

ACOM Seminar

The Impact of Volcanic Eruptions on Stratospheric Chemistry and Aerosols

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Location: FL2-1022 and <https://operations.ucar.edu/live-acom>

ABSTRACT

Volcanic eruptions release gases (e.g., H₂O, CO₂, SO₂, H₂S, HCl) and solid matter into the atmosphere. Volcanic particles can affect the climate by scattering solar radiation. In addition, stratospheric chemistry can change because of heterogeneous reactions on volcanic particles. Increased stratospheric aerosols due to numerous small eruptions since 2002 have been observed by various in-situ and remote platforms.

Here, we present two studies of the impact of small eruptions on stratospheric sulfur chemistry and optical properties. Volcanic ash is often neglected in climate simulations because ash particles are assumed to have a short atmospheric lifetime, and to not participate in sulfur chemistry. After the Mt. Kelut eruption in 2014, stratospheric ash-rich aerosols were observed for months. Here we show that the persistence of super-micron ash is consistent with a density near 0.5 g cm⁻³, close to pumice. Ash-rich particles dominate the volcanic cloud optical properties for the first 60 days. We also find that the initial SO₂ lifetime is determined by SO₂ uptake on ash, rather than by reaction with OH as commonly assumed. About 43% more volcanic sulfur is removed from the stratosphere in two months with the SO₂ heterogeneous chemistry on ash particles than without. This research suggests the need for re-evaluation of factors controlling SO₂ lifetime in climate model simulations, and of the impact of volcanic ash on stratospheric chemistry and radiation.

The January 2022 Hunga Tonga-Hunga Ha'apai volcanic eruption injected a relatively small amount of sulfur dioxide, but significantly more water into the stratosphere than previously seen in the modern satellite record. Here we show that the large amount of water resulted in large perturbations to stratospheric aerosol evolution. Our climate model simulation reproduces the observed enhanced water vapor at pressure levels ~30 hPa for three months. Compared with a simulation without a water injection, this additional source of water vapor increases hydroxide, which halves the sulfur dioxide lifetime. Subsequent coagulation creates larger sulfate particles that double the stratospheric aerosol optical depth. A seasonal forecast of volcanic plume transport in the southern hemisphere indicates this eruption will greatly enhance the aerosol surface area and water vapor near the polar vortex until at least October 2022, suggesting that there will continue to be an impact of this eruption on the climate system.

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