Correction Algorithm of Temperature Forecast Based on an Objective Optimal Scheme

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Abstract The forecast results of temperature based on the intelligent grids of the Central Meteorological Observatory and the meteorological bureau of the autonomous region and the numerical forecast model of the European Center (EC model) from February to December in 2022 were used. Based on the data of the national intelligent grid forecast, the intelligent grid forecast of the regional bureau, EC model, *etc.*, temperature was predicted. According to the research of the grid point forecast synthesis algorithm with the highest accuracy rate in the recent three days, the temperature grid point correction was conducted in two forms of stations and grids. In order to reduce the deviation caused by the seasonal system temperature difference, a temperature prediction model was established by using the rolling forecast errors of 5, 10, 15, 20, 25 and 30 d as the basis data. The verification and evaluation of objective correction results show that the accuracy rate of temperature forecast by the intelligent grid of the regional bureau, the national intelligent grid, and EC model could be increased by 10%, 8%, and 12%, respectively.

Key words Objective correction; Optimal extraction; Temperature correction; Average sliding deviation

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With economic development and the continuous improvement of people's living standards, people's demands for the refinement of meteorological services are getting higher and higher. The production of refined weather forecast that are timed, targeted and quantified has become an inevitable trend in the development of weather forecast. Temperature is one of the basic elements of weather forecast, as well as a meteorological element that the public pays close attention to[1]. It is necessary to make temperature forecasts that are timed, fixed-point and quantified in refined forecasting. At present, both the state and autonomous regions have achieved the business production and release of intelligent grid forecast. The business framework of the state and provinces jointly weaving a network has been formed, and the business of municipal-level meteorological bureaus is gradually shifting towards application and short-term and imminent monitoring and early warning. However, it should be noted that professional forecasting services are becoming the direction of reform and development for municipal-level meteorological bureaus, and conventional public forecasts, professional forecasts and impact forecasts all put forward higher requirements for the accuracy of the forecast. Through the inspection of the superior grid point prediction guidance products, the accuracy rate of the current grid point products is still insufficient compared with the prediction accuracy rate of traditional stations, and there are still shortcomings in practical applications. There is still a large space for the correction of the deviation of grid point prediction elements in Hulunbuir City. Therefore, it is very necessary to promote the research of intelligent grid correction algorithms. High-accuracy correction products will promote the development of professional forecast and other services. At present, the release technology of numerical prediction products is regarded as an effective way to improve the level of temperature prediction, and many effective and practical objective release methods have been explored, such as BP neural network method[2], decreasing average method[3], and multiple regression method[4]. Compared with the direct output results of the original model, the prediction levels of these methods have been significantly improved. Under this background, in-depth analysis and guidance of the spatial and temporal distribution characteristics of product deviations, statistical analysis of the local climate characteristics of elements, quantitative processing and introduction of forecasters' forecasting experience, and establishment of a new statistical and applicable lattice forecasting algorithm based on mature statistical forecast methods are important issues faced by lattice forecast.

1 Data and methods

The forecast results of temperature based on the intelligent grids of the Central Meteorological Observatory and the meteorological bureau of the autonomous region and the numerical forecast model of the European Center (EC model) from February to December in 2022 were used. The initial reporting times were 08:00 and 20:00. The forecast and real-time data used were all derived from the Tianqing system of the Inner Mongolia Autonomous Region Meteorological Bureau. The forecast data contained the forecast data of temperature based on the intelligent grids of the Central Meteorological Observatory and the meteorological bureau of the autonomous region, with an element time interval of 3 h and a resolution of 5 km. The two-meter temperature forecast data of EC

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model also had an element time interval of 3 h and a resolution of 0.125°. The real-time data of stations were the observation data of temperature, maximum temperature, minimum temperature from 300 regional automatic stations in Hulunbuir City. The real-time data of CLDAS grid points were also adopted, with a resolution of 5 km and a time interval of 1 h.

Based on the data of the national intelligent grid forecast, the intelligent grid forecast of the regional bureau, EC model, *etc.*, temperature was predicted. According to the research of the grid point forecast synthesis algorithm with the highest accuracy rate in the recent three days, the temperature grid point correction was conducted in two forms of stations and grids. The rolling forecast errors of 5, 10, 15, 20, 25 and 30 d were as the basis data to establish a model for temperature forecast, so as to reduce the deviation caused by the seasonal system temperature difference. The forecast model was gradually established through the weighted average deviation method and the similar deviation method. The forecast deviations of stations or grid points in the first 30 d were calculated, and then the forecast deviation was subtracted from the current forecast field to obtain the corrected forecast field. Forecast deviation and the revised temperature forecast field can be calculated as follows:

$$B_k(0, t) = \frac{1}{D}\sum_{d=1}^{D}[T_k^{NWP}(d, t) - T_k^{ODS}(d, t)]$$

$$T_k^{CC}(0, t) = T_k^{NWP}(0, t) - B_k(0, t)$$

In the formulas, k represents different stations; t is different forecast validity periods; d means the previous forecast field (which can be adjusted as needed).

On this basis, the deviation was multiplied by a certain coefficient to obtain the corrected temperature as follows:

$$T_k^{CC}(0, t) = T_k^{NWP}(0, t) - f_k \times B_k(0, t)$$

By using the program test, the 10 correction schemes of weight coefficient in the range of 0.1 to 1.0 were calculated synchronously. According to the principle of the highest accuracy rate of the 3-day forecast, the optimal objective forecast model was determined.

2 Inspection and evaluation of objective correction results

2.1 Evaluation of multi-model objective correction schemes for the national intelligent grid In 2022, the accuracy rate of temperature forecast by the national intelligent grid was around 60%, with an absolute error of 2.2 ℃, an average error of −1 ℃, and a root mean square error of 8.6 ℃. It was somewhat lower than that of urban forecast (80%). From the test results of various objective correction algorithms in this study, it is seen that there were three obvious characteristics. Firstly, the accuracy rate significantly improved compared with the national intelligent grid guidance forecast. Among them, the accuracy rate of most schemes based on the sliding deviation average scheme enhanced obviously compared with the guidance forecast. The maximum improvement rate was up to 8%, and the accuracy rate of temperature forecast reached 68% (Fig. 1). The accuracy rate of the scheme with the minimum improvement was also more than 3% higher than that of the guidance forecast. Secondly, the absolute average error and root mean square error decreased significantly compared with the guidance forecast, declining from the original 8.6 ℃ to about 5 ℃. Thirdly, the improvement effect of the similar deviation correction scheme was not as obvious as that of the average sliding deviation, but on the whole, it was improved compared with the guidance forecast. It is proved that the sliding deviation average scheme and the similar deviation correction scheme were effective in the correction based on the national intelligent grid guidance forecast, because they can improve the accuracy rate and reduce the error.

2.2 Evaluation of multi-model objective correction schemes for the intelligent grid of the regional bureau In 2022, the accuracy rate of temperature forecast by the intelligent grid of the regional bureau was about 59%, with an absolute error of 1.6 ℃, an average error of −0.6 ℃, and a root mean square error of 4.5 ℃. The difference between it and that of urban forecast (80%) became smaller. Compared with the accuracy rate of the national intelligent grid guidance forecast itself, it increased by about 10%. It is proved that the intelligent grid of the regional bureau has a greater reference value compared with the national intelligent grid guidance forecast. From the test results of various objective correction algorithms based on the intelligent grid of the regional bureau, it is found that the accuracy rate of most schemes rose significantly except the accuracy rate of some similar deviation schemes was lower than that of the national intelligent grid guidance forecast. Among them, the accuracy rate of most schemes based on the sliding deviation average scheme increased obviously compared with the guidance forecast. The maximum increase reached 10%, and the accuracy rate of temperature forecast was up to 69%. The minimum increase was also above 3% compared with the guidance forecast. The absolute average error and root mean square error declined compared with the guidance forecast, reducing from the previous 4.5 ℃ to about 3.8 ℃. The deceases of the errors were lower than those of the national intelligent grid guidance forecast because the intelligent grid forecast of the regional bureau itself was already relatively accurate. The improvement effect of the similarity deviation correction scheme showed a decrease in accuracy and an increase in error in various schemes with a coefficient of 1, indicating that certain coefficient should be adjusted in the similarity deviation correction. The overall test results reveal that the sliding deviation average scheme and the similar deviation correction scheme were effective in the correction based on the intelligent grid guidance forecast of the regional bureau, because they can enhance the accuracy rate and decrease the error.

2.3 Evaluation of multi-model objective correction schemes for the EC model In 2022, the accuracy rate of temperature forecast by the EC model was about 62%, with an absolute error of 2.1 ℃, an average error of −0.6 ℃, and a root mean square

error of 7.8 ℃. Compared with objective forecast products, the accuracy rate of the model itself was relatively low, and the range of the errors was relatively large. From the test results of various objective correction algorithms based on the EC model, it is seen that the accuracy rate of the similar deviation correction scheme and the sliding deviation average scheme increased obviously. The maximum increase was up to 12%, and the accuracy rate of temperature forecast reached 74%. The minimum increase was also above 5% compared with the guidance forecast. The absolute average error and root mean square error dropped compared with the guidance forecast, decreasing from the original 7.8℃ to about 4 ℃. As the accuracy rate of the model is relatively low and its error are large, the effect significantly increased after the scheme was corrected. However, from the perspective of the highest accuracy rate after the correction, the improvement of the final accuracy rate of the model by this scheme was closely related to the model itself. When the model is inaccurate, the accuracy rate of prediction can be significantly enhanced, but it cannot be too high. Therefore, the improvement is relative rather than absolute. However, the overall test results indicate that the sliding deviation average scheme and the similar deviation correction scheme were effective in the correction based on EC prediction.

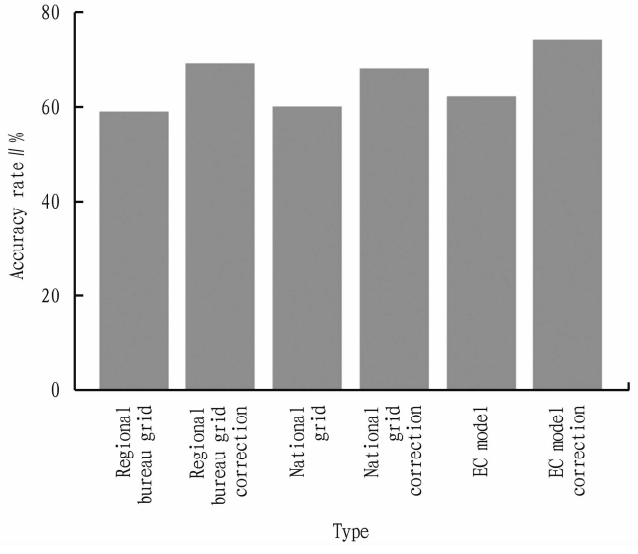

Fig. 1 Correction effects of local objective correction algorithms from February to October in 2022

3 Conclusions

Based on the data of the national intelligent grid forecast, the intelligent grid forecast of the regional bureau, EC model, *etc.*, temperature was predicted. According to the research of the grid point forecast synthesis algorithm with the highest accuracy rate in the recent three days, the temperature grid point correction was conducted in two forms of stations and grids. Through verification and evaluation, the following conclusions are obtained.

(1) To reduce the deviation caused by the seasonal system temperature difference, it is feasible to establish a temperature prediction model by using the rolling forecast errors of 5, 10, 15, 20, 25 and 30 d as the basis data. The accuracy rate of temperature forecast by the intelligent grid of the regional bureau, the national intelligent grid, and EC model could be increased by 10%, 8%, and 12%, respectively.

(2) The results show that the use of this algorithm could effectively improve the accuracy of temperature forecast, and reduce its average error, absolute error and root mean square error.

(3) On the whole, the test results show that the sliding deviation average scheme and the similar deviation correction scheme were effective in the correction based on the national intelligent grid guidance forecast, the intelligent grid guidance forecast of the regional bureau, and EC prediction.

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