

Influence of Explosive Volcanism on the Strength and Variability of the Hadley Circulation

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Radiative perturbations to the tropical energy balance resulting from volcanic aerosol injections into the lower stratosphere can be significant. Although the forcing is generally short lived (of the order of one to two years), lag in recovery from very large eruptions can contribute to the decadal scale climate variability. Explosive volcanism is thus an important component influencing natural climate variability in the tropics. Unfortunately, high-resolution records of volcanic climate effects in the tropics are rare and the separation from other variability is particularly difficult.

The use of coupled ocean-atmosphere climate system models allows an investigation into individual cases to identify the response of the climate to such strong perturbation. The full, three-dimensional information from the model offers insight into the spatial expression of the response and can help connect the proxy datasets. In particular, important aspects of the hydrologic cycle that don't leave any appreciable record, such as the transient cloud cover, precipitation over the oceans, etc, can be studied.

Here, simulations with two fully coupled NCAR climate models, the Climate System Model (CSM, Paleo version 1.4) and the Parallel Climate Model (PCM), which include volcanic aerosol treatment, are presented. First, using Pinatubo experiments as a reference, the impact of the stratospheric aerosol perturbation on the tropical circulation is evaluated. A strong impact of aerosol perturbations is found on the convective activity, release of latent heat and subsequently the meridional energy exchange through the Hadley Circulation. The contribution from the surface cooling to the circulation response is compared to the impact of strong warming in the lower stratosphere. Finally, a description of volcanic perturbations during the last Millennium is used to describe the temporal evolution of volcanic perturbations in the tropics.