An aerial photograph of a large reservoir, likely Lake Oroville, with a prominent dam in the foreground. The landscape is a mix of green hills and brownish, possibly dry, terrain. The sky is overcast with soft, grey clouds.

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

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California Water and Environmental Modeling Forum, Asilomar CA
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Competing Demands in California

Domestic



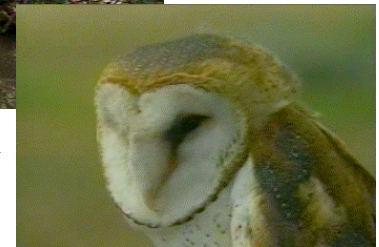
Power & Industry



COMPUTER IMAGE BY CHUCK CARTER

Navigation

Wildlife



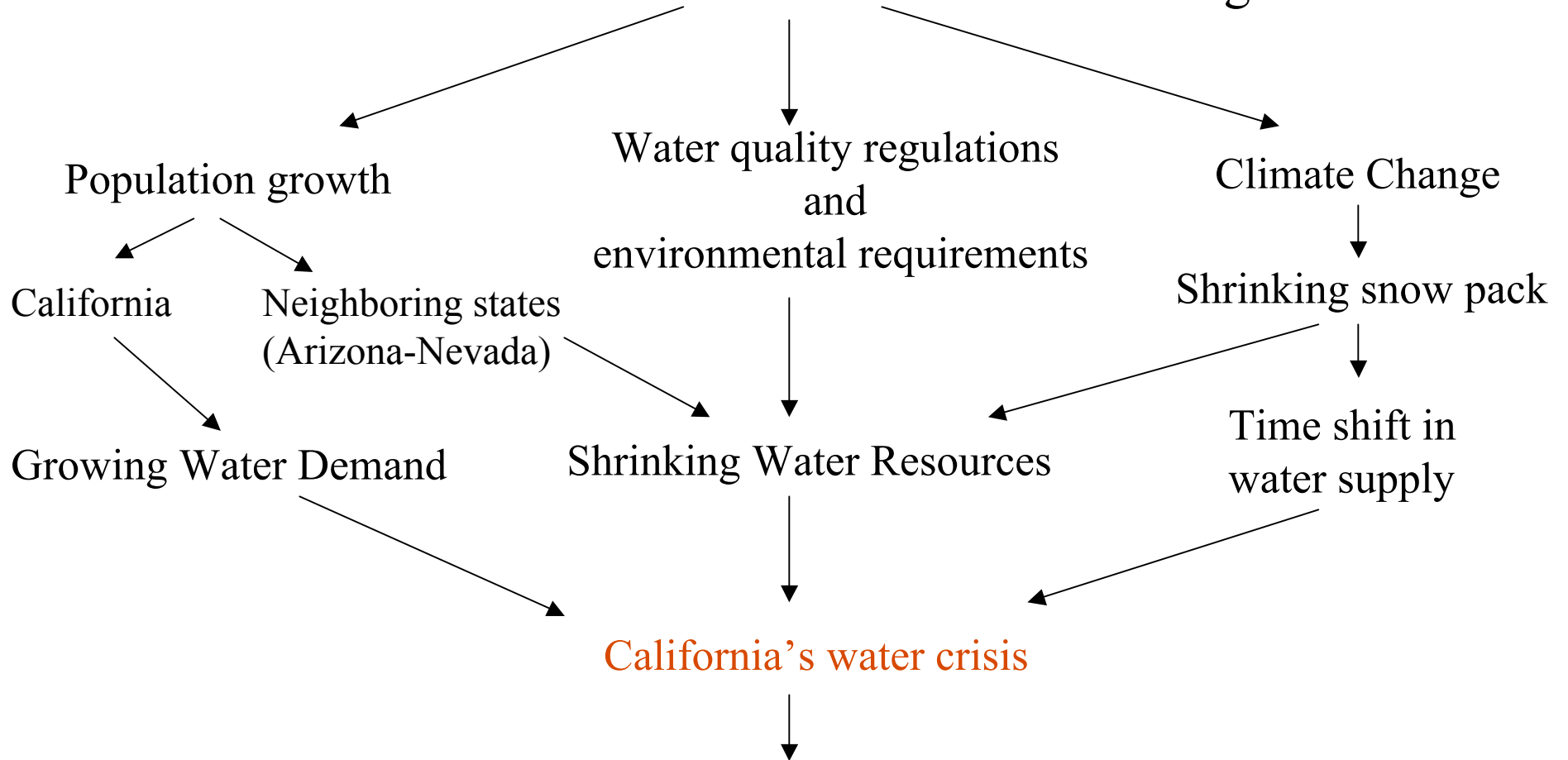
Agriculture



Recreation

CAL2030 project: Overview

In the near future **California** will be dealing with



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

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.

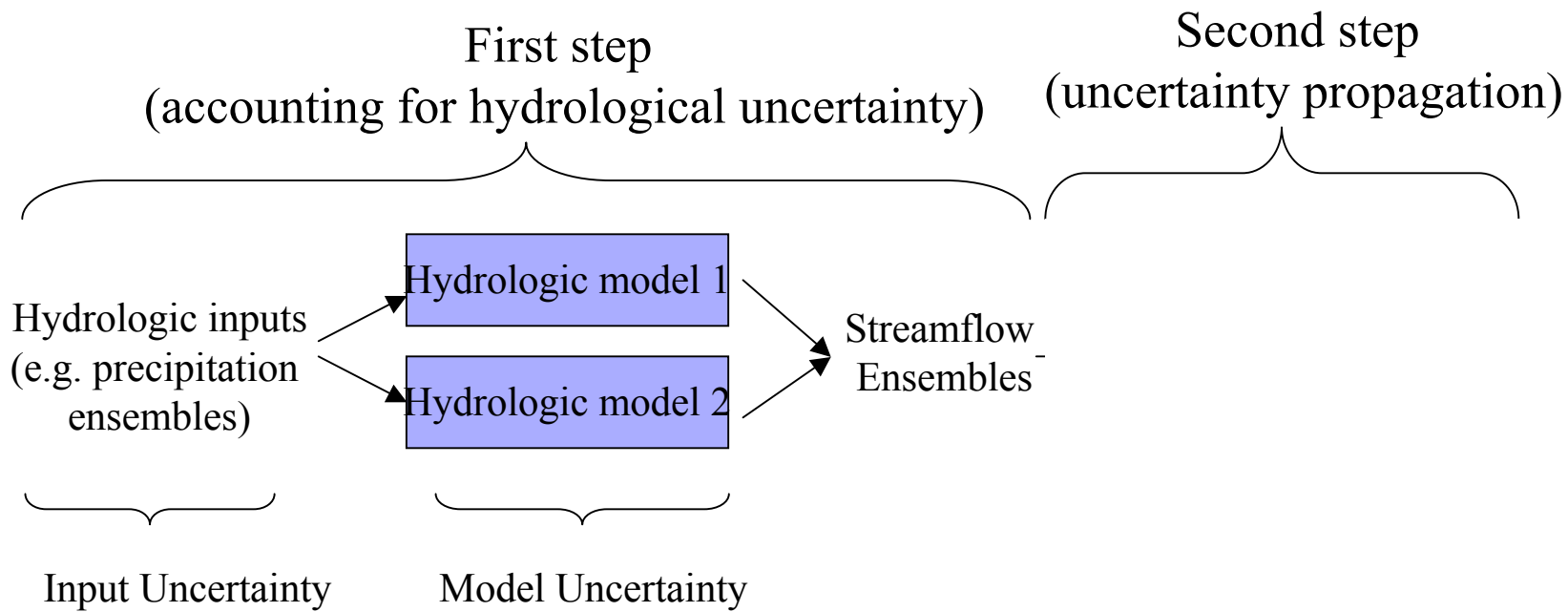


- Enables the decision makers to better handle **risk** in decision making
- Therefore **mitigate** some of social, economical and environmental impacts.
- Also manage our **limited** water resources more **efficiently** under new adaptation plans

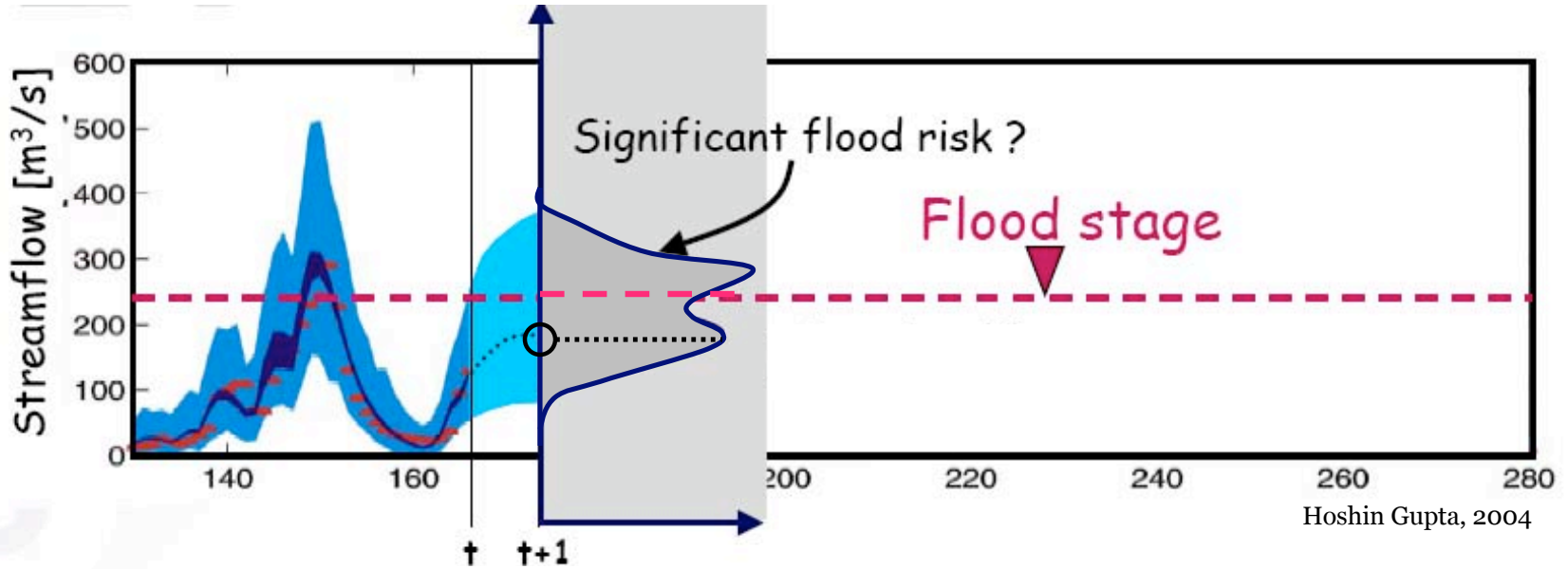
Methodology

- 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



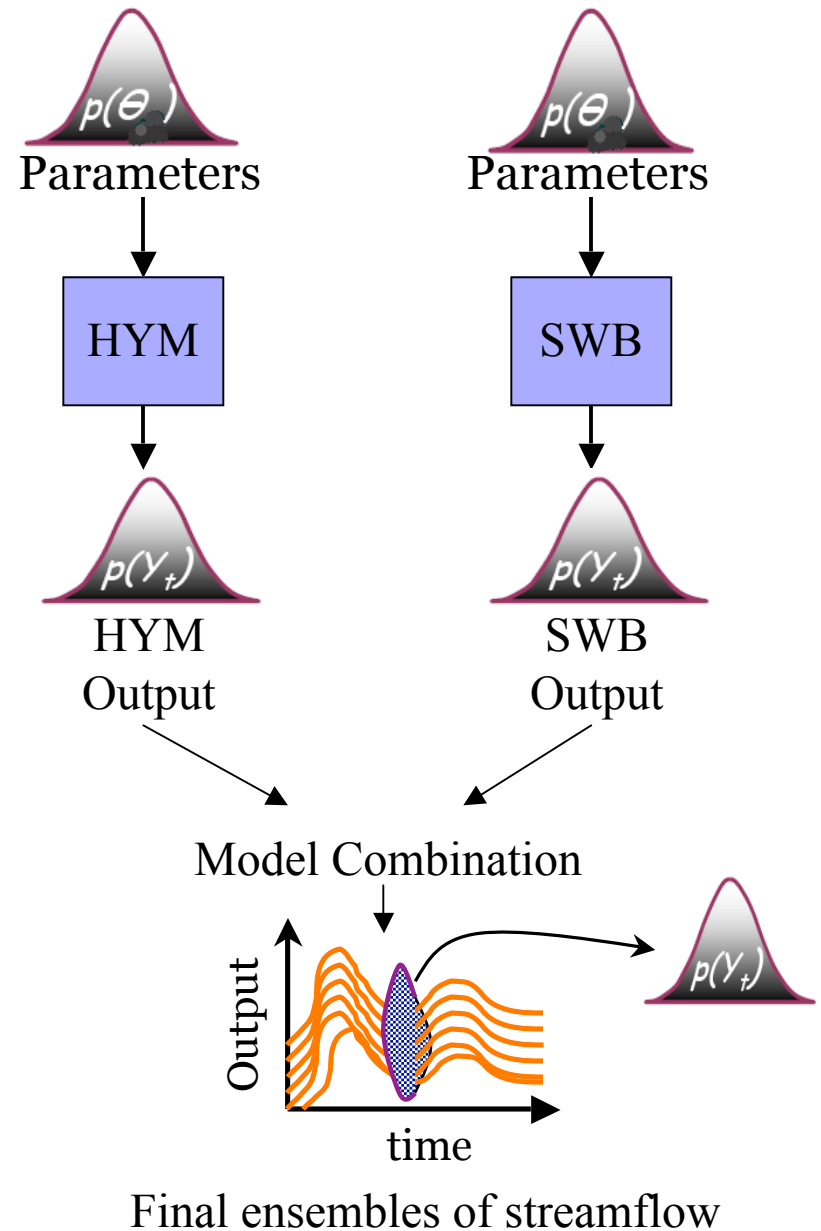
Why uncertainty is important?



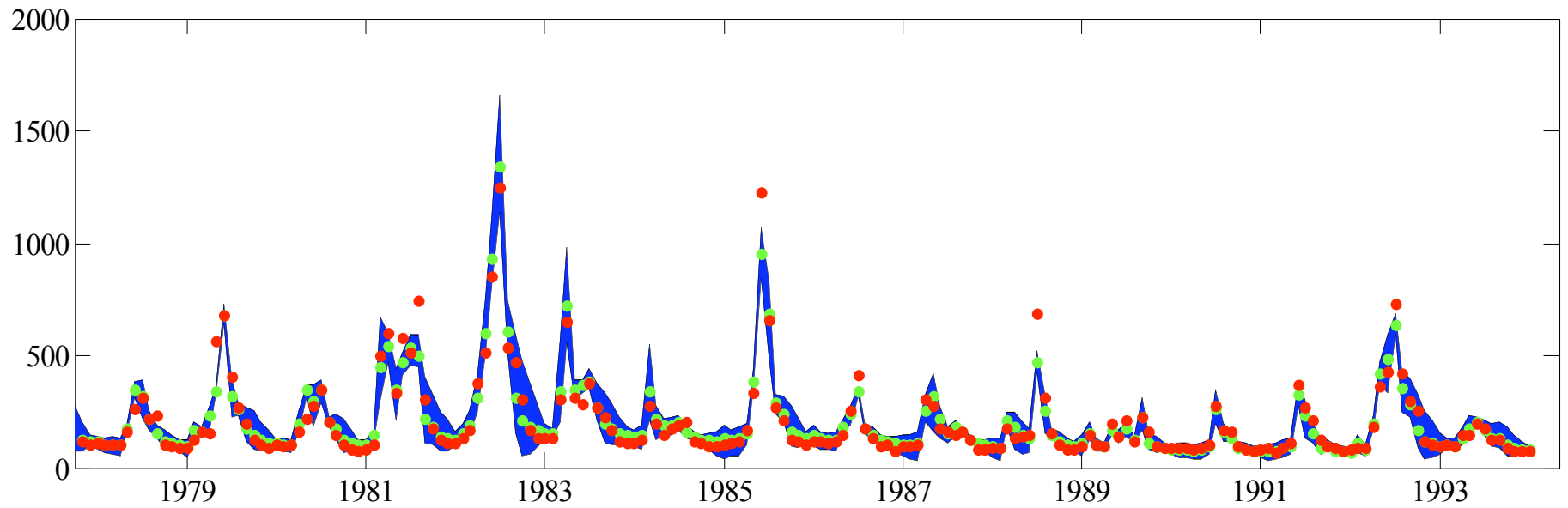
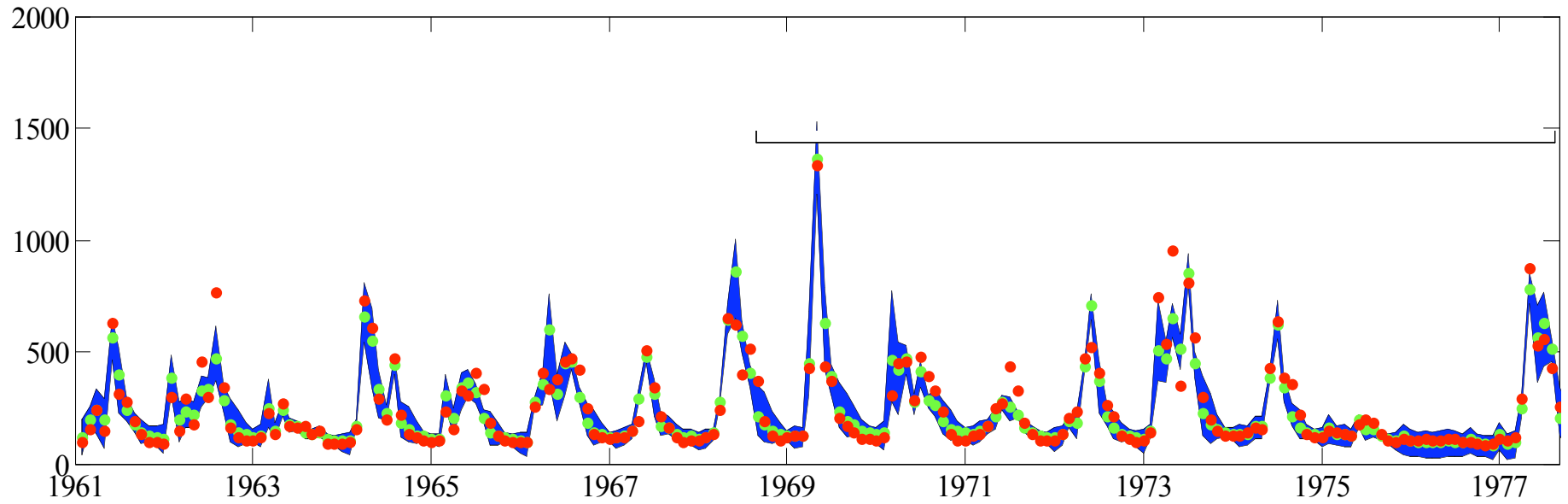
Chronicle / Michael Macor

Accounting for hydrological uncertainty

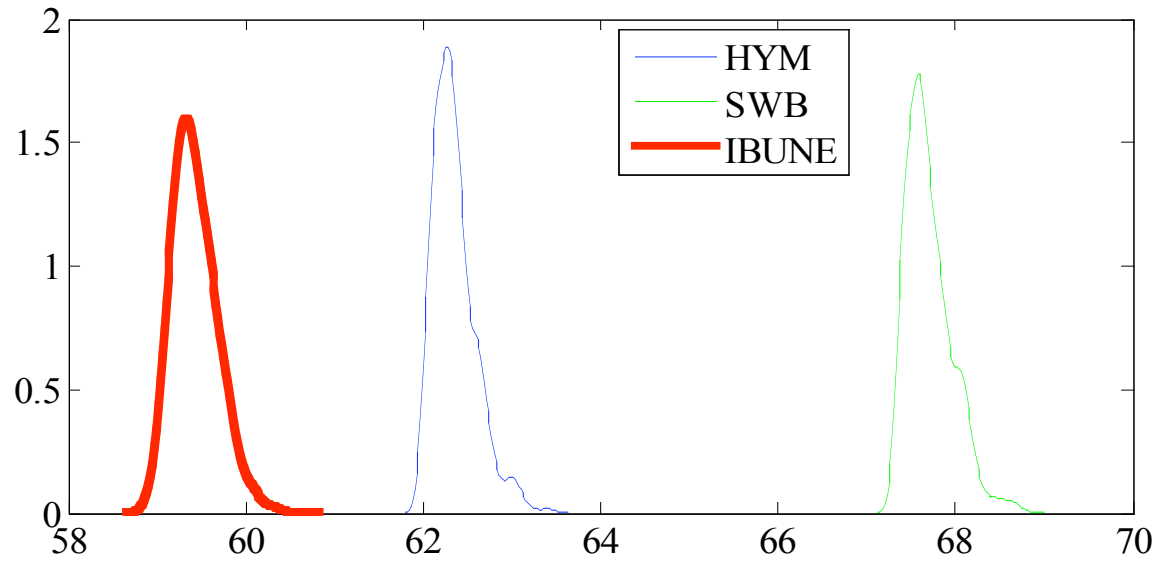
- Integrated Bayesian Uncertainty Estimator (IBUNE).
- Framework that accounts for uncertainty in input forcings, model parameters and model structure.
- Optimization + MCMC + Model combination
- Here we use it just to account for **model parameter** and **model structural** uncertainty.



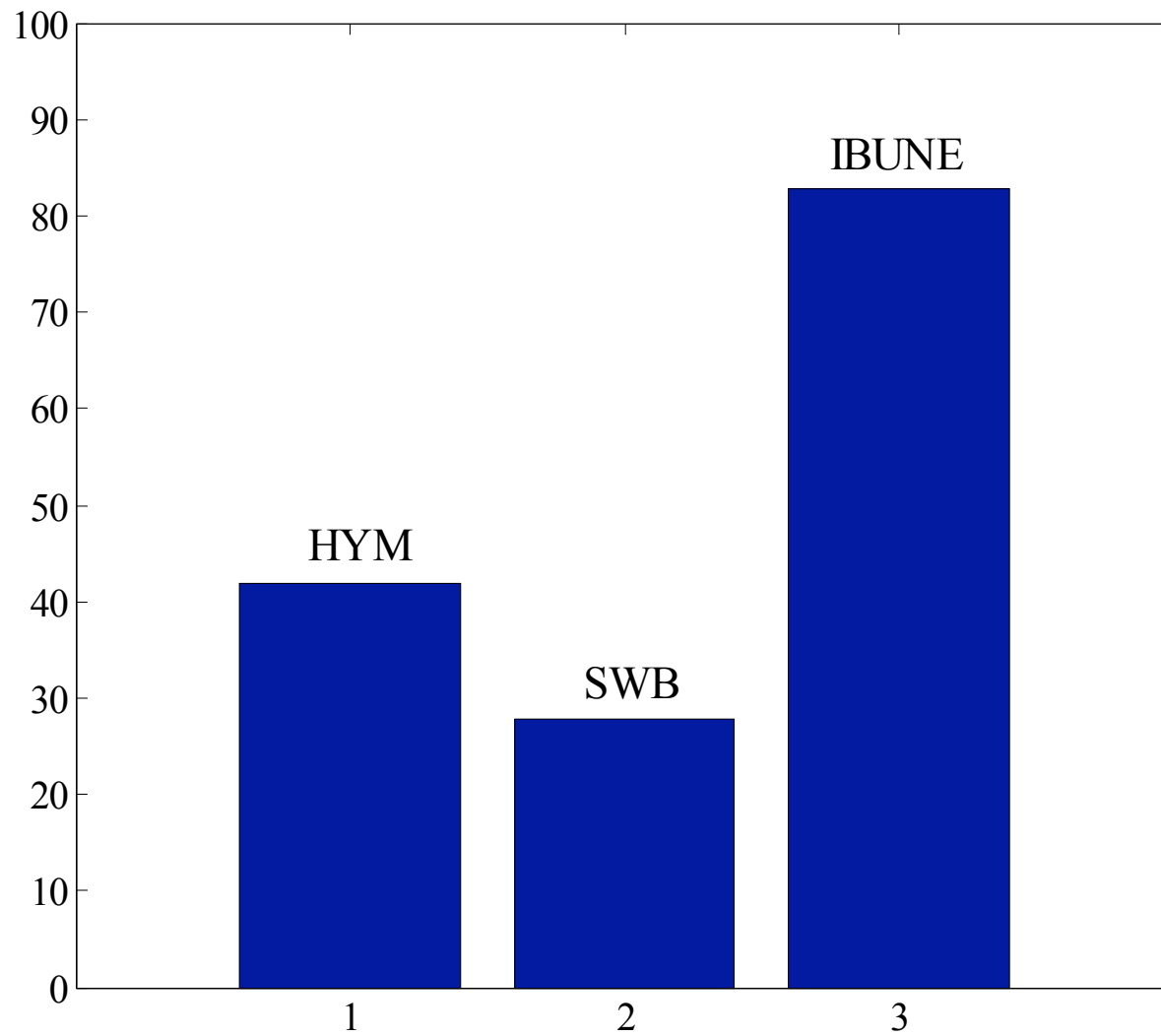
Performance of IBUNE's probabilistic and Deterministic simulations



IBUNE versus individual models



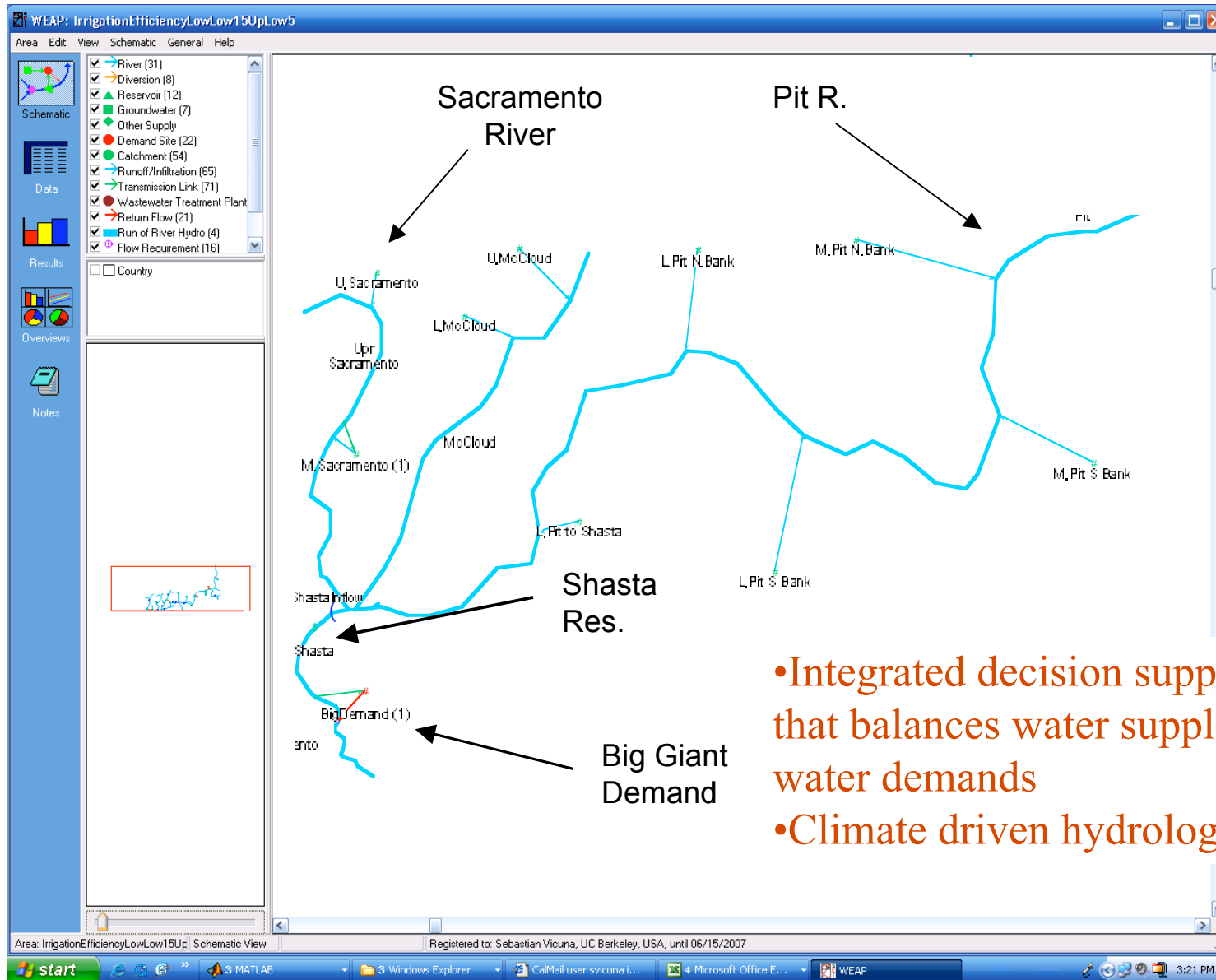
IBUNE versus individual models



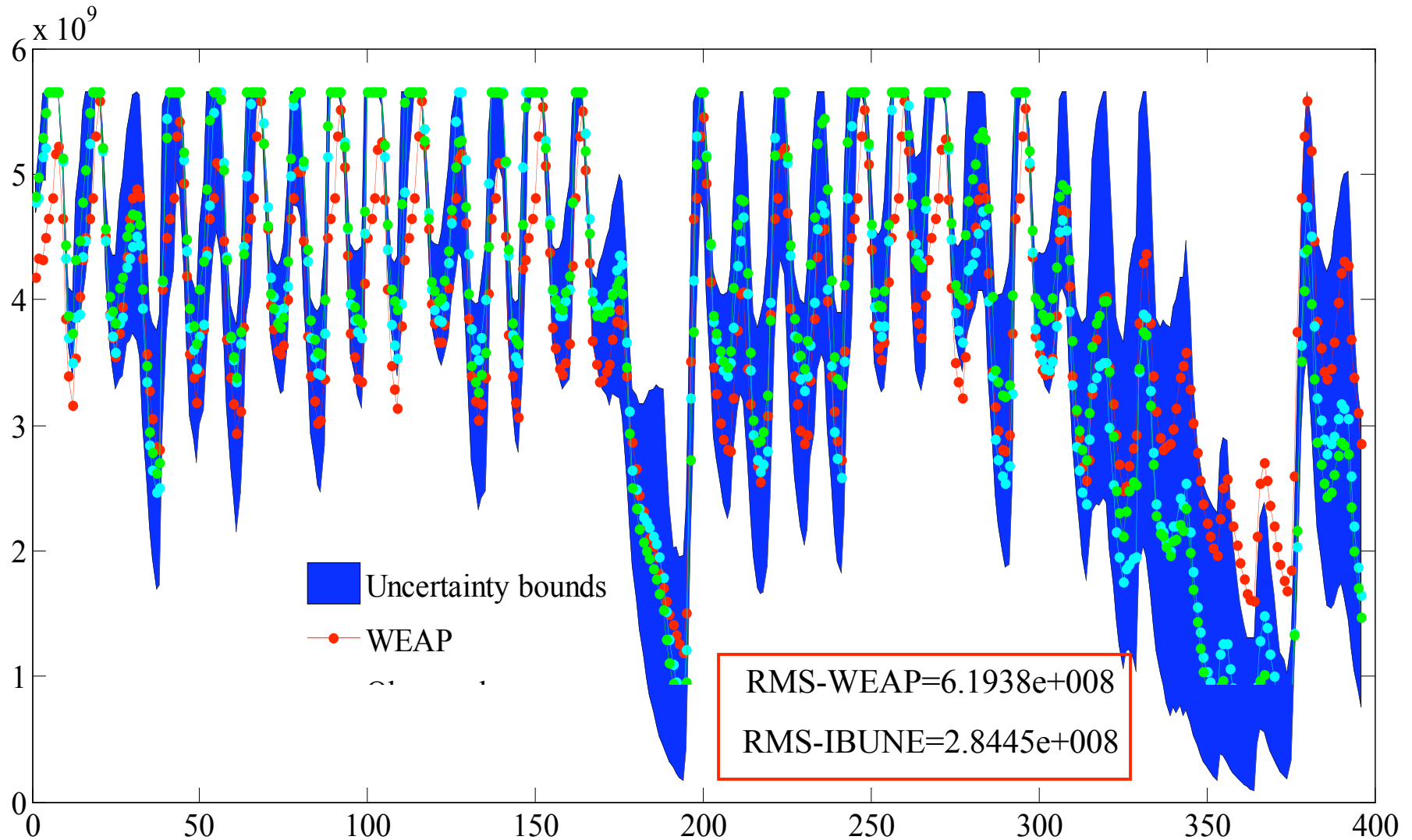
Propagation of hydrological uncertainty

- 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)

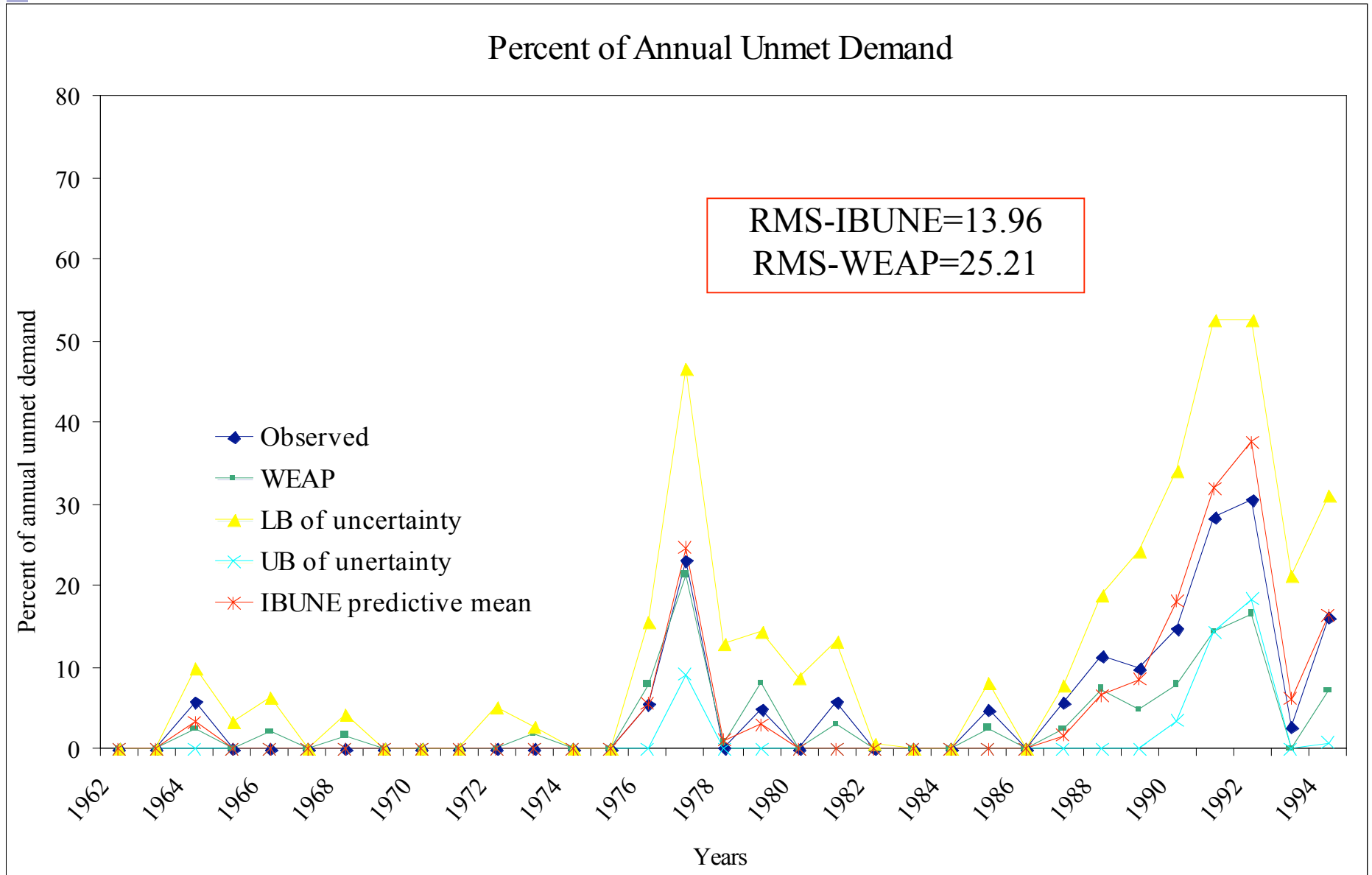
WEAP model



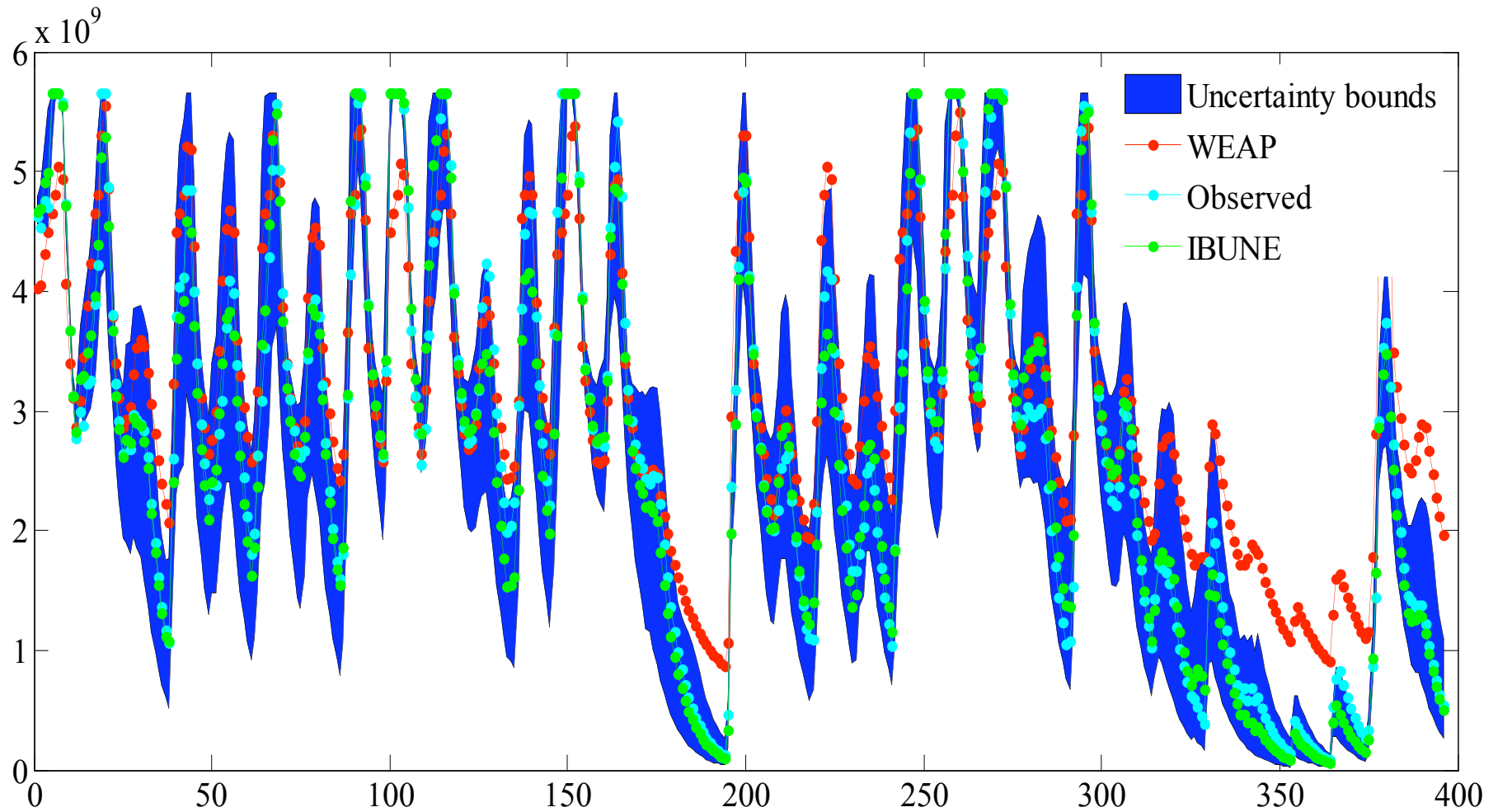
Reservoir Storage Volume-current supply, current demand



Percent of annual unmet demand-current supply, current demand

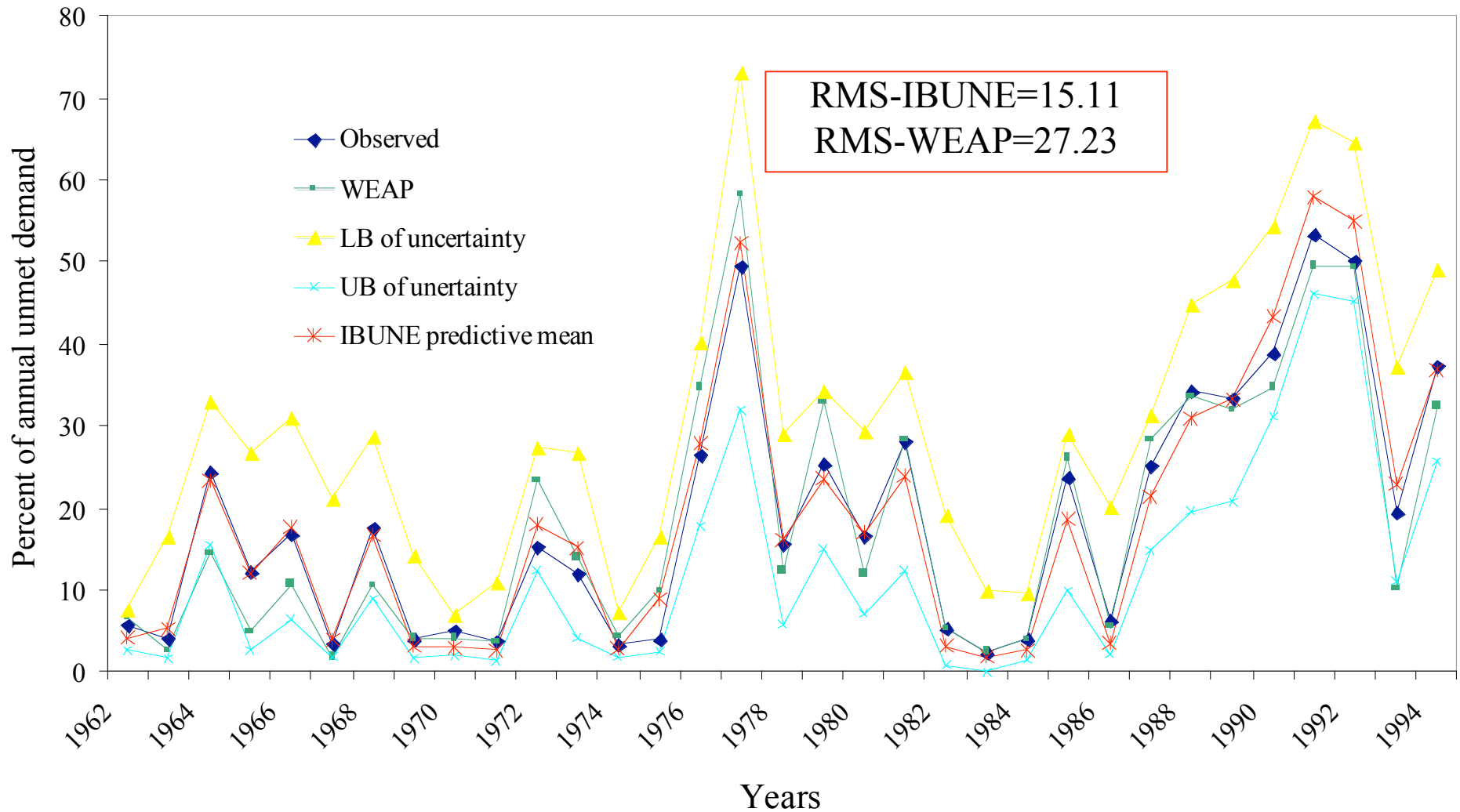


Reservoir Storage Volume-current supply, 2030 demand



Percent of annual unmet demand-current supply,2030 demand

Percent of Annual Unmet 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 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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