Day-to-Day Variability of H Component of the Geomagnetic Field in the South Atlantic Islands at Low Latitudes

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Abstract

This work is part of a development study that intend to analyze the day-to-day variability for the H component of the geomagnetic field using data from four different locations situated at low and mid-latitudes and also in different longitudes. The present study investigates the relation between the Sq current system and the South Atlantic Magnetic Anomaly (SAMA). In this paper, we discuss the mechanisms responsible for the observed variations. Since the study of the day-to-day variability could provide important contributions to the knowledge of the ionospheric dynamics.

Introduction

It is known from previous studies the fact that variations in ground magnetic records are caused by the dynamo action in the upper atmosphere (Okeke, 2000). The upper atmosphere is ionized by the Sun's ultraviolet and X-radiation to create the ionosphere, and the free ions and electrons are moved by winds arising from the heating effects of the Sun. The currents in the ionosphere have magnetic effect on the ground and are monitored using magnetometers on the Earth surface. The records show that there are regular and irregular variations. The daily variations of the geomagnetic field when solar-terrestrial disturbances are absent are called solar quiet (Sq) variations (Campbell, 1989 and Obiekezie, 2013).These daily variations in the geomagnetic fields at the earth's surface during geomagnetically quiet conditions are known to be associated with the dynamo currents which are driven by winds and thermal tidal motions in the E-region of the ionosphere (Chapman 1919). Many authors have studied various aspects of the Sq variations, such as the difference between one day and the next day in amplitude, phase, and focal latitude. This change in Sq between the two adjacent days is the day-to-day variability. The Sq variability has found applications in the determination of the Earth's electrical conductivity, in determining the baselines for quantifying of magnetospheric disturbances, and in improving the satellite main-field modeling (Obiekezie, 2013).

The present study investigates the relation between the Sq current system and the South Atlantic Magnetic Anomaly (SAMA). The Sq current system is stationary in the Earth-Sun line due to its solar origin with the Earth rotating underneath it. Because of this rotation, one can expect a modulation of Sq by the Earth's main magnetic field, with its most striking mid-latitude feature being the SAMA. This is a region of special interest due to its anomalous geomagnetic field behavior. The SAMA describes a low intensity magnetic field area, which spans from east of Africa over the Atlantic Ocean to South America (Koch and Kuvshinov, 2015).

The aim of this paper is to analyze the day-to-day variability in the H component of the geomagnetic field at four different locations. In this paper, we discuss the mechanisms responsible for the observed variations based on data during the period of September 4th, 2014 to September 21st, 2014.

Data and Method

A set of observatories located in SAMA was used in this work. Table 1 gives the geographic coordinates of all stations.

Table 1 – Geographic coordinates of the stations used

Station			Geographic	
Name	LT	Code	Latitude (º)	Longitude (º)
Ascension Island	UT	ASC	7° 56' South	14° 22' West
Tristan da Cunha	UT	TDC	37° 4' South	12° 19' West
Vassouras	UT-3	VSS	22º 24' South	43º 39' West
Trindade Island	UT-3	TRN	20º 31' South	29º 19' West

The days selected and used in this analysis are the ten International Quiet days (IQDs). These days are the set of ten quietest days in September of 2014. The ten International Quiet Days (IQD) are the ten quietest days of the month according to the classification of planetary magnetic index, Kp. The quiet-period days are generally limited to $Ap \leq 8$.

The mean hourly values were computed from the minute interval recorded data of H. The average of the hourly values for the preceding and succeeding local midnights of each of the ten quietest days was calculated. These values were subtracted from the hourly values at a fixed hour on each of these IQDs. The hourly departures were then corrected for noncyclic variation. The hourly departures corrected for noncyclic variation on quiet days give the solar quiet daily variation. The day-to-day variability in the H component was studied. This was done by calculating the variability of this hourly amplitude for a fixed hour from one IQD to the next succeeding IQD, this was done for all the IQDs for all hours of the day. The reader is referred to the explanation of this method in (Obiekezie, 2013 and Okeke, 2000) for further details.

Results and Discussion

The variabilities of Sq hourly amplitudes for the hour, t from day *i* to the next day *i*+1 for all hours of the day called the day-today variability, were calculated only for consecutive IQDs. The day-to-day variability of Sq (H) is shown in Figure 1. For the four stations, ten consecutive IQDs in September were chosen. According to Obiekezie (2013) and Okeke (2010) the variability occurrence is a dawn to dusk phenomena, although more noticeable in he daytime but turns very mild during the night in Sq (H) in all stations. This pattern was observed in this study.

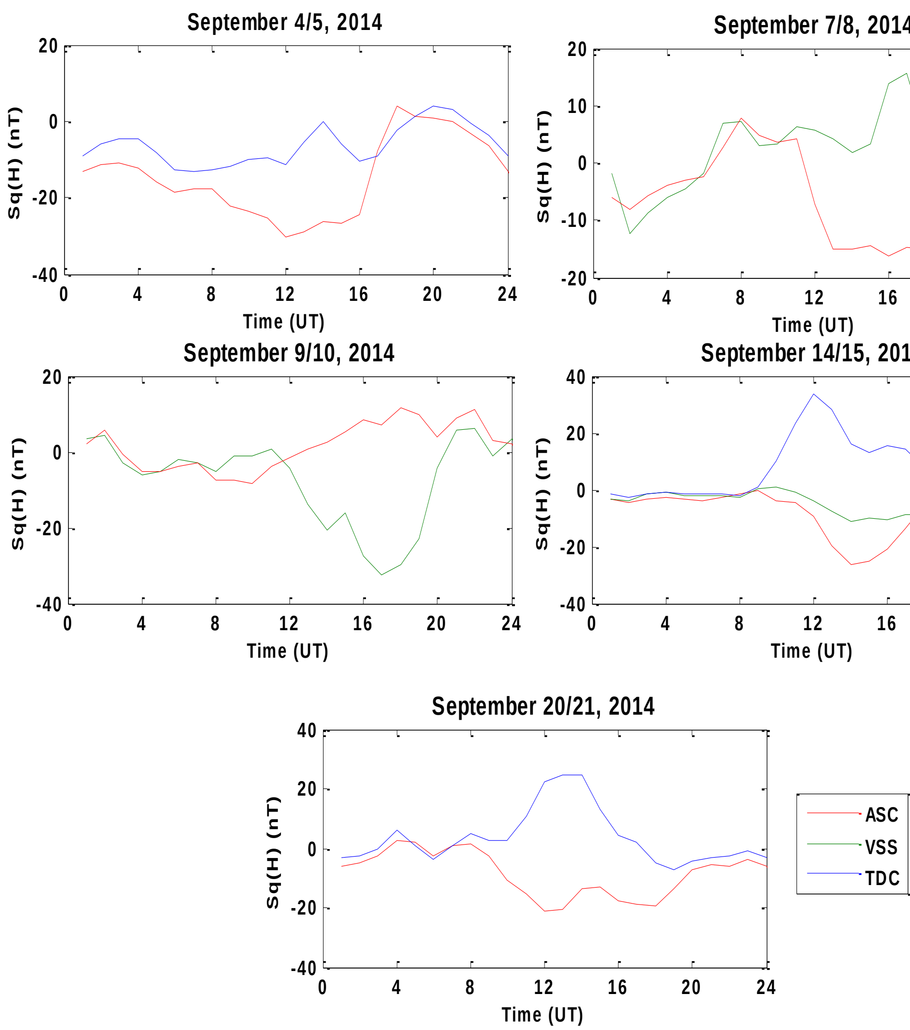

Figure 1 – Day-to-day variations in Sq (H) for the month of September.

It could be seen from Figure 1 that the variabilities between two paired consecutive days are different. For example, on 7/8 September and 9/10 September, the variations are seen to be different from one to another which are in agreement with previously research works in the area (Obiekezie, 2013 and Okeke, 2000). Observing this figure on the 7/8 September at VSS, the day-to-day variability in H was seen to have a maximum amplitude of about 15 nT and a minimum amplitude up to -12 nT, while on the 9/10, at the same station, the maximum amplitude was about 6 nT and the minimum was about -32 nT. The maxima and minima occurred at different times, therefore, exist phase variations. These amplitude and phase variations are seen to be random. According to Okeke (1998) 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.

Figure 2 shows the monthly variations in the Sq (H) for the stations used in this analysis. It is evident that the amplitude of the Sq(H) in VSS is the highest. The morphology of the curves has the same shape. Furthermore, the morphology of the curves for VSS and ASC shows a regular increase in amplitude in the morning hours and a gradual decrease from the peak value down to the night value. A kind of phase difference is observed between the stations. This may be attributed to the differences in their locations. Also, Figure 2 shows that the Sq(H) peaks are mostly around the local noon within the range of 1000 to 1400 hours for the stations used in this study which are in agreement with the diurnal variation pattern of Sq in previously works (Matsushita,1969 and Onwumechili, 1960).

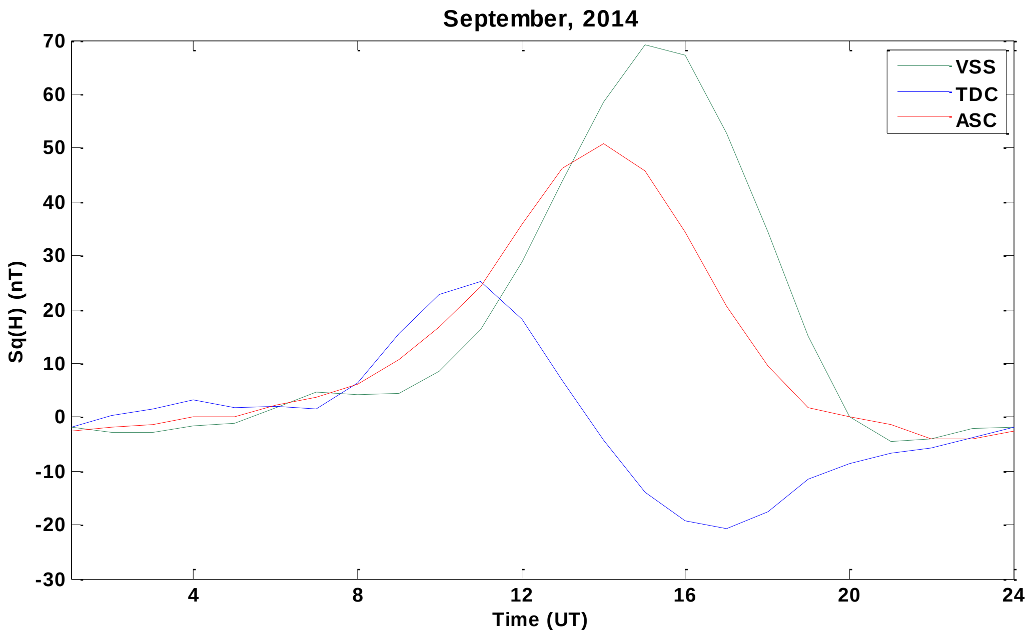

Figure 2 – Monthly variations in Sq (H).

Conclusions

This study has provided some interesting results which are in agreement with previously works in the area. The results have shown that day-to-day variability occurs at all hours of the day. This confirms that Sq is a very changeable phenomenon, with a strong day-to-day variation. Also, this study investigates the relation between the Sq current system and the (SAMA). Concerning the solar activity as a possible source for the variability of the Sq system, we observed any influence since there is no difference between the results obtained from previously researchers. However, we hope to improve our results with the data from Trindade Island and other stations in the SAMA region and outside its influence. Since a direct comparison with these studies appeared to be inconclusive due to different analysis and data sets.

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References

Campbell, W. H. The regular geomagnetic field variations during quiet solar conditions, *Geomagnetism, J. Jacobs. Ed*., **vol. 3,** pp. 386-460, Academic Press, San Diego, Calif, USA, 1989.

Chapman, S., The solar and lunar variation of the earth's magnetism, *Phil. Trans. R. Soc. Lond*, **A 218**, 1-118, 1919.

Koch and Kuvshinov, Does the South Atlantic anomaly influence the ionospheric Sq current system? Inferences from analysis of ground-based magnetic data, *Earth, Planets and Space* **(2015) 67:10**.

Matsushita, S., Dynamo currents, winds and electric fields, *Radio Science*, **vol. 4**, p. 771, 1969.

Obiekezie, T. N. Day-to-Day Variability of H and Z Components of the Geomagnetic Field at the African Longitudes, http://dx.doi.org/10.1155/2013/909258 (2013)

Okeke, F. N. and Hamano,Y., Daily variations of geomagnetic H D and Z field at equatorial latitudes*, Earth Planets Space*, **52**, 237-243, 2000.

Okeke, F. N., Day-to-day variability of geomagnetic hourly amplitudes at low latitudes, *Geophys. J. Int*., **vol.134**, pp. 484-500, 1998.

Onwumechili, A., Fluctuations in the geomagnetic horizontal field near the magnetic equator, *Journal of Atmospheric and Terrestrial Physics,* **vol. 17**, no. 4, pp.286-294, 1960.