Investigation of the relationship between the spatial gradient of total electron content (TEC) between two nearby stations and the occurrence of ionospheric irregularity

By

Teshome Dugassa et al. (2019)

General comment

The manuscript has been well improved. The authors have answered all the queries raised satisfactorily. However, in doing so they introduced some minor misconceptions and errors which I believe should be addressed before publication.

In addressing my concern in general comment 2, the authors claimed that that PRE is due to the spatial gradient of electron density near solar terminator and that the TEC gradient would help them to estimate the strength of the zonal electric field. They also make reference to the changes in Page 3, Lines 7 - 15). However, I could not unfortunately see these changes in Lines 7-15 of Page 3 as stated.
I wish to mention that it is not the gradient in TEC that enhances the PRE near solar terminator. The PRE is generated through the interaction of zonal neutral wind in the F-region and the conductivity gradient caused by the terminator as the authors clearly know. Anyway this not a problem given that the corrections have been pointed out in the specific comments.

Also, the authors did not discussed and explain well how the enhancement/reduction in spatial gradient of TEC is related to irregularities during geomagnetic storm. In Figure 5, they presented a good relationship between both parameters but did not really point out any mechanism that could have affected both. The only reason given so far as justification is the direction of IMF Bz.

In my opinion, it is important that the authors explain the practical significance of the standard deviation of the spatial gradient of TEC over 15 min (as used in the methodology section) and why they used it? Is it kind of related to definition of ROTI?

Finally in the conclusion, I find that the statement '*The spatial gradient of TEC/electron density near-solar terminator obtained from two nearby located GNSS receivers method may be an alternative method to estimate the strength of the zonal electric field''* is a little premature and too general. The authors should just mention that a relation was observed between both quantities at some particular period of the day.

Specific comments

Page 2

Line 8. to the presence of enhanced eastward electric field was thought to control the generation of plasma density irregularities.
Why was thought? It is established that the enhanced electric field is a crucial driver for irregularities generation.
Line 24-25. For accuracy I suggest you use ...'' This inhomogeneity, i.e spatial plasma density/TEC gradient, varies significantly at low-latitude region because of .....''. Remember that magnetic storm over your region of interest have the tendency of suppressing irregularities more than enhancing them.

Page 3
Line 2. Remove gradient (repetition)
Line 6. Change attempt to have attempted,
Line 19. Please change .. relating the **latitudinal/longitudinal gradient of TEC/Plasma density...'' to .... on the relationship between TEC gradient and the occurrence of ionospheric irregularities.**
Lines 21-24. I suggest the authors remove this part. They have already talked about the PRE earlier on in Page 2, line 9. They could even take this part (Page 3, Lines 21-24) to Page 2 (line 9) if they want.
But they have to remove the phrase in Lines 24-25. [Longitudinal gradient of integrated Pederson conductivity that exists across sunset terminator affects the strength of PRE and the generation of ionospheric irregularities (Tsunoda, 1985).]. Eventhough the statement is true it has already been mentioned earlier at the beginning of the introduction. I think it is not needed hereas it could lead to some confusion in the flow of idea since it will be difficult to establish a clear link between that previous statement and **the longitudinal gradient** of electron density in the statement that followed. Remember Pederson conductivity can be estimated using electron density. But for the longitudinal gradient, I wouldn't know. What you need to do here is to emphasize on the fact that there is a lack of instrumentation for the direct investigation of the relationship between electron density gradient and occurrence of ionospheric irregularities over Africa and you have done that already. Just harmonize the statement for fluidity.
Lines 28- 29. [to examine the strength of the zonal electric field]. Closely located GPS can only help you get an insight into the behaviour of electric field especially at some particular period of the day. TEC is not only modulated by electric field, but by wind and solar radiation among others. If you want to examine directly the strength of electric field, you use magnetometers which the authors already did. So adjust that statement. I think what you want to say is that closely located GPS will help study the relation between gradient and electric field at post sunset.

Page 4, Line 20. I don't understand what you mean by ... was computed **for every time**. What is your temporal resolution?

Page 5 , line 26. It provides. What provides? Intermagnet or Amber or both? Adjust the statement.

Page 8, Line 17. Change was to is.
Page 8, Line 20. Change correlate to correlates

Page 9, Line 11. the positive/negative in the spatial gradient of TEC. Remove ''in the''

Page 10, Line 31-31. Kindly removed this statement. ''Sun et al. (2013) examined the relationship between the storm-enhanced plasma density (SED)-associated irregularities (ROTI) and TEC gradients over continental United States (CONUS) during the geomagnetic storms''. This mechanism has nothing to do with the low latitude ionosphere.

Page 11
Line 4. Change could to can.
Line 5. Remove dynamically

Page 12, Line 2. Change to....observed the steepest TEC gradient .....

Page 13
Line 2-3. .....change ‘‘when the occurrence of ionospheric irregularity present (left panel) and absent (right panel)’’ ‘‘to during the occurrence of irregularities (left panel) and during their absence (right panel)’’.
Line 6. Change indicate to indicates
Line 8. Please what do you mean by occurrence of irregularities was present/ absent? Why not just use when irregularities were present /absent?
Line 15 to 16. The density gradient controls the intensity of the PRE. This is not accurate. The PRE is generated through the interaction of zonal neutral wind in the F-region and the conductivity gradient caused by the terminator.
The density gradient affects the R-T instability growth rate thus, the generation of irregularities (Ossakow, 1982; Mendillo et al., 1992 JGR)
Line 22. Change to Figure 5 (a-d) illustrates typical examples of the .....
Line 24. Change are to is

Page 14

Figure 4. Replace showing by of.
Line 3. Change are to is
Lines 10 to 11. Gradient in TEC is positive when TEC/electron density over ASAB is higher, and is negative when TEC/electron density over DEBK is higher. This is a repetition.

Page 15, Figure 5. Replace showing with of. Representative examples of .....

Page 17, Line 3. Change ‘‘their correlation’’ to ‘‘the correlation’’.

Page 19, Line 26, change covey to convey.

Page 20, Line 1. Change present to presented
Page 20, Line 4. What is summery? Do you mean summary?
Line 6. Add the year of your correlation.
Line 7. Change was to were
Line 8. Change seasons and months to month and season
Line 11. Change are to were also
Line 16. Change are to was

Page 21, lines 2-3 I think it is a little bit premature to state that ‘‘The spatial gradient of TEC/electron density near-solar terminator obtained from two nearby located GNSS receivers method may be an alternative method to estimate the strength of the zonal electric field’’. You could just report that you observed a relation between both and you mention the period when this relation was very obvious.