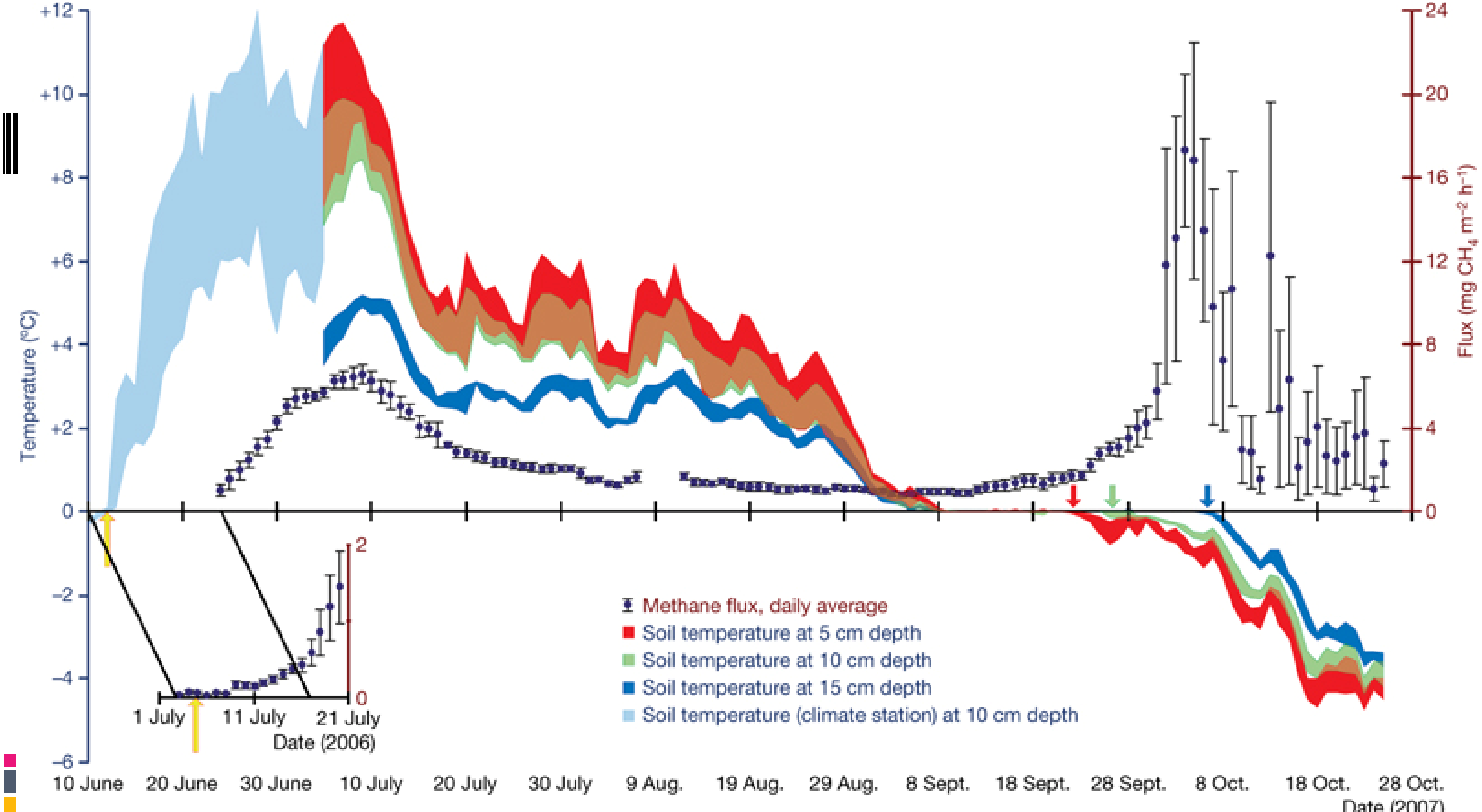
Large tundra methane burst during onset of freezing

Nature Vol.456, Dec. 2008

*Seasonal **CH4** emission from six individual chambers. The measurement site is located in a typical fen area in Zackenberg Valley, northeast Greenland, 74.30° N 21.00° W.*

The chambers provided flux measurements once pre hour.



M Mastepanov *et al.* *Nature* **456**, 628-630 (2008) doi:10.1038/nature07464

1. The arrows of the same color show the date of freezing of each horizon. Yellow arrows indicate date of snowmelt in the two years (2006 and 2007).
2. The lower inserted panel shows early-season emission in 2006 during the corresponding period relative to the date of snowmelt in 2007.
3. The emission reach a maximum when soil freezes down to -15cm.

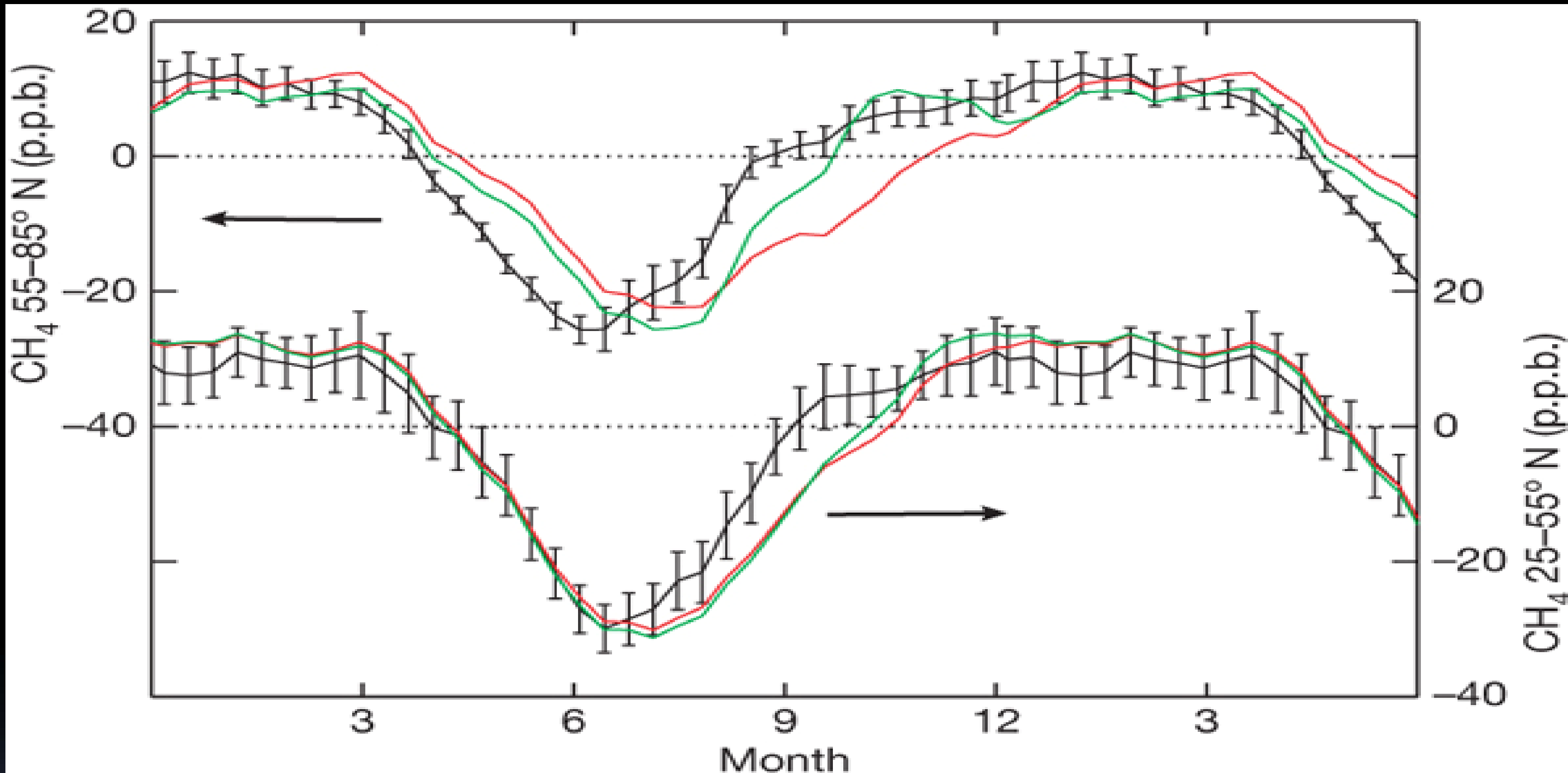
- The methane emissions fall to a low steady level after the growing season but then increase significantly during the freeze-in period.

- This very high flux happened when the active layer was gradually freezing, so methane that had accumulated in this layer was probably squeezed out through the frost action.

- The autumn fluxes varied greatly over small distances (chambers were less than 1m apart).

- Early-season flux data from Zackenberg for 2006 (M. Mastepanov *et al.*, manuscript in preparation) showing that spring emissions amounted to less than 2% of summer emissions . So methane emissions during spring from this type of tundra environment are not considered as major contributor to annual methane emissions.

Comparison of measured and model-simulated latitudinally averaged seasonal cycles of methane



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(Upper): 55-85° N ; (Lower): 25-55° N

Black, measurements (from NOAA Earth System Research Laboratory's air sampling) ;
Red, model simulation ;
Green, model simulation including a representation of additional emissions from freezing permafrost.

- At mid latitudes of the N.H., both model nicely reproduce the seasonal amplitude. (Although the phase lags the measurements by about a month in the second part of the year.)

- At high latitudes of the N.H., a deficiency of the model in simulating the timing of the concentration increase from summer to winter.

- The largest deviations occur in October when the unrepresented emissions from permafrost are highest.

- The difference of the simulated permafrost emissions is considerable and does improve the simulated seasonal cycle. However, additional information on permafrost freeze-in emissions is needed.

Conclusion

- There is no reason why CH_4 emissions during the freeze-in period should not happen everywhere that there are similar ecosystems in the world.

- The flux measurements and the model results shows that CH_4 emissions from the freezing active layer in permafrost areas may be an important missing process. It revises our view of the seasonal distribution of known emissions.

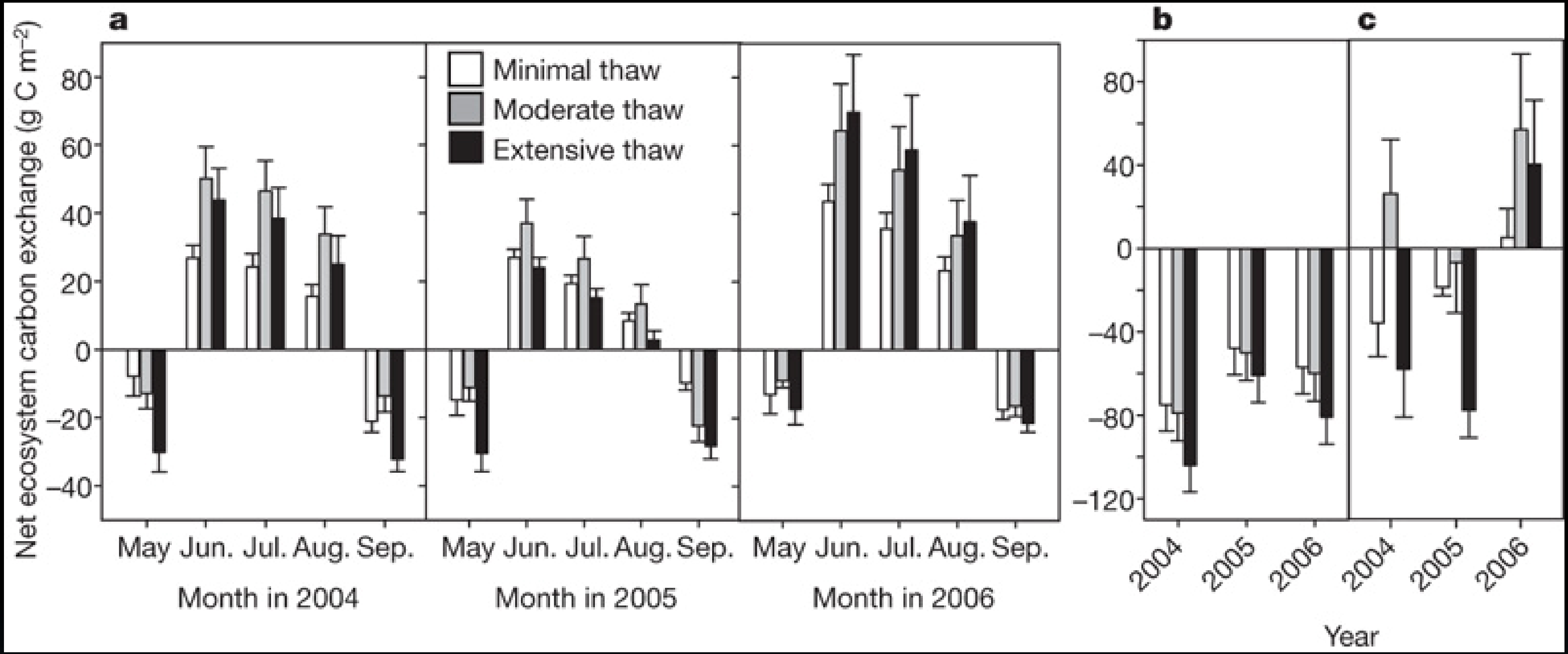
The effect of permafrost thaw on old carbon release and net carbon from tundra

Nature Vol.459, May 2009

Permafrost thaw and the microbial decomposition of previously frozen organic carbon is considered one of the most likely positive climate feedbacks from terrestrial ecosystems to the atmosphere.

In this article, the research team measured net ecosystem carbon exchange and the radio carbon age of respiration in a tundra land space undergoing permafrost thaw in Alaska, to determine the influence of old carbon loss on ecosystem carbon balance.

Net exchange of CO2 between tundra and the atmosphere for three sites (Eight Mile Lake, Denali National Park, Alaska) that differ in the extent of permafrost thaw



EAG Schuur et al. Nature 459, 556-559 (2009) doi:10.1038/nature08031

a, For the growing season (May-Sep.) over a 3-year period from 2004-06;
b, for the winter (Oct.-Apr.); and
c, on an annual basis, which is the net of the growing season and the winter.

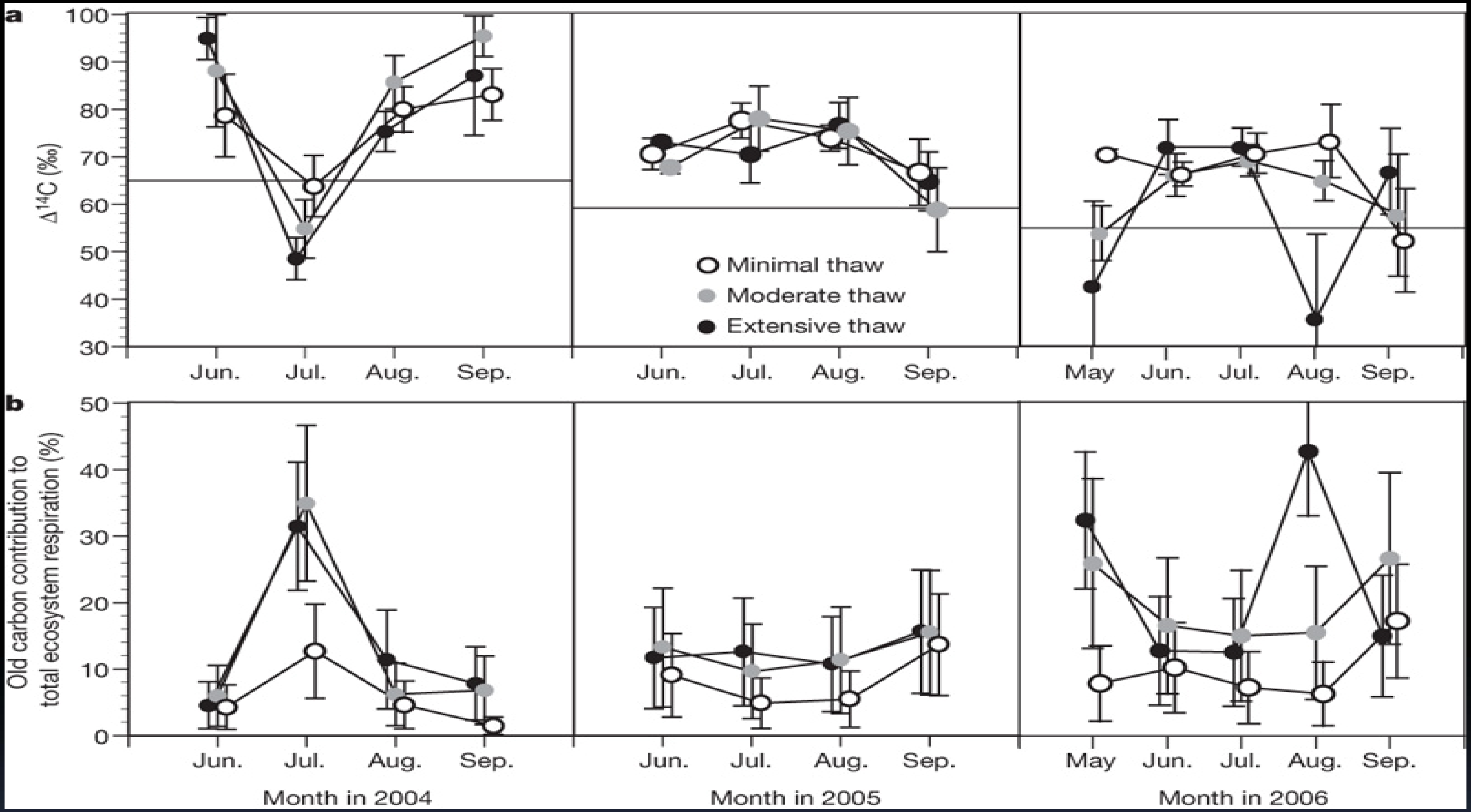
Values represent C uptake (positive) or release (negative).

- The tundra ecosystem showed net C uptake during the summer months (Jun.-Aug.) and loss in spring (May), autumn (Sep.) and winter (Oct.-Apr.). During the winter, C loss accounted for 15-18% of ecosystem respiration (Reco).

- On the annual basis across years, the extensive thaw site had significantly higher Reco. The extensive thaw site was a net C source to the atmosphere. (Losing average of $32 \mp 22 gC/m^2y$, based on annual net ecosystem C exchange.)

- However, all 3 sites were with greatest uptake in 2006. The moderate thaw site contrasted with the other 2 sites as a net sink of atmospheric C. (Gained $25 \mp 29 gC/m^2y$)

Radiocarbon values of ecosystem respiration and the proportional contribution from old carbon for three sites that differ in the extent of permafrost thaw.



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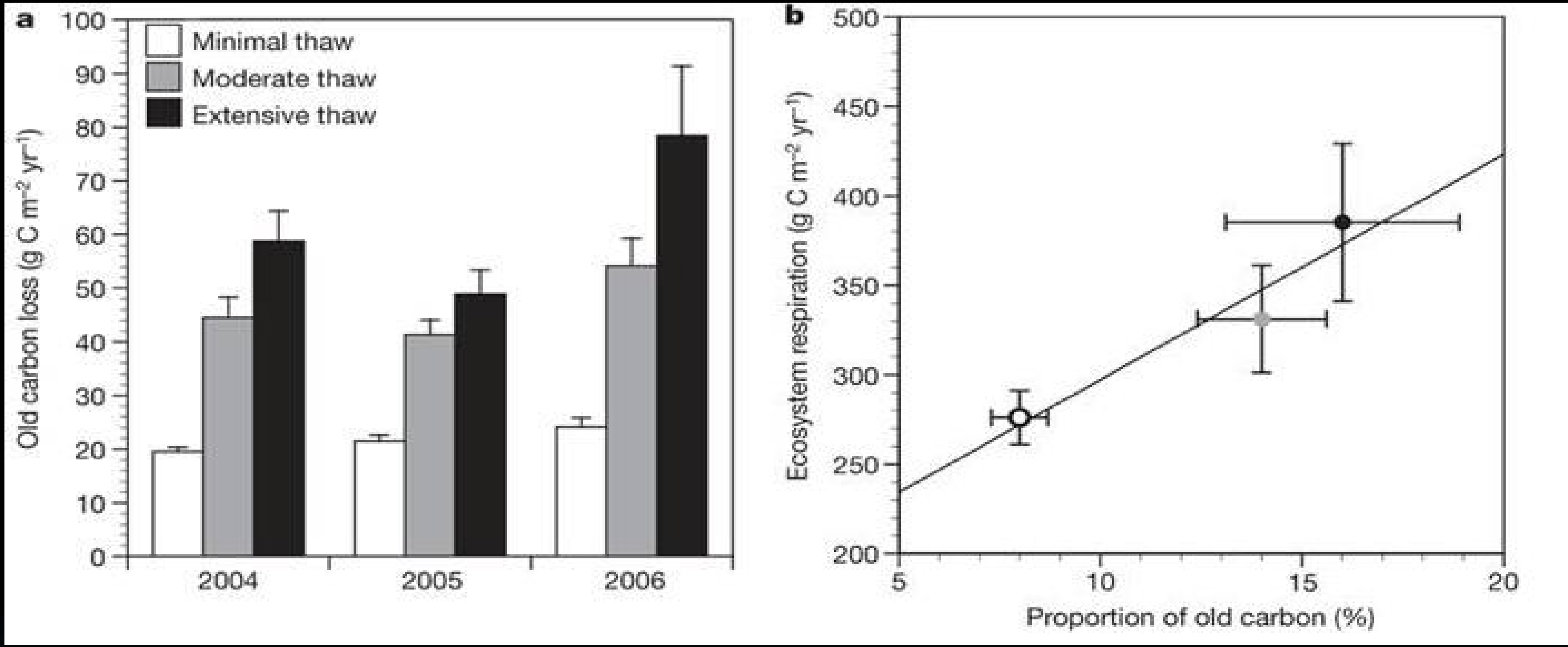
a, Radiocarbon values over a 3 years period 2004-06;
(Horizontal lines across the graphs are average atmospheric value for each year.)

b, Statistical partitioning estimate of the contribution of old C, based on the measurement from incubations of surface, deep soil, and plants.

- The imprint of old C is observed in Reco in months, or in sites, where Reco radiocarbon values drop below the current atmospheric value.

- Significant temporal variation in radiocarbon values is thought to reflect changes in the relative contribution of plant metabolism, recent detritus, and old C.

Old carbon loss and its relationship to total ecosystem respiration for three sites that differ in the extent of permafrost thaw



EAG Schuur et al. Nature 459, 556-559 (2009) doi:10.1038/nature08031

a, Growing-season loss of old C from deeper in the soil profile.

(Based on statistical partitioning estimates of mean proportional old C loss multiplied by ecosystem respiration flux measurements)

b, The relationship between total ecosystem respiration and proportional old C loss for the growing season across sites.

(The regression line is shown for n=3 sites.)

- The extensive and moderate thaw sites are projected to have lost an average of 63 and 47gC/m^2y respectively from the deep soil layers during the growing season; this was approximately 2 or 3 times greater than the deep C loss for the minimal thaw site (22gC/m^2y).

- The positive relationship observed between growing season Reco and proportional old C loss across sites and years supports the idea that the mean predicted contributions provide a reasonable picture of old C losses across sites.

Conclusion

- Increased plant C uptake cannot fully offset continued increases in old C respiration.
- Although these gains and losses are substantial, they are still small relative to the soil C stocks at this site, thus these changes would be impossible to detect with soil C stock measurements at this time.