Variability of solar activity parameters

Chapter 7:

Overall Conclusion and Future Prospect of Research

In the present work, efforts have been given to get an idea of variability of solar activity parameters during the recent solar minimum period and also to understand the effect of the solar activity parameters at the F_2 region of the ionosphere. As our dependence on technological systems operating in and through the outer reaches of our terrestrial environment is continuously increasing, it is very necessary to get a clear idea about the variability of the ionosphere, magnetosphere and the sun itself which is primary source that drives not only our terrestrial environment but also the entire interplanetary domain. The properties of solar activity parameters and the use of GPS derived ionospheric TEC as a tool for investigation of the ionosphere are explained in detail under the current research work. The study shows that the ionospheric variability is well coupled with solar activity parameters and phase of solar activity also. The ionospheric problems studied here are mainly concerned with satellite based navigation.

Over recent years, the solar activity effects of the ionospheric parameters have received renewed interest, and considerable progress has been achieved. The present research work focuses on four aspects – Firstly the behaviour of various solar activity parameters (mainly sunspot and solar radio flux) during the recent solar minimum period. It has been noted from a preliminary study that the correlation coefficient of radio emission and sunspot number was low with respect to the correlation coefficients of previous solar minima. During this minima period, the frequency distribution of correlation coefficient of radio flux and sunspot number is random whether it has a similar pattern for previous three minima which suggest an unusual behaviour of radio flux during this minimum.

Secondly, noting the unusual behaviour of radio flux, a rigorous periodic analysis of basal component of solar radio flux of different frequencies has been done as these frequencies reveal the physical nature of the source regions. The analysis has exposed that during recent extended solar minimum period the large magnetic structures (independent of sunspot activity) of solar coronal region might had a similar rotation with fairly homogeneous structure and towards the chromospheric layers the homogeneity disappears and the rotation rate was also different for different portions of the chromospheres. The periodicities obtained for X-ray flux have also been found in other solar-activity parameters which give an indication that there may be connectivity between sunspot X ray flux and some other solar activity parameters as the periodicities of both types of magnetic structures are nearly matching. This may be an indication to the underlying global mechanism that modulates different.

Thirdly, after getting some idea about the solar activity parameters, efforts have been given to understand the effect of these activity parameters on ionosphere. The earth directed coronal mass ejections (CMEs) from the sun, which result in increased pressure characterized by sudden increases in solar wind velocity, temperature and density as well as large changes in the interplanetary magnetic field (IMF) specially its north–south component (Bz), trigger the geomagnetic storms. These storms affect the ionosphere and makes such studies important from the point of view of space weather related processes. Here the effect of two geomagnetic storm of april and july 2012 on low latitude ionosphere has been studied. During the storms the depression and enhancements in VTEC compared to quiet time means VTEC was observed. This significant perturbation level in VTEC during the geomagnetic storm period may lead to the disturbances in navigation and communications systems which are now a days being used by civilian as well as military. These storm time perturbations in VTEC compared to quiet time mean values are caused by electro dynamical (PPE and DDE) as well mechanical effects (neural wind lifting effects and thermospheric composition changes) which are originated during the periods of geomagnetic storms. So these are the main key factors controlling the low latitude ionosphere’s response to the geomagnetic storm.

Fourthly, a comparative study of the model and in-situ measurement of ionospheric parameters has been done. The last chapter deals on the investigation of the effect of the solar activity parameter on ionosphereric electron content and the investigation has been done by using the in-situ measurement data of the ionosphere. The in-situ measurement of TEC using the GPS and from the IGS stations is not possible from all places. So to understand the global distribution of TEC we need model data. Among all the ionospheric models, International Reference Ionosphere (IRI) is being widely used which is constantly being improved and updated by the scientific committee. In present time the most recent version of this model is IRI 2012. In this chapter, the diurnal, monthly and seasonal variations of the GPS-TEC are compared with those derived from the latest IRI 2012 model from four different stations. The study reveals that TEC with topside option IRI-2001 overestimates the observed GPS TEC in low latitude regions in most of the times and the modeled TEC from other two options of IRI are in agreement with the observed TEC data. The matching between the IRI TEC and observed TEC is totally dependent on the local time, location and phase of the solar cycle and the largest deviations in model and observed TEC occur as a result of poor estimation of foF2 and NmF2 from the coefficients of IRI model.

As the sophistication of our space based technological systems increases rapidly, their vulnerability to disturbances in space weather also increases. Performance of modern satellites used in global communications, weather predictions, remote sensing, defense systems and a variety of ground based scientific and operational systems depends on information we have on our ionosphere. The ionosphere is a highly variable medium and the low latitude ionosphere contributes the maximum variability. So a complete understanding of low latitude ionospheric phenomena is very essential. The Indian subcontinent lies in the low latitude region and thus gives us an opportunity to study the low latitude ionosphere. The north-east India is the region which lies in the EIA zone and hence the data of agartala station has its own importance. Presently we are using the GPS dual frequency receiver as a tool for investigating the low latitude ionosphere. New instrument like ionosonde will be recently installed at our university which will give us a strong support in the ionospheric investigation.

In order to get the idea of the global distribution of TEC, the variation of TEC from all the places need to be studied. But the in-situ measurement of TEC data from all the places is not available. So for this we need to depend on model TEC data. The US based models are best for their region not for Indian regions. So to get the variability of Indian subcontinent's ionospheric region the in-situ measurement from Indian region is mostly important. As we have seen for around 92 degree longitude our study may be a significant input parameter for the modeling of ionosphere. Beside this study, it is expected to extend it for further investigation of ionosphere using GPS dual frequency receiver and ionosonde as tools.