The effect of stratospheric sulfur from Pinatubo on the oxidizing capacity of the troposphere

Narcisa Bândă Maarten Krol Thomas Röckmann *Twan van Noije Michiel van Weele Jason Williams*



Universiteit Utrecht











Model setup

- TM5 global chemistry model 3x2, 60 levels
- ECMWF ERA-Interim meteorology fields
- Aerosol module M7 coupled to photolysis
- M7 setup as recommended in Kokkola et al. 2009:
 - no soluble coarse mode, accumulation mode σ =1.2 instead of 1.59
 - no tropospheric aerosols
- Emissions from EDGAR 4.2/4.1, RETRO fires, natural emissions from MACC and LPJ
- Methane nudged up to 550 hPa with observations from background stations (for now)

Model setup

- 18.5 Tg SO₂ emitted in the grid-cell containing Pinatubo on 15th June 1991 between 17-21 km, 20-24 km, 23-27 km
- The effect on photolysis in the period June-December 1991:
 - no Pinatubo
 - with Pinatubo, without SO₂ absorption
 - with Pinatubo, with SO₂ absorption

SO₂ plume validation

SO₂ plume validation

Sulphate aerosols

Sulphate aerosols

Aerosol size (14-20 N)

Effect on photolysis rates and OH at the surface

60°S

120°W

60°W

0°

60°E

120°E

60°N 0.5 30°N 30 -1.0**ΔJO3** [%] 0° 0° 2.5 30°S -5.0 30 -7.5 60°S 60 -10.0 120°W 60°W 0° 60°E 120°E -0.160°N 60 -0.5 30°N 30 -1.0**JNO2** [%] 0° 2.5 0° 30°S -5.0 30 -7.560°S 60 -10.0 60°E 120°W 60°W 0° 120°E -0.1 60°N 60 -0.5 30°N 30 -1.0**AOH** [%] 0° 0° -2.5 30°S -5.0 30 -7.5

-0.1

60

-10.0

Aerosol scattering

on 1 December 1991

Effect on photolysis rates and OH at the surface

Aerosol scattering

Effect on photolysis rates and OH

Tropospheric CH₄ sink

| Tg/year | No Pin | Pin Aer | Pin Aer&SO ₂ |
|---------------------|-----------|------------|----------------------------|
| Emissions | 451 | 451 | 451 |
| CH ₄ +OH | -502 | -491 | -490 |
| Nudging surface | 129 | 119 | 118 |
| Nudging strat | -25 | -25 | -25 |
| Burden chng | 51 | 53 | 53 |

Note on vertical resolution

Note on vertical resolution

SO2 (ppb)

Conclusions

- The evolution of the SO₂ and sulphate aerosols can be modelled reasonably well
- Difficult to match both plume height and horizontal distributions, probably due to uncertainties in transport
- The effect on global OH is less than 1% for SO₂ and 3% for aerosols, with larger effects regionally
- This results in decreases in the CH₄ sink of 1 Tg and 7 Tg respectively in the first 6 months after the eruption

Future work:

- Improve plume evolution (injection height)
- Look at a 2-year period
- Study the effects of stratospheric ozone depletion, climate change after Pinatubo on OH, CH₄ in TM5
- 'Free running' CH₄

Acknowledgements

Philippe le Sager Joost Aan de Brugh (SRON) Jeroen van Gent (BISA) Ulrike Niemeyer (MPI-M)