Fuel consumption and carbon cycling in northern peatland ecosystems: Understanding vulnerability to burning, fuel consumption, and emissions via remote sensing of fuel moisture and radiative energy

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Project Overview

Introduction

Peatland ecosystems represent 3-5% of the global land surface and sequester 12-30% of soil organic carbon.

Climate induced changes in peatland hydrology and wildfire vulnerability can shift peatlands from being net carbon sinks to net carbon sources and ultimately lead to increased CO_2 emission to the atmosphere.

Assessing and monitoring hydrological change, fire dynamics, and associated CO_2 emissions in peatland systems is critical to understanding the global carbon cycle.

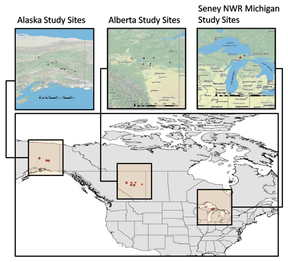
State-of-the-art remote sensing techniques can potentially provide a means to: (1) assess and monitor fuel moisture conditions in peatland systems, (2) through remote moisture assessments, predict peatland vulnerability to fire, and (3) provide improved estimates of fire-incuced CO_2 emissions via thermal remote sensing of fire radiative energy (FRE).

The overall goal of this research is to develop an understanding of how peatland fuel moisture content influences peatland vulnerability to fire, fuel consumption, and fire-related CO_2 emissions.

Approach

A variety of remote sensors (hyperspectral, thermal, LiDAR, SAR) and platforms (near earth, sub-orbitial, and satellite) used in conjunction with field experiments will be used to develop new methods of estimating fuel moisture, fuel consumption and emissions from peatland fuel types.

In order to develop an understanding of how peat moisture content influences fire regimes, ecosystem processes, and CO_2 emissions in northern peatlands, we will capitalize upon ongoing laboratory, field-based studies, and prescribed burning activities, allowing for relatively careful monitoring and fine scale characterization of water table height, peat moisture content, thermal properties of fire, as well as biomass consumption and CO_2 emissions.



Peatland Field Sites

PEATcosm Experiment

PEATcosm facility (in Houghton, Michigan): A climate controlled tunnel and platform containing 24 cube-shaped (1 m^3) mesocosms, each with peat samples under a variety of experimental treatments, will be used to develop spectral indices sensitive to peatland fuel moisture.

Northern Peatland Field Sites: Numerous peatland sites selected across a wide range of boreal peatlands that include bogs, fens, and marshes in Upper Michigan, Alberta, Canada and Alaska, will be used to retrospectively assess fuel moisture and fire vulnerability.

Seney National Wildlife Refuge: Located in Upper Michigan, which is within the southern-most area of widespread continental peatlands, will be the focus of experiments and prescribed burns.

1. Assessment of Peatland Fuel Moisture

Objective

Explore the utility of diverse sensor systems (multi-spectral, hyper-spectral, and SAR) for the detection of changes in peatland fuel moisture in relation to vegetation type, vegetation structure, and physical characteristics.

Hypothesis

Moisture induced spectral changes in peatland vegetation can improve remote estimations of peatland fuel moisture content.

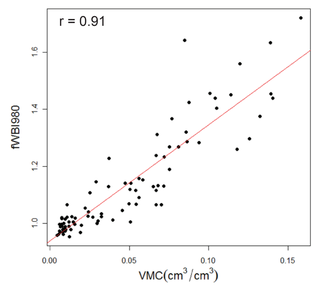
Field Measurements

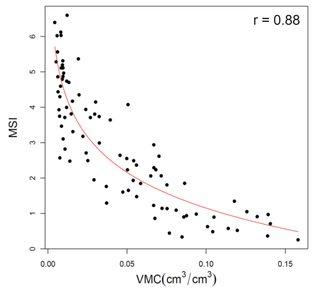
PEATcosm Experiment

Nestoria, MI Field Site

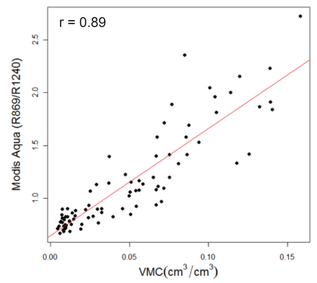
Spectral measurements are being taken at laboratory and field sites. Spectral indices sensitive to vegetation moisture content and water table position are then correlated to peat fuel moisture measurements.

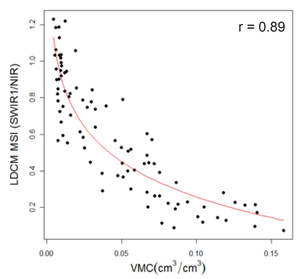
Preliminary Results





Initial results demonstrate strong linear and non-linear relationships between volumetric peat fuel moisture content and several spectral indices.





These spectral indices could potentially be applied to existing satellite sensor data to remotely estimate peatland fuel moisture content across large spatial extents.

2. Assessment of Vulnerability to Fire

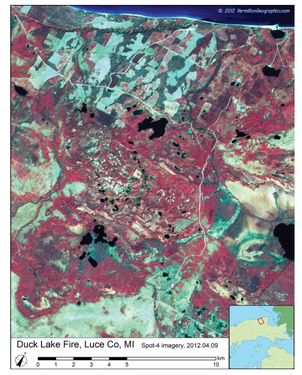
Objective

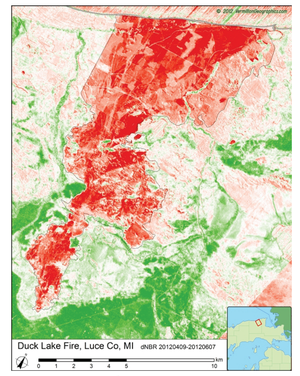
Retrospectively characterize prefire patterns of peatland drying across diverse peatlands in the Great Lake States, Canada, and Alaska to assess vulnerability to fire.

Hypothesis

Prefire estimates of peatland fuel moisture can be used to predict peatland vulnerability to fire.

Retrospective Assessment of Fire Vulnerability





Apply the best remote sensing moisture algorithms or indices to prefire satellite data, and compare moisture patterns to remote estimates of fire severity (example with SPOT images from the Duck Lake Fire, MI).

3. Improved FRE CO_2 Emissions Estimates

Objective

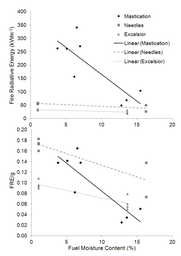
Determine the efficacy of FRE measurements for quantifying biomass consumption and CO_2 emissions in peatland systems. Characterize the impact of fuel moisture content on remote FRE measures and subsequent biomass consumption and CO_2 emissions.

Hypotheses

Satellite derived FRE measures can be used to accurately predict biomass consumption and CO_2 emissions from peatland fires.

Pre-fire moisture maps can be used to develop corrected FRE-based biomass and CO_2 emission estimates from fire in peatland fuels.

Approach



FRE is strongly correlated to biomass consumption and CO_2 emissions, but relationships are impacted by fuel moisture content.

Laboratory and prescribed burning experiments will be used to further assess the relationships between FRE derived estimates of biomass consumption and CO_2 emissions and fuel moisture content.

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