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Columnar optical, microphysical and radiative properties of the 2022 Hunga Tonga volcanic ash plumes

Huizheng Che[a], Ke Gui[a]

[a] *Chinese Academy of Meteorological Sciences, Beijing, China*

***Corresponding author e-mail**: chehz@cma.gov.cn

The Hunga Tonga-Hunga Ha'apai eruption on January 15, 2022 was one of the most explosive volcanic eruptions of the 21st century and has attracted global attention. Here we show that large amounts of the volcanic aerosols from the eruption broke through the tropopause into the lower stratosphere, forming an ash plume with an overshooting top at 25–30 km altitude. In the four days following the eruption, the ash plume moved rapidly westward for nearly 10,000 km under stable stratospheric conditions characterized by strong tropical easterlies, weak meridional winds and weak vertical motion. The intrusion of the ash plume into the stratosphere resulted in a marked increase in atmospheric aerosol loading across northern Australia, with the aerosol optical depth (AOD) observed by satellites and sun-photometers peaking at 1.5 off the coast of northeastern Australia; these effects lasted for nearly three days. The ash plume was characterized by fine-mode particles clustered at a radius of about 0.26 μm, with an observed peak volume of 0.25 $\mu m^3\ \mu m^{-2}$. The impact of the ash plume associated with the Hunga Tonga eruption on the stratospheric AOD and radiative balance in the tropical southern hemisphere is remarkable, with an observed volcanic-induced perturbation of the regional stratospheric AOD of up to 0.6. This perturbation largely explains an instantaneous bottom (top) of the atmosphere radiative forcing of −105.0 (−65.0) W m^{-2} on a regional scale.

Keywords: Hunga Tonga-Hunga Ha'apai eruption, Volcanic aerosols, Multi-satellite and ground-based observations, Aerosol optical–microphysical properties, Radiative forcing