Instrument pointing issues on ENVISAT

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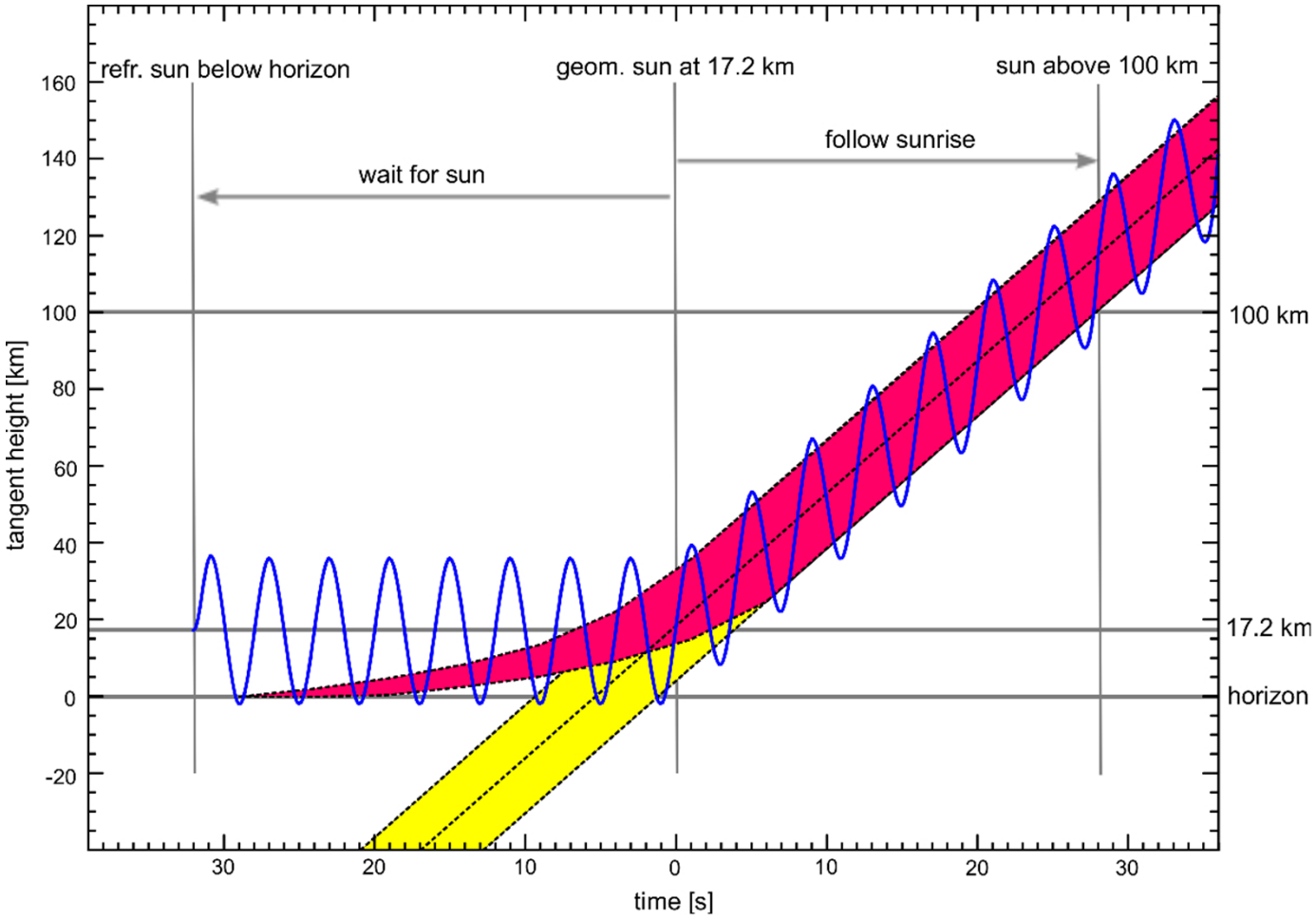
Outline

- Envisat pointing history
- SCIAMACHY pointing information – solar occultation
- MIPAS pointing information
- GOMOS pointing information
- Summary / Conclusion

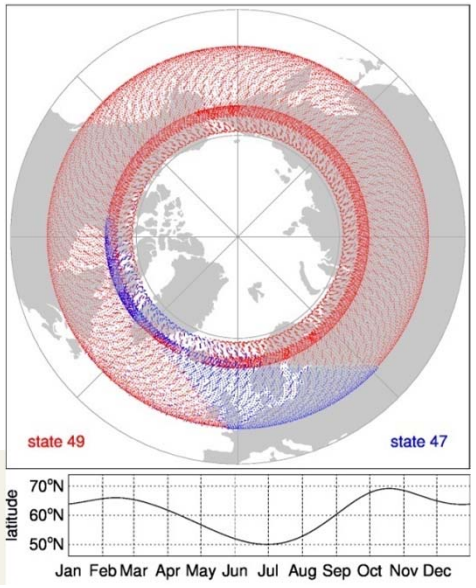
Envisat/SCIAMACHY pointing history

- Limb/occultation geometry provide height resolved information.
- Accurate pointing knowledge is essential.
- SCIAMACHY pre-launch (1999) pointing error budget in elevation ±45mdeg (2.5km, dominated by platform part).
- 2002-2003: Large pointing anomaly observed (seasonal variation ±800m, SCIAMACHY, GOMOS, MIPAS, ASAR).
- Dec 2003: Update On-board SW (remaining ±220m).
- 2005-2007: GOMOS "SATU-Y pointing anomaly"
- 2007: SCIAMACHY misalignment investigation (M. Gottwald, DLR) Elevation offset of 1 km has been reduced to 110-170m.
- 2009-2010: 2nd GOMOS "SATU-Y pointing anomaly"
- 2012: SCIAMACHY solar occultation pointing knowledge: ±26m (next slides).

SCIAMACHY solar occultation measurement sequence



- Once per orbit NH 49N-69N
- Scan over solar disk!
- Follow sunrise up to 280km.



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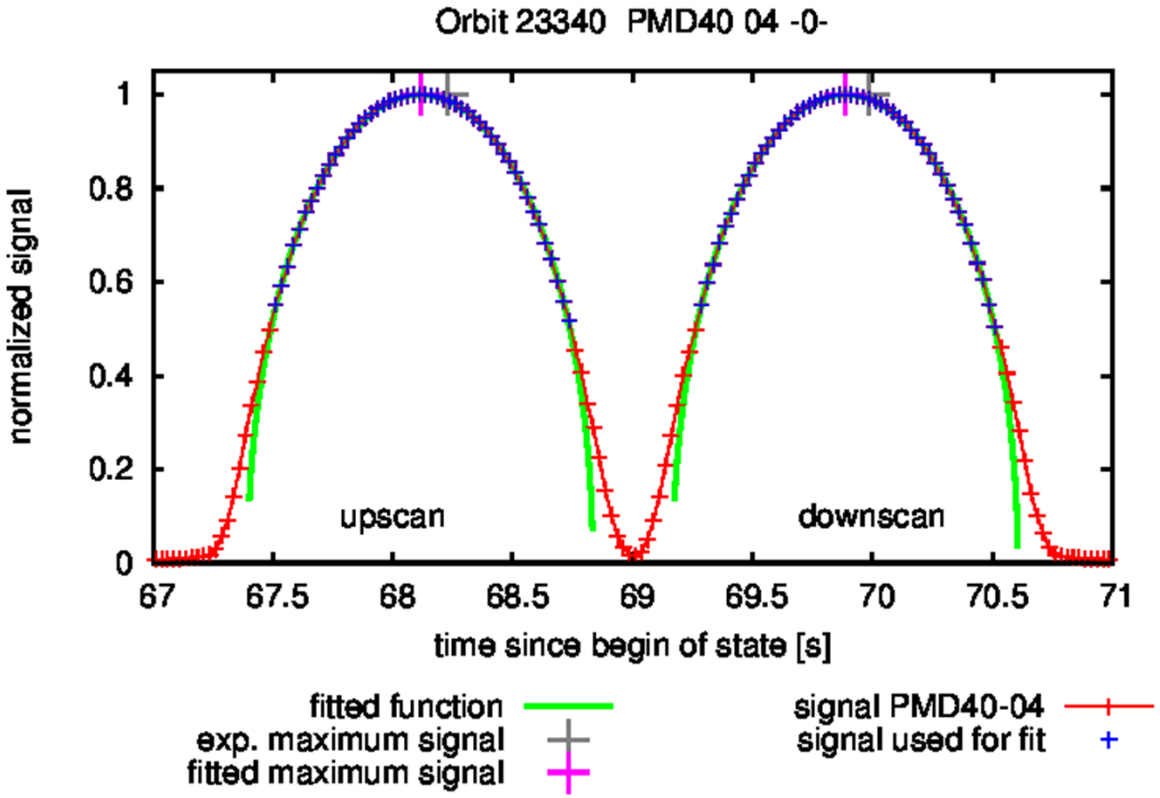
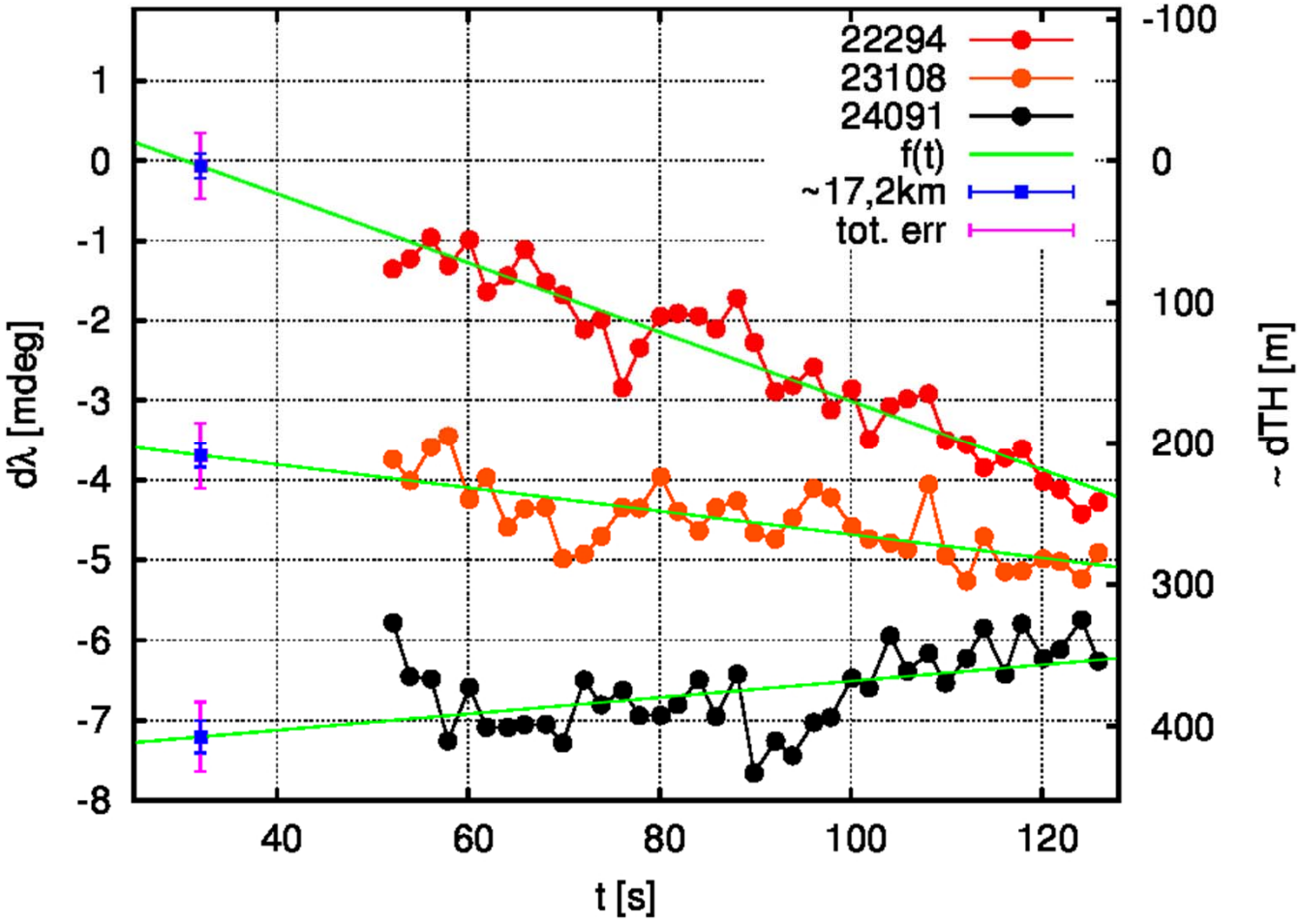
Fitting the solar center from scans



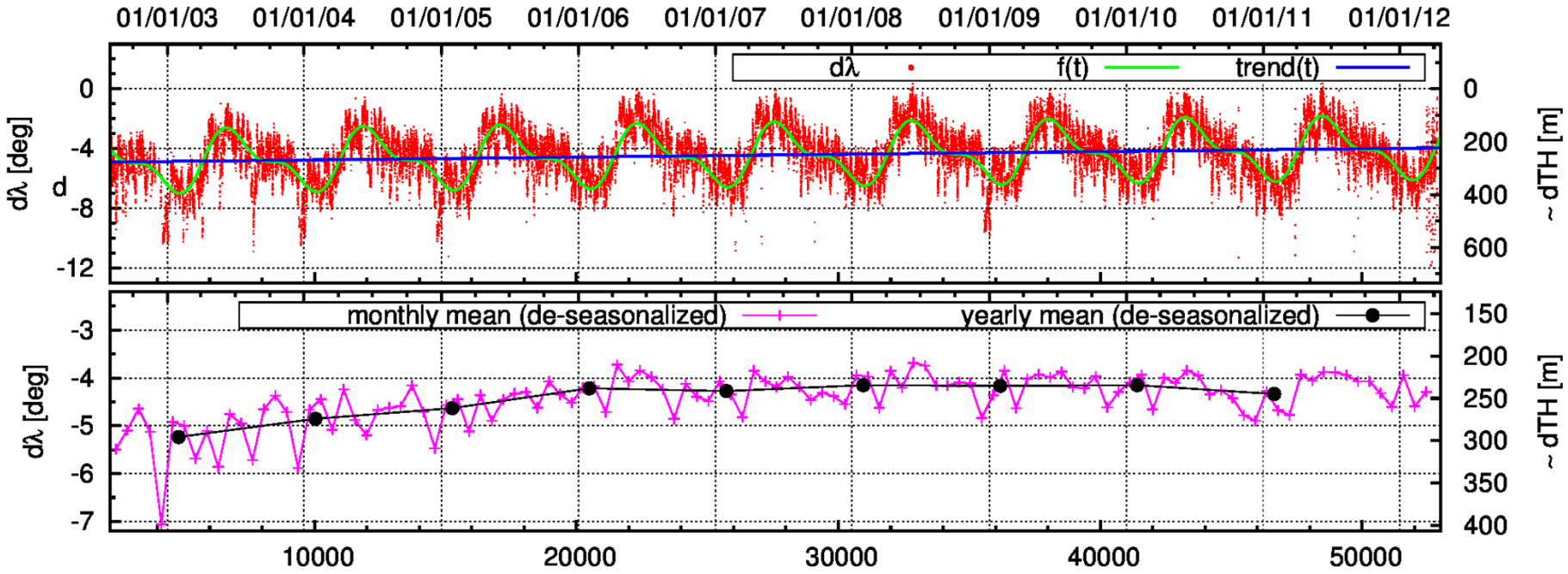
- Fit the center of the solar disk from intensity function of the scan over solar disk: Measured elevation angle!
- Solar elevation angle calculated from platform attitude information: Calculated elevation angle!
- Difference is mispointing!

EAOs of individual measurements



- 3 sequence of elevation angle offsets (EAO)
- EAO time dependent!
- Fitting of a straight line with slope *b*.
- *EAO at 17.2 km used in time series.*

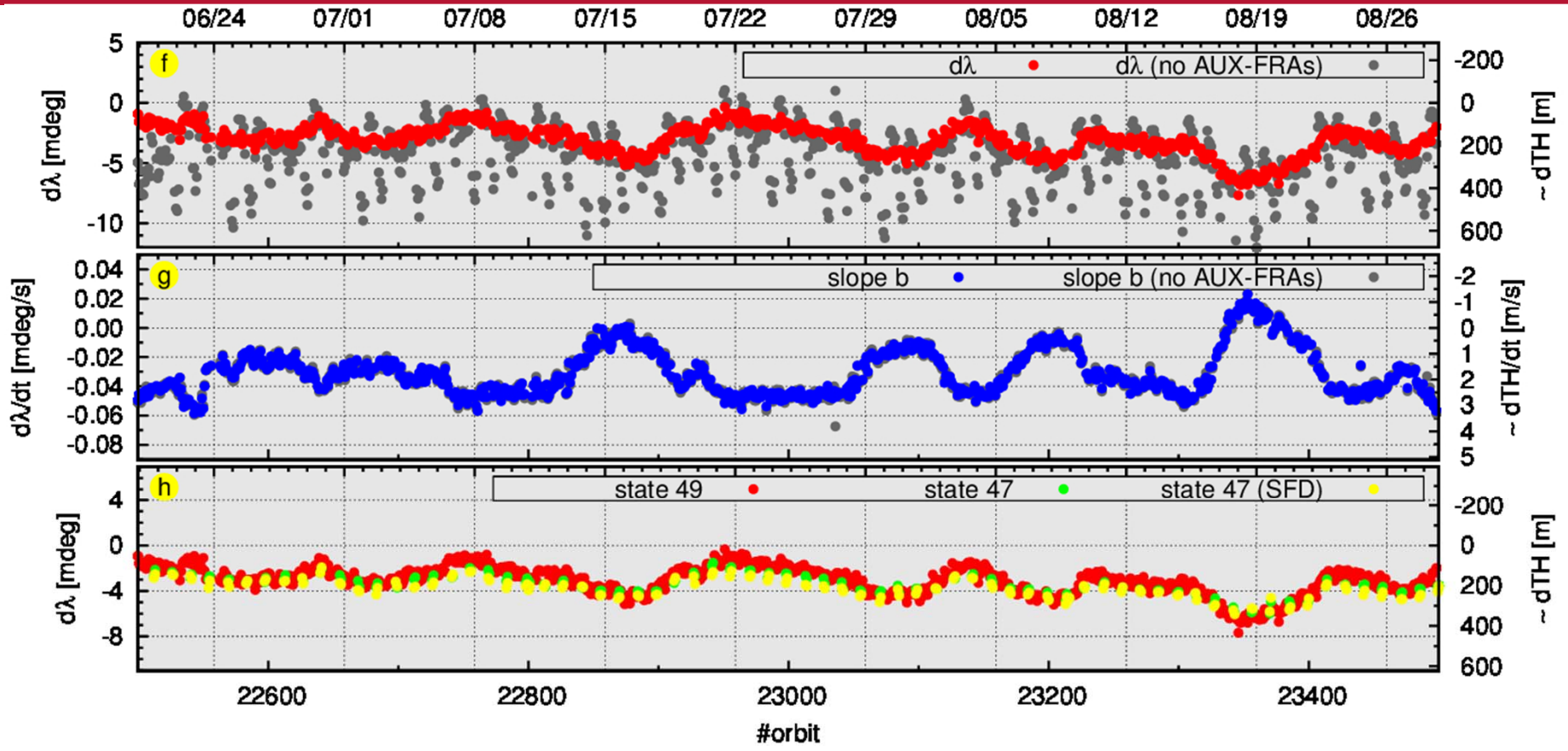
Elevation angle mispointing time series



- Red dots: individual offsets / Green line: Fitted function
- Large tangent height anomalies (Attitude test, Orbit change, OCM excluded)
- Seasonal cycle ±127m, mean offset 249 m.
- 50 m drift 2002-2006, stable further on.
- Remaining tangent height uncertainty <26 m for individual measurements.

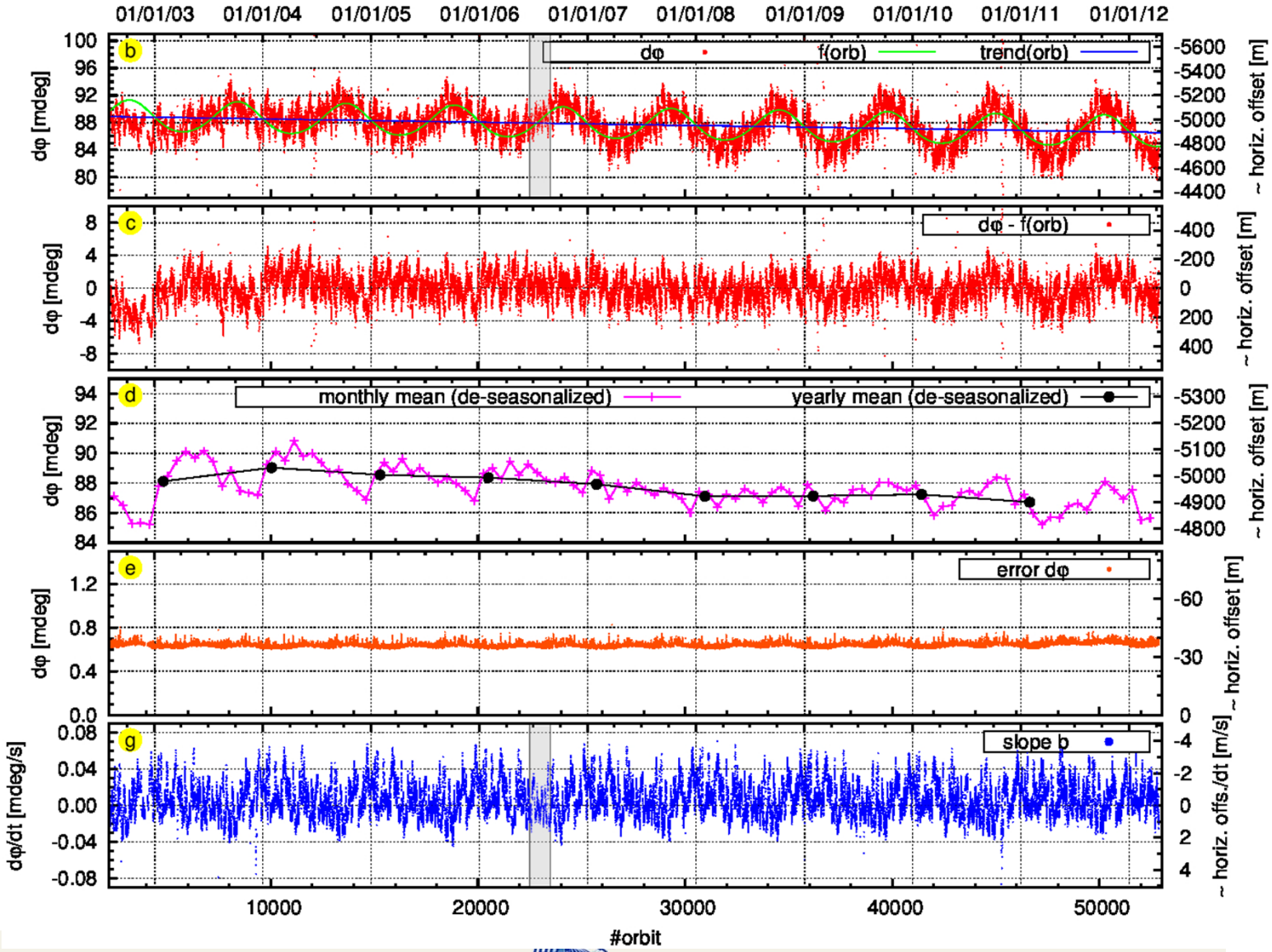
Bramstedt et al, AMT, 2012

Elevation angle mispointing time series – 2 month



- Gray: No AUX-FRAs, Blue: Slope b, Yellow: Sun Follower Device (SFD).
- Zoom in for June – August 2006
- Slope *b* and EAO are anticorrelated (on short time scales, **not** the seasonal pattern).

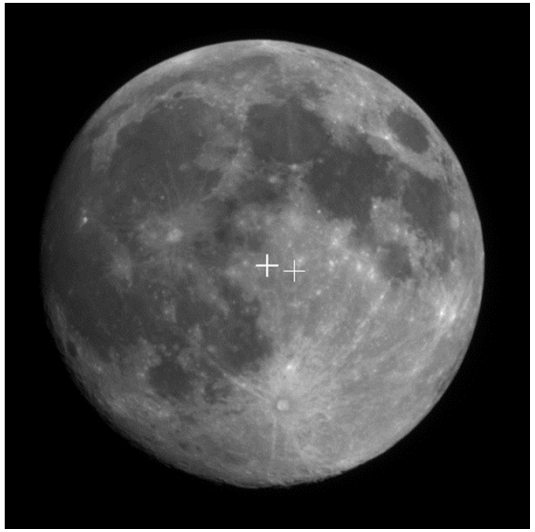
Azimuth angle mispointing time series



- Azimuth direction controlle by SFD
- 127m seasonal cycle
- 5km mean offset

Further SCIAMACHY pointing information

- Further (possible) sources of pointing information:
  - Sun Follower Device (SFD) used in solar / lunar measurements.
  - Azimuth solar occultation (seas. cycle ~138m, offset ~5km).
  - Sub-solar measurements (different platform axis).
  - Lunar occultation (SH):
    - Inhomogenous, varying target (phase, libration).
    - Individual lunar images from ROLO suitable (2 test cases)
    - Larger ROLO image set not accessible (yet?).
  - GOMOS star tracker information



- SCIAMACHY limb measurements:
  - Solar occulation has different azimuth.
  - Limited to NH.
  - In limb community discussed drifts in limb TH not supported by this study.

Conclusion SCIAMACHY solar occultation

- Precise Pointing information derived for SCIA solar occultation (27m).
- Elevation angle offset: Seasonal cycle ±127m, mean offset 249 m.

- Limited to NH only, different azimuth compared to SCIA limb.
- Additonal information source:
  - Lunar occultation (very limited)
  - GOMOS stellar occultation (Star tracker), same platform.

- Goal: Improve pointing also for SCIA limb and MIPAS.

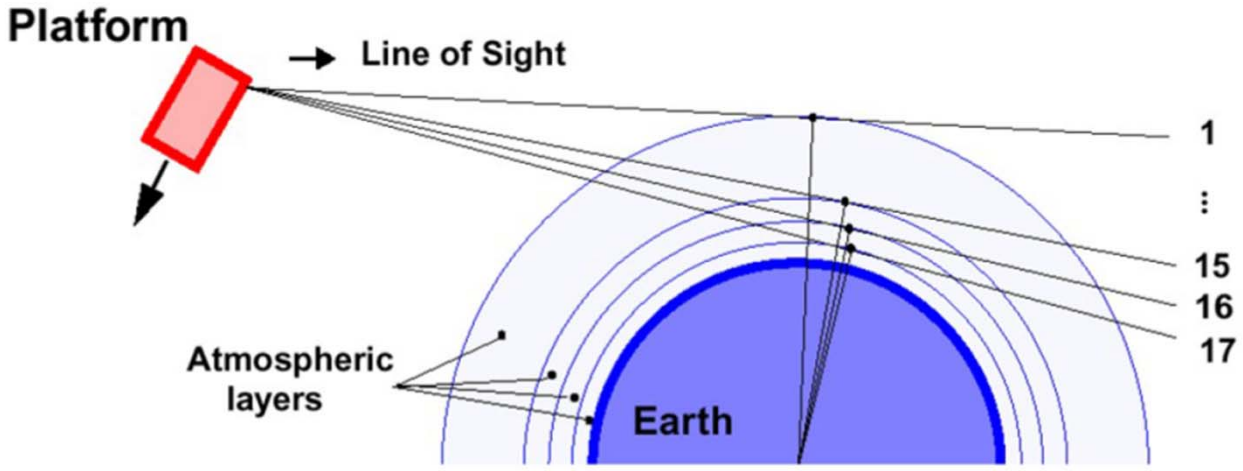
- Can information used to improve AUX-FRAs (better pointing/attitude for the platform on system level)?

MIPAS pointing information [1/5]

- Requirement
  - Absolute pointing knowledge (a posteriori) 1.8km
  - 1.8km at limb corresponds roughly to 32mdeg
  - Ownership battle between instrument prime and platform prime
    - Special LOS measurement mode. MIPAS cube corner mirrors are stopped at maximum path difference and the instrument is used as a radiometer to look at stars passing through the field of view. The pointing error is estimated from the expected time the star is at the center of the field of view versus measured time.
- Altitude determination in L1
  - CFI SW is used to compute Envisat position at time of measurement using the orbital state vector information.
  - A correction is applied to the pointing angles taking into account the pitch and roll error estimated from LOS measurements (and lately MIPAS alignment matrix and elevation mirror non-linearity).
  - From the position and corrected angles, another CFI SW is used to compute the tangent altitude height taking into account refraction in the atmosphere.

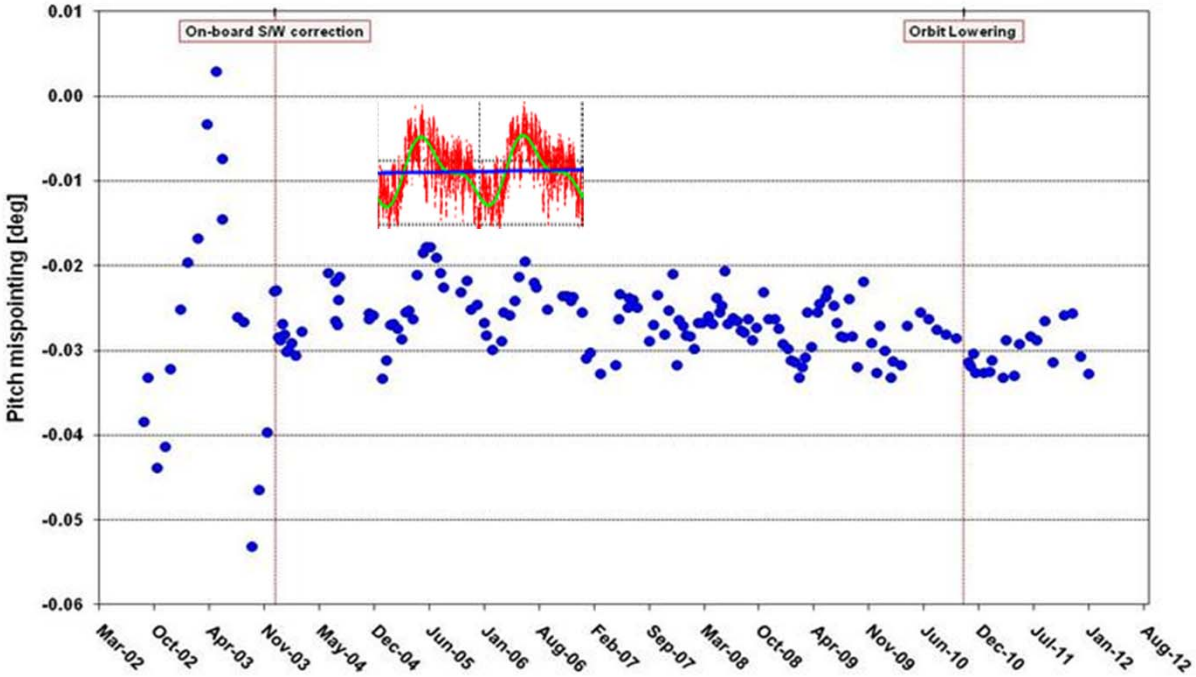
MIPAS pointing information [2/5]

- Impact on data product
  - Absolute knowledge of altitude is not a concern for L2 profile accuracy. Retrieval is done against a pressure grid.
  - May be a concern for validation with other instruments if done on the altitude grid
  - The L2 concern is the relative knowledge of altitude between two consecutive measurements. Assumed to be <150m according to error budget.



MIPAS pointing information [3/5]

- Special LOS measurement mode
  - Residual pitch error estimated to be in the order of -25mdeg
  - Seasonal variation and trend (similar to Sciamachy inverse)
  - Detector noise degradation toward the end of mission, less stars are seen and estimation become poor



MIPAS pointing information [4/5]

- Investigations and improvements
  - L2 can estimate altitude information from retrieval
    - According to community, accurate to around 0.5km
  - At the beginning, compared to L2, L1 reported altitudes had an orbital variation up to 1km.
    - Similar to a platform pitch of 10mdeg and a roll of 60mdeg
  - After investigation, it was found that the alignment matrix of MIPAS was not taken into account in L1.
    - A patch to reduce error was done in IPF5 through auxiliary data file. Difference compared to L2 less than 0.5km.
    - Now in IPF7.
  - Other minor improvements
    - Elevation mirror non-linearity correction (<250m)
    - Refraction model error due to approximation at low altitude was giving none physical behavior (<50m)
  - Still 2km offset in sideways compared to L2. Was not a priority, few measurements are done in sideways.

MIPAS pointing information [5/5]

- Suggestions for future work to improve MIPAS altitude
  - Try to use Sciamachy time series to estimate MIPAS seasonal variation more accurately instead of a simple bias (around -25mdeg)
  - Use precise orbit (~2m) and restituted attitude (orbital variation of ~500m)
  - Improve sideways
  - Improve atmospheric refraction calculation similar to GOMOS

GOMOS pointing infomation

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