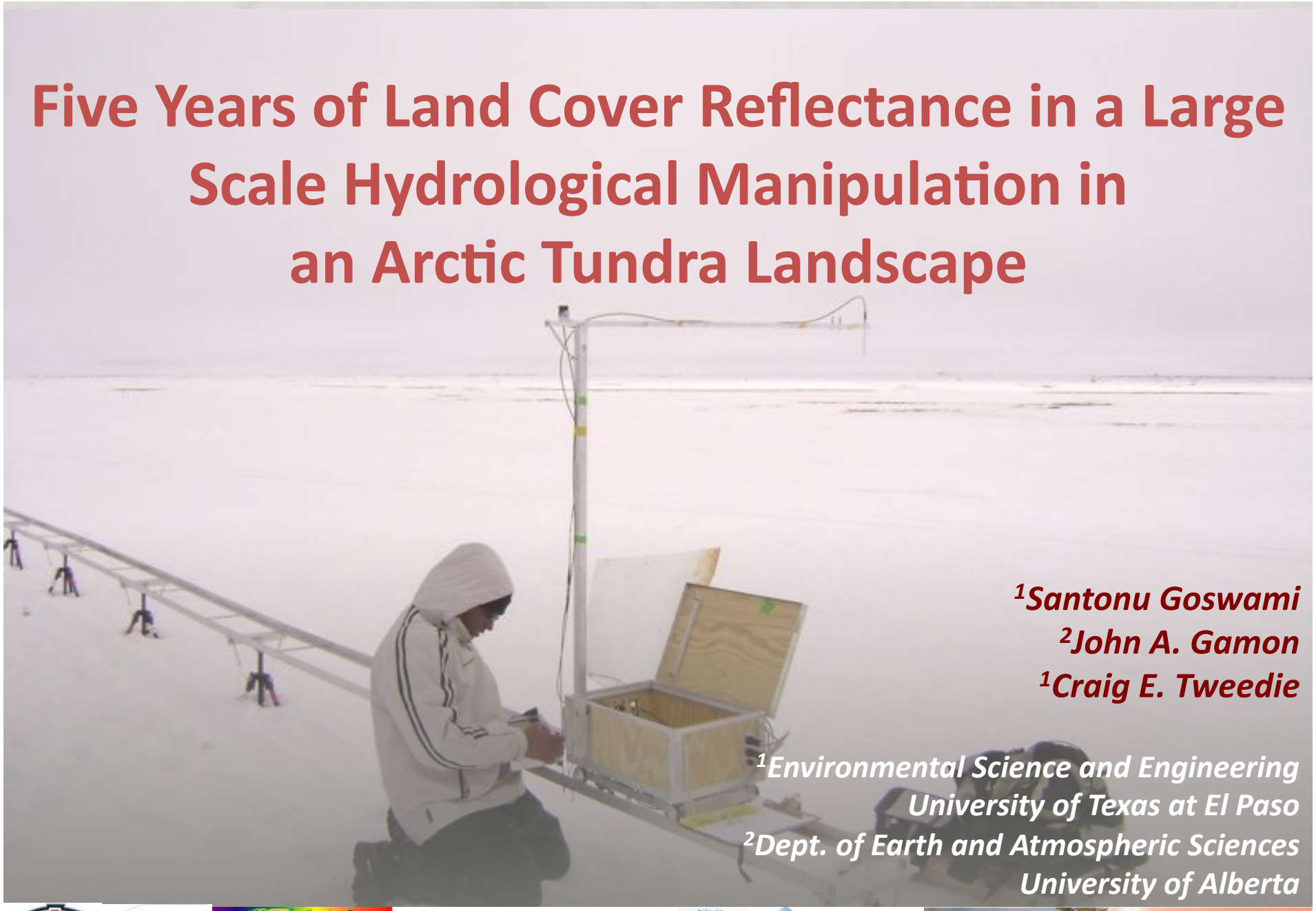
Five Years of Land Cover Reflectance in a Large Scale Hydrological Manipulation in an Arctic Tundra Landscape



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CH2MHILL Polar Services
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Importance of Surface Hydrology (Soil Moisture) in ecosystem structure and function

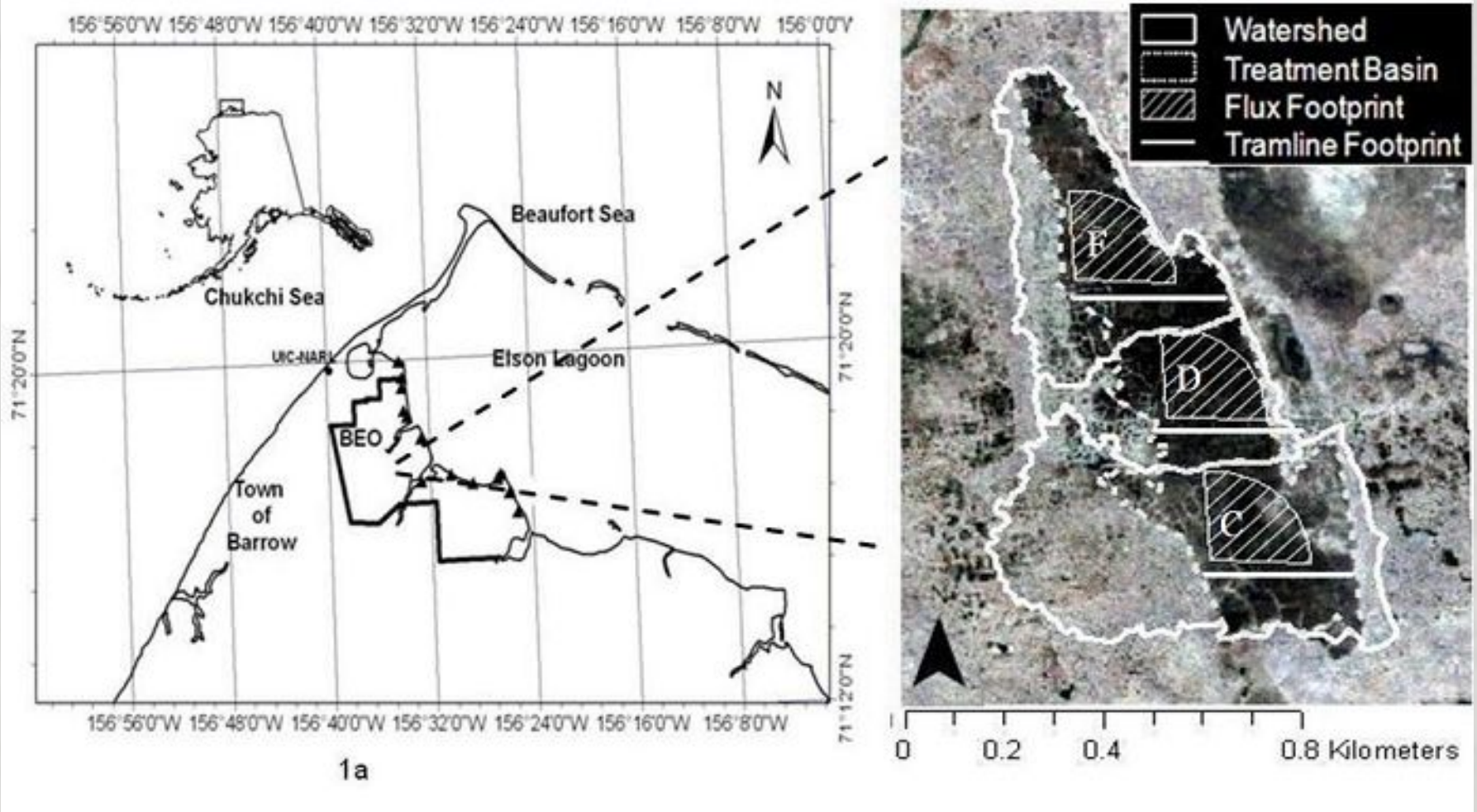
- Many observed and modeled change responses of arctic terrestrial ecosystems are related to surface hydrology:
  - Surface energy budgets (Chapin et al. 2005, Euskircken et al. 2007)
  - Land-atmosphere carbon exchange (Merbold et. al 2009, Wolf et al. 2008)
  - Geomorphic processes (Lawrence and Slater 2005, McNamara and Kane 2009)
  - Provision of ecosystem goods and services (Milennium Ecosystem Assessment)
  - Plant phenology and response to warming (Arft et al. 1999, Walker et al. 2006)

Plants as an indicator of change

- Detecting biotic responses to a changing environment is essential for understanding the consequences of global change.
- Plants can work as effective indicators of
  - changing conditions and, depending on the nature of the change,
  - respond by increasing or decreasing amounts of green-leaf biomass, chlorophyll, and water content.
  - important effects on ecosystem processes such as NPP and nutrient cycling.

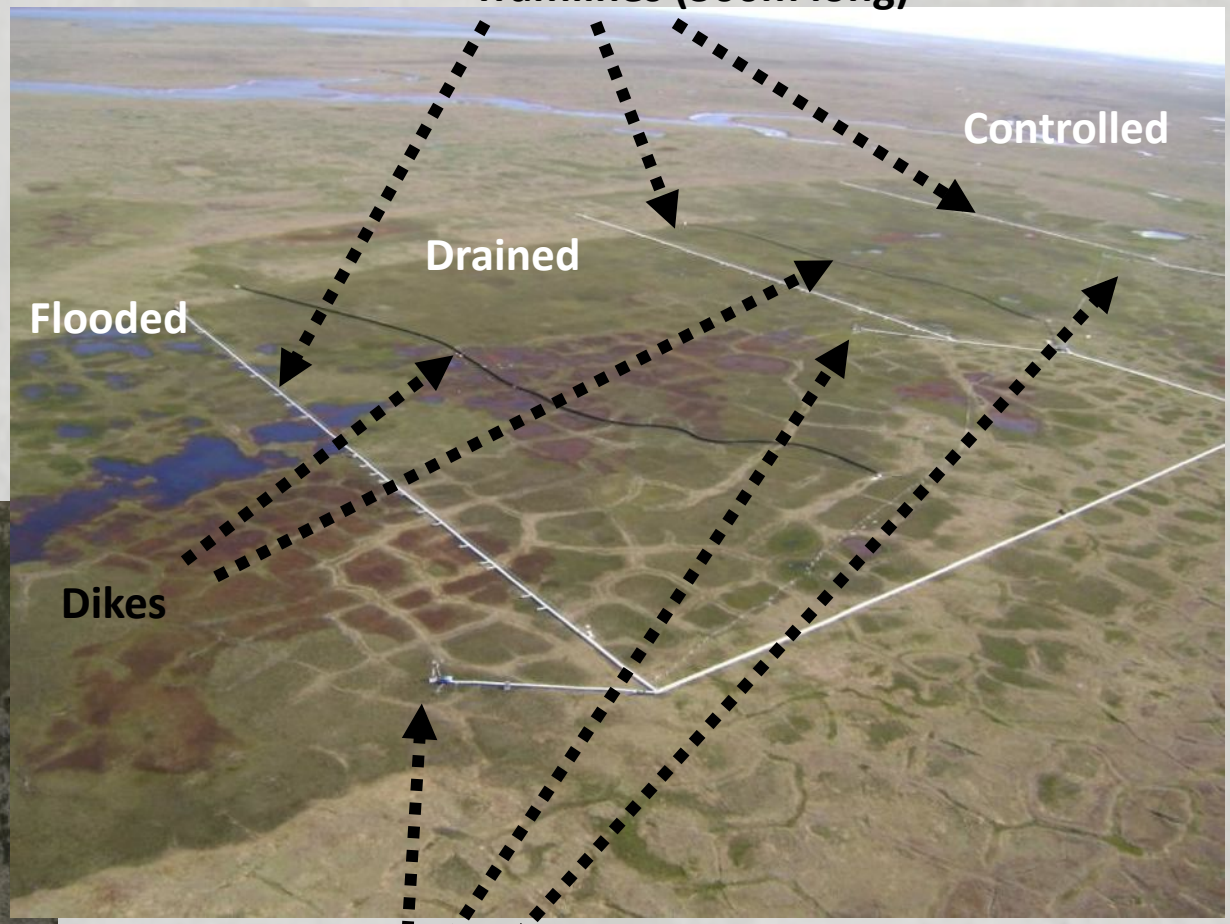
- Plant phenology is detectable using remote sensing technologies and therefore scaleable over space and time (e.g. NDVI).

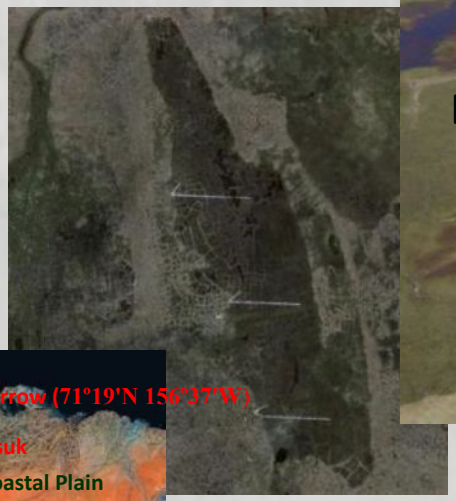
Study Site - Biocomplexity Experiment, Barrow, Alaska

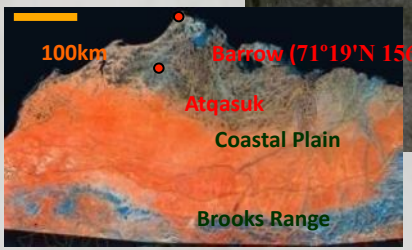


Experimental Setup: Biocomplexity Experiment

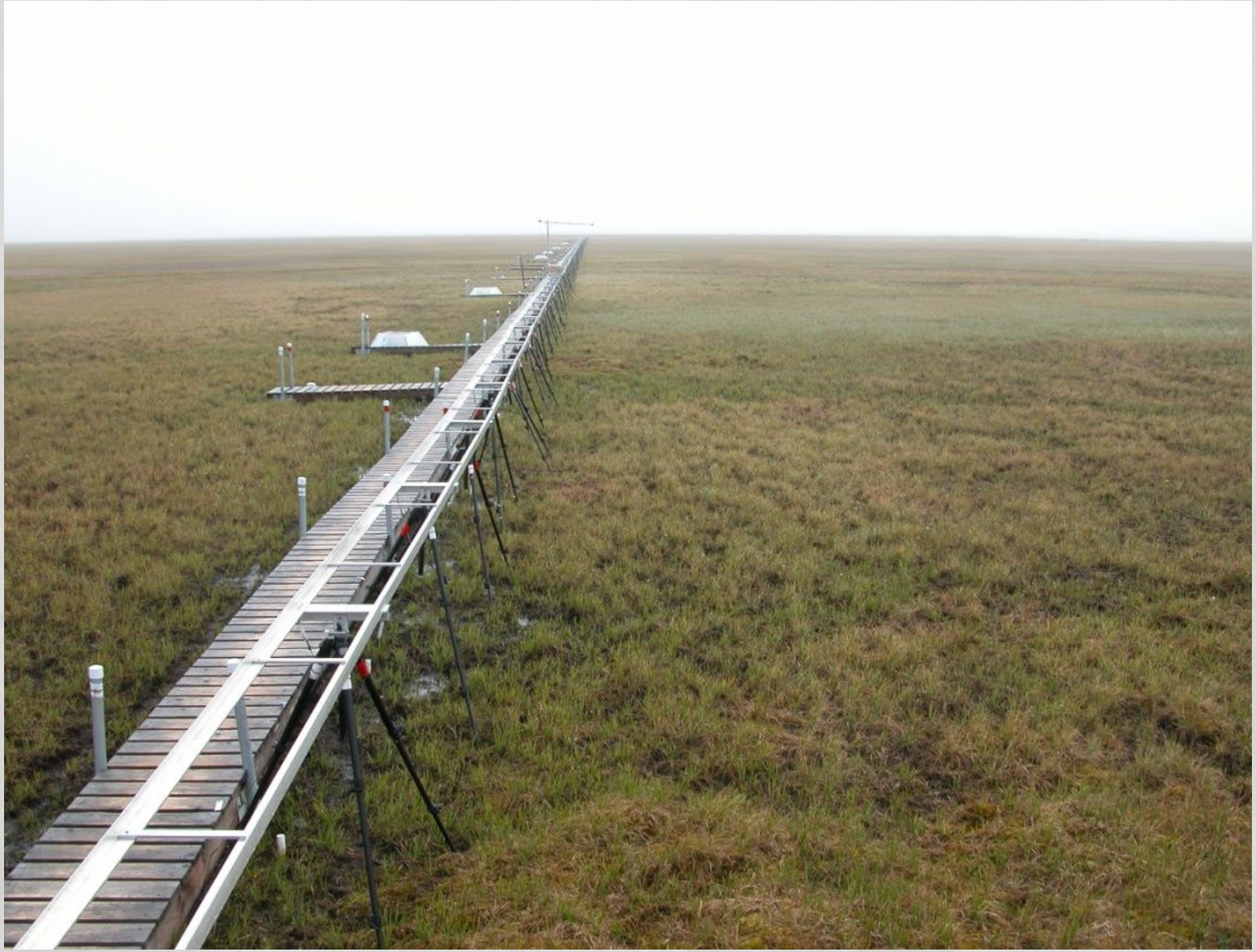
- Large-scale Hydrological Manipulation experiment to study the effect of varying Soil Moisture on ecosystem Carbon Balance in the Arctic







The Tram System



The Tram System

The Tram System

The Tram System

Near surface remote sensing technology

- Measurements are made at every meter along each of the three 300 meter tramlines (precise and repeatable)
- Collects hyperspectral data in the vis-nir region and digital images of vegetation
- More than 200,000 data files collected in 5 years
- Has the ability to carry various sensors packages
- Can be used to study change in phenology, sun angle effect on vegetation etc
- Standardized sampling design is part of a larger effort (SpecNet) to compare ecosystem responses using a combination of spectral reflectance and flux measurements

Tramline system in the biocomplexity experiment is the largest ground based spectral data monitoring system that we are aware of internationally

Measurement of Reflectance

- **Reflectance**

  $= I_{Target} / I_{Downwelling}$

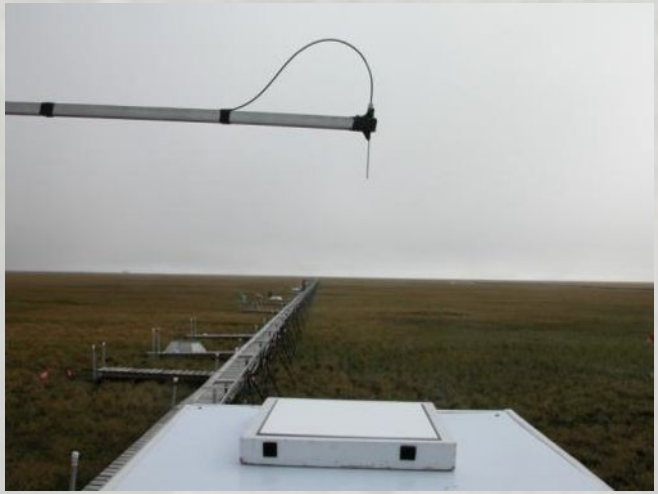
  = Radiance/Irradiance

- **Reflectance correction**

$= (R_{Target} / R_{Downwelling}) \times (R_{Downwelling} / R_{Panel})$

- **NDVI (**Normalized Difference Vegetation Index**) calculation**

$= (R_{800}-R_{680}) / (R_{800}+R_{680})$



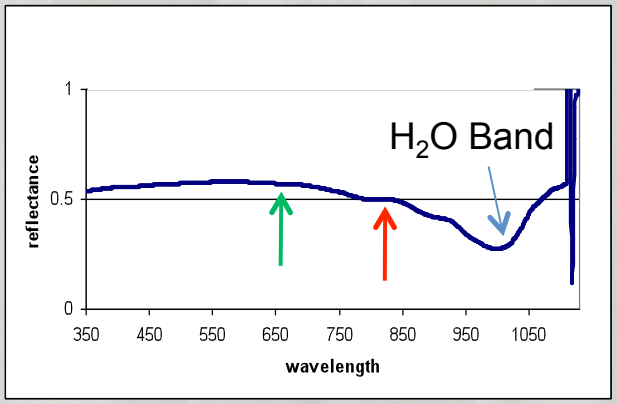
- Also measures water table depth, thaw depth.

Questions being asked in this study

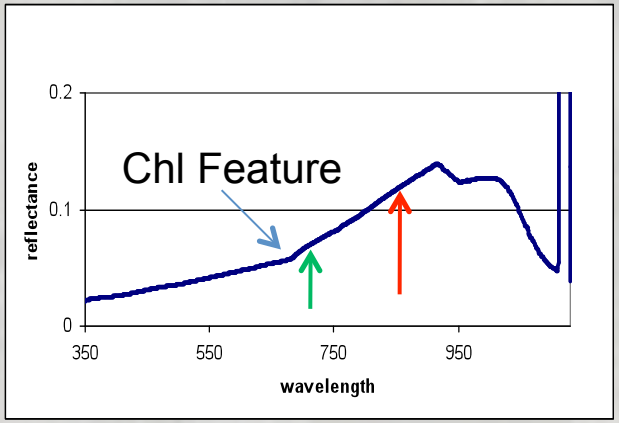
- How does land-surface phenology (i.e. surface reflectance properties) change inter-annually?

- Is there any detectable effect of experimental treatment (flooding and draining) on surface reflectance?

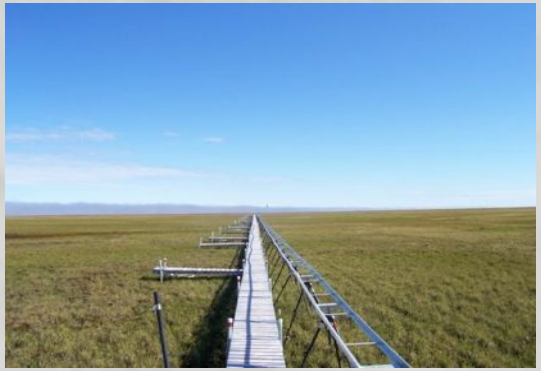
Transition Throughout the Season

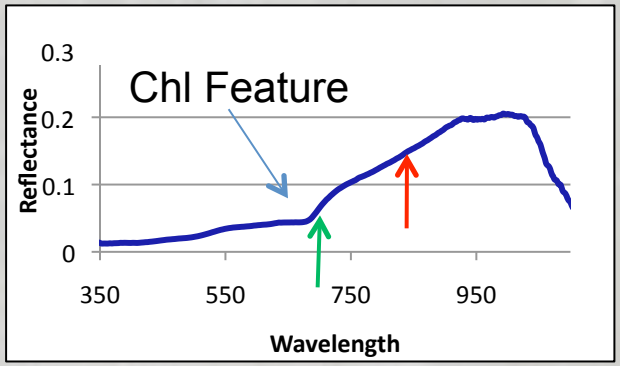


1st Week of June



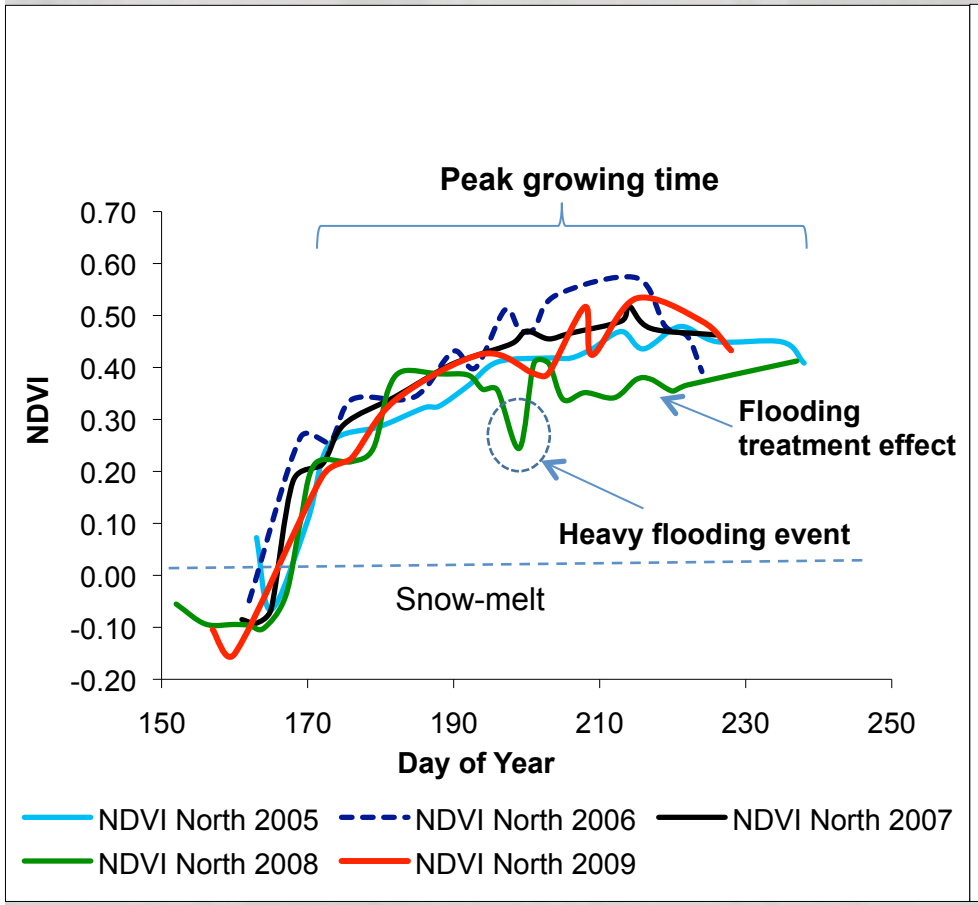
3rd Week of June

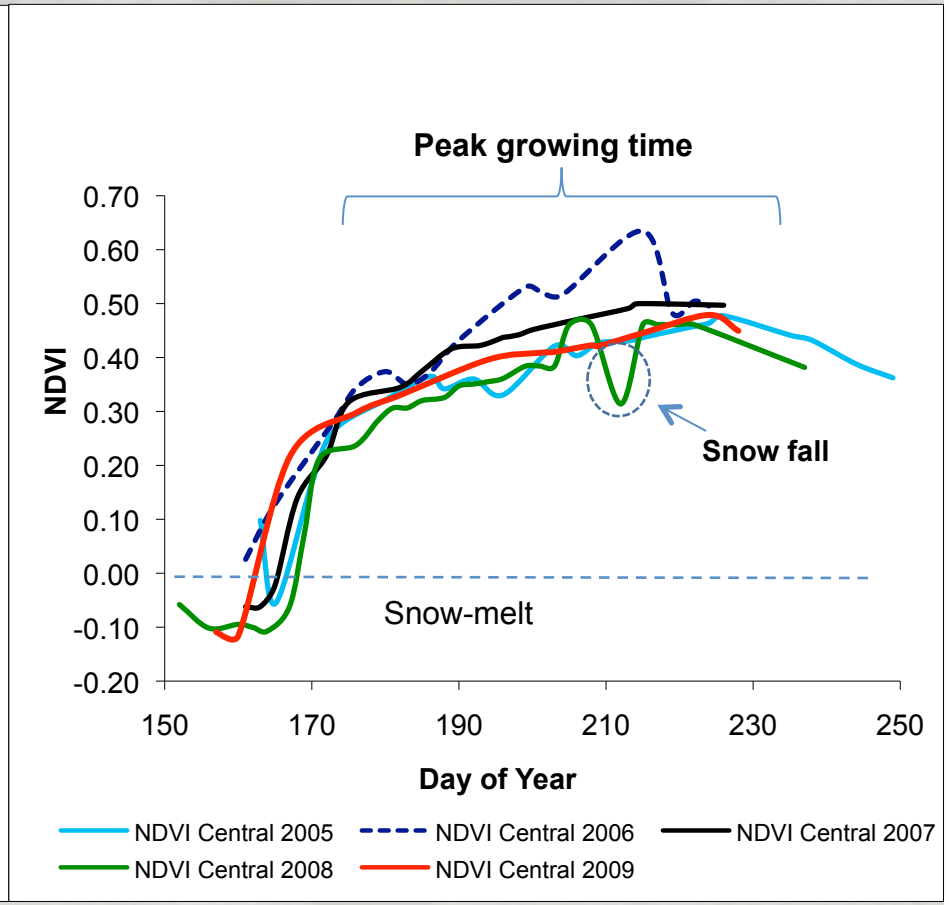




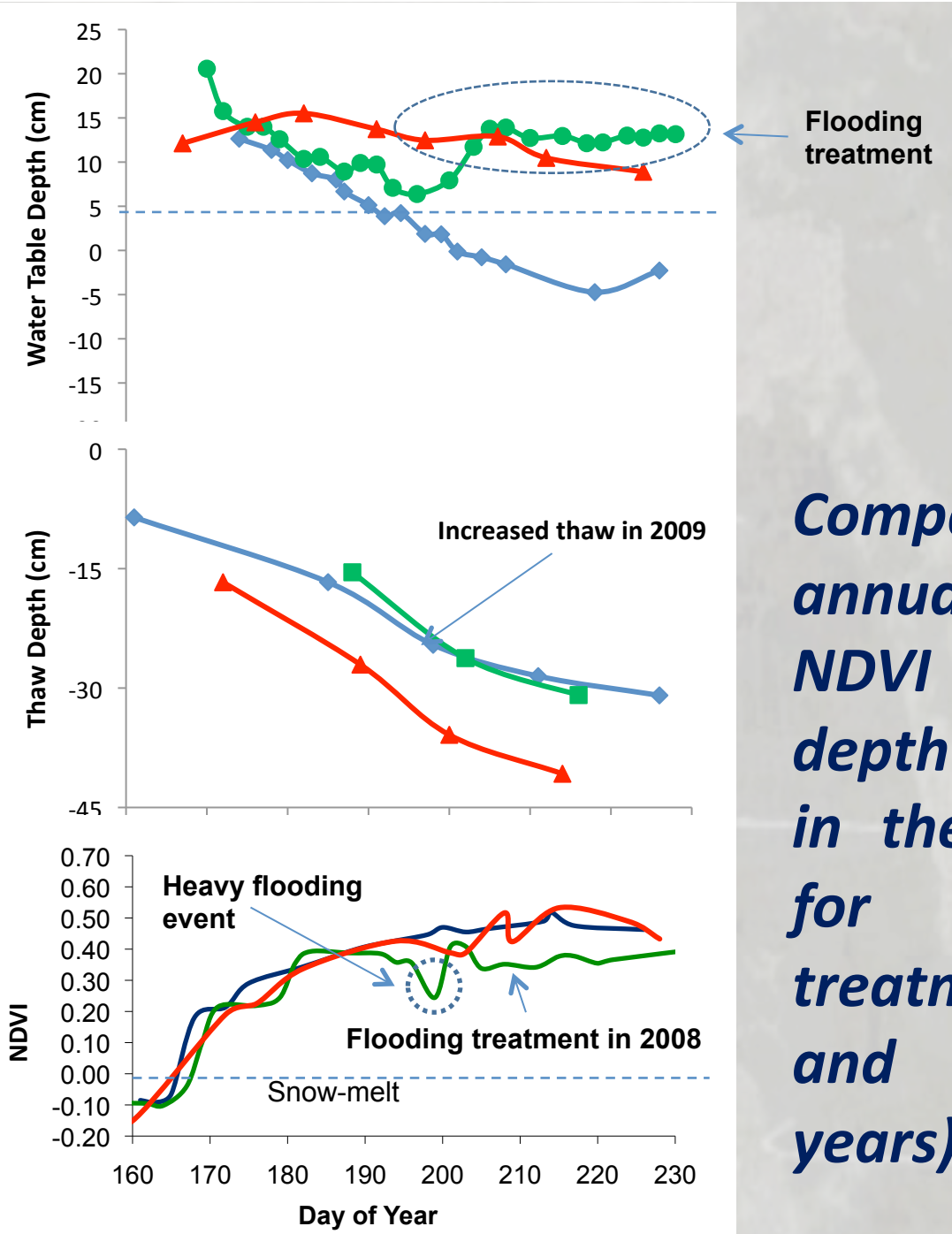
1st Week of August

Inter-annual variability of NDVI in the treatment areas for pre-treatment years (2005, 2006, 2007) and treatment years (2008 and 2009)





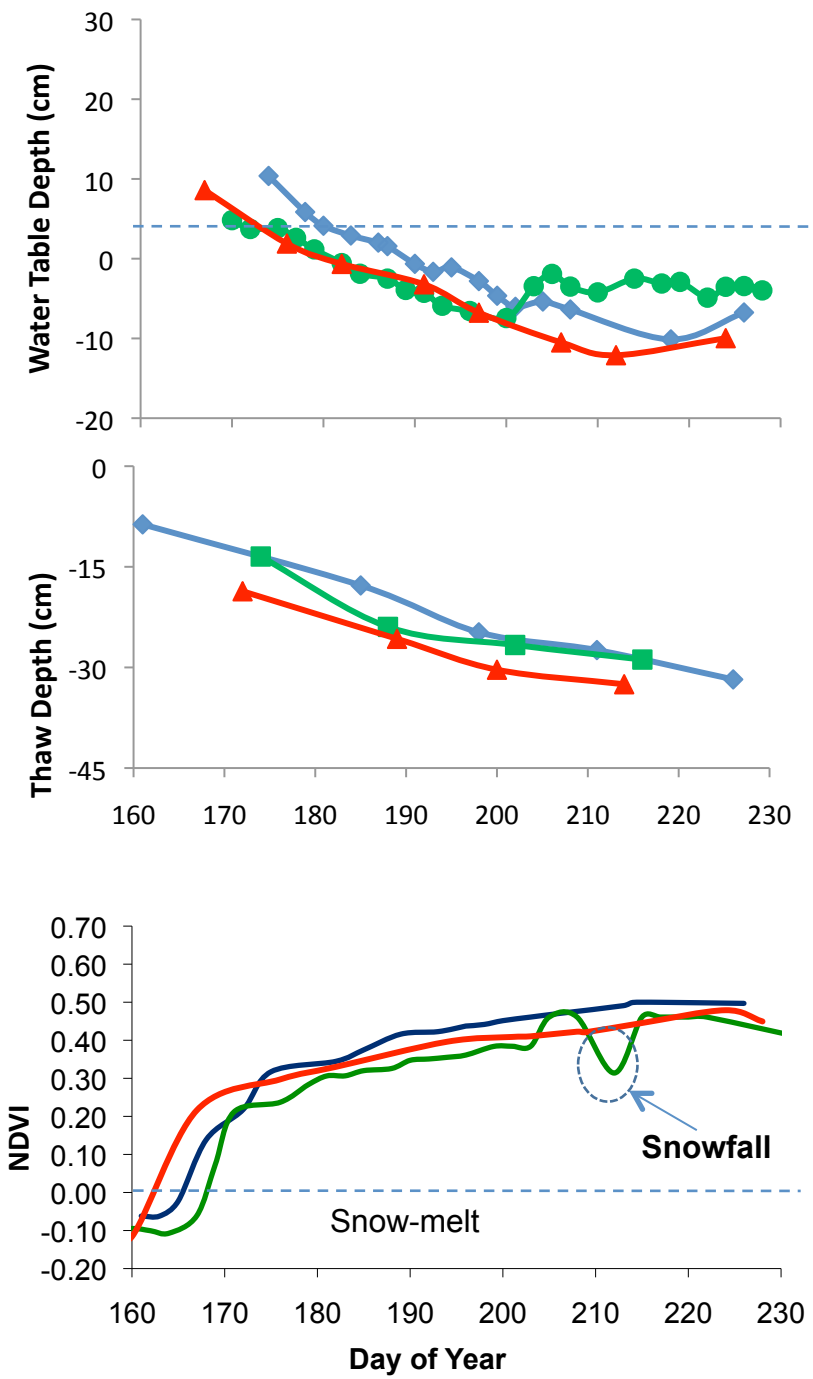
FLOODED **DRAINED**



Flooded

2009
2008
2007

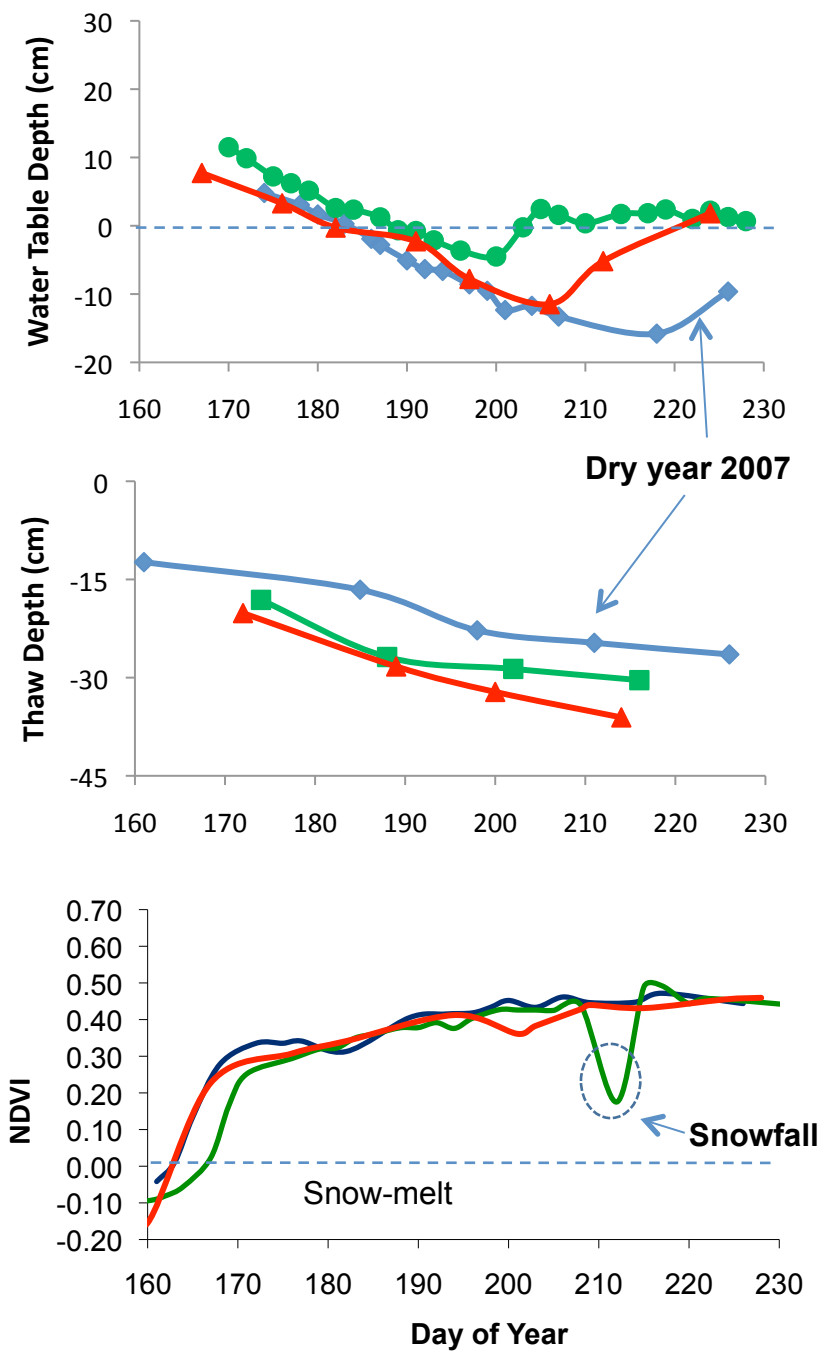
Comparison of inter-annual variability of NDVI to water table depth and thaw depth in the flooded section for 2007 (pre-treatment) and 2008 and 2009 (treatment years)



Drained

- 2009
- 2008
- 2007

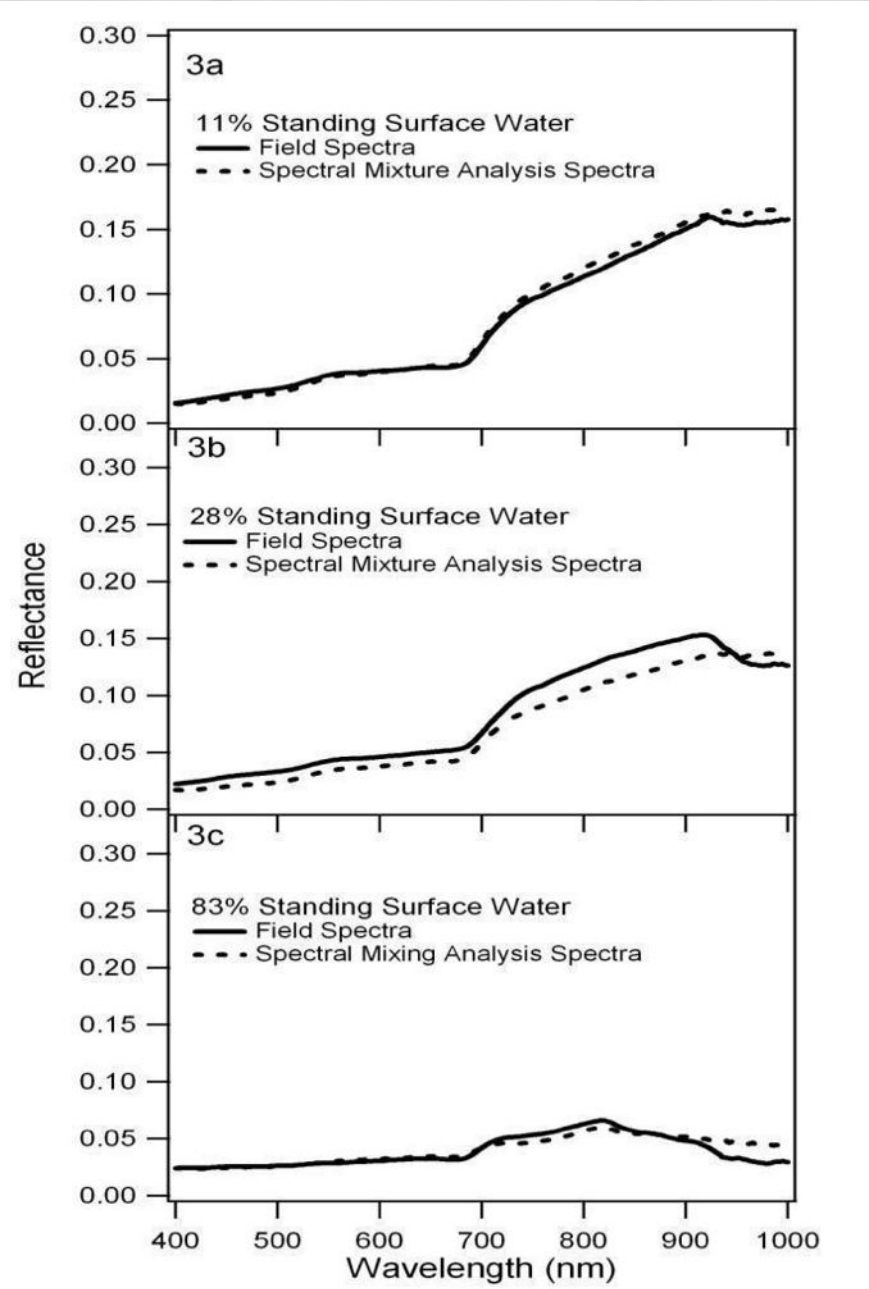
Comparison of inter-annual variability of NDVI to water table depth and thaw depth in the drained section for 2007 (pre-treatment) and 2008 and 2009 (treatment years)

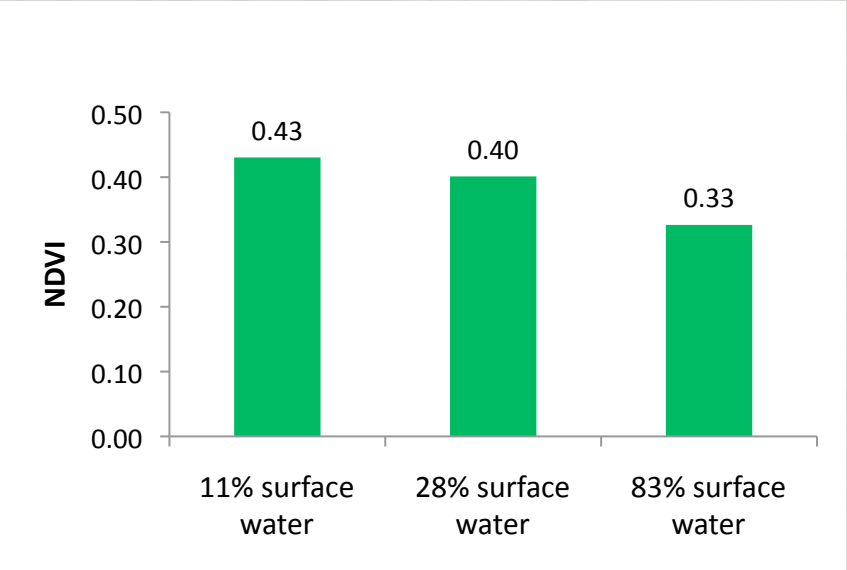


Control

- 2009
- 2008
- 2007

Comparison of inter-annual variability of NDVI to water table depth and thaw depth in the control section for 2007 (pre-treatment) and 2008 and 2009 (treatment years)

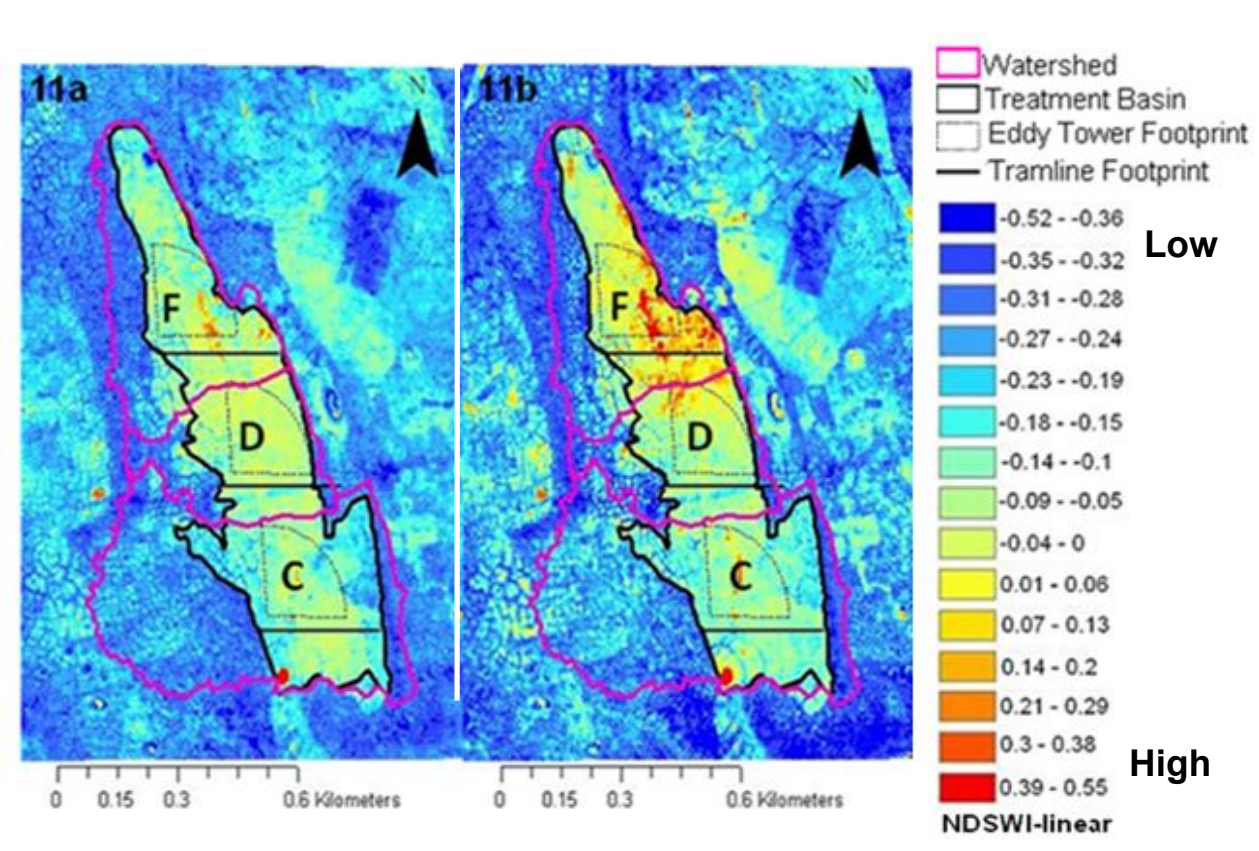




Standing surface water has a significant effect on reflectance spectra.

This has profound effect on the NDVI values.

The spectral range (400-1000nm) offers the ability to detect several things, including water. Using a spectral index (NDSWI) capable of capturing multi-dimensional surface hydrological dynamics can improve the sampling capabilities of this system



Quickbird 2002 **Quickbird 2008**

NDSWI (Normalized Difference Surface Water Index) =

$$\frac{(R_{490}-R_{1000})}{(R_{490}+R_{1000})}$$

Goswami et. al – submitted, JGR Biogeosciences

Summary and Conclusion

- ***Changes in vegetation cover during the growing season was clearly detectable using surface reflectance.***
- ***Seasonal patterns of the NDVI values showed some differences with flooding. The flooded section showed bigger differences than the drained section.***
- ***The seasonal patterns in NDVI was least different for the control section among the years.***
- ***NDVI values were compromised by varying water cover (among other things), so simultaneously tracking NDVI and NDSWI might be a better approach in this landscape.***
- ***Alternatively, other methods like Spectral Mixture Analysis can probably help here.***

Acknowledgements

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