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Stratospheric Sulphur

3D Chemical Transport Model Simulations and MIPAS/ENVISAT Observations

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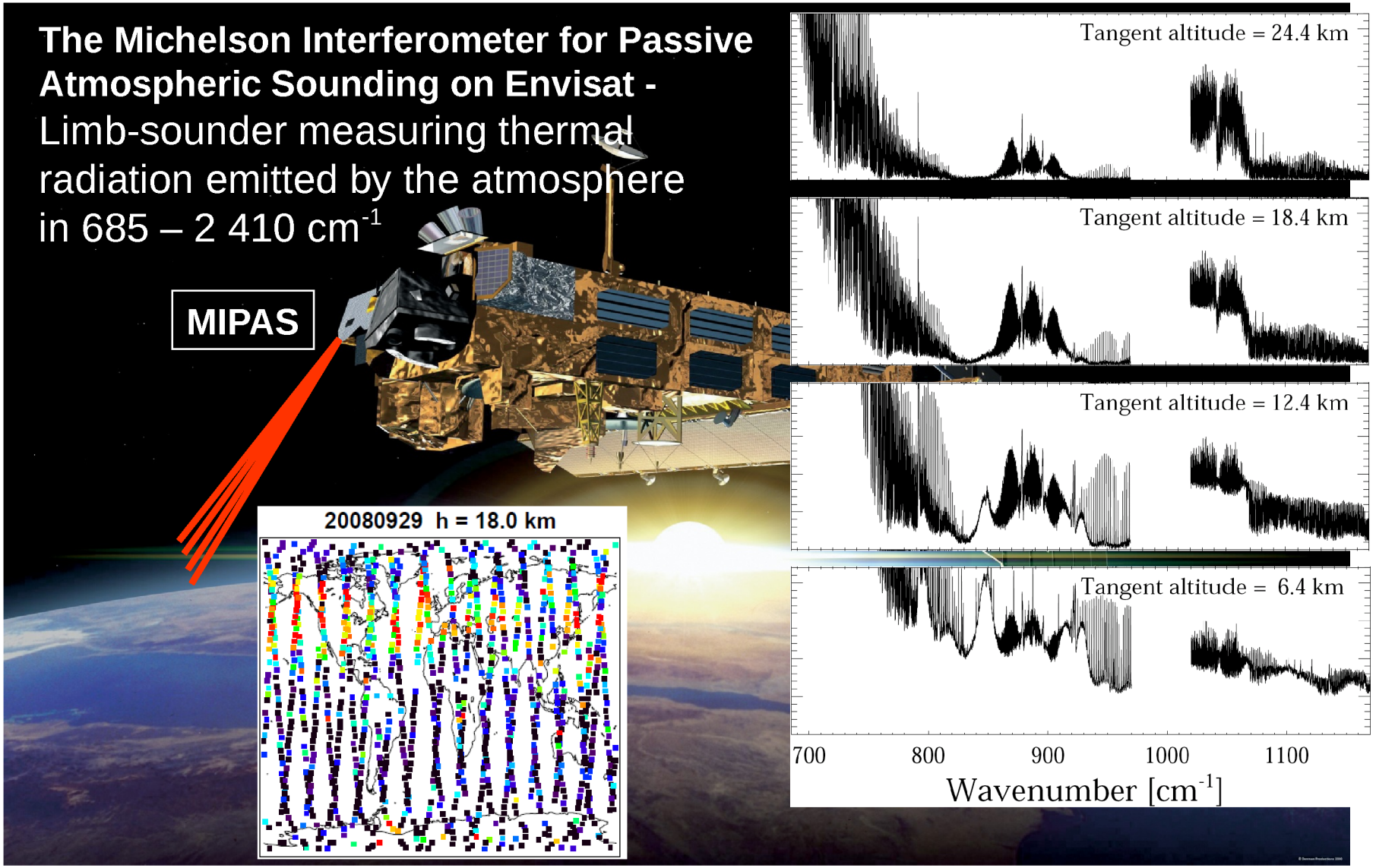
Credit: *NASA*
Sarychev Volcano
12/06/2009

The Michelson Interferometer for Passive Atmospheric Sounding on Envisat -
Limb-sounder measuring thermal radiation emitted by the atmosphere in 685 – 2 410 cm^{-1}



MIPAS products (2002-2012) by KIT

SO_2 volume mixing ratio profiles

- Retrieval from mean spectra: 13-45 km, monthly & zonal averages (18 profiles/month, 10° latitude bins)

→ Höpfner et al., ACP, 2013

- *Retrieval from single limb-scans:* 8-20 km, *high temporal and horizontal resolution (up to 2000 profiles/day)*

→ Höpfner et al., ACP, 2015

OCS volume mixing ratio profiles

- *Retrieval from single limb-scans:* 8-35 km, *high temporal and horizontal resolution (up to 2000 profiles/day)*

→ Glatthor et al., GRL, 2015 (upper troposphere)

→ Glatthor et al., in prep., 2016 (stratosphere + UT biomass)

Aerosol volume density profiles

- *Retrieval from single limb-scans:* 8-~33 km, *high temporal and horizontal resolution (up to 2000 profiles/day)*

→ Günther et al., in work

CTM

- 3D isentropic chemical transport model (*Sinnhuber et al., 2003*).
- 29 levels at 335 – 2 726 K potential temperature (~ 10 - 55 km).
- Horizontal resolution: 3.75° longitude x 2.5° latitude.
- Horizontal transport: driven by wind fields and temperature from ERA-Interim reanalysis data.
- Vertical transport: driven by diabatic heating rates from ERA-Interim.

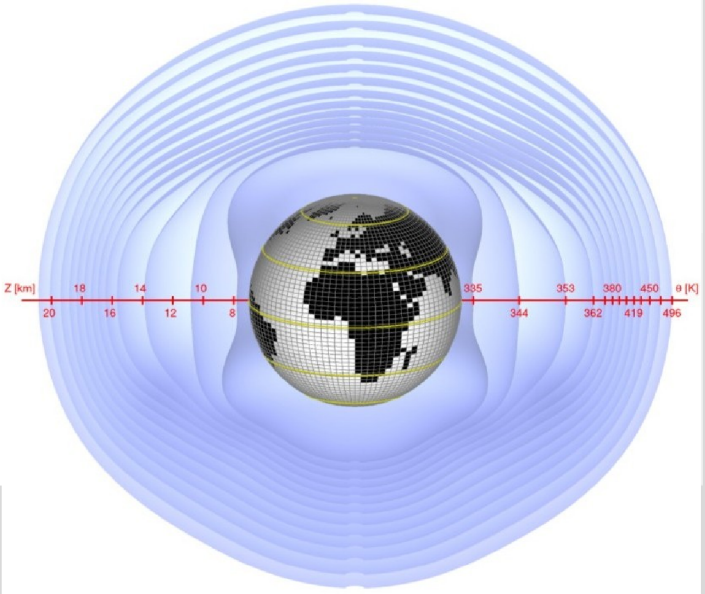


Illustration of the typical spatial resolution of the B3DCTM. The horizontal resolution is 2.5° latitude × 3.75° longitude. There are 29 levels of potential temperature θ ranging from 335 K to 2726 K (only the UTLS region up to 20 km is shown here). Horizontal and vertical grid are not drawn on the same scale. From Aschmann (2011).

CTM

- OCS → SO_2 by photolysis.
- SO_2 → H_2SO_4 (gas) by reaction with OH.

- Bottom boundaries:
  - OCS: MIPAS.
  - SO_2: 0pptv.
  - H_2SO_4: 0pptv.

- SO_2: volcanic eruptions from Höpfner et al. (2015, ACP). 30 volcanoes, SO_2 masses for 10-14km, 14-18km, and 18-22km.

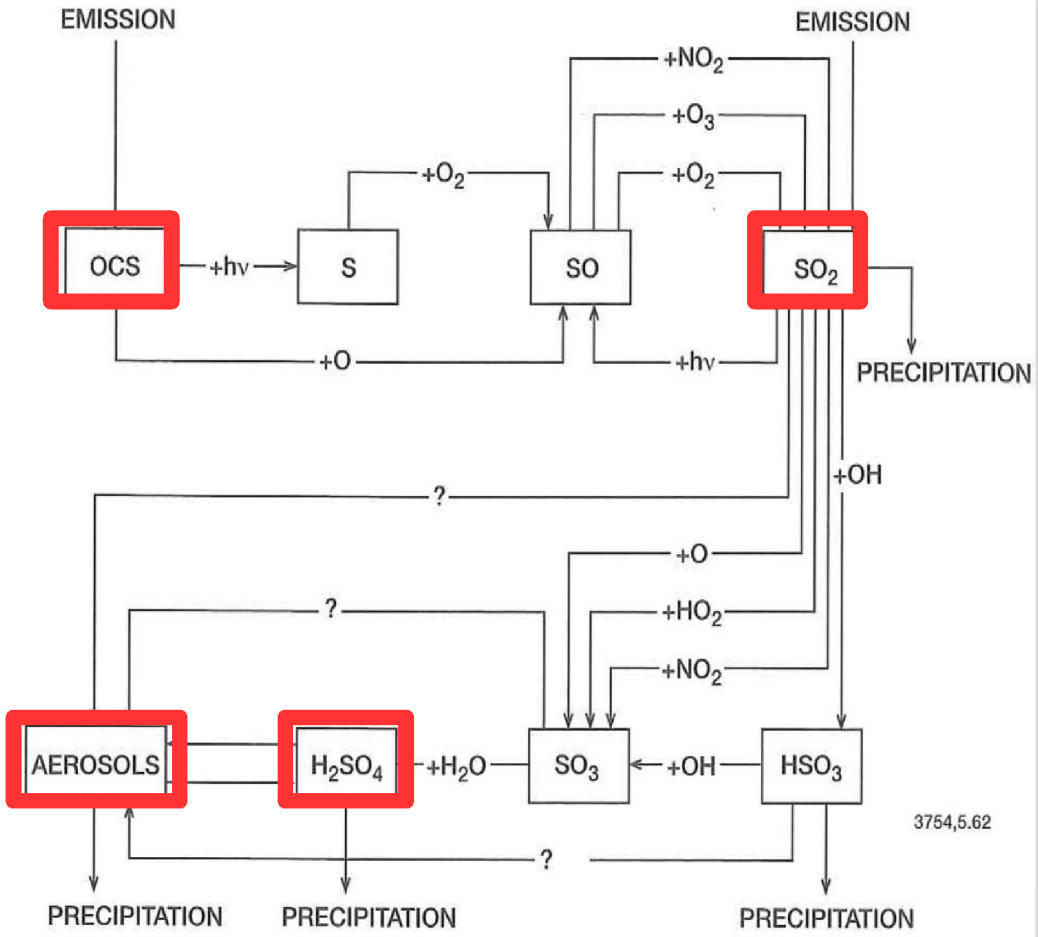
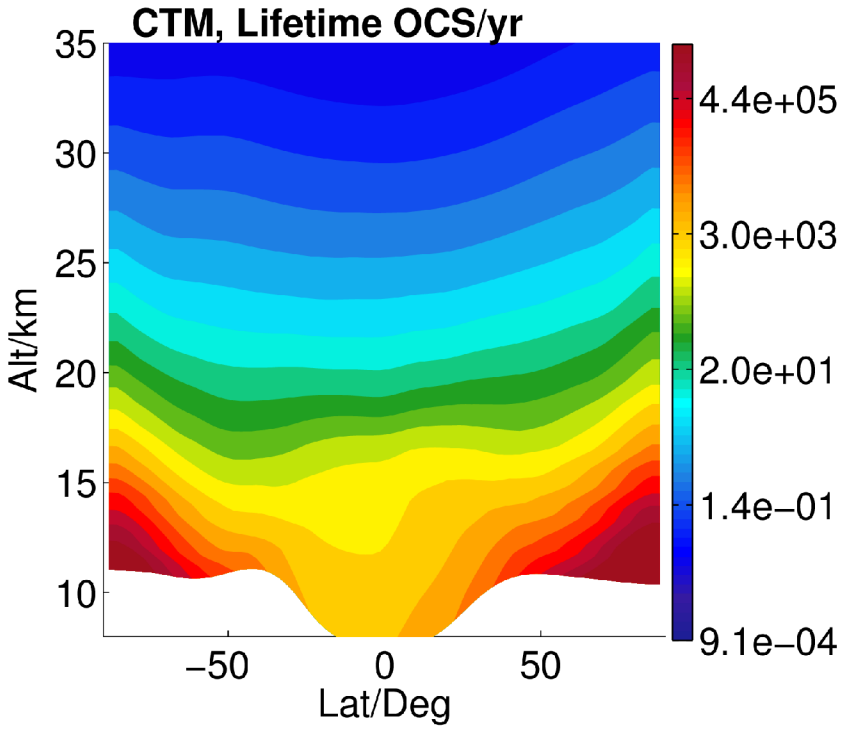


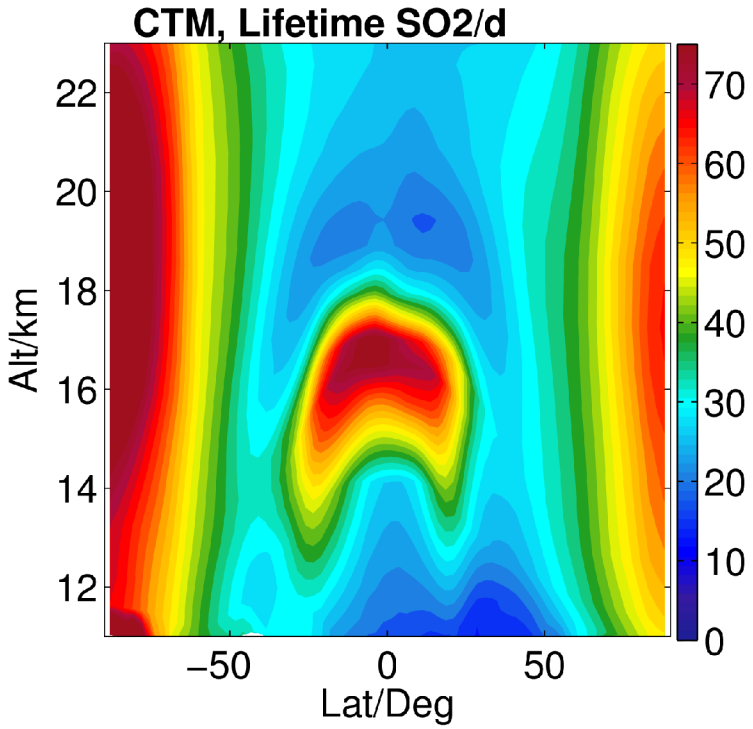
Figure 5.61. Primary sulfur reactions in the middle atmosphere.

Brasseur and Solomon, 2005

Lifetimes as implemented in CTM

- Annual zonal mean local lifetime of OCS (photolysis) and SO_2 (reaction with OH).
- Maxima for OCS: missing / weak sunlight.
- Maxima for SO_2: missing / weak sunlight and low temperatures.

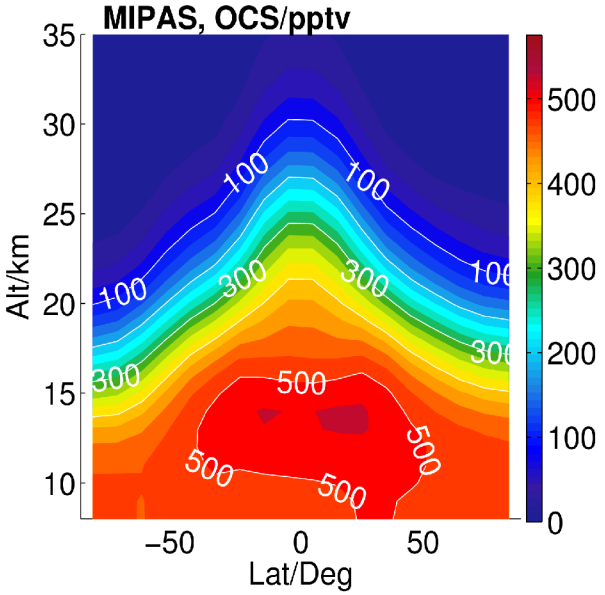




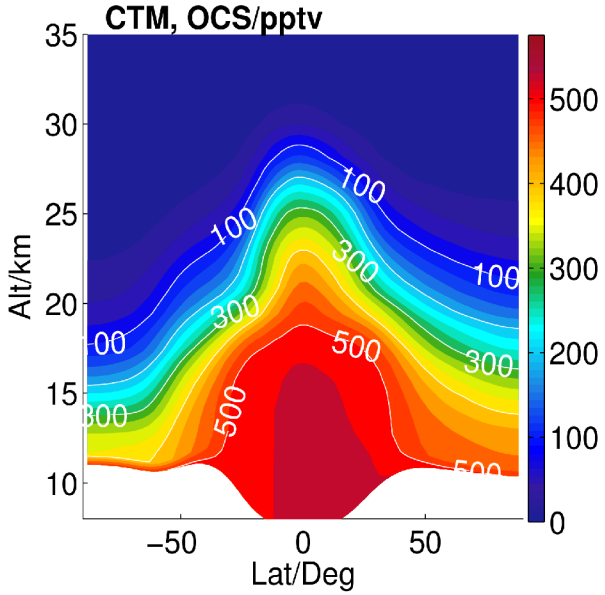
OCS

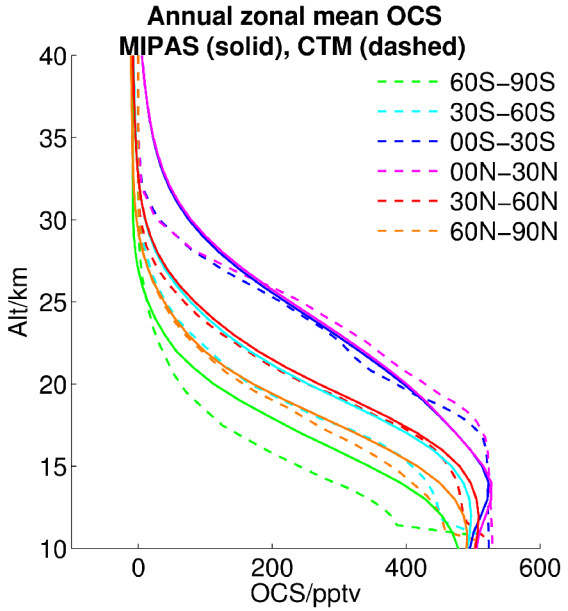
Annual zonal mean OCS (2002-2012):

MIPAS



CTM





SO_2

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MIPAS

CTM

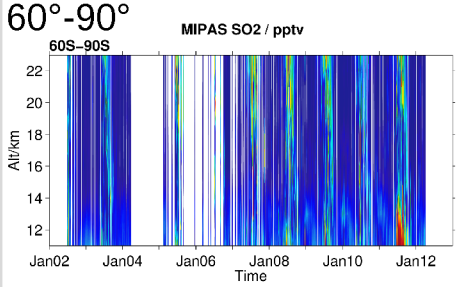
SH

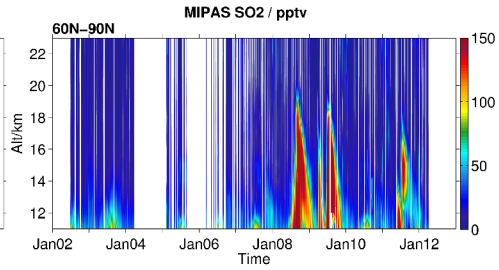
NH

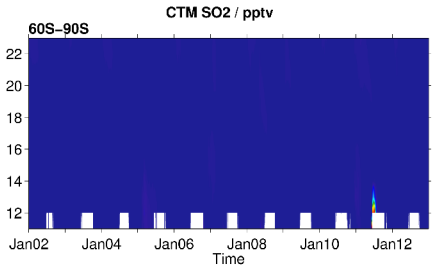
SH

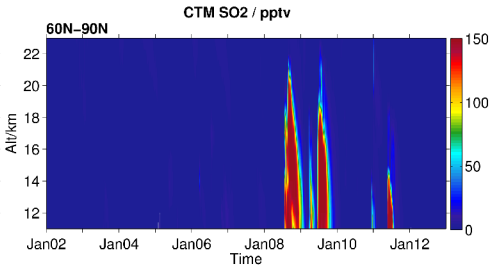
NH

60°-90°

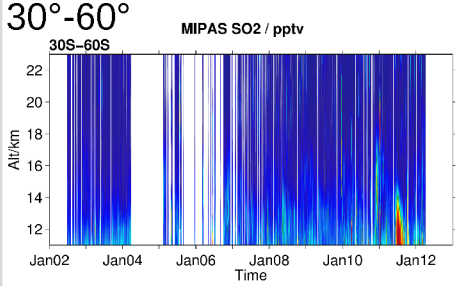


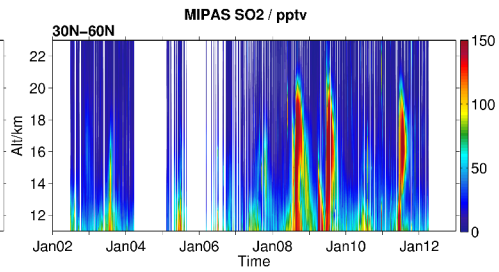


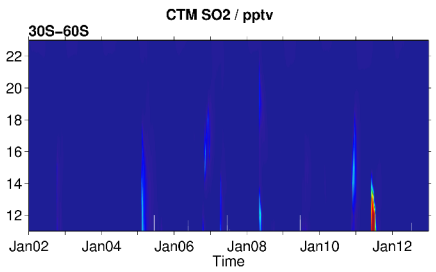


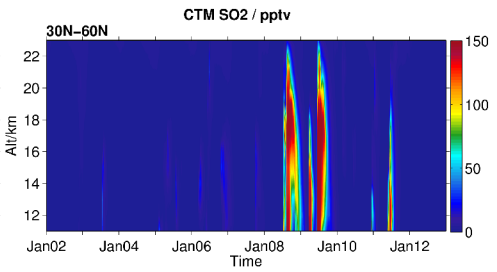


30°-60°

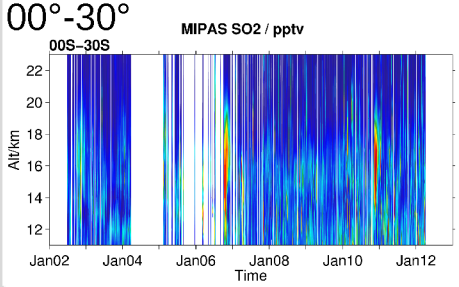


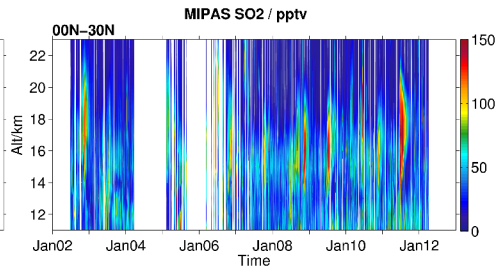


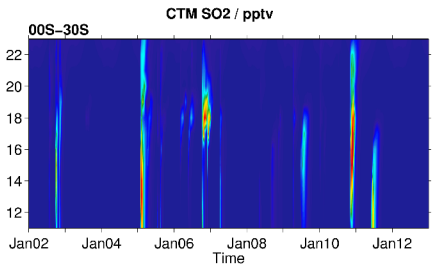


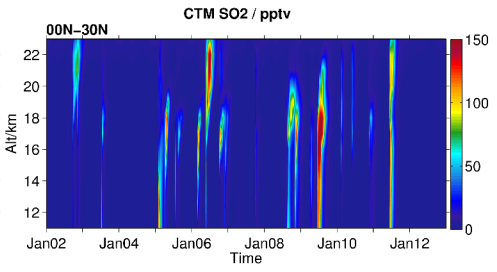


00°-30°









SO_2

MOD: modified injection altitudes & masses.

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MIPAS

CTM_{MOD}

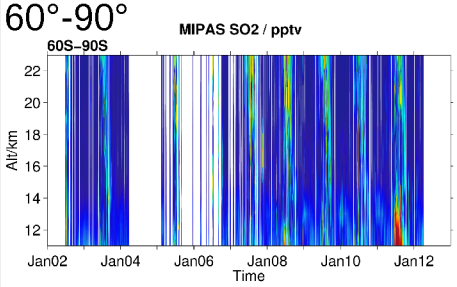
SH

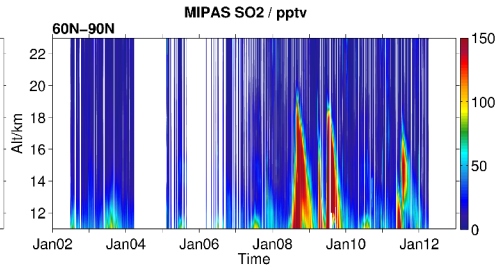
NH

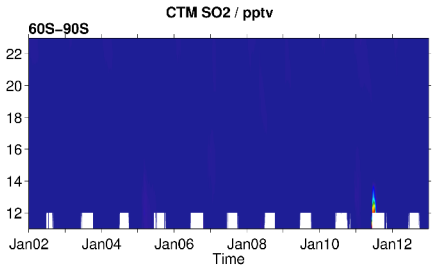
SH

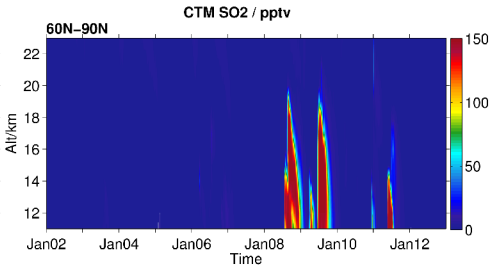
NH

60°-90°

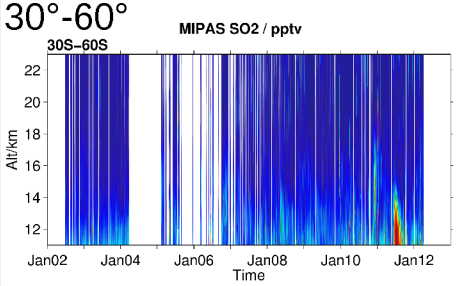


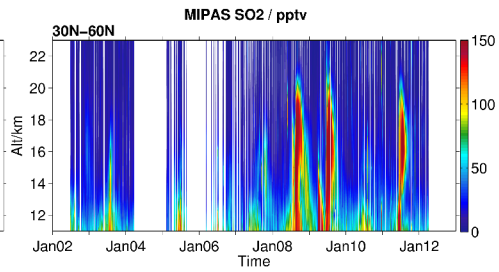


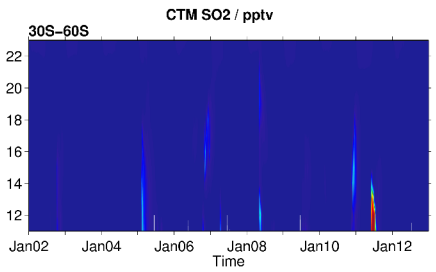


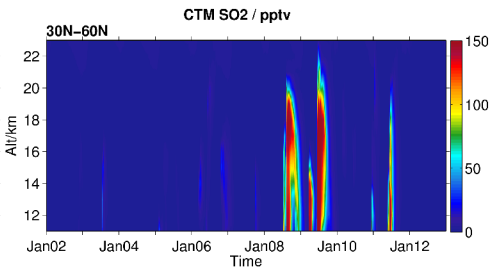


30°-60°

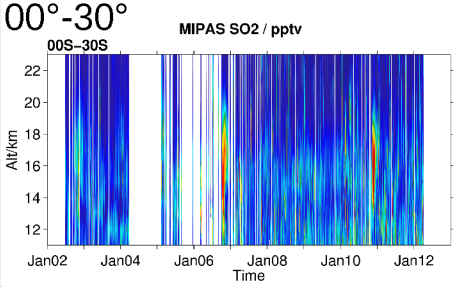


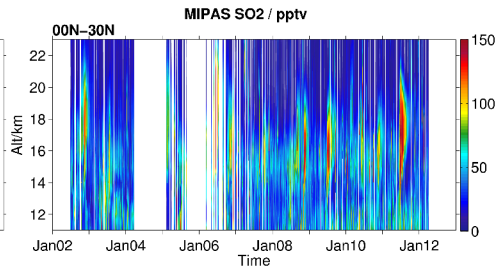


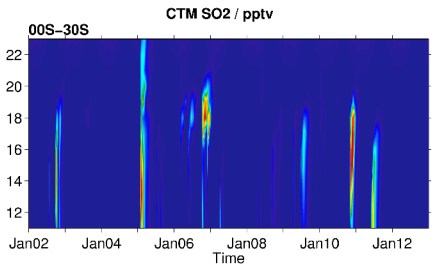


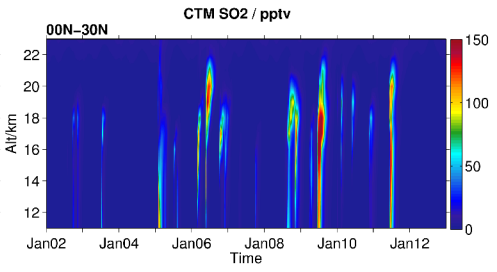


00°-30°





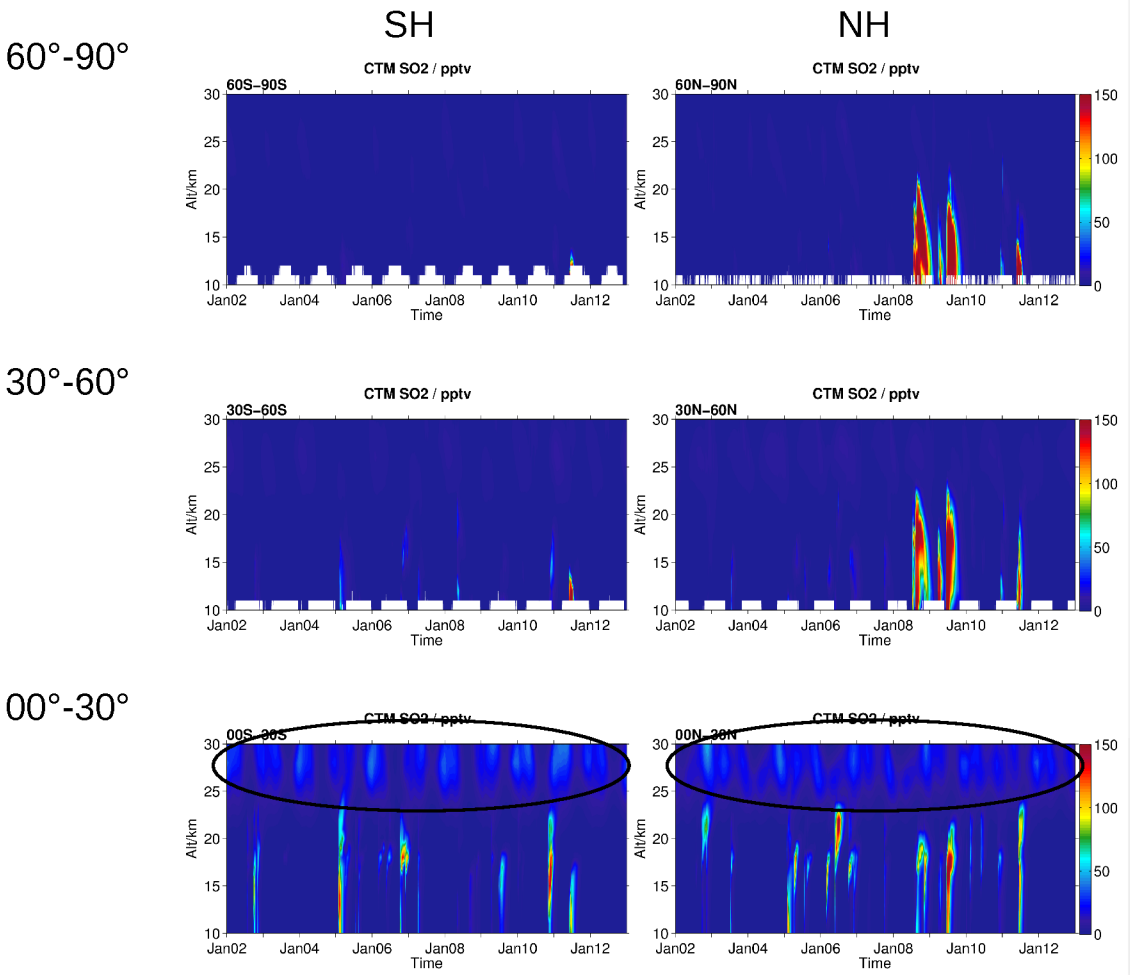




SO_2

- Bruehl et al. (2015, JGR): enhanced SO_2 values due to OCS photolysis at around 28 km.

CTM



SO_2

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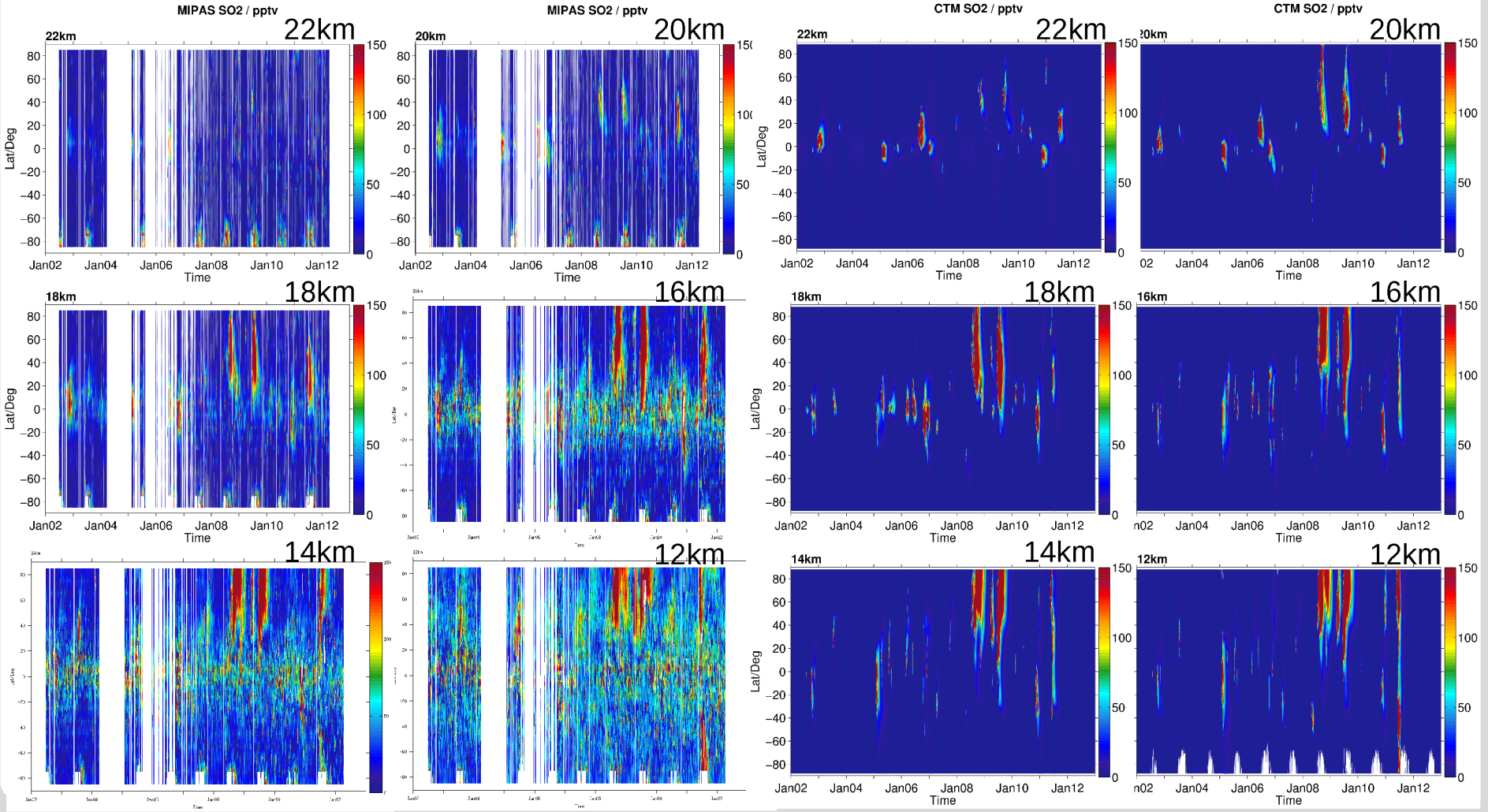
MIPAS

CTM



SO_2

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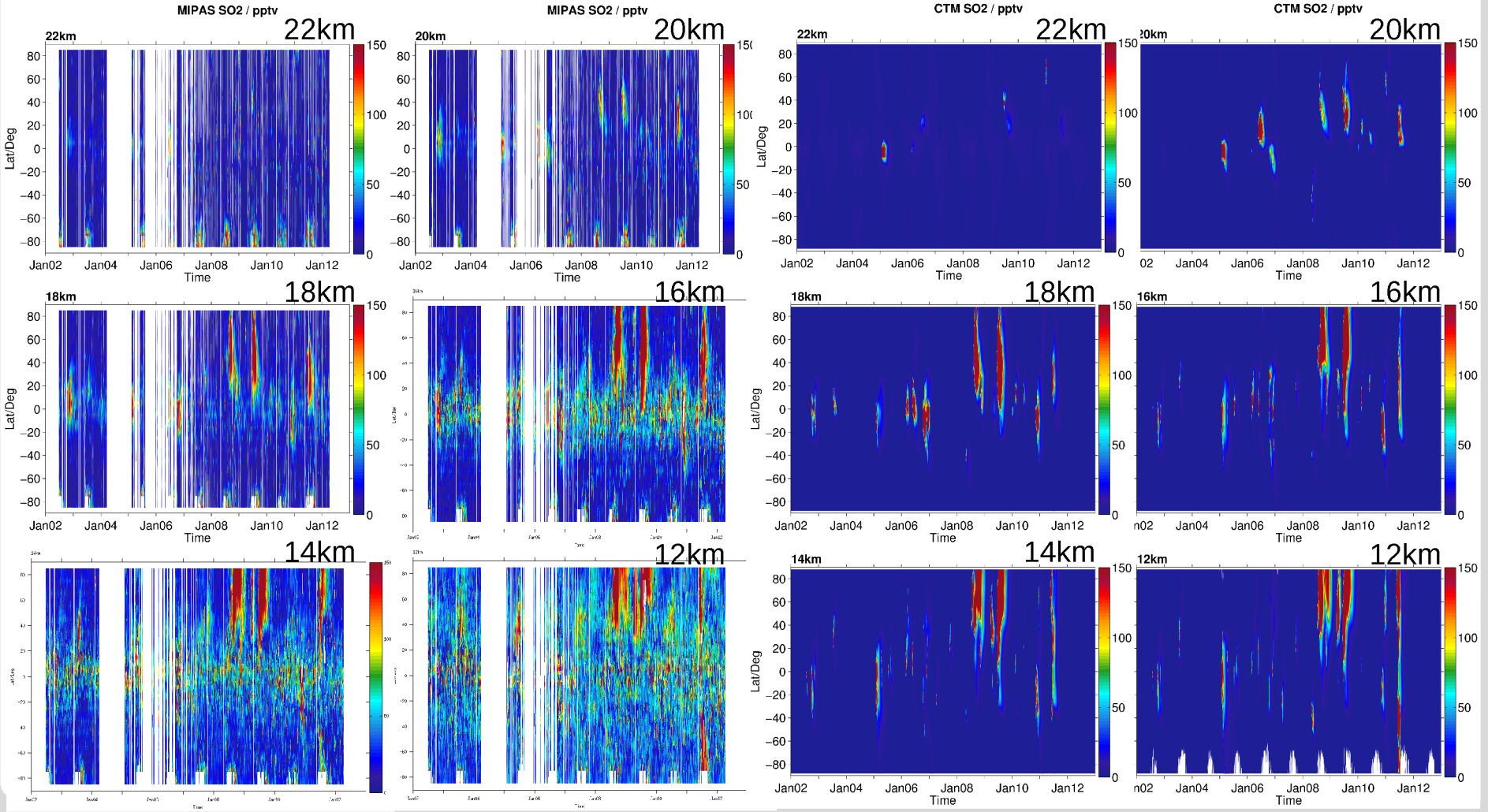
MIPAS

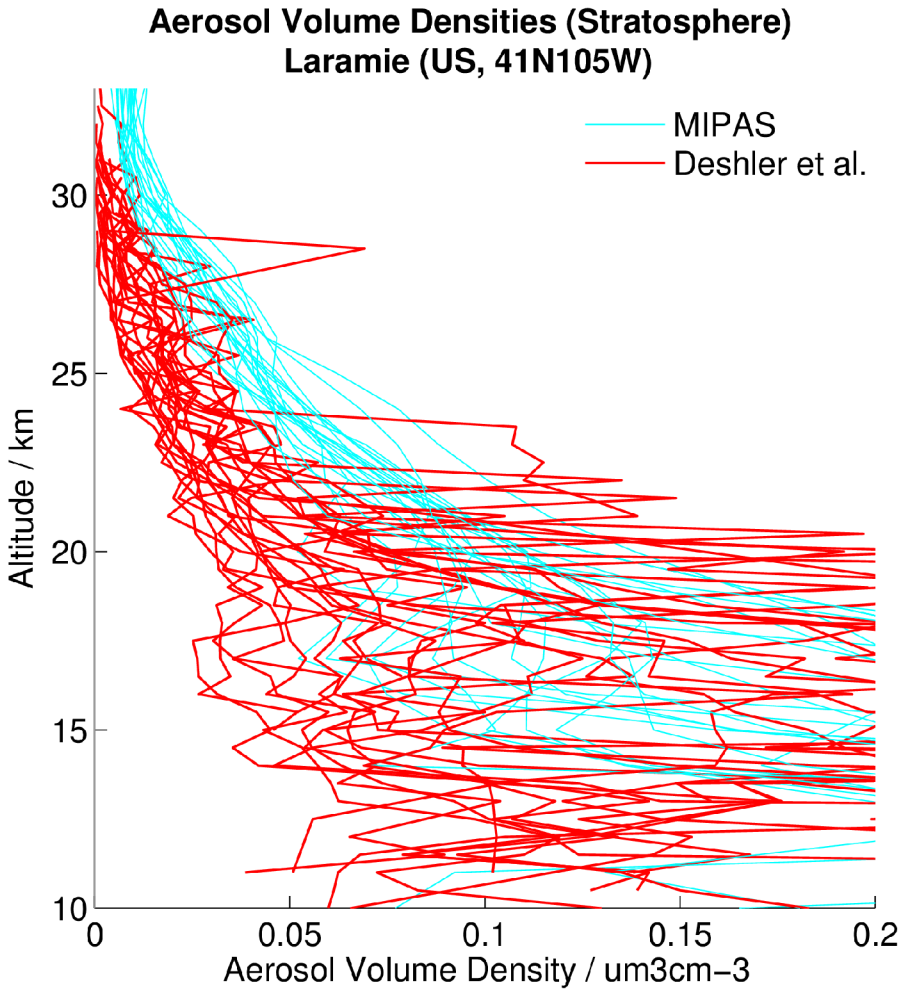
CTM_{MOD}



Stratospheric Aerosols, MIPAS

- New MIPAS retrievals for stratospheric aerosol.
- MIPAS signal for particles <~1µm Insensitive to size, only sensitive to particle volume density.
  → Volume densities of aerosols retrieved.
- Assumption: 75-mass%-sulphuric acid.

- Comparison to sulphate aerosol volume densities by Deshler et al. (2003, JGR): positive offset.
  → Linear height dependent subtractive fit applied.



Stratospheric Aerosols, MIPAS

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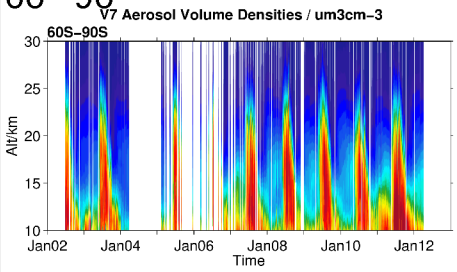
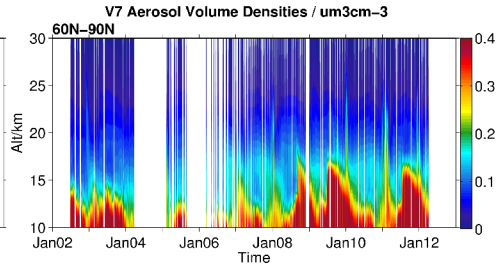
Original data

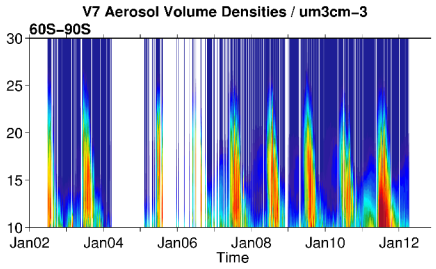
With height dependent fit

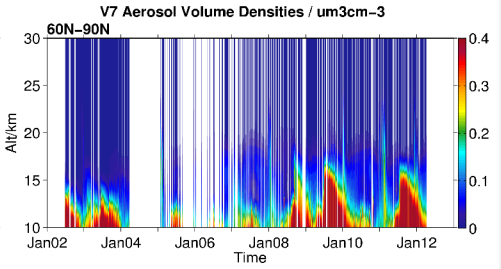
SH NH SH NH

60°-90°

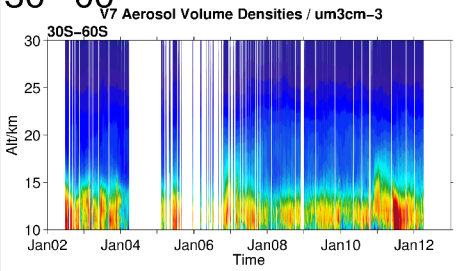


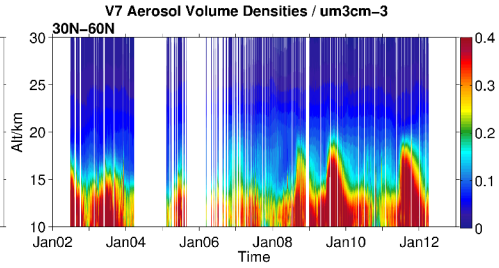


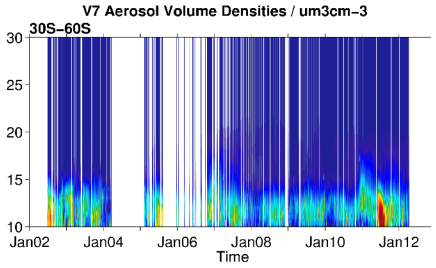


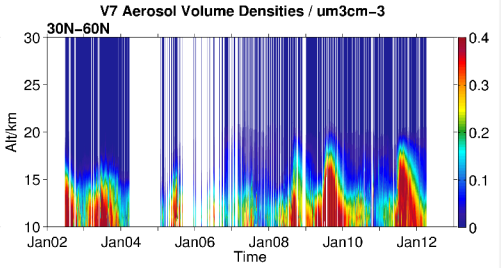


30°-60°

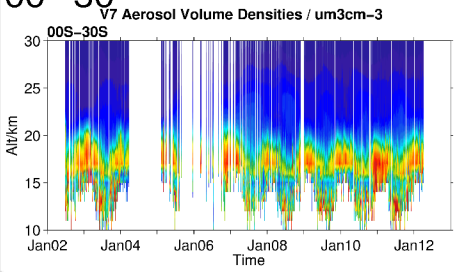


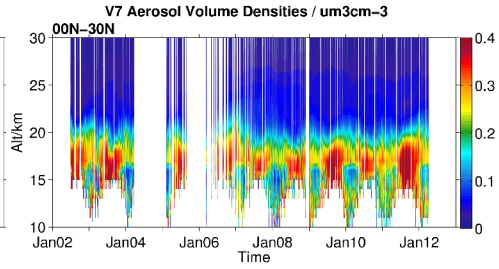


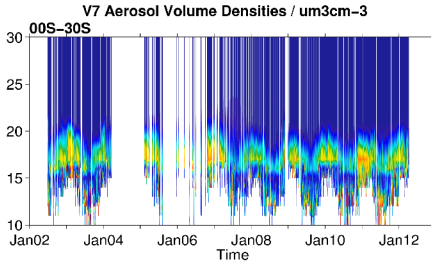


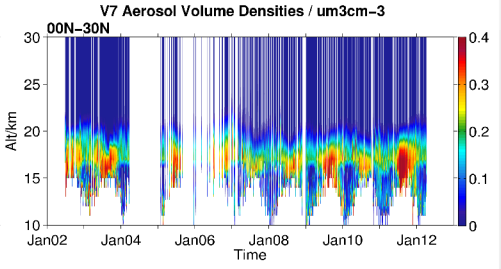


00°-30°

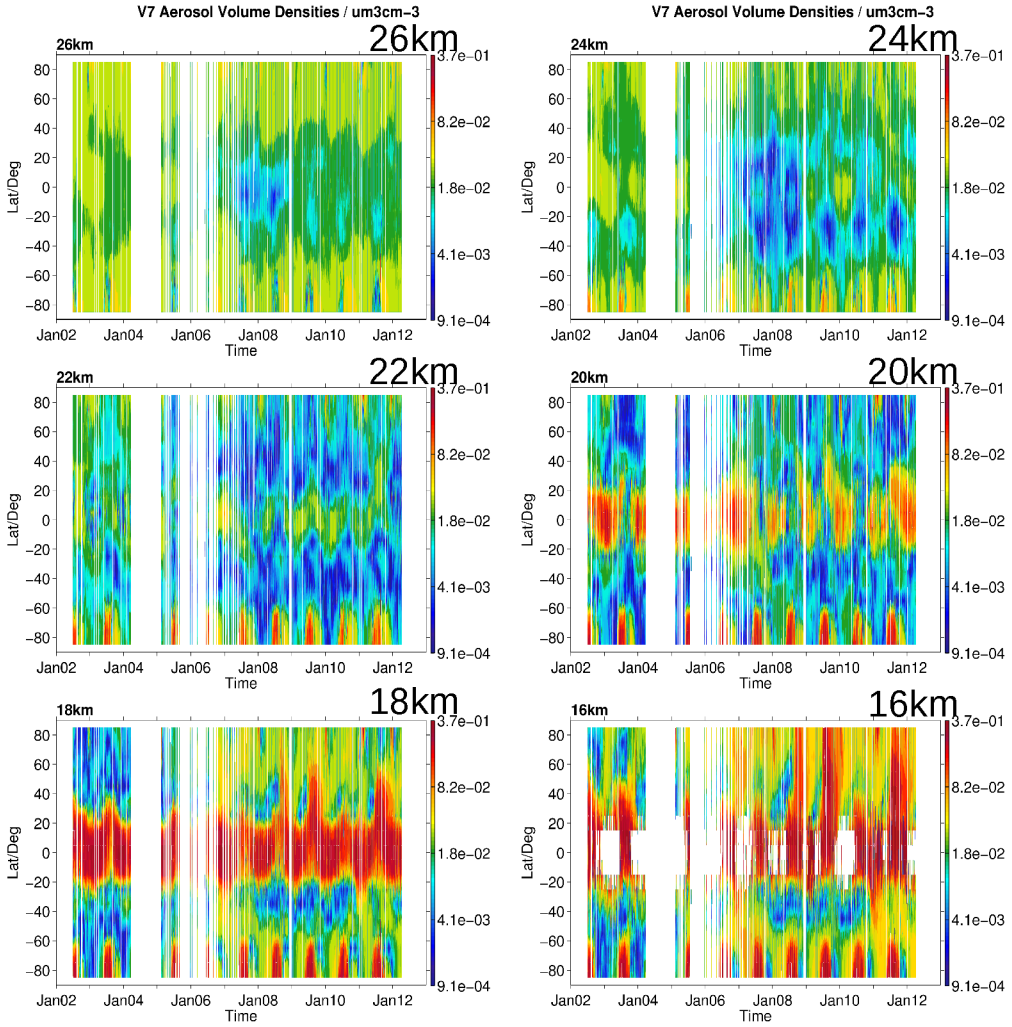








Stratospheric Aerosols, MIPAS



Future Work

- CTM:
  Implementation of further mechanisms (sources, sinks)
- MIPAS:
  Analysis of MIPAS aerosol data, filter data for clouds, etc.
- Further comparisons MIPAS & CTM.
- → Sulphur budget from OCS, SO_2, and sulphate aerosols from MIPAS & CTM.

Credit: *www.nationalgallery.org.uk*
Turner, 1839, The Fighting Temeraire

Sources

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