

Analysis of Precipitation Variability using Memory Based Artificial Neural Networks

Shyama Debbarma, Regent Education and Research Foundation Group of Institutions, India

Parthasarathi Choudhury, NIT Silchar, India

Parthajit Roy, NIT Silchar, India

Ram Kumar, Katihar Engineering College, Katihar, India

ABSTRACT

This article analyzes the variability in precipitation of the Barak river basin using memory-based ANN models called Gamma Memory Neural Network(GMNN) and genetically optimized GMNN called GMNN-GA for precipitation downscaling precipitation. GMNN having adaptive memory depth is capable techniques in modeling time varying inputs with unknown input characteristics, while an integration of the model with GA can further improve its performances. NCEP reanalysis and HadCM3A2 (a) scenario data are used for downscaling and forecasting precipitation series for Barak river basin. Model performances are analyzed by using statistical criteria, RMSE and mean error and are compared with the standard SDSM model. Results obtained by using 24 years of daily data sets show that GMNN-GA is efficient in downscaling daily precipitation series with maximum daily annual mean error of 6.78%. The outcomes of the study demonstrate that execution of the GMNN-GA model is superior to the GMNN and similar with that of the standard SDSM.

KEYWORDS

Downscaling, Precipitation, Climate Change, Gamma, Genetic Algorithm, GMNN, SDSM, Forecasting,

1. INTRODUCTION

Recently, climate change has attracted the attention of scientific community of multidisciplinary area due to its effects on human society and natural resources. Anthropologic activities have provoked the climate system causing significant changes in hydrologic cycle, ecosystem etc. Changes in hydrologic cycle have direct impact on human society due to changes in rainfall distribution, water availability, flood and drought (Gleick, 1987; Burn, 1994; Simonovic, 2001; Sivakumar, 2011). Water resource of a region is often affected due to changes in the precipitation pattern. Precipitation being a critical element speaking to atmosphere of a locale is viewed as the most vital variable for examining the effects of atmospheric changes, particularly on the water assets of an area. To study the climate change effects on water resources because of changes in precipitation, its changeability in the spatial and temporal domain is required to be assessed (Langousis and Kaleris, 2014). Global climate models (GCMs) are an important tool available for estimating the anticipated impacts of changing climate. GCMs are the numerical models that are normally used to simulate the response of the changing climate both in present and future climate based on the forcing by greenhouse gases and aerosols. GCM outputs are coarse in spatial resolution and often required to convert the outputs of GCMs into

DOI: 10.4018/IJAMC.2019010102

Copyright © 2019, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.

local climatological variables necessary for analysis of changes in the climate. A technique known as ‘downscaling techniques’ is used to convert the coarse GCM output into finer resolution.

Two major approaches of downscaling techniques are dynamical downscaling and statistical or empirical downscaling technique. Dynamic downscaling derives local-scale information through Regional Climate Model (RCM) while empirical downscaling is based on the principle that regional and local climates are the results of the interaction of the atmospheric and oceanic circulation as well as regional topography, land-sea distribution and land use, etc. (von Storch et al., 2000). Thus, empirical downscaling derives local climatic information from the larger scale through inference using stochastic or deterministic functions. Statistical downscaling models usually implement linear methods such as multiple linear regression, local scaling, canonical correlation analysis, or singular value decomposition (Salathe, 2003; Schubert and Henderson-Sellers, 1997; Conway et al., 1996). Statistical downscaling model (SDSM) is a well-recognized statistical downscaling tools to implements a regression based method (Wilby et al., 2002). Linear methods generally do not provide reliable information on various projected meteorological variables which includes rainfall and temperature (Xu, 1999; Schoof and Pryor, 2001). To overcome the situation, attempts were made to investigate the applicability of nonlinear methods such as artificial neural network (ANN) and analogue methods (Bishop, 1995; Zorita et al., 1995; Singh and Borah, 2013; Shao and Li, 2013). ANNs is recognized as one of the effective method in solving nonlinear and time-varying problems (Aziz et al., 2014; Jeong et al., 2012; Bhattacharjee et al., 2016). ANNs can approximate highly nonlinear relationships of input-output data series better than other nonlinear regression techniques due to their typical network structure and the nonlinear (Acharya and Nitha, 2017; Sharma and Virmani, 2017; Chatterjee et al., 2016). The performance of standard ANN models like Multilayer perceptron are comparable to that of the multiple regression downscaling methods (Weichert and Bürger, 1998; Cannon and Whitfield, 2002; Coulibaly, 2001). All things considered, a few studies have additionally demonstrated that the standard ANNs that are often utilized for hydrologic modeling are not appropriate to time varying problems, and often fail to yield optimal solution (Aksoy and Dahamsheh, 2009; Coulibaly et al., 2001; Lang, 1990).

Other classes of neural systems that incorporates memory structure to represent temporal features of input-output relationship which are found to be more appropriate for modeling complex nonlinear system (Coulibaly et al., 2001; Li et al., 2016; Li et al., 2016). This memory can store the past information of a time series of input sequences. Memory may be incorporated in two in the neural network systems either by feed forward delays or feedback delays. Time Delay Neural Network (TDNN) is an example of feed forward memory which involves explicit inclusion of delays with a fixed memory resolution (Lang, 1990; Williams and Zipser, 1989; Principe, 1993). The drawback of TDNN is its inability to adjust the values of the time delays automatically. Recurrent neural network(RNN) is a feedback delays network that utilizes a trace of the previous states of the input series. One of the problems associated with RNN is that the training scales badly with both network and problem size (Williams and Zipser, 1989). To overcome these drawbacks, the research community started searching new types of memory. In literature, a special type of neural system based on gamma memory which includes properties of feed forward as well as feedback delays (Principe, 1993). This gamma memory based neural system has been suitably used for solving temporal problems in various fields (Lawrence, 1997; Choudhury and Roy, 2015). Studies have reported that ANN when trained with traditional learning algorithms such as gradient descent algorithm often fall into local minima and cannot reach the global optimal. Associated problems with this algorithm are the slow learning convergence and easily get trapped at local minima. There are various algorithms available in literatures (Kumar et al., 2016). Optimization techniques such as genetic algorithm is proved to be an efficient technique for optimizing the performance of ANN in various ways (Kumar et al., 2016; Chau et al., 2005). Integration of genetic algorithm with ANN models was found capable to improve the performance of the ANN models. Genetic algorithm being based on the survival of the

12 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/article/analysis-of-precipitation-variability-using-memory-based-artificial-neural-networks/216112

Related Content

The Role of Artificial Intelligence in Healthcare: Successful Factors, Challenges, and Ethical Considerations

Munish Gupta, Shapali Bansal, Naveen Sharma, Anita Goyal and Girish Lakhera (2024). *Artificial Intelligence and Machine Learning-Powered Smart Finance* (pp. 173-186).

www.irma-international.org/chapter/the-role-of-artificial-intelligence-in-healthcare/339168

Ensemble Model for the Risk of Anemia in Pediatric Patients With Sickle Cell Disorder

Jeremiah Ademola Balogun, Adanze O. Asinobi, Olawale Olaniyi, Samuel Ademola Adegoke, Florence Alaba Oladeji and Peter Adebayo Idowu (2019). *International Journal of Computers in Clinical Practice* (pp. 33-59).

www.irma-international.org/article/ensemble-model-for-the-risk-of-anemia-in-pediatric-patients-with-sickle-cell-disorder/257498

A Modified Cuckoo Search Algorithm for Data Clustering

Preeti Pragyan Mohanty and Subrat Kumar Nayak (2022). *International Journal of Applied Metaheuristic Computing* (pp. 1-32).

www.irma-international.org/article/a-modified-cuckoo-search-algorithm-for-data-clustering/284572

Dantzig-Wolfe Decomposition and Lagrangean Relaxation-Based Heuristics for an Integrated Production and Maintenance Planning with Time Windows

Najib Mohamed Najid, Marouane Alaoui-Selsouli and Abdemoula Mohafid (2016). *Handbook of Research on Modern Optimization Algorithms and Applications in Engineering and Economics* (pp. 601-629).

www.irma-international.org/chapter/dantzig-wolfe-decomposition-and-lagrangean-relaxation-based-heuristics-for-an-integrated-production-and-maintenance-planning-with-time-windows/147531

The Great Salmon Run Metaheuristic for Robust Shape and Size Design of Truss Structures with Dynamic Constraints

Ahmad Mozaffarian and Mehrzad Ebrahimnejad (2014). *International Journal of Applied Metaheuristic Computing* (pp. 54-79).

www.irma-international.org/article/the-great-salmon-run-metaheuristic-for-robust-shape-and-size-design-of-truss-structures-with-dynamic-constraints/114206