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Investigating the evolution and interactions of the September 2017 CME events with EUHFORIA

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Coronal Mass Ejections (CMEs) and their Interplanetary counterparts (ICMEs) are the primary source of strong space weather disturbances at Earth and other places in the heliosphere. Key parameters determining the geo-effectiveness of CMEs are their plasma dynamic pressure and internal magnetic field intensity and orientation. In addition, phenomena such as the interaction with other CME structures along the way, or the pre-conditioning of interplanetary (IP) space due to the passage of previous CMEs, can significantly modify the properties of single CME events and influence their geo-effectiveness. Therefore, investigating and modeling such phenomena via physics-based heliospheric models is crucial in order to assess and improve our space weather prediction capability in relation to complex CME events.

In this regard, we present a comprehensive analysis of the CME events that erupted from AR 12673 during the unusually active week of September 4-10, 2017, with the aim of validating for the first time the prediction capabilities of the EUHFORIA model in the case of complex CME events. As AR 12673 rotated along with the solar disk, CMEs were launched over a wide range of longitudes, interacting with each other and paving the way for the propagation of the following CMEs. Following the eruptions, ICME-related signatures were observed at both Earth and Mars, while associated particle events were reported at Earth, Mars, and STEREO-A. In terms of impact on Earth, an intense geomagnetic storm, triggered by a strong southward magnetic field associated to an ICME sheath, was recorded on September 8, 2017.

In order to study these CME-CME interactions and their influence on the geo-effectiveness of single CMEs, we simulate the events using the EUHFORIA model. With the intent of preserving a predictive approach, we use kinematic, geometric and magnetic input parameters for the CMEs as derived from remote-sensing and multi-spacecraft observations of the CMEs and their source regions. We model CMEs first using an over-simplified cone model, and then a more realistic flux- rope model so to quantify the improvement in the prediction of the interplanetary magnetic field and CME geo-effectiveness at Earth in the latter case. Furthermore, we investigate the modelling of CME-CME interactions considering the spatial and temporal evolution of ICMEs in terms of their shocks, sheaths and ejecta structures in the heliosphere, and we quantify the impact of such phenomena on the propagation and evolution of single CME events. Results from this study will not only benchmark our current prediction capabilities in the case of complex CME events, but will also provide better insights on the large-scale evolution and interaction of complex CME events in the inner heliosphere.