Long-Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles
Proceedings IAU Symposium No. 340, 2018
D. Banerjee, J. Jiang, K. Kusano & S. Solanki, eds.

doi:10.1017/S1743921318001990

Nonlinear Autoregressive Model (NARX) of Stationary Forbush Decrease Indices Based on Levenberg-Marquardt Feedback Algorithm

Sankar Narayan Patra, Subhash Chandra Panja, Amrita Prasad, Soumya Roy and Koushik Ghosh

Astronomical Instruments Design Laboratory, Instrumentation Science Dept., Jadavpur University, Kolkata, India
Corresponding email id: sankar.n.patra@gmail.com

Abstract. Artificial Neural Network based Nonlinear Autoregressive Model is designed to reconstruct and predict Forbush Decrease (FD) Data obtained from Izmiran, Russia. Result indicates that the model seems adequate for short term prediction of the FD data.

Keywords. ANN, Autoregressive, Adaptive L-M algorithm, Short Term Prediction & MSE

1. Introduction

FD is a rapid reduction of 2-30% of galactic cosmic ray intensity occurring usually after a coronal mass ejection (CME) (Patra *et al.* 2011) (Patra *et al.* 2011). This event sustains for few hours even up to several days. The phenomena explained as the possible reason of a FD are like the shocks associated with the Helium enhancement in the interplanetary conditions (Gold 1960) disordering of the outer geomagnetic field by the outflowing gas from the Sun (Barnden 1973) parent flare longitude; sweeping away of cosmic ray particles by traveling disturbances in which the solar wind speed is raised and the diffusion coefficient is reduced (Nishida 1983) rigidity dependence of the cosmic ray modulation and effects of the geomagnetic field upon the magnitude of the decrease (Lockwood 1971) magnetized plasma cloud (Burlaga *et al.* 1981) combined effect of interplanetary phenomena(energetic particles, solar wind plasma and magnetic field) (Cane & Richardson 1995) superposition of the several processes including diffusion ,convection and adiabatic energy losses plus curvature and gradient drift effects in the interplanetary magnetic field (Fluckiger 1991) long lived co-rotating high speed solar wind stream (ifedili 1996) extremely high solar activities and turbulence in the heliosphere and complex plasma and magnetic disturbances formed as a result of the outburst of the solar wind (shah *et al.* 2005). It has been demonstrated that (Kudo *et al.* 1985) for the solar cycle 20,the interplanetary magnetic field shows a weak negative correlation with cosmic ray whereas there is a possible high anti-correlation for the solar cycles 21-23. On the other hand, there have been some evidence of the short term increase in cosmic ray intensity occurring inside FD (Iucci *et al.* 1985) that may be associated with magnetic clouds. For the present analysis we have taken the index RF(source:IZMIRAN, Russia & source file:IFsRF_list) (Belov *et al.* 2005). In our approach, we have developed NN model for the present FD indices based on Nonlinear Autoregressive (NARX) (Pucheta *et al.* 2011) model for forecasting of the sampled signal. The learning rule used to adjust the NN weights is based on the Levenberg-Marquardt (L-M) algorithm.

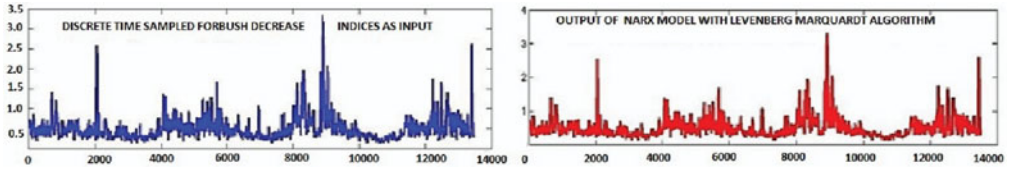

Figure 1. Input & Predicted Waveforms of FD indices

2. Nonlinear Autoregressive Model of the FD Indices using NN:

The predictor system here have been considered as an autoregressive model-based nonlinear adaptive model based on the artificial neural network to execute the results via time lagged feed-back networks with Levenberg-Marquardt learning technique.

3. Result & Discussion

Sampled signals are obtained from the adaptive nonlinear Autoregressive model. During the learning phase for each epoch, the entire 13514 targets are divided in 70% in training, 20% in validation & 10% in testing target time step Learning is achieved when the value of MSE becomes very small (i.e. global minima). The best validation performance occurs at 1052 epochs with a value of 0.0002109. Regressions, R is used to measure the correlation between outputs and targets.MSE is the average squared difference between outputs and targets. Lower values of MSE are better as theoretically zero indicates no error. R value of 1 indicates a close relationship and 0 represents a random relationship.On the basis of the results, it can be concluded that L-M algorithm can efficiently predict the FD indices with high regression correlation for both training and testing. The training error is 0.00025488 and testing error is 0.0003014, indicative of more than 70% accuracy. In this case, the correlations, except for the one at zero lag, fall approximately within the 95% confidence limits around zero, so the model seems to be adequate.

4. Acknowledgement

We express our sincere gratitude to Dr. Belov, Dr. Eroshenko and their team from IZMIRAN, Russia. Also we acknowledge UGC BSR Start-Up project [No-30-103/2015(BSR)] financial support.

References

Patra, S. N., Ghosh, K., & Panja, S. C. 2011, *Ap&SS*, 334, 317
Patra, S. N., Ghosh, K., & Panja, S. C. 2011, *IJEER*, 3, 237
Gold, T. 1960, *ApJs*, 4, 406
Barnden, L. R., 1973, *ICRC*, 2, 1277
Nishida, A., 1983, *JGR*, 88, 785
Lockwood, J. A., 1971, *SSRv*, 12, 658
Burlaga, L., Sittler, E., Mariani, F., & Schwenn, R., 1981, *JGRA*, 86, 6673
Cane, H. V. & Richardson, I. G., 1995, *JGRA*, 100, 1755
Fluckiger, E. O., 1991, *Proc. 22nd ICRC*, 5, 273
Ifedili, S. O., 1996, *Solar Phys.*,168,195
Shah, G. N., Mufti, S., Darzi, A., & Ishtiaq, P. M. 2005, *ICRC*, 1, 351
Kudo, S., Wadu, M., Tanskanen & Kodama. M., 1985, *Proc. of 19th ICRC (SH-5)*, 2376, 246
Iucci, N., Parisi, M., Storini, M., & Villoresi,G. 1985, *Proc. of 19th ICRC*, 2376, 226
Belov, A. V. *et al.*, 2005, *Proc. of 29th ICRC*, 1, 375
Pucheta, J. A. *et al.*, 2011, *Computacin y Sistemas*, 14, 423

https://doi.org/10.1017/S1743921318001990 Published online by Cambridge University Press