North Slope Science Field Report 2000

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I. Airborne Imaging Activity

Two different airborne imaging campaigns were conducted over the North Slope in Summer 2000. In addition to image acquisition activities, substantial effort was put into modifications of the imaging systems.

A. Validation of NOAA AVHRR Greenness Products

Very high spatial resolution multispectral digital images (Kodak DCS camera) were acquired to support analyses of spatial-temporal patterns of greenness derived from NOAA Advanced Very High Resolution (AVHRR) normalized difference vegetation index (NDVI) data sets. Transects were selected to cross a range of apparent hot and cold spots of cumulative seasonally integrated NDVI (SINDVI). DCS images will be processed to estimate the fraction of shrub cover within sample areas, to test the hypothesis that hot spots of greenness accumulation derived from AVHRR data correspond to areas having higher shrub abundance.

A DCS 420 CIR imaging system was operated on a Cessna 185 along six E-W trending transects varying between 146:18:10 W and 151:24:17 W long. The DCS system is owned and operated by SDSU and is composed of a digital camera and laptop computer. The system captures digital images with a single solid state array in color infrared (CIR) or true color formats. We operated the system in the CIR mode. The aircraft is owned and was operated by Tom George of Terra-Terpret of Fairbanks, AK. By flying at 1066 m above ground level, images were captured with a ground sampling distance (GSD) equal to 0.5 m.
Images were captured at 10 second intervals at a ground speed of approximately 50 m/sec. to achieve a spacing of approximately 500 m between image frames. Thus the transects were sub-sampled and continuous strips or mosaics cannot be generated. The specific transects (flightlines) and general time of imaging were as follows:

Lines 1 & 2 (W-SW from Deadhorse) -- Early evening 27 July 2000
77km each
70:13:38 N, 151:05:47 W to 70:10:36 N, 149:01:14 W
70:08:05 N, 151:14:22 W to 70:06:29 N, 149:05:54 W

Lines 3 & 4 (E of Deadhorse into the ANWR) -- Late morning 28 July 2000
84km each
69:44:07 N, 146:22:43 W to 69:43:22 N, 146:18:10 W
69:44:57 N, 146:42:48 W to 69:39:39 N, 146:21:10 W

Lines 5 & 6 (W-NW of Toolik Lake) -- Early afternoon 28 July 2000
97km each
68:53:24 N, 151:22:21 W to 68:50:54 N, 149:14:48 W
68:46:57 N, 151:24:17 W to 68:44:14 N, 149:10:53 W

We were extremely fortunate to have mostly cloud free weather conditions at the beginning of our limited window of opportunity for imaging. Patchy clouds and associated shadows were present within the sensor field-of-view for lines 3 and particularly 4. Some high cirrus clouds affected imaging conditions for lines 1 and 2. Lines 5 & 6 can be considered "golden."

Inspection of image displays and histograms of selected digital image frames from each transect/flight line show that the dynamic range of image brightness values was optimal within the capability of the DCS CIR system with minimal saturation of pixels. We are currently developing batch processing procedures for the 1000+ frames that were captured. The necessary processing steps for the single-chip array of the DCS CIR camera are to unmix multiple waveband contributions to the at-sensor radiance, and to interpolate values recreating the near infrared, red and green bands from which NDVI is derived.

B. Calibration/Validation at Eddy Flux Tower Sites

The SDSU Airborne Data Acquisition and Registration (ADAR) System 5500 is a true multispectral imaging system that operates on aircraft and images in the visible and near infrared portion of the spectrum. After learning from tests conducted summer 1999 that an automated, non-operator mode is less than ideal for image capture, modifications were made spring and early summer 2000 to minimize the size and weight of the four camera imaging system. Upon completion of these modifications in mid-summer, the system is now small and light enough to enable an operator to fit on-board the SDSU Sky Arrow aircraft within weight and balance specifications.

The plan for Summer 2000 was to capture complete image coverage of the flux tower footprints at Barrow and Atqasuk and mostly complete coverage of the flux aircraft footprint between Barrow and Atquasuk. Due to continual, low stratus cloud cover throughout the end of July and most of August, the first opportunity to fly the Sky Arrow at reasonable altitudes for digital imaging (1000 - 3000 m above ground level) was not until August 31, 2000. Only coverage of the Barrow tower footprint coverage was possible. Images were captured with a GSD = 0.5 m and 1 m from altitudes of 1066 m and 2130 m AGL respectively. Imagery was acquired at 10 second intervals along nine separate flightlines used for testing the system and panel calibration as well as data gathering. Subsequently, the Barrow tower images have been band-to-band registered. Georeferencing, and stitching of the ADAR images into a mosaic is underway.

II. Energy Balance Measurement Activity

An examination of thermal infrared data collected using satellites (NOAA-AVHRR) and the flux aircraft over the past two years has indicated that the apparent contrast in vegetation-soil surface temperature is a major determinant of thermal emission spatial patterns. Greater vegetation density leads to larger thermal emissions because the cold soil background is obscured from the instantaneous field-of-view of the sensor. We hypothesize that the soil-vegetation temperature gradient also creates a temperature inversion below the top of the vegetation canopy. The resulting stable conditions in this layer are likely to affect the soil-vegetation-atmosphere transfer of energy and water vapor.

We have hypothesized that the soil-vegetation contrast is greater under clear skies (high insolation) than on cloudy days when diffuse radiation penetrates the canopy and the lower radiation loads result in less warming of the plant elements. If this hypothesis is valid, then satellite observations of thermal emissions and their relation to the surface energy balance will be biased to the infrequent clear sky days.

Temperature Profile Measurements

In order to test the inversion hypothesis outlined above, we mounted six type T thermocouples with radiation shields at various heights from the surface along a mobile 1 meter tower platform. The measurement heights were adjustable in order to ensure that temperatures were measured at ground level, within the canopy, at the canopy height, and above the canopy. Temperature measurements were taken over a two-week period in Barrow, Atquasuk, and along the Dalton Highway:

July 19-24 and 26th, 2000-Continuous day and night time measurements
Barrow: Mosses and lichens, dry tundra, wet tundra, and barren

July 25, 2000 -Daytime measurements
Atquasuk: Low shrub, small tussocks, wet tundra, and dry tundra

July 30, 2000 -Daytime measurements
Kuparuk River Watershed: Shrub and tussock tundra
At Barrow, four sampling sites were chosen that represented the major components of the flux tower footprint including dry tundra, wet tundra, mosses and lichens, and barrens. Measurements were made continuously through both cloudy and cloud free conditions for a period of five days. Additional measurements within other vegetation types including small tussocks, low shrubs, and wet tundra were made within the eddy flux tower footprint at Atquasuk. The final sets of measurements were made along the Dalton Highway between Prudhoe Bay and Toolik Lake in the Kuparuk River watershed in areas of shrub and more developed tussock tundra (compared to the tussocks at Atquasuk). From our preliminary analysis it appears that a temperature inversion does exist under sunny conditions, typically at the height and/or within the vegetation canopy. Currently we are investigating the significance of the inversion on both sensible and ground heat flux and examining what temperatures are driving these fluxes.

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Shrub and tussock tundra