Investigation and Assessment of Climate-engineering Methods that modify the Composition of the Atmosphere (Geo-Ozon)

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GEO-OZONE

Extension of the project 'Implications and risks of engineering solar radiation to limit climate change'

- Goal: understand risks and side-effects of stratospheric sulfur injections
- UBA Project (FKZ3711 97 109)
- Studies are performed with EMAC (ECHAM5-MESSY)
  - including atmospheric chemistry module MECCA
  - including aerosol micophysical module GMXE (M7)

Why do we study climate-engineering?

- Effectiveness of most geoengineering techniques is unclear.
- Undesirable side effects and risks are not well understood.
- Debate on geoengineering should be accompanied by independent research activities.
- Impact of sulfur injection into the stratosphere on ozone concentration and stratospheric dynamics are still not completely understood.

How do we study climate-engineering?

- We perform set of experiments with different emission strength and different background conditions.
- Use a model coupled to atmosperic chemistry and aerosol microphysics.
  - Include impact of aerosol evolution.
  - Include interaction with ozone and other chemical species.
  - Model resolution: (T42L90)

Impact of sulfate injections

Experiment description:

- Sulfur emissions of 2, 4 and 8 Mt(S)/y
- Emitted into the stratosphere at a height of 25 km (30 hPa)
- 3 years pre-simulation
- Annual averages over 3 years (2 and 8 Mt(S)/y)
- Annual average over 6 years (4 Mt(S)/y)
- Results are compared to a 5 years control simulation without emissions

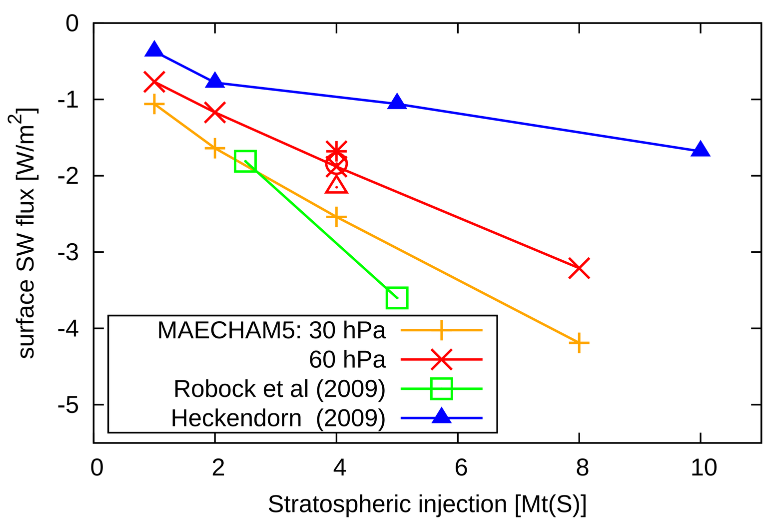

Figure 1: Radiative forcing from continuous stratospheric sulfur injections from different studies. Yellow and red: our study, Niemeier et al. (2011). Yellow and red indicate emission levels of 30 and 60 hPa. Blue and green should be compared to the 60 hPa emission scenario.

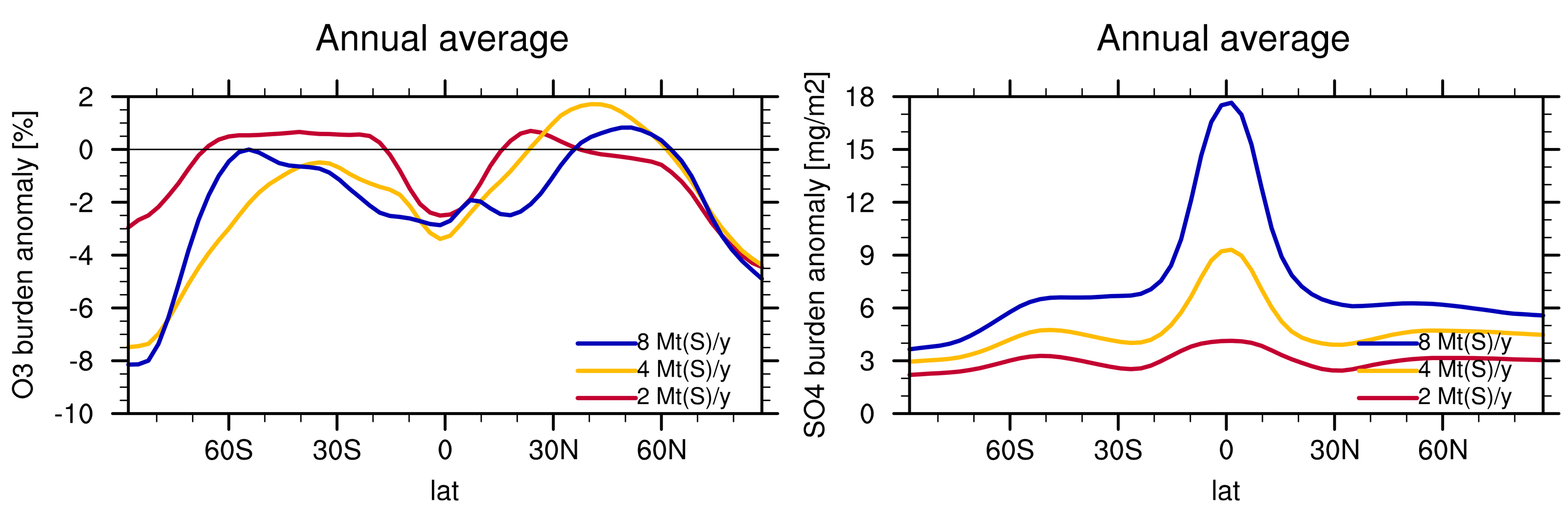

Figure 2: Burden of ozone (left) and sulfate aerosol (right), yearly and zonal average.

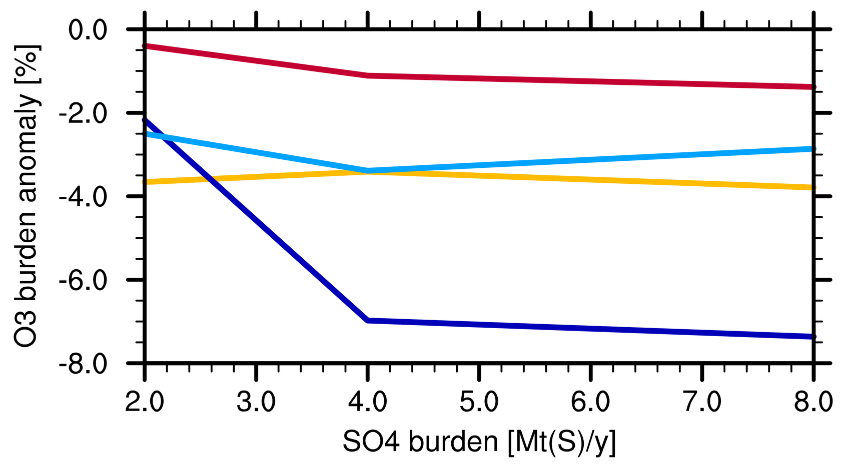

Figure 3: Anomaly of ozone burden [%] versus sulfur emission [Mt(S)/y] for global data (red), and zonal mean data at 80^o N, equator and 80^o S

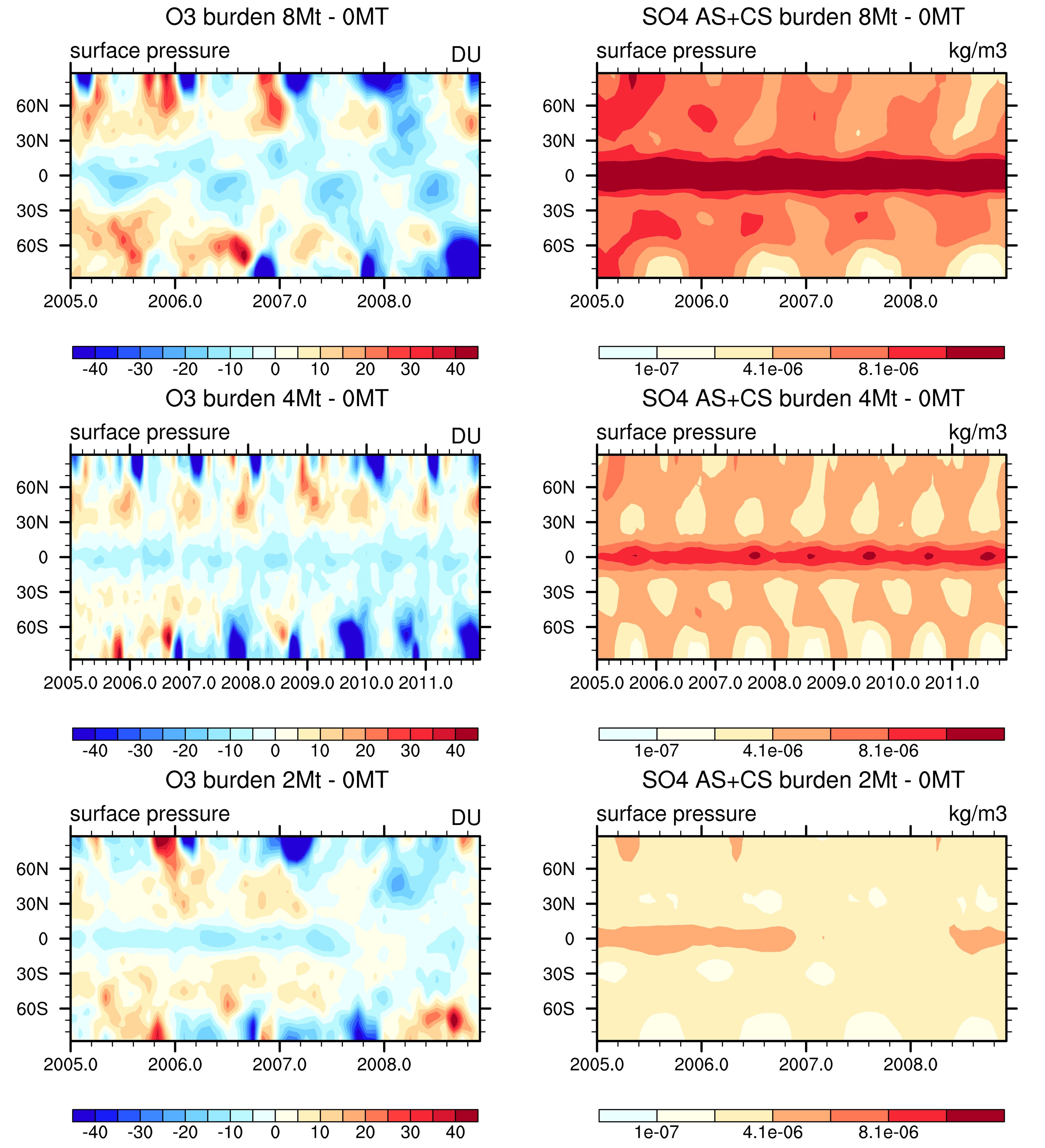

Figure 4: Ozone burden [DU] (left) and sulfate burden [kg/m2] (right) as Hovmoeller diagramm. Anomalies are given as differences to the control simulation.

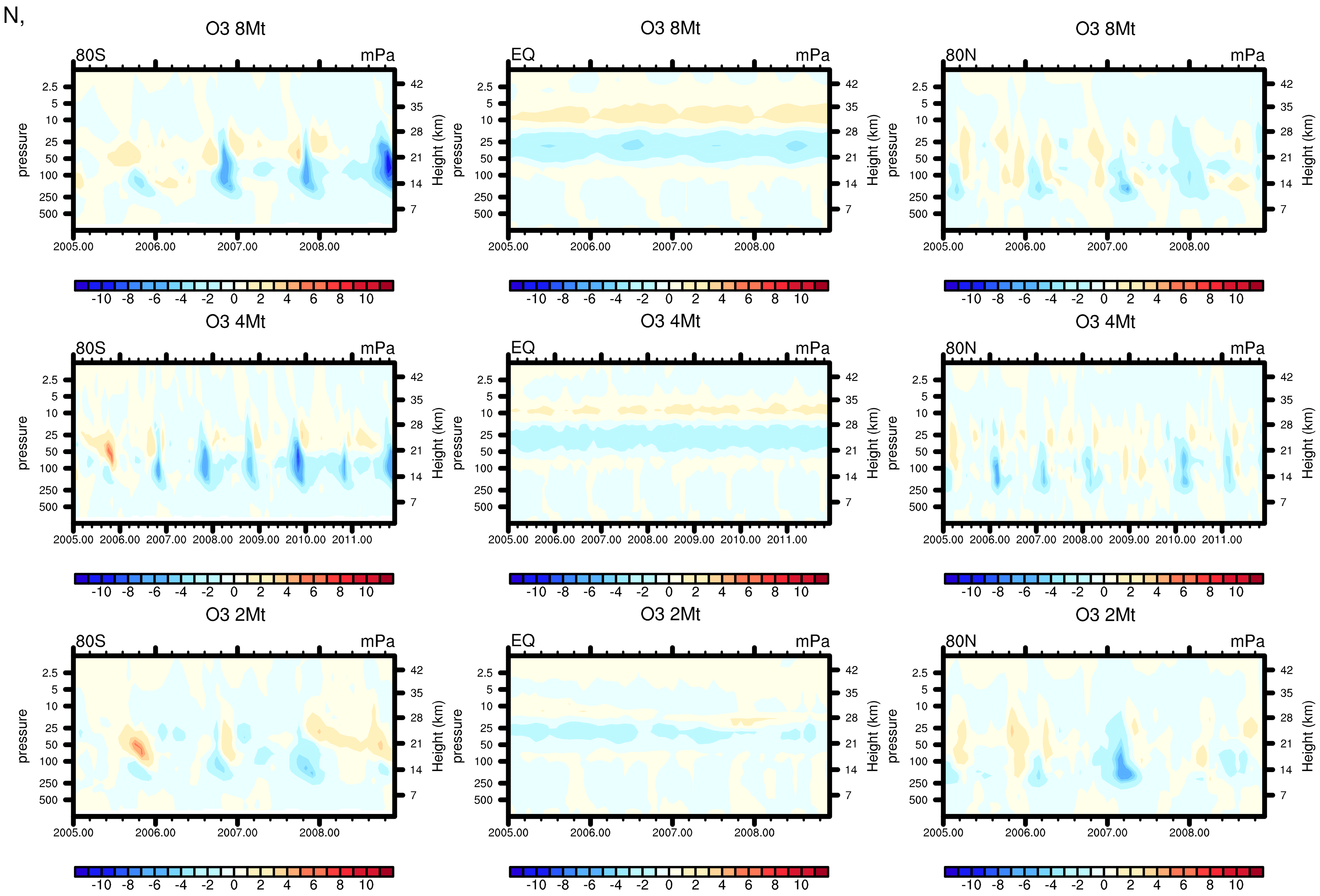

Figure 5:
Ozone concentration [mPa] over time as vertical cross section at 80^o S (left), equator (middle) and 80^o N (right) for three different emission strength.

Summary

- Injection of 2, 4, 8 Mt(S)/y sulfur into the stratosphere decreases the ozone concentration (Fig. 2 + 3)
  - Globally by 1% to 1.5%, at the equator by 2% to 3%,
  - At 80 N by 3% to 5% and at 80 S by 2% to 8%
- Intensification of polar vortex blocks meridional sulfate transport (Fig. 4)
- Vertical profiles show areas of decreasing ozone concentration and an increase above (Fig. 5).
- Results are comparable to previous studies (Tilmes et al, 2008; Heckendorn et al, 2009)
- Open questions:
  - Dynamical impact on polar vortex
  - Dynamical impact on quasi biannual oscillation

References

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