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Horizontal Component Variation in Geomagnetic Stations During Annular Solar Eclipse on January 26th, 2009

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***Abstract*—Some studies suggest a relationship between the effects of the solar eclipse on the magnetic field recorded at ground-based geomagnetic stations. This study uses 5 seconds data record of the geomagnetic horizontal (H) component at three ground-based geomagnetic stations in Indonesia (Kototabang, KTB; Pelabuhan Ratu, PEL, and Kupang, KUG). These stations are passed by solar eclipse trajectory. The purpose of this study is to analyze the correlation of annular solar eclipse on January 26th, 2009 toward the diurnal geomagnetic variations in H components. We used data from the preceding date of solar eclipse, the date of solar eclipse, and the succeeding date of solar eclipse. The correlation values of H component signal during solar eclipse showed that it is decrease if we compared with the correlation values of preceding and succeeding date. The H component at Kototabang, Pelabuhan Ratu, and Kupang has increased two hours before the eclipse and decreased four hours after the eclipse. The highest change in H-amplitude was observed at Pelabuhan Ratu because its located close to path of solar eclipse. It shows that the solar eclipse affects on the measurement of geomagnetic field especially in H components at ground-based geomagnetic stations which passed by solar eclipse trajectory.**

Keywords—Horizontal Component Variation, Annular Solar Eclipse, Geomagnetic Stations

I. INTRODUCTION

Annular solar eclipse occurred on January 26th, 2009 between 08:00 to 11:00 UTC. The eclipse trajectory starts from the north of Sulawesi and Borneo turning south and passing through the Sunda Strait, across the Indian Ocean and ended in southern Africa. The trajectory map from NASA showed that the peak of solar eclipse occured at 7:58:39 UTC and occuring over the Indian Ocean for 7 minutes and 53.7 seconds.

Some geomagnetic stations in Indonesia are passed by this eclipse, there are Kototabang (KTB), Pelabuhan Ratu (PEL), and Kupang (KUG). The aims of this study are to determine the effect of solar eclipse on the H component of geomagnetic field at geomagnetic stations in Indonesia.

Reference [1], [2], and [3] stated that the greatest disruption in the Earth's magnetic field observations occured in the H component. This study used normalized cross-correlation to compare the H component from magnetometer signal betweenduring the eclipse with a day before and after the eclipse at the same hours.

The most significant changes occured in the ionosphere due to the closest layer to sun. As a result, the reduced sunlight during eclipse allegedly disturbing the ionosphere layer.

Presented in this paper is the study investigating changes in the geomagnetic diurnal variation in H component during the annular solar eclipse on January 26th, 2009 as it affects some geomagnetic stations in Indonesia.

II. DATA

This study used data from the H component of geomagnetic field from the ground-based geomagnetic observation stations: Kototabang (KTB), Pelabuhan Ratu (PEL), and Kupang (KUG) with coordinate information, the eclipse obscuration, and timing of the eclipse showed at Table I.

TABLE I. GEOMAGNETIC STATIONS, GEOGRAPHIC COORDINATE, OBSCURATION, AND TIMING OF JANUARY 26TH, 2009 ECLIPSE AT KOTOTABANG (KTB), PELABUHAN RATU (PEL), AND KUPANG (KUG)

Station	Lat (S)	Lon (E)	Obscuration	Start (UTC)	End (UTC)
KTB	0°13'48"	103°19'12"	75.5%	08:27:57	10:57:54
PEL	7°06'00"	106°36'00"	83.0%	08:19:42	10:50:12
KUG	10°12'0"	123°42'00"	53.4%	08:32:21	-

We used diurnal variation data of the H (horizontal) component from 3 stations the day before, during, and after the eclipse, from 25th to January 27th, 2013. Diurnal data were compared between the events before, during, and after the eclipse.

The coupling between ionosphere, magnetosphere, and Sun-Earth space environment is taken into consideration, and solar activity and magnetic activity during eclipse are checked firstly. According to the data from National Oceanic and Atmospheric Administration (NOAA)/Space Weather Prediction Center (SWPC), from January 25th to 27th, 2009 only on January 25 th, 2009 a sudden impulse occurred at 22:25 UTC.

III. METHOD

Amplitude Change

To determine amplitude change of H component during solar eclipse, we used comparison between a day before, during, and after the solar eclipse. The comparison used time and frequency domain to determine the change that caused by solar eclipse. We changed the signal from the time domain to be frequency domain using discrete Fourier transform.

Cross Correlation

In the analysis of the signal, the comparation signal is done by the cross-correlation method. Cross-correlation methods used in identifying similarity of signal. The calculations with this method is similar to the convolution of two functions which include the reversal signal convolution, shifting, multiplication, and summation, while in the cross-correlation only cover a shift, multiplication, and summation (without reversal).

From the results of cross-correlation is then performed calculations normalized cross-correlation to get the correlation values between the two signals to be compared. In determining the similarity of signals, as in [4], used normalized cross-correlation function:

$$\rho(l) = \frac{r_{xy}(l)}{\sqrt{r_{xx}(0) r_{yy}(0)}} \qquad (1)$$

Where $\rho(l)$ is the normalized cross-correlation value with a range of 0 to 1, $r_{xy}(l)$ is cross-correlation between two signals in function of x and y, $r_{xx}(0)$ and $r_{yy}(0)$ is an auto-correlation in l=0 which has a value equal to the accumulated root mean squareof 2 signals.

IV. RESULTS AND DISCUSSIONS

From the analysis that has been done, comparative results obtained from diurnal variation the day before, during, and after the eclipse. In Kototabang, Pelabuhan Ratu, and Kupang an increase in the H component respectively 15 nT, 50 nT, and 30 nT two hours before the eclipse and decreased respectively by 20 nT, 50 nT, and 40 nT four hours after the eclipse.

Fig. 1 showed the increase in the H component at all stations before the eclipse and decrease after the eclipse. It suggests that the solar eclipse caused an increase in geomagnetic activity in the H component

The highest change of the H component occured in Pelabuhan Ratu because this location is near the eclipse path. The blue box in Fig. 1 showed the timing of the eclipse, it is about 8:00 to 11:00 UTC. Three hours of the H component data for each station were analyzed using Fourier transform spectrum (Fig. 2). The results in the timing of the eclipse showed an increase of amplitude at

frequency below the 0.01 Hz. The increase in amplitude occurred in Pelabuhan Ratu. The maximum obscuration is positively correlated with changes in the value of the H component and the amplitude spectrum.

From the results of the correlation signal (Table II) with normalized cross-correlation formula showed that the correlation between current data with the data before the eclipse decrease (yellow blocks) than the correlation ofthe data before and after the eclipse. It suggests that the eclipse affects the magnetic field observation at H components.

According to [5], [6], and [1] during a solar eclipse the changes in the magnetic field of ionospheric effects are occured. Diurnal variations in the geomagnetic field in a quiet day caused by the flowof dynamo currents in the ionospheric E layer.Solar eclipse caused changes in the ionosphere and magnetosphere component specially in the changes of electron density continuously as in [7].

During the eclipse, partly of the ionosphere deterred from heating and solar radiation. It resulted a change in the flow pattern and observed in the surface as a change in the geomagnetic field. Solar eclipse improve the processes in ionospheric E layer and affect the diurnal variation of the geomagnetic (Solar quiet / Sq).

TABLE II. RESULT OF NORMALIZED CROSS-CORRELATION BETWEEN THE SIGNAL FROM KTB. KUP, AND PEL ON JANUARY 25TH TO 27TH, 2009.

KTBH	25	26	27
25	1	0.5092	0.9245
26	0.5092	1	0.6349
27	0.9245	0.6349	1
KUPH	25	26	27
25	1	0.8679	0.9386
26	0.8679	1	0.8629
27	0.9386	0.8629	1
PELH	25	26	27
25	1	0.994	0.9982
26	0.994	1	0.996
27	0.9982	0.996	1

V. CONCLUSION

Ionization of electromagnetic radiation in the annular solar eclipse January 26th, 2009 influencedthe geomagnetic field on the traversed area and recorded at geomagnetic station as follows: (1) there is an increase in the H component in Kototabang, Pelabuhan Ratu, and Kupang before the eclipse and decrease after the eclipse. (2) There is an increase in the H component spectrum during the eclipse. (3) The highest changes in the H component occurred at Pelabuhan Ratu because this location is near the eclipse path. (4) The normalized cross-correlation value indicated a decrease in the correlation value of the digital signal recording at H component due to the influence of the eclipse.

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