UNIVERSITY OF OXFORD

Sulfate aerosols formed **rapidly** after the **Hunga Tonga-Hunga Ha'apai** eruption.

Background

Hunga Tonga-Hunga Ha'apai (HTHH) is a remote, undersea volcano, located ~70 km NNW from the main island of Tongatapu (Tonga) in the South Pacific. On 15 January 2022, HTHH produced the largest explosive volcanic eruption since Pinatubo (Philippines) in 1991. Here we quantify the sulfate aerosols produced by the eruption using Advanced Himawari Imager (AHI) measurements.

Results

- First signs of sulfate appear ~17.5 hours following the eruption (Fig. 1)
- We observe a maximum total mass of sulfate of ~0.7 x 10^9 kg
- Effective radii and optical depths were typically ~1.8 μm and ~0.25 (at 8.6 μm), respectively.
- Rapid formation of sulfate may partly explain low SO_2 amount (~0.3-0.4 Tg) detected by TROPOMI and IASI

Method

Detection

To objectively identify potential sulfate layers seen in true colour imagery (Fig. 2), we take a brightness temperature difference (BTD) between the 8.6 and 10.4 μm channels, correct the BTD for water vapour, and then label pixels as sulfate if the water vapour-corrected BTD is less than -1.5 K (Fig. 3).

Retrieval

We ran 1D radiative transfer simulations (discrete ordinates method) for a single sulfate layer at ~28 km (asl) with a cloud-top temperature of 219 K (Fig. 5). Surface temperatures were based on the maximum 10.4 μm brightness temperature in a given scene. Refractive index data assume a 70.2 wt% H_2SO_4 (29.8 wt% H_2O) solution at 211-218 K (Tisdale et al., 1998). Sulfate aerosols are assumed spherical, conform to a lognormal distribution (spread of 1.65 μm) and have a density of 1830 kg m^{-3} (Haynes, 2014). Simulations were performed for a set of optical depths (0-9.9 in steps of 0.1) and effective radii (0.1-15 μm in steps of 0.1 μm) to produce look-up tables (LUTs). The LUTs were interpolated to retrieve the optical depth and effective radius (Fig. 4) on a per-pixel basis.

Fig. 1

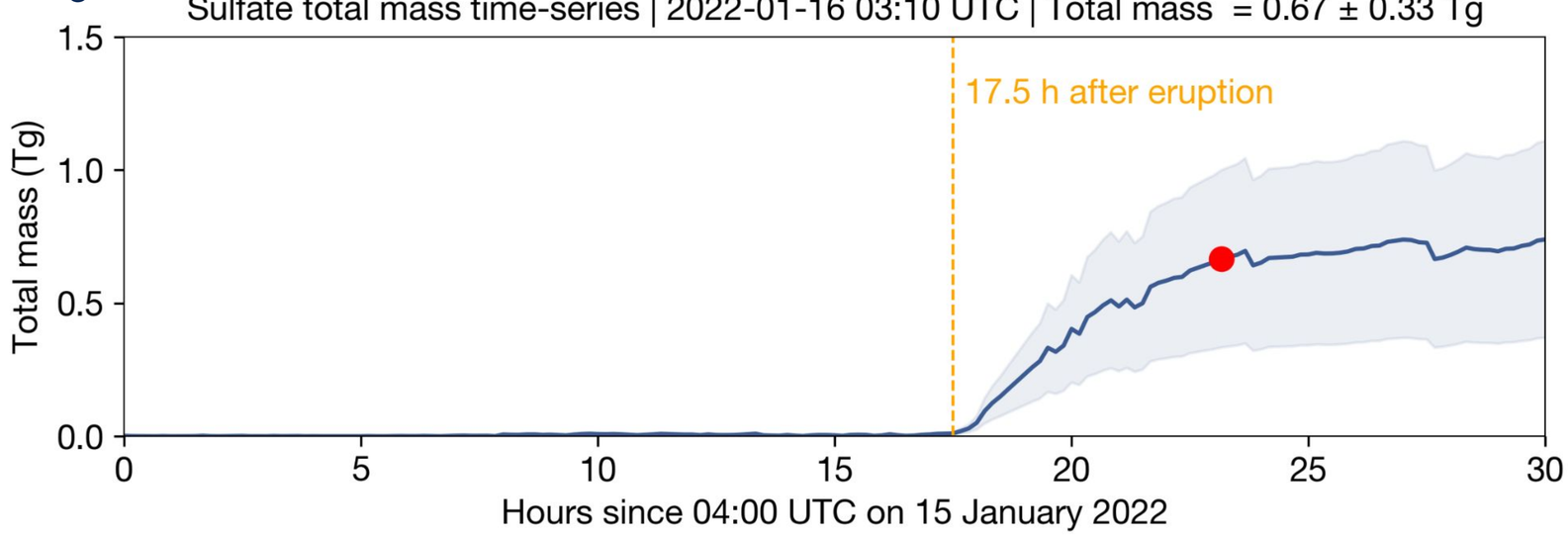
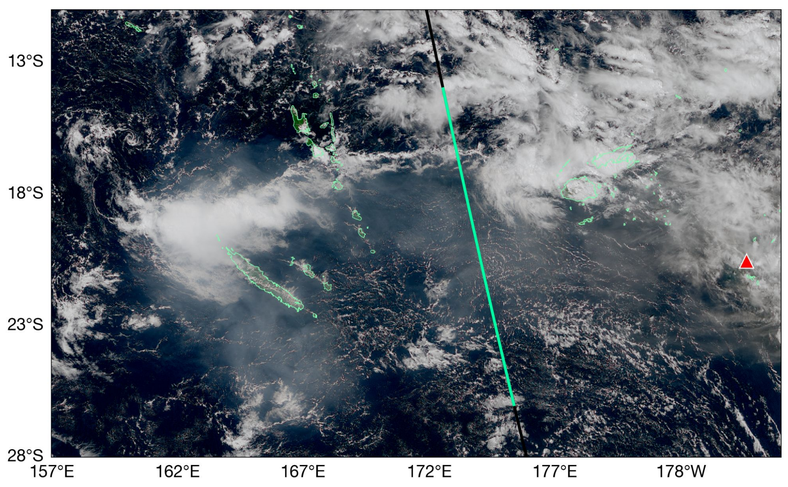
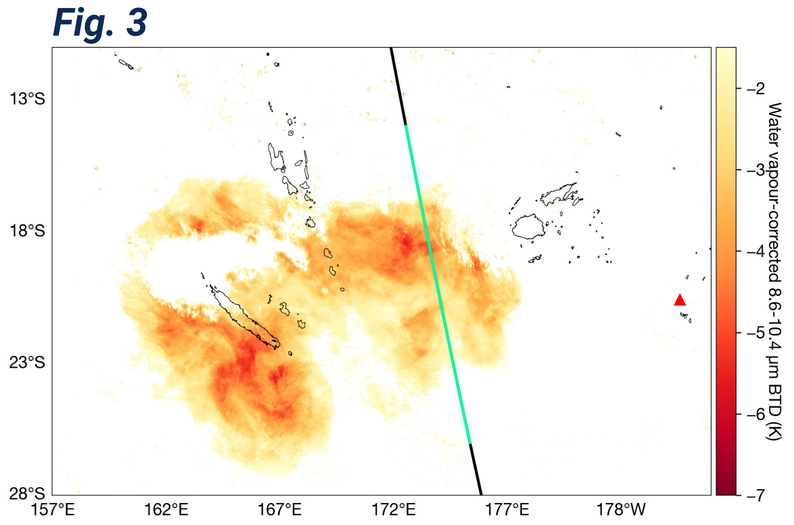


Fig. 2



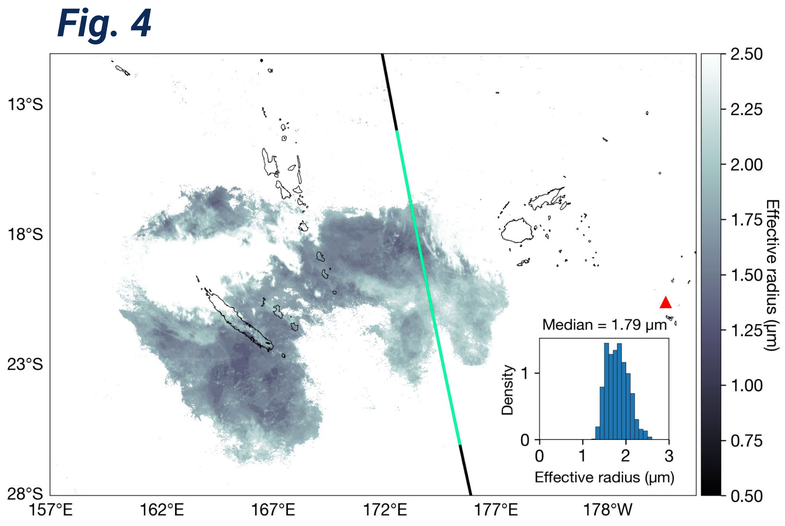
AHI true colour image reveals the formation of 'milky' coloured volcanic cloud.

Fig. 3



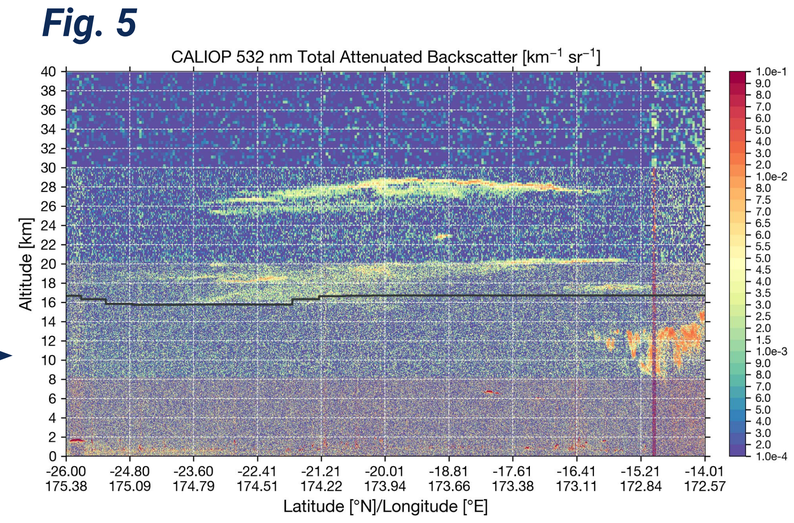
BTD analysis suggests the volcanic cloud is largely composed of sulfate aerosols.

Fig. 4



Retrievals indicate effective radii sizes of ~1.8 μm (median).

Fig. 5



CALIPSO intersection reveals two layers at ~30 and ~20 km largely composed of spherical and non-spherical particles, respectively.

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