Impacts of uncertainty in efficient management of California's water resources

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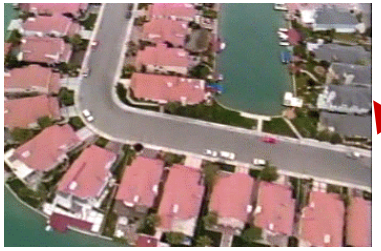
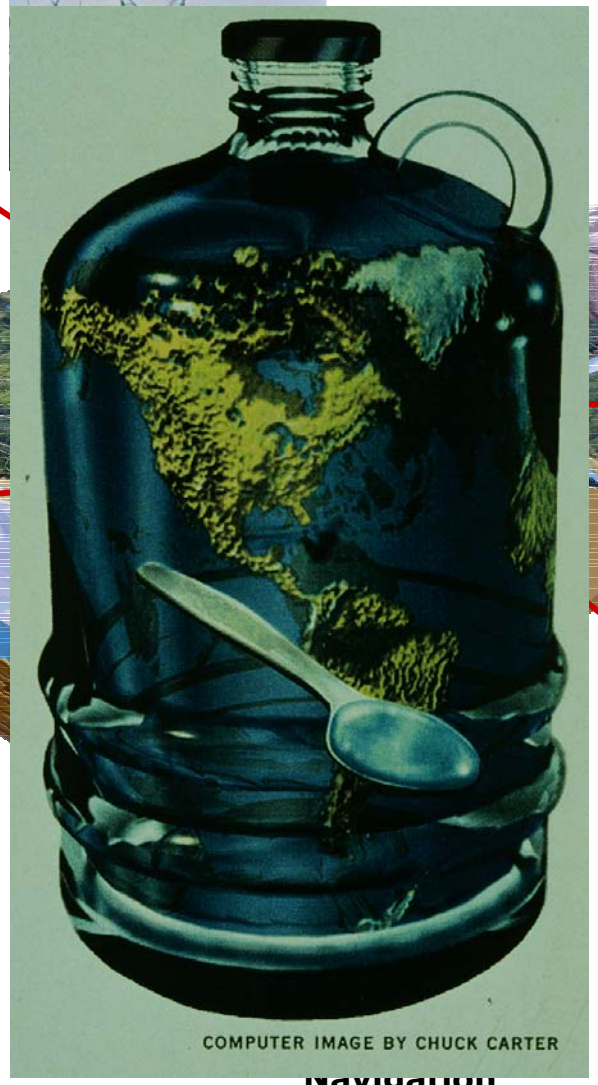
Competing Demands in California

Domestic



Power & Industry



Wildlife

Agriculture

Recreation

Navigation

CAL2030 project: Overview

This calls for an integrated, efficient and sustainable plan to management of water resources
which is one of focuses of the Berkeley Water Center

CAL2030 project: system integration

- This integrated system will include an open and flexible platform that connects all California's water systems.
- Why an open platform?
  - More efficient resource management by allowing decision makers to test different possible coordinated operation scenarios.
  - Improved system reliability in term of water supply by considering:
    - uncertainty in future hydrologic events (e.g. impacts of climate change).
    - uncertainty within the management system (e.g. modeling processes).
    - disaster management issues such as exploring alternative water supply sources in case of a catastrophe.

CAL2030 project: characteristics of the platform

A few major characteristics of such a platform are that it:

- contains multiple modeling components

  (e.g. surface water component, ground water component) that can be attached and detached from the main platform without causing any operational challenges for the user

- is flexible enough to accept different kind of inputs as source of water supply (including historical hydrologic records or direct output of any hydrological model).

- can be operated on various time scales (e.g. daily, monthly, and seasonally). This way the platform can be operated for both water supply and flood control purposes.

CAL2030 project: pilot project

Conduct a pilot project to focus on some of the raised issues in a smaller scale by:

- Identifying and assessing *end-to-end uncertainty* in a water resources management system with multiple users such as Sacramento River Basin.
- Evaluating the reliability of water supplies by analyzing the estimated uncertainty.
- Evaluating if more accurate estimation of the uncertainty leads to sustainable management of our limited water resources in the state of California.

Impacts of reliable forecast

More reliable forecast can:
Change our perspective of expected future extreme events such as Floods and Droughts.

- Enables the decision makers to better handle risk in decision making
- Therefore mitigate some of social, economical and environmental impacts.
- Also manage our limited water resources more efficiently under new adaptation plans

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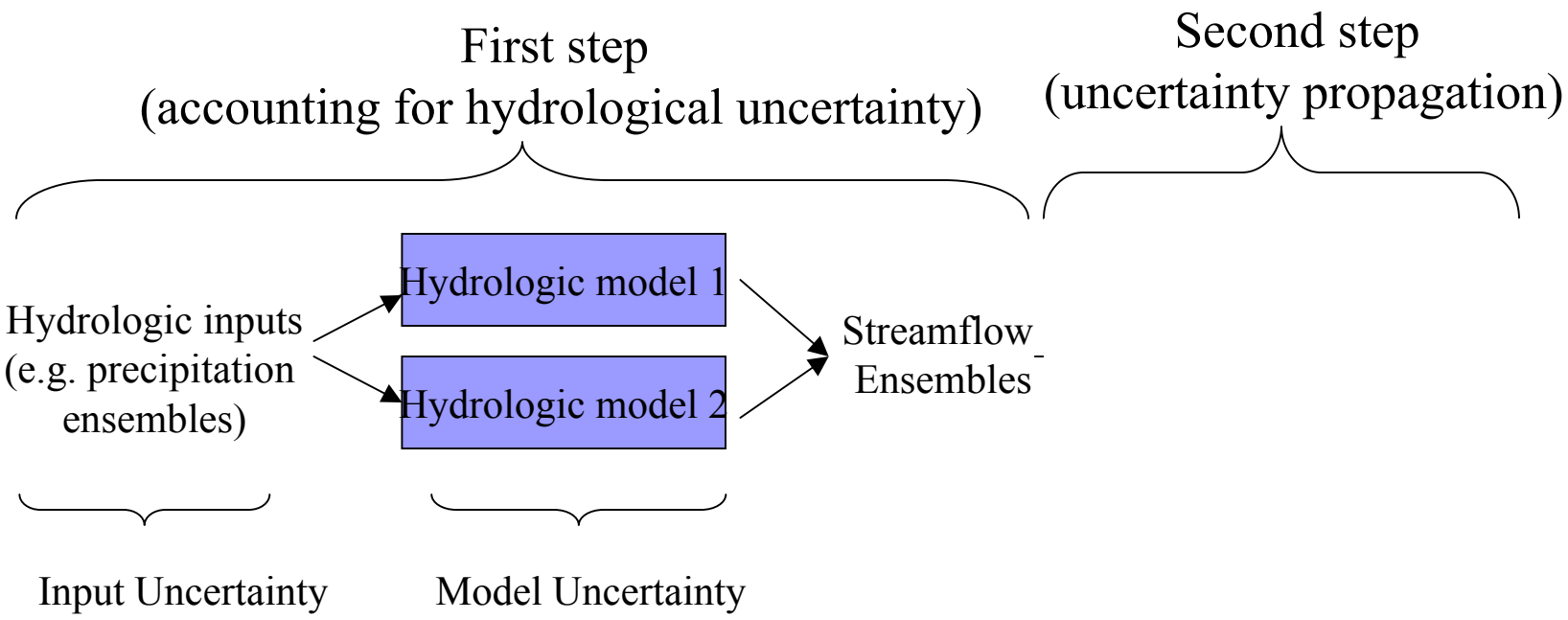
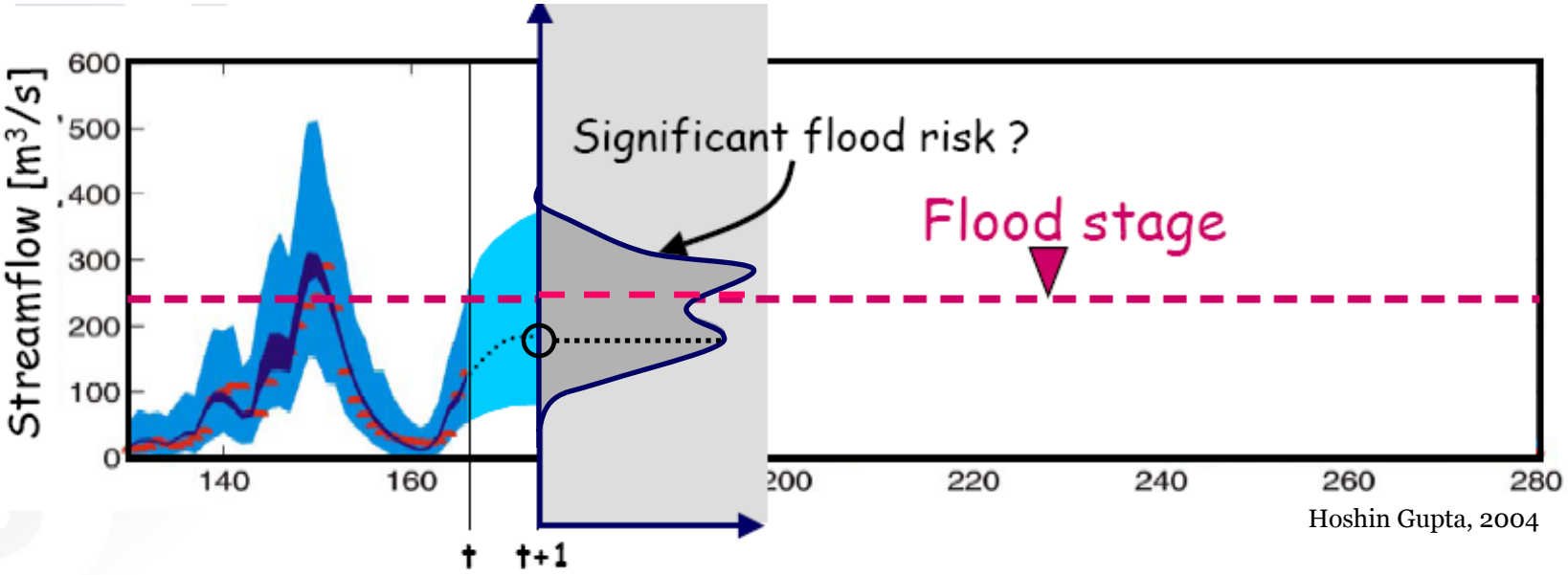
Methodology

- Study area: Upstream of Shasta reservoir in Sacramento basin (including all the catchments that contribute to the inflows to Shasta).
- Monthly precipitation and temperature data from 1962-1994.
- Single aggregated demand which represents the water demand south of Shasta.
- Two simple hydrologic models to generate streamflow ensembles.
  - Hydrologic MODel (HYMOD,5 par)
  - Simple Water Balance model (SWB, 5 par)
- Using the Water Evaluation and Planning (WEAP) model for resource management and planning (developed by the Stockholm Environment Institute).

Methodology



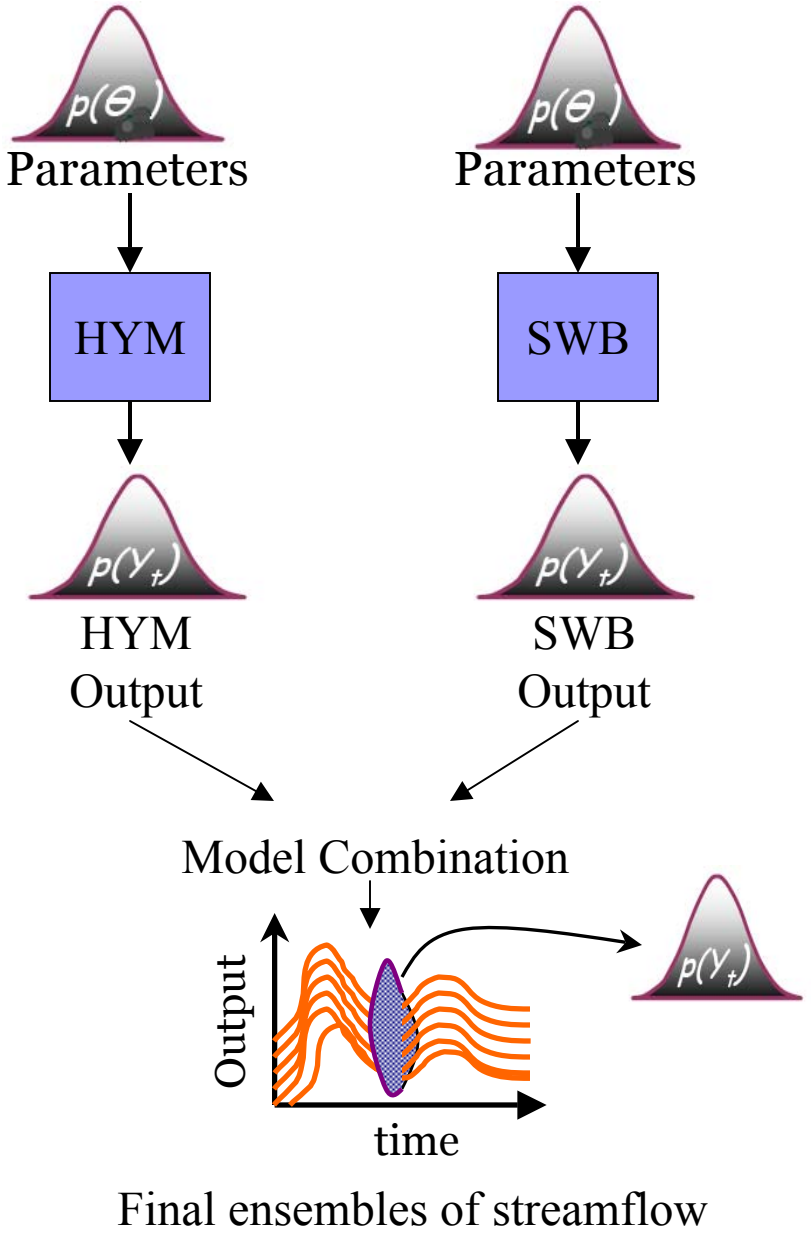
Why uncertainty is important?



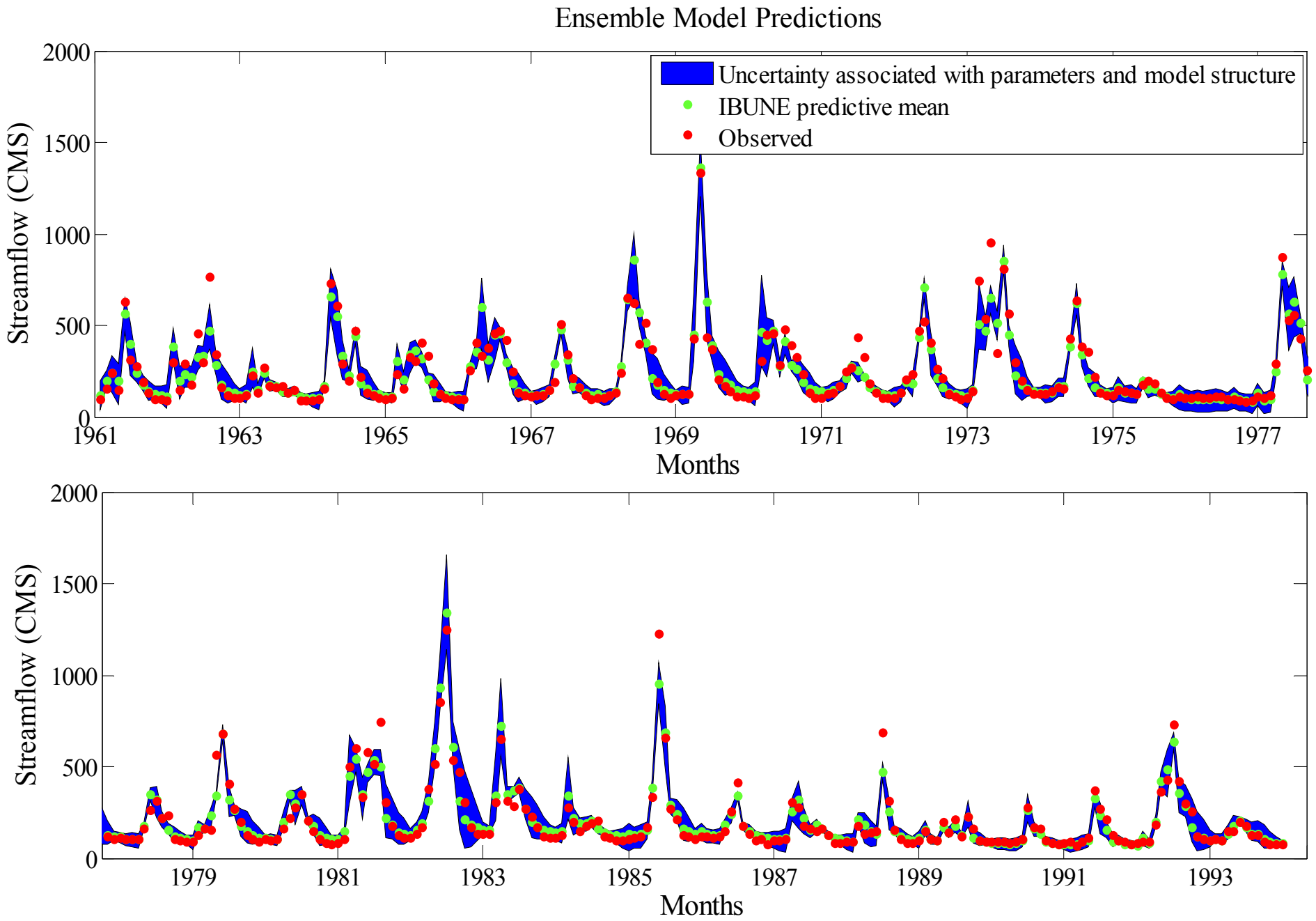
Hoshin Gupta, 2004

Accounting for hydrological uncertainty

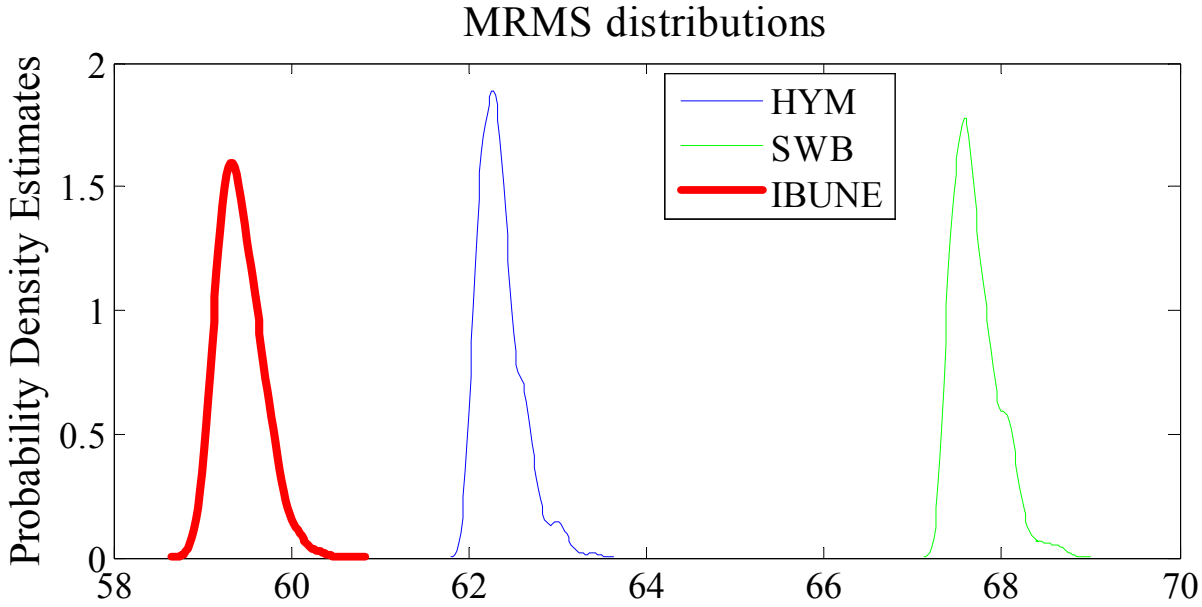
- Integrated Bayesian Uncertainty Estimator (IBUNE).
- Framework that accounts for uncertainty in input forcings, model parameters and model structure.
- Optimization + MCMC + Model combination
- Here we use it just to account for model parameter and model structural uncertainty.

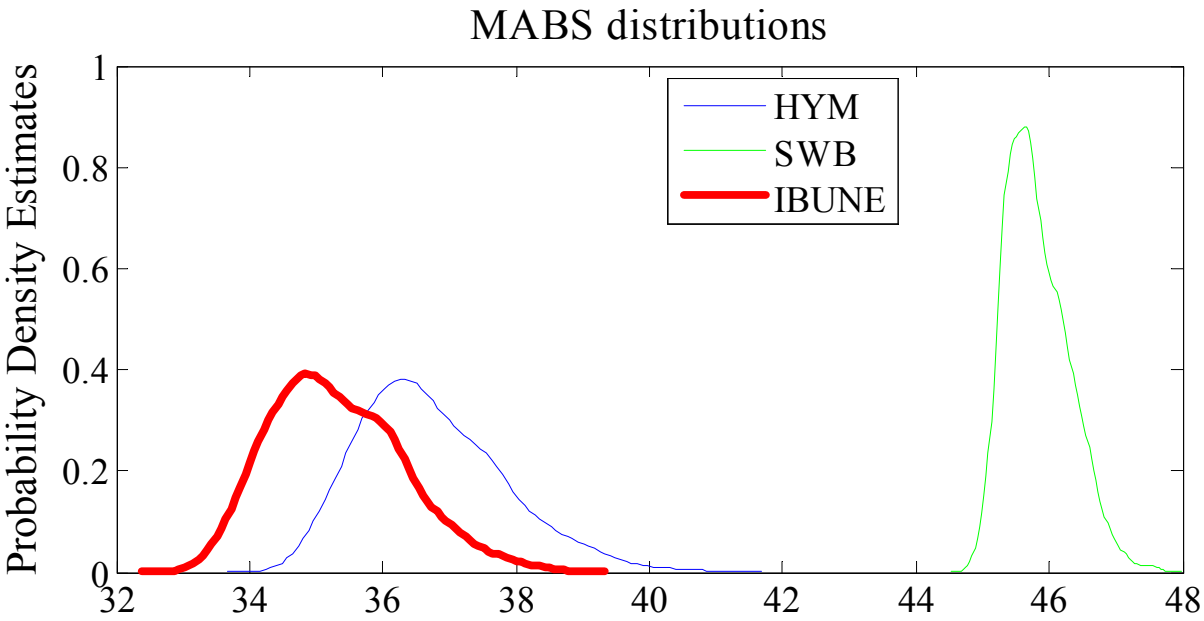


Performance of IBUNE's probabilistic and Deterministic simulations

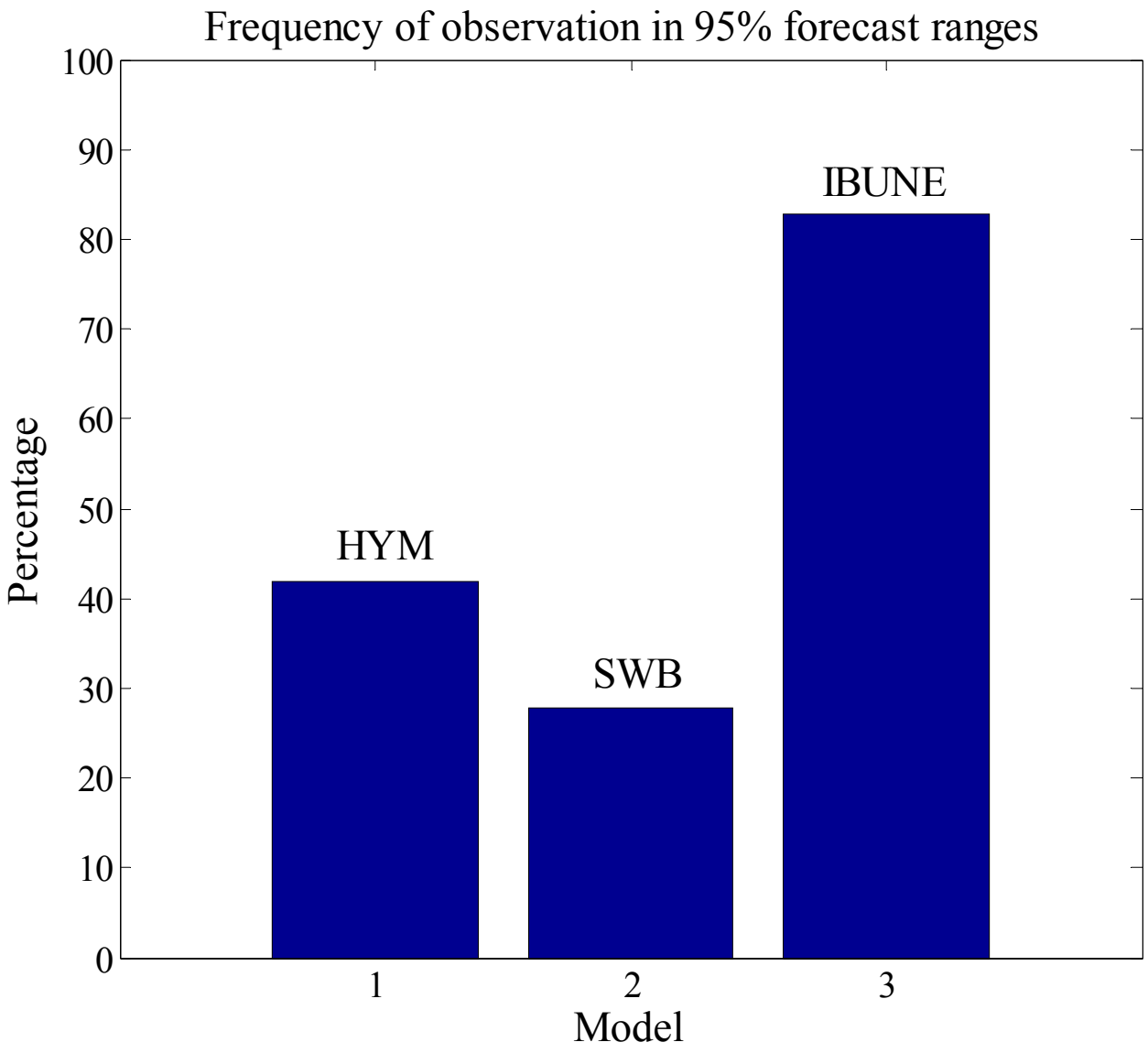


IBUNE versus individual models





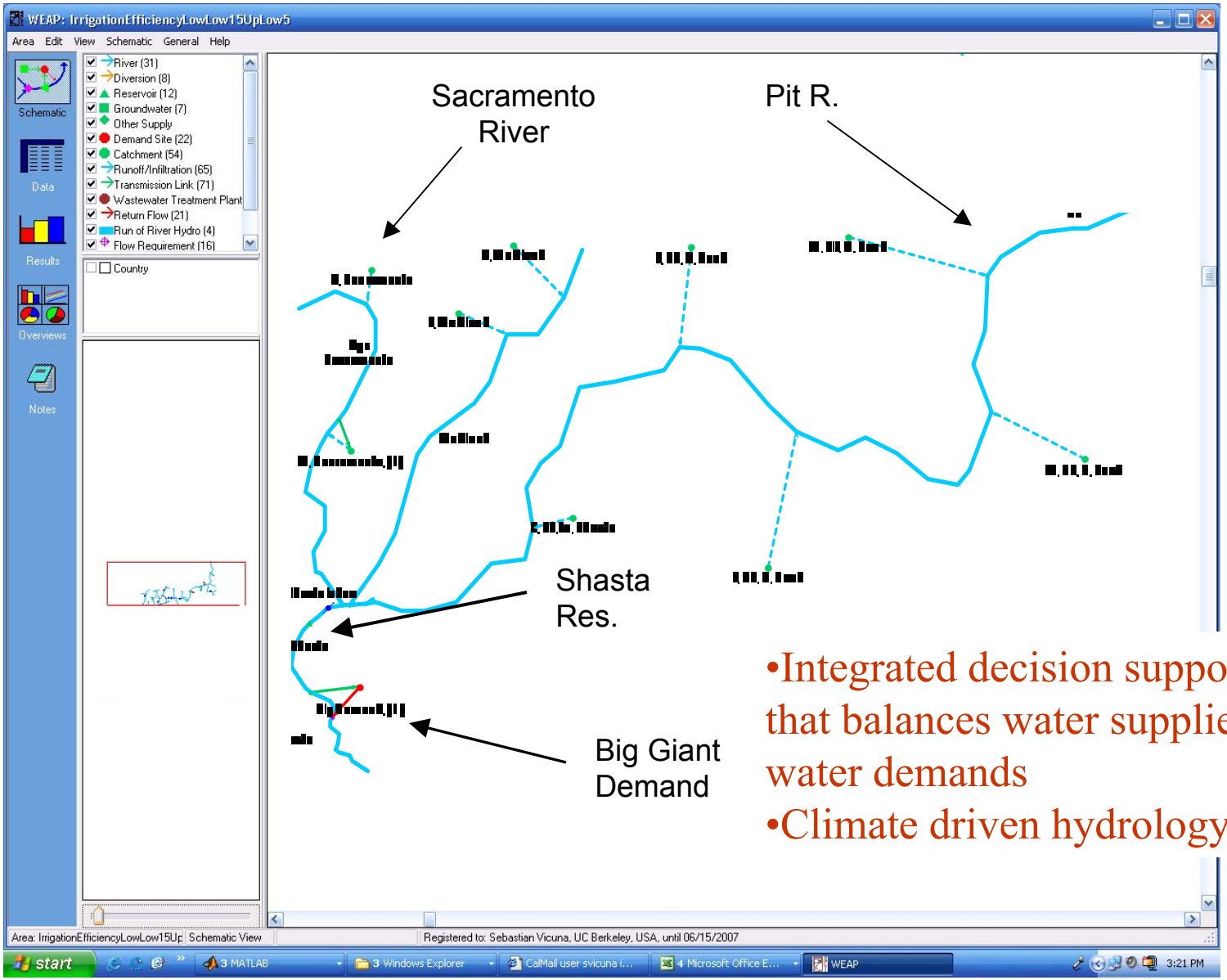
IBUNE versus individual models



Propagation of hydrological uncertainty

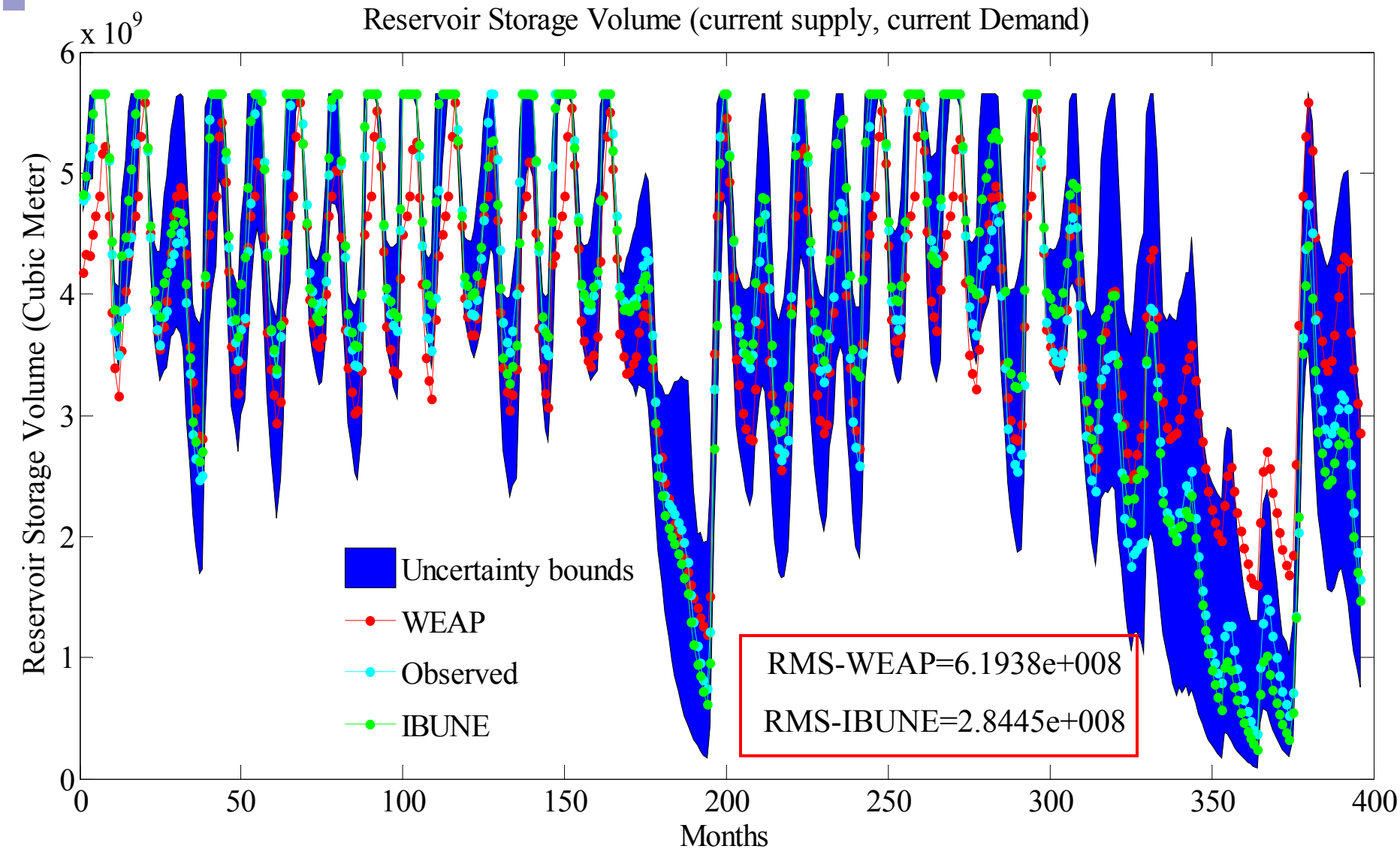
- Propagate the estimated uncertainty through a water management and planning model such as WEAP.
- Looking at the inflow to Shasta Dam.
- Single aggregated demand which represents the water demand south of Shasta.
- Evaluating the reliability of water supplies by analyzing the estimated uncertainty.
- Two scenarios:
  - Scenario 1: current supplies, current demand
  - Scenario 2: current supply, future demand (considering population growth for year 2030)

WEAP model

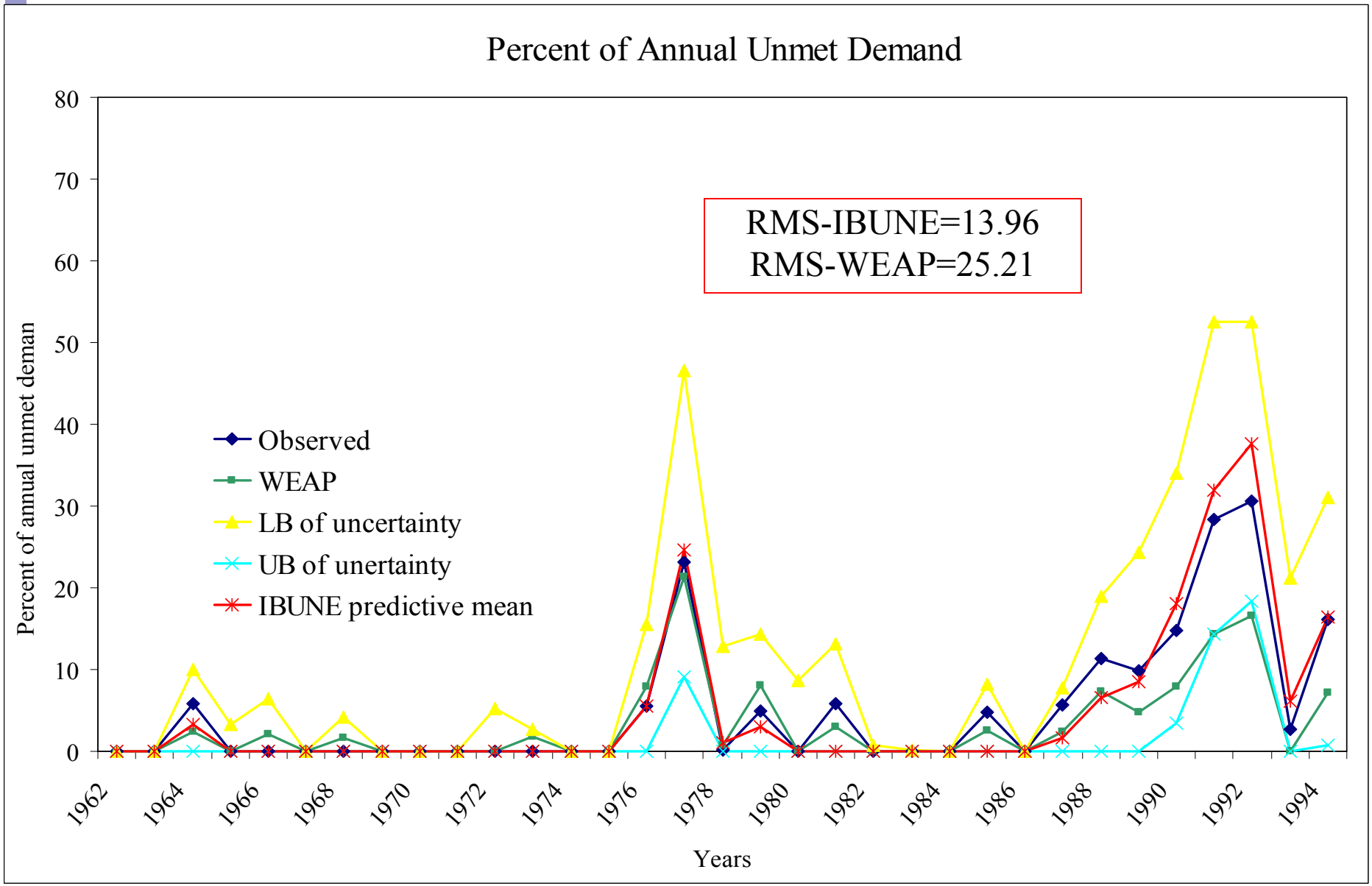


- Integrated decision support system model that balances water supplies and multiple water demands
- Climate driven hydrology

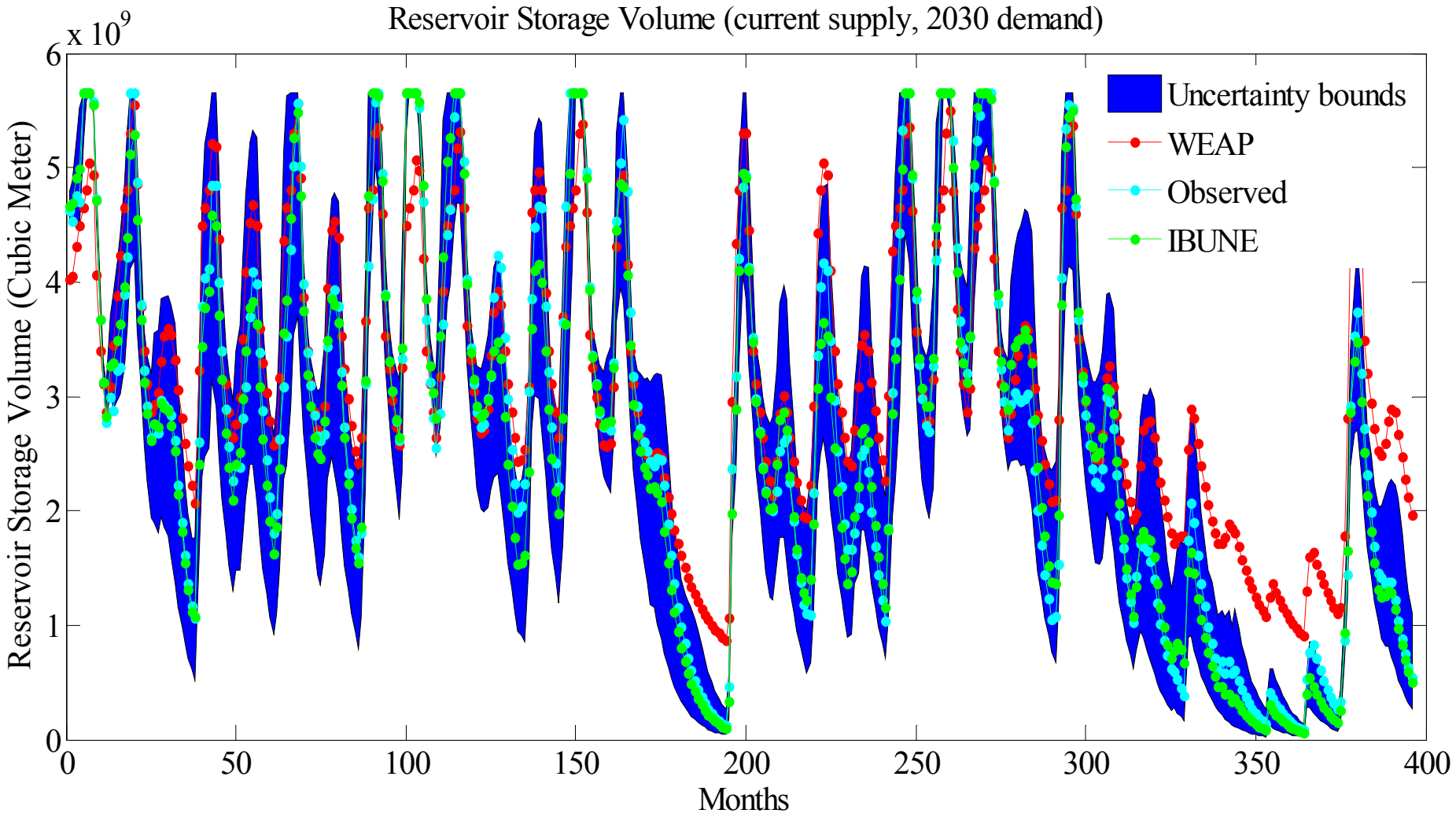
Reservoir Storage Volume-current supply, current demand



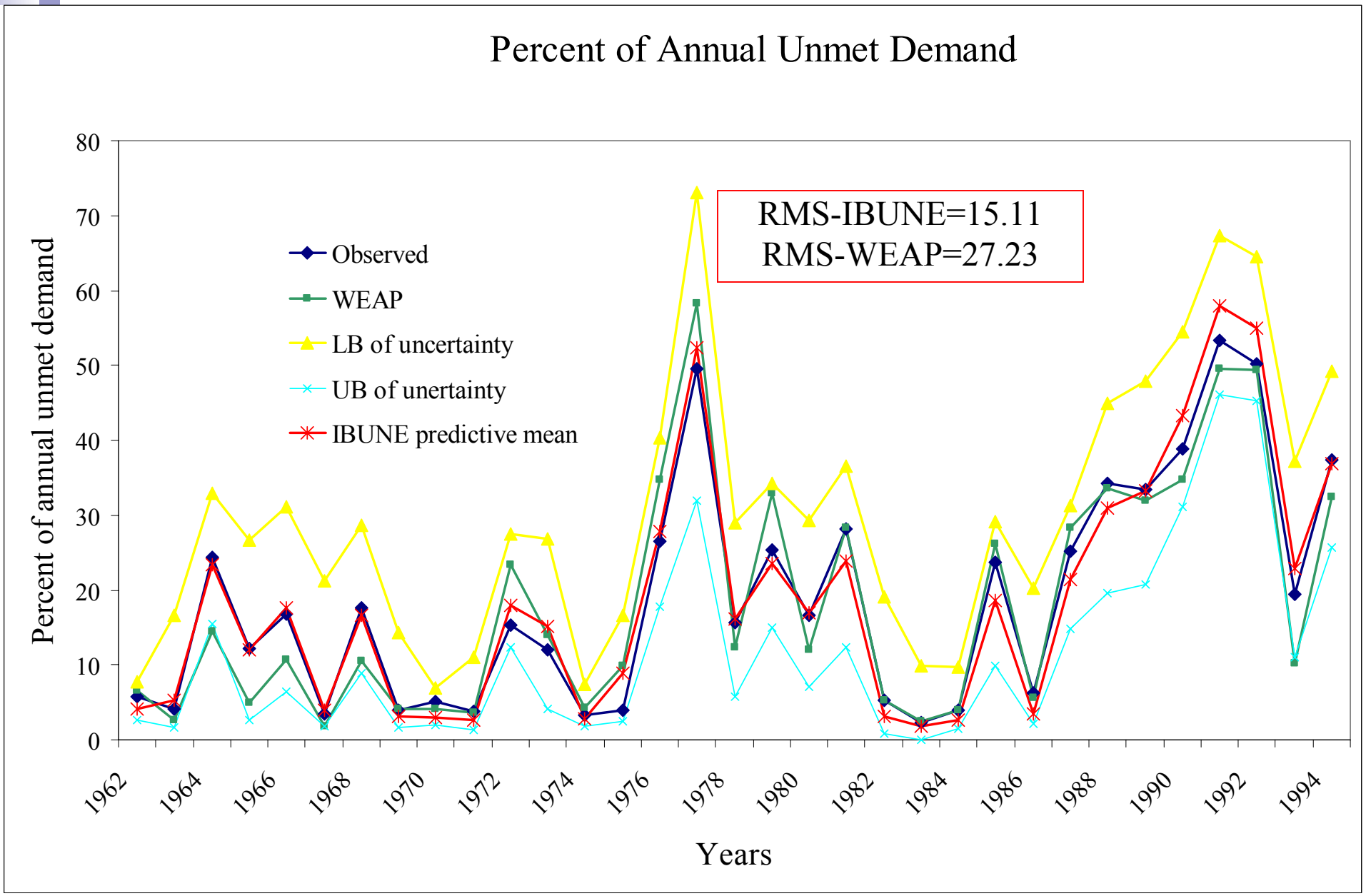
Percent of annual unmet demand-current supply, current demand



Reservoir Storage Volume-current supply, 2030 demand



Percent of annual unmet demand-current supply,2030 demand



Preliminary conclusion

- IBUNE is an innovative steps toward higher accuracy and more reliable hydrological forecasts including floods and water supply.
- Accounting for model structural uncertainty (considering multiple models) considerably improves prediction of water management variables.
- More accurate prediction of these variables can lead to more efficient operation of reservoir consequently more efficient management of water resources.
- More precise assessment of uncertainty in the future events can help more reliable decision making and also provide an opportunity to consider alternative operational coordination strategy.

Thanks

Questions?

Man is a complex being; he makes the deserts bloom and lakes die. (Gil Stern)

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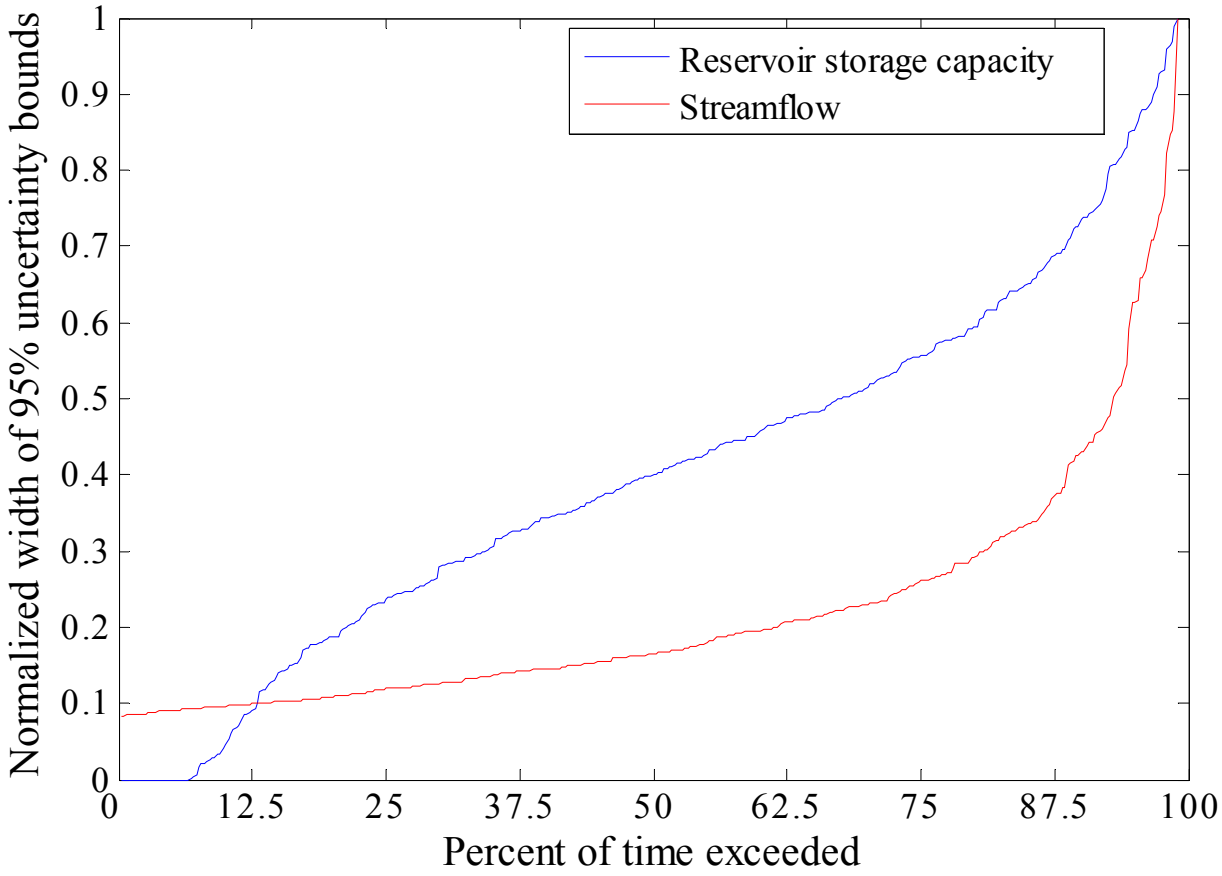
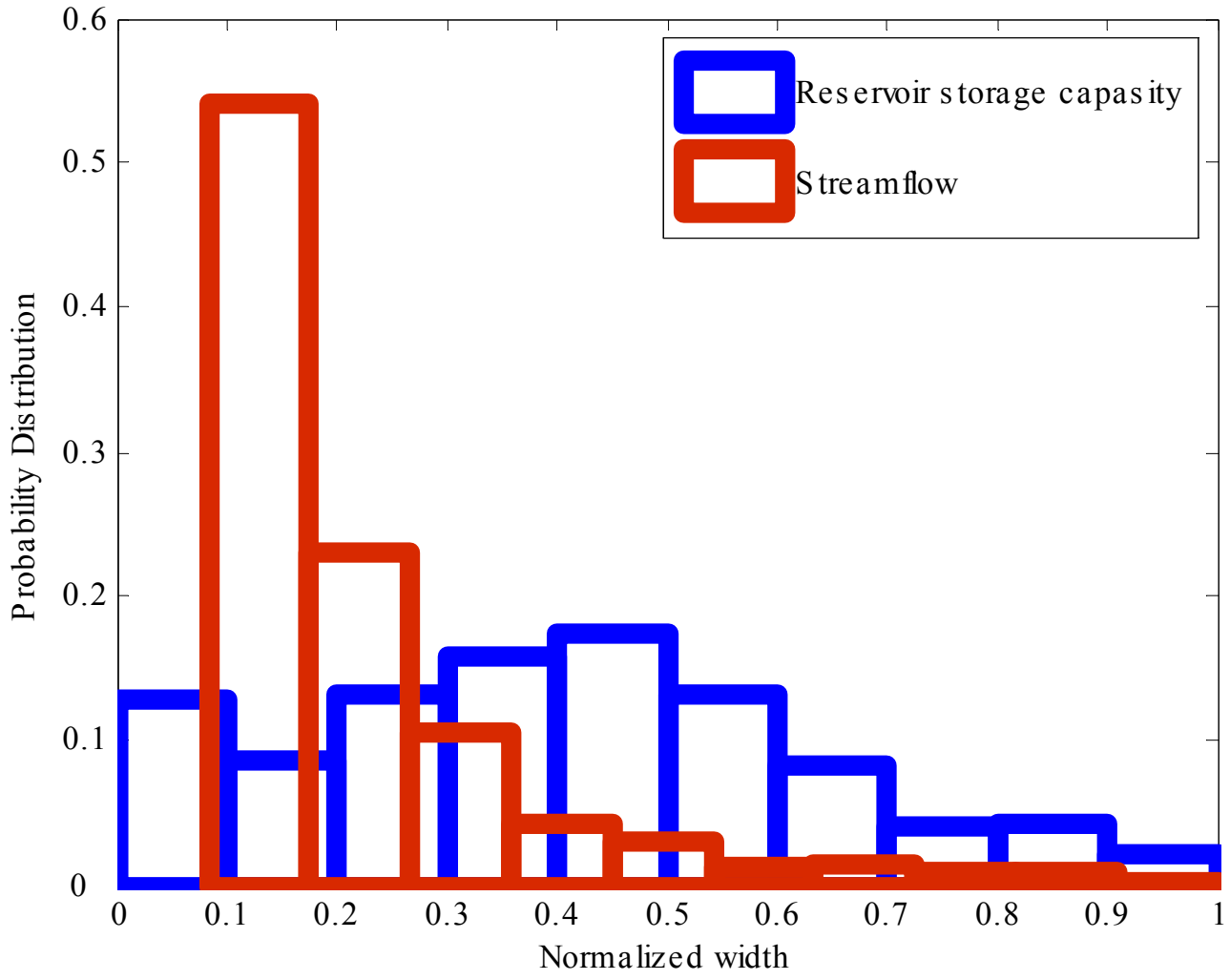
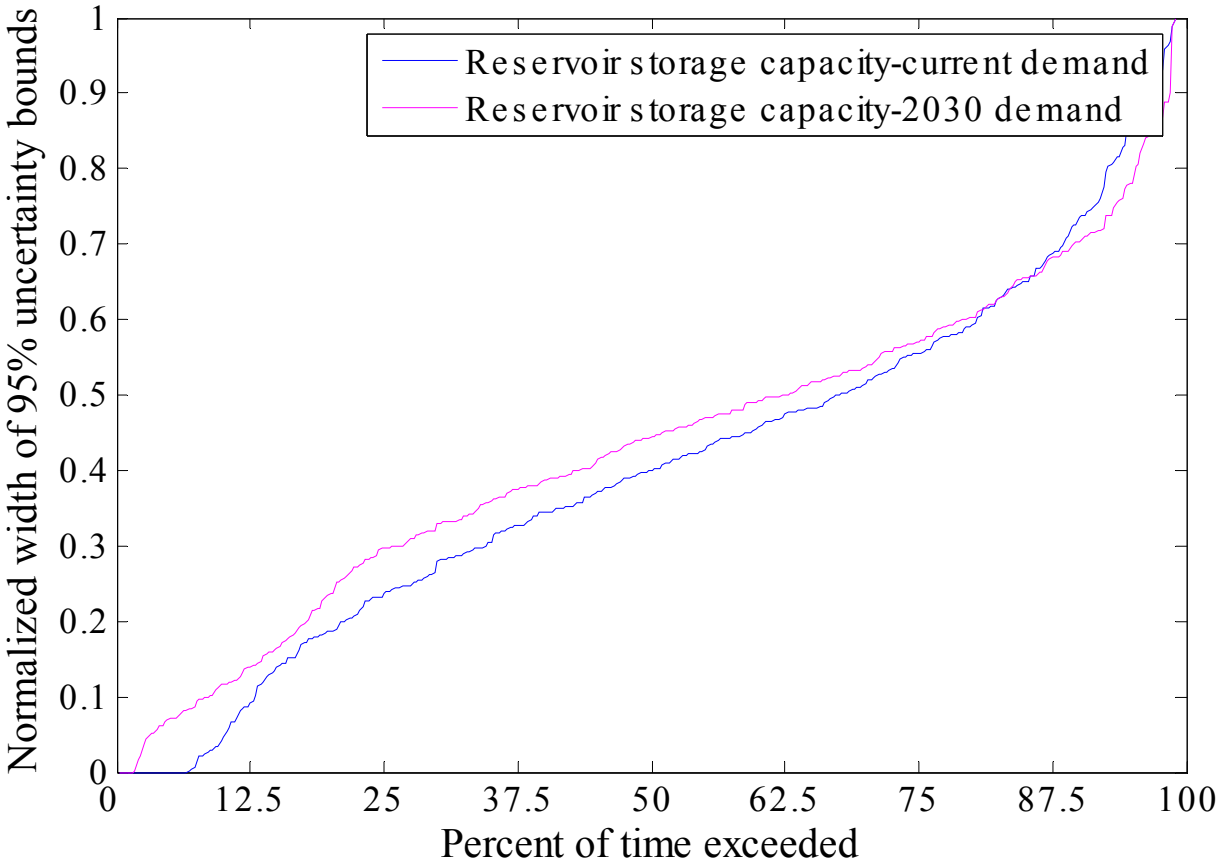
Future steps….

- Assessing the uncertainty in input forcing.
  - Retrospective
  - Climate change
- We are still looking for better ways of analyzing and interpreting the impacts of hydrological uncertainty on future water supply.
- Also we would like to answer the following questions in our pilot project:
  - Will this accuracy lead to sustainable management of our limited water resources in the state of California?
  - What kind of alternative operational coordination strategy, considering the assessed uncertainty within the system, will decrease the risks in supply reliability and facilitates more efficient management of water resources?
  - What are the socio-economical impacts of more accurate quantification of uncertainty in the hydrologic component of the system?

Normalized width of 95% uncertainty bound from streamflow to Reservoir




Reservoir storage capasity
Streamflow
Probability Distribution
Normalized width
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Reservoir storage capacity-current demand
Reservoir storage capacity-2030 demand
Normalized width of 95% uncertainty bounds
Percent of time exceeded
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
12.5
25
37.5
50
62.5
75
87.5
100

A closer look: an excerpt of the hydrograph