Study of the Ionospheric Total Electron Content over central India using Artificial Neural Network

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Extended Abstract

The ionosphere over central India falls very close to the Equatorial Ionization Anomaly (EIA) region where sharp latitudinal gradient in the ionization is observed. It is expected that as the sun shines over the geographic equator, the ion and electron density should be maximum around that region and will go on decreasing towards the poles but the measured values show this density to have a peculiar crest around $\pm$ 15° magnetic latitude and trough around the magnetic equator. The latitudes which fall in the EIA region has the highest concentration of electron density and it is roughly about $2/3^{rd}$ of the global density distribution. A vital parameter to study the ionosphere of the EIA region is the Total Electron Content (TEC) which gets enhanced or depleted according to varying solar activities which originate from the sun in the forms of Coronal Mass Ejections (CMEs) and solar flares. TEC also show seasonal variations.

It is well known in literature that 10.7 cm (or 2.8 GHz) solar radio flux (F10.7 index) is a very good indicator of solar activity and forecasting of space weather. It is reported in Solar Flux Units (SFU) and can vary from below 50 to > 300 SFU over the course of a solar cycle. As the radio emissions come from the chromosphere and corona, it is able to track the Extreme Ultra Violet (EUV) emissions that impact the ionosphere. As a result it becomes a valuable input in predicting the daily variation of TEC. Another important parameter that is closely related to the TEC variations is the Planetary K-index (Kp) or simply the K-index. This is generally used to characterize a geomagnetic storm's magnitude as it is clear that geomagnetic storms cause drastic change in the ionosphere further causing abrupt changes in the TEC variation. Further parameters useful in studying how the TEC could vary are the Disturbance storm time (Dst) index and the southward turned Bz component of Interplanetary Magnetic Field (IMF). The Dst index is the disturbance field which is symmetric axially with respect to the dipole axis. Whenever there is a major storm, the horizontal component of the geomagnetic field gets depressed and this depression is recorded in nT as the Dst index. Supplementing the Dst index is the the IMF, Bz which turns from northward to southward as the onset of storm occurs. Use of these parameters as inputs to a self learning system like the Artificial Neural Network (ANN) would help in predicting the TEC variation during different solar activity phases.

Inspired from the neural networks which constitute animal brains, an ANN has a collection of connected nodes known as the artificial neurons. Each connection similar to the synapses in a biological brain, can transmit a signal from one artificial neuron to another. These connections between neurons are called edges. Artificial neurons and these edges have a weight that self adjust as learning proceeds. This weightage may increase or decrease the strength of the signal at a connection. These neurons have a threshold above which the signal is sent. Generally, neurons are aggregated into different layers that perform various transformations on their inputs. Signals travel from the input or the first layer, traverses multiple layers and finally arrives to the output or the last layer. This paper presents a study on the variation of the ionospheric TEC over Indore using this ANN technique to observe for any correlation with the parameters such as the F10.7 solar radio flux, the Dst index and IMF,Bz and the Kp index that would help in predicting future TEC variations.

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