Geophysical Research Letters

Supporting Information for

Near-Real-Time analysis of the ionospheric response to the 15 January 2022 Hunga Tonga-Hunga Ha'apai volcanic eruption

B. Maletckii[1], E. Astafyeva[1]

1 – Université Paris Cité, Institut de Physique du Globe de Paris (IPGP), CNRS UMR 7154, 35-39 Rue Hélène Brion, 75013 Paris, email : maletckii@ipgp.fr

Contents of this file

Introduction

The supplementary material consists of Figures S1 - S4 and Table S1.

Figure S1 illustrates the difference between dTEC/dt parameters obtained from 30-sec and 1-sec data. 1-sec dTEC/dt signal has larger amplitudes and is more disturbed than 30-sec one.

Figure S2 shows dTEC/dt signatures generated by different sources. The biggest peak-to-peak disturbance amplitude corresponds to the 2011 Great Tohoku-Oki earthquake, however the response to the Tonga volcanic eruption has a similar amplitude, which emphasizes the unprecedented response to this eruption. Signature pick-to-pick disturbance amplitudes due to the Tonga Eruption outscores the one of the 2015 Calbuco Eruption by a factor 2.5.

Figure S3 provides details about the NRT and Quasi-NRT TTD techniques. We visualize the picker part of the techniques and provide maxima points.

Figure S4 demonstrates the sound speed profile of the 15th of January 2022 that was used to compute weighted average velocity, and the scheme summarizing the assumptions used to compute the on-ground onset time of the eruption. We use this vertical velocity to estimate the on-ground onset time of the sub-eruptions.

Table S1 presents comparison of the eruption onset time between non-ionospheric methods and our estimation based on velocities of the co-VID.

Figures

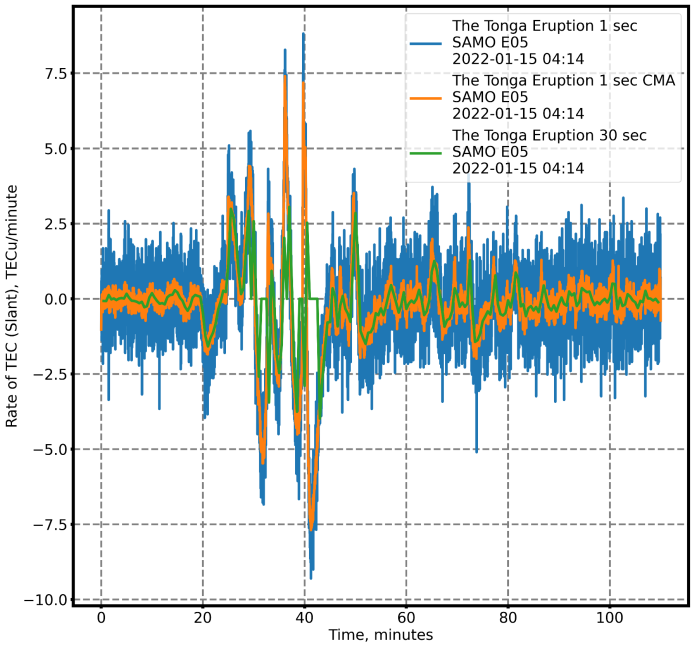

Figure S1. Comparison of dTEC/dt parameters with different data cadences. The blue line is 1-sec data; the orange line is 1-sec data after applying a centered moving average filter (5-sec window); the green line is 30-sec data.

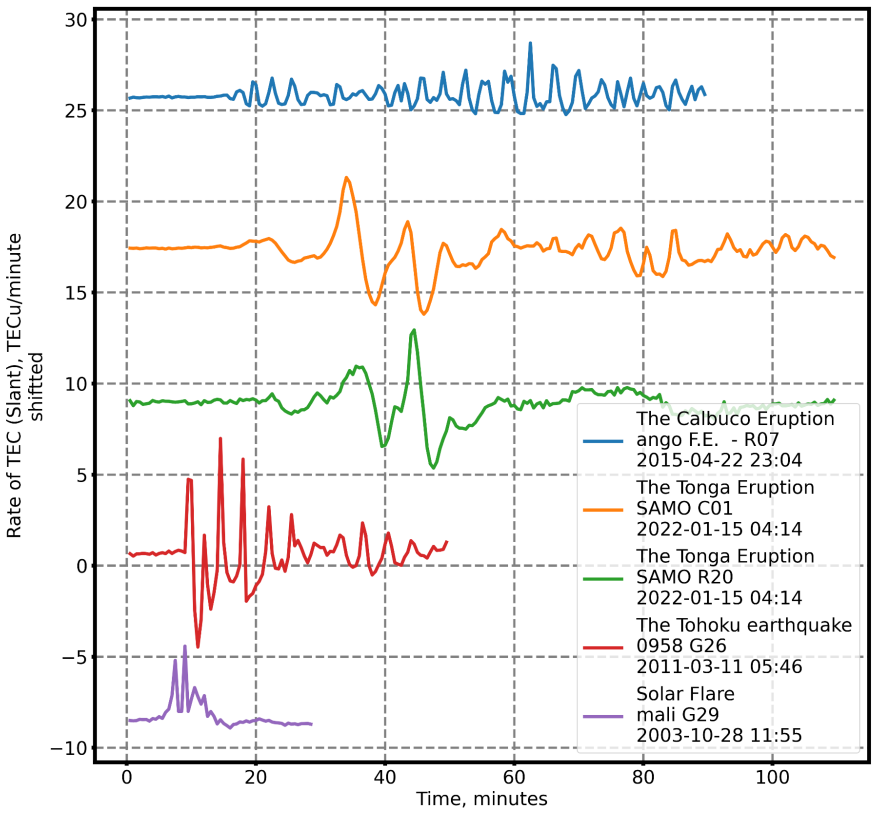

Figure S2. Comparison of dTEC/dt responses generated by different sources. Time starts from the event onset.

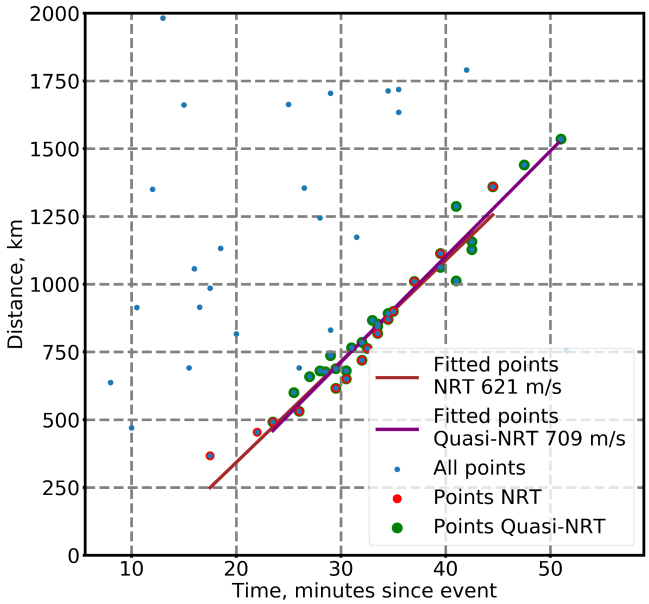

Figure S3. The two fitting algorithms in the TID velocity's slope: the NRT - the brown line, the Quasi-NRT - purple. The blue dots correspond to the first maximums of each series. The red and the green dots are used for the linear regression by the NRT and the Quasi-NRT algorithms, respectively. Based on the Quasi-NRT estimations, the NRT-method has 11.1% accuracy.

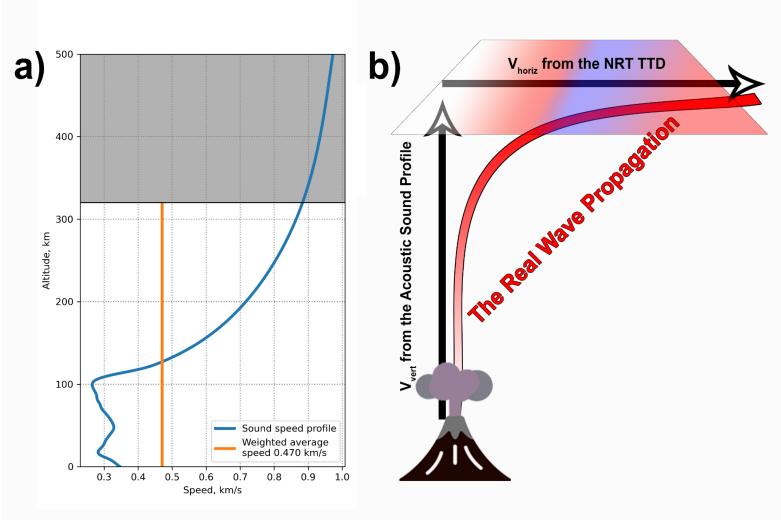

Figure S4. (a) The sound speed profile for the 15 January 2022 and at the time and location of the eruption; **(b)** The scheme explaining approximations to compute on-ground onset time using vertical and horizontal components of the disturbance's velocity. Horizontal velocity is obtained from "D1-GNSS-RT" and/or NRT TTD. Vertical velocity is obtained from an acoustic sound profile.

Event Number	Onset USGS	Onset Poli & Shapiro (2022)	Onset Wright et. al. (2022)	Onset raw VTEC Astafyeva et al. (2022)	Onset dTEC/dt NRT TTD current study
1	04:14:45	04:16:00.07	04:28±2	04:08:43	04:08:26
2	-	-	04:36	04:20:00	04:31:03
3	-	-	05:10	04:48:30	05:02:09
4	-	-	05:51	04:55:21	05:04:54

Table S1: Time onsets (UT) of 4 main HTHH volcano eruptions as estimated from on-ground techniques (USGS - column 2; Poli & Shapiro, 2022 - column 3; Wright et. al, 2022 - column 4), and from the ionosphere (by using raw VTEC (Astafyeva et al., 2022) - column 5, by using the dTEC/dt NRT TTD - column 6)