Hydrology & Permafrost Working Group Highlights & Synthesis Updates

70+ members

John Kimball, David Butman (WG leads)

Photo credit: Scott Zolkos; In: Natalli et al. 2021. *PNAS* 118 (21)

Activities address ABoVE Hydrology & Permafrost [1]objectives:

- Processes controlling changes in PF distribution & properties, & their impacts.
- Nature, causes & consequences of hydrologic changes, Incl. water storage, mobility & distribution.
- Ecosystem water/energy/carbon cycle linkages.

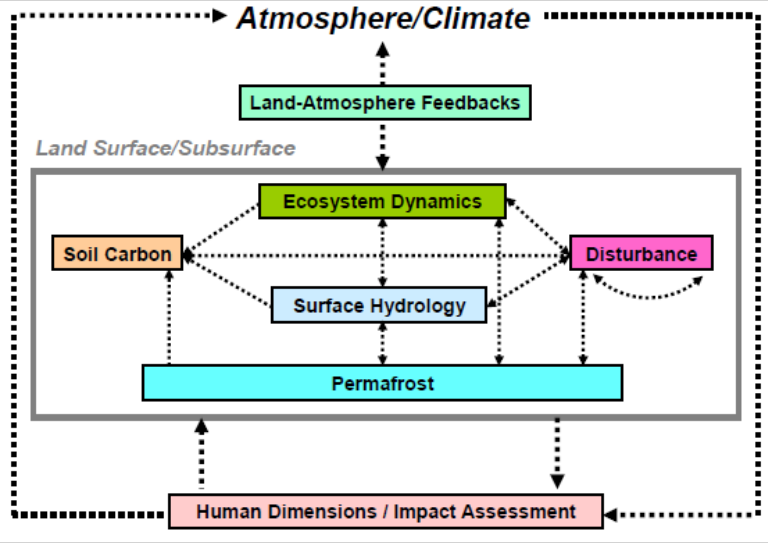
<u>Crosscutting with other WGs, incl.</u>:

- Snowscapes, Disturbance, Modeling, Wetlands, Vegetation & Carbon dynamics.

[1]ABoVE Concise Experiment Plan; ABoVE Implementation Plan

PF thaw-driven geomorphologic and ecological changes

[1]ABoVE science themes and linkages



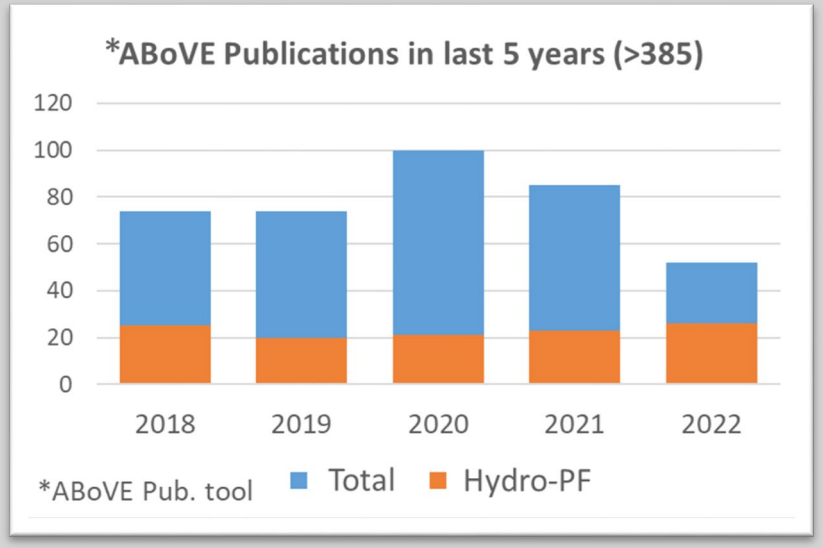
WG member accomplishments

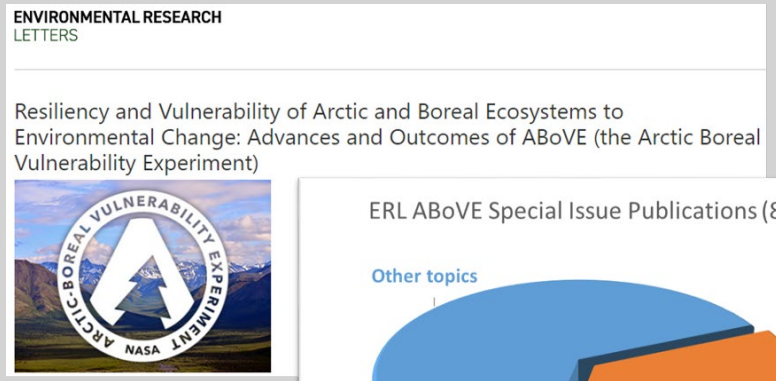
In the last 5-years:

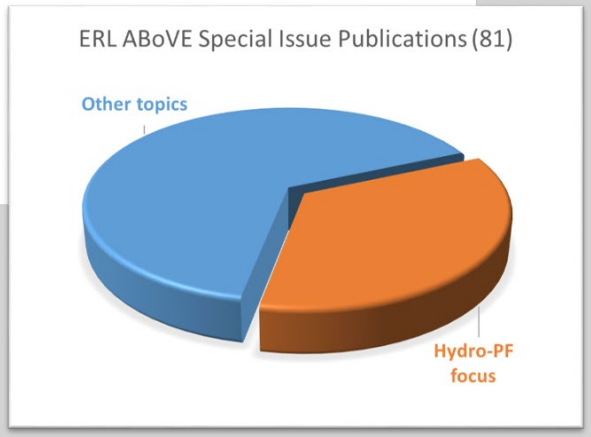
- >100 Hydro-PF related publications, representing ~30% of total ABoVE publications;
- ~35% of papers contributed to *ERL* ABoVE Special Issue have Hydro-PF focus
- ~70 datasets archived (ASC, ORNL DAAC)

Since Jan-22:

- ~22 active projects, Incl. both NASA and affiliated
- ~8 new geospatial datasets archived
- >27 papers published



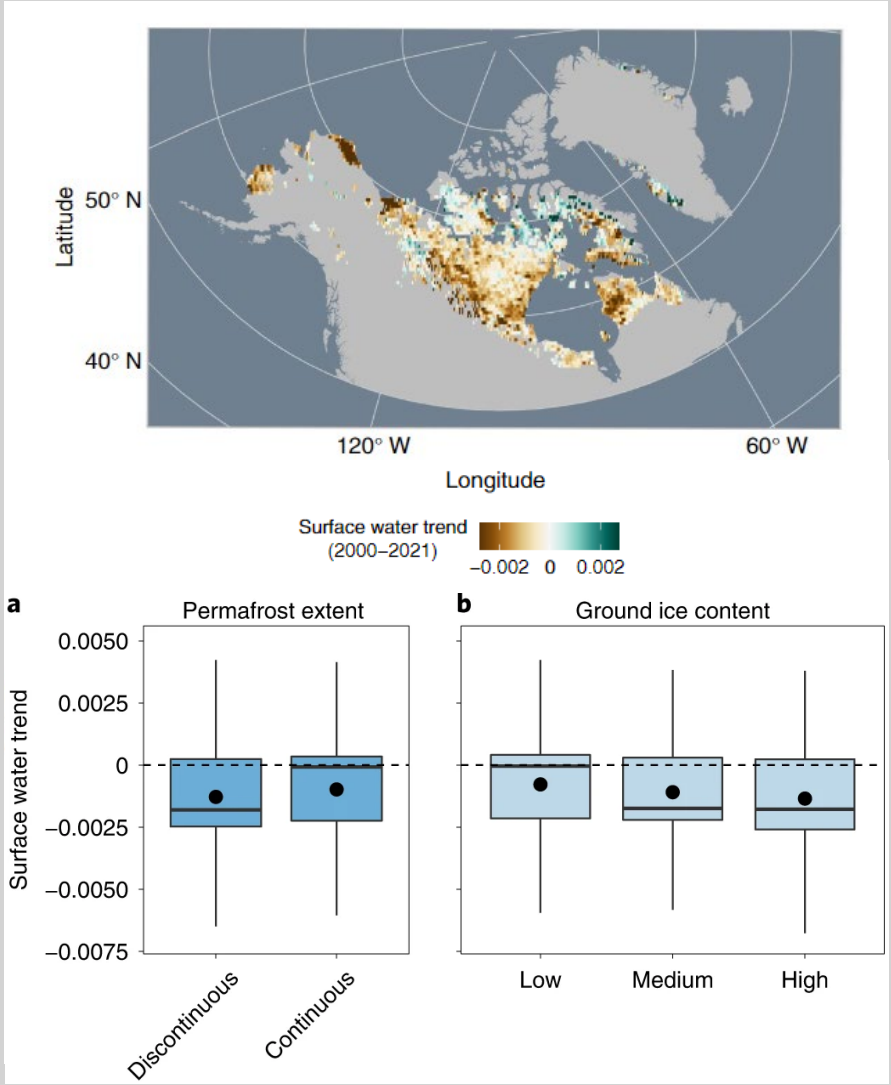




Better understanding of PF & hydrology trends, drivers, & ecosystem impacts

- Permafrost thaw drives surface water decline across lake-rich regions of the Arctic (E. Webb, et al. 2022. *Nature Climate Change* 12).
- Monitoring 13 years of drastic catchment change and hydro-ecological responses of a drained thermokarst lake (K. Turner, et al. 2022. *Arctic Science* 8, 4).
- Drivers of historical and projected changes in boreal ecosystems (T. Jorgenson et al. 2022. *ERL* 17).
- Thaw-induced impacts on land and water in discontinuous permafrost: Review of Taiga Plains and Taiga Shield, NWT (S. Wright et al. 2022. *Earth-Science News* 232).

Permafrost thaw drives pan-Arctic surface water decline

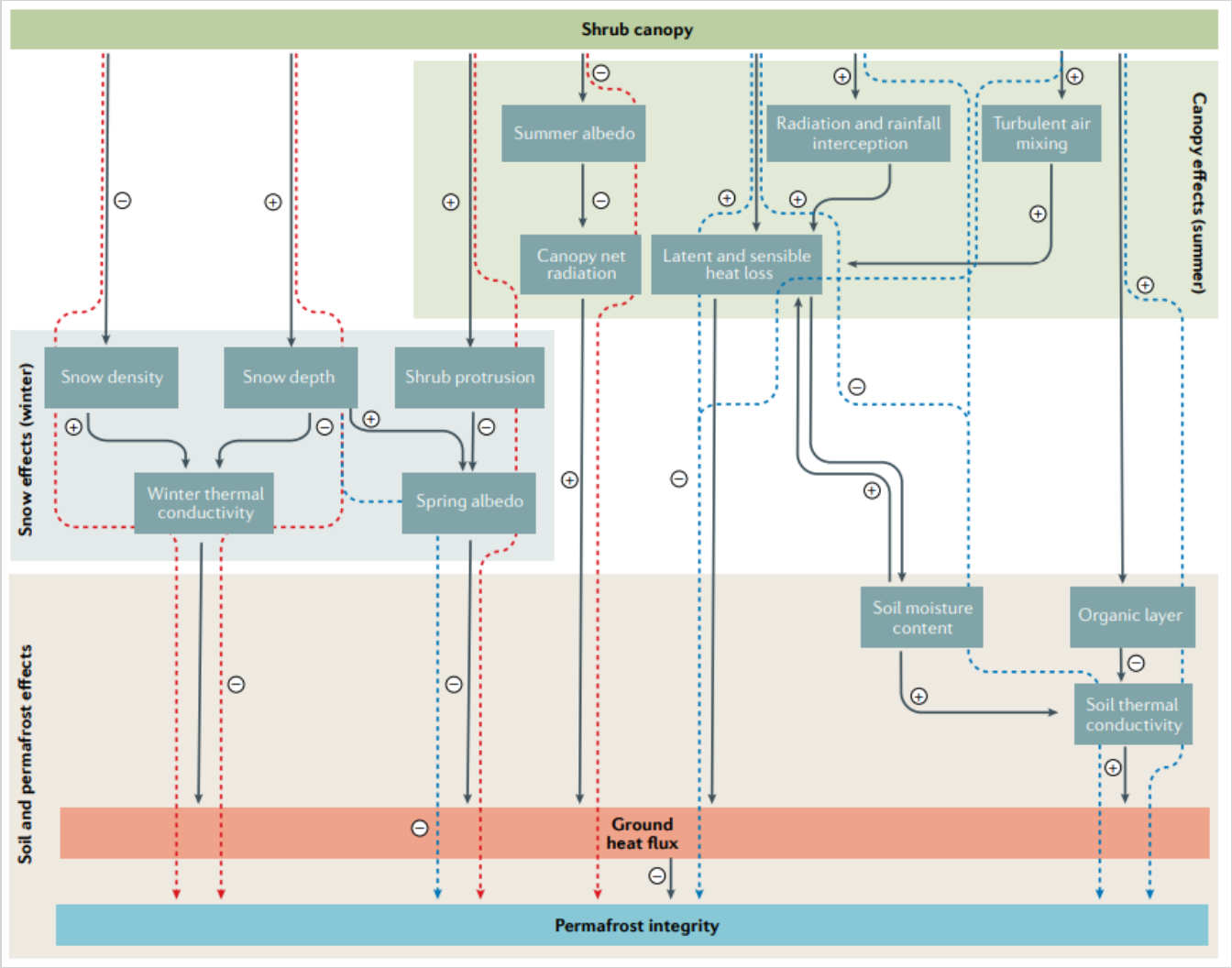


E. Web, et al. 2022. *Nature Climate Change*, 12, 841

Improved models & predictions of hydro-ecological processes, & linkages in PF landscapes

- Clarifying relations between tundra greening, soil hydrology & PF thaw (M. Heijmans et al. 2022. *Nature Rev. Earth & Environ.* 3).
- Resolving patterns and drivers of aged organic carbon export in discontinuous permafrost headwaters (J. Koch et al., 2022. *GBC* 36, 4).
- Improved characterizations of tundra soil moisture and organic matter profiles (K. Bakian-Dogaheh et al., 2022. *ERL*, 17, 2).
- ML predictions of aquatic CO2 and CH4 concentrations relative to water body size and fire disturbance (S. Ludwig et al., 2022. *GBC* 36, 4).

Tundra shrub influence on permafrost stability



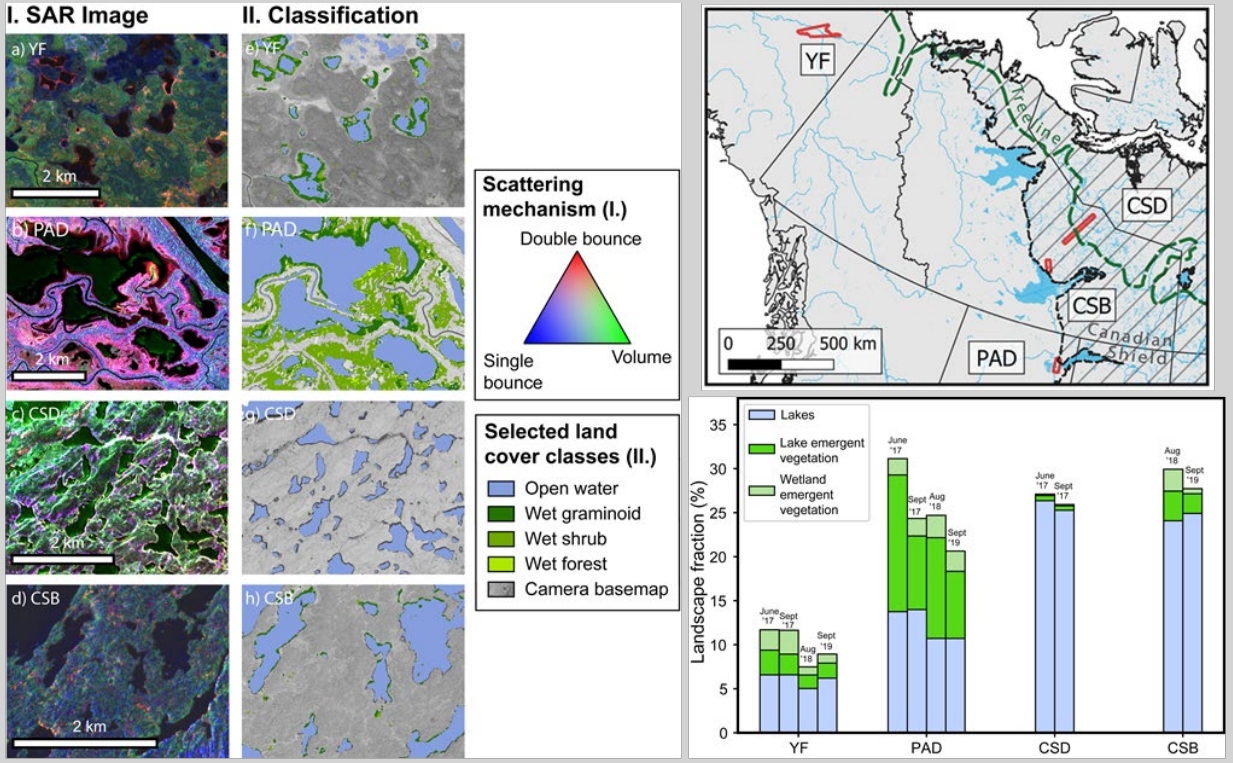
Heijmans, M.P.D. et al., 2022. *Nature Rev. Earth & Environ*. 3, 68-84.

New understanding of hydrologic influence on Arctic-boreal carbon sequestration & storage

- Importance of lake emergent aquatic vegetation for estimating arctic-boreal methane emissions. (E. Kyzivat, et al. 2022. *JGR Biogeosci*. 127, 6).
- Snow and soil moisture controls on tundra C sequestration (D. Zona et al. 2022. *Sci. Reports* 12, 1; Zona et al. 2022b. *GCB).*
- Hydrologic and landscape controls on DOM composition across western North American lakes (M. Kurek et al. 2022. *GBC* 37, 1).

Importance of lake emergent vegetation (LEV) on landscape methane emissions

(LEV: ~16% of lake area, from >4,500 lakes mapped)



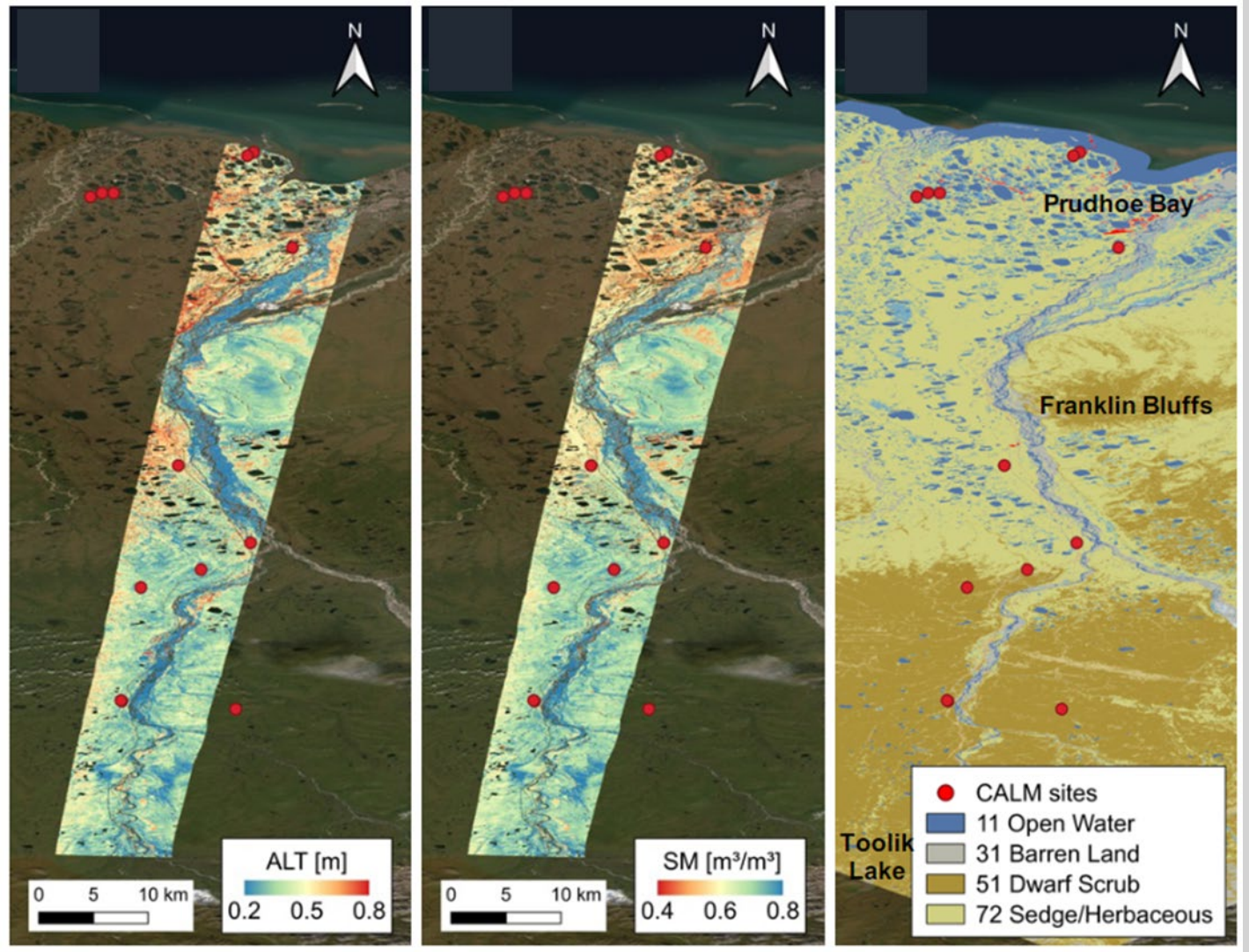
YF: Yukon Flats; CSD: Canadian Shield, Daring lake; Canadian Shield, Baker creek; PAD: Peace Athabasca Delta

E. Kyzivat, Smith, Garcia-Tigreros et al., 2022. *JGR Biogeosci*. 127, 6.

New remote sensing capabilities & data to resolve climate-terrain-Veg.-PF patterns & linkages

- Combined L-band InSAR and P-band PolSAR retrievals of ALT and SM in permafrost soils (R. Chen et al. 2022. *Earth and Space Science*)
- Satellite monitoring of tundra soil organic properties from SMAP (Y. Yi et al. 2022. *WRR* 58, 4).
- Geomorphological patterns of remotely sensed methane hotspots (L. Baskaran et al. 2022. *ERL* 17, 1).
- SAR sensitivity to postfire permafrost changes in tundra (Y. Yi et al. 2022. *IEEE TGRS* 60).

UAVSAR 30m soil moisture & Active Layer Thickness: AK North slope (Aug, 2017)

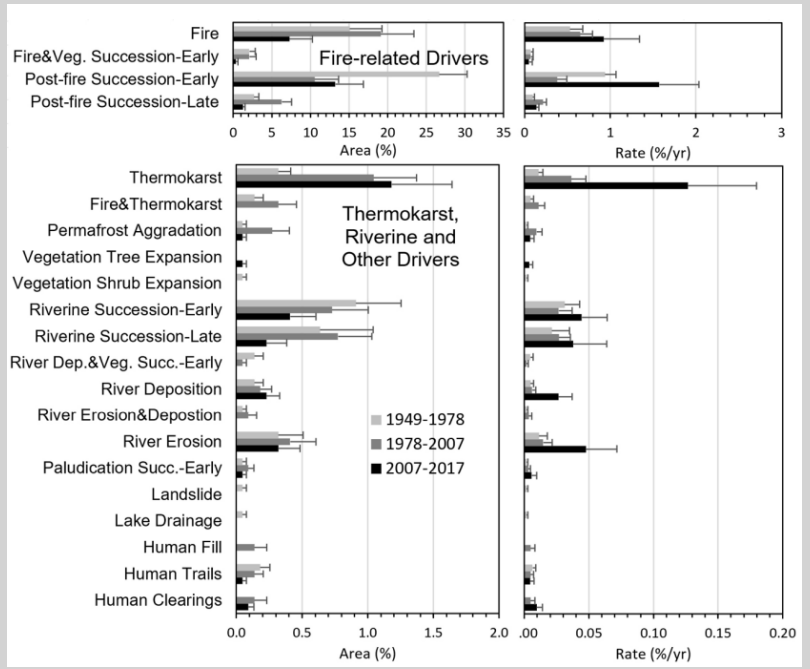


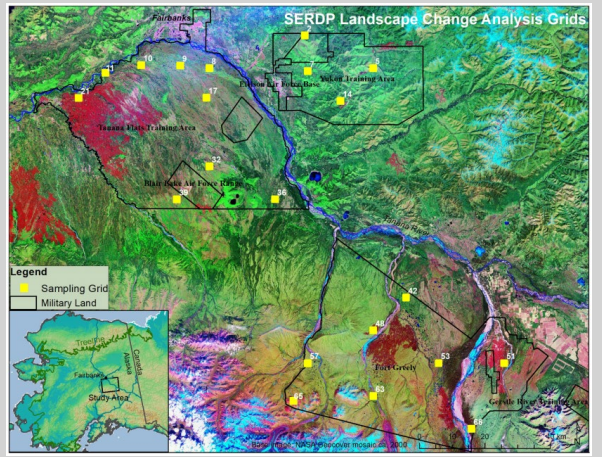
R. Chen, R.J. Michaelides, Y. Zhao, et al. 2022. *Earth and Space Science*, doi:10.1029/2022EA002453

Wrap-up of Phase II Synthesis Activities

- AK Boreal Ecotype trends & drivers
  - T. Jorgenson et al., 2022. *ERL* review paper
- Active layer properties & upscaling
  - Improved tundra soil dielectric models (K. Bakian-Dogaheh, et al. 2022. *ERL* 17, 2).
  - Alaska SAR ALT upscaling (J. Whitcomb et al. In prep.)
  - Northern Hemisphere ALT trends (Z. Liu et al. In prep.)
- Permafrost Hydrol. & Carbon linkages
  - Impact of changing snow and soil moisture regimes on tundra C sequestration (D. Zona et al., 2022a. *Sci. Reports* 12, 3986; Zona et al. 2022b. *GCB*, doi: 10.1111/gcb.16487)

AK Boreal Ecotype Changes and Drivers





M.T. Jorgenson, D.R.N. Brown, C.A. Hiemstra et al. 2022. *ERL* 17, 4

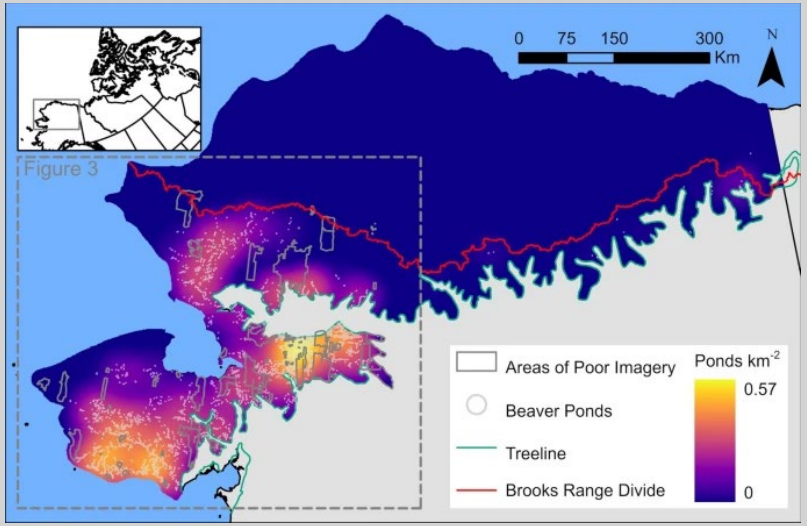
New Hydro-PF related Phase III projects (ROSES-21):

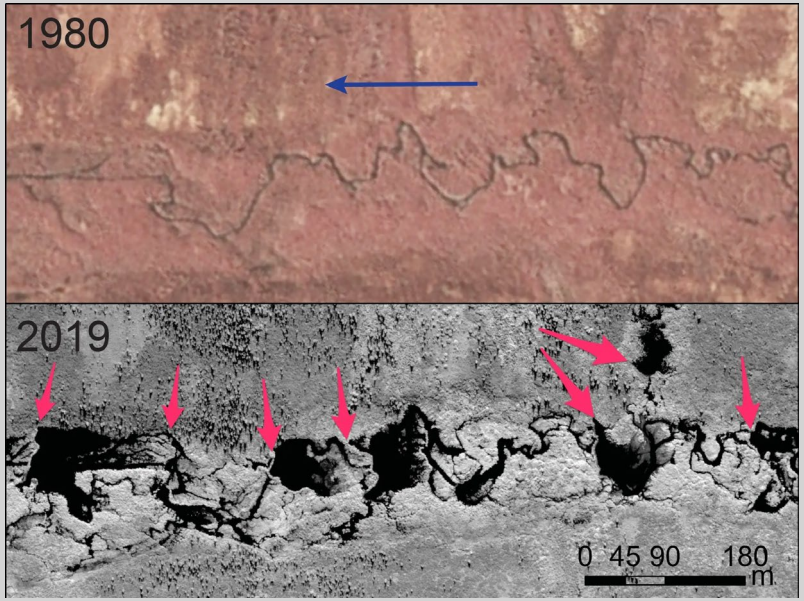
- Characterizing Widespread Disturbance from Beaver Engineering in the ABoVE Domain (PI: K. Tape)
- Hi-Res Mapping of Soil FT and ALT Trends for Improving Understanding of Permafrost Dynamics and Vulnerability (PI: J Du)
- Enhanced Methane Emissions in Transitional Permafrost Environments (PI: C. Miller)
- Role of Linked Hydrological, Permafrost, Ground Ice, and Land Cover Changes in the ABR (Q. Zhuang)

Cross-cutting themes:

- Hydrology & PF links to wildlife, disturbance, carbon, climate, LC change
- Include resolution/upscaling issues; RS, ML, mechanistic process models

Expanding beaver ponds in Arctic Alaska (1949-2019)
(K.D. Tape, et al. 2022. *Sci. Reports* 12, 7123)





Potential Synthesis Topics for Phase III (Filling knowledge & data gaps)

What's happening in deeper permafrost zones? How are changes in talik development and connectivity affecting water budgets, and 3-D flows of energy and materials?

- Relatively more is known about near-surface conditions than deeper geophysical energy and flow pathways (e.g., Walvoord and Striegl, 2021. *Front. Clim.*)
- Crosscutting with other disciplines by affecting movement and cycling of water, water quality, animal habitats, C fates, GHG emissions and climate feedbacks

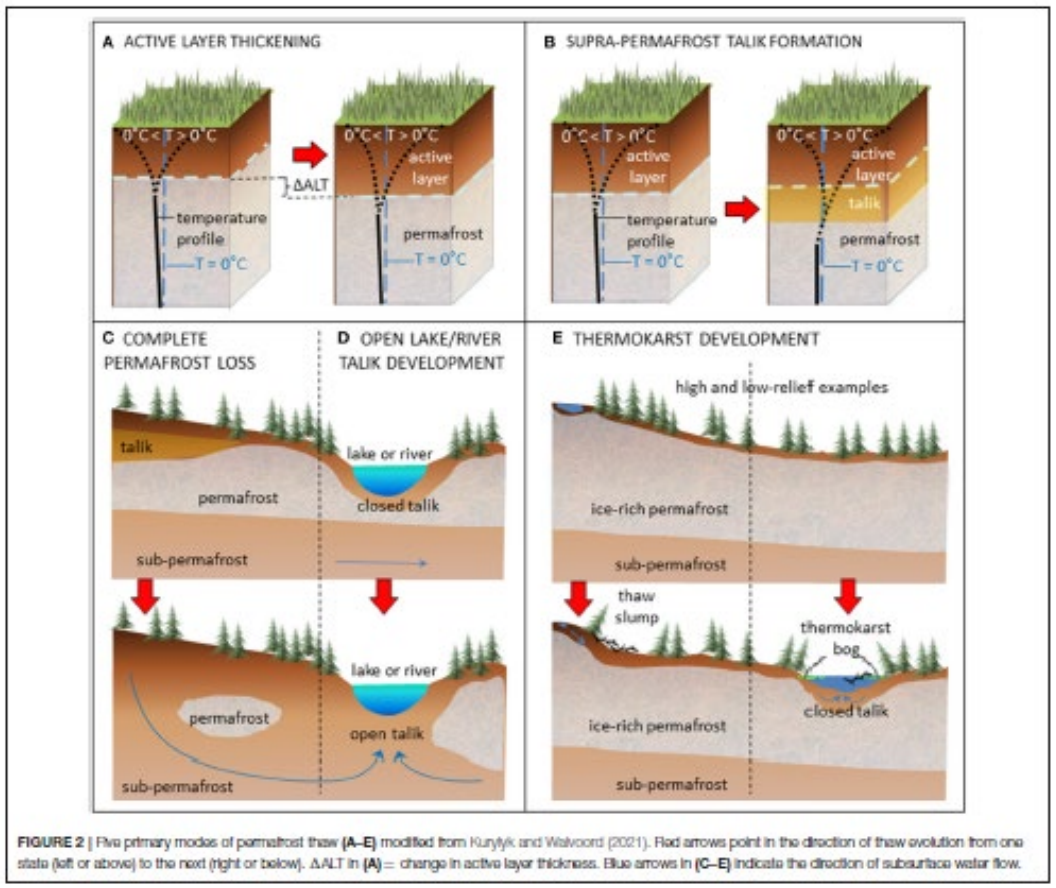


FIGURE 2 | Five primary modes of permafrost thaw (A–E) modified from Kurylyk and Walvoord (2021). Red arrows point in the direction of thaw evolution from one state (left or above) to the next (right or below). ΔALT in (A) = change in active layer thickness. Blue arrows in (C–E) indicate the direction of subsurface water flow.

Looking ahead…

- Phase II wrap-up (projects, data deliveries, synthesis activities) & transition to Phase III (current)
- New *ERL* focus issue on Permafrost Vulnerability to Climate Change (Jan-23 submission deadline)
- New satellites coming online with strong Arctic-Boreal focus:
  - SWOT (Launched 12/16/22): Surface water storage and discharge dynamics
  - NISAR (2024): permafrost, wetlands, biomass structure
- SnowEx Alaska campaign (Spring-23)
- Cross-cutting initiatives:
  - Permafrost Pathways: Adaptation & mitigation strategies addressing PF thaw
  - Q-ARCTIC: Clarify PF feedbacks with climate change
  - Arctic-COLORS: Land influence on the nearshore Arctic