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Project code: Meyer-01

Methane Emissions from Thermokarst Lakes Using Remote Sensing and Field Data

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Alaska USGS: B. Jones

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Institutional Collaborations

- **Academia:**
  - University of Alaska Fairbanks
  - University of Wyoming
- **Governmental:**
  - Alaska DNR Division of Geological and Geophysical Surveys
  - Alaska USGS
  - NWT Geoscience Office, Yellowknife, NWT, Canada
- **Research Centers:**
  - Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research in Potsdam, Germany

And… but… therefore

- Warming permafrost is storing a large amount of old carbon **AND** is releasing it into the atmosphere through methane bubbles raising from thermokarst lakes (permafrost carbon feedback "PCF" to climate warming).

- **BUT…** the magnitude of the PCF during the past 60 years (historical imagery) has not been quantified.

- **Remote sensing data (optical and SAR) can detect methane bubbles and, when calibrated with field work, can be used to quantify the PCF associated with thermokarst lakes.**

Data

Optical RS
Lake boundaries from 60 years of air- and spaceborne RS data

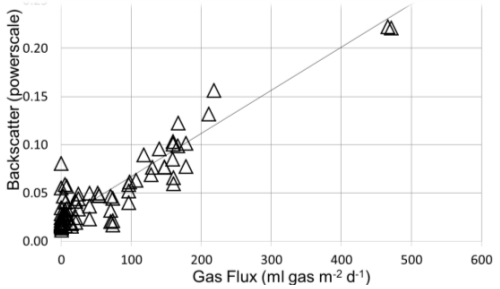
Field work
Thaw bulb geometry
SOC
CH4 Data

Radar RS
Polarimetric L-band SAR data

Modelling

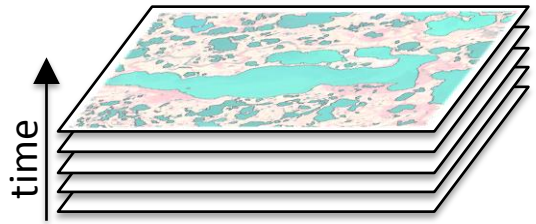
SOC regression model

CH4 regression model



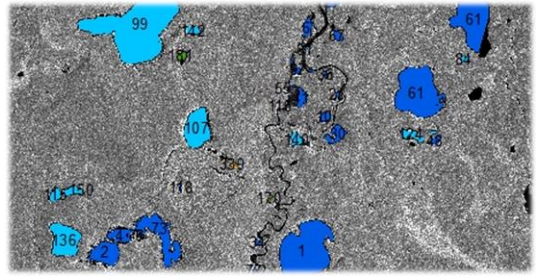
Products

Historical Hydro
Multi-temp lake boundaries



SOC maps & CH4 emission vulnerability maps

Lake-bound CH4 Emissions



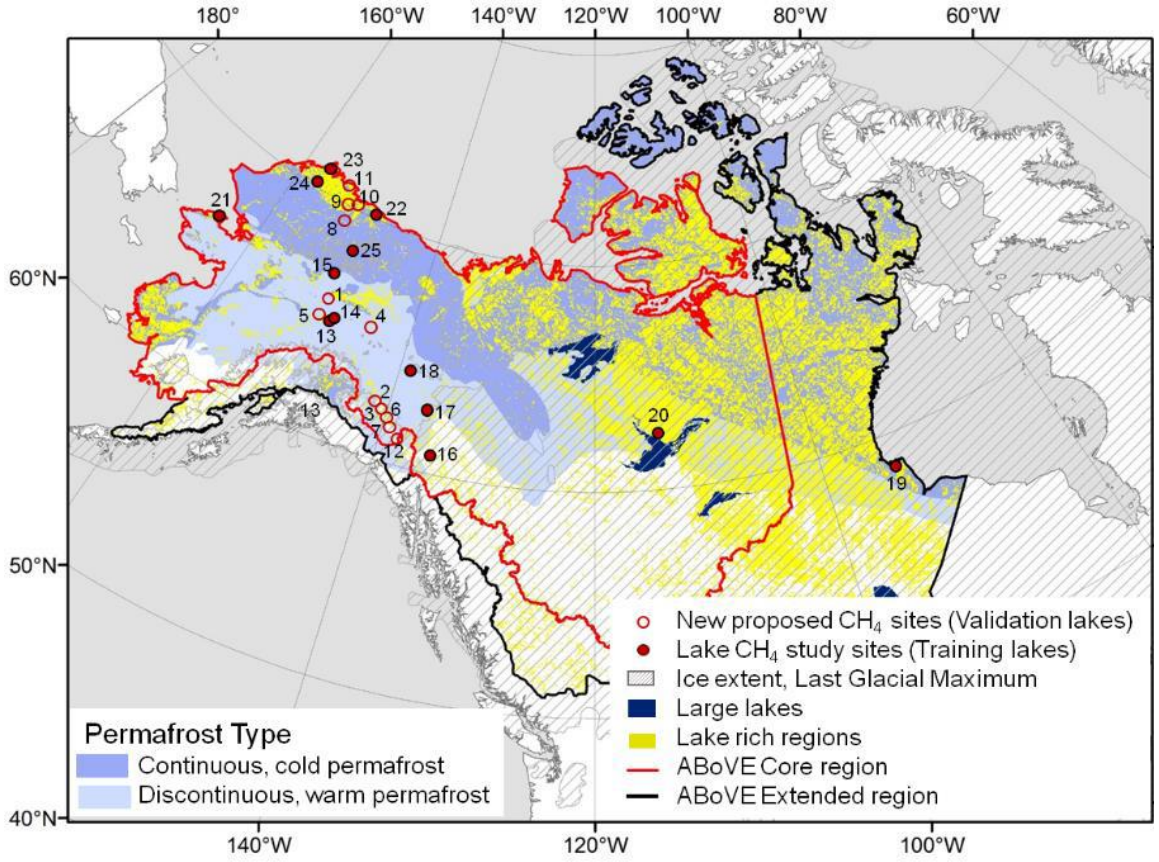
Science Questions

- **Tier 2 Science Question addressed:**
  - **SQ 3.6:** How are the magnitudes, fates, and land-atmosphere exchanges of carbon pools responding to environmental change, and what are the biogeochemical mechanisms driving these changes?


Photo: Katey Walter Anthony

Field Studies

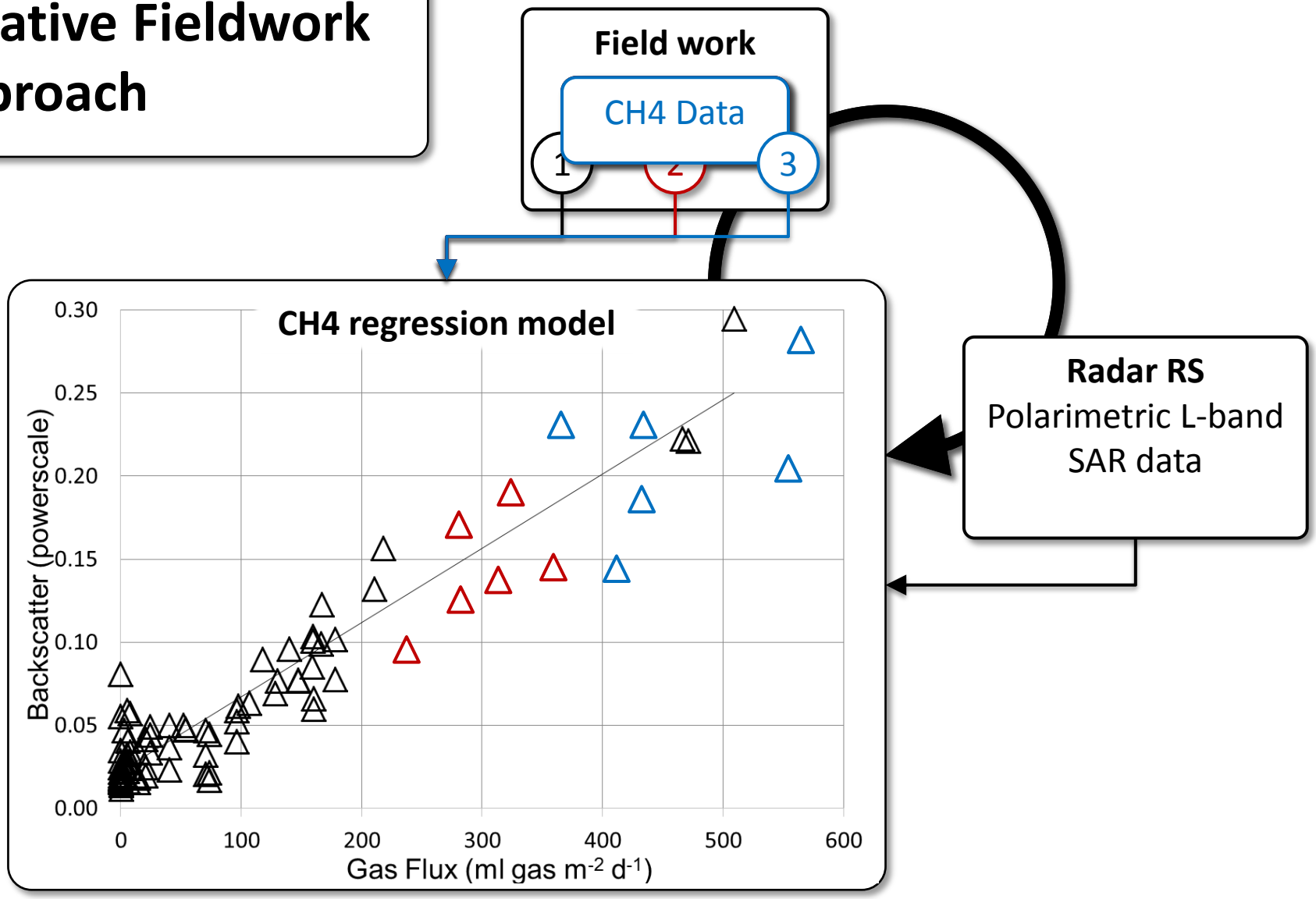
- **23 thermokarst lake districts across ABoVE Science Domain (thousands of lakes)**



- **In-Situ Measurement types:**
  - Lake CH4 emissions measurements (“bubble traps”)
  - Soil Organic Carbon (SOC) samples at eroding shores
  - Geophysical measurements of thaw-bulb geometry (A. Persekian)

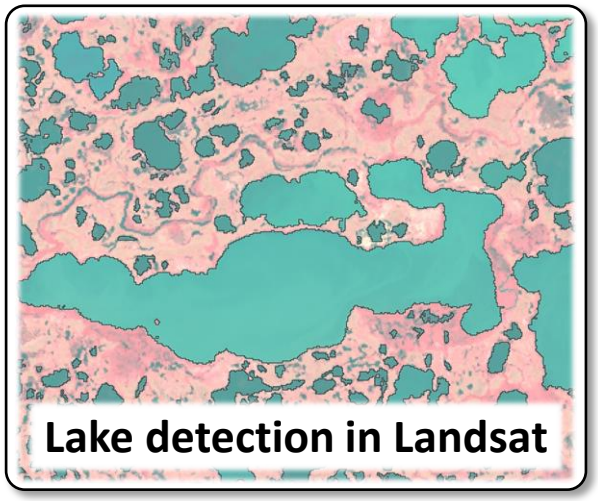
- **Measurements will be taken in late fall right after freeze up**

Iterative Fieldwork Approach

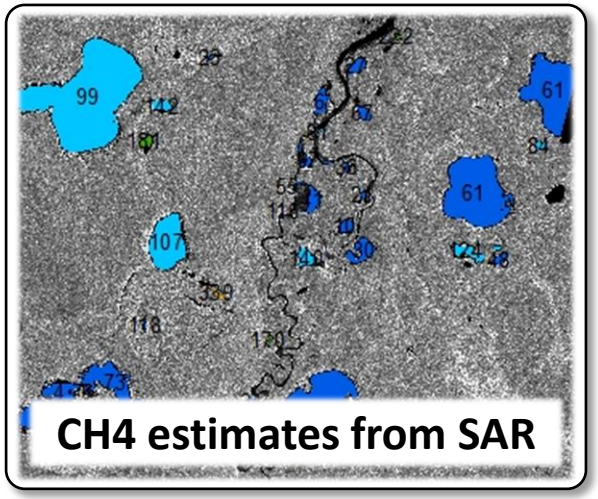


Spaceborne Remote Sensing

- **<u>Optical</u>: Medium- to high-res optical remote sensing data (Landsat, Spot Series, WorldView Series)**
  - **Goals:** lake boundaries and lake change; CH4 emission estimation

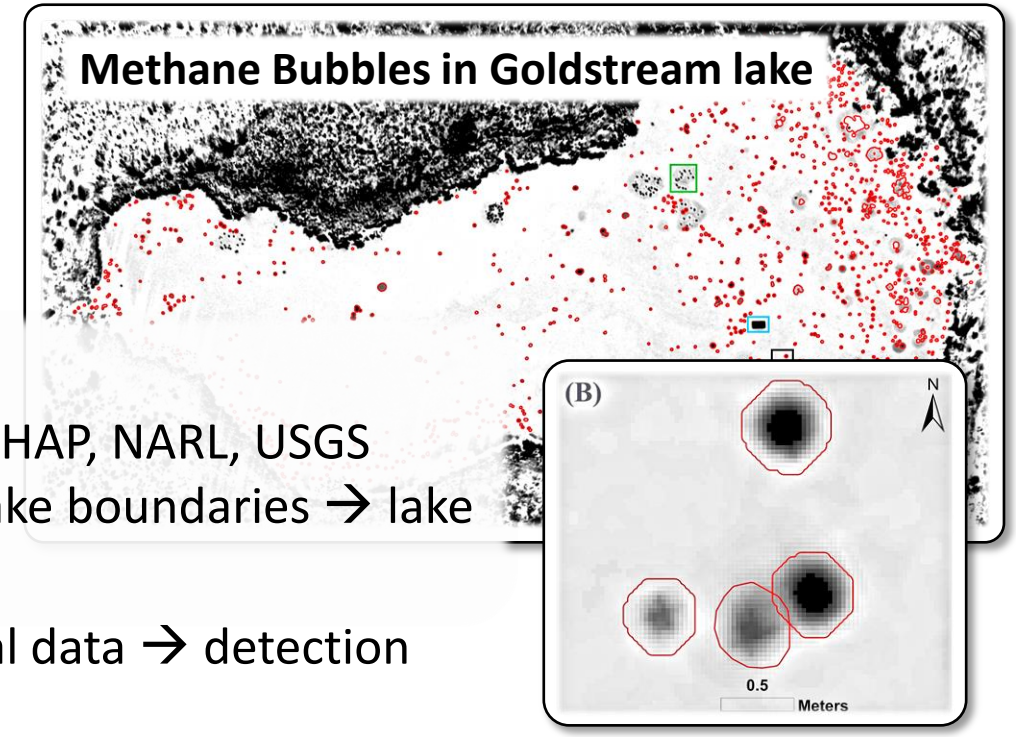

Lake detection in Landsat

- **<u>SAR</u>: Polarimetric L-band SAR data (ALOS PALSAR; ALOS-2; SAOCOM; NISAR) available from ASF**
  - **Goals:** CH4 lake methane emission measurements



CH4 estimates from SAR

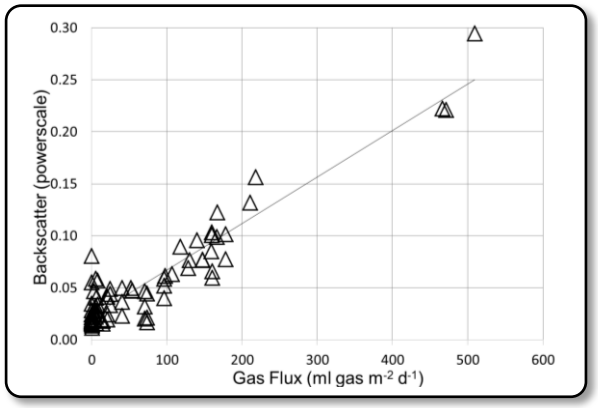
Airborne Remote Sensing



- **Optical:**
  - Historic airborne optical data (AHAP, NARL, USGS Historic Imagery) → historical lake boundaries → lake change
  - 8 years of recent high-res optical data → detection methane bubbles in ice
- **SAR:** Historical data from AirSAR and Alaska Statewide Digital Mapping Initative (SDMI) → high-res DEMs for geocoding
- **No new airborne data collects were proposed, BUT …**
  - **Airborne L-band SAR over calibration sites would be valuable**
  - **We'd like to continue our own high-res optical data collects**

Modeling Approaches

- **CH4 estimation:** Correlation models
  - **Driver data:** CH4 field measurements & SAR observations



- **SOC input to lakes:** numerical & regression models
  - Driver data: SOC and CH4 field data

- **Extensive error propagation modeling for accuracy estimation**

Data Formats and Metadata Standards

- **Work with the Geographic Information Network of Alaska (GINA) and ABoVE team data geocoding/sharing**
- **Raster-based products:**
  - GeoTIFF format
  - Fully embedded geocoded meta information → easy distribution via Open Geospatial Consortium (OGC) Web Mapping Services (WMS) and Web Coverage Services (WCS)
- **Vector-based data:**
  - Shapefile and zipped Keyhole Markup Language (kmz) formats → compatibility with most GIS and image processing tools

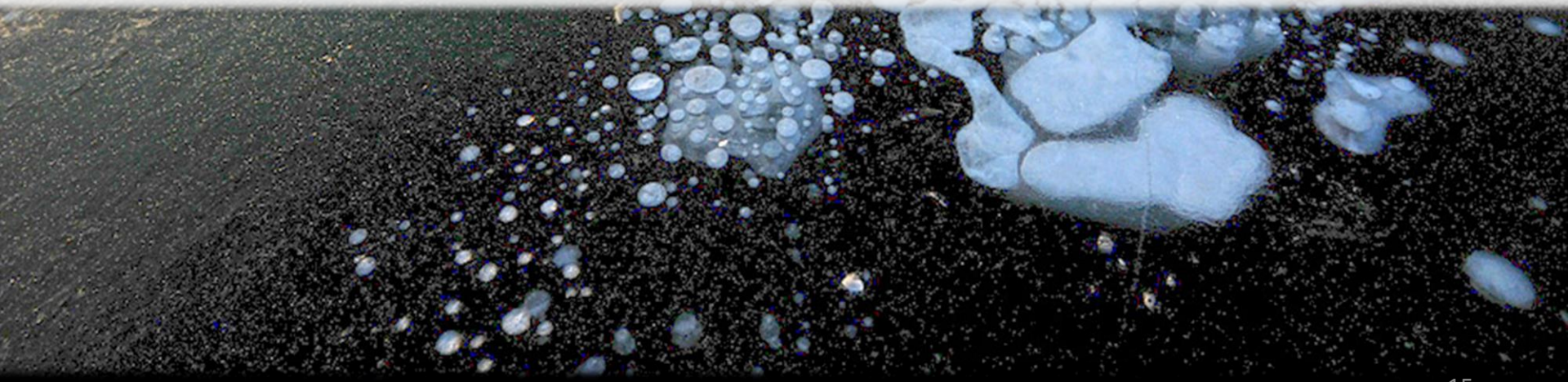
Geospatial Data Products

Product name	Product description	Format	Spatial coverage
Multi-temporal layers of geocoded RS imagery	Geocoded & terrain-corrected raster imagery; UTM projection	GeoTIFF; WMS; WCS	Full project application region (i.e. ~~25~~ **23** ABoVE sub-regions)
Historical Hydro	multi-temporal historical lake boundaries	Shapefiles; kmz	All lakes within project application region
Lake-bound CH_4 ebullition emission maps	Geocoded feature layer product with associate attribute table	Shapefiles; kmz	All lakes within project application region
Regional SOC stock maps	Geocoded raster product, mg SOC m^{-2}, standard deviation mg SOC m^{-2}	GeoTIFF; WMS; WCS	Regions around **selected** active thermokarst margins of lakes
Regional CH_4 emission vulnerability maps	Geocoded raster products, mg SOC m^{-2}, standard deviation mg SOC m^{-2}	GeoTIFF; WMS; WCS	Regions around active thermokarst margins of lakes
Present-day regional-scale net lake CH_4 emission budget	Tabularized data; emission via ebullition in ml gas m^{-2} d^{-1} and mg CH_4 $m^{-2}d^{-1}$ standard deviation in ml gas m^{-2} d^{-1} and mg CH_4 $m^{-2}d^{-1}$	CSV	Complete project application region
Ebullition flux data from bubble traps	Tabularized data of field-measured ebullition rates measured by submerged bubble traps in ml gas m^{-2} d^{-1}; standard deviation in ml gas m^{-2} d^{-1}	CSV	Field study lakes **(number of study lakes reduced due to reduction in project duration)**
Bubble CH4 content and isotopes	Tabularized data of CH_4% measured in ebullition bubbles and the stable isotopes ($\delta^{13}C_{CH4}$, $\delta^{13}C_{CO2}$, δD_{CH4}) and $^{14}C_{CH4}$ ages of bubbles; standard deviations.	CSV	Field study lakes **(number of study lakes reduced due to reduction in project duration)**
Soil carbon data	Tabularized data of bulk density, gravimetric ice content, organic C, and ^{14}C ages measured on soil samples; standard deviation.	CSV	Soils surrounding field study lakes **(number of study lakes reduced due to reduction in project duration)**

Other expected products / outcomes

- **Interesting non-traditional products:**
  - **Open-hole hazard maps:** Open holes significant hazards for snow machines
  - **"Cooking fuel" maps:** CH4 seeps often used for heat and cooking
- **Interaction with and engagement of local communities:**
  - Community visits during field campaigns (incl. presentations)
  - Involving communities in research (traditional knowledge; class projects)

Questions?



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