OCN/ATM/ESS 587…..The Ocean (#4)

- The Gulf Stream and climate
- Ocean/atmosphere interactions in the past (glaciations)
- States of the global atmosphere/ocean

The Gulf Stream and Climate:

'One of the benign offices of the Gulf Stream is to convey heat from the Gulf of Mexico, where otherwise it would become excessive, and to disperse it in regions beyond the Atlantic for the amelioration of the climate of the British Isles and all of western Europe.'

and were this not to happen ...

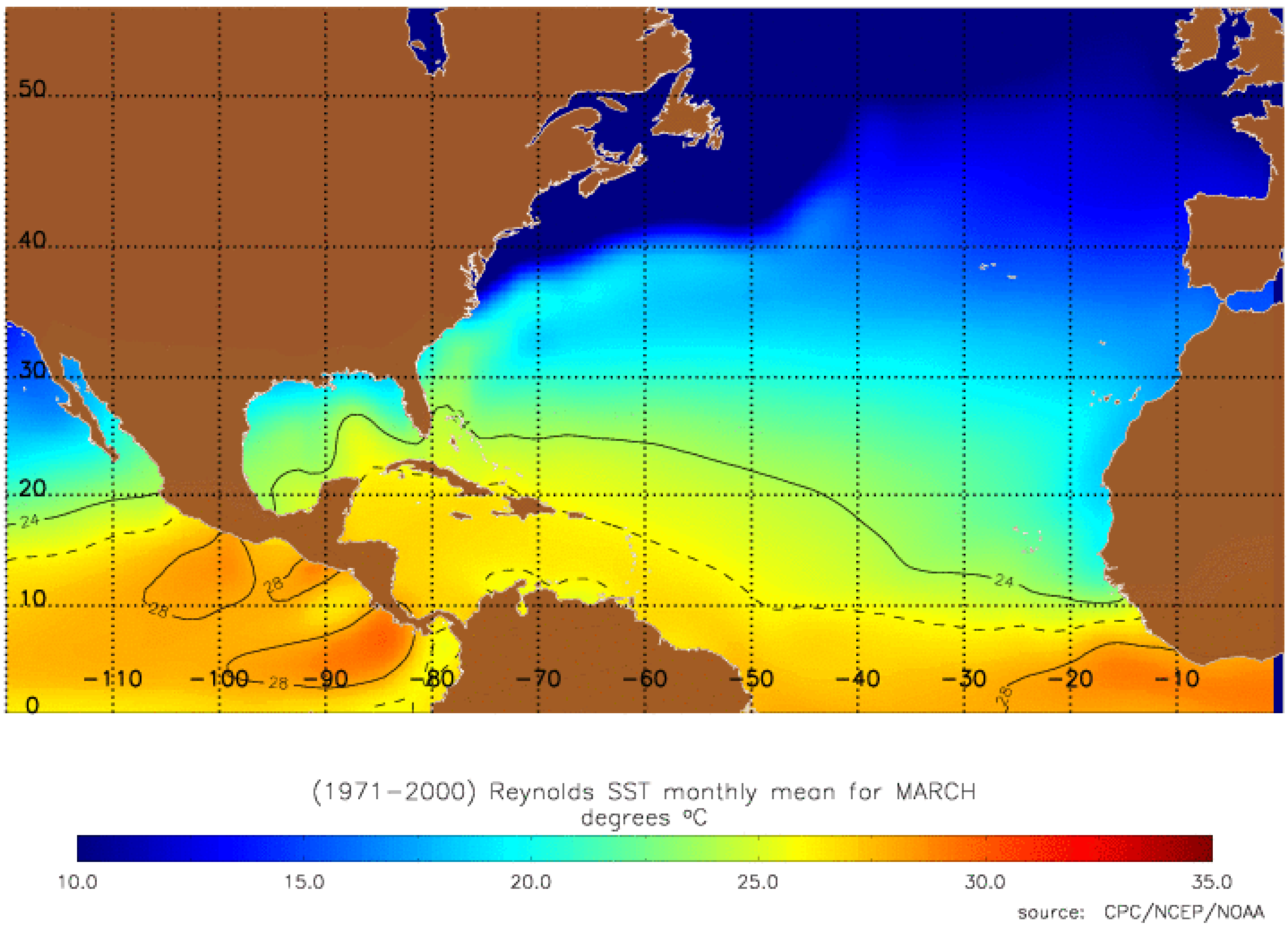
'.. the soft climate of both France and England would be as that of Labrador, severe in the extreme, and ice-bound.'

…Matthew Fontaine Maury, in *The Physical Geography of the Sea* (1855)

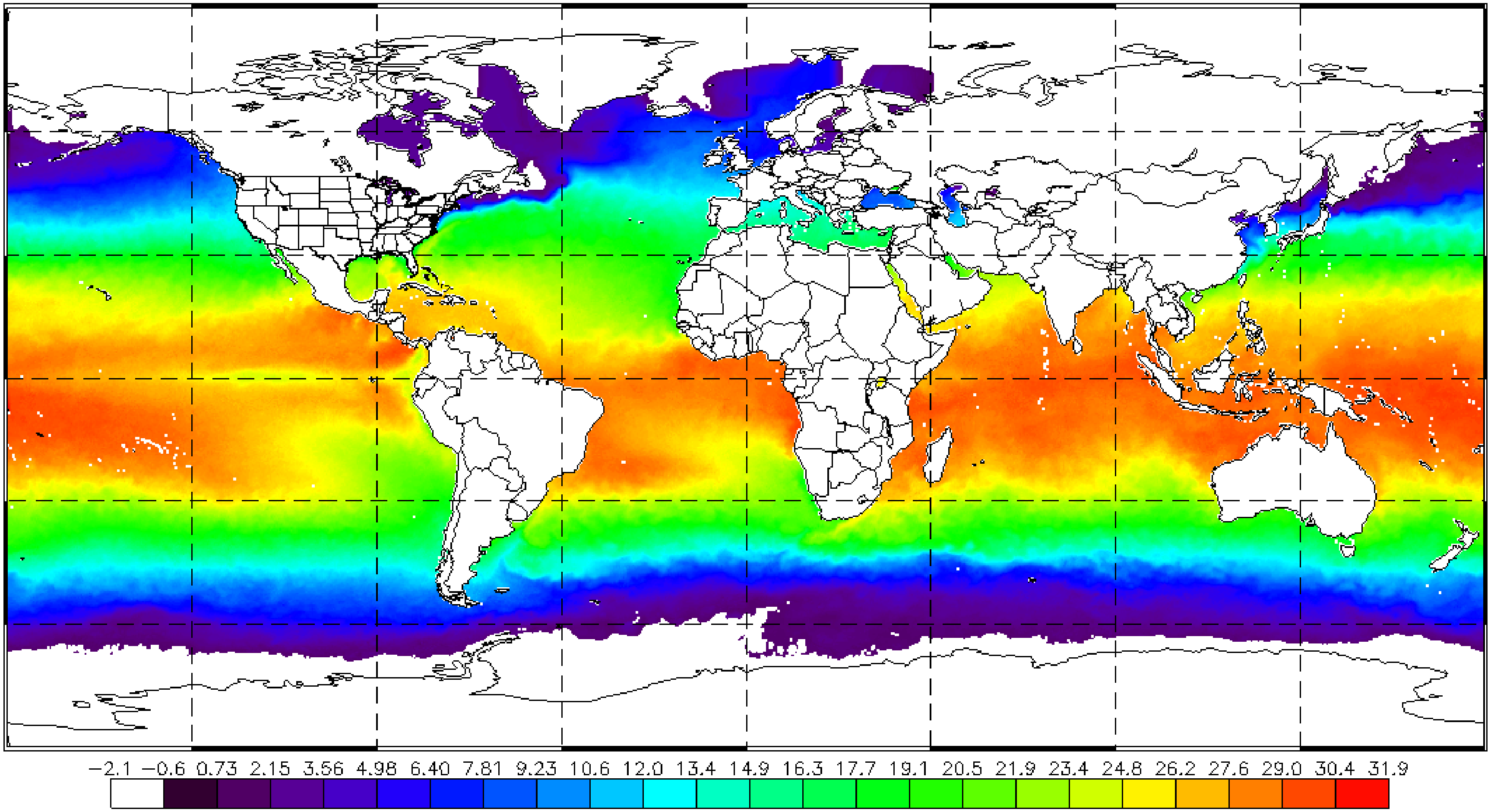
N SW England
4/18/2005

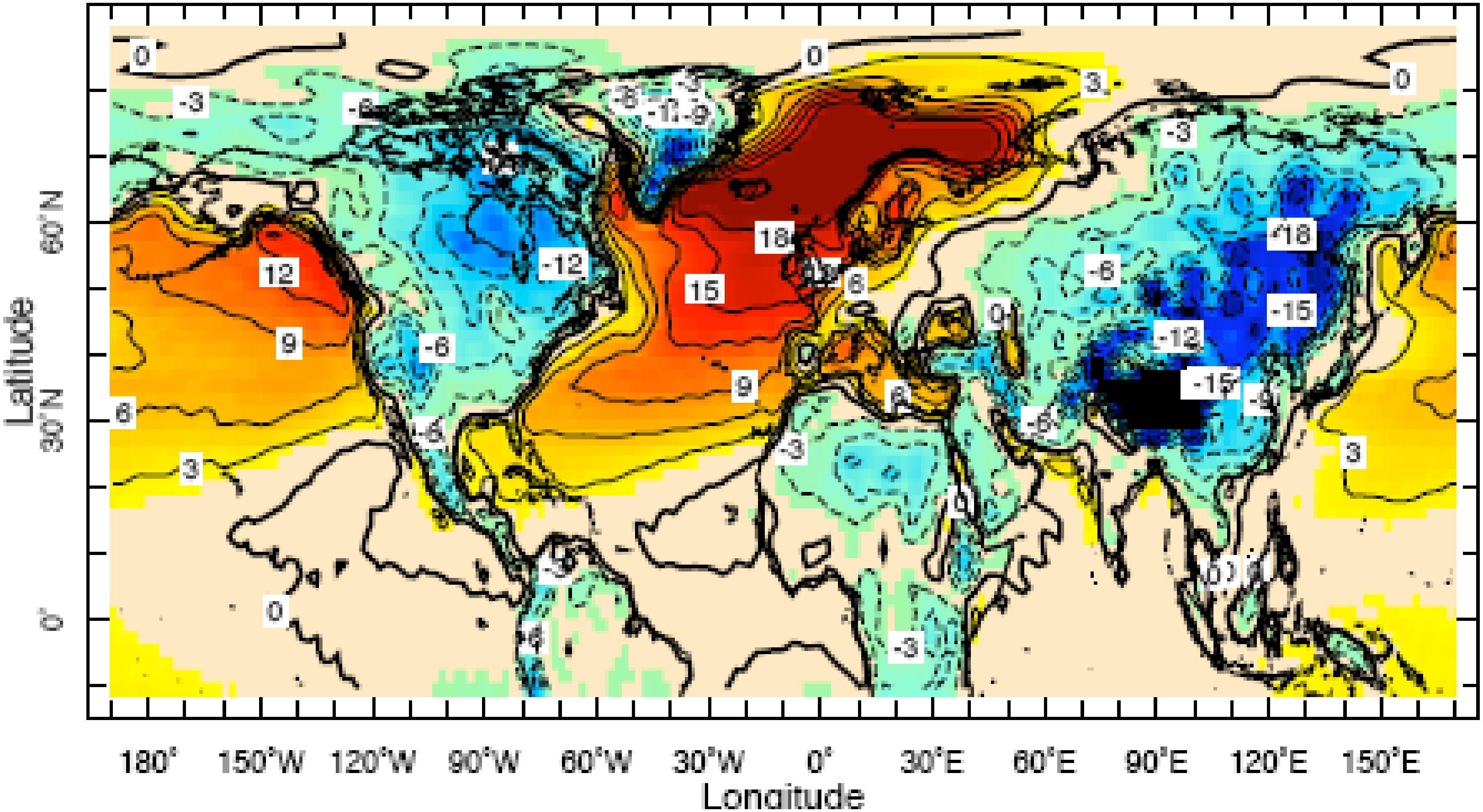
Palm trees are known to grow in the southern part of Ireland (~50°N) due to the mild climate there; is this the influence of the Gulf Stream?

March Sea Surface Temp (°C)

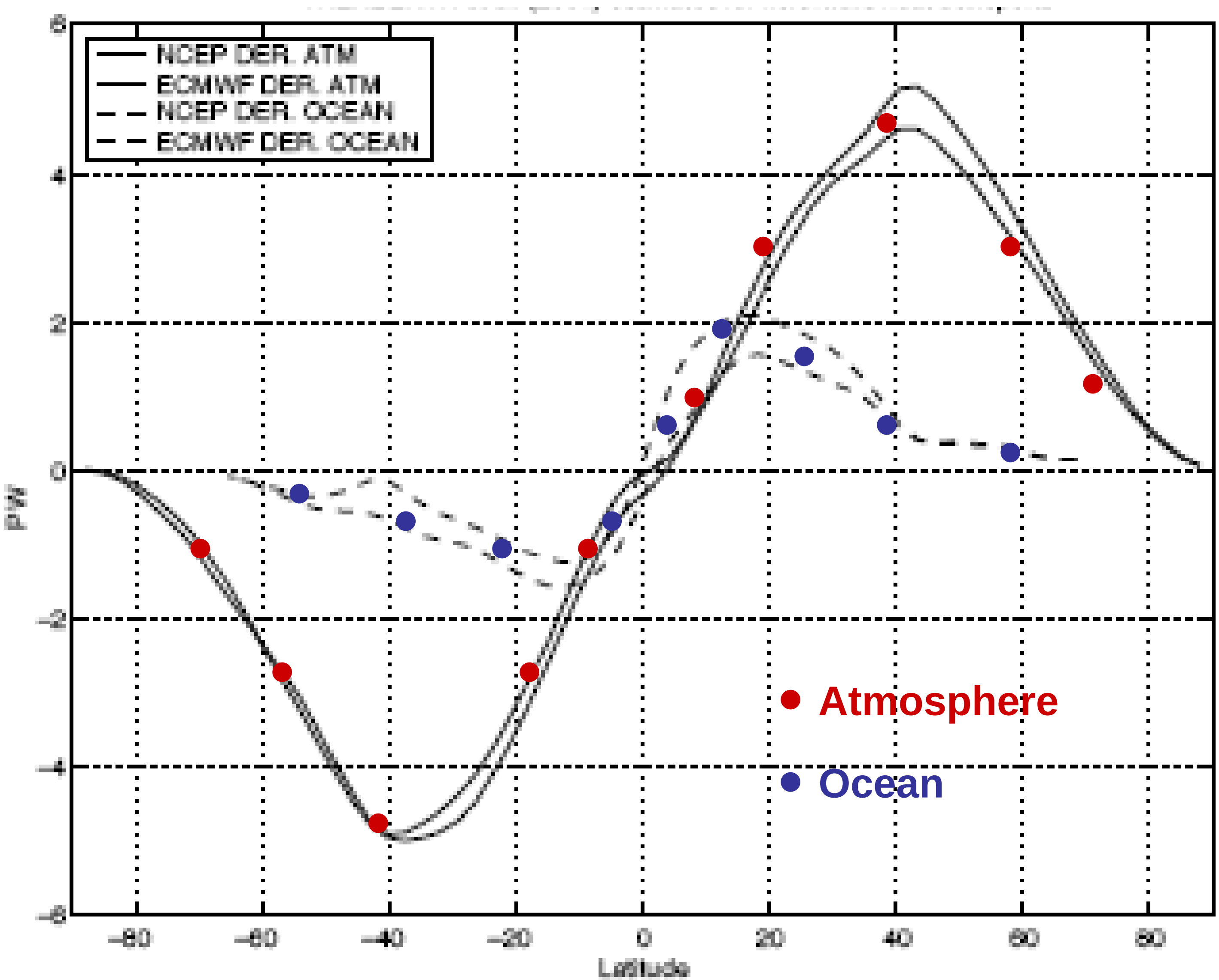


Monthly Mean Satellite-only Nighttime SST for March, 1995





Departure (°C) from the zonal mean January air temperature derived from the NCEP/NCAR reanalysis.



Poleward heat transport by the atmosphere and ocean

Contributions of heat transport and heat release from the ocean to air temperatures over the Northern Hemisphere:

(1) Winter atmospheric heat transport across 35°N: 6 PW, or 54 watts/m^2

(2) Annual mean ocean heat transport across 35°N: 1.3 PW, or 11 watts/m^2

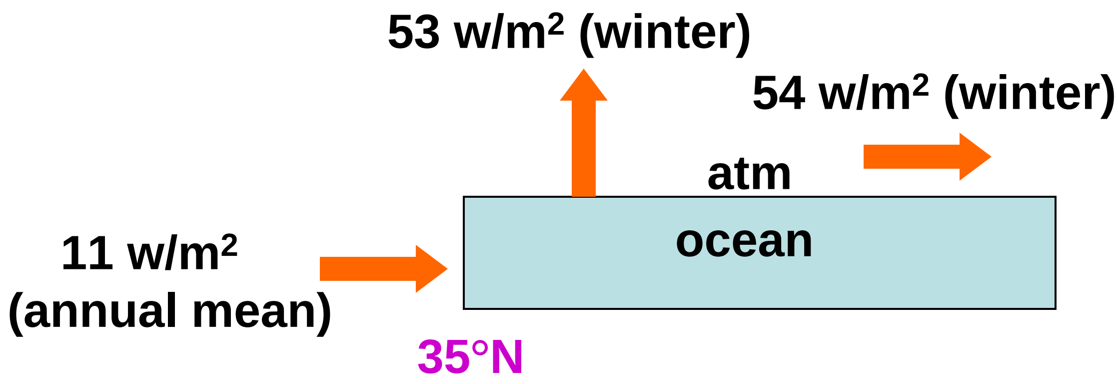
(3) Seasonal ocean heat release north of 35°N: 53 watts/m^2

Assume a sensitivity of 2 watts/m^2 per °C; then warming north of 35°N is

27 °C due to atmospheric heat transport

6 °C due to ocean heat transport

27 °C due to storage



Seager et al., 2002

The total release of sensible, latent, and radiative heat from the ocean to the atmosphere, Dec-Feb.

[note: > 0 implies ocean loses heat]

(a)

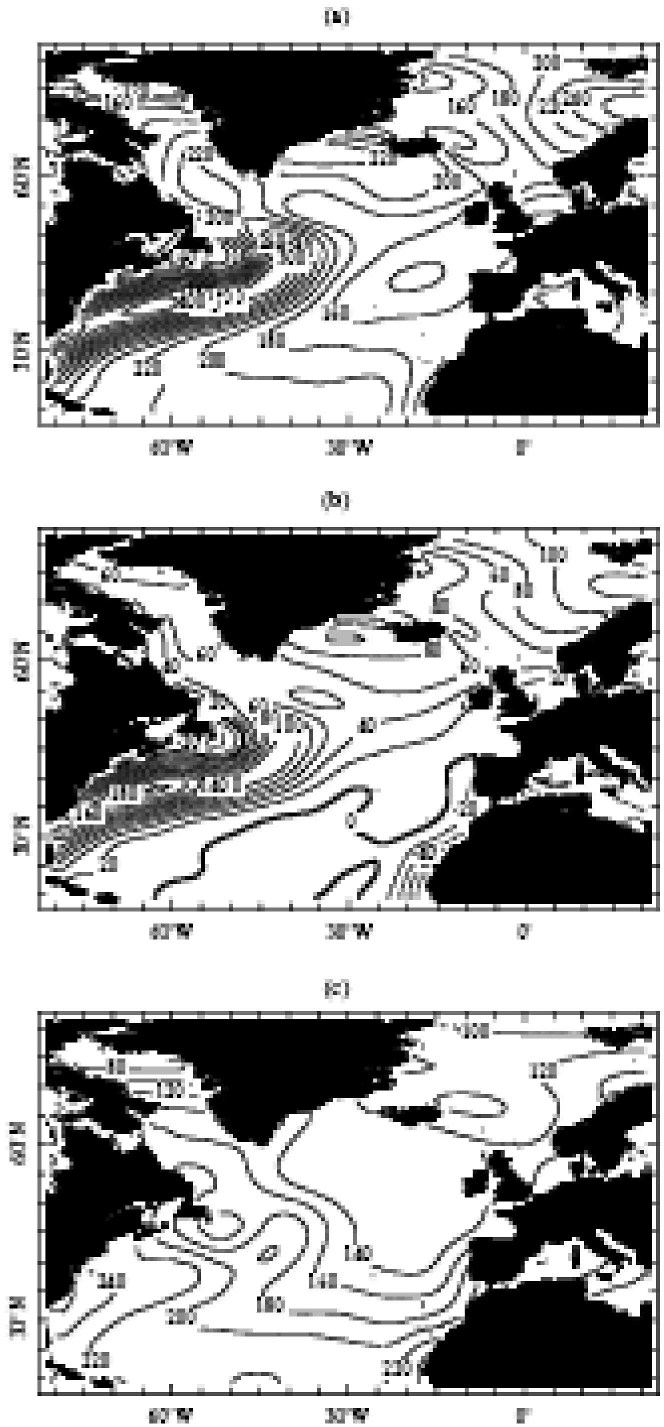
Ocean heat flux convergence

[small!]

(b)

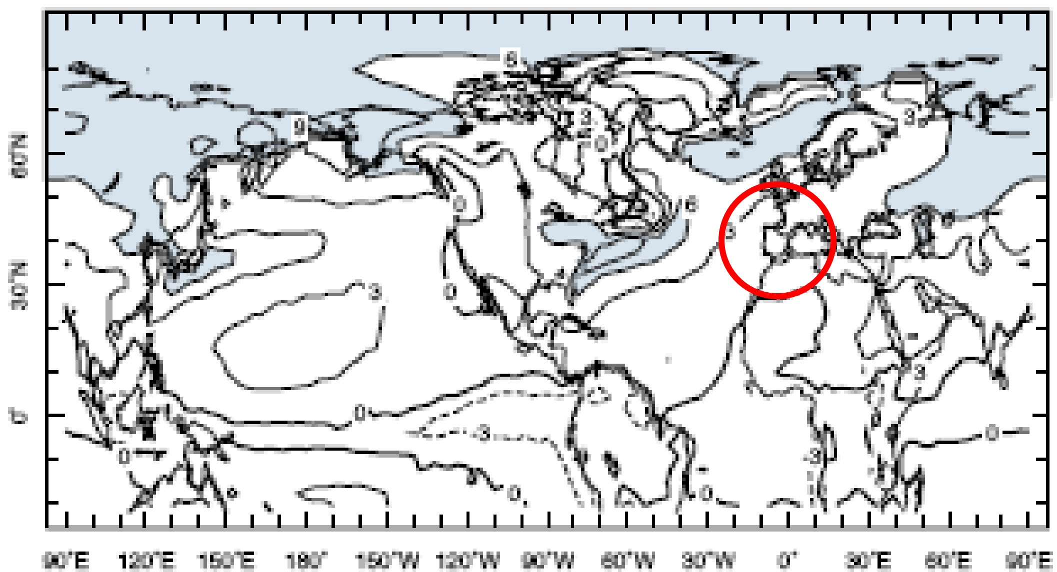
Atmosphere heat flux convergence

(c)

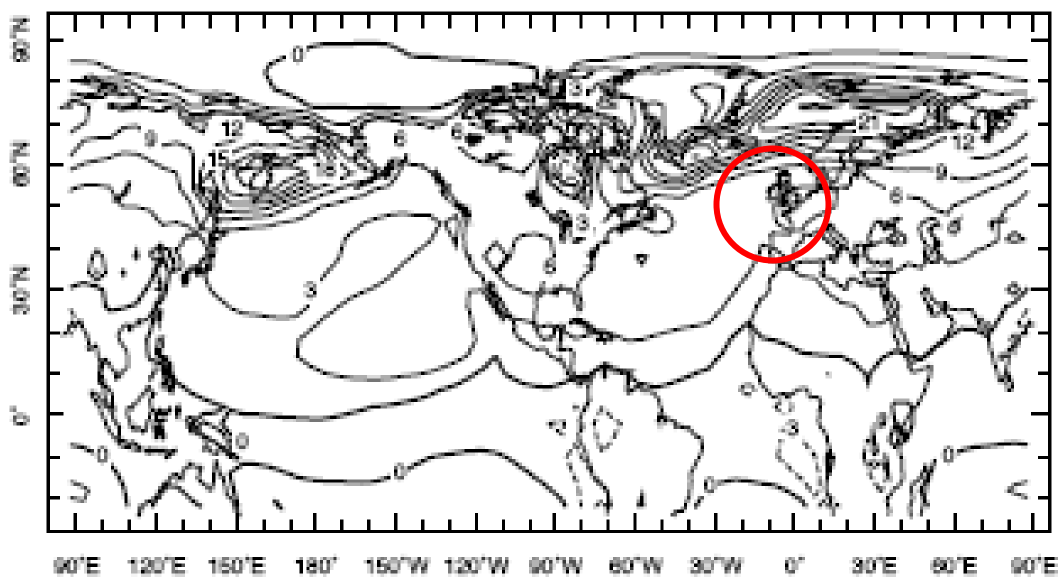


Difference in January surface air temperature (deg C) with OHT minus no OHT

CCM3 model, fixed sea ice



GISS model, interactive sea ice

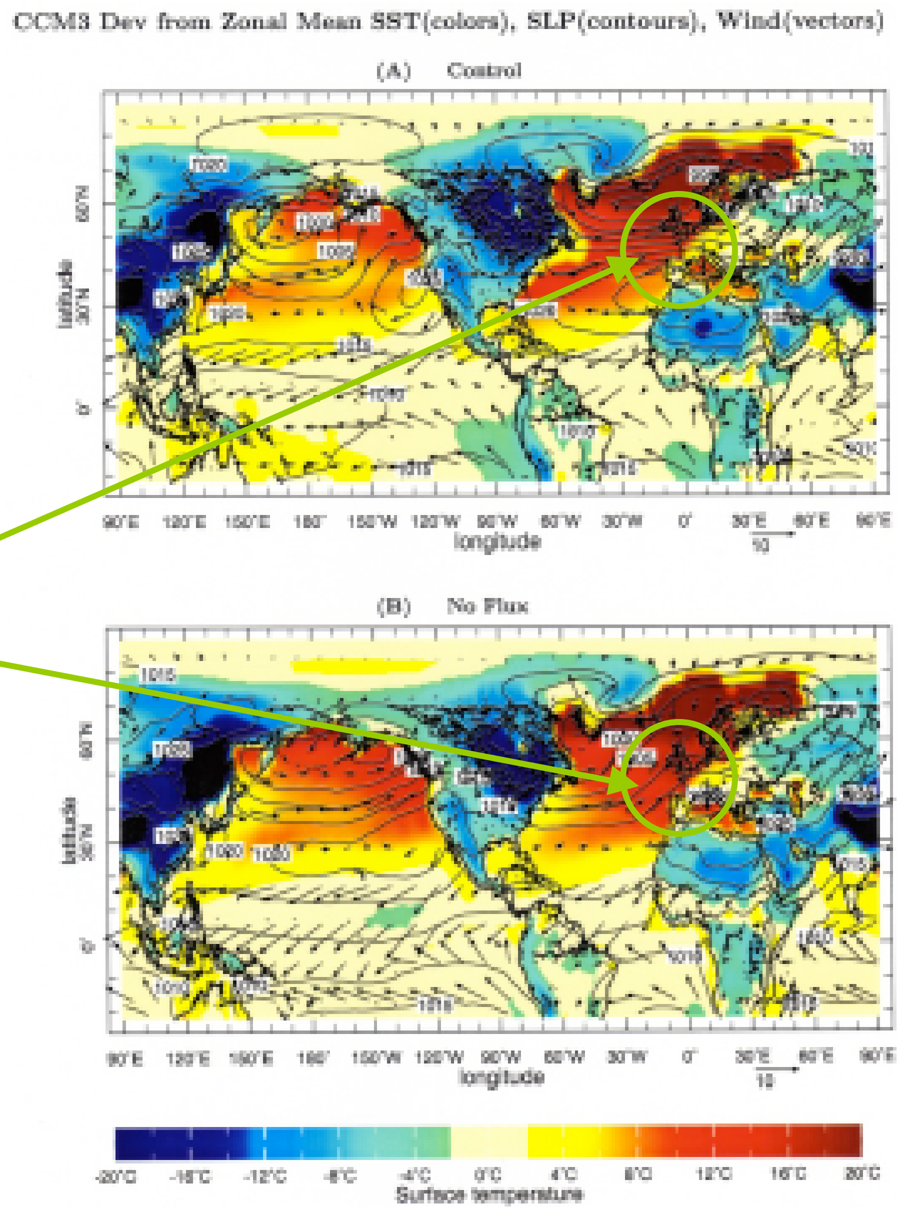


Departure of winter temperature from zonal mean, CCM3 model

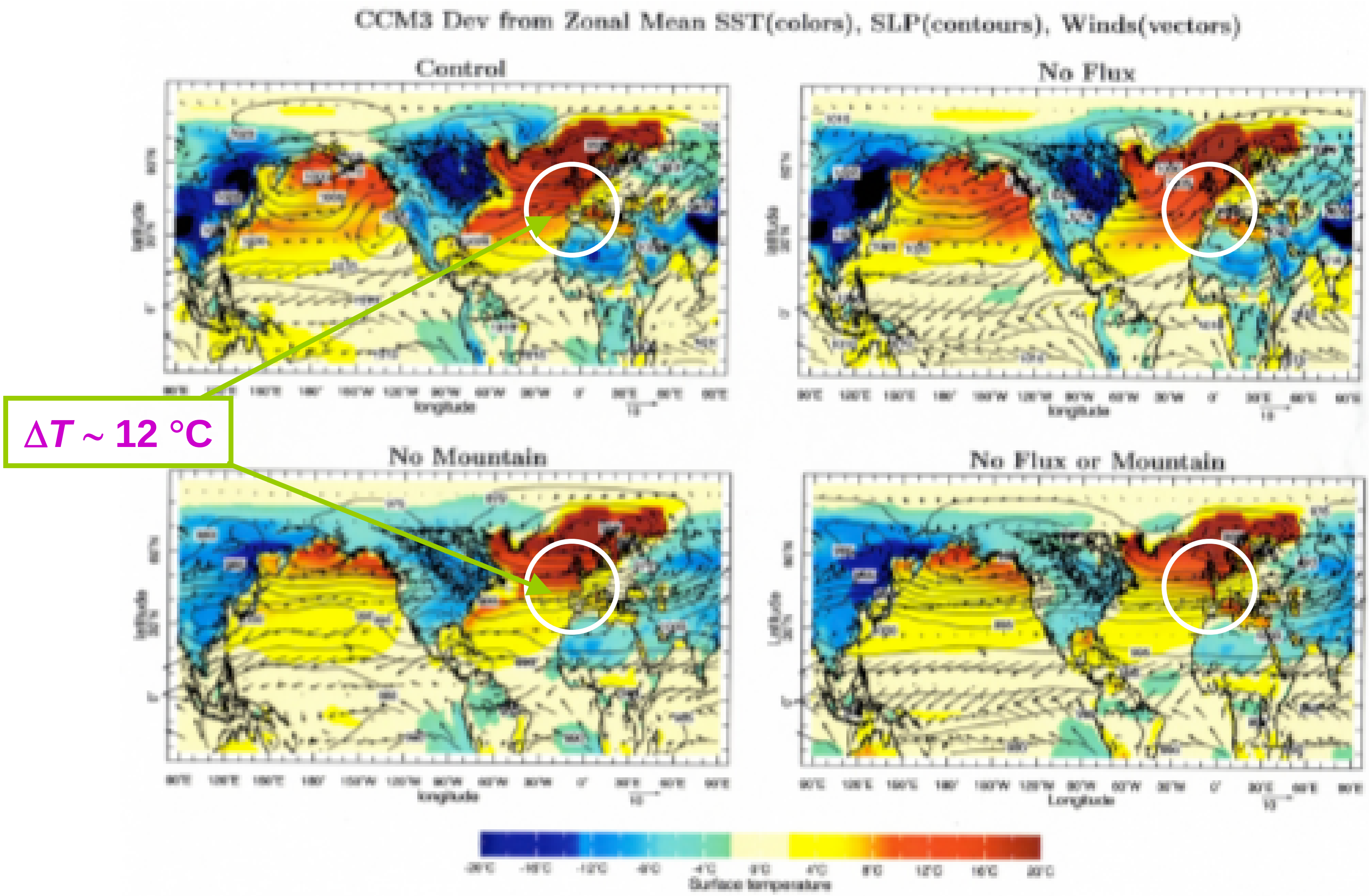
with OHT

ΔT ~ 3°C

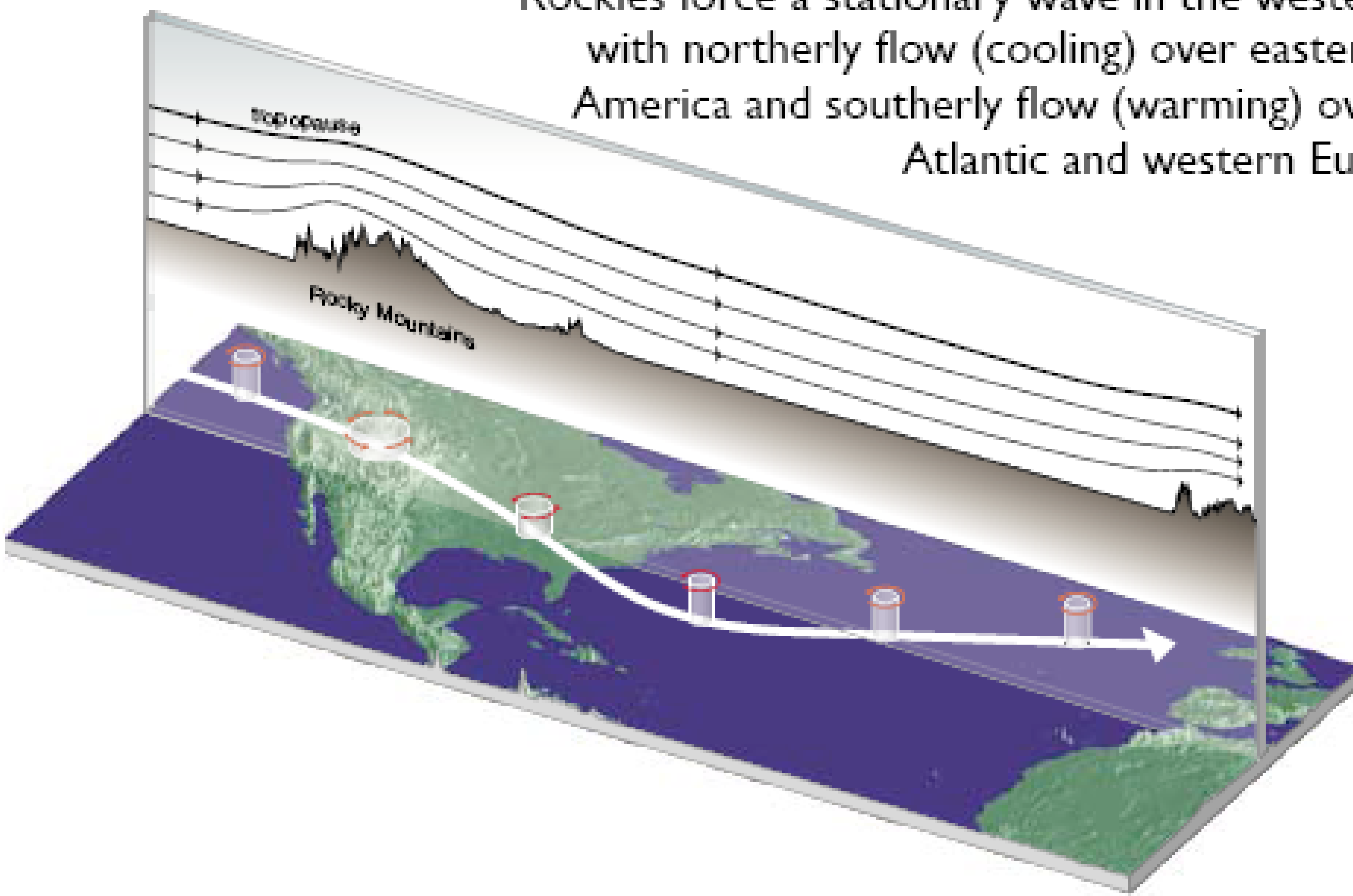
no OHT

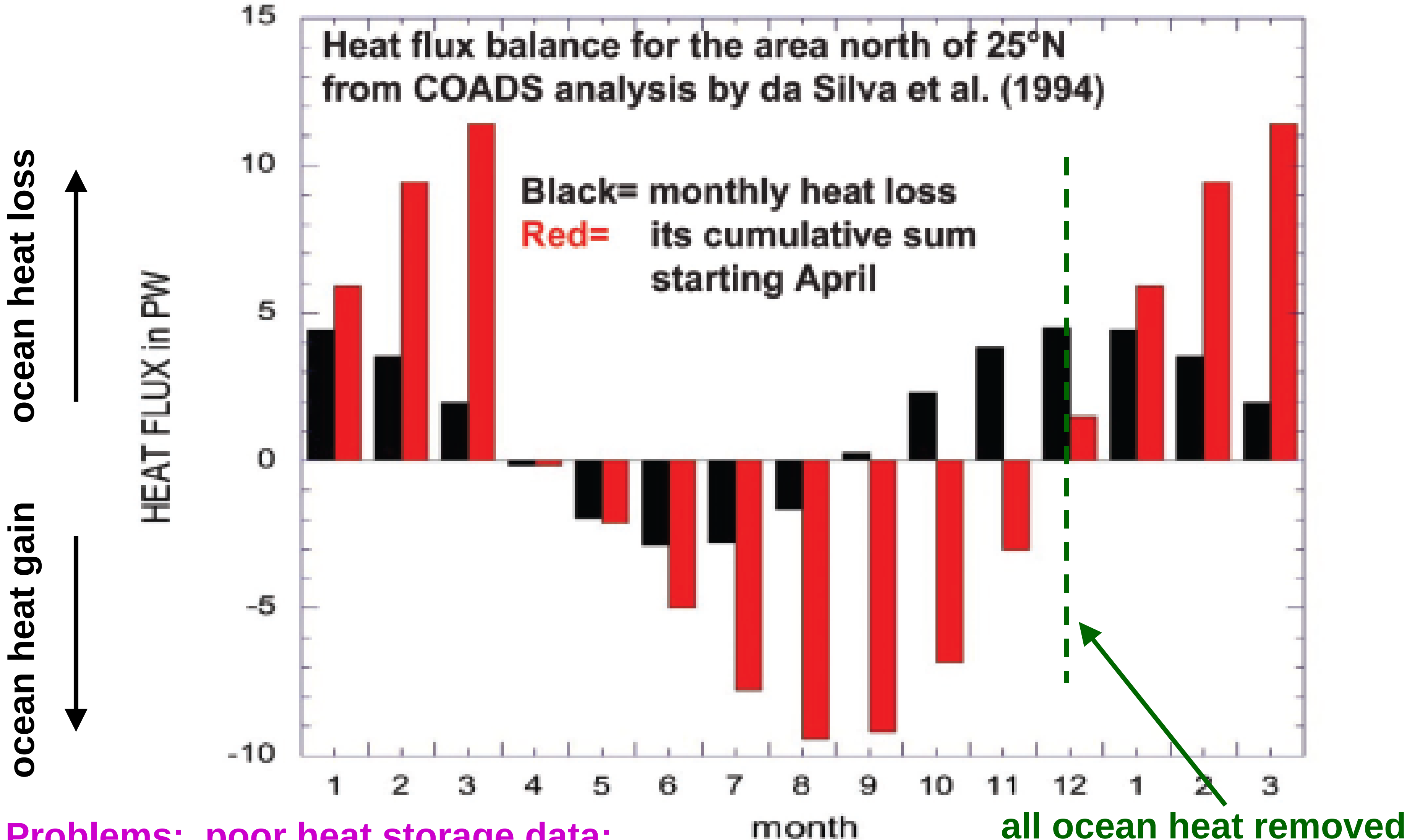


T change due to mountains is caused by deepening of trough over western N. Atlantic and eastern seaboard



Because of need to conserve angular momentum, Rockies force a stationary wave in the westerlies with northerly flow (cooling) over eastern N. America and southerly flow (warming) over E. Atlantic and western Europe

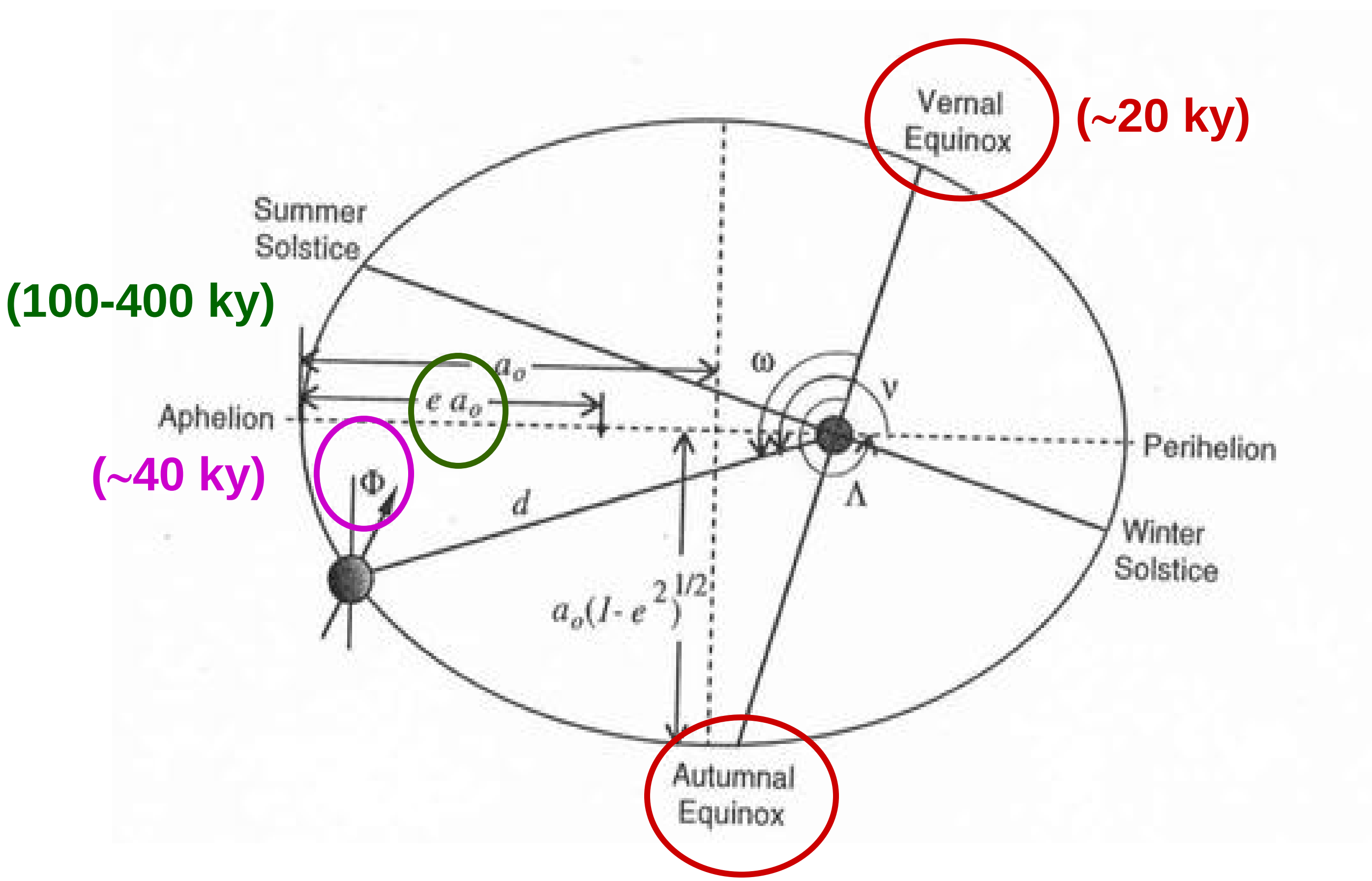




Problems: poor heat storage data; effects of fresh water; etc.

Rhines and Hakkinen, 2003

Climate variations: quasi-regular…



A schematic drawing showing the Milankovich orbital parameters.

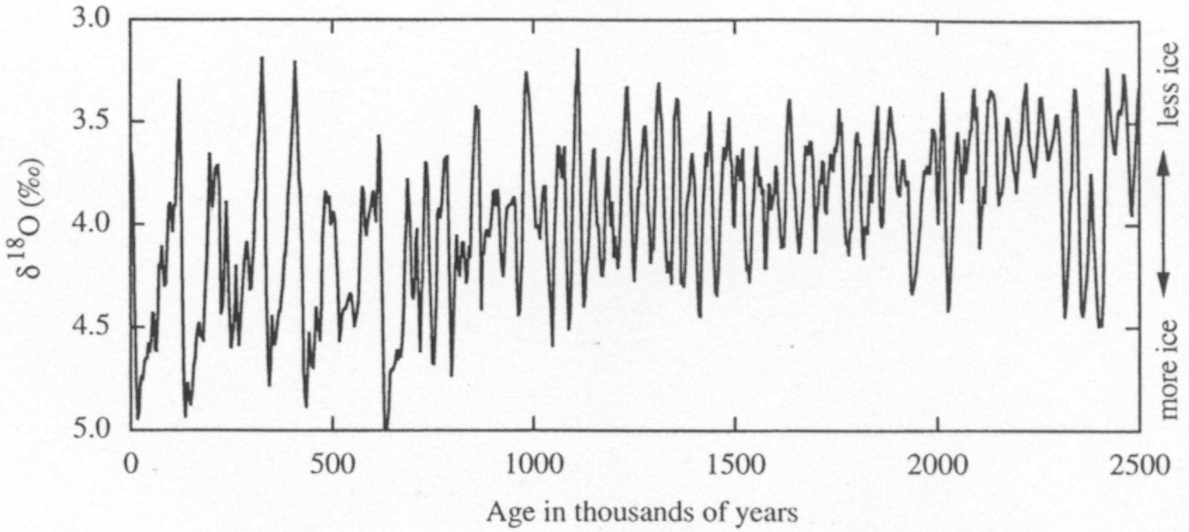
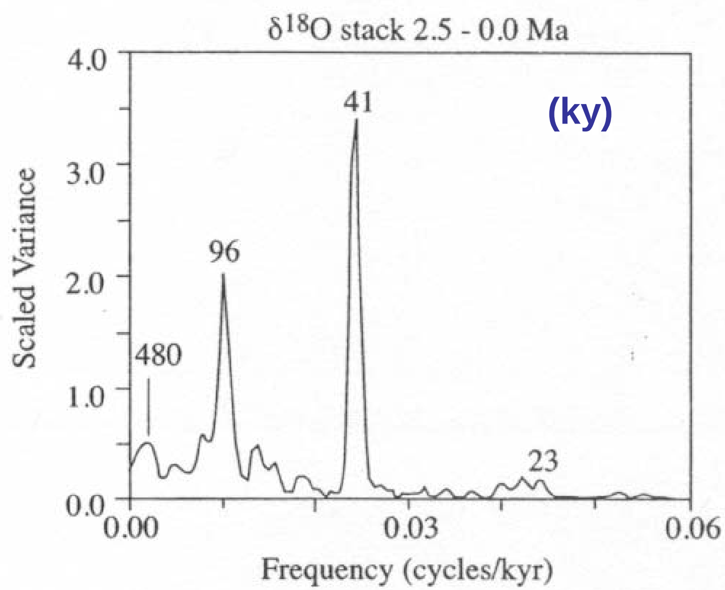


Fig. 8.6 History of $\delta^{18}O$ over the last 2.5 million years derived from several ice cores. [Plot made from data provided by M. E. Raymo and previously published in Raymo *et al*. (1990). Reprinted with permission from Elsevier Scientific Publishers.]

Fig. 8.7



$$\delta^{18}O = \frac{\left(\frac{^{18}O}{^{16}O}\right) - \left(\frac{^{18}O}{^{16}O}\right)_{standard}}{\left(\frac{^{18}O}{^{16}O}\right)_{standard}} \times 1000$$

[from Hartmann]

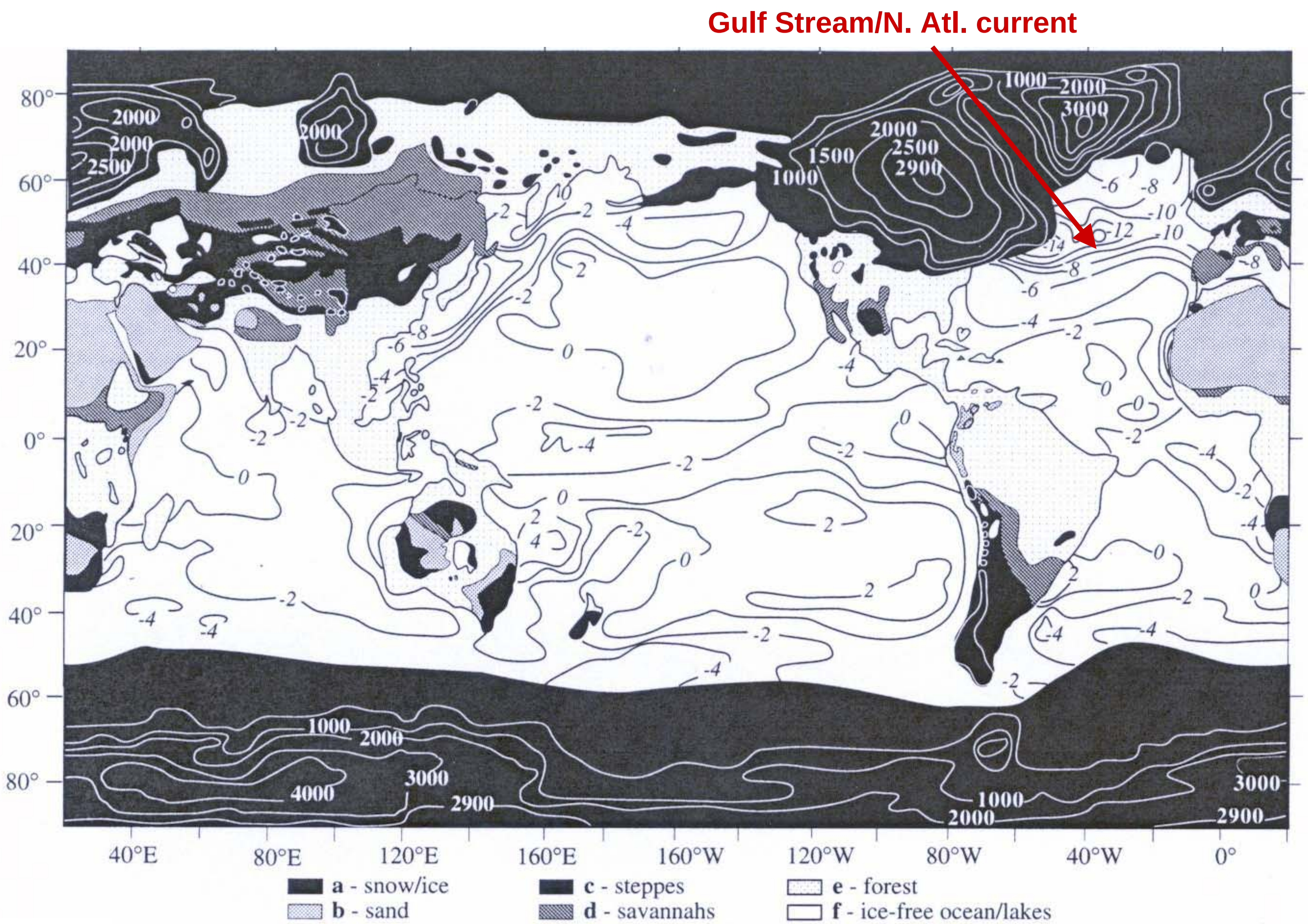
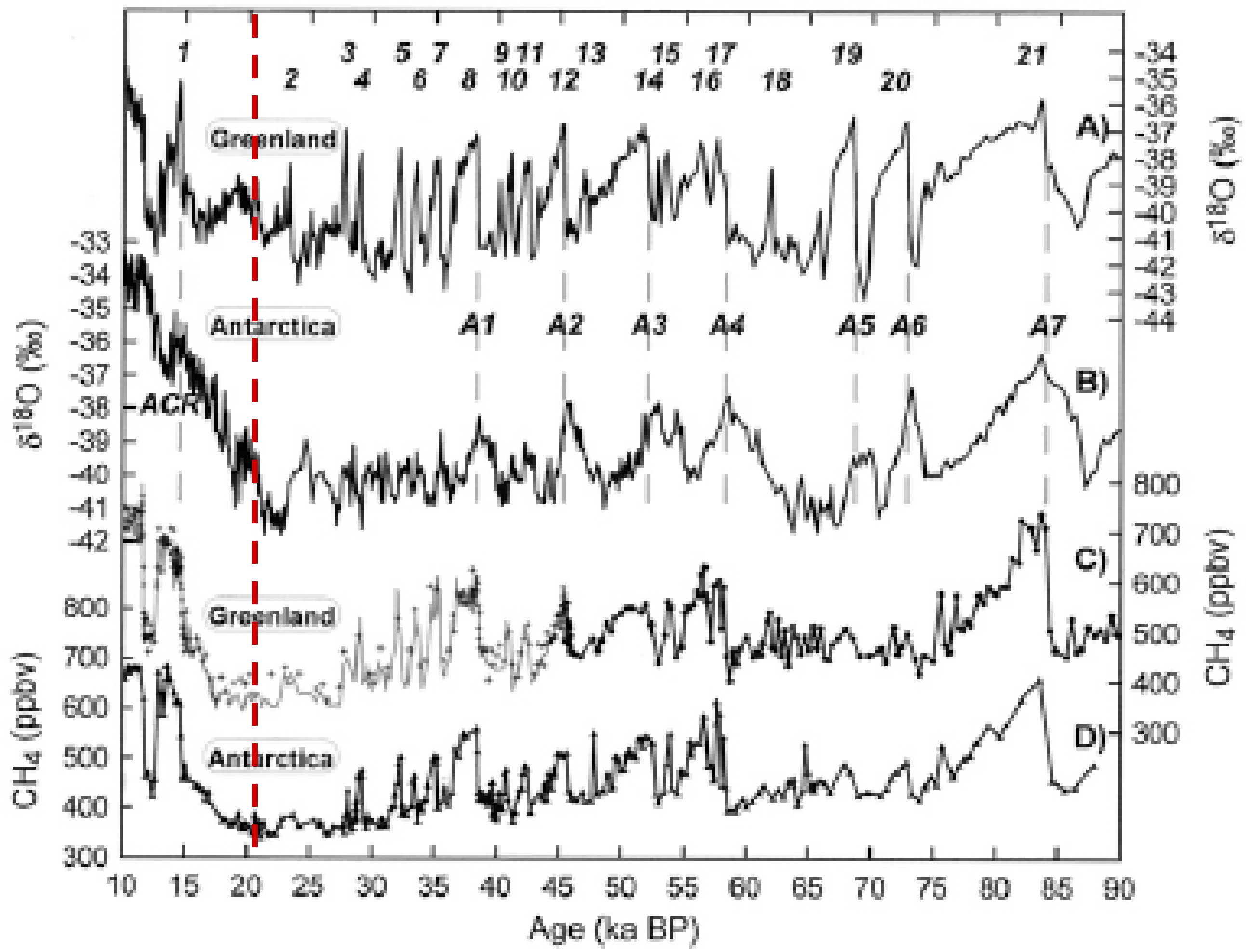


Fig. 8.8 Earth's surface conditions during August 18,000 years ago. Contours in ocean areas indicate departures of SST from present values in °C. Contours in snow and ice regions indicate depth of ice in meters. [From CLIMAP Project Members (1976), © by the AAAS.]

[from Hartmann]

90,000 years of Greenland and Antarctic climate



- Rapid warmings (then cooling, then sudden cooling) in Greenland

- No such things in Antarctica

- bimodality in Greenland (Wunsch 2001)

Blunier and Brook (2001)

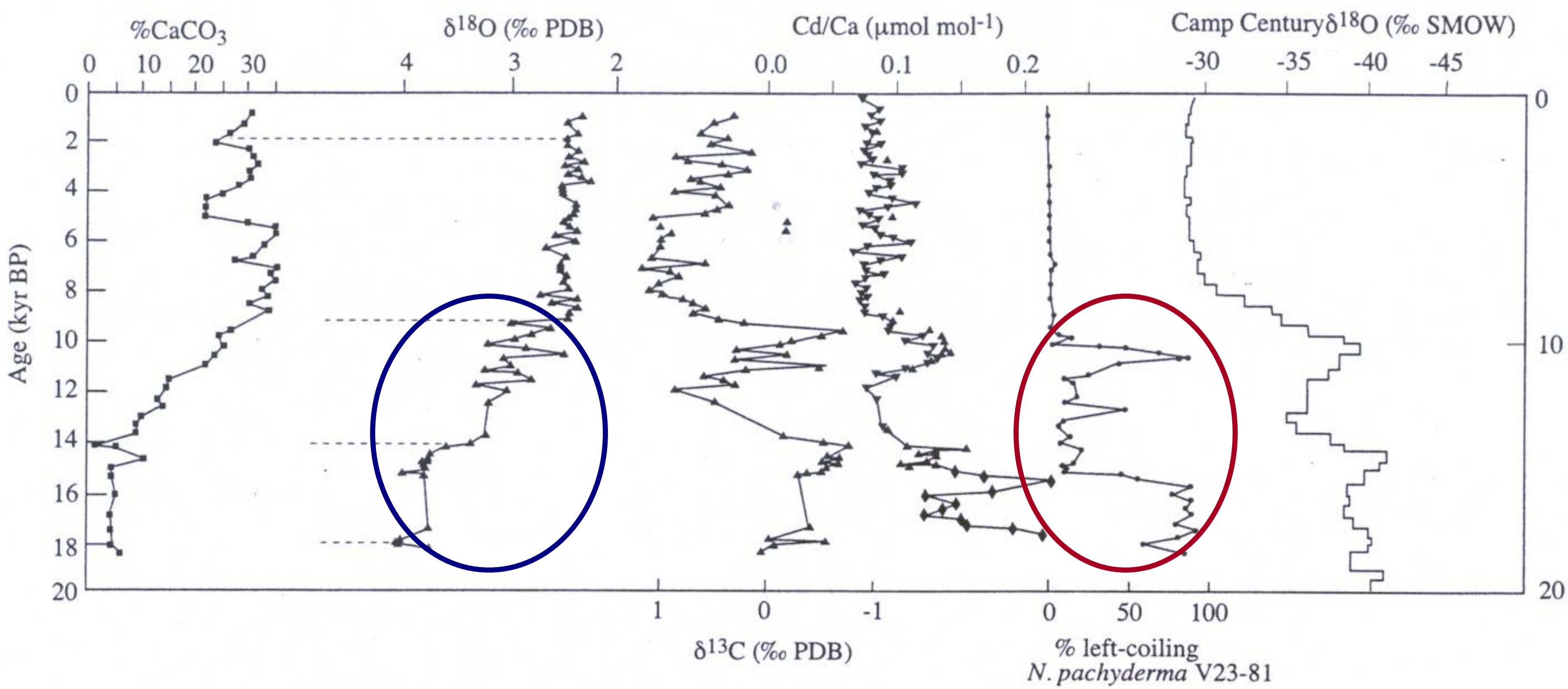


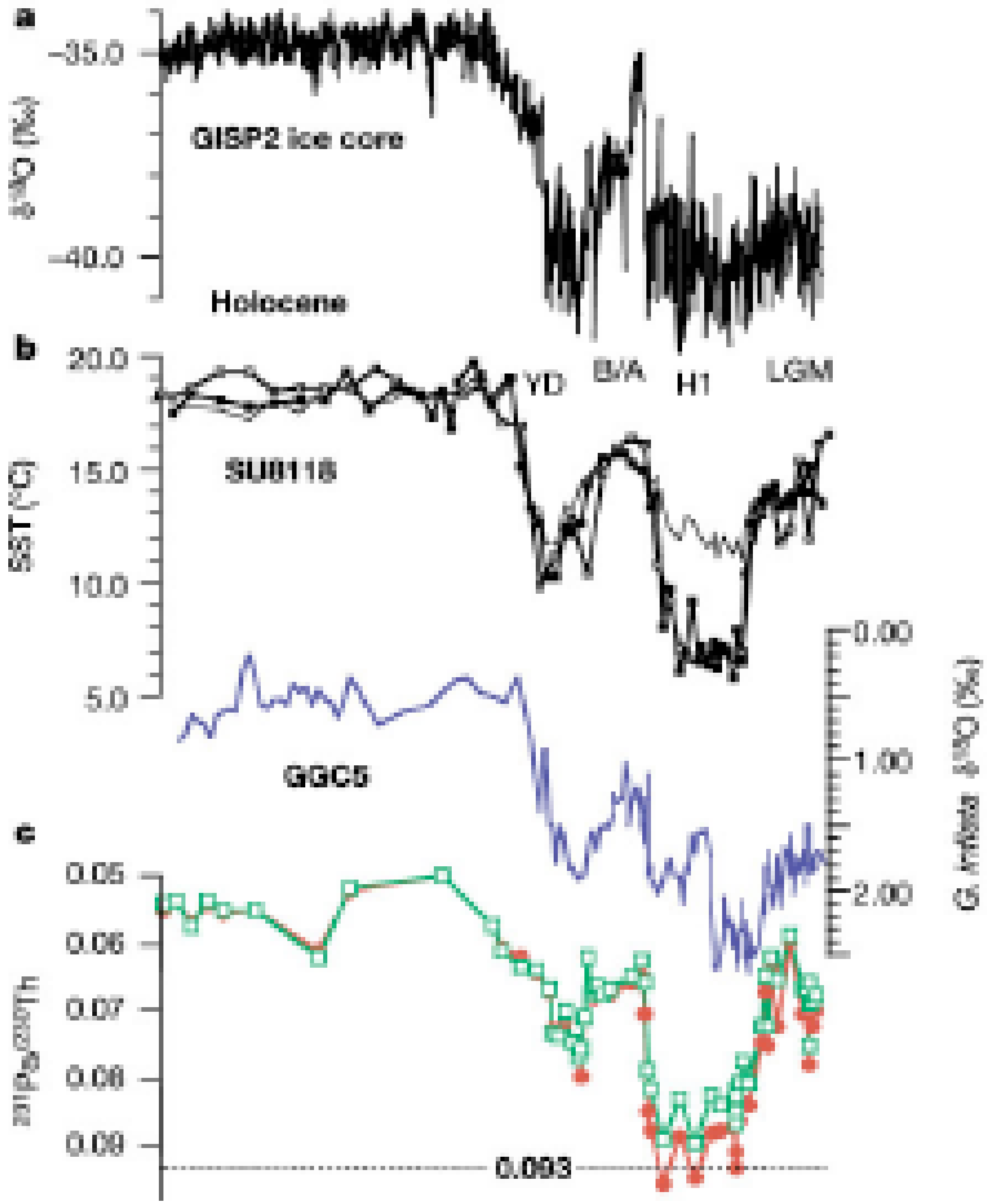
Fig. 8.11 Time histories taken from an ocean sediment core raised from 4450-m depth at 34°N, 58°W. Shown are the calcium carbonate content, ^{18}O isotope abundance, ^{13}C isotope abundance, and the cadmium/calcium ratio. Also shown are the *N. pachyderma* abundance from a north Atlantic sediment core and ^{18}O isotope fraction from a Greenland ice core (*N. pachyderma* are planktonic foraminifera that prefer cold water). Note the brief cool episode about 11,000 years ago during a period when the global ice volume was declining. [From Boyle and Keigwin (1987), © Macmillan Magazines Limited.]

[from Hartmann]

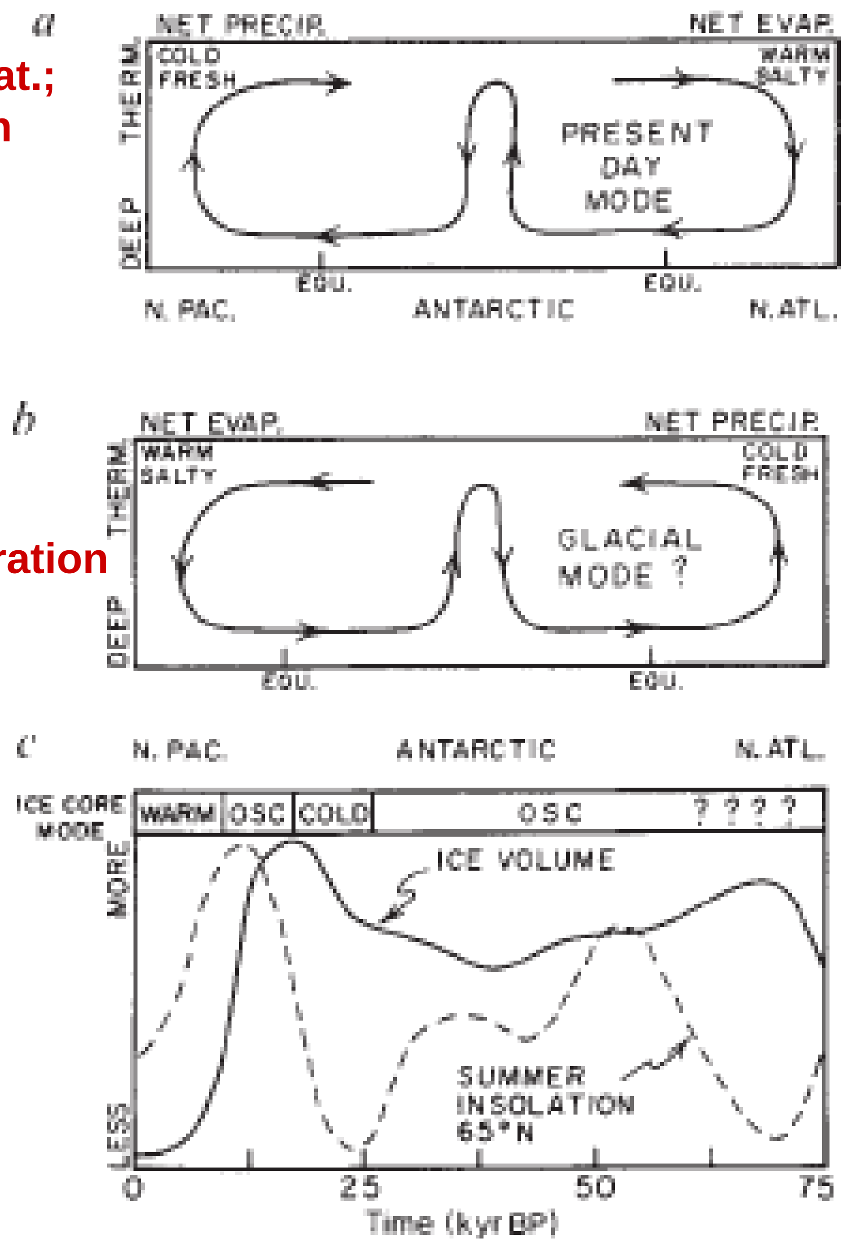
Greenland

Subpolar N Atlantic SST

overturning circulation proxy, Bermuda rise



cool; closed at high lat.;
low net evaporation



warm; open to high lat.;
high net evaporation
NADW

warm; high net evaporation
NPDW??

cold; ice covered;
low net evaporation

Broecker et al., 1985