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Quiet time Variation of the Geomagnetic H-component strength over Ilorin, North Central Nigeria

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Abstract

The study of the geomagnetic H-component variation during the geomagnetic solar quiet days, sq(H) was investigated using the horizontal (H) component hourly data from geomagnetic field measurement from a ground based MAGDAS (Magnetic Data Acquisition System) fluxgate magnetometer for a period of twelve (12) months in the year 2008.The location of the measuring instrument is at Ilorin, an equatorial electrojet station located at the geomagnetic coordinates (-1.82^0 and 78.90^0) and geographical coordinates (8.50^0 and 4.68^0) respectively. Results of the investigations show a noon-time-peak value for all the months considered. It was observed that the magnitude of the Sq(H) shows an increase in amplitude from dawn to noon and a decrease to the minimum daytime value. The variations in the geomagnetic field at this location can be attributed to the combined effect of latitudinal variation, influence of solar activity conditions and E X B field.

Keyword: geomagnetic field, ionosphere, MAGDAS

1. Introduction

The MAGDAS magnetometer was installed in University of Ilorin, Nigeria on August 2006. The station has since provided magnetic data for many scientific investigations in African sector and scientific reports e.g., [1, 2, 3] to mention few. The study of the horizontal (H) component of geomagnetic field have shown the prominent impact it plays on the ionospheric dynamo, it influences the electric field velocity that serves as a key driver of the ionosphere particularly at the low and equatorial latitudes. The low and equatorial latitude regions exhibit the ionosphere anomalous, while the high latitude ionosphere said to be complicated emphasizes phenomenon like different current systems that influences region's magnetic activity [4]. Earth's magnetic field also referred to as a geomagnetic field, which extents from the Earth interior to the outer space where it interacts with the solar wind. Geomagnetic field are the consequence of the electric current generated by the continuous moving molten iron in the fluid outer core of the Earth through a self-exciting process called geodynamo process [5]. The geomagnetic field comes from both the inner and outer of the Earth, which are referred to as the stable and variable fields. The stable field is produced by the core dynamo current of the Earth interior and the crustal field produced by earth's crustal magnetic rocks while the variable field is produced by the current systems in the magnetosphere, ionosphere and their induction currents [3]. The variable field extends out into space, where it interacts with a stream of fast-moving charged particles emanating from the Sun. The equatorial ionosphere of height between 60 - 160 km above earth surface is the region of high solar flux because the sun is directly overhead there. Hence, there is maximum rate of ionization and electron density. The study of the region is so important to the field of space and communication Physics because of its special attribute due to the unique orientation of the earth's magnetic field lines that are almost horizontal to the magnetic equator. An intense current sheet known as the equatorial electrojet (EEJ) flowing along the magnetic meridian characterized the region [6]. [7] suggested that the EEJ strength can be estimated by this relationship:

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$EEJ = \Delta H_{EEJ} - \Delta H_{non-EEJ;}$ where ΔH_{EEJ} is the variation of H component from the midnight baseline for a station on the EEJ belt and $\Delta H_{non-EEJ;}$ for a station off the EEJ belt. Where their differences give the estimated EEJ strength of that particular longitudinal belt. In days where geomagnetic disturbances are absent, the EEJ reverses its direction at any particular time of the day. This reversed process is known as the counter electrojet (CEJ) [8,9]. The reversal translate to decrease in H-component values and subsequent depression on Sq(H), quiet time variation in H-component beyond the baseline or nighttime level. This work studied the diurnal monthly and seasonal variations of H-component for ILR and subsequent estimation of the strength of EEJ for ILR being an EEJ belt station.

2. Data and Method of Analysis

The year 2008 (leap year) magnetic data set used in this research work were obtained from the Magnetic Data Acquisition System (MAGDAS) facility at the University of Ilorin, North central Nigeria, on the 96^0 magnetic meridian (MM) belt. Data for TAM (Tamanrasset, Algeria) gotten from INTERMAGNET website. Table 1. gave the geographical and geomagnetic location parameters of the stations whose data was utilized for this study. The location of the stations on the world map is shown in figure1. The days used for the analysis were selected from the ten (10) international Quiet Days (IQDs) routinely selected for each month and published by the German Research Centre for Geoscience (GFZ), Potsdam based on the kp index, available online at http://www.gfz-potsdam.de/kp-index/qddescription.html.

Station	Abbreviations	Country	Geographical		Geomagnetic	
			Lat (°)	Lon (°)	Lat (°)	Lon (°)
Ilorin	ILR	Nigeria	8.50	4.68	-1.82	78.90
Tamanrasset	TAM	Algeria	22.80	5.50	25.40	80.60

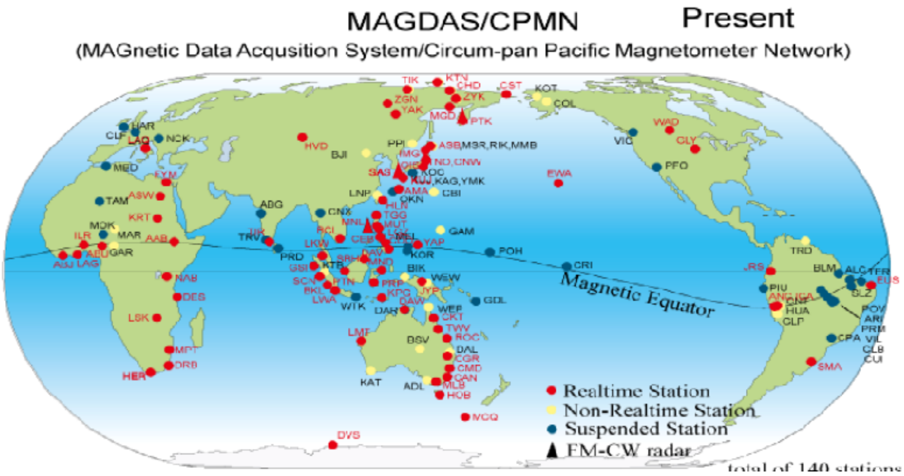

Fig.1.MAGDAS/CPMN(Magnetic Data Acquisition System/Circum-pan Pacific Magnetometer network) System

The data were the minute averages of H, the geomagnetic north-south component that were converted to daily hourly values. The average of the hourly records of the geomagnetic H-component were considered with respect to the local time of the station considered. Nigeria is +1 ahead of Greenwich Meantime (GMT). The local time (LT) for the selected station were utilized throughout the analysis. Baseline values (BAL) were calculated by averaging the value of 4 hrs flanking the local midnight (2300, 2400, 0100 and 0200 LT). Many researchers, including [1, 10, 9] have used this approach in their various work.

The BAL value for the H- component is thus given by $BAL(H) = \frac{H_{23} + H_{24} + H_{01} + H_{02}}{4}$ (1)

where H_{23}, H_{24}, H_{01} and H_{02} are the hourly values of H - component at 23-, 24-, 01- and 02-hours LT. The operation of eqn. (1) above were carried out for the geomagnetic station considered at their local time. The solar quiet amplitude Sq(H) for a particular hour t, were deduced by subtracting the baseline, BAL (H), for a particular day from each of the hourly values H_t for that particular day H_t.

$$Sq(H) = H_t - BAL(H) \quad (2)$$

$\text{where}, t = 01 \text{ to } 24 \text{ (hr) LT}$

3. Result and Discussion

The results of the diurnal monthly variation of the geomagnetic H- component for Ilorin (ILR) station were shown in Figures 2. The dotted points represent the daily values of Sq(H) and the red thick line represents the diurnal monthly average of the hourly values of Sq(H) for the ten quietest days of the months at the station considered. For our description henceforth, the mean of the Sq(H) hourly values for each hour of all the ten quiet days of a month is termed hourly value for each month. The results of the hourly values of Sq(H) for ILR station in Fig.2 reveals that the diurnal variation of Sq(H) presents the same trend in every month of the year 2008 at a specified magnitude. A pattern of the Sq(H) variation is symmetry about local noon in all months of the year considered, in agreement with work of [3,10,11]. The morphology of the diurnal monthly variations of Sq(H) for ILR shows a regular increase in amplitude from dawn to a noon peak value before gradually decreasing to a minimum daytime value. This value remained at baseline level through the nighttime period. The highest Sq(H) observed at noon hour and minimum Sq(H) observed in the nighttime was as a result of the continuous solar heating of the upper atmosphere [3]. The peak value noted for ILR can be attributed to the equatorial intensification due to daytime solar activity as photo-ionization and minimum loss rate. The absence of solar radiation at night suggest that the nighttime variation came from non-ionospheric sources (e.g., Magnetosphere etc.).

The diurnal monthly variations of Sq(H) at ILR station for the months of the year 2008 also indicate that there were gradual increase and decrease in Sq(H) magnitudes before and after the noon peak.

The maximum amplitudes of Sq(H) variation recorded for the year were ~97 nT at 1100h LT and ~93 nT at 1100h LT in the months of January and March respectively. The minimum magnitude of the Sq(H) observed at the pre and post peak Sq(H) value were noticed to be -8.0 nT at 0700h LT of September and -47 nT at 1700hr LT for month of January.

The depression observed after noon peak in the months of January, March, May and October with respective magnitudes of --45 nT at 1700h LT, -40 nT at 2100h LT, -20 at 1700h LT and -40 nT at 2000h LT were attributed to phenomenon known as counter electrojet (CEJ) in [3]. CEJ is a geomagnetic phenomenon whose attributes are seen during the geomagnetic quiet conditions as a negative depressions in the magnitude of the geomagnetic H-component during the post noon hours, [12].

Figure 3 represents the seasonal variation of Sq(H) at ILR. The seasonal Sq(H) variation peak value was observed during the March equinox (February, March and April) at about 1100h LT with a magnitude of 64 nT. The minimum seasonal Sq(H) variation amplitude was observed during the June solstice (May, June and July) at around 1200h LT and magnitude of 46 nT. The station shows a unique pre and post-noon peak time of nearly baseline values.

Figure 4. depicts the plots of EEJ strength observed over ILR for yea 2008. it was observed That the EEJ strength peak for all the months considered were almost symmetrical about local noon. Month January recorded the peak amplitude of 40nT a 1200hr LT.with least peak value credited to month of May with 12 nT at 1200hr LT. Moreover, EEJ strength during morning and night time were about the baseline level. A notable decrease in EEJ(CEJ) was seen in the morning and afternoon but Afternoon CEJ was more pronounced in the month of February with value -5.7 nT at 1600 hr LT.

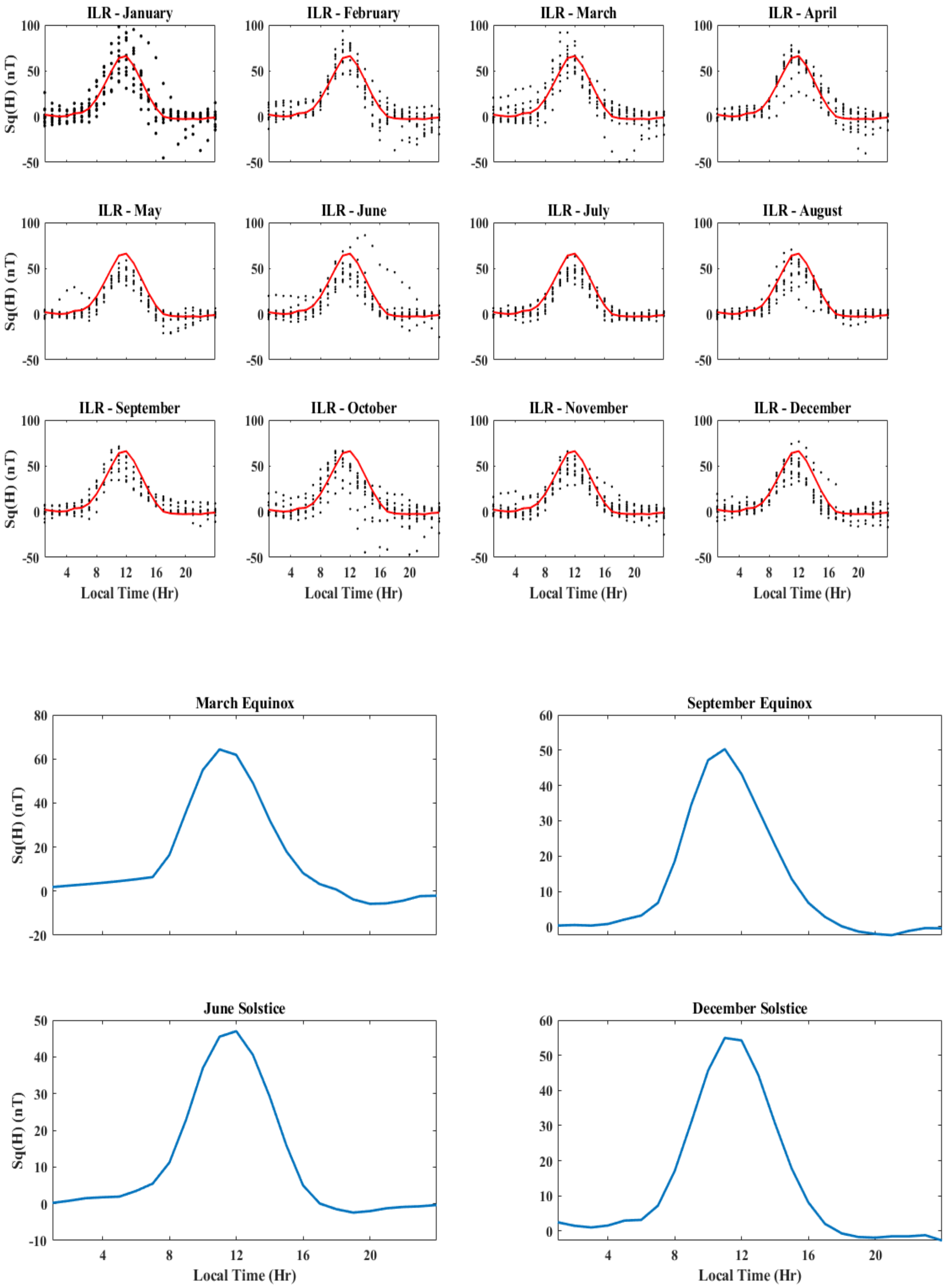

Fig.3: Seasonal Variation of Sq(H) for Ilorin.

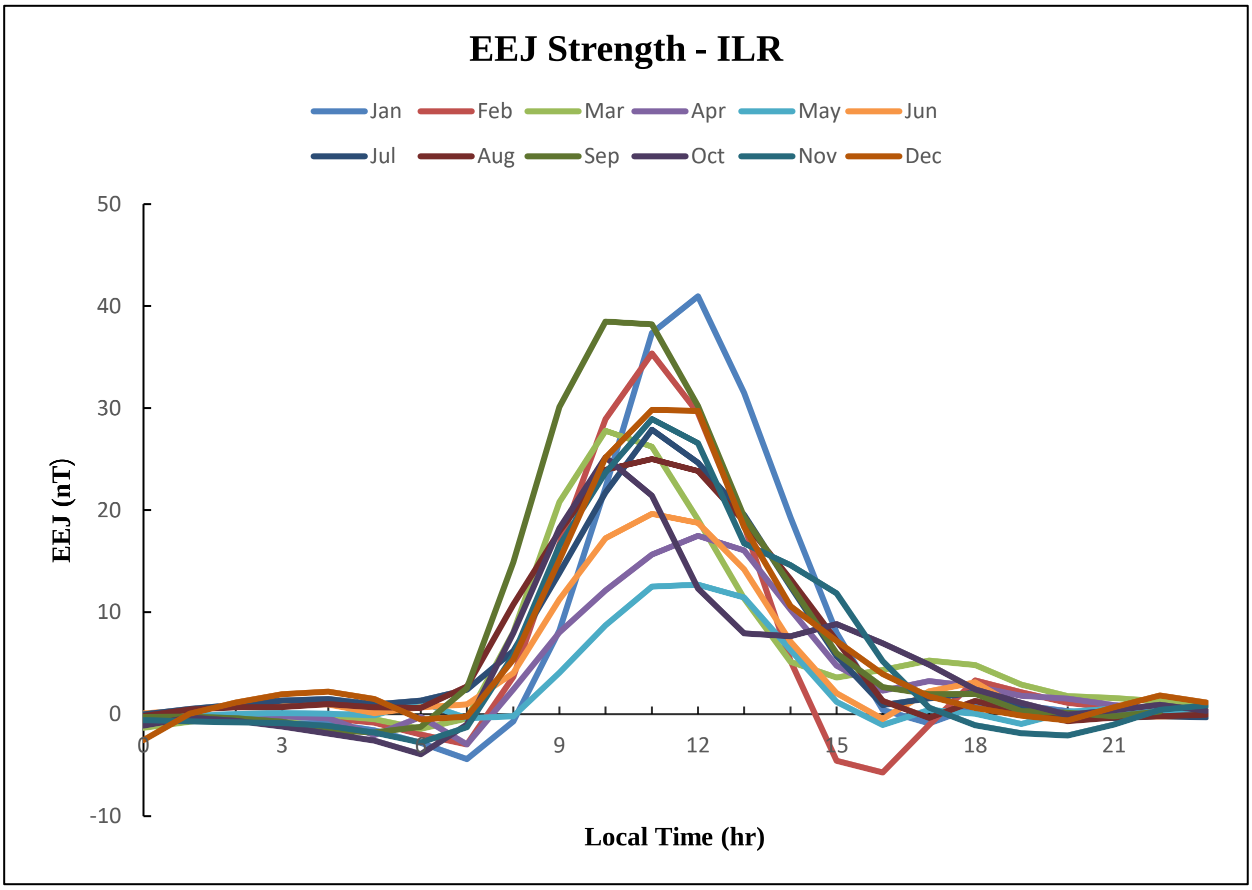

Fig.4: EEJ Strength plots over Ilorin

4. Conclusion

This present work gives the results of investigation of the quiet time geomagnetic H-component variation over Ilorin, the study affirmed that there is Sq variation in horizontal component of the earth magnetic field on quiet days year-round. The magnitudes are greater during the daytime (noon) hours than the nighttime hours. This is mainly due to the variability of the ionospheric processes and physical structure such as conductivity and wind structure. The maximum EEJ strength recorded in January was in agreement with previous-work of [11] that significant positive correlation exist between the diurnal variation of geomagnetic H-component and EEJ, especially in January, 2008. The conclusion drawn from the study shows that the geomagnetic field variations in ILR an equatorial electrojet station are higher due to solar activities in the station due to its unique orientation around the equator.

1. The maximum Sq(H) and EEJ strength amplitudes of Sq(H) 97 nT at 1100h Lt and 40 nT at 1200h LT observed in January 2008 at ILR were as a result of the station latitudinal position.
2. The seasonal variation showed the equinoctial Maximum Sq(H) of 64 nT and 50 nT at noon for March and September equinoxes due to the continuous heating of the upper atmosphere.
3. The diurnal variation is present in the horizontal component of the earth magnetic field during the quiet days the year-round. The noon time magnitudes are greater than the pre- and post-noon magnitude. This is accounted for by ionospheric processes such as photo ionization.
4. The high amplitude noticed for ILR can be attributed to the location of the station around the equatorial latitude and as such EEJ (equatorial electrojet) current which is a eastward current flowing positive in the morning resulted in the enhancement in Sq(H) values recorded for the station.

5. The EEJ strength of max value of 40 nT was observed in month January at 1200hr LT.

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- Centre for Atmospheric Research, National Space Research and Development Agency, Nigeria.

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