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Magnetic storm time effect on upper and lower atmosphere: An analysis through GPS and remote sensing observation over Guwahati

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The role of solar geomagnetic factors on the upper atmosphere is though well studied, their effects at the lower atmosphere are yet to be understood. The paper is an attempt to examine association if any between ionospheric variabilities and lower atmospheric parameters at different solar geomagnetic ambiances. For this purpose total electron content (TEC) data collected at Gauhati University (26°10' N, 91°45' E) from GPS observation and temperature and wind data received from Radiosonde and satellite data are utilized. The study carried out for Low, Medium and High solar activity conditions. The result shows strong association of positive and negative ionospheric effects on tropopause temperature during strong geomagnetic storm situation in high solar ambiances. The possible causes especially related to appleton anomaly crest zone are highlighted.

Keywords: TEC (total electron content), GPS, Magnetic storm, Tropopause temperature, Wind parameter, Sunspot number.

1 Introduction

The upper atmosphere and the role of contribution of solar geomagnetic factors in this region have been well studied for the last few decades. It is well known that dynamical and diverse features of the ionosphere more so during geomagnetic situation, there is still a need to understand the behavior of ionosphere during geomagnetic storm events especially on anomaly crest region like Guwahati. Effects of geomagnetic storms on TEC have been studied at a large number of stations covering almost the entire globe[1-8]. There are still not enough evidences in the role of such disturbances in the lower atmosphere. There are only a few reports presenting changes in the lower atmosphere parameter like temperature, wind during magnetic storm[9]. The complex nature of the magnetic storm time variation caused by large number of factors from prompt penetration of high latitudinal electric field, disturbances in Dynamo Electric field (DDE)[10-13] and also injection of charged particles and generation and penetration of high energetic charge make the entire atmosphere system from lower to upper very complex[14].

Under this background, the paper examined the correlation if any between ionospheric parameter like TEC and lower atmospheric variability like temperature and wind during magnetic storm and at different solar situation. For this purpose TEC data are collected from GPS receiver installed at Gauhati University and temperature data are collected from Radiosonde operated at Guwahati and satellite data has been used to study the wind velocity at 23 °N - 28 °N Lat and 87 °E - 97 °E Lon at 80 km grid.

2 Data and Analysis

The work is based on Faraday Rotation data collected through two different L-band frequencies that are used to determine TEC from orbiting satellites. At Gauhati University (26:2 °N, 91:75°E) laboratory, a GPS receiver set up has been used for collection of TEC data for medium solar activity (MSA) and low solar activity (LSA) period whereas for high solar activity (HSA) period, FR data are collected through satellite radio beacon (RB) signal like AST-6 and ETS-II. The Geomagnetic index data are collected from World Data Center for Geomagnetism, Kyoto, Japan and lower atmospheric parameter viz. tropopause temperature is collected from Radiosonde data operated at Guwahati. For the experiment, wind data are also considered at23 °N – 28 °N Lat and 87 °E - 97 °E Lon at 80 km grid. Here Dst profiles are examined regularly. In the present study, the geomagnetic storm events are studied

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which are occurred during high solar activity period (1980-81) and medium solar activity period (2011-12) has been analyzed in detail. As a reference, a moderate geomagnetic storm of July 2009 has also been measured under low solar activity period.

In this paper, certain approach has been adopted for selecting the TEC fluctuation during geomagnetic storm from the normal quiet day TEC pattern. Firstly 10 quietest days have been selected for the concerned month and hourly average has been marked for each day. Similarly standard deviation has also been calculated for the same 10 quiet days on the hourly basis using the following formula:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - x')^2}$$

Where σ = standard deviation, x_i = each value of data set, x' = the average mean of the data and N = the total number of data points

Utilizing this technique, the quiet day average of TEC of every hour of each day for the month is obtained and the variation of excursion of these values from the ±SD limits is obtained. The diurnal TEC excursion for each hour of the day is then calculated from the [TEC (mean) +S_D].

The storms are classified on the basis of the intensity of Dst index as listed below in the Table 1.

3 Observations

3.1 TEC variations during magnetic storm of April 1981(HSA)

Figure 1(a) has been drawn from April 7-17, 1981 during strong and severe geomagnetic storm event with Dst = -311 nT for high solar activity (HSA) period. To examine sensitivity of the upper ionosphere variable with the tropopause temperature, TEC fluctuations during storm period over quiet days, maximum standard deviation (S_D+) has been considered and are presented in the figures ±5 days before and after the onset day of the geomagnetic storm. From Fig.1 (a) one can see a negative phase of TEC to about 60% from its average S_D TEC profile on 12 April 1981 followed by a decrease of TEC to another 40% from its S_D limit on 13 April 1981.The variation of TEC (enhancement or depletion from its quiet day value) reduces both in magnitudes and duration with recovery of storm.

Again to understand the relation between TEC and the tropopause temperature, ∑Kp, TEC and tropopause temperature from 7th to 17th July 1981 have been drawn in Fig. 1 (b and c) respectively. Temperature variation at 100 mb height has been drawn against the geomagnetic event of 12 April 1981 along with the variation of TEC peak which have been extracted from the daily TEC pattern. From the above two figures one can conclude that with the decrease of the TEC peak on the onset day, there is also a decrease of temperature by 6K on the storm day where ∑Kp = 51.

3.2 TEC variations during magnetic storm of July1981 (HSA)

The S_D plot of the geomagnetic storm for 25 July 1981with Dst = -226 nT is shown in Fig. 2 (a). It is clear from the plot that storm induced TEC changes its phase alternately from +ve to the –ve values. A clear +ve phase during postnoon on 24 July and a –ve phase during the day hours of the event are well received from the plot and this duration decreases as time progresses and reduces till the second day of the event.The duration of negative phase decreases with the weakening of storm and tries to return to its quiet day value.

Similarly, in Fig. 2 (b and c), ∑Kp index and TEC peak, tropopause temperature are plotted respectively. Here, both the temperature and TEC peak follows a decreasing trend on the storm day by 4K and 40% decrease in TEC, respectively from its S_D limit.

3.3 TEC variations during magnetic storm of October1981 (HSA)

Figure 3 (a) shows the S_D variation of the TEC covering a strong magnetic stormon 20 October 1981 with Dst = -192nT. On the day of the event, morning time negative phase is observed followed by an enhancement of TEC with the onset of SC if it occurs during prenoon hours. The noon time TEC may be 50% high from its average S_D limit. The magnitude of positive effect depends on the severity of the storm.

Figure 3 (b and c) has been drawn against the geomagnetic ∑Kp index from 15-25 October 1981 and TEC, tropopause temperature profiles, respectively.

Table 1 — Number of geomagnetic storm events along with Dst index, ∑Kp index and sunspot number, Rz.

Event	Dst-index	∑ Kp	Rz
12 April 1981	-311nT	51	305
25 July 1981	-226nT	53	304
20 October 1981	-192nT	41	297
22 July 2009	-83nT	25	12
9 March 2012	-131nT	44	110
15 July 2012	-127nT	47	129

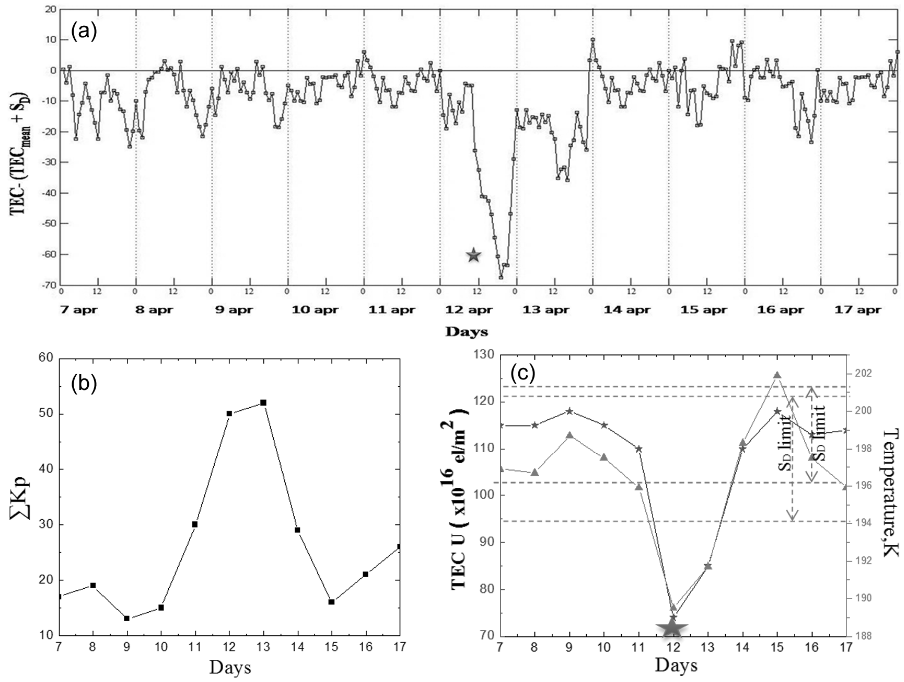

Fig. 1 – (a) SD (average) plot of TEC during April 1981 magnetic storm. The ★ mark represent the geomagnetic storm event of 12 April 1981, (b) Kp variation during 7 – 17 April 1981 and (c) TEC and Tropopause temperature during geomagnetic event of 12 April 1981.

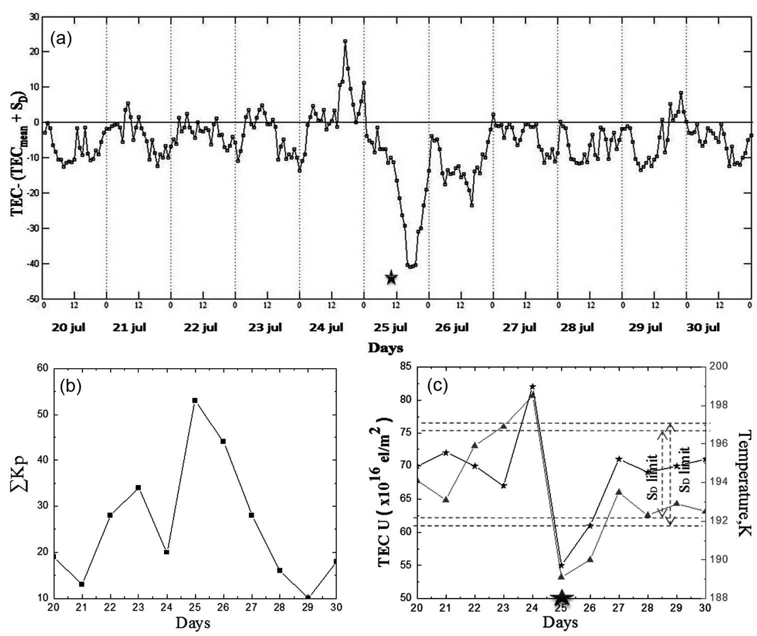

Fig. 2 – (a) SD (average) plot of TEC during July1981 magnetic storm. The ★mark represent the geomagnetic storm event of 25 July 1981, (b) Kp variation during 20 – 30 July1981 and (c) TEC and Tropopause temperature during geomagnetic event of 25 July 1981

The ∑Kp goes to 41 on the storm day and this effect can be seen in the TEC peak and the tropopause temperature, respectively, which presents that in both the case, with the increase of the TEC peak on the onset day, there is an increment of temperature to about 3 K on the same day.

3.4 TEC variations during magnetic storm of March 2012 (MSA)

The effect of a typical geomagnetic storm during medium solar activity (MSA) period on TEC variation at our station is shown in Fig. 4 (a). This is the case of 9 March 2012 geomagnetic storm with Dst = -131nT.

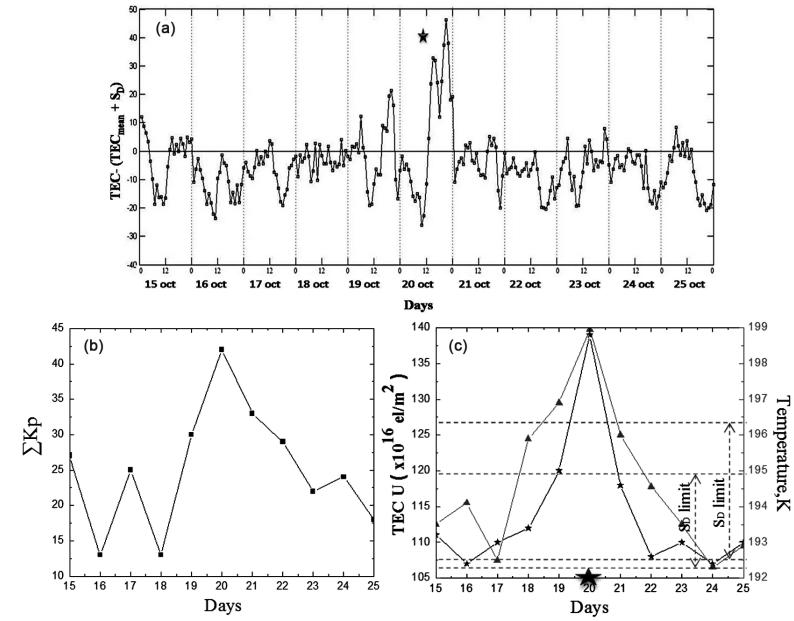

Fig. 3 – (a) SD (average) plot of TEC during October 1981 magnetic storm. The ★ mark represent the geomagnetic storm event of 20 October 1981, (b) Kp variation during 15 – 25 October1981 and (c) TEC and Tropopause temperature during geomagnetic event of 20 October 1981.

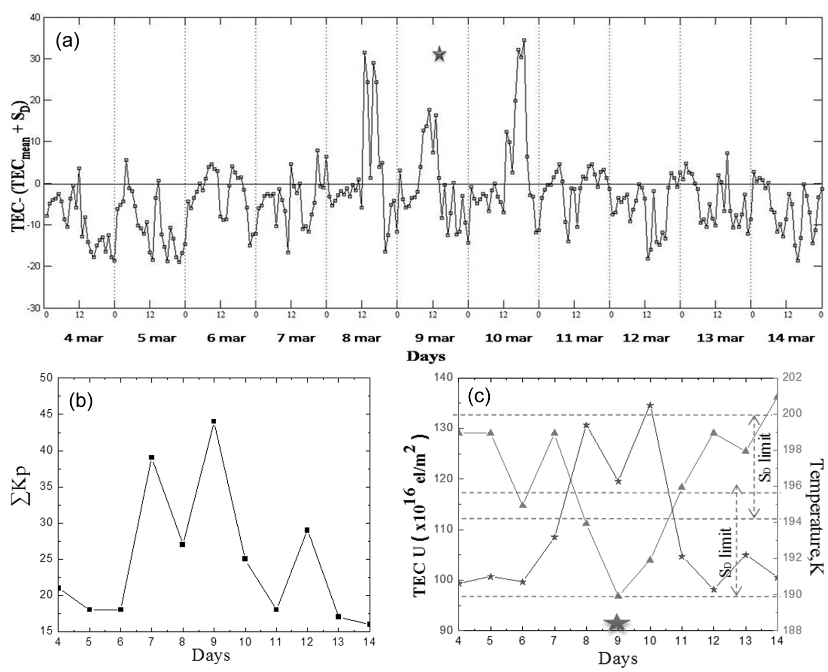

Fig. 4 – (a) SD (average) plot of TEC during March2012 magnetic storm. The ★mark represent the geomagnetic storm event of 9 March 2012, (b) Kp variation during 4 – 14 March 2012 and (c) TEC and Tropopause temperature during geomagnetic event of 9 March 2012.

TEC shows an enhancement both on storm day by 20% and SSC day by 30% at 12.00 IST from its S_D limit. But there is a surprisingly enhancement of TEC by 35% even after a stormy day. The noontime TEC magnitude though observed to be always high from its average S_D limit irrespective of severity of storms, the growth and decay rate may be different with the storm intensity.

Again in Fig. 4 (b and c), ∑Kp, TEC and tropopause temperature are plotted from 4th to 14th March 2012 and it is observed that a decrease of temperature to about 3 K on the day of the event is found. In this case, it can be seen that the tropopause temperature doesn't follow the similar trend of TEC as presented in the above cases (1-3) of high solar activity period. However, in this case one of the reasons for decrease of temperature may be because of high influence of E- phase QBO.

3.5 TEC variations during magnetic storm of July 2012 (MSA)

Similarly, the geomagnetic storm event for 15 July 2012 where Dst = -127 nT, the TEC shows periodic variation of +ve and –ve phase with time. On 14 July 2012, the morning time TEC build up rate is larger than normal S_D limit and this +ve phase continues up to post noon hours of the day as illustrated in Fig. 5 (a). On the day of the event, a –ve phase of TEC starts and reaches to about 50 % and this lasts till the second day of the storm. It is noted that the basic behavior of storm induced TEC during July 1981 and July 2012 are fairly similar which shows a positive phase on the day before the event followed by a negative phase on the onset day.

Figure 5 (b and c) have been drawn against ∑Kp and TEC, tropopause temperature indicating a strong geomagnetic storm on 15 July 2012 where an increase of temperature to about 3 K on the storm day is found and it lasts for the next three days of the event. As seen in the 3.4, here too the TEC and tropopause temperature doesn't follow the same direction. The E-phase of QBO was present during January to April 2012 and W-phase QBO was present during the rest of the year. Therefore, we can conclude that there is no direct relationship between TEC and tropopause temperature for MSA period. However, the changes in temperature may be due to the QBO phase.

3.6 TEC variations during magnetic storm of July 2009 (LSA)

This is a special case considering a moderate geomagnetic storm of 22 July 2009 with Dst = -83 nT which is a low solar activity period. On the event day as indicated in the Fig. 6 (a), TEC shows an enhancement from the average S_D limit to about 10%. The daily variation of ∑Kp is also plotted in the Fig. 6 (b). But the tropopause temperature drawn against the geomagnetic event as shown in Fig. 6 (c) does not seem to change with the change in TEC. Or it can be said that in low solar activity period geomagnetic disturbances have no influence on tropopause temperature.

From the above observation it is seen that and the tropopause temperature is dependent on the ionospheric TEC with respect to the intensity of the geomagnetic storm. To examine the correlation between TEC and the tropopause temperature during the geomagnetic storm events, following diagram has been established.

Figure 7 shows the correlation between TEC and tropopause temperature during the high, medium and low solar activity period. It is observed that during

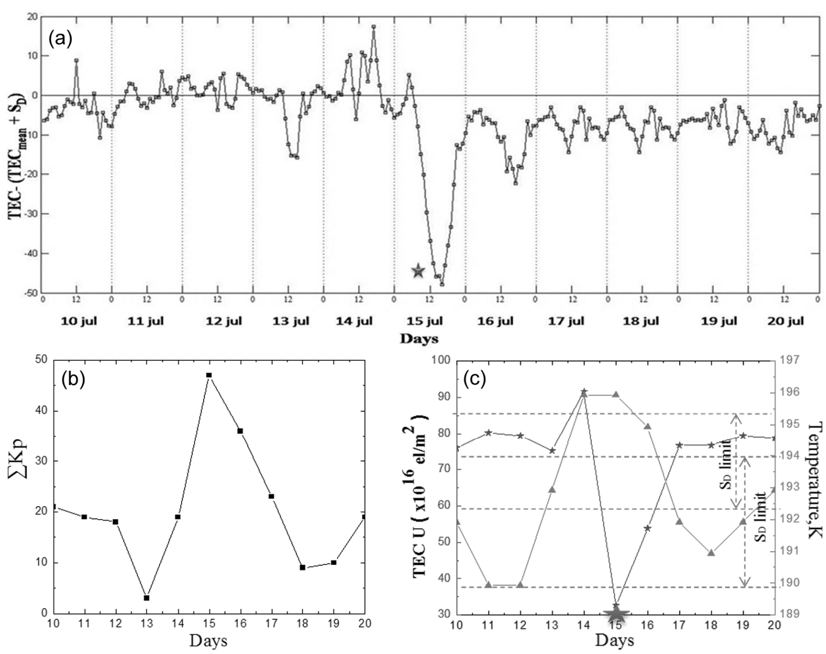

Fig. 5 – (a) SD (average) plot of TEC during July 2012 magnetic storm. The ★ mark represent the geomagnetic storm event of 15 July 2012, (b) Kp variation during 10 – 20 July 2012 and (c) TEC and Tropopause temperature during geomagnetic event of 15 July 2012.

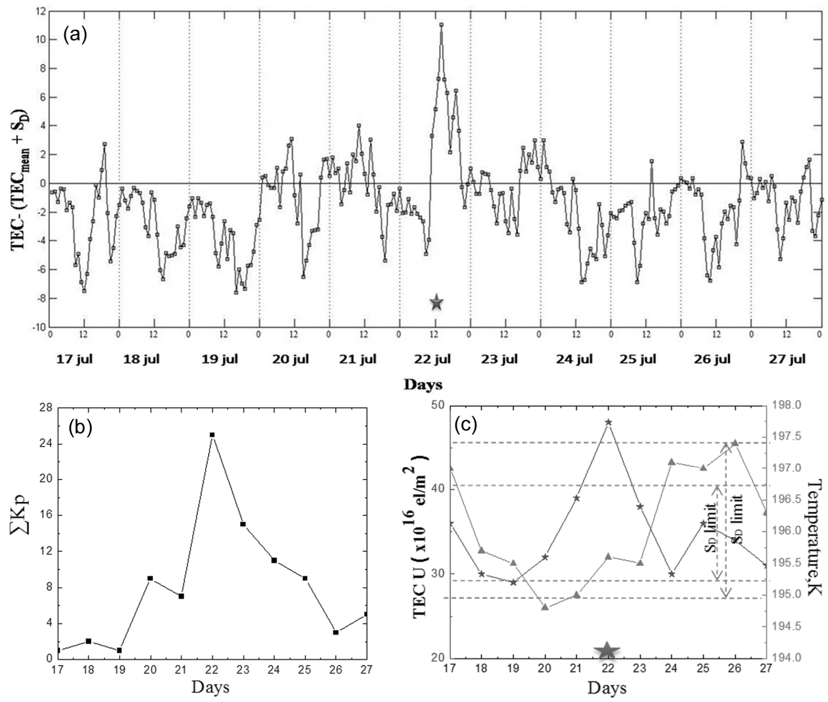

Fig. 6 – (a) SD (average) plot of TEC during July 2009 magnetic storm. The ★ mark represent the geomagnetic storm event of 22 July 2009, (b) Kp variation during 17 – 27 July 2009 and (c) TEC and Tropopause temperature during geomagnetic event of 22 July 2009.

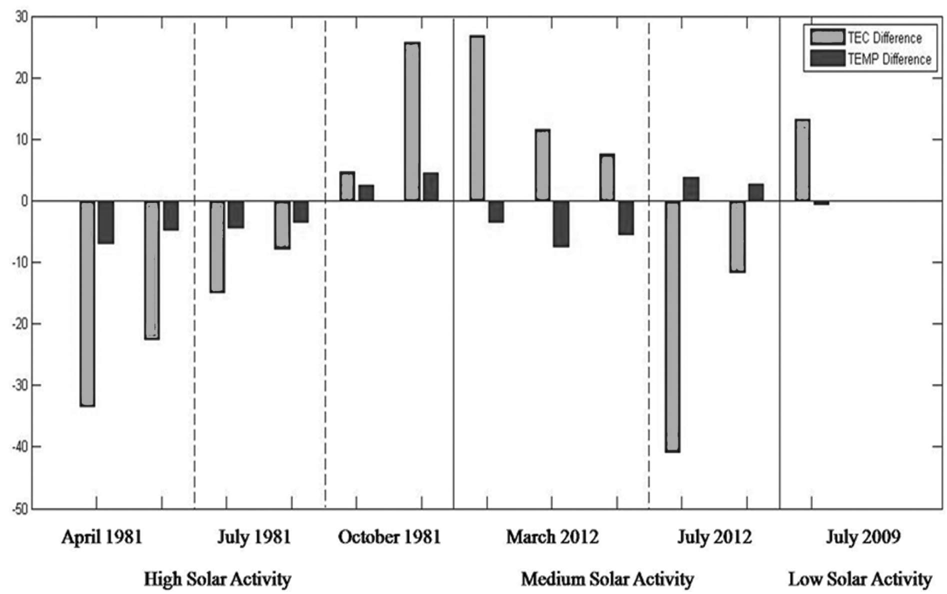

Fig. 7 – Histogram of TEC and tropopause difference for high, medium and low solar activity period.

HSA period, basically for April 1981 and July 1981 magnetic storm, when TEC decreases, tropopause temperature also decreases. While for October 1981 magnetic storm, temperature increases with the increase in TEC. But during MSA period, there is a decrease of temperature with the increasing TEC for March 2012 magnetic storm. Similarly for July 2012, increase of temperature is found to exist with the decrease in TEC. Or it can be concluded that the increase and decrease in temperature during MSA period is basically due to the effect of QBO phase. In the case of LSA period, it is seen that TEC is independent of tropopause temperature.

4 Discussions

From the above results it is observed that during high solar activity period with sunspot number above 300, TEC shows a decrease to about 40% to 60% from its S_D TEC profile for strong geomagnetic storm event with Dst<-200nT. But in the case of medium and low solar activity periods, the TEC values have both negative and positive effect with respect to S_D TEC limit without showing much relation either with the intensity of the storm and the sunspot number. As a consequence it is seen that the ionospheric phenomenon are fairly complex during strong to severe geomagnetic disturbances. The situation is far more complex over anomaly crest station. Such situation is difficult to explain through only storm induced disturbances in the ionosphere such as Prompt Penetration of high latitudinal electric field, heating by particle precipitation, disturbances in dynamo electric field (DDE) and also injection of charged particles and generation and penetration of high energetic charge are some of the causes that make the entire atmosphere system very complex during magnetic storm. It is difficult to associate a single storm induced parameter leading to such changes especially in the anomaly crest region like Guwahati. Some of the possible causes of +ve and –ve storm as reported by earlier workers are inhibition or enlargement of EXB drift during strong storms. This explanation may be the result of +ve ionospheric effect as shown in case 3, case 4 and case 6. In the case of a day time storm, a quick penetration of electric field directed eastward raises low latitude plasma upward due to the E×B drift where the recombination rate is slow. An increase in the electrodynamics drift will lift more plasma from the equatorial region which diffuses down along the field lines to higher latitudes and increase of TEC at station under the anomaly crest region. However the –ve storm effect seen in the number of cases cannot be explained with this mechanism. Similar observations arealso reported by Batista *et al*.[3]. Working over a series ofstations in the Brazilian sector (including southern equatorialanomaly stations), they have observed that daytime depletion in the storm induced TEC is the resultant effect of compression ofequatorial ionization anomaly (EIA) where westward electric fieldproduces downward EXB drift that reduce the pumping of ionisation process from the equator decreases resulting in the –ve ionospheric effect in the equatorial anomaly zone. This is expected especially during the strong geomagnetic storm as presented in the case 1,case 2 and case 5. Another important parameter that may also cause an effective change in TEC duringstorm is the height of the F-layer. The storm induced component of equatorward neutral wind or crossfield (EXB) drifts mayincrease the F-layer height at low or low-mid latitudes. Such changesin height would modify the effective magnetic field factor (M) significantly[15] and this may lead to subsequent changes in the TEC.

However, it is interesting to know that the tropopause temperature shows one to one corresponds with TEC variation both for +ve and –ve ionospheric effects for HSA period. Some of the continous plot of TEC,tropopause temperature and sunspot number have been plotted for HSA, MSA and LSA period. Figure 8 (a and c) have been drawn against HSA, MSA and LSA period to see the daily variation of TEC, tropopause temperature and sunspot no., respectively. It is observed that during HSA period with sunspot no. above 300, the three parameters seem to follow a similar trend throughout the month. In the case of MSA period, a relationship can be observed between TEC and temperature whereas sunspot number seems to be independent. Further, during LSA period, no link between any of these three parameters can be noted.

There is no direct physical and dynamical mechanism till date for associating ionospheric parameters with tropospheric variabilities. One of the significant mechanisms was proposed by LaStoviEka[16] which established the relationship between tropospheric effects of geomagnetic storms. For the tropospheric effects, the agent is responsible which must basically skip across the stratosphere. Two factors fulfill this request, one is the galactic cosmic ray flux which is modulated by the geomagnetic storm and another is the global electric circuit and or atmospheric electricity which is basically affected by in situ changes of conductivity and by ionospheric or magnetospheric electric fields and currents. The energy of precipitating particle of geomagnetic storm is lost not only through ionization, but also through heating, excitation and dissociation processes which results in effects of various intensities in the neutral middle atmosphere. Such effects are likely to exist in atmospheric temperature, wind, composition and behavior of middle atmosphere boundaries. An important part of the middle atmosphere response to geomagnetic storms is changes of minor

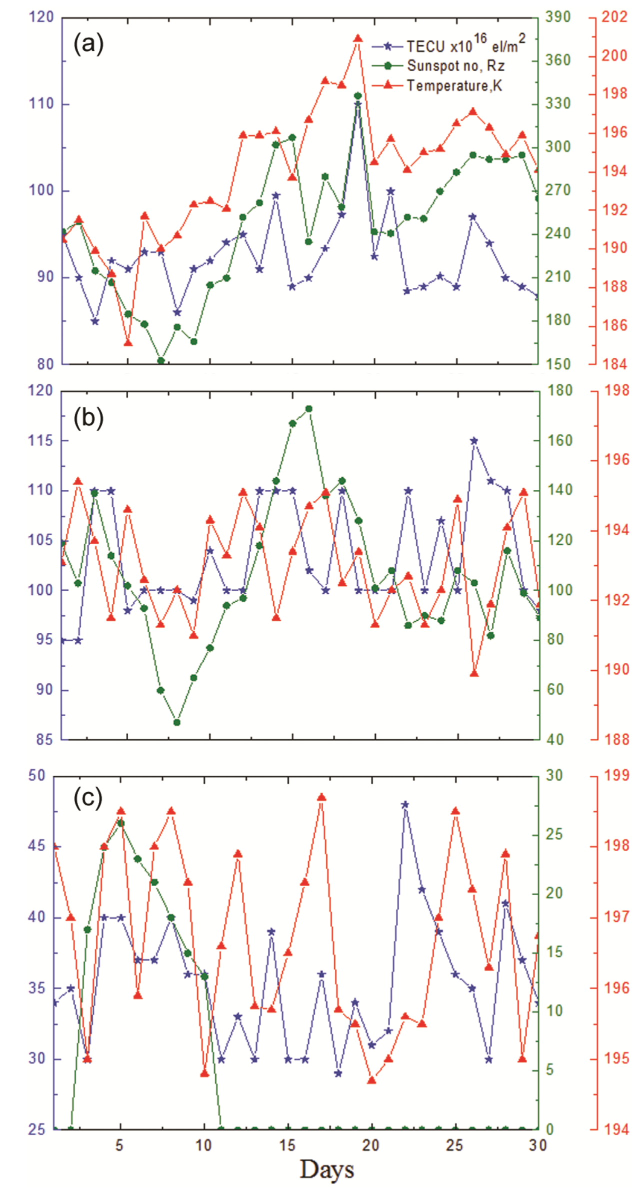

Fig. 8 – (a) Daily TEC, Tropause temperature and Sunspot no. variation during HSA period, (b) Daily TEC, Tropause temperature and Sunspot no. variation during MSA period and (c) Daily TEC, Tropause temperature and Sunspot no. variation during LSA period.

component composition, particularly of NO, as a consequence of energetic particle impact on production of atomic nitrogen. Due to the quasi-continuous particle penetration in the auroral zone as a result of geomagnetic activity, the NO concentration in the middle atmosphere is, similarly to the lower thermosphere, remarkably higher at high latitudes and it further decreases toward low latitudes. This was confirmed by rocket and satellite observations, summarized by Rusch, Clancy[17] and Lastovicka1[18].

Another reason for the changes in tropopause temperature during such magnetic storm is the existence of the quasi-biennial oscillation (QBO) in several solar-terrestrial parameters[19-20]. The zonal equatorial stratospheric winds show a clear QBO effect, where the winds change between east and west. QBO affects the stratospheric flow from pole to pole by changing the effects of extra tropical waves[21].

From the above analyses of the tropospheric response to geomagnetic storm, it has been found that (i) tropospheric responses have a regional character possibly due to changes in circulation and orography. (ii) the tropospheric response to geomagnetic storm is much more pronounced in HSA period which may be because of sunspot number which is above 300. Since the energy of geomagnetic storm-related to atmospheric effects is by several orders of magnitude higher than the input energy of solar wind/geomagnetic storm origin, therefore the process must involve triggering along with/or amplification phenomena for which changes in tropopause temperature can be seen. (iii) The MSA response of the troposphere substantially depends on the phase of the QBO. Researchers have found that geomagnetic and weather links are stronger during particular QBO phase. Tinsley and Denn[22] suggest that it could be related to its role in the dynamic coupling of the stratosphere to the troposphere and the resultant chemical transport. The coupling processes between troposphere and ionosphere is complex especially in equatorial anomaly zone and the future aim is to extend this study for large number of magnetic storm causes covering within a solar cycle period.

To study the effect of QBO, the horizontal wind velocity over the Guwahati region is also plotted against ±10 days of the geomagnetic events. **Fig**ure 9 (a and e) shows the horizontal wind velocity over 100 mb height. During the geomagnetic storm of 12 April 1981and 25 July 1981 wind velocity sees to decreases by 6 m/s from its normal quite day. Both this was the case of E-phase QBO effect.

Figure 9 (c) represents a magnetic storm occurring on 20 October 1981 where wind velocity seems to increase to about 4 m/s. Same effects can be seen for Fig. 9 (d) indicating a strong geomagnetic storm on 9 march 2012 with Dst = -131 nT. Here horizontal wind velocity seems to decrease to 4 m/s. The E-phase of QBO was present during January to April, 2012 and W-phase of QBO starts after that. In the

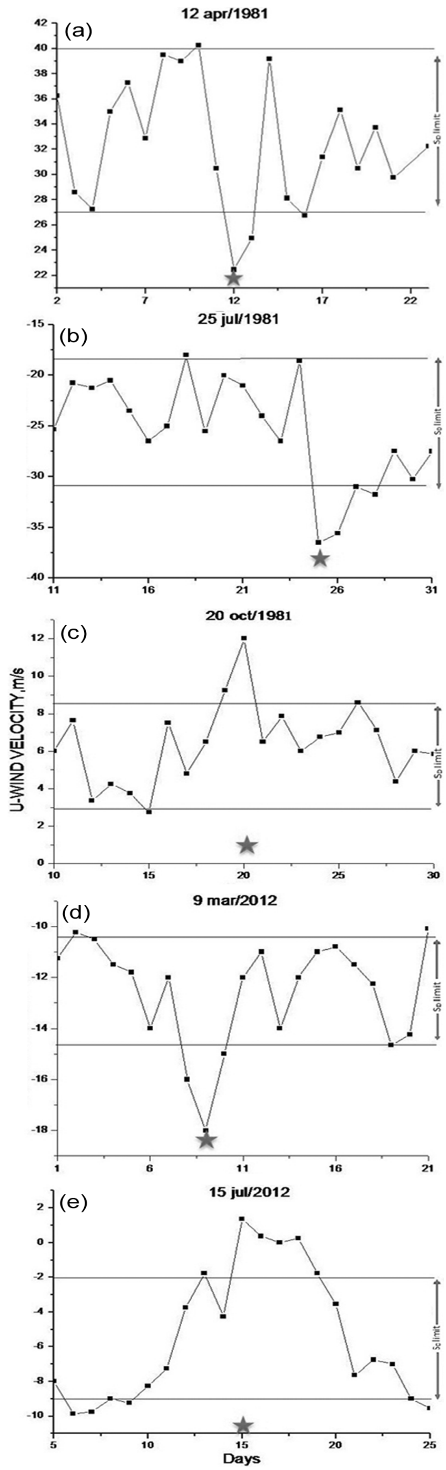

Fig. 9 – (a) The horizontal wind velocity during geomagnetic event of 12 April 1981, (b) The horizontal wind velocity during geomagnetic event of 25 July1981, (c) The horizontal wind velocity during geomagnetic event of 20 October1981, (d) The horizontal wind velocity during geomagnetic event of 9 March 2012 and (e) The horizontal wind velocity during geomagnetic event of 15 July 2012

case of July 2012 geomagnetic event, wind velocity is found to increase by 3 m/s on the onset day and this was a case of W-phase QBO.

The change of tropopause temperature and the vertical wind velocity followed by geomagnetic storm is found to be linked to each other. One can observe that during HSA period, with the decrease (increase) in tropopause temperature, the wind velocity also decreases (increases). Similar cases are also detected for MSA period. Again to study the direct effect of geomagnetic storm on tropopause temperature, sunspot number (a parameter of geomagnetic storm) has been considered.Intervals of sunspot number as used in this paper are a parameter characterizing average levels of solar activity. It is known that an increase in average sunspot number means an increase in solar flux. The presented behaviour of temperatures in the upper troposphere at Guwahati station indicates that this increase involves a small decrease in the solar flux which penetrates the earths atmosphere down to the troposphere.

Figure 10 (a) shows the existence of sunspot number on tropopause temperature for HSA period. The figure describes that tropopause temperature changes with the sunspot number. This may because increased (decreased) UV radiation produces more (less) total ozone which depends strongly on the spectral distribution of the changes in solar radiation. The increased uv radiation enhances the solar heating of the stratosphere, causing the temperature to rise. Thus as in-phase variation of solar uv flux with sunspot number would produce an in phase variation of temperature with sunspot number.

Similar study has been carried forward for MSA period which is shown in Fig. 10 (b). It can be clearly seen that sunspot number below 150 does not seem to effect the tropopause temperature. A few comparative result is shown in follwing Table 2 and Table 3.

From the above experiment we can conclude that 11 year solar cycle seems to affect the lower stratosphere-upper troposphere temperature during geomagnetic storm condition mainly for high solar activity period. The signal appears as a basic, consistent pattern in correlations between height of 15 km (stratospheric constant-pressure level) and the solar cycle in which the highest correlations are in the subtropics.

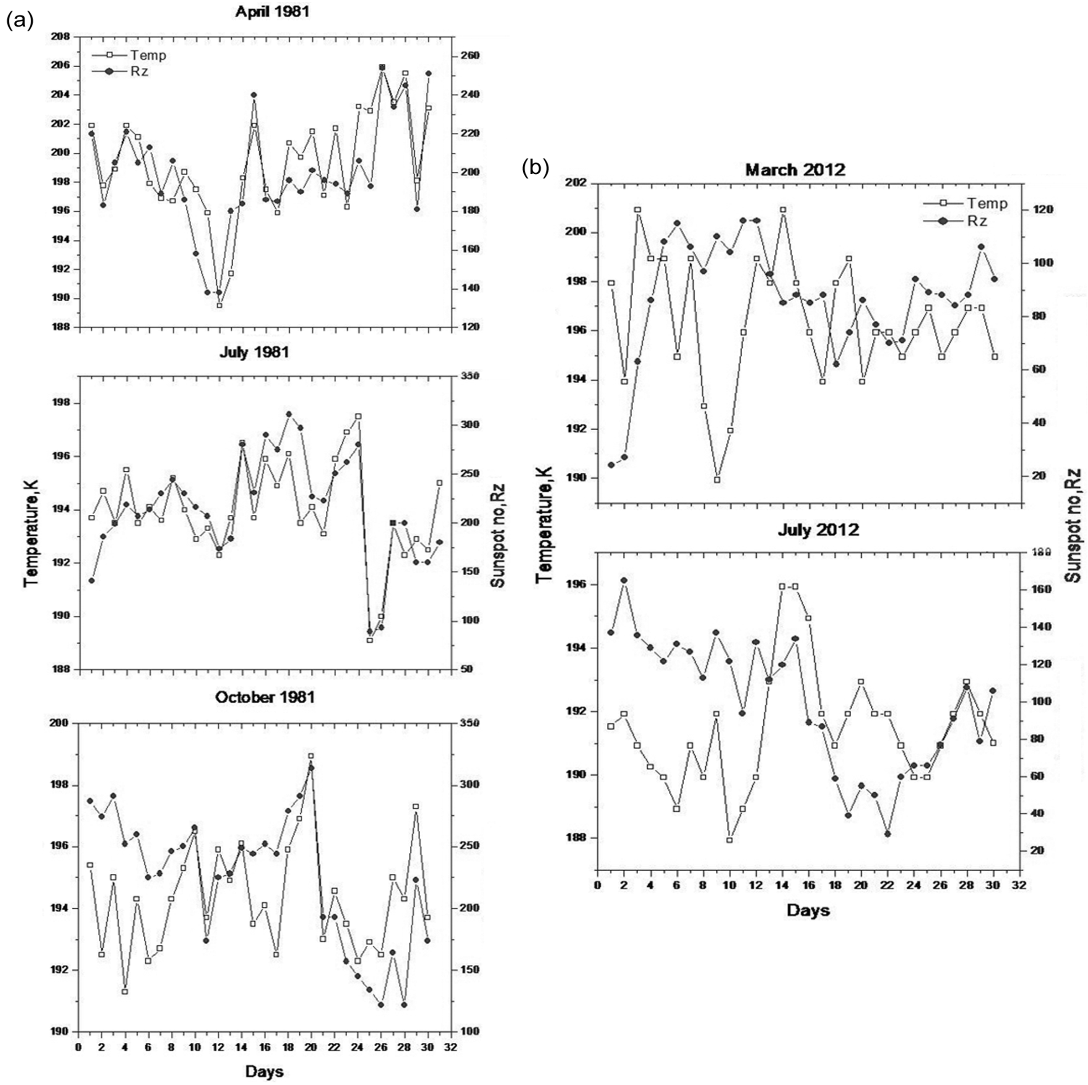

Fig. 10 – (a) The sunspot number and tropause temperature variation during high solar activity period and (b) The sunspot number and tropause temperature variation during medium solar activity period.

Table 2 — Corerelation co-efficient of tropopause temparature with sunspot number during high solar activity period.

Year	Normal			Magnetic Storm		
	$Rz\text{-}Temp_{tropopause}$		Correlation co-efficient(r)	$Rz\text{-}Temp_{tropopause}$		Correlation co-efficient(r)
December 1980	$y = 0.003x + 192.1$	$R^2 = 0.002$	0.04915	$y = 0.026x + 188.5$	$R^2 = 0.164$	0.405987
April 1981	$y = 0.013x + 194.9$	$R^2 = 0.015$	0.123199	$y = 0.103x + 178.7$	$R^2 = 0.624$	0.790488
July 1981	$y = 0.002x + 193.2$	$R^2 = 0.004$	0.068112	$y = 0.026x + 188.2$	$R^2 = 0.634$	0.79672
October 1981	$y = 0.003x + 193.7$	$R^2 = 0.009$	0.098912	$y = 0.019x + 190.4$	$R^2 = 0.432$	0.65761
March 1989	$y = 0.007x + 199.2$	$R^2 = 0.01$	0.099776	$y = 0.067x + 191.6$	$R^2 = 0.480$	0.6935
April 1990	$y = 0.005x + 204.9$	$R^2 = 0.004$	0.069927	$y = 0.049x + 196.9$	$R^2 = 0.488$	0.699025
March 1991	$y = 0.004x + 198.9$	$R^2 = 0.014$	0.120653	$y = 0.031x + 193.0$	$R^2 = 0.578$	0.760843
June 1991	$y = 0.006x + 193.6$	$R^2 = 0.005$	0.073145	$y = 0.042x + 185.8$	$R^2 = 0.550$	0.720832
March 2001	$y = 0.015x + 196.7$	$R^2 = 0.016$	0.126446	$y = 0.069x + 186.0$	$R^2 = 0.632$	0.795556
September 2002	$y = 0.01x + 195.4$	$R^2 = 0.019$	0.139597	$y = 0.058x + 186.5$	$R^2 = 0.529$	0.727559

Table 3 — Corerelation co-efficient of tropopause temparature with sunspot number during medium solar activity period.

Year	Normal			Magnetic Storm		
	$Rz\text{-}Temp_{tropopause}$		Correlation co-efficient(r)	$Rz\text{-}Temp_{tropopause}$		Correlation co-efficient(r)
January 1983	$y = -0.019x + 205.7$	$R^2 = 0.010$	-0.10094	$y = 0.055x + 198.1$	$R^2 = 0.067$	0.258799
March 1993	$y = 0.005x + 200.6$	$R^2 = 0.000$	0.025436	$y = 0.042x + 198.8$	$R^2 = 0.032$	0.179879
September 1993	$y = 0.012x + 198.6$	$R^2 = 0.001$	0.033488	$y = 0.014x + 198.6$	$R^2 = 0.007$	0.087542
April 1994	$y = 0.012x + 200.3$	$R^2 = 0.003$	0.062318	$y = 0.010x + 200.8$	$R^2 = 0.006$	0.081954
March 2012	$y = 0.005x + 196.1$	$R^2 = 0.003$	0.058426	$y = -0.016x + 197.7$	$R^2 = 0.019$	-0.14073
July 2012	$y = 0.001x + 191.4$	$R^2 = 0.000$	0.022896	$y = -0.003x + 191.8$	$R^2 = 0.005$	-0.07447

5 Conclusions

The present authors have studied the influence of severe and moderate geomagnetic storm on ionosphere and as well as on the lower atmosphere. It is observed that during high and medium solar activity period, the TEC values have both positive and negative effect with respect to average Q-day TEC value depending on the intensity of the storm. Possible reason for positive and negative effect of TEC during geomagnetic storms may be the electric field generated by a magnetic storm penetrates to the equator which will enhance the equatorial anomaly effect thereby pumping ionization density to low latitude station like Guwahati. Another reason is anomaly effect may sometimes so strong that station like Guwahati comes within the anomaly thereby pumping of density from Guwahati to high latitude station; thereby decrease in the density over Guwahati. Some other parameter like neutral wind effect may bring ionization density from pole to the equator enhancing the total electron content or during strong storm; the effect goes up to the lower atmosphere. This paper also presents some variations in tropopause level of the atmosphere during some strong and moderate geomagnetic storm and a relationship can be established between ionospheric parameter and lower atmospheric parameters along with the indivisual changes in the parameters can be seen in both ionosphere and tropopause. The vertical wind component and tropopause temperature which become highly variable during magnetic storms is seem to cause mainly by QBO effect, solar activity, seasonal variation etc. It is also noted that tropopause temperature changes with the sunspot number. This may be because of increased or decreased uv radiation produces more or less total ozone which depends strongly on the spectral distribution of the changes in solar radiation. Further study will be necessary.

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