Integrating multiple sites

tuning – events

Putting sites into context

Estimate age of tephra based on multiple sites

Find age of hemlock decline

Spatiotemporal pattern of env/climate shifts

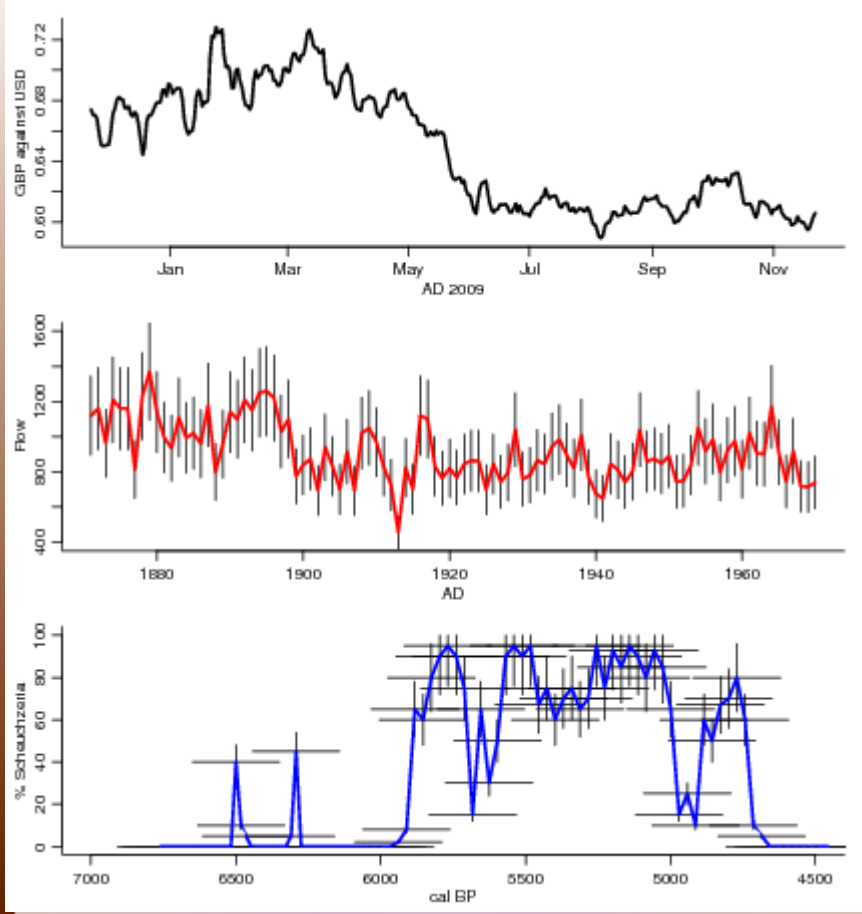
Compare with key sites (NGRIP, Hulu, …)

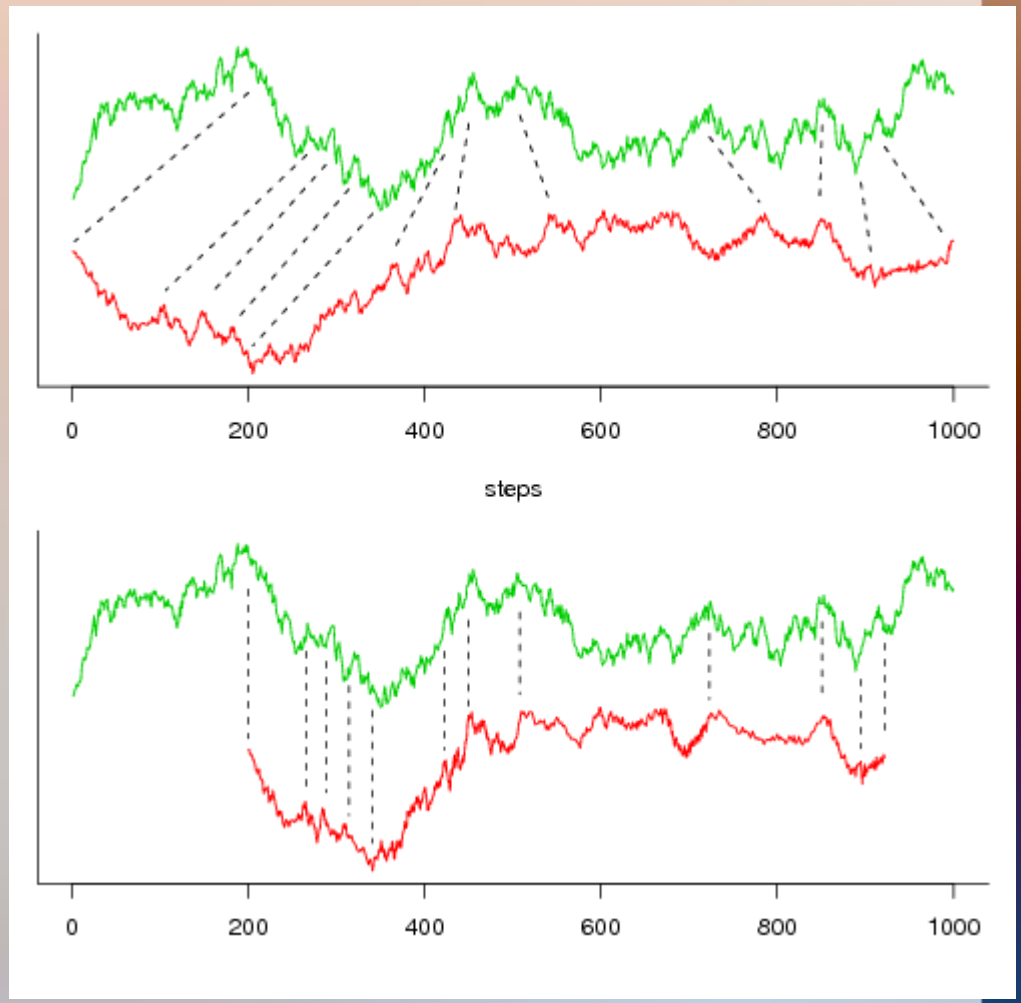
Alternative names:

- Place on same time-scale, correlate, synchronize

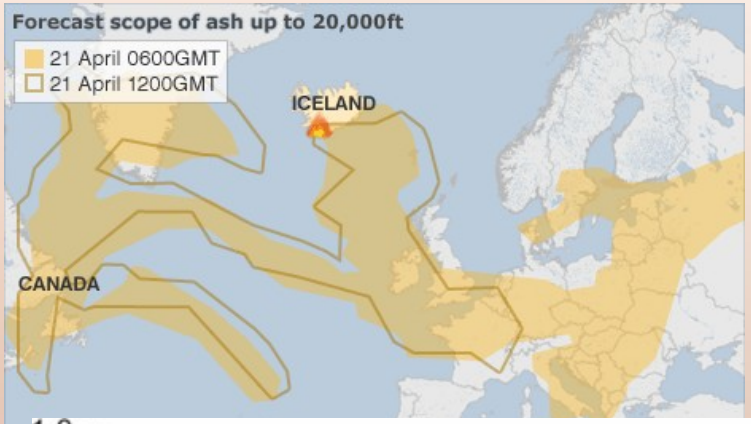
Tuning

- Major (climate) events must have been synchronous
  - e.g. tephra, sediment layers separated by valley/ocean
- Use events to tune/tie between proxy sites
- Tie-points provide age-markers → chronology

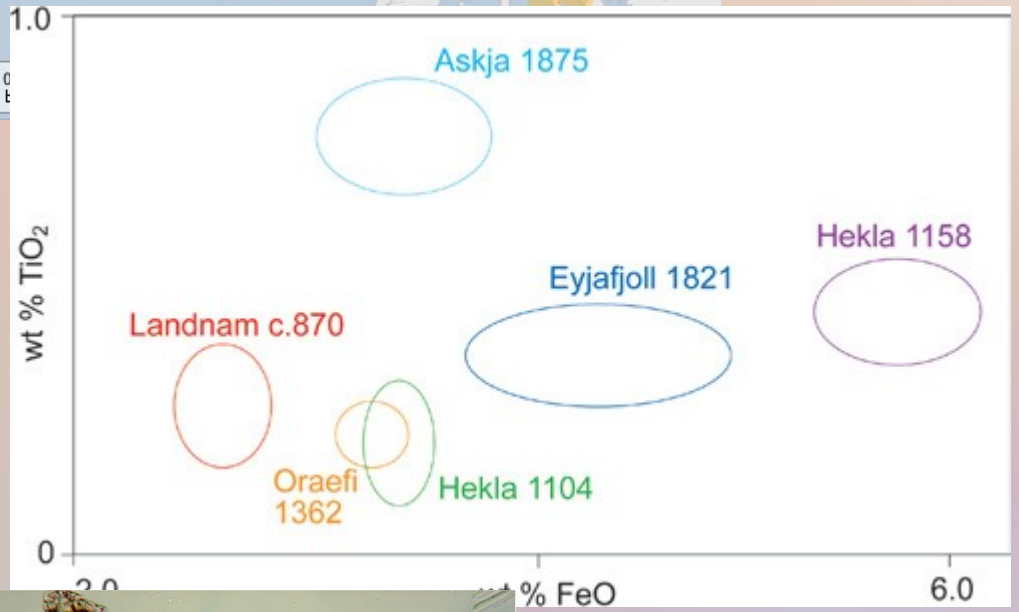


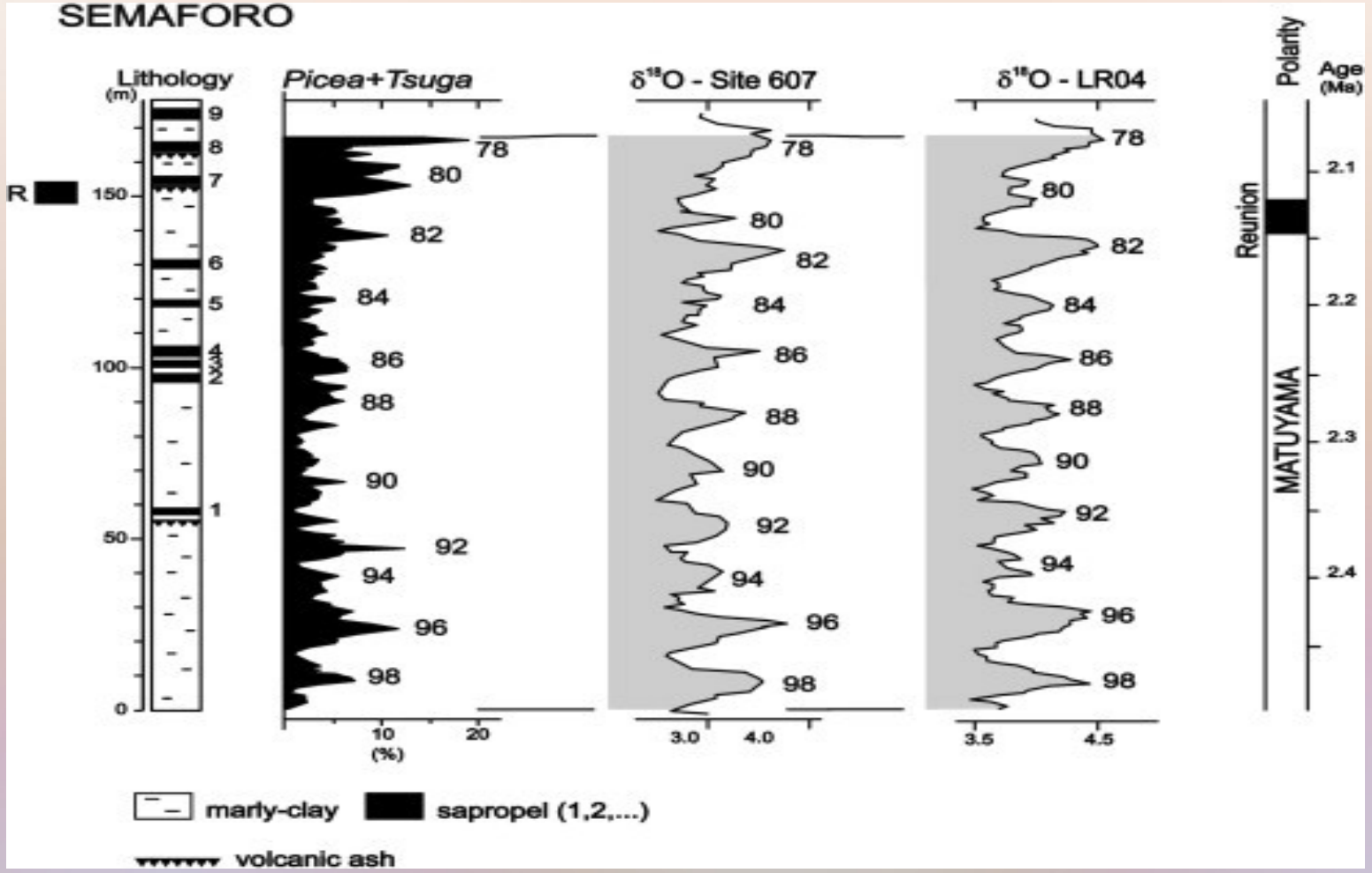


Blaauw, “almost accepted” (Quat. Sci. Rev.)

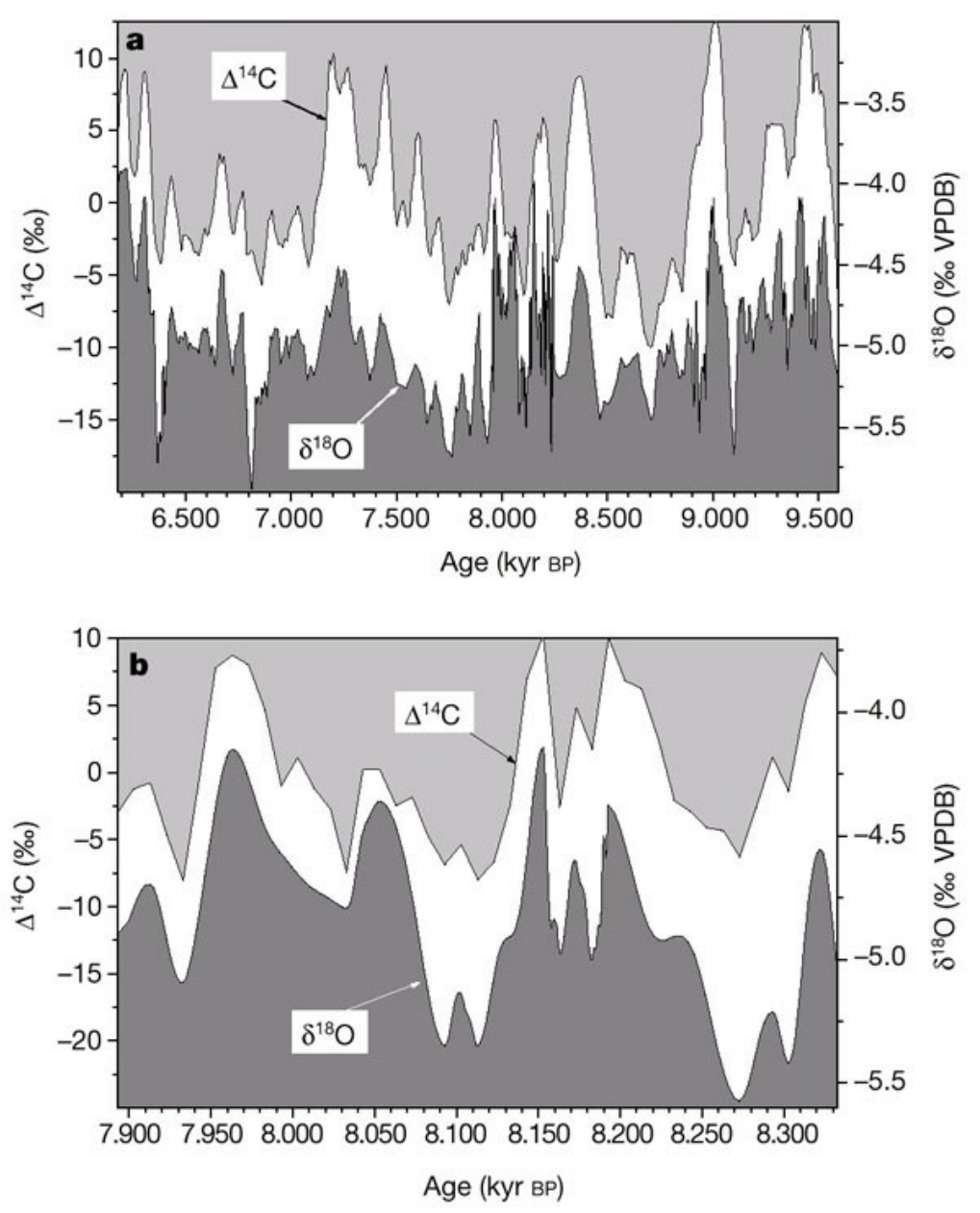

Forecast scope of ash up to 20,000ft
21 April 0600GMT
21 April 1200GMT
ICELAND
CANADA


6
5
4

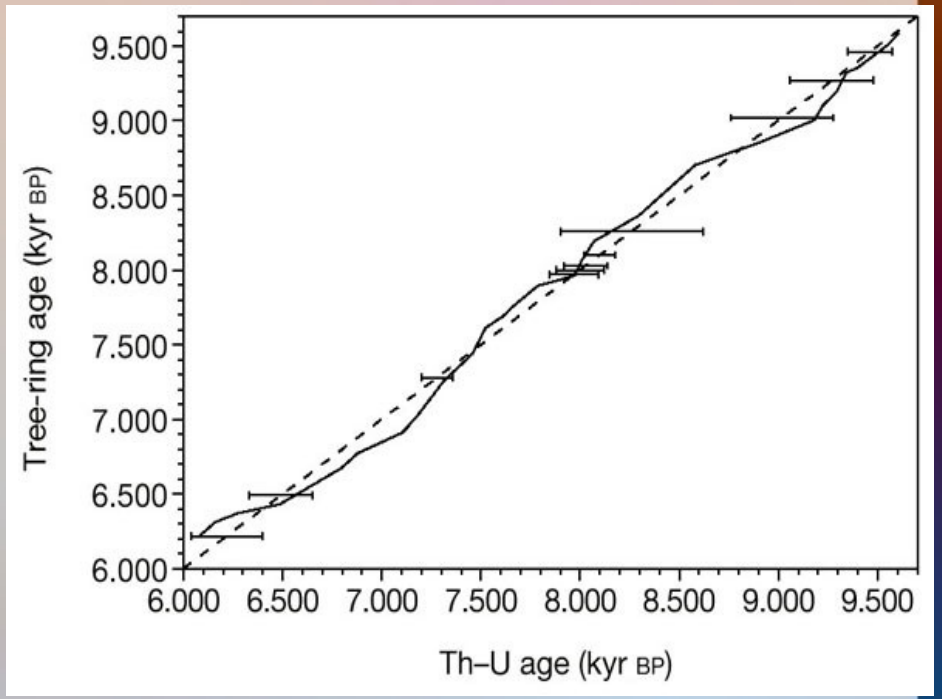

1.0
0
wt % TiO2
Askja 1875
Hekla 1158
Eyjafjoll 1821
Landnam c.870
Oraefi 1362
Hekla 1104
% FeO
6.0



Fusco, 2010. Picea+Tsuga pollen record as a mirror of oxygen isotope signal? *Quaternary International*

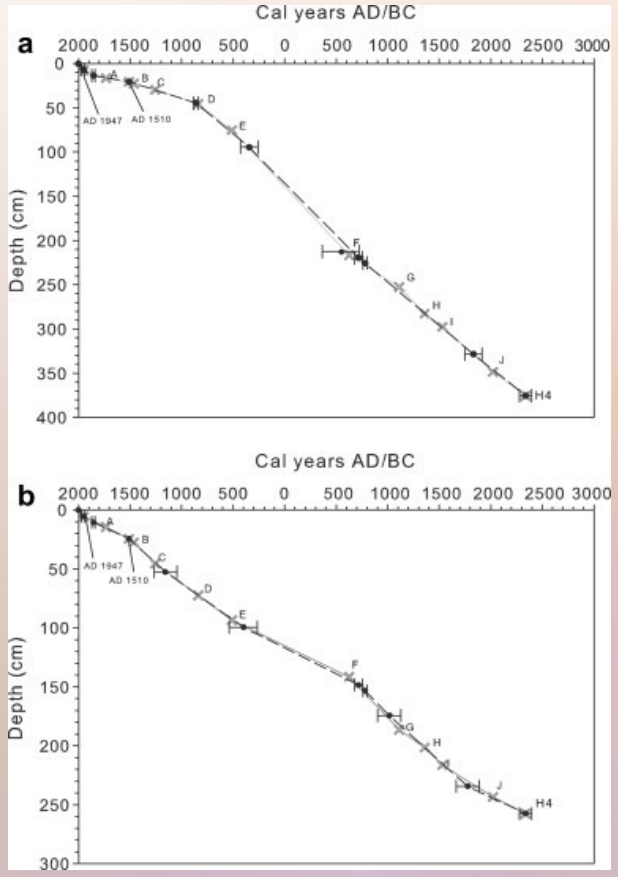


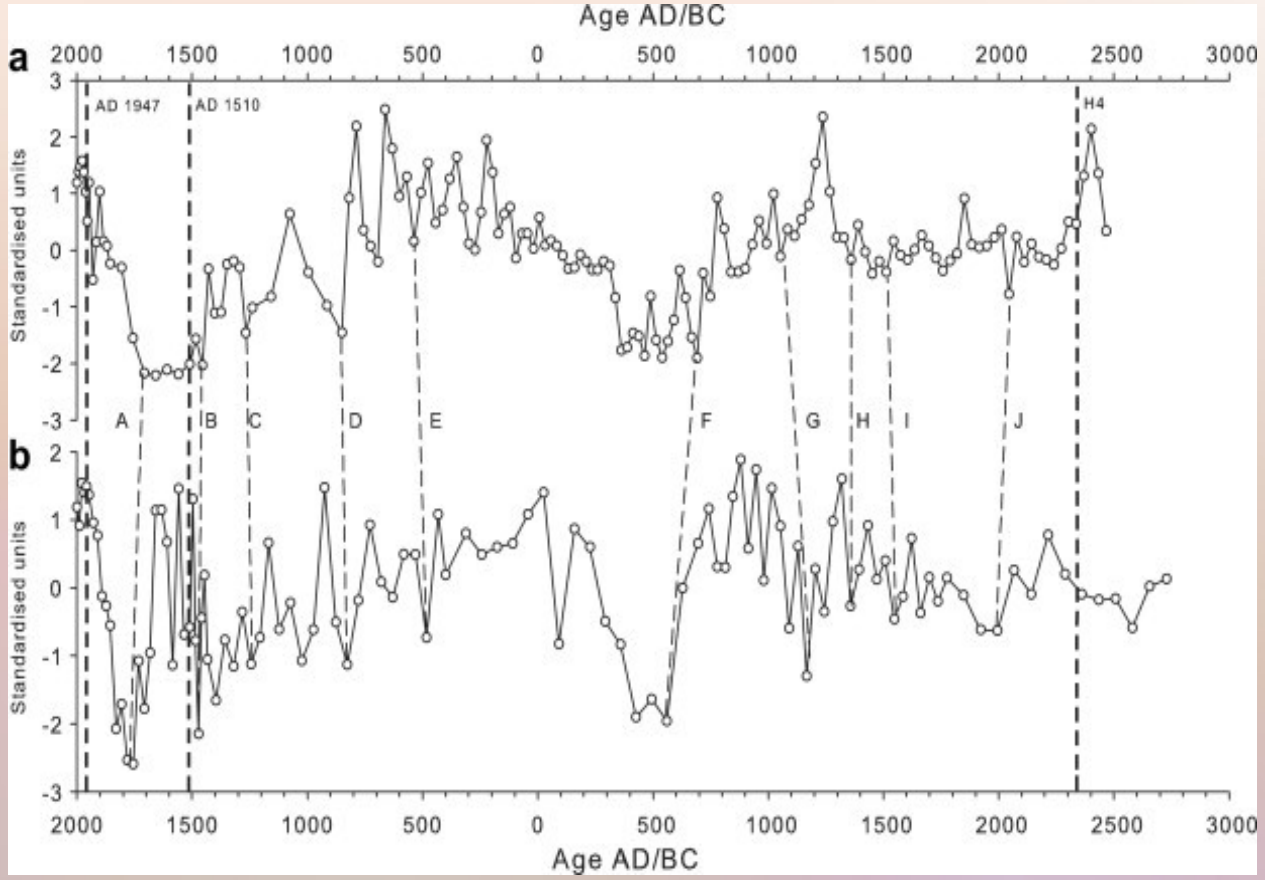
U/Th dated



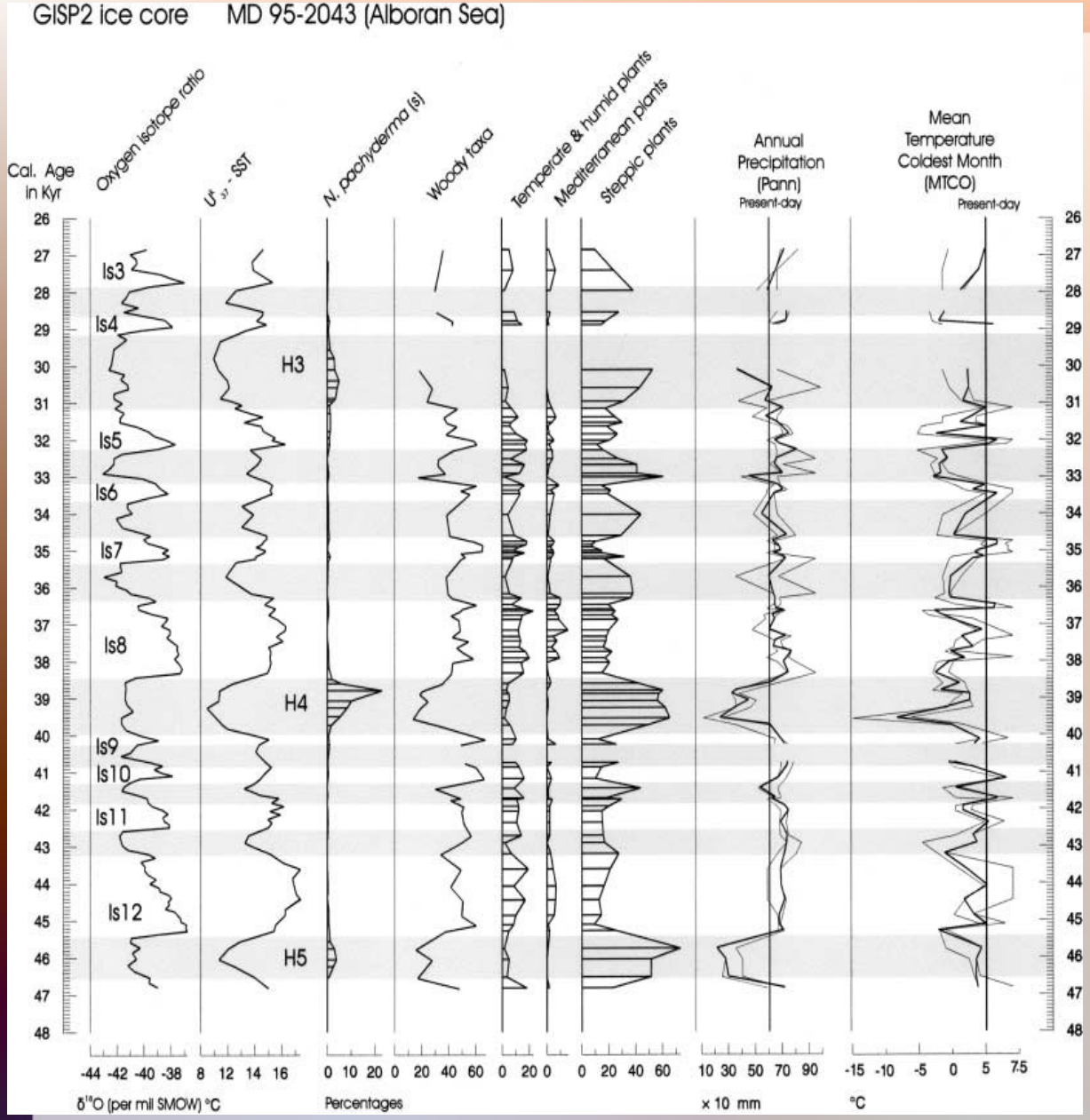
Neff et al. Nature 2001

Oman $d^{18}O$ & $d^{14}C$





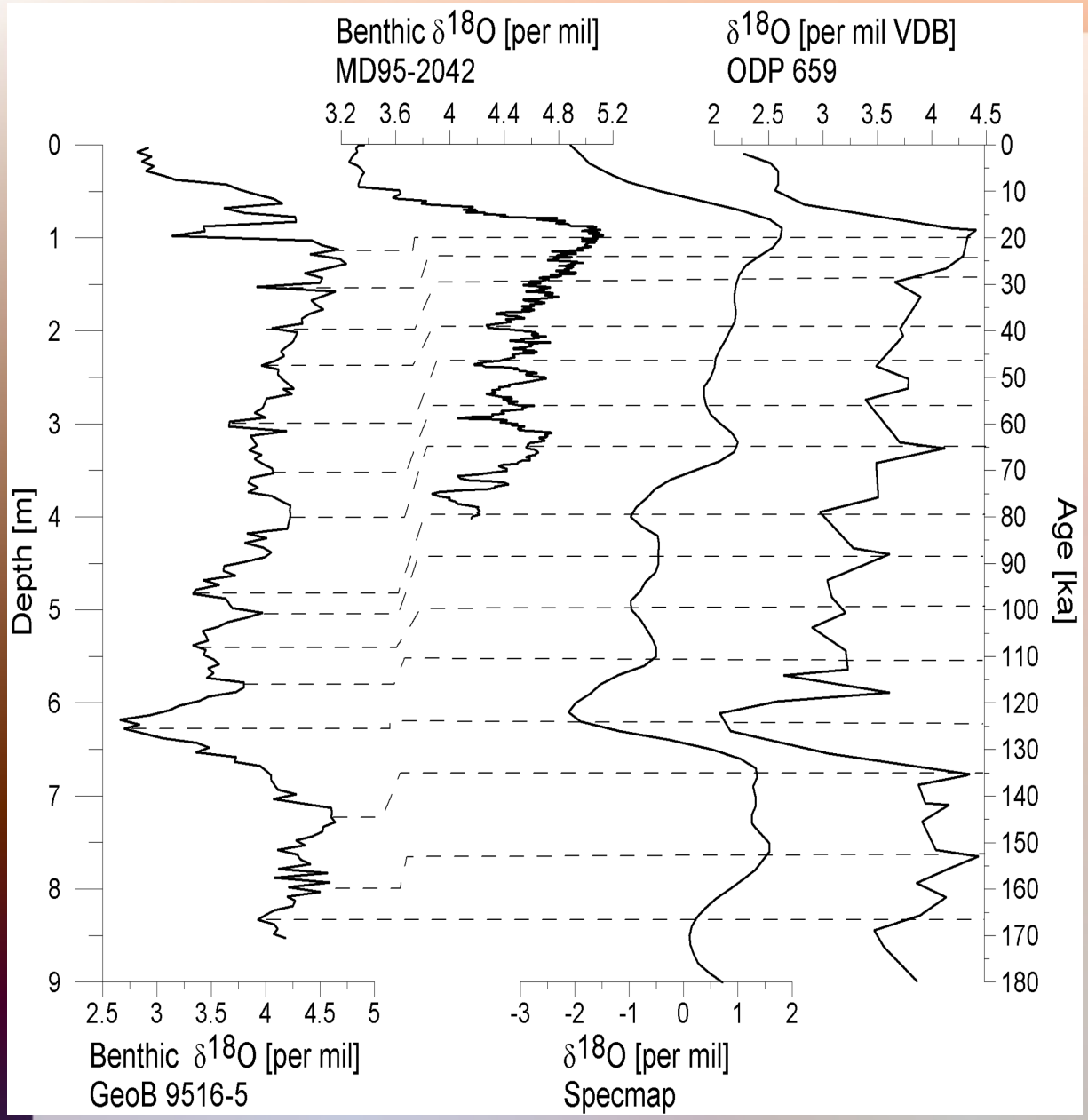
Swindles et al., 2010. A 4500-year proxy climate record from peatlands in the North of Ireland: the identification of widespread summer 'drought phases'?
Quaternary Science Reviews

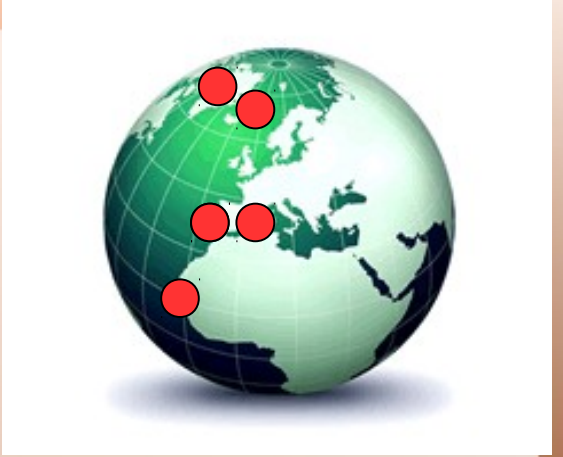


No dates

"Millennial-scale pollen changes are synchronous with Greenland events"

Sanchez Goñi et al. Climate Dynamics 2002 Alboran Sea



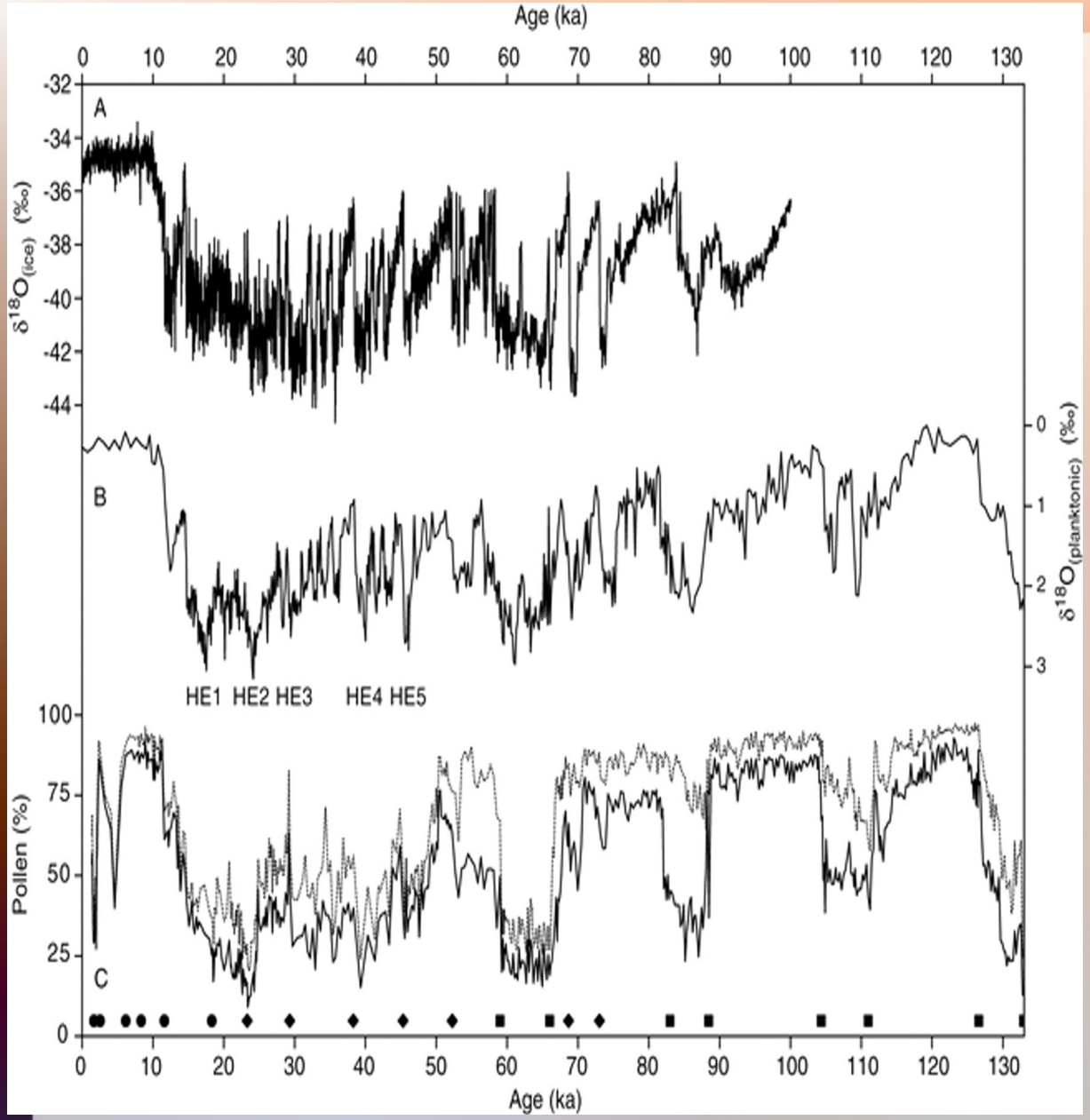


No dates

"Millennial-scale dust fluxes are synchronous with North Atlantic Heinrich stadials"

Itambi et al. Paleoceanography 2009

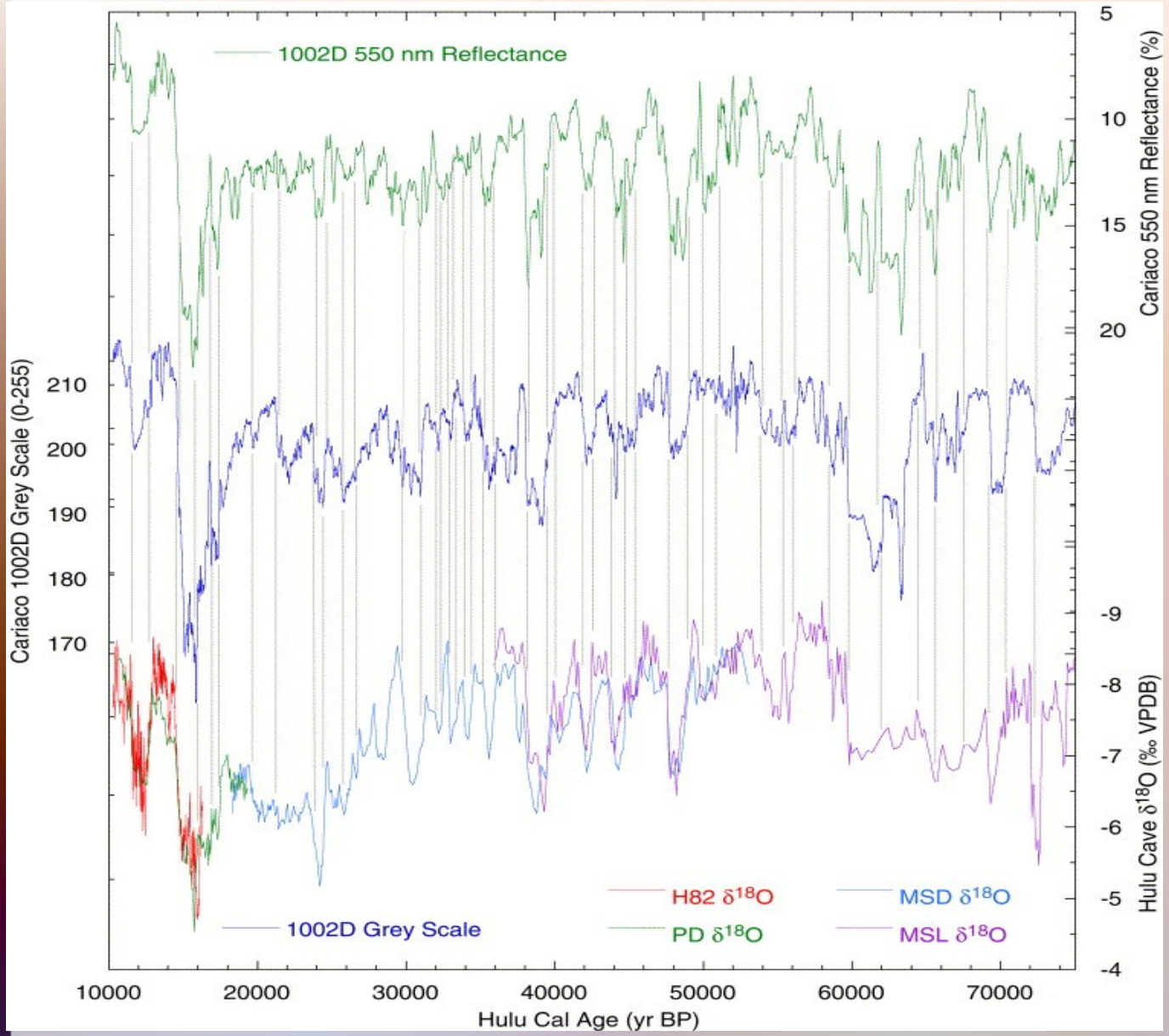
Senegal

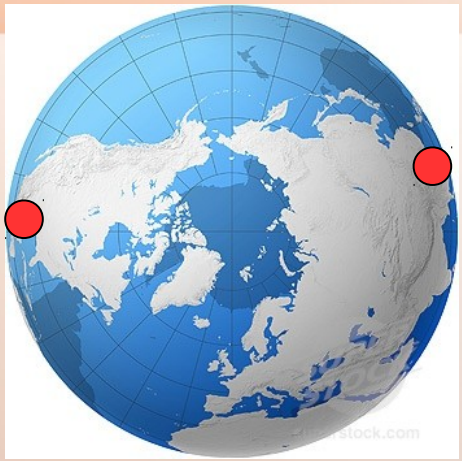


Age model based on calibrated ^{14}C ages (circles), astronomical calibration (squares), and tuning to GISP2 chronology (diamonds)

Tzedakis et al. Geology 2004

Greece





No dates (for this part)

Vital for IntCal09

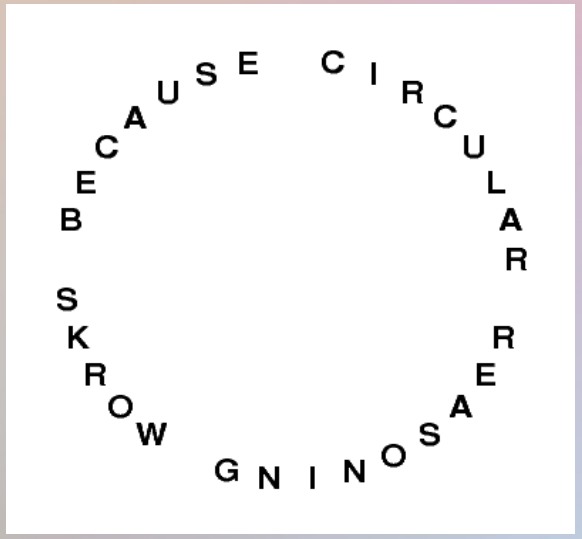
Hughen et al. 2006

Cariaco Basin (Venezuela) tuned against Hulu Cave (China)

Tuning

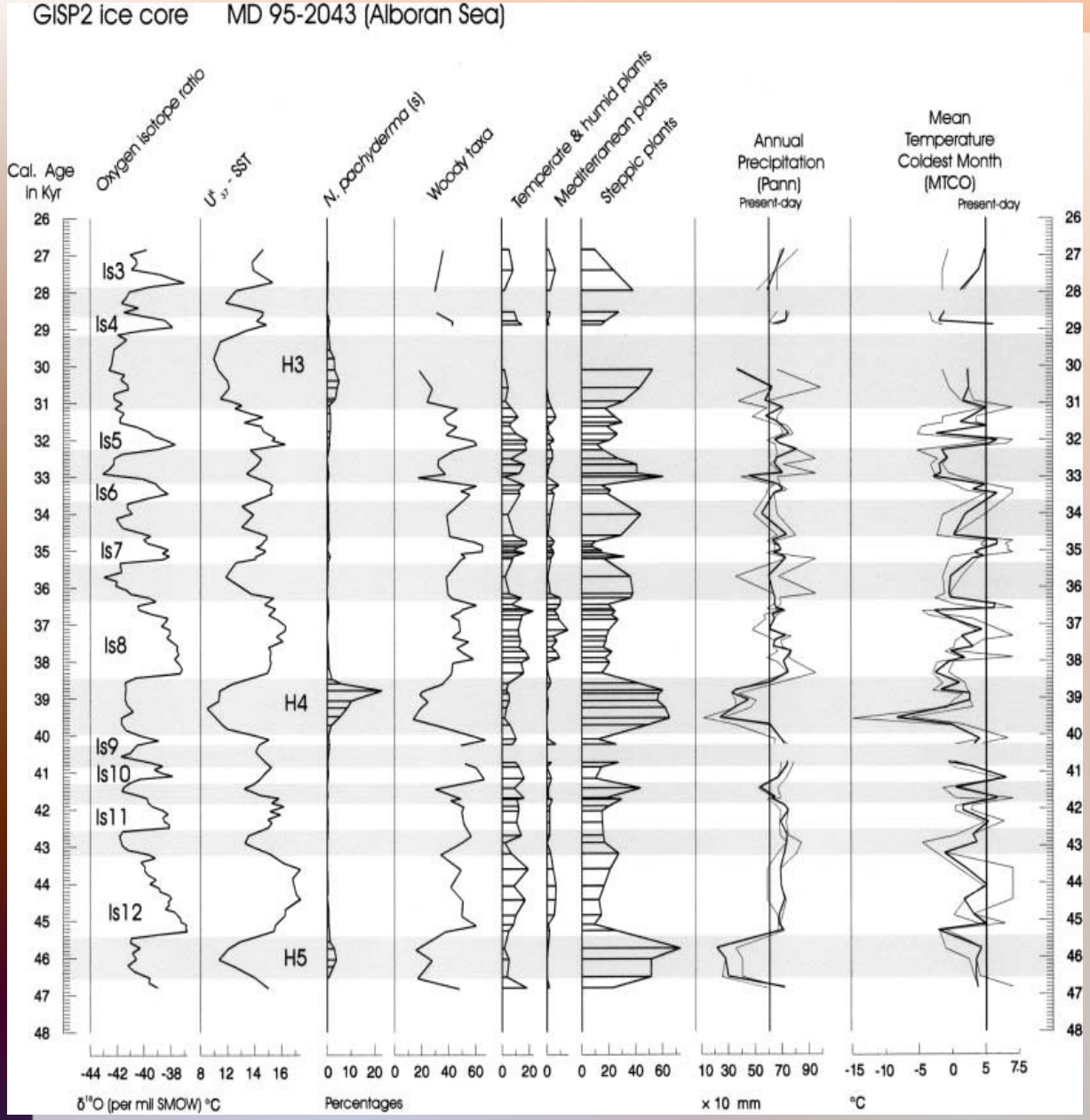
- Major local event must be expressed on large scale
  - So should also be found back in other sites
  - Event shapes can be used as ID (saw, tephra)
- Events happened simultaneously
  - So provide very precise tie-points for age-models!
- Use events to glue to famous well-dated archives
- Especially handy where ^{14}C has problems (old, ocean)
- Between tie-points, assume linear accumulation

- Isn't this circular reasoning?
- How precise are tie-points for age-models?
- Do independent data support tuning?



Circular reasoning in palaeoclimate

- Before dating, no robust time frames and thus much freedom to speculate about chronologies and correlations. Few could resist the urge to fit their results into existing framework, e.g. pollen zones. Thus arose 'coherent myths' or 'reinforcement syndrome' (Oldfield 2001 *The Holocene*)
- Dachnowski 1922, PNAS: peat layers synchronous between US and Europe
- von Post (1946) warned us about this
- Problems still exists, suck-in smear effect (Baillie 1991), 'precisely dated known event becomes associated with more poorly dated events' (Bennett 2002 JQS)



"Millennial-scale pollen changes synchronous with Greenland events"

Of course, because they were *tuned* (via SST)!!!

Sanchez Goñi et al. Climate Dynamics 2002 Alboran Sea

Courtillot et al. (EPSL '07, ‘08) correlate a $\delta^{18}O$ record to $\delta^{14}C$.

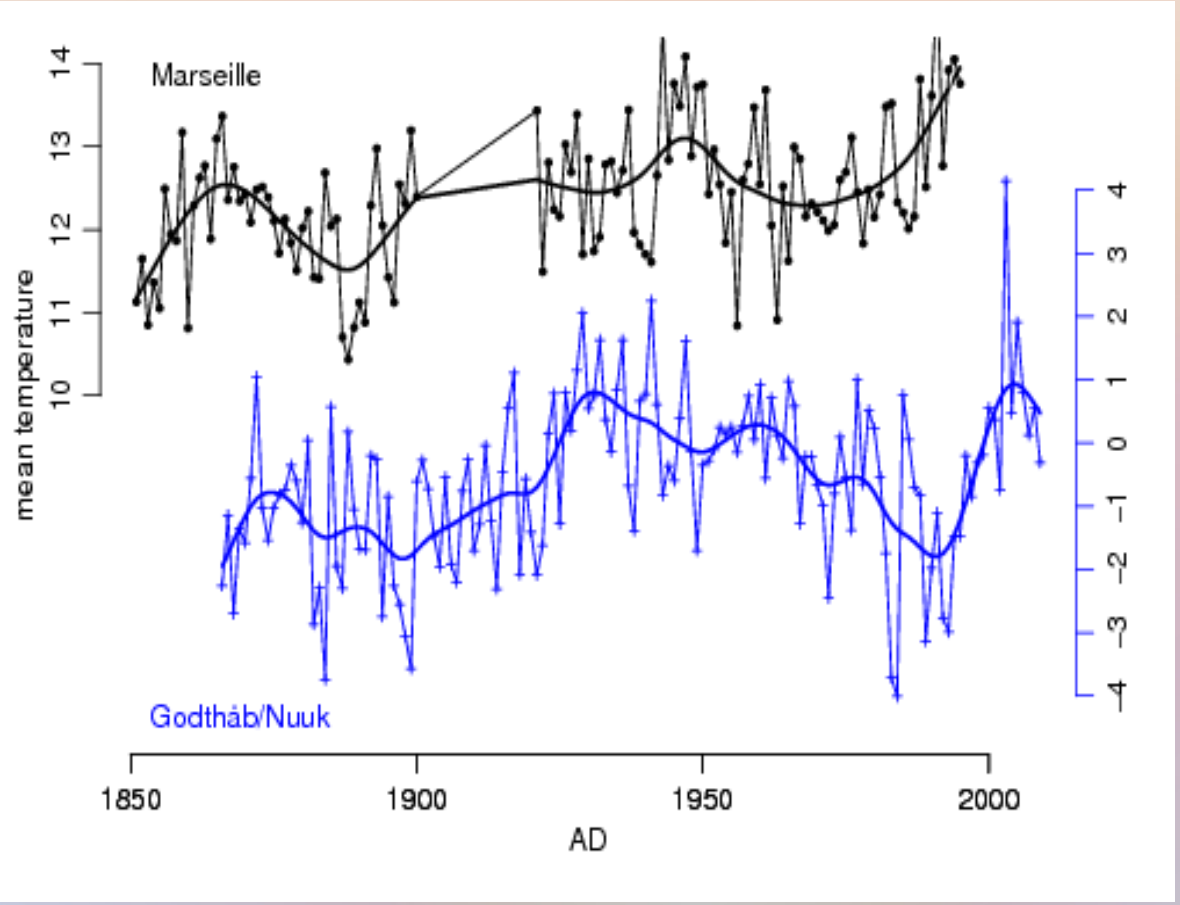
"The match can of course not be perfect because of the uncertainties. If solar variability played only a minor role in the past two millennia, tuning could not improve the correlation. […] It is therefore not surprising that the tuned curve should reveal the link between solar activity and $\delta^{18}O$."

Bard and Delaygue (EPSL '08) comment: "To prove correlations and make inferences about solar forcing, only untuned records [...] with their respective and independent time scales, should be used.”

How precise are tie-points?

- Depends on reliable event-IDing (order, shape, tephra)
- Resolution/noise: did we catch the event?
- Multiple/different proxies: do they agree?
- How precisely dated is 'mother archive'?
  - NGRIP: uncertainty thousands of years
  - SPECMAP: c. 5,000 yr uncertainties
  - Radiocarbon: errors stated more explicitly
- Linear accumulation between tie-points?

Are all climate events global?



“We have adopted the following strategy with regard to age models. In the case of pollen records from marine cores, isotope stratigraphies provide a solid basis for the chronology. However for terrestrial records [...], reliance on radiometric dating alone to create an independent age model results in pollen changes apparently occurring at slightly different times from the events shown in the Greenland ice core. The temporal offset is often small and is not consistent from site to site, even in the same region. Furthermore, the nature of the vegetation changes at these terrestrial sites is similar to those shown in adjacent marine cores – where the chronology is based on the isotope stratigraphy. Thus, in describing the vegetation changes during D–O events at terrestrial sites, we have assumed that the mismatch between the radiometric age assignments and the observed changes in vegetation is most likely to reflect changes in sedimentation rate and problems with the radiometric age model – an assumption consistent with the interpretation of the original authors.”

Harrison and Goñi, *in press.* Global patterns of vegetation response to millennial-scale variability and rapid climate change during the last glacial period. *Quaternary Science Reviews*

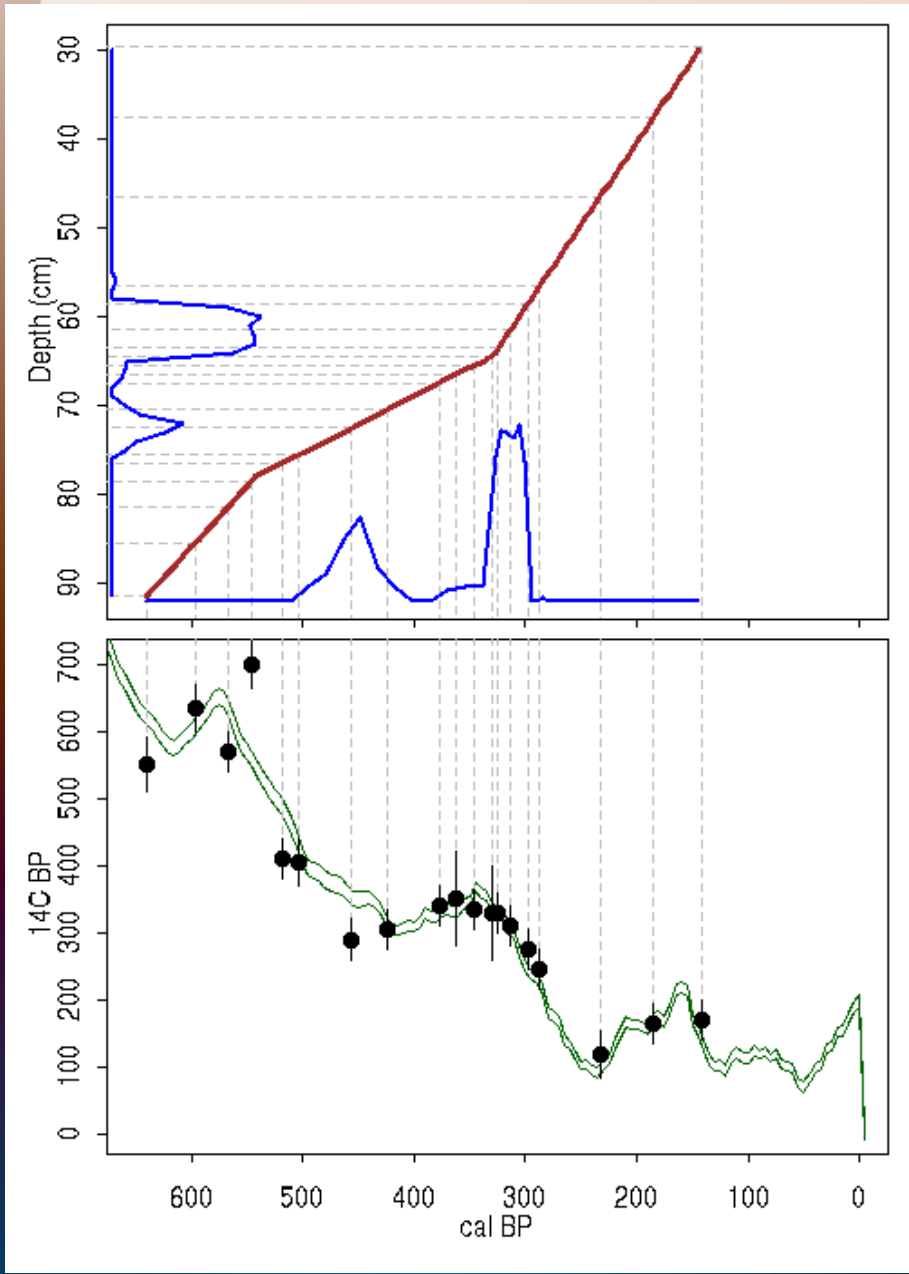
“Too often the paleo literature aims to rationalize why a particular hypothesis remains appropriate, rather than undertaking to deliberately test that hypothesis.

[…] scientific communities without adequate data have a distinct advantage: one can construct interesting and exciting stories and rationalizations with little or no risk of observational refutation [...] based on interpretations of a few intriguing, but indefinite observations that appeal to their followers, and which eventually emerge as “textbook truths.”

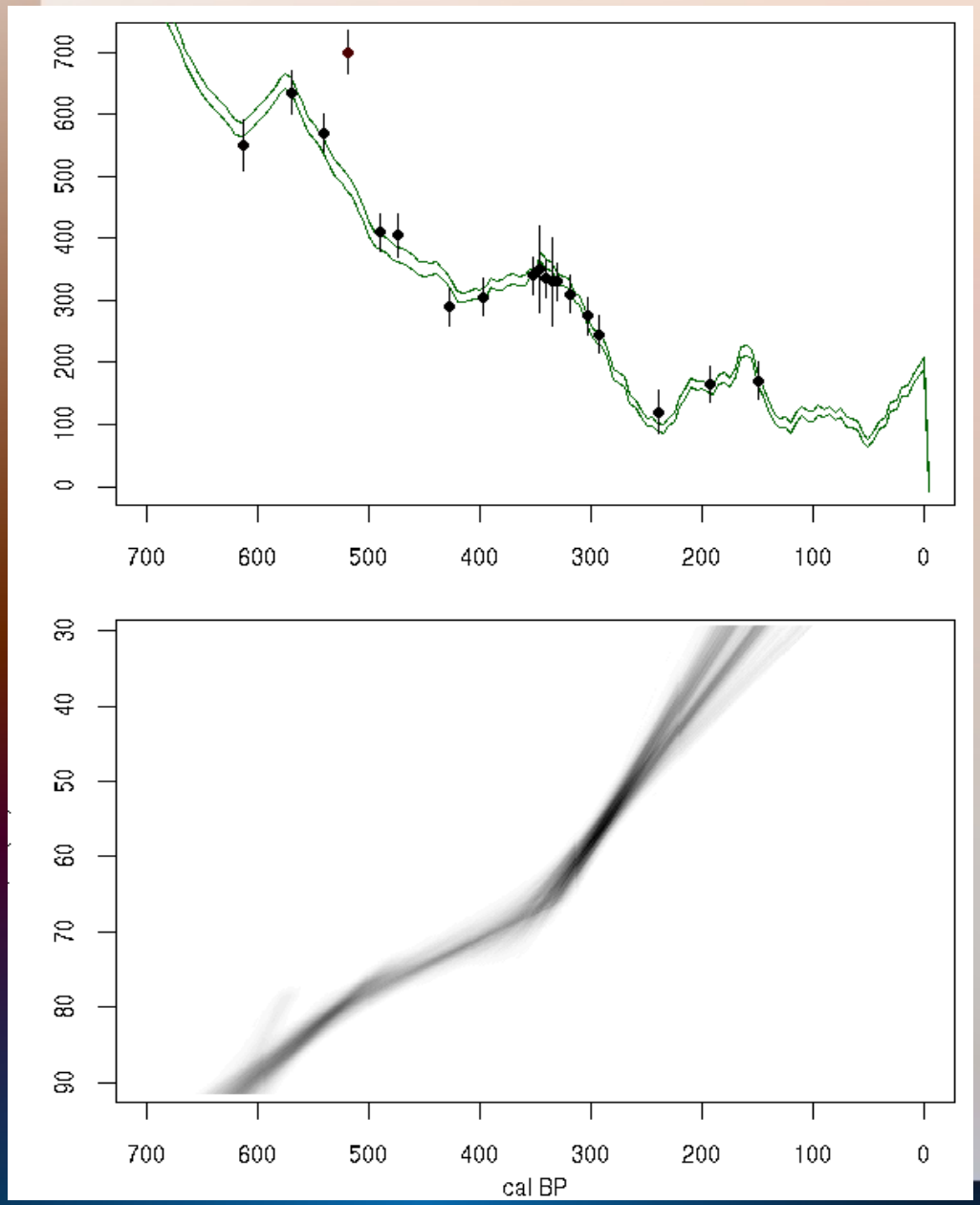
[…] As both human beings and scientists, we always hope for explanations of the world that are conceptually simple yet with important predictive skills […]. But some natural phenomena are intrinsically complex and attempts to represent them in over-simplified fashion are disastrous.

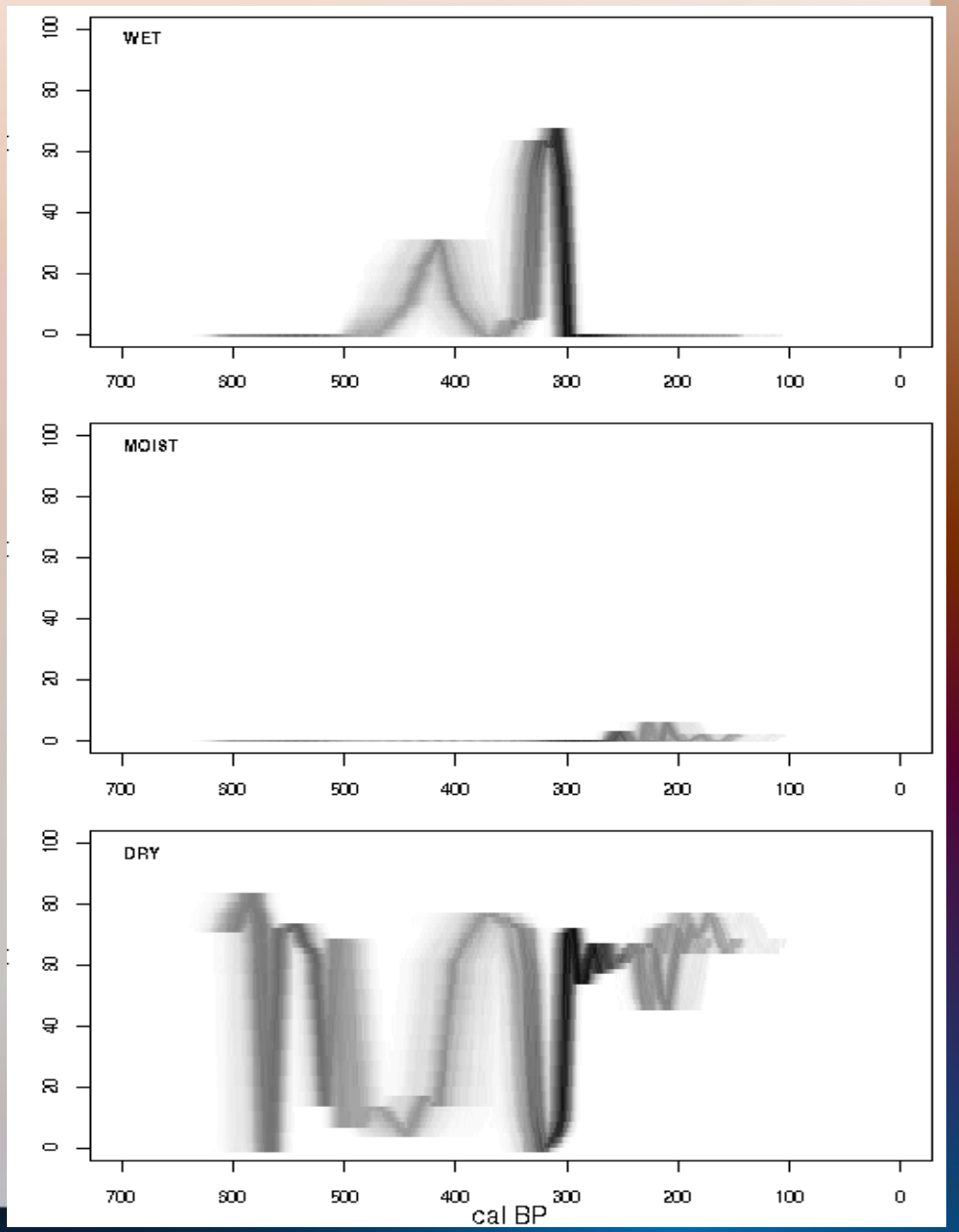
Wunsch, 2010. Towards understanding the Paleocean. *Quat. Sci. Rev.*

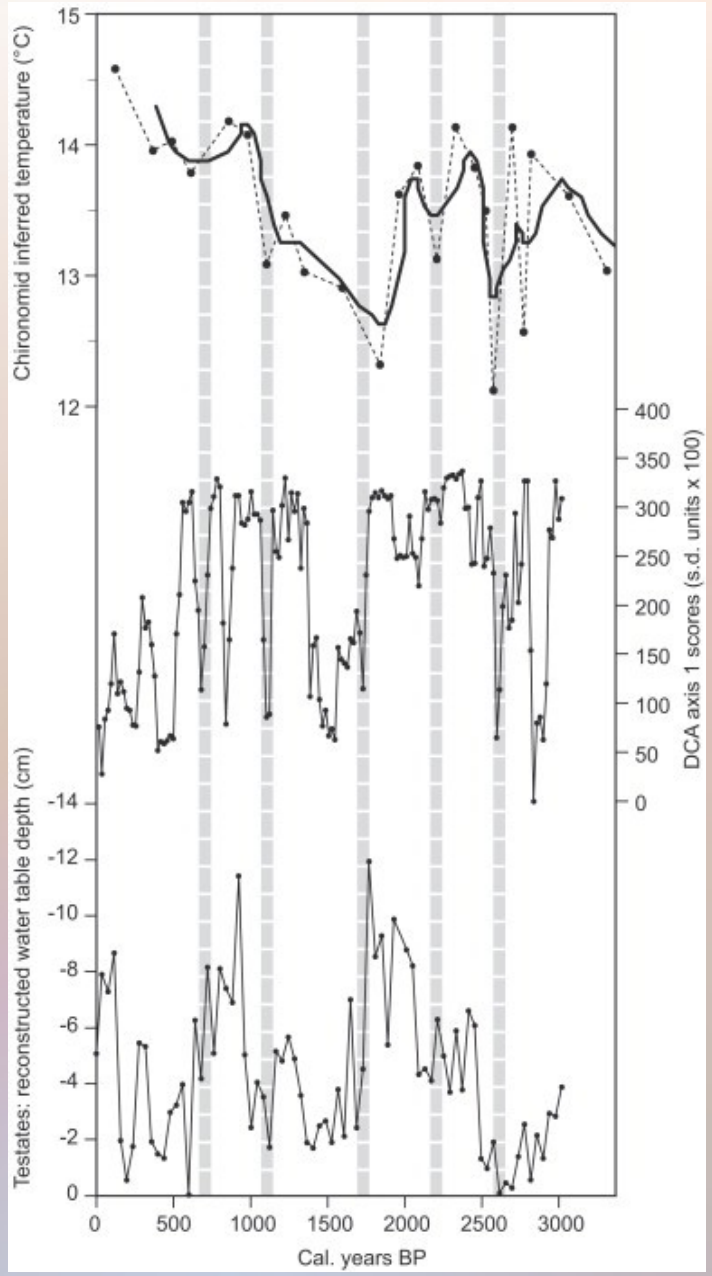
Independently dated archives

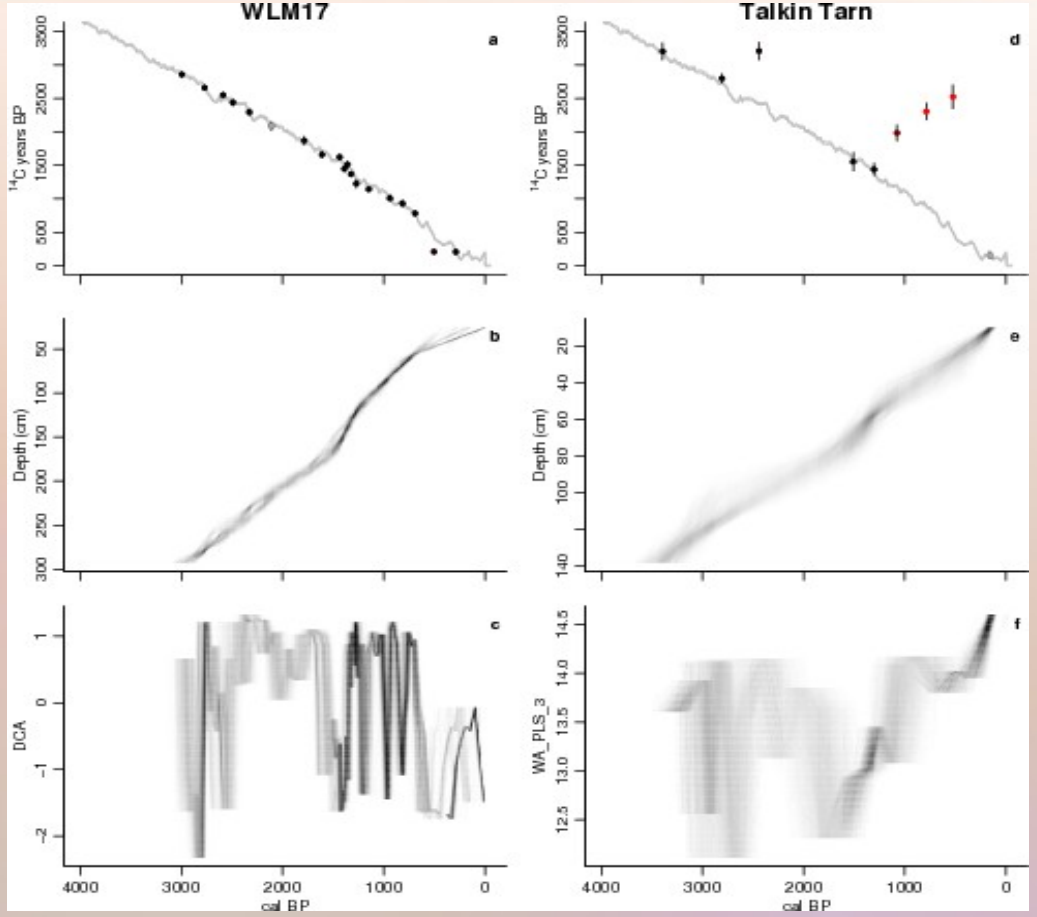


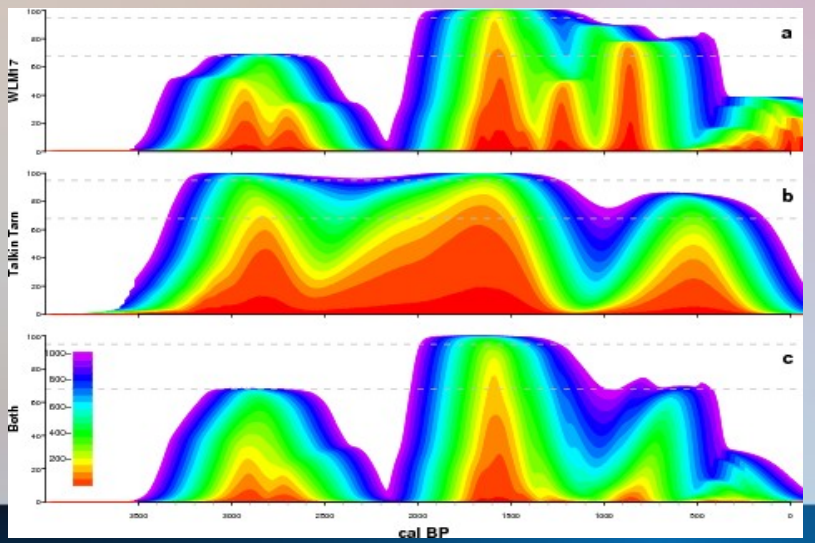
Grey-scale ghost graphs





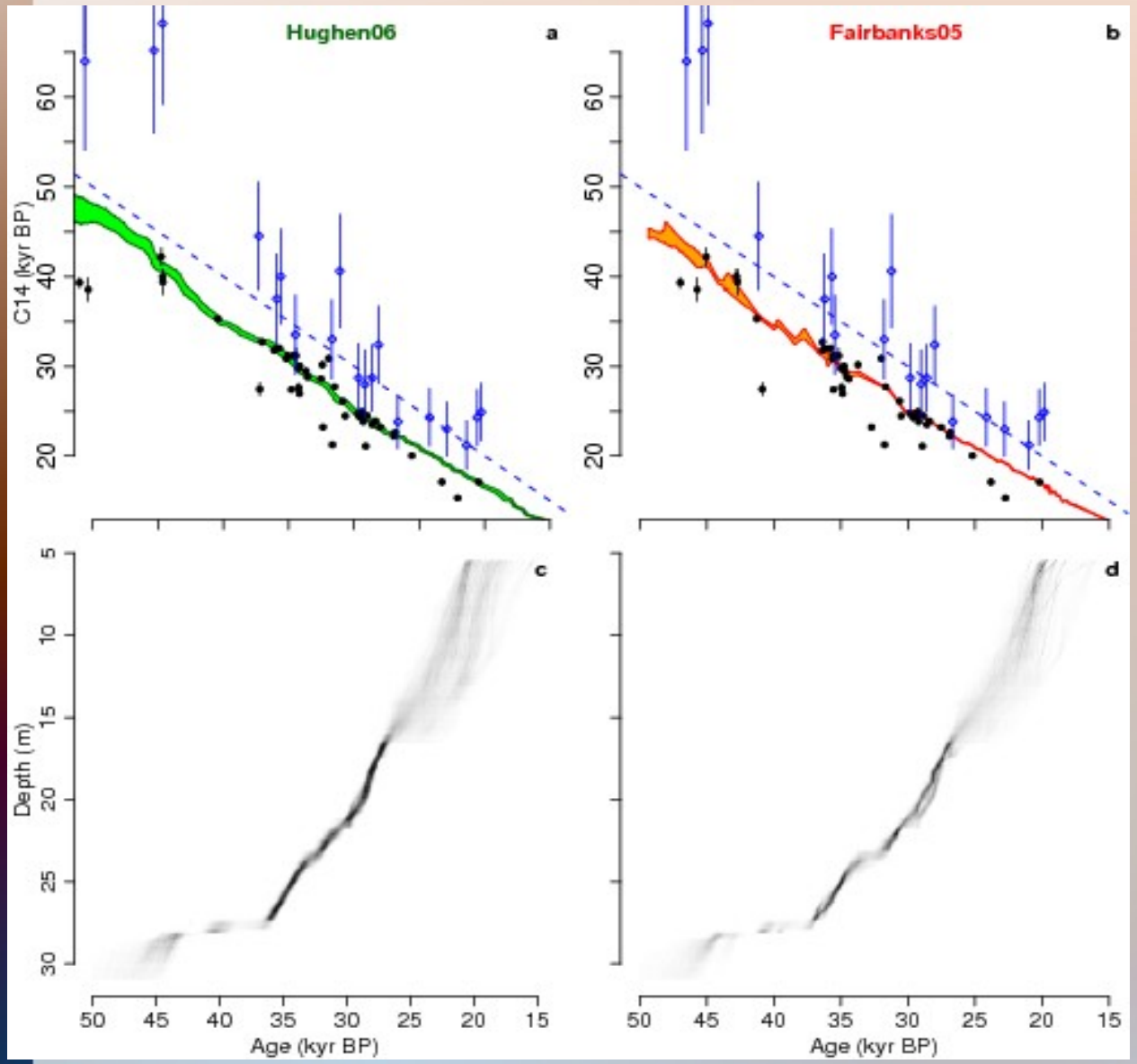




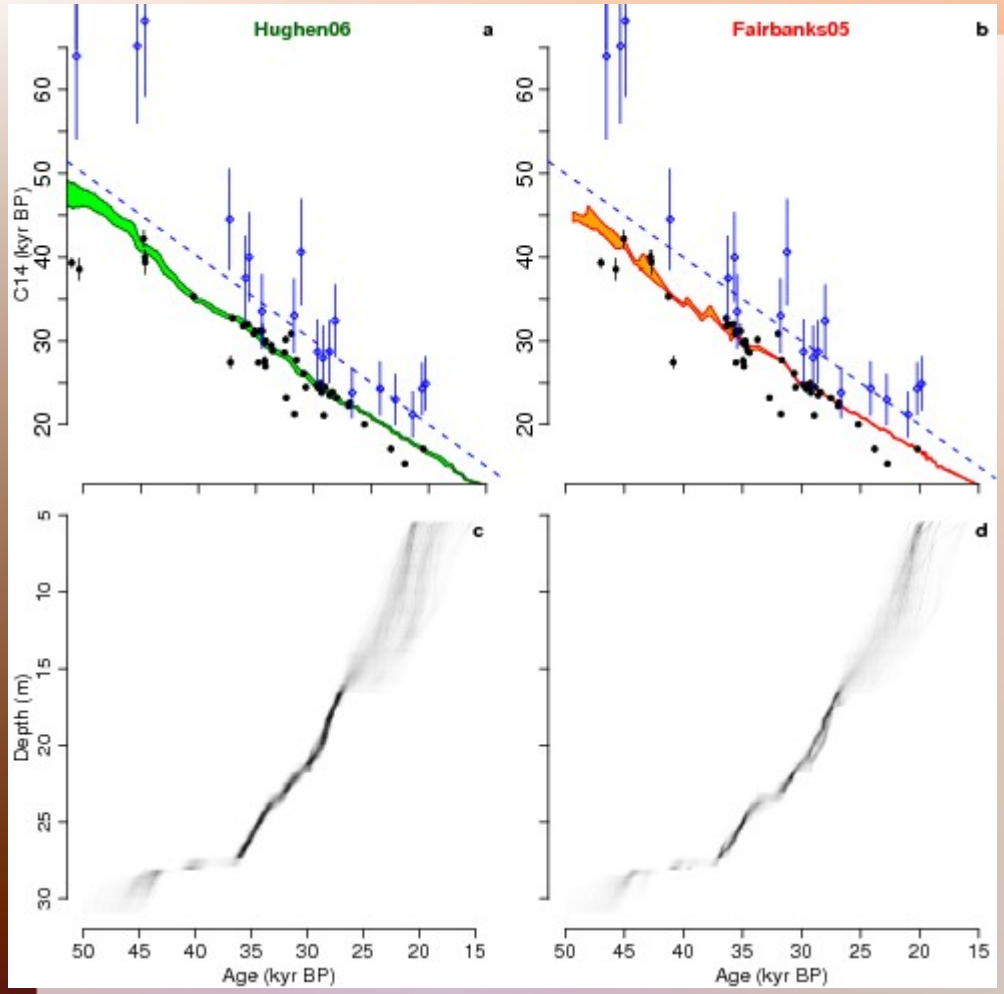


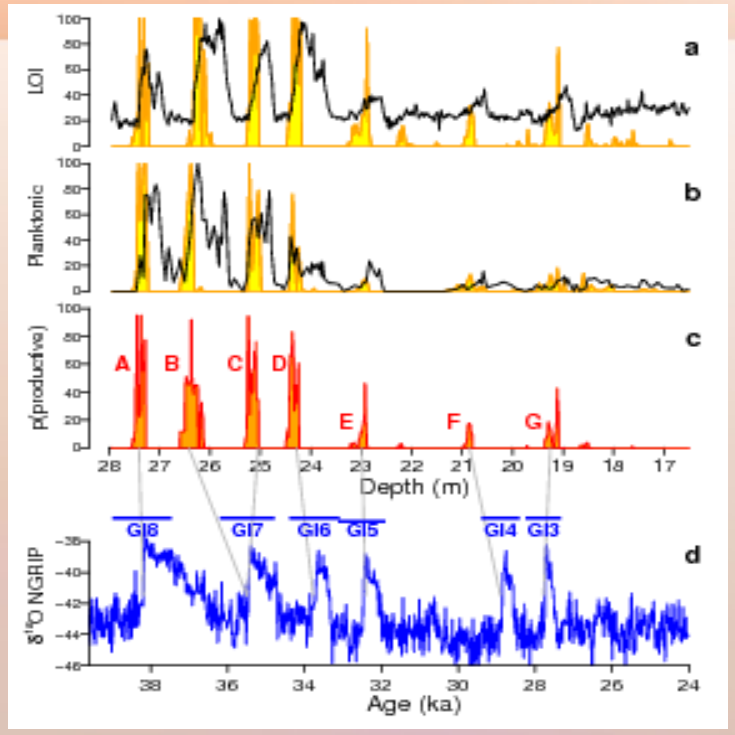
Barber and Langdon 2007, Quat. Sci. Rev.
Charman et al. 2009, Quat. Sci. Rev.

Independent support for tuning?

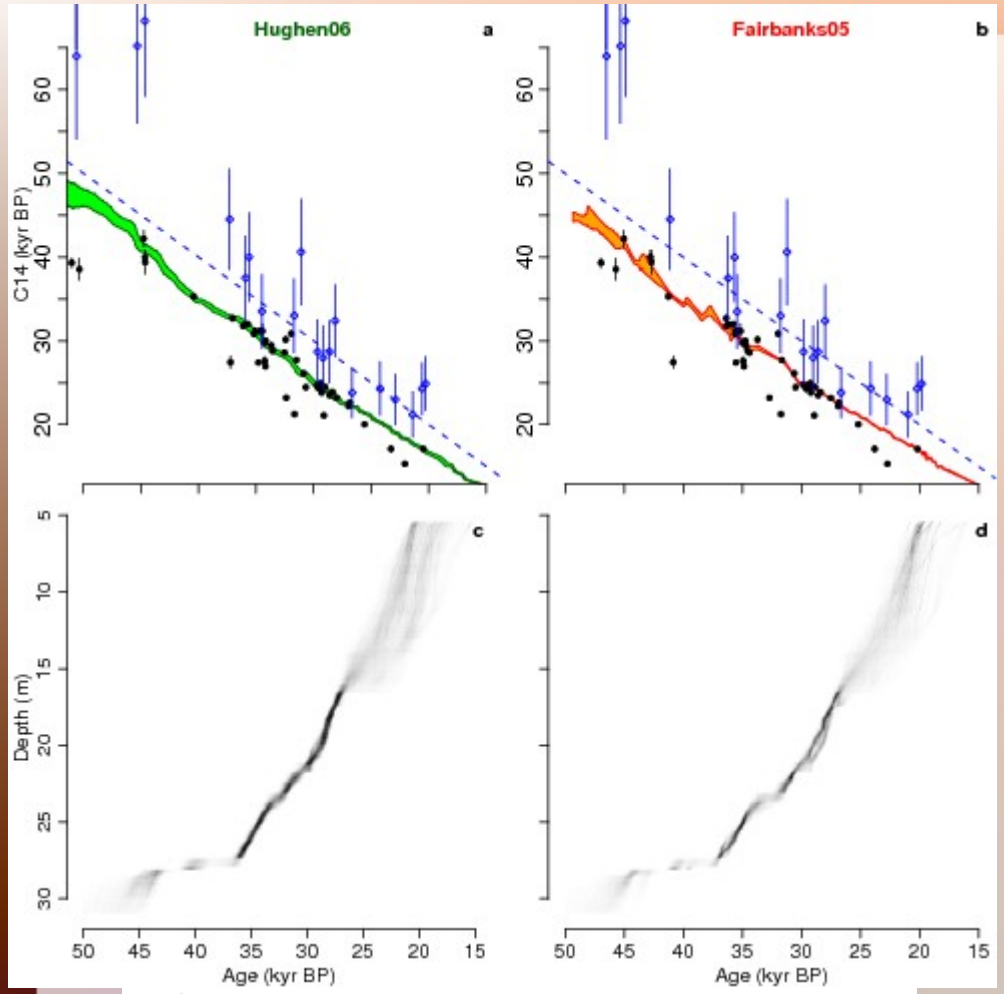


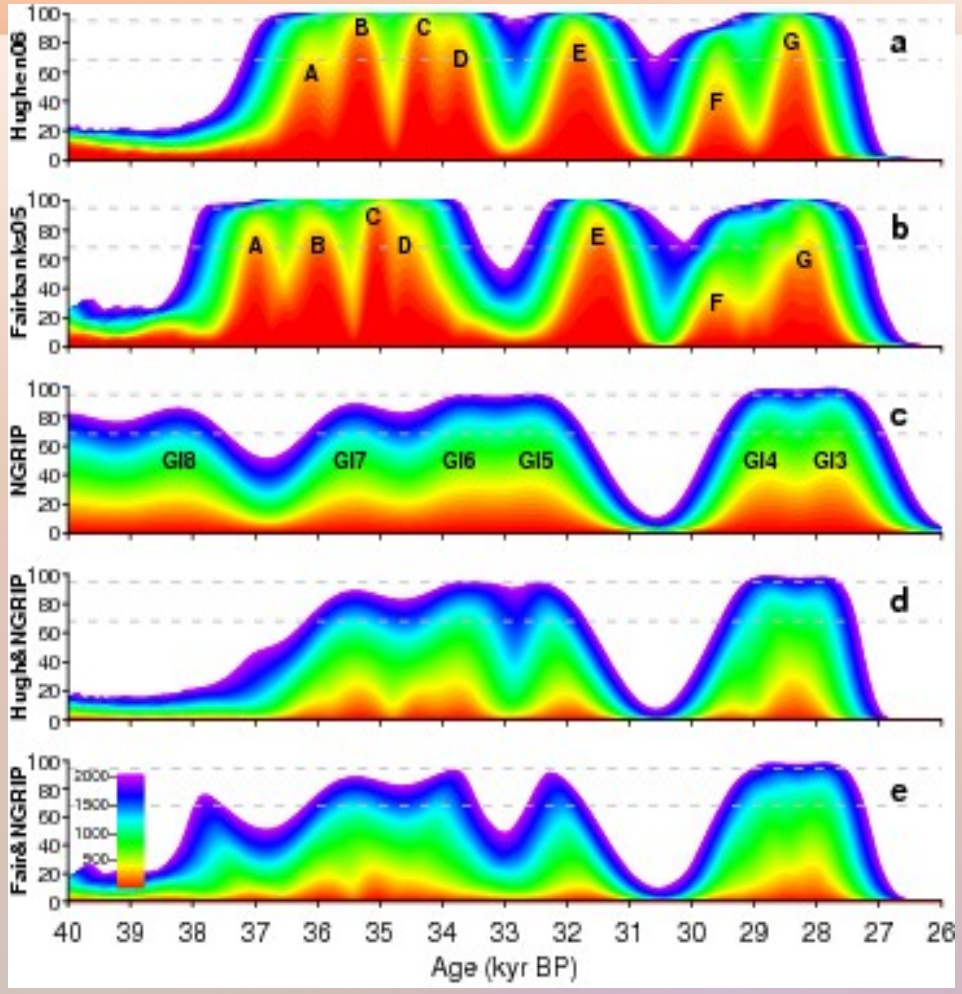
Blaauw et al 2010, JQS

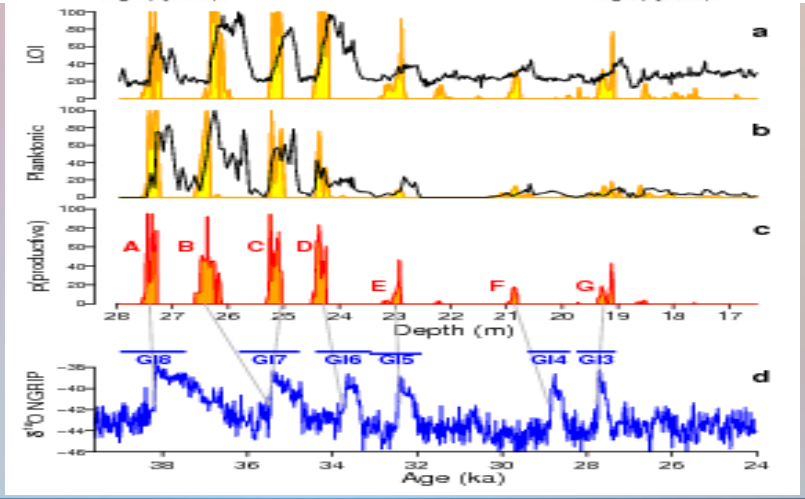




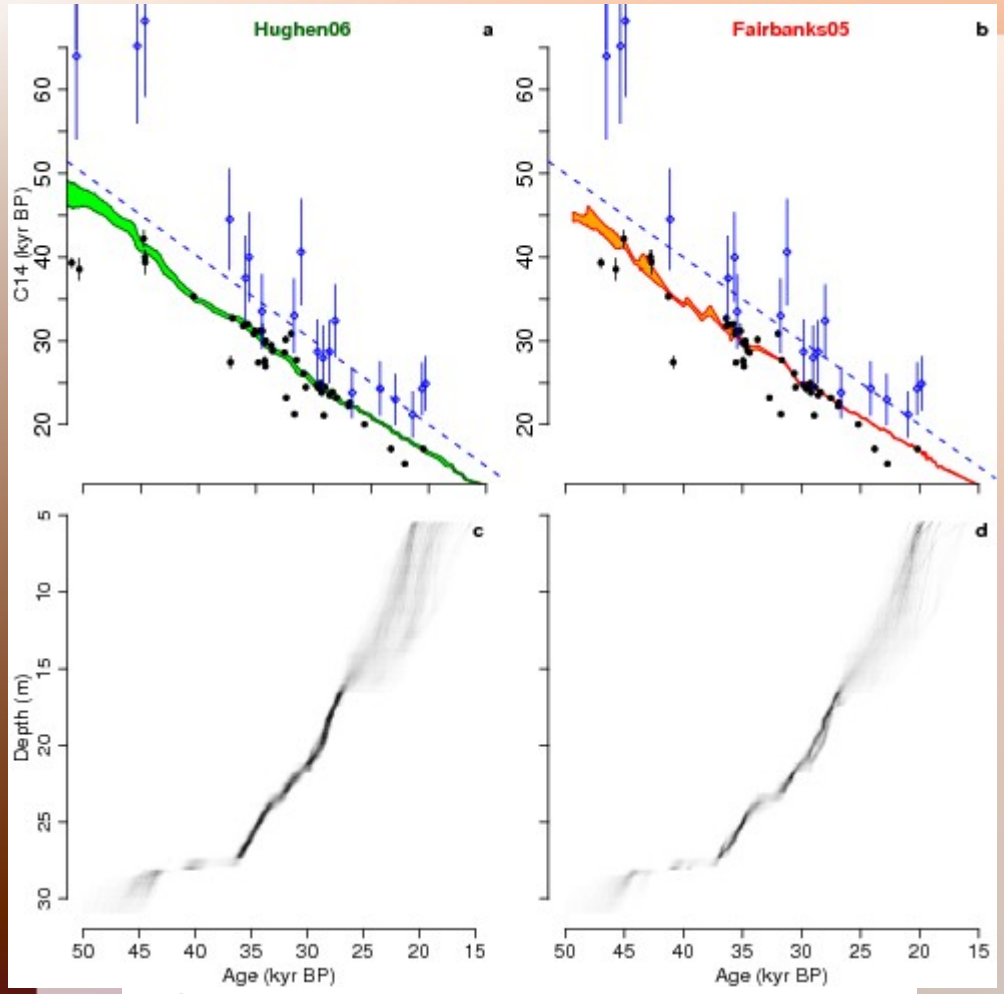
Blaauw et al 2010, JQS

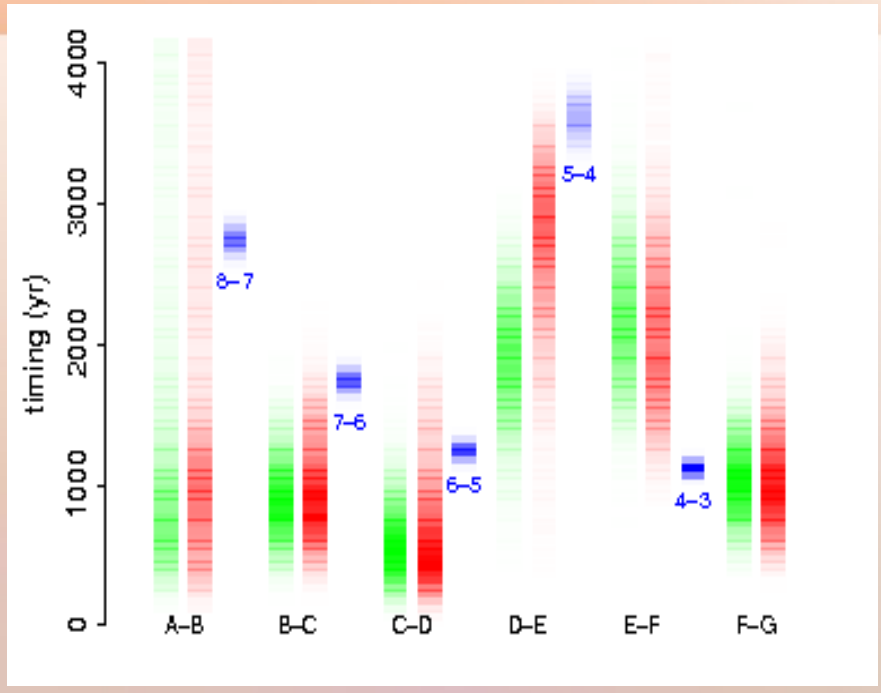


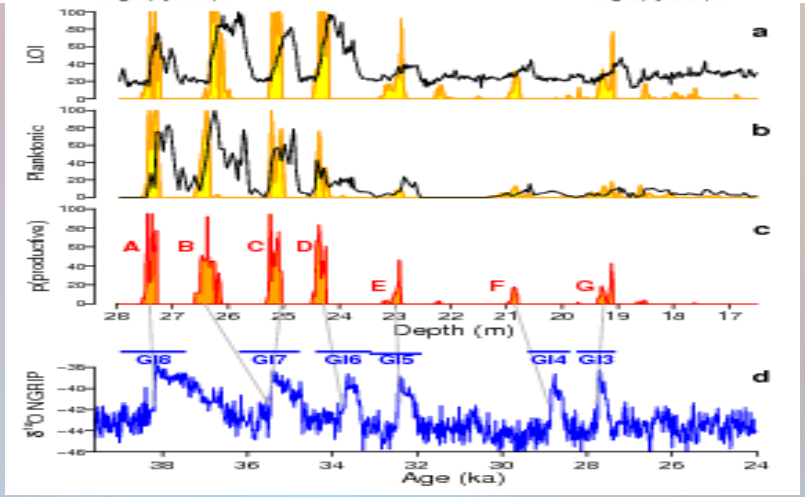




Blaauw et al 2010, JQS

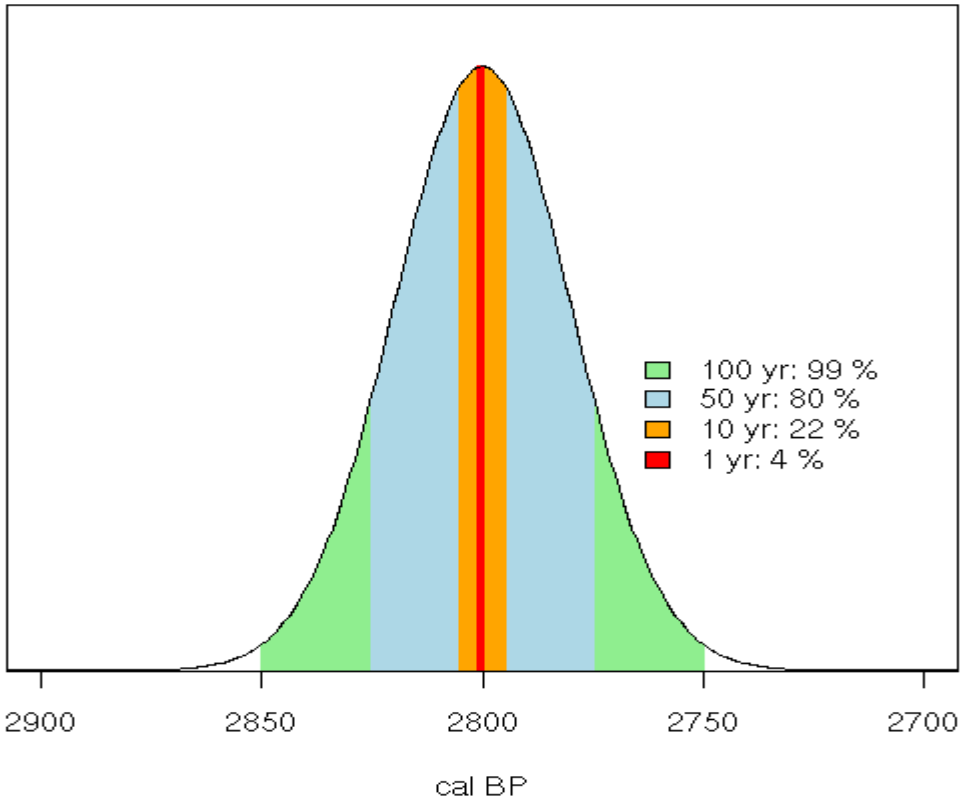






Blaauw et al 2010, JQS

Know your resolution



Tuning

- Cannot use tuning for spatio-temporal patterns
- Keep time-scales independent+errors
- Assume non-synchroneity until proven false
- Our eyes/minds are eager to interpret patterns
  - Use quantitative, objective methods (e.g. for tuning)

Timing of events

Leads and lags of known events between sites

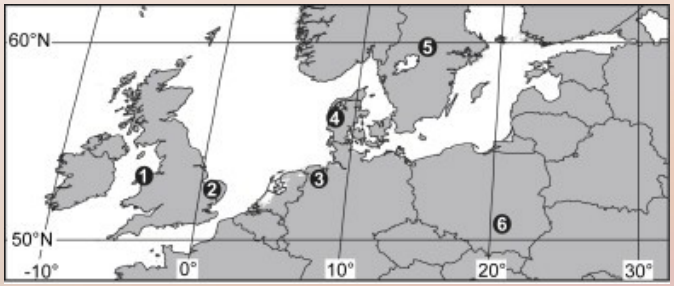
To find leads/lags between sites we must be sure we have found the correct event

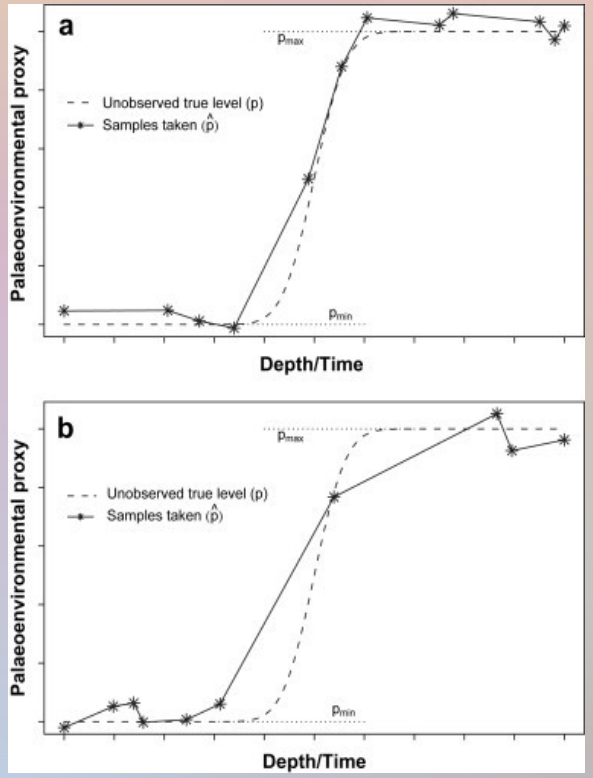
- Tephra layers
- Hemlock decline

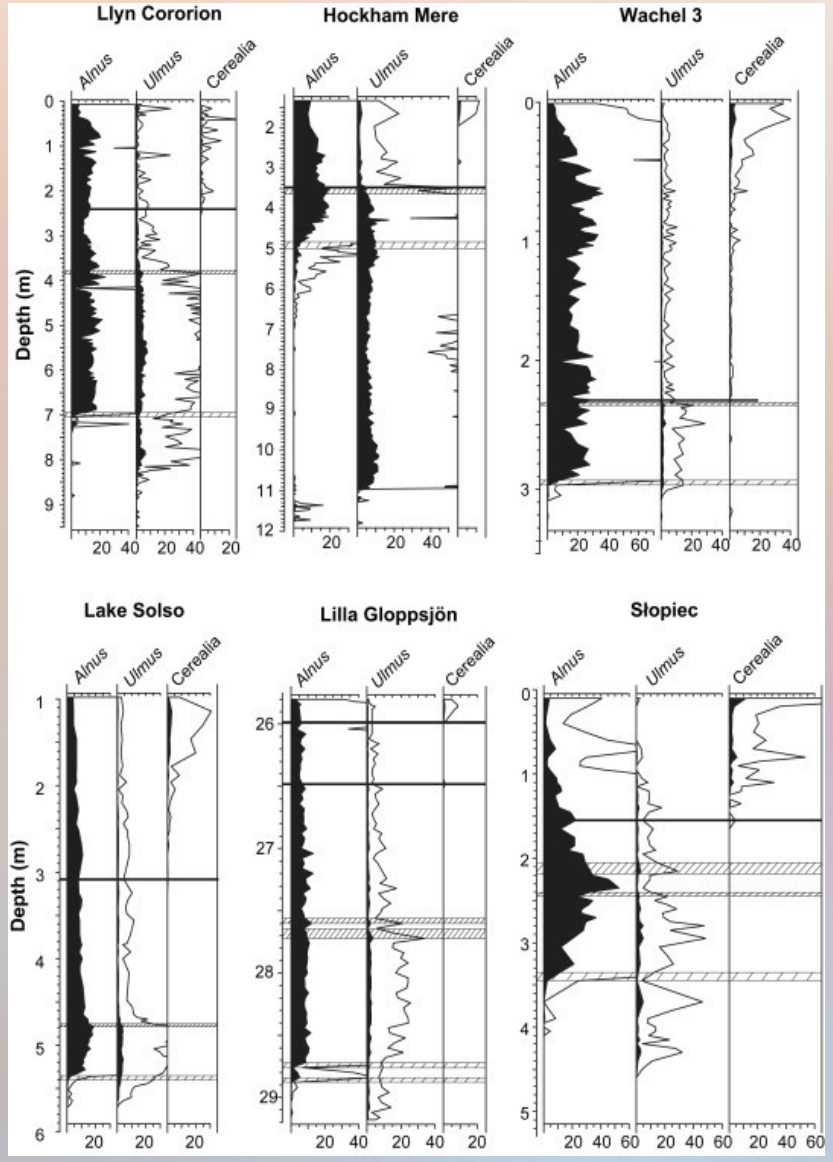
But what with timing multiple events?

- Wet-shifts in bogs
- Multiple Hemlock sub-declines

Order of events between archives

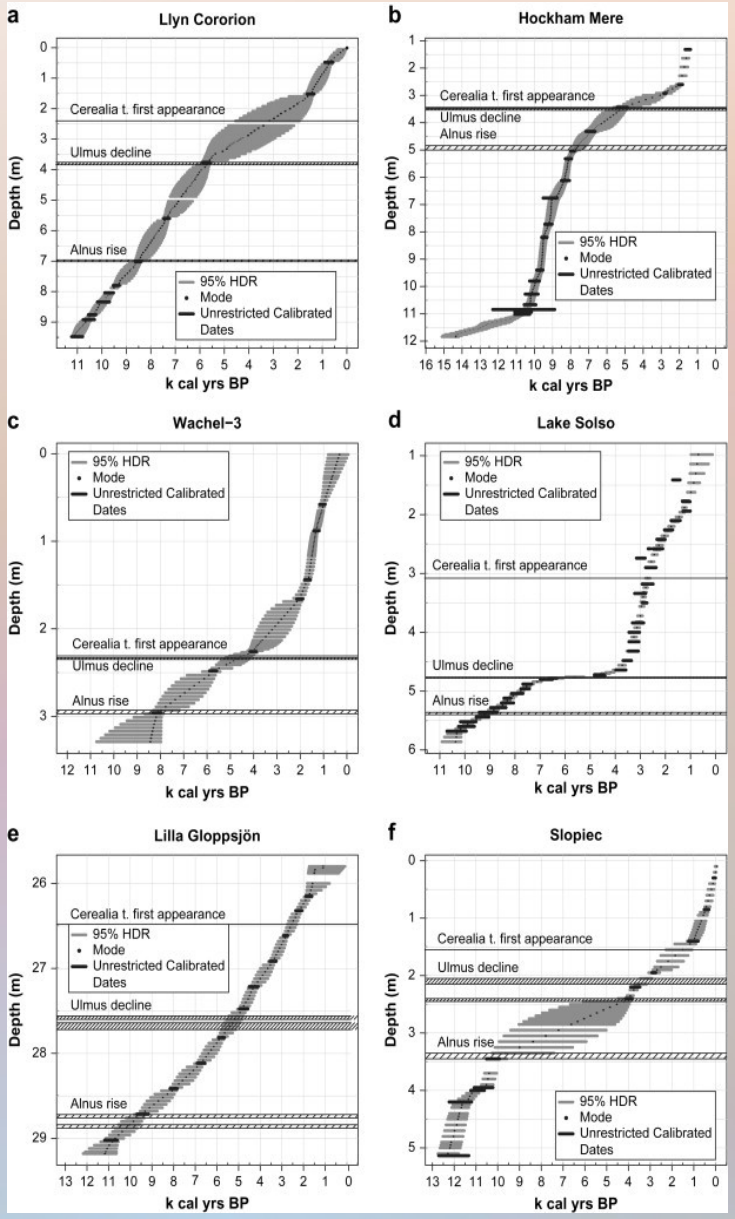


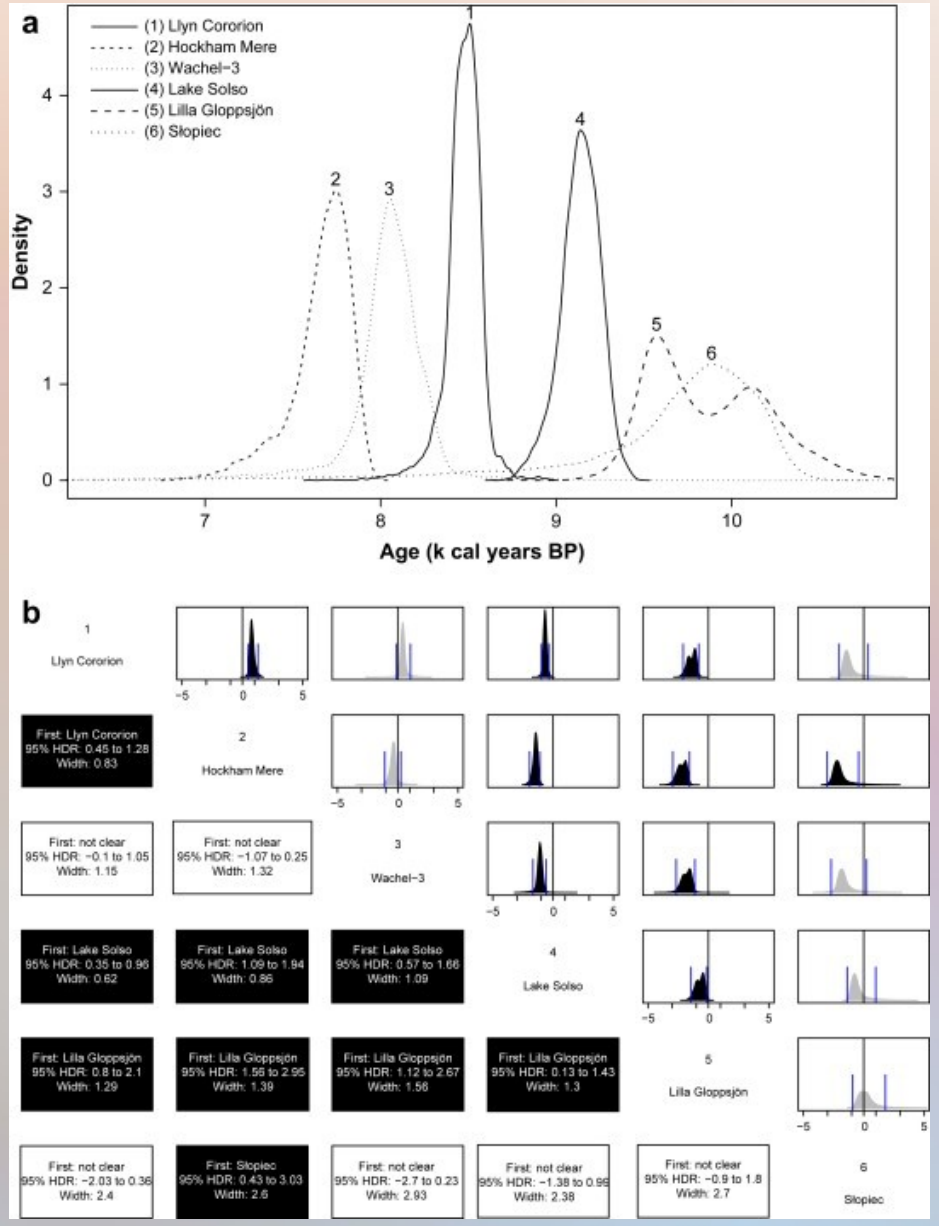




Parnell et al., 2008. *Quaternary Science Reviews*

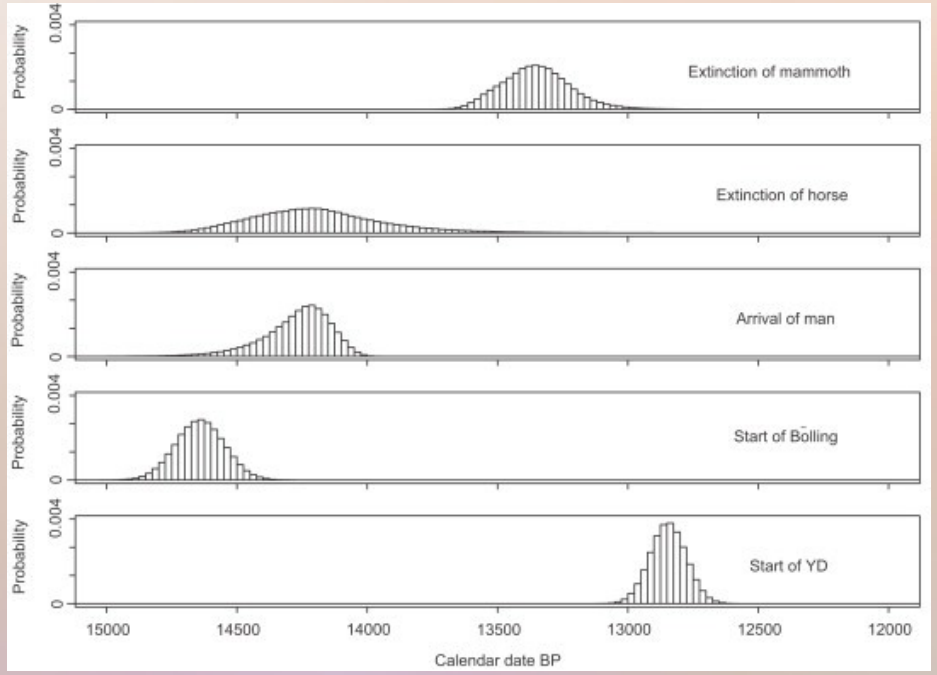
Order of events between archives

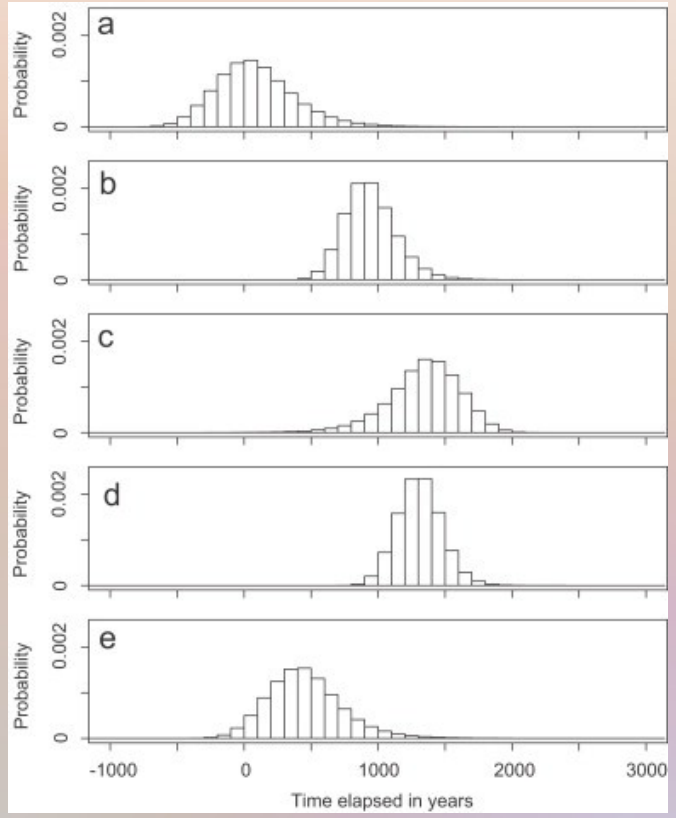




Parnell et al., 2008. *Quaternary Science Reviews*

Timing between events

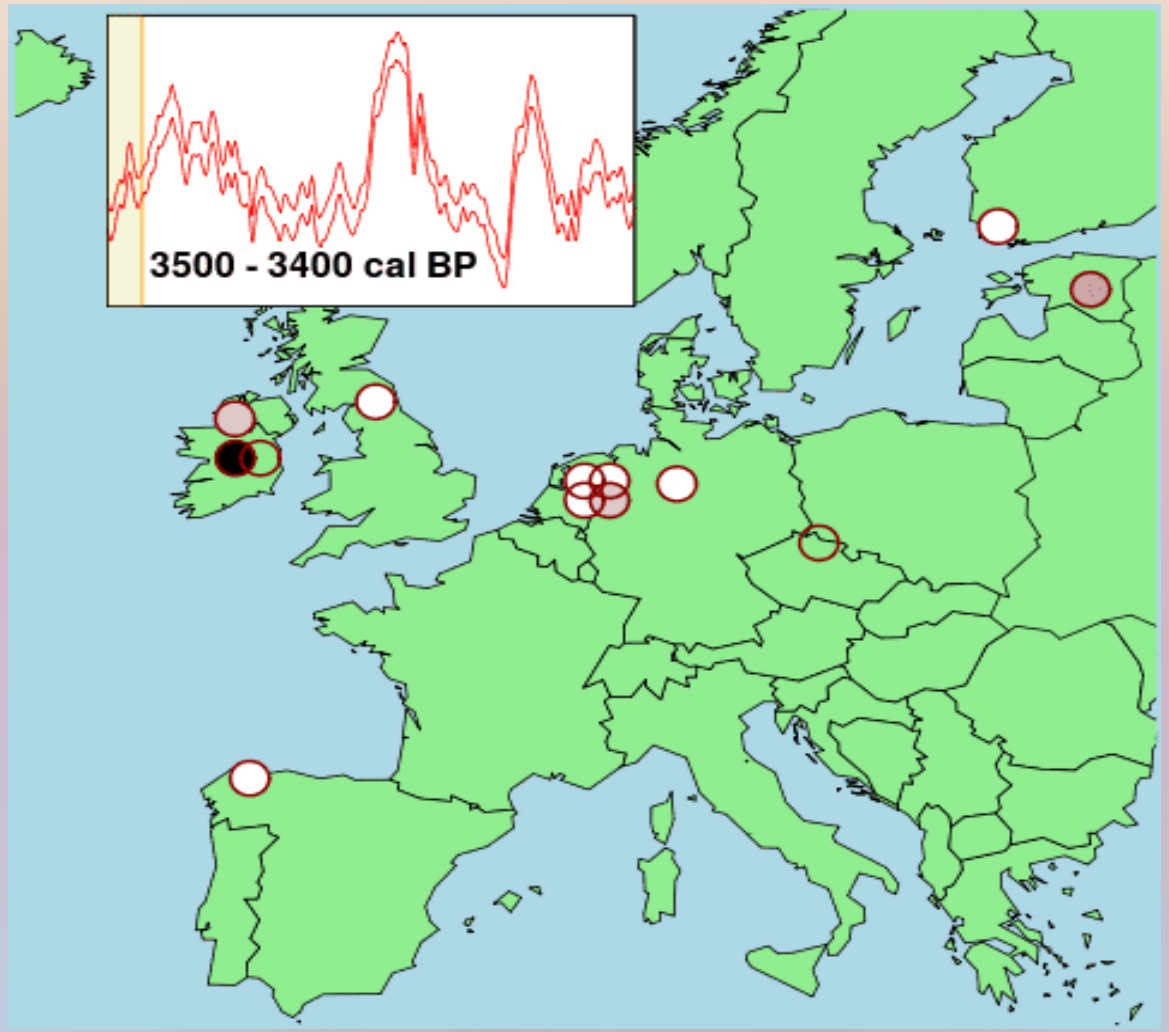




Estimates of the length of time elapsed between (a) the arrival of humans and the extinction of horse, (b) the arrival of man and the extinction of mammoth, (c) the extinction of horse and the SYDCP, (d) the SBWP and the extinction of mammoth, and (e) SBWP and the extinction of horse in Alaska and Yukon.

Buck and Bard 2007. *Quat. Sci. Rev.*

Meta-analysis Europe



Blaauw et al. in prep.