

Permafrost thawing as a possible source of abrupt carbon release at the onset of the Bølling/Allerød

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Permafrost thawing as a possible source of abrupt carbon release at the onset of the Bølling/Allerød

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based on EPICA Dome C CO₂

WAIS Divide Ice Core CO₂ (Marcott et al., 2014) published 30 October 2014

Carbon Cycle Changes

After the WAIS Divide Ice Core CO₂ record

Take-Home-Messages

Dynamics at onset of Bølling/Allerød (14.6 ka BP)

atm $\Delta^{14}\text{C}$ (Tahiti corals) drops by 55‰

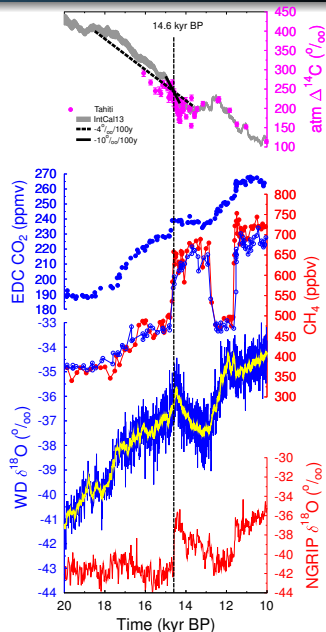
CO_2 EDC rises by 10 ppmv

CH_4 rises by 150 ppbv

WAIS Divide $\delta^{18}\text{O}$ start of
Antarctic Cold Reversal (ACR)

NGRIP $\delta^{18}\text{O}$ (ΔT_{NH}) jumps
within decades

(Reimer et al 2013; Durand et al 2013; Parrenin et al 2013;
Monnin et al 2001; EPICA 2006; WAIS 2013; NGRIP 2004)



Carbon Cycle Changes

Atm $\Delta^{14}\text{C}$ & CO_2 changed by the same process: Results from carbon cycle box model BICYCLE

$\Delta(\Delta^{14}\text{C}) = -50$ to -60‰
in 200 – 250 years.

CO_2 : +10ppmv in EDC
+22 ppmv in atmosphere

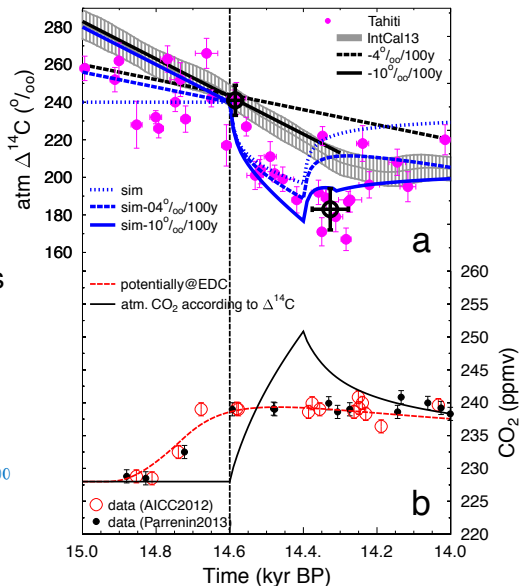
C cycle model (box, EMIC)

- (1) Validated with Suess Effect
- (2) Agree, reproduce anomalies

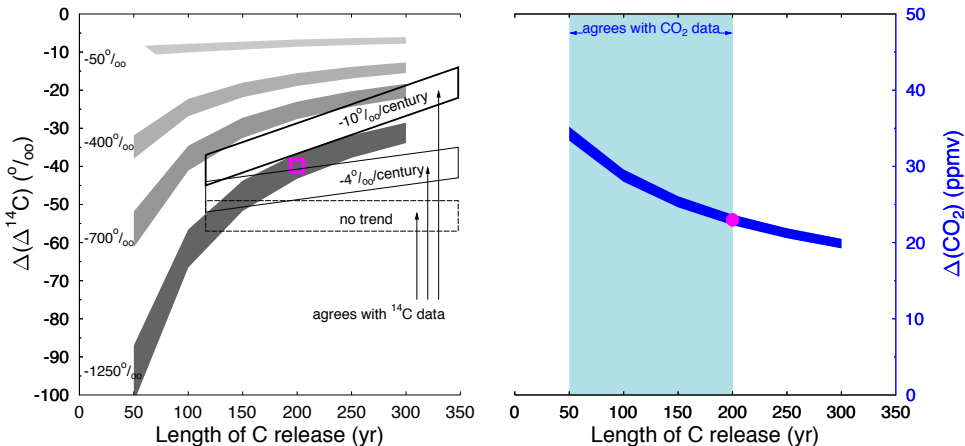
Absolute dated (U/Th)
atmospheric CO_2 peak
starting at 14.6 kyr BP

$\Delta(\Delta^{14}\text{C})(\text{atm-source}) = -1250\text{‰}$
needed (not deep ocean DIC)

(Reimer et al 2013; Durand et al 2013;
Parrenin et al 2013; Veres et al 2013)



Atm $\Delta^{14}\text{C}$ & CO_2 changed by the same process: Results from carbon cycle box model BICYCLE

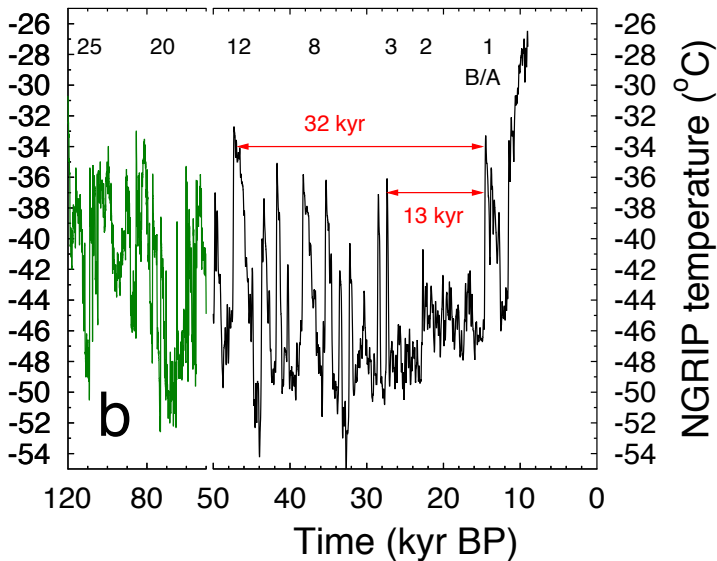


$\Delta(\Delta^{14}\text{C})(\text{atm-source}) = -1250\text{‰}$ needed (not deep ocean DIC)

CO_2 outgassing over at max 200 yr

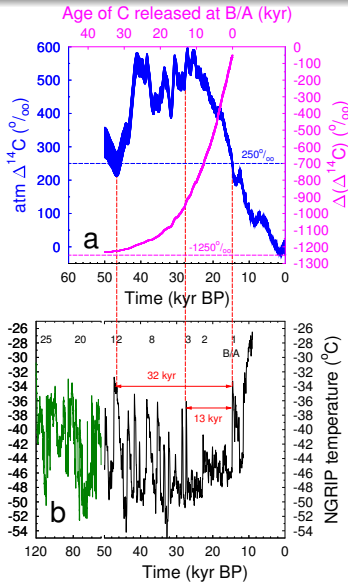
(maximum peak length due to ice core CO_2 data)

Source of very old carbon virtually free of ^{14}C ???



Last time NH was similar warm as B/A was D/O 12 at 47 kyr BP.

Source of very old carbon virtually free of ^{14}C ???



$\Delta(\Delta^{14}\text{C})(\text{atm-source})$:
 -1250‰ needed,
 not found in ocean

⇒ permafrost thawing

Last time NH was similar warm as
 B/A was during
 D/O 12 at 47 kyr BP.

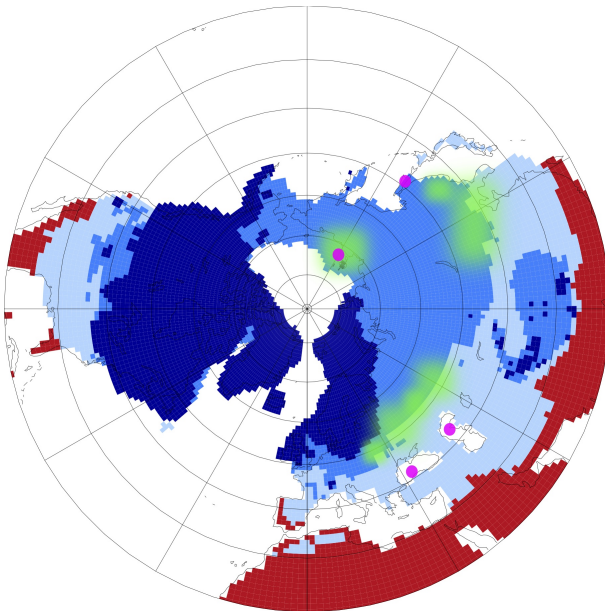
Soil C produced
 during D/O 12
 would have the $\Delta^{14}\text{C}$ signature
 necessary to explain $\Delta^{14}\text{C}$.

(Reimer et al., 2013; Kindler et al., 2014)

Permafrost thawing: Where?

PMIP3 LGM

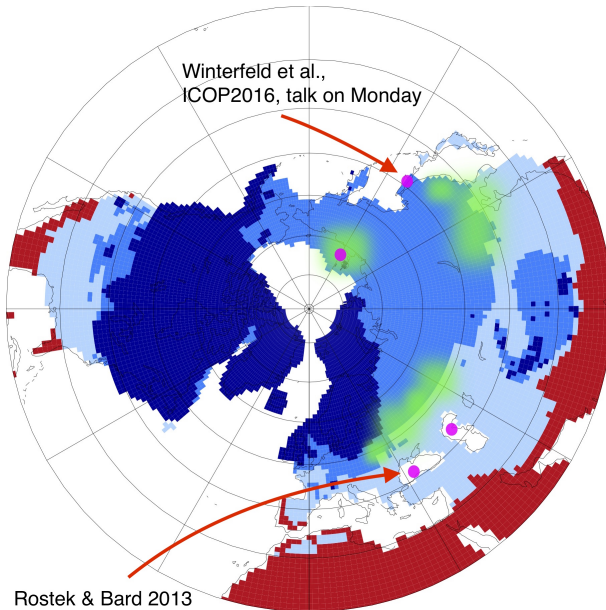
(Saito et al 2013)



Permafrost thawing: Where?

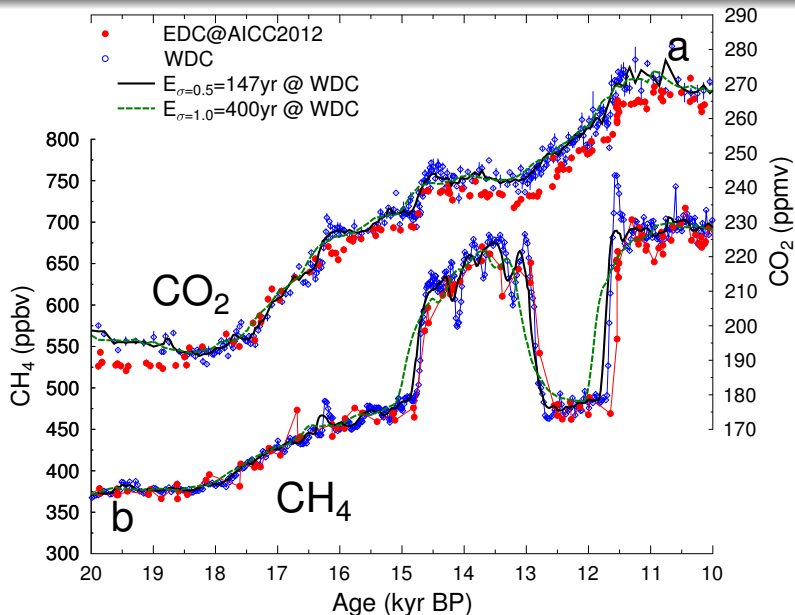
PMIP3 LGM

(Saito et al 2013)



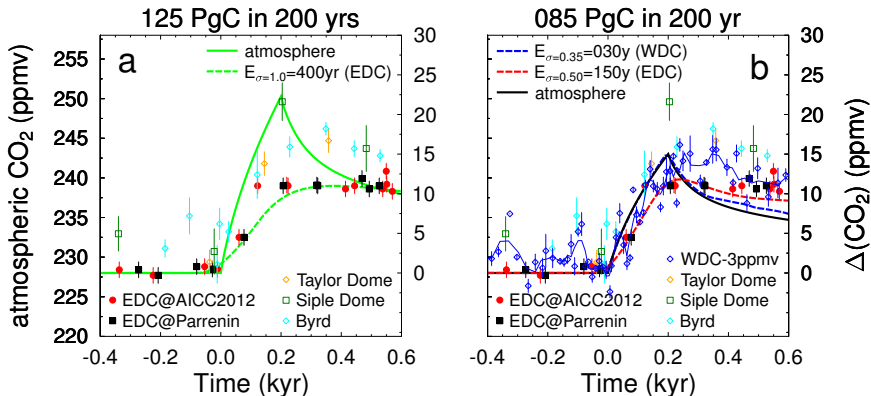
After the WAIS Divide Ice Core CO₂ record

New high resolution CO₂ from WAIS Divide (WDC)



Marcott et al. 2014, Nature, 30 Oct 2014

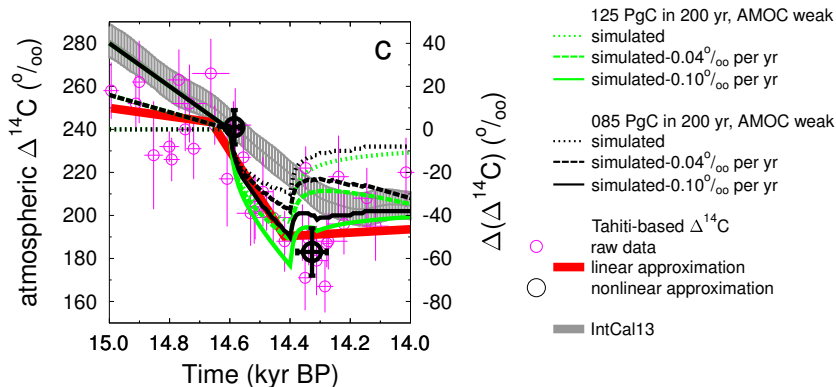
New high resolution CO₂ WAIS Divide Ice Core (WDC)



Permafrost thawing still valid with smaller CO₂ amplitude:
Release of 85 instead of 125 PgC
leading to atm. ΔCO_2 of 15 instead of 22 ppmv.

Parrenin 2013, Veres 2013, Smith 1999, Ahn 2004, Neftel 1988, Pedro 2012, Marcott 2014

New high resolution CO₂ from WAIS Divide (WDC): Atmospheric $\Delta(\Delta^{14}\text{C})$

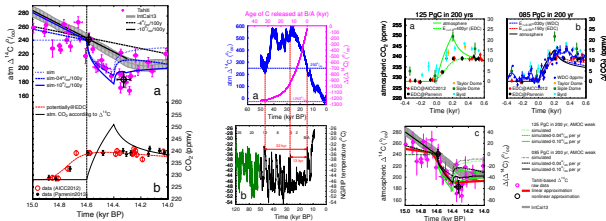


In revised WDC-based scenario:
CO₂ essential free of ^{14}C necessary
($\Delta(\Delta^{14}\text{C}) = -1250\text{‰}$)

Reimer 2013, Durand 2013

Take-Home-Messages

Take-Home-Messages — 14.6 ka Event



- Old permafrost is (so far) the only plausible source of very old carbon virtually free of ^{14}C .
- Permafrost thawing hypothesis still valid when new WDC CO_2 data are considered, 85 PgC in 200 years lead to atm ΔCO_2 of 15 ppmv.
- After the new WDC CO_2 data, the C-amplitude gets smaller, but the need for ^{14}C -free C gets more urgent.
- Results can be used to U/Th-date the atmospheric CO_2 peak (starts to rise at 14.6 kyr BP).