ANALYSIS OF DIURNAL VARIATION OF EARTH GEOMAGNETIC FIELD COMPONENTS AT ADDIS-ABABA; AN EQUATORIAL STATION IN AFRICA

AGBO, G.A.,[1] & IFEANYICHUKWU, B. J.,[2]
INDUSTRIAL PHYSICS DEPARTMENT
EBONYI STATE UNIVERSITY ABAKALIKI.[1&2]

NWIFIOR, K[3]
PHYSICS DEPARTMENT, EBONYI STATE COLLEGE OF EDUCATION
IKWO, EBONYI STATE.

Abstract.

Ten yean analysis of earth geomagnetic field components has been studied using data from Addis-Ababa observatory. The result of the analysis shows that throughout the yean under study that there is maximum rise in amplitudes of (he H-Component at around the noon-time. The-morning decay rate was found to be greater than the evening decay rate. The diurnal variation of solar daily variation on both conditions followed the variation pattern of solar daily variation and can be attributed to the solar variability such as conductivity and winds structures in the atmosphere. The scattering of variation is more in disturbed conditions than in quiet conditions. This is obviously due to the ionospheric disturbances originating front external drives, such as space weather effects and a storms result of the variability of the night-time distant current.

Keywords: Diurnal variation, Geomagnetic field components, equatorial station.

Introduction:

Geomagnetic is the study of science of the magnetic field of the earth. In the real sense the magnetic fields of the earth overflow round the region of the earth up to several earth radii referred to as the magnetosphere. So many materials such as rocks can serve as a source of proof or evidence that the earth is a big magnet. The geomagnetic field strength of the earth varies both in space and time. The strength of the earth's field is measured at a number of magnetic observatories all over the world. The result of those observatories at ground level and earth satellite above show that the main sources of the earth's main field is beneath the earth's surface (Onwumechili, 1997).

By Gauss mathematical means of spherical harmonics analysis the geomagnetic field is both of internal and external origin but that the field of internal origin is much more in strength than that from external source. The Gauss spherical analysis separates the field into internal and external terms. The internal field is further separated into thedipole and non-dipole fields. The external sources are believed to be caused by various dynamic processes in the atmosphere and magnetosphere.
The sun's radiation is directly overhead at the equatorial region and magnetic field lines in this region are parallel. As a result the equatorial region is dynamic, hence there is need to carry out frequent research in this region to ascertain any feature that might arise. The aim of this work is therefore to study the diurnal variation of the geomagnetic field components using data from Addis-Ababa observatory. The choice of Addis-Ababa is that it is in equatorial region in Africa having permanent geomagnetic observatory running for some times now.

Geomagnetic Field Components

Magnetic fields pervade the universe. Sometimes these fields are very weak. In interstellar space, they are perhaps a million times weaker than on the surface of the Earth, in contrast the magnetic fields of stars can be many orders of magnitude greater than the terrestrial Held. At both extremes, however, the magnetic field is dynamically important to the

environment in which these fields are found. In a non-electrically-conducing environment the situation is quite different, for example, on the surface of the Earth where the gases are neutral and not electrically conducting, we tend to consider magnetic fields as once useful for navigation.
The Earth acts like a large spherical magnet: it is surrounded by a magnetic Held thatchanges with time and location. Sometimes these fields are very weak. In interstellar space, they are perhaps a million limes weaker than on the surface of the Earth, f he field is generated by a dipole magnet (i.e. a straight magnet with a north and South Pole) located at the center of the Earth. The axis of the dipole is offset from the axis of the Earth's rotation by approximately 11 degrees. This means that the north and south geographic poles and the north and south magnetic poles are not located in the same place. At any point and time, the Earth's magnetic field is characterized *by* a direction and intensity which can be measured. Often the parameters measured are the magnetic declination, D, the horizontal intensity, H. and the vertical intensity, Z. From these elements, all other parameters of the magnetic field can be calculated.
Deep inside the Earth and high in the atmosphere the magnetic field assumes much greater importance. The fluid

motions in the electrically conducting core of the Earth generate magnetic fields that react back on those motions. The magnetic field generated in the core extends far into space where it interacts with the magnetic field and plasma from the sun. The magnetic field shields the Earth from the lull onslaught of energetic charged particles from the sun,but also takes some fraction of these panicky and accelerates them to high energies into the atmosphere causing the auroras. 1 he aurora in fact were probably man'sfirst observed phenomenon that were caused by magnetic processes, well before the discovery of the terrestrial magnetic field as- an aid to navigation or the discovery of sunspots, the dark areas in the photosphere caused by strong magnetic fields.

The Earth’s magnetic field is a vector quantity: at each point in space it has strength and a direction. The first regular geomagnetic observatory close to the magnetic equator was established at Trivandrum, India in 1841. The observations were restricted to the declination component and significant solar daily, seasonal and solar cycle variations were shown (Broun. 1874). Later, a standard geomagnetic observatory was established in India at Kodaikanalin 1902 by the magnetic survey of India, as a base station for the magnetic survey, which is located within three degrees from the magnetic equator.

An ionospheric radio sounding station was also established at kodaikanal in 1952 and both the ionosphere and the magnetic observations are continued even today. However, it was the establishment of a geomagnetic observatory at Huancayo, peru in 1922 that brought into attention the abnormally large solar daily variation of the horizontal component. H, at an equatorial station. Combining the data from Huancayowith the data from the low latitude stations KodaikanalMadras in India and Antipole and Bulavia. (Egedal, 1947) showed that an enhancement in the solar daily variation of H (SqH). Occurs within 5^0 latitude centered on the dip equator. He suggested that this enhancement was caused by a band of electric current of about 300km in width flowing over the dip equator which was later named “Equatorial electroject” by Chapman, in 1951.

During the international geophysical year. (IGY). several geomagnetic observatories were established within the equatorial electroject (EEJ) belt. Analysing the lunar tides in the critical frequency at the equatorials stations in Peru and in India during IGY period. (Rastogi, 1962a) predicted that the equatorial electroject current strength must be stronger in Peru than in India. Later using the geomagnetic data from the equatorial observatories K.iY. (Raslogi, 1962b) confirmed that the electroject current is indeed stronger in Peru in India. The strength of the electrode! current was shown to vary roughly inversely to the background mean value ol the geomagnetic field H at the station. It was suggested that electrical conductivity over that

magnetic equator is inversely proportional to the strength of the H field(Chandra *et al.,* 1999). Although it was apparent that the geomagnetic field variations were unique at quiet-times, conditions for quietness had to be assumed pragmatically in order to (rack seasonal and y ear-to year changes. The principal source of the quiet-lime field was discovered in the E-region of the ionosphere, where the ion density and collision frequency permitted the flow at an electron current. "This current was driven by the daily thermal-tidal motions and thermospheric winds moving the ionization through the earth's main field as in a dynamo. The term "tensor conductivity" is used to indicate the fact that the ionospheric plasma had different conducting properties depending on the direction of the forced motion with respect to the main field in the ionosphere.The
dynamo current of Sq. form two vortices on the day side of the earth, counter clockwise in the Northern Hemisphere, clockwise in the Southern Hemisphere and large in the summertime regions. A special conductivity property, in the region of the dip equator where the earth's main field is horizontal, causes a concentration of eastward currents called the equatorial electroject. In the Polar Regions, disturbance like currents can be separated from the Sq by wavelength discrimination in the spherical harmonic analysis.

Tidal forces acting upon the earth's atmosphere can generate lunar-tide dynamo currents in the day time ionosphere as semidiurnal Held variations in lunar time. These currents, usually several gamma in size, are modulated *by* the local ionization to show location and seasonal changes. Any process that momentarily disrupts the lower regions of the ionosphere can be seen as a modification of the local dynamo current system. (A sudden increase in E-region). Conductivity by intense solar Hare radiation or a sudden decrease in conductivity along the path of a solar eclipse excites a delectable change in the quiet-day surface field.
More so, the large solar daily variations of the earth's magnetic field at the ground stations were suggested by (Stewart. 1983) as due to the movement of the conducting upper atmosphere across the vertical component of the earth's magnetic Held arising due to the solar heating influence of the atmosphere. At the magnetic dip equator the midday eastward polarization fieldgenerated by global scale dynamo action gives rise to a downward Hall current. A strong vertical polarization field is set up which opposes the downward How of current due to the presence of non-conducting boundaries. This field in

turn gives rise to the intense Hall current which (Chapman, 1951) named the equatorial electroject (EEJ). The phenomenon has been given various attentions and has attracted several research workers both in the past and recent limes.

2. Materials and Methods

Hourly values of H D Z components of geomagnetic field data were obtained from world Data Center for Geomagnetism. Kyoto, Japan website (www.wdc-kyoto.org). The concept of local time was used throughout the analysis as Addis-Ababa (AAE) is 3 hours ahead of the Greenwich Meridian Time (CMT). The international quiet and disturbed days(IQDS) and (IDDS) was selected and used to generate the diurnal variation of geomagnetic field components. 1 he ten year hourly averages was taken and plotted to givethe diurnal amplitude variation for the said period.

The data is made up of hourly values of geomagnetic field horizontal intensity, H, declination intensity, D and verticalintensity, Z, recorded Addis-Ababa (Lat 9°N and long 38.7°E for a ten-year period 1986 to 1995.

International quiet and disturbed days as published by Australian Geophysical science (Agbo, Chikwendu and Obiekezie, 2010) was selected to obtain geomagnetic solar quiet daily (Sq) and solar disturbed daily (Sd) variations.

The base-line values, $H_0,\ D_0,\ Z_0,$ for the geomagnetic elements is the mean value at 24 hours local time and 1 hour local time. The mean of the two hours flanking the midnight was the Sq and Sd for each hour of the day which is a measure of the amplitude variation.

Thus:

$$H_0 = \frac{H_{24} + H_1}{2}$$

$$D_0 = \frac{D_{24} + D_1}{2}$$

$$Z_0 = \frac{Z_{24} + Z_1}{2}$$

The hourly departure of H, D, and Z from midnight $(\Delta H,\ \Delta D\ and\ \Delta Z)$ were calculated by subtracting the midnight base line values from the hourly values such that

$$\Delta H_t = H_t - H_0$$

Similarly

$$\Delta D_t = D_t - D_0$$

and

$$\Delta Z_t = Z_t - Z_0$$

Where , t = 1, 2, . . . 24 hours.

The hourly departure so calculated is further corrected non-cyclic values to remove the difference between the 2400 hours of one day and 0100 hours of the next day. Thenon-cyclic correction (Agbo, 2007) is obtained by making series adjustment in the daily hourly values of Sq. The linear adjust values at the hours, t - 1. *2* ... 24 hours is

$$Sq = V_t + (t-1)\,\Delta$$

Where

$$\Delta = \frac{V_1 - V_2}{23}$$

Thus, the solar quiet (Sq) and disturbed (Sd) daily variation in II D Z are the values obtained alter the correction of non-cyclic variation.

3. Results and Discussions

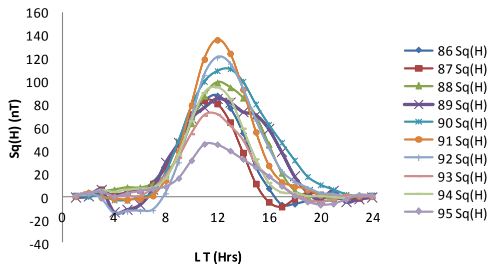


Fig 12: Graph of Sq variation for H-component for Quiet Days in 1986-1995.

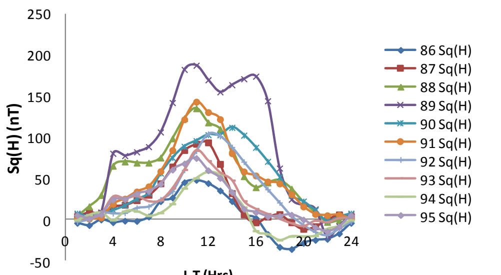


Fig13: Graph of Sd variation for H-component in Disturbed Days in 1986-

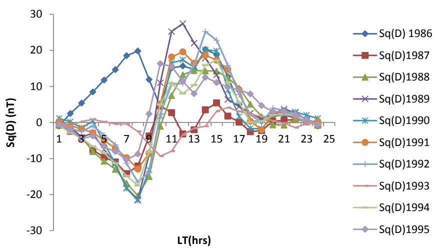
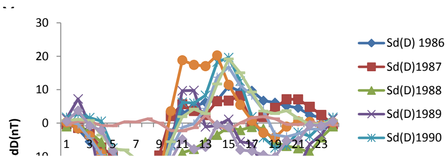


Fig 14: Graph of Sq variation for D-component for quiet Days in 1986-1995.

In each month there is a set of five international quiet and disturbed days' data. The set for Sq variations for each day, of the five international quiet and disturbed days are averaged to obtain the mean hourly value for each month as in January December 1986 as a representative for all the years in this study.



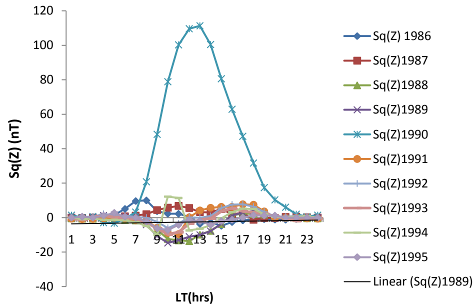


Fig16: Graph of Sq variation for Z-component for quiet Days in 1986-1995.

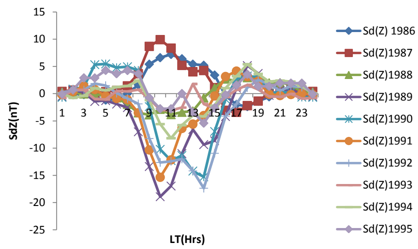


Fig 17: Graph of Sd variation for Z-component for disturbed Days in 1986-1995.

Figure 1-6 is a pair wise variations of geomagnetic field components which indicated that there is a visible solar disturbance daily variation in all the elements (H,D,Z) under study. Various reason have been given to explain these night-time variations, which include convective drift current in the magnetosphere and the asymmetric ring currents in the magnetospheric currents, magnetospheric effects like the westward ring current even during fairly quiet periods, variation due to disturbances indicating possible non-ionospheric origin and a partial ring current in the right side magnetosphere. Obviouslyit is clear that, the Sq and Sdon one day/month/year are clearly different from Sq and Sd of another day/month/year even at the same hour. This implies that, there is day-to-day/ month-to-month/year-to-year variability in the ionospheric conditions in the region of interest-Also, as expected; the scattering of the day-to-day/month-to-month/y ear-to-year variation is more on the disturbed condition than the quiet condition. This is clue to the ionospheric disturbances originating from external drives such as space weather effects, storms etc. For example the year noted for a very pronounced and most disturbed year within the period of studs in 1986 which has the highest storm intensity of about 50nT in H-component. Generally, the magnitude of the variation on disturbed days are always greater than those of quiet condition and this could be due to extra input of energy into the ionosphere during storms and other ionosphericphenomena. ThusSq(H) is always at maximum in both conditions. The implication is that during the quiet days of the years studied (1984-1996), the variations of H-component were seen to be most in the year 1990but this could not cause geomagnetic storm. On the other hand, the variations of H-component in the disturbed days which were found to be most in the year 1999 caused a negligible storm in the geomagnetic Held variations in disturbed days.

4. Conclusion

The equatorial electroject exhibits diurnal variations on both quiet and disturbed days throughout the year. The day-time magnitude of the solar dailyvariation in magnetic field is greater than the night time magnitudes for all the months in the three elements, H, D and Z. The diurnal variation of solar daily variation on both conditions followed the variation pattern of solar daily variation and can be attributed to the solar variability such as conductivity and winds structures in the atmosphere. The scattering of variation is more in disturbed conditions than in quiet conditions. This is obviously due to the ionospheric disturbances originating from external drives, such as space weather effects and a storms result of the variability of the night-time distant current. The magnitude of annual means is greater in element H than D and 7. at any given condition.

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