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Azimuthal expansion of the substorm current wedge at the geosynchronous orbit

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Abstract

In this work we present observations from two geosynchronous satellites (GOES–5 and GOES–6) and from six ground-based stations, during the two magnetospheric substorm events of April 1, 1986 and May 7, 1986. Our data analysis shows evidence that the substorm initiation and development mechanism includes the cross-tail current disruption, the substorm current wedge generation and the azimuthal expansion of the plasma sheet. This mechanism seems to be triggered somewhere close to the earth, in a longitudinaly narrow sector near the local midnight and it expands both eastward and westward with velocities of the same order.

1 Introduction

During magnetospheric substorms, the behaviour of the magnetic field in the near-geosynchronous magneto-tail follows a very definite pattern. The magnetic field becomes more tail-like on the night-side prior to the onset of the substorm expansion phase. This onset is marked by a reconfiguration of the magnetic field towards a more dipolar configuration (Sauvand and Winckler, 1980). This process is called dipolarization and it is due to the reduction of a portion of the cross-tail current (Lui, 1978; Kaufmann, 1987). It has been attributed to the formation of a substorm current wedge (McPherron *et al.*, 1973). In this wedge model, earthward field-aligned currents flow from the magnetotail to the ionosphere on the eastern side of the wedge, continue in the ionosphere, formatting a westward electro-jet, and return back to the magneto-tail by tailward field-aligned currents on the western side of the wedge. The current wedge itself is nonstationary in time; it expands both eastward and westward with time, from a longitudinally narrow onset sector (Nagai, 1982; Lopez *et al.*, 1988). The purpose of this contribution is to determine the coherence of the events that compose a magnetospheric substorm phenomenon according to the above described model.

2 Data presentation

In this work, magnetic field data from two geostationary satellites GOES-5 and GOES-6, located at 282°E (geographic longitude) and 265°E, respectively, have been used. The magnetic field data are presented in dipole VDH coordinate system. We have also used magnetic field data from six ground Observatories which are located within 202°E and 294°E. They are mostly middle and low latitude stations.

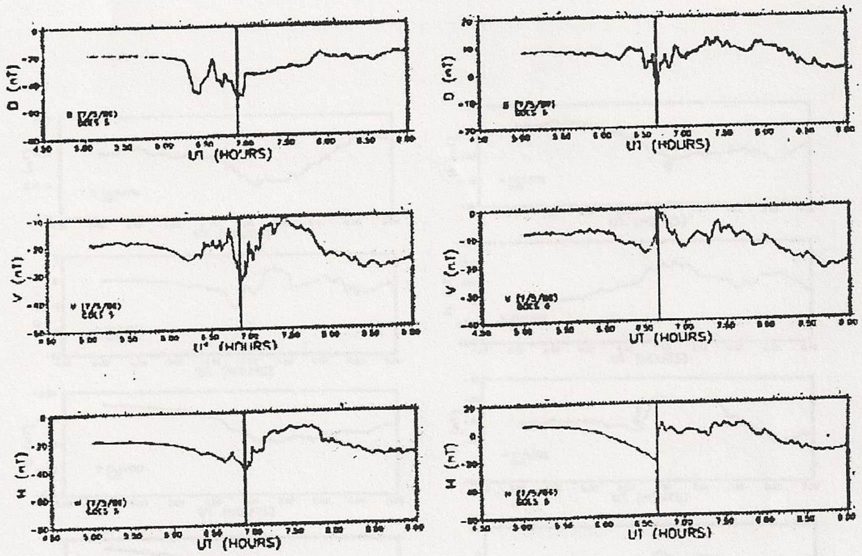

Figure 1: The D, V and H component from GOES–5 and GOES–6 magnetic field data on May 7, 1986

3 Data analysis

Two substorm events were selected to be examined. The first one occurred on May 7, 1986, between 05:00–09:00 UT and the second on April 1, 1986, between 08:00–12:00 UT.

3.1 May 7, 1986 event

Figure 1 presents the 1-minute values of H, V and D component from GOES–5 and GOES–6 satellites. The onset of the substorm expansive phase is marked with the vertical lines. From both V- and H-component magnetograms we can clearly see the change in the magnetic field geometry to a more tail-like configuration prior to the expansive phase onset. The D-component is affected by the substorm associated field-aligned currents. The substorm growth phase begins with a positive perturbation in the D component at GOES–6, while at GOES–5 it begins with a negative perturbation. As the substorm progresses, the two satellites record D-component disturbances of the same sign. The picture we obtained from the above is the following: the current wedge was triggered in a longitudinally narrow sector

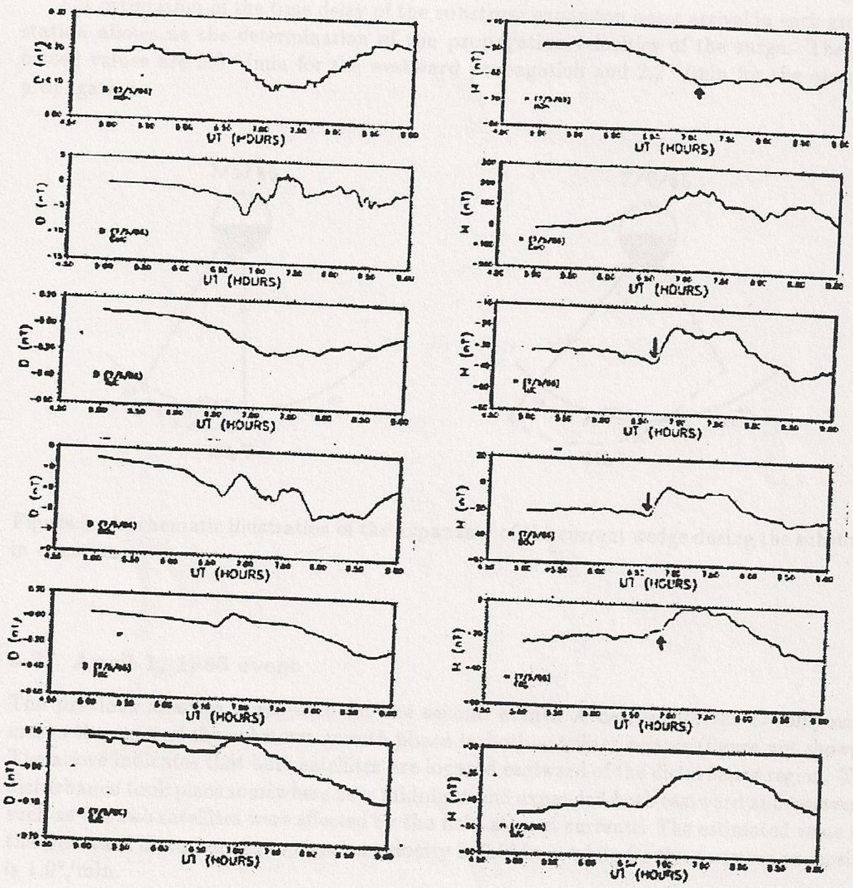

Figure 2: D and H magnetograms from six ground Observatories on May 7, 1986.

shortly after midnight. Initially, GOES–6 was westward of the wedge, while GOES–5 was eastward of the wedge. The disturbance expands both eastward and westward, in such a manner that eventually both satellites are located on the eastern side of the wedge. The shematic presentation of the above pattern is given in Fig. 3.

The estimation of the time delay of the substorm expansion onset arrival in each ground station allows us the determination of the propagation velocities of the surge. The estimated values are 3.6 °/min for the westward propagation and 2.2 °/min for the eastward propagation.

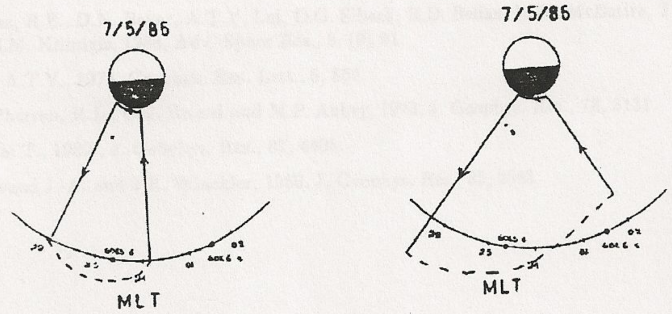

Figure 3: A schematic illustration of the expansion of the current wedge during the substorm in question.

3.2 April 1, 1986 event

The previous analysis is repeated for the second event. A decrease of the D-component marks the start of the substorm growth phase in both satellites sectors (figure not shown). The above indicates that both satellites are located eastward of the disturbance region. The disturbance took place somewhere near midnight and expanded both eastward and westward such as the two satellites were affected by the field-aligned currents. The estimated value for the westward disturbance propagation velocity is 0.9°/min while for the eastward expansion is 1.9°/min.

4 Concluding remarks

The magnetic signatures of two substorm events were observed in the near geosynchronous region (6.6 R_E) and these signatures are in conformity with the cross-tail current disruption model. In our cases, the disruption of the cross-tail current seems to be triggered in a longitudinally narrow sector shortly after local midnight. It expands both westward and eastward with velocities of the same order, although the eastward propagation seems to be less intense than the westward one. Finally, the propagation velocities are rather small (1°/min – 3.5°/min) and they are comparable to the values that are given by Lopez *et al.*(1988) and Kokubun and McPherron (1981).

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