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During Geomagnetic Storms, Ionospheric Scintillation Effects Human Bodies on Equatorial Anomaly Region Bhopal City of India

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Abstract: *GPS L – band signals get affected by ionospheric scintillation as a result satellite navigation too gets affected. The most extreme scintillation activity is expected to occur near the equatorial region during geomagnetic storms. The behavior and morphology of low latitude ionosphere is different from the other latitudes. The space weather conditions in low latitude show different nature because of the geomagnetic field. Due to penetration of soft, high energetic particles the plasma density increases, which is the main source of generation of ionospheric irregularities scintillation. GPS scintillation at low latitudes are primarily associated with equatorial spread F. Equatorial spread F is caused by ionospheric irregularities with a spatial spectrum extending from 100 km to less than 1 meter. When GPS signals encounter the ionospheric irregularities of various sizes produced during high geomagnetic and solar activity. They undergo drastic changes in their phase and amplitude scintillation indices. The accuracy and reliability of GPS system get affected by scintillation. Also observe the atmosphere air molecule's content and deviation of electrons, protons, neutrons according to flow rate. In the present paper we have studied the scintillation activity at low latitude station Bhopal.*

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I. Introduction

The topmost layer of our earth environment that is known as ionosphere and it is ionized by solar radiation and cosmic ray radiation. It appears 75 to 1000 kilometres from the sea-level of the earth. The communication is based on that ionic layer, but due to a scintillation event of geomagnetic storm, highly affected the time domain and distortion or noise appearance in the communication because the scintillation is the term provided to fluctuated amplitude and phase diffractions of the received signals and directly related to the electron density irregularities in the ionosphere[1-4].The main sources of ionospheric fluctuations are plasma instabilities. Due to plasma instabilities, the ionospheric fluctuations are produced after sunset over the magnetic equator[11, 12].

Research shows that these are small scale structures in the ionospheric plasma density so that plasma density variations occur rapidly across the unique orientation of the geomagnetic field, but slowly along the geomagnetic field the scale length of ionospheric fluctuations can range from a few meters to several kilometres across the magnetic field. Research shows that ionospheric irregularities occur in – The aurora and polar cap F-region almost all the time (Aarons & Allen, 1971).In the auroral E-region in times of geomagnetic activity (Greenwald, 1973).In the equatorial E-region (Balsley & Farley 1973).In the equatorial F-region at night (Farley, 1970).Temperate latitude only in the night time F-region during times of geomagnetic activity (Herman, 1966)[12-18]. The ionospheric irregularities present a large dependence on the solar flux, the local time, the season, the latitude and longitude and the magnetic disturbances[10].

The phase and amplitude of a radio signal passing through these irregularities undergo significant fluctuation and these fluctuations are the cause of degradation in the GPS navigation accuracy and limitations of the GPS system tracking performance[13].

Scintillation observations have been used to identify and diagnose irregular structure in highly varied propagation media. Research fields like atmospheric physics, geophysics, ionospheric physics, ocean acoustics, astronomy and radio physics have benefitted through scintillation research. Voluminous studies based on observations have been performed on ionospheric amplitude and phase scintillation[1-3]. The major scintillation activity has been observed during the solar maximum period, near the magnetic equator and in the midnight sector .The equatorial scintillation is mostly produced by F-layer irregularities, it may also occur during the day and it varies with magnetic and solar activity, time, season and latitude[5-8].

The solar Geomagnetic storms have a very low effect on the earth. The earth's atmosphere and its layer protect to humans from the solar flares, but due to cosmic ray radiations affected our forbush, temperature, climate, electrical phenomenon, health of human and animals of earth[7].

In the rest part of the paper, section II – parameters and methodology, section III – Observations of ionosphere, section IV - Effect of Geomagnetic Storm, section V - Results and Discussion. Finally, section VI - conclude the final outcomes in conclusion.

II. Parameters And Methodology

To accomplish this study,

- Dst index (disturbance storm time index is a measure of geomagnetic activity used to assess the severity of magnetic storms).
- GPS amplitude scintillation, $S4$ index (The S4-Index is a measure to describe the amplitude- respectively the intensity fluctuations of a signal) have been used.
- Altitude(km)- the height from the sea-level or the Earth used for charged particle.

We have selected the geomagnetic storms that occurred during the year 2014-15. We have selected only those geomagnetic storms events for which the GPS data were available.

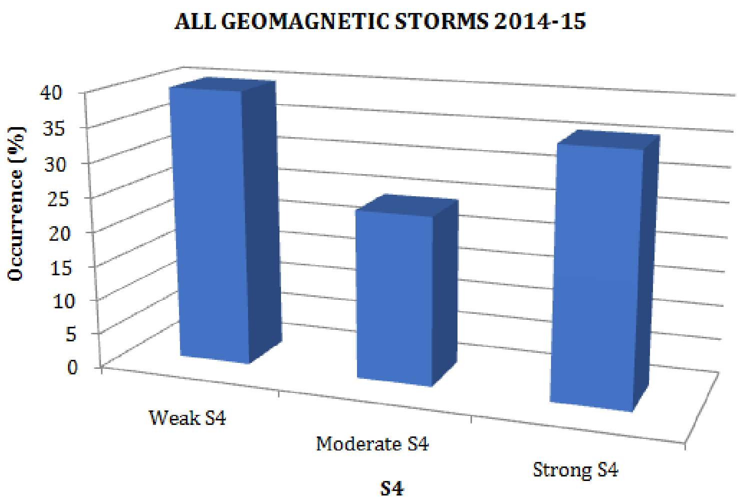
Based on the intensity of Dst index we could have observed the occurrence of geomagnetic storms and we have divided the selected geomagnetic storms into three categories – Intense Geomagnetic Storms, Moderate Geomagnetic Storms and Weak Geomagnetic Storms.

The ionospheric scintillations have been measured using a 12-channel dual frequency NovAtel GPS receiver with embedded software to calculate and store TEC values in HDD of the PC via and RS -232 cable. The primary purpose of the GSV 4004 GISTM is to collect ionospheric scintillations and TEC data from all visible GPS satellites. In order to detect the occurrence of amplitude and phase scintillation activity the analysis took into consideration that the S4 measurements from the GPS satellites must exceed values of 0.5. On the bases of S4 index we also classified the percentage of occurrence of geomagnetic storms.

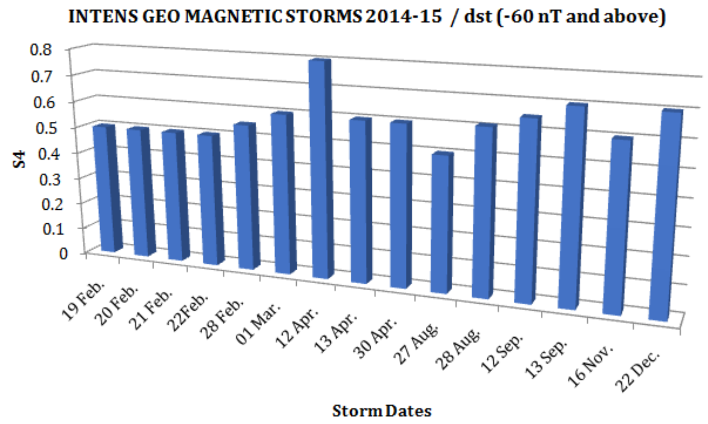
We then identified scintillations observed during all the categories of geomagnetic storms separately.

III. Observations Of Ionosphere

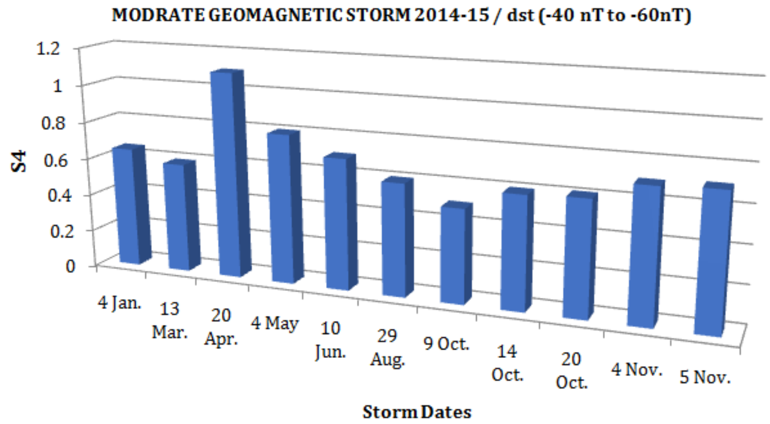
Figure 1: We have observed a number of geomagnetic storms in the year of 2014-15. We have analyzed all the Intense, Moderate, Weak geomagnetic storms and S4 index.



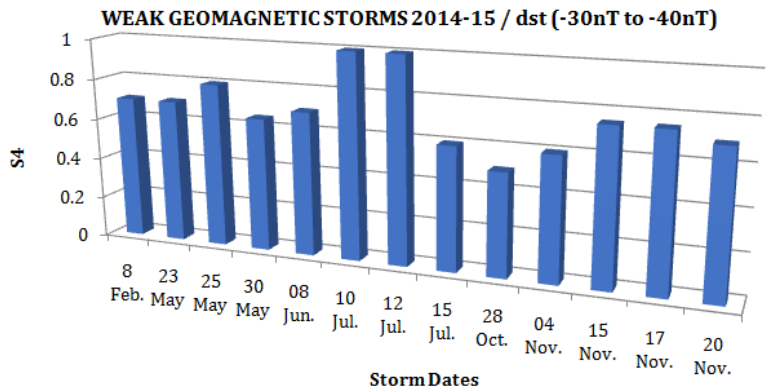
(a) Occurrence vs S4.



(b) S4 vs Storm dates.



(c) S4 vs Storm dates.



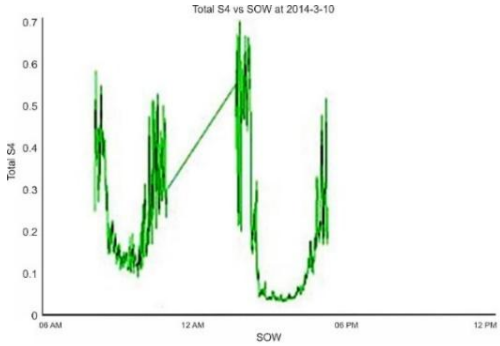
(d) S4 vs Storm dates.

In the above figure 1(a), we can see the occurrence percentage of S4 geomagnetic storm. Here we can categorize in three level weak, moderate and strong. Here we can see the weak S4 have highest percentage of occurrence compare to remaining to levels. And moderate S4 occurrence have lowest and Strong S4 have medium percentage of geomagnetic storm. In the above figure 1(b), we can see the different dates of 2014 with S4 but here only we can represent only intense geomagnetic storm. And here we can see 12 April 2014 have a highest intensity Geostorm of the year. In the above figure 1(c), we can see the different dates of 2014 with S4 but here only we can represent only moderate geomagnetic storm. And here we can see 20 April 2014 have a highest moderate Geostorm of the year. In the above figure 1(d), we can see the different dates of 2014 with S4 but here only we can represent only weak geomagnetic storm. And here we can see 28 October 2014 have a highest weak Geostorm of the year.Some of the patterns are shown below-

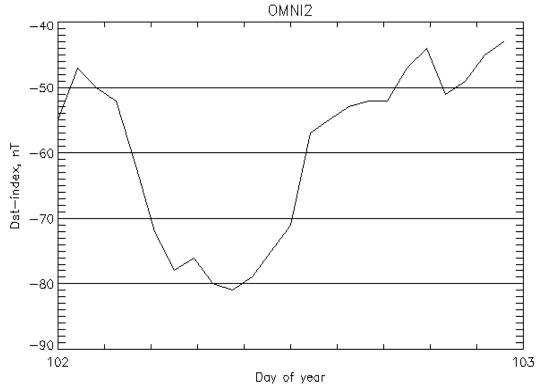
Figure 2: show that the geomagnetic storm according to different dates of year 2014 and each date have S4 and Dst performance.

12 April 2014 (Intense Storm)

S4

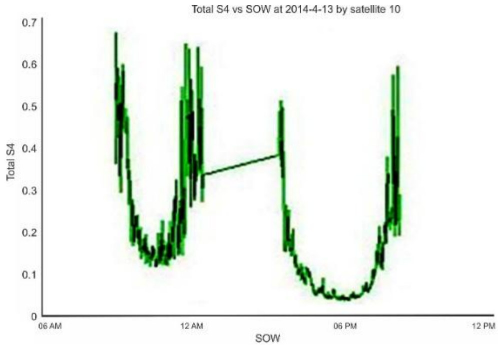


Dst

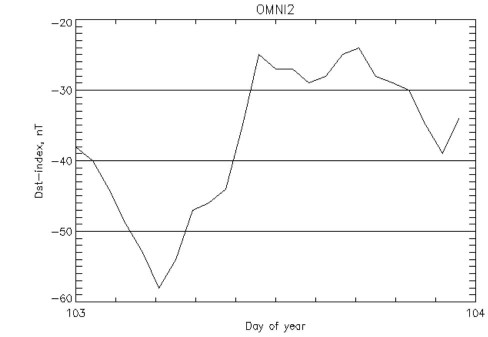


13 April 2014 (Intense Storm)

S4

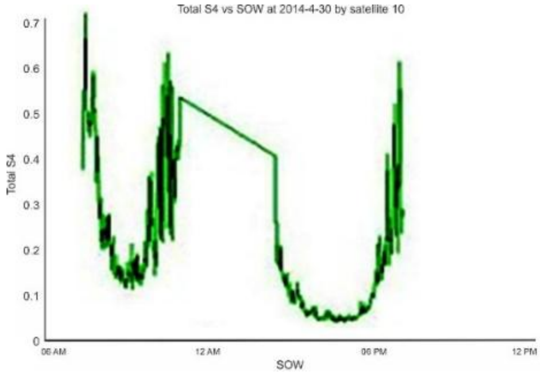


Dst

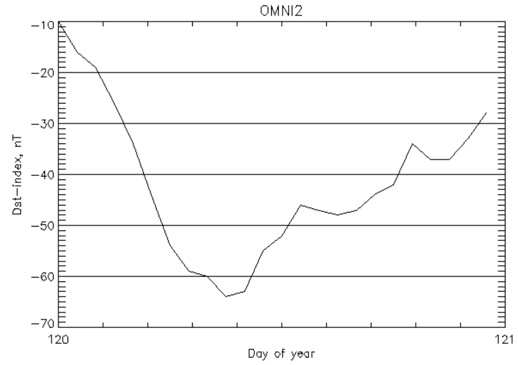


30 April 2014 (Intense Storm)

S4



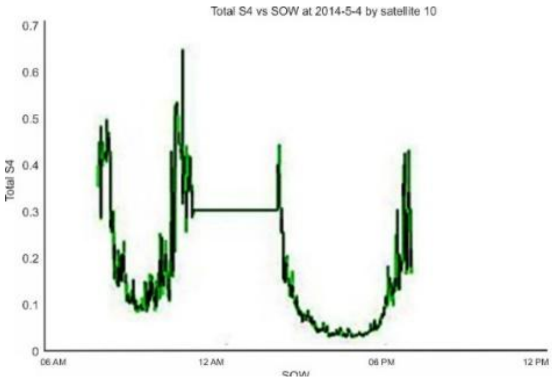
Dst

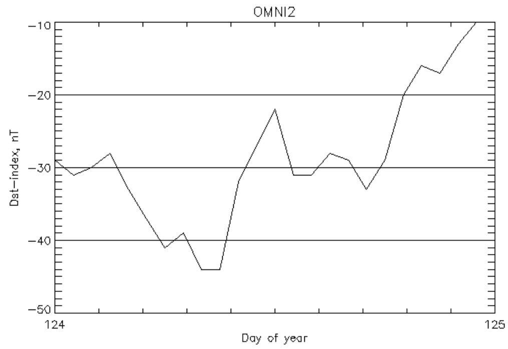


4 May 2014 (Moderate Storm)

S4

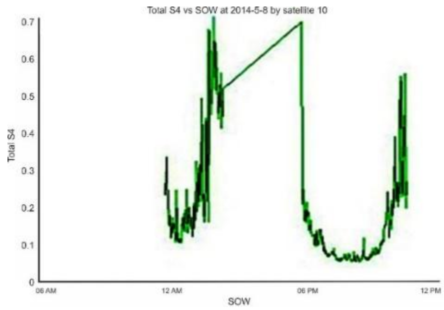
Dst

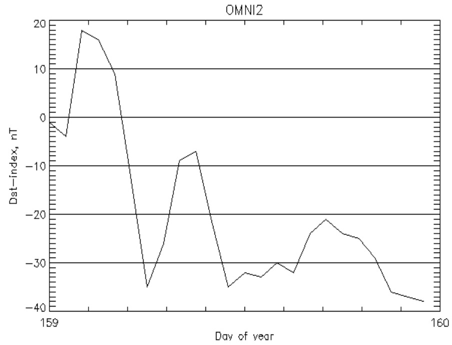




8 June 2014 (Weak Storm)

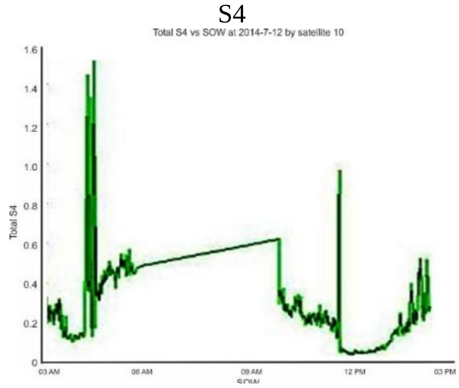
S4 Dst

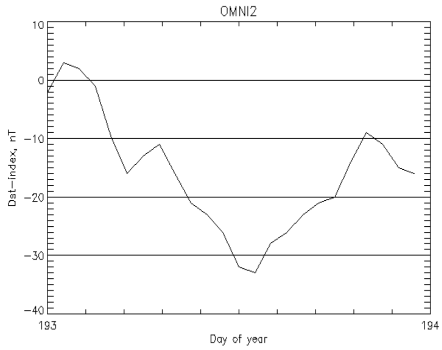




12 July 2014 (Weak Storm)

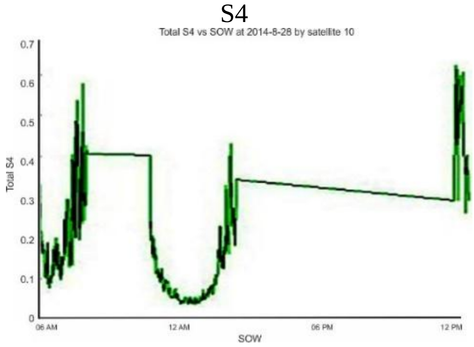
S4 Dst

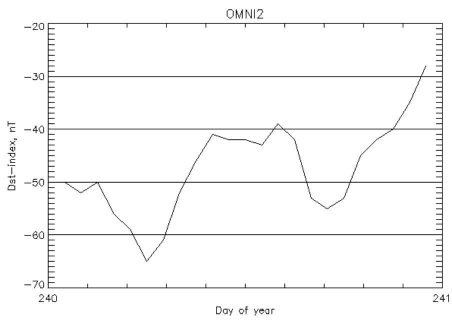




28 August 2014 (Intense Storm)

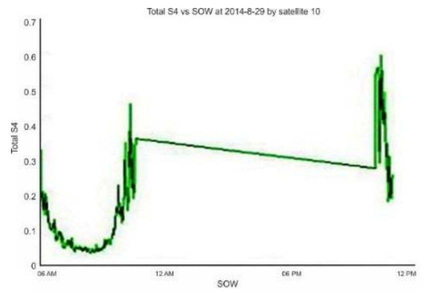
S4 Dst

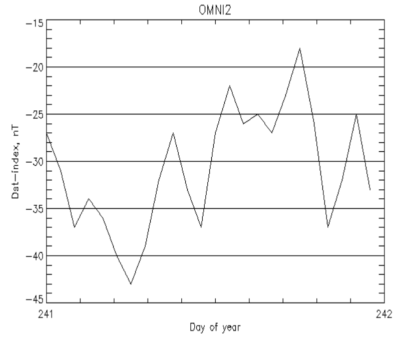




29 August 2014 (Moderate Storm)

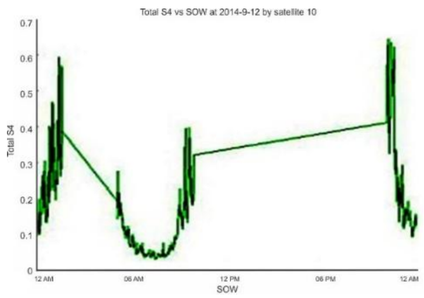
S4 Dst

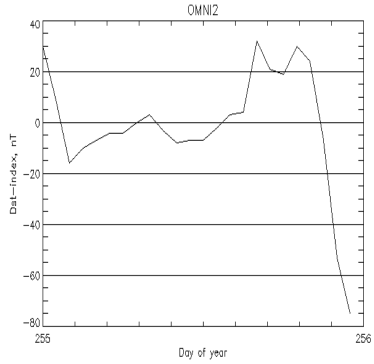




12 September 2014 (Intense Storm)

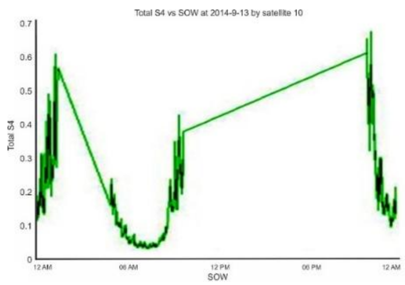
S4 Dst

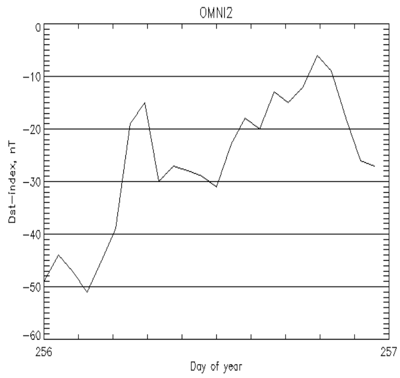




13 September 2014 (Intense Storm)

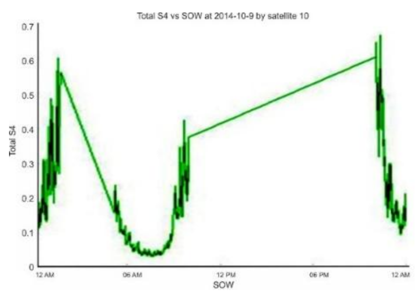
S4 Dst

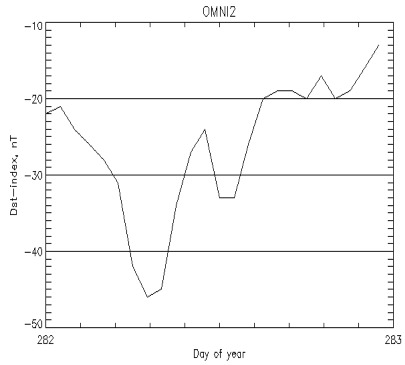




9 October 2014 (Moderate Storm)

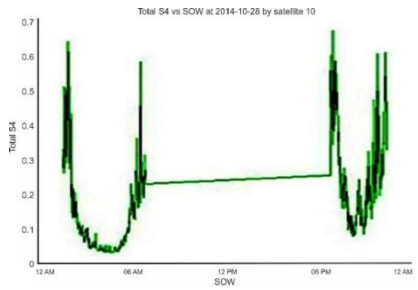
S4 Dst

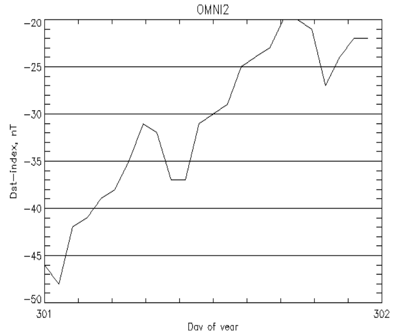




28 October 2014 (Weak Storm)

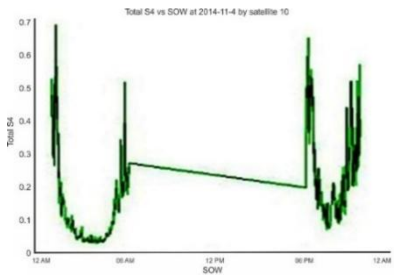
S4 Dst

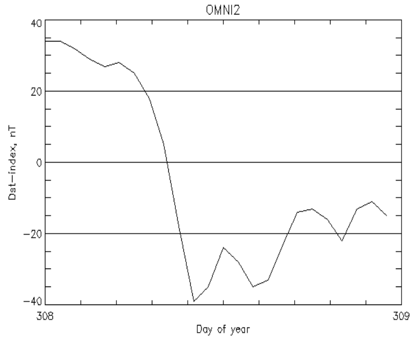




4 November 2014 (Moderate Storm)

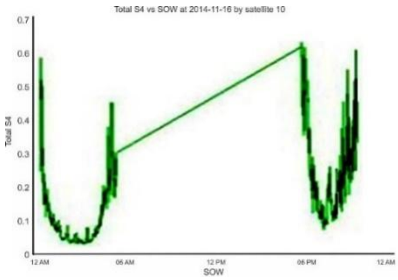
S4 Dst

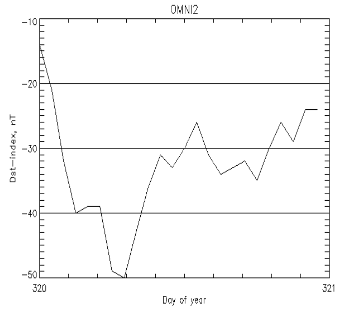




16 November 2014 (Intense Storm)

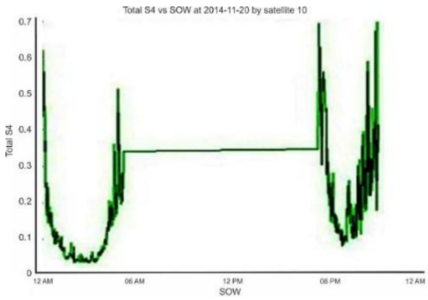
S4 Dst

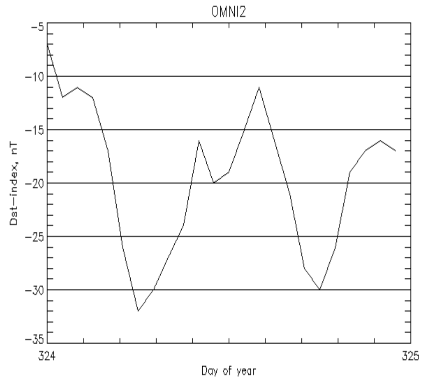




20 November 2014 (Weak Storm)

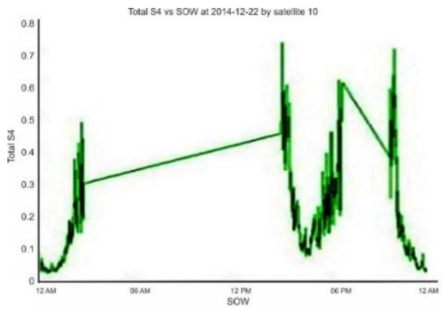
S4 Dst

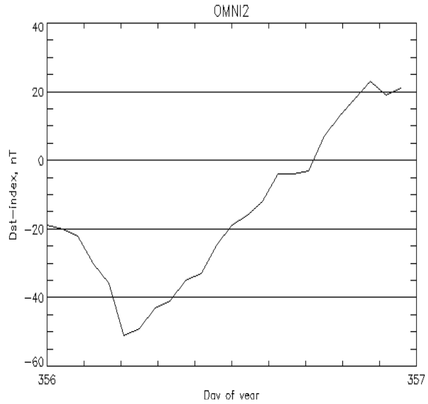




22 December 2014 (Intense Storm)

S4 Dst

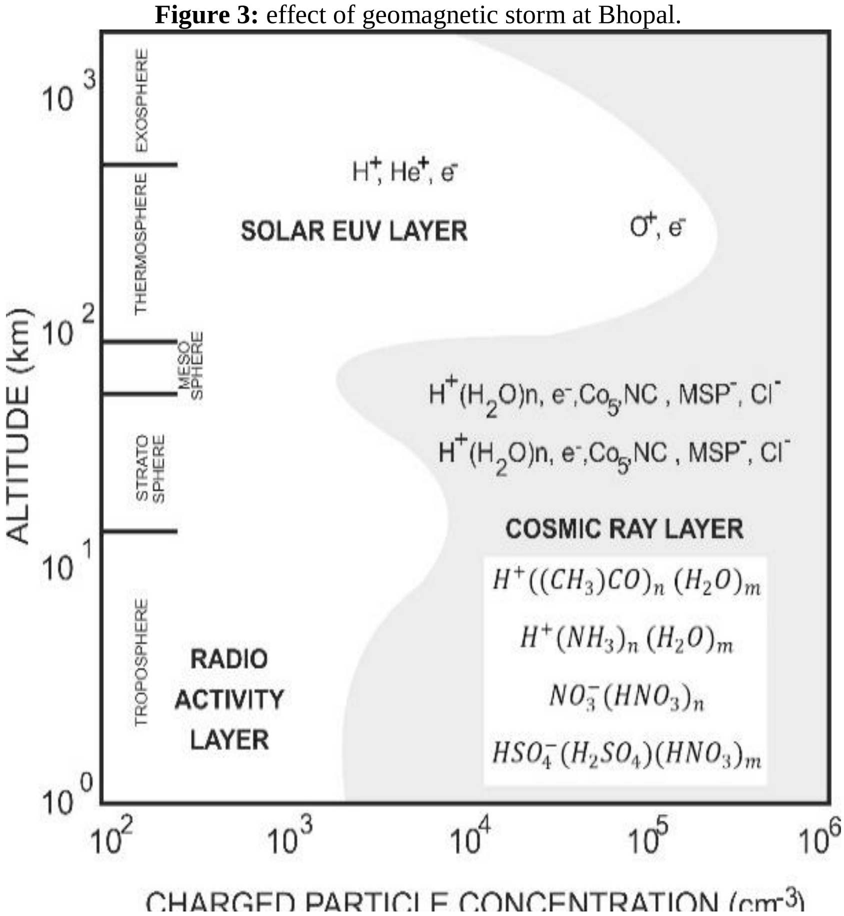




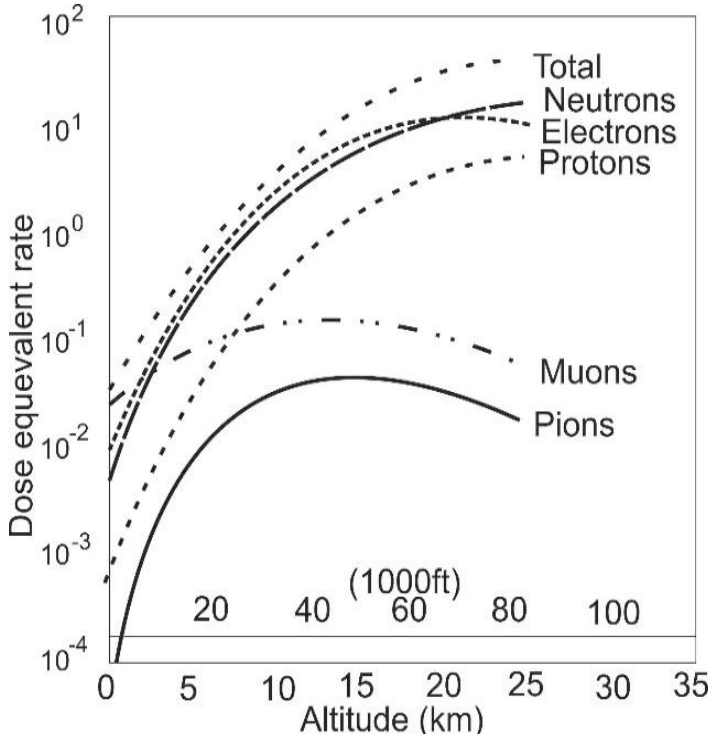
IV. Effect of Geomagnetic Storm

Increased the forbush reduce in cosmic ray intensity considered by latitudes 23.2599° N during this geomagnetic storm. And here we show the effect on this station graphically. The flow rate of the galactic cosmic rays show on the upper atmosphere is liked by the solar wind and the geomagnetic area's field. The cloud cover and GCR fluxes are striking correlations on long time scale are considered as according to short time scale no countable correlation is found. These considerations are related to climate variations on the short time duration as well as long time. On terrestrial processes, the cosmic ray really affected the Bhopal station in the term of electrical scenario, cloud production process, variation of temperature, climate and human health.

Figure 3: effect of geomagnetic storm at Bhopal.



(a) Changes in air molecule's content.



(b) Cosmic rays functioning during geomagnetic storm.

According to figure 3, here discussed the perspective of that so (a) Ionization density-height profile of the Earth's atmosphere and the major ion species at various altitudes. (b) Radiation exposure due to cosmic rays as a function of latitude at 23.2599° N geomagnetic latitude. The radiation exposure to specific nucleons is also illustrated.

To become imperative to observe the temporal variations of the global electric circuit and the mechanisms responsible. It is enhancing the charge moment of thunderstorms. By the influence of radiation, the human nervous system affected very low rate.

V. Results and Discussion

The observations show that high magnitude scintillation (0.5 or above) has been observed during the period of every geomagnetic storm (Intense, moderate, weak).For intense and moderate geomagnetic storm, the magnitude of scintillations reaches to high while the magnitude of scintillation was low for weak geomagnetic storms as compare to the intense and moderate geomagnetic storms .It was also observed that the scintillation activities were higher too at sometimes when there was no storm i.e. if the S4 is higher it doesn't mean that the storm will be occurred.

Geomagnetic storms can occur any day, any time, but according to our study, they are generally occurred after sunset or in the early morning hours at low latitudes. The geomagnetic storms are harmful to electrical transmission equipment, especially transformers - inducing core saturation, constraining their performance (as well as tripping various safety devices), and causing coils and cores to heat up .The moderate geomagnetic storms prevailed for a short period of one hour to many hours, reaching to a high intensity, mostly one time in a day, but sometimes it reaches to high intensity many times in the day.

Moderate geomagnetic storms sometimes followed by an intense storm throughout the day .We have also found that the greater number of geomagnetic storms occurred in equinox months. The geomagnetic activities are low in the winter and summer months. The intensity of the storms was low too in these seasons .It is observed that S4 reaches to its high within the range of one hour before and one hour after the high intense geomagnetic storm of the day.

In the figure 1 observed that the maximum S4 values occurred at 16:46Hrs local time (558960s). At that time, C/No and Phase scintillation values are decreased, which is evident of strong scintillation. The intensity (S4 index) of the scintillation activity is stronger around the equatorial ionization anomaly (EIA) region in the Indian region. During the intense scintillation events, the GPS receiver is found to lose its lock reducing the number of satellites available which in turn decrease the probability of position ionospheric radio wave communications and the GPS-based navigation systems. Figure 2(S4) shows scintillation event observed at the Bangalore station on 17th July 2004 for the same satellite PRN No.1. It can be seen that, no scintillation activity observed during that time. Hence, scintillations are highly variable with respect to spatially and temporally. Figure 2 (Dst) show scintillation event observed at the Bhopal station(23.2599° N) on 17th July 2003 for the same satellite PRN No.1. It can be seen that, a slight scintillation activity is observed during that time. Hence, scintillation occurrences are related to magnetic and solar activity (solar cycle), time of day, season and location. Figure 3 (a) and (b) indicates the harm of the Bhopal station or earth.

VI. Conclusions

A good correlation was found between Dst index and S4 index. Ionospheric scintillation can affect the performance of GPS positioning and navigation systems. As a warning system real time scintillation detector can be implemented. An ionospheric scintillation event result observed at Bhopal station is presented. The probability of occurrences of such scintillation events will be analysed. The geomagnetic activity on Earth's atmosphere has significant effects on technology, power grid and relative temperature on Earth. We conclude the final observation of effect of air molecule's ionised in the presence of cosmic radiation appear according to altitude and dose equivalent rate according to altitude in kilometres get higher rate neutron, electron and protons. These reasons affect human bodies. A model should be developed for now and prediction of forecasting the ionospheric scintillations. Based on forecasting, the solar flare ejected the cosmic ray radiation affected our Earth layer and atmosphere. The outcome of the research work will be useful for the understanding the morphology of GPS ionospheric scintillation. It would be helpful for communication, navigation systems and also helpful to health related issues of human being, produced by the ionization and temperature variations.

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