Supplementary material to: Convection and scavenging - parameterisation uncertainties in atmospheric chemistry modelling. Part 1: Implications for global modelling

H. Tost, M. G. Lawrence, and P. Jöckel

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1 Uptake of HNO_3 on ice

The importance of the uptake, scavenging, sedimentation of HNO_3 on ice has been analysed with a sensitivity study using the T1 convection scheme, but a lower horizontal and vertical resolution. Nevertheless, the effects are in agreement with previous model studies (e.g., v. Kuhlmann and Lawrence, 2006).

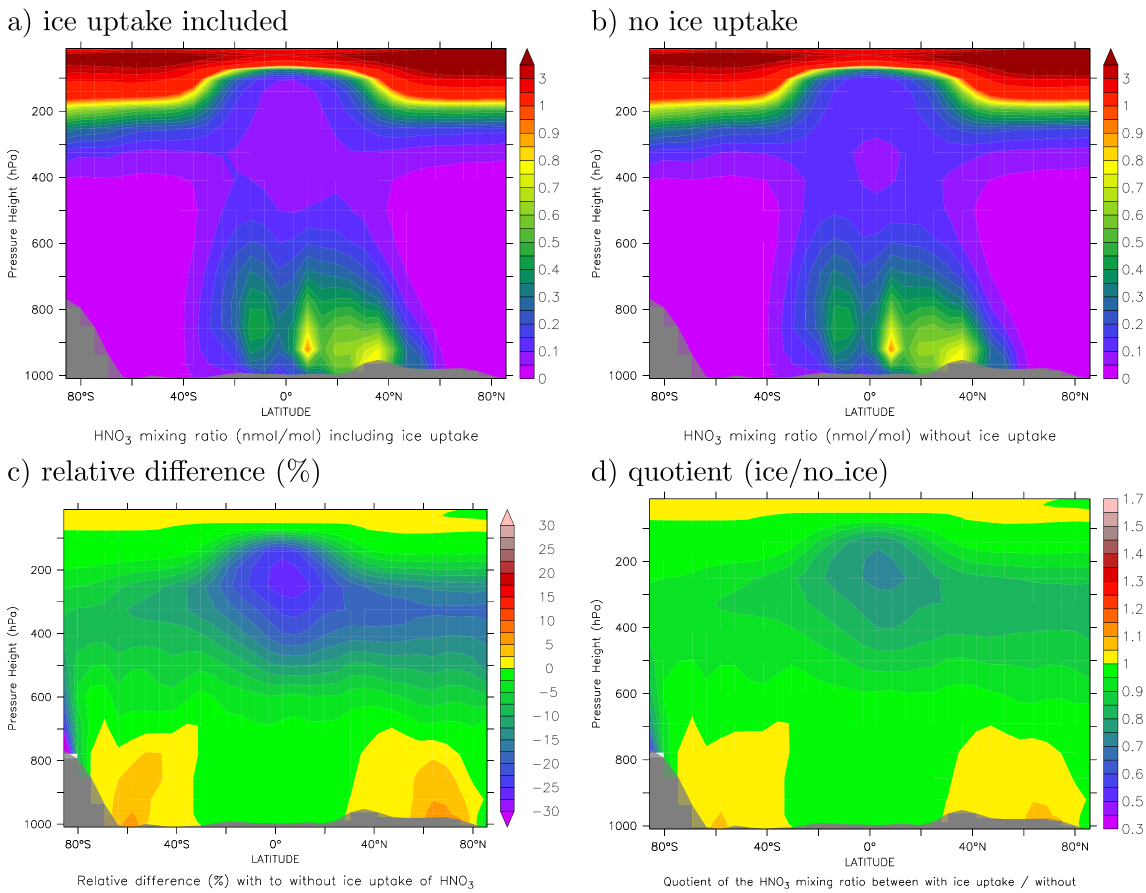

Figure 1: Zonal average HNO_3 distribution in a simulation with ice uptake included (a), with no ice uptake (b) (both in nmol/mol), the relative difference between the two (c), and the quotient between the two simulations (d).

2 Precipitation at the surface

Even though the surface precipitation has already been analysed in Tost et al. (2006), the simulation setup is slightly different and therefore these figures are shown in this supplement. The patterns are quite similar, only ZHW has lower precipitation (partly due to the reasons explained in Tost et al. (2006)). Compared to CMAP precipitation data for that period, all agree reasonably well.

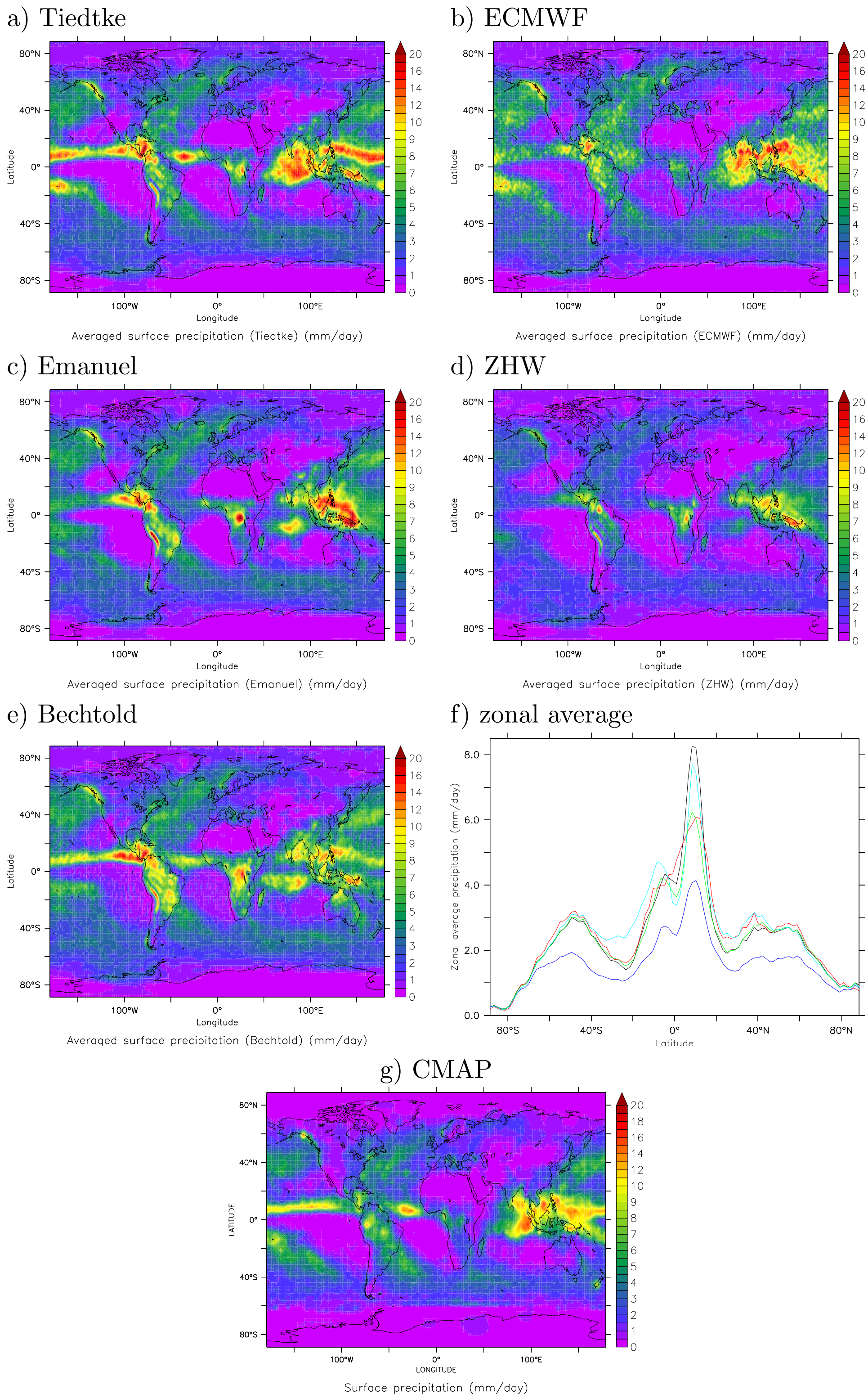

Figure 2: 4 month average of the surface precipitation (both convective and large-scale): a) to e) for the five simulations and f) the zonal average of all simulations. Panel g) depicts the CMAP precipitation for that period.

3 Outgoing long-wave radiation at the top of the atmosphere (OLR)

Since the radiation budget must not be substantially altered by an exchange of the convection scheme, the model setups have been tuned to achieve realistic outgoing long-wave radiation. This is shown in these figures, comparing to NOAA radiation data in the last panel.

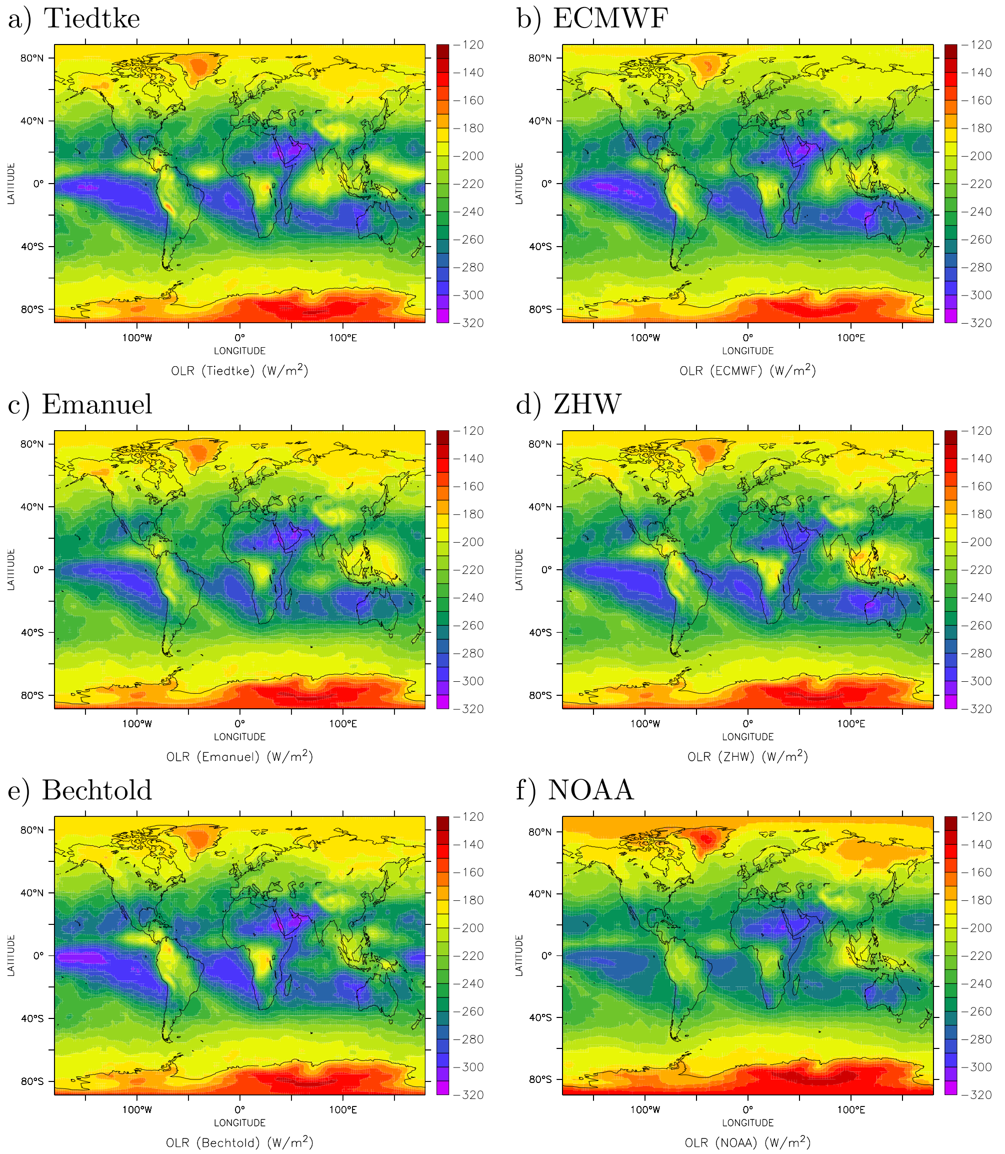

Figure 3: 4 months average of the outgoing long-wave radiation (top of the atmosphere) for the five simulations (a) to e)) and from the NOAA dataset (f)).

4 Upward mass fluxes: relative differences

To address the differences in the updraft mass fluxes this figure contains the relative differences compared to the T1 reference.

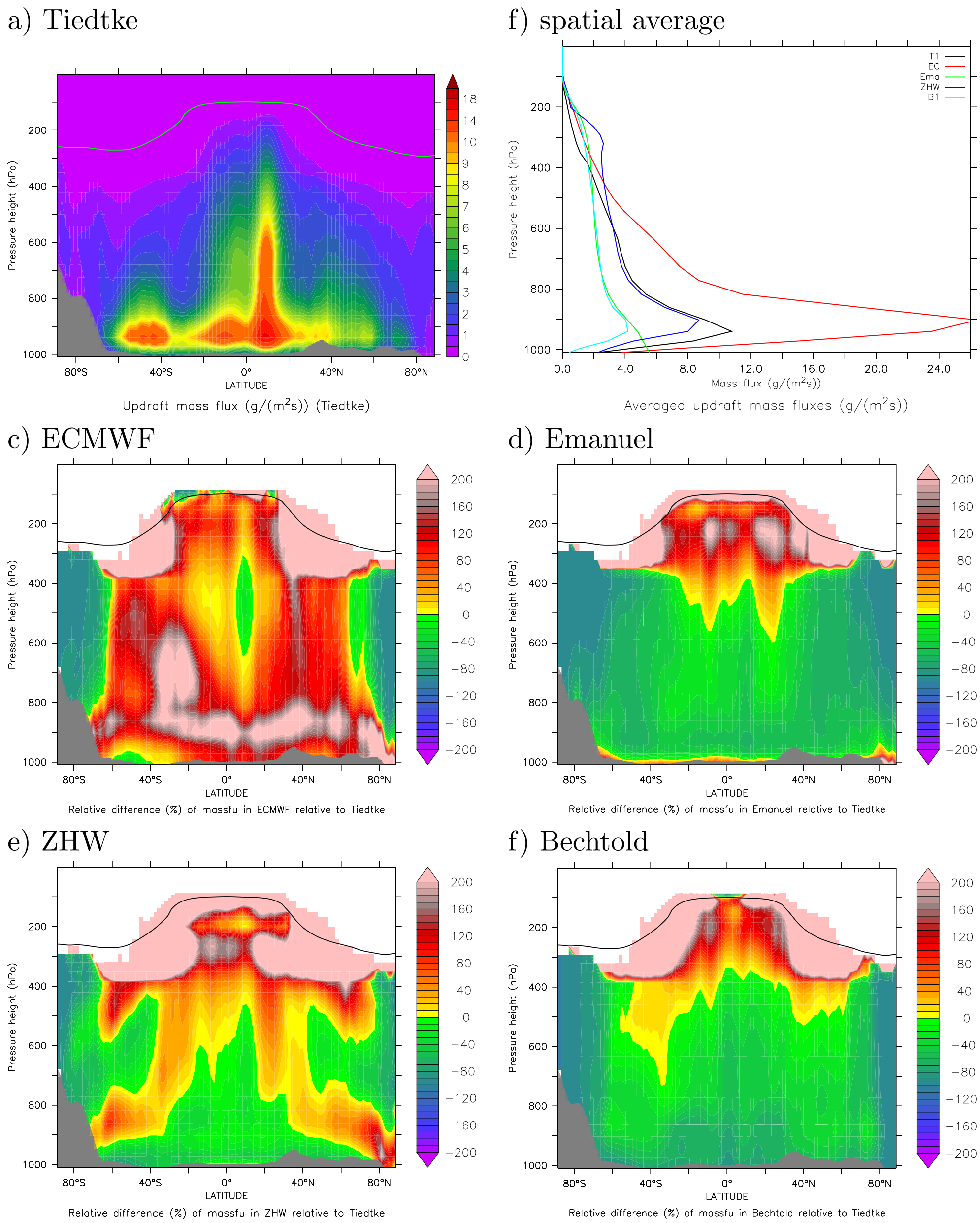

Figure 4: 4 months average of the zonal averaged convective updraft mass fluxes (a) for the T1 simulation , b) the average vertical profile. The relative differences to T1 (in %) are shown in panels c)-f). The dark line denotes the tropopause and the grey shaded area the zonal mean orography.

5 Downward mass fluxes

In addition to the upward convective mass fluxes, the downdraft mass fluxes play an important role in downward transport of species from the upper and mid troposphere into the boundary layer. This can both be species enriched in the UTLS region, but also clean air without a high pollutant loading. Fig. 5 shows the downdraft mass fluxes for the individual simulations.

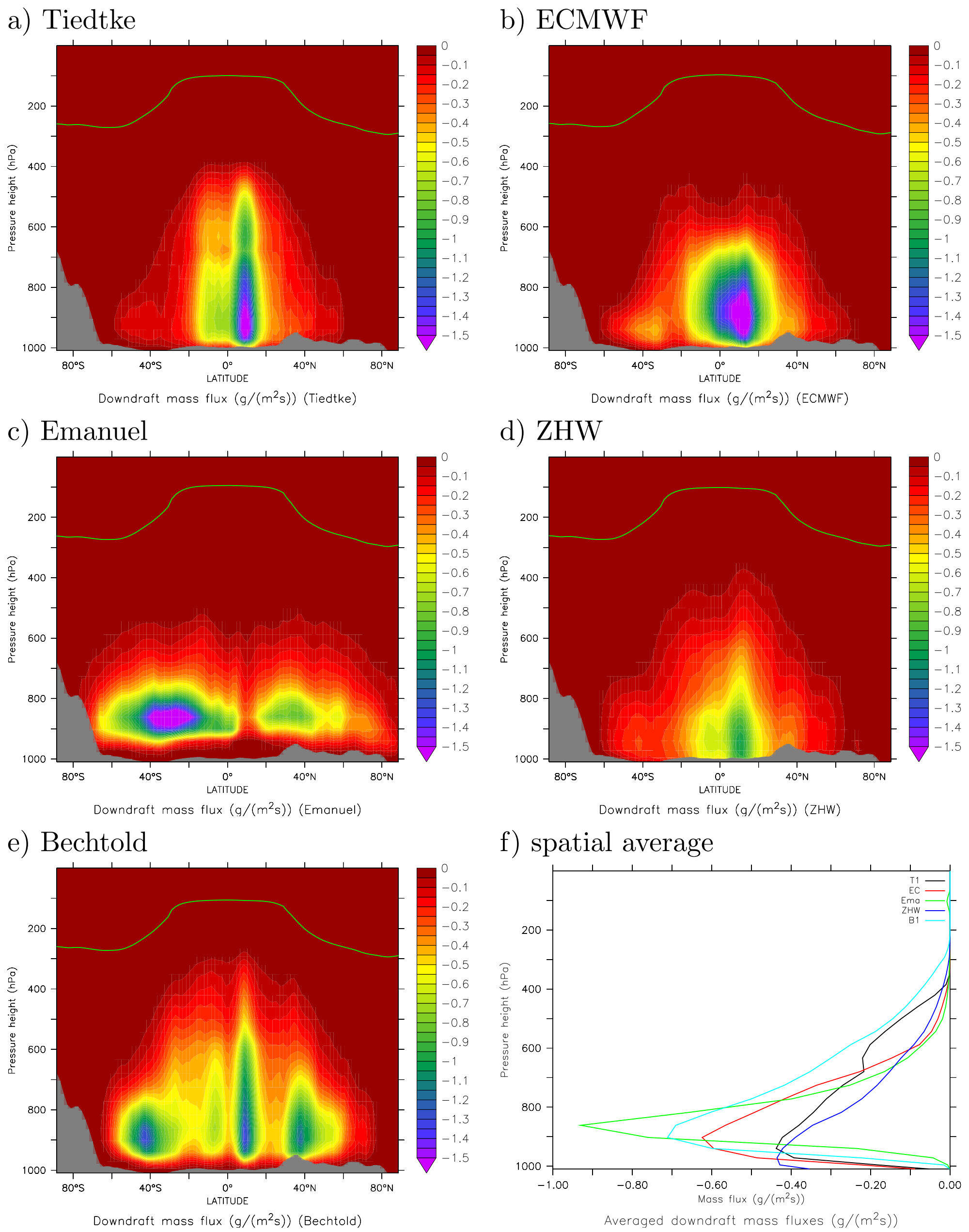

Figure 5: 4 months average of the zonal averaged convective downdraft mass fluxes (a-e) and average vertical profile (f). The green line denotes the tropopause and the grey shaded area the zonal mean orography. The negative values indicate the downward motion of the air.

6 Chemical species

6.1 OH

Since OH is the main oxidant some of the differences in oxidised compounds analysed in the main document can be better understood with the help of the analysed differences in the hydroxy radical distributions.

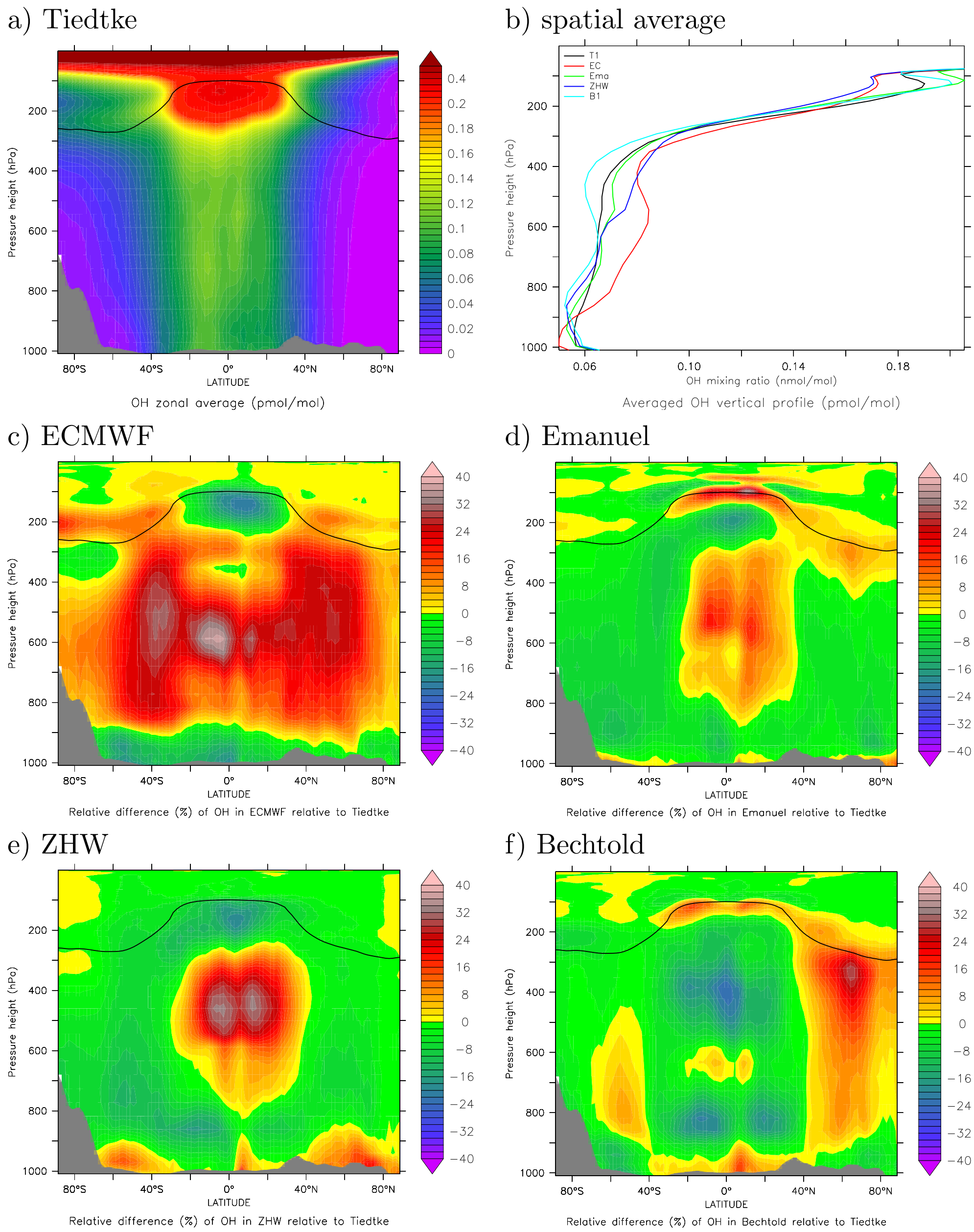

Figure 6: 4 months average of the zonal mean OH (in pmol/mol) (a), and the average vertical profile (in pmol/mol) in the five simulations(b). Panels c) to f) depict the relative difference in % with Tiedtke as the reference: $((X - T1)/T1 \cdot 100)$. The black line denotes the tropopause and the grey shaded area the zonal mean orography.

7 Wet deposition

The detailed wet deposition fluxes for nitrate and sulphate and the respective differences to the reference simulation are added, helping in estimating the differences in the tracer distributions due to scavenging and wet removal processes.

7.1 Nitrate

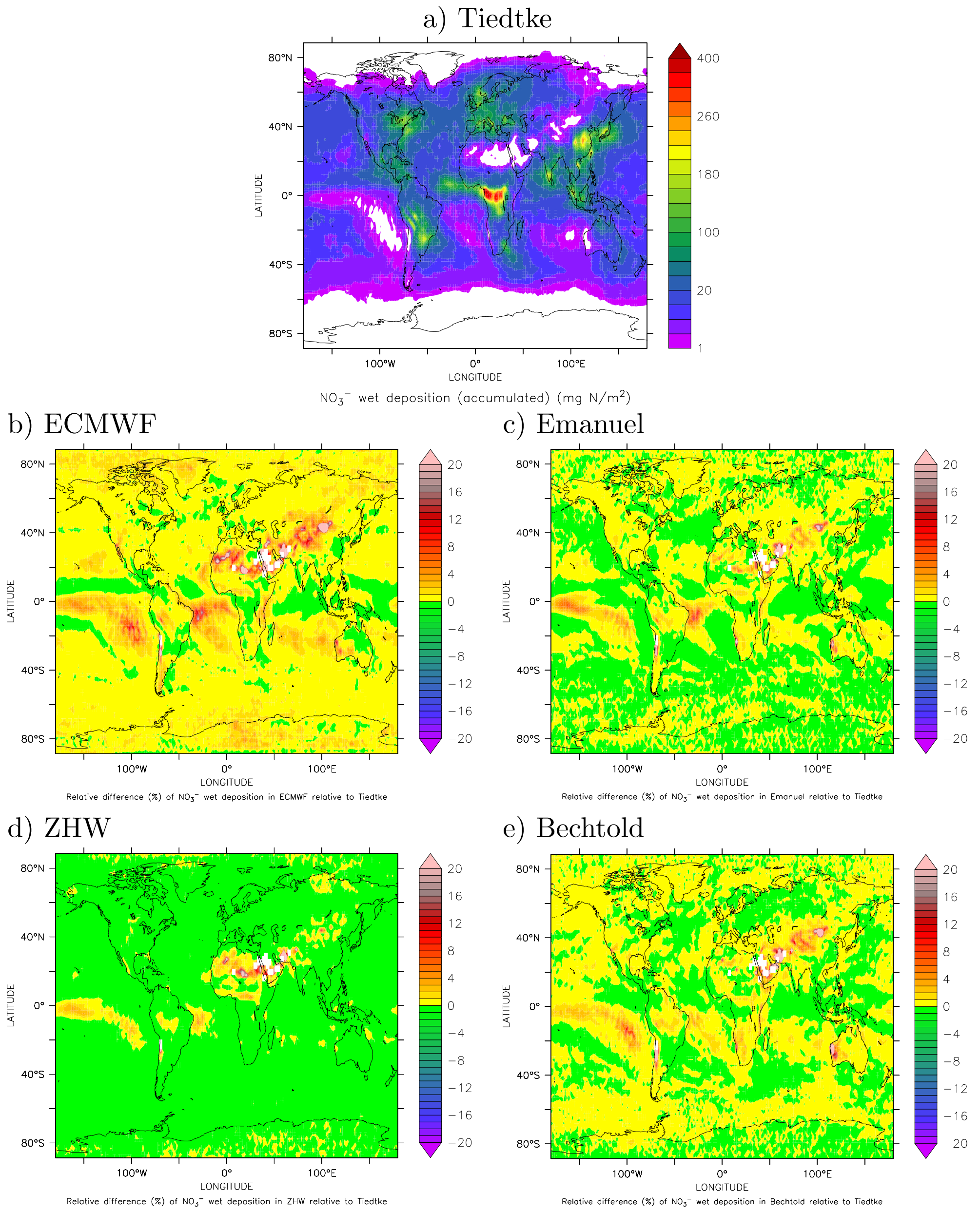

Figure 7: 4 months accumulated nitrate wet deposition flux at the surface (in mg N / m^2) for the T1 simulation (a) and relative differences (in %) of the other simulations to the T1 simulation (b) to e)).

7.2 Sulphate

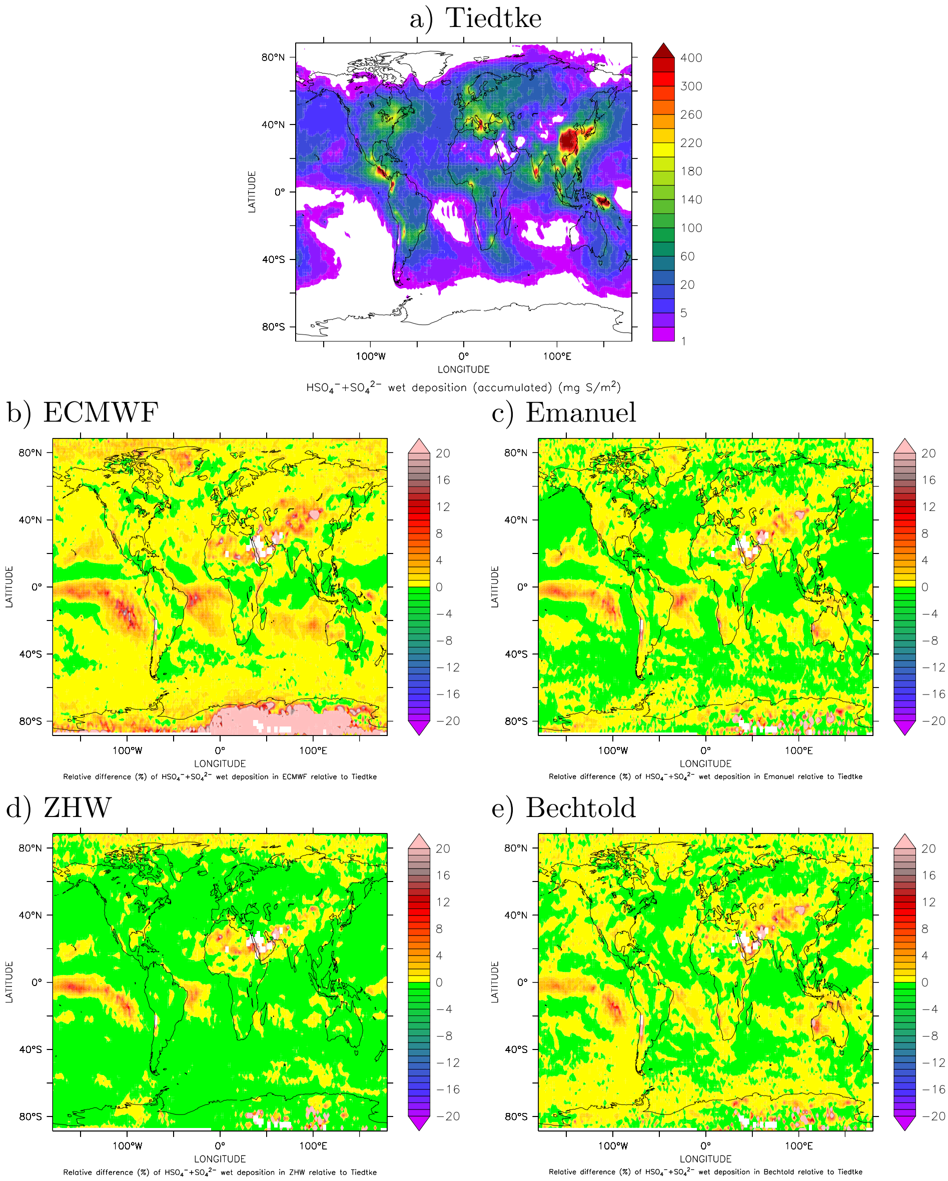

Figure 8: 4 months accumulated sulphate wet deposition flux at the surface (in mg S / m^2) for the T1 simulation (a) and relative differences (in %) of the other simulations to the T1 simulation (b) to e)).

Additionally, a table with the linear regression and correlation coefficients using the same observational data as in Tost et al. (2007) is provided for nitrate (upper) and sulphate (lower).

References

Tost, H., Jöckel, P., and Lelieveld, J.: Influence of different convection parameterisations in a GCM, Atmos. Chem. Phys., 6, 5475–5493, 2006.

Simulation	Correlation (R^2)	slope	intercept
T1	0.29	0.43	76.02
EC	0.31	0.46	93.94
Ema	0.26	0.43	93.29
ZHW	0.20	0.19	52.49
B1	0.20	0.39	98.65
Simulation	Correlation (R^2)	slope	intercept
T1	0.29	0.40	113.9
EC	0.37	0.44	119.9
Ema	0.32	0.42	136.2
ZHW	0.32	0.31	92.8
B1	0.30	0.35	129.0

Table 1: Correlation and linear regression of simulation results (scaled to annual values) for comparison with observations (annual values) for nitrate and sulphate.

Tost, H., Jöckel, P., Kerkweg, A., Pozzer, A., Sander, R., and Lelieveld, J.: Global cloud and precipitation chemistry and wet deposition: tropospheric model simulations with ECHAM5/MESSy1, Atmos. Chem. Phys., 7, 2733–2757, 2007.

v. Kuhlmann, R. and Lawrence, M. G.: The impact of ice uptake of nitric acid on atmospheric chemistry, Atmos. Chem. Phys., 6, 225–235, 2006.