Climate Change and the Permafrost Carbon Feedback

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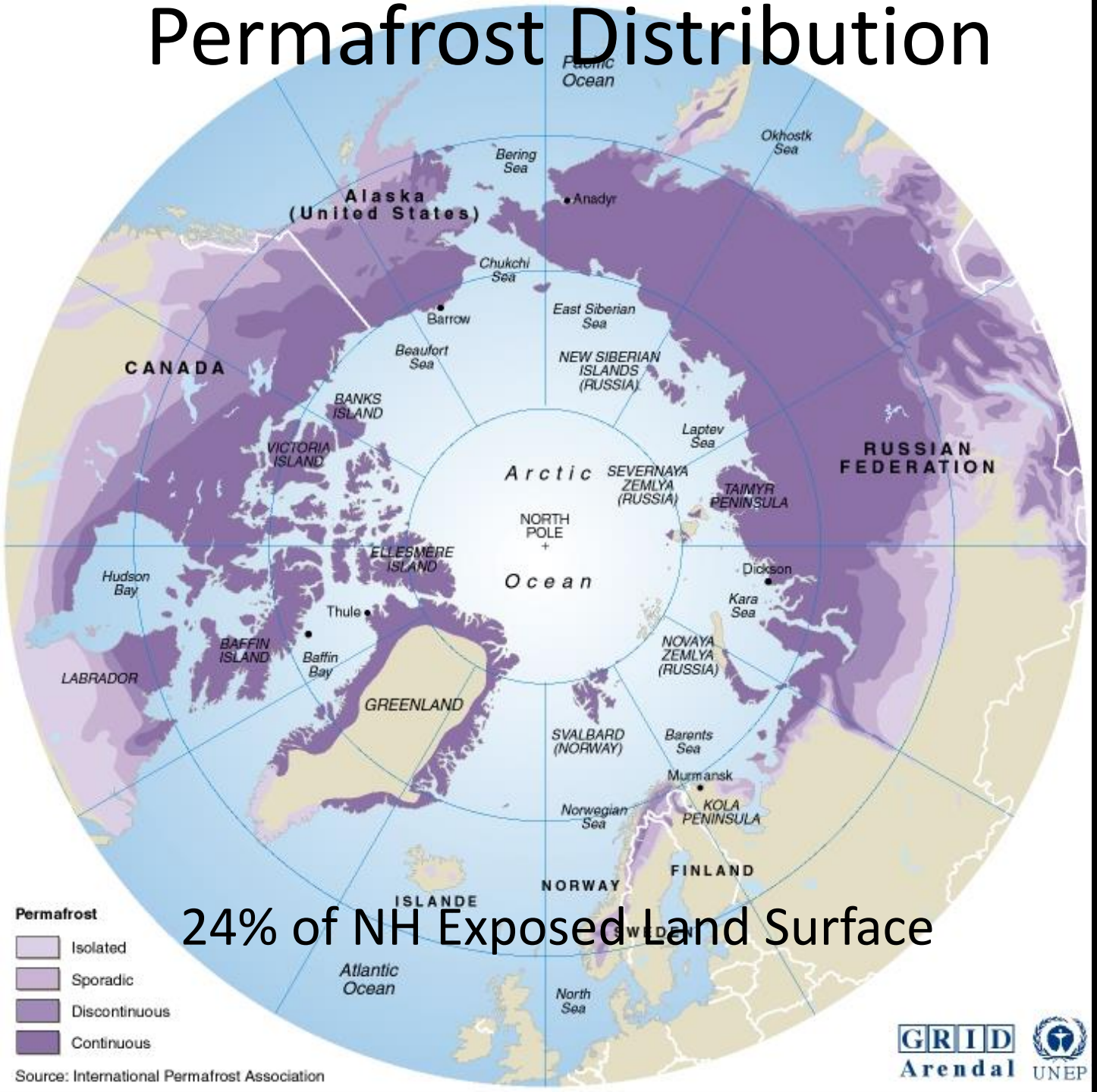
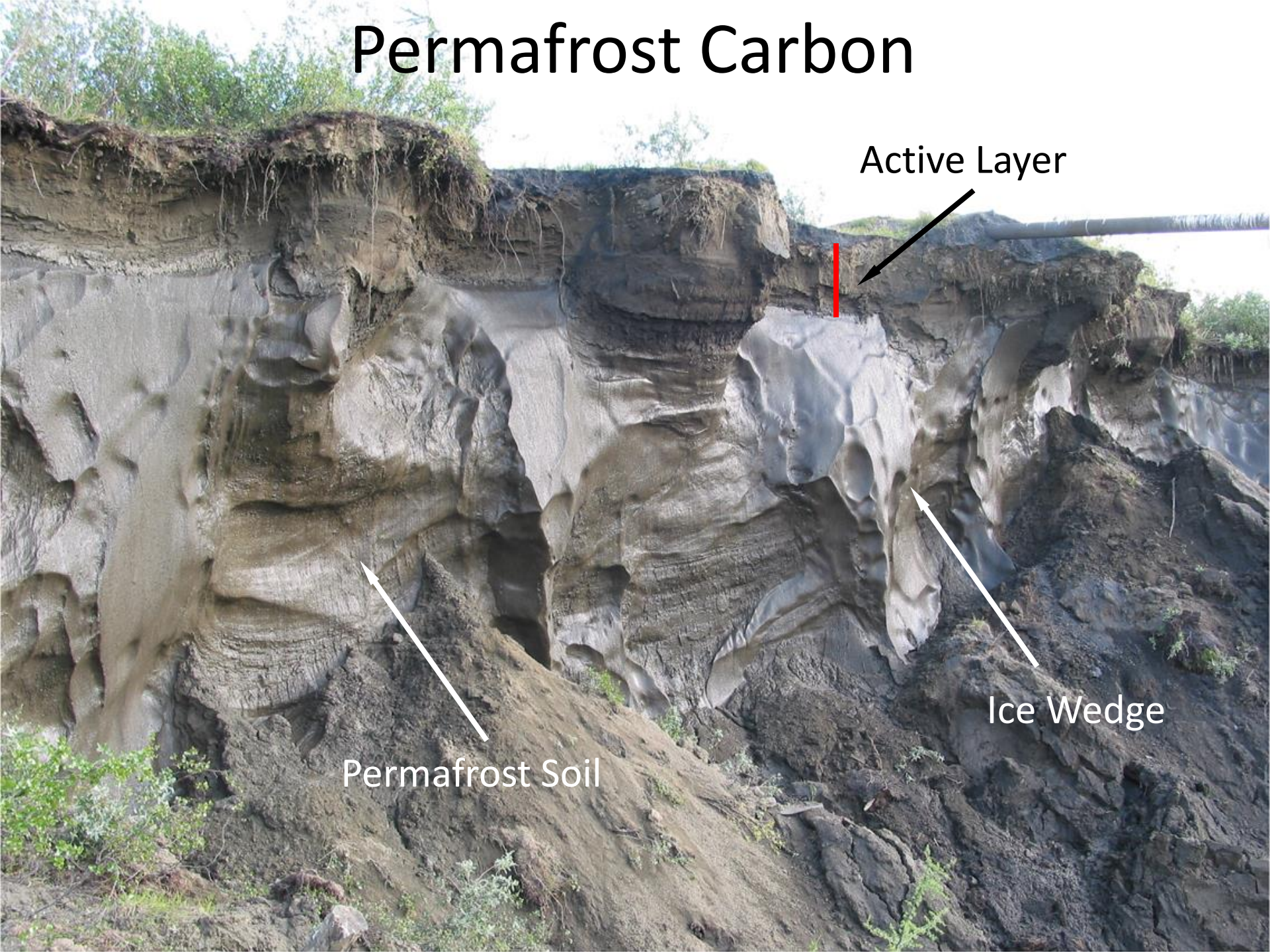
Permafrost Distribution



24% of NH Exposed Land Surface

[Brown et al. 1998]

Permafrost Carbon



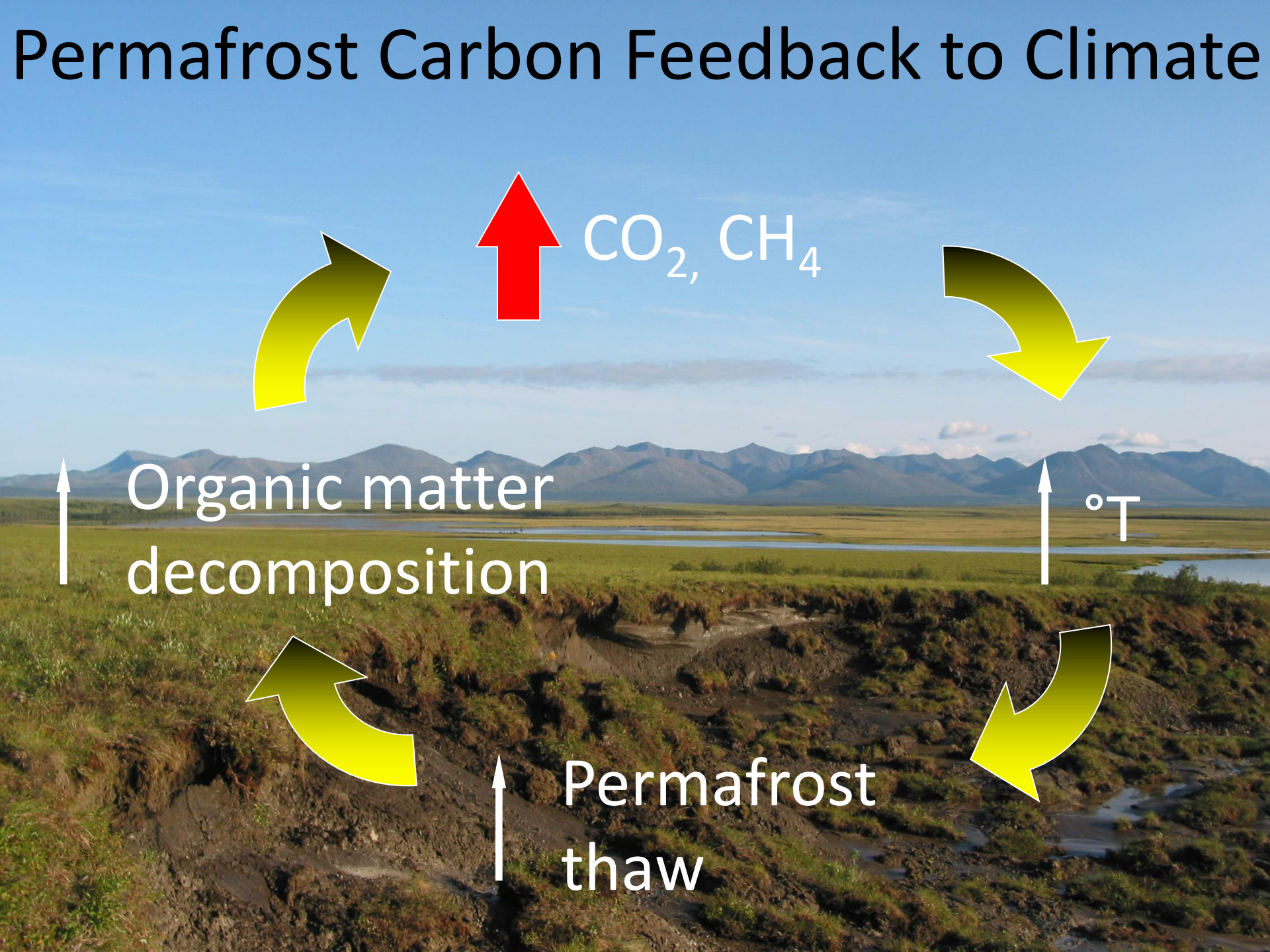
Global Carbon Pools

Global Vegetation C	650 Pg
Global Soil C (1m)	1500 Pg
Atmosphere	841+ Pg

Permafrost Zone Soil C	
Peatlands (several m)	277 Pg
Mineral Soil (3m)	747 Pg
Siberian Deep C (~25m)	407 Pg
Alluvial Deep C (~25m)	241 Pg
	1672 Pg

[Jobaggy et al. 2000, Field et al. 2007, Zimov et al. 2006, Tarnocai 2009, Schuur et al. 2008]

Permafrost Carbon Feedback to Climate



Permafrost Carbon Feedback to Climate

What is the **magnitude**, **timing**, and **form** of the permafrost carbon release to the atmosphere in a warmer world?

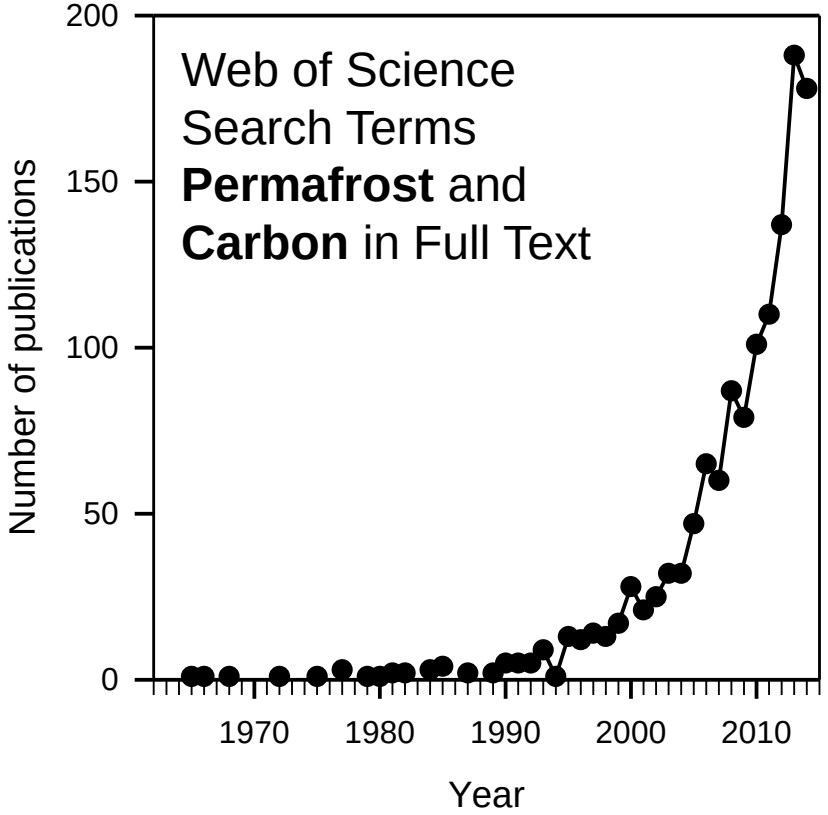
Cumulative C Emissions: 1850-2005 (2012)

Fossil Fuel Emissions	365 Pg
Land Use Change	151 Pg

Permafrost Zone C Emissions: Future 2100?

7-11% Loss?	120-195 Pg
Expert Survey (Schuur 2013)	

Permafrost Carbon Network



www.permafrostcarbon.org

Working Groups

1) Carbon Quantity
2) Carbon Quality
3) An/Aerobic
4) Thermokarst
5) Modeling Integration

Current number of:

Members: 230+

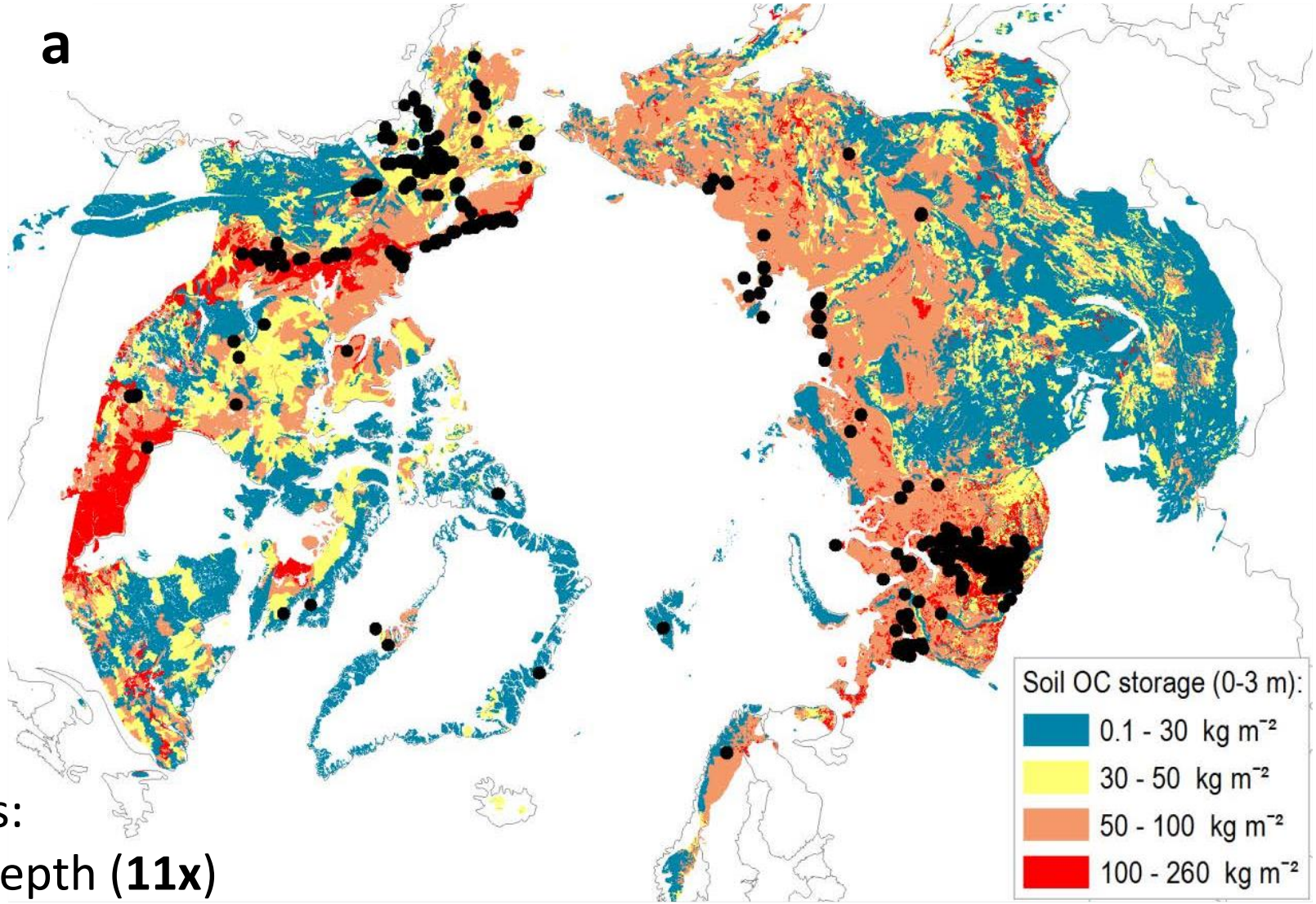
Institutions: 88

Countries: 17

Soil Carbon (Surface 0-3 m)

↑1035
±150 Pg

33% of Global soil carbon (0-3m)



Inventory
524 pedons:
0-200 cm depth (**11x**)
356 pedons:
0-300 cm depth (**8x**)

Hugelius et al. 2014 Biogeosciences Discussions
Tarnocai et al. 2009 Global Biogeochemical Cycles

Soil Carbon (Deep >3 m)

b

***Yedoma Region:**

↓ 210±70 Pg

456±45 Pg

***Arctic Deltas:**

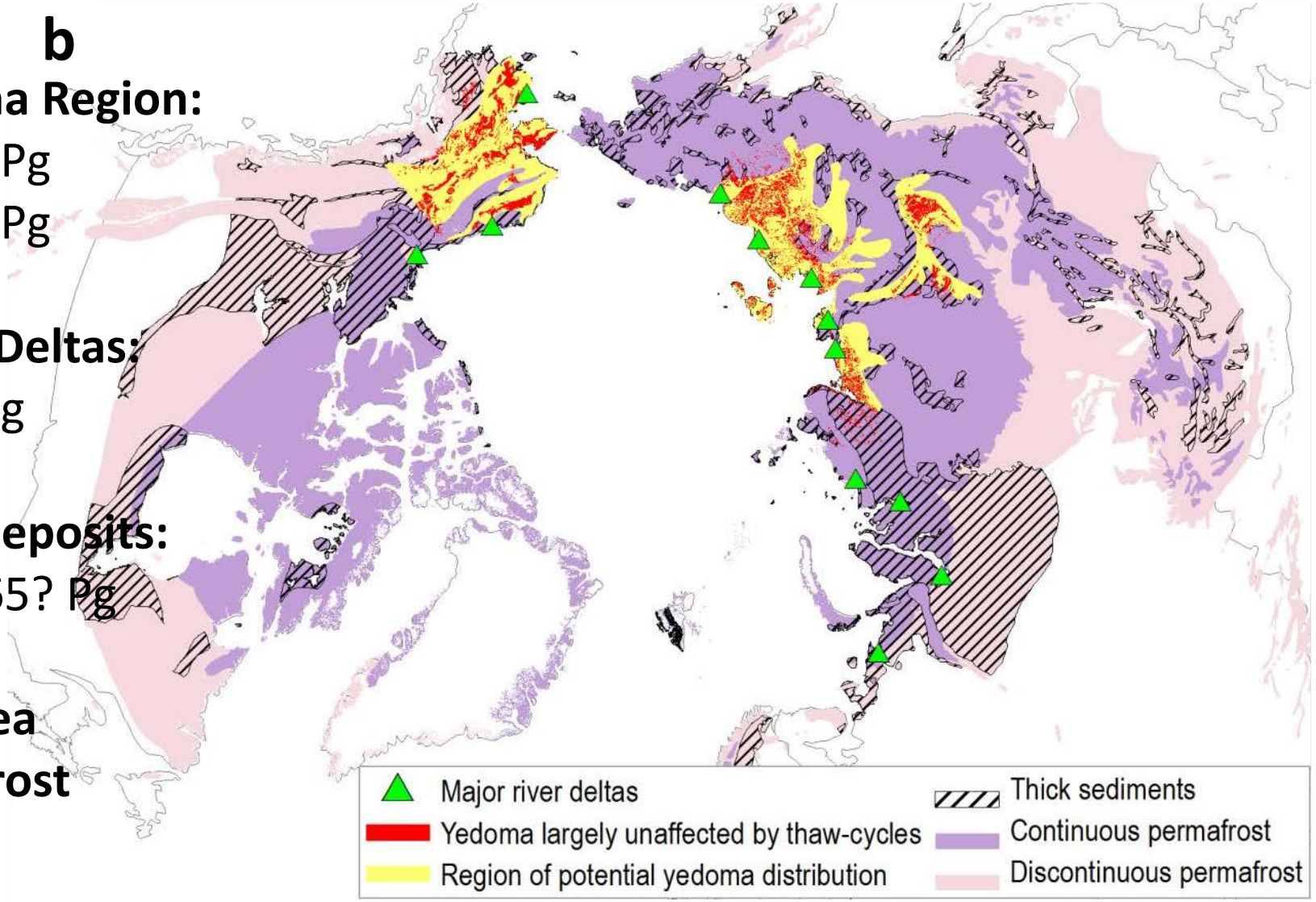
↓ 91±39 Pg

Other Deposits:

↑ ~350-465? Pg

Undersea Permafrost Carbon:

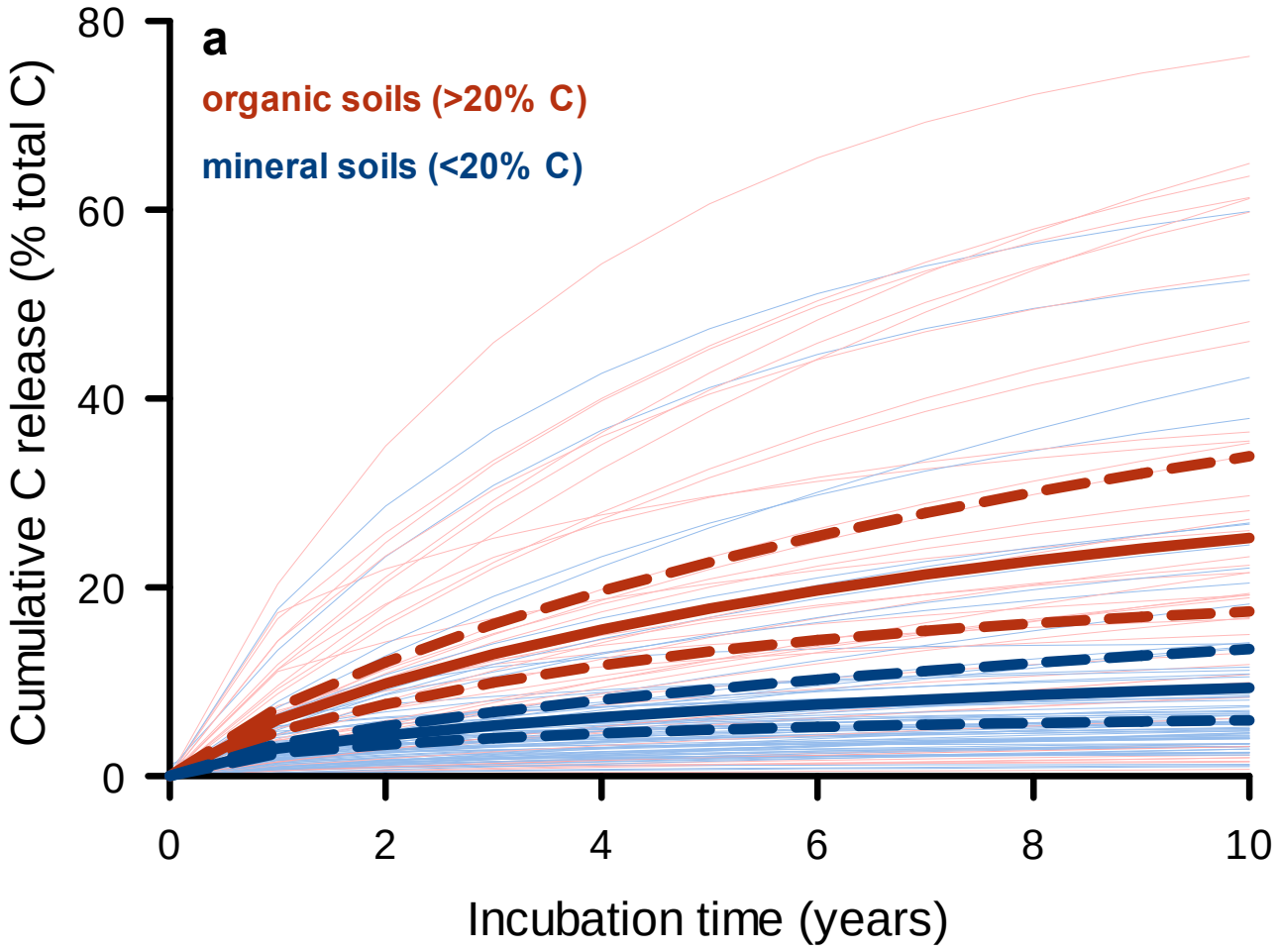
? Pg



Known Permafrost Carbon = 1330-1580* Pg

Hugelius et al. 2014
Strauss et al. 2013
Walter-Anthony et al. 2014

Potential Carbon Release



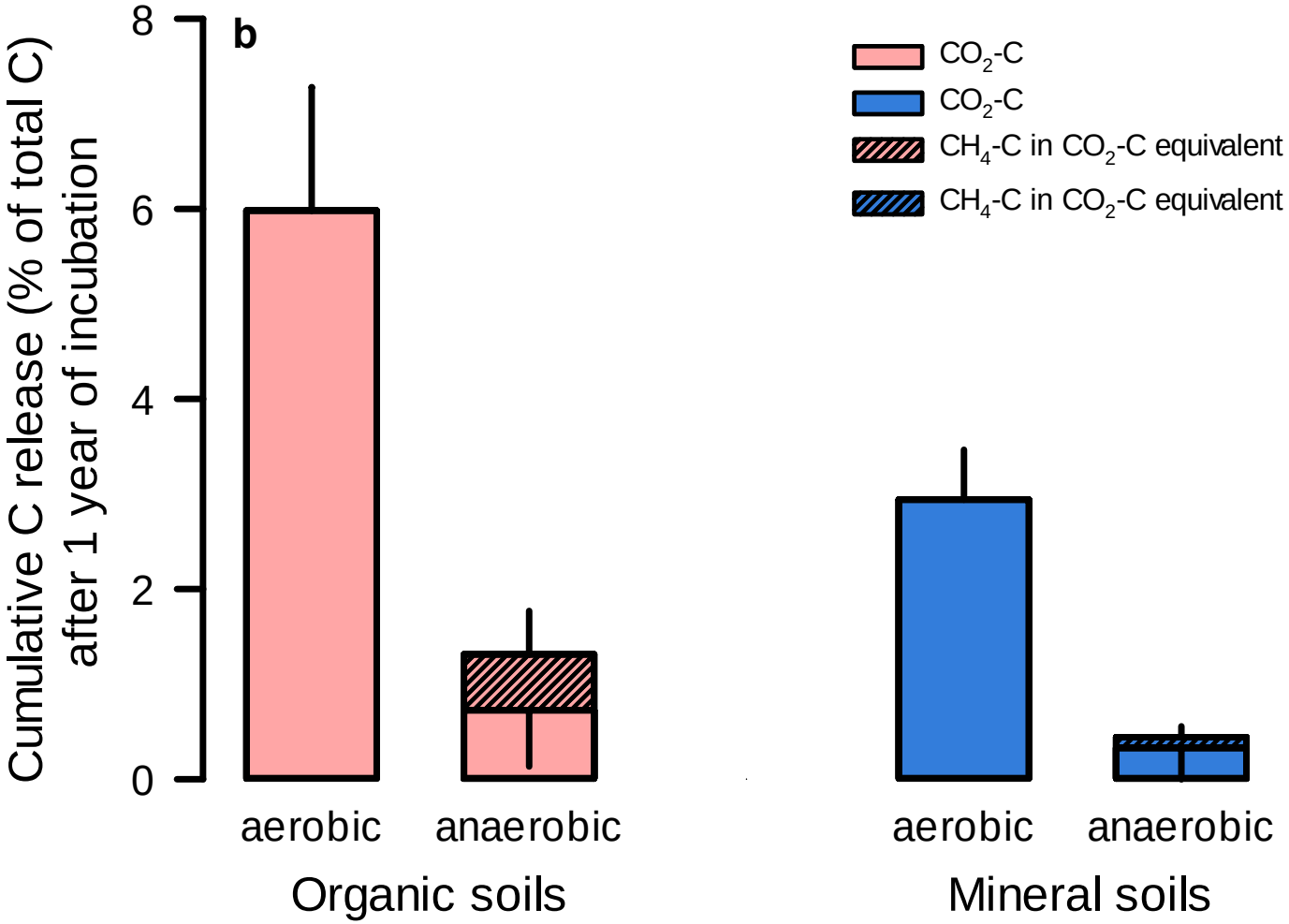
Laboratory Incubation
10 year projection
constant temp (5degC)

Organic Soils (>20%C):
17-34%

Mineral Soils (<20%C):
6-13%

Schädel et al. 2014 Global Change Biology
Elberling et al. 2013 Nature Climate Change

Anaerobic Influence on Carbon Release



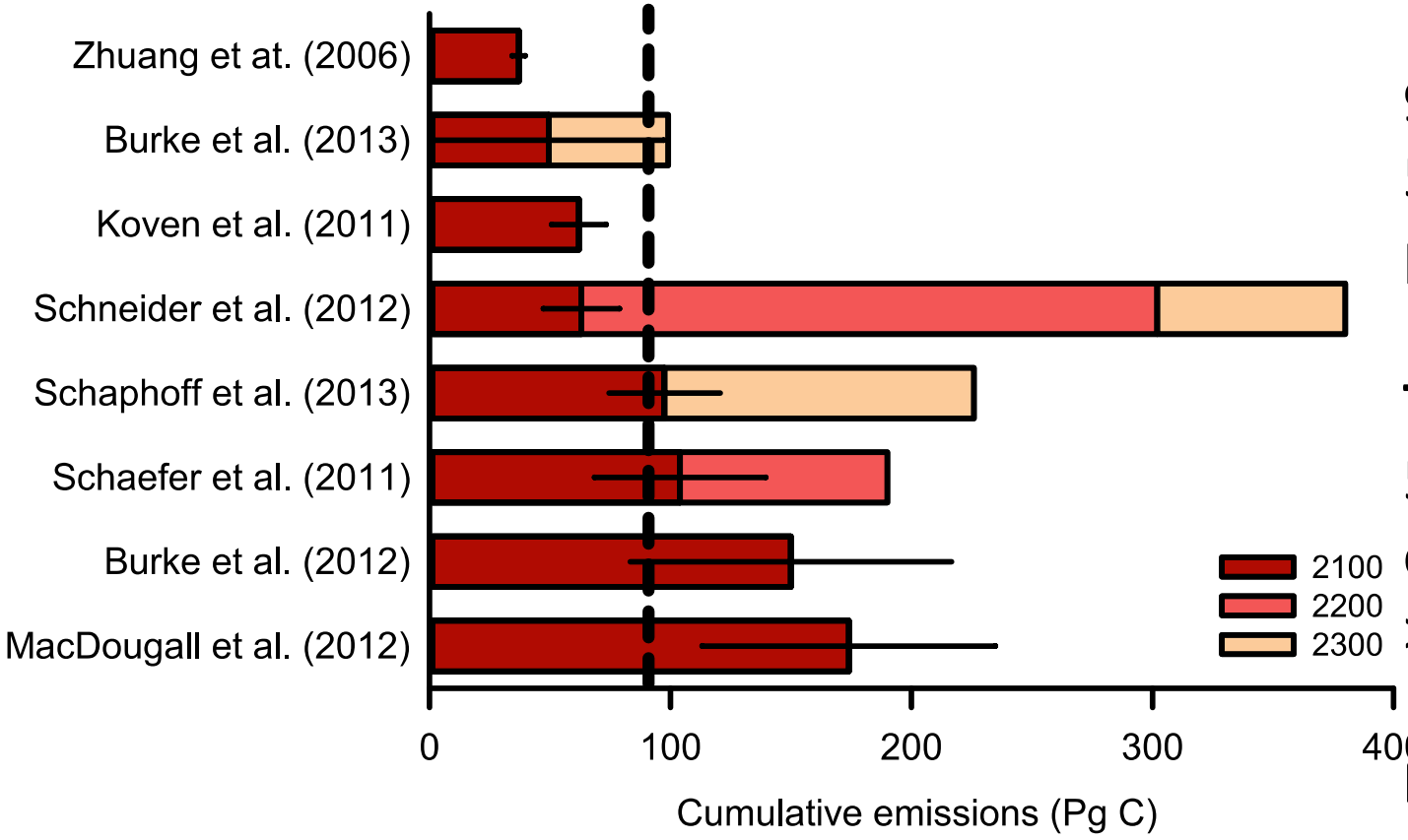
Methane Release
(by weight)
Mineral: 3%
Organic: 7%

Methane Release
(by GWP)
Mineral: 25%
Organic: 45%

Impact of C Loss
Aerobic > Anaerobic

Schädel et al. 2014 Global Change Biology; Treat et al. in press Global Change Biology

Dynamic Model Projections



By 2100 (RCP8.5)

Ensemble Mean

92±17 Pg C

5-15% of initial pool

Timescale

59% of permafrost carbon emissions >2100

Methane?

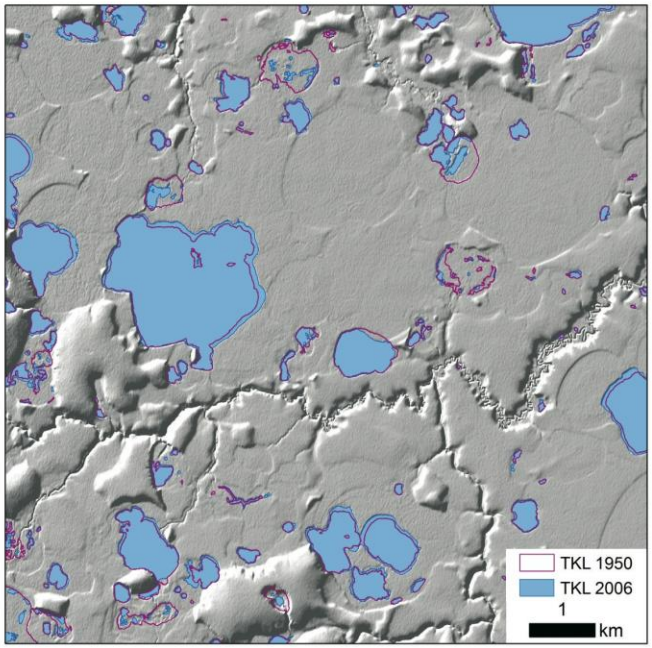
Expert survey

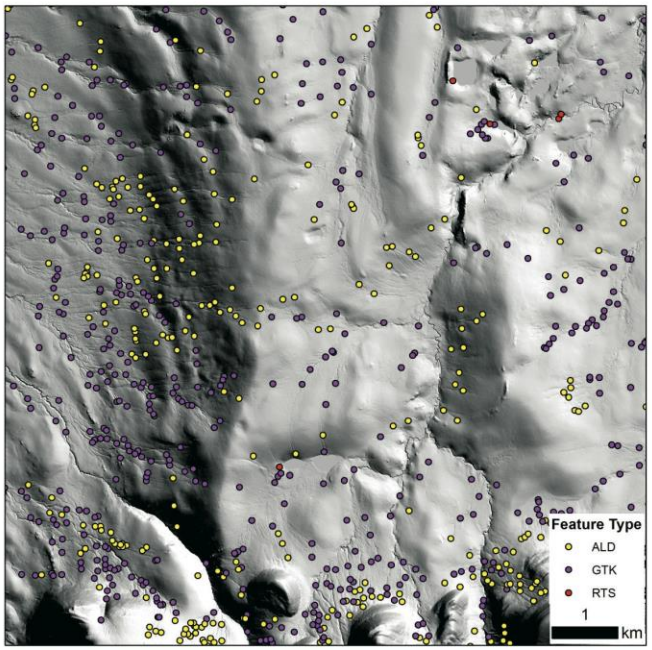
2.3%

35-48% more warming impact

Schaefer et al. 2014 Environmental Research Letters

Abrupt Thaw (Thermokarst)





Lowland

Net decreasing lake area: Seward Pen (= some increase + whole lake draining)

Upland

>7500 features

1,700 km^2 area

North Slope

Krieger et al. 2012

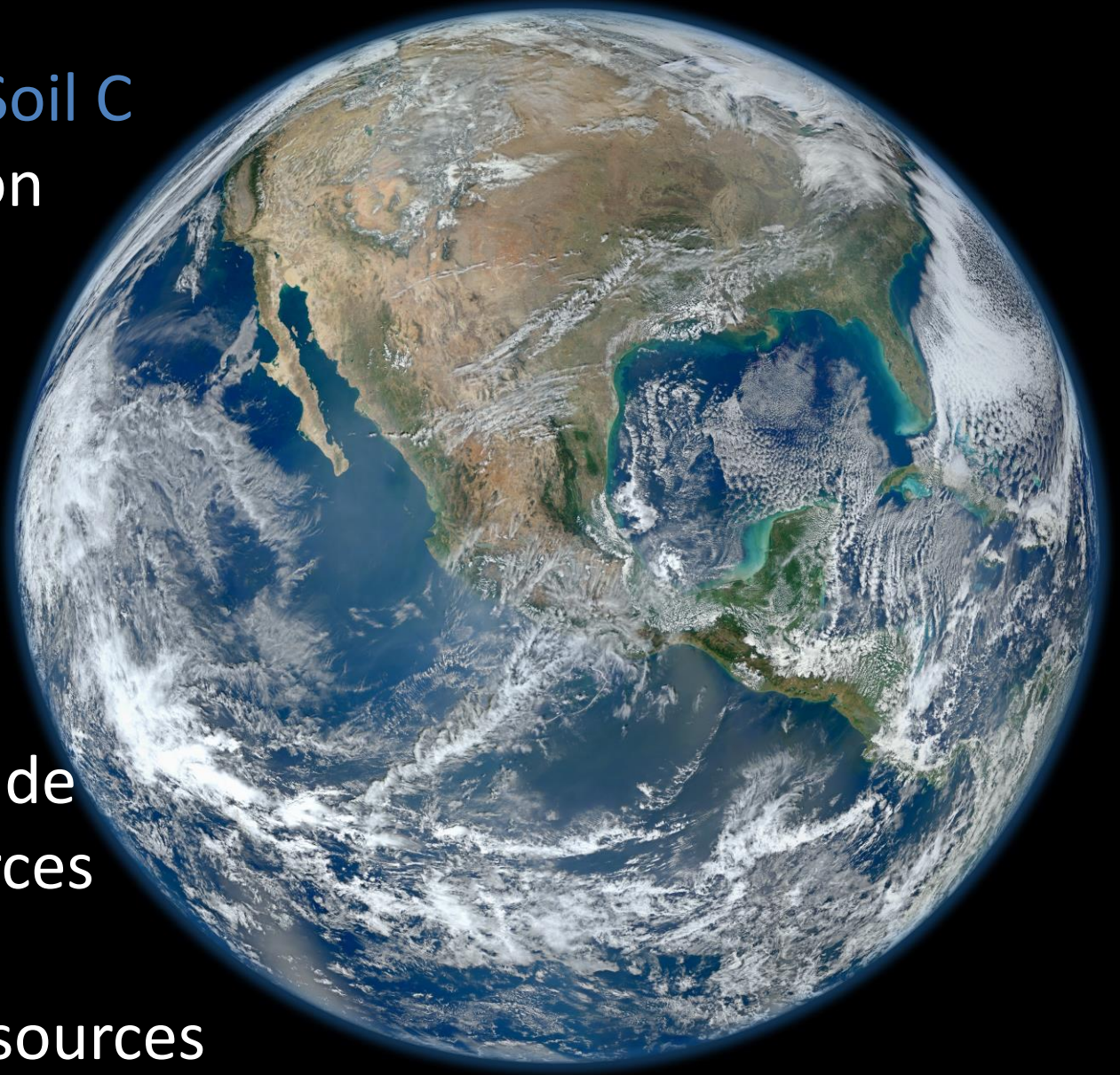
Jones et al. 2011 JGR BGS

Permafrost Carbon Emissions

Permafrost Zone Soil C
Vulnerable Fraction
~5-15% by 2100

10% of known
permafrost C pool
=130-160 Pg

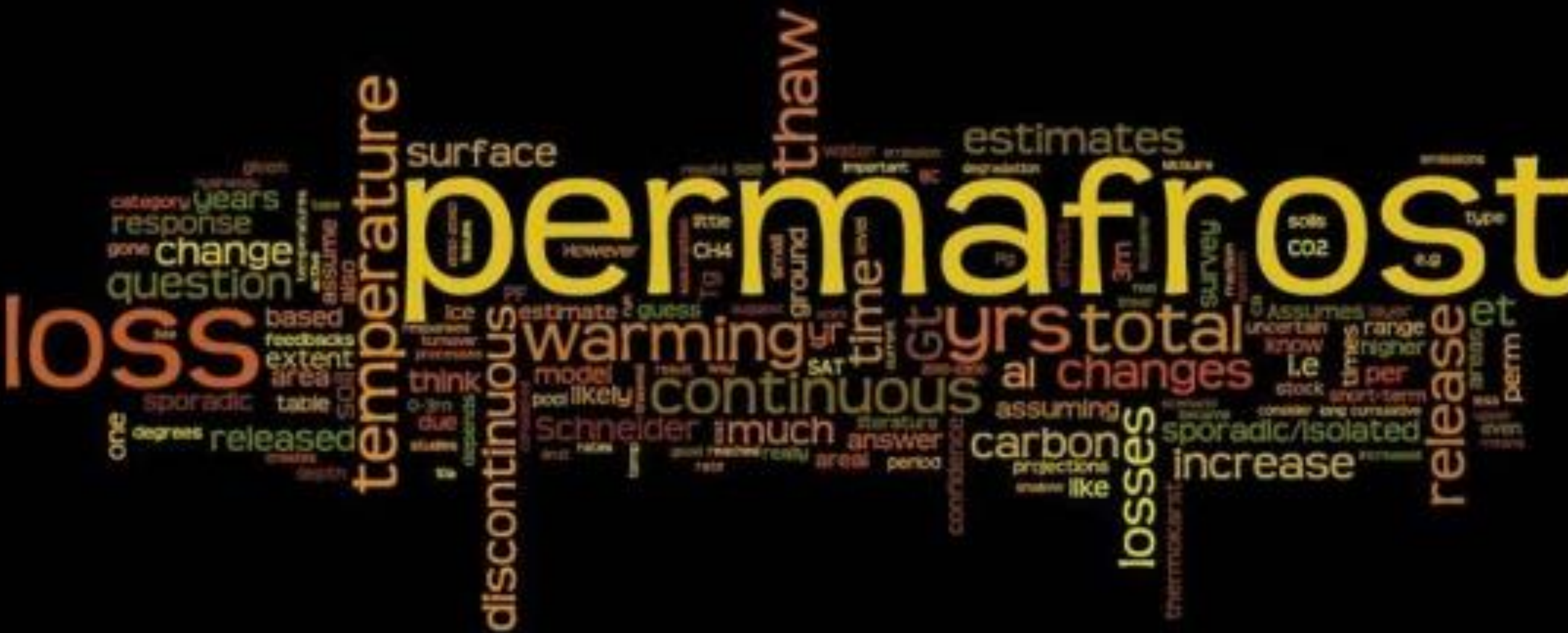
Similar in magnitude
to biospheric sources
(land use change)
Less than human sources
(fossil fuel)



Schuur et al. in press Nature

Might there be Arctic carbon cycle ‘surprises’?

Yes


permafrost
loss
temperature
thaw
discontinuous
warming
continuous
yrs
total
estimates
surface
release
losses
changes
carbon
increase
sporadic/isolated
question
change
response
years
time
much
released
Schneider
answer
assuming
estimate
guess
model
think
likely
based
feedbacks
extent
area
sporadic
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Gt
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Survey
Assumes
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perm
SAT
CH4
CO2
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type
e.g
However
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projections
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areal
Ice
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thermokarst
category
gone
assume
degradation
important
emissions
answer
due