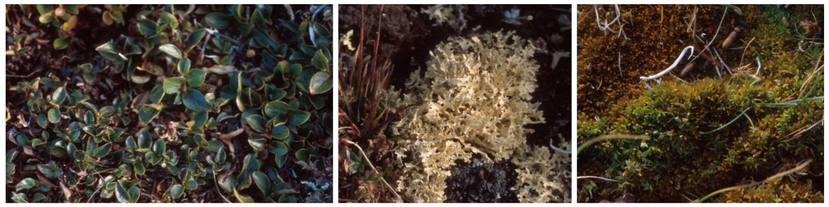
Remote Sensing of Tundra Vegetation in the Alaska North Slope

Karl F. Huemmrich[a,b], Sergio A. Vargas Z.[c], Petya P.K. Campbell[a,b], Craig Tweedie[c], Elizabeth Middleton[b]
[a]University of Maryland Baltimore County; [b]Code 618, Goddard Space Flight Center, Greenbelt, MD, USA,
[c]University of Texas El Paso, El Paso, TX



Vascular Plants | Lichens | Mosses

Introduction

In 2017 NASA's The Arctic-Boreal Vulnerability Experiment (ABoVE) collected is a unique set of Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS NG) spectral imagery of high latitude ecosystems providing the opportunity to examine the information content of imaging spectrometer data to study an array of characteristics of tundra landscapes. Algorithms utilizing the AVIRIS spectral information were developed to extend localized ground measurements to the region by applying them to the aircraft imagery. Distributions of plant functional type coverage, chlorophyll content (Chl), and gross primary productivity (GPP) for three study areas along a north-south transect on the Alaskan North Slope are derived from the hyperspectral imagery. These characteristics are compared with Normalized Difference Vegetation Index (NDVI) values to guide the interpretation of this index in tundra landscapes.

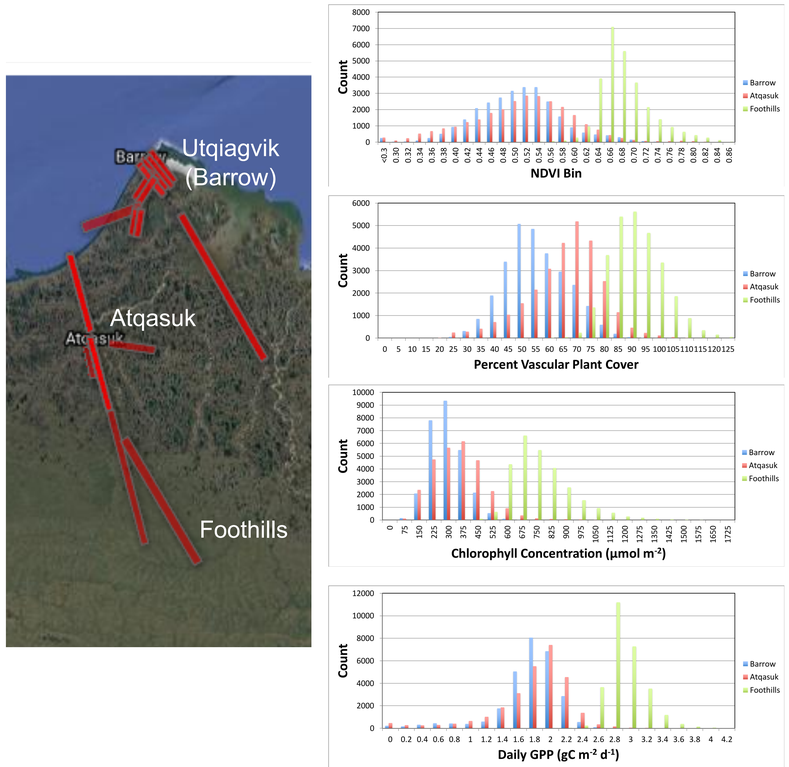
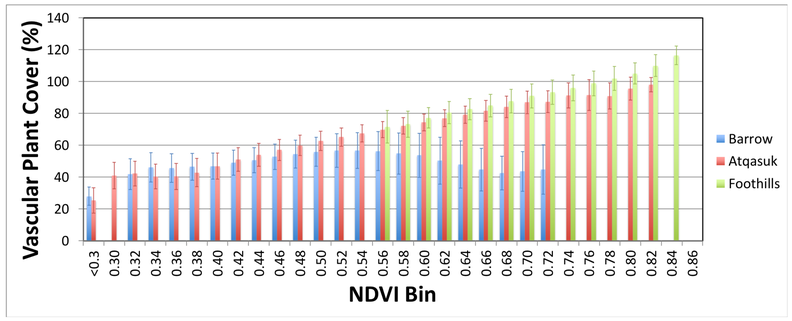
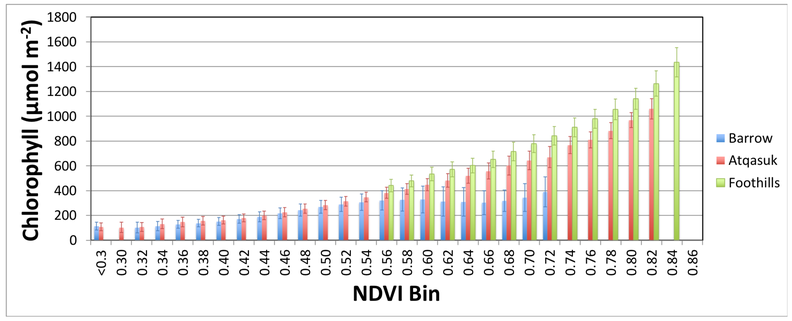


Figure 1. Three study areas were chosen along a N-S transect: Utqiaġvik (Barrow), Atqasuk, and the southernmost of the AVIRIS NG North Slope flightlines, called Foothills. AVIRIS NG fightlines from 2017 and site locations are shown in left figure. At each site 27,803 5x5 m pixels were extracted (~70 ha). Vascular plant cover, GPP, and Chlorophyll Concentration were calculated from AVIRIS NG spectral reflectances using coefficients derived from Partial Least Squares Regressions on ground measured training data collected in Utqiaġvik and Atqasuk. Histograms of these variables along with NDVI for the three sites are shown in the figures on the right.

NDVI and Ecosystem Variables

NDVI has been widely used to reveal patterns of change for tundra in the form of greening and browning trends. The precise ecological meaning of changing NDVI is presently not clear. For the three study sites the values of Vascular Plant cover, Chlorophyll, and GPP derived from AVIRIS NG hyperspectral data have been binned by the pixel's NDVI values (Figure 2).





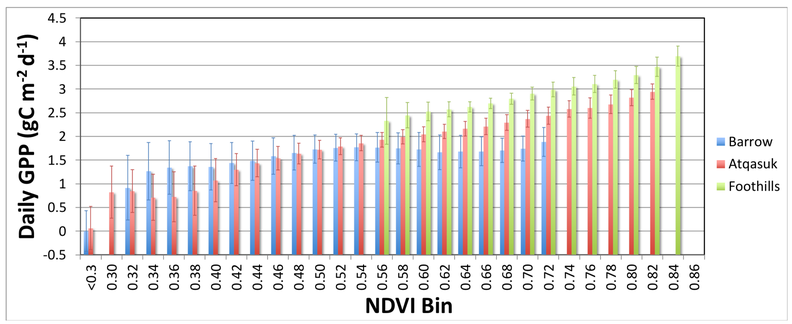


Figure 2. Average values of vascular plant cover, chlorophyll content, and GPP for pixels within 0.02 NDVI bins for the three study areas (Figure 1). Error bars are ±1 standard deviation.

Generally, increasing NDVI relates to increasing values of the variables, however for NDVIs beyond 0.58 in the Barrow region the values remain flat or decrease. Also, for Chl and GPP at the Atqasuk and Foothills sites, there are statistically significant differences in the variable values for the same NDVI values.

Mapping

AVIRIS NG imagery are used to map the area around Utqiaġvik, covering the Barrow Environmental Observatory (Figure 3).

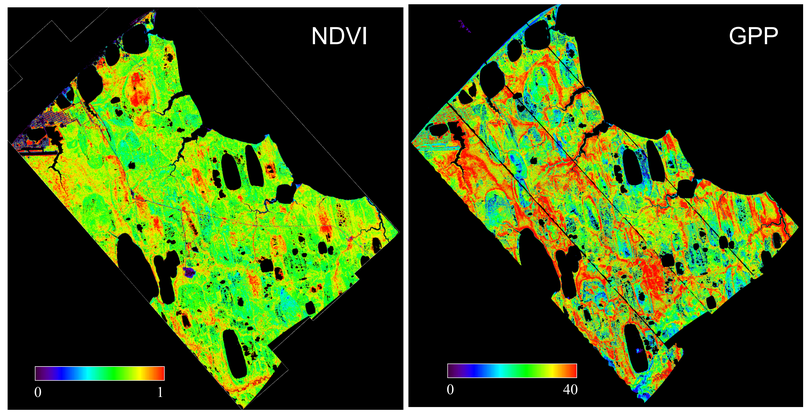


Figure 3. Maps of NDVI (left) and GPP (right) derived from AVIRIS NG imagery for the region near Utqiaġvik (Barrow) for July 9 and 14, 2017.

Phenology

The AVIRIS NG imagery were collected during green-up for these sites, therefore some site differences are due to different timings of seasonal change. Green-up rates were evaluated using ground measured NDVI over 50 m transects collected during springs of 2011-2017 in Utqiaġvik and Atqasuk. Accumulated Growing Degree Days (GDD) were calculated from DAYMET air temperatures (daymet.ornl.gov). The best fit over all of the data used daily maximum air temperature with a base temperature of -3° C in the GDD calculation.

Site	Date of AVIRIS NG Overpass	GDD	Fraction of green up
Barrow	7/9/17	355.0	0.34
	7/14/17	424.0	0.44
Atqasuk	7/9/17	593.0	0.69
	7/14/17	683.5	0.83
Foothills	7/9/17	813.5	1.02
	7/14/17	920.5	1.18

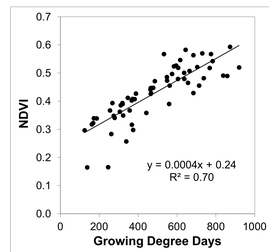


Figure 4. Calculated values of accumulated GDD for the overpass days for each site and the estimated fraction of green-up, i.e. the time from start of growing season to summertime NDVI values, based on air temperatures. The relationship between springtime NDVI and accumulated GDD from ground measurements shown in plot on right.

Acknowledgments

The authors wish to thank Robert Hollister and Steve Oberbauer for their teams' efforts making the field measurements.
This work is supported by NASA grant NNX17AC58A.