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Numerical modeling to reproduce characteristics of VLF radio waves from Indian Antarctic station Maitri and Bharati

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1 Extended Abstract

Long path VLF radio wave propagation has a distinctive feature that during its propagation it experiences large variations of solar irradiation and degree of ionization. The propagating radio waveguide modes and modal conversion is completely different that for shorter path (<3000 km). Study of radio signal characteristics in Antarctic region during summer period in the Southern Hemisphere gives us a unique opportunity to explore such interesting phenomena as the . In addition, there is an extra feature in this path during summer which is whole day presence of solar radiation and hence the D region in at least some sections of the propagation path. In 2007-2008 and 2015-2016 Indian Centre for Space Physics made a flag mark in the understanding of long path VLF radio wave research in Indian permanent base Maitri We have presented long-distance propagation characteristics of VLF signals transmitted from VTX (18.2 kHz) and NWC (19.8 kHz) from India and Australia respectively recorded simultaneously at Indian permanent stations Maitri (Lat. 70°45′S, Long. 11°40′E) and Bharati (Lat. 69°424′S, Long. 76°10′E). A very stable diurnal variation of the signal (both amplitude and phase) has been obtained with no signature of nighttime fluctuation due the presence of 24 hours of sunlight for both the stations. Signals from VTX (18.2) and NWC (19.8) have been recorded using AWESOME, SoftPAL and UltraMSK instruments. We have presented various temporal and spatial properties of VLF signal amplitude profile by various numerical modelling and examine their irregularities due to excess solar ionization. Firstly the signal amplitude is numerically reproduced by using International Geomagnetic Reference Field (IGRF) and Long Wavelength Propagation Capability (LWPC) model. The modal attenuation was thoroughly examined during two specific time duration (a) when the entire path is in sunlit and (b) when the entire path is dark. It is found that the signal suffered more modal conversion which appears in the signal as oscillations during the night time. Secondly, Secondly the spatial signal amplitude variation is reproduced by using advanced GPI ion chemistry model by calculating the ionization rate by using Monte-carlo simulation. The entire long path for VTX-Maitri ($\sim$ 10000 km) has been divided by 20 segments each of distance of 500 km to compute the electron density profile over the entire path. From observation and modeling, a very interesting features came out for VTX-Maitri path, where the stronger signal (1 MW) from NWC suffers huge attenuation in comparison to weaker signal (500 kW) from VTX. It is found that as soon the NWC signal enters into antarctic ice mass, it suffers severe attenuation. This is why in Maitri, the received NWC signal is very faint. From modal attenuation it is found that the VLF signal suffers a huge attenuation during propagating over Antarctic land and sea ice. Thirdly, this outcome has been reestablished by studying the temporal profile of VLF signal using solar zenith angle model and LWPC. The ionospheric steepness parameters (β) and effective reflection height h' has been computed from solar zenith angle profile and using LWPC whole day VLF signal has been reproduced which matches with the observed results to a great extent. The simulated temporal profile of the signal also corroborates the antarctic ice mass attenuation phenomena. This is the first time in Indian context where such an ice mass induced attenuation has been reported.

References

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