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Some initial results from a Global Atmospheric Model of Electricity

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1 Extended Abstract

The study of electromagnetic coupling between the troposphere and ionosphere began as early as the beginning of the eighteenth century, though the concept of global electric circuit (GEC) developed only in the early twentieth century making further progress in the first decades of the twenty first century. The atmospheric electromagnetic coupling, starting from the Earth's surface to the upper ionosphere occurs almost at the speed of light, whereas other mechanical coupling processes happen at a much slower rate [Rycroft, 2006]. Atmospheric conductivity plays the most vital role in coupling the lower regions of the atmosphere and the ionosphere. Pure theoretical modeling of the electrostatic coupling between the troposphere and ionosphere dates back to the year 1973 [Park and Dejnakarintra, 1973]. Several theoretical models in this topic are available in literature. But in each of these models, one or different atmospheric parameters governing the distribution of conductivity have been omitted which were taken as first order approximation to the problem. So, our study deals with the development of a global atmospheric model of electricity whose basic structure is based on the foundations led by the previous models but a few modifications infused into it to fill the gaps. In this model, the conductivity (σ) is assumed to vary only along altitude with no horizontal variation. Below $\sim$ 70 km, the effects of geomagnetic field on the atmospheric conductivity are almost negligible so that it is isotropic in this region. Again, in the near-Earth space, radioactivity phenomena such as release of radon and its progenies influence the conductivity distribution. So, its altitude profile is further divided into a number of segments depending on the atmospheric conditions and it is calculated separately in each of these segments which are then combined to give a resultant height distribution. From this conductivity profile and solving the three basic equations, namely, the Faraday's law, the charge conservation law and the Ohm's law, the electrostatic potential and the electric field are calculated. As a result of this electric field, the electrons experience a drift velocity. Incorporating this term into the continuity equation for the total concentration of molecular ions, the altitude profile of electron density is determined. This electron density profile is then used in the Long Wavelength Propagation Capability (LWPC) code to derive the VLF signal amplitude/phase under normal unperturbed situation. Next to consider the effects of lightning and seismic activities, additional changes are incorporated in the model. To study the effects of lightning, the thundercloud is represented by a vertical dipole that suffers repeated lightning discharges and for seismo-ionospheric anomalies, we consider a distribution of radon concentration such that it is maximum over the epicenter and decreases exponentially with distance from it limited within the earthquake preparation zone (EPZ). This anomalous radon concentration is then varied with time in such a way that it begins to increase days to weeks before the occurrence of the main event intensifying only few days before the main shock and diminishing after the event. With these modifications and repeating the same exercises as done for quiet condition, the VLF signal amplitude/phase under disturbed conditions are obtained and compared with observations. Presently, the conductivity profile starting from ground surface up to the ionospheric F-region altitudes have been successfully computed that matches well with the existing dataset. Next, we plan to use this conductivity profile to further calculate the electric field and study its modulations and effects on ionospheric electron density distribution and radio signal propagation under the influence of perturbing events as discussed above.

References

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