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EFFECT OF SUBSTORMS ON THE 29-31 OCTOBER, 2003, SUPERSTORM

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Abstract. In the paper of Iyemori and Rao [*Ann. Geophys*., 1996] it was shown that storm-to-substorm correlation is positive only at substorm growth phase, while substorm expansion weakens or ceases the storm enhancement. Panasyuk et al. [2004], when studying the superstorm on 29-31 October, 2003, cast doubt on the result of Iyemori and Rao. We have examined the same substorms, as analyzed by Panasyuk et al. [2004], and shown with one-minute resolution that the effect of Iyemori and Rao holds true for this superstorm as well for any other storm, thus rehabilitating the famous result of Iyemori and Rao.

Introduction

There is no doubt that substorms and storms are statistically related phenomena. The point of controversy is the storm behavior in response to substorm expansion onset. Up to 1994 there was a perfect consensus about the enhancement of storm by substorm expansions (this is sketched in Fig. 1a). The supporters of this view believed that particle injections associated with substorm expansion intensify the ring current, which they considered to be the principal contributor to the storm-time depression. An attempt to provide an experimental evidence of the paradigm sketched in Fig. 1a was performed e.g., by Pudovkin et al., [1968], Isaev and Pudovkin [1972], who found a positive substorm-to-storm correlation, that is storm enhancement during substorms. Unfortunately, this result was obtained by those authors from hourly data that fail to distinguish which phase of substorm is related to storm enhancement.

In 1994 Iyemori [Iyemori, 1994] for the first time used the data with one-minute resolution and revealed that substorm expansion leads to storm weakening. In his analysis, Iyemori used the superposed epoch technique separately for the storm main phase (89 substorms) and recovery phase (97 substorms). His result is schematically shown in Fig. 1b. Somewhat later, this result was published in the paper [Iyemori and Rao, 1996].

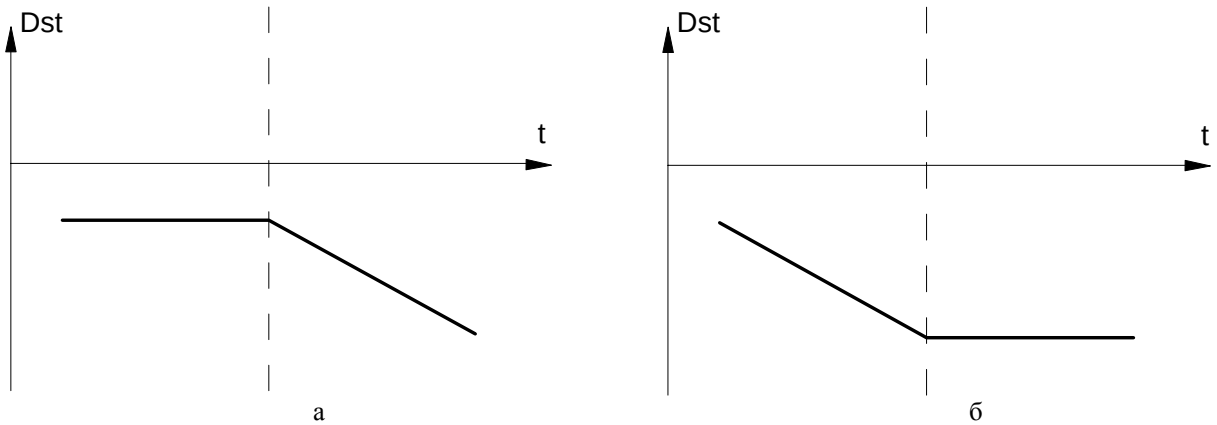

Figure 1. Sketch illustrating two controversial views on substorm-to-storm relation: a) the response of Dst to substorm expansion onset (the dotted vertical line) suggested before 1994; b) the response revealed by Iyemori [1994] and Rao [1996].

Panasyuk et al. [2004] cast doubt on the effect of Iyemori by stating that for the superstorm on 29-31 October 2003 more appropriate is the old point of view, which implies that the main contribution to the storm currents is provided by the ions accelerated in the course of substorm expansions. Unfortunately, again, this conclusion was based on the hourly values of Dst.

Further we demonstrate that using the data with higher temporal resolution leads to a different statement.

Data

In our analysis we used the *SYMH* index from the Kioto world data center. The *SYMH* index is an analogue of *Dst* but with one-minute resolution. The data were processed by the superposed epoch analysis, with the time of substorm expansion taken for the zero moment. We considered the onsets of the same six substorms that had been examined in the work of Panasyuk et al. [2004]. They are

29 October 2003, 14.33 UT

29 October 2003, 19.00 UT
30 October 2003, 19.30 UT
30 October 2003, 20.04 UT
30 October 2003, 21.10 UT
31 October 2003, 00.15 UT

Results

Fig. 2 illustrates the behavior of the *Dst* (*SYMH*) index averaged over six substorms under study. It is seen that that the storm intensifies at the substorm growth phase only, while the substorm expansion ceases this intensification. That is, the superstorm of the end of October 2003, responses to substorms exactly in the same manner as all other storms, that is in consistence with [Iyemori, 1994] and [Iyemori and Rao, 1996].

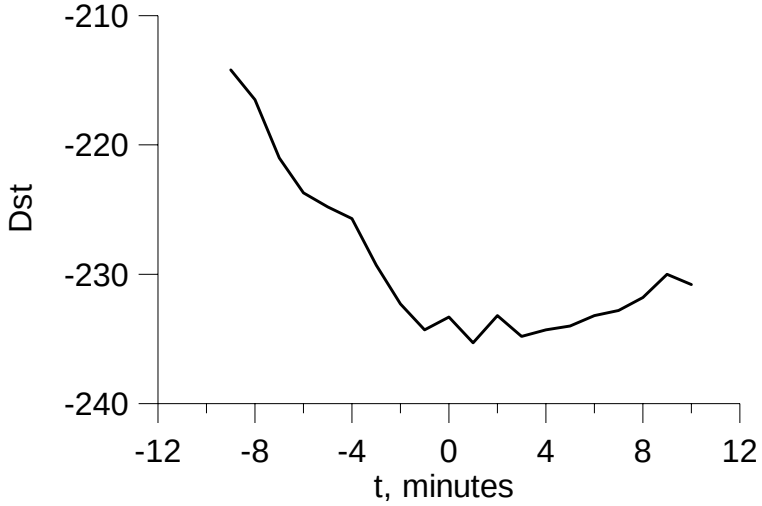

Figure 2. One-minute Dst index, averaged over six substorms occurred during the 29-30 October 2003 superstorm. The zero moment refers to substorm expansion onset.

Discussion and conclusion

In the studies [Siscoe and Petchek, 1997; Maltsev, 2004], the negative effect of substorm expansion in storm development is explained by cross-tail current reduction in association with substorm onset. The effect can be easily understood if we admit that it is not the ring current that primarily controls the storm-time Dst variation. The cross-tail current contribution should be included.

Thus, by the above analysis of the substorms occurred during the 29-31 October 2003 superstorm, we have shown that substorm expansion onset slows down storm intensification, thereby rehabilitating the famous result of Iyemori and Rao.

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