Characterization of Geomagnetic Parameters at Different Region

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Abstract—Geographical factors theoretically affect geomagnetic field variation due to the exposure to the sun's activities. Previous scientist says that the region that being exposed to the sun light for a period of time will experienced to the high ultraviolet light. Earth's magnetic field is approximately a magnetic dipole, with the magnetic field S pole near the earth's geographic North Pole and the other magnetic field N pole near the earth's geographic South Pole. Earth magnetic data can be measured by magnetometer, Magnetic Data Acquisition System (MAGDAS) and by certain measurement. For this project, earth magnetic field from 3 different regions; Manado (Indonesia) for equatorial region, Onagawa (Japan) for northern region and Cooktown (Australia) for southern region are chosen to be analyzed. The analysis is based on the different parameters of MAGDAS data focusing H, and Z parameters. From the analysis, the earth magnetic polar at different region can be mapped and defined. The results are useful to give the regional magnetic data and also give a significant contribution of a new knowledge on our earth magnetic activities that are closely related to the space activities. The data are supplied by Space Environment Research Centre (SERC), Kyushu University Japan. Both parameters are monitored for one month on January and April 2006. This factor also should be considered in designing the radio communication and propagation technologies.

I. INTRODUCTION

The magnetic field is one of the important properties of the earth. The main magnetic field originates from hydro magnetic processes in the liquid outer core and its configuration and secular variations also depend upon the structure and dynamic processes in core mental boundary [1]. The geomagnetic field gas a regular variation which depends on local time, latitude, season and solar wind. The disturbances in the geomagnetic fields are caused by fluctuations in the solar wing impinging on the earth and the structure of the earth surface itself.

A. Geographical Factors of Geomagnetic Parameters

Geomagnetic field is magnetic field in and around the earth. The intensity of the magnetic field at the earth's surface is approximately 32000 nT at the equator and 62000 nT at the north pole (the place where a compass needle points vertically downward). During June, July and August, the northern hemisphere is exposed to more direct sunlight because the hemisphere faces the sun. The same is true of the southern hemisphere in December, January, and February. It is the tilt of the Earth that causes the Sun to be higher in the sky during the summer months which increases the solar flux [2].The earth currently has an axial tilt of about23.44°. Figure 1 shows the description of relations between axial tilt (or Obliquity), rotation axis, plane of orbit, celestial equator and ecliptic. Figure 2 shows the magnetic latitudes located around the world. The earth magnetic field are most affected to the latitudes of the earth as compared to the longitude of the earth. Earth is shown as viewed from the Sun; the orbit direction is counter-clockwise (to the left). The axis remains tilted in the same in the same direction towards the stars throughout a year and this means that when a hemisphere (a northern or southern half of the earth) is pointing away from the Sun at one in the orbit the half an orbit later (half a year later) this hemisphere will be pointing towards the Sun. Whichever hemisphere is currently tilted toward the Sun experiences more hours of sunlight each day, and the sunlight at midday also strikes the ground at an angle nearer the vertical and thus delivers more energy per unit surface area [3].

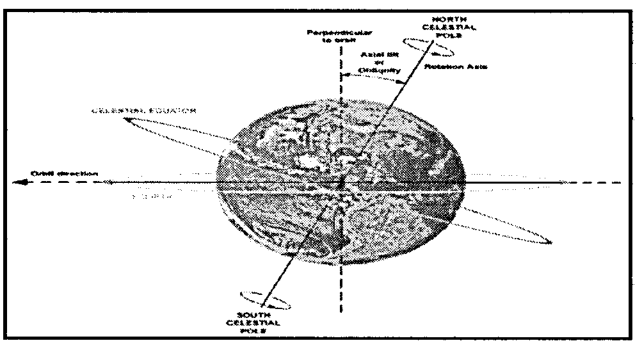

Figure 1: The Axial Tilt Obliquity of the Earth
[From Dna-webmaster]

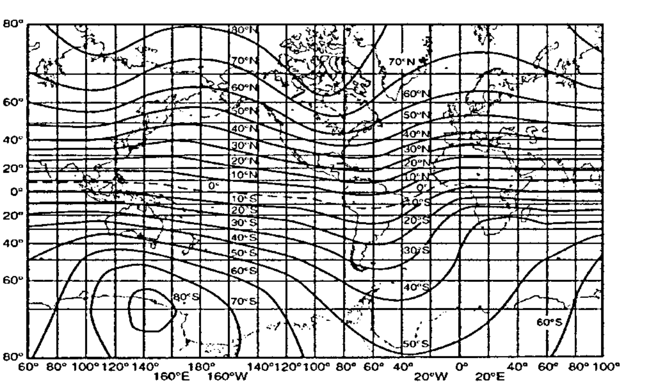

Figure 2: Magnetic Latitudes. The dashed line is the Dip equator. This is where the magnetic field is horizontal to the earth's surface. From Valley [1965]

It is extremely important to understand such storms because of the effects they have on life on Earth. Geomagnetic storms can affect radio communication, satellite drag, auroras activity and even the safety of astronauts in Earth orbit [4].The geomagnetic storm activities effects to the radiation hazards to humans, biology, disrupted the navigation, satellite and communication systems, geologic exploration, electric grid and pipelines systems [5].

B. Geomagnetic Elements

Since geomagnetic field is a vector field, at least three elements (components) are necessary to represent the field. The elements describing the direction of the field are declination (D) and inclination (I). D and I are measured in units of degrees. D is the angle between magnetic north and true north and positive when the angle measured is east of true north and negative when west. I is the angle between the horizontal plane and the total field vector. An element describing the field intensity is the total intensity (F) which can be measured using the formula (1).

$$F=(X^{2+}Y^2+Z^2)^{1/2} \qquad (1)$$

Where X is referred to the geographic northward value, Y is referred to the eastward value and Z is referred to the downward value. The H component defines the horizontal component of the total field intensity which can be measured using formula (2).

$$H=F*\cos(I) \qquad (2)$$

Where F is referred to the total intensities and I is referred to the inclination angle. The Z component defines the vertical component of the total field intensity which can be measured using formula (3).

$$Z=F*\sin(I) \qquad (3)$$

These elements are generally expressed in units of in nano Tesla (10^{-9}Tesla / 10^{-5} Gauss). Combinations of the three elements frequently used in geomagnetism are HDZ, XYZ and FDI. The position of the earth magnetic components are visualize in figure 3.

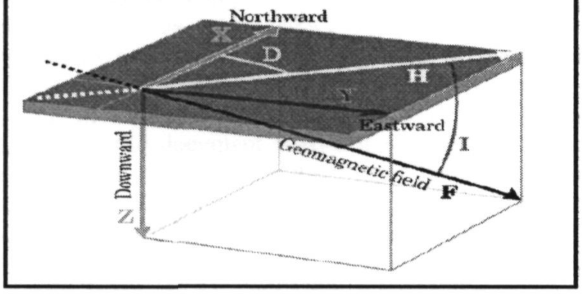

Figure 3: Earth Magnetic Field

C. Geomagnetic Variation

Geomagnetic variations are caused by 3 factors which are core field variations, solar variation and solar wind-magnetosphere interaction [6]. The core field variations consist of reverse, westward drift and secular variation. For Earth, a reversal can be defined as a globally observed change in sign of the Gaussian coefficient that is stable over long periods of time. Secular variation is loosely used to indicate slow changes with time of the geomagnetic field (declination, inclination, and intensity) that are (probably) due to the changing pattern of core flow. The term secular variation is commonly used for variations on time scales of 1 year and longer. The slow variation of the field with time is most likely due to the reorganization of the lines of force in the core, and not to the creation or destruction of field lines. The variation of the strength and direction of the dipole field probably reflect oscillations in core flow.

The 2nd factor that caused geomagnetic variations, solar radiations are changes in the amount of solar radiation emitted by the sun [6]. Interaction of solar particles, the solar magnetic field, and the earth's magnetic field, cause variations in the particle and electromagnetic fields at the surface of the planet. The 3rd factor that caused geomagnetic variations is solar wind magnetosphere interaction which is caused by magnetic storm and aurora sub storm. The magnetic storm and aurora sub storm causes variation in the earth magnetic field [6].

D.MAGDAS

MAGDAS is a system of 50 real time magnetometers that are being deployed by Kyushu Sangyo University of Fukuoka, Japan, as part of Japan's leading contribution to International Heliophysical Year of the United Nations (IHY). The 1-sec magnetic field data from the coordinated ground-based network made it possible to study magnetosphere processes by distinguishing between temporal changes and spatial variations in the phenomena, clarify global structures and propagation characteristics of magnetosphere variations from higher to equatorial latitudes, and understand global generation mechanisms of the Solar-Terrestrial phenomena. Figure 4 shows the MAGDAS station all around the world and shows the components of M AGDAS/CPMN magnetometer system for real-time data acquisition. The yellow bullet in the figure shows installed magnetometer and the red bullet shows planned magnetometer. A triangle in this figure refers to FM- CW radar [7].

Magnetic field digital data ($H+\delta H$, $D+\delta D$, $Z+\delta Z$, $F+\delta F$) are obtained with the sampling rate of 1/16 seconds, and then the averaged data are transferred from the overseas stations to the SERC, Japan in real time. Three observation ranges of ±2,000nT, ±1,000 nT, and ±300 nT can be selected for high, middle, and low-latitude stations, respectively [7].

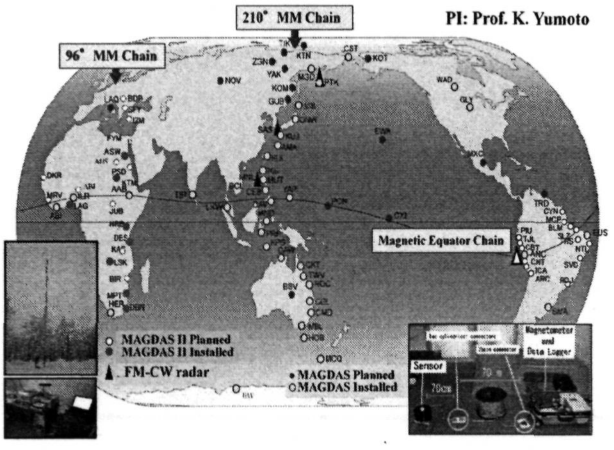

Figure 4: MAGDAS/CPMN system of the SERC, Kyushu University

II. METHODOLOGY

The earth magnetic data will be collected from MAGDAS. The data will be use to be monitoring the variation in component H and Z of the earth magnetic field. For this project, data from MAGDAS station located at Cook Town (Australia), Manado (Indonesia) and Onagawa, (Japan) for January and April 2006 was chosen to be analyzed. The data that chosen on January 2006 show there are only several geomagnetic activities occur on that month while the data chosen on April 2006 show that there are geomagnetic activities occur on that month referring to the Kp index. The estimated Kp-index gives a good indication of how disturbed the Earth's magnetic field has been during the most recent three-hour period. The storm can be ranging into certain scale depending on their Kp-index (refer to the Table 1).

The data satisfy the objective of the project since the station is located at the north, centre and south station of the world. The Cook town station is located at longitude 15.467°S; 145.250°E, Manado station is located at longitude 1°N; 124° whereas Onagawa station is located at longitude 38.433°N; 141.467°E [8]. All the data from MAGDAS file was simulated by using MATLAB software and the simulation was done for all the parameters of the magnetic fields. The process of the project was shown in Figure 5.

The first process is to extract MAGDAS data from MGD file to text document. Next if the data is available, the data is shown in the command window. Then if the data is not available in the command window, the MAGDAS data is extract again from MGD file to text document and read by using read_1M.m again. The graph is then plotted and analyzed. There will be some error in data processing occurs if the data is incomplete. The data will be corrected by doing an interpolating based on the average of the value of H and Z parameters. The corrected data then will process again to get the result.

TABLE 1
NOAA SPACE WEATHER SCALE FOR GEOMAGNETIC STORM

Category		Physical measure	Average Frequency (1 cycle = 11 years)
Scale	Descriptor		
G 5	**Extreme**	Kp = 9	4 per cycle (4 days per cycle)
G 4	**Severe**	Kp = 8, including a 9-	100 per cycle (60 days per cycle)
G 3	**Strong**	Kp = 7	200 per cycle (130 days per cycle)
G 2	**Moderate**	Kp = 6	600 per cycle (360 days per cycle)
G 1	**Minor**	Kp = 5	1700 per cycle (900 days per cycle)

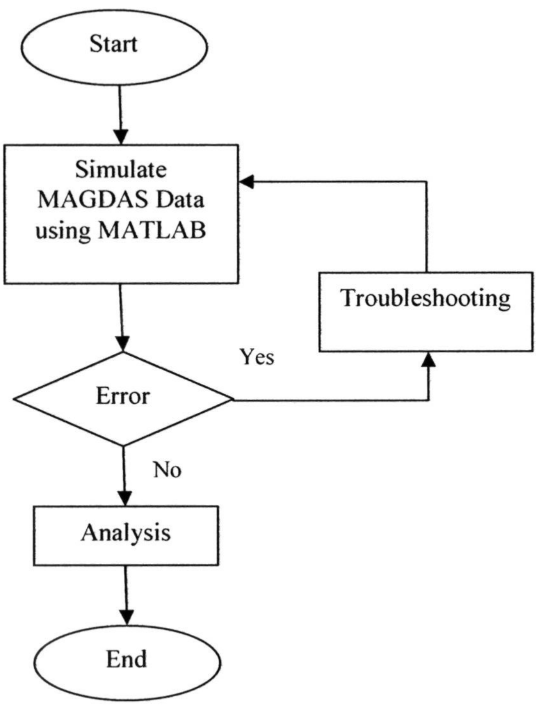

Figure 5: Simulation Process MAGDAS Data

III. RESULTS AND DISCUSSION

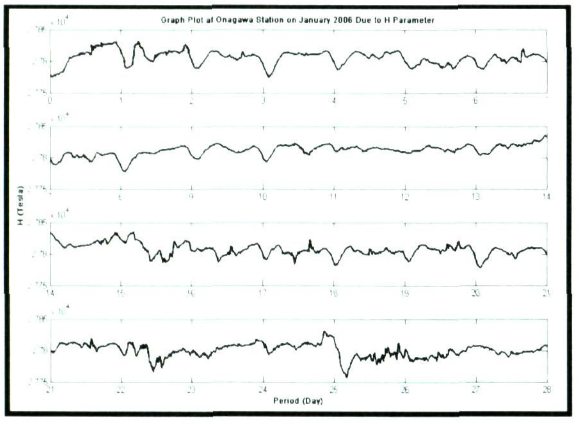

Figure 6: H plot on Jan 2006 at Onagawa Station

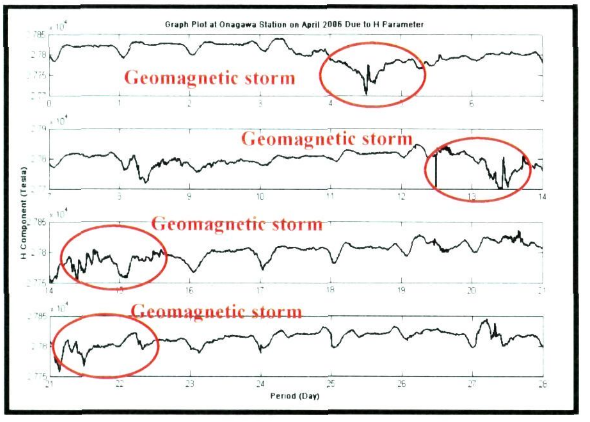

Figure 7: H plot on April 2006 at Onagawa Station

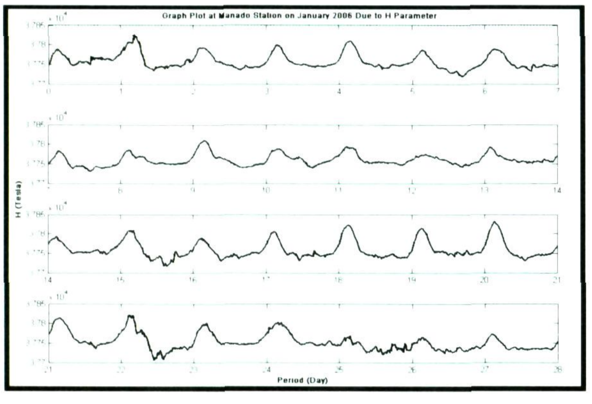

Figure 8: H plot on Jan 2006 at Manado Station

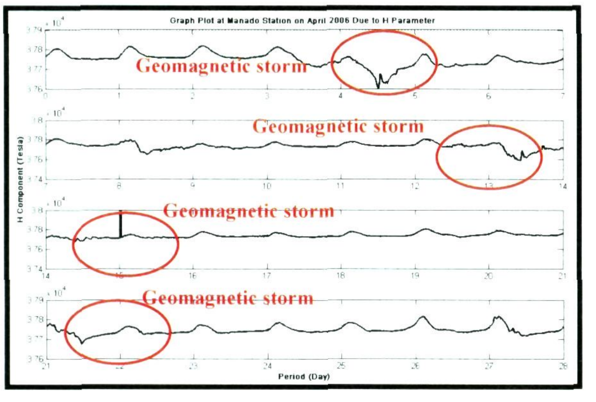

Figure 9: H plot on April 2006 at Manado Station

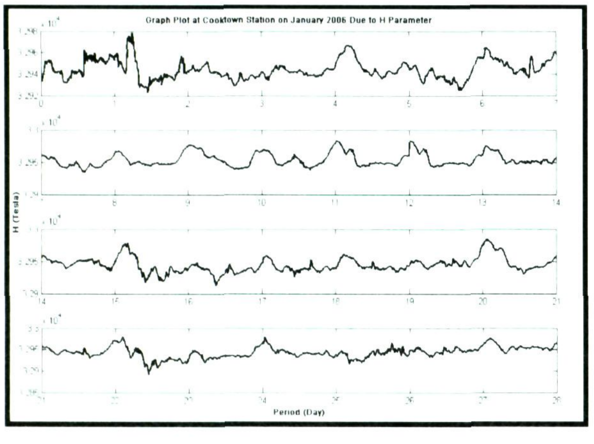

Figure 10: H plot on Jan 2006 at Cooktown Station

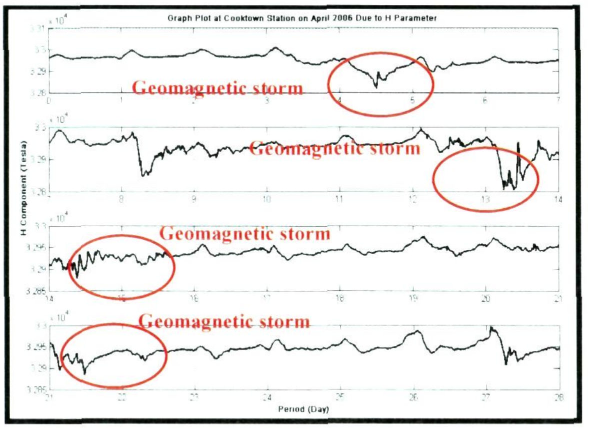

Figure 11: H plot on April 2006 at Cooktown Station

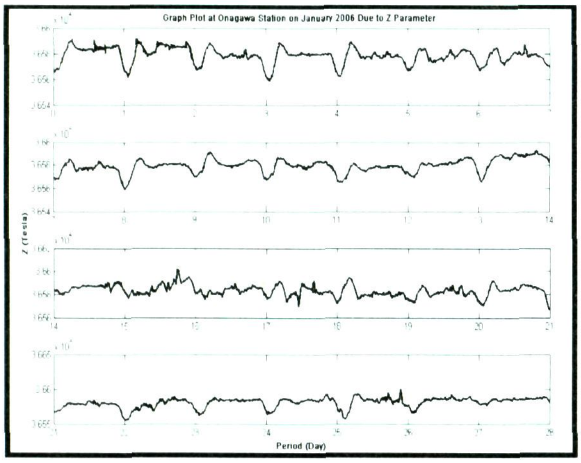

Figure 12: Z plot on Jan 2006 at Manado Station

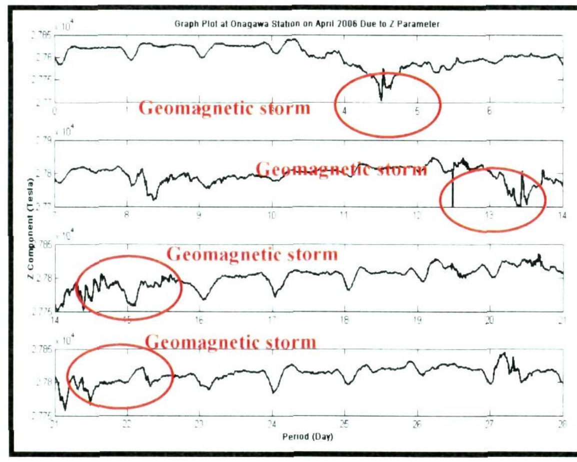

Figure 13: Z plot on April 2006 at Manado Station

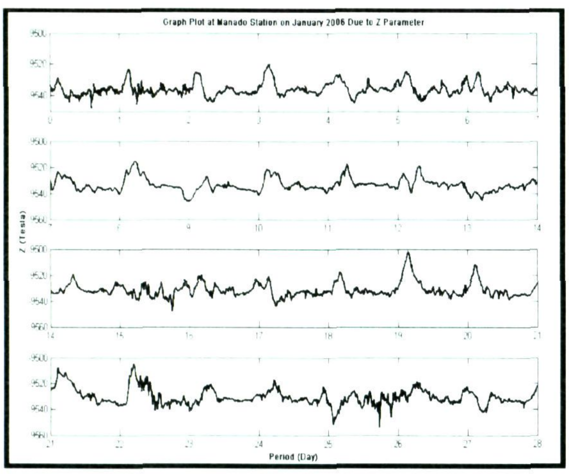

Figure 14: Z plot on Jan 2006 at Manado Station

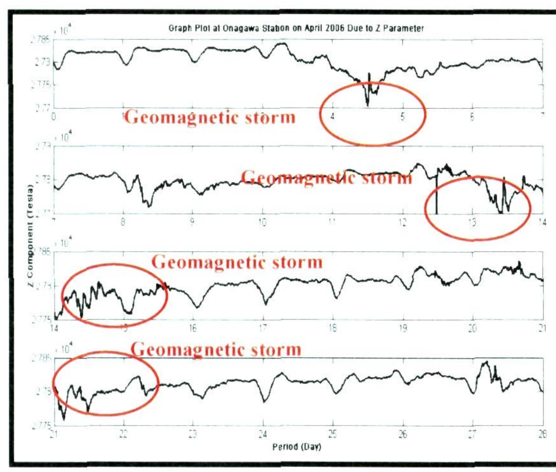

Figure 15: Z plot on April 2006 at Manado Station

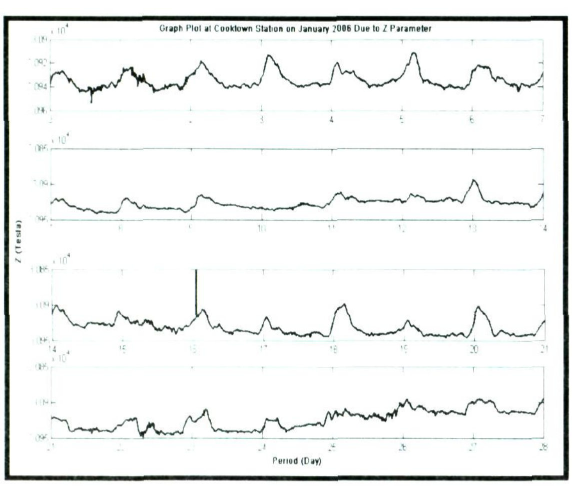

Figure 16: Z plot on Jan 2006 at Cooktown Station

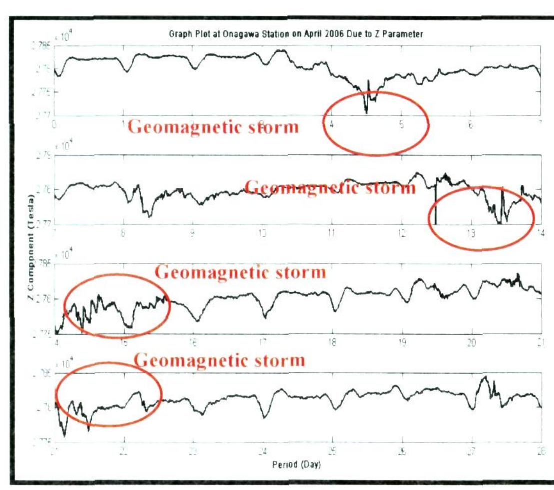

Figure 17: Z plot on April 2006 at Cooktown Station

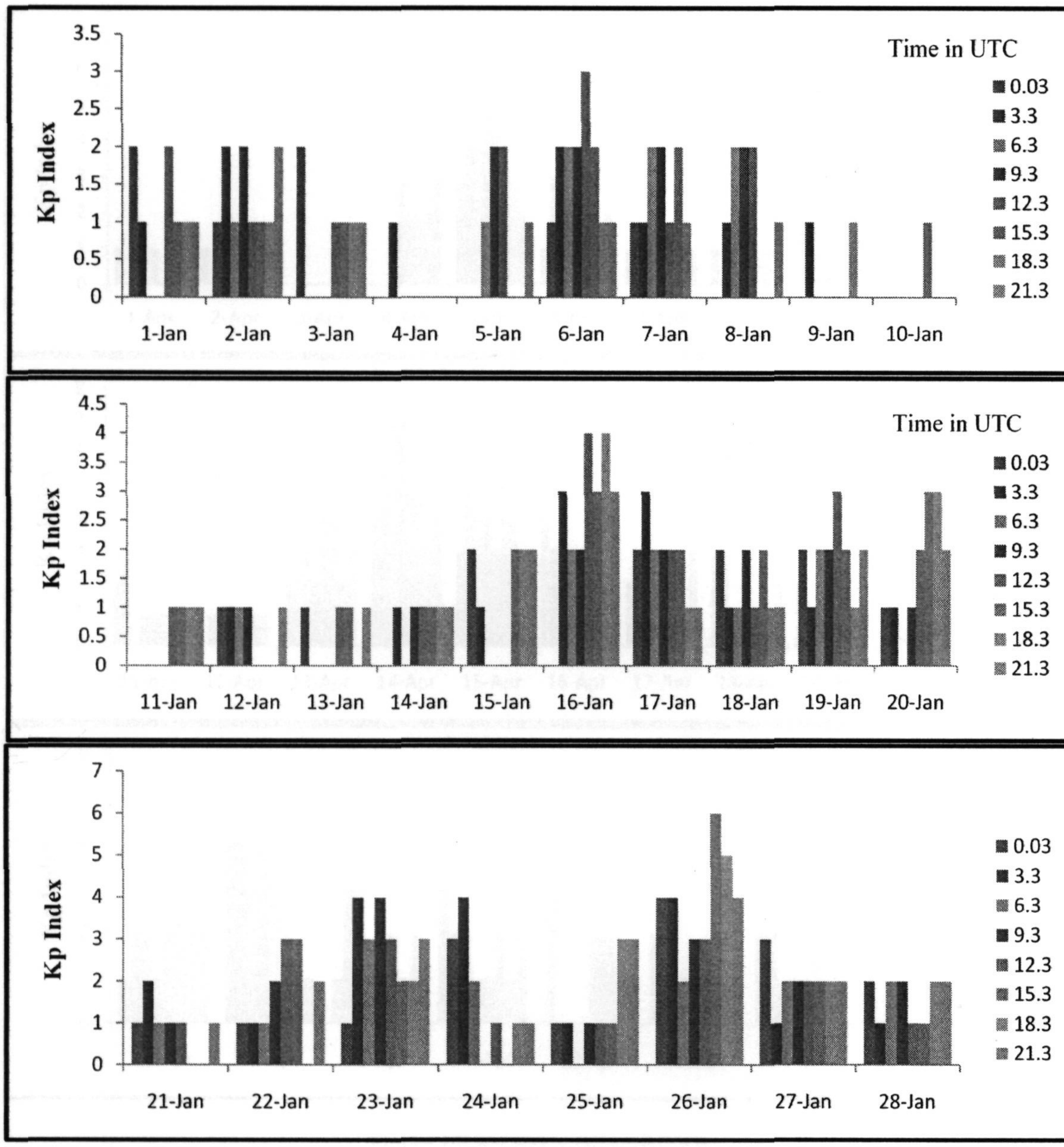

Figure 18: Kp Index on January 2006

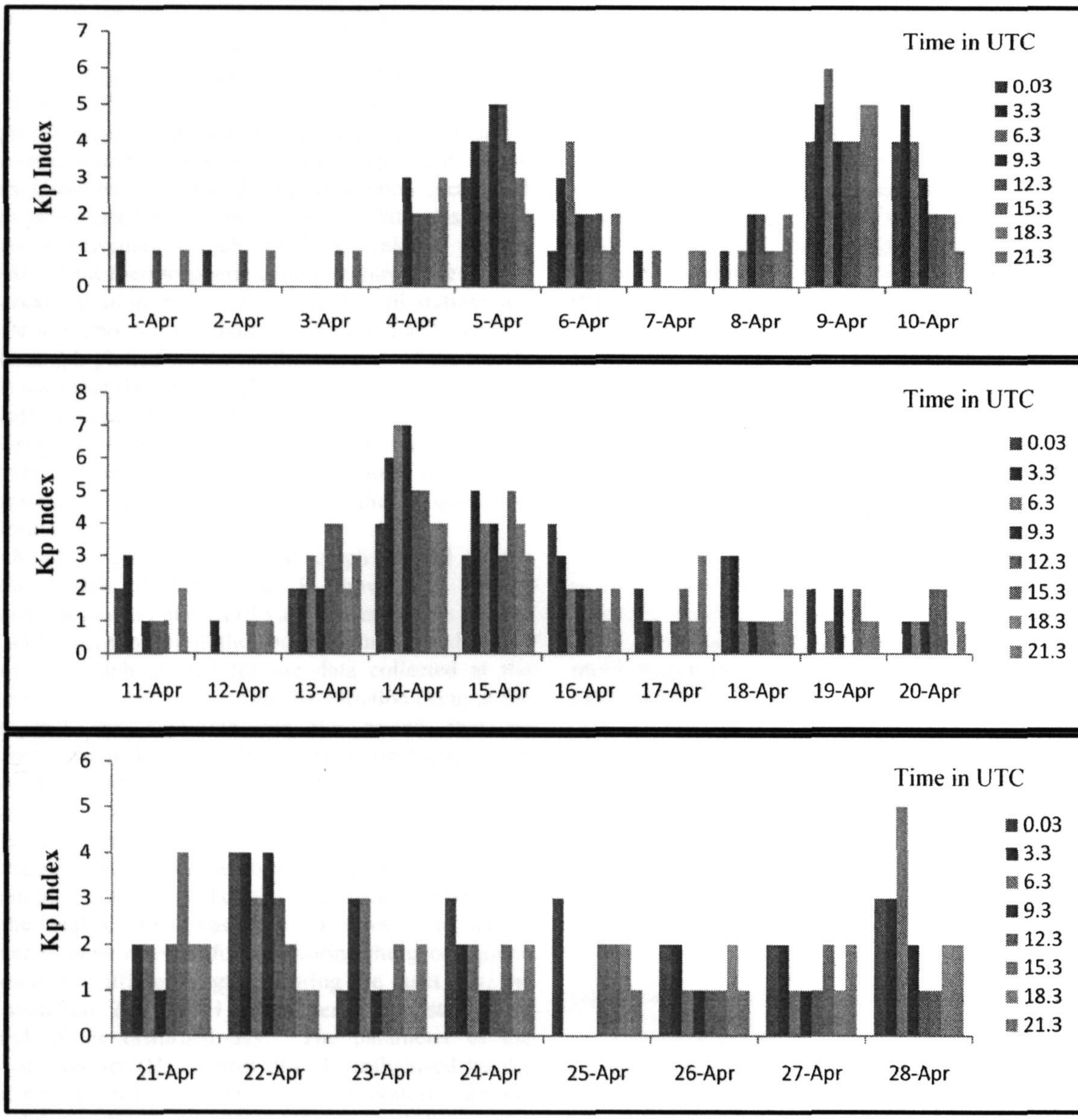

Figure 19: Kp Index on April 2006

The value of the Kp index for January 2006 and April 2006 are shown in figure 18 and figure 19 respectively. Both of the tables are plotted referring to the Kp index supplied by Space Weather Prediction Center, National Oceanic And Atmospheric Administration (NOAA). It is shown that the large positive storm effect was more pronounced in the Southern Hemisphere during the morning-noon sector and negative phase reached to lower magnetic latitudes in the Northern Hemisphere which may be related to the asymmetry of the thermospheric condition during the storm.
The diurnal variation in H components for all stations are illustrates in Figure 6 until Figure 11. Figure 6 and Figure 7 show the graph plotted on the northern region of the world. It can be seen that the value of H parameter on January 2006 are slightly decreased on each of the start and end of the day. These times are early morning and midnight time respectively. When there is geomagnetic storm occurs, the variations due to the H component are higher as compared to the normal day.
Figure 8 and Figure 9 show the graph plotted at the equatorial region of the world. It shows that the H component on January and April variation maintains regular pattern and consistent for all the phase. Figure 10 and Figure 11 show the graph plotted for the data collected at the southern region. It can be seen that the variation occur at the daytime and the nighttime for the month that no geomagnetic event detected. The variation are higher when there is an events detected at that time. The diurnal variations in Z components for all station are illustrated from Figure 12 until Figure 17. It can be seen that the value of Z component also show the higher variation when there is geomagnetic events detected on the date mentioned before.
From the analysis that was done, it shows that the H parameter is most relevant for monitoring the geomagnetic activities at the different region. During the quiet day, the phase variation due to H parameter is constantly as compared to the disturbed day. The parameter of the horizontal intensity (H) is most directly influenced by the external field contributions. Magnetic observatories around the world record the amplitude and direction of disturbance fields that are superposed on the internal main field of the earth. On the records, at the onset of a geomagnetic storm, there often occurs a sudden spike-like change in field strength shown by the northward (H) component.
This spike is thought to represent the shock from the arrival of the solar-wind disturbance at the day side of the magnetosphere boundary. Then there typically follows a slower, H-component increase that has been identified with the compression of the Earth's Sun-facing side of the main field. The magnetosphere stand-off position can be estimated from the size of this positive field increase at the Earth's surface. The geomagnetic field variation has a spatial dependence primarily on latitude and is affected by other factors including time of the year and level of solar activity.

IV. CONCLUSION

As a conclusion, the characterization of the earth magnetic field at the different region has been seen. These studies show that at northern region and southern region, the decrease in H during a magnetic storm can approximately be represented by a uniform magnetic field parallel to the geomagnetic dipole axis and directed toward south. The earth magnetic fields are strongly effect at the northern and the southern region of the earth due to the higher variation that can be seen on the graph plotted. The variation during geomagnetic events can be seen using the H and Z component of the earth magnetic field but the most important parameter is H component since it can be used to the detect magnetic storm. The parameter of the earth magnetic field for example horizontal intensity (H) is most directly influenced by the external field contributions. Variations in vertical intensity (Z) are strongly influenced by the electrical conductivity of the subsurface and contain information on the field contributions induced in the Earth by the external variations. For further research, more station at geographical area need to be consider so that more precise of the earth magnetic field parameters could be mapped. The monitoring period also can be expended maybe for a year of case study.

ACKNOWLEDGEMENTS

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