

Is It All Hot Air?

Climate Change, Global Warming & The Pacific Northwest

Purpose of this Talk

The Oregon State University Institute for Natural Resources is putting together materials to educate the public about climate change. The goal is to provide **reliable** and **relevant** science-based information about climate change and its causes and potential impacts on the Pacific Northwest. Reliable information constitutes sources that are both unbiased and timely. Relevant information is targeted to people's concerns about their own personal and family health and happiness, as well as local, regional, national and international extensions. This information is provided in the hope that it will help the public reach their own conclusions about the implications of climate change and global warming, and how they may choose to act, as an individual, community, state or nation.



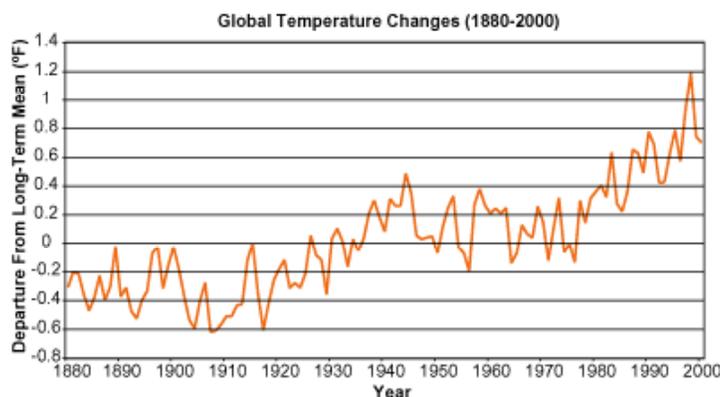
The Story of Climate Change

- Trends, observed global patterns indicating climate change
- Causes, drivers of the observed global trends
- Predictions, the future as speculated through science models
- Impacts, potential consequences to the Pacific Northwest

Trends

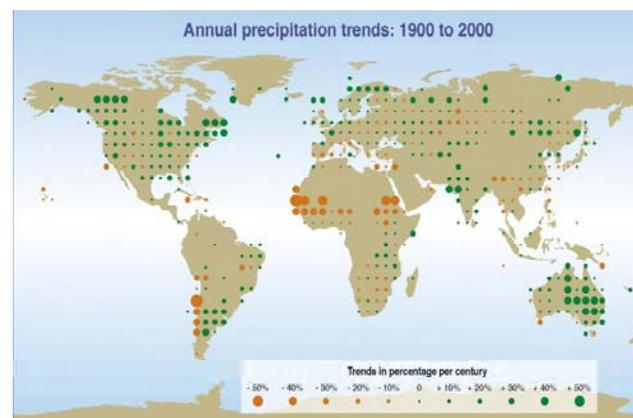
Global Climate Change Over the Last Hundred Years

The past 100 years has shown some observable trends in global climate.



Source: US National Climate Data Center 2001

◀ The Earth's surface has warmed 1.1°F since 1900.



Source: IPCC 2001

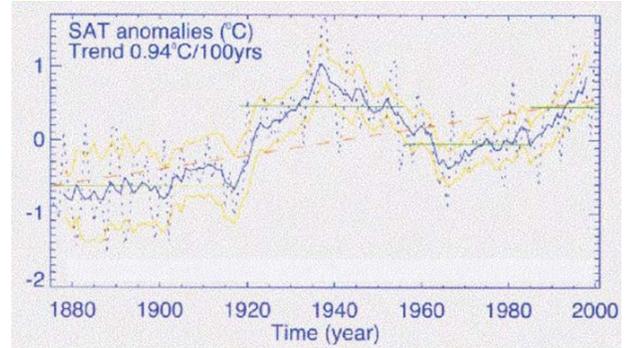
Changes in global rainfall patterns ► have been observed.

Alternate Views on Trends

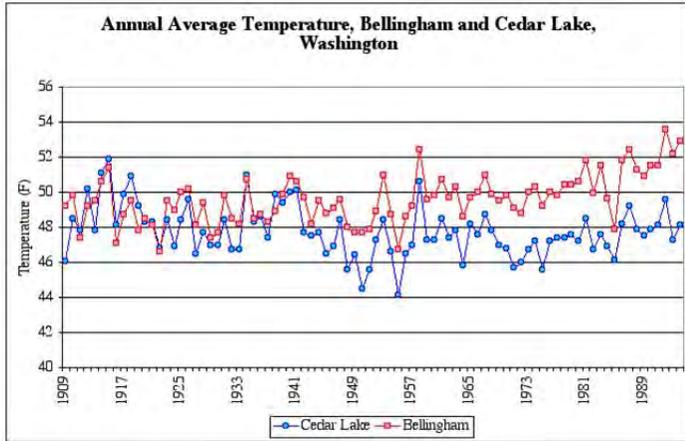
Not all observations support the case for climate change.

Regional temperatures haven't gone up everywhere

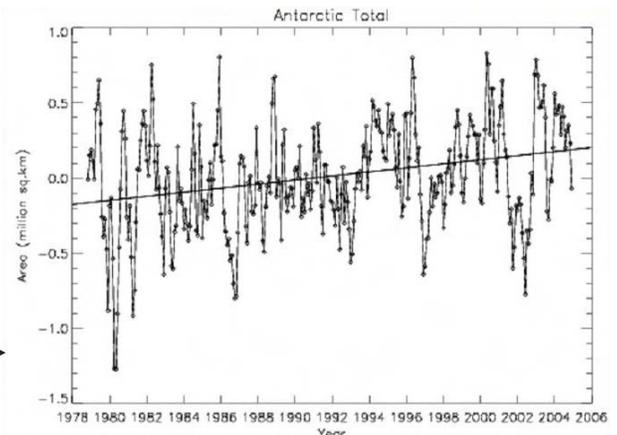
Arctic air temperatures are no higher now than they were in the 1930s and 1940s



Polyakov, I, et al., 2002. Trends and Variations in Arctic Climate Systems. EOS, Transactions, American Geophysical Union, Vol. 83, 547-548.



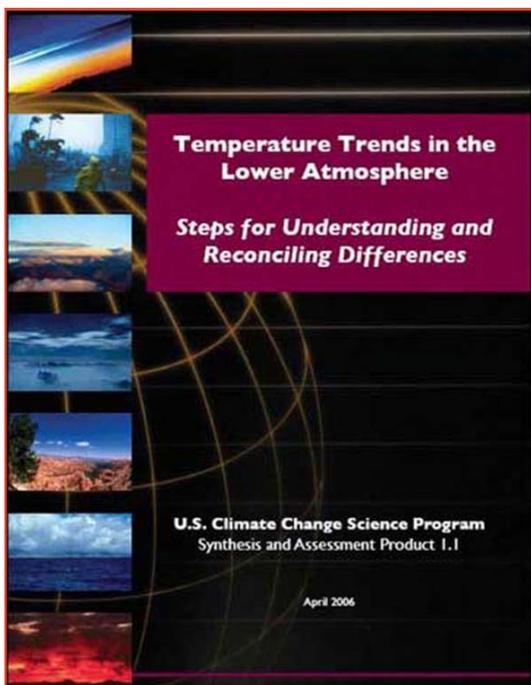
Antarctic sea ice has increased in extent from 1978 to 2005



Antarctic Sea Ice Area Anomalies, 1978-2005, from NSIDC (2006)

Reconciling Differences

Differences in trends and their interpretation can only be reconciled through debate and synthesis within the science community.



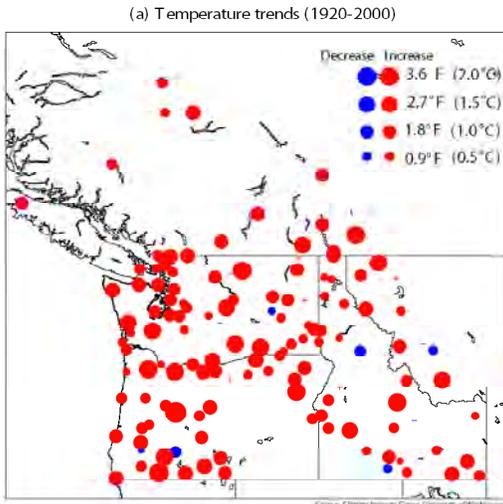
Excerpts:

Previously reported discrepancies between the amount of warming near the surface and higher in the atmosphere have been used to challenge the reliability of climate models and the reality of human-induced global warming. Specifically, surface data showed substantial global-average warming, while early versions of satellite and radiosonde data showed little or no warming above the surface. This significant discrepancy no longer exists because errors in the satellite and radiosonde data have been identified and corrected. New data sets have also been developed that do not show such discrepancies.

- The observed patterns of change over the past 50 years cannot be explained by natural processes alone⁵, nor by the effects of short-lived atmospheric constituents (such as aerosols and tropospheric ozone) alone.

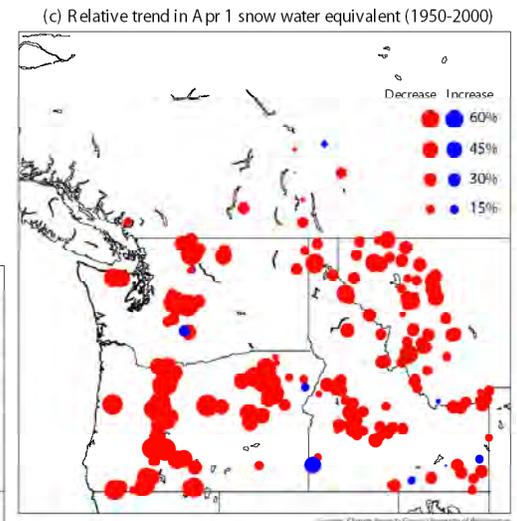
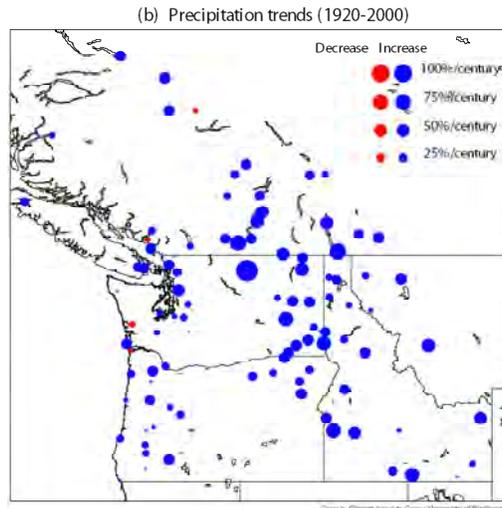
Pacific Northwest Climate Change Over the Last Hundred Years

Global climate trends are observable at the local level as well.



▲ Region-wide warming.

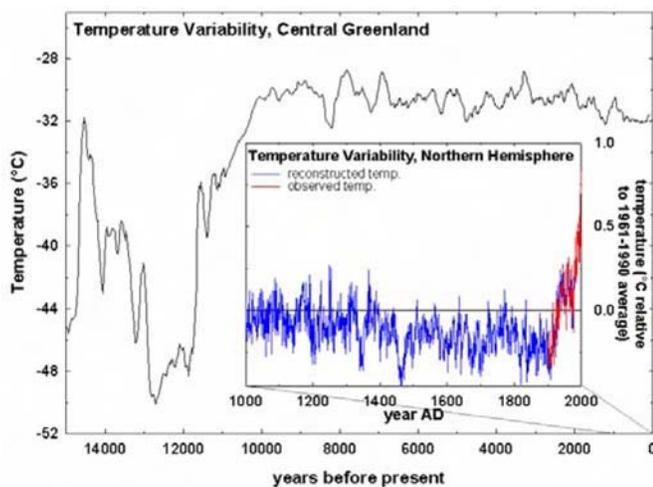
Rainfall increases in eastern Washington & southern British Columbia.



▲ Decline in April 1st Snow pack. At lower elevations there has been a decline of greater than 50% since 1950.

Global Climate Change over Thousands of Years

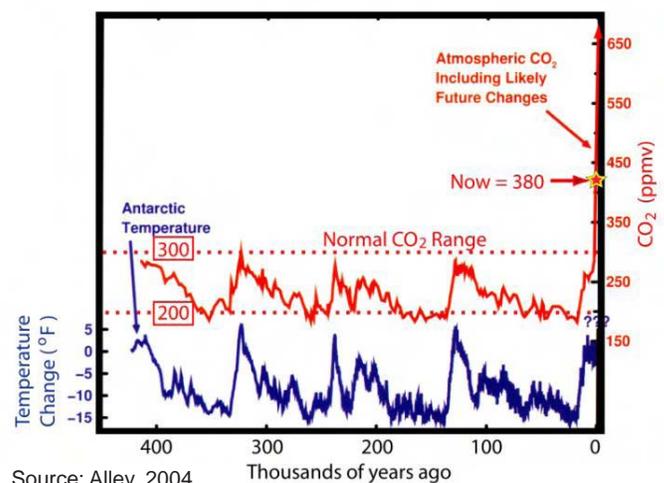
Global climate varies over time scales of 10,000 to 100,000 years. Even given this variability, the changes observed over the last hundred years, when compared to the climate record of the last 1,000 years, are dramatic.



Source: Climate Impacts Group, University of Washington

▲ Northern hemisphere temperature variability is highly variable over geologic timescales.

Recent changes in CO₂ and temperature are dramatic.

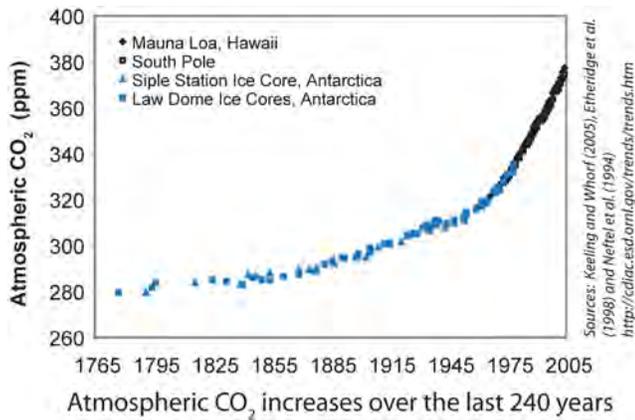


Source: Alley, 2004

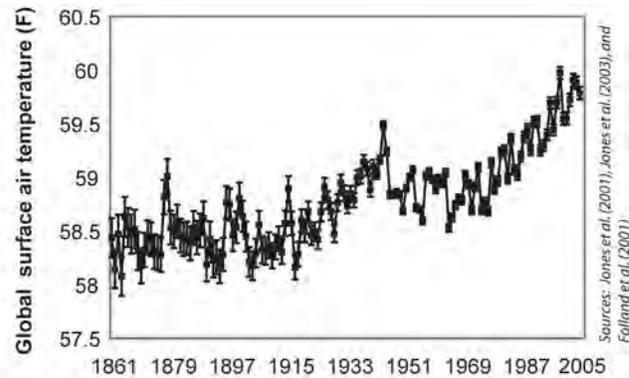
Causes

Trends in Emissions and Global Temperature

Levels of atmospheric CO₂ and global temperature show a similar pattern. Atmospheric CO₂ has increased 34% since 1750, and global temperature has increased 1.1°F in the past 100 years.



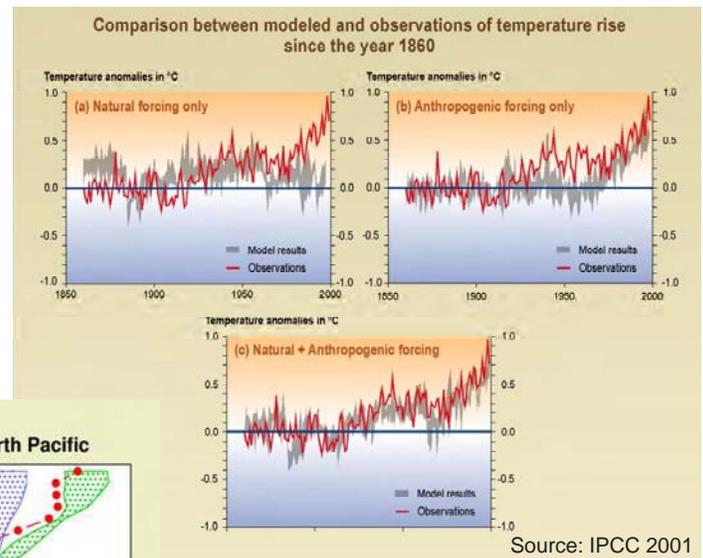
Source: Climate Impacts Group, University of Washington



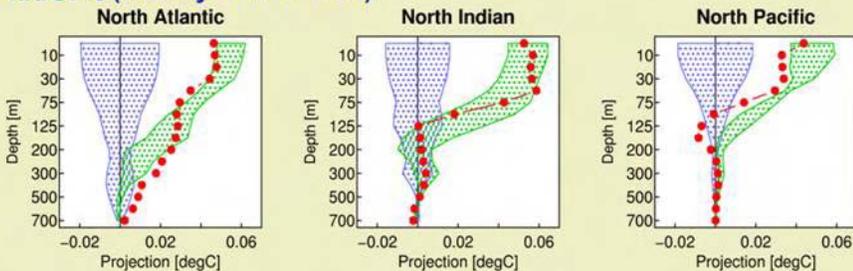
Source: Climate Impacts Group, University of Washington

Are We Causing Global Warming?

Modeling of air temperature and sea temperature shows that observed increases in temperature cannot be explained by natural influences alone. Only once human-sourced CO₂ is added in can we explain observed changes in global temperature.



HadCM3 (Hadley CM3 Model)



Key:
Blue: Temperature distribution with no anthropogenic forcing (the blue swath). Signal strength values falling within this region can be forced simply by 'natural variability'.
Green: Temperature distribution produced by five different climate-change model runs with anthropogenic forcing (greenhouse gasses and aerosols produced by human activity).
Red: The red dots show the signal strength estimated from the observations. The agreement between what is observed, and what is expected to arise from anthropogenic forcing, is excellent in all ocean basins.

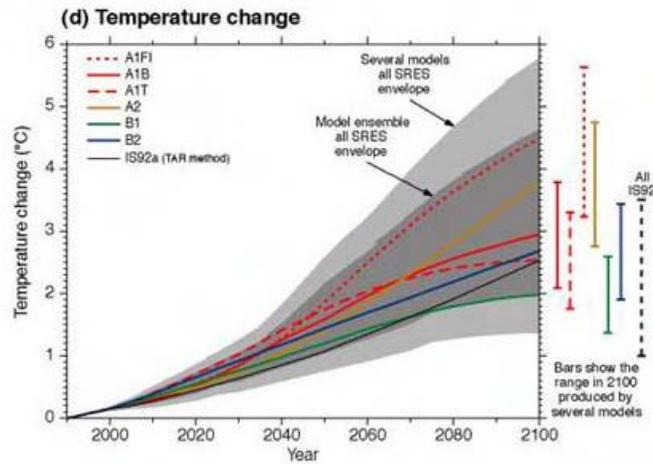
Barnett et al 2005

Global Predictions

Global Warming in the 21st Century

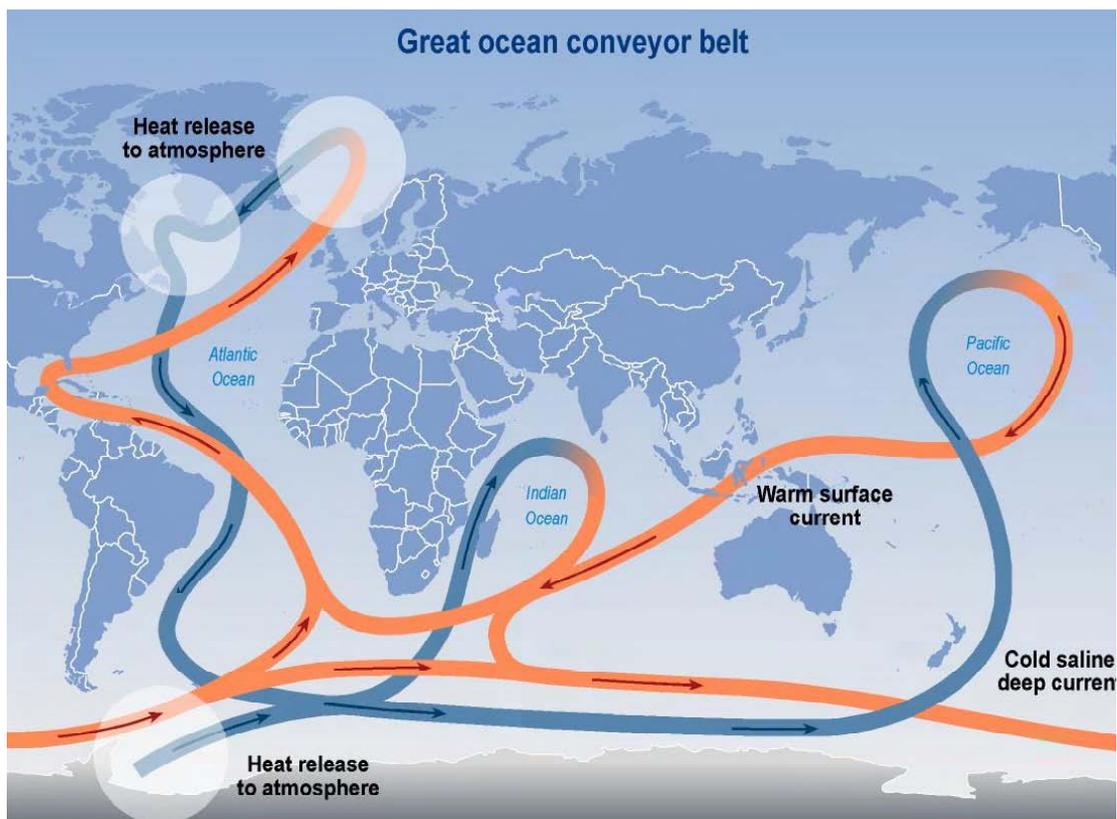
We know the 21st century will be warmer, but projections of future greenhouse gas concentrations are highly uncertain and this makes precise prediction of global warming difficult.

The projected increase in global average temperature by 2100, relative to 1990, ranges from 2.5 to 10°F



Does This Extra Heat Matter?

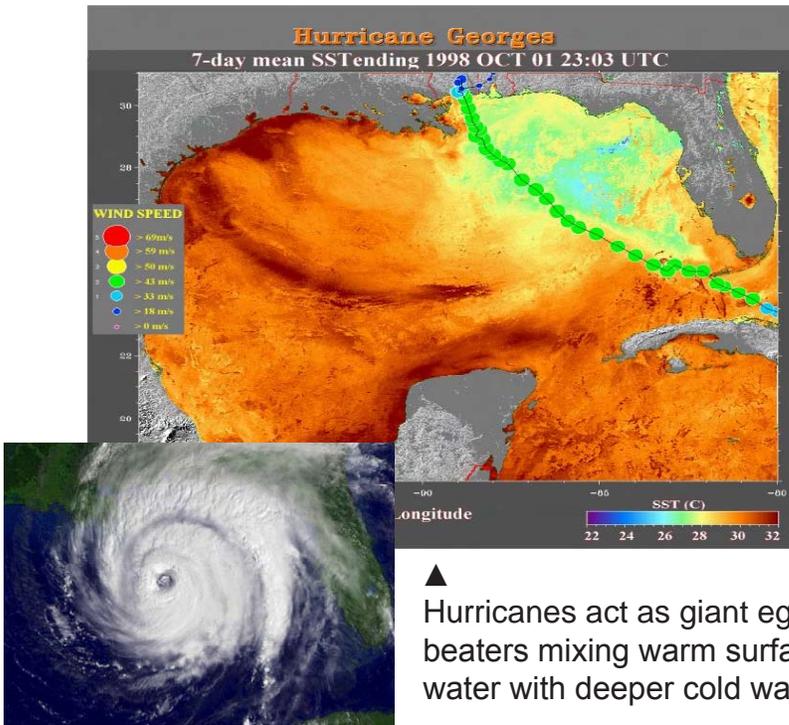
Currents in the Earth's oceans and atmosphere move heat from the tropics to the poles. Without this circulation the tropics would be much hotter and poles much colder. Heat drives this circulation, and therefore changes in the amount of heat available may alter global ocean and atmospheric circulation, affecting regional climates including the Pacific Northwest.



Source: IPCC 2001

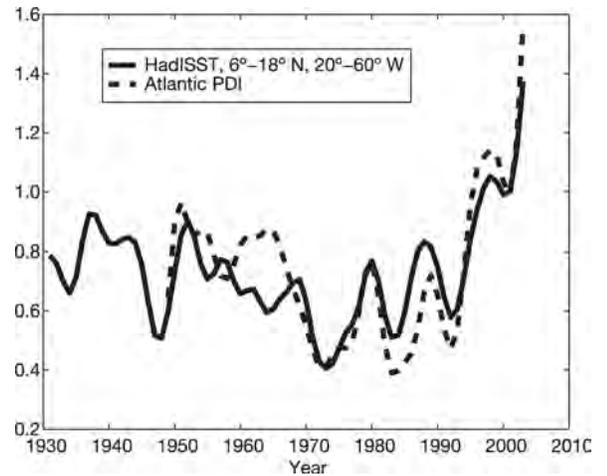
Extra Heat and Hurricanes: Is there a link?

No evidence has been shown to link global warming and hurricane **frequency**. However, a relationship has been observed between sea temperature and hurricane **intensity** (15% increase wind speed) and **duration** (60% increase in life time) since 1970.



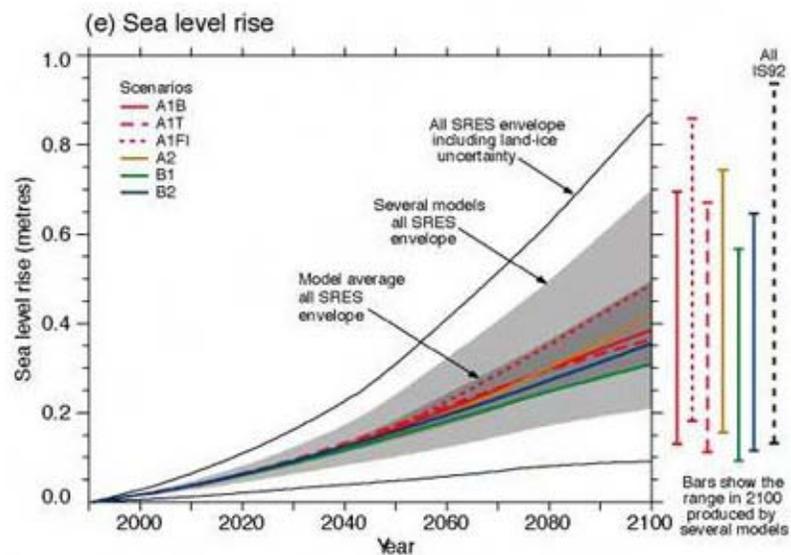
Intensity of North Atlantic hurricanes is increasing.

Total Power Dissipated by North Atlantic Hurricanes



Global Sea Level Rise

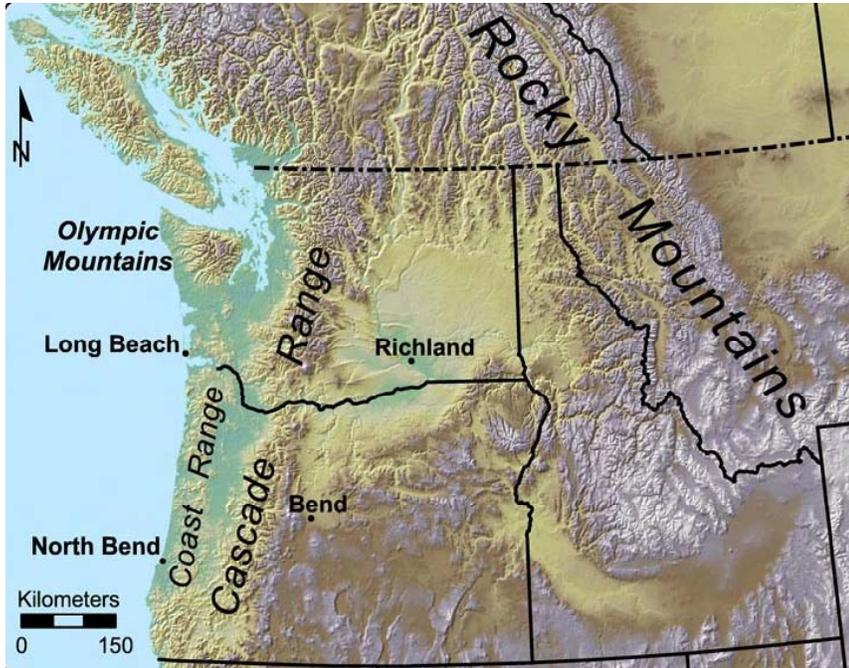
Models predict varying degrees of sea level rise through thermal expansion of the oceans and eventually melt water. Local seal level rise will vary due to the influence to local factors such as tectonic uplift and prevailing ocean conditions.



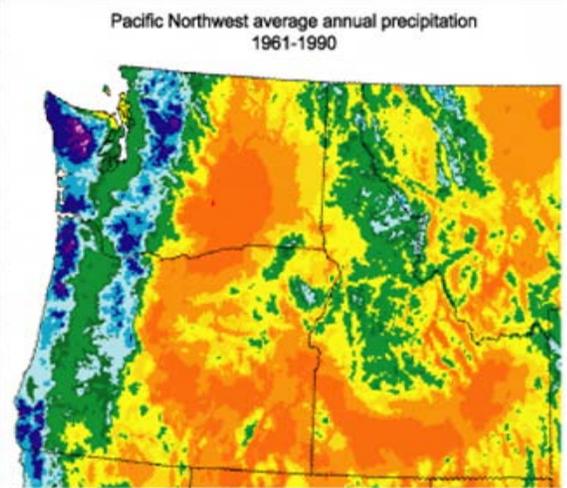
Pacific Northwest Predictions

Climate Influences on the Pacific Northwest: Topography

Regional topographic features, such as the Coastal and Cascade mountain ranges, influence local climate.

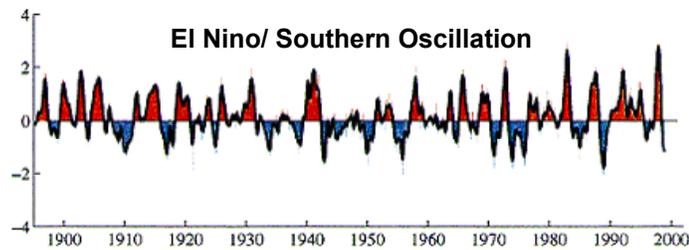


Precipitation patterns follow topography



Climate Influences on the Pacific Northwest: Ocean

The Pacific Northwest has two unique climate patterns that contribute to the variability of the region, the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO).



Source: Climate Impacts Group, University of Washington

▲ El Niño winters tend to be warmer and drier than average. La Niña winters tend to be cooler and wetter than average.

Warm phase PDO winters tend to be warmer and drier than average. Cool phase PDO winters tend to be cooler and wetter than average.

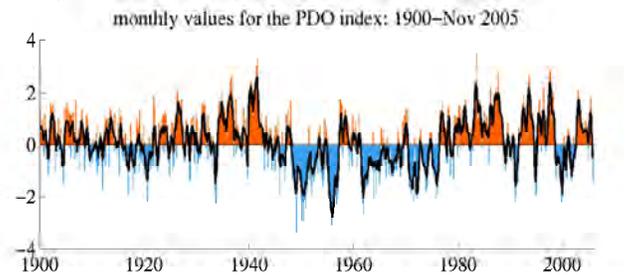
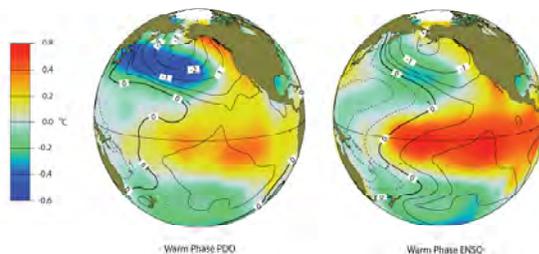


Image source: Climate Impacts Group, University of Washington



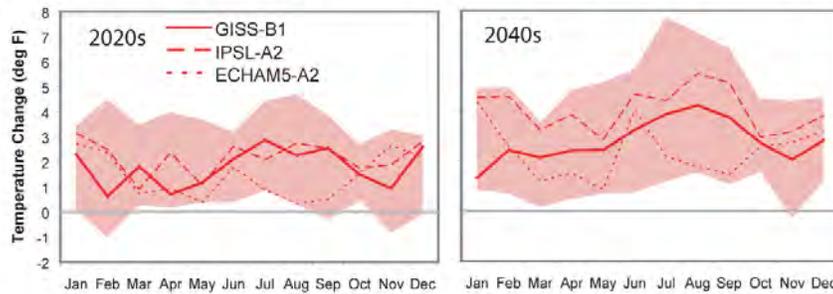
◀ When the two events are in-phase the potential for temperature and precipitation extremes increases

Source: Climate Impacts Group, University of Washington

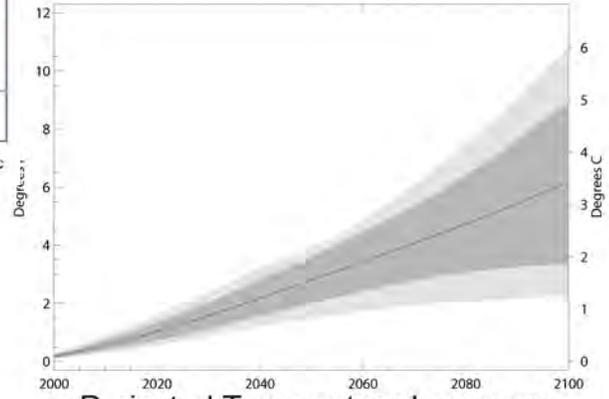
21st Century Changes in Pacific Northwest Temperature

All climate models project that Pacific Northwest temperatures will increase. The projected increases exceed the year to year variability experienced during the 20th century.

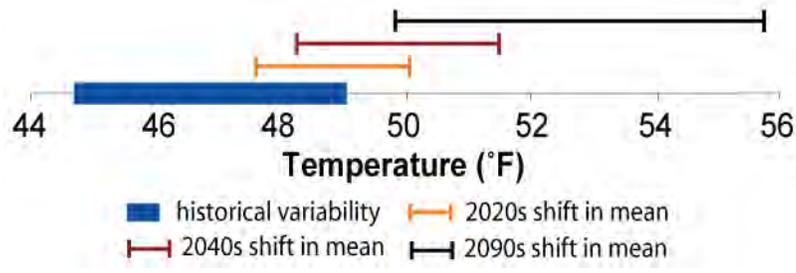
Temperature Change Compared to 1970-2000 Average



Source: Climate Impacts Group, University of Washington



Source: Climate Impacts Group, University of Washington

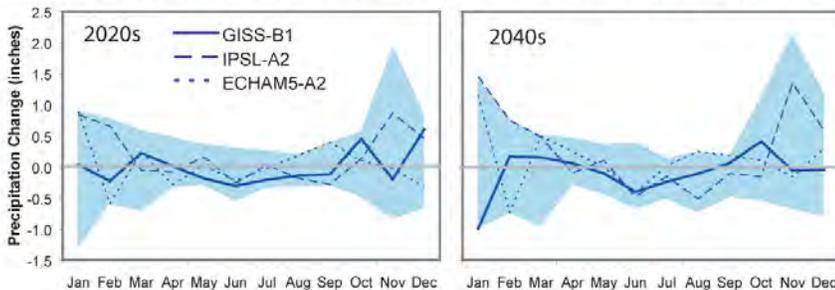


■ historical variability ▨ 2020s shift in mean
 ▨ 2040s shift in mean ▨ 2090s shift in mean

21st Century Changes in Pacific Northwest Precipitation

Many climate models project a slight increase in precipitation especially during winter months. Natural year-to-year and decade-to-decade fluctuations in precipitation are likely to be more pronounced than longer term trends associated with global warming

Precipitation Change Compared to 1970-2000 Average

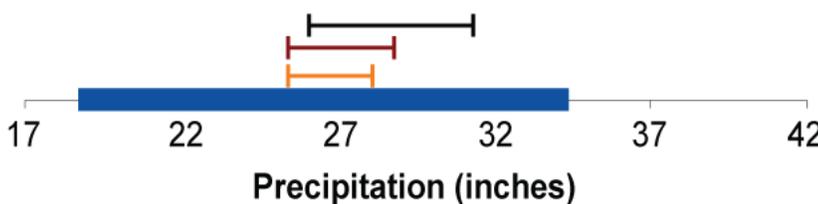


Source: Climate Impacts Group, University of Washington

2020s	Temperature (°F)	Precipitation (%)
low	0.7	-4
average	1.9	2
high	3.2	6
2040s	Temperature (°F)	Precipitation (%)
low	1.4	-4
average	2.9	2
high	4.6	9
2080s	Temperature (°F)	Precipitation (%)
low	2.9	-2
average	5.6	6
high	8.8	18

Projected changes in annual PNW temperature and precipitation

Source: Climate Impacts Group, University of Washington



■ historical variability ▨ 2020s shift in mean
 ▨ 2040s shift in mean ▨ 2090s shift in mean

2001 & 2005 Predictions of Pacific Northwest Climate

In 2005 new and more sophisticated global climate change models were released. The University of Washington used the new models to look at PNW climate predictions. The new models show smaller temperature increases and drier 2020 precipitation projections, as well as greater warming in summer than in winter. The old models showed more warming in winter than summer.

temperature (°C)	2020s		2040s	
	old	new	old	new
lowest	1.4	0.4	1.7	0.8
average	1.7	1.1	2.3	1.6
highest	2.1	1.8	2.9	2.6

Source: Climate Impacts Group, University of Washington

precipitation %	2020s		2040s	
	old	new	old	new
lowest	2	-4	-3	-4
average	6	2	4	2
highest	14	6	9	9

Source: Climate Impacts Group, University of Washington

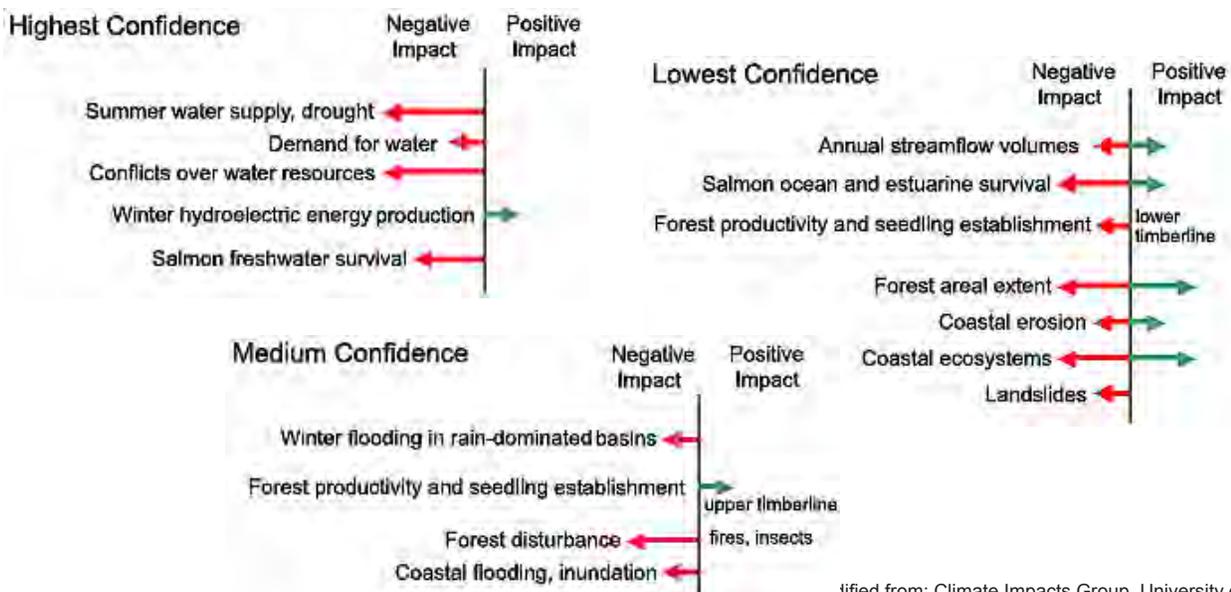
Recent models show new predictions for changes in regional temperature and precipitation, as compared with earlier models.

Pacific Northwest Impacts

Scientific Consensus on Impacts on the Pacific Northwest from Global Warming

Negative impacts on Pacific Northwest water resources include:

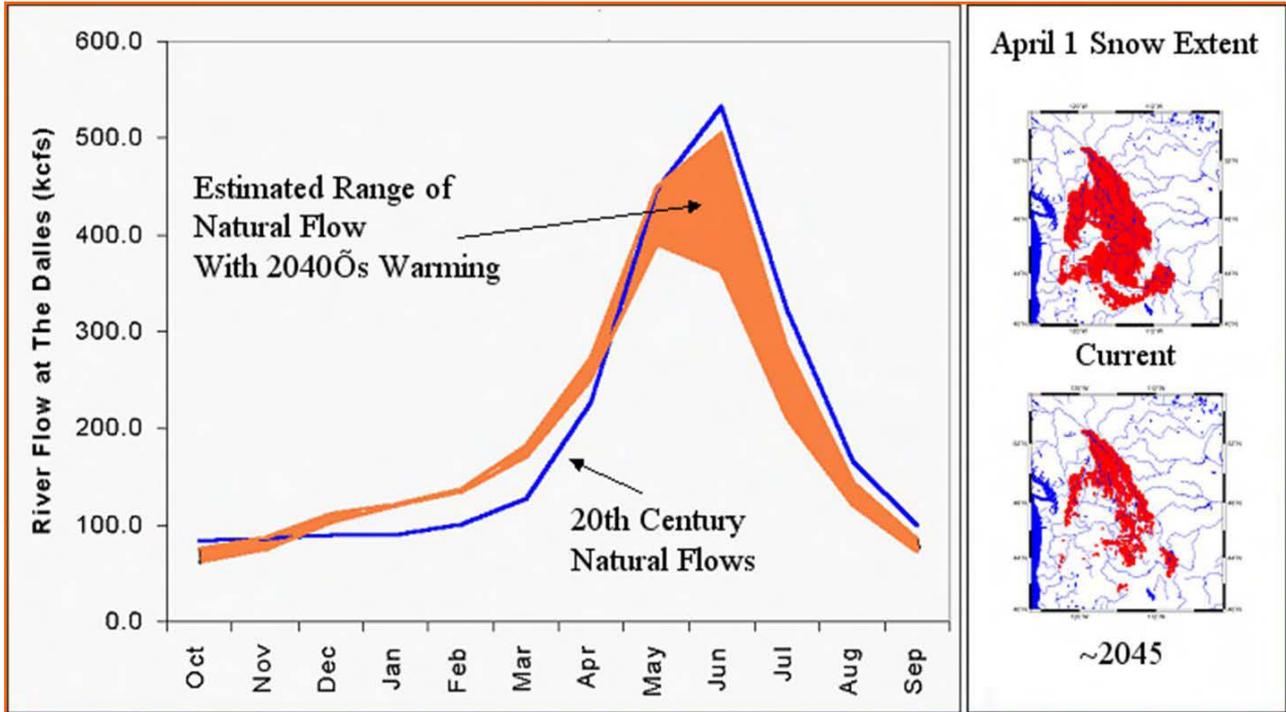
- reduction in snowpack
- stresses on endangered salmon
- impacts on east-side forests with slower growth and more fires from warmer summer
- local population losses of wildlife and plants if climate shifts are faster than ability to migrate
- increased beach erosion and beach loss along the Northern Oregon Coast



ified from: Climate Impacts Group, University of Washington

Climate Impacts: Pacific Northwest Water Resources

Warmer 21st century temperatures would mean less winter snow accumulation, higher winter stream flows, earlier spring snowmelt, earlier peak spring stream flow, and lower summer stream flows.



Source: Climate Impacts Group, University of Washington

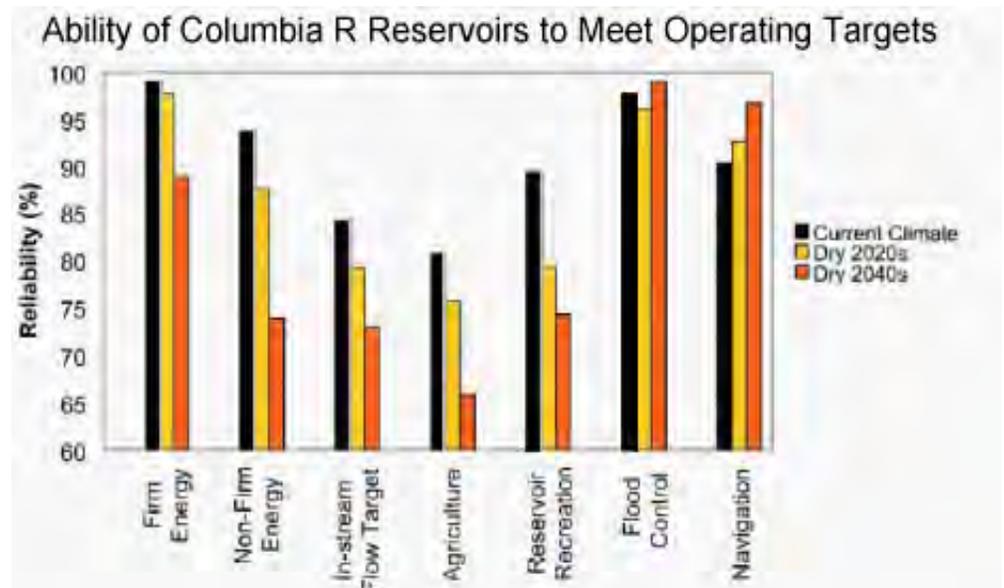
▲ Predicted Columbia River Flows in 2040

Water Resource Case I: Water Allocation Conflicts

Earlier peak river flows, lower summer streamflows, and lengthened summer low flow will heighten competition over water use for:

- Hydropower generation
- Instream flow protection for endangered species
- Irrigation
- Recreation

Issues facing Columbia River reservoirs based on the drier predictions of new climate change models. ▶

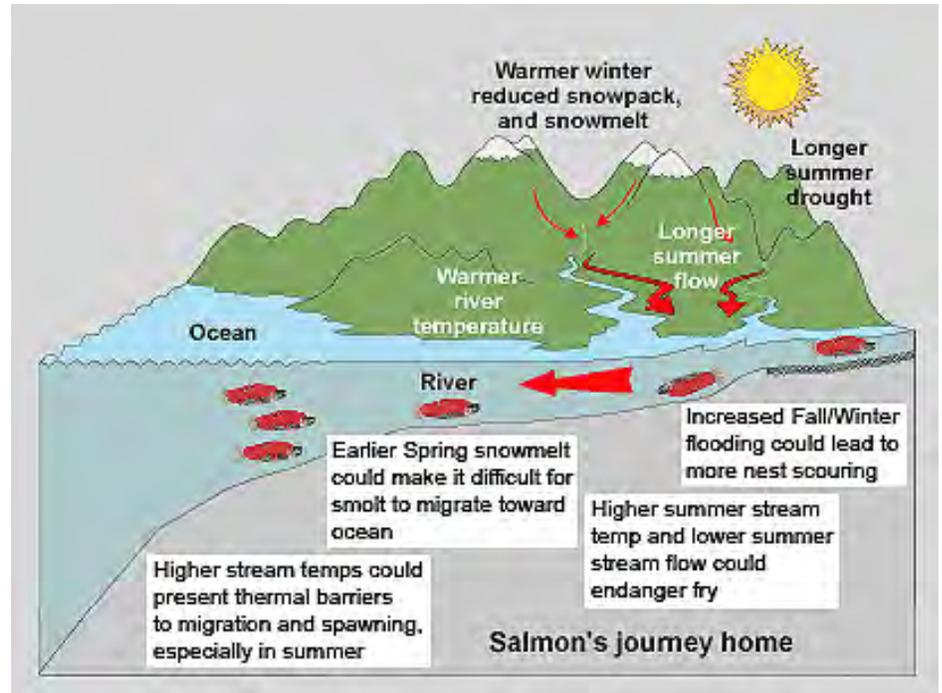


Modified from: Climate Impacts Group, University of Washington

Water Resource Cases: Salmon

Changes in annual patterns of stream flow will be detrimental to salmon rearing, migration and spawning in some transient river systems. Increased water temperatures in summer may exceed the tolerable limits for trout and salmon. There may be Endangered Species Act implications for power generation & irrigation through higher in-stream flow standards.

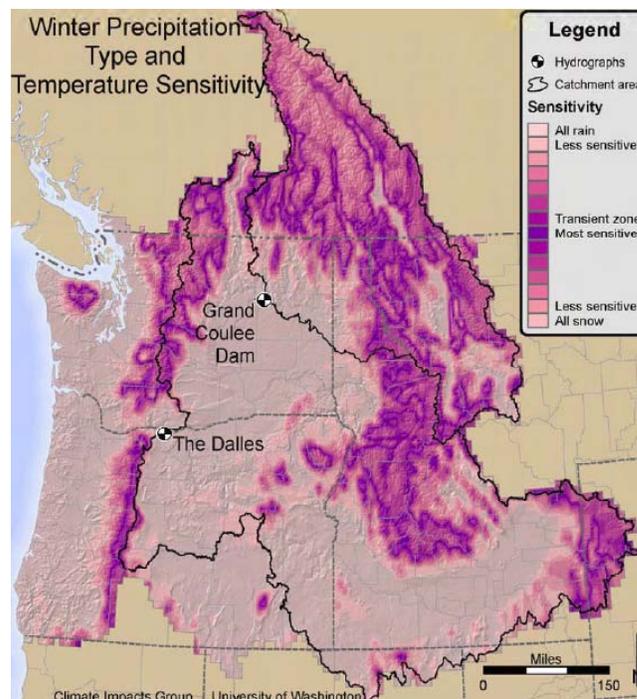
Major impacts of
climate change
on the life cycle
of Salmon



Modified from: Climate Impacts Group, University of Washington

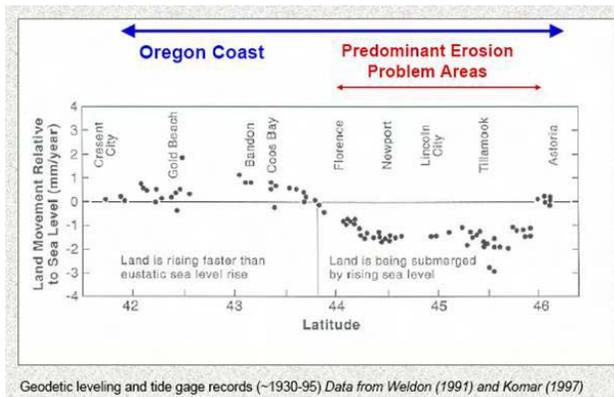
Water Resource Case II: Snow Pack and Skiing

Warmer winter temperatures would mean later opening dates, shorter seasons and more rainy days for ski areas below 5,000'



Sea Level Rise and Coastal Erosion

Predicted sea level rise will increase coastal erosion hazards along the northern Oregon coast. This hazard is most severe occur during El Niño events when local sea level is higher.



▲ Points north of Florence are likely to experience the effects of rising sea level.



Fishing Rock Oregon Coast

Source: Sea Grant

Adapting to and Mitigating Climate Change in the Pacific Northwest

When looking at the issue of climate change in the Pacific Northwest, it is important to recognize that the past is not a reliable guide to the future. Climate change considerations will need to be integrated into planning processes, including an honest appraisal of current policies. Additionally, it is important to monitor regional climate and resources for medium and long-term change. Adaptability in the face of the unexpected will likely be important.

Mitigation strategies that make economic and environmental sense include:

- Green energy generation initiatives
- Fuel and energy efficiency
- Water resource conservation measures

Summary

- Climate change is happening globally and in the Pacific Northwest.
- Humans are contributing to global warming and climate change in a measurable way.
- The quickest and greatest impact in the Pacific Northwest will be on water resources due to more rain and less snow at lower elevations.
- These water resource impacts will cause increased conflict over water for irrigation, instream flows and electricity generation.
- IF we exercise foresight now through sound planning and use of readily available technology, the Pacific Northwest is well placed to deal with climate change and global warming.