ACE+ — Atmosphere and Climate Explorer

Based on GPS, GALILEO, and LEO-LEO Radio Occultation

Main Scientific Goals

Accurate observations of humidity and temperature in the troposphere and stratosphere - including their variability - are highly important in climate change research (IPCC, 2001). ACE+ serves this need with its mission goals:

- To **measure** climatic variations and trends at different vertical levels and throughout all seasons. This in order to improve our understanding of the climate system as well as to detect different fingerprints of global warming;
- To **improve the understanding** of climatic feedbacks defining the magnitude and characteristics of climate changes in response to given forcings;
- To **validate** the simulated mean climate and its variability in global climate models;
- To **improve** - via data assimilation - the **parameterisation** of unresolved processes in climate models and the quantification of variations in external forcing of climate.

Mission Objectives

Primary objectives:

- Measurement of climate variability and trends as an initial key component of long-term occultation observations of climate,
- Contribution to detection of climate changes and support of climate change predictions via high-quality global reference data,
- Validation of global circulation models (GCMs), both in simulated mean climate and climate variability,
- Improvement, via data assimilation methods, of physics parameterisations in GCMs, and of external forcing knowledge,
- Improvement of the understanding of climate feedbacks determining magnitude and properties of climate changes,
- Study of atmospheric structures and processes in the troposphere and tropopause regions at high vertical resolution,
- Demonstration of the novel LEO-LEO occultation technique, and of the novel use of GALILEO-LEO occultation.

Secondary objectives:

- Contribution to improved numerical weather prediction (NWP),
- Support of analysis, validation, and calibration of data from other space missions.

Spin-off objectives:

- Ionosphere and space weather investigations,
- Assessment and improvement of present water vapour attenuation models,
- Study of turbulence in the lower troposphere.

Observational Requirements

Horizontal coverage	global
Horizontal sampling	< 700–1600 km
Vertical domain	2–15 km for humidity 2–50 km for temperature
Vertical resolution	1–2 km
Temporal sampling	< 12–24 hrs
Accuracy of humidity	< 0.003–1 g/kg rms
Long-term stability humi.	< 2% RH / decade
Accuracy of temperature	< 1 K rms
Long-term stability temp.	< 0.1 K / decade
Spatial distribution	homogeneous over each day
Local time (LT) distribution	homogeneous, or fixed LT
Mission duration	5 years

Mission Elements

Space segment:

Small constellation of micro-satellites, each of them carrying:

- a precision L-band receiver and related antennae for GPS/GALILEO-LEO occultations
- a precision X/K-band transmitter (on 2 satellites) and receiver (on 2 counter-rotating satellites) and related antennae for LEO-LEO occultations (3 frequencies)

Ground segment:

- Satellite operation and control
- Fiducial stations for Precise Orbit Determination
- Level 1b processing and archiving centre
- Science data centres for higher level product generation and for data assimilation

Data products:

Profiles of bending angle and transmission, and retrieved profiles of refractivity, humidity, temperature, and pressure (or geopotential height) as a function of height.

System Concept

- 4 micro-satellites in 2 sun-synchronous orbits, each satellite: mass ~150 kg and power ~80 W,
- flying in a stable constellation (2 counter-rotating orbits) – to optimise the quality of occultation measurements,
- at two altitudes (~650 km and ~800 km, 2 satellites/orbit) – to optimise the spatial distribution of occultations.

ACE+ was selected, in May 2002, as top-priority future ESA Earth Explorer Opportunity Mission

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