Understanding the Causes and Implications of Enhanced Seasonal CO$_2$ Exchange in Boreal and Arctic Ecosystems

Brendan Rogers and Gretchen Keppel-Aleks

Co-I's: Scott Goetz, Sue Natali, Christopher Schwalm, Amber Soja
Collaborators: Bruce Cook, Matt Hansen, John Kimball, Jeffrey Masek, Bill Riley, Kevin Schaefer
Motivation & Background
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(Graven et al., 2013)
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(Zhao and Zeng, 2014)
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(Murray-Tortarolo et al., 2013)
Motivation & Background

(Forkel et al., 2016)
We will conduct a *bottom-up, data-driven* model attribution study.
### Hypotheses

<table>
<thead>
<tr>
<th>Growing season productivity</th>
<th>Winter respiration</th>
</tr>
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<tr>
<td>Climate (summer warming)</td>
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<td>Productivity (labile substrates)</td>
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*1901-2011 Temperature Trend*
Benchmarks

Atmospheric CO$_2$

- Develop benchmarks from CO$_2$ flask data, total column observations, and aircraft campaigns
- Use GEOS-Chem to transport CO$_2$ tracers
- Test seasonal cycle amplitude, amplitude trends by latitude, monthly (shape) trends, N-S gradients by latitude and season, and IAV (among others, e.g. ILAMB)
- Challenge to separate meaningful changes from model biases in diagnostics
- Develop framework that can be used to quantify contribution from hypothesized mechanisms
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(Keppel-Aleks et al., 2013)
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**Additional benchmarks**
- Gridded flux products (upscaled FLUXCOM, MODIS, TCF, SMAP L4_C, SIF)
- Synthesis of *in situ* seasonal fluxes (tundra, boreal forest), focus on functional relationships
- Changes to arctic-boreal vegetation and fire regimes
Changes to arctic-boreal landscape

- Focus on landscape-level, ecosystem-type attributes, especially as linked with disturbance
  - Tractable given current & expected data sets
  - Directly relate to CLM & other land models
  - Should impact seasonal CO$_2$ fluxes (Forkel et al., 2016)
Changes to arctic-boreal landscape

Fire Databases

North America

Eurasia-Russia
Changes to arctic-boreal landscape
Fire Databases

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- New AVHRR-based continuous fields (0.05°, 1981-present, Hansen) = changing PFTs
- Burned area + PFTs = severity, mortality, succession trajectories, and evolving stand age
- Additional constraints on changing productivity vs. vegetation structure from GIMMS\textsubscript{3g} products
- Regional validation with ABoVE datasets
Potential model developments

- Optimize boreal-arctic PFT productivity, with a focus on post-fire trajectories
- Incorporate new mechanistic representation of respiration in frozen soils, accounts for thin water films surrounding soil particles (Schaefer and Jafarov, 2016)
- Add CO$_2$ diffusion through the soil and root conductive tissue as has been done for CH$_4$ (Riley et al., 2011)
- Add heat from exothermic respiration into soil column
- Play with phenology routines (e.g., Forkel et al., 2014; Chen and Che 2016) to address early spring GPP bias
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We’re looking for good postdocs!!

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