Utilizing a high vertical and horizontal resolution dataset of SO_2 for modelling volcanic eruptions in WACCM

Emma Axebrink, Johan Friberg, Moa K. Sporre
Department of Physics, Lund University, Sweden
emma.axebrink@nuclear.lu.se

Summary

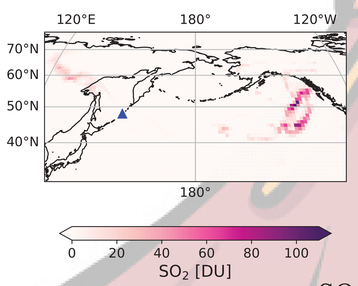
This study aims to investigate the importance of utilizing a high vertical and horizontal dataset of stratospheric volcanic SO_2 emissions in the global climate model WACCM. The aerosol lifetime is dependent on the injection height of the SO_2 cloud. So far, we have modelled climate impact for the volcanic eruption of Sarychev in June 2009. The results show that the vertical resolution and, horizontal resolution is important for the duration of the climate effect from/after a volcanic eruption.

Method

WACCM is an atmospheric community climate model with a top altitude of 150km. We ran WACCM simulations with 3 different SO_2 emissions datasets:

- M16: Default SO_2 dataset in WACCM, vertical resolution of 1 km [2]
- S21: Has high vertical (200 m) and horizontal resolution [1]
- S21-column: Same as S21, but released at volcano site (withouth horizontal resolution).

All simulations are nudged with MERRA2 data. S21 and S21-column were created with satellite data from AIRS and CALIOP [1].
Figure 3-7 show background corrected data from simulations.



SO_2 input data

Figure 1: Horizontal resolution of the SO_2 cloud in the S21 dataset. The blue triangle marks the location of the volcano Sarychev.

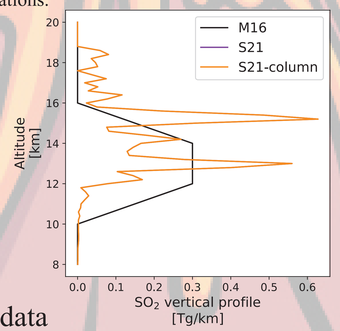


Figure 2: Vertical resolution of the SO_2 cloud for all three datasets. S21 and S21-column have the same vertical profile.

Results

Our high vertical resolution datasets have stronger and longer lasting climate impact compared to the default SO_2 dataset in WACCM. All three datasets initially have similar concentrations of SO_2, but the SO_2 in M16 is removed faster from the stratosphere compared to the other two datasets, figure 3. Stratospheric SO_4 concentration are higher for the datasets S21 and S21-column compared to M16 as seen in figure 6 and 7. This could potentailly be explained by faster transport of SO_2 and SO_4 out of the stratosphere for M16 since the SO_2 is injected at lower altitude.
The importance of utilizing a high vertical and horizontal SO_2 input dataset is clearly visible in figure 4 where S21 (S21-column) have a 50% (25%) higher SAOD than M16. This result in a stronger global clear sky volcanic forcing in S21 compared to M16 (figure 5).

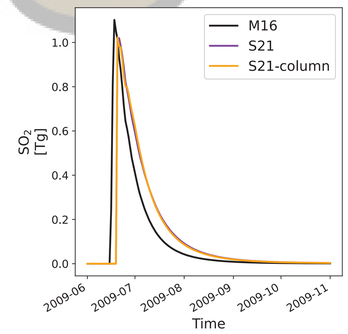


Figure 3: Time series output from WACCM of daily summed SO_2 from volcanic emission.

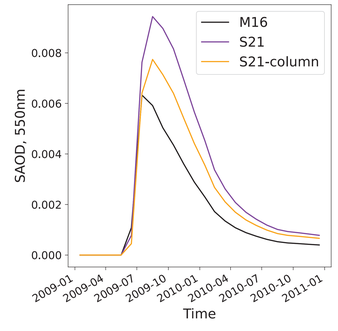


Figure 4: Time series of global monthly mean SAOD.

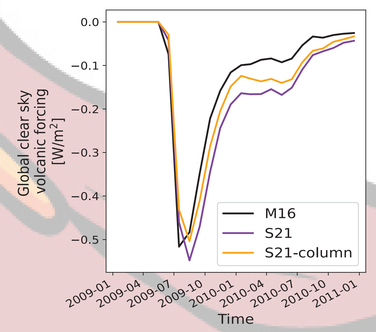


Figure 5: Time series of global monthly mean net volcanic forcing.

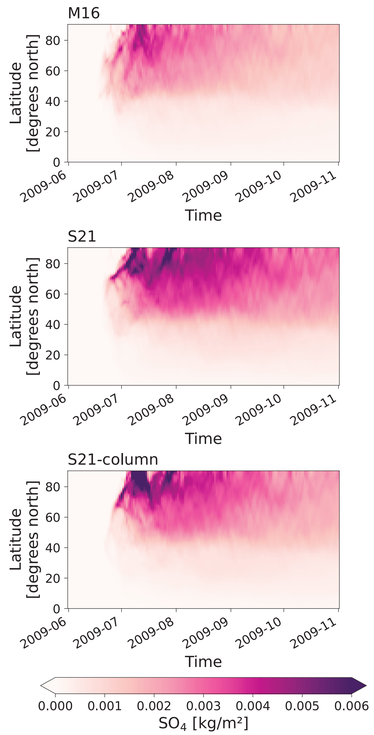


Figure 6: Time series of stratospheric SO_4 across the northern hemisphere for the three datasets.

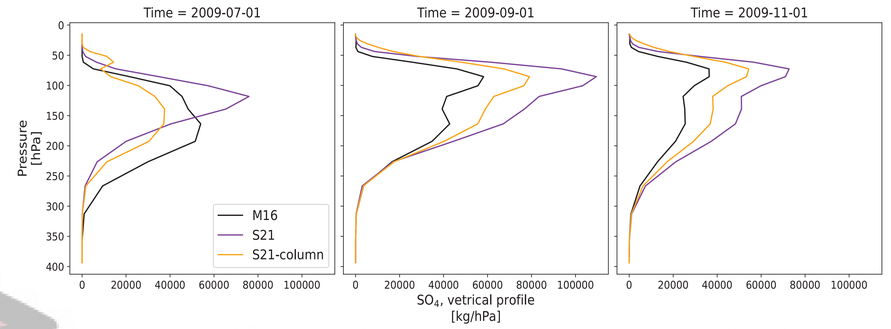


Figure 7: Stratospheric SO_4 vertical profiles at three times. Approximately two weeks, 2 months and 4 months after the eruption respectively.

References

[1] Sandvik, O. S., Friberg, J., Sporre, M. K., and Martinsson, B. G.: Methodology to obtain highly resolved SO2 vertical profiles for representation of volcanic emissions in climate models, Atmos. Meas. Tech., 14, 7153–7165, https://doi.org/10.5194/amt-14-7153-2021, 2021.
[2] Mills, M. J. et al. (2016), Global volcanic aerosol properties derived from emissions, 1990-2014, using CESM1(WACCM), J Geophys Res-Atmos, 121(5), 2332-2348, doi:10.1002/2015jd024290

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