How does the impact of tropical volcanic eruptions depend on eruption season?

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1. Introduction

Here we examine how the season of eruption affects the distribution of aerosols, and the resulting differences in surface forcing and sulphate deposition.

Volcanic eruptions were simulated with the MAECHAM5-HAM general circulation model (T42/L39) including detailed aerosol microphysics (Niemeier et al. 2009). Volcanic eruptions are simulated by injecting SO₂ into the lower stratosphere (30 hPa), with parameterized chemistry converting SO₂ to H₂SO₄ aerosols. The model is run in a free running climate mode, with modern day external forcings, including climatological SSSs.

We focus here on simulations of the eruption of Los Chocoyos (14°N, 91°W, ~84ka), the largest eruption (700 Mt SO₂) in the Central American Volcanic Arc (CAVA) timeseries of the last 200ka (Kutterolf et al. 2006). For comparison, we also simulate a Pinatubo strength (17 Mt SO₂) eruption at the Los Chocoyos location.

3. Sulphate Burden

Total atmospheric sulphate (SO₂) aerosol burden, as a function of latitude and month after eruption, is shown below (Fig. 3) for the four simulations (see Table 1).

- The morphology of the sulphate burden distribution is quite different for the simulations of different magnitudes. In comparison to the LP simulations, in the LC simulations we see that: 1. Sulphate is relatively restricted from the polar latitudes, most likely due to the enhanced zonal winds (see Box 2) acting as mixing barriers. 2. There is a much stronger and faster initial movement of sulphate from the tropics to the extratropics, likely a byproduct of the strong tropical heating (see Box 2). 3. Together, these two factors lead to high sulphate burdens in the midlatitudes of each hemisphere.

- There is a high degree of hemispheric asymmetry in the LC simulations compared to the LP simulations. While the LC1 simulation shows a NH-SH burden asymmetry comparable to that of both LP simulations (with most sulphate in the NH), the LC7 simulation shows more sulphate in the SH.

4. Radiative Forcing

In addition to the LC1 and LC7 simulations, we have also performed simulations of eruptions in April and October. Figure 4 shows the aerosol optical depth (AOD) distributions resulting from LC strength eruptions in four different seasons.

- The Apr. and Oct. eruption AOD distributions are comparable to the Jul. and Jan. distributions, respectively.

5. Sulphate Deposition

The deposition of sulphate to the surface is shown in Fig. 6 as a function of latitude and month after eruption for the LC1 and LC7 simulations.

- Most sulphate is deposited to the surface between 3 and 12 months after the eruption.

- The strong zonal winds at ~60° latitude in winter impede the transport of sulphate to the high latitudes.

- As a result, there is a sizeable difference between sulphate deposited to the Antarctic and Greenland land masses as function of eruption month (Fig. 7).

6. Conclusions

For eruptions of LC magnitude, the season of eruption has significant effect on hemispheric asymmetry of SO₂ loading, AOD, surface radiation, and SO₂ deposition.

- All are related to anomalous dynamics: zonal winds and probably Brewer-Dobson circulation changes.

Ongoing work is focusing on:

- Better understanding of the direct effect of LC strength eruptions on atmospheric dynamics.

- The influence of the dynamically induced AOD hemispheric asymmetry on surface climate effects.