Geomagnetic Field Variations at the South America Equatorial Electrojet

L. Benyosef*
L. Piaulino*
M. Lopes*

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Resumen

En este trabajo se presenta parte del estudio de las variaciones del campo geomagnético en el Electrochorro Ecuatorial sobre América del Sur. Fueron utilizados datos de las componentes horizontal H y vertical Z del campo geomagnético grabadas en dos estaciones de repetición: Cachoeira do Arari (01º 00’ 41’’ S y 48º 57’ 48’’ O); Capitão Poço (01° 44’ 05’’ S y 47° 03’ 43’’ O) ubicadas en el Estado del Pará, Brasil.

Estas variaciones en regiones de bajas latitudes presentan características originales. Datos de tres observatorios magnéticos, Isla de Ascensión, Tatuoca y Huancayo también fueran utilizados en este estudio.

Palabras clave: *Electrochorro Ecuatorial, campo geomagnético, estación de repeticion, fluxgate, componente horizontal, variación magnética*.

Abstract

This paper presents part of a study of the geomagnetic field variations at the South America Equatorial Electrojet. We have used data from the horizontal (H) and vertical (Z) components of the geomagnetic field recorded in two repeated stations: Cachoeira do Arari (01º 00’ 41’’ S and 48º 57’ 48’’ O) and Capitão Poço (01° 44’ 05’’ S and 47° 03’ 43’’ O) both located in the Para State, Brazil.

These variations at low latitude regions present original characteristics. Data from three magnetic observatories Ascension Island, Tatuoca and Huancayo were used in this study also.

Key words: *Equatorial Electrojet, geomagnetic field, repeated station, fluxgate, horizontal component, magnetic variation*.

* Observatorio Nacional de Rio de Janeiro, Rua General José Cristino 77, CEP 20921-400, Sao Cristovao, Rio de Janeiro, RJ, Brasil.

Introduction

The Brazilian Electrojet region has different characteristics whose study and interpretation enable better understanding of the dynamics of the phenomenological region. The region electrojet over Brazil's Amazon (Figure 1) is a zone with many difficult points to access.

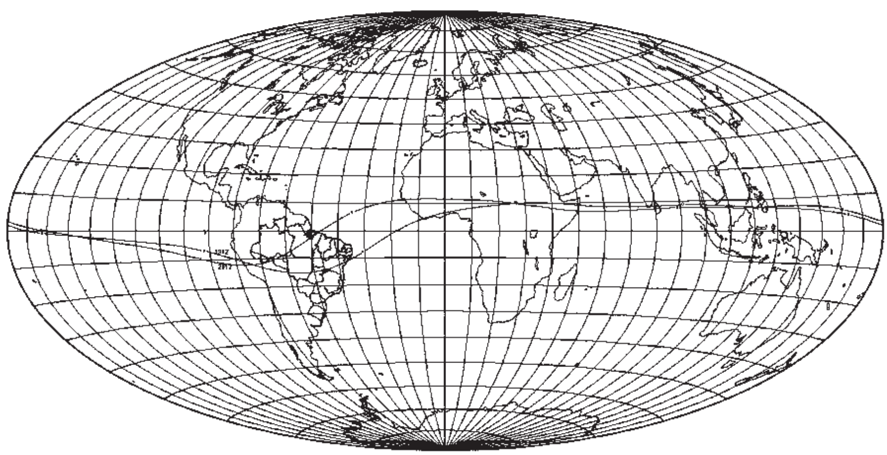


Figure 1. Variation of magnetic inclination between 1912 and 2012. Source: ON.

Short period variations, a phenomenon analyzed in this work, are originated due to systems of electric currents generated by the movements of the atmospheric layers, ionized through the lines of the geomagnetic field. In periods without geomagnetic activity and eliminating the contributions of smaller timescale, as geomagnetic pulsations and the Moon, it has a diurnal variation.

The geomagnetic pulsations, which will be analyzed and classified in this work, are magnetic variations in a short time interval (between 0.2 seconds and 17 minutes) that occur in the geomagnetic field, resulting from interactions between electrically charged particles of the solar wind, the plasma magnetosphere and ionosphere.

This work analyzes the changes in the magnetic field recorded at Cachoeira do Arari (CAA) and Capitão Poço (CAP) repeated stations, comparing them with records of three magnetic observatories also located at low latitudes: Tatuoca (TTB), Huancayo (HUA) and Ascension Island (ASC).

This study considered the occupation in the period from 13 to 27 November 2008. The instrument used was a triaxial fluxgate magnetometer LEMI-417 with period 1 secong and the sensors were buried 1 meter from surface and aligned with

(H, D, Z) components of the local geomagnetic field. The data was reduced to 1 minute according to IAGA format.

Table 1
Coordinates of the magnetic observatories and repeated stations used in this study

Observatories/ rep. stations	*Abrev*	*Latitude*	*Longitude*	*Elevation (m)*
Tatuoca	TTB	1° 12.3’ S	48° 19.4’ O	54
Huancayo	HUA	12° 02.3’ S	75° 19.4’ O	3313
Ascension Island	ASC	7.949° S	14° 19’ W	177
Cachoeira do Arari	CAA	1º 00’ 41’’ S	48º 57’ 48’’ O	76
Capitão Poço	CAP	1° 44’ 05’’ S	47° 03’ 43’’ O	80

In this study magnetic variations were analyzed considering periods between 1 and 17 minutes. In the first part of this study we analyzed H and D variations recorded in CAA, CAP, TTB, HUA and ASC. All repeated stations and observatories are located at low latitude, near the region of the Equatorial Electrojet.

H Component

In the Equatorial Electrojet, the H component increases about 1, 5 times when compared with the other regions of the earth. This increase occurs because the contribution of the external currents is amplified by the currents induced into the Earth, since, in this region; the induced magnetic field produced into the Earth is nearly aligned with the external magnetic field (Acuña and Cabrejos, 2002).

The results obtained in this work shows that the days had a calm activity between the period of November 13th and 24th, by the end of November 24th the occurrence of SSC* approximately at 11:50.

PM at all stations and observatories indicates the beginning of a more intense activity, which lasts until 27th, and can be more noticeable on the 25th.

Despite the big amount of activity, it is possible to identify two Si in the 25th graphic, the first one is registered at 02:46, 02:46 am, am 02:39 am, 02:43 am and 02:45 am in ASC, CAP, TTB, CAA and HUA respectively , the second one started at 11:58 am in CAA and in TTB, at 12:01 pm in CAP and ASC and at 12:03 pm in HUA.

The differences between the activities registered in calm and in not calm days can be noticed in the graphics below. The day November 24th begins as a calm day, follows the expected behavior, with the biggest intensities in the middle of the day and without important changes during the rest of the day. On the other hand, it is possible to notice a more intense activity, because of this, it is observed that the variations don’t follow any expected pattern, and are registered throughout the day, which makes more difficult to detect clearly the maximum value reached.

a)

b)

c)

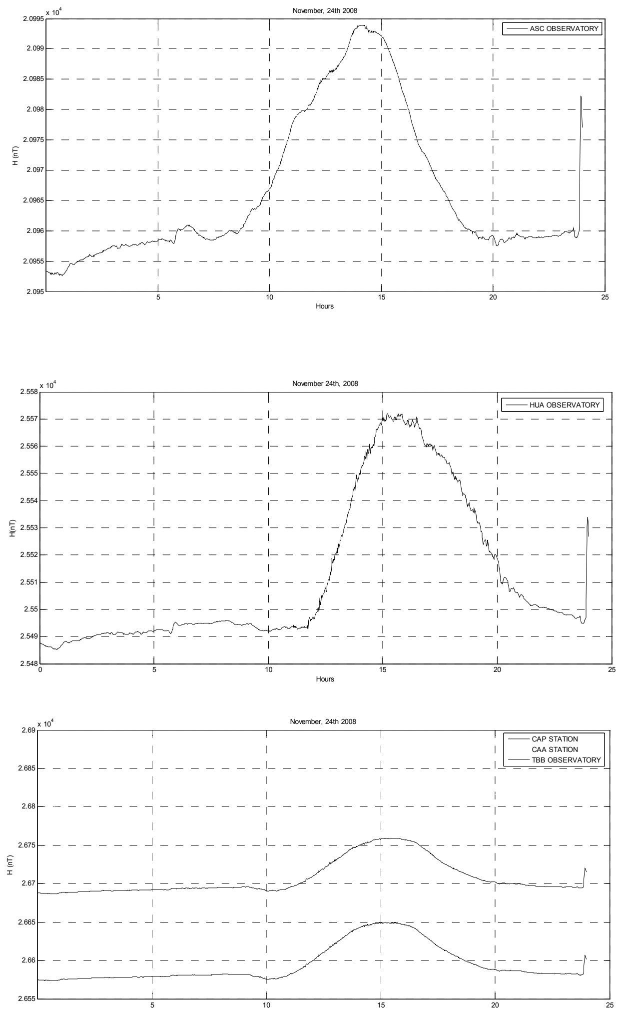
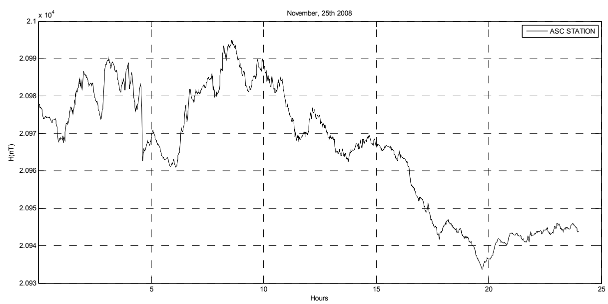


Figure 2. Start of a Magnetic Storm - H component - registered in November 24th in the observatories/stations a) ASC, b) HUA and c) CAA, CAP and TTB.

The amplitudes graphic shows the amplitude variations during the whole period studied. In this graphic is possible to observe that the amplitudes are almost always bigger in HUA, this might be explained by the fact that HUA is 3313 meters above the sea level while CAA, TTB and CAP are almost in the sea level. This difference of altitudes explains why the variations are felt more intensely in HUA than in the other stations. The distances from the stations to the Equatorial Electrojet also influence the amplitudes: the near the station, the bigger the amplitude. This difference can be observed by the amplitude H in the figure, because ASC is in bigger latitudes. At the end of 24th November initiates a magnetic storm that is well recorded in the instruments from all repeated stations and observatories

This storm continues throughout the next day 25th November and it's more intense in the records of HUA than other observatories and repeated stations.

a)



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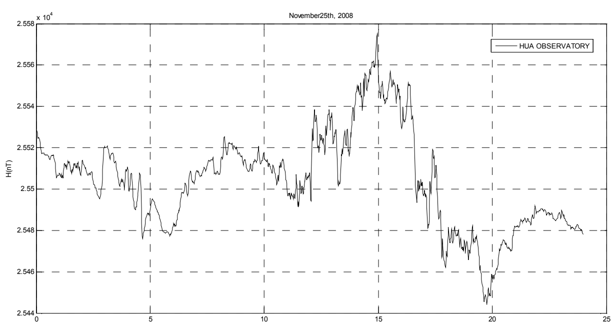

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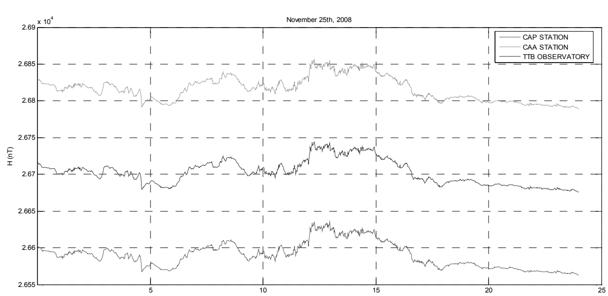


Figure 3. Magnetic Storms - H component - registered in November 25th in the observatories/stations a) ASC, b) HUA and c) CAA, CAP and TTB.

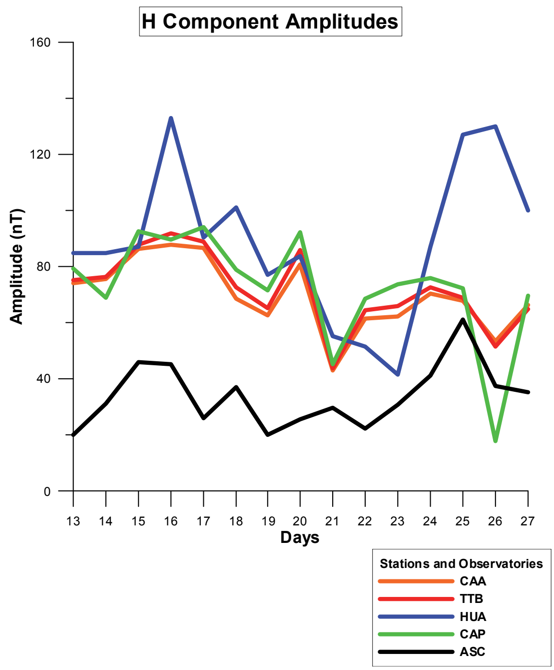


Figure 4. The observed amplitudes between November (13th and 27th) 2008.

The observed amplitudes shown in Figure 4 were considered as the differences between maximum and minimum daily values.

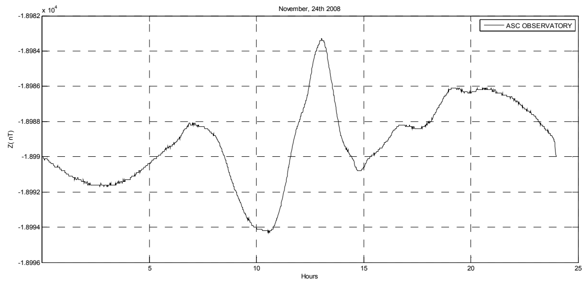
Z Component

The planet Earth behaves as an imperfect conductor, with magnetics and electrical properties that depend on its topography and on its distribution of magnetic permeable and conductive material within. Due to these circumstances, the Z component daily variation measured in an observatory in land is largely influenced by the topography and underground structure that surrounds the observatory in which the measure was taken (Acuña and Cabrejos, 2002).

The geology of the places in which the stations used in this work are placed is quite distinct, since the HUA station is located in the Andes and TTB e CAA are two different islands formed by marine and fluvial sediments.

The HUA station, located in Peru, is placed in a mountainous region in the Andes. The Andes in the central part of Peru may be subdivided into three parts, the Western Cordillera, High Plateaux and Eastern Cordilleira. Huancayo is located between the High Plateux and the Eastern Cordillera (Dorbath *et al.*, 1989).

a)



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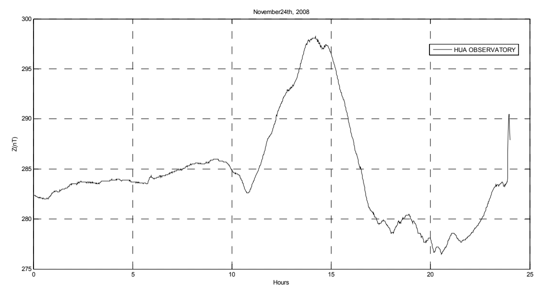

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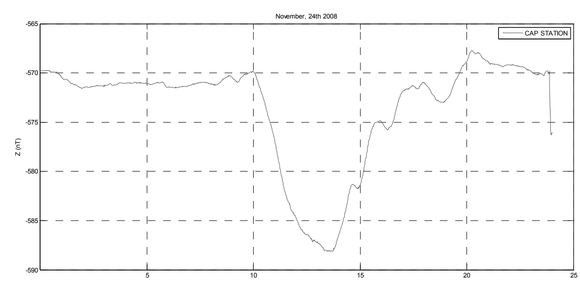

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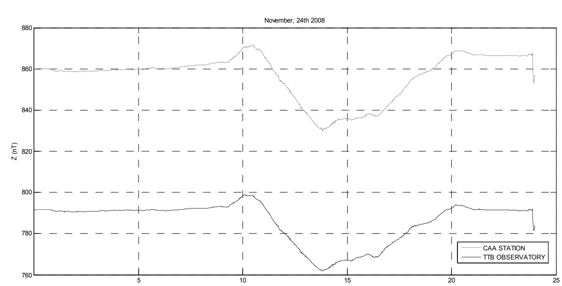
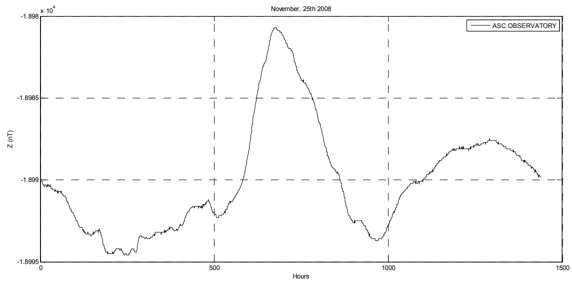


Figure 5. Start of a Magnetic Storm - Z component - registered in November 24th in the observatories/stations a) ASC, b) HUA and c) CAP and d) CAA and TTB.

a)



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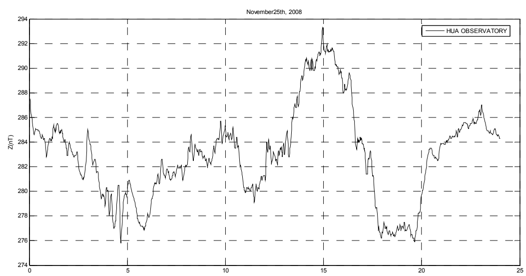

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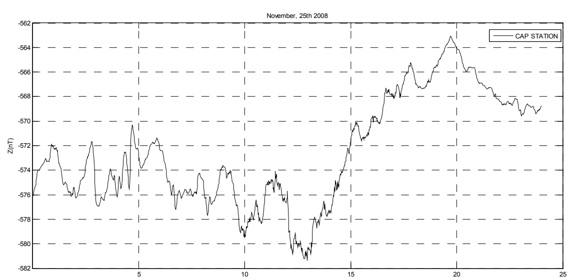

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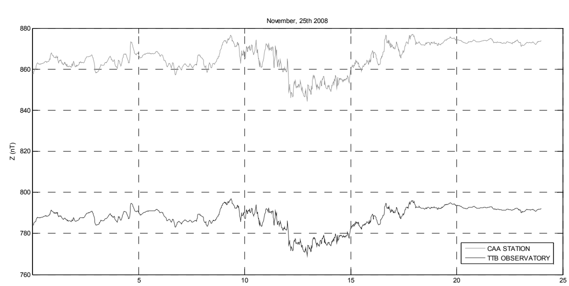

Figure 6. Magnetic Storm - Z component - registered in November and 25th in the observatories/stations a) ASC, b) HUA and c) CAP and d) CAA and TTB.

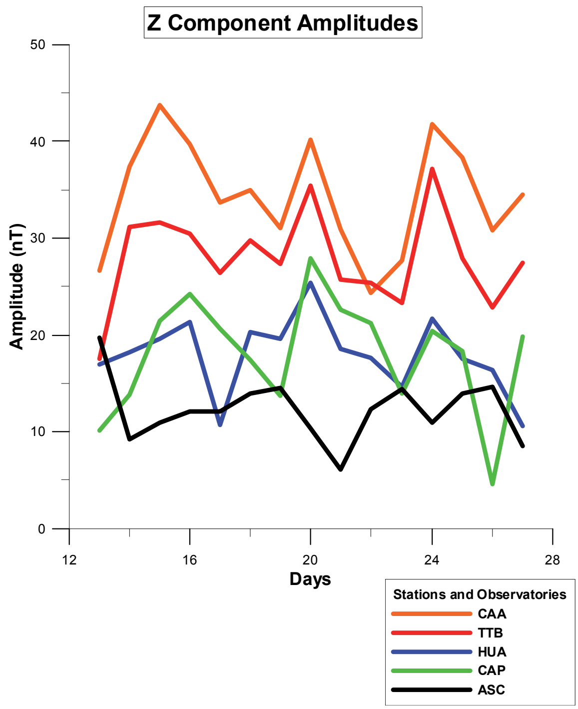

Figure 7. The amplitudes observed in the period between November (13^{th} and 27^{th}) 2008.

The High Plateau is formed by moderately folded and thrusted marine Mesozoic and continental Paleogene rocks, covered by Miocene volcanic sediments. The Eastern Cordillera is mainly formed by fold and faulted Precambrian and Paleozoic rock. The contact between the High Plateau and the Eastern Cordillera is covered by Cenozoic basins oriented NW-SE, this basins include the Huancayo Basin (Dorbath *et al.*, 1989).

On the other hand, the region where TTB, CAP and CAA are placed is composed by holocenic sediments, forming packages between 2 to 5 meters thick mainly made of fine to very fine sands, with well selected pieces of coal scattered and, eventually, pieces of ceramics. This sediments cover the older ones below, that forma a package that might reach 10 meters thick, constituted mainly by bioturbated sands, with selection varying from moderated to good , fine to mediums grains, it can be locally conglomeratic. Pelites and shales are also present (Tatumi *et al.*, 2008).

These differences in the place's geological settings certainly exerts some influence in the Z component behavior, what makes such difference registers between the stations, as observed in the graphics.

Much of the variation in Z reflected in the ASC magnetogram comes from electric currents induced in the Atlantic Ocean, because ocean water is a good electrical conductor.

In the graphics below it is possible to notice a pattern: the value's intensities in TTB and stations CAA are similar and bigger than the ones in HUA. It is also observed that the variations in TTB and CAA are opposite to the ones in HUA.

Besides, the Z component values are slightly larger in CAA when compared to TTB and CAP, this might be explained by the distances from the stations to Equatorial Electrojet, in this context, it is possible to say that the values are smaller in TTB observatory and CAP station because it is near the EEJ than CAA station. The same justifications can be used to explain the low values recorded in HUA, since this stations is almost under the EEJ. Already in ASC the Z component values are bigger because it is far the EJJ.

The amplitude's graphic supports the geological influence in the Z component, since it shows a great similarity between the TTB, CAA and CAP graphics that are all geographically near and have similar geological settings. No similarities are noted in HUA and ASC graphics, since this places have very different geology.

Figure 7 shows the observed amplitudes. These values were considered as the differences between maximum and minimum daily values.

Discussion

The results presented are about the horizontal (H) and vertical (Z) components of the geomagnetic field, all of them were recorded in low latitudes in the stations of CAA, TTB, CAP, HUA and ASC, in other words, they are all near the Equatorial Electrojet.

Conclusion

For analyzed period was possible to note that in some aspects the H and Z components behavior was according to the expected. The H component has much higher values than the Z component, which is expected since in the EEJ the I = 0, then the H reaches its maximum value.

For the reason explained above, the Z component in the cities near the EEJ is smaller than the ones that are farther other information of this component is that it is negative when recorded in latitudes under the EEJ, it also behaves very differently in the places that have distinct geology, in other words, more common places that are far away from each other as HUA and ASC for example, and behaves similarly in places with similar geology, usually happens in places that are near to each other as TTB and CAA.

Unlike Z component, the H component is not related with the geology, but with the localization of the station or observatory. It was noted the altitude and latitude may cause differences in the H component and its amplitude.

In this work it is possible to conclude that the EEJ really exerts a strong influence in the Earth magnetic field, affecting in different ways the distinct areas depending on their geological setting and their distance from the EEJ.

Acknowledgments

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