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Comment on angeo-2021-42

Anonymous Referee #2

Referee comment on "Diagnostic study of geomagnetic storm-induced ionospheric changes over very low-frequency signal propagation paths in the mid-latitude D region" by Victor U. J. Nwankwo et al., Ann. Geophys. Discuss.,
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Report for:

Diagnostic study of geomagnetic storm-induced ionospheric changes over VLF signal propagation paths in mid-latitude D-region by Nwankwo et al.

This paper presents VLF signal analysis over two propagation paths associated with 15-20 geomagnetic storms in the mid-latitude region from September 2011 to October 2012. The authors characterized VLF signal disturbances according to the five metrics/parameters defined at different times in the diurnal variation. Based on analysis they found dipping in five VLF parameters (ranging from 25% to 80% of the analyzed cases) during the storms compared to the respective pre-storm values. Further, the authors added virtual heights and critical frequencies of the E- and F-regions from ionosonde stations nearby the VLF transmitters.

The paper is interesting, however, based on my observation, I recommend major revision with the following modifications.

1) The propagation disturbances of the VLF/LF waves have been extensively studied for several decades showing that the signals are strongly affected by the geomagnetic storms at high and mid-latitudes. However, the previous studies are not properly referred to in the text

and so the results presented by the authors are not properly evaluated with reference to the previous studies. The authors are recommended to state clearly what results are newly added to our knowledge about the VLF propagation disturbances and D-region ionosphere.

2) Authors are advised to mention the significance of the five metrics or how they are connected to the ionospheric variation/properties. What do these five metrics tell us about the D-region ionosphere? This has to be discussed clearly.

3) Authors combined VLF observations of D-region ionosphere with ionosonde observations of E and F regions ionosphere. It will be meaningful to compare the D-region parameters (like electron density, or D-region reference height) deduced from VLF observations with the ionosonde parameters. This is the major concern for the paper.

4) Statistical results should be summarised effectively with one/two figures. Repetition of the same kind of figures confuses the goal of the paper.

5) "The MDP signal appears to be more responsive (about 68% for combined analysis shown in figs 7 and 9) to geomagnetic perturbations than other signal metrics"
A more detailed discussion is needed. For example, how does geomagnetic storm dominates over daytime solar ionization in determining VLF amplitudes?

6) "A rise in SRT and SST amplitude under geomagnetic storm conditions"; what does this mean in connection to ionosphere during the geomagnetic storms? An explanation is needed.

7) What could be the physical reason for "strong storm responses" on DHO path compared to the responses on GQD path, though both the GQD and DHO are almost at the same latitude (GQD is slightly higher). Ionosonde results may also be checked with satellite electron precipitation data in this regard.

8) Figure 2: Mention the name of the transmitters in Caption.