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Growth and global persistence of stratospheric sulfate aerosols from the 2022 Hunga Tonga-Hunga Ha´apai volcanic eruption

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Stratospheric sulfate aerosols play a key role on atmospheric chemistry and Earth's radiation budget, but their size distribution, a critical parameter in climate models, is generally poorly-known. We address such gap for the 2022 Hunga Tonga-Hunga Ha\'apai (HT-HH) volcanic eruption by exhaustively analyzing photometric observations from the worldwide open-access AERONET network.

A trimodal size distribution of aerosols, uncommon in the AERONET database [1], is detected at a worldwide scale with a middle mode in the fine range associated to HT-HH aerosols, shown to be poorly-absorbing. This volcanic mode is used as a marker of the lifetime and size evolution of volcanic aerosols.

We highlight a rapid growth of volcanic aerosols, as they traveled westward in the stratosphere in the days following eruption. Their effective radius increases from 0.22-0.23 µm above the closest to source AERONET site in Australia (4000 km from the eruption site, 1.5 days after eruption) up to 0.39 µm m above La Réunion island (13000 km, 7 days after eruption). Such early aerosol growth rate, faster than observed for other stratospheric eruptions, is likely due to the exceptional hydration of the stratosphere by this phreatomagmatic eruption, accelerating the oxidation of SO_2 and the aerosol growth rate by coagulation and condensation processes.

Despite a short-lived perturbation of the optical depth of the total atmospheric column, the analysis of VSD from >20 stations in various regions and atmospheric environments of the southern hemisphere (Australia, Africa, South America, Western Pacific region) shows a month-long persistence of HT-HH sulfate aerosols, with a peak radius in 0.3-0.5 µm, until December 2022 (time of writing). Volcanic aerosols are found to disperse progressively to higher latitudes in the southern hemisphere, taking about 3 and 4 months to reach 34°S and 43°S respectively. After a period of variability in aerosol size, we observe a slow aerosol growth rate in the months leading up to December 2022. Nevertheless, one year after eruption, HT-HH sulfate aerosols remain smaller than 1991 Pinatubo particles. Smaller aerosols backscatter more efficiently visible light and sediment more slowly than larger particles, implying stronger and longer-lasting negative radiative forcing.

Keywords: Hunga Tonga-Hunga Haápai stratospheric volcanic eruption, sulfate aerosols, aerosol size, photometry, climate

References

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