Operations in a rapidly changing Arctic: Minding the cryosphere and cultivating international cooperation

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SERDP • ESTCP
SYMPOSIUM
2018 | Enhancing DoD's Mission Effectiveness

Relevance & motivation

- Arctic terrestrial environments undergoing rapid change – global drivers & local amplifiers → ice-albedo feedback
- Transformative change in land cover, surface morphology, hydrology & other aspects relevant to operations & risk evaluation
- Cryosphere amplifies change in the Arctic & injects a major element of uncertainty
- Magnitude of Arctic change & impacts on operations require international research collaboration
- Geographic & geopolitical factors necessitate situational awareness across Arctic cap (land & ocean)
- Key research & operational challenges at cryosphere interface (land surfaces, coastal regions)
- Alaska: Essential DoD install-lations, strategic importance, serves as natural lab & testbed

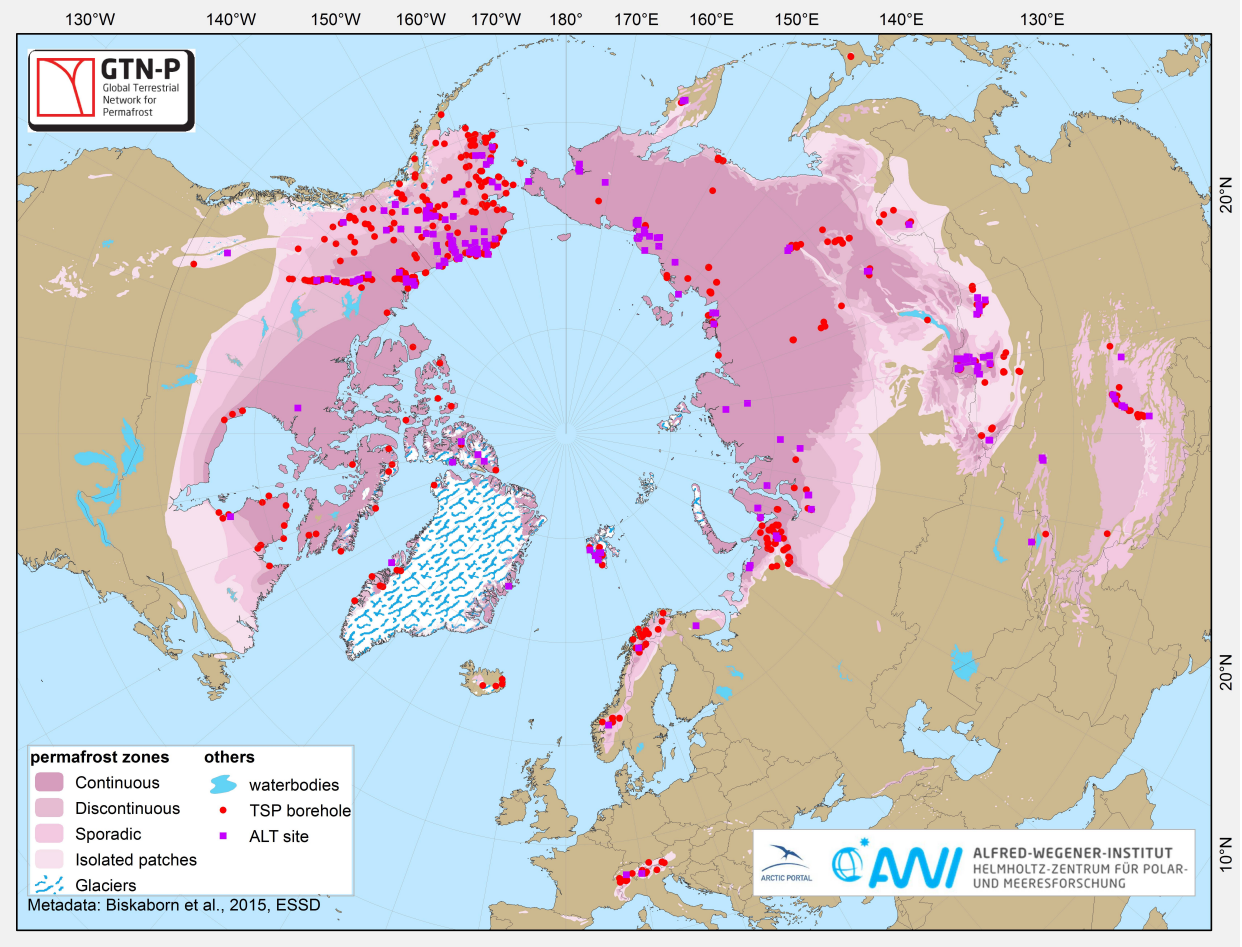
Presentation outline

- Introduction
- Permafrost in northern Alaska
- Wildfires in interior Alaska
- Conclusions:
  - Short-term needs
  - Long-term needs

- International collaboration & relevance of international perspectives:
  - Permafrost obs. networks
  - Satellite remote sensing
  - Operating in a rapidly changing Arctic
  - Transboundary concerns
- Key partners:
  - JAXA & JAMSTEC (Japan)
  - ESA GlobPermafrost
  - EU Horizon2020 Nunataryuk
  - Sandia National Lab

Arctic terrestrial permafrost distribution

- International programs provide critical information on state of Arctic permafrost
- GTN-P focused on temperature monitoring sites
- Increasing use of satellite remote sensing & model output to track permafrost evolution (ESA program GlobPermafrost)



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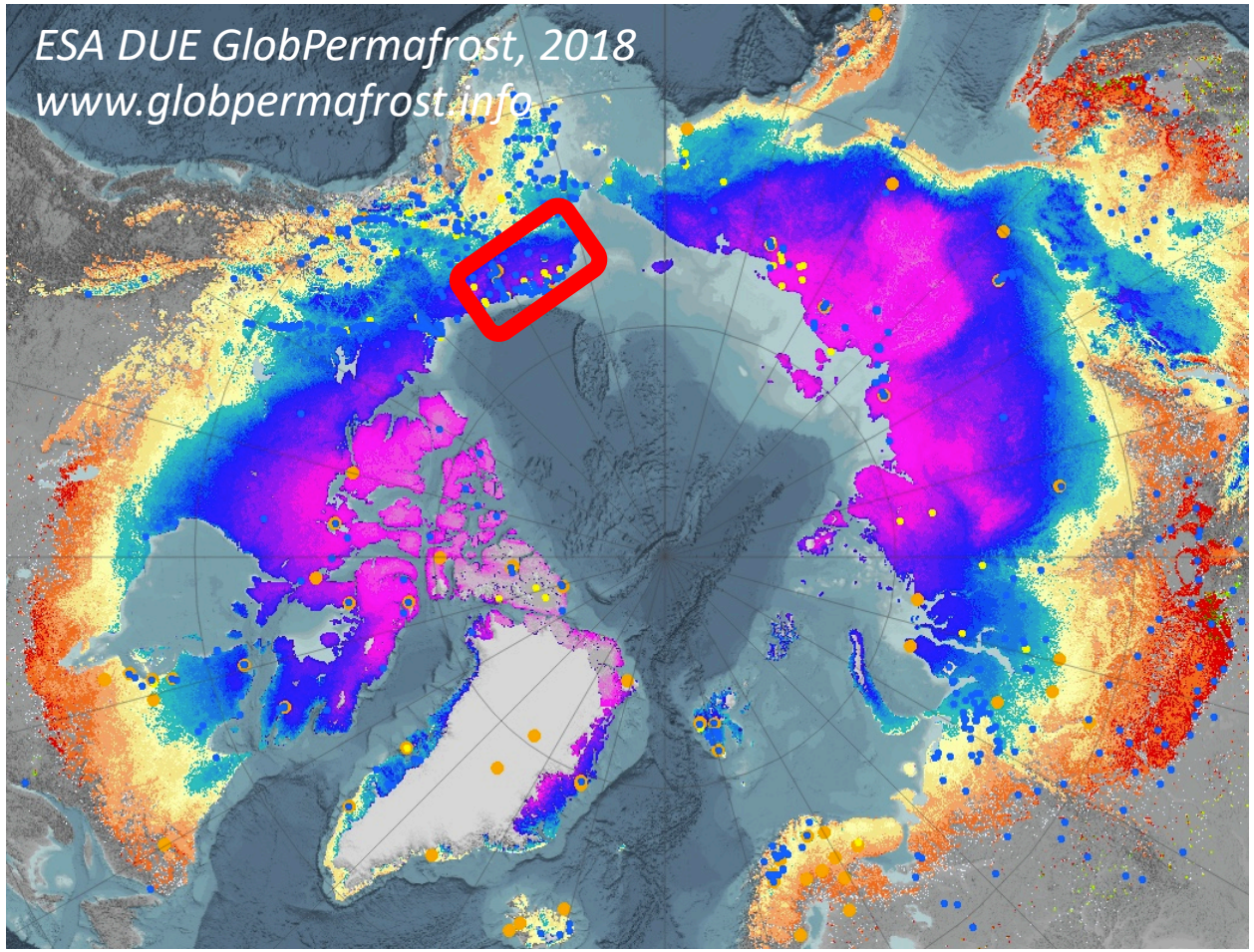

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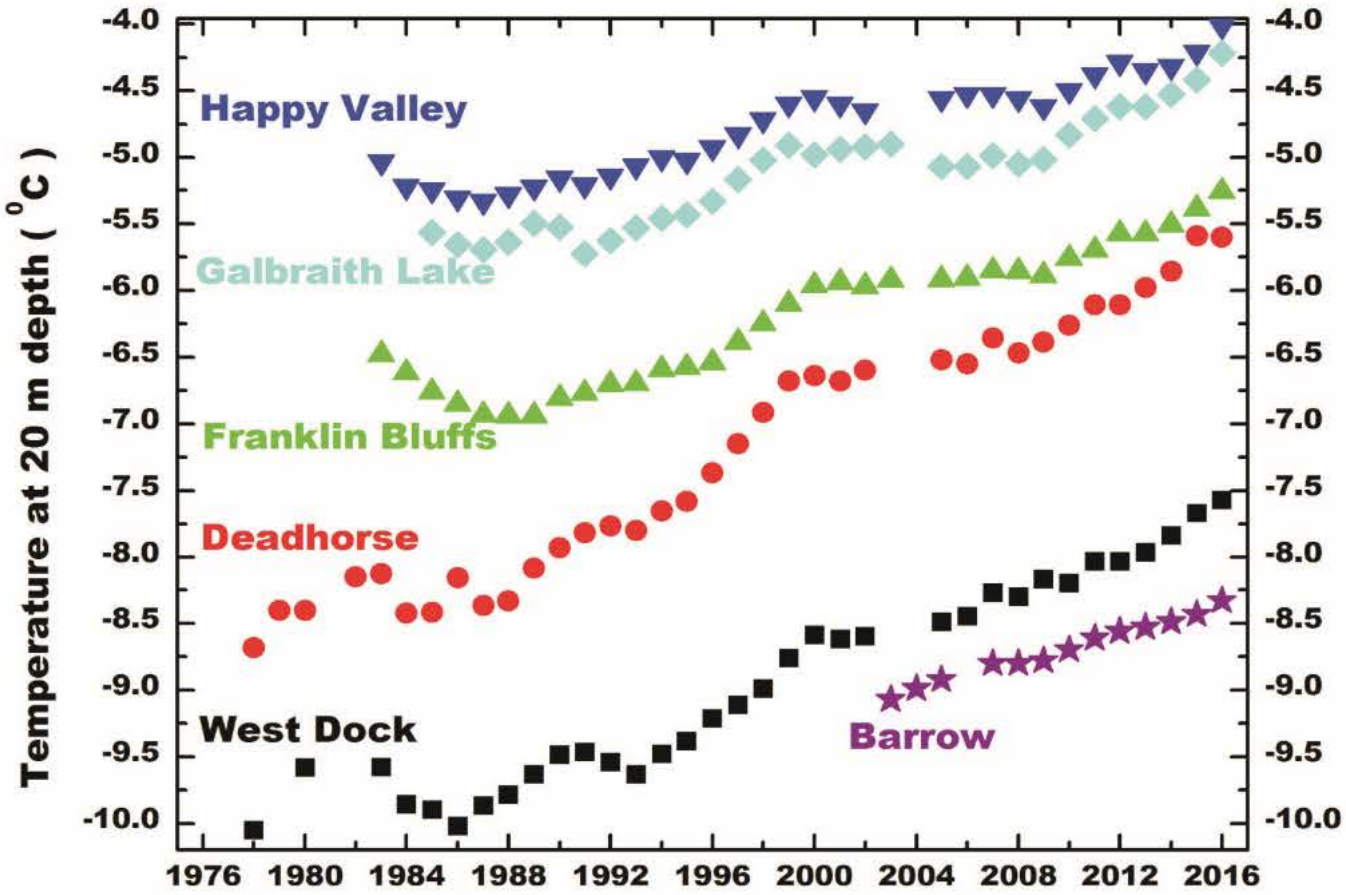
Up to 1˚C/decade warming in Northern Alaska permafrost

- Surface and borehole temperature logging → substantial warming throughout interior and Arctic Alaska
- What are future projections & consequences of such warming?



Romanovsky et al., 2018

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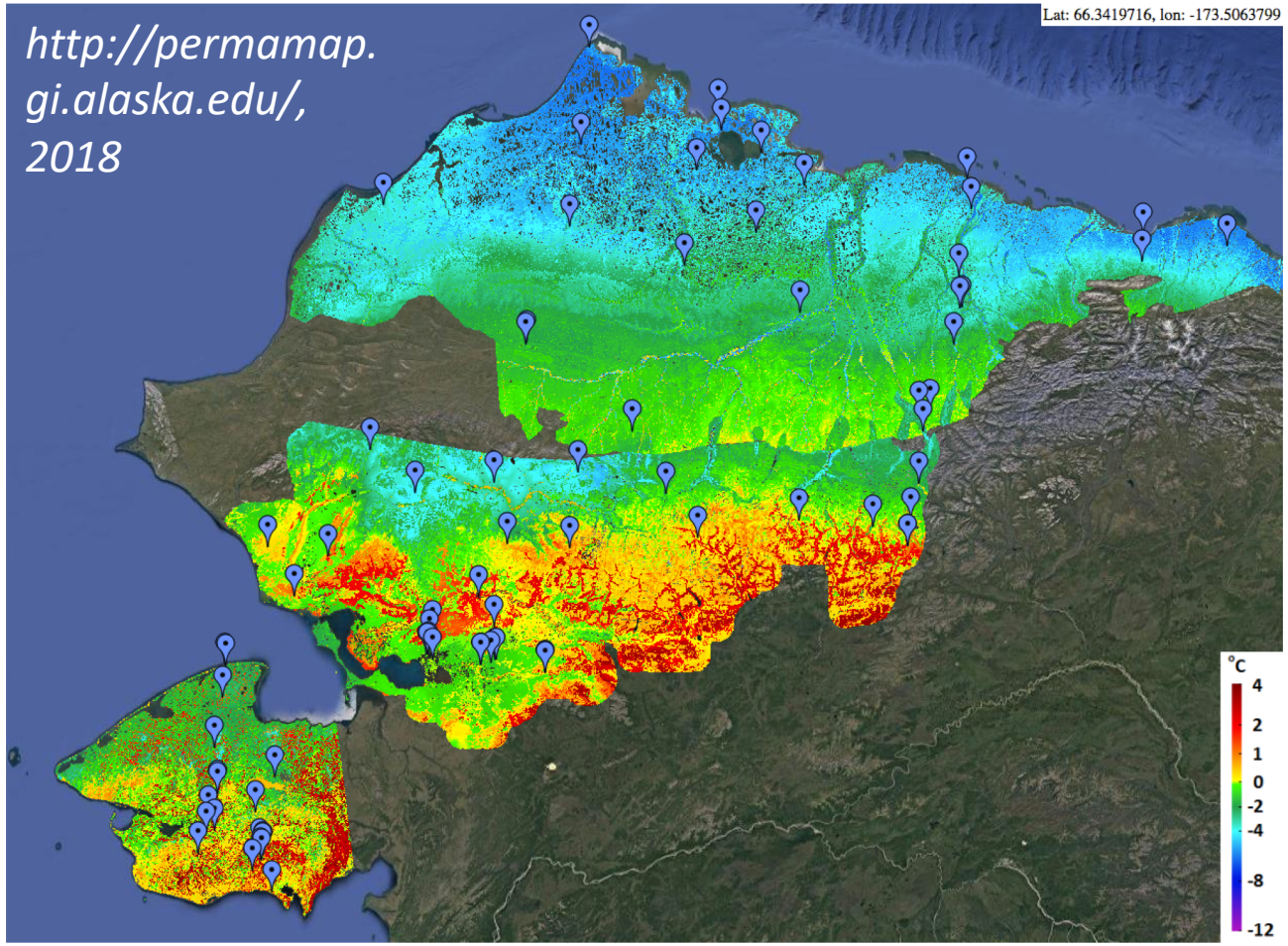

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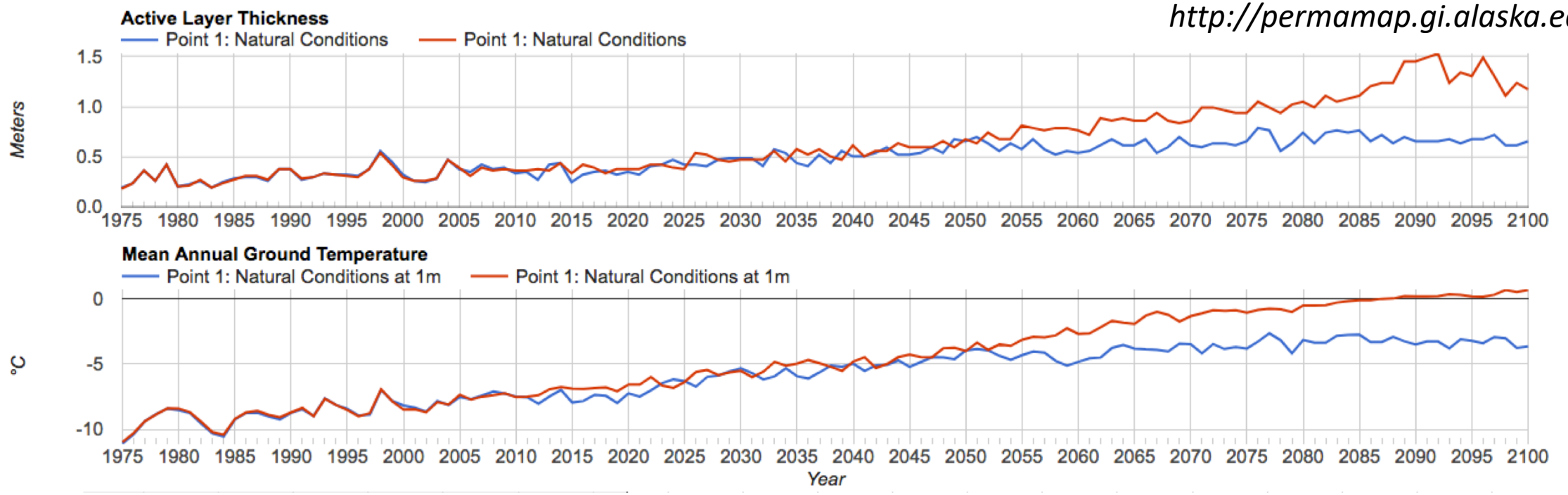
Model projections of permafrost state near Oliktok Pt., AK

http://permamap.gi.alaska.edu/, 2018



- Different warming scenarios (RCP 4.5 & 8.5) diverge by mid-century
- Need for downscaled model output (snap.uaf.edu) to assess impacts

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Permafrost in warming climate → Thermokarst

- Thermokarst: Surface slumping, restructuring of surface hydrology as result of subsurface thaw – irreversible & non-linear response typical of cryosphere elements
- Challenge to surface operations & threat to infrastructure
- Much of Alaska & Siberia susceptible to thermokarst

Photo provided by the Fairbanks DOT office

Thermal properties (snow, air, water, ice, organic and mineral soil)
Heat transfer and fluid flow
Subsidence, flooding and drainage

Wildfire as disturbance to permafrost

Iwahana et al., 2016

- Largest tundra fire in history
- Long-term impacts on land surface processes, hydrology & infrastructure
- Transboundary issues with tundra (& boreal forest) fires near & across U.S. – Canada border

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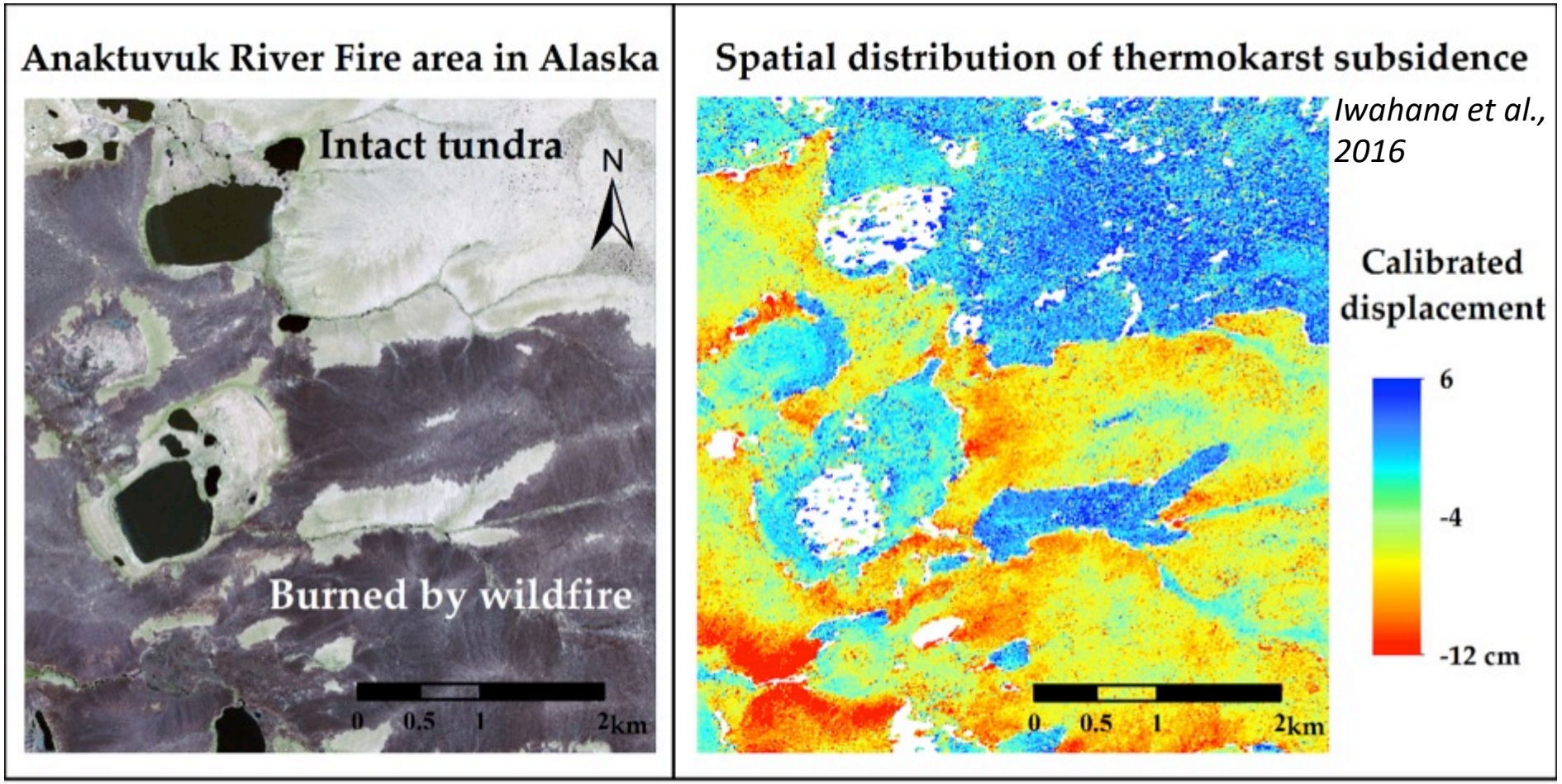
Permafrost impacts & infrastructure threats from InSAR



Iwahana et al., 2016

- Synthetic aperture radar interferometry (InSAR) as key tool
- Image pair (July 2007→ July 2008)
- Assessment of ground subsidence due to fire action

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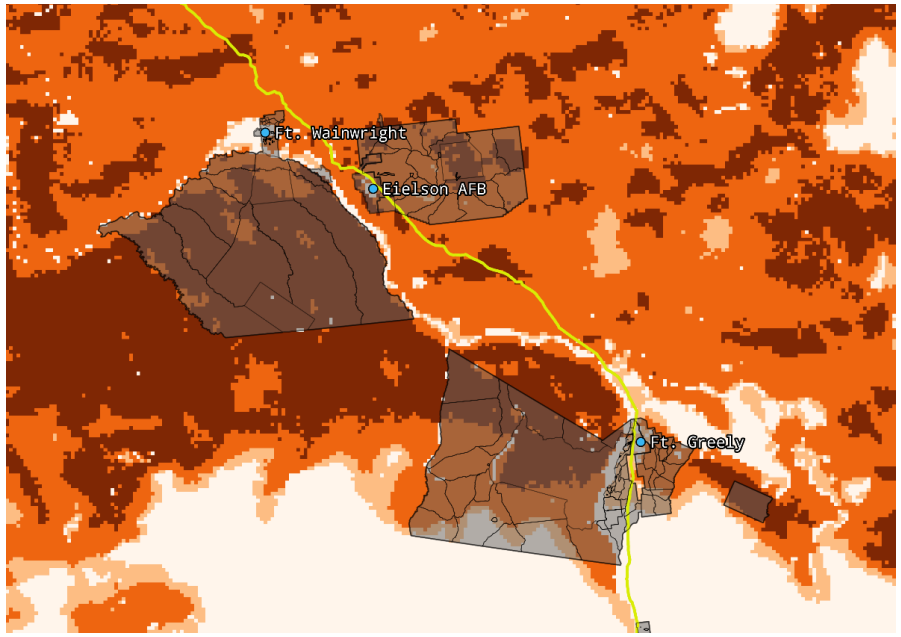
Assessing present & future operational challenges in interior AK

- Led by SNAP at IARC: Permafrost & fire dynamics modeling to assess:
  - Frozen ground travel
  - Operational temperature thresholds
  - Long-term fire modeling
  - Seasonal fire patterns

Climate Change Baseline Analysis for the United States Army Garrison, Fort Wainwright, Alaska

Cooperative Ecosystem Studies Unit CESU-17-10



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Karl Slingerland

University of Alaska:
Nancy Fresco
Sergey Marchenko
Peter Bieniek
Michael Lindgren
Alec Bennett
Matthew Leonawicz
Julien Schroder
Angelica Floyd
Maija Wehmas
Tom Kurkowski

October 2018

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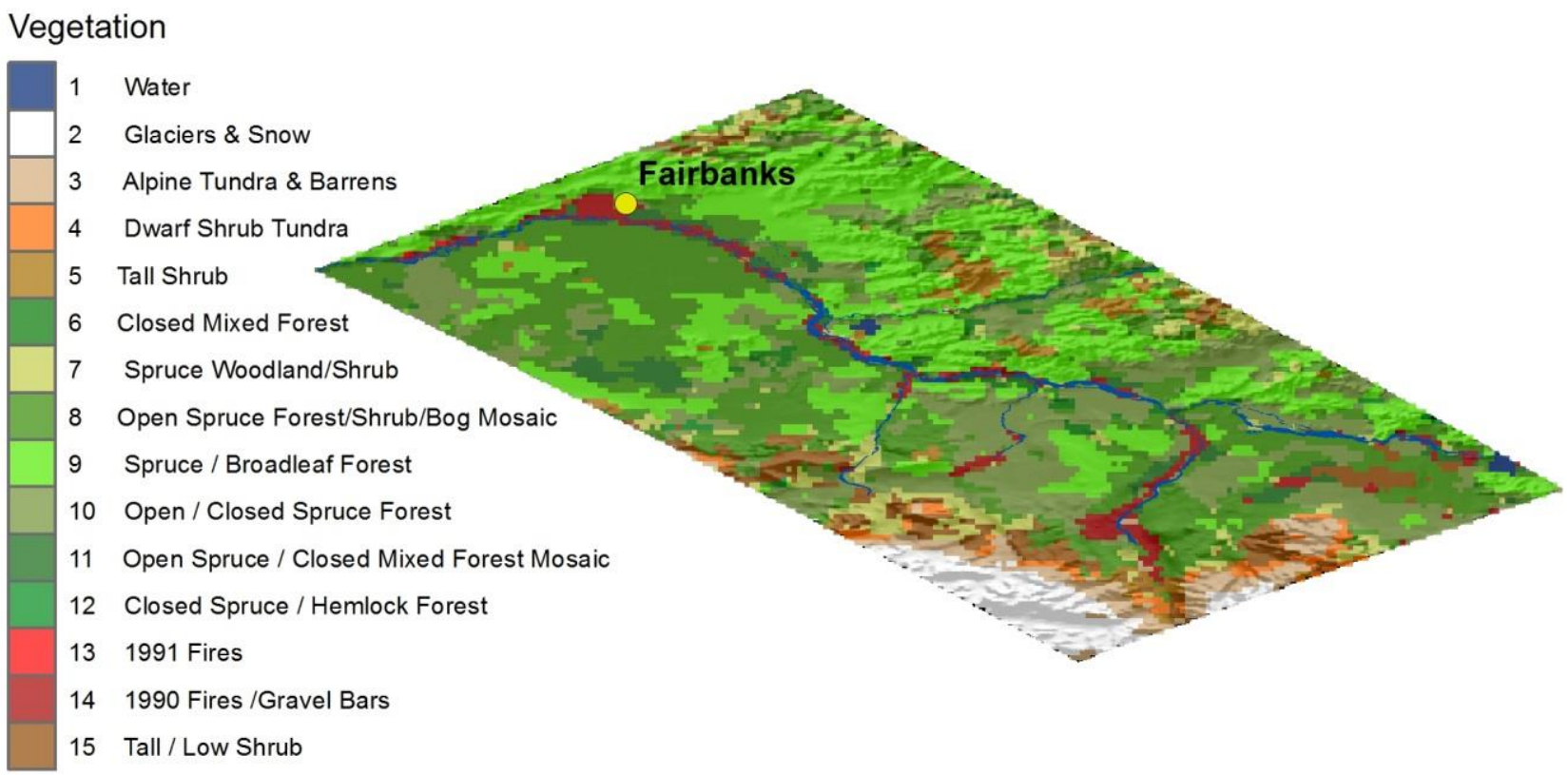
Assessing present & future operational challenges in interior AK

- Permafrost & vegetation-wildfire modeling require detailed vegetation maps
- Data obtained from in situ & remote sensing observations
- For remote sensing increasing reliance on platforms & sensors deployed by other nations



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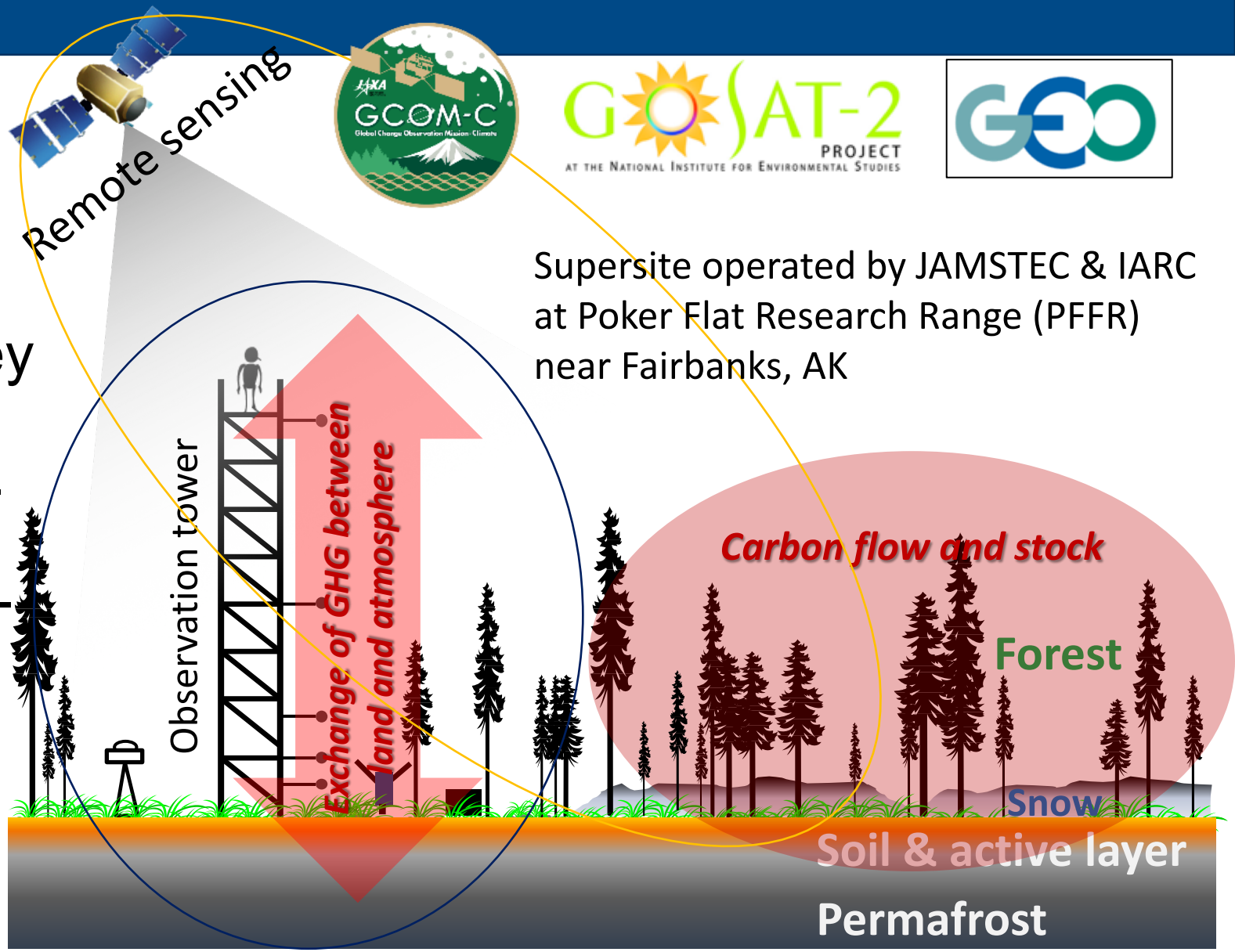
Boreal forest studies: Collaboration with Japan

- JAMSTEC/JAXA-IARC collaboration to calibrate validate products from newly launched satellites
- PFFR in interior AK as key long-term test site
- Potential to derive operationally relevant data & information (fire & permafrost dynamics & prediction)



Supersite operated by JAMSTEC & IARC at Poker Flat Research Range (PFFR) near Fairbanks, AK

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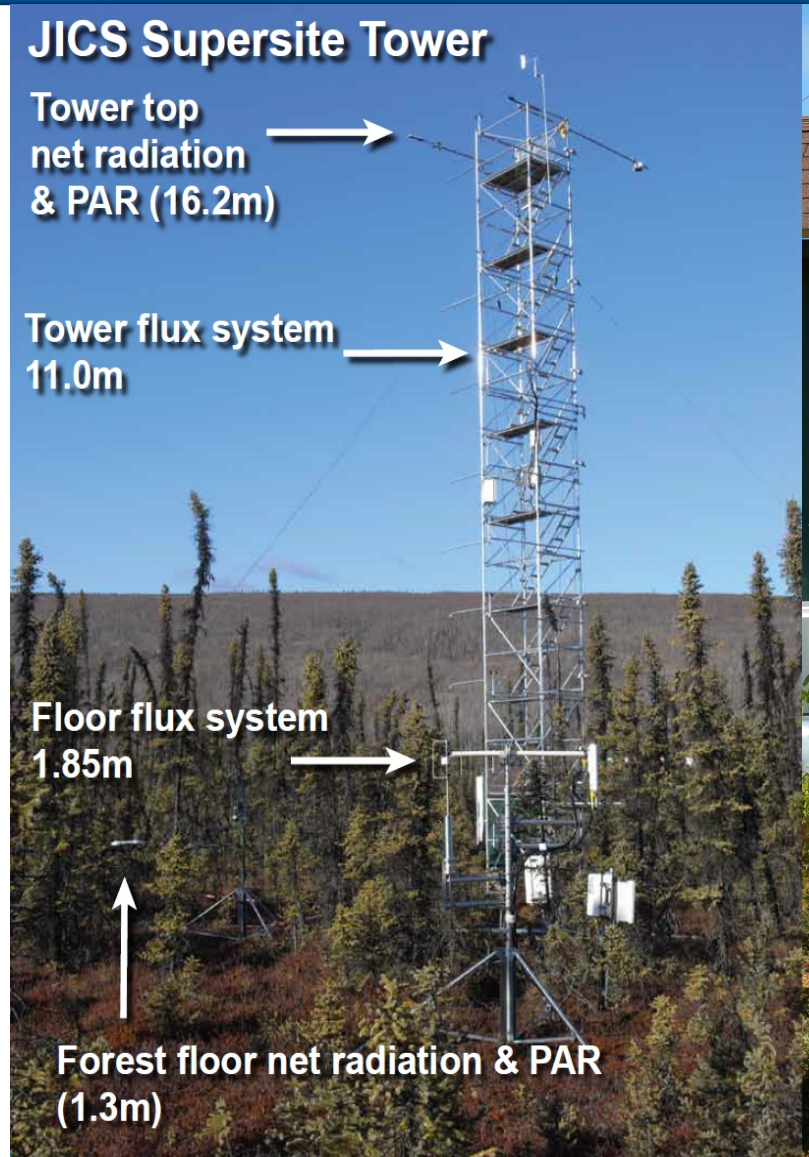

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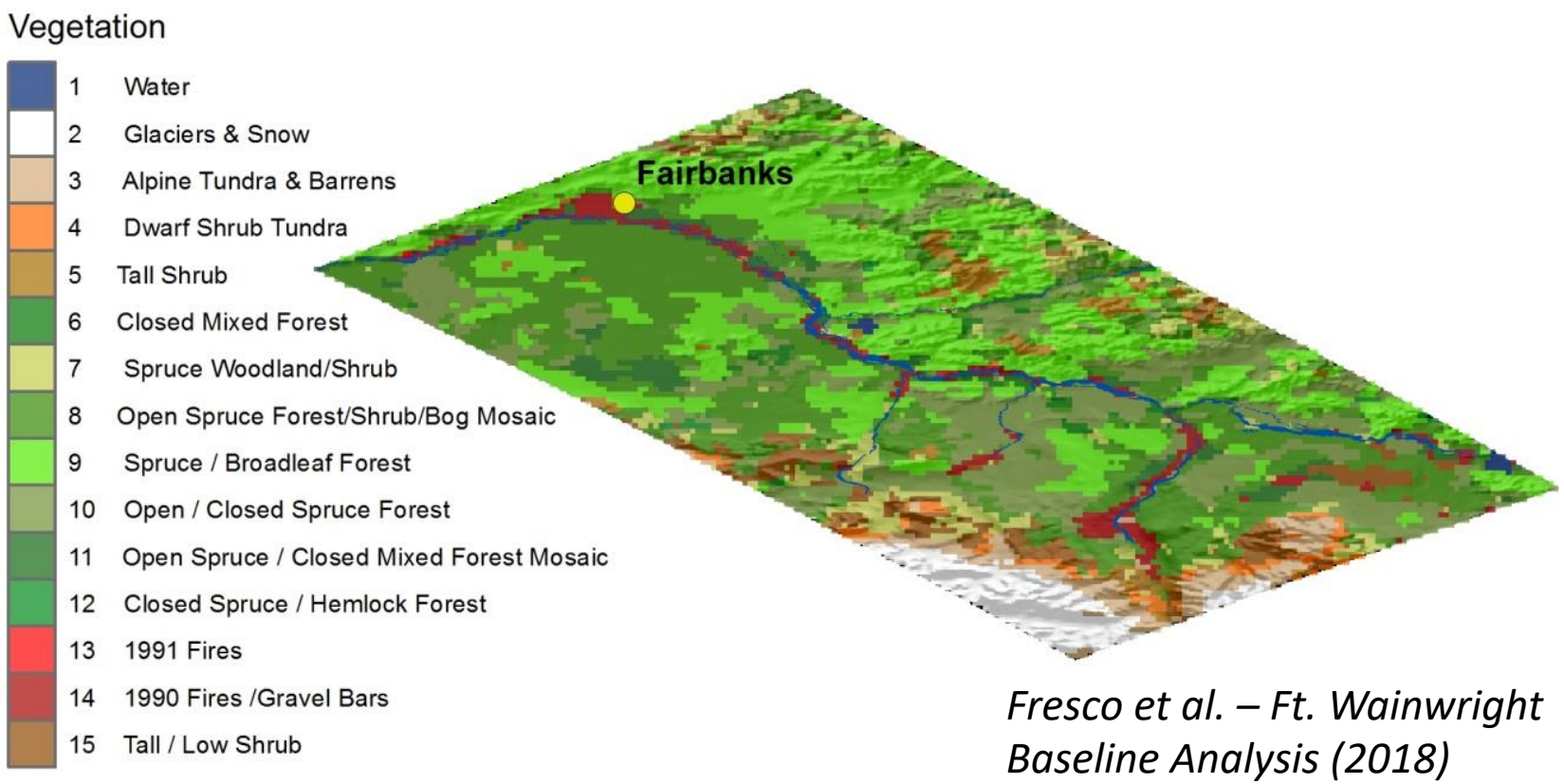

Fresco et al. – Ft. Wainwright Baseline Analysis (2018)

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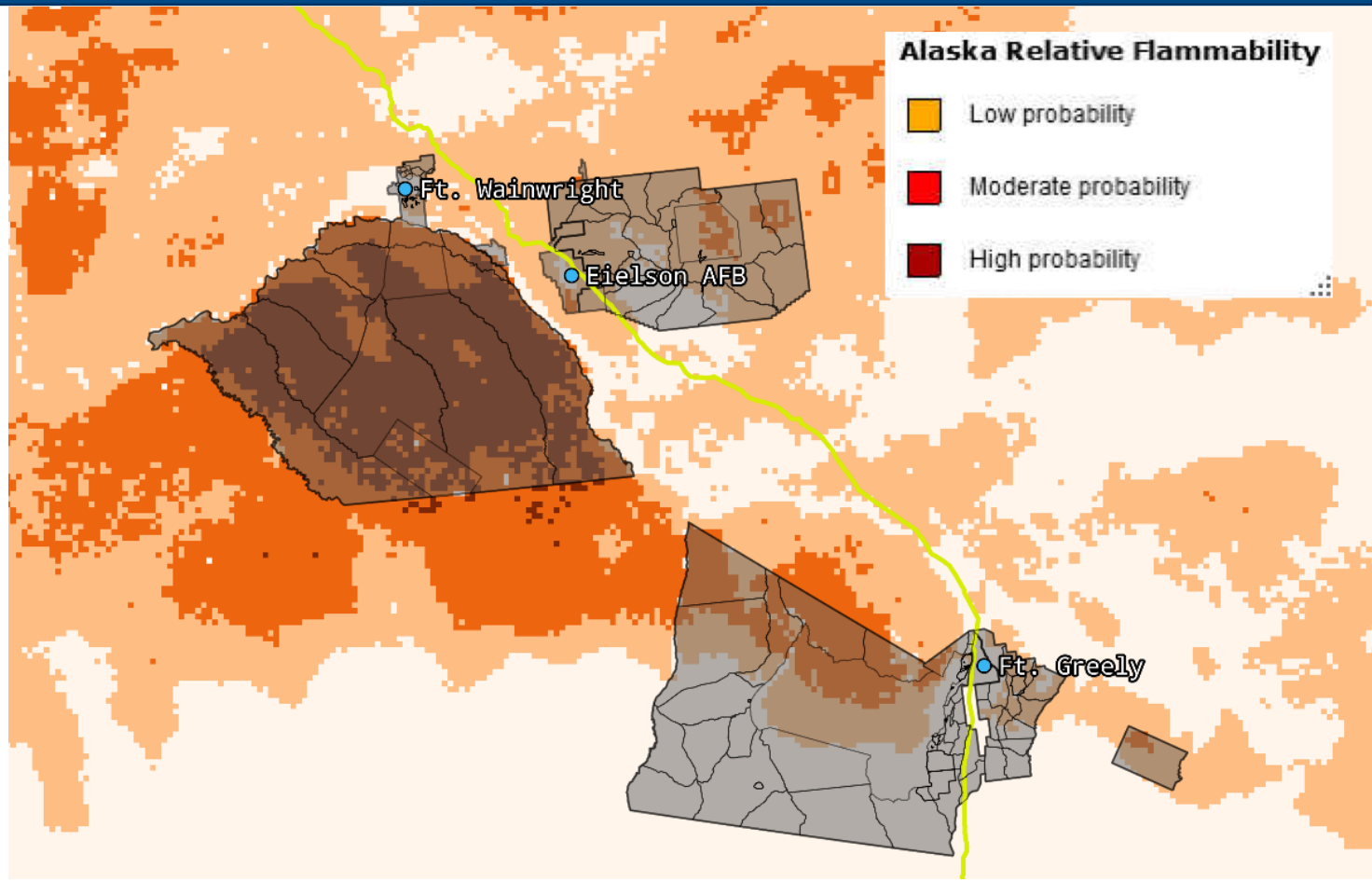
Assessing fire risk for DoD lands in interior AK

- Increase in fire risk derived from land surface-vegetation model
- Status for 20th century: low 0.5-0.75 burns/100yrs; high: 1.25-1.5 burns/100yrs
- Spatial patterns & temporal evolution relevant for range management & long-term planning



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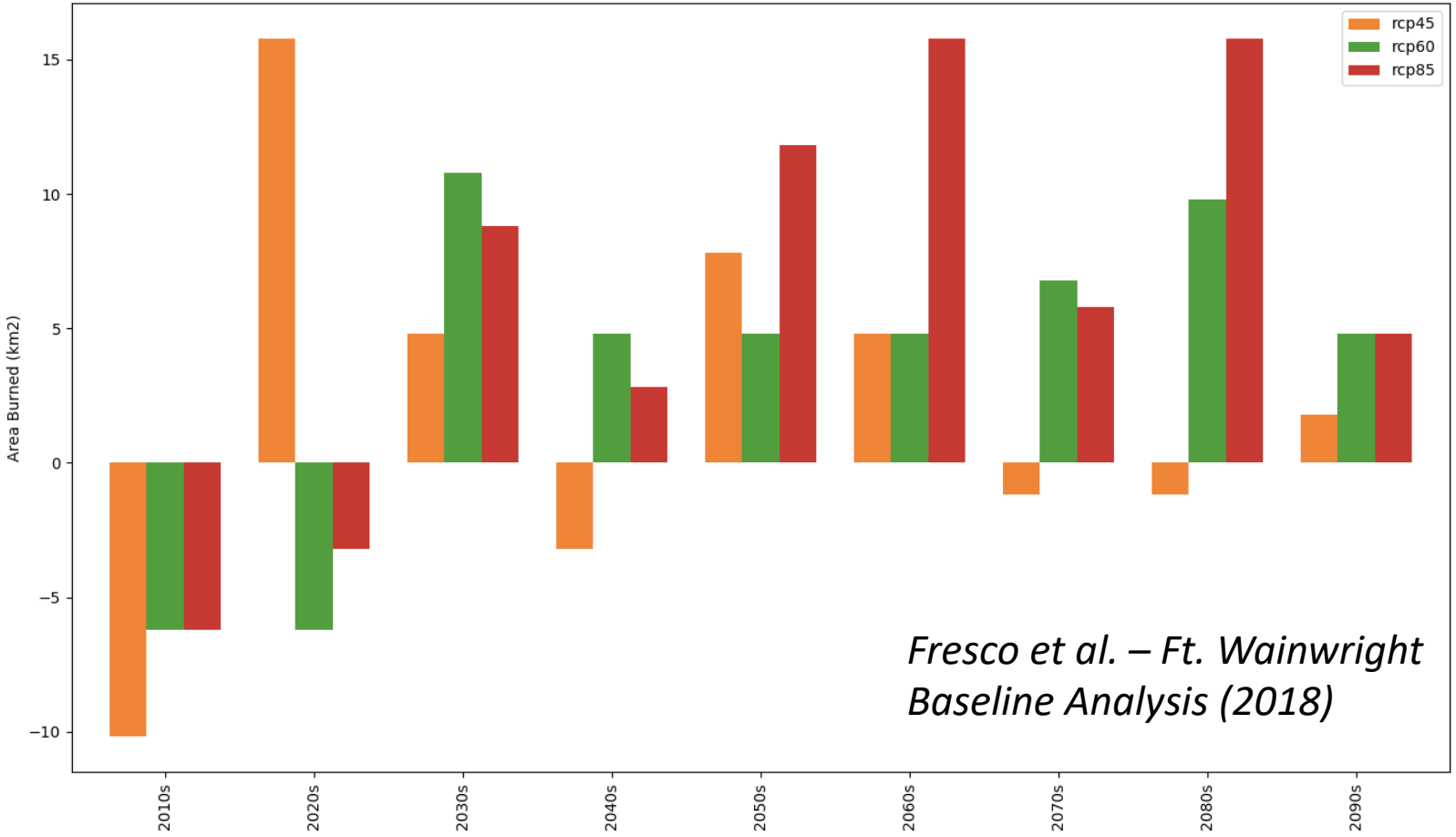
- Increase in fire risk derived from land surface-vegetation model
- Projections for 21st century indicate broad increase in fire risk for DoD lands in interior AK



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Conclusions

- Broad set of observations on changing Arctic environments available through international efforts
- Coordination of space- & surface-based observations of mutual benefit
- Cryosphere has emerged as critical element of impacts in Alaska and pan-Arctic
- Lack of integrated data sets & model outputs for planning & decision support is key problem
- Non-linear response of cryosphere environments require close collaboration between researchers & operators
- Different information needs on short to long timescales require nuanced approaches

Operational challenges involving the terrestrial cryosphere

Photos courtesy of G. Larsen & T. Douglas (USACE-CRREL); E. Clark (USA-CRTC)

Snow: Visibility, rotor wash, trafficability (drifts, loose snow)
Permafrost: Trafficability
River ice break-up: Flooding & other hazards

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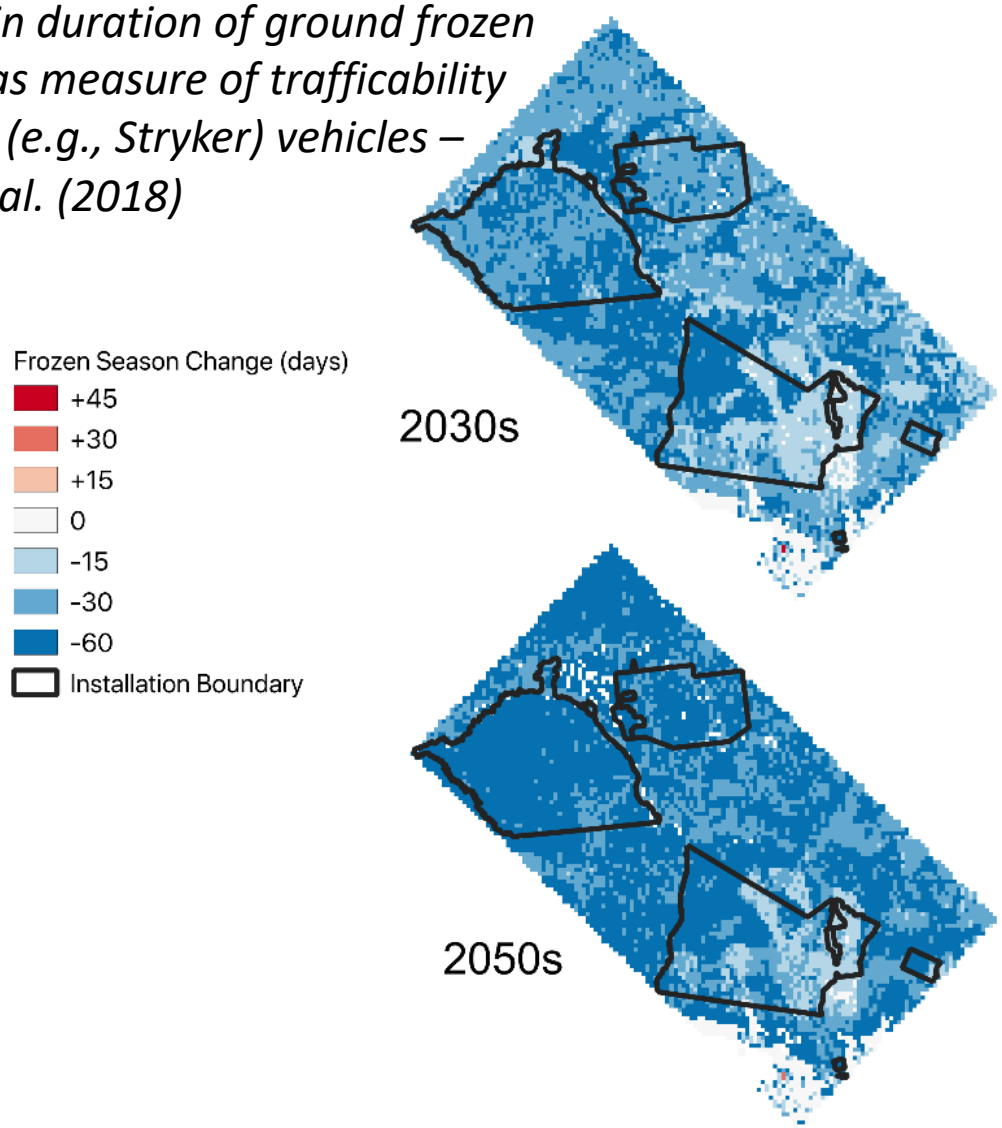
Urgent need for trafficability models in a changing Arctic

- Surface transportation challenges derive from:
  - Changing snow deposition & redistribution patterns
  - Shortened seasonal operating window
  - Development of thermokarst
  - Increasing rain-on-snow & winter thaw events

Changes in duration of ground frozen to 0.5 m as measure of trafficability for heavy (e.g., Stryker) vehicles – Fresco et al. (2018)



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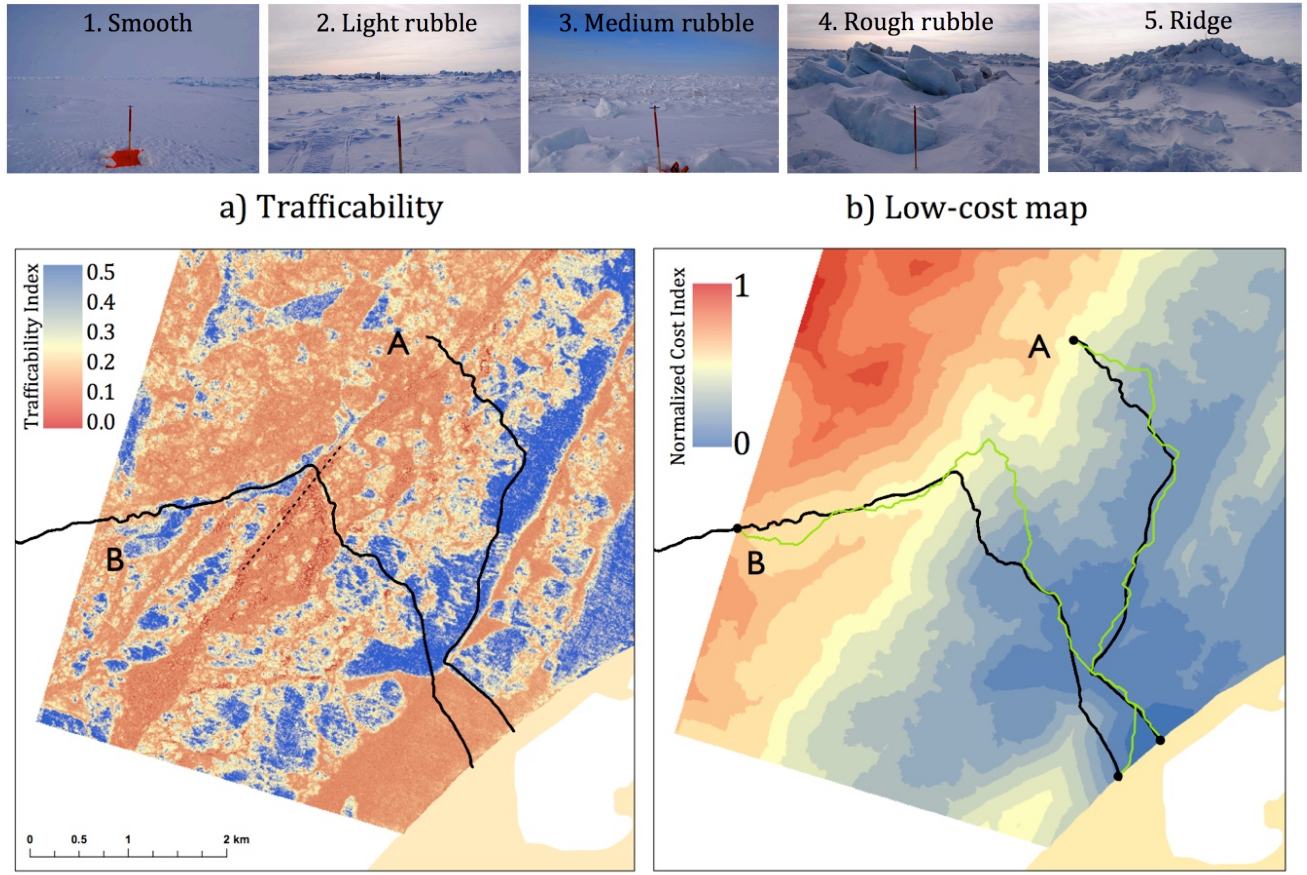
- Potential for InSAR with new satellites (e.g., NISAR) coming online)



Sea ice trafficability model w/ predictive capabilities – Dammann et al. (IEEE, 2018)

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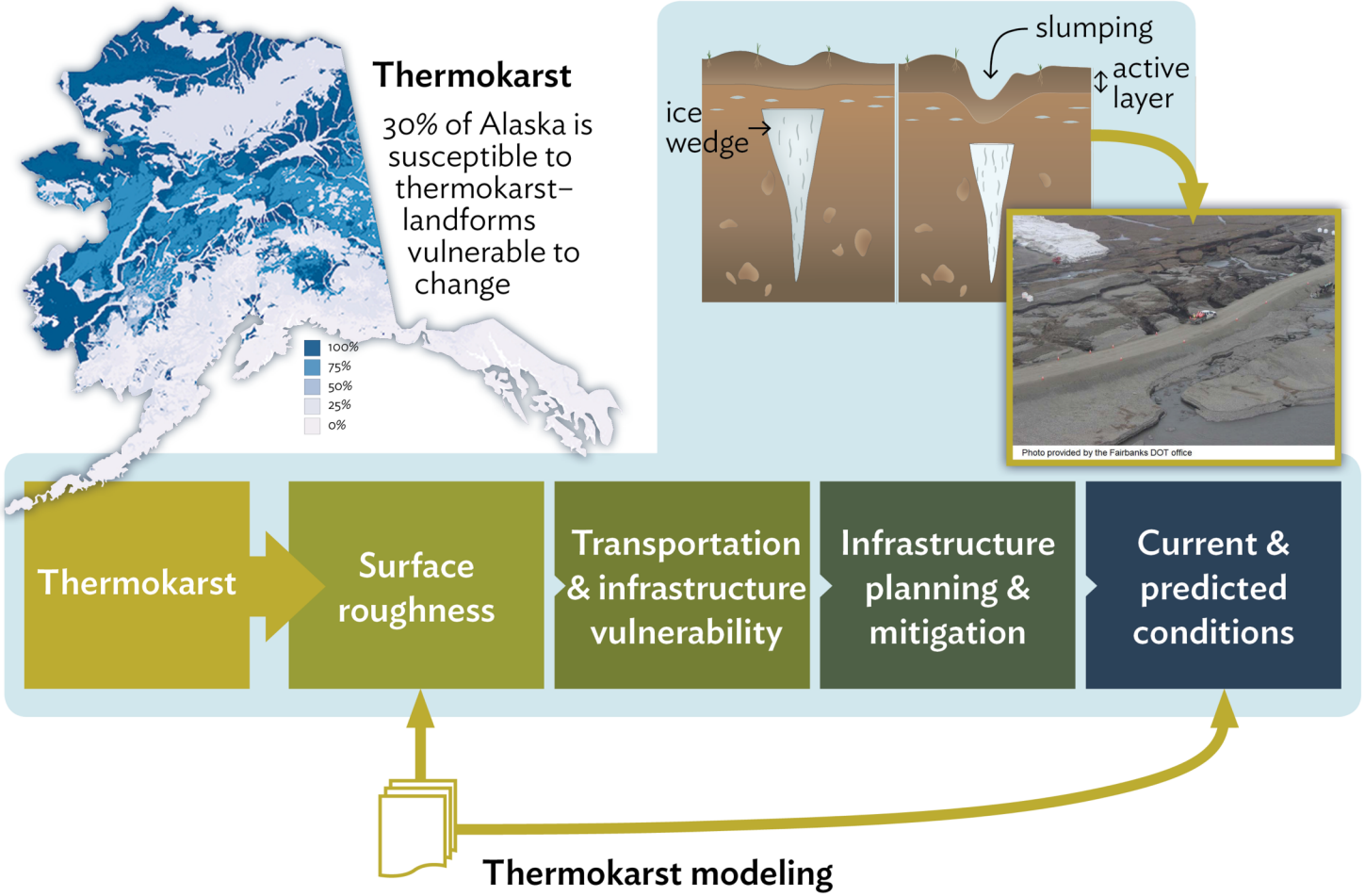
Long-range infrastructure planning & design

- Infrastructure planning & design time horizons extend across period of major environmental changes in Alaska & Arctic → DoD UFC 3-130
- Need for integrated approaches that draw on high-resolution climate data & prediction information products



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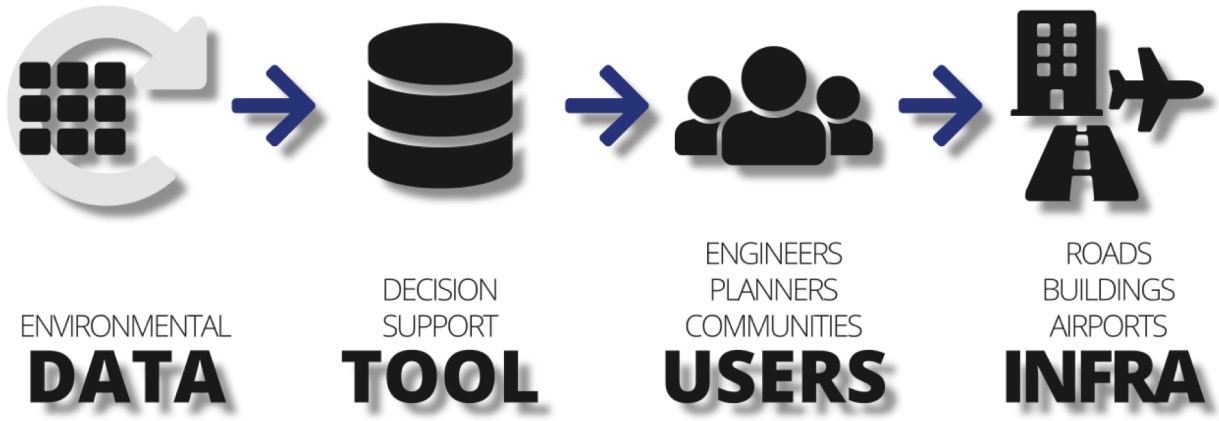
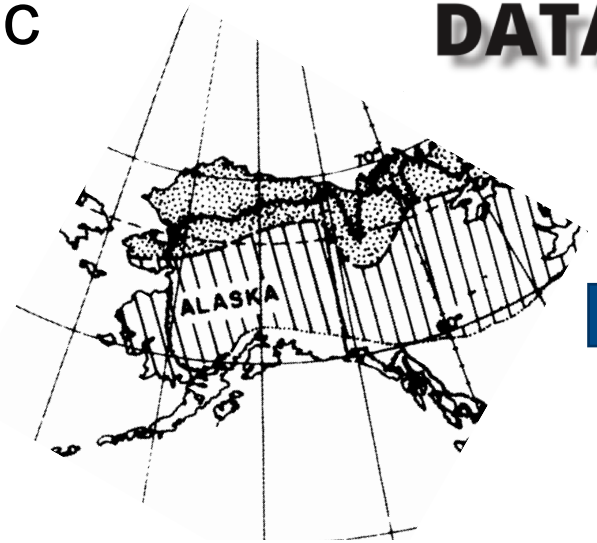
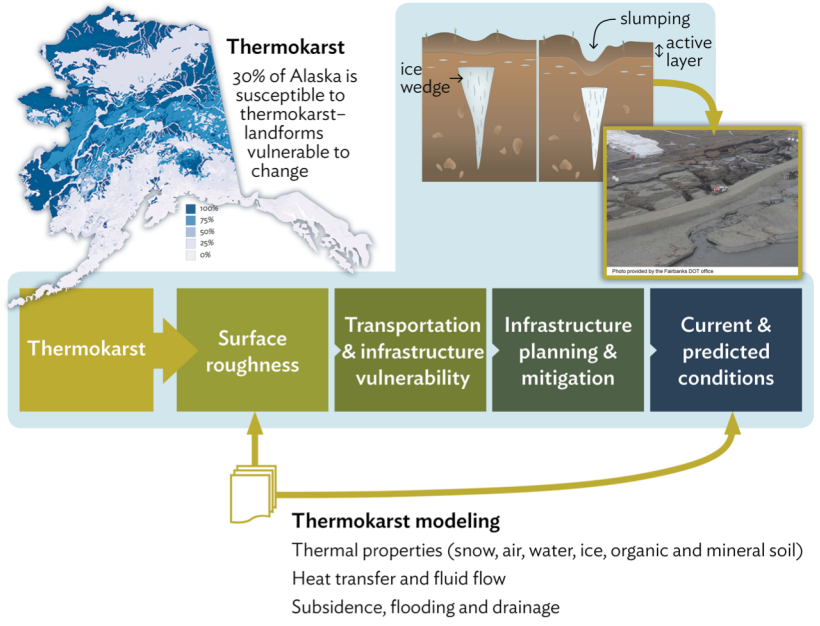




Unified Facilities Criteria Arctic & Sub-Arctic 3-130 (2004 – inactive): Distribution of permafrost (obsolete!)



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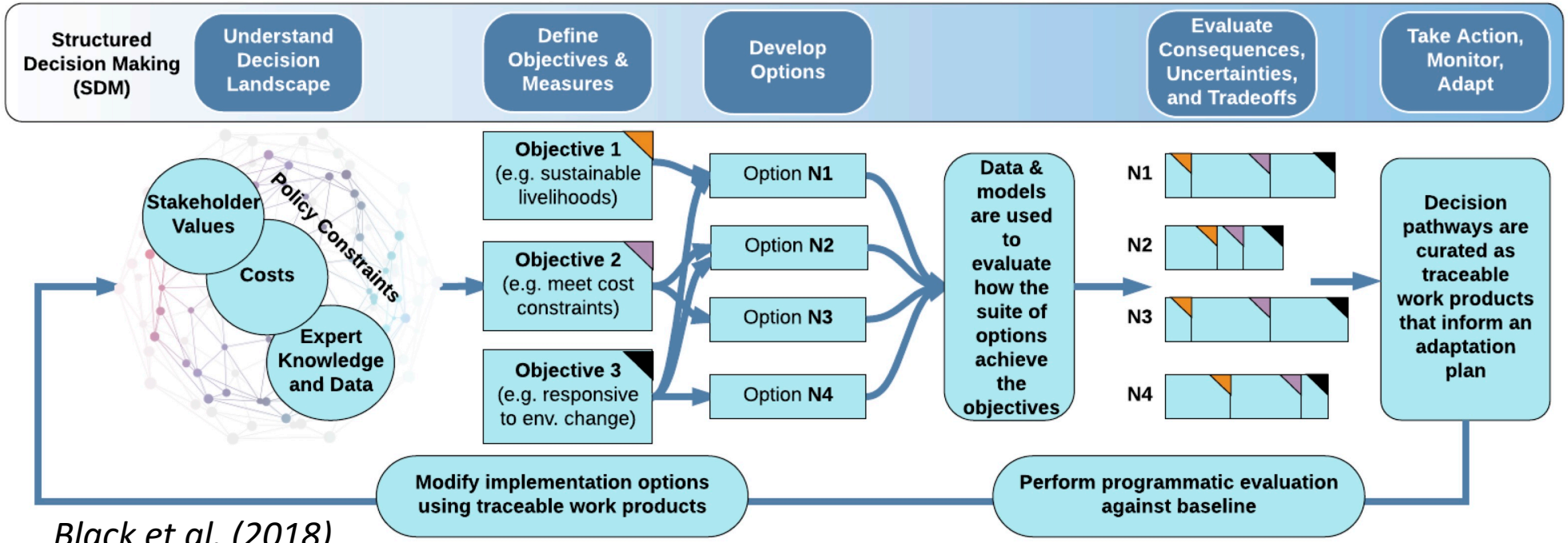
Long-range infrastructure planning & design

- Structured decision-making as key element of decision support systems

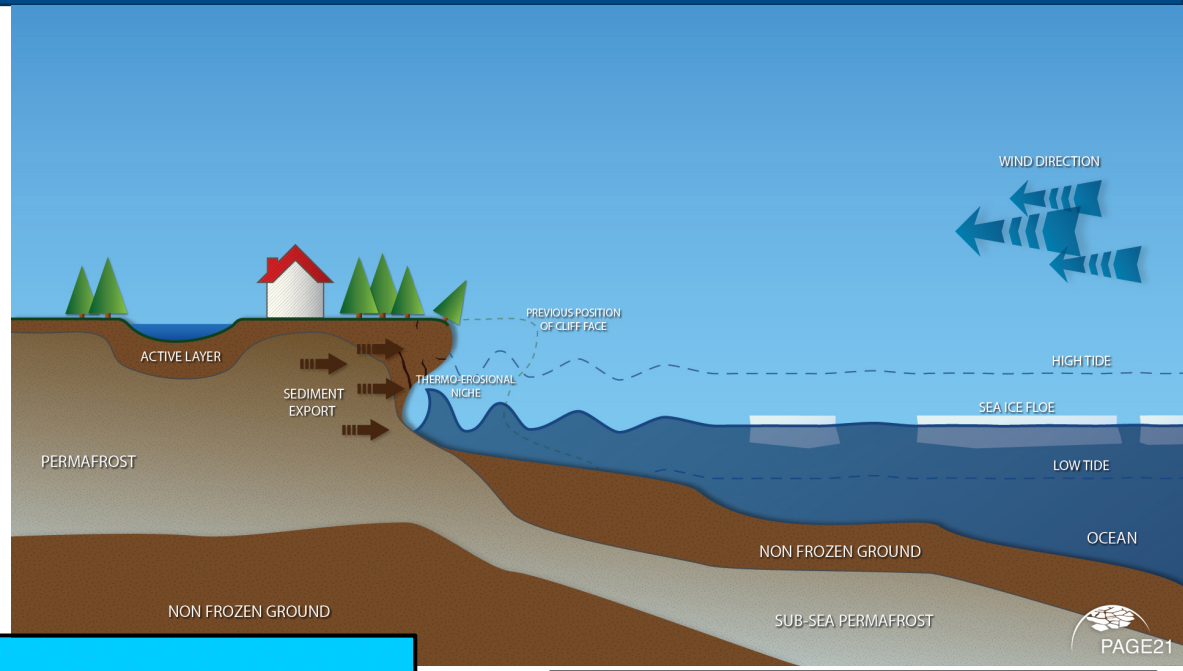


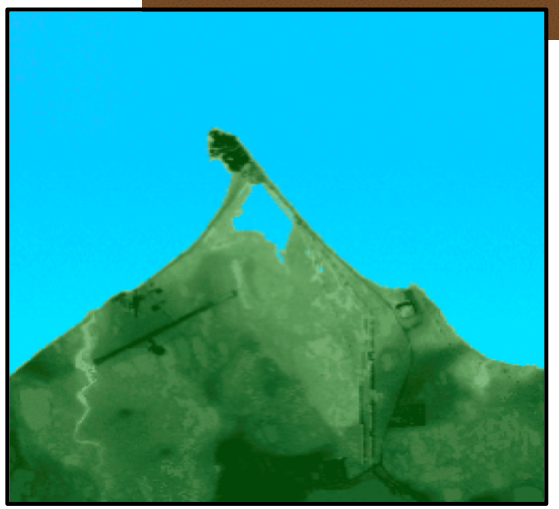
Black et al. (2018)

- Minimizes risks, increases adaptation options, ensures accountability in regulatory & operations context

Coastal processes of increasing importance

- Critical infrastructure, incl. DoD sites, at coastal locations
- Example of Oliktok Pt, AK: USAF Radar Site, ENI petroleum facilities, DOE ARM site, Quintillion fiber optic line, Iñupiat subsistence activities
- Partnering with Sandia National Lab and EU Horizon 2020 project Nunataryuk – Alfred Wegener Institute, Potsdam-Germany





Storm surge modeling example for Oliktok Pt. USAF Radar Site (Alexeev & Bennett, IARC, 2018)

Nome, AK – fall storm (Reuters, 2011)

Contacts & web resources

Online data access & analysis tools

- Scenarios Network for Alaska & Arctic Planning (SNAP), snap.uaf.edu

Dr. Scott Rupp (Director), tsrupp@alaska.edu

- USGS Climate Adaptation Science Center, casc.alaska.edu

Dr. Sarah Trainor (Director), sftrainor@alaska.edu

- Alaska Center for Climate Adaptation & Policy, accap.uaf.edu

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