Classification of Magnetosheath Jets using Neural Networks and High Resolution OMNI (HRO) data.

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Abstract

The Magnetosheath is a highly disturbed region between the Bowshock and the Magnetopause. In this region, several phenomena occur, including "Magnetosheath Jets". These jets are enhancements of dynamic pressure above the general fluctuation level, indicating a locally increased plasma flow. Such jets are believed to be a key element in the coupling of solar wind and magnetosphere while also being possibly associated with other physical phenomena such as magnetic reconnection and the population of the radiations belts.

In this work, we use a dataset with thousands of magnetosheath Jets that has been created based on the concept that there are two main types of jets. The jets found in the Quasi Parallel Magnetosheath ($\theta_{Bn} < 45°$) and those found in the Quasi-perpendicular ($\theta_{Bn} > 45°$), where θ_{Bn} is the angle between the Interplanetary Magnetic Field (IMF) and the bow shock's normal vector. 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 11/2015 – 03/2019.

We use one-minute High Resolution OMNI (HRO) data that were measured outside of the Magnetosheath and have been time-shifted to the Earth's bowshock in order to predict the class (Quasi-perpendicular / Quasi-parallel) of the Jets that were later observed inside the magnetosheath region by MMS. The predictive classification is done with Neural Networks (NNs) and multiple inputs including several solar wind particle moments, electric field, and IMF values.

Using this data and a deep NN with optimized hyper-parameters, we achieve predictive classification of the Jet type with accuracies up to 92%.

These results 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 direct connection between the solar wind particle population before and after its complex interaction with Earth's bow shock as measured by different missions.