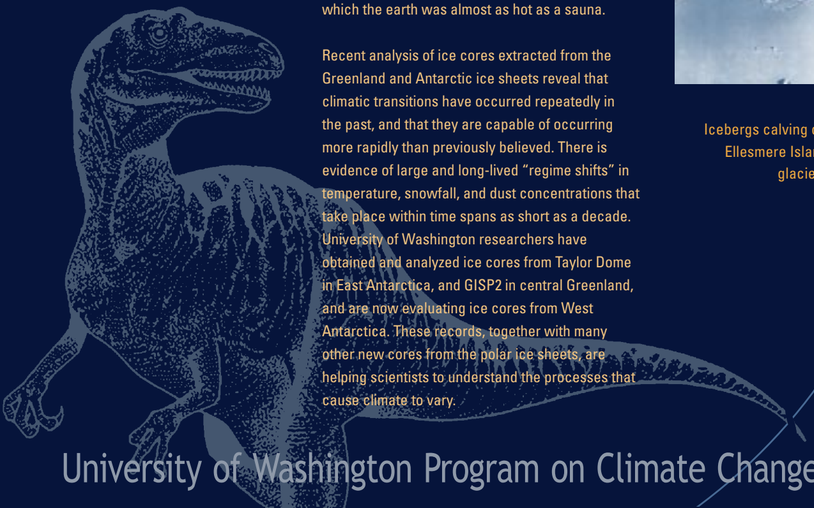
# Chaotic Past

climate is highly variable and can change abruptly



In the age of the dinosaurs—100 million years ago—tropical plants and animals ranged as far north as the shores of the Arctic. In contrast, during most of the past two million years, vast ice sheets covered much of North America and Northern Europe. Geological evidence indicates that there may have even been intervals in which the earth was entirely ice covered, followed by intervals in which the earth was almost as hot as a sauna.

Recent analysis of ice cores extracted from the Greenland and Antarctic ice sheets reveal that climatic transitions have occurred repeatedly in the past, and that they are capable of occurring more rapidly than previously believed. There is evidence of large and long-lived "regime shifts" in temperature, snowfall, and dust concentrations that take place within time spans as short as a decade. University of Washington researchers have obtained and analyzed ice cores from Taylor Dome in East Antarctica, and GISP2 in central Greenland, and are now evaluating ice cores from West Antarctica. These records, together with many other new cores from the polar ice sheets, are helping scientists to understand the processes that cause climate to vary.

Icebergs calving off Ellesmere Island glaciers

University of Washington Program on Climate Change

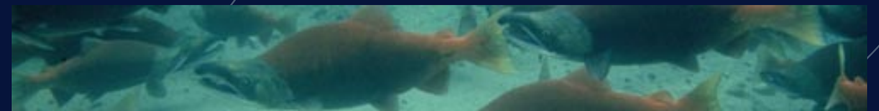
# Variable Present

the oceans, atmosphere, and land biosphere are interconnected

The rise of human civilization has occurred during a period of relative warmth and stability of the climate system that followed the retreat of the continental ice sheets 15,000 years ago. Yet even within this benign interval, temperature and rainfall are subject to year-to-year and decade-to-decade swings that seriously impact agriculture, fisheries and water resources over large areas of the world, including the Pacific Northwest.

University of Washington researchers have made fundamental contributions to explaining how the winds and ocean currents in the tropical Pacific interact to produce El Niño, the leading cause of year-to-year climate variations over North America. They have also shown that a pattern of climate variations, known as the "Arctic Oscillation" or the "North Atlantic Oscillation" modulates the severity of winter weather over large areas of the Northern Hemisphere, the shielding capacity of the strato-spheric ozone layer, the thickness and extent of Arctic pack ice, and the locations of regions of sinking North Atlantic ocean water.

An understanding of connections between shifts in ocean-climate and salmon health and abundance are necessary to maintain salmon fisheries.



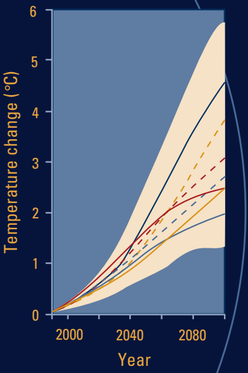
Deployment of a buoy in an array of moorings that measures winds; air, sea-surface, and subsurface temperatures; relative humidity; and ocean currents (TAO project of NOAA/PMEL)

# Uncertain Future

climate change is inevitable, but how abrupt will it be?

As greenhouse gases accumulate in the atmosphere, global mean temperature is expected to rise to well beyond the levels typical of the past 10,000 years. Just how far and fast temperature will rise will depend on the future rates of consumption of fossil fuels, the rate of uptake or release of carbon by the marine and land biospheres, and the sensitivity of the climate system to this greenhouse forcing. Some scientists have warned that greenhouse warming could trigger an abrupt and irreversible regime shift of the climate system. University of Washington scientists are leaders in the effort to quantify and reduce the uncertainties inherent in projections of future climate change.

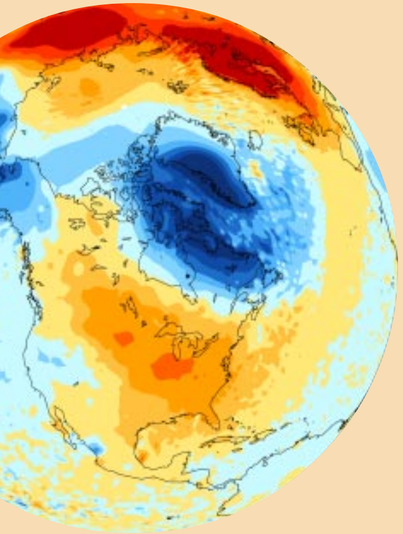
Ecological and societal impacts of climate change vary by region. For the Pacific Northwest, which depends upon the mountain snow pack for its summer water supplies, global warming poses the threat of water shortages and low stream flows, damaging to salmon. The University of Washington Climate Impacts Group has taken the lead in quantifying these risks and stimulating a productive dialogue between climate scientists and long range planners in industry and government agencies.




Projected temperature responses to a number of reasonable scenarios of greenhouse gas and other human-related emissions (adapted from a recent report by the United Nations)

phone: 206-543-6521 fax: 206-543-6393

# Academic Program



Global temperature associated with the Arctic Oscillation, an atmospheric pattern of variability with connections to extreme weather events and long-term climate trends. Blue and red indicate cooler and warmer than normal temperatures, respectively.

## interdisciplinary research and teaching

The Program on Climate Change (PCC) is the focal point for climate related teaching and research at the University of Washington. It offers a tightly linked sequence of three graduate-level courses, taught every year, that fulfill requirements in more than one department. There are additional elective courses at the graduate and undergraduate levels. The annual summer institute, which focuses on PCC's major research themes, stimulates cross-disciplinary interactions and training. PCC also supports graduate students and postdoctoral researchers and provides seed grants for innovative interdisciplinary research. Interaction among faculty within PCC promotes the integration of existing observational and modeling efforts within and between individual departments, providing a powerful synthesis approach for addressing the problems of climate change. PCC capitalizes on University of Washington's exceptional range of expertise in climate related fields.

## affiliated units

Applied Physics Lab, College of Engineering, Department of Atmospheric Sciences, Department of Earth & Space Sciences, Joint Institute for the Study of the Atmosphere and Ocean (JISAO), Pacific Marine Environmental Lab (NOAA/PMEL), Quaternary Research Center, School of Oceanography

# Scientific Themes

## learning from the past

What did the global patterns of temperature, precipitation and wind look like during various periods in the earth's history?

How abruptly is climate capable of changing?

What factors are instrumental in making climate change?

What are the lessons for the future?

## determining the fate of greenhouse gases

What is the fate of carbon dioxide released into the atmosphere?

What are the land and ocean sources and sinks?

What determines the concentrations of more reactive greenhouse gases such as methane?

How will energy policy impact the atmospheric concentrations of greenhouse gases?

What technologies can help mitigate the introduction of greenhouse gases into the atmosphere?

## predicting future climate

How much is the earth likely to warm in response to the buildup of greenhouse gases in the atmosphere?

How much does natural variability affect the accuracy of predictions?

What research needs to be done in order to provide policy makers with more reliable projections?

## assessing the impacts of climate change

How do natural and human induced climate change impact ecosystems and societies?

How serious are the risks of catastrophic impacts?

Based on assessment of these risks, are costly measures warranted to reduce the rate of greenhouse warming?

To what extent can the adverse impacts of climate change be alleviated if long range planning is informed by long range climate projections?

## interpreting current changes

Are the pronounced climate trends of the past few decades a sign of things to come or are they a manifestation of some longer term climate cycle that will eventually reverse itself?

To what extent are these climate trends induced by human activities?

Does the ocean merely respond passively to decade-to-decade climate changes or does it serve to amplify or even cause some of them?



Photos: NASA Earth Observatory team; Andrew Hendry, L. Stratton, Tropical Atmosphere Ocean Project, NOAA/PMEL; JISAO; Dunbar and Greenaway 1956/Canada Defence Research Board; Illustrations: arttoday.com@2002; UN Report referred to is by the Intergovernmental Panel on Climate Change

# Program on Climate Change

## University of Washington

http://depts.washington.edu/uwpcc