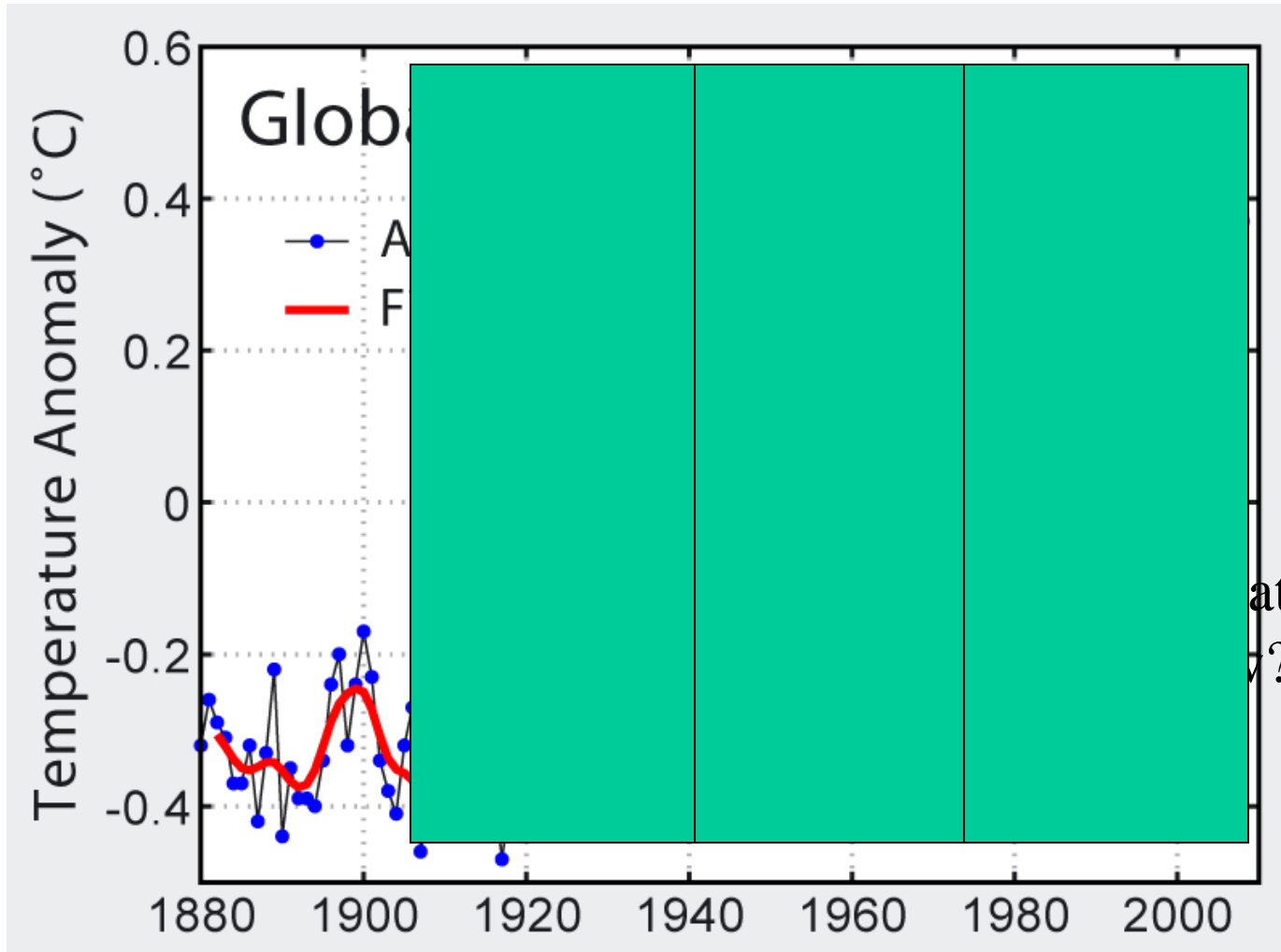


Rapid climate change, and ice sheets

Observed temperature



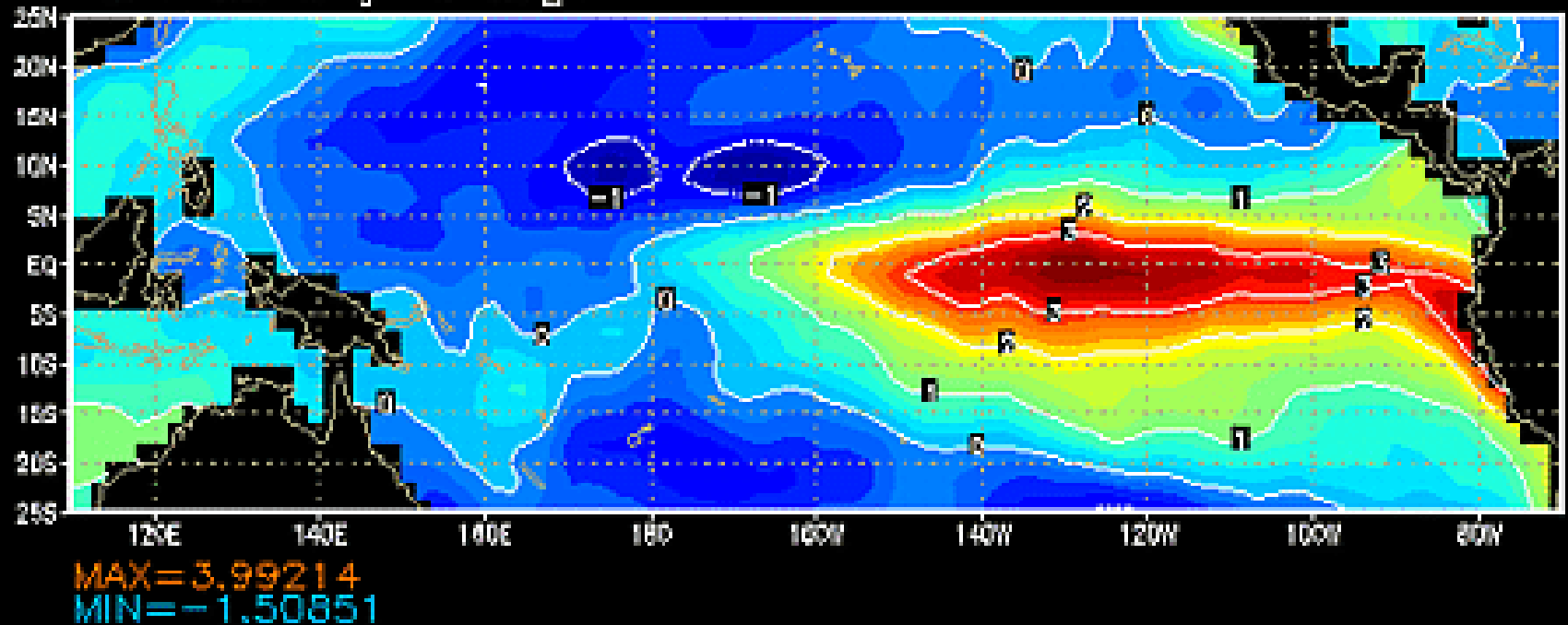
Compare to longer record

IPCC, TAR

Sea surface temperature
Difference from normal
El Nino year

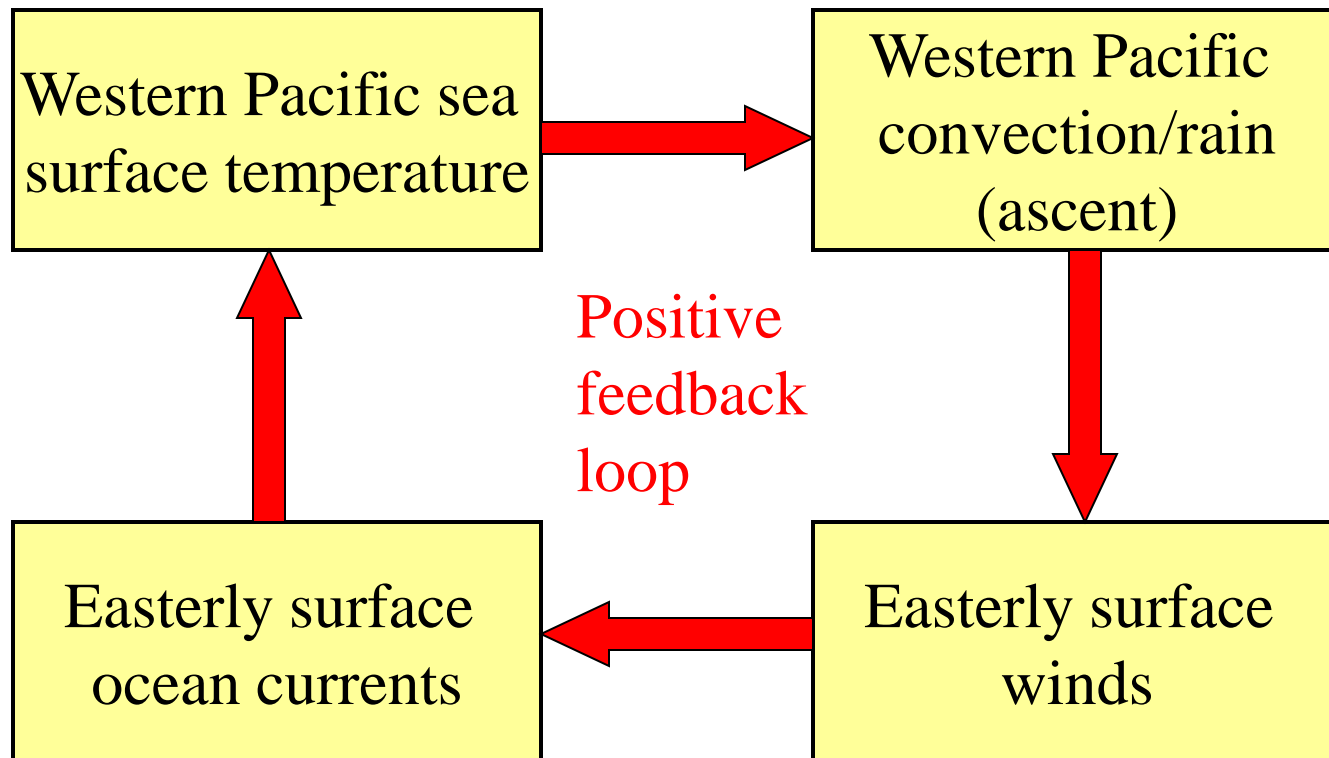
lat: plotted from -25 to 25
lon: plotted from 110 to 290
t: averaged over Dec 1982 to Feb 1983
lev: 0

NCEP Anomaly air degC

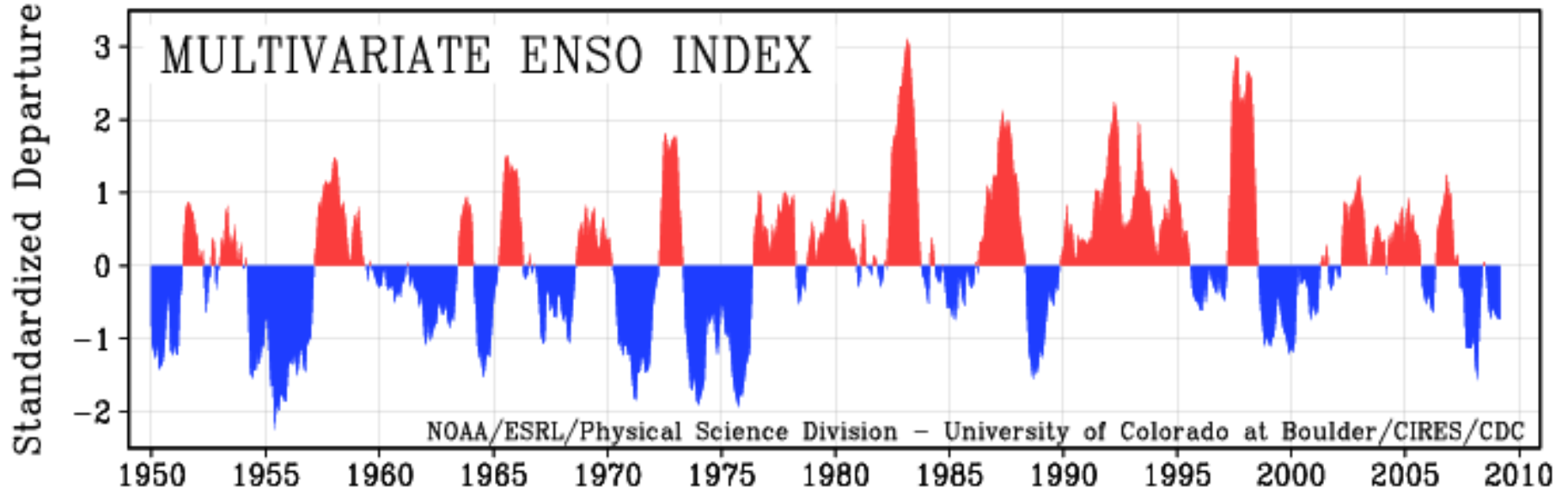


Atmosphere-ocean coupling

Consider the loop of interactions...



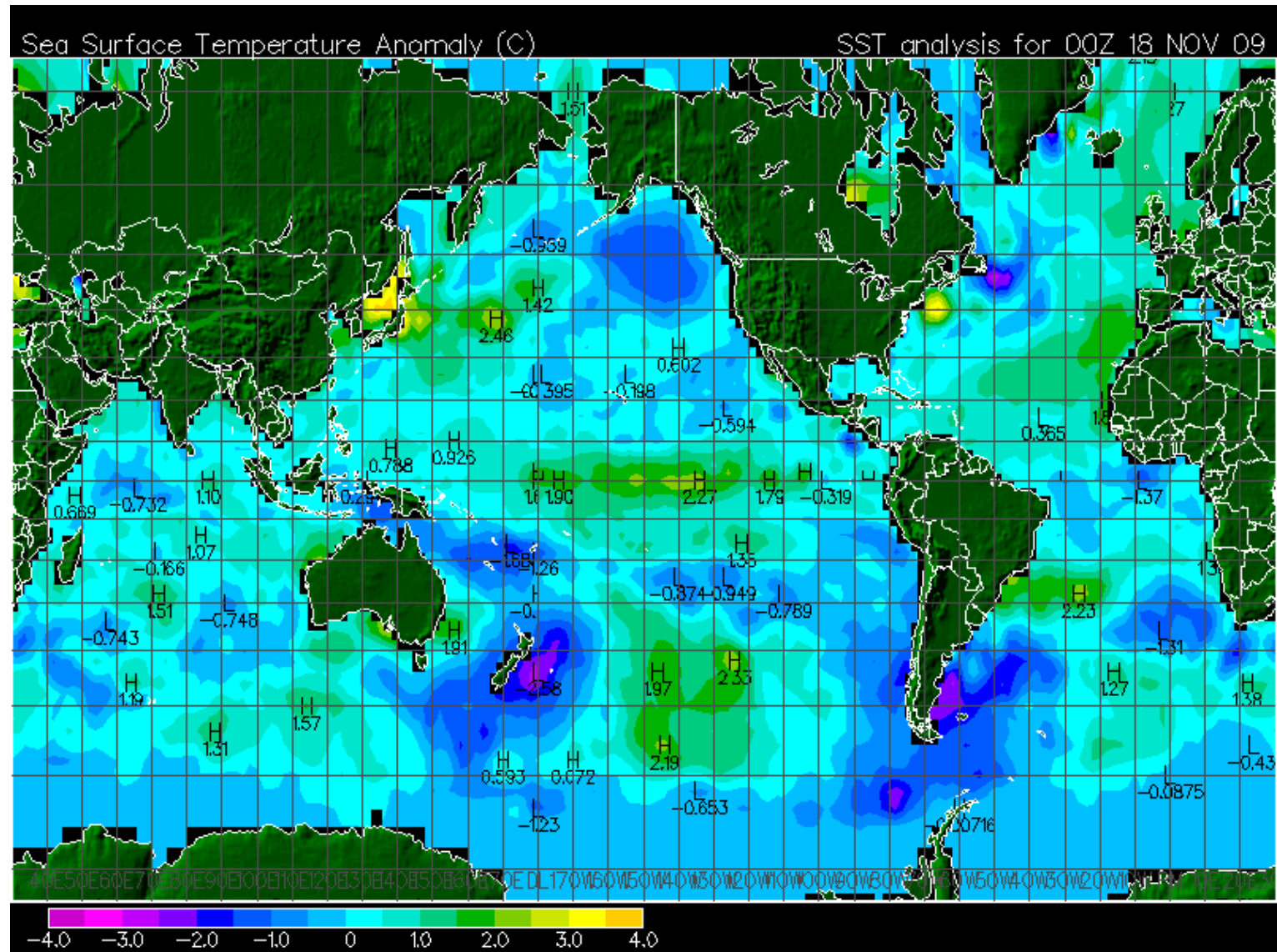
Set of positive interactions, allows small changes to become amplified



A measure of the average temperature in the eastern Pacific Ocean relative to the western Pacific.

CIRES/PSD, Boulder

Latest SST map



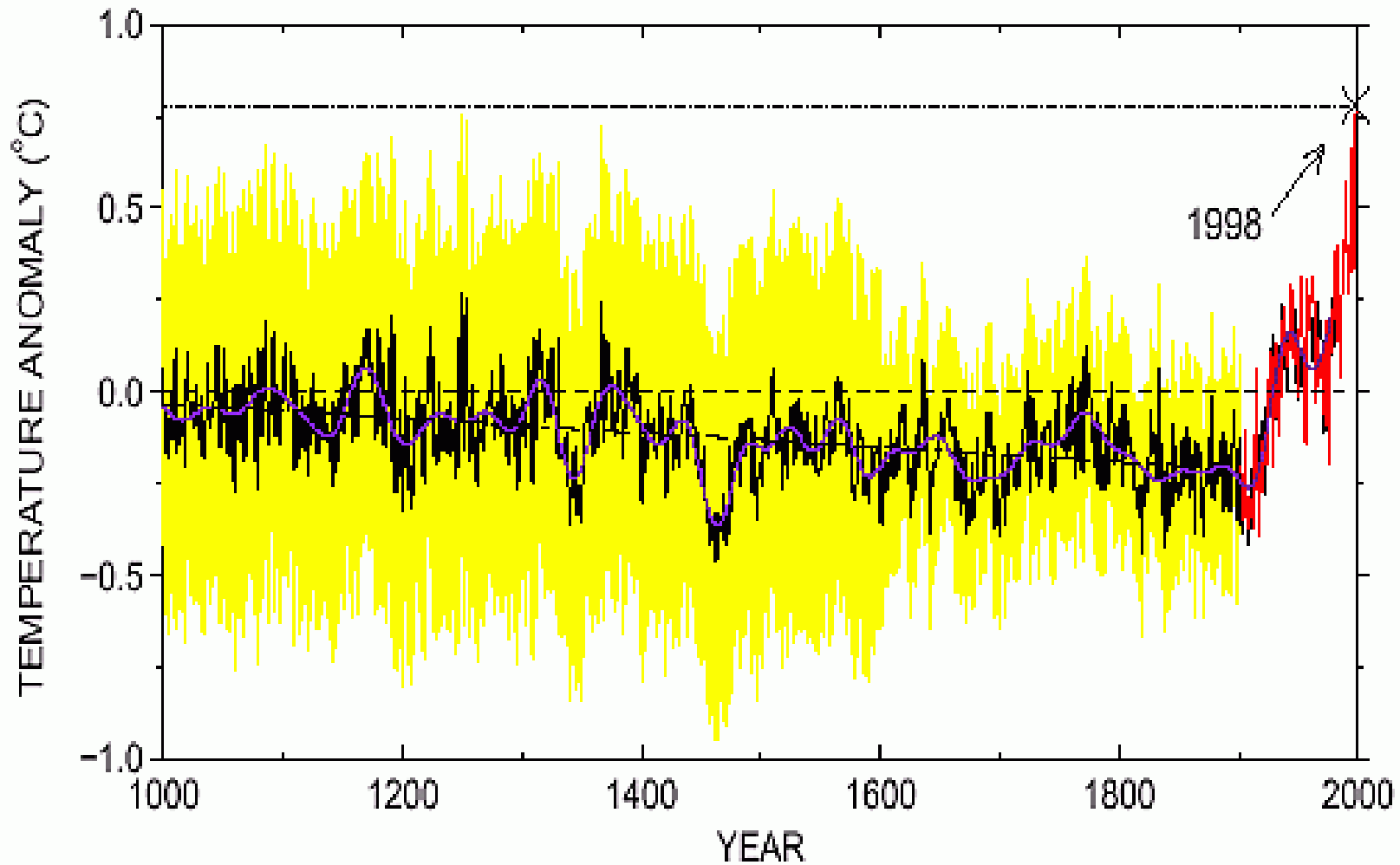
Overturning ocean circulation...

- A. Requires brine rejection
- B. Keeps the Arctic warmer than otherwise
- C. Will stop with increased CO₂
- D. All of the above
- E. None of the above

El Nino causes...

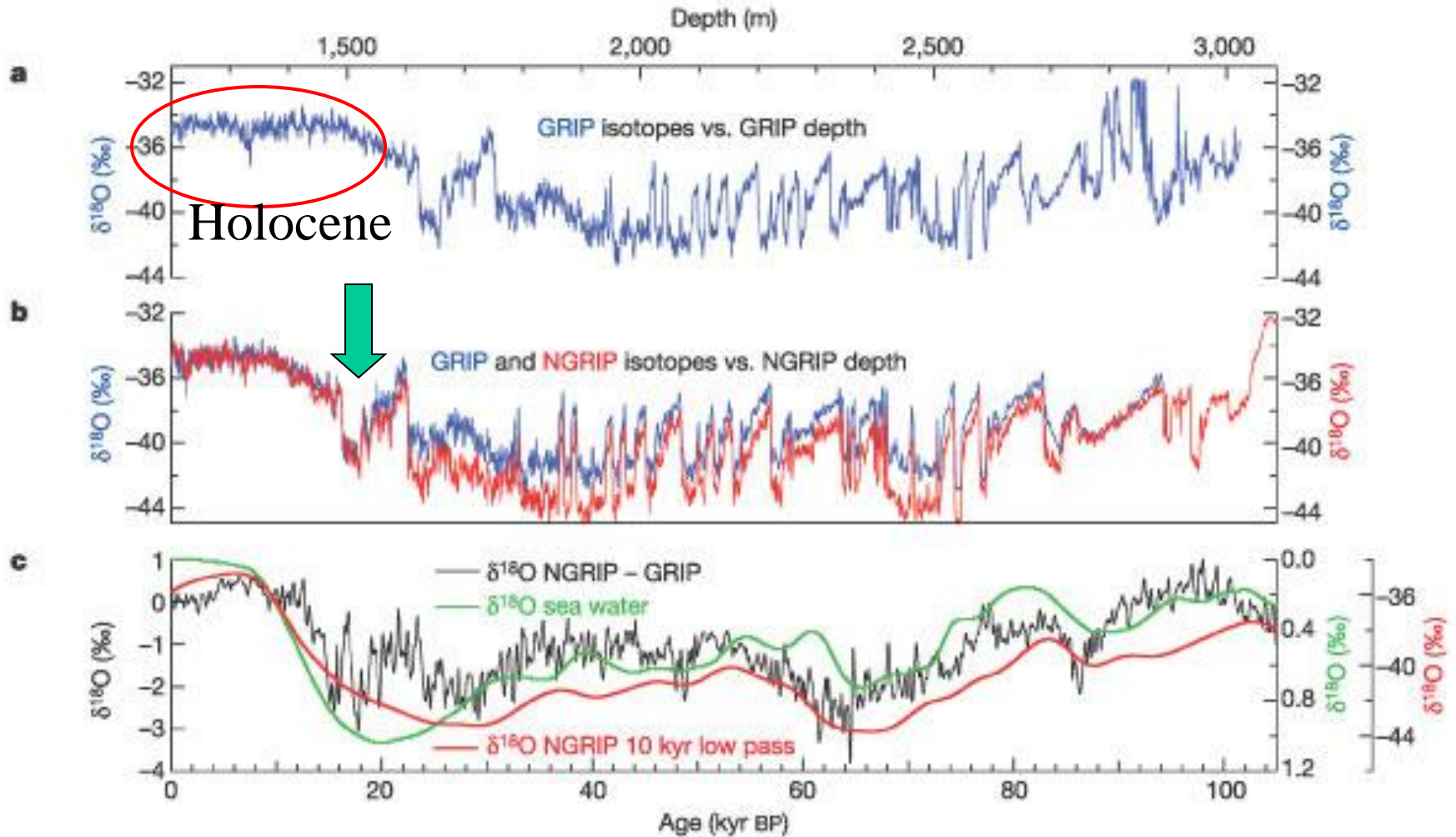
- A. Bad weather for everyone
- B. Natural variations in climate
- C. Long term trends in global temperature
- D. No change in vegetation
- E. None of the above

Temperature estimated from tree rings



The infamous “Hockey Stick” by Mike Mann and others

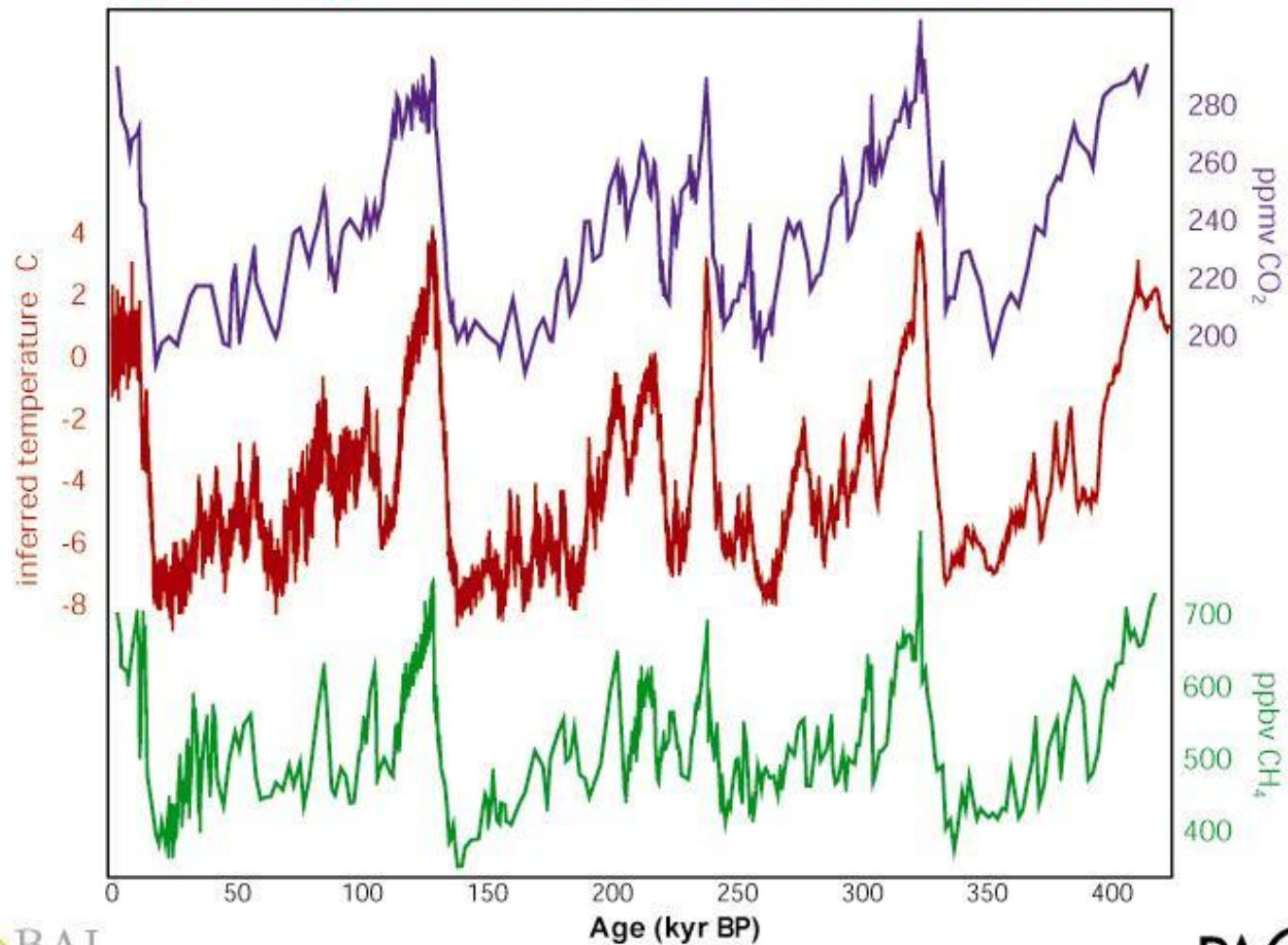
Ice cores from Greenland



What happened during de-glaciation?

Climate almost change its mind?

4 glacial cycles recorded in the Vostok ice core



Variability

- Variability can be natural
(say, volcanoes, El Nino...weather)
- Or forced by human activity

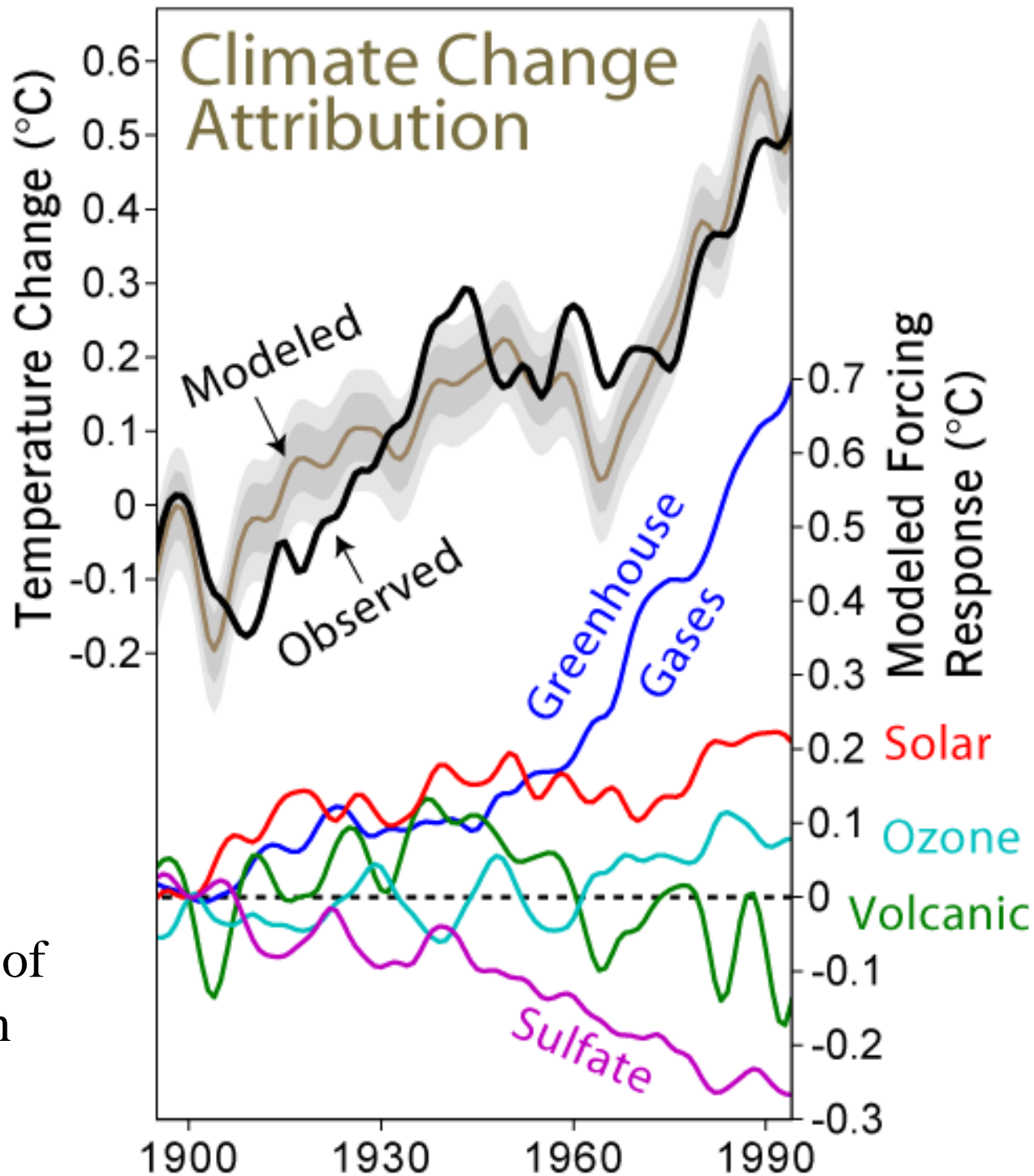
Not enough to say “might be an influence”

(this is just a hypothesis)

Also need to test, “is it true”

(the experiment is the next part of the scientific method)

Using a climate model, the MAUGNITUDE of the influences can be determined.



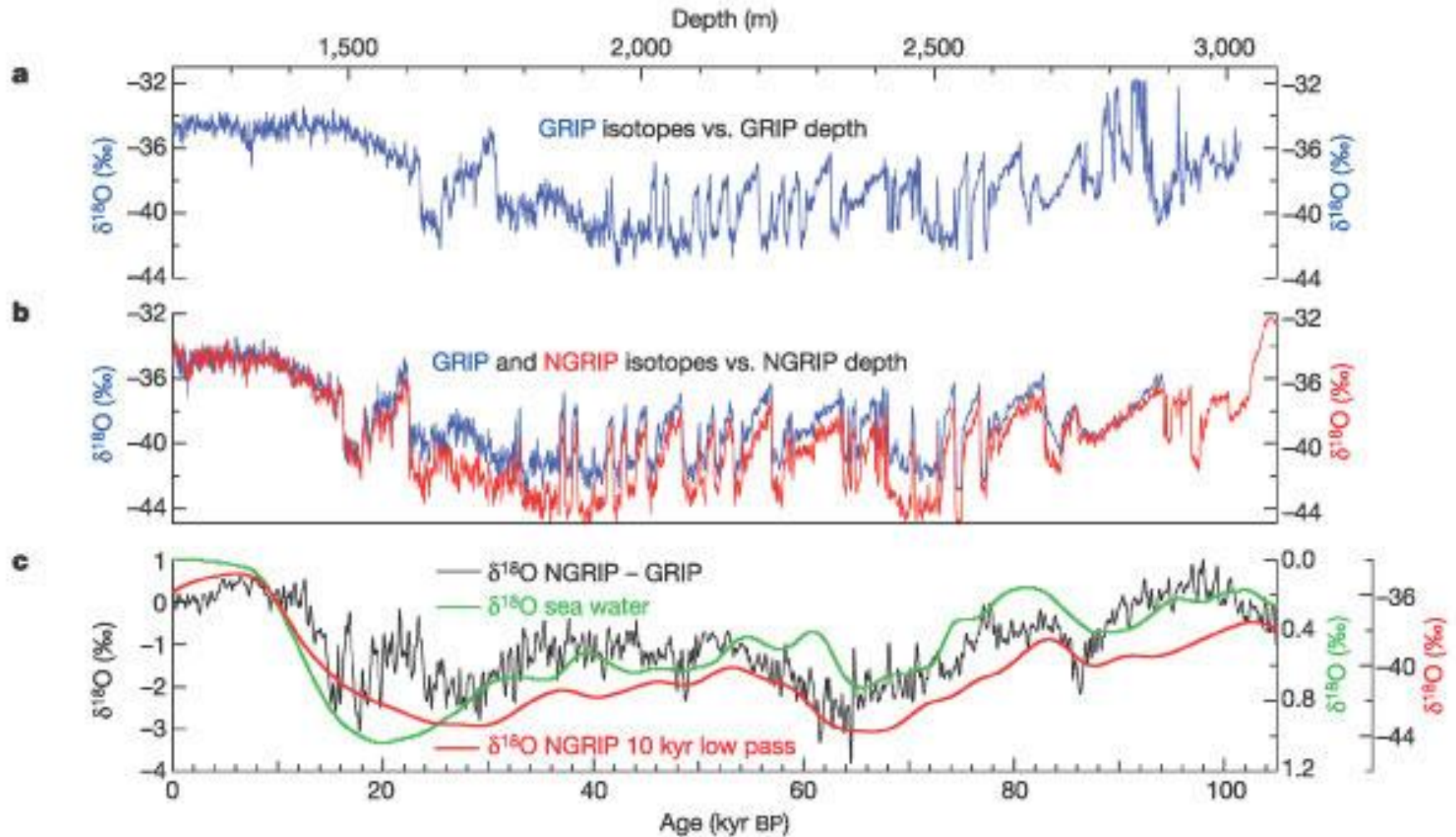
From previous lectures

- Lack of salinity variation (sea ice or evaporation) changes the production of deep water in the North Atlantic
- But also temperature can change density.

- What about sea level...
- Surely melting will cause sea level change?

Scott and the ocean, part 1

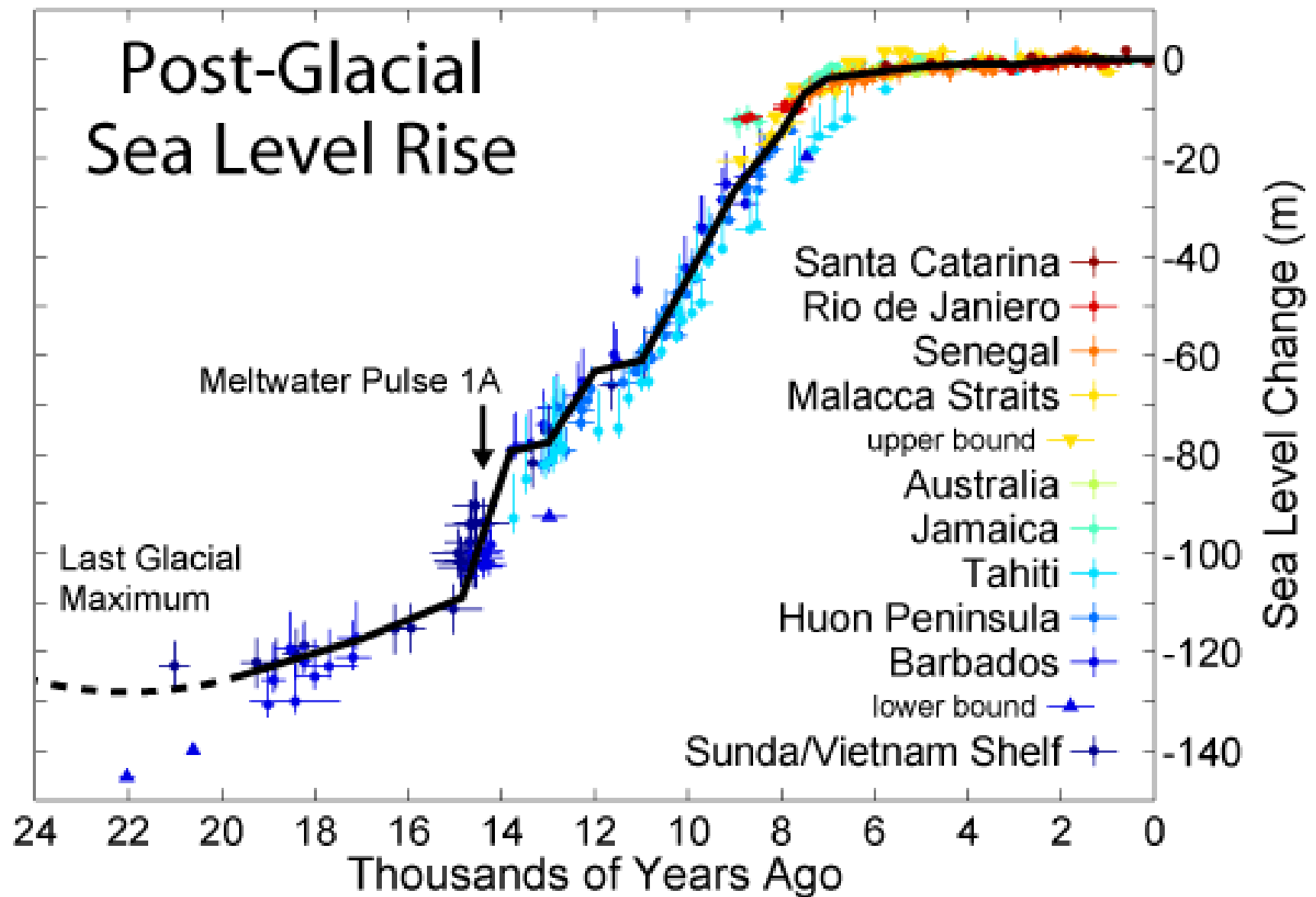
Ice cores from Greenland



Last ice age (21000 years ago)



Post-Glacial Sea Level Rise



What about melt water?

- Scott, part 2: The update

Home work

Find a friend (from 1060, or elsewhere)

Find a pack of cards

»Note University of Colorado does not endorse gambling!

Find a high value prize!

Each....

You want theirs. They want yours.

To get theirs, you will have to risk yours.

But if you play it safe, they may swoop in and have the opportunity get yours first!

100 years of climate change game rules

- *Shuffle the deck*, then lay out 10 cards. Each card represents the temperature in each of the 10 years in a decade.
- Compute the temperature anomaly for the 10-year period by adding up the temperature for each card. The temperatures are Ace to 10 = 0.5K, Jack = 1K, Queen = 1.5K and King=2K. Black cards are negative, red cards are positive.
- Plot the 10-year temperature anomaly on a graph, starting with the first value at 10 years.
- Gather up the cards, and have your partner secretly remove 2 cards *of the same color* (which 2 is up to them).
- Repeat step 1-4 to add obtain the temperature anomaly for the next 10 year period, and plot this on you graph.
- At the end of each 10 year period, look at your graph, and make a decision. Do you think there is global warming or global cooling? On the graph write “W” or “C”. If you are confident, circle it, and declare:
“I bet my sweet Snickers it’s global [cooling/warming]!”
- Continue for a total of 10 rounds to complete the graph at 100 years. Remember, your partner must always remove the SAME COLOR cards.
- Use the final value at year 100 to determine if your prediction was correct.
-
- Switch. Now it’s your partners turn, and you get to remove the cards. As you partner plays, also plot their temperature on your graph (different color line), and note when they make their decision as well.

Who won?

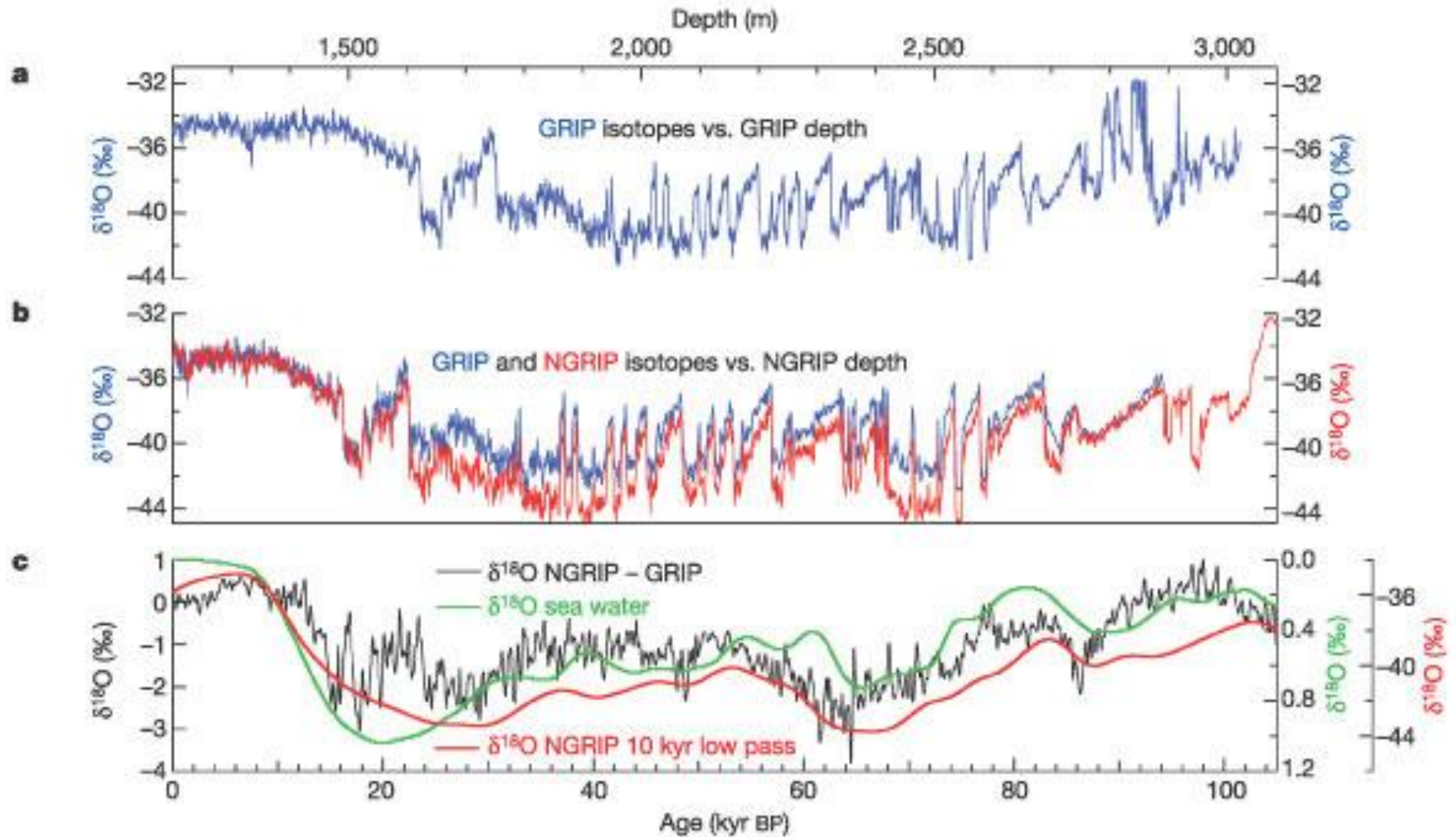
- If you decide correctly *before* your partner (you bet first), you win!
- If you bet incorrectly (even if you bet first), your partner wins.
- If you bet at the same time and both are correct, it's a tie.
- If you both bet incorrectly, it's a tie.

Whoever wins most games our gets the prize!

(best out of 5)

Scott – final results?

Ice cores from Greenland



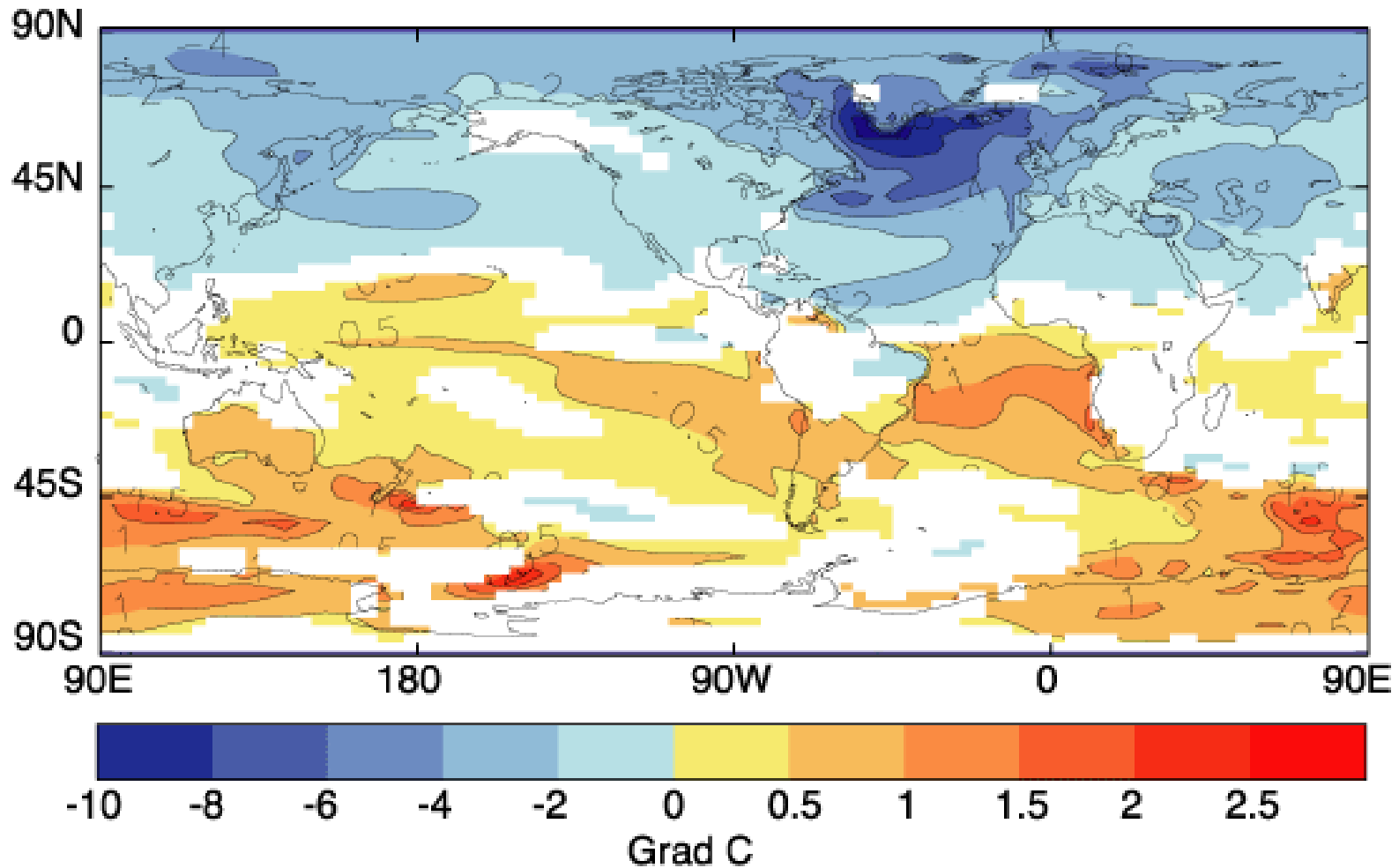
What would happen if the THC shut down?



Well, not quite...
but it is the right idea!



Change in surface air temperature after a collapse of the thermohaline circulation in the North Atlantic



Hadley Centre climate model simulation

Final answer.

El Nino causes...

- A. Bad weather for everyone
- B. Natural variations in climate
- C. Long term trends in global temperature
- D. No change in vegetation
- E. None of the above

Final answer.

Overturning ocean circulation...

- A. Requires brine rejection
- B. Keeps the Arctic warmer than otherwise
- C. Will stop with increased CO₂
- D. All of the above
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Key points

- *Loss ice sheets* due to deglaciation *freshens of the Arctic ocean*
- **Reduction in the strength of the THC** will lead to substantial changes in the temperature of the North Atlantic ocean
- And so temperature in *Europe* and parts of *North America* and *Greenland*
- *Can explain part of the difference between the Greenland and Antarctic ice core records about 8.2ka B.P.*
- Since the THC moves heat, **some places colder** while **others warmer**.
- Places that are “colder” will not be *that* cold since this is all caused by warming!
- Climate variability occurs on all time scales
- *To deduce long and slow trends, one must take into account some of the shorter scale changes may be due to natural variability*