Supplementary material to: Revisiting the Agung 1963 volcanic forcing — impact of one or two eruptions

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Abstract.

1 Reduced OH concentration in volcanic cloud

The simulations for this study were performed with the middle atmosphere version of the general circulation model (GCM) ECHAM5 (Giorgetta et al., 2006). The aerosol microphysical model HAM (Stier et al., 2005) is interactively coupled to the GCM. ECHAM5-HAM simulates the evolution of sulfate from the injected SO2 to sulfate aerosol and includes transport and sink processes like sedimentation and deposition (Niemeier et al., 2009).

ECHAM5-HAM does include stratospheric chemical reactions only for sulfate chemistry. NOx, ozone, OH concentrations are prescribed on a monthly mean basis. The model includes a simplified OH-limitation for super-volcano eruptions (Timmreck et al., 2010). We adapted this parameterization to sulfur loads after smaller volcanic eruptions.

We reduce the OH concentration when the SO_2 concentration is larger as the ratio $SO2 > \frac{k_2 * O3}{k_3}$ with k = reaction rates; OHc = climat. OH concentration $k_1 = k_{(HO2+OH)}, k_2 = k_{(O3+OH)}, k_2 = k_{(SO2+OH)}$ to this values:

- 10% of the monthly mean OH concentration for the first nine days after the eruption.
- 50% of the monthly mean OH concentration for day 10 to 29 after the eruption.
- 75% of the monthly mean OH concentration for day 30 to 60 after the eruption.

This limitation of the OH concentration slows the formation of sulfuric acid and sulfate. The simplification cannot reflect different sulfate concentrations and may not apply for small eruptions. Figure 1 and 2 show the AOD for a single simulation (dashed line) compared to the same simulation without OH-limitation, both with one eruption. The formation of sulfate is slower and, thus, the onset of the meridional transport is later with OH-limitation (Figure 1). The version without OH-limitation fits better to the measurements around 30 S in the early phase after the eruption. Opposite, the later arrival of the volcanic cloud at the south pole with OH-limitation represents the measurements better. Figure 2 shows too low AOD in the first month after the eruption with OH-limitation. The results of both model versions do not simulate the higher AOD values half a year after the eruption.

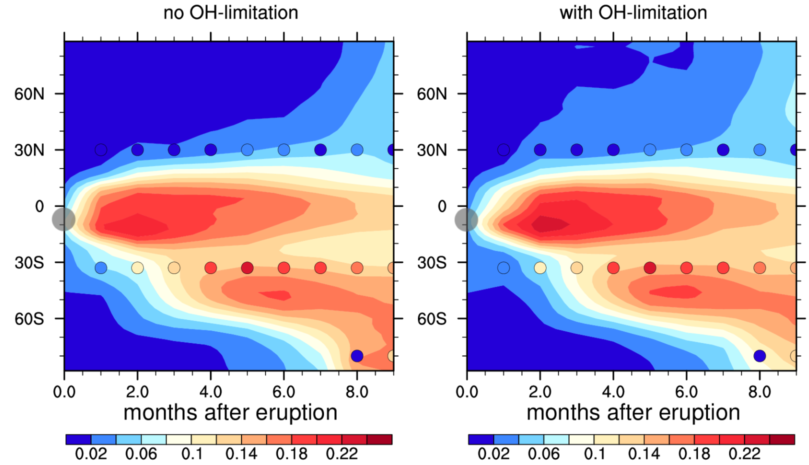

Figure 1. Zonally averaged monthly mean AOD over time for a simulation with climatological OH values (left) and a parameterized OH-limitation (right).Both simulations use one single eruption Colored circles show an average ob observation, representative for 20 S to 40 S, 20 N to 40 N, and 80 S taken from Stothers (2001).

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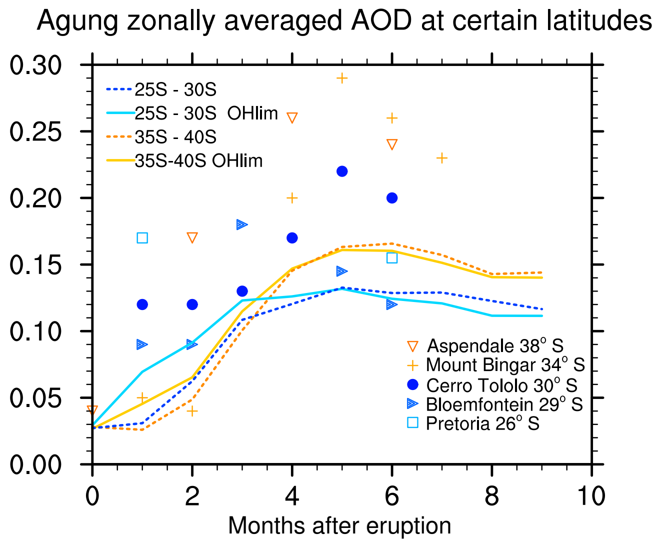

Figure 2. Monthly mean AOD over time. Colored lines show model results averaged over 25 S to 30 S and 35 S to 40 S, for one single simulation result without limited OH (solid line) and with limited OH (dashed line). Single markers show measurement data, estimated from Figure 1 in Stothers (2001).

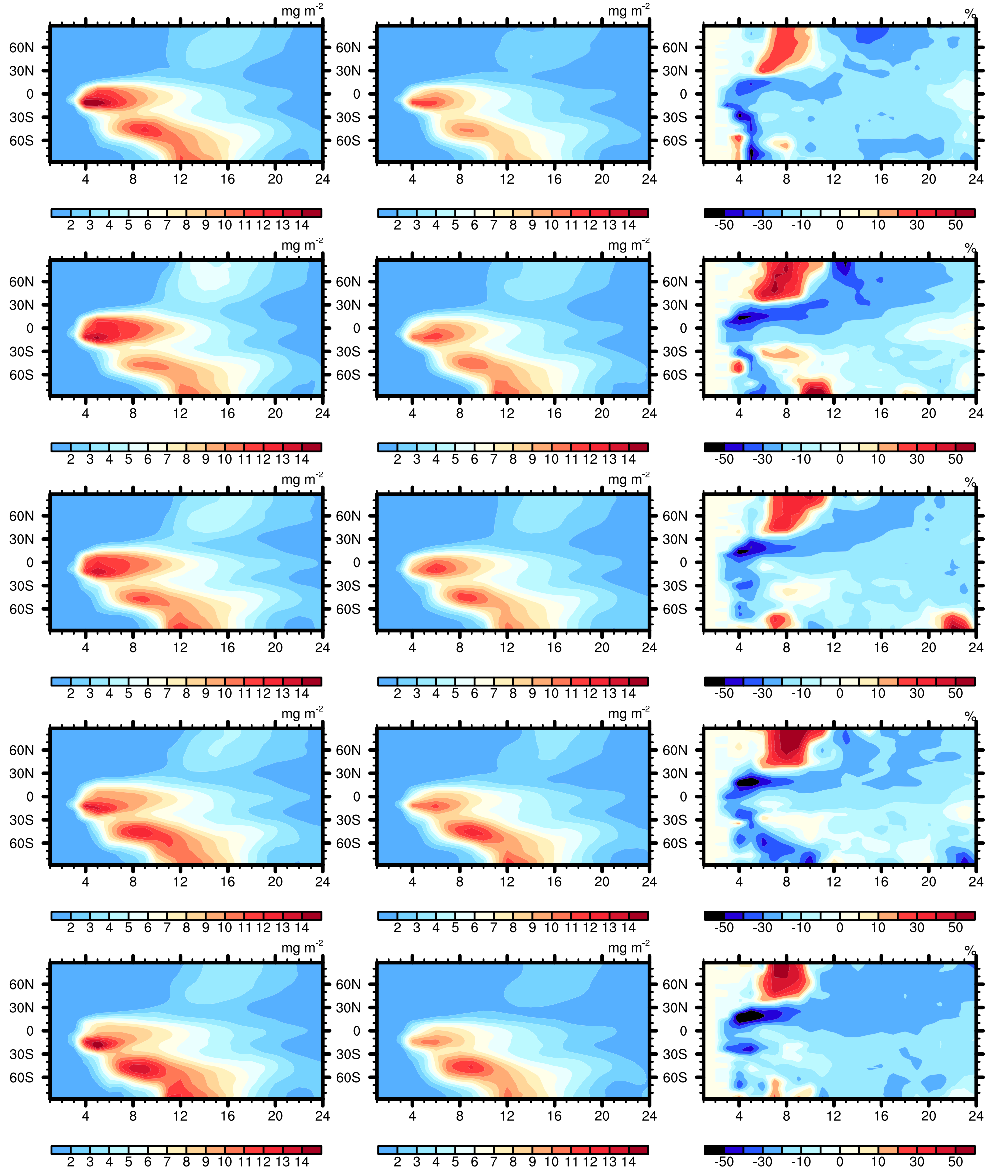

Figure 3. Sulfate burden of single simulations of AGUNG1 (left), AGUNG2 (middle) and the relative difference (right). X-axis gives the 24 month of the period 1963 to 1964.