HyspIRIs Role in Hydrological Investigations in the Alaskan Arctic Foothills: A Conceptual Drainage Basin Representation

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I. Introduction

Assessing the hydrological regime in the Alaskan Arctic is challenging given its large area and very sparse ground observation instrument network. As ground data alone can not be used to characterize the landscape ecology, plant phenology, ground thermal regimes, and atmospheric processes, there is a need to rely on remote sensing data and models to understand these processes and their complex feedback mechanisms.

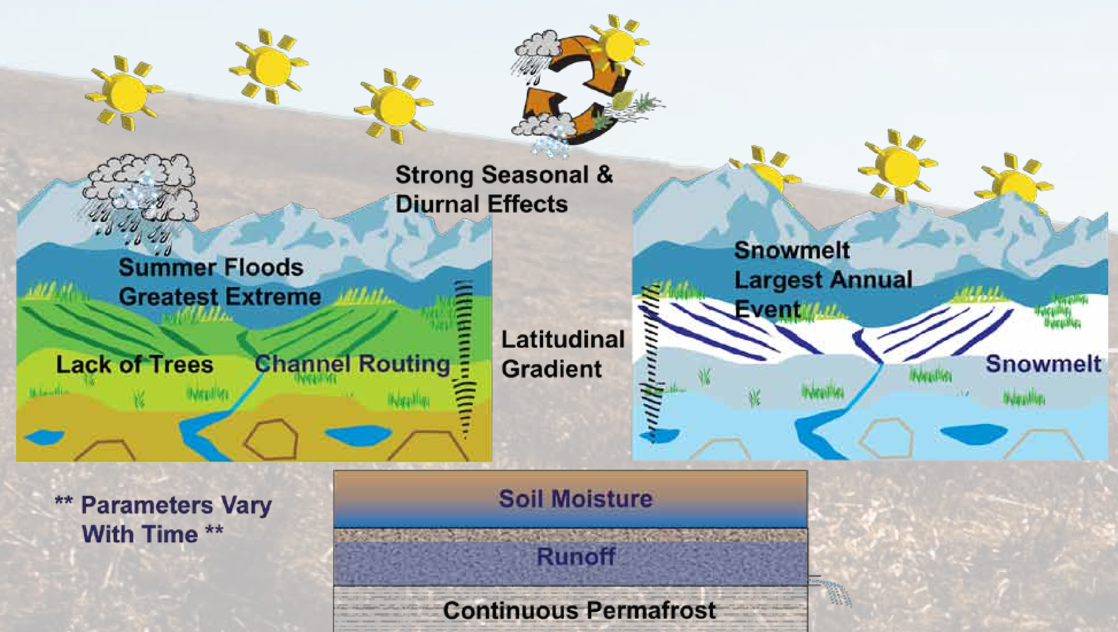
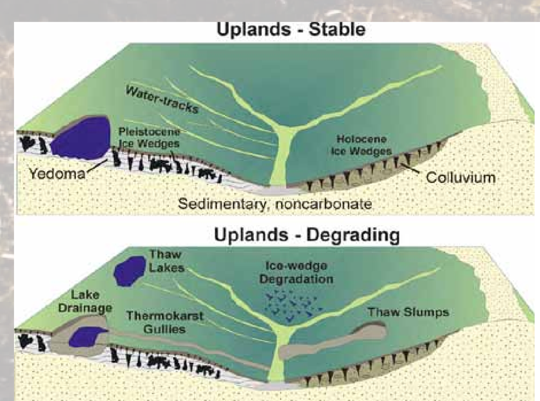


Figure 1: Basic components of Alaskan Arctic hydrology (Trochim, 2009)



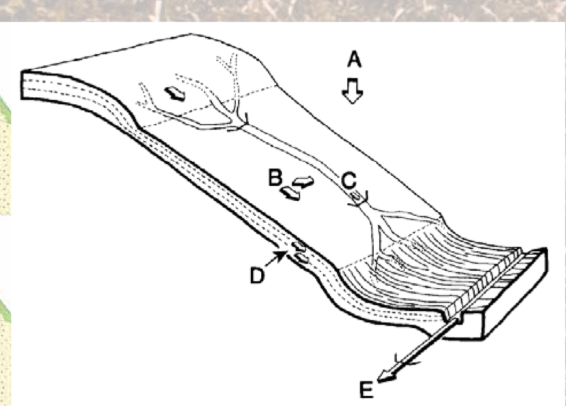


Figure 2: Evolution of permafrost and drainage basins in the foothills of the Alaskan Arctic (Martin et al., 2008)

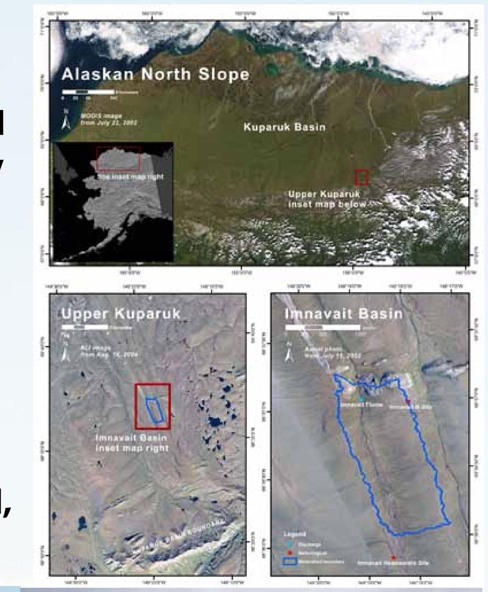
Figure 3: Idealized section of tundra showing (A) atmospheric input, (B) overland flow, (C) water-track flow, (D) active-layer flow, (E) channel flow (Everett et al., 1996)

Of the medium to coarse resolution satellite data, AVHRR, MODIS, Landsat and ASTER are the most commonly available data sets. AVHRR and MODIS with their 1 km spatial resolution in the thermal region have limited use to effectively tie hydrological processes like precipitation patterns, soil moisture regimes, evapotranspiration rates and differences in subsurface water storage to the ecological regimes. Landsat and ASTER, despite a higher spatial resolution, lack the spectral granularity to charaerize the diverse vegetation, especially the spectral variability in the extensive moss cover in the Arctic and the senescence of shrubs. The restricted temporal resolution of Landsat and ASTER poses additional limitations.

Table 1: Current NASA satellites capable of remotely sensing the VIS/NIR/SWIR/MIR/TIR spectrum for environmental studies (EO-1 user guide, 2003)

Spacecraft/Instrument	Landsat-7 / ETM+	EO-1/ALI	Terra/ASTER	EO-1/ Hyperion
Spectral Range	0.4-2.4 10.7-12.7 microns	0.4-2.4 microns	0.5-0.9 1.6-2.4 8.1-11.7 microns	0.4-2.5 microns
Panchromatic Bands	1	1	0	0
Visible Bands	3	6	2	35
Near Infrared Bands	1	2	2 (stereo)	35
Short Wave Infrared	1	1	1	172
Middle Infrared Bands	1	1	5	0
Thermal Band	1	0	5	0
Spatial Resolution	15, 30, 60 m	10, 30 m	15, 30, 60 m	30 m
Swath Width	185 km	37 km	60 km	7.5 km
Spectral Coverage	Discrete	Discrete	Discrete	Continuous
Pan Band Resolution	15 m	10 m	N/A	N/A
Stereo	no	no	yes	no
Number of Bands	7	10	14	220
Number of Spacecraft	1	1	1	1
Temporal Resolution	16 days	16 days	16 days	200 days

II. Drainage Basin Example



Methods: The Imnavait basin is part of the Toolik Lake long-term ecological research area, and has been instrumented and studied since 1985. Based on vegetation classification by Walker et al. (1996), analysis of the drainage network by Everett et al. (1996) and McNamara et al. (1997), and general hydrology based on Hinzman et al. (1996) a conceptual model was developed to represent potential uses of the HyspIRI sensor in hydrological application in the basin.

Anaysis: Five primary types of sites were chosen based on a combination of vegetation & hydrologic characteristics. A) Well-developed water track: riparian shrub complex, increased transpiration/insulation, preferential water movement; B) West-facing hillslope: shrub tundra, frost stripes, increased snow deposition in winter; C) Basin bottom: rich fen complex, saturated soil conditions, beaded stream network; D) East-facing hillslope: moist acidic tundra complex, intermittent water tracks, wind-transport of snow in winter; E) Ridge top: dry acidic tundra, well-drained soil, frost stripes

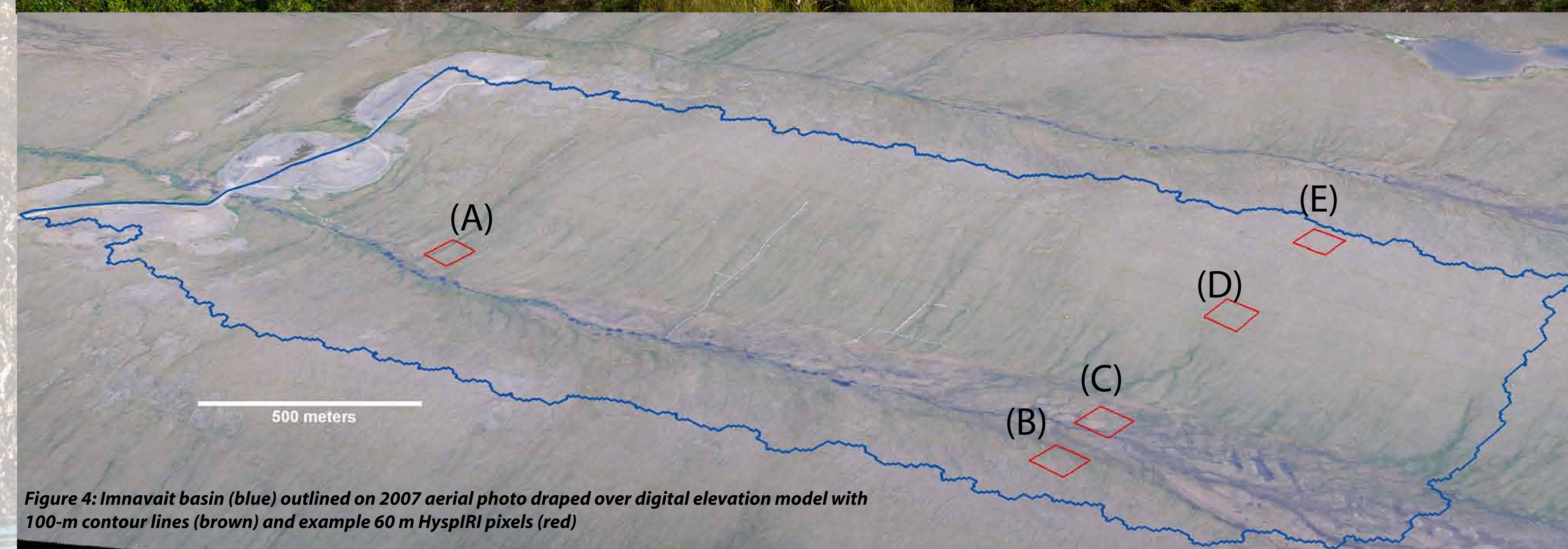


Figure 4: Imnavait basin (blue) outlined on 2007 aerial photo draped over digital elevation model with 100-m contour lines (brown) and example 60 m HyspIRI pixels (red)

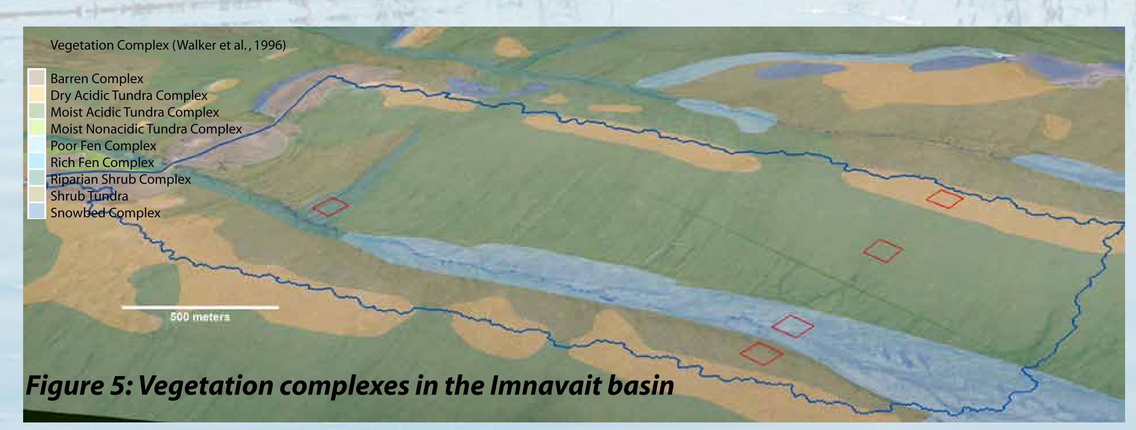


Figure 5: Vegetation complexes in the Imnavait basin

Figure 6: ASD spectrometer set-up

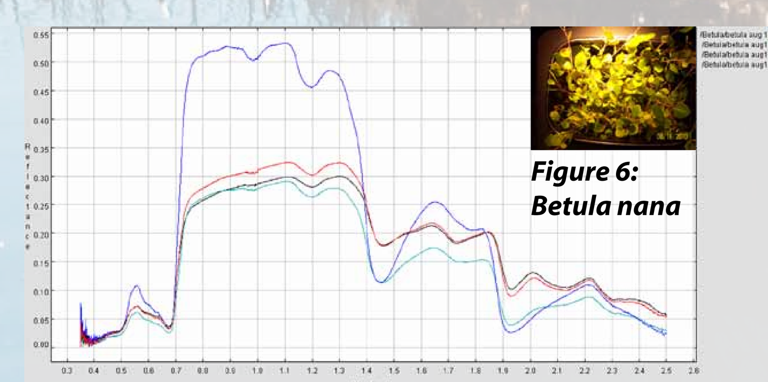


Figure 6: Betula nana

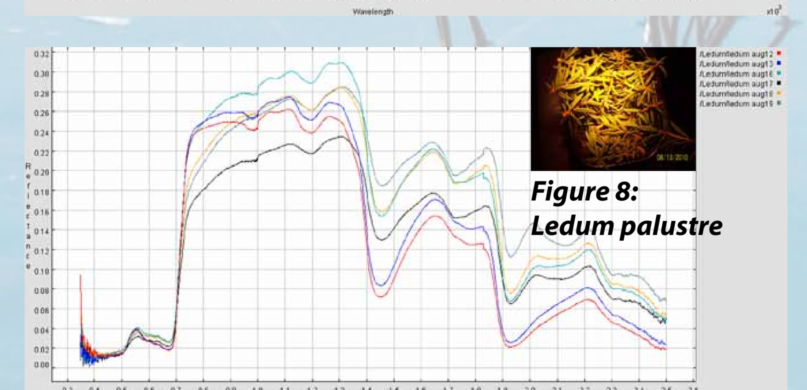


Figure 8: Ledum palustre

Methods: An ASD spectrometer was used to measure the reflectances of different vegetation types. On each day, five different measurements (averaged over 30 seconds) at different orientations were averaged. A bare fiber (~25˚ look-angle) was used and maximized heterogeniety over the sample under a full-spectrum UV light. For the shrubs (*Betula nana & Ledum palustre*) the measurements were taken within half an hour of collection, and then incrementally every 24 hours. For the mosses (*Aulacomnium palustre, Hylocomium spendens & Sphagnum angustifolium*) the samples were artificially wetted with 200 mL of water and measured, and then re-examined every 24 hours after air-drying (moss does not have stomal control during the transpiration process).

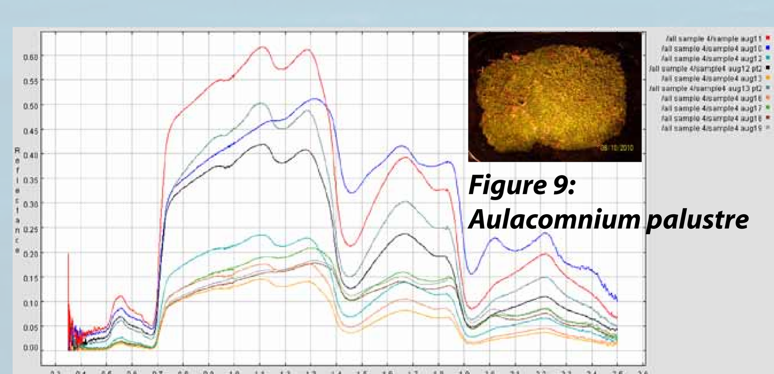


Figure 9: Aulacomnium palustre

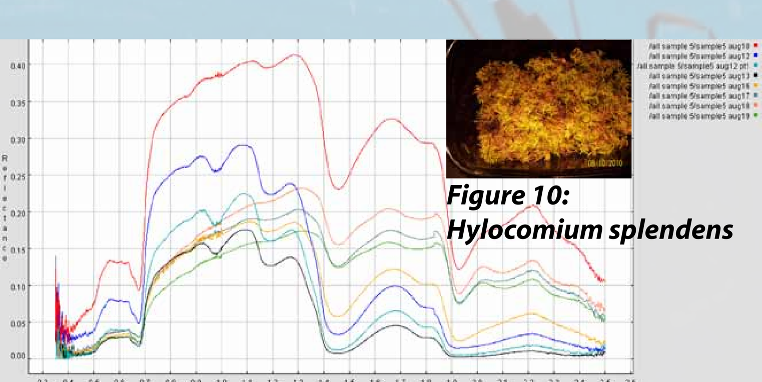


Figure 10: Hylocomium splendens

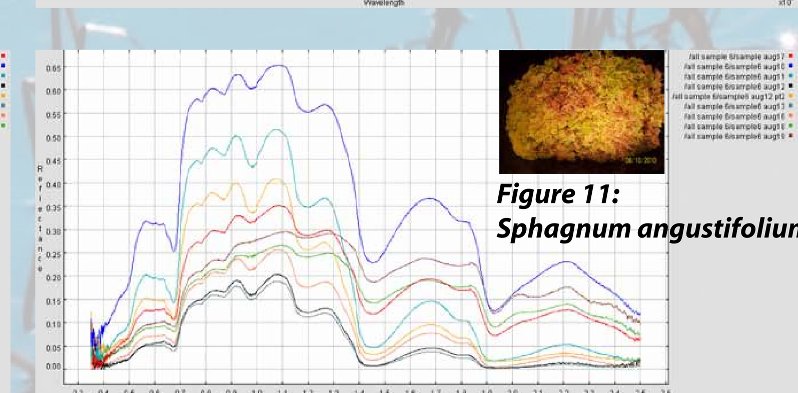


Figure 11: Sphagnum angustifolium

III. Conclusions & Recommendations

Hydrologyical systems in the Alaskan Arctic, in particular small ungaged watersheds will benefit from the application of HyspIRI VSWIR & TIR data to better understand the patterns and processes of vegetation senescence, the linkages to evaporation & transpiration rates, and moisture dynamics within a basin. The spectral resolution of the VSWIR sensor will be useful for better delineating shrub and moss qualities and distribution. If the temporal resolution of the data in this region can be maximized, there is great potential to examine the seasonal variations of these processes.

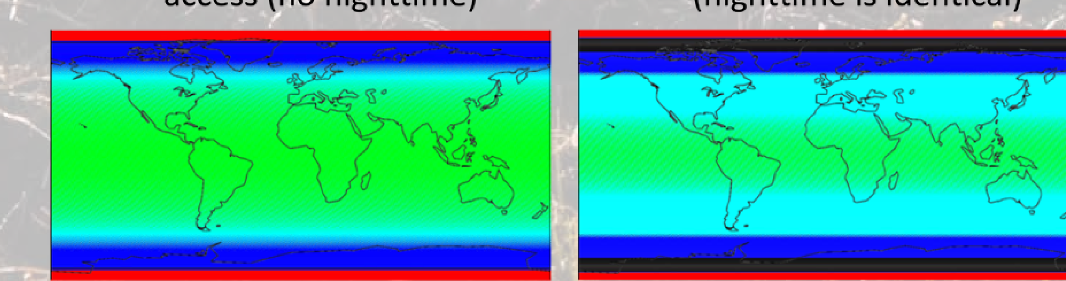
The HyspIRI satellite will provide an interesting and useful data product when examining the linkages between hydrology and vegetation. In the Arctic this will be a particularly valuable asset to scientific research in these areas.

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Complete Equatorial Coverage

Number of daytime VSWIR access (no nighttime)

• Number of daytime TIR access (nighttime is identical)



Revisit Requirement	VSWIR	TIR
Not Met	0	< 4
Met	1	4
Met, exceeded up to 2 times	2	4 to 8
Met, exceeded 2 to 4 times	2 to 19	8 to 19
Met, Daily opportunity	≥ 19	≥ 19

Effects of Sun illumination and clouds are not included.

Figure 12: Temporal resolution of HyspIRI sensor (HyspIRI Workshop, 2009)

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