Characteristics of Strong Geomagnetic Storms (Dst < -100 nT) Along 23rd Solar Cyles

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ABSTRACT

Geomagnetic storm event is causing geomagnetic field changes usually expressed with magnetograms of H, D and Z components. By using Dst index data, there was identified 91 of Strong geomagnetic storm (Dst < -100 nT) during 1996-2007 consist 71 or 78.02% are sudden commencement type and rest 20 or 21.98% are gradual storm type. There are also found that best initial phase duration lies between 0-2 hours after onset time are 46 cases or 64.78% from 71 cases total. While the main phase duration lies between 6-12 hours after onset time are 30 cases or 42.25% from 71 cases total. This value is important as a recommendation in the developing automatic detection of SC type geomagnetic storm at space weather program in Space Science Center, LAPAN.

Keywords: SC and SG types of geomagnetic storm, solar cycle, Dst index, geomagnetic field H component

6 GENERAL REMARK

In 2003, on reference is written as Shinohara et al[12] by using H component data from Onagawa, Guam, and Santa Maria observatories during 1996-2001, He was made automatic detection of Sudden Commencement geomagnetic storm system. In 2009, Santoso[9] and Santoso et al.[10] have been done the same activity by using H component data from Biak observatory and also supported by geomagnetic field data from other stations in Circum pan-Pacific Magneometer Network (CPMN). But Santoso's system had has weakness when they met Gradually Storm (SG) type geomagnetic storm.

The accuracy of identification and prediction results based on SC type geomagnetic storm was greatly influenced by the characteristics of its SC. Besides, it influenced by the amount of SG type geomagnetic storm presence. Case study on May 4, 1998 geomagnetic storm event, Tripathi and Mishra[17] and Padey et al.[8] were found different result to determine type of geomagnetic storm.

Based on these reason, we conducted study the characteristic of Strong geomagnetic storms (Dst <-100 nT) during 23rd solar cycles (6/1996 until to 9/2007)[11] by using Dst index, the incidence of SC-Sudden Impulse (SI), the incidence of flares – Coronal Mass Ejection (CME) and interplanetary shock events data and supported geomagnetic field data from Biak station.

The aim of this activity is to understand the characteristics of Strong geomagnetic storm (Dst <-100 nT) that occurred during 23rd solar cycles and to improve accuracy automatic detection of SC geomagnetic storm system.

7 GEOMAGNETIC STORM TYPES

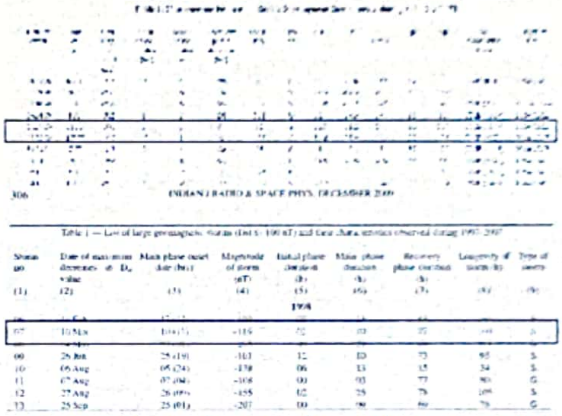
Geomagnetic storm is one of the most important phenomena in space weather system. Space weather program became an important program at Space Science Center, LAPAN associated with the effects it causes. Geomagnetic storms occur at all of the earth's surface and is strongly influenced by the activity that occurs on the surface of the sun such as flares, CME and Coronal Holes.

Geomagnetic storm generated when high-speed plasma from Coronal Mass Ejection (CME) or Coronal Holes (CH) carried by the solar wind injected into the earth's magnetosphere. Reconnection process occurs if the arrival of solar wind plasma has a magnetic field energy tends to the southward efficiently absorbed into the magnetosphere and upper atmosphere. The terrestrial ring current changes responsible for the global decline of geomagnetic field. These disturbances occur simultaneously with changes in the Earth's magnetosphere is known to have no measurable contribution to the structure and dynamics of the ionosphere.

During the increased of geomagnetic activity periods, then the low-latitude ionospheric plasma density, electric fields and currents have strong and lasting disruption globally. The magnetic disturbances on the dayside coordinates of the magnetic equator are often caused by the penetration of dayside convection electric field and are associated with disturbances at high latitude[3,4,5,6]. The direct penetration of high latitude electric fields to the lower and dynamo disturbance, they play an important role in restructuring the equatorial ionosphere and thermosphere at geomagnetic storm time. Equatorial geomagnetic field variations and electrojets events have been analyzed over the period of geomagnetic disturbance along with changes in inter-planetary magnetic field. Geomagnetic field disturbance phenomena that occurred at the Earth's surface known as a geomagnetic storm (magnetic storm).

Geomagnetic field disturbance level at low latitudes and the equator represented by the Dst index was first introduced by Sugiura[2] which is characterized by three phases, namely the initial phase, the main phase and the recovery phase. Dst values derived from the average variation of H component geomagnetic from geomagnetic observatories located around the middle and low latitudes. Dst index is the best indicator to determine the current intensity ring (ring current) and is very sensitive to indicate the level of solar disturbance. Geomagnetic storms often the last for several days. Sometimes a geomagnetic storm which occurs accompanied by SC is characterized by a sudden increase in the intensity of the magnetic field just before the main phase and named as SC type of geomagnetic storms. While a geomagnetic storm which occur without the SC called GS type of geomagnetic storm[13]. SC and SG types geomagnetic storms are one of the characteristics of geomagnetic storm that important to know. Several studies on the characteristics of geomagnetic storm have done such as by Brijesh et a[7], and Pandey and Dubey[8]. Case study on May 4, 1998 geomagnetic storm event, Tripathi and Mishra[17] and Padey and Dubey[8] were found different result to determined type of geomagnetic storm, as showed in Table 1.

Table 1. List of large geomagnetic storms (Dst < -100 nT) and their characteristic observed during 1996-2007

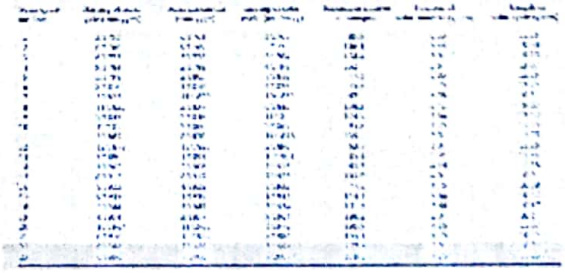


(Note : S and G stand for sudden and gradual commencement of storm, respectively).

8 SELECTION CRITERIA AND DATA SOURCE

Data which is used in this research involving Dst index to identification geomagnetic storm, H component geomagnetic field from Biak observatory during 1996-2007 (23rd solar cycles as showed in Table 1) to analysis. Beside that, also used flare, CME interplanetary shock[14], SC/SI[16] events and solar wind data.

Table 3-1. Some properties of solar cycle 1-23[11]



Identification of geomagnetic storm was done based on the Sugiura's[11] criteria marked with

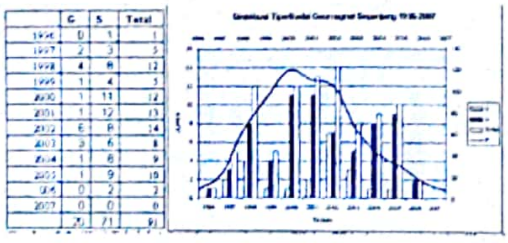
initial phase, main phase and recovery phase of Dst index at strong geomagnetic intensity (Dst < -100 nT). Further analysis is clarifying the identification results by using flare-CME, interplanetary shock, and SC/SI events and H component geomagnetic field Biak observatory. The results are tabulated and processed for analysis.

Tabel 2. Detailed of the characteristic of geomagnetic storm pattern during 23rd solar cycles

No	Tanggal Storm	Tanggal dan Onset Storm		Intensitas		Durasi		Tipe Storm		Sumber Storm
		HHMM	Dst	HHMM	Dst (nT)	Main Phase HHMM	Dst			
					2001					
					2002					

4. Results and Discussion

The identification and analysis results of the characteristics of Strong geomagnetic storms (Dst < -100 nT) using the Dst index during 1996-2007 obtained 91 Strong geomagnetic storm events (Dst <-100 nT). Where 71 (78.02%) geomagnetic storm events occur with SC types and it remains that are 20 (21.98%) geomagnetic storm events occur with SG types, as shown detailed in Figure 1.



	G	S	Total
1996	0	1	1
1997	2	3	5
1998	4	8	12
1999	1	4	5
2000	1	11	12
2001	1	12	13
2002	6	8	14
2003	3	6	9
2004	1	8	9
2005	1	9	10
2006	0	2	2
2007	0	0	0
	71	71	91

Figure 1. (Left) The distribution of geomagnetic storm occurrence with SC and SG types during 1996-2007, and (Right) it results in Histogram shape

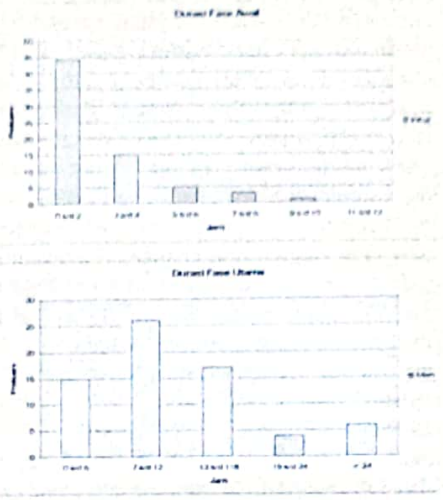


Figure 2. (top) Histogram of the initial phase duration, and (bottom) Histogram of the main phase duration of geomagnetic storm during 1996-2007

To assist the development of the automatic detection system of geomagnetic storm based on the SC type of geomagnetic storm then only 71 geomagnetic storm events are analyzed involving the initial phase and main phase duration of the SC geomagnetic storms. The results as showed in Figure 2

We have been identified 91 geomagnetic storm events along 23rd solar cycles consist of 71 cases are the SC geomagnetic storm types and 20 cases remains are the SG geomagnetic storm types.

From 71 cases of SC geomagnetic storm, we found 46 cases of geomagnetic storms with initial phase duration are about of 0-2 h after onset time and we also found that 30 cases of geomagnetic storms with main phase duration are about 6-12 h after onset time.

5. Conclusion

Along 23rd solar cycles have been identified 91 Strong geomagnetic storm events (Dst < -100 nT), consist :

- 71 storm geomagnetic events or 78.02% are sudden commencement (SC) type, and its remain
- 23 storm geomagnetic events or 21.98% are Storm Gradual (SG) type.

From 71 geomagnetic storm events total, 46 of geomagnetic storms occurs with duration of the initial phase between 0-2 hours after onset time (64.78%), and 30 of geomagnetic storms occurs with duration of the main phase between 6-12 hours after onset time (42.25%).

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