Correlation Analysis of Geomagnetic Parameters Due to Hemispheric Asymmetry

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***Abstract* – The SERC, Kyushu University was deploying MAGDAS in the CPMN region. MAGDAS can be defined as MAGnetic Data Acquisition System which monitors global electromagnetic and plasma environment change in geospace. The correlation analysis of geomagnetic parameters due to hemispheric asymmetry was discussed in this paper. In this project, the MAGDAS data is used to determine the geomagnetic disturbances at three different stations where at Manado, Indonesia (1.44˚N, 128.84˚E) for equatorial region, Cooktown, Australia (15.48˚S, 145.25˚E) for Southern region, and Amami-Oh-Shima, Japan (28.17˚N, 129.33˚E) for Northern region. To distinguish the amplitude variations at these stations, four geomagnetic parameters were considered which H, D, Z, and F components. Three different months were deliberated for Manado, Cooktown, and Amami-Oh-Shima on March, April, and January, respectively. The MAGDAS data was simulated by using MATLAB GUI and from this project, the H component at all regions is shows the earth's activities most affected by and the largest effects are at the equatorial part, Manado.**

***Keywords* – MAGDAS, Geomagnetic Parameters, Hemispheric Asymmetry, Magnetic Field**

I. INTRODUCTION

The geomagnetic models provide a picture of the earth's magnetic field and how it varies from one point on the earth's surface to another. This model is derived through mathematical analysis of a vast amount of data thus represents the magnetic field generated in the earth's core with a small scale variations at the surface and solar effects filtered out of the basic data.

In addition, the geomagnetic field model is also important to various kinds of magnetic surveys such as those used in mineral exploration and the mapping of hazardous earthquake faults. The earth's magnetic field is actually generated within its molten iron core through a combination of thermal movement, the earth's daily rotation, and the electrical forces within the core.

In fact, a compass placed in this magnetic field does not point due north, declination measures the angle between the compass reading at any point on the earth's surface and true north which measured in degrees. The Figure 1 below shows the World Magnetic Chart for declination on 1995 and the circle in the figure denote the region studied. [1]

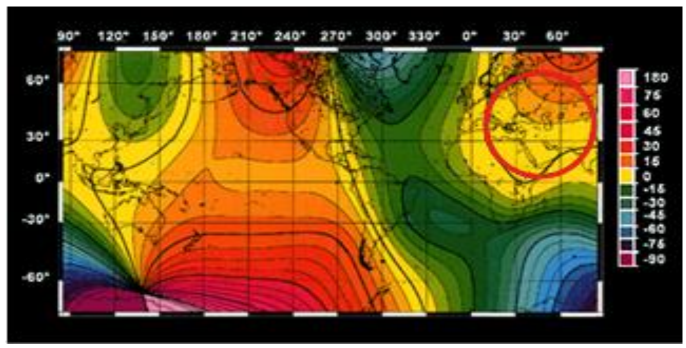

Figure 1: World magnetic Chart for declination on 1995. [1]

So, the direction and strength of the magnetic field can be measured at the surface of the earth and plotted. The total magnetic field can be divided into several components but, in this study, only four components are considered. The components are the H (Horizontal Intensity), the D (Declination), the Z (Vertical Intensity), and the F (Total Intensity). The direction of those components is indicated by Figure 2.

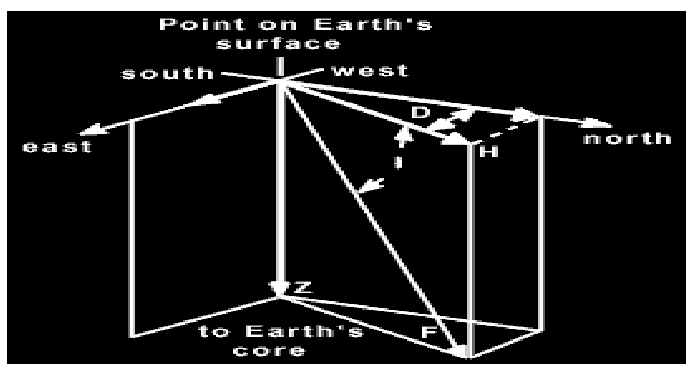

Figure 2: Direction of the H, D, and Z components. [1]

The earth's magnetic field has two magnetic poles. One in the Canadian arctic referred to as the North Magnetic Pole while one off the Coast of Antarctica, south of Australia referred to as the South Magnetic Pole.

The North magnetic pole is slowly drifting across the Canadian Arctic and the Geological Survey of Canada keeps track of this motion by periodically carrying out magnetic surveys to redetermine the pole's location. The most recent survey, completed in May 2001, determined an updated position for the pole and established that it is moving approximately northwest at 40km per year.

The observed position for 2001 and estimated positions for 2002 till 2005 are done. In year 2001, the latitude of North magnetic pole is 81.3˚N while the longitude for this year is 110.8˚W. For the year 2002, the latitude of North magnetic pole is 81.6˚N and the longitude is 111.6˚W. Then, for year 2003, the latitude is about 82.0˚N and the longitude is about 112.4˚W. A year after that, for the latitude it is increased by 0.3˚ while, for the longitude, it is increased by 1.0˚. For year 2005, the latitude north magnetic pole is around 82.7˚N and for the longitude north magnetic pole is 114.4˚W. [2]

The South magnetic pole is constantly shifting due to changes in the earth's magnetic field. Due to polar drift, the pole is moving North West by about 10 to 15 kilometers per year. The observed position for 1998 and 2004 are obtained thus for year 1998, the latitude south magnetic pole is 64.6˚S and for the longitude is 138.5˚E. Then, for year 2004 about 63.5˚S for the latitude while 138.0˚E for longitude. [3]

During the southern winter from March till September, the South Pole receives no sunlight at all. It is means that the South Pole has one of the coldest climates on earth though it is not quite coldest. Then, the temperatures at the South Pole are much lower than at the North Pole, primarily because the South Pole is located at altitude in the middle of a continental land mass, while the North Pole is at sea level in the middle of an ocean. [4]

Actually, the solar flares cause an immediate increase in the plasma density of the earth's ionosphere as a result if the interaction of the enhanced extreme ultraviolet and X-ray emissions with the neutral components in the upper atmosphere. [5]

An electrical particles streaming from the sun cause the solar wind which warps earth's geomagnetic field line, flattening them on the sun ward side and stretching them out on the downstream side. The influence of this distortion of the geomagnetic field is quite small near earth's surface and becomes larger with increasing distance from earth. [1]

To attain the reading of the MAGDAS data, there is a set of equipment of magnetometer system need to be allocated at the MAGDAS stations. The magnetometer system consists of 3-axial ring core (amorphous metallic alloys) sensors, fluxgate-type magnetometer, data logging/transferring unit, and power unit. The 50 fluxgate-type magnetometer is shown in Figure 3.

The magnetic field digital data (H, D, Z, and 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. The ambient magnetic field, expressed by horizontal (H), declination (D), and vertical (Z) components, are digitized by using the field-canceling coils for the dynamic range of ±64,000nT/bit. Three observation ranges of ±2,000nT, ±1,000nT, and ±300nT can be selected for high, middle, and low latitude stations, respectively. [6]

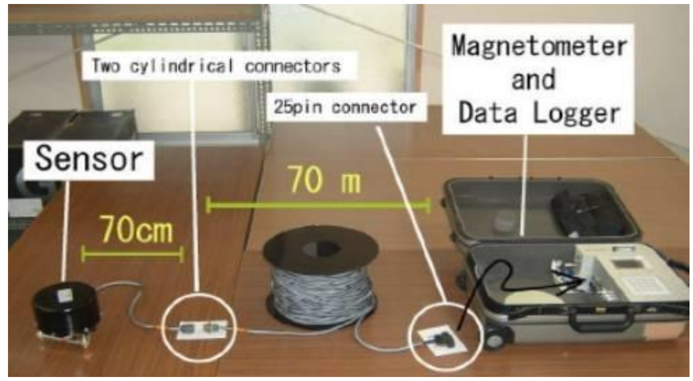

Figure 3: MAGDAS magnetometer set. [7]

The amplitude of the H component was similarly found to be greater in the sunlit ionosphere than in the dark ionosphere. The D component amplitude becomes comparable to the H component amplitude if the conductivity contrast between the dark and sunlit ionospheres is sufficiently large. [9]

II. METHODOLOGY

The MAGnetic Data Acquisition System (MAGDAS) data was received from Space Environment Research Center (SERC), Kyushu University to be analyzed. The data was monitored from Manado, Indonesia Station; Cooktown, Australia; and Amami-Oh-Shima, Japan on (1.44˚N, 128.84˚E), (15.48˚S, 145.25˚E), and (28.17˚N, 129.33˚E) respectively. The locations of these Stations are as shown with the circle in the Figure 4.

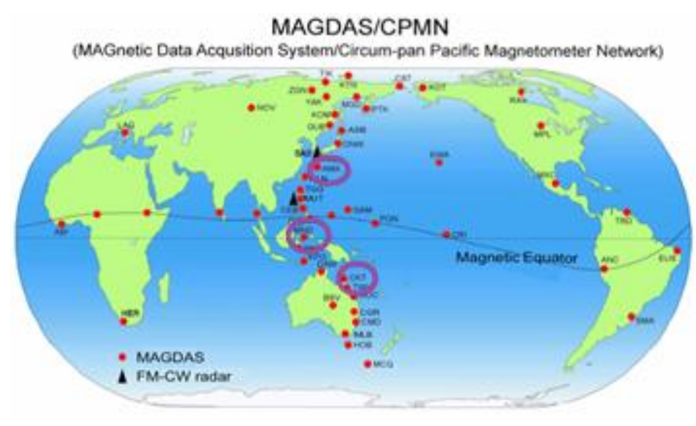

Figure 4: MAGDAS/CPMN systems of the SERC, Kyushu University. [6]

The Space Environment Research Center (SERC), Kyushu University started to construct a new ground based magnetometer network, in cooperation with about 30 organizations in the world from 2004.The SERC will conduct the MAGDAS (MAGnetic Data Acquisition System) observations at 50 stations in the CPMN (Circum-pan Pacific

Magnetometer Network) region, and the FM-CW radar observations along the 210˚ magnetic meridian as shown in Figure 4. The 1-sec magnetic field data from the coordinated ground based network made it possible to clarify global structures and propagation characteristics of magnetospheric variations from higher to equatorial latitudes. [6]

Figure 5: Geomagnetic map of the Earth with latitude and longitude. [8]

This project was concentrated on parameters which are H, D, Z, and F components. From one article, it is shows that a transition of the ionospheric conditions from quiet to disturbed in a magnetic respect is accompanied by a decrease in the effective height of the ionosphere and an increase in level of geomagnetic activity.

The process for extracting MAGDAS data from MND, CKT, and AMA file was using MATLAB GUI version R2007b simulation. The objective of this simulation is to extract the information that needed which is H, D, Z, and F components. Figure 5 below is the flowchart for the process of data simulation from data collection till the analyzing of the data.

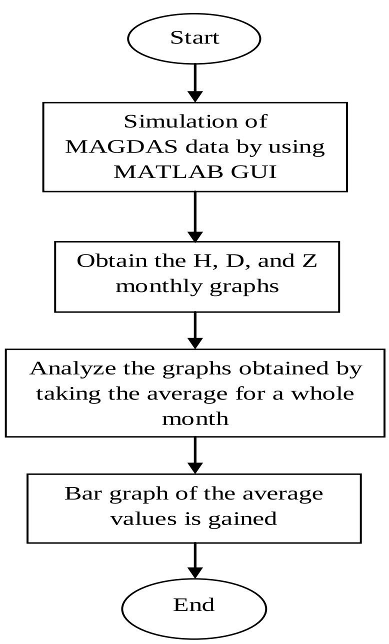

Figure 5: Flowchart process for MATLAB GUI simulation.

First of all, the simulation of MAGDAS data is done to obtain the graphs for three components which are H, D, and Z component. After that the evaluation of the graphs are done for a whole month based on the stations chosen. To see the different between those stations on three components, the average values are gained to draw a bar graph Table 1 below is the value for the average for a month at each station.

TABLE 1: AVERAGE FOR H, D, AND Z COMPONENTS.

	H-component	D-component	Z-component
Manado	39759.08	2070.071	7420.7
Cooktown	32942.12	10.6579	30921.9
Amami-Oh-Shima	34584.51	1545.411	29896.16

III. RESULT AND DISCUSSION

A. Station of Manado, Indonesia (Equatorial Region)

The MAGDAS data taken on March 2006 for Manado Station and the data is analyzed to obtain the graph. The graph is as shown in Figure 6, Figure 7, and Figure 8 below.

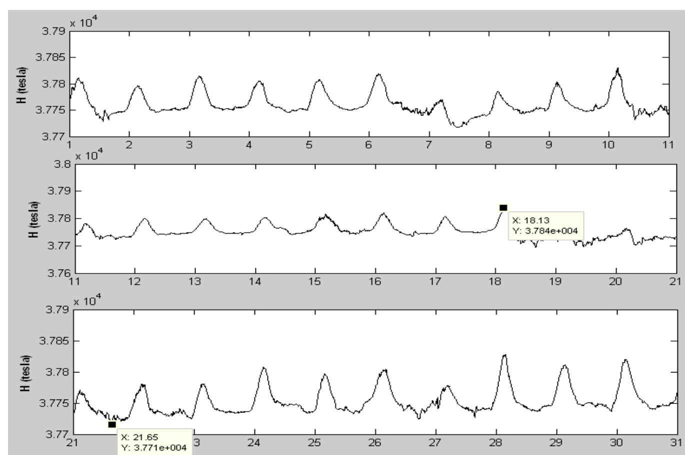

Figure 6: Graph f or H-component at Manado on March 2006.

It is clear that the maximum value for H-component at Manado is 3784 nT while the minimum value is about 3.769 nT. In this case, the maximum value is occurs at the daytime on 18th March whereas the minimum value is occurs at the daytime on 21st March. At equatorial part, it is abnormally large amplitude of solar daily variation in H field within a narrow latitude but, because of the distance of the equatorial region from the sun is smaller, then an electrical particles streaming from the sun cause the solar wind. [10]

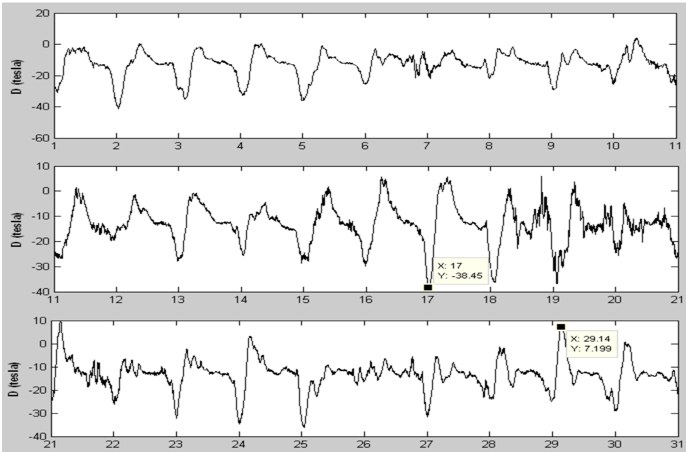

Figure 7: Graph for D-component at Manado on March 2006.

From Figure 7, the maximum value for D-component is 7.199 nT at the daytime on 29th March and for the minimum value is around -38.45 nT at the daytime on 17th March. The negative sign for minimum value is denotes the movement is anticlockwise from true north. That means, even the maximum and the minimum time occur at the daytime, but the directions of the declination is opposite side.

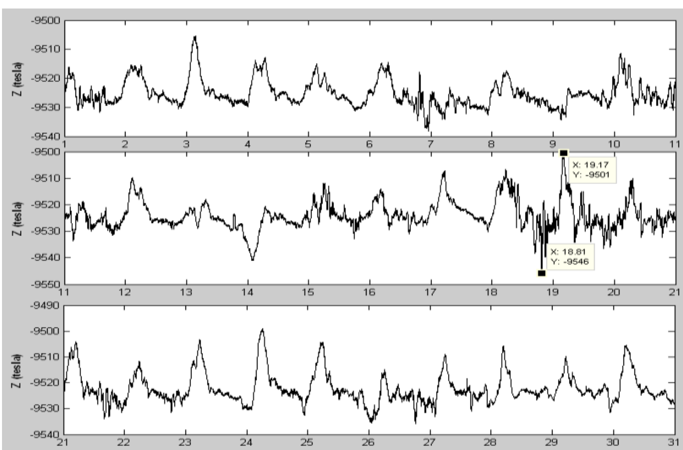

Figure 8: Graph for Z-component at Manado on March 2006.

For the Z-component, the maximum and minimum values are at the daytime. It is happens on 19th March and 18th March and their values are -9501 nT and 9546 nT respectively. For the negative sign for the Z-component, it is designate the direction of the movement is to the upwards of the earth. But, the maximum value happens right after the dawn time.

From the observation on the values for maximum and minimum, it is shows that at Manado, the earth disturbance is occur on the daytime for H, D, and Z components except for the H-component and Z-component for the minimum value, they are occur before the dawn. Since the magnetic storm signals the arrival of high energy plasma from sun following a flare or coronal mass ejection from the sun. [10]

B. Station of Cooktown, Autralia (Southern Region)

The MAGDAS data taken on April 2006 for Cooktown Station and the data is analyzed to obtain the graph. The graph is as shown in Figure 9, Figure 10, and Figure 11 below.

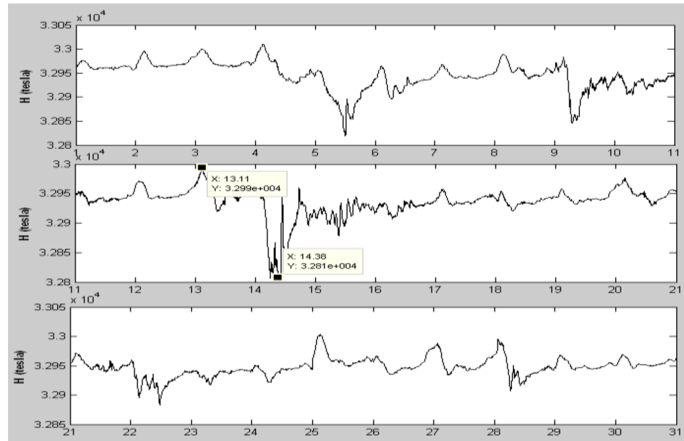

Figure 9: Graph for H-component at Cooktown on April 2006.

Then, for the H-component at Cooktown, the maximum value is 32990 nT while the minimum value is 32810 nT. These values are happen on the 13th April and 14th April at the daytime and nighttime respectively. The lower of H value is due to the penetration of some of the plasma within the influence of the geomagnetic field forming a ring current around the earth. It is the least effect compared to Manado and Amami-Oh-Shima because during the Southern winter from March till September, the South Pole receives no sunlight.

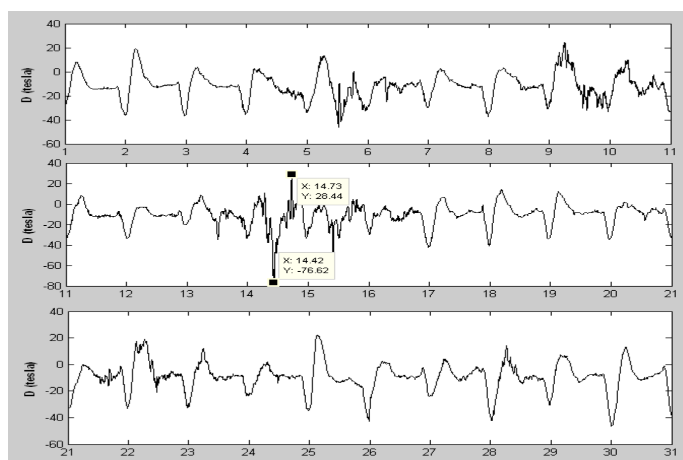

Figure 10: The graph of D-component at Cooktown on April 2006.

From the above figure, it is indicates that the maximum value occur at the daytime on the 14th April with value of 28.44 nT. While, the minimum value occur at the nighttime on the 14th April too with the value of -76.62 nT. Since the solar flare effects in H and D components at low latitude stations, it also can be said due to the penetration, the value also smaller compared to at the equatorial region.

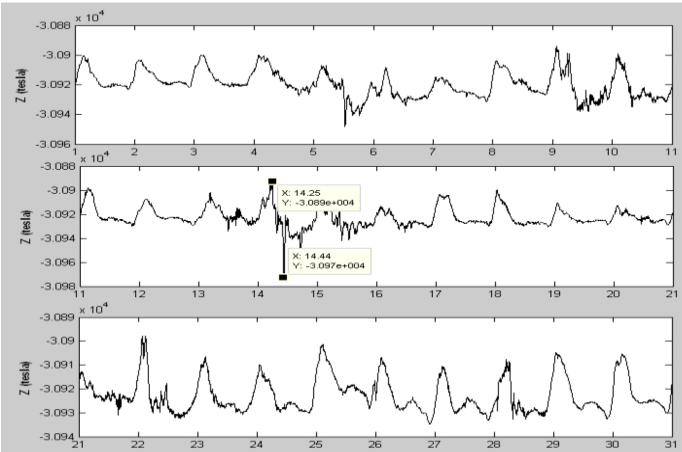

Figure 11: The graph of Z-component at Cooktown on April 2006.

As shown in Figure 11, the maximum value is -30890 nT at the daytime on 14th April and minimum value on 14th April at the nighttime is -30970 nT. As stated before, the direction of the Z component is considered positive when pointing downwards so, the negative sign indicate that the movement is towards the surface of the earth. [11]

So, the maximum value occurs at the daytime and the minimum value occurs at the nighttime for all components. So, it is approved that the influence of an electrical particles streaming from the sun cause the solar wind which warps earth's geomagnetic field lines.

C. *Station of Amami-Oh-Shima, Japan (Northern Region)*

The MAGDAS data taken on January 2006 for Amami-Oh-Shima Station and the data is simulated to get the graph. The graph is as shown in Figure 12, Figure 13, and Figure 14 below.

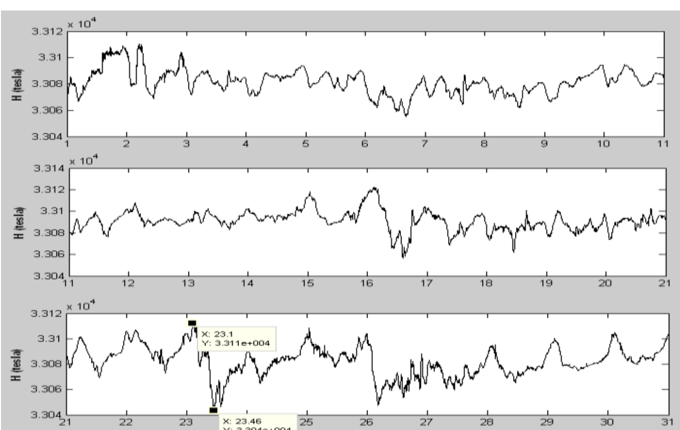

Figure 12: Graph for H-component at Amami-Oh-Shima on January 2006.

It is shows that the maximum and minimum values happen on the same day but at the daytime and nighttime respectively. It is about 33110 nT for the maximum value while 33040 nT for the minimum value. On January at the Southern region, it is summer so, the solar flares cause an immediate increase in plasma density of the earth's ionosphere as a result of the interaction of the enhanced extreme ultraviolet and X-ray emissions with the neutral components in the upper atmosphere.

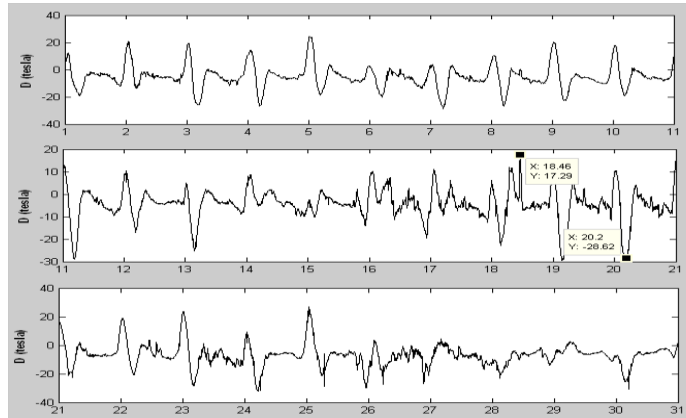

Figure 13: Graph for D-component at Amami-Oh-Shima on January 2006.

From Figure 13, it is confirm that the maximum value is on 18th January while the minimum value is on 20th January. The maximum value is occurs at the nighttime and the minimum value is at the daytime and the values are 17.29 nT and -28.62 nT respectively. The D value is in negative sign because it is representing the movements point eastward of the geographic meridian.

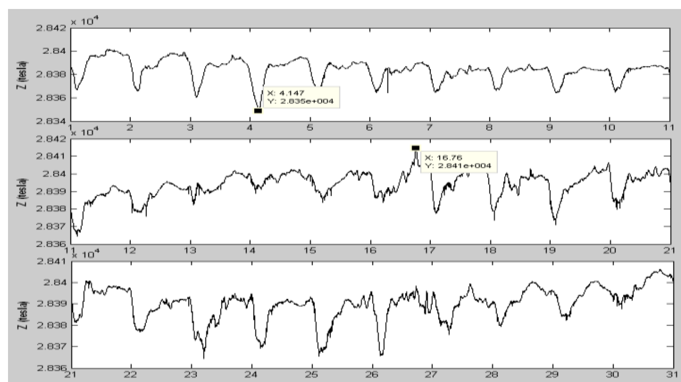

Figure 14: Graph for Z-component at Amami-Oh-Shima on January 2006.

For the last figure, the maximum and minimum values are 28410 nT and 28350 nT respectively. But, the maximum value occurs on 16th January at the daytime and as same as the minimum value happens on 4th January also at the daytime. Since the summer season has a longer daytime, so the maximum and minimum values happen at the daytime but the different time is about 18 hours.

It is important to know that the H-component is the most influence the geomagnetic activities. The H is means Horizontal Intensity which pointing to the positive North and, the total field, F is estimated from the H, D, and Z components.

From the Figure 6, Figure 9, and Figure 12, they are all H-components and since the H-component is parallel to the surface, the movement below the surface can affect the H-component instead of Z-component. The values of Z at all station are actually not as large as the H values and they are show in the Figure 8, Figure 10, and Figure 14. As stated in journal, the results show that the H-component influence measured magnetic properties in the X-component and Y-component.

As shown in the results, an equatorial part gives the highest value for H-component because it is relate to the influence of the electrical particles streaming from the sun cause the solar wind which warps earth's geomagnetic field lines, flattening them on the sun ward side and stretching them out on the downstream side. The influence of this distortion of the geomagnetic field is quite small near earth's surface and becomes larger with increasing instance from earth.

IV. CONCLUSION

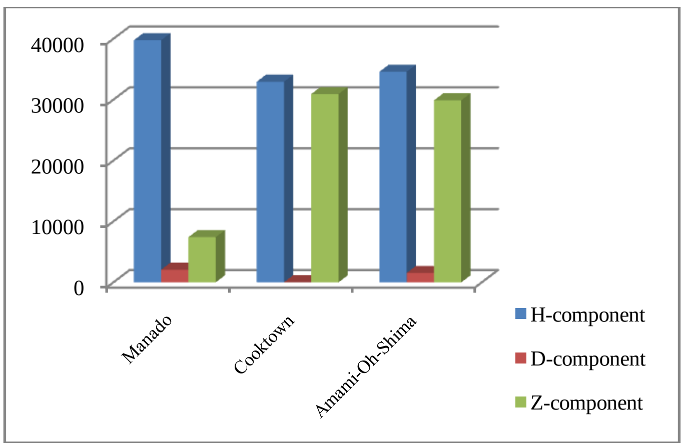

Figure 15: Average of H, D, Z, and F components for each station.

The averages for every station and for every component are calculated and the results for all stations are obtained. At Manado, the H-component is about 39759.08 nT, the D-component is 2070.071 nT, and the Z-component is 7420.7 nT. Next, at Cooktown, the value for H-component is 32942.12 nT, the D-component is around 10.6579 nT, and the Z-component is 30921.9 nT. Lastly, for the Amami-Oh-Shima station, the H-component is 34584.51 nT, the D-component is 1545.411 nT, and the Z-component is 29896.16 nT.

From the bar graph above in Figure 15, it is explained that at all regions are affected most by the H-component. Since the H-component is used to differentiate the seismic event and electromagnetic event so, it is indicate that the geomagnetic activity is correlated with the H parameter.

From research and analysis of the graphs, it is decided that the middle latitude or the equatorial part which at Manado, Indonesia is the maximum magnetic disturbance amplitudes and it is inversely proportional to the local value of the Alfven velocity, while the amplitude minimum is located on the Southern region which Cooktown, Australia and Northern region which Amami- Oh- Shima, Japan due to the maximum gradient of the cold plasma density.

It also can be concluded that the geomagnetic activities are influenced by the movement under the earth's surface. Then, the geomagnetic activities occur just below the surface or deep below the surface whether it occurs in the crust or upper mantle, from the earth's surface to about 500 miles (804.672km) below the surface.

V. REFERENCES

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