Prediction of CME arrival times using electron and plasma wave observations

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When we predict the arrival time of CMEs at the Earth, the direction and velocity of CMEs propagating in the interplanetary medium are important inputs for space weather applications. In this paper, we estimated the direction of CMEs from the measured electron arrival times and the position of CMEs from the measured type III intensity changes.

Interplanetary magnetic field lines that are draped around CMEs are lengthened and longer than the length of the nominal Parker spiral. When a CME propagates earthward, the spacecraft at 1 AU is connected with the lengthened magnetic field lines. Propagation path lengths of electrons along the magnetic field lines are estimated from measured electron velocity dispersive onsets. From the propagation path lengths of electrons, we can estimate whether the CME propagates earthward or not.

Most electron events are accompanied with kilometric type III bursts. Kilometric type III bursts that undergo sudden intensity changes when their electron beams traverse the vicinity of an interplanetary shock were reported by MacDowall (1989). For intensity change location R, derived using a density model, at time t from the associated CME launch (corresponding to the time of type III intensity change), the velocity R/t can be derived. Assuming that the CME propagates with a constant velocity, the CME arrival time can be calculated.

We analyzed three cases that electron events occurred between the launch time of a CME and the arrival time of an interplanetary shock observed by Wind. The propagation path lengths of these electron events were longer than the lengths of the nominal Parker spiral. In two cases, the CME arrival times estimated from the measured type III intensity changes and these observed times from the associated CME launch were consistent with the observed shock arrival times in prediction errors of several hours. In another case, the estimated CME arrival time was not consistent with the observed shock arrival time.

We analyzed the electron events that were observed within four days of the launch of the potential geoeffective CMEs not associated with the interplanetary shocks. Since the propagation path lengths of electrons were similar to the lengths of the Parker spiral, Wind was not connected with the lengthened magnetic field lines draped around the CMEs.