

Climate Change Impacts in the Pacific Northwest

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University of Washington



*Climate science in
the public interest*

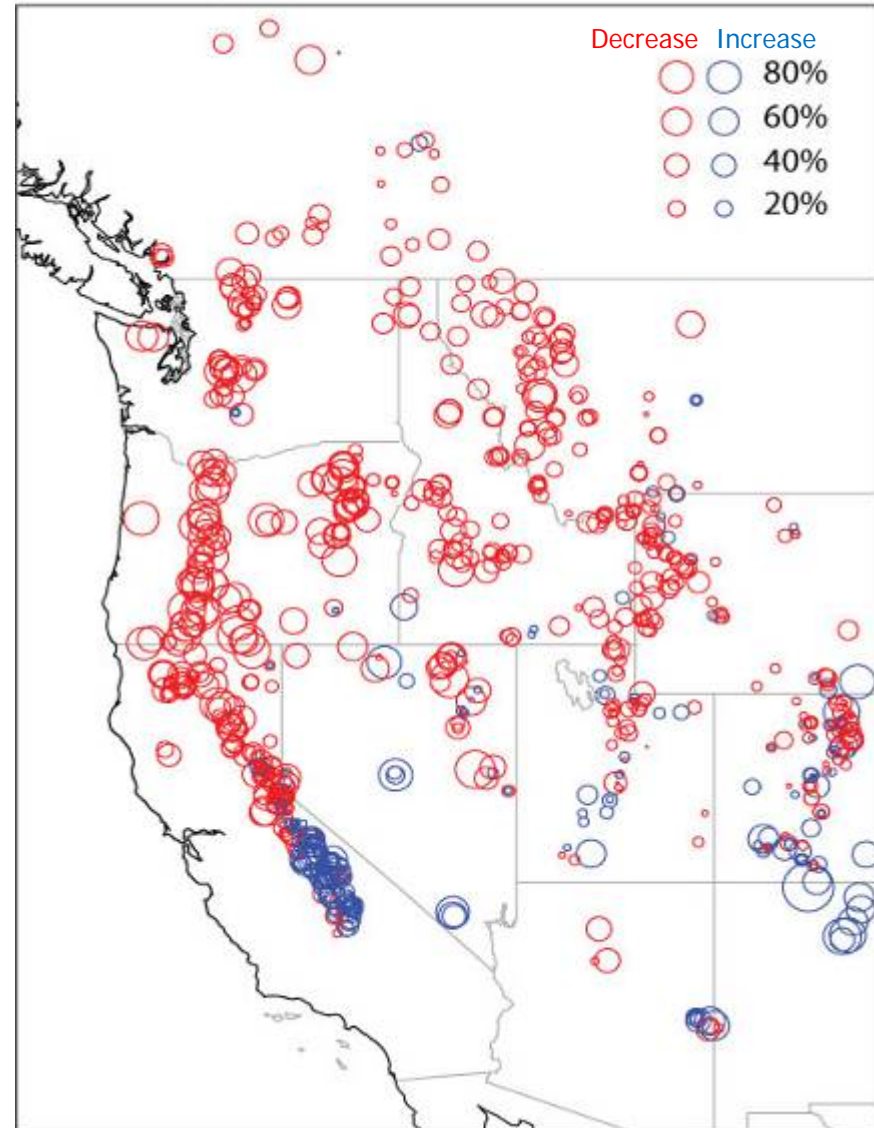
Key Trends in PNW Climate

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

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

Similar snowpack declines are seen throughout the western United States

a. April 1 SWE Observations 1950-1997



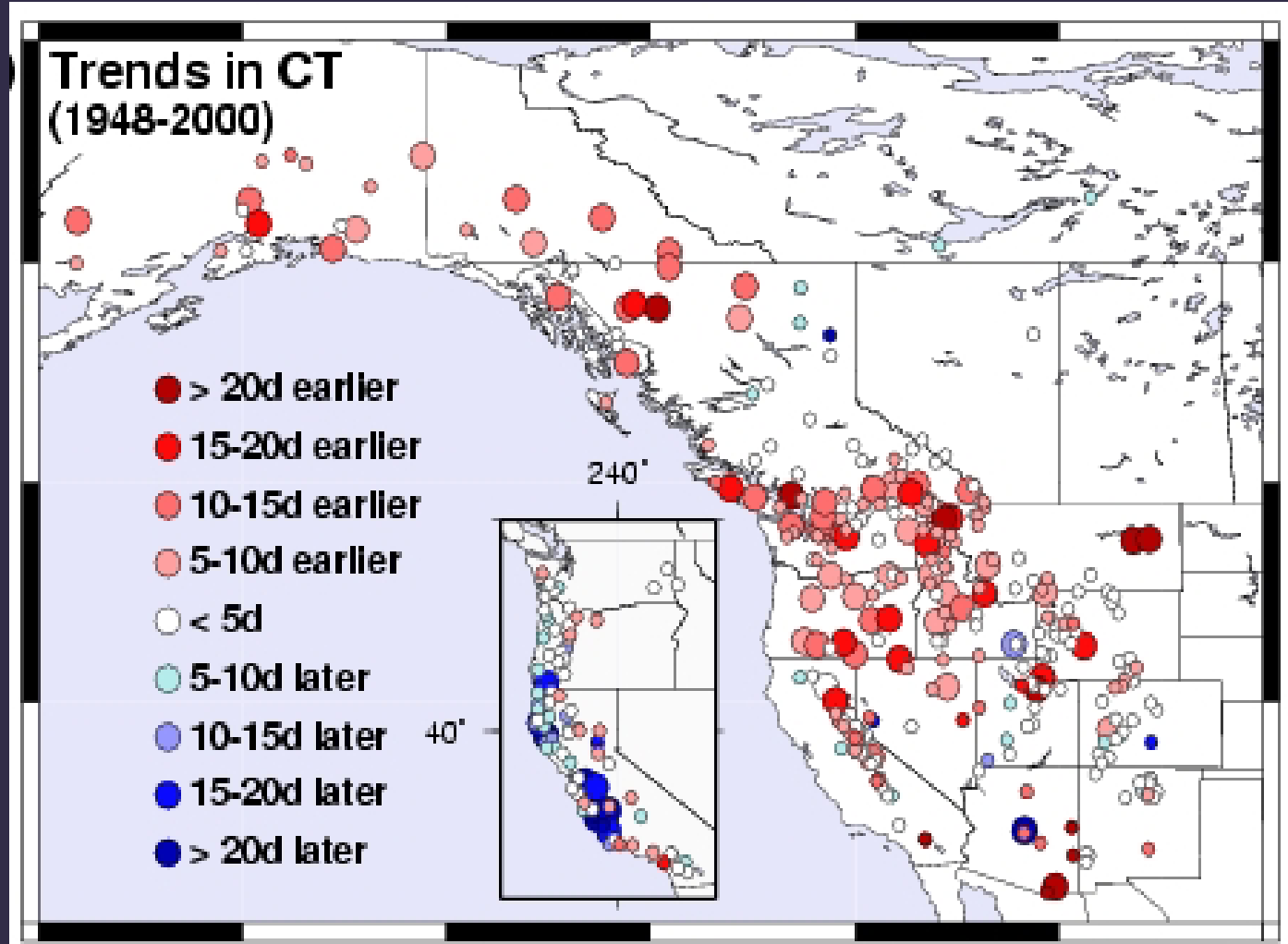
Nearly every glacier in the Cascades and Olympics has retreated during the past 50-150 years



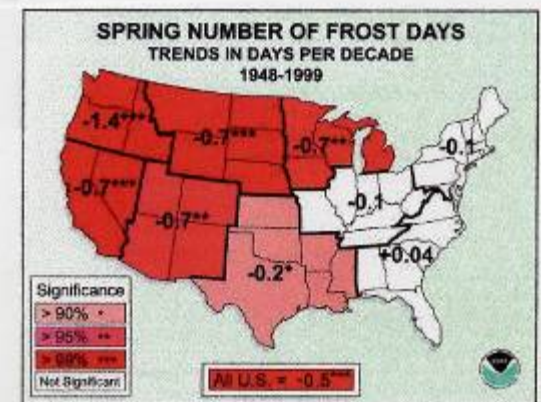
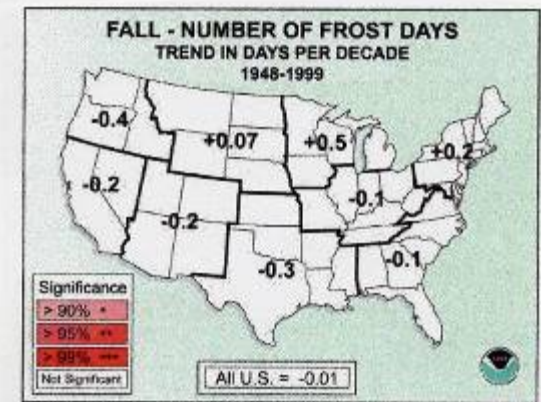
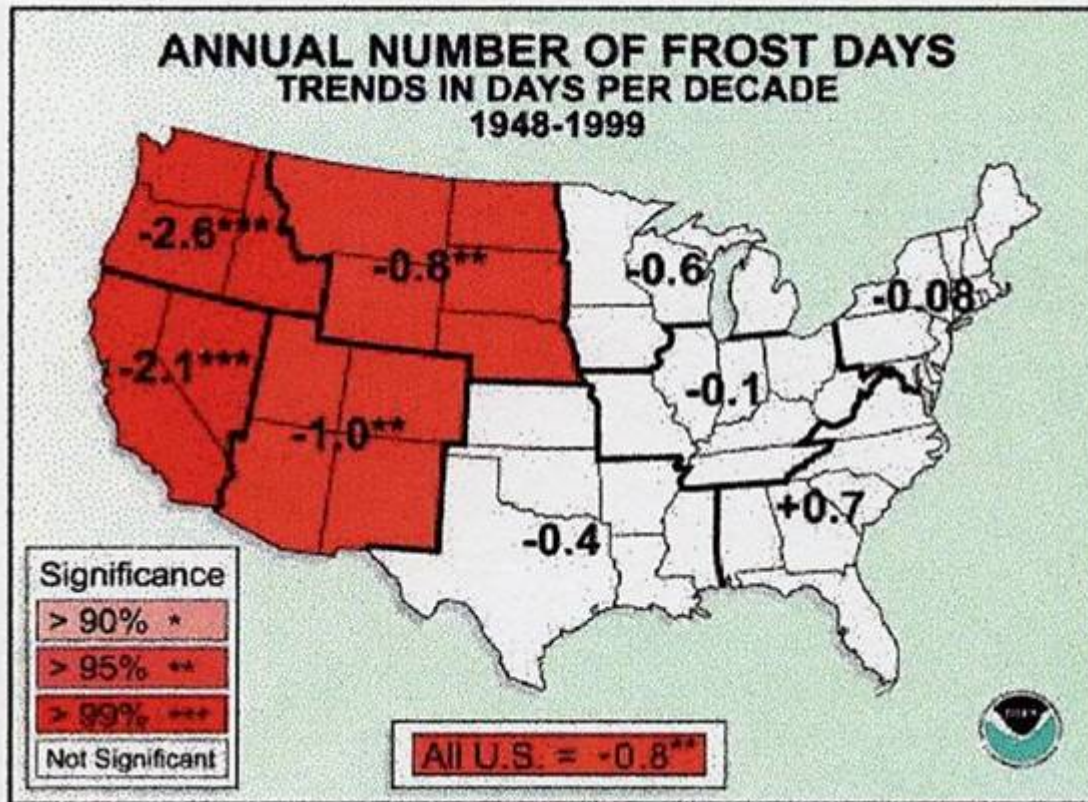
***South Cascade
Glacier, 1928 (top)
and 2000 (right)***

Trends in Spring Runoff

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



Fewer Frost Days in the Late 20th Century



Largest trends observed in the PNW; most of the trend driven by decline in spring frost days

Attribution

- Are these changes due entirely to climate change?

NO, modes of natural variability have a role in these trends (e.g., El Niño)

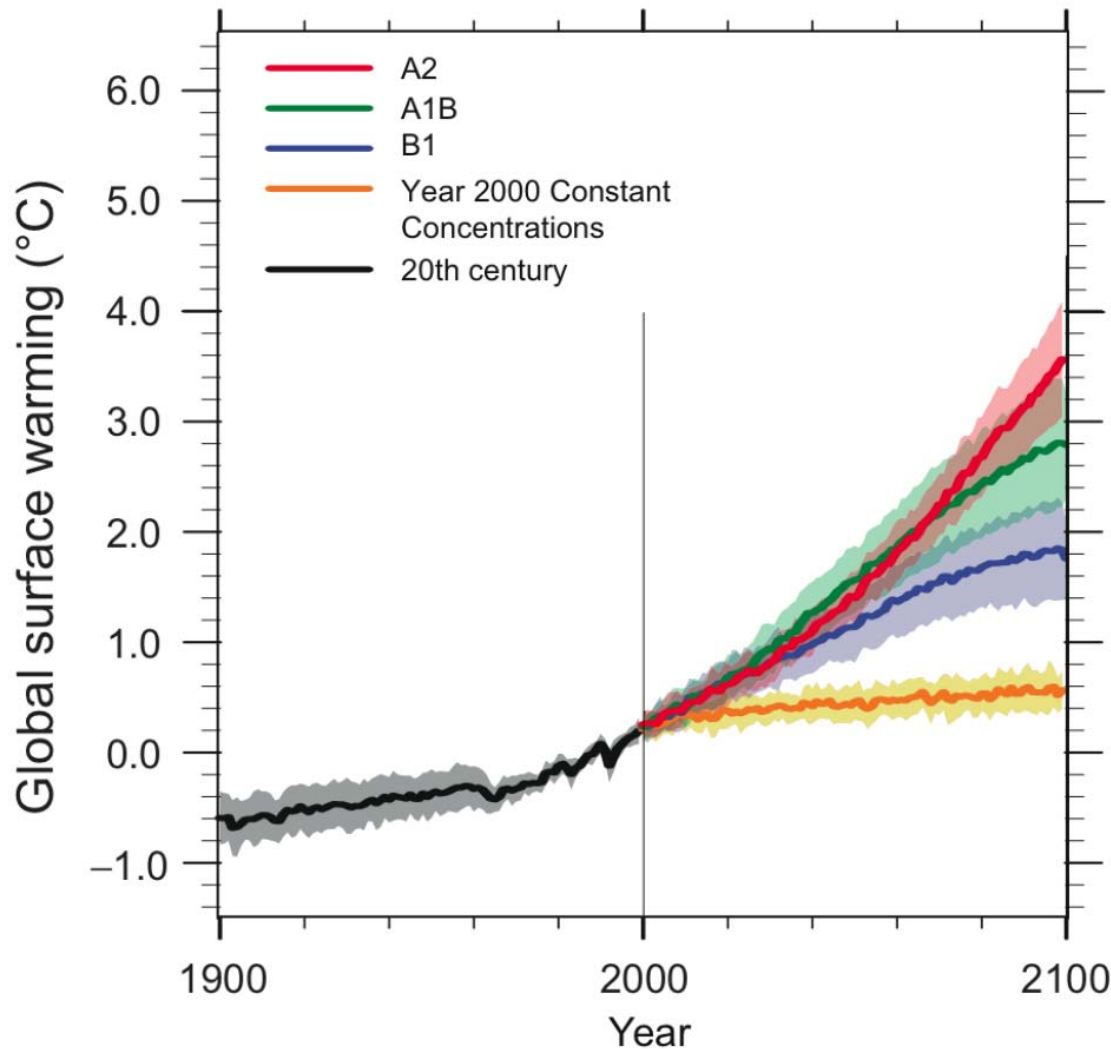
- Are these changes due entirely to natural climate variability?

NO, natural variability cannot explain all of the trends

...a climate change signal appears to be emerging at the regional scale

Projected 21st Century Global Warming

Multi-model Averages and Assessed Ranges for Surface Warming



IPCC “best estimate”
range of global-scale
warming by the
2090s:

3.2°F-7.2°F

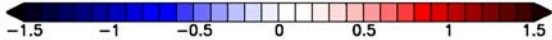
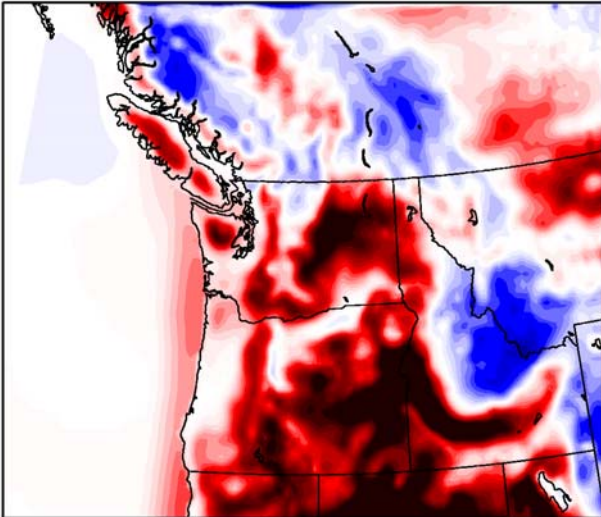
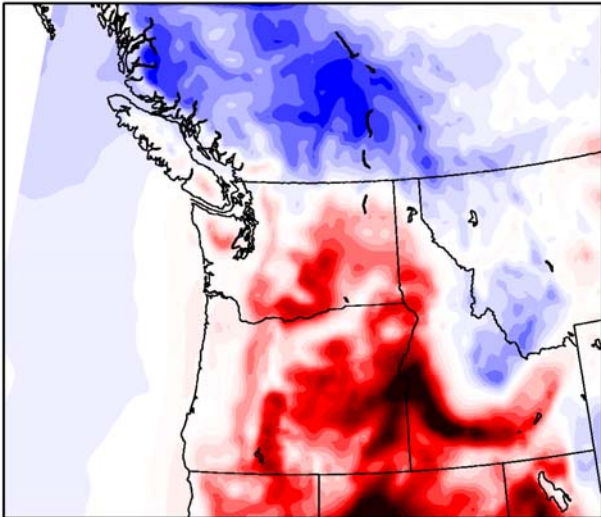
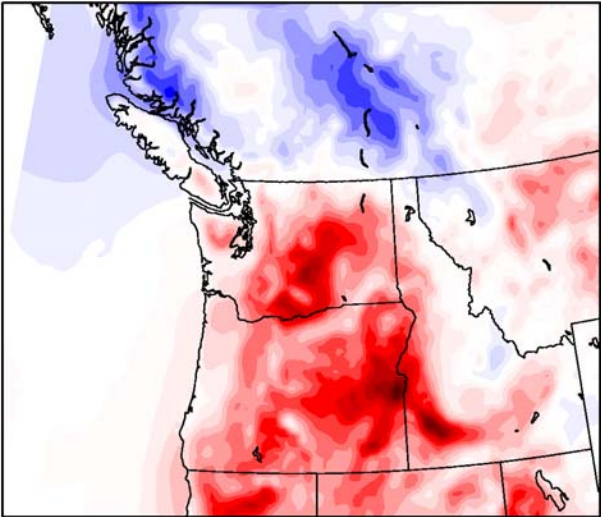
Warming in the next
few decades largely
driven by **current
and near-term**
atmospheric GHG
concentrations

Pattern of temperature change: regional model compared with global model

2020s

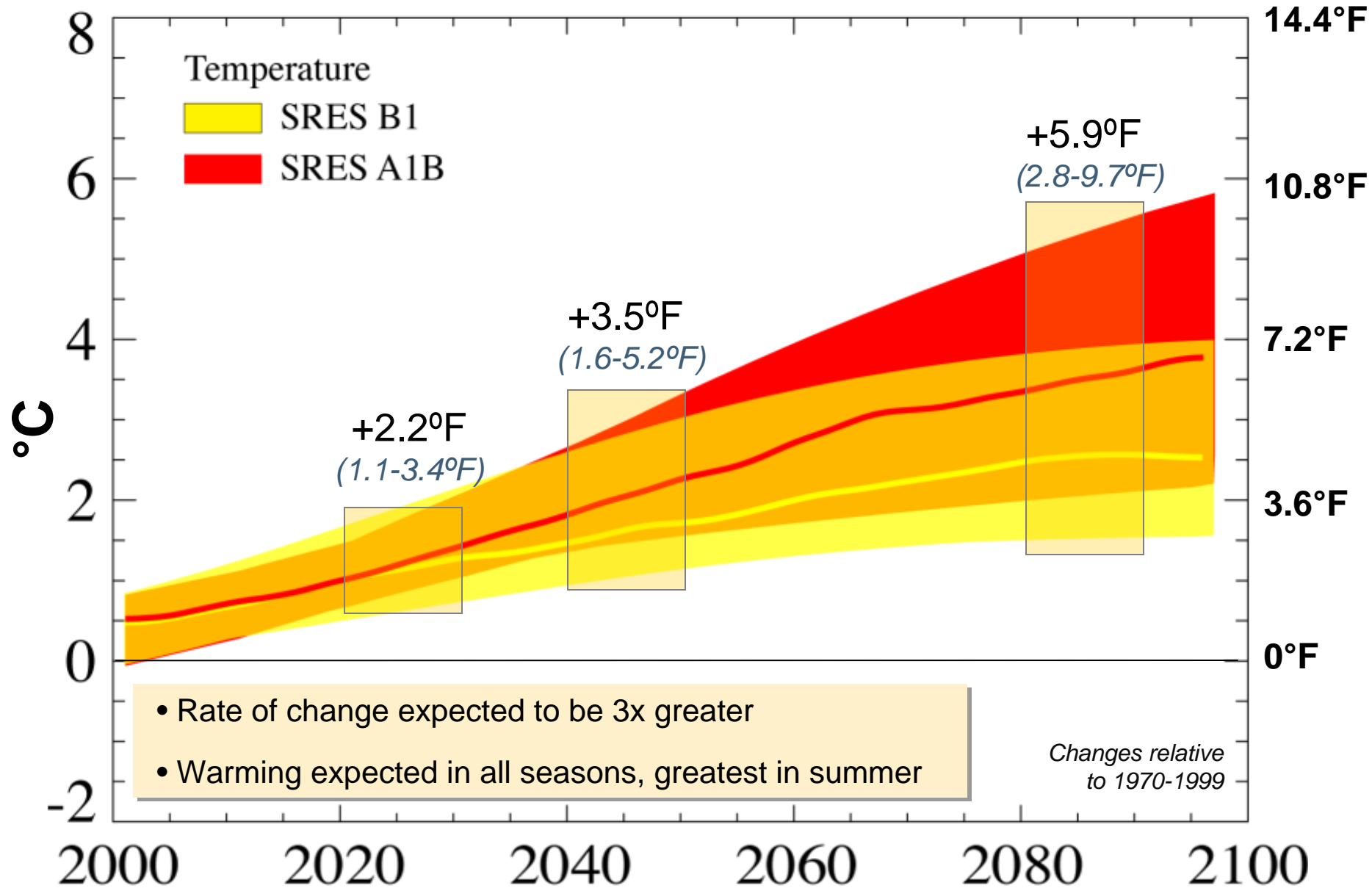
2050s

2090s



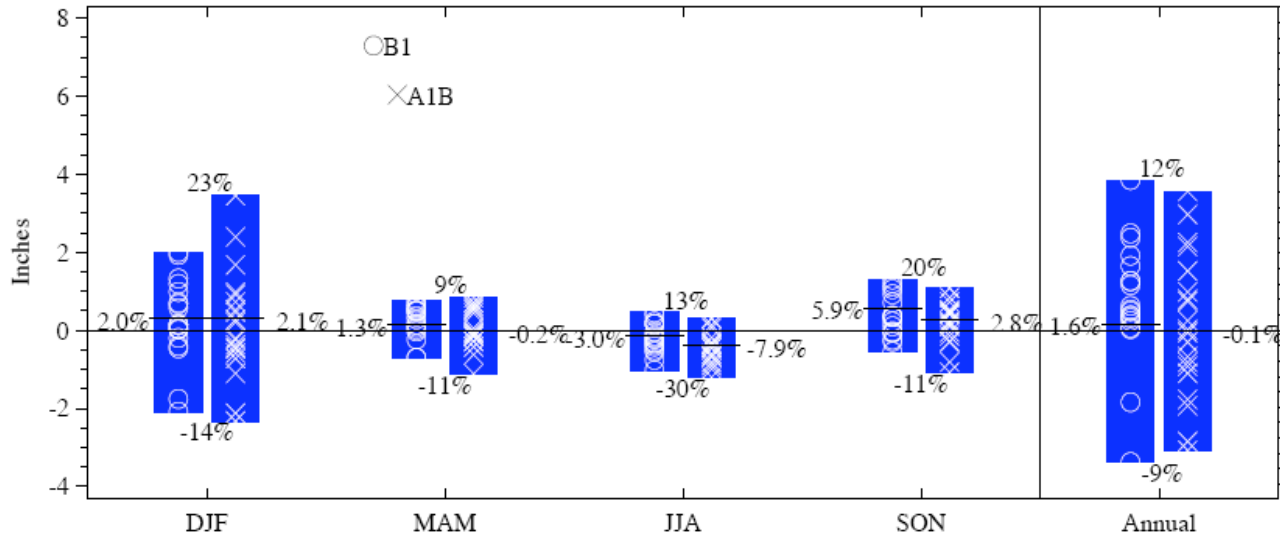
Change in Winter Temperature (degrees C) relative to global model

Projected Increases in PNW Temp

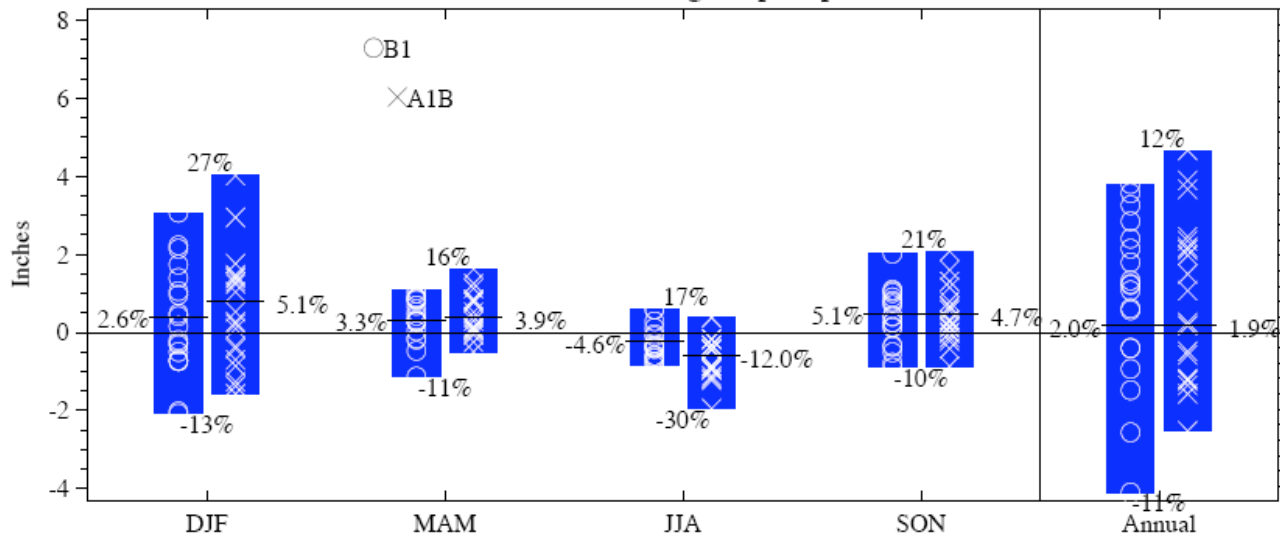


Modest Changes in PNW Precipitation

2020s change in precip



2040s change in precip



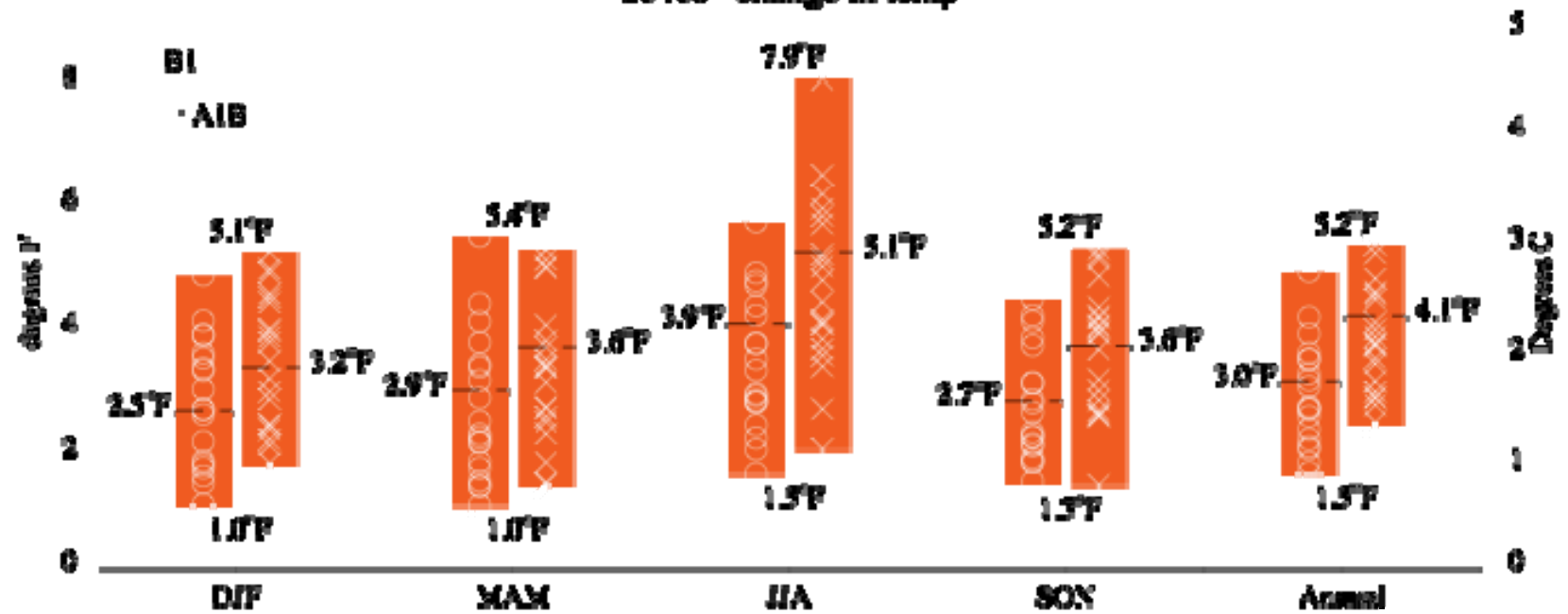
Modest increases (1-2%) in **annual average** precipitation

Most of the increase comes in the winter months (*but in what intensity?*)

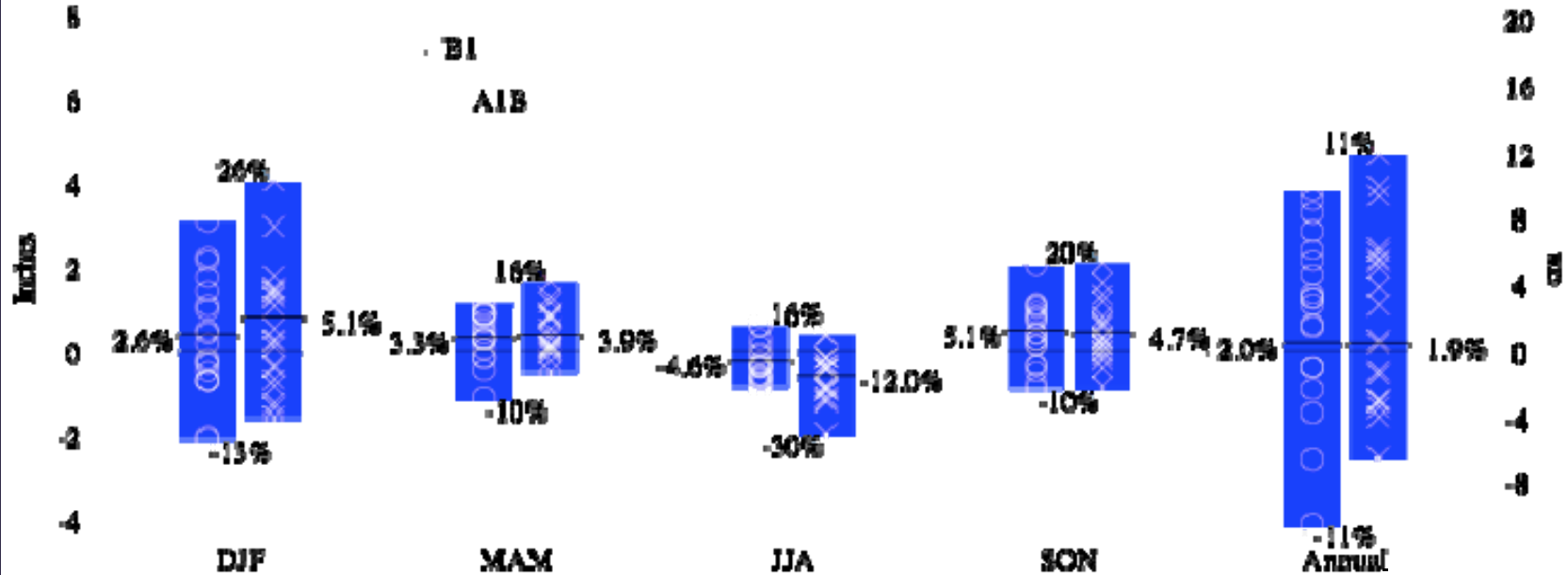
Projected increase in average does not exceed 20th century variability

Note: there is high confidence in projected temp changes, less in precipitation changes

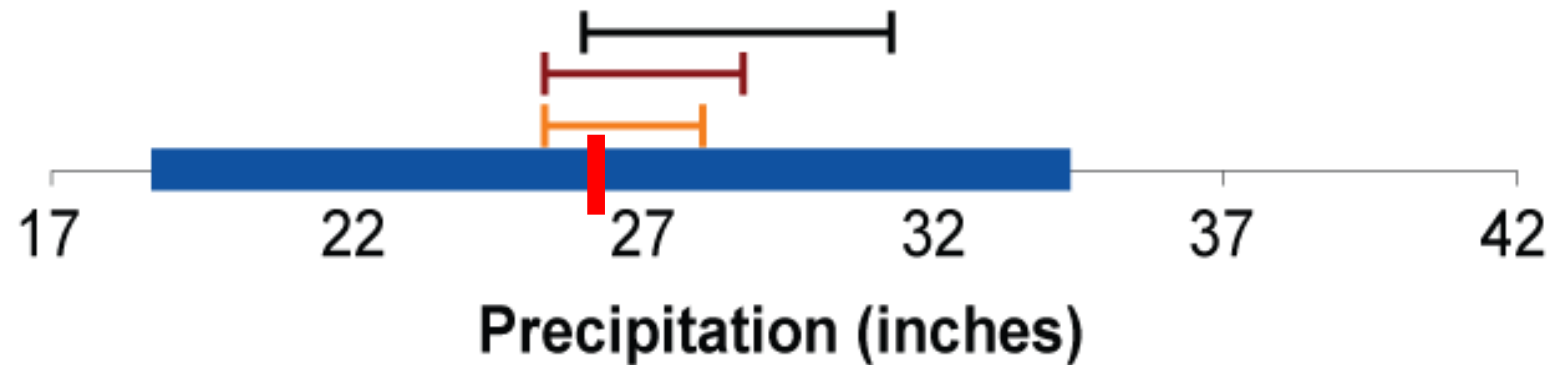
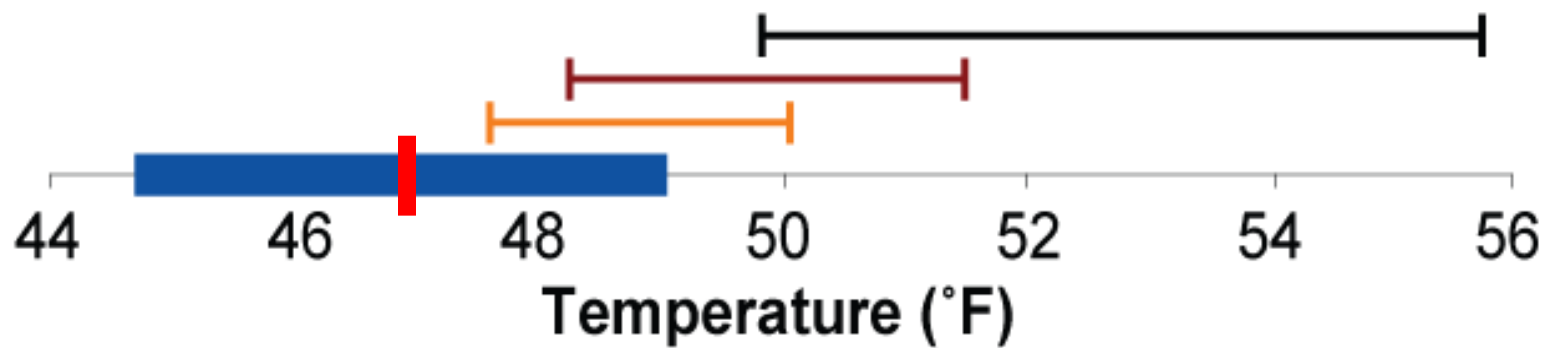
2040s change in temp



2040s change in precip



Changes Relative to the 20th Century



- historical variability
- 2020s shift in mean
- 2040s shift in mean
- **2080** shift in mean

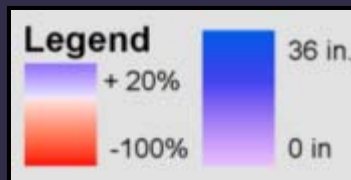
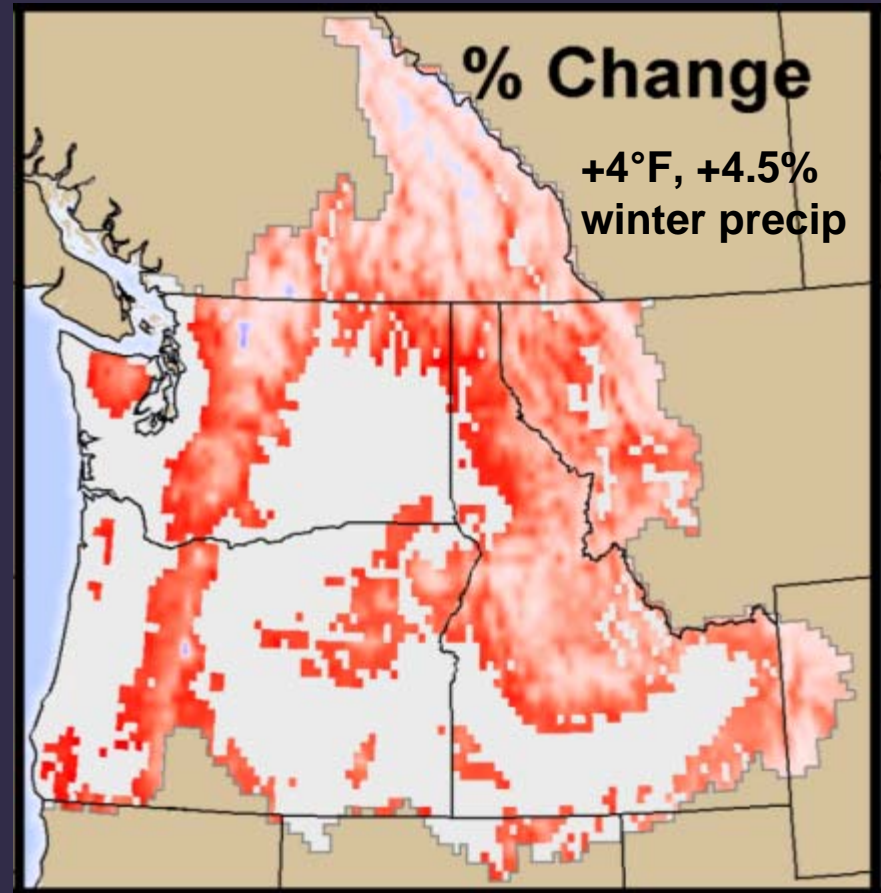
Source: Climate Impacts Group, University of Washington



Lower Spring Snowpack

Spring snowpack is projected to decline as more winter precipitation falls as rain rather than snow, *especially in warmer mid-elevation basins*

Snowpack will melt earlier with warmer spring temperatures

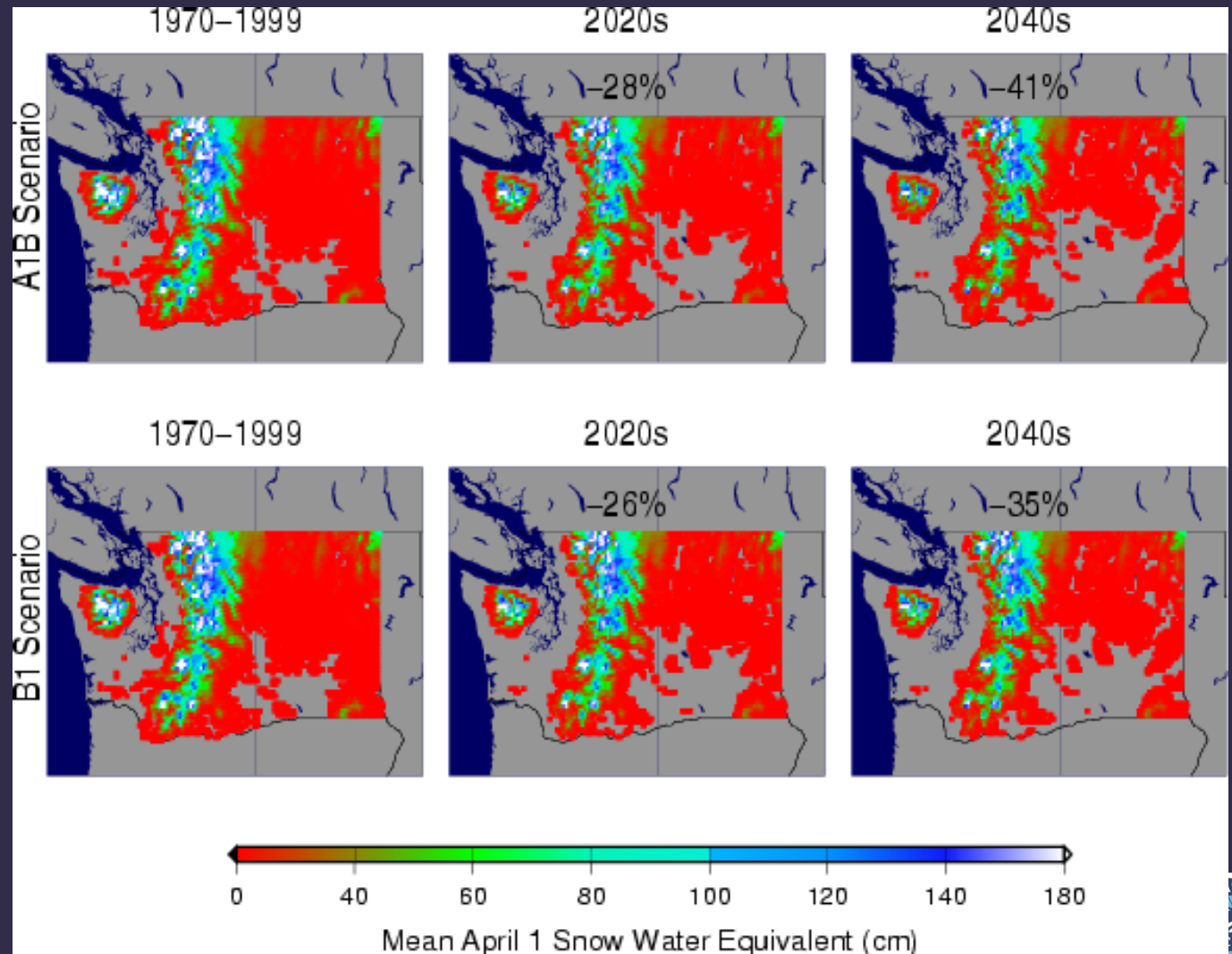


**April 1
Snowpack**

Hydrology and Water Resources

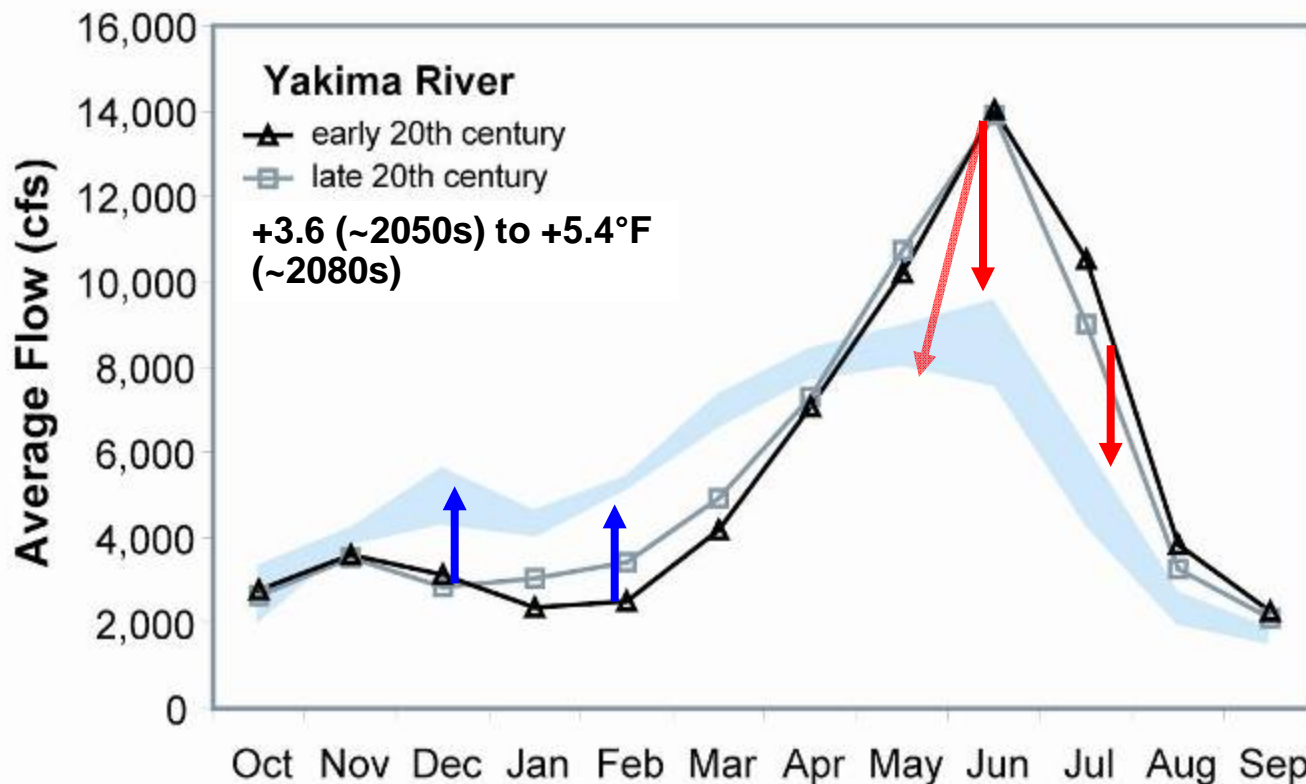
Reduced snowpack and changes in soil moisture will occur.

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



Streamflow Impacts

- Higher winter streamflows
- Earlier and lower peak runoff (*mid/high basins*)
- Lower late spring streamflow
- Lower, warmer summer streamflows



Sensitivity analysis for the Yakima River basin

Changing Risk

Risk of drought increases...

With 3.6°F warming, 50-year droughts become 10-year droughts and 10-year droughts become 2.2-year droughts
(*Scott et al. 2006*)

Risk of flooding changes....

General increase in risk of winter flooding and combined sewer overflows in low- and mid-elevation basins

Lower risk of spring flooding in snowmelt basins due to lower spring snowpack



Portland Water Supply Climate Change Study

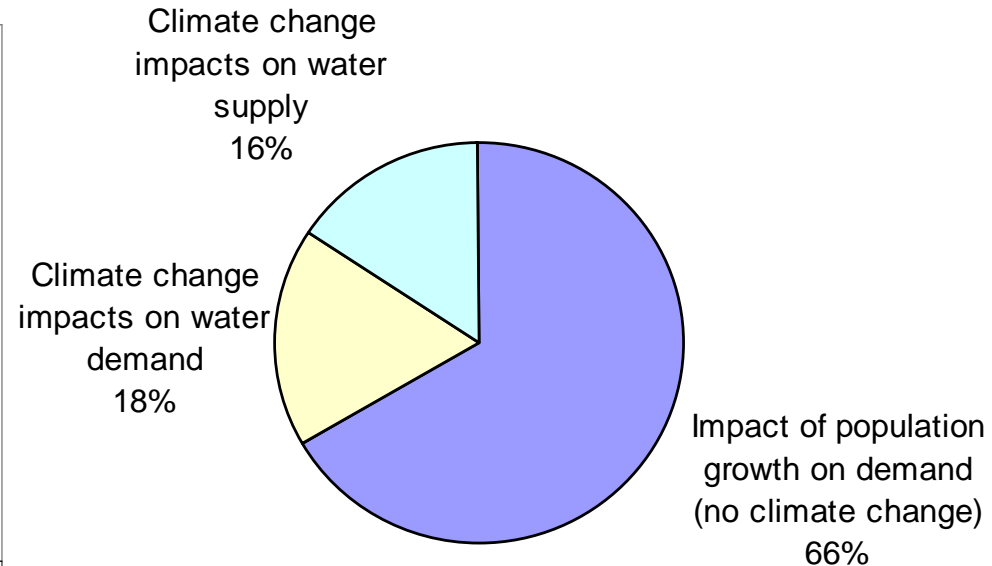
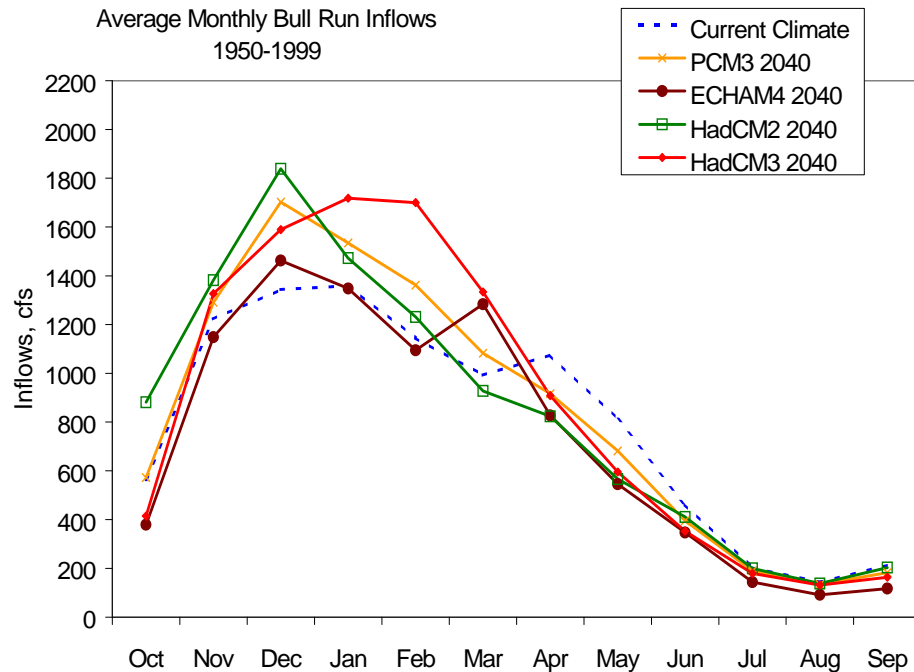


2040s WATER NEEDS IN PORTLAND (OR):

Regional growth: +40 mgd
Climate change: +20 mgd

Climate change impacts = 50% of growth impacts

Average Monthly Bull Run Inflows
1950-1999

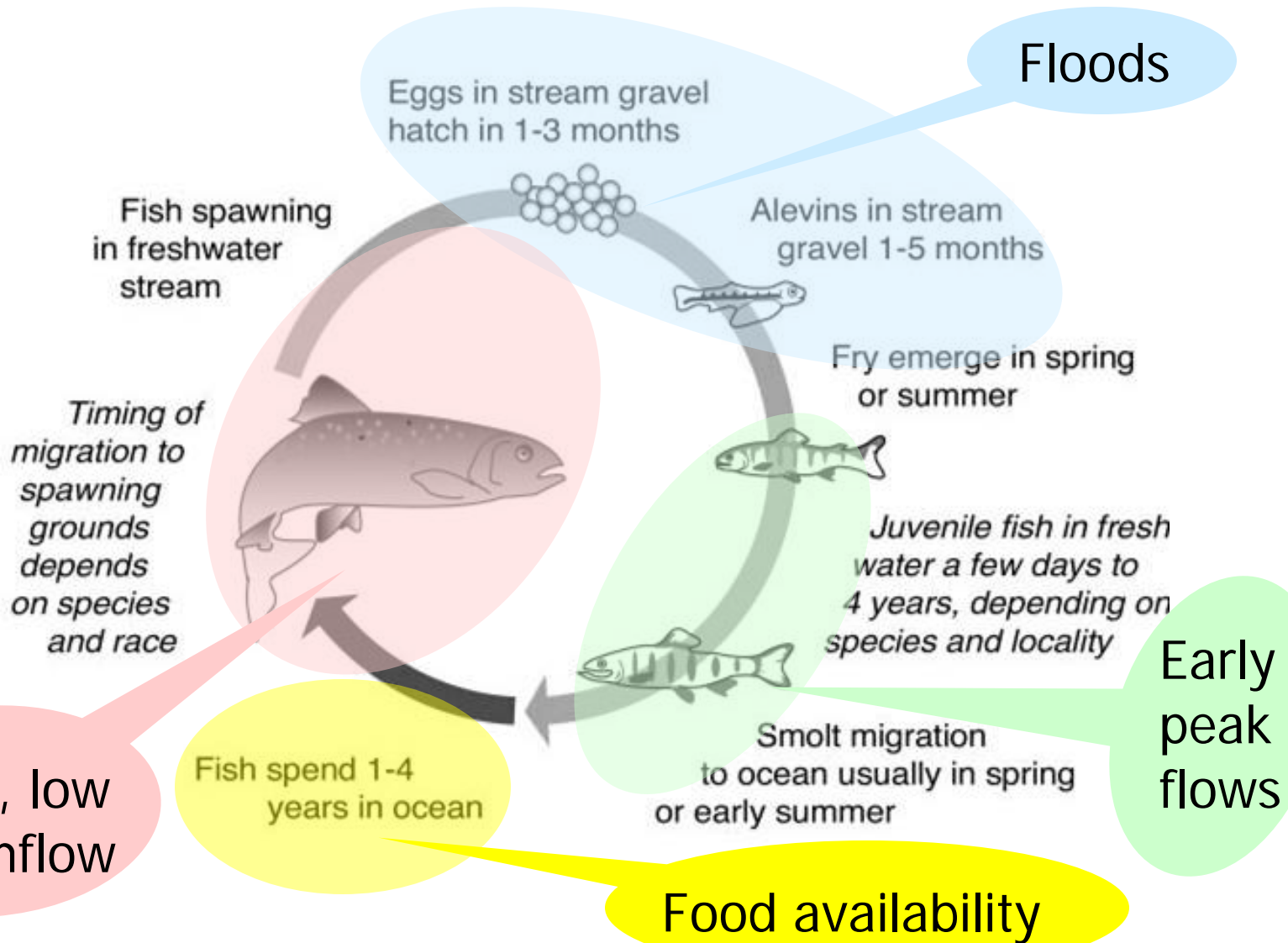


Implications for Water Management



- Increased demand among competing uses (*M&I, habitat, irrigation, water quality navigation, recreation, hydropower*)
- Increased risk of winter flooding in many basins (*changes in urban flooding less clear*)
- Water systems must manage longer and more extreme drawdown periods that in the past
- *Bottom line: Increased competition for water and increased vulnerability to drought*

Salmon Impacted Across Full Life-Cycle

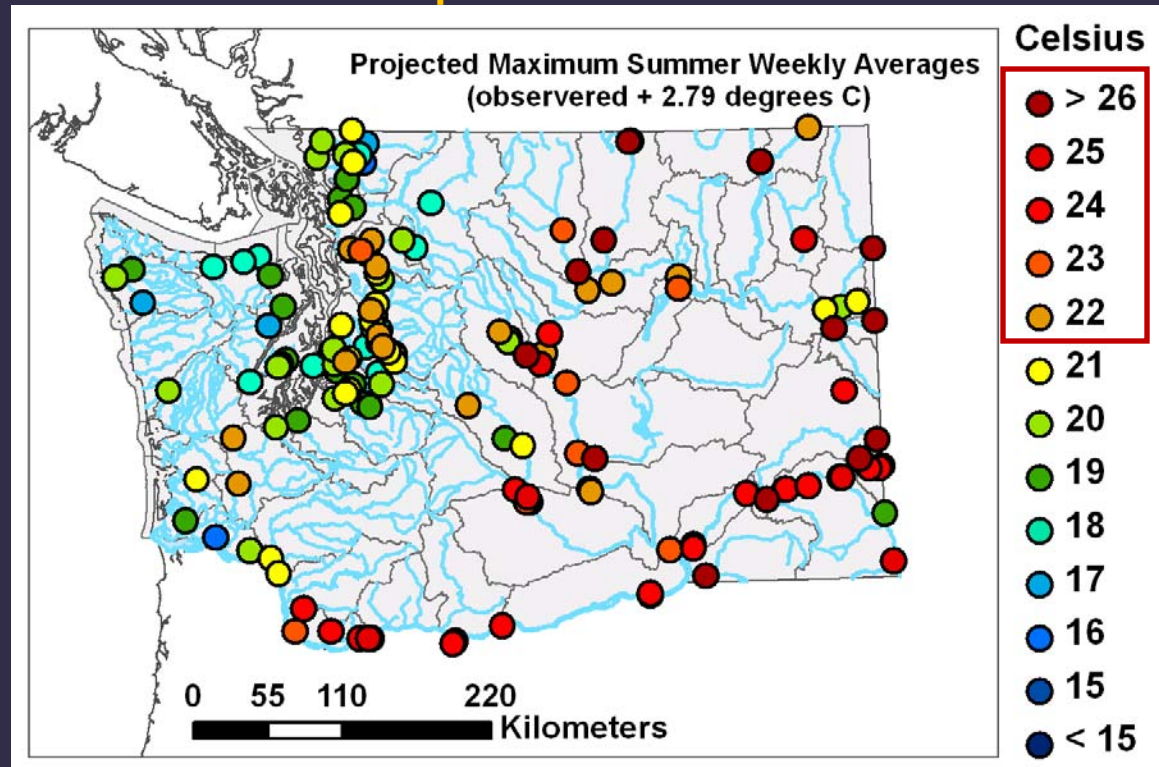


Salmon

Water temperature is already a problem in many WA stream reaches.

The incidence of violations, especially in summer, will increase with warmer summer temperatures and reduced low flows due to earlier snowmelt.

Projected Maximum Weekly Average Water Temperatures – 2040s



49% of stations exceed the 21°C (70°F) water quality criteria (changes relative to 2001-2007)

Sea Level Rise (SLR) in the PNW

Major determinants:

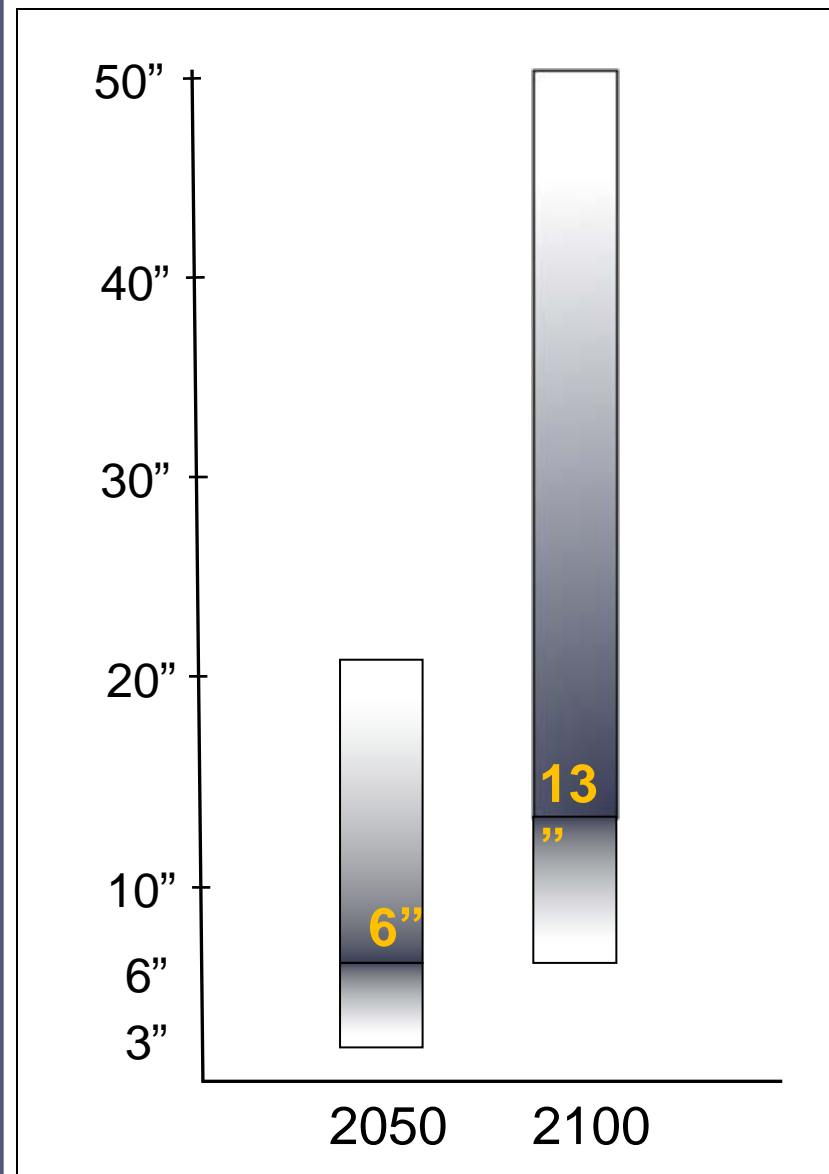
- Global SLR driven by:
 - thermal expansion of the ocean, and
 - melting of land-based ice;
- Atmospheric dynamics, particularly changes in wind which push coastal waters toward or away from shore; and
- Local tectonic processes (*subsidence and uplift*)



Coasts

Rising sea levels will increase the risk of flooding, erosion, and habitat loss along much of Washington's 2,500 miles of coastline.

- **Medium estimates of SLR for 2100:**
 - +2" for the NW Olympic Peninsula
 - +11" for the central/southern coast
 - +13" for Puget Sound
- Higher estimates (up to 4 feet in Puget Sound) cannot be ruled out.



Projected sea level rise in Washington's waters relative to 1980-99, in inches. Shading roughly indicates likelihood.

Other Projected Regional Impacts

- **Human Health**

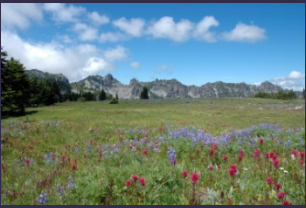
Increased thermal stress from extreme heat events, decreased air quality (ozone; particulate matter), changes in range of/habitat for/exposure to disease vectors likely

- **Recreation**

Shortened winter ski season (but improved access?), impacts in summer from forest fires

- **Hydropower**

Increased winter streamflows benefit winter hydropower production; greater tradeoffs between hydropower, instream flows, irrigation, and recreation



Other Projected Regional Impacts

- **Forests**

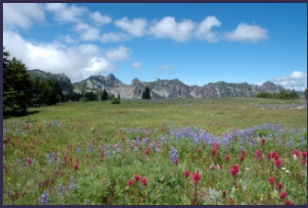
Increased risk of wildfire, vulnerability to insects, decreased growth & regeneration

- **Agriculture**

Decreased irrigation supply, increased heat stress/insects, increased growing season

- **Infrastructure**

The potential for more intense winter precipitation would increase the already high costs of stormwater management.



Forests

- Wildfires are strongly associated with climate, especially in eastside forests.
- Mountain pine beetle poses a significant threat to Washington's pine forests.
- Tree species composition will change as species respond uniquely to a changing climate.
- Productivity of Douglas-fir forests is likely to decrease statewide.



Infrastructure

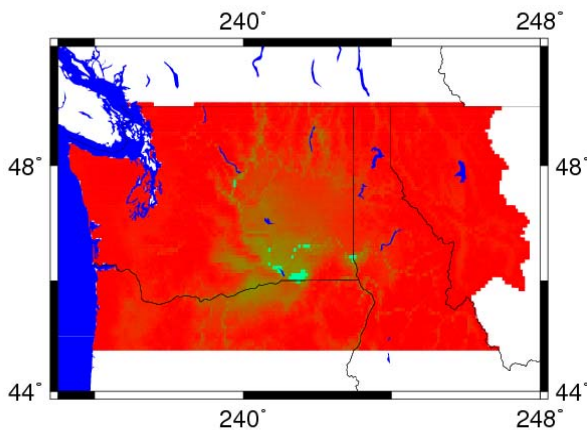
- Stormwater impacts and management already carry significant economic costs for municipalities throughout western WA, as well as the rest of the state.
- The potential for changes in precipitation intensity would increase these costs.



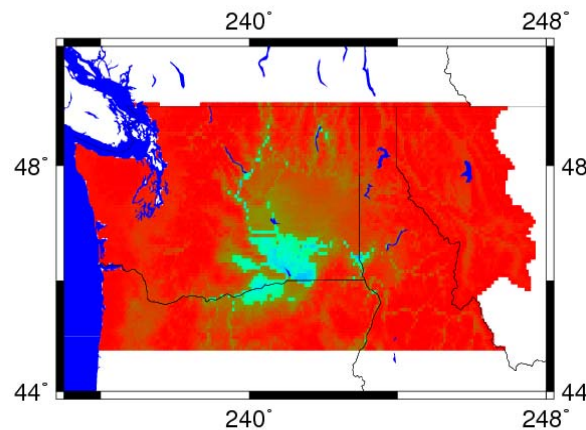
Energy

- Heating degree days will continue to dominate in the 2020s and 2040s, but cooling degree days become a much more important factor in eastern WA as the region warms.

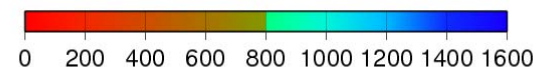
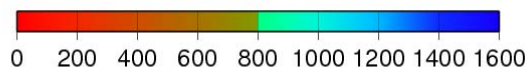
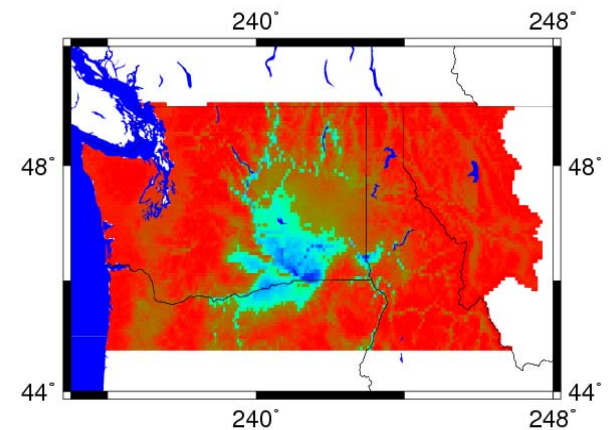
Historic



A1B 2020



A1B 2040



Cooling Degree Days (F)

Human Health

- Summer heat waves are expected to increase.
- Warmer summer air temperatures are likely impact air quality, increasing ozone concentrations and fine particulates
- Increased temperatures and flooding may alter the habitat and range of disease reservoirs and vectors (e.g., mosquitoes)