Stratospheric aerosols and PSCs as observed by GOMOS on Envisat: results for the period 2002-2005

Filip Vanhellemont, Didier Fussen, Jan Dodion, Christine Bingen, Nina Mateshvili
BIRA-IASB, Brussels, Belgium

E. Kyrölä, J. Tamminen, V. Sofieva, S. Hassinen, P. Verronen, A. Seppälä
Finnish Meteorological Institute, Finland

J.-L. Bertaux, A. Hauchecorne, F. Dalaudier
Service d' Aéronomie, France

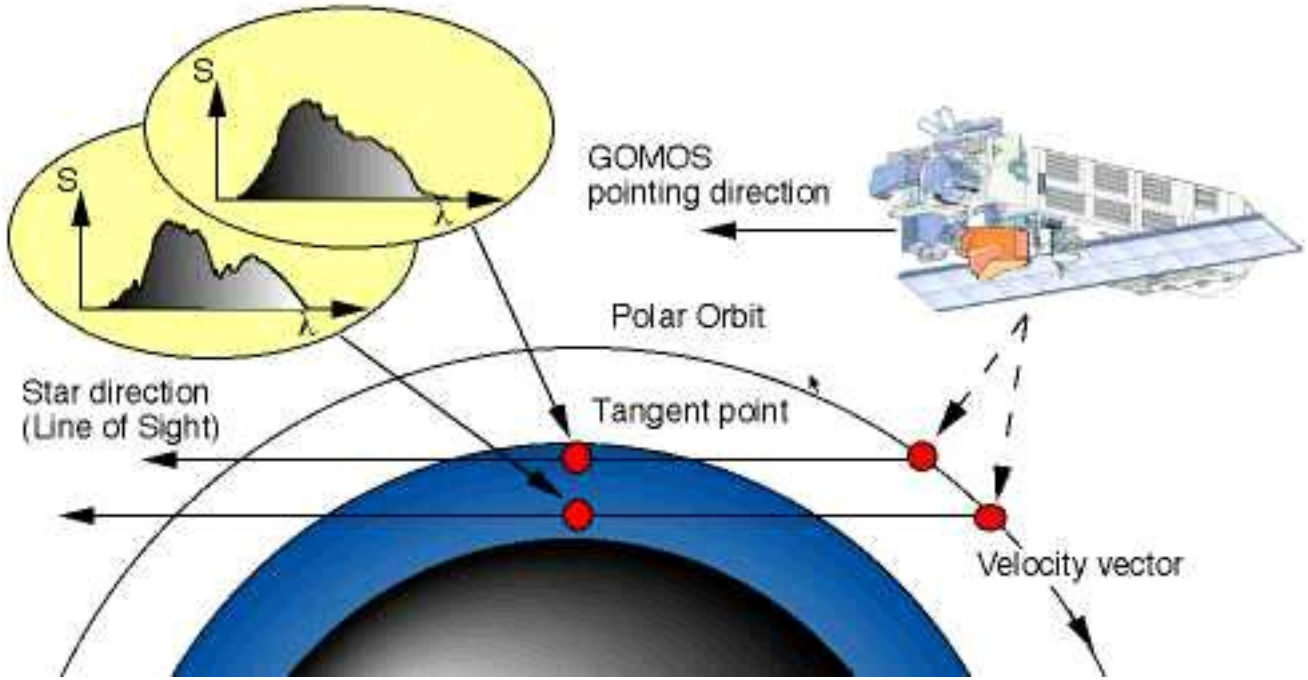
O. Fanton d'Andon, G. Barrot, A. Mangin, B. Théodore, M. Guirlet
ACRI, France

J.-B. Renard
CNRS-LPCE, France

R. Fraisse
Astrium SAS, France

P. Snoeij, R. Koopman, T. Fehr, L. Saavedra
ESA – ESTEC/ESRIN

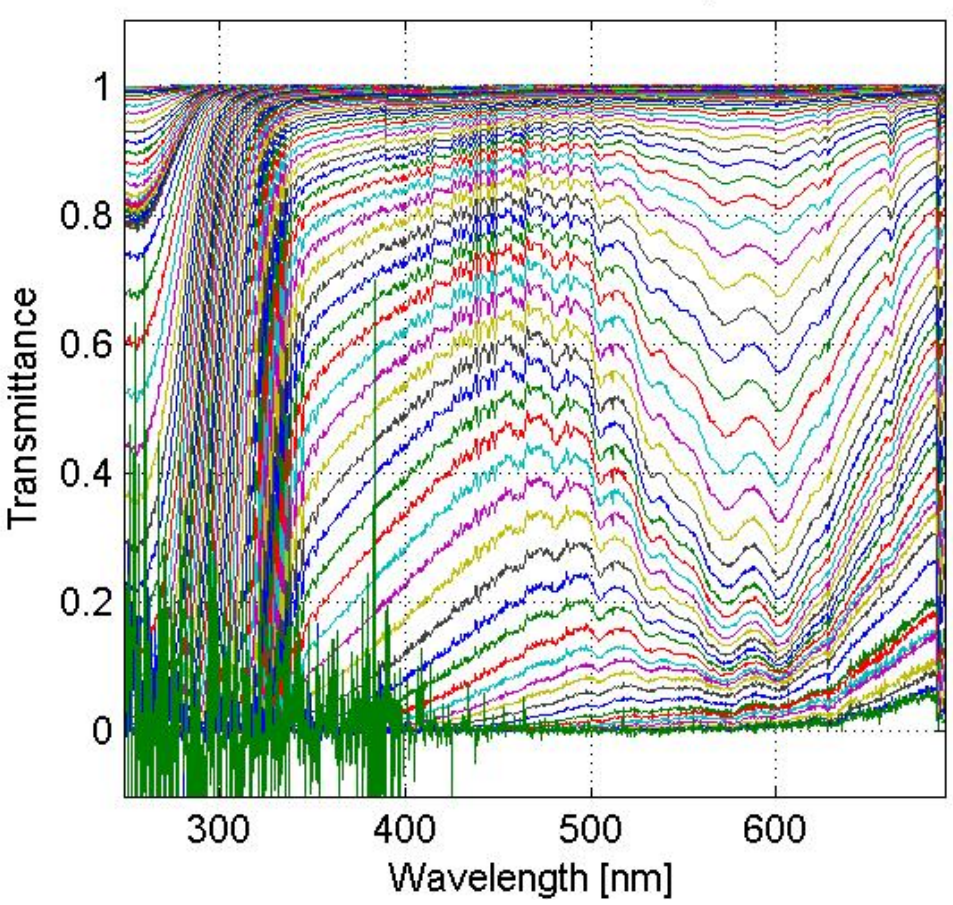
GOMOS: principle



Pro: Good vertical resolution, self-calibrating, relatively simple forward model, lots of stars available (400-500 occultations per day)

Con: relatively low S/N ratio (as compared to solar occultation)

GOMOS spectral ranges



UV/Vis:

[248-690] nm, 0.9 nm resolution, 0.31 nm sampling

O_3, NO_2, NO_3, aerosol extinction

Also: Na (mesosphere), OClO

IR:

[750-776] nm and [916-956] nm, 0.14 nm resolution, 0.06 nm sampling

O_2, H_2O

Fast photometers, 1000 Hz

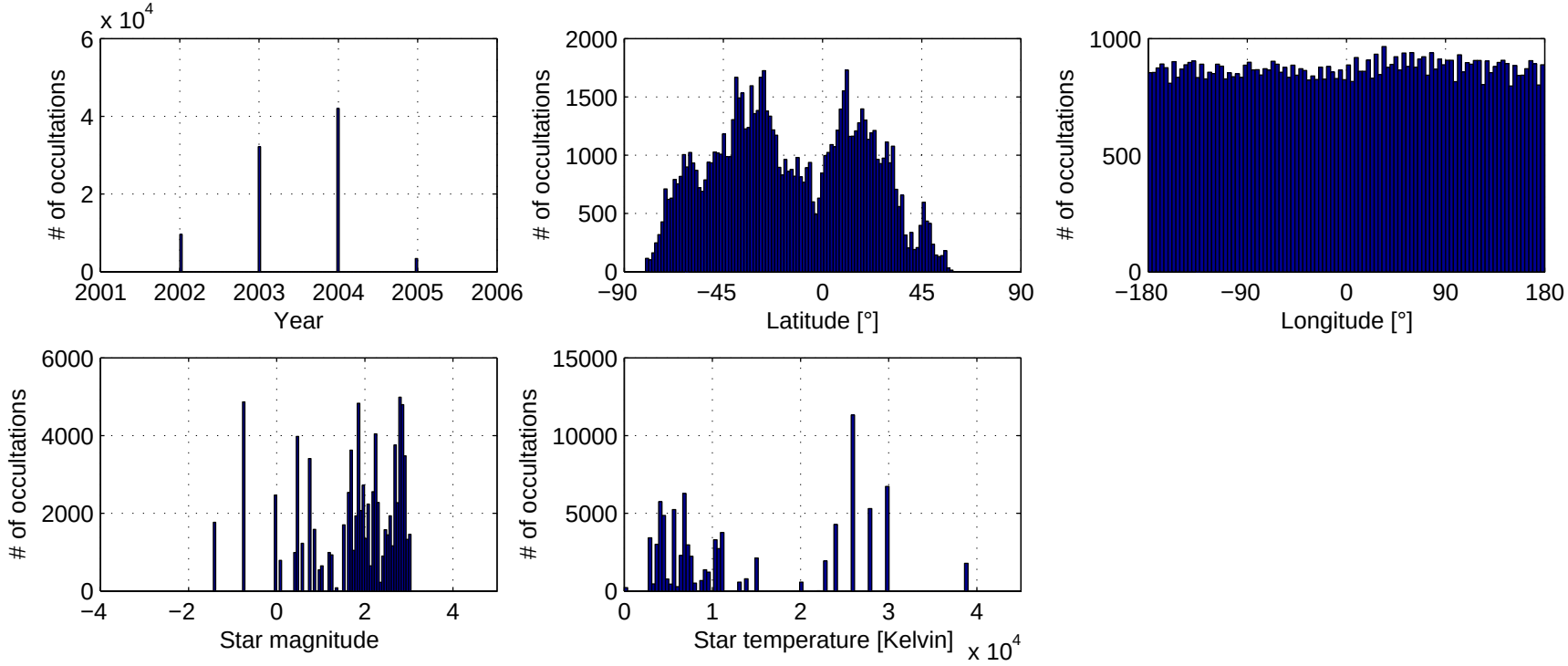
Blue [470-520] nm, red [650-700] nm

Scintillation correction, high-resolution temperature profiles

Data set description (1)

- V5.00 data: August 2002 – January 2005 (Jan. 26, 2005: GOMOS failure)
- More than 300,000 occultations measured in dark limb, bright limb and twilight conditions.
- Measurements in bright limb and twilight need background limb correction using data from the upper and lower band of the CCD. This correction is not perfect, and resulting aerosol retrievals are very poor. **When working on GOMOS aerosol extinction profiles, only use dark limb occultations!** (88,200 occultations)
- Scintillation correction is imperfect, some residual scintillation is present in the profiles. However: random nature, is removed by averaging.
- Aerosol extinction: quadratic polynomial of wavelength. This form can adequately approximate flat spectra, small particle spectra, spectra with maximum in the visible, etc.

Data set description (2)



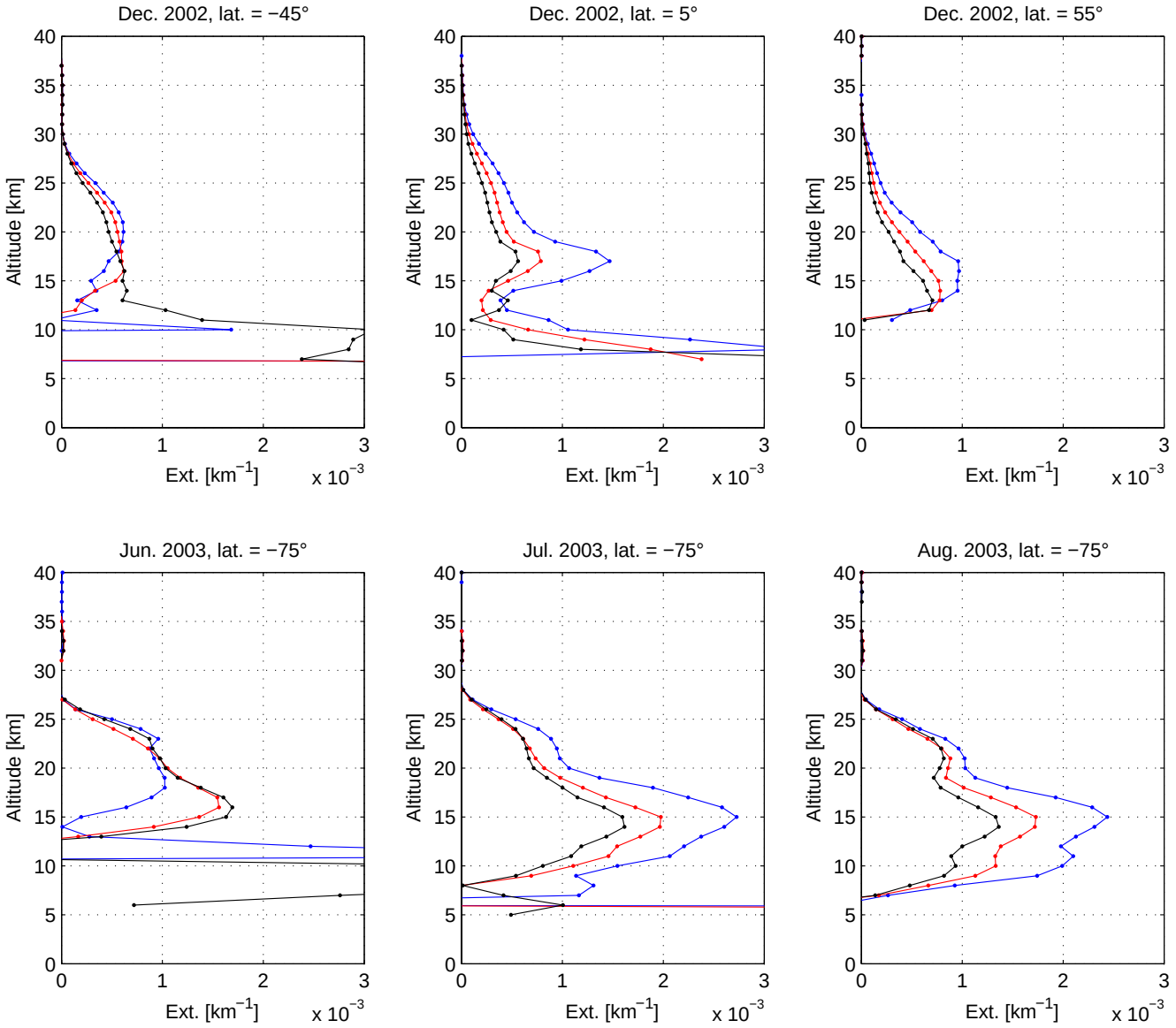
•Latitudinal coverage: good in tropical regions, midlatitudes, Antarctic regions.
•Longitudinal coverage: very homogeneous
•Star magnitudes from -1.4 to 4.1 (very bright to very weak), mostly occultations of relatively weak stars
•Star temperatures from 2,800 – 39,000 Kelvin. Temperature strongly determines the transmittance S/N ratio at a certain wavelength.

Considering the wide range of star magnitudes and temperatures, we see that the accuracy of GOMOS retrievals vary strongly. When doing retrieval statistics, we have to be careful … weighted means and variances, outlier removal.

Important remarks on stratospheric aerosols …

- For decades, sulfate aerosol levels in the stratosphere have not been as low as they are currently (last major volcanic eruption: Pinatubo, 1991)
- Low aerosol levels do not imply negligible optical extinction! Retrieval algorithms that do not take aerosols into account result in a significant bias for other species! (Vanhellemont et al, submitted to JGR, 2005)
- Aerosols are still there, performing their role in heterogeneous chemistry and radiative forcing. It is still necessary to quantify them.

Aerosol extinction: zonal mean profiles



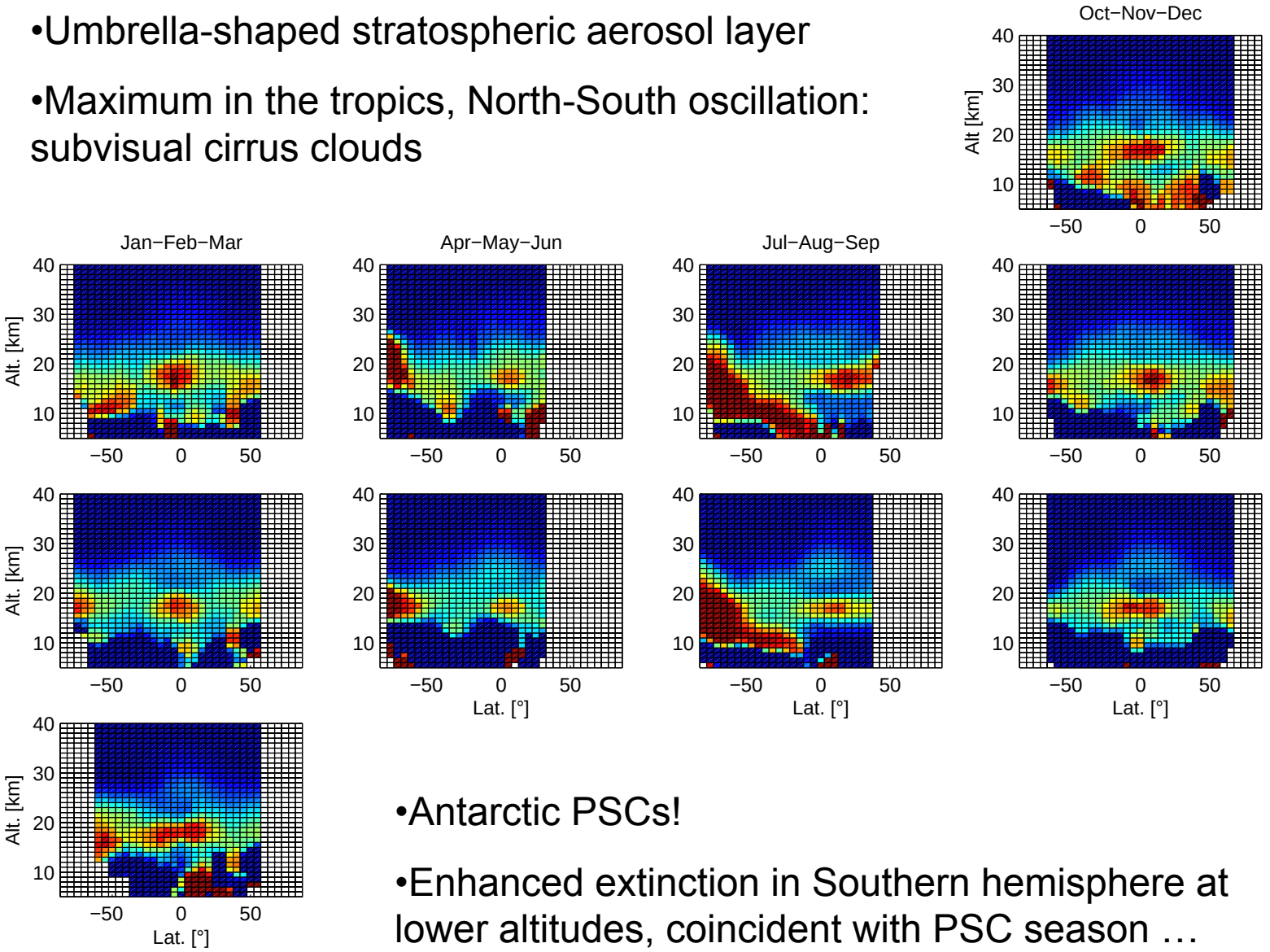
400 nm

500 nm

600 nm

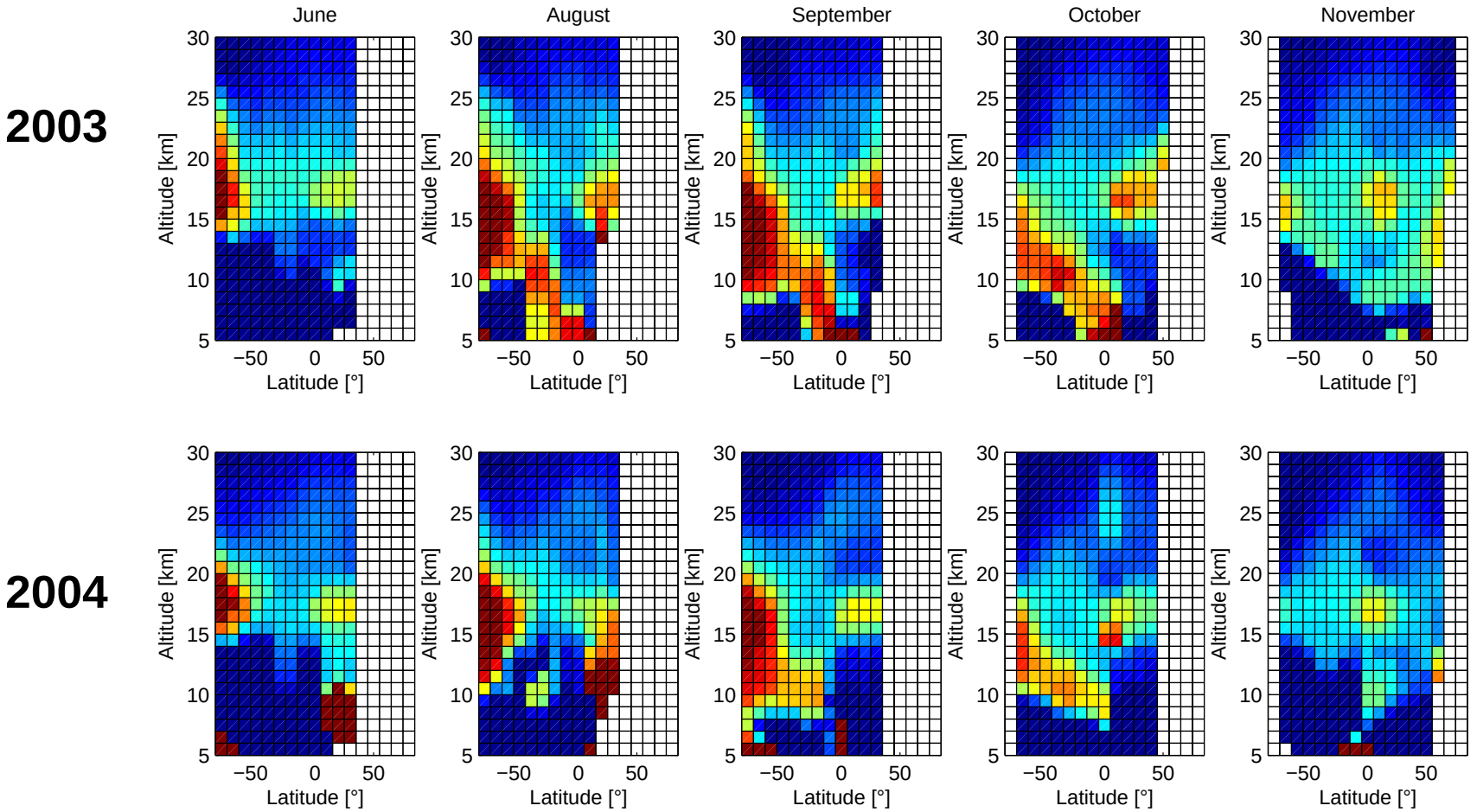
Aerosol ext. 500 nm: 3-month zonal averages

- Umbrella-shaped stratospheric aerosol layer
- Maximum in the tropics, North-South oscillation: subvisual cirrus clouds



- Antarctic PSCs!
- Enhanced extinction in Southern hemisphere at lower altitudes, coincident with PSC season …

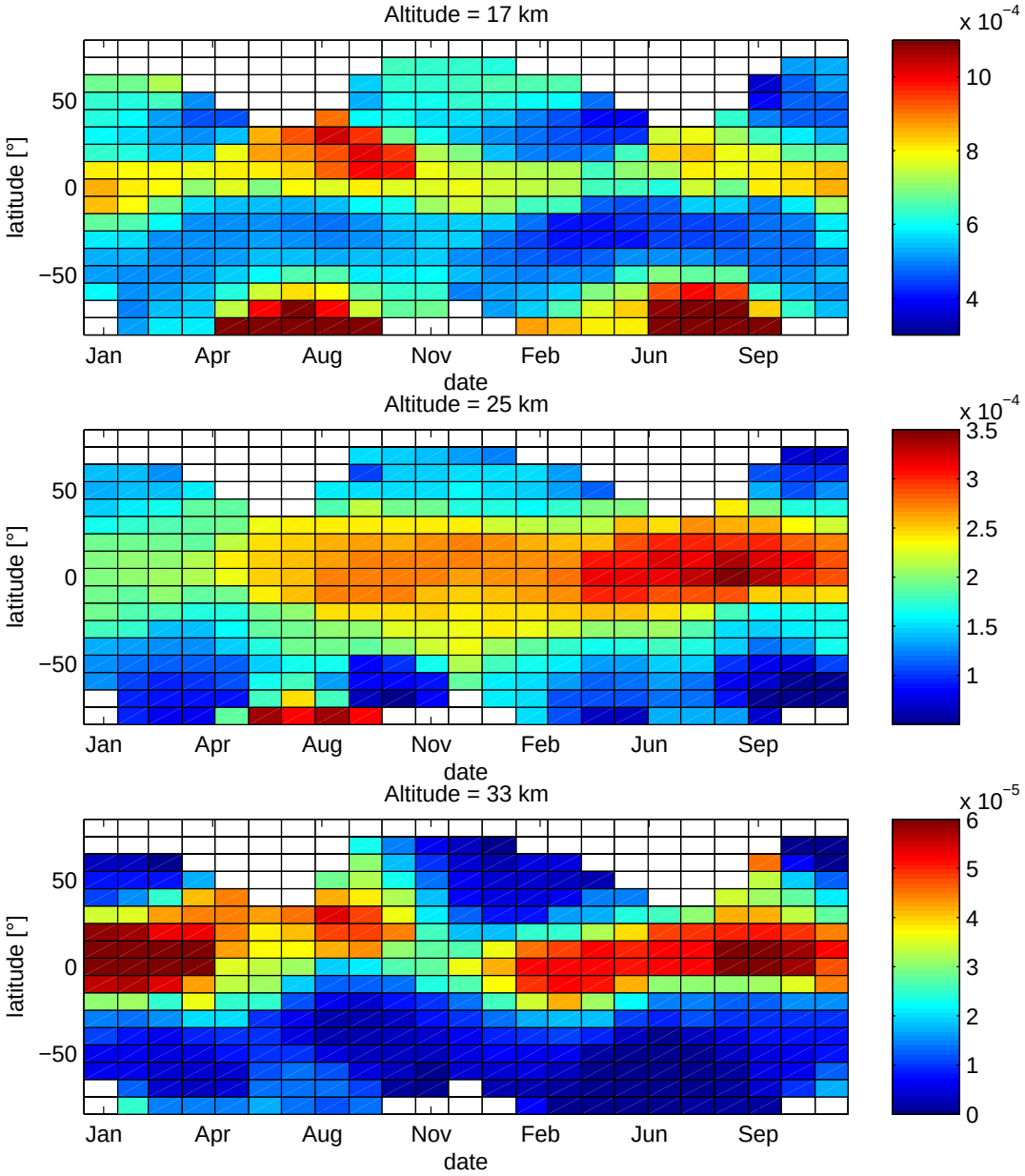
Aer.ext 500 nm: monthly zonal means in the PSC season



PSC season: end of May until October

The PSC maximum slowly moves downward in the vortex.

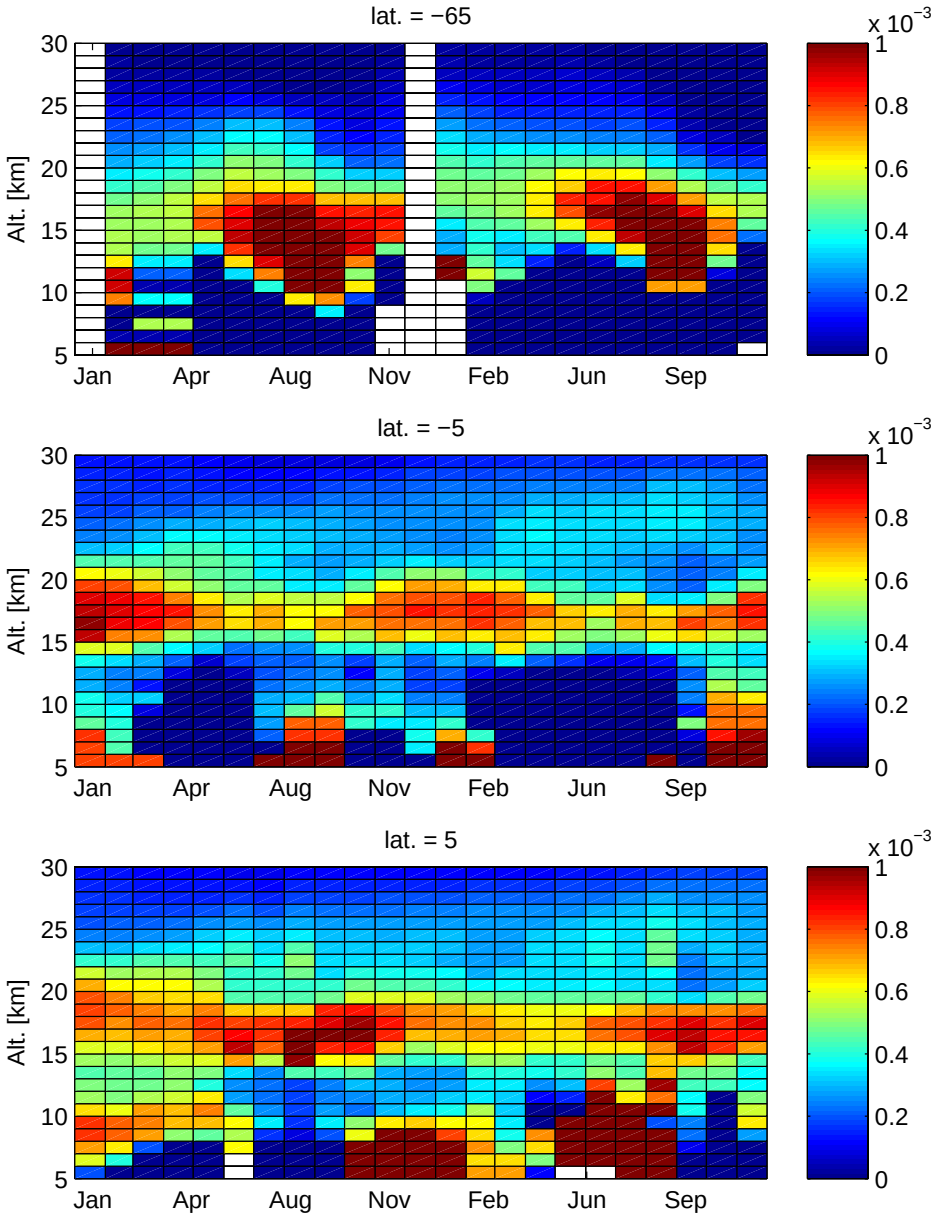
Aerosol extinc. 500 nm vs. latitude and time



North-south oscillation of subvisual cirrus maximum

Middle stratosphere: extinction increases with time …

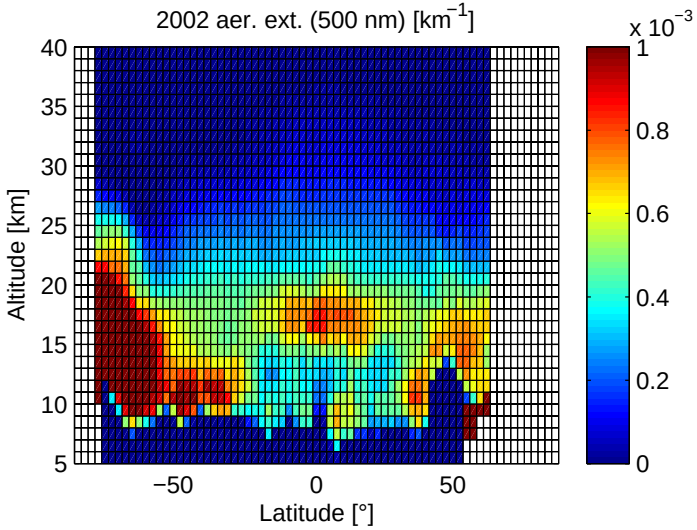
Oscillation remains visible up to 33 km

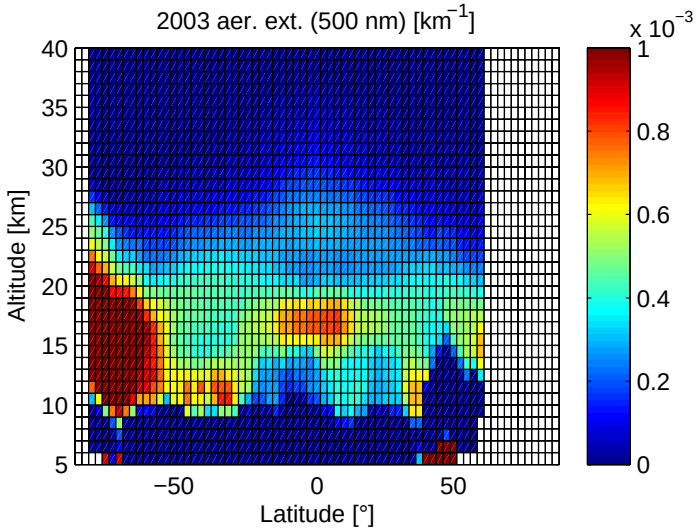


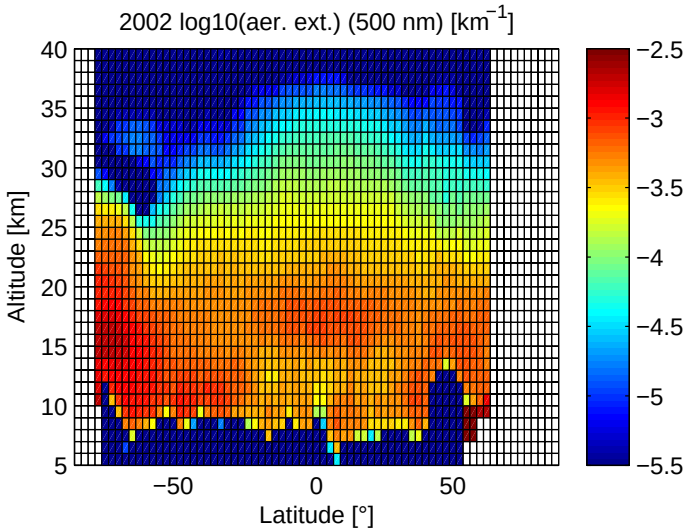
Aerosol ext. 500 nm vs. altitude and time

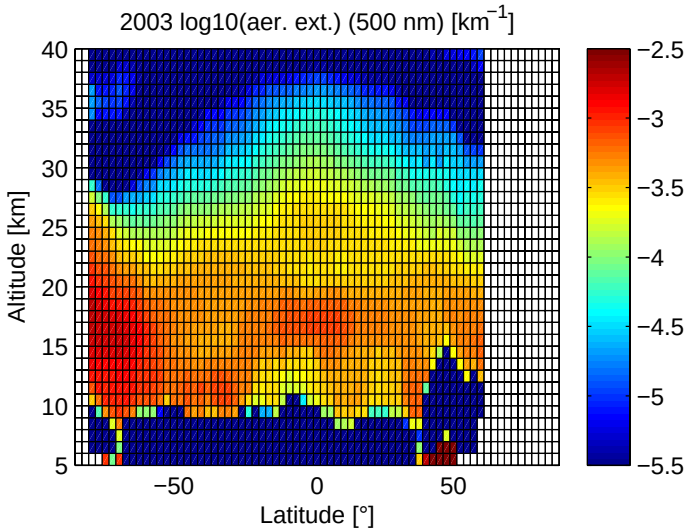
- PSC descent
- Cirrus up-down oscillation
- Temperature at the considered altitude above tropical regions can fall below 195K. No significantly stronger extinction (NAT) has been found.

Aerosol ext. 500: Yearly zonal plots

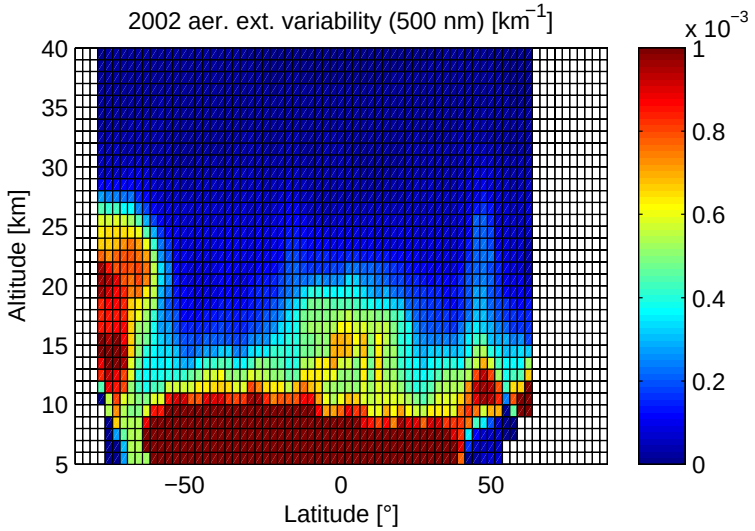


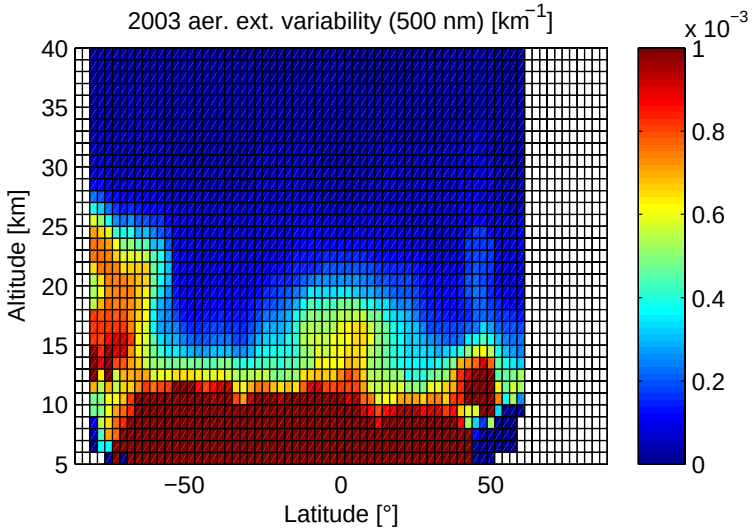


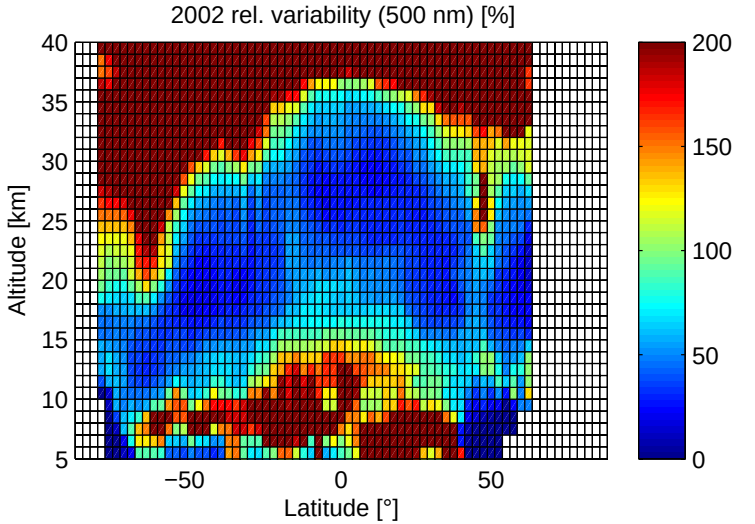


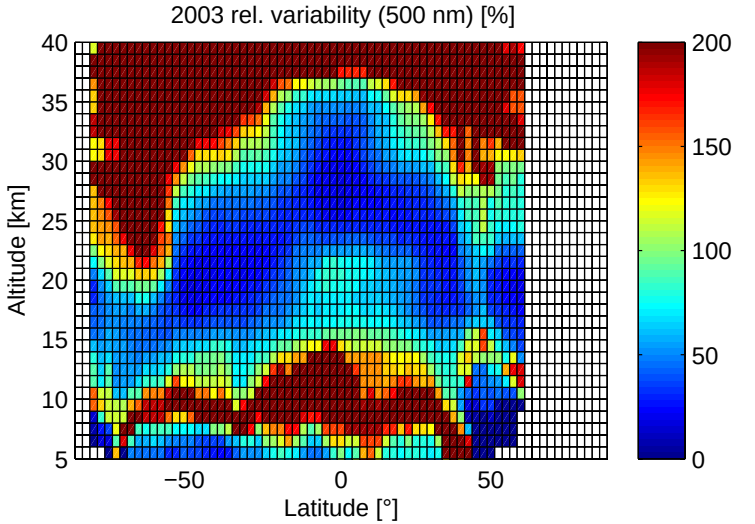


Aerosol and PSC yearly variability

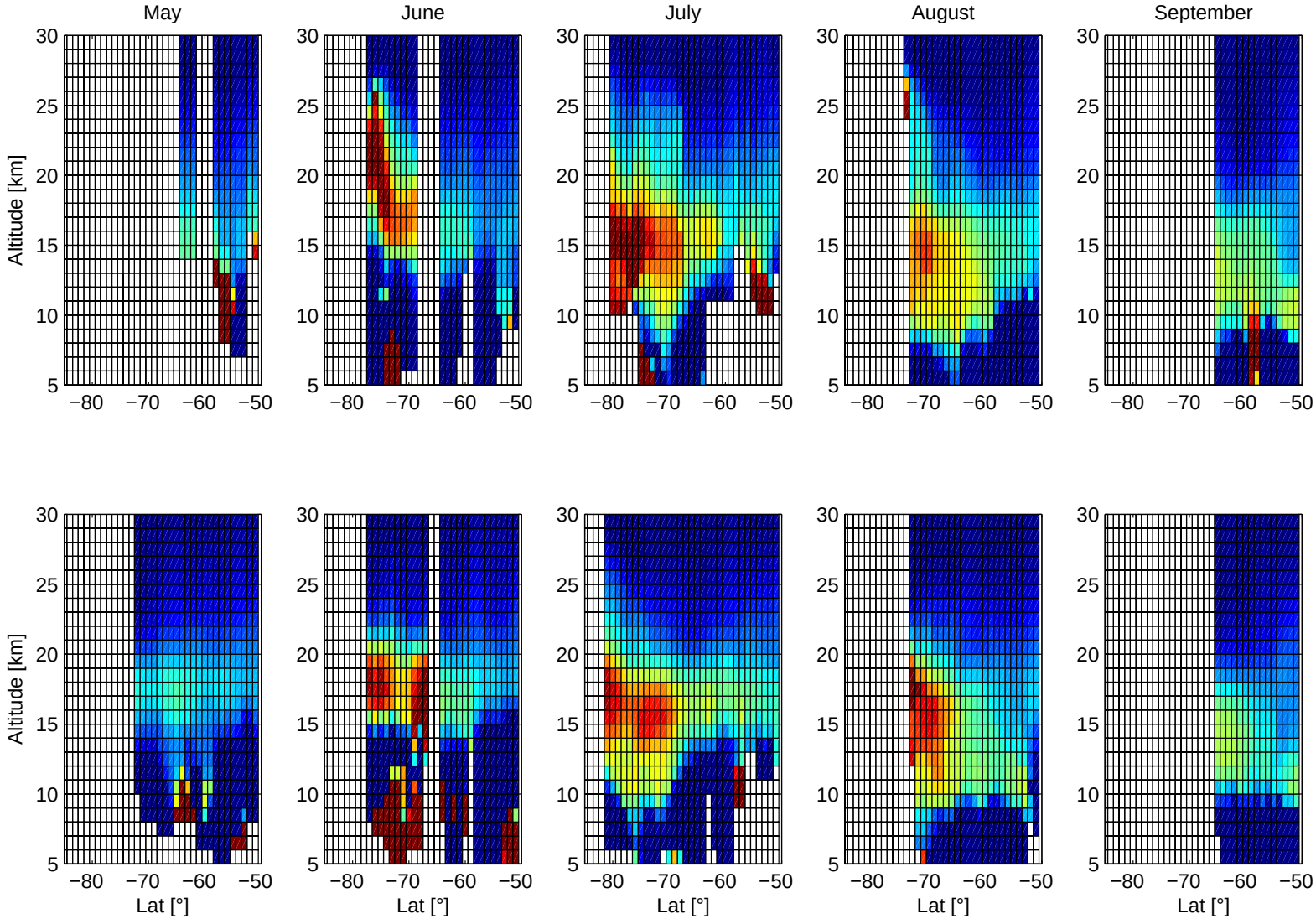




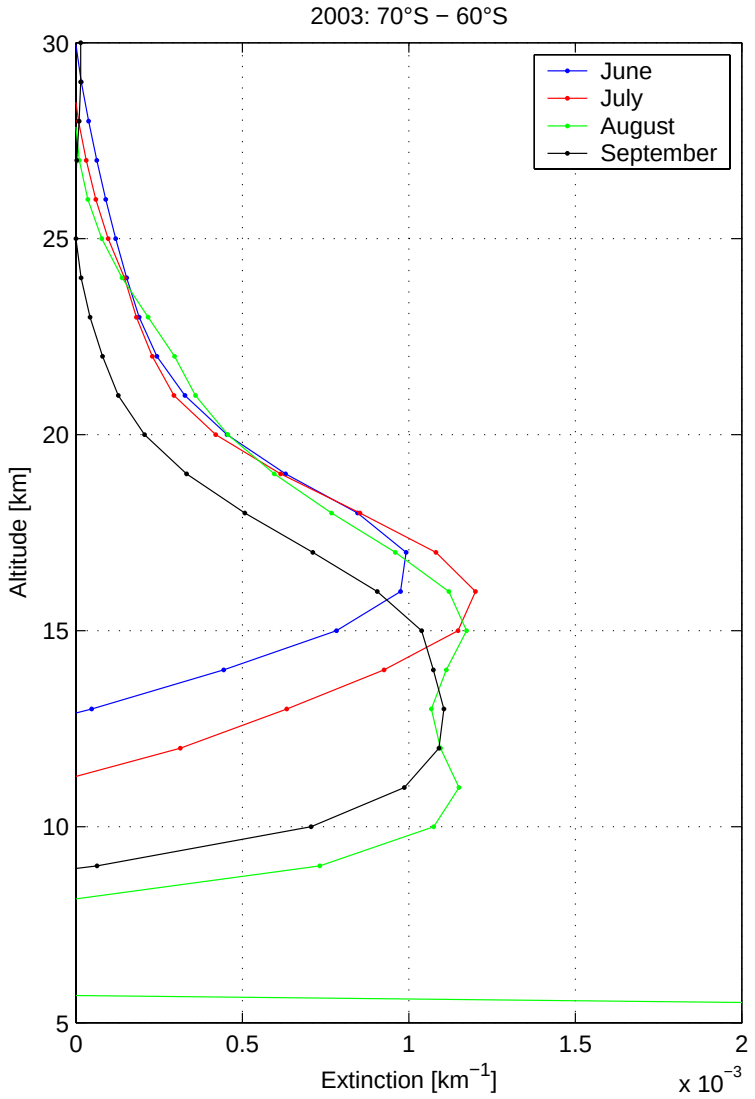




Descent of PSCs in the Antarctic vortex



PSC descent rates

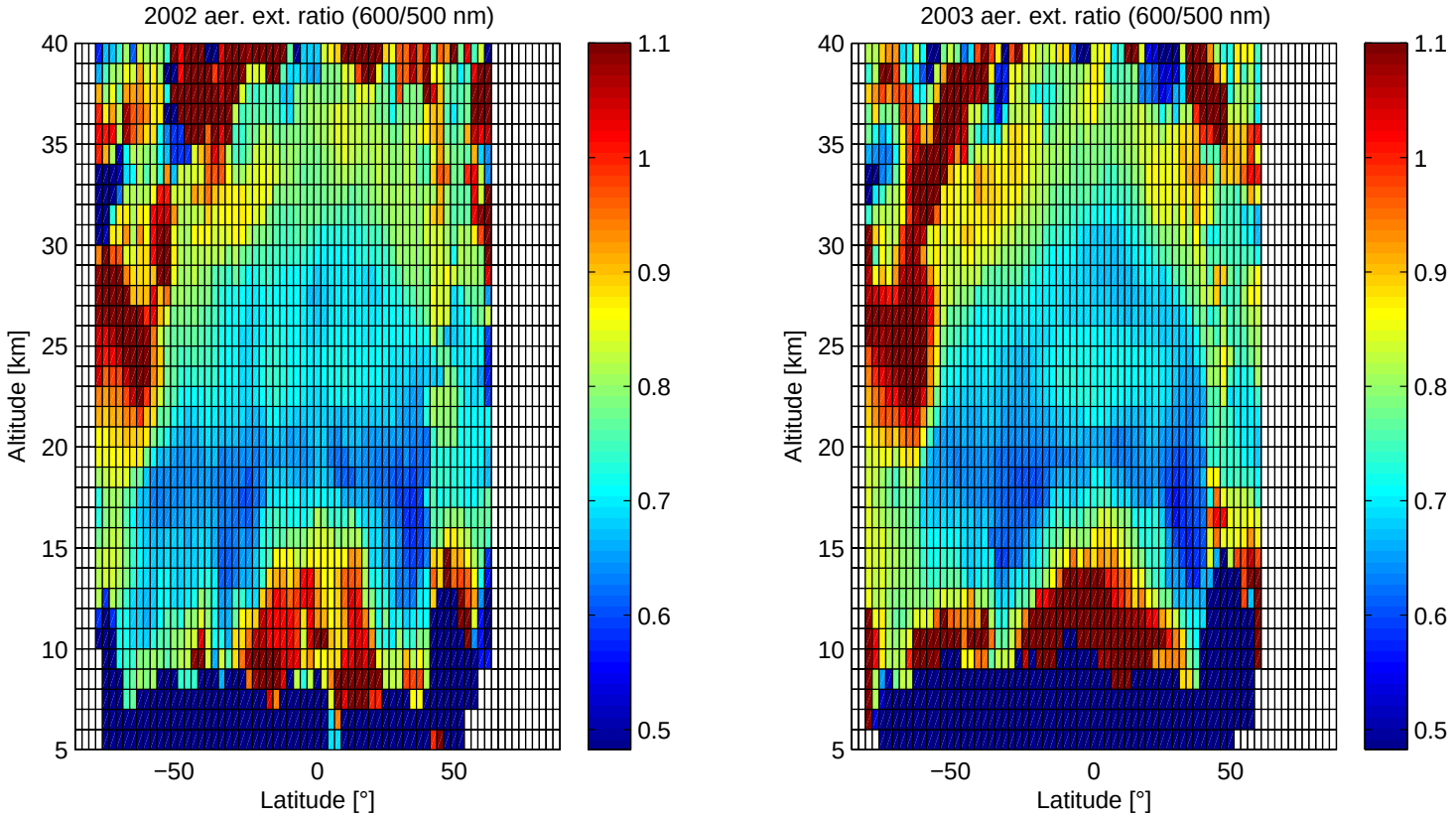


	SCIAMACHY 2003 (*) [km/month]	**GOMOS 2003 [km/month]**	**GOMOS 2004 [km/month]**
70°S - 80°S	-1.2	-1.3	-1.0
60°S – 70°S	-2.0	-1.8	-1.5
50°S – 60°S	-2.5	-2.4	-2.7

(*)*Von Savigny et al, Atmos. Chem.Phys., 5, 3017-3079, 2005*

PSCs descend faster at the edge of the vortex…

Extinction ratios vs. particle sizes



Mie theory:

Small particles: $\beta(\lambda) = A\ \lambda^{-4}$ $\beta(600)/\ \beta(500) = 0.48$

Large particles: $\beta(\lambda) = \text{constant}$ $\beta(600)/\ \beta(500) = 1$

Larger particles are present in tropospheric clouds, PSCs. This is a way to distinguish different particulate matter (PSCs, aerosols, cirrus) in extinction spectra.

Conclusion

- A GOMOS Aug. 2002 – Jan. 2005 aerosol overview is now available
- Subvisual cirrus show themselves clearly, in extinction values as well as in dynamical features (altitudinal and latitudinal oscillations)
- PSC evolution has been clearly demonstrated by GOMOS. Typical descent rates are in the range of -1 to – 2.7 km/month.
- There is a promising possibility to retrieve particle size distribution information from the extinction spectra.

Thanks!