Welcome

ARCUS Arctic Research Seminar Series

“Regional and Global Implications of Changing Permafrost”

Presented by Ted Schuur
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Regional and Global Implications of Changing Permafrost

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Center for Ecosystem Science and Society
Northern Arizona University
SEARCH
Study of Environmental Arctic Change

Sea Ice Action Team

Land Ice Action Team

Permafrost 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
Arctic is Warming 2x Faster Than Globe

Actual Temperature Measurements
Trends in Permafrost Temperature

Romanovsky et al. 2012; Global Terrestrial Network – Permafrost 2015; Biskaborn et al. 2015; Hugelius 2014
Abrupt Permafrost Thaw

Degradation of permafrost can occur rapidly at point locations
Why Should Arctic Residents Care?

Siberia, Russia

Permafrost weakens, even at <0°C degrees temperature

Inuvik Airport, NWT

Alaska, DOT
Alaska Towns, Roads, Pipeline on Permafrost

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

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.

What we want to know:

- How much?
- How fast?
- What form?

CO₂, CH₄

Organic matter decomposition

Permafrost thaw

°T
Synthesis science is a key step for translating knowledge to action.
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

Myers, Schädel, Schuur 2015
**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

NEWS

The Permafrost Carbon Network is part of the multi-million dollar Study of Environmental Arctic Change (SEARCH) project. This 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 scientists 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 project (addresses contributions of permafrost to carbon cycle)
Climate change and the permafrost carbon feedback

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 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

Schuur 2015 Nature
A simplified, data-constrained approach to estimate the permafrost carbon–climate feedback

C. D. Koven¹, E. A. G. Schuur², C. Schädel², T. J. Bohn³, E. J. Burke⁵, G. Chen⁶, X. Chen³, P. Ciais⁷, se⁸, J. W. Harden⁹, D. J. Hayes⁶, G. Hugelius¹⁰, farov¹¹, G. Krinner¹², P. Kuhry¹⁰, europe³, A. H. MacDougall¹⁴,

S. M. Natali¹⁷, ig¹²,

C Koven et al. Phil Trans R Soc A 2015
Data Constrained-Model

Permafrost Zone Soil C Emissions by 2100:
RCP8.5 = 28-113 Pg
RCP4.5 = 12-33 Pg

Accounting for CH$_4$:
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)

D. McGuire, D. Lawrence, C. Koven et al. Model Integration Working Group
Permafrost Carbon Model Intercomparison

1960-2010:
Surface permafrost loss

Warming induced loss of soil carbon

CO$_2$ 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

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1 Schuur et al. 2013 Climatic Change
2 Schuur et al. 2015 Nature
3 Schaefer et al. 2014 Environmental Research Letters [8 models]
4 Koven 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
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:**
- **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:**

Authored Public Articles:
- **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.
Permafrost Carbon Network Next Steps

Recent Synthesis Products (since Dec 2015):

**Abbott BW** et al. (2016) *Environmental Research Letters*, 11, 034014
**Schädel C** et al. 2016 in press. *Nature Climate Change*
**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](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](https://www.arcus.org/arcus/member-information)