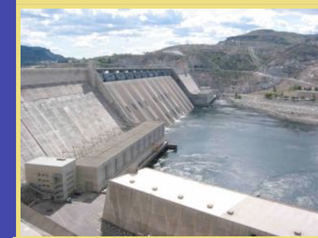
Using multi-model ensemble methods to assess climate change impacts on water management throughout the State of Washington, USA


Julie Vano[A,B]
Nathalie Voisin[B]
Lan Cuo[A]
Marketa McGuire Elsner[B]
Richard Palmer[B,C]
Austin Polebitski[B,C]
Alan Hamlet[A,B]
Anne Steinemann[B]
Dennis Lettenmaier[A,B]

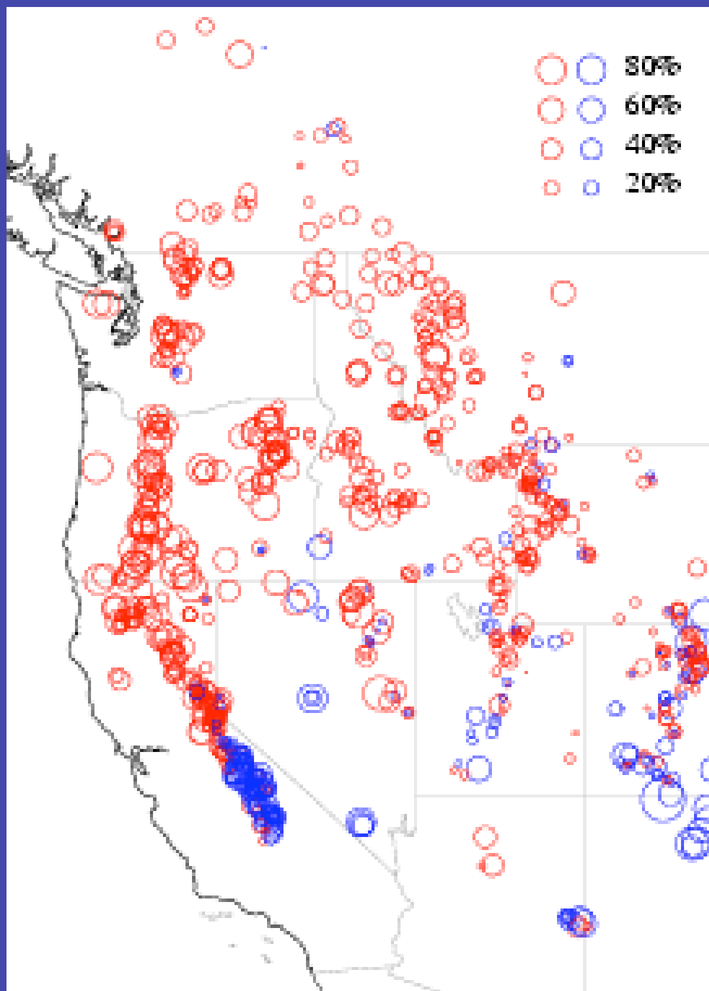
[A]Climate Impacts Group
[B]Dept of Civil and Environmental Engineering, U of Washington
[C]Dept of Civil and Environmental Engineering, U of Massachusetts-Amherst

December 2008
American Geophysical Union Fall Meeting, San Francisco

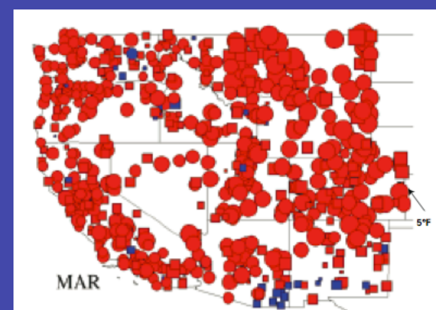
CLIMATE IMPACTS GROUP

Climate science in the public interest

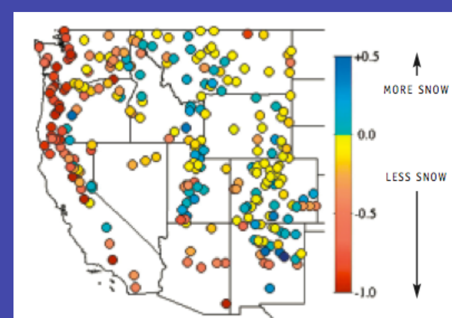
Current Climate Trends



Observed April 1 snow water equivalents, 1950-1997



March Average Min Temp on Days with Precipitation (1949-2004)



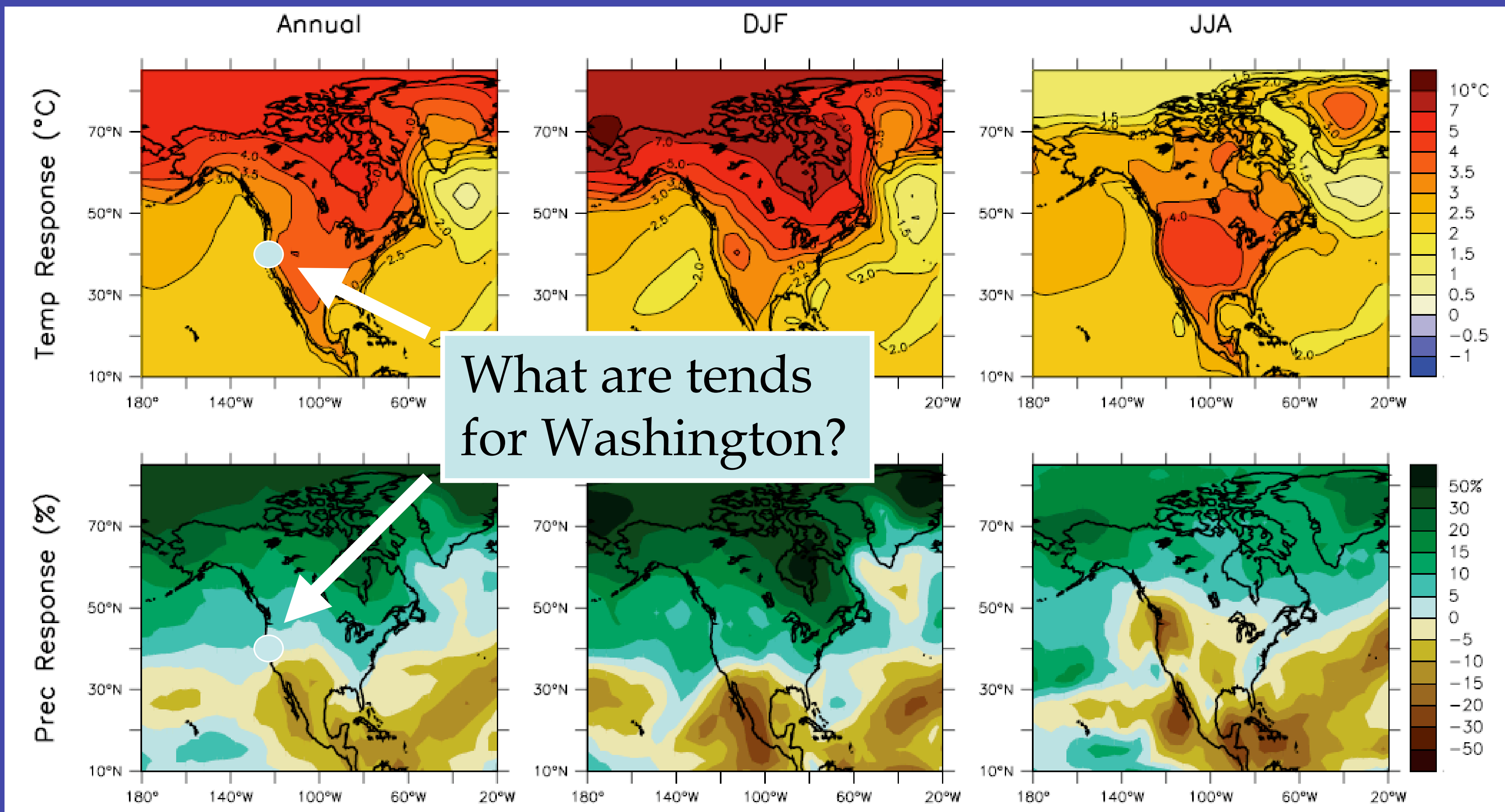
Trends in Snow vs. Rain in Winter (1949-2004)

and many more…

Mote P.W.,Hamlet A.F., Clark M.P., Lettenmaier D.P., 2005, Declining mountain snowpack in western North America, BAMS, 86 (1): 39-49

Knowles, N., Dettinger, M.D., and D.R. Cayan, 2006, Trends in Snowfall verse Rainfall in the Western United States, Journal of Climate 19: 4545-4559.

International Panel on Climate Change (IPCC) 2007



Consensus Forecasts of Temperature and Precipitation Changes from IPCC AR4 GCMs

Research Objectives

1) Is the scale (space, time) of the information provided by future forecasts relevant to water management decisions?
2) If planning relies on past variability, how does this change when we can no longer assume stationarity?
3) How can we account for uncertainty in these forecasts?
4) How can we change planning and management to account for this non-stationarity, uncertainty, and risk?

Photo courtesy of http://www.usbr.gov/dataweb/html/yakima.html

Washington State Climate Impacts Assessment

A comprehensive climate change impacts assessment for Washington State

Funding Source: Clean Air/Clean Fuels House Bill 1303

Agriculture /Economics

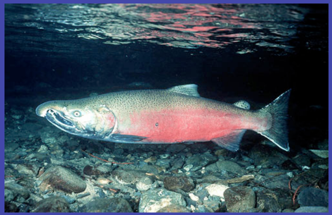
Water Resources

Coasts

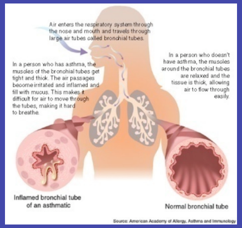
Energy

Forest Resources

Salmon

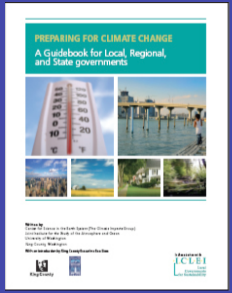


Human Health



Infrastructure

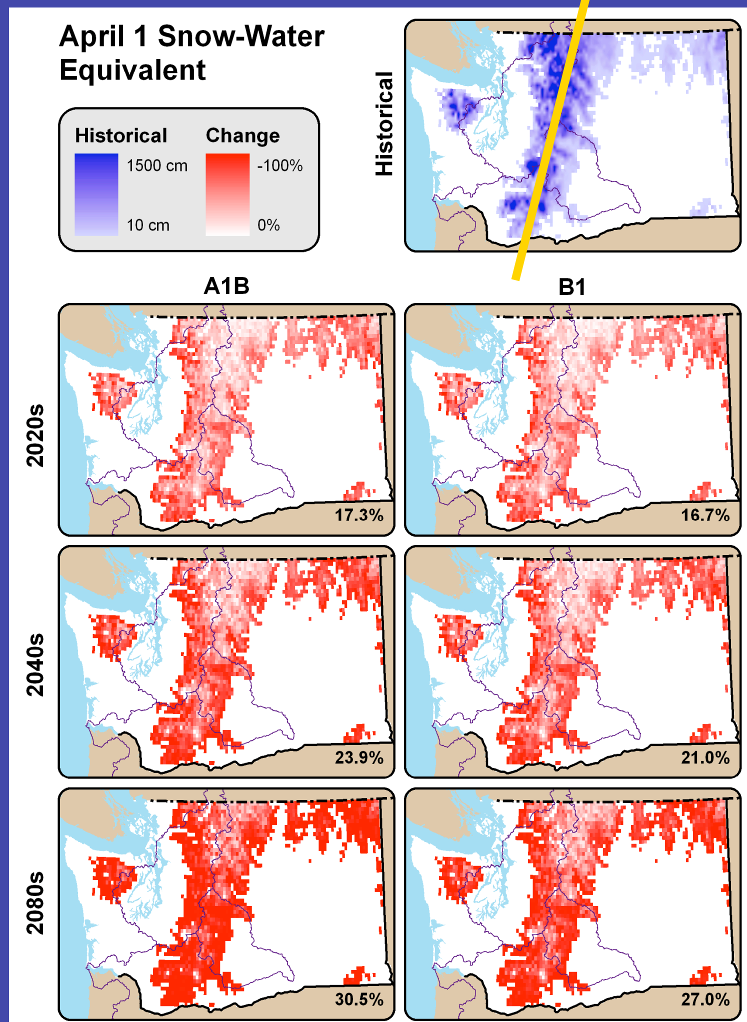
Adaptation



Washington Water Resources

Reduced snowpack and changes in soil moisture will occur.

Declines in April 1 SWE vary between 21-24% for the 2040s, depending on the emissions scenario.



Case study 1:
Yakima R basin
irrigated agriculture

Case study 2:
Puget Sound basin
municipal

Data Needs to Support a 21st Century Planning Framework Incorporating Climate Information, Uncertainty, and Risk

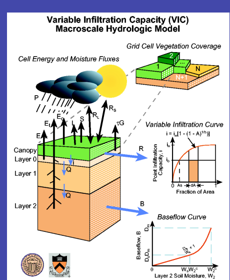
Approach provides ensemble of variables that can be used to evaluate impacts of climate change

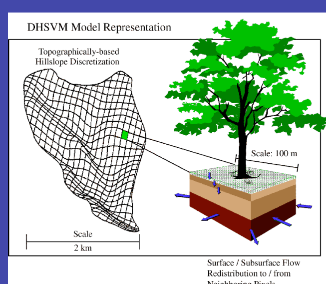
2 Emissions Scenarios X 20 GCMs

IPCC Climate Scenarios

downscaling

Hydrology Modeling



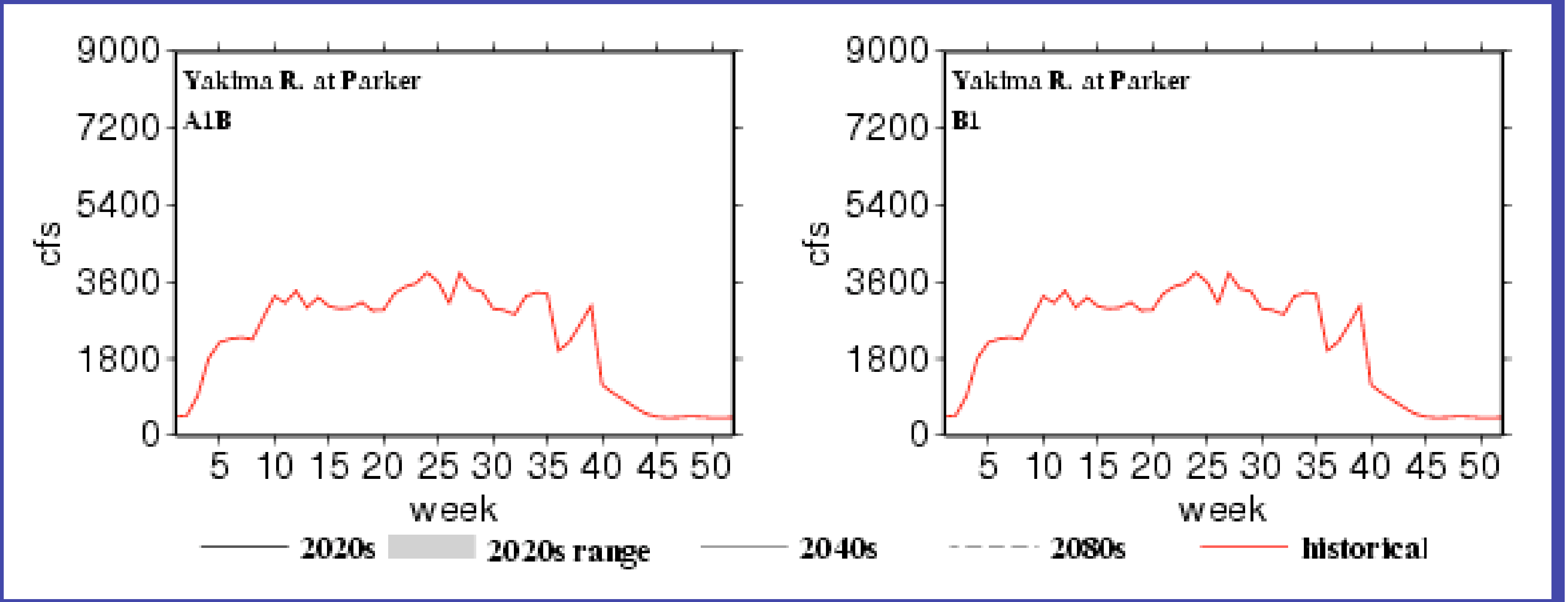


stream routing, bias correcting

Reservoir Models (Riverware, GoldSim)

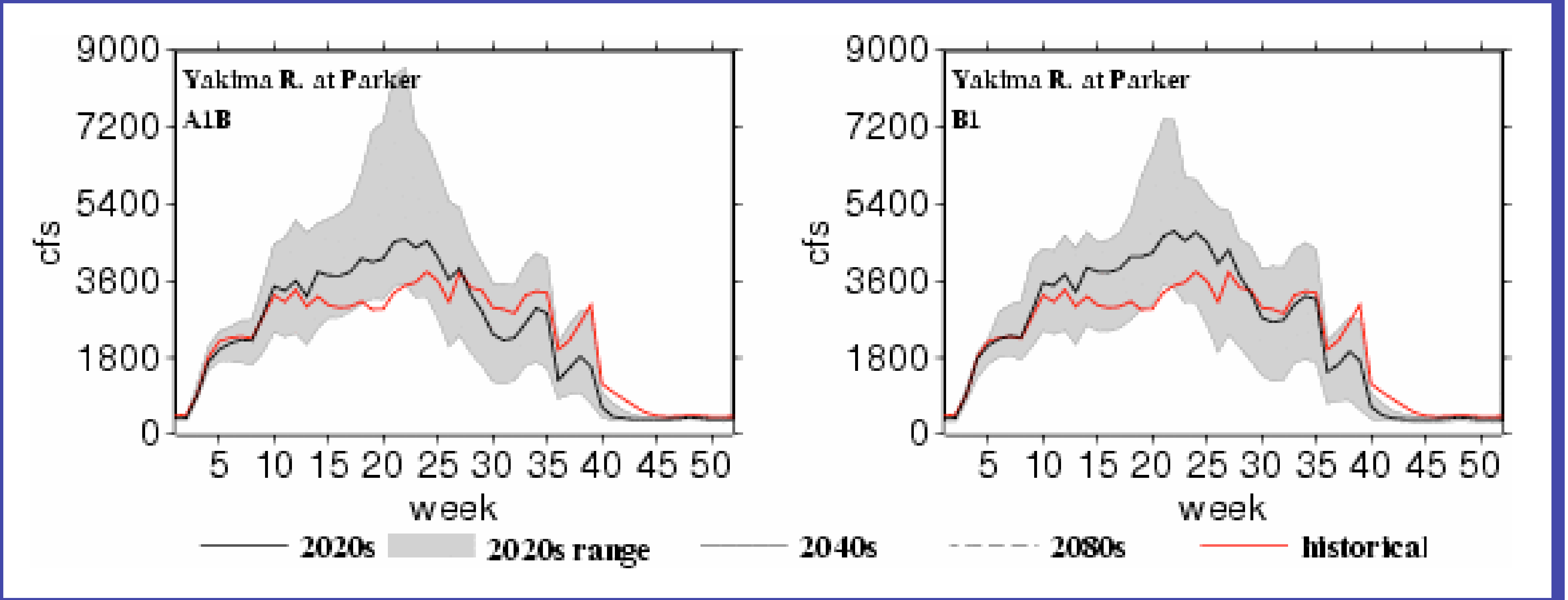
- Precipitation
- Air Temperature
- Streamflow
- Soil Moisture
- Evapotranspiration
- Anticipated Storage
- System reliability
- Water prorationing
- And more

Example of ensemble method



- Historical (1917-2006), weekly averages start Oct 1

Example of ensemble method



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- 2020s composite of A1B and B1 (2005-2035)

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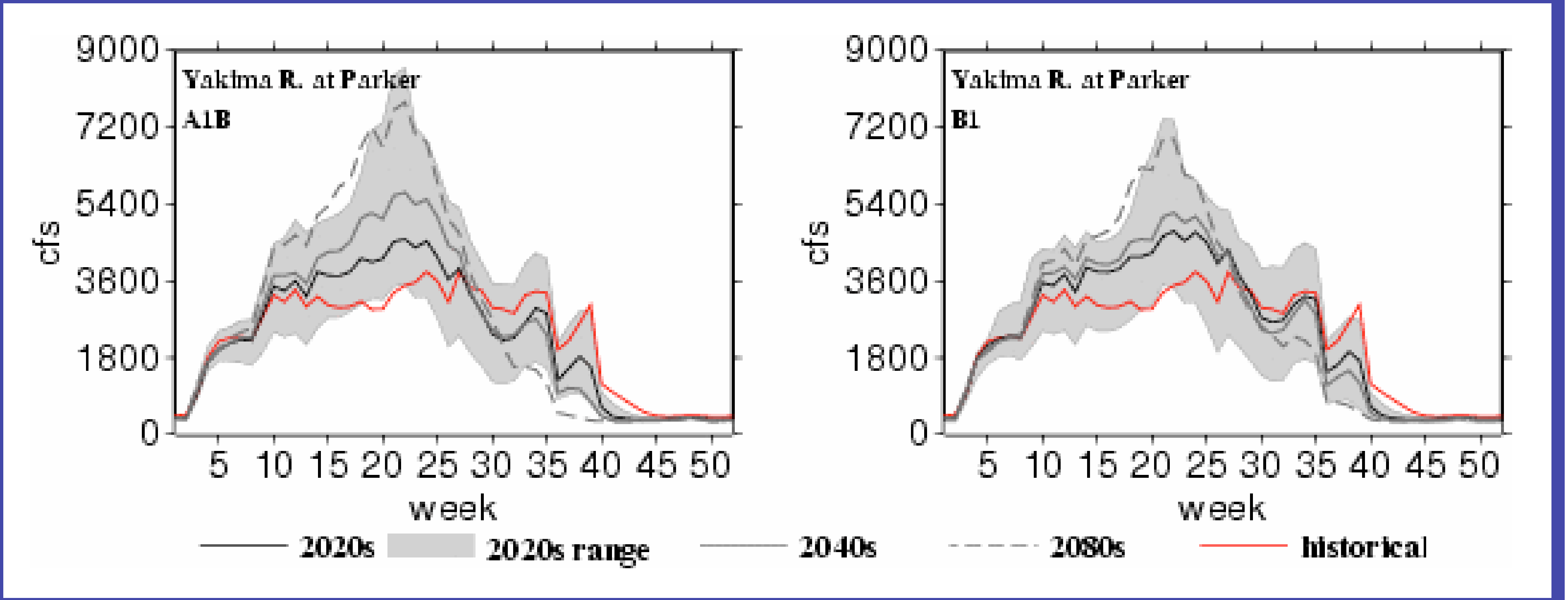

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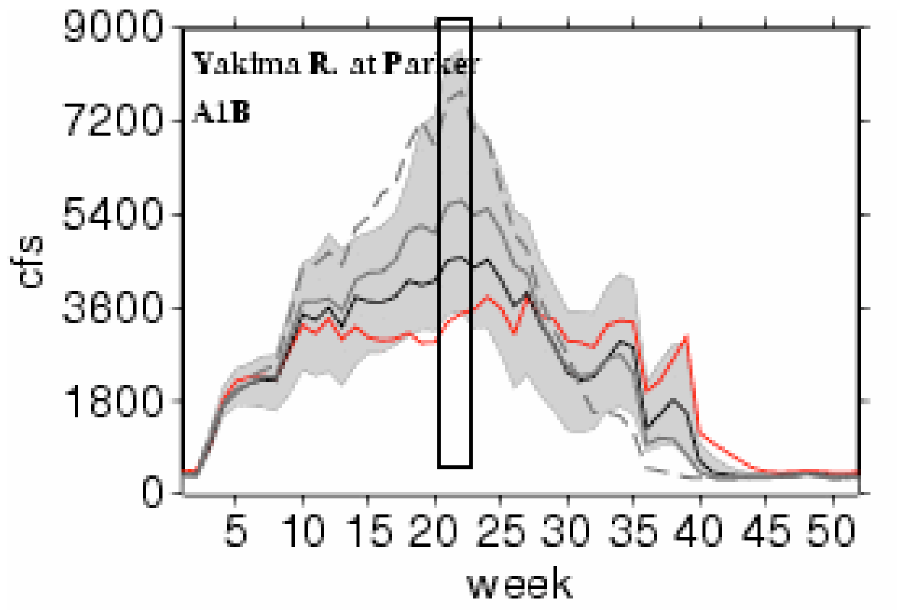

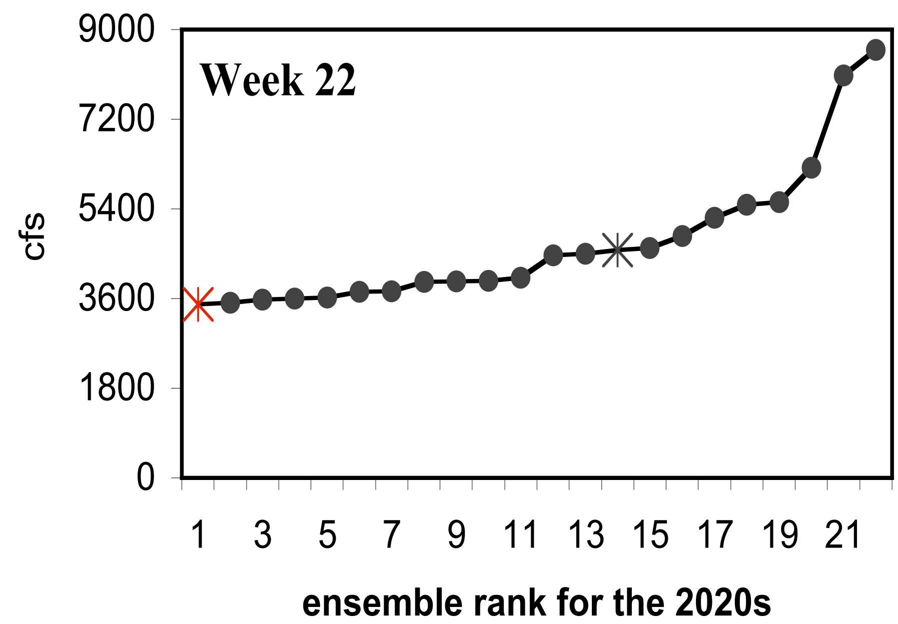

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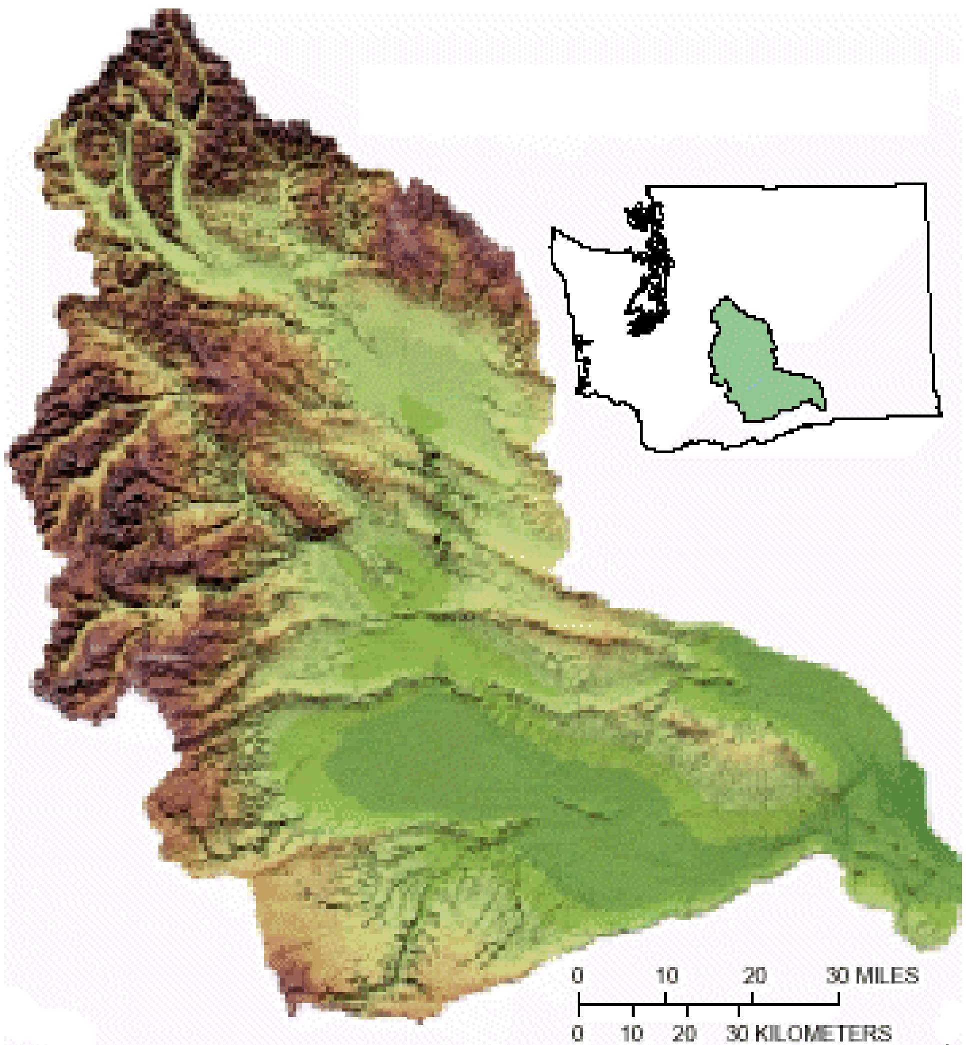
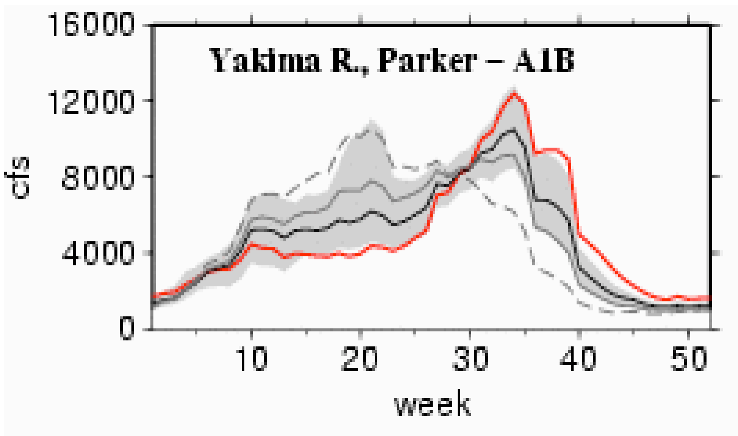
- Probability distributions at specified time

Case study 1: Yakima River Basin



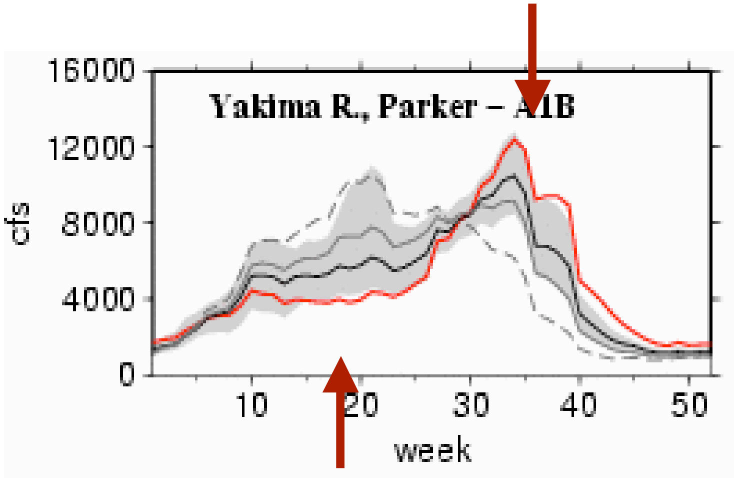
- Water supply during growing season in lower basin primarily from snowmelt, depends on reservoirs for storage
- Six USBR reservoirs with storage capacity of ~1 million acre-ft, ~25% unregulated runoff
- Managed system vulnerable to drought with increasing water use and changing snowpack
- Irrigated crops largest agriculture value in the state
- Water short years impact water entitlements

Yakima River Basin



Unregulated

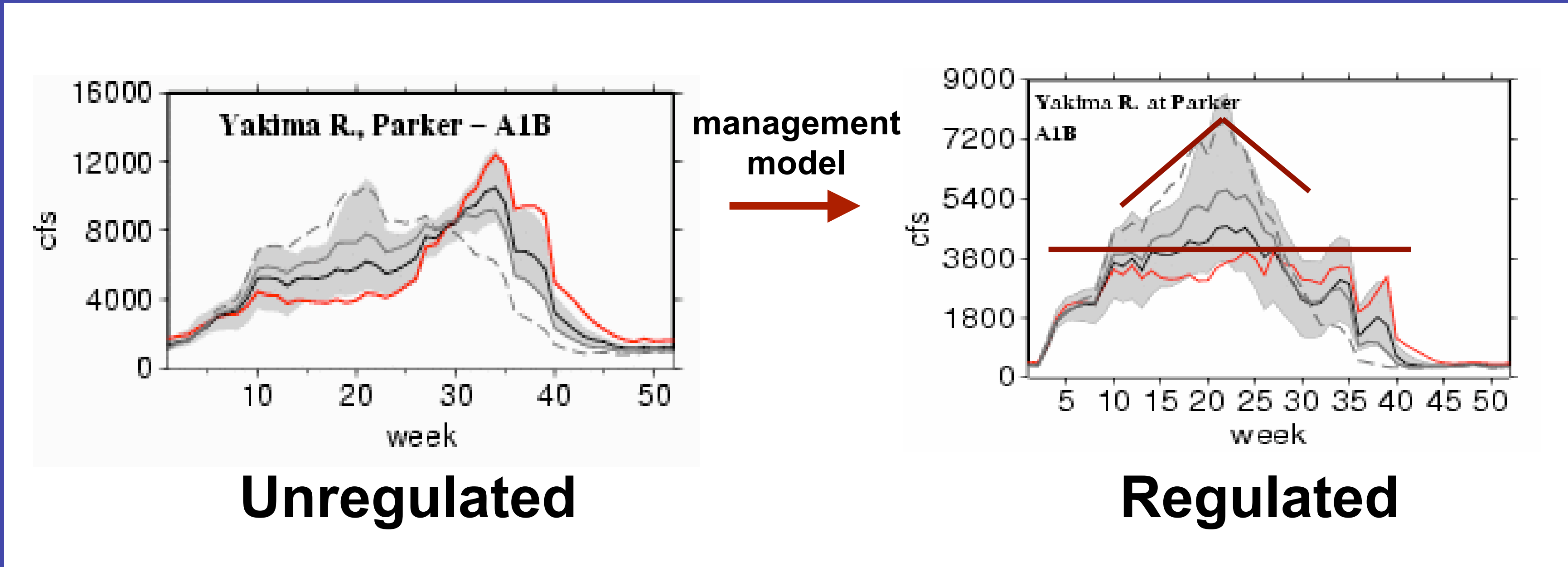
Yakima River Basin



Unregulated

- Basin shifts from snow to more rain dominant

Yakima River Basin



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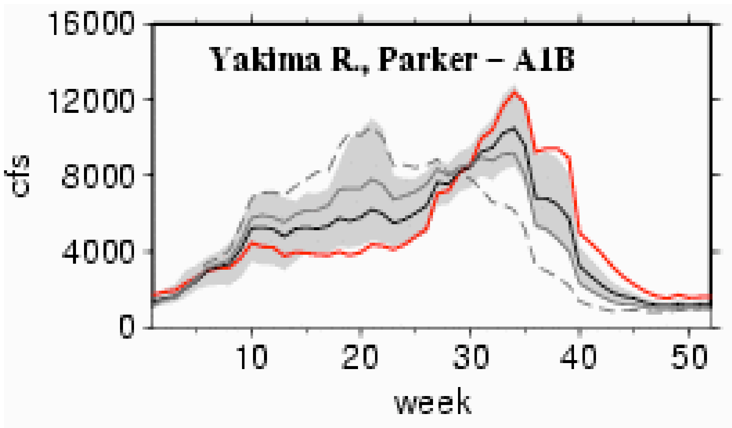
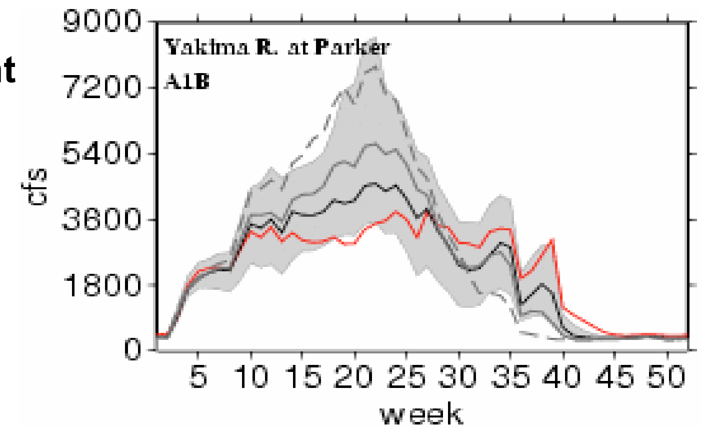
Yakima River Basin



Unregulated

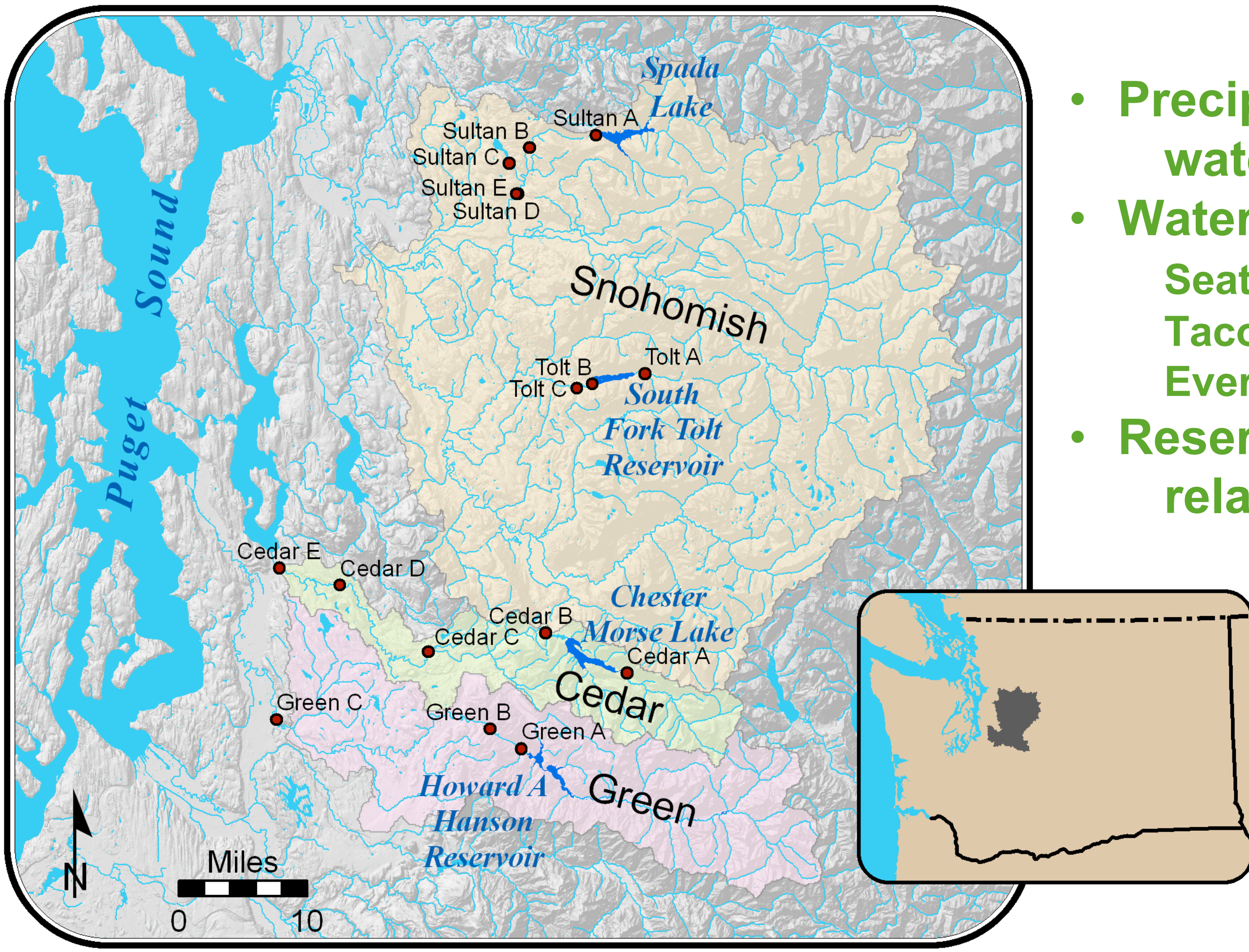
management model



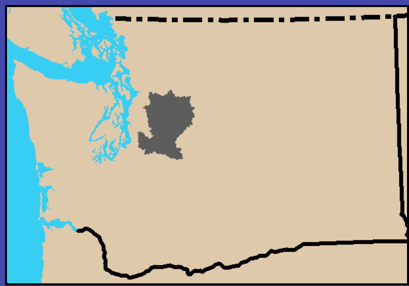
Regulated

- Basin shifts from snow to more rain dominant
- Irrigators with junior water rights water short:
  - 30% historically
  - 52% in 2020s (33% to 80% range of ensemble members)
  - 74% in 2040s
  - 95% in 2080s
- Irrigators with senior water rights projected to be water short for first time

Case study 2: Puget Sound Basin



- Precipitation in fall-winter, water demand in summer
- Water management systems:
  - Seattle - municipal, fish
  - Tacoma - municipal, flood control
  - Everett - municipal, hydropower
- Reservoir capacities small relative to annual flow

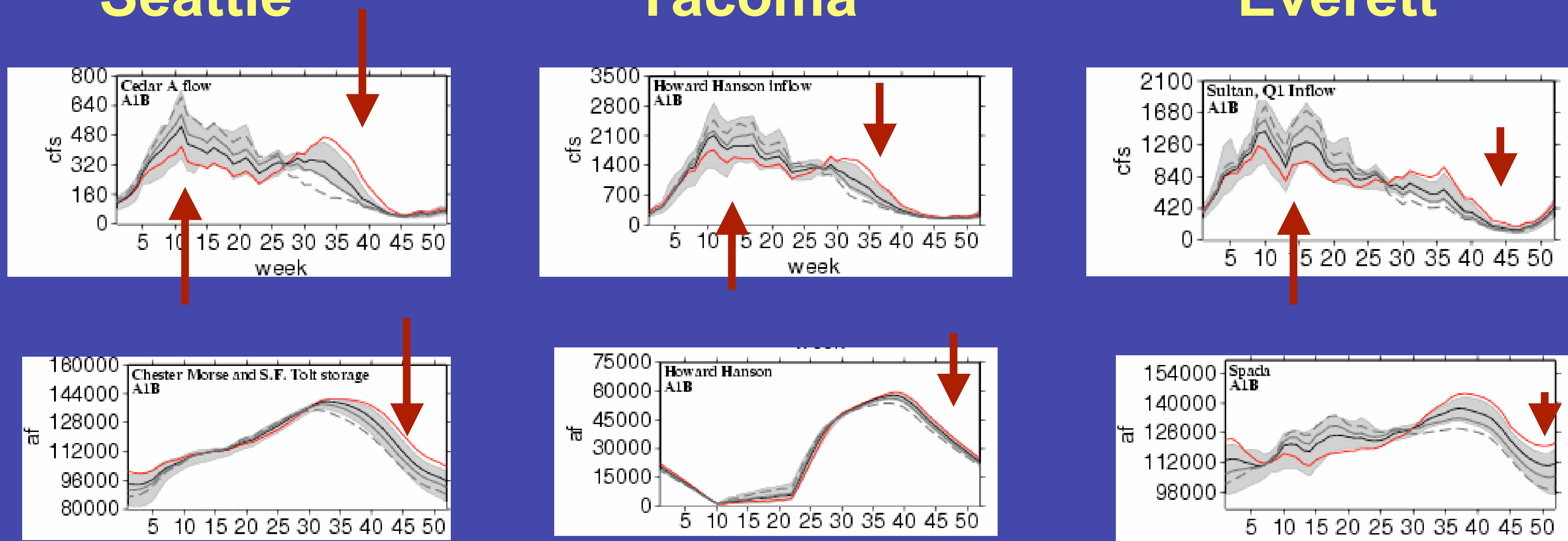


Puget Sound Basin

Seattle

Tacoma

Everett



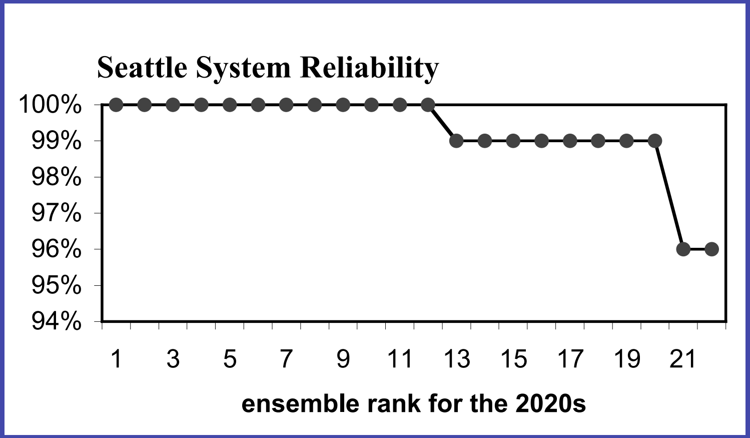
Variations in impacts within and between systems (A1B)

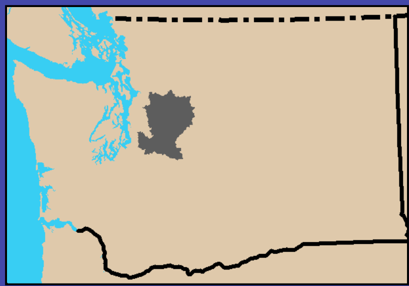
- **Seattle, springtime snowmelt peak disappears 2080s**
- **Tacoma, less transition, more constrained storage**
- **Everett, more interannual variability in storage**

Puget Sound Basin

municipal supply

- Reliability has little variability because current capacity of the system is much more than demand





Puget Sound Basin

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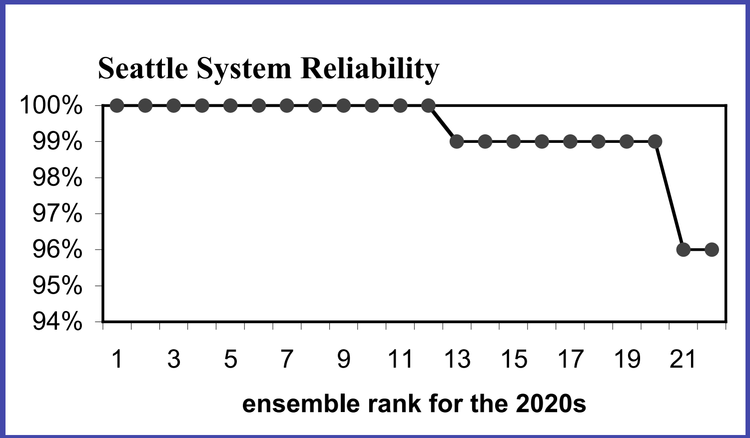
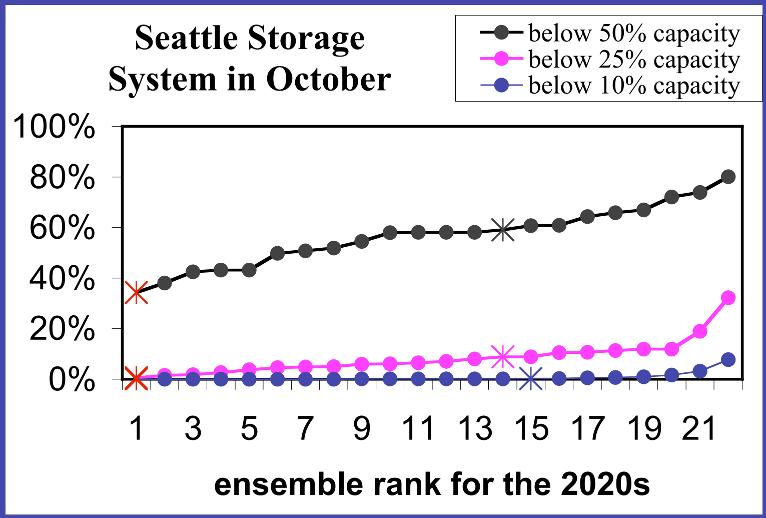
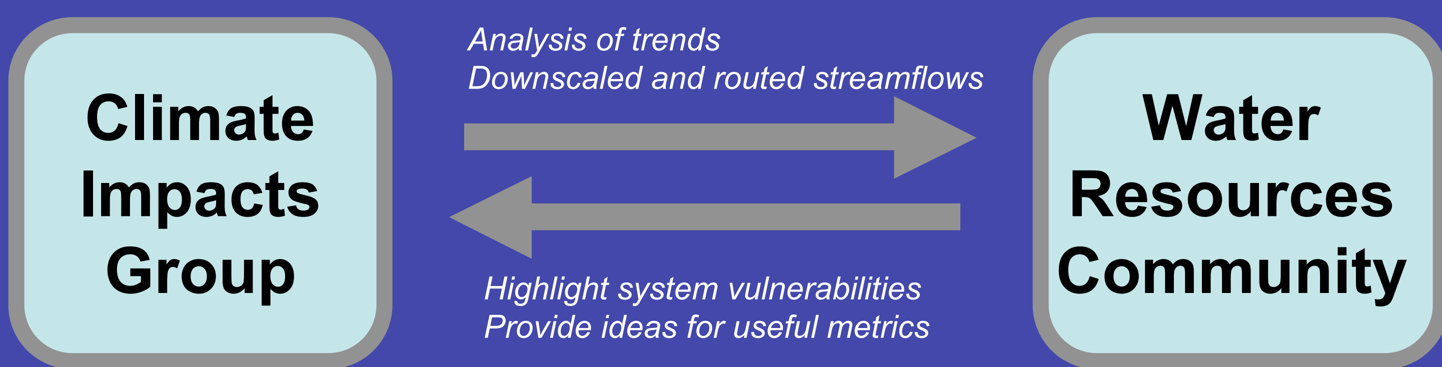


- Likelihood of storage below 50%, 25%, and 10% active capacity indicates system sensitivities



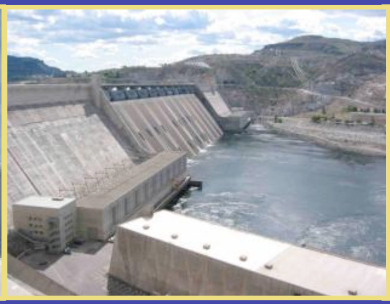
Findings

1) **Is the scale (space, time) of the information provided by future forecasts relevant to decisions?**
   Relevant, basin-specific information and metrics
2) **If planning relies on past variability, how does this change when we can no longer assume stationarity?**
   Scenarios of a transient climate
3) **How can we account for uncertainty in these forecasts?**
   Ensemble estimations
4) **How can we change planning and management to account for this non-stationarity uncertainty, and risk?**
   Adaptive responses and agreements



Future directions

- Investigate multi-model response in 2040s and 2080s
- Use transient future projections instead of delta method downscaling
- Apply scenario-based planning adaptation options
- Work with managers to further assess most relevant metrics


THANK YOU!!

The Climate Impacts Group

www.cses.washington.edu/cig

Julie Vano

jvano@u.washington.edu