Physical Review & Research International
3(2): 154-160, 2013

SCIENCEDOMAIN *international*
www.sciencedomain.org

The Variability of H Component of Geomagnetic Field at the African Sector

T. N Obiekezie[1*] and S. C Obiadazie[1]

[1] *Physics and Industrial Physics Department, Nnamdi Azikiwe University Awka, Nigeria.*

Authors' contributions

This work was carried out in collaboration between the authors. Author TNO designed the study, managed the literatures and analysis of the study. Author SCO performed the statistical analysis and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Research Article

Received 16th January 2013
Accepted 9th March 2013
Published 23rd March 2013

ABSTRACT

The investigation of the variability of the Sq(H) in the African sector was carried out using the geomagnetic field measurements of four stations located in the East, West, Central and South Africa. The study shows that the variations of the geomagnetic element were a dusk to dawn phenomenon with a none zero variation observed in the night. The variability of the nighttime Sq(H) is believed to be from sources other than the ionosphere. An enhancement in Sq(H) variations in Addis Ababa station was observed. The observed enhancement in Sq (H) variations in Addis Ababa station was attributed to the influence of Equatorial electro jet [EEJ] current system. Day- to-day variability in Sq(H) was observed in all the stations, these variability from one day to the next was seen to be both in amplitude and in phase, it does not have a definite pattern thus it is random. Equinoctial maximum in Sq(H) was observed for Mbour, Addis Ababa and Bangui stations while December Solstitial maximum was observed for Hermanus station. Latitudinal positions of the stations were found to affect the Sq(H) amplitude.

Keywords: Amplitude; variability; ionosphere; solar quiet; Africa.

1. INTRODUCTION

---

[*] *Corresponding author: Email: as27ro@yahoo.com;*

The region of the atmosphere from about 60km - 1000km, is known as the ionosphere. It is a region where ion densities are sufficiently large to affect radio wave propagation. The ionosphere due to its increasing applications in radio-communication has continued to attract a lot of interest. Zhang et al. [1] observed that the ionospheric variability is of practical interest since the variation of the ionosphere has an important impact on the trans-ionospheric radio communications. Stewart [2] postulated that the daily oscillations in ground magnetic records originate from dynamo action in the ionosphere. The daily variations of the geomagnetic field when solar-terrestrial disturbances are absent are called solar quiet (Sq) variations [3]. These Sq variations are due to electric currents flowing in the dynamo region of the ionosphere around 100 km altitude. These dynamo currents are driven by winds and thermal tidal motions in the E region of the ionosphere [4].

Doumouya et al. [5] observed that the geomagnetic field intensities on quiet time vary from one longitudinal sector to another even within the equatorial zone. Studies on solar quiet daily variation of the earth's magnetic field show that Sq varies with seasons and also on day-to-day basis. The Seasonal variation and day-to-day variations of the horizontal component of the Earth's geomagnetic field, Sq(H) had been studied by several authors which includes; Onwumechili [6], Obiekezie and Agbo [7], Rabiu [8], Agbo et al.[9], Obiekezie and Okeke [10].

It should be noted that, although much work has been done on the variations of geomagnetic components, study on the African sector has been limited. This present paper employs a set of geomagnetic data to investigate the nature of Sq(H) variations at four different locations in Africa and to deduce the mechanism responsible for the observed variations and variabilities. This work also aims at bridging the existing gap between the African sector and other world sectors.

2. METHOD OF ANALYSIS

The data set used in this analysis consists of the hourly values of the geomagnetic field horizontal intensity, H, recorded at four different observatories in Africa in the year 1987. The geographical and the geomagnetical locations of these stations are shown in Table.1. The ten internationally quite days (IQDs) in each month for the year 1987 was selected for this analysis, these IQDs are the ten quietest days of the month according to the index Kp. The hourly values of the geomagnetic component H on IQDs only were employed.

Table 1. The geographic and geomagnetic coordinates of the stations

S/n	Stations	Abbreviations	Location in Africa	Geographic		Geomagnetic	
				Lat. (^{O})	Long. (^{O})	Lat. (^{O})	Long. (^{O})
1	Hermanus	HMN	South	-34.42	9.23	-33.67	83.35
2	Addis Ababa	AAB	East	9.03	38.77	5.16	111.38
3	Mbour	MBR	West	14.40	343.02	20.36	57.16
4	Bangui	BANG	Central	4.43	18.57	4.34	90.75

The local time [LT] for all the four stations was employed throughout the analysis. The baseline values (H_B) (equation.1) was calculated as the average of the values of the hours flanking the midnight plus the midnight values [00,01,22,23].

$$H_B = \frac{H_{22} + H_{23} + H_{00} + H_{01}}{4} \qquad 1$$

Where $H_{00}, H_{01}, H_{22}, and\ H_{23}$ are the hourly values of H at 00, 01, 22, and 23 hours LT respectively.

The hourly departures of H from the baseline values dH was obtained by subtracting the baseline value for a particular day H_B from the hourly values for that particular day H_t. Thus for the hour 't'

$$dH_t = H_t - H_B \qquad 2$$

Where t = 0 to 23 hours.

The non cyclic variation (H_c) defined as a phenomenon in which the value at 00LT is different from the value at 23LT, (Vestine [11] and Rabiu [12]) was removed.

$$H_c = \frac{dH_0 - dH_{23}}{23} \qquad 3$$

The linearly adjusted values at these hours are:

$$dH_0 + 0H_c, dH_1 + 1H_c, dH_2 + 2H_c \ldots\ldots\ldots\ldots, dH_{22} + 22H_c, dH_{23} + 23H_c.$$

In other words,

$$Sq_t(H) = dH_t + tH_c \qquad 4$$

Where $Sq_t(H)$ is the solar quiet daily variation in H, while, t is the local time ranging from 00 to 23.

The hourly departures corrected for non-cyclic variation on quiet gives the solar quiet daily variation in H denoted as Sq(H)

Studying the day-to-day variabilities in the horizontal component was only possible for the consecutive International Quiet Days [IQDs]. The variability of the hourly amplitude for a fixed hour say (t) from one international quiet day (i) to the next succeeding international quiet day (i+1) are given as equation (5)

$$H_{dd} = h_{t(i+1)} - h_{ti} \qquad 5$$

Of the systematic changes in the geomagnetic daily variation at a station, the most obvious one is that associated with the seasons. For a study of the seasonal variation, the months of the year were classified following Llyod's seasons (Eleman, [13]), into (1) D-season [January, Febuary, November and December]; (2) E-season [March, April, September and October]; (3) J-season [May, June, July and August]. The seasonal values were then estimated by averaging values for all the months in a particular season. These were then plotted to show the seasonal variations in Sq[H].

3. RESULTS AND DISCUSSION

The mean of the hourly values for each individual hour for all the ten quiet days of a month is called the mean hourly value for the month. This value is plotted against local time (Fig. 1) to examine the hourly variations on quiet days. The Sq[H] diurnal variations were observed to present the same shape in all the stations except at Hermanus station. The Sq[H] amplitude at these stations increases regularly from dawn, maximizes around 8.00hrs LT for AAB, 10.00hrs for BANG and 12.00hrs for MBR and then decreases towards dusk. The variation for HMN is different almost having a minimum around the local noon hours. It is known that the geographic latitude and the Suns location largely determine both the ionization and the thermo tidal motion in the ionosphere thus the difference observed in HMN station is as a result of its latitudinal position. MBR, BANG and AAB are all equatorial stations, thus, there large amplitudes could be attributed to the equatorial intensification during the daytime as a result of solar heating or increase in solar activity during the day time. AAB were seen to present highest Sq[H] amplitudes of about 70nT. AAB station (0.18° dip latitude) lies within the equatorial electro jet strip (± 3° dip latitude); an east–west current strip that flows positive during the morning hours, thus the high Sq(H) amplitude could be attributed to the influence of the this current strip termed equatorial electro jet.

Fig. 1. also indicated that in all the stations the night amplitudes are seen not to be zero thus there is night time variation of Sq (H). Since there are no solar radiations at night which should contribute to the dissociation of ions in the ionosphere, it then means that the variations observed in the night in all the stations came from sources other than the ionosphere (e.g. Magnetosphere, etc)

The variabilities of Sq(H) hourly amplitudes for the hour t from the day i to the next day i+1 for all hours of the day called the day-to-day variability was investigated only for consecutive IQDs. Fig.2 is the plot of amplitudes of the day-to-day variability with LT for the months of May which is one of the months with the highest consecutive IQDs. It could be seen from Fig. 2 that the variability between two paired consecutive days are quite different from any other two paired subsequent consecutive days. For example, on the 15/16 May, 16/17 May and 17/18 May, the variations are seen to remarkably different from one another. Observing from this figure, on the 15/16 day at AAB, the day- to- day variability in H was seen to have amplitude up to 19nT, while on the 16/17 at the same station, the amplitude was about 32nT, while on the 17/18 it goes to about −24nT. Significant differences in amplitude as well as in phase can be seen in the other three stations. These amplitude and phase variations are seen not to have a definite pattern; it is seen to be random. Okeke et al. [14] noted that changes in the electric field control the phase and randomness of the variabilities, while the magnitude of the ionospheric conductivity controls the magnitude of the variabilities.

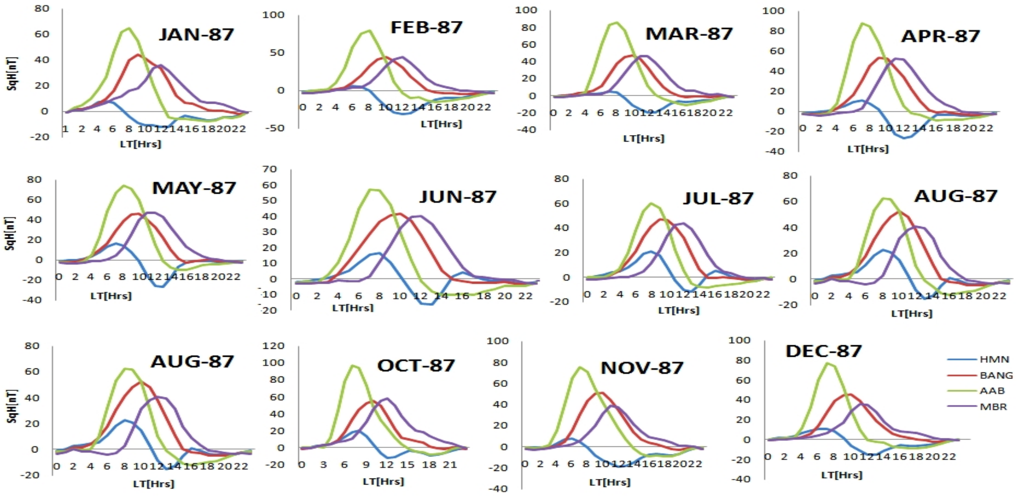

Fig. 1. Monthly variations of Sq(H) for all the stations

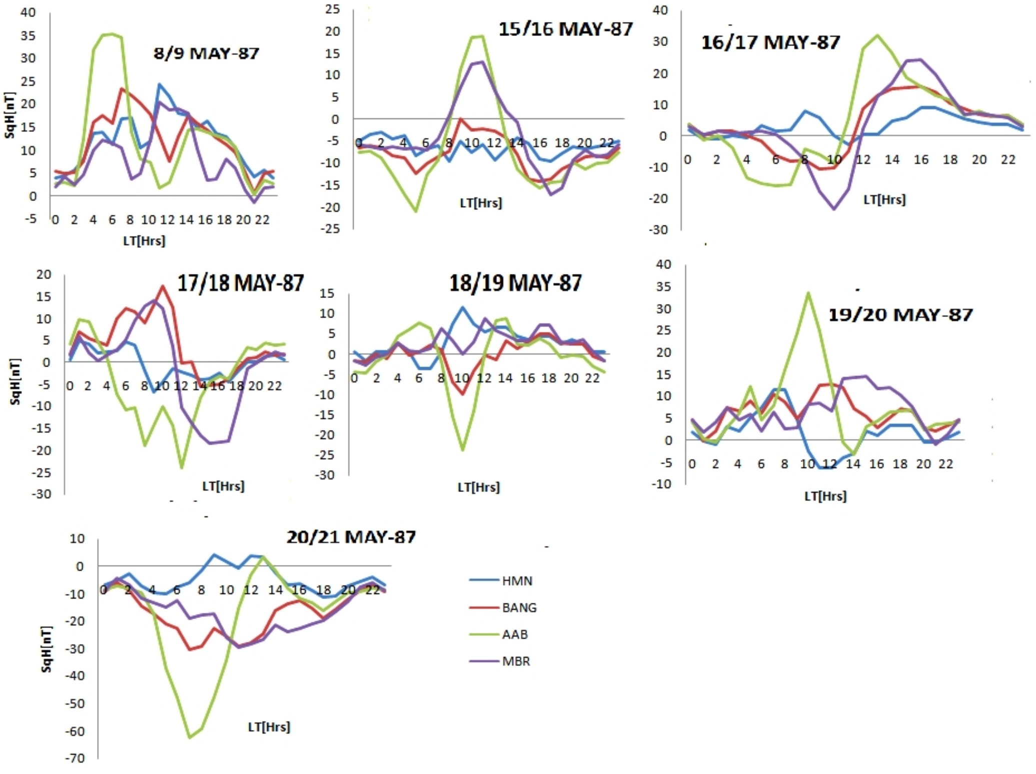

Fig. 2. Day-to-day variations of Sq(H) for all the stations

The seasonal variations of the Sq[H] as shown in Fig. 3 reveals that Sq[H] variation exhibits remarkable seasonal variations in all the stations. Equinoctial maximum and June solstitial minimum is observed in all the stations except at HMN station which shows December solstitial maximum. The equinoctial maximum occurred at Mbour, Bangui, and Addis Ababa with Sq[H] amplitudes of about 12.18 nT, 12.32 nT, and 15.00 nT respectively. Thus, the Sq[H] seasonal variation at Addis Ababa has the highest equinoctial maximum. This result at these equatorial stations is in consonance with the earlier works of Rabiu [8], Okeke et al., [14], Okeke and Hamano [15], and Obiekezie and Okeke [10]. The equinoctial maximum as observed at the equatorial stations could be attributed to the enhanced equatorial electron density during equinox when the solar activity is maximum at the equator. Also the December solstitial maximum as observed at the Hermanus station is not surprising since the solar activity is maximum during this season at any location in the Southern hemisphere. Thus, the seasonal variation so observed could be attributed to the seasonal shift in the mean position of the Sq current system of the ionosphere which depends on the latitude and the Suns location.

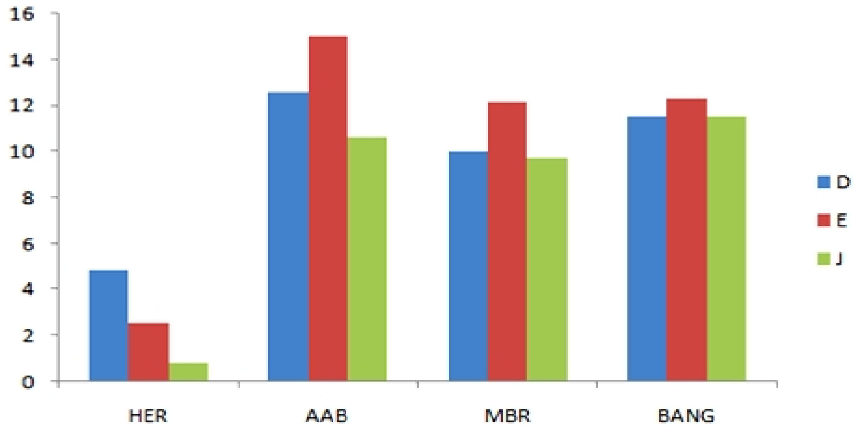

Fig. 3 Seasonal variations of the Sq[H]

4. CONCLUSION

The following conclusions can be drawn from the investigation of the Sq(H) in the African sector using the geomagnetic field measurements of four stations located in the East, West, Central and South Africa.

1. Latitudinal positions of the stations affect the Sq(H) amplitude
2. The enhanced field variations at Addis Ababa station is due to the EEJ current.
3. The Sq(H) variations exhibited a dusk to dawn phenomenon with a none zero variation observed in the night.
4. The variability of the nighttime Sq(H) is from sources other than the ionosphere (e.g. Magnetosphere, etc)
5. It is noted that the phase changes and randomness observed in the day- to- day variability is controlled by changes in the electric field while the magnitude of the ionospheric conductivity controls the magnitude of the variabilities.
6. Sq[H] variation of equinoctial maximum at Mbour, Bangui, and Addis Ababa stations, and December. Solstitial maximum at Hermanus station, suggests that the seasonal variation so observed could be attributed to the seasonal shift in the mean position of the Sq current system of the ionosphere which depends on the latitude and the Sun's location.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Zhang ML, Shi JK, Wang X, Radicella SM, Ionospheric variability at low latitude station: Hainan, China, Advances in Space Research. 2004;34:1860–1868.
2. Stewart B. Hypothetical views regarding the connection between the state of the sun and terrestrial magnetism in "Encyclopedia Brittanica", 9th ed. 1882;6:181-184.
3. Campbell WH. The regular geomagnetic-field variations during quiet solar conditions, in: Jacobs .J. (ed) Geomagnetism: Calif, San Diego: Academic. 1989;3:386-460.
4. Chapman S. The solar and lunar diurnal variation of the earth magnetism. London: Phil. Trans. Roy. Soc. 1919;A(218):1–118.
5. Doumouya V, Cohen Y, Arora BR, Yumoto K. Local time and longitude dependence of the equatorial electrojet magnetic effects, J. Atoms. Terr. Phys. 2003;65:1265–1282.
6. Onwumechili CA, In: Eds. Matsushita S, Campbell WH. Physics of Geomagnetic Phenomena. 1967;1:425-507. Academic press, New York.
7. Obiekezie TN, Agbo GA. Day to day variability of Sq(H) variation in the Indian sector. JANS. 2008;3:81–85.
8. Rabiu AB, Nagarajan N, Okeke FN, Ariyibi EA, Olayanju GM, Joshua EO, Chukwuma VU. African Journal of Science and Technology (AJST) Science and Engineering series. 2007;8:54-63.
9. Agbo GA, Chikwendu AO, Obiekezie TN. Variability of daily horizontal component of geomagnetic field Component at low and middle latitudes. Indian J. Sci. Res. 2010;1(2):1-8.
10. Obiekezie TN, Okeke FN. Variations of geomagnetic H, D and Z field intensities on Quiet days at West African latitudes Moldavian. J. Phys. Sci. 2009;8(3-4):366-372.
11. Vestine E. The geomagnetic field, its description and analysis, Carnegie Institute, Washington Publ. 1947;580.
12. Rabiu AB. Geomagnetic field variations at the middle latitudes, unpublished Ph.D. Thesis, University of Nigeria, Nsukka; 2000.
13. Eleman F. The geomagnetic field in Cosmical Geophysics, ed. Egeland A, Holter O, Omholt A. Scandinavian University Books, Oslo, Chapter. 1973;3:45-62.
14. Okeke FN, Onwumechili CA, Rabiu AB. Day-to-day variability of geomagnetic hourly amplitudes at low latitudes, Geophys. J. Intl. 1998;134:484-500.
15. Okeke FN, Hamano Y. Daily variations of geomagnetic H, D and Z-field at equatorial latitudes, Earth planet Space. 2000;52:237-243.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=201&id=4&aid=1154