Analysis of Metop/GRAS data products with new on-board tracking parameters and L2 extrapolation

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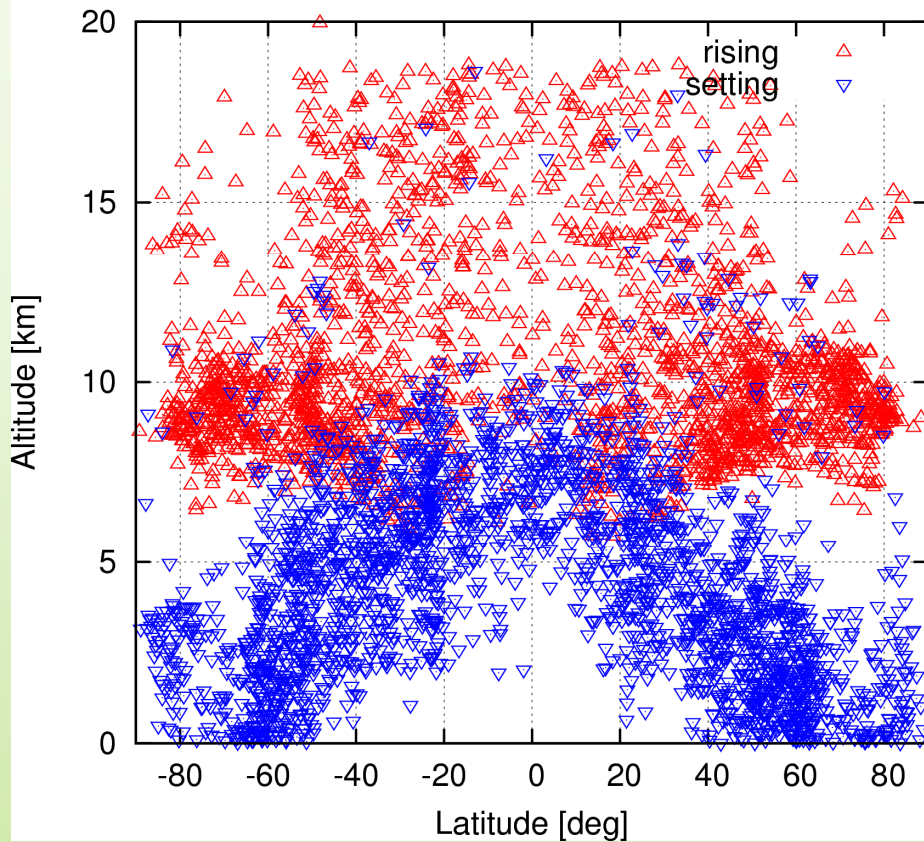
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Background

- Metop-B launched on September 17, 2012

- GRAS firmware parameter tests January 14 – March 25, 2013

- New parameter settings (for good reasons):

  - Reduced data gaps in closed loop and raw sampling tracking

  - Minimized cases of low L2 SNR

  - Drawback: L2 signal usually captured much later for rising occultations (~20 km)

  - EUMETSAT CF enabled L2 extrapolation into the troposphere

- The same parameters were later also uploaded to Metop-A (June 25)

- The ROM SAF resumed dissemination of Metop-B refractivity in demonstration mode on April 8 – with one particular outstanding issue notified to the users…

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General improvement in penetration depths (Metop-A)

Penetration depth, March 26 - April 3 (Metop-A)

Penetration depth, July 26 - August 3 (Metop-A)
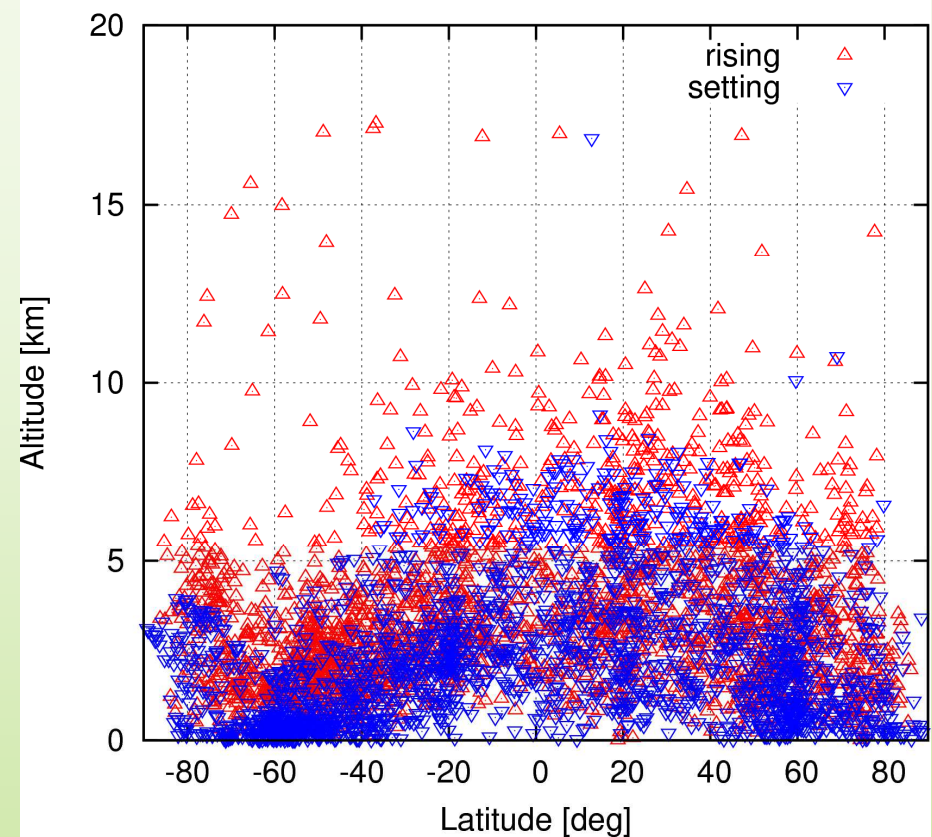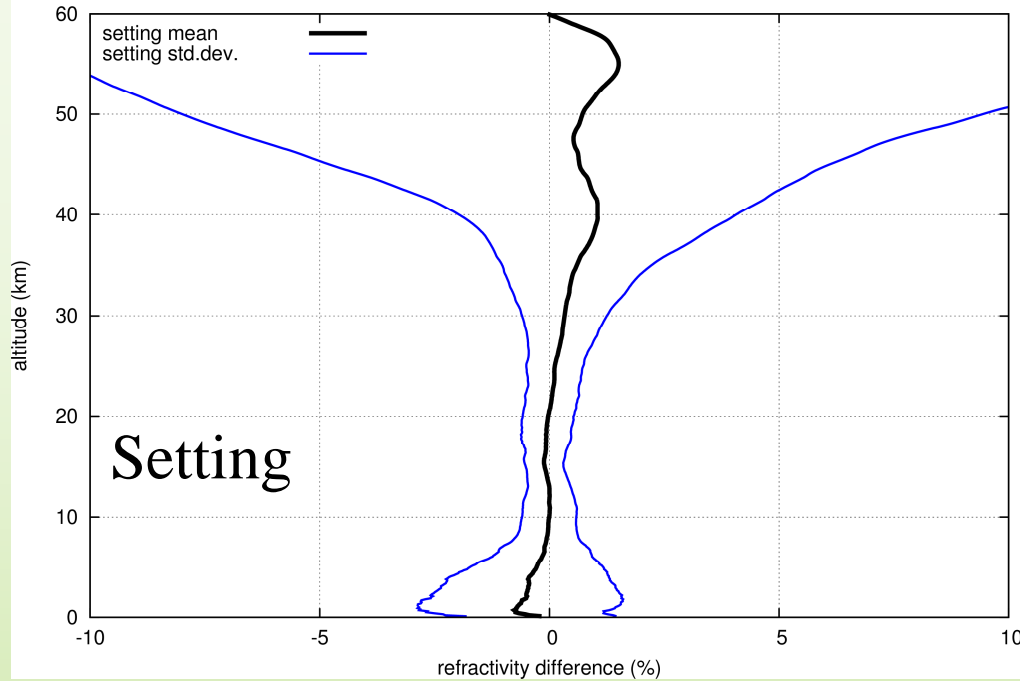
Before upload to Metop-A:

- No L2 extrapolation
- Rising (closed loop) starts around 8-10 km
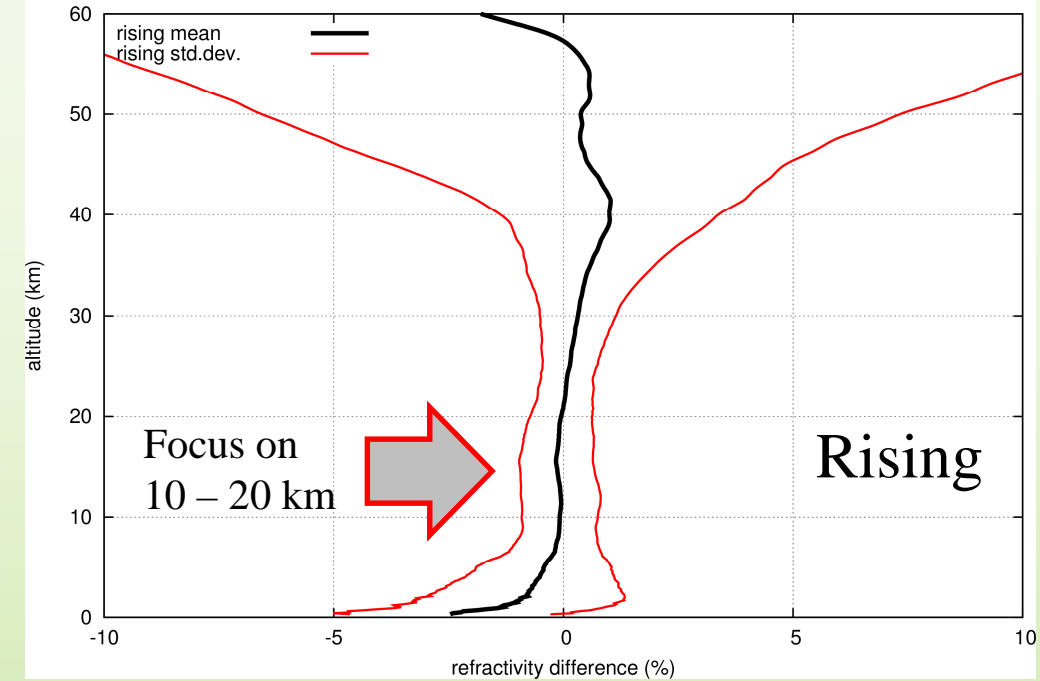- Setting (closed loop) stops high in tropics

After upload to Metop-A:

- L2 extrapolation enabled
- Both setting and rising goes to lower altitudes, in particular rising

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First refractivity statistics against ECMWF (Metop-B)


- Will focus mostly on Metop-B in the following (same problem with Metop-A)
- Will show some scaring (seemingly mysterious) statistics – and some ugly data
- Prompted the ROM SAF to introduce an extra QC check on refractivity
- Problem relates to the L2 extrapolation; EUMETSAT CF is aware of the problem and working on improving/replacing the extrapolation algorithm
- Don't pay attention to stuff below ~8 km (GO processing; closed loop)

Global statistics against ECMWF, March – April (9 days)
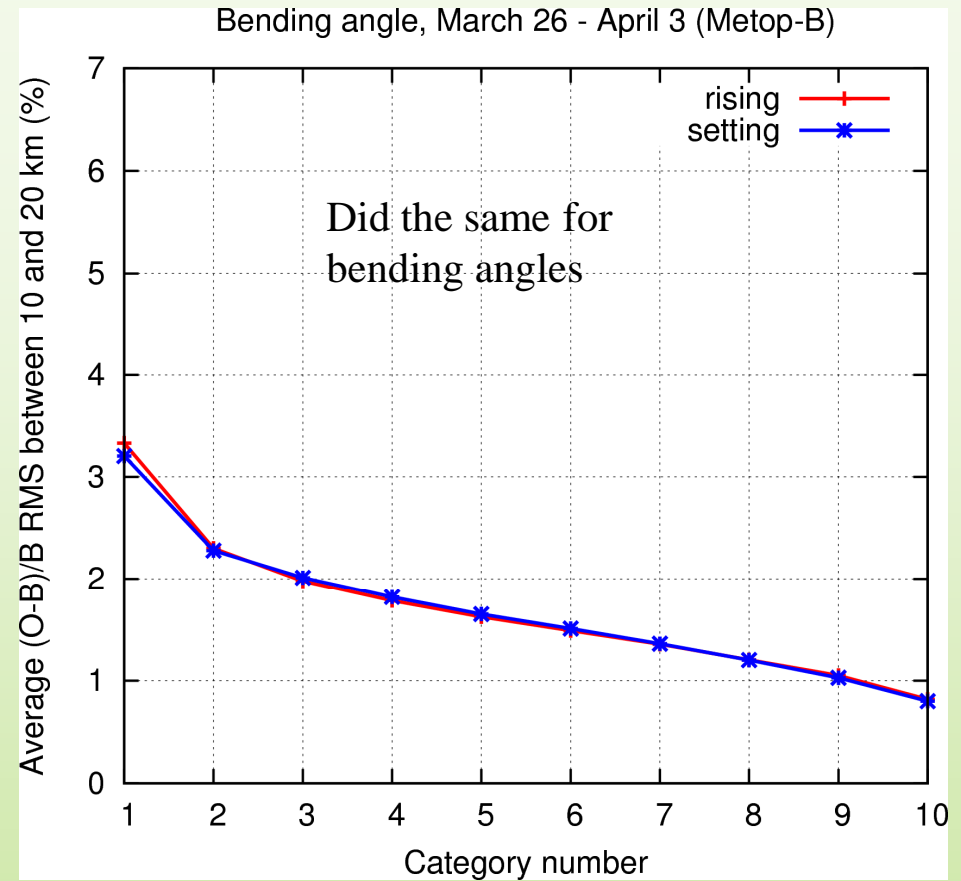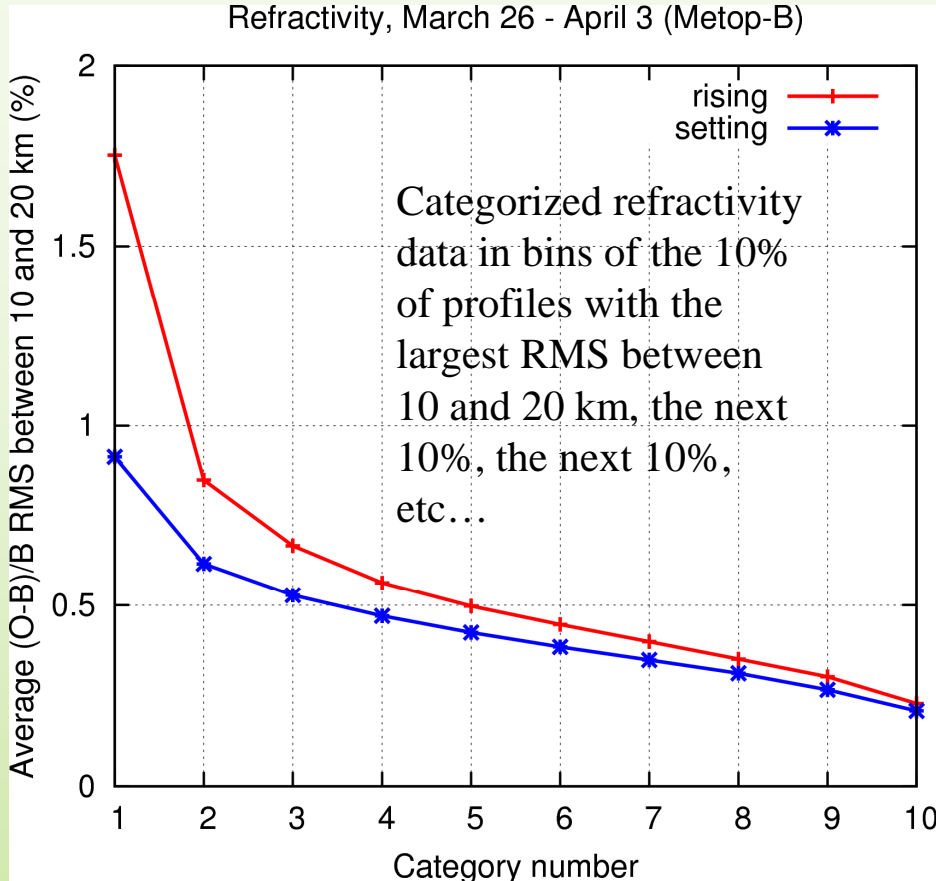

Refractivity, March 26 - April 3 (Metop-B)
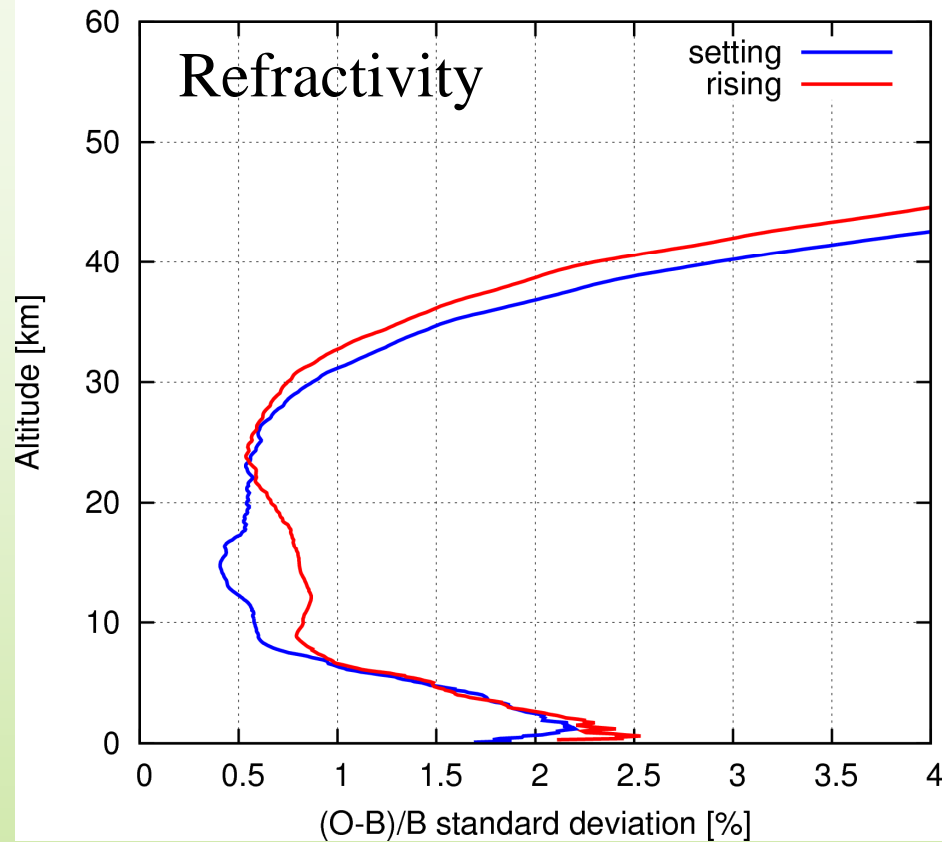
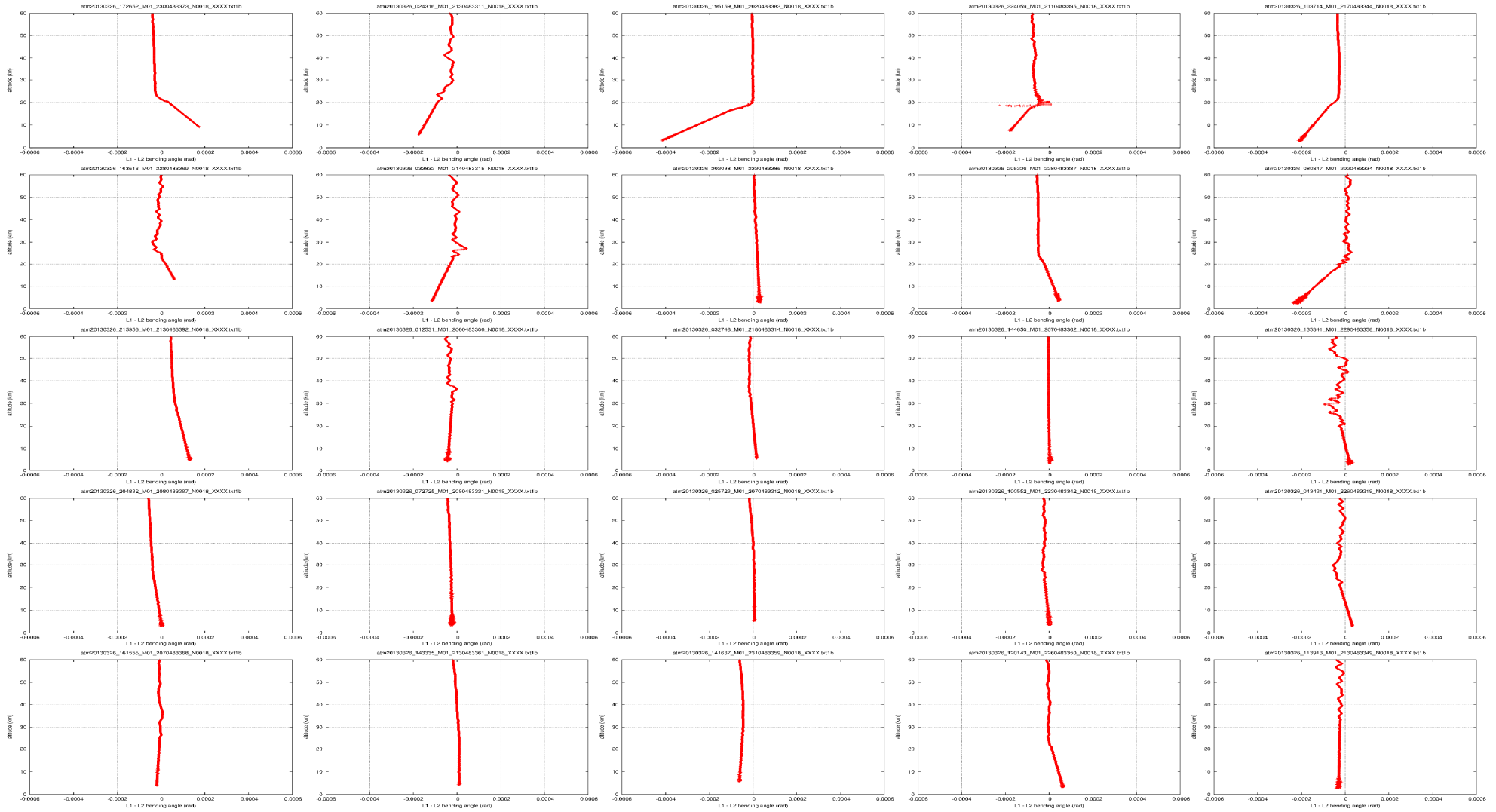Bending angle, March 26 - April 3 (Metop-B)
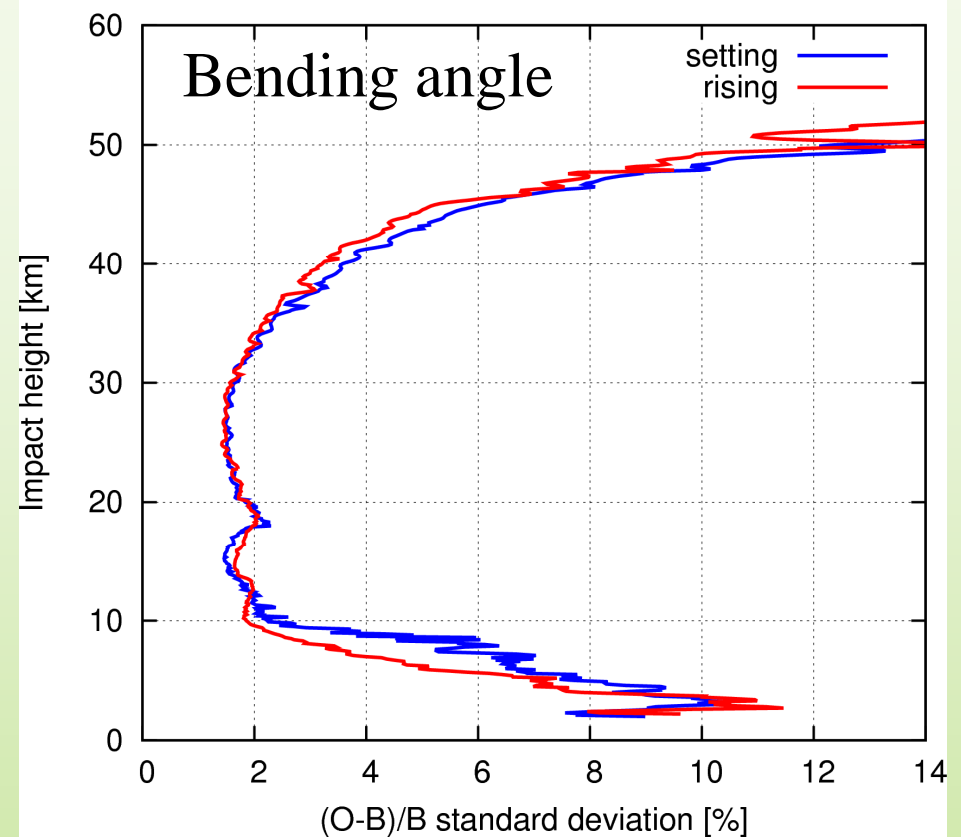
- Refractivity: Almost a factor of two larger std.dev. for rising occs. between 10 and 20 km
- Bending angle: Nothing (or very little) to see – this is why it wasn't noticed at EUMETSAT

Global statistics against ECMWF, March – April (9 days)

Refractivity, March 26 - April 3 (Metop-B)

Bending angle, March 26 - April 3 (Metop-B)

Categorized refractivity data in bins of the 10% of profiles with the largest RMS between 10 and 20 km, the next 10%, the next 10%, etc…
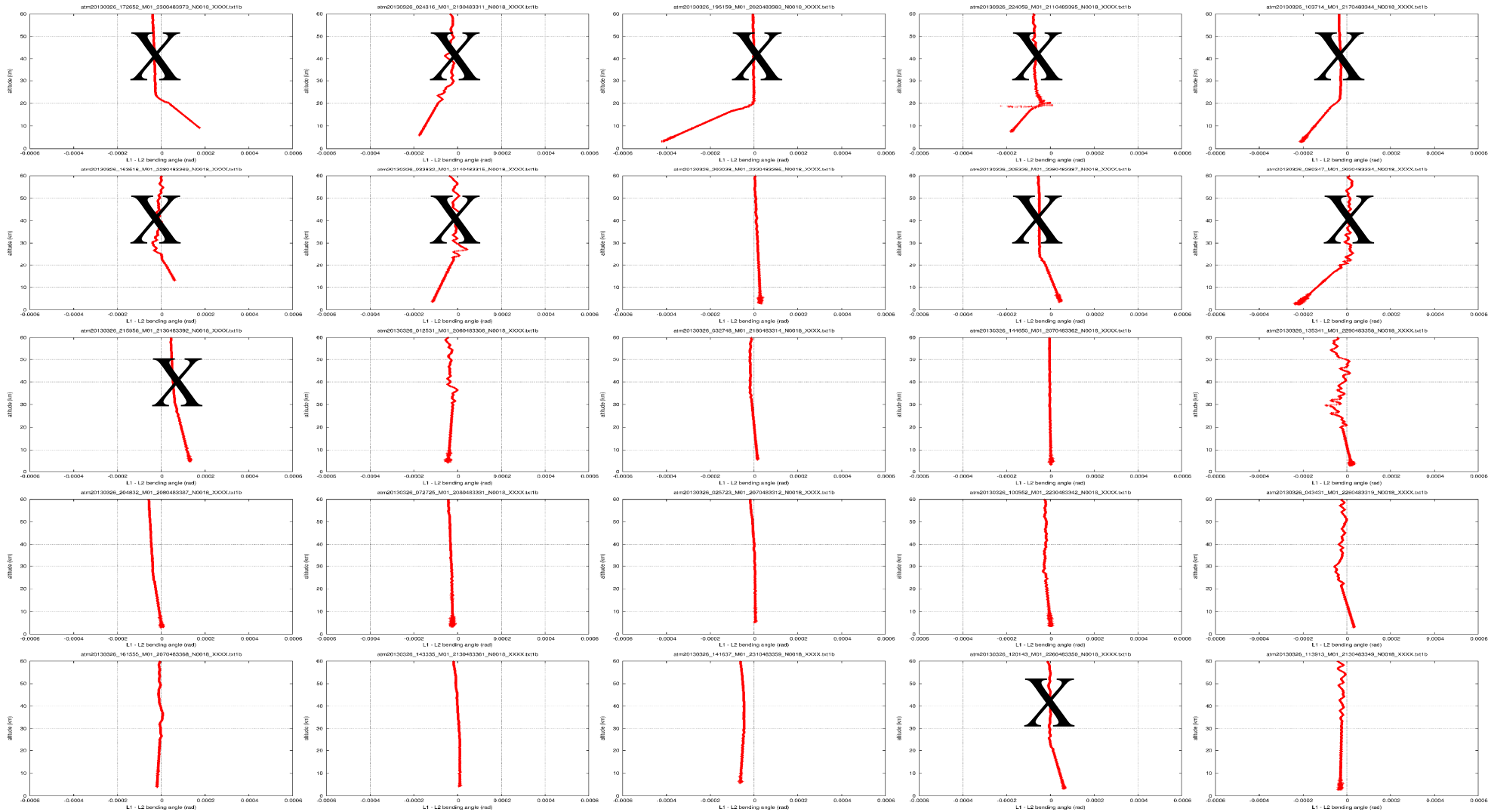
Did the same for bending angles

- Refractivity binning shows that we are not just looking at a few outliers
- But we cannot really see them in bending angle statistics
- Where/what are they…?

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X-axis is ± 600 µrad; Y-axis is 0-60 km

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X-axis is ± 600 μrad; Y-axis is 0-60 km

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Removing the largest L1 – L2 outliers (1 day)
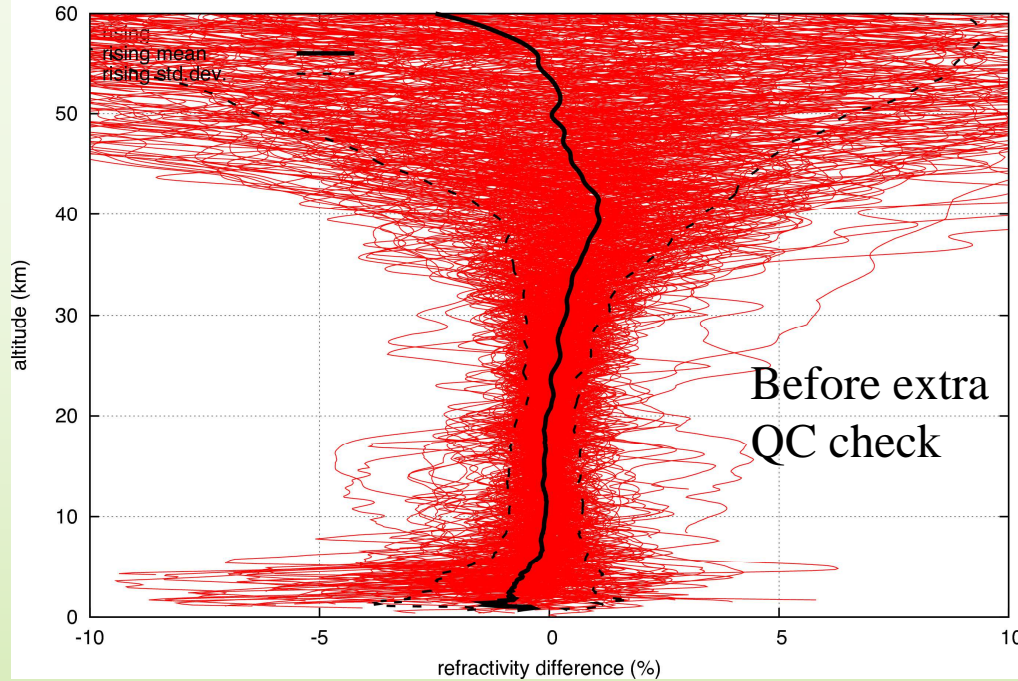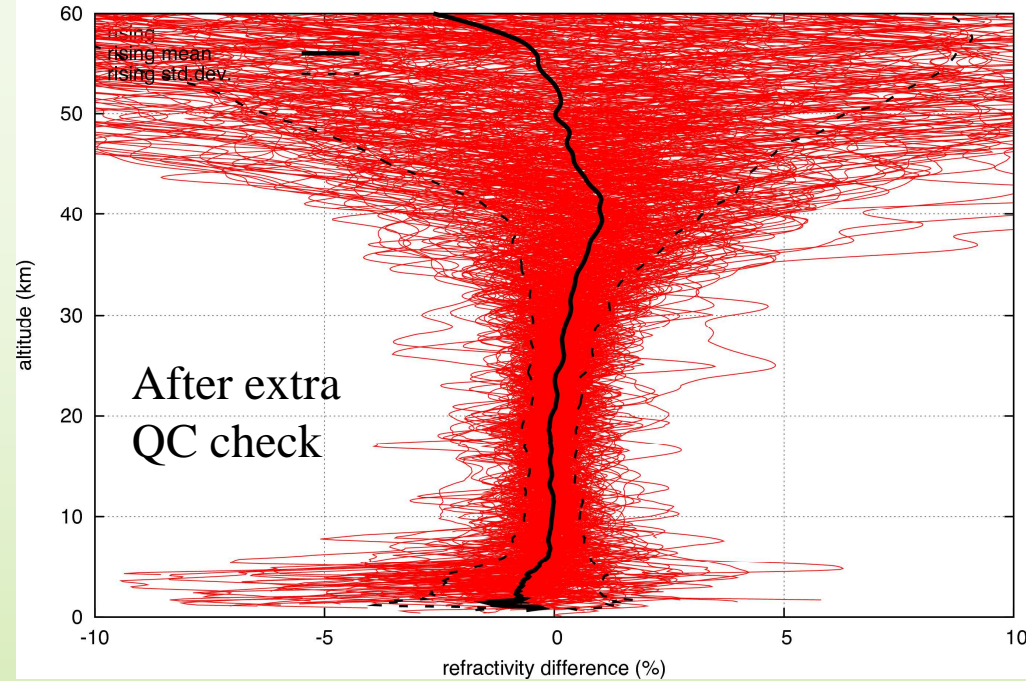
- Δ_{upper}: median L1 – L2 BA difference between 30 and 60 km
- Δ_{lower}: median L1 – L2 BA difference between 0 and 20 km
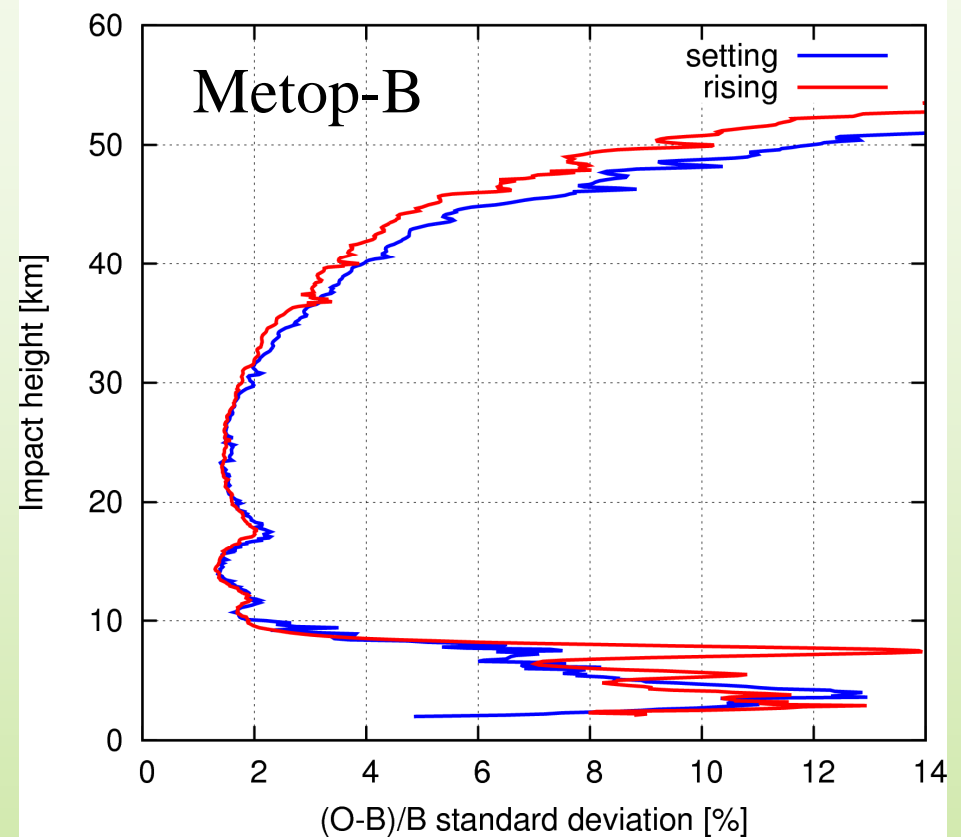- Excluded profiles with $|\Delta_{upper} - \Delta_{lower}| > $ threshold (0.0005 rad)
- Only for rising occultations – didn't work well for setting
- Catching about 6-7 % of rising occultations (flagged as bad)
- Reduced standard deviation significantly

Global statistics against ECMWF, July – August (9 days)

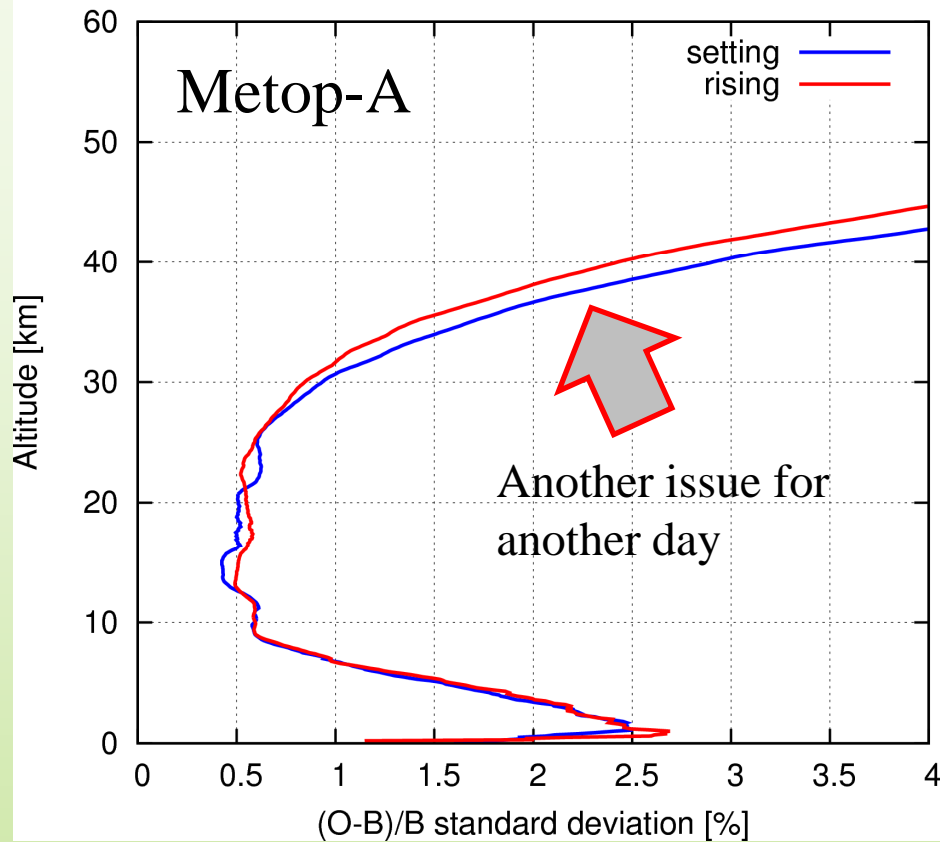Refractivity, July 26 - August 3 (Metop-B)
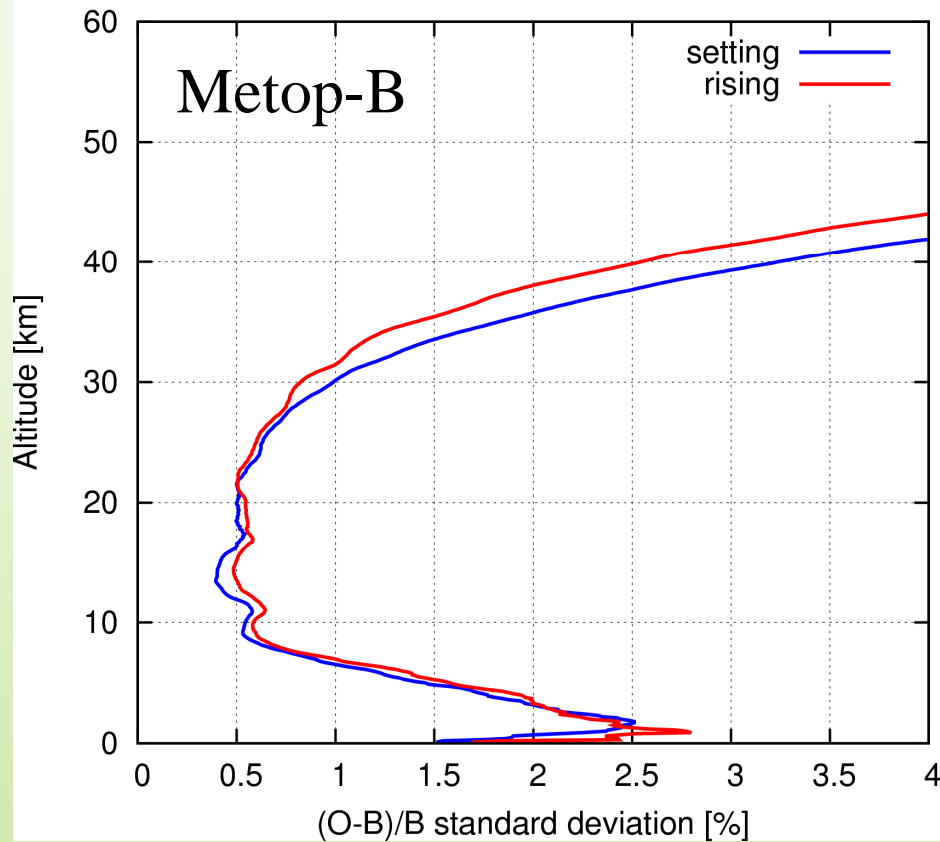
Bending angle, July 26 - August 3 (Metop-B)

- Extra QC check went into ROM SAF NRT operations on June 20

- Had immediate effect on Metop-B data

- Had effect on Metop-A data after EUMETSAT CF upload on June 25

Global statistics against ECMWF, July – August (9 days)

Refractivity, July 26 - August 3 (Metop-A)

Bending angle, July 26 - August 3 (Metop-A)

Metop-A

Metop-A

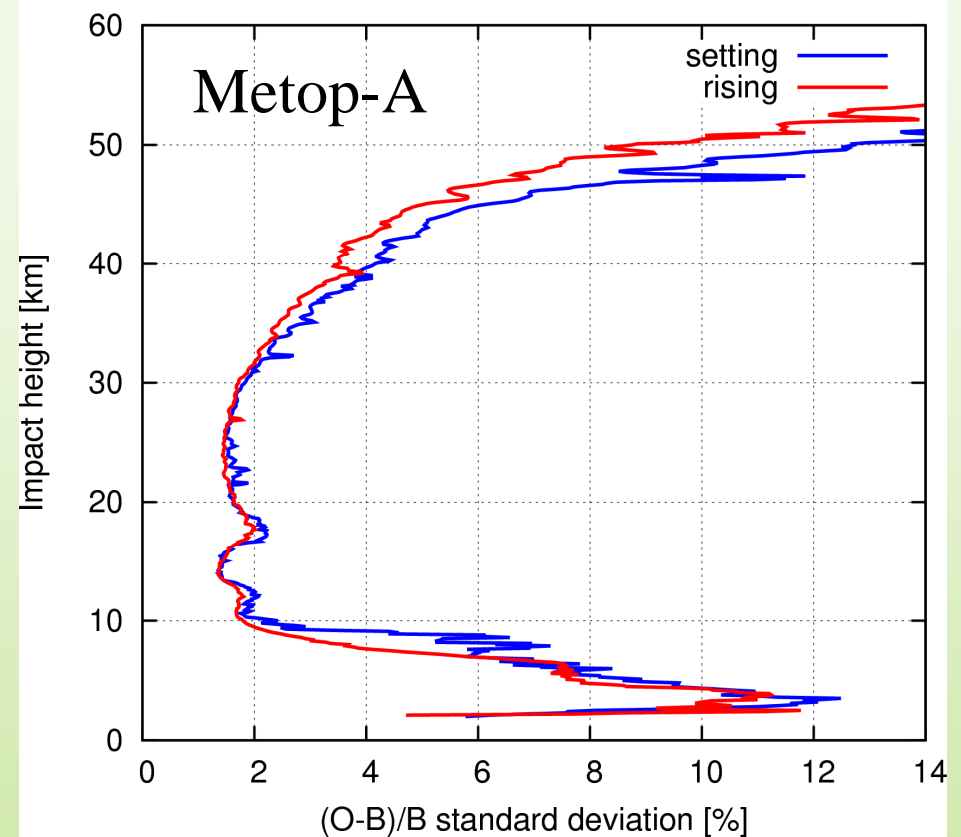setting
rising

Another issue for
another day

- Extra QC check went into ROM SAF NRT operations on June 20
- Had immediate effect on Metop-B data
- Had effect on Metop-A data after EUMETSAT CF upload on June 25

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Global statistics against ECMWF, July – August (9 days)

Refractivity, July 26 - August 3 (Metop-B)

Categorized refractivity data in bins of the 10% of profiles with the largest RMS between 10 and 20 km, the next 10%, the next 10%, etc…

Bending angle, July 26 - August 3 (Metop-B)

Did the same for bending angles

- Extra QC check is not catching everything – still small 'outliers' left
- Trade-off between quality and quantity
- Now there is a slightly <u>smaller</u> std.dev. in BA for rising occs.
- How can we understand what is going on?

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A lesson on error propagation

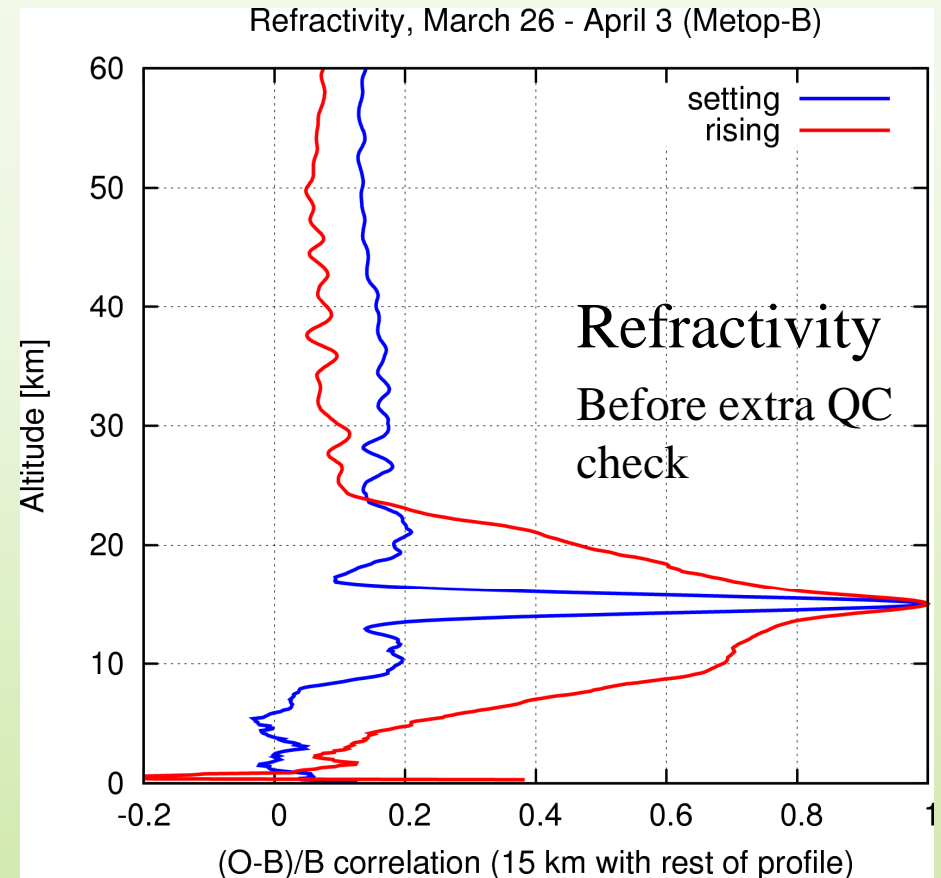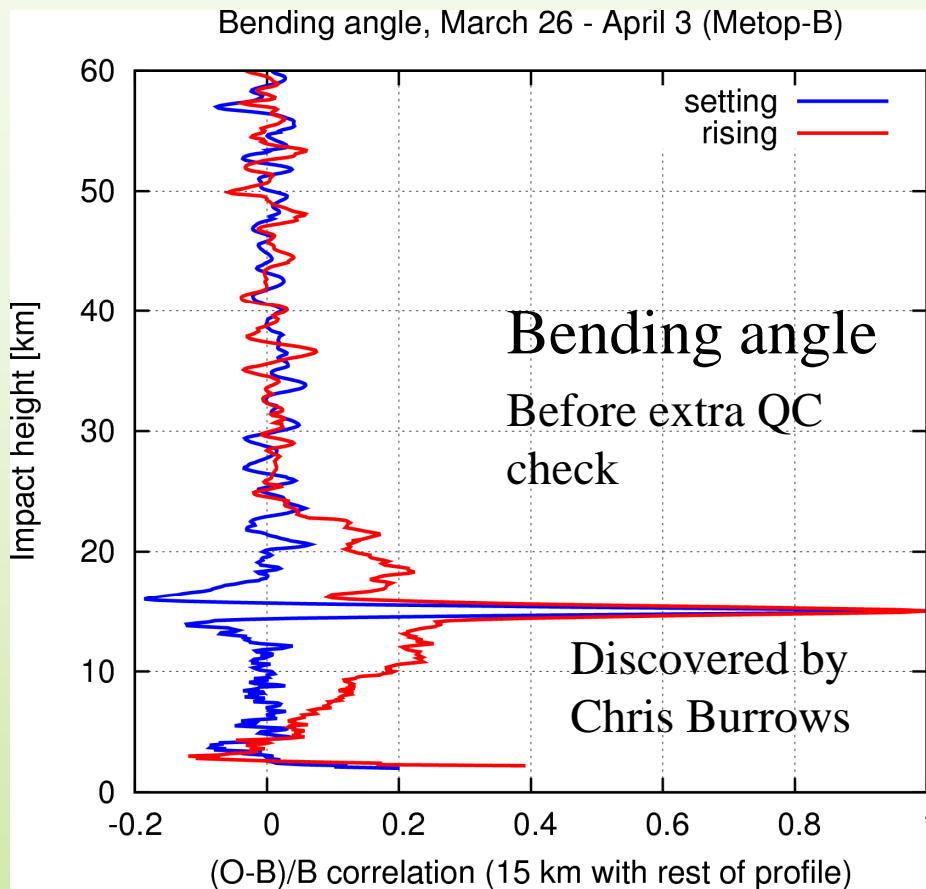L1 - L2 Bending angle · LC Bending angle · Refractivity
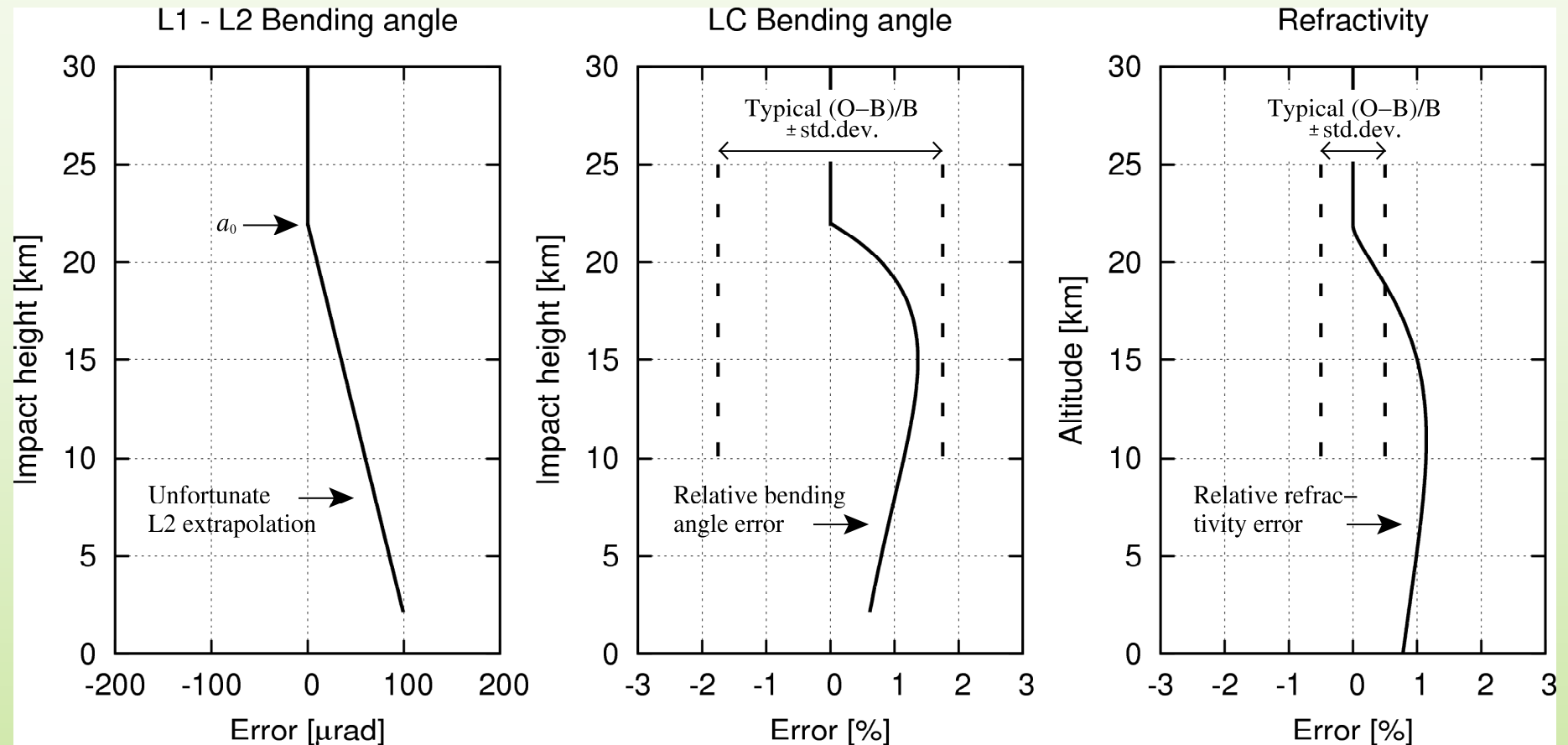
$$\alpha_1 - \alpha_2 \propto (a_0 - a)$$

$$\frac{\Delta\alpha}{\alpha} \propto \frac{(a_0 - a)}{\alpha}$$

$$\frac{\Delta N}{N} \propto \frac{(a_0 - a)^{3/2}}{\alpha}$$

A simple problem that can be solved analytically (with minor approximations)

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Global statistics against ECMWF, March – April (9 days)

Bending angle, March 26 - April 3 (Metop-B)

Bending angle

Before extra QC check

Discovered by Chris Burrows

Refractivity, March 26 - April 3 (Metop-B)

Refractivity

Before extra QC check

- Large impact on error correlations, also in bending angle
- Propagates and amplifies to refractivity
- The correlations are not really the problem, but a symptom of the problem

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Global statistics against ECMWF, July – August (9 days)

Bending angle, July 26 - August 3 (Metop-B)
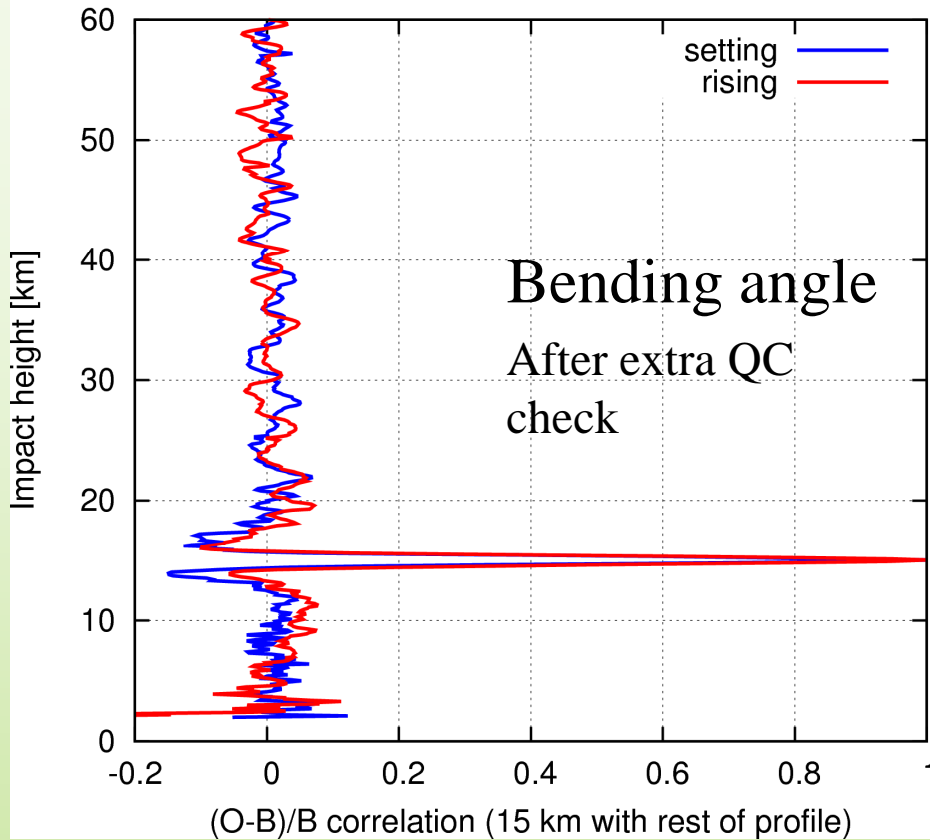
Bending angle

After extra QC check

Refractivity, July 26 - August 3 (Metop-B)

Another issue for another day

Refractivity

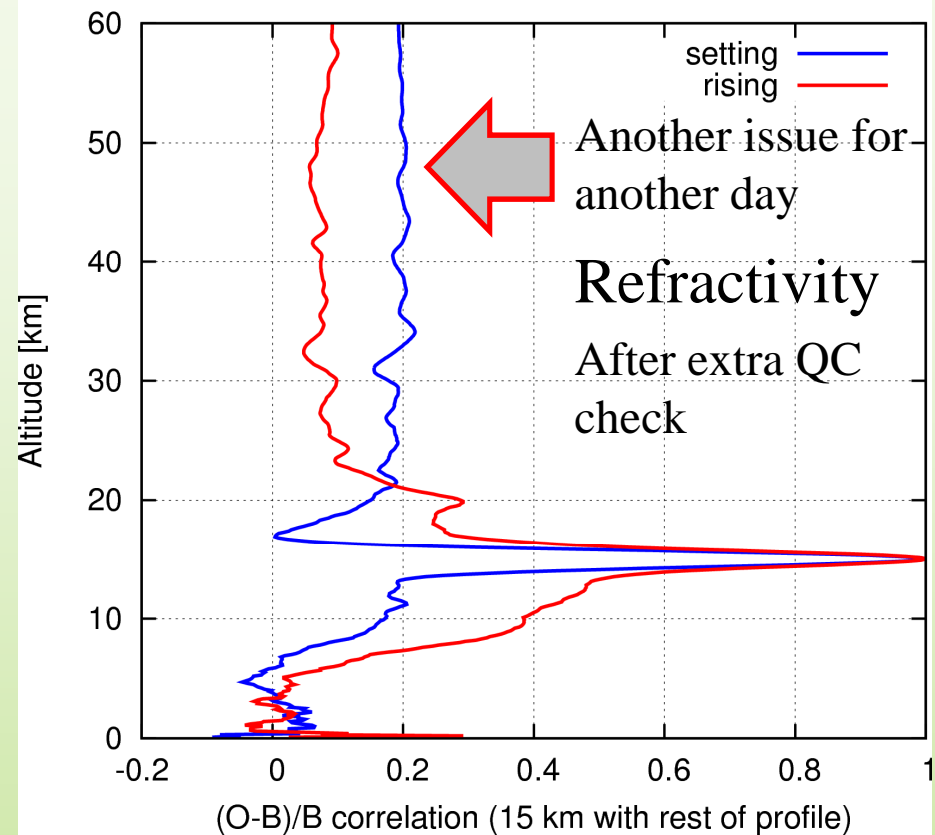After extra QC check

- Large impact on error correlations, also in bending angle
- Propagates and amplifies to refractivity
- The correlations are not really the problem, but a symptom of the problem
- Still an issue after the extra QC check – but less severe

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Final remarks

- Lesson learned: "what you see is not always what you get"; correlations can reveal things that we don't usually see in the mean and std.dev.

- What is the impact on the assimilation of bending angles and refractivity if the largest of these outliers are not removed?

- The ROM SAF does not remove these outliers, we just flag them; important that users look at the 'pcd' bit-flag (we only set the non-nominal refractivity and summary bits – not the BA bit). EUMETSAT is working on removing them.

- NWP centers have their own QC checks. Would they catch these outliers in bending angle? Do they do any harm?

- No one has complained yet!

Can we really trust the forecast for tomorrows excursion?

It says sunny and 22°C!