

Using Forecast Verification to Evaluate Forecast System Enhancements for Long-Range Hydrologic Ensemble Predictions

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Forecast Verification Strategy

Building blocks of a consistent methodology

- Elemental diagnostic verification
 - Probability forecasts (f) of binary observations (x)
- Ensemble verification
 - Summarize elemental results for all possible probability forecasts (forecast quality functions)
- Summary verification measures
 - Characterize aspects of forecast quality functions for comparison of competing forecast systems

Elemental Forecast Verification

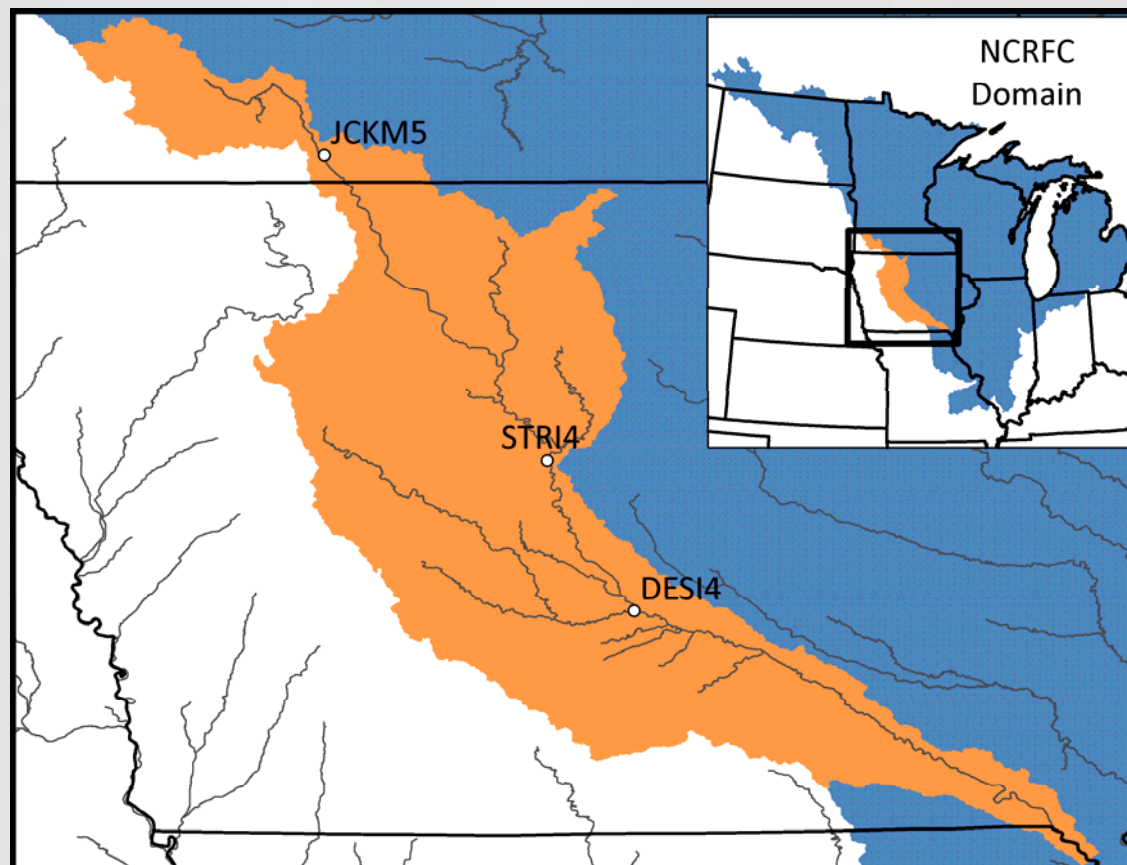


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Forecasting Midwest US Drought

NWS forecasts for the Des Moines River

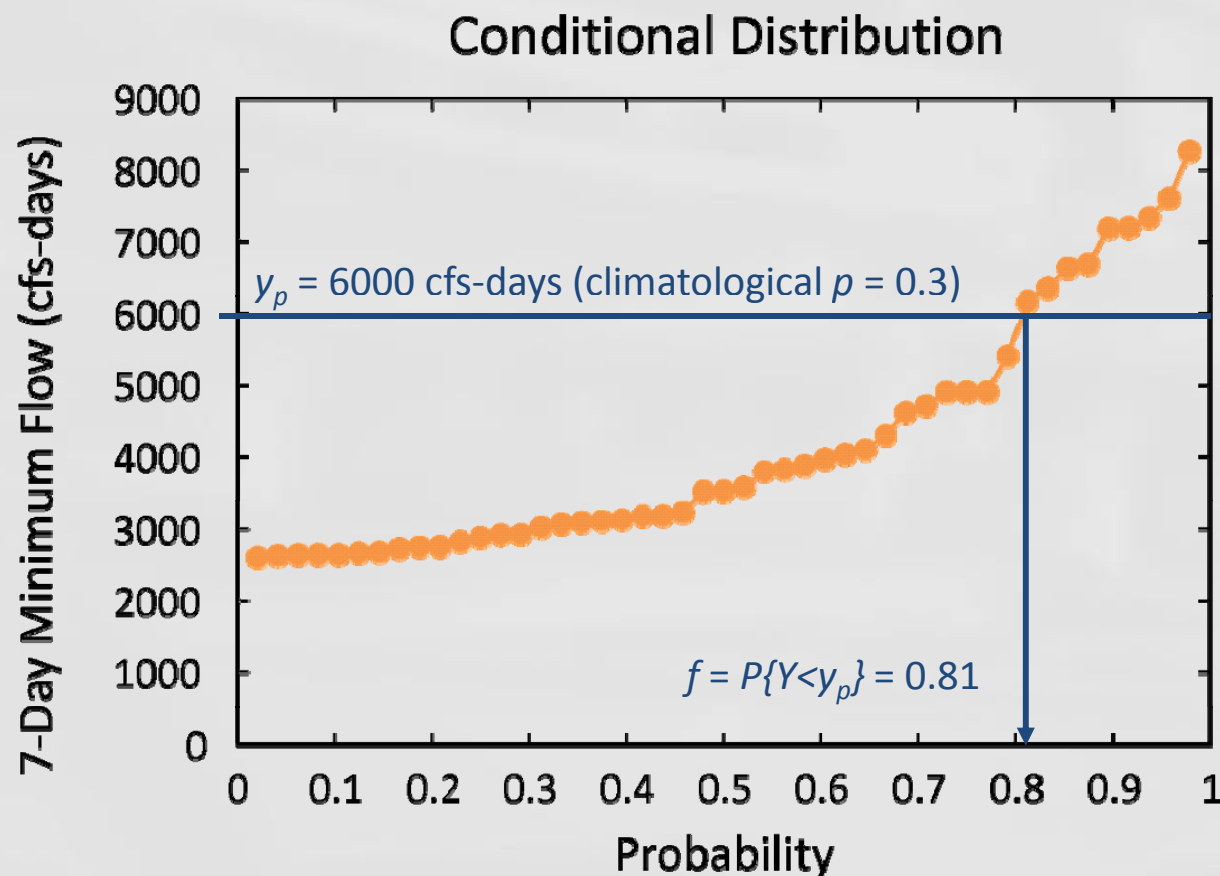


- Retrospective forecasts generated each week from 1950 to 1999
- Drought forecast: Minimum 7-day flow volume for the upcoming season (90 days)

Drought Forecast

Minimum 7-day flow volume

Issued 3 Apr 1960



- Ensemble contains a probability statement for any possible outcome
- Probability forecast for a discrete event

All forecasts from a verification data set

Skill Score

Minimum 7-Day Flow Volume ($p=0.3$)

Observed Volume (cfs-days)

Probability Forecast (f)

Forecast worse than climatology

Drought event does not occur

Drought threshold

$BS_{clim} = (1-p)^2$

Forecast better than climatology

$BS_{for} = (1-f)^2$

Drought event occurs

Climatology forecast $p = 0.3$

Ensemble Forecast Verification

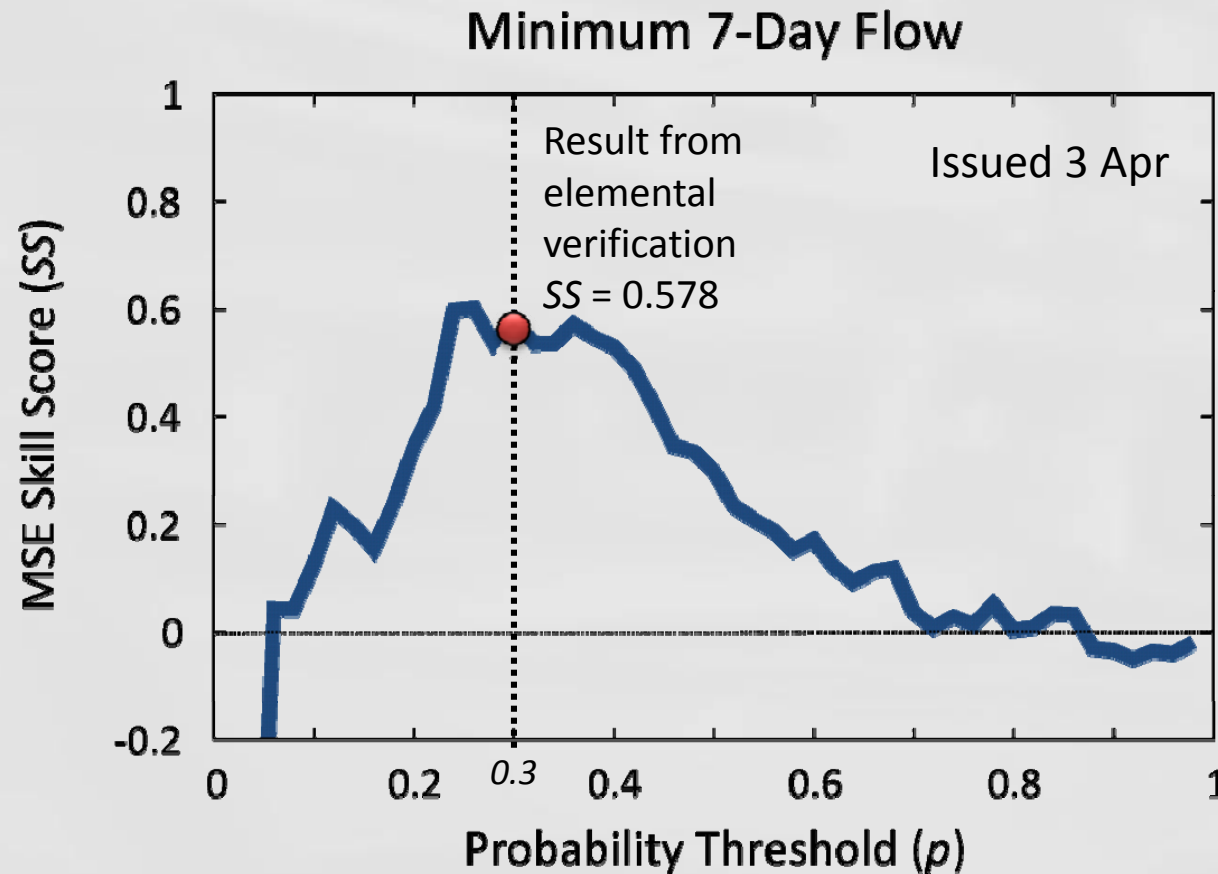


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Ensemble Drought Forecast Skill

Synthesize elemental skill with a skill function



- Skill varies with elemental outcomes
- The same ensemble forecast may be skillful and unskillful
- Skill function characterizes forecast quality for any outcome

Summary Ensemble Forecast Verification Measures

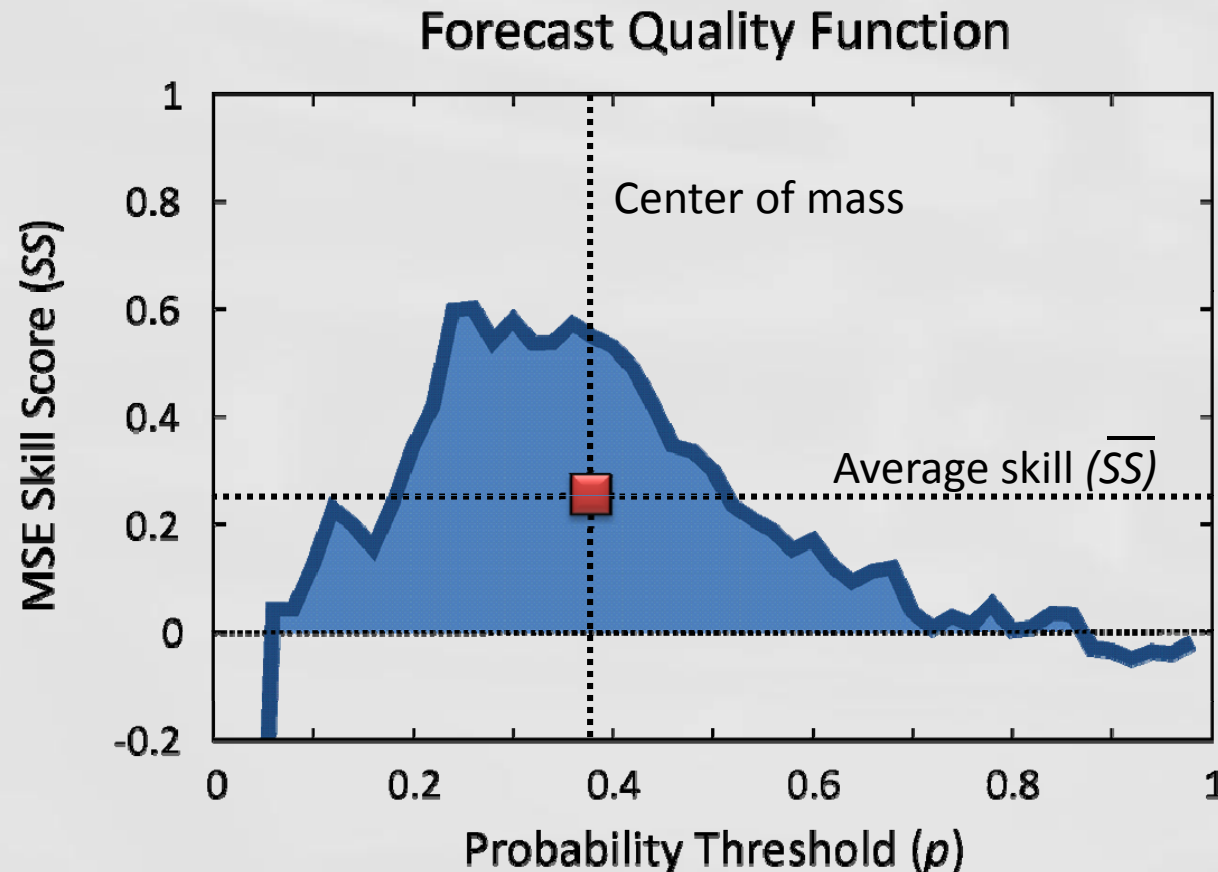


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Summary Measures

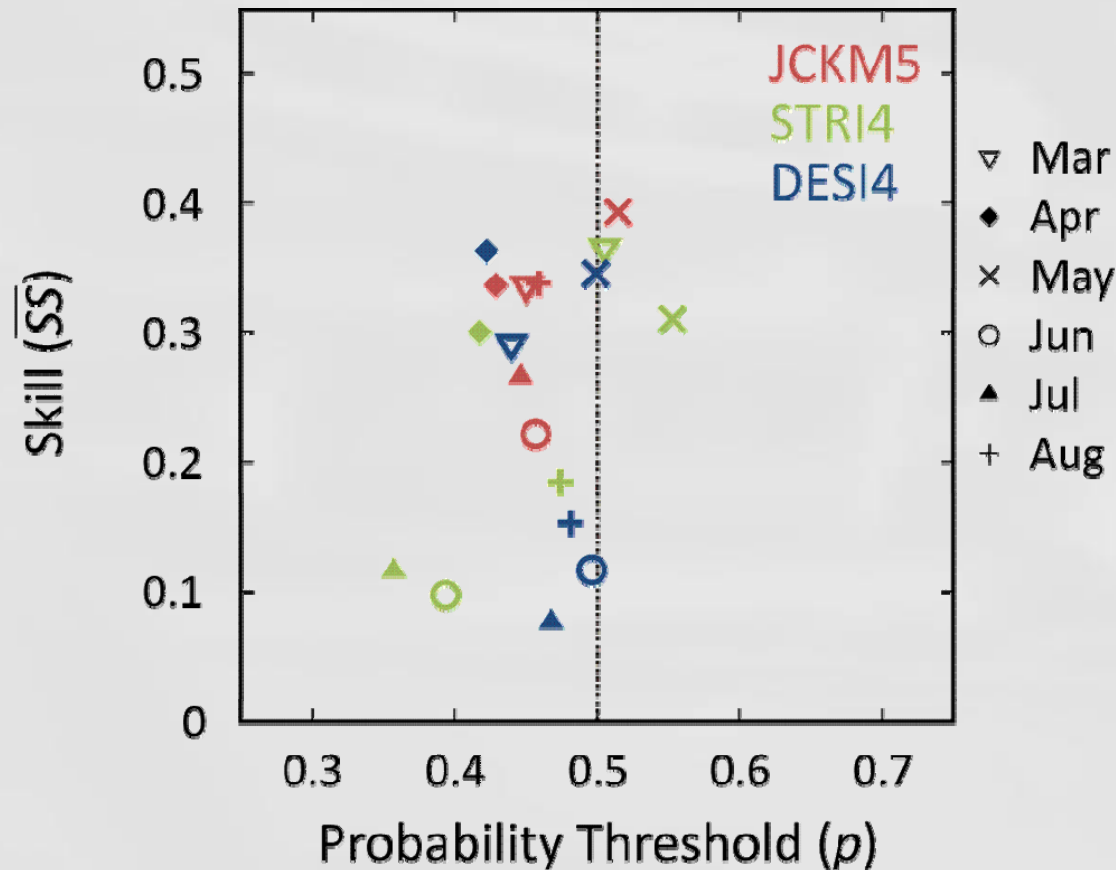
Describe aspects of a forecast quality function



- These and other measures of geometric shape summarize aspects of the forecast quality function

Summary Measures

Drought forecast quality for the Des Moines River

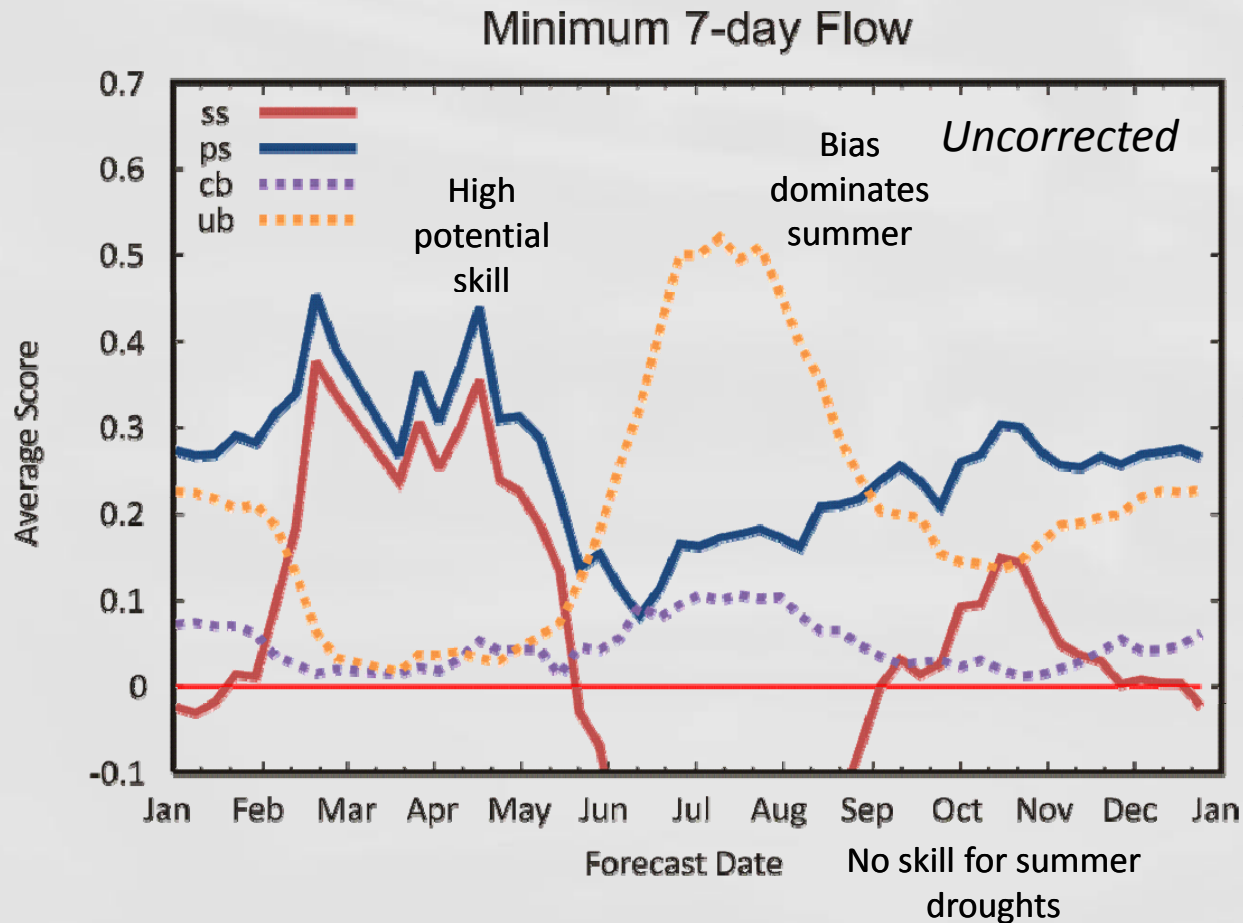


- Bias-corrected forecasts at three sites
- Skill decreases from spring to summer
- Skill highest at the upstream site
- Skill concentrated at lower flows

Summary Measures

Skill score decomposition

Forecast quality at
Stratford (STR14)
before bias-correction



- Unconditional bias in summer degrades forecast skill
- Bias correction recovers forecast skill during this season



Evaluation of Forecast System Enhancements

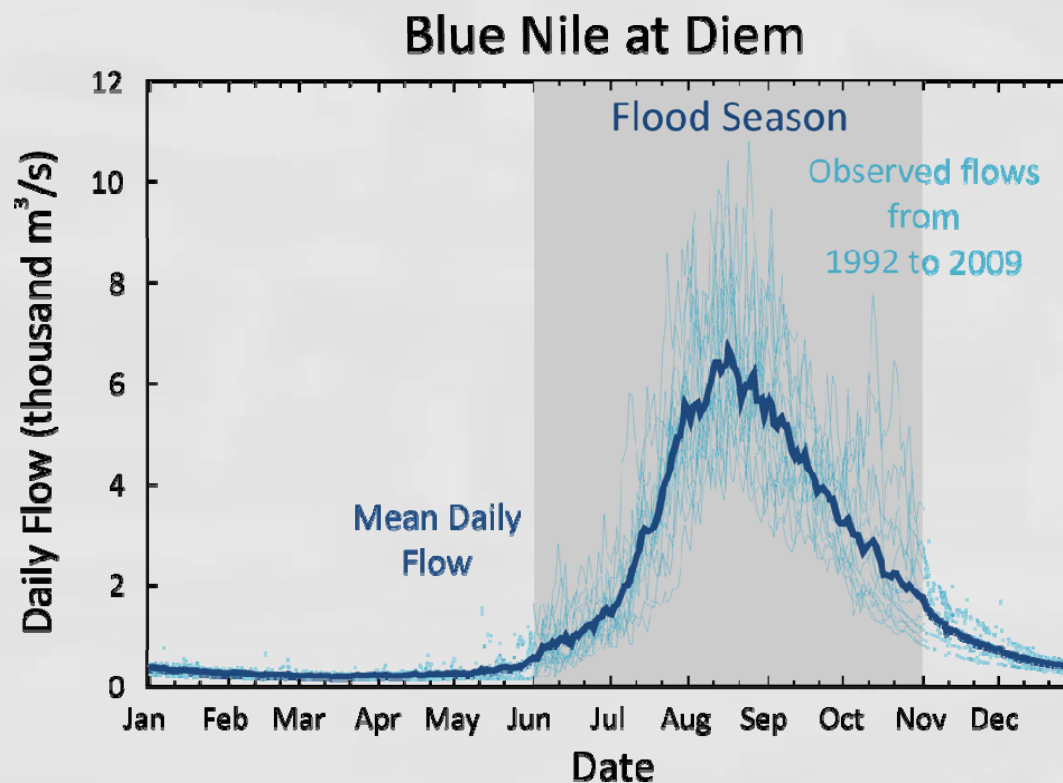


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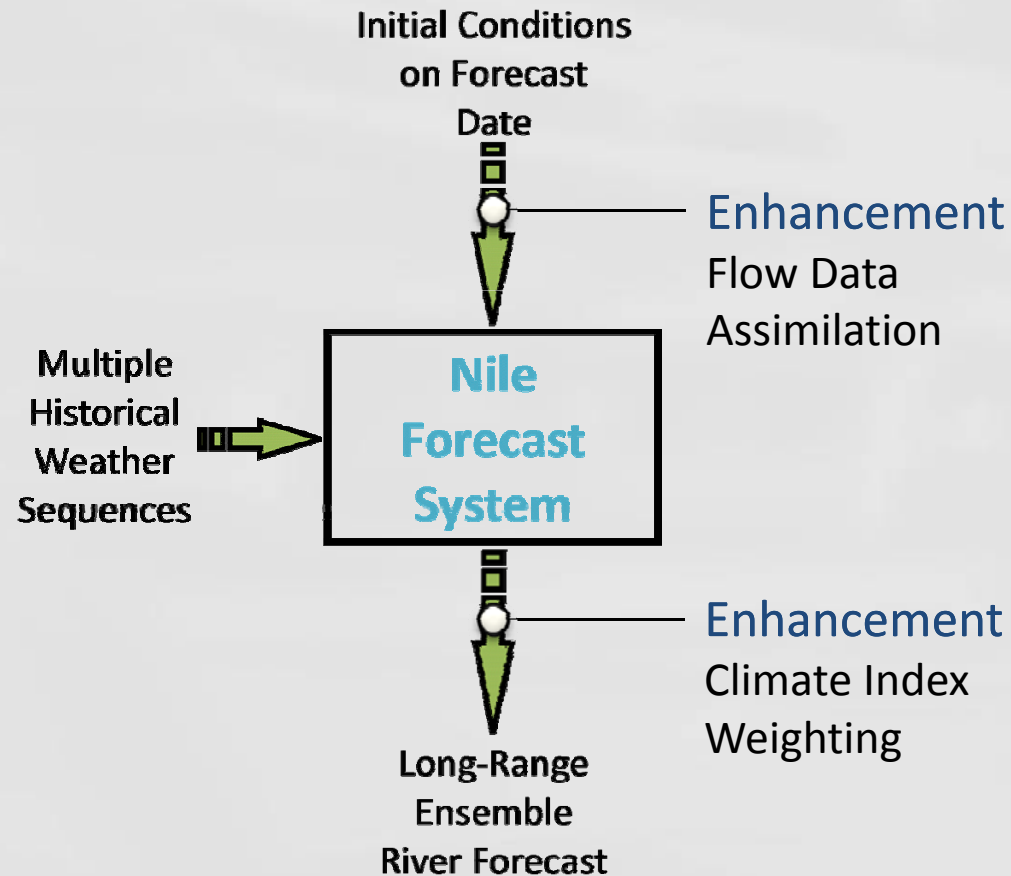
Forecasting the Nile Flood

Blue Nile at Diem



Nile Forecast System (NFS)

Proposed Forecast System Enhancements

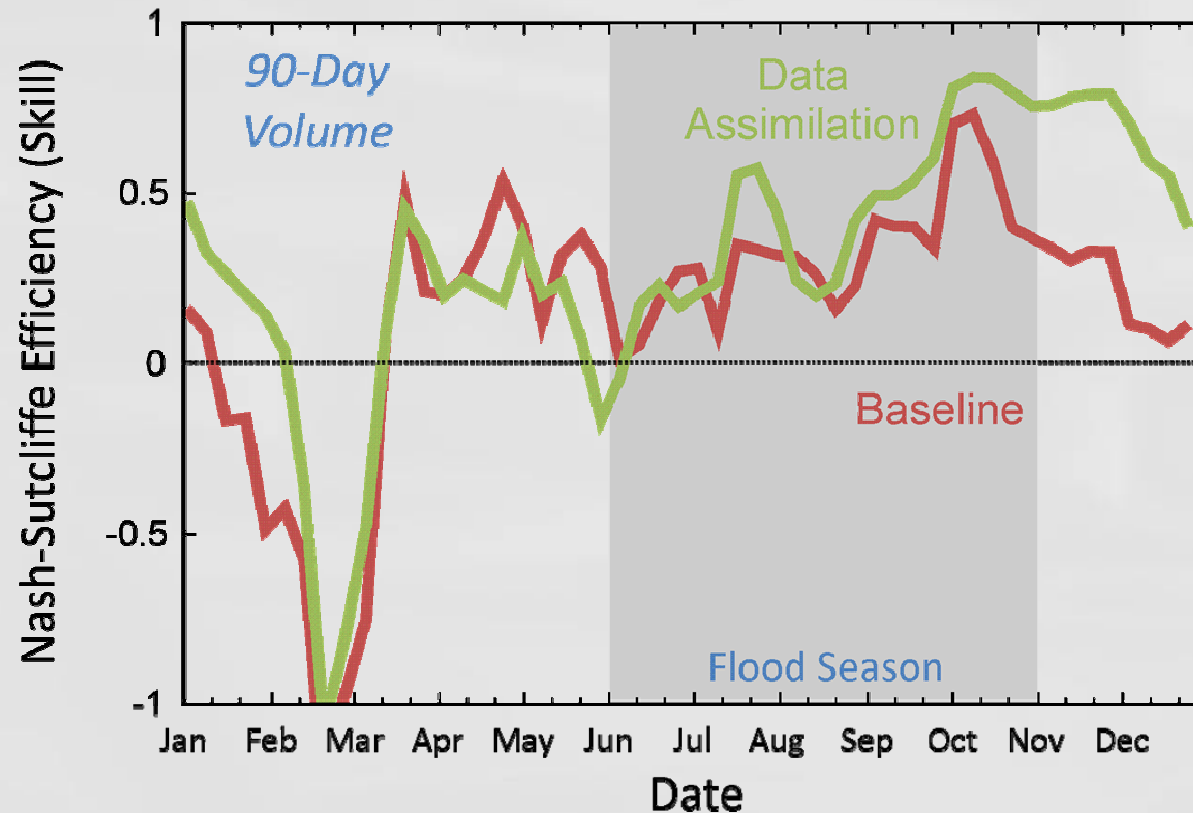


- Baseline forecasts from 1992
- Non-linear optimization to establish initial conditions
- Weighting based on how closely the ENSO index (NINO3.4) for the trace matches conditions at the time of the forecast

Traditional Evaluation

Enhancement performance in simulation mode

Simulation Mode Performance

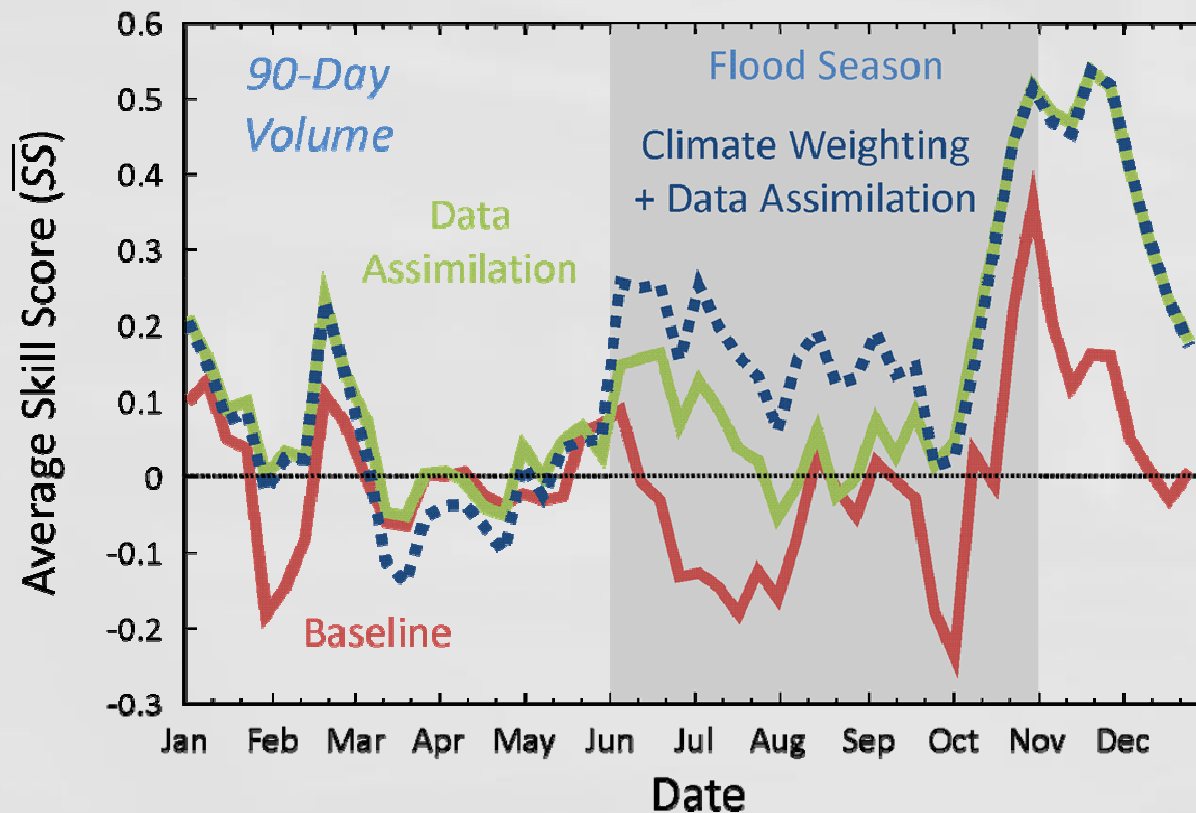


- Compare using model calibration metric
- Both simulations have good predictive accuracy
- Data assimilation better late in the flood season and recession

Verification Evaluation

Enhancement performance in forecast mode

Forecast Mode Performance

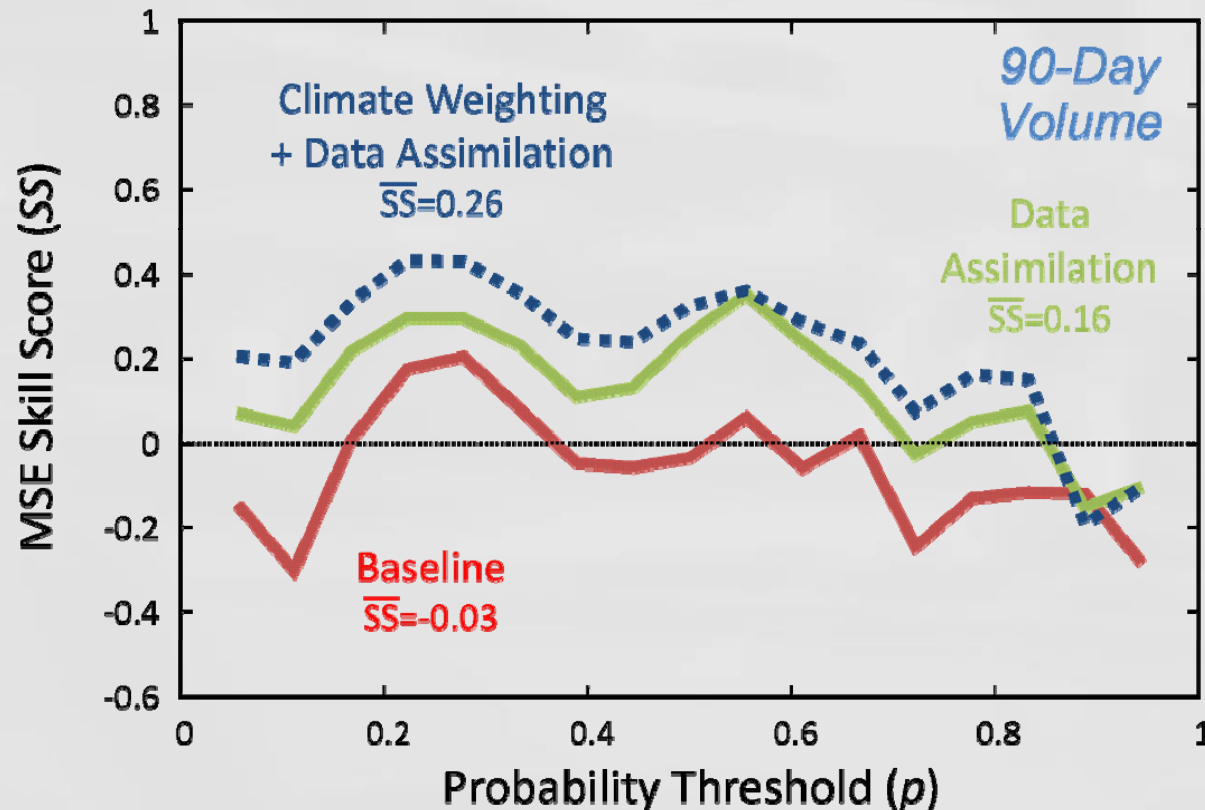


- Baseline has limited skill
- Data assimilation enhances skill during the flood season and recession
- Contribution of climate info is during the flood season

Verification Evaluation

Examining the building blocks

19 June Forecasts



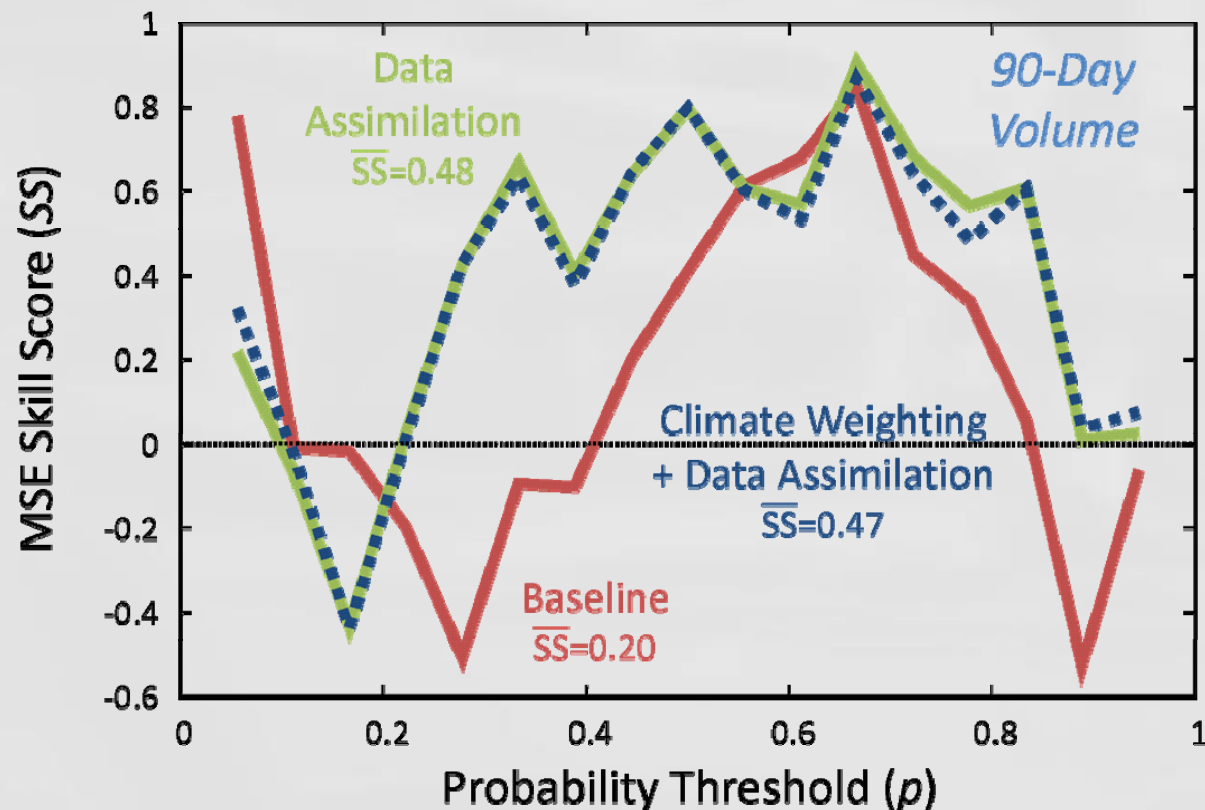
- Enhancements increase the skill of July forecasts for all thresholds



Verification Evaluation

Examining the building blocks

6 November Forecasts



- Enhancements increase the skill of July forecasts for all thresholds
- Enhancements expand the threshold range of skillful November forecasts

Concluding Remarks



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Concluding Remarks

Forecast System Evaluation

- Generation of retrospective forecasts (hindcasting) should be a routine component of hydrologic ensemble forecasting
 - Verification methods can assess quality
 - Verification results would form the basis for accepting (or rejecting) proposed enhancements to the forecasting system
 - Archival information can form the basis for generating improved forecast products (post-processing)