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Modeling of coronal mass ejections based on the dynamical behavior of solar filament eruptions

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Severe geomagnetic storms are driven by the transient increase of the southward component of the interplanetary magnetic field at the Earth. The origin is widely accepted as erupted magnetic flux ropes from the Sun, which is assumed to be seen as coronal mass ejections (CMEs). Thus the modeling of the connection between these two features is a key for understanding the Sun-Earth connection, and for achieving the practical space weather forecasts using actual observational data sets. In remote sensing of the Sun, however, obtaining the physical quantities from the direct observation of CMEs is very restricted comparing with that from the observations of the other phenomena in the low corona, such as solar filaments. In this study we use the dynamical behavior of erupting solar filaments, which is assumed as a part of the erupting magnetic flux ropes and potentially provides various quantities for the modeling of CMEs.

On November 4, 1997, an energetic flare occurred in the southwestern quadrant of the solar disk and was observed with successive occurrences of flare associated shock-wave propagation in the corona, a filament eruption, and a halo CME. A geomagnetic storm was observed three days later associated with the transient increase of the southward component of the interplanetary magnetic field. We estimated some key quantities of the erupting magnetic flux rope, i.e. its position, orientation, direction of the eruption, and the writhe of the flux rope, by making vector velocity maps of the erupting filament using the dopplergram observation in H alpha wavelength. We also estimated the magnetic flux and magnetic helicity of the flux rope using the photospheric vector magnetic filed observation. We introduce a result of a numerical simulation with these parameters and show how these observational techniques are useful for modeling CMEs by evaluating the result using the observation of the coronal shock wave and the CME.