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A generalized Magnetospheric Disturbance Index: utilizing an artifical neural network to scale to large mission datasets

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Abstract

Since MAVEN's arrival at Mars in 2014, in situ observations of the magnetic field have been made continually. During this time, the Martian magnetosphere has been disturbed by various solar transient events such as stream interaction regions (SIRs) and interplanetary coronal mass ejections (ICMEs). To understand the efficacy of solar transient events' abilities to disturb the Martian magnetosphere, statistical studies of large sets of events can be informative. Lacking an intrinsic global magnetic field, Mars' magnetosphere is a product of piled-up interplanetary magnetic field making the pre-disturbed background state of the system different event-to-event. For over a century, quantitative disturbance metrics have been employed at Earth, primarily relying on magnetometer observations [1, 2], which enable statistical studies of solar transient events on the various physical processes driven by solar wind-planetary interactions, such as aurora and atmospheric loss. However, many of these indices require assumptions about the magnetic field background, which can be highly variable at bodies with an induced magnetosphere. We present a generalized Magnetospheric Disturbance Index (MDI), which will be applicable to unmagnetized bodies, developed using MAVEN observations of over 70 solar transient events. The duration and strength of disturbances observed by MAVEN seem to have no dependence on the type of solar transient impacting the planet.

Computation of MDI requires identification of the magnetosheath about the planet. Manual identification of the magnetosheath over an entire missions dataset can be prohibitively labor intensive, therefore we have begun development of an artificial neural network (ANN) to aid in the application of MDI over an entire missions set of observations. Our ANN consists of two hidden layers to perform the identification: one Long Short-Term Memory [3] layer to determine patterns in the time series data and one layer to determine if these patterns are expected in the magnetosheath. Spacecraft position, magnetic field observations and electron observations are used as inputs to our ANN. While enabling the extension of MDI calculation to large mission datasets, the development of the ANN will be useful to many other studies requiring knowledge of the plasma regime that the spacecraft is in.

References

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