Prediction of Sea Surface Temperature in the South China Sea by Artificial Neural Networks

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Introduction Sea surface temperature (SST) significantly affects the processes of air-sea interactions. In SST predictions, the approach of artificial neural networks (ANNs) is data-driven, unlike that of the numerical models, which are physics-based. In this paper, Operational Sea Surface Temperature and Ice Analysis (OSTIA) dataset was used for training ANN models and verifying prediction results. Typically, time series SST data of a certain period were directly used for ANN's training. To reduce the prediction error caused by SST variations, the authors propose to separate SST time series data into climatological monthly mean and monthly anomaly datasets, and construct two neural network models. The combination of these two models gives the final SST prediction results.

Data

Product	Global Ocean OSTIA Sea Surface Temperature Reprocessing
Study area	0-25°N ,105-125°E
Spatial resolution	0.05°×0.05°
Temporal coverage	1 January 1985 to present
Training set	November 1985 to December 2014
Testing set	January 2015 to December 2018

Methods

The Multilayer perceptron (MLP) is adopted in this study. For predicting lead-time 12 months SST, the previous 36 months SST anomaly (SSTA) and SST mean (SSTM) values, from time step t to t-35 were used as input data. The final predicted value is the sum of SSTA and SSTM. This training method is referred to as STM and the directly training method (e.g. t-35 and t month SST to predict t+1 to t+12 SST) is referred to as DTM in the following expression .

Results

Fig. 1 shows the predicted SST distribution obtained using STM method .It is found that the predicted results are broadly consistent with those of the OSTIA SST maps in the study area.

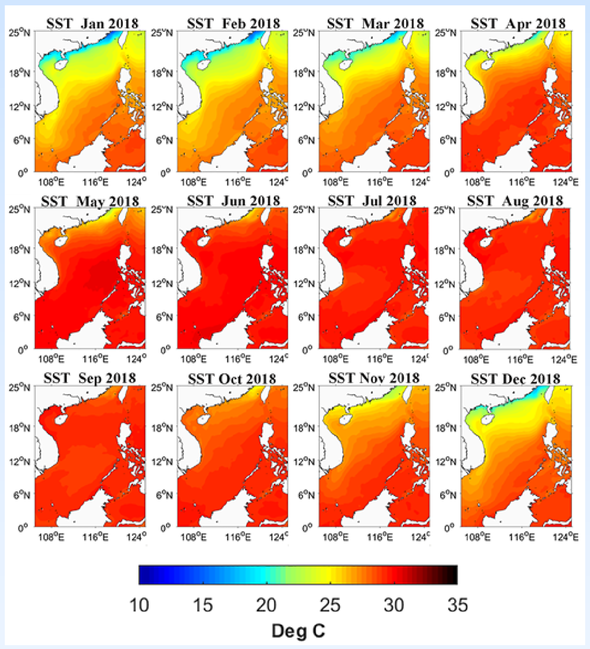

Fig. 1. The SST distribution in 2018 by STM.

Fig. 2. show the differences in SST between the predicted SST and OSTIA. Most of the anomalies predicted by these two methods are found to occur near the coastal area, southeast of Taiwan and Vietnam. This finding is consistent with the SST standard deviation distribution pattern, shown in Fig. 3. The difference between the SST data of OSTIA and that predicted by STM is smaller than that predicted by DTM, especially in the coastal and the relatively high SST perturbation area.

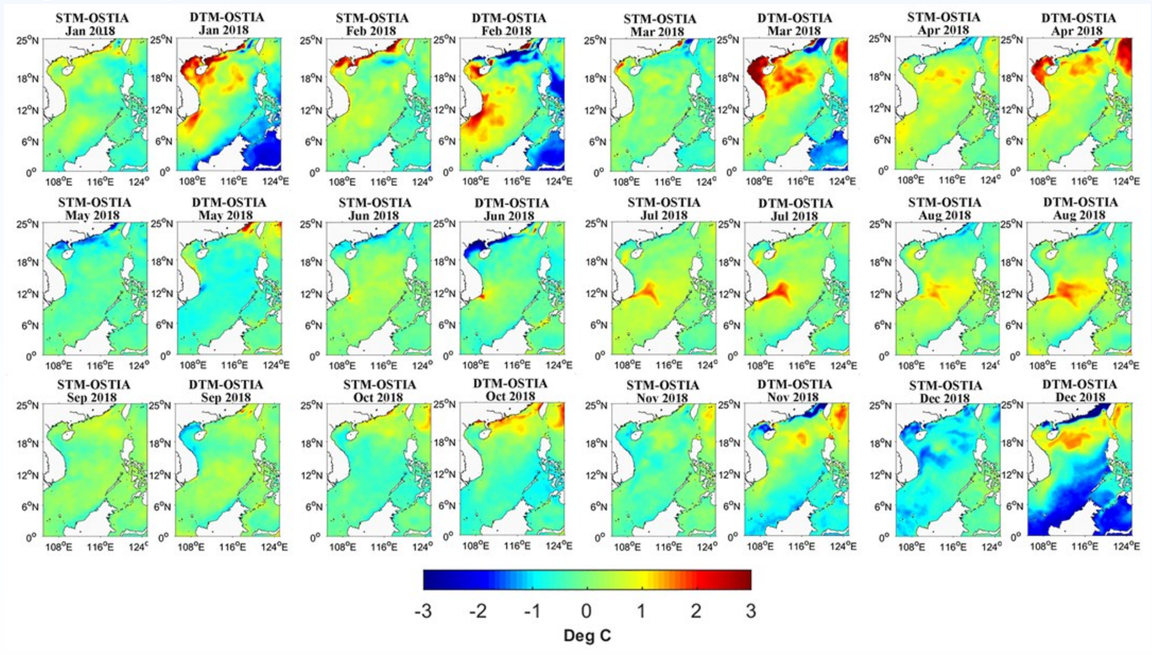

Fig.2. Monthly comparisons of the SST difference in 2018.

For STM, the biases range from -0.64 ℃ to 0.26 ℃ the mean value being -0.07 ℃; the standard deviations range from0.23 ℃ to 0.57 ℃, the mean value being 0.39 ℃. For DTM, the biases range from -0.72 ℃ to 0.46 ℃, the mean value being -0.09 ℃; the standard deviations range from 0.34 ℃ to 1.17 ℃, the mean value being 0.73 ℃.

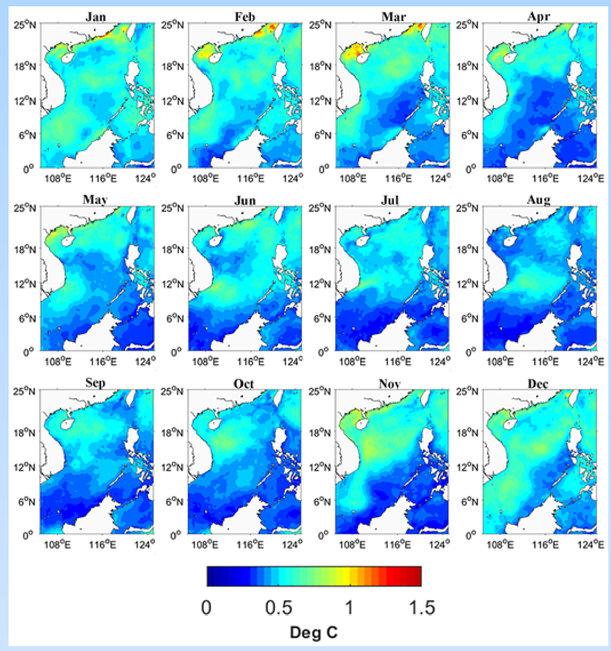

Fig. 3. Monthly SST standard deviations from 1985 to 2018.

The regional mean SST values predicted by STM was compared with the OSTIA values which is shown in Figure 4. In seasonal variability, the mean predicted SST is accordance with the OSTIA SST. Compared with 2015 and 2016, the prediction results of 2017 and 2018 has better agreement. The relatively large bias occurs in June, December of 2015, June, July and December of 2016, and December in 2018. The monthly anomaly was calculated from the OSTIA SSTs between 1985 and 2018. In these months the value is abnormally high. This may result the larger bias in prediction result.

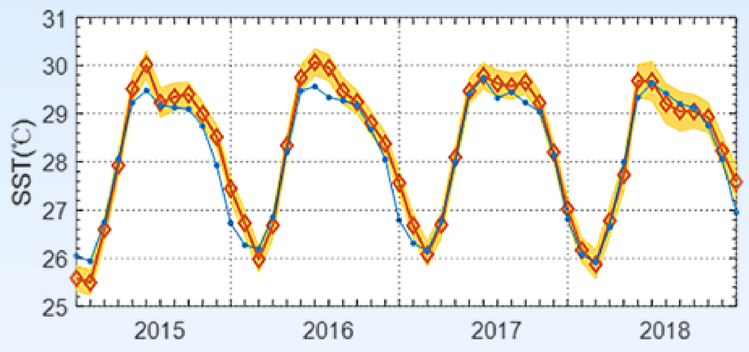

Fig. 6. The SST predicted with the STM (blue points and line); the SST of OSTIA (red diamonds and line) and its analysis error (yellow band).

The biases and standard deviations for each year during the testing period are -0.15±0.39℃ in 2015, -0.26±0.37℃ in 2016, -0.14±0.33℃ in 2017 and -0.07±0.39℃ in 2018. The RMSE values are less than 0.6 ℃.

TABLE II Yearly Statistics of SST Difference

Year	Number	Bias(℃)	Std.Dev (℃)	RMS(℃)	P(±0.5 ℃) (%)	P(±1 ℃) (%)	P(±1.5 ℃)(%)
2015	1774620	-0.15	0.39	0.53	67.01	91.78	98.30
2016	1774620	-0.26	0.37	0.53	62.70	94.57	99.12
2017	1774620	-0.14	0.33	0.39	79.66	98.79	99.84
2018	1774620	-0.07	0.39	0.45	75.60	95.73	99.45

Conclusions

The proposed STM model reduces the degree of dispersion in the prediction results, caused by SST oscillations, thus reducing the standard deviation of the prediction results and thereby improving the prediction accuracy. The average bias and standard deviation between the predicted SST and OSTIA SST are -0.16℃ and 0.37 ℃, respectively. The percentage of SST difference between the predicted SST and OSTIA SST, within ±0.5 ℃ and ±1 ℃, are 71.24% and 95.22%, respectively.