Project: **885**

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

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Recent model inter-comparison studies highlighted large discrepancies in estimation the radiative forcing of large explosive volcanic eruptions, calling into question the reliability of global aerosol model simulations for future scenarios (e.g. Clyne et al., 2021). The international WCRP/SPARC/SSiRC [1] activity has therefore established an international model data intercomparison project named ISA-MIP [2] (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 2022, we worked on the uncertainties regarding the initial SO_2 emission following the well observed June 1991 Mt. Pinatubo eruption. Six global models with interactive aerosol microphysics took part in the ISA-MIP/HErSEA[3] Pinatubo experiment: ECHAM6-SALSA (Kokkola et al., 2018), EMAC (Brühl et al., 2018), ECHAM5-HAM (Niemeier et al., 2021), SOCOL-AERv2 (Feinberg et al., 2019), ULAQ-CCM (Visioni et al., 2018), and UM-UKCA (Dhomse et al., 2020). A series of model simulations have been performed by the different groups by varying SO_2 injection amount (ranging between 5 and 10 Tg S), and the altitude of injection (between 18–25 km) (Quaglia et al., under review ACP, 2022).

We find that the common and main weakness among all the models is that they cannot reproduce the persistence of the sulfate aerosols in the stratosphere. Most models show a stronger transport towards the extratropics in the northern hemisphere, at the expense of the observed tropical confinement (Figure 1). This indicates a much weaker subtropical barrier in all the models, that results in a shorter e-folding time compared to the observations. Moreover, the simulations in which more than 5 Tg S of SO_2 are injected show a large surface area density a few months after the eruption compared to the values measured in the tropics and the in-situ measurements over Laramie, Wyoming (41 N). This results in an overestimation of the number of particles globally during the build-up phase, and an underestimation in the southern hemisphere, which draws attention to the importance of including processes as the ash injection and the eruption of Cerro Hudson for a realistic presentation of the 2nd half of 1991.

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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

[2] ISA-MIP: Interactive Stratospheric Aerosol-Model Intercomparison Project

[3] HErSEA: Historical Eruption SO2 Emission Assessment

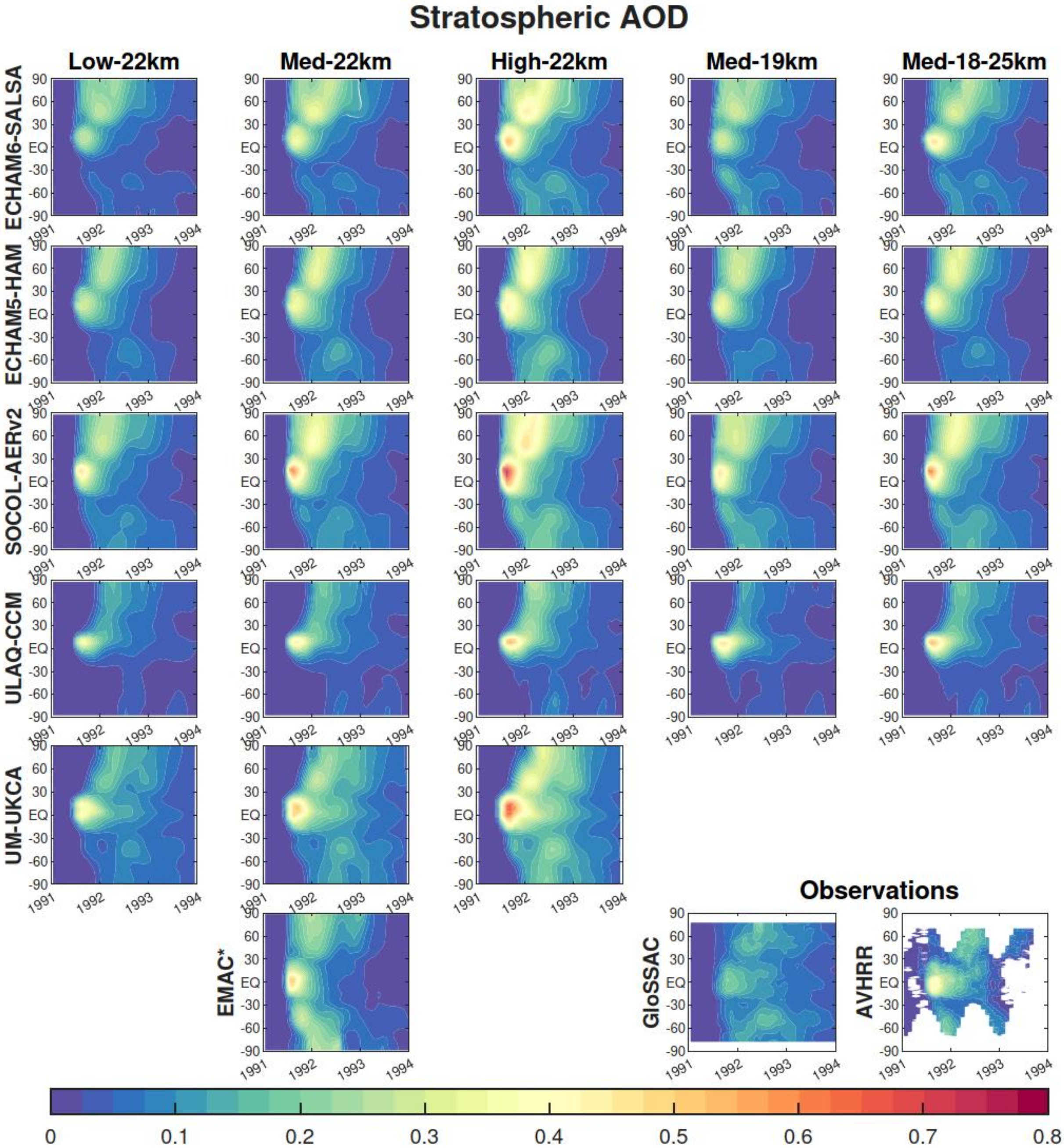

Figure 1: Time evolution of zonal stratospheric aerosol optical depth (AOD) for all models, in the Low-22km (first column), Med-22km (second column), High-22km (third column), Med-19km (fourth column), Med-18-25km (fifth column) experiments. The last row includes the different scenario simulated by EMAC and the two observations used for comparison: GloSSAC (Kovilakam et al., 20020) and AVHRR (Long and Stowe,1994). AOD is calculated at a wavelength of 550 in ECHAM5-HAM, EMAC and ULAQ-CCM, 533 nm in ECHAM6-SALSA, 525 nm in SOCOL-AERv2, 525 nm in GloSSAC, 600 nm in AVHRR. Figure from Quaglia et al., ACP in review.