

Welcome

ARCUS Arctic Research Seminar Series

“Regional and Global Implications of Changing Permafrost”



Presented by Ted Schuur
Northern Arizona University
ted.schuur@nau.edu



Regional and Global Implications of Changing Permafrost

A scenic landscape photograph of a rocky coastline. In the foreground, there is a body of water with a brownish tint. The middle ground features a steep, rocky cliffside with patches of green grass and shrubs. The background is a dense forest of tall, thin evergreen trees under a blue sky with scattered white clouds.

Dr. Ted Schuur
Permafrost Action Team Lead
Study for Environmental Arctic Change Program

Center for Ecosystem Science and Society
Northern Arizona University



SEARCH



Study of Environmental Arctic Change



Sea Ice Action Team

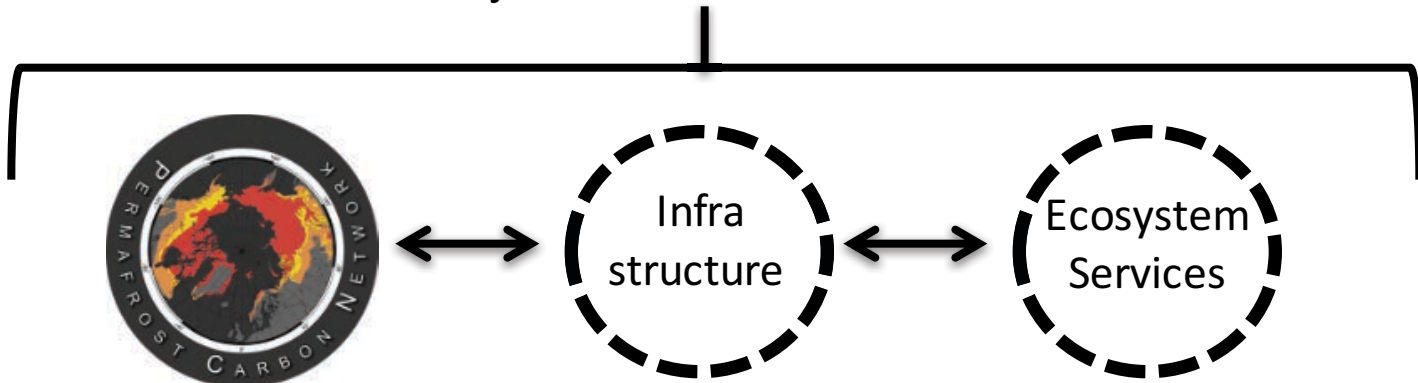


Permafrost Action Team

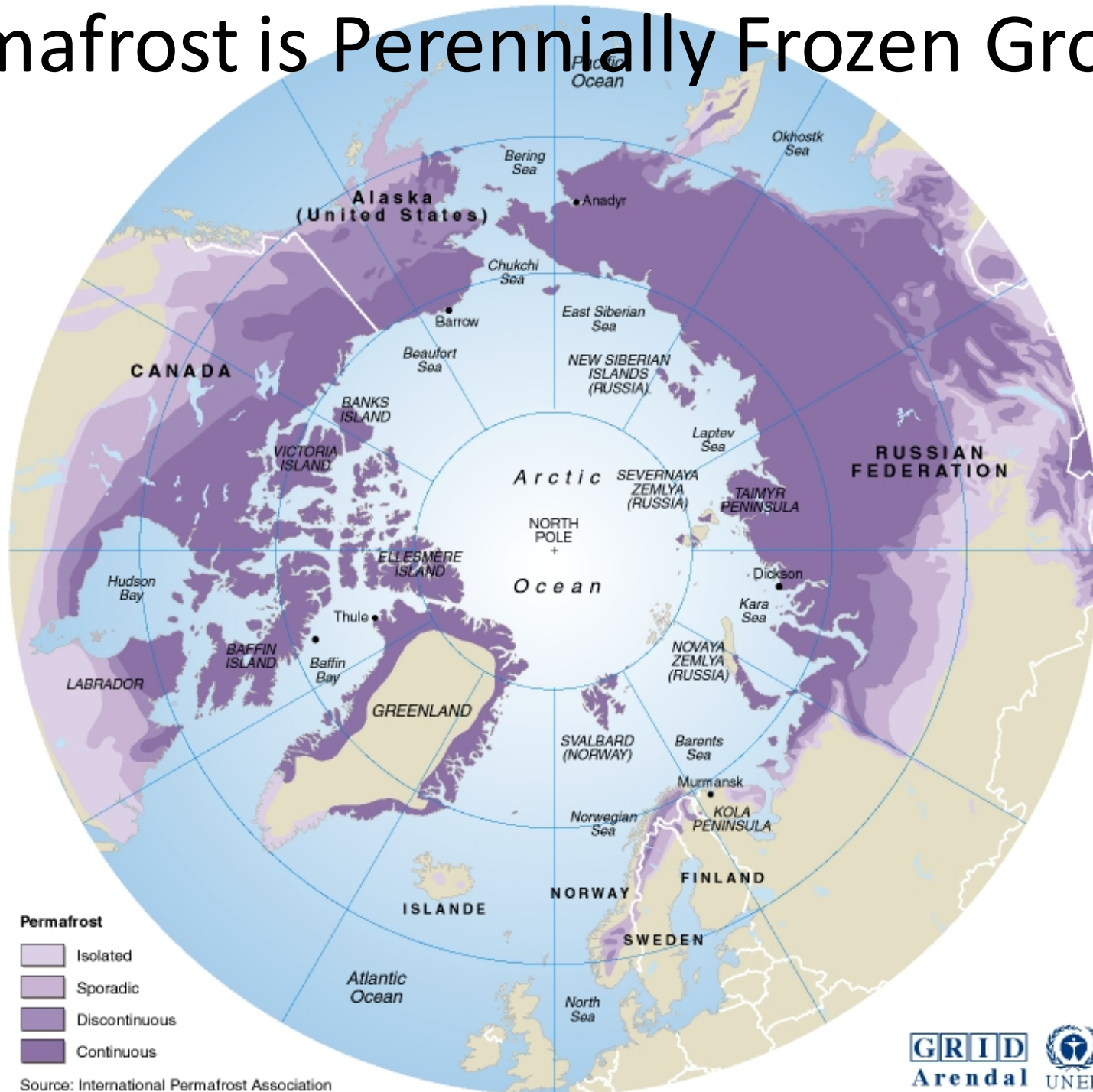


Land Ice Action Team

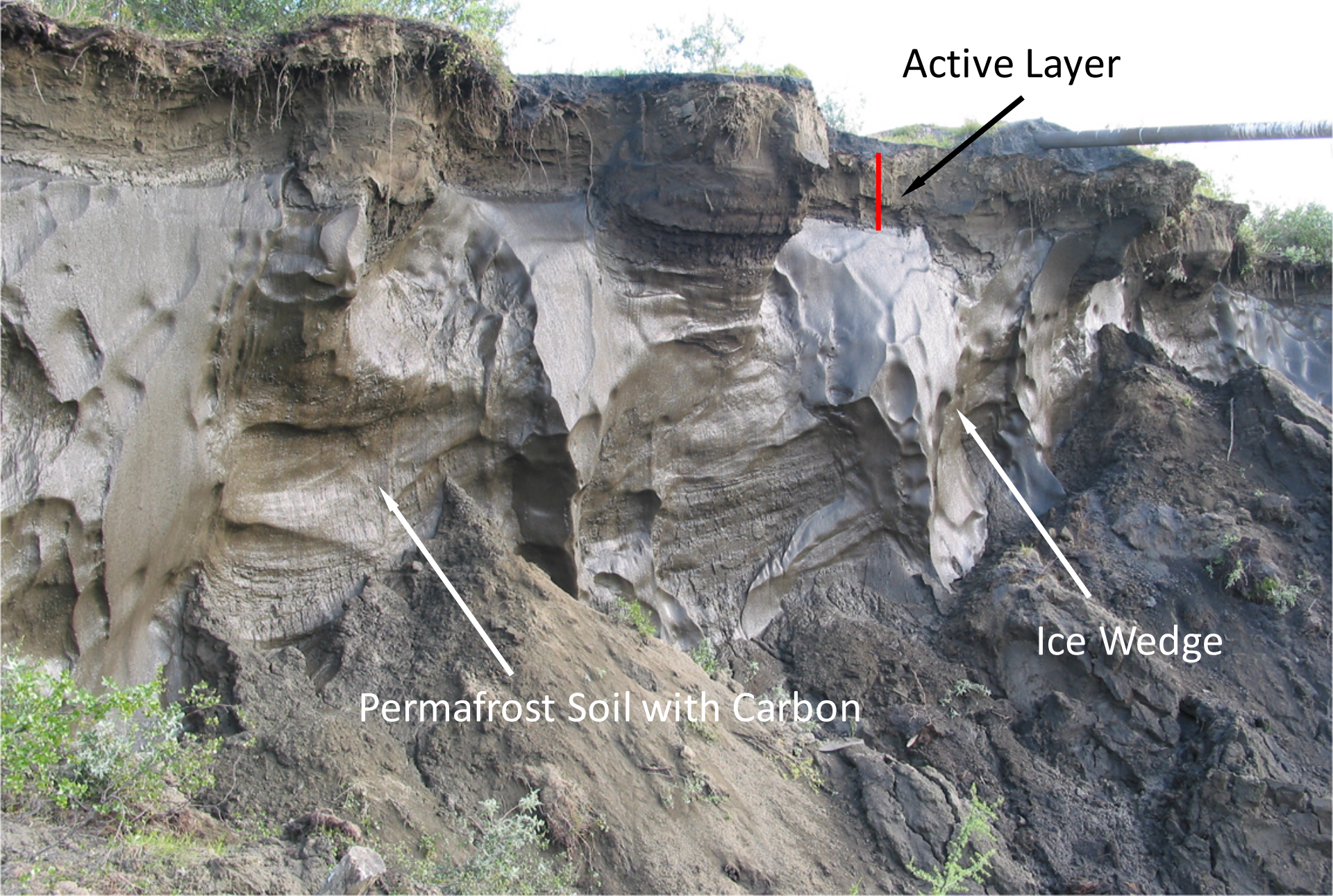
Document and Understand How Degradation of Near-Surface Permafrost Will Affect Arctic and Global Systems **USING SYNTHESIS SCIENCE**



Permafrost is Perennially Frozen Ground



Permafrost Thaws, it Doesn't Melt



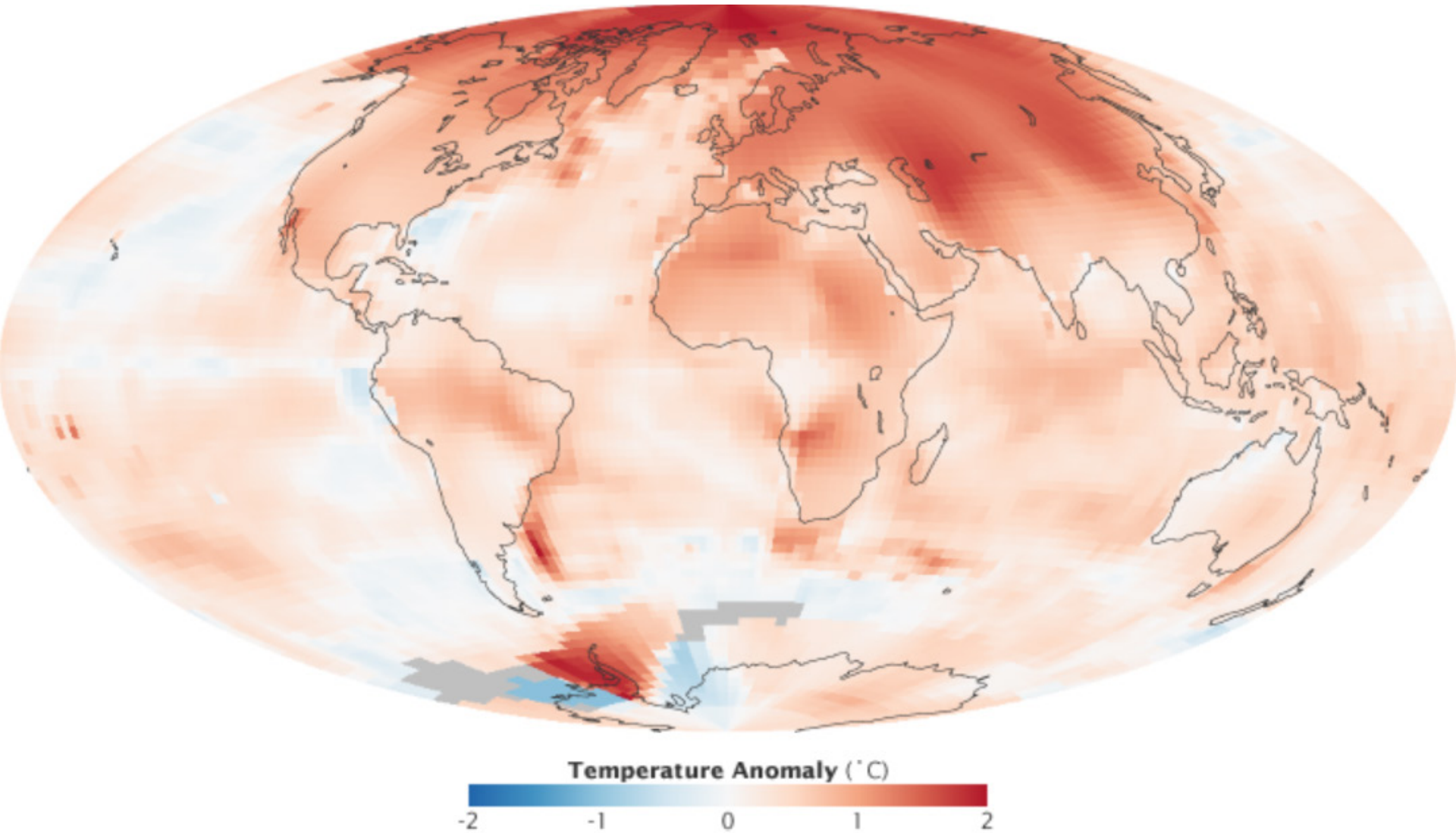
Active Layer



Permafrost Soil with Carbon

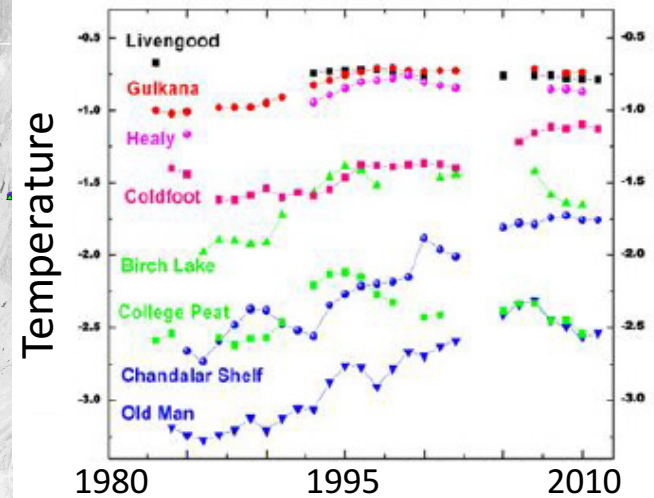
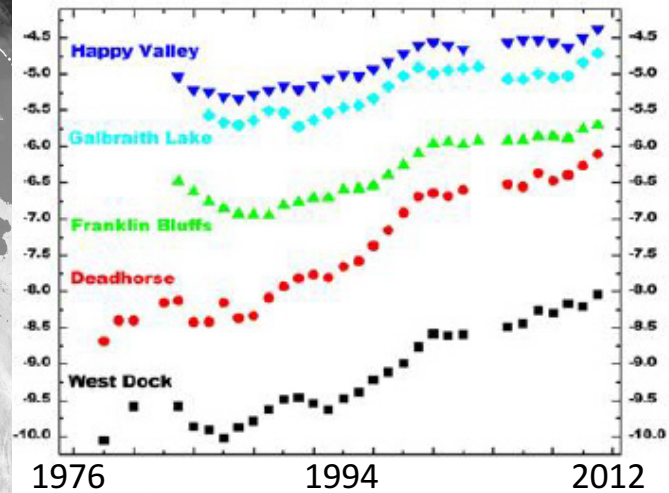
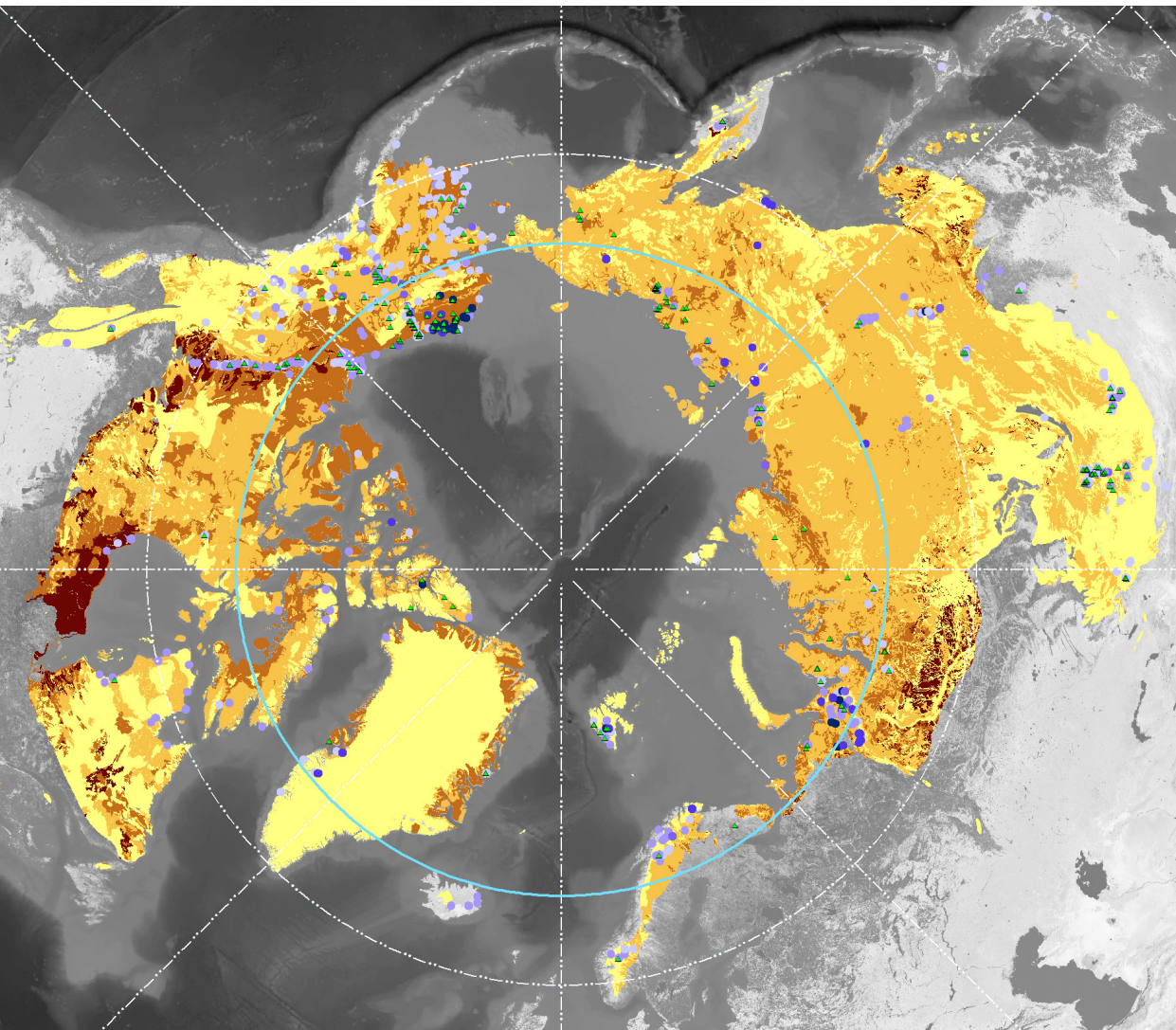
Ice Wedge

Arctic is Warming 2x Faster Than Globe



Actual Temperature Measurements

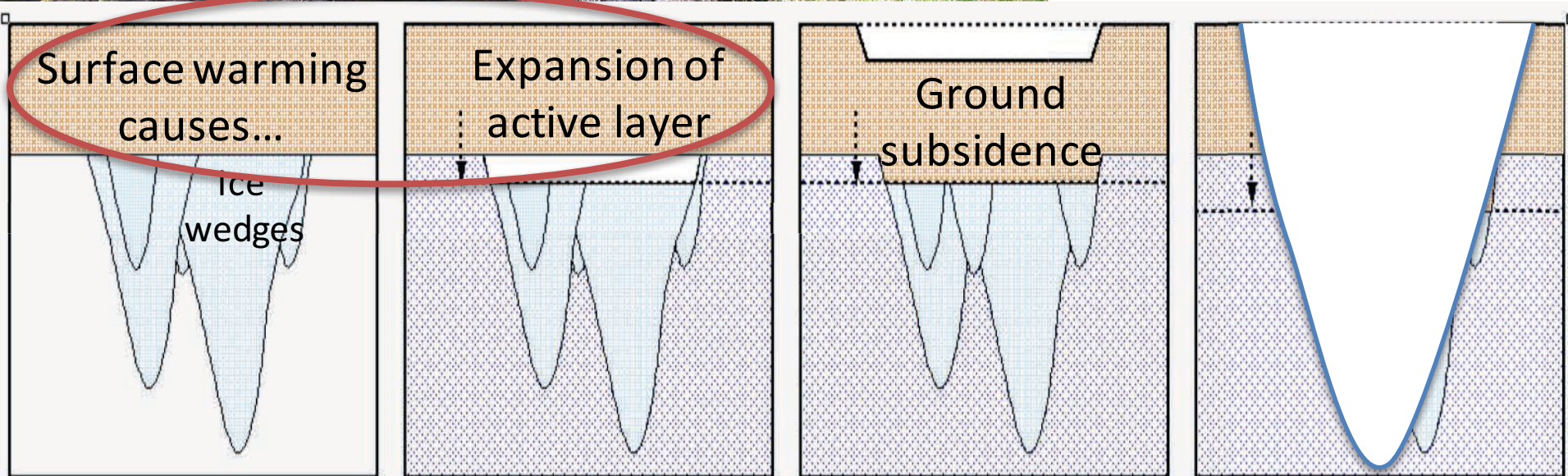
Trends in Permafrost Temperature



Abrupt Permafrost Thaw



Degradation of permafrost can occur rapidly at point locations



Why Should Arctic Residents Care?

Siberia, Russia



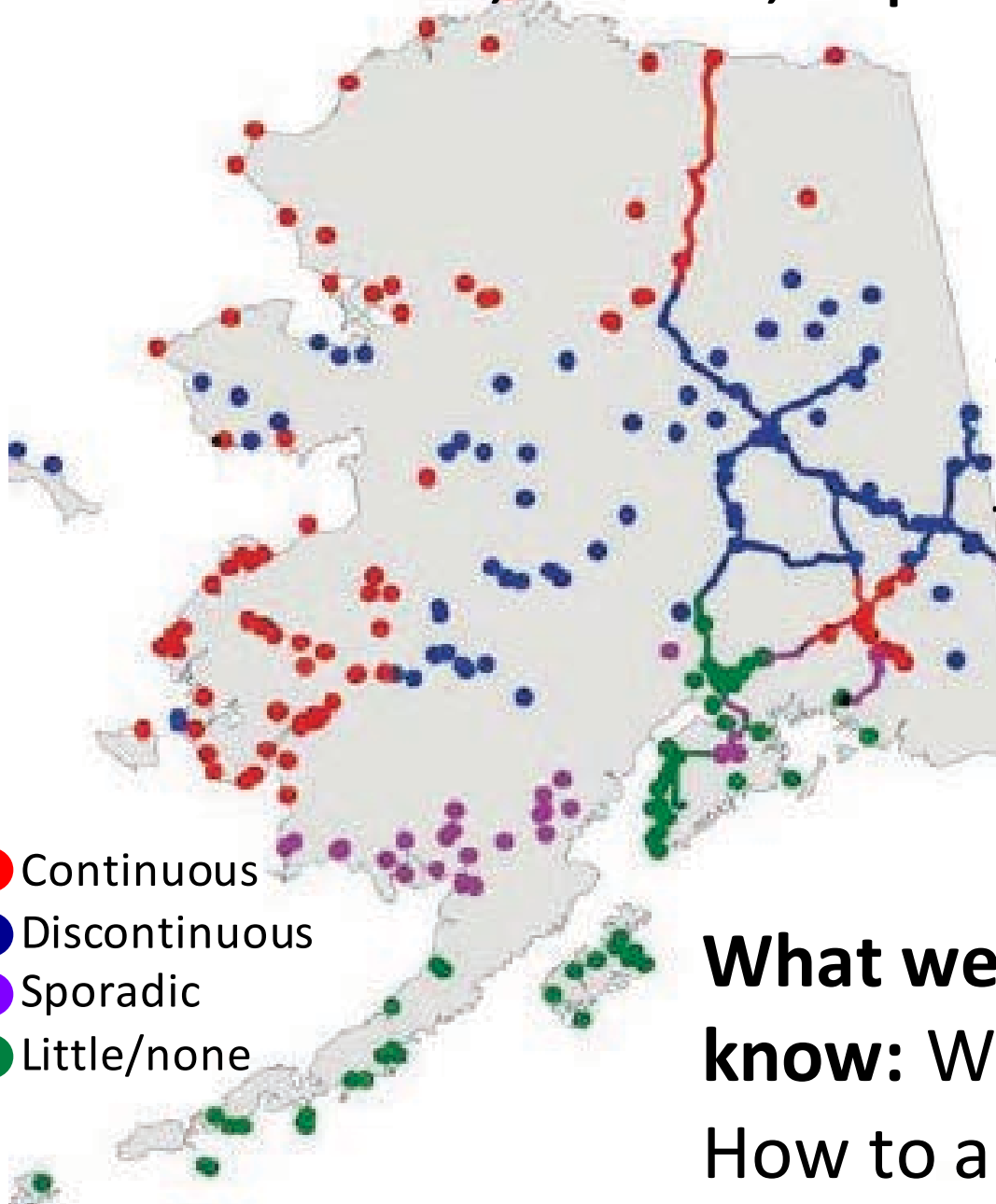
Permafrost weakens,
even at $<0^{\circ}\text{C}$ degrees
temperature



Alaska, DOT

Inuvik Airport, NWT

Alaska Towns, Roads, Pipeline on Permafrost



12,700 miles of maintained roads
29 commercial airports
DoD installations
Trans Alaska Pipeline

- Continuous
- Discontinuous
- Sporadic
- Little/none

What we want to know: Where's the ground ice?
How to anticipate abrupt thaw?

Why Should Global Society Care?

Climate change might happen faster than we think



CO₂, CH₄



What we want to know:

How much?

How fast?

What form?

Organic matter
decomposition

°T



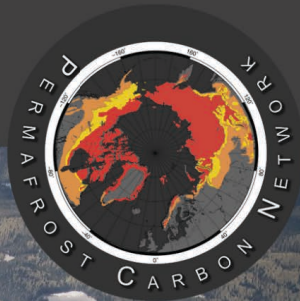
Permafrost
thaw

Synthesis science is a key step for translating knowledge to action

2015

PERMAFROST CARBON NETWORK

5-YEAR SYNTHESIS REPORT



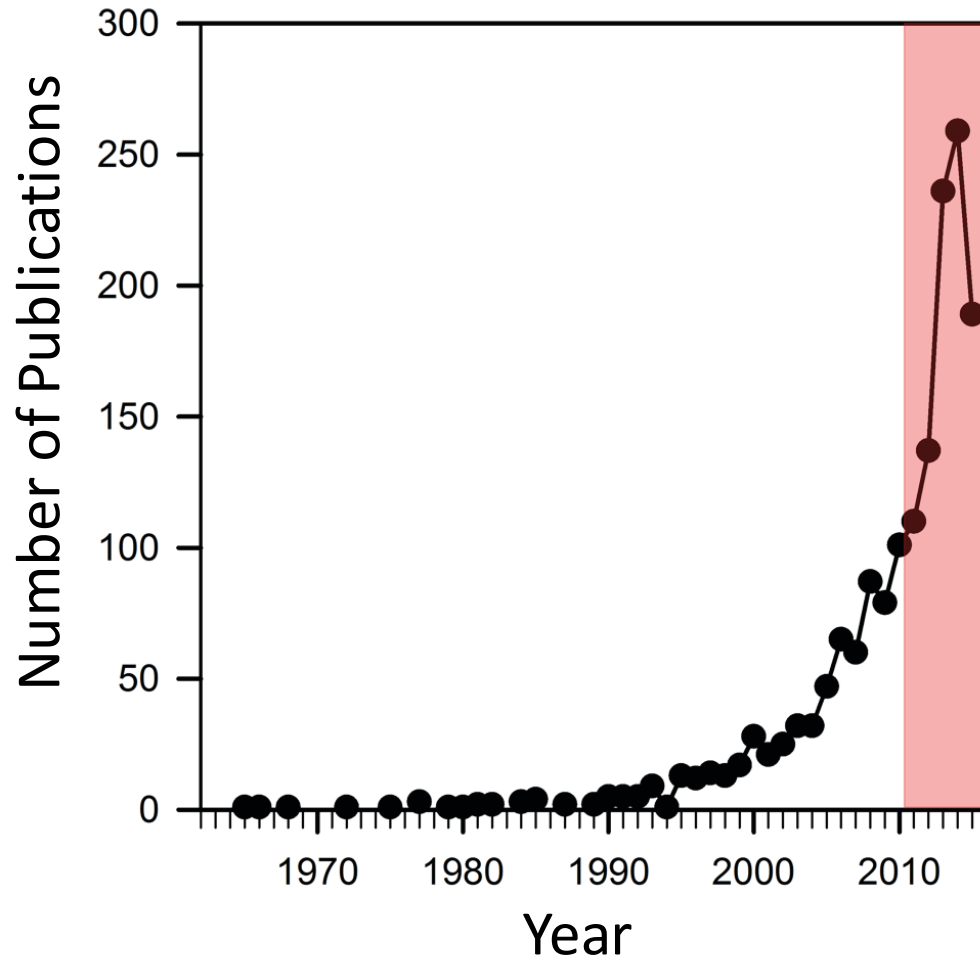
www.permafrostcarbon.org



Permafrost Carbon Published Literature

Search Terms in Science Citation Index at Web of Science (ISI)

Permafrost and Carbon in Full Text



2000–present: **91%**

2005–present: **80%**

2010–present: **55%**

Network Goal: Use synthesis science to integrate knowledge ‘under the curve’ and distill findings for decision makers and public

Permafrost Carbon Network

www.permafrostcarbon.org

OBJECTIVE: Produce knowledge through **research synthesis** that can be used to quantify the role of permafrost carbon in driving climate change, and to communicate these findings to decision makers and the broader public.

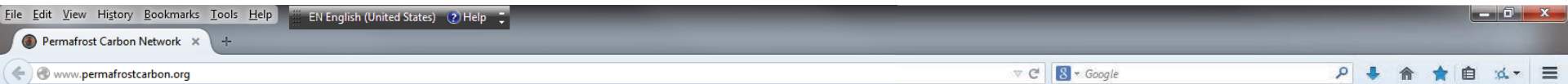
ACTIVITIES:

- 1) Organize a sequence of meetings and working groups designed to synthesize existing permafrost carbon research
- 2) Formation of a consortium of interconnected researchers to disseminate synthesis results
- 3) Permafrost carbon network website
- 4) Enhance young researcher networks

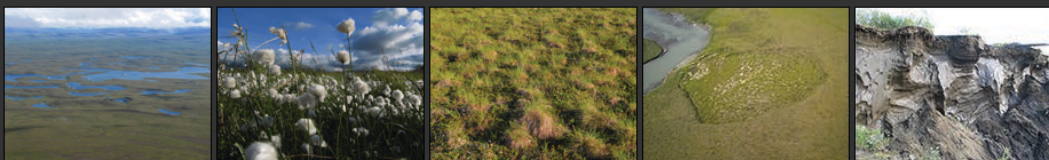


Permafrost Carbon Website

www.permafrostcarbon.org



Permafrost Carbon Network



[home](#) [people](#) [activities](#) [meetings](#) [publications](#) [maps](#) [multimedia](#) [links/login](#)

NEWS

The Permafrost Carbon Network is part of the multi-million dollar [Study of Environmental Arctic Change \(SEARCH\) project](#). The SEARCH project, headed by the University of Alaska Fairbanks as the lead institution and Northern Arizona University as one partner, is a system-scale, cross-disciplinary research program that seeks to connect the science of Arctic change to decision makers. Three Action Teams comprise a core structural aspect of SEARCH, each focused on data synthesis and model development with projections used to advance current knowledge of a changing Arctic. The Permafrost Action Team, led by Ted Schuur, will, in part, support activities developed by the Permafrost Carbon Network. The network has been successfully running for the last four years and includes more than 200 scientist from 88 research institutions located in 17 countries.

Background

Approximately 1670 Pg of soil carbon are estimated to be stored in soils and permafrost of high latitude ecosystems (Fig. 1 and Fig. 2) which is twice as much carbon as is currently contained in the atmosphere. In a warmer world permafrost thawing and decomposition of previously frozen organic carbon is one of the more likely positive feedbacks from terrestrial ecosystems to the atmosphere. Although ground temperature increases in permafrost regions are well documented there is a knowledge gap in the response of permafrost carbon to climate change.

The Permafrost Carbon Network builds on several previous synthesis efforts. These former activities include:

1. National Center for Ecological Analysis and Synthesis (NCEAS) [working group](#) on the Vulnerability of carbon in permafrost: Pool size and potential effects on the climate system (see also [Schuur et al. 2008](#))
2. International Permafrost Association (IPA) sponsored Carbon Pools in Cryosphere Region ([CAPP](#)) project which specifically focused on permafrost carbon pools including

Google Custom Search Search
powered by Google

News and Updates:

AGU Session 2014:

[Vulnerability of Permafrost Carbon to Climate Change \(session ID#: 2294\)](#)

Session chairs: Christina Schadel, Dave McGuire, David Olefeldt

Poster (B31G):

Wednesday, 17 Dec. 8:00AM - 12:20PM

Oral (B41O, B42D, B43J):

Thursday, 18 Dec. 8:00AM-10:00AM
Thursday, 18 Dec. 10:20AM-12:20PM
Thursday, 18 Dec. 1:40PM-3:40PM

Annual Meeting of the Permafrost Carbon Network

Sunday, December 14, 2014 in San Francisco. [Click here for more details.](#)



REVIEW

doi:10.1038/nature14338

Climate change and the permafrost carbon feedback

E. A. G. Schuur^{1,2}, A. D. McGuire³, C. Schädel^{1,2}, G. Grosse⁴, J. W. Harden⁵, D. J. Hayes⁶, G. Hugelius⁷, C. D. Koven⁸, P. Kuhry⁷, D. M. Lawrence⁹, S. M. Natali¹⁰, D. Olefeldt^{11,12}, V. E. Romanovsky^{13,14}, K. Schaefer¹⁵, M. R. Turetsky¹¹, C. C. Treat¹⁶ & J. E. Vonk¹⁷

Large quantities of organic carbon are stored in frozen soils (permafrost) within Arctic and sub-Arctic regions. A warming climate can induce environmental changes that accelerate the microbial breakdown of organic carbon and the release of the greenhouse gases carbon dioxide and methane. This feedback can accelerate climate change, but the magnitude and timing of greenhouse gas emission from these regions and their impact on climate change remain uncertain. Here we find that current evidence suggests a gradual and prolonged release of greenhouse gas emissions in a warming climate and present a research strategy with which to target poorly understood aspects of permafrost carbon dynamics.

Permafrost Carbon Emissions

Permafrost Zone

Soil Carbon

Vulnerable Fraction

~5-15% by 2100

10% of known

permafrost C pool

=130-160 billion tons

Similar in amount

to biospheric sources

deforestation

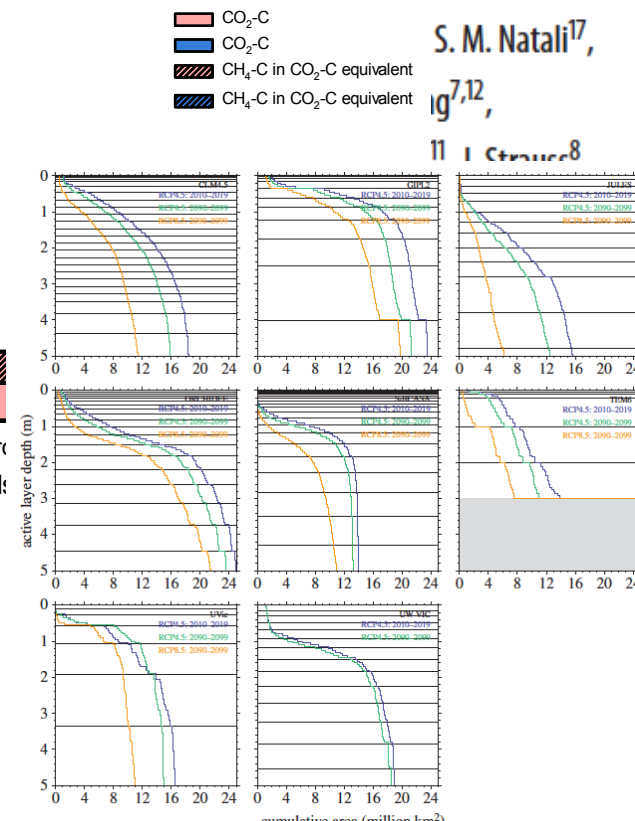
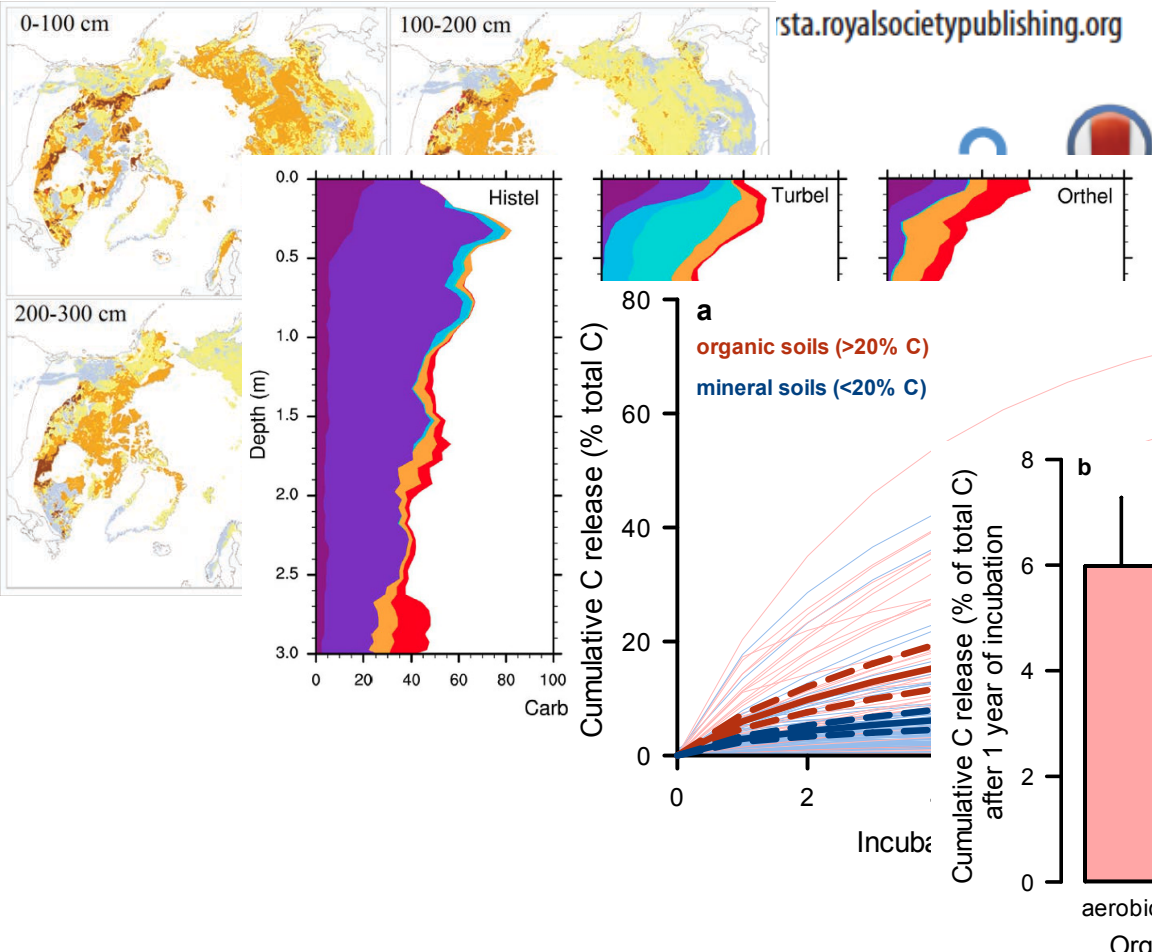
Less than human sources

fossil fuels

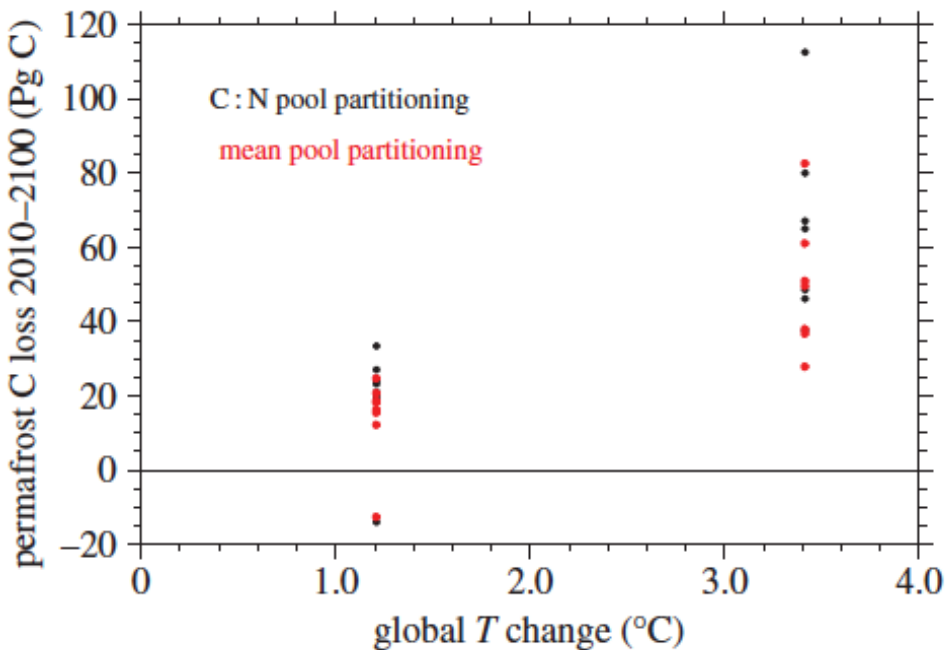
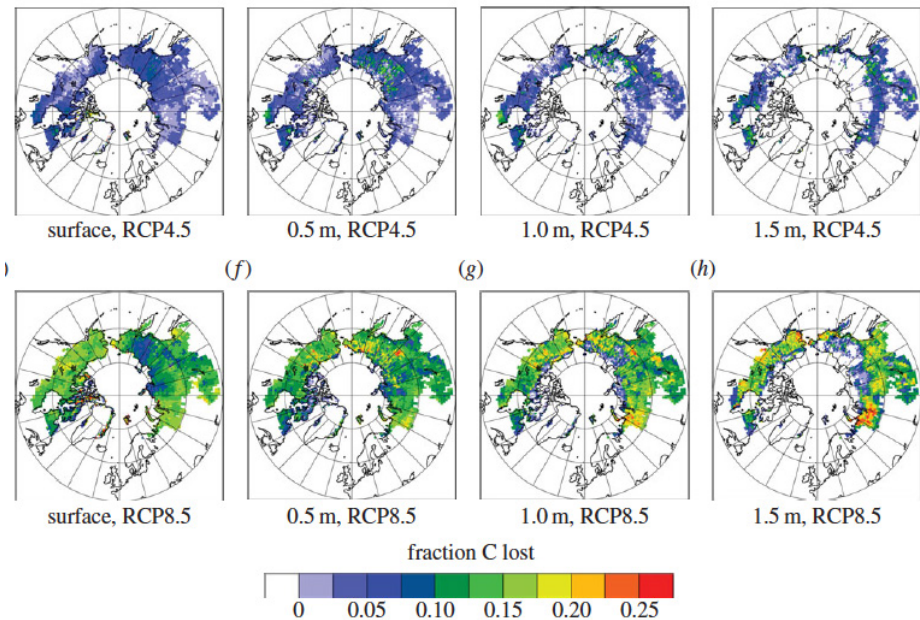


A simplified, data-constrained approach to estimate the permafrost carbon-climate feedback

C. D. Koven¹, E. A. G. Schuur², C. Schädel²,
T. J. Bohn^{3,4}, E. J. Burke⁵, G. Chen⁶, X. Chen³, P. Ciais⁷,
J. W. Harden⁹, D. J. Hayes⁶, G. Hugelius¹⁰,
S. M. Natali¹⁷,
A. H. Macdonald¹⁴,
ig^{7,12},
11 | Strauss⁸



Data Constrained-Model



Permafrost Zone Soil C Emissions by 2100:

RCP8.5 = 28-113 Pg

RCP4.5 = 12-33 Pg

Accounting for CH₄:

10-18% increase

RCP8.5 = 32-129 Pg

RCP4.5 = 14-38 Pg

Dynamic Model Simulation of Carbon Stocks

Retrospective Analysis

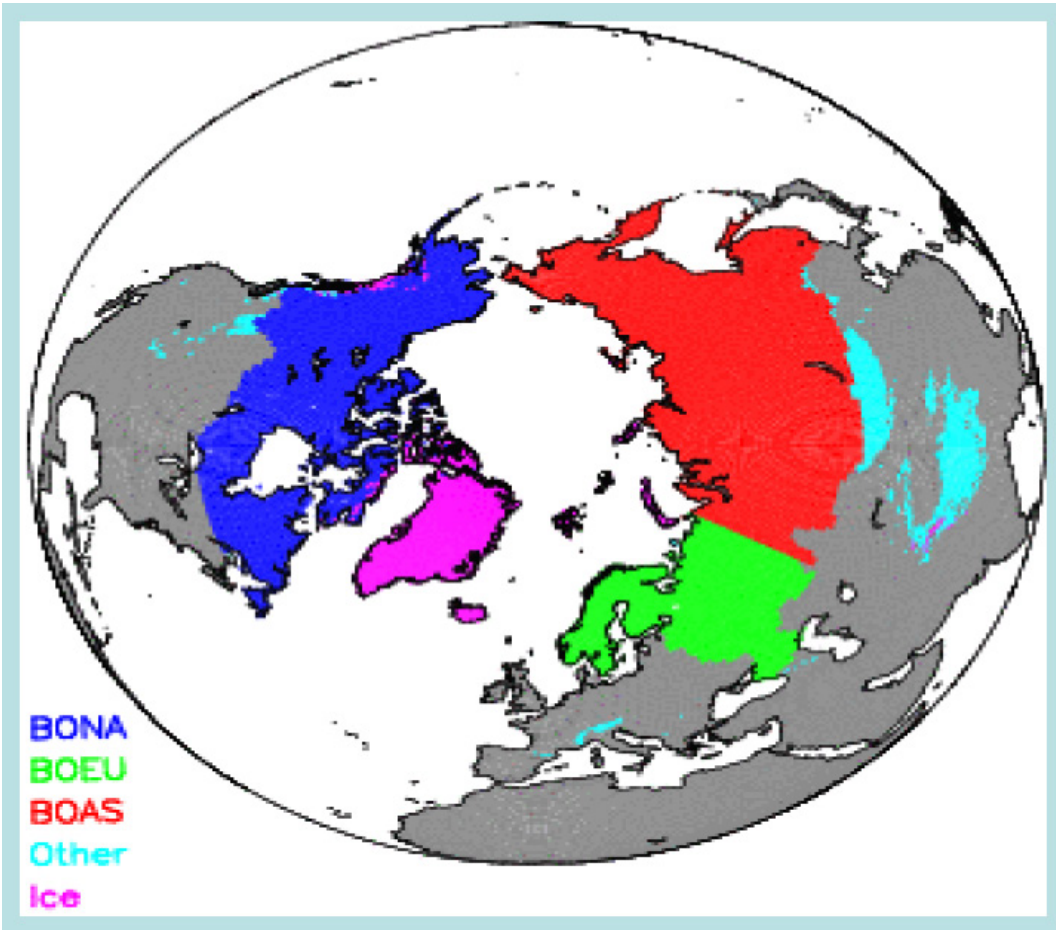
1960 to 2010
(15 models)

Vulnerability Analysis

2010 to 2300
(8 models)

Diagnostic Papers

(active layer, GPP, soil
Temp, Eurasia, Tibet,
air/soil/snow)



Permafrost Carbon Model Intercomparison

1960-2010:

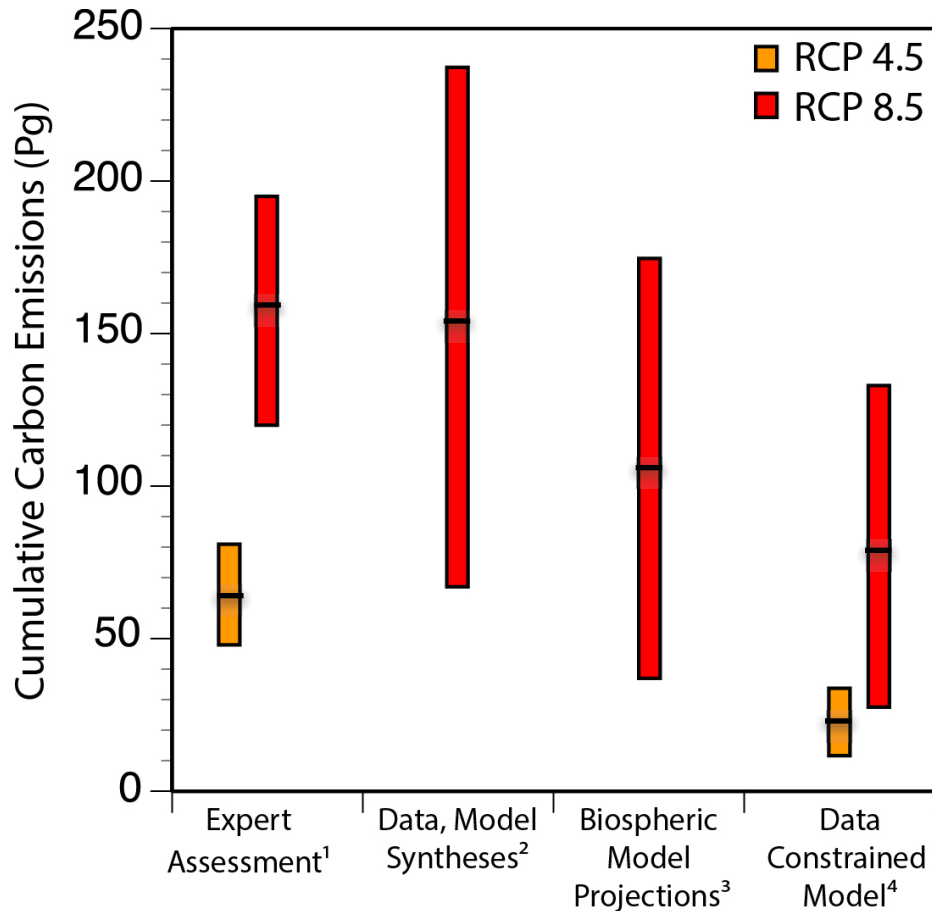
Surface permafrost loss

Warming induced loss of soil carbon

CO₂ fertilization induced vegetation
carbon gain, soil carbon gain

Net gain ecosystem carbon storage

Permafrost Carbon Emissions By 2100



Bars show ranges:
driven by IPCC warming scenarios

Effect of extra methane warming not shown:
10-18% higher?
50% higher?

Permafrost carbon pool vulnerable fraction:
~5-15%
Not likely to be 2x

¹Schuur et al. 2013 Climatic Change

²Schuur et al. 2015 Nature

³Schaefer et al. 2014 Environmental Research Letters [8 models]

⁴Koven et al. Philosophical Transactions of the Royal Society A 2015

Key Outcomes

- Permafrost C pools are large and sensitive to climate change on decadal to century time scale
- Future permafrost C emissions will not overshadow fossil fuel, but will serve to accelerate pace of climate change (weakening biospheric sink)
- But, increased permafrost C emissions will counteract mitigation measures elsewhere
- No support for catastrophic C release that could change climate abruptly (years-decade)

Might there be Arctic carbon cycle surprises?



Yes

What Can Be Done?

- Slower warming scenarios limit permafrost C emissions
- Need to forecast permafrost C emissions to quantify additional mitigation needs
- Sustained permafrost and Arctic C monitoring networks
- Evaluate risk ,cost, and mitigation of local to regional impacts of changing permafrost



Communication: Scientific Outreach

Organized Sessions:



- **American Geophysical Union 2011-2015, San Francisco, CA**
Vulnerability of Permafrost Carbon to Climate Change
(3 oral sessions, 1 poster session, 1 special session)
- **European Geosciences Union 2012-2014, Vienna, Austria**
Assessing the effects of global warming on permafrost degradation - contributions from field studies, remote sensing and modelling.
(1 oral session, 1 poster session)
- **Our Common Future under Climate Change 2015, Paris, France**
Biogeochemical Feedbacks to Climate Change.
(1 oral session, 1 poster session)
- **XI. International Conference on Permafrost 2016, Potsdam, Germany**
Climate Change and the Permafrost Carbon Feedback: Past, Present and Future



Special Issue:

- **Focus on Changing Permafrost in a Warming World: Observation and Implication**

Environmental Research Letters: Published papers: 25+





Public Outreach Activities 2015

Press Releases:

- **Climate Change and the Permafrost Carbon Feedback:**
71 news articles published (4pm 4/10/2015) including *Washington Post*, *The Globe and Mail*, *Sydney Morning Herald*, *The Guardian* ..
- **A Simplified, Data-Constrained Approach to Estimate the Permafrost Carbon-Climate Feedback:**
6 news articles published (4pm 4/10/2015) including *Daily Californian*, *Alaska Dispatch News*

Interviews:

- **Alaska Fire Season 2015:**
Atlantic Magazine. In Alaska, Too Many Fires, Not Enough Snow. Sept 2015
National Public Radio. Beneath Alaskan Wildfires, A Hidden Threat: Long-Frozen Carbon's Thaw. July 2015
Washington Post. Alaska's Terrifying Wildfire Season and What it Says About Climate Change. July 2015
BBC. Permafrost Warming in Parts of Alaska 'Is Accelerating'. Oct 2015

Authored Public Articles:

- *World Wildlife Foundation*. The Circle. Permafrost Carbon and Climate Change. Oct 2015.
- *The CarbonBrief*: What the latest science says about thawing permafrost. April 2015





Decision Maker Support

National & International Synthesis Science Reports:

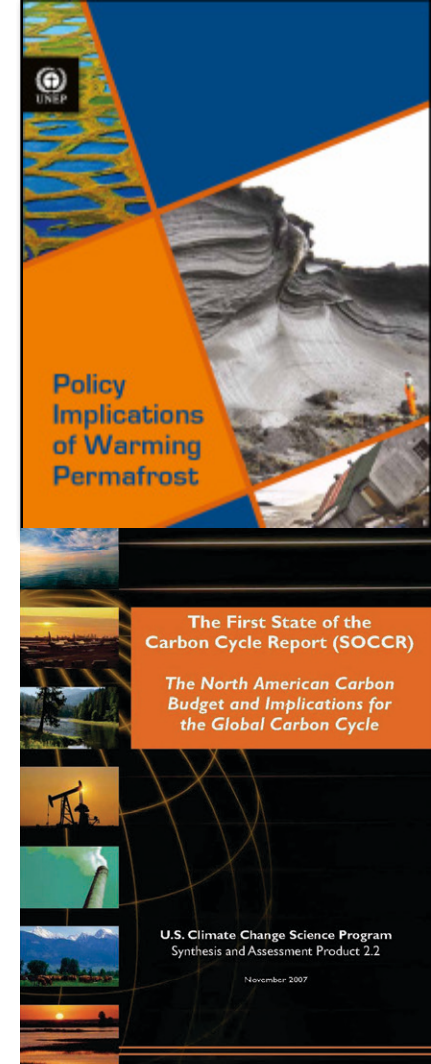
- **Policy Implications of Warming Permafrost**
United Nations Environmental Programme
- **Snow, Ice, Water, and Permafrost in the Arctic**
Arctic Monitoring and Assessment Program, Arctic Council
- **Second State of the Carbon Cycle Report (SOCCR)**
Carbon Cycle Science Interagency Working Group
- **International Panel on Climate Change (IPCC)**
Working Group I – Chapter 6 Carbon

Briefing Reports:

- **International Permafrost Association. 2015.**
SEARCH and the Permafrost Carbon Network
- **National Academies Polar Research Board. 2015.**
Rapid Change at the Poles.
- **Interagency Arctic Research Policy Committee. 2015.**
Permafrost Carbon Research Coordination Network Progress on Milestone 3.2.3.

Other Decision Maker Support:

- Materials provided to USGCRP and State Department in Advance of President Obama's presentation at the GLACIER conference. August 2015.
<https://www.whitehouse.gov/2015-alaska-trip?sid=123>



Permafrost Carbon Network Next Steps

Recent Synthesis Products (since Dec 2015):

Abbott BW et al. (2016) *Environmental Research Letters*, 11, 034014

Grosse G et al. 2016. *Environmental Research Letters*, 11, 040201

Schädel C et al. 2016 in press. *Nature Climate Change*

Vonk JE et al. 2015. *Biogeosciences*, 12, 7129-7167.

Wik M et al. 2016. *Nature Geoscience*



Upcoming Workshops:

- **Synthesis Lead meeting:** June 18-19, 2016; Potsdam, Germany
- **6th Annual Meeting, Permafrost Carbon Network:** Dec 11, 2016, San Francisco, CA

Next Gen Synthesis Products: Title: *Lead Scientist*

- **Permafrost Carbon Model Intercomparison:** *D. McGuire, D. Lawrence, C. Koven*
- **Landscape and Carbon Vulnerability to Abrupt Thaw.** *D. Olefeldt D, et al.*
- **Permafrost Region Methane Budgets:** *D. McGuire, J. Frederick, R. McDonald*
- **Where and When Will the Arctic Become Wetter or Drier?** *C. Andresen, C. Wilson*

Permafrost Action Team Next Steps

Network Development

- **Science and Action Steering Committee:**
Cathy Wilson (DOE Los Alamos National Lab, NGEE Arctic); Eric Kasischke (NASA, ABoVE); Dave McGuire (UAF/USGS, PCN); Vladimir Romanovsky (UAF, GTN-P); Kevin Bjella (CRREL); Toni Lewkowicz (U Ottawa, IPA); Merritt Turetsky (U Guelph, PCN); Dave Schirokauer (Denali NPS); Michelle Walvoord (USGS Denver); Scott Rupp (UAF, SNAP, Alaska Climate Center)
- **Synthesis Postdoctoral Researcher**
Funded by USGS Climate Science Center. Based at U Alaska/IARC
Focused on Local/Regional Permafrost Impacts
Theme 2 Infrastructure, or
Theme 3 Ecosystem Services
- **Regional Impacts of Changing Permafrost Workshop**
~September/October 2016



Network Building Lessons Learned

- Developing the human network a critical component of adding value to data observation networks
- Network engagement facilitated by a clear coherent science question
- Network production facilitated by engaging a range of scientists and stakeholders
- Built network is poised to ingest new observations and deliver results on the timeframe needed by decision makers



Thank You!

- Please join us for our next seminar on Wednesday, 18 May featuring Mark Brzezinski, Executive Director of the U.S. Government's Arctic Executive Steering Committee
- An archive of this presentation will be available online at: <https://www.arcus.org/research-seminar-series>
- Please consider joining ARCUS as an individual member! More information at: <https://www.arcus.org/arcus/member-information>



