Neural network applications in geomagnetic storm prognosis based on the pre-storm occurrence of magnetic islands in the solar wind

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So far, the problem of a short-term forecast of geomagnetic storms can be considered as solved. Meanwhile, mid-term prognoses of geomagnetic storms with an advance time from 3 hours to 3 days are still unsuccessful (see https://www.swpc.noaa.gov/sites/default/files/images/u30/Max%20Kp%20and%20GPRA.pdf).

This fact suggests a necessity of looking for specific processes in the solar wind preceding geomagnetic storms. Knowing that magnetic cavities filled with magnetic islands and current sheets are formed in front of high-speed streams of any type (Khabarova et al., 2015, 2016, 2018; Adhikari et al., 2019), we have performed an analysis of the corresponding ULF variations in the solar wind density observed at the Earth’s orbit from hours to days before the arrival of a geoeffective stream or flow. The fact of the occurrence of ULF-precursors of geomagnetic storms was noticed a long time ago (Khabarova 2007; Khabarova & Yermolaev, 2007) and related prognostic methods were recently developed (Kogai et al. 2019), while the problem of automatization of the prognosis remained unsolved.

A new geomagnetic storm forecast method, which employs a Recurrent Neural Network (RNN) for an automatic pattern search, is proposed. An ability of self-teaching and extracting deeply hidden non-linear patterns is the main advantage of Deep Neural Networks (DNNs) with multiple layers over traditional Machine Learning methods. We show a success of the RNN method, using either the unprocessed solar wind density data or Wavelet analysis coefficients as the input parameter for a DNN to perform an automatic mid-term prognosis of geomagnetic storms.


