Effect of two similar intensity geomagnetic storms on the low latitude D-region ionospheric plasma inferred using very low-frequency navigational signals

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Present work investigating the effect of two similar intensity geomagnetic storms of March 23-24, and April 23-24, 2023 over the low latitude D-region ionospheric plasma variations. The analysis utilizes very low frequency (VLF: 3-30kHz) signals from NWC (19.2 kHz from Australia) and VTX (18.2 kHz from India) recorded over low latitude station Dehradun, India. The transmitter receiver's great circle path covers the low equatorial latitude ionosphere. Both transmitter's amplitude show anomalous variation in the signal amplitude following the storm on-set day but the April storm shows a longer recovery time. The D-region ionosphere appears to be disturbed significantly following the storm. As can be seen in Figure 1 (top and bottom panels), the daily mean signal amplitude for NWC transmitters showed significant increase during storm on set and main phase day during both storms.

Similar results are also seen for VTX transmitter signal. The modelling of the VLF signal anomaly for both storms using the Long-Wave Propagation Capability (LWPC) code shows an increase in the D region reference height (h') by ~3.6 km and ~4.5 km, respectively for March and April storms. This increase in reference height is found to be associated with D-region plasma density (Ne) enhancement due to storm followed by slow recovery. The Ne was higher for the April storm compared to the March storm, which represents a positive storm effect over low-latitude regions. The change in the eastward/westward electric field is noted during storm induced disturbance dynamo and may cause ionospheric irregularities/TIDs (traveling ionospheric disturbances) (Cherniak & Zakharenkova, 2016) (Ma. Further analysis using the wavelet technique, showed the presence of wave-like fluctuations with a period varies ~40-60mins in the VLF signal analysis depicting the important role of atmospheric gravity waves/travelling ionosphere disturbances associated with the Joule heating at high latitudes, providing evidence of strong high-low/equatorial latitude coupling during storms (Maurya et al., 2018; Kumar et al., 2015). The results are important to make a reliable model for forecasting errors in communication and navigation systems owing to solar disturbances.

References

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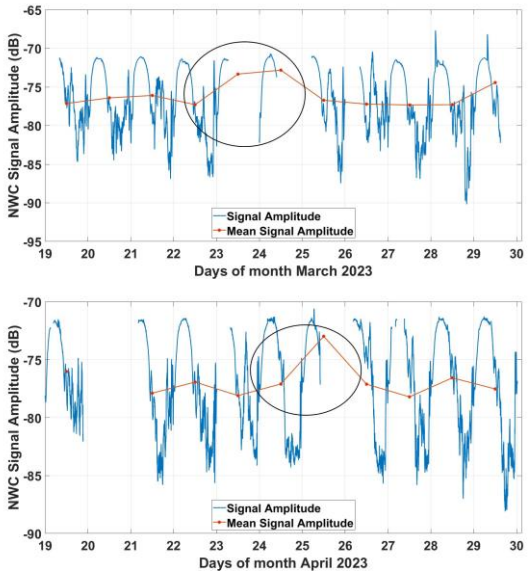

Figure 1: Daily mean NWC amplitude variation during March 2023 (upper panel) and April 2023 (lower panel) storm.