



© QT Luong / terragalleria.com

Mt Olympus at sunrise: <http://terragalleria.com>

# Northwest Climate Drivers

Nathan Mantua, Ph.D.

University of Washington

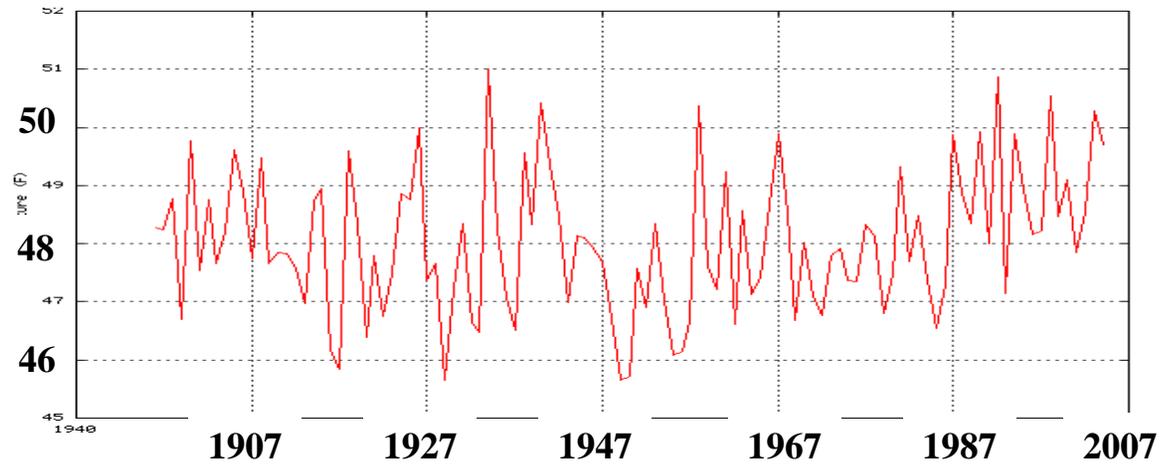
Climate Impacts Group

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

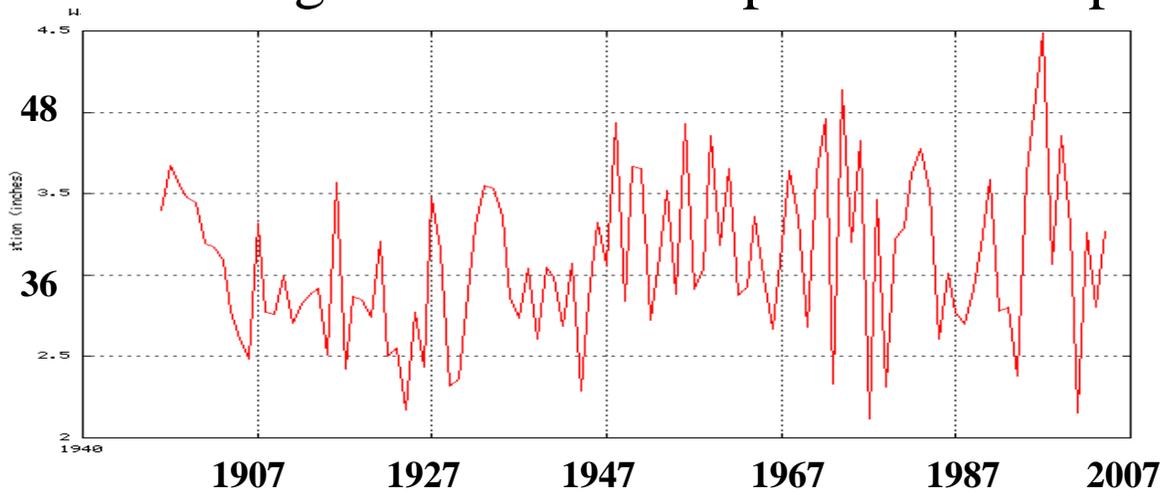
# PNW climate variability

1. What does our region's climate history tell us about "natural variability"?
2. How is climate variability experienced in the Pacific Northwest?
  - \* are there patterns within the region?
  - \* are there preferred frequencies of change (year to year, decade to decade, etc.)
3. Why does our climate vary?

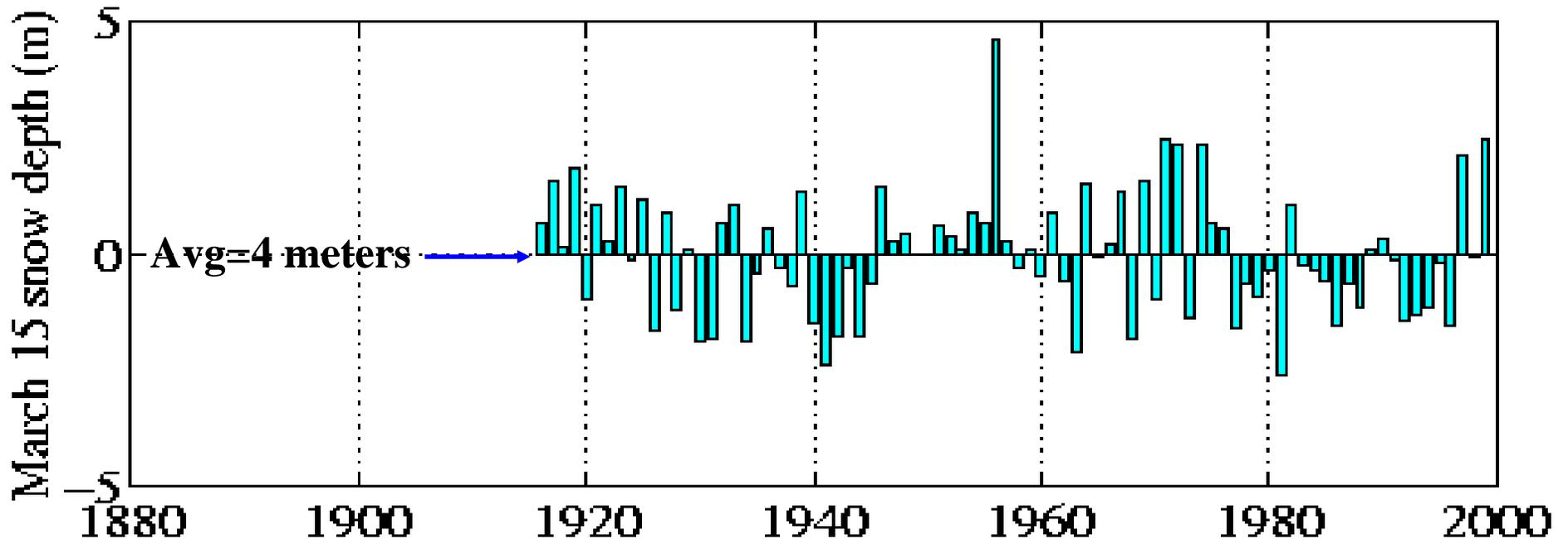
## Washington State Oct-Sept Average Temperature



## Washington State Oct-Sept Total Precip



# March 15 Snow depth anomalies at Paradise, Mt Rainier



**Avg ~ 4 meters (170 inches)**  
**January 5, 2005: 48 inches**  
**January 6, 2007: 130 inches**  
**February 10, 2008: 201 inches**

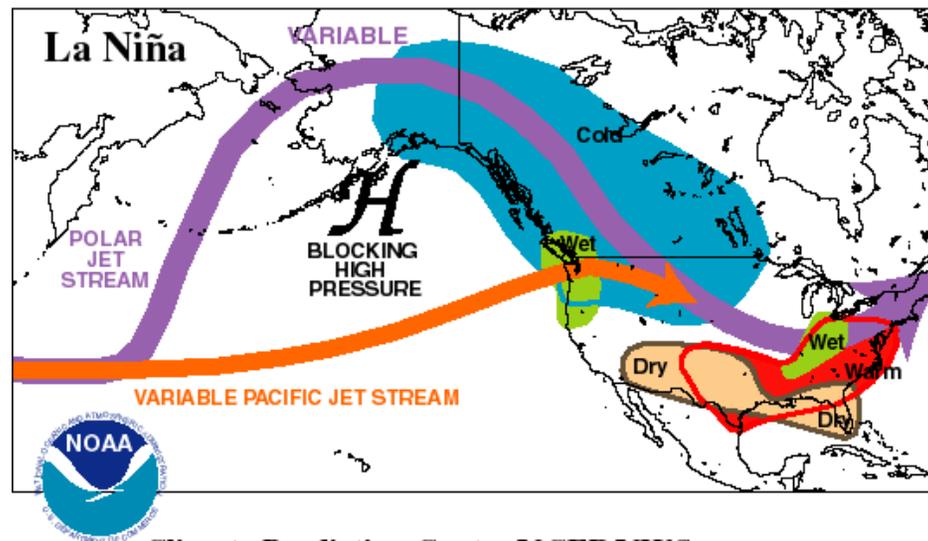
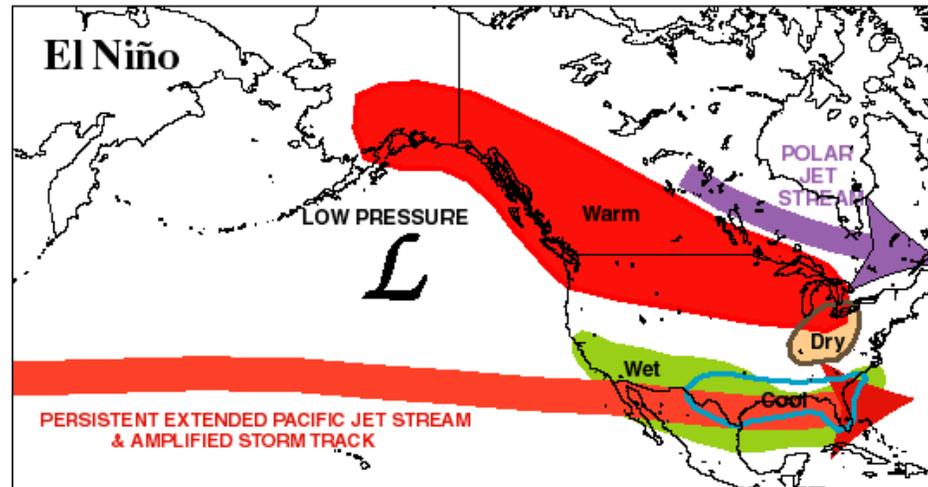
# Characteristics of variability?

- Lots of year-to-year variability in both halves of the year; longer-term variations
  - Multi-decadal “cycles” and century long trends
- temperatures and precipitation are more variable in cool season than in warm season

# NW Climate variability

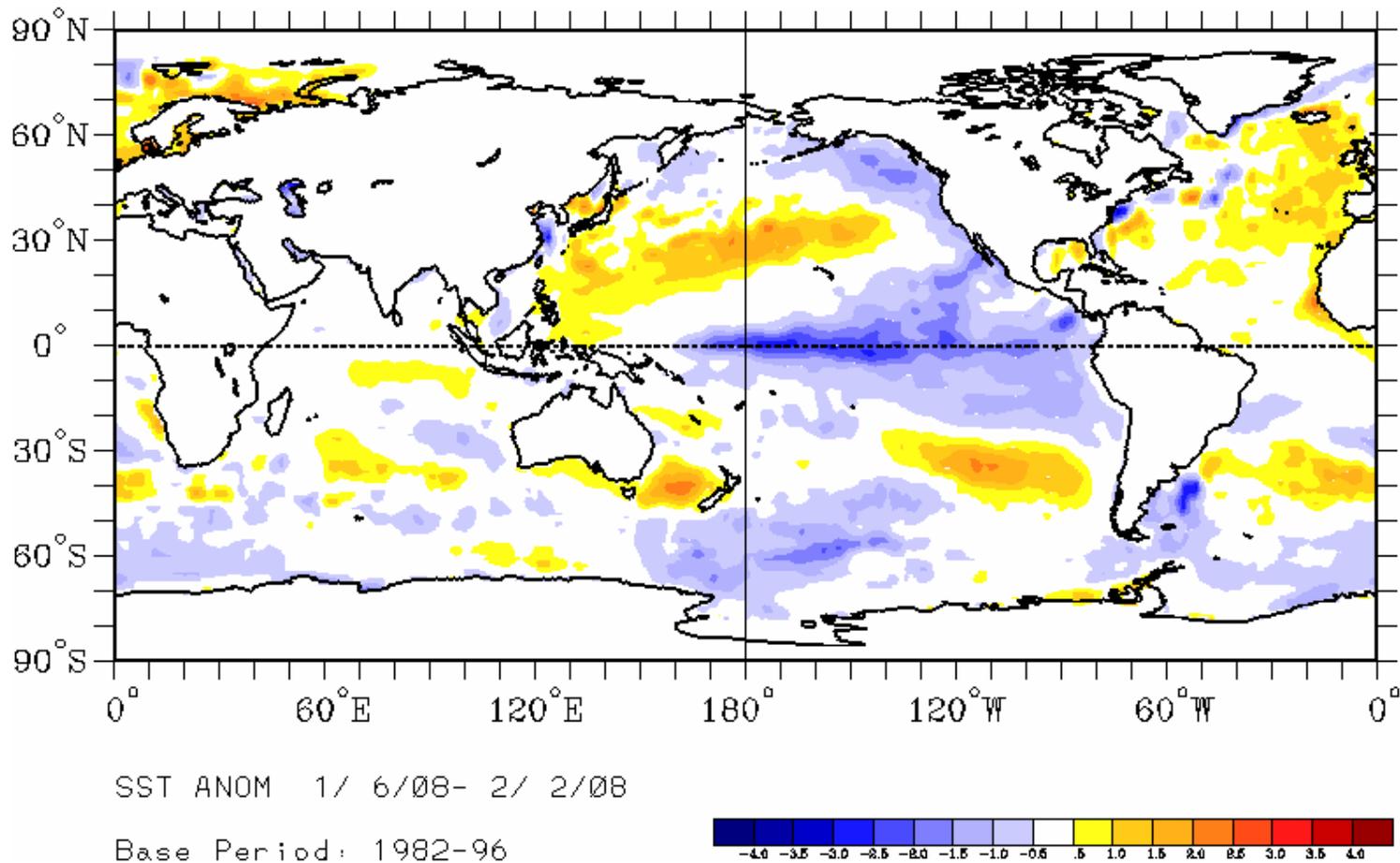
- Why the strong climate changes?
  - The chaotic nature of the climate system
  - big volcanic eruptions
  - natural patterns (like vibrations) of climate variability internal to the climate system:
    - **in the Pacific sector, changes in El Niño/La Niña (ENSO) and the Pacific Decadal Oscillation (PDO) are important factors**

**TYPICAL JANUARY-MARCH WEATHER ANOMALIES  
AND ATMOSPHERIC CIRCULATION  
DURING MODERATE TO STRONG  
EL NIÑO & LA NIÑA**



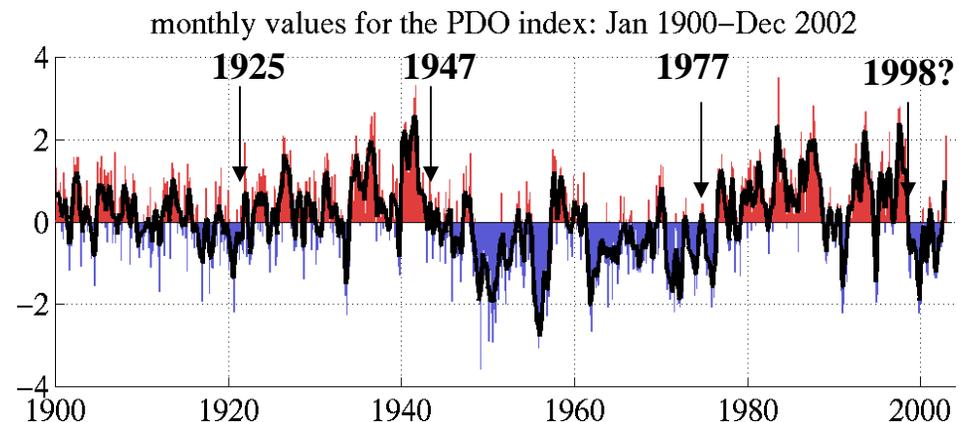
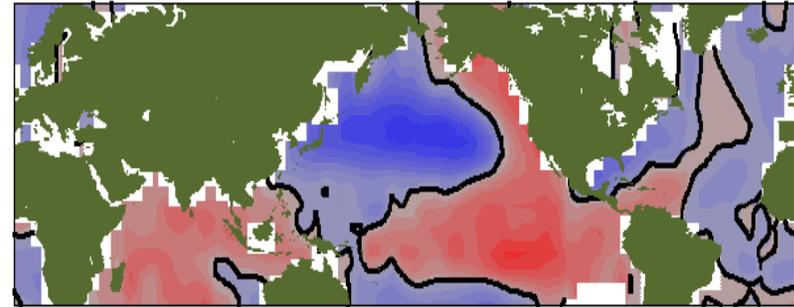
Climate Prediction Center/NCEP/NWS

# Recent ocean temperatures show the telltale signs of La Niña



# The Pacific Decadal Oscillation

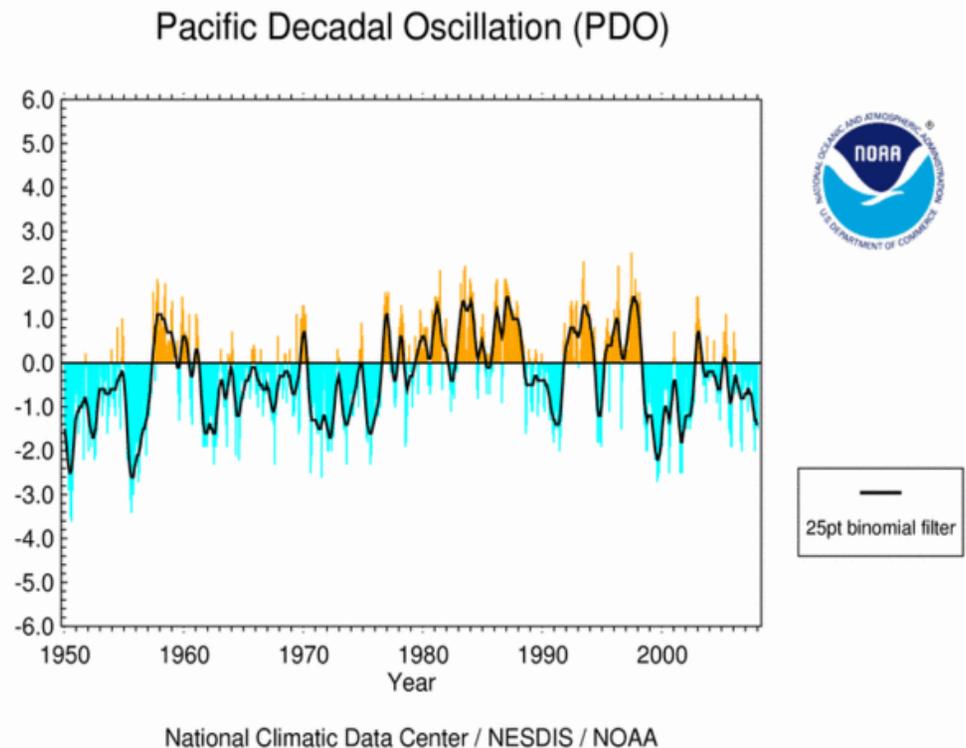
- an El Niño-like pattern of climate variability
- 20 to 30 year periods of persistence in North American and Pacific Basin climate
- warm extremes prevailed from 1925-46, and again from 1977-98; a prolonged cold era spanned 1947-76



Mantua et al. 1997, BAMS

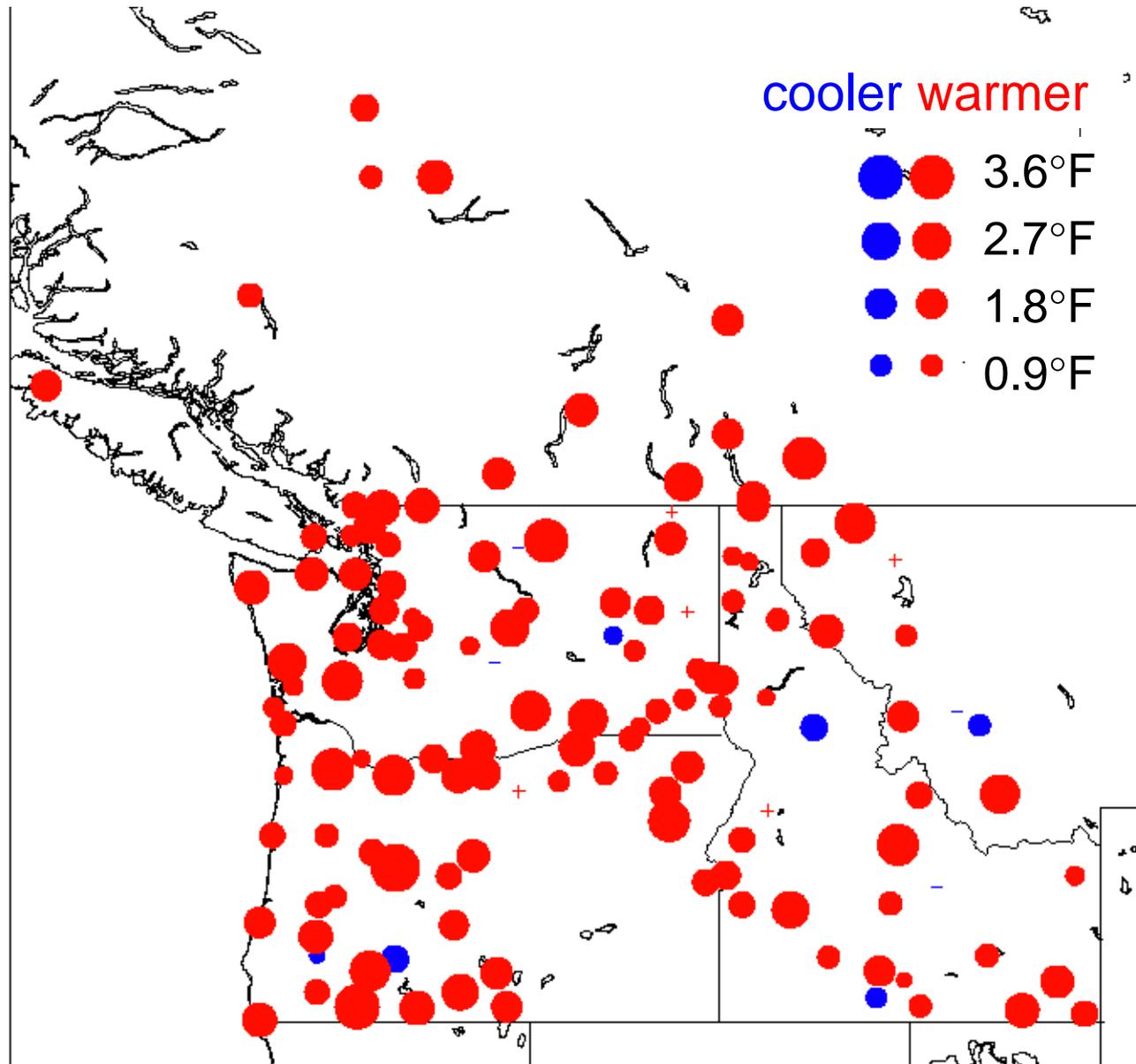
## Real time “nowcasts” of the PDO?

Because we don't know how the PDO works (key mechanisms for decadal patterns remain mysterious), we can't be sure that the SST pattern (and PDO index) is a good indicator for where we are with this pattern. Recent years have had a variable PDO index...

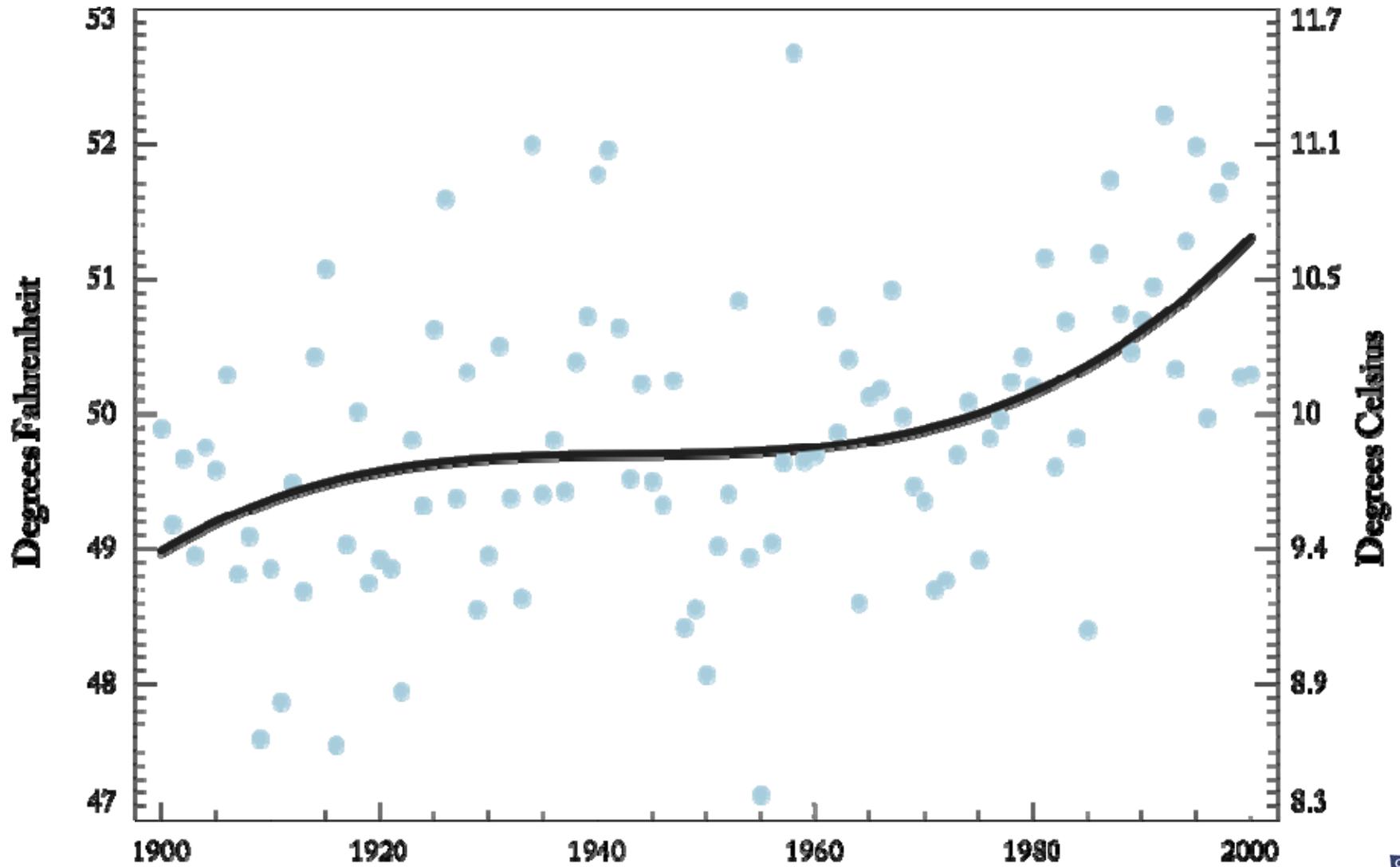


<http://www.ncdc.noaa.gov/img/climate/research/teleconnect/pdo-f-pg.gif>

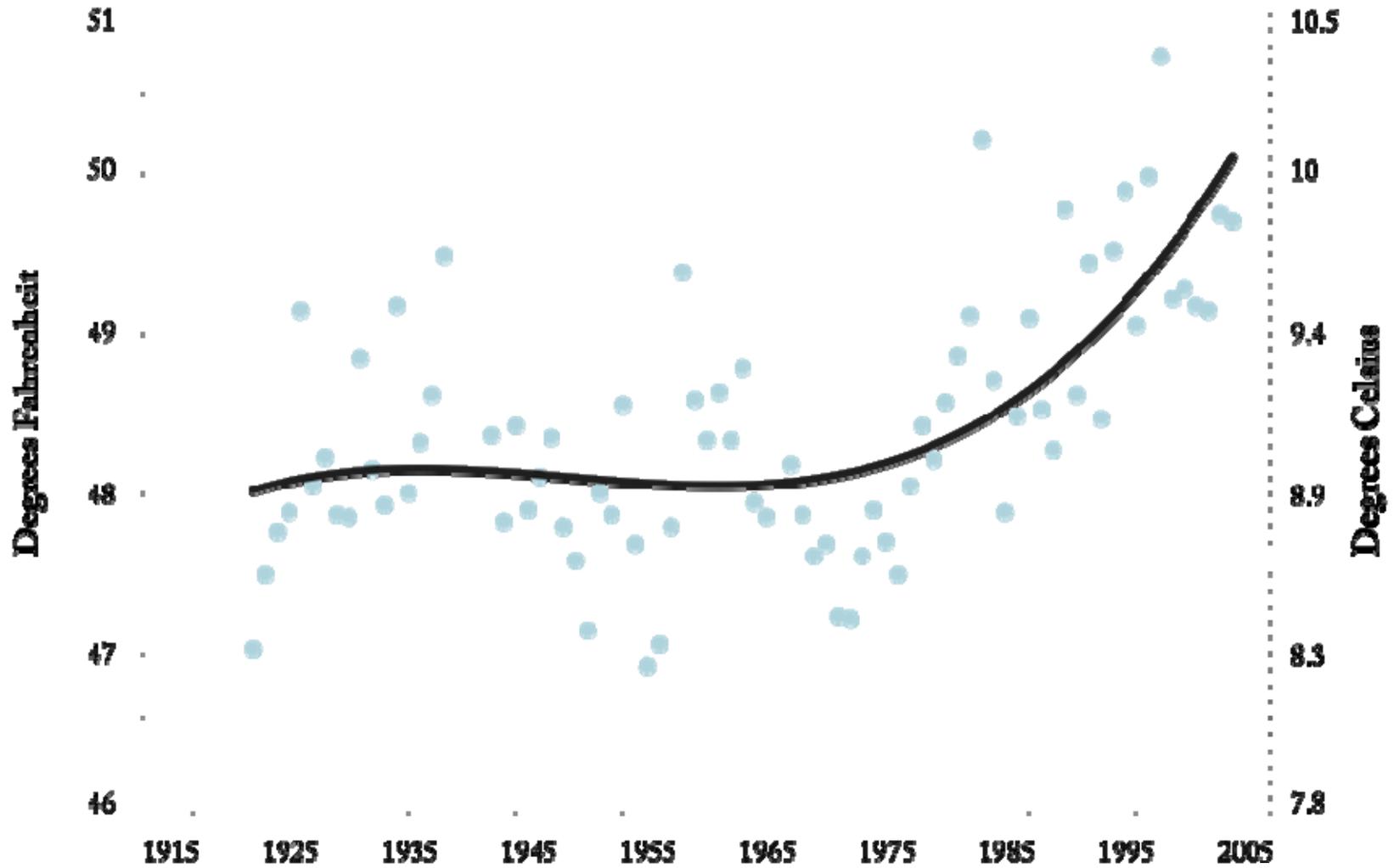
# Temperature trends (°F per century) since 1920



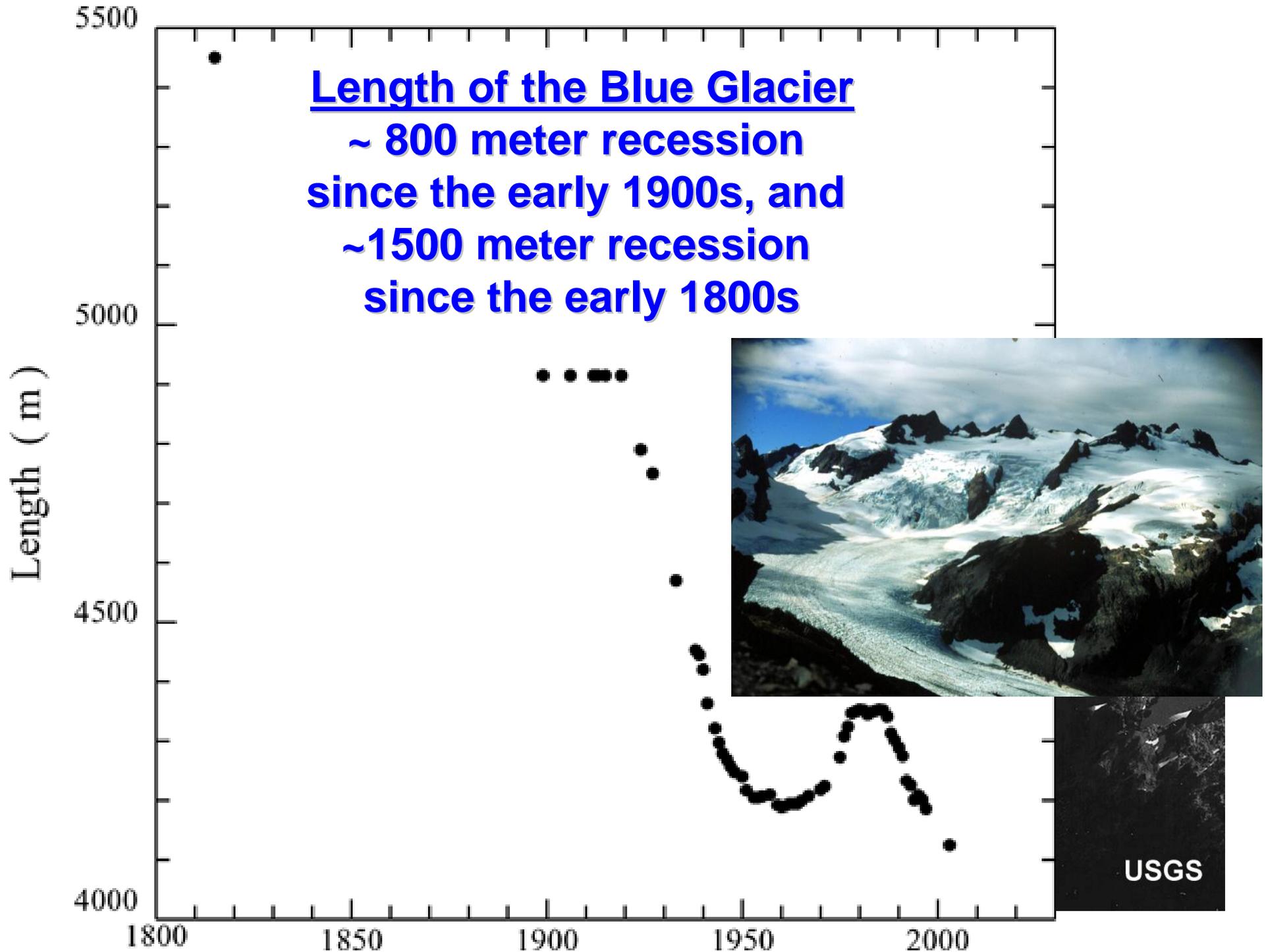
# Puget Sound Area Air Temperature



# Sea Surface Temperature (Race Rocks lighthouse, Victoria)



Length of the Blue Glacier  
~ 800 meter recession  
since the early 1900s, and  
~1500 meter recession  
since the early 1800s



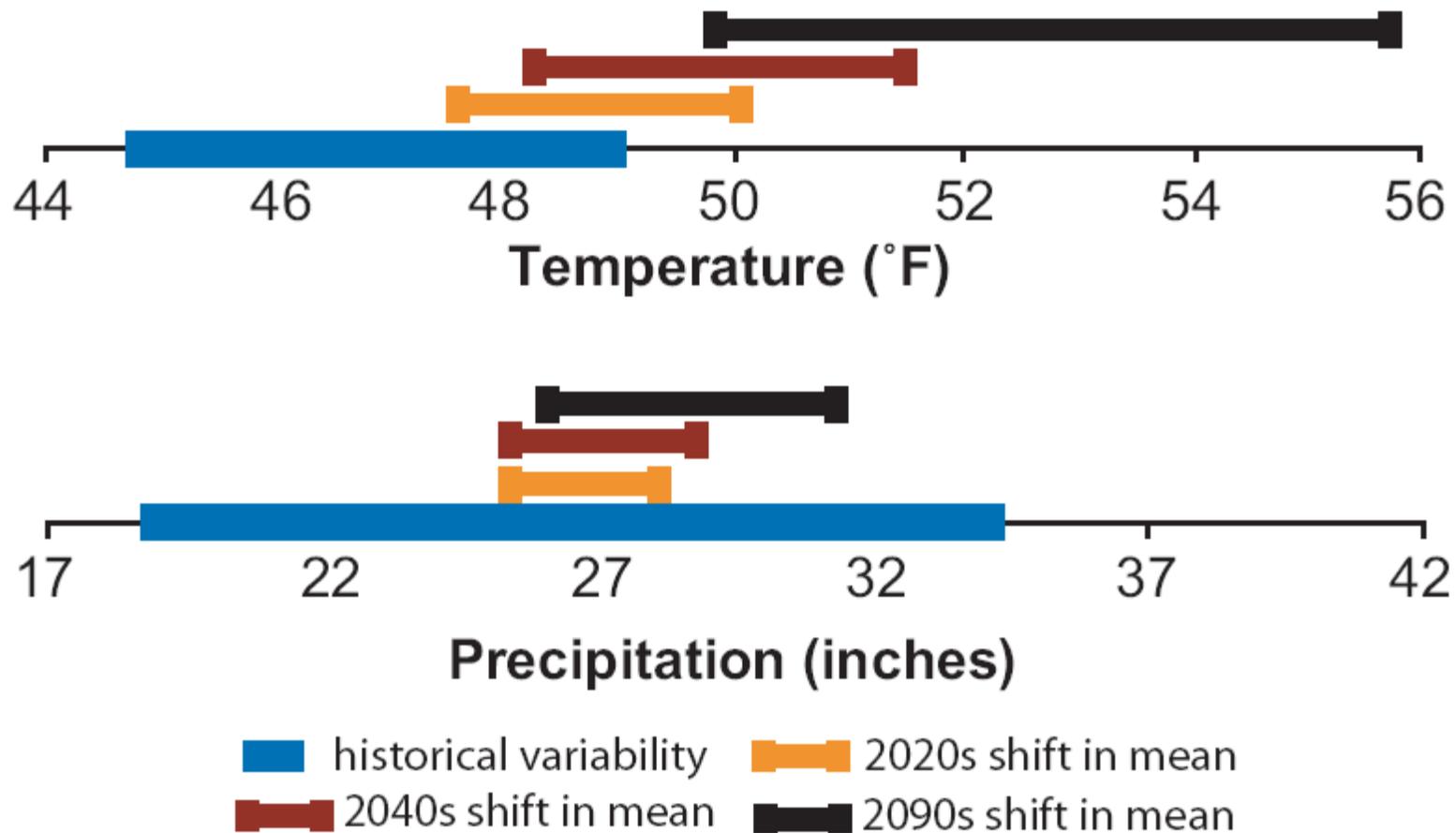
January 2053...

I DON'T CARE WHAT THEY SAY,  
THIS GLOBAL WARMING SCARE  
IS JUST A BUNCH OF LOONY  
LEFT-WING ENVIRONMENTALIST  
ANTI-GROWTH HYPE!

SO,  
IS THIS  
YOUR FIRST  
WINTER HERE  
ON WHIDBEY  
ISLAND?

HORSEY  
© 2003  
All rights reserved.  
No part of this  
comic may be  
reproduced  
without  
written  
permission  
from  
Horsey





## Comparison of observed year-to-year variability and projected shifts in temperature and precipitation from climate models

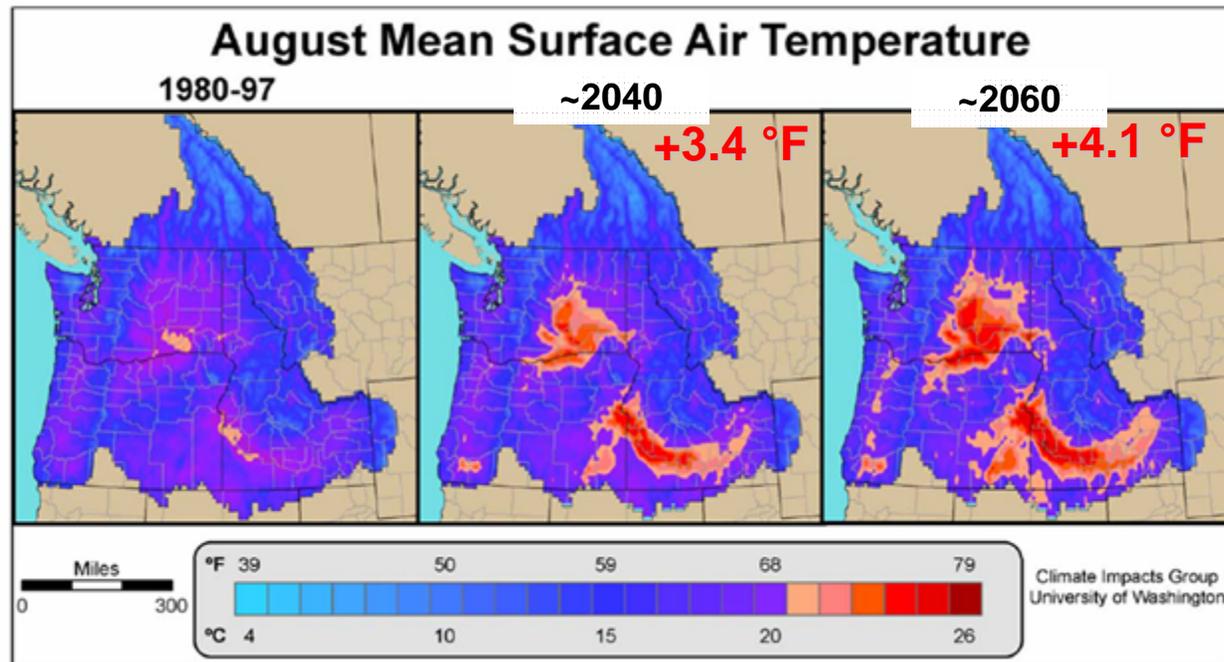
# PNW sea level rise - Mote et al 2008

SLR Estimate	Components	2050			2100		
		<u>NW Olympic Peninsula</u>	<u>Central &amp; Southern Coast</u>	<u>Puget Sound</u>	<u>NW Olympic Peninsula</u>	<u>Central &amp; Southern Coast</u>	<u>Puget Sound</u>
Very Low	Global SLR	9 cm			18 cm		
	Atm. Dynamics	-1 cm			- 2 cm		
	VLM	-20 cm	- 5cm	0 cm	- 40 cm	-10 cm	0 cm
	<b>Total</b>	<b>-12 cm (-5")</b>	<b>3 cm (1")</b>	<b>8 cm (3")</b>	<b>-24 cm (-9")</b>	<b>6 cm (2")</b>	<b>16 cm (6")</b>
Medium	Global SLR	15 cm			34 cm		
	Atm. Dynamics	0 cm			0 cm		
	VLM	- 15 cm	- 2.5 cm	0 cm	-30 cm	- 5 cm	0 cm
	<b>Total</b>	<b>0 cm (0")</b>	<b>12.5 cm (5")</b>	<b>15 cm (6")</b>	<b>4 cm (2")</b>	<b>29 cm (11")</b>	<b>34 cm (13")</b>
Very High	Global SLR	38 cm			93 cm		
	Atm. Dynamics	7 cm			15 cm		
	VLM	-10 cm	0 cm	10 cm	- 20 cm	0 cm	20 cm
	<b>Total</b>	<b>35 cm (14")</b>	<b>45 cm (18")</b>	<b>55 cm (22")</b>	<b>88 cm (35")</b>	<b>108 cm (43")</b>	<b>128 cm (50")</b>

# Temperature thresholds for coldwater fish in freshwater

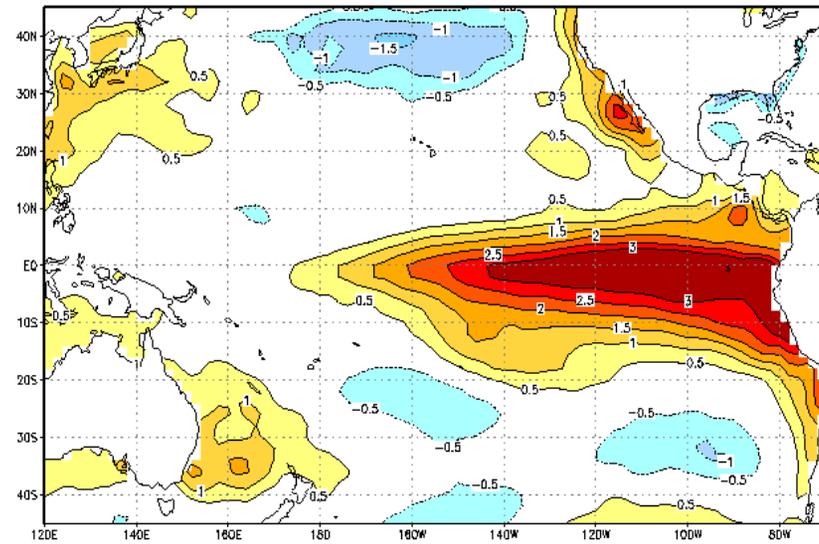
- Warming temperatures will increasingly stress coldwater fish in the warmest parts of our region

A monthly average temperature of 68°F (20°C) has been used as an upper limit for resident cold water fish habitat, and is known to stress Pacific salmon during periods of freshwater migration, spawning, and rearing.



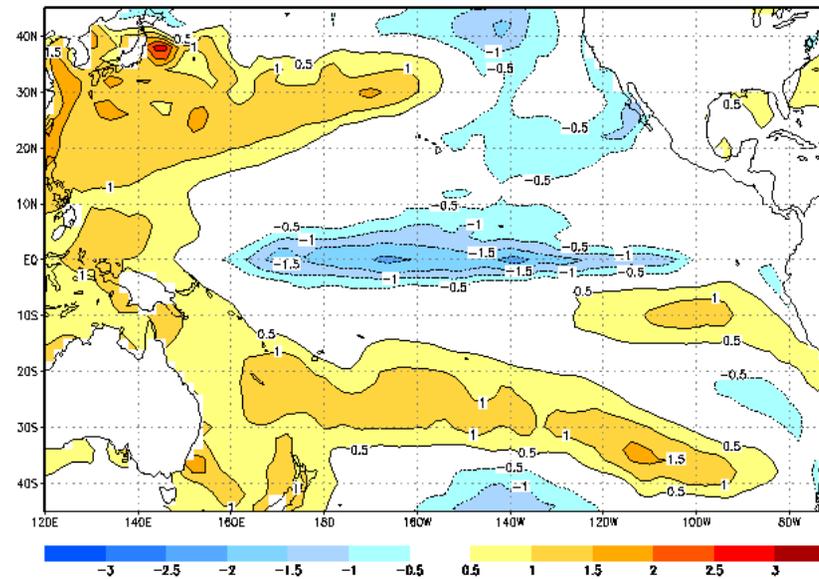
**Oct 97-Mar 98:**  
**El Niño**

Oct 97 – Mar 98 SST anomalies



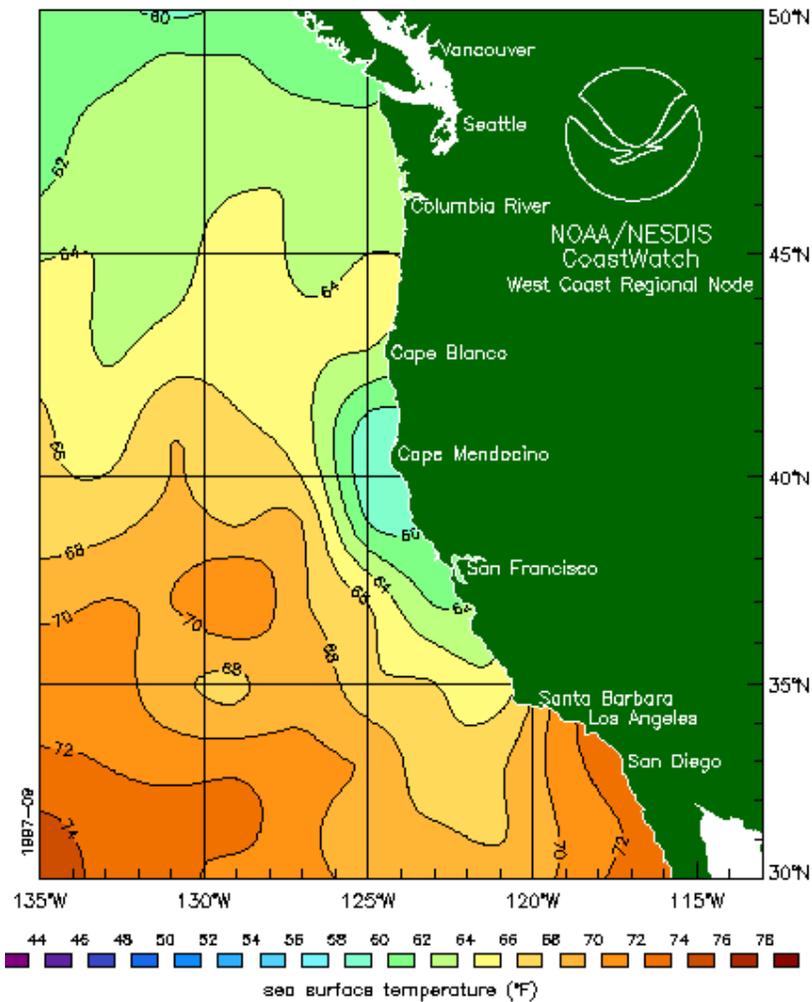
**Oct 98-Mar 99:**  
**La Niña**

Oct 98 – Mar 99 SST anomalies

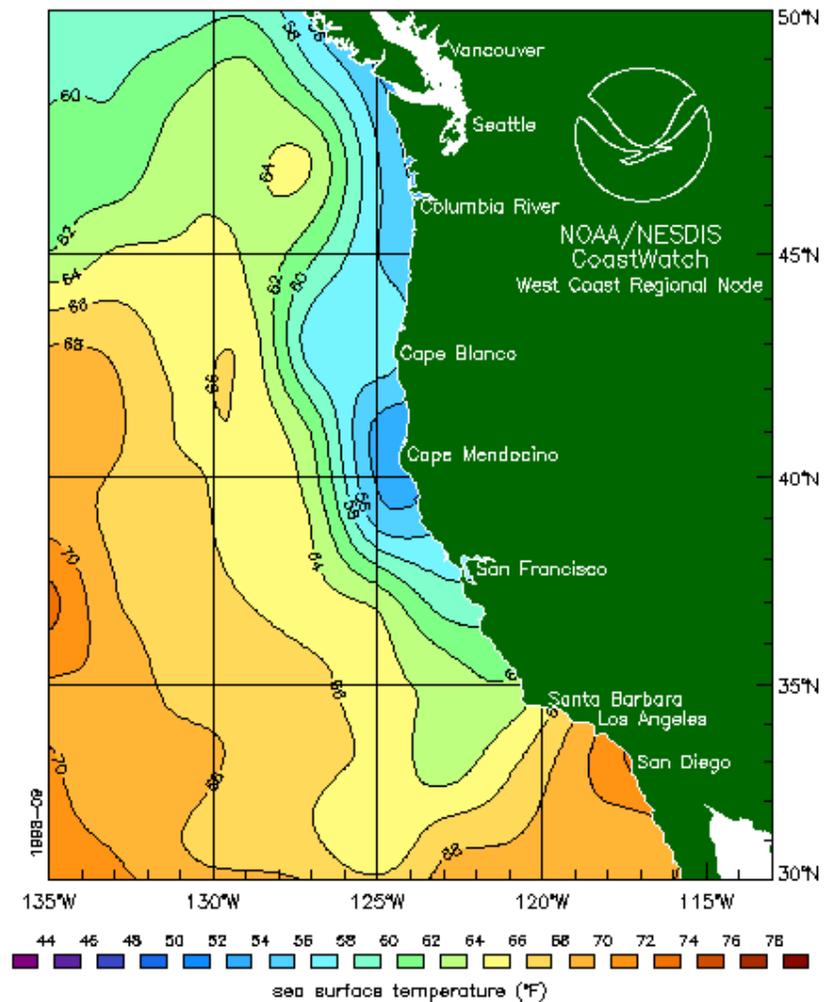


West-coast sub-arctic “upwelling” habitat is extremely dynamic and sensitive to changing wind patterns

*Sept 1997 El Niño*

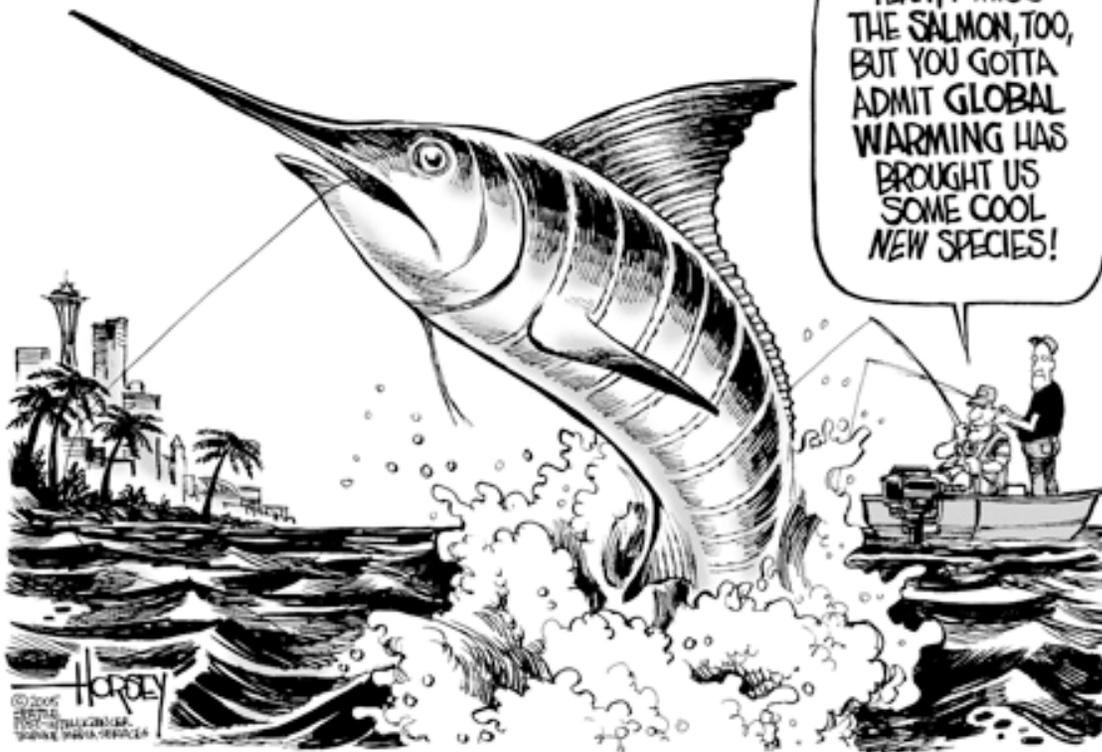


*Sept 1998 La Niña*



# In the ocean, species distributions change with temperature

Puget Sound, 2045...



134 lb marlin caught 40 mi. west of Westport, WA, Sept 2, 2005

Photo obtained from the Seattle Times web-archives

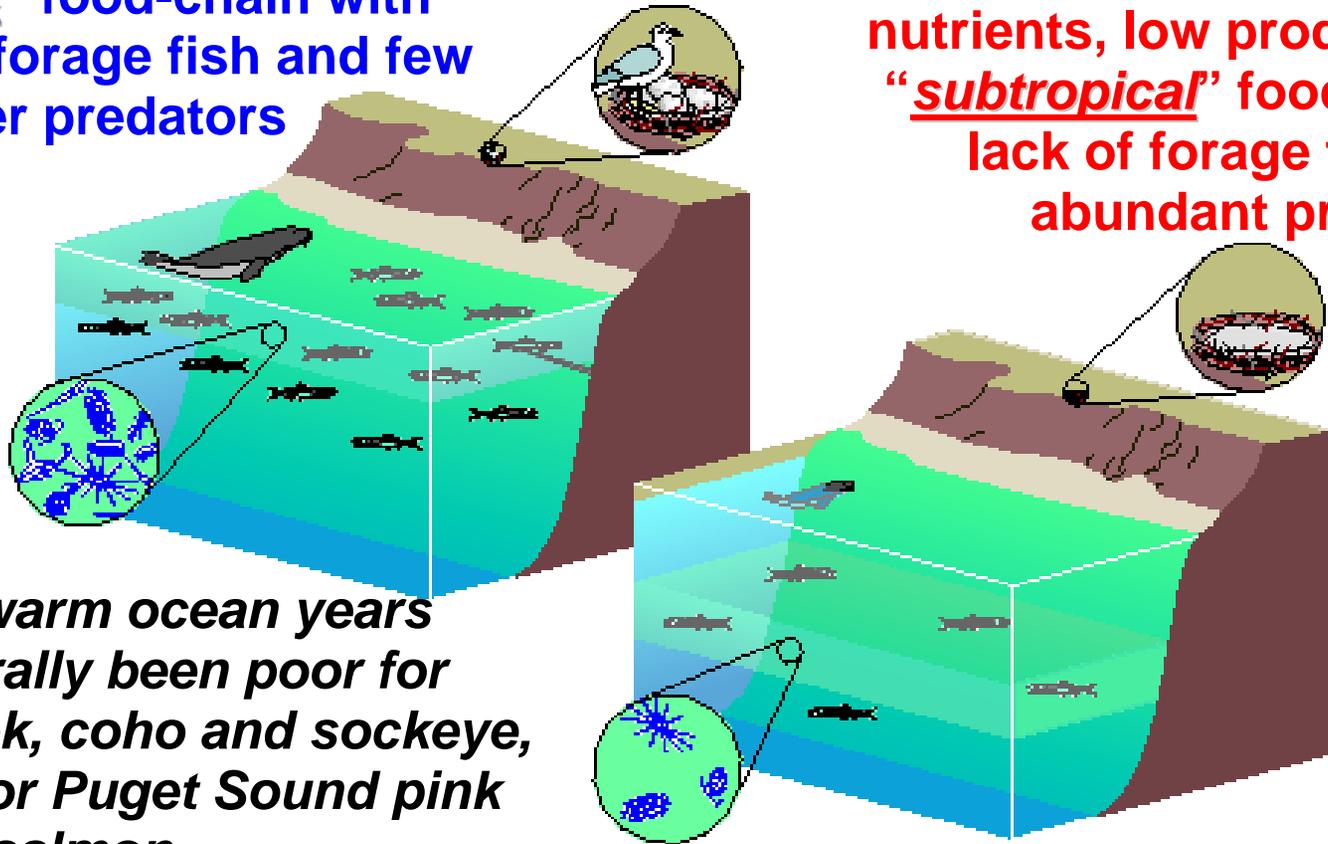
From the Seattle Post-Intelligencer, October 20, 2005

# Upwelling food webs in our coastal ocean

Cool water, weak stratification  
high nutrients, a productive  
“subarctic” food-chain with  
abundant forage fish and few  
warm water predators

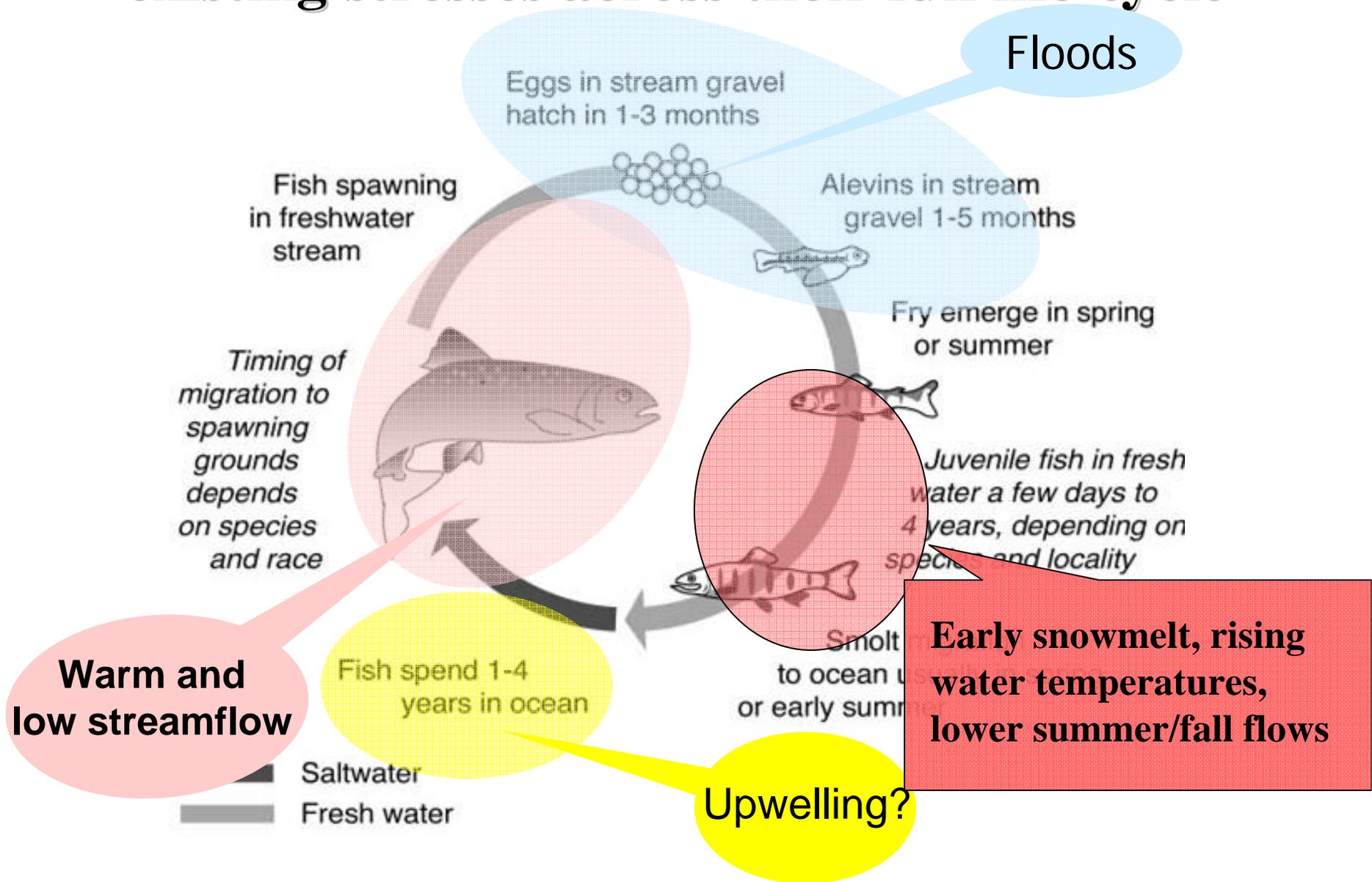


Warm stratified ocean, few  
nutrients, low productivity  
“subtropical” food web, a  
lack of forage fish and  
abundant predators



*Recently, warm ocean years  
have generally been poor for  
NW chinook, coho and sockeye,  
but good for Puget Sound pink  
and chum salmon.*

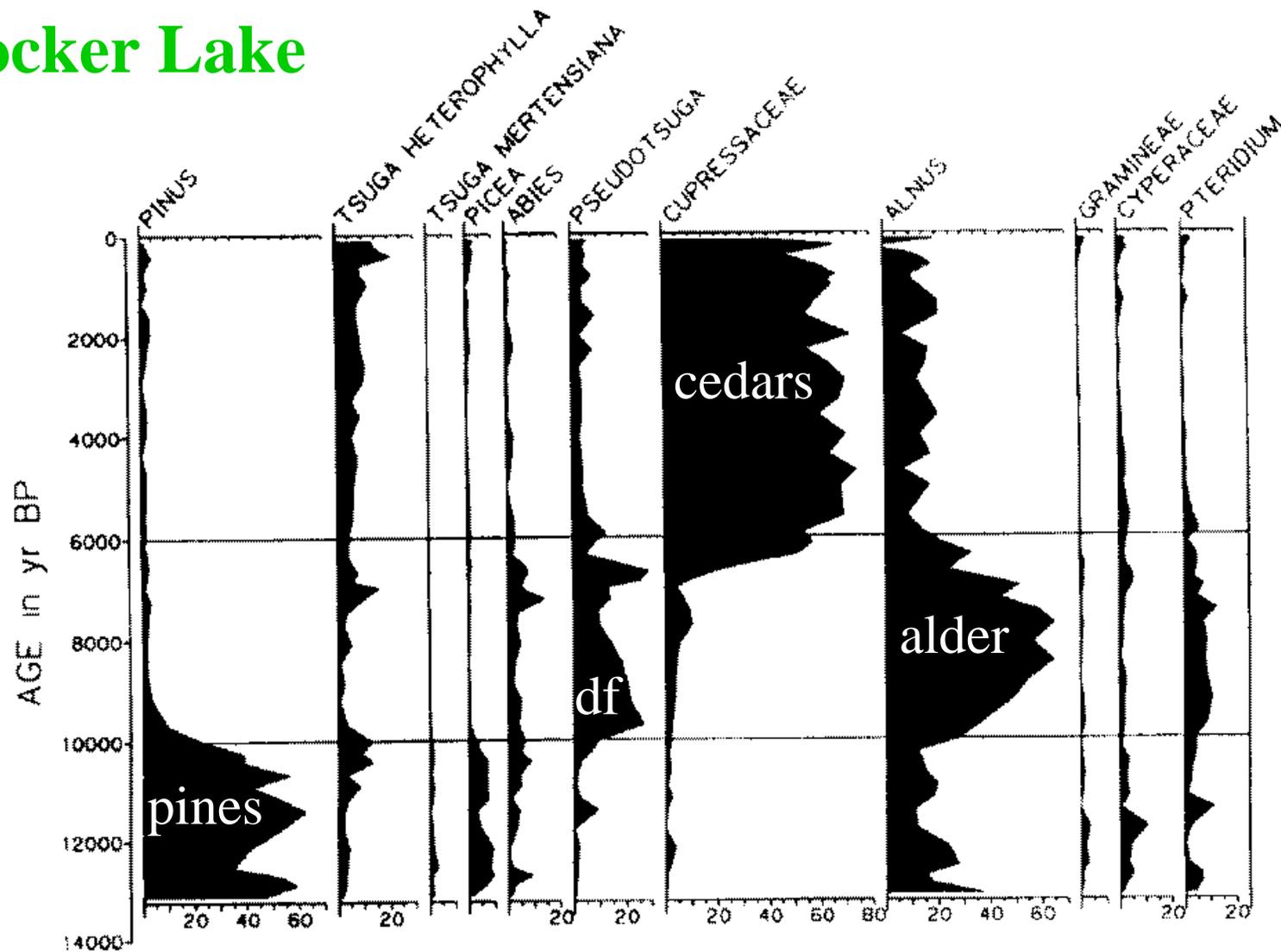
# Climate impacts on salmon must be added to existing stresses across their full life-cycle



# Recommended Reading

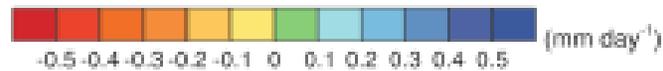
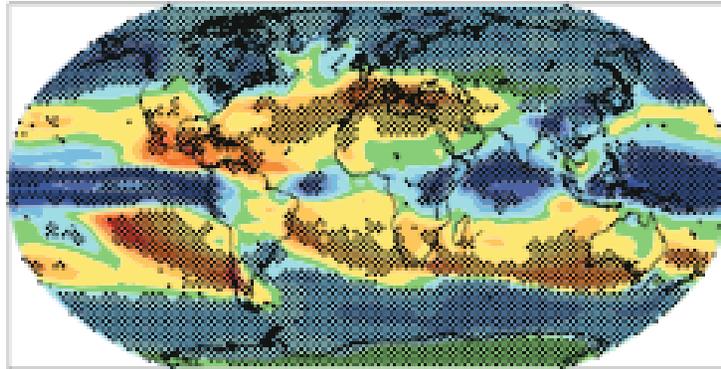
- Climate Solutions: actions to slow global warming
  - *<http://climatesolutions.org>*
- The Intergovernmental Panel on Climate Change
  - *<http://www.ipcc.ch>*
- The UW Climate Impacts Group
  - *<http://cses.washington.edu/cig>*
- RealClimate -- a “no spin zone” on climate science
  - *<http://realclimate.org>*

# Pollen records on the Olympic Peninsula Crocker Lake

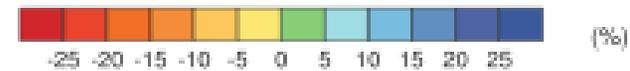
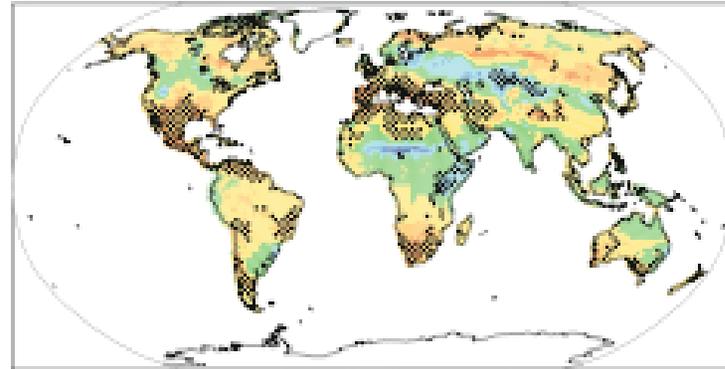


McLachlan, J. S. and L. B. Brubaker. 1995 Local and regional vegetation change on the northeastern Olympic Peninsula during the Holocene. *Canadian J. of Botany*.

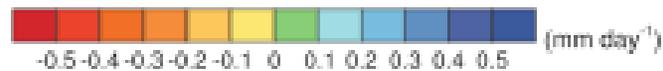
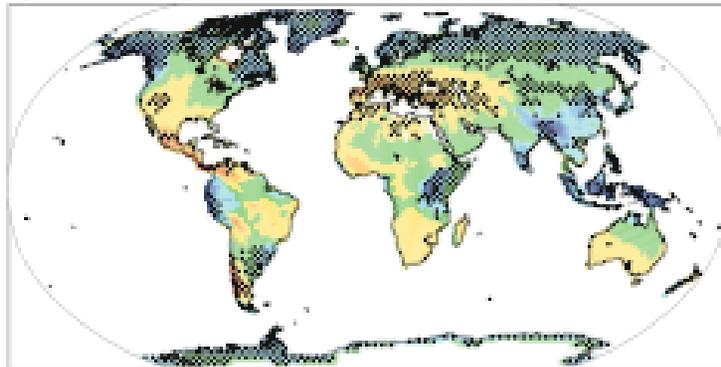
a) Precipitation



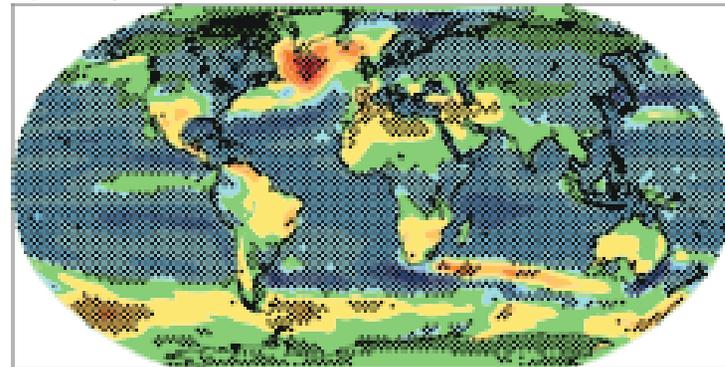
b) Soil moisture



c) Runoff

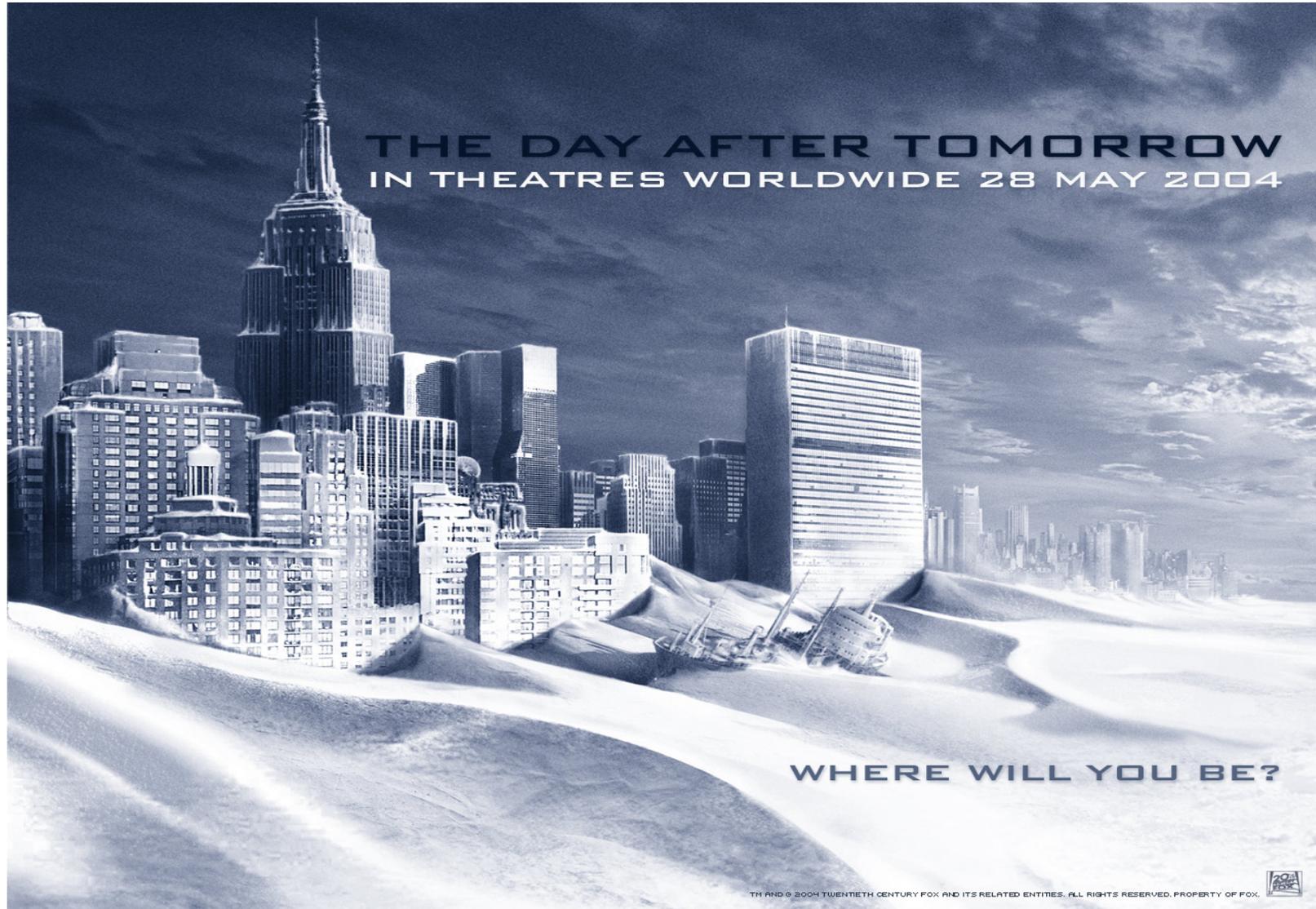


d) Evaporation



- Large regions of the dry subtropics become dryer, while wetter high latitude regions become wetter still

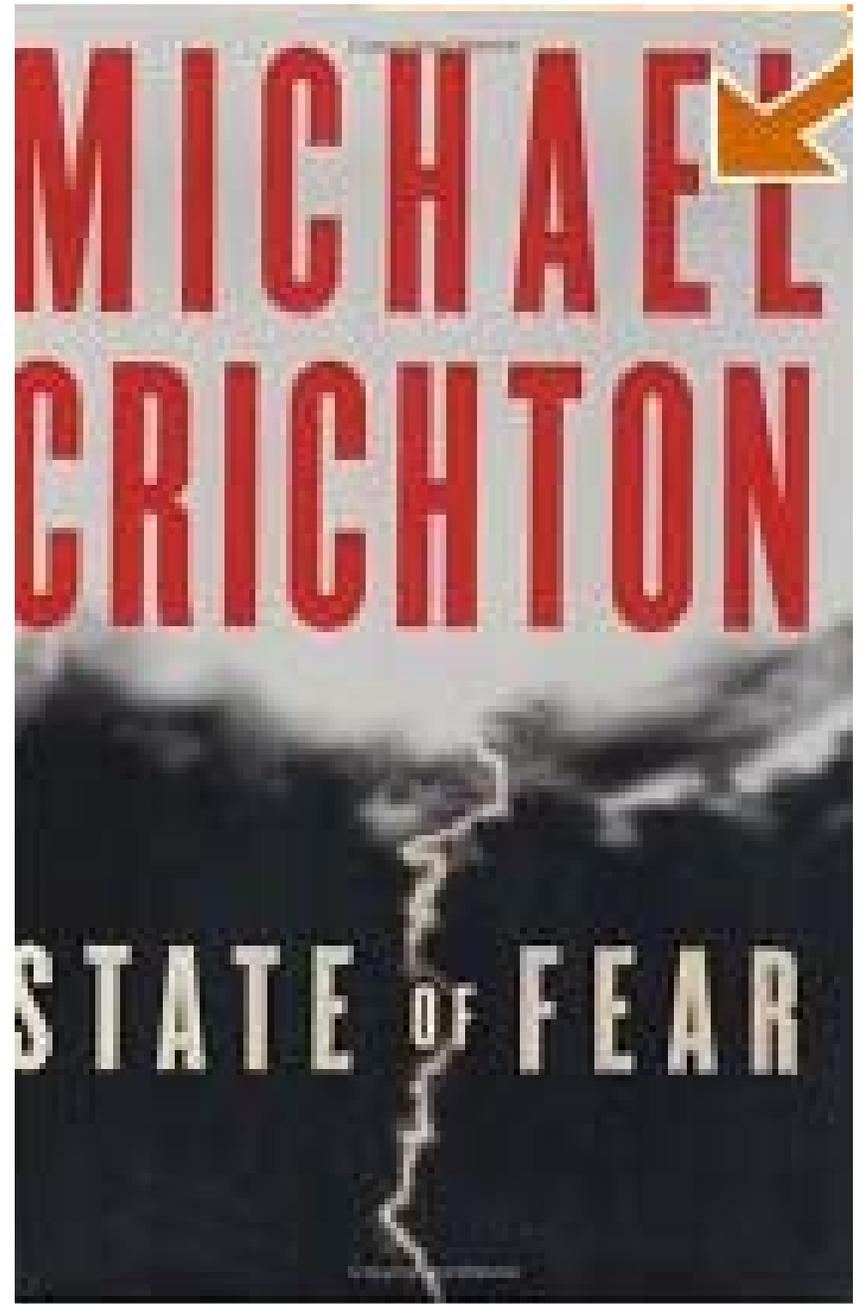
# What about the future?



# Pop-culture perspectives

Perhaps this is a good read, but *it is not good science*

Likewise, the *Day After Tomorrow* scenario might make for a fun movie, but it presents an extremely unlikely impact of global warming at a ridiculous rate of change



# **Northwest Climate: the mean**

## **Factors that influence local/regional climate:**

### 1. Latitude

- day length, intensity of sunlight

### 2. Altitude

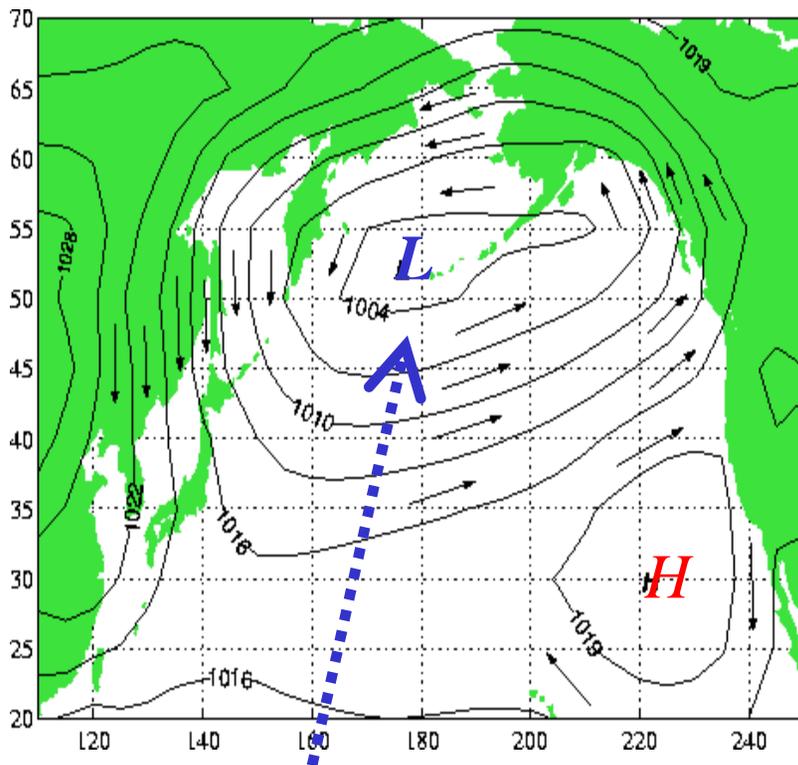
### 3. Mountain Barriers

### 4. Proximity to the ocean

- ocean currents

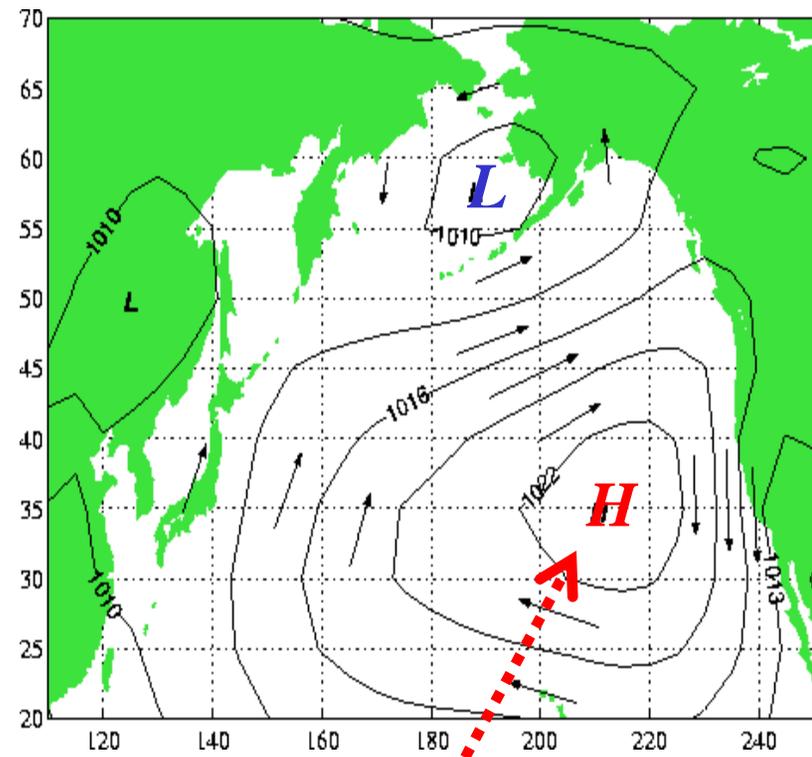
### 5. location relative to prevailing winds

**Winter winds  
and pressure over  
the North Pacific**



*“Aleutian Low”*

**Summer winds  
and pressure over  
the North Pacific**



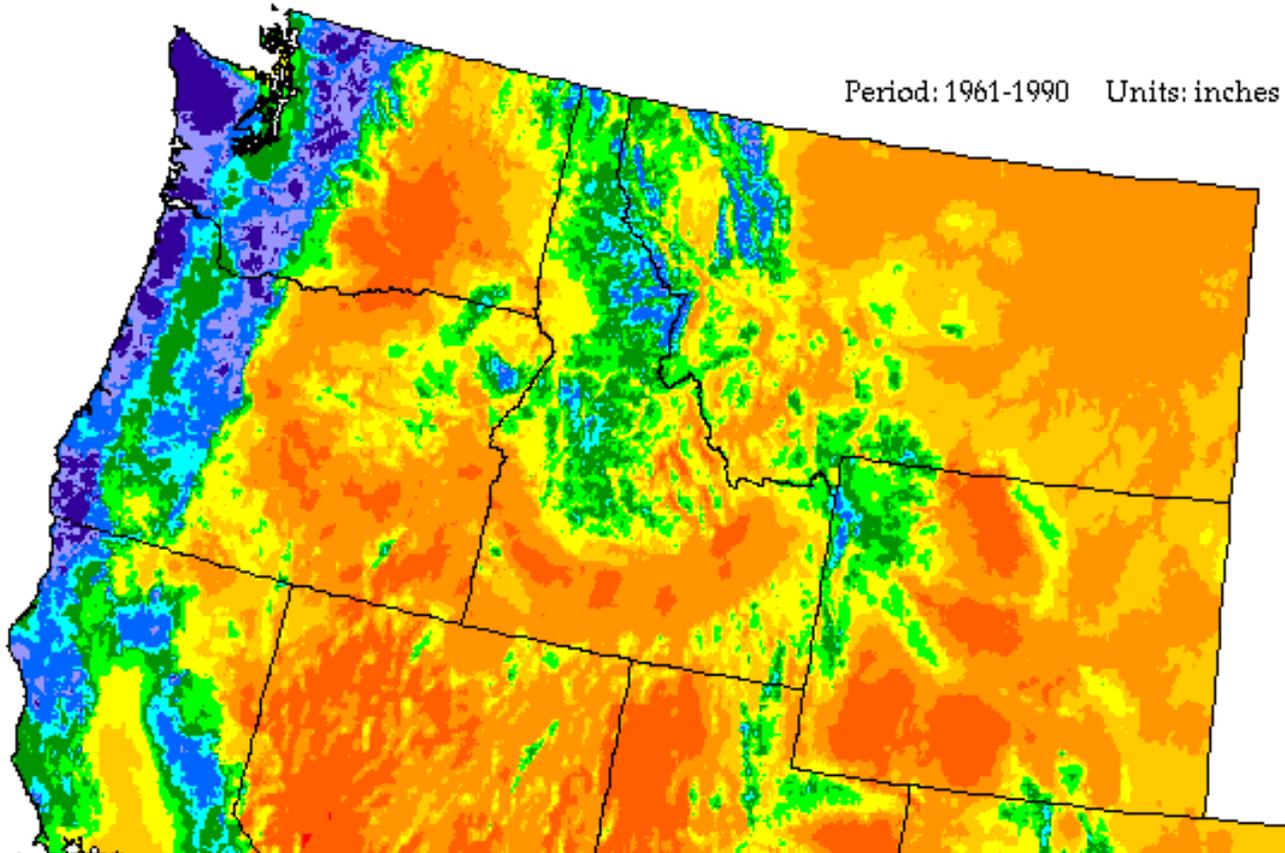
*“Subtropical High”*

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

# Average Annual Precipitation

Western United States

Period: 1961-1990 Units: inches



Copyright 2000 by Spatial Climate Analysis Service, Oregon State University

**Legend (inches per year)**

Less than 5	40 to 50
5 to 10	50 to 60
10 to 15	60 to 80
15 to 20	80 to 100
20 to 30	More than 100
30 to 40	

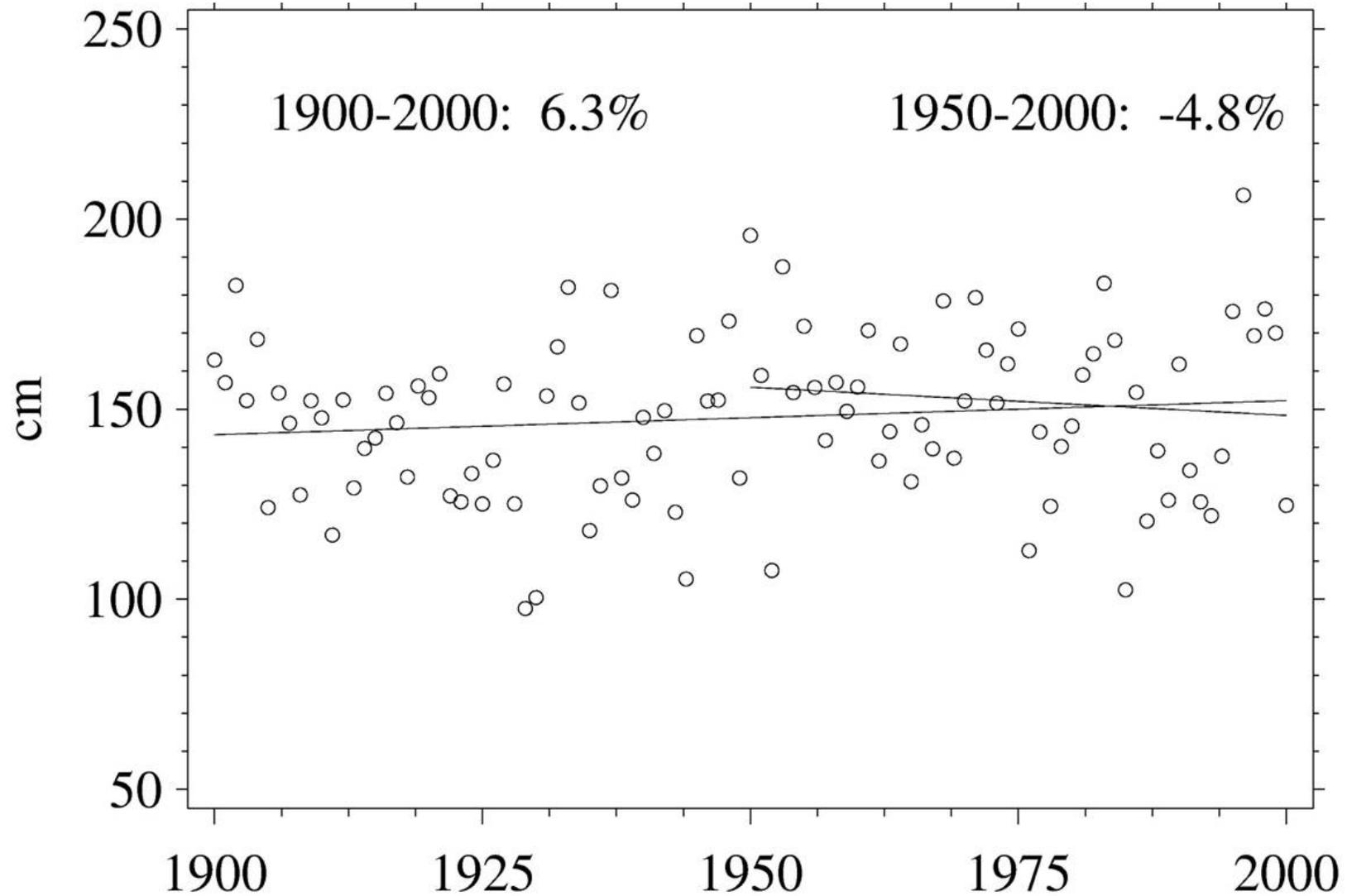
Oregon Climate Service  
<http://www.ocs.orst.edu>

# Northwest Climate Variability

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

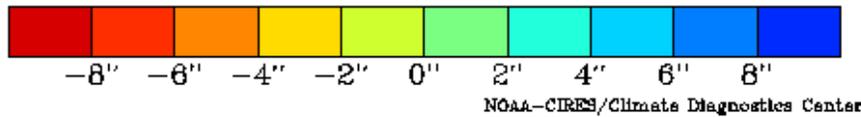
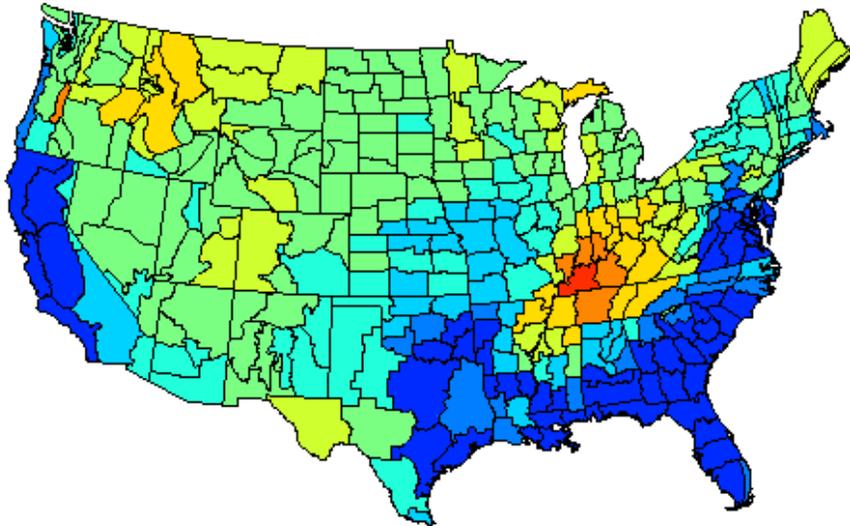
- Retreating glaciers
- Declines in low elevation and Olympic Peninsula snowpack
- Timing shifts in snowmelt runoff
- *Note that all the 20th Century warming in the PNW region is not necessarily a consequence of human-caused global warming*

# Annual Precipitation (Western WA, OR, BC)



# El Niño year precip anomalies Oct 1997- Mar 1998

Precipitation Anomalies Oct to Mar  
Versus 1950-1995 Longterm Average  
1997-98



# La Niña year precip anomalies Oct 1998- Mar 1999

Precipitation Anomalies Oct to Mar  
Versus 1950-1995 Longterm Average  
1998-99

