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A comprehensive analysis of the geomagnetic storms occurred during 18 February and 2 March 2014

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Abstract The Geomagnetic storms are considered as one of the major natural hazards. Egyptian geomagnetic observatories observed multiple geomagnetic storms during 18 February to 2 March 2014. During this period, four interplanetary shocks successively hit the Earth's magnetosphere, leading to four geomagnetic storms. The storm onsets occurred on 18, 20, 23 and 27 February. A non-substorm Pi2 pulsation was observed on 26 February. This Pi2 pulsation was detected in Egyptian observatories (Misallat and Abu Simbel), Kakioka station in Japan and Carson City station in US with nearly identical waveforms. Van Allen Probe missions observed non-compressional Pc4 pulsations on the recovery phase of the third storm. This Pc4 event is may be likely attributed to the decay of the ring current in the recovery phase.

1. Introduction

The solar activity such as solar wind, coronal mass ejection, and solar flares propagating through the interplanetary space carries a large amount of energetic particles and electrical energy. Some of these solar activities while interacting with the Earth's magnetosphere produce several geomagnetic activities with different characteristics. One of these prominent phenomena is the geomagnetic storm. Moos (1910a) identified a pattern in the horizontal component at Colaba, India. He found occasional sudden rise of the horizontal component followed by a rapid decrease lasting a few hours and a slow recovery lasting 1–3 days. These disturbances are defined as "magnetic storms" having the various phases of the storm as (i) storm sudden commencement (SSC), (ii) initial phase, (iii) main phase and (iv) recovery phase (Araki, 1994; Hafez and Ghamry, 2011, 2013; Hafez et al., 2012, 2013a,b; Ghamry et al., 2013).

The research on the geomagnetic effects of solar wind structures has typically distinguished between coronal mass ejections (CMEs) and corotating interaction regions (CIRs). The former are associated with strong disturbances whereas the latter usually give rise to moderate storms (Gosling et al., 1991; Richardson et al., 2001; Zhang et al., 2007; Youssef et al.,

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2012; Fathy et al., 2014). Both interplanetary (IP) shocks and CIRs result in a large solar wind dynamic pressure increase, which compresses the magnetopause and may significantly affect the magnetospheric current systems. Magnetic ejecta inside CMEs, on the other hand, primarily affect the Earth's magnetosphere through magnetic reconnection during a period of intense and prolonged southward Bz. Fast CMEs drive shocks and the shock plus ejecta may result in a two-step geomagnetic storms (Kamide et al., 1998).

Geomagnetic pulsations, Ultra Low Frequency (ULF) waves, are naturally occurring magnetohydrodynamic (MHD) waves in the Earth's magnetosphere. These ULF waves are classified as continuous (Pc) or irregular (Pi) pulsations. Each category is subdivided into period bands that roughly separate a specific type of pulsation. Pi 2 pulsation is an irregular magnetic fluctuations with period [40–150 s]. It is considered as the most common pulsations used in substorm research (Saito et al., 1976). Pi2 pulsations at low latitude are good indicators to substorm onset because they are not only observed in the nightside but also in the dayside (Yanagihara and Shimizu, 1966). Pi2 pulsation is considered as a result of hydromagnetic disturbances driven by sudden change in magnetospheric convection or reconfiguration in the magnetotail during the substorm expansive phase, so it is considered a better proxy of substorm onset than its counterpart at middle and high latitude (Yumoto 1986; Ghamry et al., 2011, 2012; Hamada et al., 2015; Ghamry and Fathy 2016). Plasmaspheric cavity resonance (PCR), plasmaspheric virtual resonance (PVR), and plasmapause surface mode are considered major source mechanisms of Pi2 pulsations (Allan et al., 1986; Zhu and Kivelson, 1989; Lee, 1996; Lee and Kim, 1999; Lee and Lysak, 1999; Takahashi et al., 2003; Lee and Takahashi, 2006; Kwon et al., 2013; Ghamry et al., 2015; Ghamry, 2015). Pc4 (7–25 mHz) ULF waves are abundant on the dayside (e.g., Chi et al., 1994, 1996; Kim and Takahashi, 1999; Takla et al., 2011) and are occasionally observed on the nightside (Takahashi et al., 2005). Takahashi and Anderson (1992) found that Pc4 poloidal waves at dayside can mainly be categorized into plasmapause poloidal waves and second harmonic poloidal waves outside the plasmapause. Liu et al. (2009) confirmed that Pc4 poloidal waves are mostly observed near noon around $L = 5$–6 in the inner magnetosphere.

In this paper, we analyze the multiple geomagnetic storms that occurred during 18 February to 2 March 2014. The organization of this paper is as follows. In Section 2 we describe the observations. In Section 3, we show the signature of the storms on the Egyptian observatories. In Section 4 we investigate Pi2 pulsations occurred on 26 February on the ground. In Section 5 we show Pc4 pulsations occurred on 27 February in space. In Section 6 we give the summary and conclusions.

2. Observations

During 18 February to 2 March 2014, four strong interplanetary shocks successively hit the Earth's magnetosphere, leading to four geomagnetic storms. Fig. 1 shows the solar wind speed, density, dynamic pressure, the interplanetary magnetic field B and Bz, and the disturbance storm time Dst index, respectively. The first storm started at 14:00 UT on 18 February. The Dst index dropped rapidly down to −112 nT at 09:00 UT on 19 February, corresponding to a positive pulse $P = \sim 15$ nPa and a negative (or southern) Bz = ~ -15 nT. The second storm began at 04:00 UT on 20 February when there were a sharp pulse $P = \sim 10$ nPa and a negative Bz = ~ -10 nT. The storm main phase had two-step development. On 20 February, the Dst index at first dropped from −40 nT down to −86 nT at 13:00 UT and recovered rapidly up to −40 nT at 19:00 UT, dropped rapidly again down to −66 nT at 02:00 UT on 22 February, and then gradually increases to 4 nT until the onset of the third storm at 08:00 UT on 23 February when $P = \sim 14$ nPa and Bz = ~ -5 nT. In the meanwhile, the Dst index dropped from −4 nT down to −56 nT at 00:00 UT on 24 February. The fourth storm began at 16:00 UT on 27 February when $P = \sim 16$ nPa and $Bz = \sim -18$ nT, with a minimum $Dst = \sim -99$ nT at 00:00 UT on 28 February.

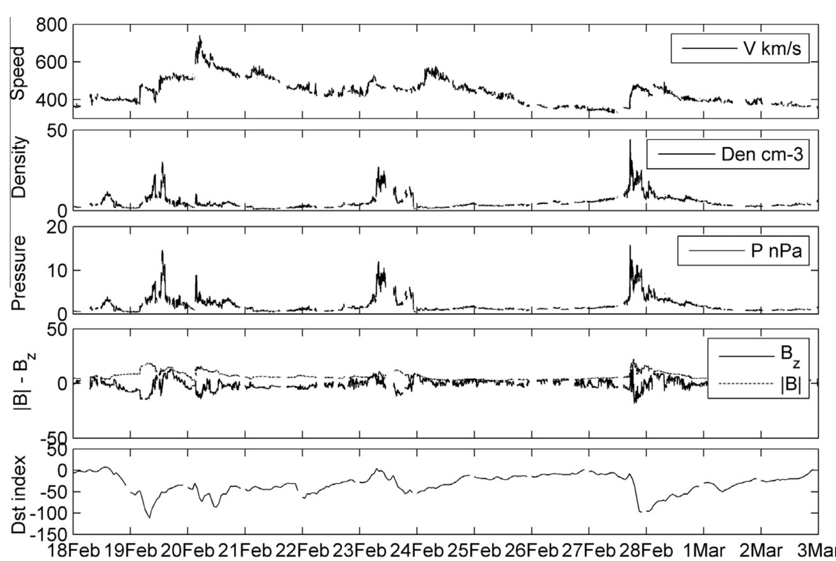

Figure 1 Shows the solar wind speed, density, dynamic pressure, the interplanetary magnetic field B and Bz, and the disturbance storm time Dst index through 18 February to 2 March 2014.