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Global dispersion and microphysical variation of the 1991 Mount Pinatubo cloud: A ground-based lidar and interactive modelling analysis.

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Major volcanic eruptions inject huge quantities of sulphur dioxide (SO_2) and ash into the upper atmosphere. Sulphuric acid aerosols, converted from emitted SO_2, significantly enhance the stratospheric aerosol layer and have complex effects on the Earth's climate.

The June 1991 eruption of Mount Pinatubo (15°N) created a volcanic aerosol cloud that dispersed westward with the prevailing zonal flow. A tropical reservoir of volcanic aerosol formed within two months after transport southward towards the equator. The global dispersion of the cloud was strongly influenced by the prevailing easterly phase of the quasi-biennial oscillation, which aided in confining the volcanic aerosol plume to the tropics. The vast majority of transport to the Northern hemisphere mid-latitudes did not occur until 3 months after the eruption, in accordance with the seasonal cycle of the prevailing stratospheric circulation.

In this analysis, we examine how the vertical distribution of the Mount Pinatubo cloud evolved over the first post-eruption year as observed by ground based lidar measurements at tropical (Mauna Loa, MLO) and Northern hemisphere mid-latitude (Table Mountain, TBM and Toronto, TOR) observatories. The climate response of this eruption is linked to hemispheric dispersion, therefore, increasing our understanding of the cloud distribution will aid in constraining post-eruption global radiative effects.

At MLO clearly descending strands of the plume are detected in the early phases after the eruption, the lidar signal then becoming more homogeneous as a tropical reservoir of enhanced aerosol forms. With the progression towards winter, the seasonal cycle of the Brewer Dobson circulation transports air masses into northern hemisphere mid-latitudes and only then do the TBM and TOR sites detect the main part of the plume. We identify similar structures within the vertical profile of the MLO lidar signal and Northern hemisphere mid-latitude sites, underlining the donor-receptor relationship between the two latitude regimes.

By comparing to daily-mean profiles from interactive simulations with a global stratospheric aerosol microphysics model, we then explore what drives the variability in the observations. In particular, we consider how particle distribution evolves through the different phases in the global dispersion, considering the effects from new particle formation and growth in the cloud.