

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

General comment

The paper is technically ok and has been significantly improved. I however, believe there are some clarifications that still need to be made.

I draw to attention of the authors to some confusion that may arise in the processing of magnetic data section mainly on the use of ΔH to represent hourly departures of H and the electrojet at the same time.

I have an issue with the way the storm cases have been analyzed in this paper. At first look there is no information on the storm except for the fact that they were moderate. We do not know when they started the main phase and even the intensity of the ring current etc... Also, it will be more appropriate to present the storm response in terms of variation of ROTI and spatial gradient with respect to variations during quiet background condition or before and after the storm or to the least study the storm effect (on irregularities and spatial gradient) with respect to some identified quiet days.

Again, it is evident that the storm will have the same effect on irregularities and spatial gradient given that a relationship between both quantities has been shown previously (section 3.2 down to Figures 4). What one might be interested in seeing is the effect of the storms on the relationship between irregularities and spatial gradient. For example how does the storm affect such relation and how the relation varies during the various storm phases?

I still find that the discussion on storm mechanism is not convincing. The authors discussed Bz polarities (page 14 lines 6-8) and effect without giving any concrete evidence (at least not from their Figures). Also, nothing has been said on the 12 April 2014 event.

Evidence of the storm time electric field using EEF was only discussed for the event of 18 February 2014 (reduction in PRE). Was there no storm effect on the PRE during the other events? If no what modulated irregularities and spatial gradient behavior?

Finally, I do not understand why the authors mixed their estimation of percentage irregularities occurrences for both quiet and disturbed days (“**all days of the year 2014 including both quiet and disturbed days**”). They had earlier presented that storm could enhance or reduce irregularities. Thus, estimating percentage occurrences during both quiet and disturbed days (without segregating the effect of the disturbances) implies a kind of “pollution” to the results especially, if several large and long lasting perturbations had occurred during the period of study, 2014.

Specific comment

Title

In the title I suggest “ionospheric irregularity” should be changed to **ionospheric irregularities**.

Abstract

Line 3-4: “Different instruments and techniques have been applied to study the behavior of ionospheric irregularities”. What are those different instrument the authors are talking about? I do not think that these lines are necessary in the abstract.

Line 6. Kindly change irregularity to irregularities.

Line 7. “derived from GPS-TEC”. Could you please delete it?

Line 8. Change are to were

Line 10. The enhancement in the intensity of $\sigma(\Delta\text{TEC}/\Delta\text{lon})$. I do not understand what you mean by enhancement in intensity.

Line 12. Same as in line 10

Line 13-14. “the relation between the spatial gradient of TEC/**electron density** obtained from two nearby located Global Navigation Satellite System (GNSS) receivers and equatorial electric field (EEF) was observed”. Remove **electron density**, What happened to the observed relation? Where you expecting not to find a relation between both quantities?

Line 15-16 “The gradient in TEC and ROTI have observed during the evening time period shows similar trends with EEF but after 1-2 hrs.” This statement is not concise. Tell us the trend as it is I find it difficult to understand. Also just let know that they have similar variations (which you must hint us about) with a delay of about 1-2 hours between both.

Line 17. Remove vast.

Line 19. Remove spatial. One seems to be confused with your use of spatial gradient, latitudinal gradient and longitudinal gradient. Be consistent. I think your study is concerned with longitudinal gradient

Line 20. remove computation.

Introduction

Page 2

Line 26. Appleton ionospheric anomaly. why not just Appleton Anomaly????

Line 28, remove the in front of literature.

Line 30, change for to from

Page 3

Line 26. Add “at those stations” at the end of the sentence.

Line 28. a closely located GPS stations. Remove a.

Line 34. Change application to applications

Data and analysis method

I appreciate the fact that the authors gave a complete description of the magnetic processing data. However in doing so they did not make it as precise as possible. For example the reader might be confused with the hourly departure of H denoted ΔH expressed by Eq. (7) and the ΔH in equation 10. Obviously both do not mean the same things but how do we differentiate? I think

the author should clearly define ΔH after equator 10 and add that this is what will be used in the rest of the paper.

Page 4

Line 18. epoch time???? Which one suit best epoch or time?

Line 22. why not just say 1 minutes VTEC values for all satellites in view were averaged.

Line 31, change applied to used

Page 5

Lines 3-4/ Read the statement and see if it is coherent.

Line 5. replace kinds with a suitable word.

Page 7-8

Line 23 and lines 1-2. Isn't this a repetition of lines 26 -28 of Page 5?

Page 8

Line 5. change were to was. Same with the other 'were' in the next sentence of same line.

Line 12. be consistent with the usage of day time. is it daytime or day time?

3. Results and discussion

Page 8

Line 19. the word reliability is not adequate here. As a matter of fact the relationship between two quantities cannot be use as a measure of the reliability of one of the quantities. Kindly use an appropriate word that describes exactly the idea you wish to pass across.

Line 20 -21. "In the analysis, we considered the daytime (07:00 - 17:00 LT) value of ΔH and haven't you said this earlier?

Line 30. Not just any pair of magnetometers please!!!!!!!!!!

What is the significance of lines 25 to 31 to your results???

Page 10

Line 23. Remove the "a".

Line 27. replace nighttime period (after 18:00 LT) with post sunset period

Page 13

Lines 22-23. What informed the choice of the storms? Were they selected randomly? What phase of the storm is represented in Figure 5?

Lines 26-28. On the other hand, when the occurrence of ionospheric irregularities is suppressed. ($ROTI_{ave} < 0.4$ TECU/min), the magnitude of $\sigma(\Delta TEC/\Delta lon)$ shows reduction (for example, 19 February 2014 and 27 August 2014). The irregularities were suppressed with respect to what day? We do not know the behavior of irregularities before or after the storm. It is true there is a reduction of ROTI which might connotes absence of irregularities due to the storm but are the reduction in spatial gradient really significant? We need to now.

Line 28-29. When did the storm start?

Lines 31-32. The enhancement/reduction in the spatial gradient of TEC in the daytime period during geomagnetic storm day appears to show inhibition of ionospheric irregularities. I do not understand this.

Line 33-35. "In the presence of ionospheric irregularities, the enhancement/reduction in the spatial gradient of TEC observed during post-sunset period during geomagnetic quiet/disturbed conditions was higher than when ionospheric irregularities are suppressed". From which Figures?

Page 14

Lines 2-3. As can be seen from Figs. 5, the geomagnetic storm appears to show a similar effect on the spatial gradient of TEC as it has on ionospheric irregularities. Were you expecting the storm effect to be different on both?

Line 6. Change storm to storms

Line 8. “or local time at which the maximum negative excursion of Dst occurs”. We didn’t see that.

Line 9-10. “When the z-component of interplanetary magnetic field (IMF Bz) turns towards northward (for example, during 19 Feb 2014) in the post-sunset period, reduction in the spatial gradient of TEC”. We didn’t see this.

Page 17

Line 12. What do you mean by occurrence variation?

Page 19

Lines 9-15. Why mix the percentage irregularities during both quiet and disturbed days?

Page 21

Lines 12-16. I clearly do not see the importance of these lines.