Climate Change and Permafrost Feedback

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A. Overview

- Large quantities of organic carbon are stored in frozen soils (1600 Pg in permafrost).
- A warming climate can induce carbon cycle changes that accelerate the release of the greenhouse gases carbon dioxide and methane from permafrost.
- Permafrost thaw can also alter the hydrologic cycle in the Arctic by reducing inundation and increasing runoff.
- Changes to the surface energy budget from permafrost thaw may also play a role in the climate system.
- Such permafrost feedbacks can accelerate climate change, but the magnitude and timing of permafrost thaw and its impact on climate change remains uncertain.

Schuur et al., 2008; Schaefer et al., 2014; Schuur et al., 2015; Liljedahl et al., 2016

B. Science Objectives

- We want to understand the sensitivity of permafrost thaw to surface air temperature and how the unfrozen soils change Arctic atmosphere and carbon cycles
- The design and analysis of our experiments is organized around three overarching questions:

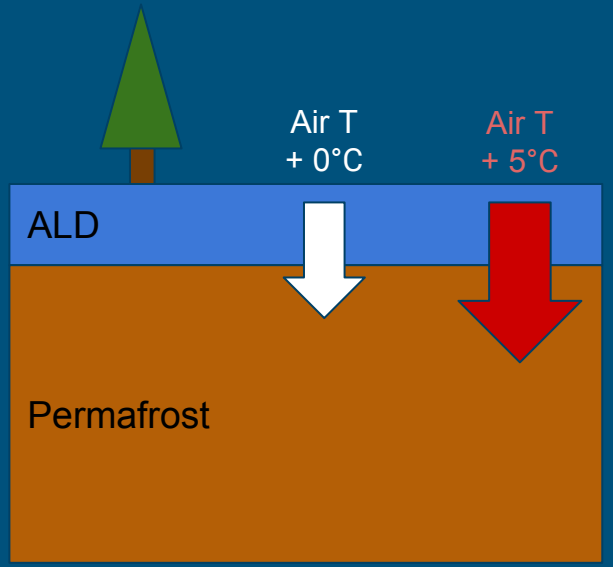
  (1) What is the temperature threshold for permafrost to completely thaw?

  (2) What is the carbon cycle response to the permafrost feedback?

  (3) How does permafrost thaw change land-atmosphere feedbacks?

C. Computational Experiments

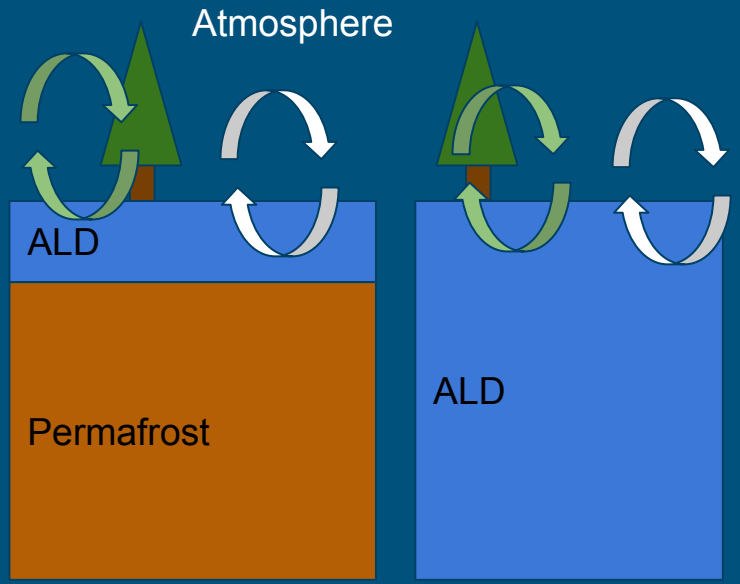
1. **Regional Simulation**
   - **Objectives:** Identify temperature threshold for permafrost to completely thaw
   - **Spatial Scale:** North of 50 °N
   - **Temporal Scale:** 100 years
   - **Sensitivity Test:** Increase air temperature by up to 5 °C at intervals of 0.25 °C



C. Computational Experiments

2. Production Simulation

- **Objectives:** Identify impacts of permafrost thaw on Arctic feedbacks
- **Spatial Scale:** Global scale
- **Temporal Scale:** 100 years
- **Sensitivity Test**
  - (1) Present vs completely thawed permafrost
  - (2) CLM offline vs online
  - (3) Prescribed vs dynamic vegetation phenology
  - (4) Prescribed vs slab ocean SSTs



D. Resource Requirement

Model State	Forcing	#runs	length	#yrs	Core hours/yr	Total core hours	Data Volume
CLM(SP)-regional (I compset)	2000 (GSWP3)	20	100	2000	150	300000	1488 G
CLM(SP)- global (I compset)	2000 (GSWP3)	2	100	200	250	50000	148.8 G
CLM(BGC)-global (I compset)	2000 (GSPW3)	2	100	200	380	76000	148.8 G
CLM-CAM-prescribed SSTs (F compset)	2000 (CAM)	2	100	200	4300	860000	708 G
CLM-CAM-slab ocean (E compset)	2000 (CAM)	2	100	200	3200	640000	708 G
Total					**8280**	**1,926,000**	**3.2 T**

E. Data Management Plan

- Single-variable time series
- Publicly available on Earth System Grid (as per CESM data policies)
- Diagnostics available through CESM run database

Supplementary Slides

Ideas we discussed on August 15

- 4 different future atmospheric scenarios / Different climate forcing
- Change parameters to cause ex) role of wind in snow drift for ALD, Rain on snow event (clm has liquid vs frozen / rain vs snow), Threshold response of temperature on ALD .And. the impact of ALD changs on carbon cycles
- **ex) What is the temperature threshold for permafrost region to be diminished? How it will affect atmosphere?**
- Temporal scale: ???
- Spatial scale: ???
- data land for non-permafrost region / ground effects on atmosphere / isolating feedbacks for permafrost
- Run two different simulations (1) uncoupled (2) coupled with atm
- 6 simulations : two coupled (icompset with satellite phenology), two coupled with BGC
- Prescribe surface SST and sea ice / slab ocean / fully coupled ocean

Ideas on August 16

- One regional simulation (50 N circumpolar): single column / increase temperature (0.5 / 1 / 2 / … 5 degree) up to 10 simulations / 100-year simulation to test temperature threshold
- Present day forcing + increase temperature by quarter degrees
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