



## Mid-latitude and high latitude ionospheric disturbances during Sudden Stratospheric Warming events observed by VLF/LF signals

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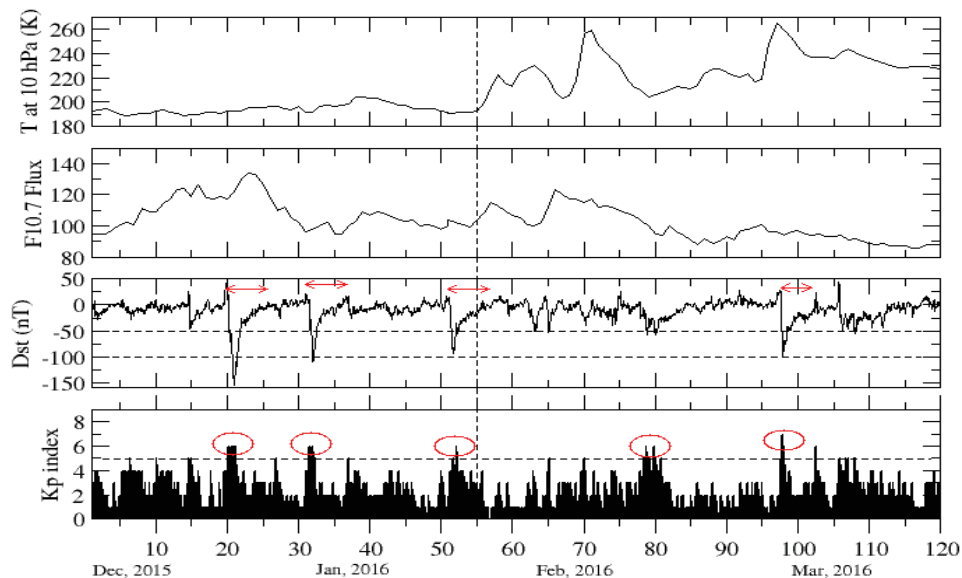
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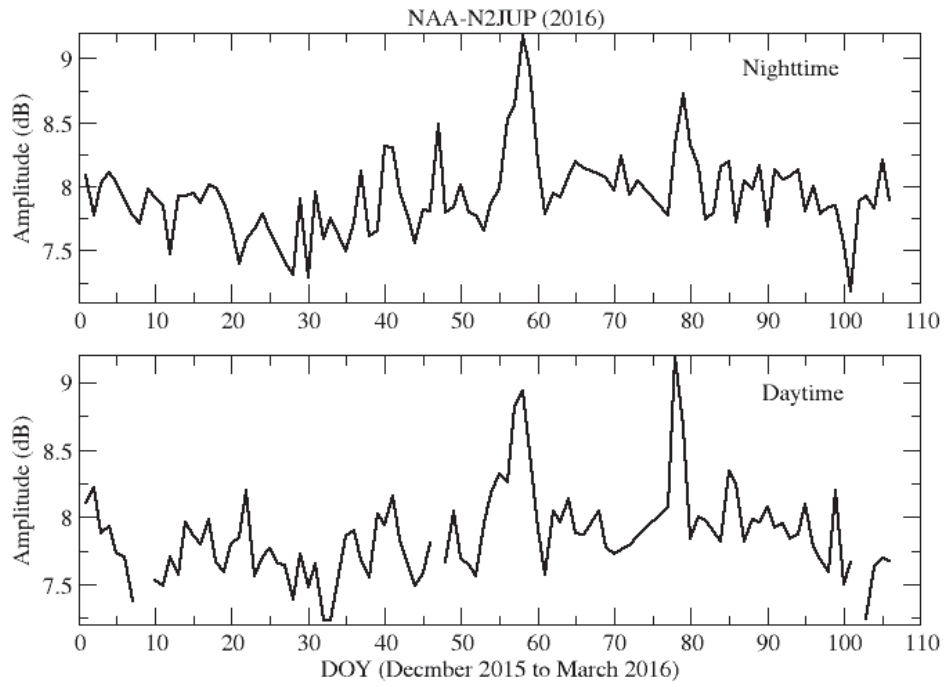
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We present mid-latitude and high-latitude D-region ionospheric disturbances during the Sudden Stratospheric Warming (SSW) events in the northern hemisphere at polar and sub-polar region. The SSW events have been detected by VLF/LF radio signals in different solar conditions. We have analysed VLF/LF radio signals transmitted from five transmitters namely, NAA, NRK, GQD, NOM and NLK, and received at several locations in Europe, USA and Japan during the events. Significant anomalies in nighttime and daytime VLF/LF signals have been found for all propagation paths associated with stratospheric temperature rise at 10hPa level occurred due to the SSW events. There is an increase or a decrease in VLF/LF amplitudes (~3-5 dB) during daytime and nighttime because of change in electron density, electron-neutral collision frequency profiles and associated modal interference effects between the propagating waves which may happen in lower ionospheric region during the SSW events.

We also analysed the TIMED/SABER mission data to investigate the upper mesospheric conditions over the VLF/LF propagation path during the same SSW period. A decrease in neutral temperature and an increase in pressure at the height of 75-80 km has been observed during the peak time of the SSW event. The VLF/LF anomalies are also found correlated and in phase with the stratospheric temperature variation and mesospheric pressure variation.



**Figure 1a.** Variation of stratospheric temperature, F10.7 flux, Dst and Kp indices during major SSW event of 2016



**Figure 1b.** VLF/LF average amplitude variation at nighttime(top) and daytime (bottom) during the major SSW event of 2016 over the path NAA-N2JUP