Bias correction of ensemble precipitation forecasts in the improvement of summer streamflow prediction skill

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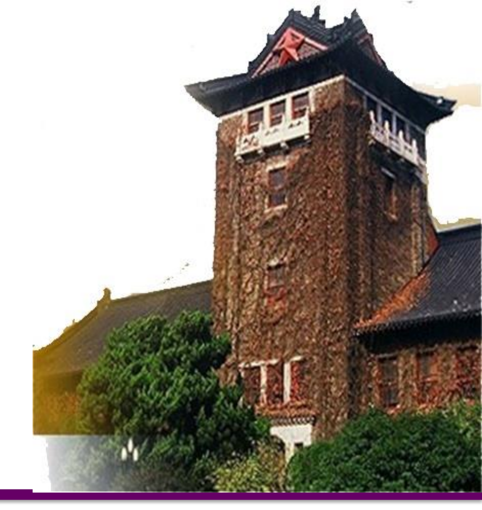


1. Introduction

With the development of ensemble forecast systems, ensemble precipitation forecasting is able to provide more uncertainty information and plays an increasingly important role in basin-scale hydrologic applications.

The Global Ensemble Forecast System (GEFS) reforecast data released by the National Centers for Environmental Prediction (NCEP) has a long-term data archive and relatively stable systematic errors, which shows great potential in hydrologic applications.

This research uses two types of bias correction methods to improve the accuracy of GEFS reforecast precipitation data. Driven by the GEFS reforecast ensemble precipitation forecasts, the VIC (Variable Infiltration Capacity) distributed hydrological model is applied to simulate the 2000-2010 summer streamflow over the Huaihe River Basin.

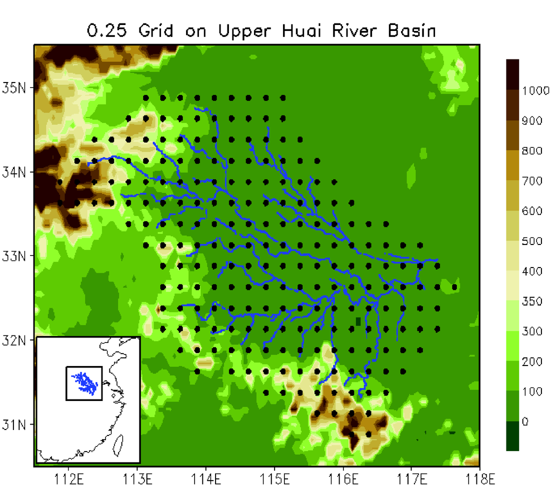
2. Objectives

1. Improve the forecast skill of ensemble precipitation forecasts from the reforecast data of the Global Ensemble Forecast system (GEFS) over the upper Huaihe River basin
2. Improve the potential capability of reforecast data to drive the Variable Infiltration Capacity (VIC) hydrologic model

3. Study region, data, and methods

Study region

Huaihe river basin (30º55'-36 º36' N, 111º55'-121º25' E) is located in the east of China, between the Yangtze river and the Yellow River, with an area of 270,000 km^2. The study area is the upper region of Bengbu hydrologic station, which has the drainage area about 121,300 km^2 and includes 220 grid points (black dots) used in the VIC model.



Data

Precipitation Forecasts	NCEP GEFS (2nd generation) reforecast data （10 members + control forecast） T254 (~40km at 40°N) 1 to 8 days T190 (~54km at 40°N) 9 to 16 days
Observations	1. China Gauge-based Daily Precipitation Analysis (CGDPA) 2. Daily streamflow at Bengbu
Research period	June - August during 2000-2010
Resolution	NCEP GEFS reforecast data：1°*1°，every 6h
	CGDPA data：0.25°*0.25°，every 24h

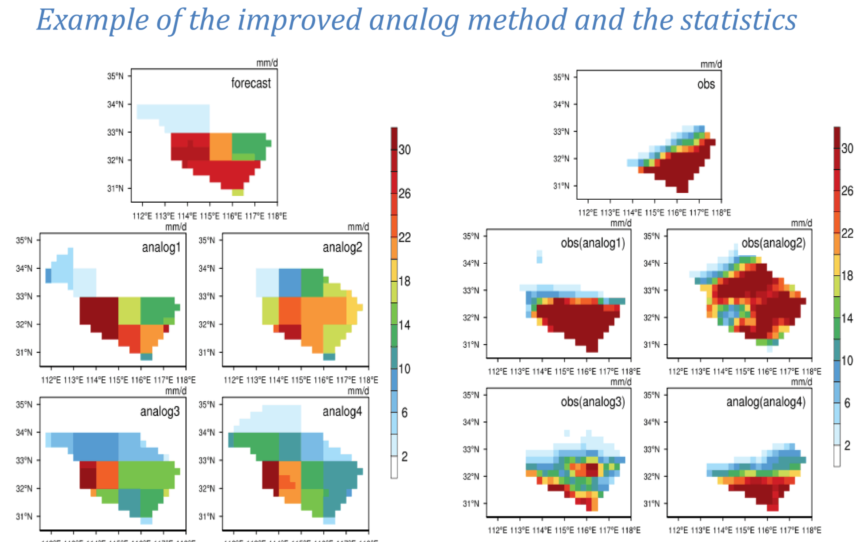
Methods

1.Frequency matching method (FMM) :

Bias correction by matching the forecasted and observed CDFs.

2. **The Analog method :**
Step1: Search the closest local reforecast analogs to the current forecast (smallest RMSE as CC > 0.6 and RE > -0.2).
Step2: Construct the analog ensemble using observed precipitation fields on the dates of the selected top analogs.

Example of the improved analog method and the statistics

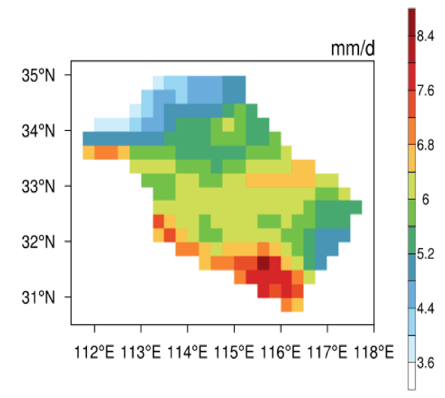


	CGDPA	raw	improved analog	basic analog
Nash（leadtime=2 day）	0.65	0.44	0.46	0.39

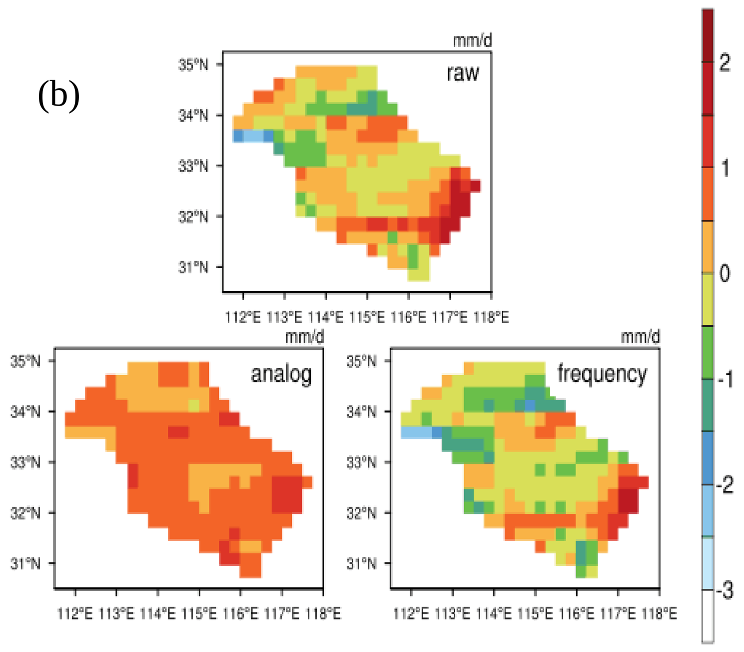
4. Results

Precipitation forecasts

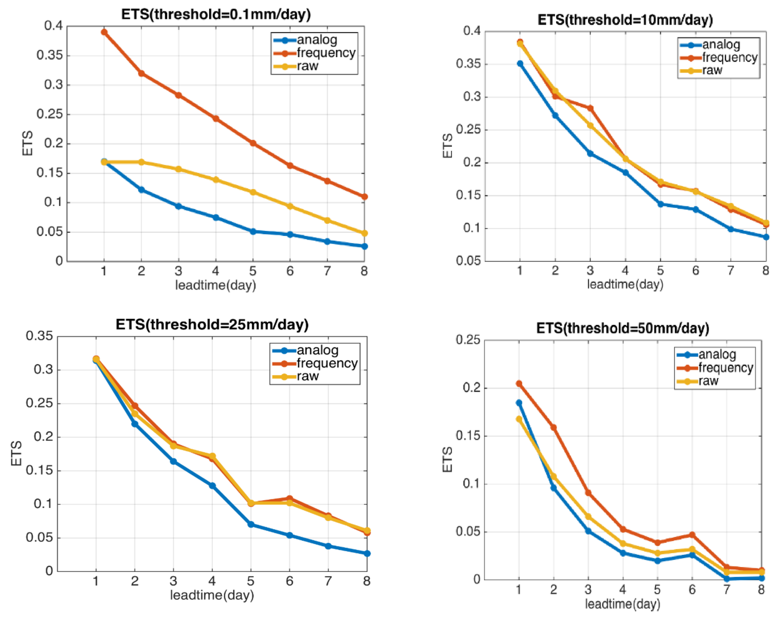
(a)



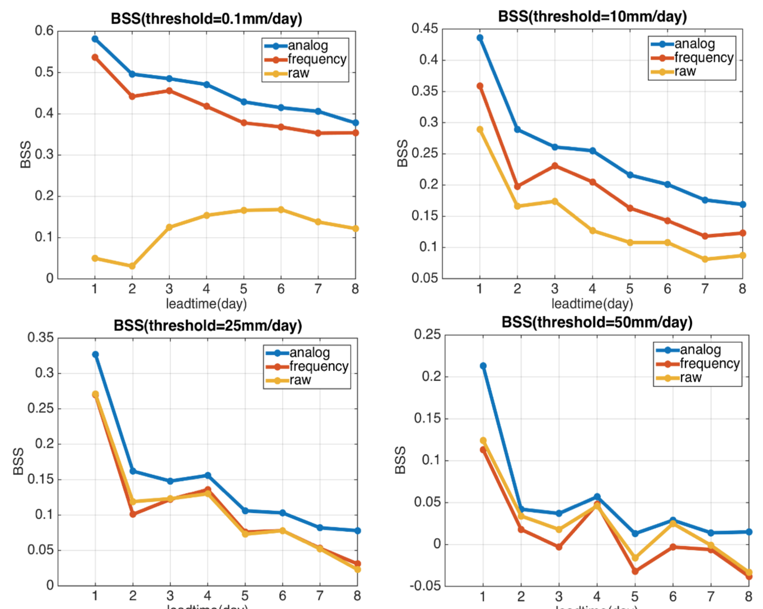
(b)



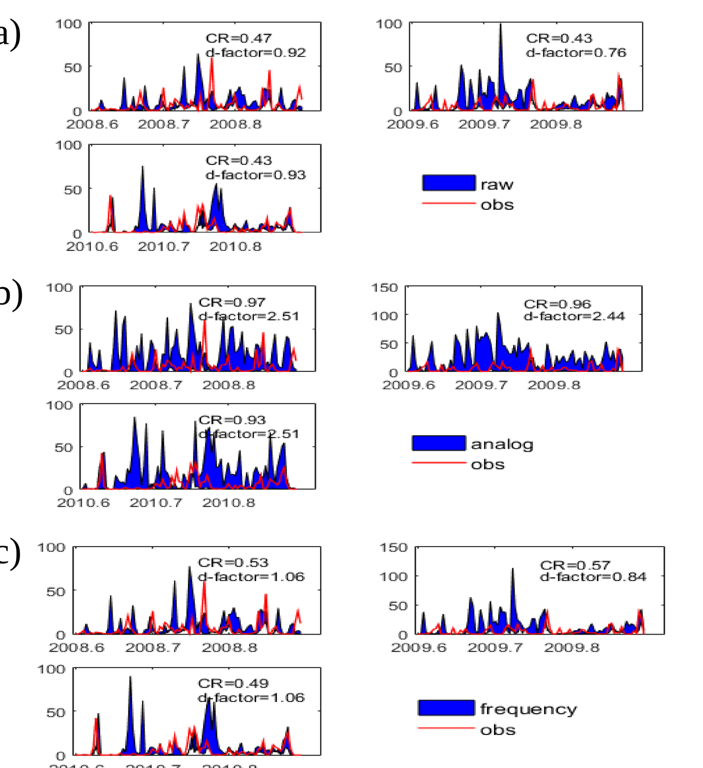
Spatial distributions of (a) mean observed summer precipitation (2000-2010) and (b) relative forecast errors (leadtime=2 d)



ETS of selected precipitation thresholds



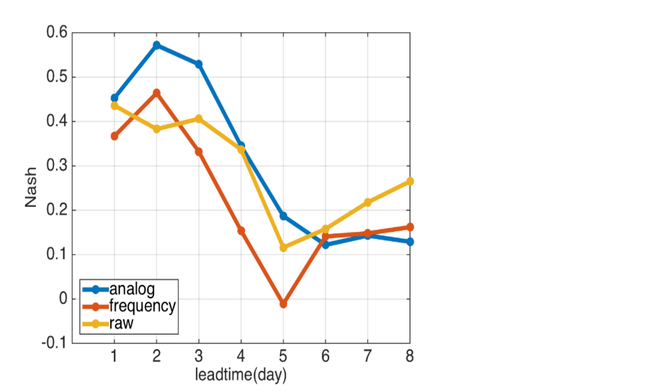
BSS of selected precipitation thresholds



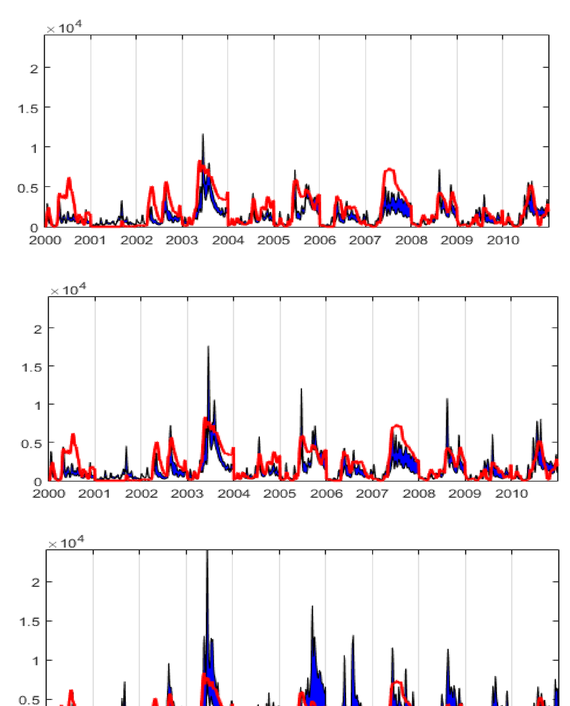
Precipitation forecasts (leadtime=2 d) of (a) raw, (b) analog, and (c) frequency. Other seasons have the similar cover rate (CR) and d-factor (not shown).

1. FMM ("frequency") improves the ensemble mean precipitation (ETS and bias), especially for light rain and heavy rain.
2. The analog method ("analog") tends to overestimate the precipitation over the whole river basin, causing positive biases. Its probabilistic forecasts are overdispersive, while probabilistic skill is the best.
3. The forecast skill of ensemble mean and probabilistic precipitation forecasts decreases quickly with the increasing leadtime. Beyond the 3 d leadtime, all precipitation forecasts have much lower skill.

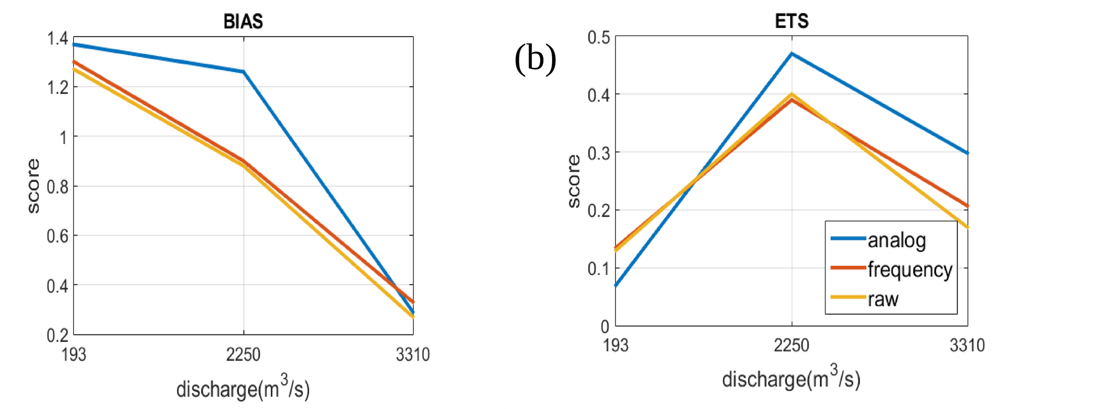
Streamflow predictions



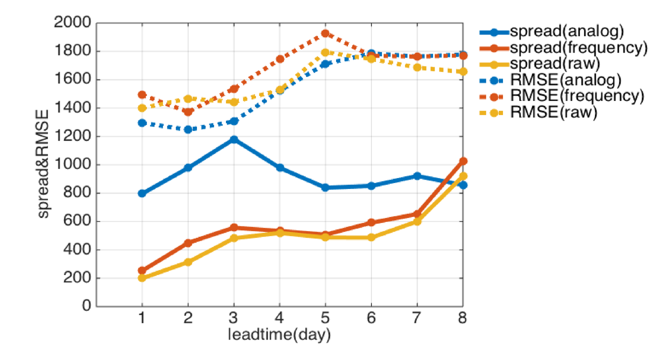
Nash-Sutcliffe efficiency coefficients of streamflow predictions during the summer periods from 2000 to 2010



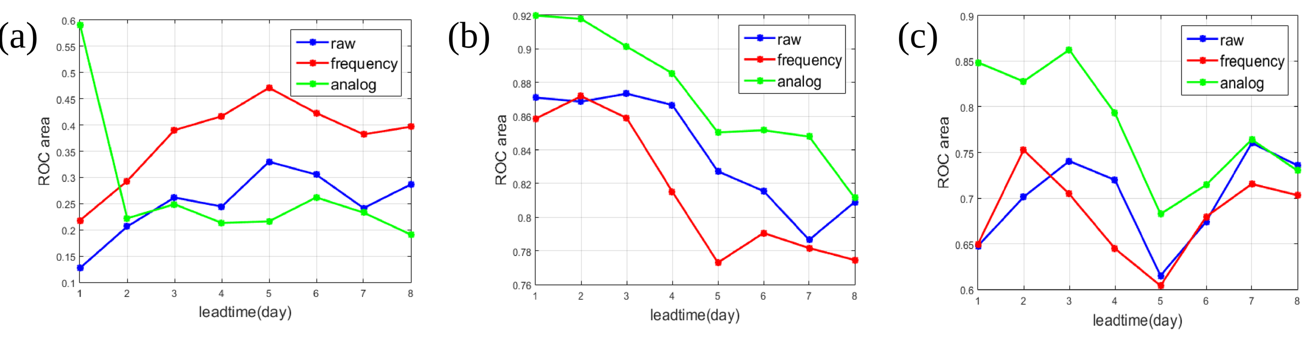
Streamflow predictions of（a）frequency,（b）raw, and（c）analog (leadtime=2 d)



(a) Frequency bias and (b) ETS of ensemble mean streamflow predictions (leadtime=2 d)



Spread and RMSE of streamflow predictions

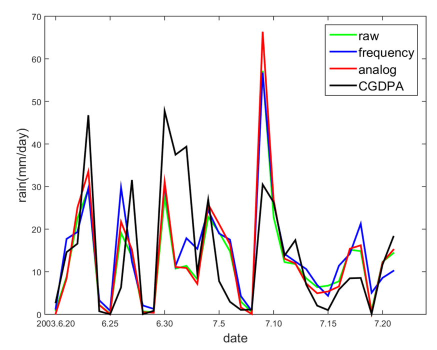


ROC areas for (a) low, (b) moderate, and (c) high streamflow during the summer periods from 2000 to 2010

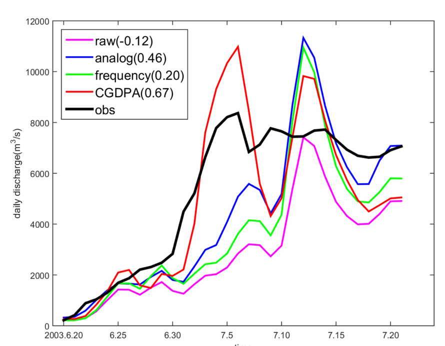
1. The streamflow predictions using bias-corrected precipitation forecasts better resemble the observed streamflow.
2. The analog-corrected precipitation forecasts can effectively improve the streamflow predictions for the 1-5 d leadtimes, with the maximum improvements at the 2-3 d leadtimes.
3. The FMM method only improves the streamflow predictions for the 2 d leadtime.

Extreme flood events

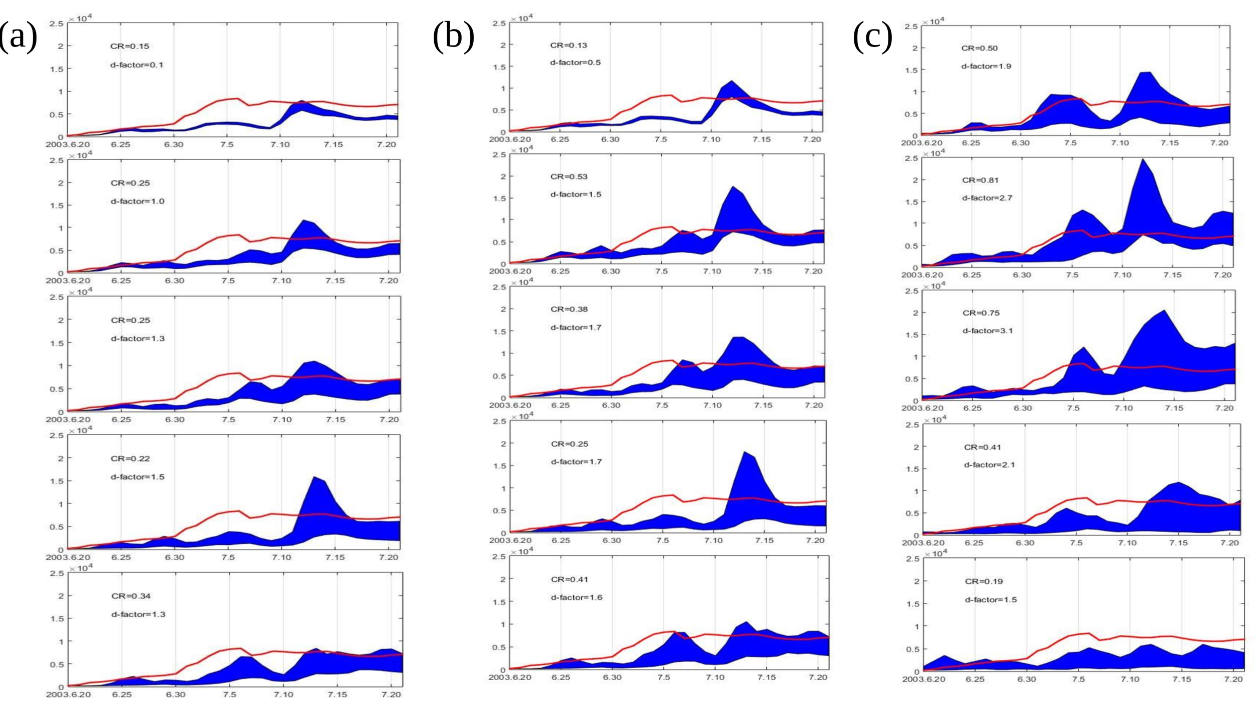
(a)



(b)



(a) Precipitation forecasts and (b) streamflow predictions (leadtime=2 d)



Streamflow predictions of（a）raw,（b）frequency, and（c）analog (from top to bottom: leadtime=1, 2, 3, 5, and 7 d）

1. The ensemble mean forecasts have the limited forecast skill, but probabilistic precipitation forecasts show great potential in improving the location of extreme rainfall events.
2. The ensemble streamflow predictions using the analog-corrected precipitation forecasts demonstrate a larger ensemble spread and higher cover rate of extreme streamflow.

5. Summary

1. The FMM method can improve the ensemble mean precipitation forecasts and the streamflow predictions for small streamflow events.
2. The analog method can improve the ensemble spread and spatial distributions with the downscaling information of the observed precipitation, and produce better probabilistic precipitation forecasts and streamflow predictions, and especially benefit the warning of the extreme floods.
3. The encouraging results suggest that the reforecast ensemble dataset adds great value to improve hydrometeorological predictions for operational applications.

Acknowledgements

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References

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