## **RAL SEMINAR SERIES**

## Impact of Stratospheric Injections From Volcanoes & Geoengineering: Pinatubo vs Hunga Eruption

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Explosive volcanic eruptions offer crucial empirical insights into the effects of natural and anthropogenic stratospheric injections on Earth's climate. The composition and early dispersion of injected materials, whether volcanic or man-made, play a key role in determining the long-term evolution of aerosol and gaseous plumes in the stratosphere.

Modern climate models have made significant strides in realistically simulating the behavior of volcanic clouds. This study used the WRF-Chem regional meteorology–chemistry model to analyze the plume evolution of the Pinatubo (1991) and Hunga (2022) eruptions. Our goal was to assess the sensitivity of plume dynamics to factors such as injection height, ash presence, initial volcanic material concentrations, and water vapor (WV) injections.

The 1991 Pinatubo eruption, the largest explosive event of the 20th century, injected an estimated 17 Mt of SO<sub>2</sub> and approximately 100 Mt of WV into the lower stratosphere. Despite this, uncertainties persist regarding the exact SO<sub>2</sub> mass and the altitude at which volcanic debris was released. Comparatively, the shallow-underwater Hunga eruption on January 15, 2022, emitted only 0.5 Mt of SO<sub>2</sub> but released 150 Mt of WV into the upper stratosphere. The resulting WV injection was largely retained in the stratosphere, increasing its water vapor content by 10%. While Hunga's SO<sub>2</sub> injection was relatively minor compared to climate-altering events like Pinatubo, its substantial WV release raised concerns about possible shifts in stratospheric chemistry and dynamics, including potential near-surface warming.

Our findings underscore the pivotal role of the early evolution of volcanic clouds in shaping the climate impacts of eruptions. They highlight the necessity of accurately simulating or prescribing these processes within climate models. By comparing Pinatubo and Hunga, we identified new mechanisms and critical uncertainties that must be accounted for when optimizing strategies such as solar radiation management. Event website.