Climate Change Impacts on Pacific Northwest Water Resources

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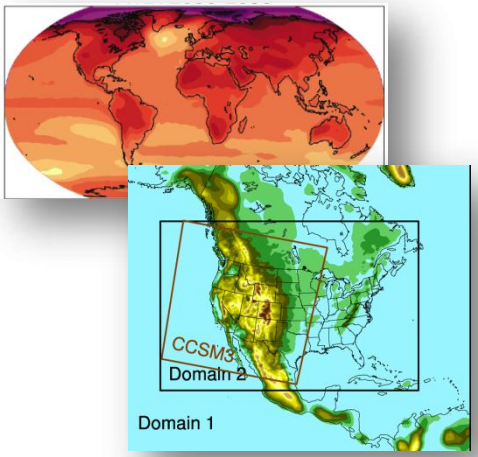
UW Climate Impacts Group

American Water Works Association
Pacific Northwest Section Annual Meeting
May 5, 2011

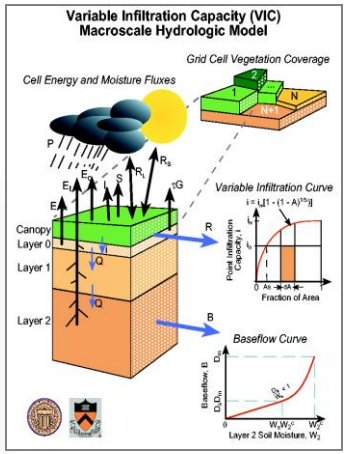
The Climate Impacts Group

An integrated research team studying the impacts of climate variability and climate change in the PNW and western US

Downscaling global climate information



Macro and fine-scale hydrologic modeling



Impacts assessments for water resources, terrestrial and aquatic ecosystems

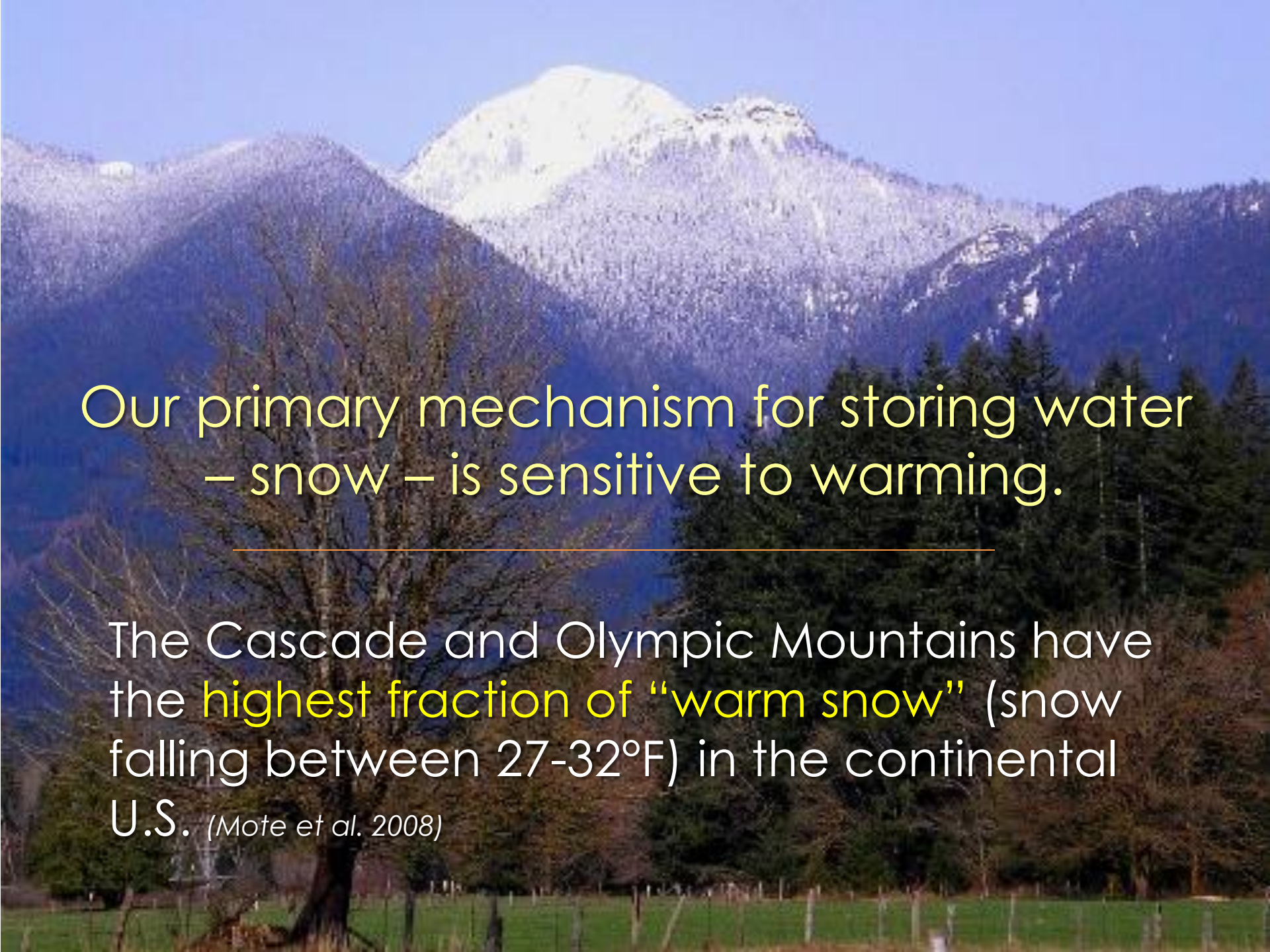
Adaptation planning and outreach

Working since 1995 to:

- Perform climate science in the public interest
- Increase regional resilience to climate variability and change
- Produce science useful to (*and used by!*) the decision making community

We care about climate and hydrologic change because:

- we have growing, and often competing, water demands
- changes in water balance are closely linked with other impact pathways (forest & aquatic ecosystems, recreation, infrastructure)



Our primary mechanism for storing water – snow – is sensitive to warming.

The Cascade and Olympic Mountains have the highest fraction of "warm snow" (snow falling between 27-32°F) in the continental U.S. *(Mote et al. 2008)*

Looking Back

Observed changes in 20th century regional climate and hydrology

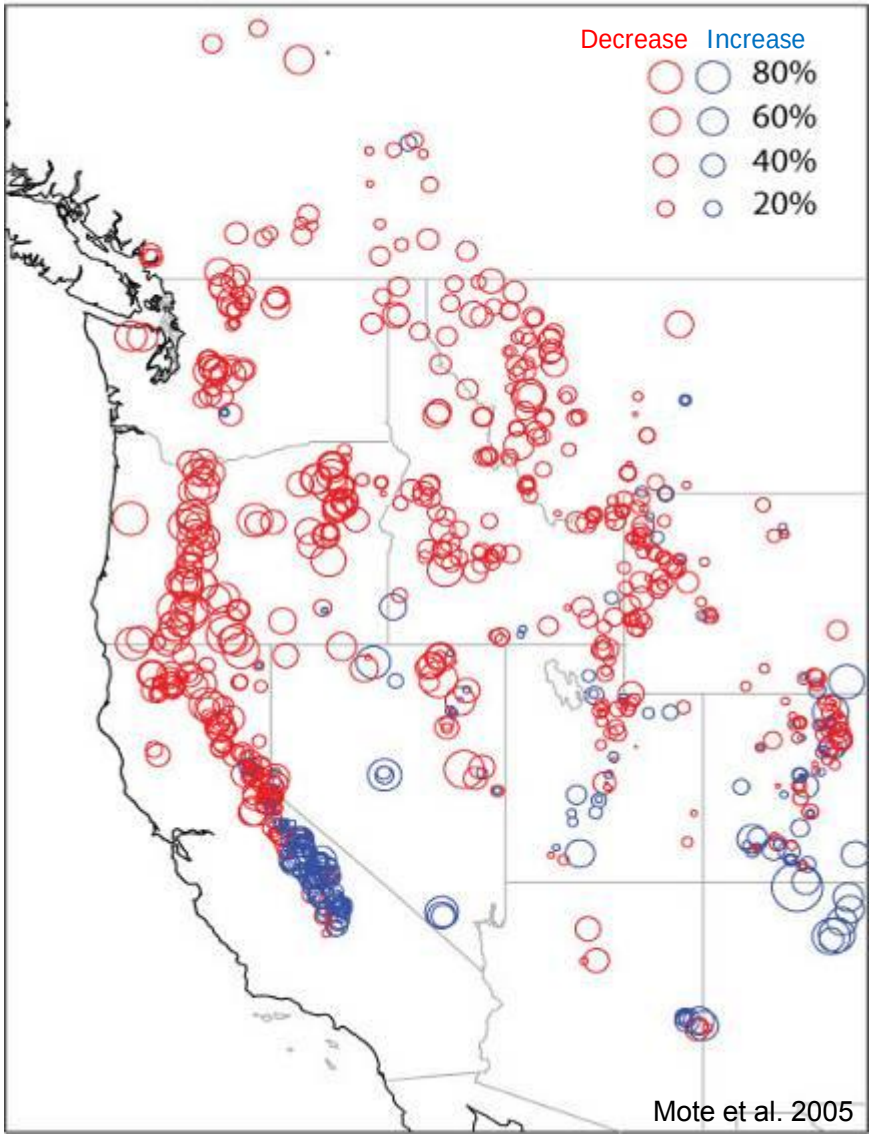
Key Trends in PNW Climate

Average annual temperature increased **+1.5°F** in the PNW during the 20th century

April 1 snowpack decreased, with losses of 30-60% at many individual stations in the PNW (1950-2000)

Similar snowpack declines are seen throughout the western United States

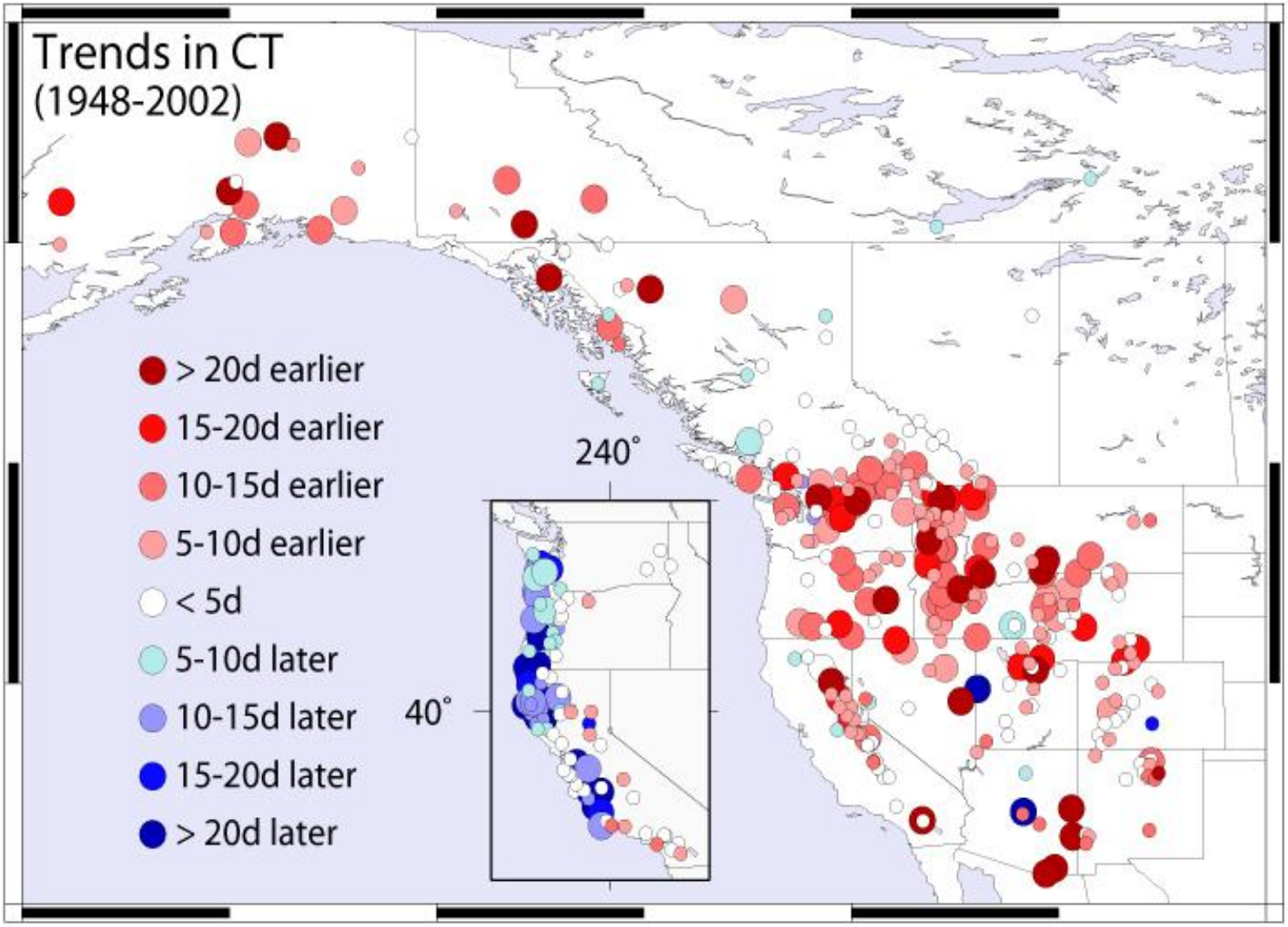
a. April 1 SWE Observations 1950-1997



Mote et al. 2005

Trends in Spring Runoff

Peak of spring runoff is moving earlier into the spring throughout western U.S. and Canada



Stewart et al. 2005 Stewart I.T., Cayan D.R., Dettinger M.D., 2005: Changes toward earlier streamflow timing across western North America, *Journal of Climate*, 18(8):1136-1155.

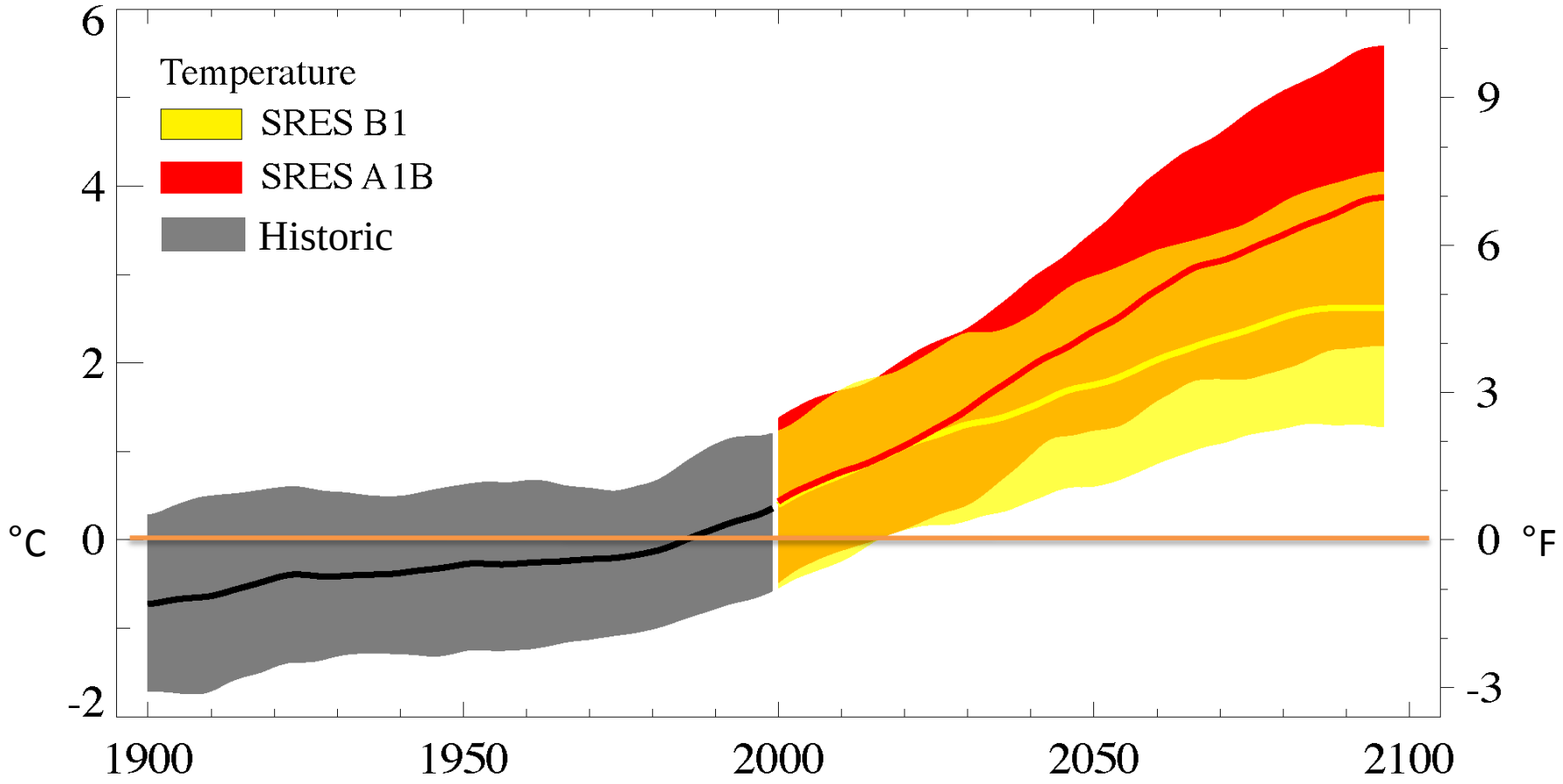
Looking Forward

Projected changes in 21st century climate and hydrology

Projected Increases in Annual PNW Temperature

** Relative to 1970-1999 average*

2020s	+2.0°F *(1.1-3.4°F)*
2040s	+3.2°F *(1.6-5.2°F)*
2080s	+5.3°F *(2.8-9.7°F)*

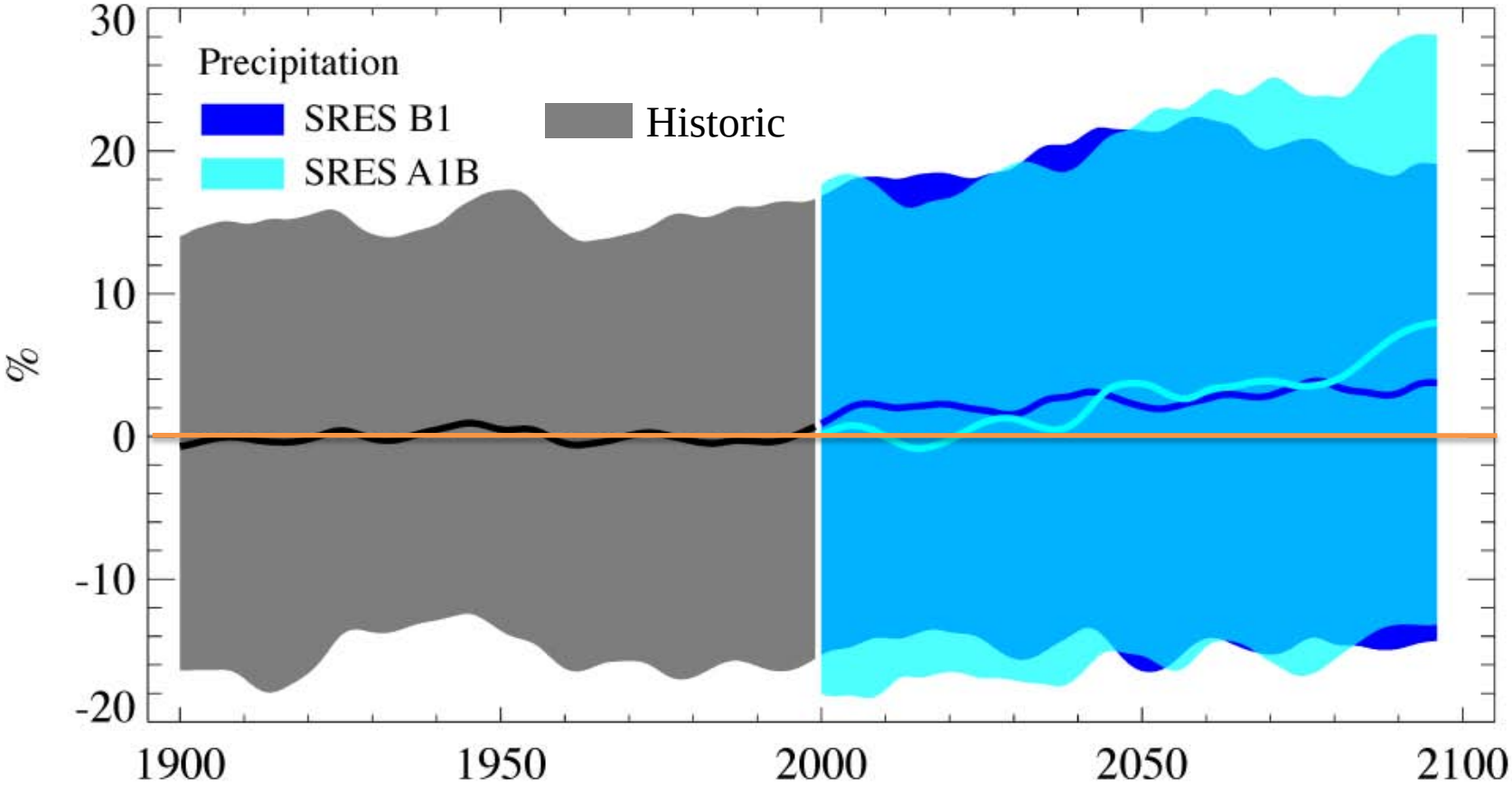


Mote and Salathé, 2009

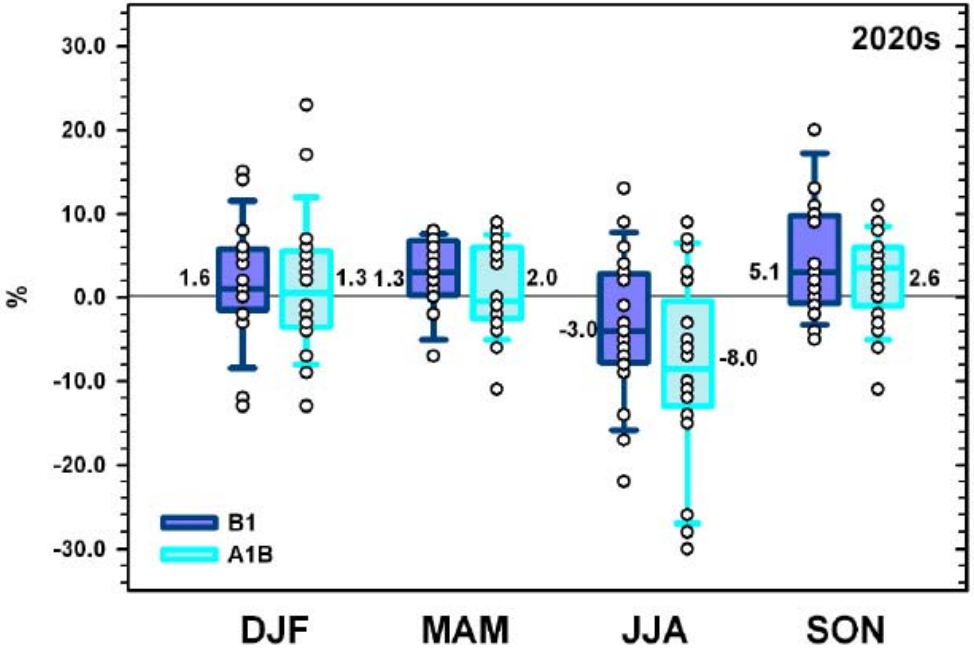
Projected Increases in Annual PNW Precipitation

** Relative to 1970-1999 average*

2020s	+1% *(-9 to 12%)*
2040s	+2% *(-11 to +12%)*
2080s	+4% *(-10 to +20%)*

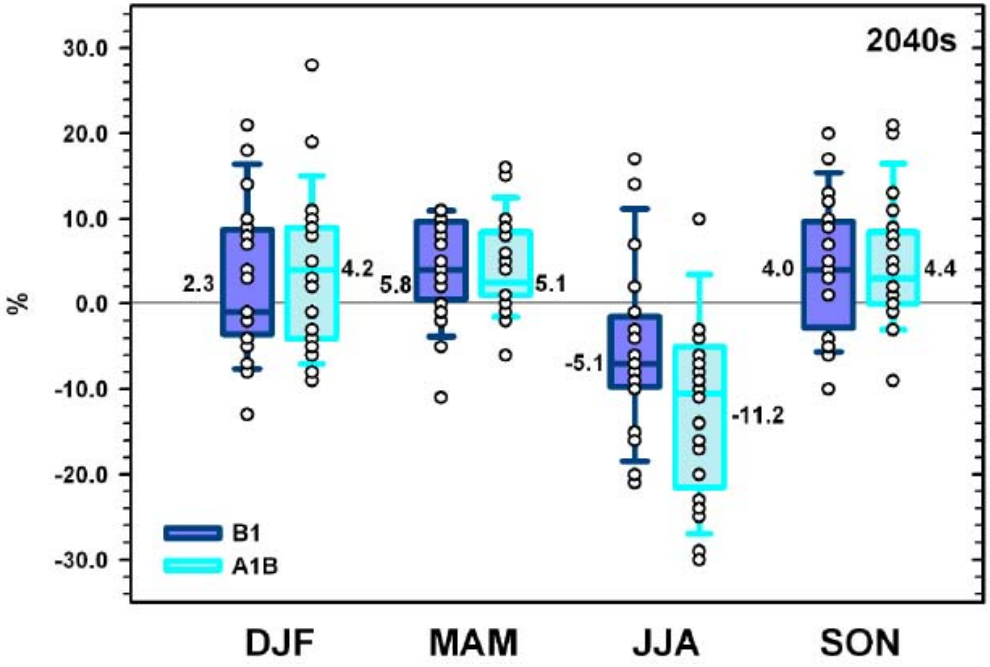


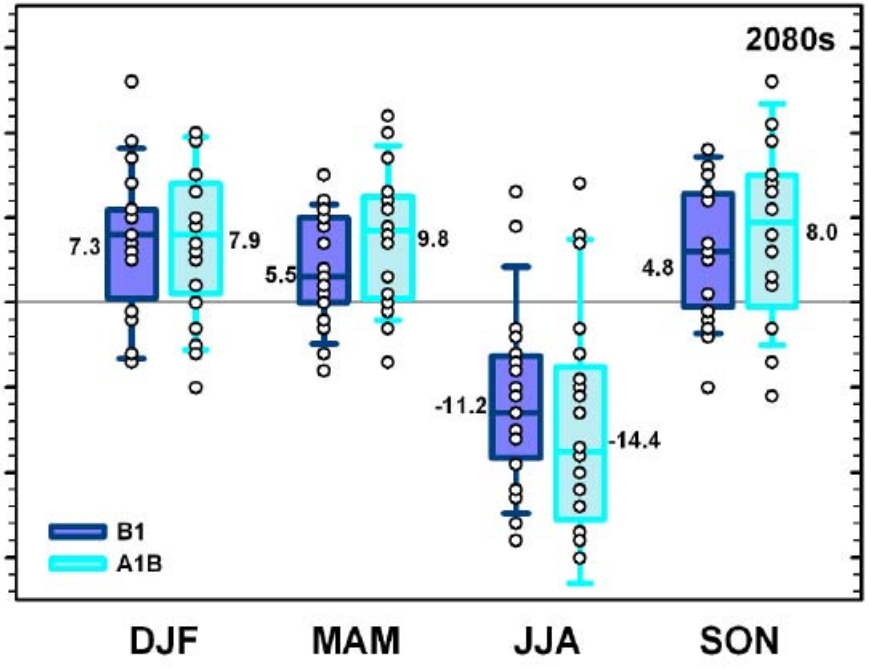
Mote and Salathé, 2009



While there is significant variability across models, we anticipate wetter winters and drier summers

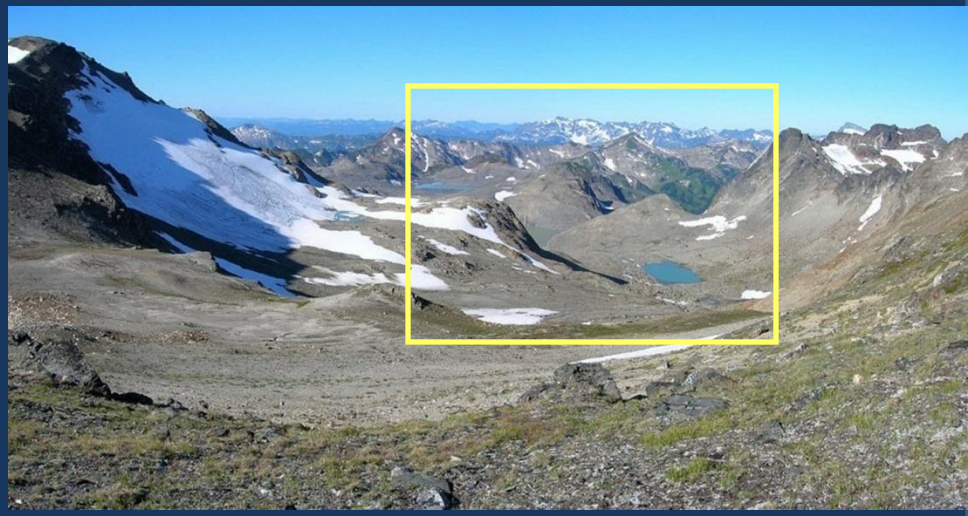
Mote and Salathé, 2009





Recession of Whitechuck Glacier (Glacier Peak Wilderness)

1973



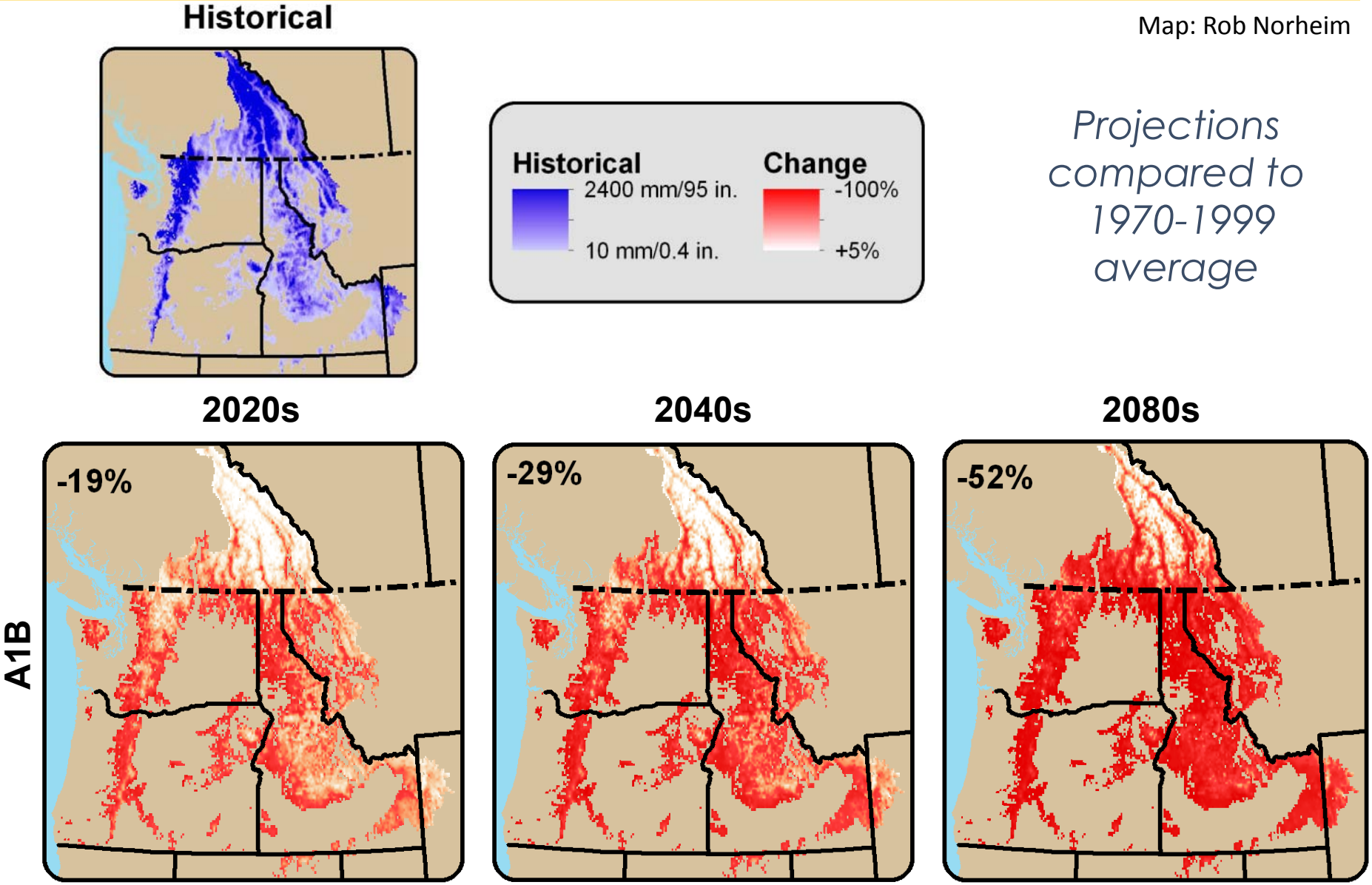
2006

North Cascades Glacier Climate Project (NCGCP)
Photos courtesy of Dr. Mauri Pelto, Nichols College

Loss of glacial mass may ***increase*** summer flow in the short term and ***decrease*** summer flow in the long term.

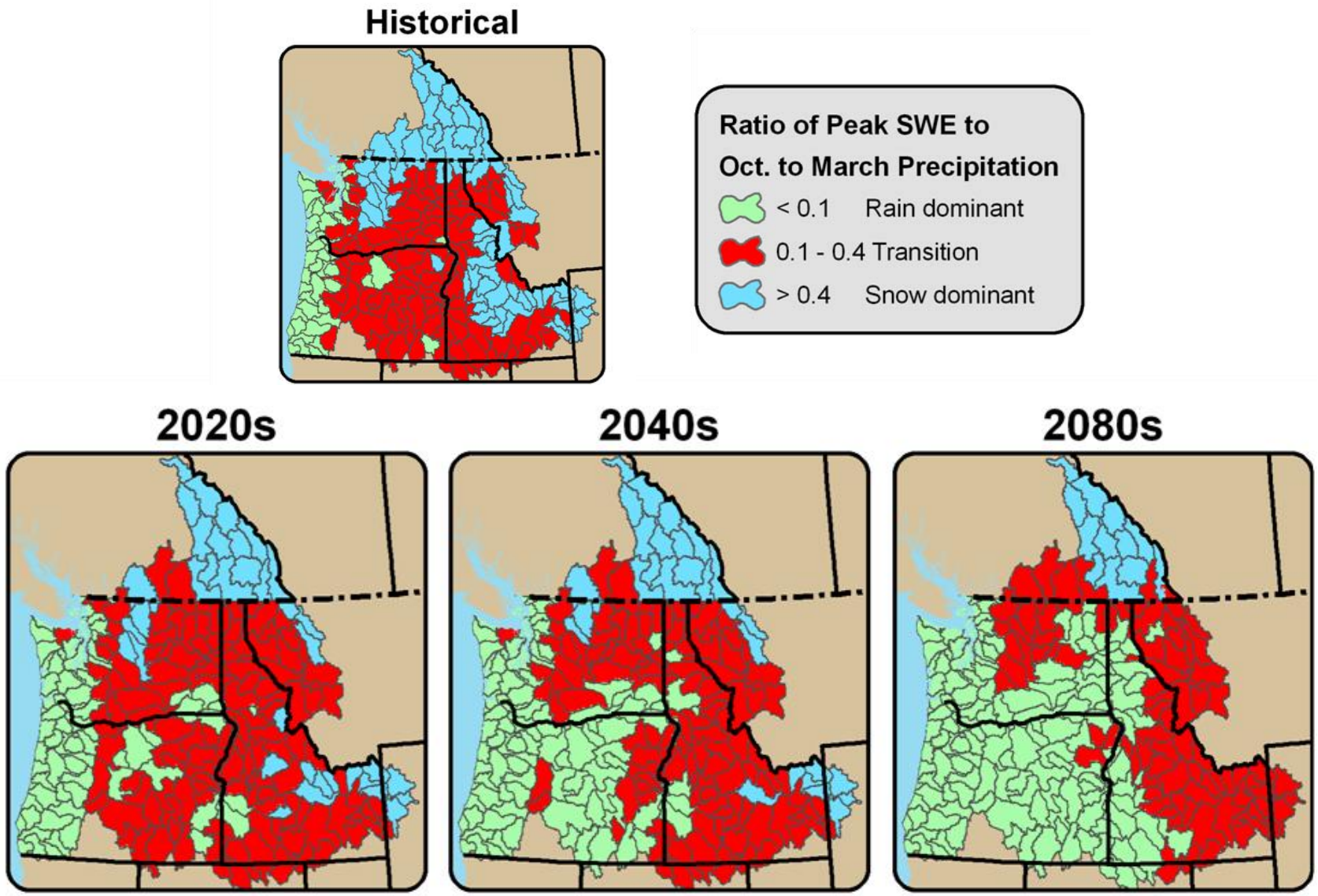
Key Impact: Loss of April 1 Snow Cover

Map: Rob Norheim



Projections compared to 1970-1999 average

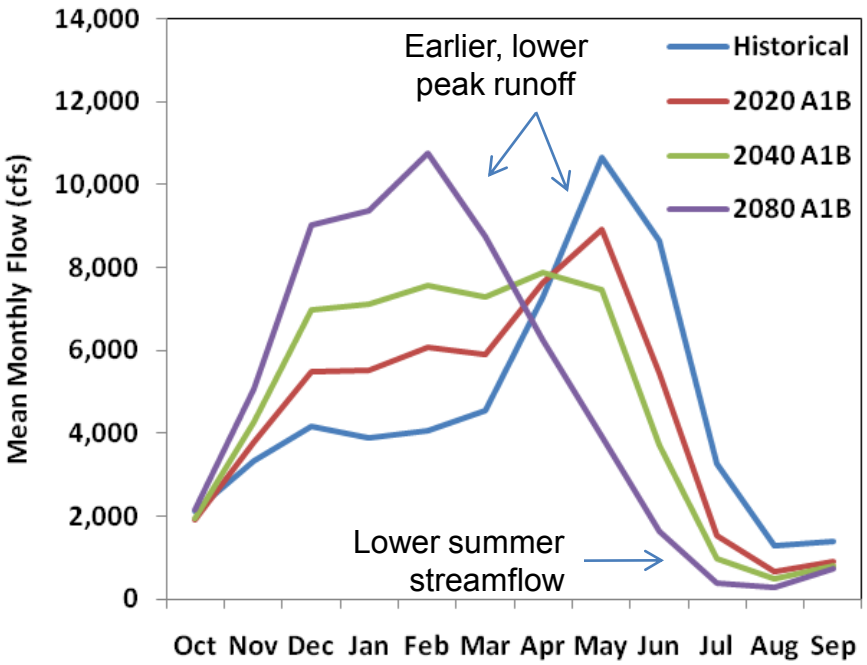
Key Impact: Shift in Hydrologic Basin Types



Map: Rob Norheim

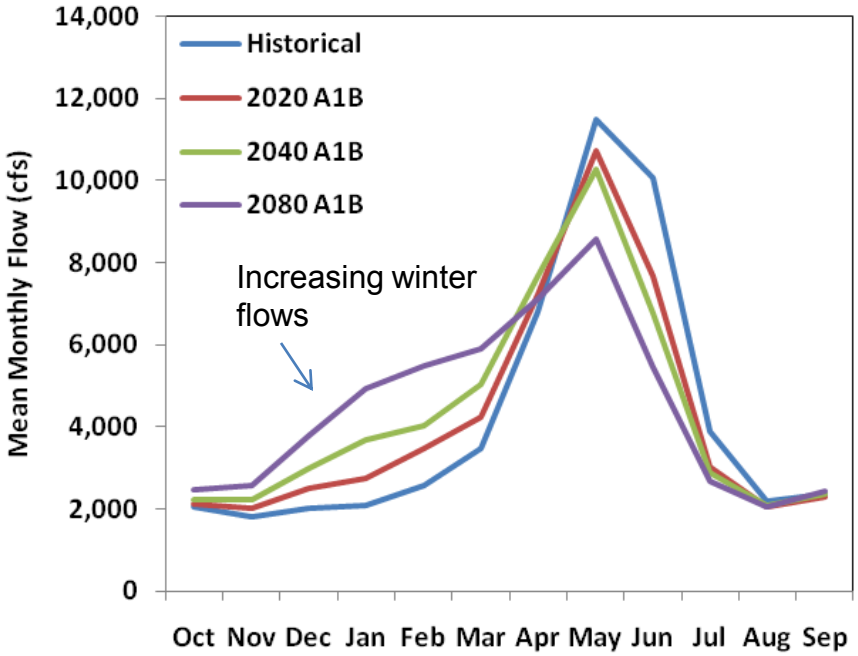
Impacts to Seasonal Streamflow Timing

Yakima River at Parker



Mix Rain/Snow "Transient" Basin

Payette River nr Payette



Snow Dominant Basin

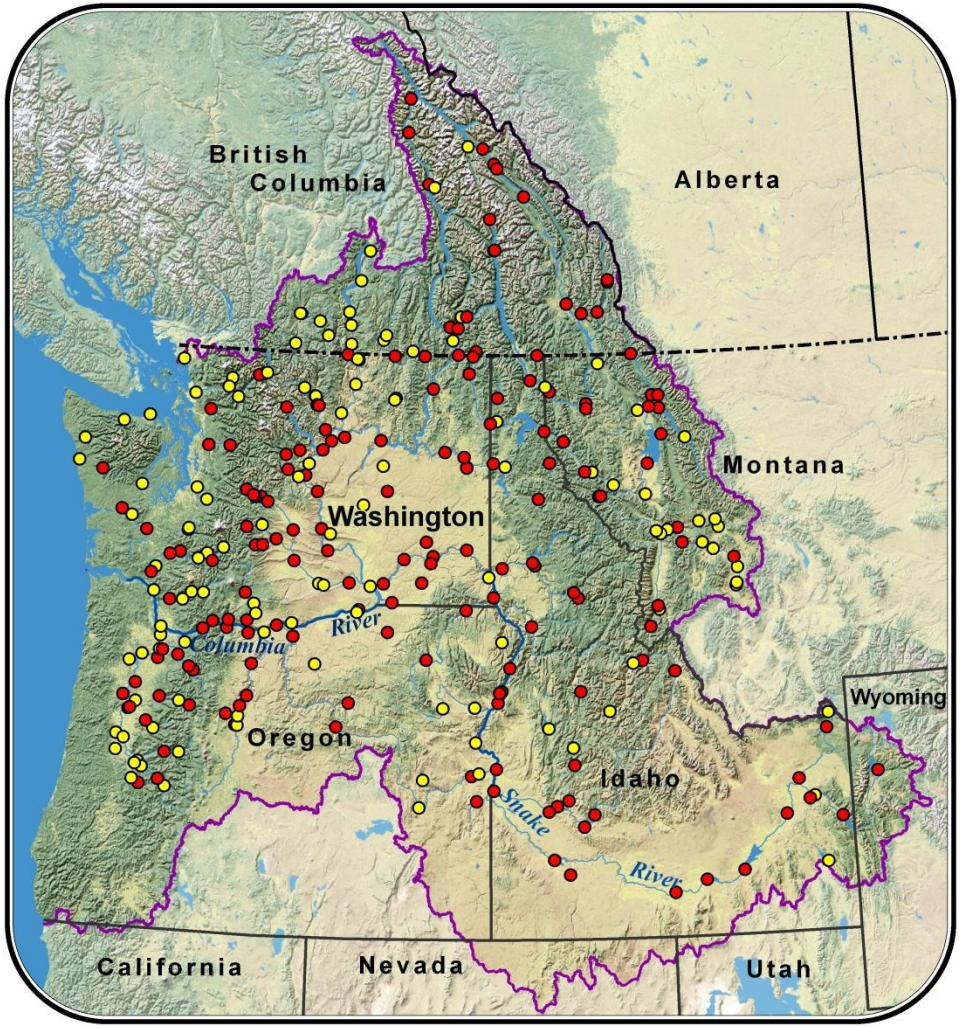
Elsner et al. 2010

Naturalized flows (i.e., no dams)

The Columbia Basin Climate Change Scenarios Project

A comprehensive suite of free 21st century hydro/climate scenarios for almost 300 sites in the PNW, including data for:

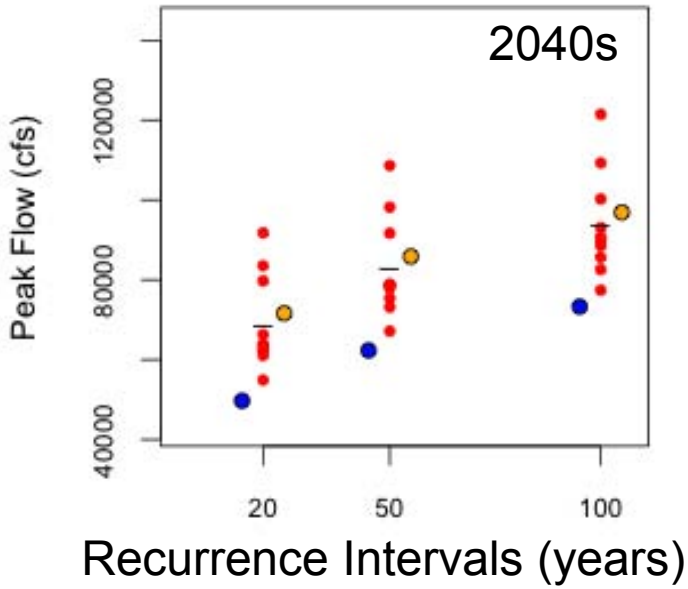
- streamflow
- evapotranspiration
- flood & low flow statistics
- precip, temp
- soil moisture
- snowpack

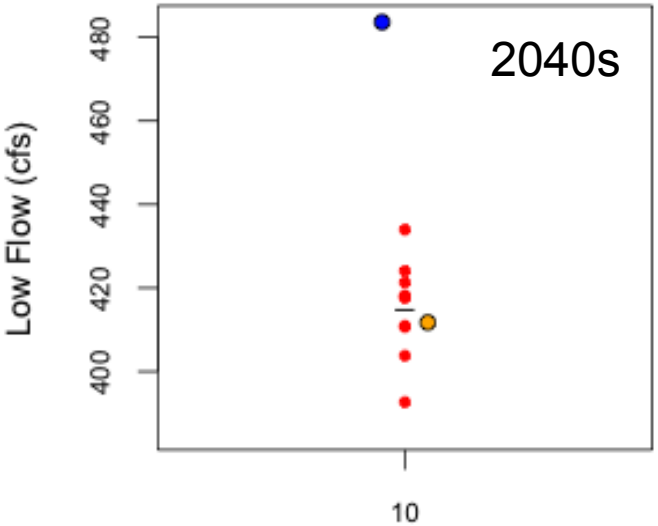


http://www.hydro.washington.edu/2860/

Changes in Hydrologic Extremes

June 2010 South Fk Rd, Payette National Forest





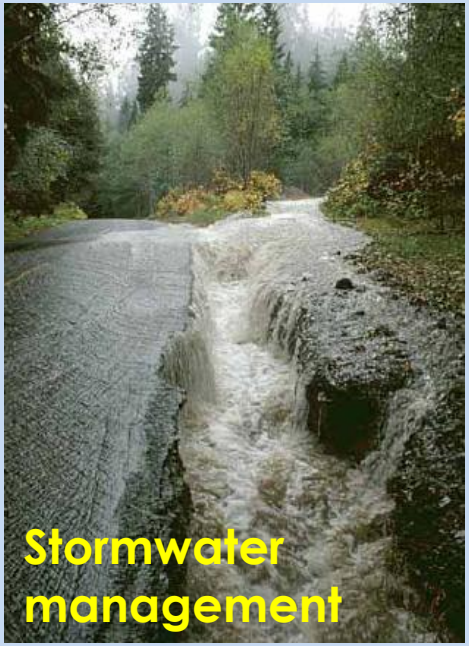
- Historical
- Hybrid Delta Projections
- Traditional Delta Projections

Looking Forward

Related Impacts

Related Impacts of Extreme Events

Floods

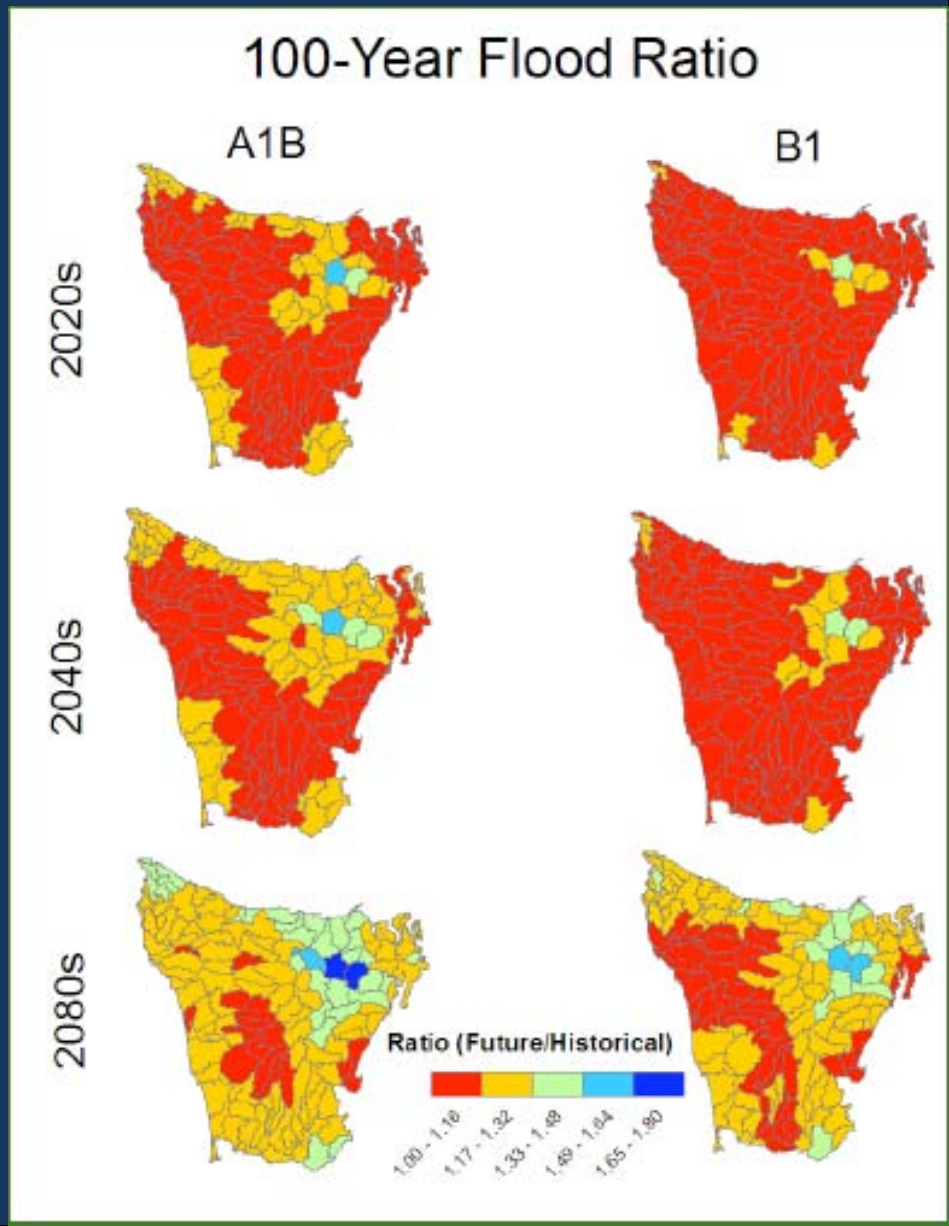


Droughts

Improving Estimates of the 100-yr Flood

- Case study Olympic Nat'l Forest

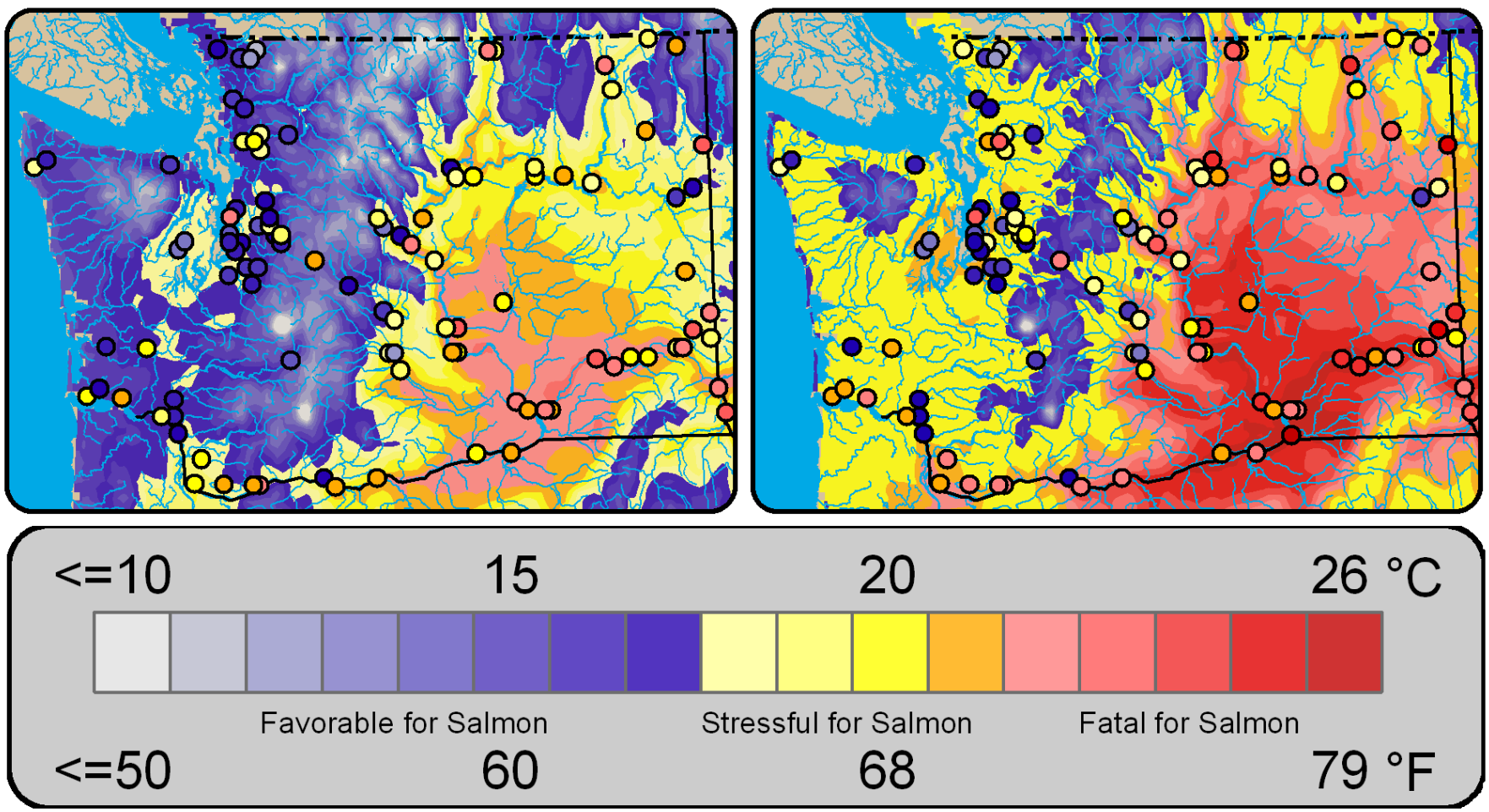
- Road management uses 100-year flood
- Typical estimates use regression equations
  - Limited ability to incorporate climate change information
- This study approach uses hydrologic model (VIC)
  - Incorporates projected changes in temperature and precipitation



Water Quality Impacts
- Salmon and Ecosystems

August Mean Surface Air Temperature and Maximum Stream Temperature

Historical (1970-1999) | 2040s medium (A1B)



* Projections are compared with 1970-1999 average

Mantua et al. 2010

Water Quality Impacts
- Algal Growth

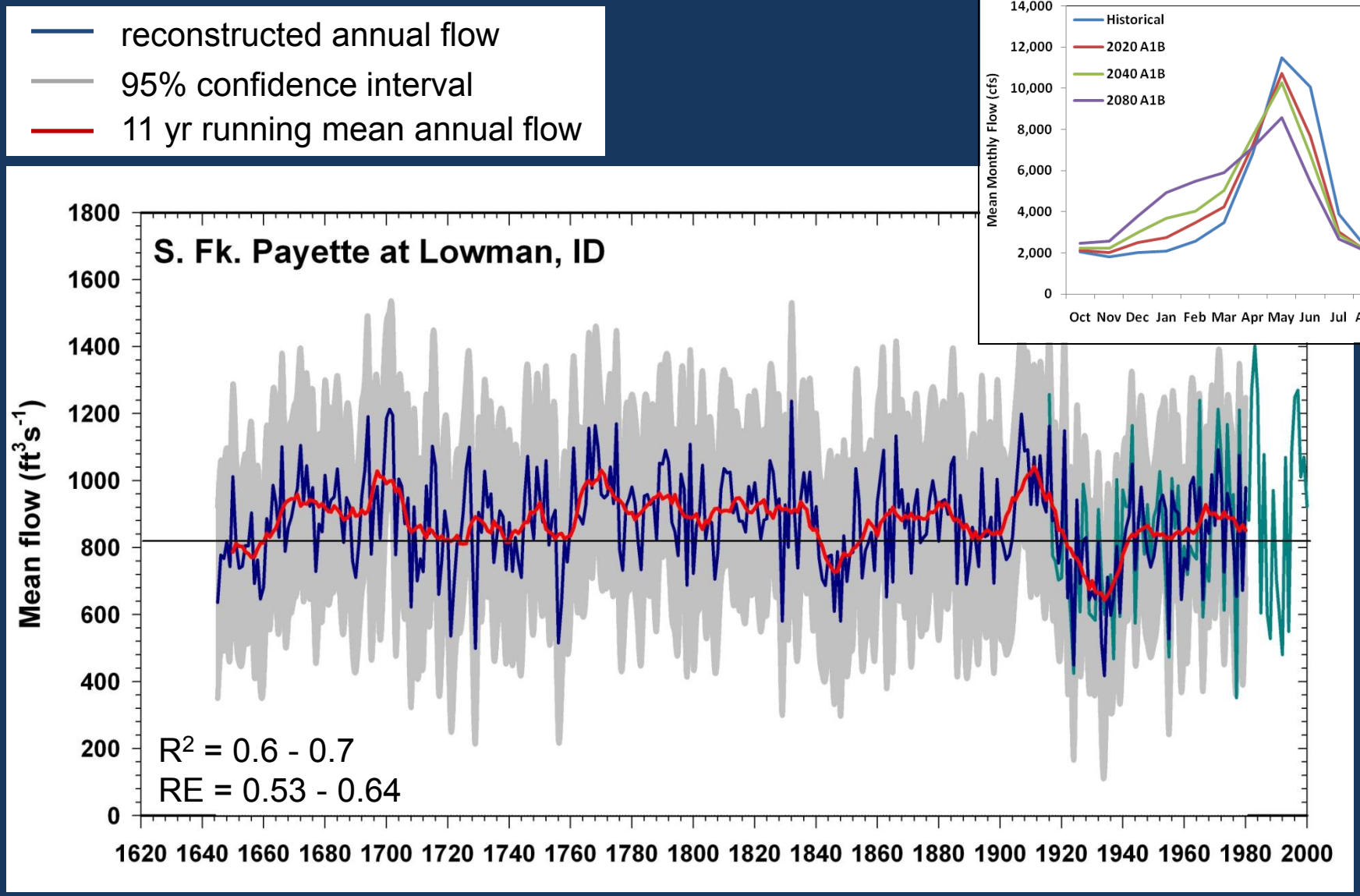
Lake Steilacoom, WA
Source: WA Dept of Ecology

- Warming temperatures may exacerbate freshwater algal blooms
- However, nutrient loading continues to be a primary driver of freshwater algal blooms

Regional Climate Change Activities

Paleo Streamflow Reconstructions

- better understanding historical variability using tree rings



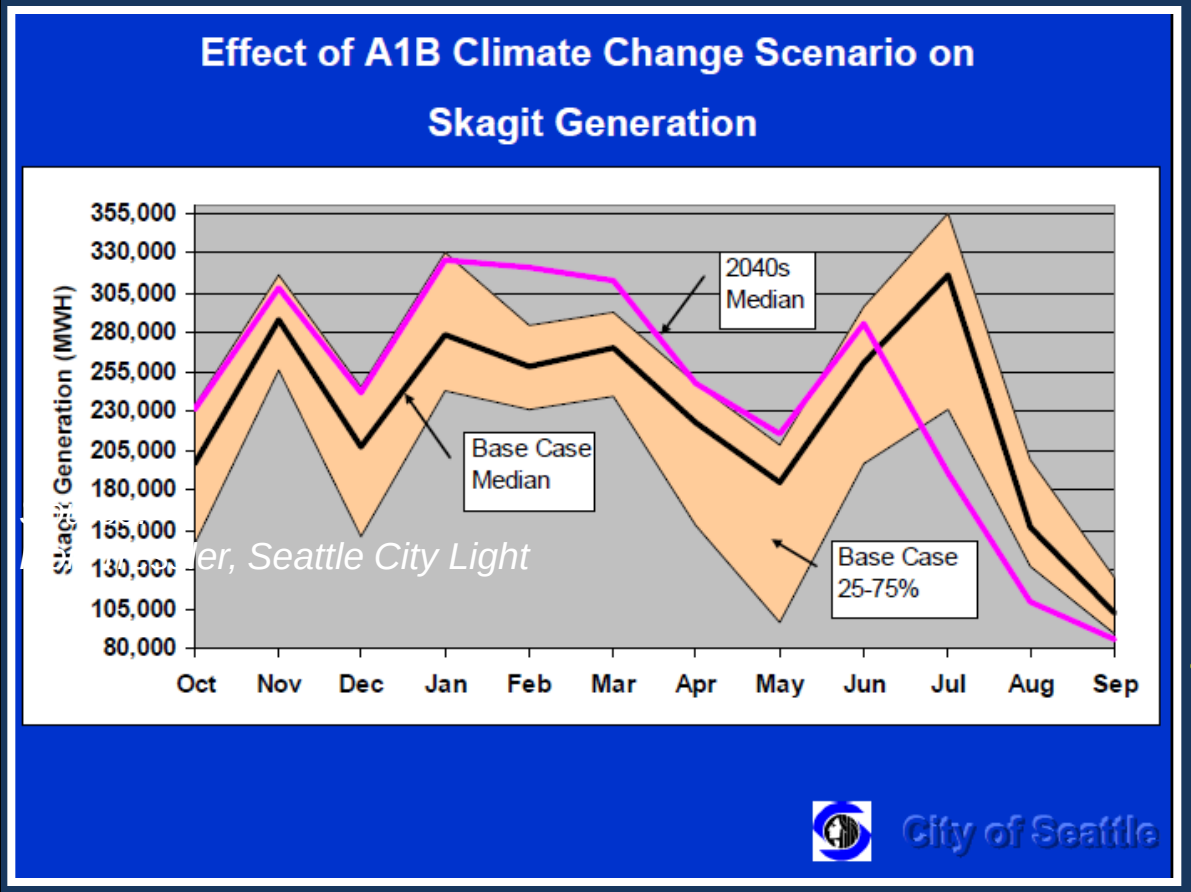
Impacts on Fish and Wildlife

Extended PNW climate & hydrologic scenarios to western US

Partners
US Forest Service
US Fish and Wildlife Service
Boise Aquatic Sciences Lab
Trout Unlimited

Impacts on Skagit River Streamflow and Temperature

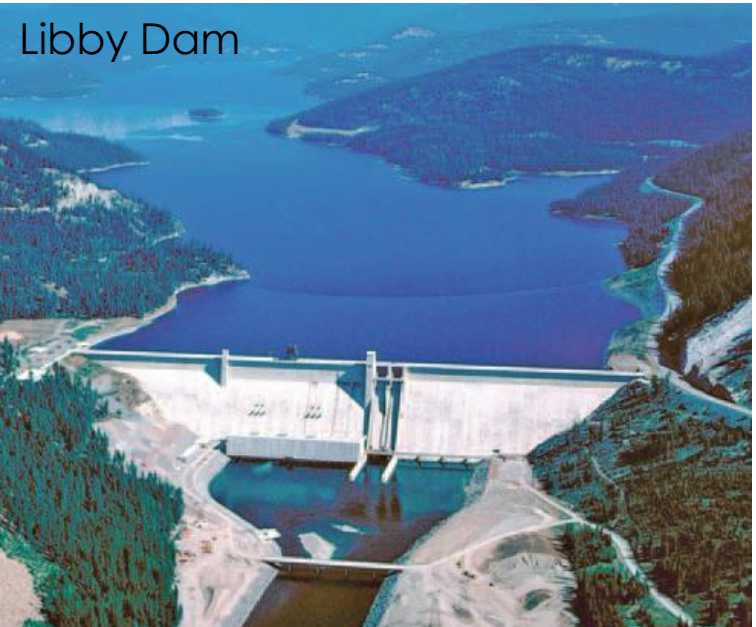
-case study with Seattle City Light



- Used projections of stream temperature and flow to evaluate impacts to current system:
  - reservoir levels
  - power generation
  - salmon health
- Next steps include developing adaptation options and improving operational tools

River Management Joint Operating Committee (RMJOC)

Partners
Bonneville Power Administration
US Army Corps of Engineers
Bureau of Reclamation



Motive:

- Consistent incorporation of climate projection information into Agencies' longer-term planning studies

Need:

- Adopt common dataset
- Establish consensus methods for data use
- Efficiently use limited resources through coordinated development of data and methods

Source: Levi Brekke (USBR)

Regional Planning Activities
- Puget Sound

Water Supply & Management Planning Process (2005-2007)

- Included research groups, regional public utilities, local governments, tribes
- Goal to develop data, information and pragmatic tools to assist in water resource and supply planning activities in the region
- Climate change technical committee worked toward establishing common building blocks

- Funded by the WA State Legislature
- First comprehensive assessment of climate change impacts on WA
- Sectors: hydrology & water management, urban stormwater infrastructure, energy, agriculture & more…

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http://cses.washington.edu/cig/