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Permafrost Discovery Gateway

Anna Liljedahl & Chandi Witharana



Taking the pulse on the changing
Arctic landscape for science &
management

Oct 22nd, 2024



Woodwell is partnering with 7 organizations:



UConn
UNIVERSITY OF CONNECTICUT
Chandi Witharana



ALASKA NATIVE
TRIBAL HEALTH
CONSORTIUM



Michael Brubaker



NSF
**ARCTIC
Data
Center**

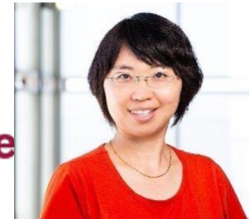


Matt
Jones



NCSA
Kenton McHenry

ASU
Arizona State
University



Wenwen Li



UAF
UNIVERSITY OF
ALASKA
FAIRBANKS

Helene Genet



ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG



Guido Grosse

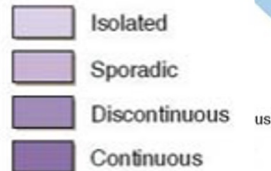
Permafrost Discovery Gateway



Enable **creation** & **discovery** of big data
to support science & applied opportunities

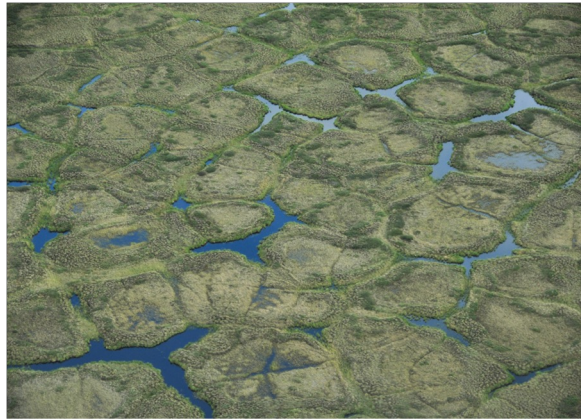
Permafrost:
Ground that remains
below 0°C for at least
two consecutive years

Permafrost



Ice-rich permafrost

Up to 70% of the top ~3m of the ground can be ice.



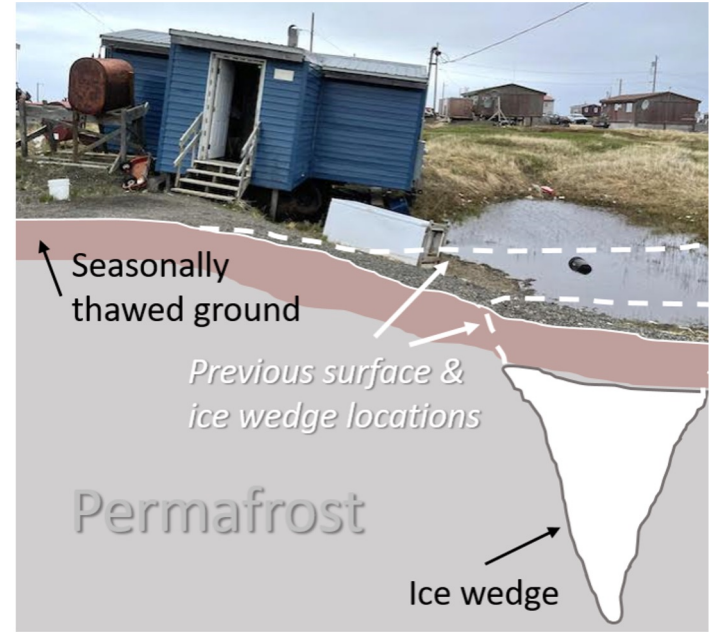
5 million people

live on permafrost in the Arctic

50% of Arctic infrastructure

is at risk of permafrost thaw damage within the next 25 yrs

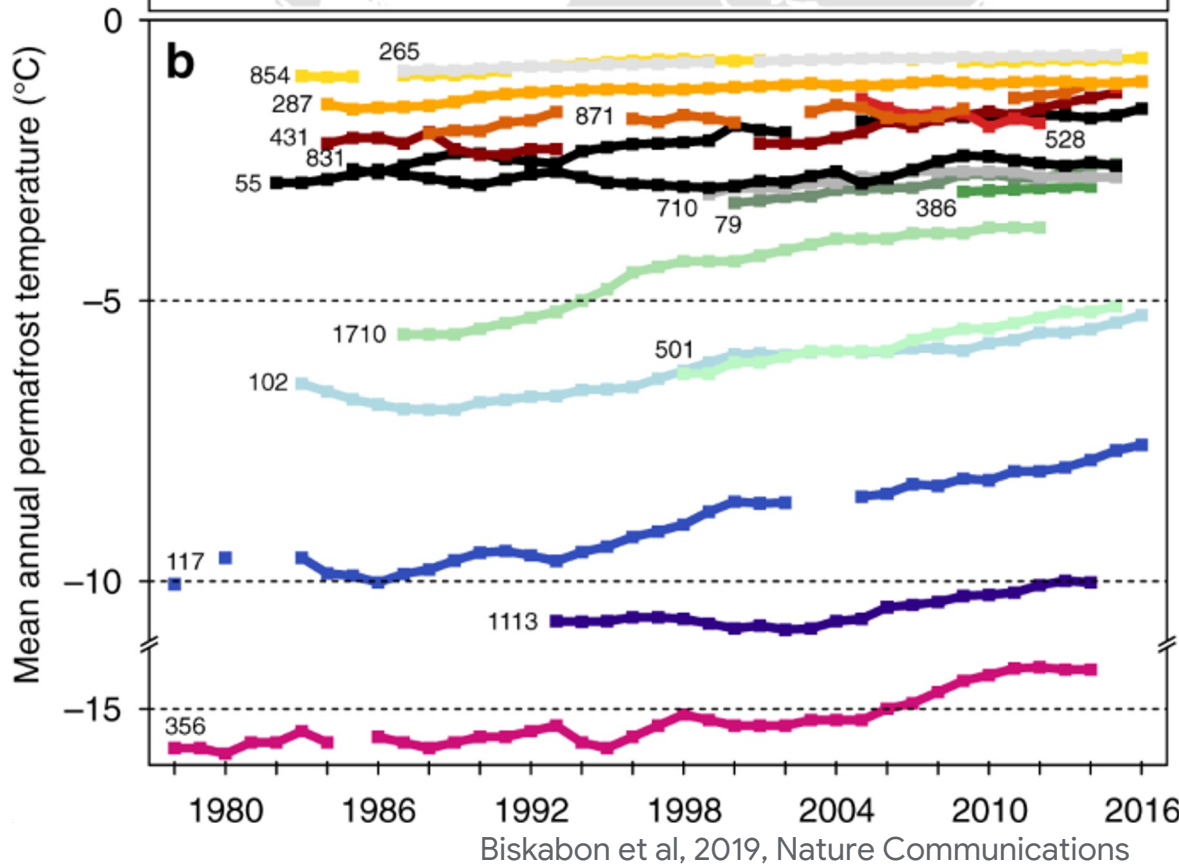
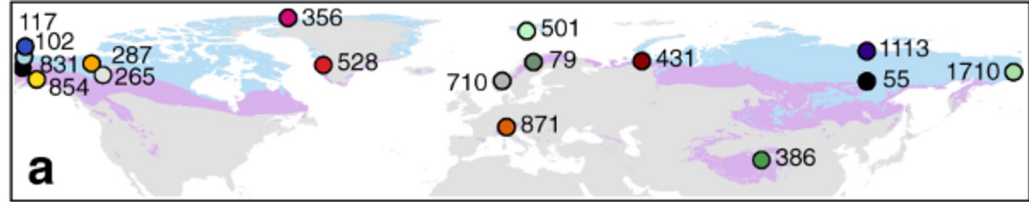
Hjort et al., 2022, Nature Reviews



Warming climate, warming permafrost

Warming of up to about 1°C per decade

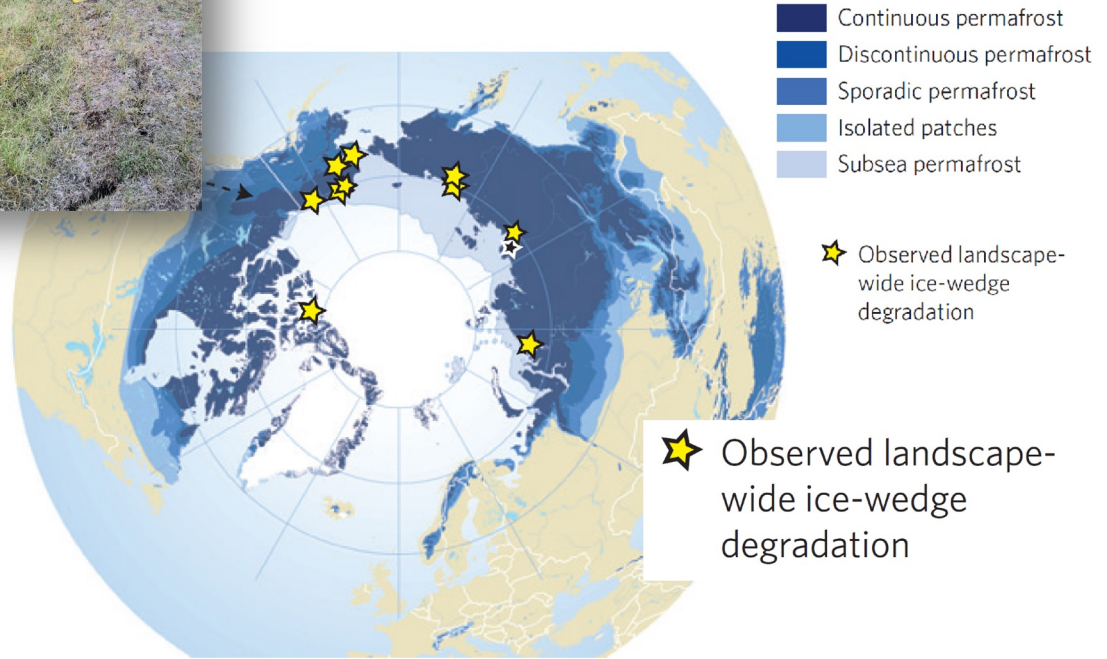
Smith et al, 2022, Nature Reviews





Ice-wedge degradation

Remote sensing analyses from several locations using satellite imagery show ground subsidence.



Science community can now assess if thawing is happening across the Arctic or just at some sites.

Finally, a pan-Arctic product where I can recognize my field site.

I want to use the big dataset too!



Tools for big data

- Increase data access
 - Remove barriers for creation & use

→ Shorten the information pipeline

→ Make science more collaborative
(incl. bridging across spatial scales)

→ Make science more useful

Permafrost Discovery Gateway

Brevig Mission, AK



This community in the Norton Sound region of

Ice-Wedge Polygons

Zoom Download (2.2 GB)

Opacity 80%

Ice-wedge polygons are ubiquitous ground features in landscapes underlain by ice-rich permafrost. Ice-wedge polygons are bounded by wedges of ice, which develop from millennia of repeated frost-cracking during cold winters and snowmelt water infiltrating the cracks in spring.

Relevance

Ice wedges are quite susceptible to thaw and thus can be an early warning of permafrost loss. Ice-wedge thaw also creates new ponds and pathways that can cause rapid lake drainage.

Methodology

High resolution satellite imagery combined with



Legend

Local Stories

LEO Network content

Ice-Wedge Polygons

Ice-Wedge Polygons

Permafrost Extent

Isolated patches

Sporadic

Discontinuous

Continuous

Surface Water Index Trend
2000-2021 (July Trend in Avg)



Permafrost Discovery Gateway

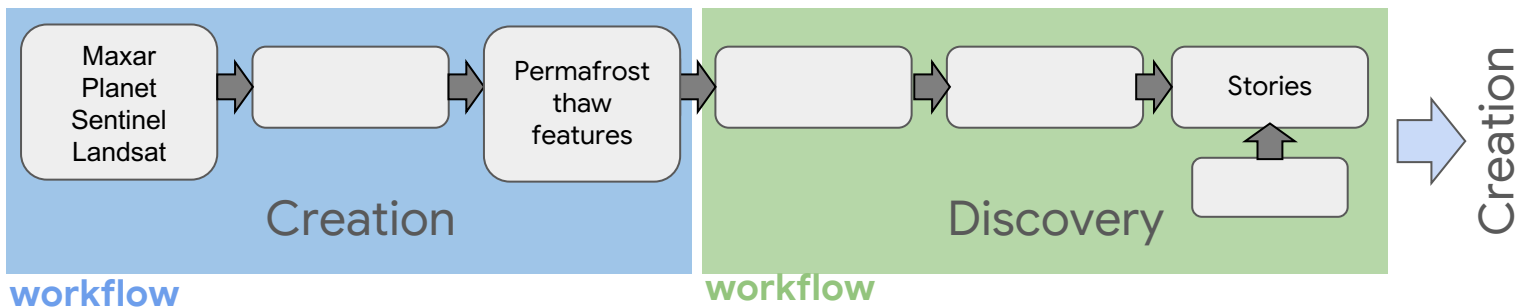




Photo: Scott Zolkos

Big data creation

.....

Monitoring permafrost thaw across the Arctic & assessing its impacts

HABITAT

High-resolution Arctic Built
Infrastructure & Terrain Analysis Tool

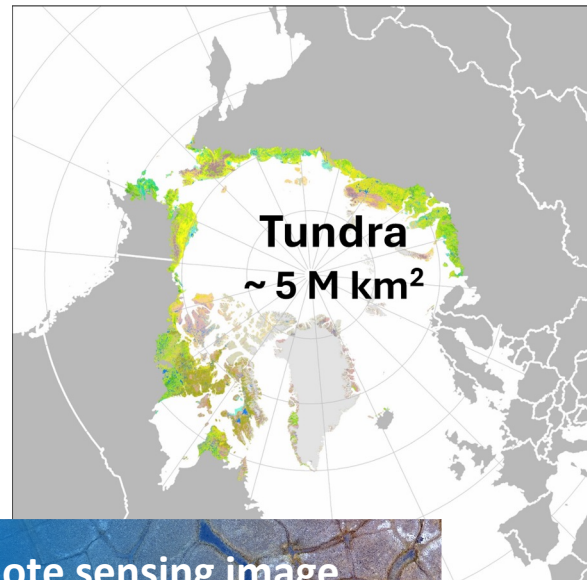


Polygonized Tundra Landscape

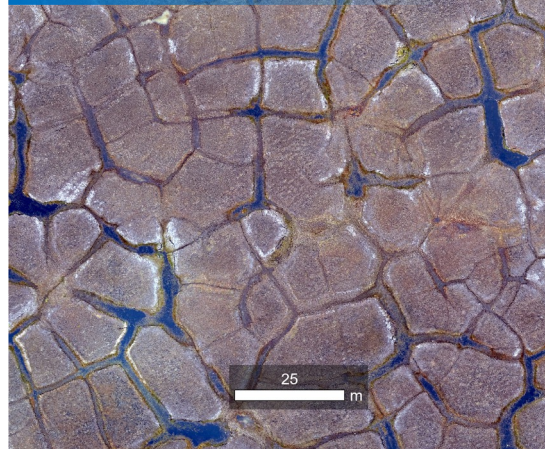
Ice-wedge
Polygon

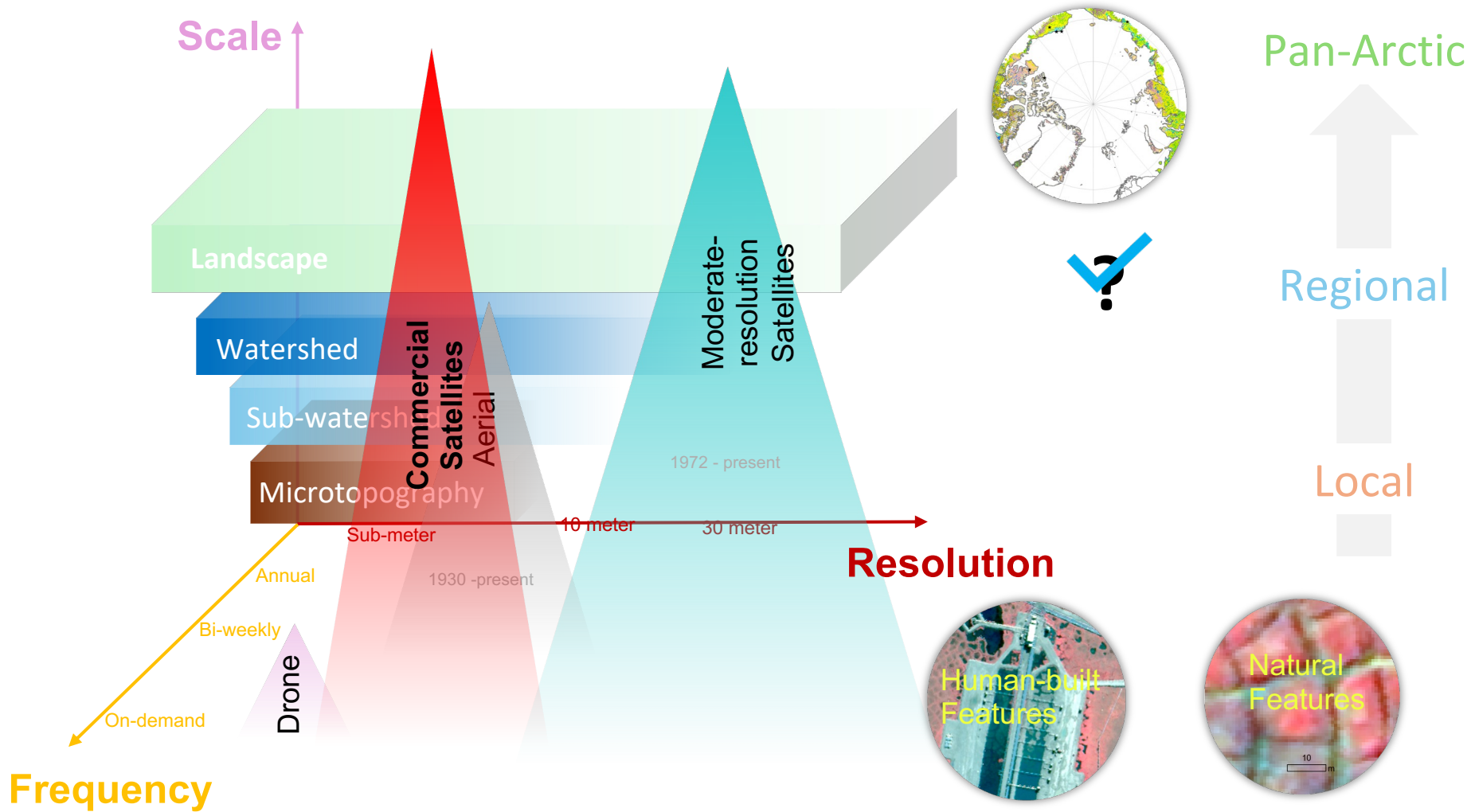
Active Layer

Permafrost



Remote sensing image

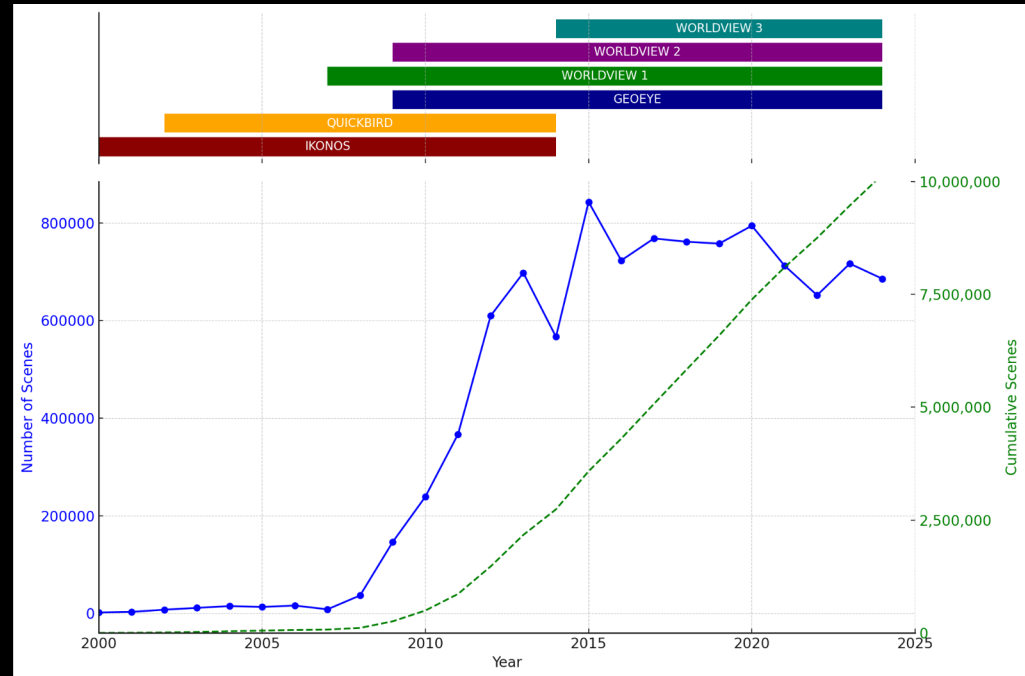
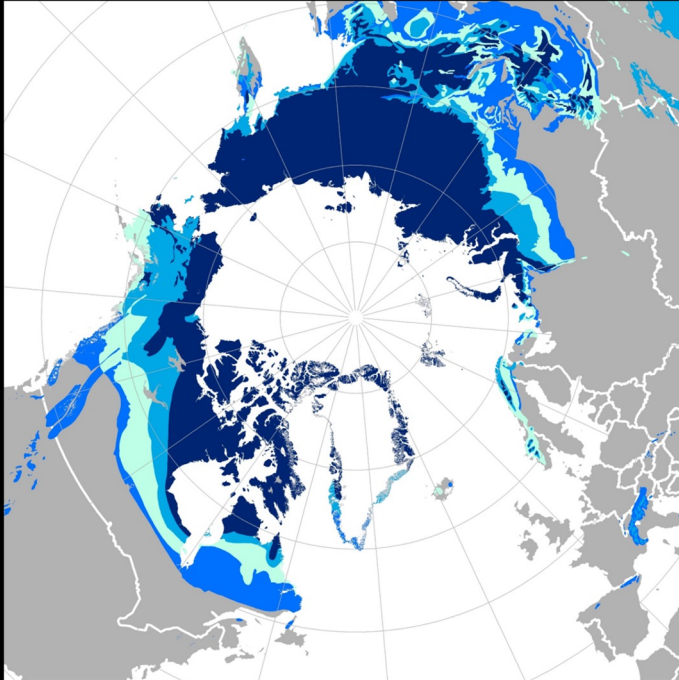




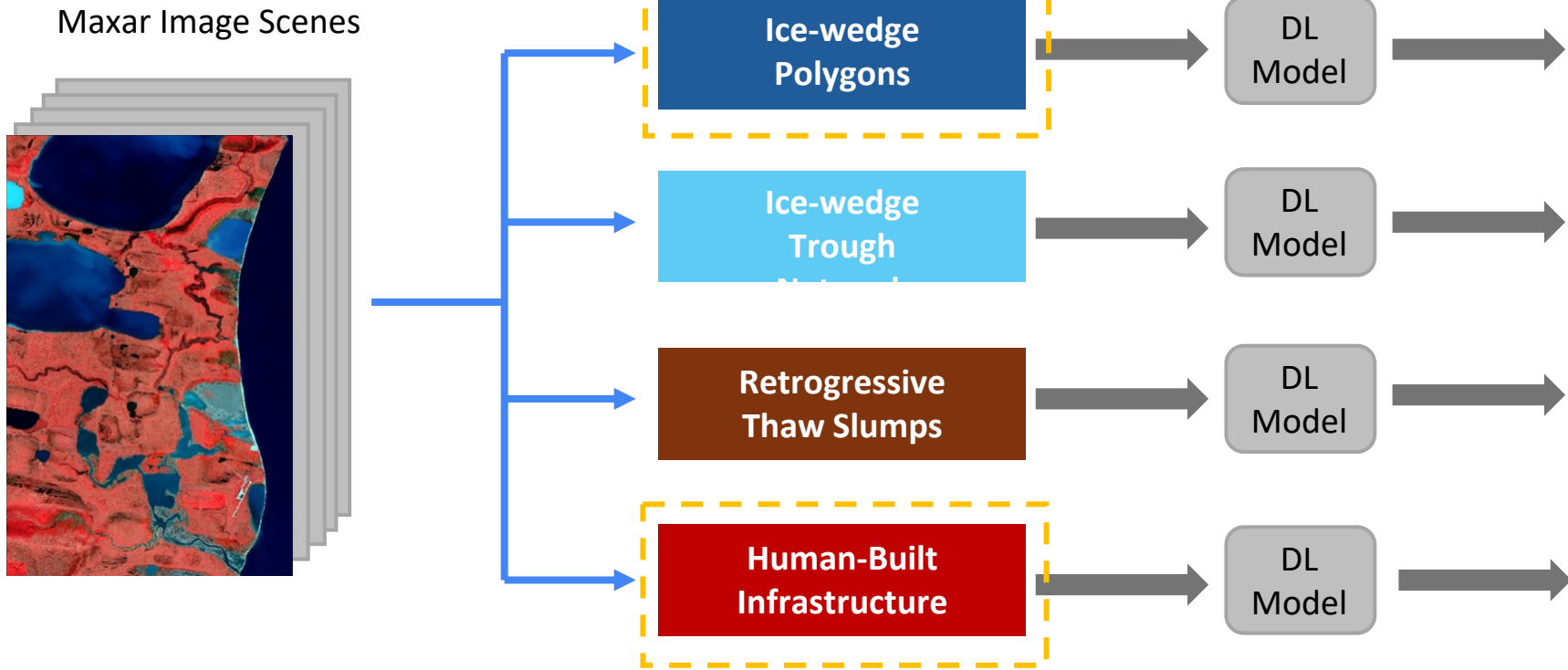
> 3 PB image data
>8 million images

*Free Access to NSF Polar Program funded researchers

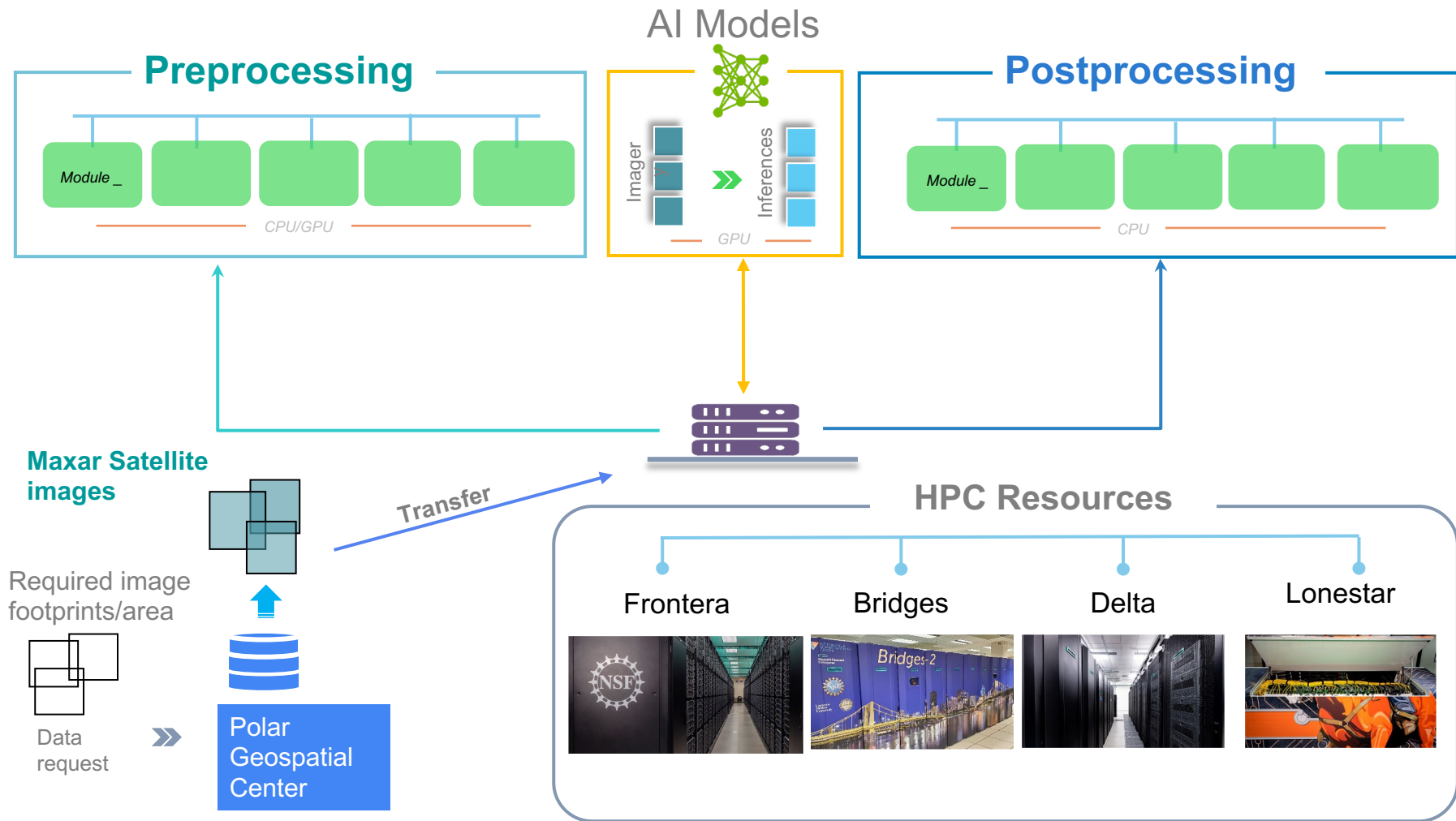
Maxar Commercial Satellite Imagery Coverage for the Arctic (2000 – 2024)

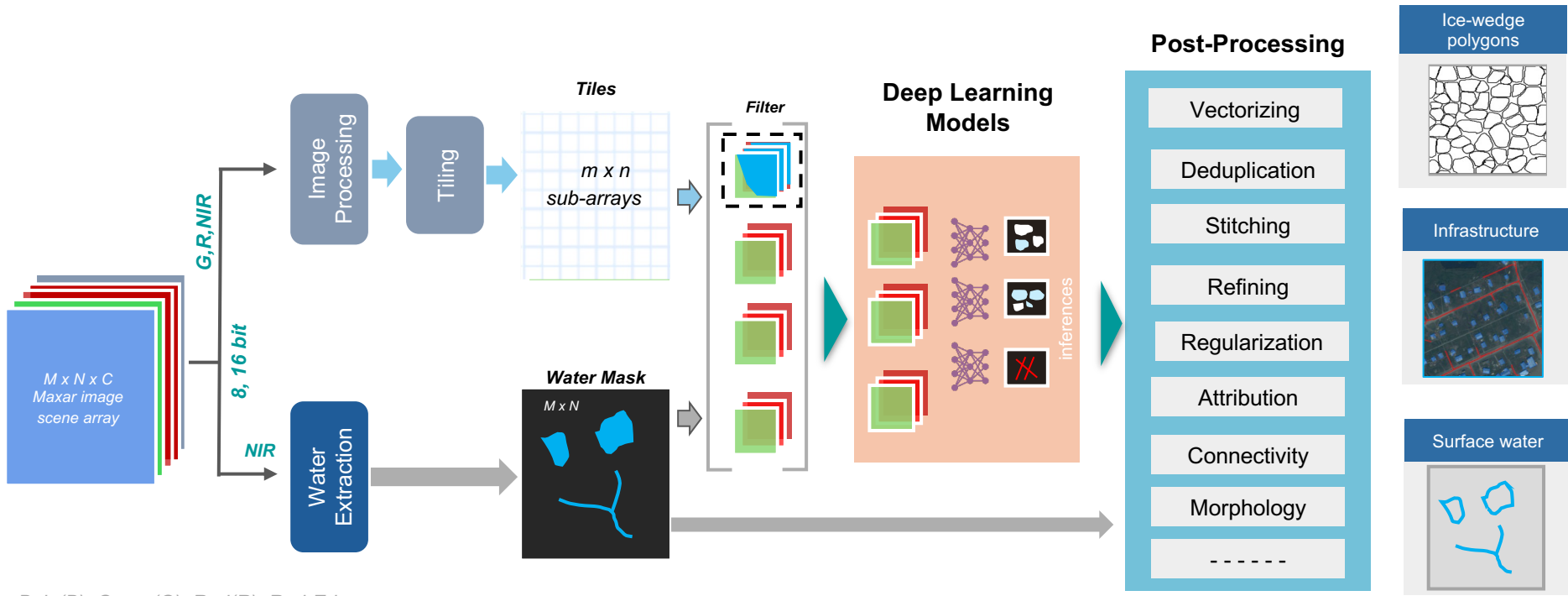


Feature Detection Workstream



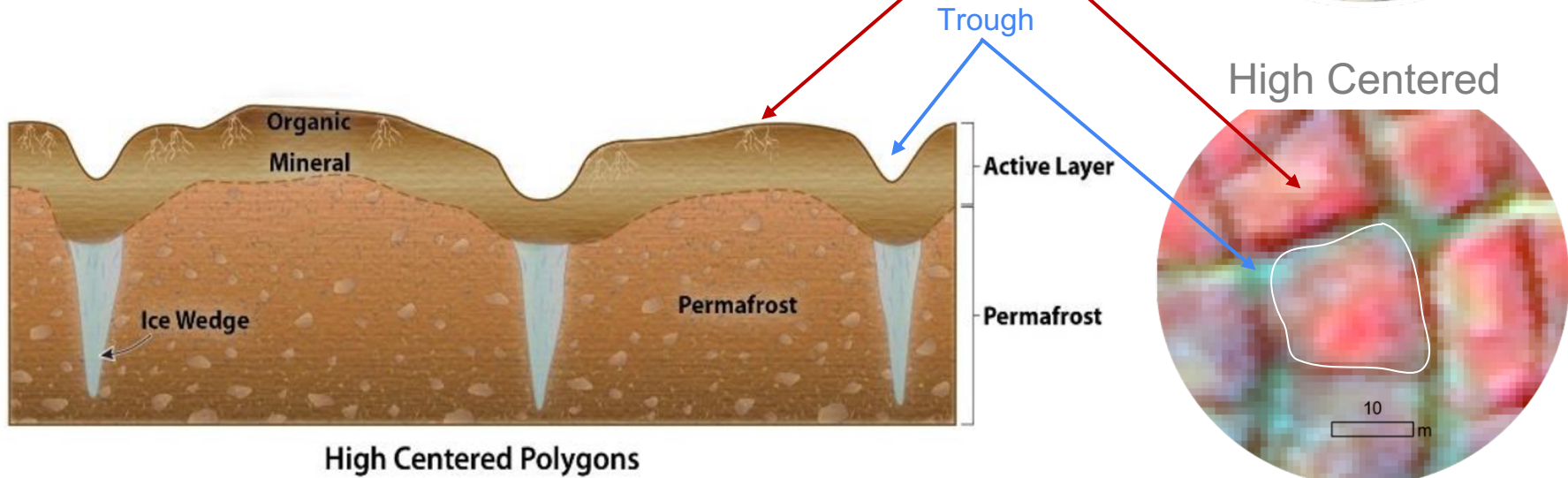
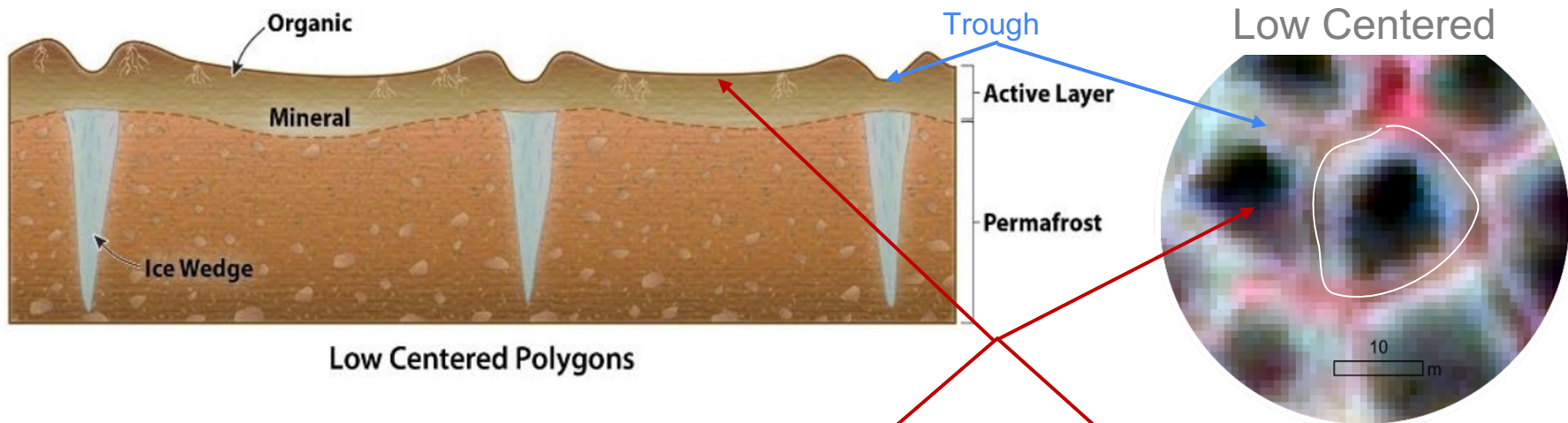
DL: Deep Learning, Semantic & Instance Segmentation

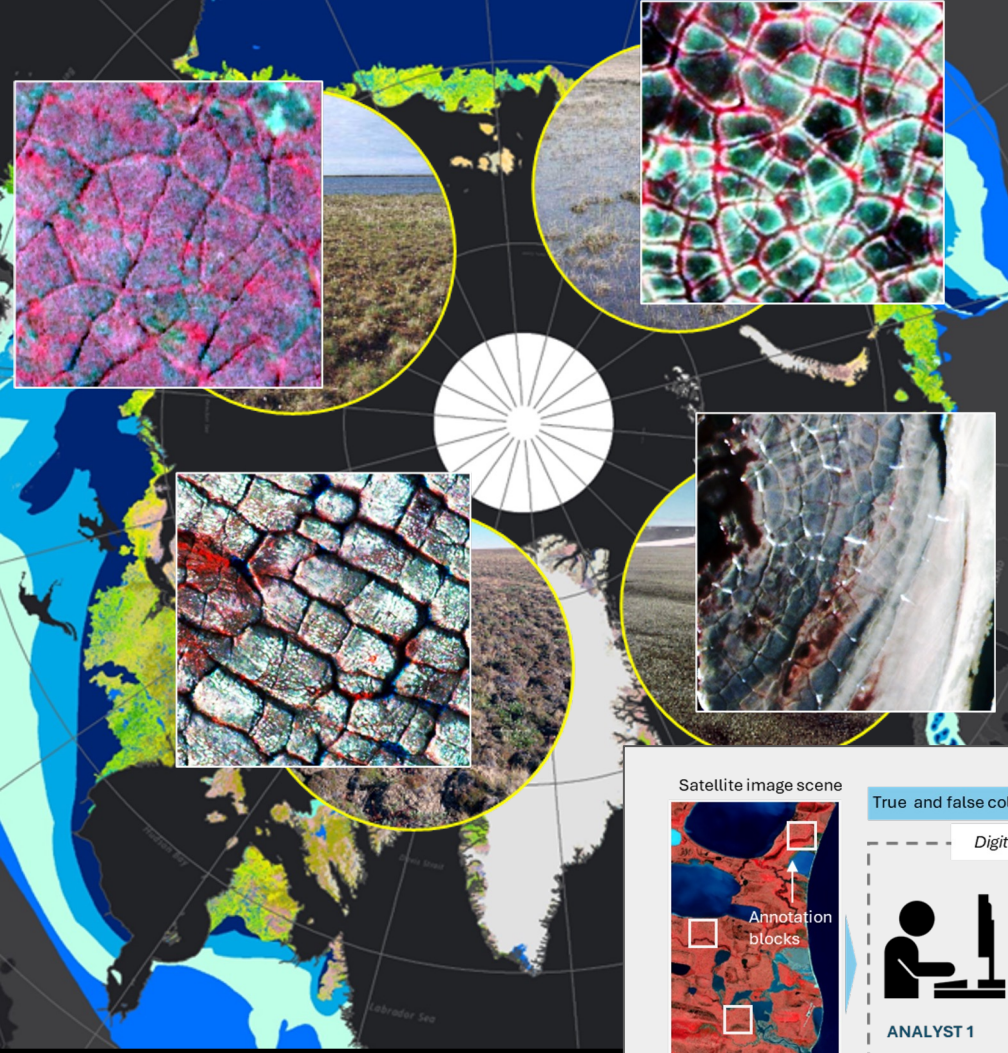




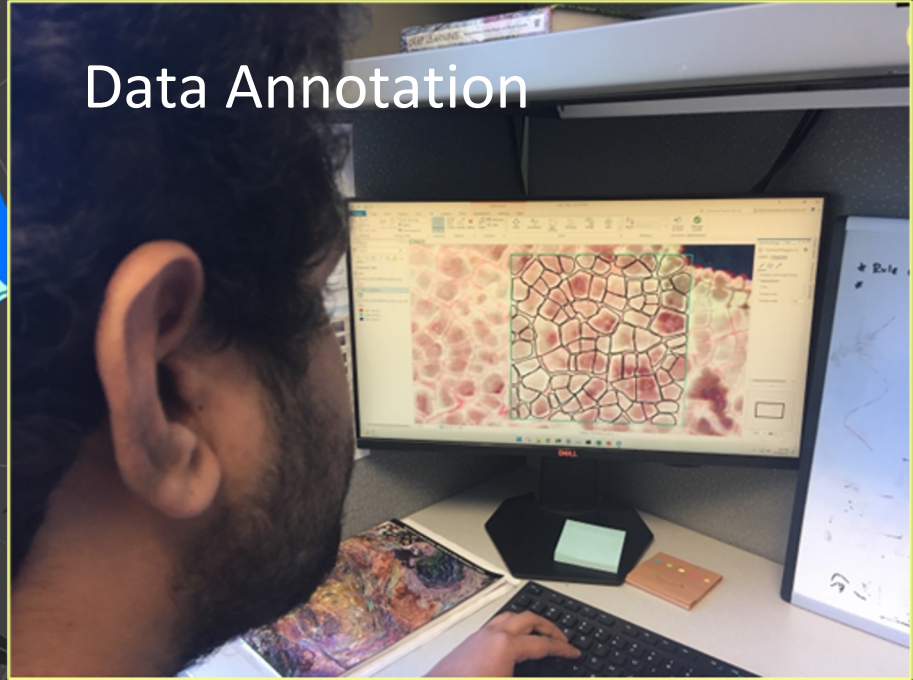
Bule(B), Green(G), Red(R), Red-Edge (RE) Near-infrared (NIR, NIR1, NIR2),







Data Annotation



Satellite image scene



True and false color composites Auxiliary geospatial layers Domain expert guidance

Digitizing & Labeling

ANALYST 1

Inspection & Correction

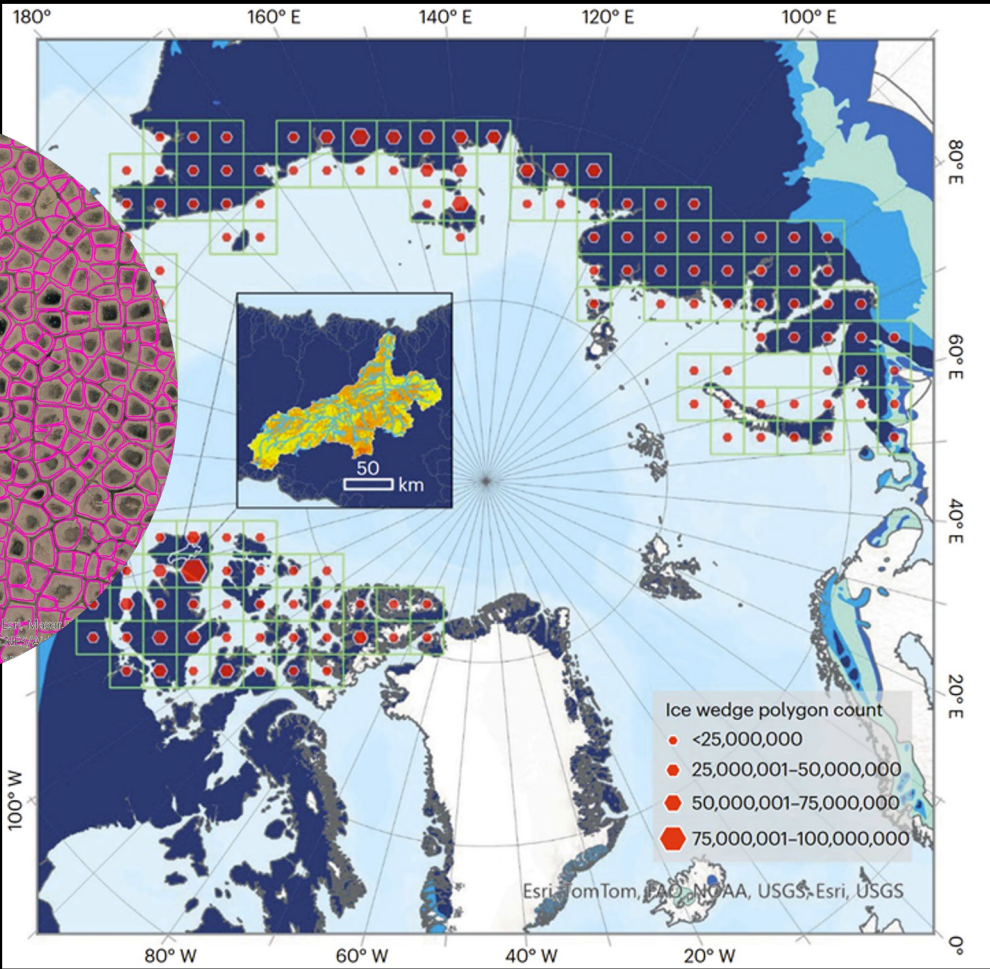
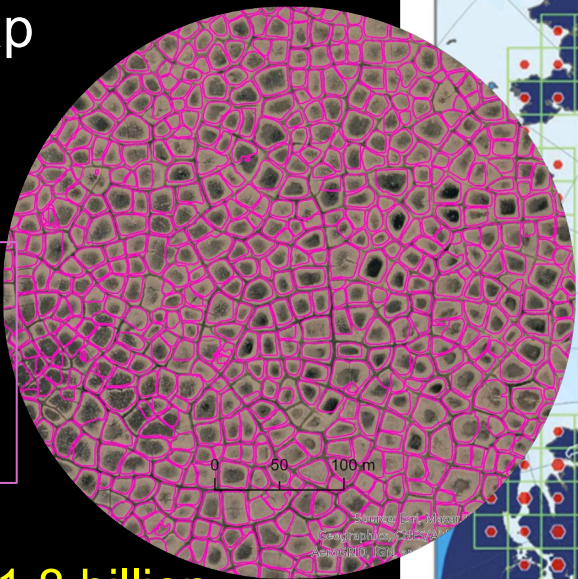
ANALYST 2

Conversion & Archiving

- SHP
- JSON
- Raster mask
- Image tiles (8bit)
- Image tiles (16bit)

The first Pan-Arctic Ice-wedge polygon map

- Over 3 million km² of Tundra
- > 30,000 Maxar commercial satellite image scenes
- ~ 0.5 PB of image data

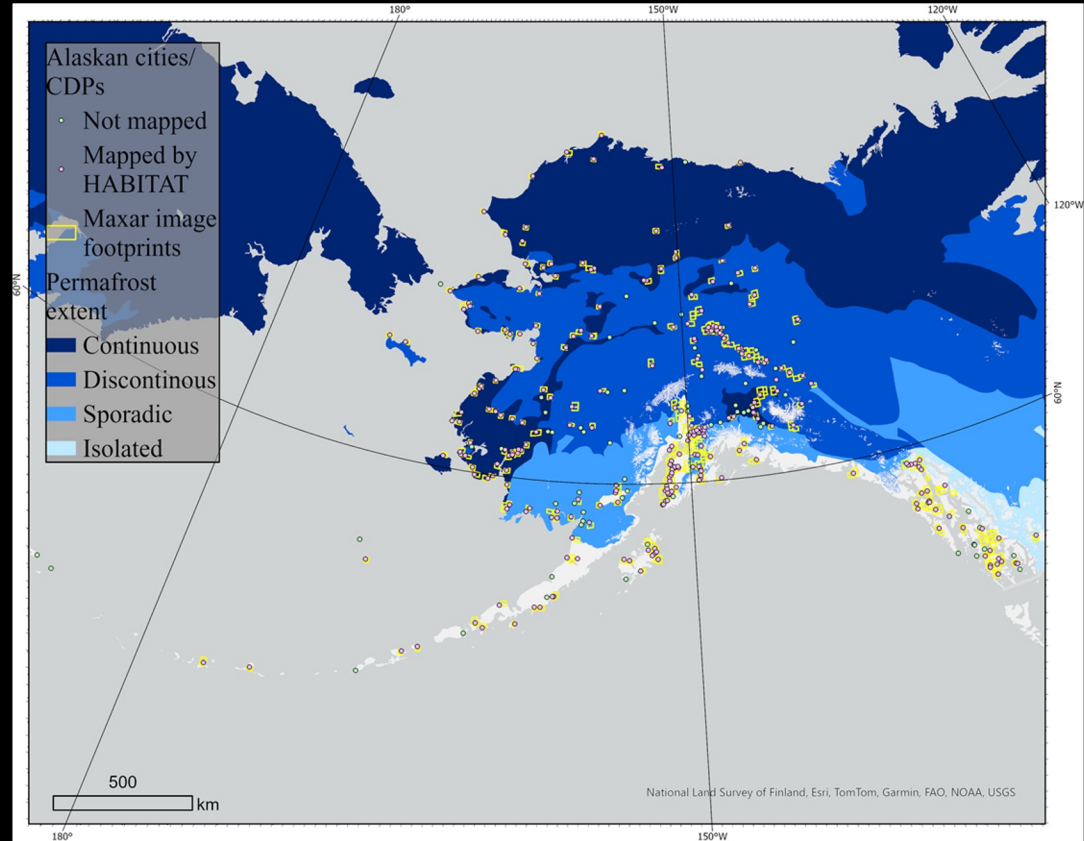


We mapped over 1.8 billion individual ice-wedge polygons from 0.5 m resolution Maxar imagery.

[Liljedahl, Witharana, Manos, 2024 Nature -Water]

Human-built Infrastructure Map

- HABITAT was used to map buildings and roads in 285 communities across the state of Alaska
- 387 Maxar satellite image scenes with resolutions ≤ 0.5 m acquired between May-Sept. of 2018-2023 were used.





MAP PRODUCT COMPARISON

Statewide building footprint

HABITAT contributes 17M m² not in Open Street Map

HABITAT (Our map)



OpenStreetMap (OSM)



Sentinel-1/2 derived Arctic Coastal Human Impact dataset (SACHI)



Retrogressive Thaw Slump map

Mapped individual RTS using Planet imagery (~3m) and how each RTS evolve over time.

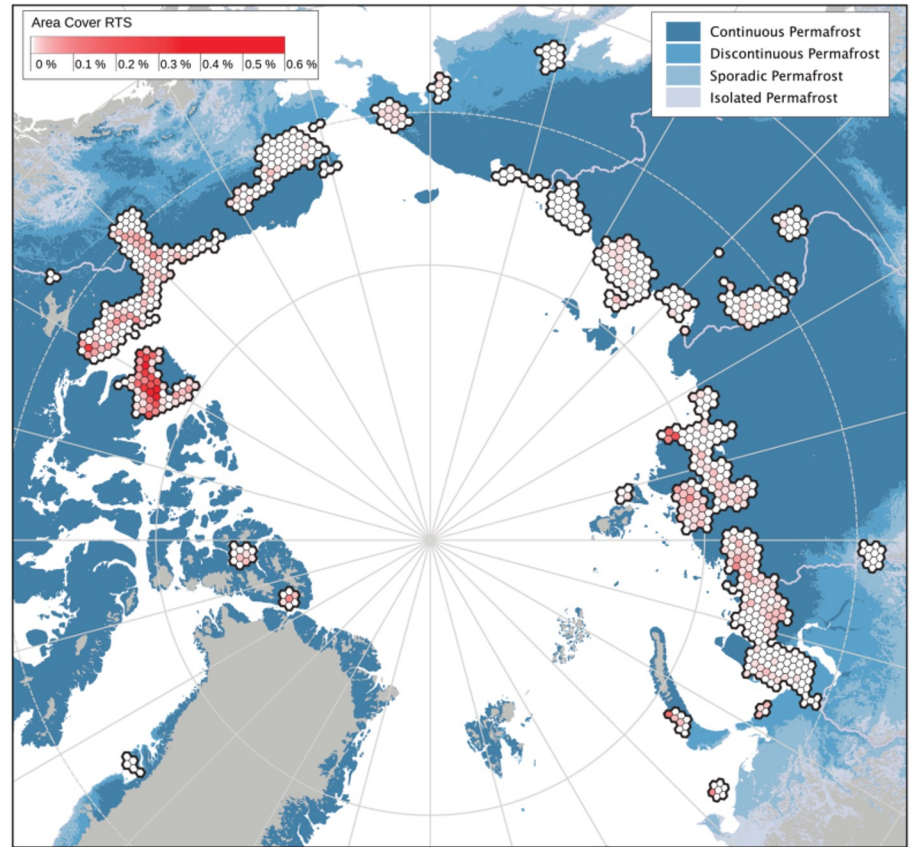
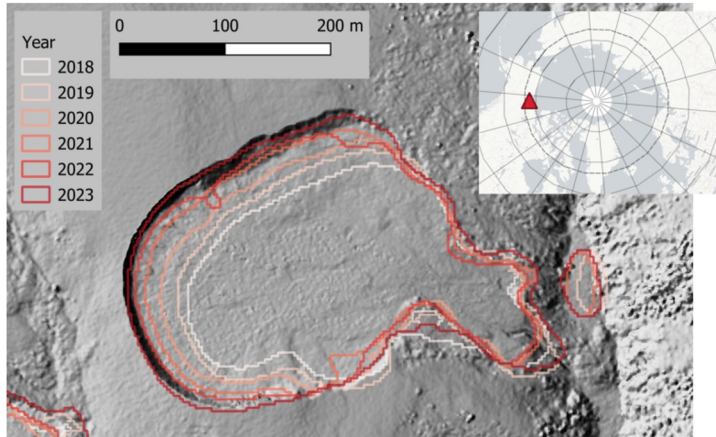
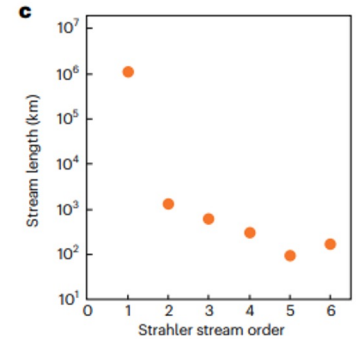
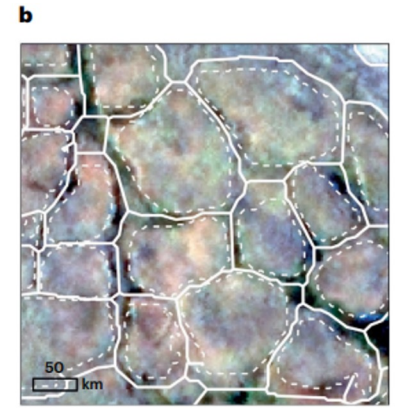
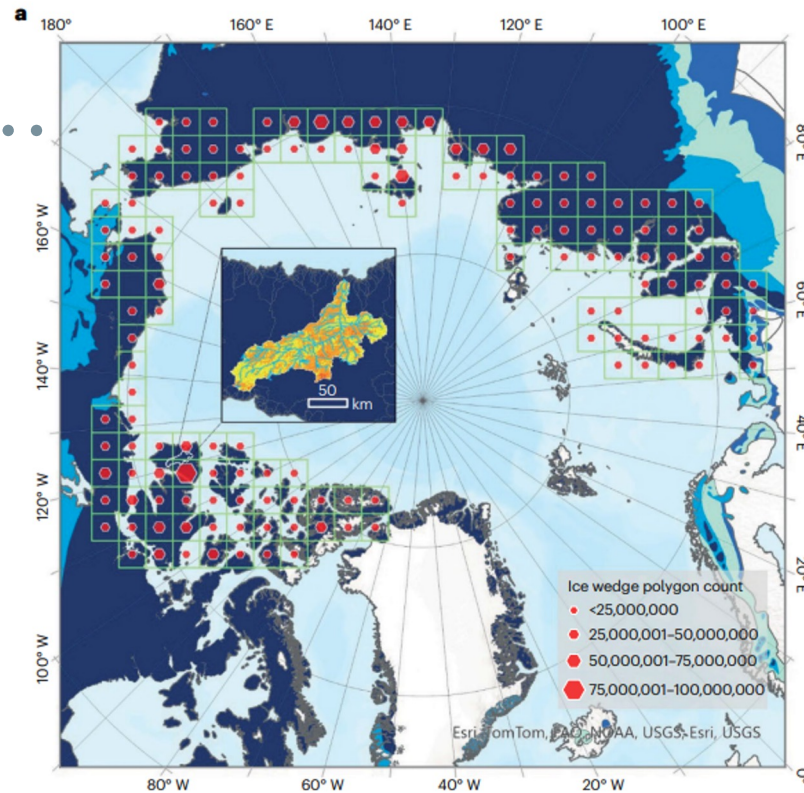


Figure 9: Affected area of RTS and ALD footprints in percent per gridcell in 2022 based on DARTS Level 2 data. Gridding is based on the H3 grid in level 4.

Big “children” data

From the ice-wedge polygon map we can estimate:

- 1) ice-wedge polygon coverage
- 2) ice-wedge network



Near-Real Time Monitoring of Lake Drainage

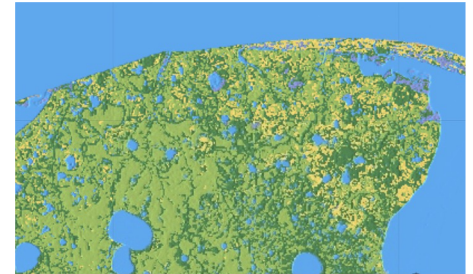
Problem

Currently, most permafrost knowledge is in the form of one-time decadal-scale snapshots of past thaw across the Arctic.



Solution

- *PDG users will be able to see which lakes have drained in the past month*



Translating science into applied information

Big data is high resolution & large coverage → Supports standardization

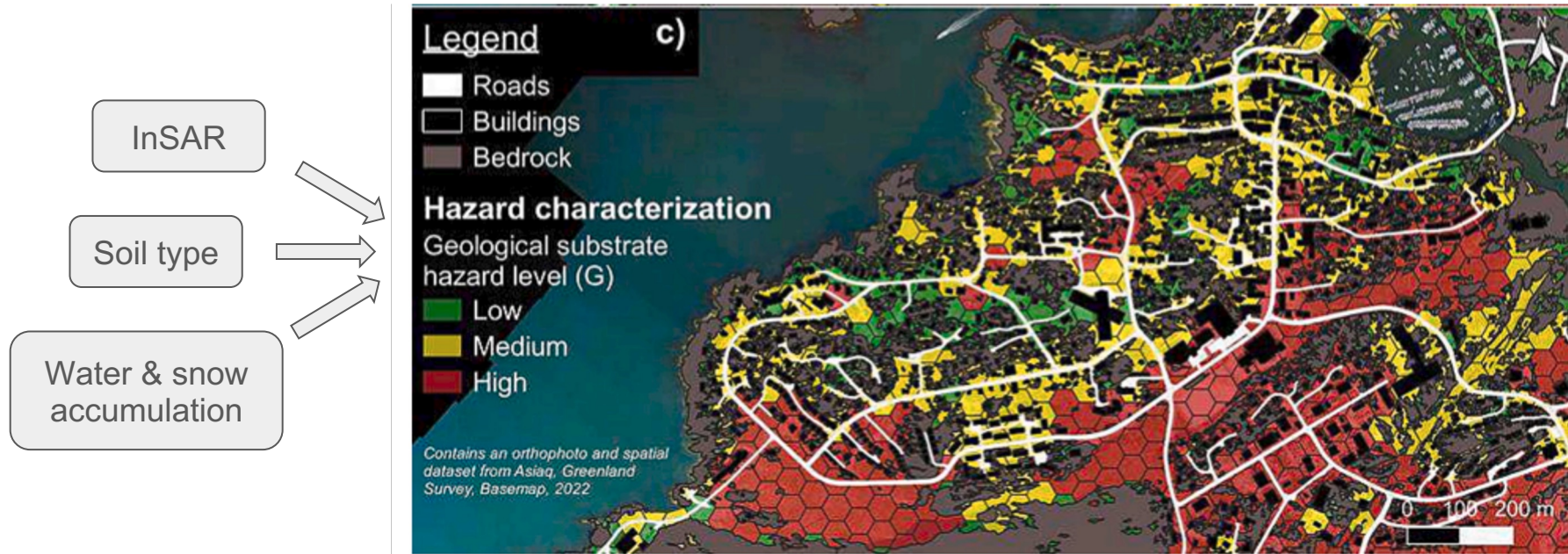
FEMA National Risk Index

Risk Index

All Natural Hazards

- Avalanche
- Coastal Flooding
- Cold Wave
- Drought
- Earthquake
- Hail
- Heat Wave
- Hurricane
- Ice Storm

permafrost?



Discovery tools

permafrost.arcticdata.io

Permafrost Discovery Gateway

Brevig Mission, AK



This community in the Norton Sound region of

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Zoom Download (2.2 GB)

Opacity 80%

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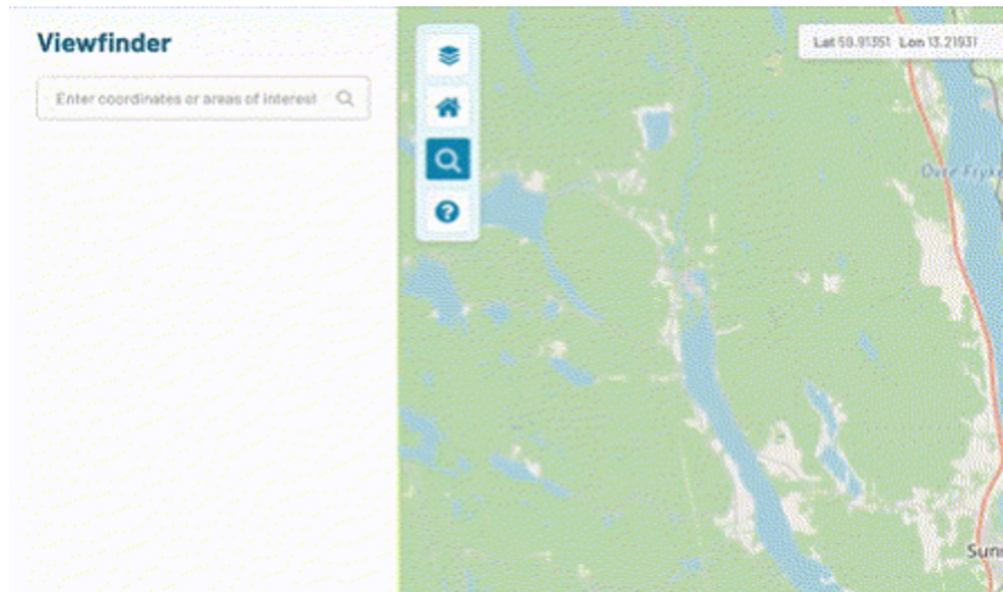
Continuous

Surface Water Index Trend
2000-2021 (July Trend in Avg)



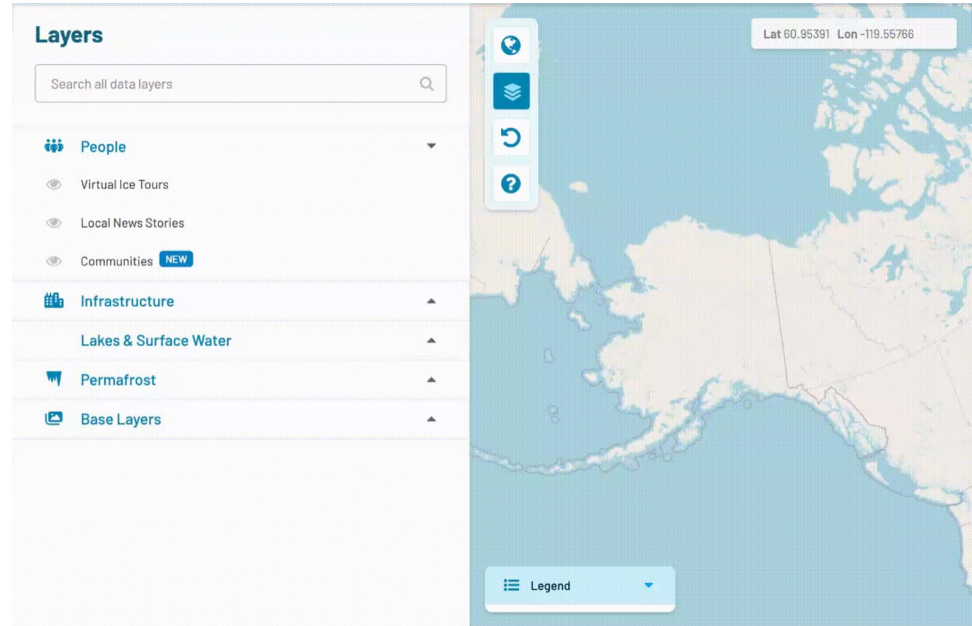
Location Search

We've introduced place name, area of interest, and lat/long coordinate-based search functionality.



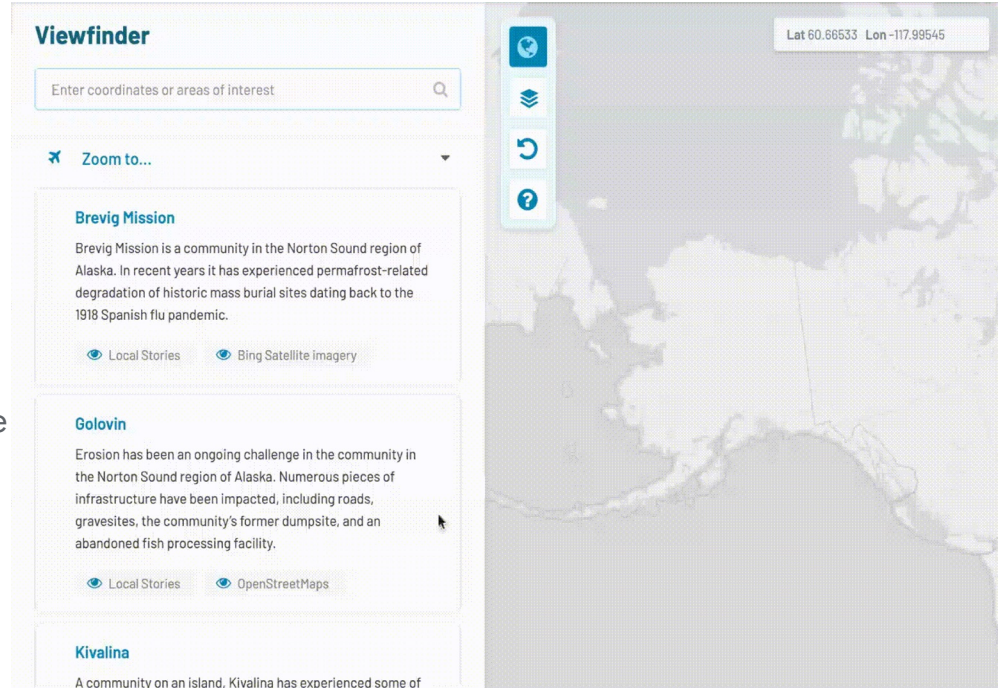
Legend Design

Legends are inside the map, including palette info of all visible layers.



Zoom to & Storytelling

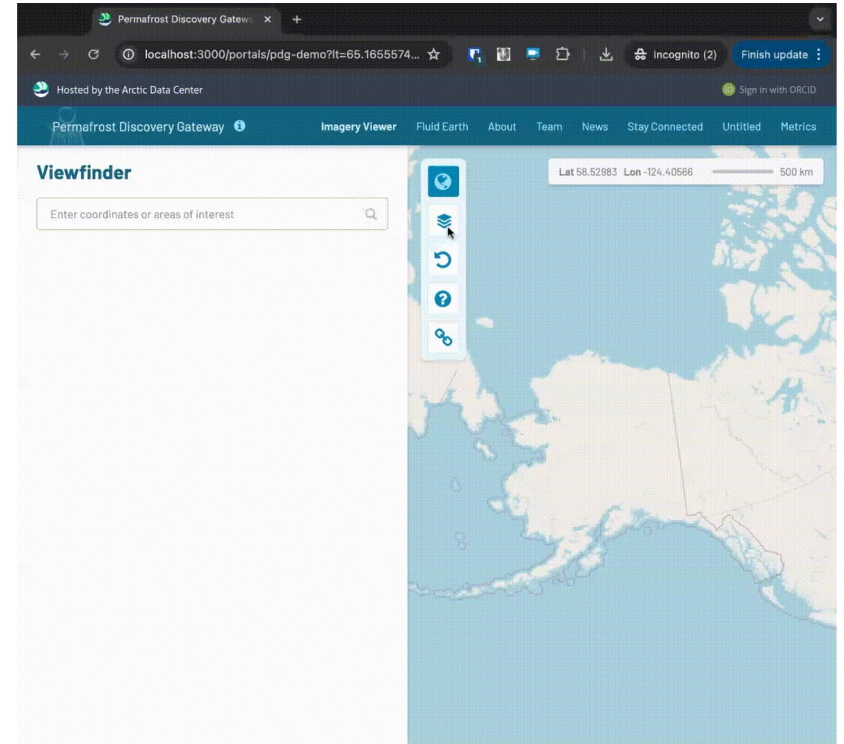
We've incorporated a storytelling element in the user interface (informed by LEO Network posts) that showcases and zooms in on communities, making it easier to discover, explore, and derive meaning from the data.



The screenshot displays the 'Viewfinder' interface. At the top left, the title 'Viewfinder' is shown above a search bar with the placeholder text 'Enter coordinates or areas of interest'. Below the search bar is a 'Zoom to...' dropdown menu. The main content area features three community story cards. The first card, titled 'Brevig Mission', describes a community in the Norton Sound region of Alaska that has experienced permafrost-related degradation of historic mass burial sites dating back to the 1918 Spanish flu pandemic. It includes two interactive options: 'Local Stories' and 'Bing Satellite imagery'. The second card, titled 'Golovin', describes erosion challenges in the Norton Sound region, mentioning impacted infrastructure like roads, gravesites, a former dumpsite, and an abandoned fish processing facility. It also includes 'Local Stories' and 'OpenStreetMaps' options. The third card, titled 'Kivalina', begins with 'A community on an island, Kivalina has experienced some of'. To the right of the text is a map of Alaska with a coordinate box at the top right showing 'Lat 60.66533 Lon -117.99545'. A vertical toolbar on the right side of the map contains icons for a globe, a list, a refresh, and a help/question mark.

Shareable URL

Users can now share a url that saves the current location and data layer configuration.



Gathering Feedback

After prototyping the functionality in the previous slides and candidates for subsequent releases, we spoke with target users to get feedback, see where the design is working, and where we might reconsider our approach.

“

I have the option to download them all [layers], deselect some of them perhaps, and then download just the ones I want. **That would be really useful to me.** It's exactly what I described.

“

This is what I like about what you guys are doing, because **you're moving away from standardized software which often is expensive for small communities.**

“

The time series would be a neat visualization for a city planner to say: **What's happening in our community?** Are we seeing expansion? Are we seeing contraction?

Problem

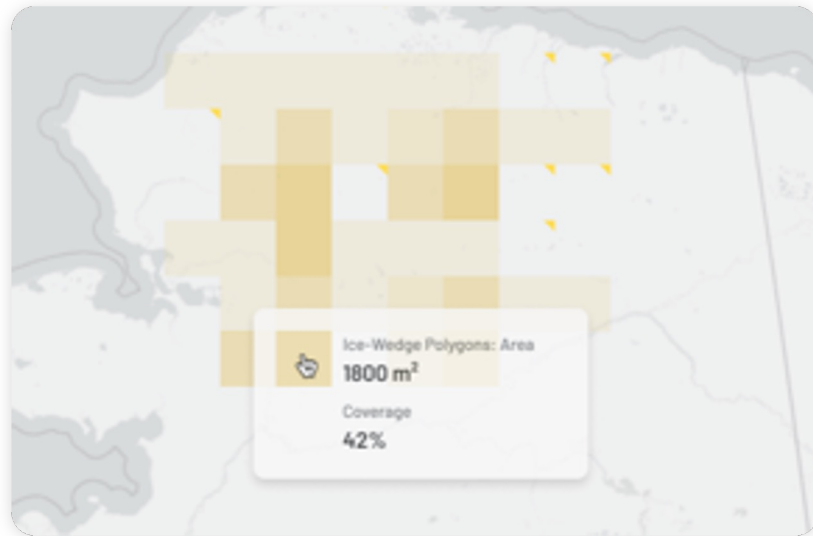
The scale of large geospatial datasets makes them difficult to understand at the global and regional levels.



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Solution

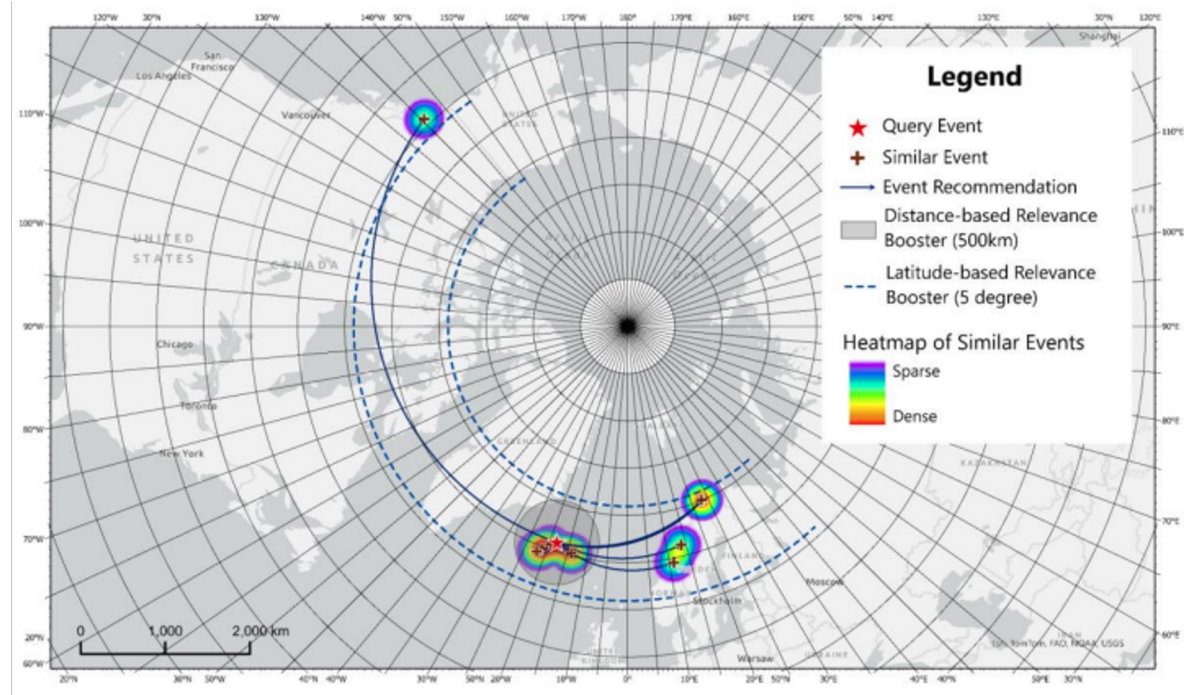
We are creating summary layers to make the data easier to understand at any zoom level.



We are incorporating tools to help find stories and news (patterns, trends, relationships to other data etc) in the big geospatial data and beyond.

AI can help us connect data/events

Spatiotemporal event recommendation with GT-R model



Giving “life” to the big geospatial data

Connecting data, connecting people



Integrating local environmental observations and remote sensing to better understand the life cycle of a thermokarst lake in Arctic Alaska

Benjamin M. Jones, Susan Schaeffer Tessier, Tim Tessier, Michael Brubaker, Mike Brook, Jackie Schaeffer, Melissa K. Ward Jones, Guido Grosse, Ingmar Nitze, Tabea Rettelbach, Sebastian Zavoico, Jason A. Clark & Ken D. Tape

Thank You

permafrost.arcticdata.io

Maybe you have ideas on new datasets or tools?
We'd love to hear from you!



