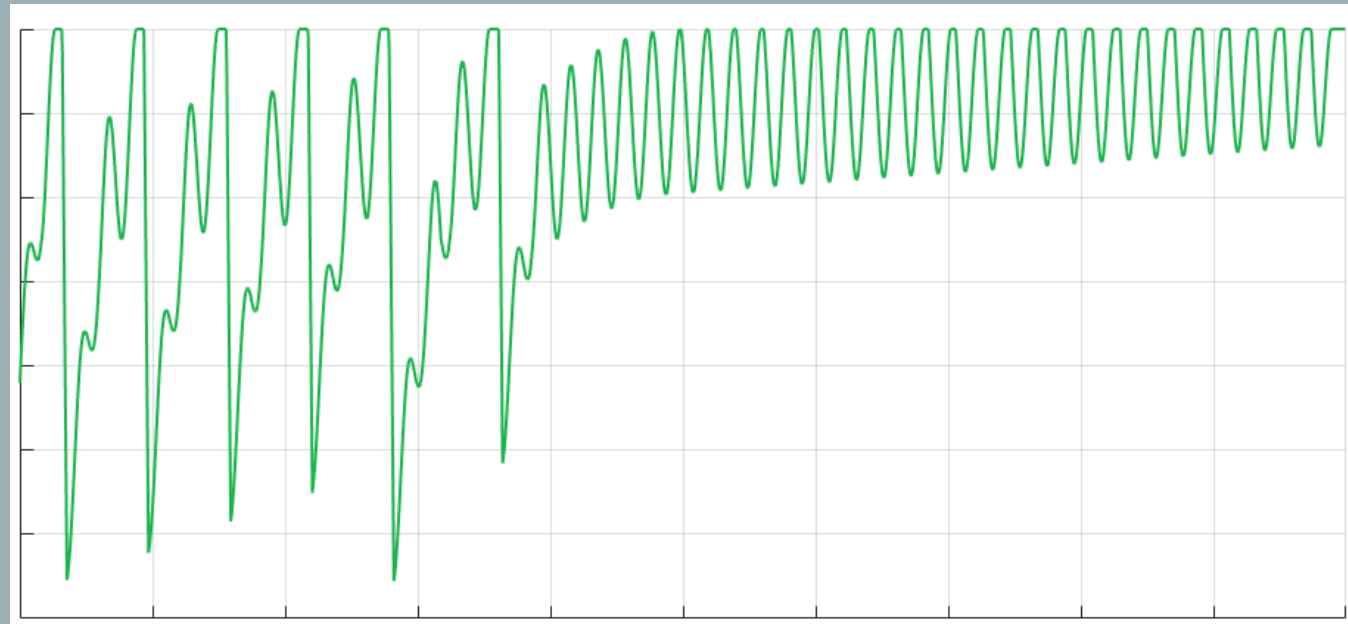
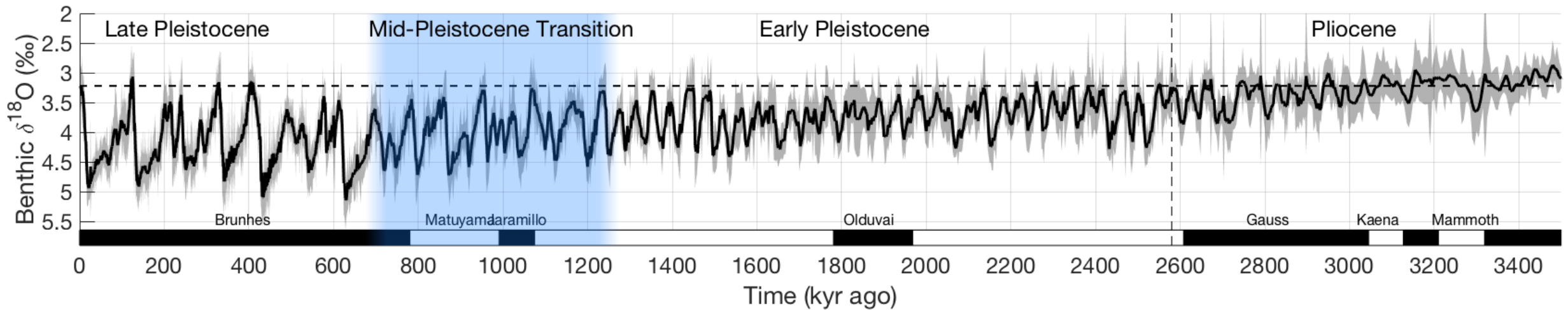


ON THE CAUSE OF THE MID-PLEISTOCENE TRANSITION

C.J. Berends, R.S.W. van de Wal, L.J. Lourens, P. Köhler

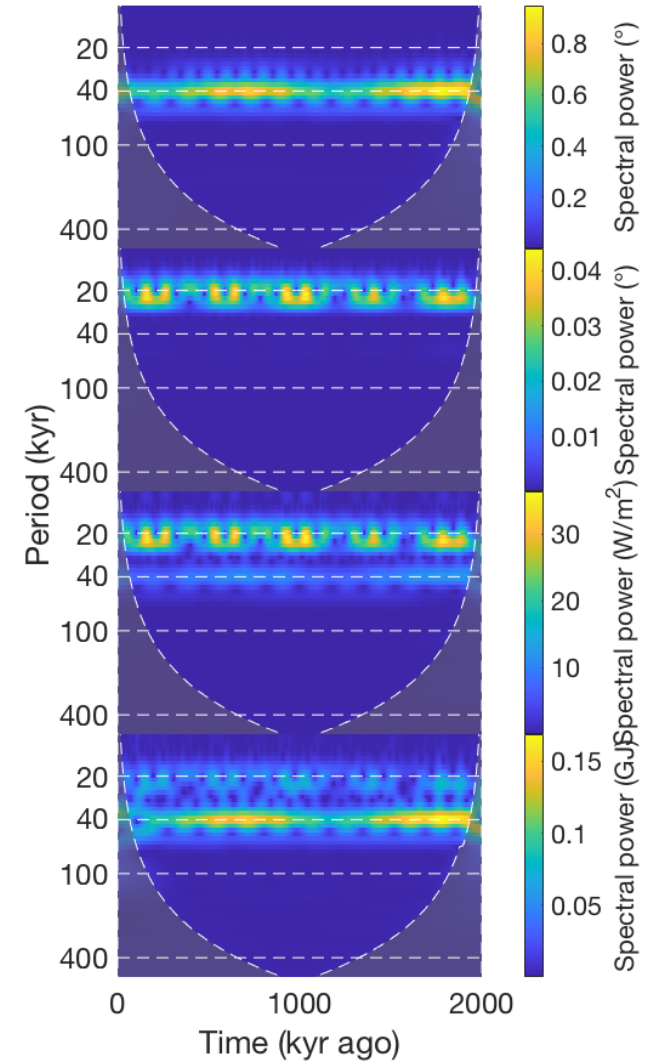
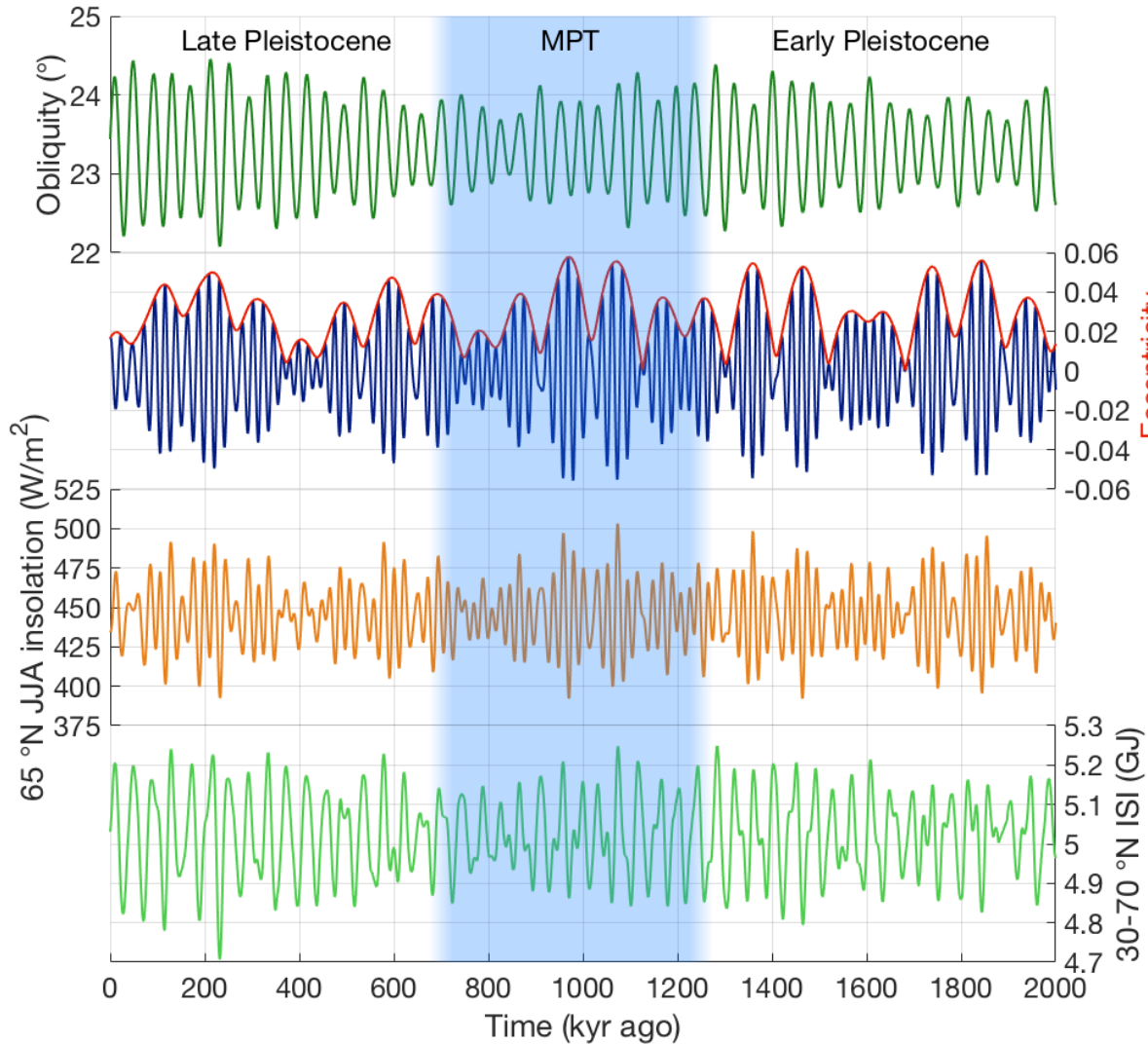


OVERVIEW



- Late Pliocene: warm world (300 – 400 ppm CO_2), small variability
- ~ 2.6 Myr ago: threshold crossed, NH ice outside Greenland
- Early Pleistocene: ~41 kyr cycles, symmetric, 40 – 60 m sea level
- Late Pleistocene: ~100 kyr cycles, asymmetric, 80 – 100 m sea level

OVERVIEW



OVERVIEW

- *How can 41 kyr forcing cause a 100 kyr response?*
- *Why did this only happen after the MPT?*

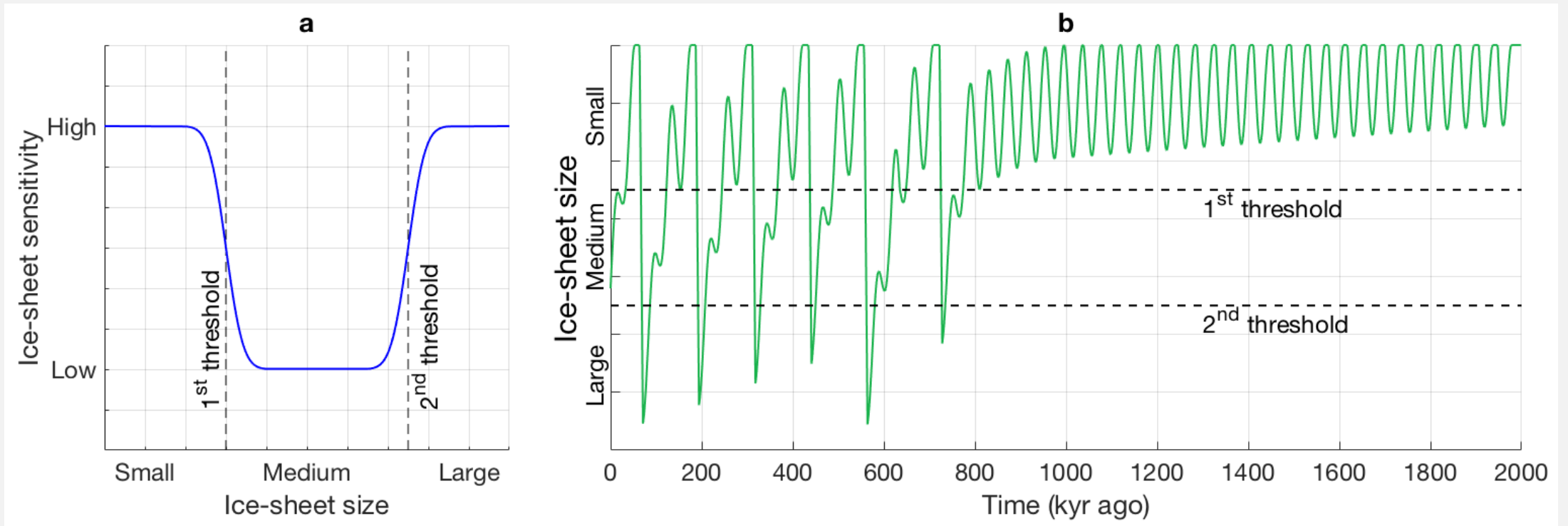
TWO-THRESHOLD FRAMEWORK

Non-linear feedbacks in the Earth system create two ice-sheet size "thresholds", separating response to insolation changes into three regimes:

- "Small": linear response to forcing, insolation maxima cause complete disappearance of ice (Early Pleistocene)
----- first threshold -----
- "Medium": self-sustained growth allows ice-sheets to survive insolation maxima, continuing growth into next insolation cycle (Late Pleistocene)
----- second threshold -----
- "Large": ice-sheets become unstable; small warming can trigger runaway retreat (needed to explain terminations)

TWO-THRESHOLD FRAMEWORK

A very simple abstract model of this two-threshold system, forced with a 41-kyr cycle plus a cooling trend, reproduces the basic features of the MPT.



GLOBAL COOLING HYPOTHESIS

- If the two-threshold view is correct, then a small background cooling would be enough to cause the MPT
- CO₂ decrease could be caused by weathering, oceanic carbon changes
- Proxy evidence remains (in our view) inconclusive
- Beyond EPICA: very interesting!

REGOLITH HYPOTHESIS

- Regolith (soil) lubricates ice sheets, facilitates sliding
 - More sliding means...
 - ...wider, thinner ice sheets, means...
 - ...larger ablation zones, means...
 - ...more sensitive to insolation changes.
-
- Early Pleistocene: N.America and Europe still covered in regolith
 - MPT: disappearance of regolith through erosion
 - Late Pleistocene: ice sheets on bedrock

DISCUSSION

- Many studies look at a single physical mechanism behind either of the two thresholds (usually the first one)
- Most are plausible; likely all contributed to some degree
- Differences between models and experimental set-up makes intercomparison difficult; more structured effort needed!
- Pre-MPT proxy data uncertainties large; cooling trend possible
- Model studies can do more to reproduce proxies; proxy studies can do more to think about implications of their findings

