

Hydrology & Permafrost WG

John Kimball (Chair, UMT),

Mark Carroll (GSFC),

Chris Derksen (Environment CN),

Mahta Moghaddam (USC), Walt Oechel (SDSU),

Stan Wullschleger (ORNL),

Elchin Jafarov (Univ. CO, INSTARR),

Franz Meyer (ASF, UAF),

Donald McLennan (CHARS),

Michelle Walvoord, Jen Rover, Burke Minsley, Neal Pastick, Brian Ebel (USGS),

Jennifer Watts (UMT),

Peter Kirchner (NPS),

Oliver Sonntag (Montréal Univ.),

Phil Marsh (Wilfrid Laurier Univ.),

Kevin Schaefer (NSIDC)

Torre Jorgenson (ABR Inc.)

Matthew Whitley (UAF)

Jon Gamon (Univ. Alberta)

Institutional Collaborations & Outreach

- Federal & state agencies
 - Multi-agency representation on HPWG: NASA, DOE, USGS, NPS, Env. CN, CHARS
 - Leverage regional monitoring networks, sampling protocols, infrastructure & outreach
 - Science value-added data products development, Cal/Val & process studies
- Local communities and Native groups
 - Local outreach from individual projects to communicate science objectives and findings
 - Leverage outreach through HPWG member agencies & infrastructure
 - Opportunities to create “indicator” maps to aid land managers/community leaders
 - Other groups, activities TBD
- Other stakeholder organizations identified
 - Interagency Arctic Research Policy Committee (IARPC) Collaborations
 - Exchange for Local Observations and Knowledge of the Arctic (ELOKA)
 - Alaska Landscape Conservation Cooperative (ALCC)
 - Imiq Hydroclimate data portal
 - Coordinate HPWG activities with ABoVE Stakeholder Engagement & Public Outreach Working Group (Larson, SEPOWG lead)

Science Questions

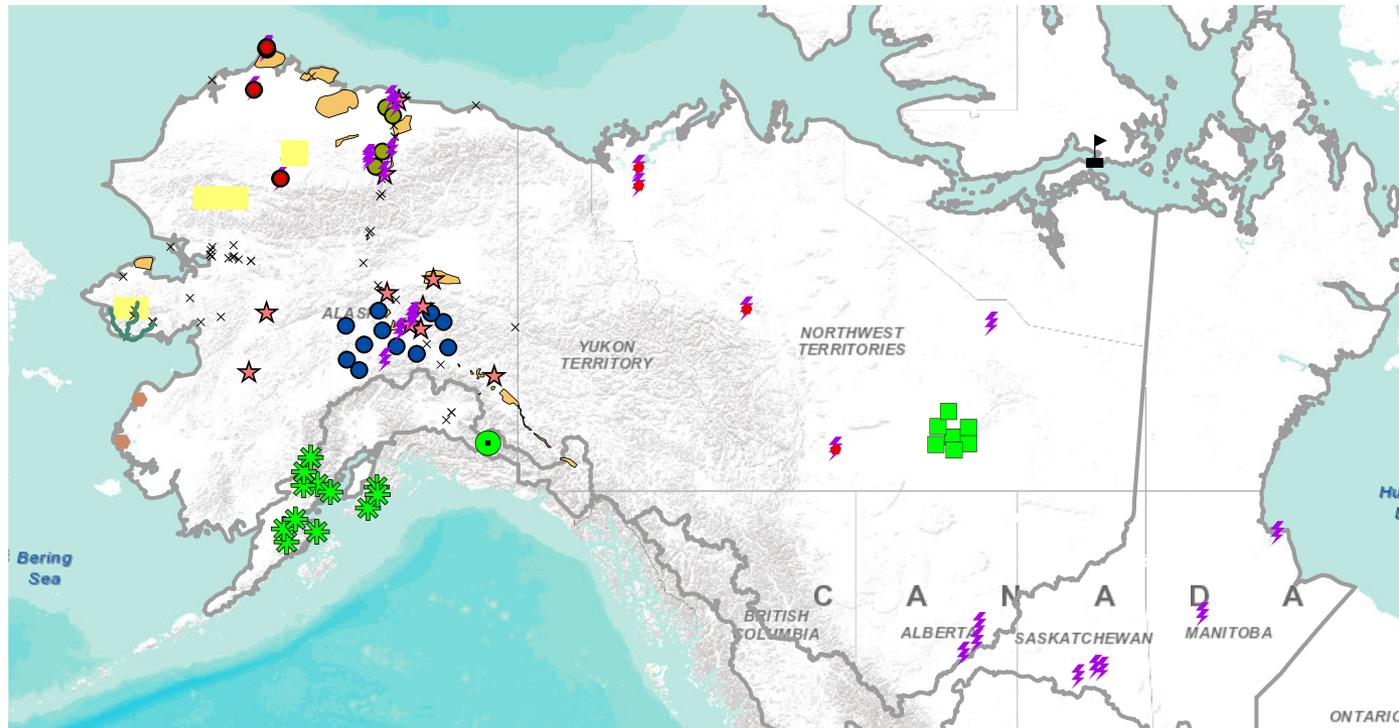
- **Where** are ecosystems experiencing accelerated rates of change in non-frozen season, ALD, PF temperature & thermokarst activity, SM, water inundation regimes & flooding, lake area, and snow & ice cover characteristics?
- **What** are the major processes controlling changes in distribution and properties of permafrost and hydrologic systems within the ABoVE domain?
- **How** are these feedbacks and changes impacting flora, fauna, carbon biogeochemistry and ecosystem services?

Incl. - veg. phenology & productivity; veg. greening/browning
- animal habitat quality & migration
- C sink/source & CO₂:CH₄ ratios; winter respiration
- human infrastructure; transportation; health

HPWG Science Objectives

- Improve understanding of processes controlling changes in distribution and properties of permafrost and hydrologic systems, including spatial/temporal patterns and controls on:
 - Non-frozen season timing & duration
 - Active layer depth, permafrost thermal profile & thermokarst activity
 - Surface soil moisture, open water inundation and lake area
 - Snow cover properties & distribution
- Investigate how recent changes in non-frozen season, active layer depth and surface hydrology are influencing vegetation greening/browning patterns, land-atmosphere carbon exchange, animal habitat & migration, transportation networks & ecosystem services
- Develop Action Plans to promote integrated data collection and analyses for the ABoVE domain
- Identify opportunities for data compilations and “big-picture” meta-analyses; this will require interacting with other WGs and research communities outside of ABoVE

Field Study Locations



- | | | |
|-----------------------------|----------------------|------------------------------|
| ♦ Kimball-04 | ● Cook-B-02 | ● Frost-01 |
| ● Moghaddam-03 | ■ Meyer-01 | □ ABoVE Domain & Core Region |
| ⚡ EC Flux Towers | ■ Bourgeau-Chavez-03 | ▬ CHARS |
| ● Schaefer-03 | ● Prugh-01 | — NGE E Seward Pen. |
| × Moghaddam-03 UAF Borehole | ★ Natali-01 | ● NGE E Barrow |
| ✱ SWAN | ■ Loboda-03 | |

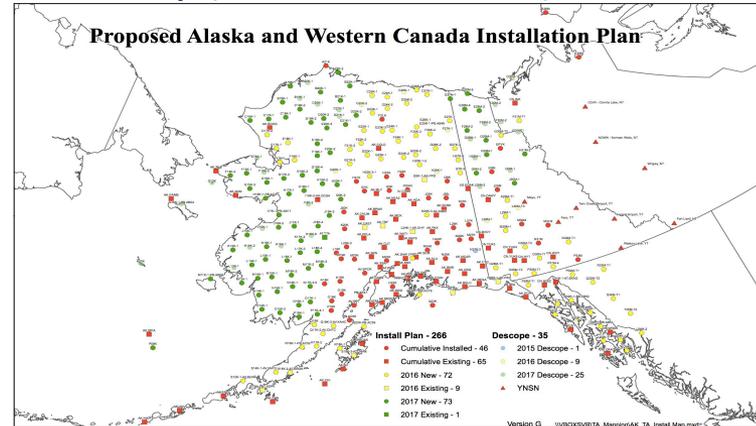
Field Studies (cont.)

- Augment ABoVE field collection with measurements provided by or in collaboration with other agencies; harmonize data collection protocols.

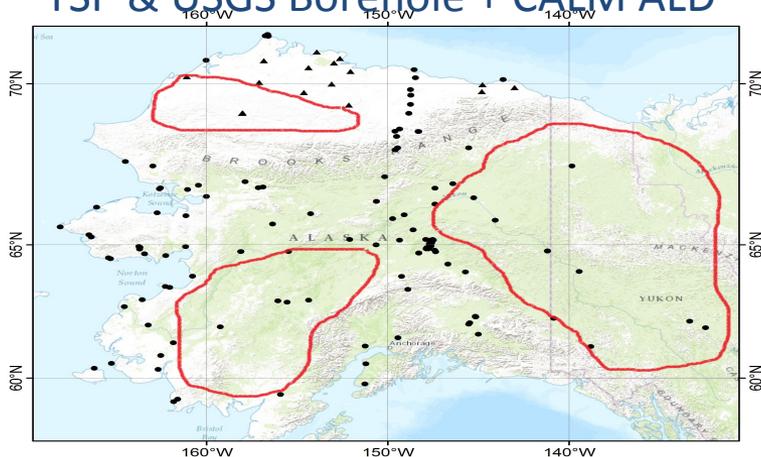
NOAA USCRN (Met; SM; ST)



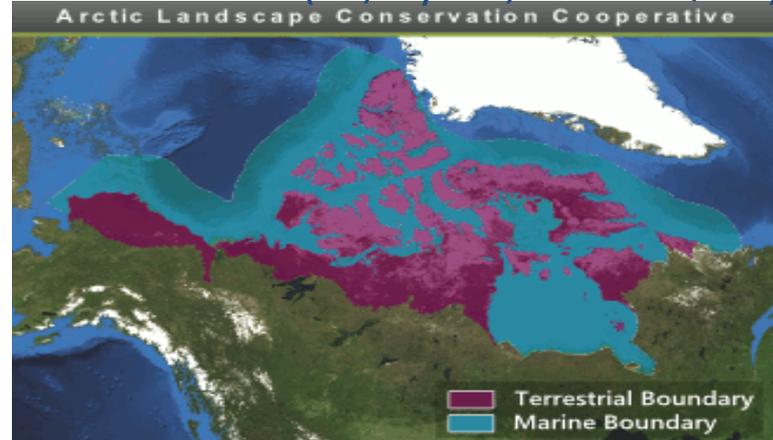
US Array (PF Thermal & ST)



TSP & USGS Borehole + CALM ALD



The Arctic LCC (PF, Hydro, Water Qual.)



Field Studies – Ground Measurements

Targeted Collection Efforts:

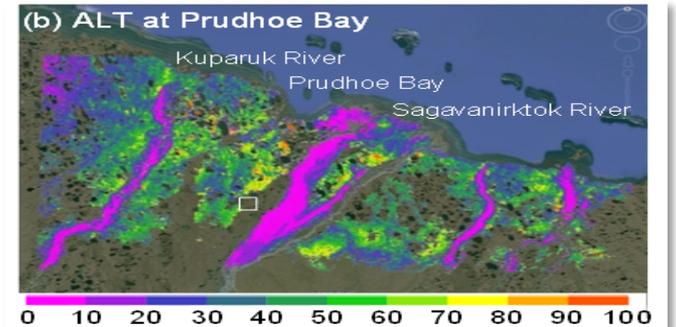
| | | | |
|------------------------|-------------------------|------------------|---------------------------------------|
| Active Layer Depth | Relative Humidity | Lake Area Distr. | Organic Layer Thickness |
| Air Temperature | Stream Flow | Precipitation | NO ₃ ⁻ Isotopes |
| Soil Temperature | Stream/Lake Temp. | Snow Depth | H ₂ O Isotopes |
| Soil Matric Potential | pH/Salinity | SWE | Ground Penetrating Radar |
| Pore Water Elec. Cond. | DOC/DIC | Surface Albedo | Magnetic Resonance |
| Water Table Depth | Aquatic CH ₄ | Solar Radiation | Electrical Resistivity Tomography |

- Field work starting summer 2016 will follow:
 - ABoVE standard protocols (TBD)
 - coordinated sampling of core data variables
 - ABoVE guidelines for data quality, formats and metadata
- Ground measurements will support process studies, Cal/Val of models, RS retrievals & data products
- Field studies combined with remote sensing & modeling for insight into key processes regulating change & to identify data/knowledge gaps

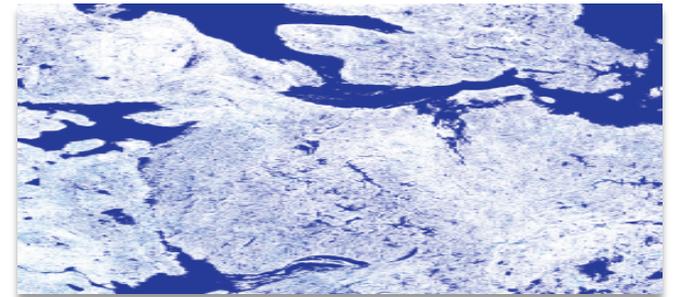
Satellite Remote Sensing

- **Satellite RS** crucial for extrapolating across domain. RS products will target & address key ABoVE science questions and objectives.
- **Products identified include:**
 - Surface freeze/thaw onset, duration, trends and anomalies
 - Active layer depth (ALD)
 - Permafrost presence/absence
 - Thermokarst features
 - Soil temperature/moisture
 - Snow cover extent & properties
 - Ground & Lake ice cover & change
 - Surface water inundation and lake bodies; water distribution change

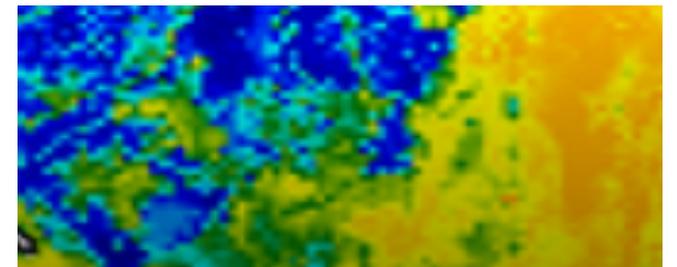
ALD Maps (L- & C-band ALOS & ERS)



Lake Body & Change Maps (Landsat)



Soil Moisture (L-band SMAP)



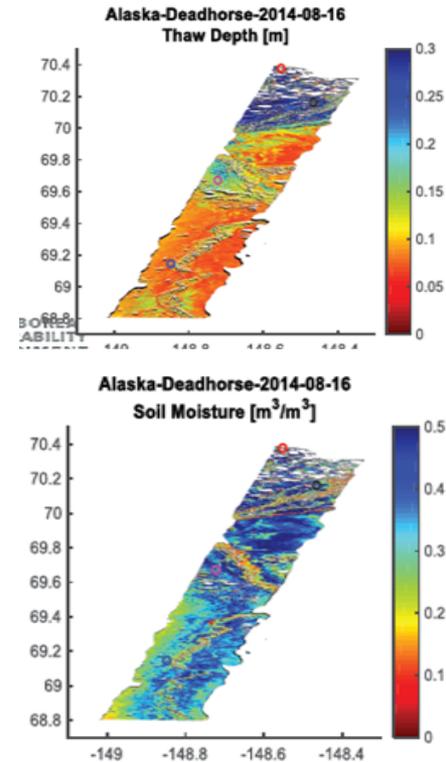
Airborne Remote Sensing

- **Used in ABoVE Phase I research:**

- *AirMOSS, UAVSAR P-/L-band* (SM; ALD; WTD; organic layer)
- *G-LiHT; NIAP; Leica ALS60* (ALD & PF related ID of land surface change & thermokarst features)
- *NISAR airborne* (Lake ice change mapping; ice hazard maps)
- *HyspIRI* (Wetland/surface water change detection & mapping)

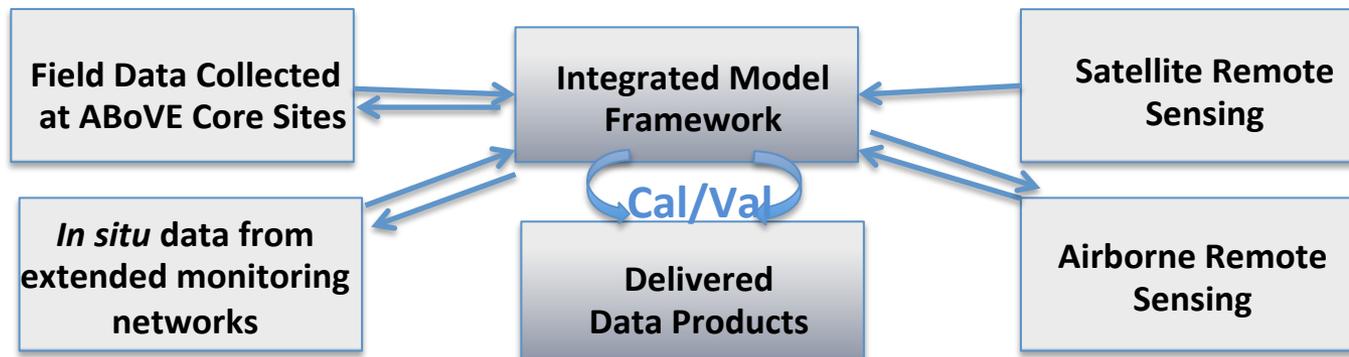
- **Airborne data needs:**

- *P-/L-band SAR* retrievals across core project & flux tower sites
- *G-LiHT & FMCW* along snow transects (pre-ICESat-2 & SnowX)
- *L-band SAR* retrievals at select lake sites to measure winter ice cover
- Joint *G-LiHT, HyspIRI/AVIRIS+MASTER, L-/P-band SAR, CARVE CO₂ & CH₄* retrievals at ABoVE core sites for integrated Hydro. , PF, & carbon research
- Increased airborne & field site representation in the YK Delta



Modeling Efforts

- **Various models identified:** InSAR FZN Ground, ReSALT, SnowModel, SUTRA, PFLOTRAN, ATS, ED, TEM, ACME/ALM, CanFIRE, TCF-PWBM, various statistical approaches, etc.
- **Required input data:** Space and airborne remote sensing, regional & local meteorology, various *in situ* measurements Incl. snow cover, soil moisture (SM), water table depth (WTD), soil and permafrost (PF) temperature, organic layer depth, onset & duration of non-frozen season, vegetation productivity, lake ice, etc.
- **Integration:** Model calibration & validation (cal/val); regional intercomparisons; improvements to model parameters & structure
- **Datasets produced:** Maps of key landscape indicators and parameters Incl. SM, WTD, surface inundation, PF & lake ice properties, thermokarst activity, snow extent & characteristics (others TBD)



Geospatial Data Products

- Products from the HPWG will target freeze/thaw (FT), active layer (ALD, ALT), thermokarst features, water table depth (WTD) surface water inundation, lake dynamics, soil moisture (SM), and snow cover properties.

| Project | Description | Spatial Extent | Temporal Coverage | Spatial Res. | Sensors Used |
|---|------------------------------------|---------------------------------------|-------------------|----------------|--|
| Surface Freeze/Thaw, PF and Active Layer Characteristics | | | | | |
| Kimball-04 | FT Trend and Anomaly Maps | ABoVE Domain | 1980-2017 | 6; 12; 25-km | AMSR; SMMR; SSMI/S; SMOS; SMAP |
| Kimball-04 | Annual ALD Maps | ABoVE Domain | 2003-2009 | 25-km | SMMR; SSMI/S; MODIS LST |
| Striegl-01 | Static ALD; sub-surface PF Maps | Alaska; Regional | 2011 | 30-m | Landsat; NIAP; G-LiHT; Leica ALS60 |
| Schaefer-03 | Surface Subsidence; ALT Maps | Sub-region, North Slope | 1991-2010 | 30; 100-m | ERS-1/2; ALOS PALSAR |
| Moghaddam-03 | ALD; WTD; SM; OLT Maps | Alaska Transects | 2014-2015 | 15; 90-m | AirMOSS; UAVSAR |
| Frost-01 | Thermokarst Maps | YK Delta Region | TBD | TBD | AVHRR; SSM/I; MODIS; Landsat; NGA; Lidar |
| Loboda-03 | ALD; Soil Temp Maps | Regional | TBD | TBD | Landsat |
| Wullschlegel-01 | Ground Ice; ALT; Soil Thermal Maps | Barrow; Seward Pen. | TBD | TBD | Landsat, etc. |
| Natali-01 | Multi-scale FT Maps | Regional | TBD | TBD | TBD |
| Surface Water Distribution & Soil Moisture | | | | | |
| Carroll-01 | Lake Extent & Change Maps | Alaska & Canada | 1991; 2001; 2011 | 30-m | Landsat; MODIS |
| Kimball-04 | Surface Inundation Maps | ABoVE Domain | 2003-2017 | 25; 5; 1-km | AMSR |
| Kimball-04/Moghaddam-03 | Soil Moisture Validation Maps | Regional | 2015 | 9-km; 15, 90-m | SMAP; AirMOSS; UAVSAR |
| Meyer-01 | Lake Change Maps; Ice Hazard Maps | Regional | TBD | TBD | ALOS PALSAR; ALOS-2; SAOCOM; NISAR |
| Cook-B-02 | Wetland/Surface Water Change Maps | Regional | TBD | TBD | Landsat; HypIRI |
| Loboda-03 | Drainage & Soil Moisture Maps | Regional | TBD | TBD | Landsat; InSAR |
| Bourgeau-Chavez-01 | SM Maps (pre & post burn); ALD | Great Slave Lake Region | 2015-2018 | TBD | PALSAR; Radarsat-2; ERS; Sentinel; SMOS; SMAP; Landsat; DigitalGlobe |
| Snow Cover Characteristics | | | | | |
| Prugh-01 | SCE; Depth; Hardness Maps | Wrangell St. Elias Region (Kennecott) | | 100-m | TBD |
| Loboda-03 | SCE; Onset; Duration Maps | Regional | | 1-km | Landsat; MODIS; ERS-1/2; Radarsat-1/2; ALOS PALSAR; ENVISAT |
| Kimball-04 | Snowpack Melt Maps | Regional | 1979-2016 | 25-km | AMSR, SMMR, SSMI/S |

Other expected products / outcomes

- Value added data products & maps (e.g lake ice hazard, flooding, thermokarst) to target data wants/needs voiced by land management agencies, land cooperatives and community organizations
- Opportunities for “big-picture” meta-analyses and data compilations to provide insight into drivers, locations, rates & impacts of environmental change across domain. *This will require collaboration with agencies, research organizations and community partners outside of ABoVE*



Potential Partnerships Beyond Those Already Part of HPWG Projects



& Others!

