

# Climate, Hydrology, and River Temperature: *climate impacts in the Western U.S.*

Guillaume Mauger

Climate Impacts Group, UW Seattle

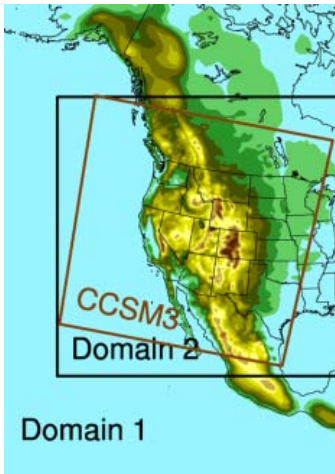
[gmauger@uw.edu](mailto:gmauger@uw.edu)



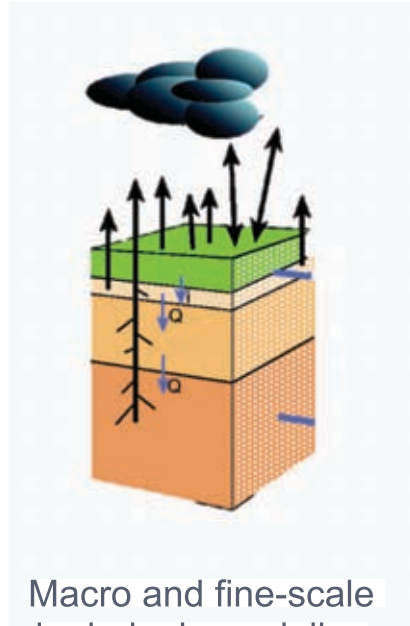


# The Climate Impacts Group

<http://www.climateimpacts.gov/>
<http://www.climateimpacts.gov/impacts/>
<http://www.climateimpacts.gov/impacts/impacts/>
<http://www.climateimpacts.gov/impacts/impacts/impacts/>



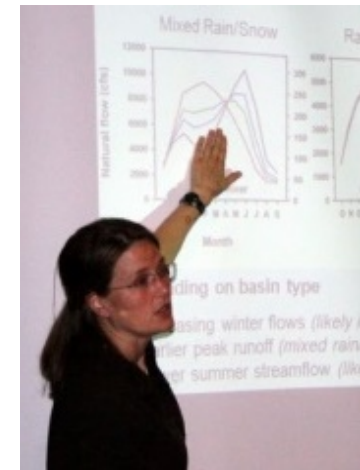
Downscaling global climate models



Macro and fine-scale hydrologic modeling



Impacts assessments



Adaptation planning and outreach

## Working since 1995 with a focus on:

- U.S. Pacific Northwest, Western U.S., Pacific Rim
- Water, forests, fish, coasts, energy, human health, urban areas
- Stakeholders: Private, public & non-governmental actors involved in climate-sensitive policymaking, planning and decision making

???? ?i?y? ?C??? ?y???e?C?? ??C?it C?d?  
 ???? ?i???? ????i/??/?/?/?/? ?/i?c??? n?n?



? ? ???? ??

- ?e? a M Rrea C?m? C?te? M? tC?
- ? o?ro?, R??  
 ????nt?? ?t? ?tC.M M?P? emC?
- ?sa a ? W?

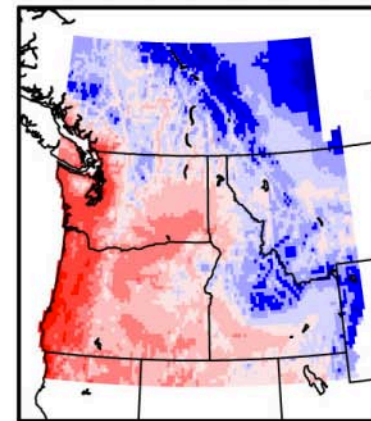
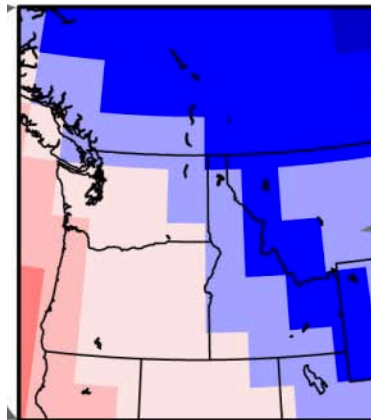
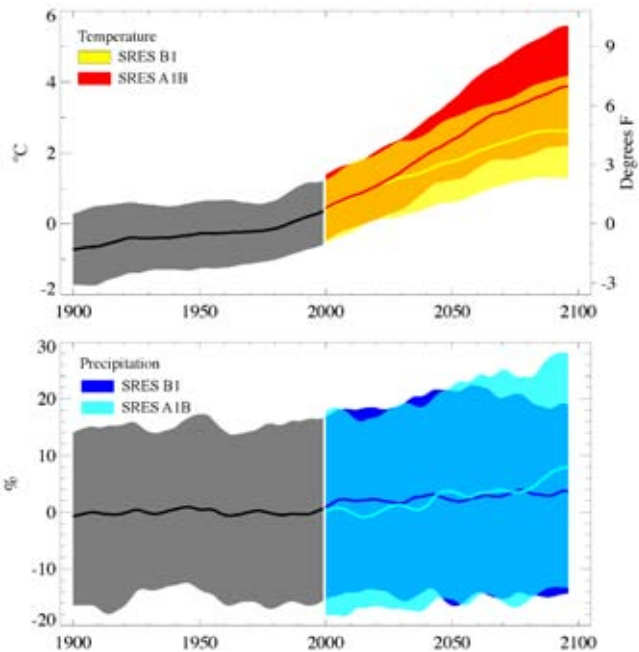


Roadmap: from scenarios to impacts

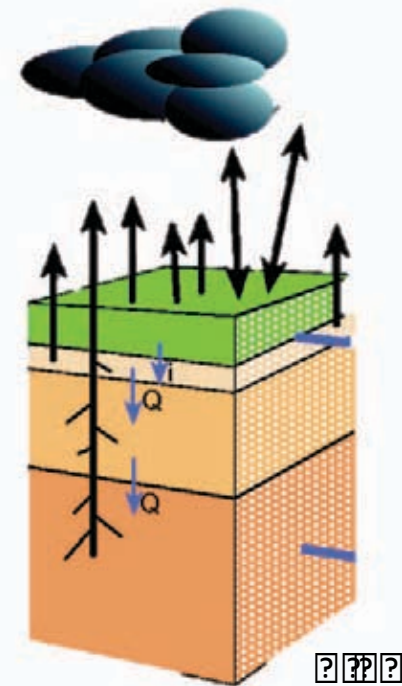
## ***GOAL:***

- Relevant climate variables
- Appropriate spatial scales
- Characterize uncertainties

# Regional Climate Model



Downscaling

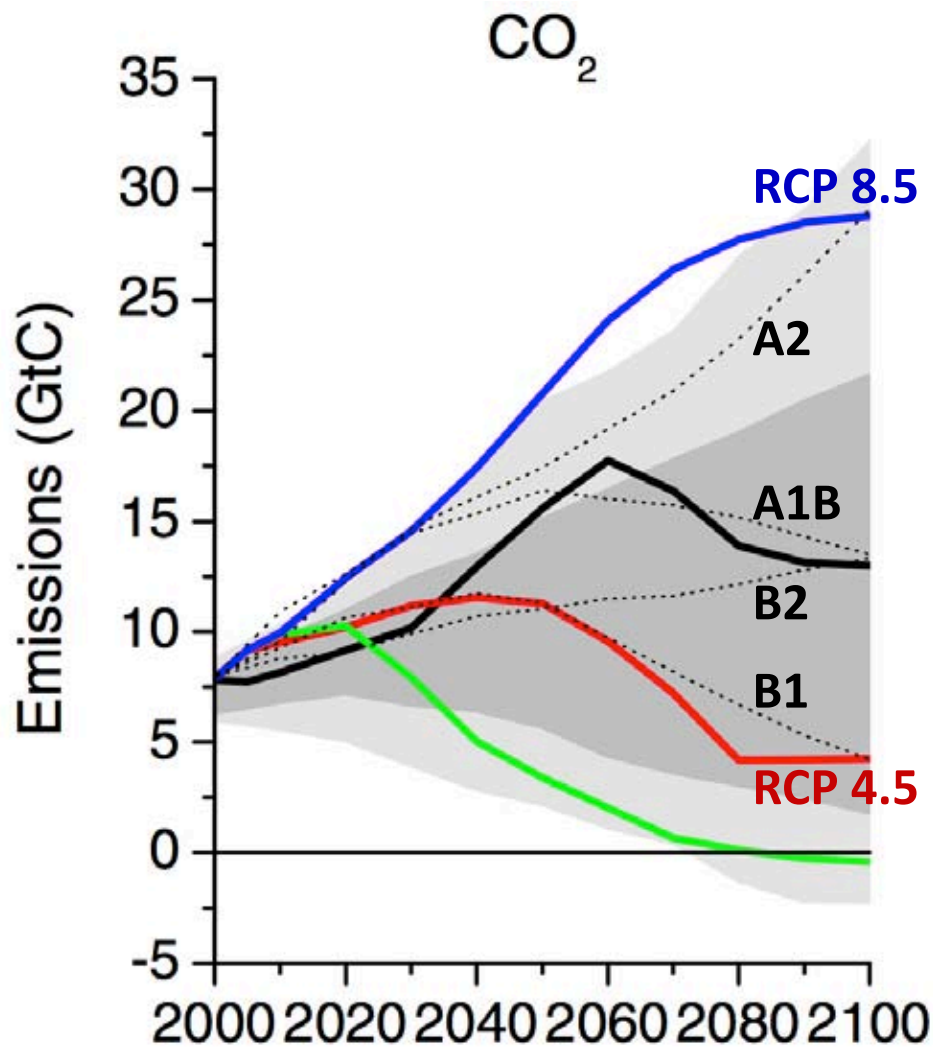


Global climate model  
 output  
 Regional climate model

Global climate model  
 output  
 Regional climate model

Global climate model  
 output  
 Regional climate model

# Greenhouse gas Emissions Scenarios

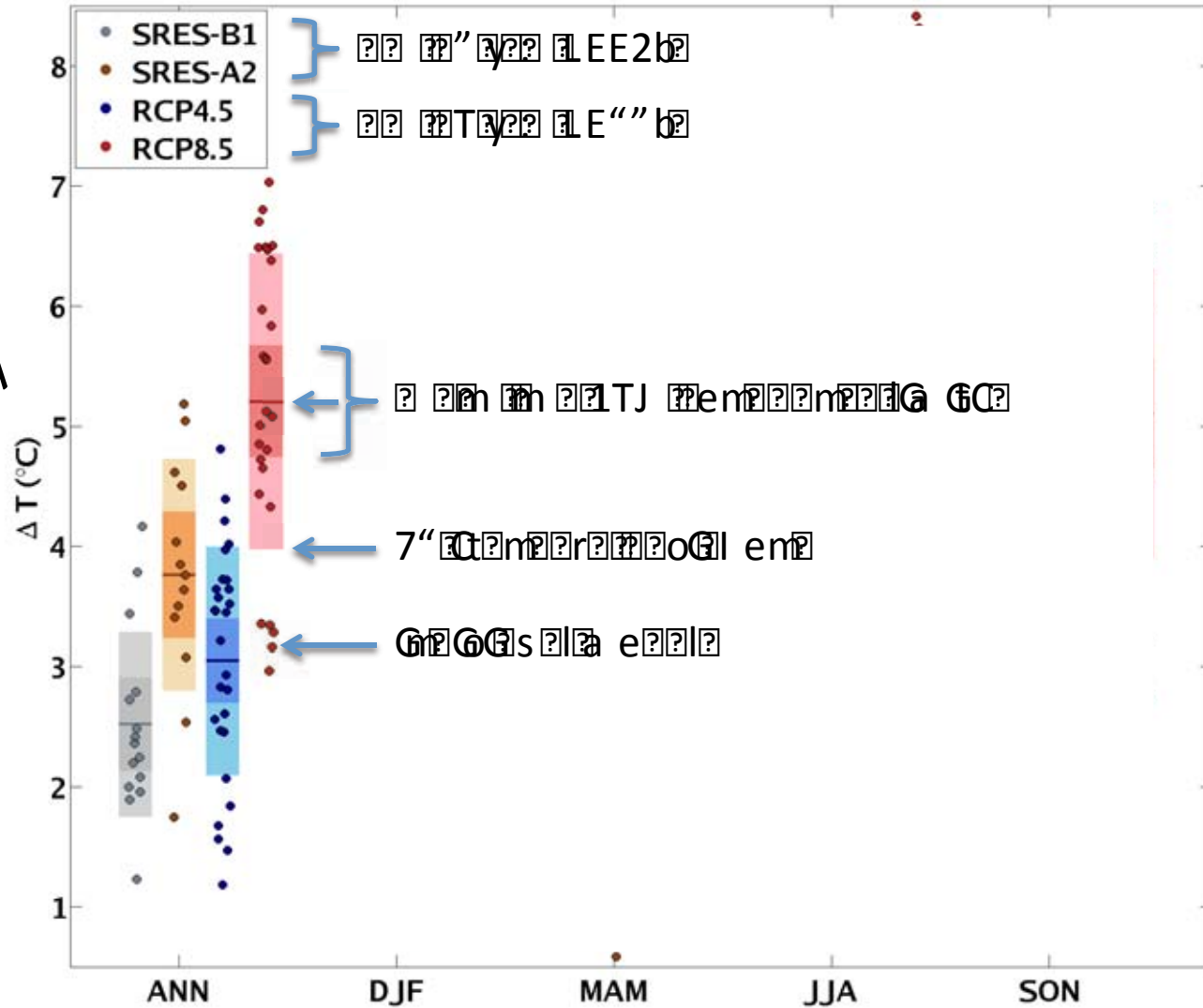


*“What if”  
scenarios of  
future emissions*

# Climate Change Impacts on the Environment

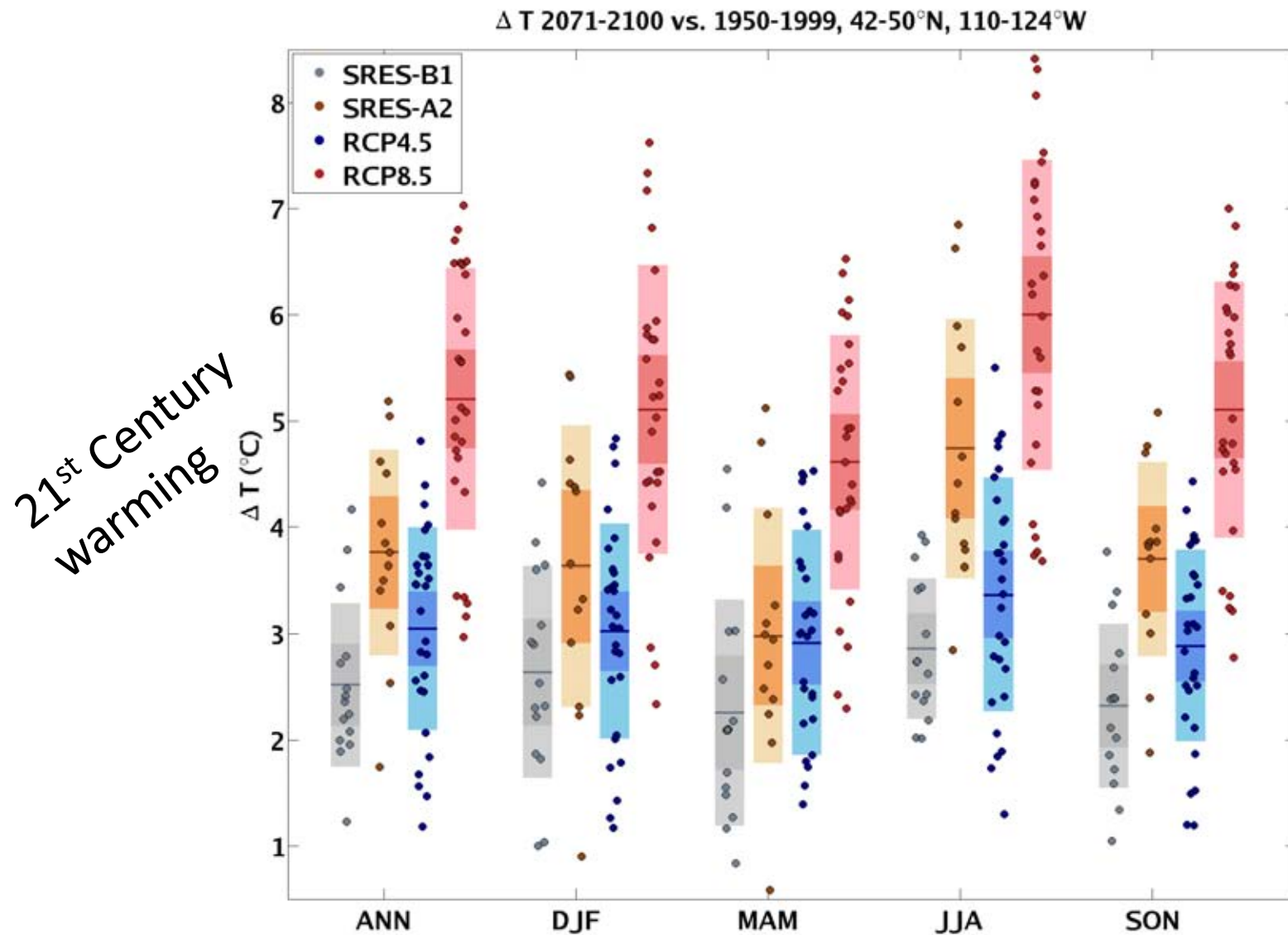
$\Delta T$  2071-2100 vs. 1950-1999, 42-50°N, 110-124°W

21<sup>st</sup> Century warming



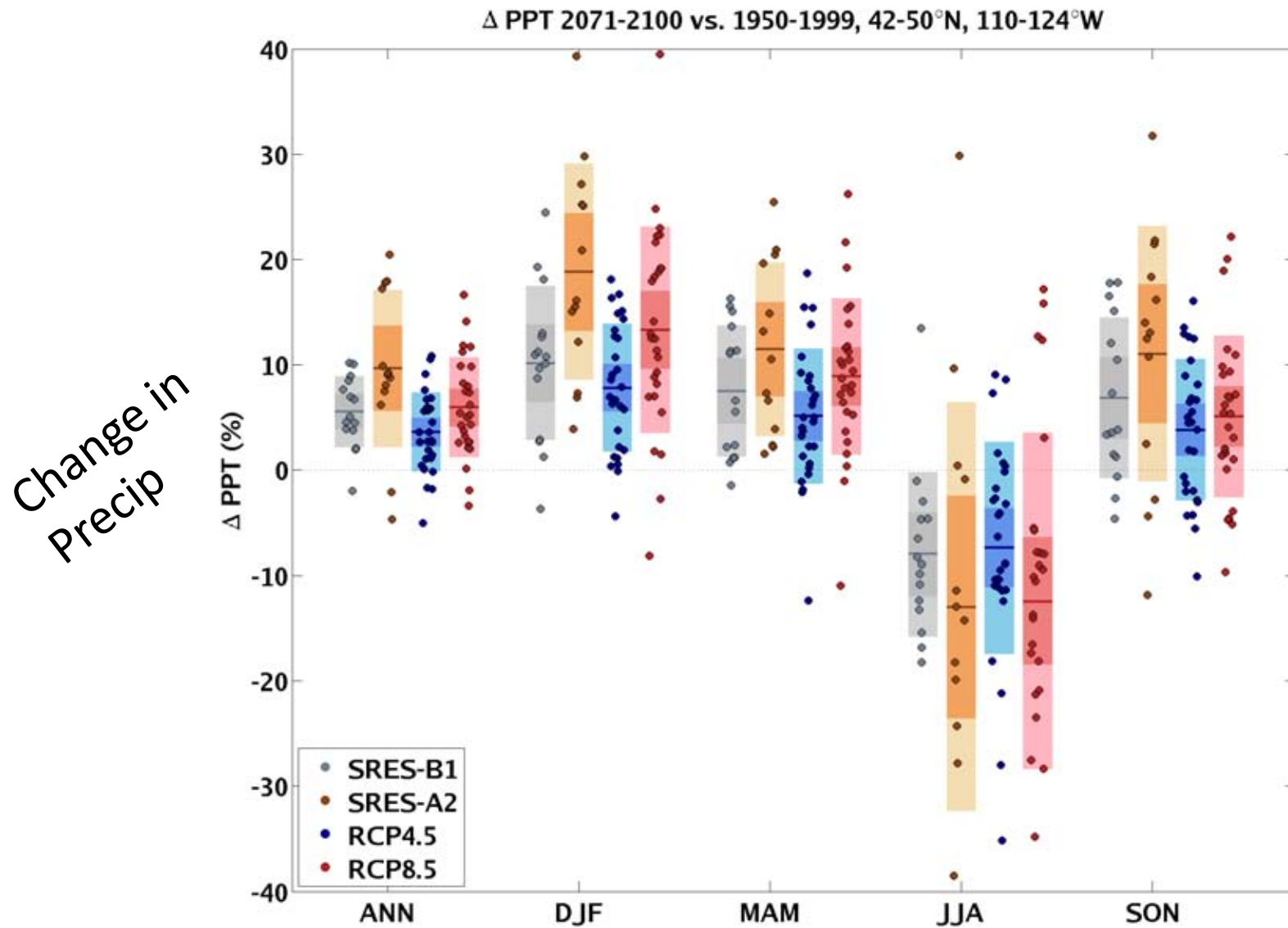


# Climate Model Projections



Source: John Abatzoglou

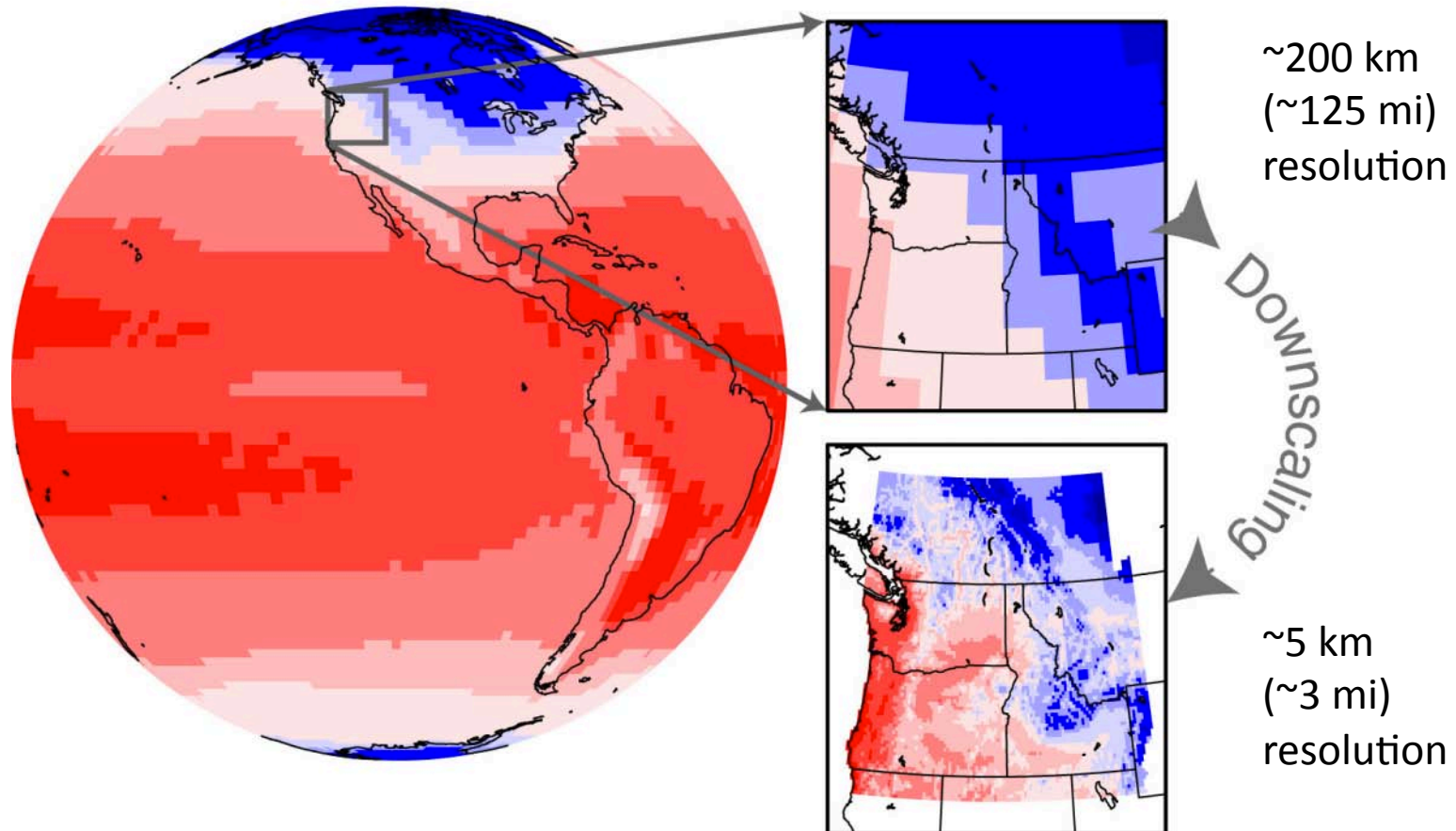
# Climate Model Projections



Source: John Abatzoglou

# Downscaling: Relates “large” to “small”

Global Climate Model Air Temperature

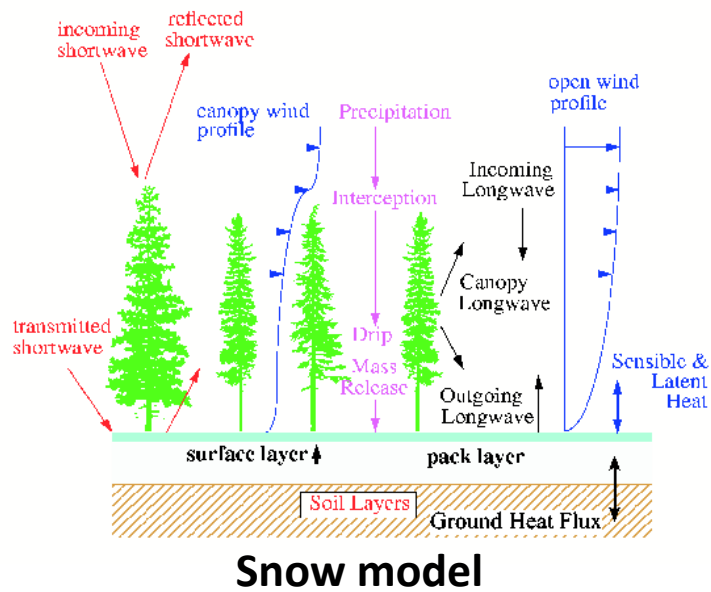


*Two approaches: Dynamical, Statistical*

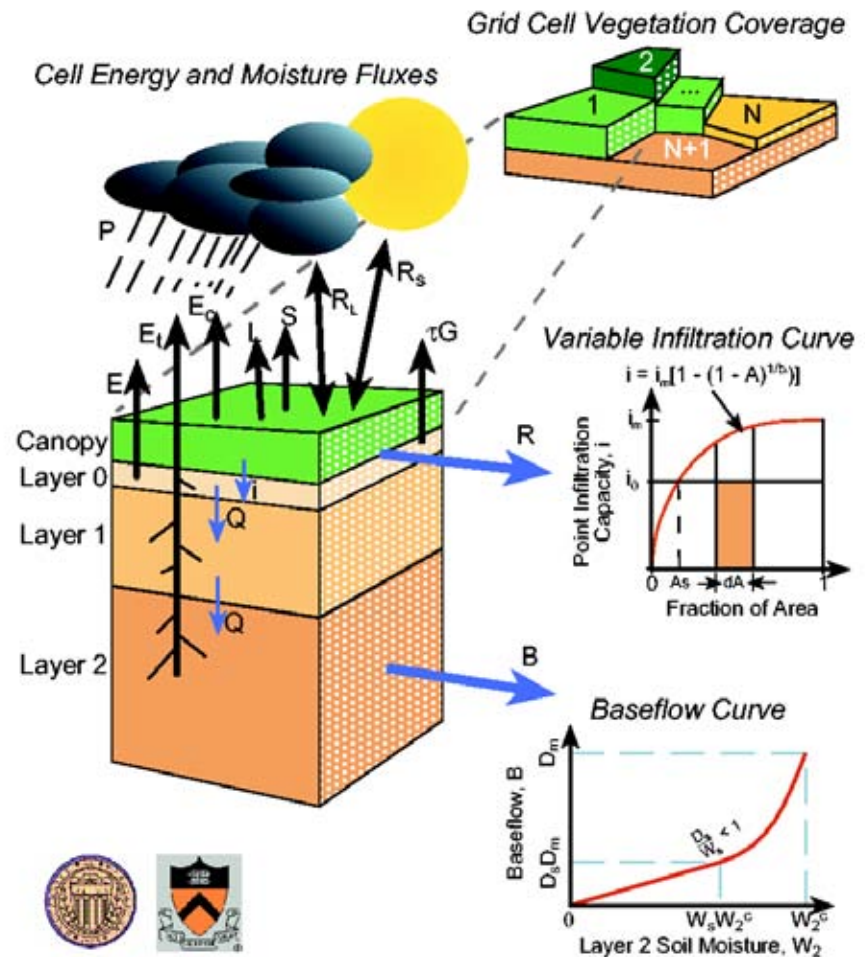
Figure source: Eric Salathé

# Hydrologic Modeling

*Translation from climate to water impacts*



## Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model



# Recent CIG impacts datasets

# Recent CIIG impacts datasets:

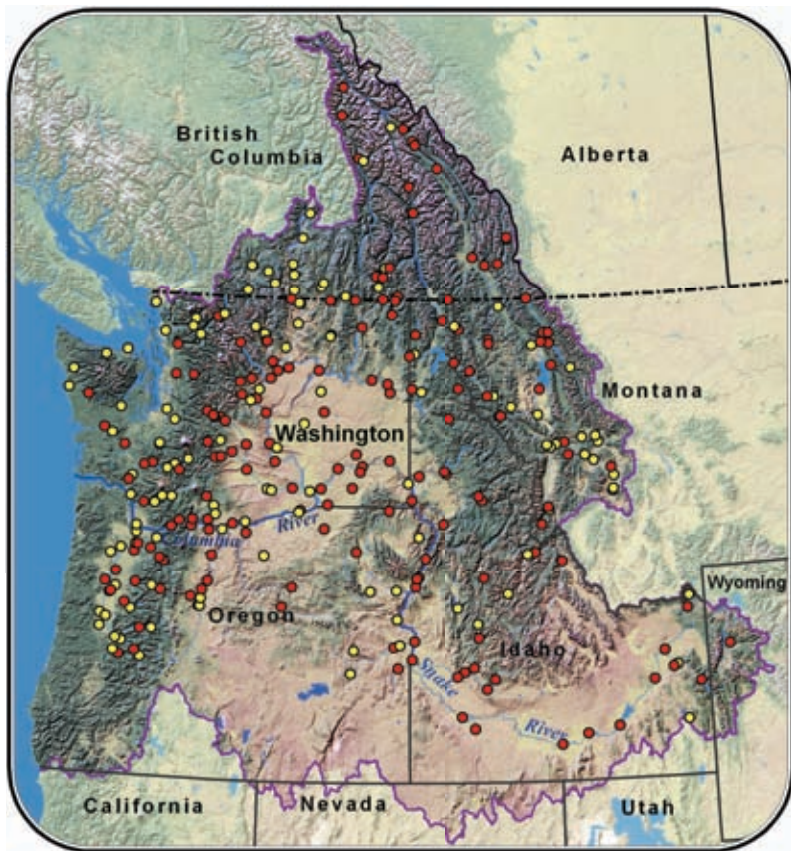
*CIIG has recently developed future climate and hydrologic projections for these regions:*

- 1. Pacific Northwest** ◦
- 2. Western U.S.** ◦
- 3. North Pacific Rim** ◦



# Watersheds of the Pacific Northwest

Watersheds of the Pacific Northwest  
with a focus on the Pacific Northwest



## Watersheds

Watersheds are defined by topography and are the primary units of water management. Watersheds are defined by topography and are the primary units of water management.

Watersheds are defined by topography and are the primary units of water management.

## Watershed Management

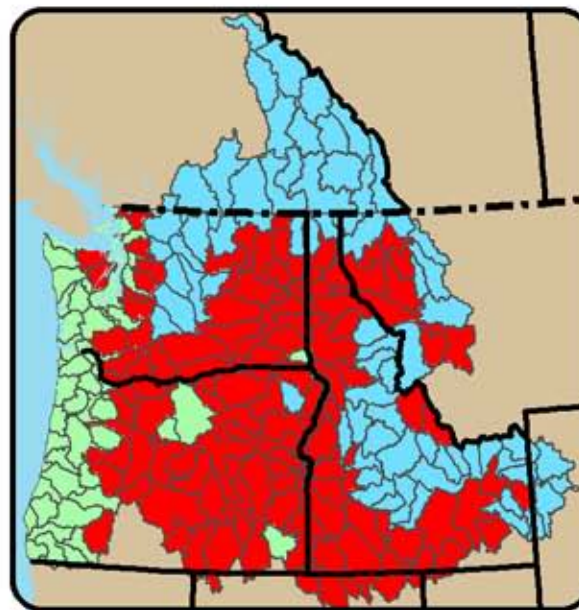
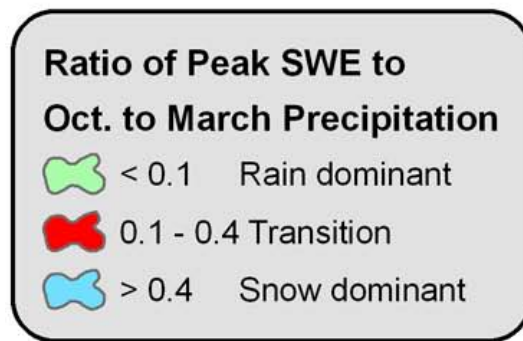
Watershed management is the process of managing the land and water resources within a watershed to protect and improve the quality of the water resources. Watershed management is the process of managing the land and water resources within a watershed to protect and improve the quality of the water resources.

Watershed management is the process of managing the land and water resources within a watershed to protect and improve the quality of the water resources.

[Watershed Management](#)

# Example gridded product:

## *Transformation From Snow to Rain dominant*



**Historical**



**2080s A1b\***

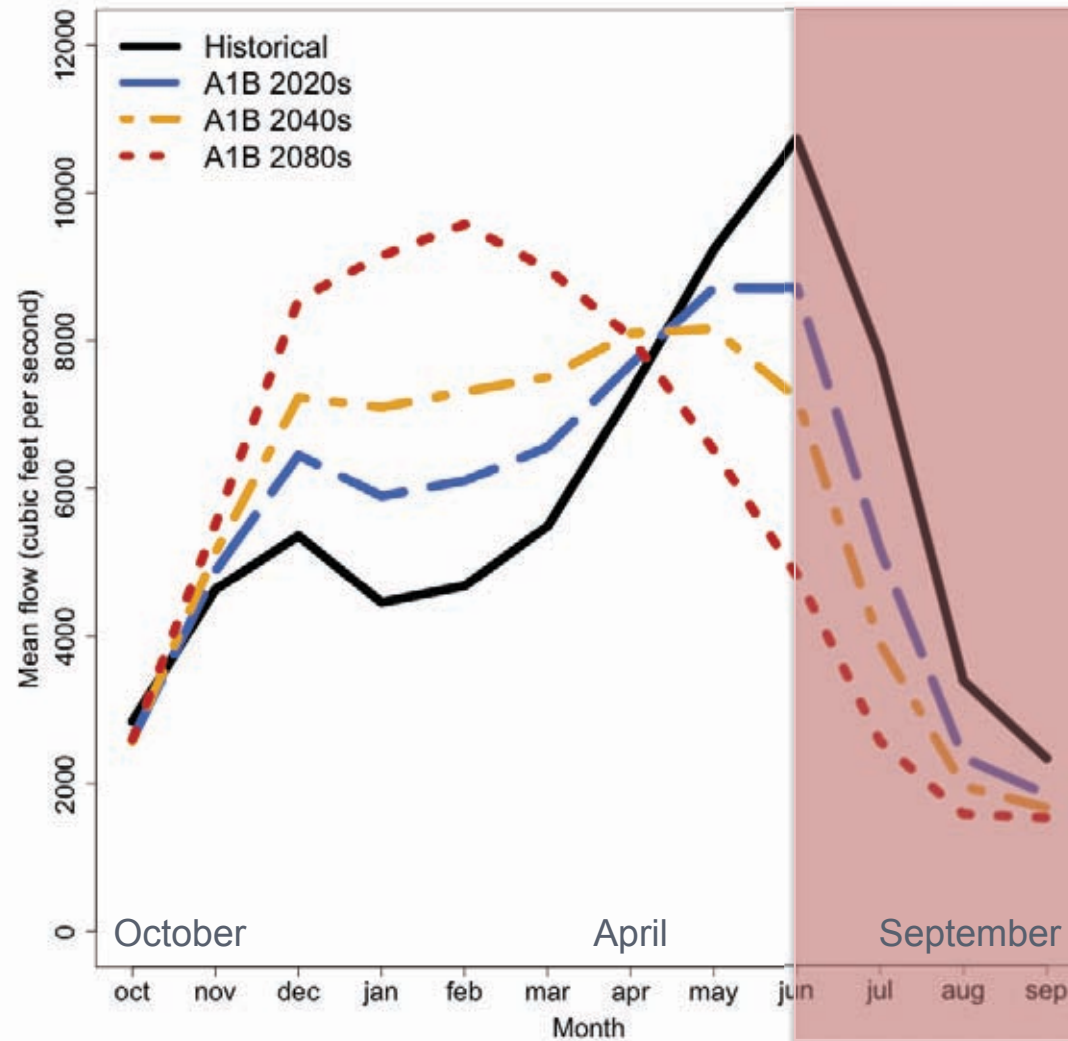
*\*Based on Composite Delta Method downscaling  
(multimodel average change in T & P)*

Map: Rob Norheim





# Shifting Streamflows – Yakima Basin



Water needed for:

- irrigation,
- instream flows,
- fall hydro-production

U a M e C G v C M P C M e s t C R

The screenshot shows a web browser window with the URL `warm.atmos.washington.edu/2860/products/sites/?site=6021`. The page title is "Climate Impacts Group - Site Specific Data - 6021". The main content area is titled "Site Specific Data" and includes a navigation menu on the left with options like "Join Project's Listserve", "Project Home", "Introduction for New Users", "Project Report", "Citations and Contacts", "Project Updates", "Climate Scenarios", "Site-specific Data", "Primary Data", and "Reservoir Model Input Data". The main content area features a "Research Site Data Spreadsheet" link, a "Site:" dropdown menu set to "SKAGIT RIVER NEAR MOUNT VERNON", and a section titled "SKAGIT RIVER NEAR MOUNT VERNON" with "Site Info: SKAMO (6021)". The site info includes USGS Id: 12200500, Latitude (DMS): 48 26 42, Longitude (DMS): 122 20 03, Latitude (Decimal): 48.445, Longitude (Decimal): -122.3342, Area: 3093 miles<sup>2</sup>, and Nash Sutcliffe Efficiency = N/A. A map on the right shows the location of the site in the Skagit River basin, spanning the border between British Columbia and Washington. A "General FTP directory" link is provided at the bottom.

Climate Impacts Group - Site Specific Data - 6021

warm.atmos.washington.edu/2860/products/sites/?site=6021

**CLIMATE IMPACTS GROUP**

## Site Specific Data

Use the pull-down menu or map links to access data and summary figures for individual streamflow locations.

[Research Site Data Spreadsheet](#)


Site: SKAGIT RIVER NEAR MOUNT VERNON

### SKAGIT RIVER NEAR MOUNT VERNON

Site Info: SKAMO (6021)

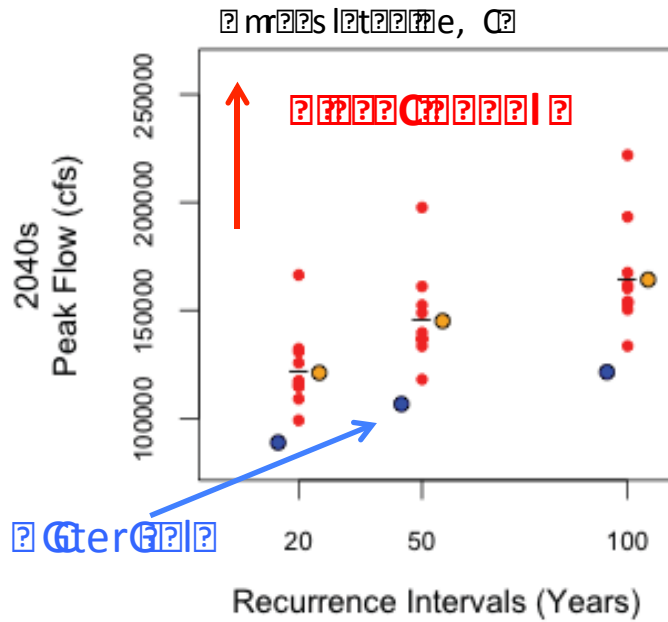
USGS Id: [12200500](#)  
Latitude (DMS): 48 26 42  
Longitude (DMS): 122 20 03  
Latitude (Decimal): 48.445  
Longitude (Decimal): -122.3342  
Area: 3093 miles<sup>2</sup>  
Nash Sutcliffe Efficiency = N/A

[General FTP directory](#)



[c MOO a :?ta eC, C G?tem??s O.OVE??](#)

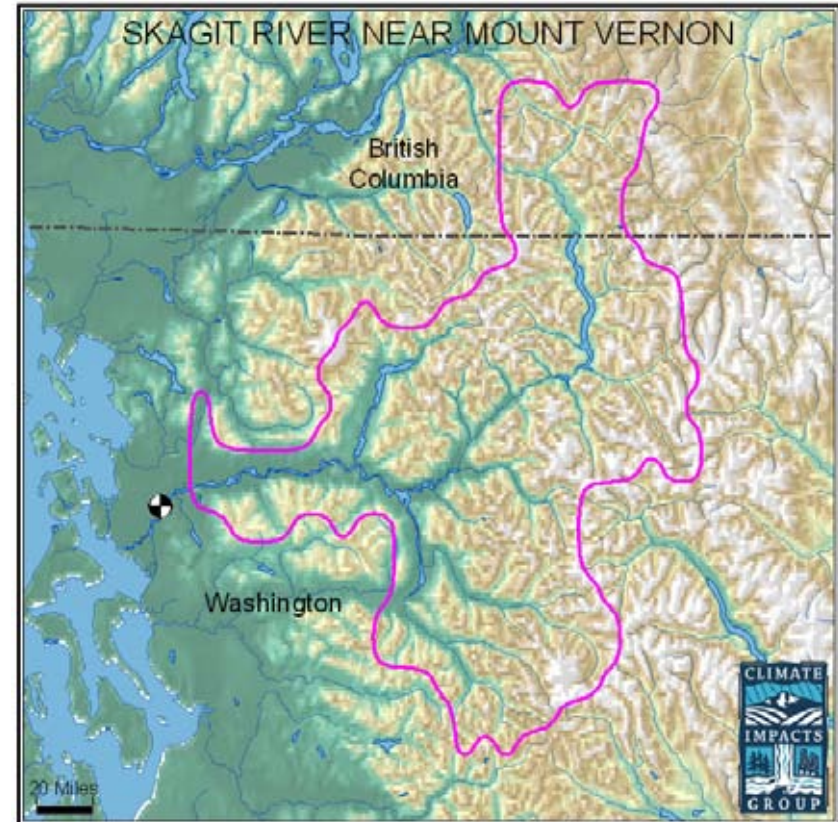
# Projecting Changing Flood Risk



Not enough reservoir space to eliminate this risk

By the 2040s:

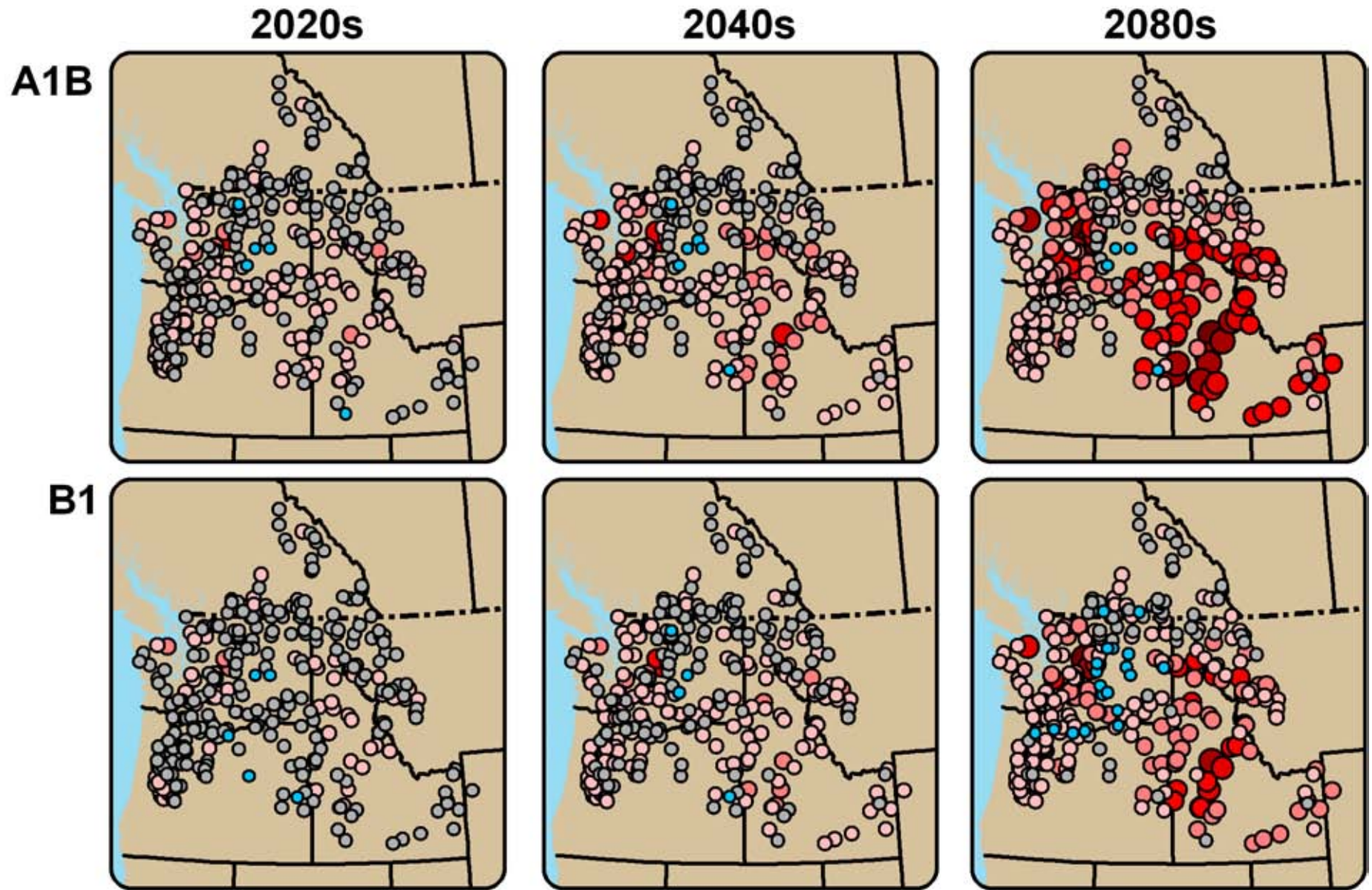
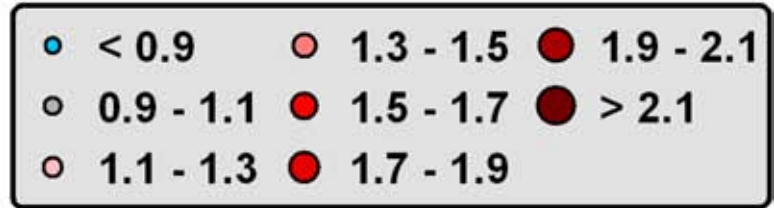
- the historical 100-year event becomes a 22-year event
- the historical 30-year event becomes an 7-year event



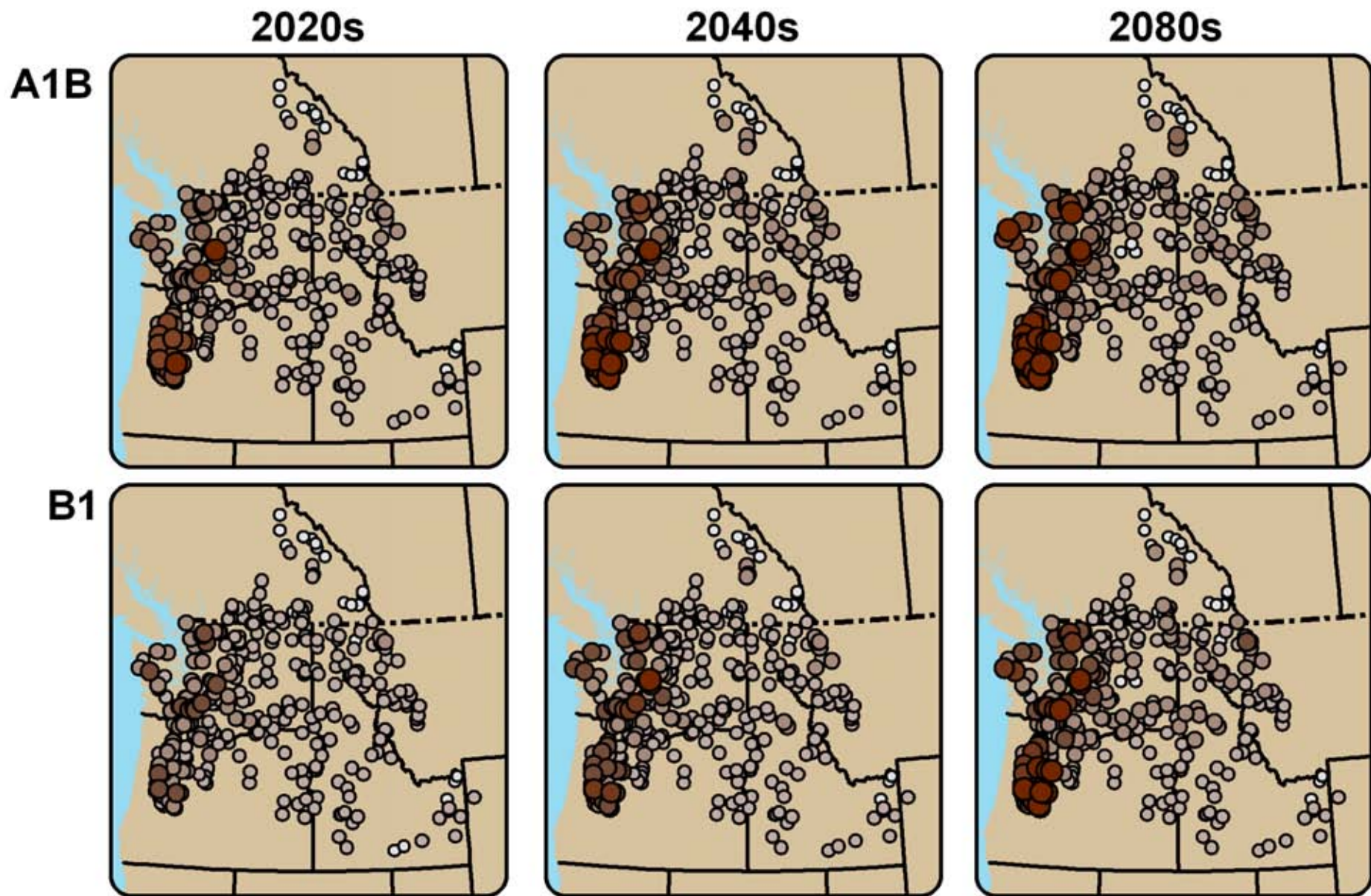
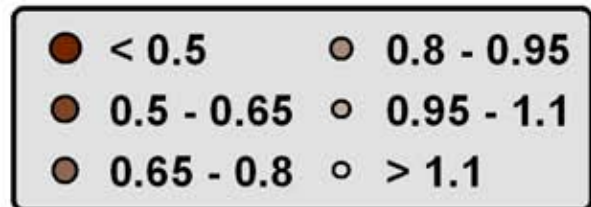
Skagit River at Mt Vernon

# Ratio of 100-year Flood Statistics

(21st Century ÷ 20th Century)



# Ratio of Low Flow (7Q10) Statistics (21st Century ÷ 20th Century)



U.S. Climate Change: A

North American Perspective

Source: U.S. Environmental Protection Agency

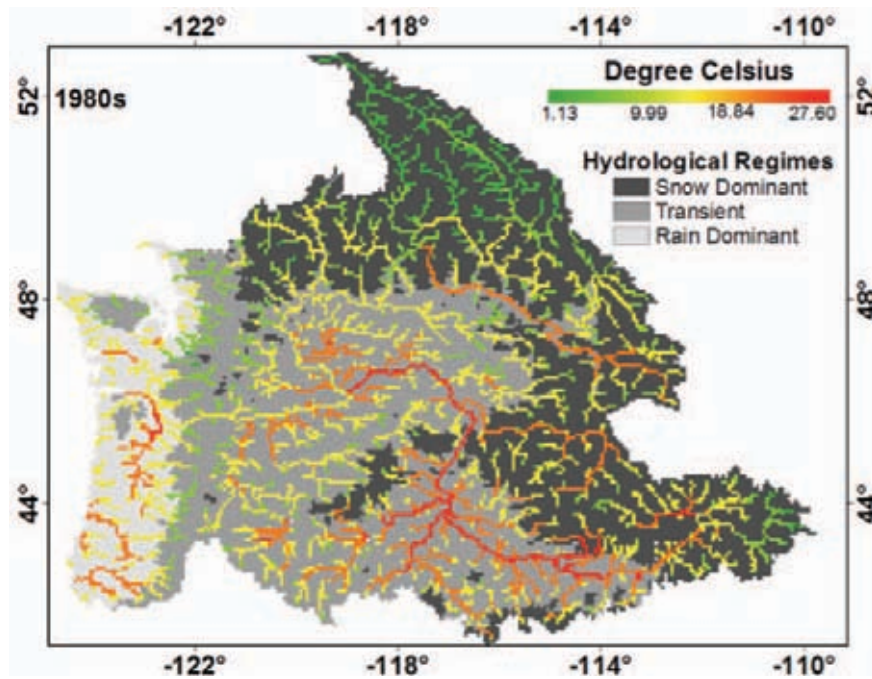


Figure 1: Hydrological Regimes in the 1980s

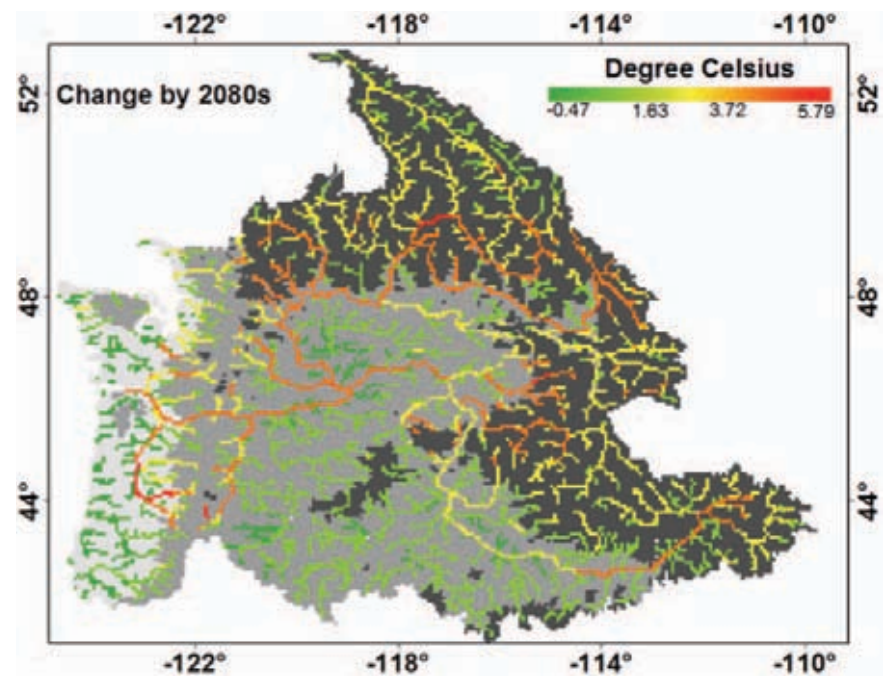
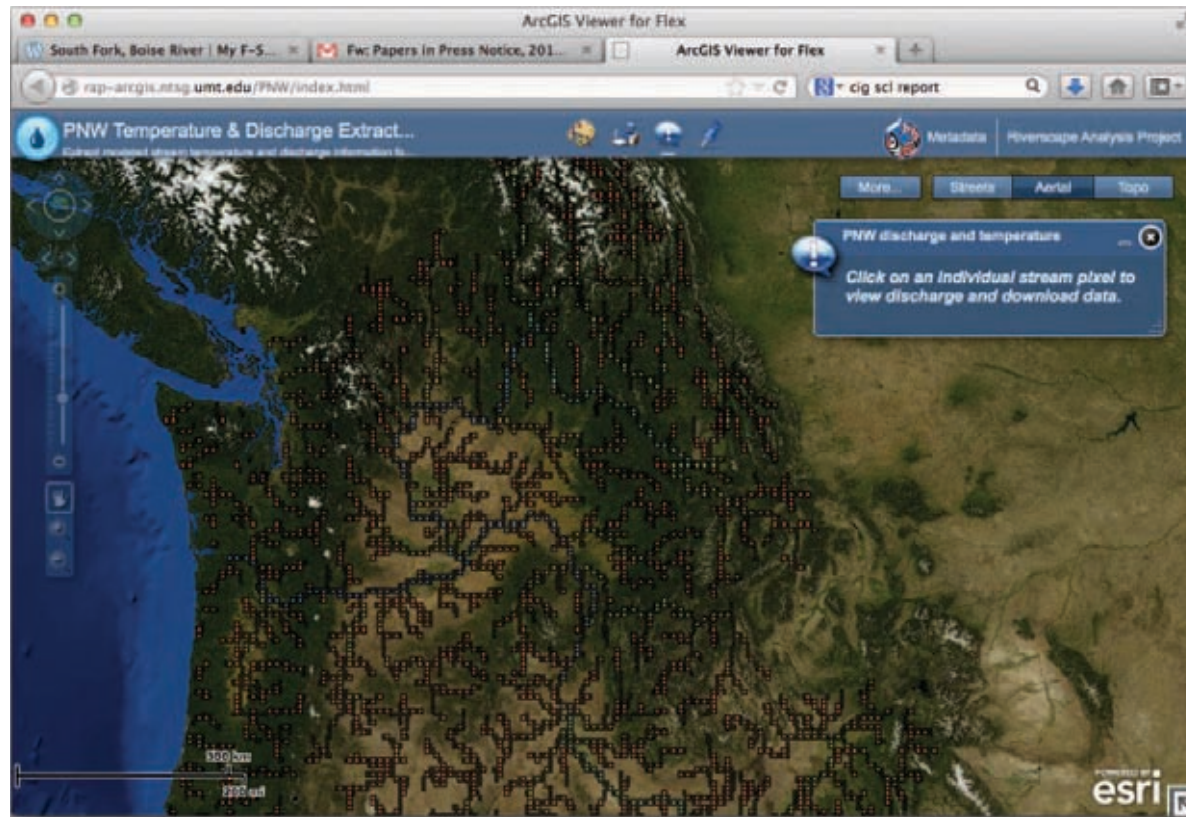


Figure 2: Projected Changes in Hydrological Regimes by the 2080s

U.S. Environmental Protection Agency (EPA) Water Quality Criteria

Water Quality Criteria for the Protection of Aquatic Life

See also: EPA Water Quality Criteria for the Protection of Aquatic Life



For more information, see the [EPA website](http://www.epa.gov/waterquality/criteria) at <http://www.epa.gov/waterquality/criteria>

# Western U.S. dataset



[http://ces.washington.edu/data/wus\\_csc.shtml](http://ces.washington.edu/data/wus_csc.shtml)

**Purpose:**

*Simplified set of projections for full Western U.S. domain*

**Resolution:** 1/16<sup>th</sup> degree (~7 km)

**Future Scenarios:** 12

A1b emissions scenario,  
Statistical & dynamical downscaling,  
Average + bracketing model projections,  
2 time periods & time-evolving runs

**Summaries for:**

Bailey Ecoregions,  
Omernik III Ecoregions  
HUC6 (12-digit) basins



# Example: Snow Water Equivalent (SWE)

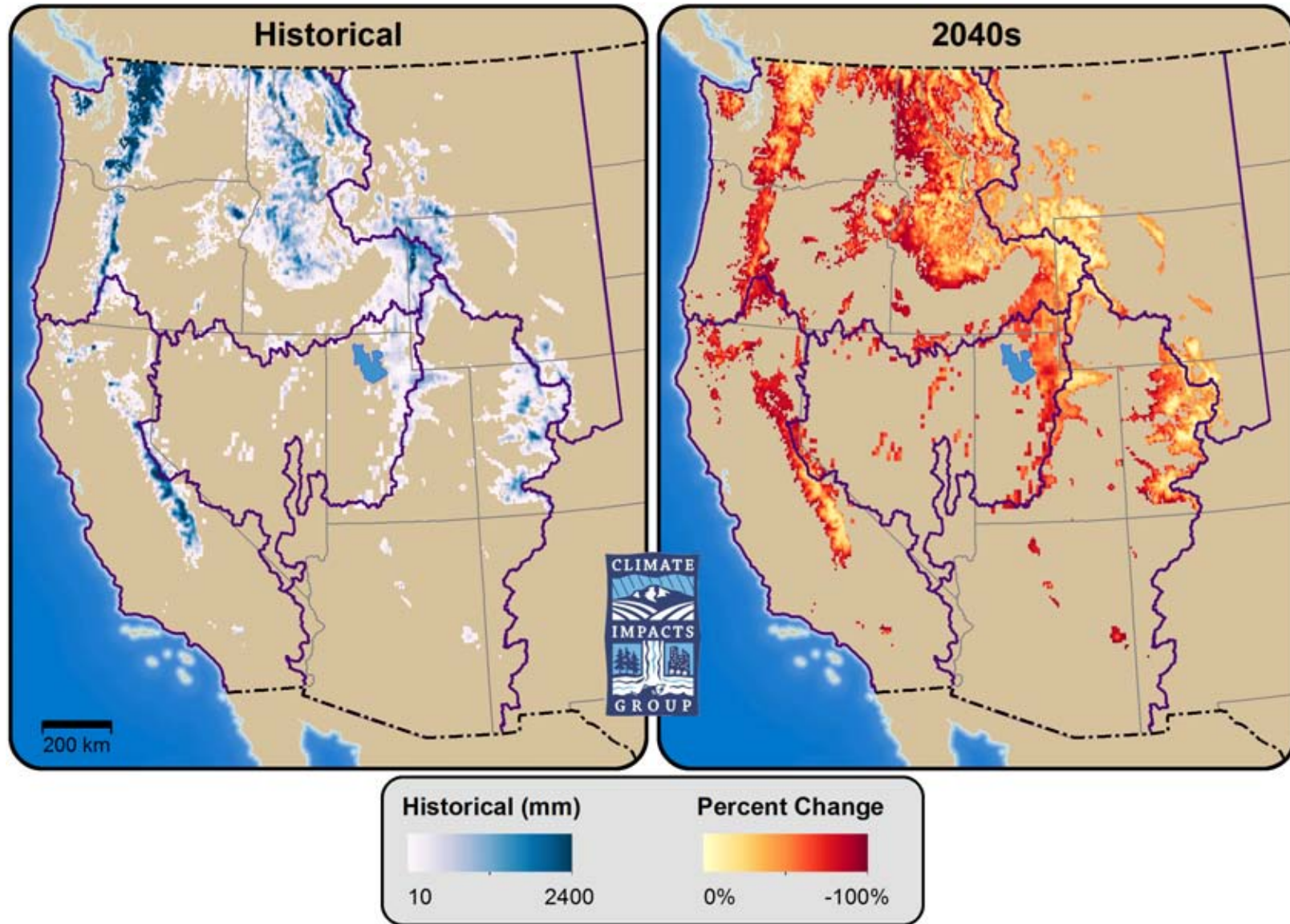
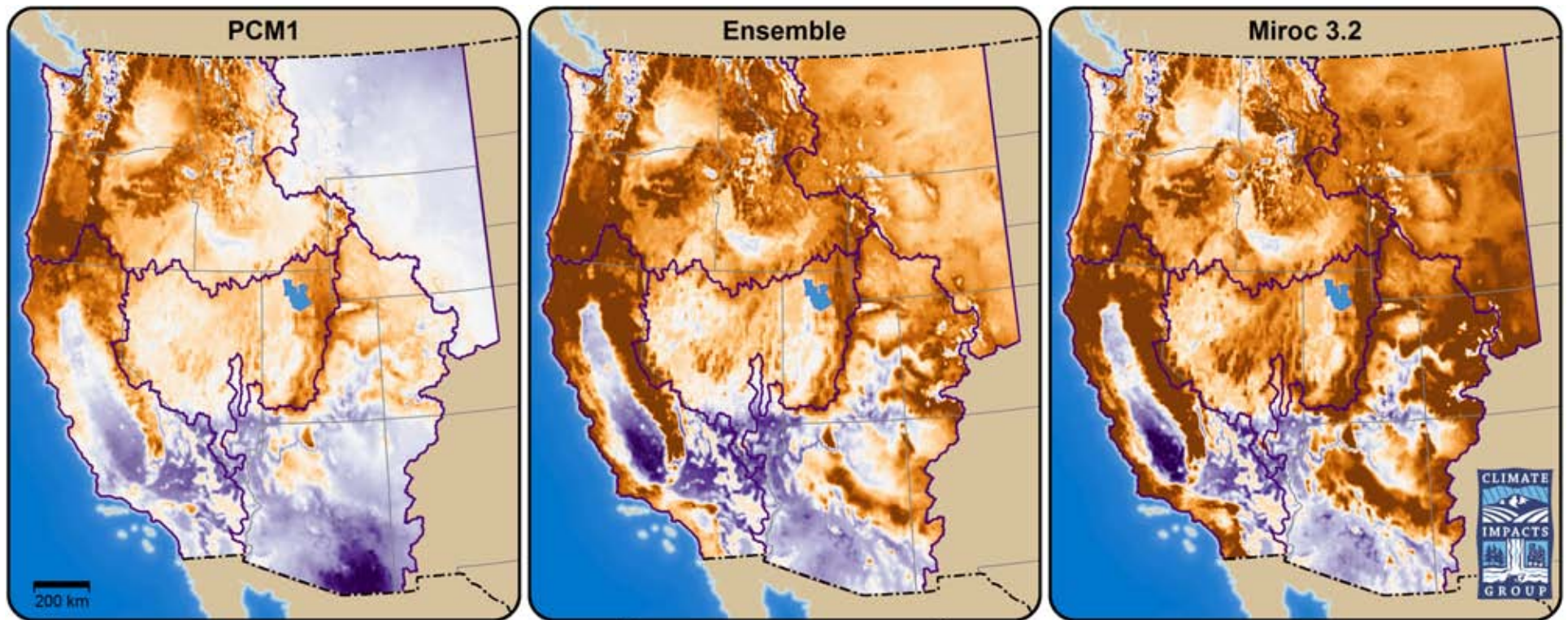


Figure source: Rob Norheim

# Example: June-Aug Water Deficit

*Projected Change, 2040s A1b:  
average + bracketing models*

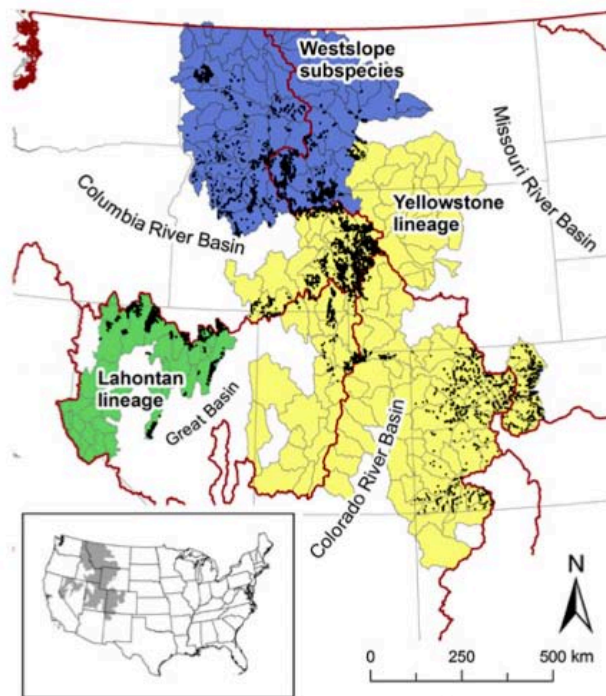


less warm

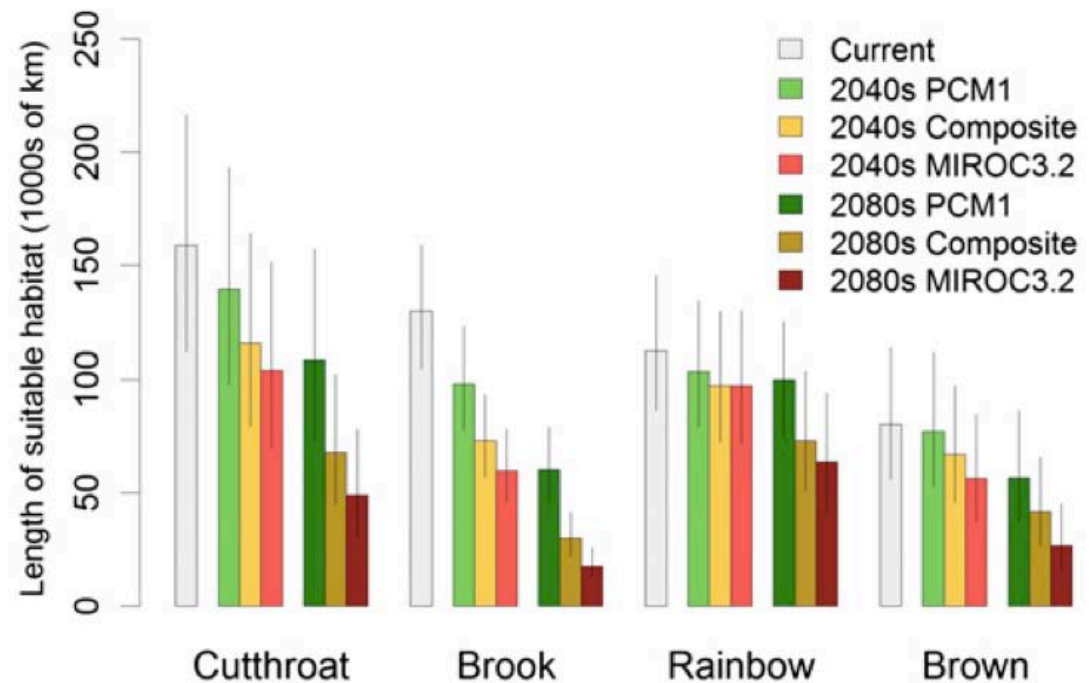
average

warmer

# Example use: Habitat suitability for trout

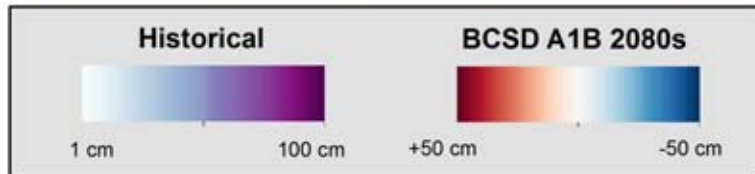
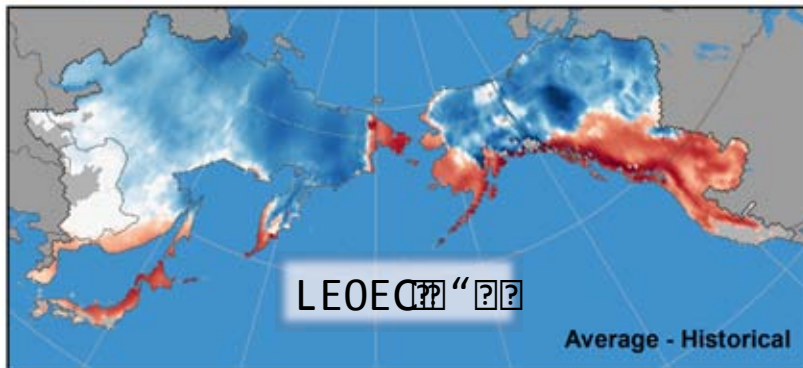
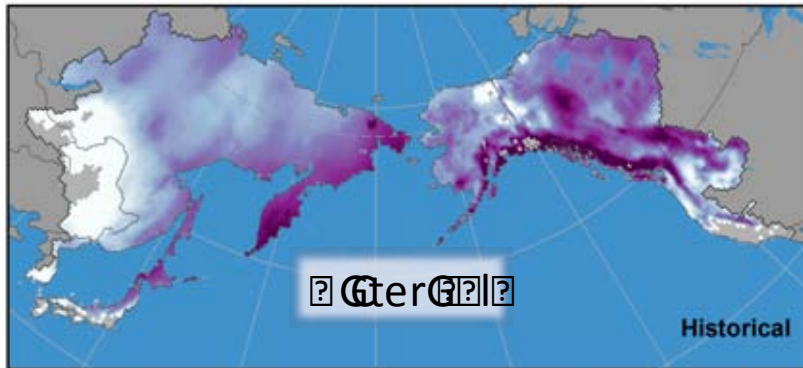


Stream length of suitable habitat



# ert 2000 2050 2100 2150 2200

2000 2050 2100 2150 2200



2000 2050 2100 2150 2200

2000 2050 2100 2150 2200

2000 2050 2100 2150 2200

2000 2050 2100 2150 2200

2000 2050 2100 2150 2200

# Summary

- Climate and hydrologic scenarios for:
  - PNW
  - Western U.S.
  - North Pacific Rim
- Available online for download in varying levels of simplicity / complexity
- Data form the basis for several existing impacts assessments

# Thanks!



[gmauger@uw.edu](mailto:gmauger@uw.edu)

[cig@uw.edu](mailto:cig@uw.edu)

Climate Impacts Group, UW Seattle