AERGOM: IMPROVED AEROSOL EXTINCTION PROFILES FROM GOMOS MEASUREMENTS.

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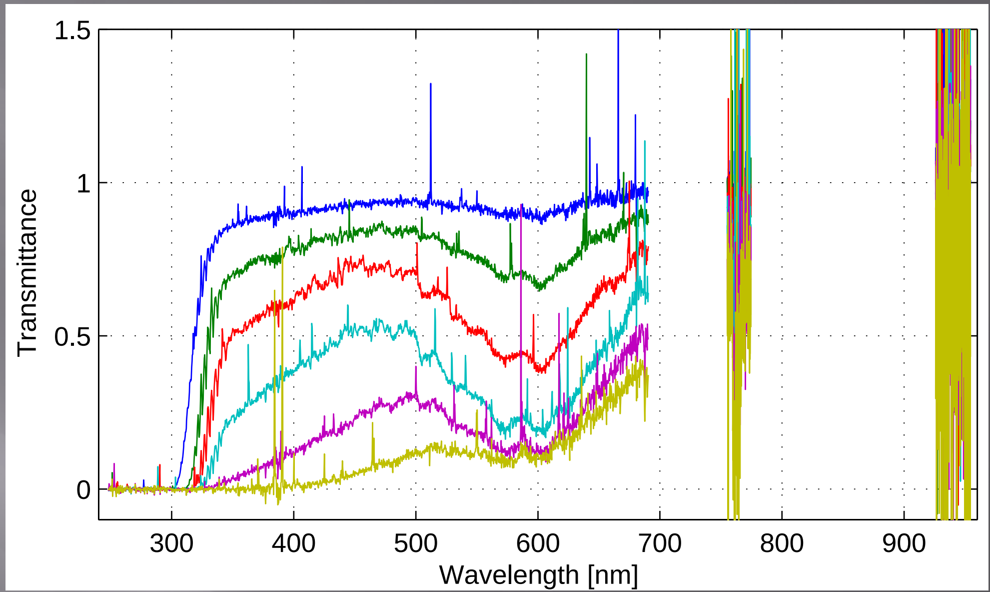
AERGOM project

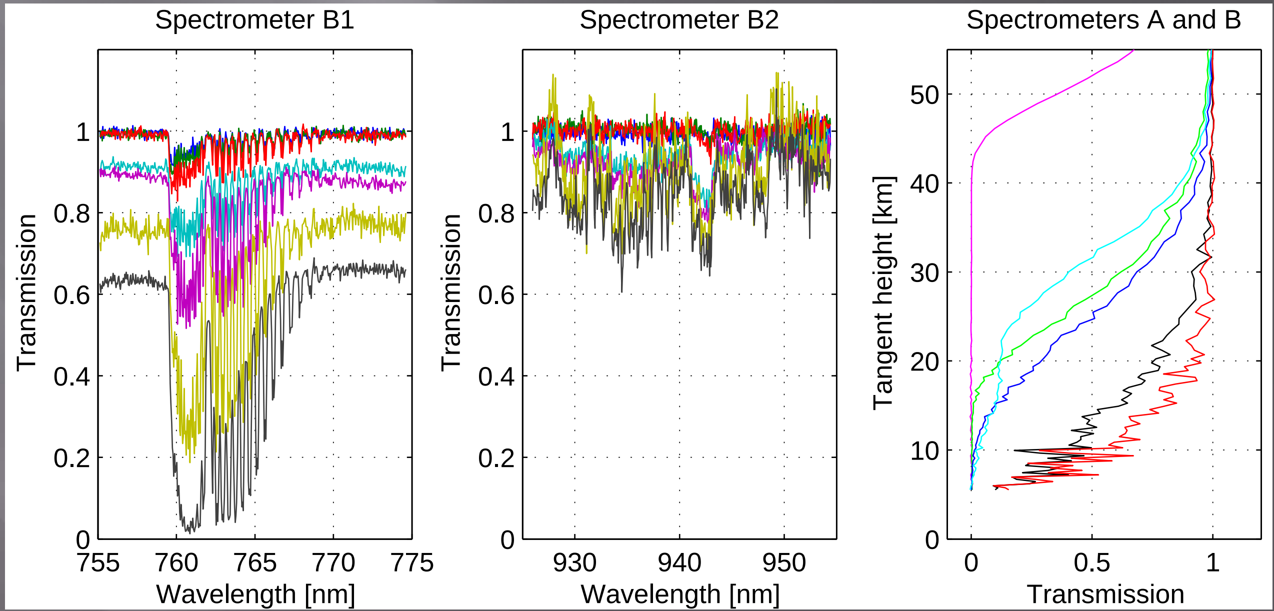
- ESA-financed
- To improve GOMOS aerosol/cloud extinction profiles.
- To verify if it is possible to derive particle size distributions and associated quantities.
- To construct a standalone prototype.
- Processing of the entire GOMOS data set using v6.01 transmittance spectra as input.
- Data validation of AERGOM results
- Follow-up of AERGOM: climatologies + data merging (Aerosol CCI; see talk Christine Bingen on wednesday)

Quick reminder: GOMOS on ENVISAT (see Erkki Kyrölä)

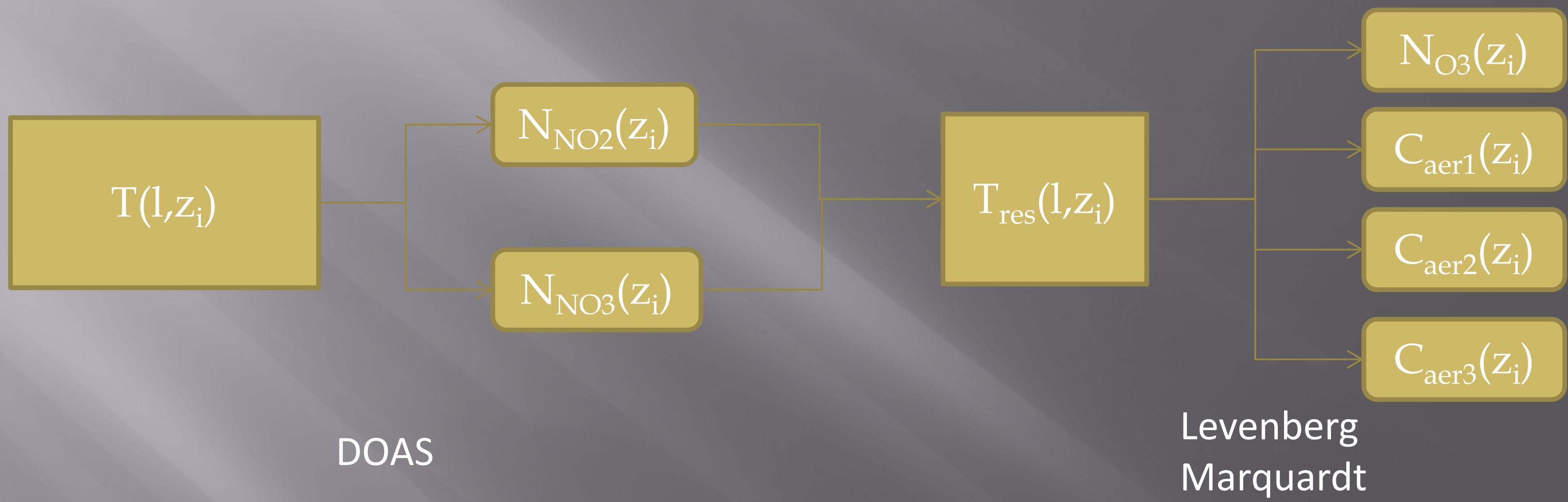
- ENVISAT: 11-year mission (March 2002 – April 2012)
- Stellar occultation
- Transmittance measurements (UV/Vis/near IR):

SPA: (248 - 690 nm)
SPB1 (750 - 776 nm)
SPB2: (916 - 956 nm)





GOMOS IPFv6.01 retrieval algorithm: spectral inversion



- For every spectrum at every tangent altitude separately
- Only SPA data (248 - 690 nm)
- Choice of aerosol quadratic polynomial (unfortunately):

$\tau(l) = C_{aer1}(l_{ref})\left[1 + C_{aer2}(l - l_{ref}) + C_{aer3}(l - l_{ref})^2\right]$ with $l_{ref} = 500\ nm$

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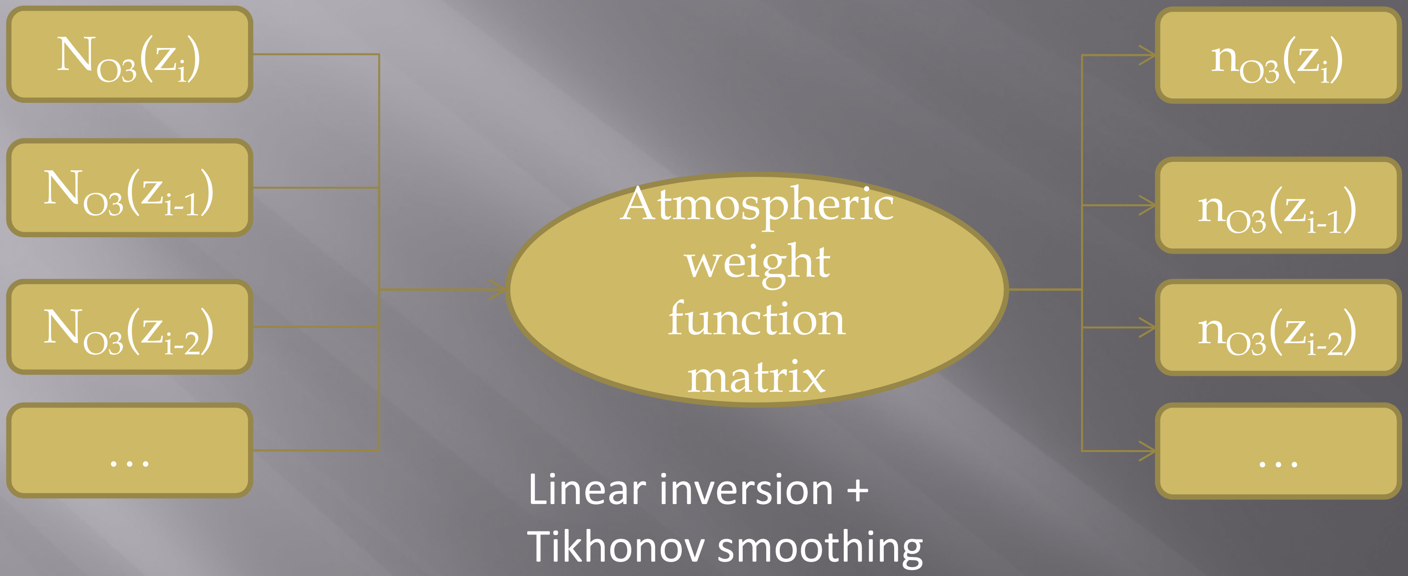
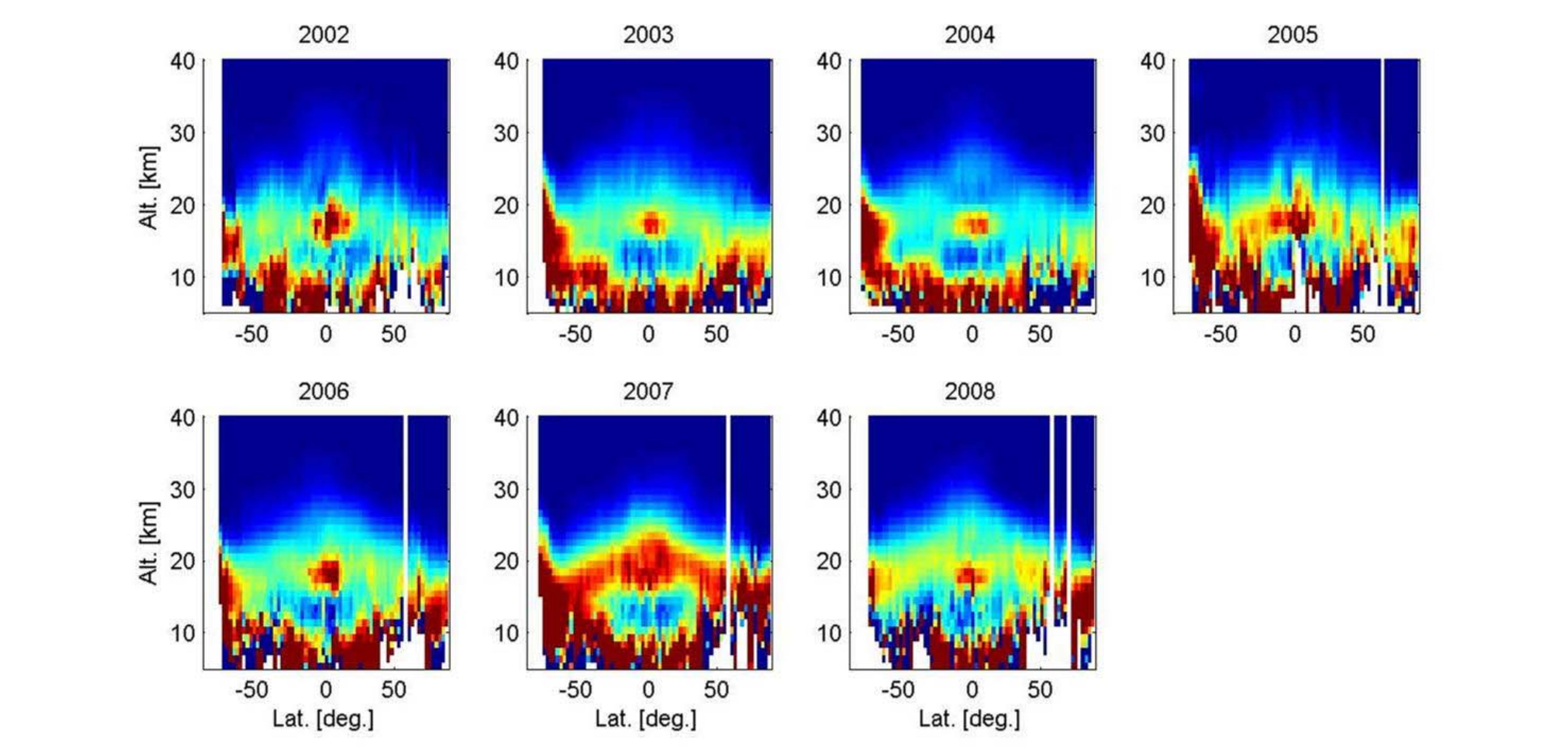


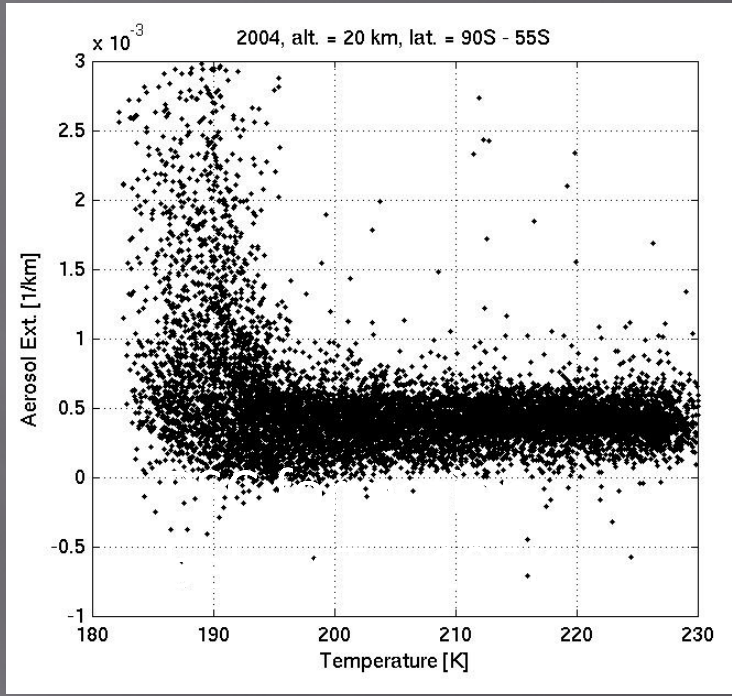
- For all species separately. So, *all spectral inversion retrieval covariances between tangent species are discarded…*
- Aerosols: only C_{aer1} (=AOD @ 500 nm) is inverted and receives Tikhonov regularization. *Result: aerosol extinction spectra "wobble" around this reference wavelength.*

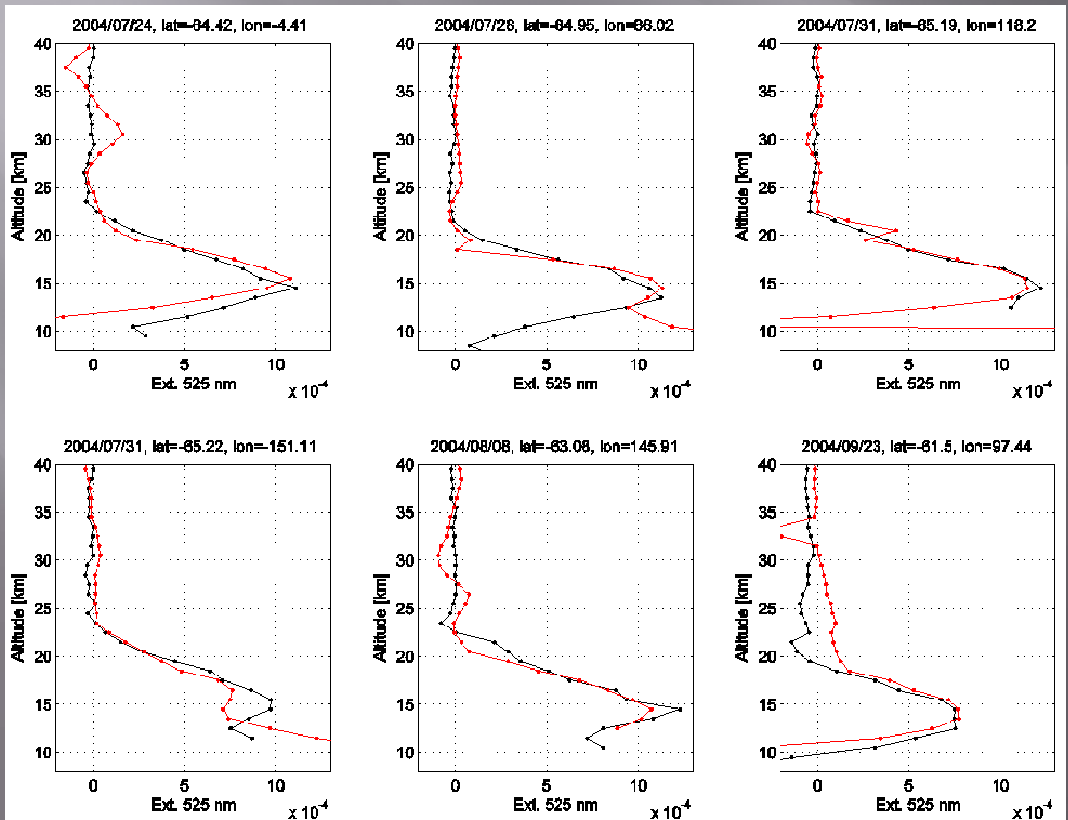
GOMOS IPFv6.01 data: aerosol extinction profiles and their problems (1)

From previous studies, we know already that aerosol extinction @ 500 nm is pretty good. Other wavelengths: very doubtable quality …



PSCs from GOMOS: ext. 500 nm





Red: GOMOS (500 nm)

Black: ACE imagers (525 nm)

AERGOM

AERGOM prototype in a nutshell

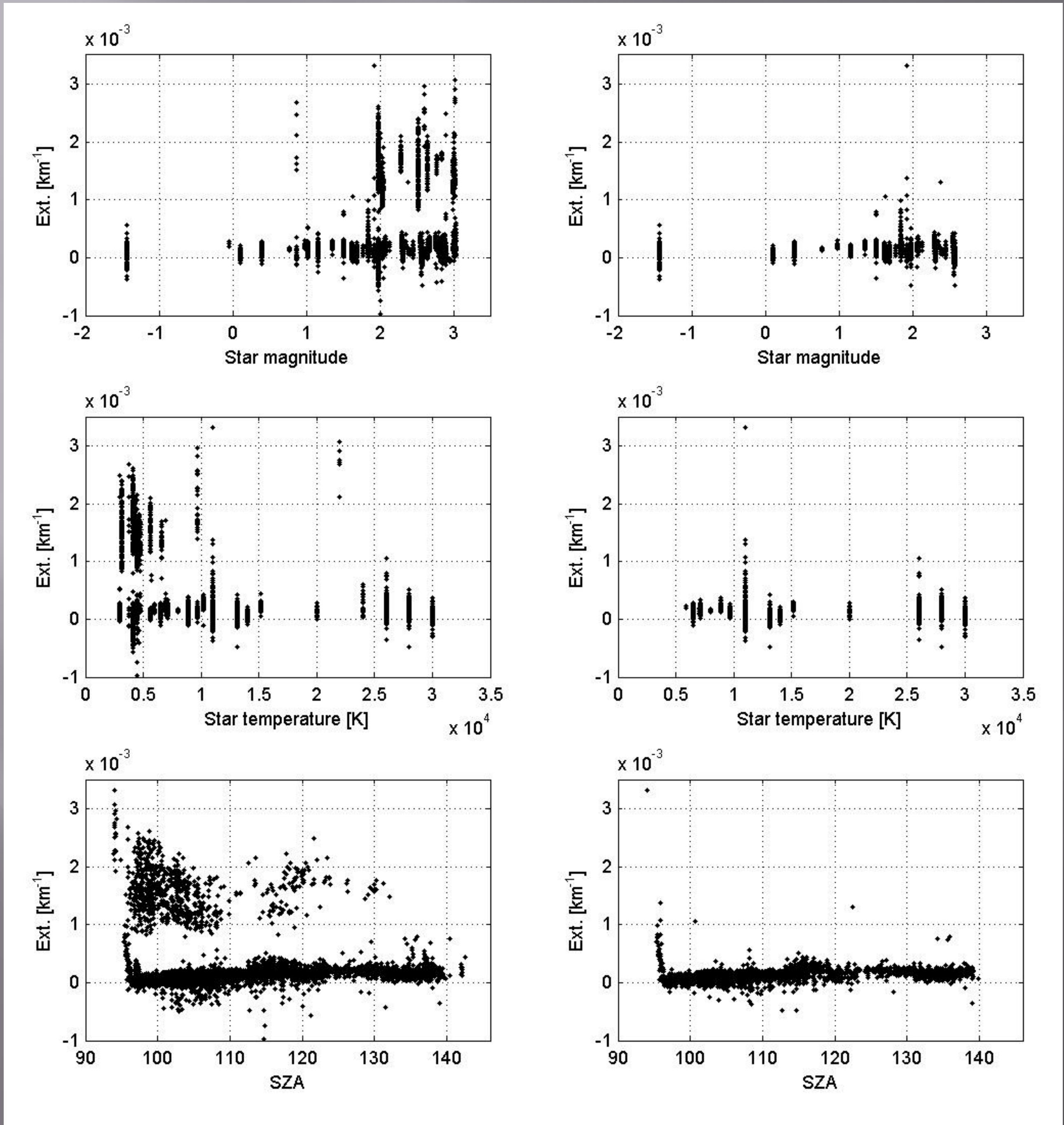
	Official GOMOS processor	AERGOM
Spectral inversion	❑ SPA ❑ NO_2, NO_3: DOAS ❑ O_3, aerosols: LM fit ❑ Aerosol spectral model: rather strange quadratic polynomial	❑ SPA, SPB1 (outside O2 band) ❑ NO_2, NO_3, O_3, aerosols: simultaneous LM fit ❑ Aerosol spectral model: Lagrange polynomial parametrized with AOD (3)
Spatial inversion	❑ All species separately, discarding covariances from the spectral inversion ❑ Tikhonov altitude regularization (one for aerosols)	❑ All species together, using the entire spectral retrieval covariance matrix. ❑ Tikhonov altitude regularization (n for aerosols (3)).
Radial inversion	❑ None	❑ Particle size distributions on a logarithmically spaced size grid. ❑ Derived quantities: N_{tot}, a_m, σ^2, a_{eff}, SAD, VD

AERGOM v1.0: data product overview

File format	NetCDF4	Standard reading libraries for Matlab, IDL, C, Python etc. are available. Also readable by BEAT (CODA).
File name	'aergom_R<orbit>_S<star>_<starttime>.nc'	Example: 'aergom_R02911_S0148_20020920_104448.nc'
Typical size	150 kByte	Total of all products (dark limb): 60 Gbytes
9 Data Groups:	AEROSOL	Slant path AOD, local extinction (+ errors)
	GAS	Slant path density, local density (+ errors)
	AIR	Slant path density, local density (+ errors)
	ECMWF	Pressure, density, temperature
	ATTRIBUTES	Star characteristics, filenames, version number, regularization params, discarded flags, cirrus selection criteria, illumination condition, …
	GEOLOCATION	Lat, lon, tangent alt, MJD, SZA
	STATISTICS	# iterations and χ^2 for spectral and radial inversion
	RADIAL	PSD: a-grid, u-grid, f_a, f_u, b (+ errors) DERIVED: N_{tot}, S, V, a_{eff}, a_m, σ^2 (+ errors)
	WEIGHT FRACTION	H_2SO_4/HNO_3 weight fraction

Batch processing of GOMOS v6.01 spectra

- Total number of files : ~ 800000
- In dark limb: ~400000
- Standard settings that we used:
  - Retrieval altitude range: 0 – 120 km
  - Aerosol ext. model: quadratic polynomial of 1/λ
  - All species (except air) are retrieved: O_3, NO_2, NO_3, aerosol extinction.
  - 20 particle size bins in the size range [0.02 – 2] μm
- Processing time for all ***dark limb*** occultations: about 2 days on 4 machines (15 simultaneous processes).
- Proportion of retrievals without numerical errors: 98.5 %

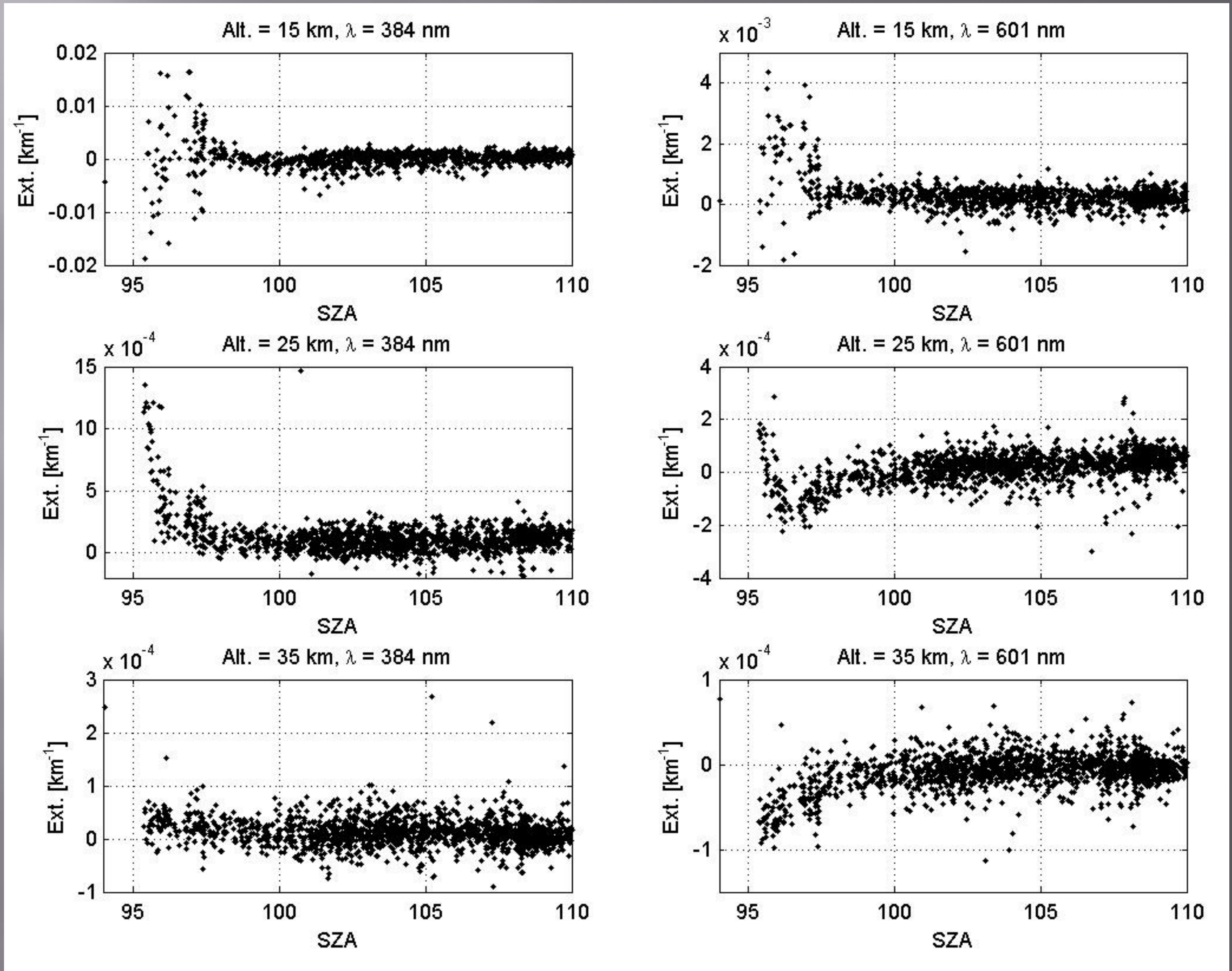


Initial data filtering

Cold, weak stars give problems …
Applying a few tresholds removes most outliers:

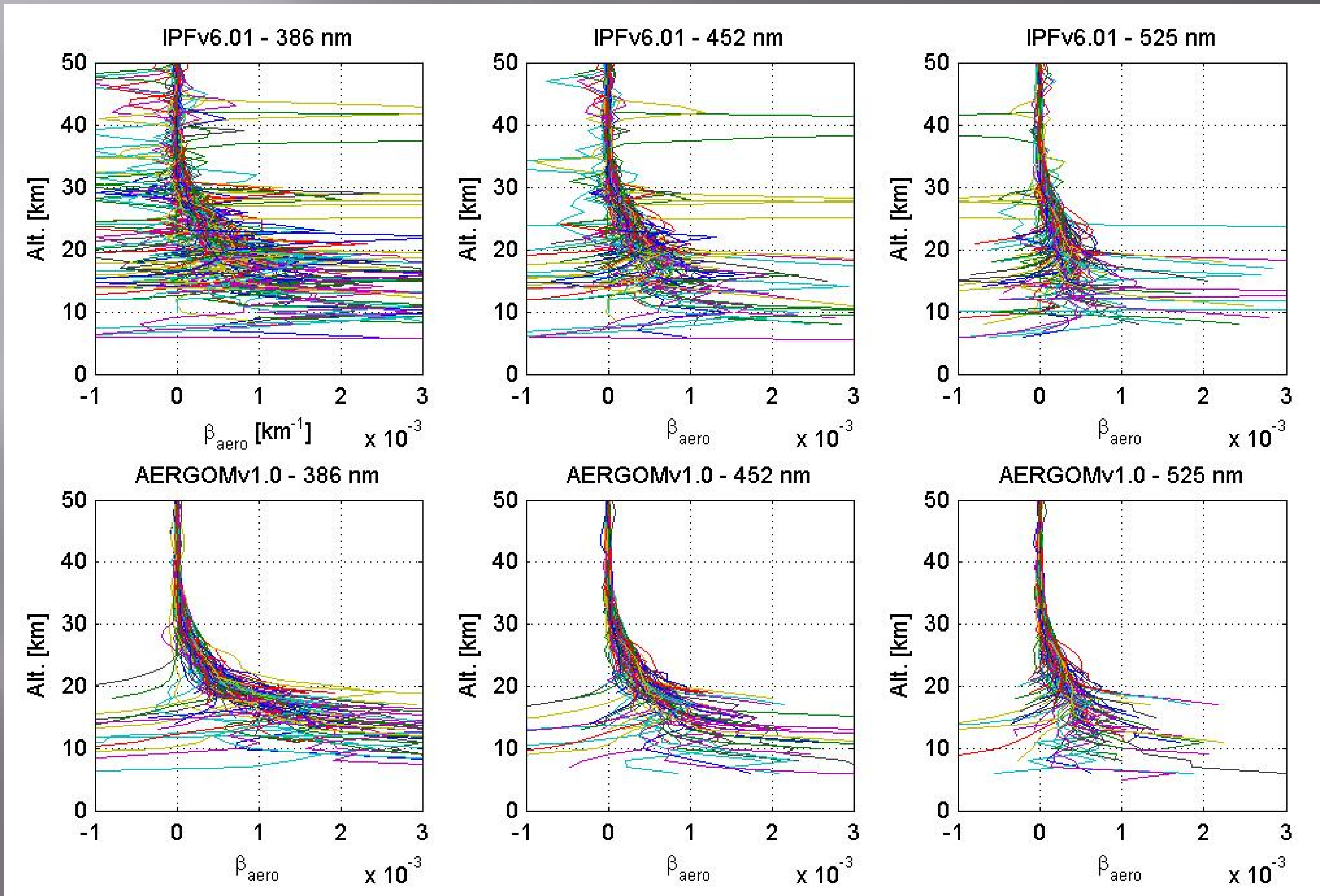
Star magnitude < 2.6
Star temperature > 5000 K

Zoom on low SZA

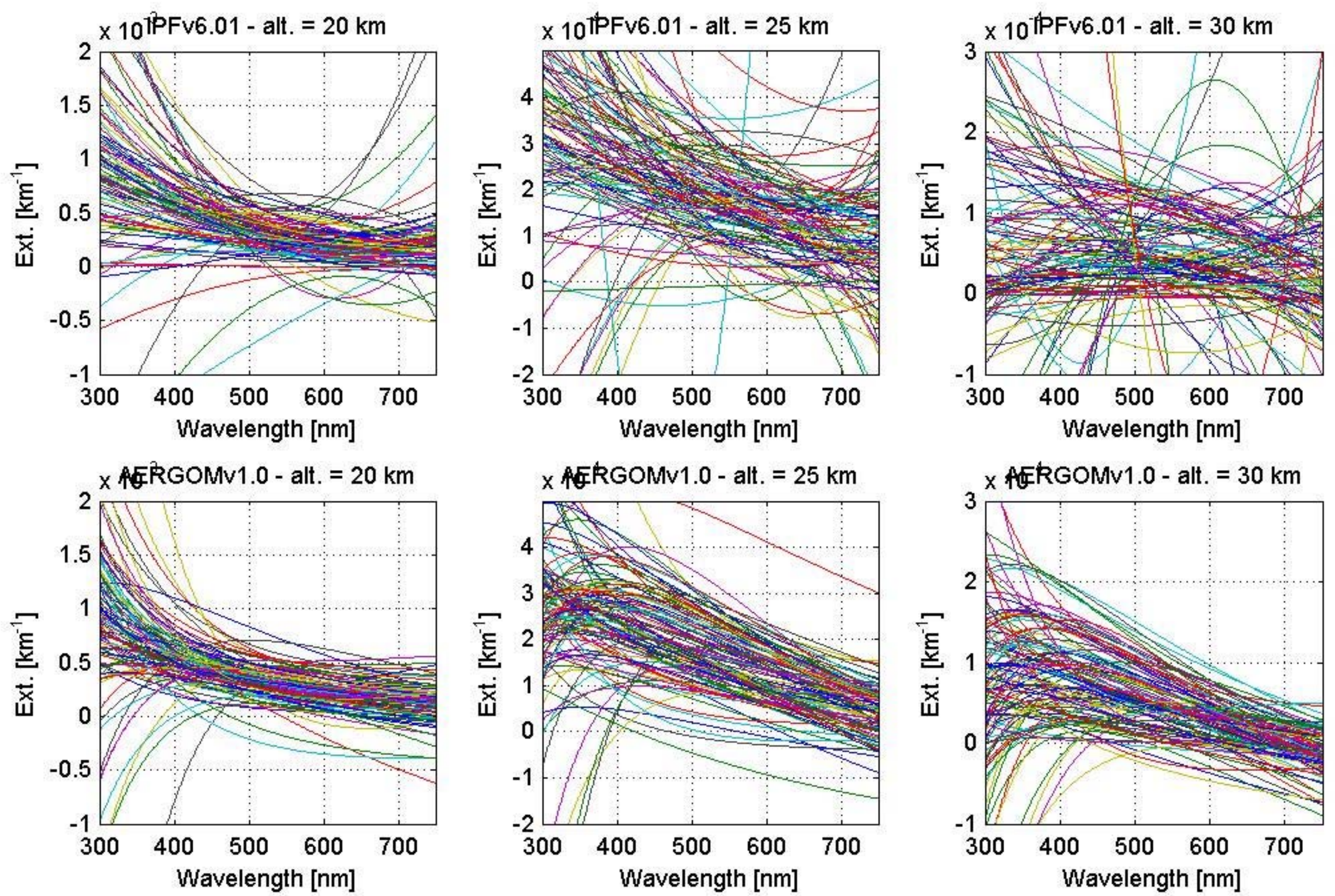


From visual inspection: **cut all data below SZA<100°** !

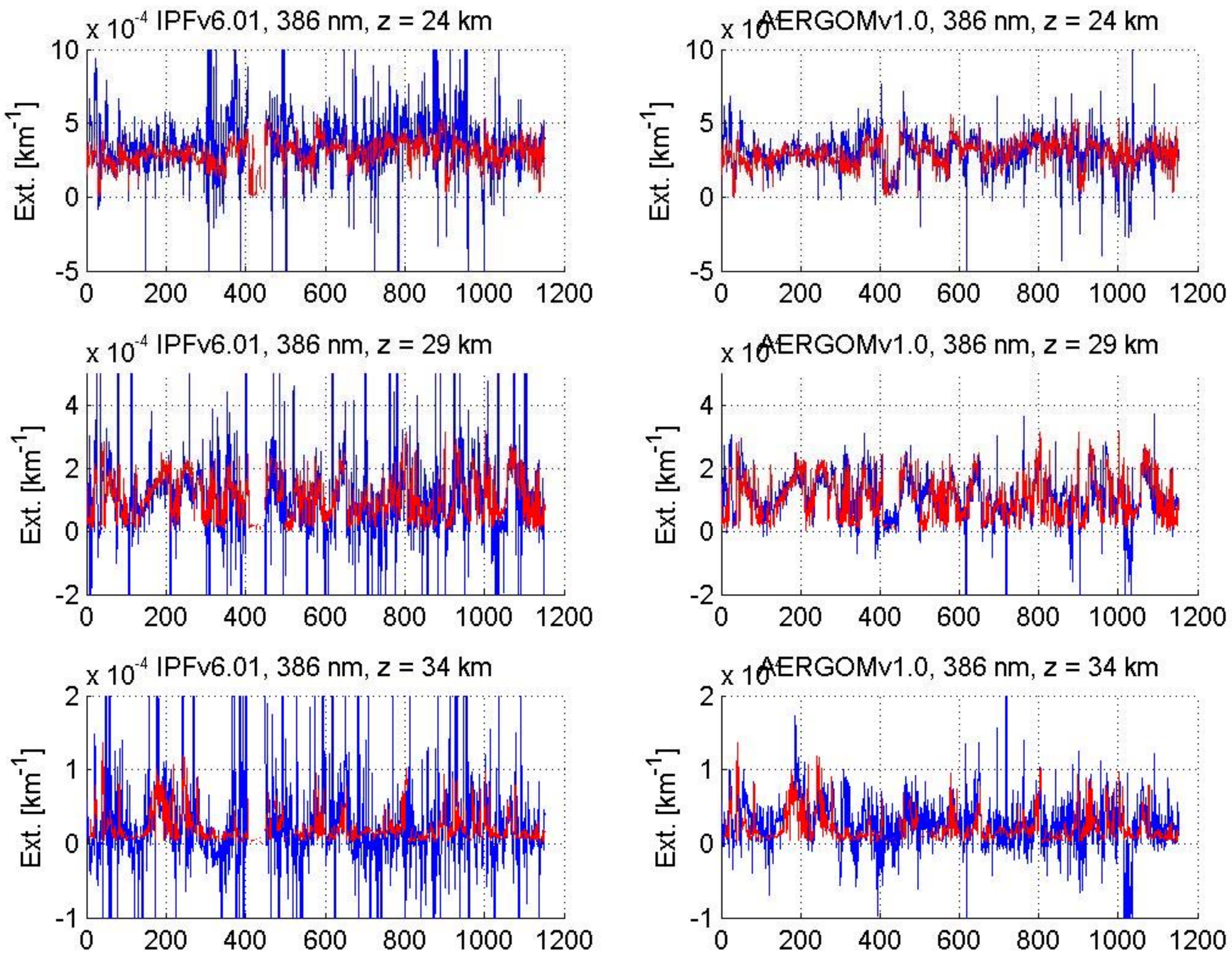
GOMOS IPFv6.01 vs. AERGOMv1.0: A random set of 115 profiles



GOMOS IPFv6.01 vs. AERGOMv1.0: A random set of 115 spectra



GOMOS/SAGEII coincidences (500 km, 12 hours): chronologically ordered.



~1100 values

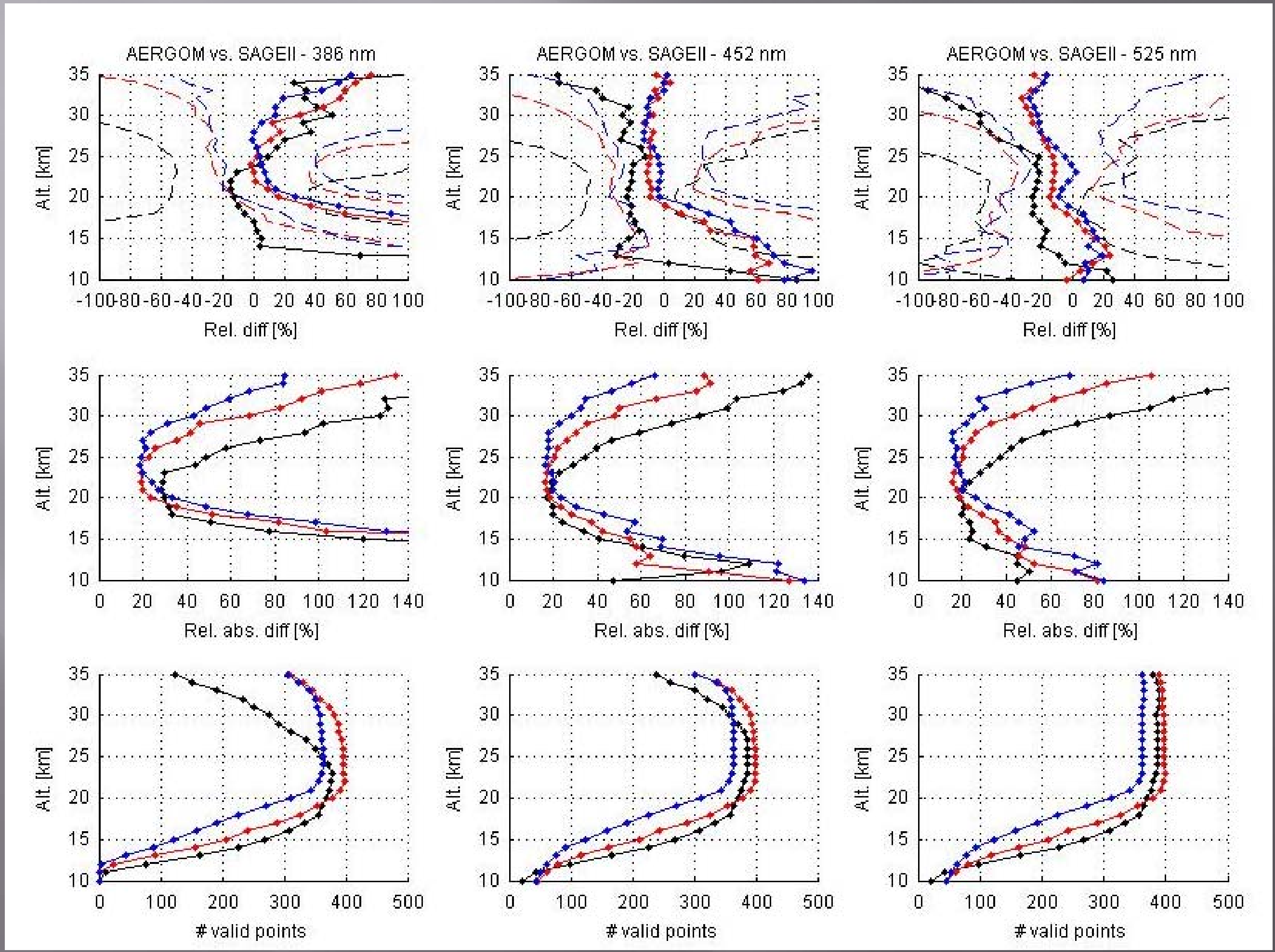
Blue: GOMOS

Red: SAGE II

Ensemble comparisons: AERGOM vs. SAGE II, SAGE III

- 3 data bins for every parameter:
  - SZA
  - star magnitude
  - star temperature
  - occultation obliquity
  - time
  - latitude

AERGOM vs SAGE2: SZA

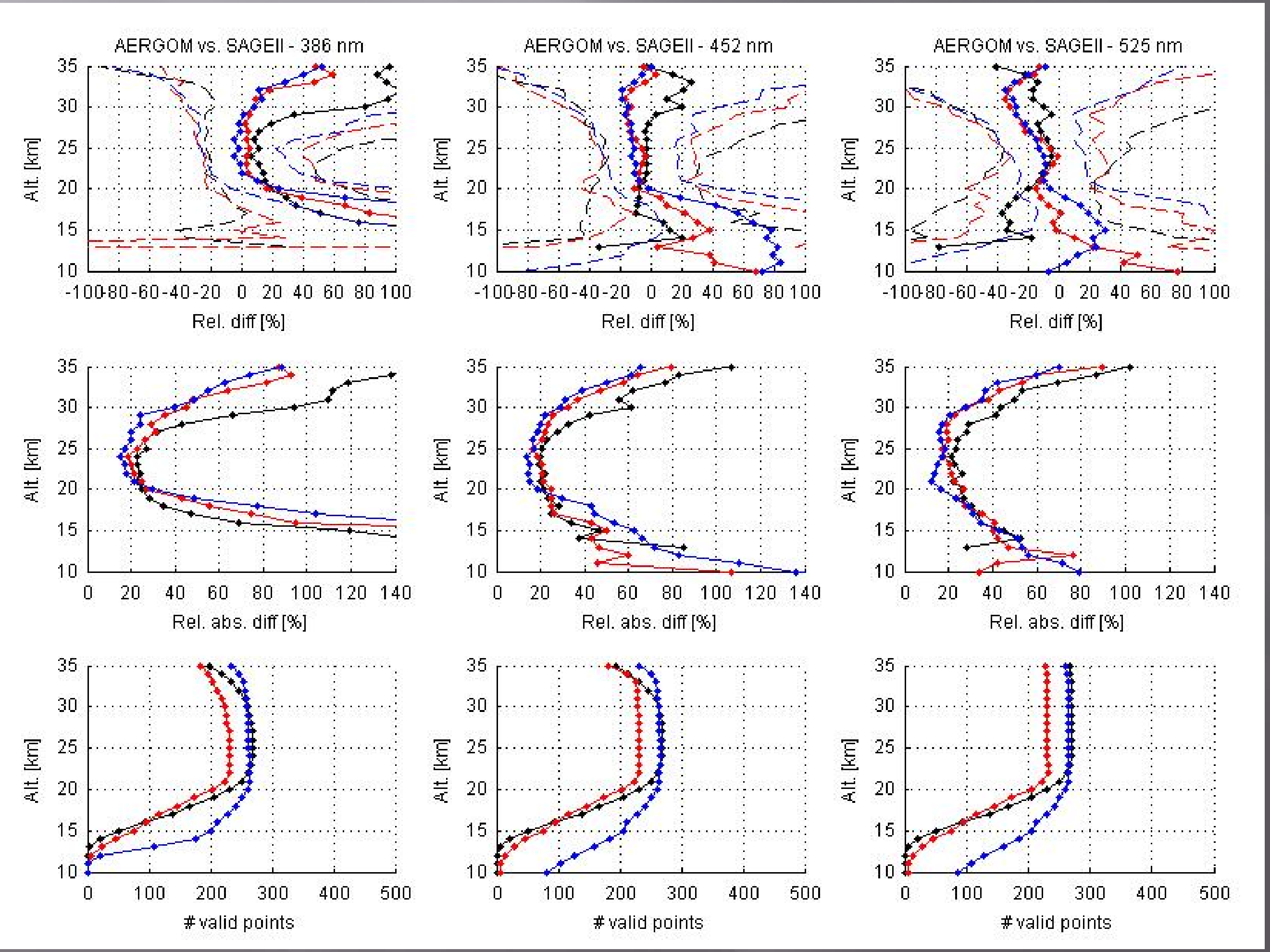


Black: SZA = [100 – 117°]
Red: SZA = [117 – 148°]
Blue: [148 – 172°]

Conclusion: better to cut data below SZA = 117°

Notice altitudinal effect for deviation: SZA is strongly correlated with latitude.

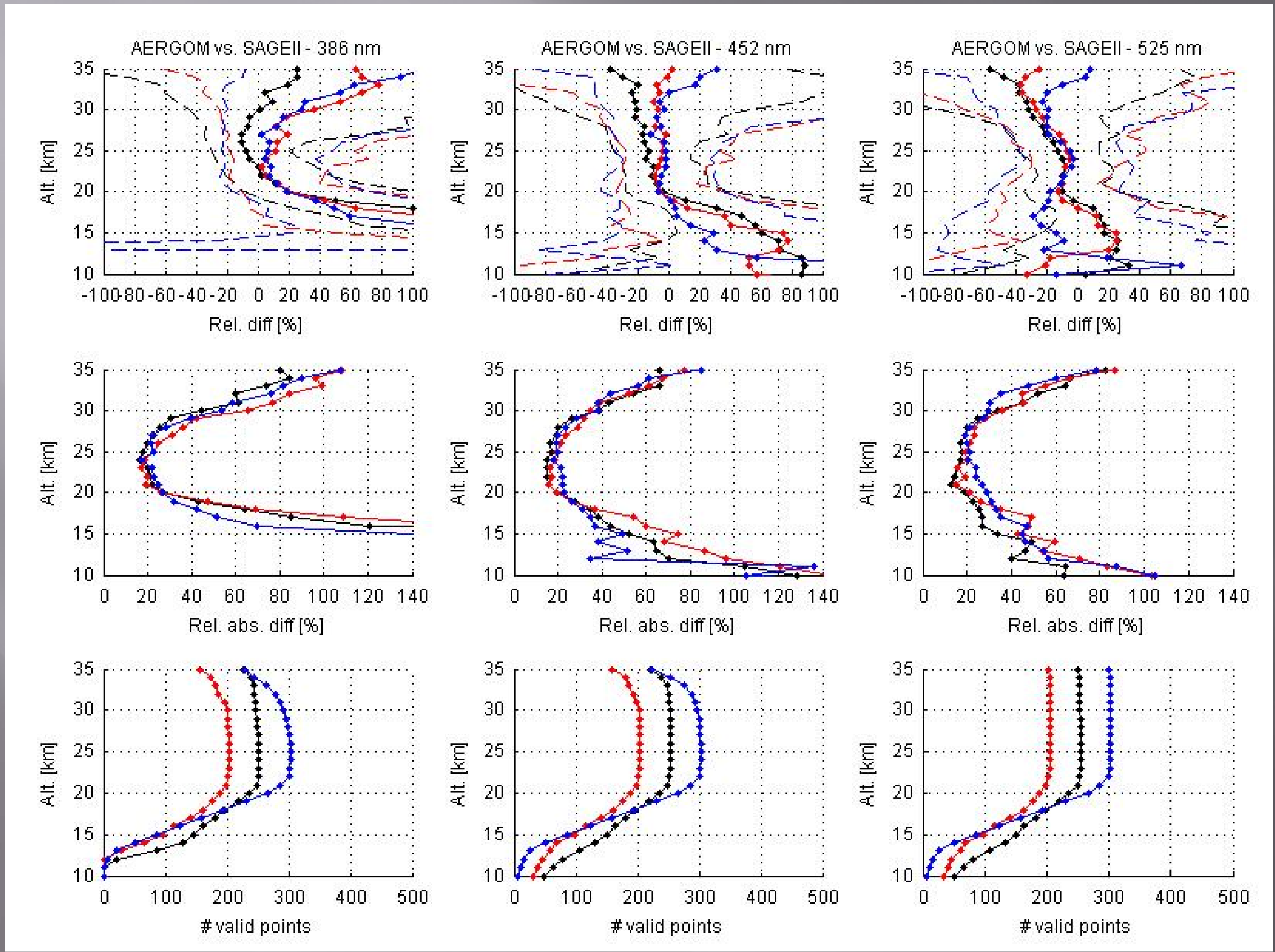
AERGOM vs SAGE2: star magnitude



Black: mag= [2.6 , 2.2]
Red: mag = [2.2, 1.5]
Blue: mag =[1.5, -1.44]

Conclusion: weak stars give higher abs. deviation (obvious)

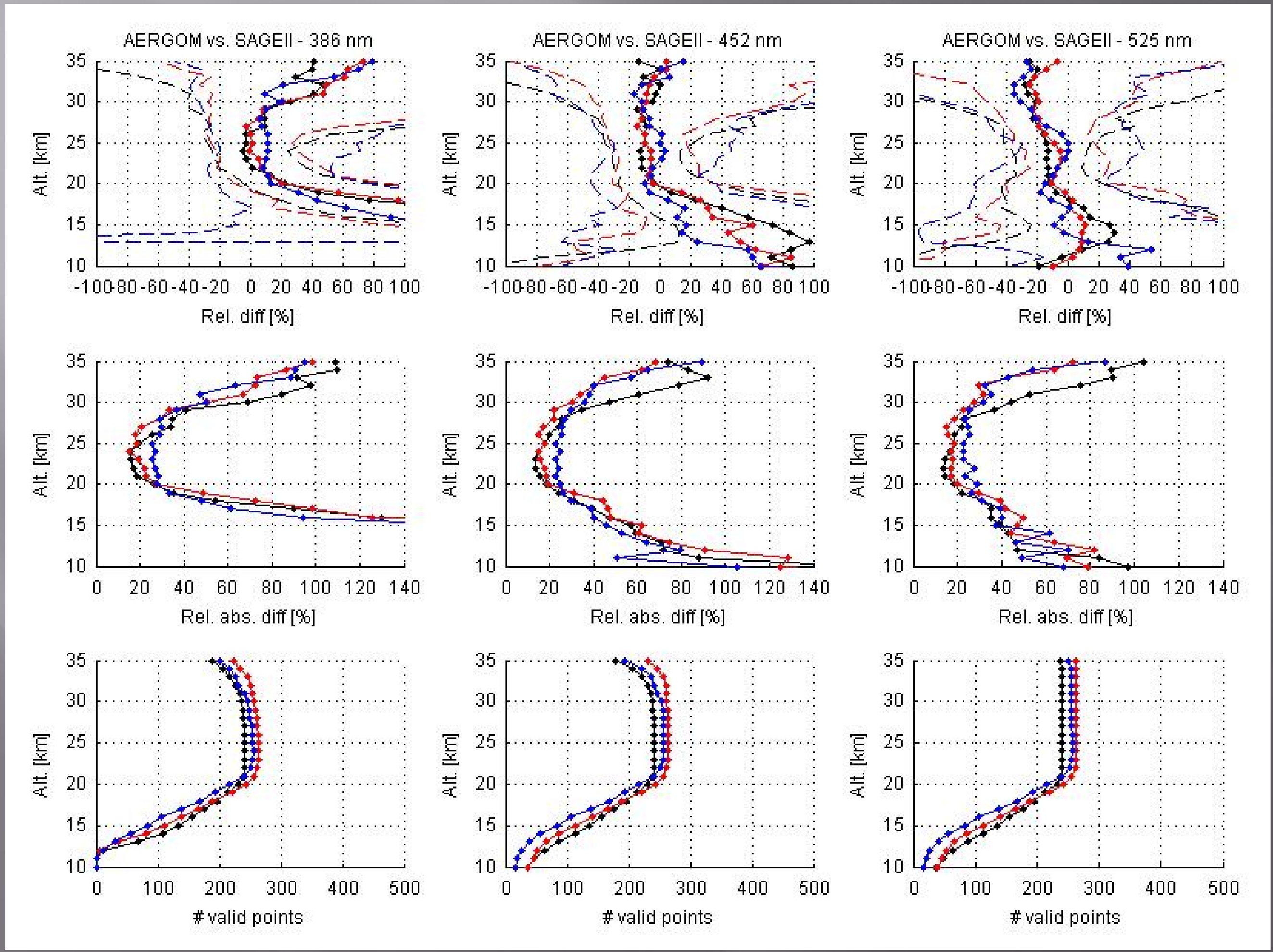
AERGOM vs SAGE2: star temperature



Black: T = [5000 , 10700] K
Red: T = [10700, 25500] K
Blue: T = [25500, 40000] K

Conclusion: no clear effect observed

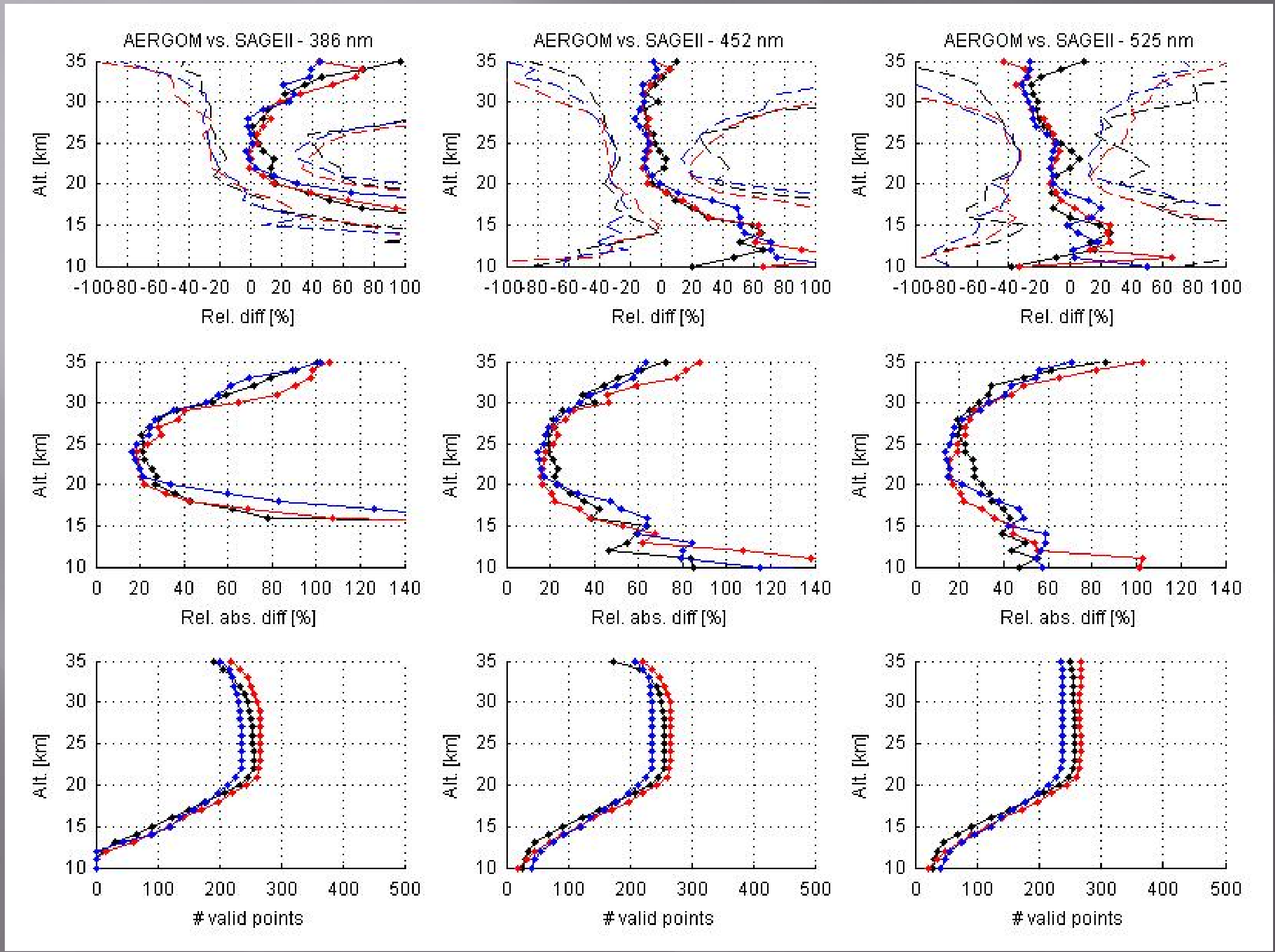
AERGOM vs SAGE2: obliquity



Black: obl= [-25°, 20°]
Red: obl= [20°, 50°]
Blue: obl =[50°, 90°]

Conclusion: no real effect observed.

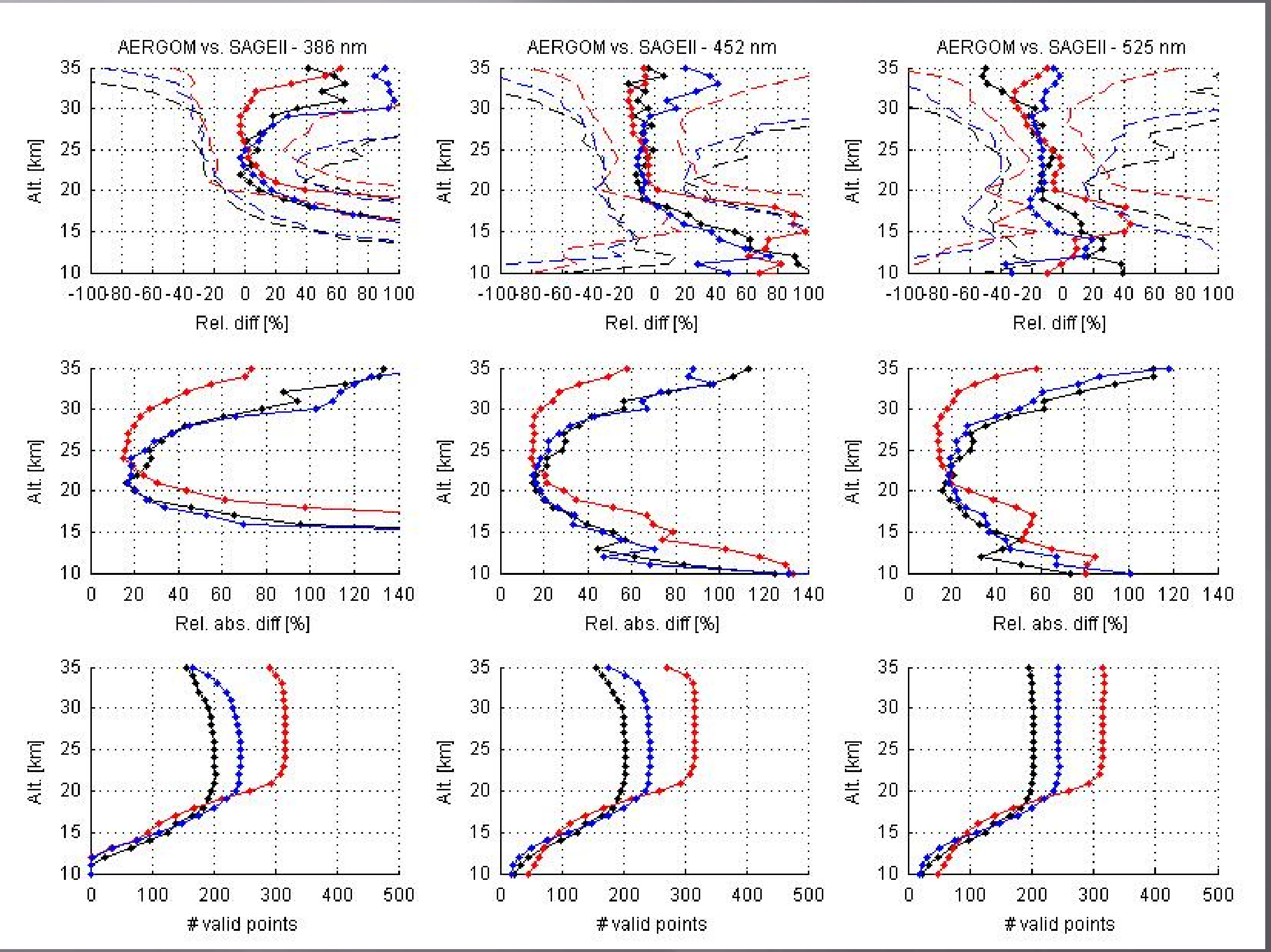
AERGOM vs SAGE2: time



Black: time= [52379 , 52790]
Red: time= [52379, 53120]
Blue: time =[53120, 53434]

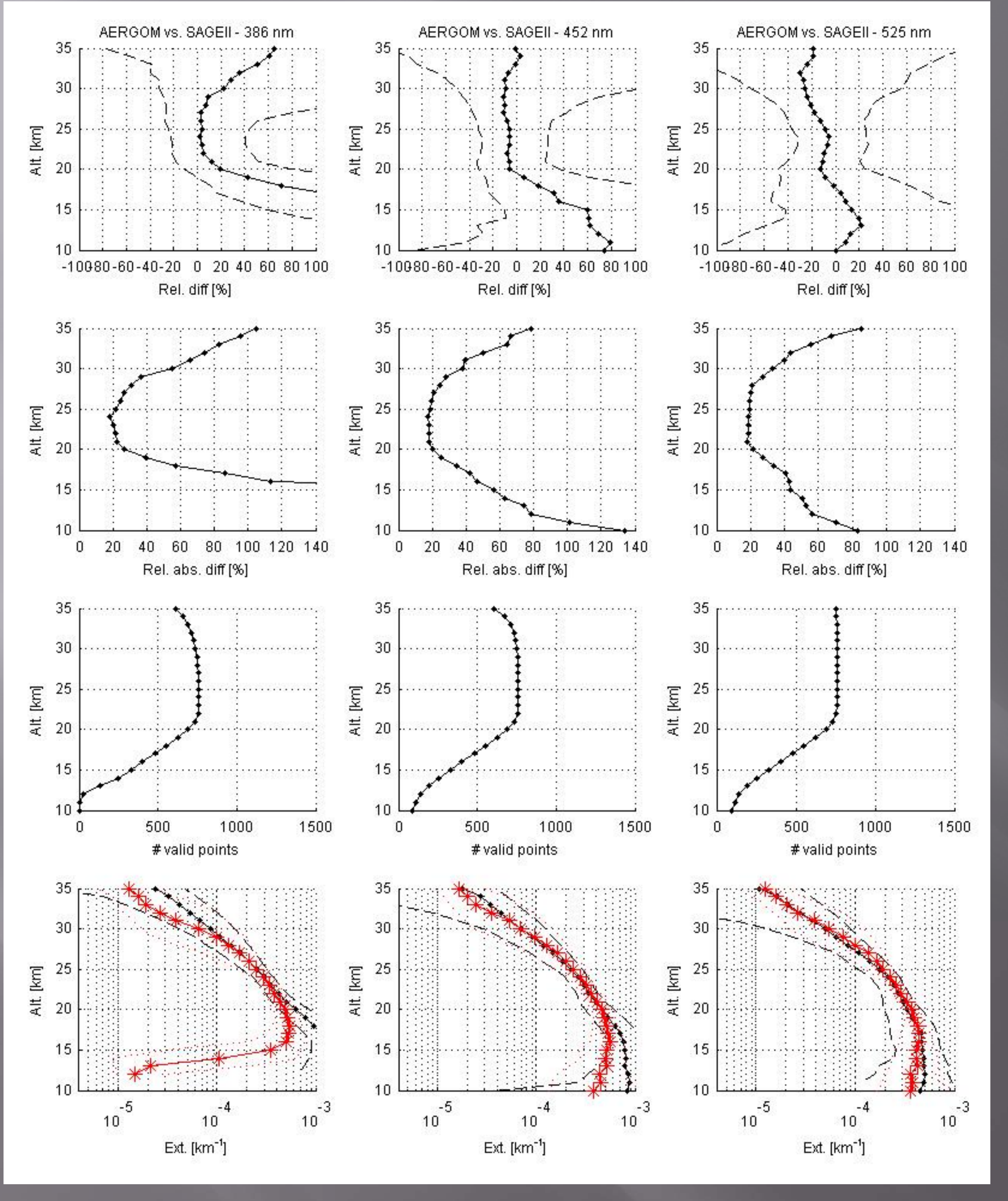
Conclusion: no real effect observed, results remain very stable and consistent.

AERGOM vs SAGE2: latitude



Black: lat= [90°S , 30°S]
Red: lat= [30°S, 30°N]
Blue: lat =[30°N, 90°N]

Conclusion: sensitivity clearly follows the latitude/altitude dependence of the aerosol layer .



AERGOM vs SAGE2: all profiles

With SZA > 117°, star temp >5000 K, star magnitude<2.6

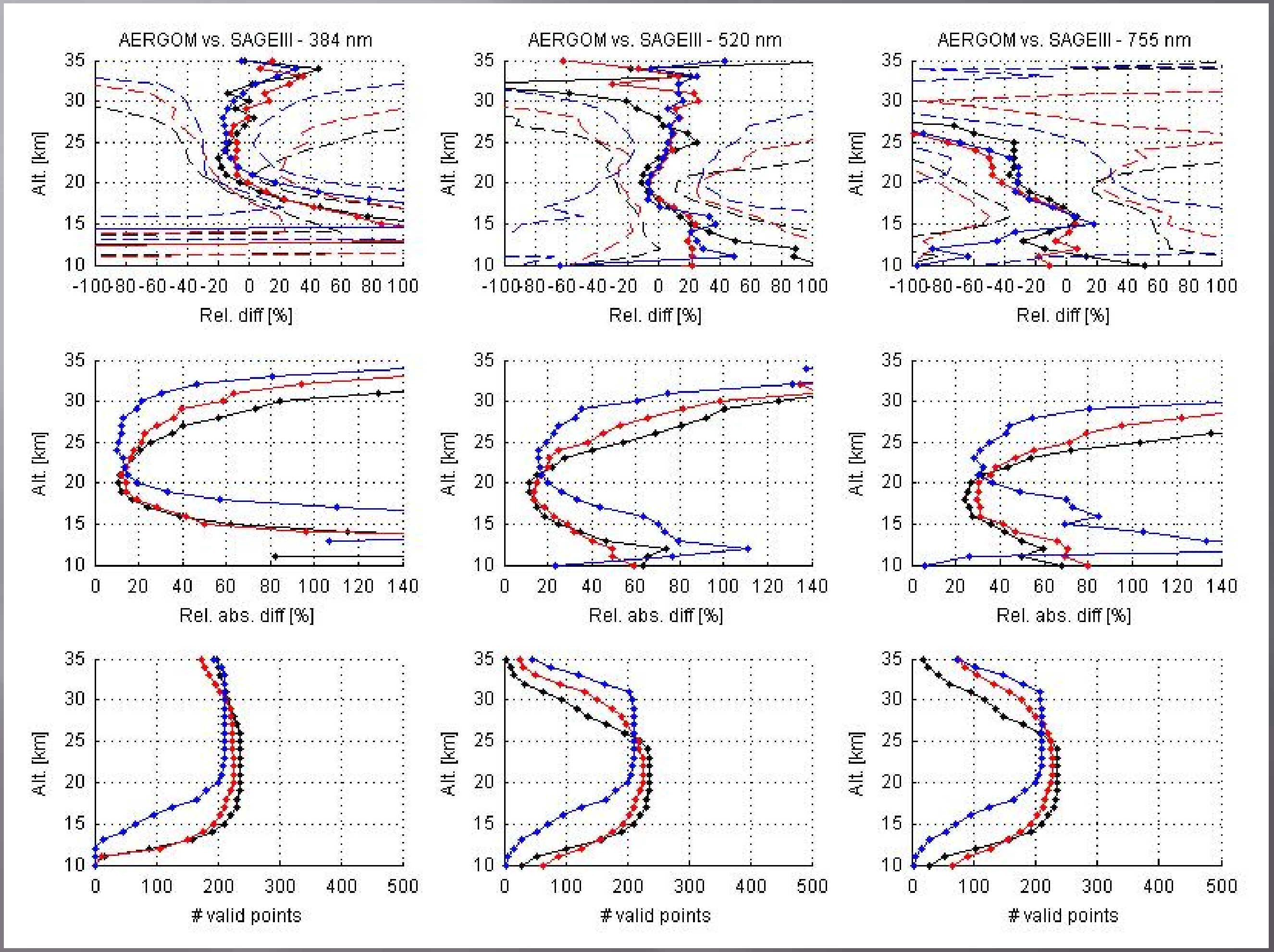
Results:
Rel. diff of 15 % or better:

- 386 nm: 20 – 30 km
- 452 nm: 17 – 35 km
- 525 nm: 10 – 35 km

Abs deviation of 40 % or better:

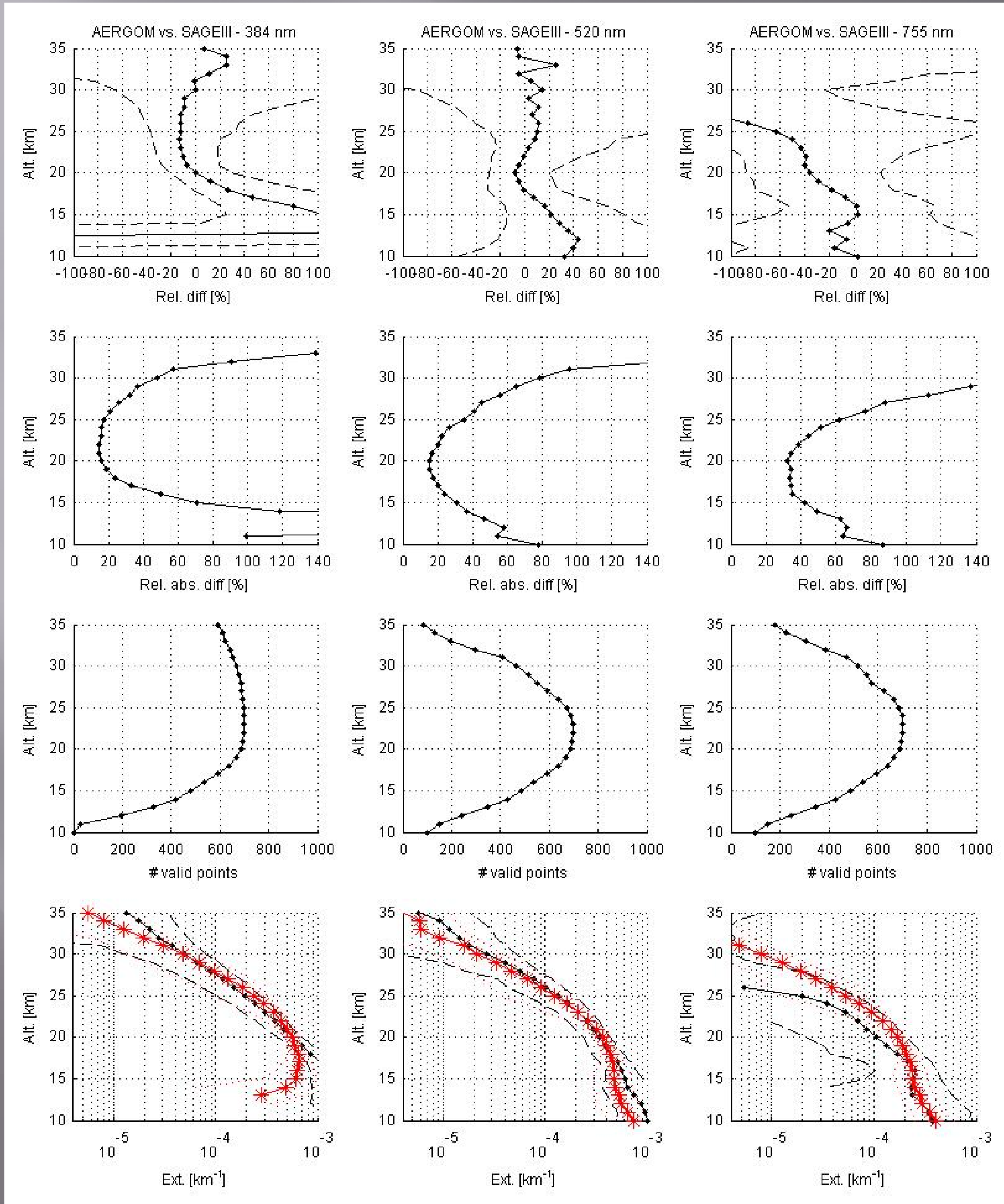
- 386 nm: 19 – 29 km
- 452 nm: 17 – 31 km
- 525 nm: 15 – 32 km

AERGOM vs SAGE3: latitude



Black: lat= [62°S , 55°S]
Red: lat= [55°S, 45°S]
Blue: lat =[45°S, 35°S]

Conclusion: sensitivity clearly follows the latitude/altitude dependence of the aerosol layer .



AERGOM vs SAGE3: all profiles

With SZA > 117°, star temp >5000 K, star magnitude<2.6

Results:

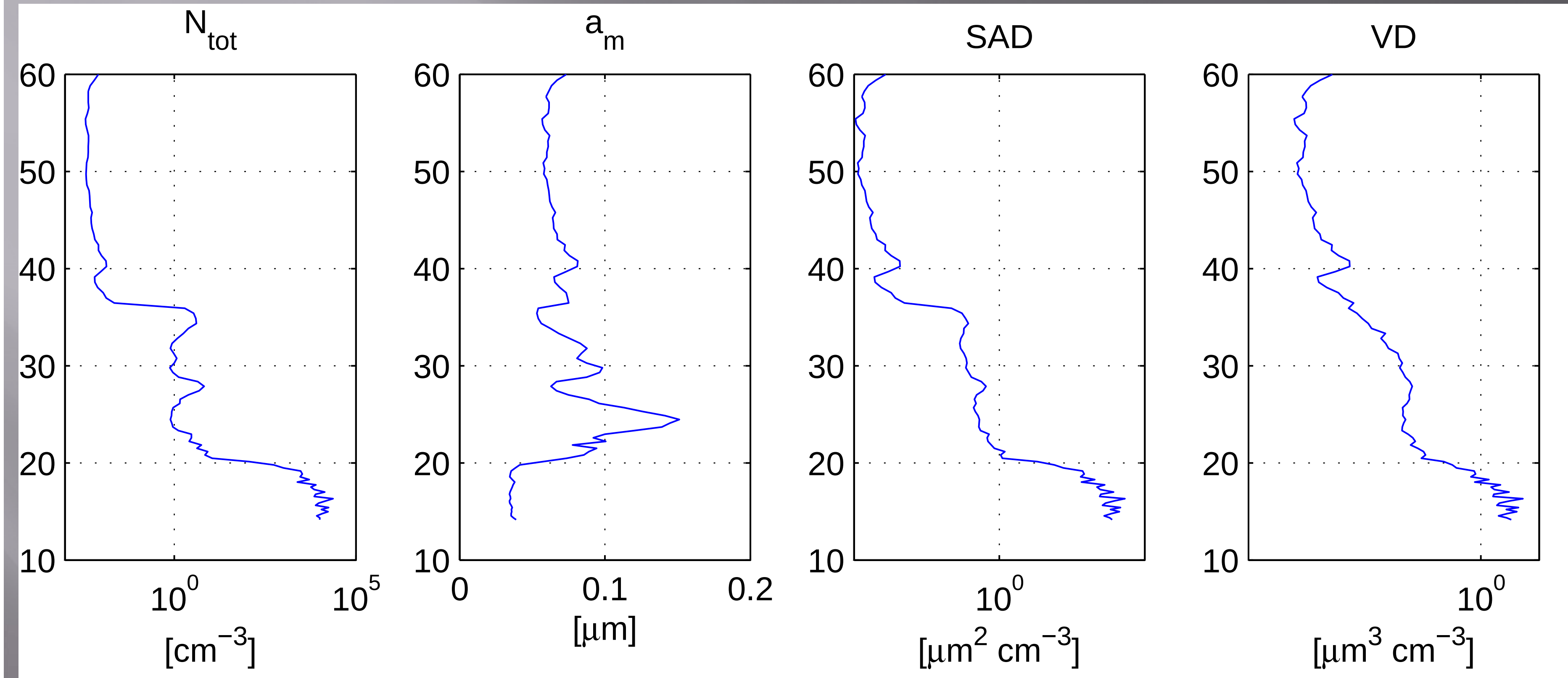
Rel. diff of 15 % or better:

- 384 nm: 19 – 32 km
- 520 nm: 17 – 32 km
- 755 nm: 10 – 17 km

Abs deviation of 40 % or better:

- 384 nm: 17 – 29 km
- 452 nm: 14 – 26 km
- 525 nm: 15 – 22 km

AERGOM: particle size information



Comparison studies ongoing

AERGOM: conclusions

- Significant improvement of aerosol extinction profiles. Oscillations, spikes, … have decreased strongly. Especially extinction at wavelengths different from 500 nm are much better.
- Still problems for certain cases:
  - Cold, weak stars
  - stray light contamination at low SZA (<117°).
- Comparisons with SAGE II and SAGE III: Typical: relative diff = 15 % or less, deviation = 40% or less.
- Particle size distributions and derived quantities are also available.