Review of Past Climates

EES 3310/5310

Global Climate Change

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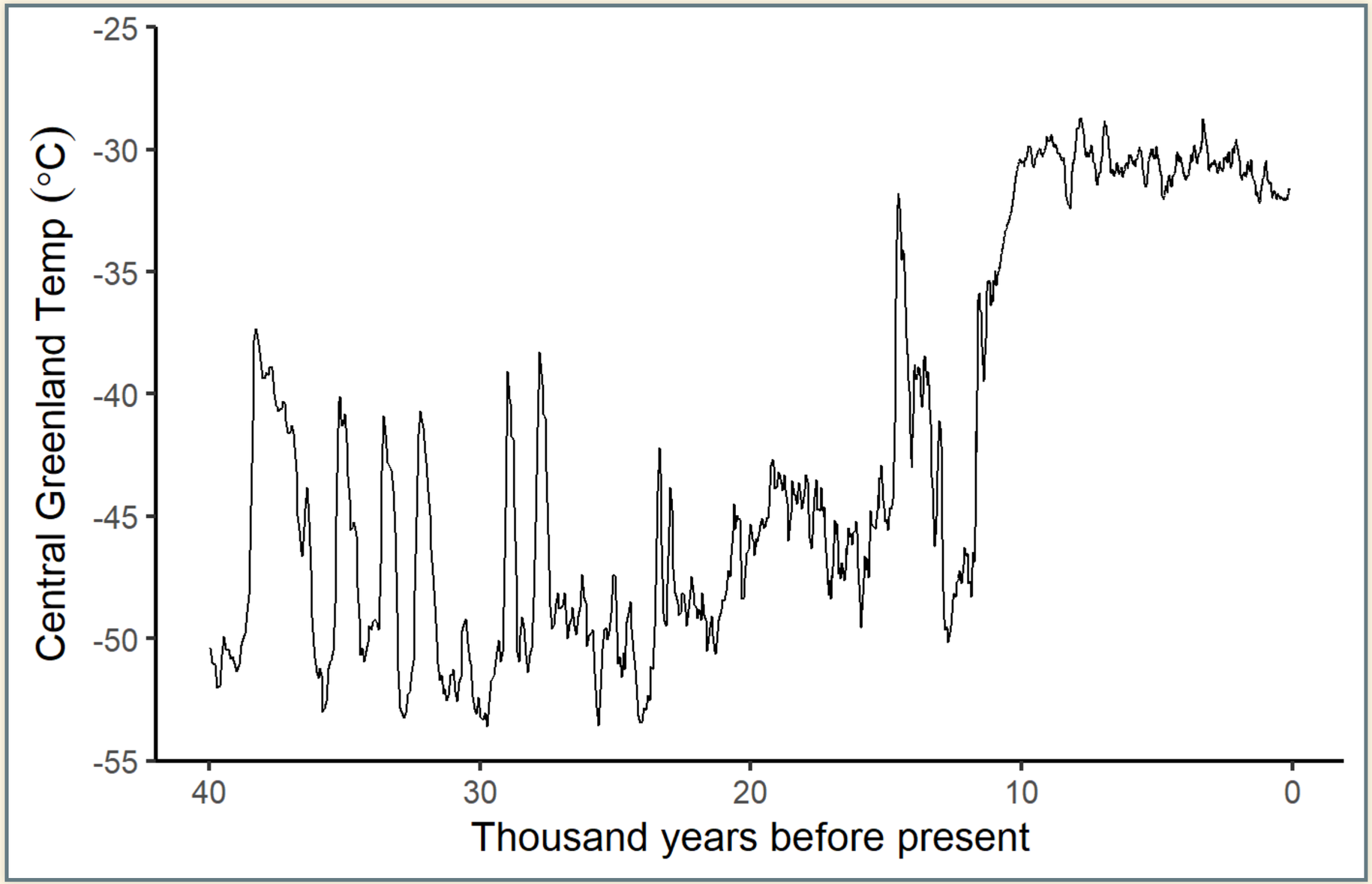
Class #15: Monday, February 10 2020

Summary of Oxygen Isotopes

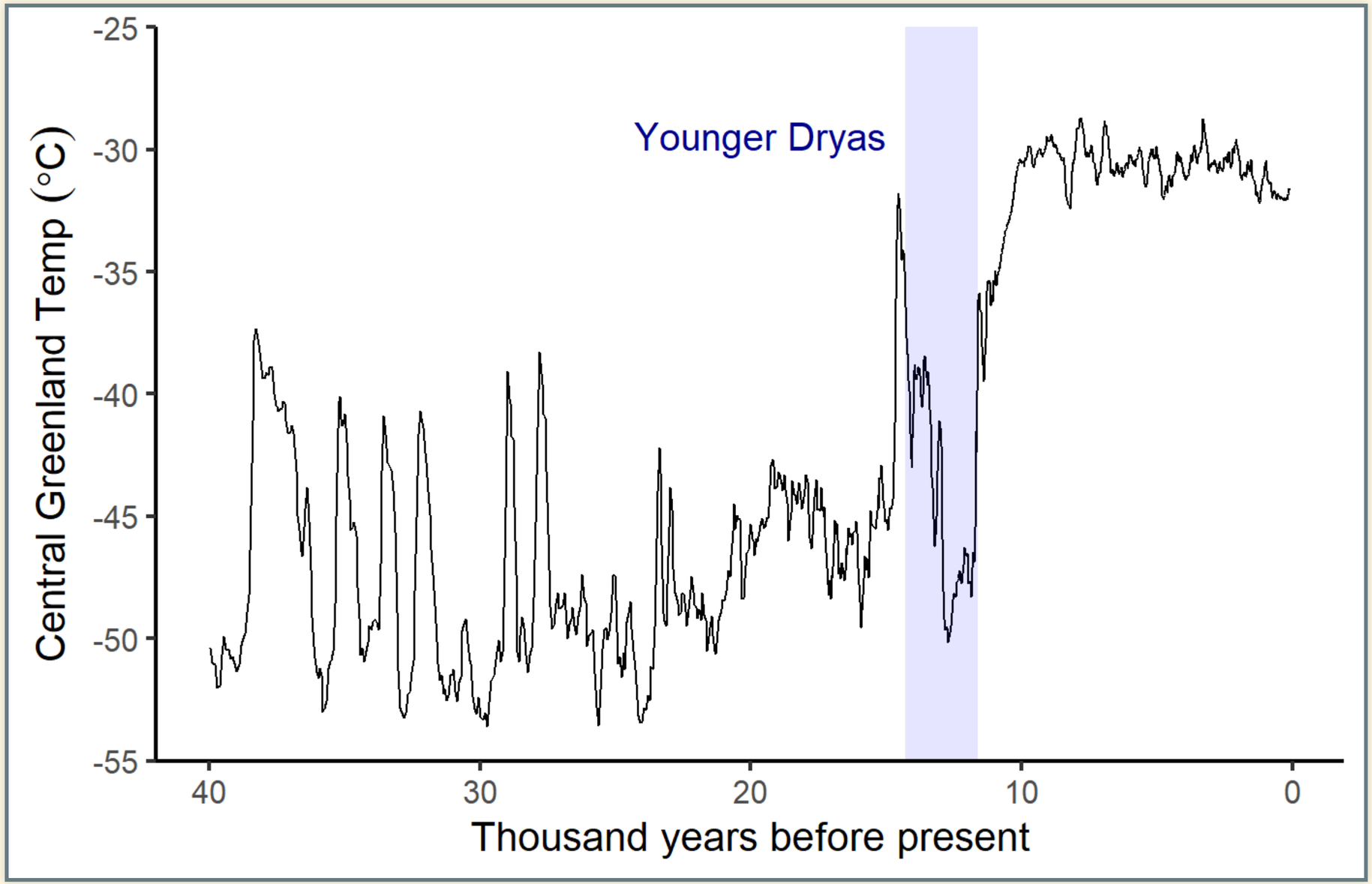
- Two different uses:
  - $\delta^{18}O$ in **glacial ice** tells us about **air temperature**:
    - Greater (less negative) $\delta^{18}O$ means warmer temperature.
  - $\delta^{18}O$ in **sea-floor sediments** (skeletons of deep-sea organisms) tells us about **sea level**:
    - Greater (more positive) $\delta^{18}O$ means lower sea-level.
- During ice-age cycles:
  - ***cold temperatures*** go with ***low sea-level***
    - $\delta^{18}O$ is *lower* than usual in glaciers, *higher* in sea-floor sediments.
  - ***warm temperatures*** go with ***high sea-level***:
    - $\delta^{18}O$ is *higher* than usual in glaciers, *lower* in sea-floor sediments.

Abrupt Climate Change

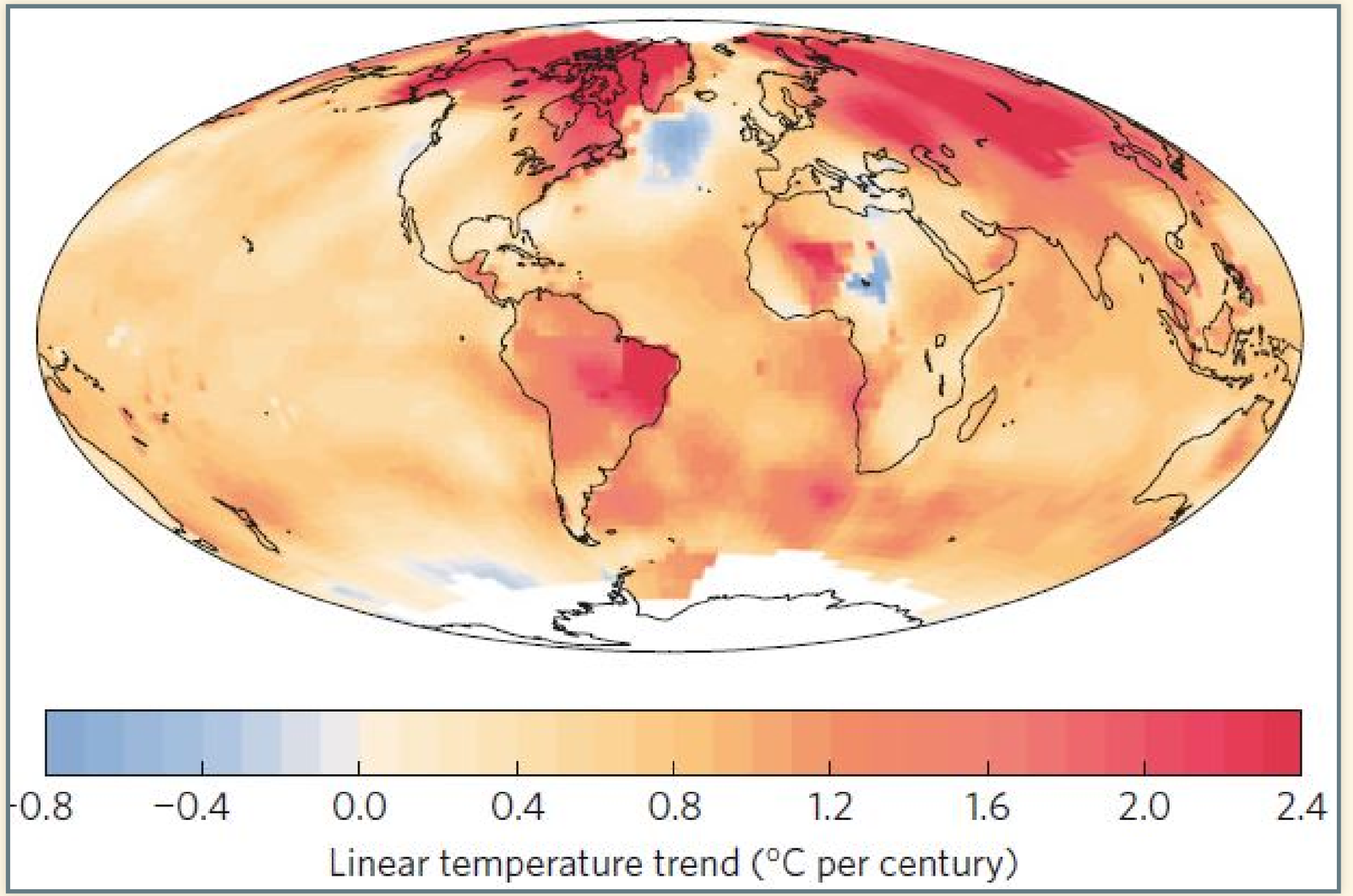
Abrupt Climate Change



Abrupt Climate Change



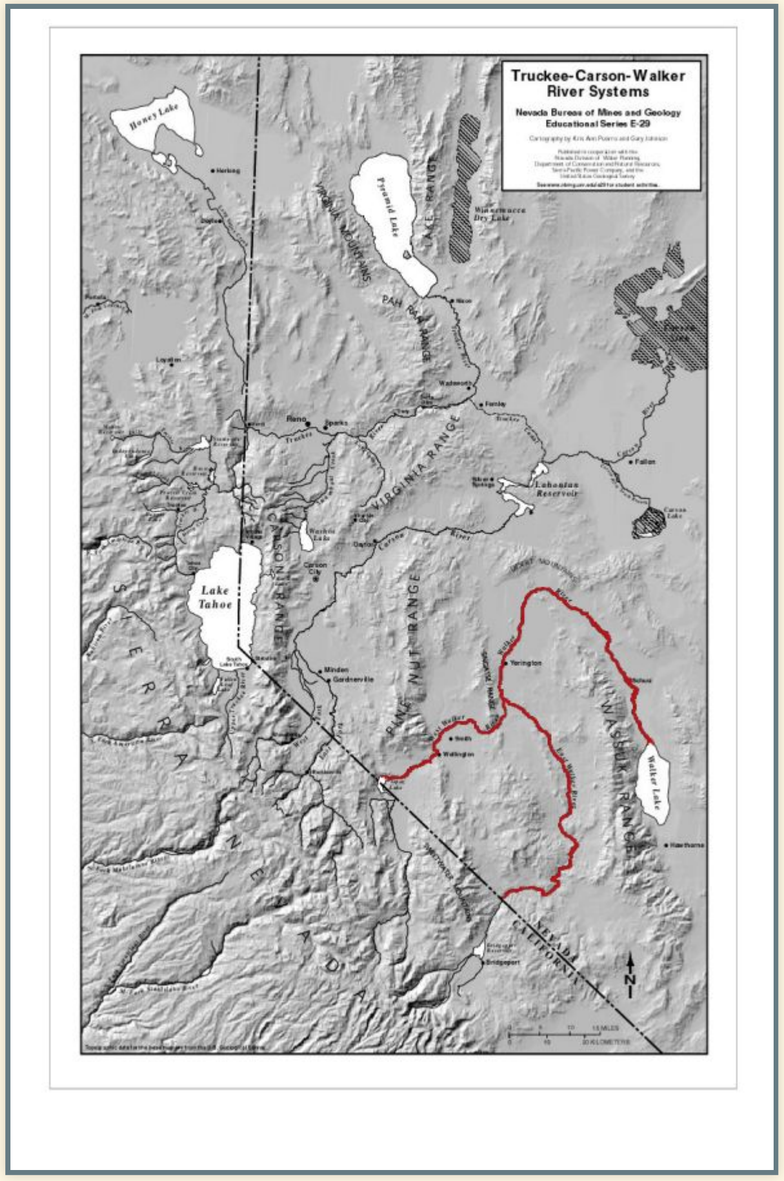
Cold Pool in North Atlantic



Warming Trend: 1900–2013

Climate in the Last Millennium

Walker River



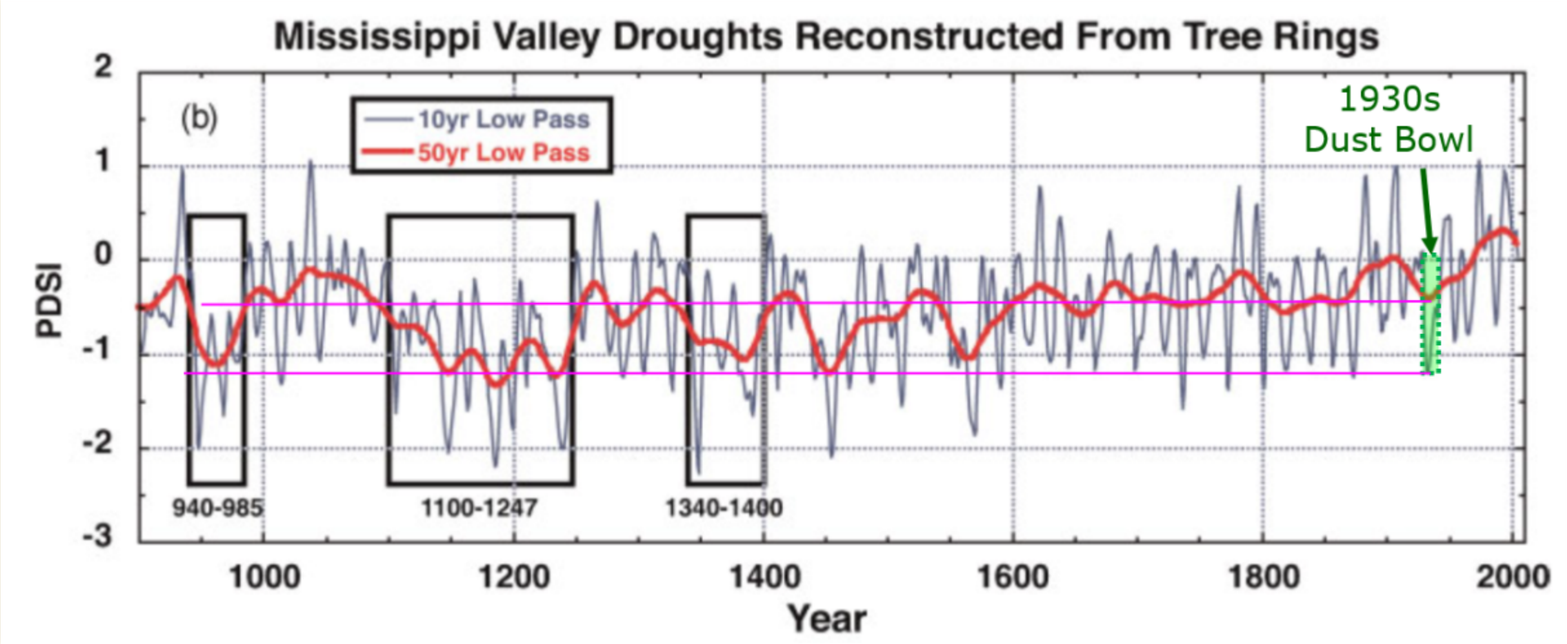
Relict Tree Stumps

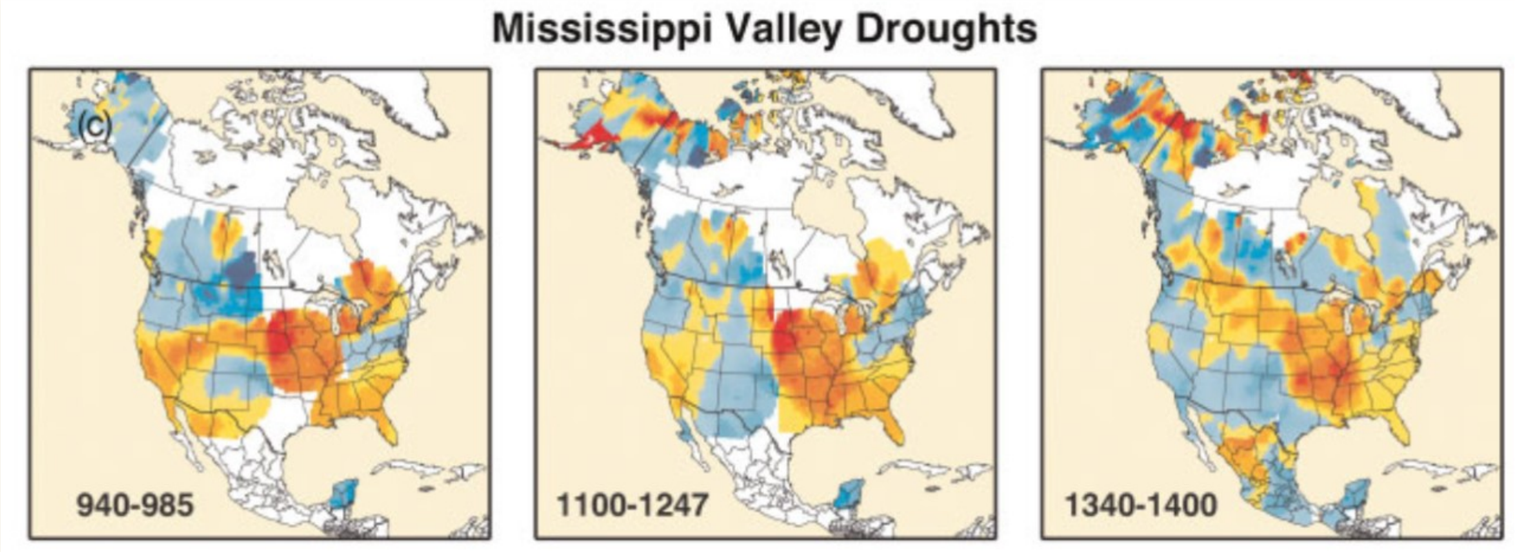
Relict Tree Stumps

Lake Tanaya, Yosemite

Chaco Canyon

Reconstructing Megadroughts





Dust Bowl vs. Megadroughts

- 1930s “Dust Bowl”
  - 6 years
  - 25% reduction in rainfall in plains states
  - Hundreds of thousands of refugees
- Medieval Megadroughts:
  - Multiple droughts
  - 60 years or longer (up to 240)
  - 40% reduction of rainfall in plains states

Questions about Carbon Cycle?

Questions about MODTRAN?

MODTRAN:

- MODTRAN calculates *emissions* and *absorption* of longwave light in the atmosphere.
- Things that don’t change during a run:
  - Heat from the sun
    - Set by “locality” of the atmosphere
  - Temperature of the ground and every layer of the atmosphere.
    - Set by “locality” of the atmosphere and “temperature offset”

Locale	I_{out} (W/m^2)	T_{ground} (K)
U.S. Standard Atmosphere	267.98	288.2
Tropical	298.67	299.7
Midlatitude winter	235.34	272.2

- For every wavenumber, MODTRAN calculates heat emission and absorption up and down at each layer.

MODTRAN:

- Emissivity (ε) = absorption
  - Fraction absorbed by layer $= \varepsilon$
  - Radiation emitted by layer $= \varepsilon\sigma T^4$
- ε small (near zero):
  - Little absorption or emission.
- ε large (near one):
  - Almost all incoming radiation is absorbed
  - Emission close to black body at temperature T.
- ε is large for wavenumbers where greenhouse gases absorb strongly.
  - Greater concentration $\rightarrow$ larger ε
- ε is small where there is little absorption
  - Atmospheric window

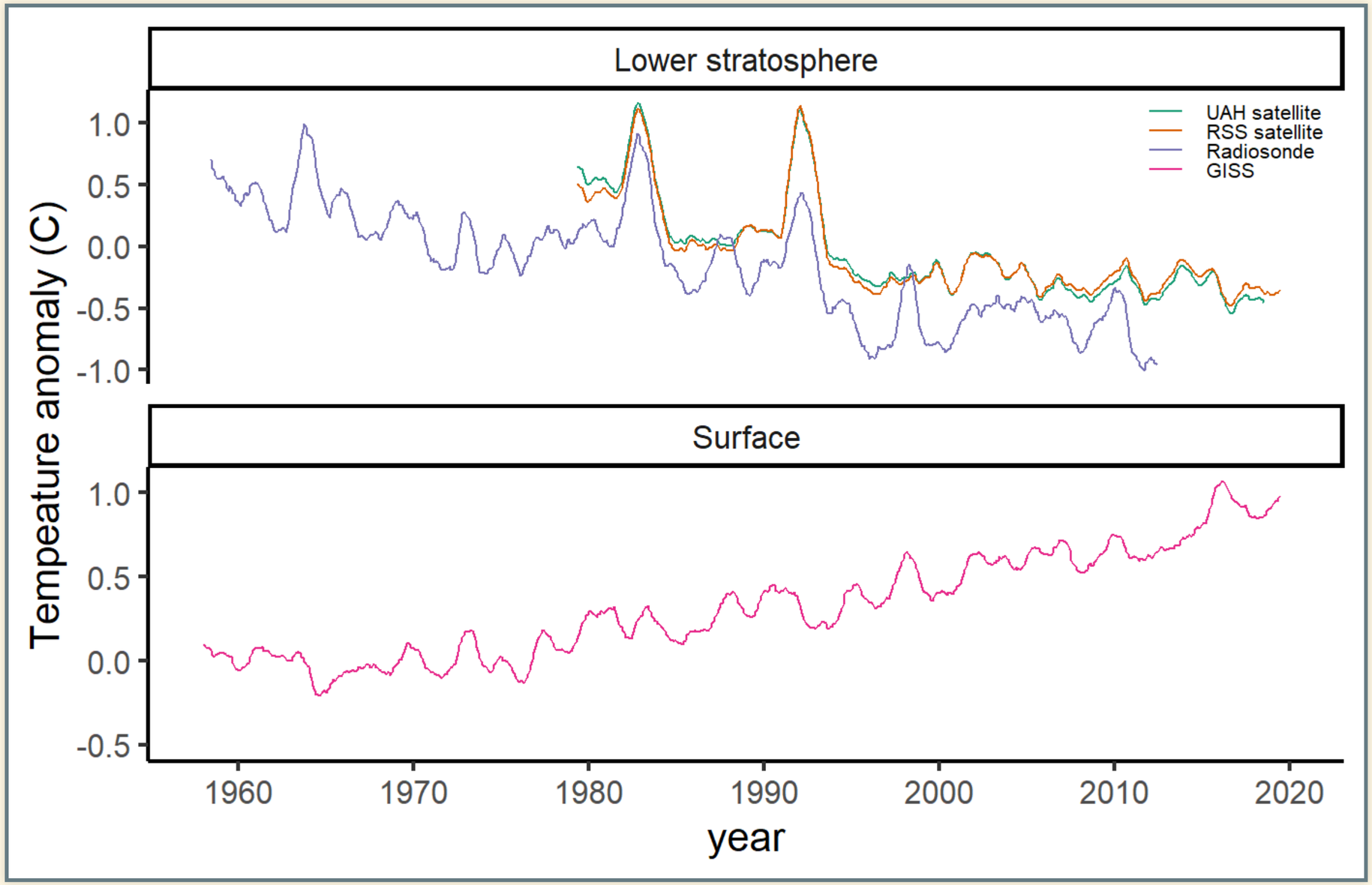
- **Looking down from space:**
  - You see emission at the temperature of the ***highest layer*** **with large** ε.
  - In atmospheric window, that layer is near the ground
  - With clouds, it's the top of the highest cloud
- **Looking up from ground:**
  - You see emission at the temperature of the ***lowest layer*** **with large** ε.
  - In atmospheric window, there's no such layer, so you see very little emission
  - With clouds, it's the bottom of the lowest cloud

Evidence for Cause of Global Warming

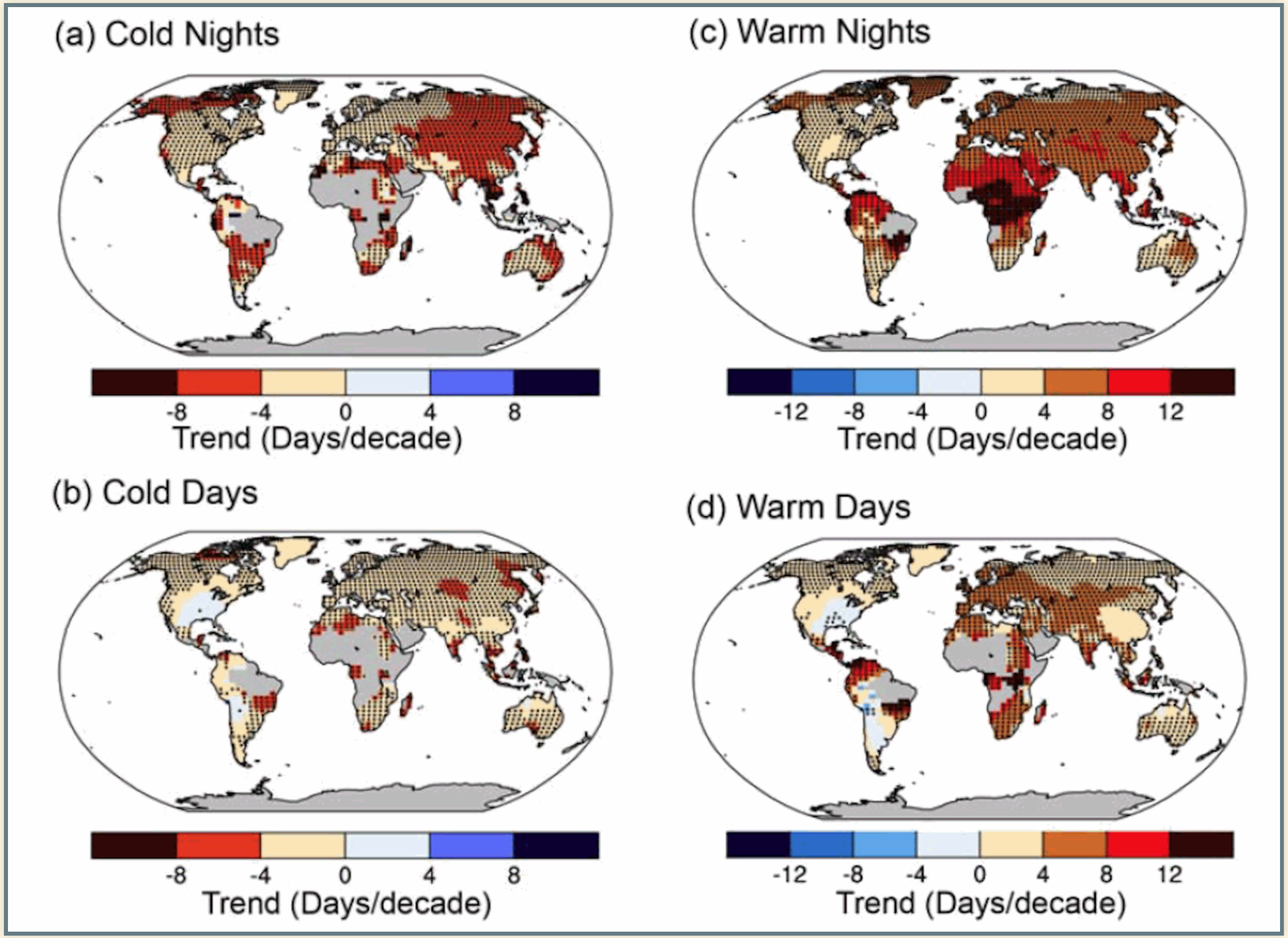
Fingerprint Analysis

- Different causes of warming produce different patterns:
  - Different places warm differently
    - Polar regions vs. tropics
    - Troposphere vs. stratosphere
  - Different times warm differently
    - Night vs. day
    - Winter vs. summer
- Observed patterns:
  - Match predicted patterns for greenhouse effect
  - Do not match predicted patterns for any other theory

Stratosphere vs. Troposphere:



Day vs. Night


(a) Cold Nights
-8 -4 0 4 8
Trend (Days/decade)
(c) Warm Nights
-12 -8 -4 0 4 8 12
Trend (Days/decade)
(b) Cold Days
-8 -4 0 4 8
Trend (Days/decade)
(d) Warm Days
-12 -8 -4 0 4 8 12
Trend (Days/decade)