JÜLICH FORSCHUNGSZENTRUM

Aerosol detection with IR limb measurements in the troposphere and stratosphere

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Motivation

Many satellite data sets of aerosol do not cover the mid- and high latitude UTLS (Ridley et al, GRL, 2015).

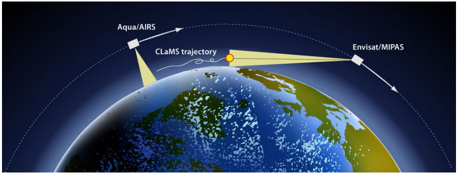
- But, when substantial amounts of volcanic aerosol are missed, the radiative forcing is underestimated.
- Aerosol from particular known sources can be used as a tracer to study troposphere $\Longleftrightarrow$ stratosphere exchange.

Motivation

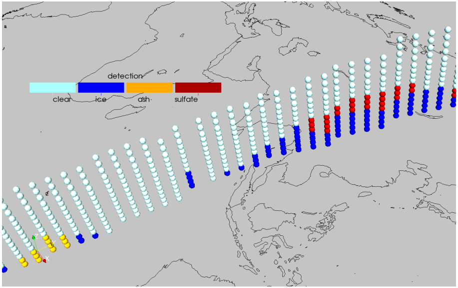
Challenges of UTLS aerosol measurements from satellite:

- interference with ice clouds
- instrument characteristics:
  - limitations in polar night for UV/VIS and solar occultation measurements
  - limitations in polar summer for CALIOP
  - UV/VIS limb measurements get optically thick for rather small extinctions, which can be reached by moderate volcanic eruptions (VEI 4 or higher) [e.g. 0.0025 (OSIRIS) – 0.02 km^{-}1 (SAGE II) @ 750 nm (Fromm 2014)]
  - IR nadir measurements are only sensitive to higher sulfate aerosol AODs of 0.01 (0.01 @ 12μm $\widehat{=}$ 0.1 @ 750 nm)

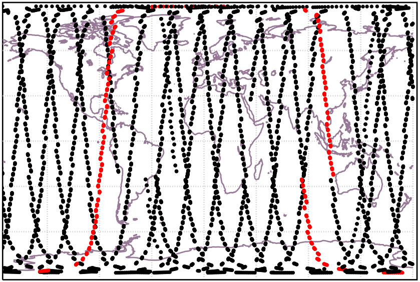
Envisat MIPAS 2002 – 2012



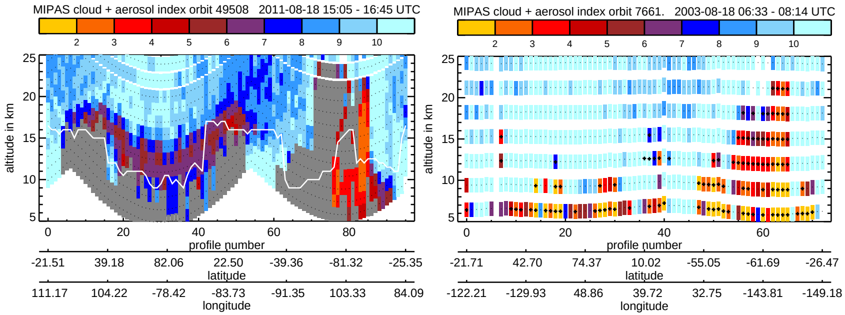
- infrared limb sounder 4 – 16 μm (2410 – 685 cm^{-1})
- global coverage (88N-89S)
- high spectral resolution: 0.0625 cm^{-1}
- limb geometry: 5 – 70 km



2011 08 18



MIPAS UTLS sampling



- 2002 – 2005: 3.0 km vertical sampling in the UTLS
- 2005 – 2012: 1.5 km vertical sampling in the UTLS

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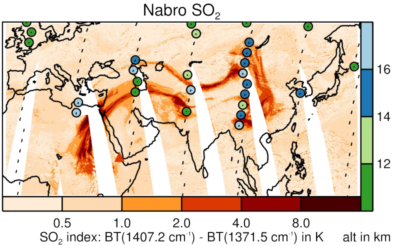
MIPAS ice cloud filter and ash detection technique



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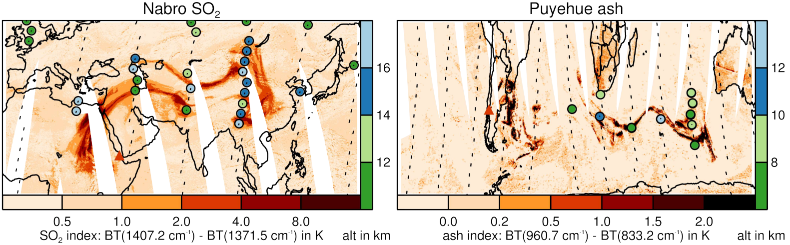

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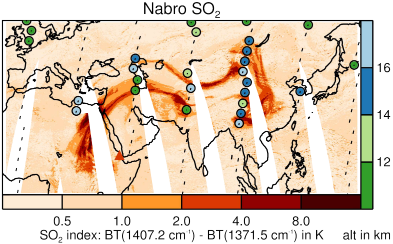

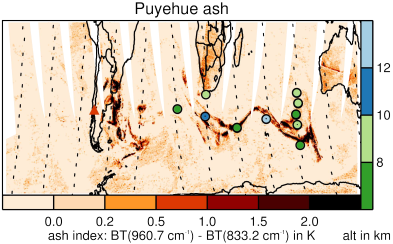

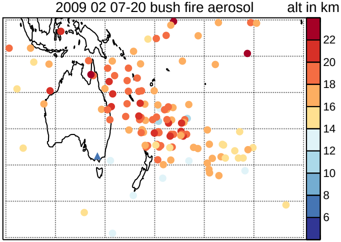

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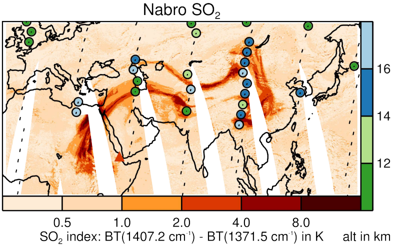
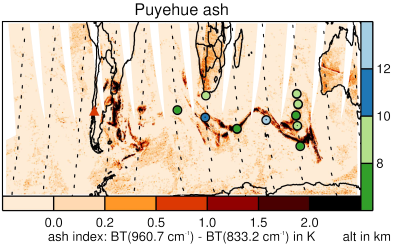
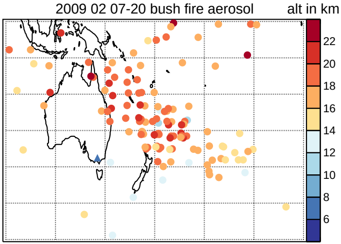
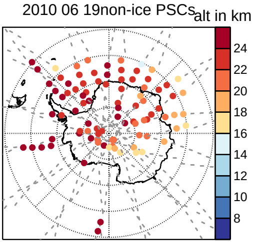






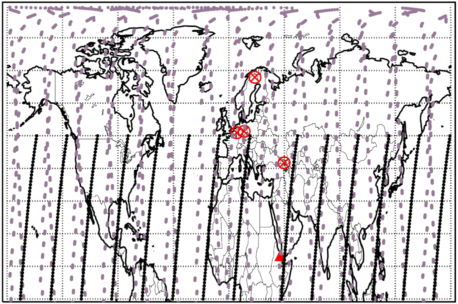


ash detection: Griessbach et al., AMT, 2014
ice cloud filter: Griessbach et al., AMTD, 2015

Characterization of MIPAS aerosol altitude

- for Nabro aerosol
- comparison with lidar and twilight measurements
- CALIOP 0 – 50°N
- ground based stations: Leipzig, Jülich, Esrange, Tbilisi

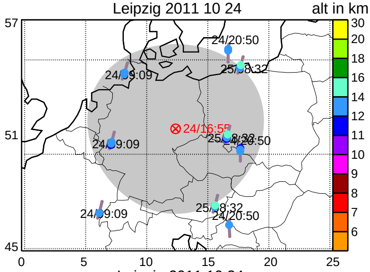
satellite tracks and ground stations

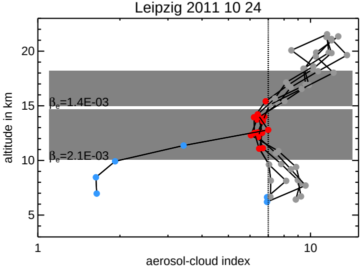


Characterization of MIPAS aerosol altitude

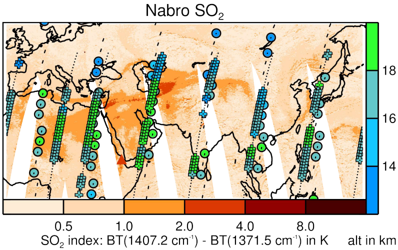
General Challenges

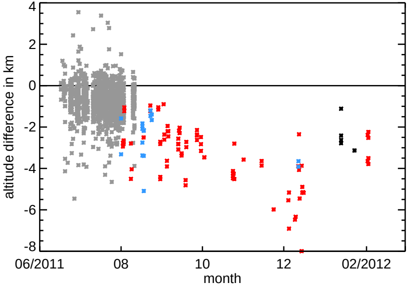
- How to find appropriate matches?
- How to compare data with different measurement principles?
- How to define the aerosol layer top and bottom for each instrument?





Characterization of MIPAS aerosol altitude

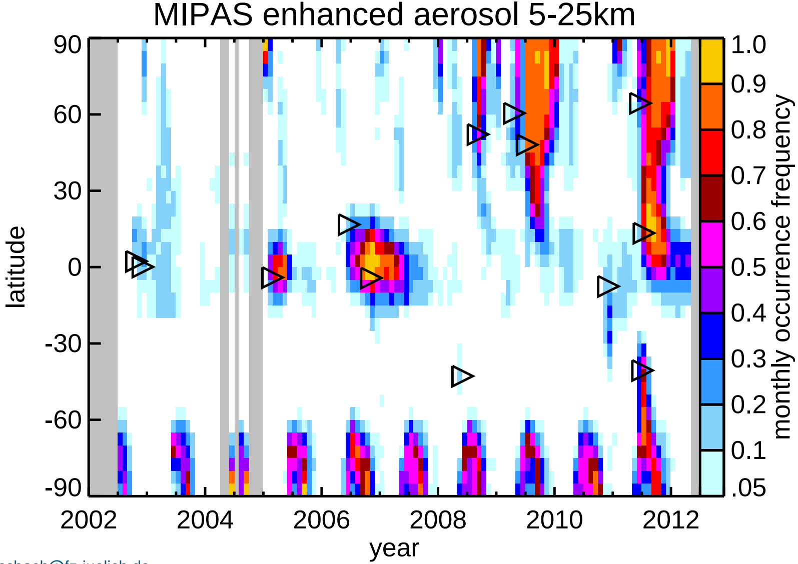




- CALIOP: 1146 – 1234 matches between 06–08/2011
- top altitude +1 km – -2.5 km, median -0.6 – -0.9 km
- 85 % underestimate top altitude
- bottom altitude -0.5 – -1.0 ± 1.0 km

- 34(L) + 7(J) + 2(E) matches between 08/2011–02/2012
- top and bottom altitude differences depend on aerosol extinction

10 years MIPAS aerosol observations



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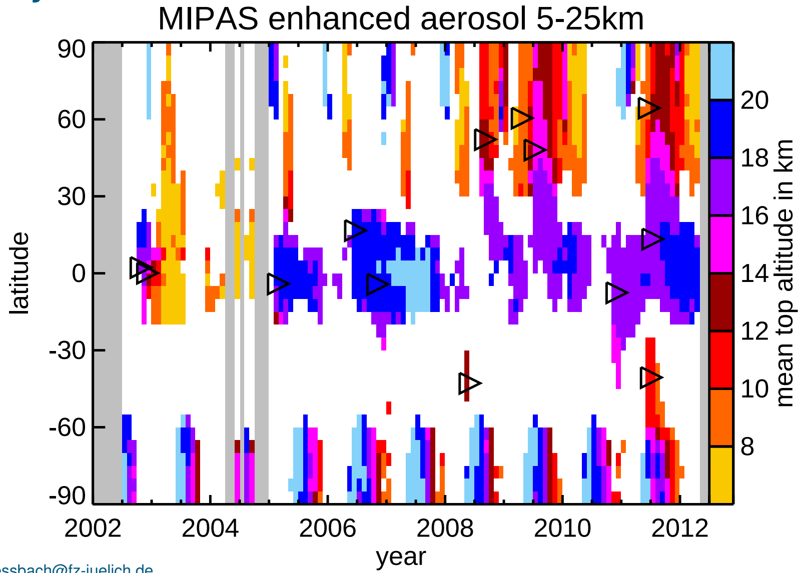

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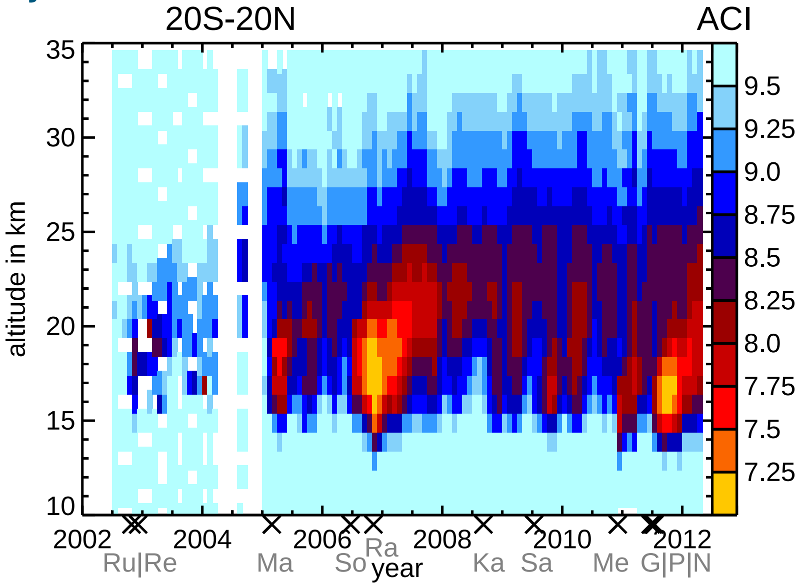

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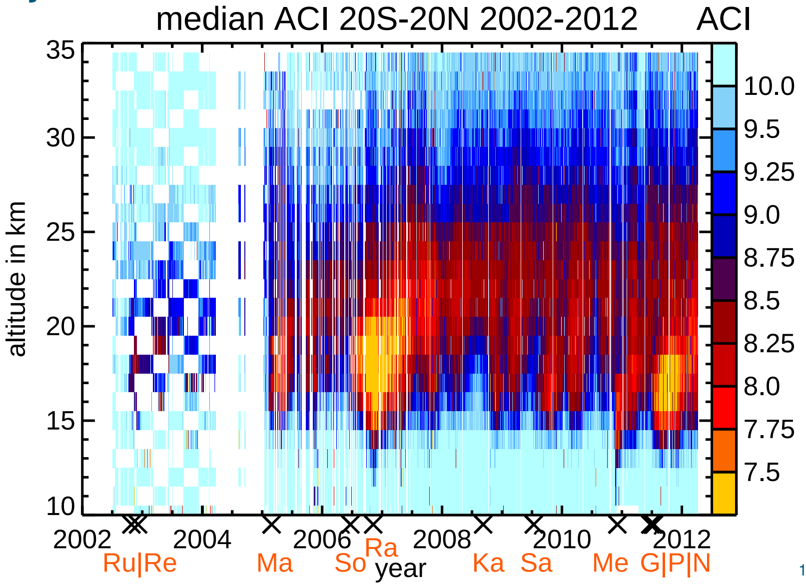

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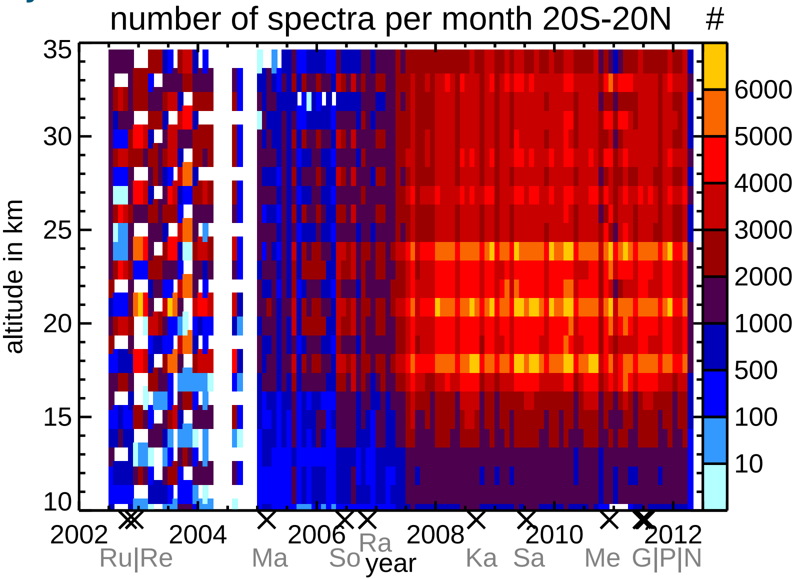

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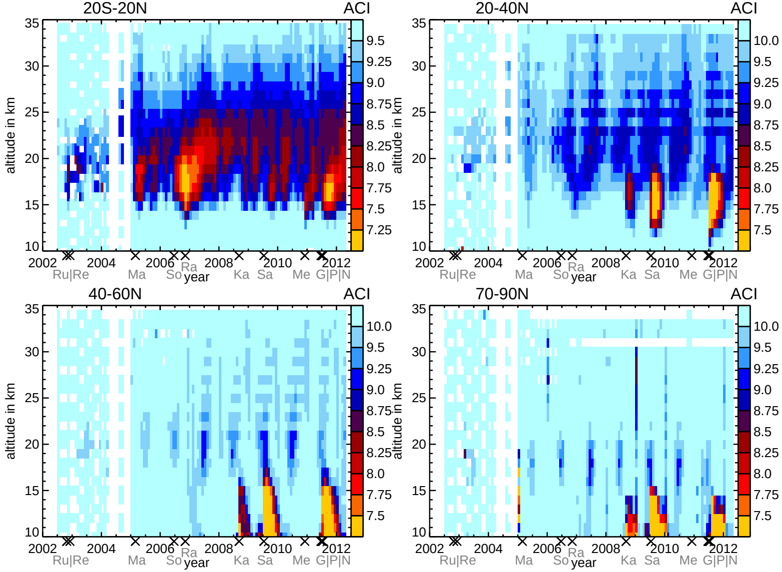

Summary

Altitude information:

- MIPAS measurements reach well below the tropopause
- MIPAS can provide aerosol layer top and bottom altitude
- comparison with lidar measurements found a general underestimation of the top altitude
- (altitude uncertainty depends on aerosol layer extinction)

Analysis of MIPAS time series:

- the MIPAS aerosol products allow us to observe volcanic aerosol, wild fires, non-ice PSCs and mineral material
- aerosol tape recorder that is fed by volcanic eruptions
- strong aerosol signals in high latitude UTLS due to tropical & high latitude volcanic eruptions

Outlook:

- retrieval of aerosol extinction including scattering (10-50%)

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