SCIAMACHY solar occultation: Tangent height determination and water vapor profile retrieval

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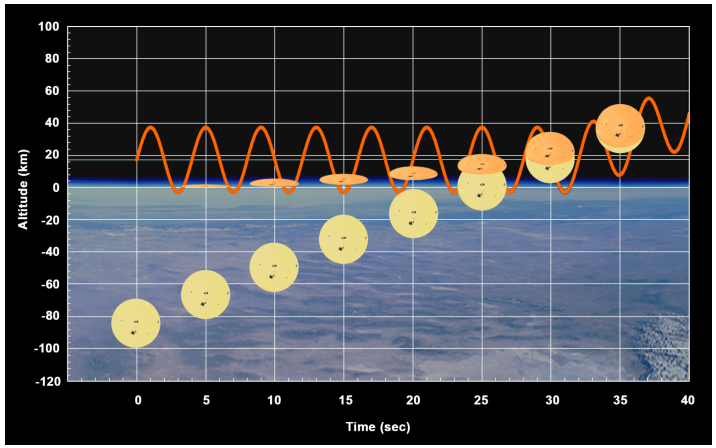

Outline

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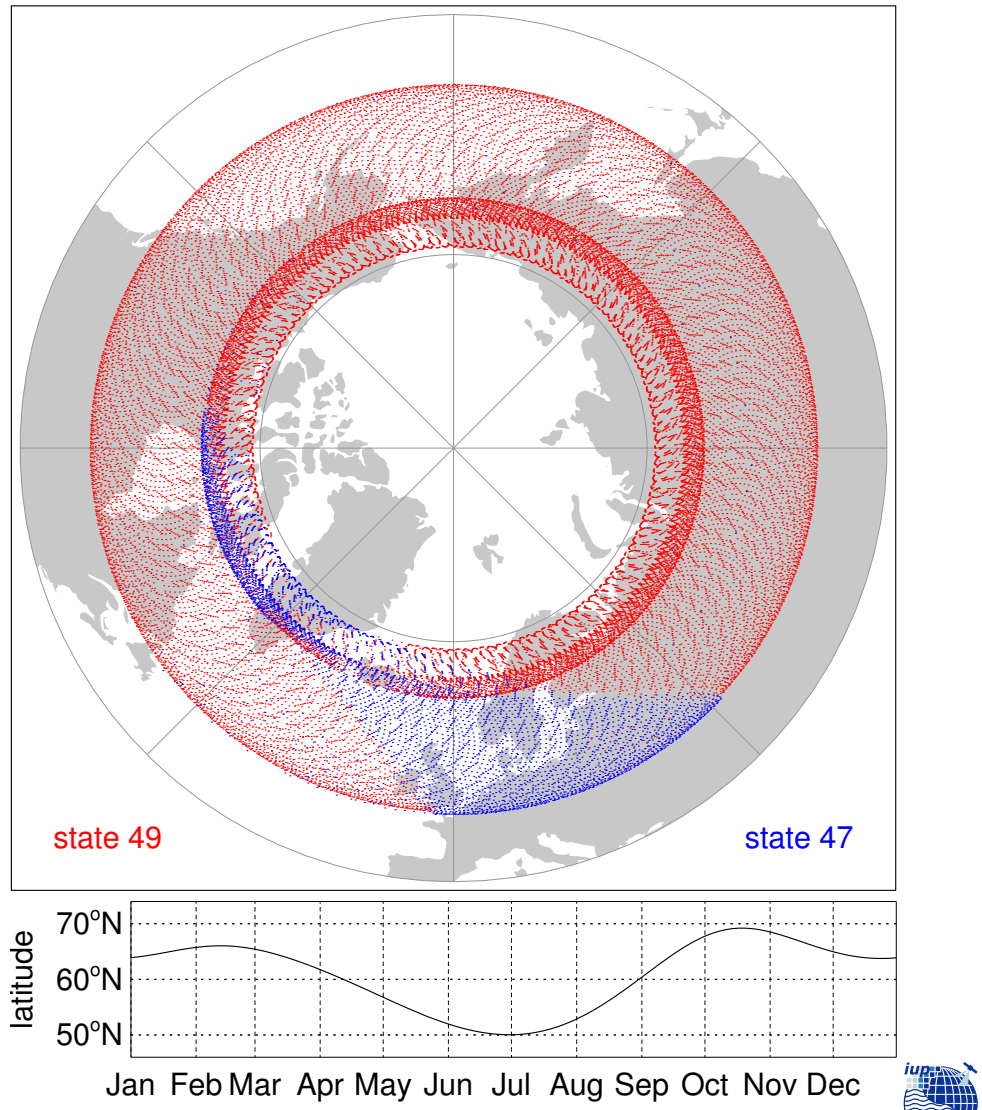
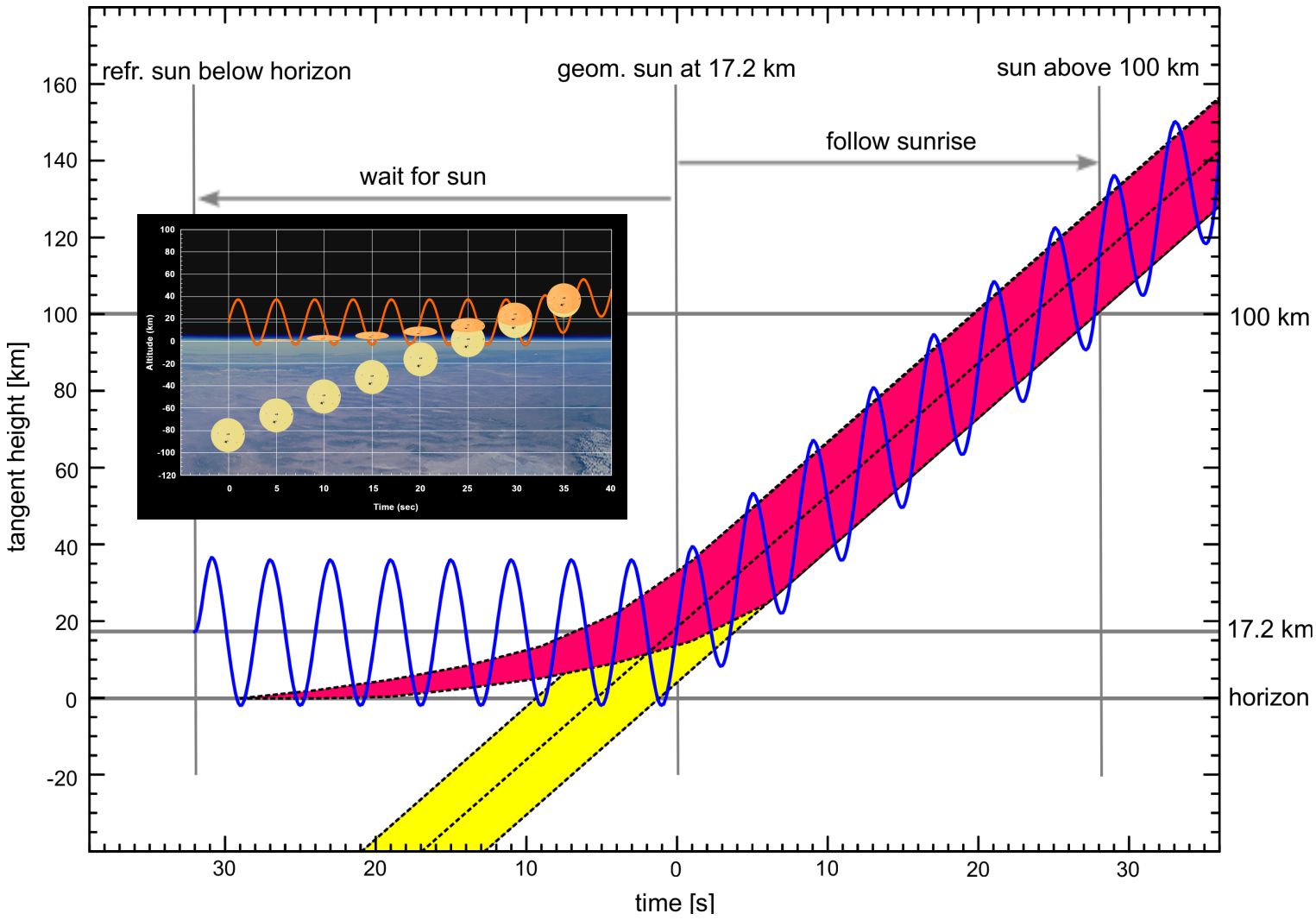
SCIAMACHY

- Sun-synchronous orbit on-board EnviSat, March 2002 - April 2012
- Imaging spectrometer
  240 - 2380 nm, 8 channels,
  0.2 - 1.5 nm spectral resolution
- Viewing Geometries:
  - Nadir: columns / clouds
  - Limb: profiles with global coverage
  - Solar occultation: profiles once per orbit, NH
  - Lunar occultation: profiles SH, when moon is in FOV (phase $>$0.5)



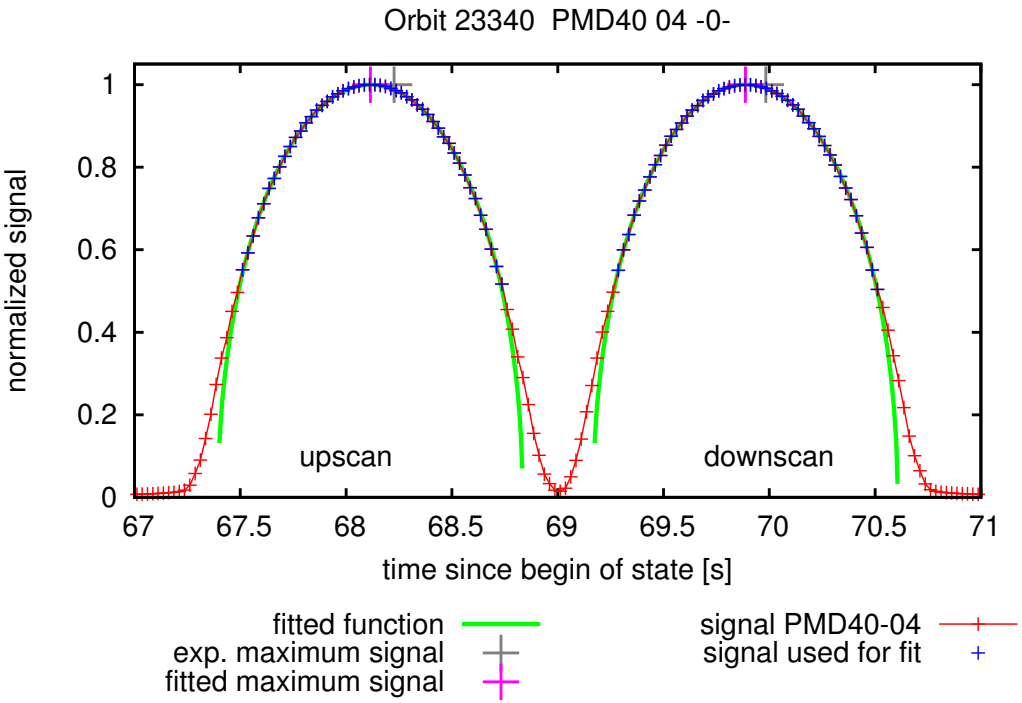
Solar Occultation Measurement Sequence



- Scan over solar disk!
- Wait for sun, until geometric sun reaches 17.2km
- Follow sunrise with pre-calculated rate up to 280 km
- Observed is sunset on ground!

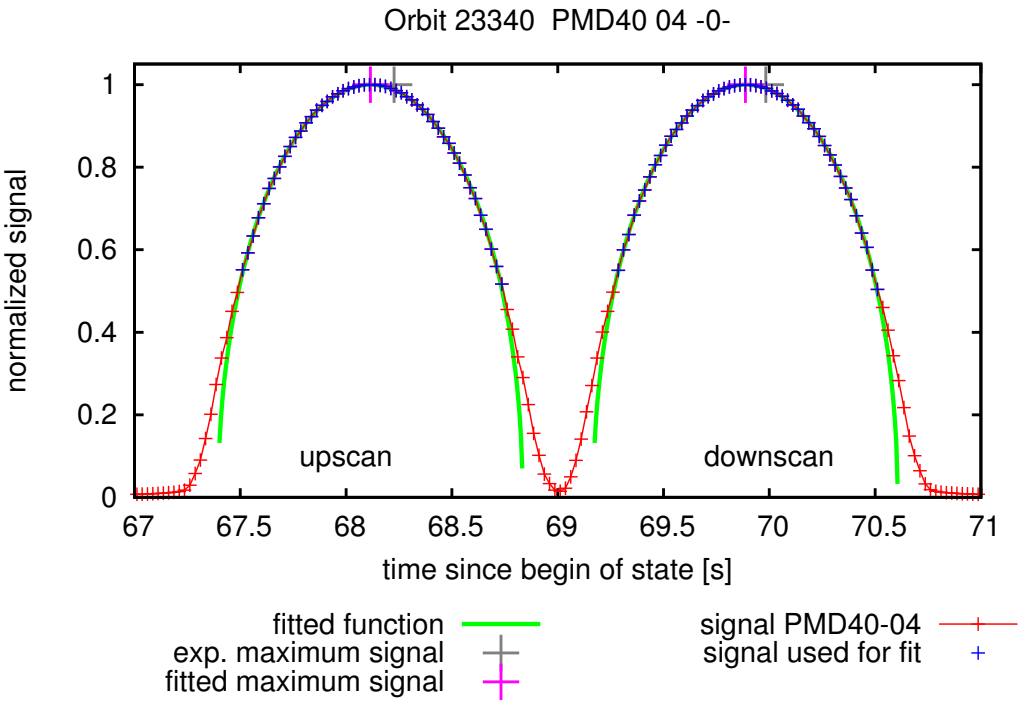
Outline

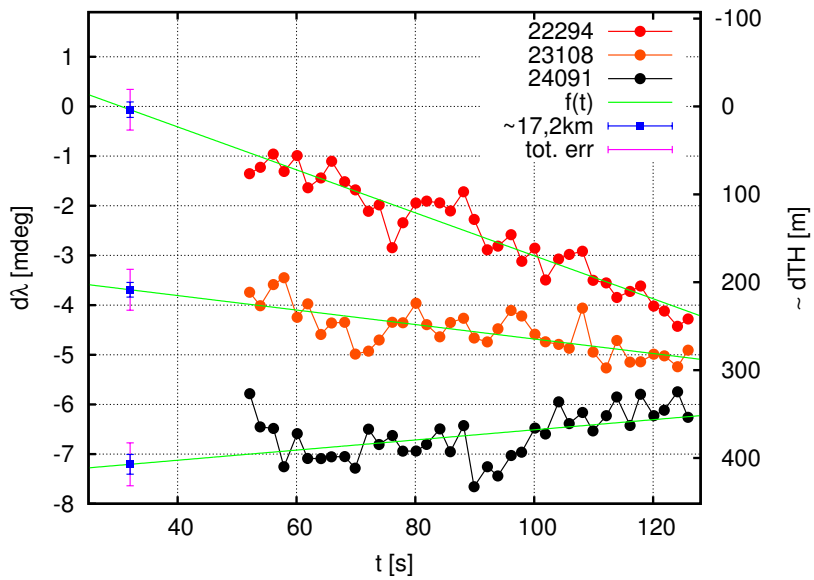
Elevation Angle / Tangent Height offset



- Pointing knowledge important for occultation measurements
- Idea: Fit the center of the solar disk from intensity function of the scans over the solar disk.
- Difference to the calculated solar position (according to platform attitude information) is a mispointing in elevation.

Elevation Angle / Tangent Height offset





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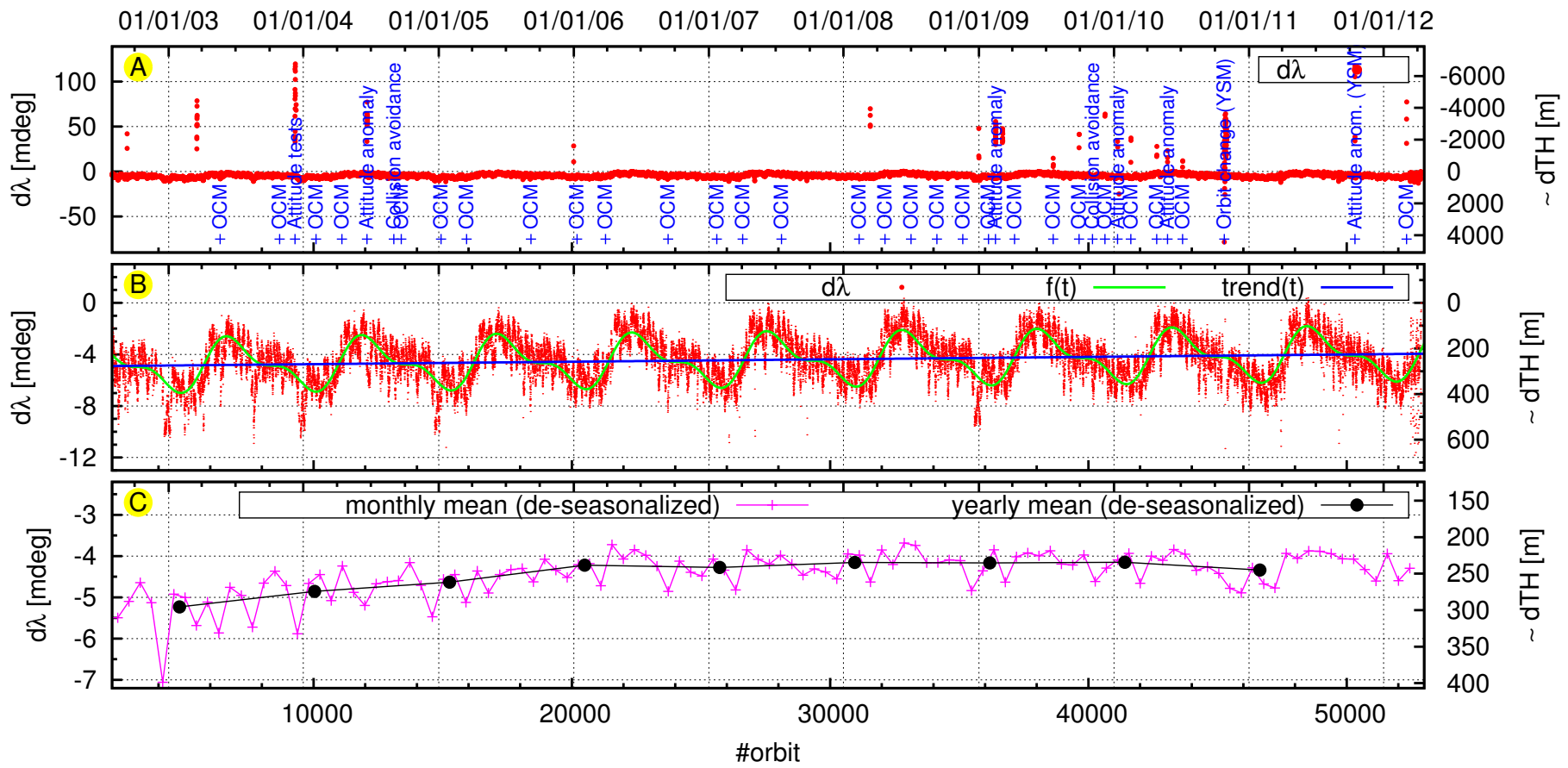


- Blue marks: OCM + known pointing anomalies.
- Red dots: Individual Offsets (scatter is not noise!!)
- Green line: Fitted function (seasonal+linear terms).
- Seasonal cycle: ±127 m. Mean offset: 249 m.
- De-seasonalized monthly and yearly mean.
- 50 m drift 2002-2006, stable further on.

Remaining Tangent height uncertainty < 26 m for individual measurements!

Bramstedt et. al. AMT, 2012

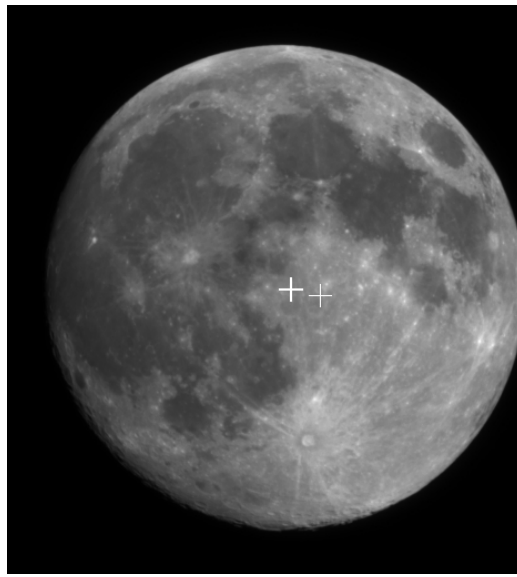
What about SCIAMACHY limb tangent heights?

Why not use the TH offsets for limb?

- Solar occultation and limb have different azimuth ($\sim$30°).
- Solar occultation limited to NH.
- Only once per orbit: Orbital pattern is very likely.

Additional pointing sources to be investigated:

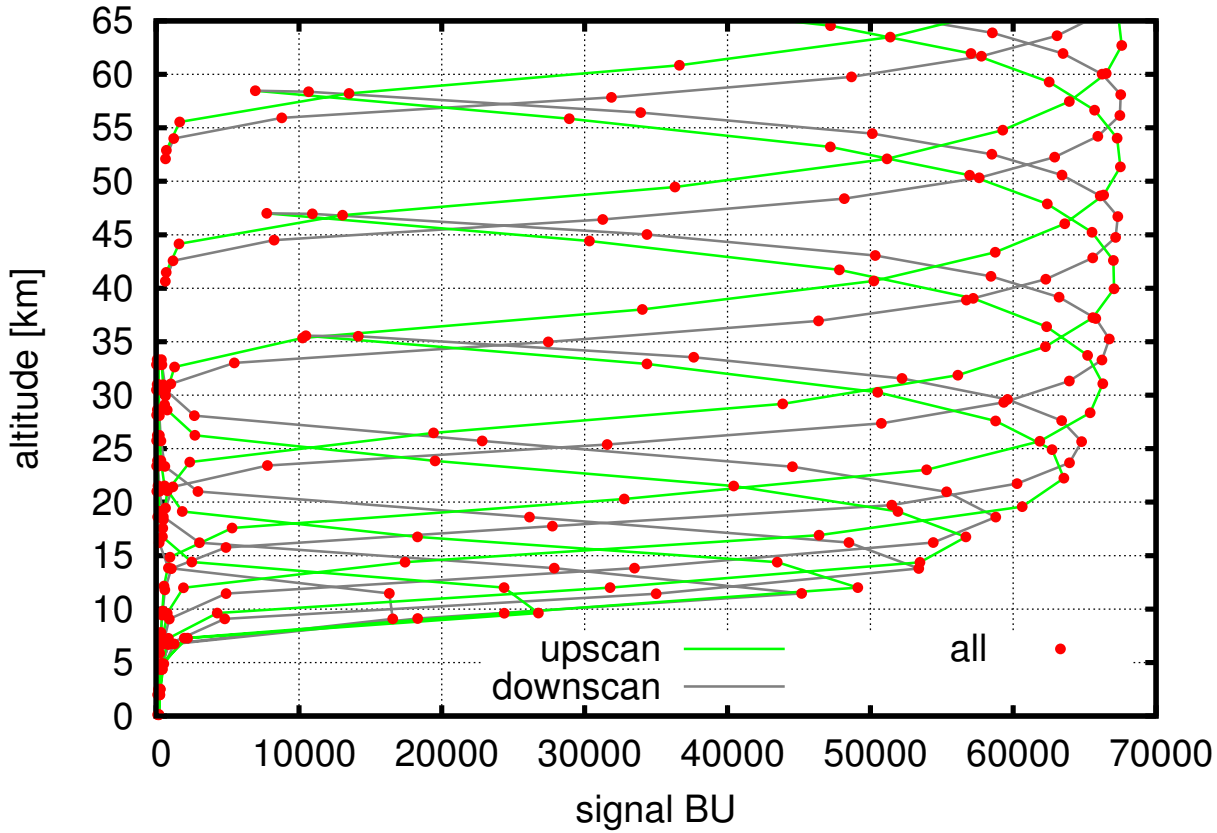
- SCIAMACHY 's Sun Follower device:
  - Azimuth of solar occultation
  - Sub-solar measurements (looking sidewards).
  - Lunar occultation (SH):
    - Inhomogenous, varying target (phase, libration).
    - Only few individual lunar images available (yet).
- GOMOS star tracker information:
  - Same platform!
  - Stellar occultations well distributed over the orbit.



T. Stone, ROLO image

Outline

Selection of measurements



Green line: Up-scan.

Gray line: Down-scan.

Red points: Measurement altitude (H_2O window).

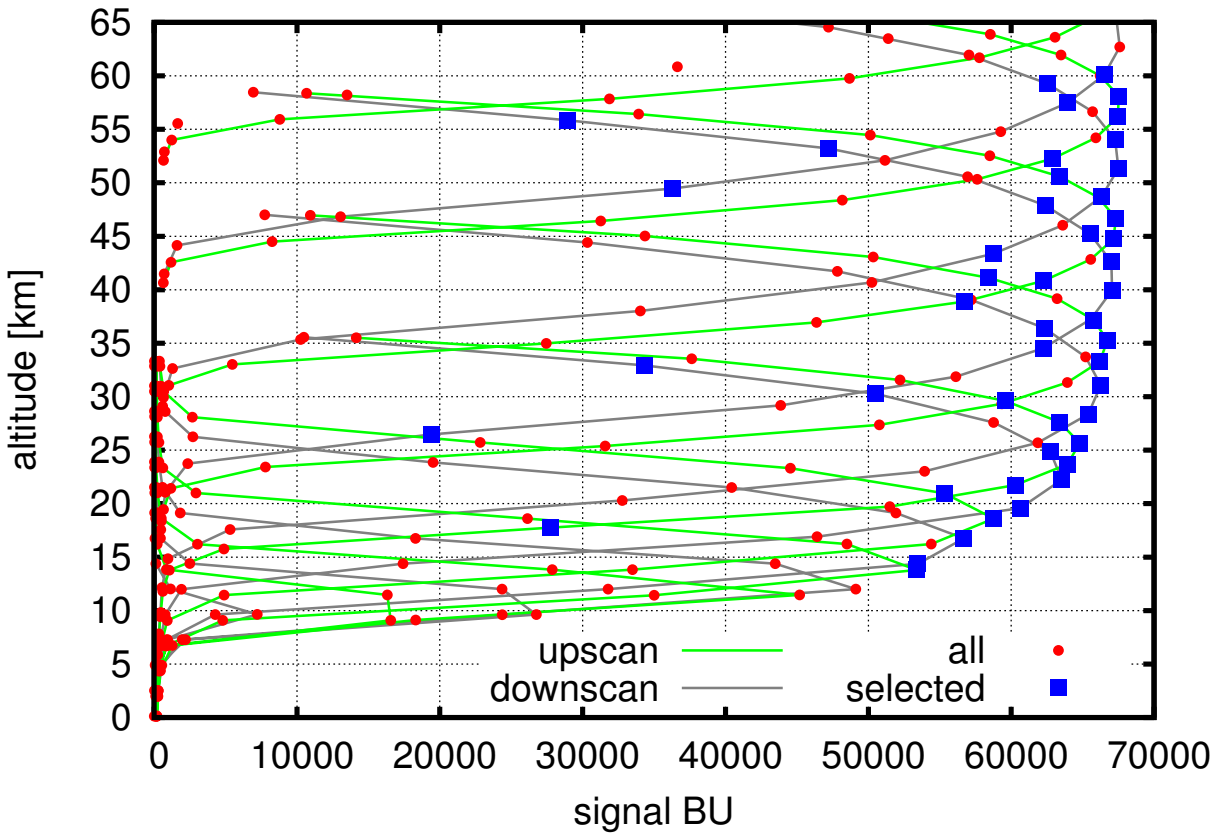
Problem: Hundreds of spectra, which one to use?

Goal: Always observe the solar center!

To select: Maximum intensity for each altitude.

Reference measurement (for transmission): Selected from $\sim$ 200 km. Solar center of an up- / down-scan measurement, resp.

Selection of measurements



- Simple: 1 km binning
- $\Rightarrow$ Lots of bad entries!
- Simple: 4 km binning
- $\Rightarrow$ Large gaps in altitude (7km)!
- 1 km binning, but search in 4 km window.
- *OK, but some altitudes to close: disturbs the retrieval.*
- Add a minimum distance criteria (1.75 km).
- $\Rightarrow$ Used setup.

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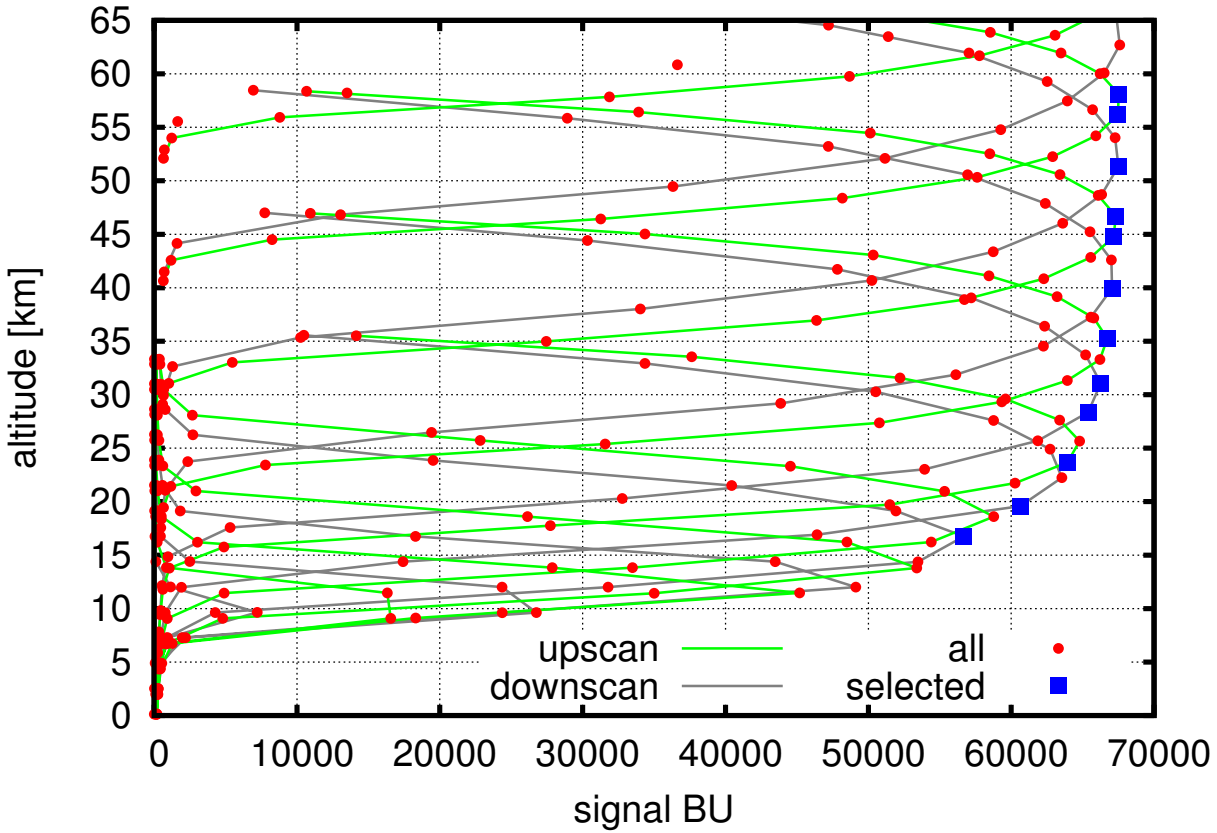

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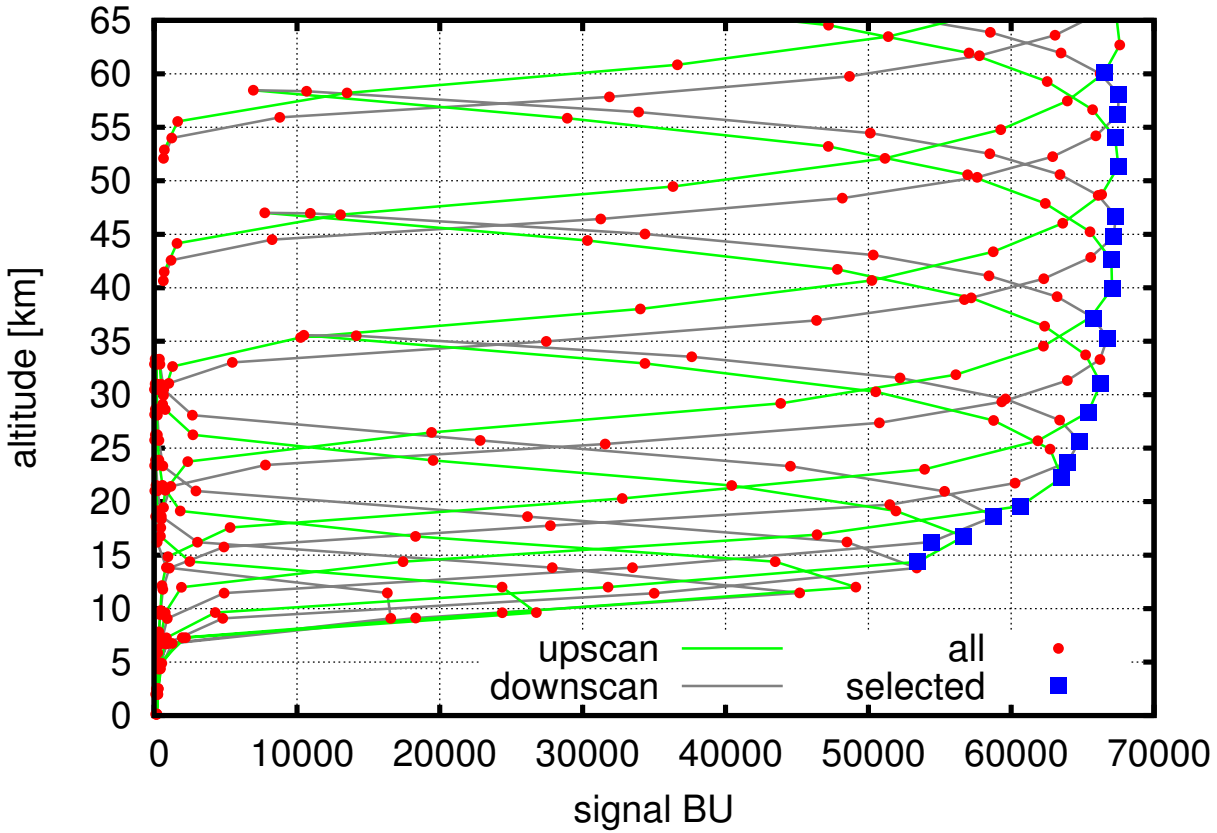

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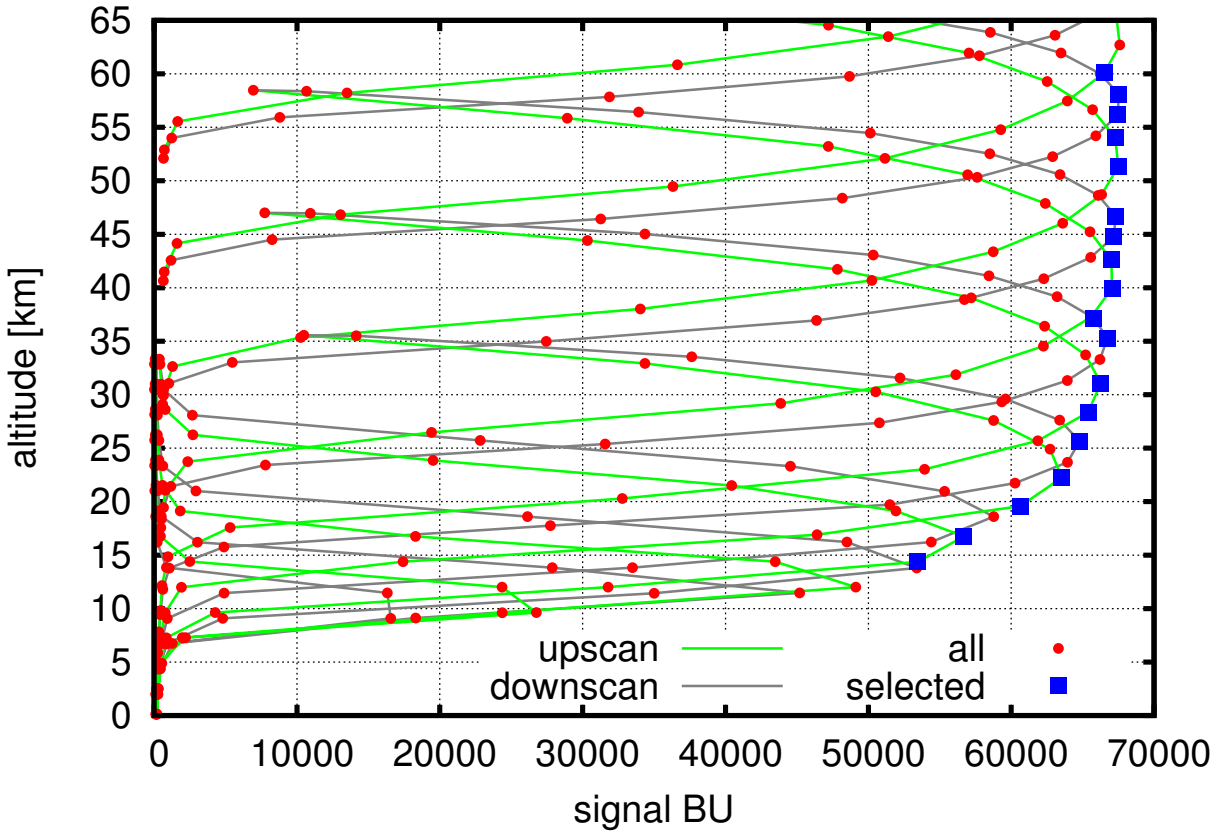

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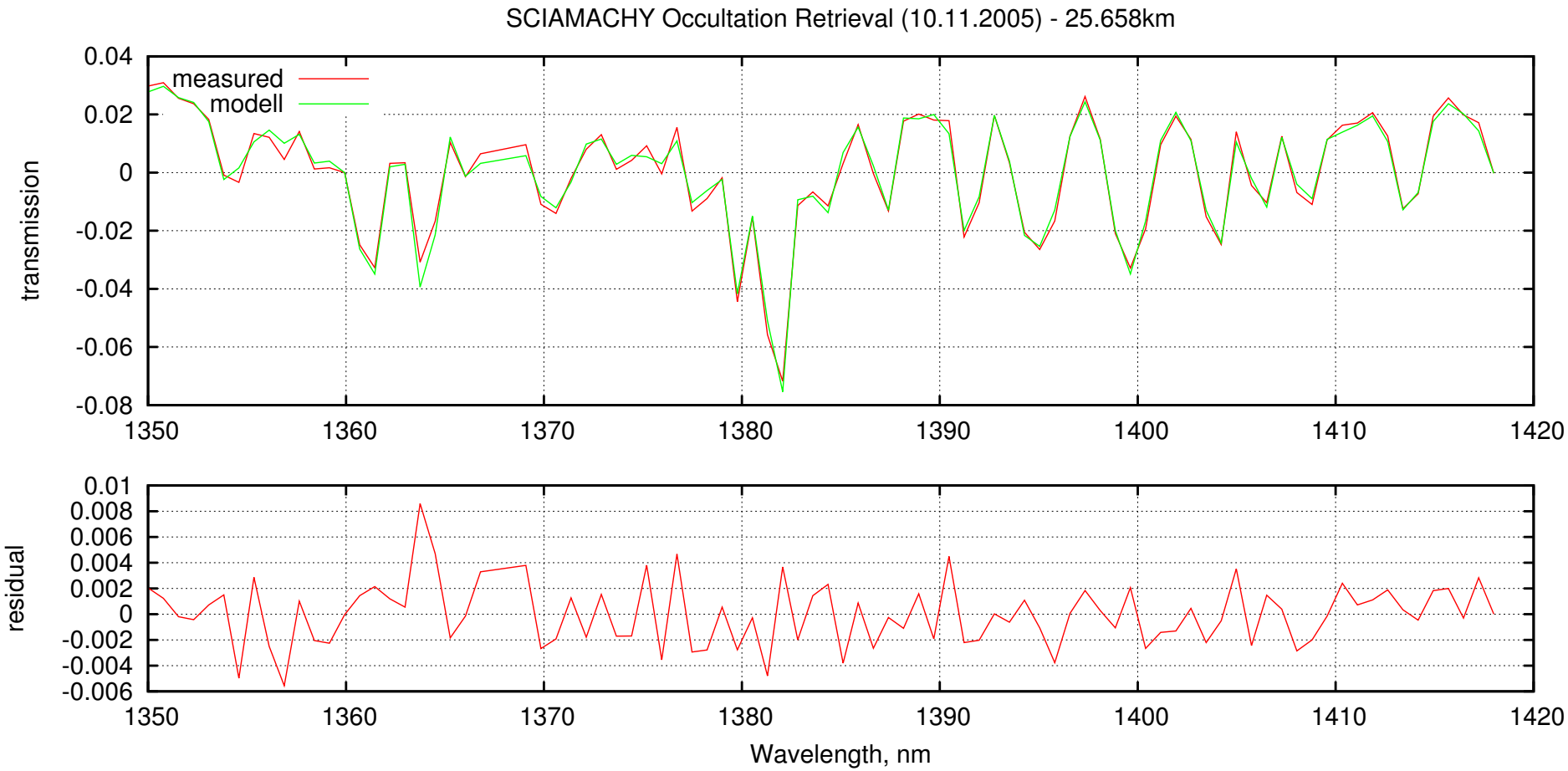
Retrieval algorithm

Forward and retrieval code: SCIATRAN 3.0
Optimal estimation with Tikhonov regularization.

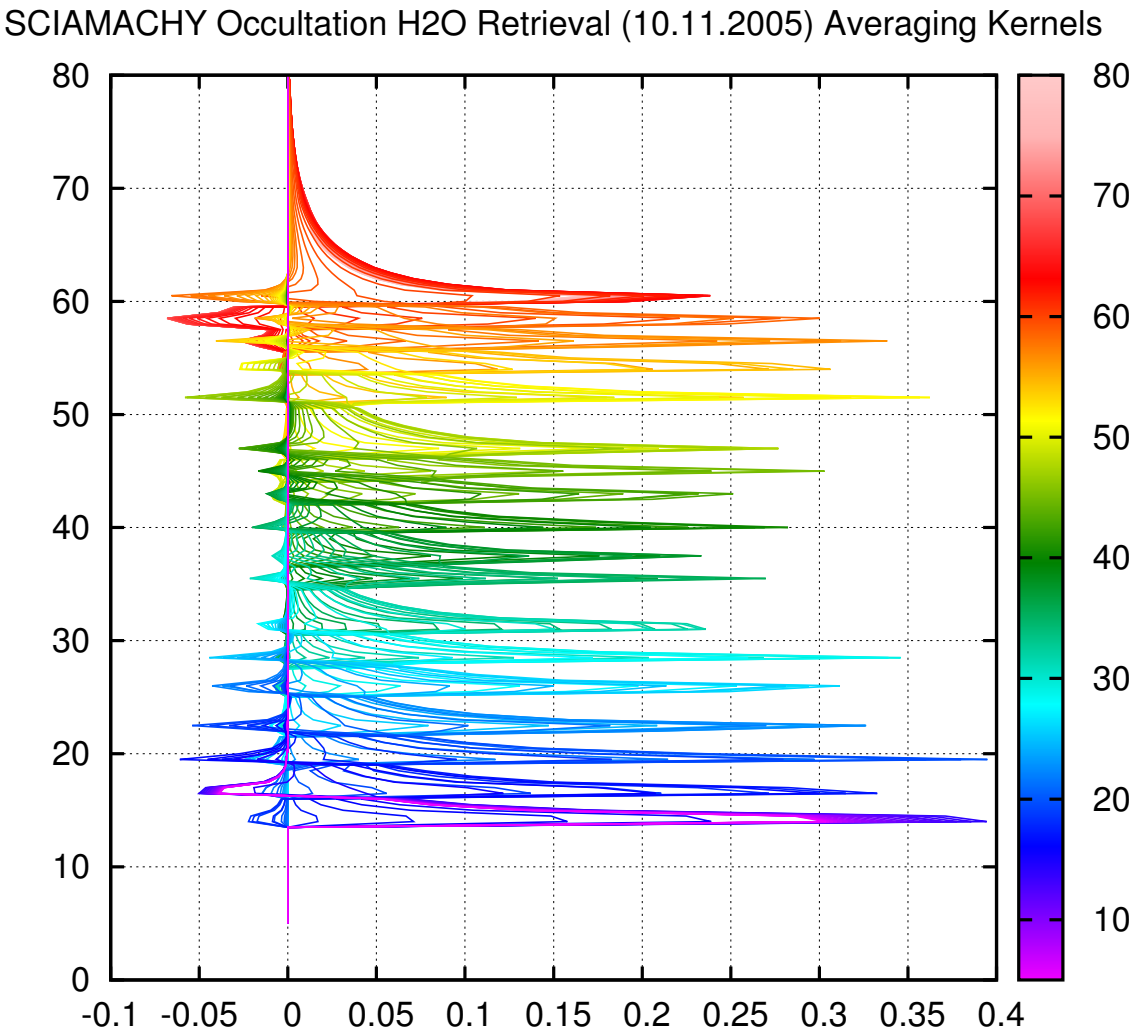
- H_2O Fit window 1350 - 1420 nm
- Transmission spectra derived from SCIAMACHY Level 1b v7.04/W
- Tangent height re-calculated, using
  - elevation angle offset,
  - read-out characteristic of detector (ch. 6 in hot mode)
- p,T profiles: ECMWF
- RTM uses ESFT (*correlated-k Exponential Sum Fitting of Transmittance Functions*) approximation for line absorbers.
- Optimized ESFT database.
  (As developed for H_2O lunar occultation, *Azam et al, AMT 2012*).

Residual

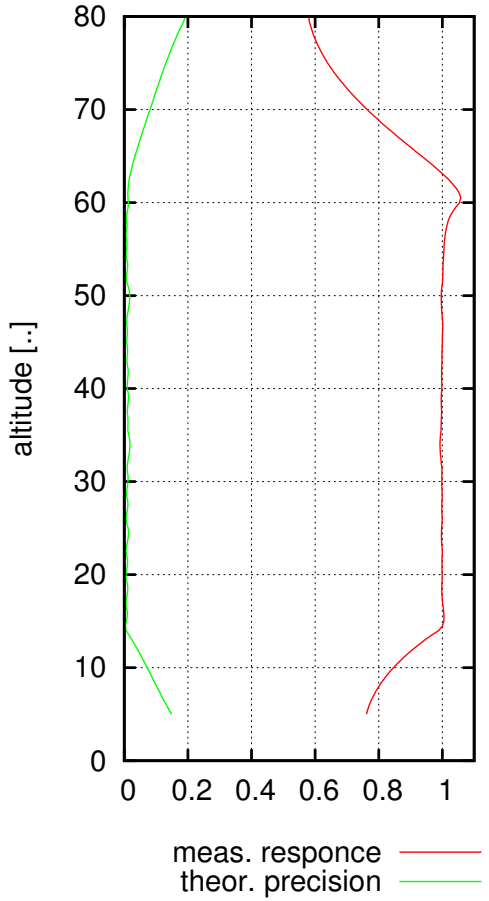


H_2O fit residual: Orbit 19333 (10.11.2005), 25.5 km altitude.

Averaging Kernel / Measurement response



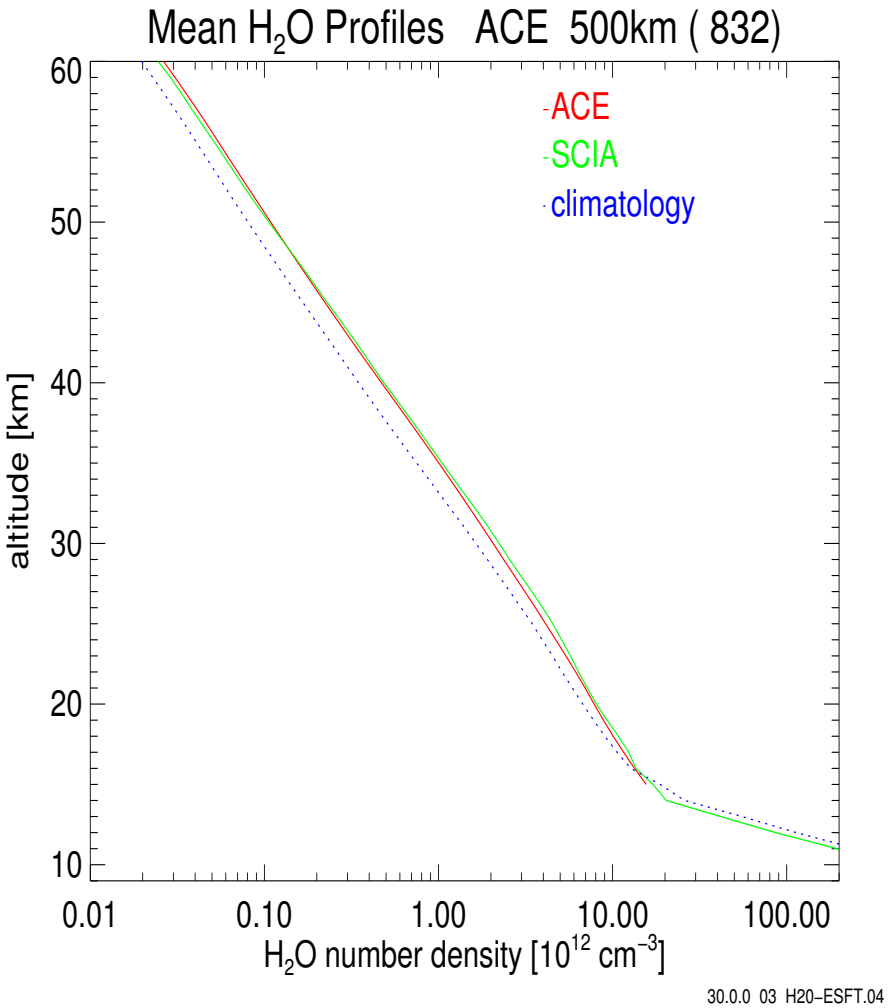
- Averaging Kernels peaks at measurement altitudes.

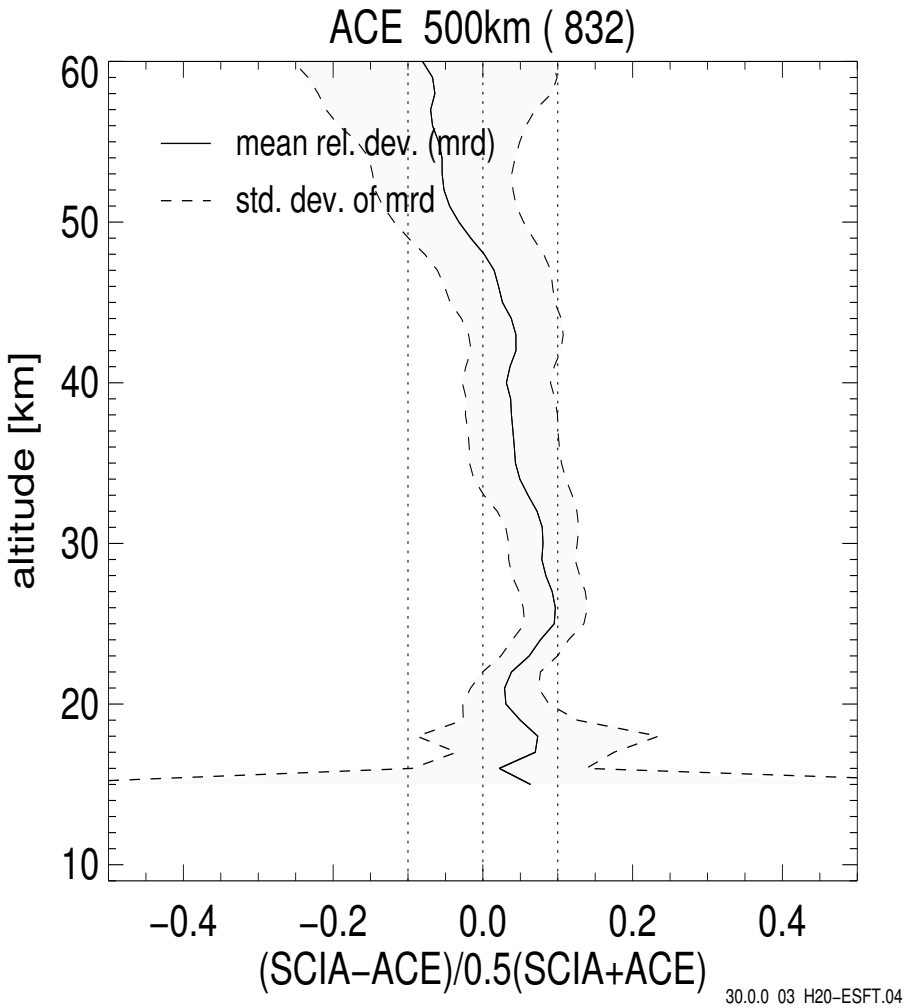


- 13 - 60 km: Profile determined by measurement.

Outline

Comparison with ACE-FTS V 3.0



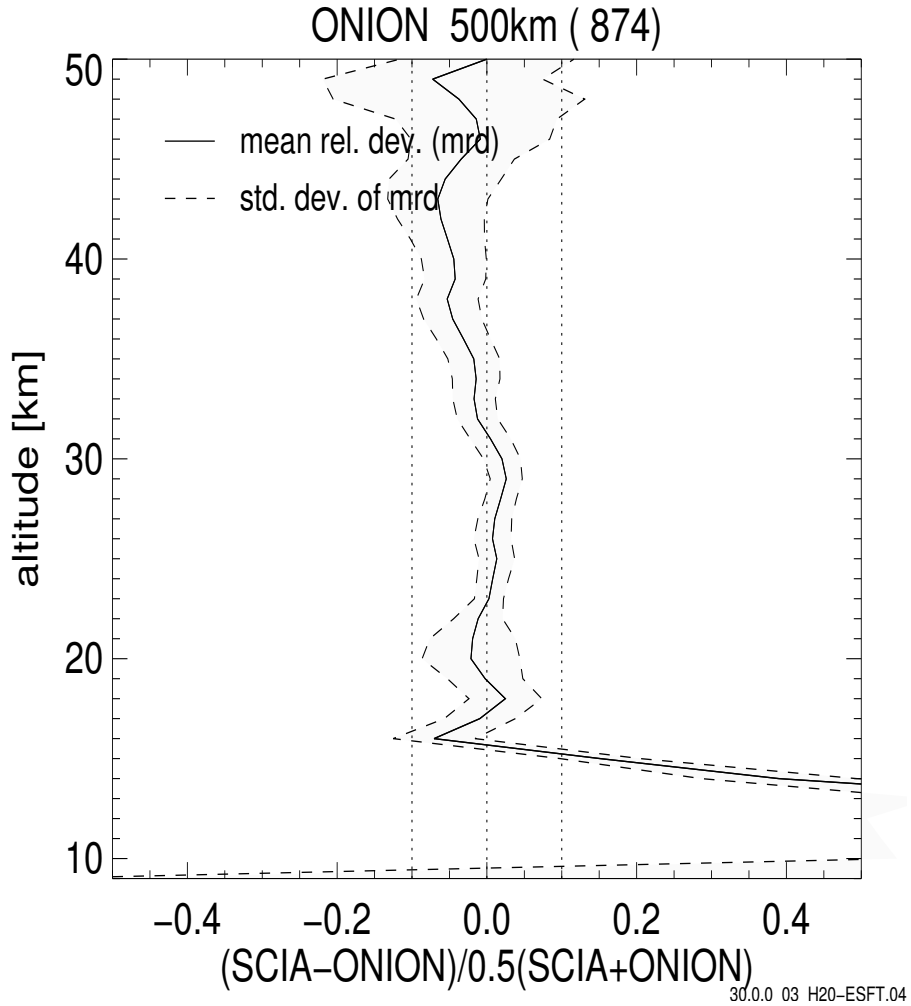


- Criteria: < 500 km, < 6 h.
- 832 co-locations (2002-2009).

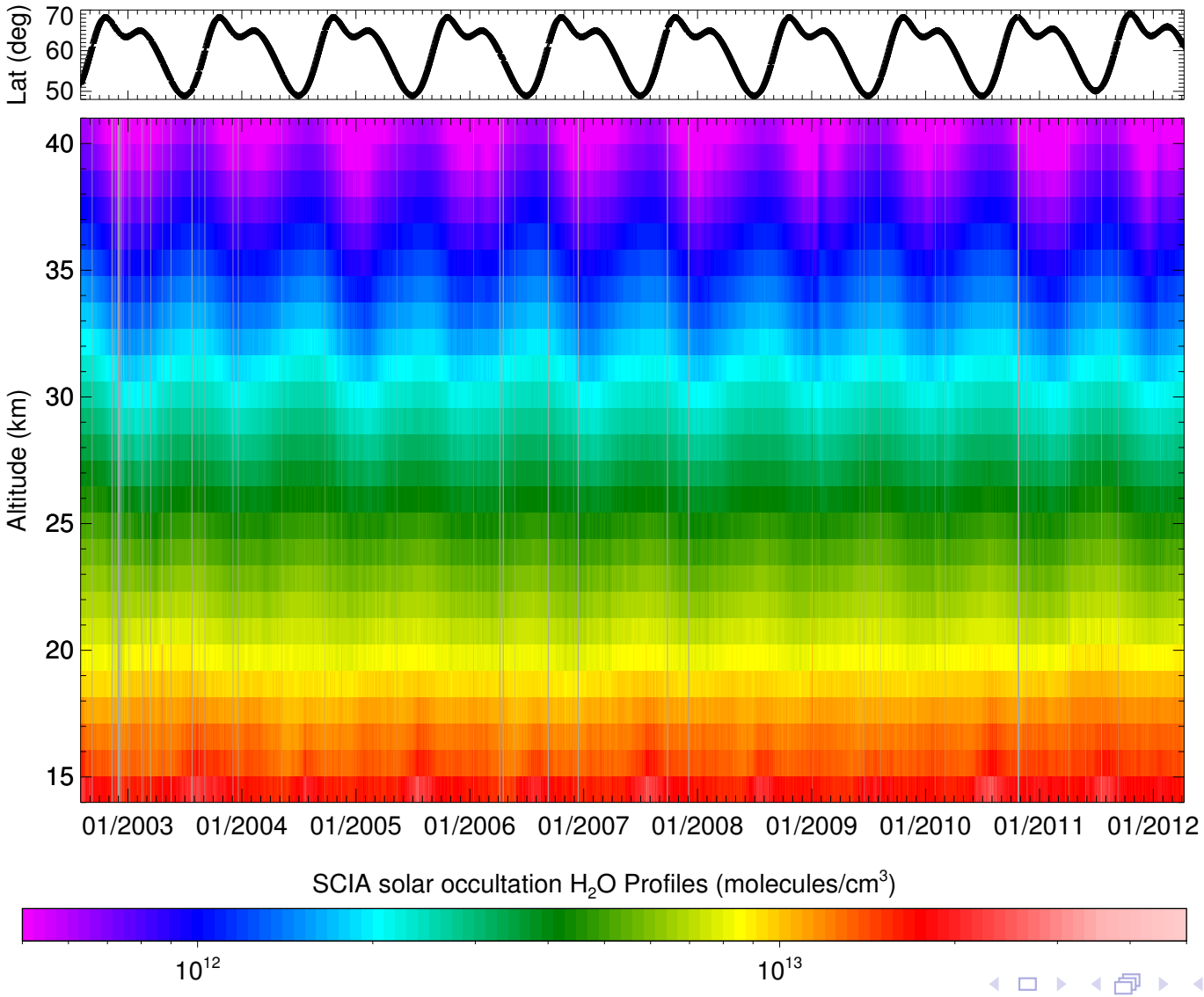
- Agreement 16 – 60 km within 10%.
- Wet bias <45 km, dry bias >50 km.

Comparison with Onion-Peeling approach

- Onion-peeling approach applied to SCIAMACHY solar occultation. *Noël et al, AMT, 2010*.
- Fit window 928 – 968 nm.
- Altitude range 15 – 45 km.
- *Preliminary* new version.
- Method details next talk by Noël et al. (applied to CO_2 /CH_4).
- Comparisons here limited to ACE co-locations.
- Very good agreement 17 –37 km.
- Slight dry bias above.



Time series of water vapor number densities



- Time series of daily means.
- Seasonal variation determined by latitude pattern.

Outline

Summary

- Precise tangent height information available for SCIAMACHY solar occultation.
- Re-calculation of geolocation taking elevation angle offsets and all instrumental details into account.
- Improved selection of measurements for the retrieval.

- Water vapor profiles derived with an Optimal Estimation scheme.
- Altitude range: 16 – 16 km.
- Good agreement with ACE-FTS V3.0 within 10% with a wet bias below 45 km.

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