data files will be added together, for Difference the file content of the reference data file will be subtracted from the file content of the primary data file.

"Sum/Difference Statistics Type"
- This droplist allows to choose among Sum/Diff Statistics Type vs. Latitude, vs. Longitude, vs. Universal Time, vs. Local Time, vs. Obliquity Angle, vs. Event Duration, No. OccSats vs. UT, vs. Longitude and Lat., vs. Universal- or Local Time and Lat., vs. Obliquity Angle and Lat., and vs. Event Duration and Latitude for occultation statistics.
- For reflection data, items 5, 6, and 7 are superseded with No. of Events versus Reflection Angle, and the last two items are superseded with No. of Events versus Reflection Angle and Latitude.
- Only available if Sum/Diff. Data is activated.

"Sum/Difference of Measure Data Type"
- This droplist allows to choose among Number of Events, mean- or rms of Distances, and mean- or rms of Time Separation.
- Only available if Sum- or Difference of Measure Data is activated.

"Primary Data File..."
- This button opens a pop-up window that allows to select a desired primary data file existing in the /<Projectname>/MAnPl/ subdirectory of EGOPS.
- The selected primary data file will be shown in the text field on the right of the button.
- The file path and file name filter are automatically set to the proper parameters and cannot be changed.

"Reference Data File..."
- This button opens a pop-up window that allows to select a Reference Data File out of all existing ones.
- Only available, if primary data file was already selected.
- The selected reference data file will be shown in the text field on the right of the button.
- The file path and file name filter are automatically set to the proper parameters and cannot be changed.

4) === Compute ===

This input group allows to compute the profiles post-processing data using the input parameters defined above. Be careful in selecting the simulation input parameters in order not to waste computation time and disk space for

results not really exploited. Note that some input combinations (very long simulation time ranges etc.) can result in very long computation times.

"Compute"
- This button causes EGOPS to start the numerical calculation by employing the corresponding software package (written in IDL). It performs the occultation/reflection statistics computations based on the current input and produces the necessary result file for subsequent visualization. (To learn more about the file structure behind EGOPS consult the "EGOPS explained..." Help entry of the main-level Help menu.)
- If a needed file is missing or incorrect (e.g., due to inappropriate direct manipulation by the user) the program may abnormally terminate with a message of varying information content (see in the log file). After correction of the problem, you can proceed as usual. (To learn more about Error Handling related to EGOPS, consult the appropriate sections of the User Manual.)
- After starting a computation, an 'Information Window' pops up with a short hint that EGOPS started profiles post-processing computing. When the calculation is finished, the 'Information Window' will be closed.

"Resulting Occultation/Reflection File"
- This text field shows the predefined occultation/reflection filename.
- Text field non editable.

7.3.4 Visibility Statistics

This input group allows to choose between differencing statistics and tracking statistics when plotting the resulting visibility statistics data files. The first step in this process is to prepare the statistics data within the visibility statistics computations window and to compute the numbers (No. of Events seen).

SPECIAL NOTES/HINTS

- This input group is only sensitive, if Differencing Visibility and/or Tracking Visibility was calculated in the corresponding MAnPl/Task-id. For 'reflection' Tasks, the input group is always insensitive.

INPUT PARAMETER(S)

1) === Display Visibility Statistics ===

This input group allows to choose between differencing statistics and tracking statistics when plotting the resulting visibility statistics data files.

"Display Vis. Statistics"
- Activating this check box activates the exclusive buttons for Differencing Statistics or Tracking Statistics plotting as well as the associated droplists.

"Differencing Statistics or Tracking Statistics"
- These exclusive buttons allow to select the plot mode.
- Selecting a specific plot mode activates the respective droplist for selection of the differencing/tracking statistics mode.
- If, e.g., only Tracking Statistics data were calculated in a specific MAnPl/Task-id, then the Differencing Statistics button will always be insensitive and vice versa.
- Only available, if 'Display Visibility Statistics' is activated.

"Differencing Statistics Mode"
- This droplist allows to select between Double Differencing, and Groundbased- or Spacebased Single Differencing.
- The droplist is only available, if Differencing Statistics was selected.

"LABEL for Tracking Statistics Mode"
- This label shows the selection of Tracking Statistics for Groundbased Tracking Sites (in the current EGOPS version, only Tracking Statistics for Groundbased Tracking Sites is possible, so no real choice is offered).

```
        - Only sensitive, if Tracking Statistics was selected.


 2) === Compute Visibility Statistics ===

    - This button opens a pop-up window that allows to select the statistics
      type, to enter the statistics computation input and to compute the
      resulting visibility statistics data file.
```

7.3.4.1 Visibility Statistics Computations

```
This input window allows to select type and related input for the computation of
visibility statistics data. These data may be graphically displayed later on.


INPUT PARAMETER(S)

 1) === Statistics Type ===

    This input group allows to choose between two visibility statistics types:
    differencing statistics and tracking statistics.

    "Differencing Statistics or Tracking Statistics"
        - These exclusive buttons allow to select the statistics type.
        - Only available,  if the corresponding statistics data were prepared in
          the chosen MAnPl/task-id.
    "DROPLIST for Differencing"
        - Allows the selection between double differencing and groundbased- or
          spacebased single differencing.
        - The number of entries depends on the data calculated in the
          corresponding MAnPl/Task-id (e.g., if only data for Double
          Differencing were prepared, the droplist shows only the entry for
          'Double Differencing').
        - Only available, if Differencing Statistics was selected.
    "LABEL for Tracking"
        - This label indicates that 'Groundbased Tracking Sites' was selected
          for tracking statistics.
        - Only active if Tracking Statistics was selected.


 2) === Statistics Computation Input ===

    This input group allows to select UT Range, <Parameter> Ranges, Occultation
    Event and Tx Type.
    - The range defaults of all shown statistics computation input values are at
      their maximum ranges. Inputted values which are out of range will be
      automatically adjusted.

    "UT Range"
        - This input field allows to modify (shorten) the shown UT range.
    "Fiducial Site Number Range"
        - This input field allows to modify the shown fiducial site no. range.
        - Input Format: (Nlo Nhi)
          'Nlo' and 'Nhi' are the lowest and highest number of the fiducial
          sites to be used, respectively. Only numbers are allowed.
        - A value which is out of range will be automatically adjusted.
        - Only available for differencing statistics.
    "Fiducial Rx Number Range"
        - This input field allows to modify the shown fiducial Rx no. range.
        - Input Format: (Nlo Nhi)
          'Nlo' and 'Nhi' are the lowest and highest number of the fiducial Rx
          to be used, respectively. Only numbers are allowed.
        - Only available if spacebased single differencing statistics was chosen
          as differencing statistics type.
    "Tracking Site Number Range"
        - This input field allows to modify the tracking site number range.
        - Input Format: (Nlo Nhi)
          'Nlo' and 'Nhi' are the lowest and highest number of the tracking
          sites to be used, respectively. Only numbers are allowed.
        - Only available for tracking statistics.
```

```
    "Rx visibility/orbit"
        - This input field allows to modify the Rx visibility time [min] per
          orbit.
        - Only available for tracking statistics.
    "Rx Number Range"
        - This input field allows to change the given Rx number range .
        - Input Format: (Nlo Nhi)
          'Nlo' and 'Nhi' are the lowest and highest number of the Rx to be
          used, respectively. Only numbers are allowed.
    "Occultation Event Type"
        - This droplist allows to choose among all occultation events, setting
          events and rising events.
        - Only active if rising as well as setting events are found. If only
          rising (setting) events are found, the droplist will be fixed to
          'Rising Events' ('Setting Events').
    "Tx Type"
        - This droplist allows to select among all possible combinations of Tx
          satellites (GPS, GAL, GLO, ACE) used during the respective MAnPl
          computation.
        - Only active if more than one Tx satellite system was used in the
          corresponding MAnPl/Task-id geometry simulation. Otherwise, the
          droplist will be fixed to the single used Tx system.


 3) === Compute ===

    This input group allows to compute the profiles post-processing data using
    the input parameters defined above. Be careful in selecting the simulation
    input parameters in order not to waste computation time and disk space for
    results not really exploited. Note that some input combinations (very long
    simulation time ranges etc.) can result in very long computation times.

    "Compute"
        - This button causes EGOPS to start the numerical calculation by
          employing the corresponding software package (written in IDL). It
          performs the visibility statistics computations based on the current
          input and produces the necessary result file for subsequent
          visualization. (To learn more about the file structure behind EGOPS
          consult the "EGOPS explained..." Help entry of the  main-level Help
          menu.)
        - If a needed file is missing or incorrect (e.g., due to inappropriate
          direct manipulation by the user) the program may abnormally terminate
          with a message of varying information content (see in the log file).
          After correction of the problem, you can proceed as usual.
          (To learn more about Error Handling related to EGOPS, consult the
          appropriate sections of the User Manual.)
        - After starting a computation, an 'Information Window' pops up with a
          short hint that EGOPS started profiles post-processing computing. When
          the calculation is finished, the 'Information Window' will be closed.
    "Resulting Visibility Statistics Data File"
        - This text field shows the predefined resulting visibility statistics
          filename.
        - Text field non editable.
```

7.3.5 Display Data Files

```
The list widget shows a list of all preselected occultation/reflection or
visibility statistics files for plotting or deleting. If no file is found, the
list widget will be insensitive. To select a file for plotting or deleting,
click on the listed filename with the mouse pointer. The 'Delete File' and
'Delete all Files' buttons can be used to remove the selected file or all listed
files, respectively.


SPECIAL NOTES/HINTS

 - Only one file at a time can be selected.


INPUT PARAMETER(S)
```

```
 1) === File LIST ===

    - The file list allows to select a file for plotting or for deleting.
    - If no file is found, the list will be insensitive.


 2) === Delete File ===

    - This button allows to delete a selected file (from the file list).
    - If no file is selected, the button will be insensitive.


 3) === Delete all Files ===

    - This button allows to delete all files (from the file list).
    - If no file is selected, the button will be insensitive.
```

7.3.6 Plot Settings

```
This input group allows to specify various plot settings. It is possible to
specify a plot title, a legend text. For 1D/2D histograms, all axis ranges and
the contour range/separation can be changed for 1D/2D contour plots. For
displaying statistical measures data, the plot options are fixed to plot data as
are and all axis ranges cannot be changed. For differencing statistics, the
fiducial site range, the number axis range and the number axis range/all sites
values can be altered. For tracking statistics, instead of the fiducial site
range the track site range can be adjusted.


SPECIAL NOTES/HINTS

 - The plot settings input window is only sensitive, if a file from the display
   data files list was already selected.


INPUT PARAMETER(S)

 1) === Title ===

    - This text input field shows a default plot title and allows to modify it.
    - All alphanumeric strings with a maximum length of 60 characters are
      allowed.


 2) === Legend ===

    - This button opens a pop-up window which allows to change the default
      legend text.


 3) === Options ===

    - This droplist allows to choose the plot options.
    - Range of Values:
      For 2D histogram/contours plots and 1D histogram versus latitude plots:
          'Plot Data as are', 'Plot Data Eq. Area Weighted' ('Plot Data as
          Percentages').
      For the other 1D histogram plots and for statistical measures plots:
          'Plot Data as are'.
      For differencing or tracking statistics:
          'Plot Data as are', Plot Data as Percentages'.


 4) === Axis Range, View Angle & Contour Range/Separation ===

    - These input fields allow to modify the preselected values of the parameter
      and number axis ranges, view angle and contour range/separation values.
    - Input Format:
      Parameter/Number axis ranges: (lo hi)
```

'lo' and 'hi' are the lower and upper boundaries of the range, respectively. The boundaries must satisfy the condition that all events are inside the selected interval.
Viewing Angle: (al az)
'al' and 'az' are the elevation and the azimuth, respectively.
Contour range/separation: (lo hi sep)
'lo' and 'hi' are the lower and upper boundary of the contour range, respectively. 'sep' is the separation of the contour lines.
Only numbers are allowed.

- For a 1D histogram, one parameter and one number axis range is adjustable. For a 2D histogram, two parameter, one number axis range and the viewing angle input field is adjustable. For 2D contours, two parameter axis ranges and the contour range/ separation is to be set. In case of statistical measures plots, no axis adjustments are allowed therefore all four input fields are set insensitive.

5) === Fiducial Range, Tracking Range, Number Axis Ranges, Number Axis Ranges/All Sites ===

- For differencing statistics: Selection among 6, 12 or 18 fiducial sites (via the Fiducial Range droplist) and adjustment of two axis ranges input fields for Number Axis Ranges and Number Axis Ranges/All Sites).
- For tracking statistics: Selection among 2, 4 or 6 tracking sites (via the Tracking Range droplist) and adjustment of two axis ranges (input fields for Number Axis Ranges and Number Axis Ranges/All Sites).
- Input Format for the Axis Ranges: Put in the lower and upper boundaries (lo hi). The boundaries must satisfy the condition that all events are inside the selected interval. For the input fields, only numbers are allowed.
- The 'FidRange' droplist is only available, if differencing statistics was chosen. In case of tracking statistics, the 'TrkRange' droplist is available.

7.3.7 Plot Window

This input group allows to specify various plot settings. It is possible to specify the number of plots to be shown in the plot window (the plot window can be split into one, two or four plot areas; for statistical measures plots, only one or two plot areas are available), to overplot another plot over the first one, to erase the last plot or to erase the full plot window and to print the content of the plot window to a PS-file.

SPECIAL NOTES/HINTS

- The plot window droplist and buttons are only sensitive, if a file from the display data files list was already selected.
- In case of a 2D-Plot, the plot viewing angle can also be also be changed by mouse movement (inside the graphics window, press the left mouse button and move the graphics cursor to get the desired view angle adjustment).

INPUT PARAMETER(S)

1) === Plot Panels ===

- This droplist allows to choose among three different plot window settings: One, two, or four display panels per plot. In case of statistical measures plots only the one and two panels per plot options are available.

2) === Plot and Overplot ===

- These two buttons allow to plot the chosen data file or to overplot a selected data file over an existing plot, respectively.
- 'Plot' is available, if a file from the display data files list was already selected for plotting. 'Overplot' is only sensitive, if a plot already exists on the plot window.

- The maximum number of plots which can be shown is restricted to 20 (for a one panel plot that means a maximum of 19 over-plots are possible, for a two panel plot, 18 over-plots arbitrarily split between the two main plots are possible).

3) === Erase Last and Erase All ===

- These buttons allow to erase the last plot of a multi-panel plot window or to completely erase the whole plot window content, respectively.

4) === Colors... ===

- This button opens a pop-up window which allows to change the plot colors and to tune their characteristics.

5) === To PS file ===

- This button opens a pop-up window for printing the content of the plot window to a PS-file. The name of the PS file, the size of the plot (DIN-A4 or letter format) and the kind of PS plot file (standard or encapsulated PS) can be specified.
- Only available, if a file from the display data files list was already plotted.

7.4 Visualize Geographic Maps

The "Visualize Geographic Maps" window interface is called via the "Geographic Maps..." entry of the "Visualize/Validate" menu.

The basic data visualized by the interface are the result data from MAnPl tasks computed under the "Mission Analysis/Planning" entry of the "Task" menu previously. The User selects specific MAnPl result data out of all MAnPl data available within the current project, by first assigning within the interface the Task-id of a desired MAnPl task. Furthermore, even if no project is currently opened, geographic maps of atmospheric/ionosphere variables can be visualized.

Having assigned a MAnPl/Task-id, information on the main input parameters of the current task is displayed at the top of the window including UT range, height level range, and the geographic area covered. In addition, full information on the input of the current task can be displayed (and printed out if desired) by one mouse click, at any time during the visualization.

The post-processing computations, possible for the result data of the current task, yield occultation/reflection event distribution data. These data, more specifically also termed "ground projection data", include information on the geometrical shape (approximate ray-path tracks about the tangent-point trajectory for a given height level range for occultation tasks, or iso-range and iso-doppler curves for reflection tasks), the type (set or rise, transmitter system), the occurrence in time, and the sequential occultation/reflection event number (within the simulated time interval) of each event (within a selected sample of events). The computations are performed within a post- processing pop-up window of the interface, which is accessed via the "Prepare Occ./Refl. Event Data..." button.

The post-processing result data are saved in "display files" which are named with the Task-id of the current task and which indicate through their file extension the type of processing ("GrProjD" for "Ground Projection Data") and the version. For instance, "MAnPltest1.GrProjD02" contains, for a current task named "MAnPltest1", the results of the 2nd post-processing run ("02") for ground projection data ("GrProjD").

In order to prepare geographic maps of parameters of atmospheric/ionospheric models available within EGOPS, 2D latitude-longitude grids of such parameters can be computed (independent of whether a project is open or not). These grids may either slice an atmosphere/ionosphere field at a selected height (possible for temperature, pressure, density, refractivity, water vapor (pressure),

specific humidity, electron density, and ionospheric refractivity (at the F1 frequency)) or contain vertically integrated quantities (possible for Precipitable Water and Total Electron Content). These computations are performed within a processing pop-up window of the interface, which is accessed via the "Prepare Atm/Ion Model Data..." button.

The maps data are saved in "display files" (under the /referdata/mapsdata subdirectory of EGOPS) which are named with the acronym of the atmosphere/ionosphere model from which they originate plus the acronym of the parameter mapped. With their extension the files indicate their type ("Map") and the version. For instance, "MSIS90_DMI-Temp.Map01" contains, from the 1st computation for the specific model and parameter ("01"), a geographic map of temperature from the dry 3D atmosphere model MSIS90_DMI.

All "display files" computed so far are basically available to be visualized (if no project is open, the atmosphere/ionosphere model maps only). For visualizing a specific result, the User needs to first select the type desired (either event distribution data or atmosphere/ionosphere model data) and then the version desired (i.e., the actual "display file" among all versions available for the selected type).

Having selected a "display file", immediate on-screen plotting is possible into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, the map projection, and the map area (and the contour levels in case of atmosphere/ionosphere model data). However, these plot settings can also be adjusted by the User before plotting. In addition, the User can decide whether to plot the data directly as they appear in the "display files" (as ground projection data showing ray-path tracks about the tangent-point trajectories in case of event distribution data or as contoured 2D images in case of atm/ion model data), or "tagged with occ./refl.event number" (in case of event distr. data), or "tagged with event times" (also in case of event distr. data), or "overplotted on event distr. data" (in case of atm/ion model data). Several important tags can be included for improving the plotting quality (Plot Tangent Point with accumulated UT tags, with LT tags, with Tx-Id tags, with Rx-Id tags or Plot Tangent Point with Tx+Rx-Id tags).

The standardized graphics output window can be used in one-panel, two-panel (stacked vertically), or four-panel mode, and "plot", "overplot", and "erase" functions can be quite arbitrarily employed. In addition, a "colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately affect the current graphics allowing for efficient color optimization.

A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file. A color PostScript file is generated (basically in the /<Project-id>/PSfiles subdirectory of EGOPS except for atm/ion data maps, for which the file is directed to the /referdata/mapsdata subdirectory) so that either a color printer may be employed to get the full colored graphics on paper or a standard b/w printer to get the grayscale/black/white analog of the on-screen plot on paper.

[Detailed help on each function of the "Visualize Geographic Maps" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Prepare some MAnPl tasks and maps of atmosphere/ionosphere model parameters, then pop-up this interface and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no problem for you.

7.5 Visualize Geographic Maps Input

7.5.1 MAnPl/Task-ids

A Task-id (Task identifier) within EGOPS denotes generally the User's name and identification of a specific Task. (Consult the "Help on Task/About Tasks" entry at the menu level in case you need to learn what an EGOPS "Task" is.)
The MAnPl/Task-id for Visualize Geographic Maps is the name and identification of the Mission Analysis/Planning (MAnPl) Task whose results are to be visualized. In fact, all files relating to the current Task will contain the Task-id as leading part of the filename. Specifically, all information relating to Mission/Analysis Planning is saved in the /MAnPl subdirectory of the /<Project-id> directory of your current Project. The Visualize Geographic Maps window can also be opened without a specific project. In this case, only maps of atmosphere/ionosphere data are possible. A MAnPl/Task-id cannot be defined at this stage because MAnPl/Task-ids are directly connected with their respective project names (therefore, the MAnPl/Task-id input field is empty and the existing MAnPl/Task-id button is inactive).

SPECIAL NOTES/HINTS

- Default MAnPl/Task-id is the last used MAnPl/Task-id.

INPUT PARAMETER(S)

1) === MAnPl/Task-id ===

   - This text field (non editable) shows the currently selected MAnPl/Task-id.
   - Only available in case of an open project. Remember that the Task-id will be the key name throughout the entire EGOPS system for identifying your current Task.

2) === Existing MAnPl/Task-ids... ===

   - This button opens a pop-up window which allows to select an existing Task-id from a list. Confirm your selection with "Ok" or choose "Cancel" to return without action.
   - Available only, if a project is open and more than one Task already exists (otherwise the only existing Task-id - MAnPldefault - is selected by default and the button/select-list window is insensitive).

7.5.2 Properties of the selected ManPl task

This input group displays starting date/time, simulation time range, height levels and geographic area of the selected MAnPl simulation.

SPECIAL NOTES/HINTS

- Only available if a project was already opened.
- It is not possible to modify the given values.

INPUT PARAMETER(S)

1) === UT Range ===

   - This label shows starting date/time of the selected MAnPl simulation and simulation time range. Thus, the time range added to the start date/time gives the time of the end of the simulation.

2) === Height Levels/Time Steps ===

   - This label shows the height levels used for the MAnPl simulation, if an

occultation task is loaded. Maximum the first two height levels (up to 4 height levels might be defined) can be shown. If a reflection task-id is selected, instead of the height levels the used time steps are shown.

3) === Geographic area ===

- Shows the geographic area for which occultation (reflection) events were computed within the time range specified in the "UT Range" input group.
- Only events are accounted for in the MAnPl computations, for which the tangent (reflection) point (precisely speaking, in case of an occultation task, the tangent point of the lowest height level specified in the "Height Levels" input) lies within the latitude-longitude region specified.

7.5.3 Prepare Geographic Map Data

This input group allows to prepare Occultation Event Data or Atmosphere/ Ionosphere Model Data which may be displayed later.

INPUT PARAMETER(S)

1) === Prepare Occultation/Reflection Event Data ===

- This button opens a pop-up window which allows to select the input for event distribution data preparation and to compute the ground projection of the resulting occultation rays (or in case of a reflection task reflection iso-range and/or iso-doppler curves). These data may be displayed later.
- Only available if a project was already opened.

2) === Prepare Atmosphere/Ionosphere Model Data ===

- This button opens a pop-up window which allows to compute atmospheric/ionospheric maps data. For this, you can select among several atmosphere/ionosphere models, a model parameter, and the atm/ion model data preparation input.
- The data may be displayed later.

7.5.3.1 Occultation/Reflection Event Distribution Data Preparation Input

This input window allows to select occulation/reflection events and to set related specifications for subsequent computation of occultation/reflection event distribution data.

INPUT PARAMETER(S)

1) === Event Distribution Data Type ===

- "Occultation (Reflection) Rays Ground Projection Data about Tangent (Specular) Points" is the single fixed option (so no actual choice is available but the input is designed to be readily expandable for add-on choices).

2) === Event Distribution Data Preparation Input ===

This input group allows to specify various parameters needed for the calculation of the event distribution data. The sensitivity of the droplists depends on whether rising and(or) setting events are found in the corresponding Mission Analyses/Planning/Task-id and on the Tx-satellite system used for geometry simulation.
The range defaults of all shown event distribution data preparation input values are representing their maximum ranges.

"UT Range"
- This input field allows to change the UT Range Date/Time range.
- Input Format: [yymmdd.hhmmss,hhhmmss]
  "yymmdd.hhmmss" defines the start date/time of the event ('yy' are the last two numbers of the chosen year, 'mm' (1st) is the month, 'dd' is the day, 'hh' are the hours, 'mm' (2nd) the minutes and 'ss' the seconds), and "hhhmmss" is the time range ('hhh' are the hours, 'mm' the minutes and 'ss' the seconds).
- Range of Values:
  The values for the year can range between 90,...,99,00,01,...,89 (that means from 1990 till 2089).
- Only numbers are allowed (and dot and comma at their correct positions).

"Occultation (Reflection) Number Range"
- Selection of the Occultation (Reflection) Number Range by keyboard input.
- Input Format: (Nlo Nhi Nstep)
  'Nlo' is the lowest occultation number of the desired range, 'Nhi' the highest one, and 'Nstep' denotes the step size defining the used events between 'lo' and 'hi'. 'step' must be an integral multiple of the Occultation Number Range. All three values are integer and must be separated by at least one blank.
- Range of Values:
  Depends on the Occultation (Reflection) Number Range in the corresponding MAnPl/Task-id.sgd(.srd)-file.

"Geographic Area"
- Allows to select an arbitrary geographic area by directly specifying the desired latitude-longitude region.
- Input Format: (LatMin LatMax LonMin LonMax)
  'LatMin' and 'LatMax' [deg] are the minimum and maximum latitude, and 'LonMin' and 'LonMax' [deg] are the minimum and maximum longitude, respectively.
  Supply numerical values with a maximum of one post-comma digit.
  Separation of the values with a blank.
- Range of Values:
  -90.0 <= LatMin, LatMax <= 90.0, with LatMax-LatMin >= 1.0 [deg]
  -180.0 <= LonMin, LonMax <= 180.0, with LonMax-LonMin >= 1.0 [deg]

"Height Levels"
- Allows to select up to 4 independent height level ranges by directly specifying the desired height level values.
- Input Format:[Hlo1 Hhi1 Hstep1 dh1, Hlo2 Hhi2 Hstep2 dh2, ...]
  Each height level range is specified by four numbers (allowing for one post-comma digit) which are separated by a blank: 'Hlo' is the lower boundary of the height range, 'Hhi' is the upper boundary, 'Hstep' is the step size and 'dh' specifies the height accuracy for the simulation (all units are in [km]).
  Different height level ranges are separated by a comma and a blank.
  Hstep must be an integral multiple of the height range, i.e., the Hlo-Hhi bounds need to be matched.
- Range of Values:
  Hlo may be >= 0.0 km (earth surface), Hhi may be up to the perigee of the lowest LEO-satellite contained in the current leo*.tle file, the minimum step size is 0.1 km and the maximum height accuracy dh of the simulation may be 0.05 km.
- For occultation task-ids always available. If two adjacent ranges are chosen with different accuracy but common boundary (e.g., Hhi1=Hlo2), then the common boundary computations will be done employing the more accurate dH (e.g., MIN(dH1,dH2)) value.

"Along-Ray Distances/Steps"
- Allows to set up to three Along-Ray Distances/Steps [km] from Tangent Point by keyboard input.
- Input Format: (D_Hlo1 D_Hhi1 ds1, D_Hlo2 D_Hhi2 ds2, ...)
  'D_Hlo' is the lower boundary of the Along-Ray Distance range interval, 'D_Hhi' is the upper boundary of the Along-Ray Distance range interval, and 'ds' is the step size (all values are in [km]).
  Only integers are allowed. The values must be separated by at least one blank. Different Along-Ray Distances/Steps ranges must be separated by a comma and a blank (after the 3rd value of a range).
- Range of Values:
  D_Hlo may start at 10 km, D_Hhi may be up to 45000 km.
- Only available for occultation tasks.

"Iso-Range Curves"

- Allows to set the iso-range curves minima/maxima range and separation number range [No. Code Chips] by keyboard input (all three numbers have to be divided by the number of code chips before input).
- Input Format: (CMin CMax CSep)
  'CMin' and 'CMax' are the minimum and maximum iso-range curve number, respectively, and 'CSep' is the separation size. Only integers are allowed. The values must be separated by at least one blank.
- Range of Values:
  From 1 to 7.
- Only available for reflection tasks and if the check box on the left was activated previously.

"Iso-Doppler Curves"
- Allows to set the iso-doppler curves minnima/maxima range and separation number range [Hz^(-1)] by keyboard input.
- Input Format: (CMin CMax CSep)
  'CMin' and 'CMax' are the minimum and maximum iso-doppler curve number, respectively, and 'CSep' is the separation size. Only integers are allowed. The values must be separated by at least one blank.
- Range of Values:
  From -999 to 999 [Hz^(-1)].
- Only available for reflection tasks and if the check box on the left was activated previously.

"Occultation (Reflection) Event Type"
- This droplist allows to choose among all occultation (reflection) events, setting- or rising events.
- Only active in case rising and setting events are found. If only rising (setting) events are found the droplist will be fixed to 'Rising Events' ('Setting Events').

"Tx Satellite System Choice"
- This droplist allows to choose among all possible combinations of the satellite systems involved in the occultation/reflection events of the current task (GPS, GAL, GLO, ACE).
- Only active in cases for which more than one Tx-system was used in the corresponding MAnPl/Task-id geometry simulation. If only one satellite system (e.g. ACE) was used, the droplist will be fixed to this option.

"Code Type"
- This droplist allows to choose between C/A or P code type.
- Only available for reflection tasks.

3) === Compute ===

This input group allows to compute the event distribution ground projection data using the input parameters defined above. Be careful in selecting the simulation input parameters in order not to waste computation time and disk space for results not really exploited.
Note that some input combinations (very long simulation time ranges etc.) can result in very long computation times.

"Compute"
- This button causes EGOPS to start the numerical calculation by employing the corresponding software package (written in IDL). It performs the occultation (reflection) event distribution data computations based on the current input and produces the necessary result file for subsequent visualization.
  (To learn more about the file structure behind EGOPS, consult the "EGOPS explained..." Help entry of the main-level Help menu.)
- If a needed file is missing or incorrect (e.g., due to inappropriate direct manipulation by the user) the program may abnormally terminate with a message of varying information content (see in the log file). After correction of the problem, you can proceed as usual.
  (To learn more about Error Handling related to EGOPS, consult the appropriate sections of the User Manual.)
- After starting a computation, an 'Information Window' pops up with a short hint that EGOPS started occultation (reflection) event distribution data computing. When the calculation is finished, the 'Information Window' will be closed.

"Resulting Occ (Refl.) Rays Ground Projection Data File"
- This text field shows the predefined resulting occultation (reflection) rays ground projection data filename.
- Text field non editable.

7.5.3.2 Atmosphere/Ionosphere Model Data Preparation Input

```
This input window allows to select atmospheric/ionospheric parameters from
various atmosphere/ionosphere models as well as related specifications for the
computation of atmosphere/ionosphere data. These data may be graphically
displayed later on.


INPUT PARAMETER(S)

 1) === Atmosphere/Ionosphere Model and Parameter Selection ===

    This input group allows to choose among several Atmosphere and Ionosphere
    Models and among a list of several respective atmospheric (ionospheric)
    Parameters.

    "Atmosphere/Ionosphere Model"
        - This droplist allows to select between six different Atmosphere Models
          (Bi-Exponential-, HLat 2D-, 3D dry-, GCM 3D-, HiVRes- and a
          User-supplied Atmosphere) and two Ionosphere Models (Double-Chapman-
          and a 3D Ionosphere).
        - Activating the GCM 3D and HiVRes Atmosphere opens an extra pop-up
          window for input of the GRIB and RAOB data file path/name,
          respectively.
    "Atmosphere/Ionosphere Parameter"
        - This droplist allows to select between temperature, pressure, mass
          density, refractivity, water vapor pressure, specific humidity, and
          precipitable water in case of Atm. Parameters and between electron
          density, vertical total electron content, and ionosphere refractivity
          in case of Ion. Parameters.
        - The Atm. (Ion.) Parameter droplist is only available, if an Atmosphere
          (Ionosphere) Model was selected from the Atm/Ion Model droplist.


 2) === Atm/Ion Model Data Preparation Input ===

    This input group allows to manipulate the Height, Lat- and Lon Grid, UT,
    Month and Solar Activity/F107 index.

    "Height"
        - Allows to set the height [km] by keyboard input.
        - The values may range from 0.0 to 20000.0 km. A maximum of one post
          comma digit is allowed.
    "Lat/Lon Gridding"
        - Allows to set the latitude/longitude grid [deg] by keyboard input.
        - Input Format: (LMin LMax dL)
          'LMin' and 'LMax' are the lower and upper grid number, respectively.
          'dL' is the grid size. Numerical values with a maximum of one (for
          LMin and LMax) or two (dL) post comma digits are allowed. The values
          must be separated by at least one blank.
        - Range of Values:
          For Latitude grid from -90.0 to 90.0 deg, for longitude grid from
          -180.0 to 180.0 deg.
    "UT"
        - Allows to select the simulation start time by keyboard input.
        - Input Format: (hhmm)
          'hh' is the hour and 'mm' the minutes. Only numbers are allowed.
        - Range of Values:
          From 0000 to 2400.
    "Month"
        - Allows to select the month by typing the month number (1=Jan, ...,
          12=Dec).
    "Solar Activity/F107"
        - Allows to select the valid Solar Activity/F107 index.
        - The index number may range from 75 to 220. Only integers are allowed.
        - Only available if an Ionosphere Model was chosen.


 3) === Compute and Batch ===
```

This input group allows to compute the atmosphere/ionosphere data using the input parameters defined above. Be careful in selecting the simulation input parameters in order not to waste computation time and disk space for results not really exploited.
Note that some input combinations (very long simulation time ranges etc.) can result in very long computation times.

"Compute"
- This button causes EGOPS to start the numerical calculation by employing the corresponding software package (written in IDL). It performs the atmosphere/ionosphere model data computations based on the current input and produces the necessary result file for subsequent visualization.
  (To learn more about the file structure behind EGOPS, consult the "EGOPS explained..." Help entry of the main-level Help menu.)
- If a needed file is missing or incorrect (e.g., due to inappropriate direct manipulation by the user) the program may abnormally terminate with a message of varying information content (see in the log file). After correction of the problem, you can proceed as usual.
  (To learn more about Error Handling related to EGOPS, consult the appropriate sections of the User Manual.)
- After starting a computation, an 'Information Window' pops up with a short hint that EGOPS started atm/ion model data computing. When the calculation is finished, the 'Information Window' will be closed.

"Batch..."
- This button opens a pop-up window for saving and computing the currently open task offline in EGOPS batch mode. Meanwhile one can do further online work within EGOPS.
- The batch job processing pop-up window allows to select the start time of the EGOPS Batch-Job and offers the possibility to show further batch job status information via an extra pop-up window.

"Resulting Atm/Ion Maps Data File"
- This text field shows the predefined resulting atmosphere/ionosphere maps data filename.
- Text field non editable.

7.5.4 Display Geographic Maps

This input group allows to choose between event distribution data and atmosphere/ionosphere model data. For atmosphere/ionosphere model data, selection is among several available plot parameters.

INPUT PARAMETER(S)

1) === Event Distr. Data or Atm/Ion Model Data ===

- These two exclusive buttons allow to select between Event Distr. Data plotting or Atm/Ion Model Data plotting.
- If EGOPS found one or more files of the chosen file type, they will be displayed in the Display Data Files list window for selecting one of them for plotting.

3) === <Parameter> ===

- This droplist allows to select among temperature, pressure, density, refractivity, water vapor, specific humidity, precipitable water vapor, electron density, vertical total electron content, and ionospheric refractivity.
- Only available, if Atmosphere/Ionosphere Model Data was selected.
  If EGOPS found one or more files of the chosen file type, they will be displayed in the Display Data Files list window for selecting one of them for plotting.

7.5.5 Display Data Files

The list widget shows a list of event distribution or atmosphere/ionosphere model data files for plotting. If no file is found, the list widget will be insensitive. A file can be selected for plotting or deleting by clicking on the listed filename with the mouse pointer. The 'Delete File' and 'Delete all Files' buttons can be used to remove the selected file or all listed files, respectively.

SPECIAL NOTES/HINTS

- Only one file at a time can be selected.

INPUT PARAMETER(S)

1) === File LIST ===

   - The file list allows to select a file for plotting or for deleting.
   - If no file is found, the list will be insensitive.

2) === Delete File ===

   - This button allows to delete a selected file (from the file list).
   - If no file is selected, the button will be insensitive.

3) === Delete all Files ===

   - This button allows to delete all files (from the file list).
   - If no file is selected, the button will be insensitive.

7.5.6 Plot Settings

This input group allows to specify various plot settings. It is possible to modify the plot title, the legend text, choose amongst several plot options, select one of five different map projections and four map area regions, to zoom in and out, and to vary the <parameter> contour range/separation.

SPECIAL NOTES/HINTS

- The plot settings input window is only sensitive, if a file from the display data files list was selected previously.

INPUT PARAMETER(S)

1) === Title ===

   - This text input field shows a default plot title and allows to modify it.
   - All alphanumeric strings with a maximum length of 60 characters are allowed.

2) === Legend ===

   - This button opens a pop-up window which allows to change the default legend text.

3) === Options ===

   - This droplist allows to choose the plot options.
   - Range of Values:
     For occultation event distributed data, one of the following 8 values: 'Plot Data as are', 'Plot Tang.P. with Occ.No. tags', 'Plot Tang.P. with UT tags', 'Plot Tang.P. with accum. UT tags', 'Plot Tang.P. with LT tags', 'Plot Tang.P. with TxSat-Id tags', 'Plot Tang.P. with RxSat-Id tags', 'Plot Tang.P. with Tx+Rx-Id tags'.

```
      For reflection event distributed data one, of the following five values:
          'Plot Data as are', 'Plot Spec.P. with Refl.No. tags', 'Plot Spec.P.
          with UT tags', 'Iso-Range only', 'Iso-Doppler only'.
      For Atm/Ion Model Data one of the following two values: 'Plot Data as
          are', 'Overpl. Data on Ev.Distr. Data'.


4) === Map Projection ===

   - This droplist allows to choose amongst Cylindrical Equidistant, Mollweide,
     Orthographic, Equal Area (Lambert), and Azimuthal (Hammer-Aithoff) map
     projection.


5) === Map Area ===

   - This droplist allows to choose amongst Global, Northern Hemisphere,
     Southern Hemisphere, and Regional map area.


6) === Zoom in... ===

   - This button allows to select a specific plot region for zooming.
   - The 'Zoom in...' button activates the graphic cursor in the plot window.
     Draw with the graphic cursor by constant pressing the left mouse button a
     rectangle over an interesting plot area. Zoom the chosen area by clicking
     the 'Plot' button.
   - Always available if the plot setting window is sensitive, and a plot was
     already displayed in the plot window previously.
     For geographic map projections the zoom function is only available with
     the 'Cylindrical Equidistant' projection.


7) === Restore... ===

   - This button allows to restore the original plot size
   - Press 'Restore' and then 'Plot' to restore the zoomed plot image to its
     original size.
   - Only available if 'Zoom in...' was pressed before.


8) === INPUT FIELD for showing/changing Map Area Choice ===

   - This input field allows to modify the map area in case of regional map
     area setting.
   - Input Fomat: (LaMin LaMAx LoMin LoMax)
     'LaMin' and 'LaMax' are the minimum and maximum latitude of the area
     [deg], and 'LoMin' and 'LoMax' stand for the minimum and maximum
     longitude [deg], respectively.
     Supply numerical values with a maximum of one post-comma digit. Separation
     of the values with a blank.
   - Range of Values:
     -90.0 <= LaMin, LaMax <= 90.0, with LaMax-LaMin >= 1.0 [deg]
     -180.0 <= LoMin, LoMax <= 180.0, with LoMax-LoMin >= 1.0 [deg]
   - The input field is available, if the plot setting window is sensitive and
     the map area droplist is set to regional.


9) === <Parameter> Contour Range/Separation ===

   - Allows to modify range and separation of the contours in the <Parameter>
     plot. The lower and upper value plus the separation (step size) can be
     specified.
   - Input Format: (lo hi sep)
     'lo' and 'hi' are the lower and upper boundaries of the contour range
     interval, respectively. 'sep' is the contour separation. Supply numerical
     values only.
   - Range of Values:
     Default values are representing the minimum and maximum contour range
     value interval. A maximum of 30 steps are allowed.
   - Only available, if atmosphere/ionosphere model data are chosen.
```

7.5.7 Plot Window

This input group allows to specify several plot settings. The first option is the number of plots to be shown in the plot window (the plot window can be split into one, two or four plot areas). The plot button displays the chosen plot and the overplot button allows to overplot another plot over the previous one. The erase function clears the plot window, whereas the colors button opens a plot colors pop-up window for manipulating and adjusting the plot colors. The 'To PS File' button opens a pop-up window for printing the content of the plot window to a PS-file.

SPECIAL NOTES/HINTS

- The plot window droplist and buttons are only sensitive, if a file from the display data files list was selected previously.

INPUT PARAMETER(S)

1) === Plot Panels ===

   - This droplist allows to choose among three different plot window settings: One, two, or four display panels per plot.

2) === Plot and Overplot ===

   - These two buttons allow to plot the chosen data file or to overplot a selected data file over an existing plot, respectively.
   - 'Plot' is available, if a file from the display data files list was already selected for plotting. 'Overplot' is only sensitive, if a plot already exists on the plot window.
   - The maximum number of plots which can be shown is restricted to 20 (for a one panel plot that means a maximum of 19 over-plots are possible, for a two panel plot, 18 over-plots arbitrarily split between the two main plots are possible).

3) === Erase Last and Erase All ===

   - These buttons allow to erase the last plot of a multi-panel plot window or to completely erase the whole plot window content.

4) === Colors... ===

   - This button opens a pop-up window which allows to change the plot colors and to tune their characteristics.
   - Only available, if a file from the display data files list was already plotted.

5) === To PS file... ===

   - This button opens a pop-up window for printing the content of the plot window to a PS-file. The name of the PS file, the size of the plot (DIN-A4 or letter format) and the kind of PS plot file (standard or encapsulated PS) can be specified.
   - Only available, if a file from the display data files list was already plotted.

7.6 Visualize/Validate Profiles

The "Visualize/Validate Profiles" window interface is called via the "Profiles..." entry of the "Visualize/Validate" menu.

The basic data visualized by the "Profiles" interface are the result data of FoMod, or OSMod, or InRet tasks computed before under the "Forward Modeling"

entry, or the "Observation System Modeling" entry, or the "Occ. Data Inv./Retrieval" entry of the "Task" menu. The User selects specific FoMod/OSMod/InRet result data, out of all FoMod/OSMod/InRet data available within the current project, by first selecting the generic type of Task (FoMod, or OSMod, or InRet) and then assigning the Task-id of a desired FoMod/OSMod/InRet task.

Having selected a generic type of Task and assigned a corresponding Task-id, information on the occultation event no. range, the generic file names, and the total number of occultation events of the current task is displayed at the top of the window. In addition, full information on the input of the current task can be displayed (and printed out if desired) by one mouse click, at any time during the visualization.

The post-processing computations possible for the result data of the current task are absolute and relative difference profiles between profiles of different tasks (of the same generic type) or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events. For visualization of statistics, also standard-deviation-of-mean profiles are automatically included being a function of the computed mean and standard deviation profiles. These computations are performed within a post-processing pop-up window of the interface, which are accessed via the "Profiles Post-Processing..." button.

For FoMod tasks, the basically available result data for this post-processing comprise "ideal" simulated phase and amplitude data (in terms of "atmospheric (ionospheric) excess phase" and "atmospheric (ionospheric) power loss") as function of occultation event time. The excess phase data are available at all frequencies as well as in form of LC data (neutral atmosphere only after linear ionospheric combination of F1/F2 phases). For visualization, also LI data (ionosphere only at L1) are automatically included being a function of the computed F1, F2, and LC data. The amplitude data are available at all frequencies.

For OSMod tasks, the basically available data comprise "realistic" simulated phase and amplitude data (in terms of "observed excess phase" and "observed power", "observed" here in the sense of end-to-end simulated observables) as function of occultation event time. The excess phase data are available at all frequencies as well as in form of LC data (for visualization, also LI data are then derived), the amplitude data at all frequencies.

For InRet tasks, the basically available data comprise simulated or observed Doppler shift profiles (as function of occ. event time), bending angle profiles (as function of impact parameter), transmission profiles (as function of impact parameter), and refractivity, density, pressure, geopotential height, temperature, water vapor, specific humidity, and liquid water profiles (as function of height). Also, in case of observed data (e.g., from the GPS/MET experiment), the original phase and amplitude data are available (as function of occ. event time). The observed excess phase data are available at all frequencies as well as in form of LC data (for visualization, also LI data are then derived), the amplitude data at all frequencies.

Furthermore, for InRet tasks, reference "ground-truth" profiles of refractivity, density, pressure, temperature, water vapor (pressure), and specific humidity can be prepared with any available atmospheric model within EGOPS, at the tangent point locations of the retrievals. These computations are performed within a processing pop-up window of the interface, which is accessed via the "Prepare Atm.Ref. Profiles..." button.
Absolute and relative difference profiles w.r.t. these reference profiles can then be computed, as well as difference profiles statistics (mean difference to "ground-truth" and standard deviations compared to "ground-truth") for samples of events. For visualization of these statistics, also standard-deviation-of-mean profiles are automatically included being a function of the computed mean and standard deviation profiles. These computations, in turn, are again performed within the "Profiles Post-Processing..." pop-up window noted a few paragraphs above.

The post-processing result data are saved in "display files" which are named with the Task-id of the current task (plus the occultation number if not profile statistics) and which indicate through their file extension the parameter concerned, the type of processing, and, for a given type, the version. For instance "InRettest1_0001.TempDif03" contains, for occultation profile no. 1

("_0001") of a current task named "InRettest1", the results of the 3rd post-processing run ("03") for a difference profile ("Dif") between temperature profiles ("Temp").
In case of atmospheric reference profile "display files", the original profile's file extension is extended by the acronym of the atmospheric model which serves as "ground-truth" atmosphere. For instance, the file "InRettest1_0001.TempMSIS90_DMI" would contain a temperature reference profile extracted from the dry 3D atmosphere model MSIS90_DMI which is co-located with the profile in "InRettest1_0001.Temp".

All "display files" computed so far for the current task are basically available to be visualized. For visualizing a specific result, the User needs to first select the parameter and the type desired (e.g., difference profiles of temperature) and then the "display file" desired (out of all available ones for the selected parameter and type, which typically may cover a range of occultation numbers and/or versions).

Having selected a "display file", immediate on-screen plotting is possible into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, the axes ranges, and the parameter axis type (default linear, another option is logarithmic in case of direct plotting of positive definite result profiles or their atmospheric reference profiles). However, these plot settings can also be adjusted by the User before plotting. After plotting the "zoom in..." button can be used for enlarging interesting details of the plot (the "restore..." button can be used afterwards to restore the original plot image size).

In addition, the User can decide whether to plot the profiles directly as they are obtained from "the display files" (as functions of time, or impact parameter, or height, dependent on the parameter) or whether the data shall be customized in various ways before plotting. The customization functionality (available always to the extent appropriate for a selected generic type of Task, parameter, and type of plot) includes a function for smoothing the profile data by a user-specified sliding filter width, a function to compute the average value over a selected range of a profile, functions to fit an exponential or a polynomial of user-specified order to a selected range of a profile, a function to select arbitrary profile subsets of the F1, F2, etc., LC, and LI data available (in case of excess phase or Doppler shift data, F1/F2 in case of amplitude data with the ability to visualize, for simulated amplitude observables, absolute or relative power), and a function to select arbitrary profile subsets of the mean, standard deviation, and standard-deviation-of-mean profiles available (in case of statistics data, with the ability to show absolute or relative standard deviations).

The standardized graphics output window can be used in one-panel, two-panel (stacked vertically), or four-panel mode, and "plot", "overplot", and "erase" functions can be quite arbitrarily employed. In addition, a "colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately affect the current graphics allowing for efficient color optimization.

A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file. A color PostScript file is generated (always in the /<Project-id>/PSfiles subdirectory of EGOPS) so that either a color printer may be employed to get the full colored graphics on paper or a standard b/w printer to get the grayscale/black/white analog of the on-screen plot on paper.

Additionally, the line style and line thickness can be directly varied by means of two droplist buttons. The annotate function allows to individually create text strings for later annotation of the plot window. Several different text parameters can be altered (i.e. the text alignment, color, direction, position, and the text size). About 16 different character sets are available for creating a text string. These text strings can also be stored for later reuse.

[Detailed help on each function of the "Visualize/Validate Profiles" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Prepare some FoMod/OSMod/InRet tasks, then pop-up this interface and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no problem for you.

7.7 Visualize Profiles Input

7.7.1 Task-ids

A Task-id (Task identifier) within EGOPS denotes generally the User's name and identification of a specific Task. (Consult the "Help on Task/About Tasks" entry at the menu level in case you need to learn what an EGOPS "Task" is.) Visualize Profiles can be used with InRet/, OSMod/, and FoMod/Task-ids. The default Task-id is the InRet/Task-id. In fact, all files relating to the current Task will contain the Task-id as leading part of the file name. Specifically, all information relating to Occultation Data Inversion Retrieval (Observation System Modeling, or Forward Modeling) is saved in the /Inret (/OSMod, or /FoMod) subdirectory of the /<Project-id> directory of your current Project.

SPECIAL NOTES/HINTS

- Default InRet/Task-id is the last used InRet/Task-id.

INPUT PARAMETER(S)

1) === DROPLIST to select an InRet/, OSMod/ or FoMod/Task-id ===

   - Allows to select between an Occultation Data Inversion Retrieval (InRet), an Observation System Modeling (OSMod), or a Forward Modeling (FoMod) Task.

2) === Existing Task-ids... ===

   - This button opens a pop-up window which allows to select an existing Task-id from a list of available Task-id entries.
   - The currently selected Task-id will be shown in the text-field on the left of the button.
   - Available only, if more than one Task already exists (otherwise the only existing Task-id - InRetdefault - is set by default and the button is insensitive).

7.7.2 Prepare Profile Data

This input group allows to prepare profiles of atmospheric parameters (retrieved profiles as well as reference profiles) for post-processing.

INPUT PARAMETER(S)

1) === Profiles Post-Processing... ===

   - This button opens a pop-up window that allows to select the processing parameter(s) and type, to specify the single/sample profile processing input and to compute the resulting post-processing data file.

2) === Prepare Reference Profiles ===

   - This droplist allows to select between Atmosphere/Ionosphere Reference

```
      Profiles preparation and FoMod Reference Profiles preparation.
    - Selecting the 'Prepare Atmosphere/Ionosphere Reference Profiles...' option
      opens a pop-up window that allows to select the atmosphere (ionosphere)
      reference model and parameter and to compute the resulting atmosphere
      (ionosphere) reference profiles file(s).
    - Selecting the ' Prepare FoMod Reference Profiles...' option opens a pop-up
      window that allows to select a FoMod parameter and to compute the
      resulting FoMod reference profile file.
    - Only available if an InRet/Task-id is selected.
```

7.7.2.1 Profiles Post-Processing Input

```
This input window allows to select atmospheric/ionospheric parameters as well as
related specifications for the computation of profiles post-processing data.
These data may be graphically displayed later on.


INPUT PARAMETER(S)

 1) === Processing for Parameter(s) ===

    - This droplist allows to choose between different parameters for profiles
      post-processing. Dependent on the modeling system choice, various
      parameters may be selected.
      For atmosphere InRet/Task-ids:
          Doppler shift, bending angle, refractivity, density, pressure,
          geopotential height, temperature, water vapor, specific humidity,
          liquid water.
      For ionosphere InRet/Task-ids:
          Total electron content, doppler shift, bending angle, refractivity,
          electron density.
      For OSMod/Task-ids:
          Phase/power.
      For FoMod/Task-ids:
          Phase/atmospheric loss.


 2) === Processing Type ===

    This input group allows to select between single profile processing and
    profile sample processing and their respective adjustments. The possible
    parameters are the same as for InRet/, OSMod/, and FoMod/Task-ids.

    "Single Profile Processing or Profile Sample Processing"
        - These exclusive buttons allow to select between single profile
          processing or profile sample processing
        - The exclusive button for profile sample processing selection is only
          sensitive, if the chosen InRet/, OSMod/, and FoMod/Task-id occultation
          event simulation type was set to sample of events/realistic geometry.
    "Single Profile Mode"
        - This droplist allows to select between difference profile(s) and
          relative difference profile(s).
        - Only available, if single profile processing was selected.
    "Profile Sample Mode"
        - This droplist allows to select between profiles statistics and
          difference profiles statistics.
        - Only available, if profile sample processing was selected.


 3) === Single Profile Processing Input ===

    This input group allows to select the primary and reference data files. For
    difference profiles, the file content of the reference data file will be
    subtracted from the file content of the primary data file. For relative
    difference profiles, the file content of the reference data file will be
    subtracted from the file content of the primary data file and the result
    then divided by the content of the reference data file.

    "Primary Data File..."
        - This button opens a pop-up window that allows to select a Primary Data
```

File from a list. The primary data files may stem from the following EGOPS subdirectories:
/EGOPS/<Projectname>/Inret/SimData/<Parameter>/ for InRet/Task-ids,
/EGOPS/<Projectname>/OSMod/ for OSMod/Task-ids, and
/EGOPS/<Projectname>/FoMod/ for FoMod/Task-ids.
The InRet/SimData/ subdirectories are /Dopp (for Doppler shift), /bend (for Bending Angle), /refr (for Refractivity), /dens (for Density), /pres (for Pressure and Geopotential Height), /temp (for Temperature), /wvap (for Water Vapor), and /liqw (for Liquid Water).
- The selected primary data file is displayed in the text field on the right of the button.
- Only available, if at least one suitable file was found.

"Reference Data File..."
- This button opens a pop-up window that allows to select a Reference Data File from a list. The reference data files may stem from the same EGOPS subdirectories as the primary data files.
- The selected reference data file is displayed in the text field on the right of the button.
- Only available, if at least one suitable file was found.

4) === Profile Sample Processing Input ===

This input group allows to specify the Occultation Number Range, to choose an atmosphere reference model and to change the sliding filter width for smoothed data.

"Occultation Number Range"
- Input field for the specification of the Occultation Number Range.
- Input Format: (lo hi step)
  'lo' and 'hi' are the lower and upper boundary of the occultation number range. 'step' is the step size. Only integers are allowed, the values must be separated by a blank.
- Range of Values:
  The maximum Occultation Number Range will be always shown in the information label above the Occultation Number Range input field.

"Atmosphere Reference Model..."
- This button opens a pop-up window which allows to select an Atmosphere Reference Model from a list of available entries.
- The selected Atmosphere Reference Model will be displayed in the text field on the right of the button.
- Available only, if at least one atmosphere reference model can be found (otherwise the button/select-list window is insensitive).

"Sliding Filter Width"
- This input field allows to change the default setting of the filter width.
- Only odd numbers from 3 to 91 can be supplied.
- Only available, if the check box ('Use smoothed Data') on the left of the input field is activated.

5) === Compute ===

This input group allows to compute the profiles post-processing data using the input parameters defined above. Be careful in selecting the simulation input parameters in order not to waste computation time and disk space for results not really exploited.
Note that some input combinations (very long simulation time ranges etc.) can result in very long computation times.

"Compute"
- This button causes EGOPS to start the numerical calculation by employing the corresponding software package (written in IDL). It performs the profiles post-processing computations based on the current input and produces the necessary result file for subsequent visualization. (To learn more about the file structure behind EGOPS consult the "EGOPS explained..." Help entry of the main-level Help menu.)
- If a needed file is missing or incorrect (e.g., due to inappropriate direct manipulation by the user) the program may abnormally terminate with a message of varying information content (see in the log file). After correction of the problem, you can proceed as usual.

(To learn more about Error Handling related to EGOPS, consult the appropriate sections of the User Manual.)
- After starting a computation, an 'Information Window' pops up with a short hint that EGOPS started profiles post-processing computing. When the calculation is finished, the 'Information Window' will be closed.

"Resulting Post-Processing Data File"
- This text field shows the predefined resulting post-processing data filename.
- Text field non editable.

7.7.2.2 Atmosphere/Ionosphere Reference Profiles Preparation Input

This input window allows to select atmospheric/ionospheric parameters from various atmosphere/ionosphere models as well as related specifications for the computation of atmosphere/ionosphere reference profiles data. These data may be graphically displayed later on.

INPUT PARAMETER(S)

1) === Atmosphere/Ionosphere Reference Model Selection ===

This input group allows to select among several atmosphere (ionosphere) models and parameters for calculation of the atmosphere (ionosphere) reference profiles.

"Atmospheric/Ionosphere Reference Model"
- This droplist allows a selection among various atmosphere/ionosphere models. The following choices are possible:
  For an "atmosphere" InRet/Task-id:
  FoMod-, Bi-Exponential-, HLat 2D Atmosphere, 3D Atmosphere dry, GCM 3D Atmosphere, HiVRes Atmosphere, and one User supplied Atmosphere
  For an "ionosphere" InRet/Task-id:
  FoMod-, Double-Chapman, and 3D Ionosphere
- Selecting the GCM 3D Atmosphere (HiVRes Atmosphere) opens a pop-up window for GRIB (Raob) data file path and file name selection.

"Reference Profiles for Parameter..."
- This button opens a pop-up window that allows to select (via a list) among several parameters for calculating the reference profiles.
- For an atmospheric reference model, the selection is among Refractivity, Density, Pressure, and Temperature (for dry atmospheres) and additionally for Water Vapor, Specific Humidity (for wet atmospheres), and Liquid Water (for cloudy atmospheres).
  In case of an ionospheric reference model, Refractivity or Electron Density are the two available parameters in the reference profile calculation.
- The selected parameter will be displayed in the text field on the right of the button.

"Reference Profiles Trajectory"
- This droplist allows to select between two different Profile Trajectories (a Vertically Profile at the Mean Tangent Point or a 3D Tangent Point Trajectory).

SPECIAL NOTES/HINTS
- No FoMod atmosphere is available in case of InRet/Tasks, which are using observed data for processing (GPS/MET and CHAMP/GPS data).
- The Occultation Number Range to be prepared for cannot be adjusted.

2) === Compute and Batch ===

This input group allows to compute atmosphere/ionosphere reference profiles using the input parameters defined above. Be careful in selecting the simulation input parameters in order not to waste computation time and disk space for results not really exploited. Note that some input combinations (very long simulation time ranges etc.) can result in very long computation times.

"Compute"

- This button causes EGOPS to start the numerical calculation by employing the corresponding software package (written in IDL). It performs the atmosphere reference profiles preparation computations based on the current input and produces the necessary result file for subsequent visualization. (To learn more about the file structure behind EGOPS, consult the "EGOPS explained..." Help entry of the main-level Help menu.)
- If a needed file is missing or incorrect (e.g., due to inappropriate direct manipulation by the user) the program may abnormally terminate with a message of varying information content (see in the log file). After correction of the problem, you can proceed as usual. (To learn more about Error Handling related to EGOPS, consult the appropriate sections of the User Manual.)
- After starting a computation, an 'Information Window' pops up with a short hint that EGOPS started atm/ion model data computing. When the calculation is finished, the 'Information Window' will be closed.

"Batch..."
- This button opens a pop-up window for saving and computing the currently open task offline in EGOPS batch mode. Meanwhile one can do further online work within EGOPS.
- The batch job processing pop-up window allows to select the start time of the EGOPS Batch-Job and offers the possibility to show further batch job status information via an extra pop-up window.

"Resulting Atm/Ion Reference Profiles Files"
- This text field shows the predefined resulting atmosphere/ionosphere reference profiles data filename.
- Text field non editable.

7.7.2.3 FoMod Reference Profiles Preparation

This input window allows to select FoMod parameters for the computation of FoMod reference profiles data. These data may be graphically displayed later on.

INPUT PARAMETER(S)

1) === FoMod Reference Profiles Preparation ===

This input group allows to select among several FoMod parameters for calculation of the FoMod reference profiles.

"Fomod Parameter..."
- This button opens a pop-up window that allows to select (via a list) among several parameters for calculating the reference profiles.
- Bending angle or Doppler shift may be selected.S
- The selected parameter will be displayed in the text field on the right of the button.

"Occultation number Range to be prepared for"
- Shows the occultation number range for which reference profiles are computed. Cannot be adjusted.

2) === Compute ===

This input group allows to compute FoMod reference profiles using the input parameters defined above. Be careful in selecting the simulation input parameters in order not to waste computation time and disk space for results not really exploited. Note that some input combinations (very long simulation time ranges etc.) can result in very long computation times.

"Compute"
- This button causes EGOPS to start the numerical calculation by employing the corresponding software package (written in IDL). It performs the FoMod profiles preparation computations based on the current input and produces the necessary result file for subsequent visualization. (To learn more about the file structure behind EGOPS, consult the "EGOPS explained..." Help entry of the main-level Help menu.)
- If a needed file is missing or incorrect (e.g., due to inappropriate direct manipulation by the user) the program may abnormally terminate

```
          with a message of varying information content (see in the log file).
          After correction of the problem, you can proceed as usual.
          (To learn more about Error Handling related to EGOPS, consult the
          appropriate sections of the User Manual.)
        - After starting a computation, an 'Information Window' pops up with a
          short hint that EGOPS started atm/ion model data computing. When the
          calculation is finished, the 'Information Window' will be closed.
    "Resulting Atm/Ion Reference Profiles Files"
        - This text field shows the predefined resulting FoMod reference
          profiles data filename.
        - Text field non editable.
```

7.7.3 Display Profiles

```
This input group allows to choose a parameter to be visualized, to select single
profile info or profile sample info and to set plot modes.


INPUT PARAMETER(S)

 1) === Parameter to be Visualized ===

    - This droplist allows to select a parameter for visualization. Following
      choices are possible:
      For atmosphere InRet/Task-ids:
          Doppler shift, bending angle, refractivity, density, pressure,
          geopotential height, temperature, water vapor, specific humidity,
          liquid water.
      For ionosphere InRet/Task-ids:
          Total electron content, doppler shift, bending angle, refractivity,
          electron density.
      For OSMod/Task-ids:
          Phase, power.
      For FoMod/Task-ids:
          Phase, atmospheric loss.


 2) === Single Profile Info or Profile Sample Info ===

    - These exclusive buttons allow to select between single profile info or
      profile sample info as profiles plotting type.
    - The 'Single Profile Info' button is always available. The 'Profile Sample
      Info' button is only available, if sample of events/realistic geometry was
      selected in the Task-id task-id used.


 3) === Single Profile Plot Mode ===

    - This droplist allows to select between profile(s) directly, difference
      profile(s), and relative difference profile(s).
    - The droplist is only available if single profile info was selected. If
      EGOPS found one or more files of the chosen file type, these will be
      displayed in the 'Display Data Files' list window for selecting one of
      them for plotting.


 4) === Profile Sample Plot Mode ===

    - This droplist allows to select between profiles statistics and difference
      profiles statistics.
    - Only available, if an InRet/Task-id without doppler shift or bending as
      parameter to be visualized and profile sample info was selected. If EGOPS
      found one or more files of the chosen file type, these will be displayed
      in the Display Data Files list window for selecting one of them for
      plotting.
```

7.7.4 Display Data Files

The list widget shows a list of Single Profile- or Profile Sample Info files available for plotting or deleting. If no file is found, the list widget will be insensitive. To select a file for plotting or deleting, click on a listed filename with the mouse pointer. The 'Delete File' and 'Delete all Files' buttons can be used to remove the selected file or all files that are allowed to be deleted, respectively.

SPECIAL NOTES/HINTS

- Only one file at a time can be selected.

INPUT PARAMETER(S)

1) === File LIST ===

- The file list allows to select a file for plotting or for deleting.
- If no file is found, the list will be insensitive.

2) === Delete File ===

- This button allows to delete a selected file (from the file list).
- If no file is selected or if the selected file may not be deleted, the button will be insensitive.

3) === Delete all Files ===

- This button allows to delete all files (from the file list) that are allowed to be deleted.
- If no file is selected or if the selected file may not be deleted, the button will be insensitive.

7.7.5 Plot Settings

This input group allows to specify various plot settings. It is possible to modify the plot title, the legend text, to choose among several plot options, to zoom in and out, and to select a Linear or Logarithmic Parameter Axis. For an FoMod/ and OSMod/Task-id, the Time Axis Range and the <Parameter> (parameter to visualized) Axis Range, and for an InRet/Task-id, the two respective <Parameter> Axis Ranges can be modified.

SPECIAL NOTES/HINTS

- The plot settings input window is only sensitive, if a file from the display data files list was selected previously.

INPUT PARAMETER(S)

1) === Title ===

- This text input field shows a default plot title, which can be modified.
- All alphanumeric strings with a maximum length of 60 characters are allowed.

2) === Legend ===

- This button opens a pop-up window which allows to change the default legend text.

3) === Options ===

- The Plot Options droplist allows to choose between plot data as are and customize plot data. For customizing plot data, an extra pop-up window

```
      will be displayed.


 4) === Zoom in... ===

    - This button allows to select a specific plot region for zooming.
    - The 'Zoom in...' button activates the graphic cursor in the plot window.
      Draw a rectangle with the graphic cursor by constantly pressing the left
      mouse button while moving the mouse to create the zoom frame.  Zoom the
      chosen area by clicking the 'Plot' button.
    - Always available if the plot setting window is sensitive and a plot was
      already displayed in the plot window previously.


 5) === Restore... ===

    - This button allows to restore the original plot size
    - Press 'Restore' and then 'Plot' to restore the zoomed plot image to its
      original size.
    - Only available if 'Zoom in...' was pressed before.


 6) === <Parameter> Axis Range ===

    - These input fields allow to modify the preselected values for the
      parameter axis ranges (lower and upper boundaries for abscissa as well as
      ordinate).
    - Input Format: (lo hi)
      'lo' and 'hi' are the lower and upper boundaries for the parameter axis
      ranges. Only numbers are allowed. The values must be separated by a blank.


 7) === Lin/Log Parameter Axis ===

    - This droplist allows to choose between Linear ('LinParAx') or Logarithmic
      ('LogPA R+', 'LogPA R-') Parameter Axis.
    - LogPA R+ denotes the logarithmic parameter axis in the positive real
      number space, LogPA R- is the logarithmic parameter axis for displaying
      negative real values.
    - Always available if the plot setting window is sensitive. The only
      exception is with FoMod- or OSMod-Tasks, for which the parameter to be
      visualized was set to ALoss or to Power, respectively. In this case, the
      droplist will be fixed to 'LinPar Ax' and set insensitive.
```

7.7.5.1 Customize Plot Data Input

```
This input window allows to set various specifications for customizing the plot
data.


INPUT PARAMETER(S)

 1) === Use smoothed Data ===

    This input group allows to smooth the data for customizing the plot data.
    The level of smoothing can be adjusted by varying the sliding filter width.

    "Use smoothed Data"
        - This check box controls the usage (non-usage) of smoothed data.
          Activating the check box activates the sliding filter width input
          field, too.
    "Sliding Filter Width"
        - This input field allows to change the sliding filter width [points].
        - Only odd numbers from 3 to 833 are allowed.
        - Only available, smoothed data are used.
    "Save smoothed Data"
        - Activating this check box allows to save the smoothed data in a file.
          The text field on the right of the check-box is showing the predefined
          filename (cannot be changed).
```

2) === Statistics Data ===

This input group allows to customize statistics data for plotting. It is possible to calculate the average, the standard deviation of the average and/or the standard deviation (absolute- and relative standard deviation). Statistics data can only be calculated, if a statistics data file was selected from the data files list.

"Statistics Data"
- The three check boxes allow to choose several statistic parameters for computation. The average, the standard deviation of the average, and/or the standard deviation can be selected.

"Absolute/Relative Standard Deviation"
- This droplist allows to select between absolute- and relative standard deviation.

3) === Overplot Mean(s) ===

This input group allows to overplot mean(s) for customizing the plot data. The parameter range can be adjusted by varying the lower and upper boundaries of the parameter range interval.

"Overplot Mean(s)"
- This check box controls the usage (or non-usage) of overplot mean(s). Activating the check box enables the input field '<Parameter> Range for Mean'.

"<Parameter> Range for Mean"
- This input field allows to change the lower and upper boundaries of the parameter range interval by keyboard input.
- Input Format: (lo hi)
  'lo' and 'hi' are the lower and upper boundary of the parameter range interval, respectively. Only numbers are allowed. The values must be separated by a blank.
- Only available, if the Overplot Mean(s) check box is activated.

4) === Overplot Functional Fit(s) ===

This input group allows to overplot functional fit(s) for customizing the plot data. The parameter range for fits, the fit mode, and the order of the fit can be adjusted.

"Overplot Functional Fit(s)"
- This check box controls the usage (or non-usage) of overplot functional mean(s). Activating the check box enables the related input options (<parameter> range for fit and fit method).

"<Parameter> Range for Fit"
- This input field allows to change the lower and upper boundaries of the parameter range interval by keyboard input.
- Input Format: (lo hi)
  'lo' and 'hi' are the lower and upper boundary of the parameter range interval, respectively. Only numbers are allowed. The values must be separated by a blank.
- Only available, if 'Overplot Functional Fit(s)' is activated.

"Fit Method"
- This droplist allows the selection between polynomial fit and exponential fit.
- Only available, if 'Overplot Functional Fit(s)' is activated.

"Order of Polynomial"
- This input field allows to change the given order of the polynomial.
- The order can range from 1st (1) to 5th (5). Only integers are allowed.
- Only available, if the fit method droplist was set to polynomial fit.

5) === Display Parameters ===

This input group allows to choose different sets of parameters for customizing plot data.
For phase as parameter to be visualized (valid for FoMod/- or

OSMod/Task-ids), F1-, F2-, etc. LC-, and/or LI phase can be selected.
For ALoss as parameter to be visualized (valid only for FoMod/Task-ids), it is possible to use F1-, F2-, etc. ALoss, whereas for power (available only for OSMod/Task-ids) it is possible to use F1-, F2-, etc. power (as absolute or relative power).
For doppler shift as parameter to be visualized (possible only for InRet/Task-ids) it is possible to choose among F1-, F2-, etc. LC-, and/or LI Dopp. One of the parameters must always be set.
For bending, refractivity, density, pressure, temperature, water vapor, specific humidity, total electron content, doppler shift, and electron density (these parameters can only be selected for InRet/Task-ids), the display parameters input group will be insensitive because nothing can be adjusted in this case.

"Display Parameters"
- This/These check-box(es) allow(s) to activate/deactivate the different possible display parameters.
- For bending, refractivity, density, pressure, temperature, water vapor, specific humidity, total electron content, doppler shift, and electron density (these parameters can only be selected for InRet/Task-ids) the display parameters input group will be insensitive.

"Absolute/Relative Power"
- This droplist allows to select between absolute- and relative power.
- Only available if power as parameter to be visualized was selected in the corresponding OSMod/Task-id.

SPECIAL NOTES/HINTS
The appearance of the display parameter field will automatically adjusted to include all necessary buttons and drop-lists for the chosen parameter to be visualized.

6) === OK and Cancel ===

'OK' saves the actual state of the customize plot data window and closes it, whereas 'Cancel' closes the window without any action done.

7.7.6 Plot Window

This input group allows to specify various plot settings. It is possible to specify the number of plots to be shown in the plot window (the plot window can be split in one two or four plot areas), to overplot another plot over the first one, to erase the last plot or to erase the full plot window, to print the content of the plot window to a PS-file, to change Line Style and Line Thickness, to adjust plot colors and to annotate the plot.

SPECIAL NOTES/HINTS

- The plot window droplist and buttons are only sensitive, if a file from the display data files list was already selected for plotting.

INPUT PARAMETER(S)

1) === Plot Panels ===

- This droplist allows to choose among three different plot window settings: One, two, or four display panels per plot.

2) === Plot and Overplot ===

- These two buttons allow to plot the chosen data file or to overplot a selected data file over an existing plot, respectively.
- 'Plot' is available, if a file from the display data files list was already selected for plotting. 'Overplot' is only sensitive, if a plot already exists on the plot window.
- The maximum number of plots which can be shown is restricted to 20 (for a

one panel plot that means a maximum of 19 over-plots are possible, for a two panel plot, 18 over-plots arbitrarily split between the two main plots are possible).

3) === Erase Last and Erase All ===

- These buttons allow to erase the last plot of a multi-panel plot window or to completely erase the whole plot window content, respectively.

4) === To PS file ===

- This button opens a pop-up window for printing the content of the plot window to a PS-file. The name of the PS file, the size of the plot (DIN-A4 or letter format) and the kind of PS plot file (standard or encapsulated PS) can be specified.
- Only available, if a file from the display data files list was already plotted.

5) === Line Style ===

- This droplist allows to choose among six different line style settings for data plots.

6) === Line Thickness ===

- This droplist allows to choose one of five different line thickness settings.

7) === Colors ===

- This button opens a pop-up window which allows to change the plot colors and to tune their characteristics.

8) === Annotate... ===

- This button opens a pop-up window which allows to annotate a plot with explanatory text and notices.
  (For learning more about plot annotation, please read the help entry of the Annotate... pop-up window).

9) === Annotation On/Off ===

- This droplist allows to turn the annotation text in the graphics window on or off.
- Only available, if an annotation was already added.

7.7.6.1 Annotate Graphics Window Input

This input group allows to create additional text annotations in the graphics window. A new text string can be written into the text input field or chosen from the selected droplist. Size, direction and alignment of the text can be manipulated. The text character set and colors are changeable, too. These entries can be further adjusted by a special set of function buttons.

SPECIAL NOTES/HINTS

- To save the annotation settings, close the annotation input window with the Quit button or leave it without saving the new settings by pressing the Cancel button.

INPUT PARAMETER(S)

1) === Select Text ===

- This droplist allows to choose an already added text entry as annotation text template. In the default state, no text entry is available and the droplist is set insensitive.
- Always available if at least one text string was added before.

2) === Text Position ===

- These input fields allow to change the default x- (left one) and y- (right one) Text Position.
- All real numbers between 0 and 1 (two digits after comma) are allowed.
- The x- and y-coordinates are normalized coordinates (from 0 to 1). Zero in x means the left side (1 the right side), whereas 0 in y means the bottom and 1 denotes the upper boundary of the plot window.

3) === Text ===

- This input field allows to enter an annotation text string.
- The appearance of this text string can then be further manipulated by changing the text size, direction, alignment, character set and the text color.

4) === Text Size and Text Direction ===

- These Sliders allow to change the default text size and direction.
- The text size can vary from 0.5 to 5.0 (minimum adjustable step size is 0.5). The text direction can vary from 0 to 360 degrees (minimum adjustable step size is 10). The direction of the text rotation is in positive mathematical sense (0 is the normal horizontal text position, whereas 90 degrees denotes the vertical text position and so on).
- The default text size is 1.5 and the default text direction is 0.

5) === Text Alignment ===

- These exclusive buttons allow to select among three different text alignment positions.

6) === Character Set ===

- This droplist allows to choose among several character sets for the annotation text string.

7) === Select Color ===

- This draw widget allows to select the annotation text color.

8) === Text Entry Modifications ===

- These six buttons allow to modify the present status of the annotation text entries, to show the whole entry content, to change entries, to delete individual entries, to delete all of them at once, or to erase the annotation text string in the graphics window.
- The Add Entry button is always available whereas the rest of the entry buttons (Change Entry, Delete Entry, Delete All, and View All) are only sensitive, if at least one entry exists. The Erase button is sensitive, if an annotation text is already displayed in the graphics window.

9) === Quit or Cancel ===

- 'Quit' saves the actual state of the annotation window and closes it, whereas 'Cancel' closes the annotation window without any action done.

7.8 Visualize Volume Data

The "Visualize Volume Data" window interface is called via the "Volume Data..." entry of the "Visualize/Validate" menu. Its operation is independent of whether a project is currently opened or not.

The interface allows to compute, visualize, and print-out "volume data". Such "volume data" within EGOPS are arbitrary 3D subdomain cubes, cut out of the generic 5D space-time domain (height-latitude-longitude-UT-month) of EGOPS' atmospheric model parameters or the generic 6D space-time domain (height-latitude-longitude-UT-month-solar activity) of EGOPS' ionospheric model parameters, respectively. Cube dimensions up to 101x101x101 data points are allowed, and the volume data may be extracted from any of the atmospheric/ ionospheric models available within EGOPS.

The atmospheric parameters available include temperature, pressure, density, refractivity, water vapor (pressure), and specific humidity. The ionospheric parameters include electron density and ionospheric refractivity (at the GPS/L1 frequency).

The preparation of the volume data sets is performed within a processing pop-up window of the interface, which is accessed via the "Compute 3D Atm/Ion Model Data..." button.

The computed volume data are saved in "display files" (under the /referdata/volumdata subdirectory of EGOPS) which are named with the acronym of the atmosphere/ionosphere model from which they originate plus the acronym of the parameter concerned. The filename extension indicates the data type ("Vol") and the version. For instance, "MSIS90_DMI-Temp.Vol01" contains data from the 1st computation of a specific model and parameter ("01") and a 3D subdomain cube of temperature from the dry 3D atmosphere model MSIS90_DMI.

All "display files" computed so far are basically available to be visualized. For visualizing a specific volume data set, the User needs to first select the parameter desired (either an atmospheric or ionospheric one) and then a "display file" desired (out of all available ones for the selected parameter, which typically may cover different models and versions). The visualization itself is performed in form of arbitrary 2D slices taken out of the selected 3D subdomain cube which are depicted as contoured images.

Having selected a "display file", immediate on-screen plotting is possible into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, the dimension which is held fixed and its fixed value (the 2D slice spanned by the other two orthogonal dimensions is singled out just at this value), the axes ranges of the 2D slice, and the contour levels to be shown. However, these plot settings can also be adjusted by the User before plotting.

The standardized graphics output window can be used in one-panel, two-panel (stacked vertically), or four-panel mode, and "plot", "overplot", and "erase" functions can be quite arbitrarily employed. In addition, a "colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately affect the current graphics allowing for efficient color optimization. EGOPS allows additionally to switch between the image/contours or the contour fill mode for plotting. Also several different contour line colors are available for an easier line recognition.

A very useful new feature is the profiles pop-window for showing horizontal- or vertical volume data profiles. To create the volume data profiles the mouse cursor has to be moved over the whole volume data plot. Then the data profile will be simultaneously displayed in an extra graphic pop-window beside the standard volume data graphics window. It can be switched (via mouse click) between an horizontal- or an vertical data profiles mode and, at any time during visualization, the volume data profile can be saved to disk.

A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file. A color PostScript file is generated (always in the /referdata/volumdata subdirectory of EGOPS) so that either a color printer may be employed to get the full colored

graphics on paper or a standard b/w printer to get the grayscale/black/white analog of the on-screen plot on paper.

[Detailed help on each function of the "Visualize Volume Data" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Pop-up the interface, prepare some volume data sets, and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no problem for you.

7.9 Visualize Volume Data Input

7.9.1 Prepare Atmosphere/Ionosphere Volume Data

The 'Compute 3D Atmosphere/Ionosphere Model Data...' button opens a pop-up window which allows to select between several different atmosphere/ionosphere models and parameters, to prepare the atm/ion model data input and to compute the resulting atm/ion maps data files.

7.9.1.1 3D Atmosphere/Ionosphere Model Data Computation Input

This input window allows to choose atmosphere (ionosphere) models, atmospheric (ionospheric) parameters as well as related input parameters for the computation of 3D atmosphere (ionosphere) data.

INPUT PARAMETER(S)

1) === Atmosphere/Ionosphere Model and Parameter Selection ===

   This input group allows to choose atmosphere (ionosphere) models and atmospheric (ionospheric) Parameters.

   "Atmosphere/Ionosphere Model"
   - This droplist allows to select among six different Atmosphere Models (Bi-Exponential-, HLat 2D-, 3D dry-, GCM 3D-, HiVRes-, and a User-supplied Atmosphere) and two Ionosphere Models (Double-Chapman- and a 3D Ionosphere).
   - Selecting the GCM 3D(HiVRes) Atmosphere opens an extra pop-up window for GRIB (Raob) data file path and name input.

   "Atmosphere/Ionosphere Parameter"
   - This droplist allows to select between temperature, pressure, mass density, refractivity, water vapor pressure, and specific humidity in case of Atmosphere Parameter and electron density and ionosphere refractivity in case of Ionosphere Parameter.
   - The Atm. (Ion.) Parameter droplist is only available, if an Atmosphere (Ionosphere) Model was selected from the Atm/Ion Model droplist.

2) === Atm/Ion Model Data Preparation Input ===

   This input group allows to manipulate Height, Lat- and Lon Grid, UT, Month and, for an Ionosphere Model, the Solar Activity/F107 index.

   "Fixed Dimension"
   - These three droplists allow to fix 3 from the 6 underlying dimensions.
   - The following settings are possible:
     Left droplist: height, latitude, longitude, and universal time.
     Middle droplist:latitude, longitude, universal time, and month.

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      Right droplist: longitude, universal time, month, and solar activity
                      index.
    - The actual parameter length of the middle (right) droplist depends
      on the setting of the left (middle) droplist.
    - The right droplist is not applicable (N/A) for an atmosphere model.
"Height (Grid)"
    - This input field allows to change the shown (default) height (grid).
    - Values from 0 to 20000 km may be supplied.
    - Only numbers with a maximum of one post comma digit and blanks to
      separate the different values (in case of height grid) are allowed.
"Lat/Lon (Grid)"
    - These input fields allow to change the shown (default) latitude/
      longitude (grid).
    - Values for latitude may range from -90 to 90 deg, for longitude from
      -180 to 180 deg.
    - Only numbers with a maximum of one post comma digit and blanks to
      separate the different values (in case of latitude/longitude grid) are
      allowed.
"UT (Grid)"
    - This input field allows to change the shown (default) universal time
      (grid).
    - The values may range from 0 to 24 hours (0 to 59 minutes).
    - In case of universal time grid, the time is given in hours (with a
      maximum of one post comma digit). The values must be separated by a
      blank.
    - The input format for universal time is hour and minute (hhmm). Only
      integers are allowed.
"Month (Grid)"
    - This input field allows to change the shown (default) month (grid).
    - The values may range from 1 (=Jan) to 12 (=Dec). Only integers are
      allowed.
"Solar Activity/F107 (Grid)"
    - This input field allows to change the shown (default) solar
      activity/F107 index (grid).
    - The values may range from 75 to 220.Only integers are allowed.
    - Only available, if an Ionosphere Model was chosen.


3) === Compute and Batch===

   This input group allows to compute 3D atmosphere/ionosphere model data using
   the input parameters defined above. Be careful in selecting the simulation
   input parameters in order not to waste computation time and disk space for
   results not really exploited. Note that some input combinations (very long
   simulation time ranges etc.) can result in very long computation times.

   "Compute"
       - This button causes EGOPS to start the numerical calculation by
         employing the corresponding software package (written in IDL). It
         performs 3D atmosphere/ionosphere model data computations based on
         the current input and produces the necessary result file for
         subsequent visualization.
         (To learn more about the file structure behind EGOPS, consult the
         "EGOPS explained..." Help entry of the main-level Help menu.)
       - If a needed file is missing or incorrect (e.g., due to inappropriate
         direct manipulation by the user) the program may abnormally terminate
         with a message of varying information content (see in the log file).
         After correction of the problem, you can proceed as usual.
         (To learn more about Error Handling related to EGOPS, consult the
         appropriate sections of the User Manual.)
       - After starting a computation, an 'Information Window' pops up with a
         short hint that EGOPS started atm/ion model data computing. When the
         calculation is finished, the 'Information Window' will be closed.
   "Batch..."
       - This button opens a pop-up window for saving and computing the
         currently open task offline in EGOPS batch mode. Meanwhile one can do
         further online work within EGOPS.
       - The batch job processing pop-up window allows to select the start time
         of the EGOPS Batch-Job and offers the possibility to show further
         batch job status information via an extra pop-up window.
   "Resulting Atm/Ion Maps Data File"
       - This text field shows the predefined resulting atmosphere/ionosphere
```

maps data filename.
- Text field non editable.

7.9.2 Display 2D Slice(s) through Volume Data

The 'Atm/Ion Parameter to be Visualized' droplist allows to choose between 6 atmosphere- and 2 ionosphere parameters for visualization. Parameters for atmosphere visualization are temperature, pressure, density, refractivity, water vapor and specific humidity. Parameters for ionosphere visualization are electron density and ionosphere refractivity.

7.9.3 Display Data Files

The list widget shows a list of atmosphere/ionosphere volume data files available for plotting or deleting. If no file is found, the list widget will be insensitive. To select a file for plotting or deleting, click on a listed filename with the mouse pointer. The 'Delete File' and 'Delete all Files' buttons can be used to remove the selected file or all listed files, respectively.

SPECIAL NOTES/HINTS

- Only one file at a time can be selected.

INPUT PARAMETER(S)

1) === File LIST ===

- The file list allows to select a file for plotting or for deleting.
- If no file is found, the list will be insensitive.

2) === Delete File ===

- This button allows to delete a selected file (from the file list).
- If no file is selected, the button will be insensitive.

3) === Delete all Files ===

- This button allows to delete all files (from the file list).
- If no file is selected, the button will be insensitive.

7.9.4 Plot Settings

This input group allows to specify various plot settings. It is possible to modify the plot title, the legend text, to choose a dimension for 2D slices, to zoom in and out of the plot window, to select parameter axis ranges and to set the slicer value (position) and to change the parameter contour range/ separation. The type of axis ranges cannot be changed, these are fixed after selecting one of the three axes for slicing (if another configuration is needed, it must be prepared separately by using the compute 3D atm/ion model data function).

SPECIAL NOTES/HINTS

- The plot settings input window is only sensitive, if a file from the display data files list was already selected.

INPUT PARAMETER(S)

1) === Title ===

- This text input field shows a default plot title and allows to change it.
- All alphanumeric strings with a maximum length of 60 characters are allowed.

2) === Legend ===

- This button opens a pop-up window which allows to change the default legend text.

3) === Fixed Dimension ===

- This droplist allows to select the fixed dimension for 2D slices. Possible grid parameters are: Height, Latitude, Longitude, Universal Time, Month, Solar Activity (any combination of 3 of these parameters are possible for Ionosphere models; for Atmosphere models, solar activity is not used).

4) === Zoom in... ===

- This button allows to select a specific plot region for zooming.
- The 'Zoom in...' button activates the graphic cursor in the plot window. Draw a rectangle with the graphic cursor by constantly pressing the left mouse button while moving the mouse to create the zoom frame. Zoom the chosen area by clicking the 'Plot' button.
- Always available if the plot setting window is sensitive and a plot was already displayed in the plot window previously.

5) === Restore... ===

- This button allows to restore the original plot size
- Press 'Restore' and then 'Plot' to restore the zoomed plot image to its original size.
- Only available if 'Zoom in...' was pressed before.

6) === Axis Range. ===

- These two input fields allow to modify the preselected values of the parameter axis ranges (lower and upper boundaries for abscissa as well as ordinate).
- Input Format: (lo hi)
  'lo' and 'hi' are the lower and upper boundaries for the parameter axis ranges. Only numbers are allowed. The values must be separated by a blank.
- The value can only be adjusted in discrete steps (step size is given in parentheses).

7) === Slice Value ===

- This input field allows to vary the position of the slicer.
- The slicer value can only be adjusted in discrete steps (step size is given in parentheses). Only numbers are allowed.

8) === <Parameter> Contour Range/Separation ===

- Allows to modify range and separation of the contours in the plot.
- Input Format: (lo hi sep)
  'lo' and 'hi' are the lower and upper boundaries of the contour range interval, respectively. 'sep' is the contour separation. Supply numerical values only. The values must be separated by a blank.
- Range of Values:
  Default values are representing the minimum and maximum contour range value interval. A maximum of 30 steps are allowed.

7.9.5 Plot Window

This input group allows to specify various plot settings. It is possible to specify the number of plots to be shown in the plot window (the plot window can be split into one, two or four plot areas), to overplot another plot over the first one, to erase the last plot or to erase the full plot window, to print the content of the plot window to a PS-file, to change the Image/Contours and Contours color and to adjust plot colors. The 'Profiles...' button opens a special pop-up window which allows to visualize data profiles by moving the mouse cursor over the volume data plot.

SPECIAL NOTES/HINTS

- The plot window droplist and buttons are only sensitive, if a file from the display data files list was already selected.

INPUT PARAMETER(S)

1) === Plot Panels ===

   - This droplist allows to choose among three different plot window settings: One, two, or four display panels per plot.

2) === Plot and Overplot ===

   - These two buttons allow to plot the chosen data file or to overplot a selected data file over an existing plot, respectively.
   - 'Plot' is available, if a file from the display data files list was already selected for plotting. 'Overplot' is only sensitive, if a plot is already displayed in the plot window.
   - The maximum number of plots which can be shown is restricted to 20 (for a one panel plot that means a maximum of 19 over-plots are possible, for a two panel plot, 18 over-plots arbitrarily split between the two main plots are possible).

3) === Erase Last and Erase All ===

   - These buttons allow to erase the last plot of a multi-panel plot window or to completely erase the whole plot window content, respectively.
   - Only available, if a file from the display data files list was already plotted.

4) === To PS file... ===

   - This button opens a pop-up window for printing the content of the plot window to a PS-file. The name of the PS file, the size of the plot (DIN-A4 or letter format) framed or unframed plot, and the kind of PS plot file (standard or encapsulated PS) can be specified.
   - Only available, if a file from the display data files list was already plotted.

5) === Image/Contours ===

   - This droplist allows to choose between two different plot color modes (the Image/Contours or the Contour Fill mode).

6) === Contour Lines Color ===

   - This droplist allows to choose among six different contour line color settings: 'Def. Contours', 'White Contours', 'Black Contours', 'Red Contours', 'Green Contours', 'Blue Contours'.

7) === Colors... ===

- This button opens a pop-up window which allows to change the plot colors and to tune their characteristics (to learn more about color manipulation, please read the help entry for the colors pop-up window).

8) === Profiles... ===

- This button opens a pop-up window which shows horizontal- or vertical volume data profiles.
- To show the volume data profiles, move the mouse cursor over the volume data plot. Press the right mouse button to switch between horizontal- and vertical data profiles mode. Press the middle mouse button (or press the left and right mouse button simultaneously) to save the profile. Volume data profiles will be saved in the ../../referdata/volumdata directory. To quit the profiles view, window press the left mouse button.
- Only sensitive, if a file from the display data files list was already plotted. In case of a two or four panel plot window 'Profiles...' is always insensitive.

7.10 Visualize Data Animation

The "Visualize Data Animation" window interface is called via the "Data Animation..." entry of the "Visualize/Validate" menu. Its operation is independent of whether a project is currently opened or not.

The interface allows to compute and visualize (by animation) "volume data". "Volume data" within EGOPS are arbitrary 3D subdomain cubes, cut out of the generic 5D space-time domain (height-latitude-longitude-UT-month) of EGOPS' atmospheric model parameters or the generic 6D space-time domain (height-latitude-longitude-UT-month-solar activity) of EGOPS' ionospheric model parameters, respectively. Cube dimensions of up to 101x101x101 data points are allowed, and the volume data may be extracted from any of the atmospheric/ ionospheric models available within EGOPS.

The atmospheric parameters available include temperature, pressure, density, refractivity, water vapor (pressure), and specific humidity. The ionospheric parameters include electron density and ionospheric refractivity (at the GPS/L1 frequency).

The preparation of the volume data sets is performed within a processing pop-up window of the interface, which is accessed via the "Compute 3D Atm/Ion Model Data..." button. (This pop-up window is in fact the identical one as that accessed within the "Visualize Volume Data" interface.)

The computed volume data are saved in "display files" (under the /referdata/volumdata subdirectory of EGOPS) which are named with the acronym of the atmosphere/ionosphere model from which they originate plus the acronym of the parameter concerned. The file name extension indicates the type ("Vol") and the version. For instance, "MSIS90_DMI-Temp.Vol01" contains data from the 1st computation of a specific model and parameter ("01") a 3D subdomain cube of temperature values from the dry 3D atmosphere model MSIS90_DMI.

All "display files" computed are basically available to be visualized. For visualizing a specific volume data set, the User needs to first select the desired parameter (either an atmospheric or ionospheric one) and then a "display file" (out of all available ones for the selected parameter, which typically may cover different models and versions).

So far, the computation and selection of specific volume data is in fact identical to that within the "Visualize Volume Data interface. However, instead of enabling static display and print-out of 2D slices through the 3D subdomain cubes, this interface allows to animate arbitrary 2D slices through the 3D cubes along the 3rd dimension. In other words, selecting one dimension as the "time axis" of the "movie" (along which the animation will proceed), one can visually explore the 3D cube in terms of motion pictures, the pictures given by the 2D slices orthogonal to the "time axis". The 2D slices are depicted as 2D images with or without contours. Thus, this interface is an ideal tool for very effectively learning about the space/time behavior of EGOPS' atmosphere/

ionosphere models.

After having selected a "display file", an immediate start of the animation is possible, kicking off the "loading" of 2D slices into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, the dimension along which the animation shall proceed (the 2D slices spanned by the other two orthogonal dimensions will then constitute the motion pictures), the range of values along the animation dimension, the axes ranges of the 2D slices, and the contour levels to be shown (default is no contour levels). However, these plot settings can also be adjusted by the User before starting the animation.

The graphics output window, after having started the animation and loaded the relevant 2D slices, shows the animation while it can be customized by a series of convenient functions. These include backward, forward, bounce, and pause modes, movie speed regulation, real-time slice number information, and arbitrary browsing through the slice series by step-by-step inspection. In addition, a "Colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately effect the current graphics, allowing for efficient color optimization. "Stop" and "Erase" functions complete the primary features, allowing for stopping and clearing up a current animation.

EGOPS allows additionally to switch between the image/contours or the contour fill mode for data animation. The color/volume or color/slice are two different animation color range modes. In the color/volume mode, the colors for each slide are physically compatible (the same data value in each slide has the same color), whereas in the color/slice mode, the full color range is used for each individual slice, which means that the colors for different slices can have different meanings. Also several different contour line colors are available for an easier line recognition.

The "MPEG Output" function conveniently allows to save the currently loaded data animation sequence as an MPEG video file. In this form the data video file can be easy transferred to another users (which don't need EGOPS to run the animation, only a common MPEG player is necessary for replaying the animated data sequence).

[Detailed help on each function of the "Visualize Data Animation" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Pop-up the interface, prepare some volume data sets, and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no problem for you.

7.11 Visualize Data Animation Input

7.11.1 Prepare Atmosphere/Ionosphere Volume Data

The 'Compute 3D Atmosphere/Ionosphere Model Data' button opens a pop-up window that allows to select amongst several atmosphere/ionosphere models and parameters, to prepare the atm/ion model data input and finally to compute the resulting atm/ion maps data files.

7.11.1.1 3D Atmosphere/Ionosphere Model Data Computation

This input window allows to choose atmosphere (ionosphere) models, atmospheric (ionospheric) parameters as well as related input parameters for the computation of 3D atmosphere (ionosphere) data.

INPUT PARAMETER(S)

1) === Atmosphere/Ionosphere Model and Parameter Selection ===

This input group allows to choose atmosphere (ionosphere) models and atmospheric (ionospheric) Parameters.

"Atmosphere/Ionosphere Model"
- This droplist allows to select among six different Atmosphere Models (Bi-Exponential-, HLat 2D-, 3D dry-, GCM 3D-, HiVRes-, and a User-supplied Atmosphere) and two Ionosphere Models (Double-Chapman- and a 3D Ionosphere).
- Selecting the GCM 3D(HiVRes) Atmosphere opens an extra pop-up window for GRIB (Raob) data file path and name input.

"Atmosphere/Ionosphere Parameter"
- This droplist allows to select between temperature, pressure, mass density, refractivity, water vapor pressure, and specific humidity in case of Atmosphere Parameter and electron density and ionosphere refractivity in case of Ionosphere Parameter.
- The Atm. (Ion.) Parameter droplist is only available, if an Atmosphere (Ionosphere) Model was selected from the Atm/Ion Model droplist.

2) === Atm/Ion Model Data Preparation Input ===

This input group allows to manipulate Height, Lat- and Lon Grid, UT, Month and, for an Ionosphere Model, the Solar Activity/F107 index.

"Fixed Dimension"
- These three droplists allow to fix 3 from the 6 underlying dimensions.
- The following settings are possible:
  Left droplist: height, latitude, longitude, and universal time.
  Middle droplist:latitude, longitude, universal time, and month.
  Right droplist: longitude, universal time, month, and solar activity index.
- The actual parameter length of the middle (right) droplist depends on the setting of the left (middle) droplist.
- The right droplist is not applicable (N/A) for an atmosphere model.

"Height (Grid)"
- This input field allows to change the shown (default) height (grid).
- Values from 0 to 20000 km may be supplied.
- Only numbers with a maximum of one post comma digit and blanks to separate the different values (in case of height grid) are allowed.

"Lat/Lon (Grid)"
- These input fields allow to change the shown (default) latitude/ longitude (grid).
- Values for latitude may range from -90 to 90 deg, for longitude from -180 to 180 deg.
- Only numbers with a maximum of one post comma digit and blanks to separate the different values (in case of latitude/longitude grid) are allowed.

"UT (Grid)"
- This input field allows to change the shown (default) universal time (grid).
- The values may range from 0 to 24 hours (0 to 59 minutes).
- In case of universal time grid, the time is given in hours (with a maximum of one post comma digit). The values must be separated by a blank.
- The input format for universal time is hour and minute (hhmm). Only integers are allowed.

"Month (Grid)"
- This input field allows to change the shown (default) month (grid).
- The values may range from 1 (=Jan) to 12 (=Dec). Only integers are allowed.

"Solar Activity/F107 (Grid)"
- This input field allows to change the shown (default) solar activity/F107 index (grid).
- The values may range from 75 to 220.Only integers are allowed.
- Only available, if an Ionosphere Model was chosen.

```
 3) === Compute and Batch===

    This input group allows to compute 3D atmosphere/ionosphere model data using
    the input parameters defined above. Be careful in selecting the simulation
    input parameters in order not to waste computation time and disk space for
    results not really exploited. Note that some input combinations (very long
    simulation time ranges etc.) can result in very long computation times.

    "Compute"
        - This button causes EGOPS to start the numerical calculation by
          employing the corresponding software package (written in IDL). It
          performs 3D atmosphere/ionosphere model data computations based on
          the current input and produces the necessary result file for
          subsequent visualization.
          (To learn more about the file structure behind EGOPS, consult the
          "EGOPS explained..." Help entry of the main-level Help menu.)
        - If a needed file is missing or incorrect (e.g., due to inappropriate
          direct manipulation by the user) the program may abnormally terminate
          with a message of varying information content (see in the log file).
          After correction of the problem, you can proceed as usual.
          (To learn more about Error Handling related to EGOPS, consult the
          appropriate sections of the User Manual.)
        - After starting a computation, an 'Information Window' pops up with a
          short hint that EGOPS started atm/ion model data computing. When the
          calculation is finished, the 'Information Window' will be closed.
    "Batch..."
        - This button opens a pop-up window for saving and computing the
          currently open task offline in EGOPS batch mode. Meanwhile one can do
          further online work within EGOPS.
        - The batch job processing pop-up window allows to select the start time
          of the EGOPS Batch-Job and offers the possibility to show further
          batch job status information via an extra pop-up window.
    "Resulting Atm/Ion Maps Data File"
        - This text field shows the predefined resulting atmosphere/ionosphere
          maps data filename.
        - Text field non editable.
```

7.11.2 Animate 2D Slice(s) through Volume Data

The 'Atmosphere/Ionosphere Parameter to be Visualized' droplist allows to choose amongst 6 different atmosphere- and 2 ionosphere parameters for visualization. Parameters for atmosphere visualization are temperature, pressure, density, refractivity, water vapor, and specific humidity. Parameters for ionosphere visualization are electron density and ionosphere refractivity.

7.11.3 Display Data Files

The list widget shows a list of all atmosphere/ionosphere volume data files available for animation. If no file is found, the list widget will be insensitive. To select a file for animation, click on a listed filename with the mouse pointer. The 'Delete File' and 'Delete all Files' buttons can be used to remove the selected file or all listed files, respectively.

```
SPECIAL NOTES/HINTS

 - Only one file at the same time can be selected.


INPUT PARAMETER(S)

 1) === File LIST ===

    - The file list allows to select a file for animation or for deleting.
    - If no file is found, the list will be insensitive.
```

2) === Delete File ===

- This button allows to delete a selected file (from the file list).
- If no file is selected, the button will be insensitive.

3) === Delete all Files ===

- This button allows to delete all files (from the file list).
- If no file is selected, the button will be insensitive.

7.11.4 Animation Settings

This input group allows to choose among various animation settings. The following settings can be modified: the plot title, the legend text, the dimension to be animated, the behavior of the color range, the parameter axis ranges, the animation range and animation step size, and the visualized parameter contour range/separation. The type of the axis ranges cannot be changed because they are fixed after the selection of one of the three axis as the animation dimension (if another configuration is needed, it must be prepared separately by using the compute 3D atm/ion model data function).

SPECIAL NOTES/HINTS

- The animation settings input window is only sensitive after a file was selected from the display data files list.

INPUT PARAMETER(S)

1) === Title ===

- This text input field shows a default plot title and allows to change it.
- All alphanumeric strings with a maximum length of 60 characters are allowed.

2) === Legend ===

- This button opens a pop-up window which allows to change the default legend text.

3) === Dimension to be Animated ===

- This droplist allows to choose the dimension to be animated amongst the 3 selected (selected in the atm/ion model data preparation input window) grid parameters. Possible grid parameters are: Height, Latitude, Longitude, Universal Time, Month, Solar Activity (every combination of 3 of these parameters is possible for Ionosphere models; for Atmosphere models, solar activity can not be used).

4) === Axis Ranges and Animation Dim. Range/Step ===

- These three input fields allow to modify the preselected values of the parameter axis ranges (lower and upper boundaries) and the animation dimension range and step.
- For the parameter axis the step size is fixed (see information label right of the input field).
- The lower (upper) boundary can only be adjusted in discrete steps.
- Only numbers are allowed. The individual values must be separated by a blank.

5) === <Parameter> Contour Range/Separation ===

- This input field allows to modify range and separation of the contours in the plot. Only sensitive, if the check-box on the left of the input field

```
      is active.
    - Input Format: (lo hi sep)
      'lo' and 'hi' are the lower and upper boundaries of the contour range
      interval, respectively. 'sep' is the contour separation. Supply numerical
      values only. The values must be separated by a blank.
    - Range of Values:
      Default values are representing the minimum and maximum contour range
      value interval.
```

7.11.5 Animation Window

```
This input group allows to select several data animation functions.
The start button begins loading of the slices whereas the stop button can be
used to interrupt the loading process anytime and for ending an animation
session. A group of 4 bitmap buttons are for reverse play, pause, forward and
cycle play. A slider is available to set the animation speed. A frame selection
slider can be used to view single frames from the whole animation data set. The
colors button allows to manipulate and adjust the plot colors. The erase button
is used to clean the plot window manually. A droplist/button group allows to
change the Image/Contours and Colors/Slice, and the Contours Colors. The MPEG
Output... button opens a pop-up window for saving the loaded animation as an
MPEG-Video.


SPECIAL NOTES/HINTS

 - The animation window buttons and sliders are only sensitive, if a file from
   the display data files list was already selected.


INPUT PARAMETER(S)

 1) === Start and Stop ===

    - The 'Start' button is for loading of the slices. 'Stop' may be used for
      interruption the loading process anytime and for ending an animation
      session.
    - 'Start' is available, if a file from the display data files list was
      selected for animation. 'Stop' is only available, if Start was used
      before.


 2) === Reverse Play, Pause, Forward Play and Cycle ===

    - These 4 bitmap buttons are for reverse play, pause, forward play and
      cycle play. Use them to select an animation direction or to pause the
      animation and view specific frame images.
    - Only available if at least two slides have been loaded.


 3) === Animation Speed Control ===

    - This slider allows to control the speed of the animation.
    - Moving it to the far right selects the maximum animation speed (the number
      of slices/second are shown in the label above the slider). The maximum
      speed depends on the used computer hardware and on the individual slice
      size.
    - Only available, if at least two slides have been loaded.


 4) === Viewing Single Animation Frames  ===

    - This slider may be used to view single frames from the animation. To use
      the frame selection slider, the animation must be paused.
    - The slider is only sensitive, if the check box above is activated.
      The check box is only sensitive, if at least two slides have been loaded.


 5) === Colors... ===
```

- This button opens a pop-up window which allows to change the animation colors and to tune their characteristics (to learn more about color manipulation, please read the help entry for the colors pop-up window).
- Only available before loading or after stopping of the animation.

6) === Erase ===

- This button allows to completely erase the animation window.
- Only available if the stop button was pressed after an animation session.

7) ==== Image/Contours ===

- This droplist allows to choose between two different animation color modes (the Image/Contours or the Contour Fill mode).

8) === Color Range ===

- This droplist allows to choose between two different animation color range modes:
- In the 'Color/Volume' mode, the colors for each slide are physically compatible (the same data value in each slide has the same color)
- In the 'Color/ Slice' mode, the full color range is used for each individual slice (the colors for different slices can have different meanings, i.e. one slice has a data range from 0 to 1, another a range from 2 to 5 and in each case the full color range is used).
- Only available before loading or after stopping of the animation.

9) === Contour Lines Color ===

- This droplist allows to choose among six different contour line color settings: 'Def. Contours', 'White Contours', 'Red Contours', 'Green Contours', 'Blue Contours', 'Black Contours'.
- Only available, if the contour line check box in the Animation Settings field is activated.

10) === MPEG Output... ===

- This button opens a pop-up window for saving the currently loaded animation sequence into an MPEG-Video file. The MPEG Output file will be stored in the ../../referdata/volume directory (the default MPEG filename can be altered).
- Only available if MPEG output is enabled via the entry "IDL MPEG License = Yes" in the EGOPS initialization file (../EGOPS/EGOPS.ini, please see SUM-OV, Section 5.1.3).

7.11.5.1 MPEG Output

The MPEG Output Pop-up Widget is the graphical user interface for storing the actual animation window content as MPEG-Video file. The Pop-up Widget shows the MPEG Output file path and allows to manipulate the MPEG Output Filename for storing of the animation data sequence (all alphanumeric strings with a maximum of 30 characters are allowed). The resulting output MPEG-Video is written to directory ../../referdata/volumdata.

SPECIAL NOTES/HINTS

- MPEG outputs are only supported, if a special MPEG feature license is available on your computer (the MPEG output license is not included in the standard IDL-license package). For more information, please contact your Research Systems, Inc. sales representative or technical support.
- It is not possible to manually change the file path for the MPEG output file.

8 Help Menu

8.1 Help on Project

8.1.1 About Projects

EGOPS work and related data are organized in "projects", providing the user with a convenient means to group the computations of a series of simulation scenarios, which for some logical reason belong to each other, into a common folder. A "Project" within EGOPS is thus a group of simulation and visualization/validation activities whose data (input/output of simulation scenarios) is separated from that of other projects.

Each project is named by a user-specified project identification, called "Project-id", which is a 25 character name to be assigned when a new project is launched, employing the "Launch new..." function.

In fact, the separation of the projects is physically reflected in the EGOPS file structure on disk, where each project's data are gathered below a /<project-id> subdirectory, which is created as subdirectory of the root directory /EGOPS during project launch.

There is one project that is integral to EGOPS, named "EGOPSProject". It belongs to the basic installation package. This is the default project of EGOPS which contains the minimal default information necessary to operate the simulation and visualization/validation functionality. (Each time a new project is started, this minimal default information is carried over from the "EGOPSProject" to the new project's directories.)

For allowing to better comprehend the example given below of what an EGOPS project could comprise, we note that the individual computational scenarios themselves gathered in a project are called "tasks" within EGOPS. A task corresponds to computing a specific simulation scenario (sequence of operations) by employing one of the four generic Task options accessible via the "Task" menu of the User Interface. These generic Task options are Mission Analysis/Planning (MAnPl), Forward Modeling (FoMod), Observation System Modeling (OSMod), and Occultation Data Inversion/Retrieval (InRet).
[More information on tasks is found under "Help - Help on Task"]

SPECIAL NOTES/HINTS

- Though it is possible to create new tasks in the default project "EGOPSProject", all generated "EGOPSProject" tasks will be deleted if you restart EGOPS. This avoids to accumulate miscellaneous tasks there which do not really comprise a meaningful logical group.
  It is recommended to launch a new project project each time you start with a fresh series of tasks constituting a new "study".

EXAMPLE

A "project" could be:

"METOP-1/GRAS temperature retrieval accuracies for different inversion techniques", for which we might assign the Project-id "M1GRAS-TretrievStudy1".

Individual "tasks" which this "project" could comprise (as arbitrary examples):

1. "Prepare a good sample of METOP occultation events for the accuracy assessment" (meaning a few "tasks" employing the Task option MAnPl)

2. "Simulate occultation data for the sample of events using a reasonable representation of the atmosphere/ionosphere" (employing the Task option

FoMod)

3. "Account for the effects imposed on the signals by the observation system (GRAS receiver + antenna, etc.)" (employing the Task option OSMod)

4. "Use these simulated METOP reference data with some selected inversion/retrieval processing chain down to temperature profiles" (different chains used, each an individual "task", based on the tools available within Task option InRet)

The output data for the temperature from the different chains could then be statistically analyzed and inter-compared by employing the visualization/ validation functionality of EGOPS.

8.1.2 Launch New

EGOPS work and related data are organized in "projects", providing the user with a convenient means to group the computations of a series of simulation scenarios (which, for some logical reason, belong to each other) into a common folder. A "Project" within EGOPS is thus a group of simulation and visualization/ validation activities, whose data (input/output of simulation scenarios) is separated from that of other projects.

For creation of a new EGOPS Project, assign it a unique, not yet existing identifier. The length of this "Project-id" of the new EGOPS Project is limited to a maximum of 25 characters (minimum length is one char). The new EGOPS/Project-id should be an arbitrary alphanumeric string which may also contain hyphen or underline characters. Longer strings, interleaved blanks, or use of other characters are not allowed.

LAUNCH NEW EGOPS PROJECT INPUT PARAMETER(S)

EGOPS allows two different kinds of input for launch new EGOPS project.

- EGOPS/Project-id:
This text input field allows the assignment of a new EGOPS/Project-id by keyboard input. Each new project should be named by a user-specified project identification, called "Project-id", which is limited to a maximum 25 character name to be assigned when a new project is launched, employing the "Launch new..." function.

- Edit <project-id>.txt...:
Opens a text input field, to which the user can make his own notices about the new EGOPS-Project (the content of this log-file can always be modified every time this newly created EGOPS-Project will be closed or opened if necessary).

8.1.3 Open

Most of the EGOPS functionality can only be used by working within an open EGOPS-Project (part of the 5 main EGOPS visualization/validation tools are also allowing some limited use of EGOPS without being inside an open project). To use the full capabilities of EGOPS, one has to enter (open) an existing EGOPS-Project (or to create a new one with the EGOPS launch new tool). Therefore, the open EGOPS project window allows for selecting and opening of an already existing EGOPS/Project-id. Selection of a project-id can be made directly by typing the EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing EGOPS/Project-ids..." button).

OPEN EGOPS PROJECT INPUT PARAMETER(S)

EGOPS allows several different kinds of input for open EGOPS project.

- EGOPS/Project-id:
This text input field allows the assignment of an already existing EGOPS/ Project-id by keyboard input. It's not allowed to assign a new EGOPS Project-

id by direct keyboard input (use the "Project - Launch new..." function for this purpose.)

- Existing EGOPS/Project-ids...:
This button/select-list window allows to select an existing EGOPS/Project-id out of all existing ones shown in the list.

- Edit <project-id>.txt...:
Opens a text input field to which the user can make his own notices about the EGOPS-Project foreseen for opening (the content of this log-file can always be modified every time this EGOPS-Project will be closed or re-opened if necessary).

8.1.4 Close

With EGOPS, only one special EGOPS Project can be open at a time, therefore the user is forced to close the currently open EGOPS project, if he wants to work with another or exits EGOPS. For this purpose, an extra window for closing the currently open EGOPS project is available.
Only the currently open EGOPS Project can be closed. If the user wants to close the currently open EGOPS project and then plans to exit EGOPS completely, it is not necessary to close the open EGOPS project manually with Close EGOPS Project and Exit EGOPS afterwards, because activating EGOPS Exit will do both actions in line (without opening the Close EGOPS Project pop-up window). The only difference between Close-Exit and Exit is that in the latter case it is not possible to make any inputs to the corresponding EGOPS project.txt file.

CLOSE EGOPS PROJECT INPUT PARAMETER(S)

EGOPS offers only one text input for close EGOPS project.

- Edit <project-id>.txt...:
This opens a text input field to which the user can make his own notices about the currently EGOPS-Project prepared for closing (the content of this log-file can always be modified every time this EGOPS-Project will be reopened or closed again, if necessary).

8.1.5 Rename

Sometimes, while doing a lot of work within one EGOPS project, the user may come to the point, finding the name of this special project not reflecting the content or spirit of his work anymore. Therefore, EGOPS offers the possibility of renaming the EGOPS project identification without changing or losing anything of the contents of the different tasks already worked out under the former project name. For this purpose, an EGOPS pop-up window for renaming an already existing (old) EGOPS/Project-id to a (new) EGOPS/Project-id is provided.
Selecting the existing (old) EGOPS/Project-id can be done by directly typing the old EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing EGOPS/Project-ids..." button). The new EGOPS/Project-id need be put in by keyboard into the right input field. The standard format conventions for EGOPS/Project-id strings of course apply also to new EGOPS/Project-ids assigned here (cf. help on "Launch new..."). There is also the possibility foreseen that the user may want to modify the renamed EGOPS project.ltxt file afterward. The "old" Project-id is renamed to the new one everywhere in the project-related file structure (project directory name, Project-id entries in the existing task input files, etc.), with one exception: the name is not changed within the input file location info string in the headers of the "old" task's output data files.

RENAME EGOPS PROJECT INPUT PARAMETER(S)

EGOPS allows several different kinds of input for rename EGOPS project.

- Old EGOPS/Project-id:
This text input field allows the assignment of an already existing EGOPS/Project-id by keyboard input. It's not allowed to assign a new EGOPS Project-id

by direct keyboard input (use the "Project - Launch new..." function for this purpose). If an EGOPS Project is currently open, its (old) EGOPS/Project-id is shown by default in the left input field.

- New EGOPS/Project-id:
This text input field allows the assignment of a new EGOPS/Project-id name by keyboard input. Be careful to use a new EGOPS project-id name that is really a new one and does not interfere with an existing one. The EGOPS/Project-id string is limited to a maximum of 25 characters name.

- Existing User-defined EGOPS/Project-ids...:
This button/select-list window allows to select an existing EGOPS/Project-id out of all existing ones shown in the list for renaming.

- Edit <new-project-id>.txt...:
Opens a text input field to which the user can make his own notices about the EGOPS-Project foreseen for renaming (the content of this log-file can always be modified every time this EGOPS-Project will be opened or closed if necessary).

8.1.6 Delete

Old EGOPS projects or EGOPS projects with no useful content (i.e. test projects) should be removed from EGOPS completely from time to time to save disk space. This can be done by using the window for deleting an already existing EGOPS Project. Deleting can be done by directly typing the EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing EGOPS/Project-ids..." button). But be careful in using this function, since deletion of a project means that all information (input/output data of all simulations performed within the project) including the project's directory structure is cleared from the disk forever!

DELETE AN EGOPS PROJECT INPUT PARAMETER(S)

EGOPS allows only one input for delete an EGOPS project.

- The EGOPS/Project-id to be deleted:
This text input field allows the assignment of an already existing EGOPS/ Project-id by keyboard input for deleting. If an EGOPS Project is currently open, its EGOPS/Project-id is shown by default in the input field. Trying to choose a non-existing EGOPS Project by direct keyboard input is inappropriate (and leads to an error message). Also, the EGOPS-internal basic or reference project "EGOPSProject" is protected from deletion (attempts lead to an error message).

- Existing User-defined EGOPS/Project-ids...
This button/select-list window allows to select an existing EGOPS/Project-id out of all existing ones shown in the list for deleting.

8.1.7 Shelve

Most of the EGOPS functionality can only be used by working within an EGOPS-Project (part of the 5 main EGOPS visualization/validation tools are also allowing some limited use of EGOPS without being inside an open project). The file content (in term of used disk space) of a project can be very substantial especially if a lot of PS-files were produced or if the project contains a great number of "big" individual tasks. For finished projects or for projects which are not needed in the near term future for further processing, EGOPS offers an elegant way to compress and store those projects for later (re)use. Therefore, to save disk space, the shelve EGOPS project window provides facilities for selecting and archiving of an already existing EGOPS/Project-id. Selecting of a project-id can be done directly by typing the EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing EGOPS/Project-ids..." button).

SHELVE EGOPS PROJECT INPUT PARAMETER(S)

EGOPS allows several different kinds of input for shelve EGOPS project.

- EGOPS/Project-id:
This text input field allows the assignment of an already existing EGOPS/Project-id by keyboard input (for obvious reasons it's not allowed to assign a new EGOPS Project-id by direct keyboard input).

- Existing EGOPS/Project-ids...:
This button/select-list window allows to select an existing EGOPS/Project-id out of all existing ones shown in the list.

- Edit <project-id>.txt...:
Opens a text input field to which the user can make his own notices about the EGOPS-Project foreseen for archiving (the content of this log-file can always be modified later again (after restoring the shelved EGOPS-Project) every time this EGOPS-Project will be closed or reopened if necessary).

8.1.8 Restore

A shelved EGOPS project can very easily be restored for later reworking on it within EGOPS by using the window for restoring an already existing archived EGOPS Project. Restoring can be done by directly typing the shelved EGOPS/Project-id name into the foreseen input field or by means of the button/select-list window ("Existing User-defined EGOPS/Project-ids..." button).

RESTORE AN EGOPS PROJECT INPUT PARAMETER(S)

EGOPS allows only one input for restore an EGOPS project.

- The EGOPS/Project-id which shall be restored:
This text input field allows the assignment of an already existing shelved EGOPS/Project-id by keyboard input for restoring. If an EGOPS Project with the same name is already existing, a warning will pop-up (an information will be displayed about the possibilities to handle this situation). Trying to choose a non-existing EGOPS Project by direct keyboard input is inappropriate (and leads to an error message).

- Existing User-defined EGOPS/Project-ids...
This button/select-list window allows to select an existing EGOPS/Project-id out of all existing ones shown in the list for restoring.

8.1.9 BatchJobs Info

EGOPS Batch Processing Information window provides information on the EGOPS batch job status. For all EGOPS batch jobs, the Job-Id, the Project- and Task-Id, Start Time, Status, and the PID number are displayed. Besides the display of batch job information, a facility for manipulation of batch jobs is provided, e.g. it is possible to terminate a running task, to restart a task, or to remove finished tasks from the job list.

POSSIBLE EGOPS BATCH PROCESSING INFORMATION WINDOW CONTENT ACTION(S)

EGOPS allows several actions to be performed on the contents of the batch processing window, namely:

- View Job's Log
Allows to show the log output of finished batch jobs.

- Refresh:
Three different refresh modes for actualizing the EGOPS batch processing information list are available.

- Terminate Task:
Currently running EGOPS batch jobs can be terminated by first marking the job in the list with the left mouse button and then activating the terminate task button.

- Restart Task:
Job restart allows to reexecute a formerly failed EGOPS batch job (job status error). Before pressing the restart task button, the corresponding EGOPS job has to be marked with the left mouse button.

- Remove Task:
This allows to remove finished (status 'finished' or 'error') EGOPS batch jobs from the information list (the job(s) must be marked with the left mouse button, before the remove task button can be activated).

- Remove finished Tasks
This allows to remove all regularly finished (status 'finished') batch job entries from the Batch Processing Information list.

8.2 Help on Task

8.2.1 About Tasks

The individual computational scenarios in an EGOPS Project [cf. "Help on Project - About Projects"] are called "tasks". A task corresponds to computing a specific scenario (or, in other words, a defined sequence of operations) by employing one of the four generic Task options accessible via the "Task" menu of the User Interface.
These generic Task options are Mission Analysis/Planning (MAnPl), Forward Modeling (FoMod), Observation System Modeling (OSMod), and Occultation Data Inversion/Retrieval (InRet). Within the EGOPS directory structure there exists, for each Project, one subdirectory for each of these generic Task options (i.e., /MAnPl, /FoMod, /OSMod, /InRet subdirectories under each /<Project-id> directory).

Each task is named by a User-specified task identification, called "Task-id", which is a 25 character name to be assigned when a new task is prepared within the pop-up window of one of the generic Task options of the "Task" menu (e.g., within the "Mission Analysis/Planning Input" pop-up window).

The Task-id is the key identification means for EGOPS to separate all files relating to a specific task from those of other tasks with usually different inputs (which will have assigned a different Task-id). In fact all files relating to a specific task will contain the Task-id as leading part of the filename. The files will be saved under the subdirectory of the generic Task option under which the task was created (e.g., in the /MAnPl subdirectory in case of a MAnPl Task).

SPECIAL NOTES/HINTS

- Assign your task a "smart" Task-id which conveys some hint to you on what this task is about. Among other things, this is very helpful during the visualization/validation of your results, where your primary selector for loading result data for visual inspection and analysis will be the Task-id.

8.2.2 Mission Analysis/Planning

Mission Analysis/Planning (MAnPl) is considered to include the analysis and planning of single LEO satellites as well as LEO constellations carrying GNSS and LEO occultation receivers, including antennae field-of-view planning and analysis, and visibility analysis with respect to ground stations for assessing, investigating and optimizing occultation event coverage and related relevant statistics. Further included are reflection data calculation scenarios which enable to analyze the reflection geometry between Transmitter (Tx) satellite, water surface (normally the ocean or several huge lakes which act as a big mirror reflecting the Tx radio signals to the Rx) and Receiver (Rx) satellite.

Such analysis requires a considerable number of "free input parameters" in a

simulation tool in order to allow for (realistic) MAnPl simulations of widely arbitrary GNSS/LEO-LEO occultation missions. (See the section "MAnPl INPUT PARAMETERS" below for an overview on the respective functionality furnished by EGOPS. Details are found in the On-line Help within the "MAnPl Input" interface window available via the "Task" menu.)

Furthermore, it is necessary to have available convenient tools for visualization of the simulation results in order to carry out simulation studies efficiently and in order to effectively comprehend and interpret the results. (See the section "MAnPl VISUALIZATION" below for a crude overview on the respective functionality furnished by EGOPS. A refined overview is given under the "Help on Visualize/Val. - Help on Visualize MAnPl Statistics, Help on Visualize Geographic Maps" entries of the "Help" menu. Details are found in the On-line Help within the "Visualize Mission Analysis/Planning Statistics" and "Visualize Geographic Maps" interface windows available via the "Visualize/Validate" menu.)

MAnPl INPUT PARAMETERS

EGOPS allows to compute Mission Analysis/Planning tasks taking into account the set of "free input parameters" outlined below, which all together provide considerable flexibility and potential for Mission Analysis/Planning. All these parameters can be - within their range of validity - freely set by the User just as desired for a specific MAnPl task.

The "MAnPl Input" window, which is available via the "Mission Analysis/Planning" entry of the "Task" menu, is the convenient interface EGOPS provides for the supply of all of these parameters (including the supply of a few input file names, providing for access to some more lengthy parameter lists required, e.g., satellite orbit elements).

- Data type:
The selection between GNSS-LEO and LEO-LEO occultation- and reflection data is possible.

- Simulation time:
Start date and time, and the total time range for a simulation.

- Height levels of interest:
For each of such height levels (and for each occultation in the time range) the corresponding occultation geometry is computed, interpreting the height levels as those tangent point heights of an occultation event for which the geometric information is sought just at the instant when the levels are crossed. The essential geometric information is the corresponding geographic coordinates of the tangent point together with the corresponding positions of the Tx and Rx satellites involved in the occultation event. Height levels are only used for calculation of occultation data.

- Time step:
Choose an integer divide of the simulation time range for the reflection data time step. Time steps are only used for reflection data calculation.

- Geographic area of interest:
Global, hemispheric or any regional area for which the coverage by occultation events is sought.

- Earth Figure model:
Spherical (R = 6371 km) or Ellipsoidal (WGS-84) Earth.

- Tx-to-Rx/Reflection ray treatment:
Straight-line approximation of rays or rays with quasi-realistic bending caused by the neutral atmosphere.

- Active space segment (Tx satellites):
Number, orbit constellation (i.e., orbit elements) and signal properties of the GNSS and LEO transmitters. The different transmitter systems (GPS, GALILEO, GLONASS, LEO) can be selected in arbitrary combinations or alone. This information is supplied by the Tx-*.tle and Tx-*.spd files in the /orbitelem and /signalprop directory of EGOPS, respectively, which are selected within the "MAnPl Input" window.

- Tx orbit propagator:
Spherical orbit approximation, Keplerian orbit or "Simplified General Perturbation (SGP)" orbit (the latter including short and long period perturbations and parameterized radiation/star drag).

- Tx antenna specifications:
Antennae pointing and characteristics including boresight direction and field-of-view width and shape for "anti-velocity" looking and forward-looking antenna.

- Spaceborne receiver segment (Rx satellites):
Number and orbit constellation (i.e., orbit elements) of receiver platforms in LEO. This information is supplied by the Rx*.tle files in the /orbitelem directory, one of which is always selected within the "MAnPl Input" window. [Please see the Software User Manual - File Format Manual (SUM-FF) for a description of the *.tle file format.]

- Rx orbit propagator:
Spherical orbit approximation, Keplerian orbit or "Simplified General Perturbation (SGP)" orbit (the latter including short and long period perturbations and parameterized atmospheric drag).

- Rx antenna specifications:
Antennae pointing and characteristics including boresight direction and field-of-view width and shape for "anti-velocity" looking and forward-looking antenna. Furthermore information on the Rx's zenith-antenna field-of-view.

- Ground segment (Fiducial and Tracking sites):
The number, location and antenna field-of-view of auxiliary GNSS/LEO receiver sites for aiding the usual single- or double-difference processing of occultation data (fiducial sites), and the number, location and antenna field-of-view of ground stations for telemetry/telecommand (tracking sites). This information is supplied by fid*.gst and trk*.gst files, respectively, in the /groundst directory of EGOPS, which are selected within the "MAnPl input" window. [Please see the Software User Manual - File Format Manual (SUM-FF) for a description of the *.gst file format.]
Satellite visibility information is then computed for the fiducial and tracking stations, as necessary for assessing the visibility conditions for single- and/or double-differencing and tracking for a given scenario.

MAnPl VISUALIZATION

EGOPS provides for the visualization of results of Mission Analysis/Planning tasks by its "Visualize MAnPl Statistics" and "Visualize Geographic Maps" window interfaces, both available through the "Visualize/Validate" menu.

The "MAnpl Statistics" interface allows to compute, visualize and print-out 1D and 2D occultation coverage statistics as function of variables like latitude, local time, duration of occultation events, etc.
Furthermore, it allows to compute, visualize and print-out visibility statistics for fiducial and tracking sites, e.g., no. of occultation events for which successful single- or double-differencing is possible by each of a given sample of fiducial sites, or no. of orbits seen for a certain time range per orbit by each of a couple of tracking sites.
[See "Help on Visualize/Val. - Help on Visualize MAnPl Statistics" for more information.]

The "Geographic Maps" interface allows to compute, visualize and print-out latitude-longitude maps (different map projections available) of occultation event coverage for arbitrary geographic areas and including information such as on the geometrical shape and time of each event.
Furthermore, it allows to compute, visualize (stand-alone or as overplot to occultation event coverage maps) and print-out geographic maps of a series of atmospheric/ionospheric variables (e.g., temperature and electron density) from all atmospheric/ionospheric models available within EGOPS. These may either slice the atmospheric/ionospheric field at a certain height or be vertically integrated quantities (e.g., total precipitable water).
[See "Help on Visualize/Val. - Help on Visualize Geographic Maps" for more information.]

8.2.3 Forward Modeling

Forward Modeling (FoMod), together with subsequent Observation System Modeling (OSMod), performs quasi-realistic simulation of observables and related required variables of the GNSS and LEO radio occultation technique. The main observables are time-tagged phase and amplitude measurements, obtained in real world by tracking occulted Transmitter signals with a LEO platform-mounted receiver for atmospheric sounding during their set/rise through the atmosphere imposed by the relative orbital motion of the Transmitter (Tx) and Receiver (Rx) satellites.

Forward Modeling itself denotes the simulation of the propagation of transmitted signals through the atmosphere/ionosphere system given the orbital motions of the Tx and Rx satellites. It results in "ideal" signals which contain the effects of the atmosphere/ionosphere media only. - "Ideal" in the sense that it is the state of the signal right before it enters the receiving antenna and before any degradations by the receiving system are incurred. Thus FoMod results allow to inspect the environmental influence alone. In addition to spaceborne radio occultations (GNSS-LEO, LEO-LEO) EGOPS allows also to simulate airborne occultations (GNSS-Airplane, LEO-Airplane) where the signal receiver is placed onboard an aircraft instead of a LEO satellite. Satellite to groundstation events can be computed, too.

Furthermore, it is quite useful in terms of computational performance to separate FoMod, involving CPU-expensive propagation simulation (i.e., ray tracing) from OSMod, since the latter can be treated very efficiently as superposition of "observation system" effects on the "ideal" signal. Thus studies of different receiving system effects can be efficiently carried out using one and the same CPU-expensive FoMod result as baseline. [See "Help on Task - Help on Observation System Modeling" for more information on OSMod.]

In case of interest in observation simulations, Forward Modeling is the natural stage in EGOPS following some planning and preparation of occultation events with desired properties within "Mission Analysis/Planning (MAnPl)" (e.g., events occurring in a geographic region of interest, etc.). In fact the geometric properties (i.e., Rx and Tx orbital arcs) of an occultation event being "forward modeled" can be, in case simulations are desired for realistic geometry, directly taken from the results of a User- selected MAnPl task (typically prepared before). For a realistic airborne occultation the mission analysis and planning part will be additionally done together with the rest of the pure forward modelling tasks in FoMod.

Such forward modelling requires a considerable number of "free input parameters" in a simulation tool in order to allow for a (realistic) FoMod simulation of widely arbitrary GNSS and LEO occultation missions. (See the section "FoMod INPUT PARAMETERS" below for an overview on the respective functionality furnished by EGOPS. Details are found in the On-line Help within the "FoMod Input" interface window available via the "Task" menu.)

Furthermore, it is necessary to have convenient tools for visualization and validation of the simulation results available in order to carry out simulation studies efficiently and in order to effectively comprehend and interpret the results. (See the section "FoMod VISUALIZATION" below for a crude overview on the respective functionality furnished by EGOPS. A refined overview is given under the "Help on Visualize/Val. - Help on Visualize/Val. Profiles" entry of the "Help" menu. Details are found in the On-line Help within the "Visualize/Validate Profiles" interface window available via the "Visualize/Validate" menu.)

FoMod INPUT PARAMETERS

EGOPS allows to compute Forward Modeling tasks taking into account the set of "free input parameters" outlined below, which all together provide considerable flexibility and potential for Forward Modeling. Nomen est omen all these parameters can be - within their range of validity - freely set by the User just as desired for a specific FoMod task.
The "FoMod Input" window, available via the "Forward Modeling" entry of the "Task" menu, is the convenient interface EGOPS provides for the supply of all of these parameters (including the supply of a "Reference MAnPl Task-id" in case simulations are desired for realistic geometry, providing for access to the input conditions and results of a prior MAnPl task).

- Type of occultation event to be simulated:
For spaceborne radio occultations a single event or a whole sample of events can be "forward modeled", whereby single events can be simulated either for an ideal geometry (assuming co-planar Tx and Rx orbits and, correspondingly, virtually-vertical tangent point trajectory) or for a realistic geometry (based on the geometry data obtained for a result event of a prior MAnPl task). Sample-of-event simulations always require event samples from a prior MAnPl task. Approximately the same is true for airborne radio occultations (only sample of realistic airborne occultation events cannot be processed).

  - Specifications for modelling a single event with ideal geometry:
  Tangent point location, azimuth of occultation plane (containing Tx, Rx, and the Earth's center), start date and time, height range over which the occultation event shall be "forward modeled", Tx and Rx orbital heights, the used Tx satellite system and the Tx signal properties. In case of an ideal geometry airborne occultation all Rx specifications are substituted by their corresponding aircraft specifications (additionally also the speed of the airplane is needed as input parameter).

  - Specifications for modeling with realistic geometry:
  Reference MAnPl Task-id (to be selected from the list of suitable MAnPl tasks existing within the current Project), event number of desired event within the MAnPl results (if single event) or event number range within the MAnPl results (if sample of events), height range over which the event(s) shall be "forward modeled", and the used Tx satellite system. In case of an airborne occultation with realistic geometry the coordinates of the start and end location, the start date and time, the occultation event height range, the airplane height and speed, the used Tx satellite system, the Tx orbit element and signal property file and the occultation event number are the key input parameters.

  - Specifications for a satellite to groundstation event:
  Reference MAnPl Task-id (to be selected from the list of suitable MAnPl tasks existing within the current Project), satellite and groundstation Id, time range over which the event shall be "forward modeled", and the used Tx satellite system.

- Choice of atmospheric and ionospheric models:

  - Climatological atmospheric model: No atmosphere, or simple dry or moist (bi-)exponential atmosphere, or dry or moist 2D atmosphere, or dry 3D atmosphere, or the GSM 3D Atmosphere, or the HiVRes Atmosphere, or a user-supplied atmosphere (default for the latter: the bi-exponential atmosphere). [If you have a source code version of EGOPS read the file usratm.SampleFile in the /prog/FORprog subdirectory of EGOPS in case you want to learn more about how to supply your own user-supplied atmosphere.]

  - Atmospheric disturbance model: In the case of a GNSS transmitter, following options are available but only in dry air: no disturbance, or gravity wave superposed, or frontal system gradient superposed, or tropopause fold superposed, or atmospheric inversion superposed. In the case of a LEO transmitter turbulence/scintillations can be superposed.

  - Climatological ionospheric model: No ionosphere, or simple double-Chapman ionosphere, or full 3D ionosphere.

  - Ionospheric disturbance model: No disturbance, or travelling ionospheric disturbance (TID) superposed, or ionospheric gradient superposed, or ionospheric trough superposed, or ionospheric storm effect superposed.

- Sampling rates for forward modeling:
1000 Hz, 500 Hz, or 250 Hz, or 100 Hz, or 50 Hz, or 25 Hz, or 10 Hz, or 5 Hz, or 1 Hz, or 0.2 Hz for all frequencies (if the upper limit of the occultation event height is larger than 90 km the sampling rates are limited to a maximum of 50 Hz, for airborne occultations the maximum sampling rate is 5 Hz, for satellite to groundstation events it is only 1 Hz).

- Signal propagation simulator:
Quasi-3D ray tracing (considering, in terms of refractivity gradients, the radial gradient only), full-3D ray tracing (accounting for the full-3D

refractivity gradient field), or wave optics propagator (for a more realistic computation dealing with diffraction and multipath effects). Accuracy of ray-tracing from Tx to Rx can be set to be <~ 1 mm, or <~ 1 cm, or <~ 10 cm (less demanding accuracy allowing faster computations but yielding more inaccurate simulated phase observables) for the first two signal propagation simulators whereas the ray tracer accuracy for the wave optics propagator can be set to be "High", "Medium", or "Low".

FoMod VISUALIZATION

EGOPS provides for the visualization of results of Forward Modeling tasks by its "Visualize/Validate Profiles" window interface available via the "Visualize/Validate" menu.

The "Visualize/Validate Profiles" window interface allows, for FoMod tasks, to post-process, visualize, customize, compare, and print-out simulated phase and amplitude data (in terms of "atmospheric(/ionospheric) excess phase" and "atmospheric(/ionospheric) power loss") as function of occultation event time. The excess phase data at the transmitted frequencies as well as the linearly corrected (LC) data (neutral atmosphere only after linear ionospheric combination of F1/F2 phases) and LI data (ionosphere only at L1) are all available for visualization and inspection, stand-alone or in combinations.

The post-processing includes functionality to compute absolute and relative difference profiles between profiles of different FoMod tasks or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events.

Customization includes, among other features, functionality to fit an exponential or polynomial of user-specified order to a selected range of a profile or to compute the time average value over a selected range of a profile (and to visualize this information by overplot on the original profile). [See "Help on Visualize/Val. - Help on Visualize/Val. Profiles" for more information.]

8.2.4 Observation System Modeling

Observation System Modeling (OSMod), together with prior Forward Modeling (FoMod), performs quasi-realistic simulation of observables, and related required variables, of the GNSS and LEO radio occultation technique. The main observables are time-tagged phase and amplitude measurements, obtained in real world by tracking occulted Transmitter signals with a LEO platform-mounted receiver for atmospheric sounding during their set/rise through the atmosphere imposed by the relative orbital motion of the Transmitter (Tx) and Receiver (Rx) satellites.

Observation System Modeling itself denotes the superposition of all sorts of relevant physical and technical influences of the observation system (antenna, receiver, platform, fiducial sites) on the "ideal" signal (phase and amplitude data) arriving at the receiving antenna, and on the "ideal" orbit data (Tx and Rx positions and velocities). In fact these "ideal" data are the output of Forward Modeling, a necessary prerequisite to be performed before Observation System Modeling can be done. [See "Help on Task - Help on Forward Modeling" for more information on FoMod.]

Many of the effects of the observation system correspond to the "classical" sort of instrumental errors (e.g., receiver noise), others are intrinsic natural parts of the receiving system (e.g., effect of the antenna gain pattern on the signal amplitude finally available). The most relevant observation system effects to be modeled include precise orbit determination (POD) errors, the antennae gain pattern, receiver noise, local multipath (due to the platform structure in the vicinity of the antenna), and differencing treatment/clocks precision. For the Realistic Receiving System Simulator (RRSS), e.g., it is now possible to include Open-Loop (OL) tracking.

Observation system modeling requires a considerable number of "free input parameters" in a simulation tool in order to allow for a (realistic) OSMod simulation of widely arbitrary GNSS occultation missions. (See the section "OSMod INPUT PARAMETERS" below for an overview on the respective functionality

furnished by EGOPS. Details are found in the On-line Help within the "OSMod Input" interface window available via the "Task" menu.)

Furthermore, it is necessary to have convenient tools for visualization and validation of the simulation results available in order to carry out simulation studies efficiently and in order to effectively comprehend and interpret the results. (See the section "OSMod VISUALIZATION" below for a crude overview on the respective functionality furnished by EGOPS. A refined overview is given under the "Help on Visualize/Val. - Help on Visualize/Val. Profiles" entry of the "Help" menu. Details are found in the On-line Help within the "Visualize/Validate Profiles" interface window available via the "Visualize/Validate" menu.)

OSMod INPUT PARAMETERS

EGOPS allows to compute Observation System Modeling tasks taking into account the set of "free input parameters" outlined below, which all together provide considerable flexibility and potential for Observation System Modeling. All these parameters can be - within their range of validity - freely set by the User just as desired for a specific OSMod task.

The "OSMod Input" window, available via the "Observation System Modeling" entry of the "Task" menu, is the convenient interface EGOPS provides for the supply of all of these parameters (including the supply of a "Reference FoMod Task-id", providing for access to the input conditions and results of a prior FoMod task).

- Forward modeling occultation event(s) selection:
The Reference FoMod Task-id can be selected from the list of suitable FoMod tasks existing within the current Project. In the case that a sample of events is available for the selected Reference FoMod task, also the event number range (or individual event number) of desired event(s) within the available FoMod events are selectable.

- OsMod sampling rate:
Default is the FoMod sampling rate (one of 1000 Hz, 500 Hz, 250 Hz, 100 Hz, 50 Hz, 25 Hz, 10 Hz, 5 Hz, 1 Hz, 0.2 Hz). In the case of a GNSS transmitter, a task with sampling rate greater than 50 Hz will not be available in the Inversion Retrieval (InRet) System later. In the case of a LEO transmitter, only tasks with a sampling rate of 10 Hz or 1000 Hz will presently be available in InRet. For the Realistic Receiving System Simulator the minimum sampling frequency is 10 Hz.

- POD error modeling:
No POD errors, or use of a "kinematic" POD error model is provided. (The latter model mimics POD position errors mainly by considering radial Tx and Rx position errors, POD velocity errors by considering along-ray velocity bias and drift errors (superposed to the "ideal" Rx velocity), and POD-induced excess phase errors by considering along-ray excess phase drift and acceleration errors incurred by along-ray velocity bias and drift errors.)

- Receiving system simulator type:
Between a parameterized- or a realistic receiving system simulator can be selected, with the following specifications (first for the parameterized- and second for realistic receiving system simulator):

For the parameterized receiver system simulator:

  - Tx/Rx antennae specifications:
  Antennae pointing and pattern characteristics, including boresight direction, field-of-view width and shape, and antenna gain at boresight (at 1 GHz), for "anti-velocity" looking and forward-looking antenna. The availability of the specific antennae depends on the type of occultation event(s) baselined via the selection of the Reference FoMod task (e.g., if a single setting occultation event was baselined, only the "anti-velocity" antennae will be available. Furthermore, the Tx antenna specifications are only sensitive in the case of a LEO-Tx antenna).

  - Receiver performance/noise modeling specifications:
  In the case of a GNSS-LEO event, No GNSS-LEO thermal noise, or Gaussian phase noise, or GNSS-LEO thermal noise can be selected, with the following specifications of the latter two:

- Gaussian phase noise model:
RMS (root-mean-square) value of the Gaussian phase noise (thermal noise).

- Realistic performance/noise model:
Loop bandwidth (single-sided), Rx antenna noise temperature, and the number of quantization levels in A/D conversion.

In the case of a LEO-LEO event, Rx thermal noise, or polynomial amplitude drifts, or 1/f amplitude noise, or sinusoidal amplitude drifts can be superimposed.

- Local multipath modeling specifications:
No local multipath, or sinusoidal local multipath, or realistic local multipath can be selected, with the following specifications of the latter two:

- Sinusoidal multipath model:
Period of the phase error, amplitude of the phase error, and (initialization) amplitude of the phase error at the topmost height of the occultation event.

- Realistic multipath model:
Ratio of multipath signal to direct signal, and source location (i.e., reflection point) of the multipath signal in (spherical) antenna coordinates.

- Differencing treatment and clocks modeling specifications:
Perfect clocks (no differencing), or real clocks (no differencing), or double differencing, or ground-based single differencing, or spacebased single differencing, with the following specifications of the latter four:

- Real clocks (no differencing):
Relative stability of the Tx clock (assumed for the worst clock in case of no differencing with real clocks involved).

- Double differencing:
Relative stability of ground clock (assumed for the worst clock in case of double differencing), and atmospheric noise per ground-to-satellite link involved in the differencing (this noise considered as clock-like noise).

- Ground-based single differencing:
Relative stability of the Rx clock (assumed for the worst clock in case of ground-based single differencing), and atmospheric noise per ground-to-satellite link involved in the differencing.

- Spacebased single differencing:
Relative stability of the Rx clock (assumed for the worst clock in case of space-based single differencing).

In the case of a LEO transmitter, only perfect clocks (no differencing) and real clocks (no differencing) are available.

For the realistic receiving system simulator:

- GRAS antenna specifications - antenna pattern files:
The select button allows to choose between two different antenna pattern files. These antenna pattern characteristic files are valid for the "anti-velocity" looking antenna (only setting GPS events can be processed because the realistic receiving system simulator is a pure GPS receiver).

- Random number seed:
The integer value of the random number seed can be set between 0 and 100, whereas 0 denotes the system clock.

- Technical specifications:
Several different features are connected together under this formal name. The system noise temperature, the number of interfering GPS satellites, the implementation loss, the antenna internal loss and the interference misalign loss.

- Loop specifications:
For open-loop tracking two different atmosphere models are available (the Bi-exponential- or a SAE-Fit atmosphere model). But it is also possible to turn the open-loop tracking off. Also adjustable are the loop period values and the start time of the 2nd value.

- FLL specifications:
It allows to specify the stop time and the filter order for the Frequency-Locked Loop (FLL) of the realistic receiving system simulator.

- Filter Specifications:
Adjustment of the L1- and CA filter specification allows for each filter the selection of the filter type and order, of the bandwidth values and the start time of the 2nd value can be modified.

OSMod VISUALIZATION:

EGOPS provides for the visualization of results of Observation System Modeling tasks by its "Visualize/Validate Profiles" window interface available via the "Visualize/Validate" menu.

The "Visualize/Validate Profiles" window interface allows, for OSMod tasks, to post-process, visualize, customize, compare, and print-out simulated phase and amplitude data (in terms of "observed excess phase" and "observed power", "observed" here in the sense of end-to-end simulated observables) as function of occultation event time.
The excess phase data at the transmitted frequencies as well as the linearly corrected (LC) data (neutral atmosphere only after linear ionospheric combination of F1/F2 phases)and LI data (ionosphere only at L1) are all available for visualization and inspection, stand-alone or in combinations.

The post-processing includes functionality to compute absolute and relative difference profiles between profiles of different OSMod tasks or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events.

Customization includes, among other features, functionality to fit an exponential or polynomial of user-specified order to a selected range of a profile or to compute the time average value over a selected range of a profile (and to visualize this information by overplot on the original profile).
[See "Help on Visualize/Val. - Help on Visualize/Val. Profiles" for more information.]

8.2.5 Inversion/Retrieval

Inversion/Retrieval of occultation data denotes the processing of simulated or observed phase and amplitude data (supplemented by the necessary geometrical information) typically via Doppler shifts, bending angles and transmissions down to quasi-vertical atmospheric profiles of refractivity, density, pressure, temperature, humidity, and liquid water.

This processing chain typically requires, sequentially, tools for ionospheric correction and conversion of the "raw" excess phase observables to neutral-atmospheric bending angle profiles, for conversion of the signal amplitudes to transmission profiles, for inversion of bending angle and transmission profiles into (complex) refractivity profiles ("Inverse Abel Transform"), and for finally retrieving the atmospheric variables (e.g., temperature) from (complex) refractivity. The air (in the troposphere) may be considered either dry or moist or cloudy in the last stage of this processing chain.

Necessary prerequisites for inversion/retrieval are either simulated observables, obtained by Observation System Modeling (OSMod) within EGOPS, or genuine observed phase and amplitude data (e.g. from the GPS/MET experiment).
[See "Help on Task - Help on Observation System Modeling" for more information on OSMod, and see, e.g., the WWW site "http://pocc.gpsmet.ucar.edu" for more information on the GPS/MET experiment and the data obtained.]

Such occultation data inversion/retrieval requires a considerable number of

"free input parameters" in a simulation tool in order to allow for flexible data processing of widely arbitrary simulated GNSS occultation missions as well as for observed data. (See the section "InRet INPUT PARAMETERS" below for an overview on the respective functionality furnished by EGOPS. Details are found in the On-line Help within the "InRet Input" interface window available via the "Task" menu.)

Furthermore, it is necessary to have convenient tools for visualization and validation of the simulation results available in order to carry out simulation studies efficiently and in order to effectively comprehend and interpret the results. (See the section "InRet VISUALIZATION" below for a crude overview on the respective functionality furnished by EGOPS. A refined overview is given under the "Help on Visualize/Val. - Help on Visualize/Val. Profiles" entry of the "Help" menu. Details are found in the On-line Help within the "Visualize/Validate Profiles" interface window available via the "Visualize/Validate" menu.)

InRet INPUT PARAMETERS

EGOPS allows to compute Occ. Data Inversion/Retrieval tasks taking into account the set of "free input parameters" outlined below, which all together provide considerable flexibility and potential for Occultation Data Inversion/Retrieval. All these parameters can be - within their range of validity - freely set by the User just as desired for a specific InRet task.

The "InRet Input" window, available via the "Occ. Data Inv./Retrieval" entry of the "Task" menu, is the convenient interface EGOPS provides for the supply of all of these parameters (including either the supply of a "Reference OSMod Task-id", providing for access to the input conditions and results of a prior OSMod task, or, alternatively, including the supply of a "GPS/MET" or "CHAMP/GPS" data path, providing for access to User-prepared GPS/MET or CHAMP/GPS data files.)

- Type of occultation data to be processed:
Simulated data (prepared by prior OSMod tasks run within EGOPS), or Observed data (prepared by the User in a directory to which at least read-access exists from the EGOPS installation; presently, GPS/MET data in the "UCAR Level 2 data" file format as well as CHAMP/GPS Level 2 data can be processed).

  - Occultation event(s) selection in case of simulated data:
  Reference OSMod Task-id (to be selected from the list of suitable OSMod tasks existing within the current Project).
  Also, in the case that a sample of events is available for the selected Reference OSMod task, event number range (or individual event number) of desired event(s) within the available OSMod events.

  - Occultation event(s) selection in case of observed data:
  GPS/MET or CHAMP/GPS data path (full directory path of the directory where the desired data reside, e.g., /home/<usr>/gpsmet/level2/occ/95.294/). Also, in the case that a sample of events is available within the selected data directory, event number range (or individual event number) of desired event(s) within the available GPS/MET or CHAMP/GPS events.

- Choice of Retrieval Processing Specifications:
"Atmospheric Processing" for the retrieval of atmospheric profiles, or "Ionosphere Processing" for the retrieval of ionospheric profiles. These processing modes allow for the following further choices:

- Choice of Bending Angle and Transmission Retrieval Specifications:

  - Choice of Bending Angle Retrieval Tool:
  Dependent on the used Tx satellite system and the selected retrieval processing, different bending angle tools are available:

    - Tools in case of Atmosphere Processing of GNSS-Tx based occultation data:
      "Advanced Geometric Optics Bending Angle Retrieval", "Advanced GNSS-LEO Wave Optics Bending Angle Retrieval", "Basic Geom. Optics/Statistical Optimization Bending Angle Retrieval", or "Basic Geometric Optics/No Optimization Bending Angle Retrieval".
    - Tools in case of Atmosphere Processing of LEO-Tx based occultation data:
      "Advanced Geometric Optics Bending Angle Retrieval" (if sampling

rate = 10 Hz), or "Advanced LEO-LEO Wave Optics Bending Angle Retrieval" (if sampling rate = 1000 Hz).
- Tools in case of Ionosphere Processing:
"Standard Ionospheric Bending Angle Retrieval".

For Advanced GNSS-LEO Wave Optics Bend. Angle Retrieval, "Canonical Transform" is possible for the Diff. Correction Type (for Advanced LEO-LEO Wave Optics Bend. Angle Retrieval, the Diff. Correction Type is insensitive). For Advanced Geometric Optics Bending Angle Retrieval and Basic Geom. Optics/Statistical Optimization Bending Angle Retrieval, the Ion. Correction Type can be varied between "Phase Correction" and "Bend. Angle Correction", whereas the Stat. Optimization Type can be chosen among "No Stat. Optimization", "Optimize invoking MSIS90_DMI", "Optimize invoking CIRA86aQ_UoG" in the first case and amongst "No Stat. Optimization", "Optimize using m+z BenA Search", and "Optimize using glob. BenA Search" in the latter case (for Basic Geometric Optics/No Optimization Bending Angle Retrieval both the Ion. Correction Type and the Stat. Optimization Type are insensitive).
For Standard Ionospheric Bending Angle Retrieval, the Ion. Correction Type is fixed to "Phase Correction" and the Stat. Optimization Type os fixed to "No Stat. Optimization".

- Choice of Transmission Retrieval Tool:
The transmission retrieval tool is only available in the case of atmosphere processing of LEO-Tx based occultation data. "Standard Channel Transmission Retrieval" (only if Advanced Geom. Optics Bending Angle Retrieval is used) and "Advanced Wave Optics Transmission Retrieval" (only if Advanced LEO-LEO Wave Optics Bend. Angle Retrieval is used) can be selected.

- Refractivity Profiles Retrieval Specifications:
For the Refractivity Profiles Retrieval/Inversion Tool, various options are possible dependent on the used Tx satellite system and the selected retrieval processing:

- Tools in case of Atmosphere Processing of GNSS-Tx based occultation data:
"No Atmos. Refractivity Profiles Retrieval" or "Abel Transform Real Refr. Profiles Retrieval".
- Tools in case of Atmosphere Processing of LEO-Tx based occultation data:
"No Atmos. Refractivity Profiles Retrieval" or "Abel Transform Complex Refr. Profiles Retrieval".
- Tools in case of Ionosphere Processing:
"No Ionos. Refractivity Profiles Retrieval" or "Abel Transform Ionos. Refr. Profiles Retrieval".

- Choice of Atmospheric Profiles Retrieval Specifications:

- For the type of Atmospheric Profiles Retrieval Tool:
"No Atmospheric Profiles Retrieval", "Real Refractivity Based Dry Air Profiles" retrieval, or "Real Refractivity Based Moist Air Profiles" retrieval. In the case of LEO-Tx based occultations, also "Complex Refr. Based Atmos. Profiles" retrieval.
The Real Refractivity Based Moist Air Profiles retrieval allows the following further choices:

- For the type of moist air retrieval:
"q,e,p,rho w. T prescribed (It)", or "q,e,p,rho w. T prescribed (In)", "q,e,rho with p,T prescribed", or "T,e,p,rho w. q prescribed (In)", or "T,e,rho with p,q prescribed", or "T,q,e,p,rho by Opt.Estimation...".
The last one opens a pop-up window for the input of the Observation + Forward Modeling error covariance matrix specifications and the background (T,q) error covariance matrix specifications.

- Atmospheric model used for prescribed parameters:
"FoMod atmosphere" (default in case of simulated data, meaning the atmosphere used in the "forward modeling" of the simulated observables), or "Bi-Exponential atmosphere", or "HLat 2D Atmosphere (CIRA86aQ_UoG)" (default in case of GPS/MET data), or the "GCM 3D Atmosphere (GCM3DAtm)", or the "HiVRes Atmosphere (HiVResAtm)...", or a "(Moist) User-supplied Atmosphere" (if moist air included in this atmosphere). [If you have a source-code version of EGOPS read the file usratm.SampleFile in the /prog/FORprog subdirectory of EGOPS in case you want to learn more about how to supply your own user supplied atmosphere.]

The Complex Refr. Based Atmos. Profiles retrieval allows the following further choice:

- Complex Refractivity Inversion Type
'T,q,e,p,rho,w by Optimal Inverse Estimation' is the single type available presently.

- Choice of Ionospheric Profiles Retrieval Specifications (only possible in case of Ionosphere Processing):

- For the Ionospheric Profile Retrieval Tool:
"No Ionospheric Profiles Retrieval", or "Electron Density Profiles Retrieval" are possible for selection.

InRet VISUALIZATION

EGOPS provides for the visualization of results of Occ. Data Inversion/Retrieval tasks by its "Visualize/Validate Profiles" window interface available via the "Visualize/Validate" menu.

The "Visualize/Validate Profiles" window interface allows, for InRet tasks, to post-process, validate against reference data, visualize, customize, compare, and print-out simulated or observed Doppler shift profiles (as function of occ. event time), bending angle profiles (as function of impact parameter), and refractivity, density, pressure, geopotential height, temperature, water vapor, specific humidity and liquid water profiles (as function of height). Also, in case of observed data, the original phase and amplitude data can be visualized (as function of occ. event time). The GPS/MET or CHAMP/GPS excess phase data at the L1 and L2 frequencies as well as the LC data (neutral atmosphere only after linear ionospheric combination of L1/L2 phases) and LI data (ionosphere only at L1) are all available for visualization and inspection, stand-alone or in combinations.

The post-processing includes functionality to compute absolute and relative difference profiles between profiles of different InRet tasks or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events.
Furthermore, reference "ground-truth" profiles of refractivity, density, pressure, geopotential height, temperature, water vapor, specific humidity, and liquid water can be prepared with any available atmospheric model within EGOPS, at the tangent point locations of the retrievals. Absolute and relative difference profiles w.r.t. these reference profiles can then be computed, as well as difference profiles statistics (mean difference to "ground-truth" and standard deviations compared to "ground-truth") for samples of events.

Customization includes, among other features, functionality to fit an exponential or polynomial of user-specified order to a selected range of a profile or to compute the time average value over a selected range of a profile (and to visualize this information by overplot on the original profile).
[See "Help on Visualize/Val. - Help on Visualize/Val. Profiles" for more information.]

8.3 Help on Visualize/Validate

8.3.1 About Visualize/Validate

The "Visualize/Validate" menu of EGOPS enables the User to post-process, compare to reference data (validate), visualize, and print-out result data of computational tasks carried out within the current project by employing one of the options of the "Task" menu previously. [See the "Help on Project" and "Help on Task" help entries to learn what EGOPS projects and tasks are.] In addition, it enables the User to visualize and visually explore atmospheric and ionospheric models within EGOPS, a capability useful for learning about the space-time behavior of the simulated atmosphere/ionosphere system, e.g., in view of selecting domains of interest for specific simulation tasks.

Five different generic types for visualization are offered, which together provide a powerful and flexible capability for preparation of EGOPS tasks and visual analysis, comprehension and interpretation of results of EGOPS tasks by the User. These five types, each of which is briefly overviewed below (see the section "OVERVIEW on VISUALIZE/VALIDATE interfaces"), are available via window interfaces caused to pop-up by selecting one of the "Visualize/Validate" menu entries. Specifically, the types are "MAnPl Statistics" (MAnPl - Mission Analysis/Planning), "Geographic Maps", "Profiles", "Volume Data", and "Data Animation". The "Geographic Maps", "Volume Data", and "Data Animation" interfaces are available already without having assigned an EGOPS project via the "Project" menu (for visualizing atmosphere/ionosphere model information), while the others need a current project assigned (the data of which are then available for visualization/validation).

Each such window interface has a standardized 600x512 pixel graphics output window as well as its specific post-processing functionality seamlessly integrated with plot customization features such as adjusting graphics axes ranges, titles, legends, map projections, etc. . A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file.

OVERVIEW on VISUALIZE/VALIDATE interfaces

"MAnPl Statistics..." - Visualize Mission Analysis/Planning Statistics:

The "MAnPl Statistics" interface allows to compute, visualize, and print-out 1D and 2D occultation coverage statistics as function of variables including latitude, longitude, Local Time, duration of occultation events, and obliquity (compared to vertical setting or rising) of tangent-point trajectories. Furthermore, it allows to compute, visualize, and print-out visibility statistics for fiducial and tracking sites, e.g., number of occultation events for which successful single- or double-differencing is possible by each of a given sample of fiducial sites, or number of orbits seen for a certain time range per orbit by each of a couple of tracking sites. Also statistical measures of number of events, (rms of) distances, (rms of) time separation as function of different latitude longitude cells or bands can be calculated and displayed. The basic data visualized in this way by the "MAnPl Statistics" interface are the result data from MAnPl tasks computed before under the "Mission Analysis/Planning" entry of the "Task" menu. The User selects specific MAnPl result data, out of all MAnPl data available within the current project, by assigning within the interface the Task-id of a desired MAnPl task.

[See "Help on Visualize/Val. - Help on Visualize MAnPl Statistics" for more information.]

"Geographic Maps..." - Visualize Geographic Maps:

The "Geographic Maps" interface allows to compute, visualize, and print-out latitude-longitude maps (using different map projections) showing occultation event coverage for arbitrary geographic areas and including information such as on the geometrical shape and time of each event. The basic data visualized in this way by the "MAnPl Statistics" interface are the result data from MAnPl tasks computed before under the "Mission Analysis/Planning" entry of the "Task" menu. The User selects specific MAnPl result data, out of all MAnPl data available within the current project, by assigning within the interface the Task-id of a desired MAnPl task.

Furthermore, this interface allows to compute, visualize (stand-alone or as overplot to occultation event coverage maps), and print-out geographic maps of a series of atmospheric/ionospheric variables (e.g., temperature and electron density) from all atmospheric/ionospheric models available within EGOPS. These may either slice the atmospheric/ionospheric field at a certain height or be vertically integrated quantities (e.g., total precipitable water). The selection of such "maps data" for a desired parameter is possible from all map data for this parameter computed so far under EGOPS (and not deleted meanwhile in the /referdata/mapsdata subdirectory of EGOPS).

[See "Help on Visualize/Val. - Help on Visualize Geographic Maps" for more information.]

"Profiles..." - Visualize/Validate Profiles:

The basic data visualized by the "Profiles" interface are the result data of FoMod, or OSMod, or InRet tasks computed before under the "Forward Modeling" entry, or the "Observation System Modeling" entry, or the "Occ. Data Inv./Retrieval" entry of the "Task" menu. The User selects specific FoMod/OSMod/InRet result data, out of all FoMod/OSMod/InRet data available within the current project, by first selecting the generic type of Task (FoMod, or OSMod, or InRet) and then assigning the Task-id of a desired FoMod/OSMod/InRet task.

For FoMod tasks, the "Profiles" interface allows to post-process, visualize, customize, compare, and print-out simulated phase and amplitude data (in terms of "atmospheric(/ionospheric) excess phase" and "atmospheric(/ionospheric) power loss") as function of occultation event time. The excess phase data at the different frequencies (F1, F2, etc.) as well as the LC data (neutral atmosphere only after linear ionospheric combination of F1/F2 phases) and LI data (ionosphere only at L1) are all available for visualization and inspection, stand-alone or in combinations. The amplitude data are available at all frequencies, stand-alone or in combination.

For OSMod tasks, the "Profiles" interface allows to post-process, visualize, customize, compare, and print-out simulated phase and amplitude data (in terms of "observed excess phase" and "observed power", "observed" here in the sense of end-to-end simulated observables) as function of occultation event time. The excess phase data at the F1, F2, etc. frequencies as well as the LC data and LI data are all available for visualization and inspection, stand-alone or in combinations. The amplitude data are available at all frequencies, stand-alone or in combination.

For InRet tasks, the "Profiles" interface allows to post-process, validate against reference data, visualize, customize, compare, and print-out simulated or observed Doppler shift profiles (as function of occ. event time), bending angle profiles (as function of impact parameter), transmission profiles (as function of impact parameter), and refractivity, density, pressure, geopotential height, temperature, water vapor, specific humidity, and liquid water profiles (as function of height). Also, in case of observed data (e.g., from the GPS/MET experiment), the original phase and amplitude data can be visualized (as function of occ. event time). The observed excess phase data at all frequencies as well as the LC data and LI data are all available for visualization and inspection, stand-alone or in combinations. The observed amplitude data are available at all frequencies, stand-alone or in combination.

For all generic Task options (FoMod, OSMod, and InRet), the post-processing includes functionality to compute absolute and relative difference profiles between profiles of different tasks or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events. Furthermore, for InRet tasks, reference "ground-truth" profiles of refractivity, density, pressure, geopotential height, temperature, water vapor, specific humidity, and liquid water can be prepared with any available atmospheric model within EGOPS, at the tangent point locations of the retrievals. Absolute and relative difference profiles w.r.t. these reference profiles can then be computed, as well as difference profiles statistics (mean difference to "ground-truth" and standard deviations compared to "ground-truth") for samples of events.

Again, for all generic Task options (FoMod, OSMod, and InRet), convenient customization functionality is available which includes, among other features, functionality to fit an exponential or polynomial of user-specified order to a selected range of a profile or to compute the average value over a selected range of a profile (and to visualize this information by overplot on the original profile).

[See "Help on Visualize/Val. - Help on Visualize/Val. Profiles" for more information.]

"Volume Data..." - Visualize Volume Data:

The "Volume Data" interface allows to compute arbitrary 3D subdomain cubes (up to 101 x 101 x 101 grid points), cut out of the generic 5D space-time domain

(height-latitude-longitude-UT-month) of EGOPS' atmospheric model parameters or the generic 6D space-time domain (height-latitude-longitude-UT-month-solar activity) of EGOPS' ionospheric model parameters, respectively. The atmospheric parameters available as such "volume data" include temperature, pressure, density, refractivity, water vapor (pressure), and specific humidity. The ionospheric parameters include electron density and ionospheric refractivity (at the F1 frequency).

Such volume data for a given parameter, the selection of which is possible from all volume data for this parameter computed so far under EGOPS (and not deleted meanwhile in the /referdata/volumdata subdirectory of EGOPS), can then be visualized and printed out in form of arbitrary 2D slices taken out of the 3D subdomain cubes.

[See "Help on Visualize/Val. - Help on Visualize Volume Data" for more information.]

"Data Animation..." - Visualize Data Animation:

The "Data Animation" interface allows to compute arbitrary 3D subdomain cubes precisely as the "Volume Data" interface allows. Also, the selection of such 3D cubes for a desired parameter is in the same way possible from all volume data for this parameter computed so far under EGOPS (and not deleted meanwhile in the /referdata/volumdata subdirectory of EGOPS).

However, instead of static display/print-out, the "Data Animation" interface allows to animate arbitrary 2D slices through the 3D cubes along the 3rd dimension. In other words, selecting one dimension as the "time axis" of the movie (along which the animation will proceed), one can visually explore the 3D cube in terms of motion pictures, the pictures given by the 2D slices orthogonal to the "time axis". A series of convenient features available such as backward/forward/bounce/pause modes, movie speed regulation, step-by-step inspection, and with/without contours display make this interface an ideal tool for very effectively learning about the space/time behavior of EGOPS' atmosphere/ionosphere models.

[See "Help on Visualize/Val. - Help on Visualize Data Animation" for more information.]

8.3.2 Visualize Mission Analysis/Planning Statistics

The "Visualize Mission Analysis/Planning Statistics" window interface is called via the "MAnPl Statistics..." entry of the "Visualize/Validate" menu.

The basic data visualized by the interface are the result data from MAnPl tasks computed under the "Mission Analysis/Planning" entry of the "Task" menu previously. The User selects specific MAnPl result data, out of all MAnPl data available within the current project, by first assigning within the interface the Task-id of a desired MAnPl task.

Having assigned an "Occultation" MAnPl/Task-id, information on the main input parameters of the current task is displayed at the top of the window, including UT range, height level range (for "Reflection" MAnPl/Task-ids the time step is shown instead of the undefined height level ranges in this case), and the geographic area covered. In addition, full information on the input of the current task can be displayed (and printed out if desired) by one mouse click, at any time during the visualization.

The post-processing computations possible for the result data of the current task are occultation (reflection) coverage statistics computations and visibility statistics for fiducial and tracking sites. [See, e.g., the "Help on Task - Help on Mission Analysis/Planning" function to learn what fiducial and tracking sites are.] These computations are performed within post-processing pop-up windows of the interface, which are accessed via the "Compute Occ. Statistics..." or "Compute Refl. Statistics..." and "Compute Vis. Statistics..." buttons.

Occultation (reflection) coverage statistics computations yield 1D and 2D statistics data in form of histogram data (discrete event distribution functions

over a 1D or 2D domain). Options available for 1D statistics include the number of events taking place in bins of user-specified width over latitude, or longitude, or Local Time, or duration of events, or obliquity of tangent-point trajectories (w.r.t. to a vertical set or rise of the tangent point). Options available for 2D statistics include the number of events taking place in boxes of user-specified size over longitude-latitude maps, or Local Time-latitude maps, or event duration-latitude maps, or event obliquity-latitude maps. It is also possible to calculate statistical measures for occultation (reflection) tasks. Different options for statistical measures are Number of Events per unit area, mean Distances, rms of Distances, mean Time Separation, and rms of Time Separation.

Visibility statistics computations yield, for each of a given set of LEO receivers involved in the current MAnPl task, the number of occultation events for which successful ground- or spacebased single differencing or double-differencing is possible by each of a given sample of fiducial ground sites (and by all sites together) or additional LEO-satellites, and the number of orbits seen for a given time range per orbit by each of a couple of tracking ground stations (and by all stations together).

The post-processing result data are saved in "display files" which are named with the Task-id of the current task and which indicate through their file extension the type of processing (and, for a given type, the version). For instance "MAnPltest1.Lat02" contains, for a current task named "MAnPltest1", the results of the 2nd post-processing run ("02") for 1D histogram data versus latitude ("Lat").

All "display files" computed so far for the current task are basically available to be visualized. For visualizing a specific result, the User needs to first select the type desired (for 2D histogram data also whether these shall be plotted as 2D histograms or 2D contours) and then the version desired (i.e., the actual "display file" among all versions available for the selected type).

Having selected a "display file", immediate on-screen plotting is possible into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, and the axes ranges (and viewing angle in case of 2D histogram plots). However, these plot settings can also be adjusted by the User before plotting. In addition, the User can decide whether to plot the data directly as they appear in the "display files" (as numbers of events), or "equal area-weighted" (in case occ. statistics data include a dependence on latitude), or "as percentages" (in case of visibility statistics data).

The standardized graphics output window can be used in one-panel, two-panel (stacked vertically), or four-panel mode (for statistical measures data the four-panel mode is not foreseen), and "plot", "overplot", and "erase last" or "erase all" functions can be quite arbitrarily employed. In addition, a "colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately affect the current graphics allowing for efficient color optimization.

A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file. A color PostScript file is generated (always in the /<Project-id>/PSfiles subdirectory of EGOPS) so that either a color printer may be employed to get the full colored graphics on paper or a standard b/w printer to get the grayscale/black/white analog of the on-screen plot on paper.

[Detailed help on each function of the "Visualize Mission Analysis/Planning Statistics" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Prepare some MAnPl tasks, then pop-up this interface and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no

problem for you.

8.3.3 Visualize Geographic Maps

The "Visualize Geographic Maps" window interface is called via the "Geographic Maps..." entry of the "Visualize/Validate" menu.

The basic data visualized by the interface are the result data from MAnPl tasks computed under the "Mission Analysis/Planning" entry of the "Task" menu previously. The User selects specific MAnPl result data out of all MAnPl data available within the current project, by first assigning within the interface the Task-id of a desired MAnPl task. Furthermore, even if no project is currently opened, geographic maps of atmospheric/ionosphere variables can be visualized.

Having assigned a MAnPl/Task-id, information on the main input parameters of the current task is displayed at the top of the window including UT range, height level range, and the geographic area covered. In addition, full information on the input of the current task can be displayed (and printed out if desired) by one mouse click, at any time during the visualization.

The post-processing computations, possible for the result data of the current task, yield occultation/reflection event distribution data. These data, more specifically also termed "ground projection data", include information on the geometrical shape (approximate ray-path tracks about the tangent-point trajectory for a given height level range for occultation tasks, or iso-range and iso-doppler curves for reflection tasks), the type (set or rise, transmitter system), the occurrence in time, and the sequential occultation/reflection event number (within the simulated time interval) of each event (within a selected sample of events). The computations are performed within a post- processing pop-up window of the interface, which is accessed via the "Prepare Occ./Refl. Event Data..." button.

The post-processing result data are saved in "display files" which are named with the Task-id of the current task and which indicate through their file extension the type of processing ("GrProjD" for "Ground Projection Data") and the version. For instance, "MAnPltest1.GrProjD02" contains, for a current task named "MAnPltest1", the results of the 2nd post-processing run ("02") for ground projection data ("GrProjD").

In order to prepare geographic maps of parameters of atmospheric/ionospheric models available within EGOPS, 2D latitude-longitude grids of such parameters can be computed (independent of whether a project is open or not). These grids may either slice an atmosphere/ionosphere field at a selected height (possible for temperature, pressure, density, refractivity, water vapor (pressure), specific humidity, electron density, and ionospheric refractivity (at the F1 frequency)) or contain vertically integrated quantities (possible for Precipitable Water and Total Electron Content). These computations are performed within a processing pop-up window of the interface, which is accessed via the "Prepare Atm/Ion Model Data..." button.

The maps data are saved in "display files" (under the /referdata/mapsdata subdirectory of EGOPS) which are named with the acronym of the atmosphere/ionosphere model from which they originate plus the acronym of the parameter mapped. With their extension the files indicate their type ("Map") and the version. For instance, "MSIS90_DMI-Temp.Map01" contains, from the 1st computation for the specific model and parameter ("01"), a geographic map of temperature from the dry 3D atmosphere model MSIS90_DMI.

All "display files" computed so far are basically available to be visualized (if no project is open, the atmosphere/ionosphere model maps only). For visualizing a specific result, the User needs to first select the type desired (either event distribution data or atmosphere/ionosphere model data) and then the version desired (i.e., the actual "display file" among all versions available for the selected type).

Having selected a "display file", immediate on-screen plotting is possible into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, the map projection, and the map area (and the contour levels in case of

atmosphere/ionosphere model data). However, these plot settings can also be adjusted by the User before plotting. In addition, the User can decide whether to plot the data directly as they appear in the "display files" (as ground projection data showing ray-path tracks about the tangent-point trajectories in case of event distribution data or as contoured 2D images in case of atm/ion model data), or "tagged with occ./refl.event number" (in case of event distr. data), or "tagged with event times" (also in case of event distr. data), or "overplotted on event distr. data" (in case of atm/ion model data). Several important tags can be included for improving the plotting quality (Plot Tangent Point with accumulated UT tags, with LT tags, with Tx-Id tags, with Rx-Id tags or Plot Tangent Point with Tx+Rx-Id tags).

The standardized graphics output window can be used in one-panel, two-panel (stacked vertically), or four-panel mode, and "plot", "overplot", and "erase" functions can be quite arbitrarily employed. In addition, a "colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately affect the current graphics allowing for efficient color optimization.

A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file. A color PostScript file is generated (basically in the /<Project-id>/PSfiles subdirectory of EGOPS except for atm/ion data maps, for which the file is directed to the /referdata/mapsdata subdirectory) so that either a color printer may be employed to get the full colored graphics on paper or a standard b/w printer to get the grayscale/black/white analog of the on-screen plot on paper.

[Detailed help on each function of the "Visualize Geographic Maps" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Prepare some MAnPl tasks and maps of atmosphere/ionosphere model parameters, then pop-up this interface and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no problem for you.

8.3.4 Visualize/Validate Profiles

The "Visualize/Validate Profiles" window interface is called via the "Profiles..." entry of the "Visualize/Validate" menu.

The basic data visualized by the "Profiles" interface are the result data of FoMod, or OSMod, or InRet tasks computed before under the "Forward Modeling" entry, or the "Observation System Modeling" entry, or the "Occ. Data Inv./Retrieval" entry of the "Task" menu. The User selects specific FoMod/OSMod/InRet result data, out of all FoMod/OSMod/InRet data available within the current project, by first selecting the generic type of Task (FoMod, or OSMod, or InRet) and then assigning the Task-id of a desired FoMod/OSMod/InRet task.

Having selected a generic type of Task and assigned a corresponding Task-id, information on the occultation event no. range, the generic file names, and the total number of occultation events of the current task is displayed at the top of the window. In addition, full information on the input of the current task can be displayed (and printed out if desired) by one mouse click, at any time during the visualization.

The post-processing computations possible for the result data of the current task are absolute and relative difference profiles between profiles of different tasks (of the same generic type) or within a sample of events as well as profile statistics (mean and standard deviation profiles) for samples of events. For visualization of statistics, also standard-deviation-of-mean profiles are automatically included being a function of the computed mean and standard deviation profiles. These computations are performed within a post-processing pop-up window of the interface, which are accessed via the "Profiles

Post-Processing..." button.

For FoMod tasks, the basically available result data for this post-processing comprise "ideal" simulated phase and amplitude data (in terms of "atmospheric (ionospheric) excess phase" and "atmospheric (ionospheric) power loss") as function of occultation event time. The excess phase data are available at all frequencies as well as in form of LC data (neutral atmosphere only after linear ionospheric combination of F1/F2 phases). For visualization, also LI data (ionosphere only at L1) are automatically included being a function of the computed F1, F2, and LC data. The amplitude data are available at all frequencies.

For OSMod tasks, the basically available data comprise "realistic" simulated phase and amplitude data (in terms of "observed excess phase" and "observed power", "observed" here in the sense of end-to-end simulated observables) as function of occultation event time. The excess phase data are available at all frequencies as well as in form of LC data (for visualization, also LI data are then derived), the amplitude data at all frequencies.

For InRet tasks, the basically available data comprise simulated or observed Doppler shift profiles (as function of occ. event time), bending angle profiles (as function of impact parameter), transmission profiles (as function of impact parameter), and refractivity, density, pressure, geopotential height, temperature, water vapor, specific humidity, and liquid water profiles (as function of height). Also, in case of observed data (e.g., from the GPS/MET experiment), the original phase and amplitude data are available (as function of occ. event time). The observed excess phase data are available at all frequencies as well as in form of LC data (for visualization, also LI data are then derived), the amplitude data at all frequencies.

Furthermore, for InRet tasks, reference "ground-truth" profiles of refractivity, density, pressure, temperature, water vapor (pressure), and specific humidity can be prepared with any available atmospheric model within EGOPS, at the tangent point locations of the retrievals. These computations are performed within a processing pop-up window of the interface, which is accessed via the "Prepare Atm.Ref. Profiles..." button.
Absolute and relative difference profiles w.r.t. these reference profiles can then be computed, as well as difference profiles statistics (mean difference to "ground-truth" and standard deviations compared to "ground-truth") for samples of events. For visualization of these statistics, also standard-deviation-of-mean profiles are automatically included being a function of the computed mean and standard deviation profiles. These computations, in turn, are again performed within the "Profiles Post-Processing..." pop-up window noted a few paragraphs above.

The post-processing result data are saved in "display files" which are named with the Task-id of the current task (plus the occultation number if not profile statistics) and which indicate through their file extension the parameter concerned, the type of processing, and, for a given type, the version. For instance "InRettest1_0001.TempDif03" contains, for occultation profile no. 1 ("_0001") of a current task named "InRettest1", the results of the 3rd post-processing run ("03") for a difference profile ("Dif") between temperature profiles ("Temp").
In case of atmospheric reference profile "display files", the original profile's file extension is extended by the acronym of the atmospheric model which serves as "ground-truth" atmosphere. For instance, the file "InRettest1_0001.TempMSIS90_DMI" would contain a temperature reference profile extracted from the dry 3D atmosphere model MSIS90_DMI which is co-located with the profile in "InRettest1_0001.Temp".

All "display files" computed so far for the current task are basically available to be visualized. For visualizing a specific result, the User needs to first select the parameter and the type desired (e.g., difference profiles of temperature) and then the "display file" desired (out of all available ones for the selected parameter and type, which typically may cover a range of occultation numbers and/or versions).

Having selected a "display file", immediate on-screen plotting is possible into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, the axes ranges, and the parameter axis type (default linear, another option is logarithmic in case of direct plotting of positive definite result

profiles or their atmospheric reference profiles). However, these plot settings can also be adjusted by the User before plotting. After plotting the "zoom in..." button can be used for enlarging interesting details of the plot (the "restore..." button can be used afterwards to restore the original plot image size).

In addition, the User can decide whether to plot the profiles directly as they are obtained from "the display files" (as functions of time, or impact parameter, or height, dependent on the parameter) or whether the data shall be customized in various ways before plotting. The customization functionality (available always to the extent appropriate for a selected generic type of Task, parameter, and type of plot) includes a function for smoothing the profile data by a user-specified sliding filter width, a function to compute the average value over a selected range of a profile, functions to fit an exponential or a polynomial of user-specified order to a selected range of a profile, a function to select arbitrary profile subsets of the F1, F2, etc., LC, and LI data available (in case of excess phase or Doppler shift data, F1/F2 in case of amplitude data with the ability to visualize, for simulated amplitude observables, absolute or relative power), and a function to select arbitrary profile subsets of the mean, standard deviation, and standard-deviation-of-mean profiles available (in case of statistics data, with the ability to show absolute or relative standard deviations).

The standardized graphics output window can be used in one-panel, two-panel (stacked vertically), or four-panel mode, and "plot", "overplot", and "erase" functions can be quite arbitrarily employed. In addition, a "colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately affect the current graphics allowing for efficient color optimization.

A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file. A color PostScript file is generated (always in the /<Project-id>/PSfiles subdirectory of EGOPS) so that either a color printer may be employed to get the full colored graphics on paper or a standard b/w printer to get the grayscale/black/white analog of the on-screen plot on paper.

Additionally, the line style and line thickness can be directly varied by means of two droplist buttons. The annotate function allows to individually create text strings for later annotation of the plot window. Several different text parameters can be altered (i.e. the text alignment, color, direction, position, and the text size). About 16 different character sets are available for creating a text string. These text strings can also be stored for later reuse.

[Detailed help on each function of the "Visualize/Validate Profiles" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Prepare some FoMod/OSMod/InRet tasks, then pop-up this interface and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no problem for you.

8.3.5 Visualize Volume Data

The "Visualize Volume Data" window interface is called via the "Volume Data..." entry of the "Visualize/Validate" menu. Its operation is independent of whether a project is currently opened or not.

The interface allows to compute, visualize, and print-out "volume data". Such "volume data" within EGOPS are arbitrary 3D subdomain cubes, cut out of the generic 5D space-time domain (height-latitude-longitude-UT-month) of EGOPS' atmospheric model parameters or the generic 6D space-time domain (height-latitude-longitude-UT-month-solar activity) of EGOPS' ionospheric model parameters, respectively. Cube dimensions up to 101x101x101 data points are

allowed, and the volume data may be extracted from any of the atmospheric/ ionospheric models available within EGOPS.

The atmospheric parameters available include temperature, pressure, density, refractivity, water vapor (pressure), and specific humidity. The ionospheric parameters include electron density and ionospheric refractivity (at the GPS/L1 frequency).

The preparation of the volume data sets is performed within a processing pop-up window of the interface, which is accessed via the "Compute 3D Atm/Ion Model Data..." button.

The computed volume data are saved in "display files" (under the /referdata/volumdata subdirectory of EGOPS) which are named with the acronym of the atmosphere/ionosphere model from which they originate plus the acronym of the parameter concerned. The filename extension indicates the data type ("Vol") and the version. For instance, "MSIS90_DMI-Temp.Vol01" contains data from the 1st computation of a specific model and parameter ("01") and a 3D subdomain cube of temperature from the dry 3D atmosphere model MSIS90_DMI.

All "display files" computed so far are basically available to be visualized. For visualizing a specific volume data set, the User needs to first select the parameter desired (either an atmospheric or ionospheric one) and then a "display file" desired (out of all available ones for the selected parameter, which typically may cover different models and versions). The visualization itself is performed in form of arbitrary 2D slices taken out of the selected 3D subdomain cube which are depicted as contoured images.

Having selected a "display file", immediate on-screen plotting is possible into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, the dimension which is held fixed and its fixed value (the 2D slice spanned by the other two orthogonal dimensions is singled out just at this value), the axes ranges of the 2D slice, and the contour levels to be shown. However, these plot settings can also be adjusted by the User before plotting.

The standardized graphics output window can be used in one-panel, two-panel (stacked vertically), or four-panel mode, and "plot", "overplot", and "erase" functions can be quite arbitrarily employed. In addition, a "colors..." function furnishes a small pop-up window, which allows a very convenient and versatile handling of a multitude of color customization possibilities, which immediately affect the current graphics allowing for efficient color optimization. EGOPS allows additionally to switch between the image/contours or the contour fill mode for plotting. Also several different contour line colors are available for an easier line recognition.

A very useful new feature is the profiles pop-window for showing horizontal- or vertical volume data profiles. To create the volume data profiles the mouse cursor has to be moved over the whole volume data plot. Then the data profile will be simultaneously displayed in an extra graphic pop-window beside the standard volume data graphics window. It can be switched (via mouse click) between an horizontal- or an vertical data profiles mode and, at any time during visualization, the volume data profile can be saved to disk.

A "Print to PostScript file" function conveniently allows immediate publication-quality printing at any time during visualization when the User considers it appropriate to conserve the current on-screen graphics as print file. A color PostScript file is generated (always in the /referdata/volumdata subdirectory of EGOPS) so that either a color printer may be employed to get the full colored graphics on paper or a standard b/w printer to get the grayscale/black/white analog of the on-screen plot on paper.

[Detailed help on each function of the "Visualize Volume Data" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Pop-up the interface, prepare some volume data sets, and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are

sure about what you want to compute and see, how to do it will soon be no problem for you.

8.3.6 Visualize Data Animation

The "Visualize Data Animation" window interface is called via the "Data Animation..." entry of the "Visualize/Validate" menu. Its operation is independent of whether a project is currently opened or not.

The interface allows to compute and visualize (by animation) "volume data". "Volume data" within EGOPS are arbitrary 3D subdomain cubes, cut out of the generic 5D space-time domain (height-latitude-longitude-UT-month) of EGOPS' atmospheric model parameters or the generic 6D space-time domain (height-latitude-longitude-UT-month-solar activity) of EGOPS' ionospheric model parameters, respectively. Cube dimensions of up to 101x101x101 data points are allowed, and the volume data may be extracted from any of the atmospheric/ ionospheric models available within EGOPS.

The atmospheric parameters available include temperature, pressure, density, refractivity, water vapor (pressure), and specific humidity. The ionospheric parameters include electron density and ionospheric refractivity (at the GPS/L1 frequency).

The preparation of the volume data sets is performed within a processing pop-up window of the interface, which is accessed via the "Compute 3D Atm/Ion Model Data..." button. (This pop-up window is in fact the identical one as that accessed within the "Visualize Volume Data" interface.)

The computed volume data are saved in "display files" (under the /referdata/volumdata subdirectory of EGOPS) which are named with the acronym of the atmosphere/ionosphere model from which they originate plus the acronym of the parameter concerned. The file name extension indicates the type ("Vol") and the version. For instance, "MSIS90_DMI-Temp.Vol01" contains data from the 1st computation of a specific model and parameter ("01") a 3D subdomain cube of temperature values from the dry 3D atmosphere model MSIS90_DMI.

All "display files" computed are basically available to be visualized. For visualizing a specific volume data set, the User needs to first select the desired parameter (either an atmospheric or ionospheric one) and then a "display file" (out of all available ones for the selected parameter, which typically may cover different models and versions).

So far, the computation and selection of specific volume data is in fact identical to that within the "Visualize Volume Data interface. However, instead of enabling static display and print-out of 2D slices through the 3D subdomain cubes, this interface allows to animate arbitrary 2D slices through the 3D cubes along the 3rd dimension. In other words, selecting one dimension as the "time axis" of the "movie" (along which the animation will proceed), one can visually explore the 3D cube in terms of motion pictures, the pictures given by the 2D slices orthogonal to the "time axis". The 2D slices are depicted as 2D images with or without contours. Thus, this interface is an ideal tool for very effectively learning about the space/time behavior of EGOPS' atmosphere/ ionosphere models.

After having selected a "display file", an immediate start of the animation is possible, kicking off the "loading" of 2D slices into the standardized 600x512 pixel graphics output window integrated into the visualization interface. This will take default settings for the title, the plot legend, the dimension along which the animation shall proceed (the 2D slices spanned by the other two orthogonal dimensions will then constitute the motion pictures), the range of values along the animation dimension, the axes ranges of the 2D slices, and the contour levels to be shown (default is no contour levels). However, these plot settings can also be adjusted by the User before starting the animation.

The graphics output window, after having started the animation and loaded the relevant 2D slices, shows the animation while it can be customized by a series of convenient functions. These include backward, forward, bounce, and pause modes, movie speed regulation, real-time slice number information, and arbitrary browsing through the slice series by step-by-step inspection. In addition, a "Colors..." function furnishes a small pop-up window, which allows a very

convenient and versatile handling of a multitude of color customization possibilities, which immediately effect the current graphics, allowing for efficient color optimization. "Stop" and "Erase" functions complete the primary features, allowing for stopping and clearing up a current animation.

EGOPS allows additionally to switch between the image/contours or the contour fill mode for data animation. The color/volume or color/slice are two different animation color range modes. In the color/volume mode, the colors for each slide are physically compatible (the same data value in each slide has the same color), whereas in the color/slice mode, the full color range is used for each individual slice, which means that the colors for different slices can have different meanings. Also several different contour line colors are available for an easier line recognition.

The "MPEG Output" function conveniently allows to save the currently loaded data animation sequence as an MPEG video file. In this form the data video file can be easy transferred to another users (which don't need EGOPS to run the animation, only a common MPEG player is necessary for replaying the animated data sequence).

[Detailed help on each function of the "Visualize Data Animation" interface is found in the On-line Help available within the interface.]

SPECIAL NOTES/HINTS

- The best way to get quickly acquainted with this visualization interface is certainly "learning by doing". Pop-up the interface, prepare some volume data sets, and try out the functionality by a "look-and-feel" approach. Where necessary, make a sidekick to a specific On-line Help topic. Given you are sure about what you want to compute and see, how to do it will soon be no problem for you.

8.4 Help on Help

8.4.1 About the Help Menue

The "Help" menu of EGOPS provides the User with On-line access to all information necessary to understand and use the software package and all of its main components and functions.
(This main-level Help information is complemented by detailed Help on each specific function of EGOPS, which is available within the pop-up window interfaces; cf. "Help on Help - Help within User I/F Windows".)

The entries of the "Help" menu comprise, in terms of type of help, the following two groups (of which the contents and structure is briefly outlined):

1) Help on the menus of EGOPS and all functions offered by these menus (including, as main entries, "Help on Project", "Help on Task", "Help on Visualize/Validate", and "Help on Help"):

This Help is directed mainly at the "working" User, who more or less recently started with EGOPS and seeks information and use support on the different main-level menus and/or any of the entries they offer. The latter represent the main functions of the software (i.e., the basic User I/F windows).

For convenience, the organization of the entries of this 1st Help group directly reflects the EGOPS menu structure (from left to right), i.e., the four entries of the Help group are "Project", "Task", "Visualize/Validate", and "Help". In particular, the subdivision of the first three entries ("Project", "Task", and "Visualize/Validate") directly reflects the ordering of the respective menu entries, whereby on top of these entries always one entry is included with general information on the rationale of the whole menu. For instance - reflecting the structure of the "Task" menu - the entry "Help on Task" of the "Help" menu contains the list of entries "About Tasks", "Help on Mission Analysis/Planning", "Help on Forward Modeling", "Help on Observation System Modeling", and "Help on Occ. Data Inversion/Retrieval".

The entry on "Help on Help", is divided into "About the Help Menu", explaining the Help function at the main level, and "Help within User I/F Windows", explaining the Help function within the pop-up window interfaces.

2) General Help, offering a basic understanding of EGOPS, technical and other helpful notes on setup and use, and a product information entry (including, as main entries, "EGOPS explained...", and "About EGOPS..."):

This Help is directed mainly at the new User, who wants to learn EGOPS basics like scientific background of EGOPS, the functionality and scope offered, the underlying concept and structure, and about sources for further written documentation about EGOPS. In addition, this Help provides Users with helpful notes on setup and usage of the software and with answers to Frequently Asked Questions (FAQs).

The above information (accessed via the "EGOPS explained..." entry) is completed with a concise product information (accessed via the "About EGOPS..." entry) giving product name, version, release, copyright, development team, a "disclaimer of warranty" statement, points of contact, and an informal section on distribution and transfer.

8.4.2 Help within User I/F Windows

The "Help within User I/F windows" function, which is available via the "Help" button at the bottom right of each pop-up window interface of EGOPS, provides the User with On-line access to all information necessary to understand and use each specific function.

This Help is directed to furnish the "working" User with "sidekick" information and provide support on all actions (e.g., selections by mouse click, input of numbers, etc.) the User can potentially perform within the given I/F window. For each of the User input parameters, Help is provided, as applicable, on its purpose, its type, its format and usage, its (range of valid) values, and its availability and side effects within the window's context.

For convenience, the organization and ordering of the Help entry list accessible via the I/F window's "Help" button directly reflects the top-to-bottom layout and logical grouping of the given I/F window. Basically, one Help entry is provided per logical "input group" (comprising one or more parameters), which gives access to general information on the group (plus some special notes or hints, if deemed useful) and to the Help on the group's parameter(s). The naming of a Help entry directly follows the naming of the "input group" in the I/F window. This way, the position of a Help entry is quickly found in the list of entries.

For the main User I/F windows, which are those directly accessed via the main-level menu entries, its Help entry is always on top of the list of "input group"-specific entries and gives general information on the whole window. In fact, this entry furnishes exactly the same information as is available via the main-level "Help" menu for the corresponding main-level menu entry.

For instance, the "Help" button within the "Mission Analysis/Planning Input" User I/F window, which is accessed via the "Mission Analysis/Planning" button of the "Task" menu, furnishes a top entry called "Help on Mission Analysis/ Planning". - This entry leads to the same information as provided by the "Help on Task - Help on Mission Analysis/Planning" entry, accessed via the main-level "Help" menu.

And as an example for an arbitrary selection, if the User desires to get Help on how to supply the "Height Levels" within the "Mission Analysis/Planning Input" window, which is the third "input group" from top within this window, the corresponding entry is found as third below the top entry in the Help entry list.

8.5 EGOPS explained

8.5.1 EGOPS Background

The Global Navigation Satellite System (GNSS, presently GPS/GLONASS) enables active limb sounding of the Earth's atmosphere and ionosphere by placing GNSS signal (L-band) receivers into Low Earth Orbits (LEO) and employing the radio-occultation (RO) technique. Radio-occultation between two LEO satellites is possible, too, if there are both transmitting (X/K-band) and receiving LEO-satellites.

The RO method bears great utility for fields like operational meteorology, climate monitoring and modelling, and space weather, due to its potential to yield virtually bias-free profiles (globally evenly distributed and under practically all weather conditions) of fundamental atmospheric parameters, such as temperature and humidity, with quite unique vertical resolution (1 km or better) and accuracy (e.g., temperature < 1K).

The RO technique has been employed, from the mid-1960s onwards, with great success by planetary missions to measure vertical profiles of density and temperature for the atmospheres of Venus, Mars and the outer planets. With the advent of the GNSS satellites, which are high performance radio transmitters in high orbits (about 20000 km) furnishing suitable L-band signals near 1.2 GHz and 1.6 GHz, along with GNSS receivers in LEO, it is now possible to make RO measurements of great utility, as noted above, also for the Earth's atmosphere.

The scientific basis of the GNSS-LEO RO technique is as follows. When (L-band) radio waves pass through the atmosphere, they are refracted through an angle determined by the refractivity gradients along the path. These, in turn, depend on the gradients of density (and hence temperature), water vapor and electron density, and so a measurement of the refraction angle contains information on these atmospheric/ionospheric variables. These effects are most pronounced when the radiation traverses a long atmospheric limb path. Measurements for a series of such paths at different tangent heights, by exploiting the eigenmotions of orbiting GNSS and LEO satellite pairs in suitable geometry, contain information on the near-vertical profile of refractivity.
Though it is not possible at radio frequencies to measure the refracted angle directly, the refraction introduces an additional Doppler shift into the received signal, and this (or the related excess phase shift) can be measured very accurately and is directly related to the refraction angle.

The LEO-LEO RO technique is similar to the GNSS-LEO one, with the exception that the (X/K-band) radio waves traversing the atmosphere are not only refracted but also absorbed. The absorption of the signal, which is mainly due to the atmospheric water vapor, contains information on the imaginary refractivity profile of the atmosphere. This knowledge of the imaginary refractivity in addition to the knowledge of the real refractivity enables to retrieve water vapor independent from temperature (this is not possible in the case of GNSS-LEO RO which means that in humid regions, the temperature profile has to be known (a-priori) in order to retrieve the humidity profile, and vice versa.

An RO profile measurement by a receiver in LEO, which performs high-performance (millimetric precision), high-rate (50 Hz or so) tracking of a GNSS/LEO signal occulted by the atmosphere near the Earth's limb, takes a period of about 1 minute, just before or after eclipse with respect to the transmitter. Scannings from top down (space to Earth's surface) are called "setting" occultations, those from bottom upwards (surface to space) are called "rising" occultations.

The number of occultation events obtained between one receiver and one transmitter satellite depends on the precise orbit parameters of the satellite. In the case of a GNSS transmitter and a receiver on a LEO, however, an estimation can be done:
A receiver on a LEO can obtain up to 29 occultation profiles per day for each GNSS transmitter. Given the operational network of GPS and GLONASS transmitters (48 satellites) and typical antennae field-of-view of GNSS receiver antennae, this allows more than 1000 globally distributed soundings per day for one receiver in LEO (with an average horizontal spacing of about 700 km). A constellation of successively more receivers reduces this horizontal spacing significantly (e.g., a 12-receiver constellation would reduce the average horizontal spacing to about 200 km per day).

In the stratosphere and upper troposphere, where the water vapor density is low, refraction variability is dominated by vertical temperature gradients, and the temperature profile can be retrieved accurately with both GNSS-LEO and LEO-LEO RO. In the lower troposphere, the water vapor effects are dominant, and the water vapor profile can be retrieved accurately - in the case of LEO-LEO RO without background information, whereas in the case of GNSS-LEO RO given temperature is needed, allowing for typical uncertainties in the prior knowledge of temperature. The height below which the information in the measurements is predominantly on water vapor varies with absolute humidity (and hence latitude); in the tropics it is typically around 7-8 km, whereas in the driest polar atmospheres, accurate temperature sounding is possible down into the planetary boundary layer (which extends up to about 1 km above the surface).

For both temperature and humidity sounding, it is necessary to account for the effects on the signals of refraction in the ionosphere. Correction for these effects can be made using RO signals at two radio frequencies available, at which the effects of the ionosphere are substantially different. In addition, exploited in a complementary way, the presence of such effects provides accurate information on the ionosphere's electron density field.

Important features of the RO technique are its "all-weather" capability and the "long-term" stability (i.e., virtual absence of biases and drifts) of RO data. Most clouds have negligible effects on the measured signals. Furthermore, the measurements have intrinsically high long-term stability, with no significant calibration problems. This feature is particularly important for climate monitoring and allows to directly combine data from different satellites and separated in time for many years.

EGOPS is a tool prepared to provide significant and effective help in addressing most of the open scientific and technical questions on the GNSS-based RO technique.

DEMONSTRATION OF THE POTENTIAL OF GNSS-LEO OCCULTATION

The potential of the GNSS-based RO technique has been demonstrated by early results from the GPS Meteorology (GPS/MET) experiment launched in April 1995 on the satellite Microlab 1. The results for temperature profile retrieval are already approaching the accuracies claimed for the technique. In the northern hemisphere extra- tropics, standard deviations of difference between GPS/MET retrievals and European Center for Medium Range Weather Forecast (ECMWF) analyses are around 1-1.5K, with biases below 0.5 K. In the southern hemisphere, agreement is also good in general, but with clear evidence that the RO measurements can identify where the ECMWF temperature analysis is deficient through lack of observations. A particularly impressive result of the GPS/MET data has been the ability to resolve the detailed temperature structure around the tropopause, in good agreement with collocated radiosondes.

The hitherto results are consistent with expected errors for this technique, i.e., less than 1 K, at a vertical resolution of 0.5-1 km in the upper troposphere and lower stratosphere, increasing to about 2 Kelvin near the stratopause (about 50 km). EGOPS will be a significant tool to study open questions regarding various components of the error budget.

The potential accuracy of RO measurements has also been assessed for water vapor. Better than 10% accuracy has been estimated for the lowest about 2 km throughout the tropics and mid-latitudes, and also, at low latitudes, for the mid-troposphere at pressures exceeding about 600 hPa. EGOPS can also play a significant role in better quantifying the potential of GNSS occultation for retrieval of water vapor information.

Regarding electron density, the potential of the RO technique has long been demonstrated by studies of ionospheres of other planets, e.g., those of Mars and Venus. First results for the Earth, based on GPS/MET data, promise that the electron density can be gained throughout the ionosphere up to near the LEO orbit height at the 1% accuracy level. This, together with the global coverage potential of the technique, can open a new era for ionospheric remote sensing of unprecedented resolution and quality.

DEMONSTRATION OF THE POTENTIAL OF GNSS-LEO OCCULTATION

The potential of the RO technique based on a LEO transmitter has not been demonstrated yet. The temperature errors for this technique are expected to be smaller than 1 K at a vertical resolution of 0.5-1 km in the upper troposphere and lower stratosphere, increasing to about 1.5 Kelvin near the stratopause (about 50 km). EGOPS will be a significant tool to study open questions regarding various components of the error budget.

The potential accuracy of water vapour is assessed to be better than 10 % within the whole troposphere all-around the world. EGOPS can play a significant role in better quantifying the potential of LEO-LEO radio occultation for retrieval of water vapor information.

FUTURE POTENTIAL OF GNSS/LEO OCEAN REFLECTED SIGNALS

The Global Navigation Satellite System (GNSS, presently GPS/GLONASS) and transmitter satellites in LEO enable to employ the radio-reflection (RR) technique by using ocean reflected GNSS/LEO radio signals, too (besides active limb sounding of the Earth's atmosphere and ionosphere by placing GNSS/LEO receivers into Low Earth Orbits (LEO) and employing the radio-occultation (RO) technique - as shown before). This RR technique can be investigated within EGOPS. As a first development step in this direction EGOPS V5.0 allows to study all geometrical aspects of RR and allow to investigate and optimize reflection event coverage and statistics.

The RR method bears great utility for fields like operational meteorology, climate monitoring and modelling, due to its potential to globally, and under practically all weather conditions, yield virtually bias-free information on ocean surface wind speed patterns and wave heights with quite good resolution (this could be already demonstrated with GNSS receivers on board of research aircraft). Nevertheless some major improvements of this radio signal detectors are necessary for successful employment of this GNSS/LEO RR signal receivers onboard LEO satellites (especially the sensitivity must be stretched to the technical limits because the received signal strengths due to the not optimal radio reflection characteristics of the rough ocean surface are only a very small fraction compared to the transmitter signal strength available for the RO technique).
Nevertheless enhancing EGOPS to such applications is a quite useful addition and will make the package even broader useful for future GNSS/LEO-related Earth Observation Missions.

REFERENCES FOR DEEPENING THE UNDERSTANDING OF GNSS/LEO OCCULTATION

The brief outline above can be considered drawn from a series of excellent references on GNSS/LEO occultation science and technology. For the convenience of further interested EGOPS User, a small expert's selection of these (which always reflects subjective judgement of course) is given below. References within the more recent of these references readily lead to further original work dealing in depth with specific aspects of the field.

- Overviews for beginners in the field:

Kursinski, E.R., Monitoring the Earth's Atmosphere with GPS, GPS World, Mar'94 issue, 50-54, 1994.

Kirchengast, G., and H.P. Ladreiter, The potential of the radio-occultation technique based on GPS/GLONASS signals for determining fundamental atmospheric parameters (in German), Kleinheub. Ber., 39, 677-686, 1996.

Kursinski, E. R., et al, A Microwave Occultation Observing System to Characterize Atmospheric Water, Temperature, and Geopotential via Absorption. J. Atmos. Oceanic Technol., 19, 1897-1914, 2002.

Kursinski, E. R., et al., An Active Microwave Limb Sounder for Profiling Water Vapour, Ozone, Temperature, Geopotential, Clouds, Isotopes and Stratospheric Winds, in G. Kirchengast, U. Foelsche, and A. K. Steiner (editors), Occultations for Probing Atmosphere and Climate, pp. 173-187, Graz, Austria, Springer-Verlag, Berlin-Heidelberg, 2004.

Silvestrin, P., and P. Ingmann, Radio occultation observations using Global

Navigation Satellite System signals - A new tool for exploring the atmosphere, Earth Obs. Quarterly, 54, 15-18, 1997. (Also WWW-online at http://esapub.esrin.esa.it/eoq/eoq54.htm)

- A few "keynotes" of "historical" interest:

Fjeldbo, G., and V.R. Eshleman, The bistatic radar-occultation method for the study of planetary atmospheres, J. Geophys. Res., 70, 3217-3225, 1965.

Fjeldbo, G., A.J. Kliore, and V.R, Eshleman, The neutral atmosphere of Venus as studied with the Mariner V radio occultation experiments, Astron. J., 76, 123-140, 1971.

Gurvich, A.S., and T.G. Krasilnikova, Navigation satellites for radio sensing of the Earth's atmosphere, Sov. J. Rem. Sensing, 7, 1124-1131, 1990 (Russian original published 1987).

- A few works being both review-like and deeper-going:

Hoeg, P., et al., Derivation of atmospheric properties using a radio-occultation technique, ESA Final Report (ESTEC Contr.No. 11024/94/NL/CN), also DMI Scientific Report 95-4 (ISBN 87-7478-331-9), 208p., 1995.

Kursinski, E.R., et al., Observing Earth's atmosphere with radio occultation measurements using the Global Positioning System, J. Geophys. Res., 102, 23,429-23,465, 1997.

Nielsen, A. S., et al., Characterization of ACE+ LEO-LEO Radio Occultation Measurements. Contr.No. 16743/02/NL/FF, ESTEC, 2003.

- And a few recent works on performance demonstration/validation:

Eriksson, P., et al., Assessment of uncertainties in LEO-LEO transmission observations through the troposphere/stratosphere, Res. Rpt. 186/2001 ESTEC Contr.No. 15341/01/NL/SF, Chalmers Univ. of Technol., Goeteborg, Sweden, 2001.

Ware, R., et al., GPS sounding of the atmosphere from Low Earth Orbit: Preliminary results, Bull. Amer. Met. Soc., 77, 19-40, 1996.

Kursinski, E.R., et al., Initial results of radio occultation of the Earth's atmosphere using the Global Positioning System, Science, 271 (Feb'96), 1107-1110, 1996.

Rocken, C., et al., Analysis and validation of GPS/MET data in the neutral atmosphere, J. Geophys. Res., 103, in press, 1998.

Steiner, A.K., G. Kirchengast, and H.P. Ladreiter, Inversion, error analysis, and validation of GPS/MET occultation data, Ann. Geophys., submitted, 1998.

- Some European GNSS occultation mission planning documents:

ESA (1996), Earth Explorer candidate mission report for assessment, Atmospheric Profiling mission, ESA Spec. Publ., SP-1196(7), 58p., ESA/ESTEC, Noordwijk, The Netherlands, 1996.

GRAS-SAG (1997), GNSS receiver for atmospheric sounding - Science advisory group report, The GRAS instrument on MetOp (Version 1), ESA/EUMETSAT publication, 38p., available, e.g., at ESA/ESTEC, Noordwijk, The Netherlands, 1997.

- Finally, some books to browse for getting acquainted with GNSS:

Hofmann-Wellenhof, B., H. Lichtenegger, and J. Collins, GPS - Theory and Practice, Springer-Verlag, Vienna, 1994.

Parkinson, B.W., and J.J. Spilker Jr. (Ed.), Global Positioning System: Theory and Applications (2 volumes), Progress in astronautics and aeronautics series (Vol.163, 763p., and Vol.164, 643p.), Am.Inst.Aeron.Astron. (AIAA) Publ., Washington, D.C., U.S.A., 1996.

8.5.2 EGOPS Capabilities, Concept and Structure

Having in view the scientific and technical background of GNSS/LEO radio occultation science (cf. the "EGOPS explained... EGOPS Background" Help text), the overall objective of EGOPS is effective treatment of as many as possible relevant aspects of GNSS-LEO and LEO-LEO radio occultation by an integrated, flexible, and user-friendly tool open for continuous improvements.

EGOPS is capable of end-to-end simulation of the GNSS/LEO-based radio-occultation technique and of processing of real occultation data.

More specifically, the major aims and capabilities of EGOPS are

1) Mission analysis and planning for GNSS (GPS/GLONASS) receivers at LEO satellites as well as LEO-LEO satellite constellations (geometry/"shape" of events, coverage, statistics for given GNSS/LEO/ground-station constellations) for occultation or reflection events.
   [Consult the "Help on Task - Help on Mission Analysis/Planning" entry of the "Help" menu for more information.]

2) Simulation of occultation observations, i.e., forward modeling of transmitter signal propagation through the atmosphere/ionosphere system plus effects of the observing system, to obtain quasi-realistic observables (with excess phase and amplitude observables as the primary ones). Airborne occultations can be processed, too (GNSS/LEO signal receivers onboard aircraft instead of LEOs) within the Forward Modeling tool.
   [Consult the "Help on Task - Help on Forward Modeling, Help on Observation System Modeling" entries of the "Help" menu for more information.]

3) Processing of simulated or observed occultation data, i.e., inversion from excess phases and amplitudes, typically via dual frequency Doppler shift, bending angle data and transmission, to atmospheric/ionospheric profiles (EGOPS V5.0 including neutral atmospheric profiles of refractivity, density, pressure, temperature, water vapor [pressure], specific humidity, and liquid water, and ionospheric profiles of total electron content, ionospheric refractivity, and electron density), as well as computation of various data product quality statistics.
   [Consult the "Help on Task - Help on Occ. Data Inv./Retrieval" entry of the "Help" menu for more information.]

For conveniently conveying to the User the results of EGOPS-based studies in the fields addressed by the above three objectives, EGOPS has integrated powerful visualization and validation functionality. It allows the User to effectively interpret any study-related processing results immediately in a user-friendly window-based working environment.

The EGOPS objectives state that EGOPS should be capable of quasi-realistic end-to-end simulation of the GNSS-based and LEO-based radio occultation (GNSS/LEO-RO) technique including mission analysis/planning for LEO-LEO constallations and GNSS receivers in Low Earth Orbit (LEO), simulation of GNSS-RO/LEO-RO observables, and processing of such simulated, and observed RO data, towards atmospheric profiles. For EGOPS V3.0 this concept was enlarged to include also geometry simulations of the GNSS-based radio-reflection (GNSS-RR) technique and offers as additional feature for RO data simulation and processing of ionospheric profiles. As major add on of EGOPS V4.0 it is possible to do mission analysis/planning and simulation of GNSS-RO observables for GNSS receivers installed on board aircraft (called airborne occultations). In addition, post-processing for different types of useful statistical information is possible (e.g., occultation or reflection event coverage statistics or statistics for quantifying the quality of retrieval products), and powerful visualization/validation capability is integrated.
The main new feature of EGOPS V5.0 is that it allows end-to-end simulations of LEO-LEO radio occultations, too.

The high-level structural components of EGOPS shall be briefly further explained below:

-> Mission Analysis/Planning (MAnPl): This component comprises the analysis and planning of single LEO satellites, LEO constellations, and LEO-LEO constellations carrying L-band and/or X/K-band occultation (reflection)

receivers, including antennae field-of-view planning and analysis and visibility analysis w.r.t. ground stations, for assessing, investigating, and optimizing occultation event coverage and related relevant statistics. This will either be done "stand-alone" or as the first stage for planning and selection of useful occultation events then exploited for observation simulations.

-> Forward Modeling (FoMod): In case of interest in observation simulations, this is the natural stage following some planning for occultation events with desired properties (e.g., events occurring in a geographic region of interest, etc.). Forward Modeling (FoMod), together with subsequent Observation System Modeling (OSMod), performs quasi-realistic simulation of observables, and related required variables, of the GNSS/LEO based RO technique. The main observables are time-tagged phase and amplitude measurements, obtained in real world by tracking occulted signals with a LEO platform-mounted receiver during their set/rise through the atmosphere imposed by the relative orbital motion of the transmitter (Tx) and receiver (Rx) satellites.
Forward Modeling itself denotes the simulation of GNSS/LEO signal propagation through the atmosphere/ionosphere system given the orbital motions of the Tx and Rx satellites. It is also possible to simulate so called airborne occultations, whereby the receiver is placed on an aircraft instead of a LEO satellite. It results in "ideal" signals which contain the effects of the atmosphere/ ionosphere media only. Thus FoMod results allow to inspect the environmental influence alone.

-> Observation System Modeling (OSMod): This next stage, following FoMod and using its "ideal" signal and orbit arcs output data, denotes the superposition of all sorts of relevant physical and technical influences of the observation system (antenna, receiver, platform, fiducial sites) on the "ideal" signal (phase and amplitude data) arriving at the receiving antenna, and on the "ideal" orbit data (Tx and Rx positions and velocities). In fact these "ideal" data are the output of Forward Modeling, a necessary prerequisite to be performed before Observation System Modeling can be done.
The most relevant observation system effects to be modeled include precise orbit determination (POD) errors, the antennae gain pattern, receiver noise, local multipath (due to the platform structure in the vicinity of the antenna), and differencing treatment/clocks precision.

-> Occ. Data Inversion/Retrieval (InRet): Inversion/Retrieval processing is the last computation stage of end-to-end simulations. In addition, besides processing of simulated data, it is applicable in an identical manner also to observed data. More specifically, the InRet function performs the processing of simulated or observed phase and amplitude data (supplemented by the necessary geometrical information) typically via Doppler shifts, bending angles and transmissions down to quasi-vertical atmospheric profiles of (complex) refractivity, density, pressure, temperature, and humidity. EGOPS also allows to process ionosphere profiles of total electron content, Doppler shift, bending, refractivity, and electron density.
This processing chain typically requires, sequentially, tools for ionospheric correction and conversion of the "raw" excess phase observables to neutral-atmospheric bending angle profiles, for conversion of the "raw" transmission to normalized transmission profiles, for inversion of bending angle profiles into real refractivity profiles ("Inverse Abel Transform"), for inversion of the transmission profiles into imaginary refractivity profiles, and for finally retrieving the atmospheric variables (e.g., temperature) from (complex) refractivity. The air (in the troposphere) may be considered either dry or moist in the last stage of this processing chain.

-> User I/F and post-processing, visualization and validation:
From the point of view of the EGOPS User I/F, there is a "Task" menu available at main level, which furnishes four generic Task options, i.e., menu entries. These correspond directly to the four main computational parts (MAnPl, FoMod, OSMod, and InRet) outlined above. Thus the simulator fully reflects the natural hierarchy of the simulation problem and the results of one task the User performs (e.g., a MAnPl task) are typically part of the input of the next-stage task (e.g., a FoMod task). (Briefly on what EGOPS "tasks" are: these are the individual computational scenarios comprised by an EGOPS Project. A task corresponds to computing a specific scenario by employing one of the four generic Task options. - For more information on "tasks", see the "Help on Task - About Tasks" entry of the "Help" menu.)

The link between the "Task" menu entries and the computational parts is provided by the four modules "MAnPl Input", "FoMod Input", "OSMod Input", and

"InRet Input", which correspond to four User I/F window interfaces, each one accessed by a specific "Task" menu entry. These Input modules directly supply the User input data to their respective computational tasks.

After any stage, post-processing and visualization/validation is possible for the results so far computed, by employing the EGOPS "Visualization/Validation System", which corresponds, at User I/F level, to the "Visualize/Validate" menu. The modular parts of this System are "MAnPl Profiles", "Geographic Maps", "Profiles", "Volume Data", and "Data Animation".

8.5.3 Written Documentation about EGOPS

The primary source for written documentation on EGOPS is the

EGOPS Software User Manual

which is received, together with the software package, by every User who acquires a version of EGOPS.

The User Manual essentially contains all information of the On-line Help text available within EGOPS plus, in addition, a documentation of example simulations and their results which were worked out within two exemplary EGOPS Projects. These example projects may be quite instructive to more or less recent Users who can probably gain much from seeing demonstrated many of the functions of EGOPS in a practical work context.

BACKGROUND DOCUMENTATION

For learning about the functionality furnished by EGOPS and for getting an overview on its background, rationale, requirements, and implementation the following reports are useful:

Kirchengast, G., End-to-end GNSS Occultation Performance Simulator functionality definition, Techn. Rep. for ESA/ESTEC No. 1/'96, 25p., Inst. Meteorol. Geophys., Univ. of Graz, Austria, 1996.

Kirchengast, G., End-to-end GNSS Occultation Performance Simulator overview and exemplary applications, Wissenschaftl. Ber. No. 2/1998, 138p. (PartI-III), Inst. Meteorol. Geophys., Univ. of Graz, Austria, 1998.

A more detailed (and more formal) summary of all requirements of the S/W design is URD and ADD in a User & Software Requirements document which, in turn, formed the basis for the software design described in an Architectural & Detailed Design document.

The latter two technical documents, which provide a rather detailed description of the EGOPS software, are of interest to (expert) Users needing to get very closely acquainted with technical details of the software.

8.5.4 EGOPS Release Notes

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                  EGOPS Release Notes  =
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 =
  = EGOPS (End-to-end Generic Occultation Performance Simulator)
   =
     =   EGOPS(R) V5.2, Release#2, issued on September 28, 2007.
      =      (c) IGAM/UG et al. 1997-2007. - All Rights Reserved.
       =
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These Release Notes comprise brief information on the following topics:

   - Contents of the EGOPS Software Package

   - Where to find the EGOPS Installation Guidelines


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                    ******************************
                    *** EGOPS Software Package ***
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You should have received:

 - A binary compressed archive file named EGOPS_v52r2.tar.gz.
   (EGOPS Version 5.2, Release#2)
   This archive file contains the entire EGOPS software package.

 - A binary compressed archive file named EGOPSv52_SUM.tar.gz;
   This archive file contains the EGOPS, Version 5, Software User Manual in
   form of a pdf file package comprising an overview, a reference and a
   file format manual part (EGOPSv52_SUM-OV.pdf, EGOPSv52_SUM-REF.pdf, and
   EGOPSv52_SUM-FF.pdf).

 - An ASCII text file named EGOPS.ReadMe, the text you are
   currently reading.


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                   ************************************
                   *** EGOPS Installation Guidelines ***
                   ************************************


 Detailed step-by-step EGOPS Installation Guidelines are provided in Section 5
 of the EGOPS Software User Manual - Overview Manual (EGOPS5_SUM-OV.pdf).
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8.5.5 About EGOPS...

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                                 E G O P S 5 =
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              End-to-end Generic Occultation Performance Simulator
              Version 5.2, Release#2, issued on September 28, 2007

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DISCLAIMER OF WARRANTY

Considerable effort has been put into the development of EGOPS V5.2 and
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Nevertheless, no warranties are made, expressed or implied, that EGOPS V5.2
is free of error, or that it will entirely meet the requirements of any
particular application. EGOPS V5.2 should not be solely relied on for
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