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Comment on angeo-2022-18

Anonymous Referee #1

Referee comment on "Latitudinal variations of ionospheric-thermospheric responses to Geomagnetic Storms from Multi-Instruments" by Rasim Shahzad et al., Ann. Geophys. Discuss., <https://doi.org/10.5194/angeo-2022-18-RC1>, 2022

Comments to "Latitudinal variations of ionospheric-thermospheric responses to Geomagnetic Storms from Multi-Instruments" by Rasim Shahzad et al.

Ionospheric responses to magnetic storms have been widely investigated due to the remarkable influences of storms on the space environment. In this paper the authors used multiple measurements that cover low to higher latitudes to investigate ionospheric and thermospheric responses to the magnetic storms of June 2015 and August 2018, including TEC measurements of ground-based receivers and the SWARM satellites, TIMED/GUVI [O/N₂] ratio, Magnetometer observations, and various indices and solar wind parameters. My major concern is that the ionosphere has complex background variations and day-to-day variations, in Figures 4-8 how did the authors exactly (there are many quantitative descriptions for the responses to the storms) determine the responses to the different phases of storms from the complex TEC variability caused by multiple factors. Maybe you have done such, whereas there is no a detailed explanation in the text. A reference for the background variation of TEC may be helpful.

In the "Discussion" section, many explanations are suggested for the physical processes that cause the storm time responses, I think there are somewhat short of convinced observation evidences and detailed analyses. Figures 9-13 may be moved to the "Discussion" section to analyze the mechanisms in more detail.

Moreover,

Lines 305-309: Please explain why the reductions (enhancements) of the [O/N₂] ratio result in the increment (depletion) of vTEC.

Line 317-324: You mentioned TEC enhancement and larger TEC variation. How did you confirm them to be related to the storms, not ionospheric background variations?

The PPEF and disturbed dynamo electric field are emphasized. You may further check the changes in the latitudinal structure of the low-latitude ionosphere such as EIA to analyze the effect of the zonal electric field, not only talk about the low-latitude density enhancement.

Minor comments:

Line 66-80: It is not a logical introduction.

Tables 1 and 2: Why the geomagnetic locations of the stations change between 2015 and 2018? Is that due to the secular change of the Earth's magnetic field?

Line 100: What does "duration of the solar activity" mean?

Line 155: What does "dTEC" stand for? Please explain in the text.

Figures 7 and 8: It is better to mark the different phases of the storms in the figures. Please explain how you calculated dTEC. What is the reference value?

Line 239-240: The lowest Dst value was -203nT around 07:00 h UT on 26 August.

This cannot be seen from Figure 3. The lowest Dst did not reach -200 nT.

Figures 10 and 11: It is better to add local time information into the figures. The distribution of the plasma density depends on local time.

Figure 12: Please indicate the positive direction of the PPEF.

In the "summary":

line 464: How did you identify ionospheric irregularities (bubbles, blobs?) from SWARM TEC measurements?

Line 469: EEJ is not a direct driver of TEC variations, the driver is ionospheric electric field.

There are many English/grammar mistakes, some suggestions (not cover all mistakes) are as follows:

Line 22: analyze -> analyzed

Line 41: trigger -> triggers

Line 67: please delete "due to PPEF", repeat with the front

Line 68: induced -> induce

Line 75: in eastward -> are in eastward

Line 76-77: The zonal electric field corresponding to horizontal component of magnetic field

Line 101: we need satellites

Line 124: a measure of -> positively correlated with

Line 125: please delete "increases in N2 decreases electron density", the determining factor is the [O/N2] ratio.

Line 171: This data aims -> these data aim

Line 172: is -> are

Line 251: VTEC -> vTEC, please keep consistent throughout the text.

Line 252: 42~50 TECU ...

Line 254: 18~20 TECU ...

Line 349: this due to -> this is due to