Accuracy Analysis of Error Compensation of BDS Broadcast Ionospheric Model Based on ABC-BP Neural Network

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INTRODUCTION

In the face of the growing demand for autonomous positioning and navigation accuracy, it is necessary to further improve the accuracy of the model and reduce the impact of the space environment on positioning. In this paper, a Back Propagation (BP) neural network optimized by Artificial Bee Colony Algorithm (ABC) is used to compensate for the error prediction of the BDS broadcast ionosphere model from 7 to 13 September 2021. For BDSKlob and BDGIM, a number ofgrid points in the Chinese region and worldwide are selected for experimental analysis. BDSKlob and BDGIM respectively selected several grid points in China and the world for experimental analysis.

METHODS

➢ ABC-BP Model

- The BP neural network connection weights are optimized using the ABC algorithm. The BP loss function is used as the adaptation value function of the ABC algorithm in order to construct a BP model optimized by the ABC algorithm.

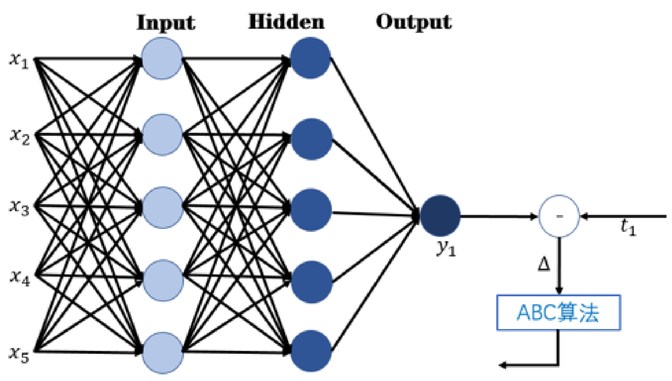

Fig.1 Error prediction model structure

➢ Error Prediction Method

- The ionospheric vertical delay of the target puncture point is calculated using the BDS ionospheric model, the GIM product published by CODE is used as the TEC reference value, and the model error value is calculated as the sample data.
- BP neural network and ABC algorithm parameter setting.
- The sample data is normalised and pre-processed, and the ABC-BP neural network is used for training and prediction to obtain predicted values of the BDS ionospheric model error and compensate for the model values.

RESULTS

➢ BDSKlob Error Compensation

Using the above method, 15 grid points were error compensated and the RMSE before and after compensation was counted for each grid point over a 7-day period.

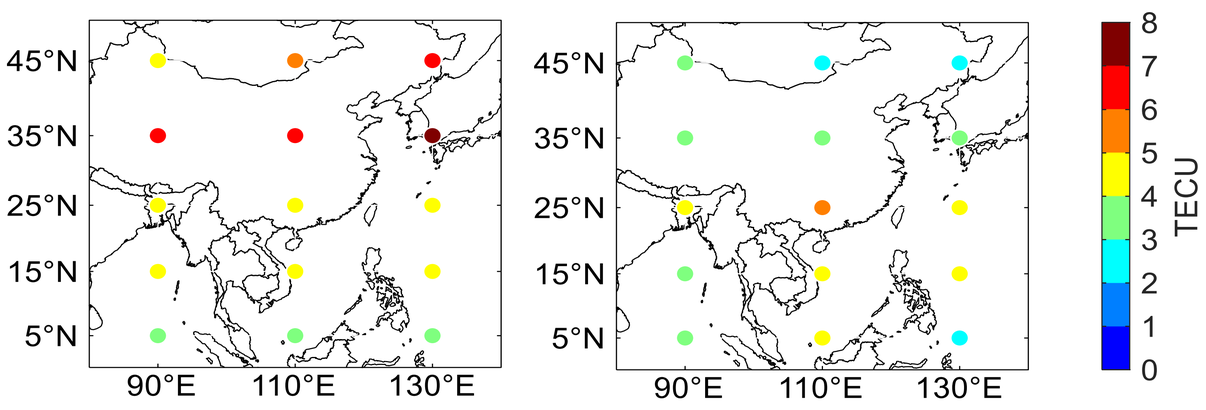

Fig.2 RMSE for BDSKlob and BDSKlob+ABC-BPNN

RESULTS

It can be seen that after compensating for the BDSKlob, the RMSE is reduced to varying degrees for most grid points, with a maximum reduction of 4.22 TECu occurring at (45° N,130° E).

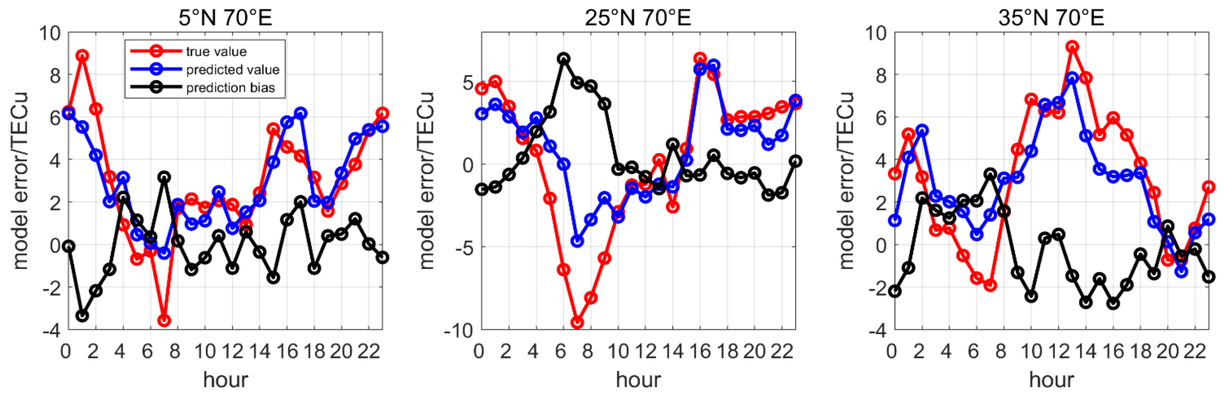

Fig.3 Error prediction of BDSKlob for partial grid points

As can be seen from the Fig.3, the BDSKlob model error prediction values are inmost cases more closely matched to the true values, with only a few cases of large deviations.

➢ BDGIM Error Compensation

For the BDGIM, the same approach was used to predict and compensate for model errors from 7 to 13 September 2021. The RMSE before and after compensation are given and shown in Fig.4 respectively.

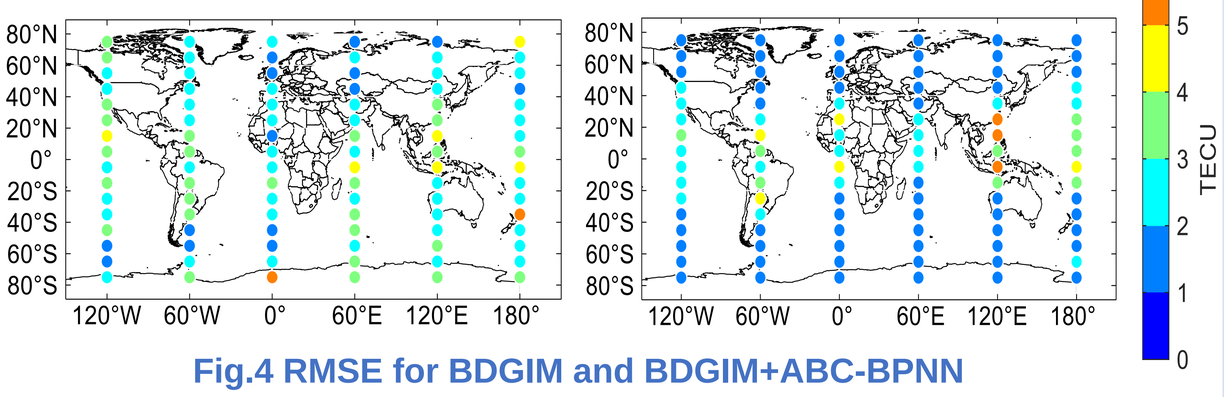

Fig.4 RMSE for BDGIM and BDGIM+ABC-BPNN

It can be visually seen that the RMS is significantly reduced in the mid and high latitudes after compensation.

Table 1 Accuracy statistics of BDGIM in different latitudes

Region	BDGIM		BDGIM+ABC-BPNN	
	RMS/TECu	Correction rate	RMS/TECu	Correction rate
High-latitude	2.19	56.41%	1.78	74.25%
Mid-latitude	3.20	71.54%	2.68	82.05%
Low-latitude	2.47	81.14%	2.18	82.13%
Global	2.84	71.36%	2.18	80.13%

It can be seen that after the error prediction compensation using ABC-BP, the accuracy of the model is significantly improved in the high and middle latitudes and not significantly improved in the low latitudes.

CONCLUSIONS

The prediction compensation of the BDS broadcast ionosphere model errors using ABC-BP neural network can achieve better accuracy results.

- ➢ For BDSKlob, the model correction rate improved to 81.66% in China after using the predicted values to compensate for the model values.
- ➢ For BDGIM, the accuracy was significantly improved in the global mid and high latitudes, with model correction rates of 74.25%, 82.05% and 82.13% for the high, mid and low latitudes respectively after compensation.