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Prediction of Sym-H index by NARX neural network from IMF and solar wind data

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Similar to Dst, the Sym-H index is also an indicator of magnetic storm intensity, but having distinct advantage of higher time-resolution. In this study an artificial neural network (ANN) of Nonlinear Auto Regressive with eXogenous inputs (NARX) has been developed to predict for the first time Sym-H index from solar wind and IMF parameters.

In total 73 great storm events during 1998 to 2006 are used, out of which 67 are selected to train the network and the other 6 samples including 2 super-storms for test. The newly developed NARX model shows much better capability than usual BP and Elman network in Sym-H prediction. When using IMF Bz, By and total B with a history length of 90 minutes along with solar wind proton density Np and velocity Vsw as the original external inputs of the ANN to predict Sym-H index one hour later, the cross-correlation between NARX network predicted and Kyoto observed Sym-H is 0.95 for the 6 test storms as a whole, even as high as 0.95 and 0.98 respectively for the two super-storms. This excellent performance of the NARX model can mainly be attributed to a feedback from the output neuron with a suitable length of about 120 min. to the external input. It is such a feedback that makes the ring current status properly brought into effect in the prediction of storm-time Sym-H index by our NARX network.

Furthermore, different parameter combinations with different history length (70 to 120 min.) for IMF and solar wind data as external inputs are examined along with different hidden neuron number. It is found that the NARX network with 10 hidden units and with 100 min. length of Bz, Np and Vsw as external inputs provides the best results in Sym-H prediction. Besides, efforts have also been made to predict Sym-H longer time ahead, showing that the NARX network can predict Sym-H index 180 min. ahead with correlation coefficient of 0.94 between predicted and observed Sym-H and RMSE less than 19 nT for the 6 test samples.