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

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21 June 2016
XI. International Conference on Permafrost (ICOP2016)
Potsdam, Germany

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

nature COMMUNICATIONS

ARTICLE

Received 7 Apr 2014 | Accepted 9 Oct 2014 | Published 20 Nov 2014

DOI: 10.1038/ncomms6520 OPEN

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 CO_2

WAIS Divide Ice Core CO_2 (Marcott et al., 2014) published 30 October 2014

Content

Carbon Cycle Changes

After the WAIS Divide Ice Core CO_2 record

Take-Home-Messages

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

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

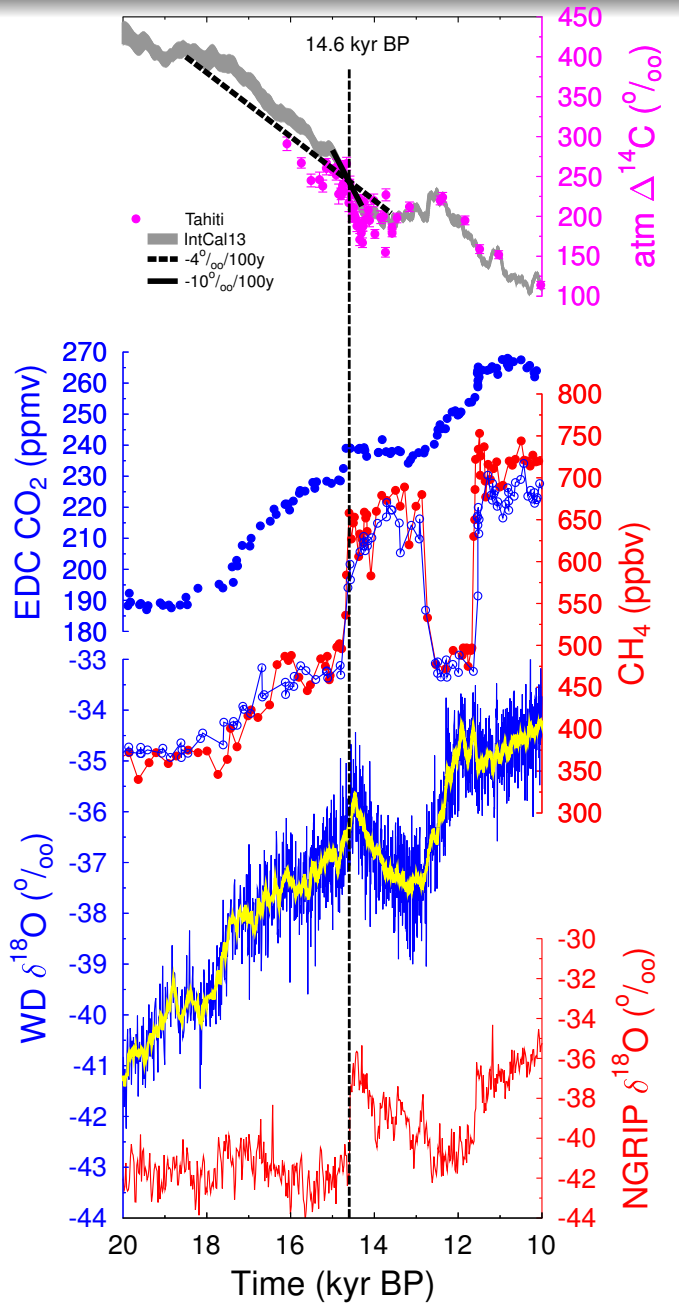
CO_2 EDC rises by 10 ppmv

CH_4 rises by 150 ppbv

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

NGRIP $\delta^{18}O$ (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 $\Delta^{14}C$ & CO_2 changed by the same process: Results from carbon cycle box model BICYCLE

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

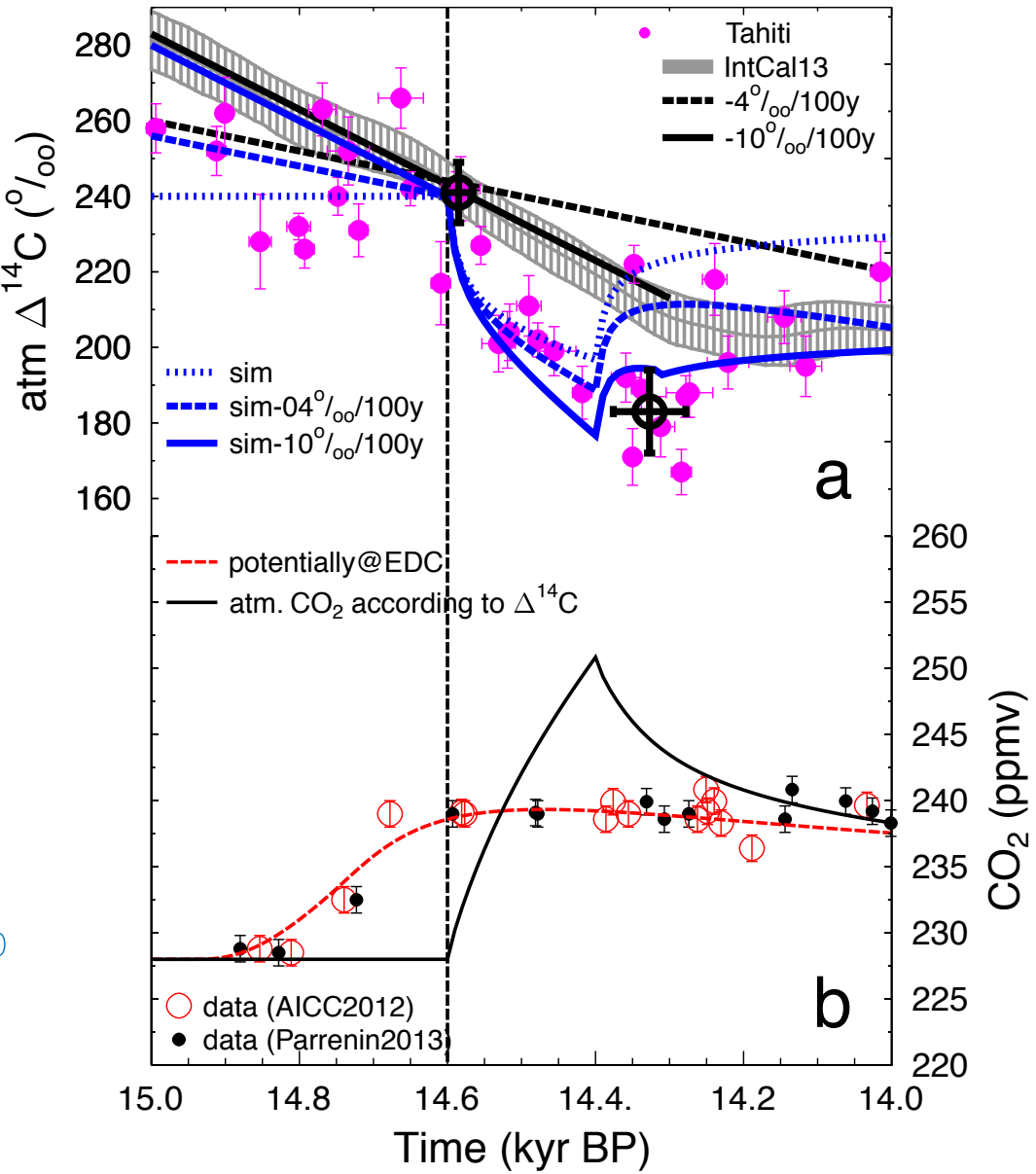
CO_2: +10ppmv in EDC
+22 ppmv in atmosphere

C cycle model (box, EMIC)
(1) Validated with Suess Effect
(2) Agree, reproduce anomalies

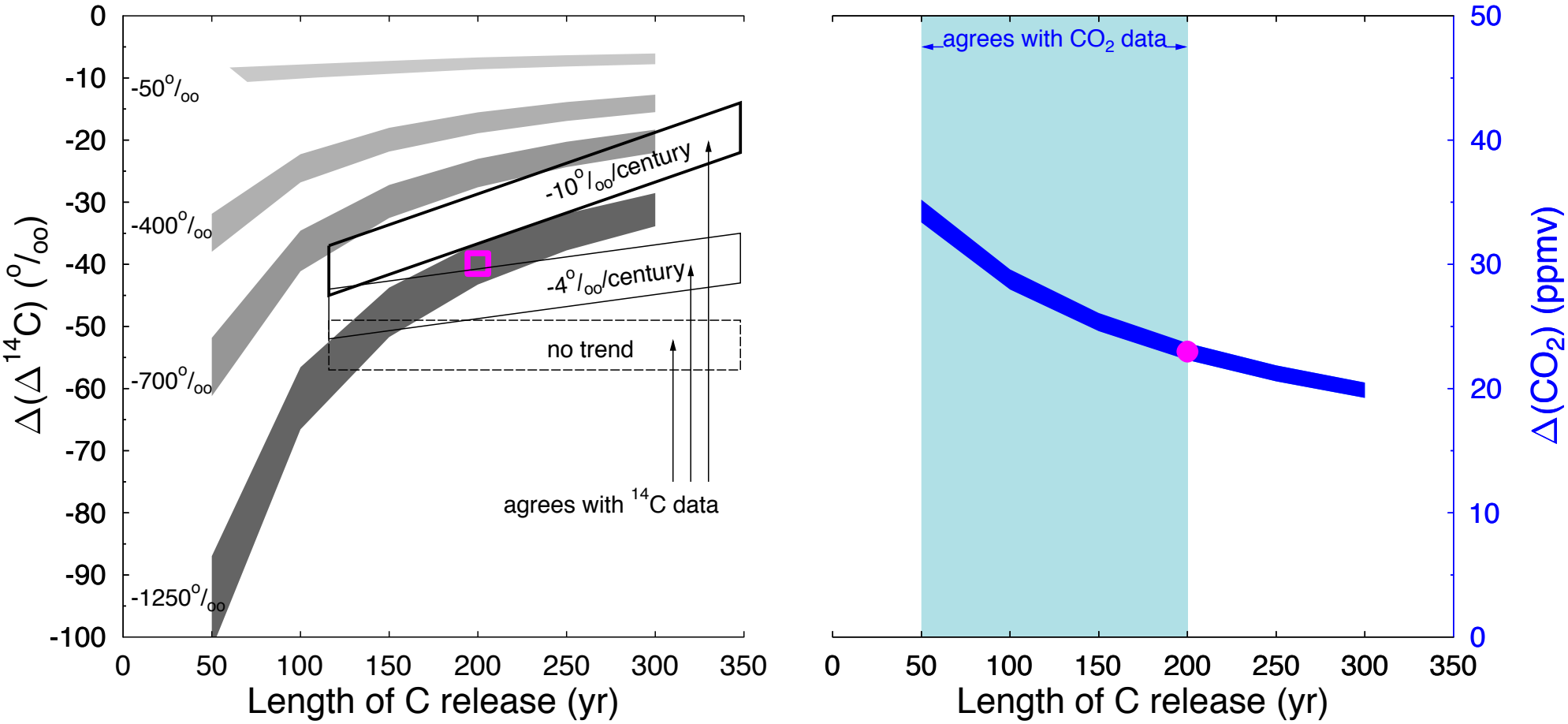
Absolute dated (U/Th) atmospheric CO_2 peak starting at 14.6 kyr BP

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

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



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

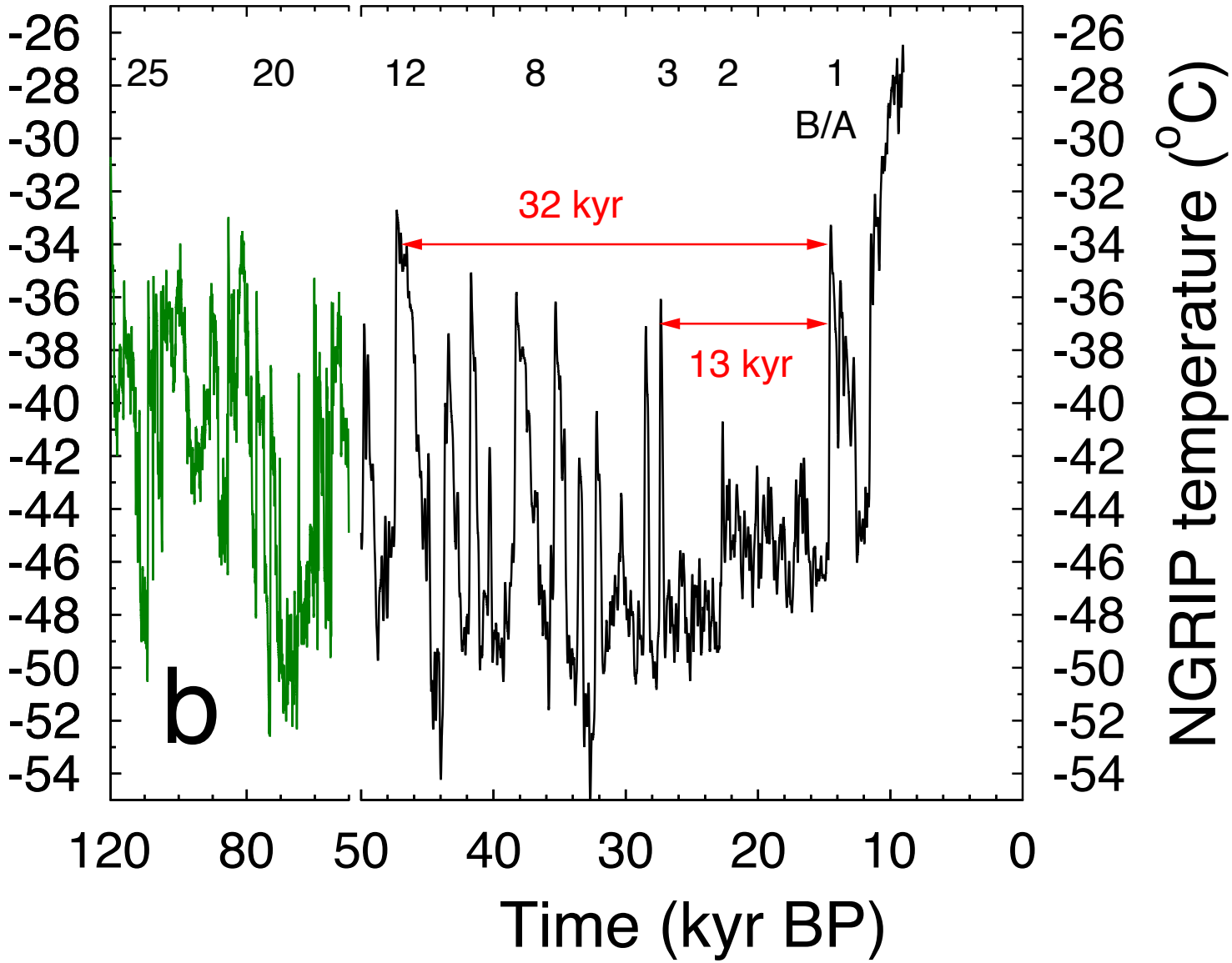


$\Delta(\Delta^{14}C)$(atm-source) = -1250‰ needed (not deep ocean DIC)

CO2 outgassing over at max 200 yr

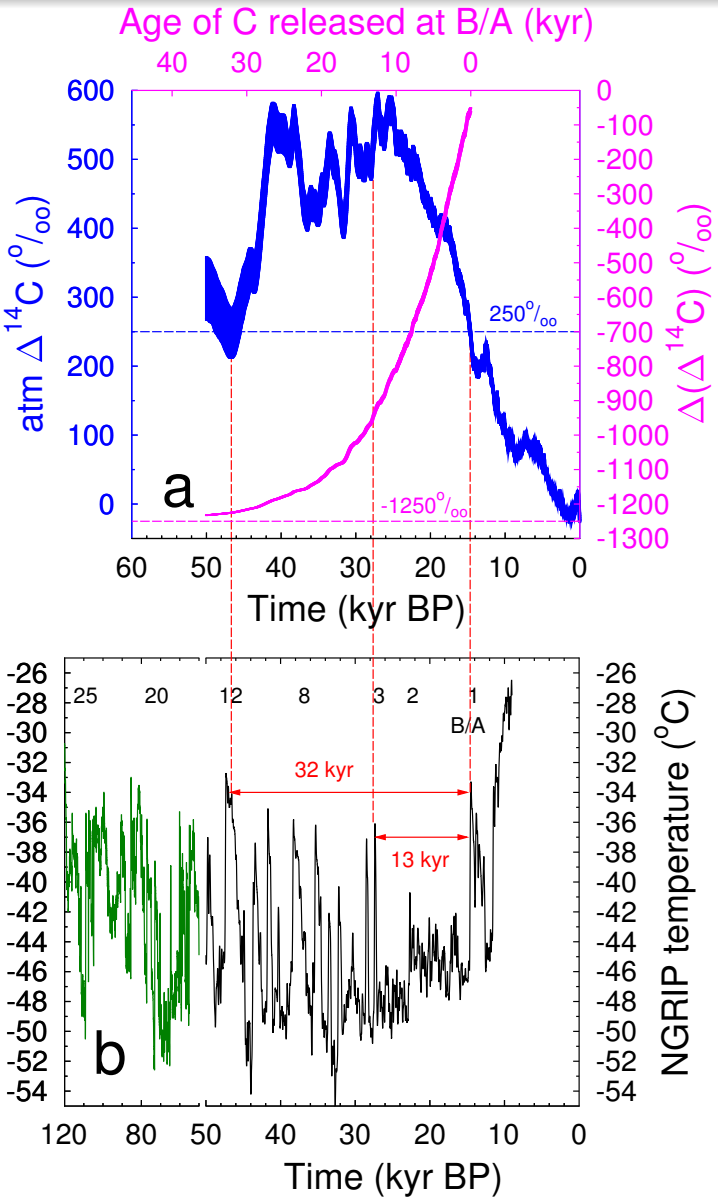
(maximum peak length due to ice core CO2 data)

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???



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

$\Rightarrow$ permafrost thawing

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

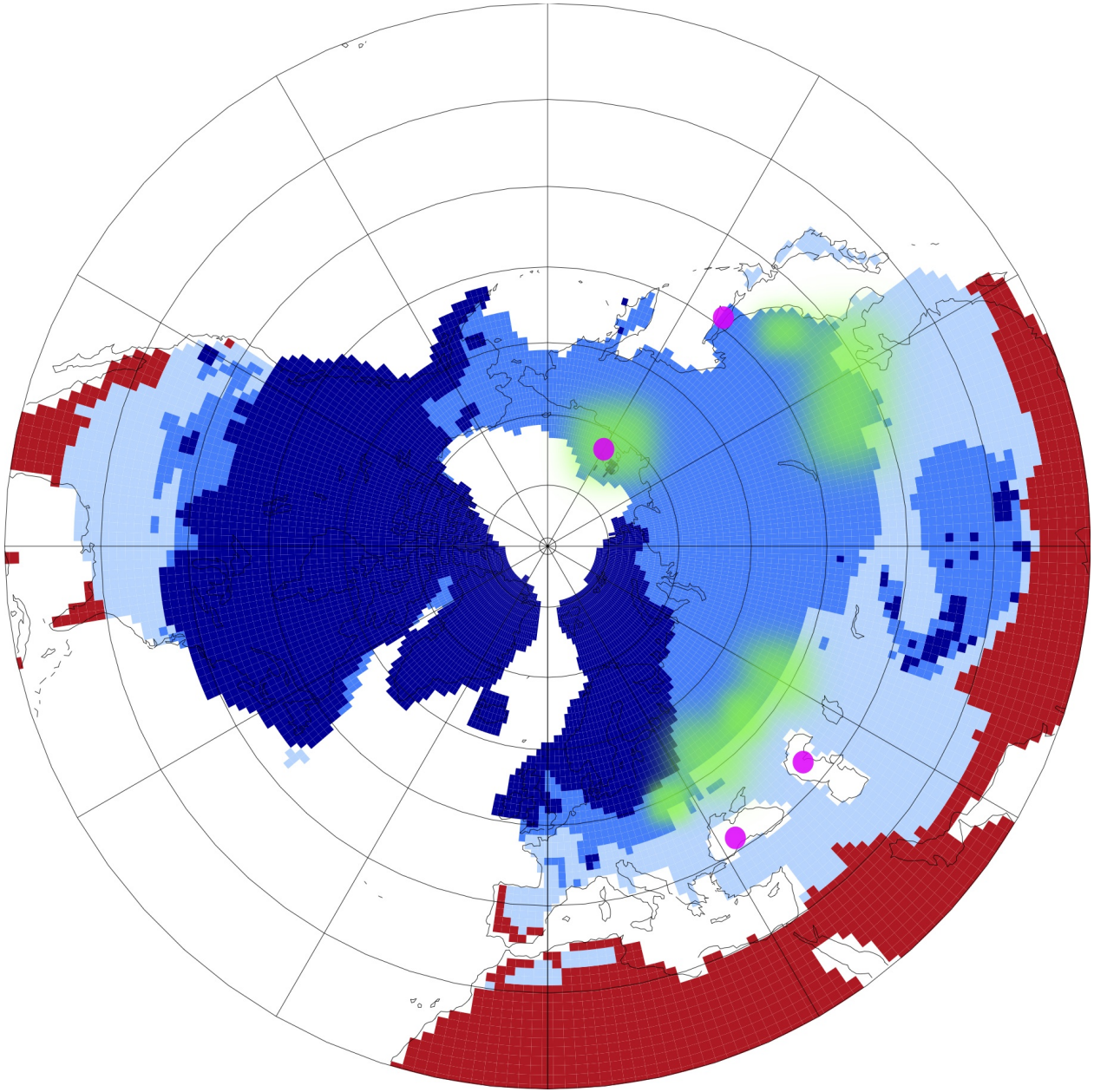
Soil C produced
during D/O 12
would have the $\Delta^{14}C$ signature
necessary to explain $\Delta^{14}C$.

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

Permafrost thawing: Where?

PMIP3 LGM

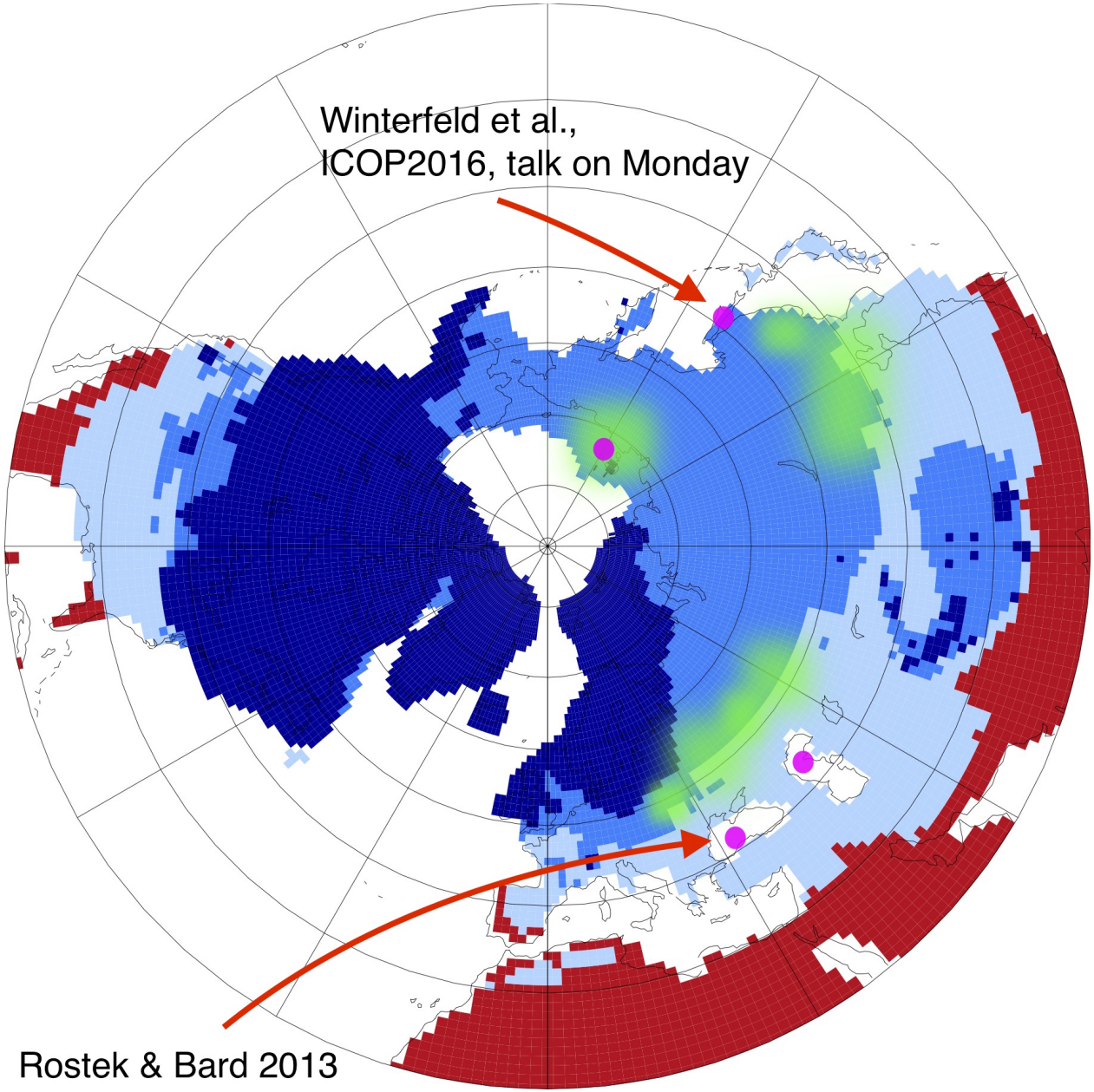
(Saito et al 2013)



Permafrost thawing: Where?

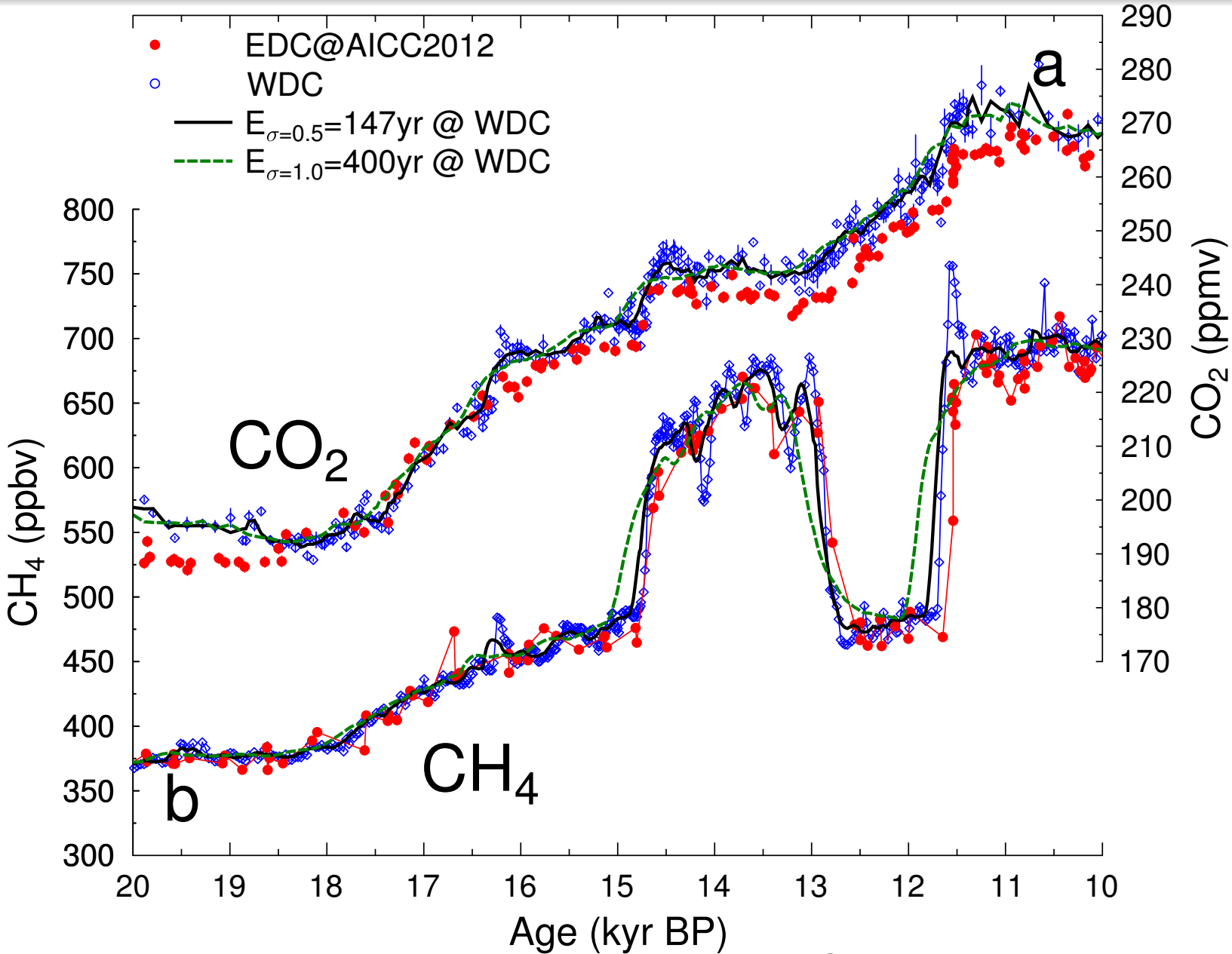
PMIP3 LGM

(Saito et al 2013)



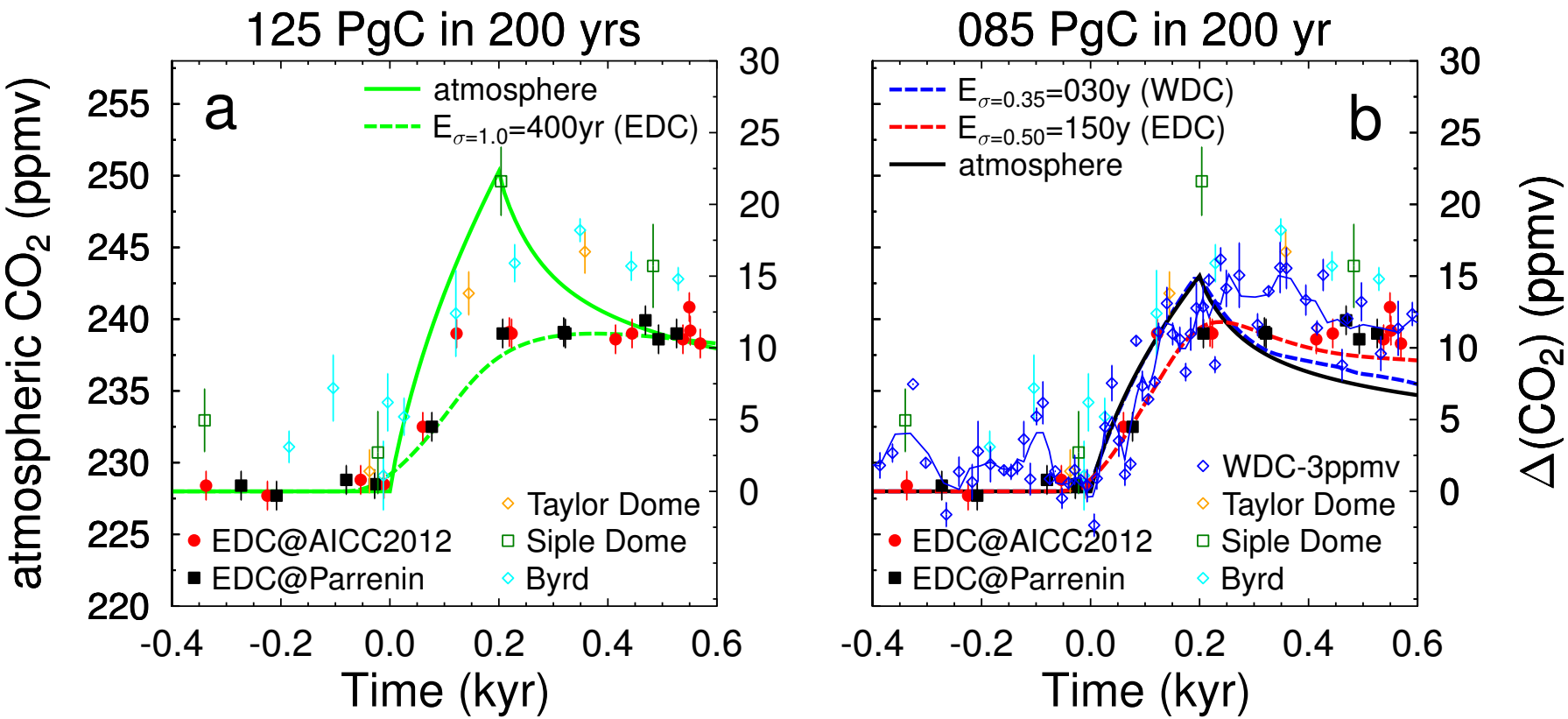
After the WAIS Divide Ice Core CO_2 record

New high resolution CO_2 from WAIS Divide (WDC)



Marcott et al. 2014, Nature, 30 Oct 2014

New high resolution CO_2 WAIS Divide Ice Core (WDC)



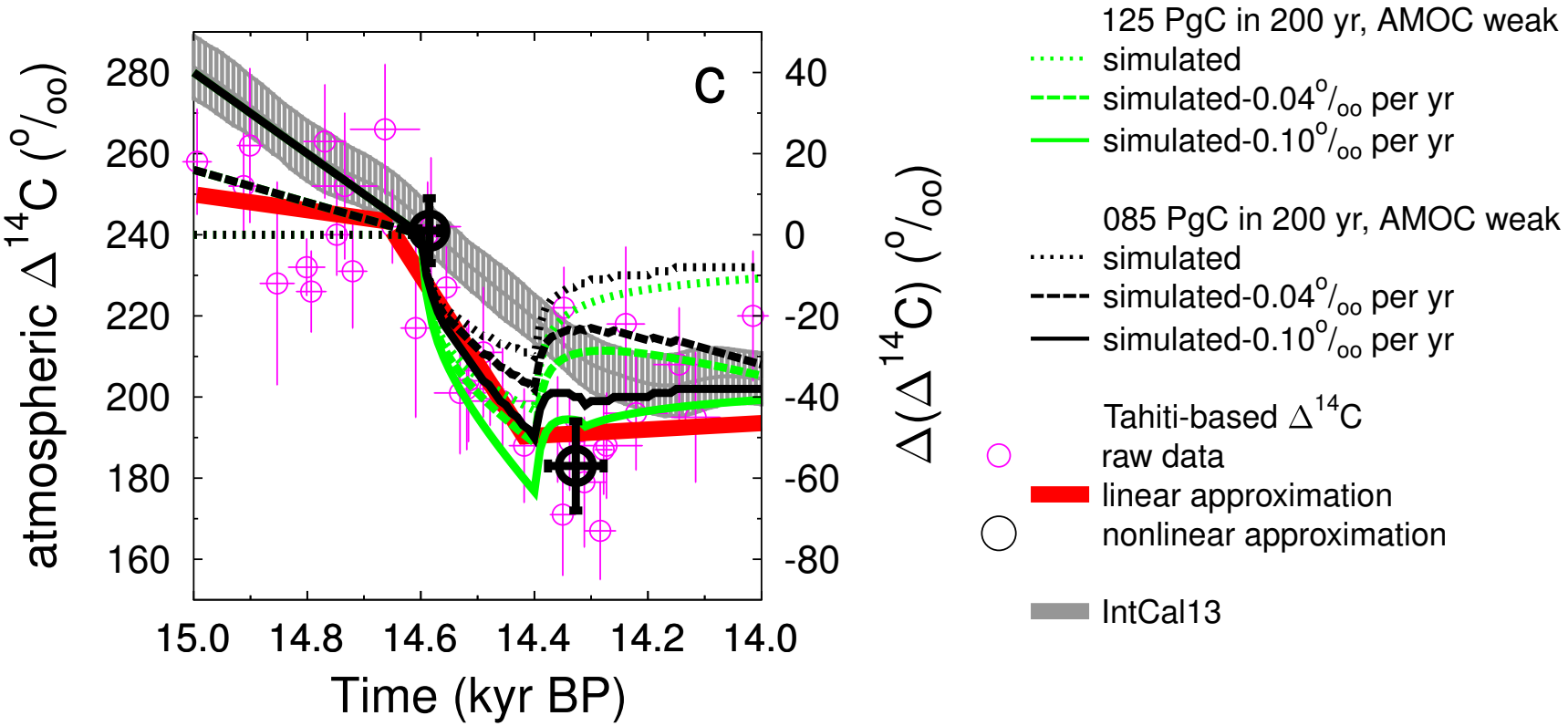
Permafrost thawing still valid with smaller CO_2 amplitude:

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 CO_2 from WAIS Divide (WDC): Atmospheric $\Delta(\Delta^{14}C)$

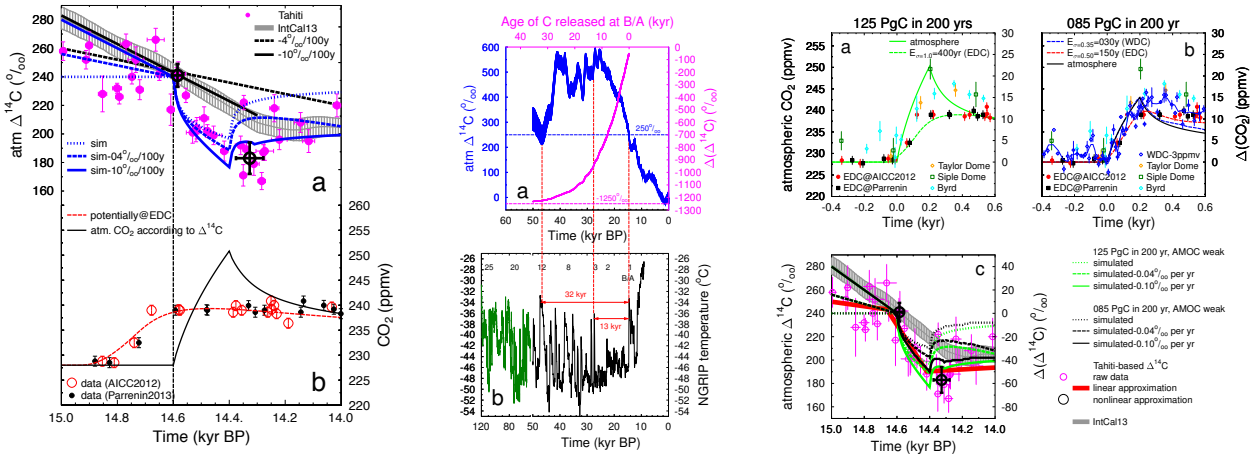


In revised WDC-based scenario:
CO_2 essential free of ^{14}C necessary
($\Delta(\Delta^{14}C = -1250‰$)

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).