Validation and operation of a coronal mass ejection arrival time forecasting system using interplanetary scintillation observations

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Coronal mass ejections (CMEs) cause disturbances in the environment of the Earth when they arrive at the Earth. However, the prediction of the arrival of CMEs still remains a challenge. We have developed an interplanetary scintillation (IPS) estimation system based on a global magnetohydrodynamic (MHD) simulation of the inner heliosphere to predict the arrival time of CMEs. In this system, the initial speed of a CME is roughly derived from white-light coronagraph observations. Then, the propagation of the CME is calculated by a global MHD simulation. The IPS response is estimated by the three-dimensional density distribution of the inner heliosphere derived from the MHD simulation. The simulated IPS response is compared with the actual IPS observations made by the Institute for Space-Earth Environmental Research, Nagoya University, and shows good agreement with that observed.
We demonstrated how the simulation system works using a halo CME event generated by a X9.3 flare observed on September 5, 2017. We find that the CME simulation that best estimates the IPS observation can more accurately predict the time of arrival of the CME at the Earth. We have validated this system using more than 10 halo CMEs and found that the error of the arrival time is reduced to less than 5 hours by using the IPS based forecasting system. These results suggest that the accuracy of the CME arrival time can be improved if our current MHD simulations include IPS data. A part of this system has been installed in a space weather forecasting of NICT, the space weather forecasting center of Japan, and operated for the daily forecasting.

Keywords: Coronal mass ejections (CMEs), interplanetary scintillation (IPS), magnetohydrodynamic (MHD) simulation , solar wind, Heliosphere

