Integrating Tower EC, Satellite Remote Sensing and Ecosystem Modeling to Identify Changes in Hydrology and Carbon Fluxes across the Alaskan Arctic

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Identifying Changing Arctic Environments

Phenology

Surface Flooding

Plant Productivity

Soil Carbon Cycling
Satellite & Reanalysis Data

Monitor Changing Earth Surface Properties

Flux Towers & In Situ Sensors

Integrate with Ecosystem Modeling for Regional Carbon Observing System

\[ GPP = \varepsilon \times PAR \times FPAR \]
\[ \varepsilon = \varepsilon_{\text{max}} \times f(VPD) \times f(T_{\text{min}}) \times f(\theta) \]
\[ R_{\text{aut}} = (1-C\text{UE}) \times GPP \]
\[ NPP \]
\[ C_{\text{met}} \quad C_{\text{str}} \quad C_{\text{rec}} \]
\[ R_{\text{het}} = f(C_{\text{pool}}, T_s, \theta) \]

\[ R_{\text{CH4}} = (R_o \times \varphi_s) \times C_{\text{pool}} \times Q_{10}^{(T_s-T_p)/10} \]

Aerobic vs Anaerobic

\[ C_{\text{CH4}} \]

Plant Soil Diffusion Ebullition

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1Watts et al. 2014 Biogeosciences
2Kimball et al. 2015 SMAP L4_C User Guide
**North Slope Tower Transect**

**Climate Variability**

<table>
<thead>
<tr>
<th></th>
<th>BEO/BES</th>
<th>ATQ</th>
<th>IVO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elev. (m)</td>
<td>6</td>
<td>15</td>
<td>568</td>
</tr>
<tr>
<td>MAT (°C)</td>
<td>-12.6</td>
<td>-9.7</td>
<td>-7.9</td>
</tr>
<tr>
<td>MSP (mm)</td>
<td>72</td>
<td>100</td>
<td>210</td>
</tr>
<tr>
<td>ALD (cm)</td>
<td>-36</td>
<td>-50</td>
<td>-60</td>
</tr>
</tbody>
</table>

**Vegetation Communities**

**BES/BEO:** Inundated & polygonal tundra (grass, sedge, moss)

**ATQ:** Moist sedge tundra & tussock

**IVO:** Tussock tundra & dwarf shrub, moss and lichen
Satellite Observations: Monitoring Regional Change

1,2 AMSR Surface Water

1982-2014

3 AMSR Non-Frozen Season

2003-2013

4 SSMI/MODIS Active Layer Depth

2003-2009

5 AVHRR/MODIS NDVI

1982-2014

Wetting
Drying
Extending
Decreasing
Increasing
Decreasing
Greening
Browning

Watts et al. 2014 ERL; Du et al. 2015 In-Review; Kim et al. 2015 ERL; Park et al. 2015 RSE; Didan et al. 2010 IGRSS
Satellite Observations: Monitoring Tower Transects

1Surface Water Inundation

1Surface (0-2 cm) Soil Moisture

1Vegetation Optical Depth

MOD13Q1 250-m NDVI

1AMSR-E/2 Daily Land Parameter Retrievals: http://www.ntsg.umt.edu/project/amsrelp
Ecosystem Modeling & Tower Carbon Fluxes

**BES**

![Graph of CH₄ emissions](image)

- **CH₄** (mgC m⁻² d⁻¹)
- **NEE**: -4 g C m⁻² yr⁻¹
- **CH₄**: 3.5 g C m⁻² yr⁻¹

**IVO**

![Graph of CH₄ emissions](image)

- **CH₄** (mgC m⁻² d⁻¹)
- **NEE**: -12 g C m⁻² yr⁻¹
- **CH₄**: 6.5 g C m⁻² yr⁻¹

Wet Sedge

Tussock
Scaling Carbon Fluxes to Regional Alaska

• Beta release of NASA SMAP L4 Carbon Maps
  - Radiometer informed soil moisture & temp.
  - 9 km spatial res. & daily NEE, GPP, Reco fluxes
  - Data from April 2015 onward

![Graph showing NEE data for May to October 2014.]

• Off-line 1 km TCF CH₄ Flux Model
  - Regional validation using tower data (5+ sites)
  - Evaluation against airborne & tall tower obs., inverse models

1SMAP L4 Global Daily Carbon Products: http://nsidc.org/data/SPL4CMDL
Project Summary & Conclusions

- **Continuous flux tower operations needed!**
  - Quantify cold season fluxes; spring/autumn periods
  - Capture interannual variability in NEE & CH₄
  - Extend tower network in Alaska to represent heterogeneous tundra environments

- **Integrate tower obs., remote sensing & modeling**
  - Satellite data driven modeling captures flux variability; detects transitions from carbon sink to source
  - Carbon budgets: NEE + terrestrial (& lake) CH₄ emissions
  - Enhance Arctic monitoring through daily passive microwave retrievals (*e.g. surface wetness/temp., frozen/non-frozen conditions, vegetation dynamics, permafrost degradation*)
Thank You!

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