

Polar Explorer: A Place-Based Virtual Learning Environment to Improve STEM Undergraduate Education

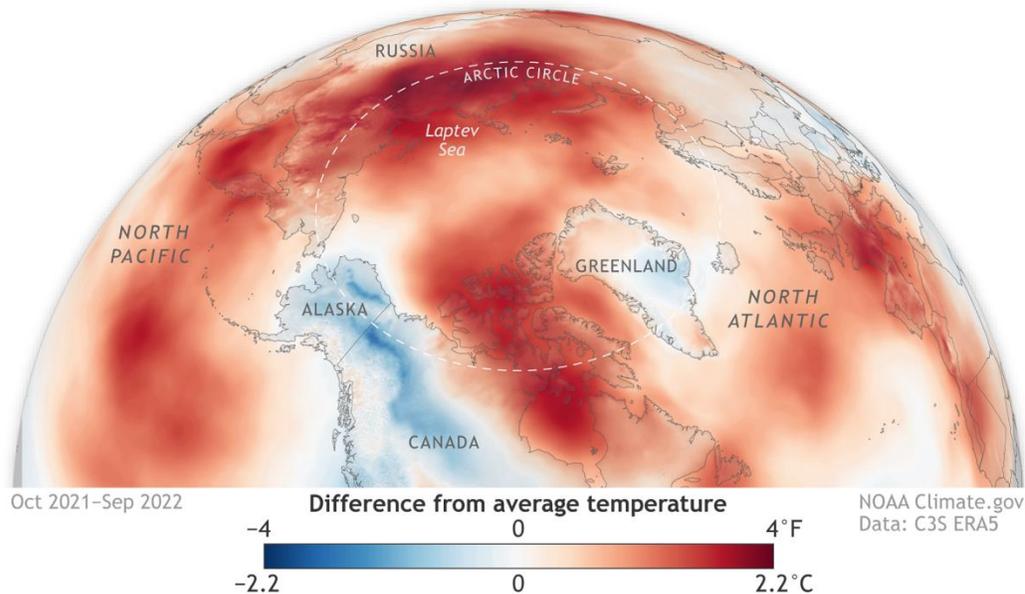
Deb Huntzinger



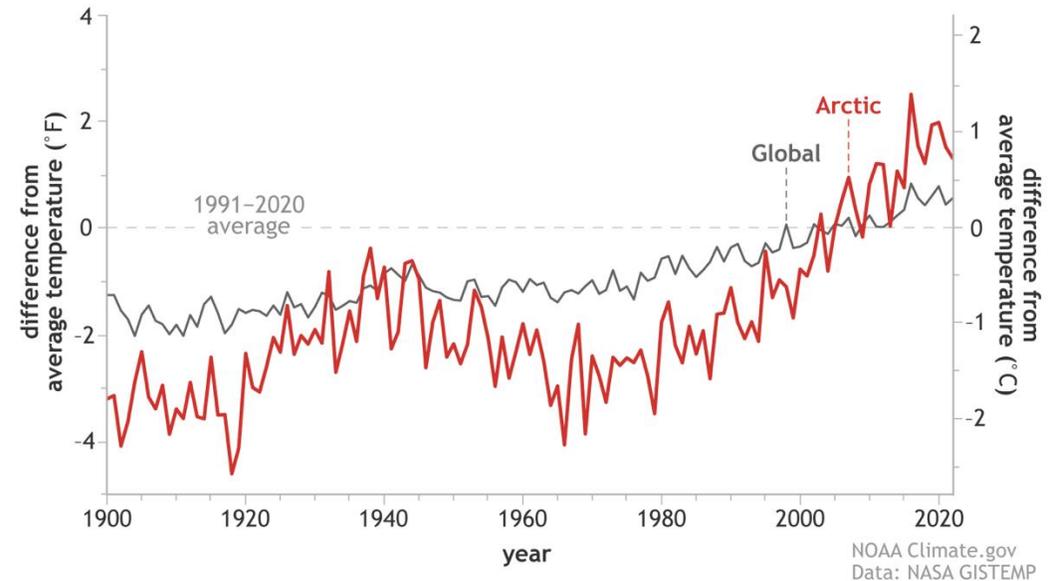
The why....

Arctic warming faster than rest of globe

2022 was Arctic's 6th-warmest year on record

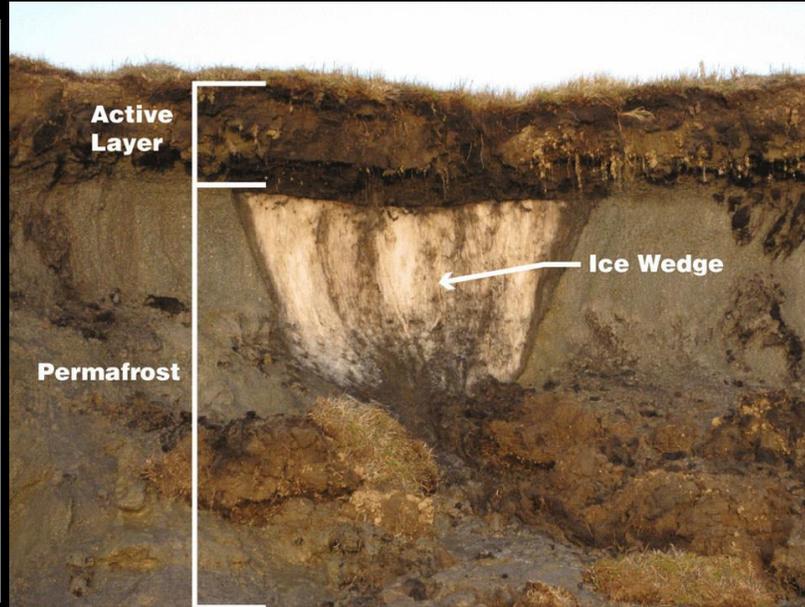
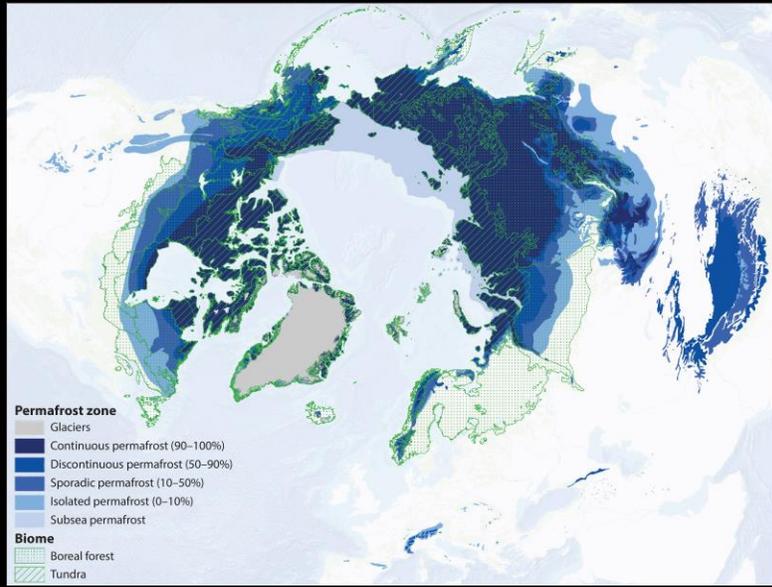


Arctic warming outpacing the global average



What is Permafrost?

Permafrost is ground that remains at or below 0 deg C for at least two consecutive years



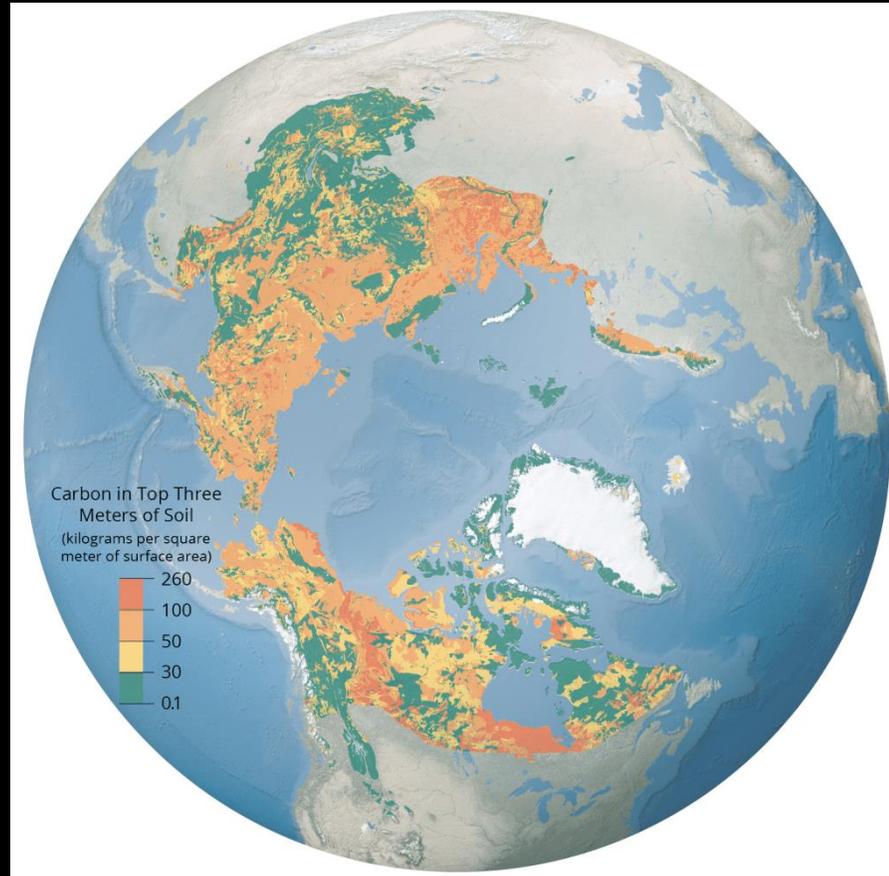
- Permafrost ranges in thickness from less than 1 m (3.3 ft) to greater than 1,500 m (4,900 ft)
- About 10% of the world is underlain by permafrost (mostly in Arctic)

Permafrost – Earth’s Gigantic Freezer

Contains ~1,500 billion metric tons of Carbon

Permafrost carbon makes up ~33% of the global soil C pool.

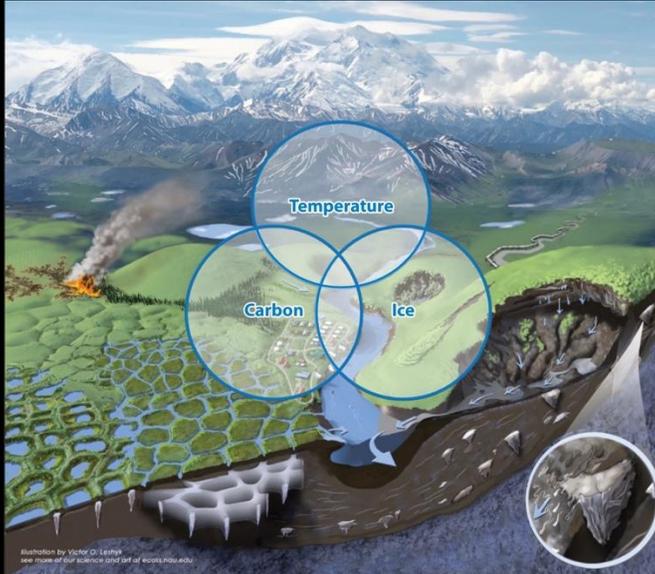
Twice as much carbon as contained in atmosphere



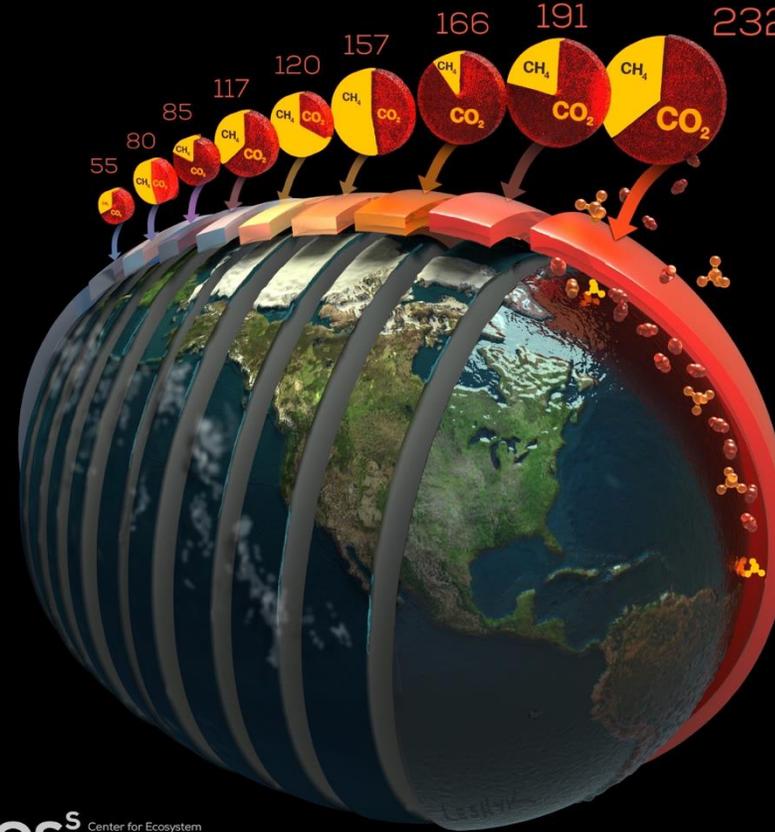
Schuur et al., (2022)



Unregulated Country of Permafrost

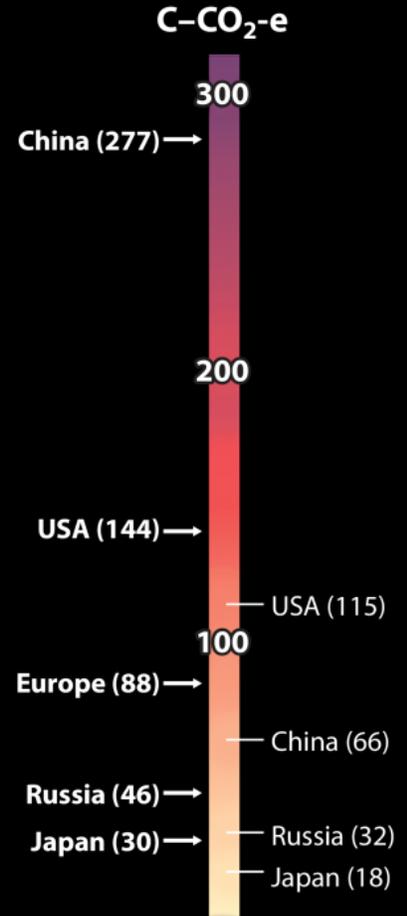


Artwork by Victor Leshyk

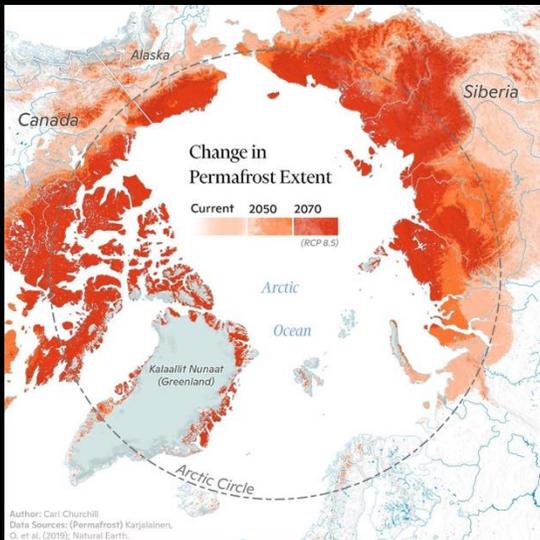


ECOS^S Center for Ecosystem Science and Society at Northern Arizona University

Schuur et al., (2022)



Schaedel et al, 2016 NCC



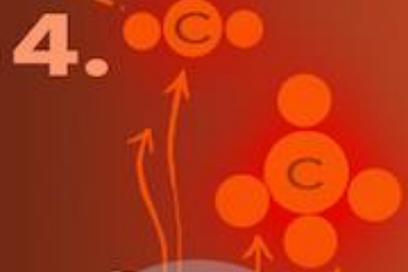
United Nations

Permafrost-Carbon Feedback

FEEDBACK LOOP: MORE GREENHOUSE WARMING

Global warming melts the ice within permafrost and causes the ground surface to collapse, where water can pond or drain away.

Organic carbon, the remains of ancient ecosystems trapped in permafrost, becomes exposed to the activity of soil microbes.



The microbes consume the organic carbon, releasing the greenhouse gases methane and carbon dioxide to the atmosphere.



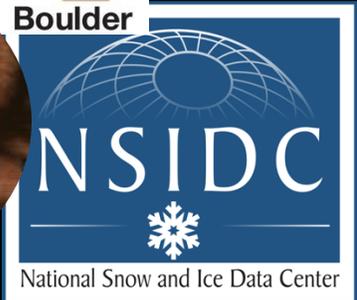
If you're not thinking about the climate impacts of thawing permafrost, (here's why) you should be

United Nations

But teaching students about permafrost & its dynamics can be challenging

- The Arctic is remote
 - Polar Explorer transports students to the Arctic virtually
 - Increases the number of students who have access to this unique region
- Changes in the Arctic are happening across a range of scales
 - Dimensions of time, temperature, volume
 - Many of these changes are happening underground
 - Polar Explorer places students in a rich 3D environment that they can explore
- Understanding impacts of permafrost thaw requires multi-disciplinary approach
 - 3D environment of Polar Explorer helps draw connections across concepts, disciplines, and ideas

Polar Explorer: A place-based virtual learning environment that transports students to the Arctic to learn about permafrost....



Scientists

+

Pioneers in building digital learning environments

+

Learning design experts

+

Artist



Interactive, Immersive Virtual Field Trips (iVFTs)

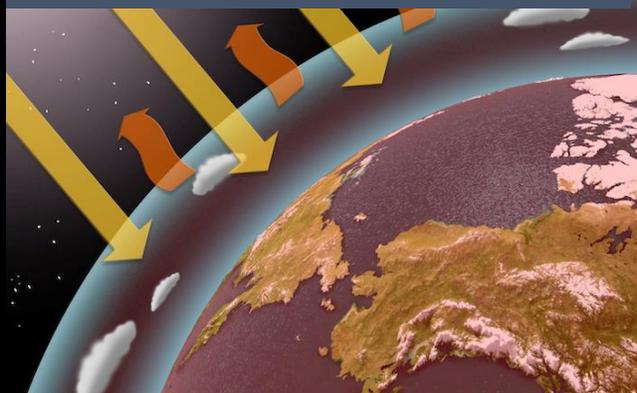
- Interactive and graphically rich 360° environments
- Range from self-guided free explorations to structured lessons to non-linear game like activities
- Learners supported with automatic adaptive feedback
- Draws on several effective teaching strategies, including:
 - Active learning
 - Inquiry learning
 - Intelligent tutoring
 - Place-based education



Polar Explorer Expeditions – Place-Based iVFTs

Energy Budget

E0



Permafrost Tunnel

E1



Permafrost Landscapes

E2



Permafrost Carbon

E3



Ecosystem Carbon

E4



Permafrost Thaw

E5



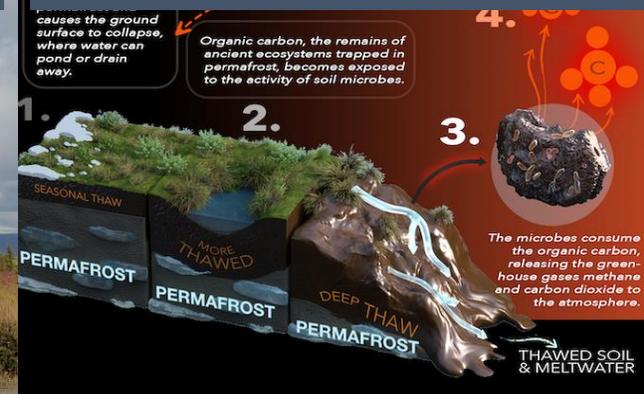
Regional Impacts

E6



Global Impacts

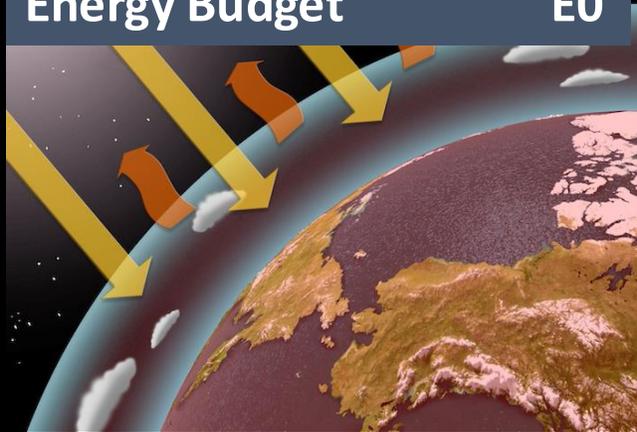
E7



Polar Explorer Expeditions

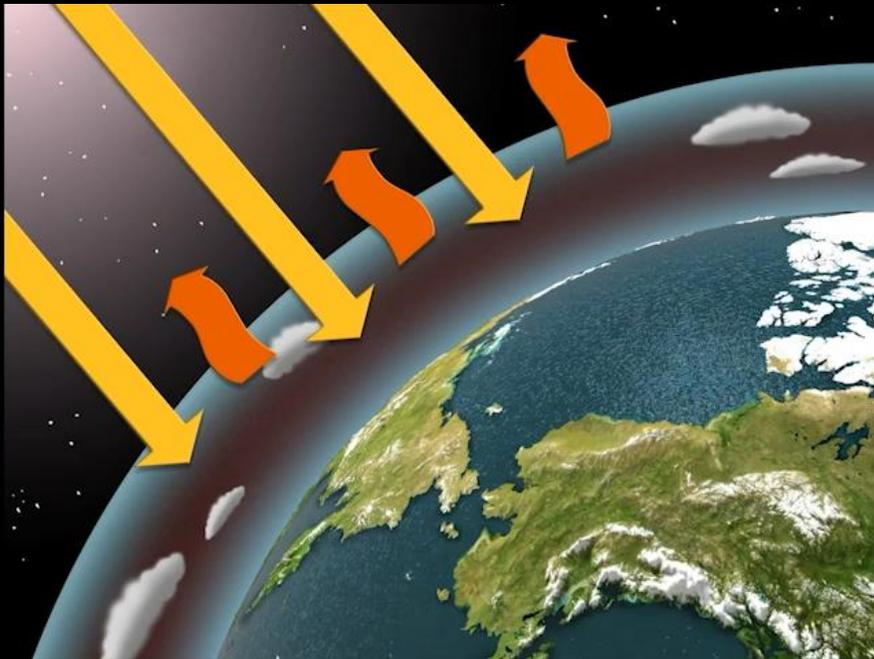
Energy Budget

E0

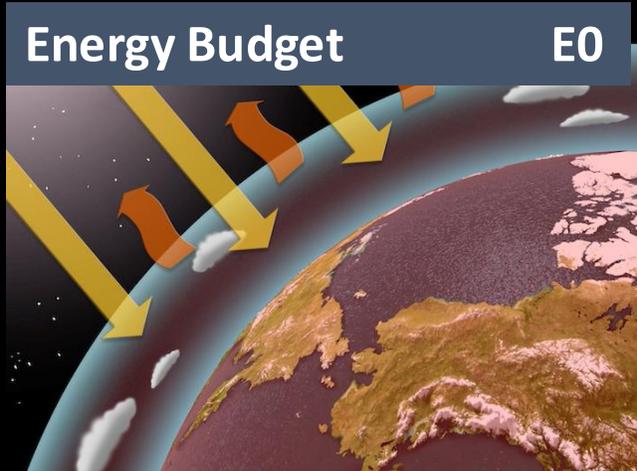


DR. DEBBIE HUNTZINGER
Climate Scientist

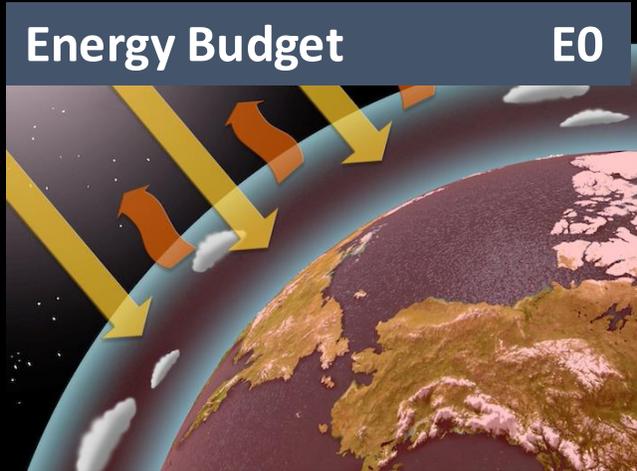
VPN ACCESS: REMOTE
AUDIO SIGNAL: STRONG +---
PROTOCOL: UKEVE



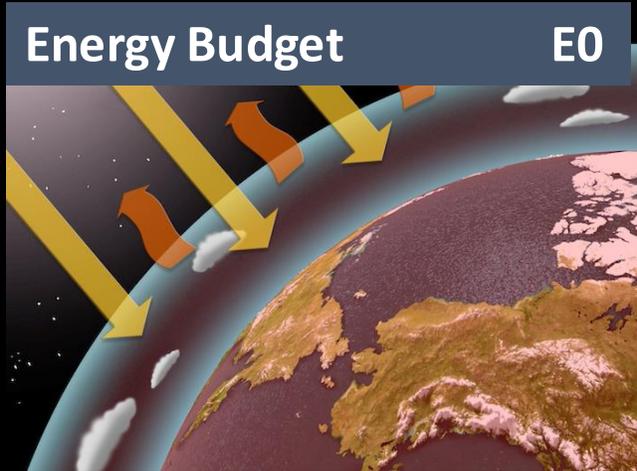
Polar Explorer Expeditions



Polar Explorer Expeditions



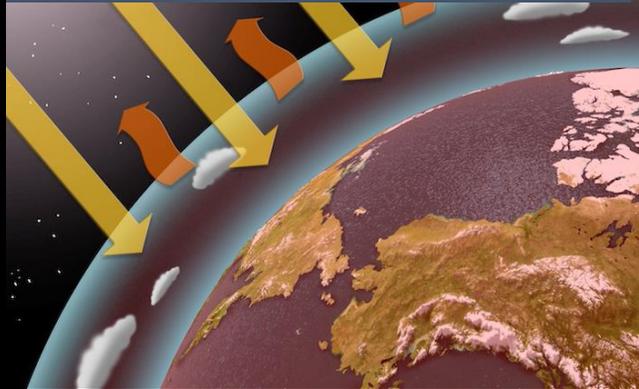
Polar Explorer Expeditions



Polar Explorer Expeditions

Energy Budget

E0



Permafrost Tunnel

E1



Permafrost Landscapes

E2



Permafrost Carbon

E3



Ecosystem Carbon

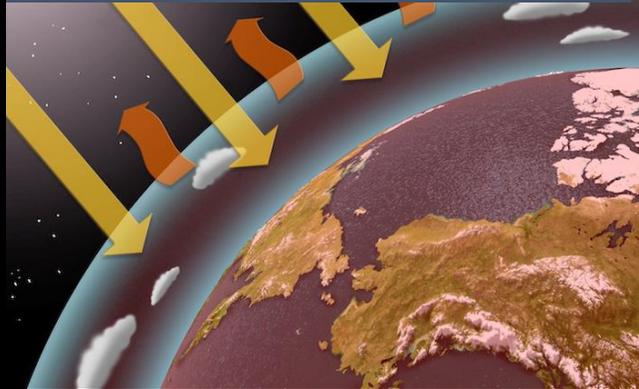
E4



Polar Explorer Expeditions

Energy Budget

E0



Permafrost Tunnel

E1



Permafrost Landscapes

E2



Permafrost Carbon

E3



Ecosystem Carbon

E4



Permafrost Thaw

E5

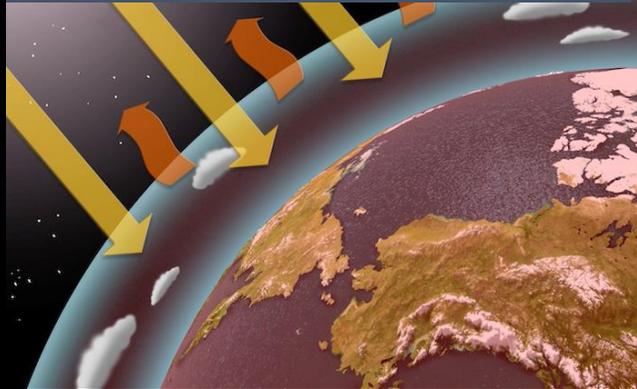


As the active layer deepens, carbon that was locked away in permafrost is now becoming part of active carbon cycle

Polar Explorer Expeditions

Energy Budget

E0



Permafrost Tunnel

E1



Permafro



on

E3



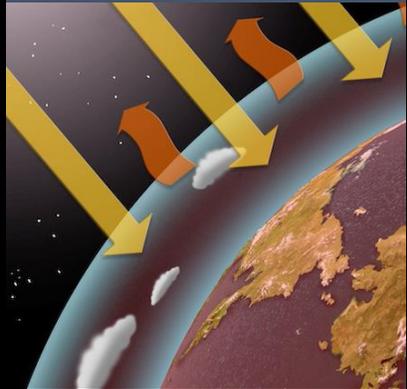
Regional Impacts

E6

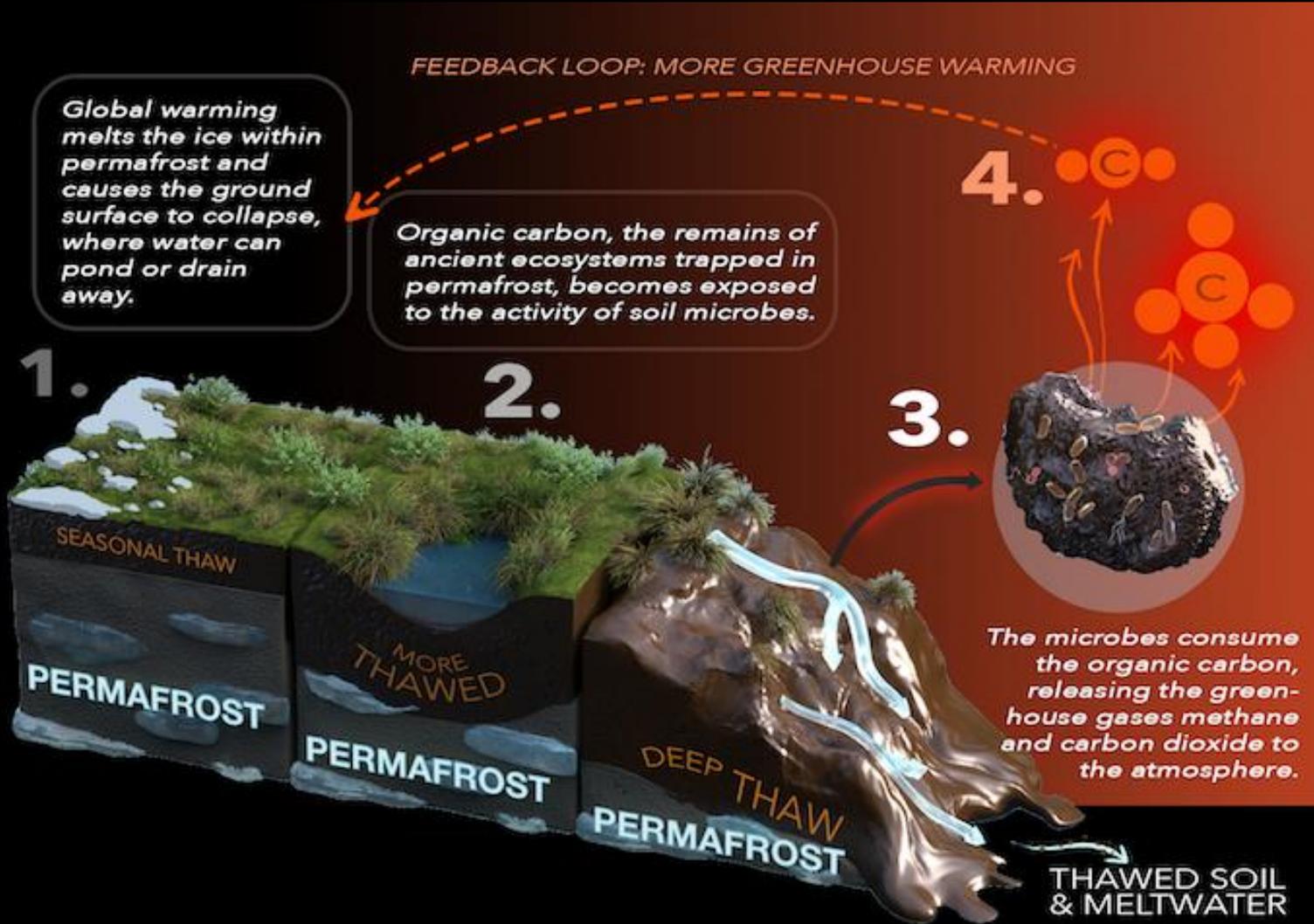


Polar Explorer Expeditions

Energy Budget



Ecosystem Carbon



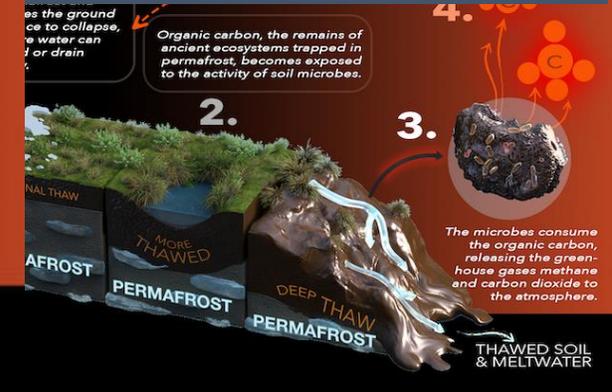
Permafrost Carbon

E3



Global Impacts

E7



Student role within Polar Explorer - Reporter

The New York Times

Reeling From Effects of Climate Change, Alaskan Village Votes to Relocate



CLIMATE CHANGE

Climate change is already scary in Alaska

Sea ice is retreating, skies are choked with wildfire smoke, and fish are vanishing.

Maddie Stone | Oct. 9, 2019



Fires burned about 2.6 million acres in Alaska in 2019, although it was far from the state's worst wildfire year. The Funny River Fire burned more than 485 square miles near Soldotna in 2014.

USDA

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As climate change and high costs plague Alaska fisheries, fewer young people are taking up the trade

By Joshua A. Bickel, Associated Press

TUESDAY, MARCH 14, 2023

The Seattle Times

WINNER OF 11 PULITZER PRIZES

INDEPENDENT AND LOCALLY OWNED FOR MORE THAN 126 YEARS

SEATTLETIMES.COM

\$2.00

Data confirms that warming is worsening floods, droughts

CLIMATE CHANGE | What had been an expected connection is backed up by a new study.

By KASHA PATEL
The Washington Post

Intense drought and heavy rainfall events occurred more often in the last eight years — the hottest years on record — than in the previous decade, according to a new

study released in Nature Water on Monday. Warmer global temperatures are increasing the extent, duration and severity of these extremes, the authors found, and are having more of an effect than natural climate patterns.

"As the world warms, we're having more intense and more frequent wet and dry events around the world, which gives us a little insight into what's going to happen in the future," said Matthew Rodell, a hydrologist at NASA

and co-author of the study. "This is an observation. It's actual data." Rodell said researchers have expected to see more droughts and floods in a warmer world based on climate model predictions, but "it's been really hard to prove." This

new analysis, which uses direct NASA satellite observations, provides "indisputable" evidence that warmer global temperatures are increasing such extreme events, Rodell said.

The team analyzed 1,056 extreme events from 2002 to 2021, using observations from NASA's Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow-On (GRACE-FO) satellites.

The satellites detect subtle variations in Earth's gravity field, which are used to measure water storage — including groundwater, soil moisture, snow, ice and surface waters — on land. Comparing current data to a longer-term

See > CLIMATE, A6



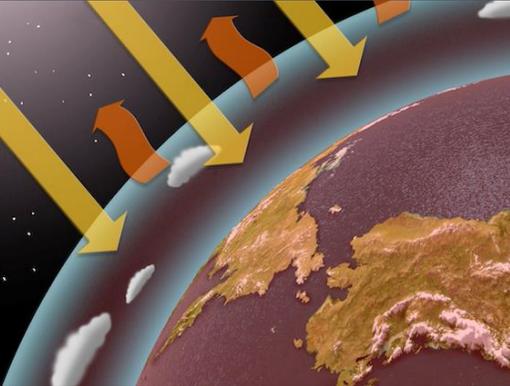
Polar Explorer – a peek inside....

Polar Base and Energy Budget Briefing



Place-Based Virtual Field Trips – Core to Polar Explorer

Energy Budget



A diagram illustrating Earth's energy budget. Yellow arrows represent incoming solar radiation hitting the Earth's surface and atmosphere. Orange arrows represent outgoing terrestrial radiation being emitted from the Earth's surface and atmosphere. The Earth is shown in a cross-section, with the atmosphere and surface layers clearly visible.

Ecosystem Carbon



A person wearing a blue jacket, a grey helmet, and a yellow safety harness stands on a metal platform. The platform is equipped with various scientific instruments, including a white sensor or camera. The background shows a grassy field under a cloudy sky.

Permafrost Tunnel E1



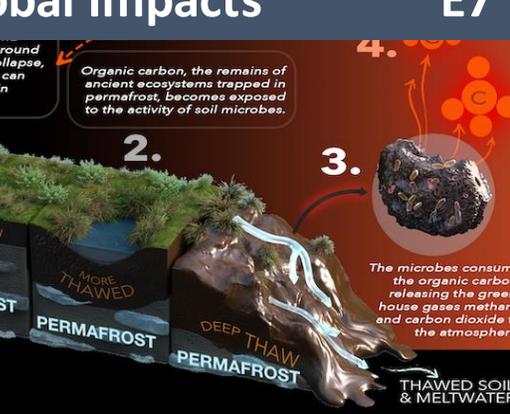
A person wearing an orange jacket, a white helmet, and dark pants stands inside a large, dark, layered permafrost tunnel. The tunnel walls are composed of distinct horizontal layers of earth and rock, showing signs of erosion and geological structure. The lighting is dim, highlighting the texture and color of the permafrost.

Permafrost Carbon E3



A person wearing a blue jacket and dark pants stands in a field next to a body of water. The field is covered with low-lying vegetation, and the water is visible in the background.

Global Impacts E7



A diagram illustrating the process of permafrost thawing and the release of organic carbon into the atmosphere. The diagram is divided into four numbered steps:

1. **PERMAFROST**: Shows a cross-section of the ground with a layer of permafrost. A label indicates "ground collapse, can in".
2. **MORE THAWED PERMAFROST**: Shows the permafrost layer becoming thinner and more exposed.
3. **DEEP THAW PERMAFROST**: Shows the permafrost layer melting, with a label "The microbes consume the organic carbon, releasing the greenhouse gases methane and carbon dioxide to the atmosphere." and an arrow pointing to a small globe.
4. **THAWED SOIL & MELTWATER**: Shows the permafrost layer completely melted, with a label "The microbes consume the organic carbon, releasing the greenhouse gases methane and carbon dioxide to the atmosphere." and an arrow pointing to a small globe.

Smells like the Pleistocene







Expedition 1 - Permafrost Tunnel Research Facility

Other landscapes and places that students will visit

Initial Testing

- Pilot testing of Energy Budget Briefing (E0) in a large enrollment (>300 total) freshman environmental science course at NAU - majority non-STEM students
- Gathered feedback on user experience, navigation, flow, & engagement
- Also surveyed lab TAs about ease of use and amount of student support required



***Polar Explorer's* upcoming testing - Improves STEM learning & Increases Accessibility of Polar Science**

- *Polar Explorer's* interactive environment improves STEM learning.
- Increases the accessibility of polar science to a diverse population of students.
- *Polar Explorer* includes formative assessment supported by intelligent tutoring.
- Enables the capture of detailed learning analytics and allows for an examination of both student behavior and learning outcomes.



Polar Explorer – some behind the scenes.....

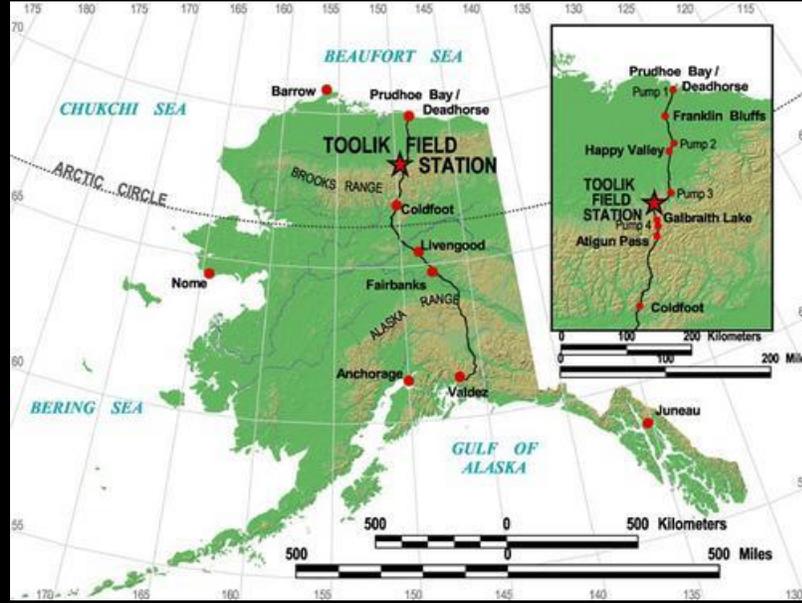
Near Fairbanks – Summer of 2022



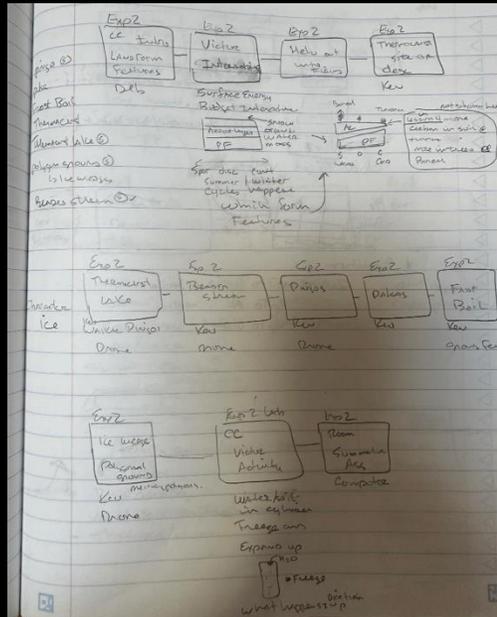
Drilling a permafrost core



And we head North!



<https://p.tourit.etx.asu.edu/tl2jve4u/586tqq1cufz26v5/index.html>





Thank you!

Deborah.Huntzinger@nau.edu

<https://etx.asu.edu/major-projects/polar-explorer/>

<https://carml.rc.nau.edu/polar-explorer/>

Polar explorer will be web-based
Available by expedition (free) and
complete PE fully integrated into
LMS (small fee per student)

