Bayesian Neural Network Modeling of Temperature Variability Record from the Western Himalaya

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A new scheme based on the concept of Bayesian neural network (BNN) theory was developed and employed to model the temperature variability record. In order to estimate intractable a posteriori probability functions, the BNN algorithm was coupled with Hybrid Monte Carlo (HMC)/ Markov Chain Monte Carlo (MCMC) simulations in which, each trajectory was updated by approximating the Hamiltonian differential equations through a leapfrog discretization scheme. The efficacy of the new approach was tested on the well known empirical models (eg. chaotic, stochastic and random) prior to applying on the actual temperature record and finally applied to model a newly constructed temperature variability record decoded from tree-ring widths of the western Himalayas spanning over a period of 1227AD-2000 AD. For modeling, the actual temperature data, optimum network parameters were chosen appropriately as a function of testing error convergence with respect to the network training. An adequate cross-validation test was run to ensure the performance of the network on the new data sets. Finally uncertainty analysis was performed to characterize and predict the model behavior by estimating standard deviation (STD) error map of posteriori covariance matrix at the network output. The predictive model study suggests that there was a negative trend in temperature variability during the year 2002, which matches well with the actual temperature pattern. The model shows positive (increasing) trend towards the year 2015. It appears that the solar forcing and radiative imbalance caused by deforestation and rising CO2 may have played significant role for significant temperature variability in this region. The new BNN modeling approach provides viable alternative tool for climate studies and could be exploited further for other kinds of environmental data modeling.

Keywords: Hybrid Monte Carlo, Bayesian neural networks, Temperature variability, Himalaya, Nonlinear model, Prediction