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Classification and quantification of solar wind driver gases leading to intense geomagnetic storms

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Abstract

Classification and quantification of the interplanetary structures causing intense geomagnetic storms (Dst ≤ −100 nT) that occurred during 1997–2016 are studied. The subject of this consists of solar wind parameters of seventy-three intense storms that are associated with the southward interplanetary magnetic field. About 30.14% of the storms were driven by a combination of the sheath and ejecta (S + E), magnetic clouds (MC) and sheath field (S) are 26% each, 10.96% by combined sheath and MCs (S + C), while 5.48% of the storms were driven by ejecta (E) alone. Therefore, we want to aver that for storms driven by: (1) S + E. The *Bz* is high (≥10 nT), high density (ρ) (>10 N/cm^3), high plasma beta (β) (>0.8), and unspecified (i.e. high or low) structure of the plasma temperature (T) and the flow speed (V); (2) MC. The Bz is ≥10 nT, low temperature (T ≤ 400,000 K), low ρ (≤10 N/cm^3), high V (≥450 km), and low β (≤0.8); (3) The structures of S + C are similar to that of MC except that the V is low ($V \leq 450$ km); (4) S. The *Bz* is high, low T, high ρ, unspecified V, and low β; and (5) E. Is when the structures are directly opposite of the one driven by MCs except for high V. Although, westward ring current indicates intense storms, but the large intensity of geomagnetic storms is determined by the intense nature of the electric field strength and the Bz. Therefore, great storms (i.e. Dst ≤ −200 nT) are manifestation of high electric field strength (≥13 mV/m).

Keywords: Geomagnetic storms; Solar wind; Driver gases; Ring current; Southward IMF; Electric field strength

1. Introduction

Geomagnetic storms are caused by streams of charged particles ejected from the Sun, to reach the Earth about a day later. There, unable to penetrate the terrestrial geomagnetic field, the charged particle would be deflected around in the magnetosheath. Due to the frozen-in characteristic of the highly conducting plasma (Baumjohann and Treumann, 1997) the energy is stored in the magnetosheath as pressure gradient force (magnetic and plasma pressure respectively), and magnetic tension force. The trapped energy re-aligns the magnetic field, as a result, the convective energy along the field lines causes the westward ring current of the plasma under the influence of gradient and curvature drift. It is noteworthy that the induced field of the ring current is opposite to the geomagnetic field. Furthermore, the changes in the westward drift of the ring current control the development of a storm; which would be detectable by appropriate ground based instruments. The dominant interplanetary structures associated with geomagnetic disturbance causing intense storm are the interplanetary manifestation of coronal mass ejections (CMEs) or high-speed solar wind stream (CIRs mechanism) (Gonzalez et al., 2001). CMEs are large scale magnetized plasma structure originated from the Sun and ejected into the interplanetary medium through solar corona. They are important sources for various activities, like geomagnetic

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storms and solar energetic particles. The fast streams emanating from the coronal holes interact with the slow solar wind, a solar wind structure called corotating interacting region (CIR) is developed. The CIRs compressing the magnetic field and the plasma ahead and sometimes, though not always, creating a shock front, which are the probable cause of recurring geomagnetic storms (Hargreaves, 1992; Zhang et al., 2006). Available literature indicates that there are several drivers responsible for a geomagnetic storm occurring in the terrestrial space, especially the intense storm. Gonzalez and Tsurutani (1987) showed that the criteria of the interplanetary structures

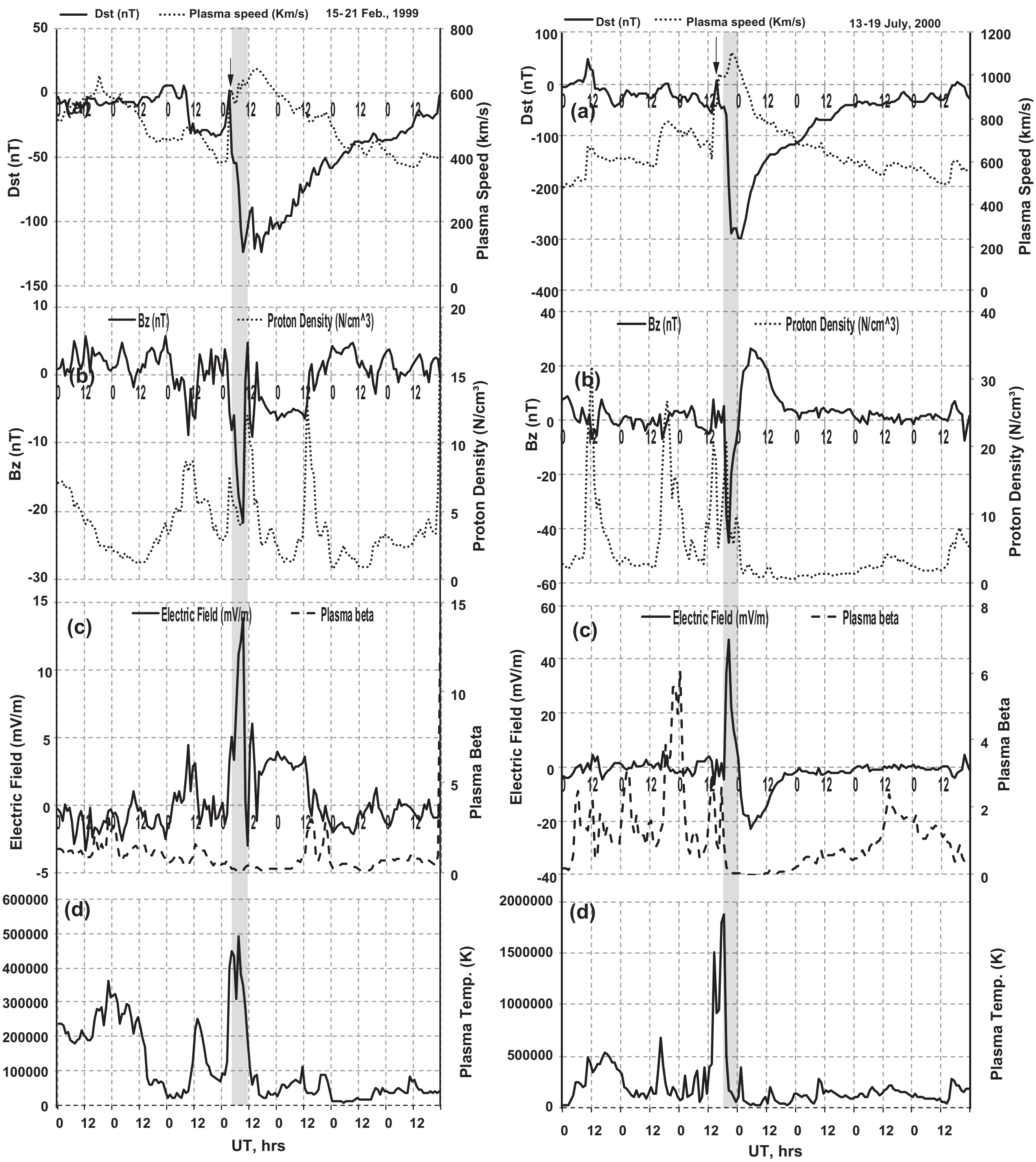

Fig. 1. Interplanetary and geomagnetic profile for storms driven by magnetic clouds. The shaded regions are corresponding to the long-duration (>3 h) of southward interplanetary magnetic field and the arrows indicates the sudden storm commencement period.

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