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Forward modeling of solar storm magnetic cores in the inner heliosphere

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Forecasting the geomagnetic effects of solar storms (coronal mass ejections, CMEs) is currently strongly limited by our inability to predict the magnetic field configuration at the CME magnetic core. This part of the CME usually has the strongest magnetic fields and leads to the strongest Dst excursions during the geomagnetic storm main phase. This is also known as the Bz problem.

Here, we demonstrate a new approach to predict Bz in a CME flux rope, which combines a novel 3D model of CME flux rope magnetic fields (3DCORE) with in situ magnetic field data from along the Sun-Earth line, provided by the MESSENGER spacecraft. Further, with the help of models such as Temerin and Li (2006) we can calculate a prediction (in hindsight) for the Dst index based on synthetic magnetic field and plasma speed data, calculated for the position of Earth.

This means that the Bz problem for non-interacting CMEs could be solved with 3D CME models such as presented here if either (1) real time in situ magnetic field data from along the Sun-Earth line is available or (2) the process of CME flux rope formation on the Sun would be sufficiently understood.