Model simulations of stratospheric aerosols from volcanic eruptions and their radiative forcing

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EMAC

(ECHAM/ MESSy Atmospheric Chemistry) model
see Jöckel et al. 2010, 2016 GMD

- ECHAM5 general circulation model with self consistent QBO
- Improved horizontal resolution: 2.8°x 2.8° (T42)→ 1.88°x1.88° (T63)
- vertical: 90 levels up to 80 km
- interactive atmospheric chemistry
- Modal aerosol module for stratosphere and troposphere, 4 soluble and 3 insoluble modes

Model setup and ref. on Christophs Poster (21)

- including ~230 explosive volcanic eruptions (2002 – 2012)
- aerosol radiative forcing calculated diagnostically online
- Astitha-dust scheme, organics and sulfur as CCMI (MACCity, GFED), simple SOA

Used satellite data for volcanoes

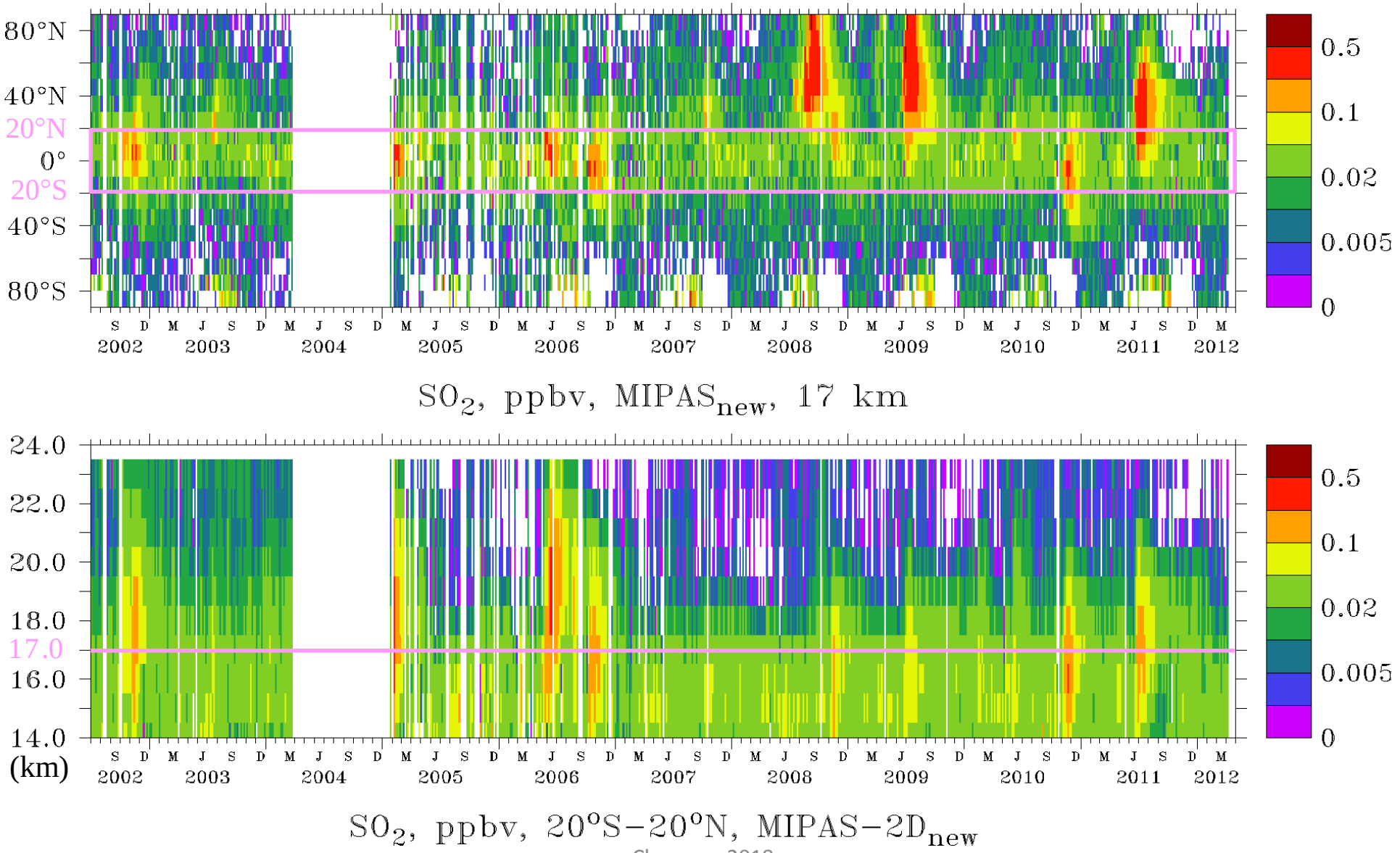
- SO_2 profiles (derived from MIPAS* on ENVISAT)
- GOMOS** aerosol extinction for detecting additional volcanoes erupting into the stratosphere, converted back to SO_2 with a parametrization by Grainger et al. 1995 and similar situations seen by MIPAS
- SO_2 columns (DU) related to volcanic emissions in Ozone Monitoring Instrument (OMI) since 2004 and Total Ozone Mapping Spectrometer (TOMS) before and other nadir satellite instruments like GOME2, AIRS
- Smithsonian volcanic data base (http://volcano.si.edu/)

3D-SO_2 plumes derived from these data sets (typically taken of a time period of 10 days) are added to the model SO_2 about at the time of the eruption(s)

* Michelson Interferometer for Passive Atmospheric Sounding

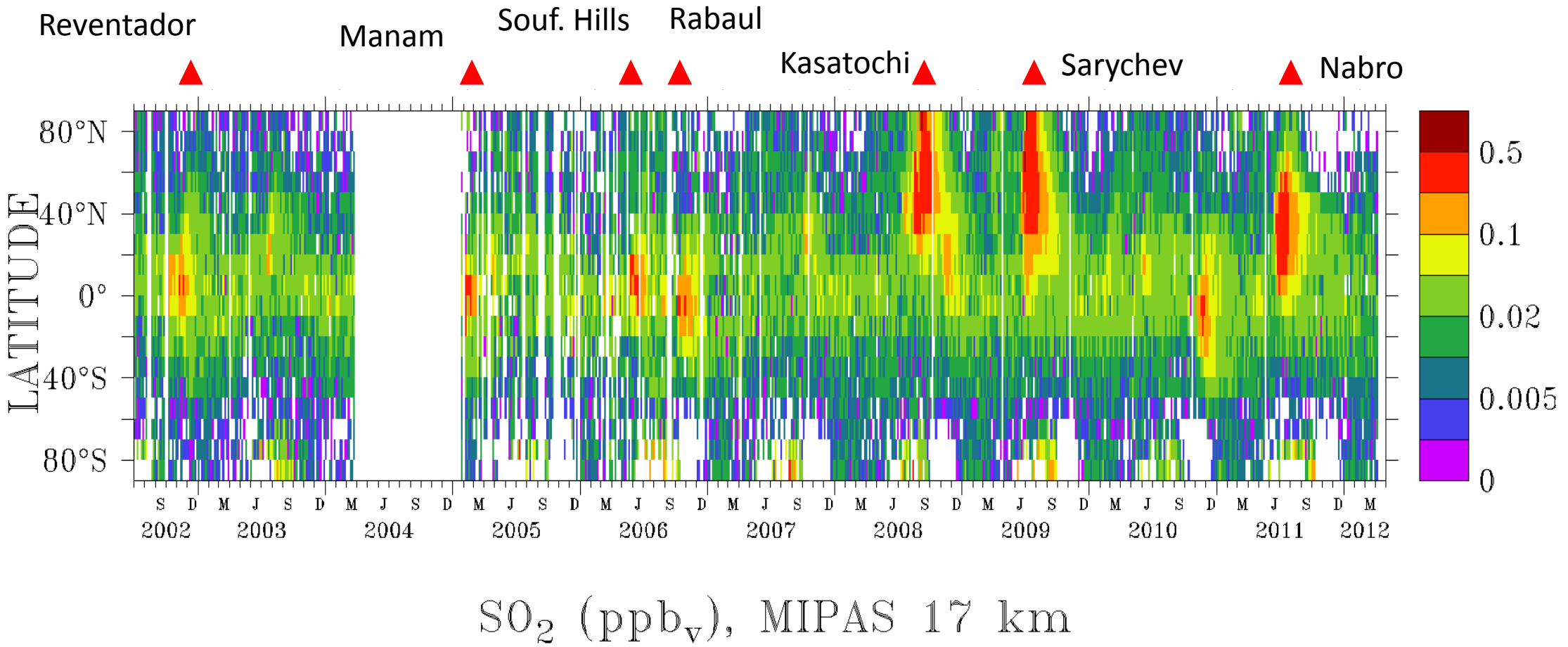
**Global Ozone Monitoring by Occultation of Stars

MIPAS SO_2 mixing ratios



MIPAS: SO_2 volcanic signature in the lower stratosphere

2002 – 2012 about 230 volcanic eruptions

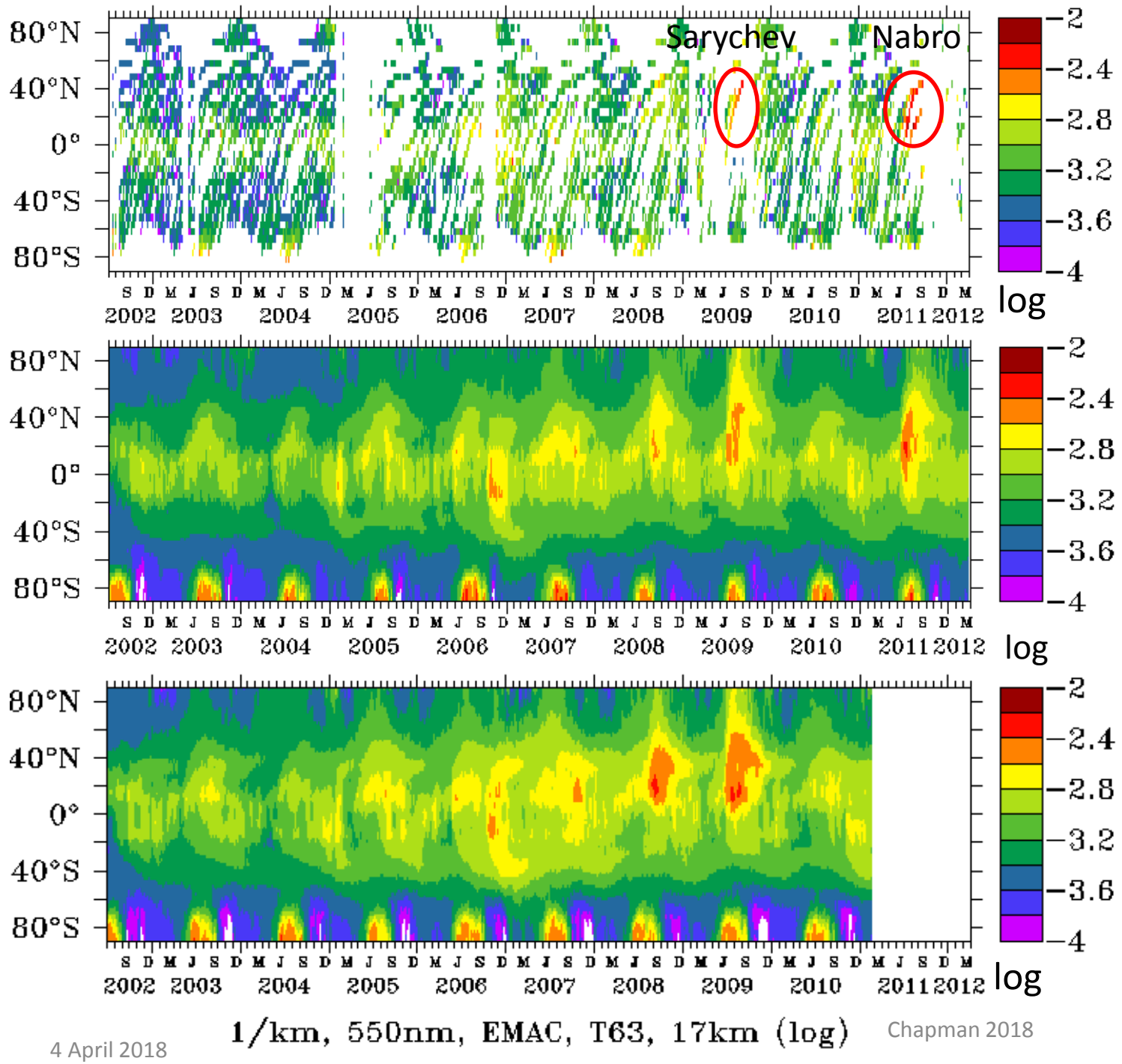


SO_2 (ppb_v), MIPAS 17 km

Inventory of volcanic eruptions in Bingen et al., 2017

MIPAS on ENVISAT 5-day data, Höpfner 2015 ACP

Aerosol extinction at 17km

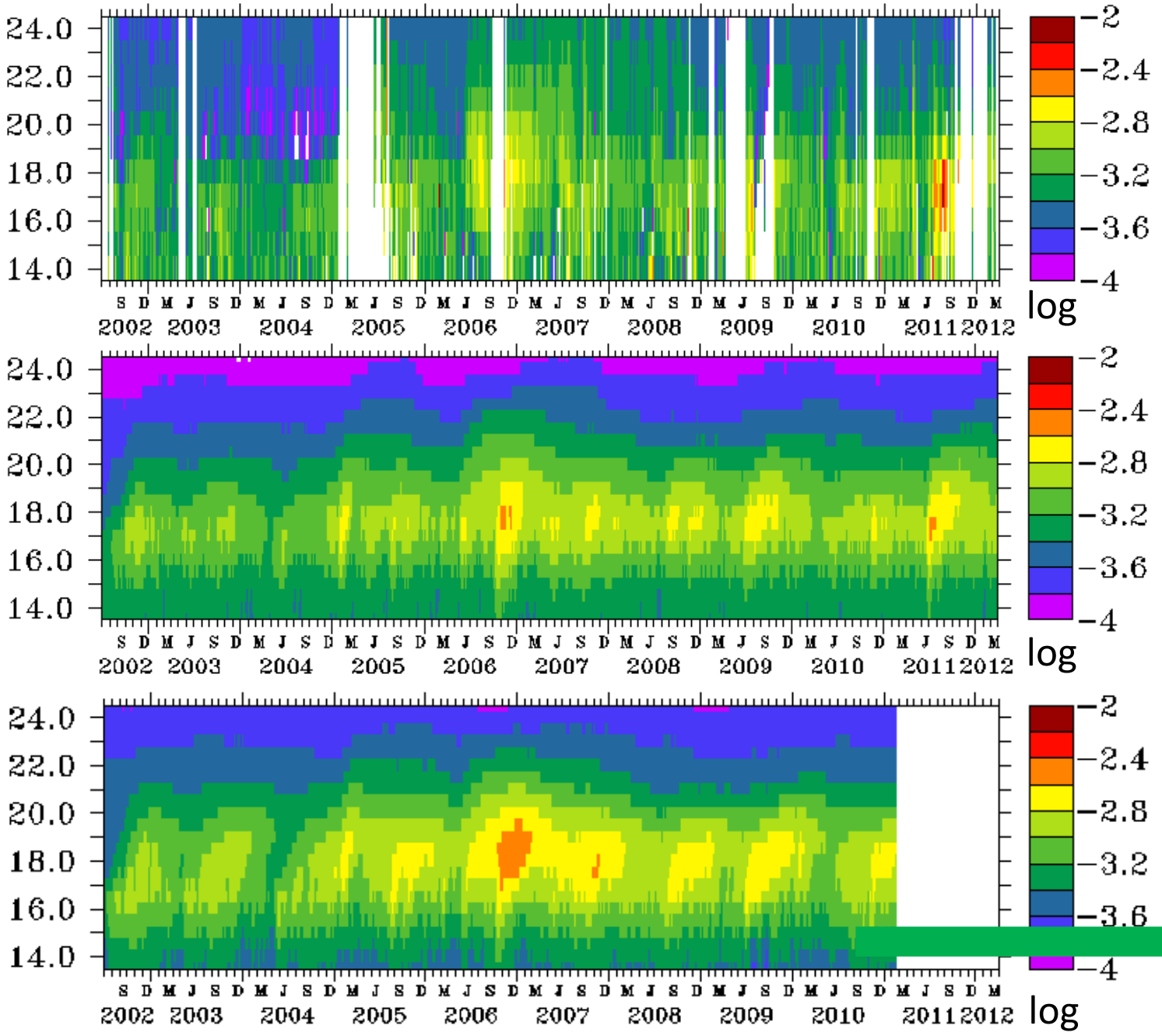


GOMOS new version 3.00
Bingen et al., 2017

EMAC simulation version 2.52
Resolution **T42: 2.8°x2.8°**

EMAC simulation version 2.52
Resolution **T63: 1.88°x1.88°**

Aerosol extinction, tropics



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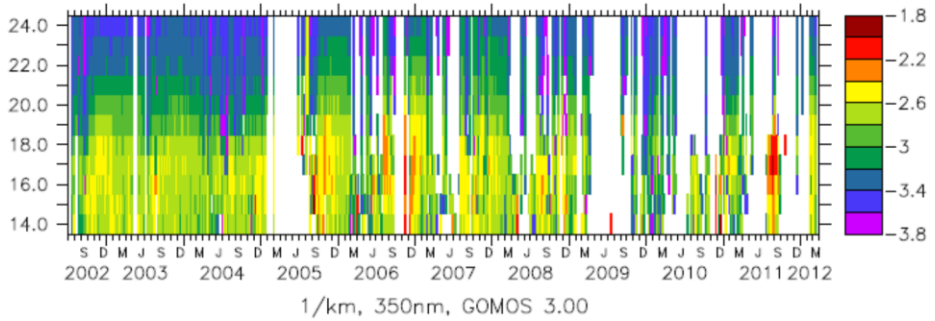
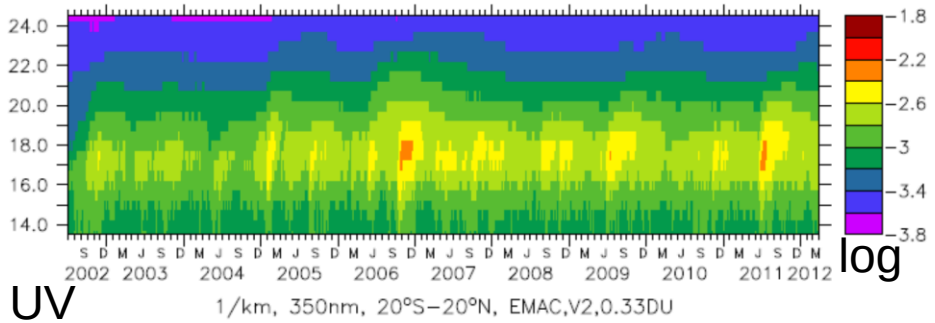
Bingen et al., 2017

EMAC simulation version 2.52
Resolution **T63: 1.88°x1.88°**

Sensitivity study about non-sulfate particles on Christophs Poster (21)

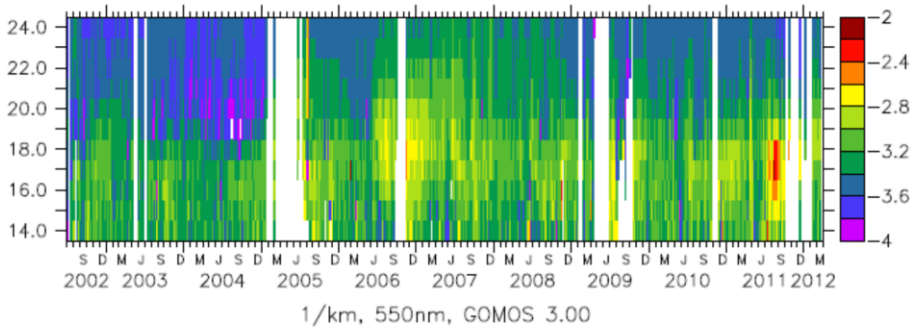
Observed and simulated extinction in UV, vis and NIR, tropics

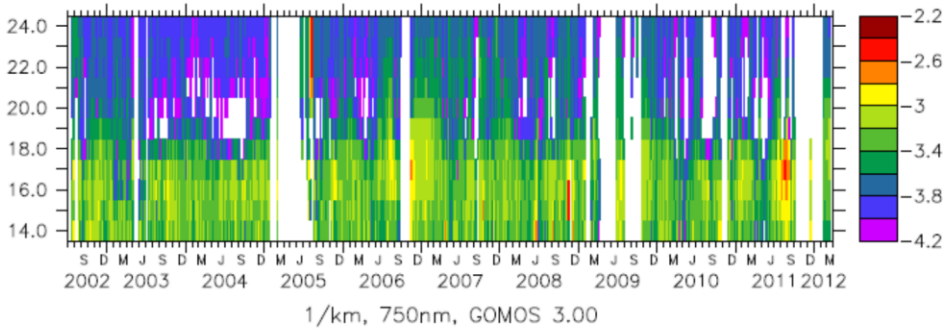


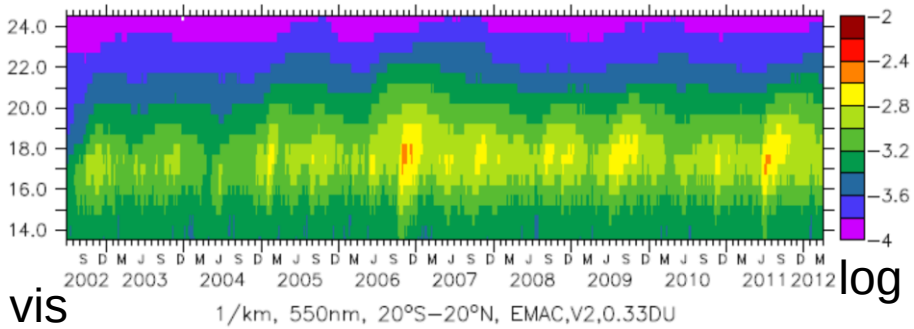


log

UV

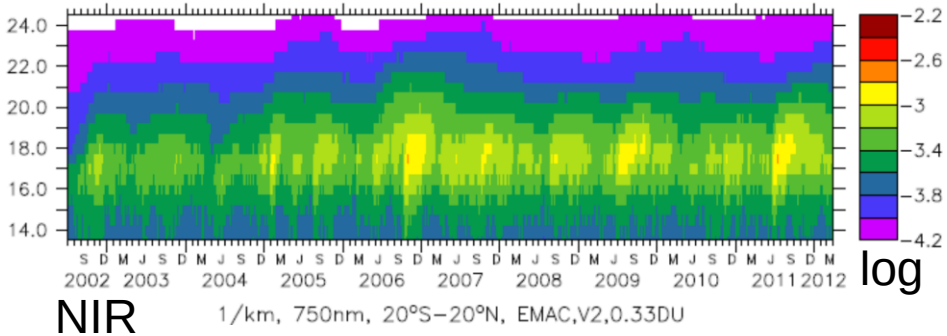






log

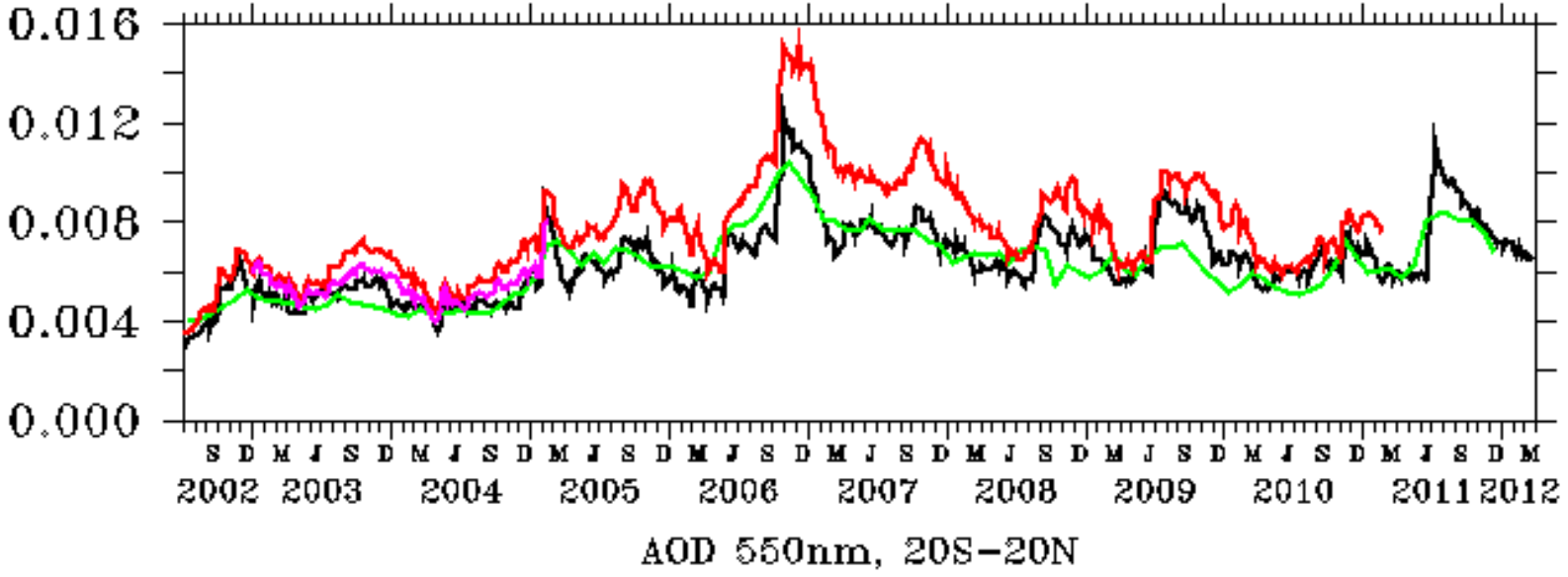
vis

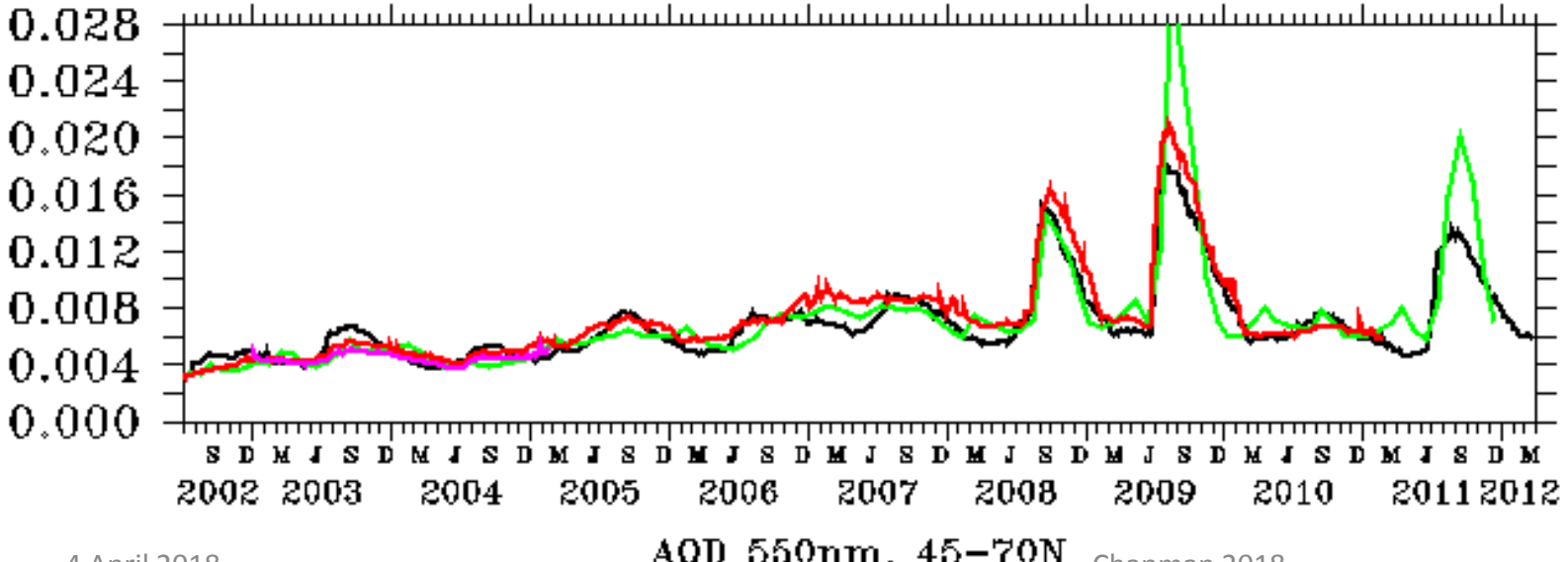


log

NIR

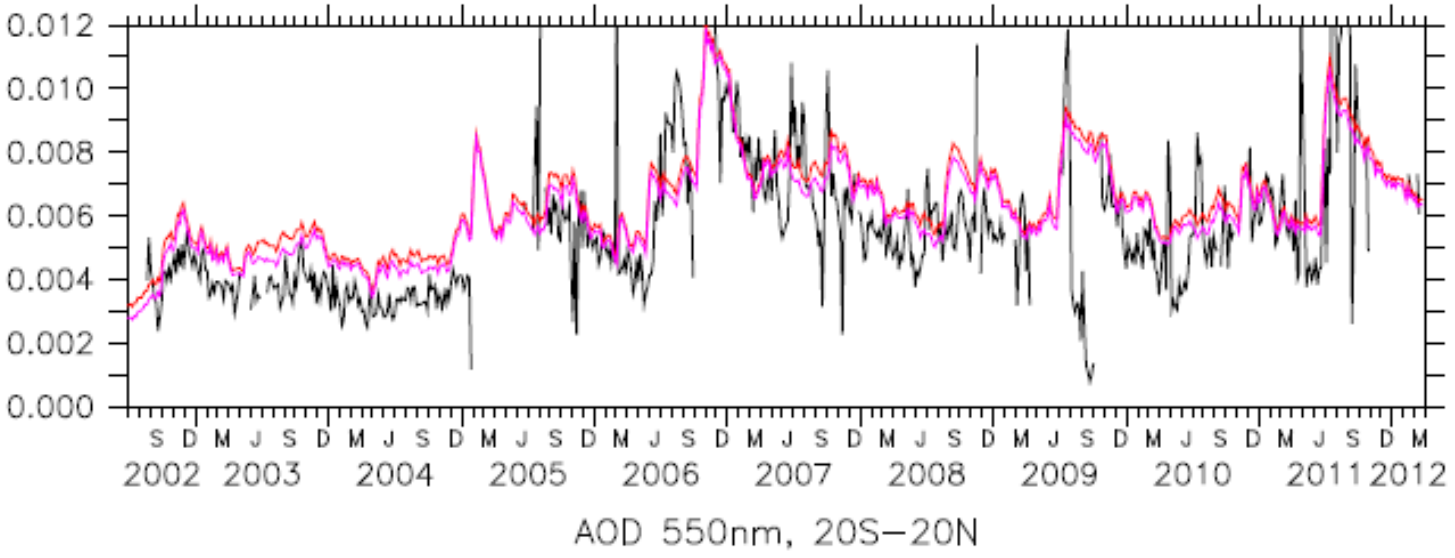
Improvement of simulated aerosol optical depth

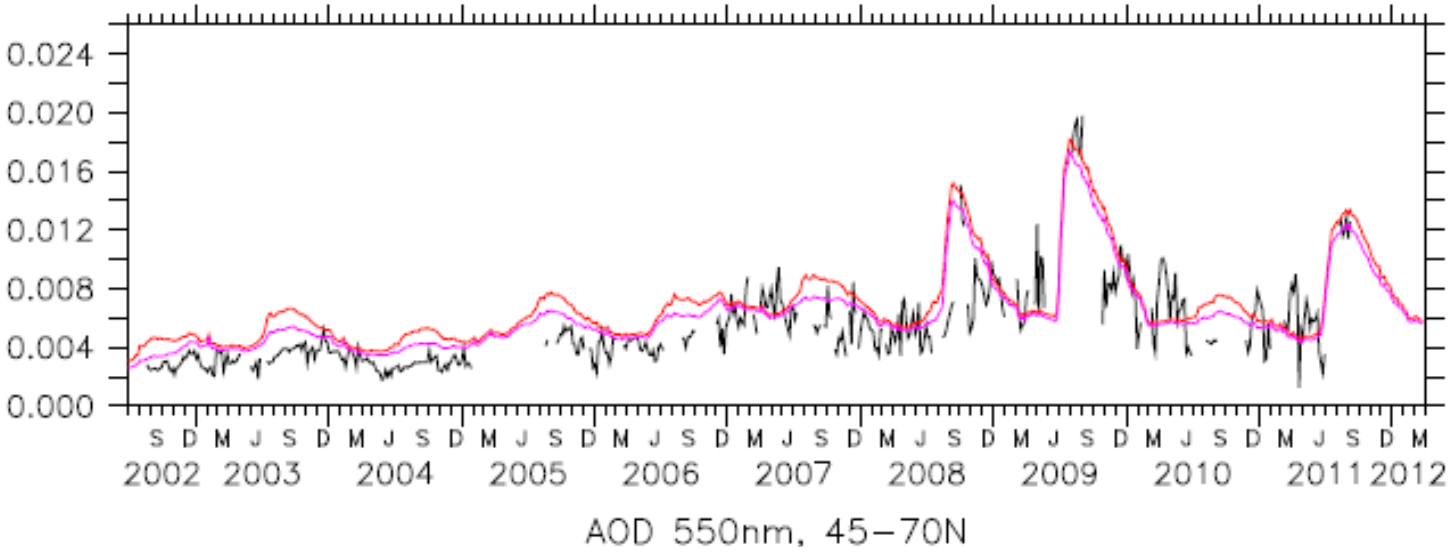




EMAC simulation version 2.52 based on MIPAS zonal averages:
T42 (2.8°x2.8°) in Bingen et al., 2017
T63 (1.88°x1.88°)
T63 (1.88°x1.88°) reduced SO_2
Satellite observations (SAGE II, Osiris)

Aerosol Optical Depth EMAC GOMOS





tropics

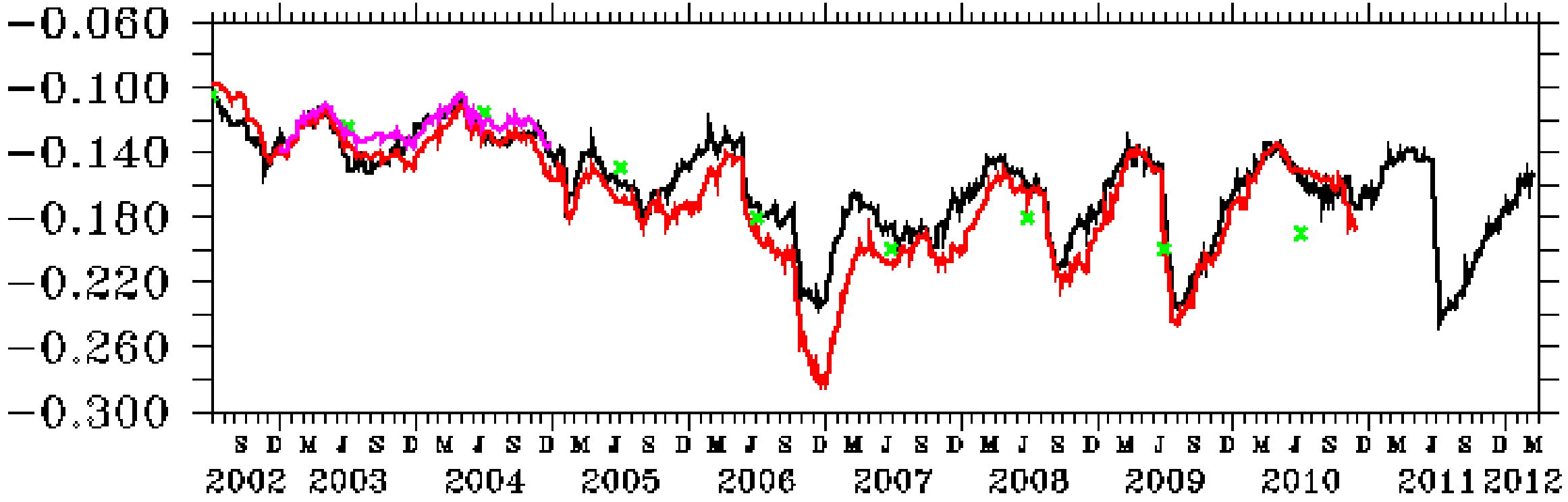
EMAC version 2 T42 2.8°x2.8°

EMAC version 2 T63 1.88°x1.88°

GOMOS satellite data

northern mid latitudes

Radiative forcing at tropopause



EMAC simulation version 2.52
based on MIPAS zonal averages:

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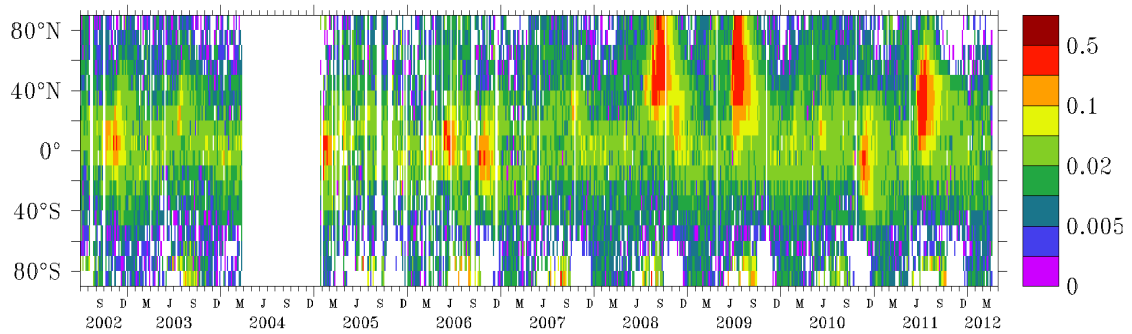
-- T63 (1.88°x1.88°) reduced SO_2

× Derived from observations (annual mean, Solomon 2011, Science)

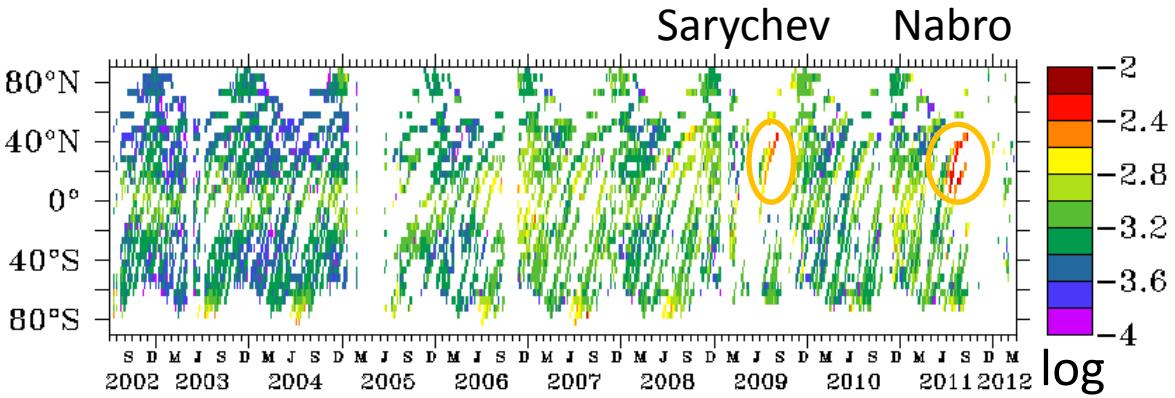
Conclusions

- Combination of **MIPAS and GOMOS** is important for detecting eruptions in data gaps
  → better attribution of individual eruptions (**3D 5day-datasets**, not possible with monthly data!)
  →Also **small volcanoes** reaching the tropical tropopause **matter** because of sulfate accumulation
  → leads to better SO_2 input for chemistry-climate models to calculate radiative forcing
  → consistent with **observations from Solomon 2011**
- Improvement of **dust and organics** in new model version (2.52)
  → better agreement with GOMOS data in lowermost stratosphere
  → Influence of Asian Summer Monsoon on stratospheric aerosol, soot and desert dust
- Convection and aerosol transport are **sensitive to model resolution** **T42 →T63**
  less dust more sulfate (aerosol water + longer lifetime)
- The combined comparison at **UV, visible and infrared** wavelengths yields strong constraints on the modelled particle size distribution

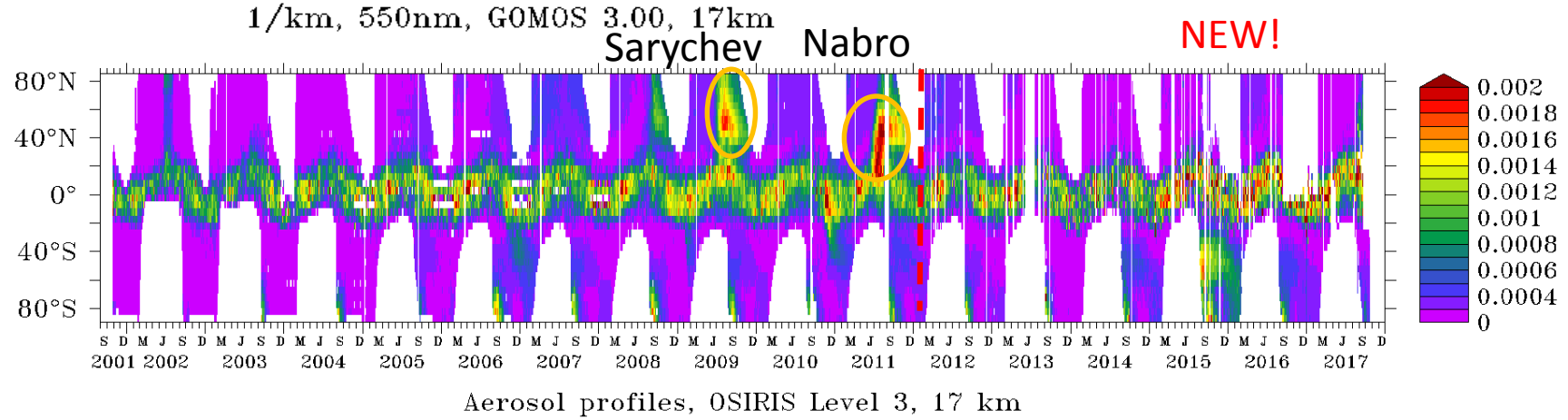
Outlook: New Satellite data sets from OSIRIS at 17km



MIPAS SO_2 Höpfner 2015 ACP



GOMOS Aerosol extinction version 3.00
Bingen et al., 2017 RSE



OSIRIS
(from Landon Rieger)

Thank you for your attention

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