Neural network-based method to characterize the robust interactions between geomagnetic storms and substorms

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Abstract:

The Earth's magnetic field is constantly perturbed by the solar wind, a plasma of ions and electrons that permeates the whole Solar System. Understanding the dynamic between the magnetosphere and the outer space medium is essential since our modern society is increasingly relying on technology that can be affected by these phenomena.

In order to characterize the interaction of the solar wind - magnetosphere-ionosphere system, many geomagnetic indices (GI) have been introduced. Among them, SYM-H has been implemented to measure its eastern component in equatorial regions in order to capture the effects of the ring current at ground level with minute time resolutions. In the polar region, the Auroral Electrojet index measures the amplitude of the envelope of the perturbations to the magnetic field.

The time series generated by these GIs reveal that the response of the magnetosphere to solar wind varies significantly with latitude and longitude. In addition, complementary observations such as the high concentration of oxygen ions in the ring current during active periods, suggest that the magnetosphere is also a dynamic driven multiscale system with coupled subsystems. Thus, in order to model it accurately, a correct understanding of the coupling of its subsystems is also necessary. And here Machine learning approaches that are particularly designed as a system science discovery technique [1], can be quite useful.

We propose, following the strategy described in [1], a system science discovery method, based on neural networks (NN) trained to forecast GIs, that are capable of highlighting some properties of storm-substorms interactions, such as the most predictable variable, or the most significant inputs and time delay that should be considered in tñsuch a model. Also, we present considerations on the efficiency of the prediction depending on different NN architectures. Our method gives considerations that should be taken into account when constructing forecasting models of coupled subsystems, such as the storms - substorms subsystem. In addition, it provides a new interdisciplinary method that can give clues on how NNs are working.

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