Original Research Article

Variability of Horizontal Magnetic Field Intensity from some Stations within the Equatorial Electrojet Belt

ABSTRACT

The variability of the horizontal component of magnetic field intensity from 7 stations within the Equatorial electrojet (EEJ) belt ($\pm 3^{\circ}$ of the magnetic equator) has been investigated using year 2008 data measured from the Magnetic Data Acquisition System (MAGDAS) magnetometers. The monthly mean hourly values shows variation in the pre-sunrise hours, within the range of 1nT to 21nT. However, dH during the day has a much higher variation than those observed during the pre-sunrise and dusk hours. The presence of Counter electrojet(CEJ) in the morning and evening hours were also observed. Also, equinoctial maximum was observed in most stations, and the horizontal magnetic field intensity over ANC located in the South American sector displays the highest amplitude, while ILR in the African sector appears to have the lowest amplitude.

Keywords: *Equatorial electrojet, Counter electrojet, Magnetic field intensity, Variability*

1. INTRODUCTION

The regular daily fluctuation in the earth's magnetic field was first observed by Graham [1]. Stewarts [2] later posited that these regular daily fluctuation in the geomagnetic field originates from thermally forced motion of conducting air moving over the magnetic field in the ionosphere. Chapman [3] noticed the existence of solar quiet current system in the ionosphere around 100km altitude, which is caused by the dominant solar-driven wind and tidal motion in the ionosphere. This current produced by electromotive forces is frequently considered to be due to the action of dynamo. Thus, wind driven dynamo results in ground perturbation.

In 1922, the geomagnetic observatory located in Huancayo Peru, the western part of South America, where the alignment of the geomagnetic field is almost along the geographic meridian, played a crucial role in equatorial electrojet discovery. The horizontal (H) component of the geomagnetic field at Huancayo was noticed to by McNish [4] to be abnormally large in comparison to Chapman [3] current system, which was based on data from mid-latitudes. Egedal [5], noted that there exist a daytime east-west overhead current within a narrow latitude belt of about 130km over the magnetic dip equator, where the geomagnetic field is horizontal. Chapman [6] called this, the Equatorial Electrojet.

Thus, Equatorial Eletcrojet is an intense ribbon of current flowing eastward in the low latitude ionosphere within the narrow region flanking the dip equator (± 3˚ of the magnetic equator). The infrequent reversal of the electrojet current at certain hours of the day is described as Counter eletcrojet, Gouin and Mayaud [7].

The investigation of worldwide solar quiet of horizontal component (SqH) at different seasons by Owolabi et al. [8] showed that SqH exhibits transient variations, with the amplitude varying at different seasons. Several studies have been carried out on SqH and EEJ using different observation and experimental tools. However, this study employs data from Magnetic Data Acquisition System (MAGDAS) magnetometers located in different longitudes along the magnetic equator chain.

2. MATERIAL AND METHODS

The year 2008 magnetic data of the Magnetic Data Acquisition System (MAGDAS) magnetometers of some stations within the equatorial electrojet belt were used for this study. Figure.1. present the global distribution of MAGDAS magnetometers while the coordinates of the stations used in the study are given in Table. 1.

Magnetic data corresponding to five most magnetically quiet days of each month in year 2008 were selected and used in this study. The international quiet days were published on Geoscience Australia website based on the magnetic activity index Kp. During quiet time, the horizontal component of the magnetic field within the EEJ belt is a combination of Sq current and EEJ current.

The baseline of each day was defined as the mean of the H component of the four (4) hours flanking the local midnight time of each station. By subtracting this baseline values from the H component gives the hourly departure (dH) which is approximately equals to the SqH.

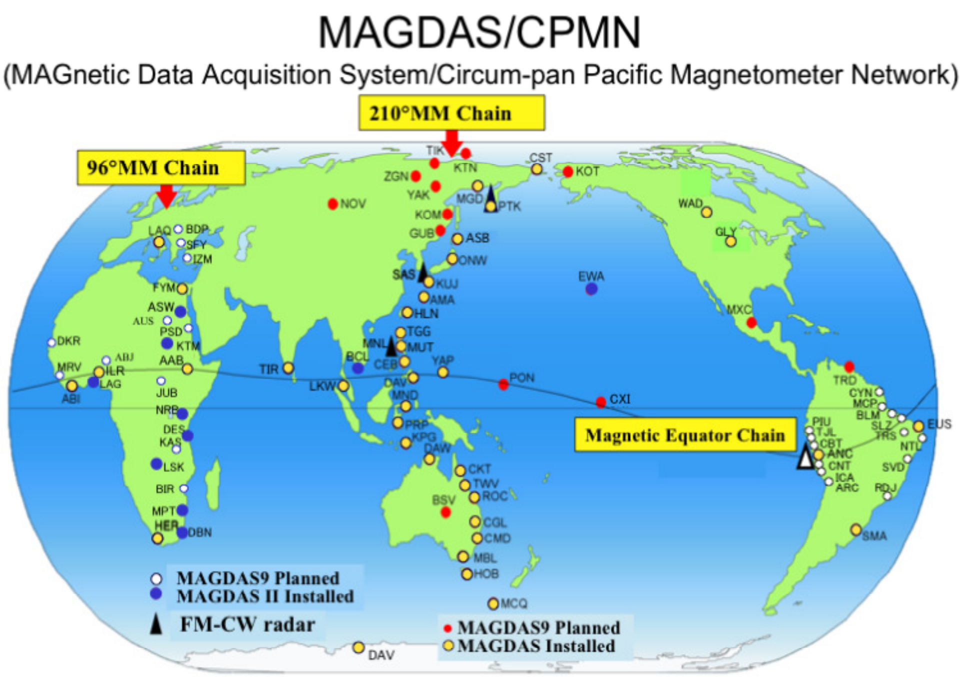

Fig. 1. The global network of MAGDAS magnetometers

Table 1: **Parameters of the stations to be used in the study**

S/N	Station	Code	Geographic Latitude	Geographic Longitude	Geomagnetic Latitude	Geomagnetic Longitude	Dip Latitude
1	Adis Ababa	AAB	9.04	38.77	0.18	110.47	0.57
2	Ancon	ANC	-11.77	-77.15	0.77	354.33	0.74
3	Cebu	CEB	10.36	123.91	2.53	195.06	2.74
4	Davao	DAV	7.00	125.40	-1.02	196.54	-0.65
5	Ilorin	ILR	8.50	4.68	-1.82	76.80	-2.96
6	Langkawi	LKW	6.30	99.78	-2.32	171.29	-1.88
7	Yap Island	YAP	9.50	138.08	1.49	209.06	1.70

The baseline values were obtained using the expression:

$$\mathbf{H_b} = \frac{\mathbf{H_{2300}+H_{2400}+H_{0100}+H_{0200}}}{4} \quad . \quad . \quad . \quad . \quad . \qquad \textbf{(1)}$$

Where H_b is the baseline value and, $H_{2300}, H_{2400}, H_{0100}, H_{0200}$ are the H values at 2300 LT, 2400 LT, 0100 LT and 0200LT respectively.

The hourly departure of H were obtained by deducting the baseline values for each station on each quiet day from the hourly values (H_t) of the corresponding station and day.

$$d\mathbf{H_t} = \mathbf{H_t} - \mathbf{H_b} \quad . \quad . \quad . \qquad \textbf{(2)}$$

Where t =1 24

The monthly mean values of each month were derived from the mean of the diurnal variations for the five quietest days in each month, and were plotted in multiple series with respect to the local time of each station.

The seasonal variations were also studied by classifying the year into three seasons, that is, the Equinox Season (March, April, September, October), denoted as E- season, June Season (May, June, July, August) , denoted as J-season and December Season (November, December, January, February) which is denoted as D -season. The Seasonal values were deduced from the mean of all the months in a particular season, after which the seasonal variations were presented in contour filled form, in the order of increasing geomagnetic longitude. That is, from ILR to ANC. Also, we obtained the noon time variation of dH across the stations for the seasons, using a group bar plot. Since dH over the equatorial region is expected to reach its peak value at about local noon as a result of increase in ionization by solar activity in accordant with atmospheric dynamo theory, Rabiu et al. [9]; Onwumechili [10].

3. RESULTS AND DISCUSSION

3.1 Monthly Variation

Fig.2. shows the monthly mean of the diurnal variation from January 2008 to December 2008, which was ploted in multiple series for some equatorial electrojet stations. The diurnal variation of all the station shows a regular and consistent variation throughout the year. It was observed that dH rises from 0700LT, reaching its peak at about local noon and leaning back at about 1700LT for all the sations considered. This result is in agreement with the works of Rigoti et al. [11], Chandra et al. [12] and Rastogi [13].

At pre-sunrise hours, dH is in the range of 1 to 21nT, where the maximum value of 21nT was noticed at LKW in August, at 0500LT while minimum value of ~ 1nT observed at other longitudes for different months of the year. From the results in fig.2, counter electrojet (CEJ) were recorded between the pre-sunrise and early morning hours and also in the evening hours. This CEJ varies in amplitude (from -1nT to -42nT), The highest CEJ amplitude of -42nT was observed around 0800LT, may 2008 at AAB. The range in dH peak during the day is higher than the range observed in the pre-dawn and dusk hours. For instance, from fig. 2, In March 2008, the maximum dH amplitude for the longitudes considered varies from about 59nT to 138nT (range ~ 79nT). In June 2008, dH varies from about 39nT to 85nT (range ~ 46nT). In October 2008, dH varies from 42nT to 121nT (range ~ 79nT). A quasi character is also noticed in dH amplitudes for other months. However, as observed from fig.2 ANC was observed to have the highest midday peak than the other stations.

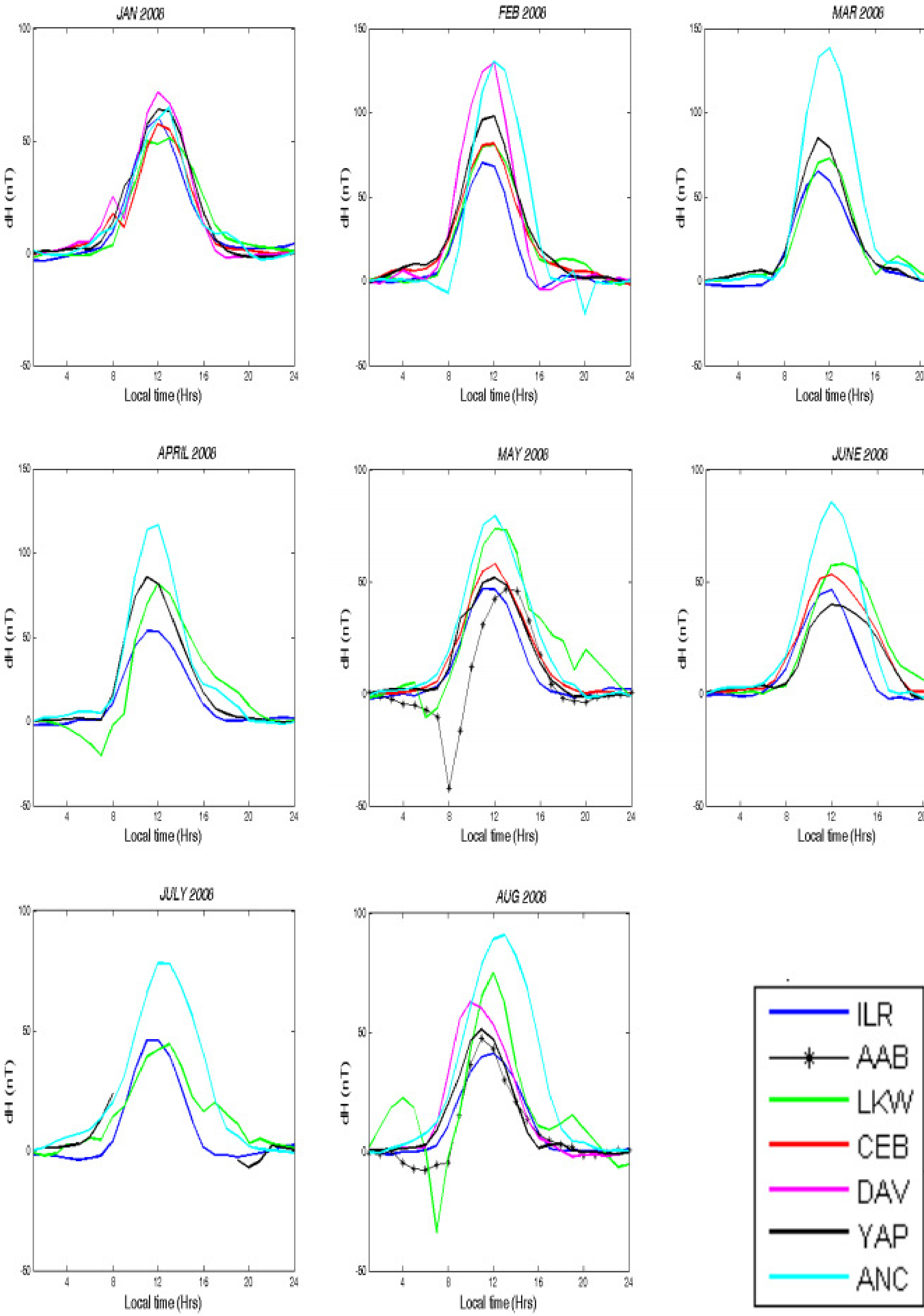

Fig. 2. Monthly mean daily variations of H field for five International Quiet days

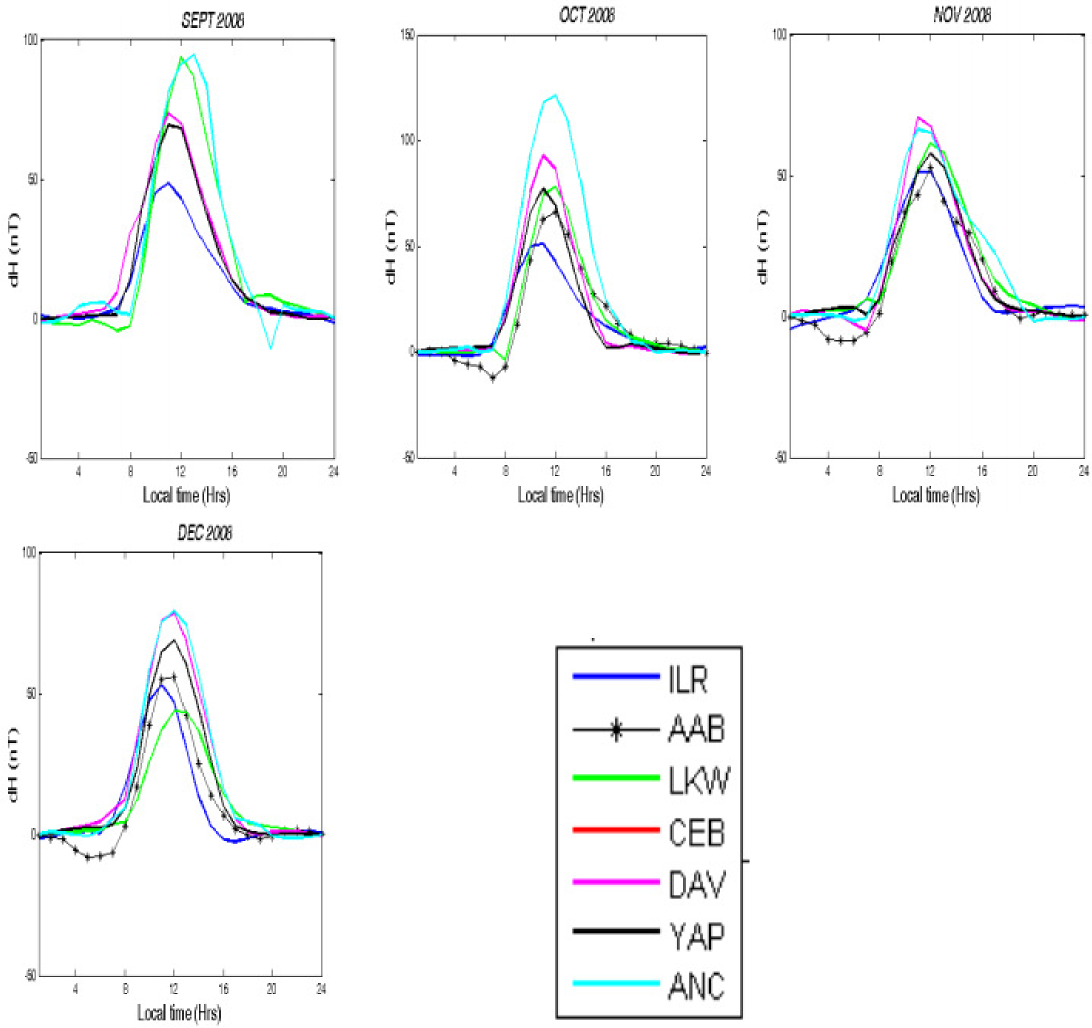

Fig. 2 continued

3.2 Seasonal Variation

Figures 3, 4 and 5, shows that dH was observed to display seasonal variation across the longitudes. Fig. 3 gives the result for the variation of dH during E-Season. It was observed that the amplitude of dH is highest at ANC reaching about 116nT at 1200LT, followed by a magnitude of 83nT at DAV. ILR has a lower variation in comparison to other stations used. The amplitude of dH increases with increasing longitude, except at YAP which has a lower amplitude than DAV. Some CEJ events were recorded at ILR and AAB in the pre-sunrise to sunrise.

From fig. 4, during J-Season, ANC was also observed to be the highest at about 1200LT with an amplitude of 83nT, while ILR and AAB has the minimum dH While a CEJ of about -23nT at 0800LT was observed at AAB station.

From fig. 5, during D-Season, ANCand DAV exhibits the maximum dH amplitude as both peaks at 1200LT with 101nT, where ILR and AAB also exhibits minimum dH amplitude. Its observed that the latitudinal positions of the stations also affects the magnetic field variability. For instance, in fig. 5 CEB and DAV are on a very close meridian, but DAV exhibits a higher magnetic field amplitude than CEB, this is likely because DAV which has a geomagnetic latitude of -1.02 ° is closer to the magnetic equator than CEB with geomagnetic latitude of 2.53°.

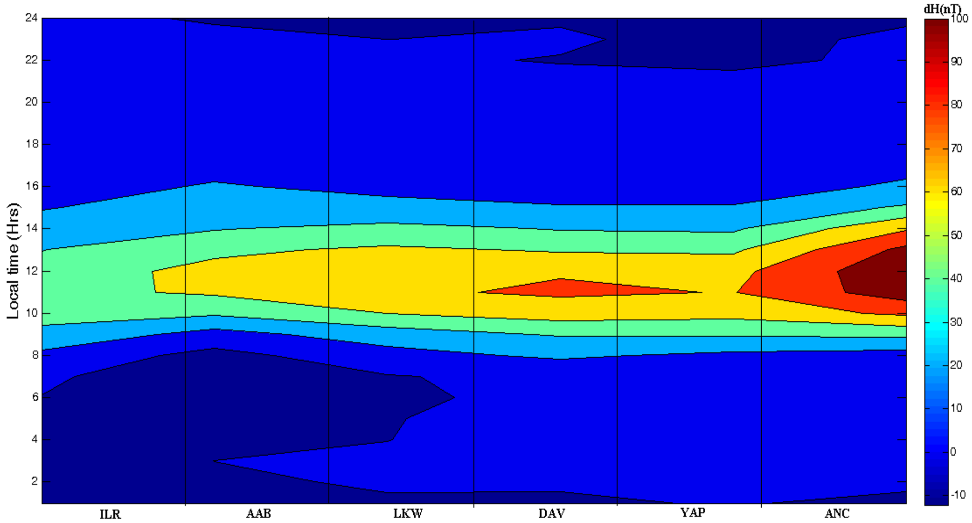

Fig. 3. dH during E-Season

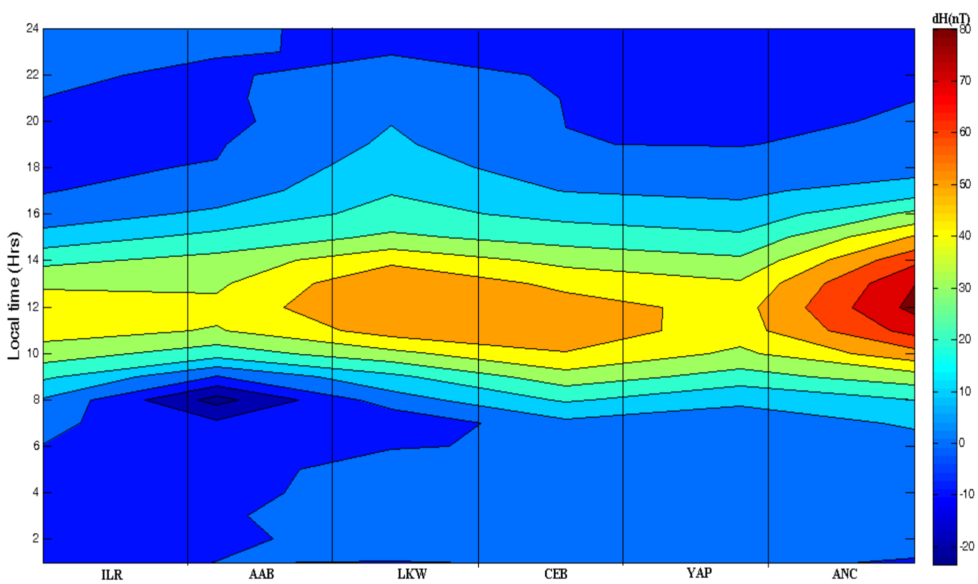

Fig. 4. dH during J-Season

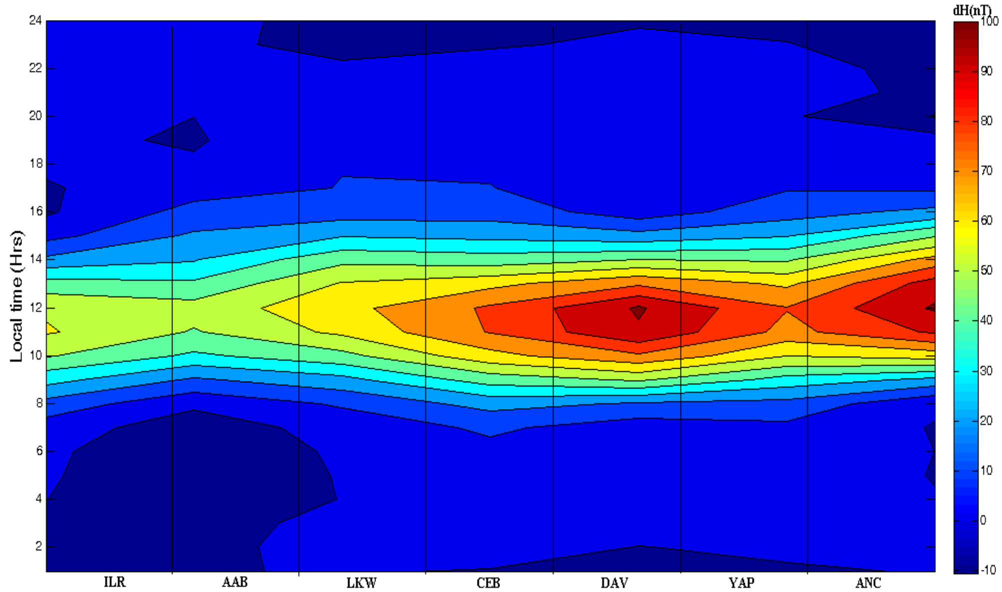

Fig. 5. dH during D-Season

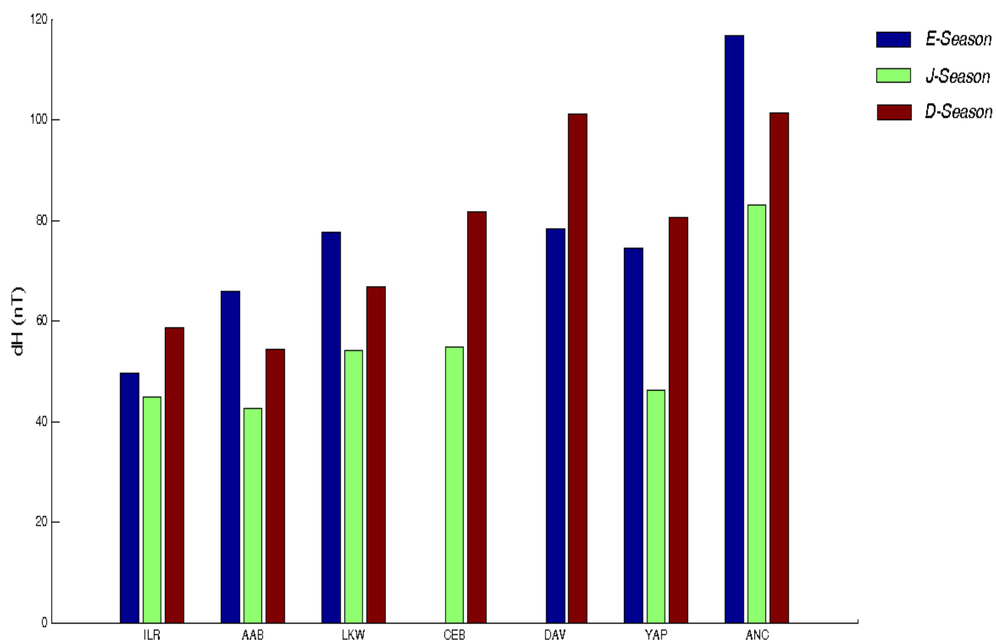

Fig. 6. Seasonal variation of noon-time dH across the stations

The group plot of the noontime seasonal variation of dH across different longitudes are presented on fig. 6. It is shown that at noon time ANC exhibits maximum dH for all seasons, with the highest amplitude during the E-season and the minimum during J-Season. In comparison to other seasons, J-Season exhibits the weakest dH at noontime for all the stations, while E-Season is maximum for most stations. The equinoctial maximum in most stations can be ascribed to intensified electron density at equatorial region during equinox seasons, due to solar activity taking place directly on the equator.

4. CONCLUSION

This study has confirmed that the horizontal component of the magnetic field along the magnetic equator exhibits longitudinal variation. The range of variation are usually large and can be upto 79nT in some months. ANC, in the South American sector has the most pronounced magnitude of dH in all seasons. The amplitude of dH appears to be weakest in ILR. The longitudinal position of the stations also affects the magnetic field intensity, as the horizontal component of the magnetic field intensity increases with increasing longitude, with respect to its closeness to magnetic equator. The seasonal variations can be ascribed to the reposition of the ionospheric current system with seasonal changes.

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