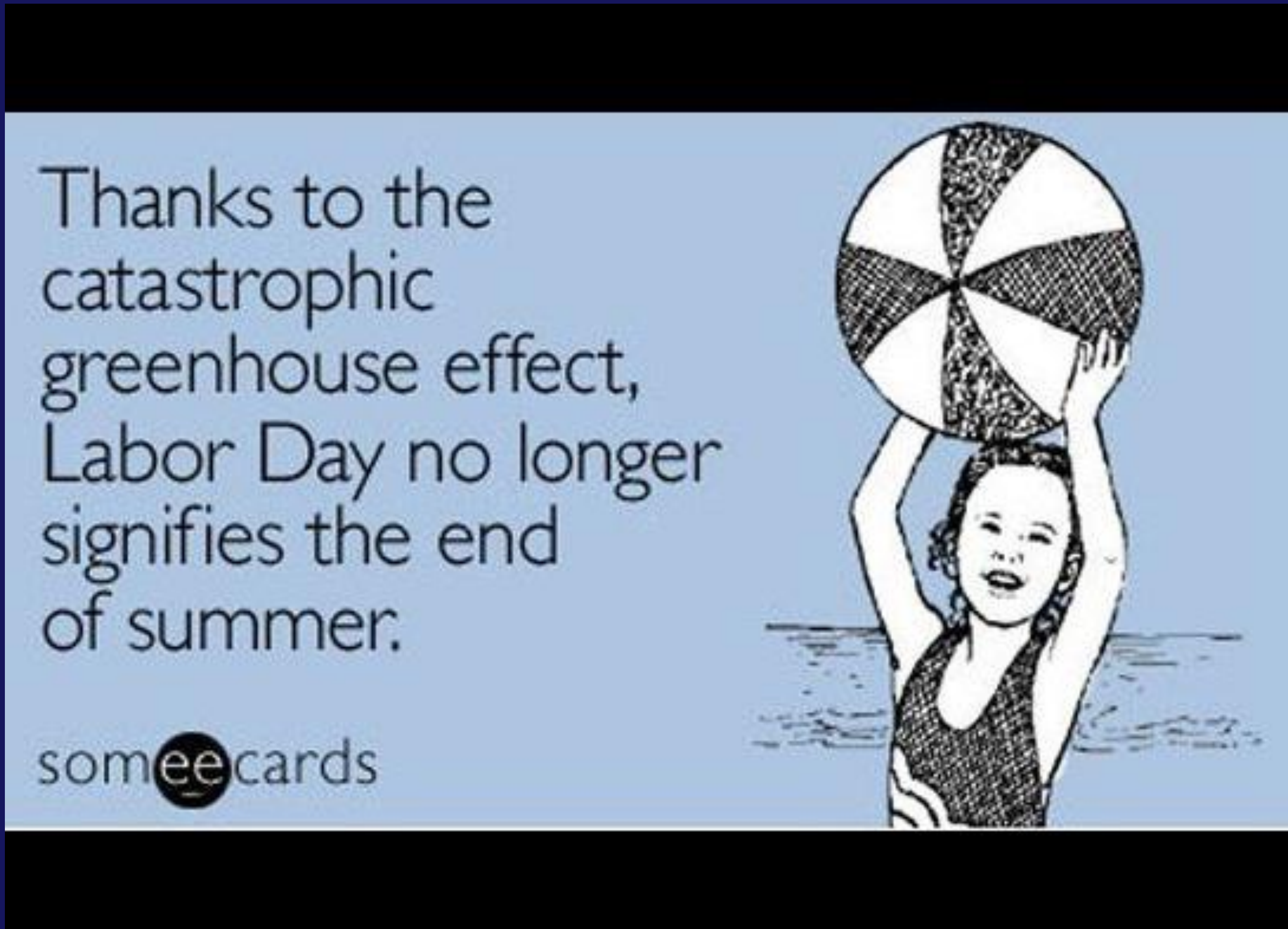
TOPIC #5

OBSERVATIONS OF CLIMATIC CHANGE & VARIABILITY in the PAST & PRESENT

"First Look"

pp 27-30 in Class Notes


Thanks to the catastrophic greenhouse effect, Labor Day no longer signifies the end of summer.
someecards

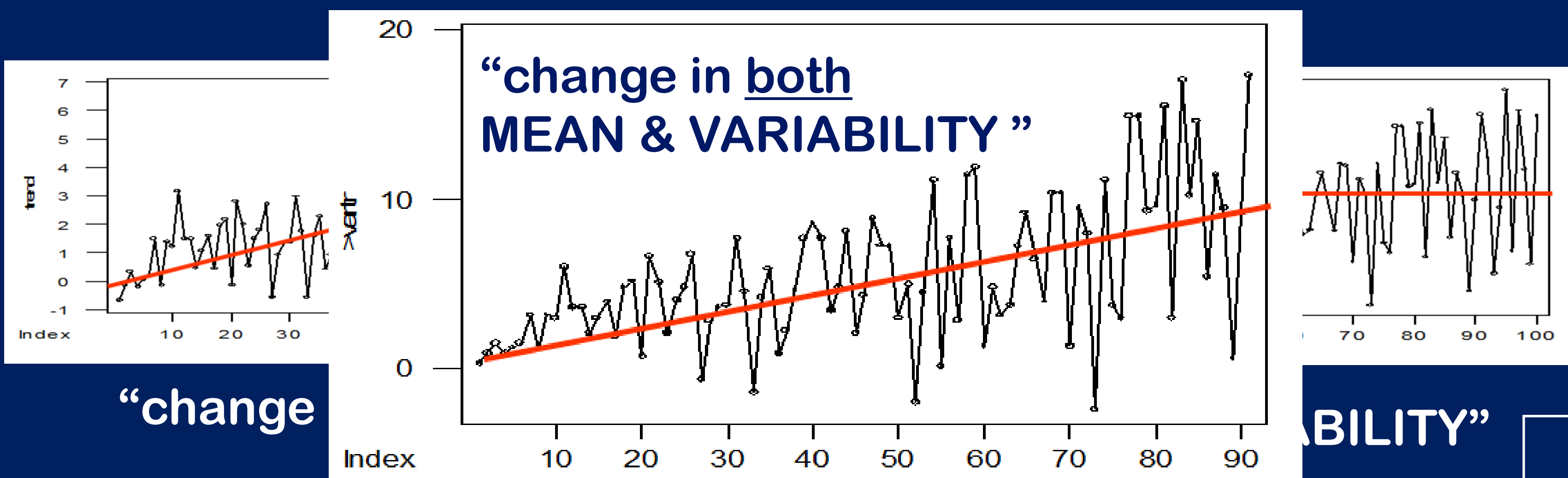
All things are connected. Whatever befalls the earth, befalls the children of the earth.

~ Chief Seattle

IMPORTANT DEFINITIONS

(from IPCC AR4 WG-1 Glossary
http://www.ipcc.ch/pdf/glossary/ar4-wg1.pdf)

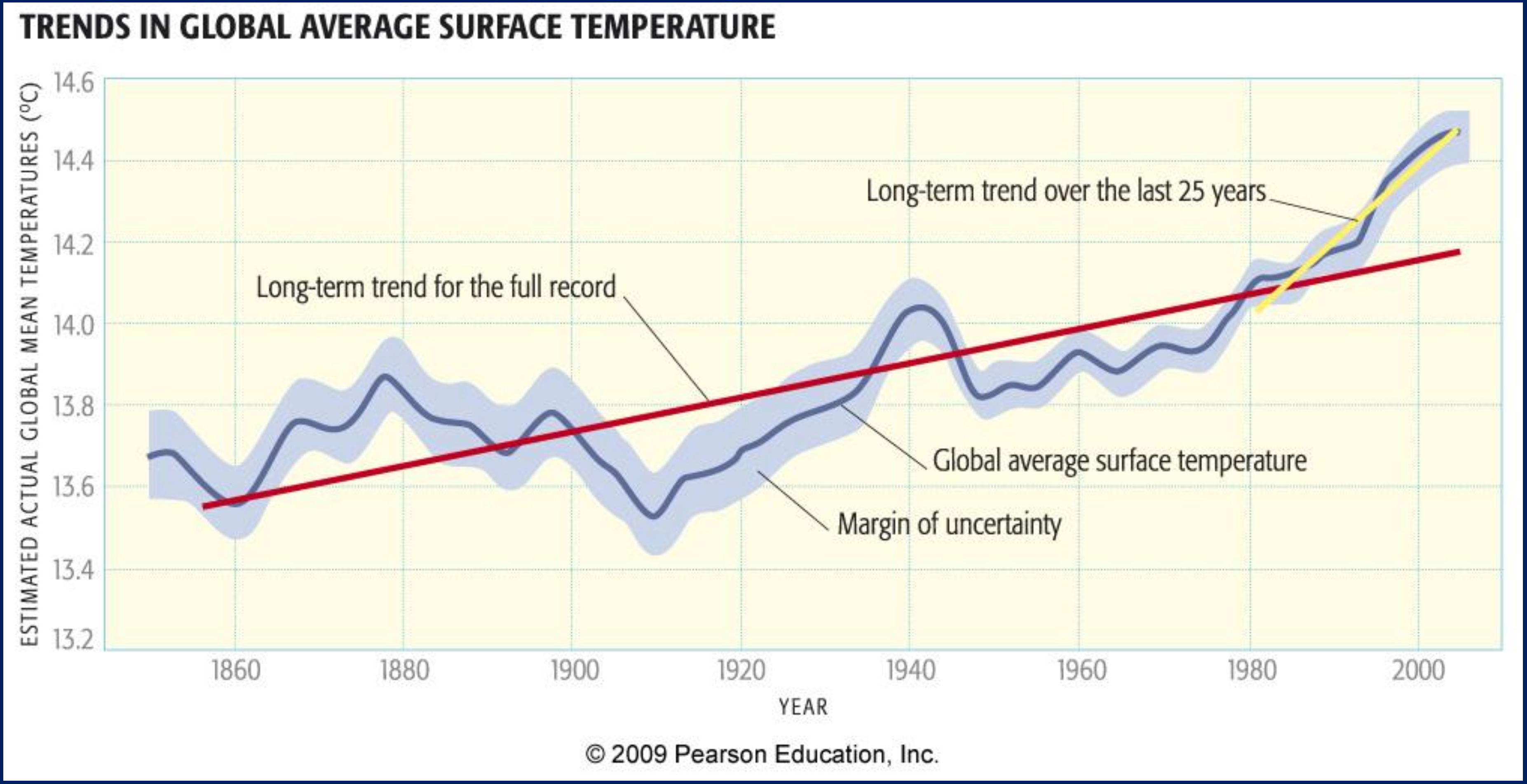
CLIMATE CHANGE: refers to a change in the state of the *climate* that can be identified . . . by changes in the **mean and/or the variability** of its properties, and that **PERSISTS** for an extended period, typically decades or longer.



“change

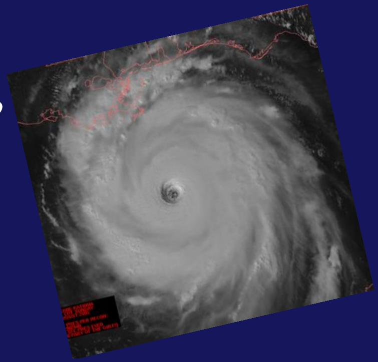
BILITY”

How is the Earth's GLOBAL Mean Temperature Changing?



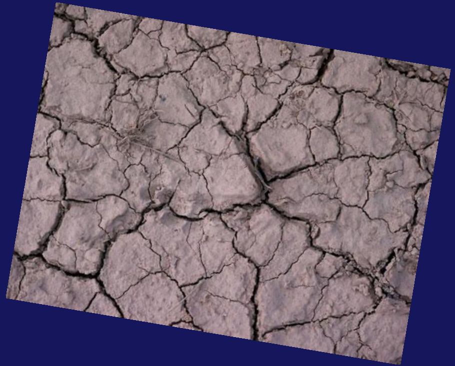
from Dire Predictions text p 36

A more general term . . .



CLIMATE VARIABILITY: refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events.

. . . can include changes in the frequency of EXTREME EVENTS . . . .



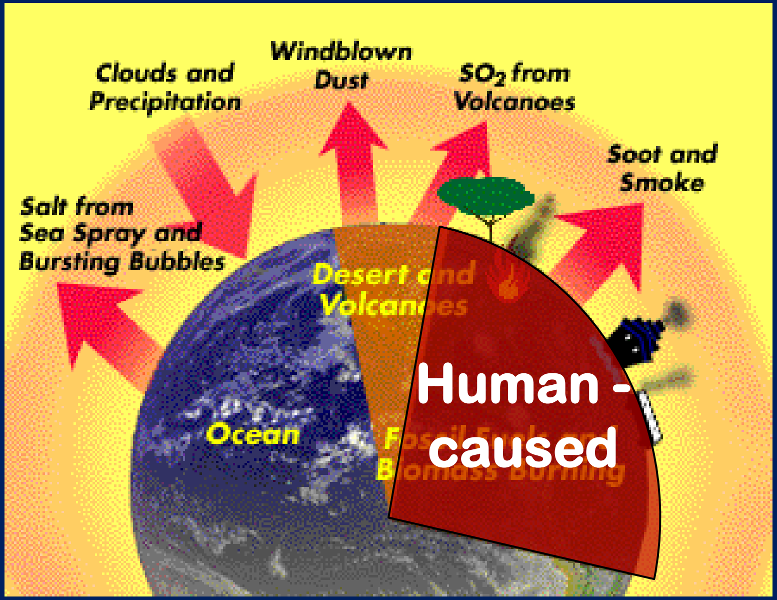
An alternative definition of "CLIMATE CHANGE" . . . .

The United Nations Framework Convention on Climate Change defines climate change as:

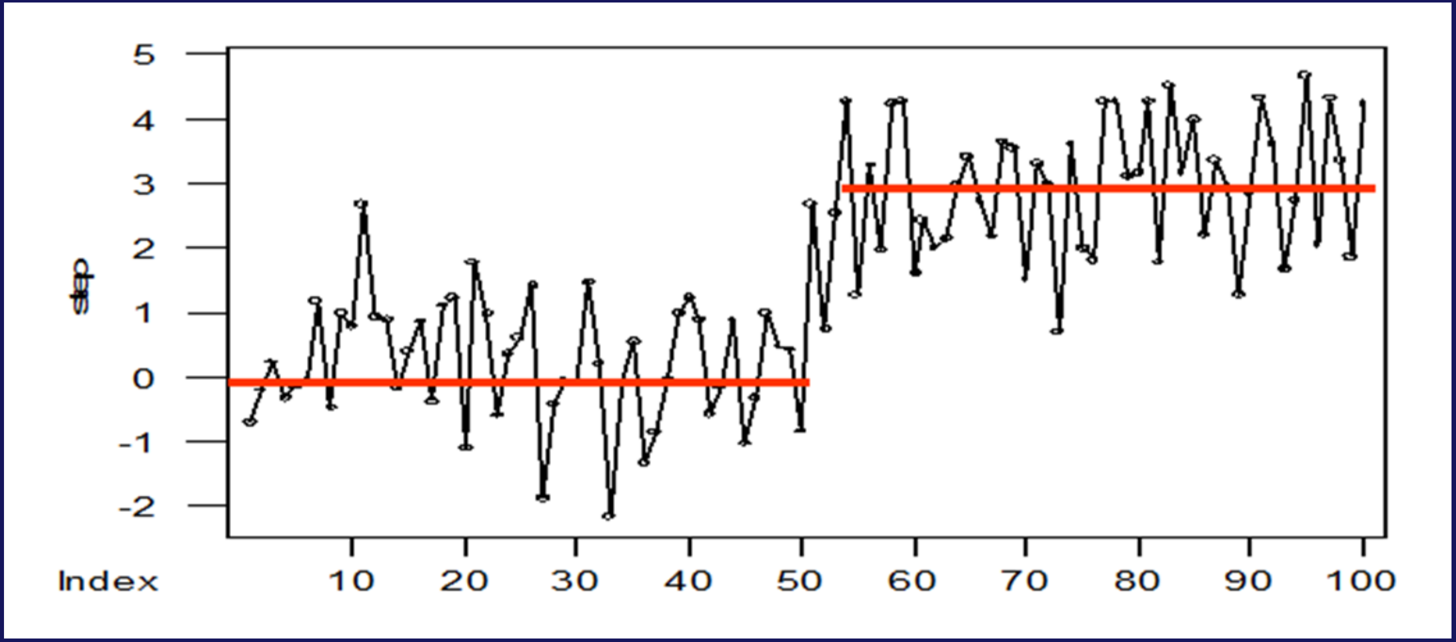
'a change of climate which is attributed directly or indirectly to HUMAN ACTIVITY that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

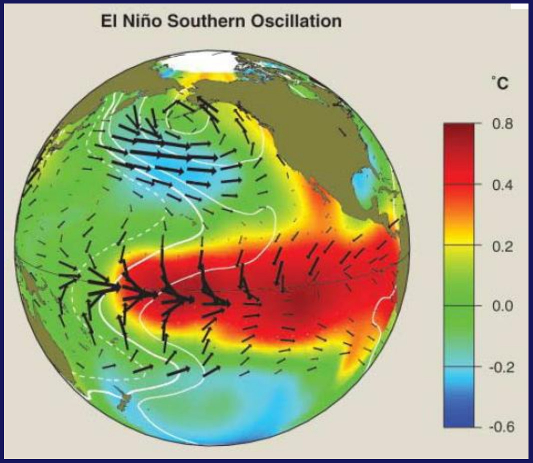
VARIABILITY may be due to:

- **natural internal processes within the climate system (internal variability)**
- **or to variations in natural or anthropogenic external forcing (external variability).**



CLIMATE SHIFT: An abrupt shift or jump in mean values signaling a change in climate regime.

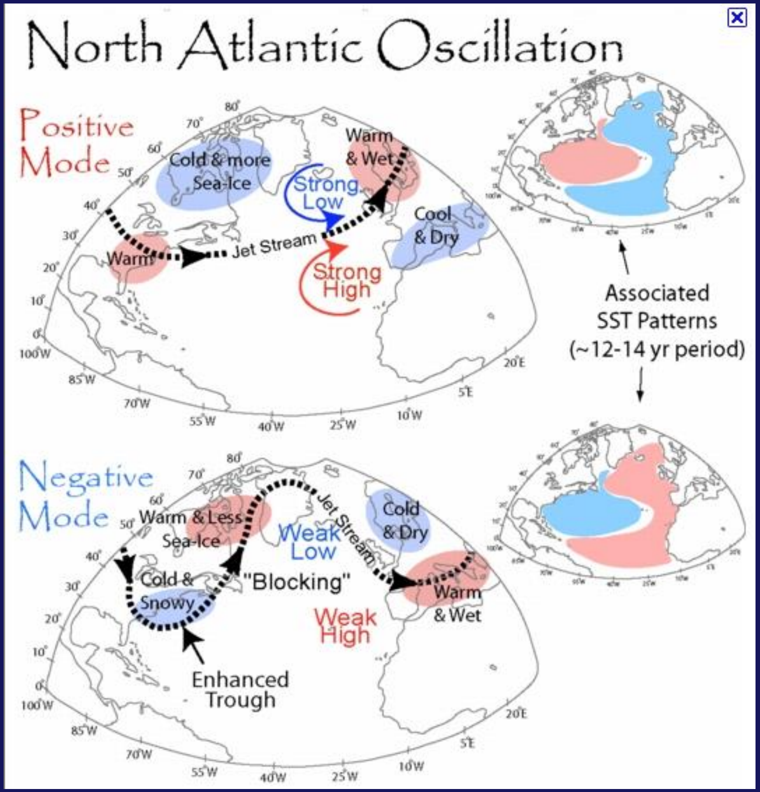




Most widely used in conjunction with the 1976 / 1977 climate shift that seems to correspond to a change in El Niño-Southern Oscillation behavior.

PATTERNS OF CLIMATE VARIABILITY:

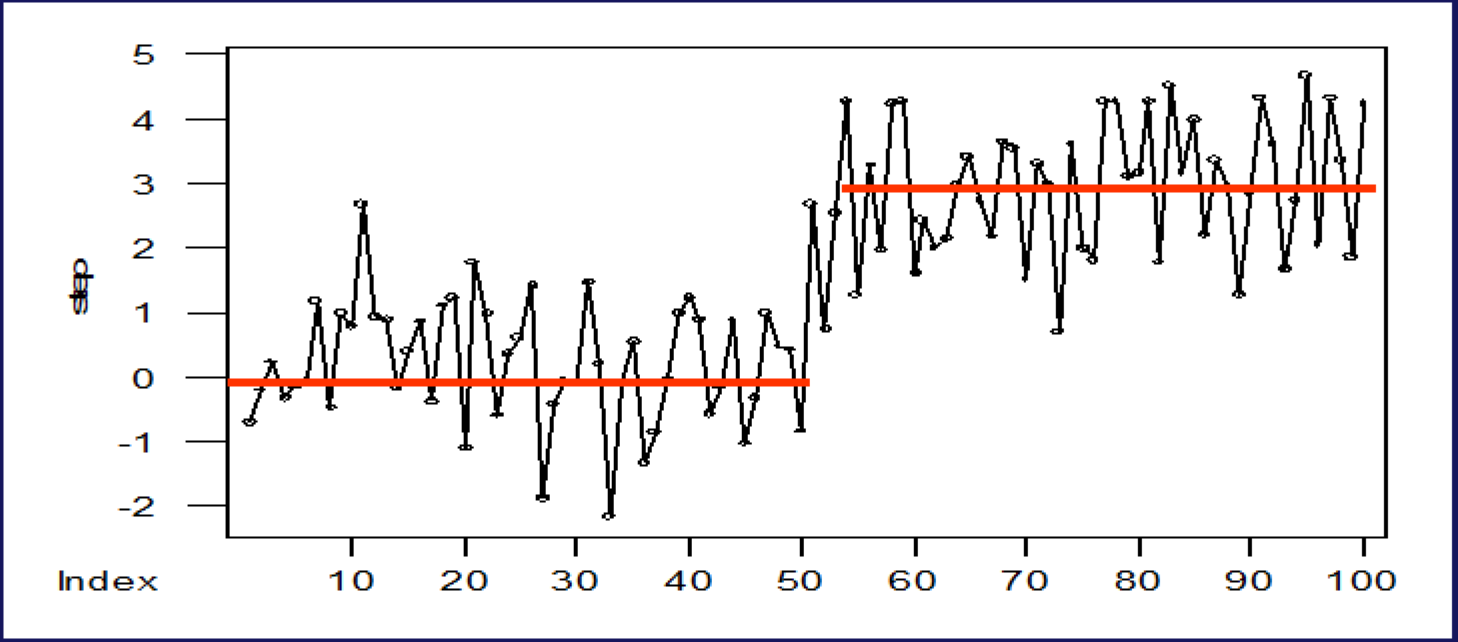
Natural variability of the climate system, in particular on seasonal and longer time scales, predominantly occurs with preferred spatial patterns and time scales, through the dynamical characteristics of the atmospheric circulation and through interactions with the land and ocean surfaces.



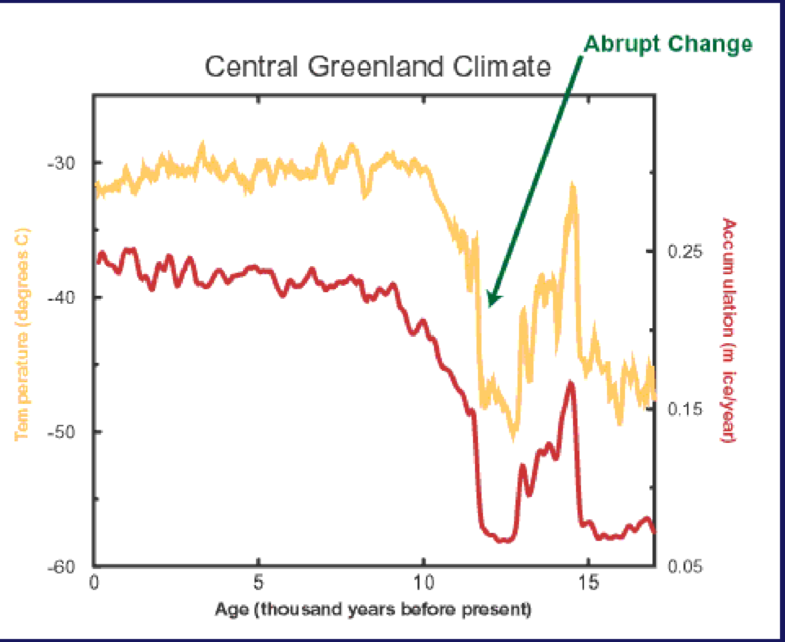
Such patterns are often called *regimes*, *modes* or *teleconnections*.

ABRUPT CLIMATE CHANGE: (sometimes called rapid climate change, abrupt events or even surprises.)

The term **abrupt** often refers to time scales faster than the typical time scale of the responsible forcing. However, not all abrupt climate changes need be externally forced.



- Some possible abrupt events that have been proposed include a dramatic reorganization of the thermohaline circulation, rapid deglaciation and massive melting of permafrost or increases in soil respiration leading to fast changes in the carbon cycle.

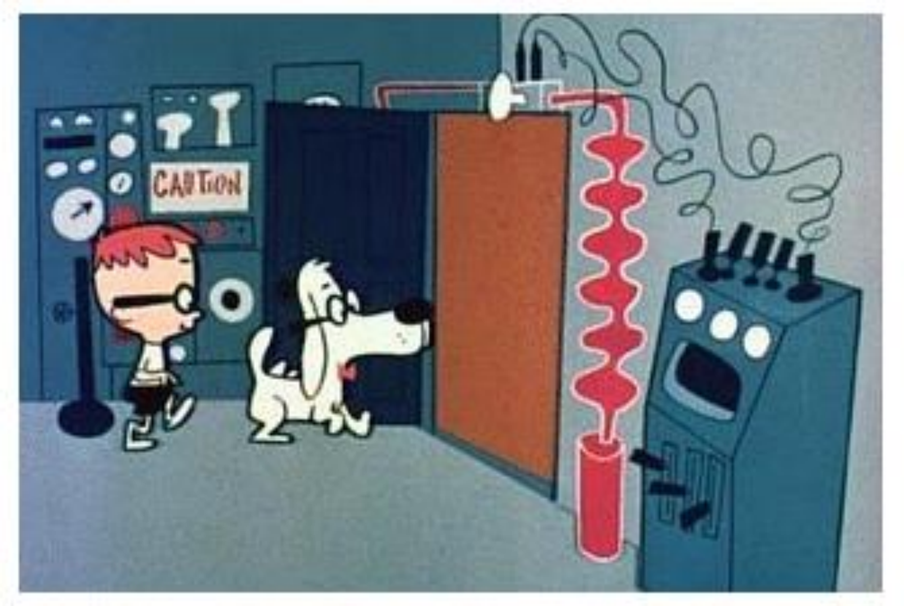


http://www.ncdc.noaa.gov/paleo/ctl/abrupt.html

- Others may be truly unexpected, resulting from a strong, rapidly changing forcing of a *nonlinear* system.

(A process is called *nonlinear* when there is no simple proportional relation between cause and effect.)

How do global change scientists "observe" climate change and variability in the distant past?

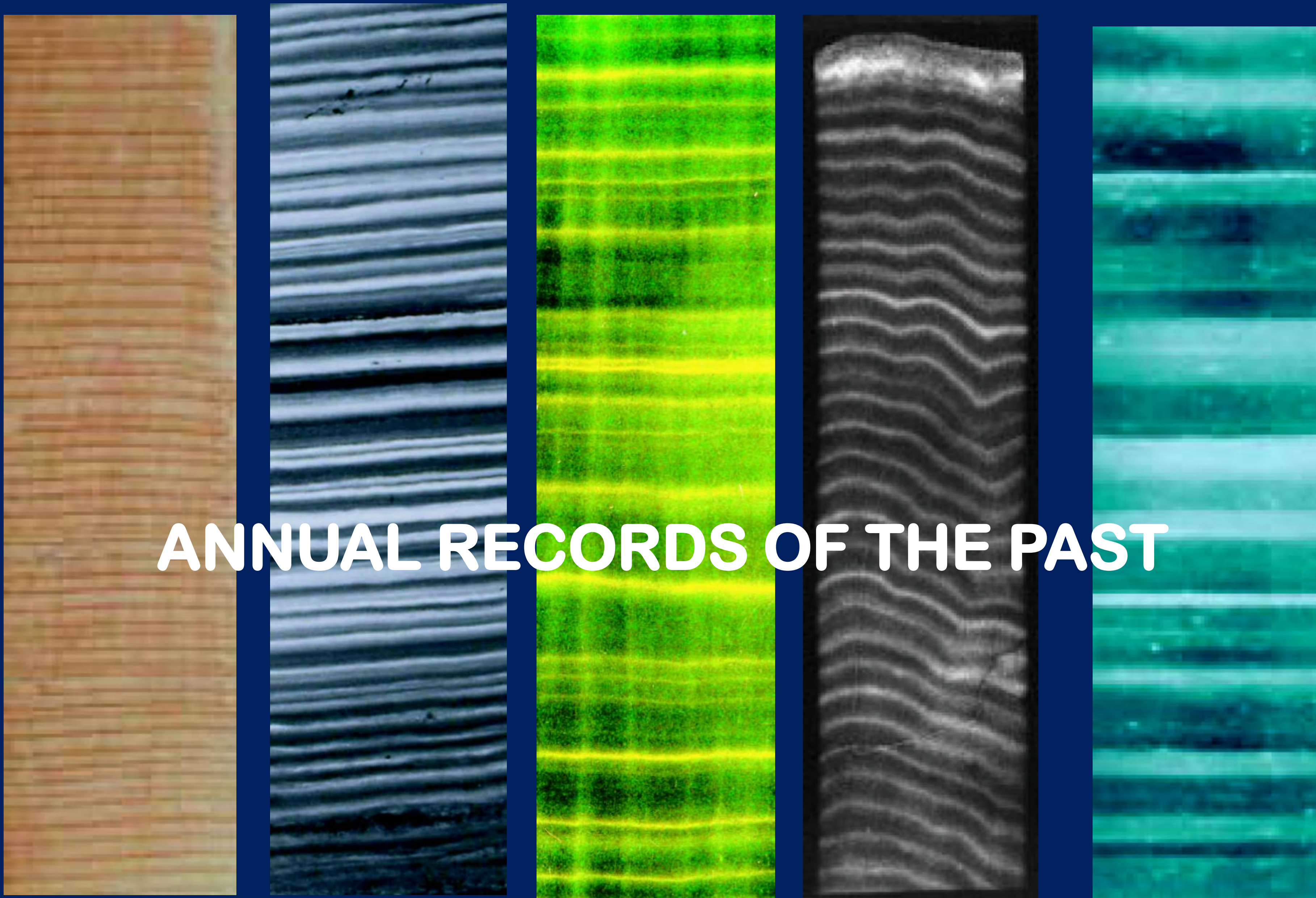


The "WAYBACK MACHINE" ??

a fictional machine from a part of the cartoon known as "The Rocky and Bullwinkle Show" used to transport Mr. Peabody and Sherman back in time.

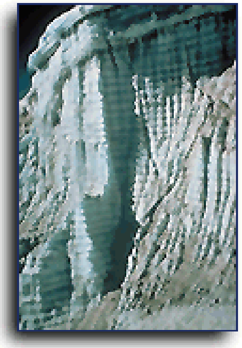
ANNUAL RECORDS OF THE PAST

Tree rings | Lake varves (sediments) | Speleothems (from cave) | Coral (annual growth) | Ice Core

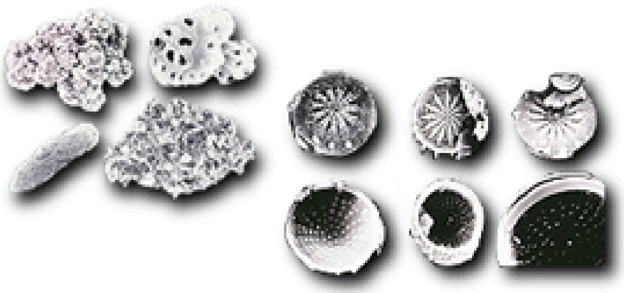


"PROXY" DATA or NATURAL ARCHIVES of CLIMATE

Corals



Ice cores



Pollen

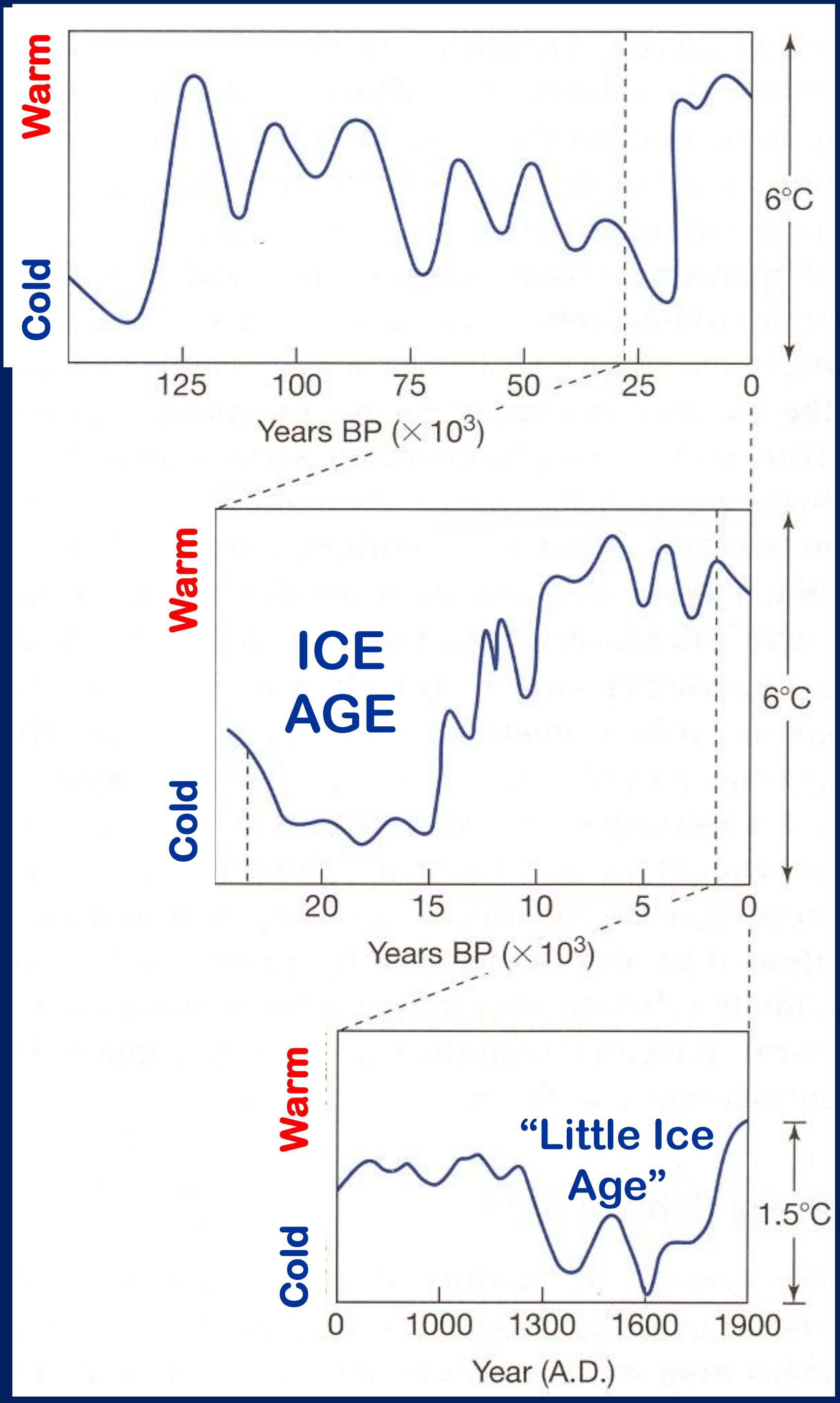
Lake, bog & ocean sediments

WHAT NATURAL ARCHIVES REVEAL:

Over different "Telescoping" Time Scales Of Variability about:

Mean Global Temperature Change

Since The Last Glacial Maximum
(Years BP = "years before present")



Generalized oxygen isotope curve from deep-sea sediments

Generalized estimates from pollen data & alpine glaciers (mid-latitudes of eastern N. America & Europe)

General estimates from historical documents (emphasis on the North Atlantic region)

Disappearing tropical glaciers: the “canary in the coal mine”

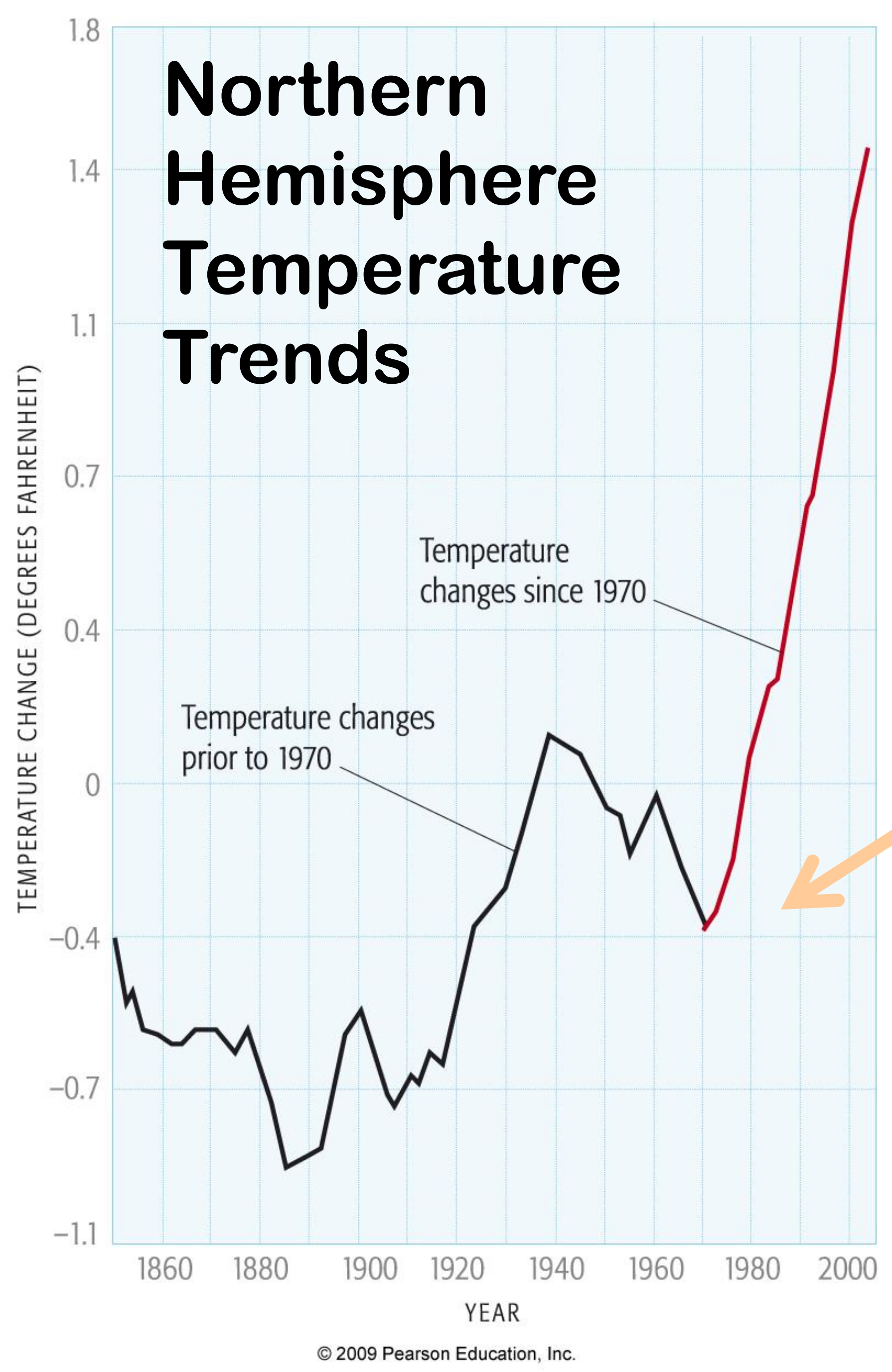
In 1978, the Qori Kalis Glacier looked like this, flowing out from the Quelccaya Ice Cap in the Peruvian Andes Mountains.

In 2000, the view of Qori Kalis has changed dramatically with a massive 10-acre lake forming at the ice margin.

How do we get records like this?

http://www.pbs.org/wgbh/nova/earth/profile-thompson.html

Figure from Dire Predictions p 45

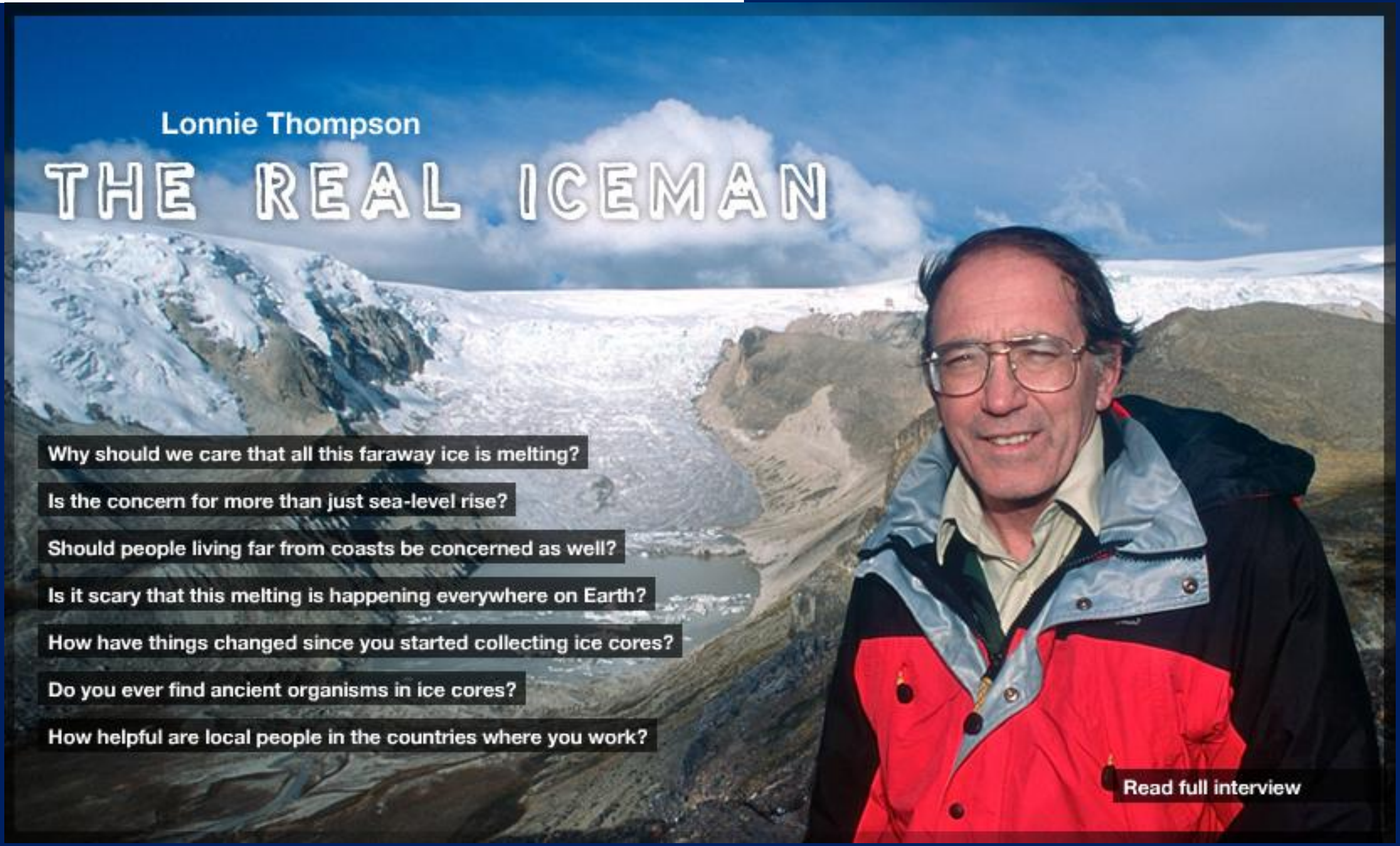


Lonnie Thompson & Ellen Mosley-Thompson began their tropical glacier research in the 1970s

Hear From the Real Iceman

By Peter Tyson | Posted 04.01.09 | NOVA scienceNOW

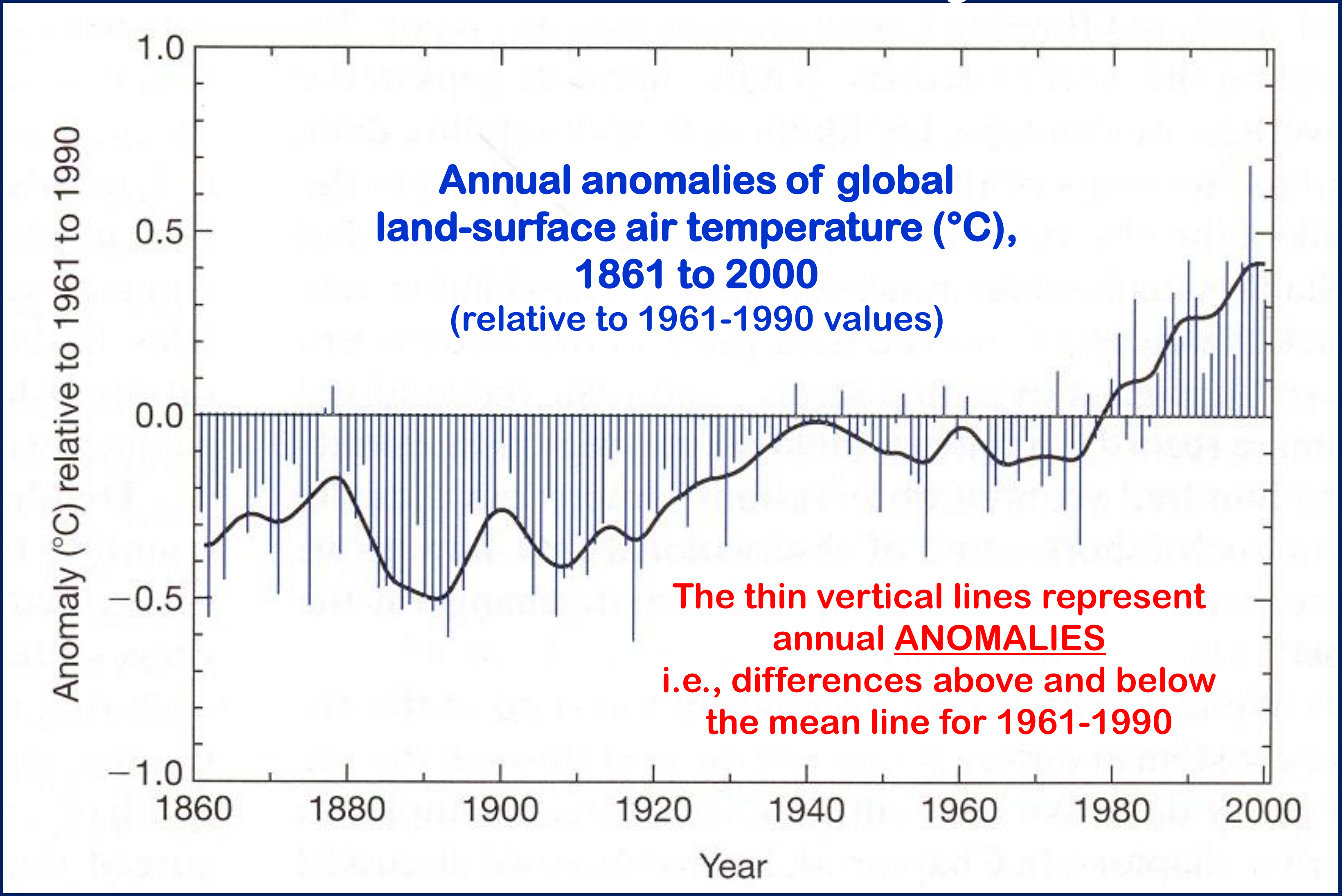
Lonnie Thompson is a senior research scientist at Ohio State University's Byrd Polar Research Center and one of the world's foremost authorities on ancient climate. Here he talks about why today's accelerated melting of glaciers should concern us on fronts as divergent as drinking water and coastal living, climate change and infectious disease, refugees and terrorism.



http://www.pbs.org/wgbh/nova/earth/thompson-glaciers-au.html

☺

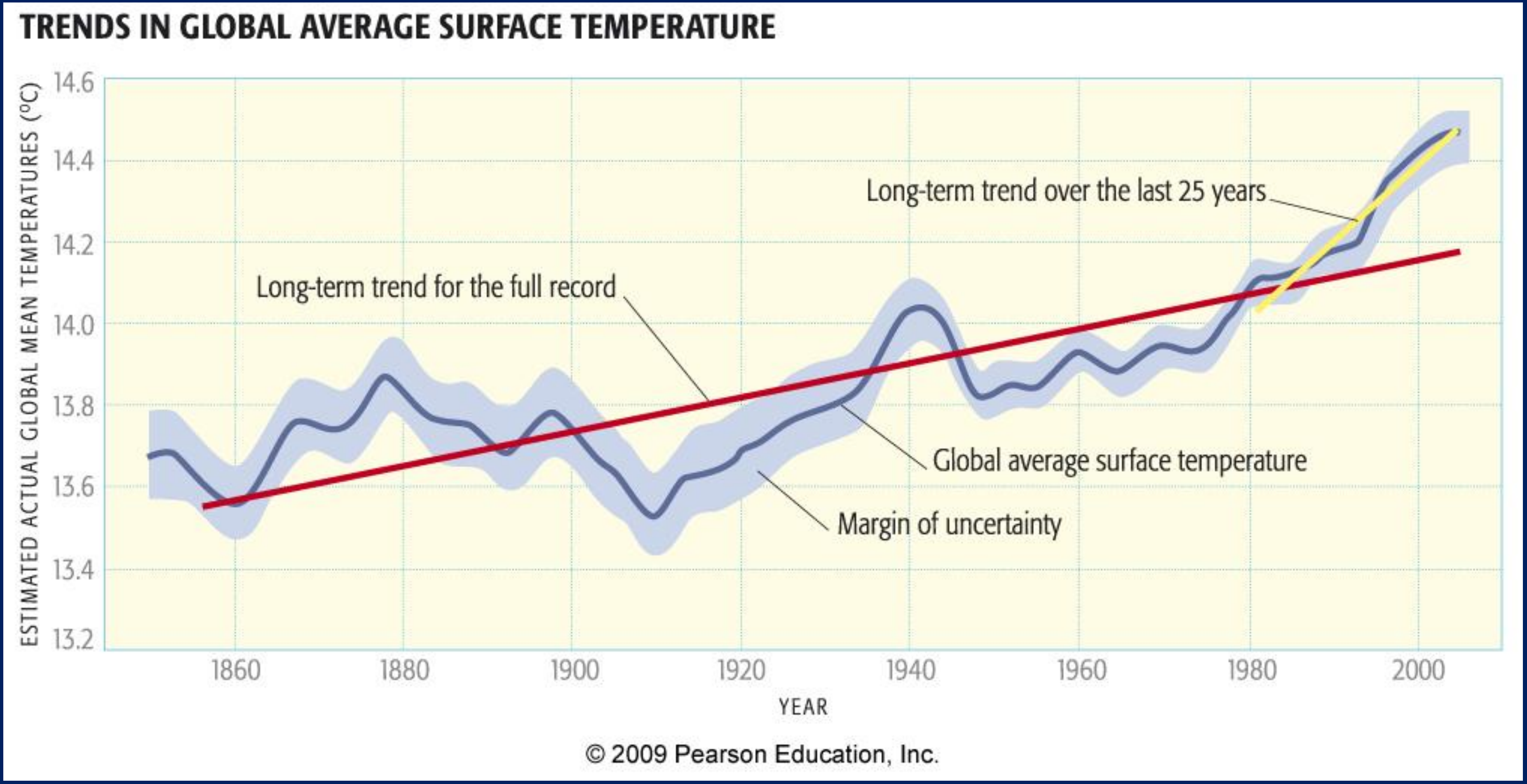
The most recent 150 years:



Remember your time series plots?

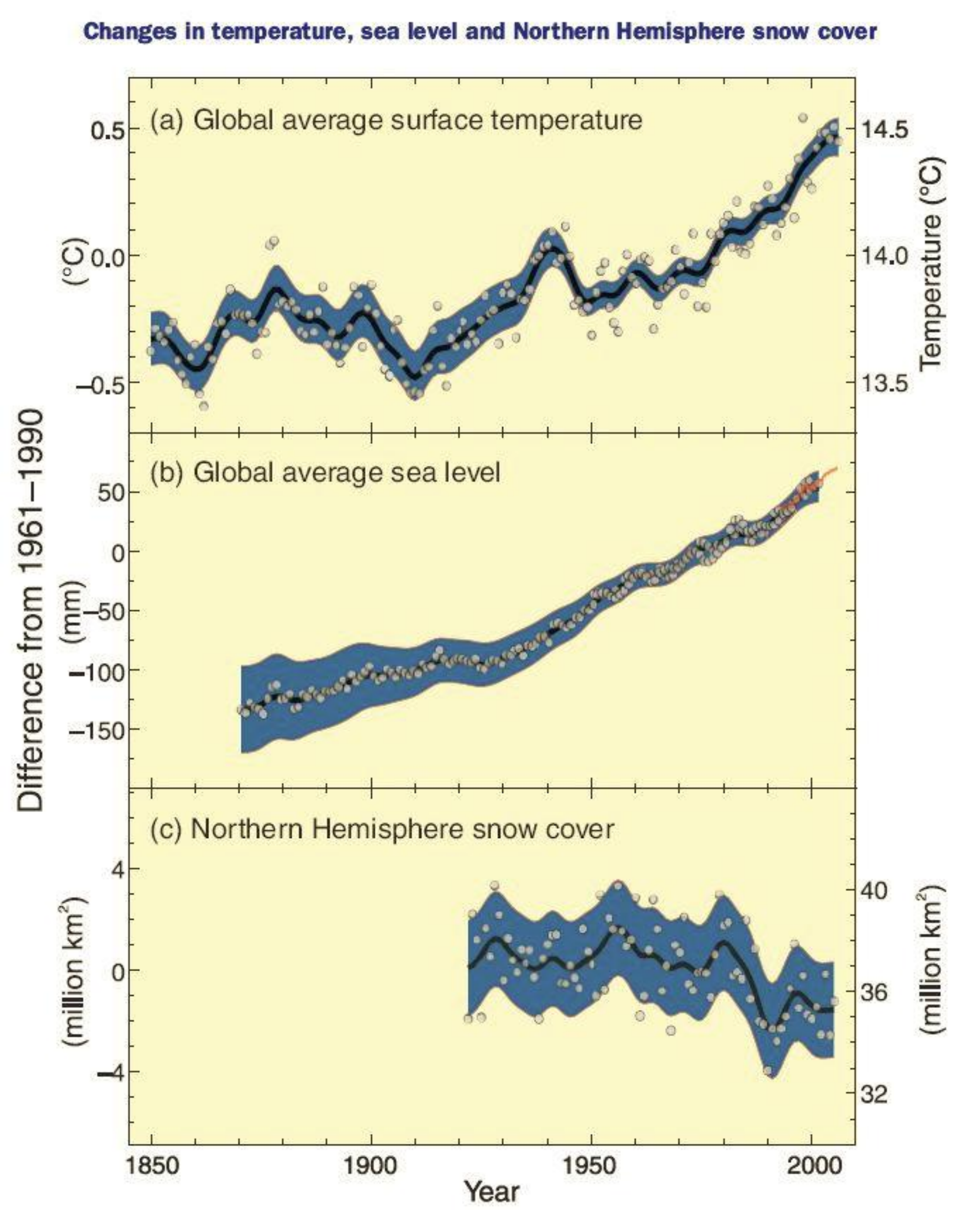
This one is in a different format!

How is the Earth's GLOBAL Mean Temperature Changing?

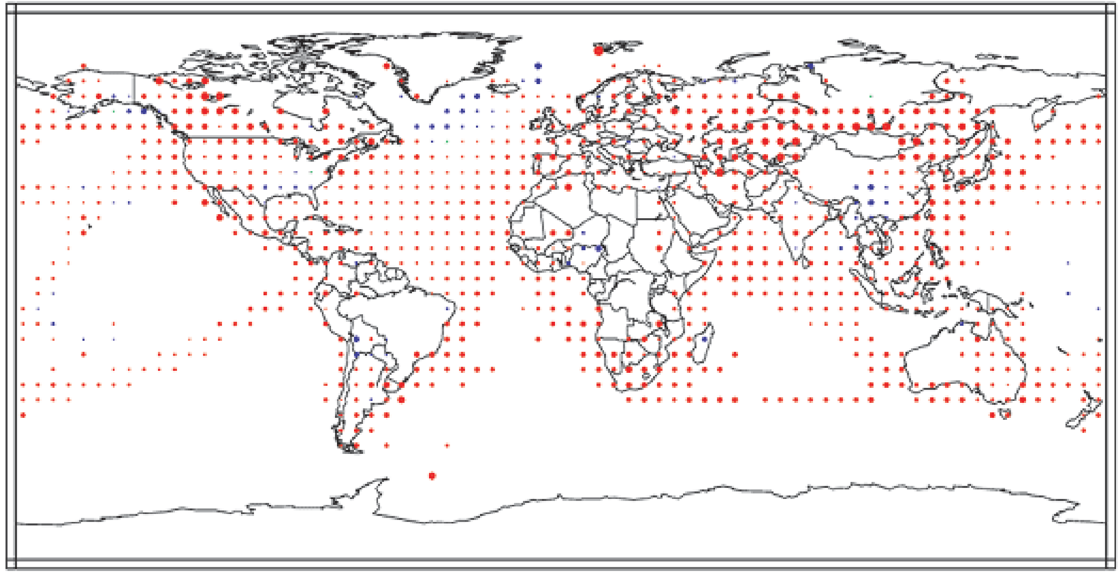


from Dire Predictions text p 36

from
IPCC 4th
Assessment
Report (AR4)



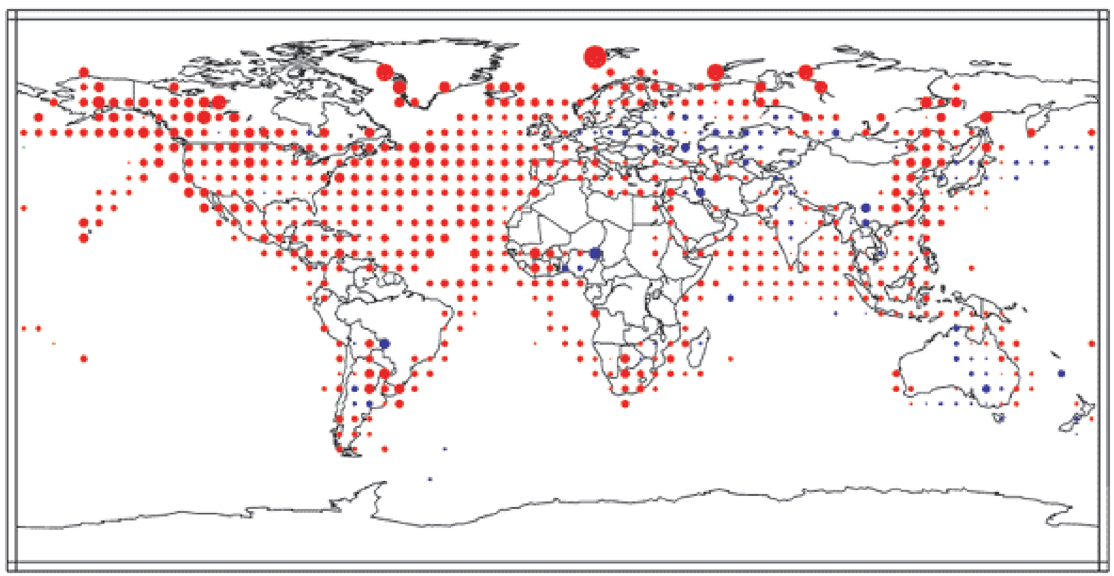
(a) Annual temperature trends, 1901 to 2000



= warming

= cooling

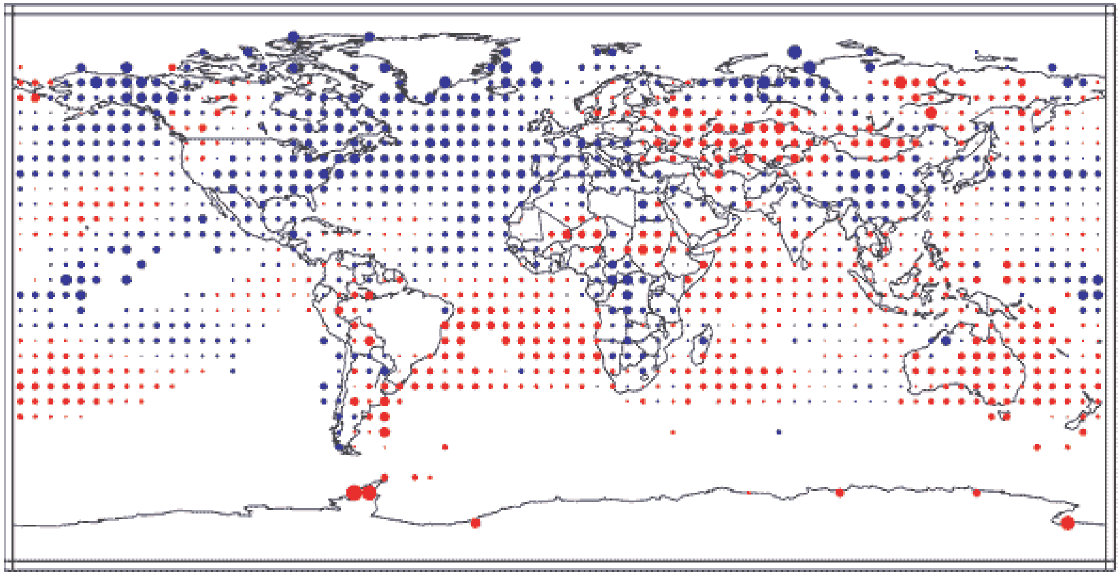
(b) Annual temperature trends, 1910 to 1945



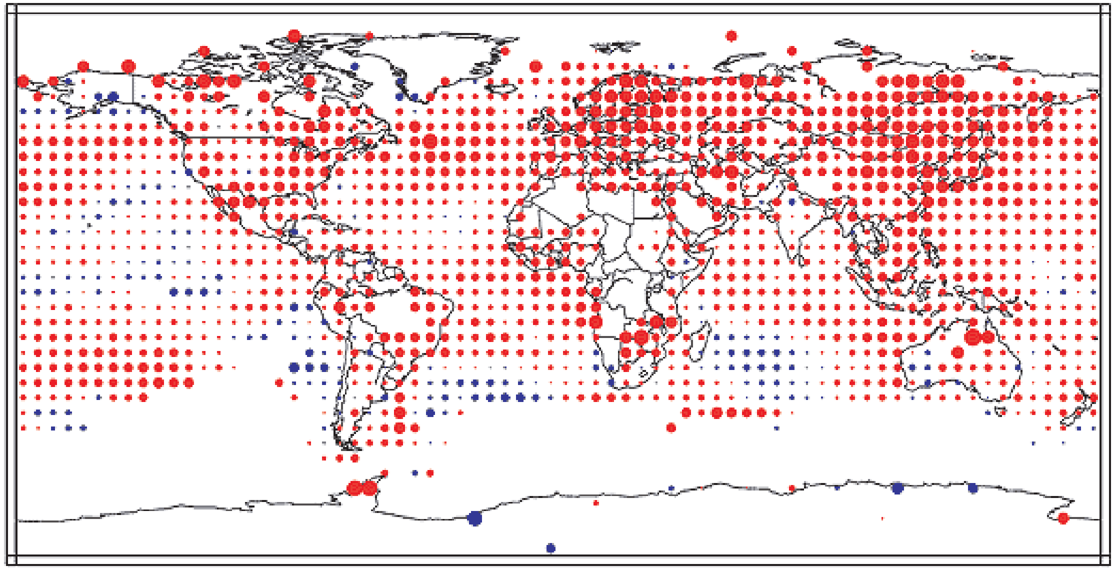
● = warming

● = cooling

(c) Annual temperature trends, 1946 to 1975



(d) Annual temperature trends, 1976 to 2000



To make an incontrovertible case about the role that humans play in global warming, what do scientists need?

1) a long-term temperature record, i.e., centuries

2) over a large part of the globe

3) To be able to say . . . . .

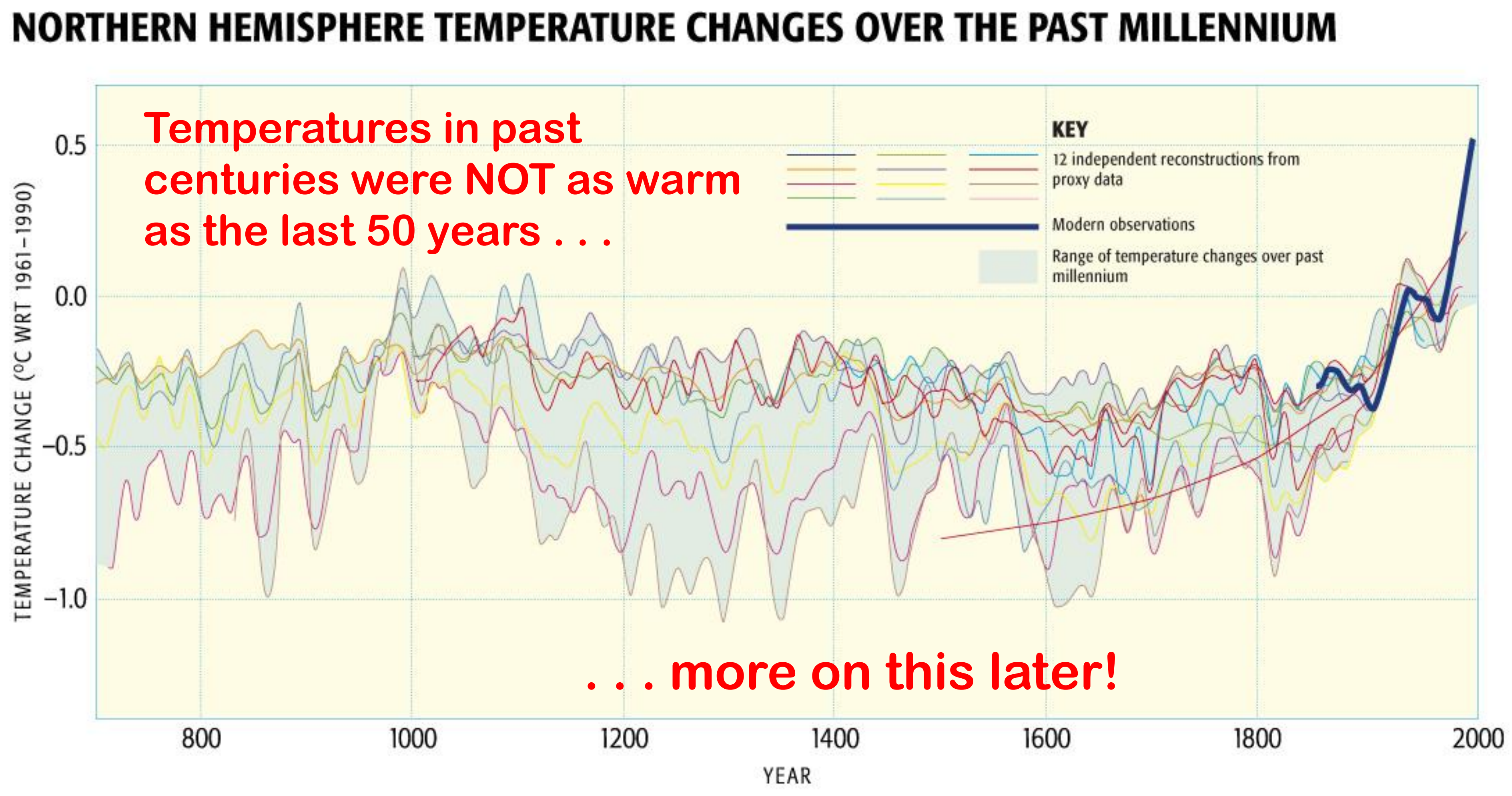
“What's the average been for several hundred years, & is this a significant departure from that?”

“And that's very difficult to do.”

(James Trefil, physicist)

p 29

How do the last 100 years compare with PAST centuries?



What about precipitation? ☺

. . . an example closer to home . . . .

from another kind of natural archive:

THE TREE-RING RECORD

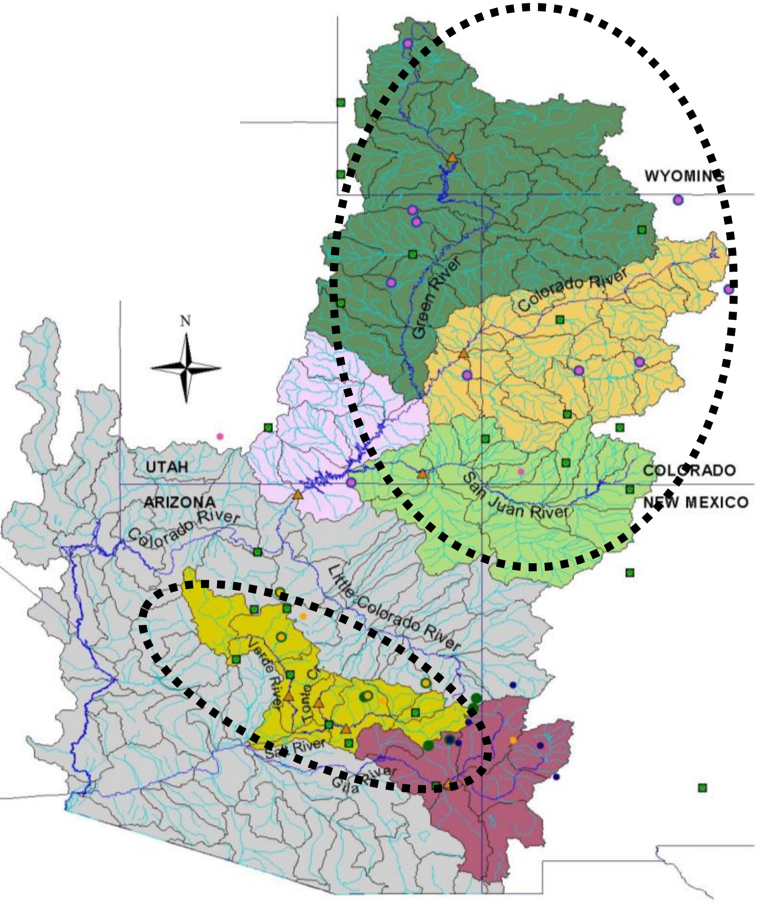
informs us about our Arizona WATER SUPPLY!

☺

LAKE POWELL – Colorado River Basin!

☺

Upper Colorado River Basin



Salt-Verde-Tonto
River Basin

"A Tree-Ring Based Assessment of Synchronous Extreme Streamflow Episodes in the Upper Colorado & Salt-Verde-Tonto River Basins"

Katie Hirschboeck & Dave Meko

Laboratory of Tree-Ring Research

&

Salt River Project

Delivering more than power.

PURPOSE: use long-term records from tree rings . . .

• to reconstruct annual streamflow in the two basins

&

• analyze variations of extreme low flow & high flow over the past several hundred years

The central question guiding our research was:

How frequently have extreme droughts or high flows occurred in both basins simultaneously in the past?

What's at stake: Reliability of the Colorado River system as a water-supply buffer for the Salt River system during times of extreme drought

OVERVIEW OF PROJECT STEPS:

1. Develop threshold procedure to identify extreme streamflow episodes: Low Flow, L (drought) and High Flow, H in each basin

   < 25th   > 75th

2. Use existing tree-ring data to refine previous tree-ring reconstructions of streamflow and produce new reconstructions

3. Define extreme synchronous streamflow scenarios: LL, HH, LH, HL in observed & reconstructed records

A TREE-RING CORE FROM THE SALT RIVER BASIN
showing ring-width variations in the 1900s

1899-1904
dry “signature” pattern

1950’s DROUGHT

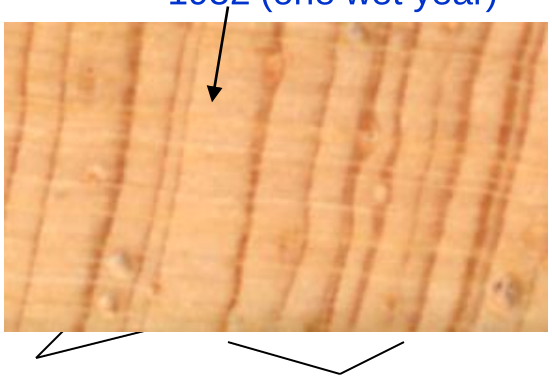
1905 -1908 **1914 – 1920**
two wet episodes

1899 &1902 = narrow rings

1900 & 1904 = missing rings

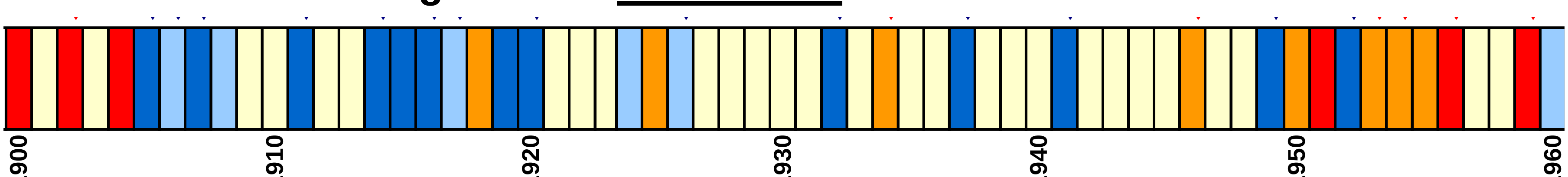
Even in a single tree,
the record of
extreme wet and dry
streamflow episodes
is evident.

1952 (one wet year)



1950 &1951 **1953 -1956**
series of narrow rings

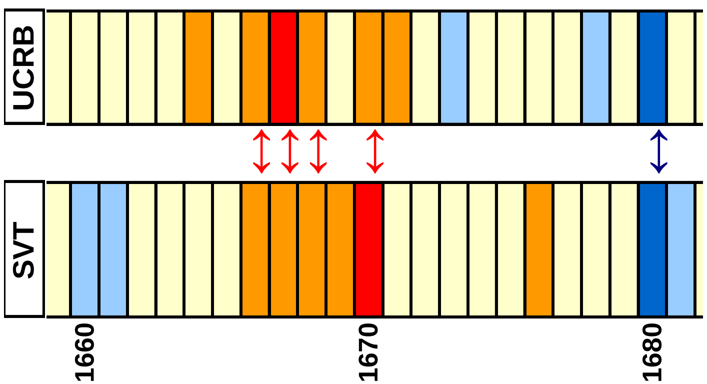
Extreme Years of High & Low Streamflow in the Salt-Verde-Tonto River Basin

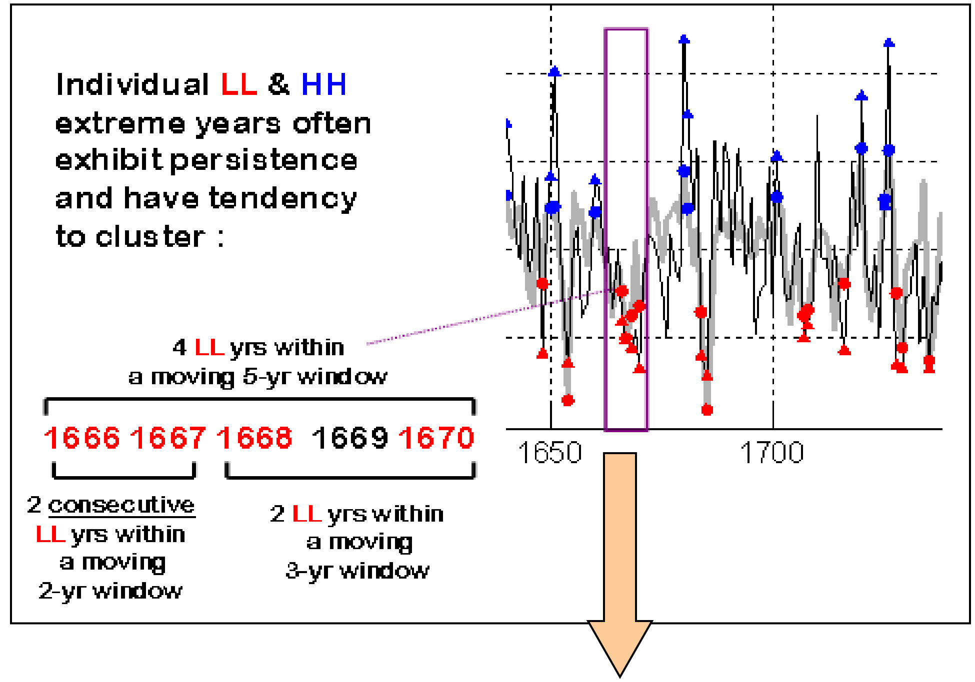


< 10th Percentile
< 25th and ≥ 10th Percentile
≥ 25th and ≤ 75th Percentile
> 75th and ≤ 90th Percentile
> 90th Percentile

Extreme High & Low Flow Years in BOTH Basins Together

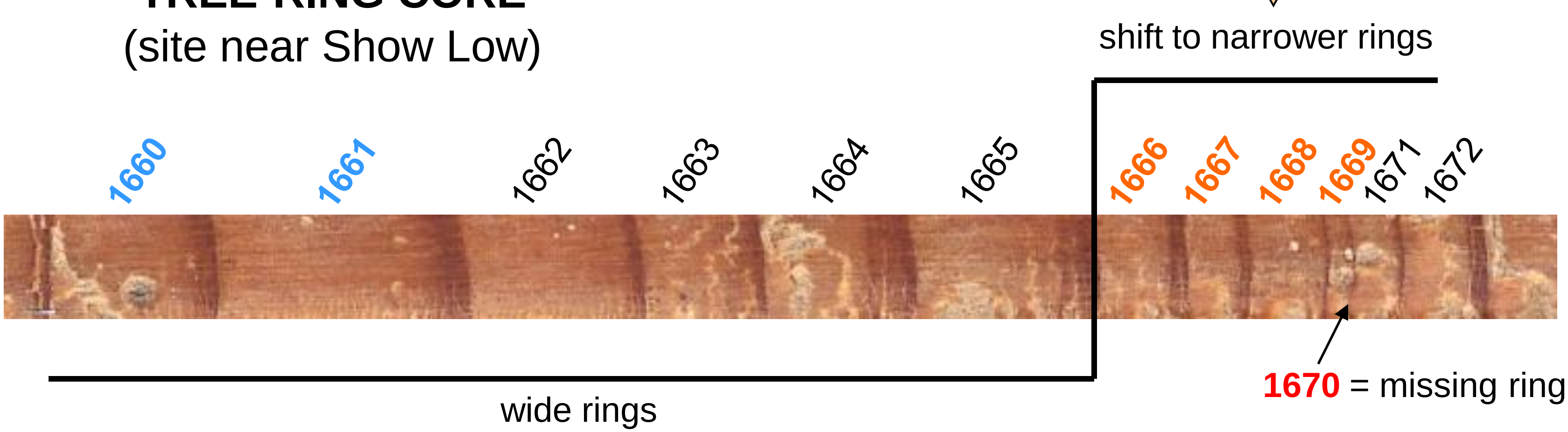
Salt-Verde-Tonto (SVT) & Upper Colorado River Basins (UCRB)

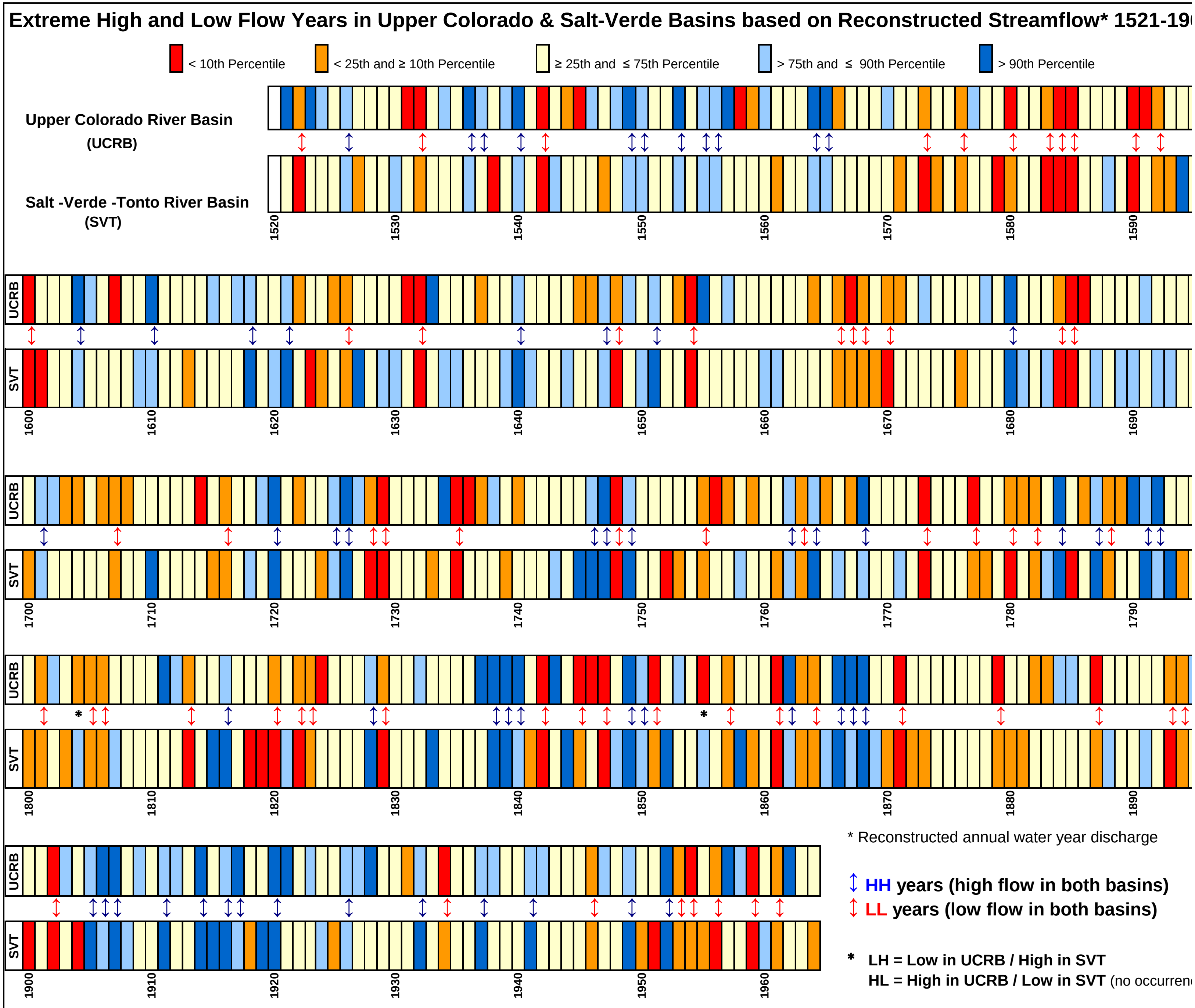




SALT RIVER BASIN TREE-RING CORE

(site near Show Low)




Extreme High and Low Flow Years in Upper Colorado & Salt-Verde Basins based on Reconstructed Streamflow* 1521-19
< 10th Percentile
< 25th and ≥ 10th Percentile
≥ 25th and ≤ 75th Percentile
> 75th and ≤ 90th Percentile
> 90th Percentile
Upper Colorado River Basin
(UCRB)
Salt -Verde -Tonto River Basin
(SVT)
UCRB
SVT
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* Reconstructed annual water year discharge
HH years (high flow in both basins)
LL years (low flow in both basins)
* LH = Low in UCRB / High in SVT
HL = High in UCRB / Low in SVT (no occurren

The results of our research indicated :

- The hypothesis that Upper Colorado River Basin (UCRB) can serve as a buffer to compensate for extreme low flow in the Salt-Verde-Tonto River (SVT) Basins in Arizona during drought periods needs to be re-evaluated.

- The assumption that streamflows in the two river systems are relatively independent of each other due to a difference in the climatic regimes needs to be reevaluated.

- Our analysis indicated that HH and LL events dominated, not HL or LH scenarios.

- Hence annual streamflow variability in the SVT – especially extreme streamflow – is not independent of annual streamflow variability in the UCRB.

- Severe drought in one basin will tend to be accompanied by severe drought in the other basin

☺

For future reference:

Most Recent Findings of the Intergovernmental Panel on Climate Change (IPCC)

See: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-direct-observations.html

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level .

- Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

- There is *medium confidence* that other effects of regional climate change on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic driver

Checklist of Direct Observations of Recent Climate Change

(we'll fill these in as the semester progresses)

TEMPERATURE:

daytime _____ nighttime _____ heat waves _____ # cold days/ frosts ______

PRECIPITATION:

water vapor _____ drought _____ heavy rains _____

HYDROLOGY:

streamflow ______ snowmelt ___ floods _____ reservoirs /dams____ water supply ____

CRYOSPHERE:

snowpack _____ mt glaciers _____ sea ice____ ice caps ____ frozen ground ______

Checklist of Direct Observations of Recent Climate Change (cont.)

OCEAN:

sea level ____ sea surface temps ____ salinity ______ corals ____ fisheries _____

BIOSPHERE:

plant / animal ranges _____ phenology_____ crop dates _____ disease ______

OTHER:

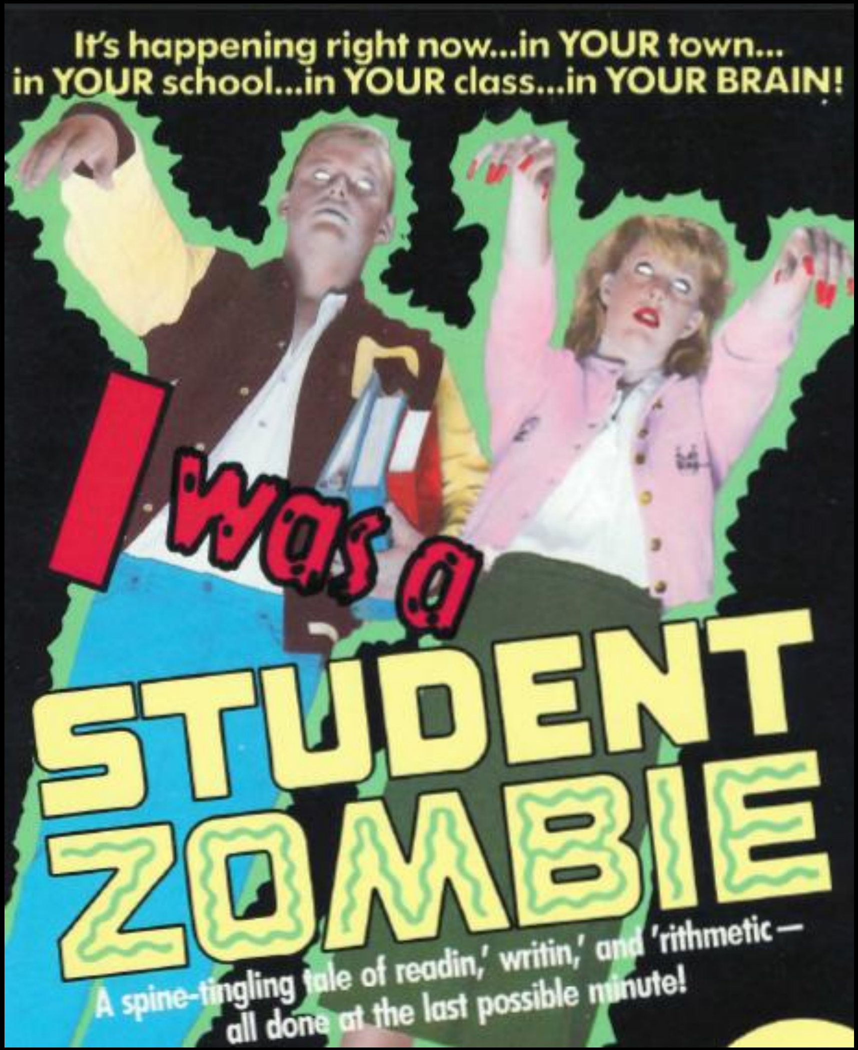
atmospheric circulation ____ wind belts / storm tracks _____ hurricanes _____

Preview of the kind of info in the IPCC report:

From the most recent IPCC Report:

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend[b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*[c]	*Likely*[d]	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Very likely*[e]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells/heat waves.Frequency increases over most land areas	*Likely*	*More likely than not*[f]	*Very likely*
Heavy precipitation events.Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*[f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*[f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*Likely*	*More likely than not*[f,h]	*Likely*[i]

http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-direct-observations.html#table-spm-2



ZOMBIE
BREAK !

GET TO KNOW YOUR GROUP!!

1. **ONE PERSON GETS GROUP FOLDER (color coded)**
2. **EVERYONE SIGNS THEIR NAME inside the GROUP FOLDER**
3. **First in alphabet in your group is TODAY's GROUP LEADER. Your job is to keep the discussion going and get assignment done!**
4. **Last in alphabet is today's NOTE TAKER**
5. **Will earn one credit toward their "GPR"**
   GPR = GROUP PARTICIPATION RESPONSIBILITY
6. **GO AROUND THE CIRCLE AND INTRODUCE YOURSELF:**
   - **Your NAME, Where from, major (if known)**
   - **What your FOOTPRINTS are!**

GROUP ACTIVITY

G-1 GROUP FOOTPRINT COMPARISON

ASSIGNMENT G-1 Group Footprint Comparison

- WORK ON G-1 TOGETHER – GROUP LEADER & NOTE TAKER work as a team – everyone else contributes! Each student will write in something!
- You will REPORT BACK TO CLASS ON GROUP'S TOTAL ECOLOGICAL, CARBON, & WATER FOOTPRINT.
- Group submits G-1 by leaving it in your group folder & returning your folde to front of the classroom
- KEEP your I-1 PART A for use in PART B (posted tonight!)

IMPORTANT:

NEVER TAKE YOUR GROUP FOLDERS OUT OF THE CLASSROOM!

Group Assignment I-1 to be completed on THURSDAY

Bring your I-1 PART A with you to class again!