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Development of daily temperature prediction model for Northeastern Thailand using artificial neural networks

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Abstract

The aims of this study was to develop the daily temperature prediction models for Northeastern Thailand. Data of 23 northeastern meteorological stations from 1980-2011 were employed for models training with 10,000 data patterns while a 1-year observation of 2014 was left out for performance comparison purpose. The performance of models were calculated by the forecast accuracy on the set of previously selected days. The developed model of daily maximum temperature forecast (T_{max} models) and daily minimum temperature forecast (T_{min} models) forecast ahead 24-72 hours. As a result, MAE was in range of 0.85-1.95 for T_{min} and 0.85-2.68 for T_{max} while RMSE varied 1.16-2.32 and 1.51-3.19, respectively. R-square, moreover, showed good relationship between predicted temperature and actual temperature. Therefore, the 24-hour forecast model is better correlation than 48 hours and 72 hours, respectively.

Keywords: Artificial neural networks, Temperature prediction, Northeastern Thailand

1. Introduction

ANN (Artificial Neural Network) model is very popular method that many researchers apply. Thai Meteorological Department (TMD) also uses ANN to predict daily temperature in short range (covering next 3 days) for Bangkok metropolis and its vicinity, as well as the North of Thailand. The developed model predicts daily temperature by variables containing daily temperature (T), the relative humidity (RH), the pressure (P) and the date order of the year (Julian date) as input. The performance of the models, which predict for the daily highest temperature and daily lowest temperature, is regarded as predictor for both areas. The minimum temperature forecast performs better than the maximum models. In addition, the 24-hr forecast is predicted better than 48 hours and 72 hours, respectively. In 2016, Kirtsaeng et al. used Kriging method in spatial form created Isotherm Map for northern Thailand. It benefited for remote areas where there have been no observation for temperature prediction [1-3].

This study uses imported data, TMD's meteorological elements, based on international standards and moderns, exchanged with the World Meteorological Organization's (WMO) member to make immediate model procession after the last element is measured.

In comparison with current dynamic model, ANN advantages are fewer amounts of computing resources and quicker processing. For overall Northeastern region, this research has been conducted developing a model to predict daily temperature with ANN using elements of following temperature, pressure and humidity from northeastern weather stations during 1980-2012 as shown in Figure 1.

2. Materials and methods

2.1 Data used

To begin the model process, import the data from 23 northeastern meteorological stations during 10 June 1980 to 27 October 2011 (total 10,000 days). The data covers the daily minimum temperatures, the maximum temperature, the relative humidity, the air pressure and the order of dates of years, at 00 UTC (07 LST) for forecasting the lowest temperature and at 09 UTC (16 LST) for predicting the highest temperature.

The model has been validated by the 365-day data series during 2014. There are 6 series consisting of 24-hr T_{max}, 48-hr T_{max}, 72-hr T_{max}, 24-hr T_{min}, 48-hr T_{min} and 72-hr T_{min}.

2.2 Model setup

This model uses 3-Layer Back Propagation Algorithm by determining 20 nodes and 50,000 iterations to create daily temperatures of 24-, 48- and 72-hour ahead.

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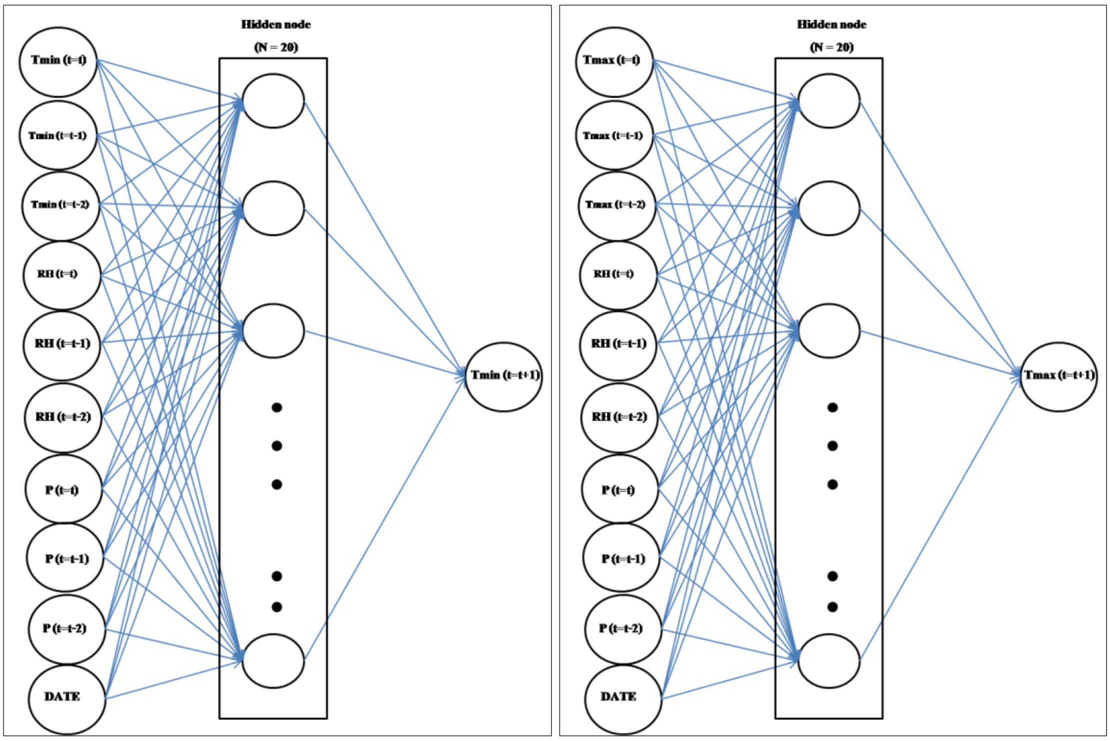


Figure 1 Schematic diagram of modeling Artificial Neural Networks

2.3 Evaluation method

Accuracy of developed model was assessed by mean of Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and Nash-Sutcliffe efficiency (EFF) [4-5].

$$MAE = \frac{1}{n}\sum_{k=1}^{n}\left|y_k - o_k\right| \quad (1)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{k=1}^{n}(y_k - o_k)^2} \quad (2)$$

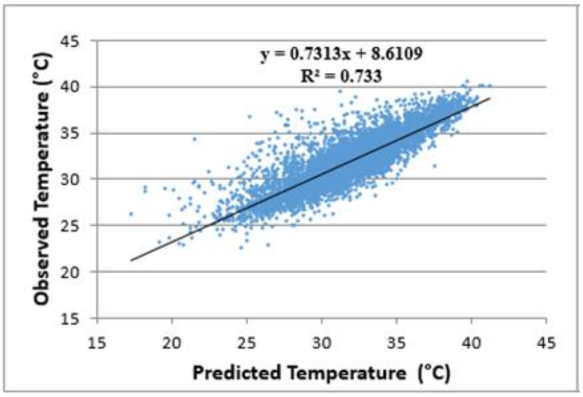
$$EFF = 1 - \frac{\sum_{k=1}^{n}(o_k - y_k)^2}{\sum_{k=1}^{n}(o_k - \overline{y})^2} \quad (3)$$

where 'y' is the forecast value and 'o' equals to measurement value.

3. Results and discussions

Of the 12 ANN models, which used 3-Layer Back Propagation Algorithm by defining 20 nodes and 50,000 iterations, their efficiency showed the R-squared value as Figure 2 shown. The models learned and trained events from imported data that were from 24 northeastern meteorological stations since 10 June 1980 to 27 October 2011 (total 10,000 days). The minimum temperature was performed better than the maximum temperature.

Maximum Temperature



Minimum Temperature

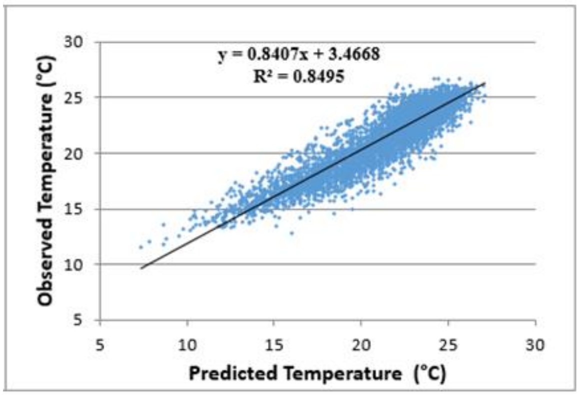


Figure 2 Example of Scatter plot (24 hour forecast) for Nakhonratchasima Station

The below Figures 3 shows MAE and RMSE of learning daily temperature. The MAE of maximum temperature forecast ranging 24, 48 and 72 hours, granted following ranges: 1.12-1.57, 1.33-1.90 and 1.50-2.02, with average of 1.20, 1.60 and 1.74. For minimum temperature of 24, 48 and 72 hours, the MAE gave ranges: 0.88-1.28, 1.07-1.51 and 1.11-1.64. The average MAE had 1.02 1.25 and 1.37, respectively.

The RMSE of maximum temperature forecast ranging 24, 48 and 72 hours, granted following ranges: 1.52-2.06, 1.77-2.48 and 1.98-2.63, with average of 1.75, 2.11 and 2.28. For minimum temperature of 24, 48 and 72 hours, the RMSE gave ranges: 1.16-1.69, 1.40-2.02 and 1.47-2.20 with average of 1.35, 1.66 and 1.73, respectively.

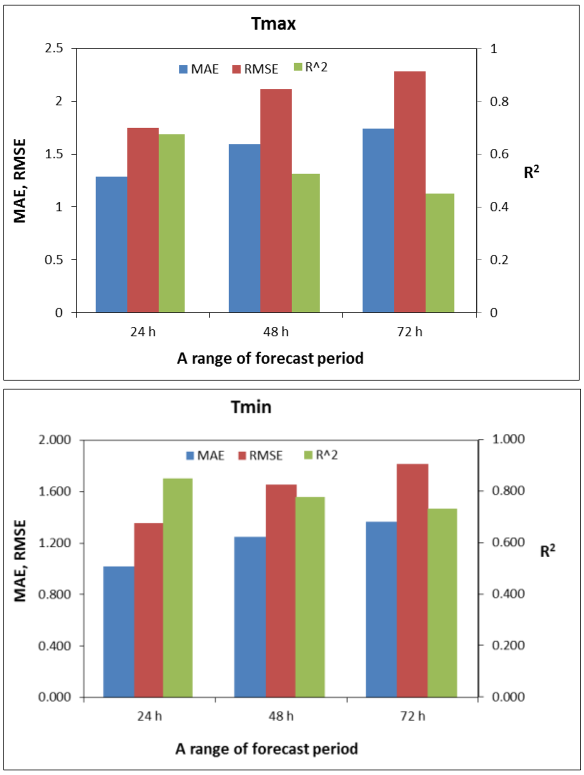


Figure 3 The MAE, RMSE, R^2 of temperature prediction

3.1 Model verification

The model efficiency of daily temperature forecast is shown as Table 1. The MAE of maximum temperature forecast ranging 24, 48 and 72 hours, granted following ranges: 1.19-2.64, 0.85-2.69 and 1.61-2.63, with average of 1.79, 2.00 and 2.13. For minimum temperature of 24, 48 and 72 hours, the MAE gave ranges: 0.86-1.92, 1.00-1.89 and 1.07-1.96 with an average of 1.27, 1.42 and 1.48, respectively.

The RMSE of maximum temperature forecast ranging 24, 48 and 72 hours, granted following: 1.51-3.01, 1.71-3.19 and 2.10-3.18, with average of 2.17, 2.49 and 2.59. For minimum temperature of 24, 48 and 72 hours, the RMSE gave ranges: 1.16-2.27, 1.31-2.30 and 1.34-2.31, with average of 1.59, 1.79 and 1.88, respectively.

The EFF of maximum temperature forecast ranging 24, 48 and 72 hours, granted ranges: 0.77-0.01, 0.14-0.71 and 0.22-0.56, with average of 0.39, 0.22 and 0.16. For minimum temperature of 24, 48 and 72 hours, the EFF gave ranges: 0.29-0.78, 0.23-0.72 and 0.21-0.70, with average of 0.61, 0.54 and 0.49, respectively.

It was found that the model provide short-period temperature forecast more accurate and efficiency than long-term temperature (in Figure 4). Therefore, the developed model could predict minimum temperature more efficient than highest temperature [5-6].

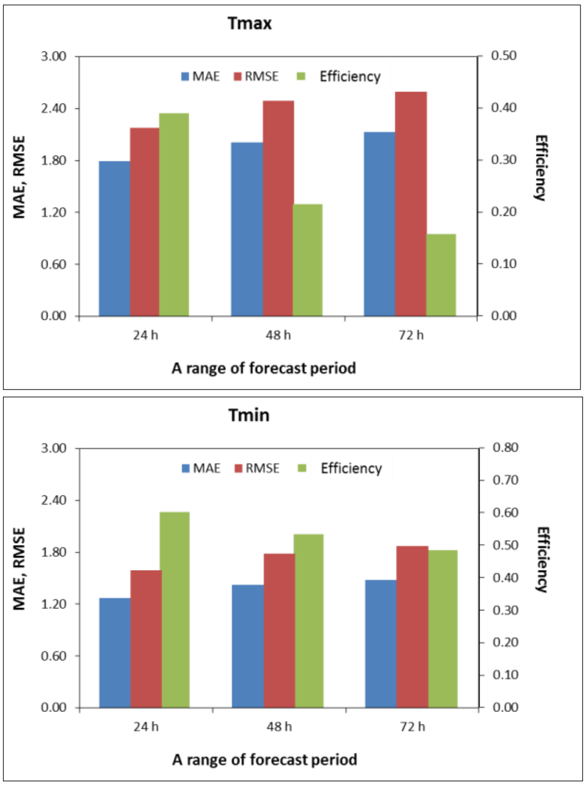


Figure 4 The model efficiency of daily temperature forecast

4. Conclusions

The developed daily temperature forecast model showed accuracy of prediction with 1-3 days temperature prediction. This model processed faster than the dynamic model while ANN model has less error in almost condition. However, in extreme case, the model was unable to predict the sudden change of temperature, but the minimum temperature could be predicted slightly accurate than the maximum. Conversely, short-term forecast, gave a better prediction than longer term forecast, consistent with results of previous studies [1-2, 6]. The model has slightly less prediction skill than Northern model [3], this due to different between specific study area.

5. Acknowledgements

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