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Simulation of the initial stage of the Mt. Pinatubo eruption using the coupled meteorology-chemistry WRF-Chem model

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Big explosive volcanic eruptions emit in the atmosphere, among other species, millions of tons of SO_2, water vapor, and solid particles, volcanic ash. SO_2 is oxidized to produce sulfate aerosols that are transported globally and cause widespread long-term climate effects. Ash particles deposit within a few months, as they are relatively large, and, it is believed, do not produce long-term climate effects. However, at the initial stage of the evolution of a volcanic cloud SO_2, volcanic water, sulfate, and ash coexist and their chemical, microphysical, and radiation interaction might be important to precondition the long-term formation and transport of a volcanic aerosol cloud.

To better understand this initial stage of a volcanic impact we simulate the aerosol plume from the largest 20th-century eruption of Mt. Pinatubo in the Philippines in June 1991 using the specifically modified Weather Research and Forecasting model coupled with chemistry (WRF-Chem). Ash, SO_2, and sulfate emission, transport, dispersion, chemical transformation and deposition are calculated using the GOCART aerosol and chemistry scheme. Effect of volcanic aerosol interaction with radiation (short and long wave) is assessed using RRTMG radiative transfer model. The simulations are conducted for two months in the equatorial belt (45S, 45N) with the periodic boundary conditions in longitude and imposing aerosols and chemicals from the MERRA2, and meteorology from the ERA-Interim along the belt's borders in latitude.

The simulations reveal the vertical separation of the aerosol plume due to aerosol (both ash and sulfate) gravitational settling and a complex dynamic evolution of the multi-layer cloud with sharp gradients of radiative heating within the plume that affects the cloud dispersion and the equilibrium altitude that are crucially important for the further large-scale plume evolution.