VARIATIONS OF GEOMAGNETIC H, D, AND Z FIELD INTENSITIES ON QUIET DAYS AT WEST AFRICAN LATITUDES

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Abstract

In the framework of the French participation to the International Equatorial Electrojet Year (IEEY), a network of ten electro-magnetic stations was installed at African latitudes. These stations measured digitally the three components of the magnetic field and the two components of the telluric electric field, and operated over a period of 20 months. The magnetic data are used to study the variations of geomagnetic H, D, and Z field intensities on quiet days. Night-time variations in all the three geomagnetic elements were observed, which suggests there is a night-time current in the West African dip equatorial latitudes. The pattern of variations observed in H element, which peaks around noon, is seen to be due to the equatorial electrojet current. A reverse current called the counter electrojet current was noticed on some days.

1. Introduction

The variations observed in the ground magnetic records on geomagnetic quiet days are found to be associated with the dynamo currents, which are driven by winds and thermal tidal motions in the E regions of the ionosphere [1]. It has been pointed out that the geomagnetic field intensities change significantly from place to place, from one day to the next, and also from hour to hour. Recent studies on the variability of the geomagnetic field intensity include the works of the authors of [2], who studied the average latitudinal profile of dH and dZ in the Indian and American zone, and [3], who studied the day to day variability in all the three elements (H, D, Z) in the Indian sector. Studies on the seasonal variations of dH have also been carried out, they include works [4, 5, 6].

It should be noted that, although much work has been done on the variations of geomagnetic field components, few results has been obtained in the West African region. This may be attributed to lack of magnetic observatories in the region; hence, the French participation in the International Equatorial Electrojet Year (IEEY) experiment in the African sector from November 1992 to November 1994 was necessary. The aim of this work is to examine the variations in the H, D, and Z field intensities in West African region, which have not been given adequate attention.

2. Data and analysis

A chain of ten magnetotelluric stations was mounted in the West African region during the French participation in the IEEY in the African sector from November 1992 to November

1994 along a 1200-km-long meridian profile between Lamto (latitude 6.2°N, Cote d'Ivoire) to the south and Tombouctou (latitude 16.7°N, Mali) to the north. These stations measured digitally the three components of the magnetic field and the two components of the telluric electric field and operated over a period of 20 months (see Table 1 for station coordinates).

The computed hourly values of the magnetic field data for the year 1993 were employed in our analysis.

Table 1. Geographic positions of the magnetotelluric stations operating during the IEEY West African experiment.

	stations	symbols of stations	latitudes (°N)	Dip-latitudes (°N)	distances (km) from dip-equator	longitudes (°W)
1	Tombouctou	TOM	16.733	5.513	611.98	3.000
2	Mopti	MOP	14.508	3.288	365.00	4.087
3	San	SAN	13.237	2.017	223.91	4.879
4	Koutiala	KOU	12.356	1.136	126.11	5.448
5	Sikass	SIK	11,344	0.124	13.75	5.706
6	Nielle	NIE	10.203	-1.017	-112.85	5.636
7	Korhogo	KOR	9.336	-1.884	-209.17	5.427
8	Katiola	KAT	8.183	-3.037	-337.1	5.044
9	Tiebissou	TIE	7.218	-4.003	-444.48	5.241
10	Lamto	LAM	6.233	-4.988	-553.61	5.01

Our analysis started with the selection of magnetically quiet days selected from the five Internationally Quite Days (IQDs) in each month for the year 1993 giving 60 quite days in a year for each of the ten stations. The hourly values for any hour *t* for the five quiet days were summed for each month hour by hour and the average was found; to get twelve (12) quite days for the year, one (1) for each month. This monthly average helped to eliminate the daily variability in the data. For the days with no data, field values were computed from the standard quite-day field model WDCA-SQ1 [7]. The mean of the hourly values H_0, D_0, Z_0 of the magnetic components for each of the 12 days was calculated and was taken as the base line. The Sq amplitude dH, dD, dZ for any hour *t* is the difference between hourly values H_t, D_t, Z_t and the mean for the day H_0, D_0, Z_0.

The data for each component were Fourier analyzed and Files of the Fourier cosines and sine coefficient up to order M = 4 were computed. The local time (LT) of the stations corresponds to the universal time (UT), so there was no need of local time to universal time conversion. The Fourier series coefficients allowed the reconstruction of the Sq for the station in any month of the year.

3. Results and discussion

Figures 1 and 2 display the Earth's magnetic diurnal variation obtained from the hourly mean values of H, D, and Z components reconstructed from the Fourier analysis of the field values for the months of January and May. The diurnal variation of the H component is observed to have the same shape in every station. The H component regularly increases from the night level, reaches its maximum around noon, and then regularly decreases down to its night level. The diurnal variation of the Z components is seen to display an opposite sign from the northern side of the Dip equator to the southern side. For the northernmost stations (Tombouctou, Mopti and San) it is negative, while for the southernmost stations (Lamto, Tiebissou and Katiola) it is positive. For the stations close to the dip equator Sikaso to the north is negative like the other northern stations, but for Nielle the Z variation is positive till June, and then became negative from July to December. It is observed that Lamto had two maxima occurring in January in both the H and Z components: the first around 10 and the other around 18 o'clock. The observed diurnal variation of the D component shows a greater variability than those of H and Z.

In the southernmost stations, (Katiola, Lamto, and Tiebissou) we observed that the D variation is negative in the morning and positive in the afternoon for the months of January, February, November, and December. It turned positive in the morning for May, June, July, and August, except for the month of May, which had two maxima: it was positive in the early hours of the morning, turned negative around noon, and then became positive again with peak around 15 o'clock. For March, April, September, and October, we observed some kind of inconsistency in the behaviour of the variation pattern; sometimes it behaves like the variations observed in the H component, this is seen mostly in April, but it maximizes around 14 o'clock.

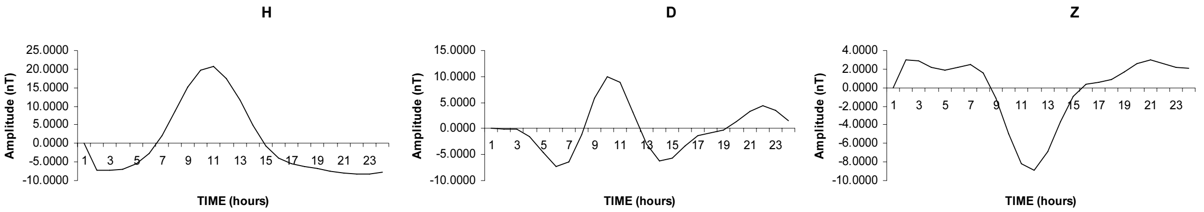
The variations in the D component are seen to be so how different in the northernmost stations (Mopti, San, and Tombouctou). For the months of January, February, November, and December, it is seen to have two minimal points around 07 and around 15 with a peak around 12 o'clock. For the other months, it is positive in the morning and negative in the afternoon. For the stations close to the dip equator Sikaso to the north and Nielle to the south, their behaviour is somewhat like that of the northernmost stations with differences observed for the months of January where two maximal points at 08 and 17 and for Nielle, 07 and 15 for Sikasso and two minimal points at 13 and 21 for Nielle, 11 and 18 o'clock for Sikasso were seen. For the month of February, it is positive in the morning and negative in the afternoon for both stations. For the month of October so much in D component variation were seen for Nielle with three minimal points at about 3.30, 12, and 18 o'clock and three peaks at about 09 (maximum) and 14 o'clock. For the Korhorgo and Koutiala stations, the variations in the D component looked alike more like those of the northernmost stations with the variation in the month of October for Korohogo looking like that of the D variation in October for Nielle station.

From all the observed diurnal variations in the H, D, and Z components using the values reconstructed from Fourier analysis, the variability in all the three elements is seen to be a dusk to dawn phenomena, more noticeably during the day time hours, turns mild during night hours, but it is found not to be zero. This goes along way to support [8] that there are no zero currents at night; it also justifies our use of the daily mean as the base line in other to get an even distribution for all the hours. Also these variabilities in all the elements are seen to be both in amplitude and in phase. The variability does not have a definite pattern; thus the variability is seen to be random. In it noted in [9] that changes in the electric field control the phase and randomness, while the magnitude of the ionospheric conductivity controls the magnitude of the variability. Our result is seen to agree with the results obtained in the same region in [6], in the central African region in [10], and also in the Asian region in [3].

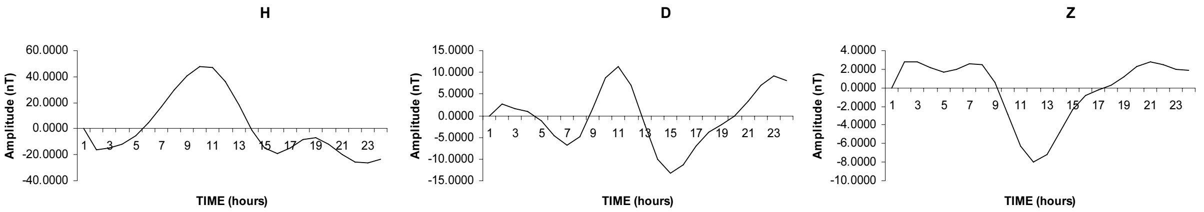
Following [6], we suggest that these diurnal variations observed in the D component may be due to meridional current flow at both sides of the dip equator with northern and southern component both in the morning and in the afternoon. It is suggested in [11] that that the observed D variation might also correspond to the existence of a most local ionospheric source; this has been recently deduced [12] from the study of the return current of the equatorial electrojet using the POGO data.

The morphology of the Amplitude curves obtained for H and Z components diurnal variations with extremum in H around 12 o'clock might be interpreted to be due to the magnetic signature of an east-west ribbon of ionospheric currents along the dip equator, namely, the equatorial electrojet. For Lamto which had two maxima occurring in January, the first around 10 and the other around 18 o'clock, this could be due to a reverse current called the counter electrojet current flowing; for details on this counter electrojet, see [6].

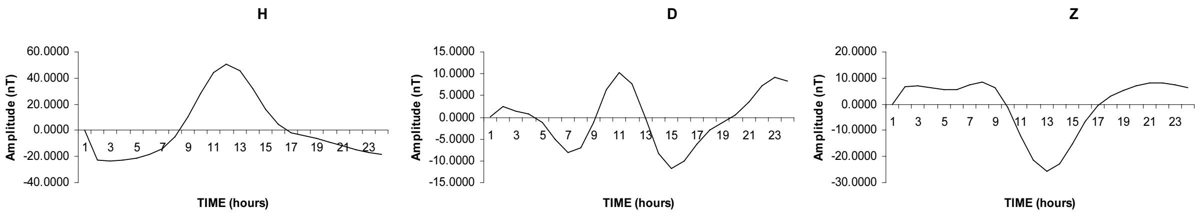
TOM



MOP



SAN



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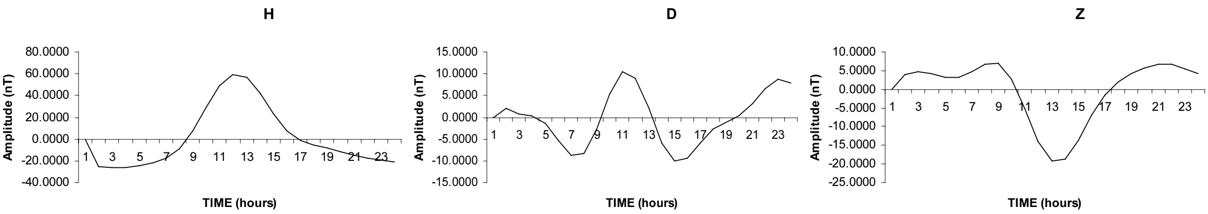

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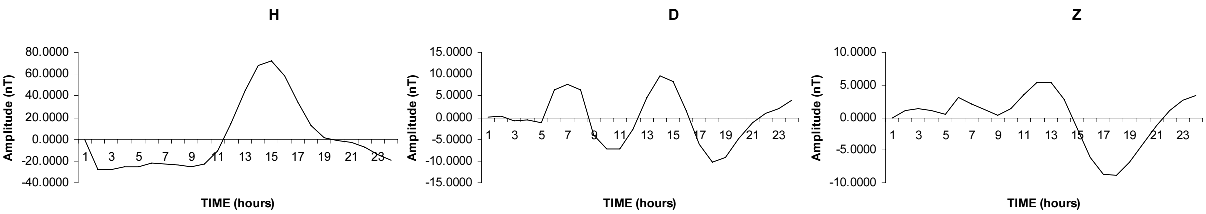
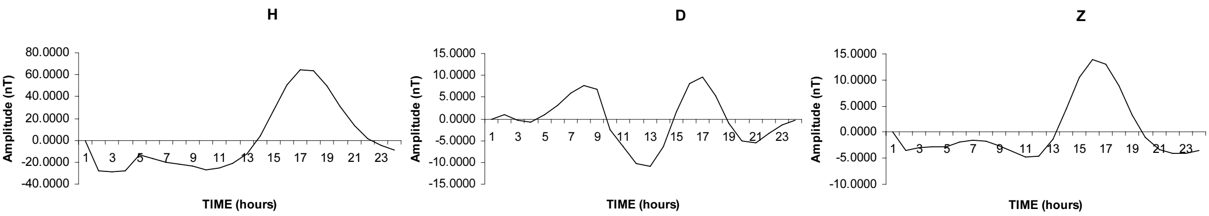


NIE



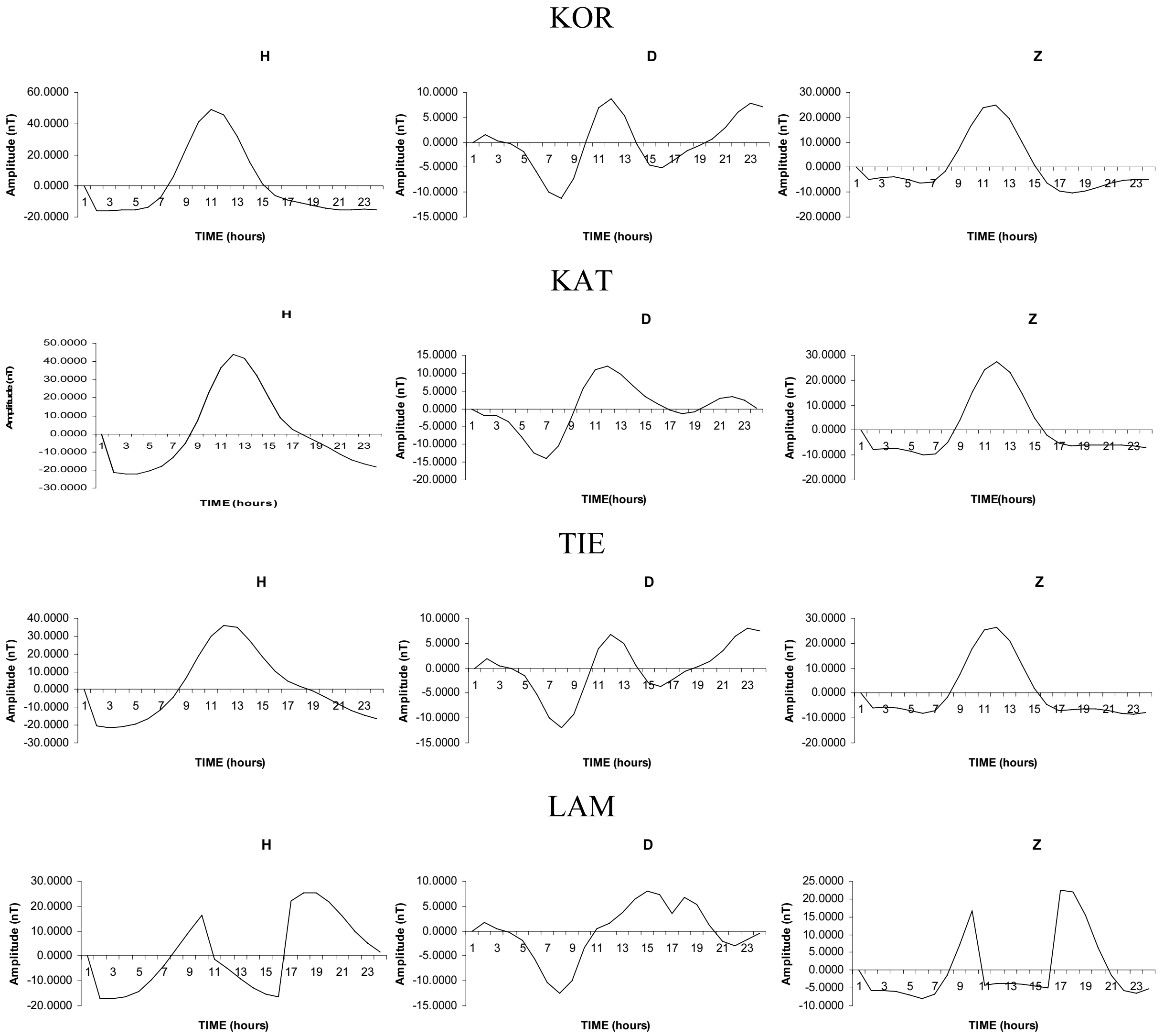
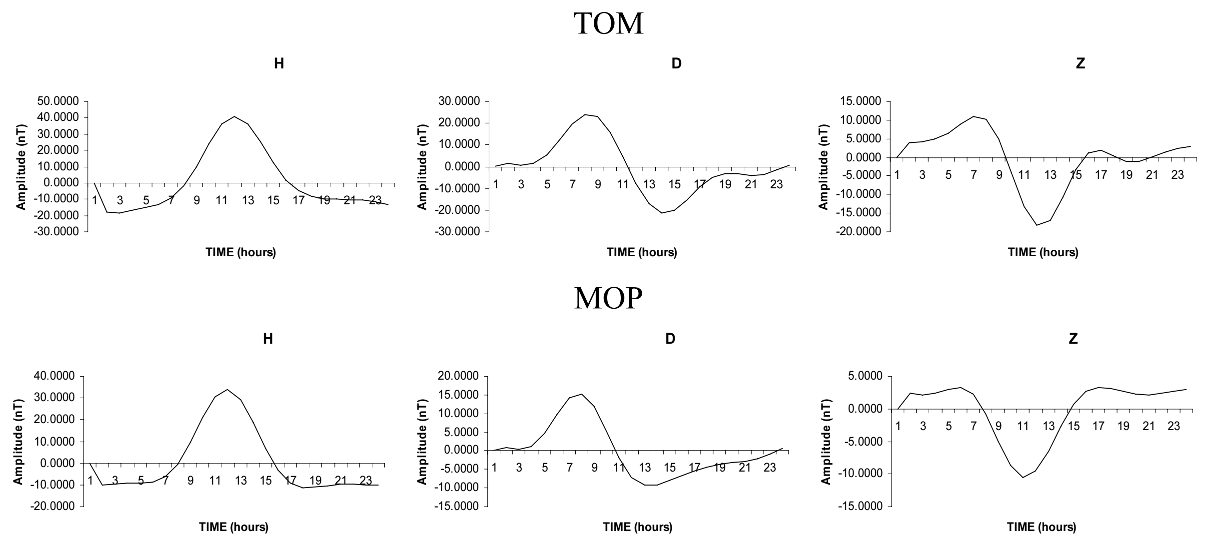


Fig. 1. Variations of the Horizontal (North H, East D) and vertical components of the magnetic Field for the month of January reconstructed from the Fourier analysis of the field Data [Amplitude (nT) plotted against Time (hours)].



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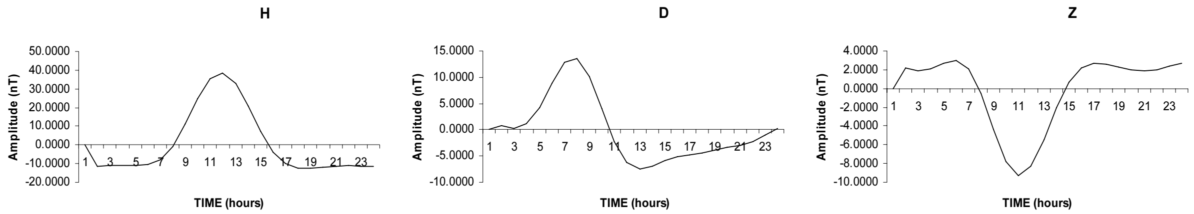

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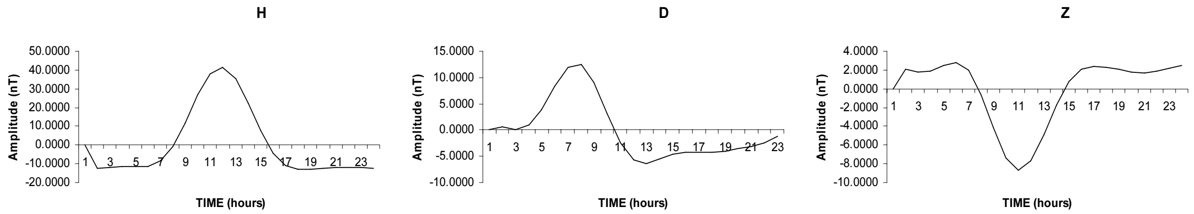

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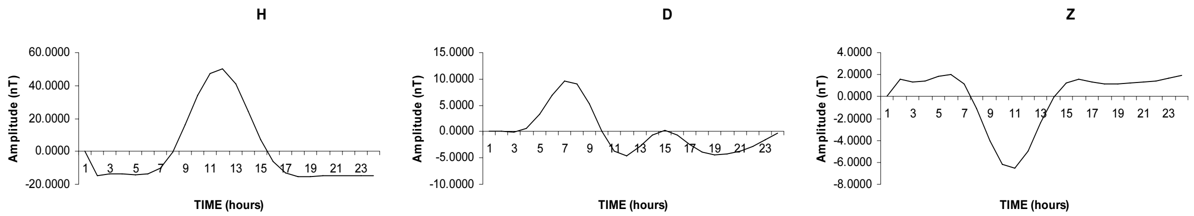

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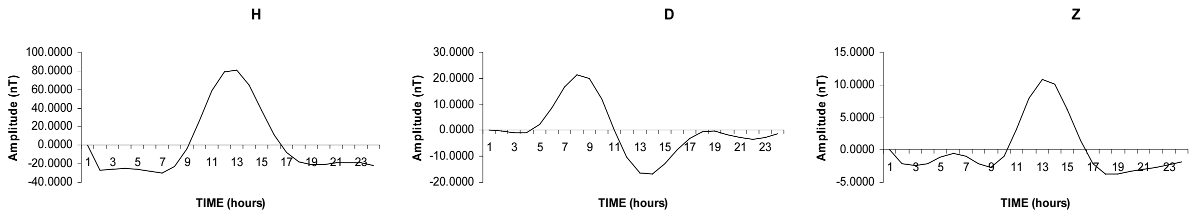

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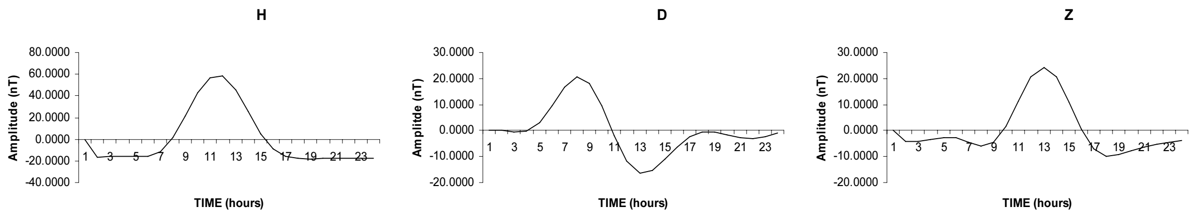

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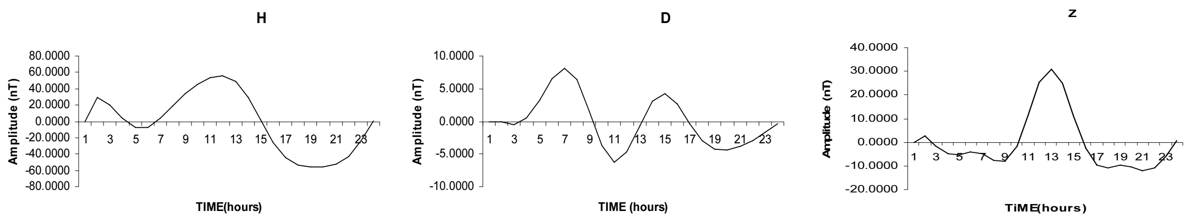

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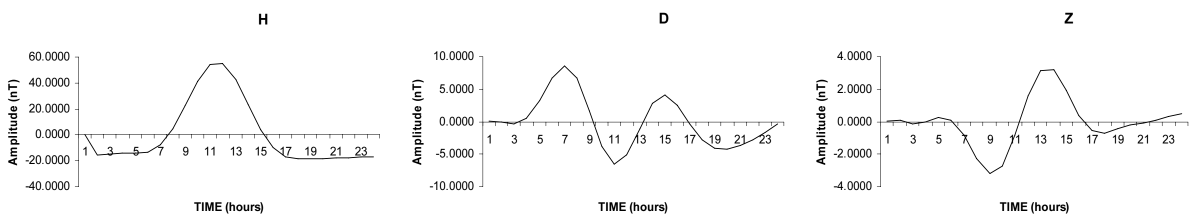

LAM

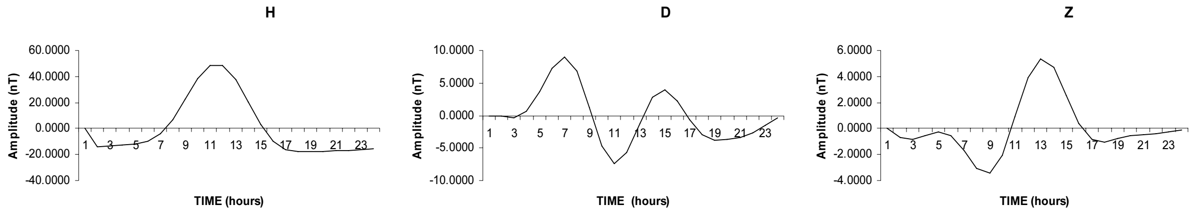

Fig. 2. Variations of the Horizontal (North H, East D) and vertical components of the magnetic Field for the month of May reconstructed from the Fourier analysis of the field Data [Amplitude (nT) plotted against Time (hours)].

4. Conclusions

The study on the variation of geomagnetic field intensities on the West African latitudes has yielded some interesting results which will add to the few existing results in the area. The results obtained are found to be in agreement with some existing results from other regions where similar studies had been carried out. The following conclusions may be drawn from this study.

There is night-time variation in all the geomagnetic elements; thus, there is night-time current in the West African dip equatorial latitudes. The element D showed more variability than the other two elements H and Z. The pattern of variation observed in H and Z fields with peak around noon in H is seen to be due to the equatorial electrojet current. On some day, a reverse current known as the counter electrojet current is observed. More research work is suggested to be carried out in the future in the West African region to help to bridge the gap existing between this region and other regions of the world.

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