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High latitude and mid-latitude ionospheric disturbances associated with some major stratospheric warming events in the Northern hemisphere

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We present several case studies of high latitude and mid-latitude D-region ionospheric disturbances during the northern hemispheric Sudden Stratospheric Warming (SSW) events, in different solar conditions, as sensed by sub-ionospheric very low frequency (VLF) and low frequency (LF) radio signals. We have analysed VLF/LF radio signals from five transmitters (e.g., NAA, NRK, GQD, NPM, NLK) received at several places 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 due to the SSW events that occurred during solar quiet conditions. Simulation of VLF/LF diurnal variation are carried out using the well known Long Wave Propagating Capability (LWPC) code within the earth-ionosphere wave guide to quantify the ionospheric anomalies caused by the respective SSW events. In addition, we have also analysed the SABER instrument data on board the TIMED satellite to investigate the mesospheric temperature response corresponding to the VLF/LF reflection heights due to the SSW events, which revealed mesospheric cooling associated with stratospheric temperature enhancement but with 1-3 days delay between the maximum of stratospheric temperature and minimum of mesospheric cooling. Interaction of the upward propagating tropospheric transient planetary waves, resulting from the breaking of polar vortex during SSW period, with the tidal waves and small-scale gravity waves are believed to be the main cause of electron density perturbations in the ionosphere which in-turn affected the VLF/LF propagation in the earth-ionosphere wave guide.