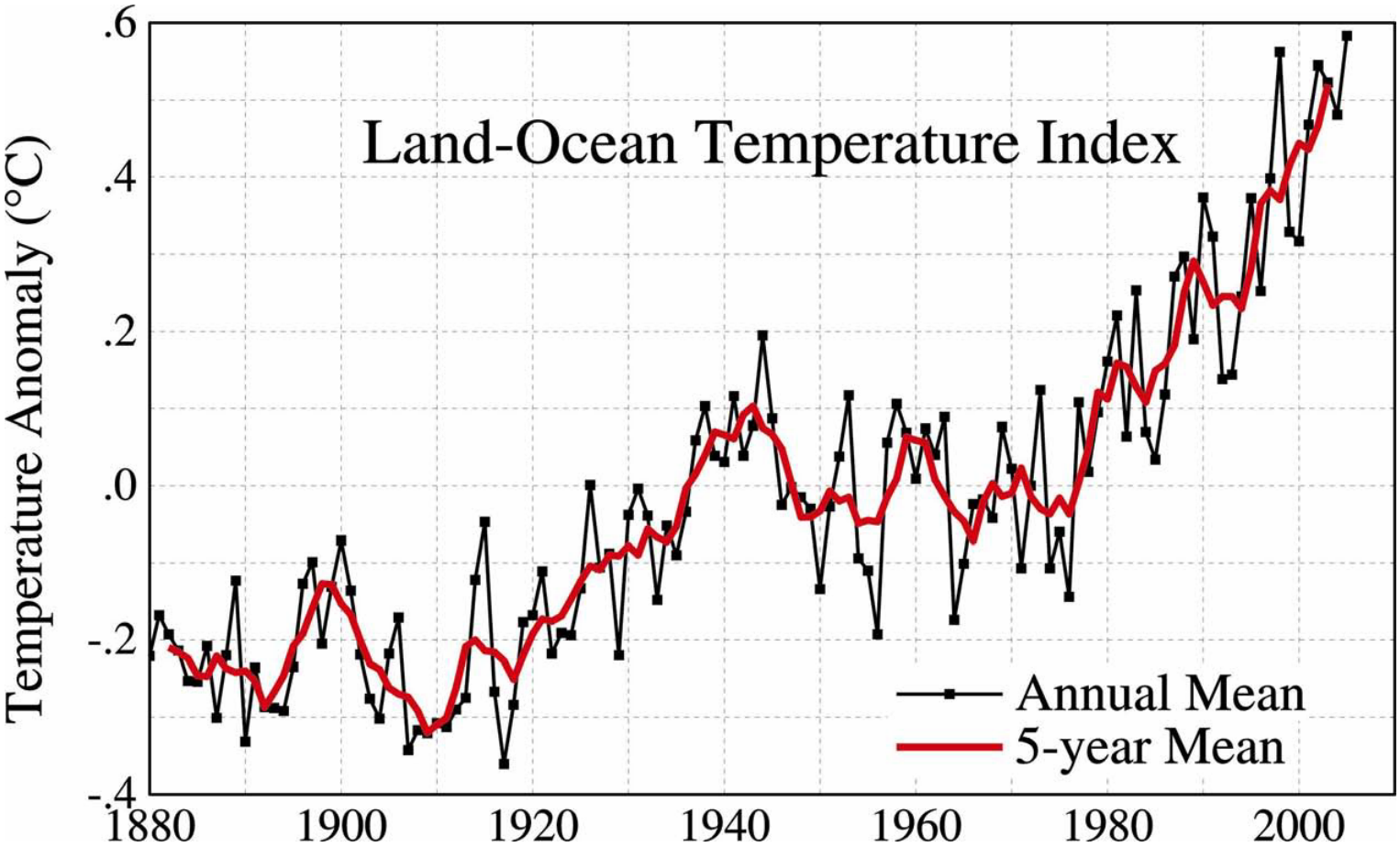

Lecture 16
Impact of Climate Change

Two main effects associated with climate change:

(1) An increase in global mean temperature discussed in a number of lectures (global warming).

(2) An increase in evaporation everywhere, driven by increased greenhouse gas concentrations and increased temperatures. The increase in evaporation also implies an increase in precipitation, because the atmosphere can't store water vapor indefinitely. There is no clear consensus on how the increase in precipitation will be distributed. However, we do know that it will not be distributed uniformly. This increase in evaporation and precipitation is known as the intensification of the hydrologic cycle.

Projection to the future? (globe and regions)



Global mean surface temperature change based on surface air measurements over land and SSTs over ocean. *Source:* Update of Hansen et al., *JGR,* 106, 23947, 2001; Reynolds and Smith, *J. Climate,* 7, 1994;Rayner et al., *JGR,* 108, 2003 (afterJames E.Hansen 2006).

Weather Forecast

“The weather man does it with a crystal ball” Don’t remember the source

Projection of Future Climate Change

“Our crystal balls are computer models (GCMs) and satellite data”

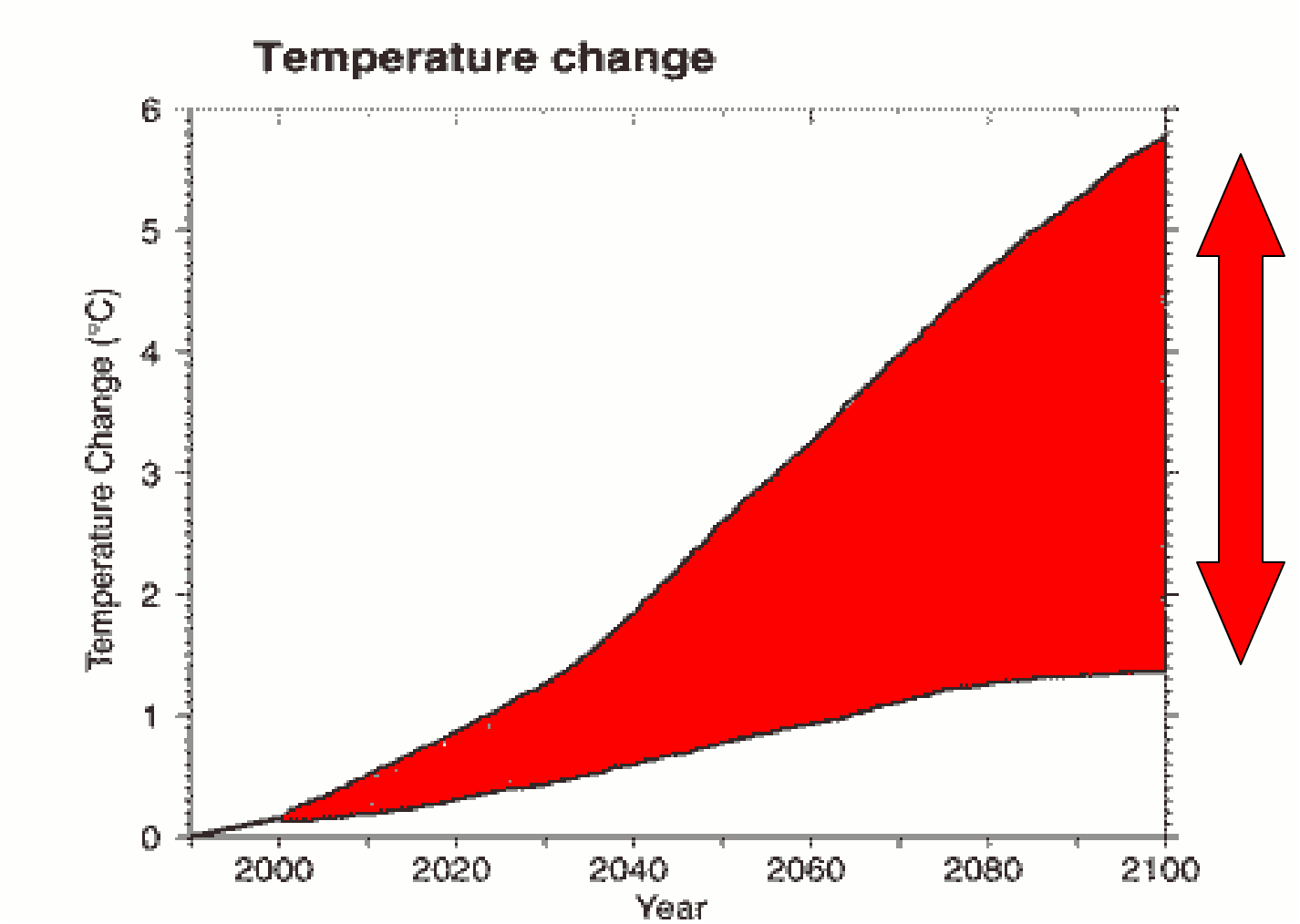
Something to do with Greenhouse Warming

“It is difficult to get a man to understand something when his salary depends upon his NOT understanding it”

Uptown Sinclair (from the file Anthony Stier sent me)

An Inconvenient Truth Al Gore (2006)

Uncertainty about the future: This plot shows the upper and lower limits of the warming over the coming century predicted by current GCM simulations.

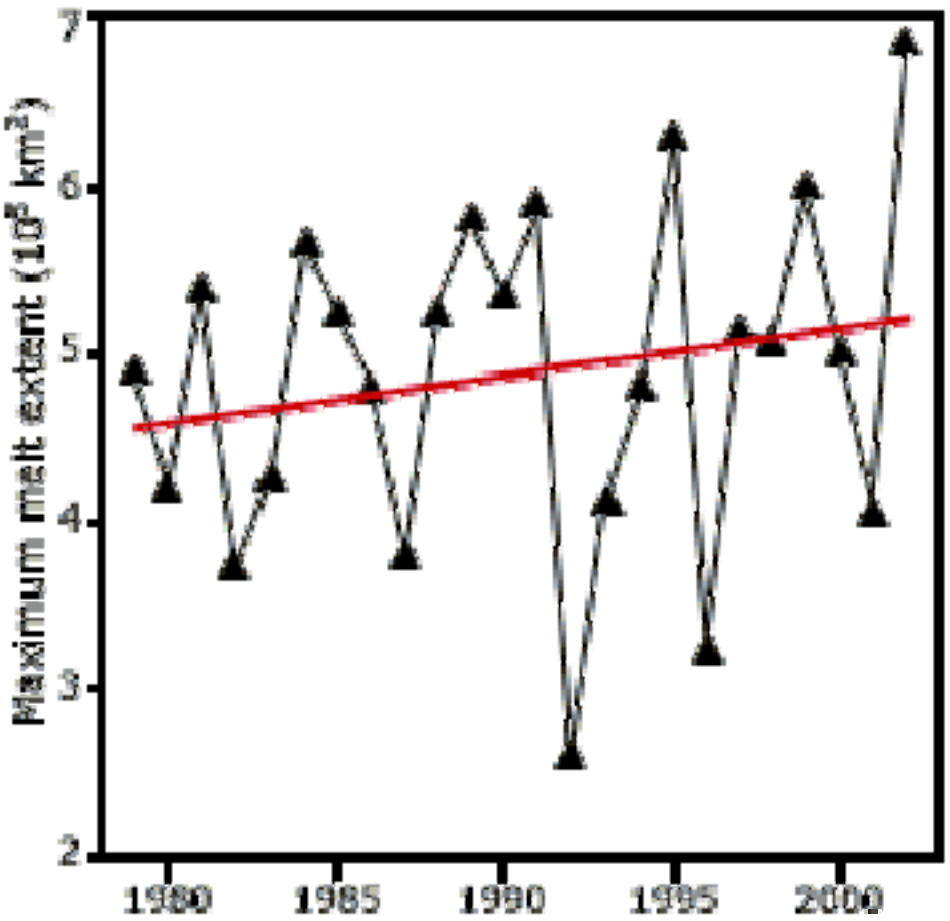


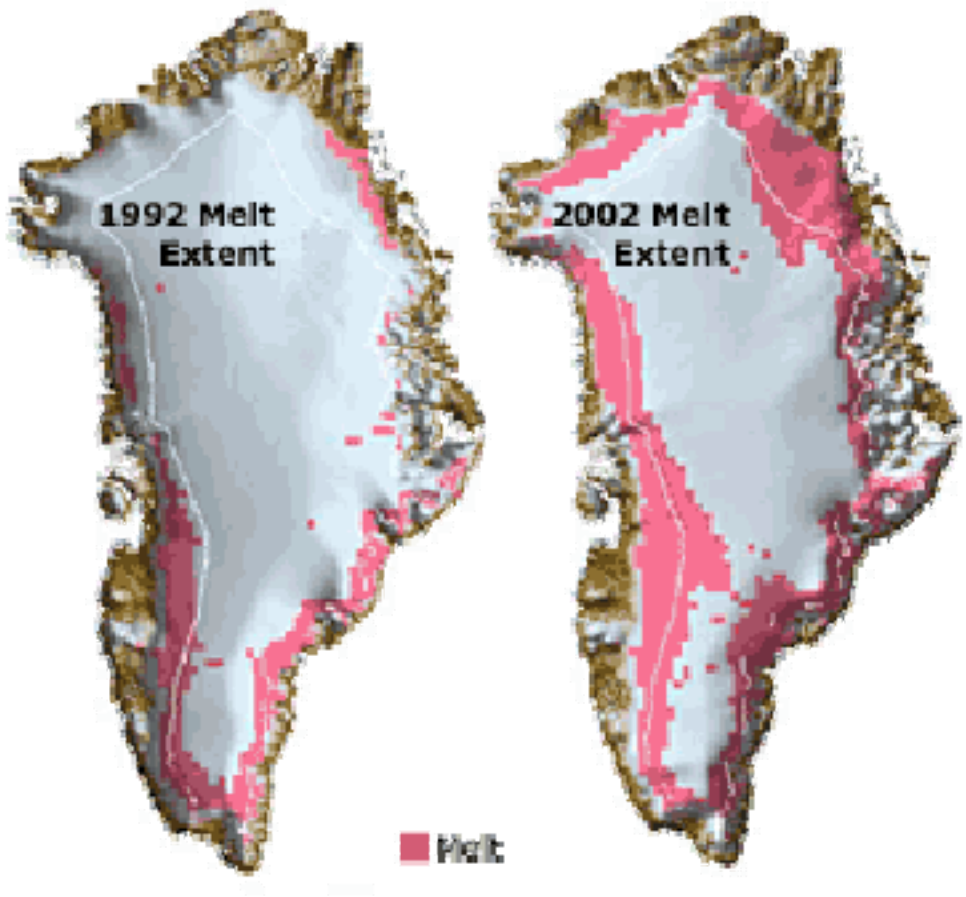
This range is due to two factors: (1) uncertainty in emissions scenarios and (2) different model sensitivities (i.e. different simulations of climate feedbacks).


1938
Climate Change Impacts
Hileman Photo
1981
Grinnell Glacier
Glacier National Park
1850
Key photo

Mountain glaciers all over the world are in retreat. This is the Qori Kalis glacier in Peru in 1978.

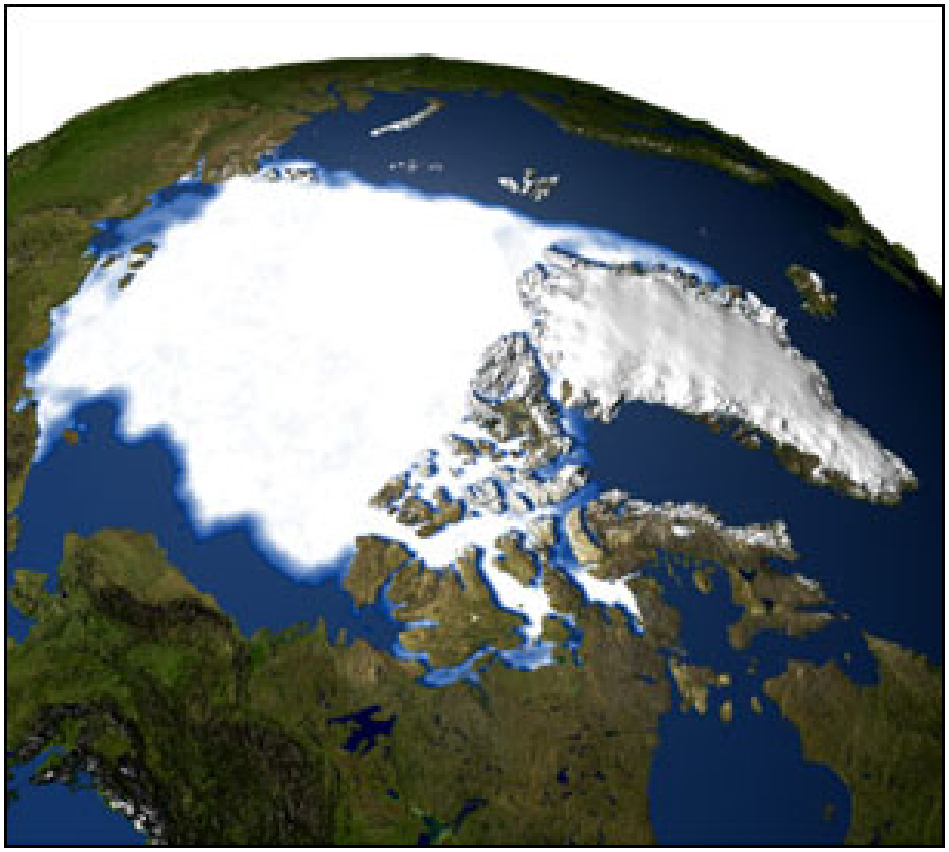
Here is the same glacier in the year 2000. The lake covers 10 acres.



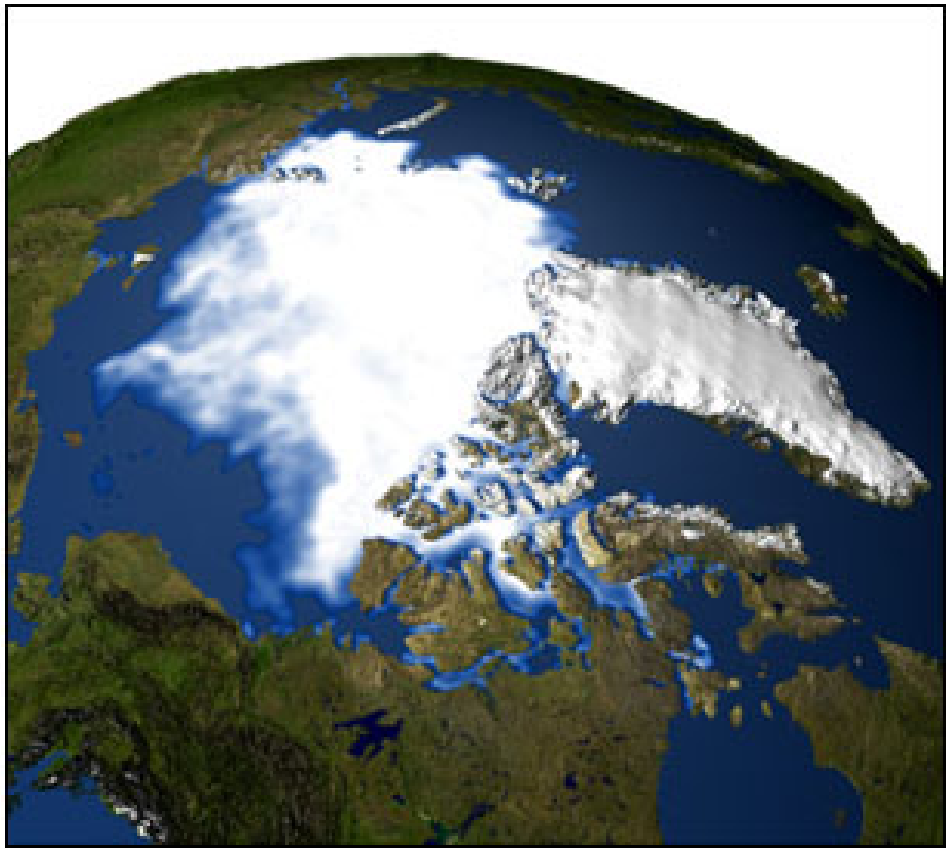


From space, we can monitor the extent of melting of the world's major ice sheets. Greenland has experienced a large increase in melting over the past few decades. Images courtesy of Konrad Steffen and Russell Huff, CIRES, University of Colorado at Boulder

Arctic researchers see early warming signals



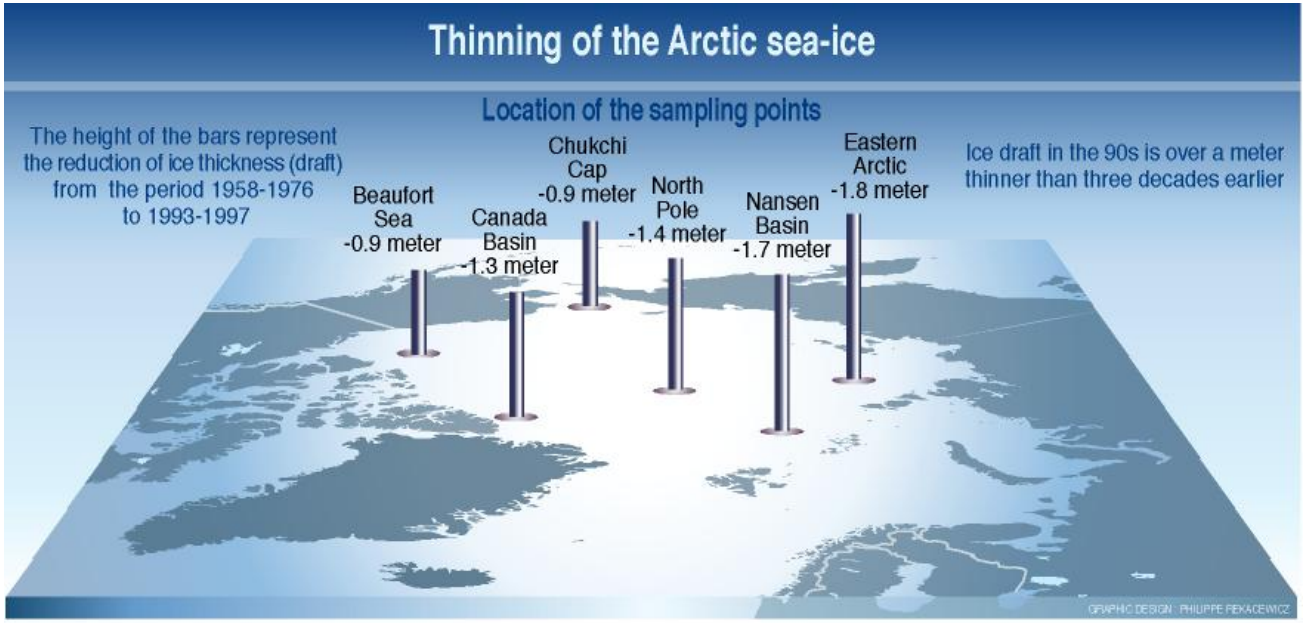
1979



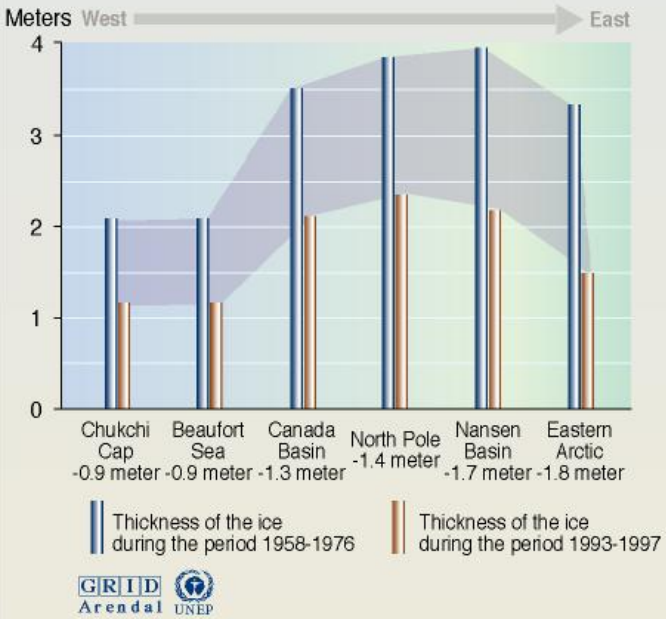
2000

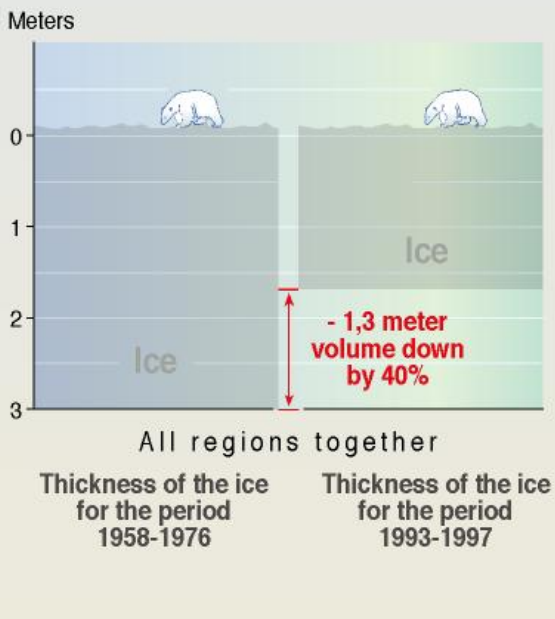
Based on satellite data, these images show Arctic sea ice. The ice cover shrunk by 9 percent a decade over that time.

Thinning of the Arctic sea-ice



Thinning of the Arctic sea ice cover





Note: comparison of sea-ice draft data acquired on submarine cruises betwen 1993 and 1997 with data from 1958-1976 indicates that mean ice draft at the end of the melt season has decreased by 1,3 m (from 3,1 m to 1,8 m). Value is down by 40%

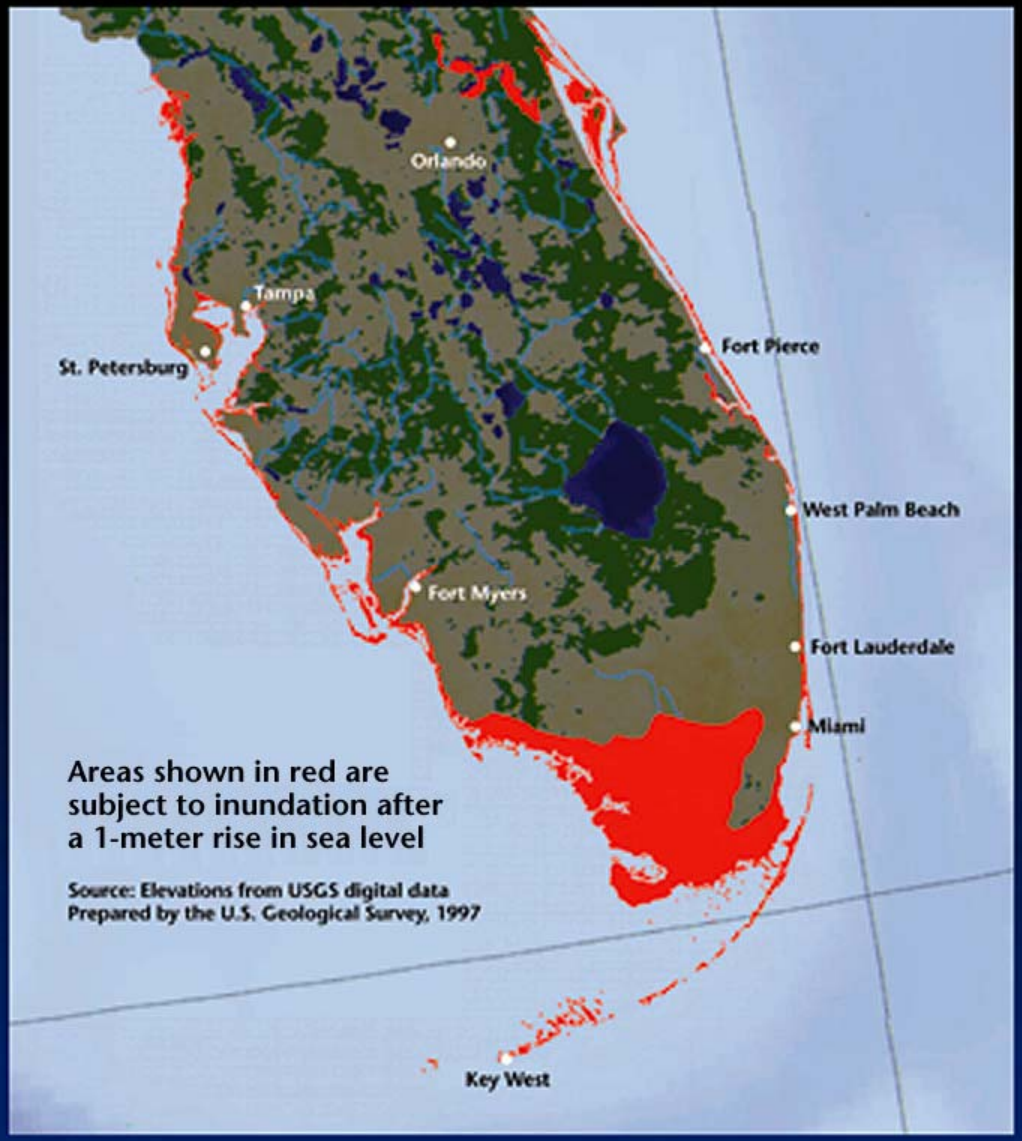
Sources: D.A. Rothrock, Y.Yu and G.A. Maykut, Thinning of the Arctic sea-ice cover, University of Washington, Seattle, 1999.

Why will sea level rise as the climate warms?

We discussed the effect of changes in the size of glaciers and ice sheets on sea level in the context of the 100,000 year glacial-interglacial cycles that have characterized Earth's climate over the past 1 million years.

In addition, sea level will rise as the climate warms due to the thermal expansion of seawater, i.e., the fact that seawater expands as it warms.

South Florida Shoreline Change after a 1-Meter Rise in Sea Level



Potential impact of sea-level rise on Bangladesh

Bangladesh, one of the world's poorest nations, is also the country most vulnerable to sea-level rise. The population is already severely affected by storm surges. Catastrophic events in the past have caused damage up to 100 km inland.

Today

Total population: 112 Million

Total land area: 134,000 km^2

1.5 m - Impact

Total population affected: 17 Million (15%)

Total land area affected: 22,000 km^2 (16%)

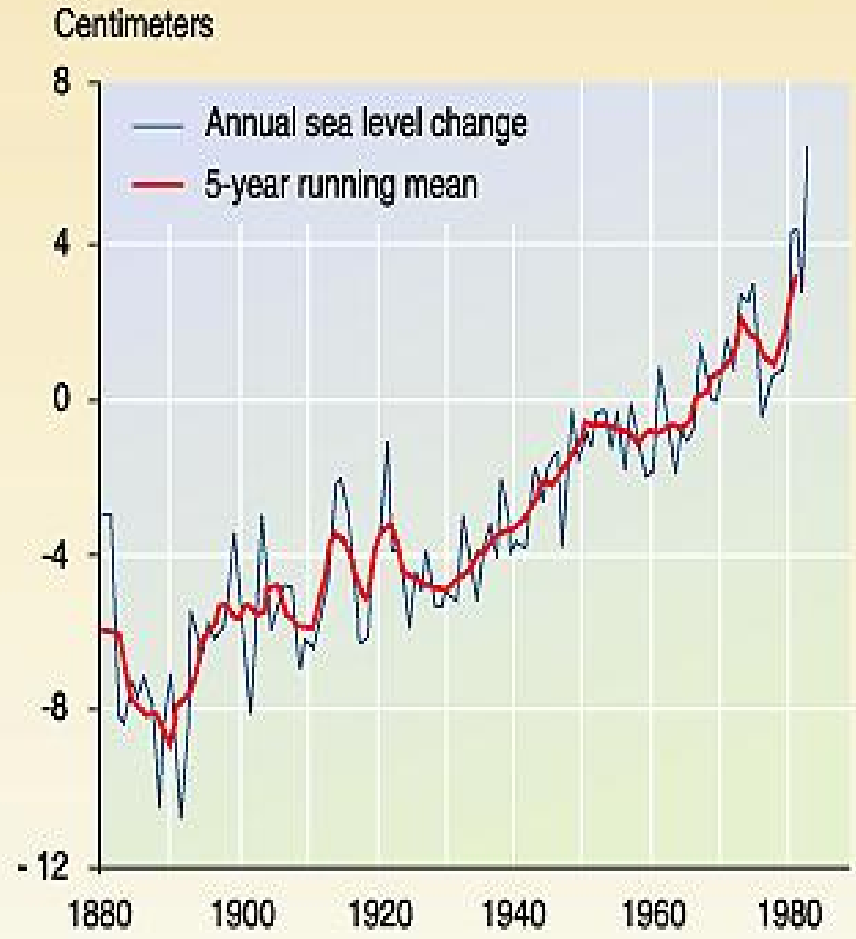
At present expected rates of sea level rise, this scenario would occur something like 150 years from now.

GRID Arendal UNEP

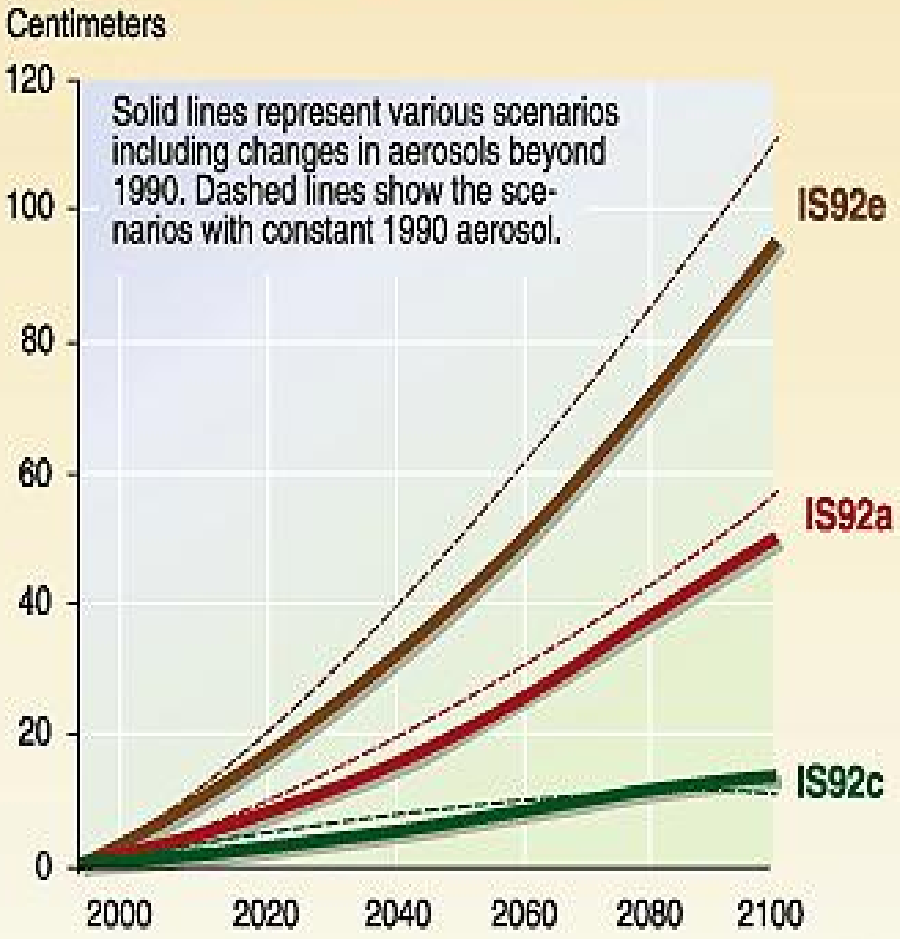
Source : UNEP/GRID Geneva; University of Dacca; JRO Munich; The World Bank; World Resources Institute, Washington D.C.

Sea level rise due to global warming

Sea level rise over the last century



Sea level rise scenarios for 2100



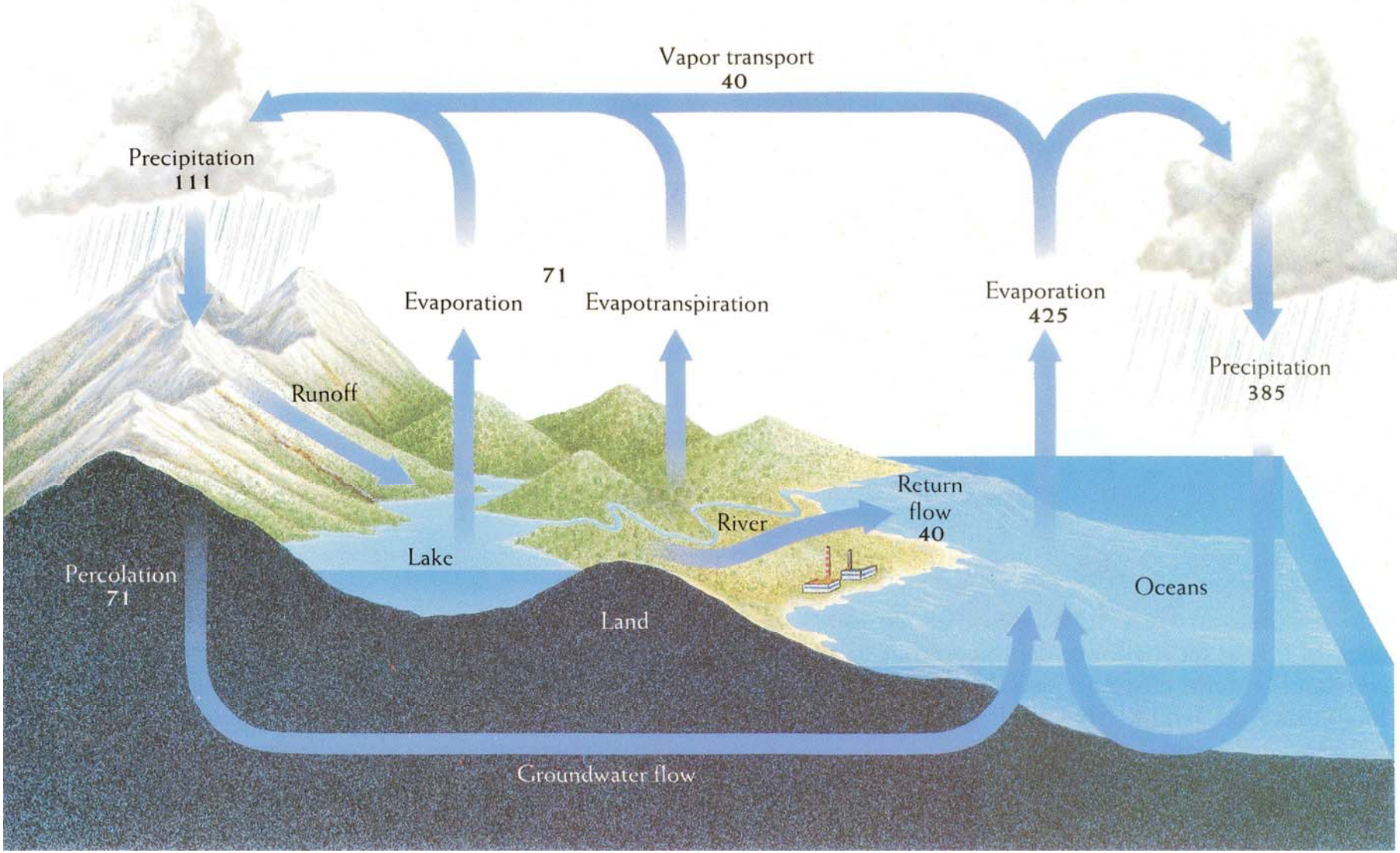
About 2/3 of the observed sea level rise is probably attributable to thermal expansion of seawater; the remainder is due to melting of glaciers.

GRID Arendal UNEP

GRAPHIC DESIGN : PHILIPPE REKACEWICZ

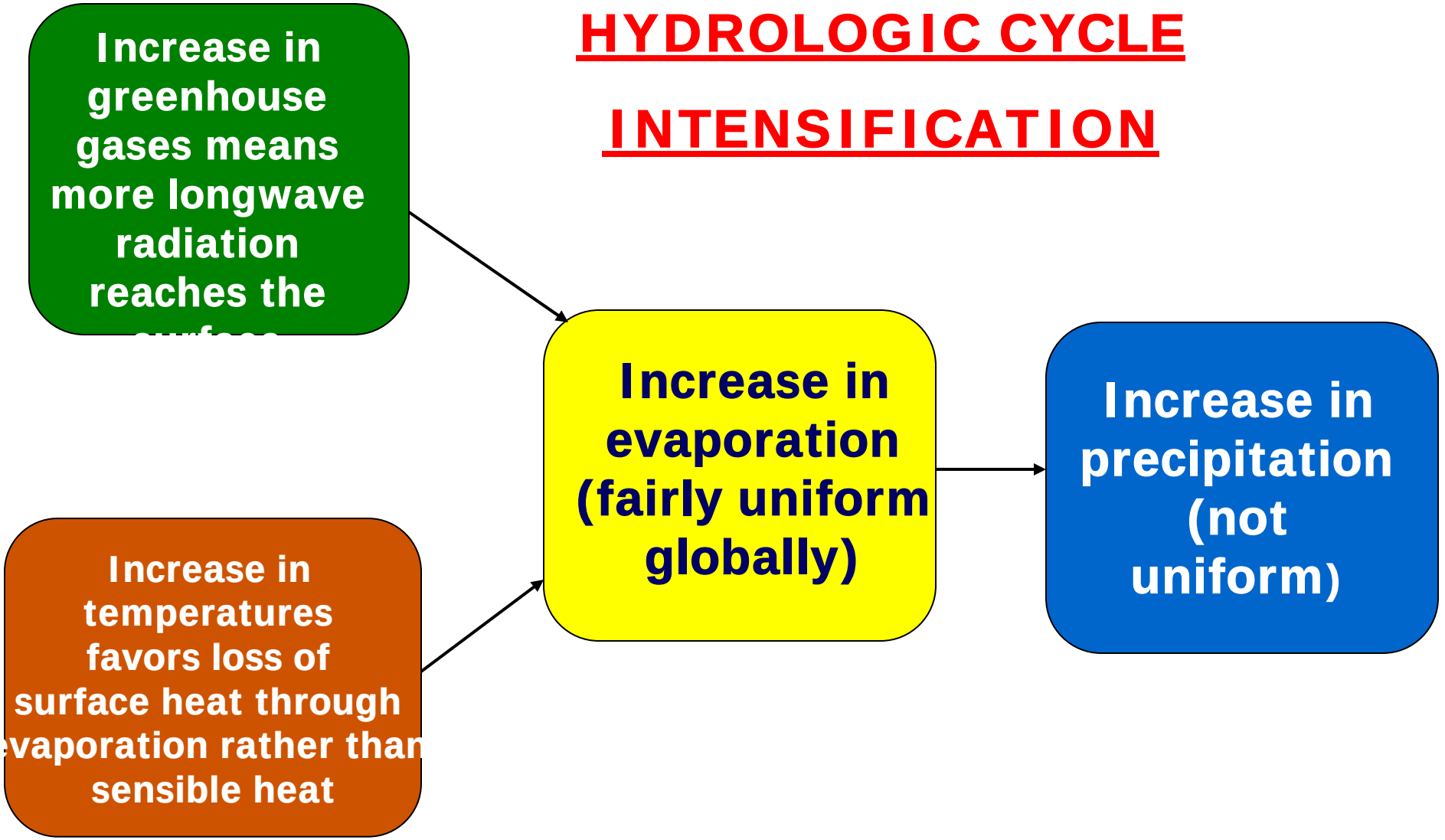
Source: Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996; Sea level rise over the last century, adapted from Gornitz and Lebedeff, 1987.


Another important issue: The
intensification of the hydrologic cycle

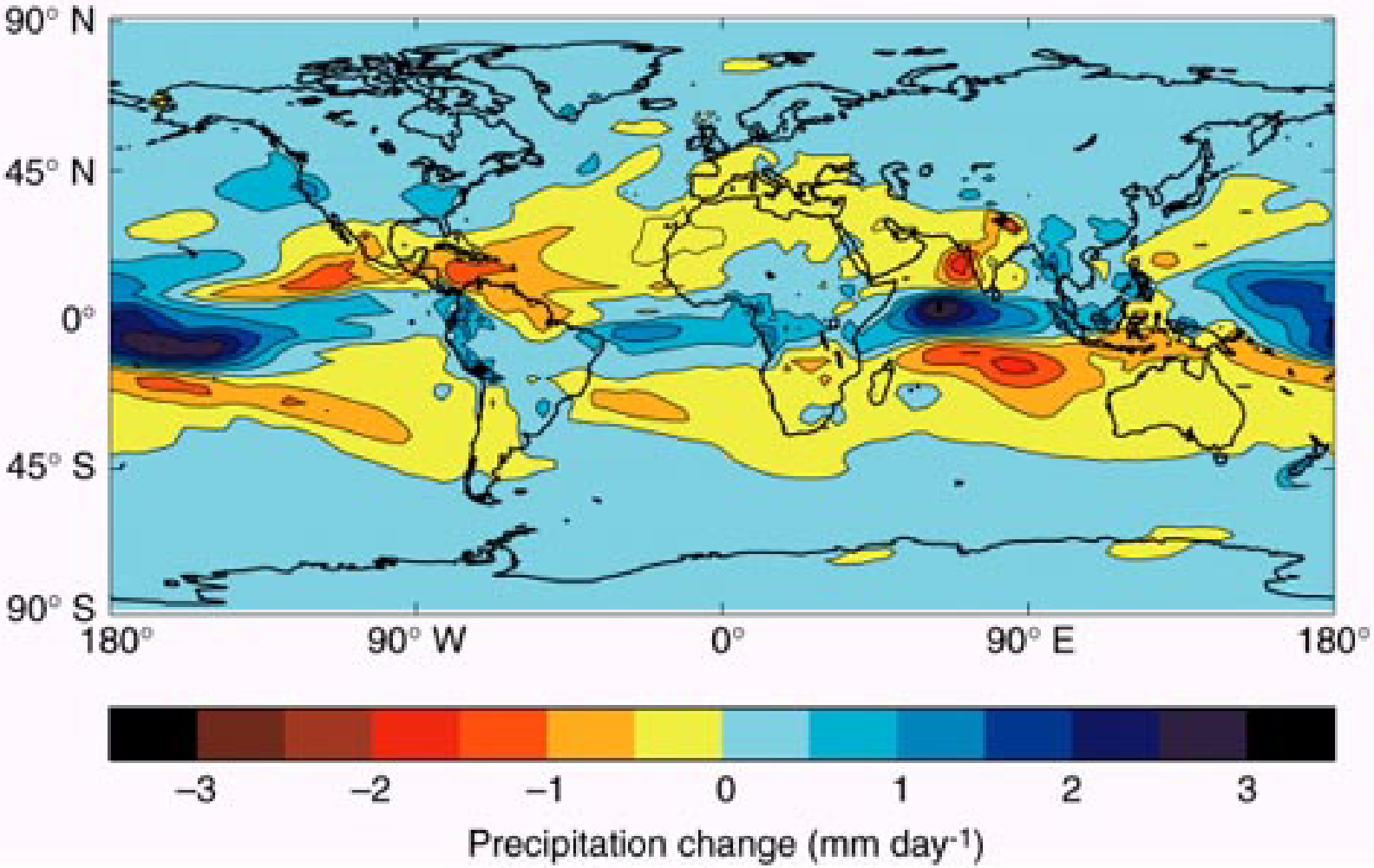


Earth's water budget. The units of the water flows are thousands of cubic kilometers per year.

HYDROLOGIC CYCLE INTENSIFICATION



Precipitation for the 2050s



The projected change in annual precipitation for the 2050s compared with the present day, when the climate model is driven with an increase in greenhouse gas concentrations equivalent to about a 1% increase per year in CO_2.

The Met Office - Hadley Centre for Climate Prediction and Research.

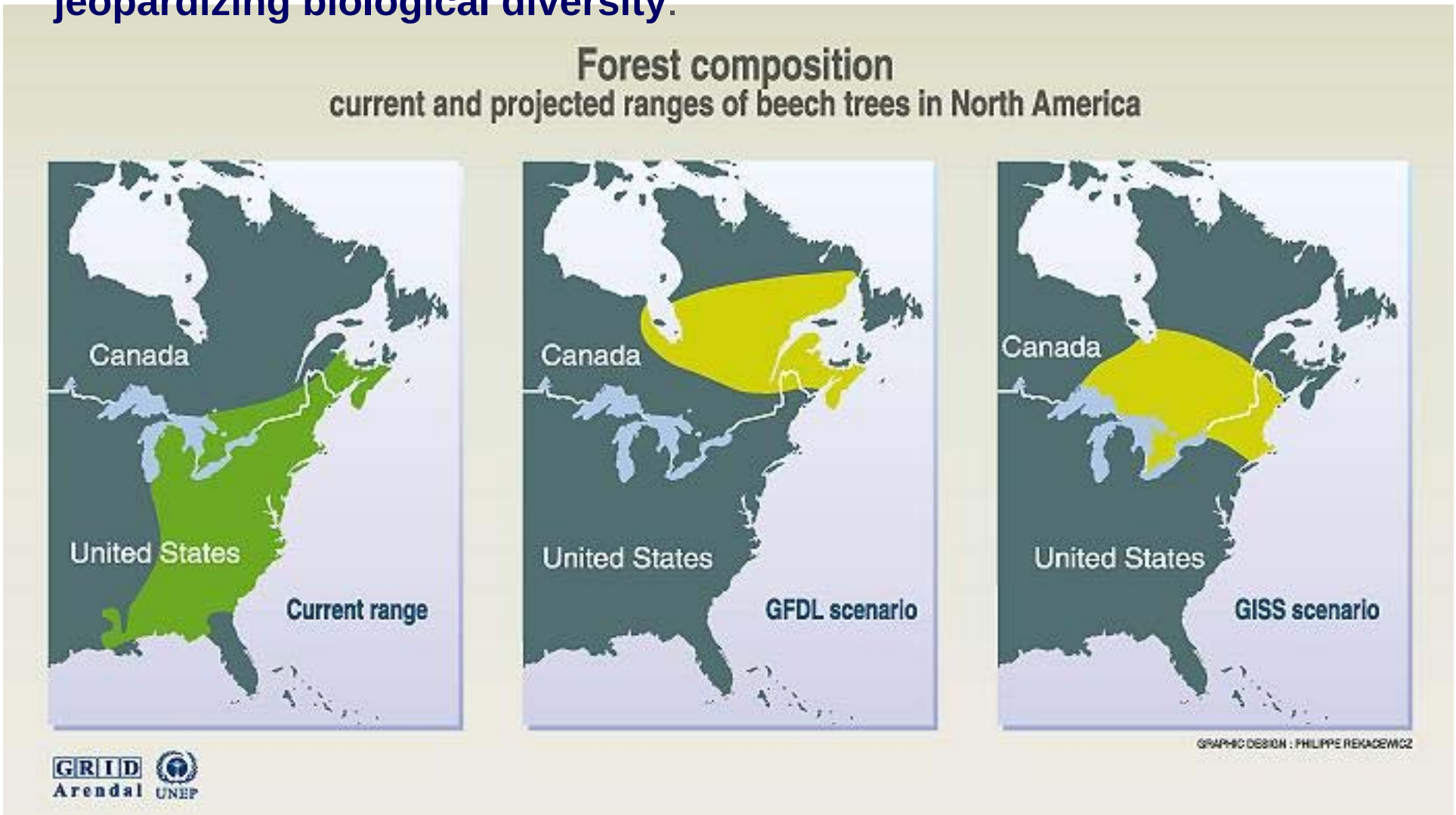
Effect on Ecosystems

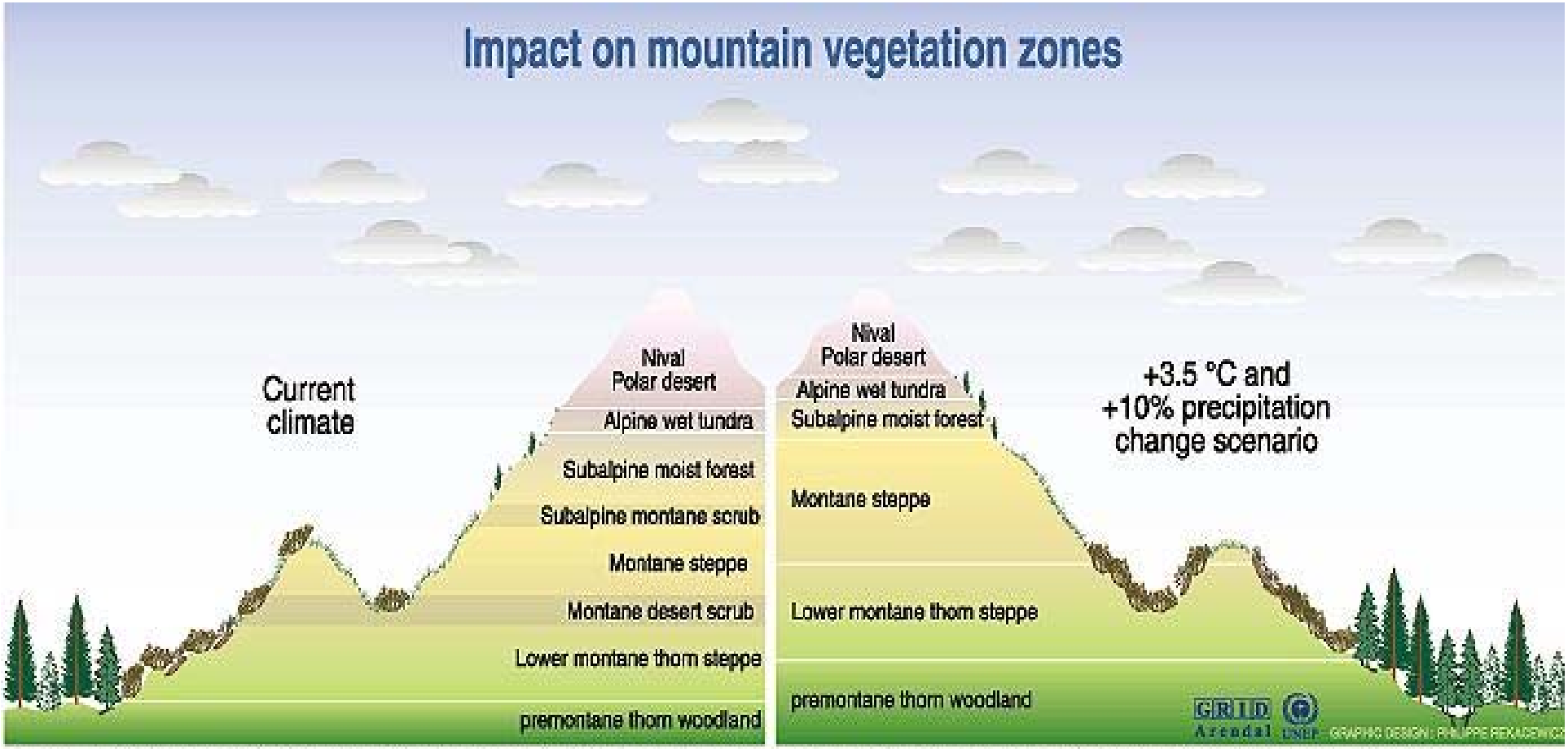
Ecosystems will be forced to adapt to climate change for two reasons:

(1) temperatures will be warmer.

(2) precipitation will be distributed differently.

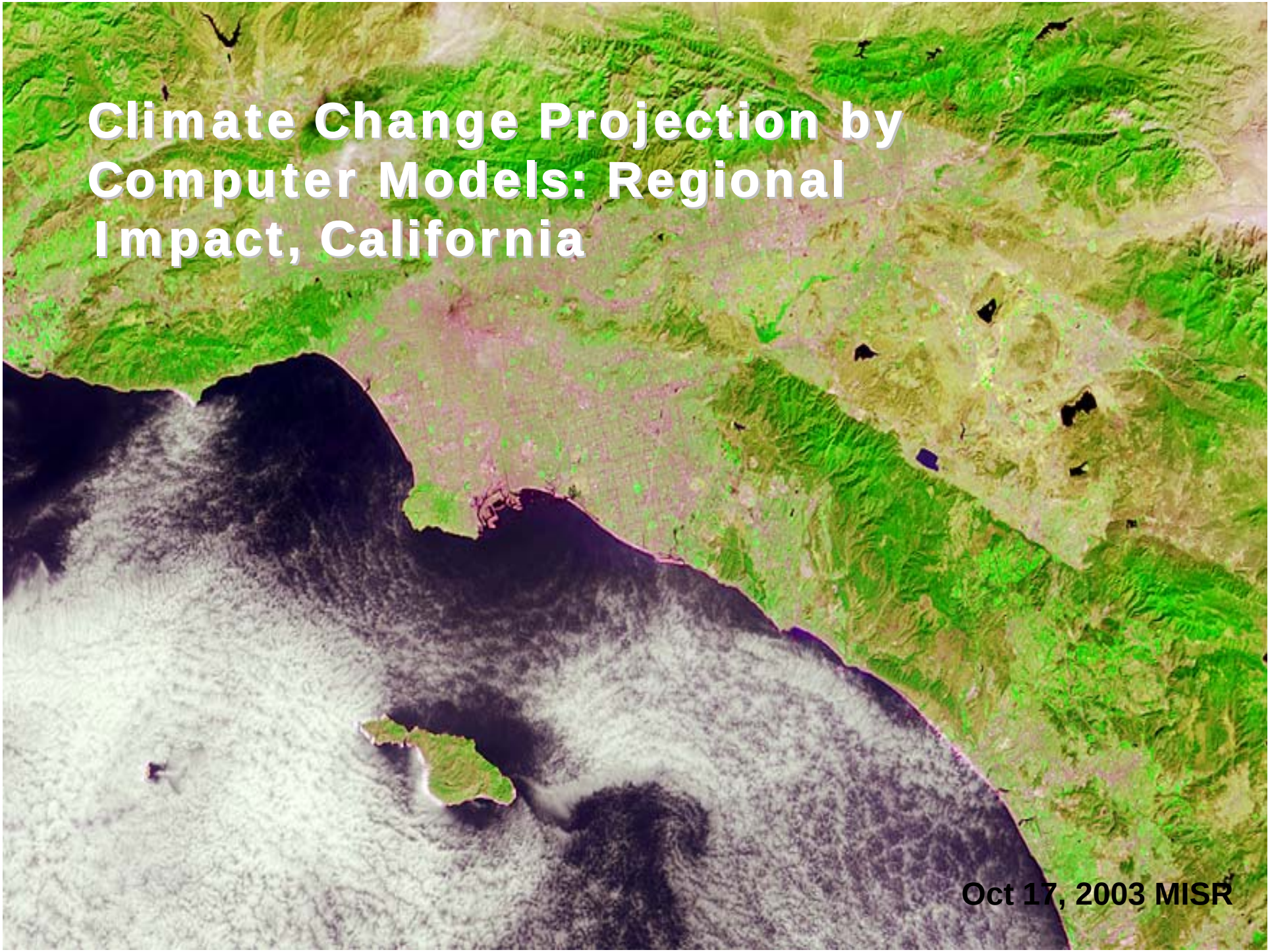
One easily anticipated effect of climate change is species migration to higher latitudes. For example, a warmer climate may have significant effect on forests composition. Decidous forests will probably move northwards and to higher altitudes, replacing coniferous forests in many areas. Some tree species will probably be replaced altogether, jeopardizing biological diversity.





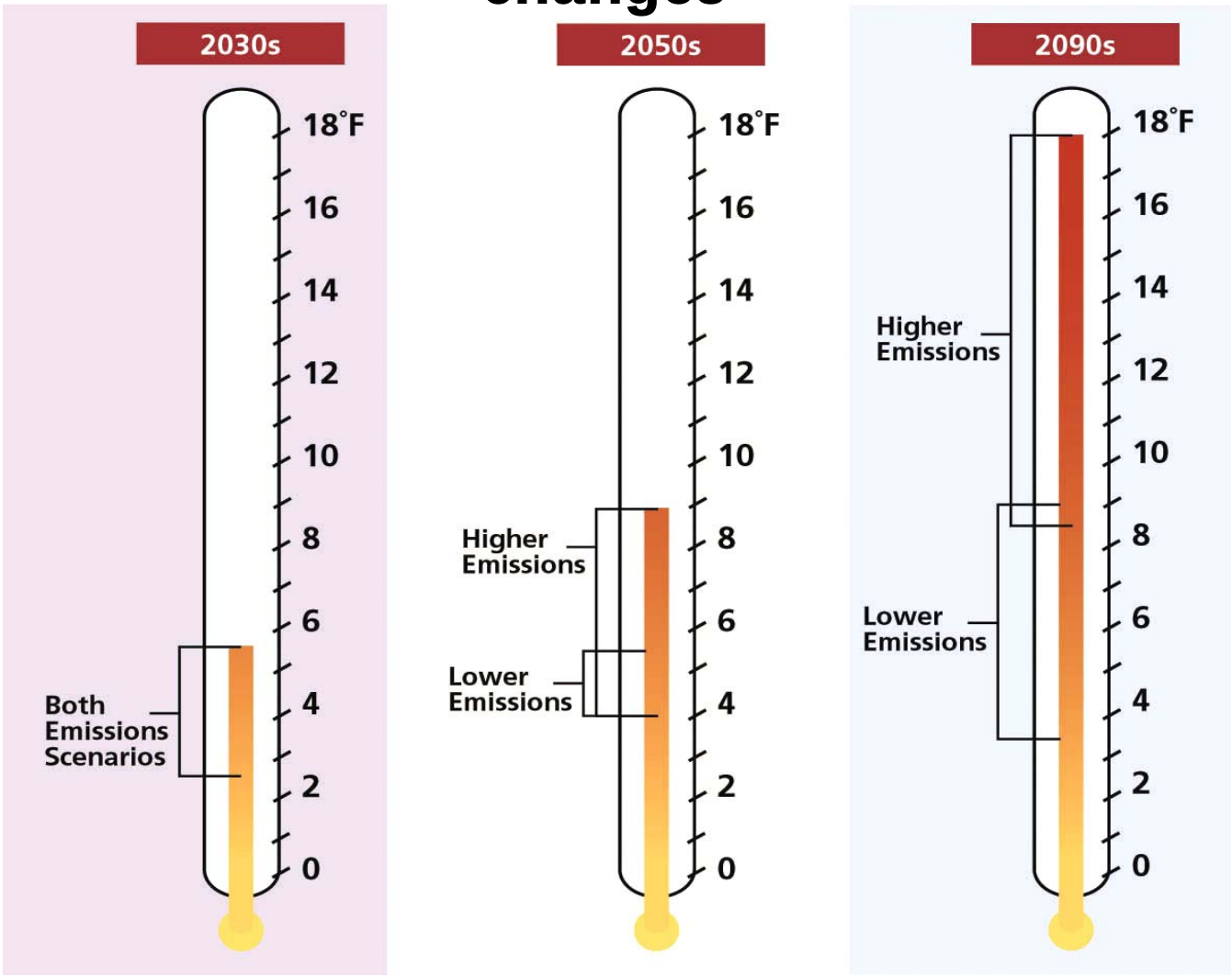
Sources: Martin Benitson, Mountain environments in changing climates, Routledge, London, 1994; Climate change 1995, Impacts, adaptations and migration of climate change, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change (IPCC), UNEP and WMO, Cambridge press university, 1996.

Species would also migrate to higher altitudes. The figure shows a comparison of current vegetation zones at a hypothetical dry temperate mountain site with simulated vegetation zones under a climate-warming scenario. Species and ecosystems with limited climatic ranges could disappear.


Climate Change Projection by Computer Models: Regional Impact, California
Oct 17, 2003 MISR

Rising Temperatures

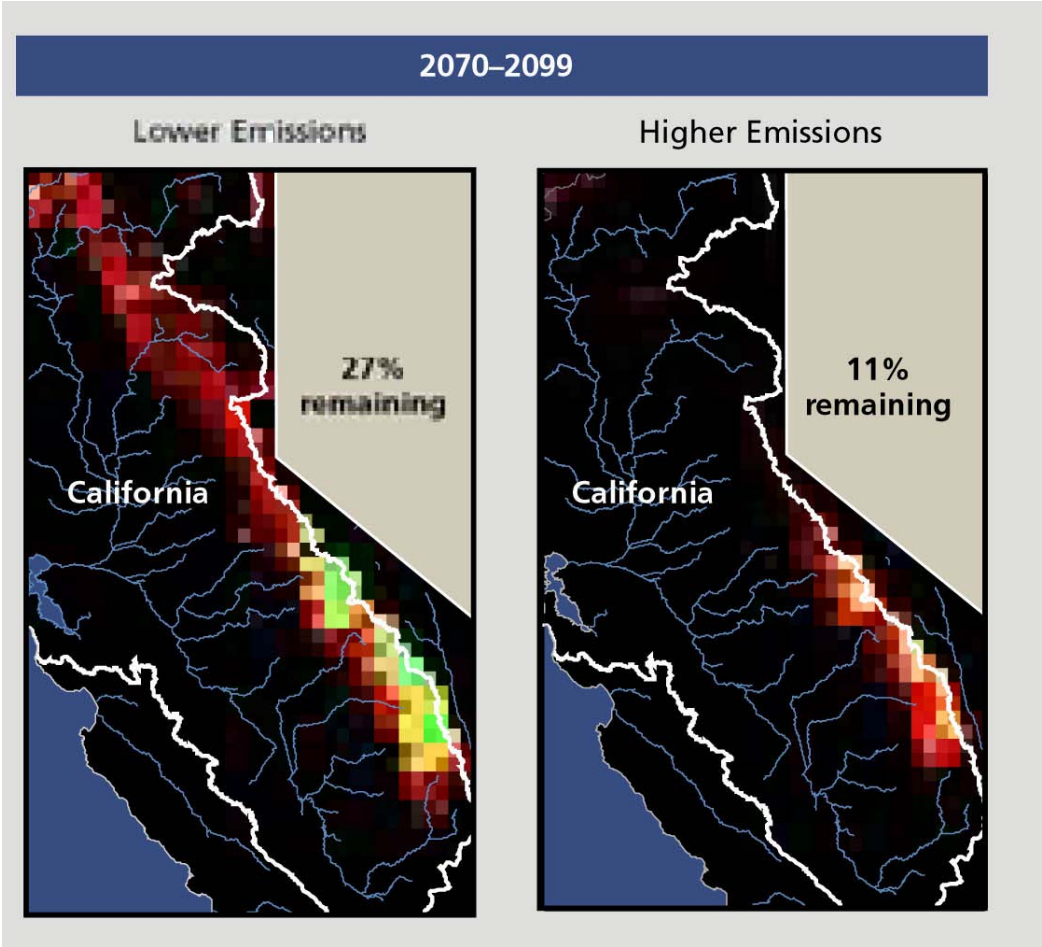
California statewide
Projected average summer temperature changes



Source: A Luers/Union of Concerned Scientists

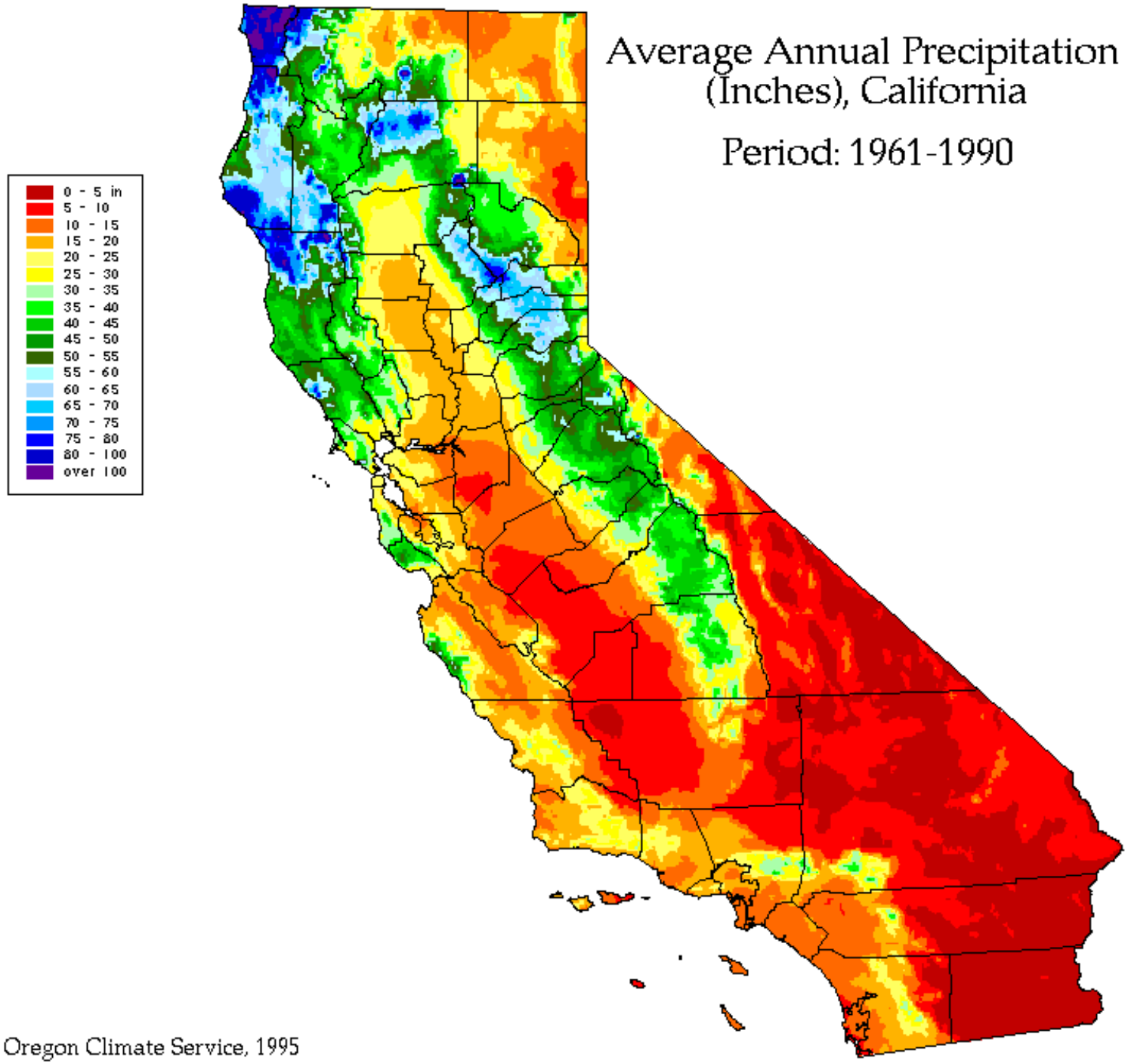
Diminishing Sierra Snowpack

% Remaining, Relative to 1961-1990

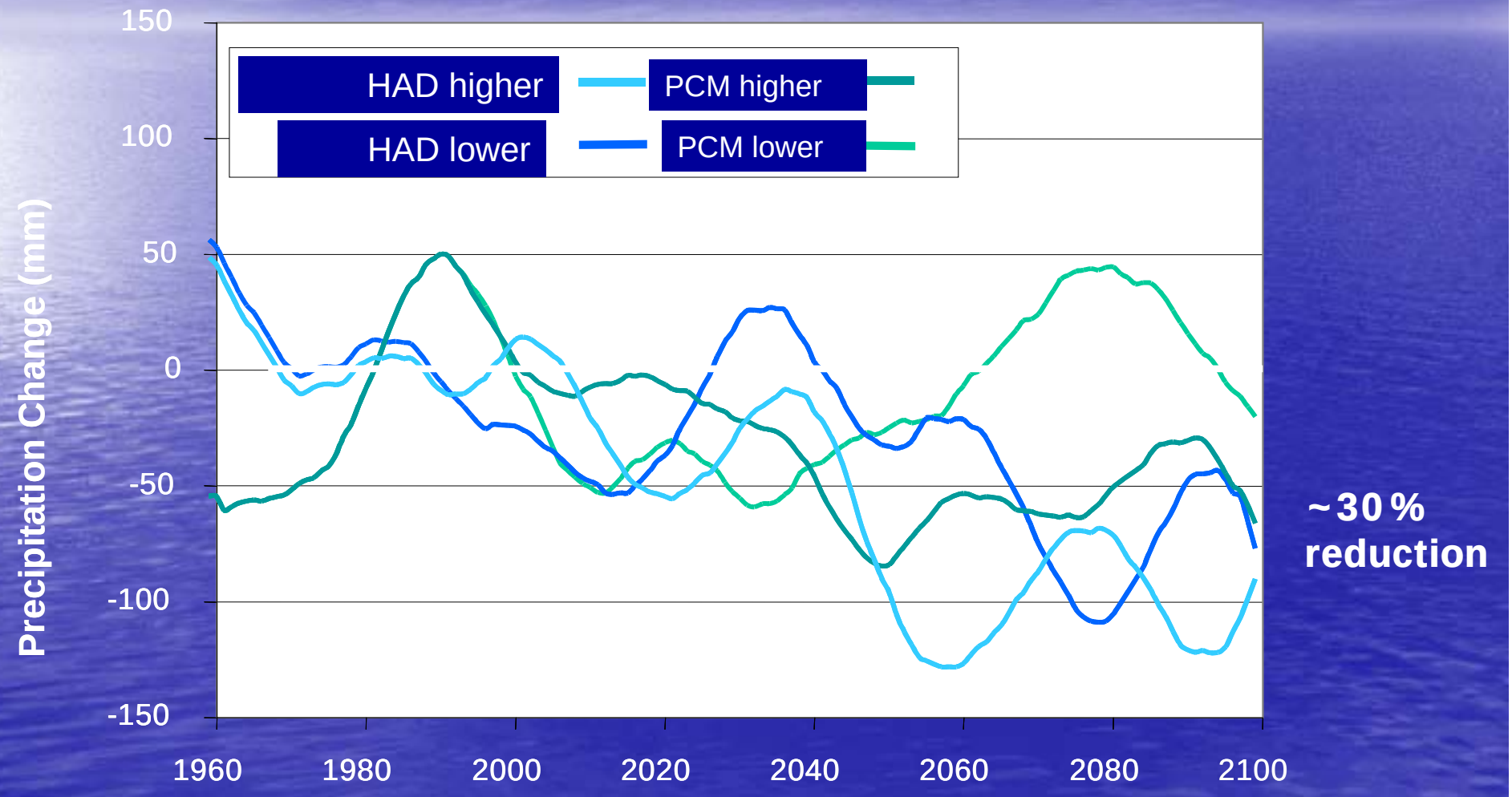


Source: A Luers/Union of Concerned Scientists

This shows how the more sensitive global model projects snowpack to change in the Sierras. The change in snowpack is significant because it comprises approximately half the total water storage capacity of California, the other half being contained mainly in human-made reservoirs.


Average Annual Precipitation
(Inches), California
Period: 1961-1990
0 - 5 in
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 100
over 100
Oregon Climate Service, 1995

Precipitation Projections
Statewide, Winter



~30% reduction

Source: A Luers/Union of Concerned Scientists

Effects of Climate Change on California: A Research Frontier

- Precipitation and snow distribution (mountain ecosystems, ski industry)
- Santa Ana events (human health, wildfire)
- Runoff/streamflow (coastal wetlands)
- Sea surface temperatures (ocean ecosystems)

Summary remarks: This course (Climate Change) is designed for students from all backgrounds. It is intended
(1) to provide the scientific background necessary to understand climate related issues, particularly global warming,
(2) to gain a scientific understanding of the human influence on climate in the past and the future, and
(3) to obtain an appreciation for the role of science in shaping political debate and decision on climate issues where accurate scientific information is essential.