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Using HYSPLIT with SAGE III/ISS Aerosol Observations to Model the Hunga Tonga-Hunga Ha’apai Plume

The January 2022 eruption of the Hunga Tonga-Hunga Ha‘apai (HTHH) volcano injected unprecedented volumes of aerosols and water vapor into the stratosphere. The evolution of the plume dynamics and chemical processing of the injected constituents is a unique event and opportunity of which even with global monitoring instruments instantaneous observations of that evolution are still sparse. One such instrument, the Stratospheric Aerosol and Gas Experiment III (SAGE III) onboard the International Space Station (SAGE III/ISS), saw changes to the stratosphere caused by the eruption in the days following. SAGE III/ISS retrieves vertically resolved profiles of ozone, aerosol, water vapor, and nitrogen dioxide and observed distinct and highly enhanced aerosol layers relative to the preceding background conditions in the short window following the eruption. SAGE III/ISS offers 0.5 km vertically resolved profiles of aerosol extinction coefficient derived from direct measurement of atmospheric transmission with inherently high accuracy and precision from the high signal to noise ratio afforded by the solar occultation technique at the cost of spatial and temporal sampling. Repeat observations offer point samples of evolution that are temporally and spatially conjoined, but the highly valuable information contained therein can be joined with dynamic modeling and trajectory analysis offered by a tool such as The NOAA Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model to produce more dense instantaneous analyses of plume composition. The presented research effort employs HYSPLIT to map a series of SAGE aerosol observations backwards in time to both produce a proxy for a simultaneously sampled point cloud of the injected aerosol’s quantities and the following evolution of those points in time and space. The resulting analysis is an effective volumetric representation of the injected aerosol at arbitrary time intervals. The fusion of empirical observations and dispersion modelling such as with HYSPLIT can improve dynamic model accuracy and increase the utility of point measurements. Ultimately this improves our understanding of plume properties, behavior, and impacts on atmospheric composition and dynamics within sudden highly localized events. Plans to integrate data from additional satellite and in-situ instruments may further strengthen this approach.

Topic

Atmospheric composition (Earth and planets), chemistry and transport

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