Intelligent Revision Application of Similar Collection Method in Strong Wind Forecasting in Complex Terrain Areas of Transmission Channels

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Abstract. With the continuous development of numerical weather prediction technology, the weather forecast mode can provide refined forecasts of meteorological elements such as wind fields and temperatures for the power grid, but there are large errors in the terrain of the power grid transmission channel area. This paper selects in-situ microeoreorological observations of power grid transmission channels during Typhoon Hagupit no. 04 in 2020, and uses the similar set (AnEn) algorithm to re-analyze grid data of European short- and medium-term forecasting centers, and constructs a revised model of wind field forecasting in complex terrain areas of transmission channels, and applies them to strong wind forecasting of transmission channels. The results show that the numerical forecasting mode has a large forecast error in the near-ground area of the complex transmission channel, with a root mean square error of 5.1 m/s. The forecast error in the complex terrain area of western Zhejiang is greater than that in the northern and eastern coastal areas; The similar set method can effectively correct the near-ground wind field, and the forecast error is 4.09 m/s before revision, and the error is reduced to 1 m/s after revision.

Keywords: Transmission channels · Micrometeorological device observation · Revision of numerical forecasts · Similar set methods · Strong wind forecasting for complex terrain

1 Introduction

With the development of supercomputers and the maturity of numerical weather prediction technology, numerical weather prediction models are applied to meteorological services as an important forecasting method, which can provide more accurate forecasts of meteorological elements for weather, climate, water conservancy, electricity and other applications [1]. However, in the process of numerical weather prediction, due to the imperfection of the initial conditions and model defects, there is initial value uncertainty

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and pattern uncertainty in the numerical weather prediction model, and this uncertainty will restrict the forecasting technique. However, the terrain in the transmission channel area is more complicated, because the model does not describe the terrain sufficiently and the observation data of the complex terrain is not fully utilized, so the forecast error in the transmission channel area is large. It is also relatively difficult to combine weather systems of different scales with such complex and steep terrain, so it is more difficult for numerical forecasting models to make good forecasts in these areas, which involves complex terrain processing on the one hand, and data processing on complex terrain on the other hand [2].

In order to minimize the error of the numerical weather prediction model and improve the prediction level, a large number of research and practical business applications use statistics, machine learning and other methods to revise the model output results [3].

In this paper, aiming at the problem that numerical weather prediction has a large deviation in the strong wind forecast of the transmission channel, this paper makes full use of the existing in-situ observation of the micro-meteorological device of the transmission channel, selects the re-analysis grid data of the European short- and medium-term forecast center based on the AnEn algorithm, constructs a revised model of the wind field forecast of the complex terrain area of the transmission channel, and applies the model to the strong wind forecast during Typhoon Hagupit in 2020, and analyzes the error of the numerical forecast in the ground wind field forecast in Zhejiang [4]. Explore the revised plan for ground wind field forecasting in Zhejiang.

2 Information and methods

2.1 Description of Information 3. Math and Equations

The numerical forecast grid data used in this article is the 5th generation of global atmospheric reanalysis data (ERA5) of the European Centre for Medium-Range Weather Forecasts (ECMWF). The ERA5 data provided by ECMWF has been updated continuously in near real time (lag of 5 days) since 1979, with a horizontal resolution of 31 km and a temporal resolution of 1 h. In order to carry out the revision of the strong wind forecast of the transmission channel, this paper selects the data of 24 h after the landfall of Typhoon No. 04 in 2020, that is, from 20:00 on August 3, 2020 to 20:00 on the 4th, Beijing time as the forecast field, and the variable is the full wind speed of 10 m near the ground.

The observation data used in this paper are in situ observations of micrometeorological devices in transmission channels in Zhejiang, including 10 min average wind speed, wind direction, maximum wind speed, air temperature, humidity, air pressure and precipitation, and the observation data collection time interval is 10 min. The data period used in this article is from 20:00 on August 3, 2020 to 20:00 on August 4, 2020, and the average wind speed of 10 min is selected in this article, and the average wind speed of 1 h is obtained by calculation. A total of 1,875 micrometorological device stations are used in this paper, and the distribution of their stations is shown in Fig. 1, which shows that Zhejiang's transmission lines are dense, and the transmission channels are mostly in special sections with complex terrain such as plateaus and mountains. The distribution of micrometeorological devices in the southeast coastal areas of the Middle

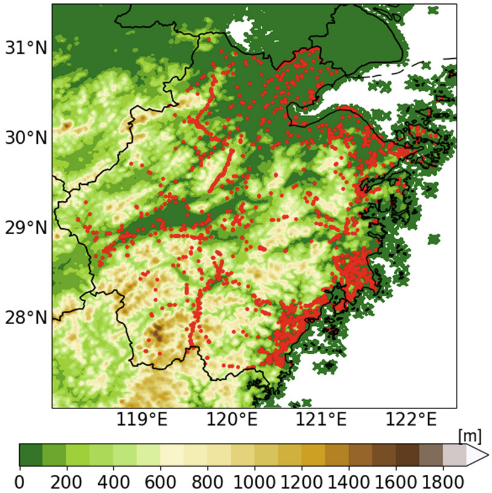

Fig. 1. Micrometeorological device site distribution map, the red solid dot in the figure is the micrometeorological observation station, the shadow is the terrain height, and the unit is **m**.

East, such as Wenzhou and Taizhou, the scattered distribution of transmission channels in the complex terrain areas of the southern mountainous areas, and the distribution of stations in the plains of northern Zhejiang is relatively uniform. The typhoon best path data was selected from the Typhoon Dataset of IBTrACS (International Best Track Archive for Climate Stewardship) and the Meteorological Information Center of the China Meteorological Administration.

2.2 Similar Set Method

Monache et al. applied the similar set method to the interpretation and application of numerical forecast results and error revision, the basic assumption is that for similar weather conditions, similar forecast results should be formed in the numerical model forecast and have similar forecast error distribution characteristics, so historical forecast and observation data can be used to construct a forecast revision model. The brief steps for applying and forecasting revisions to the similar set method are as follows:

1) Build a sample dataset. Select the numerical weather forecast mode to construct the historical time series forecast field in the grid forecast data as $\alpha\tau$, where τ represents different time and α represents meteorological features. The station observation data corresponding to the time of the numerical forecast field are selected, and the historical time series observation field is constructed, which is recorded as O_t, and O represents the meteorological features. The prediction field $\alpha\tau$ space at the same time is interpolated into the observation field and recorded as A_t, so as to complete the spatio-temporal matching of historical forecasts and observations.
2) Select the field to be corrected. The current forecast is selected as the field to be revised, recorded as ft, where t represents the "current" forecast time. Similarly, the

space of the field to be revised is interpolated into the observation space and recorded as f_t.

3) Calculate the "similarity". Use Eq. (1) to calculate the "similarity" of the current forecast A_t to the historical forecast A_t. Where t represents the current moment, t' represents the historical moment, [−t˜,t˜] represents the time window of the forecast revision, Nv represents the number of factors of the elements involved in the forecast revision, and ω_t represents the weight of the I_t factor, which represents the standard deviation of the I_t factor at different times.

$$||F_t, A_{t'}|| = \sum_{i=1}^{N_v} \frac{w_i}{\sigma_{f_i}} \sqrt{\sum_{j=-\tilde{t}}^{\tilde{t}} \left(F_{t+j} - A_{t'+j}\right)^2} \quad (1)$$

4) Calculate similar weights. Use the "similarity" between the current moment obtained in step 3 and different historical moments, and select the most similar historical forecast $||F_t, A_\tau||$, where τ = 1,…,n. Use Eq. (2) to calculate the similar weights ω_j of each member. Where tj represents the historical moment corresponding to the $t_j$similar observation.

$$\omega_j = \frac{\frac{1}{\left\|F_t, A_{t_j}\right\|}}{\sum_{\tau=1}^{n}\left(\frac{1}{||F_t, A_\tau||}\right)} (2) \quad (2)$$

5) Complete the weighted revision. Use the "similarity" between the current moment and different historical moments obtained in step 3), select the actual observations corresponding to n most similar historical forecasts, and construct a set of n observations, which is recorded as O_j, where j = 1,…,n. Using the similar weights calculated in step 4), the revised forecast is calculated by Eq. (3) and recorded as F_{AnEn}.

$$F_{AnEn} = \sum_{j=1}^{n} \omega_j O_j \quad (3)$$

2.3 Revised Model for Strong Wind Forecasting for Transmission Channels

Referring to the above calculation steps, this paper selects the observation data of the micro-meteorological device of the transmission channel from 20:00 on August 3 to 13:00 on August 4 to construct the observation time series O_t, and of the 1 875 stations in Zhejiang, a total of 1 510 effective observation stations were used to construct samples, and the effective observations in the samples total 36 034 groups; Select era5 grid point data spatial interpolation from 20:00 on August 3 to 13:00 on August 4 to obtain the site forecast time series A_t; In this paper, only the wind speed is selected as the correction factor, so the factor weight and standard deviation are both 1; The time window for the revision of the forecast is selected as 3 h before the forecast; In this paper, in the calculation of similarity weights, only the first 5 sets of historical forecasts with the lowest similarity are selected, that is, the value of n is 5; The ERA5 forecast at 14:00 on

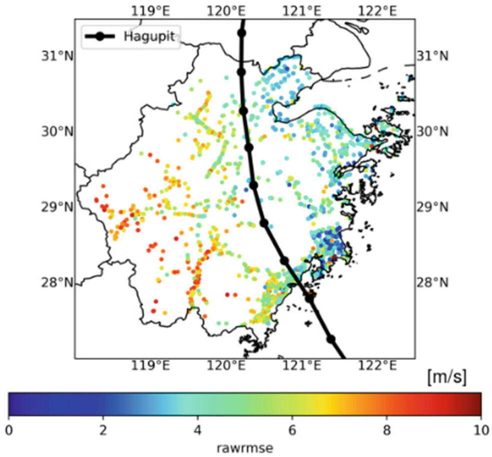

Fig. 2. Micrometeorological observation and ERA comparison chart (the solid black dot line is the typhoon "Hagupit" path, and the colored dot is the deviation of the average wind speed of the observation for 1 h and the forecast, in **m/s)**

August 4 is selected for the revised field, and the micro-meteorological observation data applied to the inspection field at this time are tested by F_R the root mean square error of formula (4), and the forecast and correction accuracy are tested. Where m is the number of stations 1,510, F_{AnEn_i} represents the revised forecast value of the ith site location, and O_i represents the micrometeorological device observation at the site location.

$$F_R = \frac{1}{m}\sum_{i=1}^{m}\sqrt{\left(F_{AnEn_i} - O_i\right)^2} \quad (4)$$

3 Results of the Revision of the Strong Wind Forecast for Transmission Channels

3.1 Micrometeorological Observations Compared with ERA5

Figure 2 shows the statistical chart of the root mean square error of 25 times from 20:00 on August 3 to 20:00 on August 4, micrometeorological observations and ERA5 data at 1 510 station locations, from Fig. 2, it can be seen that in the high-altitude complex areas of western Zhejiang, the forecast error is large, and the error of some stations exceeds 8 m/s; The error in the northern plain of Zhejiang is relatively small in the mountains, and the error in some stations is close to 2 m/s; In coastal areas, the forecast error is slightly lower than in the mountains, although some stations also have an error of more than 10 m/s; Combined with the travel path of Typhoon Hagupit, it can be seen that the left side of the typhoon's travel path has a larger forecast error than the right side, which is mainly related to the structure of the typhoon wind circle.

Figure 3 shows the rms error distribution map and boxline diagram of all test stations from 20:00 on August 3 to 20:00 on August 4. From Fig. 3, it can be seen that the root

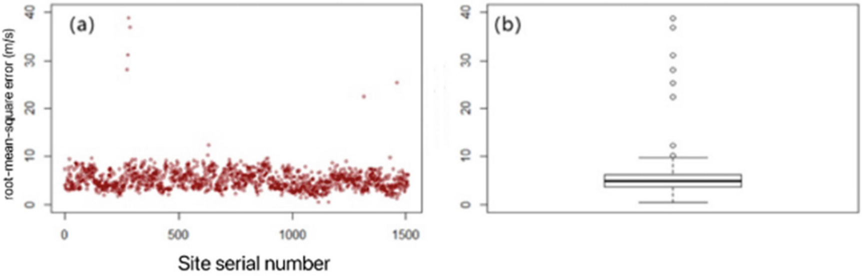

Fig. 3. 1,510 micro-meteorological device observations with era5 1 h rms error distribution (a) and boxline diagram (b) observed by 1,510 micro-meteorological devices from 20:00 a.m. to 20:00 p.m. on **August 4**

mean square error of most observations and forecasts is less than 10 m/s; However, the rms error of individual stations exceeds 30 m/s, for example, the rms error of the Wenzhou Tian'ao Line reaches 55 m/s, and the Wenzhou Tian'ao Line is located near the typhoon landing point, which indicates that the model forecast may have a large error under the condition of extreme wind speed; On average, the rms error of 1 510 stations was 5.13 m/s.

3.2 Revised Forecasts for Strong Winds in Transmission Channels

This article selects ERA5 at 14:00 on August 4 as the field to be revised, and applies the AnEn method to carry out strong wind revision. Figure 4 shows the root mean square error before and after the revision of 1 510 stations at 14:00 on August 4. It can be seen from Fig. 4 that AnEn can reduce the rms error of ERA5, the rms error before revision, especially in the complex terrain area of western Zhejiang, is greater than 5 m/s, and the rms error of most site locations after revision is reduced to 1 m/s; Near the center of the typhoon, there was a large root mean square error before the revision, and the error after the revision was reduced, but the reduction was smaller than in other areas; In coastal areas, especially in areas near typhoon landing sites, the effect of the revision is more obvious; However, there are still individual sites, and the contrast effect before and after the revision is not obvious.

Figure 5 shows the distribution map and boxline diagram of the station-by-station rms error before and after the revision. It can be seen from Fig. 5 that the forecast rms error of some station locations before the revision is large, more than 30 m/s, and the rms error can be effectively reduced through AnEn; Before the revision, the average rms error of all test stations was 4.09 m/s, and after the revision, the rms error was reduced to 1 m/s, and the rms error reduction rate reached 76%. However, it is worth noting that there are still 149 stations where the correction effect is not obvious, and the rms error of these 149 stations increases by 0.88 m/s after revision, accounting for 13% of the total sample, and there are very few stations whose revision effect is poor, such as the observation of the Min 4R21 line station before the revision is closer to the actual situation, the error is less than 1 m/s, and the error increases to 6 m/s after revision,

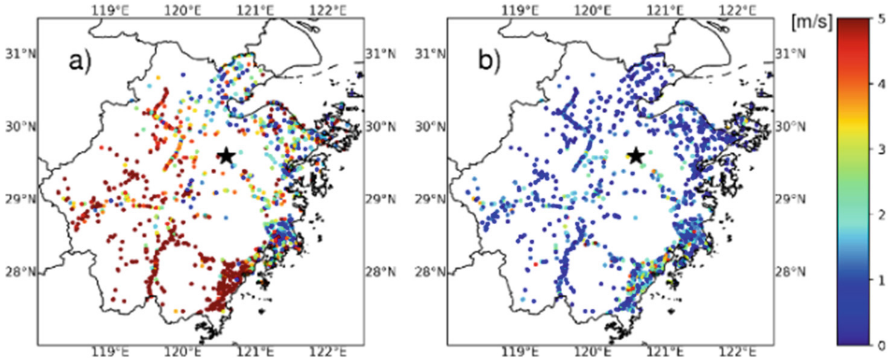

Fig. 4. ERA5 as the field to be revised, the root mean square error distribution map before (a) and after the revision (b) (the correction time is 14 o'clock on August 4, the colored solid dot is the root mean square error, and the black pentagram is the center position of the typhoon at the current **moment)**

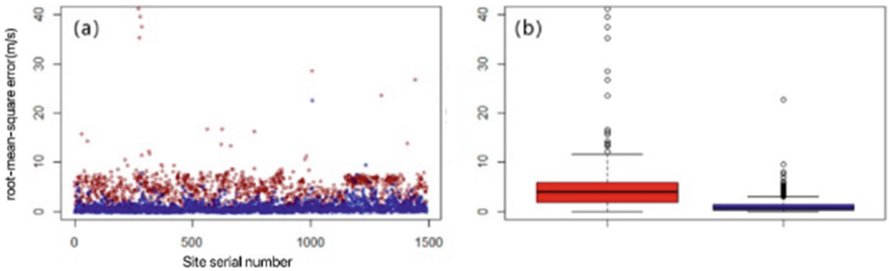

Fig. 5. ERA5 as a field to be revised, 1 510 micro-meteorological device observations with ERA5 1 h rms error distribution (a) and box map (b) (before revision (red) after revision **(blue))**

which indicates that the AnEn method needs to be debugged and applied for station by station.

4 Conclusion

In this paper, based on the micrometeorological device observation of the transmission channel and the ERA5 grid point data, a revised model of strong wind forecasting of the transmission channel is constructed, and the revised test of Typhoon Hagupit no. 04 in 2020 is selected. The test results show that:

1) The numerical forecasting mode is in the near-ground area of the complex transmission channel, and the forecast error is large. In this example, the root mean square error is 5.1 m/s, and the forecast error of individual measuring stations is even more than 30 m/s; The forecast error in the complex terrain areas of western Zhejiang is greater than that in the northern and eastern coastal areas.

2) The similar set method can effectively correct the near-ground wind field, and the forecast error in the selected cases in this paper is 4.09 m/s before revision, and the error is reduced to 1 m/s after revision; In coastal areas, especially near typhoon landing sites, the revision effect is more pronounced.

It should be pointed out that the revision of meteorological elements of transmission channels using similar collection methods in this paper has just begun, and further in-depth research is needed. For example, when using the AnEn method, you can increase the feature factor, increase the sample time series length, etc.; At the same time, this paper only revises the strong wind forecast, and the follow-up research can also be carried out on other factors such as temperature and precipitation; The time window selected in this paper is 3 h, and the number of members of the revised set is 5, and the influence of different parameters on the AnEn revision results can be discussed in subsequent studies.

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