Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2011, 2 (6):563-569

Pelagia Research Library

ISSN: 0976-8610
CODEN (USA): AASRFC

Thermosperic wind response to geomagnetic activity in the low latitudes during the 2004 Equinox seasons

Sivla, W.T[1] and Okeke, F.N[2].

[1]*Department of Physics, Kogi State University, Anyigba*
[2]*Department of Physics and Astronomy, University of Nigeria, Nsukka*

ABSTRACT

Thermospheric cross-track wind speeds deduced from STAR accelerometer aboard the CHAMP Satellite are used to study wind speed response to geomagnetic activity in the low latitudes during the 2004 March and September equinox seasons. The geomagnetic effect was not distinct for the two levels considered. Maximum speeds going above 250m/s were observed at the two levels considered. Our CHAMP observed wind turned eastwards from 20.00 to 23.00SLT and westwards from 07.00 to 09.00SLT instead of 17.00-19.00SLT and 05.00-08.00SLT respectively, as predicted by previous observations. Our study presented is focused on global scale variations in the thermospheric cross-track wind speeds between 7.5^0*N and* 10.5^0*N geographic latitudes. Use of many satellites for simultaneous measurements at several points in space is suggested.*

Keywords: Equinoxes, Thermospheric wind, CHAMP satellite, Geomagnetic activity.

INTRODUCTION

The 87^0 orbit inclination of the German Satellite Challenging Minisatellite payload (CHAMP) ensure a nearly complete latitudinal coverage, whereas the solar local time is completely sampled (0-24h) approximately every four months (Bruinsma and Biancale, 2003).The altitude of the CHAMP satellite varies by about 40km between the perigee and apogee, and its mean altitude by tens of kilometers over one year (Menvielle et al., 2007). With the STAR accelerometer placed at the center of gravity of CHAMP, thermospheric density and cross-track wind speed retrievals can be made. The accelerometer measures the non-gravitational accelerations. By accurately modeling the solar, earth radiation pressure and atmospheric lift, atmospheric drag perturbations which cause the largest signals can be retrieved. With the large data generated from the accelerometer it is now possible to study the effect of solar and geomagnetic activity levels on thermospheric wind speeds using the same data set.

The orbital period of the CHAMP satellite is about 90 minutes. With 15 orbits per day, it crosses any low latitude band 15 times during its ascending motion and 15 times during its descending motion. This takes place at different longitudes due to the rotation of the earth. The satellite measurements at the same geographic latitude; although at different longitudes, are within a small range of local solar time. When satellite data at given latitude are displayed in the local time domain, data at different times are measured on different days (Zhang et al., 2003).

The thermospheric wind speeds can be longitudinally averaged to obtain the diurnal wind speed variations. Geomagnetic storms have a great effect on the composition and dynamics of the thermosphere. Due to high spatial and temporal variability of the geomagnetic input, the characteristics of the thermospheric response are still quite vague, due to the lack of sufficient data (Lühr and Liu, 2006).

This paper presents and discusses results from a study of cross-track wind at different geomagnetic activity levels during the March and September 2004 equinoxes covering six months. The cross-track wind speeds are longitudinally averaged to obtain the diurnal wind speed variations from latitudes 7.50N to 10.50N.

DATA SOURCES

The A_p index is the occurring maximum 24-hour value obtained by computing an 8-point running average of successive 3-hour a_p indices during a geomagnetic storm event and is uniquely associated with the storm event. Figure 1 shows the distribution of the Ap geomagnetic index values during the 2004 equinox seasons. The geomagnetic index values are supplied by the World Geomagnetic center in Kyoto, Japan.

The thermospheric winds presented in this study are derived from the triaxial accelerometer measurements on board CHAMP.

The methodology to compute the cross-track wind speeds is given by Sutton et al.,(2007) in the formula below

$$w_y = v_{r,y} - \frac{a_y}{a_x} v_{r,x}$$

Where w_y is the cross-track wind speed, $v_{r,y}$ the component of the satellite cross-track speed, $v_{r,x}$ the component in the along track, a_y the component of the drag acceleration in the cross-track direction and a_x the component in the along track direction.

The time period considered in this study are the six months covering the March and September equinox seasons of 2004.During this period CHAMP visited all local times at least once. Figure2 shows the distribution of the number of derived wind speed measurements across all the local times.

RESULTS AND DISCUSSION

March Variation

For high geomagnetic activity (Ap>7), westward wind speeds peaked from 10.00-14.00 SLT with values exceeding 250m/s in some few instances as be seen in figure 3a. From 18.00-19.00 SLT, wind direction switched eastward with maximum speeds of about 250m/s occurring from 11.00-01.00 SLT. Zero crossing occurred in the morning hours from about 06.00-08.00SLT.

Maximum speeds occurred from about 10.00-12.00SLT during the low activity periods as can shown in figure 3b.Maximum eastward speeds were observed from about 23.00-01.00 SLT. Wind direction switched westward from 07.00-09.00SLT.

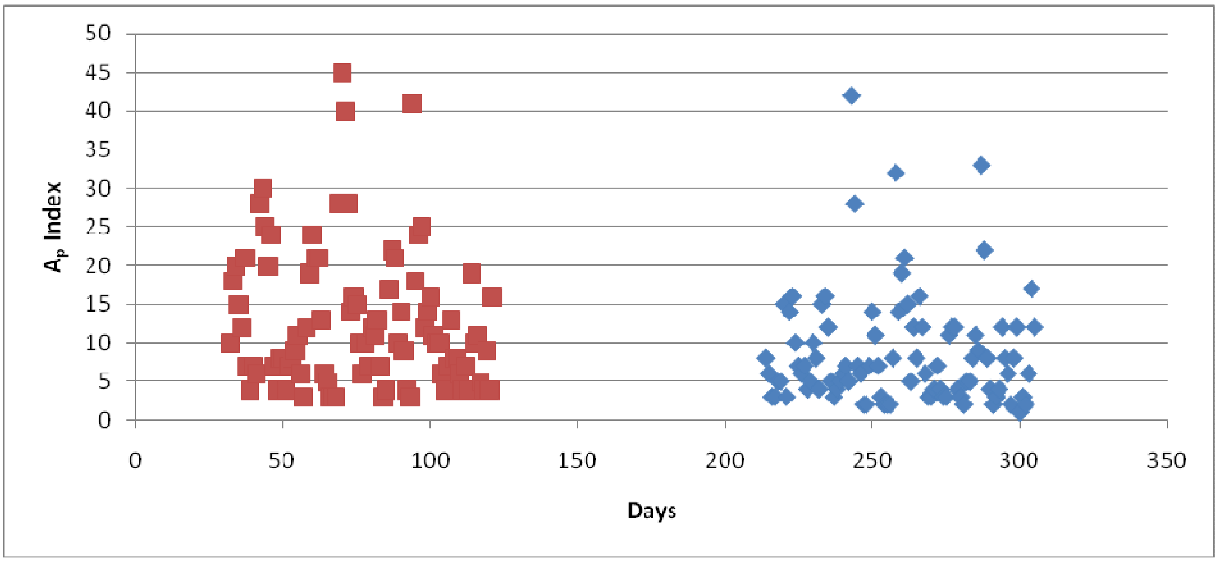

Fig.1: Distribution of the A_p geomagnetic index values versus days of March and September 2004 equinoxes.

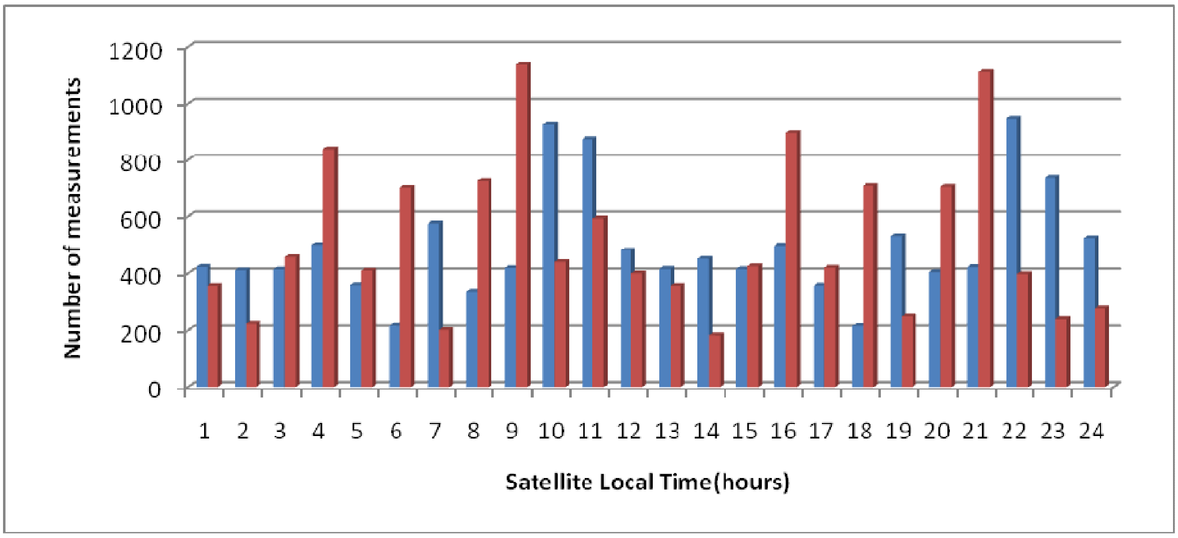

Fig.2: Number of measurements in each local time bin at high (blue) and low (red) geomagnetic activity levels

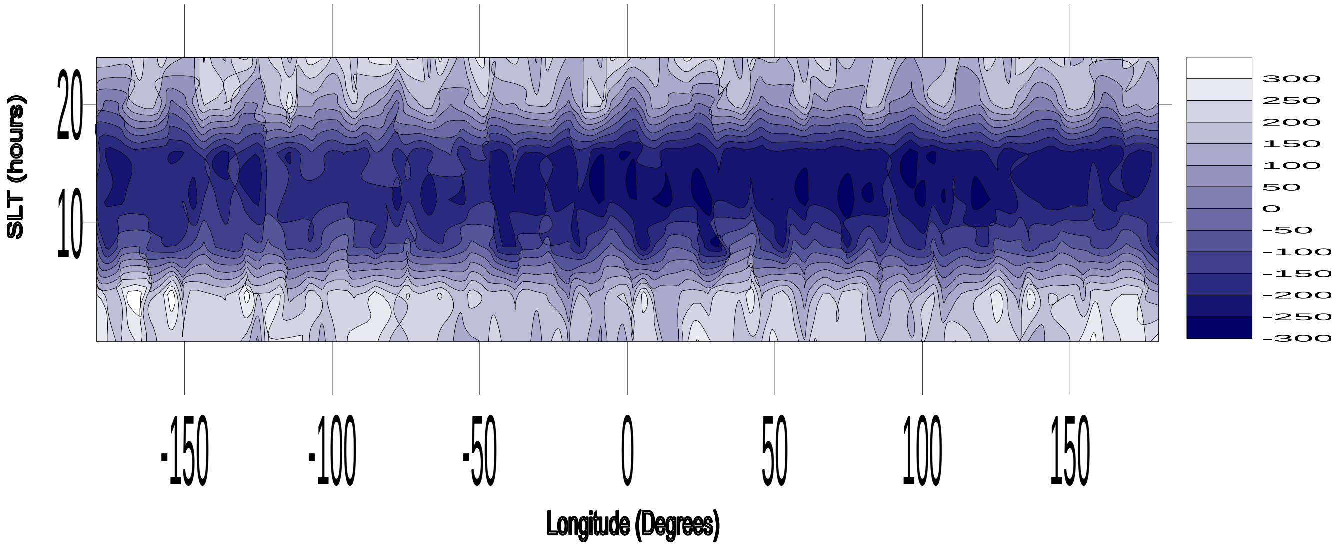

Fig.3(a) Distribution of wind speeds across the Satellite local times during the high activity for the March equinox

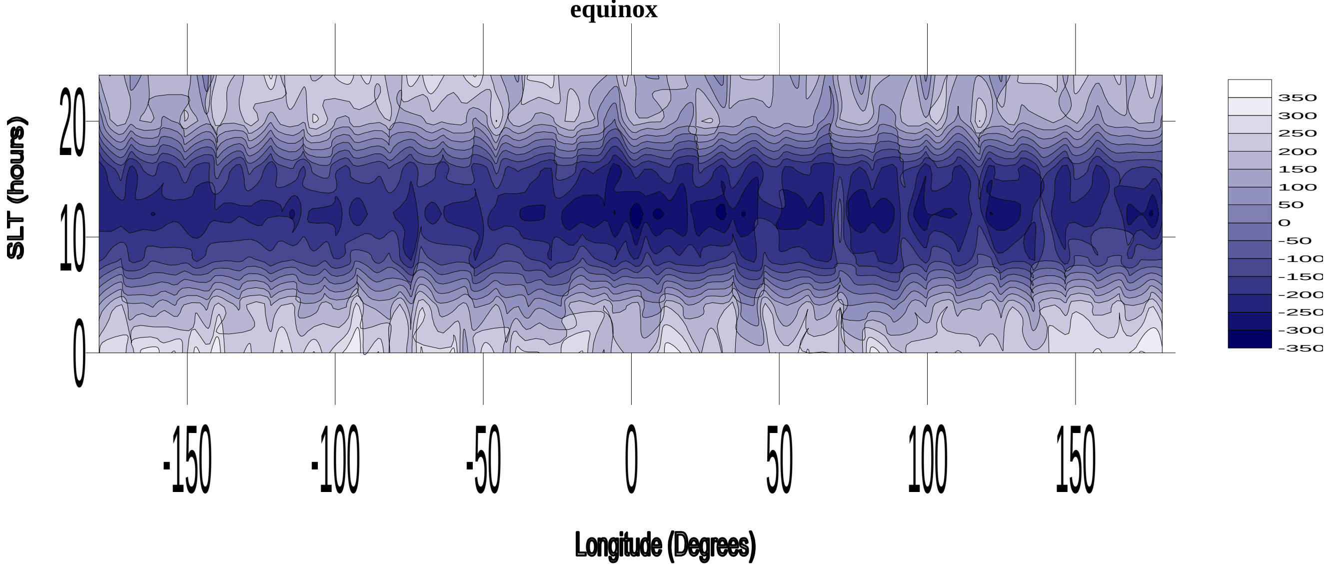

Fig.(3b) : Distribution of wind speeds across the Satellite local times during the low activity for the March equinox

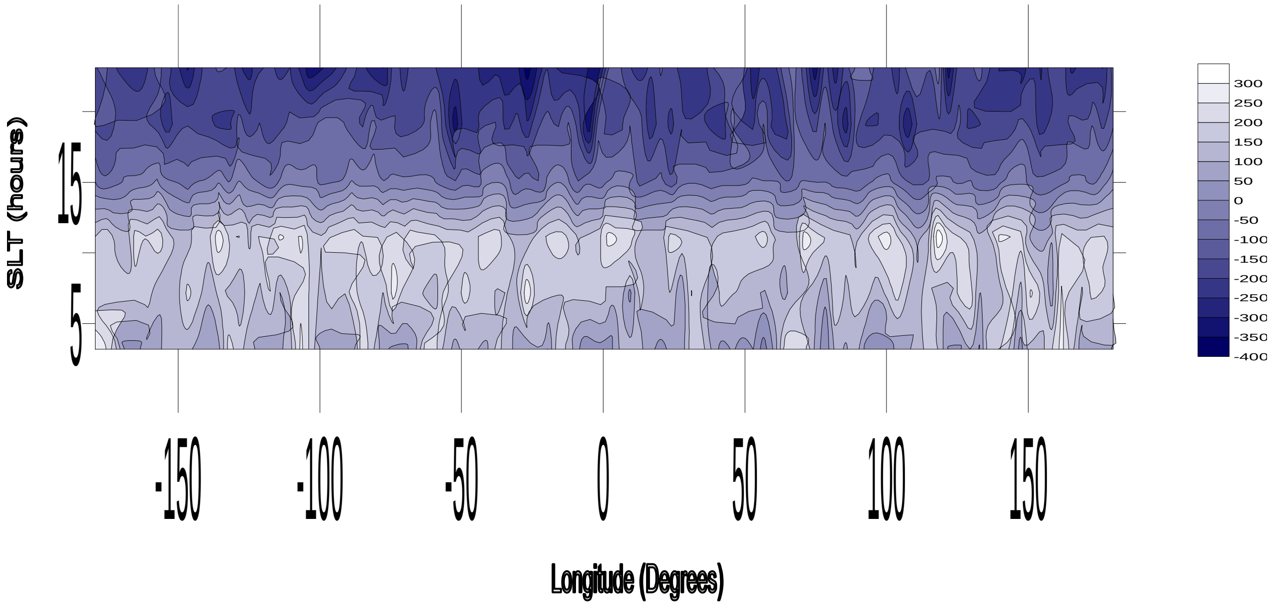

Fig.3(c) Distribution of wind speeds across the Satellite local times during the high activity for the September equinox

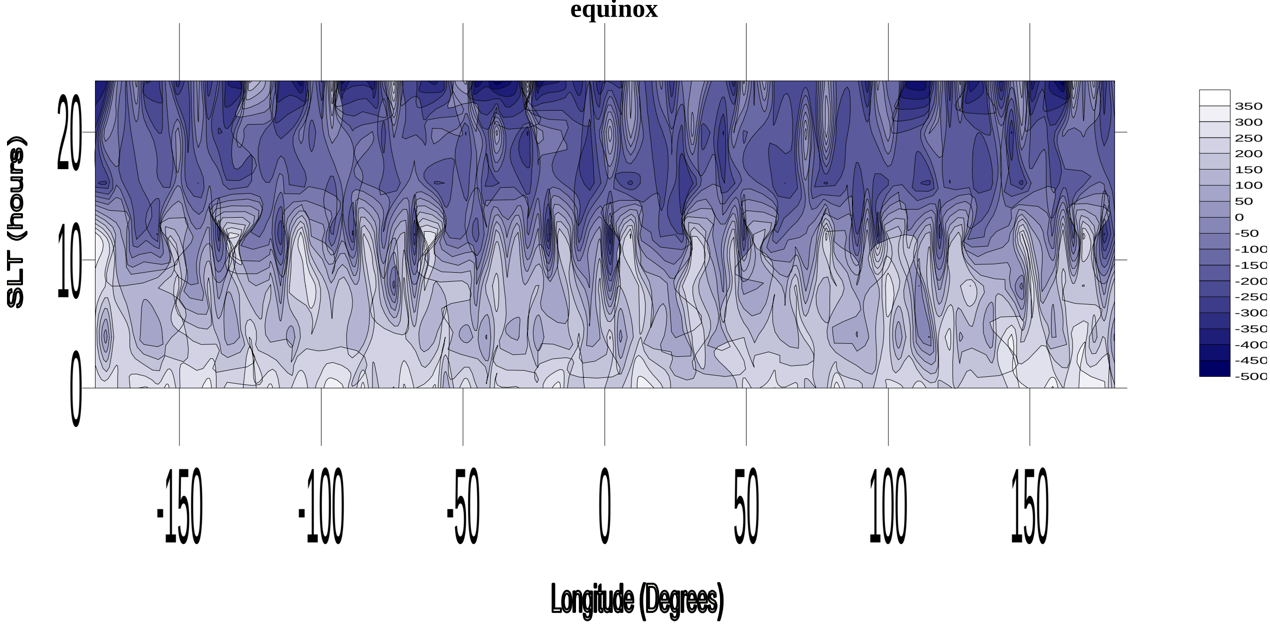

Fig3d: Distribution of wind speeds across the Satellite local times during the low activity for the March September equinox

September Variation

Wind direction was observed to be eastward for most of the daytime hours at the considered geomagnetic activity levels as can be seen in figures 3c and 3d.Maximum speeds going above 300m/s are seen to occur at the levels. The westward switch in wind direction occurred at about

12.00SLT for the high activity level. The time of switch is not clearly defined for the low activity level, but wind direction is observed to be westward from midday to midnight.

The September equinox wind behavior as observed in this study is not consistent with studies carried out by Liu et al., 2006. In their observations zonal winds were observed to be eastward for most of the night, for geomagnetic activity index $Kp<3$. In their study longitudinally averaged wind speeds with maximum values between 160 and 200m/s were observed in the eastward and westward directions.

The three-dimensional coupled ionosphere-thermosphere model of Maruyana et al.,(2003), developed using simulations at equinox, moderate solar activity(F10.7=150) and geomagnetically quiet condition(Ap=7) at about 376km near Jicarmaca showed wind variation between eastward and westward switches occurring at about 18.00LT and 06.30LT.

The Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIEGCM) simulation results of Biondi et al.,(1999) on the solar flux dependence of quiet –time($Kp \leq 3$) F-region wind at night and low solar flux effect on the equatorial nighttime wind between 255 and 285 km altitude during the equinox seasons(March, April, September, October) showed the winds to be consistently eastward and switching westward at about 06.00LT.

CONCLUSION

We have used the same data set from the model by Sutton et al., (2007), to study zonal wind variation in the low latitudes at two different geomagnetic levels during the March and September 2004 equinox seasons. Our studies revealed large wind amplitudes for the 2 levels considered. Maximum speeds going above 250m/s were observed. The September equinox daytime winds were surprisingly eastwards. Variations at different geomagnetic activity levels for each of the equinox seasons considered did not reveal distinct differences in the speeds.

Winds from previous studies were measured on different days and data produced under different assumptions therefore differences in wind structures and magnitudes are expected.

From their studies on “zonal wind variation Across West Africa during the high solar flux using CHAMP Satellite Accelerometer Data”, Sivla and Okeke,(2010) suggested the use of more precise accelerometers in order to reduce the uncertainties in the wind speed estimates. Simultaneous measurements need to be carried at several points in space to overcome the spatial-temporal ambiguity of single satellite measurements. We suggest more studies be carried out using data from the GRACE satellite which is in orbit, to ascertain the large amplitudes and time of phase change in the study

Acknowledgements
The authors thank Dr. Eric Sutton of the Department of Aerospace Engineering Sciences, Universty of Colorado, Boulder, U.S.A., who created the data base used for the study

REFERENCES

[1] Menvielle M.,Lathuillere C.,Bruinsma S., and Viereck R.(**2007**), *Ann. Geophys*.,25, 1949-1958.

[2] Biondi,M.A., Sazykin, S.Y., Fejer, B.G., Meriwether, J.W., and Fesen, C.G.(**1999**), J. *Geophys.Res.*,104,17091-17106.

[3] Luhr H. and Liu H. (**2006**): The thermopheric response to geomagnetic storms. ILWS Workshop. GOA.

[4] Maruyama,N., Watanabe, S., Fuller-Rowell (**2003**), *J. Geophys.Res*.,108(A11),1396.

[5] Sivla, W.T., and Okeke, F.N. (**2010**), *The Nigerian Journal of Space Research*: 6, 32-41.

[6] Sutton, E.K., Nerem, R.S. and Forbes, J.M. (**2007**), *Journal of spacecraft and Rockets*. Accepted for publication.

[7] Zhang, S.P., Goncharenko, L.P., and Salah, J.E. (**2003**), *J. Geophys. Res*.108 (A11051, doi: 10, 1029/2002JA009512, 2003.