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Energetics of Magnetosphere-Ionosphere system during Main Phase of Intense Geomagnetic Storms over three Solar Cycles

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Abstract. Solar wind kinetic energy gets transferred into the Earth's magnetosphere as a result of dynamo action between magnetosphere and solar wind. Energy is then dissipated among various dissipation channels in the MI system. In the present study, energetics of 59 intense geomagnetic storms are analyzed for the period between 1986 and 2015, which covers the three consecutive solar cycles SC 22, 23 and 24. The average solar wind energy impinging the MI system is estimated using Epsilon parameter, the coupling function. Moreover, the relative importance of different energy sinks in the MI system are quantified and is found that more than 60% of solar wind energy is dissipated in the form of ionospheric Joule heating.

Keywords. ring currrent injection, ionospheric Joule heating, auroral particle precipitation

1. Introduction

Geomagnetic storms are major disturbances in Earth's magnetosphere due to the interaction with the solar wind, which results in transfer of tremendous solar wind energy into the Earth's inner magnetosphere-ionosphere (MI) system. This energy gets dissipated through different dissipation channels in the system. Magnetospheric energy budget is continuously varying with geomagnetic disturbances such as storms and substorms. It is also being changed in accordance with different phases of geomagnetic disturbances.

In the present study, solar wind energy input as well as different energy sinks in the MI system during main phases of intense geomagnetic storms for the period from 1986 till 2015 have been analyzed in detail.

2. Data and methodology

Solar wind and plasma parameters are taken from OMNI database (http://omniweb.gsfc.nasa.gov/form/dxl.html). Dst index, AE index and AL index are taken from WDC, Kyoto, Japan (http://wdc.kugi.kyoto.u.ac.jp/). Solar wind kinetic energy (E_{SW}), energy coupling function and major energy sinks in the MI system are estimated from empirical formulations that were proposed by Weiss *et al.* (1992), Perreault & Akasofu (1978), Gonzalez *et al.* (1994) and Ostgaard *et al.* (2002).

3. Overview

Figure 1(a) shows the temporal variation of solar wind input energy rates and magnetospheric energy rates for November 26-27, 2000, a typical geomagnetic storm, while figure 1(b) shows the corresponding time integrated energy dissipations in the MI system. Figure 2(a) shows the distribution of the three major energy sinks during main phases

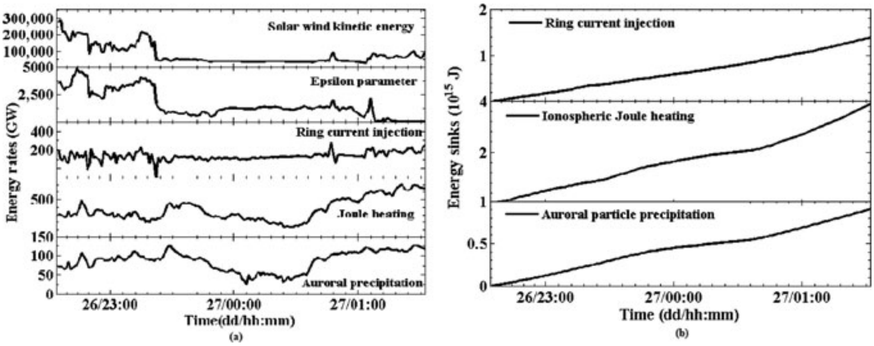

Figure 1. (a) Temporal variation of solar wind energy input and magnetospheric energetics and (b) Time integrated energy dissipations in the MI system for a typical intense geomagnetic storm, November 26-27, 2000.

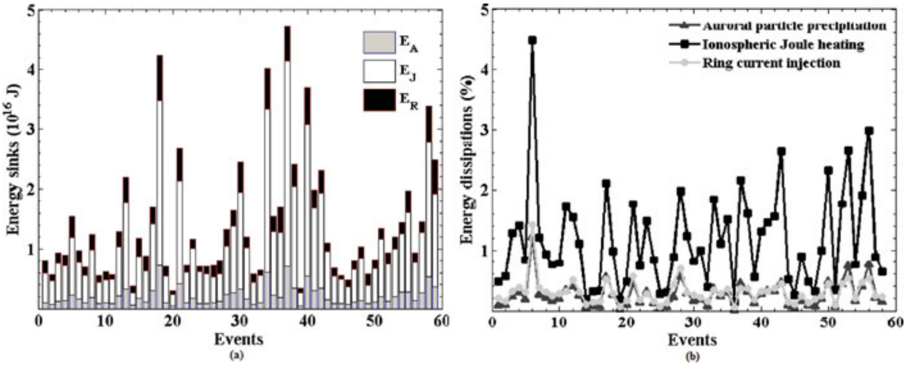

Figure 2. (a) Temporal variation of the three major energy sinks in the MI system and (b) Contribution of solar wind kinetic energy dissipated into them over three solar cycles SC 22, 23 and 24.

of intense geomagnetic storms and Figure 2(b) depicts the contribution of solar wind kinetic energy transferred to the Earth's MI system.

Solar wind kinetic energy available in magnetosphere ranges from 4.8×10^{17}J to 1.6×10^{19}J. The average solar wind energy input using the Epsilon parameter is estimated to be 7.3×10^{16}J. The average rate of ring current injection, ionospheric Joule heating and auroral precipitation while considering three solar cycles are 123 GW, 426 GW and 90 GW respectively. On an average, 19% (0.5% of E_{SW}), 66% (2.0% of E_{SW}) and 14 %(0.4% of E_{SW}) of the total energy dissipation in the MI system are distributed among ring current injection, ionospheric Joule heating and auroral particle precipitation respectively.

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