Tropospheric Heating and Cooling over Equatorial Latitude

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ABSTRACT

We have made an attempt to study the tropospheric meteorological parameters such as temperature, and wind variability over the low latitude region. The upper tropospheric temperature and wind variability has been obtained from the NCEP-NCAR Reanalysis data. The 200 mb temperature shows sensitive to severe geomagnetic storm. The decrease in the upper tropospheric temperature after the severe geomagnetic storm condition has been observed during the east phase of QBO. The increase in the upper tropospheric temperature by about 3°K has been observed after the magnetic storm (event) and west phase of QBO. The upper tropospheric temperature also shows the changes with solar activity period. The time lag between onset of event and its effect becomes minimum during transition phase of QBO. The horizontal and vertical wind velocity also shows increase (or decrease) during w-(or e-) phase of QBO followed by severe magnetic storm.

1. INTRODUCTION

One of the earliest works of geomagnetic forcing of the lower atmosphere is by Macdonald and Woodbridge (1959). The time delay between a geomagnetic event and changes in atmospheric circulation at different location was studied by Mustel et al. (1977). Lastovicka et al. (1992) and Lastovicka (2002) formulated meteorological induced changes of the tropospheric response to geomagnetic storm. Occurrence probability of solar-geomagnetic – weather relations has been studied by several workers [Bucha and Bucha, 1998; Bhattacharya et al., 1998; Bochnicek et al., 1999; Avdyushin and Danilov, 2000; Danilov and Lastovicka, 2001]. Xiong et al. (2006) studied the planetary wave type oscillation in the ionosphere and found the relationship with the geomagnetic activity.

In order to further ascertain the solar-geomagnetic-weather relation over Indian continent and the time delay between geomagnetic event and changes in tropopause temperature (or wind), we analyze the 5 year's NCEP-NCAR Reanalysis data in this paper. Southern part of the India is located near to the ocean coast which provided further advantage to study the influence of mountain-land-ocean on the upper tropospheric variations.

2. DATA SETS

The NCEP-NCAR Reanalysis

The National centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) have completed a reanalysis project with a current version of the Medium Range

Forecast (MRF) model (Kalnay et al., 1996). This data set is a reanalysis of the global observational network of meteorological variables (wind, temperature, geopotential height, humidity on pressure levels, surface variables, and flux variables like precipitation rate).

Geomagnetic Index

In the present study, we have analyzed in detail geomagnetic storm occurred during solar cycle 23. Nearly 75 severe and strong (Dst <-100 nT) geomagnetic storm were observed from January 2000 to December 2005. The data of geomagnetic activity index is obtained from the web site http://swdcwww.kugi.kyoto-u.ac.jp/index.html.

2. RESULTS

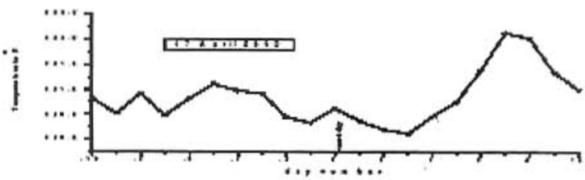


Figure.1: This figure shows the tropopause temperature variation during geomagnetic event of 07 April 2000 and W-phase of QBO

Figure 1 shows the temperature variation at 200 mb, before and after the onset of geomagnetic event, i.e., 07 April 2000. The equatorial magnetic activity index (Dst) was -288 nT. This was the case of severe geomagnetic storm. The tropopause temperature has been found to be depending upon several parameters such as solar activity, QBO-phase, season of the year, land or ocean etc. The tropopause temperature decreases (or increases) after onset of the event in E-phase (or W-phase) of QBO. Since the convective activity over the land is more pronounced then the ocean, the influence of geomagnetic activity has been found over the land area. Fig. 1 shows the increase in tropopause temperature by about 3°K after 6 days of the onset of the event. This event correspond to the land region. The stratospheric (50 hpa) zonal wind velocity over the equatorial region was 12.7 m/s in April 2000. This was the case of W-phase of QBO, and high solar activity period. This event was before monsoon period. The seasonal variation of the temperature shows the changes in tropopause temperature from winter to summer is ~ +3°K.

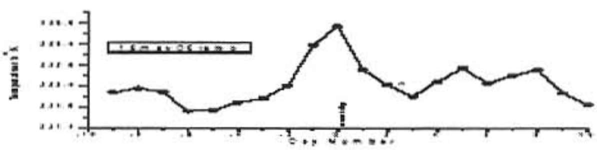


Figure 2: This figure shows the tropopause temperature variation during geomagnetic event of 15 May 2005. This was the time for transition phase of QBO.

Figure 2 shows the tropopause temperature over Indian continent (low latitude) obtained during geomagnetic activity of 15 May 2005. The maximum magnetic activity index (Dst) was <-263 nT. The lower stratospheric zonal wind velocity in May 2005 was 5.0 m/s. This was the period of minimum zonal wind velocity period. The time lag between the geomagnetic event and maximum increase in temperature is minimum and it coincides with the minimum lower stratospheric zonal wind velocity variation. The increase in temperature has been obtained to be about 2°K.

Figure 3 shows the horizontal wind velocity variation obtained during geomagnetic activity of 4 April 2004. The maximum geomagnetic activity index (Dst) was -112 nT. The equatorial lower stratospheric zonal wind velocity in April 2004 was 1.1 m/s. The horizontal wind velocity increases by about 15 m/s after 2 days of the onset of the event. The influence of geomagnetic activity on the tropopause horizontal wind velocity found to be maximum during solar minimum activity condition. The atmosphere during solar minimum condition is unstable, therefore, the influence of magnetic activity has been seen on the dynamical parameters more effectively then the solar maximum activity condition. The time lag between maximum geomagnetic activity and maximum changes in wind velocity is minimum, i.e., 2 days. This shows the influence of lower stratospheric zonal wind velocity on the time lag between cause and effect.

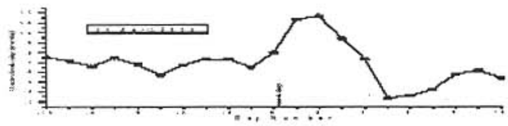
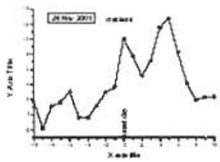


Figure 3: This figure shows the horizontal wind velocity variation obtained during geomagnetic event of 04 April 2004 and transition phase of QBO.

Figure 4a shows the vertical wind velocity obtained during geomagnetic activity of 24 Nov 2001 over the low latitude Indian continent region. The maximum geomagnetic activity index (Dst) on 24 Nov 2001 was -221 nT. This event correspond to maximum solar activity, E-phase of QBO, winter condition, unstable atmosphere, over the continent and the equatorial zonal wind velocity of -20.5 m/s. The presence of jet stream might have increased the time lag between onset of the event and its effect. We have also tried to see the influence of magnetic activity over the ocean. Fig 4b shows the vertical wind velocity obtained over the Bay of Bengal. The vertical wind velocity over the ocean shows the time delay between maximum geomagnetic activity and its effect on increase in vertical wind velocity by about 4 days. The presence of jet stream might have delayed the effect.



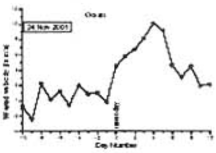


Figure 4: This figure shows the 200 mb vertical wind velocity obtained during geomagnetic event of 24 Nov 2001and E-phase of QBO. Fig. 4a corresponds to continent region and Fig 4b correspond to the Ocean region.

3. CONCLUSION

We have studied the influence of severe geomagnetic storm on the Indian equatorial tropopause temperature, and wind variation. The severe and strong (Dst < -100 nT) geomagnetic storm between 2000 and 2005 has been studied in the present work. Some of the storms occurred on 7 April 2000, 31 March 2001, 30 Oct 2003, 21 Nov 2003, 8 Nov 2004 etc. The change in the tropopause temperature and wind velocity over Indian continent followed by the geomagnetic storm is found to be influenced by the solar activity and QBO phase. The effect of magnetic storm is prominant on temperature during high solar activity and on wind during low solar activity period. The tropopause (200 mb) temperature increases by about 2.5°K during w-phase of QBO and decreases by about -3°K during E-phase of QBO. The three to five days time lag has been observed between onset of the event and change in temperature. The time delay between onset of the event and maximum change in temperature becomes minimum during transition phase of QBO. The decrease in horizontal wind velocity before onset of the event during E-phase of QBO has been observed. The pronounced effect has been observed over east coast of India. The effect of magnetic storm on the tropopause temperature and wind velocity is not seen during monsoon period. Similar to the horizontal wind velocity, vertical wind velocity also shows the changes in wind velocity followed by the onset of the magnetic storm. The zonal wind velocity on 4^{th} April was minimum and it shows no time lag between onset of the event and maximum increase in wind velocity. The wind velocity followed by the geomagnetic activity found to be distorted in the presence of strong planetary wave at tropopause height.

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NCEP Reanalysis data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.cdc.noaa.gov/