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A data-driven coupled modeling approach to predicting the magnetic structure of interplanetary coronal mass ejections

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Unraveling the formation and evolution of coronal mass ejections from the Sun to the Earth remains one of the outstanding goals in current solar-terrestrial physics and space weather research. In this work, we present our data-driven modeling principle designed to tackle specifically the question of predicting the magnetic structure of interplanetary coronal mass ejections.

Our modeling paradigm consists of three components:
a) a data-driven non-potential model of the coronal magnetic field up to 2.5 RSun fed by a time-sequence of vector magnetograms
b) a versatile flux rope magnetic field model
c) a three-dimensional MHD model that computes self-consistently the dynamics in the inner heliosphere from 0.1 AU up to the orbit of Mars (Euhforia).

The key feature of our approach is to employ a flux rope model in Euhforia whose parameters are determined solely through data-driven modeling. While the time-dependent kinematics and morphology of the flux rope are fitted using EUV and coronagraph observations, the magnetic parameters are directly obtained from the data-driven coronal model. In addition to presenting the modeling scheme, we showcase results of the modeling using well-observed case studies and comparisons with in-situ observations. Finally, we discuss future horizons for our model.