



# **DOWNSCALING GLOBAL MEDIUM RANGE METEOROLOGICAL PREDICTIONS FOR FLOOD PREDICTION**

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# Background

Flood prediction systems exist

- in developed Countries
- What about developing countries?

The potential for global flood prediction system exists

- Global weather prediction models : analysis and forecasts are available
- Practical Issues: mismatch between the spatial resolution of weather and hydrology models ( until recently)



# Objectives

1. Objective of the scheme: Predict streamflow and associated hydrologic variables, soil moisture, runoff, evaporation and snow water equivalent :

- ☐ At a global scale
  - Spatial consistency
  - Especially in ungauged or poorly gauged basins
- ☐ Lead time up to 2 weeks

2. Objective of this talk: Mississippi Basin case study.

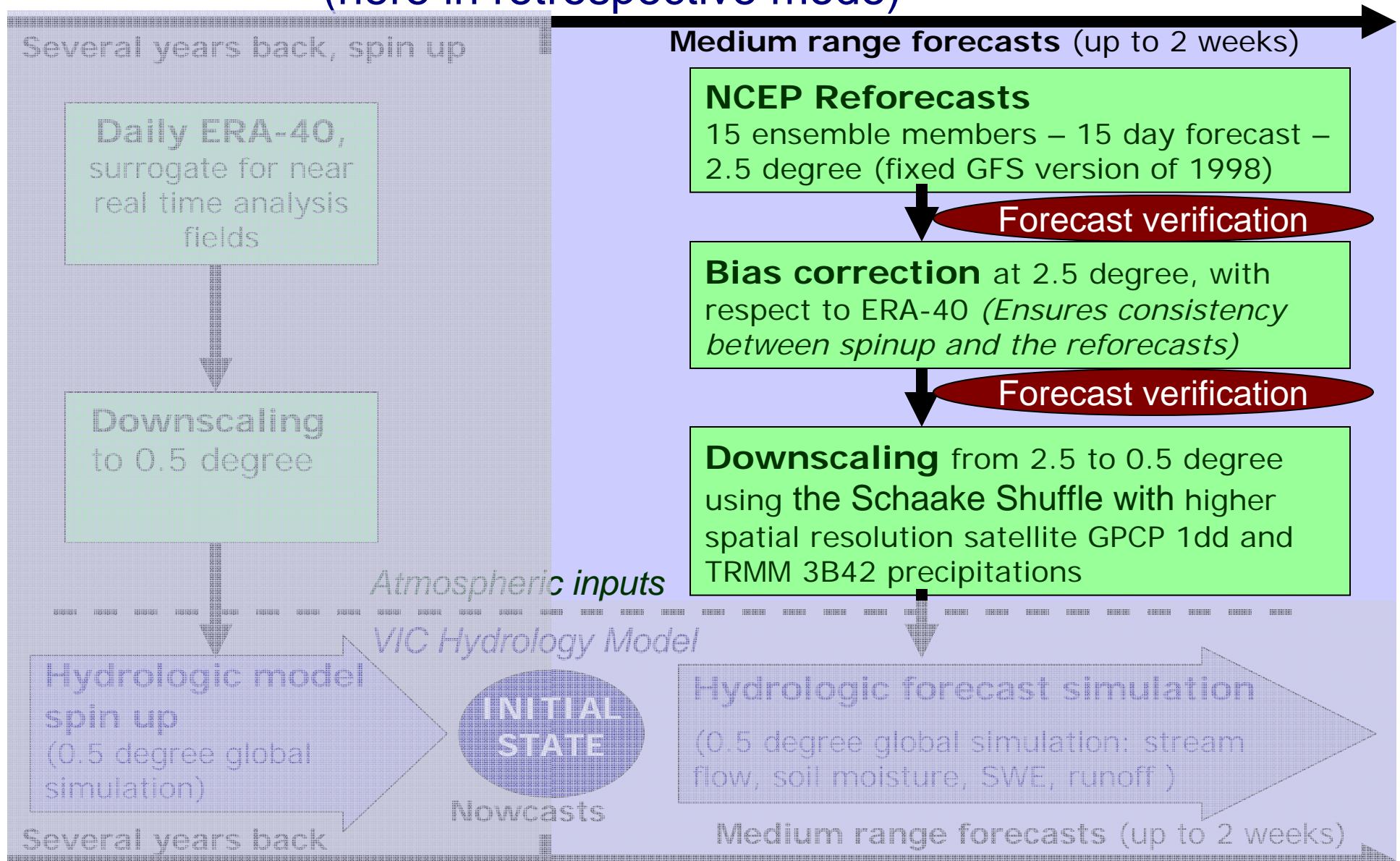
- ☐ Good data to validate and check the scheme
- ☐ Verification of forecast error statistic predictions resulting from application of the downscaling sequence on the weather forecasts



# Outline

1. The prediction scheme
2. Processing on the weather forecasts
3. Bias Correction validation
4. Forecast verification before and after Bias Correction
5. Conclusions

# 1. The global prediction scheme (here in retrospective mode)





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## 2. Processing of the weather forecasts

### Bias correction: Quantile-Quantile technique with respect to ERA-40 climatology

- GFS reforecast , 1979-2001 daily CDF for the 15 ensembles, for each lead time, based on time of the year
- ERA-40 (Obs) , 1979-2001 daily CDF , based on time of the year
- Extreme values: fitted distributions

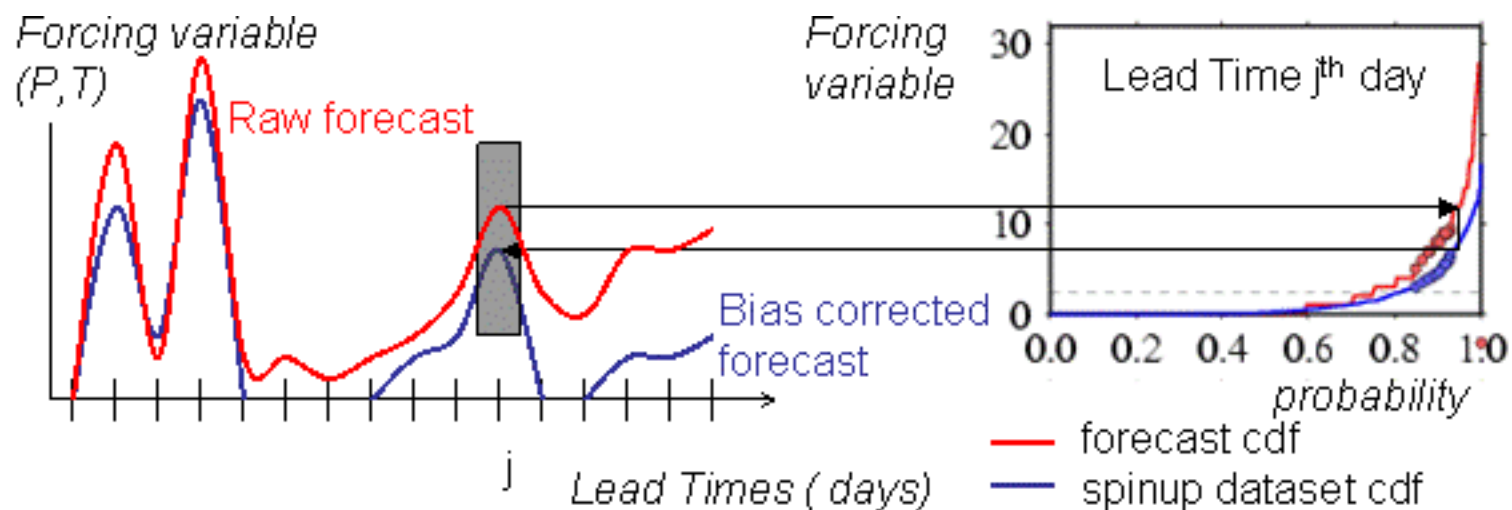


Figure adapted from Wood and Lettenmaier, 2006: A testbed for new seasonal hydrologic forecasting approaches in the western U.S.

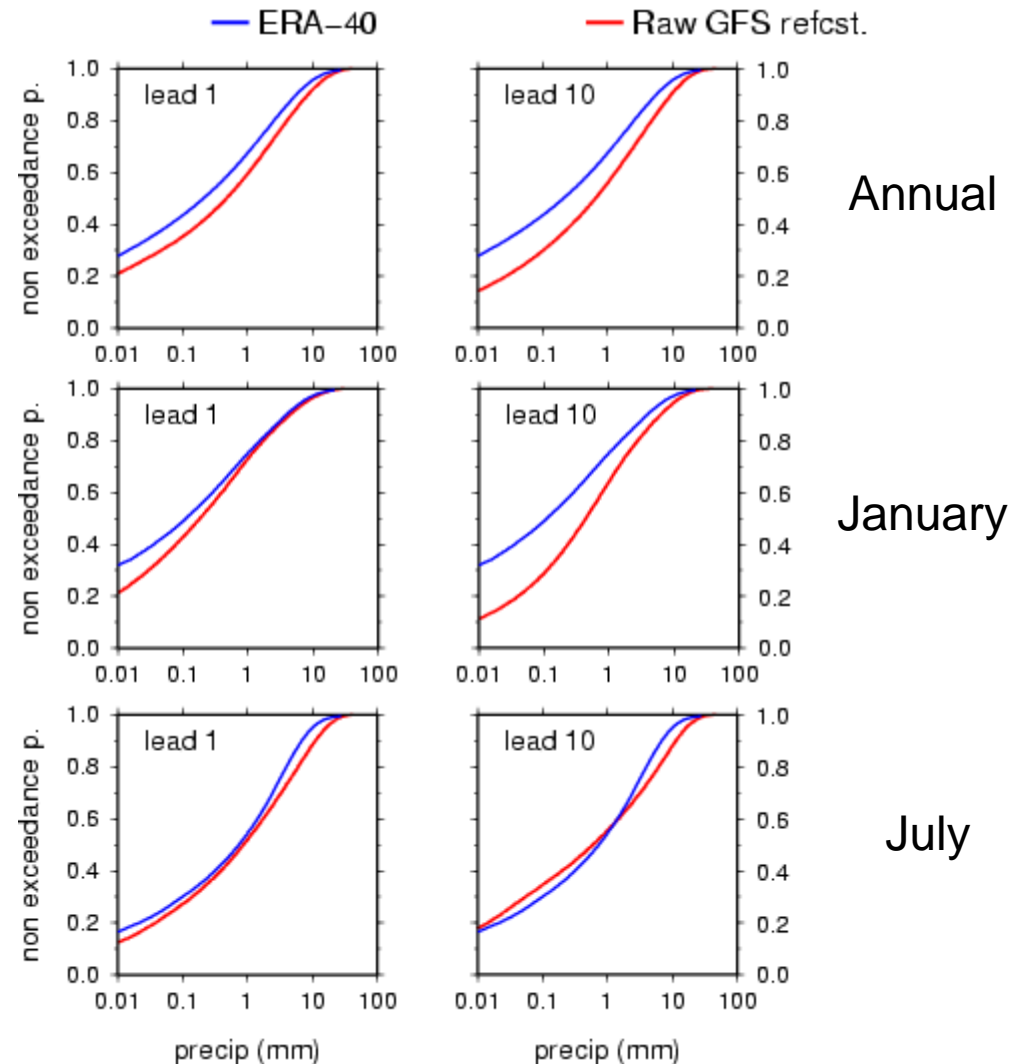
## 2. Processing of the weather forecasts

Mississippi Basin:

- ERA-40 usually has lower estimates of precipitation

⇒ **Bias correction  
(quantile – quantile  
technique)**

1979-2001 CDF for the Mississippi basin,  
daily mean precipitation

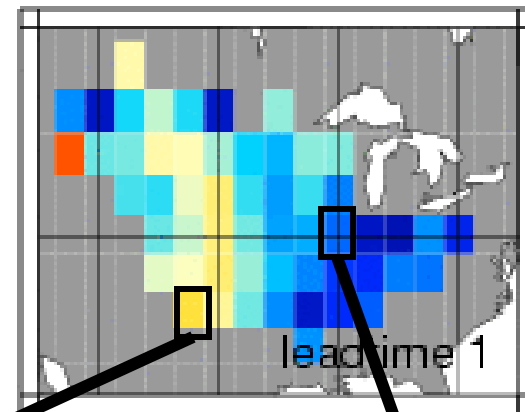
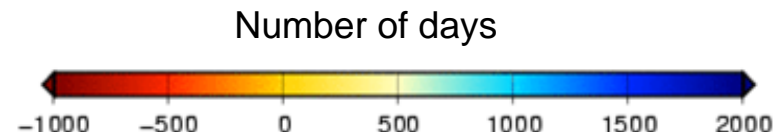


## 2. Processing of the weather forecasts

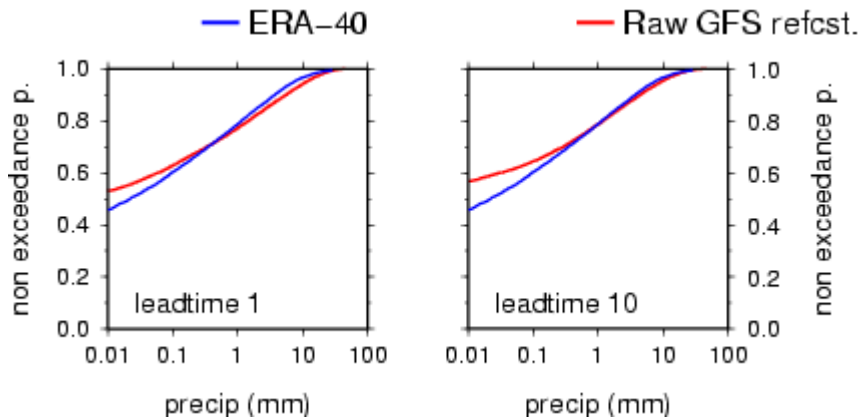
### Mississippi Basin:

Difference in the number of precipitation events  $\geq 1\text{mm}$  in the 1979-2001 period

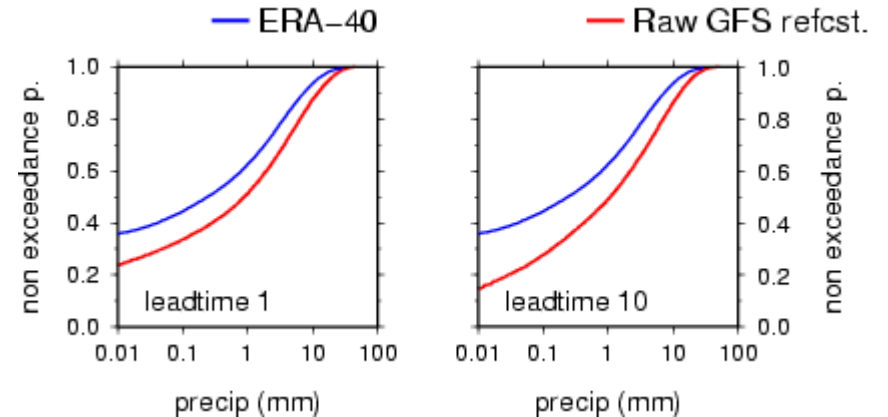
GFS refcst avg - Obs



Annual CDF for Cell (35°N, 102.5°E)



Annual CDF for Cell (40°N, 90°E)





# Outline

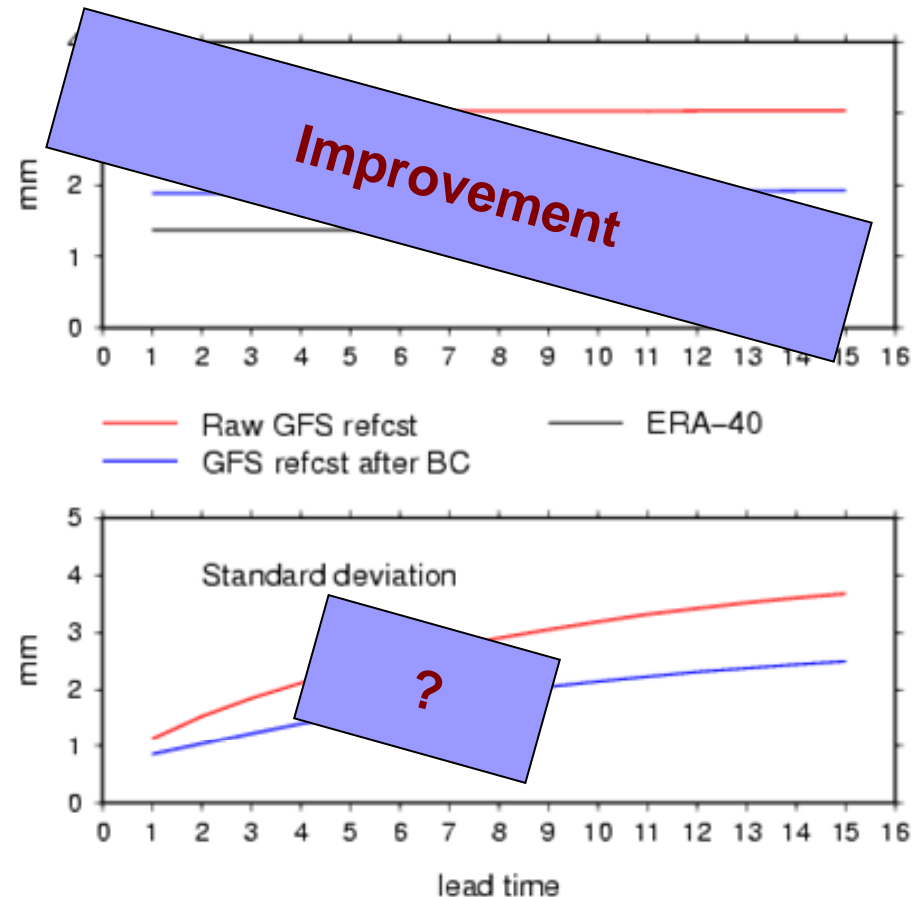
1. The prediction scheme
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### 3. Bias Correction Validation

Mississippi Basin: Mean and standard deviation, annual daily values

- BC is independent for each lead time:
    - ☐ The mean is flattened for all lead time, long lead time are not wetter than short lead time anymore.
    - ☐ Ensemble standard deviation decreased
  - Both
    - ☐ correction for intermittency AND
    - ☐ distribution fitting for extreme values
- add water : BC GFS refcst mean does not match exactly the ERA-40 mean

Threshold is GFS refcst avg & Obs  $\geq 0\text{mm}$   
8386 events

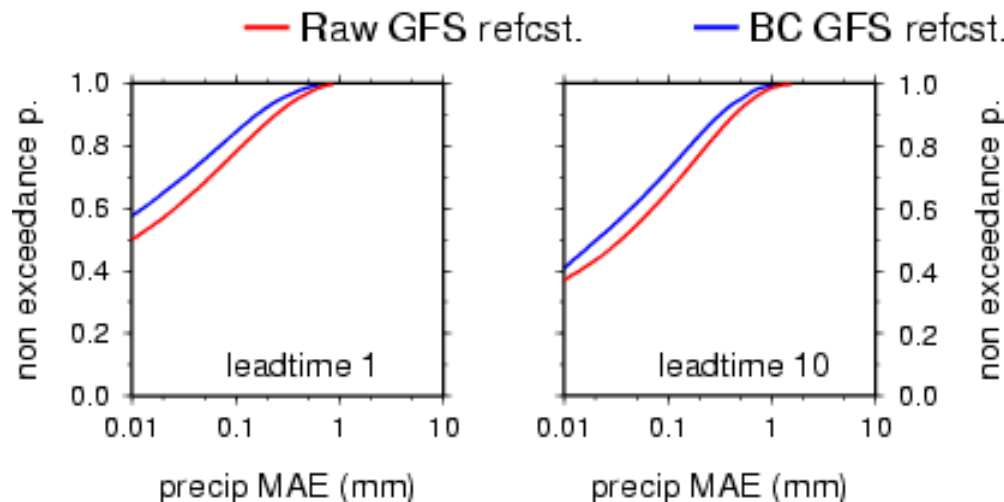


### 3. Bias Correction Validation

#### Mississippi Basin: CDF of precipitation forecast MAE

- Improvement of the MAE of daily precipitation forecast

Non Exceedence probability plot for the precipitation forecast Mean Absolute Error, Mississippi Basin average, daily annual mean





# Outline

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## 4. Forecast Verification

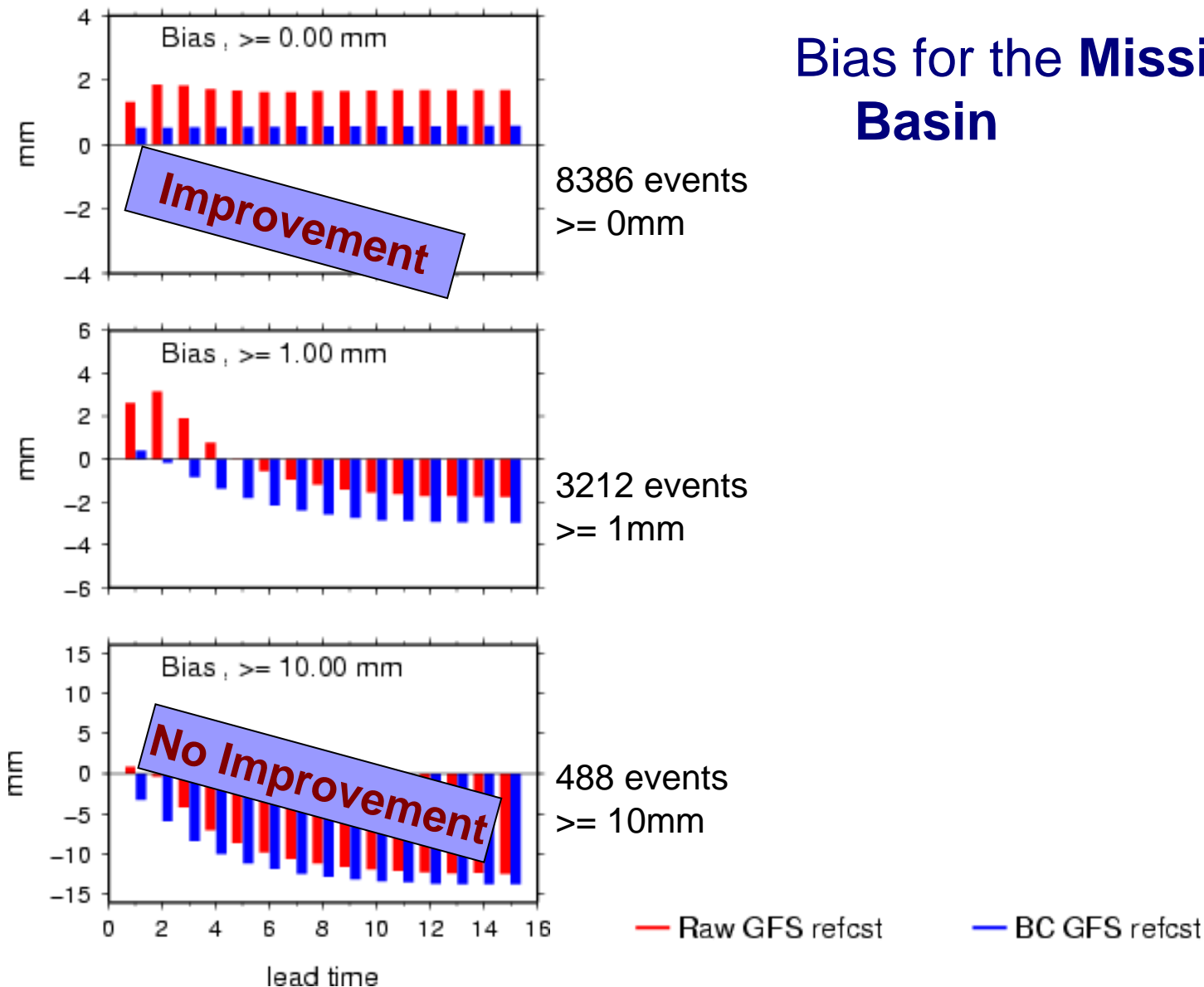
- Skill maintained or improved?
- Ensemble statistics that make sense for an hydrology application ( spread, reliability, mean ...)?

### **Validation of skill related statistics:**

- ☐ Bias
- ☐ RMSE
- ☐ Rank histogram
- ☐ Continuous Rank Probability Score (CRPS)

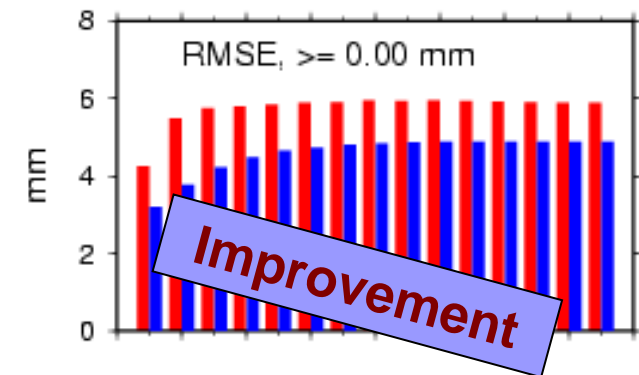
## 4. Forecast verification

### Bias for the Mississippi Basin

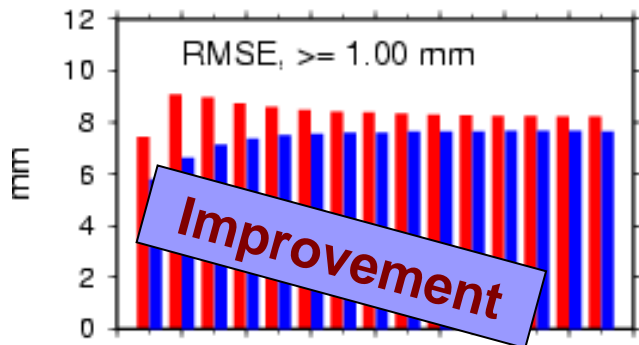


## 4. Forecast verification

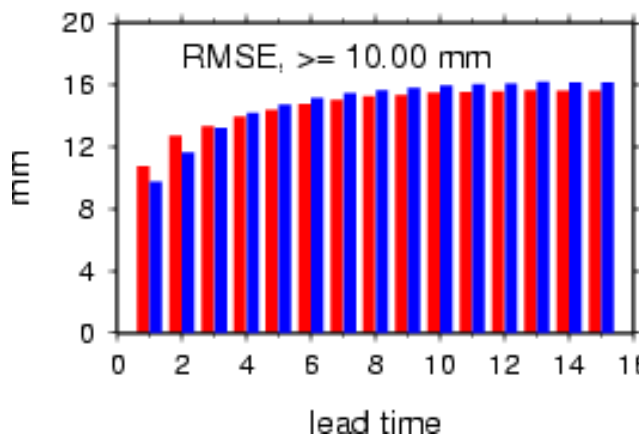
### RMSE for the Mississippi Basin



8386 events  
 $\geq 0$ mm



3212 events  
 $\geq 1$ mm



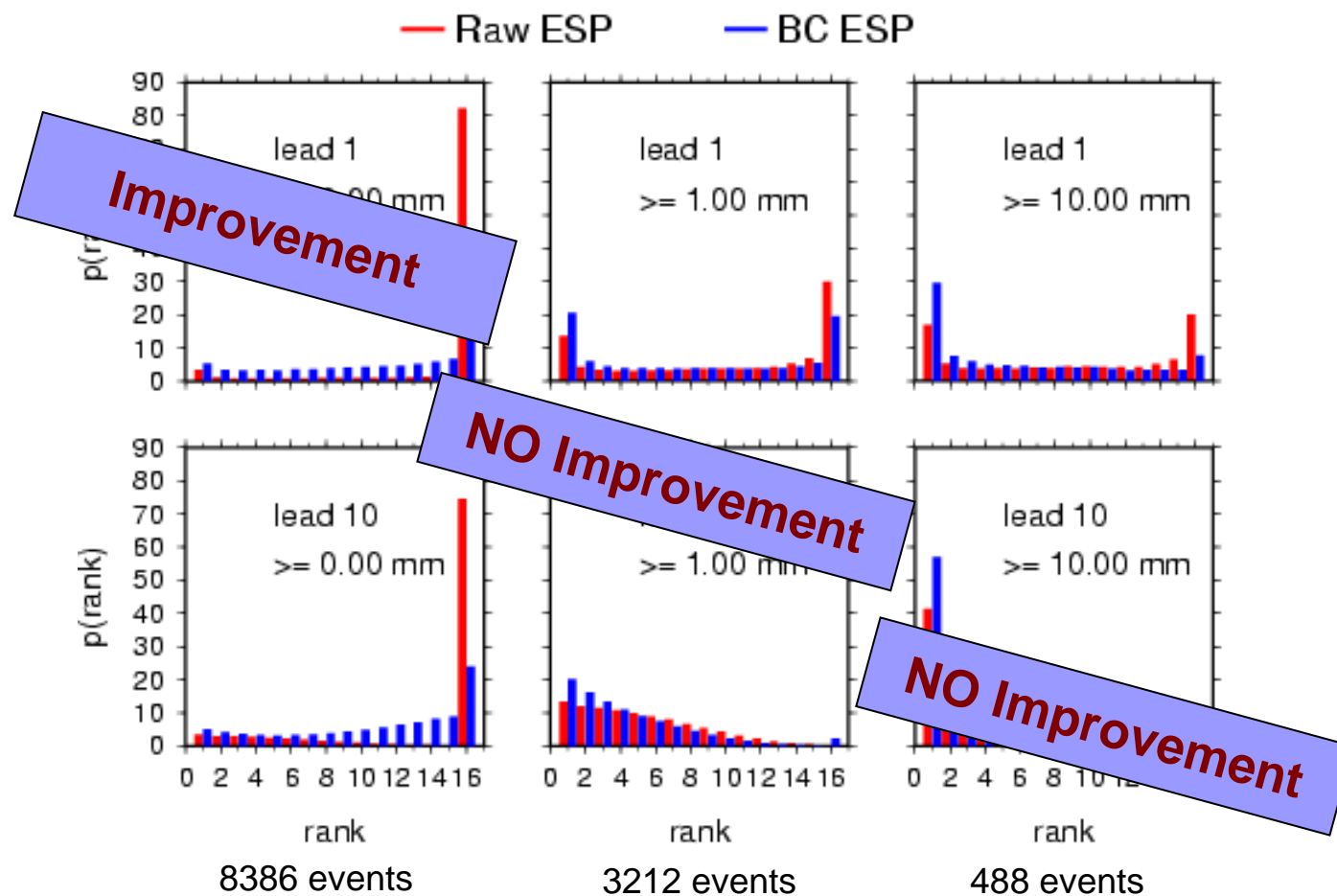
Raw GFS refcst

BC GFS refcst

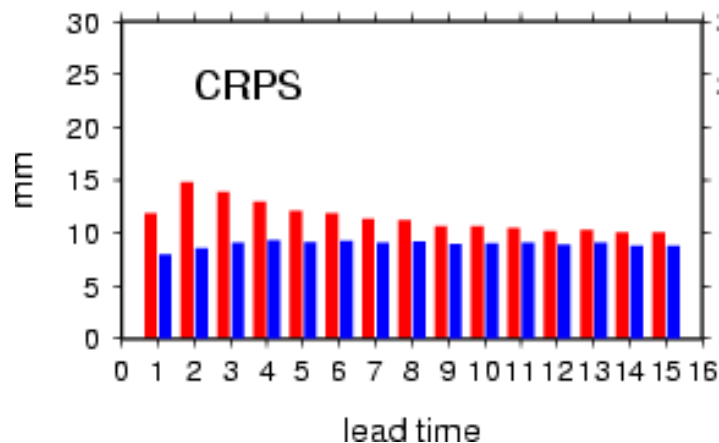
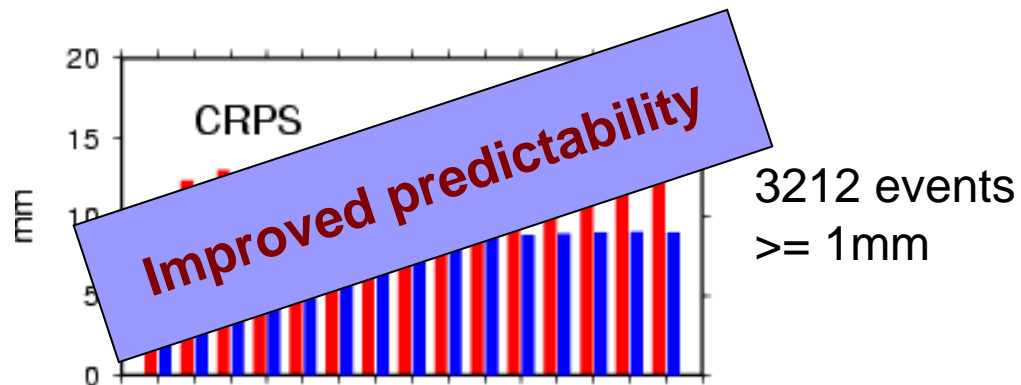
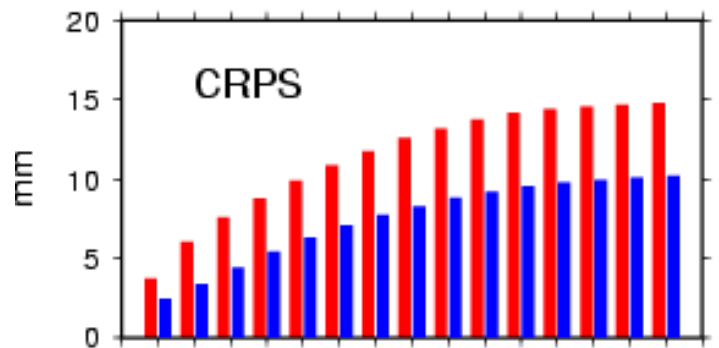
## 4. Forecast verification

### Rank histograms for the **Mississippi Basin**

More reliability in the ensemble spread?



## 4. Forecast verification



### Continuous Rank Probability Score (CRPS)

- Probabilistic weighted average error
- Related to the rank histogram and to the mean absolute error
- Index for predictability

⇒ The smaller the CRPS, the better

— Raw GFS refcasts

— BC GFS refcasts



## 5. Conclusions

- Validation of the bias correction : reduced mean errors
- Impact of bias correction on forecast verification:
  - Improved RMSE
  - Improved intermittency (rank histograms)
  - No improvement in ensemble reliability, especially with longer lead times (rank histograms)
  - Improved predictability (CRPS)
- Does forecast calibration as a subsequent step improve both reliability AND predictability?

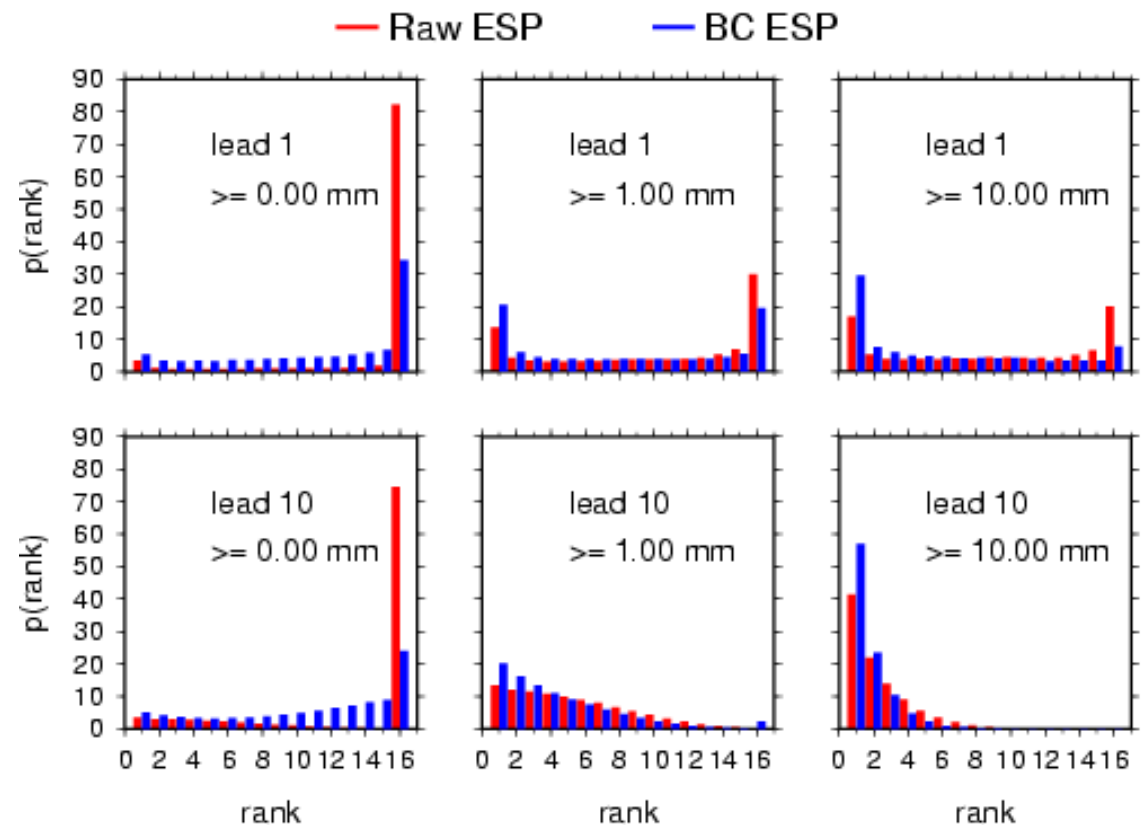
Poster: Zambeze and Danube Basins case studies

Thank you!

# Forecast Verification

- Rank histograms, annual, Mississippi Basin

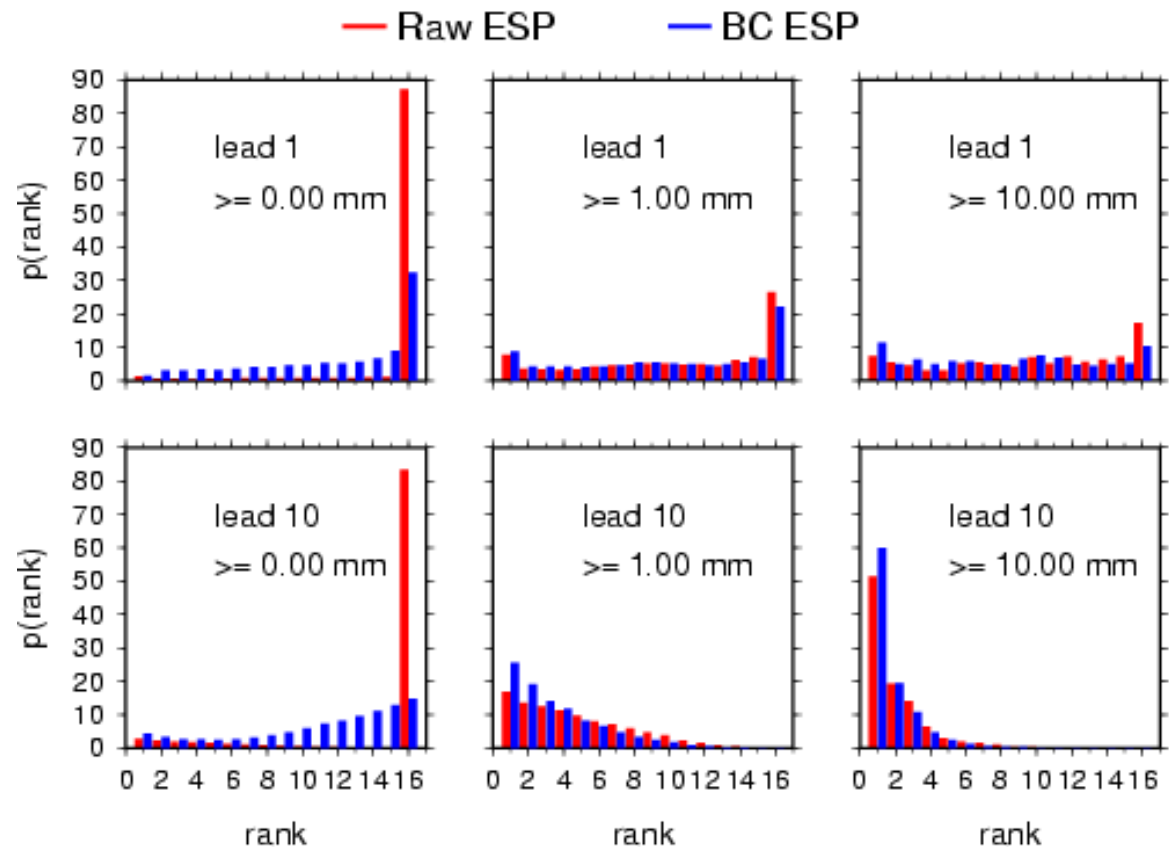
Precipitation forecast rank histograms for different lead times  
for missip



# Forecast Verification

- Rank histograms, January, Mississippi Basin

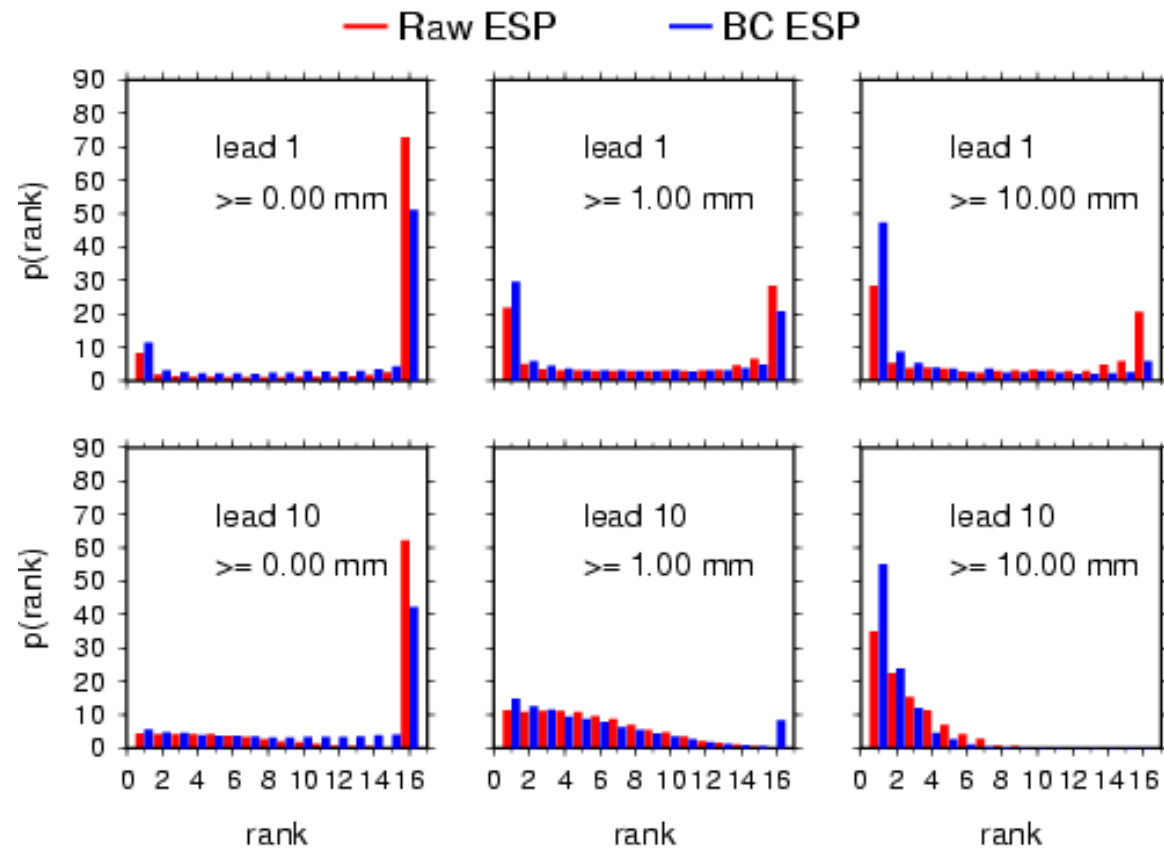
Precipitation forecast rank histograms for different lead times  
for missip, month 1



# Forecast Verification

- Rank histograms, July, Mississippi Basin

Precipitation forecast rank histograms for different lead times  
for missip, month 7

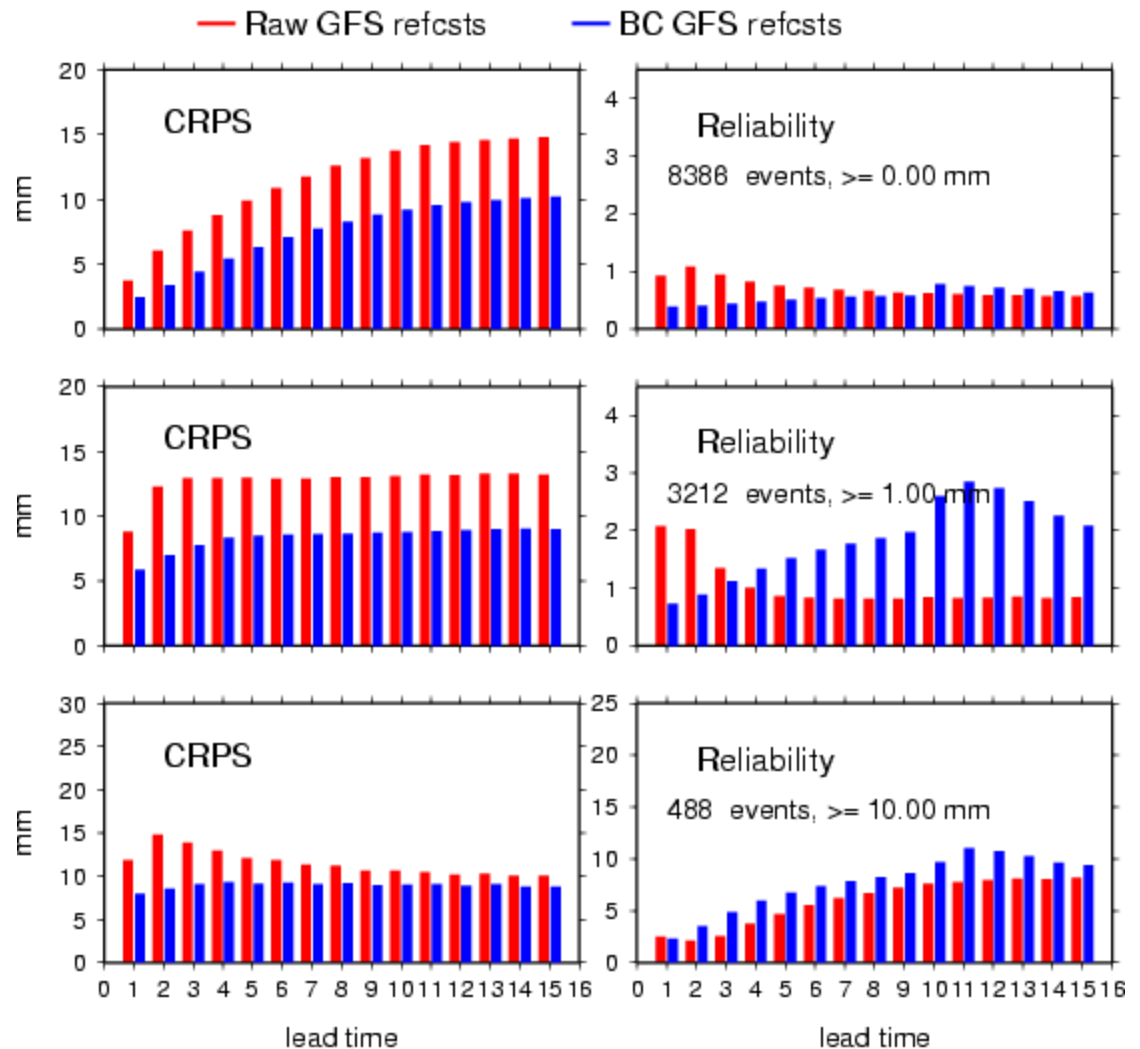


# Forecast Verification

- CRPS annual, Mississippi Basin

Precipitation forecast CRPS for different lead times

for missip

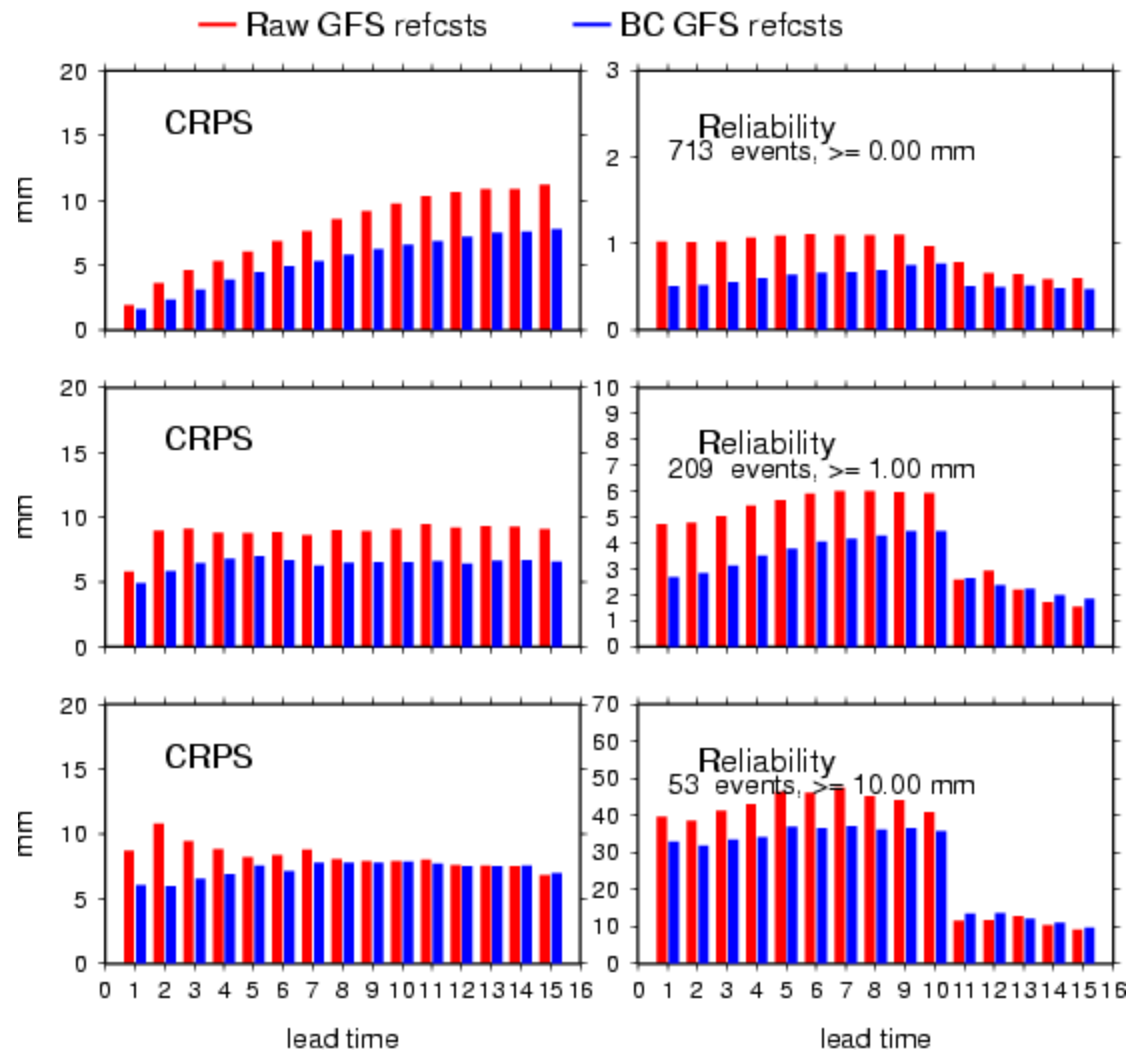


# Forecast Verification

- CRPS January, Mississippi Basin

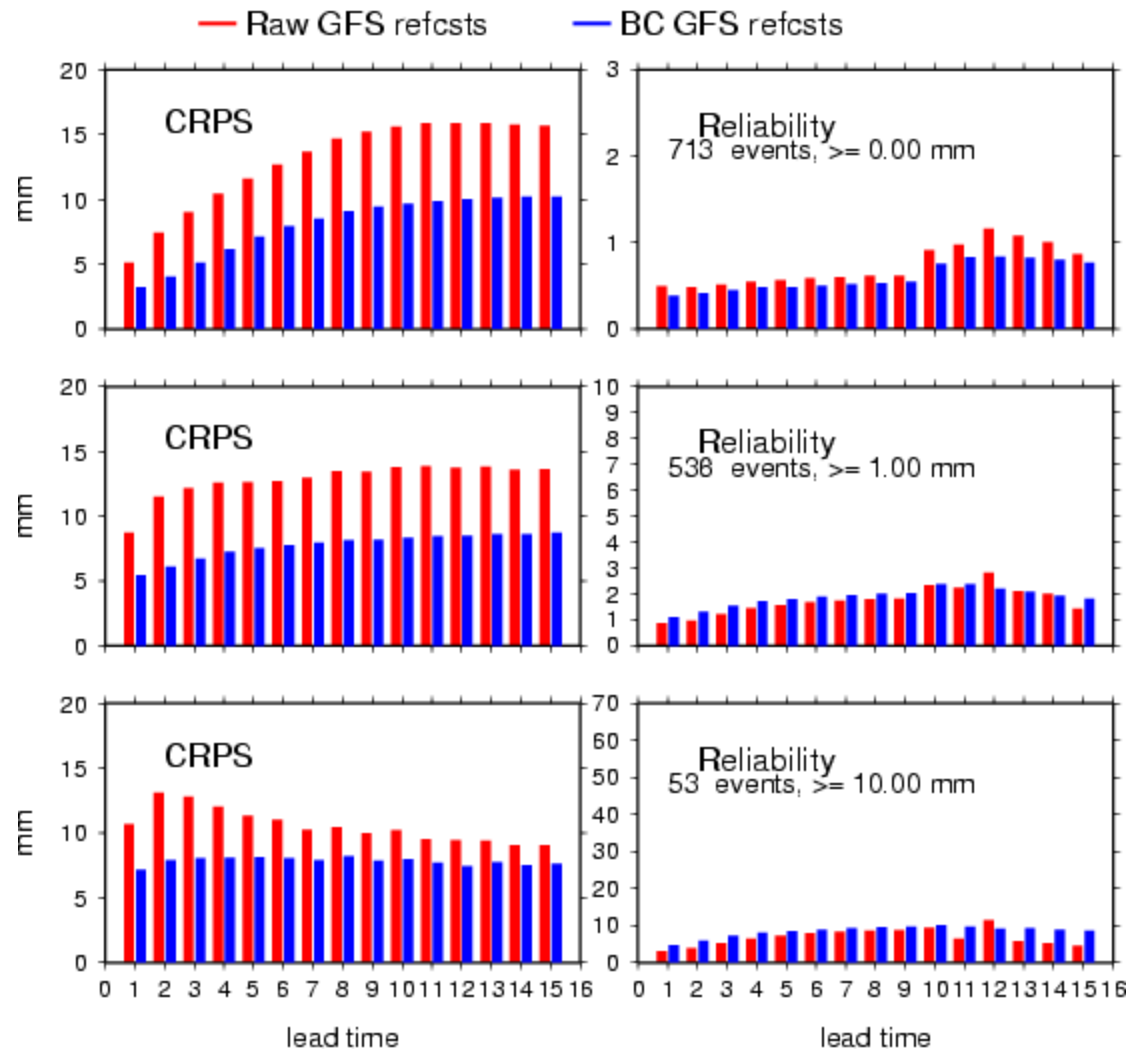
## Precipitation forecast CRPS for different lead times

for missip, month 1



- CRPS July, Mississippi Basin

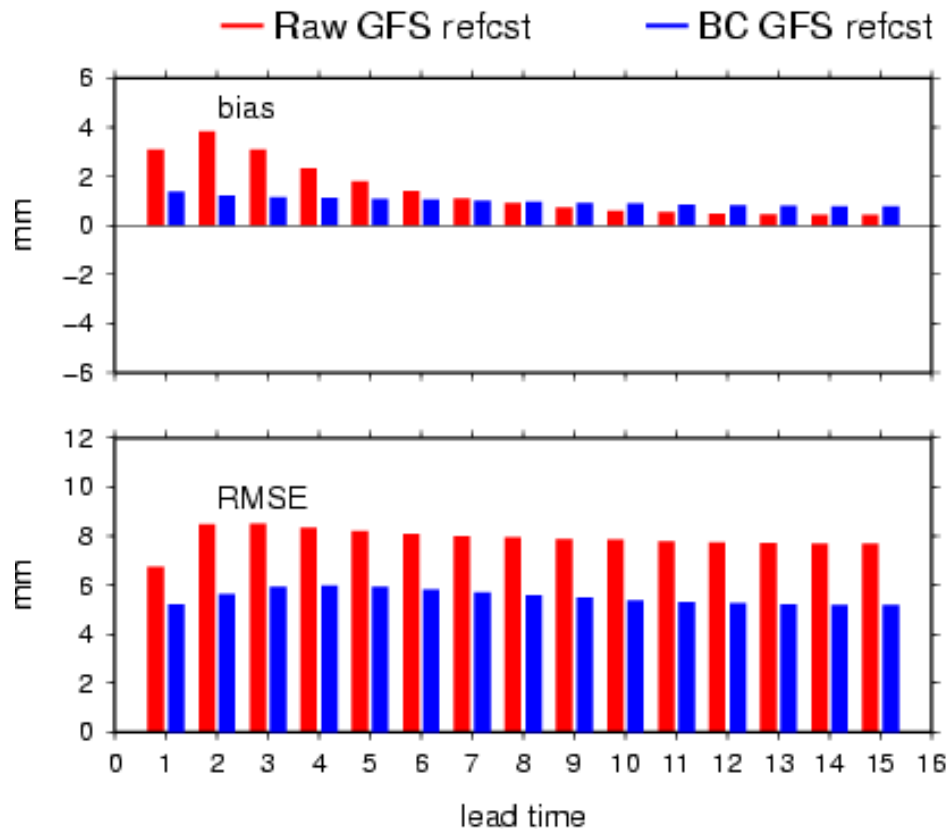
Precipitation forecast CRPS for different lead times  
for missip, month 7



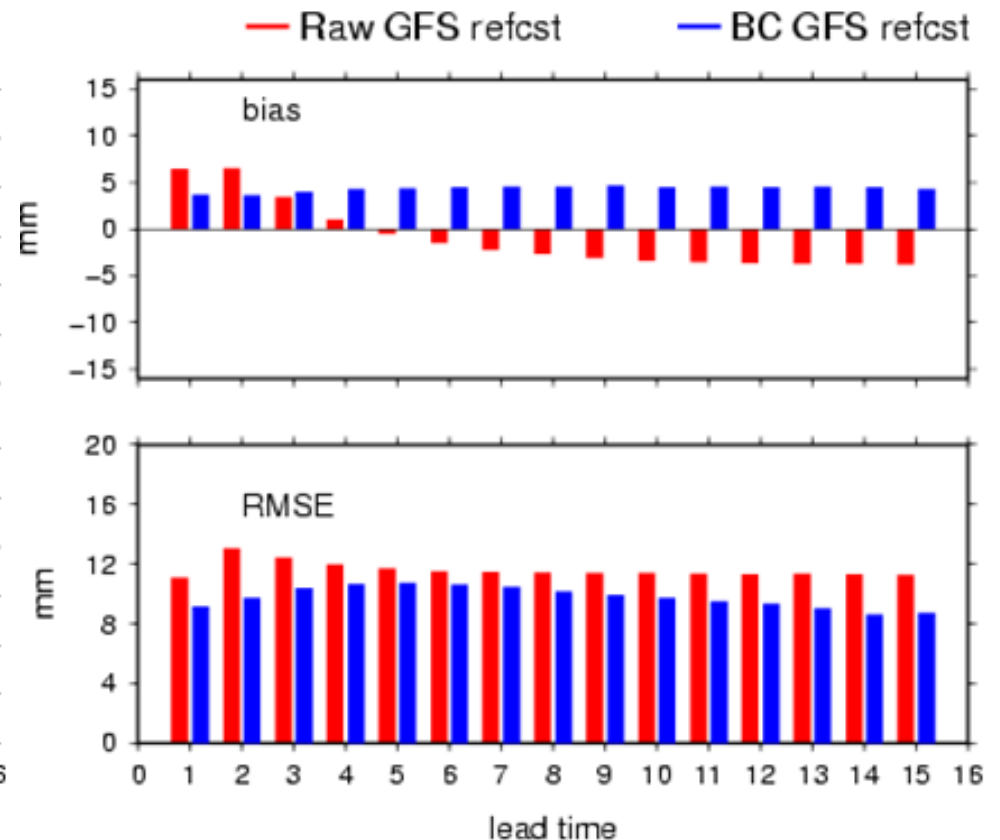
# Forecast Verification

- Bias and RMSE, annual, Mississippi Basin  
threshold is GFS refcst avg  $\geq 1\text{mm}$  and  $\geq 10\text{mm}$

for missip, threshold is 1.00 mm



for missip, threshold is 10.00 mm

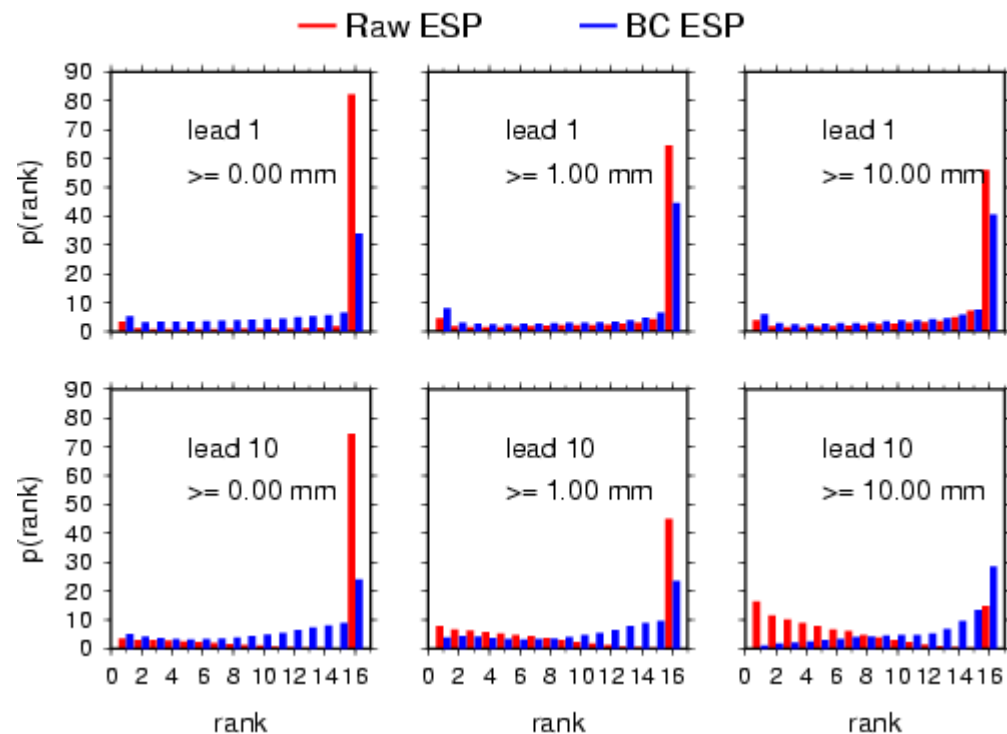


# Forecast Verification

- Rank histograms, annual, Mississippi Basin

Threshold is for the GFS refcst avg (variable with lead times)

Precipitation forecast rank histograms for different lead times  
for missip



# Forecast Verification

- CRPS, annual, Mississippi Basin  
threshold is GFS refcst avg  $\geq 1\text{mm}$  and  $\geq 10\text{mm}$

