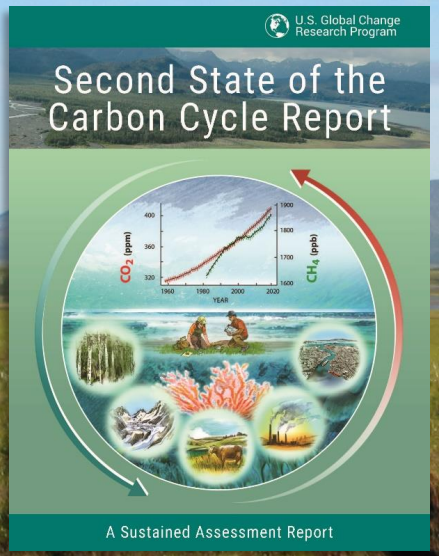
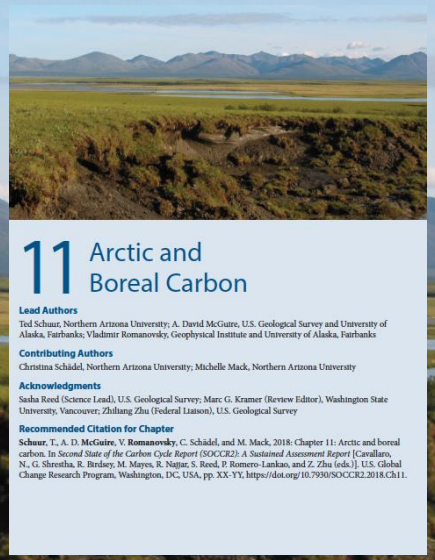
ECOS Center for Ecosystem Science and Society at Northern Arizona University

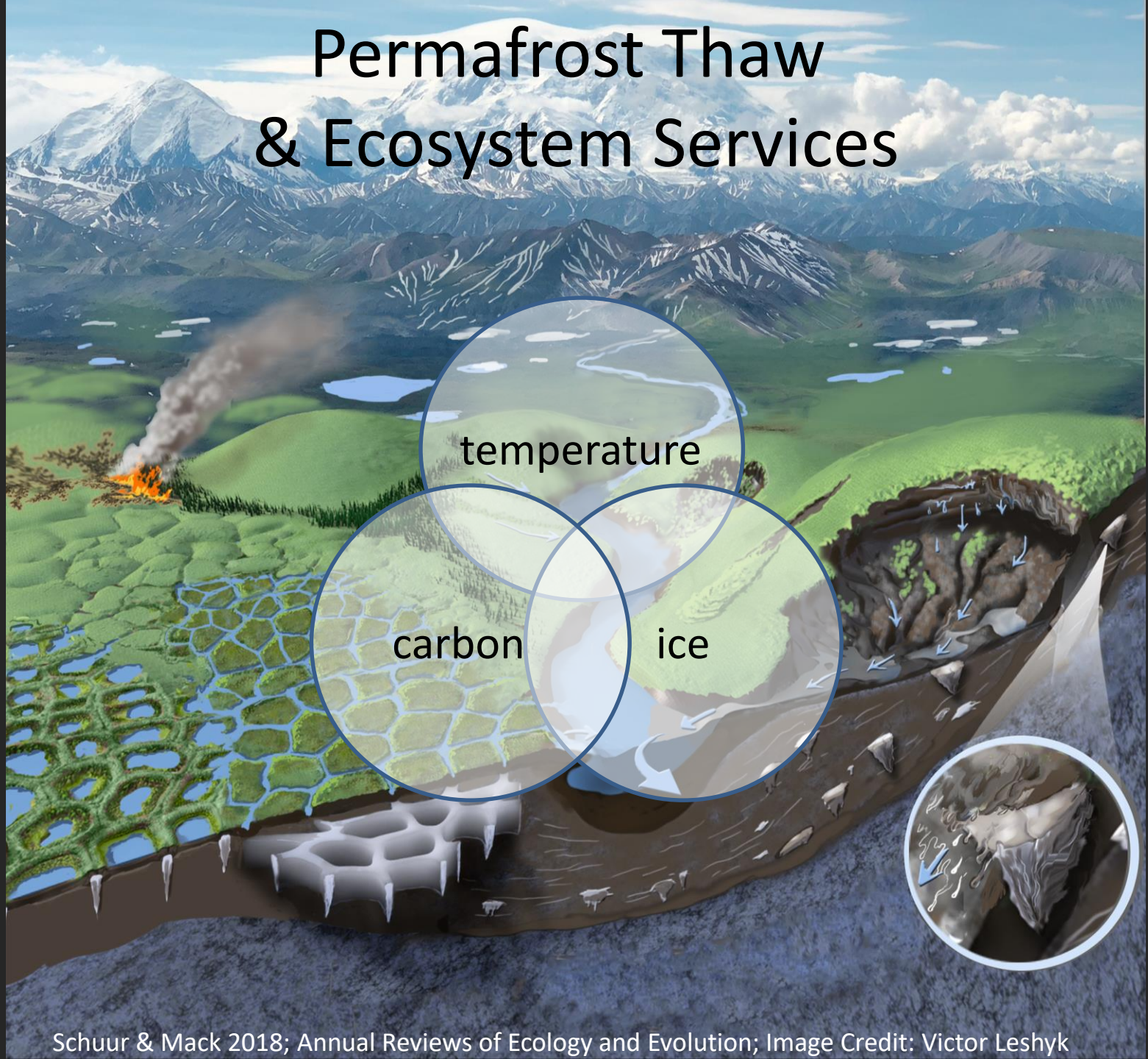
State of the Carbon Cycle
Arctic and Boreal Carbon





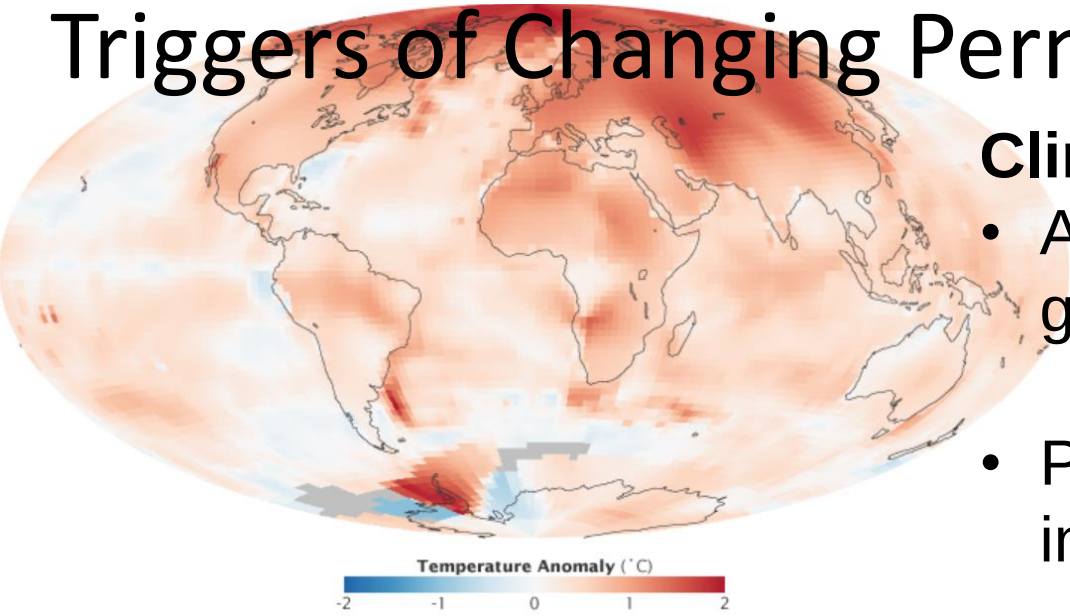
Drs. Ted Schuur, Dave McGuire, Vladimir Romanovsky
Michelle Mack, Christina Schaedel

Permafrost Thaw & Ecosystem Services



Schuur & Mack 2018; Annual Reviews of Ecology and Evolution; Image Credit: Victor Leshyk

Triggers of Changing Permafrost and Carbon



Climate:

- Arctic warming 2x faster than globe
- Permafrost temperatures increasing over 40 year record

Ecosystem Disturbance:

- Fires burn soil organic layer, which insulates permafrost
- Increased frequency of large fire years + extreme fire events

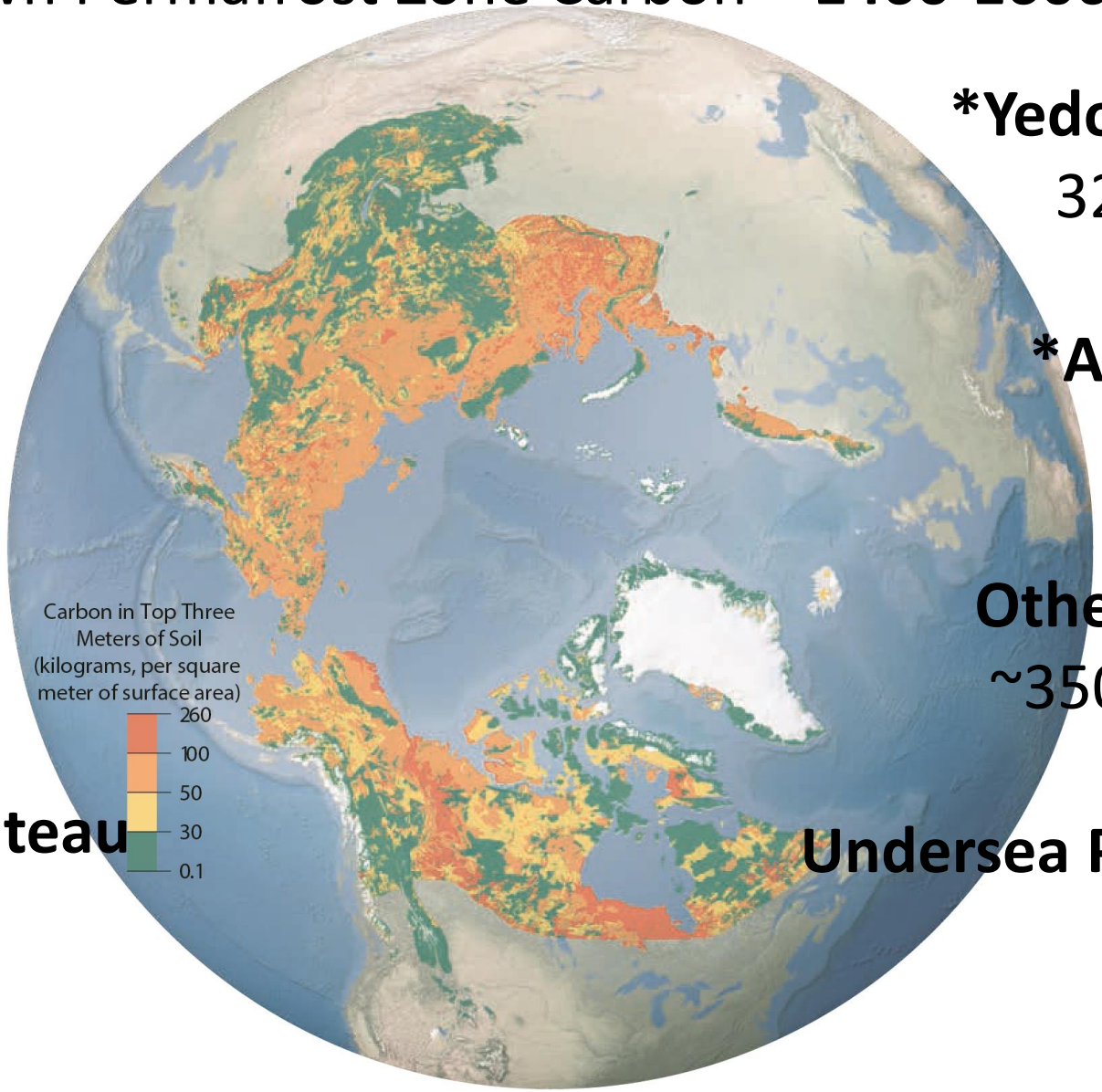
Permafrost Carbon

Known Permafrost Zone Carbon = **1460-1600* Pg C**

1035
±150 Pg C
(0-3m)

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

Tibetan Plateau
15.3 Pg C
N. China
20.4 Pg C



***Yedoma Region**
327-466 Pg C

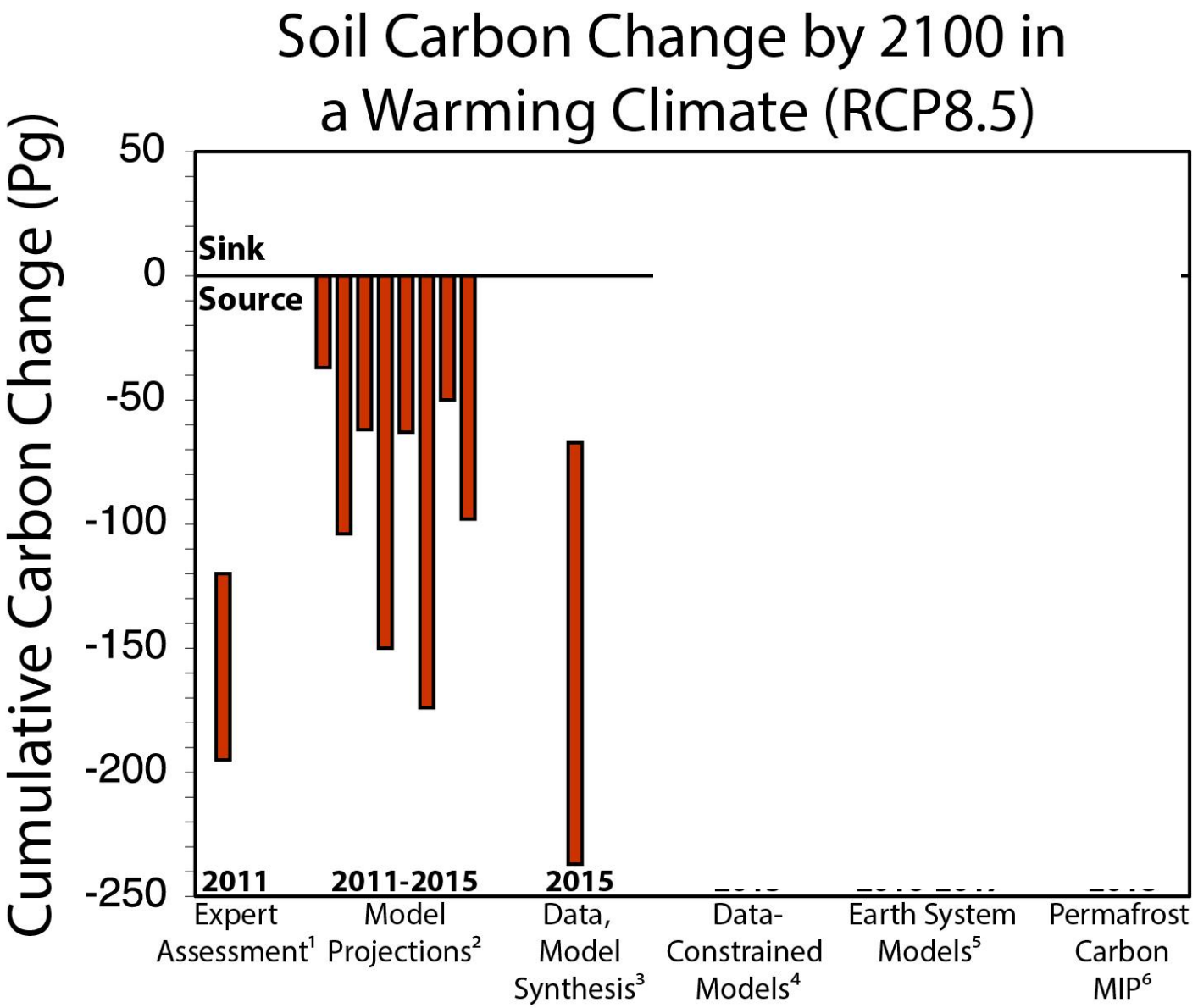
***Arctic Deltas**
96±55 Pg C

Other Deposits:
~350-465? Pg C

Undersea Permafrost:
? Pg C

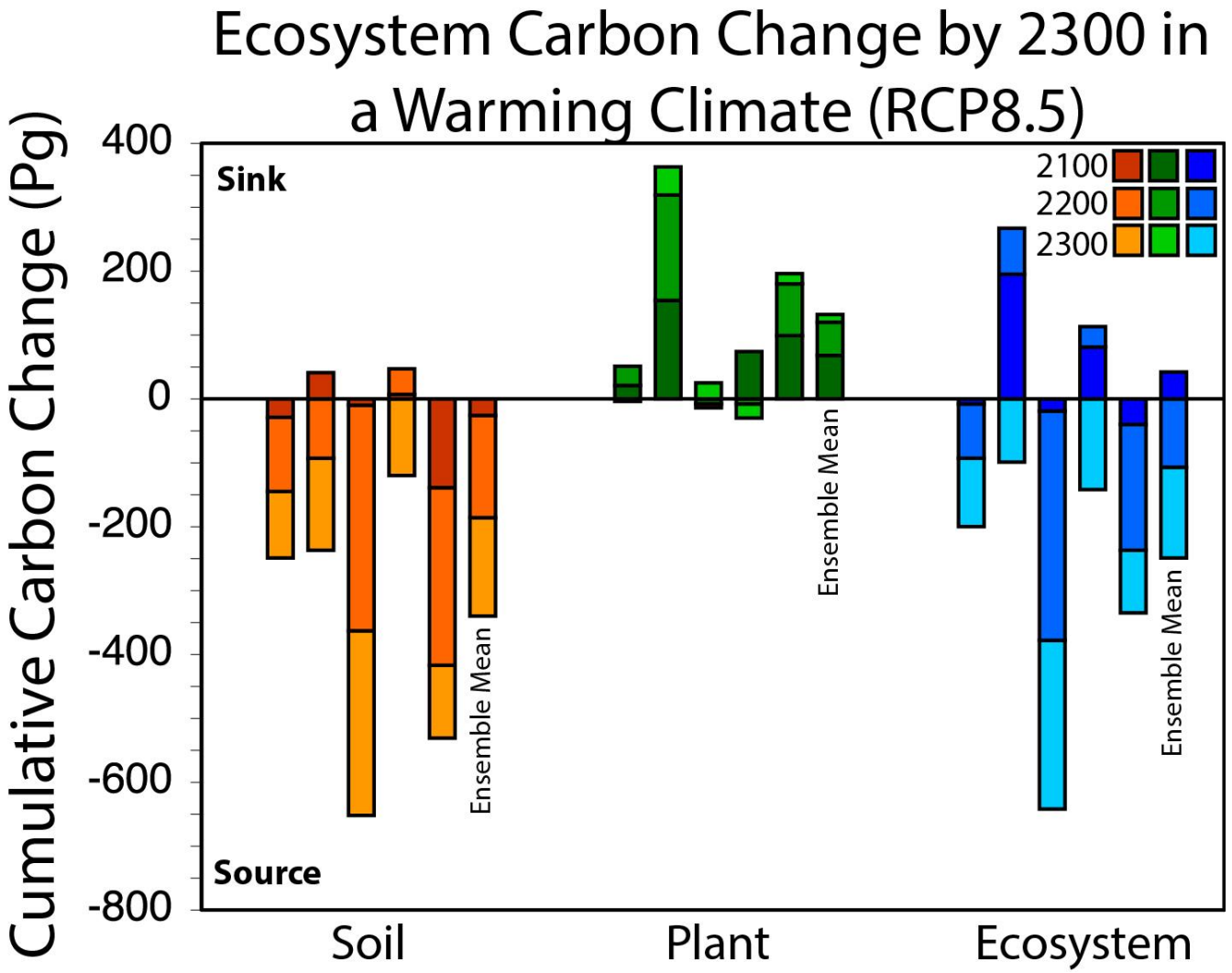
Zimov et al. 2006; Tarnocai et al. 2009; Hugelius et al. 2014; Strauss et al. 2017; Schuur et al. 2018

Permafrost Carbon Emissions Synthesis



[1]Schuur et al. 2011 Nature Comment; 2013 Climatic Change; [2]Schaefer et al. 2014 Environmental Research Letters [8 models];
[3]Schuur et al. 2015 Nature; [4]Koven et al. Philosophical Transactions of the Royal Society A 2015; Schneider von Deimling et al. 2015;
[5]MacDougall al. 2016; Burke et al. 2017; [6]McGuire et al. 2018

Permafrost Carbon Model Intercomparison



Plants offset soil C loss via increased biomass and new soil C inputs

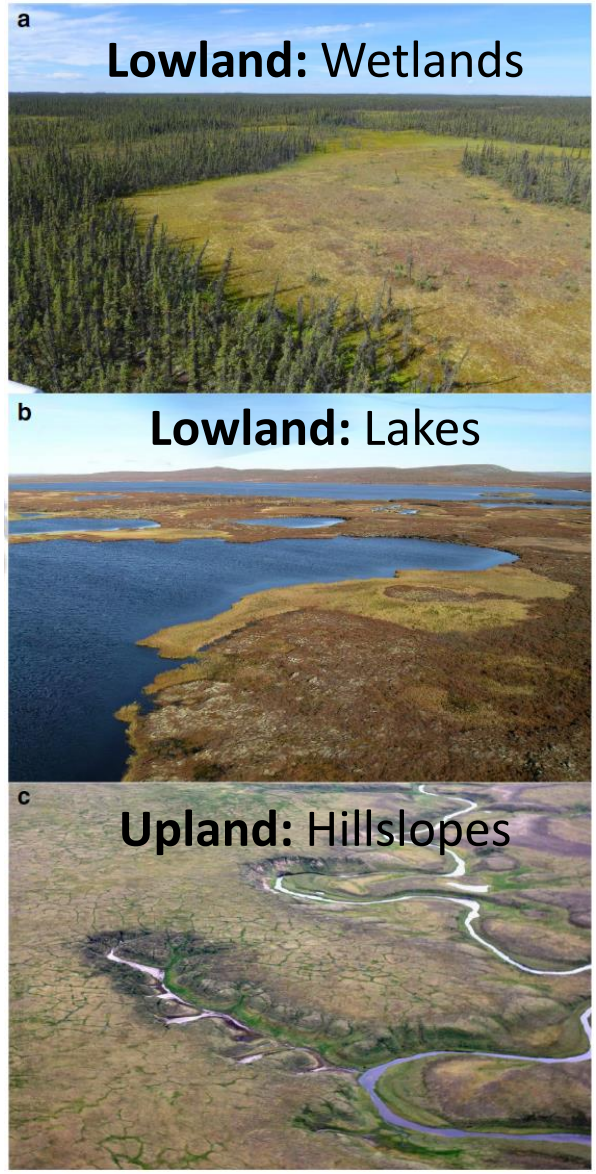
Plant offset pushes large accelerating climate feedback into next century and beyond

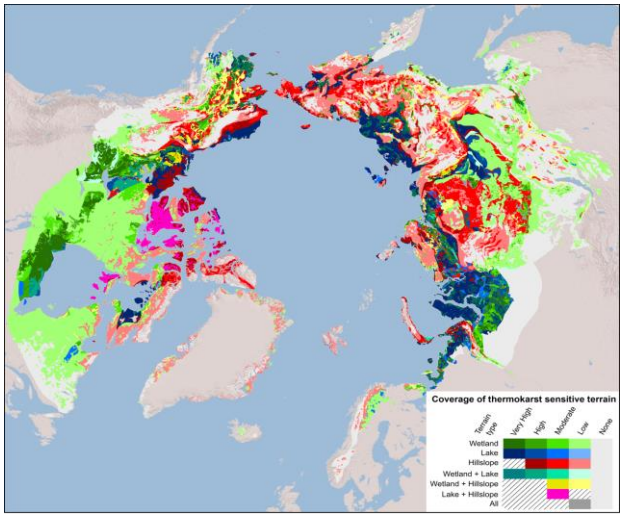
Mitigation helps reduce emissions

RCP4.5 = Reduction of 35 Pg C (+3 to -113 Pg C)

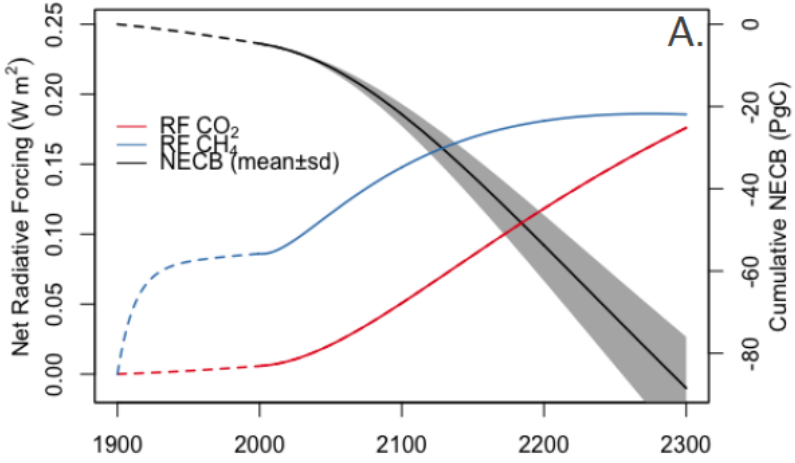
McGuire et al. 2018

Abrupt Thaw Landscape Impact





Olefeldt et al. 2016



Turetsky et al. 2019

Sensitive terrain = 20% of land area; 50% of carbon pool

Abrupt thaw= 84 Pg C net release by 2300 (RCP 8.5)

Equivalent to 40% of the Permafrost Carbon MIP release

Methane = 20% of emissions; 50% of climate impact

Arctic and Boreal Carbon: Key Findings

Arctic temperature rise is about 2.5x faster than whole Earth.
Permafrost temperatures have been increasing over the last 40 years.
Disturbance by fire is higher now than in the middle of the last century

Permafrost zone soils store 1,460 to 1,600 billion tons organic carbon, 2x contained in the atmosphere and about an order of magnitude more carbon than contained in plant biomass

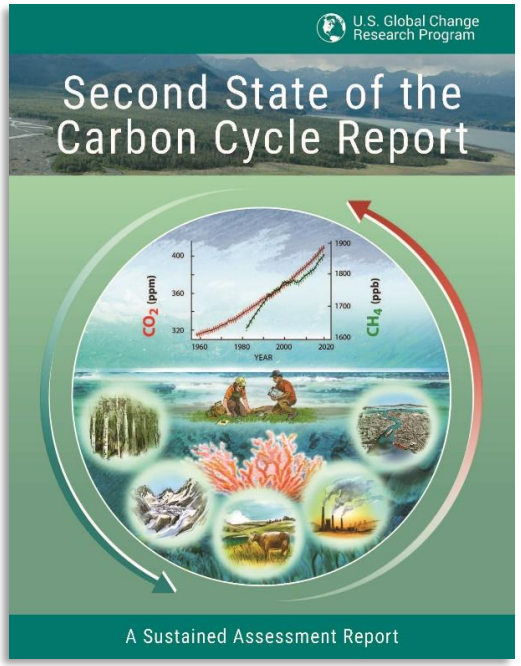
Following the current warming, 5% to 15% of the organic soil carbon (mean 10% value equal to 146 to 160 Pg C) is considered vulnerable to release to the atmosphere by the year 2100

Some Earth System Models project that carbon releases will be initially offset by increased plant uptake. However, these findings are not always supported by empirical measurements or other assessments, suggesting that structural features of many models are still limited

2018 & 2019 National & International Synthesis Science Reports:

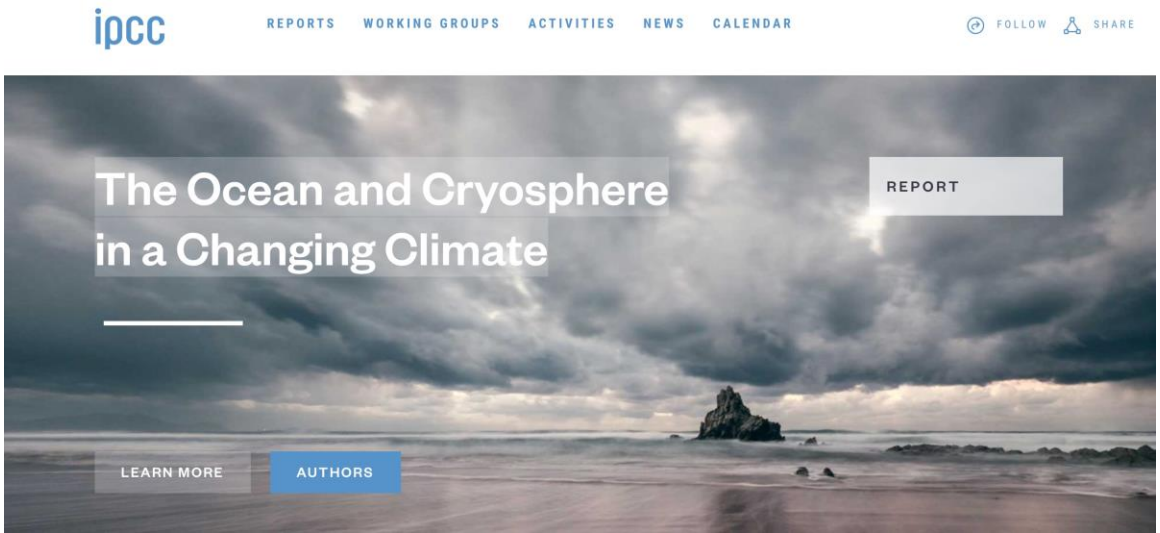
- **IPCC Special Report on Global Warming of 1.5°C**
  Public release October 2018

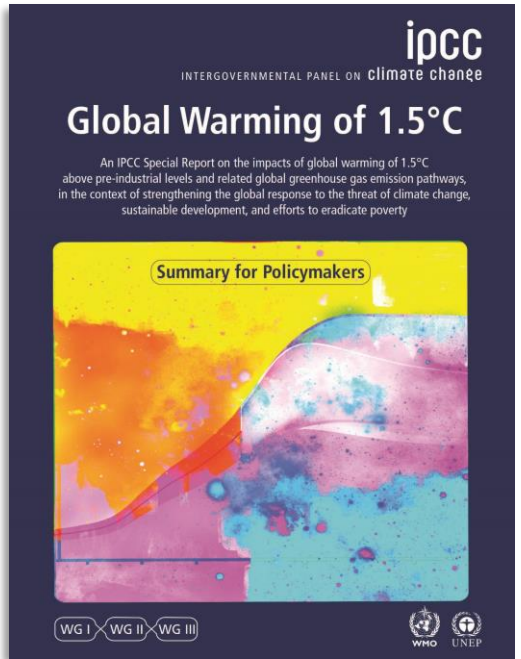
- **Second State of the Carbon Cycle Report (SOCCR)**
  Carbon Cycle Science Interagency Working Group
  Public release, November 2018 [Events at AGU]



Upcoming:

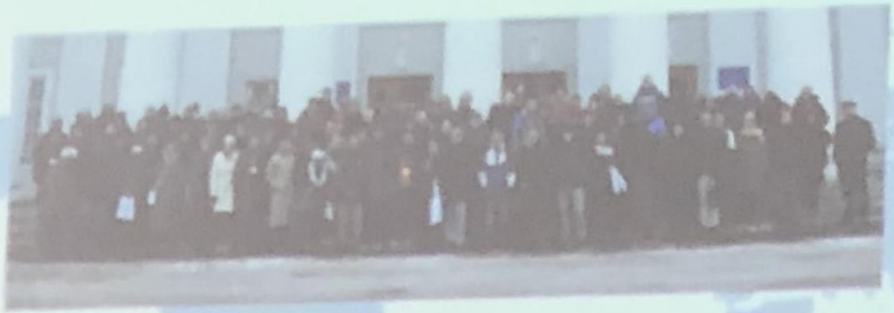
- **IPCC Special Report on Oceans and Cryosphere in a Changing Climate (SROCC)**
  ENDED: Expert comment period (Second Order Draft)
  May 15 2019: Published deadline for cited papers
  Sept 15 2019: Summary for Policymakers release





Kazan, Russia
Republic of Tatarstan

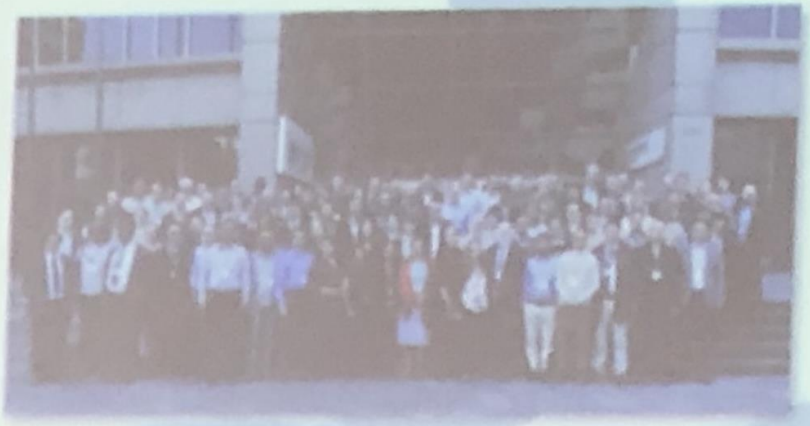
Thank you for the memories!



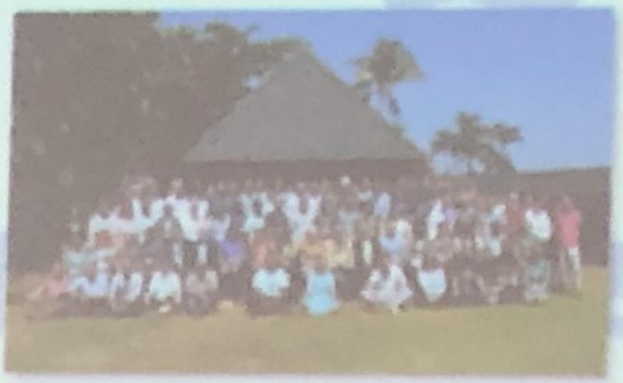
LAM4
Kazan (Russian Federation)
Mar 2019

LAM3
Lanzhou (China)
July 2018

LAM2
Quito (Ecuador)
Feb 2018



LAM1
Nadi (Fiji)
Oct 2017



Published papers: Cut off date May 15, 2019

Honorary Chapter Author Elsa, looking a bit peeved at the state of her shrinking cryosphere…

Honorary Chapter Author Moana, looking a bit nervous at the rising sea levels…

Coordinating Lead Author Martin, motivating the team Tatar-style

Monica, dreaming of less

Chris, dreaming of coffee

Coordinating Lead Author Mike, looking unperturbed, as usual

Why:
The rapid changes taking place in the Arctic call for immediate policy responses well informed by science. Today's policy decisions concerning the Arctic will have substantial long term and global consequences.

How:
Strong and iterative collaborations—in which Arctic scientists and decision makers inform one another—will help ensure that research adequately anticipates policy and management needs.

Who:
Understanding and responding to the changing Arctic requires the combined efforts of scientists from many disciplines, Indigenous knowledge holders, resource managers, and others operating in the Arctic

What:
A novel conference of Arctic scientists and decision makers jointly exploring the science needed to inform decisions concerning the Arctic in the coming decades.