Relationship of solar activity with magnetosphere and ionosphere disturbance during Coronal Mass Ejection (CME) Event on September 6, 2017

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Abstract. This study aims to determine the magnitude of the disturbance due to CME on September 6, 2017, in the magnetosphere and ionosphere, then compare its effect at high, middle, and low latitudes. The data used are the daily variation of the H component geomagnetic and the ionogram, representing low latitude. Geomagnetic storms are indicated by the intensity of the H component of the earth’s magnetic field experiencing a very significant decrease reaching \(-250\) nT, while ionosphere storms are indicated by an increase in the critical frequency the F\textsubscript{2} layer by 14.1 MHz. As a comparison at each latitude, the magnitude of geomagnetic disturbance is represented by the K index. High latitudes have a K index greater than those at middle and low latitudes. Low latitude produces a smaller K index among other latitudes whose magnitude has strengthened the Dst index. The K index at high latitudes is 9, the K index at middle latitudes and low latitudes is 7. Based on the K index values at all latitudes, the northern hemisphere's high latitudes are categorized as extreme storms, and the northern hemisphere mid-latitudes and low latitudes are categorized as strong storms.

1. Introduction
Coronal Mass Ejection (CME) is one of the solar activities [1] that causes the ejection of charged particles [2], which are then flown by the solar wind to the Earth's magnetosphere [3]. The CME can cause geomagnetic storms [4] and ionospheric storms [5]. This interference adversely affects all human activities in outer space [6] and also for long-distance telecommunications [7]. The solar activity, which always occurs periodically every eleven years or known as the solar cycle [8], makes this impact felt throughout the year [9]. The relationship of solar activity with geomagnetic and ionosphere storms can be determined by studying several special events [10], which in this study use the CME event on September 6, 2017.

The CME events of September 6, 2017, have previously been investigated by many researchers who have taken into account disturbances in the magnetosphere and ionosphere at high latitudes and middle latitudes [11, 12]. However, beyond those two latitudes, low latitudes also have a very significant effect due to these disturbances, as reported globally by the WDC for Geomagnetism Kyoto, which is described by the index Dst. Based on this reason, we re-investigated the CME event on September 6, 2017, by taking into account the low latitude, precisely at the Kototabang geomagnetic observation station.
2. Method
The determination of geomagnetic disturbances used the H component data of the earth's magnetic field recorded by the fluxgate magnetometer at Kototabang station (0.23 LS, 100.32 East Longitude). The magnitude of the geomagnetic storm is obtained by the difference between the daily variation in the H component of the earth's magnetic field and its calm day. Quiet days are obtained using the identification of a multiple Fourier series by first determining the average of the five quietest days in a month. Meanwhile, ionosphere disturbances' determination used critical frequency data for the F2 layer (f0F2) recorded by ionosonde CADI Sumedang (6.5 LS, 107.6 BT). The f0F2 data were obtained first by scaling ionogram. The ionosphere storm magnitude is determined by the difference between the daily variation value of the critical frequency of the F2 layer (f0F2) and the median f0F2. The magnitude of the disturbance in the magnetosphere is shown by a graph of the H component's intensity with time, and the disturbance in the ionosphere is shown by a graph of the daily variation value of f0F2 with time.

3. Result and Discussion
CME 6 September 2017 resulted in a sudden increase in the H component of the earth's magnetic field. The intensity decays rapidly and increases for several hours, then ends with a slow recovery for two days. During geomagnetic storms, ionospheric storms also occur several hours after disturbances in the earth's magnetic field.

3.1. The level of disturbance in the magnetosphere
The geomagnetic storm begins with a decrease in the earth's magnetic field's intensity on September 8, 2017, at 00.00 UT of -201 nT, then increases to -25 nT at 06.00 UT. The increase in intensity was followed by a very fast and significant decrease in a very short time, reaching -250 nT at 12.00 UT. The recovery of the earth's magnetic field intensity occurred for approximately 24 hours, which began on September 9, 2017, and then ended on September 10, 2017. The level of geomagnetic strength shown in Figure 1 is categorized as a very strong storm, with a range of intensity values between 200 nT to 300 nT, which has strengthened the Dst index (Figure 2).

![Figure 1. Earth's magnetic field disturbance for September 2017](image-url)
In this study, the K index at high latitudes and middle latitudes was used to compare geomagnetic disturbances for all latitudes. The K index of high latitude is represented by College stations, while Frederickburg stations represent the K index of middle latitude. As shown in Figure 3, Figure 4, and Figure 5, the K index at high latitudes is worth 9, while the K index for middle and low latitudes is worth 7. These figures show that geomagnetic disturbances at high latitudes are more significant than geomagnetic disturbances at middle and low latitudes.

**Figure 2.** Dst index for September 2017

**Figure 3.** Index K at Kototabang (low latitude)

**Figure 4.** Index K at Fredericksburg (middle latitude)
3.2. The level of disturbance in the ionosphere

During geomagnetic storms, ionospheric storms also occur. Based on Figure 6 and Figure 7, ionospheric storms starting with $f_0F2$ increased on September 8, 2017, at 07.30 UT at 9.09 MHz, which was then accompanied by a decrease of 8.95 MHz. At 10.00 UT, $f_0F2$ experienced an increase to 11.4 MHz then experienced a very significant decrease to 6.77 MHz precisely at 11.30 UT. The decrease in frequency was also followed by a sudden increase in frequency reaching 14.1 MHz at 15.30 UT. Then there was recovery a few hours after that.

**Figure 6. Ionosphere disturbance September 8, 2017**

**Figure 7. Ionosphere disturbance for September 2017**
4. Conclusion
A relationship between solar activity and the magnetosphere and ionosphere is clearly observed during the CME event of September 6, 2017, specifically in low latitudes where solar activity causes extreme storms, positive storms, and negative storms. Geomagnetic storms have strengthened the Dst index reaching a maximum intensity of -250 nT, which is categorized as a very strong storm. Meanwhile, 3 hours later, an ionosphere storm appeared, which could reach the critical frequency of the F2 layer of 14.1 MHz. The K index of 9 is obtained at high latitudes, while those at middle and low latitudes are 7. Based on these values, disturbances at high latitudes are categorized as extreme storms, while disturbances in middle latitudes and low latitudes are categorized as strong storms. Thus, the geomagnetic disturbances at high latitudes are more robust than those at middle and low latitudes.

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