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Fuxi Model Precipitation Forecast Correction Algorithm Based on Matrix Transformation

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ABSTRACT

A precipitation area correction model is designed by using the ideas of matrix rotation and matrix translation. The errors of the precipitation forecasts of the Fuxi large - scale model are statistically learned, and the precipitation area deviation is corrected according to the statistical values. The test results show that the precipitation area error after correction is reduced by 2% compared with that before correction, and the deviation is reduced by 1%.

Keywords: Matrix rotation, Matrix translation, Cumulative precipitation, Correction, Precipitation area.

INTRODUCTION

Precipitation, as an important meteorological element, has a crucial impact on people's production and life. Accurate precipitation forecasting and correction are of great significance for many fields such as agricultural production, water conservancy projects, and transportation. Matrix transformation, as an effective mathematical tool, plays an important role in precipitation correction. At present, with the continuous progress of meteorological observation technology and the development of numerical prediction models, people have higher and higher requirements for the accuracy of precipitation forecasting. However, existing precipitation forecast products often have certain errors and need to be corrected to improve their accuracy. The matrix transformation method provides a new idea and approach for precipitation correction. In recent years, discriminant neural networks have been used to distinguish between historical climate simulation samples and observation samples, and cyclic consistent statistical and dynamic constraints have been used to standardize domain - adaptation neural networks, so as to overcome the defects of existing bias correction methods and enhance the effective identification and correction of climate model biases. Internationally, the United States can correct the first - to fourth - order precipitation moments with a resolution of about 1° for daily precipitation forecasts, getting rid of the interaction between model parameterization biases and the chaotic evolution of climate dynamics, opening up a new way for big - data - enhanced climate prediction. Domestically, many scholars have also conducted a large number of studies on precipitation correction based on matrix transformation. The multi - model precipitation correction technology based on probability

matching developed by the Jiangxi Intelligent Grid Meteorological Forecasting Technology Innovation Group won the first prize in the National Intelligent Forecasting Technology and Method Exchange Competition. This technology obtains a more reasonable precipitation spatial distribution and intensity characteristics by integrating different data sources and reasonably allocating weights. This study starts from the perspective of image transformation. By constructing a combined model of matrix rotation and translation and training the model parameters, the precipitation area is corrected in order to improve the forecasting ability of the precipitation area.

DATA

In this study, the 6 - hour cumulative precipitation forecasts of Fuxi [1] are taken as the objects to be corrected, and the 6 - hour cumulative precipitation analysis field of Rise [2] is used as the actual situation field. A total of 8,442 samples during the period [2020 - 2023] [06 - 08] were collected for training.

Tabel 1: Training and Observation data

FuXi		Rise	
1、2020 2、2021 3、2022 4、2023	06/07/08	1、2020 2、2021 3、2022 4、2023	06/07/08

METHODS

A correction model is constructed using a custom matrix translation operator. Let N be an nxn coordinate matrix. The rotated coordinate point v' can be calculated by v' =R*v, where R is the corresponding rotation matrix. The rotation formula is:

$$R = \begin{pmatrix} cos\theta, -sin\theta \\ sin\theta, cos\theta \end{pmatrix} \quad (1)$$

$$N' = \begin{pmatrix} R & \cdots & R \\ \vdots & \ddots & \vdots \\ R & \cdots & R \end{pmatrix} * N$$

The matrix translation algorithm is used to calculate the rotated matrix coordinates, and d is the number of translation grid points.

$$N_{new} = N' + d \quad (2)$$

Tabel 2: Rotation, Translation Algorithm Training

Input: Training data fcst_old

Output: Model parameters

Repeat

B=[0°,90°]

for i εB ;do

| for jε[-5,5];do

| for kε[-5,5];do

| x_{new}~ Trans (i, x_{old}) $+d_j + d_k$

| min $\| X_n - X_{n-1} \|$

Input:Model,fcst¬

Output:fcst_new

fcst_newt = Trans (fcstt) + d_s

Label 3: Forecast correction using rotation and translation algorithms

ANALYSIS

A comparative test was carried out on the precipitation processes in North China, China, before and after correction from June to August 2024. The results show that the TS score has a certain increase for different levels of precipitation thresholds, indicating that this method has a positive effect on improving the systematic errors of the model.

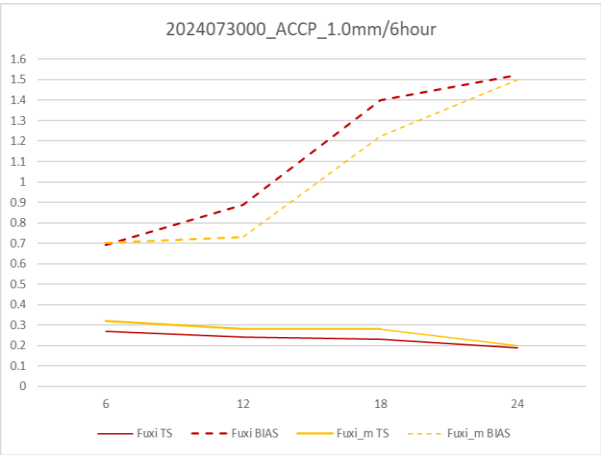

Fig 1: score of 1.0mm accumulated precipitation forecast

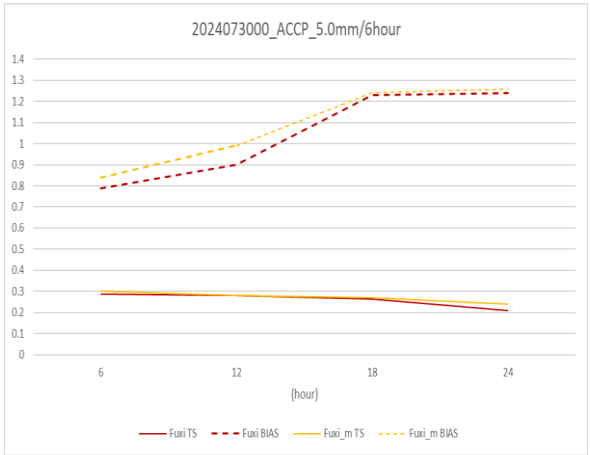

Fig 2: score of 5.0mm ccumulated precipitation forecast

A correction comparison was carried out on a significant precipitation process in North China, China, in July 2024. The results show that the corrected model after training has a significant improvement in the forecasting ability of this process, and the trend of the precipitation area is closer to the actual situation.

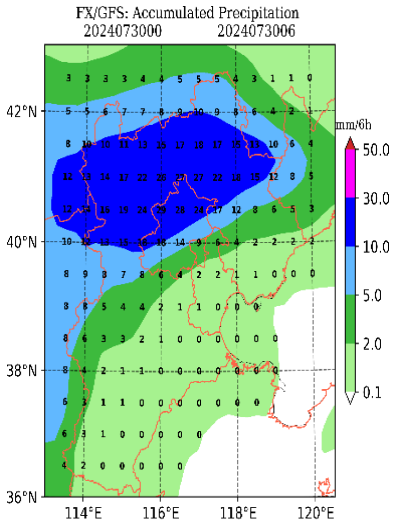

Fig 3: Original forecast result

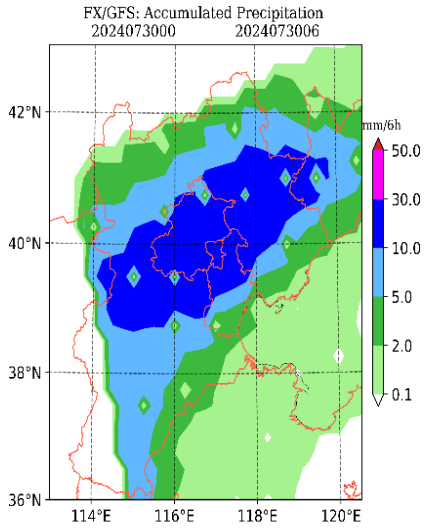

Fig 4: Optimized forecast result

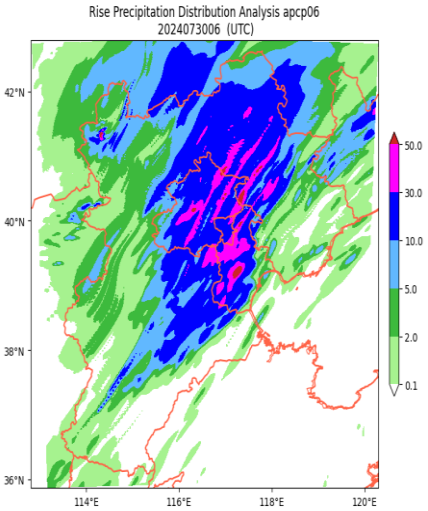

Fig 5: Observed result

CONCLUSIONS AND PROSPECTS

The precipitation correction based on matrix rotation and translation operators can effectively improve the forecasting ability of the precipitation area of numerical models, and enable more accurate prevention and rescue responses to disasters caused by extreme precipitation areas.

The limitation of this method is that it cannot improve the magnitude of precipitation extremes. In future research, it is planned to explore the addition of diffusion generation operators to further improve the forecasting ability of precipitation extremes.

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