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EFFECT OF CYCLIC CORRECTION ON SOLAR QUIET GEOMAGNETIC FIELD VARIATION

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ABSTRACT

In analyses of the solar quiet field, it is necessary to determine and remove the non-cyclic variation, which is regarded as an after effect of magnetic storms and not part of the true solar quiet variation. For this study the cyclic correction method was used to correct for the non-cyclic variation in the horizontal components during solar quiets days of year 2007-2009 for seven stations along the 210MM. Five of the ten observed relatively quiets days were selected for each month of each year to study the geomagnetic intensity of the horizontal H component. The Magnetic Data Acquisition System (MAGDAS) data recorded in minutes was converted to hourly values using codes written with MATLAB program. The baseline (BL) value was deduced by calculating the hourly average value of the 4 hours from the local midnight (0100, 0200, 2300 and 2400 LT). The obtained values were further corrected for non cyclic variation. The results revealed that the corrected and uncorrected solar quiet horizontal field shows the same pattern for diurnal, monthly and seasonal variation with observable differences most dominant at the peaks and minimum points between 5LT to 14LT. The non-cyclic variation field obtained was seen to be latitudinal dependent with equatorial stations having the highest values and Ashibetsu, Culgoora , Camden, and Cooktown showed irregular variation which is due to their latitudinal position. The Seasonal variation shows semi- annual pattern with maximum during the equinoctial season which is due to enhanced electron density at the equinox seasons. The result of this study confirm that the cyclic correction method used to correct for non-cyclic variation shows that the non-cyclic variation has the same pattern as the solar quiet variation and the difference between the corrected and uncorrected values of the solar quiet *variation is more prominent at the minimum and maximum points between 5lt to around 14lt.*

Keywords: *[solar quiet, non-cyclic variation, cyclic correction, geomagnetic horizontal component]*

INTRODUCTION

The study of variations in the Earth Magnetic Field is of great interest in oil exploration, communication, and space weather studies and climates changes. These variations are caused by current presence in the conducting layer of the atmosphere called the ionosphere. These current are generated by a dynamo process in the ionosphere (Price and Wilkins, 1963). Geomagnetic variations ranges from large irregular disturbances called geomagnetic Storms to slow regular disturbances which are classified as the solar Quiet variations (Adebesin 2014)

Different studies from different researchers have been carried out using various methods to correct the non-cyclic variation from observed values of H and to understand the morphologies of the ionosphere and its interaction with the magnetosphere. Price and Wilkins (1963) attempted to estimate for the non-cyclic variation by obtaining the difference in the mean valve of the magnetic elements for two intervals of time of an hour or more centered near the beginning and the end of the Greenwich day. Also, D. J Stone and A. T Price (1963) obtain the values for non-cyclic variation by using the local quiet days instead of the international quiets days, he concluded that the preliminary study of the non-cyclic variation tends to confirm the established theory of the field and that the field is a relatively slowly varying field which can be regarded as the last phase of the slow exponential decay of negative DST (disturbance storm time) after magnetic storms.

In this study, a non cyclic variation which is regarded as an after effect of geomagnetic storms and not part of the true solar quiet variation has been observed. This non cyclic variation field is generally attributed mainly to decay of current flowing westward in an ionized belt surrounding the earth at a distance of several earth radii (A.T Price 1963). This ring current is produced or intensified during geomagnetic storms and its subsequent decay produces a gradual rise in the observed valves of the horizontal components of the geomagnetic field.

For this study the cyclic correction method which is defined as an estimate such that the value at 0100 LT is not different from the value at 2400 LT were used to correct for non cyclic variation in the solar quiet variation in H (S_qH) and the differences between the corrected and uncorrected values of the solar quiet variation were observed. For proper analyses of the solar quiet field, it is necessary to determine and remove the non-cyclic variation.

Oliver Reynolds wulf (1963) employed this method and obtained the corrected values of SqH which he used in his work on the possible effect of atmospheric circulation on the daily variation of the earth magnetic field and obtained that variation in the earth magnetic field may not only be as a result of solar activities but that large scale prevailing winds in the lower ionosphere may be playing an important part in the variation. Rabiu (2011) also corrected for non-cyclic correction in his study of the estimation of Equatorial electrojet strength along the 96^0 and 210^0 magnetic meridian, Bolaji et al (2013) also used the corrected hourly value of Sq.(H) in his study on the variability of horizontal magnetic field intensity over Nigeria during the low solar activity year 2009 and he observed maxima Sq(H) values between the hours of 1000 and 1200 LT.

MATERIAL AND METHODS

This study used Magnetic Data Acquisition system (MAGDAS) data for the horizontal magnetic component H for seven stations at different latitude along the 210 magnetic meridian. The three years under investigation are 2007, 2008 and 2009 which are years with minimum solar activities

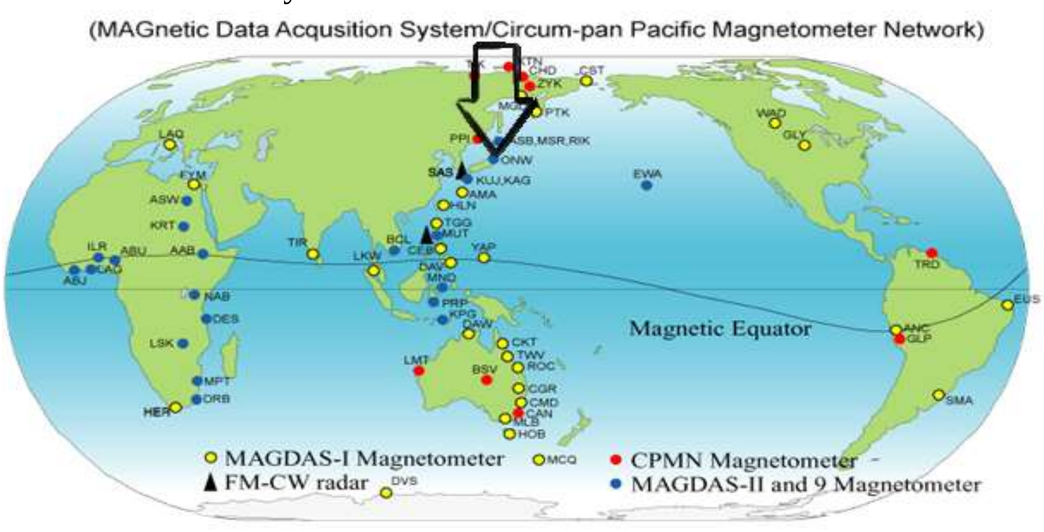

Figure 1. MAGDAS stations distribution with arrow showing study area

Five of the ten observed relatively quiets days were selected from groups of days for each month obtained from Geosciences Australia catalogue to study the geomagnetic intensity of the horizontal H component. The MAGDAS data recorded in minutes were converted to hourly values using codes written with

MATLAB program. The baseline (BL) value was deduced by calculating the hourly average value of the 4 hours from the local midnight (0100, 0200, 2300 and 2400 LT). Therefore, the BL value for the horizontal (H) component is expressed as follows

$$\boldsymbol{BL = (H_{23} + H_{24} + H_{01} + H_{02}) \div 4} \qquad (1)$$

where $\boldsymbol{H_{23}, H_{24}, H_{01}\, and\, H_{02}}$ are the hourly values of H components at 2300, 2400, 0100 and 0200 LT respectively

The hourly departure of H from midnight baseline is obtained by subtracting the midnight baseline values for a particular day from the hourly values for that particular day.

Thus for `t' hour in LT:

$$\boldsymbol{\Delta H_t = H_t - H_0} \qquad (2)$$

where t = 1 to 24 hours

The hourly departure of H from midnight baseline is obtained by subtracting the midnight baseline values for a particular day from the hourly values for that particular day.

The hourly departure is further corrected for non- cyclic variation, a phenomenon in which the value at 0100 LT is the same as the value at 2400 LT Vestine (1967) and Rabiu (2000). This is done by making linear adjustment in the daily hourly values of ΔH which can be done by consider the hourly departures ΔH at 0100 LT, 0200 LT…..2400 LT as $V_1, V_2 \ldots\ldots V_3$ and calculating $\boldsymbol{\Delta_c}$ **as**

$$\Delta_c = \frac{V_1 - V_{24}}{24} \qquad (3)$$

The linearly adjusted values at these hours are

$$V_1 + 0\,\Delta_c; V_2 + 1\Delta_C + \cdots V_{23} + 22\,\Delta_c; V_{24} + 23\Delta_c$$

$$S_t(V) = V_t + (t-1)\Delta_c \qquad (4)$$

where t is the local time ranging from 0100 to 2400.

The hourly departures corrected for non-cyclic variation gives the solar daily variation in H where Sq (H) denote the solar quiet variation in H**.** The data were analyzed using a MATHLAB program that displayed the result graphically. With the program the following steps were taken thereafter

- The calculated $H_t – H_0$ values were plotted against local time(LT) for each month of the years

- The corrected $S_t(V)$ valves computed and plotted against local time(LT)
- The $H_t - H_0$ and the $S_t(V)$ were plotted together to observe the difference between the corrected and the uncorrected values of the Sq.(H) thus providing the non-cyclic variation field

RESULTS AND DISCUSSION

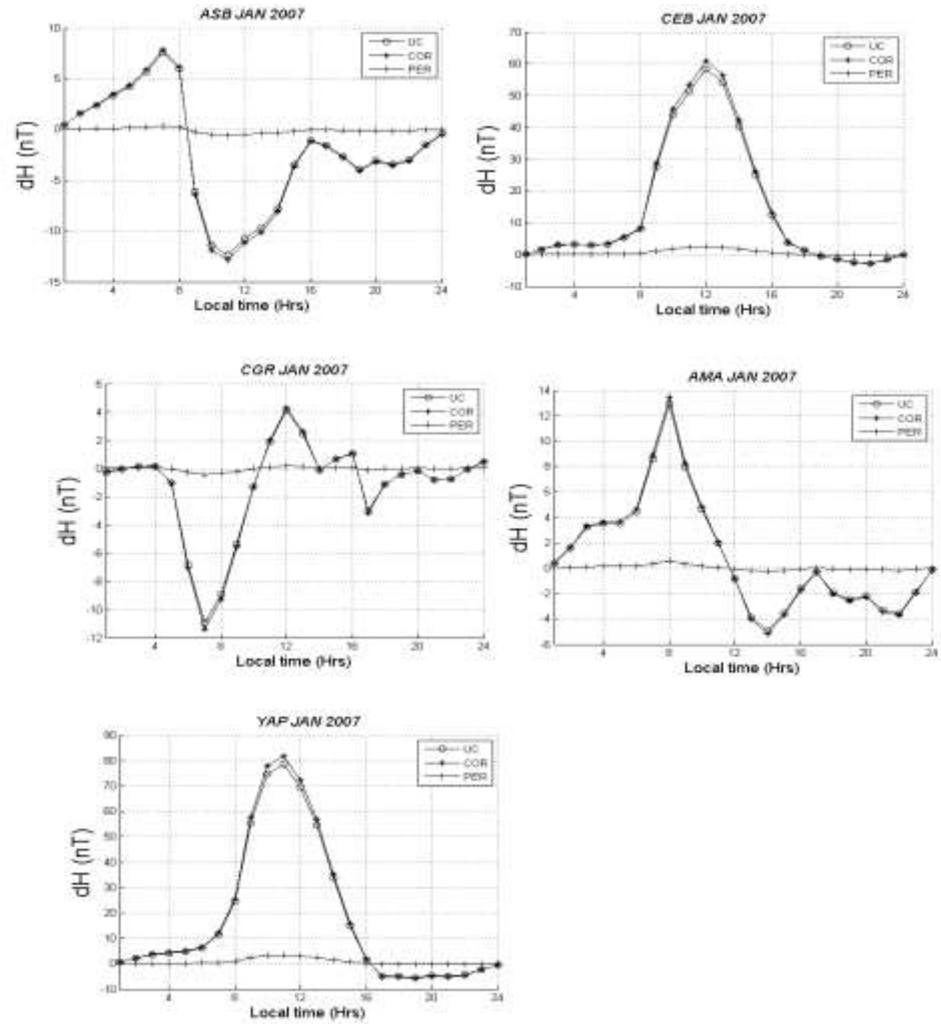

Figure 2: Monthly median variation of dH for ASB, CEB, CGR, AMA, YAP in January 2007

The solar quiet values that were derived from the measured geomagnetic element of the horizontal intensity (H) have been computed for all the months during the years 2007. There were a number of data gaps which occurs as a result of interruption in the data recording.

The mean of the hourly values of each individual hours for all the five quiet days of a month is called the mean hourly value of the month. This value is plotted against local time (figure 2). The plot shows the value of the Sq.(H) that has not been corrected for non-cyclic variation (UC), the values that have been corrected (COR) and the value obtained from differences between the corrected and the uncorrected values (PER) for the month of January. The Sq.(H) mean diurnal variation of the corrected and uncorrected values were observed to present the same shape in all the stations for all months throughout the year 2007 , the noticeable difference in the two values were observed at the minimal and maximal point of the plot. The differences between the corrected and uncorrected values are visible at either the peak values or the minimum and in some station it occurs at both. It is known that the geographic latitude and the Sun’s location largely determines both the ionization and the thermo tidal motion in the ionosphere thus the difference observed in the stations is as a result of its latitudinal position.

CEB (Cebu) and YAP (Yap Island) are both 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. The different between the corrected and uncorrected values were observed at these stations between 1000 LT to 1200 LT. The variation was seen to be somehow different in the northern stations. ASB (Ashibetsu) shows two maxima around 0500 LT and 1400 LT and minimal around 0900 LT -1100 LT and the differences between the corrected and uncorrected values of SqH were observed to be prominent between 0900 LT- 1300 LT, AMA (Amami-ohshima) and CGR (Culgoora) show at lot of irregularities due to data non availability thus the different between the corrected and uncorrected values were not prominent.

3.2 Seasonal variation of the non cyclic variation field

Fig. 4.14 shows the seasonal mean variation of the non-cyclic field for year 2007 obtained using the cyclic correction method Vestine (1967) and Rabiu

(2000) the northern hemisphere stations AMA and ASB peaked around 1500 LT while the equatorial stations YAP peaked around local noon and the sourthern hermisphere stations CMD(CAMDEN) peaked around 0800 LT for the solstical Months. The Equatorial Stations shows the highest value for the seasonal non cyclic variation field for the the year of study with the eqinoctical months having the highest value. Forbes (1981) noted that the seasonal variability could be partially explained by the seasonal variation of lunar semi-diurnal tide. The seasonal change in the non cyclic variation just like the Sq variation can be attributed to a seasonal shift in the mean position of the Sq current system of the ionospheric electrojet.(okeke 1998).

The fig 3 shows that the valves of the non cyclic field is relatively small with highest value of 4nT for the equatorial stations YAP and CEB. This result is in agreement with the conclusion of A.T Price(1963) that the non cyclic field is a slowly varying field.

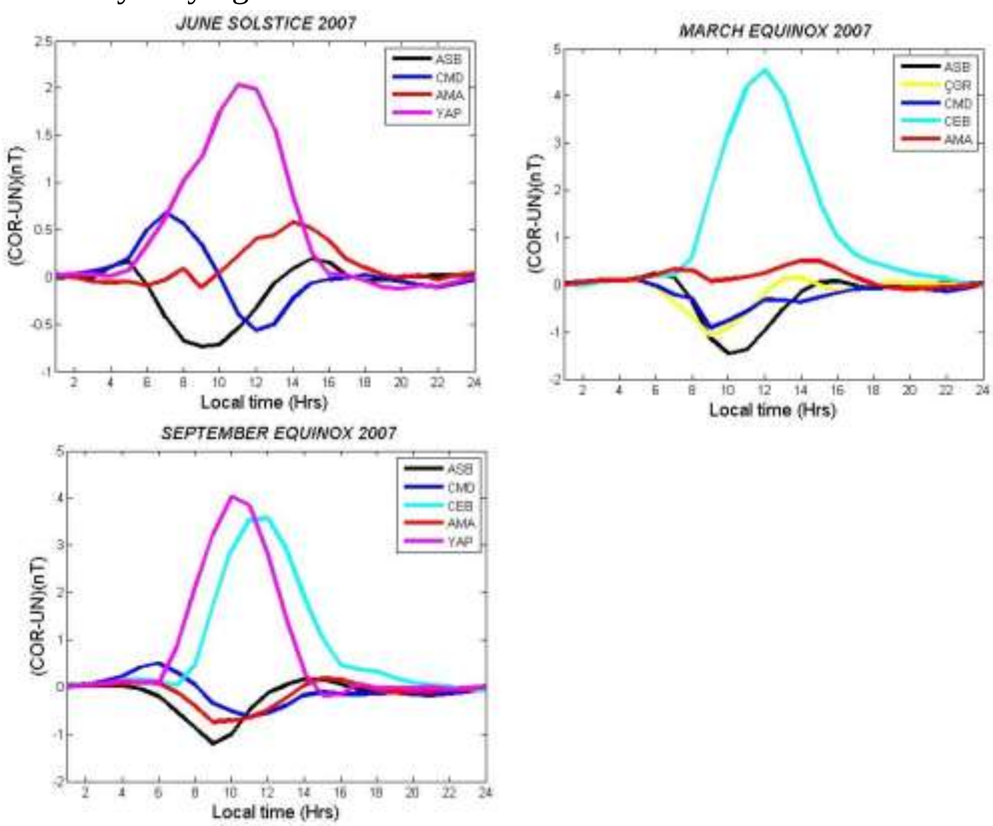

Figure 3: Seasonal non cyclic variation for 2007.

Table 1: Geographic and Geomagnetic Location of the Observed Stations

Statio code	Station Name	Nation	Geographic Latitude	Geographic Longitude	Geomagnetic Latitude	Geomagnetic Longitude	Dip Latitud
ASB	Ashibetsu	Japan	43.46	142.17	36.43	213.39	
CEB	Cebu	Philippines	10.36	123.91	2.53	195.06	2.74
YAP	Yap island	FSM	9.50	138.08	1.49	209.06	1.70
CMD	Camden	Australia	-34.06	150.67	-44.06	227.92	
CKT	Cooktown	Australia	-15.48	145.25	-24.62	218.38	
CGR	Culgoora	Australia	-30.32	149.57	-40.17	225.75	

CONCLUSION

In this study the cyclic correction method by Vestine (1967) and Rabiu (2000) was used to correct for non-cyclic variation for solar quiet field intensity component Sq.(H) along the 210 magnetic meridian using five quietest days of each months. The cyclic corretion method used to correct for non cyclic variation in this study shows that the non-cyclic variation has the same pattern as the Sq(H) and the difference between the corrected and uncorrected values of the Sq(H) is more prominent at the minimum and maximum points between 5 LT to around 14 LT. The results also shows that the non cyclic variation is a slowly varying field with maximum value of 4nT this agrees with the work of Albert price (1940). It was also observed that minimum value of the field were also observed for the Northern and Sourthern hermisphere stations and maximum for the equatorial stations. Also, it exhits semi-annual pattern with equinotical maxima and solstitial minima for all the years of study and this shows that the non cyclic field like the Sq(H) varies seasonal and is latitudinal dependent.

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