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Alteration of a magnetic cloud's structure across the bow shock: results from 3D hybrid simulations

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Magnetic clouds (MCs) are a subset of coronal mass ejections which are characterised by an enhanced and smoothly rotating magnetic field. Recent studies have shown that their magnetic structure can be significantly modified when they cross the Earth's bow shock, and that the extent of this modification is closely related to the encountered shock configuration. In this work, we investigate the interaction of an MC with a bow shock using 3D hybrid simulations. They allow us to have access to the large-scale MC-bow shock interaction, but also to processes taking place at the ion scales, which are of critical importance in the quasi-parallel regime, in particular in the emergence of the ion foreshock region. The MC's magnetic structure is modelled by a flux rope which propagates with the solar wind flow inside the simulation domain. We examine its alteration across the different shock geometries, from quasi-perpendicular to quasi-parallel, and find a good agreement with the results from previous studies based on modelling and combined observations from different spacecraft (ACE, Cluster, Geotail). We also investigate the consequences of the MC's passage on the bow shock, the magnetosheath and the foreshock.