Multi-instrument detection in Europe of ionospheric disturbances caused by the 15 January 2022 eruption of the Hunga volcano

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The eruption of the Hunga volcano in the Pacific Ocean on 15 January 2022 provides a unique opportunity to study ionospheric disturbances expected to be caused by such a strong natural phenomenon [1]. Travelling ionospheric disturbances have been detected after large volcanic eruption already in the past (see for example [2]). Because of the rarity of eruptions of this strength, this event is the first that can be studied with ionospheric data from modern instruments. We focus on the detection of the ionospheric effects of the eruption in Europe. Despite the large distance from the point of origin, atmospheric acoustic waves are detected travelling along great circles in both directions. These disturbances in the lower atmosphere in turn cause subsequent appearance of ionospheric signatures, as can be seen in the left panel of the figure below.

Dense observational networks providing both ionosonde observations and GNSS receivers are available in Europe. This allows us to track the passing disturbances with relatively high resolution in both time and space. We combine a variety of data, such as atmospheric pressure measurements, Doppler measurements, ionosonde soundings, GNSS derived TEC data, and in situ observations in order to study the disturbances across the region, including their vertical propagation. The right side panel of the below figure shows the movement of the TIDs over Europe, as seen in detrended TEC.

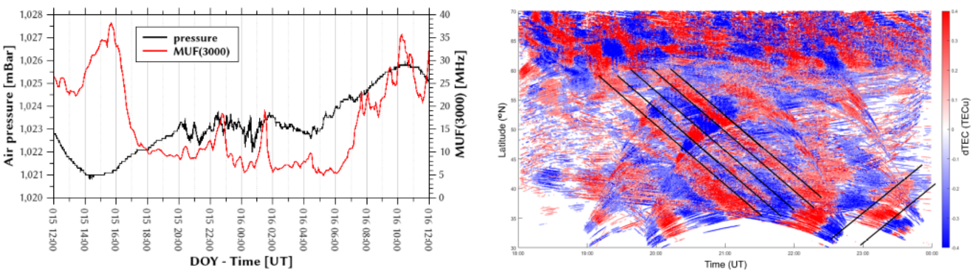

Figure 1. Left: $MUF(3000)$ from the EB040 ionosonde and co-located pressure measurements. Atmospheric disturbances during the night are followed by peaks in $MUF(3000)$. Right: detrended TEC over central Europe showing the passage of travelling disturbances apparently propagating in different directions.

References

[1] E. Astafyeva, "Ionospheric Detection of Natural Hazards", *Reviews of Geophysics*, **57**, 4, pp. 1265–1288, 2019, doi:10.1029/2019RG000668.

[2] D.H. Roberts, J.A. Klobuchar, P.F. Fougere, and D.H. Hendrickson, "A large-amplitude traveling ionospheric disturbance produced by the May 18, 1980, explosion of Mount St. Helens", *Journal of Geophysical Research*, **87**, A8, p. 6291, 1982, doi:10.1029/JA087iA08p06291.