Abrupt Changes in Atmospheric $\Delta^{14}C$ and CO_2 at the Onset of the Bølling/Allerød: the Permafrost Thawing Hypothesis

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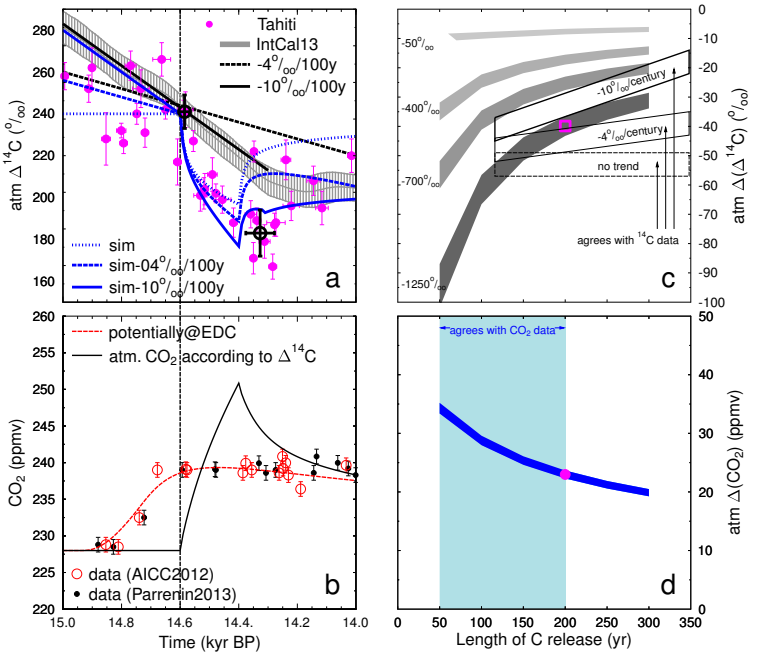
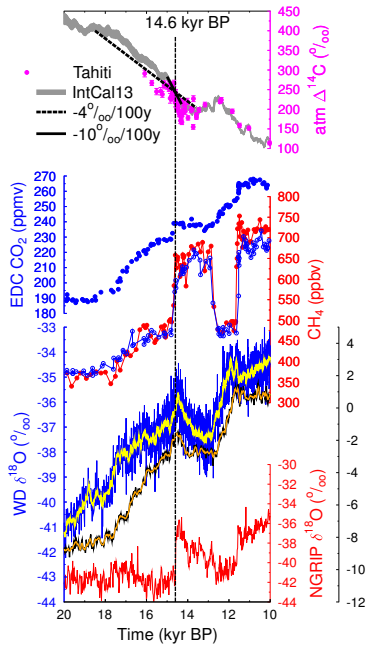
One of the most abrupt and yet unexplained CO_2 rises found in the ice cores (>10 ppmv in two centuries) occurred quasi-synchronous with the abrupt northern hemispheric warming into the Bølling/Allerød around 14,600 years ago. Here we use U/Th dated atmospheric $\Delta^{14}C$ from Tahiti corals as independent and precise age control for this CO_2 rise in combination with simulations to show that the release of old nearly ^{14}C-free carbon might have caused these changes in CO_2 and $\Delta^{14}C$. The $\Delta^{14}C$ data also independently constrain the magnitude of the carbon released to about 125 PgC. We suggest, in line with CH_4 records and terrigenous biomarkers, that carbon released from thawing permafrost in the high northern latitudes might be the source of the abrupt CO_2 rise, partly caused by Siberian shelf flooding during meltwater pulse 1A. Our findings highlight the potential of the permafrost carbon reservoir to modulate abrupt climate changes via greenhouse-gas feedbacks.

Simulated $\Delta^{14}C$ and CO_2

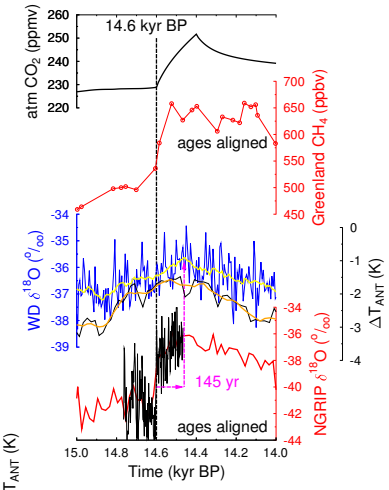


Left: Simulation vs data. Right: Best-guess scenario (125 PgC in 200 yr) against data.

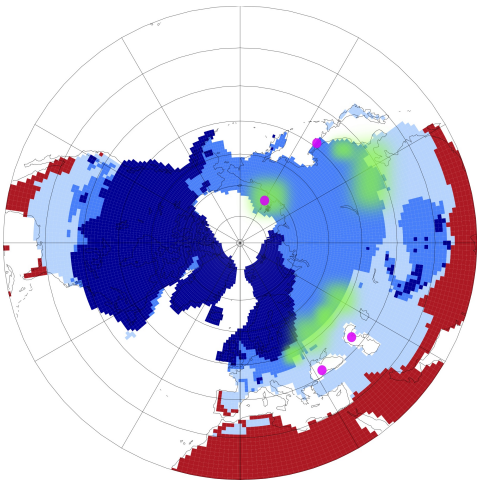
Termination I



15–14 kyr BP

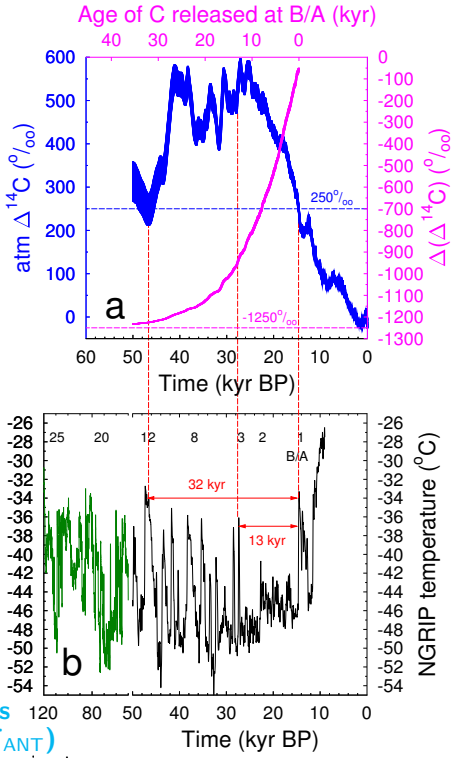


Permafrost thawing — where?

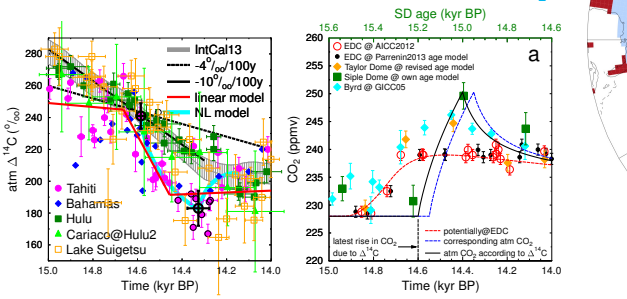


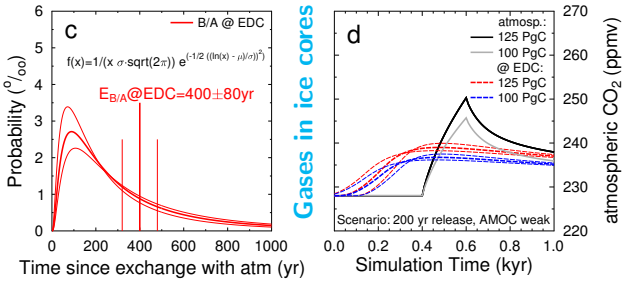
PMIP3 LGM: ice (dark blue), permafrost (blue), seasonal frozen (light blue), not frozen (red), potential thawing (green).

^{14}C signature of old soil carbon

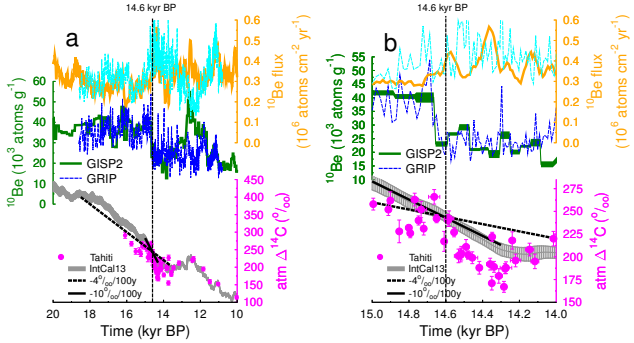


$\Delta^{14}C$ Details on Data CO_2

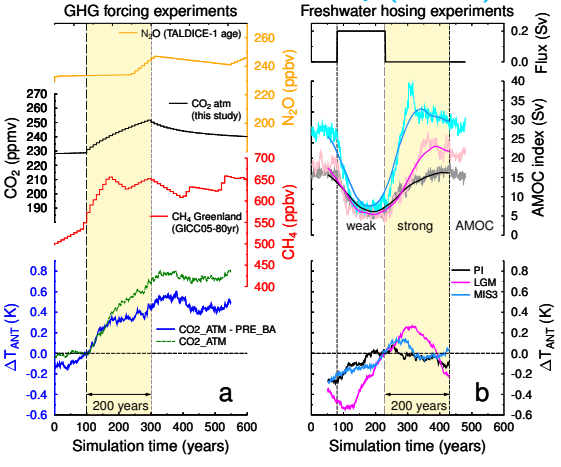




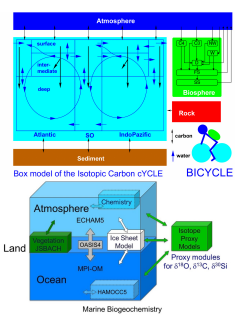
^{10}Be data indicate no change in ^{14}C production rate



GHG versus AMOC impacts on Antarctic surface temp (ΔT_{ANT})



Methods



Reference for ^{14}C data:
Durand, N. et al. Comparison of ^{14}C and U-Th ages in corals from IODP #310 cores offshore Tahiti. Radiocarbon 55, 19471974 (2013).