Project: **885**

Project title: **Stratospheric Sulfur and its Role in Climate (SSiRC) data project**

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Stratospheric sulfate aerosol is an important climate driver, causing solar dimming in the years after large volcanic eruptions. Hence, a growing number of general circulation models are adapting interactive sulfur and aerosol schemes to improve the representation of relevant chemical processes and associated feedbacks. However, uncertainties of these schemes are not well constrained. calling into question the reliability of global aerosol model simulations for future scenarios (e.g. Clyne et al., 2021; Quaglia et al., 2023). The international WCRP/SPARC/SSiRC[1] activity has therefore established an international model data intercomparison project named ISA-MIP (Timmreck et al., 2018; https://isamip.eu) to better understand changes in stratospheric aerosol and its precursor gaseous sulfur species that are a direct input of major volcanic eruptions.

In this project period we have analyzed the background conditions of the sulfur cycle which have not been addressed in a global model intercomparison project before. Assessing background conditions in global models allows us to identify model discrepancies as they are masked by large perturbations such as volcanic eruptions, yet may still matter in the aftermath of such a disturbance. We analyzed the atmospheric burden, seasonal cycle, and vertical and meridional distribution of the main sulfur species among nine global atmospheric aerosol models that are widely used in the stratospheric aerosol research community (Brodowsky et al., 2023).

We find that differences in the atmospheric sulfur budget among the models arise from the representation of both chemical and dynamical processes, whose interplay complicates the bias attribution. Several problematic points identified for individual models are related to the specifics of the chemistry schemes, model resolution, and representation of cross-tropopause transport in the extratropics. The analysis on the simulated effective radius, surface area density (SAD), and extinction in the tropics and at Laramie Wyoming (41 N) in comparison to observations reveals notable differences among models (Figure 1). While the effective radius shows some agreement among models and is within the uncertainty of optical particle counter (OPC) measurements in Laramie in all models, SAD exhibits larger discrepancies, reflecting the variations in aerosol burdens. Extinction levels also vary significantly with ECHAM6-SALSA showing the highest values. Elaborating further on the reasons for the size distribution uncertainties would require a closer look at the individual microphysical processes, as was also highlighted in our Pinatubo study (Quaglia et al., 2023), but such data were unfortunately not available by most ISA-MIP models.

References

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[1] WCRP: World Climate Research Programme, SPARC: Stratosphere-troposphere Processes And their Role in Climate, SSiRC: Stratospheric Sulfur and its Role in Climate

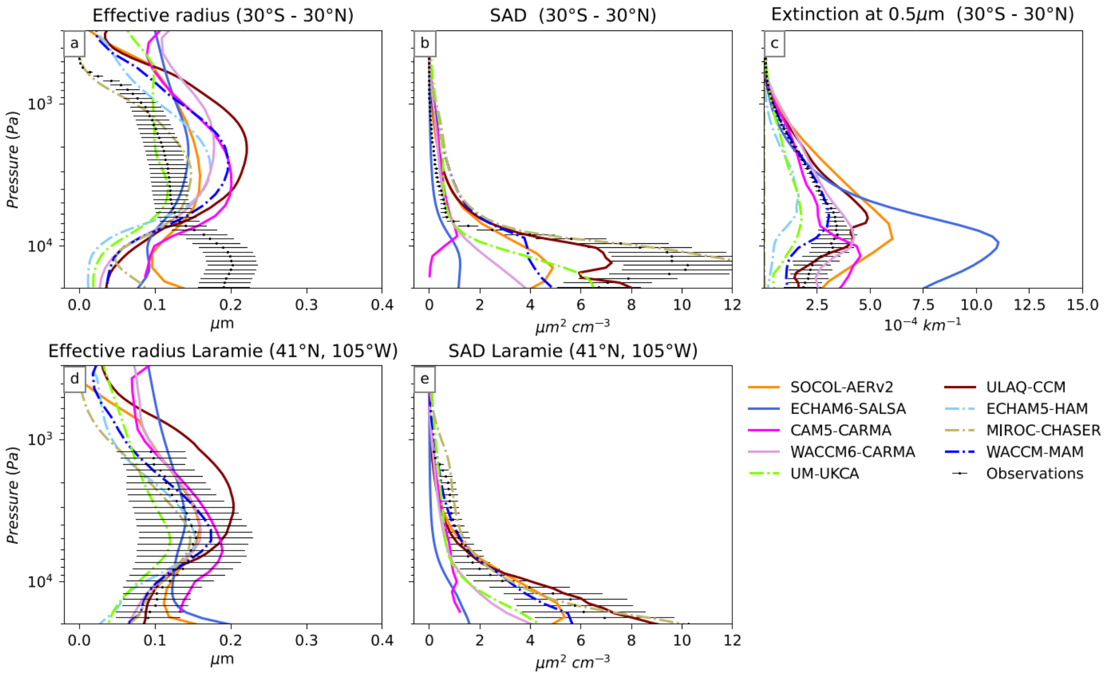

Figure 1: The effective radius, surface area density (SAD), and extinction for each model in the tropical region (30° S to 30° N) and in a single grid cell at Laramie (41° N, 105° W). Additionally, we show the effective radius and SAD for SAGE II observations (Thomason et al., 2018) in panels (a) and (b) and the extinction from GloSSACV2.2 (Kovilakam et al., 2020; NASA/LARC/SD/ASDC, 2022) in panel (c). Observations in panels (d) and (e) are derived from OPC measurements (Deshler and Kalnajs, 2022). Models with sectional aerosol schemes are shown as solid lines, while modal aerosol schemes as dash-dotted lines (Brodowsky et al, 2023).