

Introduction to Huybers' Model

Somyi Baek



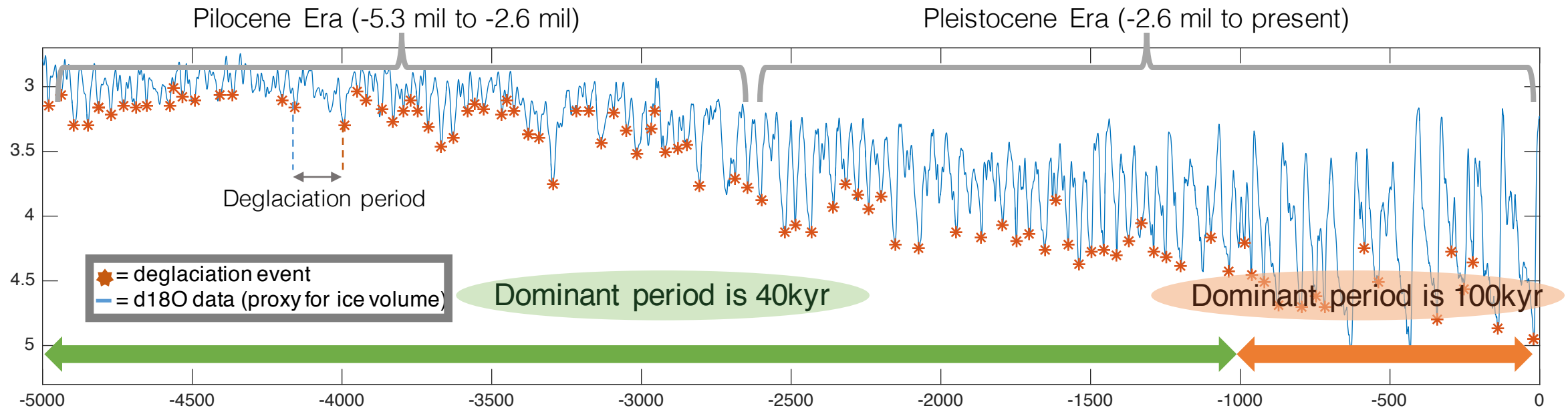
UNIVERSITY OF MINNESOTA



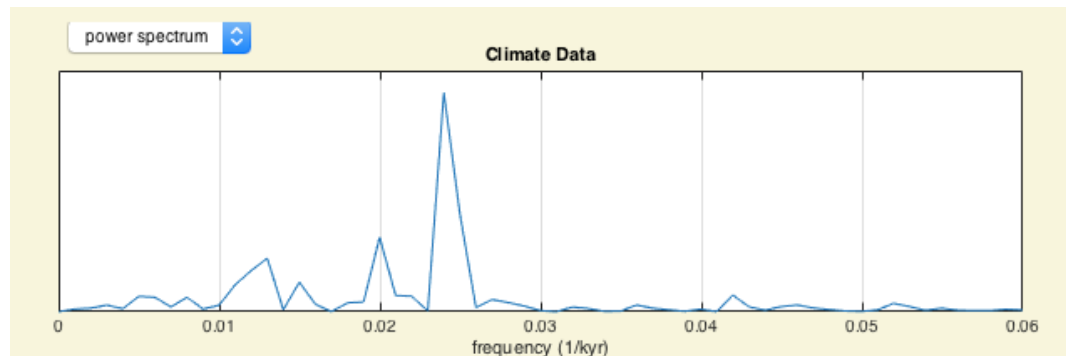
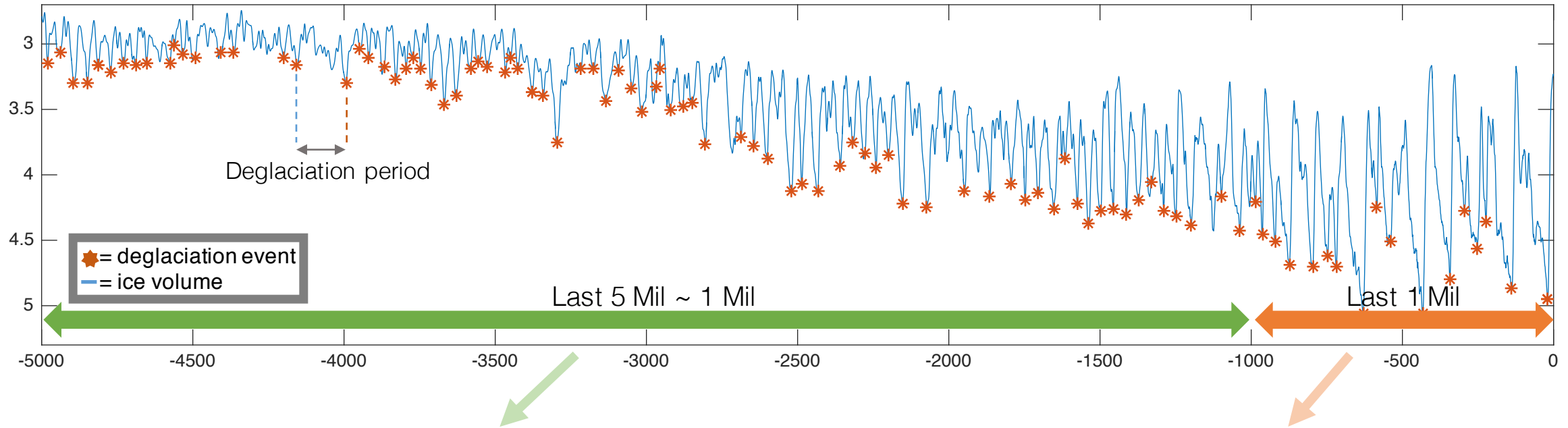


Motivation behind Huybers' model

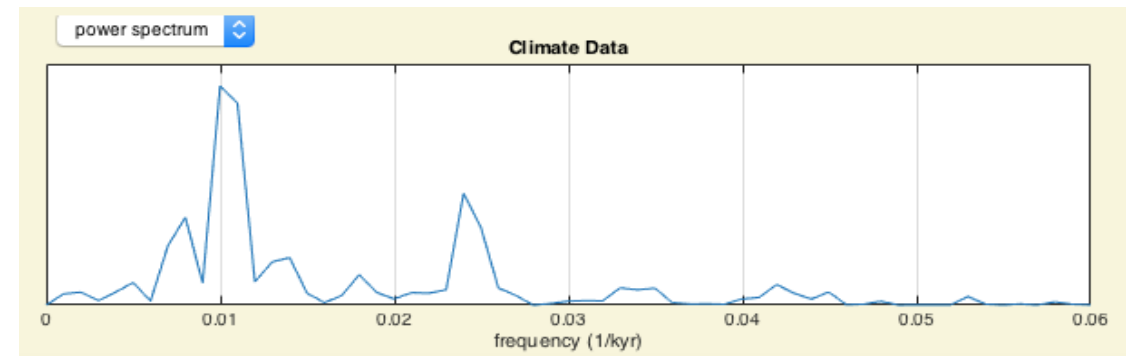
- Mid-Pleistocene Problem (MPT)
- “*Did the main forcing for glacial cycles change from obliquity to eccentricity?*”
(40kyr phase) (100kyr phase)



Power spectrum analysis to confirm 40k and 100k periods



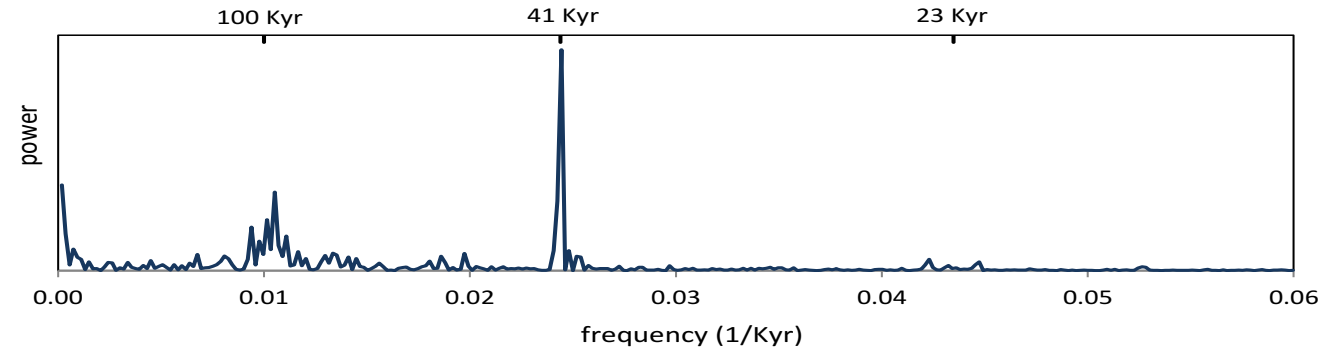
Dominant peak at $\sim 0.025 = 40\text{kyr}$ period



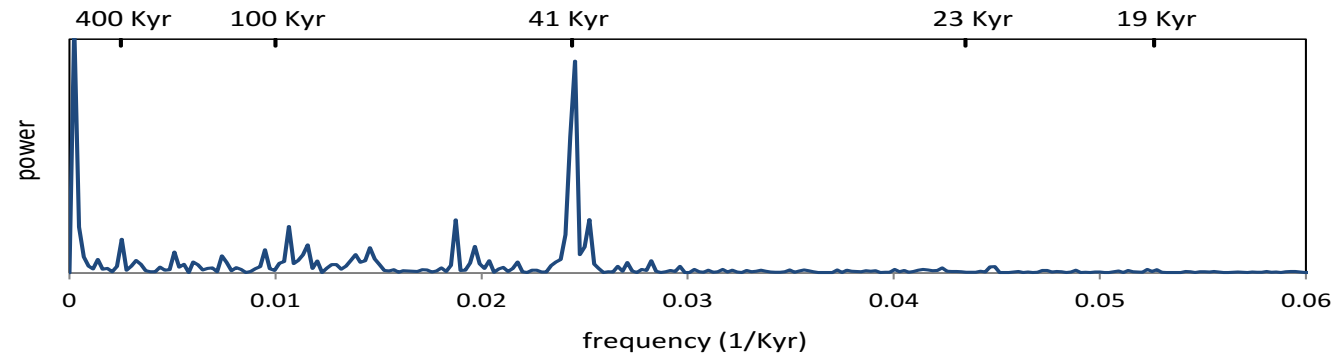
Dominant peak at $\sim 0.01 = 100\text{kyr}$ period

Last Million Years is Different

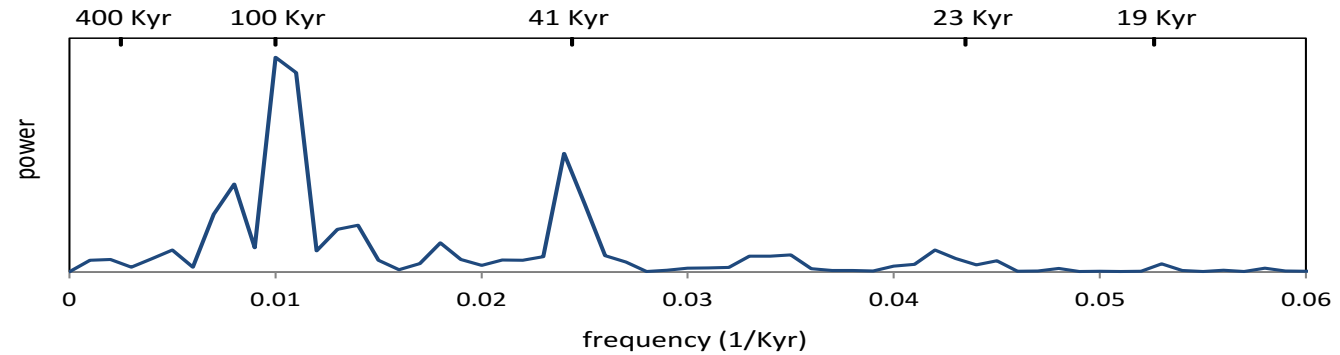
-5 to 0 Myr



-5 to -1 Myr

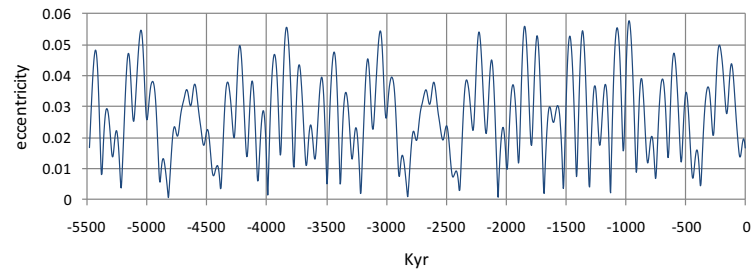


-1 to 0 Myr

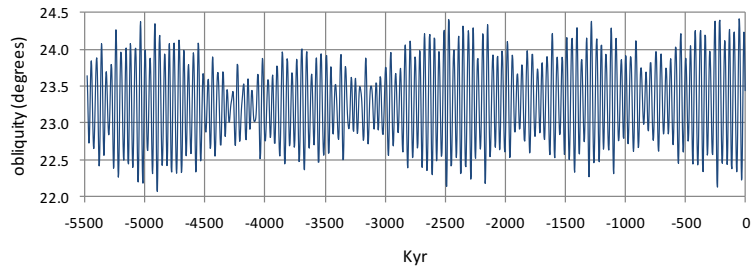
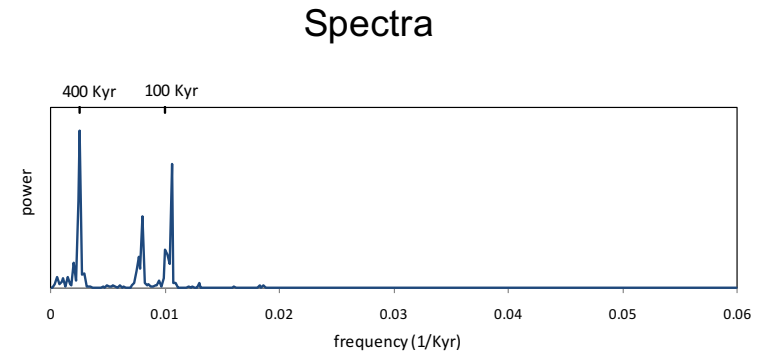


Power spectrum analysis of Milankovitch cycles

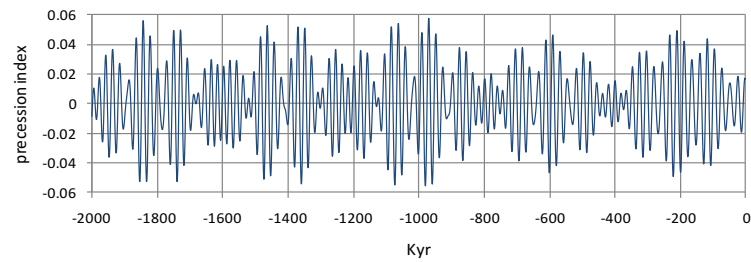
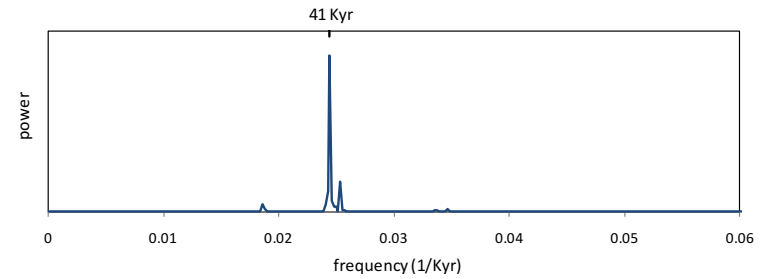
Laskar's computations



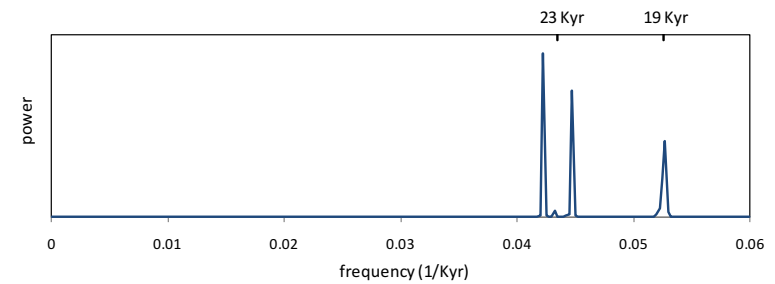
Eccentricity



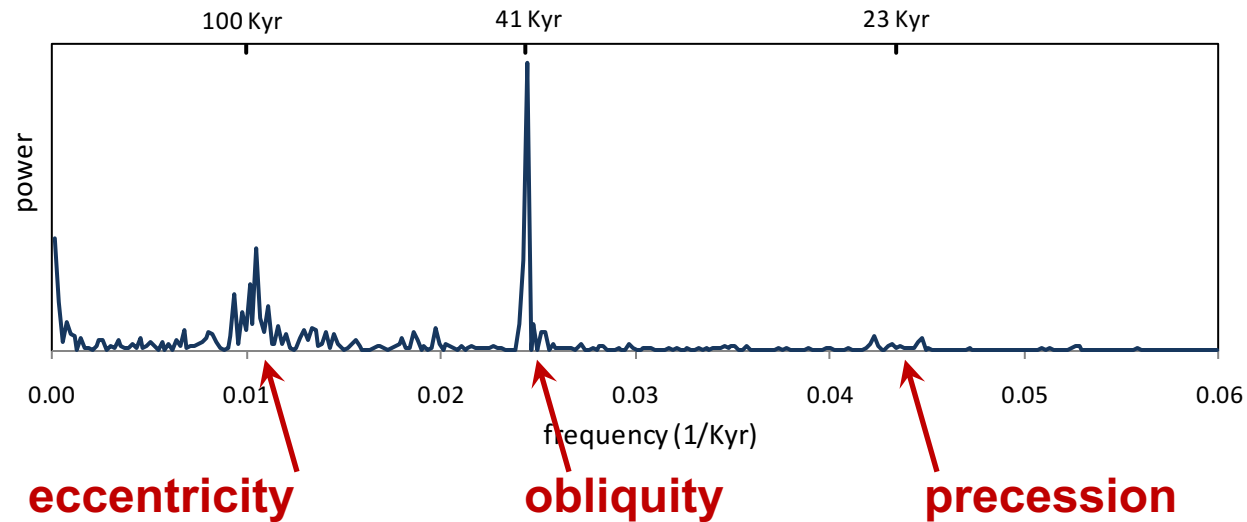
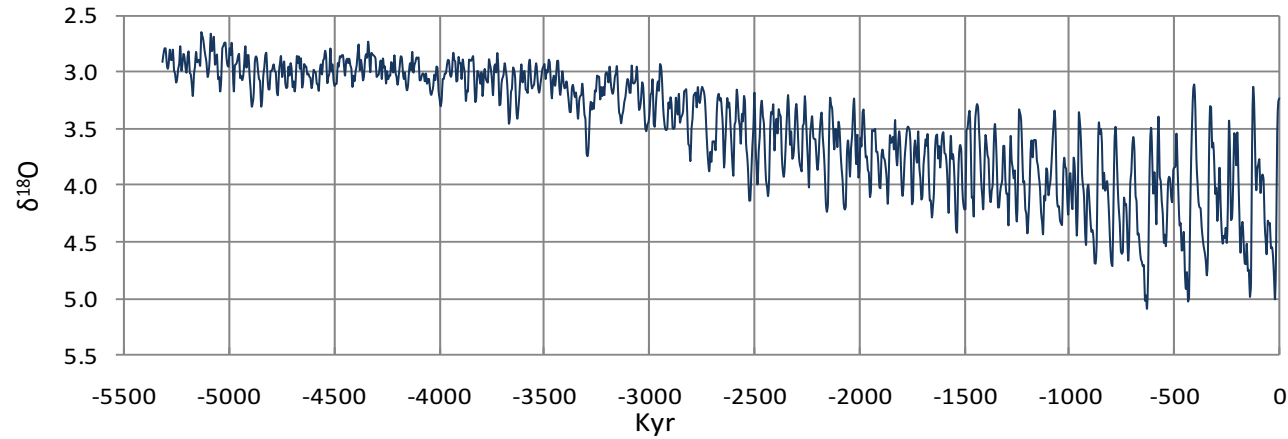
Obliquity



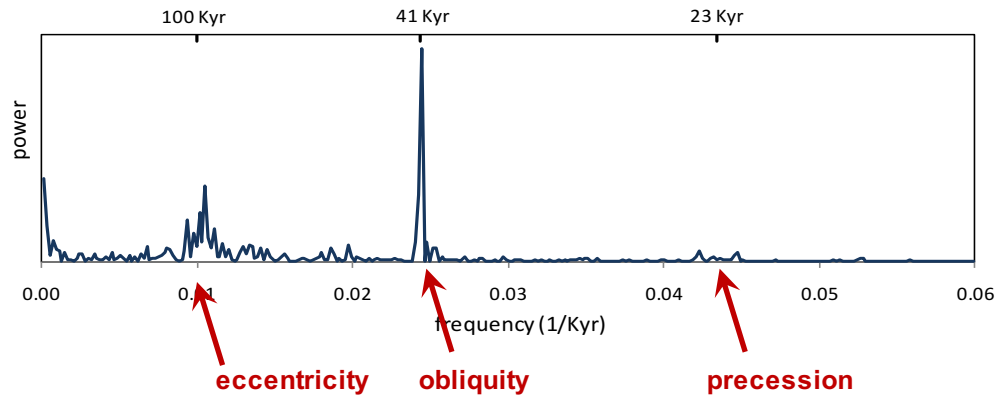
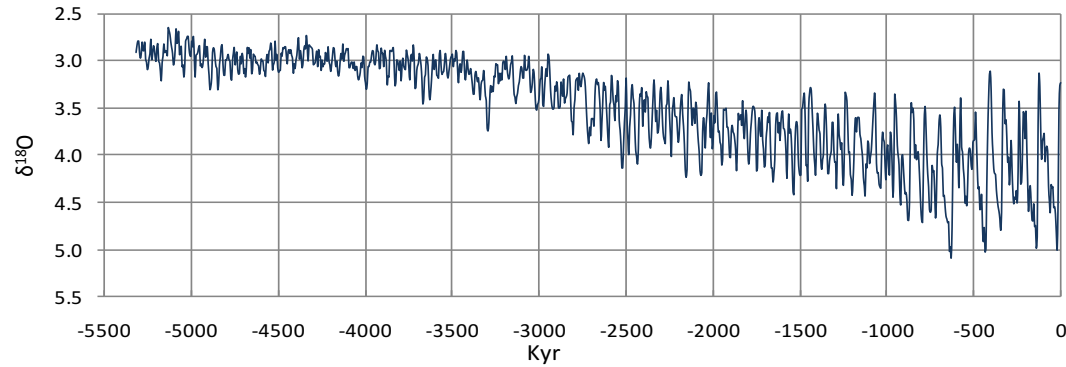
Precession



Power spectrum analysis of Climate data using Milankovich cycles



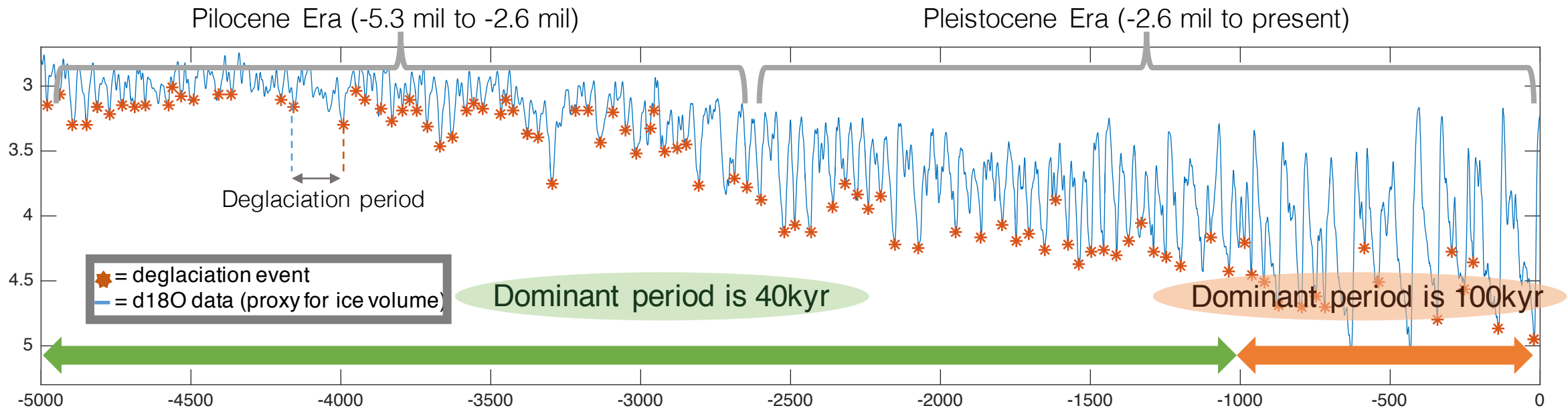
Power spectrum analysis of Milankovitch cycles



Conclusion Remains:
The Milankovitch cycles
“pace” the Earth’s climate.

Exactly how is not so clear.

“Did the main forcing for glacial cycles change from obliquity to eccentricity?”
(40kyr phase) (100kyr phase)

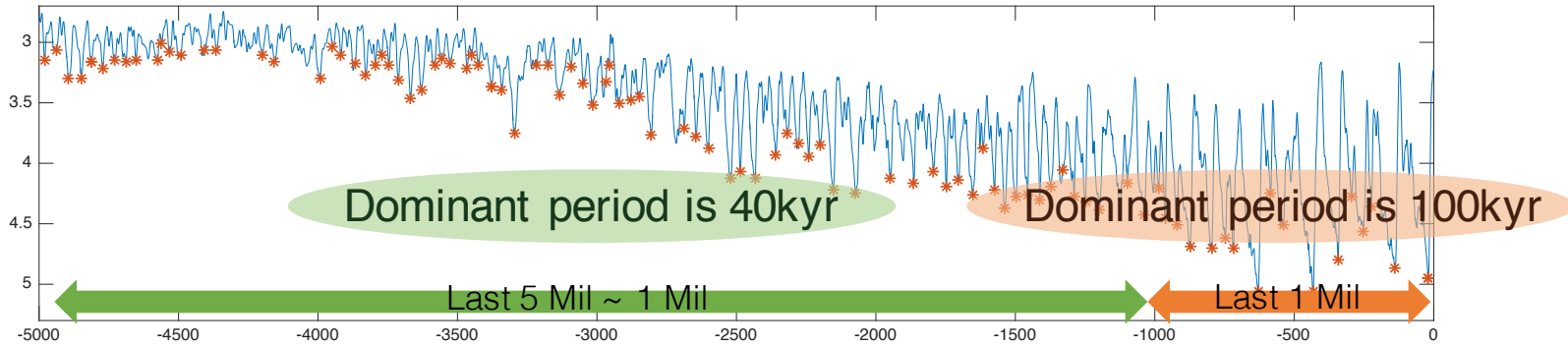


Huybers' Analysis of Deglaciations:

Issue of circular reasoning

- Data sets (stacks of data from individual sediment cores) are usually “orbitally tuned”, i.e., the “age model” is adjusted so the cycles in the data line up with Milankovitch cycles.
- Using tuned data sets to conclude that Milankovitch theory is valid is circular reasoning.
- Huybers rederived the “age model” for a Pleistocene data set without using orbital tuning.
- He concluded that the deglaciations are triggered by obliquity.

Peter Huybers, "Glacial variability over the last two million years: an extended depth-derived age model, continuous obliquity pacing, and the Pleistocene progression," *Quaternary Science Reviews* 26, 37-55 (2007).



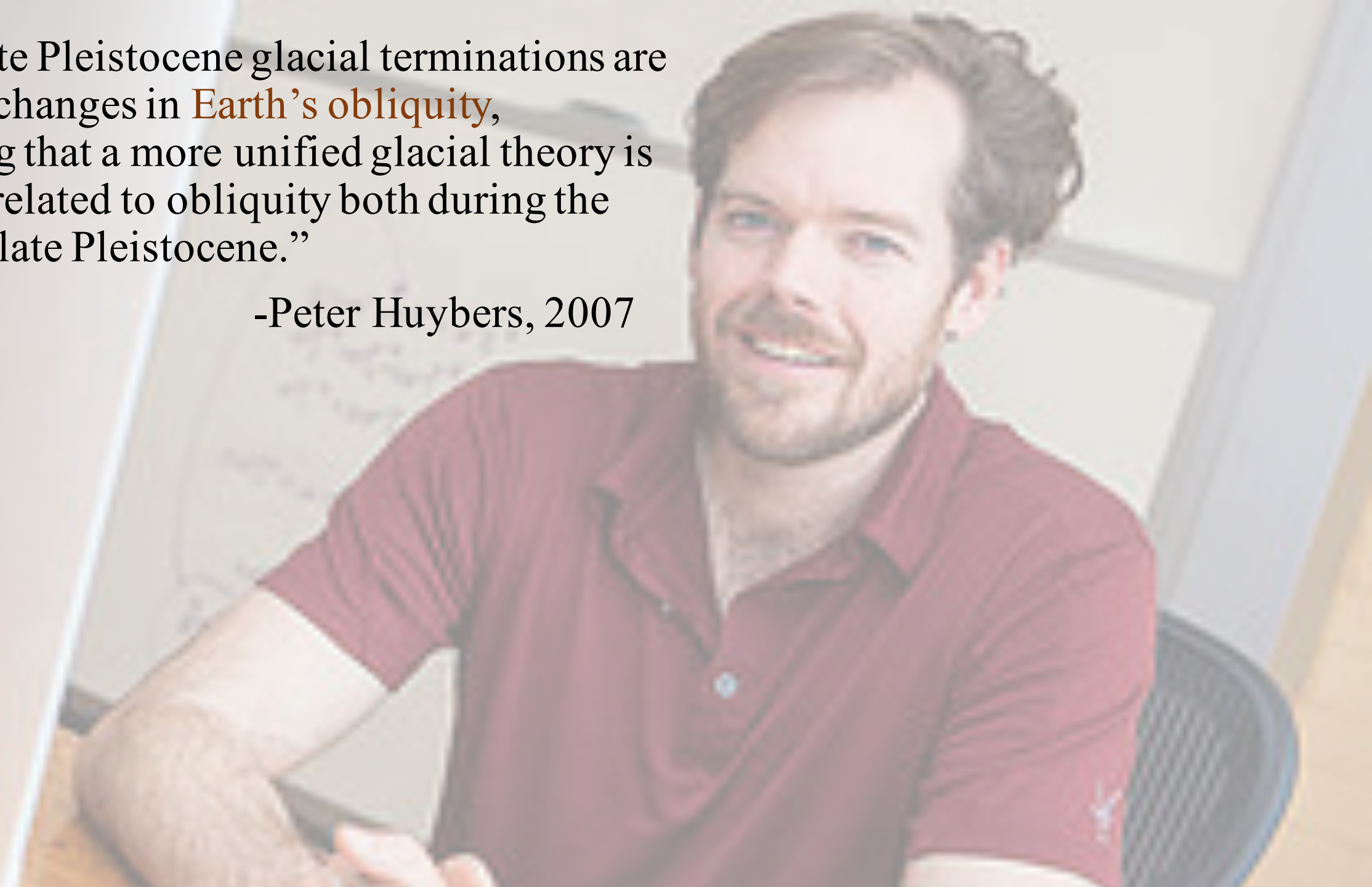
*“Did the main forcing for glacial cycles **change** from obliquity (40kyr period) to eccentricity (100kyr period) at -1 Mil year?”*



*“No, it did **NOT** change. It has been **ONLY obliquity** (40kyr) pacing the glacial cycles for the last 2 Million years”*

“... the late Pleistocene glacial terminations are paced by changes in **Earth’s obliquity**, suggesting that a more unified glacial theory is possible, related to obliquity both during the early and late Pleistocene.”

-Peter Huybers, 2007



Huybers' Model

$$V_t = V_{t-1} + k_t \quad \text{----- Ice Volume}$$

$$T_t = at + b + c\theta_t \quad \text{----- Threshold}$$

If $V_t \geq T_t$, reset over 10kyr to $V_t = 0$ ----- Growth Terminating criterion

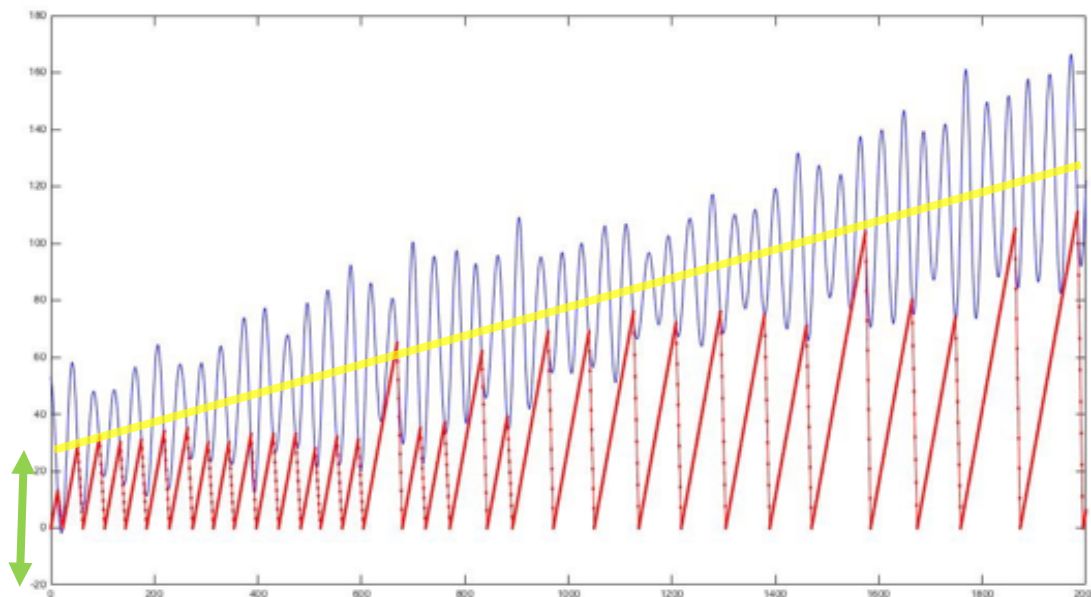
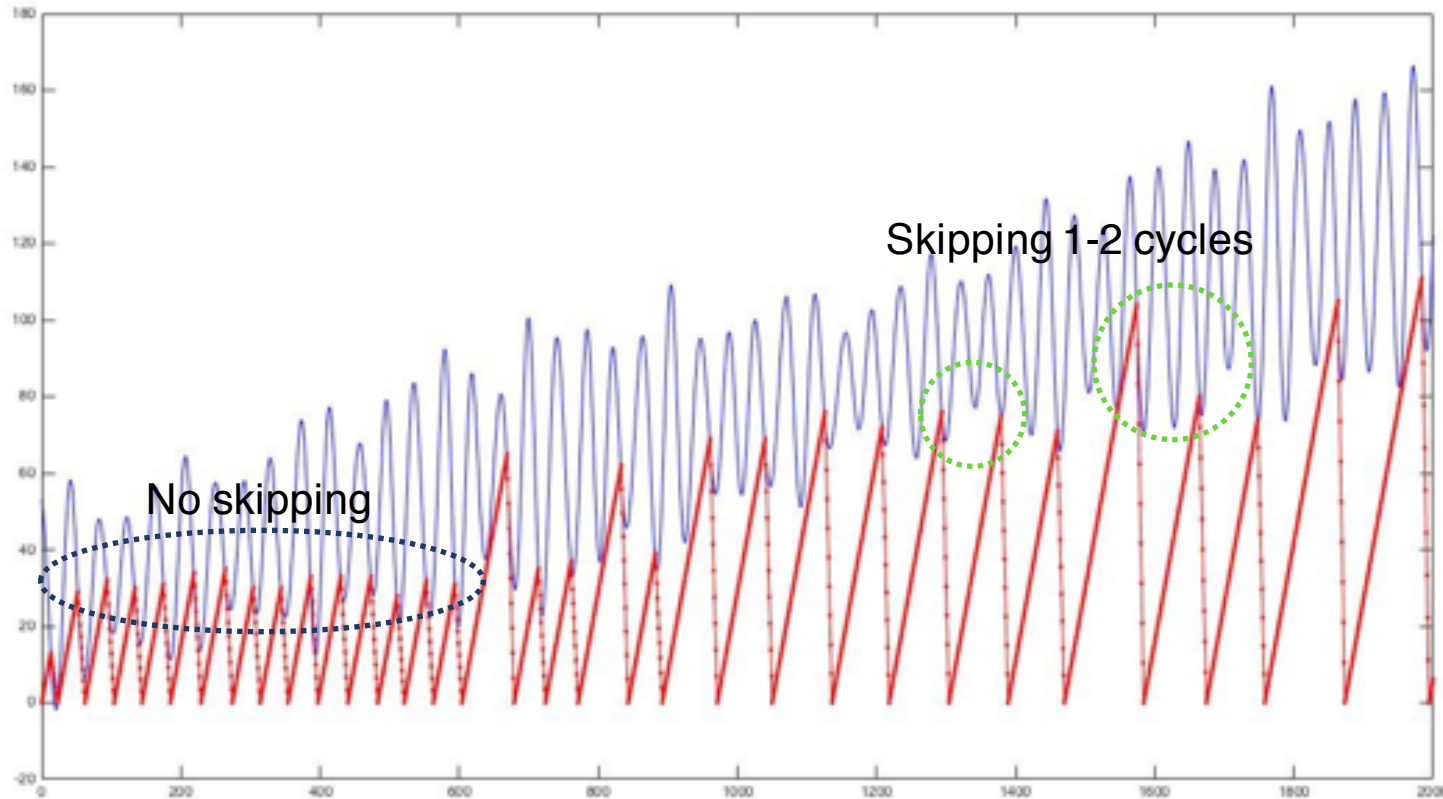


Figure:
Model simulation for last 2 Mil years
with $a=0.05$, $b=126$, $c=20$

BLUE: Threshold function T_t
RED: Glacial volume V_t

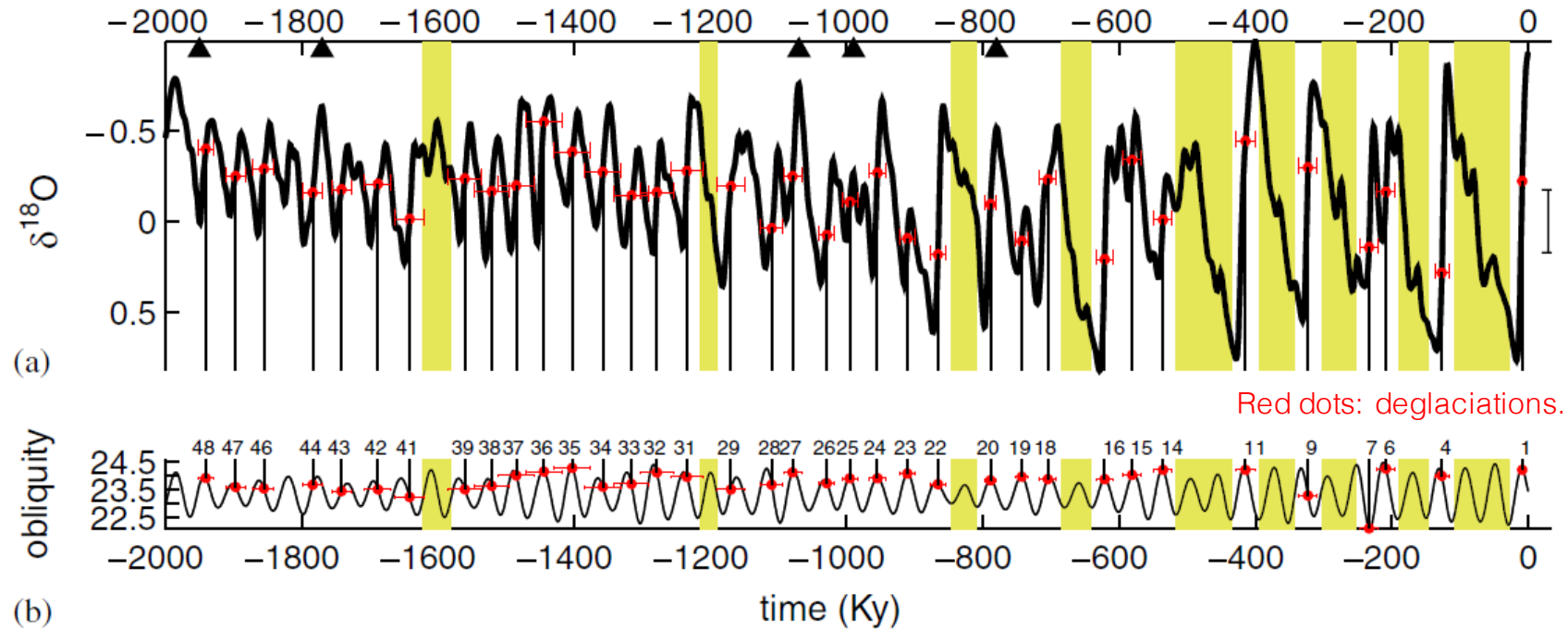
How did obliquity give rise to the shift to 100kyr period?



“...An explanation for the 100 Ka glacial cycles only requires a change in the likelihood of **skipping an obliquity cycle**, rather than new sources of long-period variability.”

- Peter Huybers, 2007

Huybers' Analysis of Deglaciations



$$V_t = V_{t-1} + k_t$$

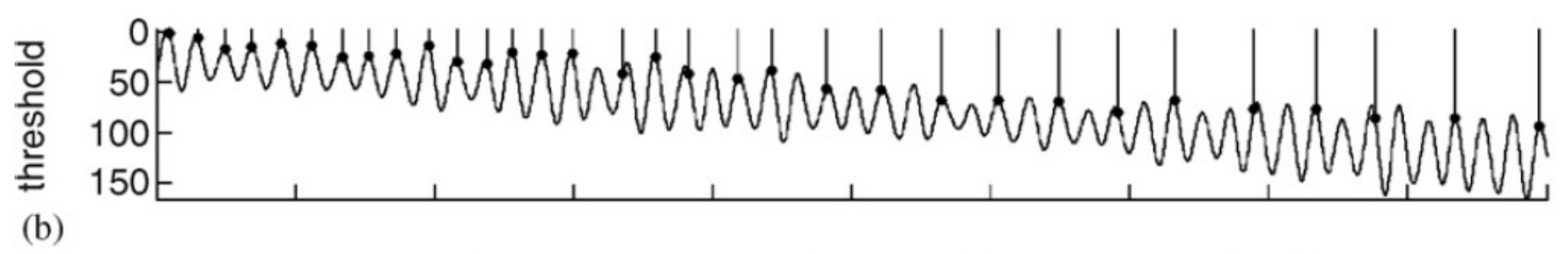
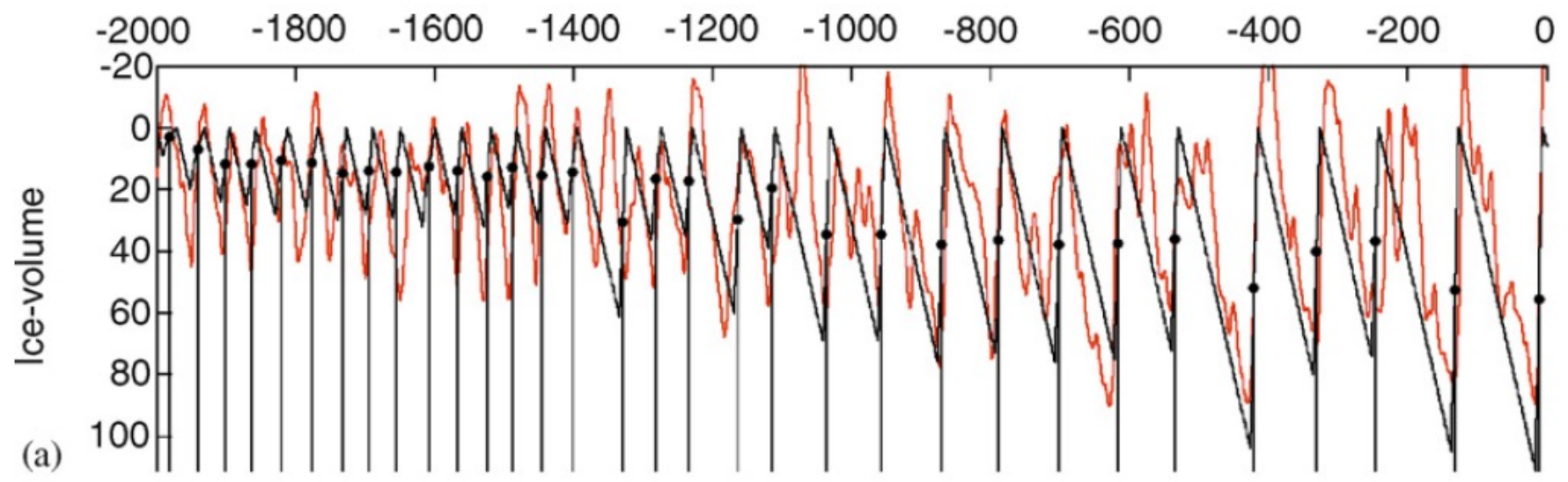
$$T_t = at + b + c\theta_t$$

If $V_t \geq T_t$, reset over 10kyr to $V_t = 0$

$$a = 0.05$$

$$b = 126$$

$$c = 20$$



Huybers' model produces the decline in temperature and the increase in period and amplitude of the glacial cycles,

but it depends heavily on an unspecified decline in the sensitivity of the triggering mechanism over last two million years.