

**Stereo Plume Height and Motion Retrievals for the Record-Setting Hunga Tonga-Hunga Hai'apai Eruption of 15 January 2022**

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**Additional Supporting Information (Files uploaded separately)**

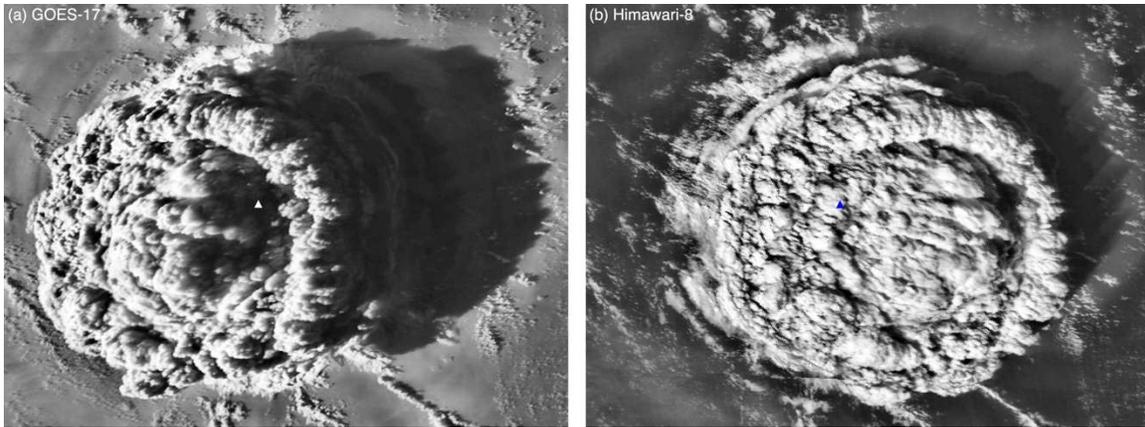
Captions for Movies S4 to S6 corresponding to files ms01, ms02, and ms03.

**Introduction**

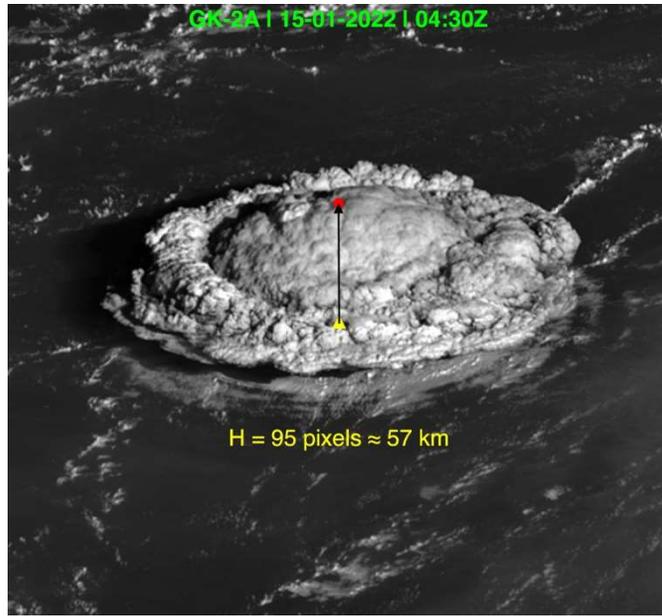
This supporting information (SI) provides contrast-enhanced versions of the GOES-17 and Himawari-8 visible images in Figure 1 of the article (S1), an independent geometric estimate of the maximum plume height at 04:30Z obtained by applying the side view method to the corresponding GEO-KOMPSAT-2A image (S2), and additional shadow-based height estimates for the 04:50–05:00Z time slots (S3). The SI also provides the following animations on 15 January 2022 of 20-hour GOES-17 Full Disk infrared contrast-enhanced brightness temperature (ms01), 7-hours of jointly retrieved GOES-17 MESO and Himawari-8 heights, horizontal advection vectors (ms02), and assigned temperatures (ms03).

The GEO-KOMPSAT-2A geostationary satellite, stationed at 128.2°E, Advanced Meteorological Imager (AMI), virtually identical to ABI and AHI, observed the plume at a ~67° view zenith angle. Although not ideal, the side view allows a rough estimate of peak height using the method described in Horváth et al., 2021a. In the highest-resolution red band, the vertically projected instantaneous field of view (VIFOV) is ~550 m. The foreshortening due to the deviation from the perfect 90° side view is  $\text{COS}(23^\circ)$  or ~8%.

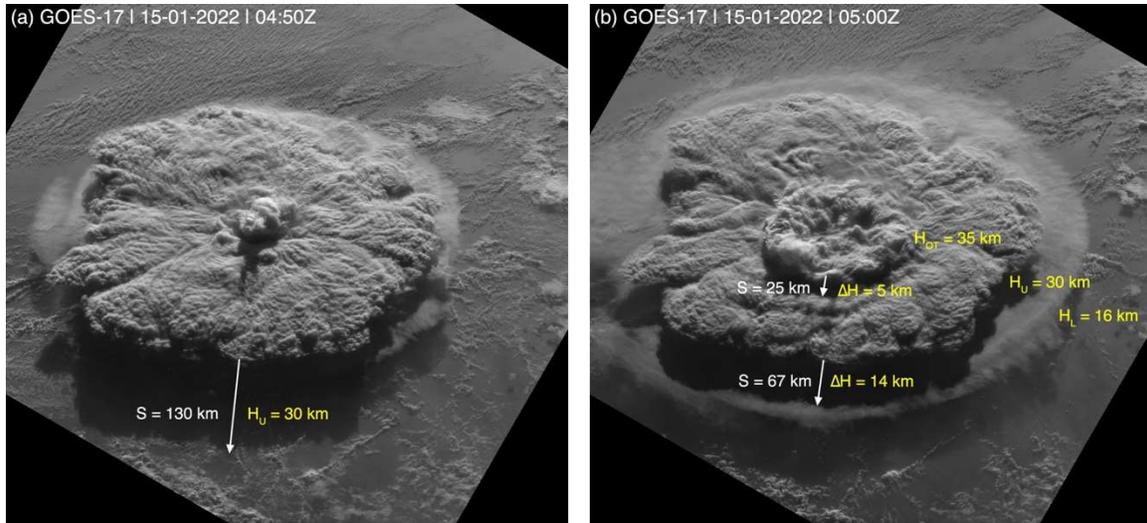
Height estimation near the vent can be done by counting the pixel numbers between the known volcano base location and the dome top, assumed to be above the vent along the local vertical. The base-to-top distance is approximately ~95 pixels, corresponding to a foreshortening corrected height of ~57 km. This is consistent with the maximum GOES-17 and Himawari-8 stereo retrievals height presented in the paper.



**Figure S1.** Image of the plume on 15 January 2022 at 04:30Z from (a) GOES-17 and (b) Himawari-8, enhanced by the Contrast Limited Adaptive Histogram Equalization (CLAHE) plugin of the Fiji package (Schindelin et al., 2012). Compared to Figure 1 of the paper, the enhanced images better reveal the layered plume structure in the shadowed areas.



**Figure S2.** Red band ( $0.64 \mu\text{m}$ ) image of the plume on 15 January 2022 at 04:30Z from GEO-KOMPSAT-2A. The image was rotated by the geodetic colatitude. The yellow triangle and the red dot mark the volcano base and the top of the dome, respectively. The black arrow indicates that the base–top distance is 95 pixels, which corresponds to a height of  $\sim 57 \text{ km}$  at the GK-2A view zenith angle of  $67^\circ$ .



**Figure S3.** Plume structure deduced from GOES-17 (a) 04:50Z and (b) 05:00Z red band images (rotated by the geodetic colatitude), showing the development and collapse of an overshooting top (OT) at the center of the plume. From the length of shadows ( $S$ ) cast on the ocean surface or lower-level plume layers, we identified a lower umbrella spreading near the tropopause at  $H_L = 16$  km altitude, an upper umbrella at  $H_U = 30$  km altitude, and parts of the collapsing OT at  $H_{OT} = 35$  km altitude.

**Movie S4.** Movie of the GOES-17 Full Disk infrared ABI Band 14 (11.2  $\mu\text{m}$ ) brightness temperature (K) shows the progression of the volcanic plume edge and dome features on 15 January 2022 from 02:50Z through 23:50Z. Darker colors indicate lower brightness temperatures, whereas lighter colors indicate higher brightness temperatures.

**Movie S5.** Movie panels show the jointly retrieved GOES-17 MESO and Himawari-8 heights and horizontal advection vectors at their parallax corrected locations on 15 January 2022 from 07:06Z through 14:06Z. The retrievals are centered on the volcano (20.536°S, 175.382 °W) indicated by the magenta triangle. The magenta vector scale at the upper right indicates a 50 m s<sup>-1</sup> wind in each direction. Arrow color indicated height on the same scale as Figure 2a.

**Movie S6.** Movie panels show the assigned temperatures for each GOES-17 MESO and Himawari-8 retrieval and the associated advection speed on 15 January 2022 from 07:06Z through 14:06Z. Dot color indicates advection speed on the same scale as Figure 2b.