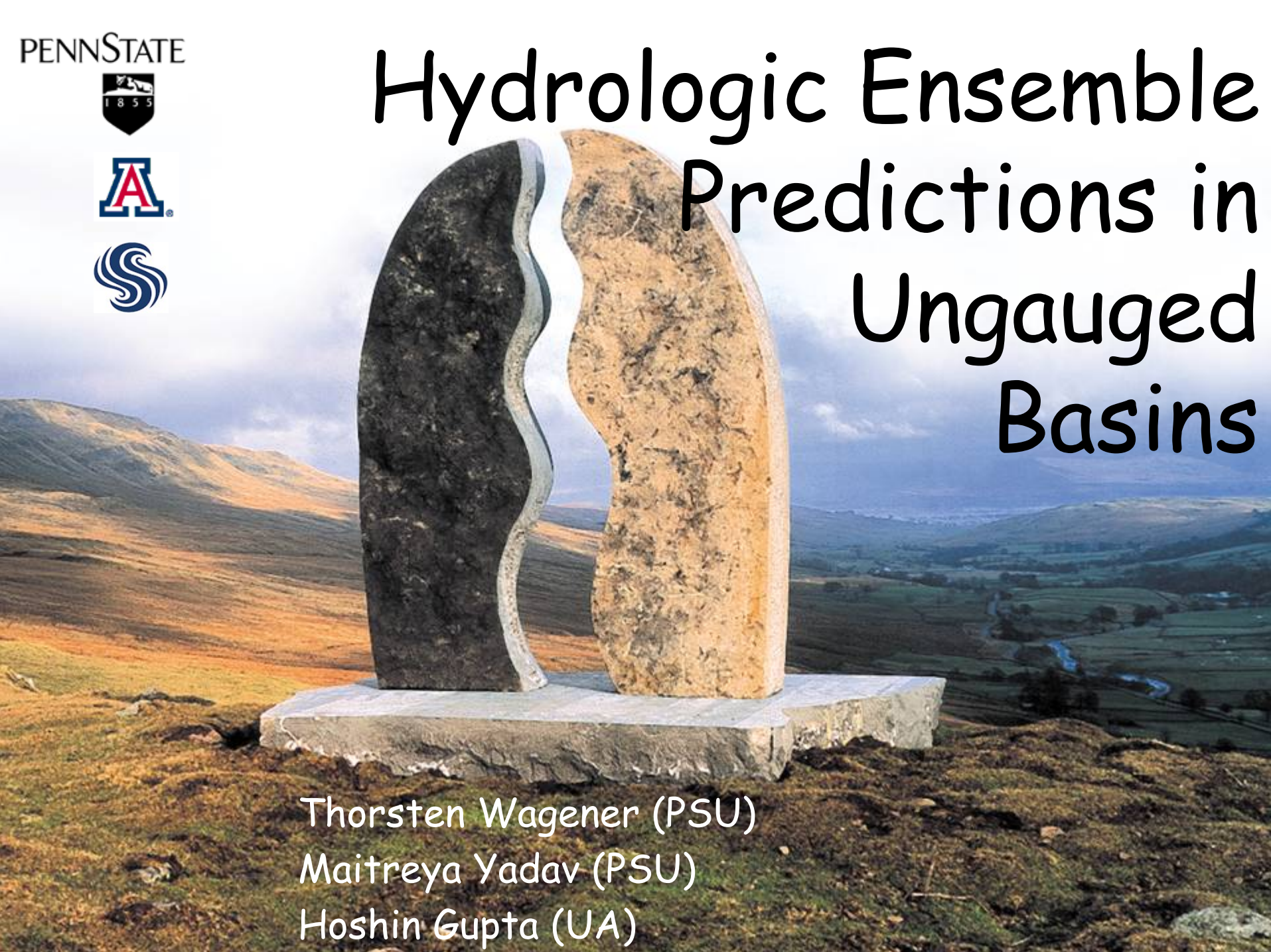
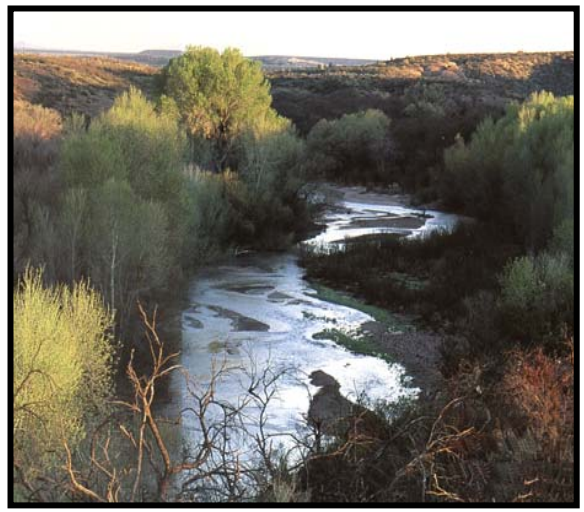


Hydrologic Ensemble Predictions in Ungauged Basins

Thorsten Wagener (PSU)
Maitreya Yadav (PSU)
Hoshin Gupta (UA)

Hydrologic Models are important Elements in Water Resources Studies

- Need for hydrologic models
  - flood forecasting,
  - water resources (e.g. reservoir design and operation),
  - low-flow predictions, drought impacts…
- Hydrologic models vary widely in complexity
  - Conceptual, Physically-based, Empirical
  - Lumped, Distributed



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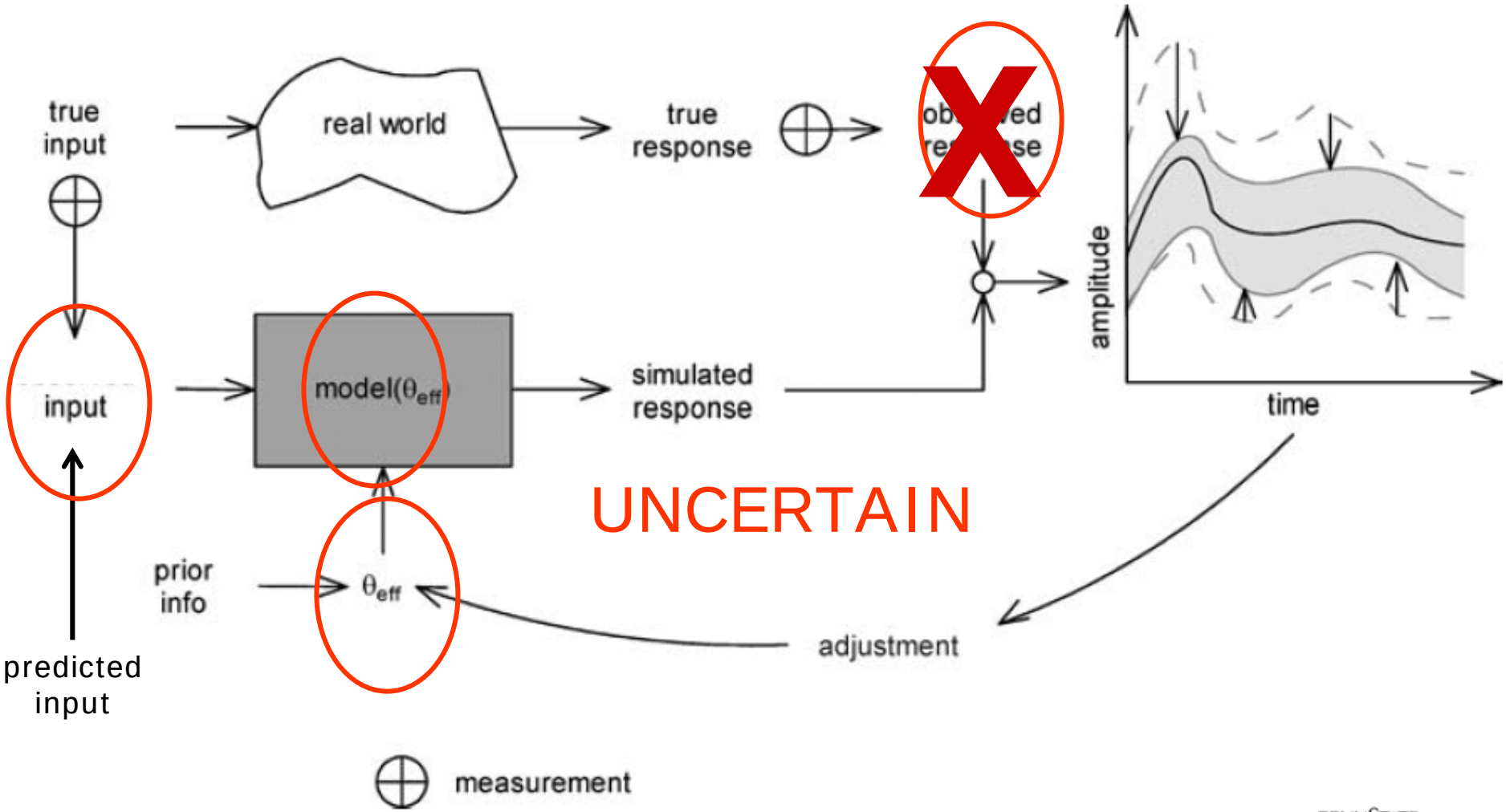
Hydrologic Models require Calibration to provide Reliable Predictions



[Wagener and Gupta, 2005, *SERRA*]

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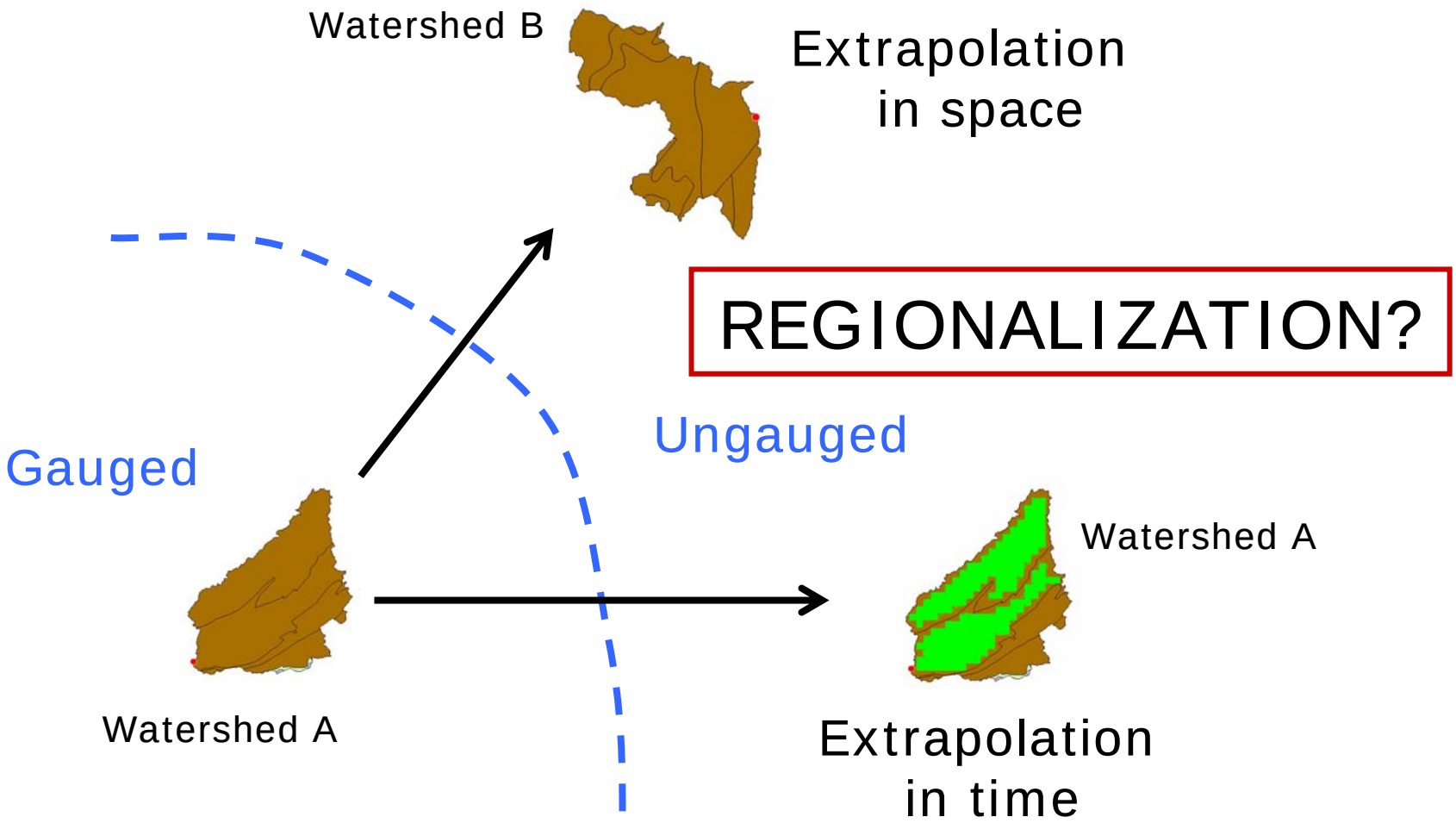
What can we do if Watershed Response Observations are Unavailable?



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Predictions in Ungauged Basins are associated with large Uncertainties

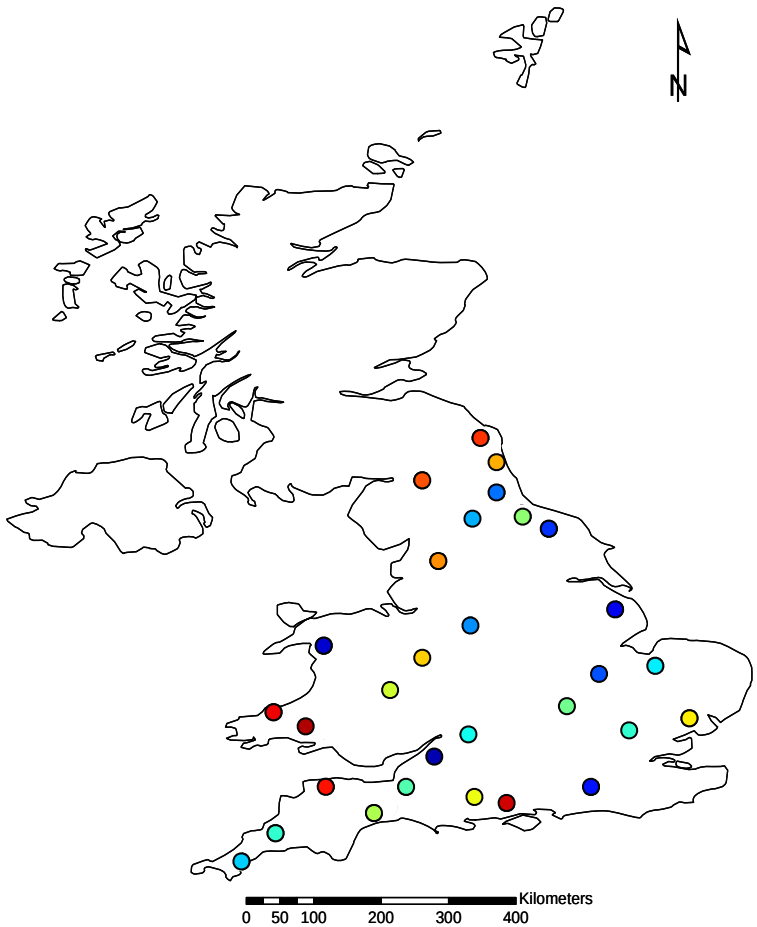
These stem from:

- Model structural uncertainty
- Parameter uncertainty
- Randomness in natural processes
- Uncertainty in data (static and dynamic)
- Regionalization approach

The main problem is the lack of correlation of our conceptual model parameters to watershed characteristics at the scale of interest.

[Wagener and Wheater, 2006, *J. Hydrology*; McIntyre et al., 2005, *WRR*]

30 Watersheds in the UK as Case Study



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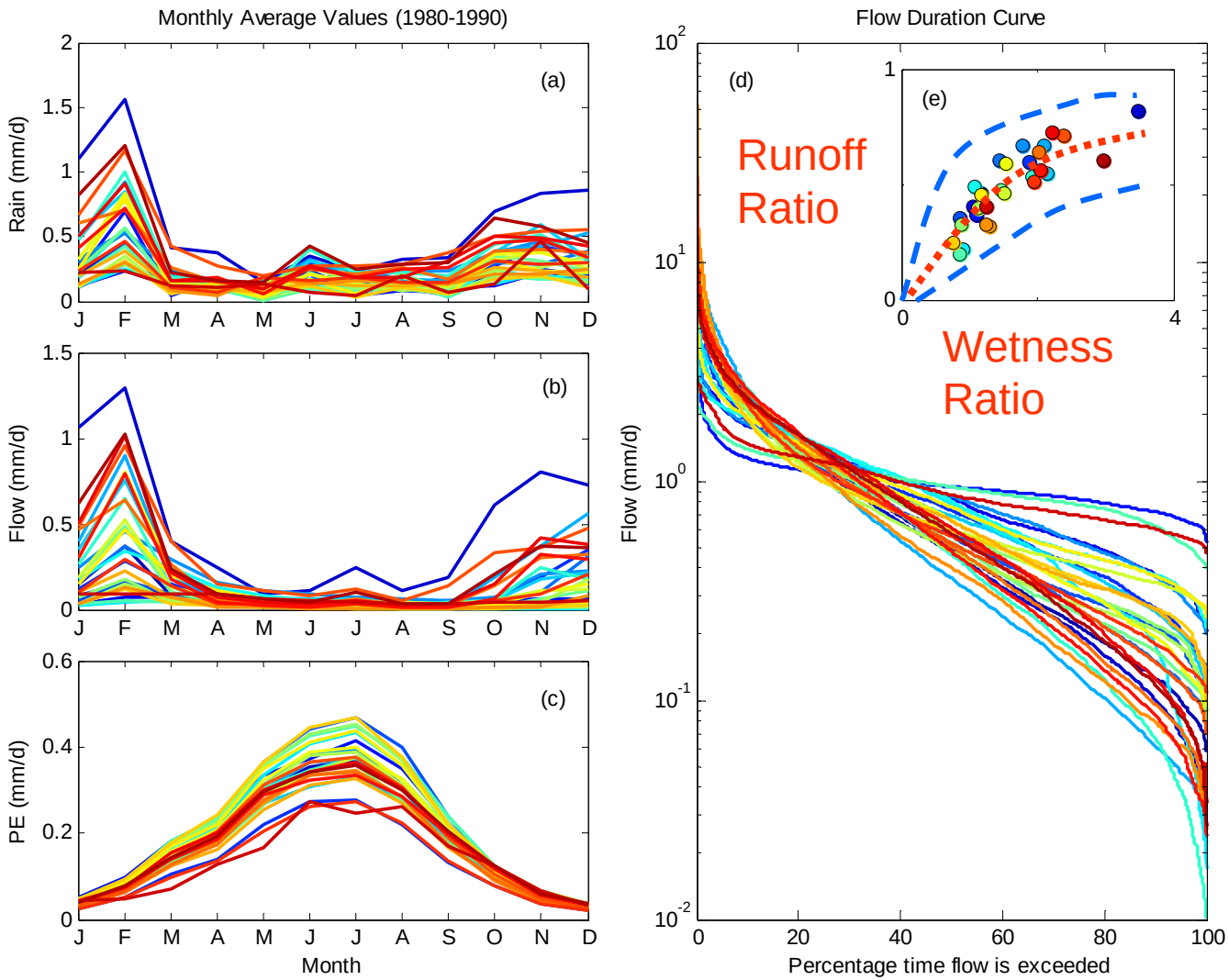
Forcing and Response Data



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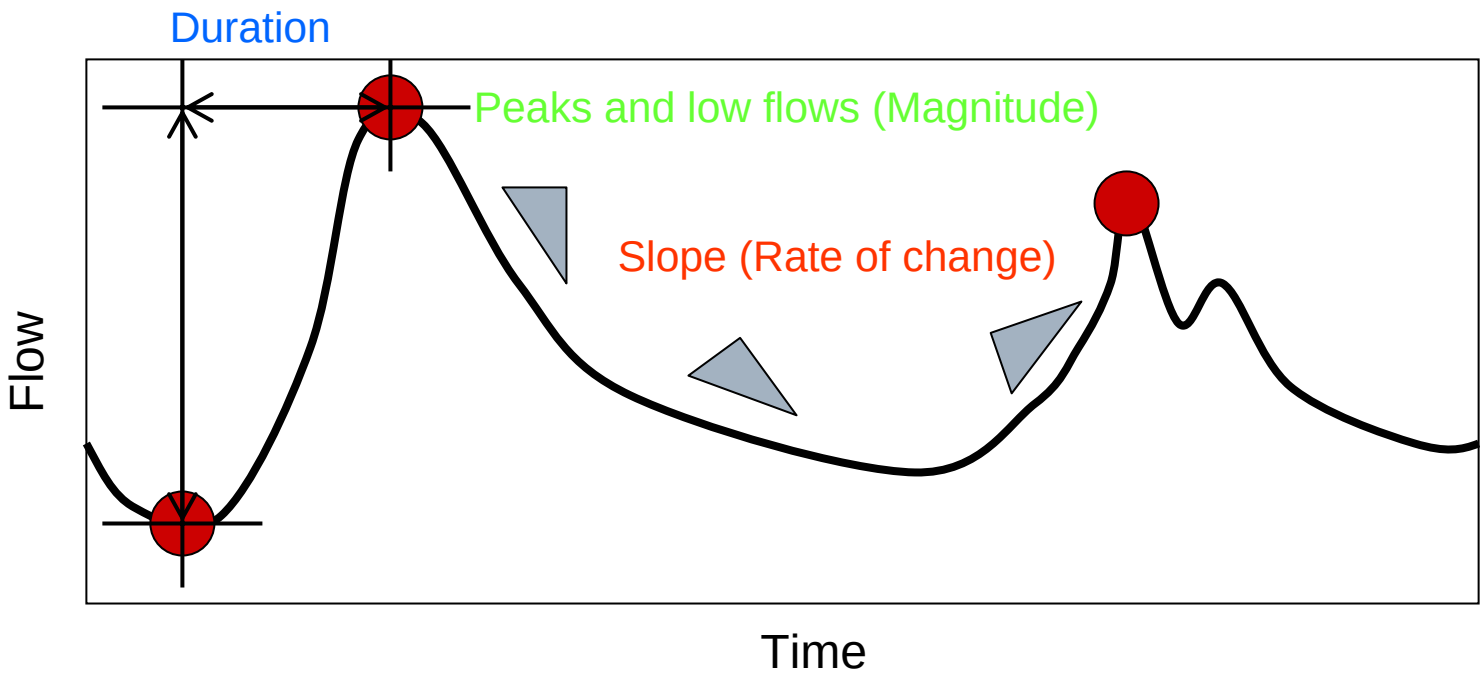
We present a new Model-independent Approach

Based on:

1. Relationships between physical characteristics and response characteristics of watersheds
2. Regionalizing response characteristics as constraints on ensemble model predictions

[Yadav et al., in Press, *MOPEX Redbook*]

Understanding Watershed Response



37 response characteristics categorized into seven groups (High, average, low magnitude, timing, duration, frequency and rate of change)

[e.g. Olden and Poff, 2003; Yu and Yang, 2000; Shamir et al., 2004; 2005; and others]

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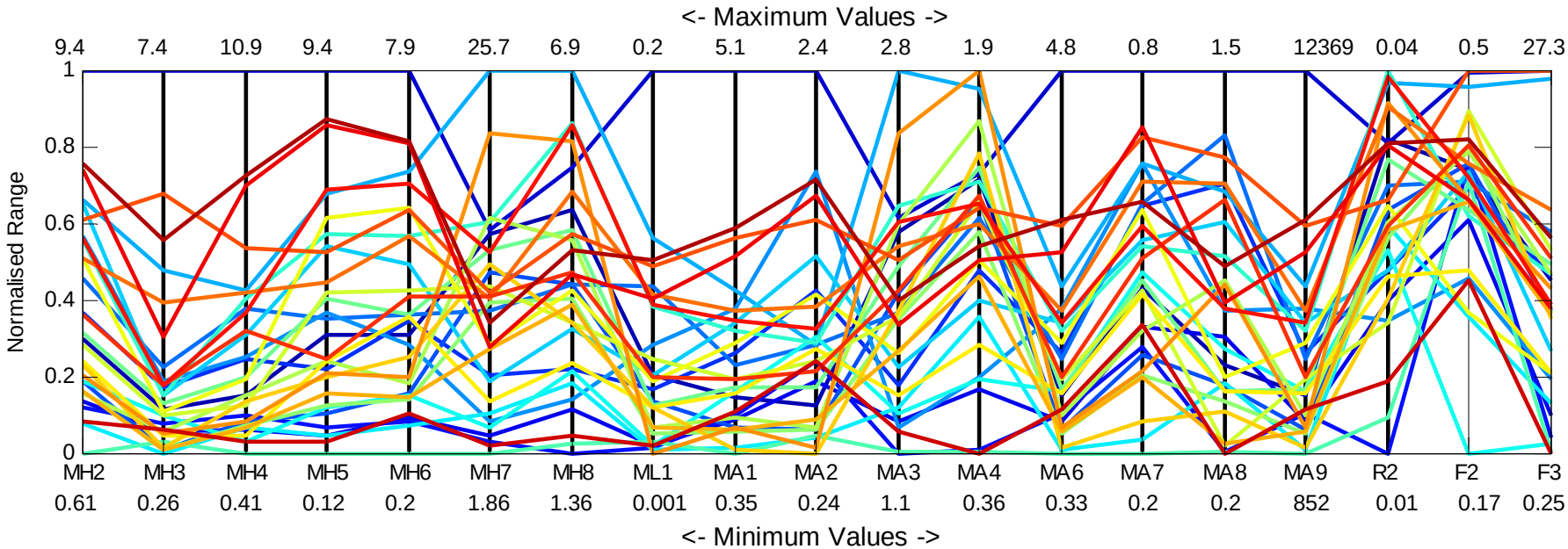
Watershed Behavior described using 19 (37) Dynamic Characteristics



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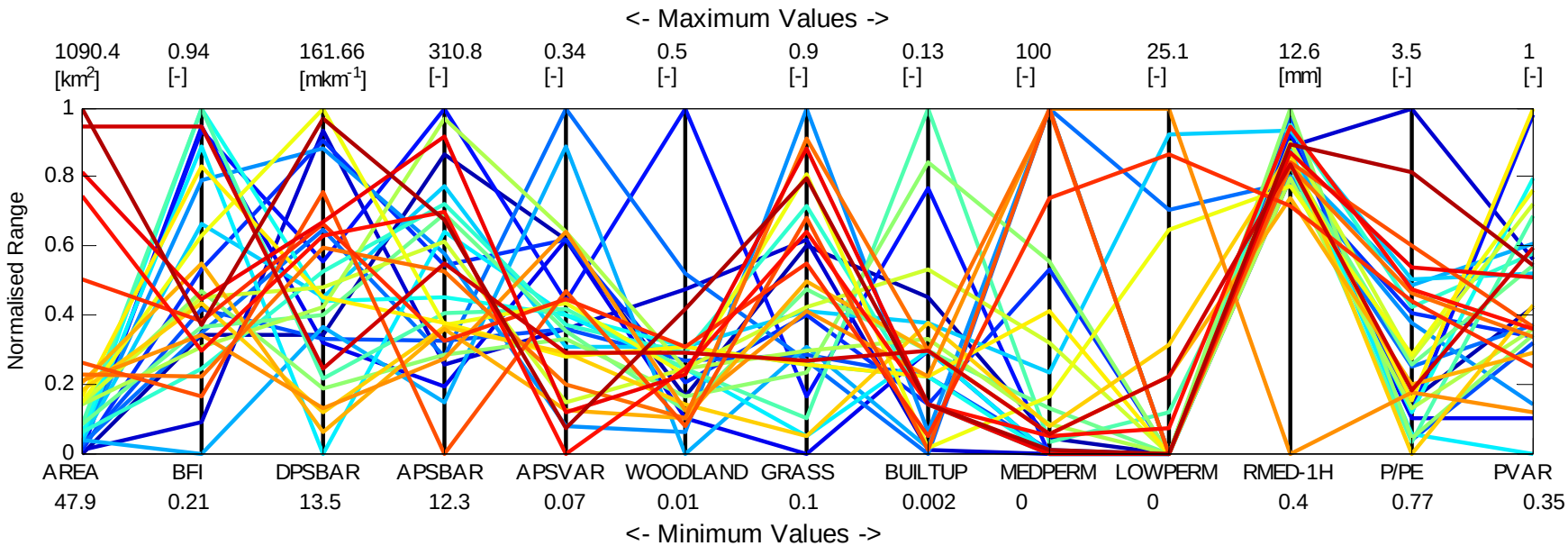
Watershed Structure described using 13 (25) Physical Characteristics



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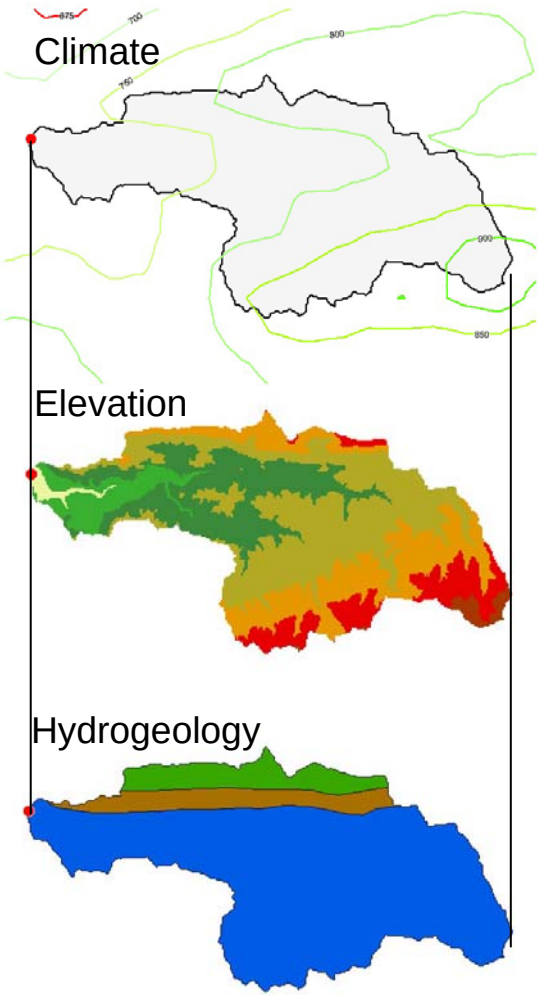
High Correlation between Response and Physical Characteristics

Linear Correlation >0.8



P/PE
Max Feb, Max Nov, Mean, Runoff ratio

DPSBAR (Slope)
Median, Runoff ratio

BFIHOST
High flow discharge, Skewness and Variability in flow, High pulse count

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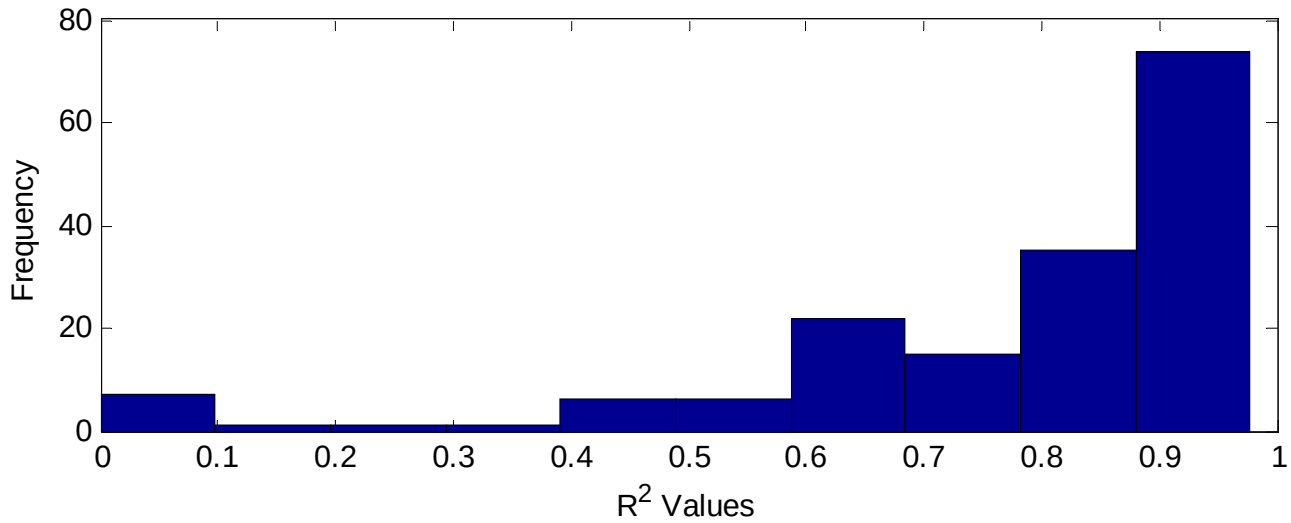
Stepwise Regression leads to high R^2 Values

- Forward stepwise regression
- 6 fold cross validation – 5 ungauged and 25 gauged watersheds



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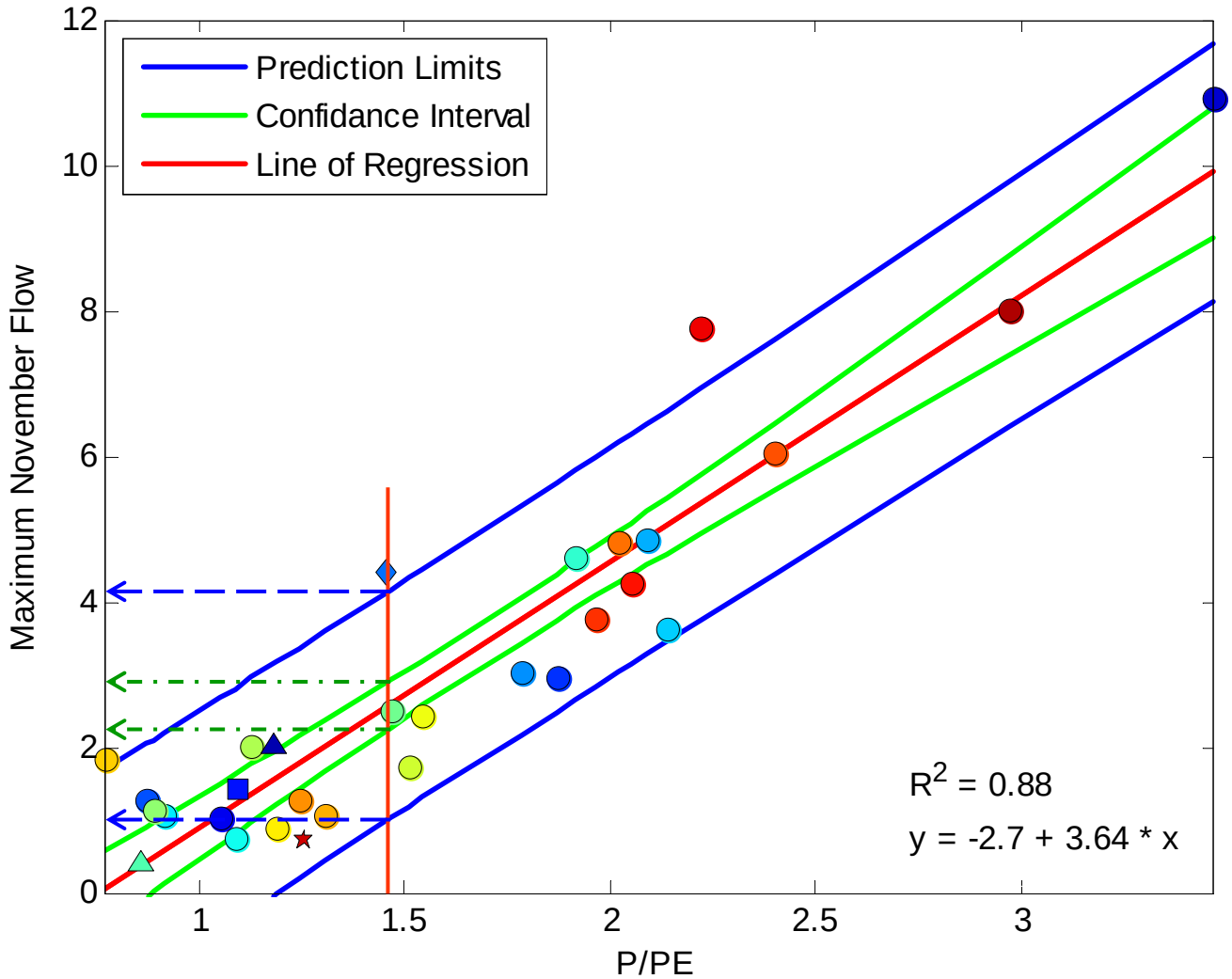
High Correlation creates narrow Uncertainty Corridor in Regression



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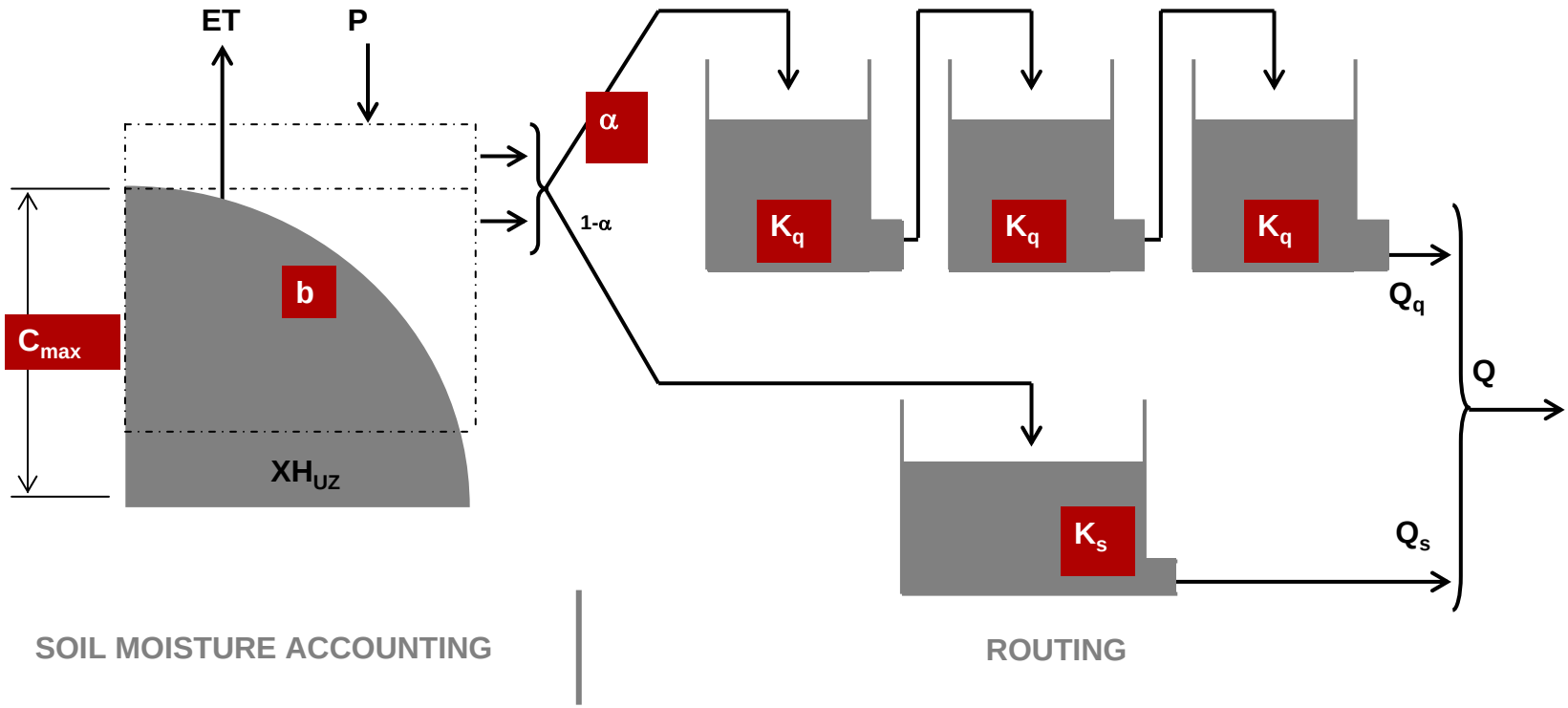
Using Parsimonious Watershed Model as Test Case



We ran a Uniform Random Sampling selecting 10,000 Parameter sets from the a priori feasible space.

[Boyle et al., 2000, *WRR*; after Moore]

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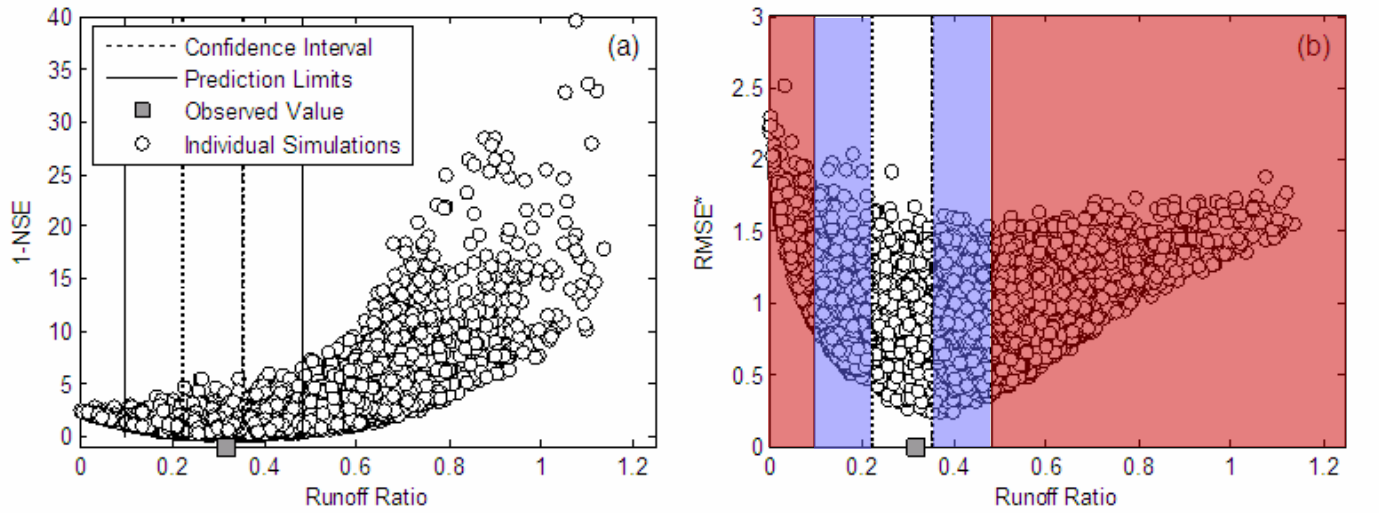
We can Constrain the Ensemble Predictions in an Ungauged Basin



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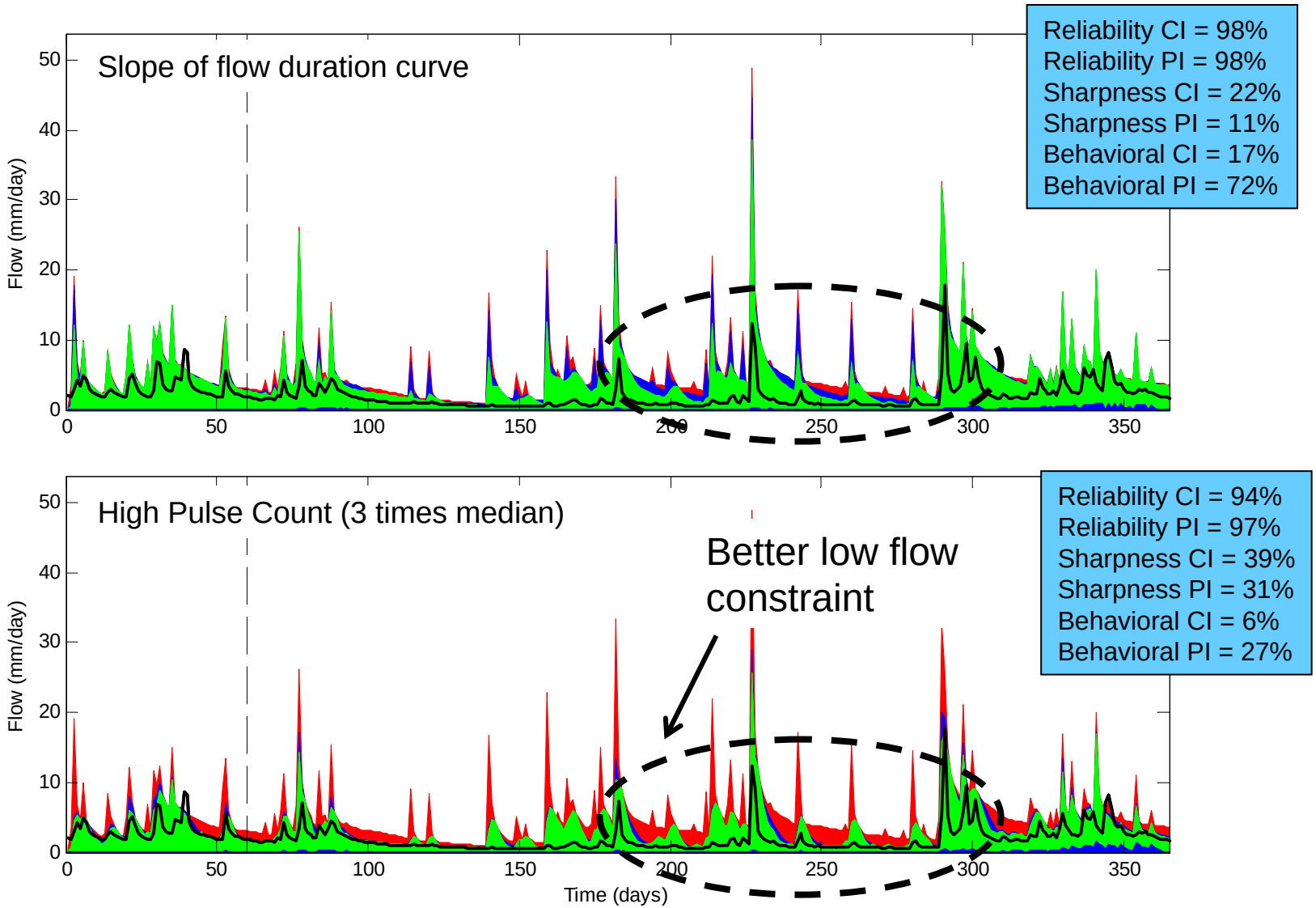
Evaluating Reliability and Sharpness for Ensemble Forecasts

- RELIABILITY: How much of the observation is contained by the ensemble?

- SHARPNESS: How wide are the ensemble prediction ranges (compared to the initial ranges)?

Two Individual Response Characteristics as Constraints



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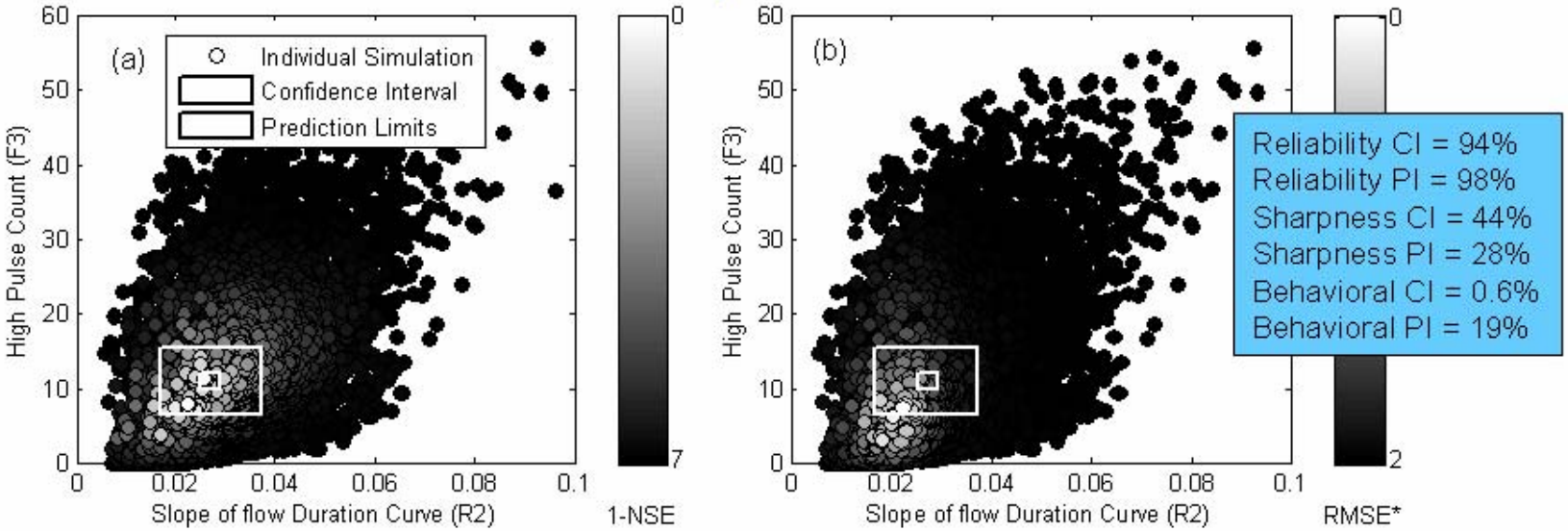
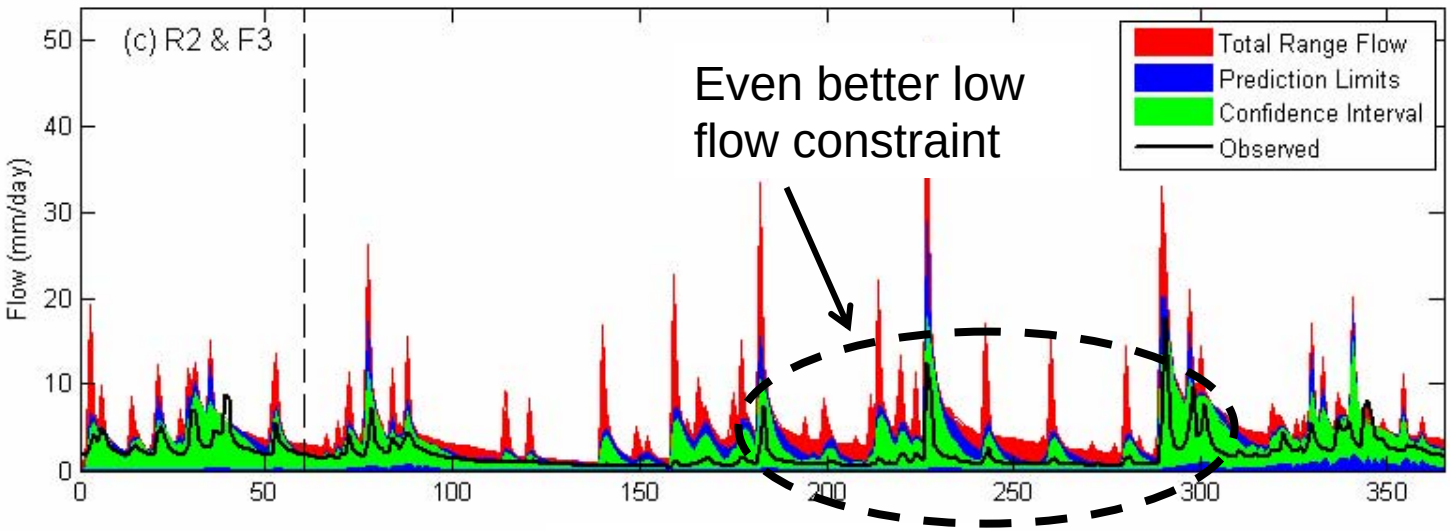
Applying two Response Characteristics yields even better Constraint





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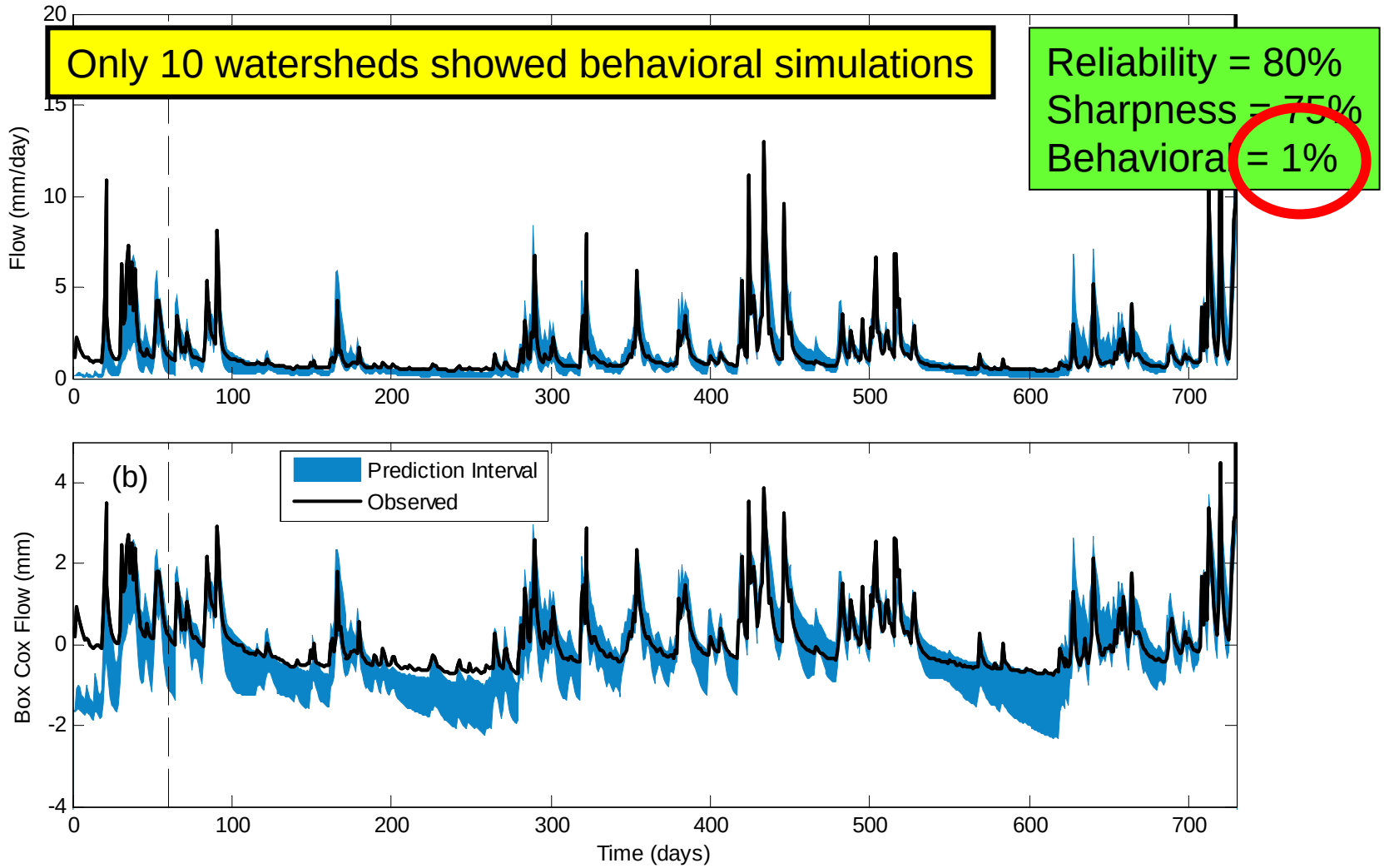
Good Results obtained by using all 19 Response Characteristics as Constraints simultaneously



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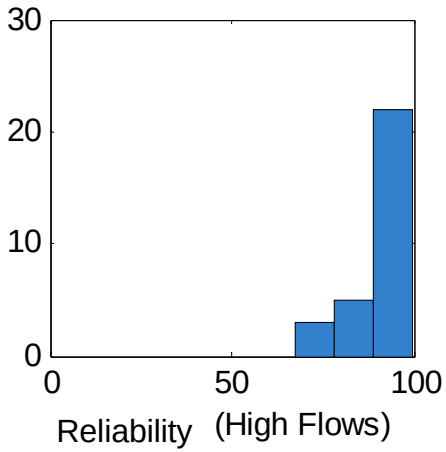
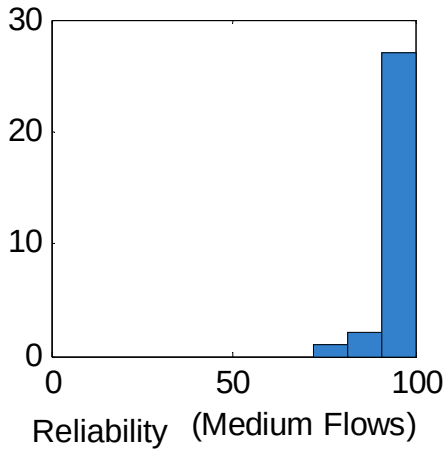
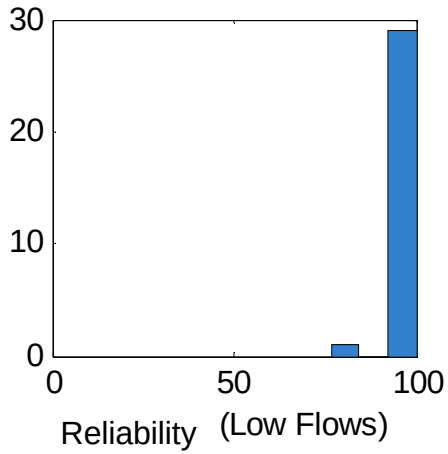
Three selected Response Characteristics show very good Results across 30 Watersheds for PL

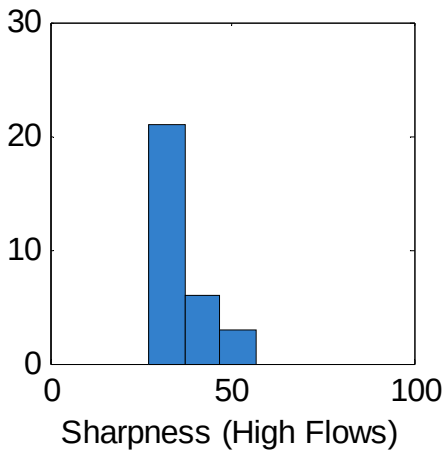
high pulse count, runoff ratio, and slope of flow duration curve

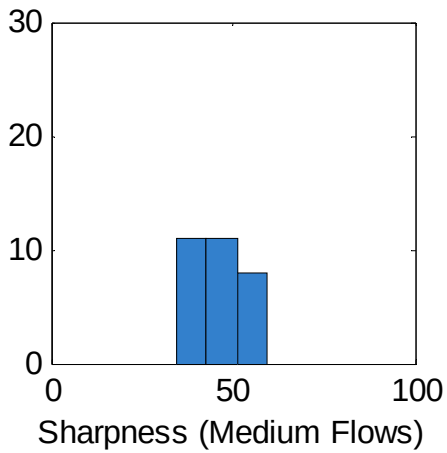
Prediction Limits

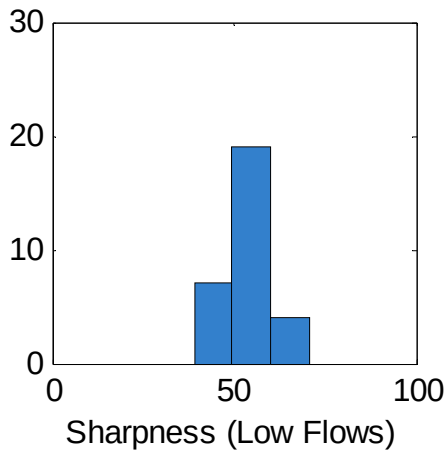












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Why is this a Good Approach to Tackle the Ungauged Basins Problem?

- Based on empirical evidence
- Not biased by model structure error
- Avoids calibration problem
- Applicable to lumped and distributed models
- Applied at scale of interest

QUESTIONS ?

Funded by NWS & NSF SAHRA

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