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Global dynamic evolution of the cold plasma inferred with neural networks

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The electron number density is a fundamental parameter of plasmas and is critical for the wave-particle interactions. Despite its global importance, the distribution of cold plasma and its dynamic dependence on solar wind conditions remains poorly quantified. Existing empirical models present statistical averages based on static geomagnetic parameters, but cannot reflect the dynamics of the highly structured and quickly varying plasmasphere environment, especially during times of high geomagnetic activity. Global imaging provides insights on the dynamics but quantitative inversion to electron number density has been lacking.
We propose an empirical model for reconstruction of global dynamics of the cold plasma density distribution based only on solar wind data and geomagnetic indices. We develop a neural network that is capable of globally reconstructing the dynamics of the cold plasma density distribution for L shells from 2 to 6 and all local times. We utilize the density database obtained using the NURD algorithm [Zhelavskaya et al., 2016] in conjunction with solar wind data and geomagnetic indices to train the neural network.
This study demonstrates how the global dynamics can be reconstructed from local in-situ observations by using machine learning tools. We describe aspects of the validation process in detail and discuss the selected inputs to the model and their physical implication.