Magnetopause Energy Transfer: Techniques, Statistics and Comparison to Global MHD Simulation

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The solar wind kinetic energy fuels all dynamical processes within the near-Earth space, including magnetic storms and substorms during which spectacular auroral displays are observed. The solar wind energy is extracted in a dynamo process at the magnetopause converting kinetic energy into magnetic energy. Global energy conversion at the magnetopause can be estimated using global proxies and global three-dimensional magnetohydrodynamic (MHD) simulations, while locally in situ data can be used. To achieve an observation-based global estimate of the energy transfer rates across the magnetopause, a large statistical database must be developed and analysed. The first multi-spacecraft mission Cluster II provides a good opportunity to carry out this task.We present methods to investigate the magntetopause energy conversion using Cluster data, and show that the multi-spacecraft methods give best estimates of the investigated parameters at the magnetopause. However, using the multi-spacecraft methods, the number of events is limited by constraints such as the inter-spacecraft separation. Hence, single spacecraft methods are tested and validated against the multi-spacecraft methods, and we find here that the weighted average of the different methods given by the Generic Residue Analysis gives results comparable to multi-spacecraft methods and often gives better results using constraints like no net magnetic field along the normal to the magnetopause.We develop a large database of Cluster magnetopause crossings, and apply the validated methods to infer the energy conversion rates. We investigate the spatial variation of the energy transfer from the large statistics, especially as a function of the solar wind conditions. We also compute the global energy transfer using a magnetohydrodynamic (MHD) simulation GUMICS-4 and compare the results with the Cluster statistics. We find that the spatial variation of the energy transfer from GUMICS-4 is in good accordance with the observation-based statistics.

Keywords: Magentopause, Energy conversion, Generic Residue Analysis,MHD simulation, Cluster