Global MHD Simulation of the Coronal Mass Ejection on 2011 March 7: From Chromosphere to 1 AU

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Performing realistic simulations of solar eruptions and validating those simulations with observations are important goals in order to achieve accurate space weather forecasts. Here, we perform a global MHD simulation of the fast CME that occurred on 2011 March 7. The simulation is made using the newly developed Alfven Wave Solar Model (AWSoM) in Space Weather Modeling Framework (SWMF), which describes the background solar wind starting from the upper chromosphere to 1 AU. Physical processes included in the model are multi-species thermodynamics, electron heat conduction (both collisional and collisionless formulations), optically thin radiative cooling, and Alfven-wave pressure that accelerates the solar wind. The Alfven-wave description is physically consistent, including non-WKB reflection and physics-based apportioning of turbulent dissipative heating to both electrons and protons. We initiate the CME by using the Gibson-Low analytical flux rope model and follow its evolution for days, in which time it propagates beyond 1 AU. A comprehensive validation study is performed using observations from SDO, SOHO, STEREOA/B, and OMNI. Our results show that the new model can reproduce many of the observed features near the Sun (e.g., CME-driven EUV waves, deflection of the flux rope from the coronal hole, “double-front” in the white light images) and in the heliosphere (e.g., CME-CIR interaction, shock properties at 1 AU). The CME-driven shock arrival time is within 1 hour of the observed arrival time, and nearly all the in-situ parameters are correctly simulated, which suggests the global MHD model as a powerful tool for the space weather forecasting.