Relationship between storm-time and non-storm-time substorms: A Neural Network Approach

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A geomagnetic storm is commonly identified by the existence of a main phase during which the magnetic field on the Earth's surface is depressed. This depression is caused by the ring current flowing westward in the magnetosphere, and can be monitored by the Dst index. During the main phase of magnetic storms, intense magnetospheric substorms occur. These are known as storm-time substorms. Substorms do also occur when there are no magnetic storms and these substorms are called non-storm-time substorms.

In this study, we attempt to identify differences between storm-time and non-storm-time substorms. We use the AL index and the Dst index as proxies to represent the westward electrojet current and the ring current respectively.
Our approach is Elman recurrent neural network in which the AL index is the only input parameter and the output parameter is the Dst index. Elman recurrent network is a class of feed-forward multi-layer neural networks with a feedback loop from the hidden layer connected to the input layer. This feeback connection allows the Elman network to detect and generate time-varying patterns.

The data set of both the AL and Dst indices consist of 1-hourly averaged data compiled by the World Data Center C2 of Kyoto University, and were taken from the database of WDC C1 in Denmark over the internet. We made separate datasets from the period of 1967-1982 for both the storm-time and non-storm-time substorm periods. Our training data of the storm-time period, consist of 50 storm intervals: 21 intense, 24 moderate, and 5 weak storms covering a period of about 3,000 hours.
The network is trained by feeding the input with the hourly averaged AL index, and as the output we provide the corresponding hourly Dst index covering the training period. The network outputs are then compared with the observed Dst.
Correlation coefficient for the storm-time substorm amounts to about 0.76. Similar neural network for non-storm-time substorms will be trained. We will show how the storm-time network reproduce the Dst index when the non-storm-time AL index is given, and attempt to identify differences between storm-time and non-storm-time substorms.