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

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Seney Field Sites
Site 12
Site D
Site B
Site E

Alberta Field Sites
Nodder
BC06
BCC
Chisholm
Sand Dune Fen
BC35
UFO
BOB

Abstract: With climate change, northern latitudes are experiencing change in the timing, duration and extremes of precipitation and temperature. The vulnerability of peatlands to wildfire depends on the fuel moisture conditions of the organic peat which have an average depth in boreal and subarctic systems of 2.5 meters. The ability to remotely map and monitor peatlands over time with reference to moisture conditions allows for spatially explicit assessments of trends in moisture patterns. Sites were set up in boreal Alberta Canada, Alaska and Michigan's upper peninsula for development of algorithms for monitoring ground fuel moisture with Synthetic Aperture Radar (SAR) satellite imagery. Data were collected in the summers of 2010 and 2011 over forested bogs and open and treed fens as well as other lowland ecosystems. Evaluations of the datasets by ecosystem type, with and without ancillary information on aboveground biomass, are evaluated. Vegetation biomass is the primary confounding factor in estimating soil moisture conditions from SAR imagery and information on biomass has been found to improve moisture prediction algorithms.
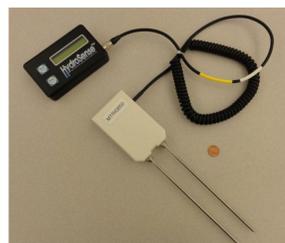
Overall Objective

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
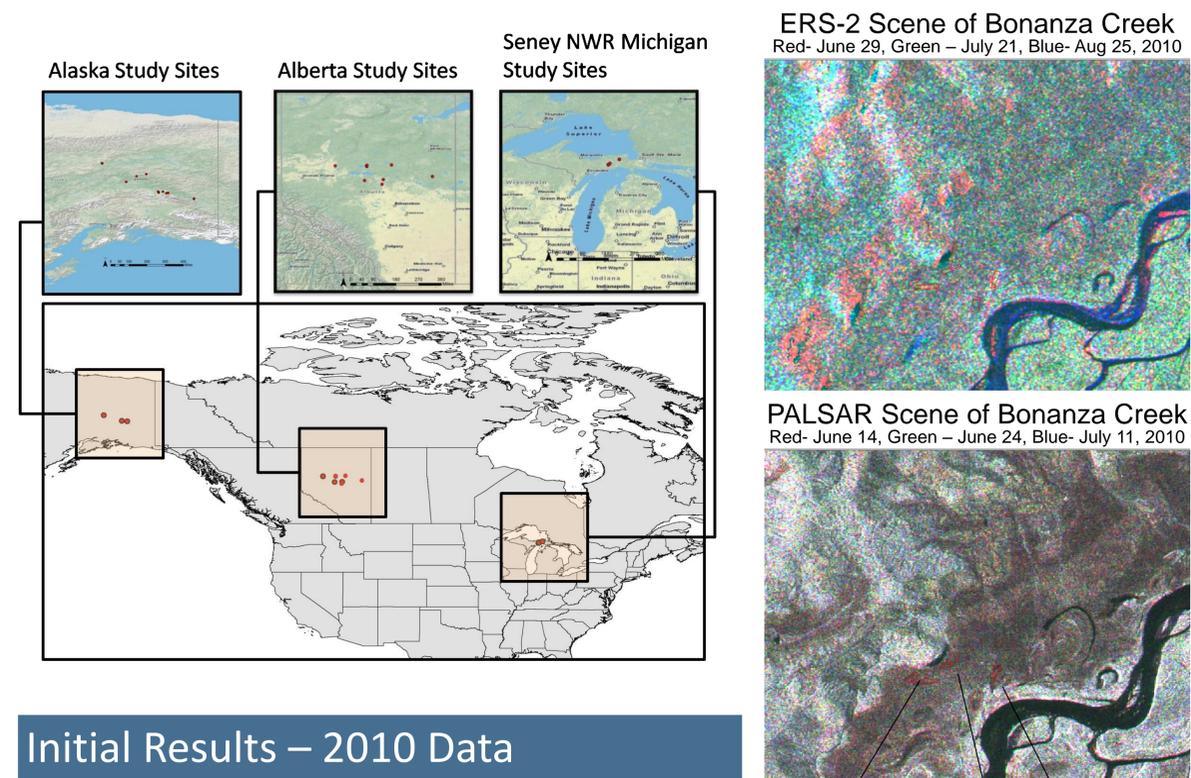
Field Measurements

- Soil moisture data were collected with water content reflectometers calibrated specifically for peat soils.
- Sites were selected in a wide range of boreal peatlands and include bogs, fens, and marshes in northern Michigan (Seney NWR), Alberta, Canada and in Alaska.
- Summer 2010 and 2011 field measurements collected surface soil moisture measurements coincident with satellite SAR overpasses.
- Biophysical parameters and data (vegetation cover, density, height, diameter, peat depth, organic soil horizons, etc.) were measured in the field to aid in the SAR soil moisture analysis. Plant biomass and structure affects the SAR backscatter from a site and will be used to improve algorithm performance.

Study Areas and Satellite Image Acquisition

Alaska Study Sites   Alberta Study Sites   Seney NWR Michigan Study Sites

ERS-2 Scene of Bonanza Creek
Red- June 29, Green – July 21, Blue- Aug 25, 2010

PALSAR Scene of Bonanza Creek
Red- June 14, Green – June 24, Blue- July 11, 2010

Initial Results – 2010 Data

APEX   BC1   BC2

•SAR IMAGERY STATUS

- Of the 100+ image acquisitions requested in 2010 over all sites, only 13 PALSAR Images were collected
- 24 ERS-2 images and 6 Envisat images were acquired in 2010 over the non-forested sites
- In 2011, PALSAR failed in operation in April, ERS-2 was decommissioned in the spring
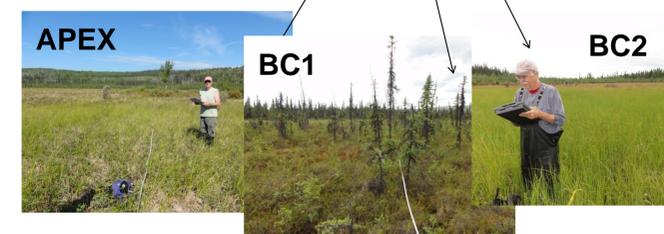
- Envisat became the focus in 2011
  - All sites were imaged
  - Coincident field data collected
  - Data processing is underwayE

- L-band data appears promising for
- soil moisture monitoring in peatlands
- Research will continue with integration of PALSAR and soil moisture

Location	Site	Lat	Long	Type	Description
Alberta	BOB	55.249699	-111.326	Fen	Partially open fen, many trees
	Wagon Wheel	55.919498	-113.678	Bog	Black spruce Bog
	Chisholm	54.793201	-114.22	Bog	Burned in 2001
	Burned Crow Nodder Bog	56.0135	-115.228	Bog	Burned in 2011
	Uninteresting Fen Open	55.883	-115.096	Fen	Open, over 100% moss cover
	Burned Crow Burn Bog	55.8727	-115.11	Bog	Black spruce Burned in '06
	Burned Crow Bog	55.876099	-115.105	Bog	Black spruce Burned in '35
	Sand Dune Fen	55.0681	-114.149	Fen	Sedge Fen
	Burned Crow Centennial Bog	55.897999	-115.083	Bog	Black spruce un-burned for 100+ yrs
	McLennan	55.8657	-116.916	Fen	Partially open fen, many saplings
Bonanza Creek, AK	Apex 1	64.7009	-148.313517	Fen	Open Fen, Sedges and Grasses
	Apex 2	64.700183	-148.30535	Fen	Open Fen, Sedges and Grasses
	BC 2	64.702333	-148.2812	Marsh	Marsh--Sedges and Grasses, Aquatics
	BC 3	64.696617	-148.28785	Marsh	Tussock Marsh-Sedges and Grasses
	BC 1	64.70305	-148.301517	Bog	Black Spruce Bog
	BC 4	64.70425	-148.297367	Bog	Black Spruce Bog
Delta Junction, AK	DF 1	63.84768	-145.716411	< 30 cm Peat	Burned Forest 1999
	DF 2	63.900458	-145.763811	< 30 cm Peat	Burned Forest 1999
	DF 3	63.904017	-145.764127	< 30 cm Peat	Burned Forest 1999
	DF 4	63.917531	-145.759934	< 30 cm Peat	Burned Forest 1999
	DF 5	63.921963	-145.762834	< 30 cm Peat	Burned Forest 1999
	DDS	63.891922	-145.738121	< 30 cm Peat	Black Spruce Forest - Dry
	GMS	63.820454	-144.973129	< 30 cm Peat	Black Spruce Forest - Moist
	GWS	63.806909	-144.976632	< 30 cm Peat	Black Spruce Forest - Wet/Tussocks
Seney, MI	Seney B	46.19214229	-86.01790606	Fen	Open Fen - few trees
	Seney D	46.18878719	-86.01708463	Fen	Open Fen - few trees
	Seney E	46.18508797	-86.01288743	Fen	Open Fen - few trees
	Site 12	46.251	-85.941	Bog	Forested Bog
	Sleeper Lake	46.460128	-85.459007	Fen	Open Fen Burned in '07

Sites ranged from 70-5650 stems/ha, 2.5-4.2 m tree ht, 3.1 to 8.7 cm tree diameter

Soil Moisture vs. PALSAR L-HH Backscatter; All Forested Bog Sites

$y = 2.3352\ln(x) - 17.916$
$R^2 = 0.79$

Backscatter (dB)
Volumetric Soil Moisture (%)
● All Forested Bogs
▲ McLennan Forested Fen

Soil Moisture vs. ERS-2 C-VV Backscatter; Bog - All Forested and Burned Sites

$y = 1.3704\ln(x) - 12.319$
$R^2 = 0.25$

Backscatter (dB)
Volumetric Soil Moisture (%)