Hydrology & Permafrost WG

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Matthew Whitley (UAF)
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Institutional Collaborations & Outreach

• Federal or state agencies
  – Multi-agency representation on HPWG: NASA, DOE, USGS, NPS, Env. CN, CHAR
  – Leverage regional monitoring networks (e.g. USArray, USCRN), infrastructure & outreach
  – Science value-added, including data products development, Cal/Val & process studies

• Local communities and Native groups
  – Local outreach from individual projects to communicate science objectives and findings
  – Outreach through HPWG member agencies & infrastructure
  – Opportunities to create “indicator” maps to aid land managers/community leaders
  – Other groups, activities TBD

• Other stakeholder organizations
  – 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 activities with ABoVE Stakeholder Engagement & Public Outreach Working Group (Larson)
**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
  - Snowcover 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 HPWG 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 Studies

![Map of study sites](above.nasa.gov)

### Field Measurements

<table>
<thead>
<tr>
<th>Active Layer</th>
<th>Relative Humidity</th>
<th>Lake Area Thickness</th>
<th>Organic Layer Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Temp</td>
<td>Stream Flow</td>
<td>Precip.</td>
<td>NO$_3^-$ Isotopes</td>
</tr>
<tr>
<td>Soil Temp</td>
<td>Stream/Lake Temp</td>
<td>Snow Depth</td>
<td>H2O Isotopes</td>
</tr>
<tr>
<td>Soil Matric Potential</td>
<td>pH/Salinity</td>
<td>SWE</td>
<td>GPR</td>
</tr>
<tr>
<td>Pore Water EC</td>
<td>DOC/DIC</td>
<td>Surface Albedo</td>
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</tr>
<tr>
<td>Water Table Depth</td>
<td>Aquatic CH$_4$</td>
<td>Solar Radiation</td>
<td>ERT</td>
</tr>
</tbody>
</table>

[above.nasa.gov](above.nasa.gov) @NASA_ABoVE
Cross-WG Synergies

• Synergies with other WGs:
  – Coordinated modeling, parameterization, validation & data products
    \((Modeling\ Framework\ &\ Comparisons)\)
  – Wildlife impacts from changing snow cover, winter thaw events & surface flooding
    \((Wildlife\ &\ Ecosystems)\)
  – Fire disturbance interactions with surface wetting/drying trends, altered snow regimes
    & NF seasons \((Fire\ Disturbance)\)
  – Impacts of changing surface hydrology, permafrost & ALD dynamics on NEP, C exchange
    & storage \((Carbon\ Dynamics)\)

• Data gaps / needs:
  – Integrated field data collection of critical HP variables (e.g. ALD, SM, ST, Snow)
  – Lateral movement of surface/sub-surface water & materials (DOM, C species, N, sediment)
  – Lake & river ice phenology, incl. properties, timing, duration, trends & monitoring at
    relatively fine \((<=100m\ Res.)\) spatial scales
  – Finer scale spatial Info. on snow cover properties (structure, depth, density, SWE) &
    regional snow monitoring
  – Comprehensive water budget characteristics (P, ET, Q, storages)
  – Coordination with other research activities & local knowledge: NASA Arctic-Colors
    \((Arctic-Coastal\ Land\ Ocean\ inteRactions)\) campaign; The Arctic Landscape Conservation
    Cooperative (ALLC); PaLEON \((PaleoEcological\ Observatory\ Network)\); The Interagency
    Arctic Research Policy Committee (IARPC)
Space/Airborne Remote Sensing

- Data products will target freeze/thaw (FT), active layer depth or thickness (ALD, ALT), thermokarst features, water table depth (WTD) surface water inundation, lake dynamics, soil moisture (SM), and snow properties.

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

*Text in blue indicates airborne*
Airborne Remote Sensing

Existing airborne remote sensing included in HPWG projects:

• **AirMOSS P-; UAVSAR L-band** (Moghaddam-03; Kimball-04)
  - detect seasonal ALD, SM, WTD, organic layer depth
  - data used as inputs in biogeochemical models (carbon flux maps)

• **HyspIRI** (Cook-B-02)
  - wetland/surface water change maps
    (mapping wetland species CH$_4$ emission control factors?)

• **NIAP; Leica ALS60** (Striegl-01; Frost-01)
  - thermokarst features, ALD, sub-surface PF features, landscape physical properties influencing hydro. & PF processes

• **G-LiHT** (Striegl-01)
  - detecting landscape physical properties influencing hydro. & PF properties

• Trail Valley Creek (NWT) airborne radar campaigns targeting SWE (Chris Derksen)

• NGEE and CHARS (TBD)
Modeling

- **Datasets produced:** HPWG modeling activities will provide maps of key landscape indicators and parameters for SM, WTD, surface inundation, PF & lake ice properties, thermokarst activity, snow extent & characteristics (others TBD)

- **Models identified:** InSAR FZN Ground, ReSALT, SnowModel, SUTRA, PFLOTRAN, ATS, ED, TEM, ACME/ALM, CanFIRE, TCF-PWBM, various statistical approaches

  *The HPWG has started a model table list. This can be found under ABoVE Google Docs.*

- **Model input data:** (wide range of spatial/temporal res.) satellite & airborne RS, gridded surface met & in situ measurements

- **Data gaps/needs:** Airborne P- & L-band retrievals across project and flux tower sites; Airborne LiDAR and HF-radar along snow transects; Winter L-band SAR at select lake sites; Joint LiDAR, HyspIRI/AVIRIS+MASTER, airborne SAR and CARVE CO$_2$ & CH$_4$ retrievals at ABoVE core sites; Pre-ICESat-2 retrievals at ABoVE core sites; representation in YK Delta
Completed AIP Input & Objectives for ABoVE 2A

- An initial AIP draft has been produced by HPWG members
- The following actions targeted during the 2A meeting:

  **Mature draft:**
  - field measurements table (additional input)
  - field measurement location maps (spatial coordinates needed)
  - expected datasets table (additional input)
  - expected model(s) table (additional input)

  **Identify:**
  - timing & synergies between/among WG projects & HPWG members
  - any data gaps/needs not yet included in draft AIP
  - opportunities for “big-picture” meta-analyses and data synthesis
  - opportunities for coordinated data sharing and community outreach

  **Draft:**
  - plans/requests for coordinated airborne observations (with C. Miller)