SUPPLEMENTARY MATERIAL VOLCANICA

Supplementary Material for:

The radial spreading of volcanic umbrella clouds deduced from satellite measurements

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Prata et al. (2025) should be cited if this material is used independently of the article.

Supplementary

The radiosonde profiles shown here were obtained from the University of Wyoming upper air archive (https://weather.uwyo.edu/upperair/sounding.html) and acquired using a python script and the metpy package (https://unidata.github.io/MetPy/latest/index.html). The Figures show the temperature and dew point as a function of pressure (hPa) on a Skew-T plot. The area of the shaded region is equal to the Convective Available Potential Energy (CAPE) and is a measure of the instability of the environment and provides an approximation of the maximum updraft speed (w_u) [North and Erukhimova,2009] (see page 181, section 7.5).

$$w_u = \sqrt{2CAPE}.$$

The CAPE was shown to be important for the Krakatau 2019/2020 eruption as the atmosphere was in a highly convective state [Prata et al., 2020]. Although the CAPE was not used in the analysis, it was calculated for all the radiosonde profiles used and only considered important in the Krakatau continuous phase and the convective storm case (Hector), where the CAPE is the main source of energy. For the Hector case shown (Fig. 24), w_u=13.6 ms^{-1}, but in other cases w_u~90 ms^{-1}. CAPE may also have been important for sustaining the Hunga 13 January 2021 eruption, where w_u≈86 ms^{-1}.

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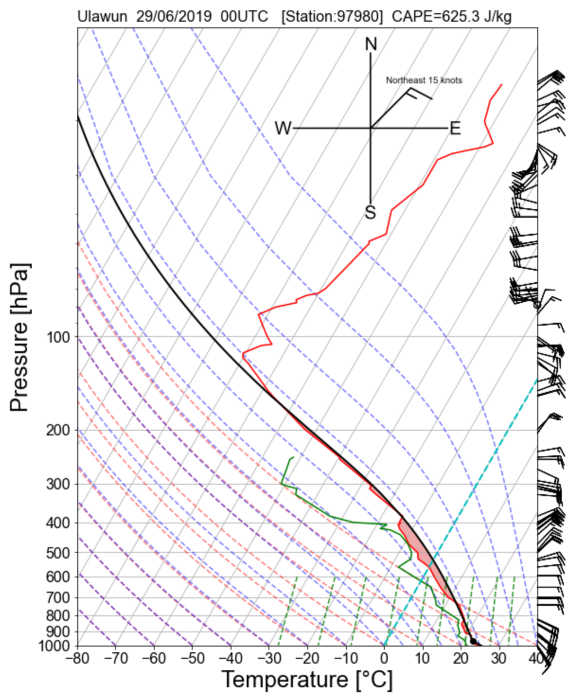

Figure S1: Skew-T plot showing vertical profiles of temperature (red), dew point temperature (green), and the zero degree isotherm (black) on 29 June 2019 at 00 UTC. CAPE=625.3 J kg^{-1} (w_u=35.4 ms^{-1}). Wind barbs are in knots (1 knot=0.514 ms^{-1}). The inset plot shows an example for reading a wind barb: the long segment is 10 knots and the shorter is 5 knots.

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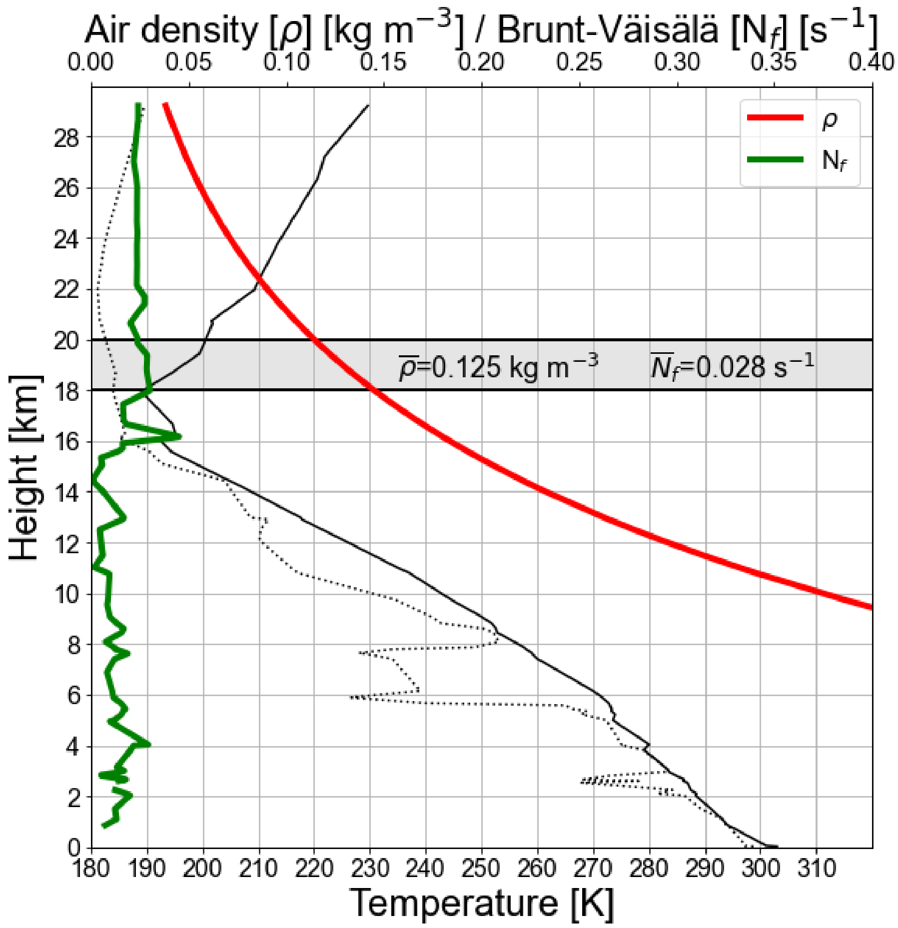

Figure S2: Vertical profiles of temperature (solid black), dew point temperature (dashed black), Brunt-Väisälä frequency (green) and air density (red) on 13 January 2022 at 00 UTC.

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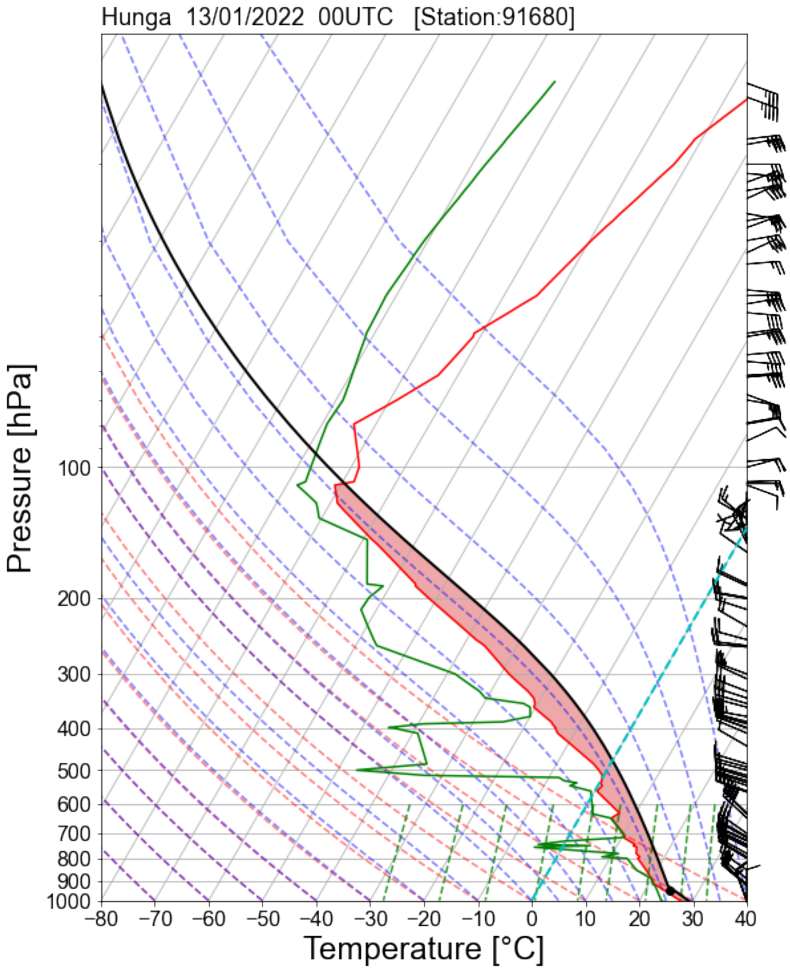

Figure S3: Skew-T plot showing vertical profiles of temperature (red), dew point temperature (green), and the zero degree isotherm (black) on 13 January 2022 at 00 UTC. CAPE=3689 Jkg^{-1} (w_u=85.9 ms^{-1}). Wind barbs are in knots (1knot=0.514 ms^{-1}).

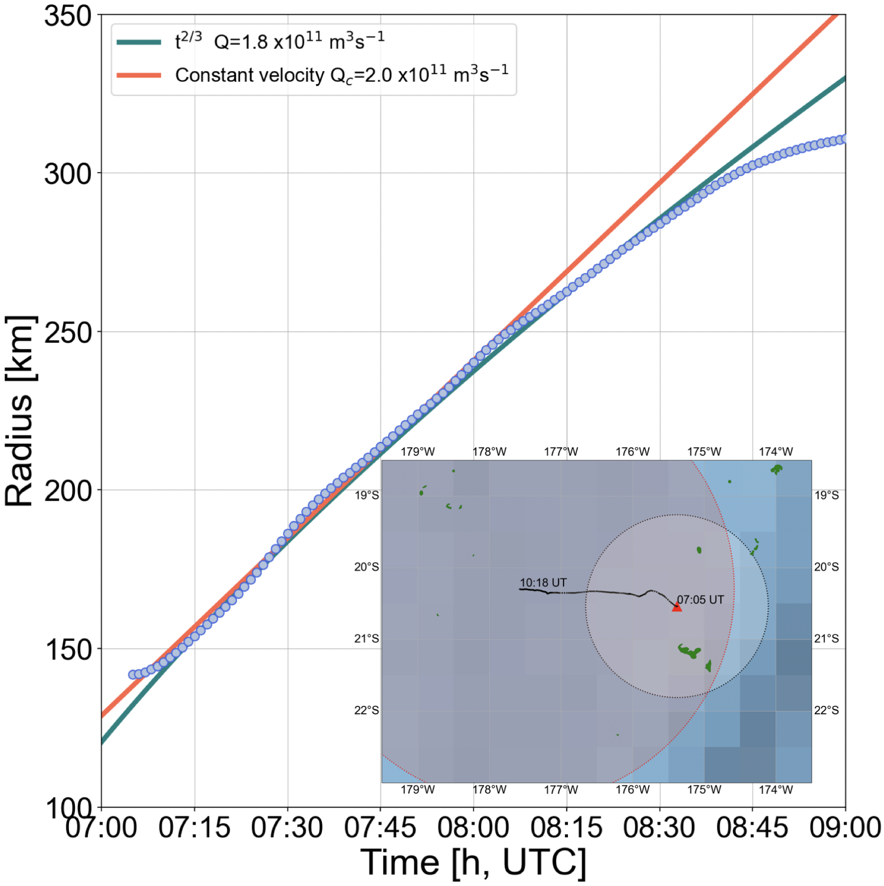

Figure S4: Radial velocity, v_r and radius as a function of time for the 15 January 2022 eruption of Hunga determined from 1-minute ABI data. Best fit lines based on $t^{2/3}$ and t (constant velocity) are included, together with the volumetric fluxes determined using the fits. The inset map shows the location of the centroid of the 225 K contour after a parallax correction was applied. The CAER circles at the start and end of the period of data analysis are also shown.

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