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ARTICLES

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The age distribution of global soil carbon inferred from radiocarbon measurements

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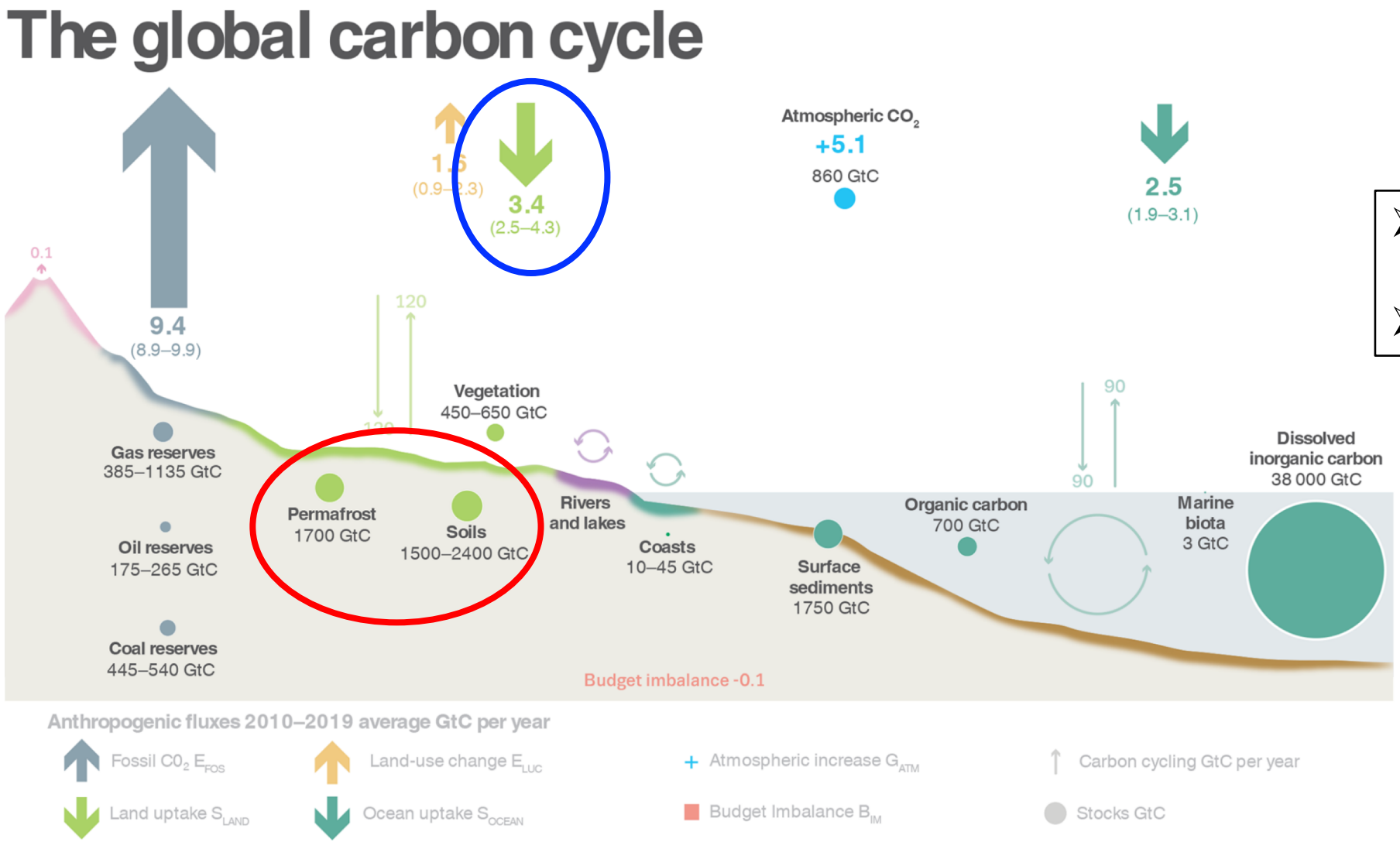
RUBISCO

REDUCING UNCERTAINTIES IN BIOGEOCHEMICAL INTERACTIONS THROUGH SYNTHESIS AND COMPUTATION

P. Friedlingstein et al.: Global Carbon Budget 2020



- Soils + Permafrost: ~4100PgC
- Uptake 1/3 CO_2 emission

Radiocarbon ^{14}C

- The least abundant isotope of carbon:

  C-14 (< 10^{-10} %) 6 protons, 8 neutrons

- ^{14}C is the longest lived radioactive isotope, and decays to ^{14}N by emitting a β particle (electron):

$$^{14}_{6}C \rightarrow \beta^{-} + ^{14}_{7}N + \gamma(energy)$$

Applications of radiocarbon

- Determining the age of C in a closed system

  half-life 5730 years;

- As a purposeful tracer

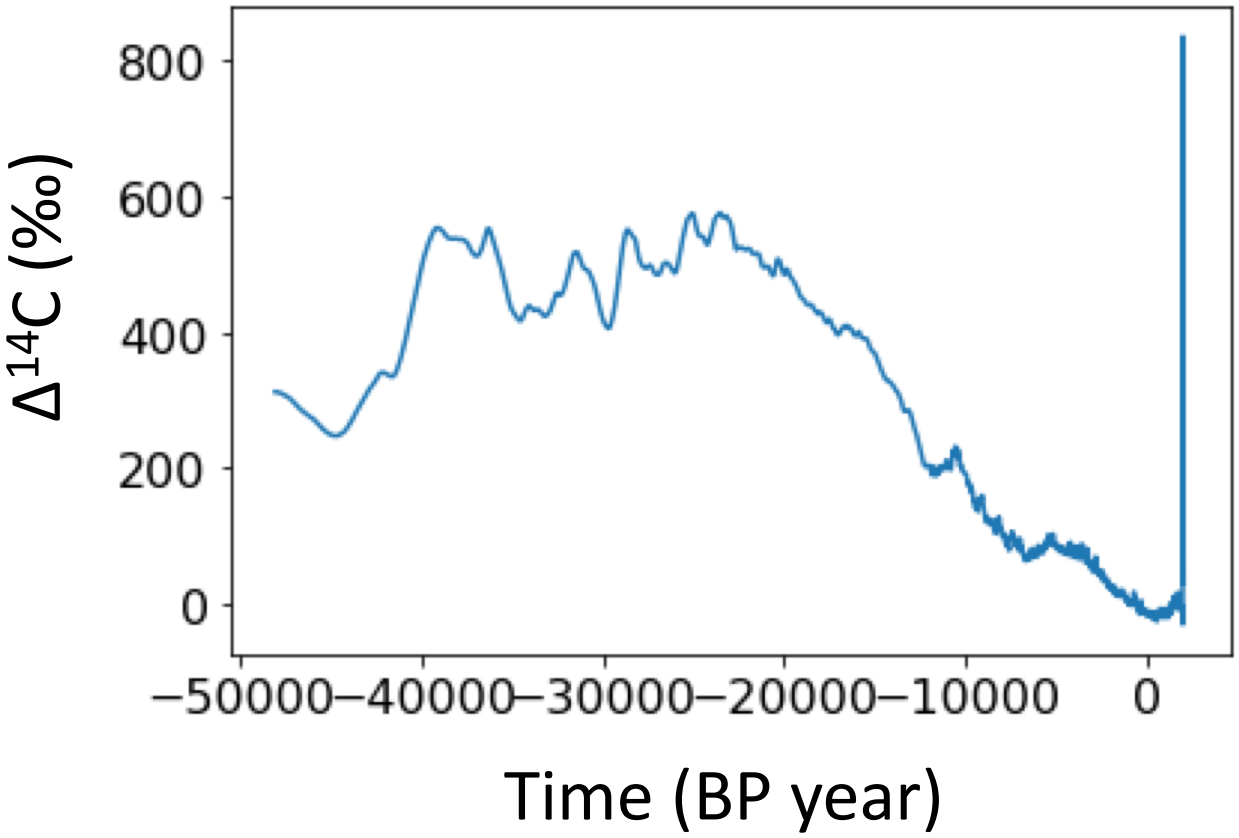
  tracing pathways (allocation)

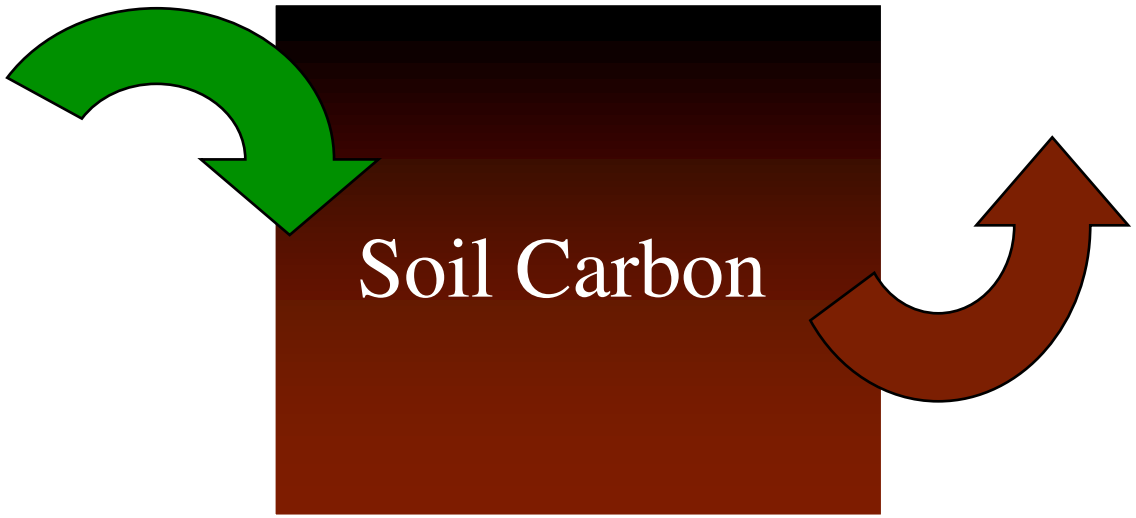
- **For open systems, a measure of the rate of exchange of C with other reservoirs**

  Mean residence time versus mean age

Carbon mean age in a one-pool model

Past Changes in Atmospheric ^{14}C



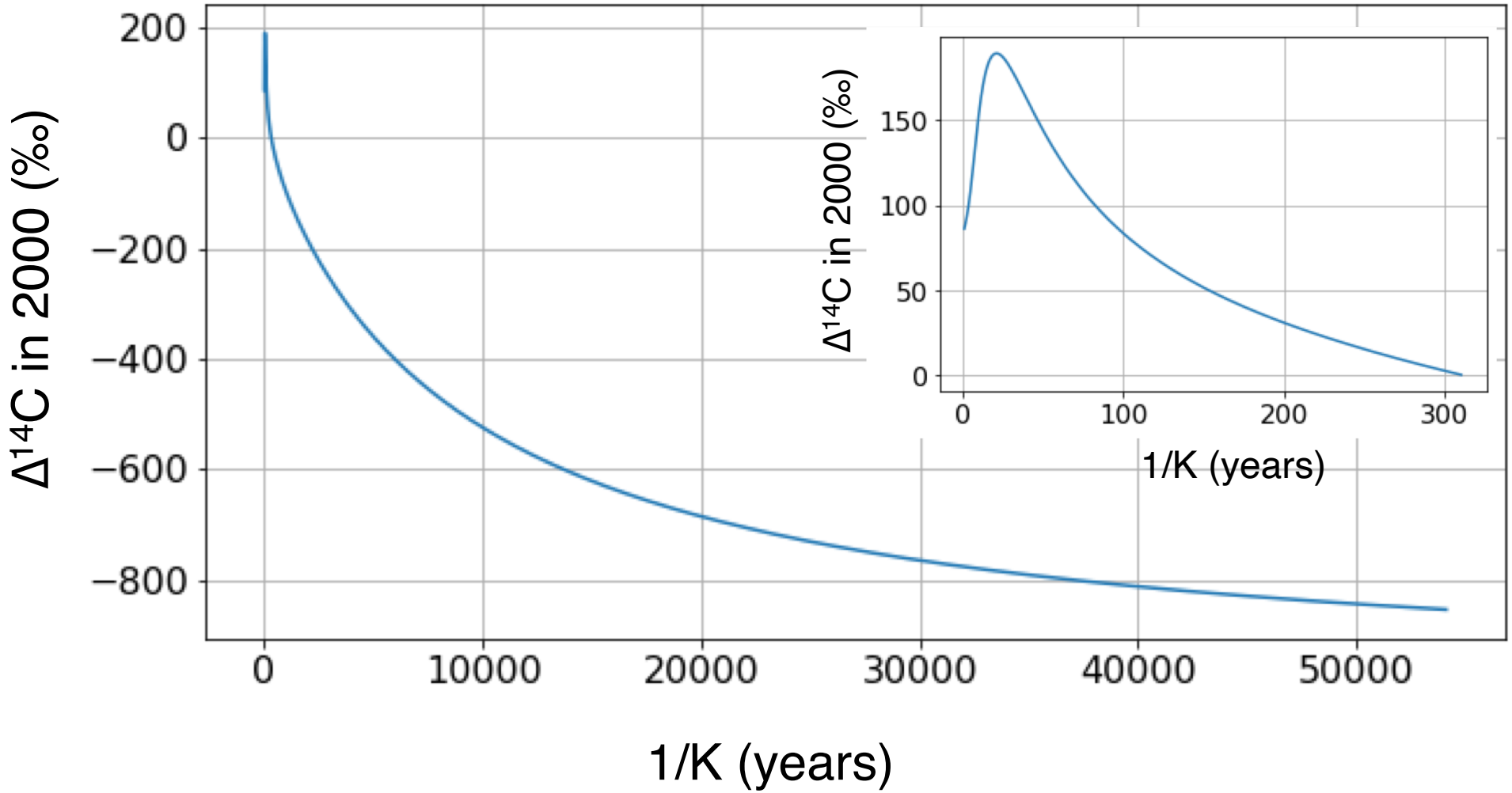


Δ Soil C = 0

$C_{IN} = C_{OUT}$

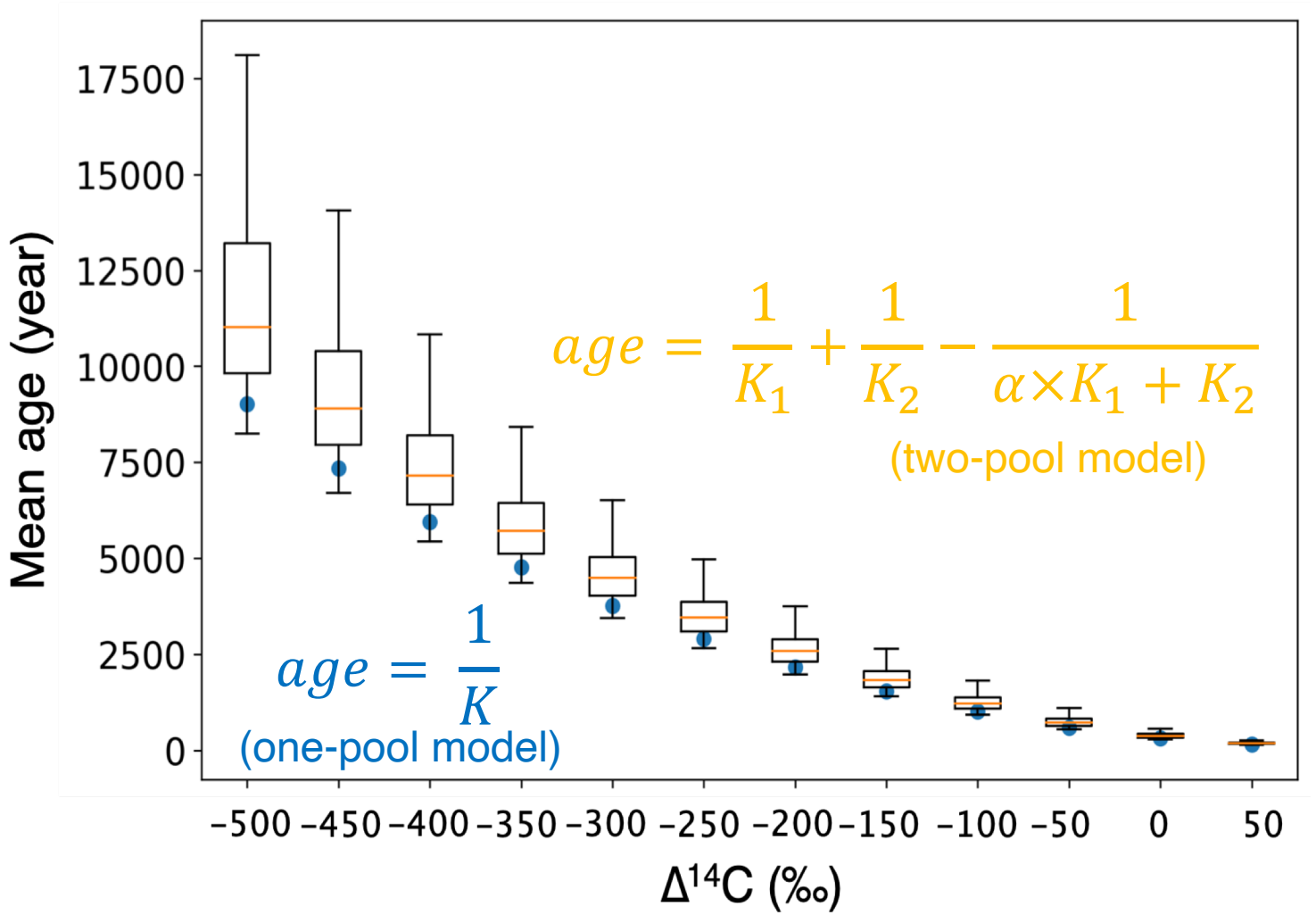
$d^{14}C/dt = I_{14C} - K^{14}C - \lambda^{14}C$

Carbon mean age in a one-pool model

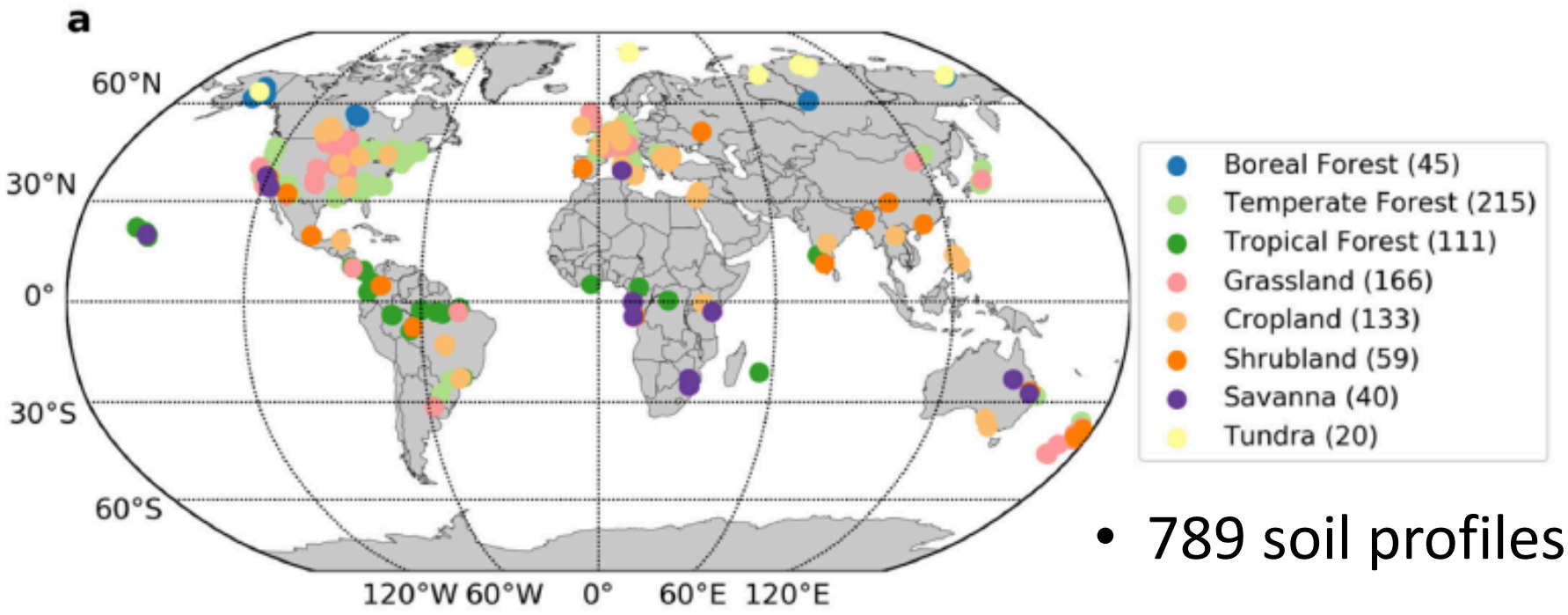


Mean age = 1/K

Carbon mean age by one-pool and two-pool models



Locations of soil ^{14}C profiles



- 789 soil profiles
- $\Delta^{14}C$ measurements of bulk soil
- Coverage of major land biomes and climate condition

soilradiocarbon.org

ISRaD
Int'l Soil Radiocarbon Database

About Database R Package Contribute News FAQ Credits

International Soil Radiocarbon Database

ISRaD news & technical updates

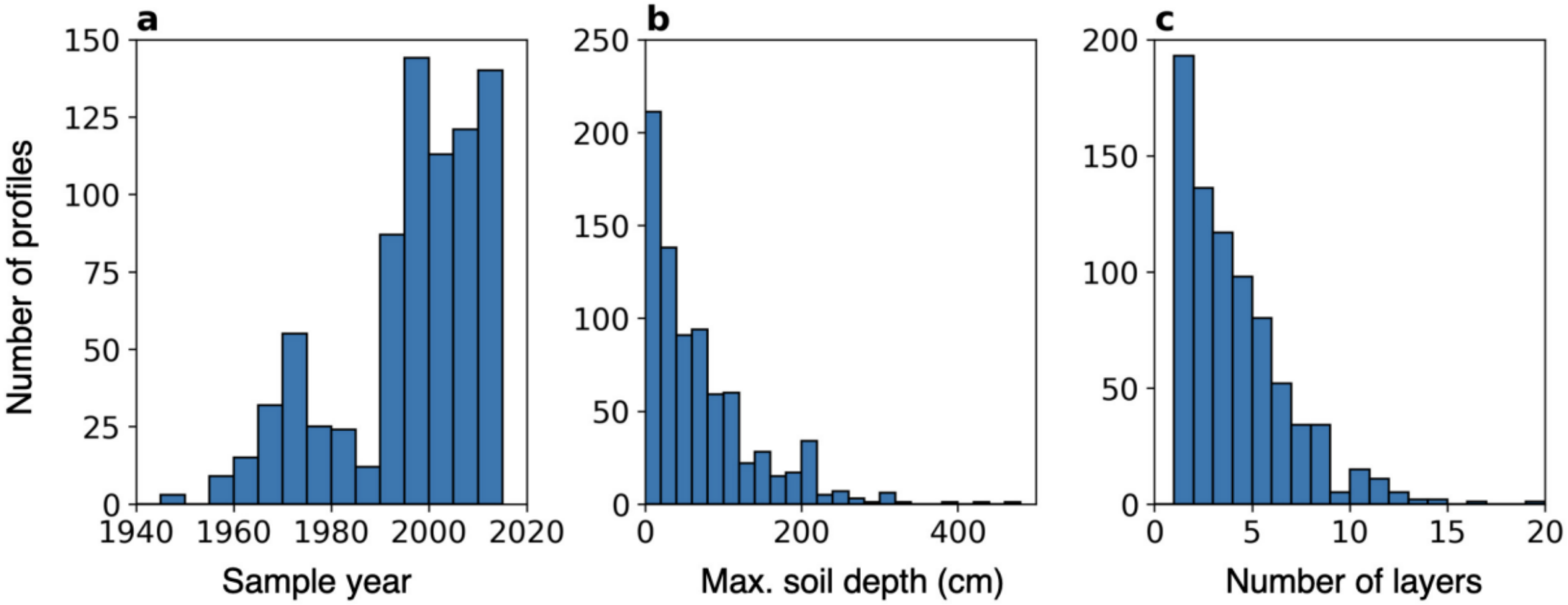
Introducing ISRaD Version 1.0!

A new manuscript detailing the construction and utilization of ISRaD was just published in Earth System Science Data. Hear we describe database fundamentals, and the application of radiocarbon data for describing the earth system. You can find the manuscript here.

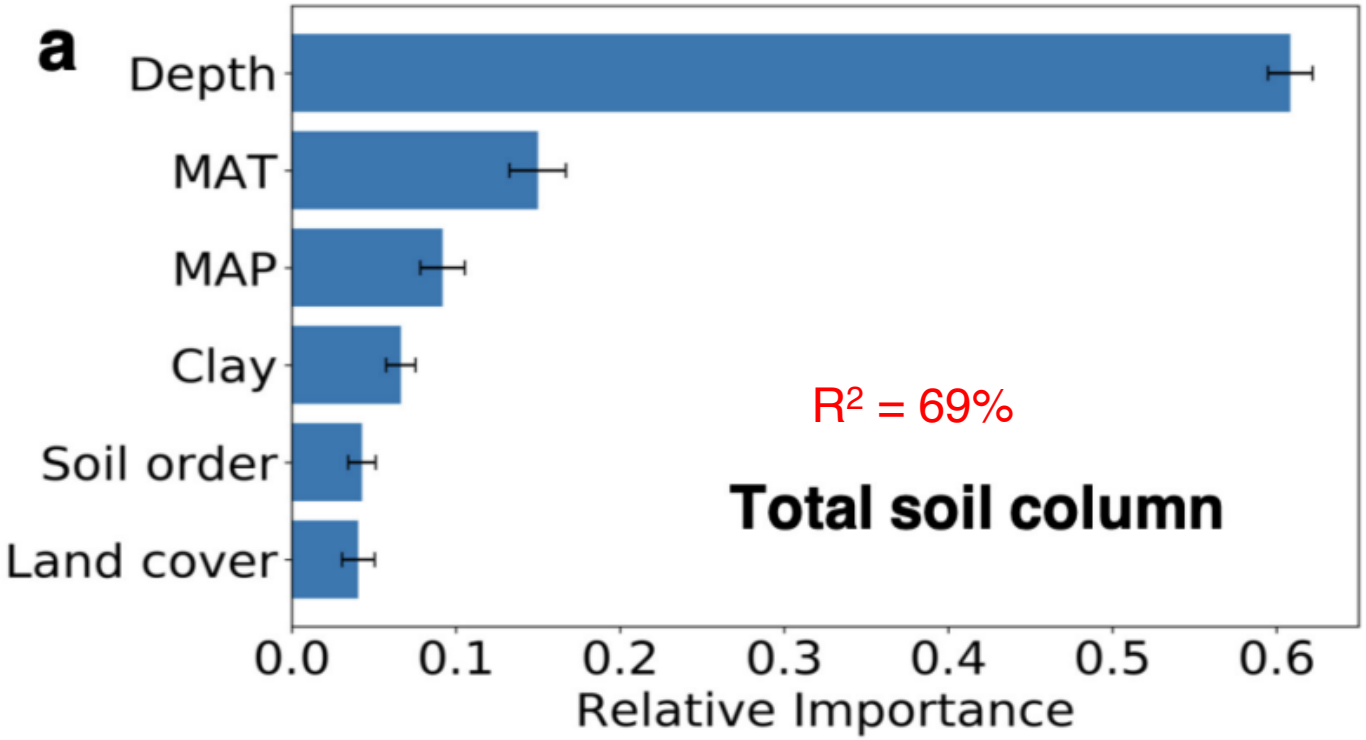
An open-source database for the synthesis of soil radiocarbon data: International Soil Radiocarbon Database (ISRaD) version 1.0

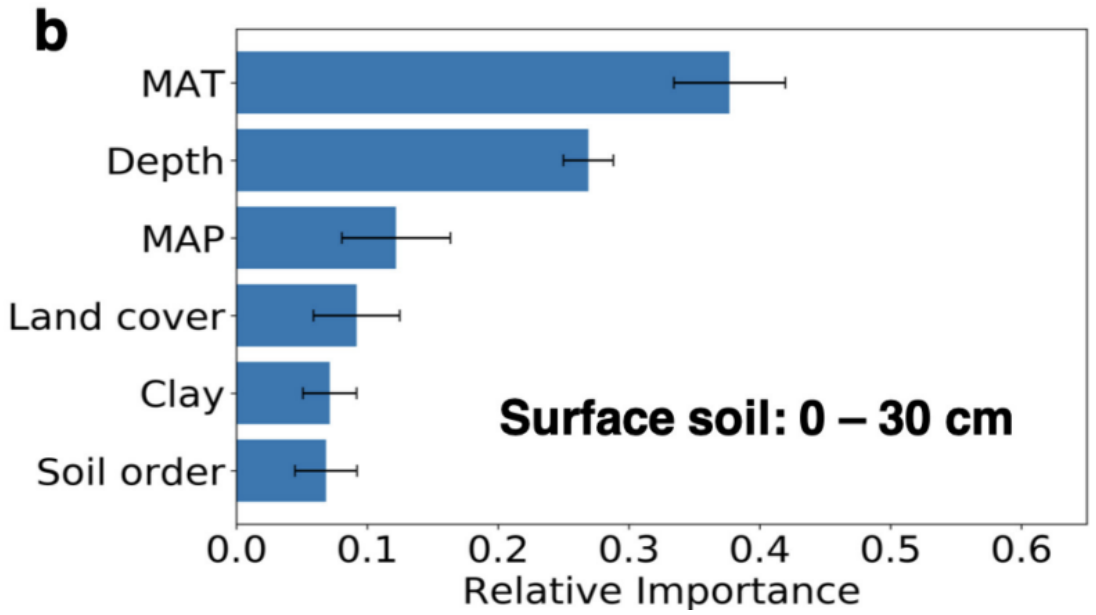
Corey R. Lawrence[1], Jeffrey Beem-Miller[2], Alison M. Hoyt[2,3], Grey Monroe[4], Carlos A. Sierra[2], Shane Stoner[2], Katherine Heckman[5], Joseph C. Blankinship[6], Susan E. Crow[7], Gavin McNicol[8], Susan Trumbore[2], Paul A. Levine[9], Olga Vindušková[8], Katherine Todd-Brown[10], Craig Rasmussen[6], Caitlin E. Hicks Pries[11], Christina Schädel[12], Karis McFarlane[13], Sebastian Doetterl[14], Christine Hatté[15], Yujie He[9], Claire Treat[16], Jennifer W. Harden[7,17], Margaret S. Torn[3],

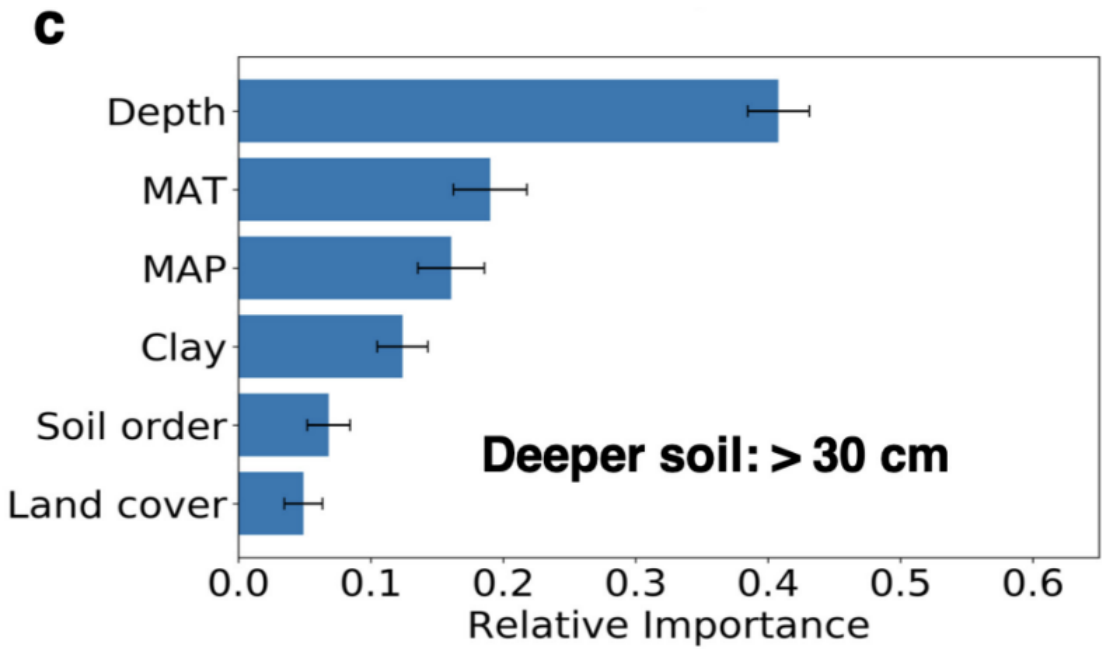
Frequency distribution of soil profiles



Relative variable importance from the random forest algorithm







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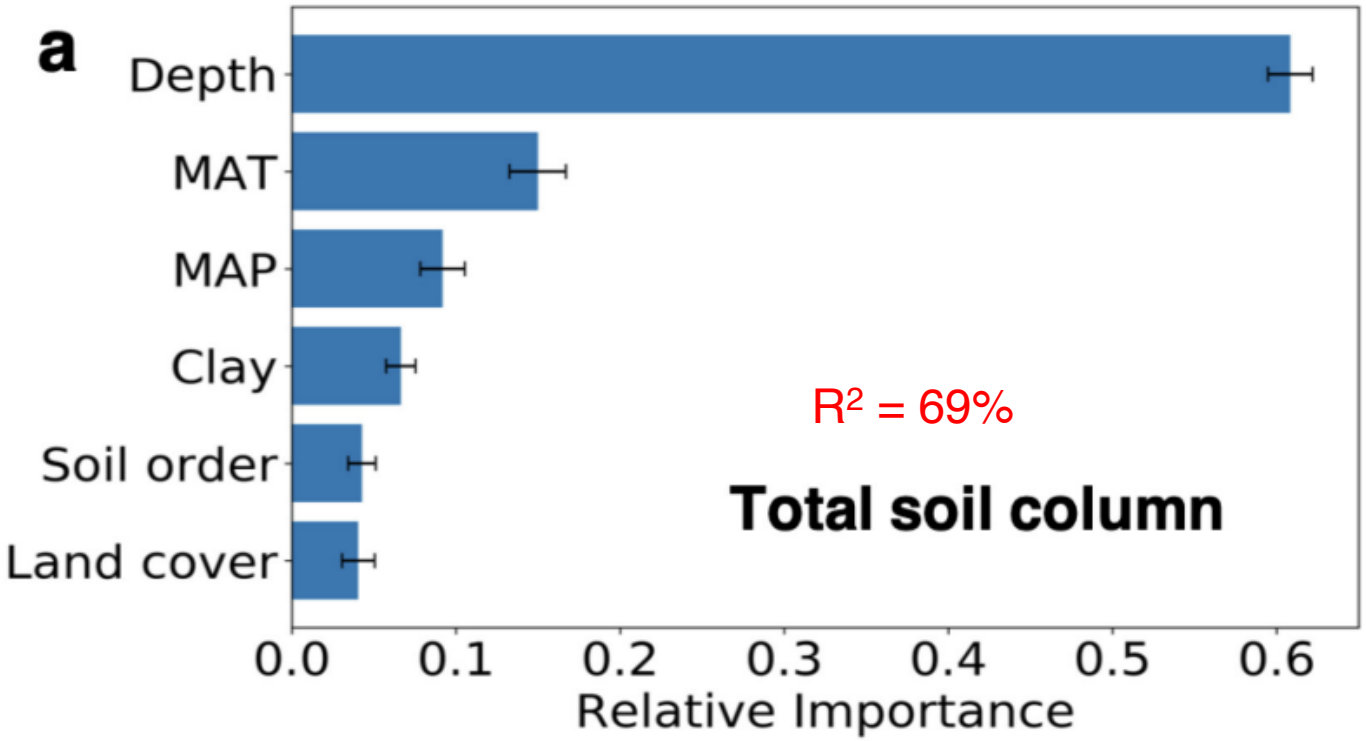

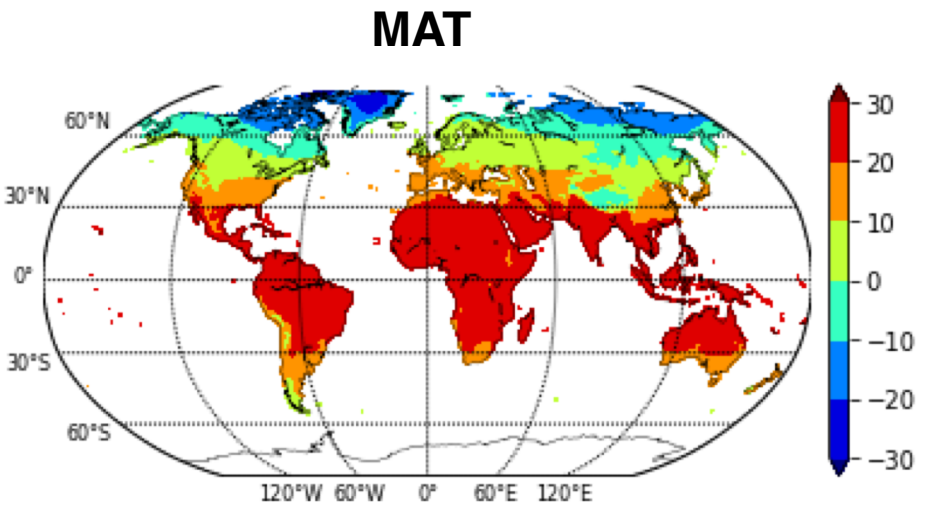

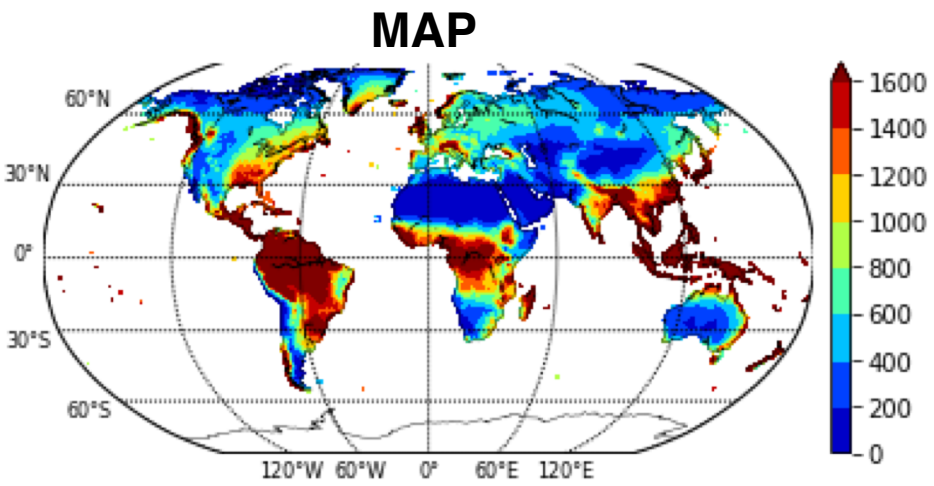

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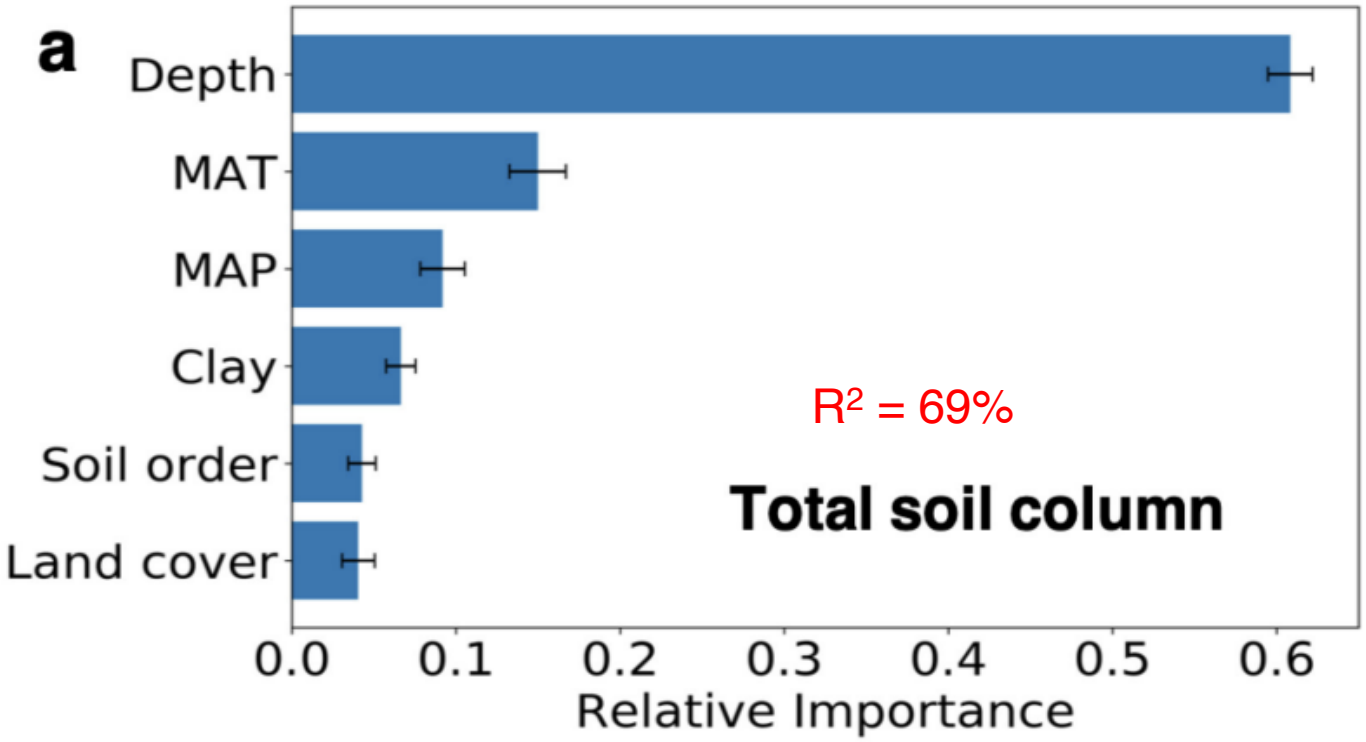
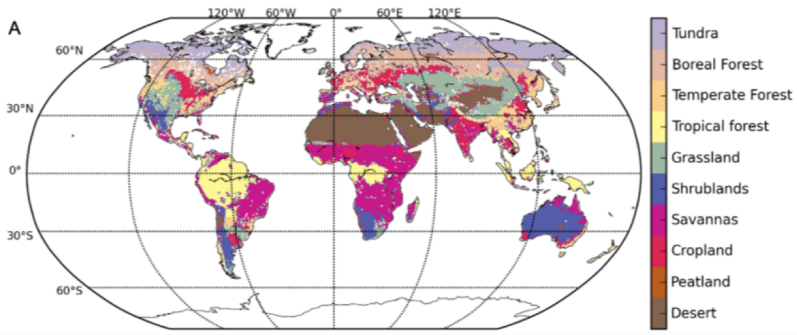
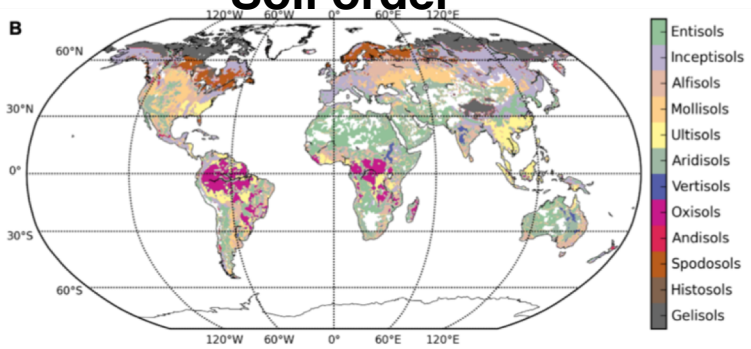


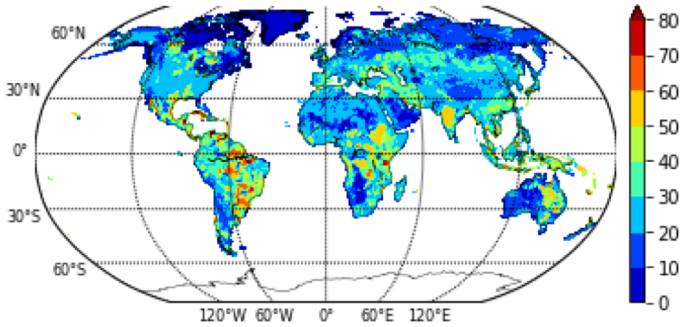
Land cover type



Soil order

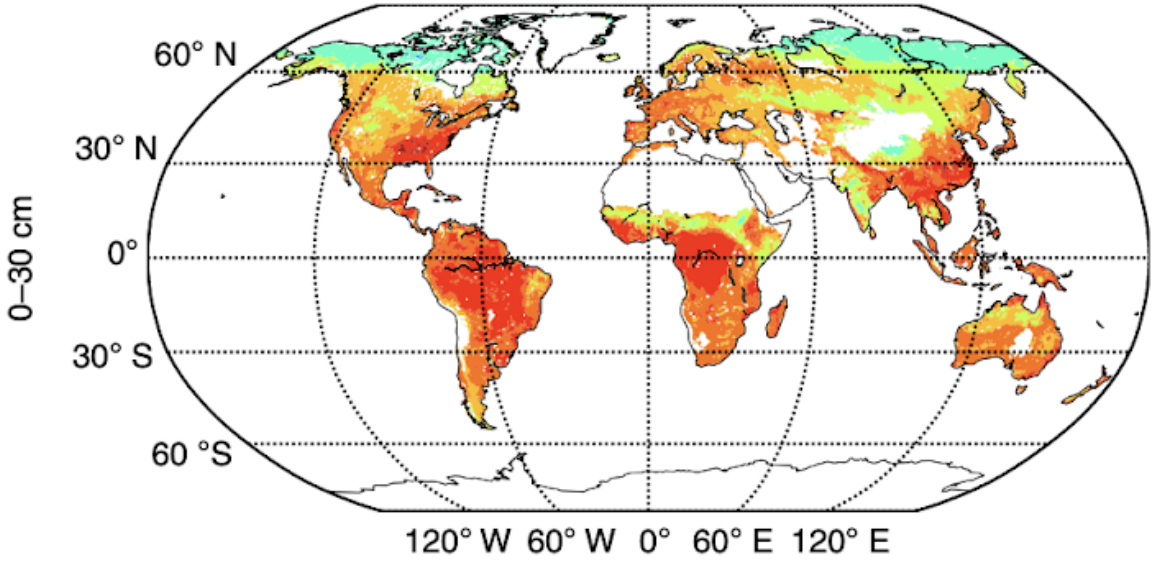


Soil clay



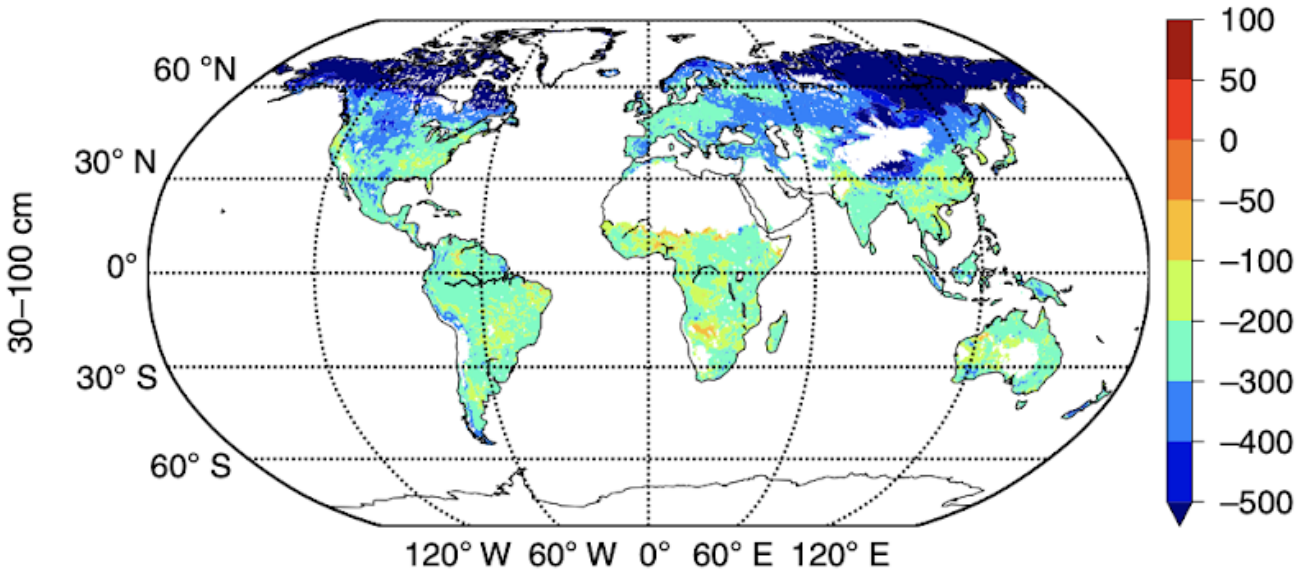
Strong depletion in radiocarbon with latitude and depth

Surface soil: 0 – 30 cm



–97 ± 24‰

Subsurface soil: 30 – 100 cm

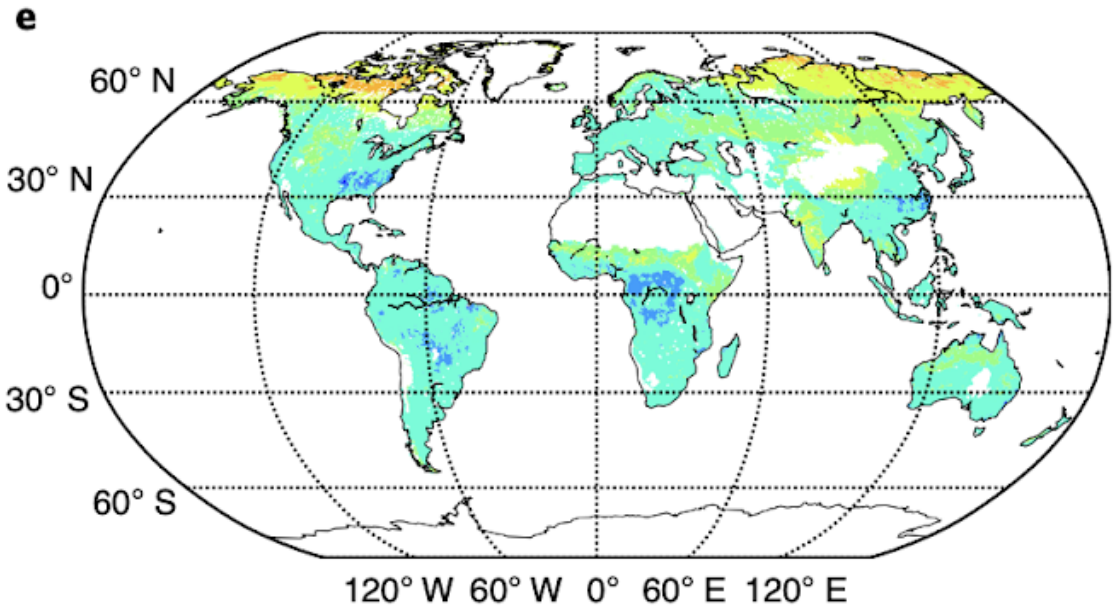


–391 ± 56‰

Global mean: –391 ± 56‰

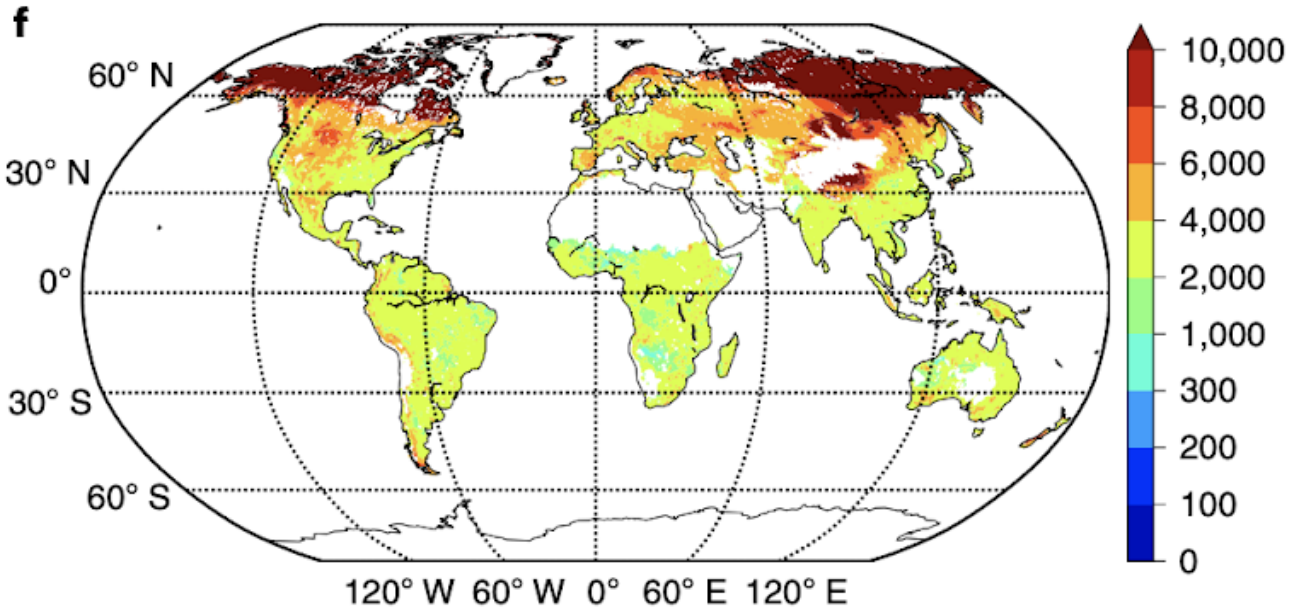
Millennial carbon age in high latitude and deep soils

Surface soil: 0 – 30 cm



1390±310 years

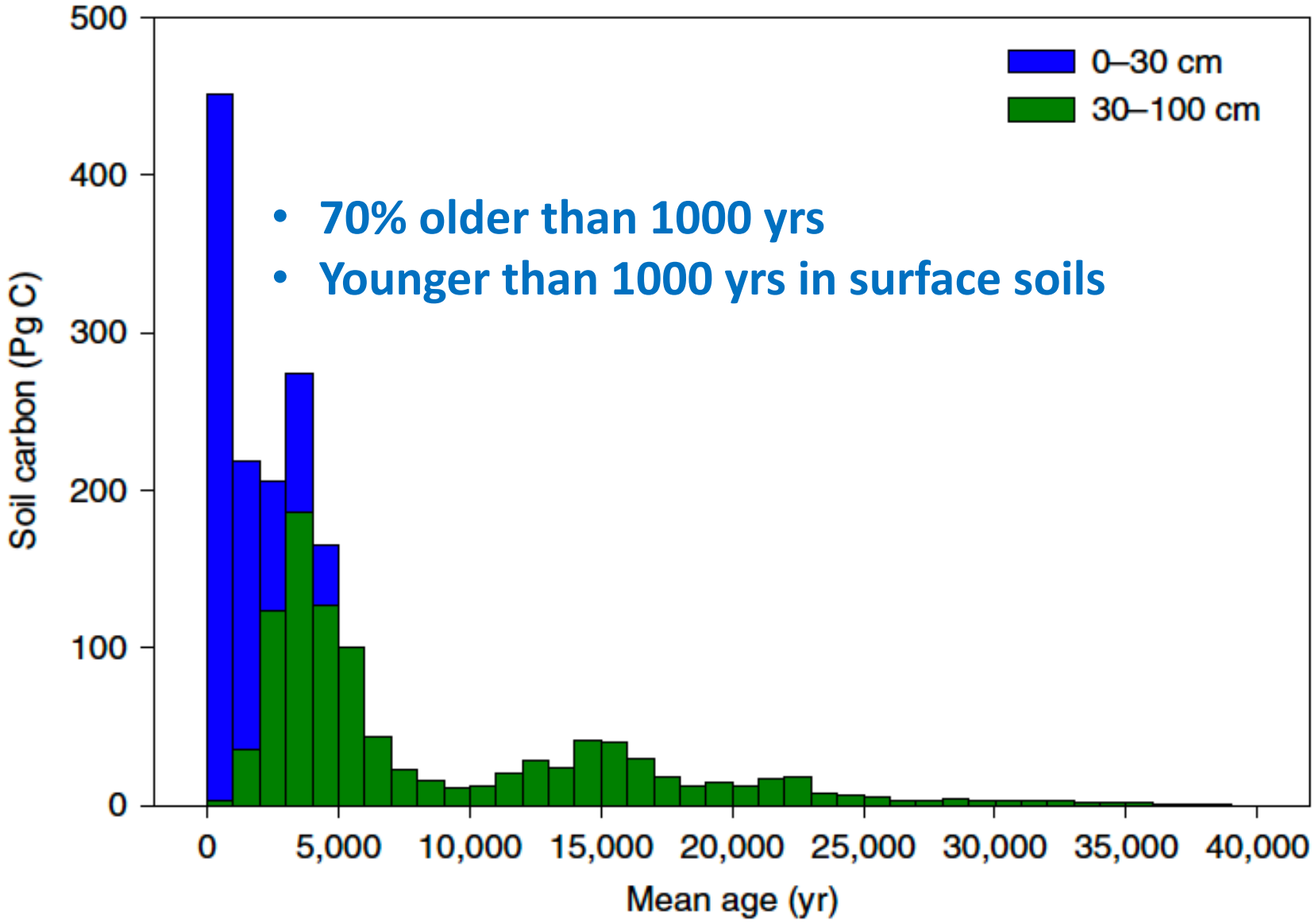
Subsurface soil: 30 – 100 cm



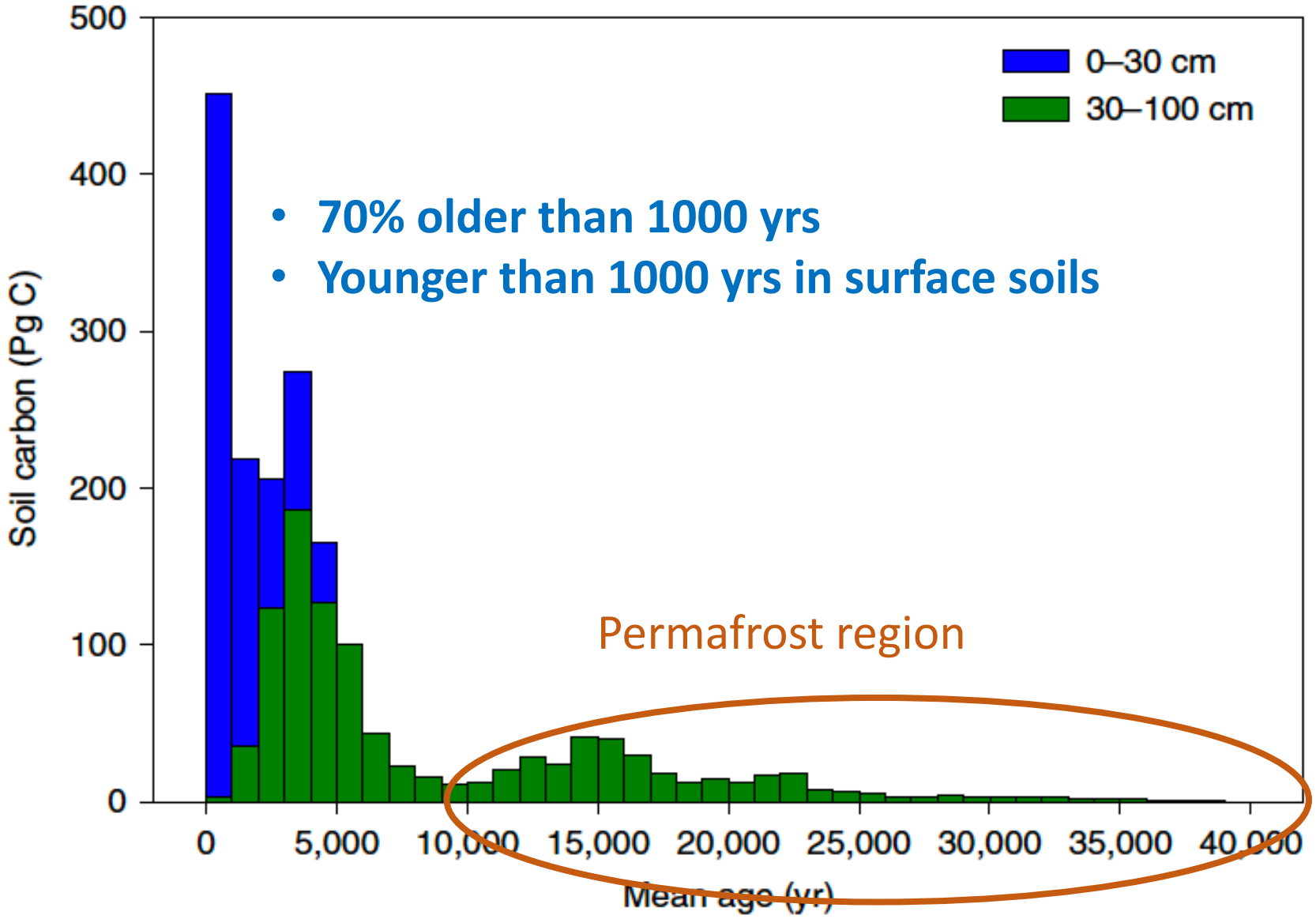
8280±2820 years

Global mean: 4830±1730 years

Majority of soil carbon older than 1000 years

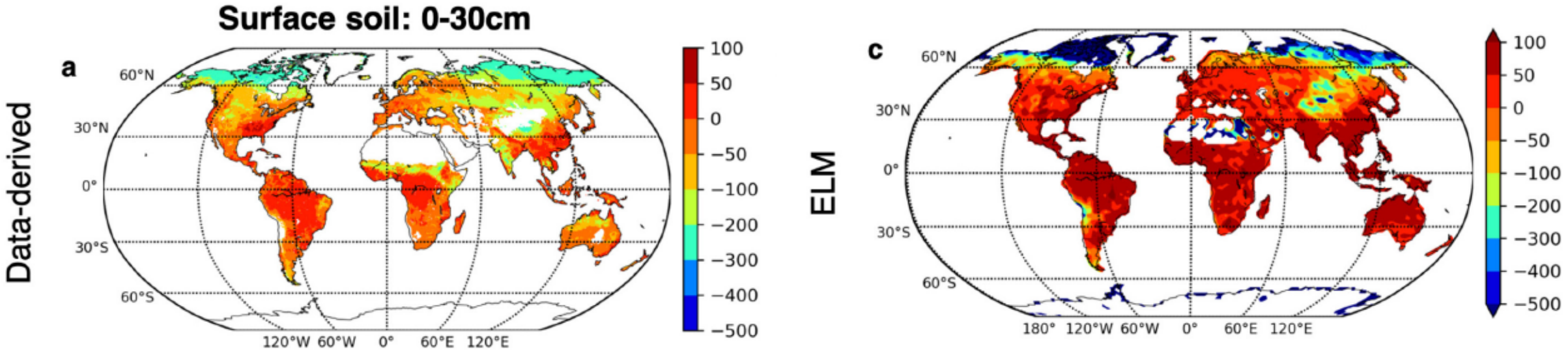


Majority of soil carbon older than 1000 years



Less depleted soil radiocarbon in models

Surface soil: 0 – 30 cm



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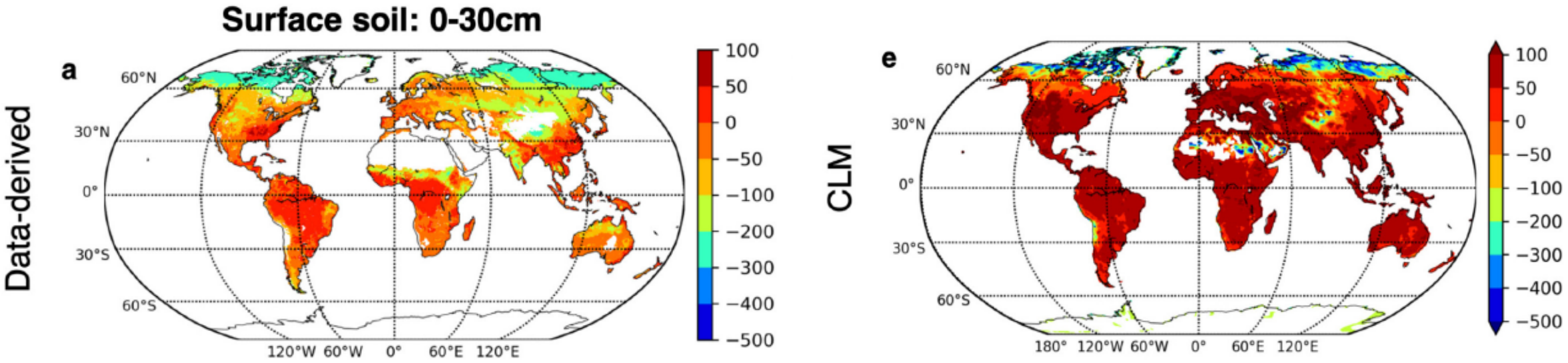
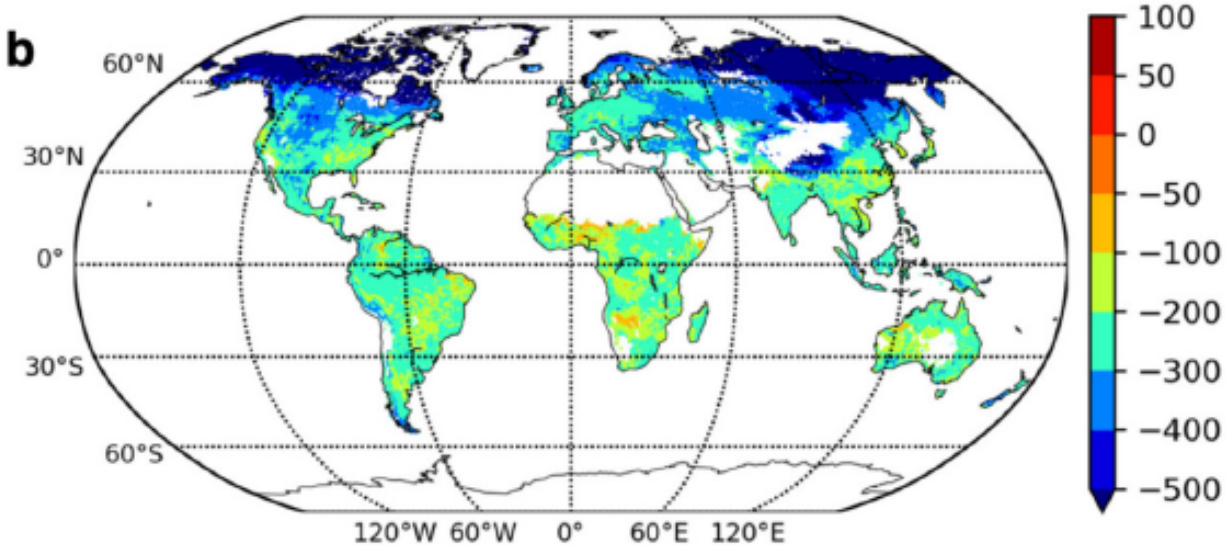
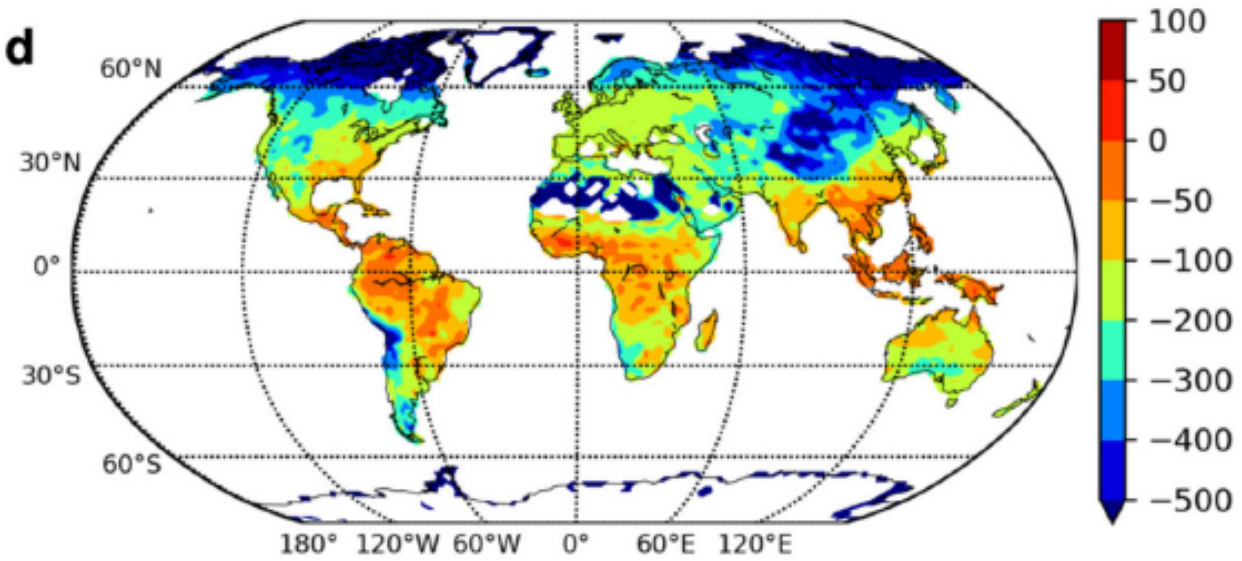


Less depleted soil radiocarbon in models

Subsurface soil: 30 – 100 cm



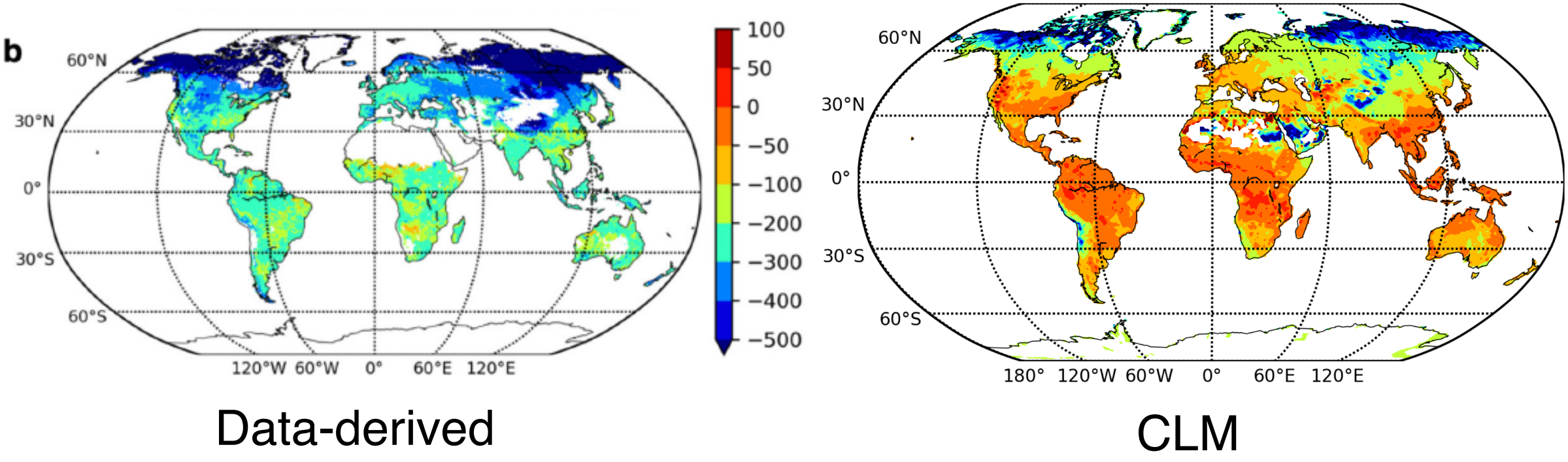
Data-derived



ELM

Less depleted soil radiocarbon in models

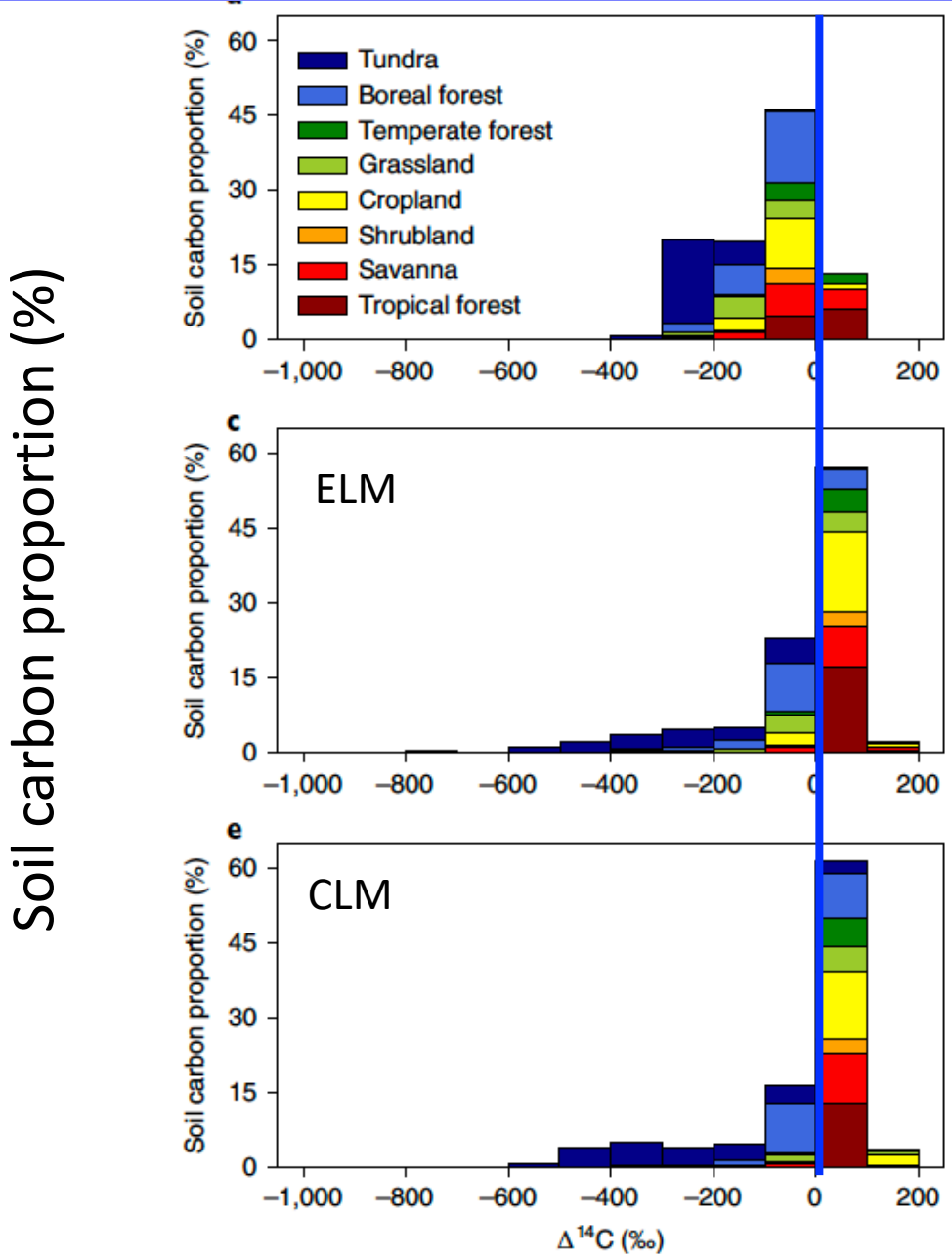
Subsurface soil: 30 – 100 cm



Data-derived

CLM

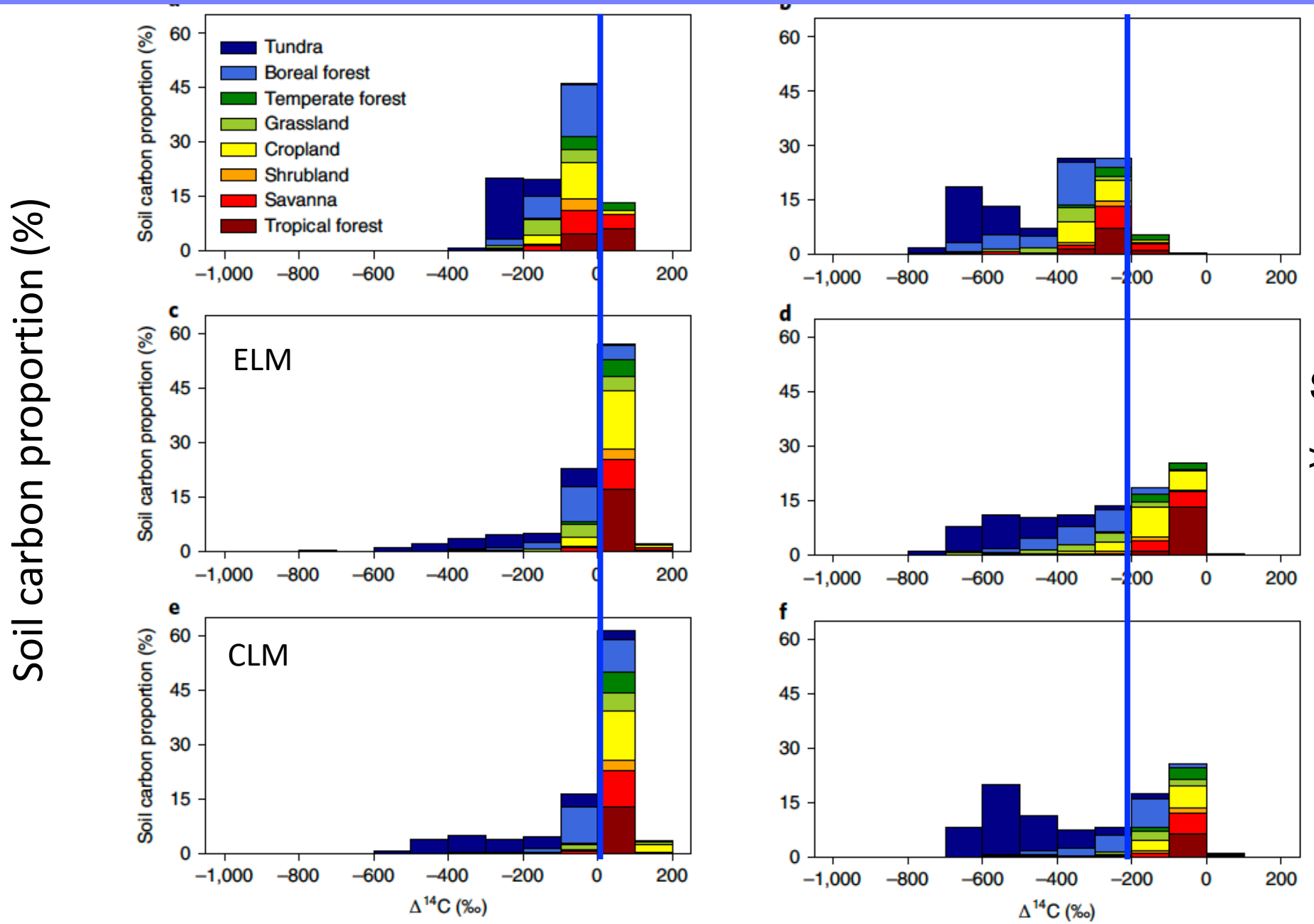
Higher proportion of carbon with enriched radiocarbon



- Surface soil: 0 – 30 cm
- Modern radiocarbon: 15%

  vs > 60%

Higher proportion of carbon with enriched radiocarbon



Subsurface: 30 – 100cm

> -200‰: 5% vs 50%

Conclusions

- Soil depth and climate are important predictors for global $\Delta^{14}C$
- Much older mean carbon age than expected
- Land surface models may considerably underestimate the age of soil carbon.