Evaluating Neural Network Performance in Forecasting Key Geomagnetic Indices During Solar Cycle 25

Mostafa Hegy[1]

(1) Geomagnetic and Geoelectric Department, National Research Institute of Astronomy and Geophysics, Cairo, Egypt.

Abstract

Geomagnetic storms, characterized by sudden disturbances in Earth's magnetic field, pose significant risks to technological infrastructure and human activities. This study evaluates the performance of neural network (NN) approaches for predicting different geomagnetic indices during Solar Cycle 25. Nonlinear Autoregressive Networks with Exogenous Inputs (NARX) were trained and tested using solar wind parameters as predictors and geomagnetic indices (Dst, Kp, and Ap) as outputs. The models were evaluated for prediction accuracy, robustness, and computational efficiency using metrics such as root mean square error (RMSE), mean absolute error (MAE), and the cross-correlation coefficient (R). The results demonstrated strong forecasting capability, achieving Root Mean Squared Error (RMSE) values as low as 0.011 and correlation coefficients up to 0.99 for Dst index predictions. These results highlight the NARX model's robustness and accuracy in capturing the complex dynamics of geomagnetic storms. This comprehensive evaluation supports the model's utility for operational space weather forecasting, providing significant improvements over baseline forecasting methods.