# Soft Computing Approaches on Climate Modeling and Weather Predictions: A Review

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**Abstract: Weather forecasting is the use of science and technology for predicting the weather condition at a location for future time. It is not a new phenomenon. Since 650 BC, the Babylonians used to predict weather on cloud patterns and astronomical observations. Day by day the weather forecasting has become more complex due to drastic change in climatic conditions and weather parameters. As the climatic conditions have changed, the traditional method of weather forecasting could not be helpful in accurately predicting the weather. The emergence of soft computing models in the year 1990 helped a lot in predicting the weather. This paper makes review of all soft computing approaches for climate modeling and weather forecasting since its inception. The contribution of soft computing in weather forecasting has now become a challenge and further new models are being developed by the researcher in meteorology.**
**Keywords: Weather Forecasting, Soft Computing Techniques, Climate Models, Ensemble Modeling, Hybridization of Models.**

## I. INTRODUCTION

Soft computing techniques have become very familiar in different fields like medical science, pattern recognition, physics, chemistry and stock market analysis. The different techniques present in soft computing domain makes it easier to predict the future market conditions in stock market analysis, diagnosis the future consequences of a patient in medical science, recognizes the pattern etc. The further developments in the field of soft computing has made it more easier for doctors to do medical diagnosis, the weather scientists to predict the future weather easily. The soft computing techniques are performing better than the tradition statistical methods of prediction of weather. The statistical methods like linear regression, ARIMA are now prevailed by the soft computing techniques like SVM, MLP, and Decision Tree etc.

The prediction of weather like rainfall in Delhi is to be predicted by using traditional statistical techniques, then by use of soft computing techniques. This paper will make a survey of different techniques used for predicting the weather in Delhi by use of advanced techniques of soft computing.

The use of soft computing techniques and machine learning plays an important role in predicting the future weather. The prediction of weather includes prediction of temperature, rain fall, wind-flow, flood etc. The result says that the prediction of weather conditions is more promising when we use the soft computing techniques than the traditional approaches.

## II. OBJECTIVES

Weather forecasting is the prediction of atmospheric condition at a particular place by considering the different weather parameters. Earlier the prediction of weather was done by man- made predictions looking at weather conditions. Gradually, the drastic change in weather parameters is not so easy any more to predict the weather manually. This weather condition made it compulsory for the researchers and meteorological department to predict the weather condition by applying different mathematical and statistical predictors. Now-a-days, soft computing techniques have become familiar in research to predict in the medical field, pattern recognition and weather forecasting. This study makes a review on the soft computing approaches for weather forecasting in Delhi.

## III. LITERATURE REVIEW ON WEATHER PREDICTION MODELS

### *3.1. Studies Abroad:*

Hamidi et al. [3] have made a comparative study of Support Vector Machine (SVM) and ANN for predicting precipitation in two synoptic stations in Hamadan (Airport) in the west of Iran. They have invested the potential of SVM and ANN to model the weather forecasting in terms of precipitation amounts. The precipitation estimate of SVM was compared with that of ANN model. The results of SVM and ANN were compared based on root mean squared error (RMSE) and concluded that SVM outperformed the ANN in predicting the precipitation.

Weather analysis is playing a vital role in meteorology and has become a challenge for the researchers in the last century. The historical time series data all over the world is collected and analyzed for useful knowledge extraction. Talib et al. [4] have implemented K means clustering and J48 Decision Tree for weather analysis and suggested that future work may expend the database for important weather parameters and it may be implemented for agriculture sector with cutting edge technologies.

Gocken et al. [6] have used ANFIS (Adaptive Network Based Fuzzy Inference System), ANN and MRA (Multiple Regression Analysis) for weather forecasting and concluded that ANFIS could be used for further weather forecasting studies.

Strobach et al. [8] have used machine learning algorithms to improve climate prediction and reduce the uncertainties. It shows that learning algorithms can help to better assess the climate prediction. The SLA (Sequential Learning Algorithm) method provided better predictions than the other contemporary climate models. In this, the output of the model was divided into two periods, a learning period in which the weights were updated. The other is prediction period in which the weights remained fixed. The SLA method does not rely on any assumptions in the distributions of climate variable; hence it is robust and can be used for any climate variable.

Chawsheen et al. [9] have used SARIMA (Seasonal Auto Regressive Integrated Moving Average) model and suggested that temperature prediction in Iraq was more accurate. The temperature in Iran has been changed like the other areas in the world. The changing phenomena of climate have been studied by many researchers among them the SARIAM and ARIMA models are important. The fitted SARIMA model is a good general model for fitting temperature data in accurate prediction of climate.

Wang et al. [12] made as study of SARIMA using the weather data of Shouguang city, China from 1996 to 2008 and conclude that SARIMA model has good model fitting degree in decision making for agricultural irrigation.

Tektas M. [15] has compared the ANFIS and ARIMA models for weather forecasting as a case study in Istanbul and found that ANFIS was better when compared on the basis of MAE, RMSE and R2. The study of statistical and neuro-fuzzy network models for forecasting the weather in Turkey developed the models. Nine years data (2000-2008) comprising of daily average temperature, air pressure and wind speed was used. The criteria of performance evaluation were calculated for estimation of the better model. The performance comparison of ANFIS and ARIMA models on the basis of MAE, RMSE and R2 indicate that ANFIS yields promising result in predicting the weather.

As weather is a natural phenomenon, the forecasting is a great challenge for the scientists and researchers. Jain et al. [18] have presented a study of the use of weather forecasting techniques with time series data. They have focused on the performance of Exponential Smoothing (ETS) model and Autoregressive Integrated Moving Average (ARIMA) during prediction of different weather parameters such as rainfall, air temperature, relative humidity, gust etc. The study of comparing the ETS and ARIMA model with estimation of MAE, MASE, RMSE, AIC and BIC could conclude the better performance of a model.

The time series forecasting utilizes the soft computing approaches for time series prediction like ANN and SVM. It is apprised that time series information is combination of linear and non linear each therefore individual model is not capable of handling the issue. So, hybridizing of models is the point to be explored more. Sanghani et al. [19] have conjointly studied regarding the ANN and SVM and analyzed that hybridizing the models by exploiting the strength of individual models could be a new technique for better weather forecasting.

Amato M. D. [21] has suggested that an interesting direction for future research could involve a comparison between Multiple Regression Analysis (RMA) and Rough Set Theory (RST). Here the rough set theory has been applied to a large number of property transactions for mass appraisal problems. The results of RST are encouraging than MRA.

Jain G. et al. [22] have presented a study of the use of weather forecasting techniques with time series data. They have focussed on performances of Exponential Smoothing (ETS) model and Auto Regressive Integrated Moving Average (ARIMA) model during prediction of different weather parameters such as rainfall, air temperature, relative humidity and gust etc.

Bushara N. O. et al. [23] have made a review of using various computational intelligence tools in weather forecasting and focused on the capabilities of neural networks in the prediction of several weather phenomena such as rainfall, temperature, flood and tidal level etc. The feed forward network and radial basis function networks have illustrated a good performance and reasonable prediction accuracy.

Weather forecasting has become so important in day to day life that it plays a major role to make more informed daily decisions, and to keep out of danger. Unlike traditional weather forecasting, modern weather forecasting involves combination of soft computing models. Saxena A. et al[24] have presented a survey using artificial neural network (ANN) approach for weather forecasting to yield good result and could be considered as an alternative to traditional meteorological approaches. The major ANN models alike BP and MLP predict the weather phenomenon like temperature, thunderstorm, rainfall etc.

Data mining is the technique used to extract the knowledge from the set of data. The data mining technique can be used in weather forecasting to help the farmer to yield worthy productive and nourish the soil fertility. Shivaranjani P. et al[25] have a made a review on supervised and unsupervised machine learning algorithms to perform weather prediction of rainfall for daily, monthly and yearly.

Maqsood I. et al.[26] have developed neural networks based ensemble models and applied for hourly weather forecasting of Southern Saskatchwan. The ensemble neural network can be easily developed to perform multi class classification problem without increasing the calculation complexity. The ensemble model is contrasted with MLPN, ERNN, RBFN, and HFM. The empirical results indicate that HFM is less accurate than RBFN. In comparison, the ensemble of neural networks produces more accurate and promising results.

As the weather is a continuous, data sensitive, multi dimensional dynamic process, forecasting of weather is a formidable challenge. Adeyemo A. B. [28] has presented the use of soft computing techniques, SOM and CANFIS for knowledge discovery and prediction of rainfall and weather parameters for climate change studies using historical time series data collected from Nigeria for about sixty years. The ensemble of soft computing models will yield more promising and accurate result.

*3.2. Studies in India:*

Babu et al. [1] have made a comparison of ANFIS (Adaptive Network Based Fuzzy Inference System) and ARIMA (Auto Regressive Integrated Moving Average) for weather forecasting. They have used the relative humidity, ambient air temperature, air pressure and wind direction from University of waterloo and predicted the climate using ANFIS and ARIMA. In ARIMA, the average testing errors for weather prediction is 0.858 whereas in case of ANFIS, it is 10.356. So, it was shown that ARIMA is more promising method for weather forecasting than ANFIS.

Meera et al. [2] have reviewed different weather forecasting methods and suggested that Artificial Neural Network(ANN) with back propagation uses iterative process of training in which the output with targeted output are compared and the error is calculated. This error is used to readjust the weights of bias to get better output. The mean squared error (MSE) between the predicted and targeted output is used for this purpose. The ANN with back propagation is recommended for the weather prediction more accurately.

Kumar et. al [5] have proposed the new methodology for weather forecasting using Artificial Neural Network in which feed forward back propagation network is used. This process presented promising accuracy and efficiency in weather prediction.

Jayasingh et al. [7] have applied text mining approach for faster weather forecasting and concluded that J48 Decision Tree with text data gives quicker prediction than numeric data. The numeric time series data is converted into text data by applying text mining approach. The comparison was done by using the numeric and text data in J48 Decision Tree. The text data gives promising result in less time. Also they suggested that Natural Language Processing may be helpful for faster weather prediction.

In an agricultural country like India, rainfall prediction is a challenge. The success and failure of agriculture depends on the proper prediction of rain fall. Any deviation in rain fall makes a drastic change in the production of agricultural items. Many algorithms are already used for prediction of rain fall. But, the prediction is not accurate as desired. The application of data mining, Neural Network, Fuzzy Logic and ANFIS could make the prediction of weather better than the traditional prediction mechanisms. Rupa et al. [10] have suggested that ANFIS approach used in rainfall prediction yields good result which can be the best alternative for traditional weather prediction techniques.

Jayasingh et al. [11] have made a comparison between J48 Decision Tree, SVM and MLP for weather prediction on the basis of 4 different error parameters like RMSE (Root Mean Squared Error), MAE (Mean Absolute Error), RAE (Relative Absolute Error) and RRSE (Root Relative Squared Error). The three soft computing models were fed with the time series weather data of 10 years and the prediction of weather was done. They concluded that J48 decision Tree performed consistently better than the other two.

Sharma et al [13] have made weather forecasting using soft computing techniques and concluded that ANFIS is highly appreciated for temperature forecasting.

Rao et al.[14] have proposed an efficient approach for weather forecasting using SVM and suggested that proper selection of parameters can replace the few neural networks by SVM.

Sharma et al. [16] have made the prediction of weather by using Multiple Linear Regression (MLR) and ANFIS on the metrological data. In this study, the ANFIS and MLP models were used to analyze the meteorological data for temperature forecasting, relative humidity, wind speed. ANFIS is highly appreciated on the basis of RMSE.

Sharma et al. [17] have made a comparison of three soft computing techniques, Bayesian Regression, Support Vector Regression, and Wavelet Regression for monthly rainfall forecast and concluded that that Wavelet

Regression was found to be most efficient in rain fall prediction on the basis of RMSE, MAE, R and NSE in the 102 years rain fall data of Assam.

Nayak et al. [20] have made a survey on rainfall predictions using different neural network architectures over 25 years and concluded that forecasting techniques that use MLP, BPN, RBFN, SOM and SVM are suitable to predict rainfall than other forecasting techniques such as statistical and numerical methods.

The maximum temperature, minimum temperature, rainfall, humidity from the historical time series data were used to predict the future weather condition based upon the parameters. Tripathy A. K. et al [27] have analysed that the combination of ANN and PSO has remarkably lowered the error rate with variation of 4+1 % for yearly dataset.

Applying soft computing approaches for climate modeling and weather predictions is feasible than any other short term prediction techniques. Rahul G. K. et al [29] have suggested that applying soft computing techniques for weather modelling to forecast minimum temperature, maximum temperature and pressure. They suggested that MLFFNN with BPA is found to be the better combination for weather forecasting.

## IV. ANALYSIS

The emergence of soft computing techniques has helped a lot in accurately predicting the weather for future time. The traditional methods of weather forecasting fail to predict the weather due to drastic change in climatic conditions now-a-days. The historical time series data of weather is vast and of both linear and non linear in nature. So, only one type of soft computing model will not be helpful in predicting the weather for both types of data set. It requires that ensemble modeling of soft computing techniques will be the solution to tackle the situation. It is the process of running two or more related but different analytical models and then synthesizing the results into a single score or spread in order to improve the accuracy of predictive analysis and data mining applications. The application of text mining also helps in predicting the weather more accurately and quickly. So, in addition to the numeric data, text data also helps us in predicting the weather.

## V. CONCLUSION AND FUTURE SCOPE

Hybridizing the soft computing models will help in obtaining more promising and accurate results. The best parameters of one model will be taken and will be used as input in another model. Thereby, we are using the advantages of two different soft computing models to customize as per our requirement to predict the more hopeful results. The conjoint models will predict the weather by exploiting the strength of the individual models. The soft computing models after being hybridized will give better results not only in weather forecasting but also in other research area like disease prediction in medical science, stock market prediction and many more.

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