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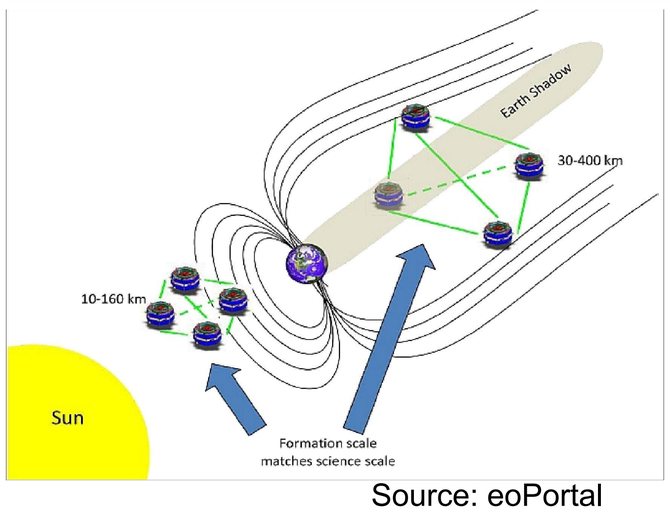
Heliophysics Data Analysis with Unsupervised Machine Learning

ID 255

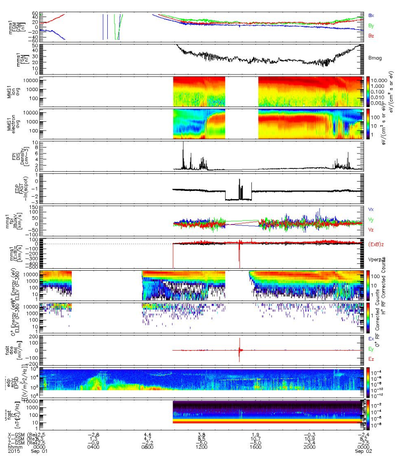
The study of the Earth's heliosphere and its complex system of electromagnetic interactions plays a key role in understanding the fundamental physics of space. Magnetic reconnection and plasma turbulence are closely interrelated fundamental processes in the dynamics of the magnetosphere. Research on turbulence and reconnection focuses on how magnetic reconnection occurs in a turbulent system and how turbulence and reconnection interact. To address these questions, several spacecraft have been sent into space in recent years. NASA's Magnetospheric Multiscale (MMS) Mission aims to observe traces of magnetic reconnection in Earth's magnetosphere at an unprecedented rate. MMS measures more than 100 GB of data every day; however, due to limitations in the memory of the probes, data overwriting continuously occurs, resulting in irreversible loss of information. Initial inspection of raw data and subsequent selection of relevant datasets are performed by scientists through visual examination, introducing subjectivity into the analysis process. Therefore, the adoption of an automated procedure becomes imperative to ensure objectivity and efficiency in the preliminary analysis. Artificial Intelligence represents the perfect candidate for this task due to its ability to recognize patterns and extract information from data.

Data Preprocessing



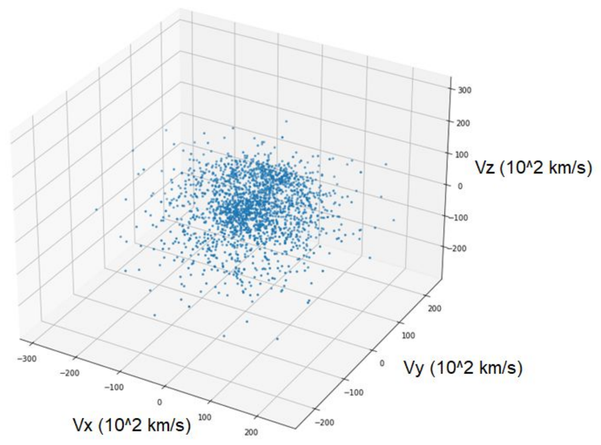
Source: eoPortal

The spacecraft collect and transmit the data to Earth

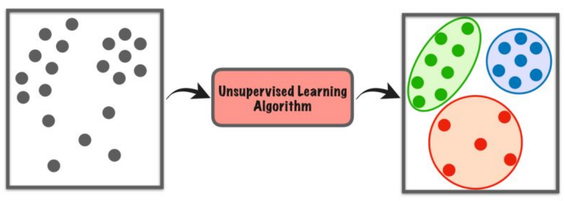


Source: Spedas

Preprocess the data for Machine Learning analysis

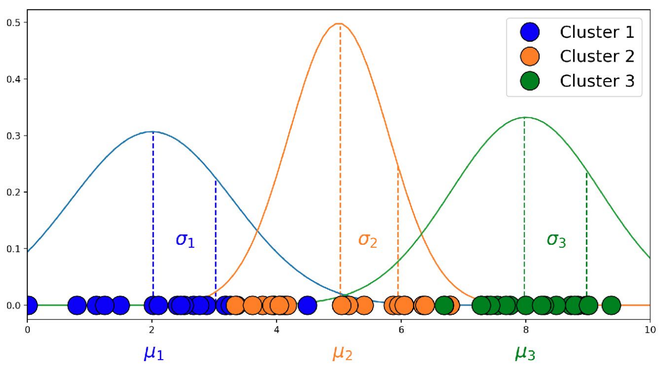


Data Analysis: GMM Clustering

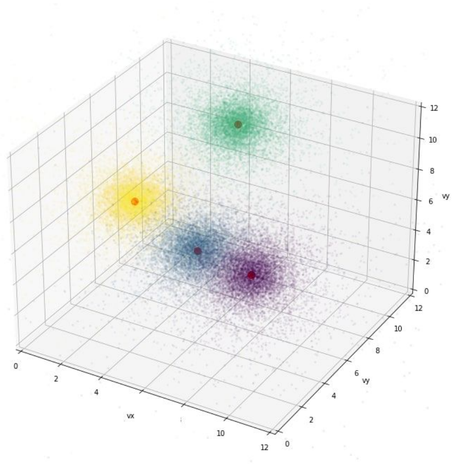


Source: Towards Data Science

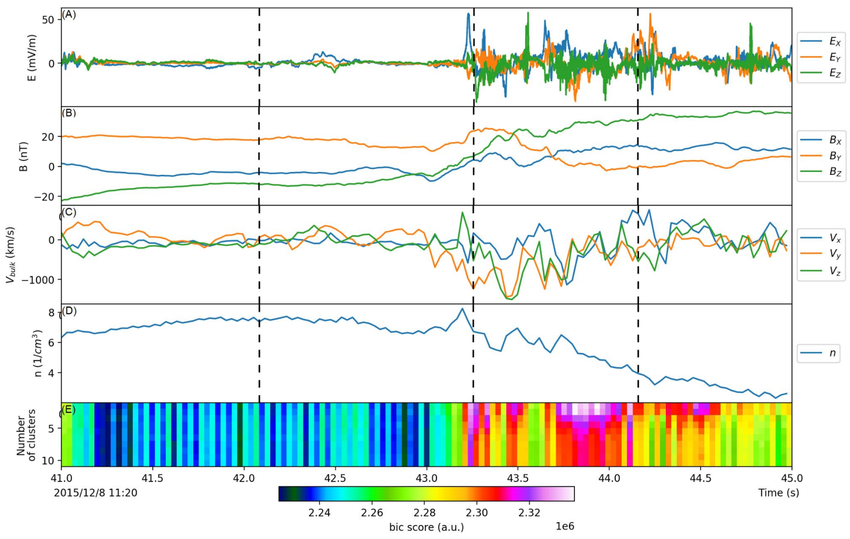
Unsupervised Machine Learning finds patterns within the data independently



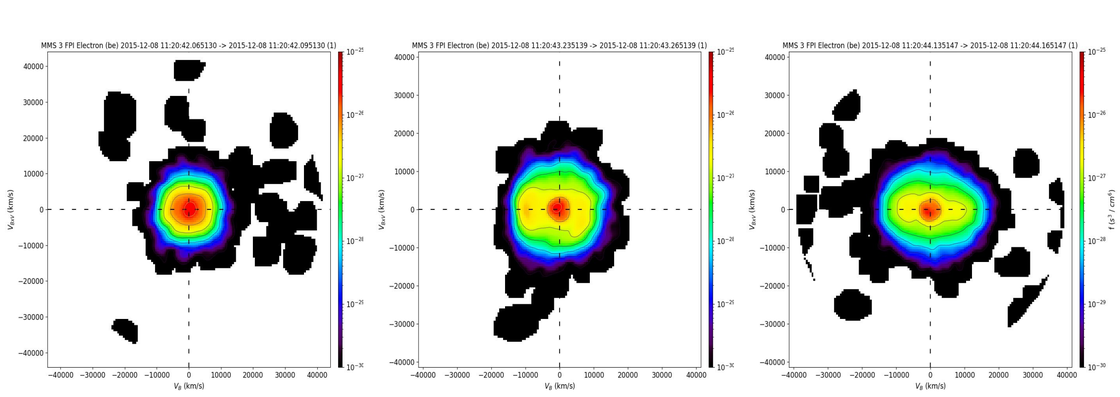
GMM identifies clusters by assuming that data arise from Gaussian distributions



Automatic Detection of Plasma Features



We identify reconnection regions through features extracted by the algorithm



The complexity of the clustering is a good indicator of interesting regions in space where magnetic reconnection might be present

References

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