RELATIONSHIPS BETWEEN MICROCLIMATE, VEGETATION AND SOIL TEMPERATURES, AND INITIATION OF XYLEM SAP FLUX DURING SEASONAL THAW TRANSITIONS IN A BOREAL FOREST AND THEIR CHARACTERIZATION WITH RADAR REMOTE SENSING

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Poster Presentation preferred.

Abstract:

Land surface seasonal transitions between predominantly frozen and thawed conditions occur each year over roughly 50 million square kilometers of Earth´s Northern Hemisphere profoundly affecting surface meteorological conditions, ecological trace gas dynamics, and hydrologic activity. The study of freeze-thaw transitions is a key component in better understanding land-atmosphere carbon exchange and the cycling of water, carbon, and energy in the high latitudes. Microwave remote sensing techniques have been demonstrated to be effective tools for delineating seasonal freeze/thaw transitions in the terrestrial high latitudes as indicators of key growing season processes. Past efforts characterizing freeze/thaw processes in boreal forests have focused on application of time series radar backscatter amplitude to delineate landscape freeze/thaw state. NASA's Soil Moisture Active/Passive (SMAP) mission, currently under development, will provide measurements of soil moisture and surface freeze/thaw state. Major science objectives of SMAP support the understanding of processes linking terrestrial water, energy and carbon cycles, the quantification of net carbon flux and the extension of capabilities for weather and climate prediction models. Characterization vegetation biophysical response to climate drivers as the springtime thaw transition occurs is fundamental to interpretation of remote sensing data sets characterizing ecosystem processes related to seasonal thaw.

In this study, we utilize in situ measurements of soil temperature, vegetation stem temperature, vegetation sap flux, and stand-level climate to investigate the relationships between climate and vegetation biophysical activity during springtime thaw in the Bonanza Creek Experimental Forest, on the Tanana River floodplain, near Fairbanks, Alaska. Tree stem temperature is measured with thermistors implanted in the stems of several trees. Trees monitored include a variety of species representative of growth conditions extending from well-drained to poorly-drained boggy soil conditions. Soil temperature profiles are monitored for each growth condition/species situation. Xylem

sap flux is monitored using a constant energy input method. Within-canopy air temperature is also measured in the forest stand. Measurements are made every 10 minutes, with 2-hour averages stored on a data logger. Air temperature, relative humidity, and solar radiation are also available from a nearby weather station. We examine relationships between landscape component temperatures and initiation of vegetation growing season, using xylem sap flux as the growing season indicator, for thirteen years of in situ data collections (1994-2006). The soil thaw horizon is compared to vegetation thaw timing, and both are compared to the initiation of sap flow in the trees. Correspondence between vegetation thaw, soil thaw, and sap flux initiation is compared across tree species and growth conditions. We apply satellite L-band radar time series observations to examine seasonal freeze/thaw processes as compared to the vegetation biophysics. Retrospective time series backscatter are available from the JERS synthetic aperture radar (SAR). Contemporary data sets are available from the ALOS PALSAR. We investigate relationships between the remote sensing data products, soil freeze/thaw dynamics, vegetation freeze/thaw status, and the initiation of seasonal growth processes in trees as determined from the xylem sap flux data sets, and the potential of L-band radar to distinguish among these processes. The optimal component freeze/thaw state variable for determination of springtime initiation of vegetation growth processes varies with species and growth situation.

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.