Motivation

Major volcanic eruptions have a significant impact on stratospheric and tropospheric climate, chemical composition and the atmospheric circulation. The climate effects are global if the volcanoes are located in the tropics and subtropics. As the last three major volcanic eruptions (1963 M. Agung, 1982 El Chichon and 1991 Mt. Pinatubo) occurred during El Niño events and at different Quasi-Biennial Oscillation (QBO) phases, it is difficult to understand from these three cases alone, what part of the climate anomalies following the eruptions results from the volcanic radiative forcing and what part has to be explained by internal modes of variability of the climate system, including ENSO-Southern Oscillation, the QBO or extratropical wave-mean flow interaction. Therefore this study is concentrating on model results only.

Part I: Based on the coupled chemistry climate model (CCM) MAECHAM4CHEM we investigate the changes of the Brewer Dobson Circulation (BDC) following major volcanic eruptions. The CCM is coupled to an interactive stratospheric chemistry module taking the chemical feedbacks of volcanic aerosols into account. Two transient experiments were run one from 1960 to 1999 and one from 1980 to 1999 forced by prescribed observed sea surface temperatures, QBO phases, solar cycle, volcanic eruptions and the Pinatubo eruption. The model results are based on 3 volcanic eruptions (n=5): two eruptions of Agung (A) March 1963, El Chichon (E) April 1982 and Pinatubo (P) in June 1991.

Changes of the BDC after the Pinatubo eruption

The composite anomalies are calculated for three volcanic eruptions: (A) 1963 Mt. Agung, (E) 1982 El Chichon and (P) 1991 Mt. Pinatubo, which is accompanied by enhanced/weakened wave propagation into the stratosphere (not shown).

Changes of the BDC after major volcanic eruptions

The CCM results are based on 3 volcanic eruptions (n=5): two eruptions of Agung (A) March 1963, El Chichon (E) April 1982 and Pinatubo (P) in June 1991.

How is the BDC changing?

Conclusion I

• The model simulates a strengthened mass stream function in the tropics and extratropics (Hadley cell). The mass stream function: positive/negative anomalies indicate an enhanced/weakened mass stream function (Fig. 5).

Ozone anomaly in the tropics

The observed total ozone changes are visible in the stream function (not shown).

Net cooling due to direct aerosol effects, with a change in the vertical in O-QBO. The anomalous ozone values) in the tropics due to direct sulphate aerosol heating and in situ chemical ozone loss (e.g. Robock, 2000).

Changes of the Brewer Dobson Circulation due to major volcanic eruptions in different ECHAM simulations

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