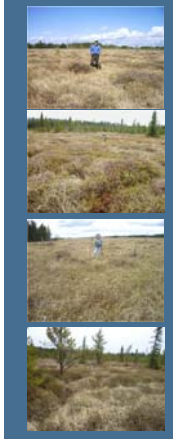
Monitoring Soil Moisture in Boreal Peatlands to Assess their Vulnerability to Wildfire

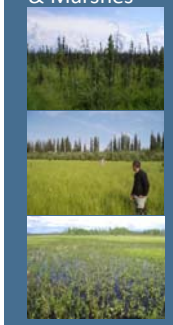
Laura Louise Bourgeau-Chavez, Michigan Tech Research Institute, laura.chavez@mtu.edu (Presenter)
Merritt R. Turetsky, Univ. of Guelph, mrt@uoguelph.ca
Eric S. Kasischke, University of Maryland, College Park, ekasisch@geog.umd.edu
William K. Schultz, Michigan Tech Research Institute, wkschult@mtu.edu

Contact Information:
Laura Bourgeau-Chavez
lchavez@mtu.edu
734-913-6873
Michigan Tech Research Institute
3600 Green Court Suite 100
Ann Arbor, MI 48105

Seney NWR Fens



Alaska Bogs , Fens, & Marshes



Alberta Bogs & Fens

Abstract: A central factor that controls vulnerability of peatlands to deep below ground burning are seasonal and inter-annual variations in soil moisture and water table levels. An ability to map and monitor soil moisture remotely would greatly assist us in understanding the thresholds of moisture conditions and water table depths that allow deep peat burning. In the summer of 2010, peatlands were monitored for soil moisture at over 20 locations in the Upper Peninsula of Michigan, Central Alberta, and Alaska using both field deployable soil moisture probes with data loggers (for remote sites) and handheld instruments (for more easily accessible site locations). Each of these 4 hectare area sites were measured for distributed moisture condition coincident with satellite overpasses from L-band 23 cm synthetic aperture radar (SAR) sensors (ALOS PALSAR) and C-band 5.7 cm SARs (ERS-2, Envisat, and/or Radarsat-2) between May and September 2010. A few sites were also monitored in past summers. Probe depth measurements ranged from 6 cm to 30 cm. The sites selected represent a range of peatland types and biomass cover, from open fens to forested bogs. Algorithms will be developed to best map and monitor moisture condition from the SAR data. Both polarimetric analysis (when fully polarimetric data are available) and time series analysis are being investigated to aid in the soil moisture mapping methodology.

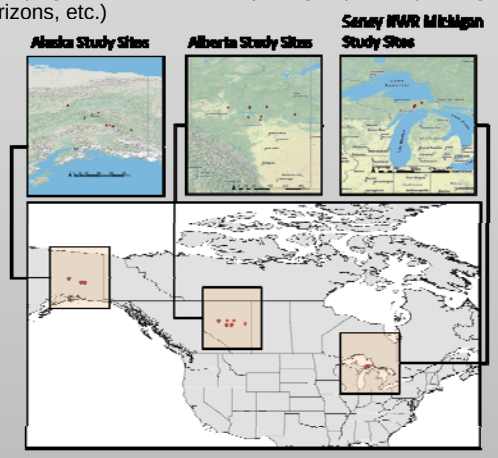
Overall Objective

The overall objective of this project s to develop satellite synthetic aperture radar (SAR) remote sensing techniques for monitoring surface soil moisture in boreal peatlands (bogs & fens both forested & shrubby/herbaceous sites)

- C-band (5.7 cm) ERS-2, Envisat, and Radarsat-2 SAR data have been demonstrated as useful for monitoring moisture in non-forested, herbaceous-dominated sites
- L-band (23 cm) PALSAR SAR data are more useful for monitoring soil moisture in the more shrubby and forested sites due to greater penetration of the canopy

Approach and Study Area

- Sites were selected in a wide range of boreal peatlands from northern Michigan (Seney NWR) to Alberta, Canada and Alaska for assessment
- Summer 2010 field measurements collected included surface soil moisture coincident with satellite SAR overpasses and biophysical data (vegetation cover, density, height, peat depth, organic soil horizons, etc.)



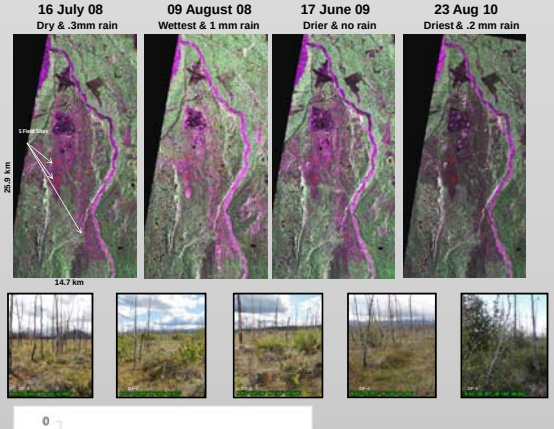
- C-band 2010 ERS-2 and Envisat data were collected over the open fen sites at Seney NWR, and 2008-2010 Radarsat-2 over the burned sites in Delta Junction Alaska
- Acquisition requests were placed for 2010 PALSAR data for all sites (2 collections per month May to September)
- Limited PALSAR data were actually collected in 2010.

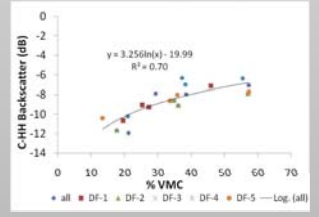
Field Data Measurements and Analysis Underway

- Soil moisture data were collected with water content reflectometers calibrated specifically for the peat soils
- Biophysical parameters were measured in the field to aid in the SAR soil moisture analysis. Plant biomass and structure affects the SAR backscatter from a site.

Summer 2010 Measurements: June to August							Range of Volumetric Soil Moisture		
Site	Peat Depth (cm)	Tree Density (stems/ ha)	Dominant Tree Species	Tree Height (cm)	Dominant Cover	Shrub/Sedge Vegetation Height (cm)	6 cm depth	12 cm depth	20 cm depth (uncalibrated)
Seney Fen B	111.5	70	Tamarack (*Larix laricina*)	270	Shrub	25.3	14-20 %	23-33%	20-43%
Seney Fen D	124.1	--	--	--	Shrub	18.1	21-38%	37-45%	44-65%
Seney Fen E	105.5	120	Black Spruce (*Picea mariana*)	310	Sedge	48	7-17%	16-24%	12-22%

Early Results from Polarimetric RadarSAT-2 of Alaska Burned Sites





- Field measurements of 13 to 58% Volumetric Water Content (VMC)
- Dynamic range in backscatter ~6 dB for each polarization
- All polarizations show an increase in backscatter related to an increase in soil moisture with significant ($p<0.05$) relationships
- Best predicting relation was log soil moisture with C-HH backscatter for all sites combined ($R^2 = 0.70$), C-VV relation was similar ($R^2 = 0.67$)
- Moisture does appear to affect C-HV backscatter (R^2 of 0.42) which theoretically is most sensitive to biomass

Site	Year Burned	Organic Soil	Burn Severity	Woody Biomass Regrowth (g/m²)	Revegetation
DF-1	1999	6.8 cm fibric/4.2 cm mesic	Light	10.93	Moss/shrubs&trees/grasses
DF-2	1999	3.2 cm mesic	Moderate	9.28	Moss/shrubs&trees/grasses
DF-3	1999	3.6 cm mesic	Moderate	15.37	Moss/shrubs&trees/grasses
DF-4	1999	2.0 cm mesic	Moderate	13.49	Moss/trees/grasses
DF-5	1999	1.2 cm mesic	Moderate	30.74	Moss/shrubs&trees/grasses

Next Steps

Strategy for analyzing limited PALSAR data over study sites will be to group sites with similar biophysical characteristics from Alaska, Alberta and Seney to compare SAR vs. soil moisture relationships