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Uncertainties in the Volcanic Aerosol Data Sets and Radiative Forcing

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Volcanic activity is an important natural cause of climate variations because tracer constituents of volcanic origin impact the atmospheric chemical composition and optical properties. Chemical transformations and gas-to-particle conversion of volcanic tracers form a volcanic aerosol layer that remains in the stratosphere for 2–3 years after an eruption, thereby impacting the Earth's climate because volcanic aerosols cool the surface and the troposphere by reflecting solar radiation, and warm the lower stratosphere, absorbing thermal IR and solar near-IR radiation. The perturbations of the Earth's radiative balance caused by strong volcanic eruptions dominate other forcings for 2–3 years. Their effect is seen in the atmosphere for about 5–7 years, and for much longer in oceans. Data sets of volcanic aerosol optical depth provide a key input into the climate models for calculating volcanic impact on climate.

Sulfate volcanic aerosols are transported globally by the Brewer–Dobson stratospheric circulation and eventually fall out in 2–3 years. A significant amount of volcanic aerosols that penetrate to the troposphere through the tropopause folds is washed out in storm tracks. Aerosols deposited in downward branches of the Brewer–Dobson circulation in the Polar Regions are preserved in the polar ice sheets, recording the history of the Earth's explosive volcanism for thousands of years. However, the atmospheric loadings calculated using volcanic time series from high-latitude ice records, suffer from uncertainties in observation data and poor understanding of atmospheric transport and deposition processes. The global instrumental observations of volcanic aerosols have been conducted during the last 25 years by a number of remote sensing platforms.

At present, there are several volcanic aerosol data sets used in climate simulations. The data sets are constructed either using direct optical depth observations or by calculating aerosol distribution using aerosol loadings based on ice core data. The aerosol optical depth in various data sets differs by 20-30%. Another source of uncertainty is caused by a poor knowledge of aerosol chemical composition and size distribution characterized by the aerosol effective radius. The sensitivity calculations with different effective radii show that total optical depth vary as much as 20% when effective radius changes are in the reasonable range.

In this paper we discuss different aerosol data sets, associated uncertainties, and how they translate in the uncertainties in radiative forcing and climate response.