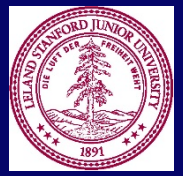
The Permafrost Dynamics Observatory

Kevin Schaefer

Albert Chen, Jingyi Chen, Richard Chen, Kazem Dogaheh, Elchin Jafarov, Lin Liu, Roger Michaelides, Mahta Moghaddam, Andy Parsekian, Taylor Sullivan, Alireza Tabatabaeenejad, Jeff Thompson, Howard Zebker



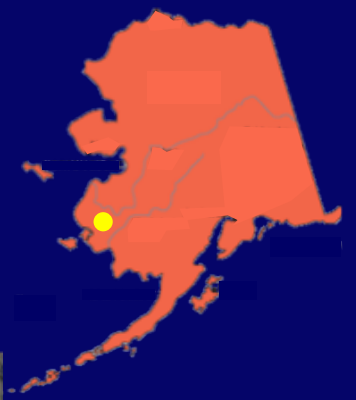
Overview

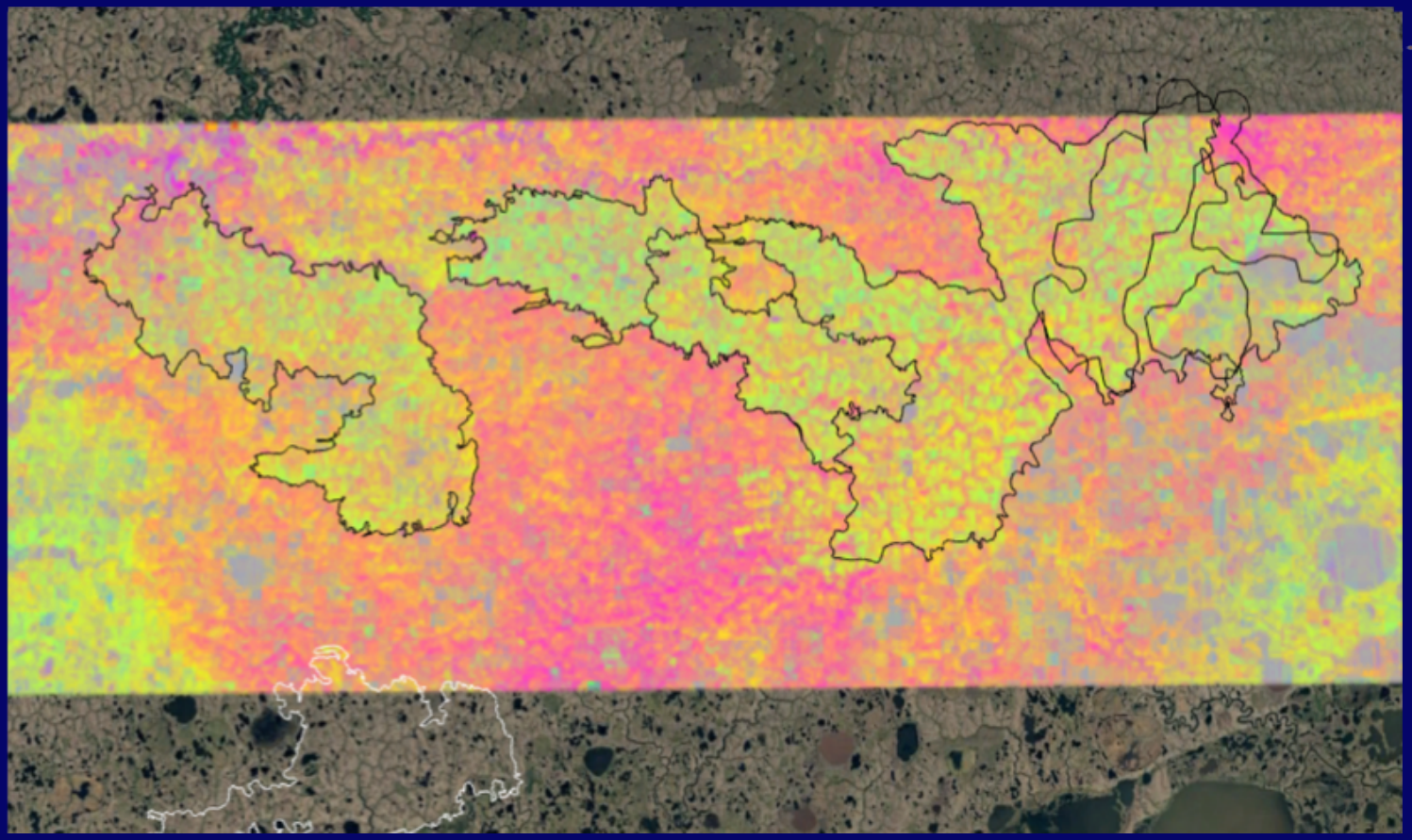
- Objective 1: Combine InSAR and backscatter to measure soil moisture and ALT
  - L-band & P-band
  - Fire, thermokarst, seasonal surface deformation
- Objective 2: Validate with in situ observations

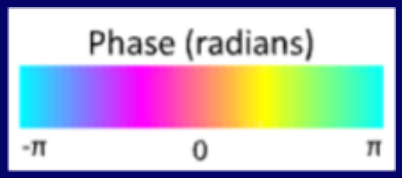
Processing Strategy

All 90 swaths ★Pilot Patches

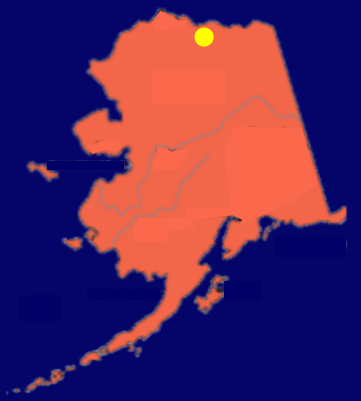
Preliminary Peek: 2015 Fires Yukon-Kuskokwim Delta

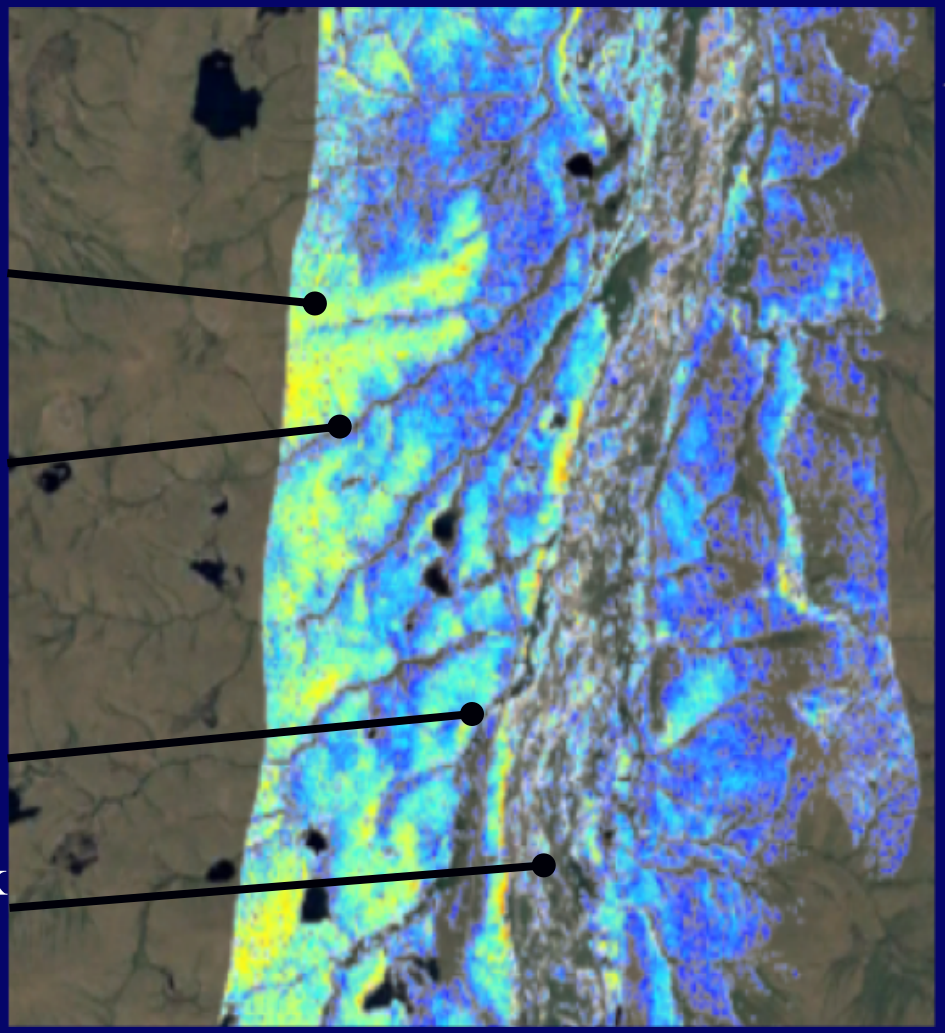






Preliminary Peek: Happy Valley, South of Deadhorse



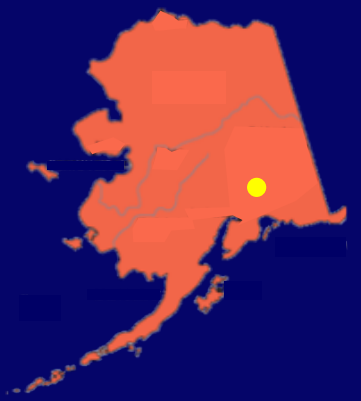


Gathering Validation Data

- Road-Swath intercept strategy
- Soil moisture & ALT multiple techniques

2017 Field Team, Fairbanks, AK

A Typical Survey

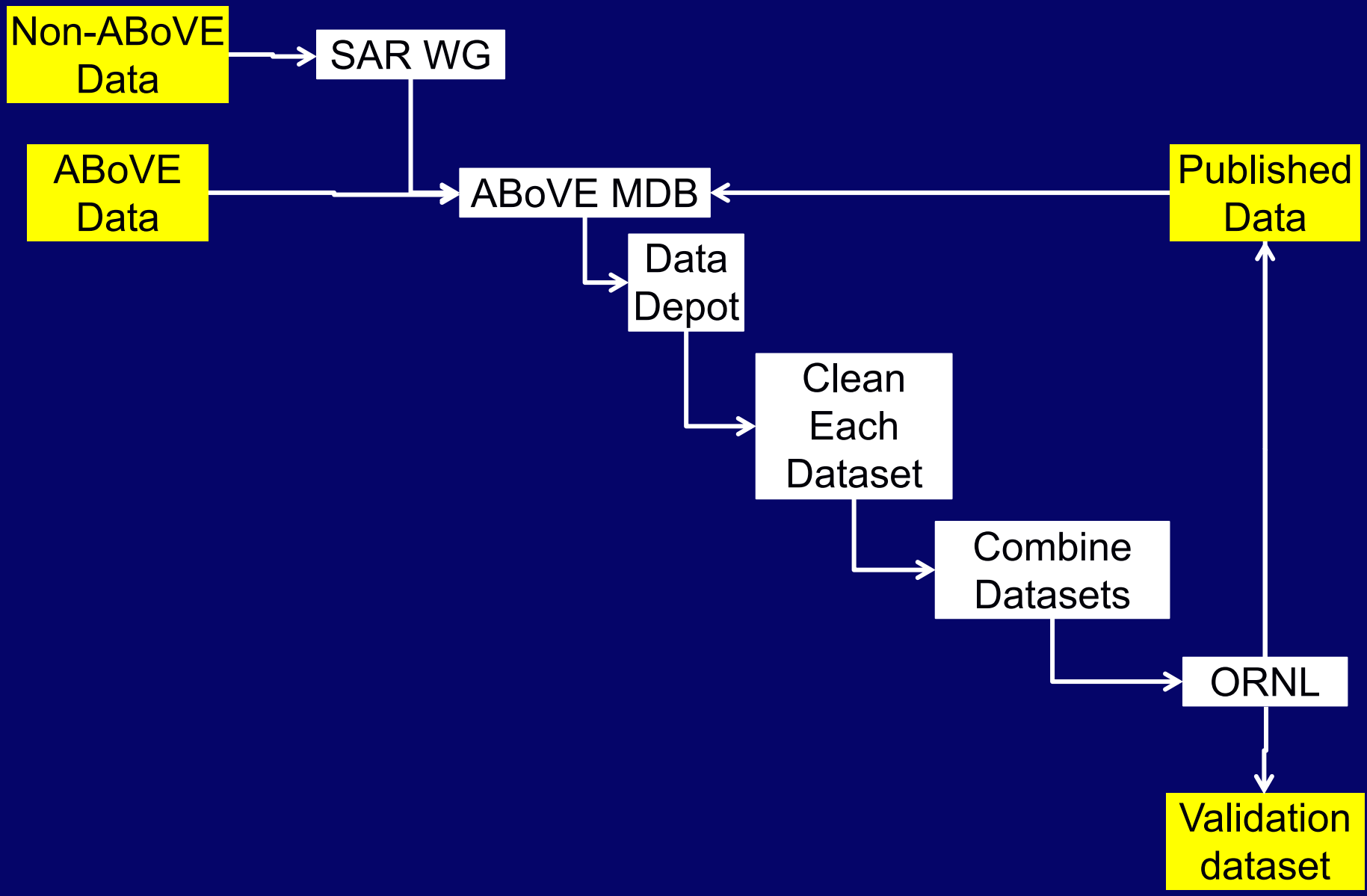


- 20-100 m surveys every meter
- 31 surveys, 1.7 km

SAR Working Group

- 2017: gathering data
- 2018: Integrated Validation Dataset
  - ~ 50 teams
  - ~100 data files
  - ~ 200 sites
- Breakout Session Today

Data Integration Work Flow

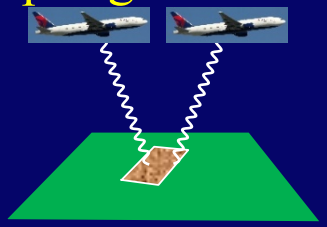


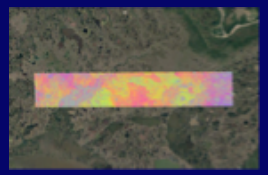
The End

Processing Flow

InSAR (ReSALT algorithm)

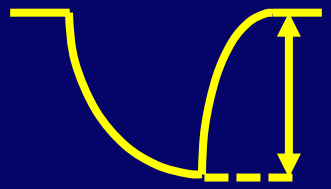
Spring Fall





Interferogram

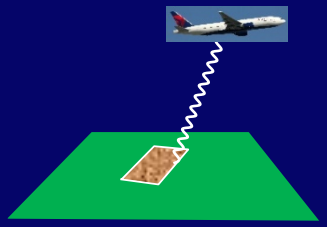
Seasonal Subsidence

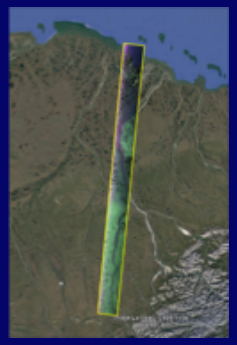


ALT
Soil Moisture

Backscatter (AirMoss algorithm)

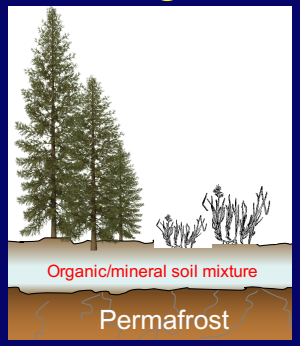
Fall



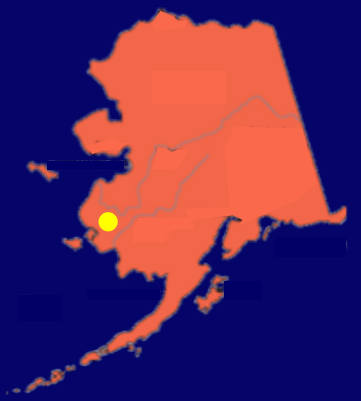


Backscatter

Scattering Model



Probing Active Layer Thickness (ALT)



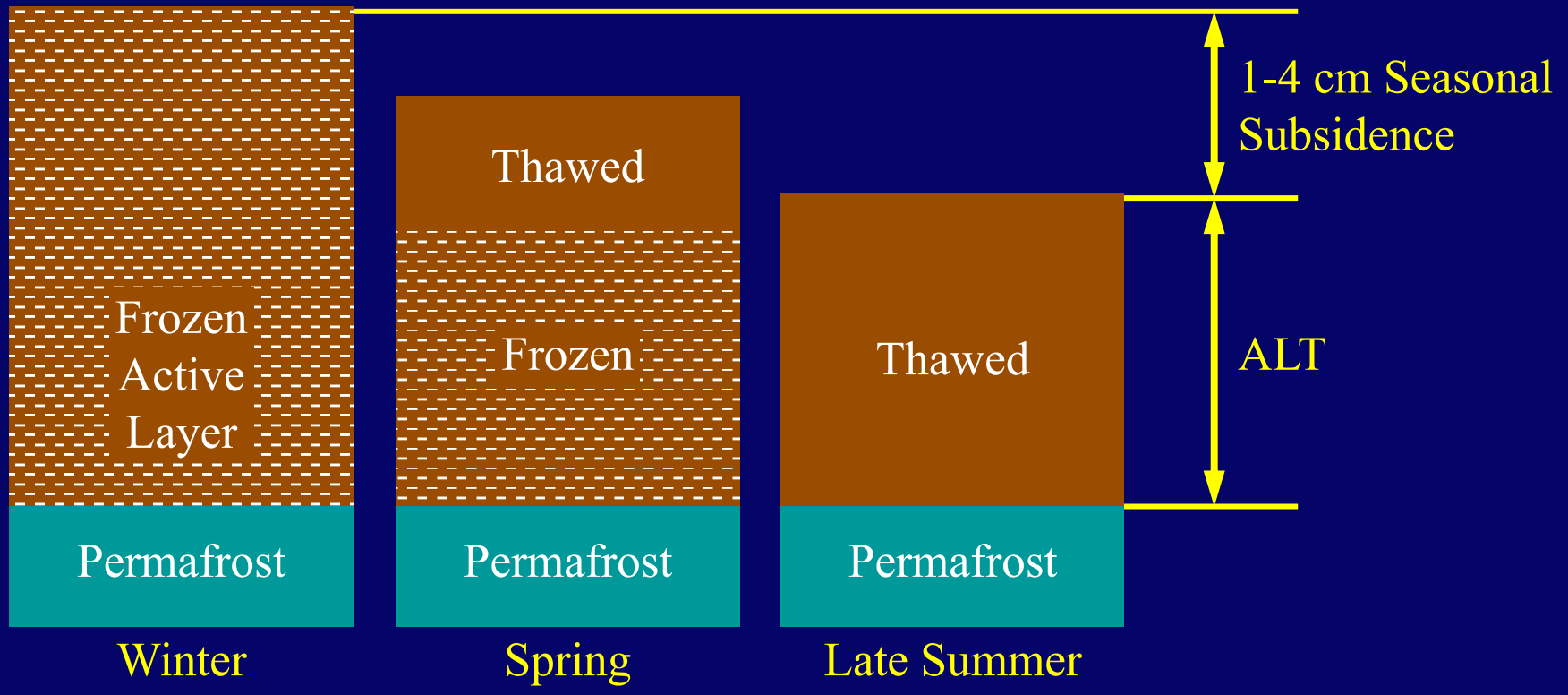
Push into ground

Thumb at surface

Pull and measure

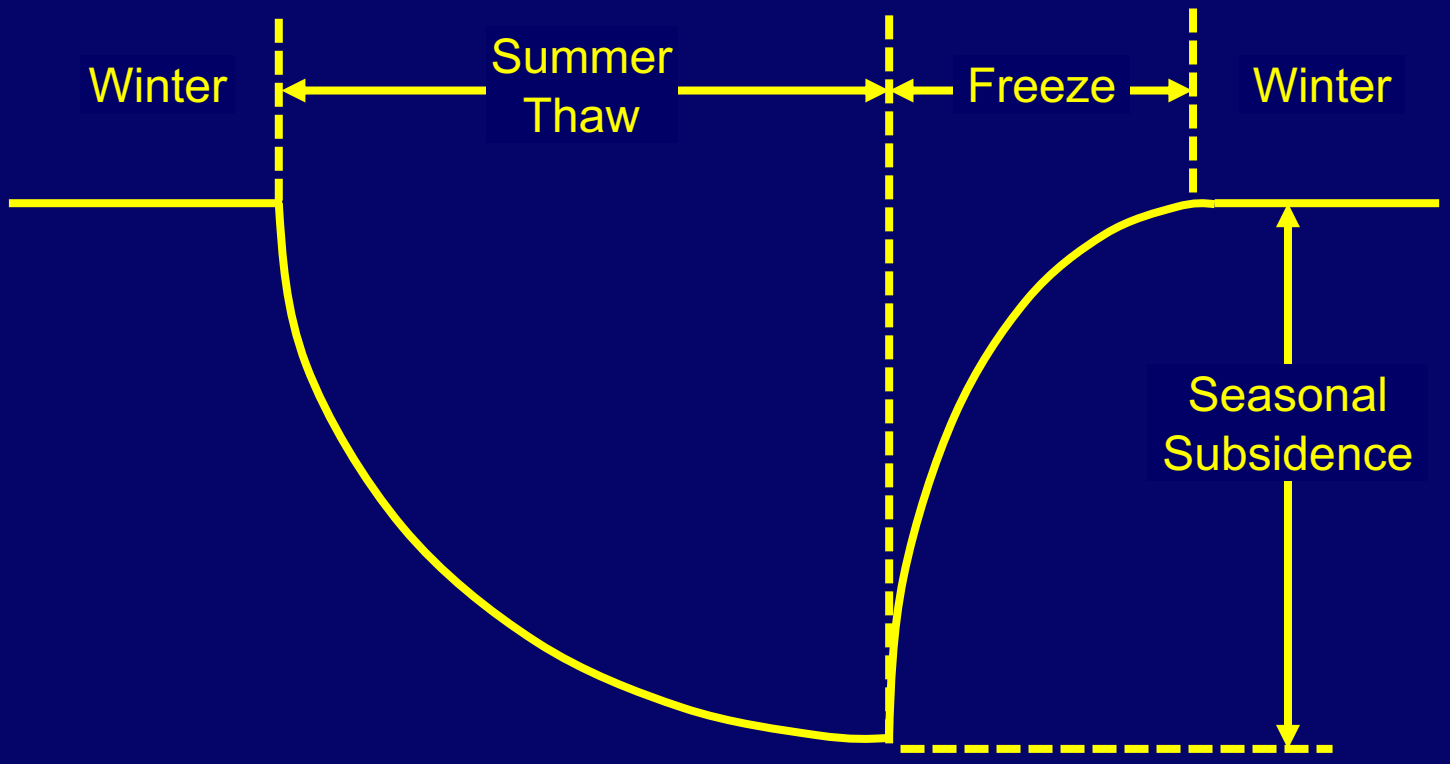
Multi-purpose Probe

Leveraging the Freezing of Soil Water



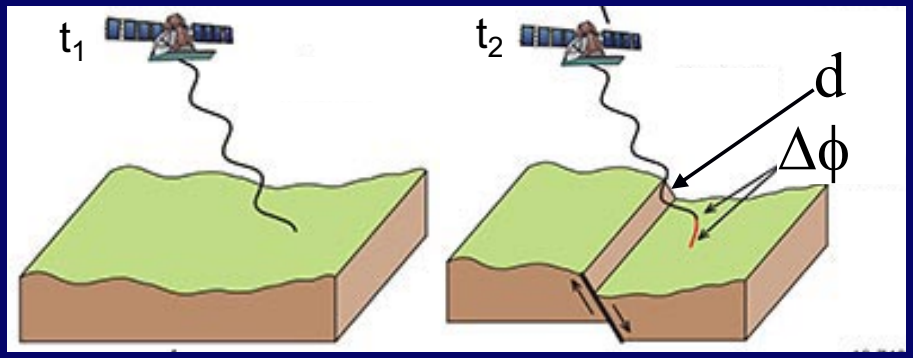
- Water expands 9% when frozen
- Soil expands ~4% when frozen

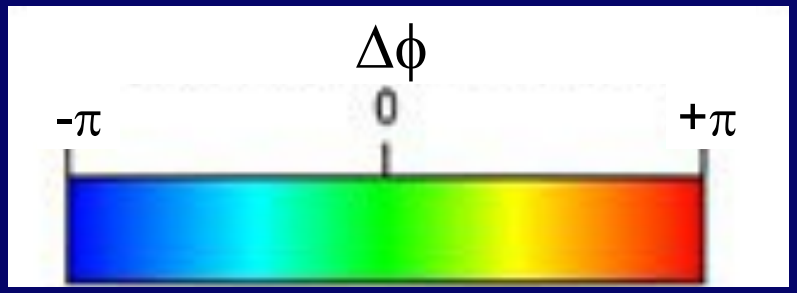
Seasonal Subsidence Model

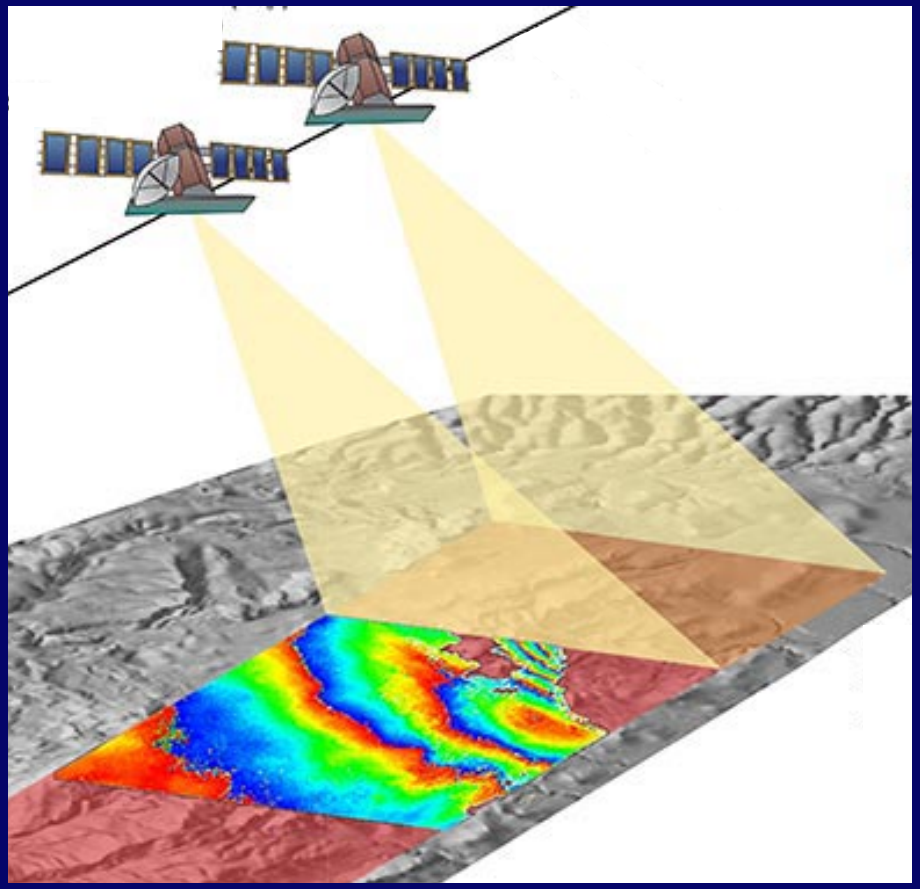


What is InSAR?

- Phase difference between 2 SAR scenes ($\Delta\phi$) to measure relative surface displacement (d)

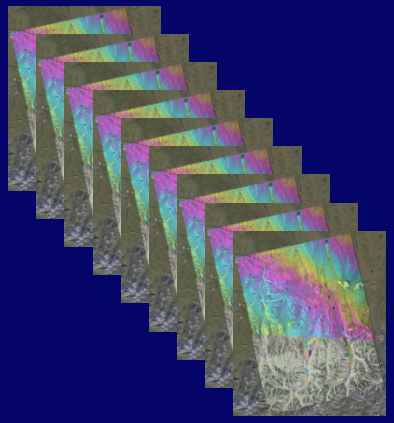


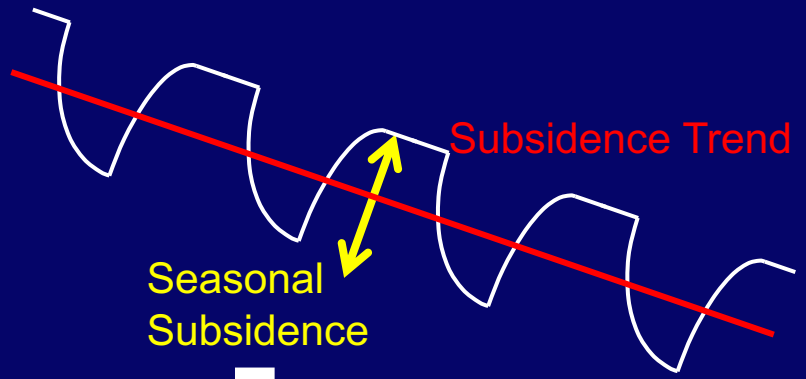


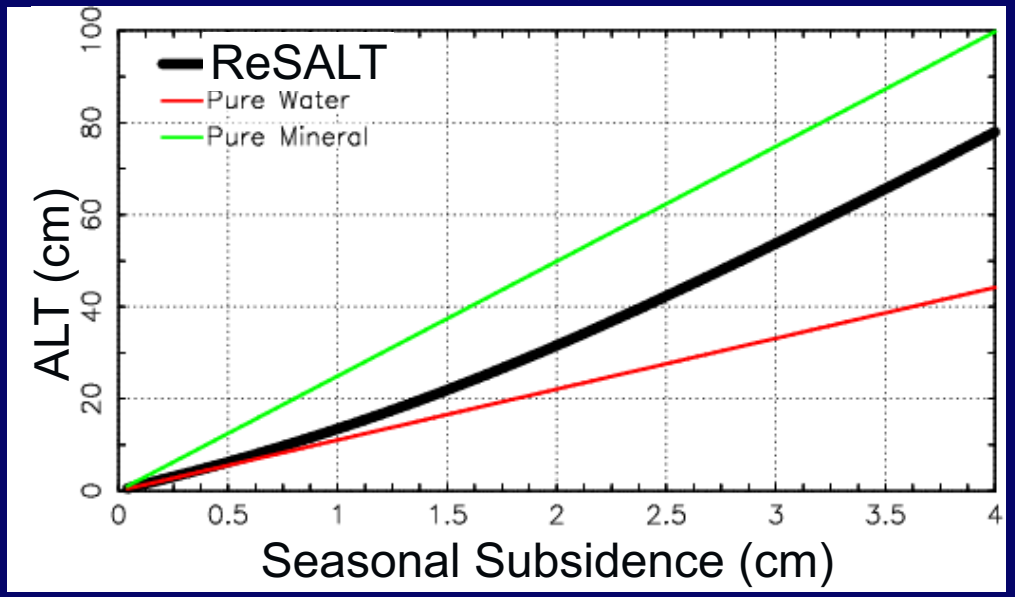


Remotely Sensed Active Layer Thickness (ReSALT)

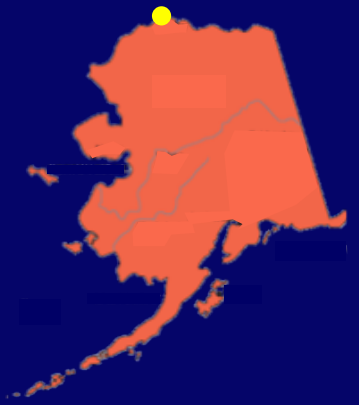
Interferogram Stack

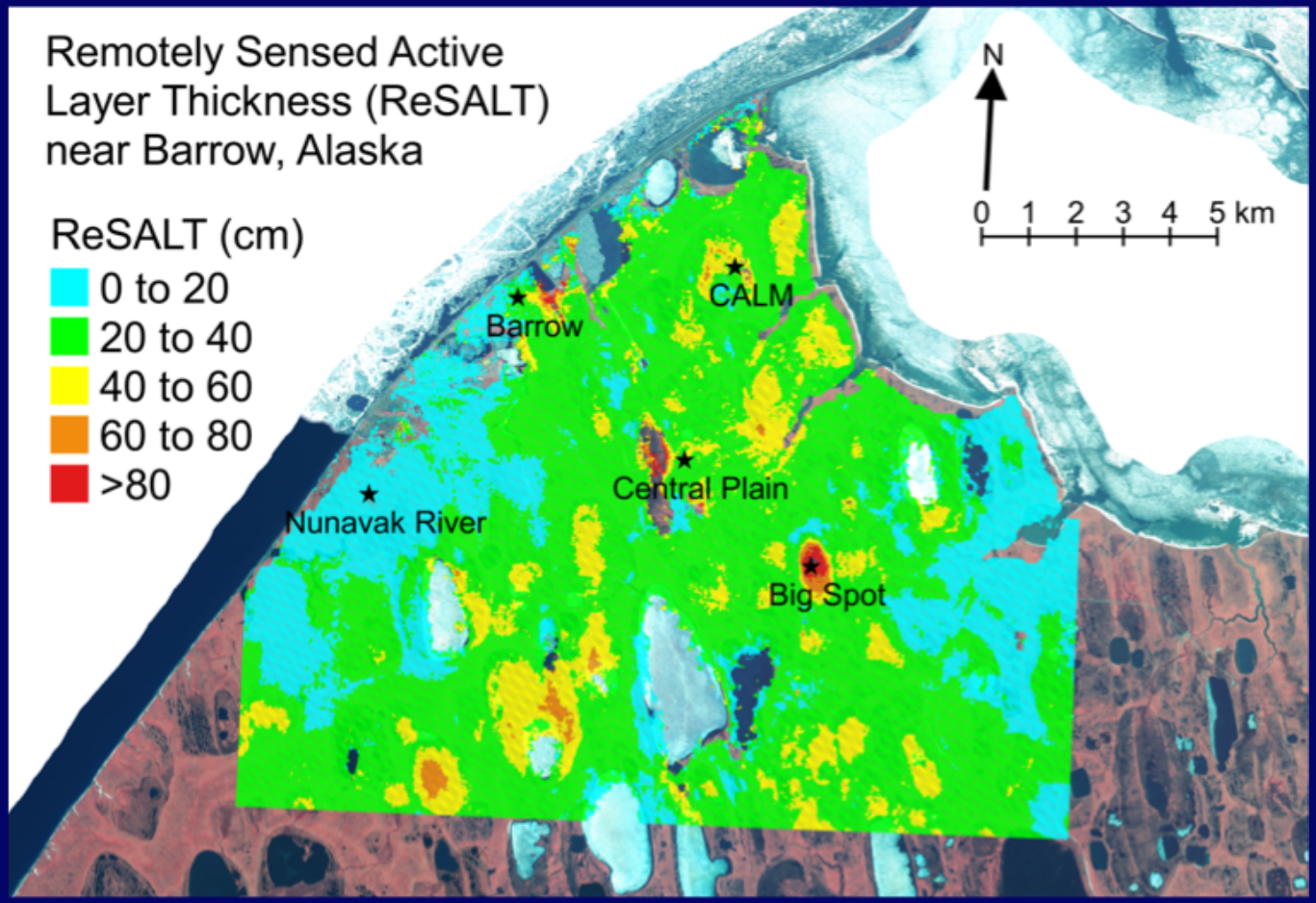






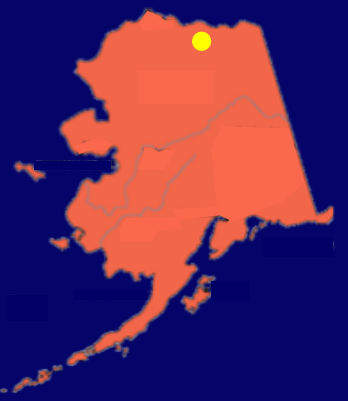
ReSALT Barrow



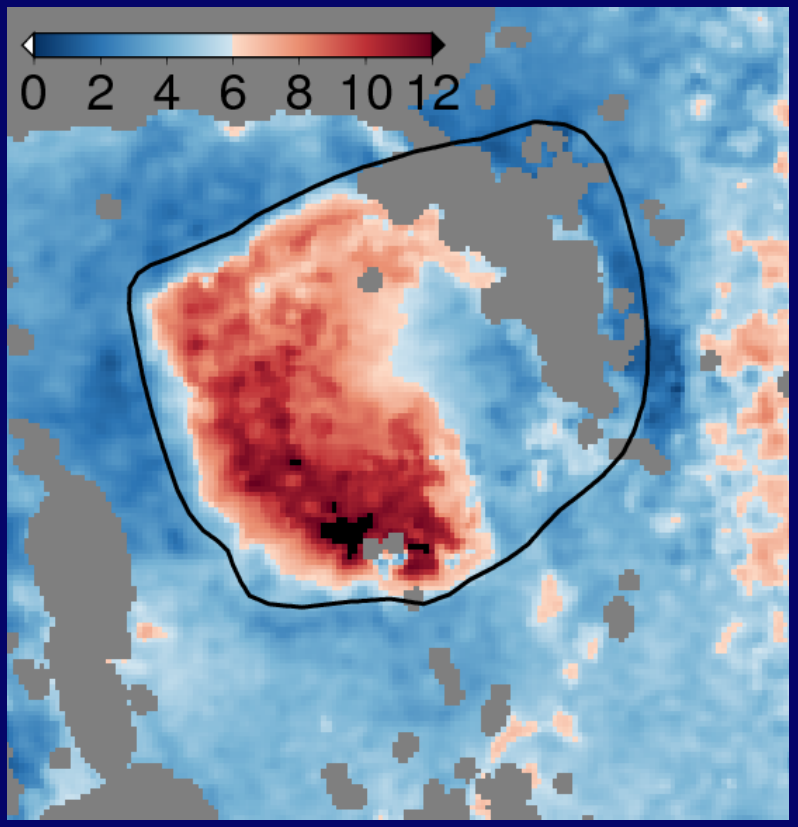


ALOS (L-band, 2006-2011)

Lin's Lake, Deadhorse

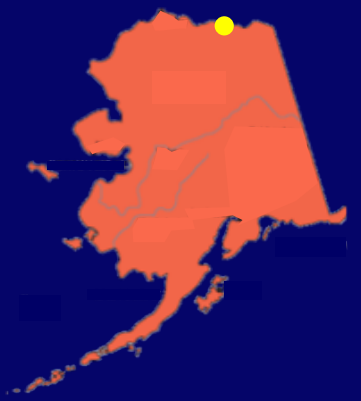


Visible Image



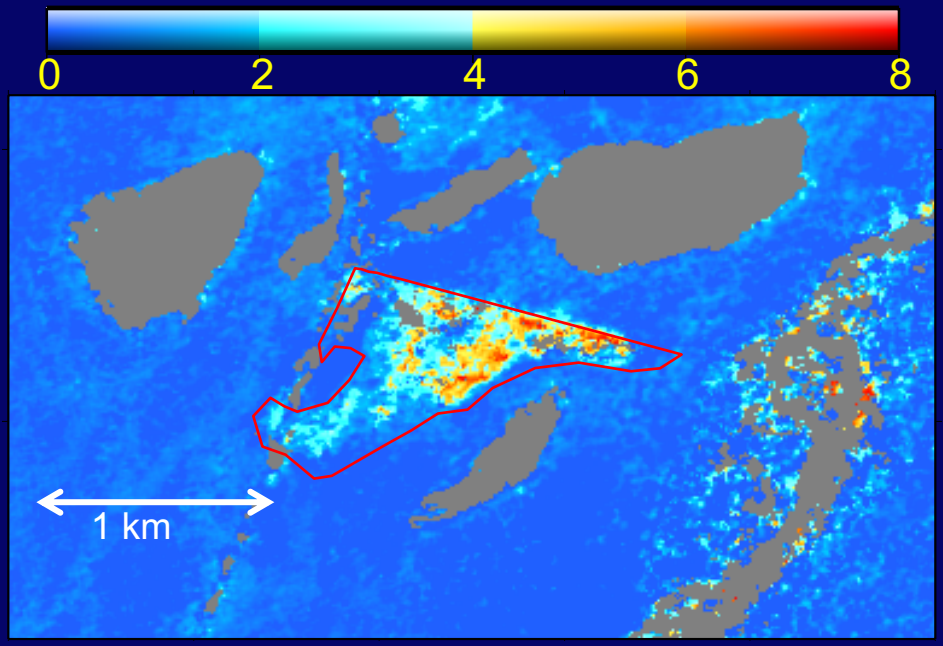
Seasonal subsidence (cm)

Individual Thermokarst Features

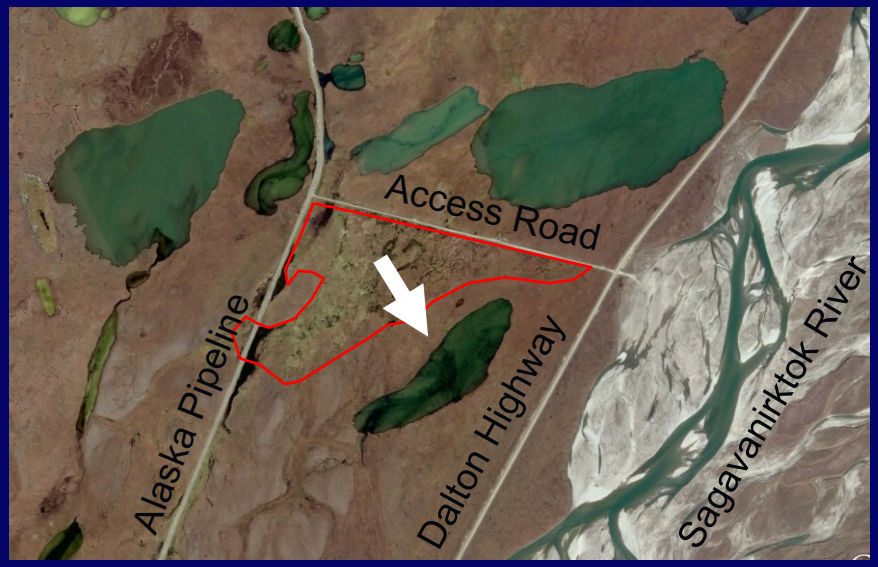


Pipeline Thermokarst, Deadhorse

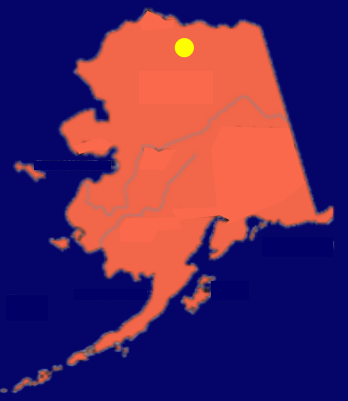
Subsidence trends (cm yr^{-1})



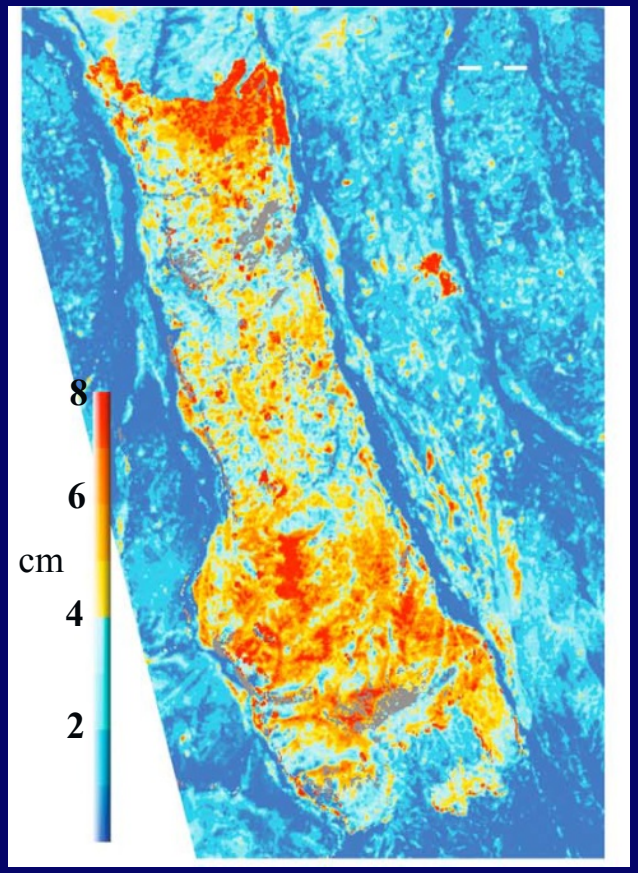
Thermokarst expansion



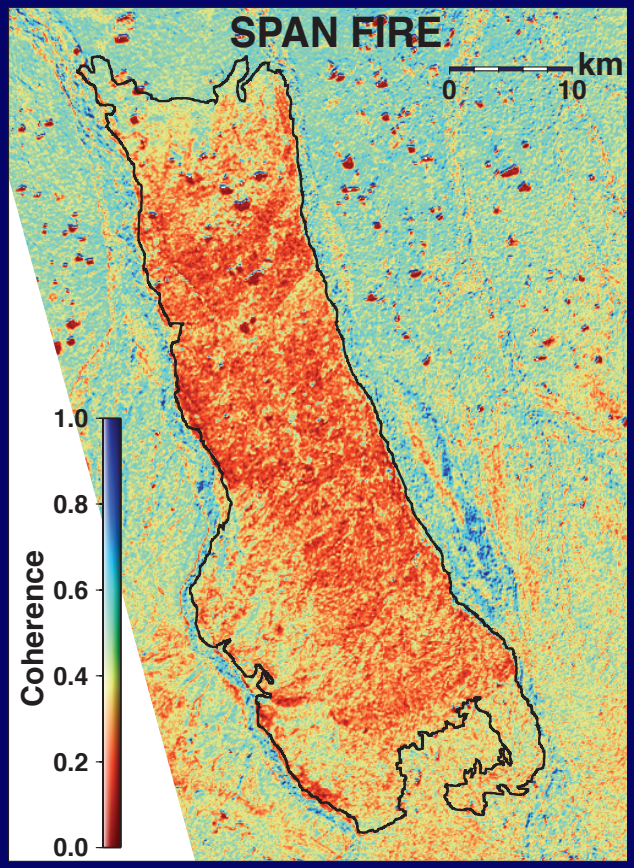
Anaktuvuk Fire (2006), North Slope



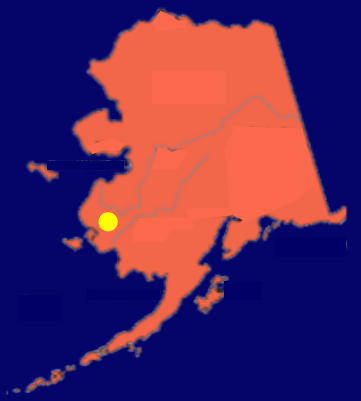
Seasonal Subsidence after fire

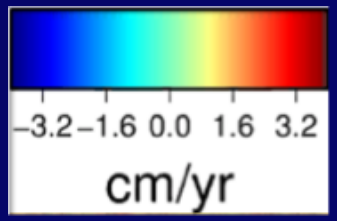


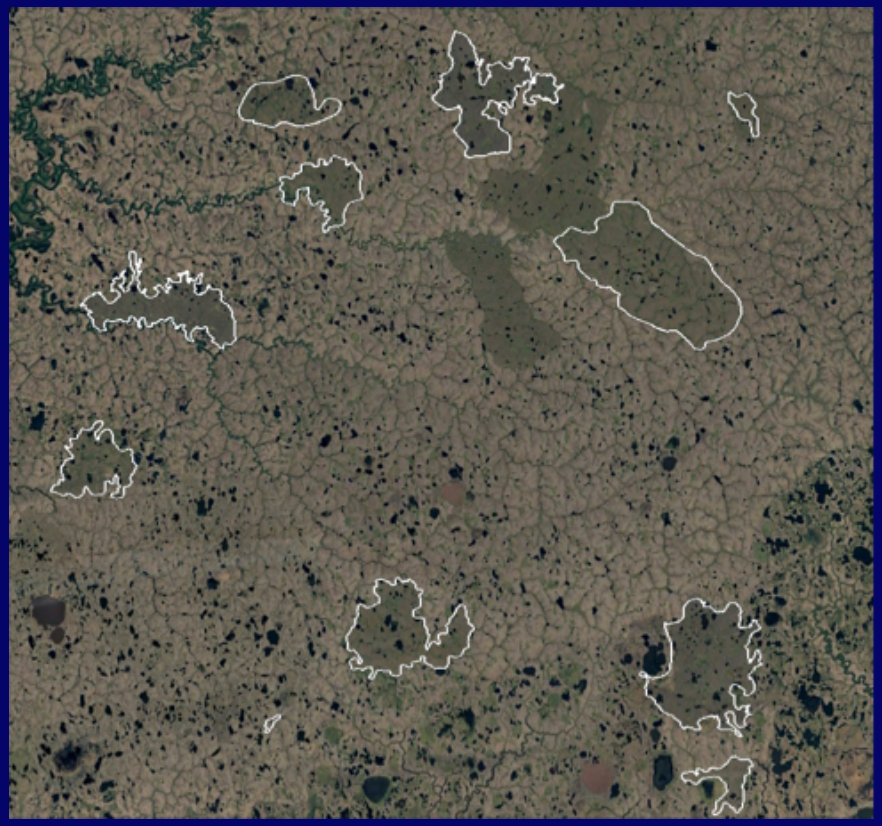
Coherence Loss



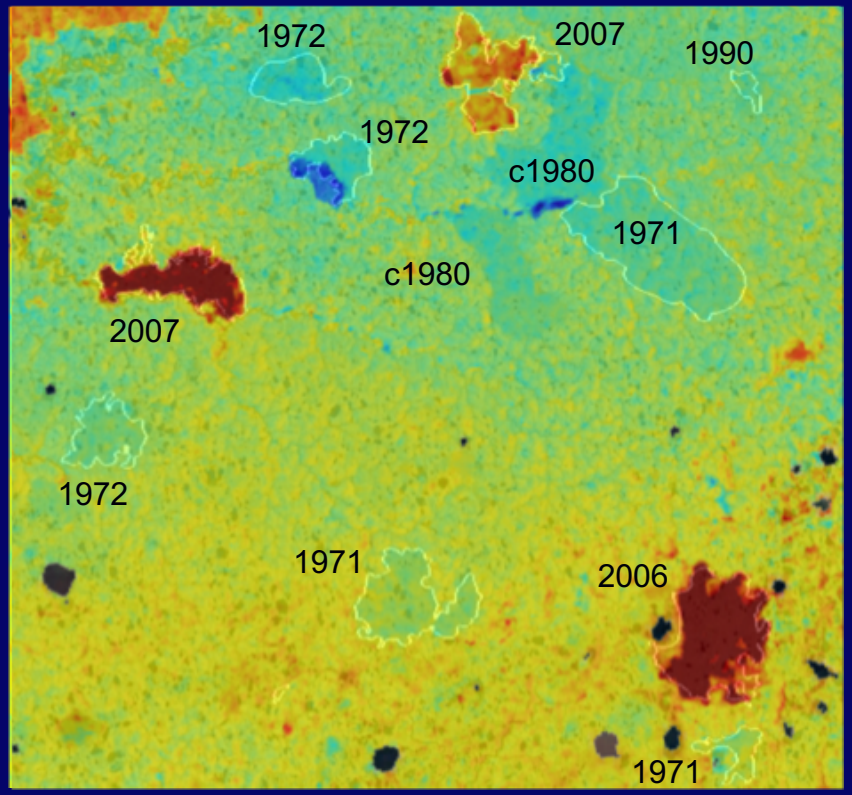
Yukon-Kuskokwim Delta Fires







Fire Scars from LandSat

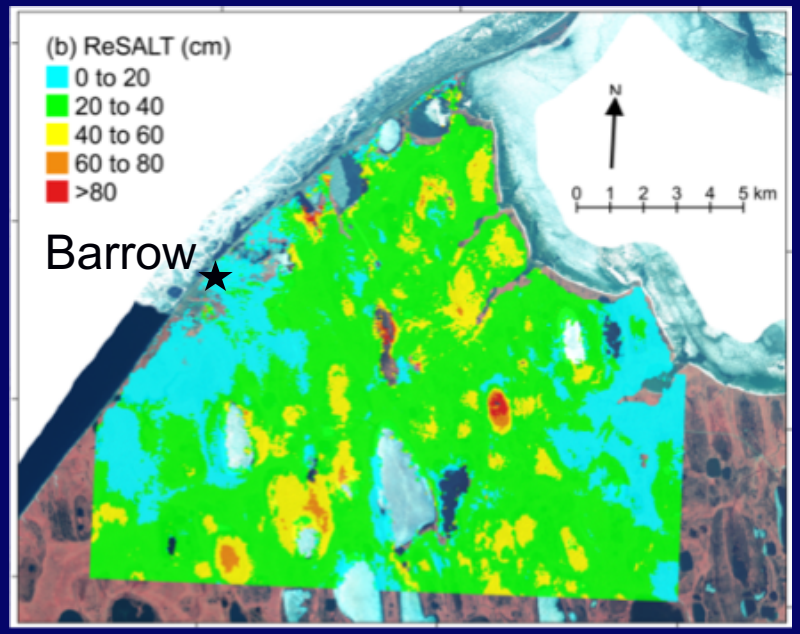


ALOS Subsidence trends (cm yr^{-1})

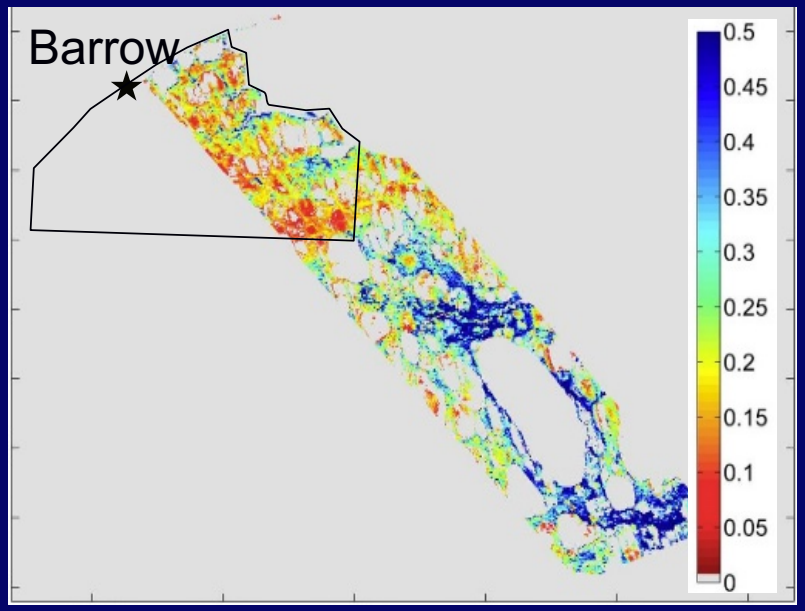
Permafrost Dynamics Observatory

- Combine InSAR and backscatter to measure soil moisture and ALT

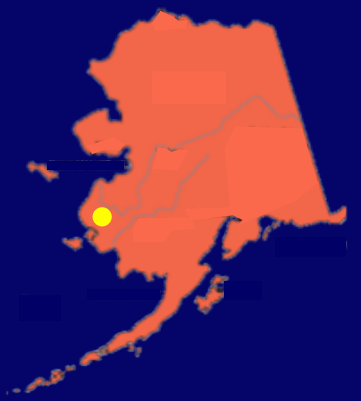
ReSALT: ALT from InSAR + **AirMOSS: Soil Moisture**



+



Fires Increase ALT

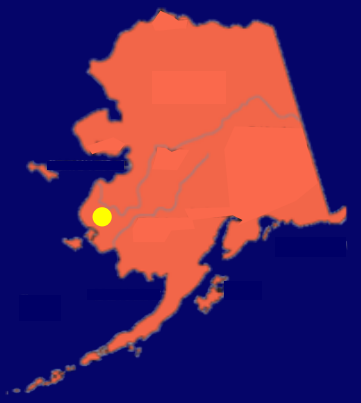


- Reduces insulation by burning organic matter
- Decreases Albedo

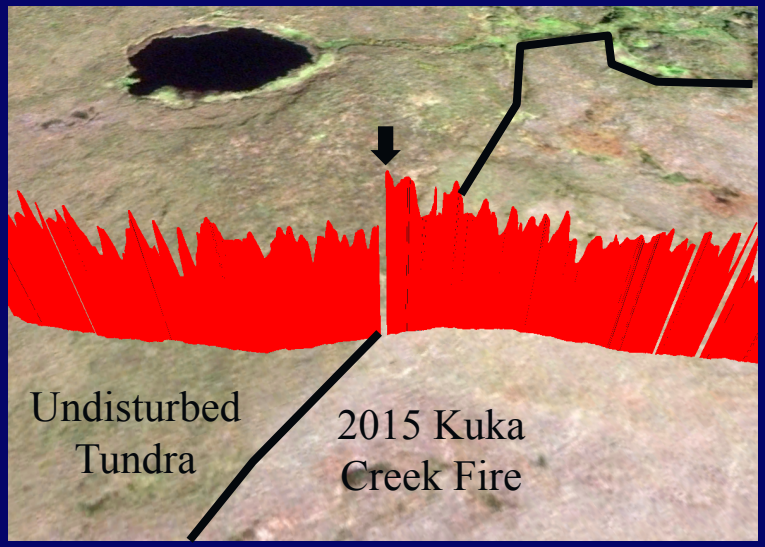
Kuka Creek Fire (2015), Yukon-Kuskokwim Delta

Close up of Sphagnum Moss Clump

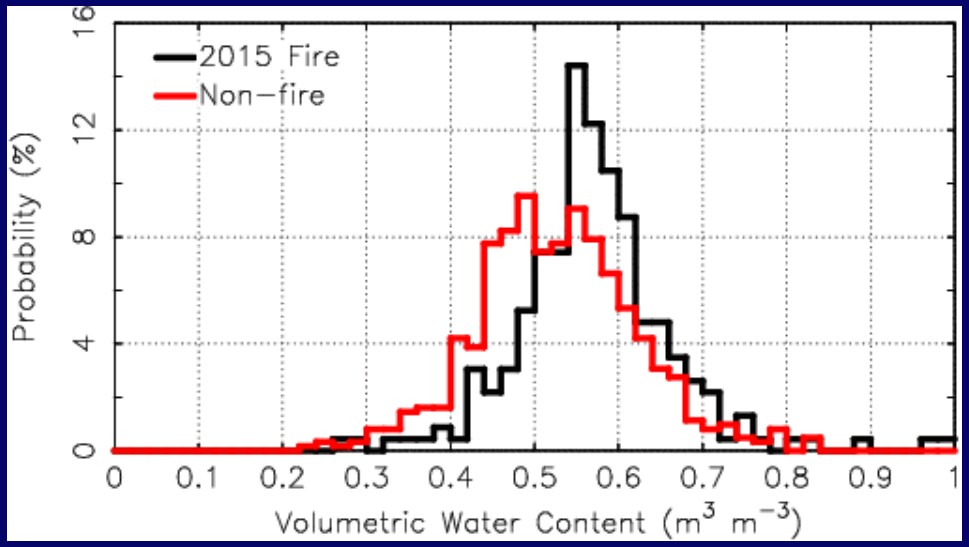
ALT Increases due to Fire



Kuka Creek Fire, Yukon-Kuskokwim Delta

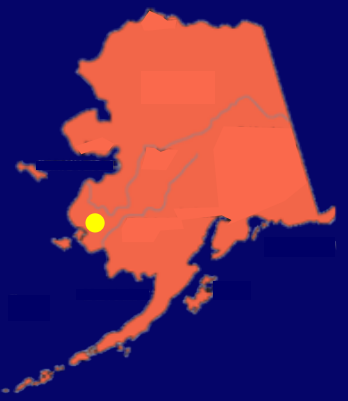


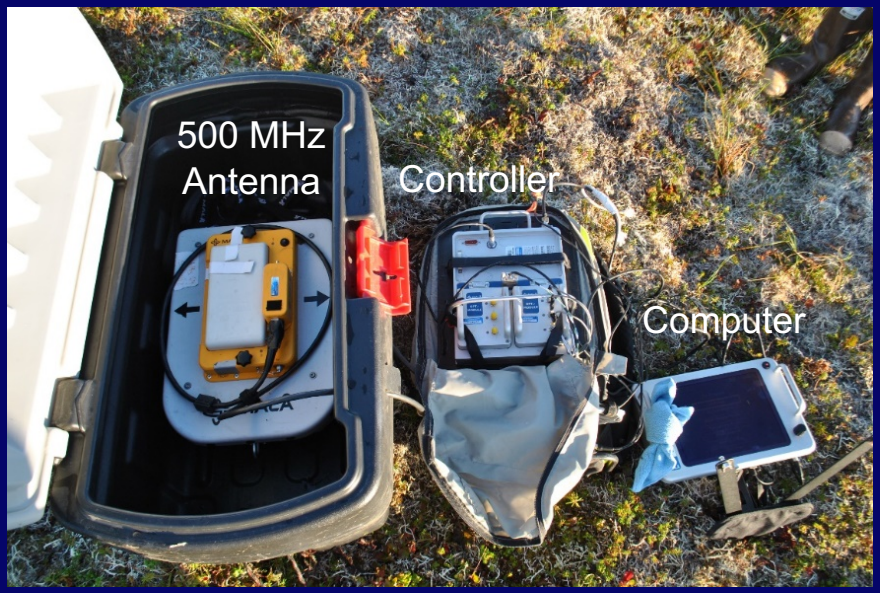
GPR measurements of ALT



Probing measurements of ALT

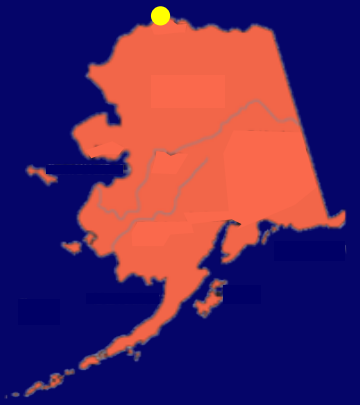
GPR Surveys

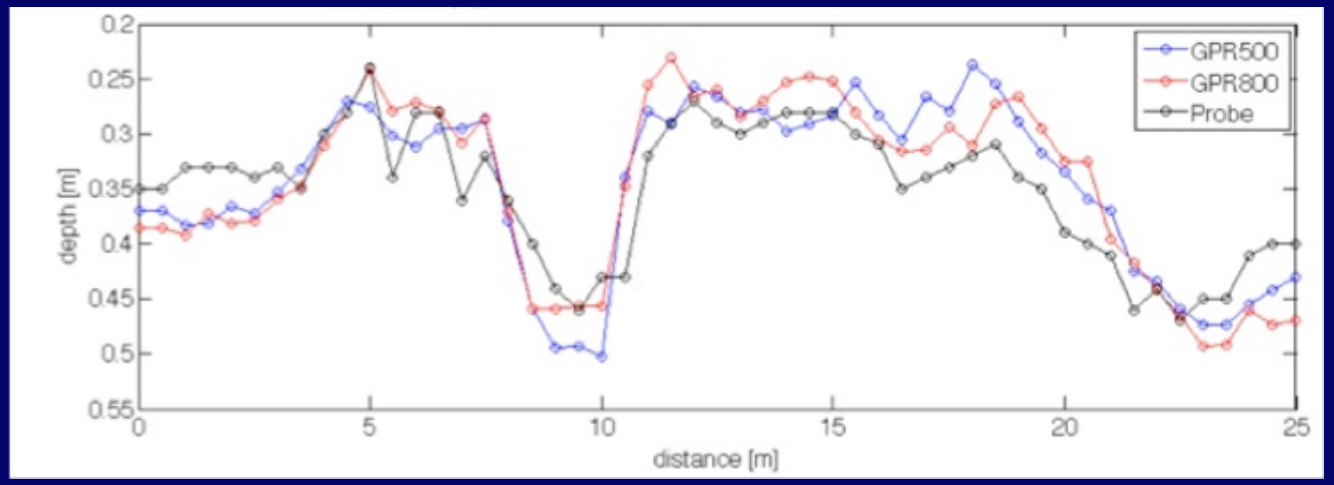




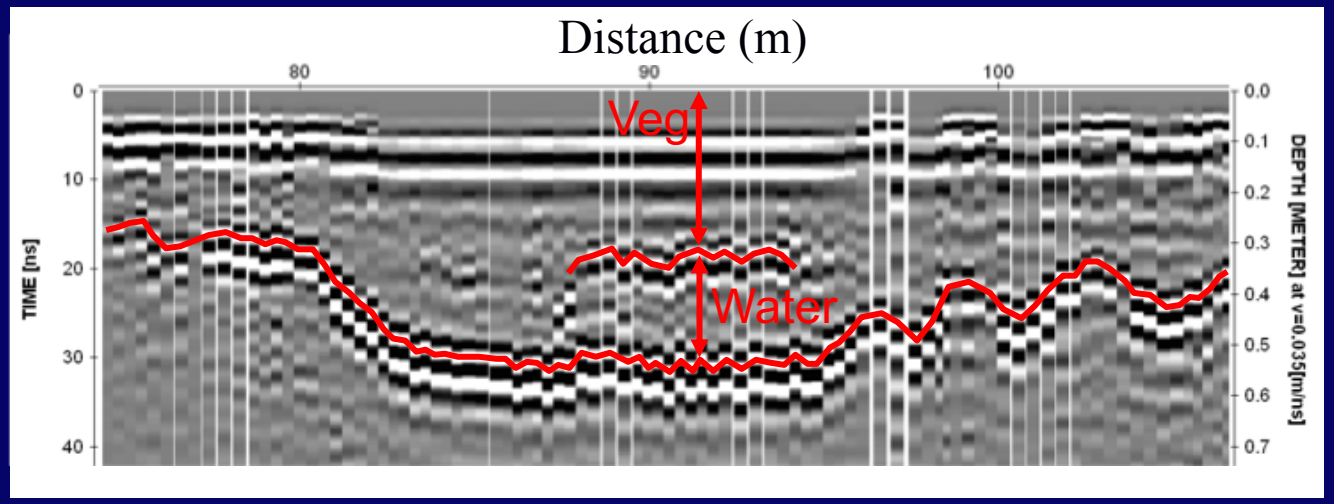
- 500 MHz (60 cm) antenna works best
- 20-30 cm trace spacing
- 2-6 km per day (4-6 hours)

ALT from GPR



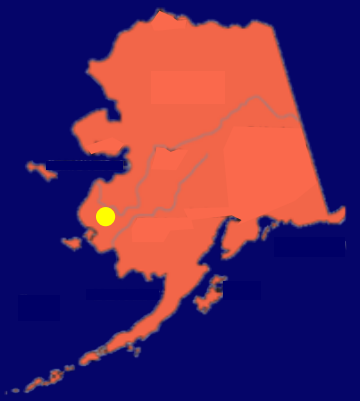


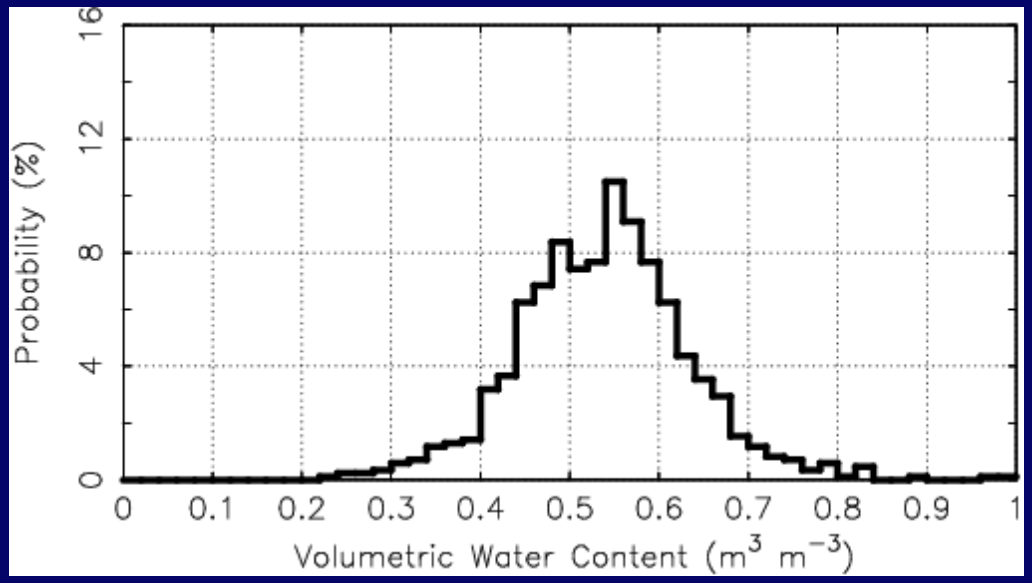
Calibration survey, Barrow



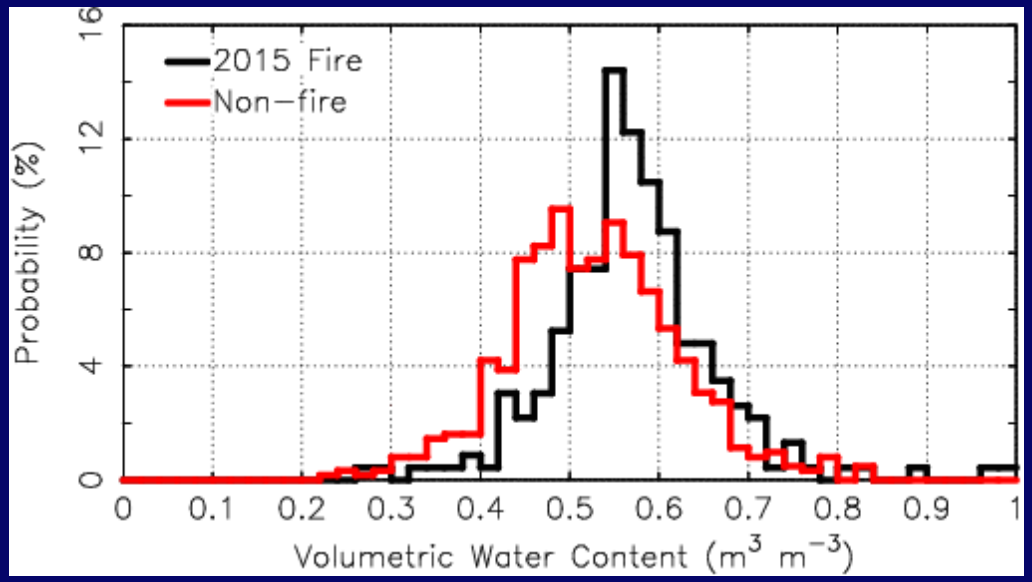
Radargram showing floating vegetation mat, Barrow

VWC Yukon-Kuskokwim Delta





All trace-probe pairs



burned and unburned areas