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Reply on RC2

Victor U. J. Nwankwo et al.

Author 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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We (authors) thank the reviewer (Referee #2) for accepting and making time to review our manuscript. Your effort and expertise are highly appreciated. We are happy that this effort is appreciated and hope to take advantage of your suggestions to ensure a better version of work.

We have taken note of your observations and depending on the Editor's recommendations, we will address them in a revised version accordingly. However, I will provide preliminary short responses to them in the meantime.

1) This manuscript is a revised work of a paper we submitted in May 2016 (due to extended delay in getting the required data). While it is true that "VLF/LF waves have been extensively studied for several decades", we consulted and duly cited the works at our disposal at the time (e.g., see lines 56-73). This work is also built on our previous effort (e.g., Nwankwo et al. 2016) in which we cited many other supporting works. However, your observation is noted, and we will include relevant prior work in the revised version.

2) Some of the factors on which our characterized metrics are based include i) the diurnal signature and ii) the propagation characteristics of VLF narrowband measurements. We will include the significance accordingly. Some authors reported the overall depression of the diurnal signal with respect to a baseline but these metrics allowed us to study both the storm effects and the local time-variant signal responses.

3) We have already addressed this issue in a separate work in which we combined simultaneously observed VLF variations with TEC data from multiple GNSS/GPS stations (around the transmitter and receiver) to probe geomagnetic storm effects as they propagate down to the lower ionosphere from the magnetosphere. Although there is a revised version of this work, you may look up the idea here:
<https://www.essoar.org/doi/10.1002/essoar.10504067.1>. Appropriate connection between the two will be done in the revised version.

4) There is an important observation/finding associated with the statistical analysis done

here. We have statistically analysed the metrics for (i) 1-day (mean value) before, during and after the storms (figure 7) and (ii) 2-day (mean value) before, during and after the storms (figure 9). Interestingly, the percentage dip of the MBSR and MASS increased significantly in the 2-day mean signals before the events (when compared with the 1-day mean value). It will be challenging to summarise the statistics in one/two figures because of the need to show results of the two propagation paths (GQD-A118 and DHO-A118). Also, the plots need be large enough for readers to see and compare. However, we will look into ways of better summarizing the results.

5) We will work on this important suggestion and revert accordingly. However, we speculate that the responses are related to positive storm effect which affects, albeit small, the attenuation of the VLF radio waves (Fagundes et al. 2016).

6) The SRT and SST indirectly relate to ionospheric responses at sunrise and sunset. Our findings show that storms-induced disturbances do not have significant impact on such responses, and since the sunrise and sunset signatures relate to mode conversion in the VLF propagation path this might imply that the D-region density is not a significant contributor to this effect. This and more detailed explanation will be provided in the revised manuscript.

7) This is a very good scientific question! We observed a trend associated with the DHO-A118 region in our TEC analysis (not included here), which may (to a good extent) address this important question. This will be updated in the revised manuscript. We will also check with satellite electron precipitation data as suggested, and perhaps perform Ovation-Prime auroral model runs for the intervals of interest – see https://www.ngdc.noaa.gov/stp/ovation_prime/data/

8) The name of the transmitters will be mentioned in the caption as suggested.

Thank you very much for your valuable comments.