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Ionospheric Near Real time look on Hunga Tonga-Hunga Ha'apai eruption via GNSS

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The Hunga Tonga-Hunga Ha'apai (HTHH) volcano of 15th of January 2022 is one of the most powerful eruptive events over the last 30 years. Early VEI evaluations are proposed to be at least 5. Beside this event, the HTHH volcano erupted multiple times since the 21st of December 2021, however the most noticeable occurred on the 15th of January. Atmospheric shockwaves, caused by this explosion, propagated around the globe, and the tsunami waves struck the coastlines earlier than forecasted. The explosive eruption produced quite significant response in the ionosphere. The existence of it provides an opportunity to gain a better understanding of the eruptive evolution and its atmospheric response throughout this period of time in addition to the standard set of tools.

In this contribution, we use a local network of GNSS receivers to analyze the ionospheric disturbances of the HTHH volcano eruption in the near-field (i.e., less than 2000 km). We apply our previously developed methods [1] to detect and locate the explosive events and their ionospheric signatures in a near-real-time (NRT) scenario. In previous works, we demonstrated that those methods are suitable for detection of ionospheric perturbations with TEC derivative.

To detect co-volcanic ionospheric disturbances (co-VID), we use the TEC time derivative approach. It allows to observe response with a significant rate of TEC and was previously used for detection and characterisation of coseismic travelling ionospheric disturbances generated by large events. However, we modified the developed method to proceed 30 sec data in addition to 1-second data for this event. The first perturbations appeared ~12-15 minutes after the eruption onset. Further, the instantaneous velocities are estimated to be about ~500-800 m/s in a near field. Finally, from the obtained velocity vectors of co-VID propagation we calculate the position of the source in the ionosphere.

Besides, we used the TEC time derivative approach to produce NRT Travel Time Diagrams (TTD). We suggest an automatic algorithm to obtain velocities' amplitude values from the NRT TTD. Based on that, the co-VID's velocity is about ~600 m/s. NRT-TTD with 1-second data showed two ionospheric responses corresponding to the 15th of January HTHH's volcanic activity.

1. B. Maletckii and E. Astafyeva, "Determining spatio-temporal characteristics of coseismic travelling ionospheric disturbances (CTID) in near real-time", *Sci Rep*, **11**, 20783, 2021 , doi: 10.1038/s41598-021-99906-5.