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Mathematical modeling of the moderate storm on 28 February 2008

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ABSTRACT

The sun is an active star with plasma-filled prominences. The sudden ejection of the solar plasma creates storms in the form of bursting or spraying. A magnetospheric storm is a typical phenomenon that lasts 1–3 days and involves all magnetosphere from the earth's ionosphere to the magnetotail. The storms are known by different categorical names such as weak, moderate, strong, intense. One of these is the moderate geomagnetic storm on February 28, 2008, which occurred in the 24th solar cycle. The reason for discussing this storm is that it is the first moderate storm in the 24th solar cycle. In this study, we investigate the storm and entered the 24th solar cycle. The correlation among the parametres has been investigated via statistics. The solar wind parameters and the zonal geomagnetic indices have been analyzed separately and then the interaction with each other has been exhibited. The author has concluded the work with two new nonlinear mathematical models. These explain the storm with 79.1% and 87.5% accuracy.

1. Introduction

Structures formed by plasmas take their dynamics from this medium. Dynamic structures are generally evolving over time. The relationship between each variable in the structure must be carefully analyzed in order to understand the structure. Due to their dynamism, these structures have been seriously studied for decades (Gonzales et al., 1994; Stern, 1996; Saba et al., 1997; Gonzales et al., 1999). The correlation of the variables and the models that can be established on the basis of this relation may also allow for the prediction of future events. The magnetosphere is such a plasma environment. This study focuses on the magnetosphere effects of 28 February 2008 geomagnetic storm. The extraordinary the interplanetary magnetic field (IMF) conditions and solar wind plasma emissions create a geomagnetic storm.

The solar events enclose coronal clouds related with coronal mass ejection (CME) produced by solar flares spread out from active sunspot regions or less often from coronal holes. A (CME) is a large solar plasma cloud that is thrown at a speed of about 800 km/s from the sun into the interplanetary space. These high-speed solar wind flows from the sun's coronal holes affect the earth's magnetic field (Fu et al., 2010a, b). This disturbance in the earth's magnetic field is called as a geomagnetic storm (or storm) and lasts for about 1–3 days. During this time, storm covers all the magnetosphere from the earth's ionosphere to the magnetotail (Fu et al., 2012, 2014). A storm is basically determined by solar wind plasma parameters (solar wind dynamic pressure (P), electric field (E), magnetic field (B_z), flow speed (v), proton density (N)) and zonal geomagnetic indices (AE, ap, Kp, Dst). Let's roughly glance at magnetic activity indices. AE is the hourly auroral electrojet index, ap is the three-hour range planetary index derived from Kp, Kp is the three-hour quasi-logarithmic planetary index and Dst is the hourly index related to the ring current. Dst is a geomagnetic index used to determine the level of a geomagnetic storm (Mayaud, 1980; Hanslemeier, 2007). Geomagnetic storms are classified according to the Dst index (Loewe and Prölss, 1997). Let's roughly look at solar wind now. The characterizing properties of the solar wind can be determined by satellites (Moschou, 2016). The solar wind affects the earth's magnetic field. The magnetic field is dominated by the magnetosphere. The solar wind is a supersonic flow of ionized plasma and magnetic field. The solar wind mainly consists of electrons and protons, and very small amounts of helium and heavy ions. Solar flow from the sun is due to the difference in magnetic pressure between the corona and the interplanetary space. As the solar winds are conducting, a magnetic field travels through the solar wind plasma. It's velocity from the corona (plasma-dense) is supersonic. Since space plasmas are as hot and rare as they cannot be produced in the laboratory, studies on the physical processes of solar wind interpret the nonlinear properties of space plasma also (Brueckner and Bartoe, 1983; Zou and Huang, 2013; Hollweg, 1975; Soon et al., 2000). It will make sense to talk about solar wind parameters. The reaction of the magnetopause to the changes in the solar dynamic pressure is remarkable. The solar wind and the dynamic and thermal pressures of the IMF are matchless parameters that control the earth's magnetopause (Sibeck et al., 1991). In addition, the power and orientation of the IMF have an impact on the shape of the magnetosphere. When the IMF returns to the south ($Bz < 0$), the magnetopause moves

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Table 1
Geomagnetic storm Dst index.

Class	Number	%	Dst range (nT)
Weak	482	44	−30 to −50
Moderate	346	32	−50 to −100
Strong (i.e., intense)	206	19	−100 to −200
Severe (very-intense)	45	4	−200 to −350
Great	6	1	< −350

inward and the nightside magnetopause moves outward (Sibeck et al., 1991; Fu et al., 2011, 2013). When the solar winds reach the magnetosphere energy transfer is made (Adebesin et al., 2012). Energy is transferred from the solar wind through magnetosphere reconnection

Table 2
Descriptive analysis.

	N	Minimum	Maximum	Mean	Std. deviation
B_z (nT)	120	−6.5	6.5	−0.159	2.2648
T (K)	120	27,315	492,028	195,787.64	144,645.407
N (1/cm^3)	120	0.8	20.3	5.242	3.8191
V (km/s)	120	338	785	517.82	176.565
P (nPa)	120	0.02	6.20	2.1279	1.27566
E (mV/m)	120	−2.98	3.28	0.4532	1.08759
β	120	0.64	10.36	2.1887	1.51883
Kp	120	3.0	53.0	28.650	13.5465
Dst (nT)	120	−52	3	−21.08	13.472
ap (nT)	120	2	56	17.98	13.917
AE (nT)	120	16	1188	268.51	228.503

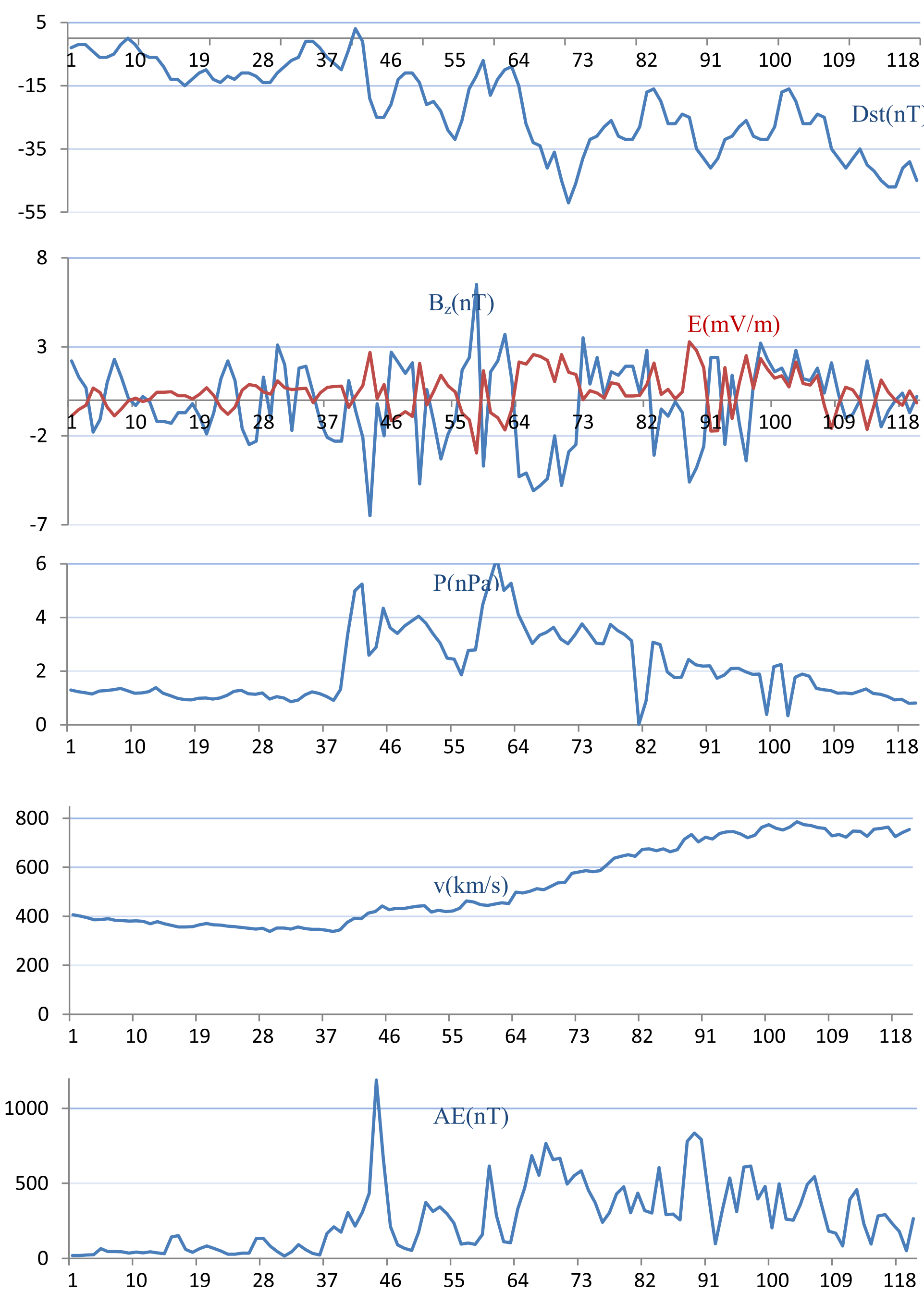

Fig. 1. From top to bottom parameters shown are Dst index, B_z magnetic fields (nT), E electric fields (mV/m), solar wind dynamic pressure P (nPa), flow speed v (km/s) and AE (nT) index for 26–30 February 2008 (from NASA NSSDC OMNI data set). Abscissa consists of 5 day hours.

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