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Interactive comment

Interactive comment on "Geomagnetic Conjugate Observations of Ionospheric Disturbances in response to North Korea Underground Nuclear Explosion on 3 September 2017" *by* Yi Liu et al.

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Paper by Liu et al. "Geomagnetic. . ." promises to be an interesting and important study. However, in the current form the presentation of observational results is not convincing. Authors discussed the magnitude of expected electric field disturbance about 11 mV/m (p. 9). How this estimate was obtained? It would be better to discuss the magnitude and waveform of TEC disturbance, that authors had actually measured.

Response: We appreciate the reviewer for the valuable comment. LAIC electric field can be roughly estimated by the following expression: (6) where is the total propagation velocity of ionospheric disturbances, E is LAIC electric field, and B is the magnetic field.

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Based on the LAIC electric field penetration model proposed by Zhou et al. (2017), it is found that LAIC electric field is perpendicular to the magnetic field. Therefore, total propagation velocity of ionospheric disturbances generated through E$\times$B drift can be calculated by . The value of horizontal velocity obtained by the least square estimation was $\sim$280 m/s in this study. Total magnetic field intensity and magnetic inclination angle I around UNE test site calculated by International Geomagnetic Reference Field (IGRF) model were 4.39*10ˆ-5 T and 57.90°, respectively. Therefore, LAIC electric field can be roughly estimated by equation (6) to be 14.5 mV/m.

Compared with the magnitude and time scale of ionospheric disturbances caused by earthquakes, there are inconsistencies in our study. Based on IGS station observations around Tibet and Nepal, Kong et al. (2018) reported that TEC disturbances exceeded 0.3 TECU and lasted for 15-20 minutes during 2015 Nepal earthquake. However, it was found that the UNE-generated ionospheric disturbances were relatively smaller and lasted within 5 minutes in Figure 4. Therefore, it is possible to distinguish natural earthquakes and UNE events based on GNSS observations.

Fig. 1. According to this map, there are several GPS stations in the vicinity of nuclear testing ground. Why not to provide TEC data from both the conjugate point and the same hemisphere site?

Response: We appreciate the reviewer for the valuable comment. In this work, in order to obtain smooth relative STEC data, only carries phase observation data of satellite elevation angle greater than 30° within 3 hours after the UNE are utilized to derive the relative STEC, which to some extent limit the number of observations. From Figure 5, we present the IPPs tracks of relative STEC derivatives. The red lines indicate the IPPs tracks obtained by IGS stations in the northern hemisphere. The blue lines indicate the magnetic conjugate positions of the IPPs tracks obtained by IGS stations in the southern hemisphere. It is found in the GPS dataset that there are no observation data (IPPs, ionospheric piecing points) in the vicinity of nuclear test site during the UNE event. Therefore, there is no way to investigate the response of TEC disturbance in the

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vicinity of nuclear testing ground in this work.

Fig. 2. In this plot only the moment of TEC disturbance can be seen. However, the waveform of TEC disturbance is not shown anywhere. Additional Figure with extended time scale is needed.

Response: We appreciate the reviewer for the valuable comment. Figure 1 show the time sequences of raw data corresponding to relative STEC disturbances presented in Figure 4 in the revised manuscript. Compared with the magnitude and time scale of ionospheric disturbances caused by earthquakes presented in Kong et al. (2018), ionospheric disturbances presented in Figure 1 were relatively smaller and lasted with 5 minutes. It is difficult to found the ionospheric disturbances in response to UNE from the relative STEC time series. Therefore, the numerical third-order horizontal 3-point derivatives of relative STEC are used for extracting the ionospheric disturbances in this work.

Figure 1. The time sequences of raw data corresponding to relative STEC disturbances presented in Figure 4 in the revised manuscript. The ionospheric STEC disturbances in response to UNE are represented by the red rectangles.

Fig. 3. The same problem with this plot. Only the moment of FAC impulse can be seen, but not its waveform. Additional Figure with extended time scale is needed. Plot for another day is not necessary.

Response: We appreciate the reviewer for the valuable comment. Figure 2 show the time sequences of raw data corresponding to ionospheric current disturbances presented in Figure 6 in the revised manuscript. Compared with the magnitude of current disturbances in Figure 6, current disturbances presented in Figure 2 were relatively smaller. It is difficult to found the ionospheric disturbances in response to UNE from the current time series. Therefore, the numerical third-order horizontal 3-point derivatives of current are used for extracting the ionospheric disturbances in this work.

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Figure 2. The time sequences of raw data corresponding to ionospheric current disturbances presented in Figure 6 in the revised manuscript. The ionospheric current disturbances in response to UNE are represented by the red rectangles.

Reference: Kong, J., Yao, Y., Zhou, C., Liu, Y., Zhai, C., Wang, Z., and Liu, L.: Tridimensional reconstruction of the Co-Seismic Ionospheric Disturbance around the time of 2015 Nepal earthquake, J. Geodesy, 3, 1-12, 2018.âĂČ Editorial comments: Fig. 1. Lines with geomagnetic coordinates are needed. The reference to Ren et al. (2012) is absolutely irrelevant. All the names in ref. at line 213 are misspelled. Few comments concerning interpretation: Theoretical model of FAC generation at the front of the acoustic pulse has been presented in [Pokhotelov O.A., Parrot M., Pilipenko V.A., Fedorov E.N., Surkov V.V., and Gladyshev V.A., Response of the ionosphere to natural and man-made acoustic sources, Annales Geophysicae, 13, N11, 1197- 1210, 1995; Pokhotelov O.A., Pilipenko V.A., Fedorov E.N., Stenflo L., and Shukla P.K., Induced electromagnetic turbulence in the ionosphere and the magnetosphere, Physica Scripta, 50, 600-605, 1994; Pokhotelov, O.A., Pilipenko V.A., and Parrot M., Strong atmospheric disturbances as a possible origin of inner zone particle diffusion, Annales Geophysicae, 17, 526-532, 1999].

Response: We appreciate the reviewer for the valuable comment. We have corrected accordingly. We would like to thank the reviewer again for the valuable comments, which help a lot to improve the quality of the present paper. We hope that the reviewers will be satisfied with our responses and revisions, and we look forward to hearing from the reviewers soon.

Please also note the supplement to this comment:
https://www.ann-geophys-discuss.net/angeo-2018-122/angeo-2018-122-AC4-supplement.zip

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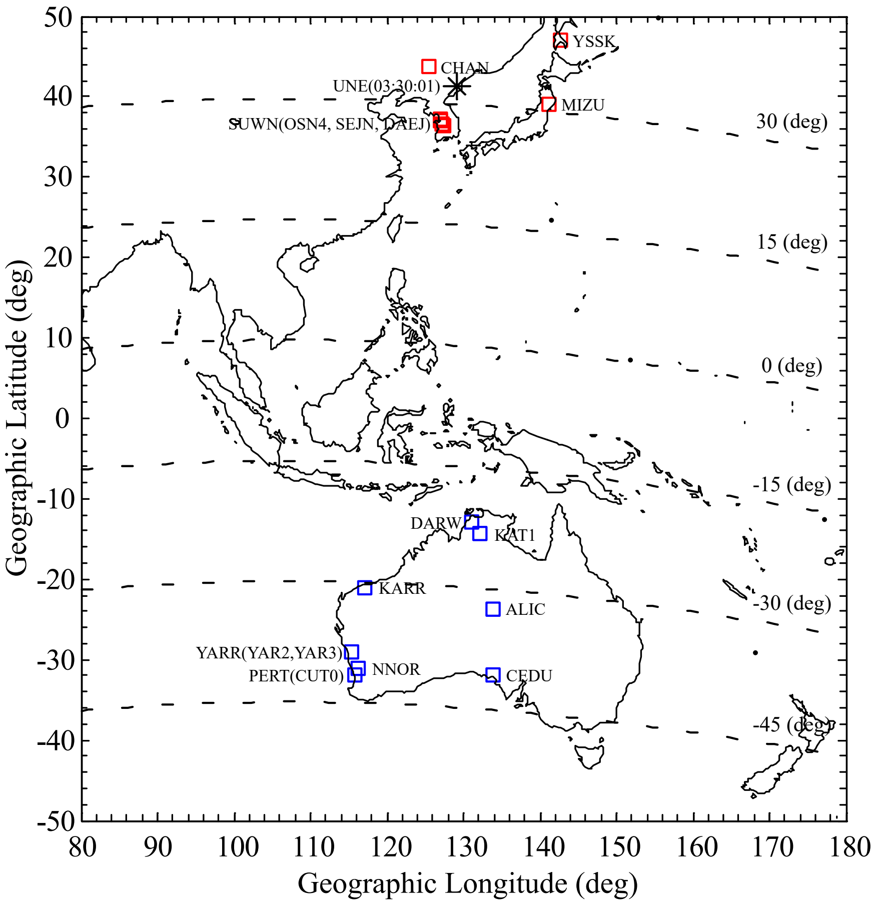

Fig. 1. figure1

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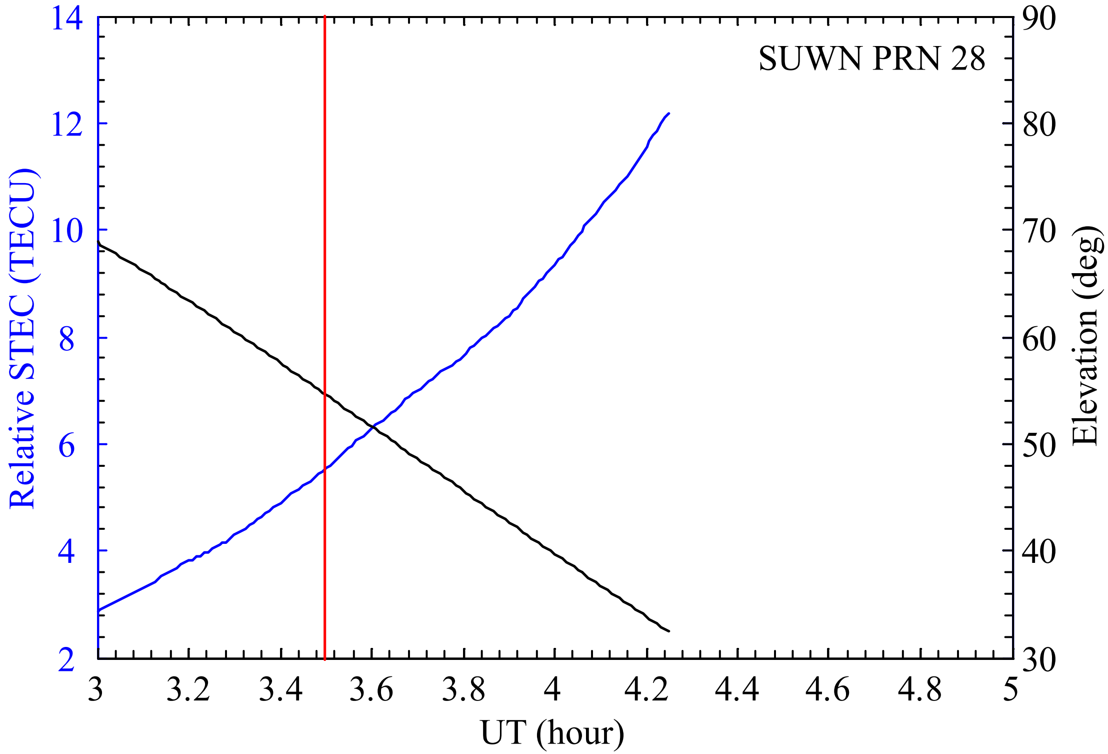

Fig. 2. figure2

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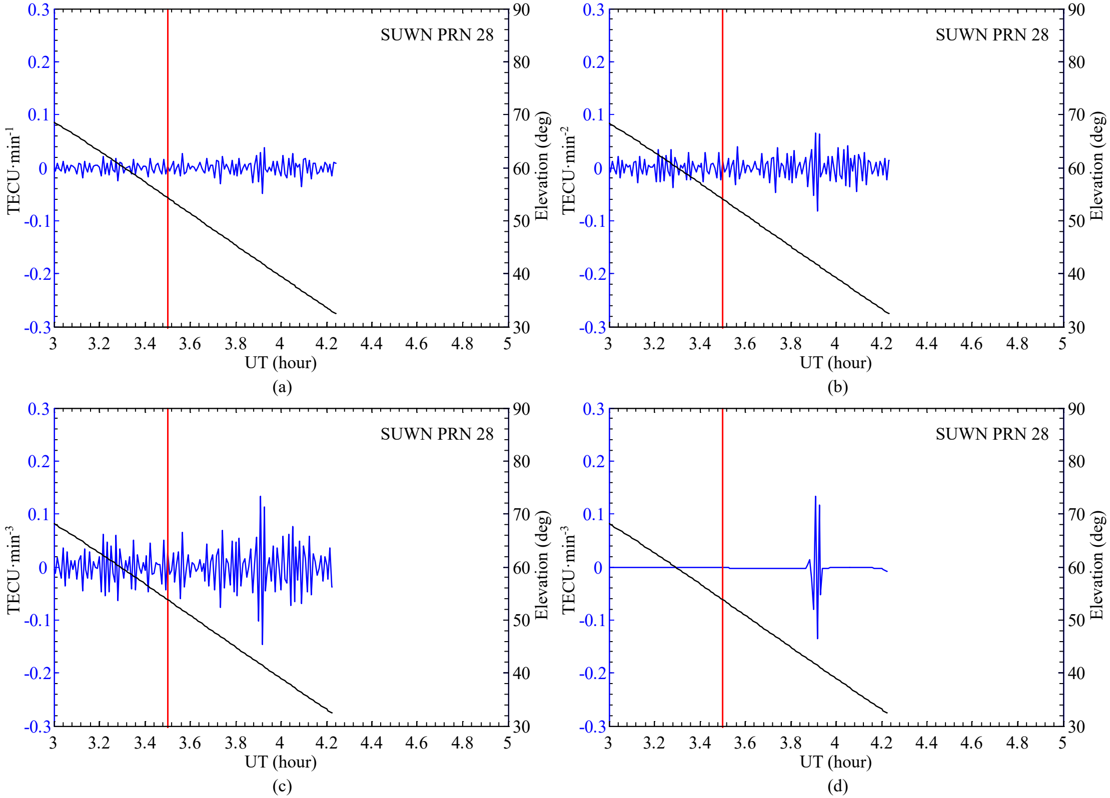

Fig. 3. figure3

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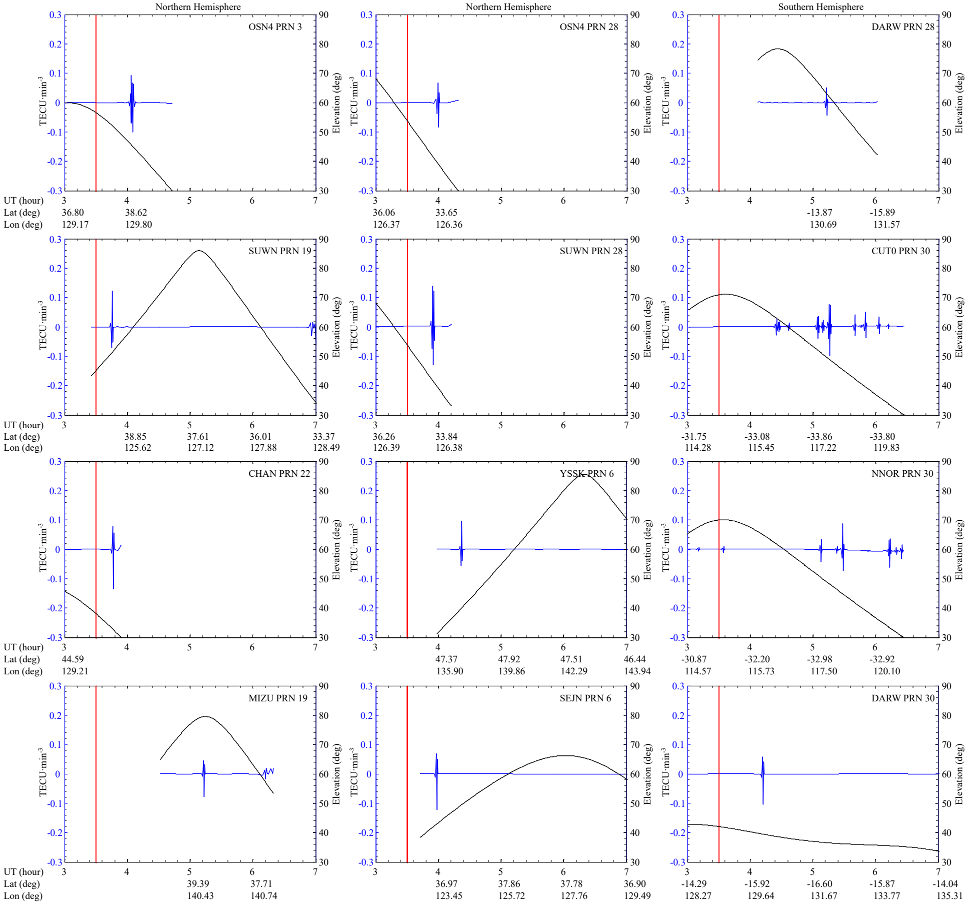

Fig. 4. figure4

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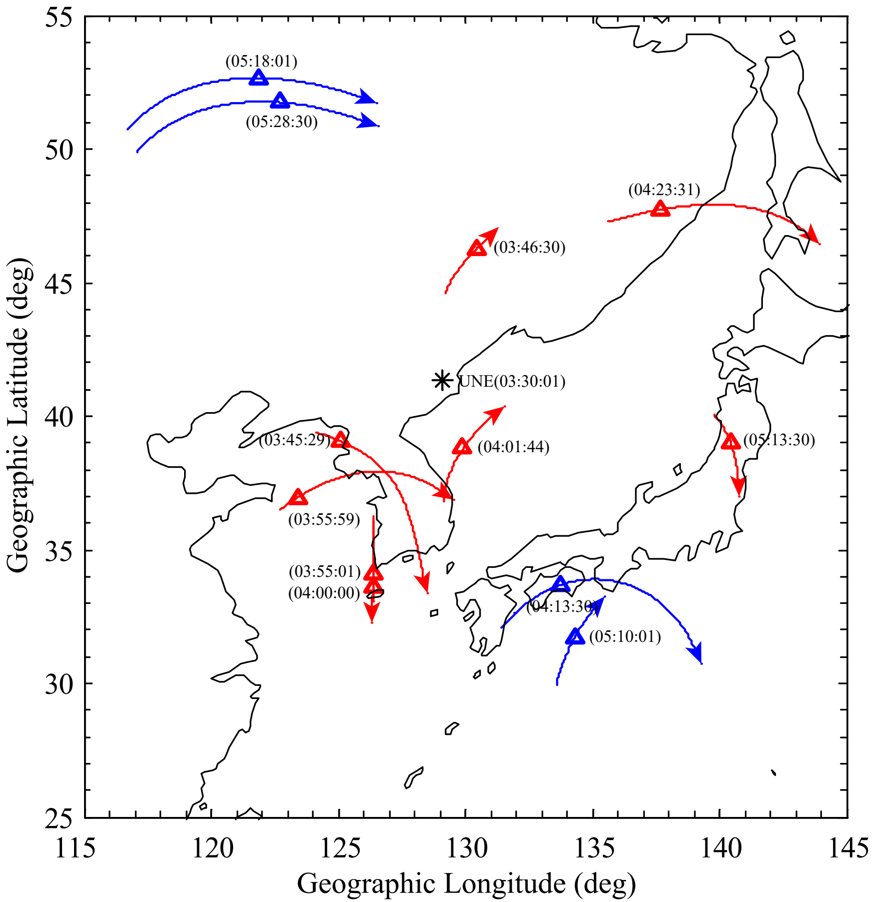

Fig. 5. figure5

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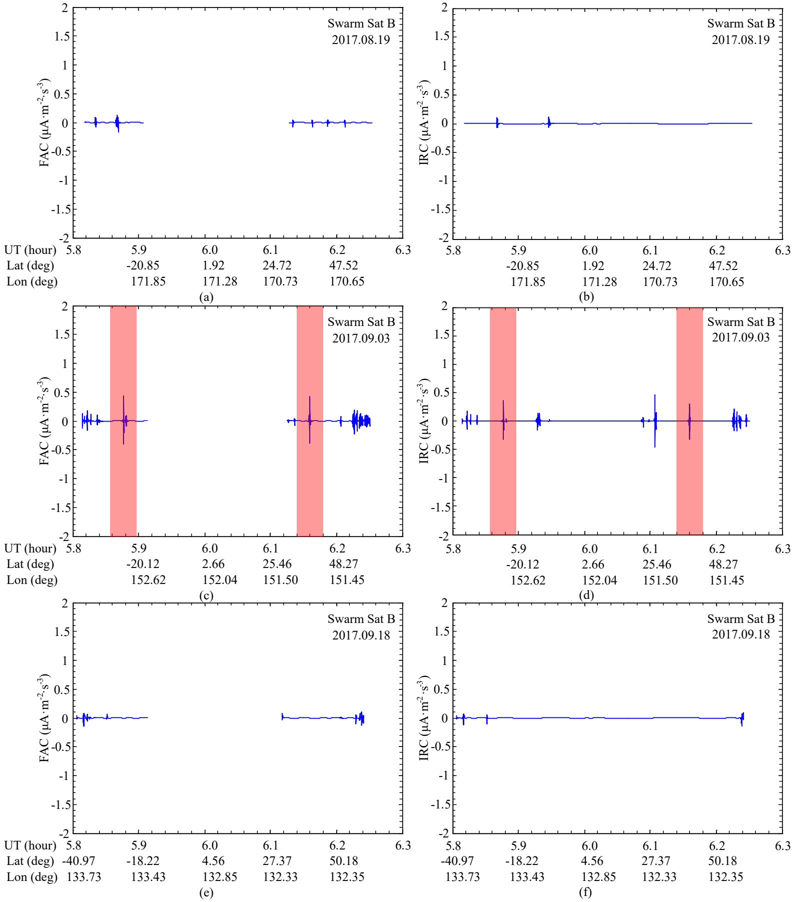

Fig. 6. figure6

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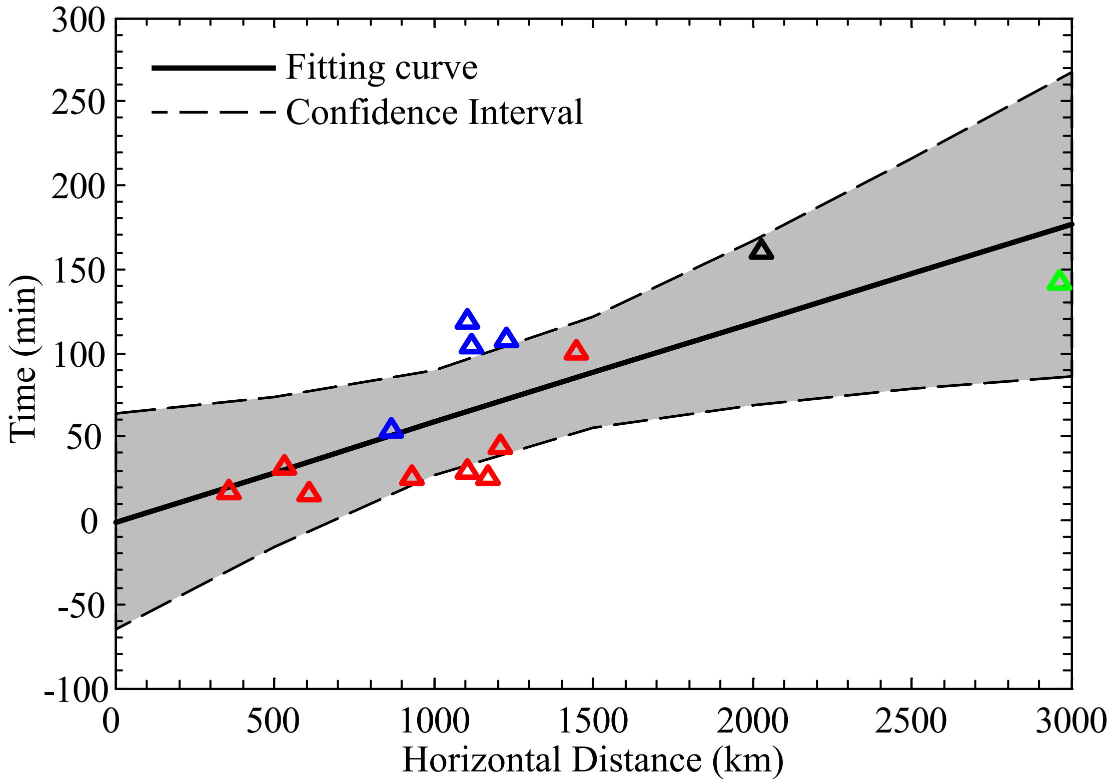

Fig. 7. figure7

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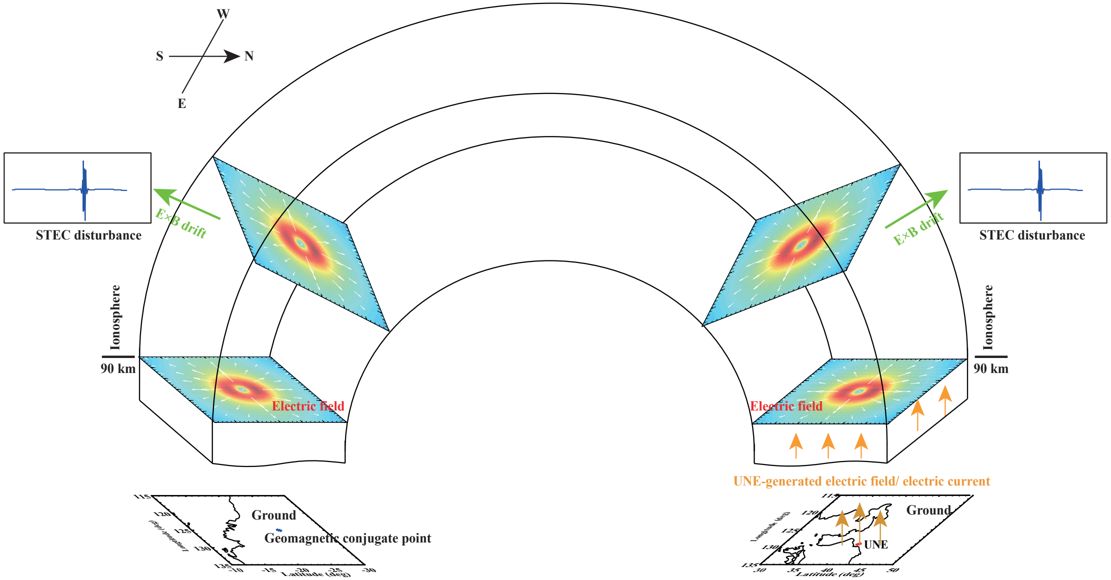

Fig. 8. figure8

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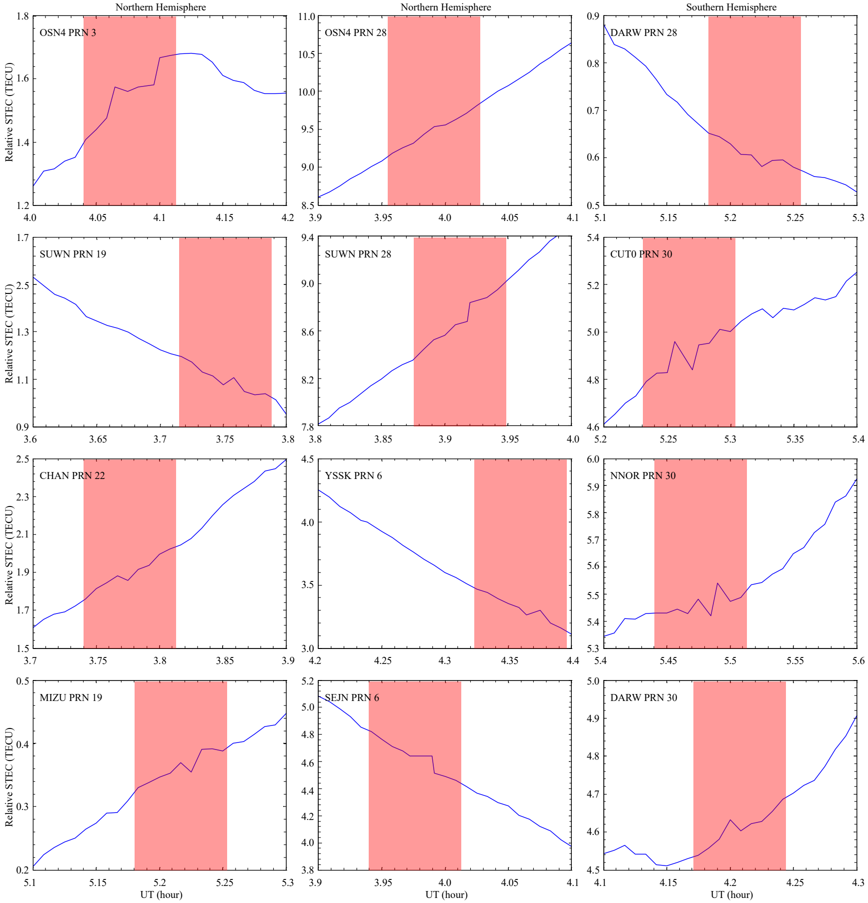

Fig. 9. figure1_response3

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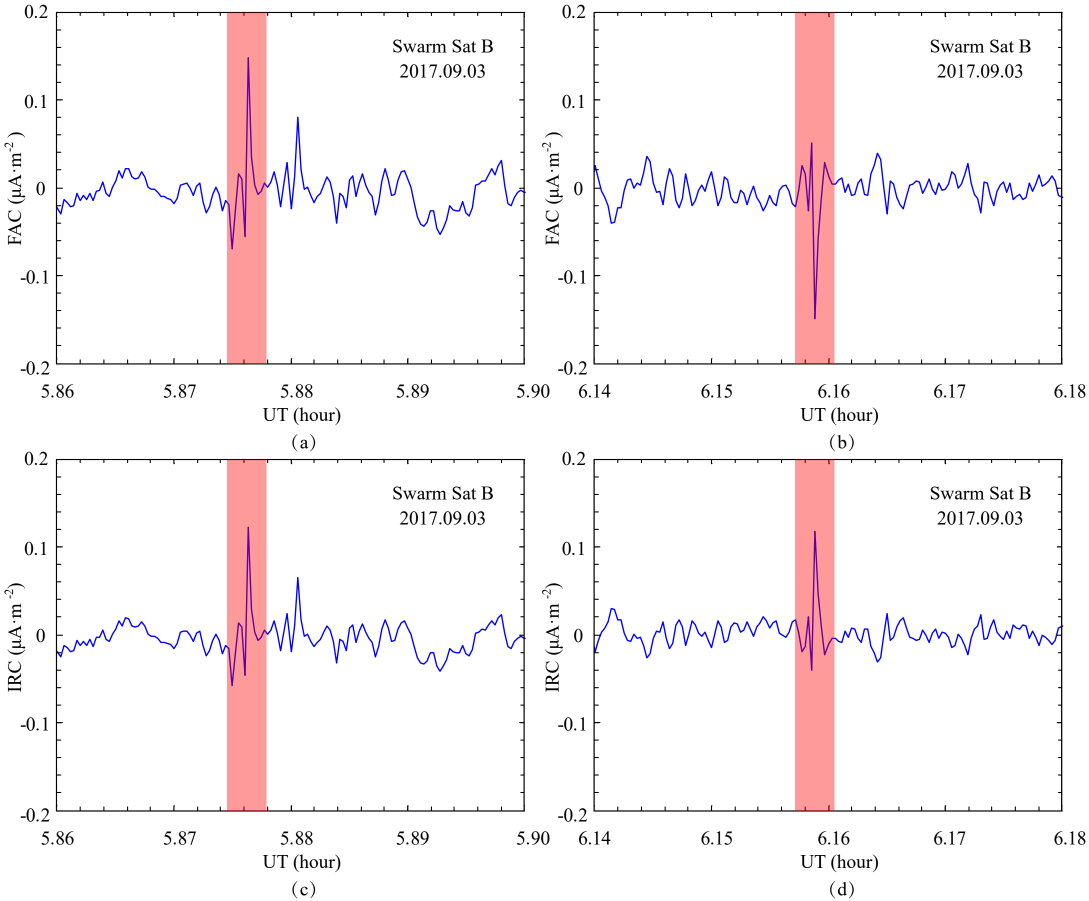

Fig. 10. figure2_response3

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