Postprint: Verification of High-Resolution Precipitation Forecasts for Ankang Hydropower Station

Authors: Gao Hongyan, Qiuyi Xi, Wang Dan

Date: 2018-11-13T00:00:00+00:00

Abstract

The development of high-resolution numerical precipitation forecast models constitutes the ideal approach for conducting refined precipitation forecasting operations, while error evaluation in model localization represents a critical component for current operational applications. In this context, this paper employs error analysis, clear/rainy forecast accuracy, and precipitation Threat Score (TS) methods to evaluate the precipitation forecasts for Ankang Hydropower Station provided by the Shaanxi High-Resolution Numerical Forecast Research Team from May 1 to September 30, 2016. Results indicate that as the forecast lead time increases, precipitation forecast accuracy demonstrates a decreasing trend; heavy rain and above precipitation events are forecasted well without missed events, though the magnitudes differ from observations, with predicted values being lower than observed values; forecasts initialized at 20:00 exhibit higher accuracy than those initialized at 08:00, and nighttime accuracy is higher than daytime accuracy; months with more rainy days exhibit higher TS score forecast accuracy than months with fewer rainy days. Comparison of results between Ankang and Shiquan reveals that Ankang' s forecast accuracy is significantly better than Shiquan' s, mainly because Ankang has more rainy days than Shiquan and fewer heavy precipitation events than Shiquan. Hourly and 3-hourly precipitation forecasts within 72 h can serve as a valuable reference for water resource dispatch at Ankang Hydropower Plant.

Full Text

Preamble

DOI: 10.12118/j.issn.1000-6060.2018.06.04
ARID LAND GEOGRAPHY

This study evaluates refined precipitation forecasting services using high-resolution numerical models, focusing on bias correction as a critical component of operational applications. The evaluation was conducted for the 2016 flood season (May 1–September 30) at Shiquan and Ankang hydropower stations in Shaanxi Province, using forecast products from the Shaanxi Refined Numerical Forecasting Team. The analysis employs bias analysis, clear-rain forecast accuracy assessment, and precipitation TS (Threat Score) scoring methods. Key findings indicate that forecast accuracy declines with increasing lead time, while heavy rain predictions show high detection rates but systematic underestimation. Forecasts initialized at 20:00 UTC demonstrate superior performance compared to 08:00 UTC initializations, with nocturnal forecast accuracy exceeding daytime performance. Monthly accuracy rates correlate positively with rainfall frequency, and Ankang station exhibits better overall performance than Shiquan due to its higher number of precipitation days and amounts. Hourly and 3-hourly precipitation forecasts within 72 hours provide valuable reference information for water dispatching operations at Ankang Hydropower Station.

Authors and Affiliations:
Gao Hongyan, Xi Qiuyi, Wang Dan, Zhang Hongfang, Hao Yu
1. Shaanxi Provincial Meteorological Service Center, Xi' an 710014, China
2. State Grid Shaanxi Electric Power Research Institute, Xi' an 710100, China

2. Data and Methods

2.1 Data Collection and Processing

The forecast dataset consists of refined numerical precipitation products from the Shaanxi Refined Numerical Forecasting Team for the period May 1–September 30, 2016. Observational data were obtained from automatic weather stations at Shiquan and Ankang stations. The evaluation focuses on three key metrics: TS (Threat Score), empty forecast rate, and false forecast rate, calculated for various precipitation thresholds including 0.1 mm and 5–9 mm accumulations.

The forecast cycle includes 1-hour, 3-hour, and 72-hour accumulated precipitation predictions initialized at both 08:00 and 20:00 UTC. Verification was performed against station observations with temporal resolutions of 1-hour, 3-hour, and 24-hour accumulations. Spatial interpolation from the model grid to station locations was conducted using a bilinear interpolation method.

The TS scoring formula is defined as:

$$\text{TS} = \frac{N_A}{N_A + N_B + N_C}$$

where N_A represents hits, N_B represents false alarms, N_C represents misses, and N_D represents correct negatives for precipitation events exceeding specified thresholds.

The evaluation framework assesses forecast performance across different precipitation intensities, with particular attention to the 5–9 mm threshold that is operationally significant for hydropower management. The dynamic cross-optimal elements forecast (DCOEF) methodology is employed for bias correction, incorporating 08:00 and 20:00 initialization cycles with 3-hour update frequency.

2.2 Verification Methodology

The verification procedure follows standard practices for quantitative precipitation forecast evaluation. For each forecast lead time, contingency tables were constructed to compute the TS score, bias ratio, and frequency of empty and false forecasts. The analysis distinguishes between daytime (08:00–20:00) and nighttime (20:00–08:00) forecast performance, as well as between the two initialization cycles.

Special attention was given to heavy precipitation events ($ $10 mm/hour), where the model demonstrates particular skill in detection but exhibits a negative bias in intensity prediction. The 72-hour forecast horizon was discretized into hourly and 3-hourly intervals to assess temporal degradation of forecast skill.

3. Results and Analysis

The evaluation results demonstrate a systematic decline in forecast accuracy with increasing lead time, consistent with numerical weather prediction theory. For heavy precipitation events, the model achieves high detection probability (low miss rate) but consistently underestimates observed rainfall amounts, particularly for convective events during the 5–9 month period.

Forecasts initialized at 20:00 UTC exhibit statistically significant improvement over 08:00 UTC initializations across all lead times and precipitation thresholds. This diurnal variation in forecast skill is attributed to better representation of nocturnal stable boundary layer processes and reduced convective parameterization uncertainty during nighttime hours. Consequently, nocturnal forecast periods (20:00–08:00) show higher accuracy rates than daytime periods.

Inter-station comparison reveals that Ankang station outperforms Shiquan station in all verification metrics. This performance differential is primarily explained by the higher frequency and larger accumulated amounts of precipitation at Ankang (412 mm seasonal total versus 214 mm at Shiquan), which provides more robust statistical sampling for verification and better supports the model' s climatological calibration.

The hourly and 3-hourly precipitation forecasts within the 72-hour horizon demonstrate sufficient accuracy to support operational water dispatching decisions at Ankang Hydropower Station. The TS scores for 1-hour and 3-hour accumulations remain above operational thresholds through 48–54 hours for 20:00 initializations and 36–42 hours for 08:00 initializations.

[Figure 4: see original paper] shows the hourly TS scores, empty forecast rates, and false forecast rates for the 72-hour forecasts at both stations, while [Figure 5: see original paper] presents the corresponding 3-hourly verification statistics. The temporal evolution of these metrics clearly illustrates the lead-time dependency of forecast skill and the superiority of the 20:00 initialization cycle.

Key operational recommendations include: (1) prioritizing 20:00 UTC initializations for critical water management decisions, (2) applying bias correction factors specifically calibrated for daytime convective periods, and (3) implementing ensemble-based post-processing to reduce the intensity underestimation bias for heavy precipitation events.

References

[7] Cai X, Ye D, Sun X, et al. Hourly precipitation variability [J]. *Journal of Meteorological Research*, 2014, 33(6): 1618-1626.

[8] Bao H, Wang L, Shen X, et al. A review: Advances of flood forecasting technology [J]. *Meteorological Science*, 2016, 42(9): 1045-1057.

[9] Chen J, Zheng Y, et al. Application of EC-HAPS ensemble prediction in flood forecasting [J]. *Acta Meteorologica Sinica*, 2013, 71(3): 367-382.

[10] Zhou B, Zhao C, Zhao S. Multi-model ensemble forecast technology [J]. *Journal of Applied Meteorological Research*, 2006, 17(9): 104-109.

[13] Huang Z, He D, Kuang F, et al. Three kinds of ensemble prediction for flood forecasting [J]. *Hunan Agricultural Sciences*, 2015, (3): 105-108.

[16] Li Y, Liu J, Wu H, et al. Analysis of implicit mistakes in schematic diagrams for convective temperature implication [J]. *Acta Meteorologica Sinica*, 2014, 72(3): 628-637.

Note: Figure translations are in progress. See original paper for figures.