You are cordially invited to attend the Dissertation Defense of ESE PhD Candidate

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Date: Tuesday November 29, 2011
Time: 3:00 p.m.
Location: Bioscience Room 2.168

MONITORING ECOSYSTEM DYNAMICS IN AN ARCTIC TUNDRA ECOSYSTEM USING HYPERSPECTRAL REMOTE SENSING AND A ROBOTIC TRAM SYSTEM

ABSTRACT

Global change, which includes climate change and the impacts of human disturbance, is altering the provision and sustainability of ecosystem goods and services. These changes have the capacity to initiate cascading affects and complex feedbacks through physical, biological and human subsystems and interactions between them. Understanding the future state of the earth system requires improved knowledge of ecosystem dynamics and long term observations of how these are being impacted by global change. Development of remote sensing methods is a key to such advancement because satellite remote sensing is the only feasible means by which landscape to continental-scale change can be observed.

The Arctic appears to be impacted by climate change more than any other region on Earth. Arctic terrestrial ecosystems comprise only 6% of the land surface area on Earth yet contain an estimated 25% of global soil organic carbon, most of which is stored in permafrost. If projected increases in plant productivity do not offset losses of soil carbon to the atmosphere as greenhouse gases forecast with warming, regional to global greenhouse warming could be enhanced. Soil moisture is an important control of land-atmosphere carbon exchange in arctic terrestrial ecosystems. However, few studies to date have examined using remote sensing, or developed remote sensing methods for observing the complex interplay between soil moisture and plant phenology and productivity in arctic landscapes. This study was motivated by this knowledge gap and addressed the following questions as a contribution to a large scale, multi-investigator flooding and draining experiment funded by the National Science Foundation near Barrow, Alaska (71°17′01″ N, 156°35′48″ W):

- Can optical remote sensing be used to monitor the surface hydrology of arctic landscapes?
- What are the spatio-temporal dynamics of land-surface phenology (NDVI) in the study area and if hydrological treatment has any effect on inter-annual patterns?
- Is NDVI a good predictor for aboveground biomass and leaf area index (LAI) for plant species that are common in an arctic landscape?
How can cyberinfrastructure tools be developed to optimize ground-based remote sensing data collection, management and processing associated with a large scale experimental infrastructure?

The Biocomplexity project experimentally manipulated the water table (drained, flooded, and control treatments) in a vegetated thaw lake basin to investigate the effects of altered hydrology on land-atmosphere carbon balance. In each experimental treatment, hyperspectral reflectance data were collected in the visible and near IR range of the spectrum using a robotic tram system that operated along a 300m tramline during the snow free growing period between June and August 2005-09. Water table depths (WTD) and soil volumetric water content were also collected along these transects. During 2005-2007 measurements were made without experimental treatments, which were run in 2008 and 2009 which involved water table being raised (+10cm) and lowered (-10cm) in flooding and draining treatments respectively.

A new spectral index (NDSWI) was developed and tested at multiple spatial andtemporal scales. NDSWI uses the 460nm (blue) and 1000nm (IR) bands and was to capture surface hydrological dynamics in the study area using the robotic tram system. When applied to high spatial resolution satellite imagery, NDSWI was also able to capture changes in surface hydrology at the landscape scale. Interannual patterns of the land-surface unexpectedly lacked marked differences under experimental conditions. Measurement of NDVI was, however, compromised when WTD was above ground level. NDVI and NDSWI and NDVI were negatively correlated when WTD was above ground level, which held when scaled to MODIS imagery collected from satellite, suggesting that published findings showing a ‘greening of the Arctic’ may be related to a ‘drying of the Arctic’ in landscapes dominated by vegetated landscapes where WTD is close to ground level. For all six key plant species examined, NDVI was strongly correlated with biomass ($R^2 = 0.83$) and LAI ($R^2 = 0.70$) but showed evidence of saturation above a biomass of 100 g/m$^2$ and an LAI of 2 m$^2$/m$^2$. Extrapolation of a biomass-plant cover model to a multi-decadal time series of plant cover observations suggested that Carex aquatilis and Eriophorum angustifolium decreased in biomass while Arctophila fulva and Dupontia fisheri increased 1972-2008. New cyberinfrastructure tools were developed to enhance management and quality control of large volumes of hyperspectral data collected during the study in collaboration with UTEP’s Cyber-ShARE Center of Excellence. Tools included Symantic Abstract Workflows and ontologies, software for data specification and verification, and an online vegetation spectral library. This research has strong implications for improving remote sensing observations of arctic change.

**Committee:**

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