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Editorial

Introduction to Special Issue on high speed solar wind streams and geospace interactions (HSS–GI)

1. Introduction

This special issue of the Journal of Atmospheric and Solar-Terrestrial Physics is devoted to research into high speed solar wind streams (HSSs) and their effects on the region of near-Earth space commonly known as 'geospace'. Interest in the effects of HSSs has increased during the last solar cycle and, following the successful meeting focusing on corotating solar wind streams in Manaus, Brazil (Tsurutani et al., 2006), we recognised the need for further work on the topic, with particular focus on HSSs and their effects in the inner magnetosphere, ionosphere, and neutral atmosphere. As a result the High Speed Solar Wind Streams and Geospace Interactions (HSS–GI) Workshop was held at Hilltop, St. Martin's College in Ambleside, UK, from 2 to 7 September, 2007 (Kavanagh and Denton, 2007; Denton et al., 2009), sponsored by the Department of Communication Systems at Lancaster University. The majority of the work presented in this special issue was prompted by discussion and interaction at the workshop. It is indeed an indication of the importance of HSSs that the papers in this issue cover the entire region from the Sun and solar wind, through the magnetosphere, and into the ionosphere, thermosphere, and down to the stratosphere. It is hoped that this research will stimulate more understanding, appreciation, and research, into these important drivers of physical phenomena within geospace.

2. High speed solar wind streams—recent progress

Periodic HSSs have been known to exist since research by Snyder et al. (1963), with the source of such streams being traced to solar coronal holes by Krieger et al. (1973). Since this early work, further links between HSSs and recurrent activity within geospace have been reported by numerous authors, and the relationship between such events and phenomena within the magnetosphere has become increasingly apparent.

As is widely known, HSSs typically produce less significant deflections in geomagnetic indices such as Dst than transient phenomena such as coronal mass ejections (CMEs). As a result HSSs are sometimes regarded as less important drivers of geomagnetic activity. This has led to many studies, where event-selection is based solely on the Dst signature, overlooking HSS-events and hence neglecting their significance. At the workshop, this was referred to as 'the Dst mistake'. Comparisons between HSS- and CME-driven events do reveal important differences in their effects within all regions of geospace (e.g. Lindsay et al., 1995; Borovsky and Denton, 2006) and whilst CME-events certainly produce the largest geomagnetic storms, HSS-events are particularly important for phenomena such as relativistic electron acceleration, radiation belt enhancements, and satellite anomalies (e.g. Wrenn et al., 2009). In terms of the energy input to the magnetosphere, HSSs are found to input a total-energy-per-event which is similar in magnitude to that during CMEs; indeed the ratio of the energy-deposited-in-the-magnetosphere to the energy-input-to-the-magnetosphere appears to be greater for HSSs than for CMEs (e.g. Turner et al., 2006, 2009; Kozyra et al., 2006; Guarnieri, 2006).

It is known that HSSs are particularly important for acceleration and loss processes in the Earth's radiation belts and in recent years much interest in the community has focused on determining the principal acceleration and loss mechanisms (e.g. Tsurutani et al., 2006; Horne, 2007; Liemohn and Chan, 2007; Reeves, 2008). An important source population for the ring current/radiation belts is the Earth's plasma sheet and in this issue the timescales for delivery of plasma sheet material to the inner magnetosphere during HSSs are evaluated by Denton and Borovsky (2008). Results indicate a super-hot and super-dense plasma sheet forms at the onset of a HSS-driven storm and is convected Earthwards in a period of a few hours. Energisation of this plasma sheet population during HSSs leads to formation of a enhanced ring current (Jordanova et al., 2009; Sørbø et al., 2009), which is subsequently energised leading to enhanced fluxes in the radiation belts. Fluxes within the belts may fluctuate rapidly during HSSs revealing the balance between sources and sinks, and also our ability to reproduce such fluctuations using theoretical models (Lam et al., 2009).

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The derivation of radiation belt radial diffusion coefficients during periods of high speed solar wind is discussed by Pahud et al. (2009), who also examine the solar wind speed dependence of ULF wave power using ground-based magnetometer data.

Recently, a number of authors have revealed the importance of a 9-day periodicity in the solar wind speed and consequences for the lower atmosphere (e.g. Temmer et al., 2007; Lei et al., 2008; Mlynczak et al., 2008; Thayer et al., 2008). In this issue Emery et al. (2009) show that the global electron hemispheric power (a proxy for the strength of auroral activity) also exhibits a 9-day periodicity. Loss of energetic particles from the magnetosphere into the atmosphere induces detectable changes in the Earth's ionosphere where an decrease/increase in spectral hardness is evident during HSSs (Birch et al., 2009). Such energetic particle precipitation (particularly relativistic electron precipitation during HSSs) may induce the generation of NO_x (odd nitrogen) at lower altitudes, with possible subsequent links to ozone depletion in the stratosphere (Turunen et al., 2009).

The large amplitude Alfvénic fluctuations, which occur during HSSs have implications for the generation of recurrent substorms (Lyons et al., 2009; Morley et al., 2009), HILDCAAs (Tsurutani and Gonzalez, 1987), source and loss processes within the radiation belts (Sandanger et al., 2009), and for resultant auroral activity (D'Amicis et al., 2009). In addition, superposed-epoch analysis indicates the Russell-McPherron effect also plays a role in the coupling between the solar wind and the magnetosphere [McPherron et al., 2009]. Whilst it is clear that the southward-IMF coupling between the solar wind and the magnetosphere during Alfvénic fluctuations is important, it is still not clear whether there is a significant difference between the driving of the magnetosphere in an on–off fashion versus a steady average fashion (Denton et al., 2009). In the future we plan to determine whether or not such on–off driving is important.

Although the papers contained in this special issue highlight the importance of HSSs, and also reveal how physical processes within geospace respond to HSS-events, it is clear that much remains to be discovered about these fascinating phenomena.

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