VARIATION OF TOTAL MAGNETIC– FIELD DURING LOW SOLAR ACTIVITY

O. S. Ayanninuola*, Umar, I. and B. Aisha

Department of Physics, Nasarawa State University, PMB 1022, Keffi, Nigeria
*Corresponding Address: teejayone4real@yahoo.com

Received: April 18, 2012; **Accepted:** August 28, 2012

Abstract

In this research work, the Variation of total magnetic field has been carried out. The total magnetic field curves show significant variation in amplitude and phase similar to the horizontal field component and different from the declination and vertical field components. Our results show also that there is clear and significant seasonal and latitudinal variability in the amplitude and phase of the total magnetic component. Clear evidence of the effect of equatorial electrojet was found as there was increased in amplitude occurring for station near and/or at dip equatorial region. It is therefore becomes necessary for the study of $S_q(F)$ to be carried out

***Keywords**: Magnetic fields, solar quiet, Equatorial electrojet, Amplitude, Ionosphere.*

INTRODUCTION

Generally magnetic records are observed to be varying (Alex, 1992). These variations are caused by a number of sources that are internal and external to the earth surface. The magnetic records produced by the sources are generally time dependent ranging from seconds to years. The main magnetic field variation takes number of years while external geomagnetic field components vary in a shorter time interval. The daily variations of geomagnetic records were earlier discovered on records and these were associated with the apparent movement of the sun across the sky (Hitchman & Lilley, 1998). During low solar activity the quiet daily variations observed during geomagnetically quiet conditions are known to be associated with dynamo currents driven by winds and thermal motions in the E–region of ionosphere(Champman, 1951; Okeke & Hamano, 2000). Apart from the variations caused by the sun there is also a lunar variation of the geomagnetic field components caused by lunar tides. This work discusses only the daily variation caused by solar activity.

In the work of (Campbell, 1997) it was observed that the observatory records and magnetic fields models based on them, indicate that the form of S_q field variations have a spatial dependence primarily related to geographical latitude. Also, the daily variation of the geomagnetic field as typically observed at mid – latitude stations during quiet periods originate in the ionosphere some 100 km above earth surface (Campbell, 1997). Meanwhile, the solar component of the quiet daily variation S_q is the result of the enhancement of the conductivity of E– region of the ionosphere induced by solar radiation.

Moreover, earlier works of (Bartel & Johnson, 1940; Egedal, 1947), found that the diurnal ranges of horizontal field component (H) at the stations near the equator peaks around the dip equator with assumptions that the amplitude of the daily variation in D and Z components were unaffected.

However, the usefulness of earth magnetic field in our modern world have been navigation and exploration geophysics, infrastructures and other modern activities, which are technologically based and can be affected by rapid magnetic field variations driven by the dynamic processes near the earth space environment. Most magnetic mapping exercises involve measuring the amplitude or total magnetic field component of earth magnetic field .However, geomagnetic texts commonly include figures which compare variations of the components of the magnetic field at direct locations on the globe without including total field. In this present work, curves for S_q total field variations are derived from a global model based on analysis of observatory data recorded during a year with very low level of solar activity. Such total mapping in which the parameter measured is generally the total – field contains a daily variation signal.

MATERIALS AND METHODS

The Data

The geomagnetic data set consists of hourly mean values of geomagnetic field elements (H, Z, F) recorded in sub– African continent. The data were collected during low solar activity at different magnetic field stations being Mbour (MBO), Bangui (BNG), and Tamanrasset (TAM). The data were obtained from the website of intermagnet (www.intermagnet.com). The data is made up of hourly values of geomagnetic field horizontal intensity, (H) and vertical intensity, (Z) recorded at various aforementioned stations. The International Quiet Days (IQDS) were selected and used to generate the geomagnetic solar quiet daily, S_q variation for each month of the year 1996. After thorough inspection of data of all the months of the year 1996, it was observed that the following months March, June and December were available for all the stations of interest. These months were also selected to represent different seasons in the year. In our analysis only five quietest days in the ten international quiet days in a month were consider. This is to ensure absolute quietness of record data. Where a record is missing in any of the five quietest days in a month, the day is replaced by the next quiet day in the list of the ten international quiet days in that month.

The concept of local time is used throughout the analysis. The variation baseline is obtained from 2 hours flanking local midnight that is 24 h LT and 1 h. LT. The daily base line value (H_o, Z_o) for the geomagnetic elements H and Z are the mean values of the hourly values at these 2 h $H_o = (H_{24} + H_1)/2$; $Z_O = (Z_{24} + Z_1)/2$, where (H_{24}, Z_{24}) and (H_1 ,Z_1) represent the values of the geomagnetic elements H, Z at 24 h LT and 1 h LT, respectively. The midnight base line values were subtracted from the hourly values to get the hourly departures from midnight for the particular day, the i^{th} day. That is $\Delta H = H_t - H_0$; $\Delta Z = Z_t - Z_0$
Where $t = 1\ to\ 24$; ΔH and ΔZ are hourly values of magnetic elements of H and Z, respectively. The hourly values of the departure ΔH and ΔZ were further corrected for non–cyclic variation accordingly to give the measure of the solar daily variation in the three components H, Z and F.

RESULTS AND DISCUSSION

Using the data analysis as, we were able to calculate the values of the various geomagnetic field components S_q(H), S_q(Z) and S_q(F) at difference stations (MBO,BNG,TAM) at every hour. The discussion of the results is based on observations and literatures as already reviewed earlier.

The Sq variations in H, Z and total field, F are here represented by the S_q(H), S_q(Z) and S_q(F) . Fig. 1 to 8 show the typical curves for S_q variation in H, Z and F for three seasons: March equinox, June Solstice and December solstice at different magnetic observatories (TAM, BNG, MBO). Regional variability in the S_q field and local effects, such as induction in the vicinity of the oceans and conductivity anomalies may perturb these curves at some locations (lilley & parker, 1976).

From Fig. 1 to 8, it shows that S_q(H) follows S_q(F) closely in BNG stations and shows little closely variation at the other two stations. Also, the S_q(F) variations closely follows the same pattern in the three seasons, which correspond to the work of (Hitcheman *et al.*, 1998). It is also observed that the S_q(H) variation shows consistency and maintains regular pattern at BNG, and MBO throughout the three seasons. Also, Z– component of geomagnetic field showed maximum values around local noon hours. This is an abnormal feature and not a common phenomenon. (Alex *et al.*, 1992) found similar abnormal Z variation phase with the H variation, and suggested that it could be the cancellation of EEJ.

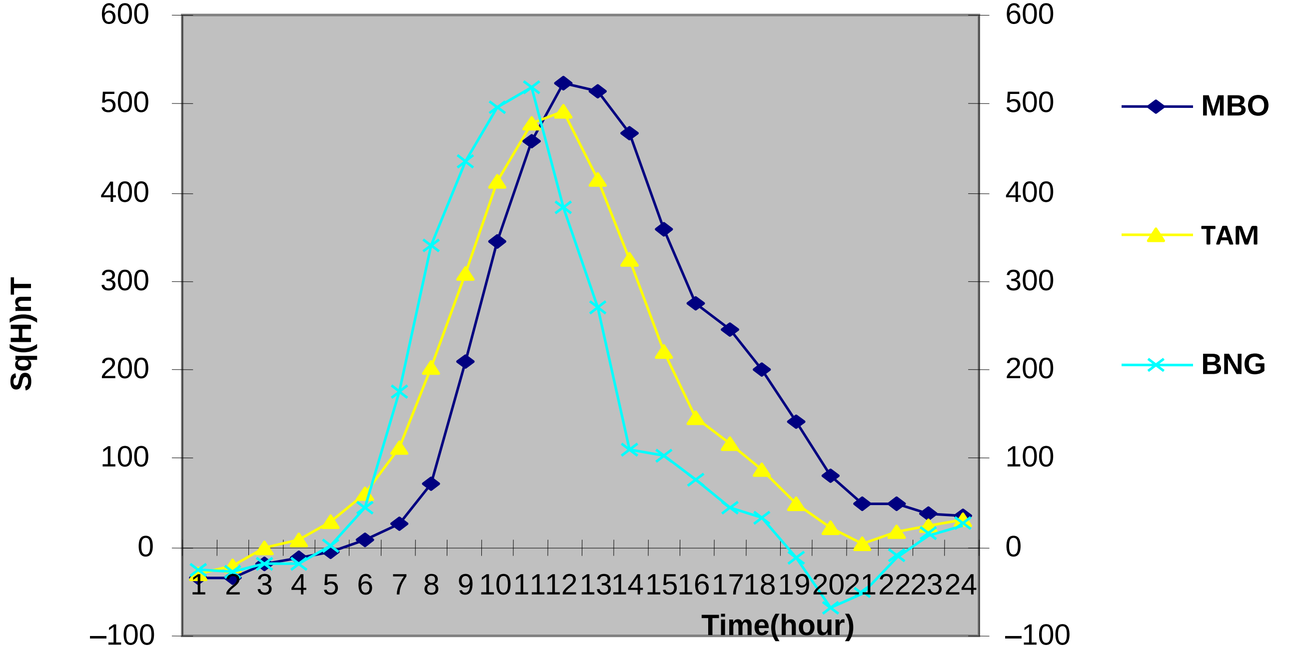

Fig. 1: Sq(H) variation in March at MBO, TAM and BNG 1996

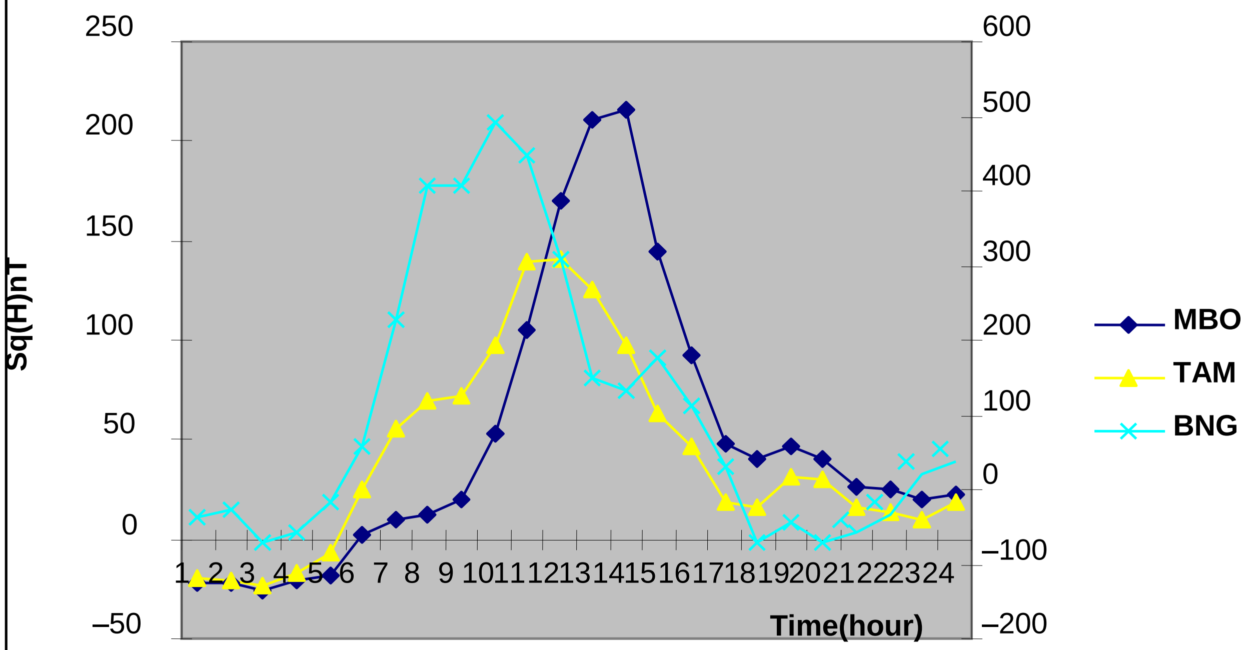

Fig. 2: Sq(H) variation in December at MBO, TAM and BNG 1996

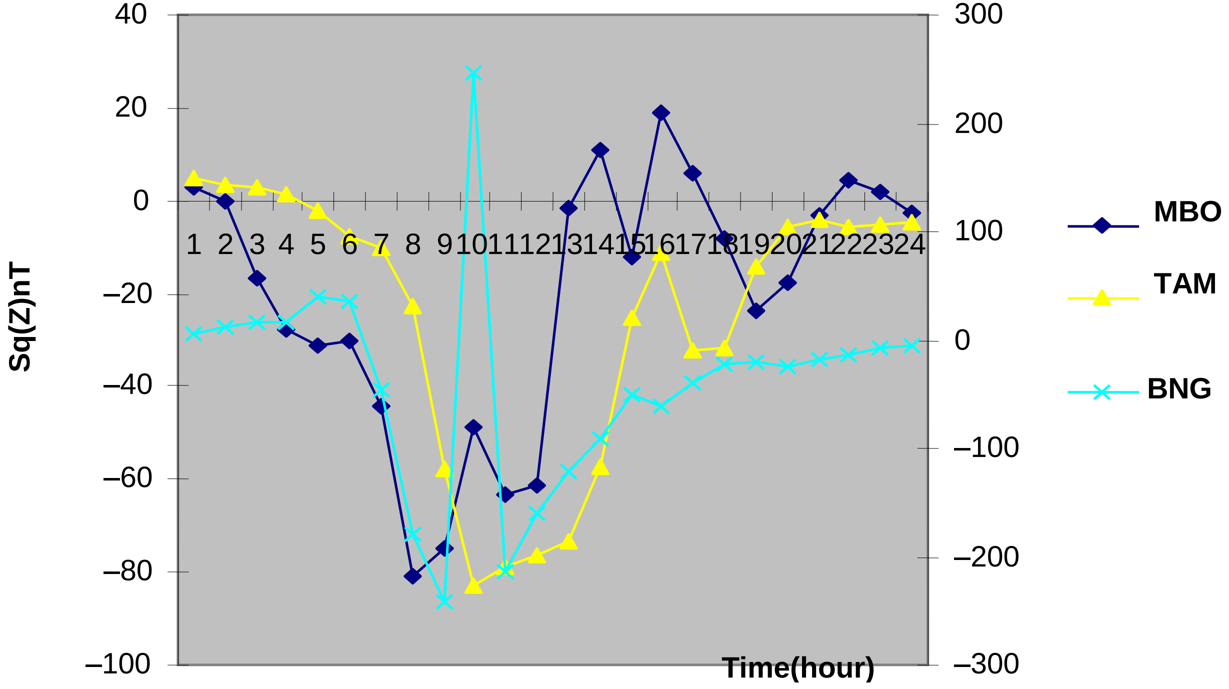

Fig. 3: Sq(Z) variation in March at MBO,TAM and BNG 1996

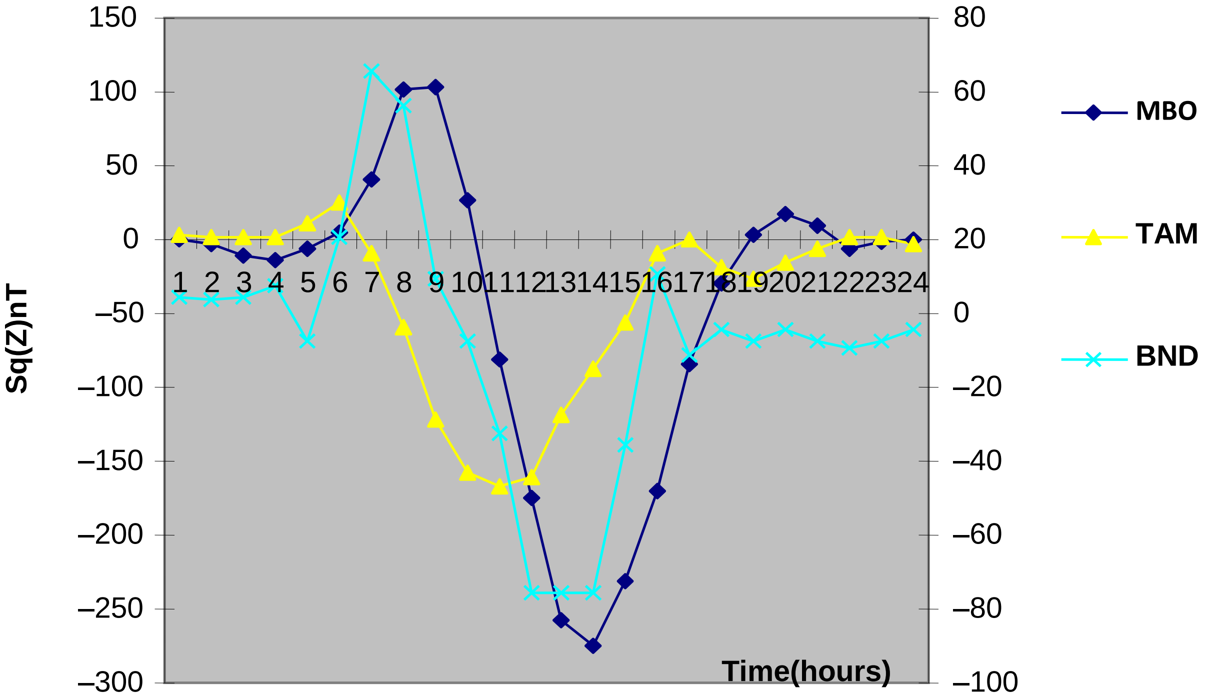

Fig. 4: Sq(Z) variation in June at MBO, TAM, BNG at 1996

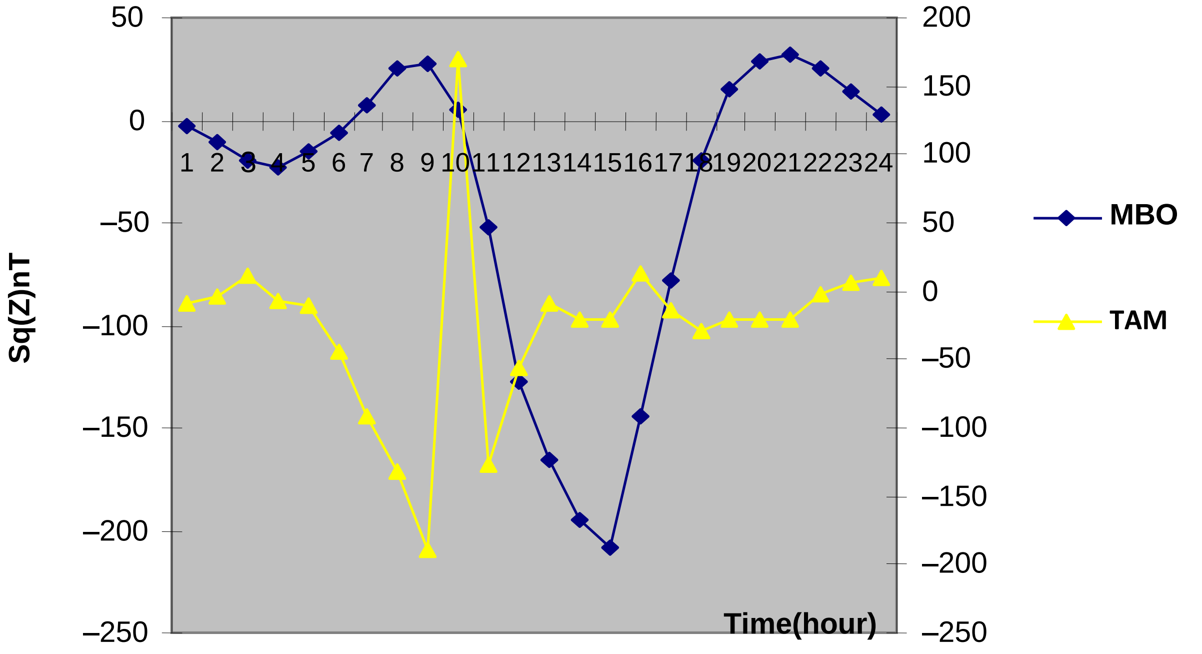

Fig. 5: Sq(Z) variation in Dec at MBO, BNG at 1996

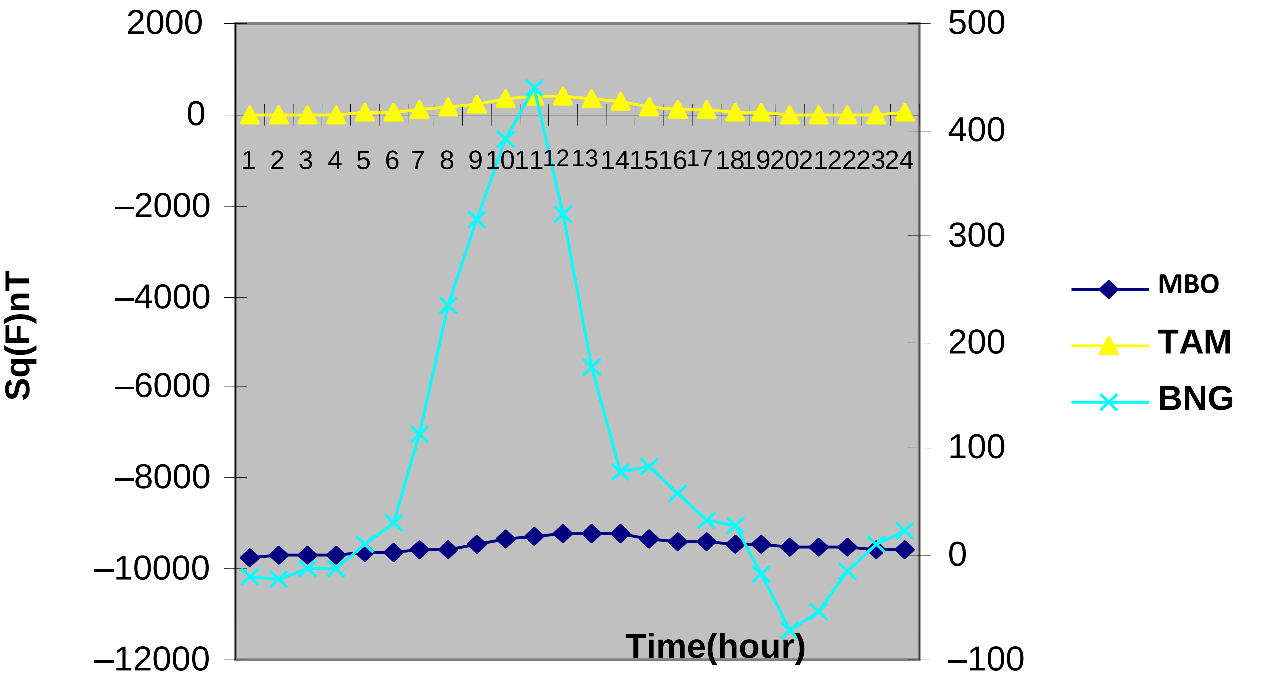

Fig. 6: Sq(F) variation in March at MBO, TAM and BNG 1996

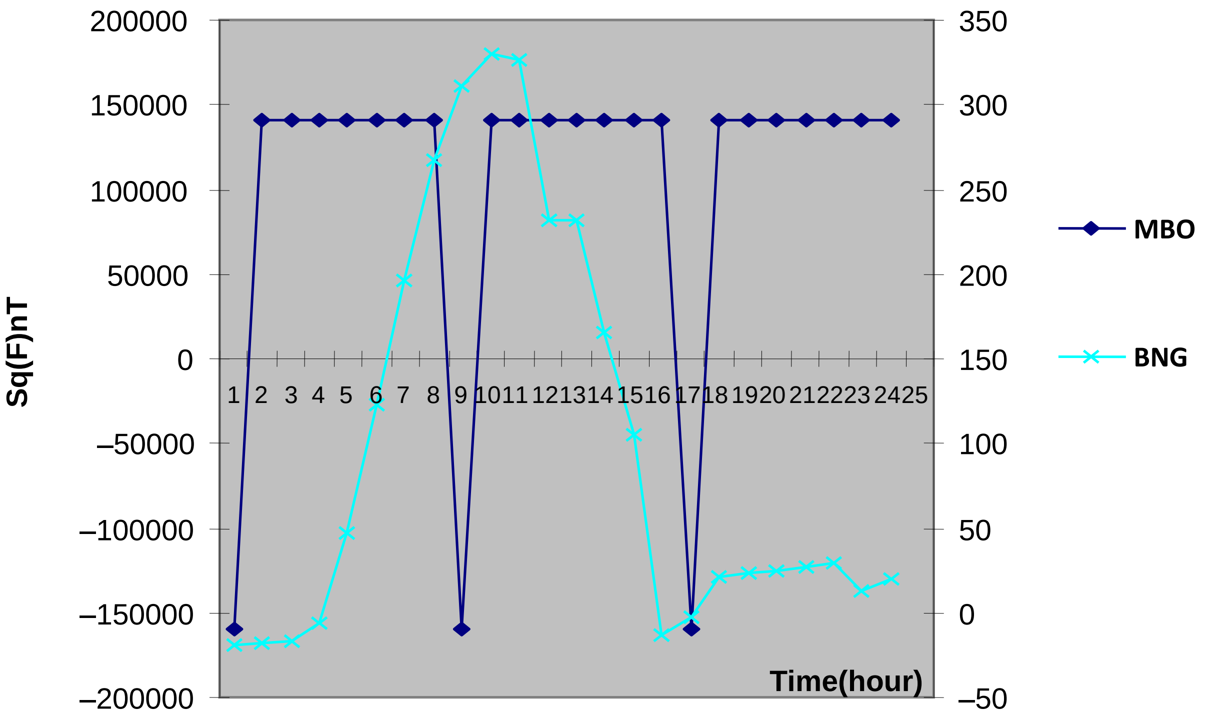

Fig. 7: Sq(F) variation in June at MBO and BNG in 1996

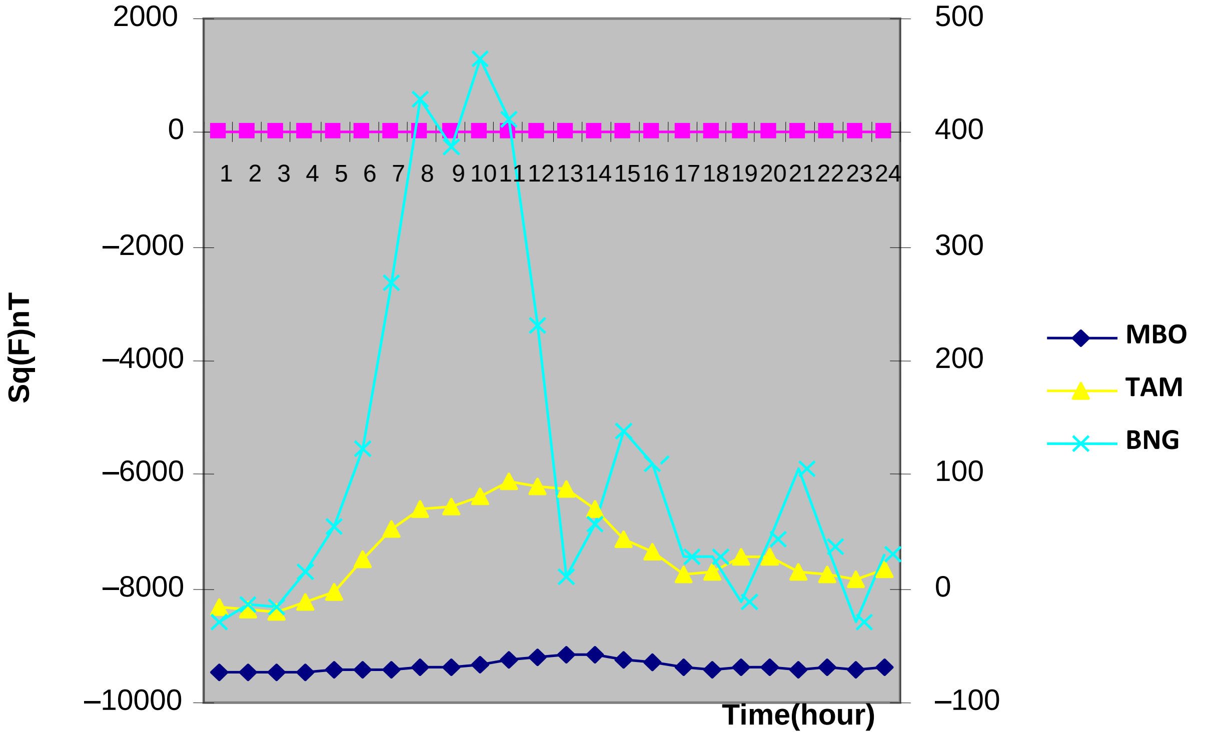

Fig. 8: Sq(F) variation in December at MBO, TAM and BNG 1996

CONCLUSION

Typical curves of the S_q variation of the total field summarise its form over the globe except at every high latitudes. The curves show that total – field variations have a seasonal variability and a distinct latitudinal dependence. There is a pronounce maximum in the daily variation at the equator and in both hemisphere on either side of this maximum, there are bands where the amplitude of total field is subdued. Such characteristics are important in understanding the total quiet field variation present in magnetic survey data and indeed in any exercise involving the monitoring of earth’s magnetic field.

REFERENCES

Alex, S. (1992*).* Variation of Geomagnetic field components during low Solar activity. Geophysical Research, 23: 3124– 3133.

Bartel, J. & Johnson, H. F. (1940). Geomagnetic tides in horizontal intensity at Huancayo part. Geophysical Research, 45: 264 –308.

Campbell, W. H. (1997). Introduction to Geomagnetic fields, Cambridge University Press, New York.

Champman, S. (1951). The Equatorial Electrojet as detected from the abnormal electric current distributions aboveHuancayo, Peru and elsewhere, Arch. Meteorol. Geophysics Biclimator, 4: 368– 390.

Egedal, J. (1947). The Magnetic diurnal Variation of the horizontal field near the Magneticequator. Geophysical Research, 52: 449.

Hitchman, A. P., Lilley, F. E. M. & Campbell, W. H. (1998). The quiet daily variation of the total Magnetic field, Geophysical Research Letters, 25: 2010.

Lilley, F. E. M. & Parker, R. L. (1976). Magnetic daily Variations compared between the East and West coasts of Australia. Geophysical Journal Astro. Soc., 44: 719–724.

Okeke, F. N. & Humano, Y. (2000). Daily Variation of Geomagnetic H, Z and D fields at equatorial latitudes. Geophysical Research, 52: 237–243.

www.intermagnet.com.