Simulating Arctic permafrost seasonal thaw conditions in the laboratory

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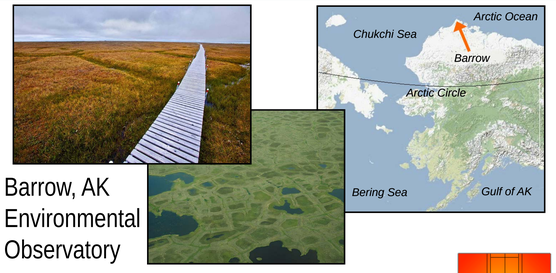
ABSTRACT

- High latitude ecosystems, which contain nearly half the global stocks of soil carbon (C) have emerged as an important focal point for the study of global climate change. Currently, the fate of C and nitrogen (N) in Arctic soils is poorly understood. This is in part due to uncertainties involving permafrost thaw and degradation. With a controlled approach in the laboratory, a more advanced understanding of the complex ecosystem processes in Arctic permafrost soils may be obtained. Here, we describe a system that reproduces and accelerates seasonal thaw patterns in the lab, and allows for the continuous monitoring and sampling of geochemical changes.

NEXT GENERATION ECOSYSTEM EXPERIMENTS (NGEE-ARCTIC)

- NGEE Goal: to develop a process-rich, high-resolution ecosystem model, from bedrock to top of vegetative canopy, to improve predictions in high-latitude ecosystems on the scale of the ESM grid cell
  - Field and lab experiments
  - Physical, chemical, biological processes

INTRODUCTION



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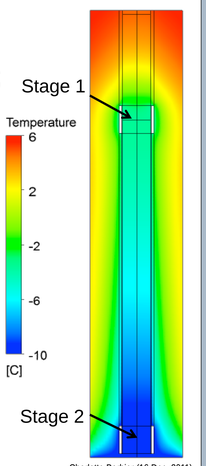
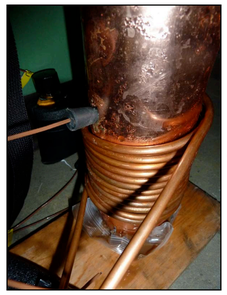
- Arctic already experiencing rapid changes in climate, particularly temp; not only an environmental issue, but an *energy* issue
- Region is critical to our understanding of *global* climate model predictions
- Permafrost thawing with increasing temperatures could release more C into our atmosphere but the magnitude of this effect is unknown
- Permafrost microcosm, using intact core, allows for 1) top-down thaw in controlled setting and 2) constant access for continuous sampling

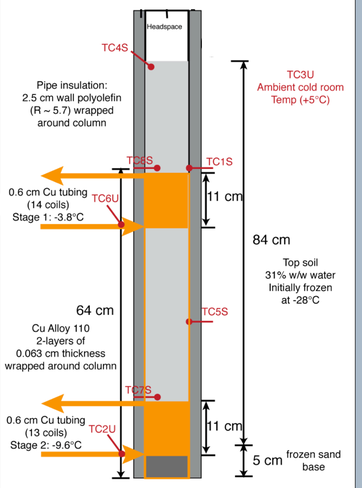


Charlotte Barbier (16 Dec. 2011)
ORNL Modeling & Simulation Group

BOX 1: EXPERIMENTAL SETUP

- Local top soil cores used first as a prototype to test experimental conditions: ~35% (w/w) water content
- Copper Alloy 110 sheathing, ¼ in Cu coils, 2 stages of cooling using antifreeze, thermocouples used to monitor temp along length of core, moisture probes, and microrhizons for soil water collection (Box 2)



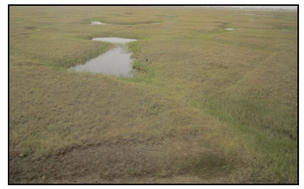


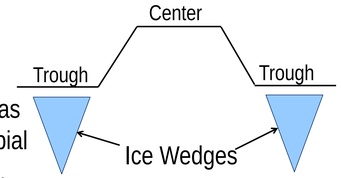
PROTOTYPE OBSERVATIONS

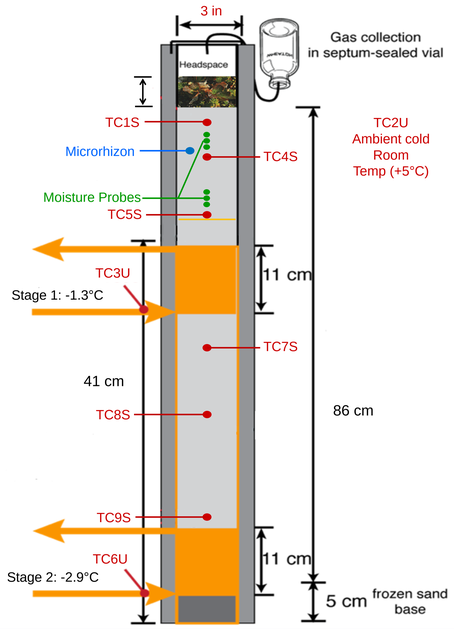
- Controlled thaw mimics natural thaw progression
- Water drains from thawed surface to transition zone
- Only shallow thaw depths achieved (~25-35cm) compared to active layer thaw *in situ* (40-50cm)
- Future modifications: microrhizon and moisture probe contact with soil, reduce thermocouple noise

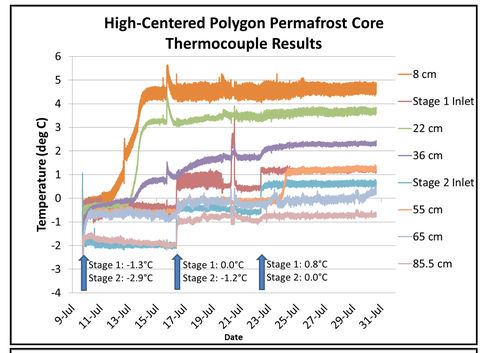
BOX 2: PERMAFROST CORE RESULTS

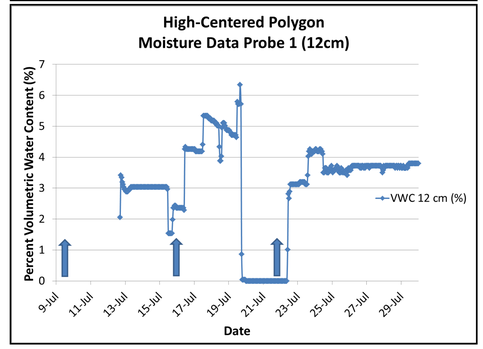
- Landscape: Thaw lakes and interstitial polygonal tundra
- Vegetation includes grasses, sedges, and mosses
- High-centered polygon "center" core used to validate prototypes
- Permafrost core sampling with hydraulic SIPRE auger
- Observables: moisture content, temperature of soil, thaw depth
- Future directions: head space gas (CO_2 and CH_4) evolution, microbial activity, inorganic and organic N, isotope studies, proteomics

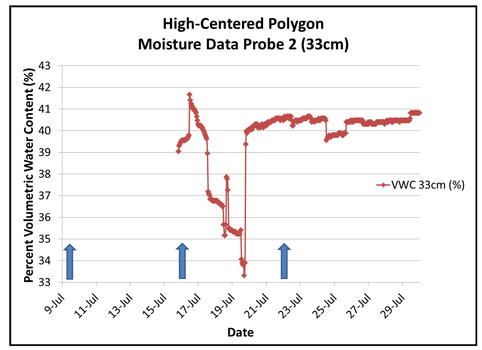












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ACKNOWLEDGEMENTS

Research sponsored by the Office of Biological and Environmental Research within the U.S. Department of Energy's Office of Science. Collaborations on the NGEE project include scientists and engineers at ORNL, LANL, BNL, LBNL and UAF, as well as our partners at leading universities and other state and federal agencies.