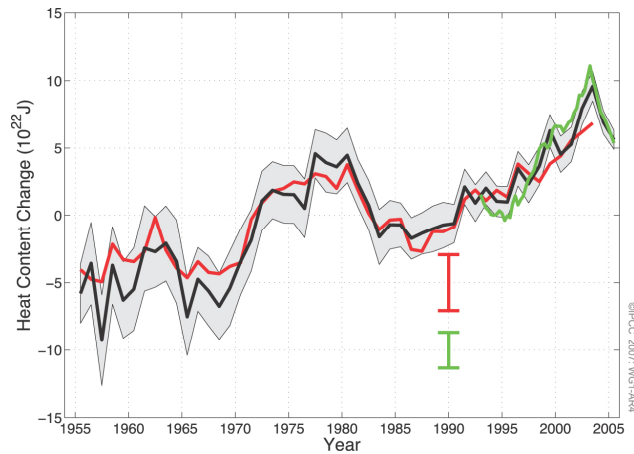


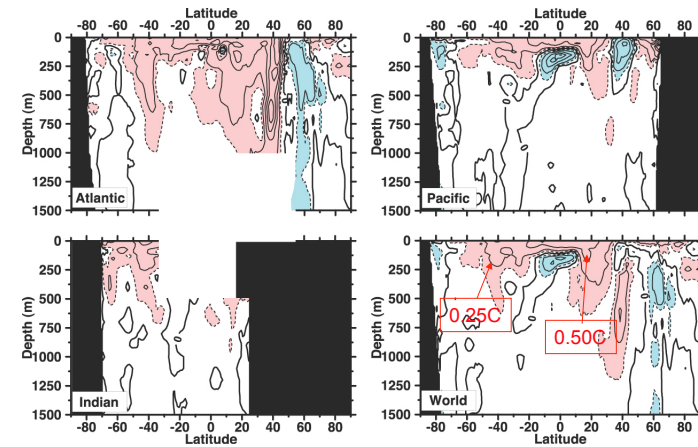
## Global Ocean Heat Content (0-700m)



- Solid lines are three independent estimates (95% confidence interval in grey)

IPCC 2007 Fig TS.16

## Change in upper ocean temperature (1955-2003)



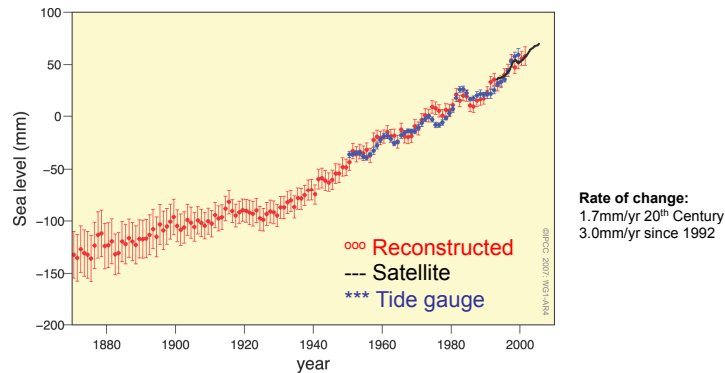
Trends in ocean temperature (averaged east-west) from 1955-2003

warming > 0.125C

cooling < 0.125C

IPCC 2007 Fig 5.3

## Global Sea Level Rise



- At least half of the rise since 1960 is due to thermal expansion
- The remaining is due to melting glaciers and ice caps

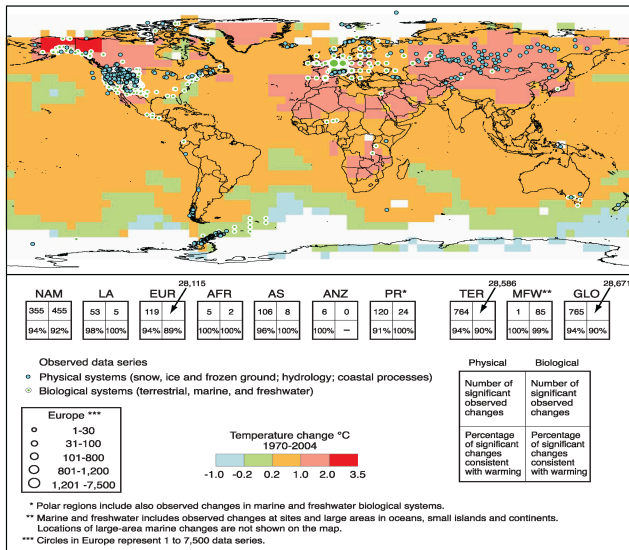
IPCC 2007 Fig TS.18

## Other signs of (global) warming

- melting mountain glaciers
- rising sea level (due to warming and ice-melt)
- timing of seasonal events
  - e.g. earlier thaws, later frosts
- thinning and disappearing Arctic sea ice
- species range shifts (poleward and upward)
- earlier blossom dates for hundreds of species

## Observed changes in physical & biological systems

NAM North America  
 LA Latin America  
 EUR Europe  
 AFR Africa  
 AS Asia  
 ANZ Ausie/NZ  
 PR Polar Regions  
 TER Terrestrial  
 MFW Marine/Fresh W  
 GLO Global (All)



Of the changes seen in >29,000 data sets, 90% are in the direction expected as a response to warming

IPCC 2007 WG2 Fig TS.1

## Other signs of (global) warming

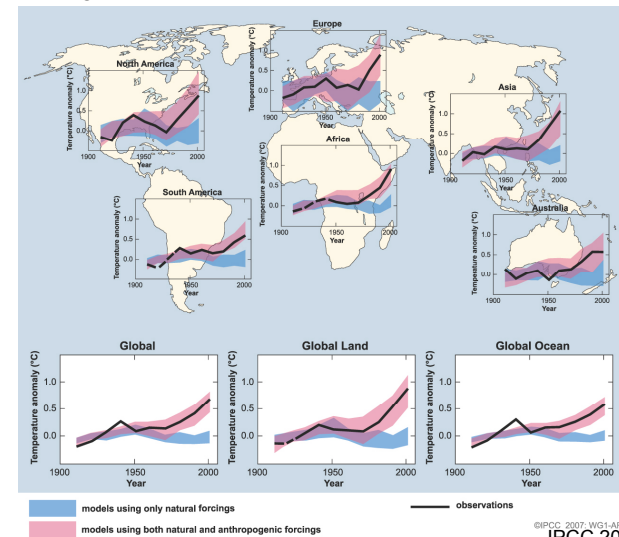
- melting mountain glaciers
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- timing of seasonal events  
 e.g. earlier thaws, later frosts
- thinning and disappearing Arctic sea ice
- species range shifts (poleward and upward)
- earlier blossom dates for hundreds of species

Every one of these data sets can be questioned. Taken together, the totality of evidence of global warming over the past Century is quite convincing.

## Trends in 20<sup>th</sup> Century Climate

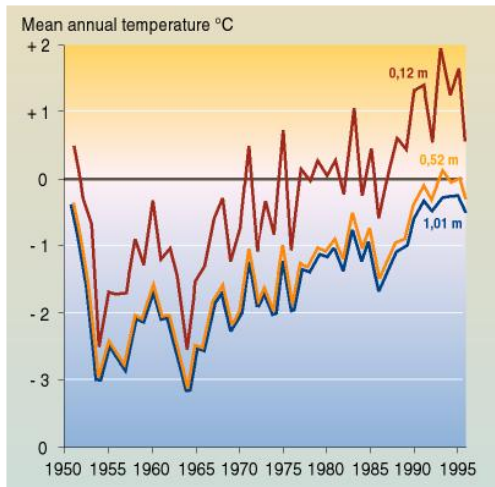
- Material taken from the most recent IPCC report  
 – What is the IPCC?
- Global Trends
- Regional Trends
- Pacific Northwest
- Summary

- Warming seen over all land and ocean regions  
 – More in higher latitudes than in tropics; more over land than water

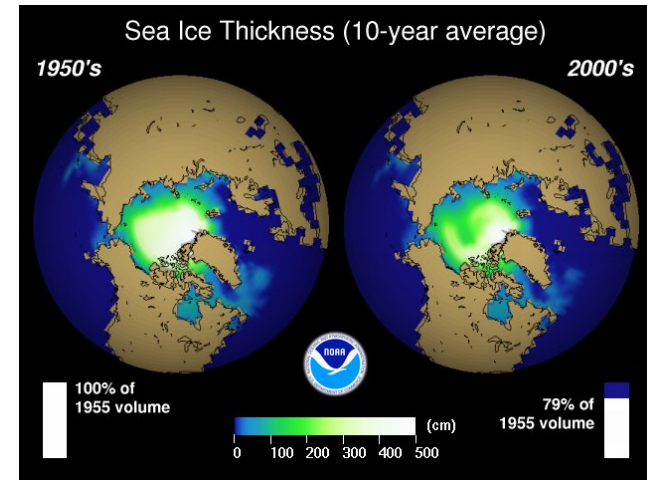


©IPCC 2007 WG1-AR4  
 IPCC 2007 Fig SPM4

## Change in Permafrost Temperatures in Alaska

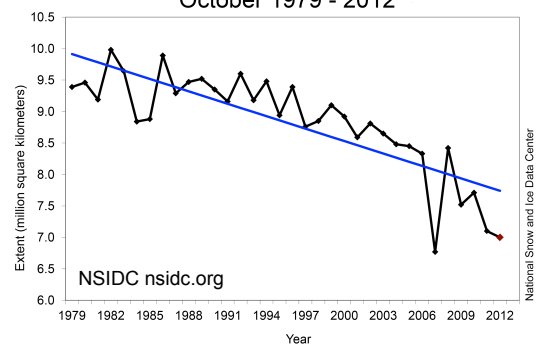


## Sea Ice Thickness



## Arctic Sea Ice Extent

Average Monthly Arctic Sea Ice Extent  
October 1979 - 2012



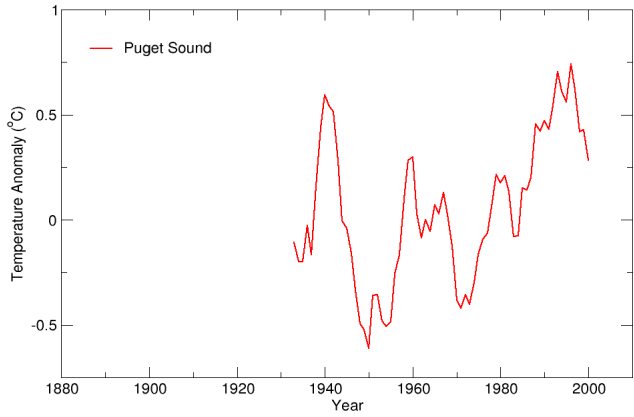
Extent of Arctic sea ice has decreased by about 25% from 1979-2012

n.b. measurements started in 1979

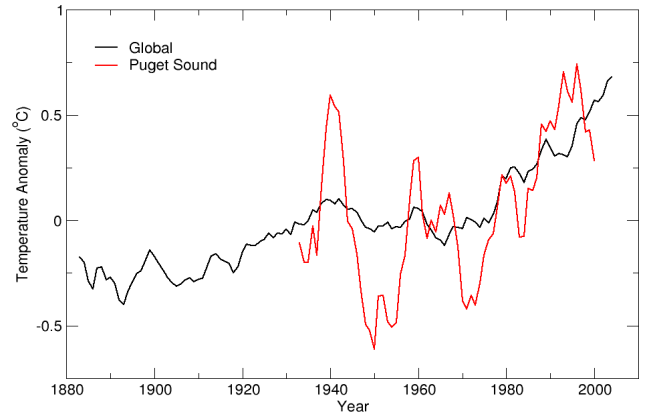
## Trends in 20<sup>th</sup> Century Climate

- Material taken from the most recent IPCC report
  - What is the IPCC?
- Global Trends
- Regional Trends
- Pacific Northwest
  - Temperature
  - Precipitation
  - Runoff & Stream flow
  - Snow pack
- Summary

# Puget Sound compared to Global Mean

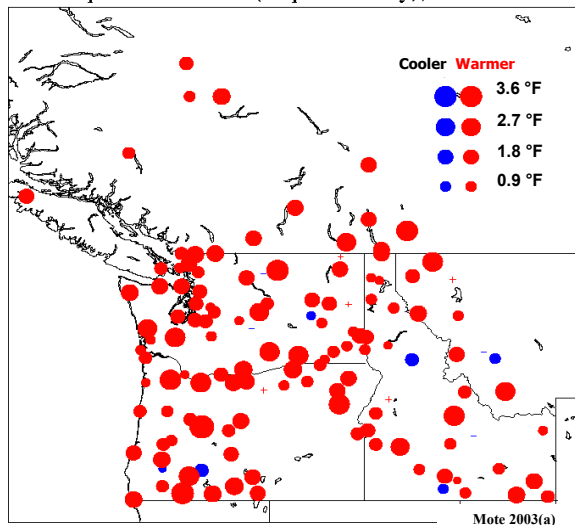


# Puget Sound compared to Global Mean



## Temperature Trends by Station

Temperature trends (°C per century), since 1920



154 stations with long records

Almost every station shows **warming**

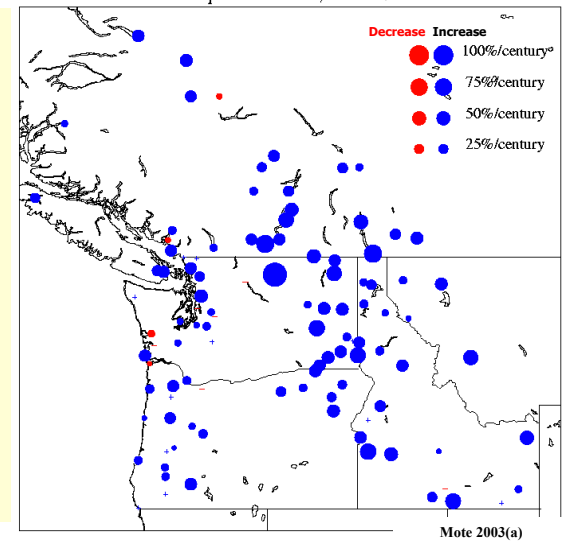
Urbanization **not** a major source of warming



## Precipitation Trends by Station

Precipitation trends, since 1920

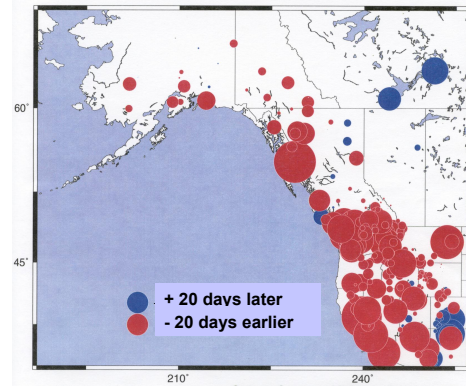
- 165 stations with long records
- Most stations becoming wetter – **average increase of 2.9 inches (14%)...**
- ...however, it is more difficult to assess trends due to challenges in measuring precipitation



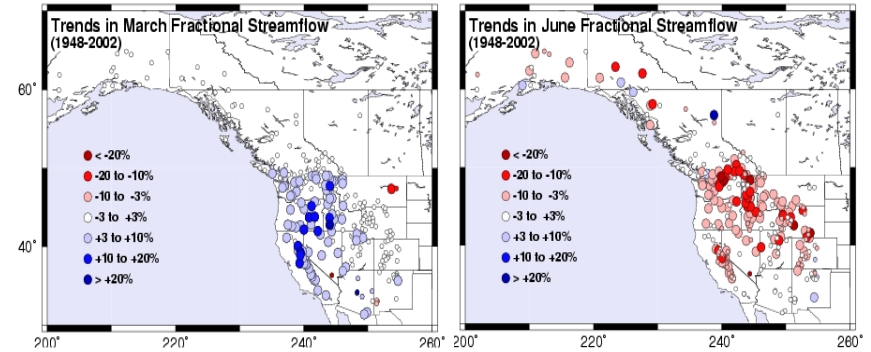
## Trends in the Timing of Spring Runoff

Peak of spring runoff is moving earlier into the spring throughout western US and Canada

- Advances of 10-30 days between 1948-2000
- Greatest trends in PNW, Canada, and AK
- >30% of trends are statistically significant at the 90% level, especially in the PNW



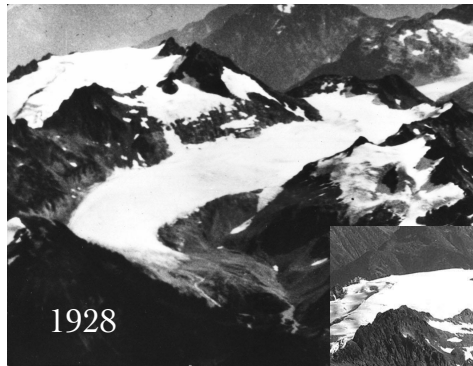
## Changes in Streamflow



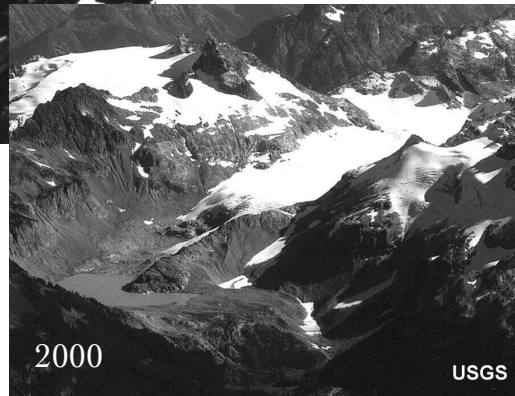
As the west warms, Spring flows increase and Summer flows drop.

Source: Cayan et al. (in review). "Changes in Snowmelt Runoff Timing in Western North America under a 'Business as Usual' Climate Change Scenario", submitted to Climate Change 3.27.03

Figure by Iris Stewart, Scripps (UCSD)

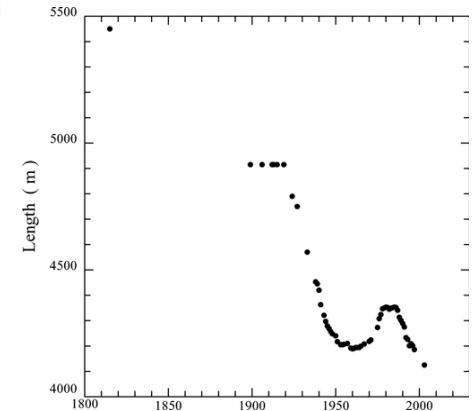


The South Cascade glacier retreated dramatically in the 20th century

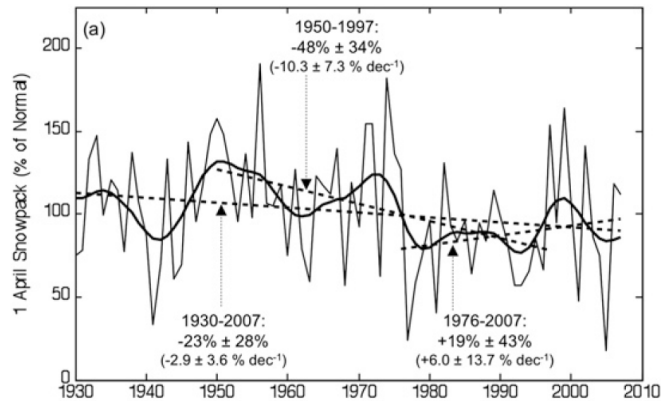


## Length of the Blue Glacier (Olympics)

About 800 meter recession since the early 1900s, and ~1500m since the early 1800s



## Cascade snowpack has decreased in the last 80 years but ...



But there is a lot of natural variability so attribution is not possible (yet)

## Summary: Pacific Northwest Climate (~1920 - 2100)

- Late 20<sup>th</sup> Century Trends
  - Temperature: there has been a regional warming trend
  - Precipitation: no significant trend
  - Runoff & Stream flow: peak flows are happening earlier in Spring; Summer flows are reduced
  - Snow pack: decreased over the past 80 years

*But there is a lot of natural variability in each quantity, so attribution is not possible (yet)*
- Projections of Future Climate Changes
- Impacts of Future Climate Changes

## Trends in 20<sup>th</sup> Century Climate

### Summary

- Material taken from the most recent IPCC report
- Global Trends
  - Global, annual averaged temperature has increase ~0.85°C (1.5°F) in past 100 years
  - Warmest in NH since at least 1000 years ago (limit of data for annual records)
- Regional Trends
  - More warming over land than ocean
  - More warming in high latitudes than tropics
  - Warming at surface, aloft and in upper ocean
- Pacific Northwest
  - About 1°C warmer since 1920
  - About 15% wetter
  - Compared to 1950, Spring runoff is about 10-30 days earlier, and stream flow has increased in spring and decreased in summer