David Horsey, Seattle Post-Intelligencer

Weather, Climate and Future Climate Projections

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Mt. Rainier National Park Climate Change Workshop

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Climate Science in the Public Interest

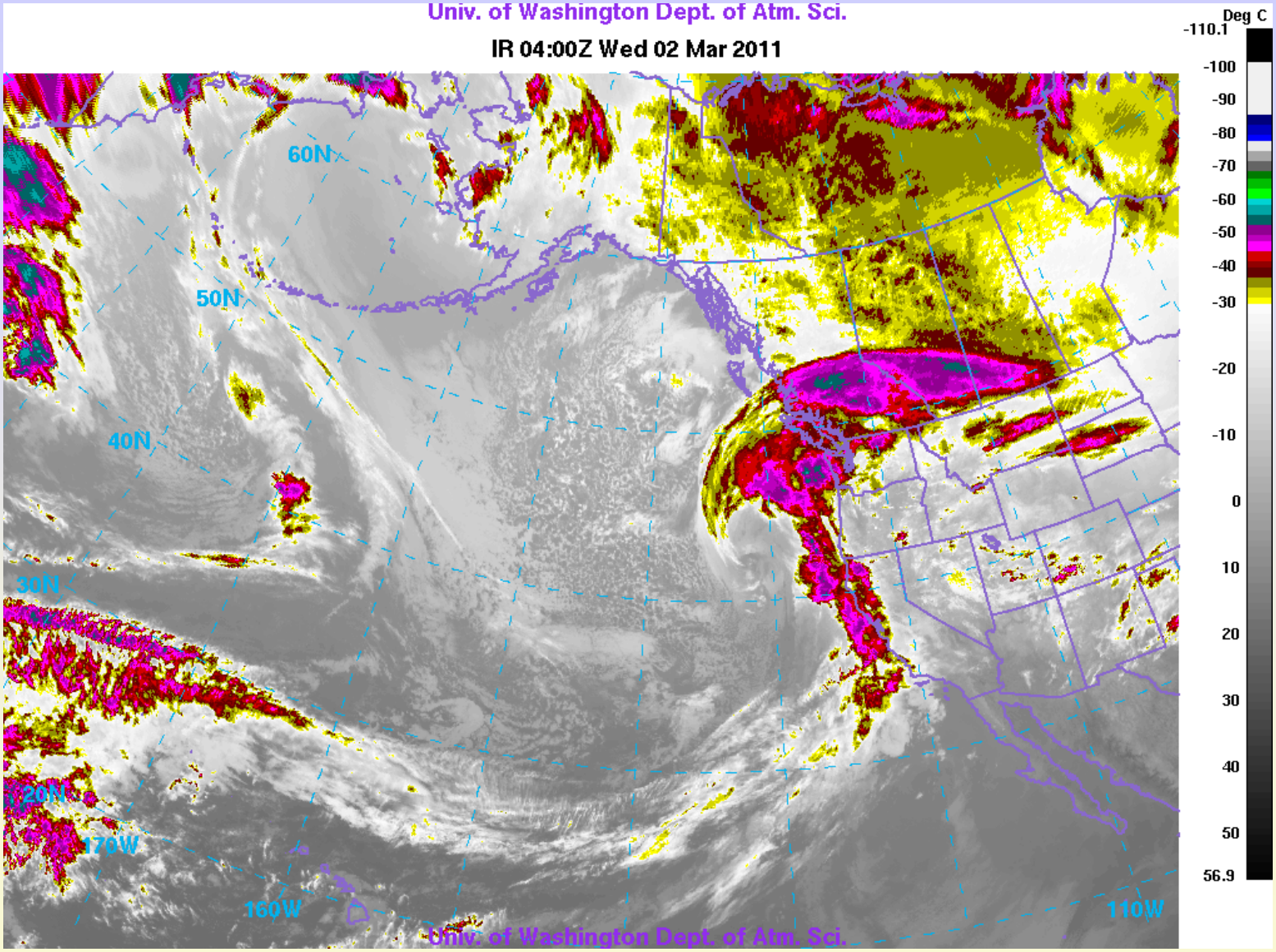
CLIMATE is what you expect

WEATHER is what you get,

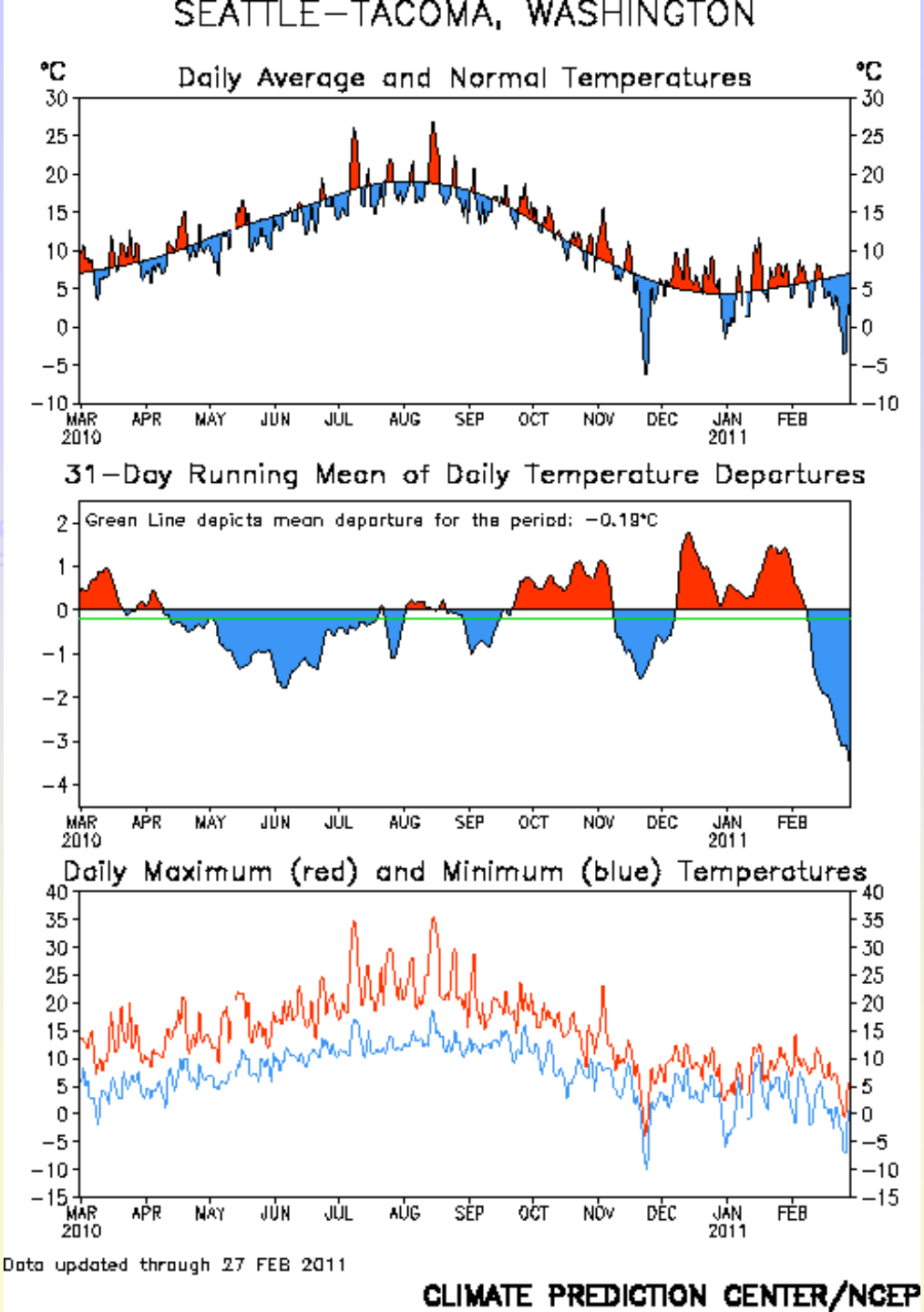
weather is the exact state of the atmosphere at a specific time and place

weather elements: air temperature, air pressure, humidity, clouds, precipitation, visibility, wind

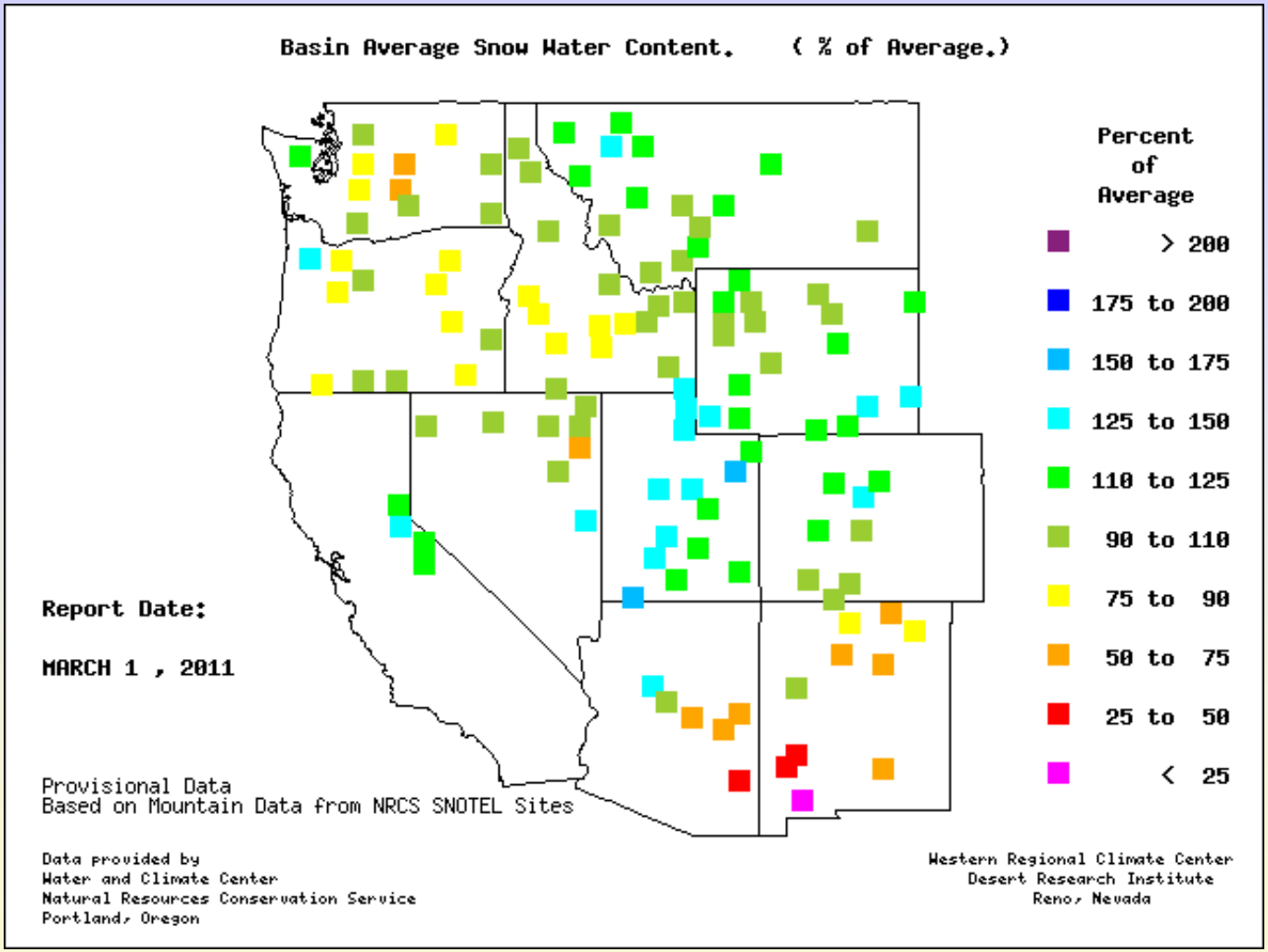
infrared satellite image from 8pm last night



Climate is simply the statistics of weather: at right are 3 ways to view Sea-Tac's observed daily temperatures from the past year



“Snow Water” as of March 1, 2011



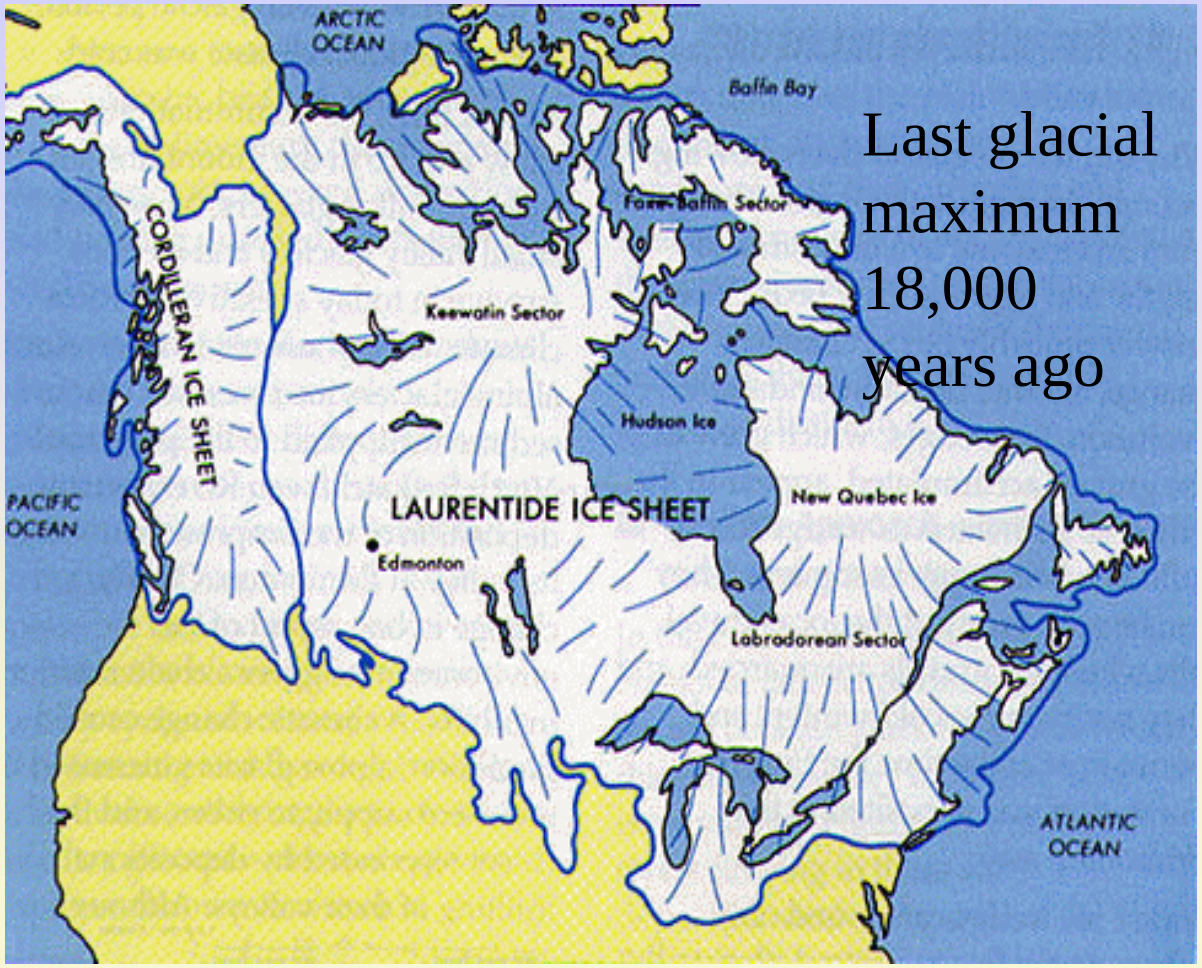
http://www.wrcc.dri.edu/snotelanom/basinswe.html

Climate

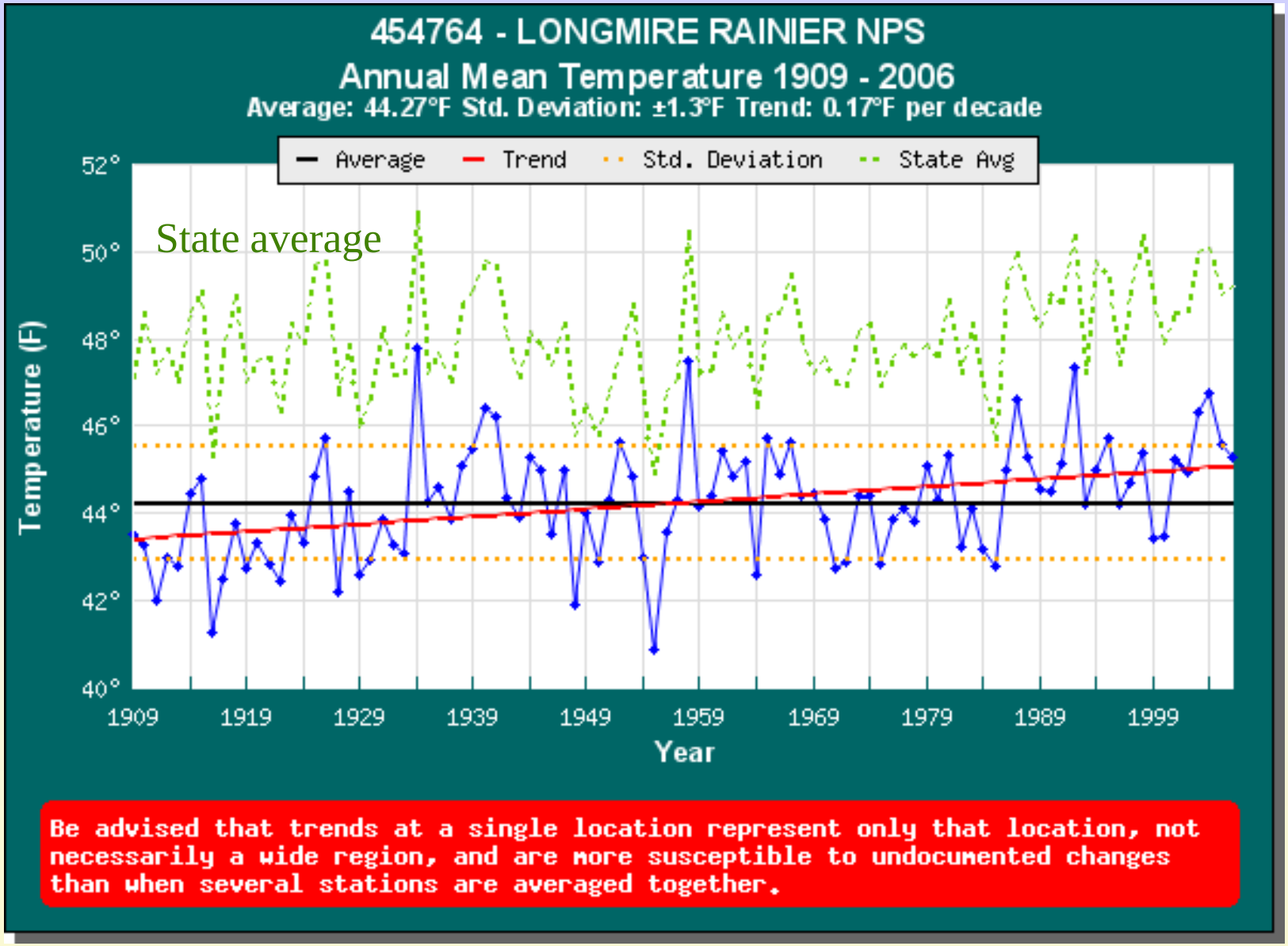
The statistics of weather at a particular place for a specified window of time

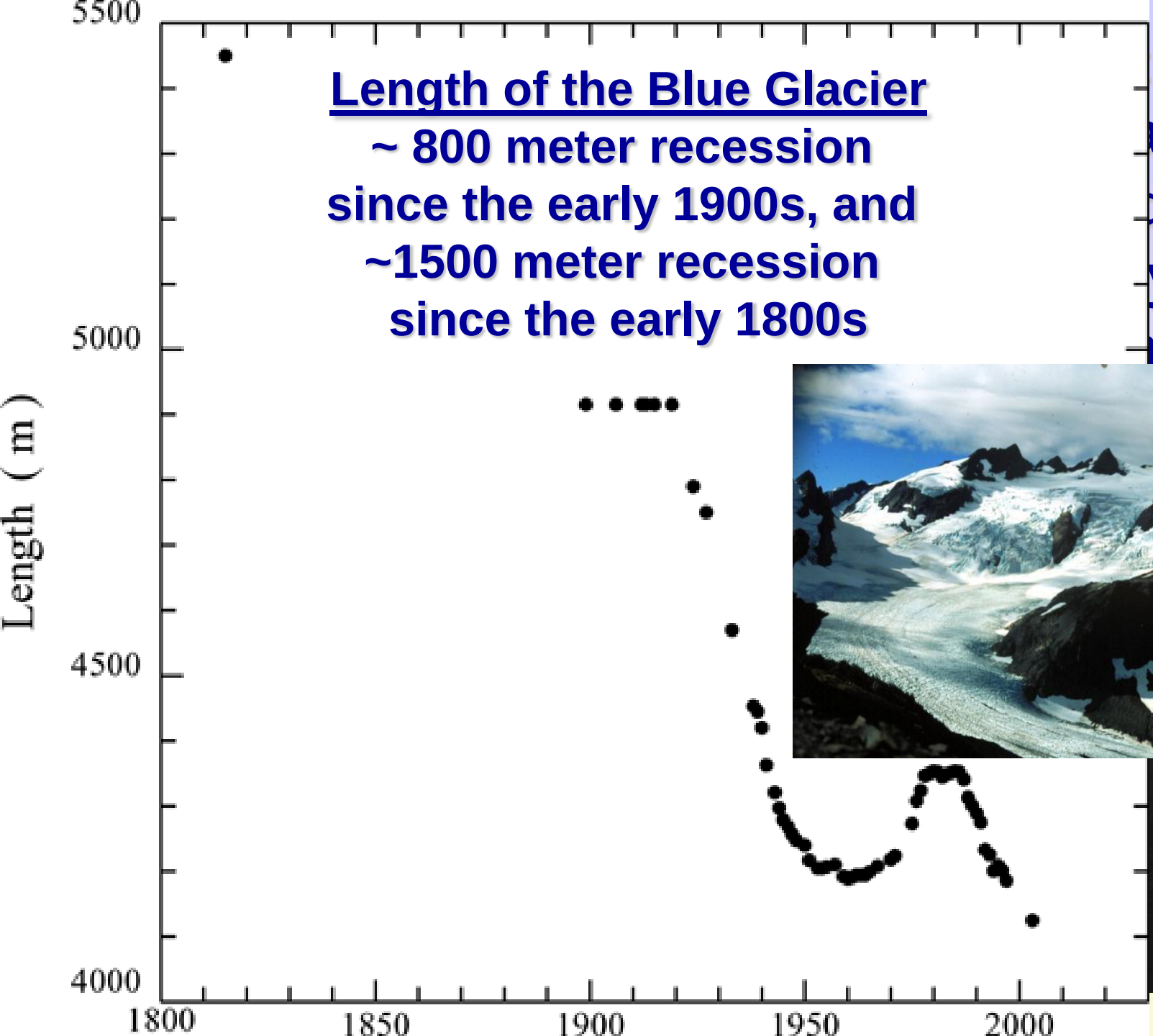
- examples:
  - monthly averaged temperature and precipitation
  - average number of cloudy days per month
  - frequency of snow days (number per year)
  - Annual average snowfall

Climate has varied over long time periods



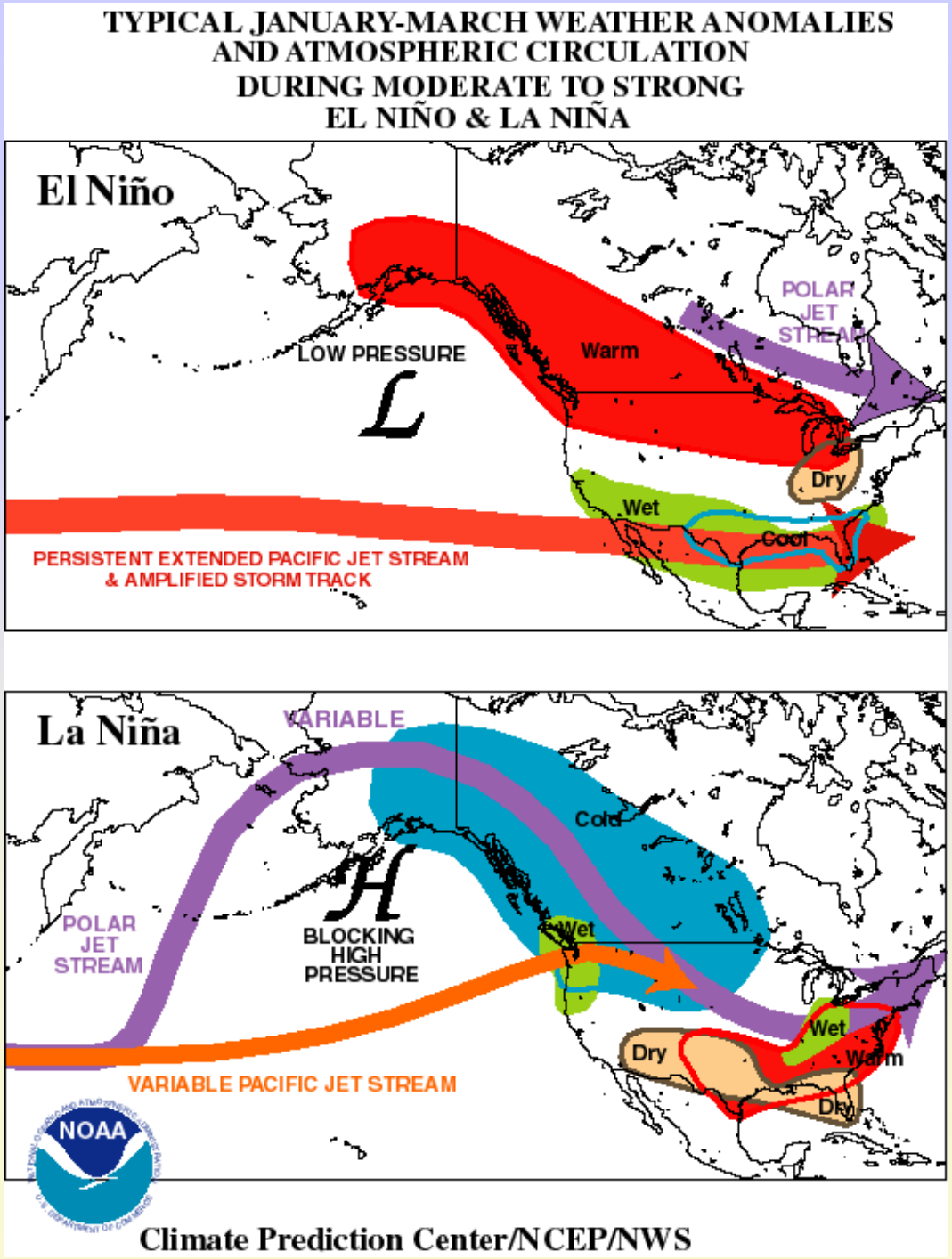
Longmire Annual Temperature: 1909-2006



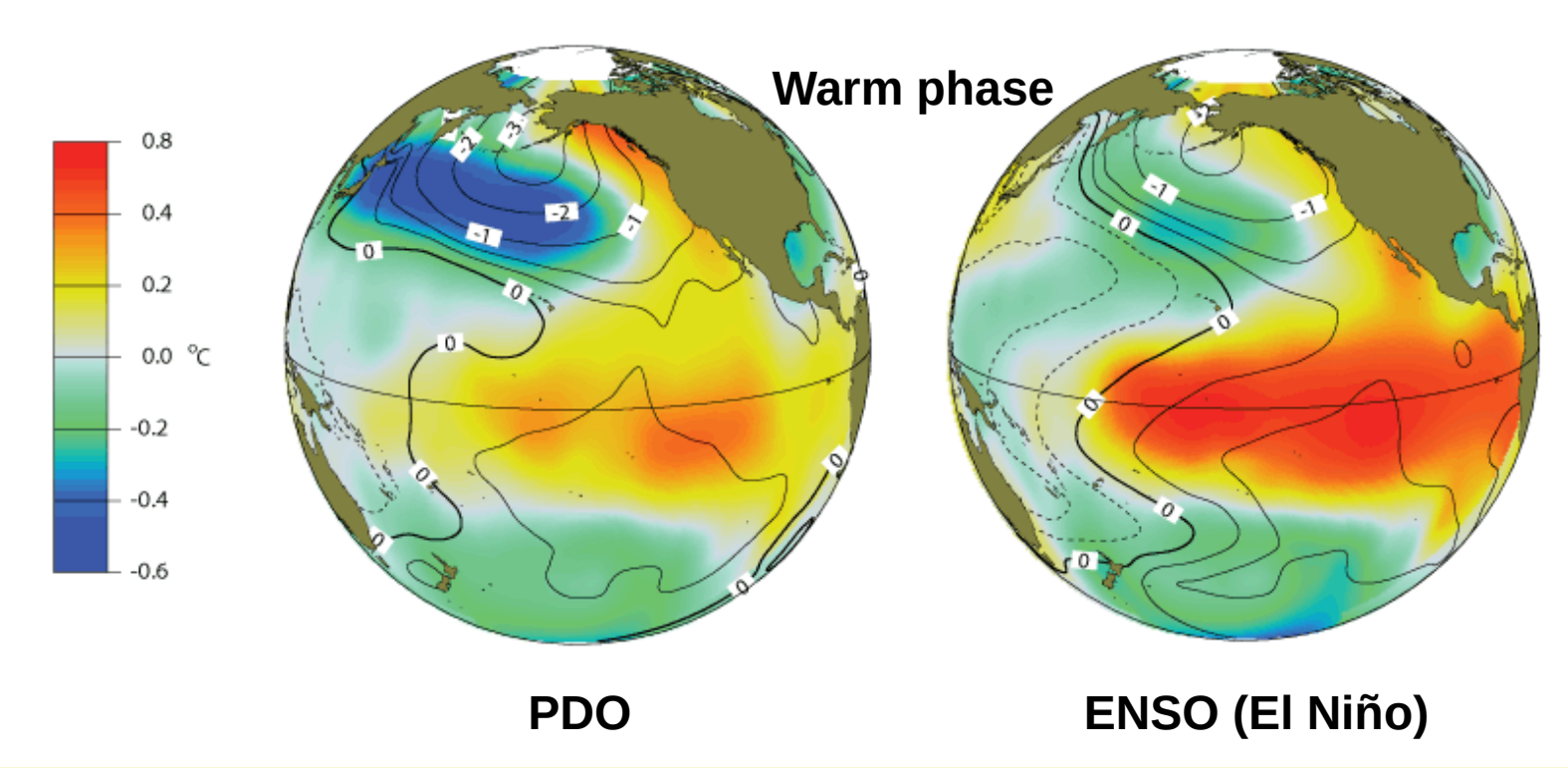

Length of the Blue Glacier
~ 800 meter recession
since the early 1900s, and
~1500 meter recession
since the early 1800s
Length (m)
5500
5000
4500
4000
1800
1850
1900
1950
2000


USGS

El Niño and La Niña play a prominent role in causing year to year variations in Northwest Climate (especially our winter climate)



Pacific Decadal Oscillation	El Niño/Southern Oscillation
20-30 years	6-18 months
North Pacific	Equatorial Pacific



Source: Climate Impacts Group, University of Washington

Observed Impacts of 20th Century Climate Changes in the PNW Region

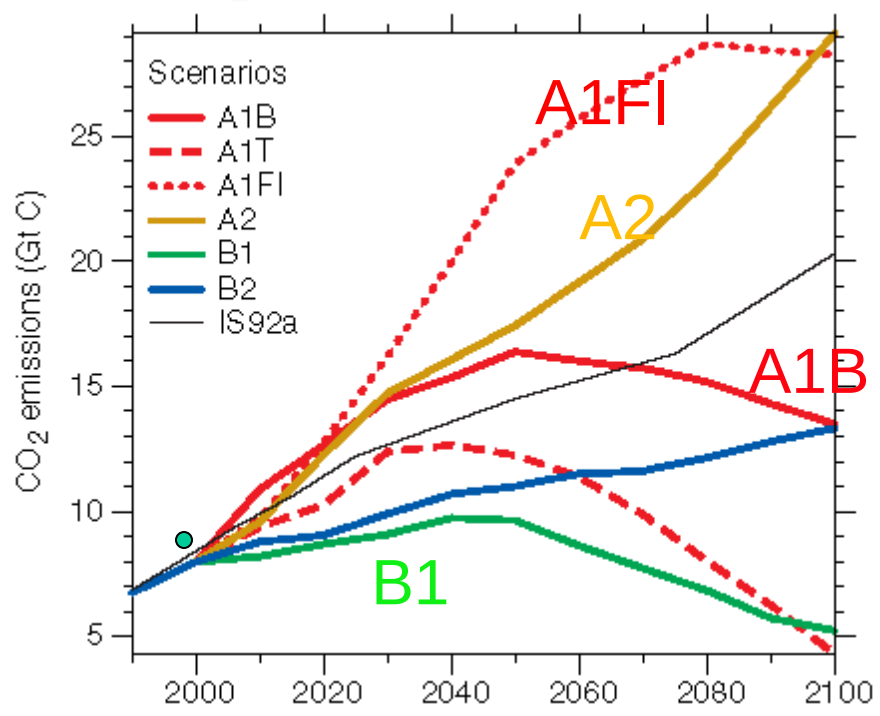
- Warming trends (~ 1.5 F/century), small trends in precipitation
- Retreating glaciers
- Declines in low elevation and Olympic Peninsula snowpack (at least from 1930s to 2000s)
- Timing shifts in snowmelt runoff (from 1948-2000)
  - ***Recent modeling studies suggest that ~35-60% of the observed hydrologic trends from 1950-99 are a consequence of human-caused global warming (Barnett et al. 2008: Science)***

A chain of assumptions and models are needed for future climate change scenarios

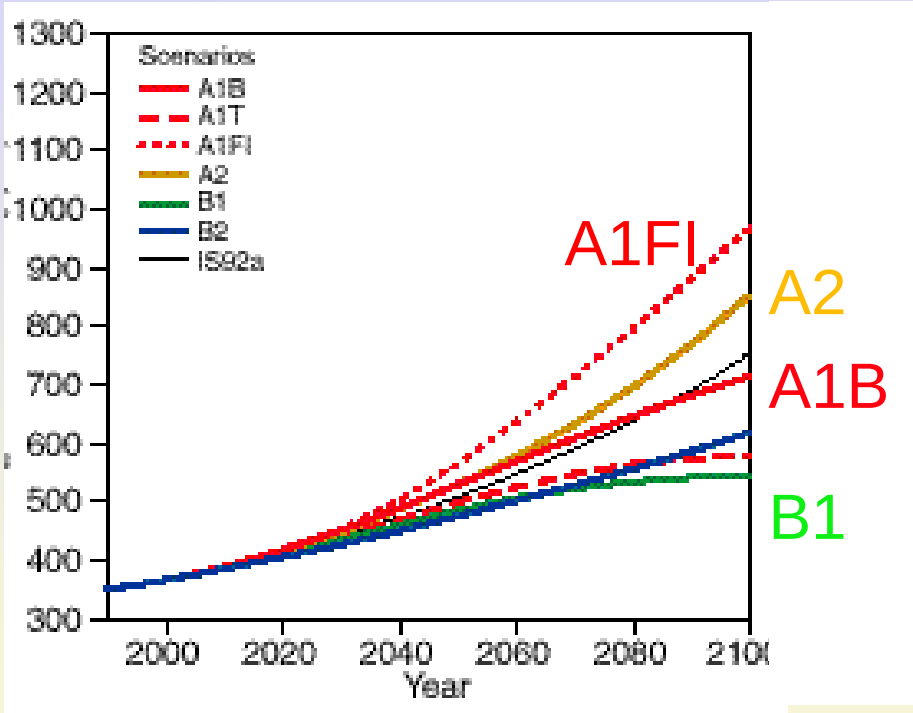
1. Start with a greenhouse gas emissions scenario
   - either specify atmospheric concentrations, or use a carbon cycle model to develop them
2. Choose a global climate model -
   - 20 were used in the IPCC's Fourth Assessment
3. Downscale the coarse resolution climate model output
   - Do this to develop more realistic regional temperature and precipitation fields required for impacts (e.g. hydrologic, stream temperature) model inputs

How much Carbon Dioxide will be released into the atmosphere?

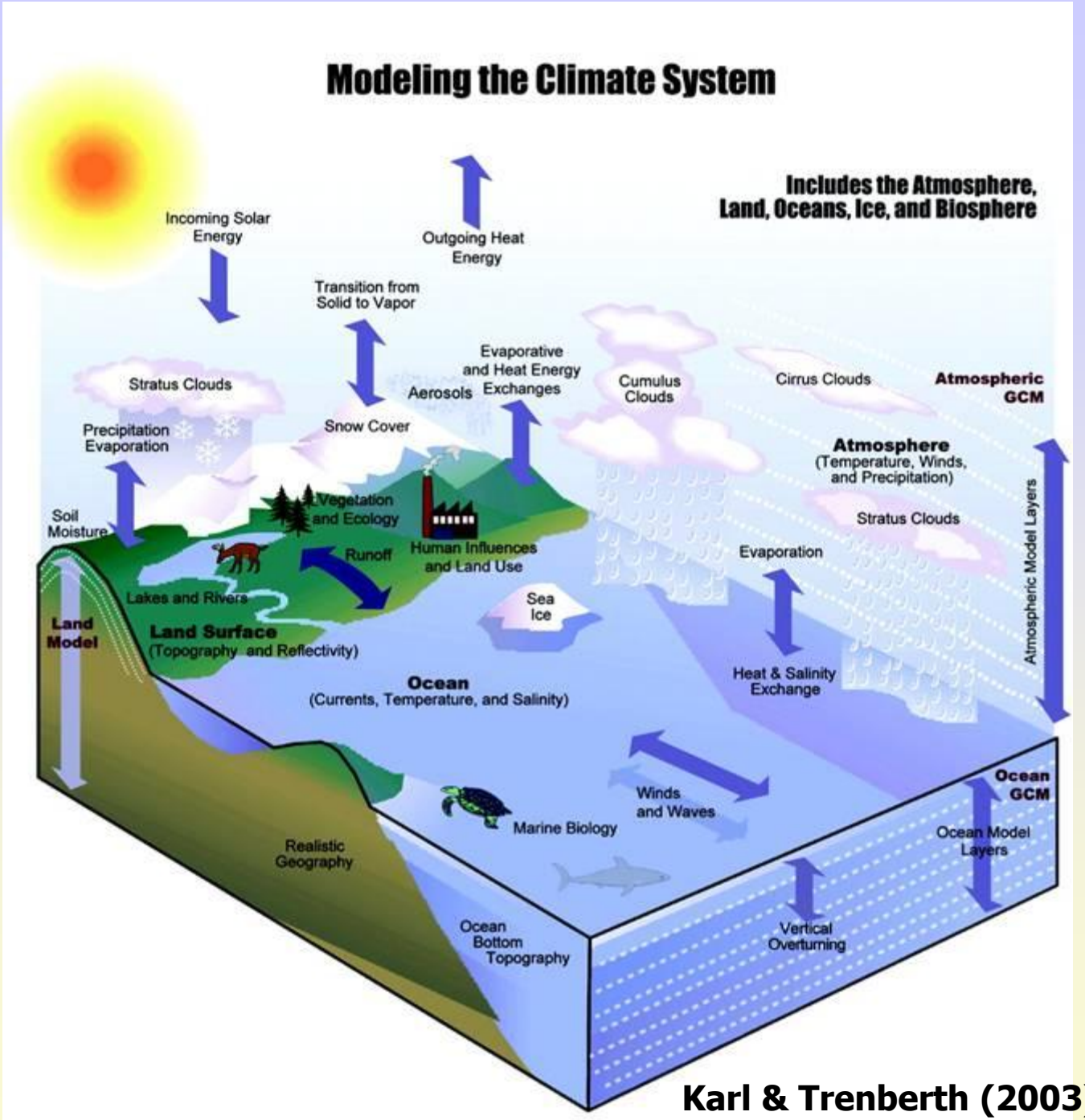
CO_2 Emissions Scenarios



CO_2 Concentrations

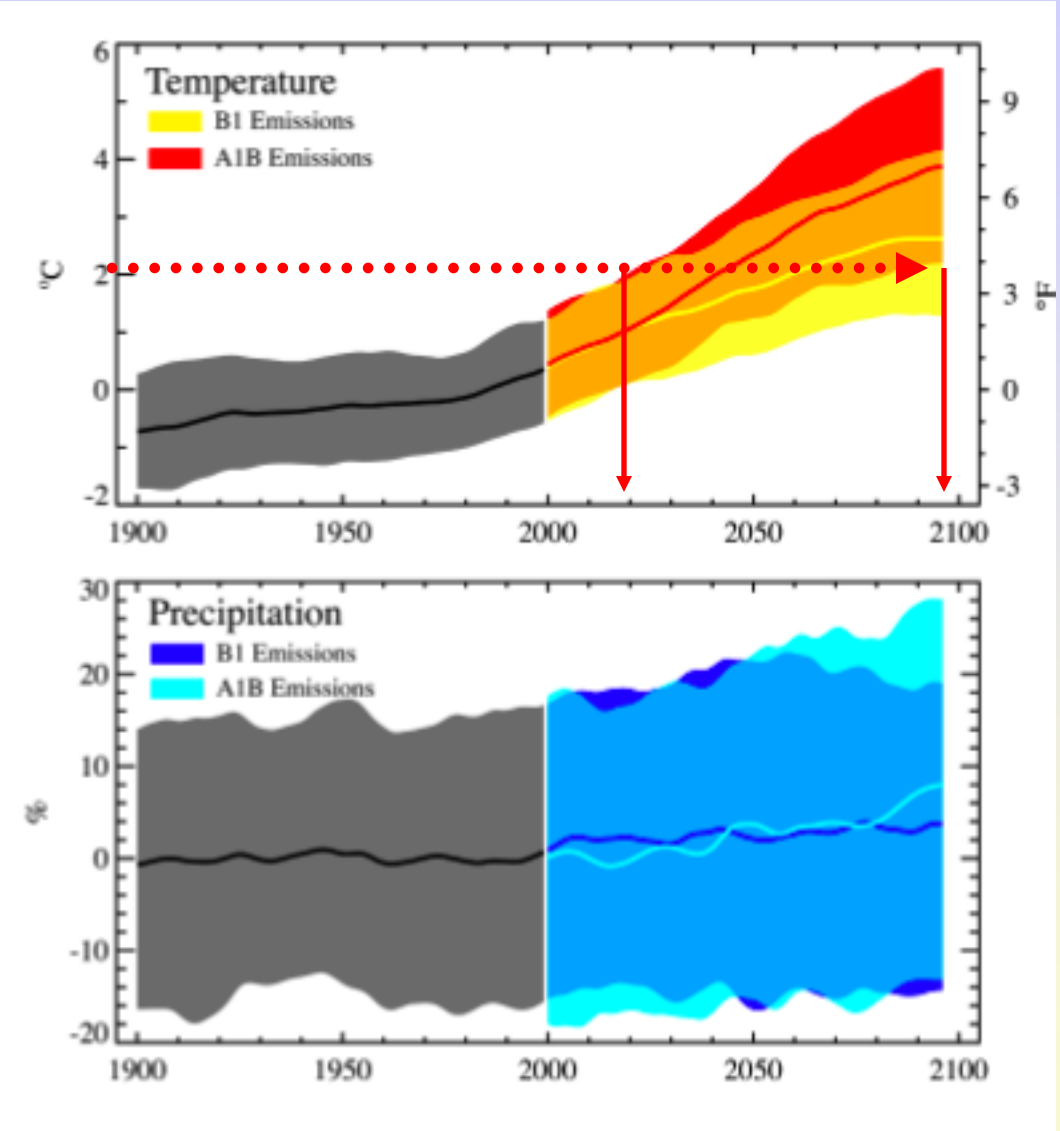


Estimates depend on population and economic projections, future choices for energy, governance/policy options in development (e.g., regional vs. global governance)



Karl & Trenberth (2003) Science

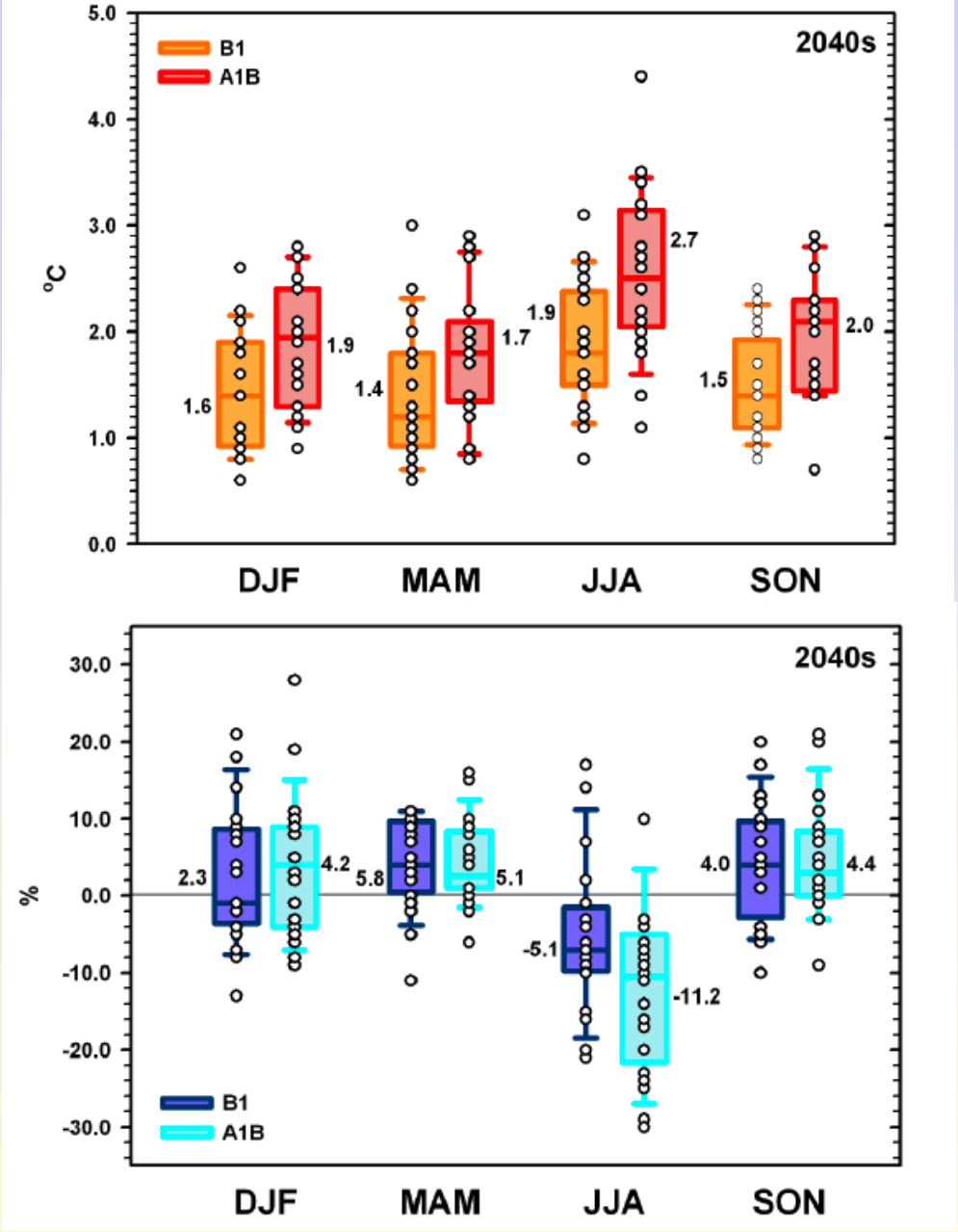
21st Century PNW Temperature and Precipitation Change Scenarios



- Projected changes in temperature are large compared to historic variability
- Changes in annual precipitation are generally small compared to past variations, but some models show large seasonal changes (most show ***wetter autumns and winters*** and ***drier summers***)

Mote and Salathé (2009): WACCIA

Climate Change Scenarios for the Pacific Northwest

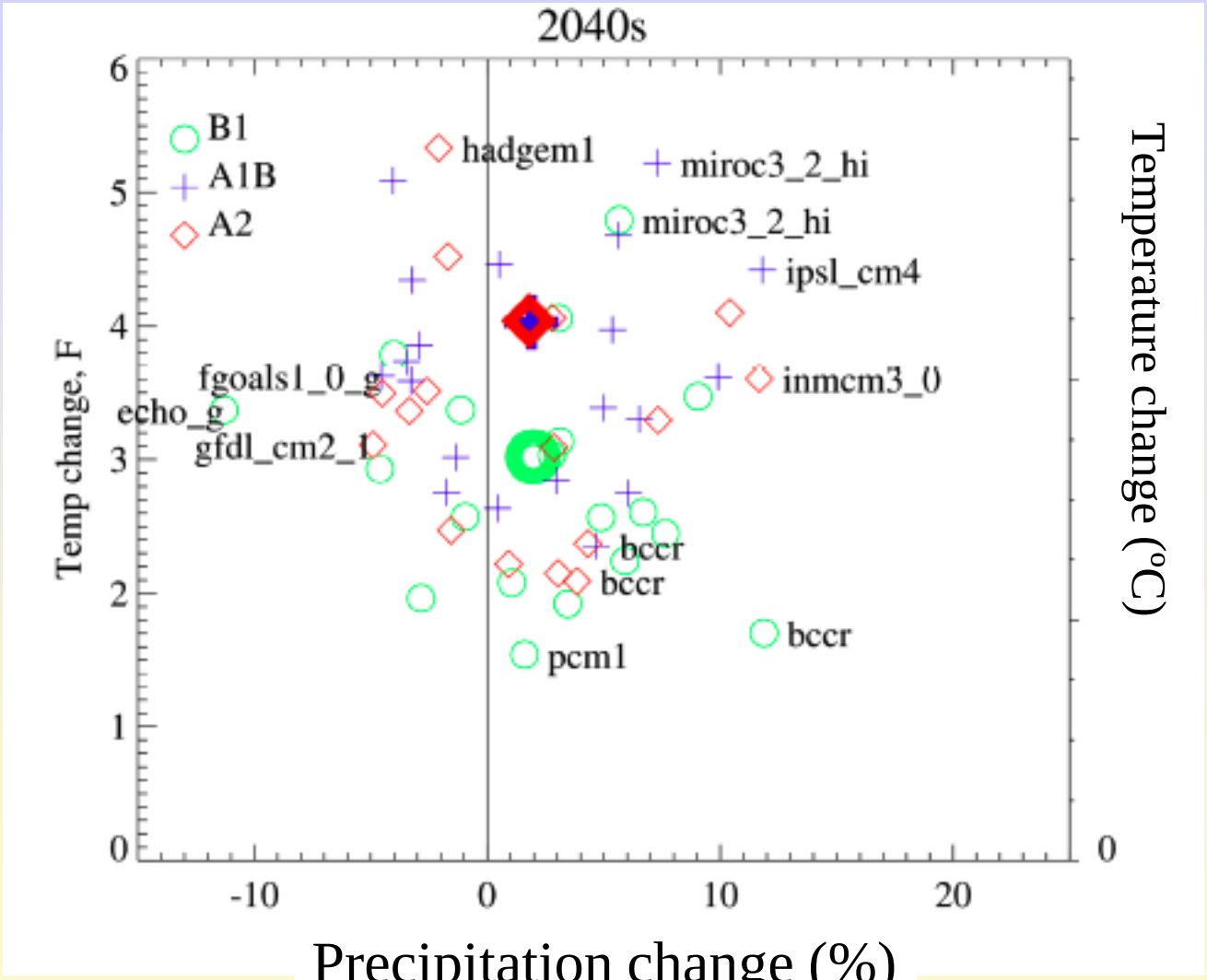


All of these scenarios show warming for the 2040s, but different scenarios warm at different rates

Most (not all) show increasing precipitation in winter, spring and fall, and decreasing precipitation in summer

Mote and Salathé (2009)

Climate model + emissions scenario combinations yield a range of temperature and precipitation change scenarios



21st century PNW climate scenarios relative to past variability

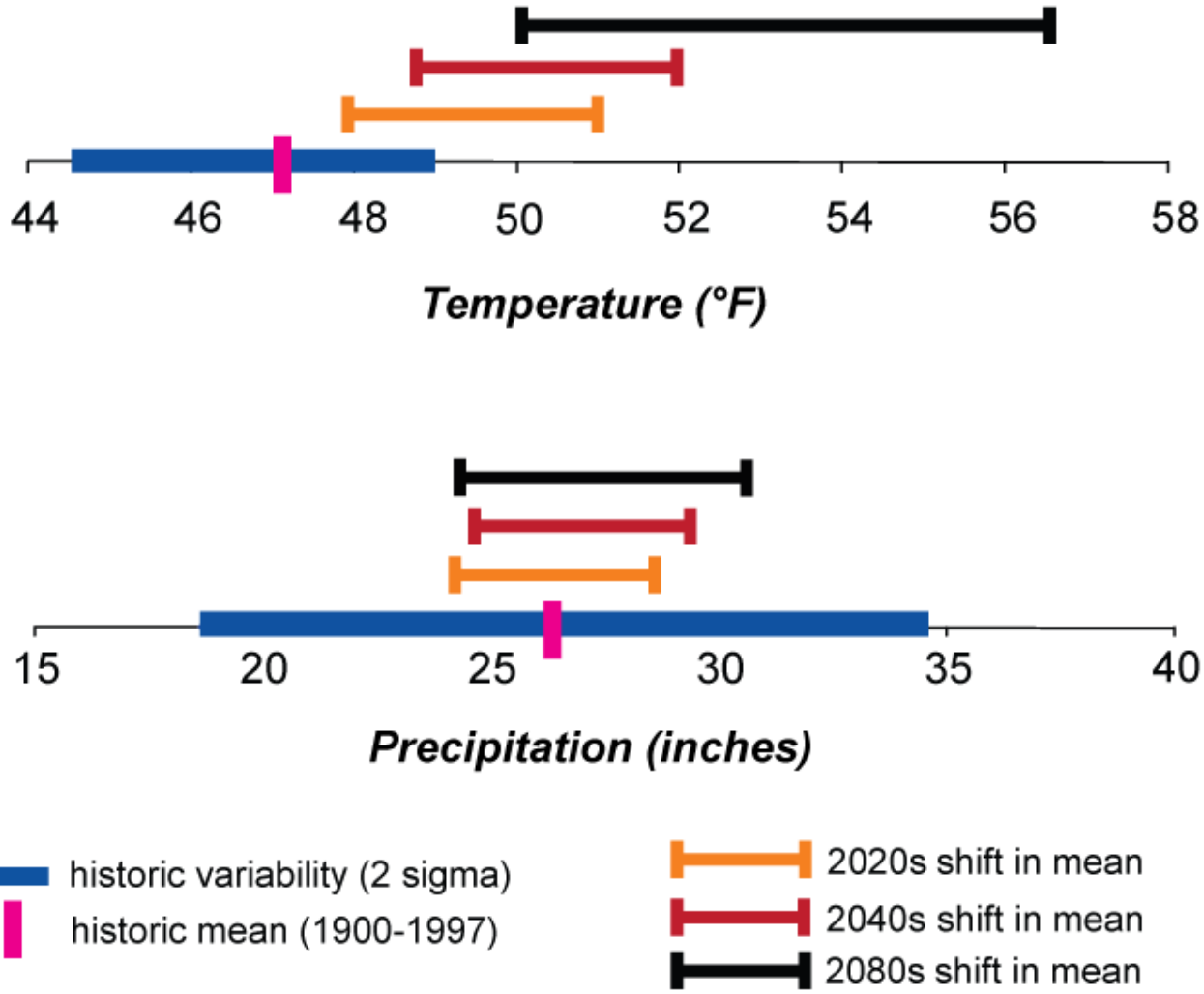
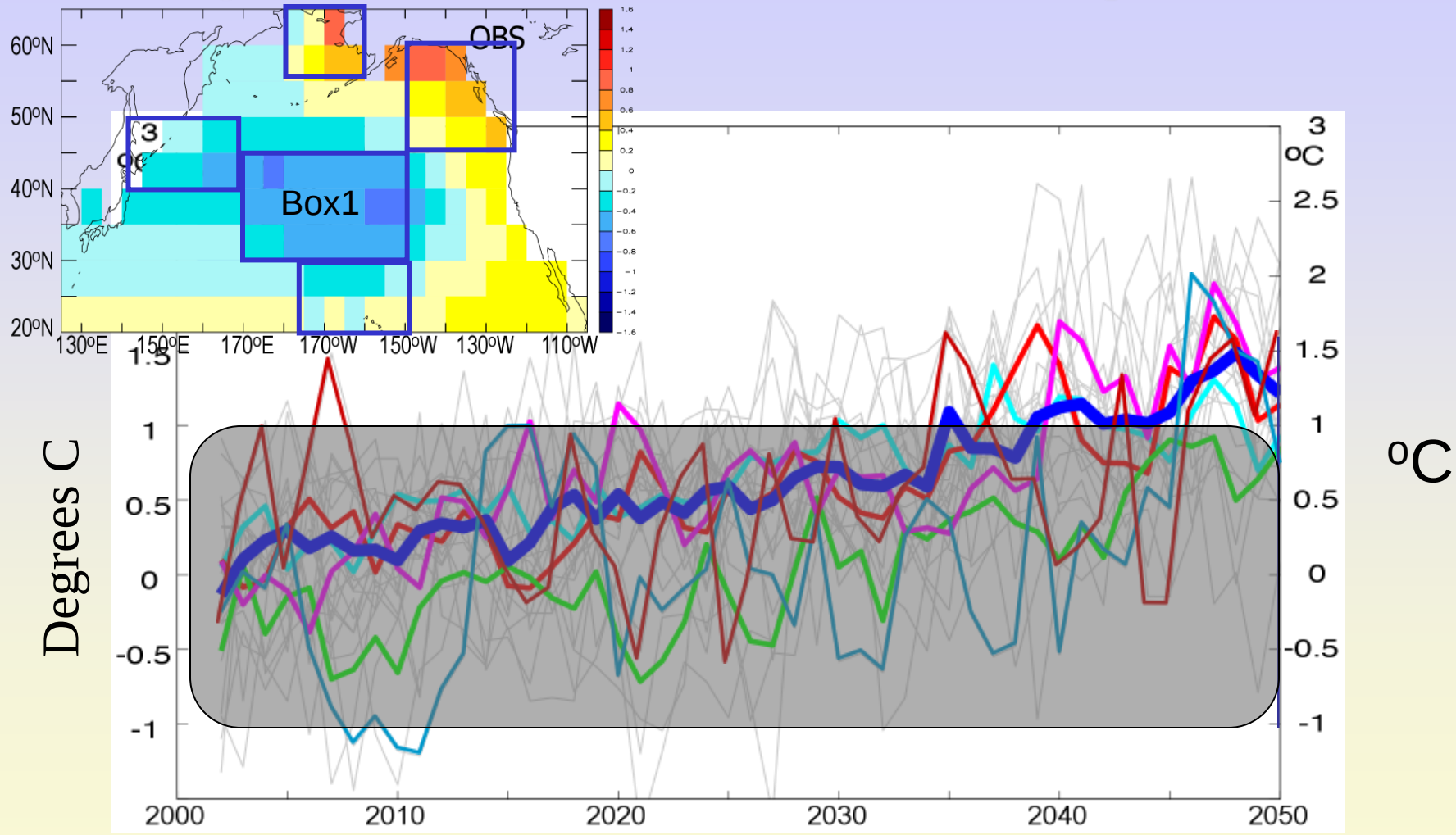


Figure source: Climate Impacts Group, University of Washington

Climate change and natural variations

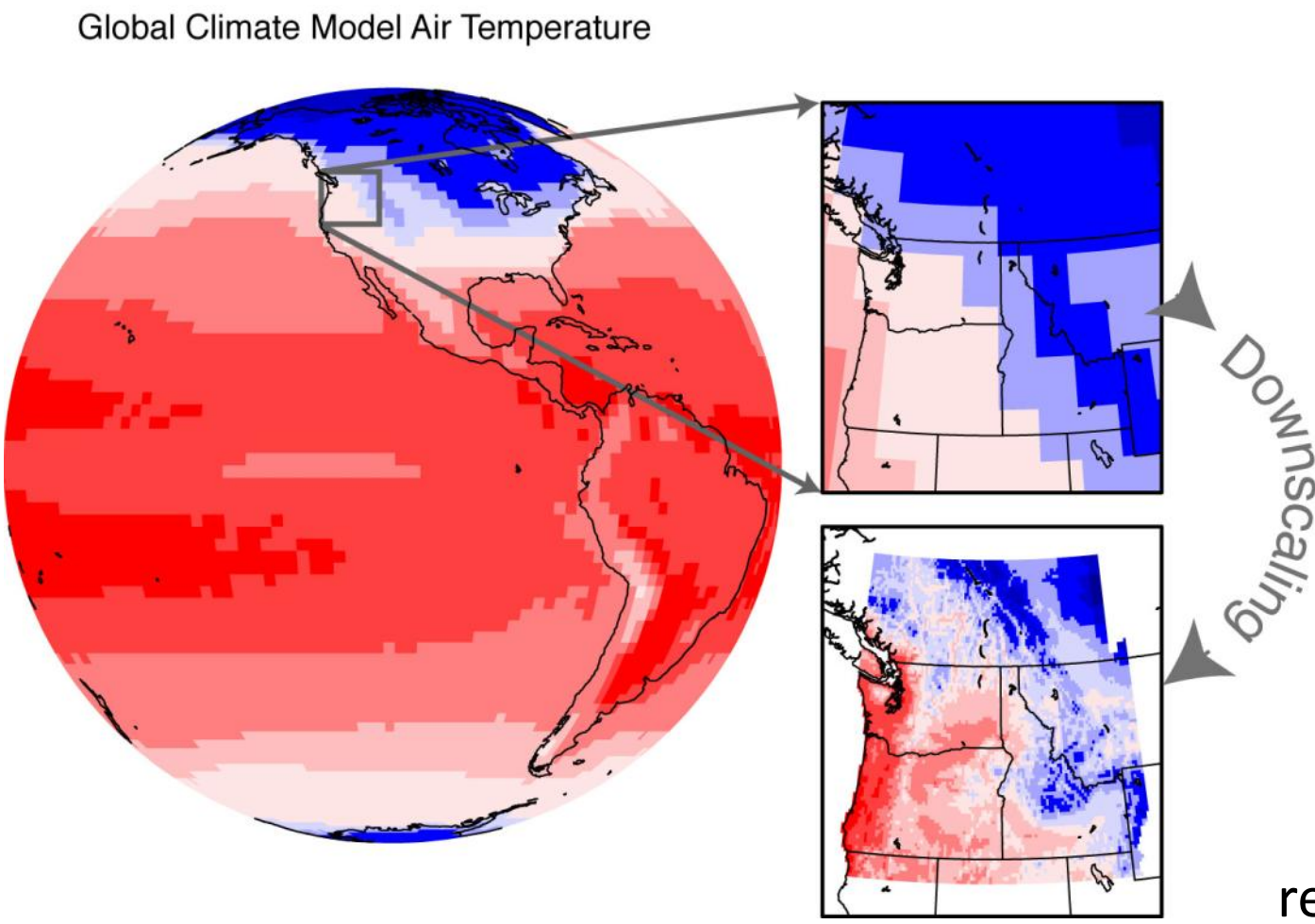
- Climate change may be manifest partly as a change in the relative frequency of natural variations (e.g., El Niños vs. La Niñas)
- Likely changes with ENSO are very uncertain
  - It currently isn't clear if ENSO will be stronger, weaker, or unchanged in a warmer future! (see Collins et al 2010, Nature Geosciences)

The future will not present itself in a simple, predictable way, as natural variations will still be important for climate change in any location



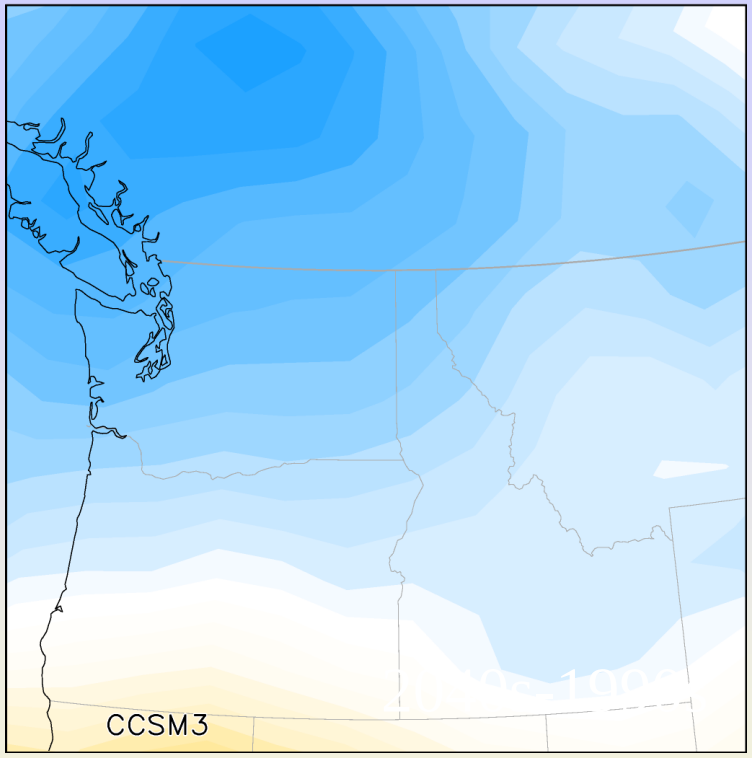
Overland and Wang *Eos Transactions* (2007)

Downscaling
Relates the “Large” to the “Small”

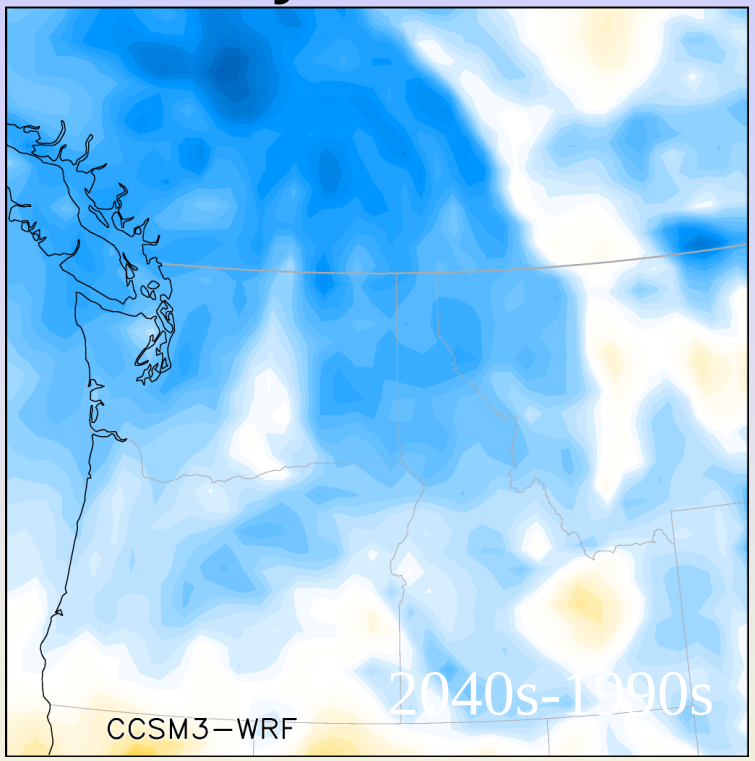


"Dynamical vs Statistical Downscaling" CCSM3

Statistical



Dynamical



Dynamical downscaling redistributes the precipitation changes from the global models in a more physically realistic way
(Salathè et al. 2010)

Some closing thoughts

- All climate model projections for the future will be wrong
  - Emissions scenarios are stories about what might happen; informing climate system models with these stories yields "**scenarios**", not **predictions**, for future climate
- There are good reasons for screening GCM scenarios, using weighted average ensembles, selecting specific methods for downscaling, and choosing specific tools for impacts assessments
- Even with all these careful steps, you still end up with **scenarios** about future climate