Classification of Magnetosheath Jets using Neural Networks, Solar Wind Observations and High-resolution IMF Measurements

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Abstract

Magnetosheath jets are enhancements of dynamic pressure resulting from solar wind interaction with the bow shock and indicating a locally increased plasma flow. Jets are believed to be a key element in the coupling between the solar wind and the magnetosphere while also being associated with other physical phenomena such as magnetic reconnection, radiations belts, ionospheric flow enhancements and throat auroral features. All these phenomena are directly connected to space weather field, thus making jets a key research component.

In this work, we use a dataset that includes several thousands of magnetosheath jets that have been classified into four classes. The first two main categories are jets found in the Quasi-parallel magnetosheath ($\theta_{Bn} < 45°$) and those found in the Quasi-perpendicular ($\theta_{Bn} > 45°$), with θ_{Bn} being the angle between the Interplanetary Magnetic Field (IMF) and the bow shock's normal vector. Two more categories are based on different transitions between the mentioned cases. "Boundary" jets are found when we have a switch from quasi-parallel bowshock to quasi-perpendicular or vice versa, and "Encapsulated" jets are jets holding quasi-parallel characteristics while the surrounding plasma before and after the jet is of quasi-perpendicular nature.

This initial dataset has been derived by using in-situ measurements of various plasma moment quantities and magnetosheath magnetic field as measured by the Magnetospheric Multiscale (MMS) mission during 09/2015 – 05/2019.

We then use solar wind data, measured outside of the magnetosheath, in L1, in order to predict the four (4) classes of the jets that were later observed inside the magnetosheath region by MMS. The predictive classification is done with deep Neural Networks (NNs) and several different inputs including several solar wind particle moments, electric field, and IMF values.

Preliminary results already support the initial classification scheme of the magnetosheath jets. More importantly, they show that even in the absence of crucial information, such as the angle of the IMF, the use of machine learning methods allow a connection between the solar wind particle population before and after its complex interaction with Earth's bow shock as measured by different missions.