

# Lecture 27: Instrumental Observations

Ch. 17

# The Earth's Climate History

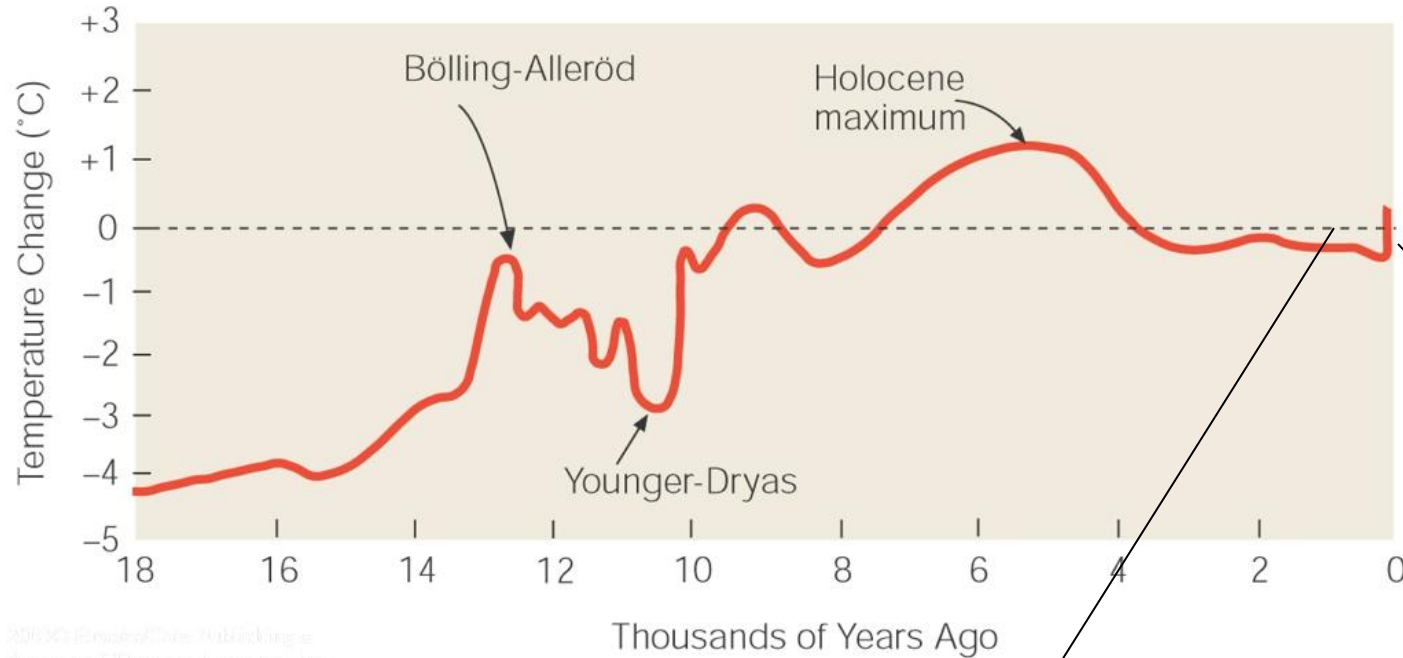
1. **Over the last century, the earth's surface temperature has increased by about 0.75°C (about 1.35°F).**
2. Little Ice Age = Cooling during 1,400 A.D. – 1,900 A.D. (N.H. temperature was lower by 0.5°C, alpine glaciers increased; few sunspots, low solar output)
3. Medieval Climate Optimum (Warm Period) = Warming during 1,000 A.D. – 1,300 A.D. in Europe and the high-latitudes of North Atlantic (N.H. warm and dry, Nordic people or Vikings colonized Iceland & Greenland)
4. Holocene Maximum = 5,000-6,000 ybp (1°C warmer than now, warmest of the current interglacial period)
5. Younger-Dryas Event = 12,000 ybp (sudden drop in temperature and portions of N.H. reverted back to glacial conditions)
6. Last Glacial Maximum = 21,000 ybp (maximum North American continental glaciers, lower sea level exposed Bering land bridge allowing human migration from Asia to North America)
7. We are presently living in a long-term Icehouse climate period, which is comprised of shorter-term *glacial* (e.g., 21,000 ybp) and *interglacial* (e.g., today) periods. There were four periods of Icehouse prior to the current one.
8. For most of the earth's history, the climate was much warmer than today.

# Historical Climate: Instrumental Observations

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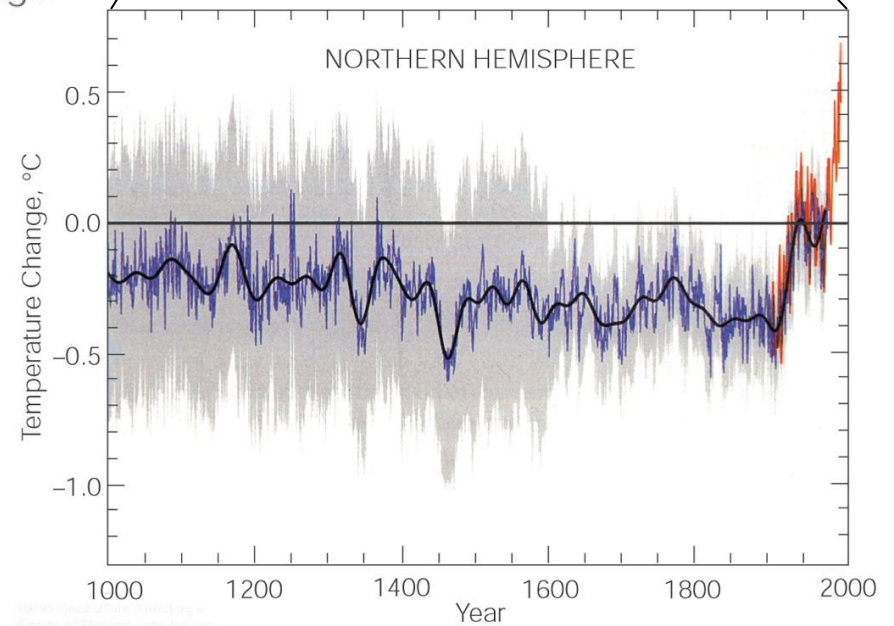
- How has surface air temperature changed since 1800s?
- How have glaciers and sea level change in the past 100 years?
- Name four evidences that support a gradual warming of high northern latitudes in the last two decades.

# Climate Change Since the Last Glacial Maximum



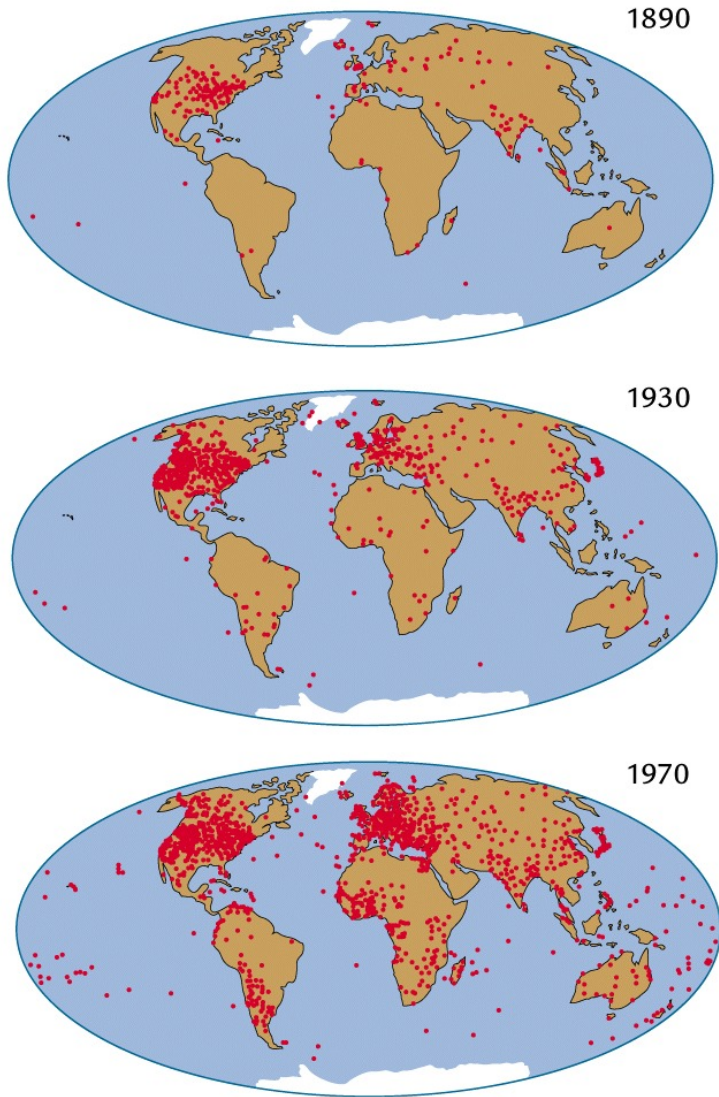
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**The earth appears to experience another abrupt climate change during the past 100 years.**

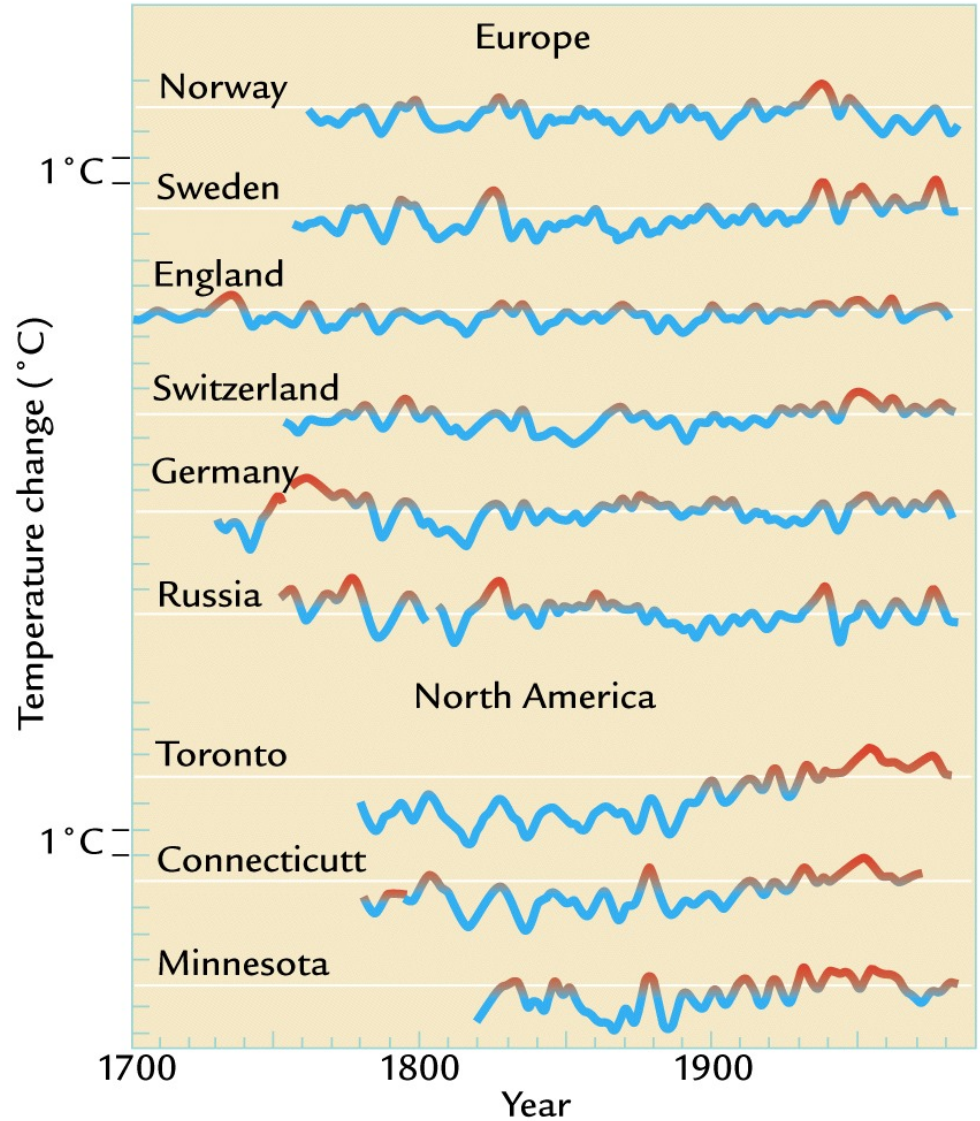


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# Instrumental Records

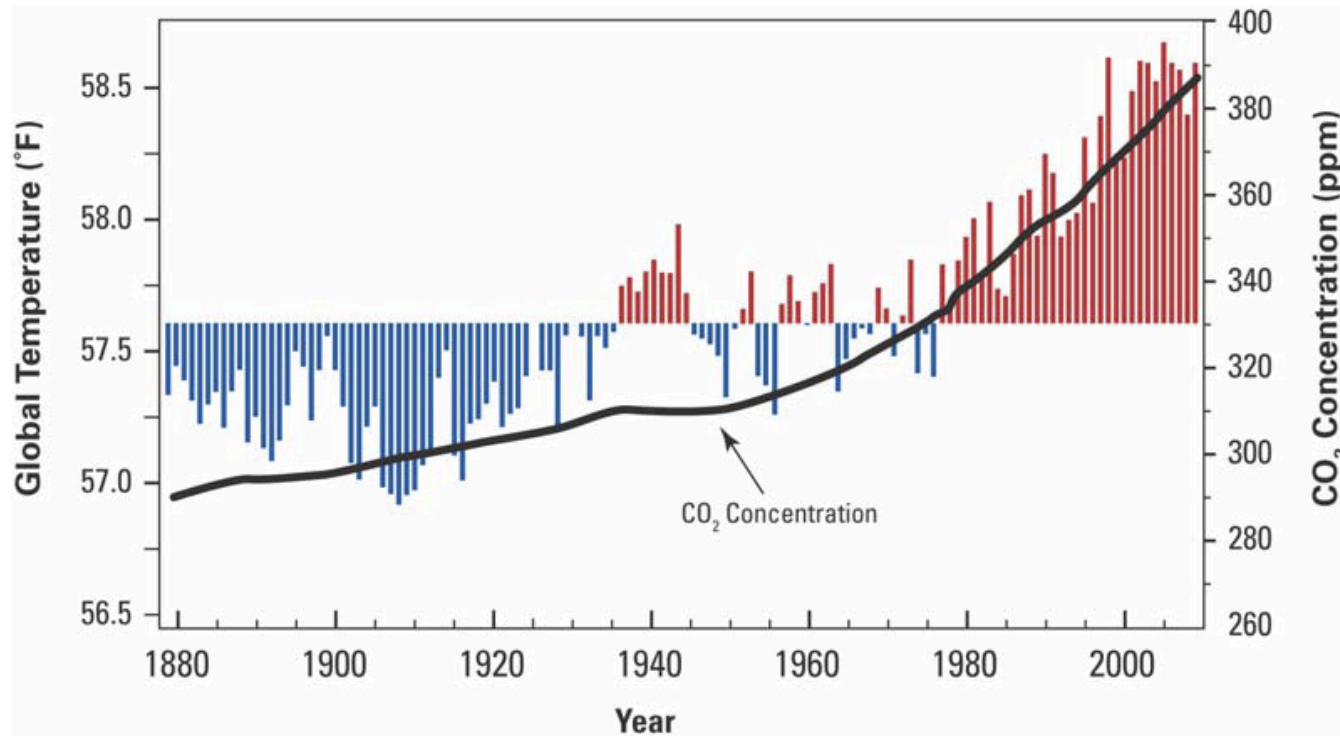


Temperature stations increased significantly during the 20<sup>th</sup> century



> 200 years of temperature records in Europe and North America

## Global surface temperature change: 1880-2009

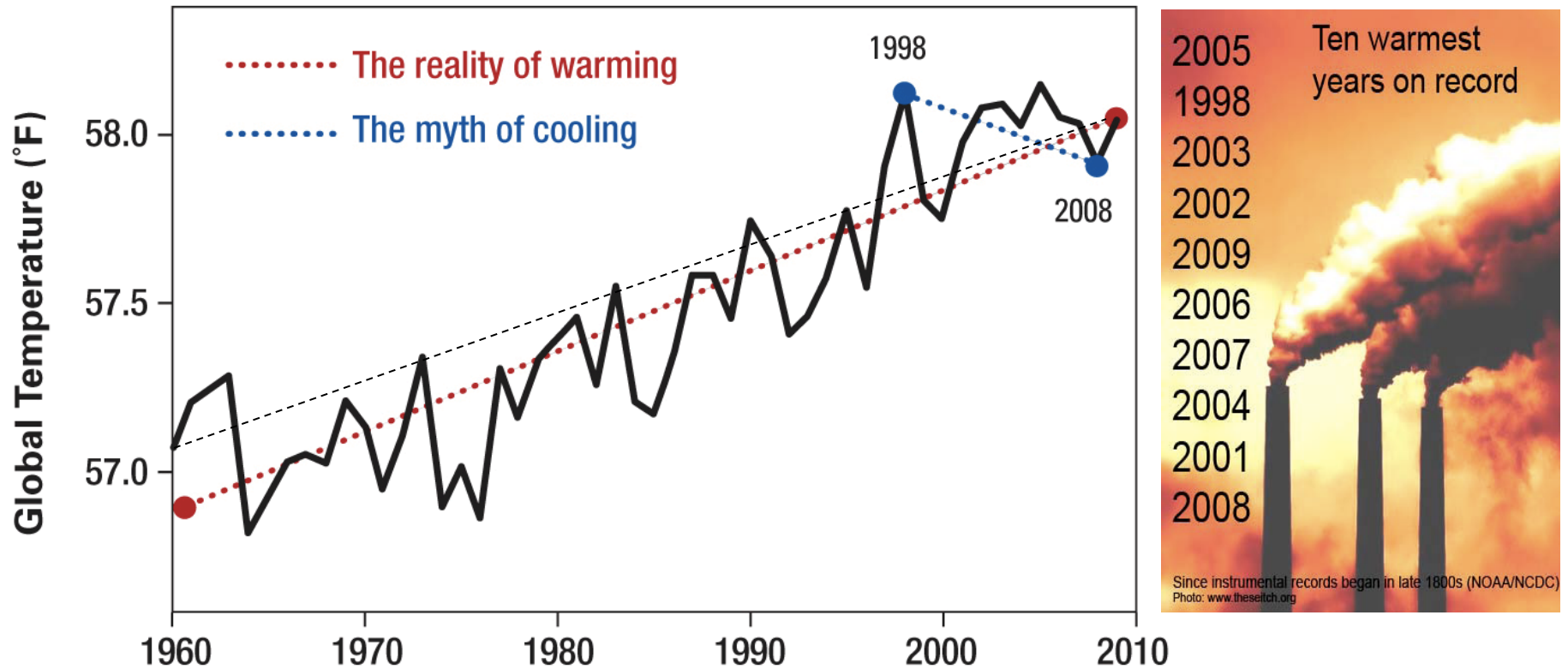


**Data over the globe (land and sea).**

**Warming periods: 1900-1945 (by 0.5°C), the mid-1970s to present.**

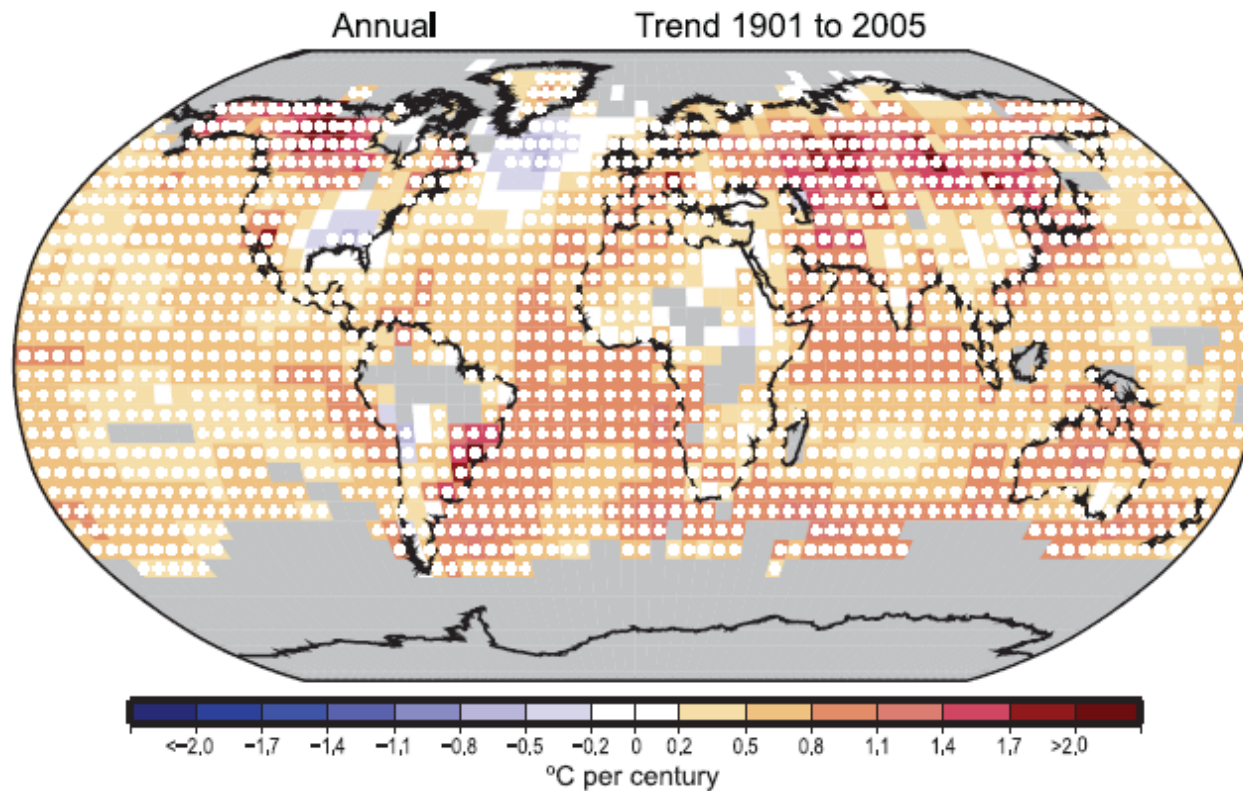
**The warmest decade: the 1990s. The warmest year: 1998. Top 20 includes every single year since 1992.** Over last 25 years warming ~ 0.5°C. Over past century warming ~ 0.75°C

**Cooling periods: 1945-1975.** [http://www.ucsusa.org/global\\_warming/science\\_and\\_impacts/science](http://www.ucsusa.org/global_warming/science_and_impacts/science)



The year 1998 was particularly warm and has been used to falsely claim that the following decade has seen little change or a cooling in temperature. Red shows the correct trend from 1960 through 2008, blue is an erroneous trend over ten years resulting from “cherry-picking” the start and finish dates. Source: NOAA/NCDC data1, design idea K. Hayhoe.

# Surface Air Temperature Trends Over the Past Century



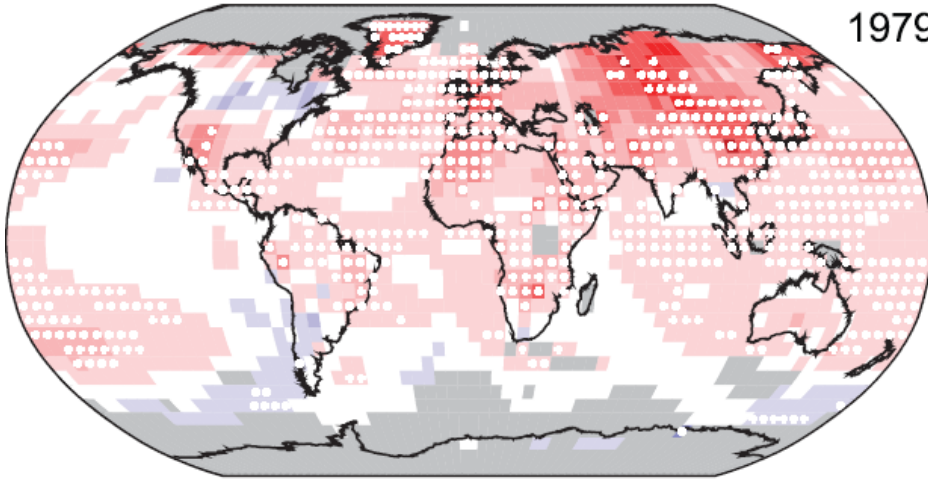
- Warming greatest **at night** over northern **mid-to-high latitude land**
- Stronger warming** during **winter and spring**
- Greater than the global average in some areas
- Cooled in some areas (southern Mississippi Valley in USA)



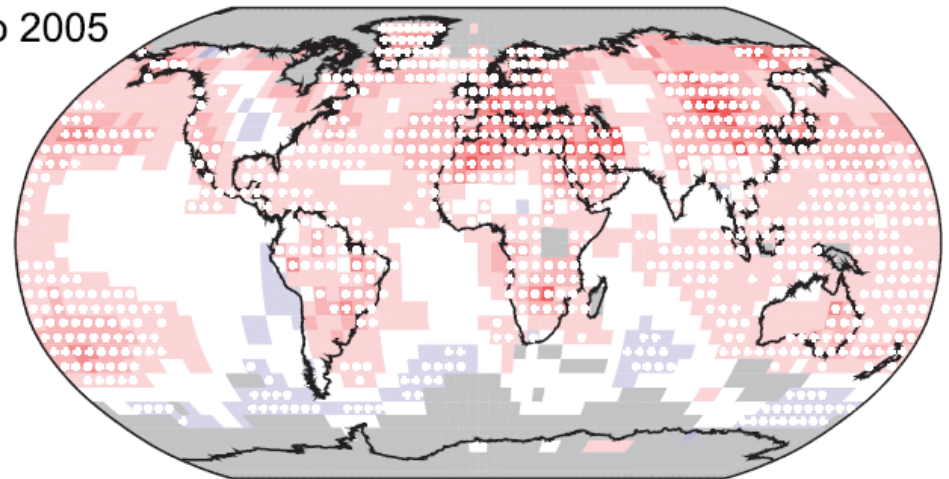
# Annual Surface Temperature Trends in °C/decade

Trend  
1979 to 2005

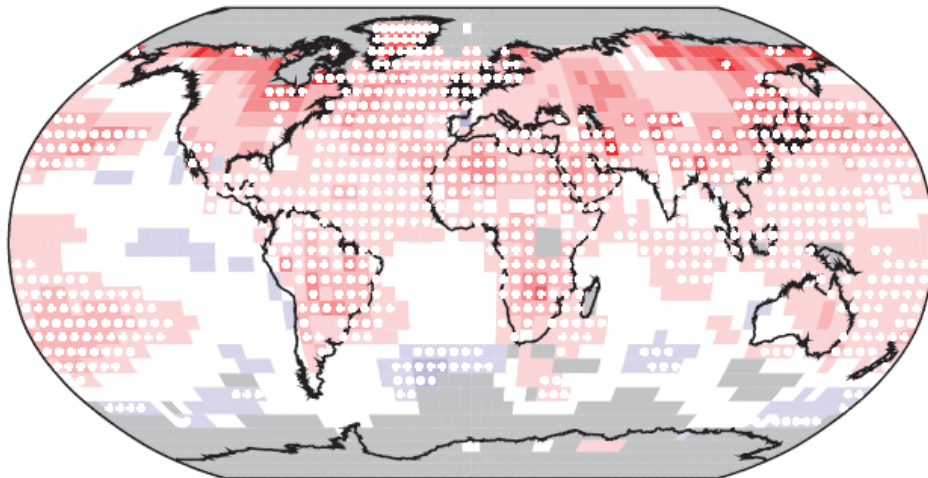
MAM



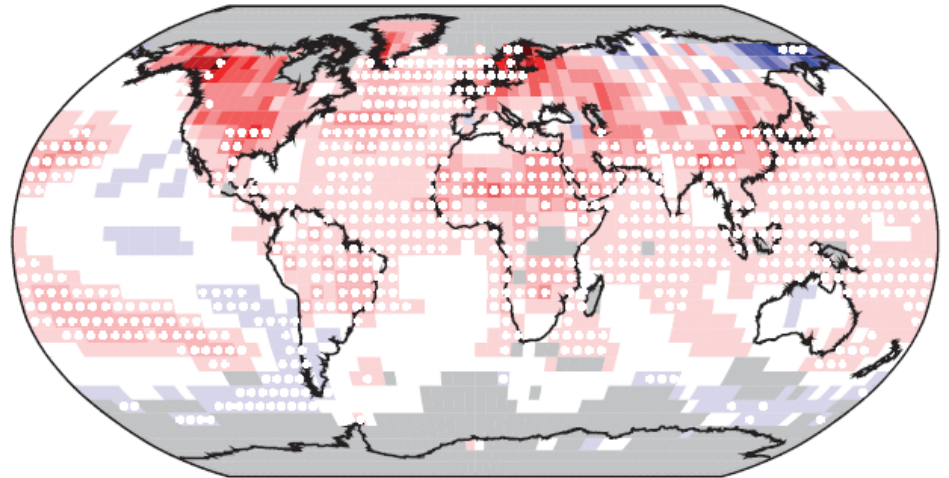
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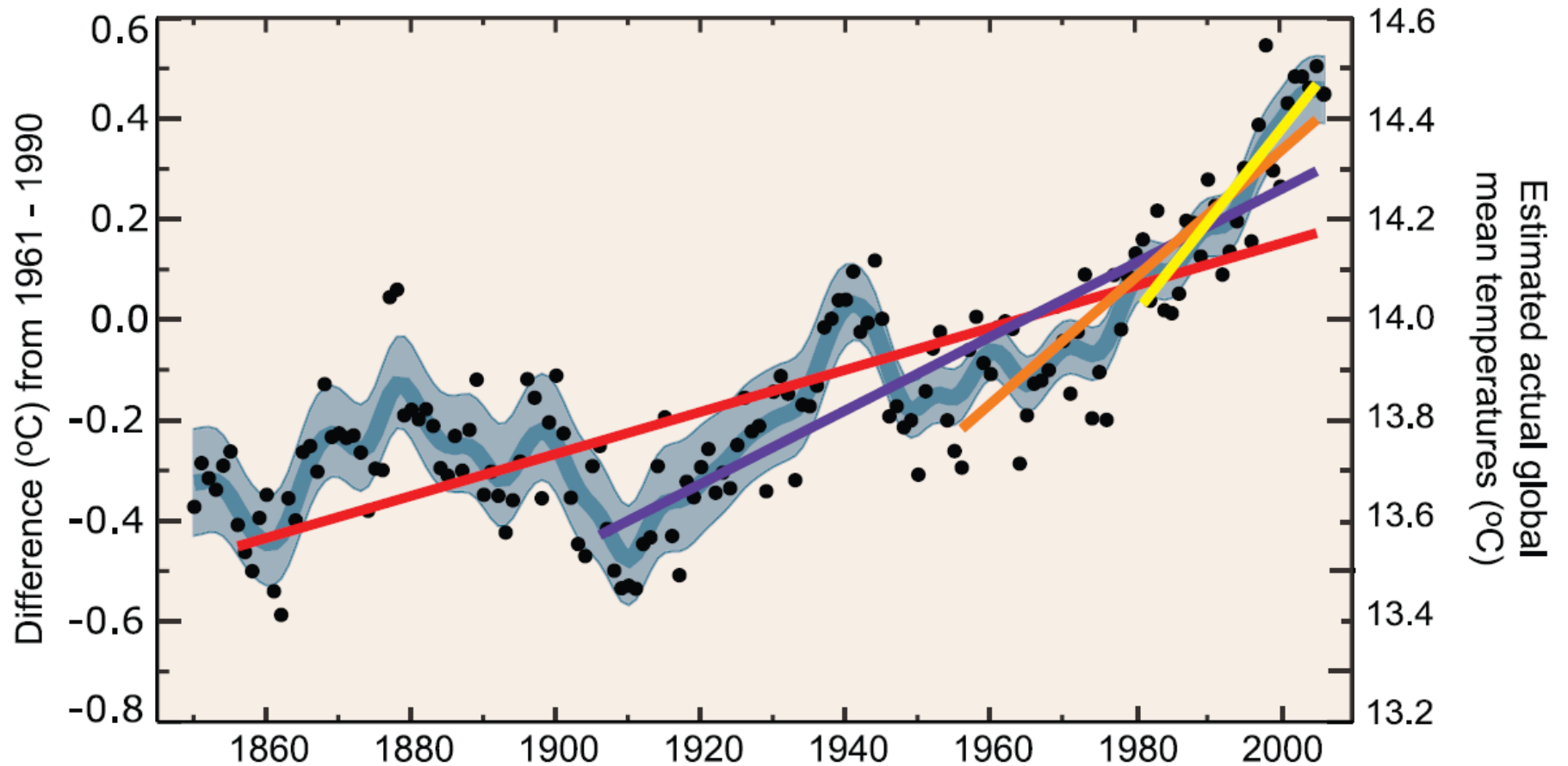
SON



DJF



# Global Mean Temperature



	Period Years	Rate °C per decade
● Annual mean		
— Smoothed series		
■ 5-95% decadal error bars		
	25	0.177±0.052
	50	0.128±0.026
	100	0.074±0.018
	150	0.045±0.012

# Glaciers and Sea Level

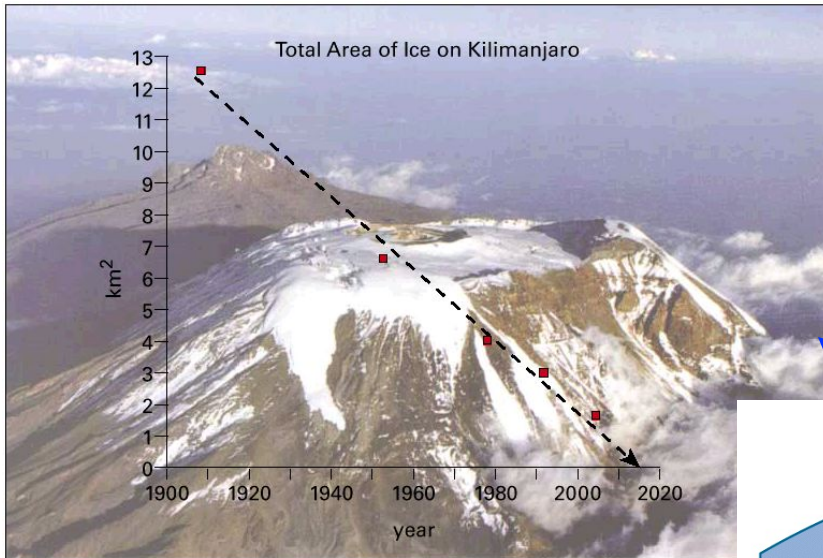
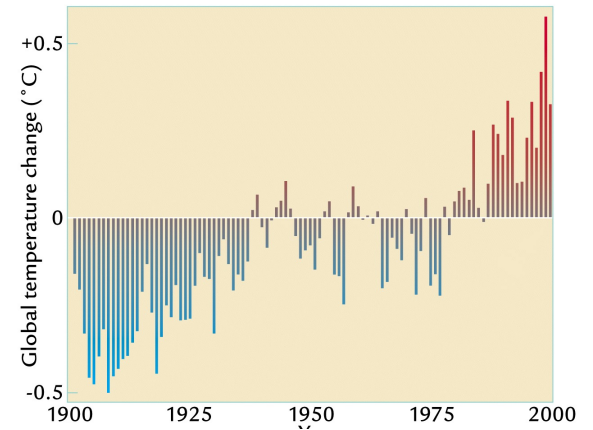
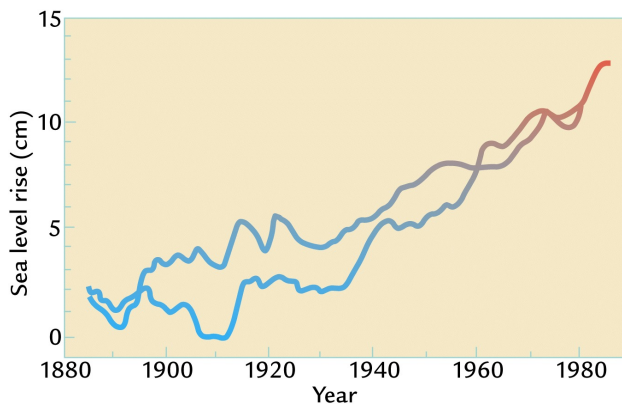


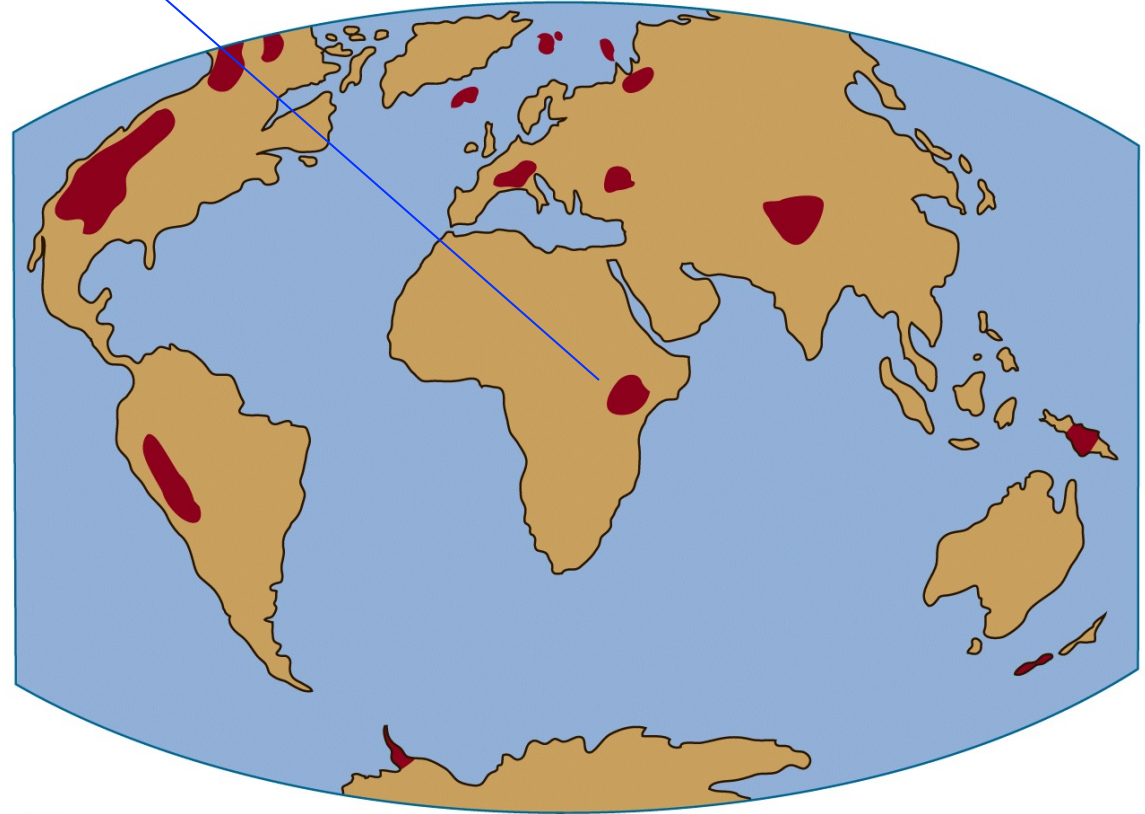
Photo: G. Mazula. Data: L. Thompson. *PAGES NEWS*, vol 9, N 2, July 2001.



**Kilimanjaro glaciers will disappear in 15 years.**



**Sea level rises 12 cm last century.**



● Melting glaciers

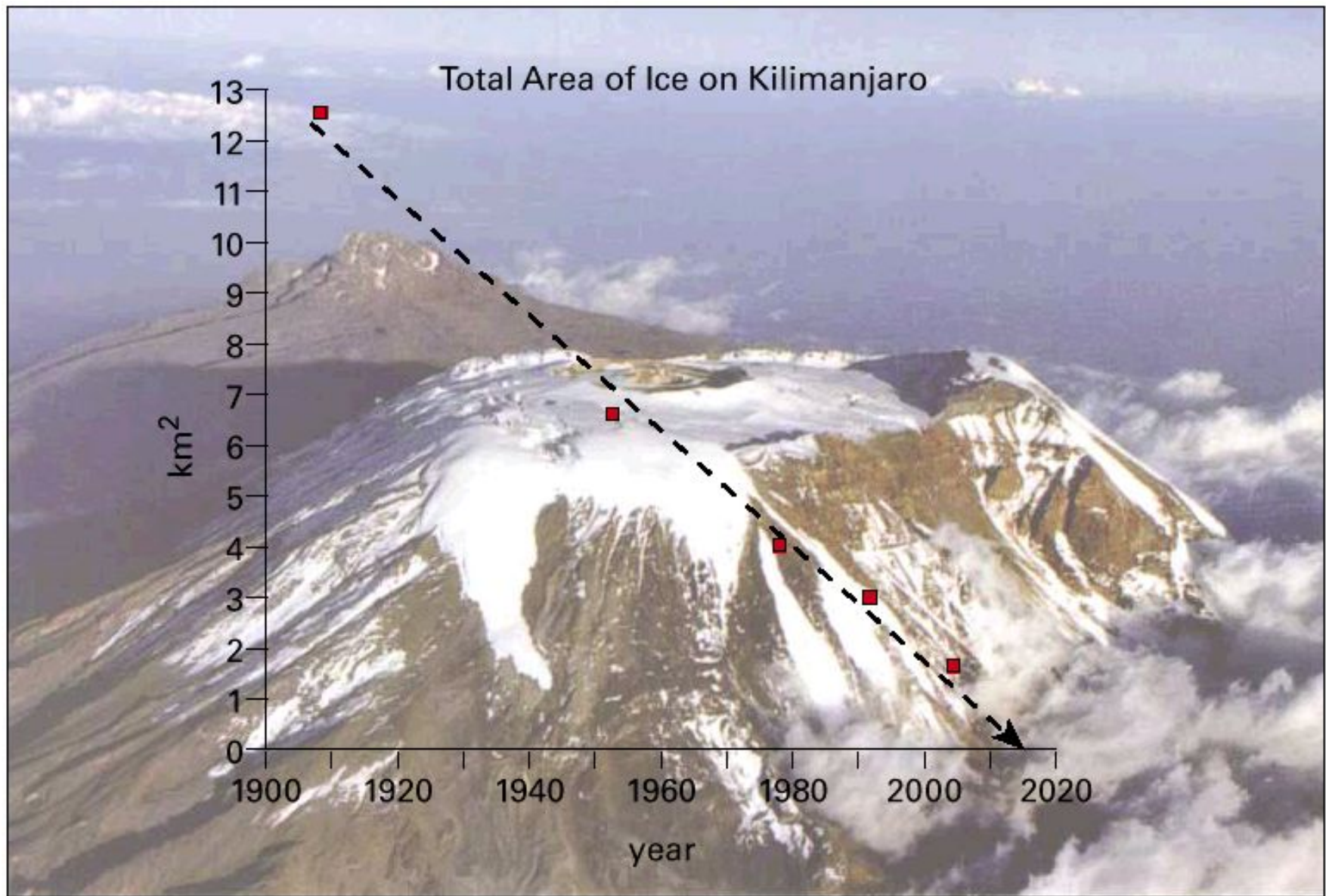
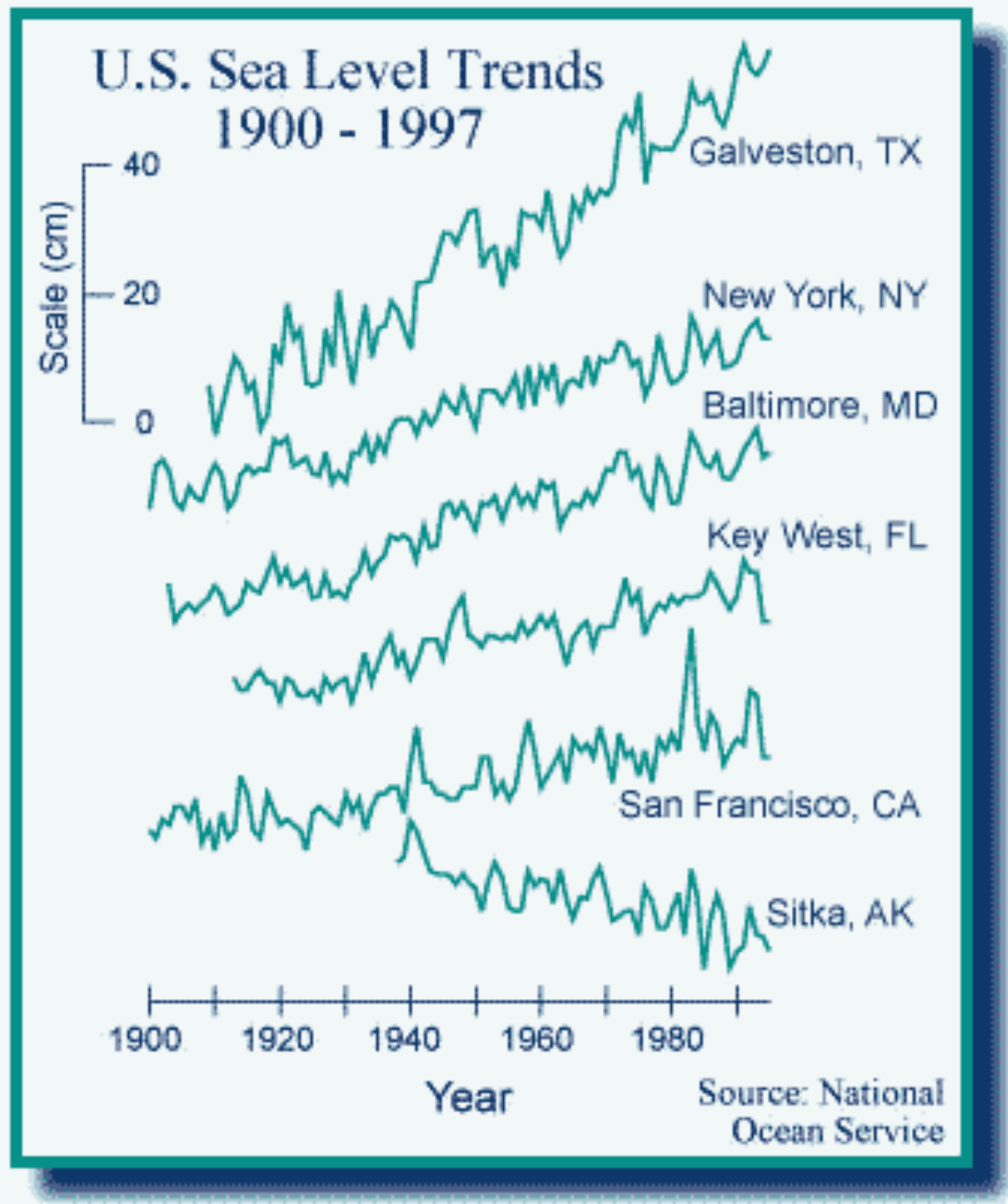


Photo: G. Mazula. Data: L. Thompson. *PAGES NEWS*, vol 9, N 2, July 2001.

Sea-level has rose  
~4-8 inches (10-20  
cm) globally during  
the past century.



# Reason for Climate Concern

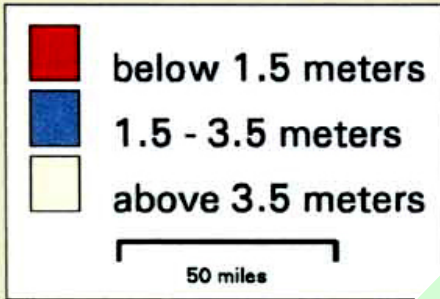


Oceans might rise by **65 m** if all of earth's glaciers, which cover **10%** of the land surface, were to melt.

At present, **70%** of the world's sandy beaches are retreating.

Smaller predicted sea level change of **1 m** might still devastate many areas.

# Sea Level Rise in the Next 100 Years



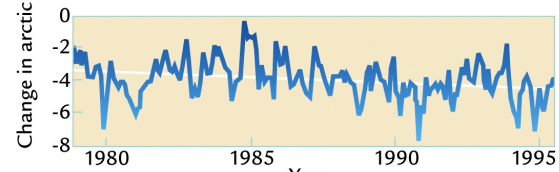
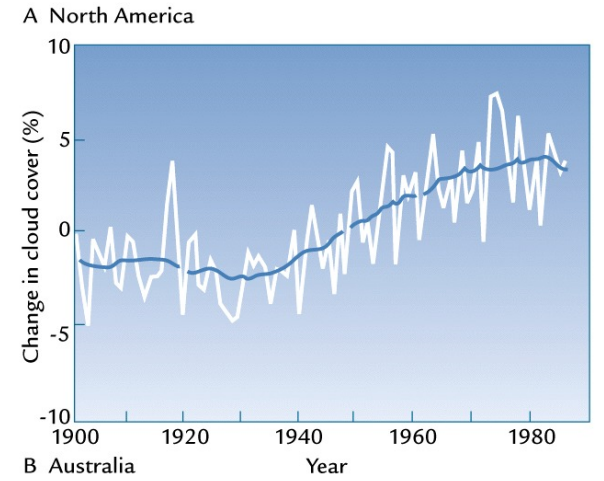
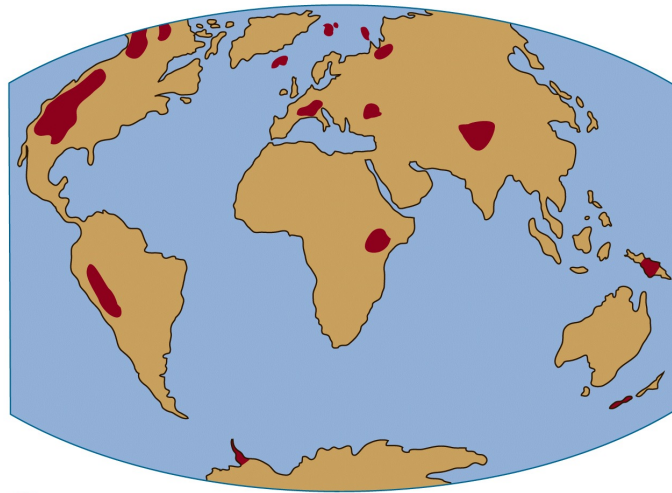
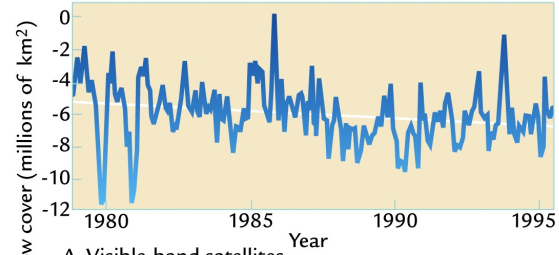
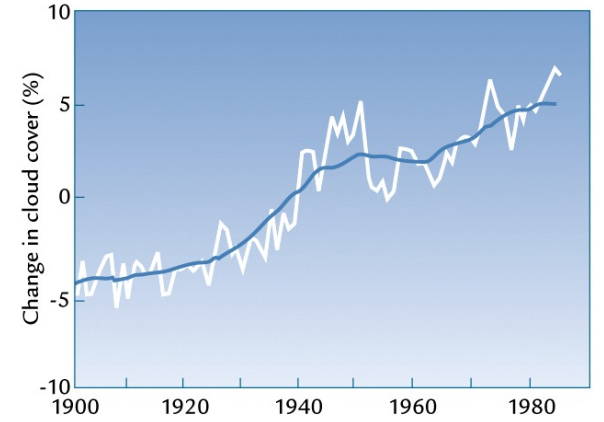
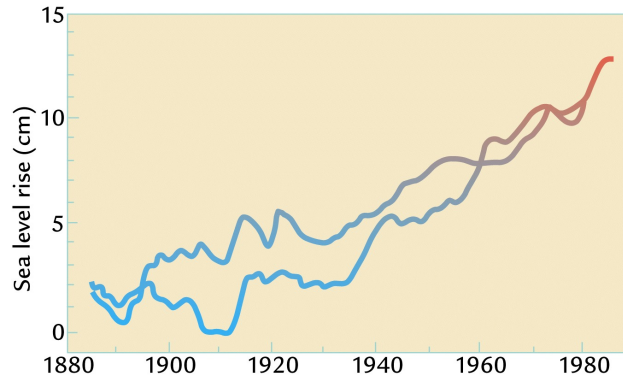
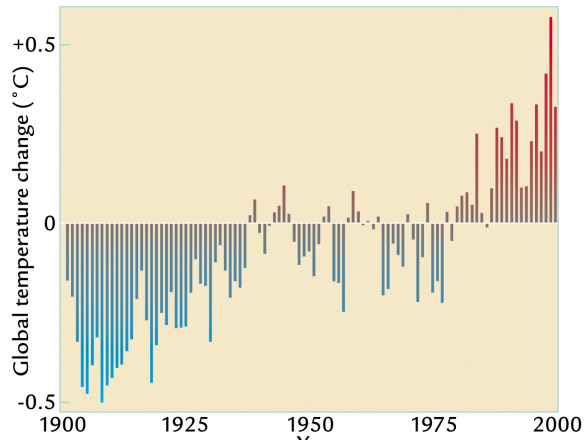
Whooping Crane breeding habitat



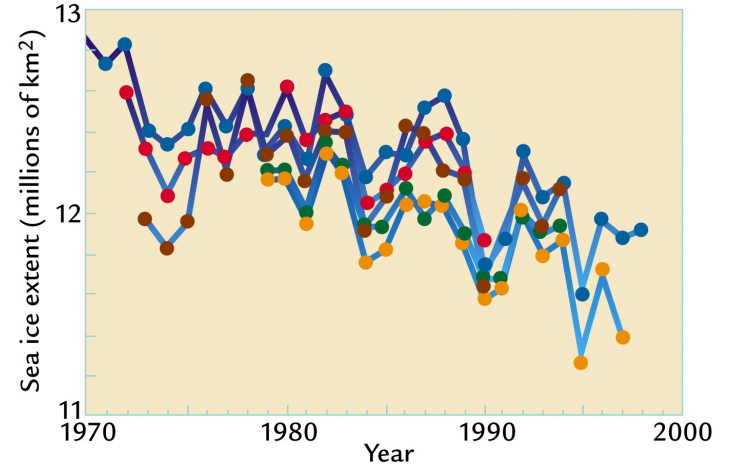
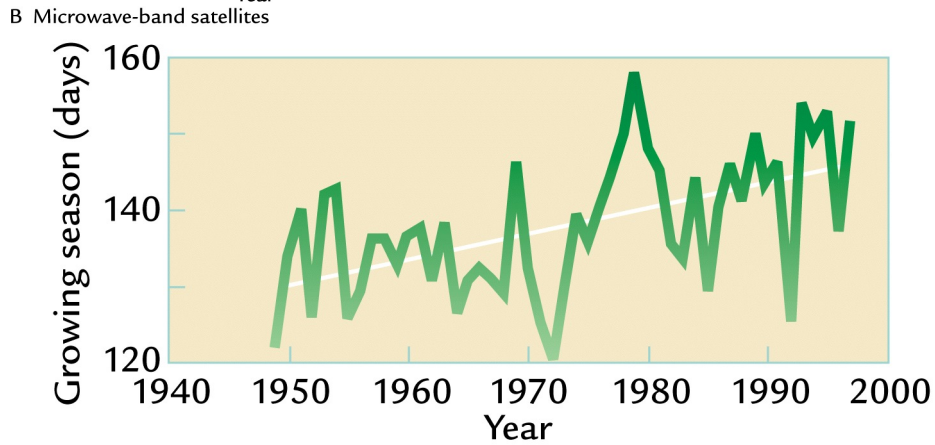
• Texas has 1400 miles coast line. Texas coast is highly vulnerable to sea-level rise.

• Projected sea-level rise in the 21<sup>st</sup> century by IPCC AR4 is 4-35 inches. If this occurs, many important places on the Texas Coast would disappear

• Recent studies suggests that IPCC AR4 may underestimate sea-level rise.



● Melting glaciers





***An increasing body of observations gives a collective picture of a warming world and other changes in the climate system***

- **Global mean surface temperature increase (NH, SH, land, ocean)**
- **Melting of glaciers, sea ice retreat and thinning**
- **Rise of sea levels**
- **Decrease in snow cover**
- **Decrease in duration of lake and river ice**
- **Increased water vapor, precipitation and intensity of precipitation over the NH**
- **Less extreme low temperatures, more extreme high temperatures**

# Recent Range Shifts due to Warming

Species Affected	Location	Observed Changes
Arctic shrubs	Alaska	Expansion into shrub-free areas
Alpine plants	Alps	Elevational shift of 1-4 m per decade
39 butterfly spp.	NA, Europe	Northward shift up to 200 km in 27 yrs.
Lowland birds	Costa Rica	Advancing to higher elevations
12 bird species	Britain	19 km northward average range extension
Red & Arctic Fox	Canada	Red fox replacing Arctic fox
Treeline	Europe, NZ	Advancing to higher altitude
Plants & invertebrates	Antarctica	Distribution changes
Zooplankton, fish & invertebrates	California, N. Atlantic	Increasing abundance of warm water spp.

Walther et al., Ecological responses to recent climate change, Nature 416:389 (2002)

## Summary:

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