Observations from field to space: a new integrated high-latitude hyperspectral laboratory for surface water and vegetation characterization in Alaska's Arctic and boreal regions

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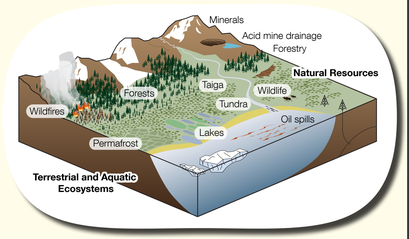
What is the HyLab?

- An NSF funded research facility at the Geophysical Institute (GI), University of Alaska Fairbanks (UAF).
- Provides low-cost, in-state field-based and airborne hyperspectral and thermal data acquisition capabilities.
- Supports data acquisition, processing, and analysis for resource exploration and ecological research (see lower box for an overview of our expertises).
- Coordinates education, training and public outreach activities related to technique and application of imaging spectroscopy.

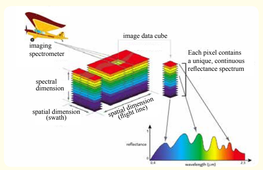


Would you like to know more?

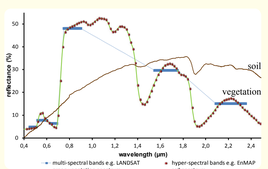
www.hyperspectral.alaska.edu

What is hyperspectral imaging?

- Also known as Imaging Spectroscopy, it is a remote sensing technique where images are acquired in many contiguous and narrow spectral regions, so that each pixel contains a reflectance spectrum.

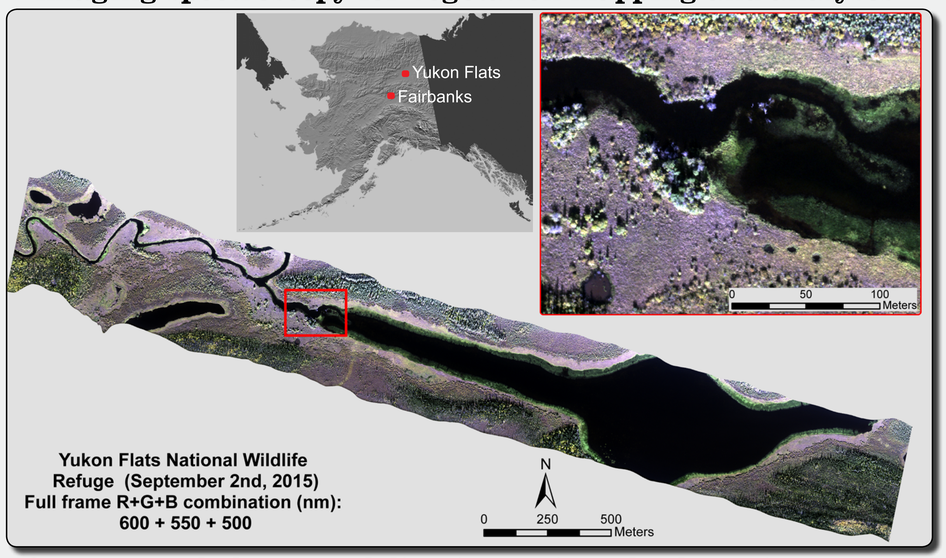


- Reflectance spectra provide the basis for the discrimination and characterization of different target materials.
- Hyperspectral imaging provides a means for detailed mapping of materials and the derivation of physical, chemical, and biological variables with unprecedented accuracy.

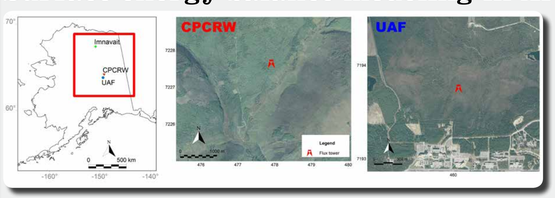


Alaska's Arctic and boreal regions, largely dominated by tundra and boreal forest, are witnessing unprecedented changes in response to climate warming. However, the intensity of feedbacks between the hydrosphere and vegetation change are not yet well quantified in the Arctic regions. This lends considerable uncertainty to predictions of how much, how fast, and where the Arctic and boreal hydrology and ecology will change. Also unknown is how vegetation change will impact water resources and climate dynamics in Arctic and boreal Alaska. With a very sparse network of observations (meteorological, flux towers, etc) in the Alaska Arctic and boreal regions, remote sensing is the only technology capable of providing the necessary quantitative measurement for surface water and vegetation monitoring from local to global scales in a feasible economic way. Over the last decades, the University of Alaska Fairbanks (UAF) has become the research hub for high-latitude research. UAFs newly established Hyperspectral Imaging Laboratory (HyLab) currently provides field observations, acquisition and processing of multiplatform airborne and satellite multispectral and hyperspectral remote sensing as well as ecological modelling to help unravel seasonal and spatio-temporal variability in surface water and energy balances and vegetation biophysical properties from local to global scales Arctic and boreal regions.

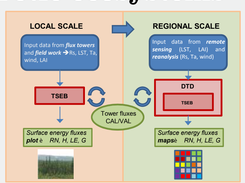
Imaging spectroscopy for vegetation mapping and analyses

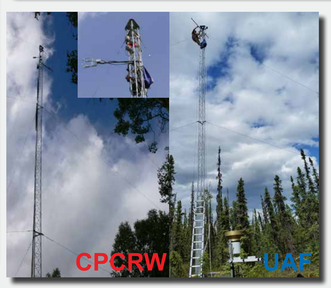


Surface energy balance modeling in Arctic and sub-Arctic ecosystems

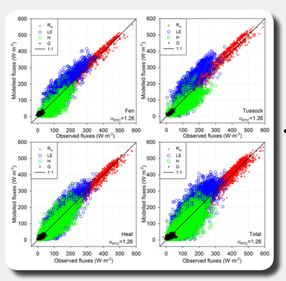


- Modeling regional surface energy fluxes in Arctic tundra (Imnavait) and Boreal forest (CPCRW and UAF) using a thermal-based remote sensing model (TSEB and DTD).





- Establishment of two flux towers in Inerior Alaska's birch (Caribou Poker Creek Research Watershed, CPCRW) and black spruce forests (University of Alaska Fairbanks, UAF).
- Data collection since 2011



- TSEB results in Imanvait AON flux towers from 2008 to 2012. Rn is net radiation, LE is latent heat, H is sensible heat and G is soil heat fluxes.

Our tools

The HySpex instrument

- VNIR-1800 and SWIR-384 cameras (400 - 2,500 nm);
- pushbroom HS cameras with low stray light levels, low sensitivity to polarization, and low smile and keystone effects;
- across track FOV of 17° and 16° respectively that can be increased to 34° and 32° (using a FOV expander).

In airborne mode the instrument:

- is mounted with a passive vibration dampening to an Aviat Husky A-1B airplane or similar airplanes (Beaver, Bushhawk, etc.);
- is connected to an IMAR iTrace RT-F400 IMU/GPS (Inertial Measurement Unit / Global Positioning System) unit;
- is controlled by a compact, high-performance data acquisition unit (DAU), connected with a 1 terabyte solid state drive and a compact, touch screen flat-panel monitor.

In the field configuration:

- the two HS cameras are mounted on an automated rotation stage affixed to a surveyors-grade tripod;
- the horizontal swaths of HS data are possible for targets at a distance of ~3 meters to hundred's meters;
- a rugged, field portable data acquisition unit is used to control the rotation stage and cameras during in-situ imaging;
- power supply is provided by a generator.

The FLIR instrument

- FLIR A325sc Infrared Camera (7.5 - 13.0 µm).
- HFOV and VFOV of 25° and 18.8°, respectively.

The PSR+3500 Spectro-Radiometer

- Fast, full-spectrum UV-VIS-NIR measurements (350 - 2,500 nm);
- high Resolution Field Portable Spectroradiometer with 512 element Si array and two 256 element extended InGaAs arrays;
- various optics ranging from 1° to 25° for reflectance, radiance and irradiance measurments.

Field-based operation:

- the PSR+ spectro-radiometer is powered by batteries and connected to a rugged PDA which provides GPS, photo tagging, and voice notes;
- our self-developed software allows in-field mineral identification and classification;
- usage of handheld contact probe allows field measurements on outcrops or mapping open pits even at cloudy conditions.

Laboratory operation:

- high signal-to-noise ratio for improved reflectance values by using full-range tungsten lamps;
- detailed analysis of field samples in order to build Arcitc spectral libraries from natural covers.

The National Science Foundation (NSF) Major Research Instrumentation (MRI) Program, funded the University of Alaska Fairbanks (UAF), to establish hyperspectral imaging capabilities in the State of Alaska **(NSF grant number 1338193)**. The MRI enables UAF to establish a new capability in airborne hyperspectral imaging that has not previously existed, and inherently opens doors to new basic and applied research, and research training. Surface energy balance research activities are based in part upon work supported by the Alaska NASA EPSCoR Program (projects NNX13AB28A and NNX10AN02A). We also want to acknowledge the support of Alaska EPSCoR NSF award #OIA-1208927 and the state of Alaska.