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Prediction of Solar Wind Power Supply into the Dayside Ionosphere (Extended Abstract)

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Power supply from the solar wind causes Joule heating in the ionosphere, particularly in the polar region. The generator is formed by interactions between the solar wind and the coupled system of the magnetosphere and the ionosphere. The precise prediction of the solar wind energy dissipation in the ionosphere is an important theme in terms of space weather. We focus on the impulsive response of the magnetosphere-ionosphere (M-I) coupled system to solar wind discontinuities. Solar wind discontinuities hit the bow shock and the magnetopause. They cause electromagnetic disturbances in the magnetosphere and drive electric currents flowing into the dayside ionosphere. Although the total energy input of this process is small (~1 GW) compared with well-known substorms (>10 GW) or storms (>100 GW), our approach gives a good clue not only for the prediction of response time but also for understanding of the generator in the M-I coupled system.

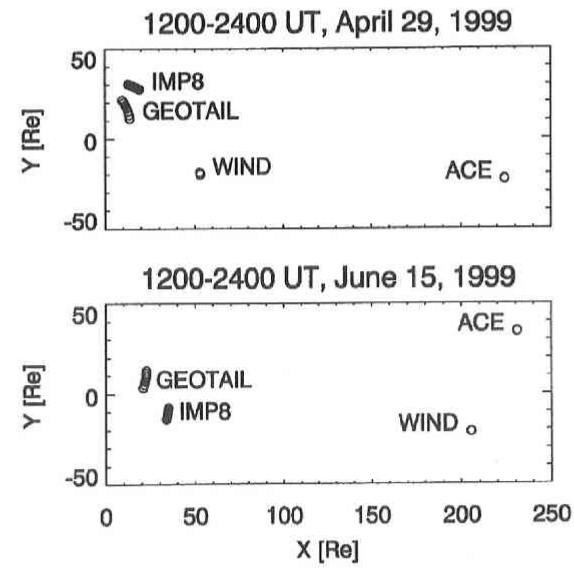

Fig. 1. Positions of the four spacecraft during the time periods of 1200-2400 UT on April 29, 1999 (top) and June 15, 1999 (bottom). Circles are plotted by 2-hour interval with the Y projections plotted against X.

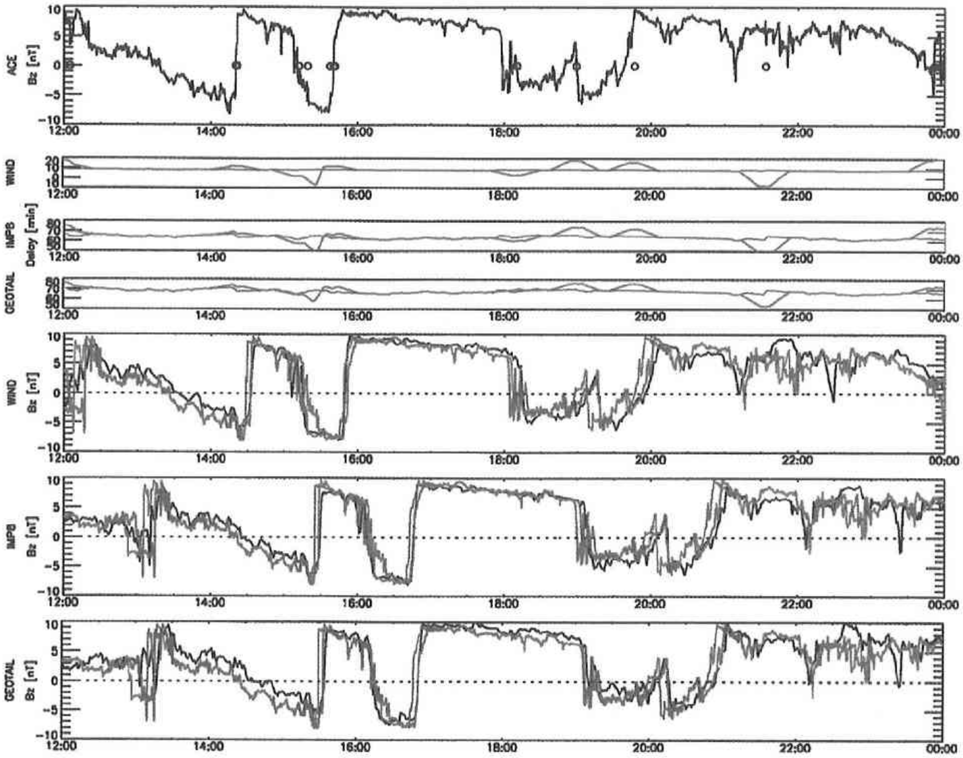

Fig. 2. Time series of IMF Bz measured by the four satellites for the time interval of 1200-2400 UT on June 15, 1999. IMF Bz trains observed at ACE are shown in the top panel (a). The detected timing of TDs are indicated with circles. Delay functions of the TD shift (advection shift) are shown by red (yellow) lines in the panels (b), (c), and (d) for Wind, IMP8, and Geotail, respectively. Shifted time series of ACE Bz using the two delay functions are plotted with the Bz trains of other spacecraft, Wind (e), IMP8 (f), and Geotail (g). Red and yellow lines are time series corresponds to the TD shift and advection shift, respectively.

Using data obtained from ground-based magnetometers in the Arctic and Antarctic and solar wind monitors in the interplanetary medium, it is shown by the Kataoka *et al.*, [2002] that the orientation of solar wind tangential discontinuity (TD) is a key to understand the transient response and to estimate the arrival times of the structures in the solar wind. Based on the results of the event studies, we have developed a new technique for accurate prediction of the Earth arrival times of solar wind structures. Propagation times from a solar wind monitor in the interplanetary space to the Earth are determined as a continuously varying function of time. The delay function is adjusted around the timing of TDs. This method reduces uncertainty in propagation times predicted by the standard advection shift method. Details of this technique will be published elsewhere.

ACE solar wind data are used to predict the arrival times of IMF turnings at Wind, IMP8, and Geotail spacecraft when all spacecraft exist in the interplanetary medium.

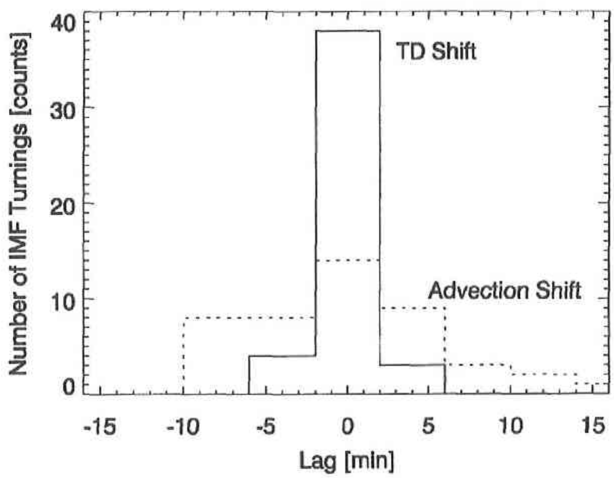

Fig. 3. Estimation errors of observed times of IMF turnings from those predicted using two estimates; TD shift (solid) and advection shift (dotted). Histogram shows the total number of events observed by the four satellites for the time interval 1200-2400 UT on April 29 and for the same time interval on June 15, 1999.

We use the same events selected by Weimer *et al.*, [2002] to check the accuracy of our method by comparing their best-fit time delays. The spacecraft locations in two events are depicted in Figure 1. Figure 2 shows the traces of IMF Bz measured by the four satellites for the time interval of 1200-2400 UT on June 15, 1999. IMF Bz trains observed at ACE are shown in the top panel (a). The timings of detected TDs are indicated with circles. Delay functions of the TD shift (advection shift) are shown by red (yellow) lines in the panels (b), (c), and (d) for Wind, IMP8, and Geotail, respectively. Shifted time series of ACE Bz using the obtained delay functions are plotted with the Bz trains of other spacecraft, Wind (e), IMP8 (f), and Geotail (g). Red and yellow lines show the time series corresponding to the TD shift and the advection shift, respectively. From Figures 1 and 2, it is apparent that this technique can predict accurately the IMF turnings at different satellite locations over the wide range of interplanetary medium. All the arrival times of the IMF turnings are corrected by 1-10 min properly, and the obtained time delays are close to the ones derived by Weimer *et al.*, [2002].

Figure 3 shows the histograms of the prediction errors of the two methods. Total 45 distinct discontinuities observed by four satellites are accounted for the time interval of 1200-2400 UT on June 15, 1999 and for the same time interval on April 29, 1999. It is found that the TD shift predicts 84% of IMF turnings within 2-min errors. On the contrary, the advection shift predicts only 31% of IMF turnings within 2-min errors.

This technique would contribute to both basic research and space weather prediction. This technique seems to have the best accuracy compared to the former methods developed to extrapolate solar wind properties downstream from the L1 point to the Earth. Another useful point of this technique is that we can identify the discontinuity arrivals at the Earth with physical meanings: TDs bounding different solar wind structures have such orientations in cases of hitting against the magnetosphere. This technique may open a new solar wind statistics using the TD normal vectors. The TD normal vectors are necessary to understand the TD-bow shock interaction and the reconnection geometry of the dayside magnetopause as suggested by Kataoka *et al.*, [2002]. There is a great potential that the TD normal vectors will become additional basic parameters of the solar wind. That is, it gives useful information on the first contact portion of the magnetosphere with TDs and the propagation directions of the disturbances. Further, we are going to develop a technique to predict solar wind power supply into the dayside ionosphere by combining this technique with 3-D MHD simulations.

References

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