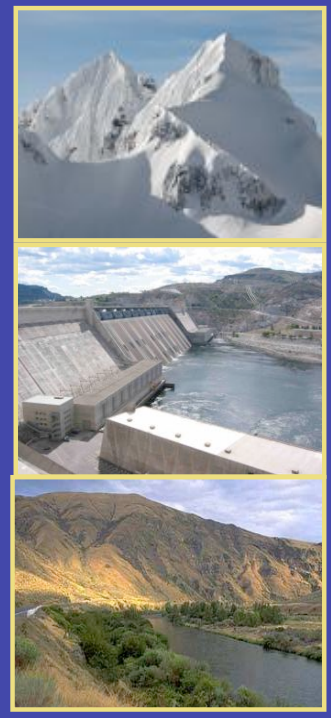
Climate Change: Water Planning Horizon Forecasts



Julie Vano
Dennis Lettenmaier
Alan Hamlet
Marketa McGuire Elsner

Climate Impacts Group
Department of Civil and Environmental Engineering
University of Washington

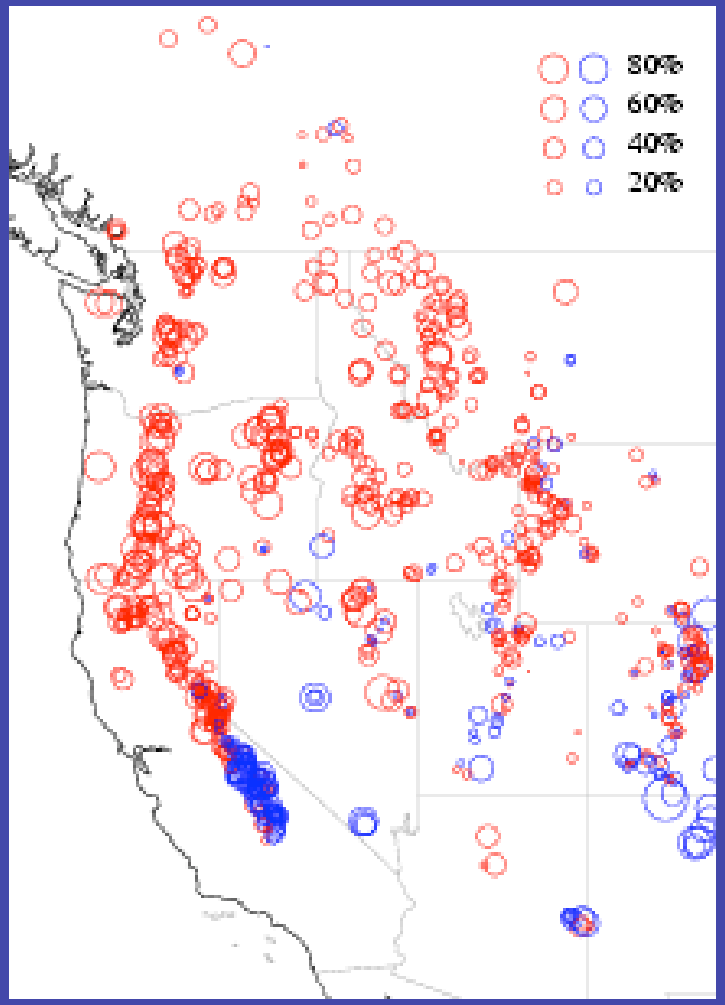
October 23, 2008
AWRA-WA 2008 Annual Conference

Climate science in the public interest

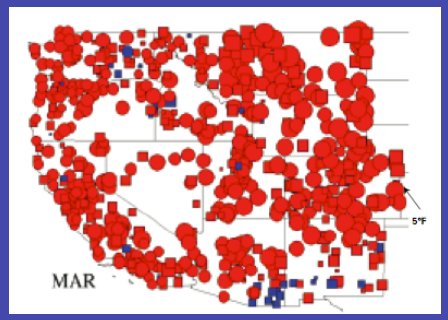
Recession of South Cascade Glacier
Upper Skagit River Basin, Washington

Source: U.S. Geological Survey
http://ak.water.usgs.gov/glaciology/south_cascade/

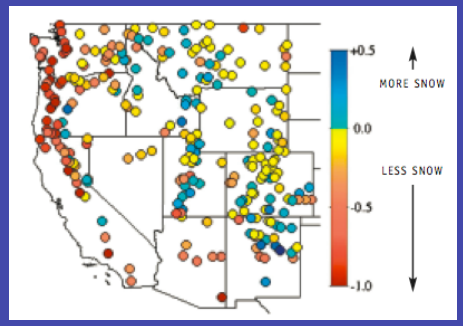
Current Climate Trends



Observed April 1 snow water equivalents, 1950-1997



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



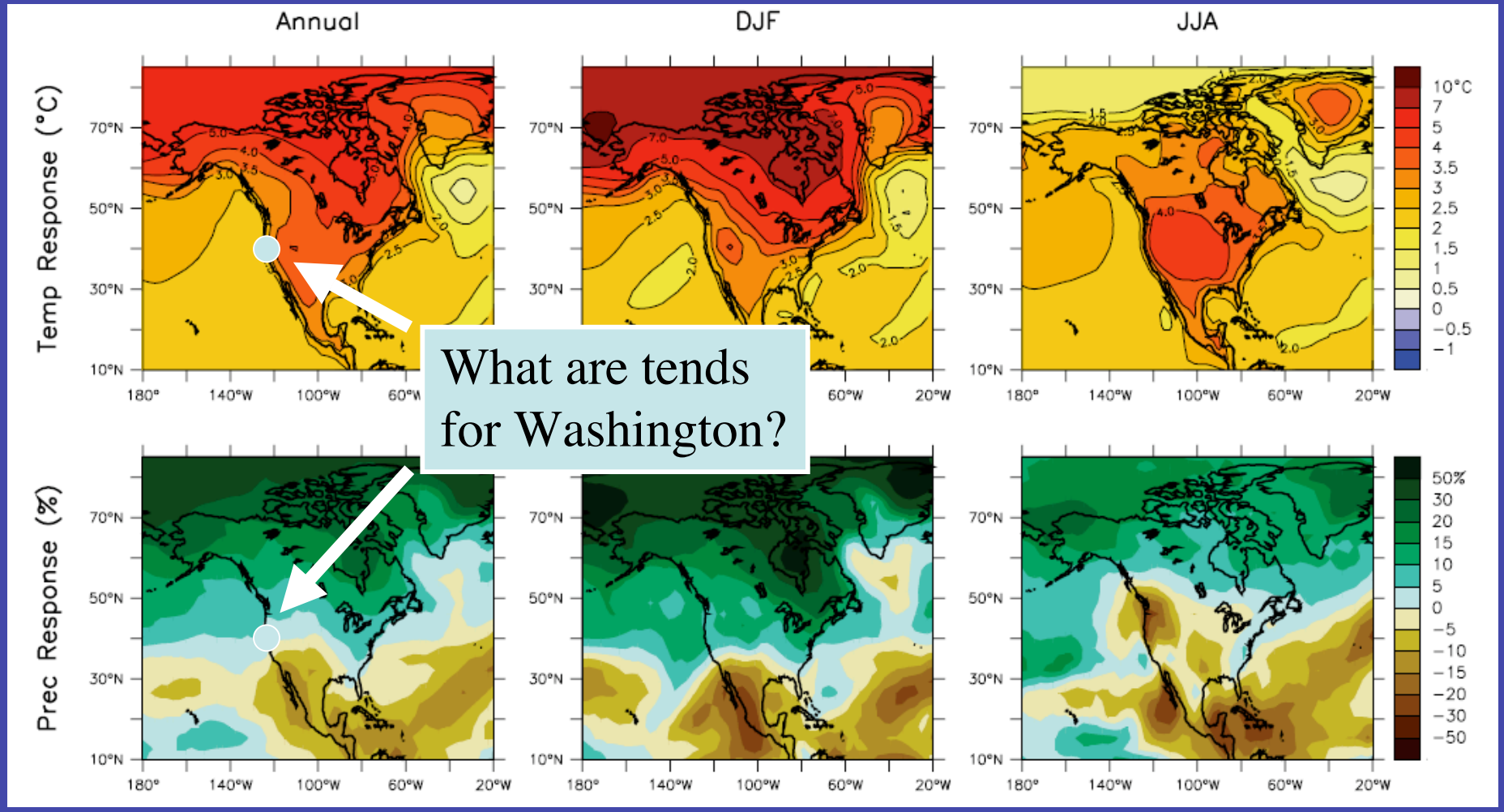
Trends in Snow vs. Rain in Winter (1949-2004)

and many more…

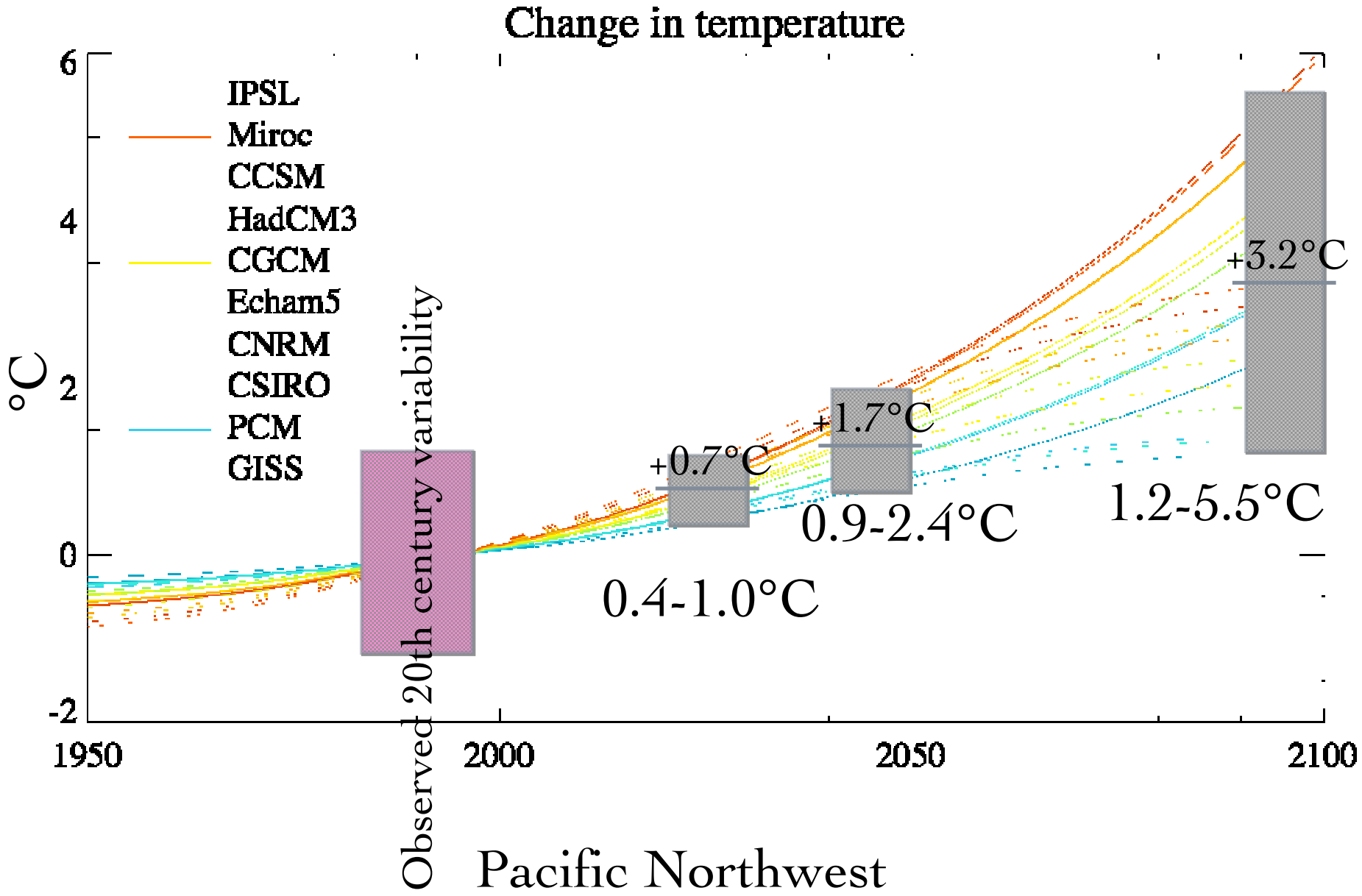
Mote P.W.,Hamlet A.F., Clark M.P., Lettenmaier D.P., 2005, Declining mountain snowpack in western North America, BAMS, 86 (1): 39-49

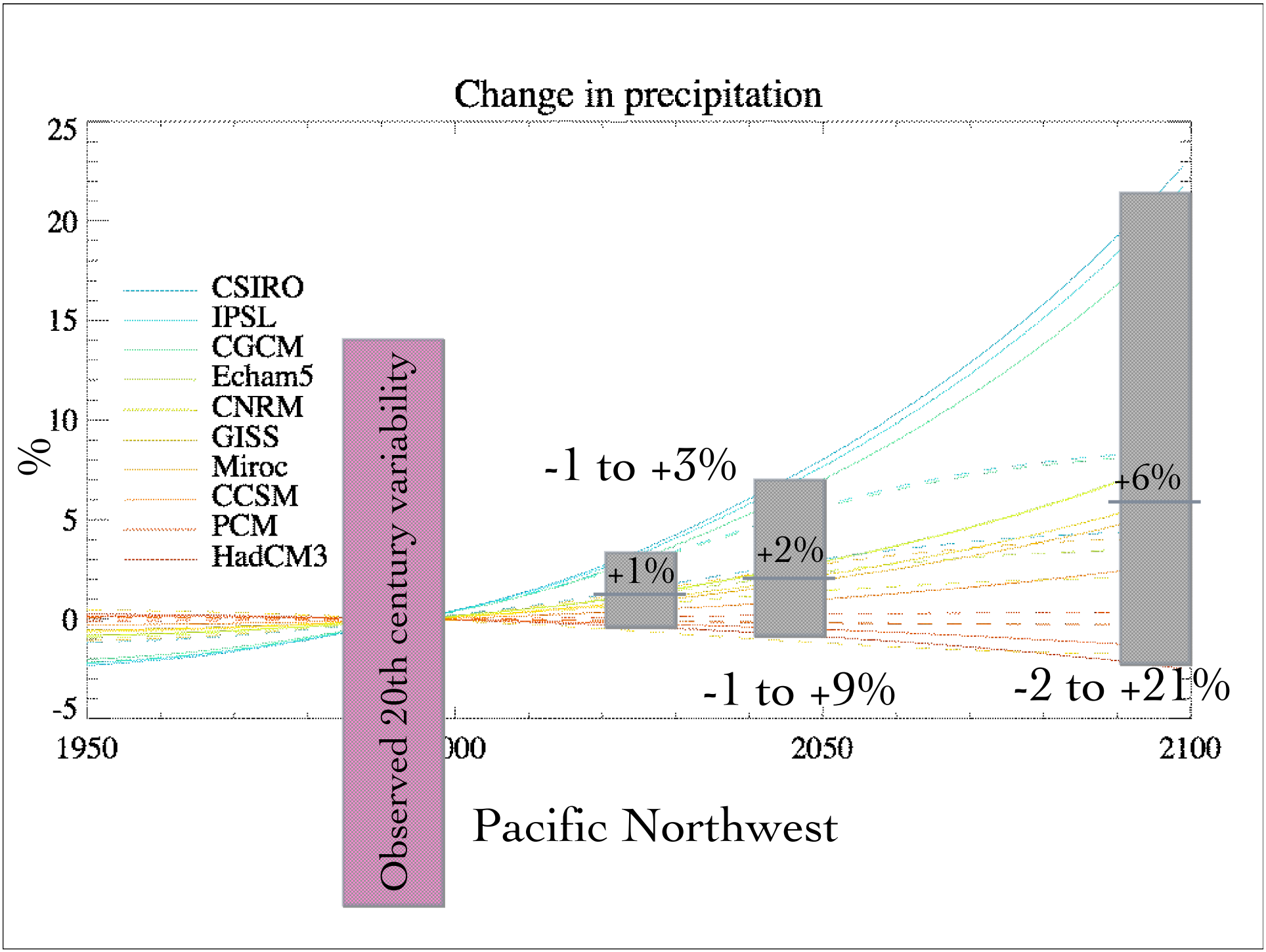
Knowles, N., Dettinger, M.D., andD.R. Cayan, 2006, Trends in Snowfall verse Rainfall in the Western United States, Journal of Climate 19: 4545-4559.

International Panel on Climate Change (IPCC) 2007



Consensus Forecasts of Temperature and Precipitation Changes from IPCC AR4 GCMs


Change in temperature
6
4
2
0
-2
°C
1950
2000
2050
2100
IPSL
Miroc
CCSM
HadCM3
CGCM
Echam5
CNRM
CSIRO
PCM
GISS
Observed 20th century variability
+0.7°C
+1.7°C
+3.2°C
0.4-1.0°C
0.9-2.4°C
1.2-5.5°C
Pacific Northwest


Change in precipitation
25
20
15
10
5
0
-5
%
CSIRO
IPSL
CGCM
Echam5
CNRM
GISS
Miroc
CCSM
PCM
HadCM3
Observed 20th century variability
-1 to +3%
+1%
+2%
+6%
-1 to +9%
-2 to +21%
1950
2050
2100
Pacific Northwest

Water Planning Concerns

1) Is the scale (space, time) of the information provided by future forecasts relevant to 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 and uncertainty?

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

Overview

- Project goals
- Methodological approach
- Preliminary findings
- Water management case studies:
  - Puget Sound (municipal)
  - Yakima R Basin (ag)
  - Columbia R Basin (energy)
- Generalizable trends
- Future directions

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

Washington State Climate Impacts Assessment

CLIMATE IMPACTS GROUP

STATE OF WASHINGTON
DEPARTMENT OF COMMUNITY, TRADE AND ECONOMIC DEVELOPMENT

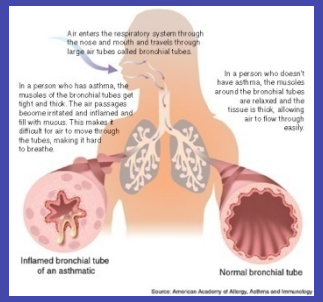
WASHINGTON STATE
Department of Ecology

Funding Source: Clean Air/Clean Fuels House Bill 1303

Answers to FAQ regarding HB 1303 from the Washington State Legislature website:
http://apps.leg.wa.gov/billinfo/default.aspx

A comprehensive climate change impacts assessment for Washington State

Human Health



Infrastructure

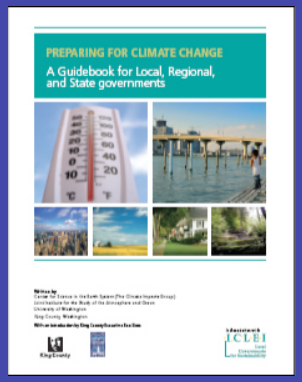
Agriculture/Economics

Water Resources

Coasts

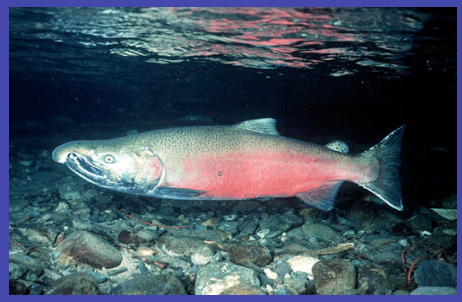
Energy

Forest Resources



Adaptation

Salmon



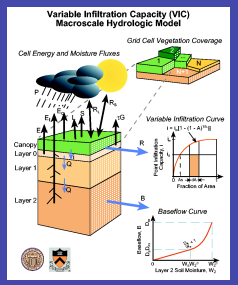
Data Needs to Support a 21st Century Planning Framework Incorporating Climate Information and Uncertainty

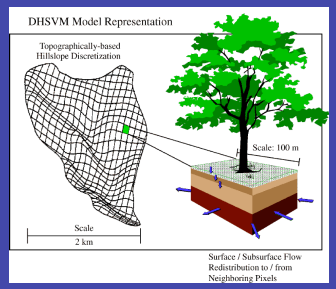
2 Emissions Scenarios X 20 GCMs

IPCC Climate Scenarios

downscaling

Hydrology Modeling





stream routing, bias correcting

Reservoir Models (ColSim, Riverware, GoldSim)

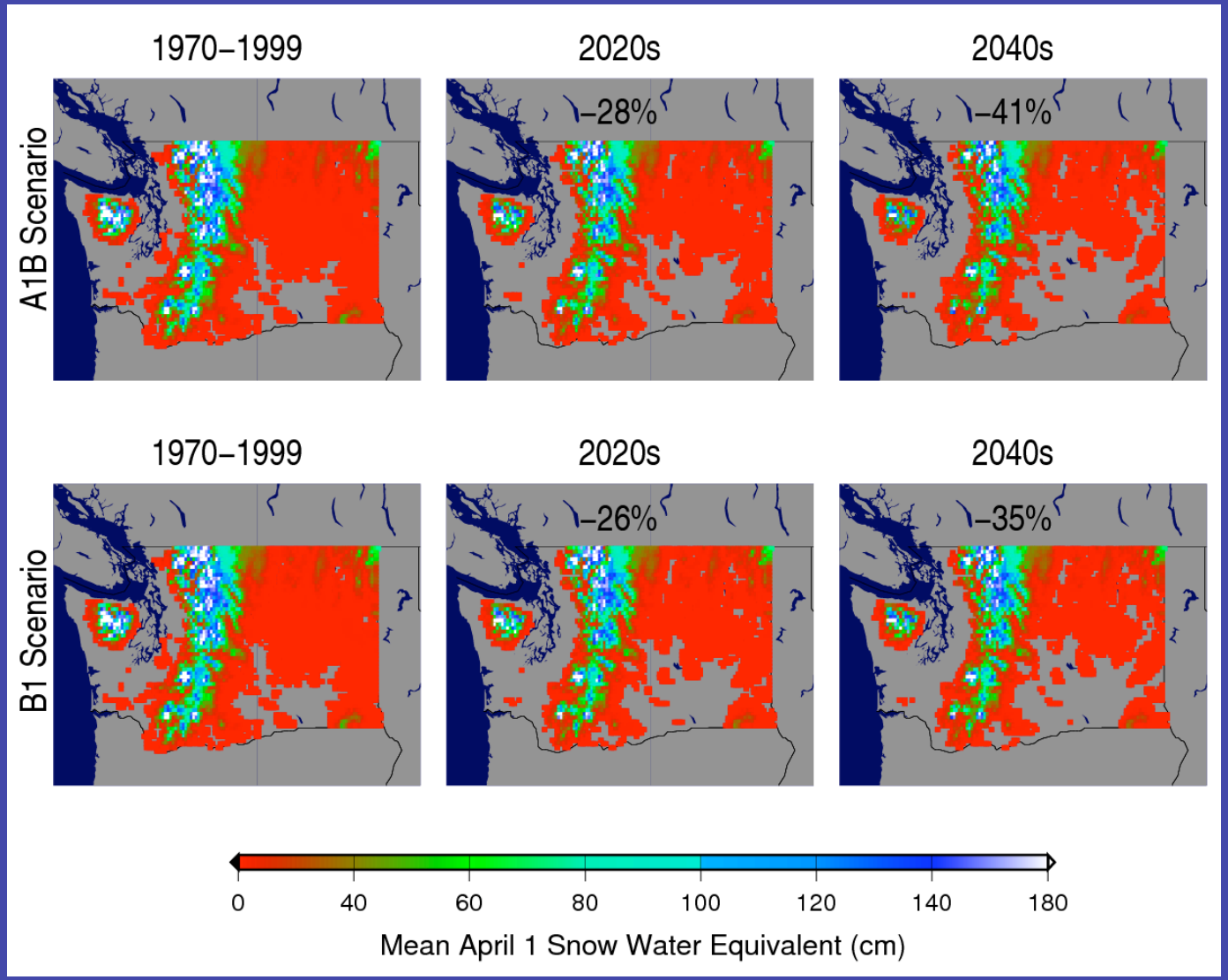
Approach provides ensemble of variables that can be used to evaluate impacts of climate change

- Precipitation
- Air Temperature
- Streamflow
- Soil Moisture
- Evapotranspiration
- Vapor Pressure Deficit
- Anticipated Storage
- And more!

Preliminary findings: declines in snow

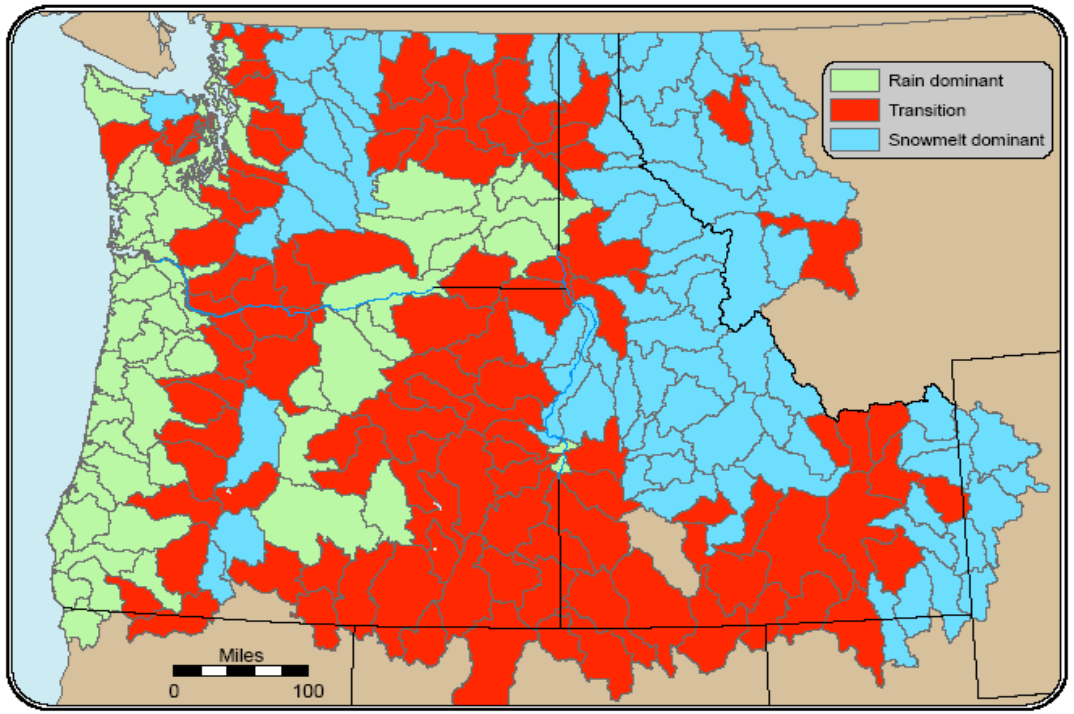
Reduced snowpack and changes in soil moisture will occur.

Declines in April 1 SWE vary between 35%-41% for the 2040s, depending on the emissions scenario.

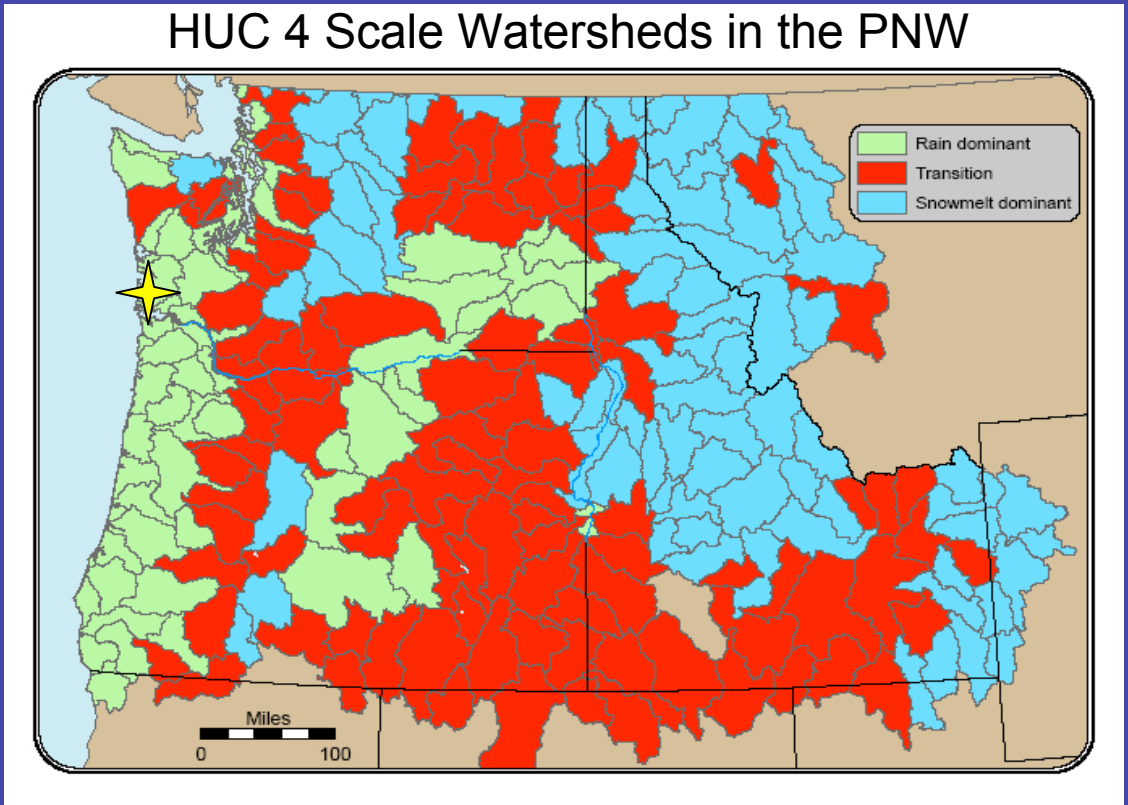


Basins sensitive to hydrologic change

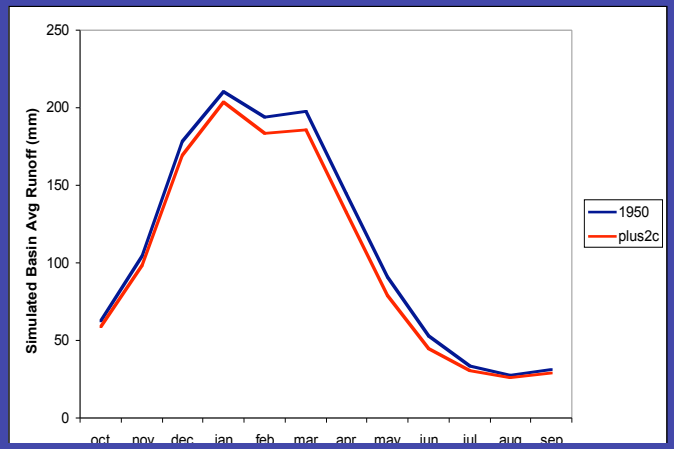
HUC 4 Scale Watersheds in the PNW



Basins sensitive to hydrologic change

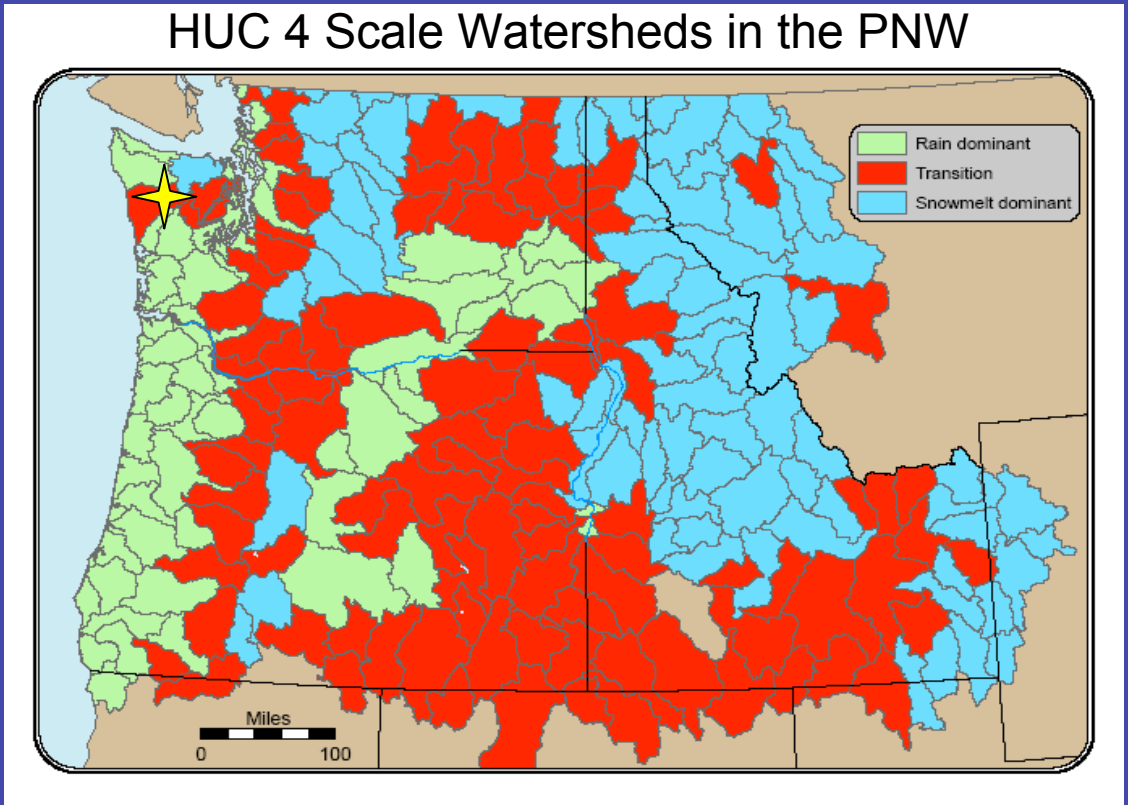


Chehalis River

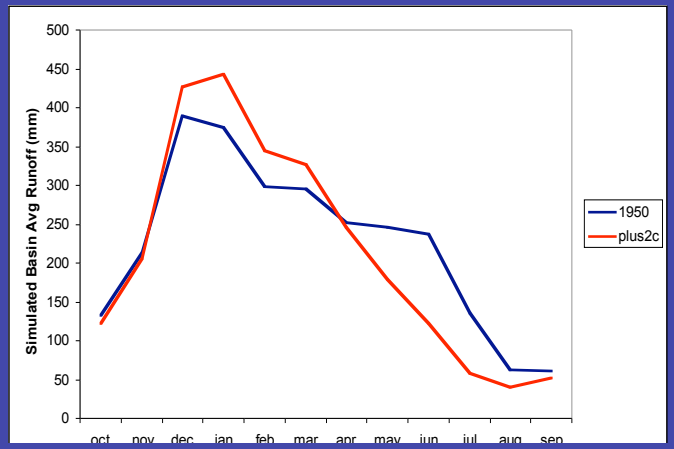


Rain Dominant Basins: no significant change from warming alone

Basins sensitive to hydrologic change



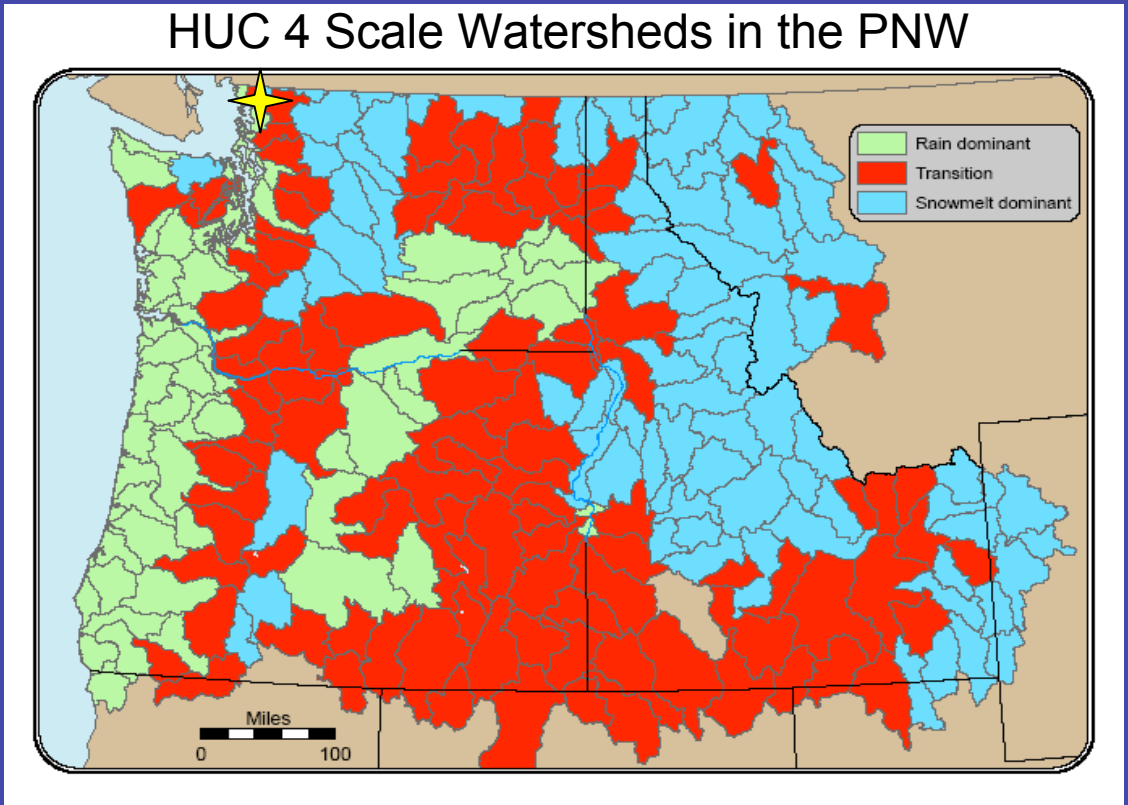
Noh River



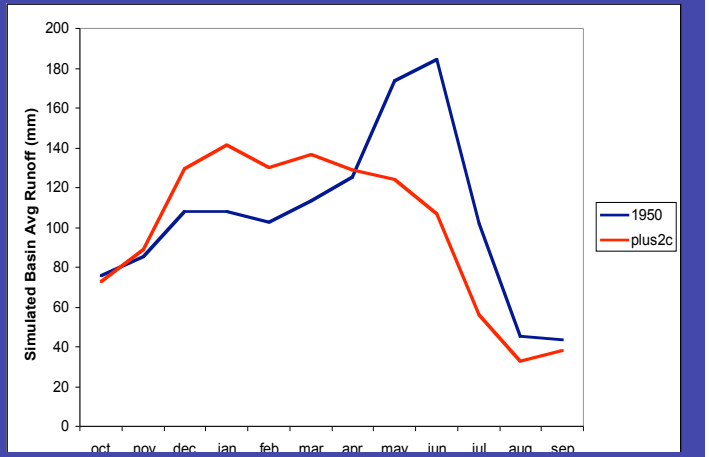
Rain Dominant Basins: no significant change from warming alone

Mixed Rain and Snow Basins: more precipitation falls as rain instead of snow, leading to an increase in flooding in winter even if precipitation remains the same

Basins sensitive to hydrologic change



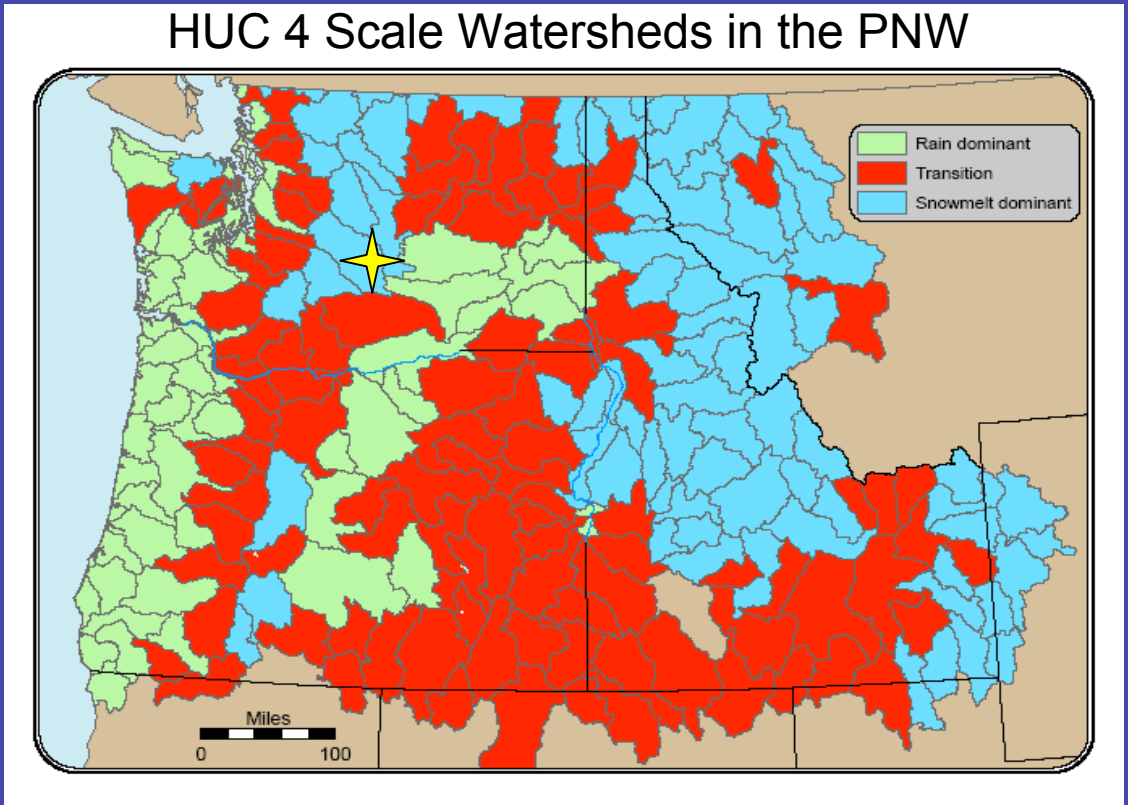
Nooksack River



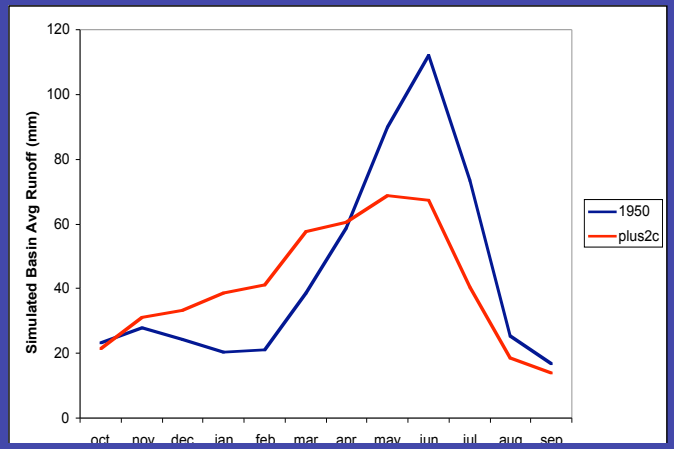
Rain Dominant Basins: no significant change from warming alone

Mixed Rain and Snow Basins: more precipitation falls as rain instead of snow, leading to an increase in flooding in winter even if precipitation remains the same

Basins sensitive to hydrologic change



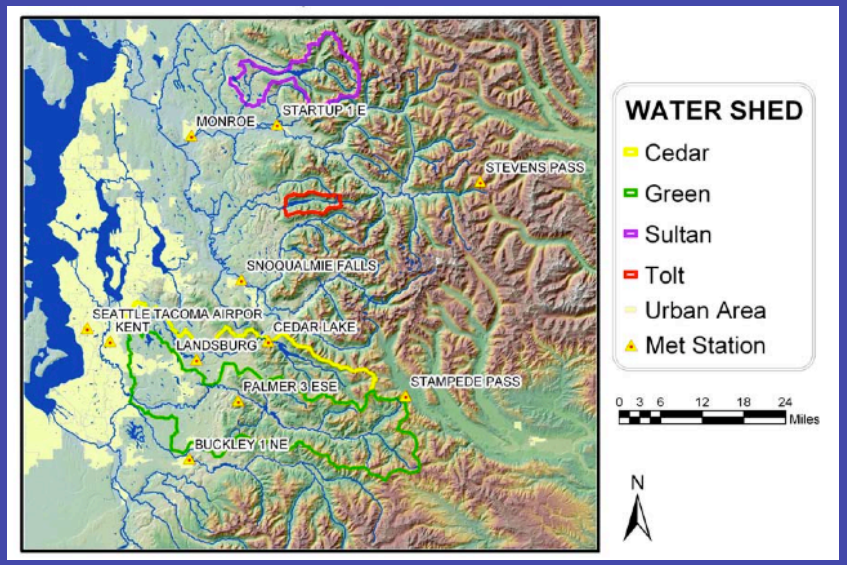
Naches River Basin



Rain Dominant Basins: no significant change from warming alone

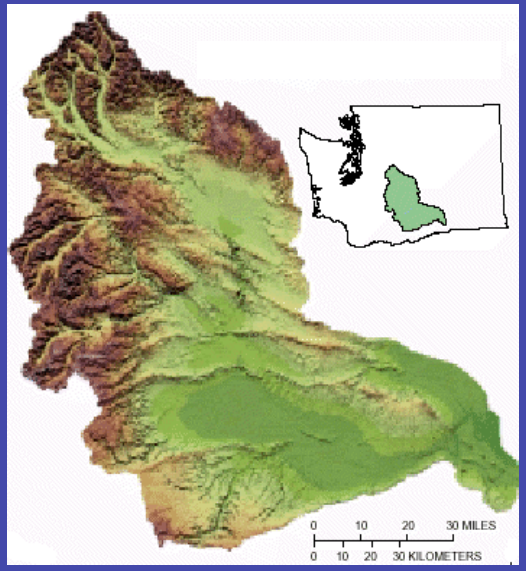
Mixed Rain and Snow Basins: more precipitation falls as rain instead of snow, leading to an increase in flooding in winter even if precipitation remains the same

Snowmelt Dominant Basins: increased winter flow, earlier and reduced peak flow, lower summer flows



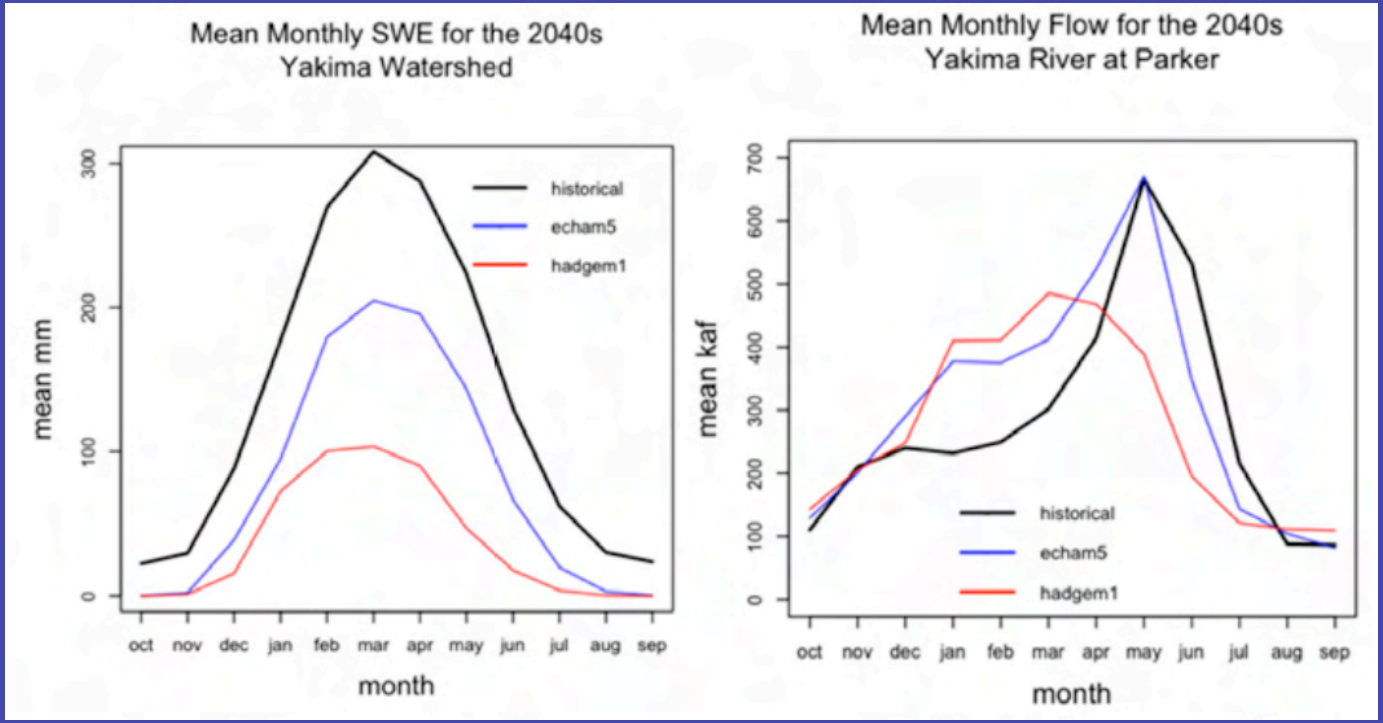
Puget Sound
(Seattle, Tacoma, Everett)

- Cedar System, ~80% Seattle's water supply
- Historically more snow dominated
- In 2020s and 2040s the ensemble of A1B scenario runs indicate that winter streamflows increase as basin shifts to rain-dominant basin



Yakima River Basin

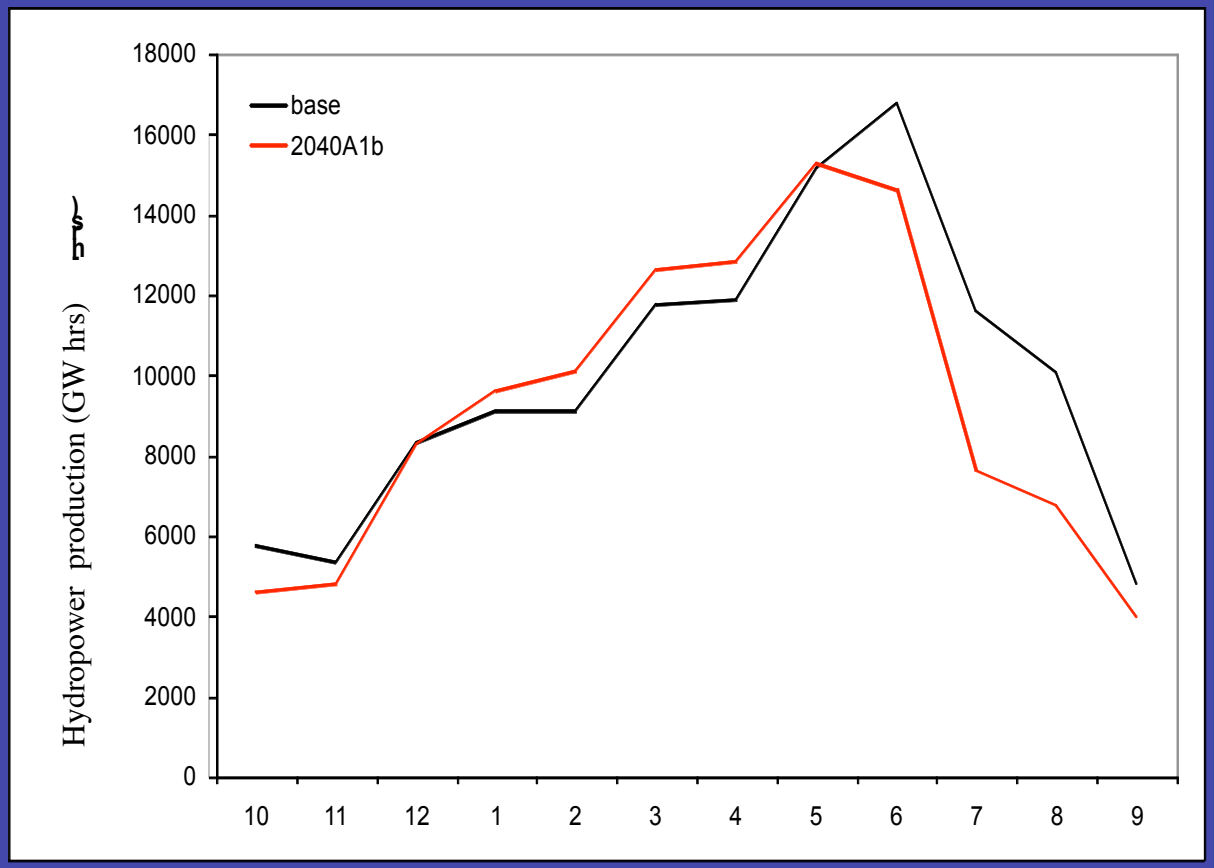
- Average annual SWE in the Yakima above Parker is projected to be 31-68% of historic levels by the 2040s for two “middle of the road” scenarios
- Winter streamflows increase as basin shifts to rain-dominant basin



** Preliminary results - subject to change**

Columbia River Basin

- System-wide energy production in 2040s using ColSim model
- Wintertime increases, summertime decreases



** Preliminary results - subject to change**

Generalizable trends

- Temperature change will effect water management even if precipitation does not change
- Basin characteristics indicate sensitivities to warming
- Changes in quantity and timing, specifically increases in wintertime flows and reduction summer flows
- Future climate will be substantially different than the past

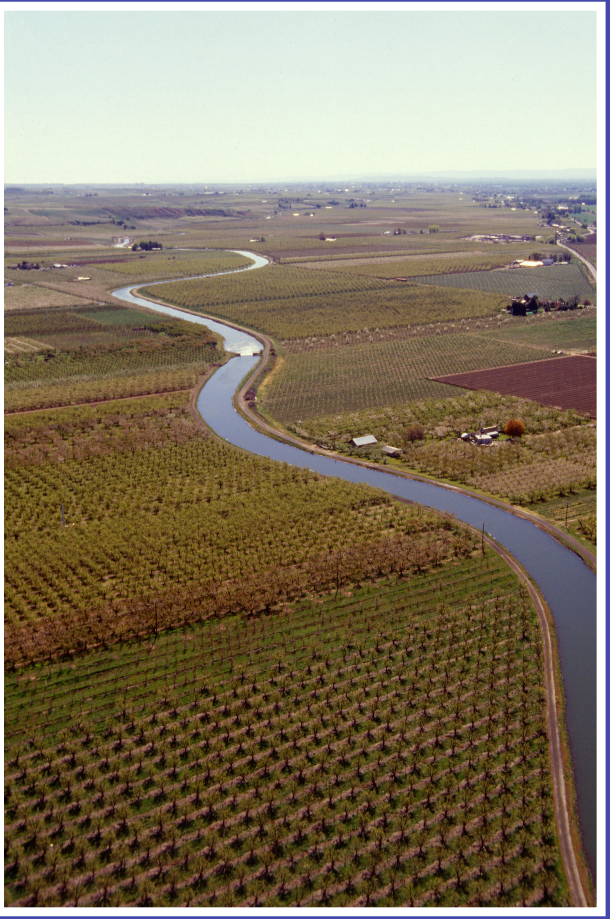
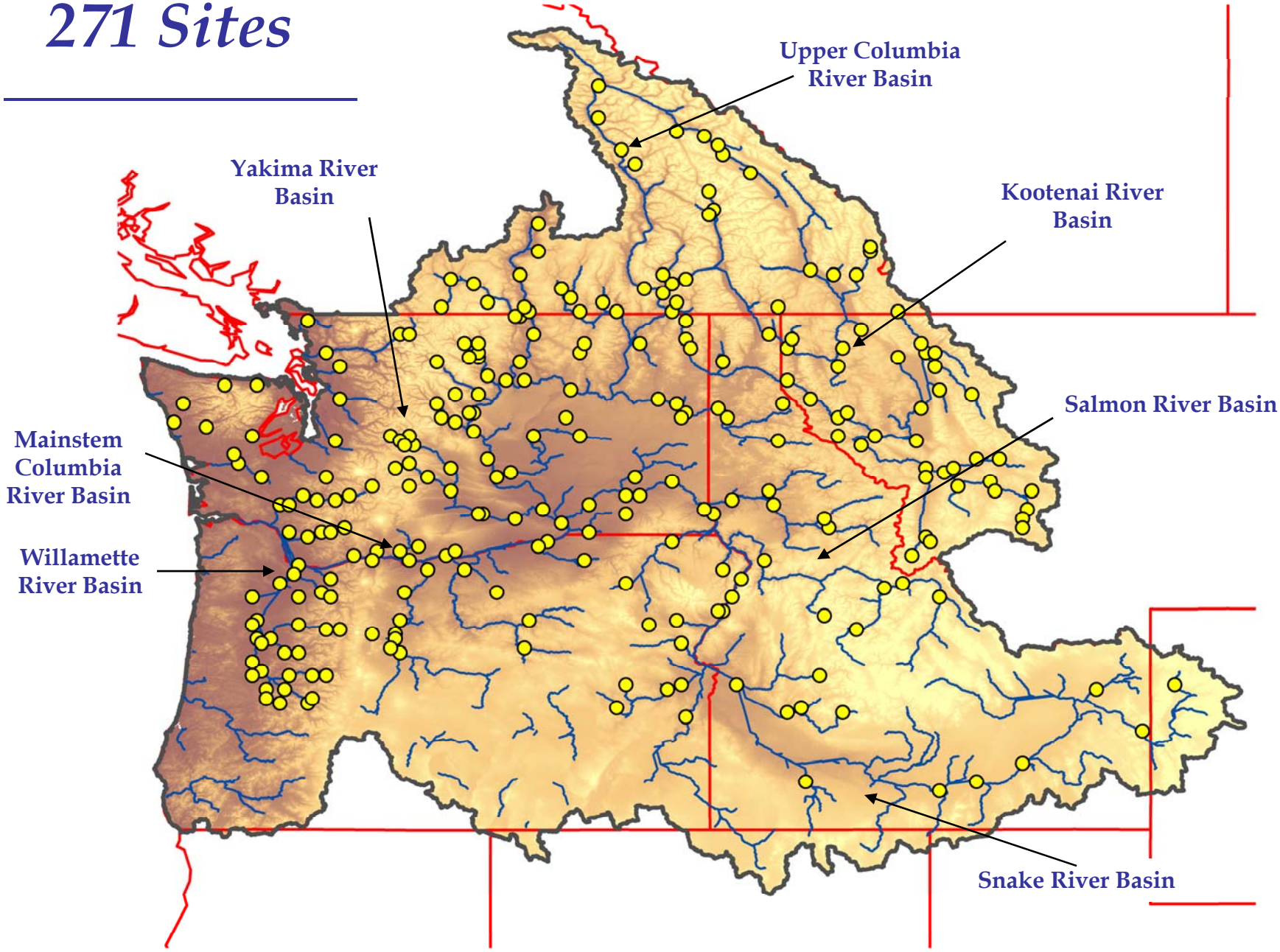


Photo courtesy of http://www.ars.usda.gov/is/graphics

Future directions

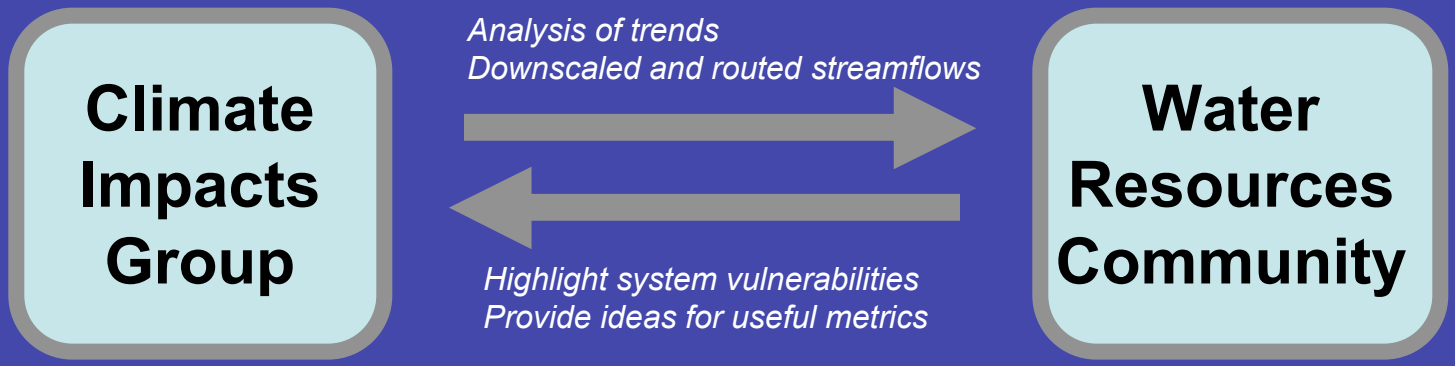
- Move beyond general trends to watershed specific information
- Use scenario based planning to evaluate options rather than the historic record
- Release final report - Winter 2009
- Convene workshop - February 12, 2009
- Provide access to climate change scenario data for specific watersheds

271 Sites


Upper Columbia River Basin
Yakima River Basin
Kootenai River Basin
Salmon River Basin
Mainstem Columbia River Basin
Willamette River Basin
Snake River Basin

Water Planning Concerns

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 and uncertainty? Adaptive responses and agreements



Thank you! And, stay tuned…

Workshop February 12, 2009
Report will be released Winter 2009

The Climate Impacts Group
www.cses.washington.ed/cig

Julie Vano
jvano@u.washington.edu