ABSTRACT

Modeling of lower ionospheric perturbations along Very Low Frequency radio wave propagation paths due to diverse physical phenomena

The prime focus of this Thesis is theoretical modeling of lower ionospheric perturbations due to several terrestrial and solar or extra-terrestrial phenomena using very low frequency (VLF) radio wave propagation as a detection tool. Based on the availability of VLF data of our own network, we analyzed the total solar eclipse that took place in the Indian subcontinent on July 22, 2009 and the Nepal earthquake (M=7.3) that occurred on May 12, 2015. The signal propagation characteristics change as the length of a VLF propagation path between a pair of transmitter and receiver increases. So to study such behavior, the VLF data collected at the Indian Antarctic stations Bharati and Maitri have also been studied.

Two different aspects of the effects of solar eclipse on the ionosphere have been presented. One is the study of generation of atmospheric gravity waves (AGWs) during the eclipse and the other is the theoretical reproduction of the VLF signal modulation during the eclipse period. For the first aspect, Fourier and wavelet analysis on the VLF data showed waves with periods of the order of few minutes to hours during eclipse maximum time and for the second aspect, a D region ion chemistry model was developed and later coupled with the Long Wavelength Propagation Capability (LWPC) code. The results thus obtained matched the observed signal modulations quite satisfactorily. To study the possible seismo-ionospheric anomalies associated with the May 12 earthquake, both VLF data and satellite data were analyzed. From analysis of outgoing longwave radiation (OLR) data obtained from NOAA satellite, we found enhancements in the daily Eddy field few days prior to the main shock. We also found excitation of AGWs before few days of the earthquake. Numerical simulation emphasizing the true variation of solar illumination over the JJI-IERC propagation path produced the observed nightward shifts of terminator times (both during sunrise and sunset, SRT and SST). The observed increase in VLF daylength was 32 minutes while that obtained from simulation was 25 minutes. For long path study, we coupled the Solar Zenith Angle Model (SZAM) with LWPC code to take into account the solar zenithal variation over the paths. The diurnal signal variation and the time of occurrence of sunrise and sunset minima thus obtained matched our observations to good extent.

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