Evaluation of Polarimetric SAR for Monitoring Surface Soil Moisture in Boreal Alaska

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ABSTRACT

The ability to monitor surface soil moisture at a landscape scale is a widely sought tool for a range of applications from monitoring hydrological conditions, to prediction of fire danger to understanding post-fire recovery in boreal regions. The utility of traditional single channel satellite radar remote sensing for monitoring soil moisture across a landscape is limited by confounding factors of varying biomass and surface roughness. The recent launch of fully polarimetric (4 channel) Radarsat-2 and PALSAR provides potential for improved soil moisture monitoring capability in a variety of cover types through multiple channels and polarimetric analysis. Research was conducted in Delta Junction Alaska to begin understanding the polarimetric response of C-band (5.7 cm wavelength) energy from recently burned black spruce forests. Initial results of a comparison of a wet versus a dry date of Radarsat-2 imagery and various polarimetric parameters show strong potential for this application. Polarimetric decomposition techniques were applied to the Radarsat-2 data to better understand the scattering from these landscapes where the tree canopy has been removed, and to allow for improved extraction of soil moisture. Continued research will examine a time series of images and coincident soil moisture. We begin with the burned sites which have a simple forest structure and exposed ground surface, and will expand future analysis into mature black spruce forests.

Background

• In previous research, single channel satellite C-band (5.7 cm wavelength) SAR methods were used to assess ground surface soil moisture (fuel moisture) in recently burned forests to aid in the prediction of wildfire potential (*Bourgeau-Chavez et al. 2007a,b; Abbott et al. 2007*)

• Strong relations were found between C-band backscatter from recently burned forests, *in situ* moisture and the Drought Code (DC) of the Canadian Forest Fire Danger Rating System

• However, variable surface roughness and vegetative biomass proved to be confounding factors, inhibiting assessment of this method's robustness across the landscape

Why Use Polarimetric SAR (POLSAR) Data?

POLSAR data provides potential utility for improving monitoring capabilities, by:

1) reducing the confounding factors
2) extending the application of this method beyond recently burned forests

How can polarimetric analysis be used to improve surface soil moisture assessment at a landscape scale?

In recently burned boreal forests?

In mature boreal forests?

R-2 POLSAR Initial Analyses

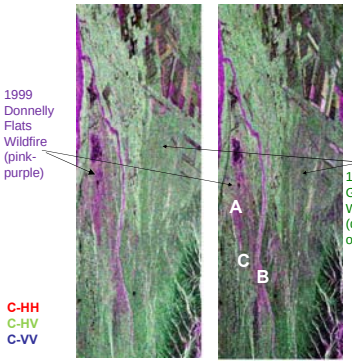
Radarsat-2 RGB Composites

Delta Junction, AK Drier versus Wetter Date

Comparison of two Radarsat-2 scenes covering two wildfire burn scars and a mature black spruce forest

Drier Date
16 July 2008 *DC=306
*VMC 36% 0.3 mm rain

Wetter Date
9 August 2008 DC=98
VMC 57% 1 mm rain



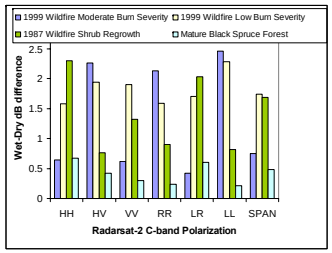
Note: small amount of rainfall on both dates

*VMC = Volumetric Water Content

0 ← * DC = Drought Code → +

Moist — More Dry

Comparison of Backscatter at Various Polarizations from Four Test Sites



• All sites exhibit higher backscatter on the wet versus the dry date

• Wet-Dry changes in backscatter for Mature forest are all below 1 dB, indicating low utility

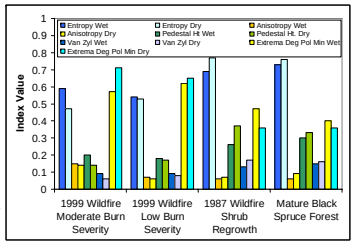
• HH polarization shows the largest change in backscatter for the higher biomass sites (1987 Wildfire and Mature forest)

• LL circular polarization shows the largest change in backscatter for the 1999 burn sites.

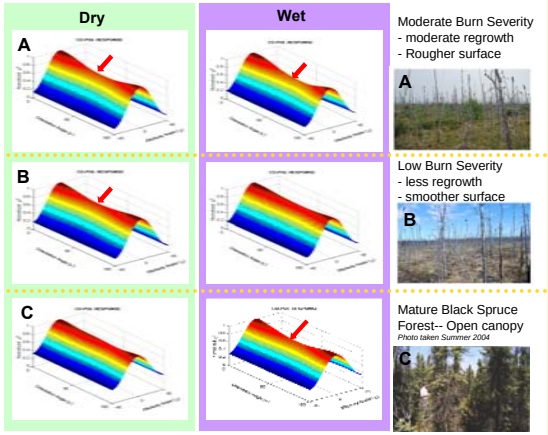
Comparison of Polarimetric Parameters from Four Test Sites

• Entropy, Anisotropy, Van Zyl index, and Pedestal height decrease from wet to dry conditions for the low biomass sites (1999 Wildfire sites)

• Entropy, Anisotropy, Van Zyl index, and Pedestal height increase from wet to dry conditions for the highest biomass sites (1987 Wildfire and Mature Spruce)



Summer 2008 Polarimetric Response Plots



Moderate Burn Severity
- moderate regrowth
- Rougher surface

Low Burn Severity
- less regrowth
- smoother surface

Mature Black Spruce Forest-- Open canopy
Photo taken Summer 2004

• Sites with shrubby biomass regrowth (1987 wildfire) and the forested site exhibit more of a saddle shaped polarimetric response plot on the wet versus the dry date, indicating more multiple scattering with some double bounce on the wetter date

• The lower severity burn site with very low biomass regrowth and a smooth surface showed a saddle shaped response plot on the drier date which changed to a smoother plot under wetter conditions, indicating predominating surface scattering (cf. modeling by Wang *et al.* (2000) for sites with biomass <1kg/m^2)

Next Steps

Initial observations of changes in polarimetric variables from wet to dry conditions show potential to aid soil moisture monitoring.

• Empirical relations between SAR backscatter and polarimetric variables will be used to develop algorithms to better estimate surface soil moisture from Radarsat-2 POLSAR data using: Seven R-2 images from Summer 2008 and 2009 representing relatively wet to moderately dry conditions (DC range 93 to 311).

• ALOS L-band PALSAR data will be used to develop soil moisture retrieval algorithms from mature forest sites using: Seven PALSAR images from Summer 2008 and 2009 representing wet to moderately dry conditions (DC range 76 to 340).

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