Understanding the Causes and Implications of Enhanced Seasonal CO_2 Exchange in Boreal and Arctic Ecosystems

Brendan Rogers and Gretchen Keppel-Aleks

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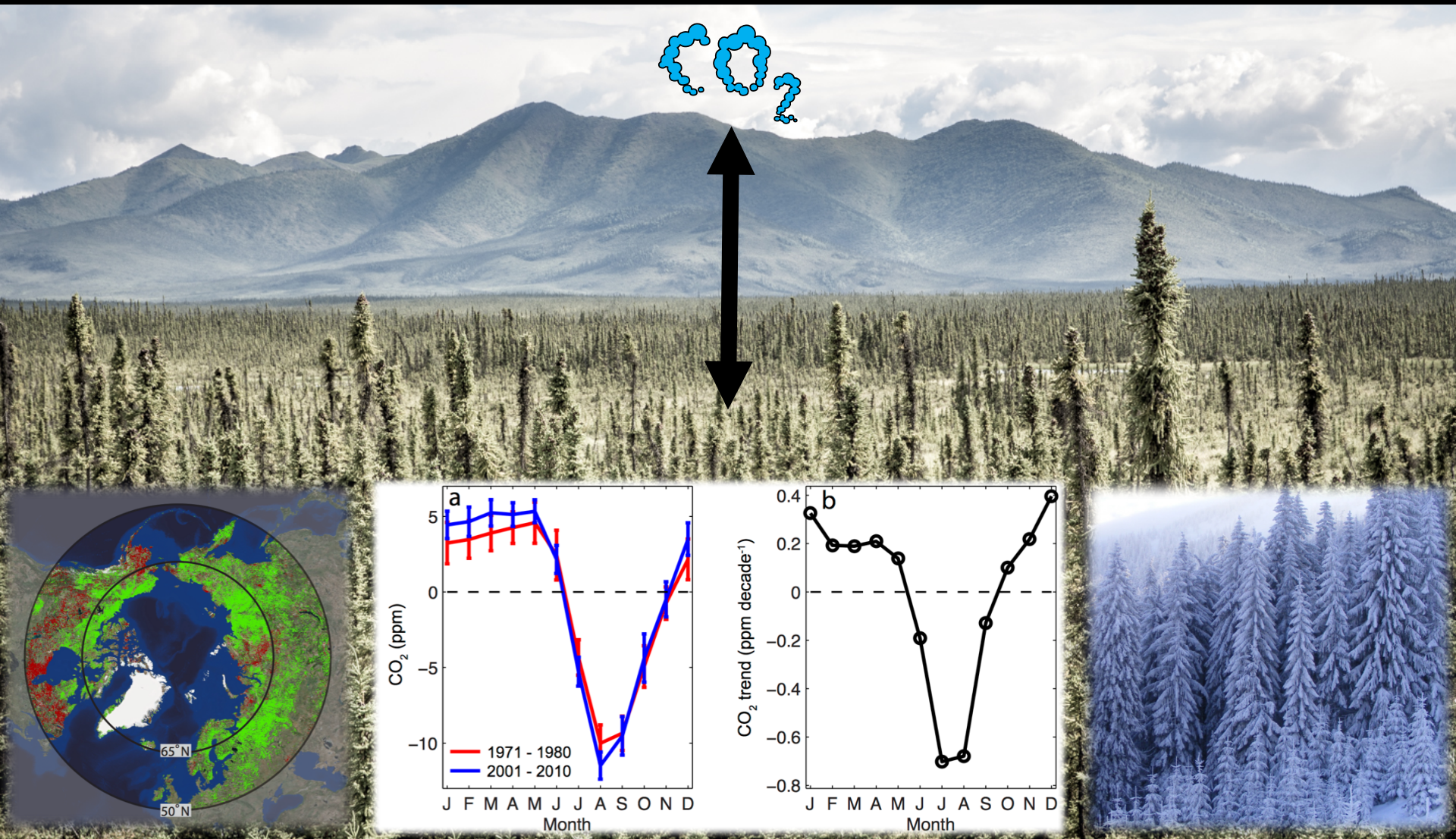
Collaborators: Bruce Cook, Matt Hansen, John Kimball, Jeffrey Masek, Bill Riley, Kevin Schaefer



Motivation & Background

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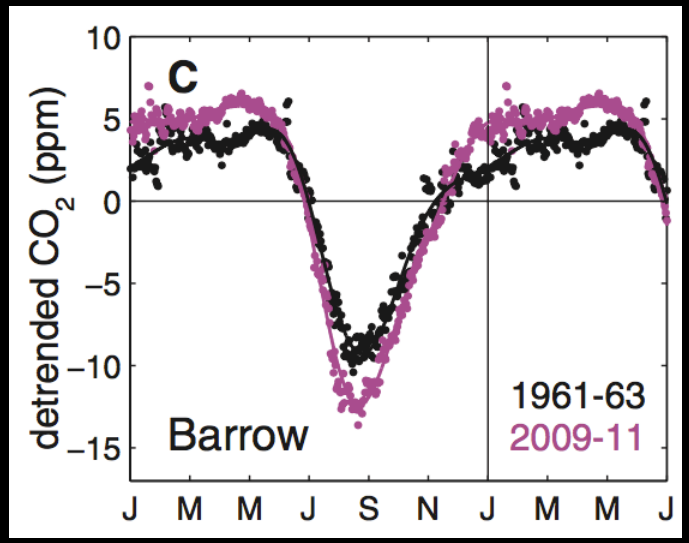
(Graven et al., 2013)



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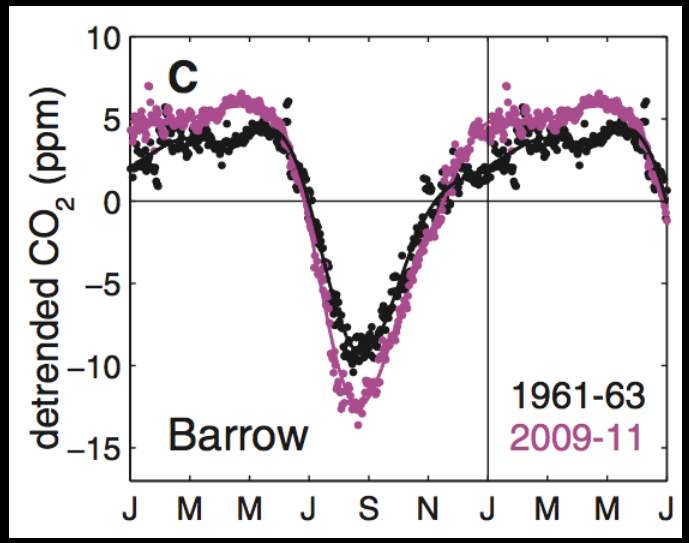

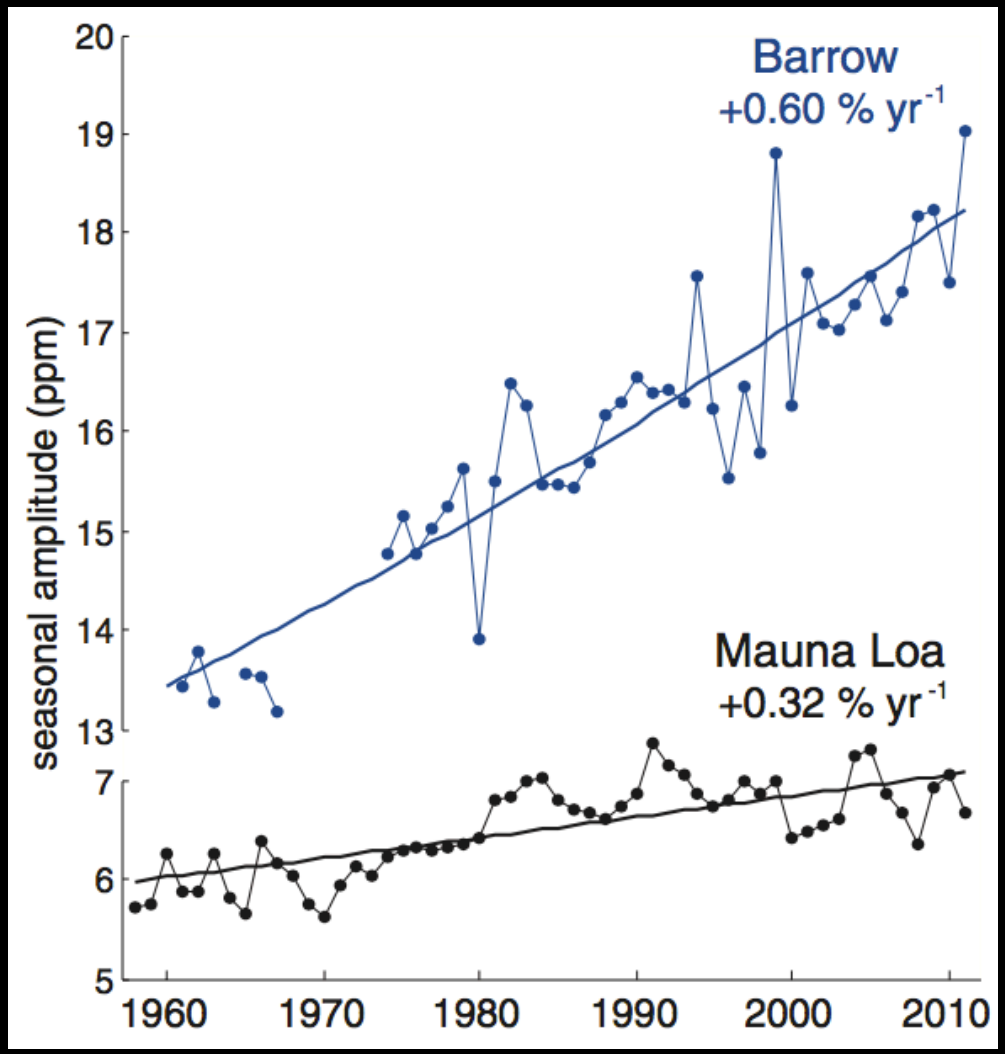

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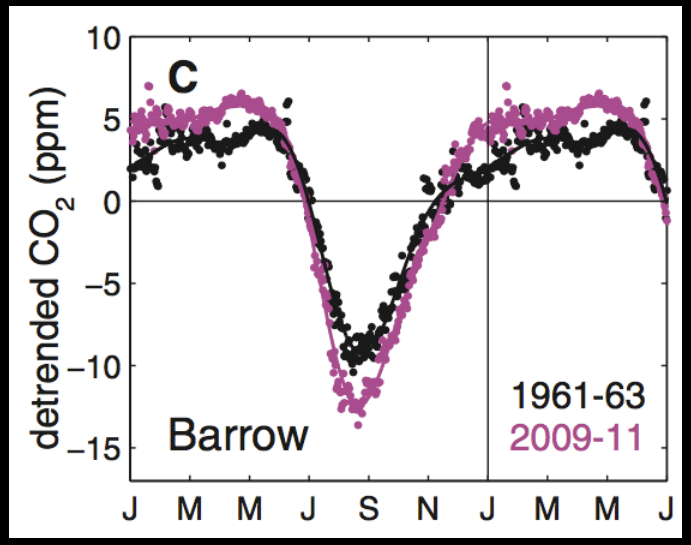

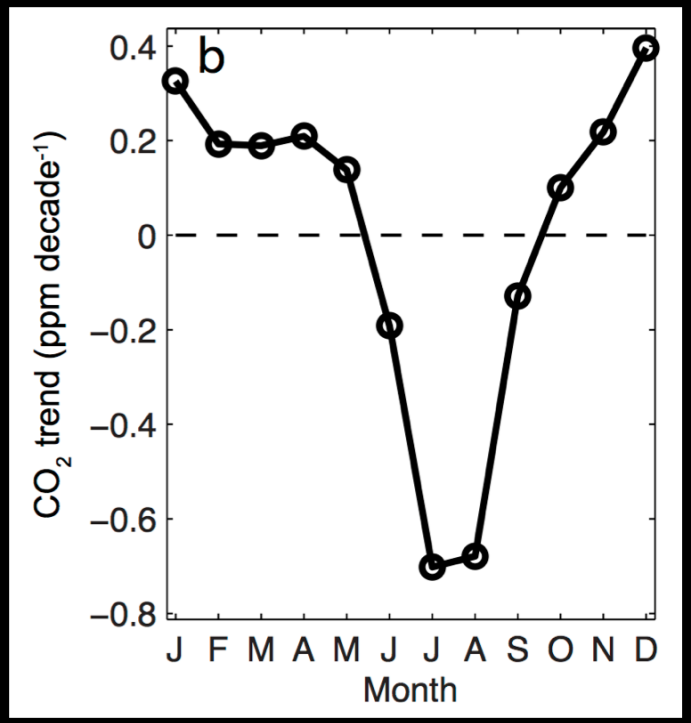

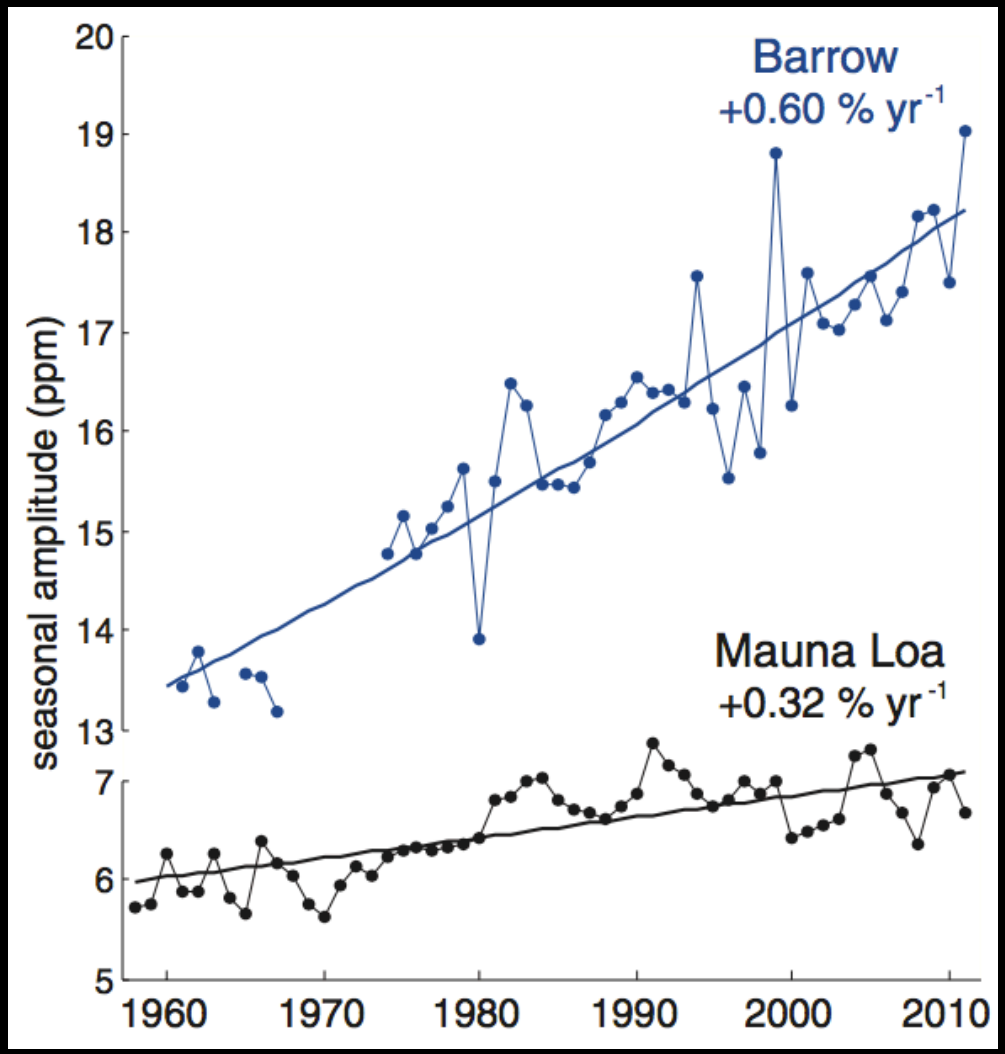

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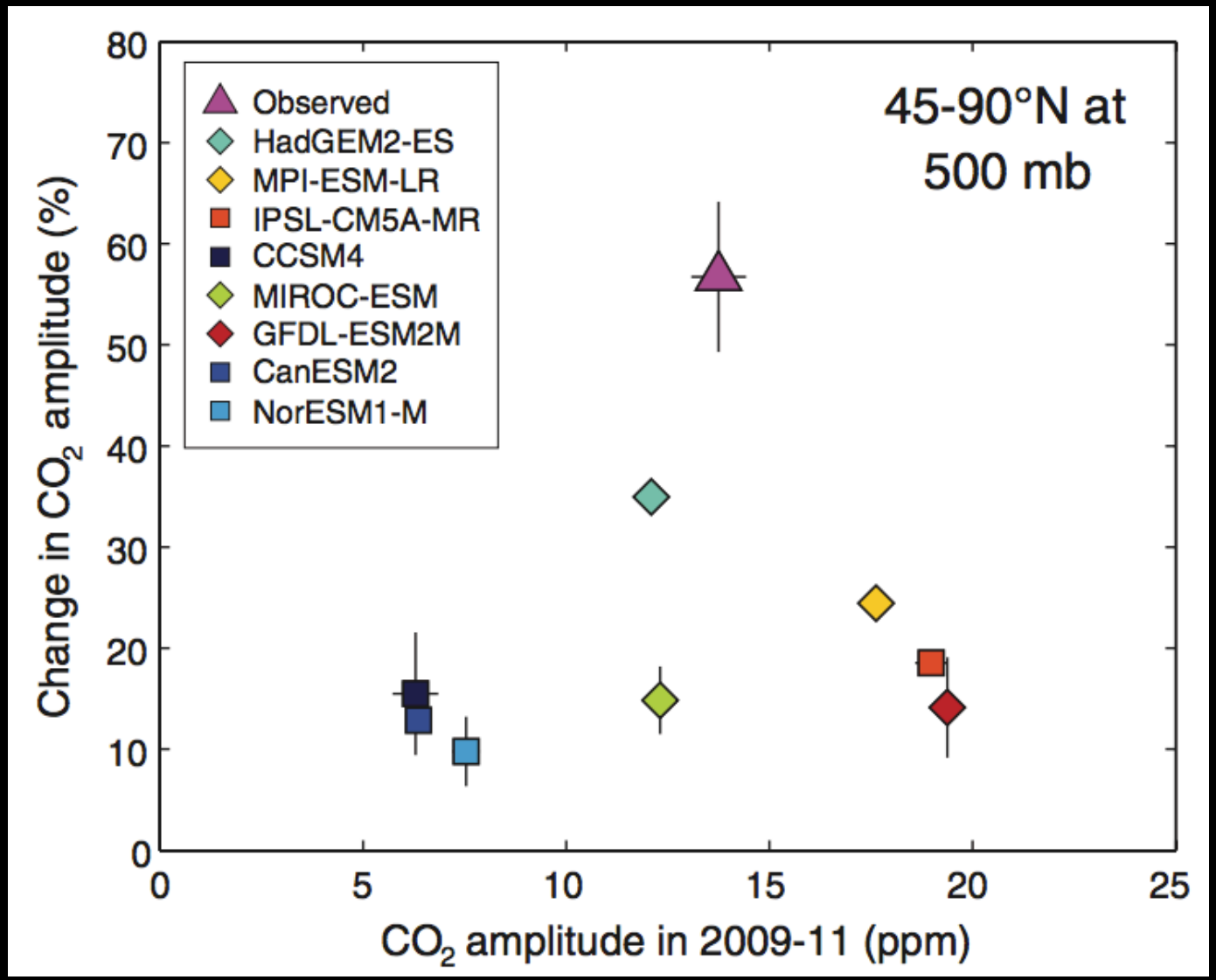

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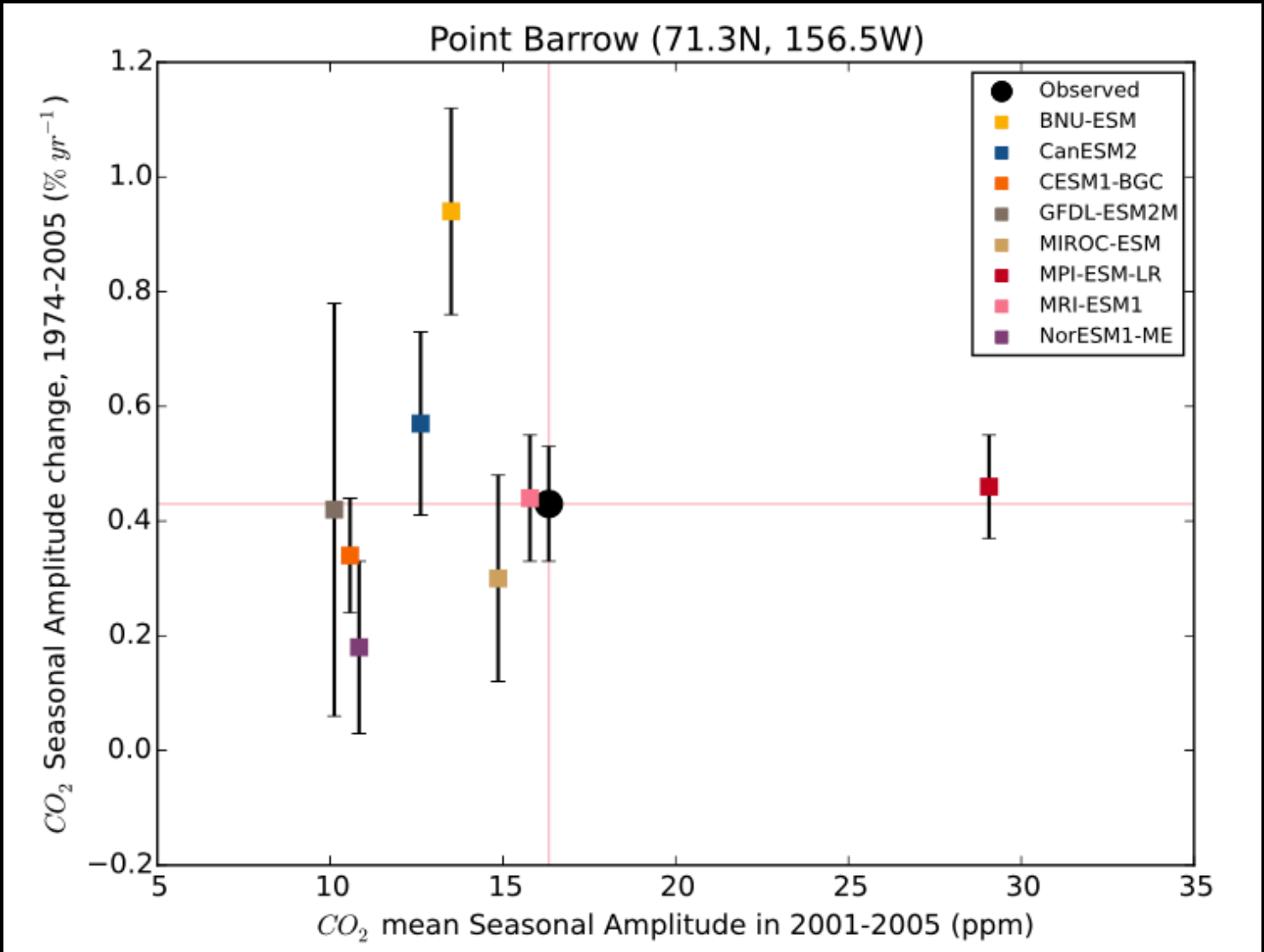

(Zhao and Zeng, 2014)

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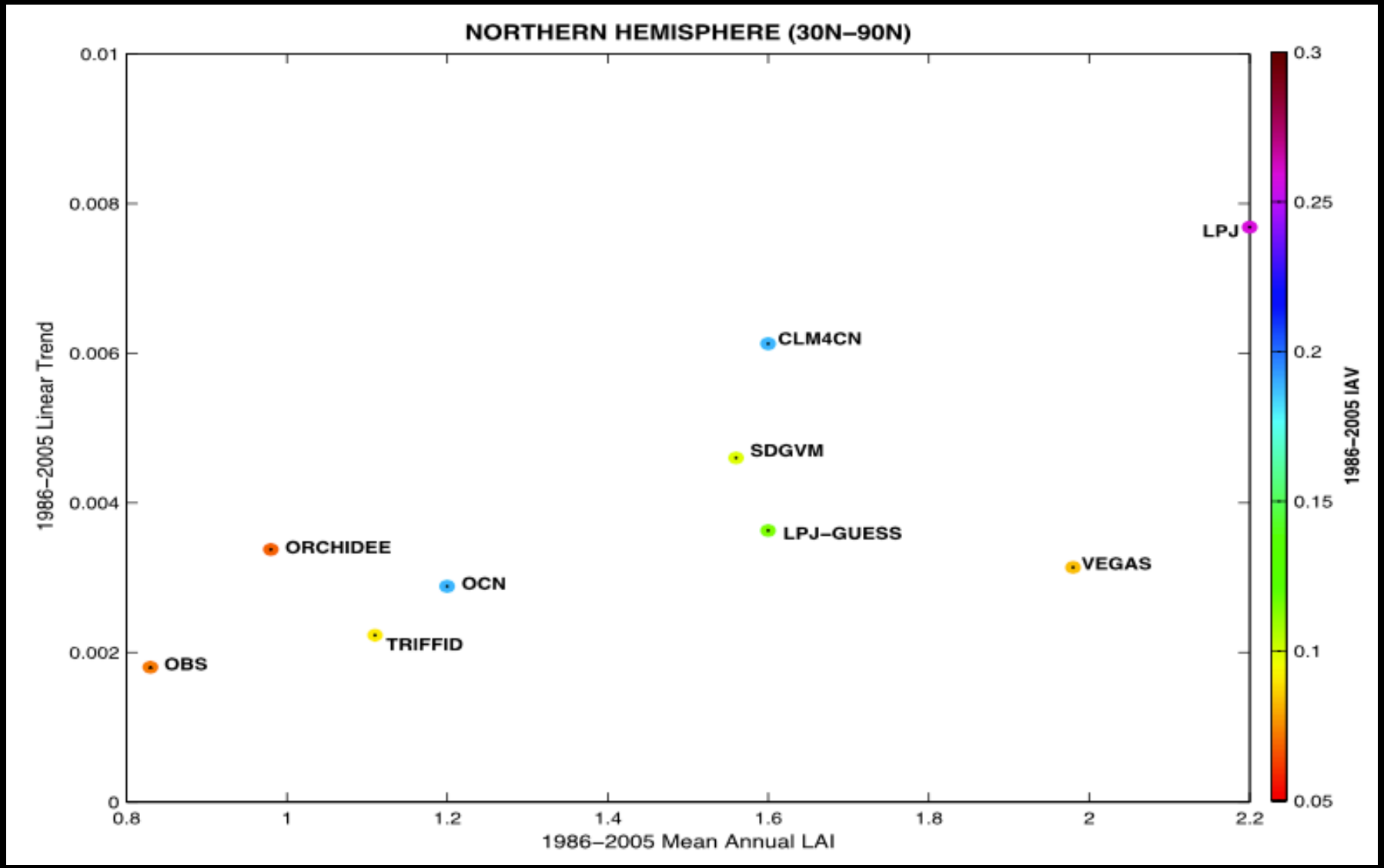

(Murray-Tortarolo et al., 2013)

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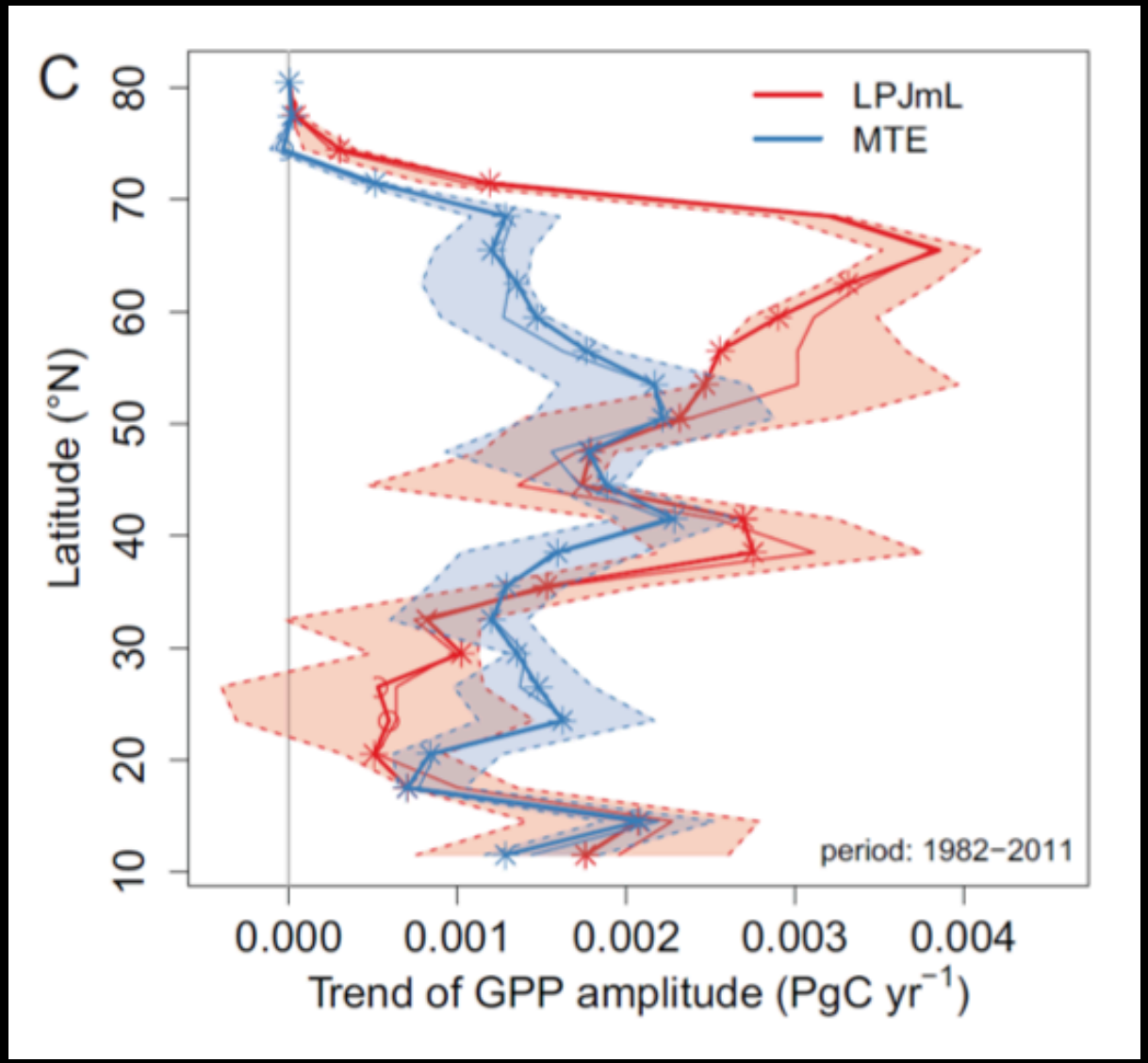

(Forkel et al., 2016

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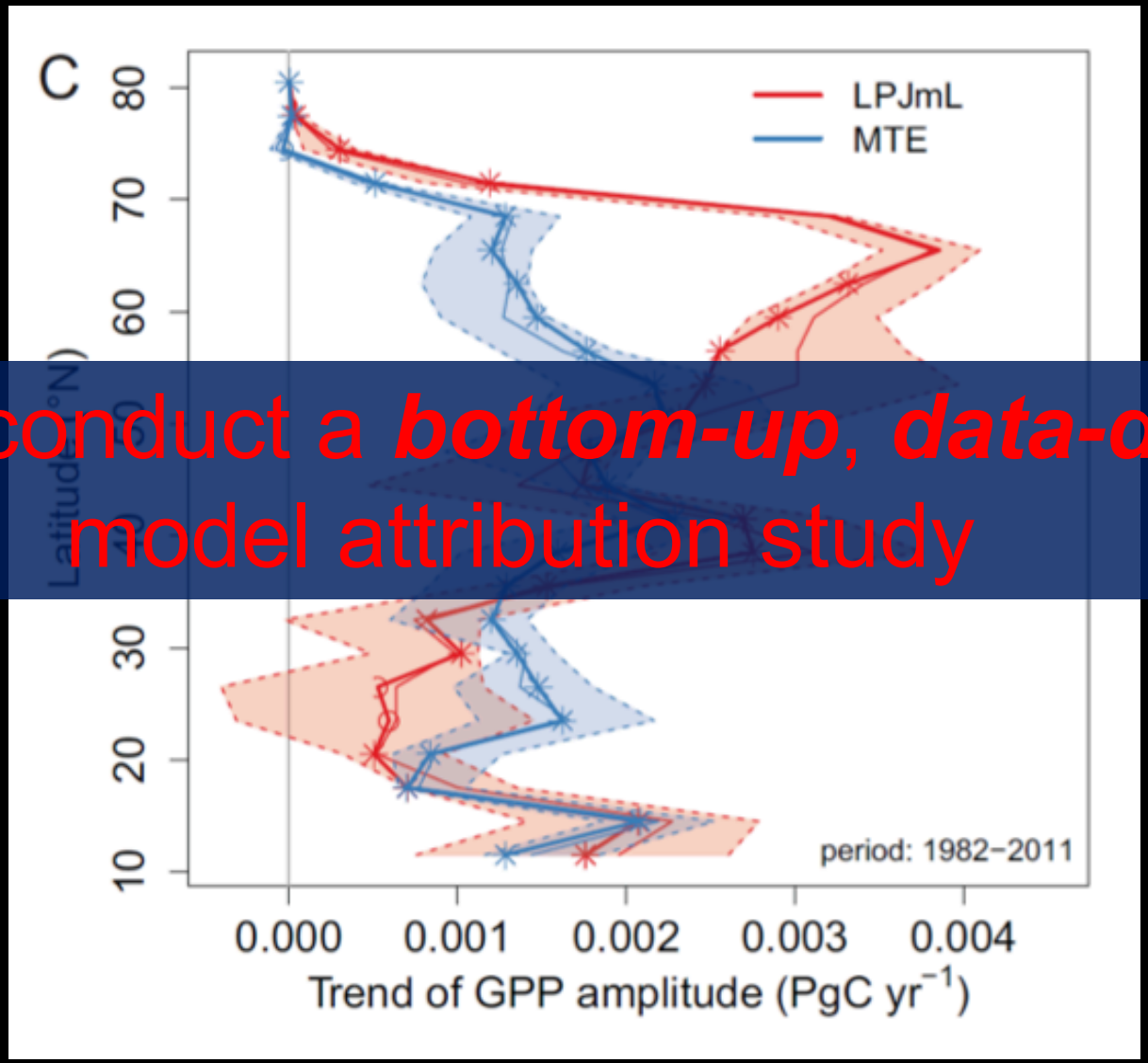

We will conduct a ***bottom-up***, ***data-driven*** model attribution study

(Forkel et al., 2016)

Hypotheses

Growing season productivity	Winter respiration
Climate (summer warming)	Climate (winter warming)
CO_2	Productivity (labile substrates)
N deposition	Snow (cover and depth)
Veg-tundra	Vegetation
Veg-boreal-cover	Delayed gas diffusion
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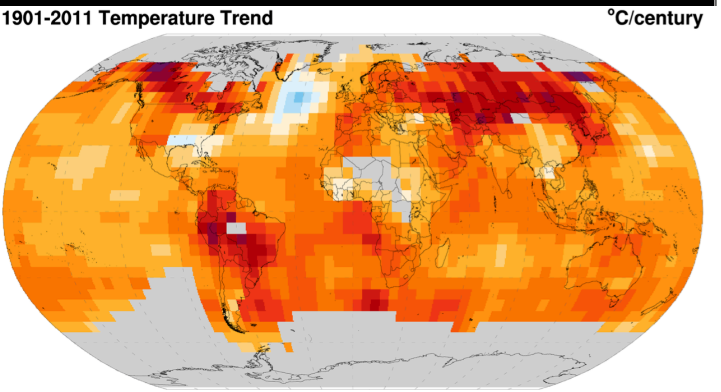
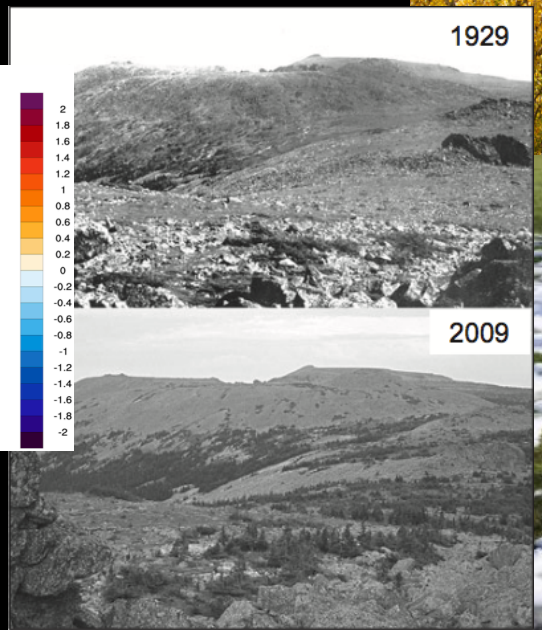
Permafrost (plant-available N & H_2O)	





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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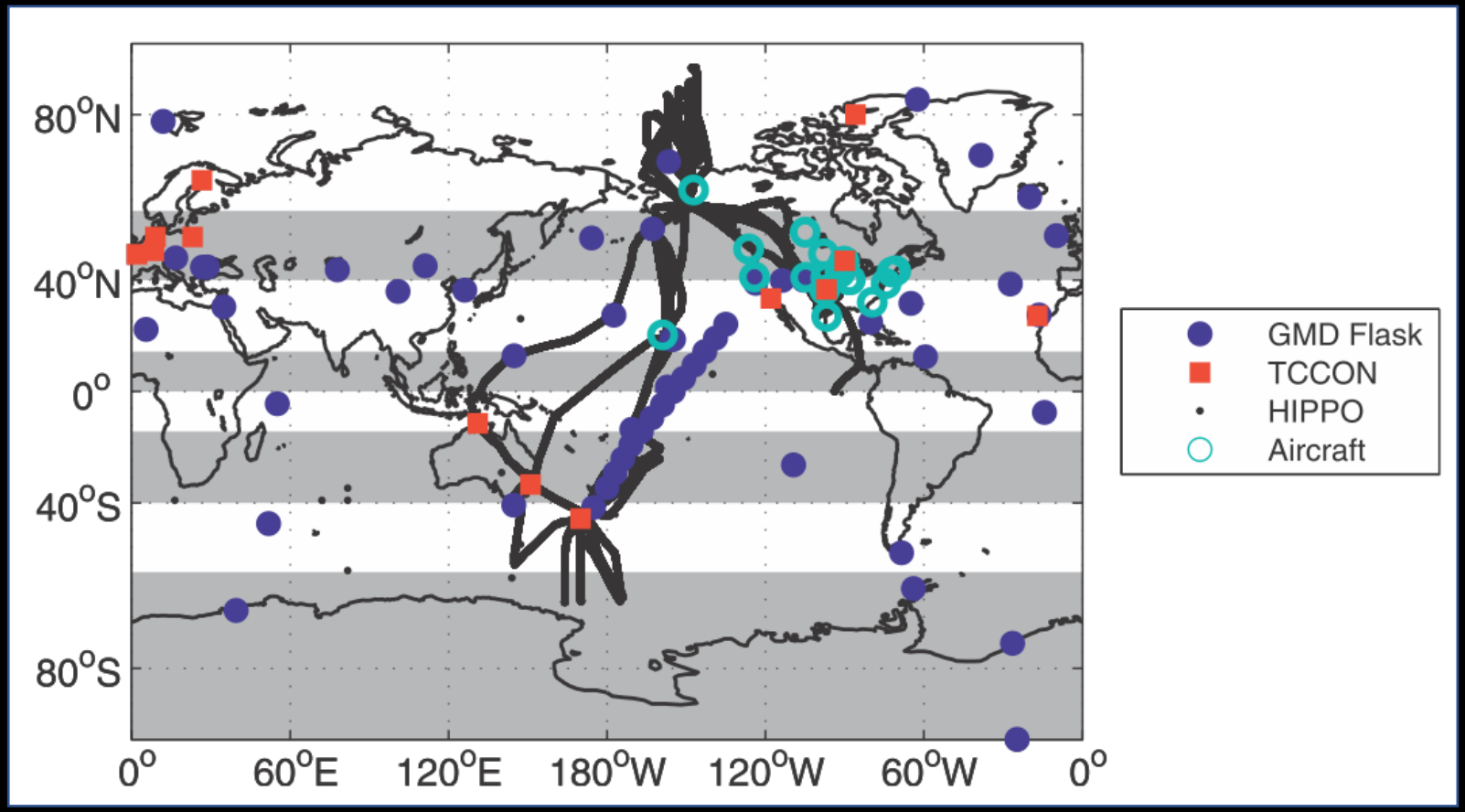

(Keppel-Aleks et al., 2013)

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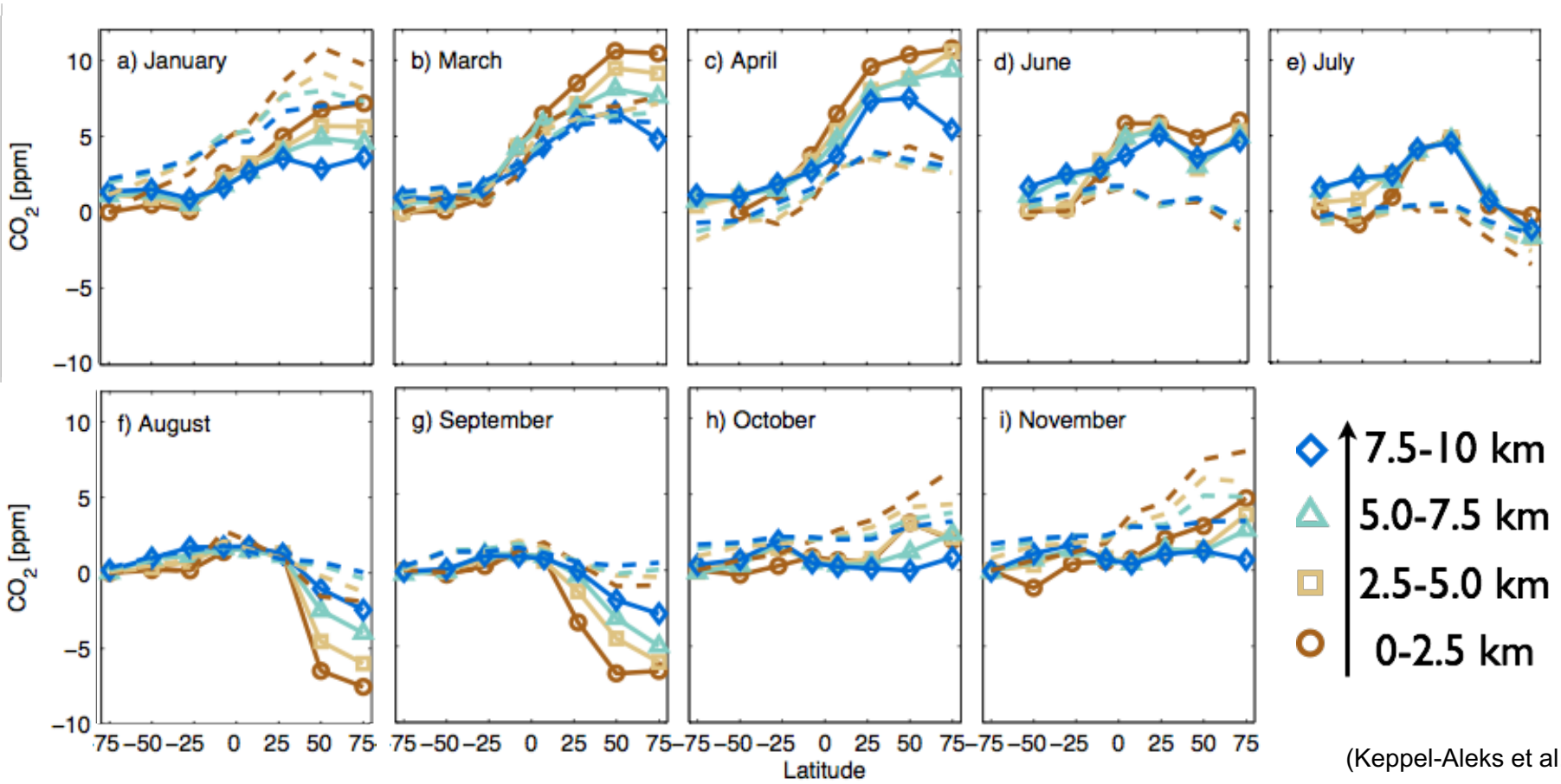

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Additional benchmarks

- 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

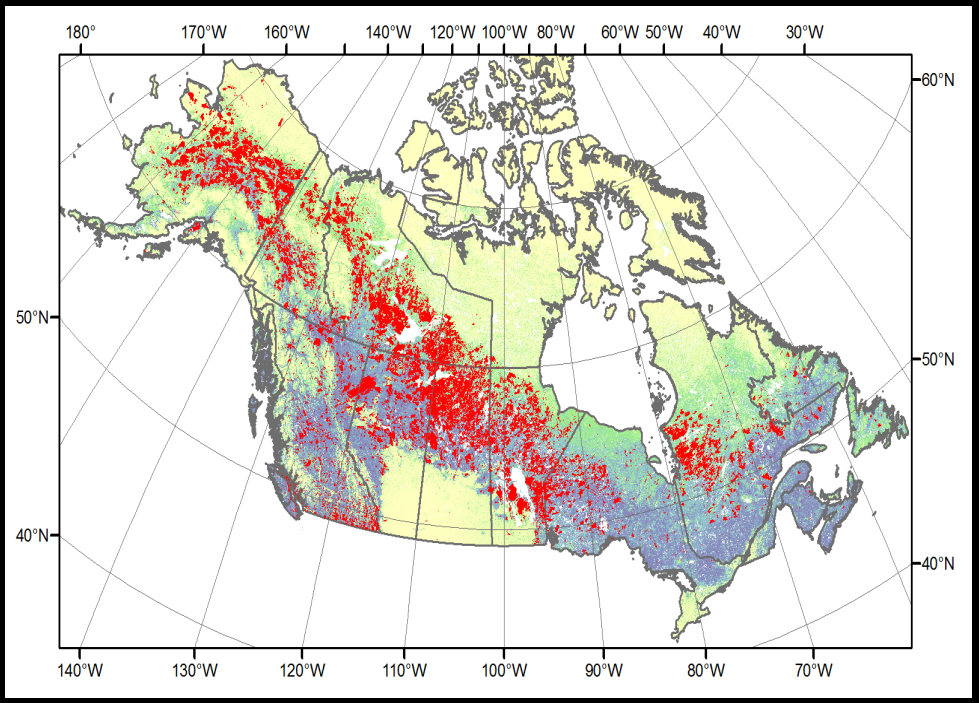
Changes to arctic-boreal landscape

- Focus on landscape-level, ecosystem-type attributes, especially as linked w/disturbance
  - Tractable given current & expected data sets
  - Directly relate to CLM & other land models
  - Should impact seasonal CO_2 fluxes (Forkel et al., 2016)

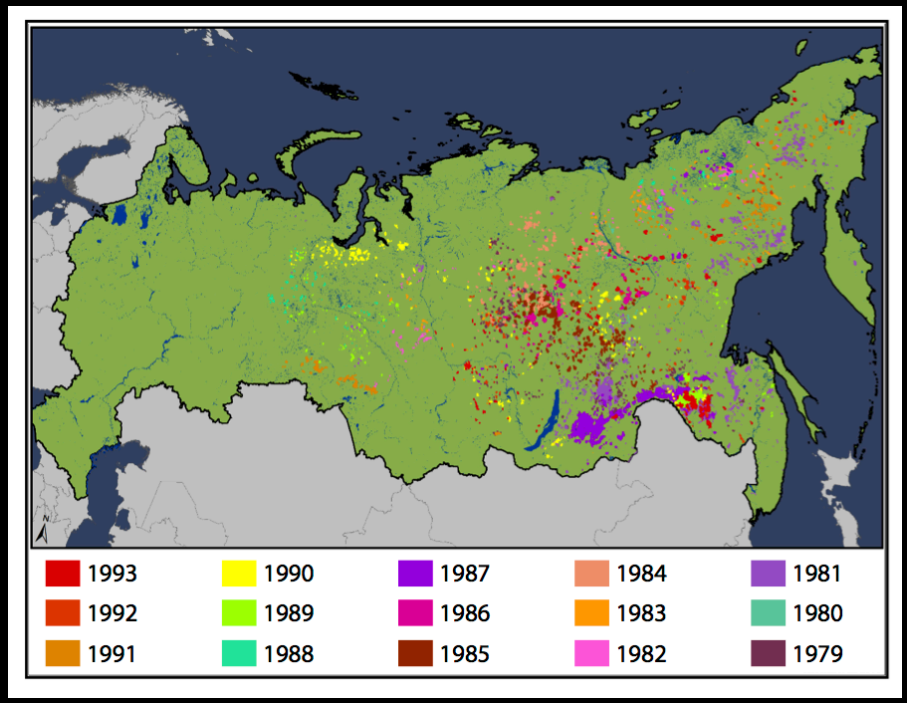
Changes to arctic-boreal landscape

Fire Databases

North America



Eurasia-Russia



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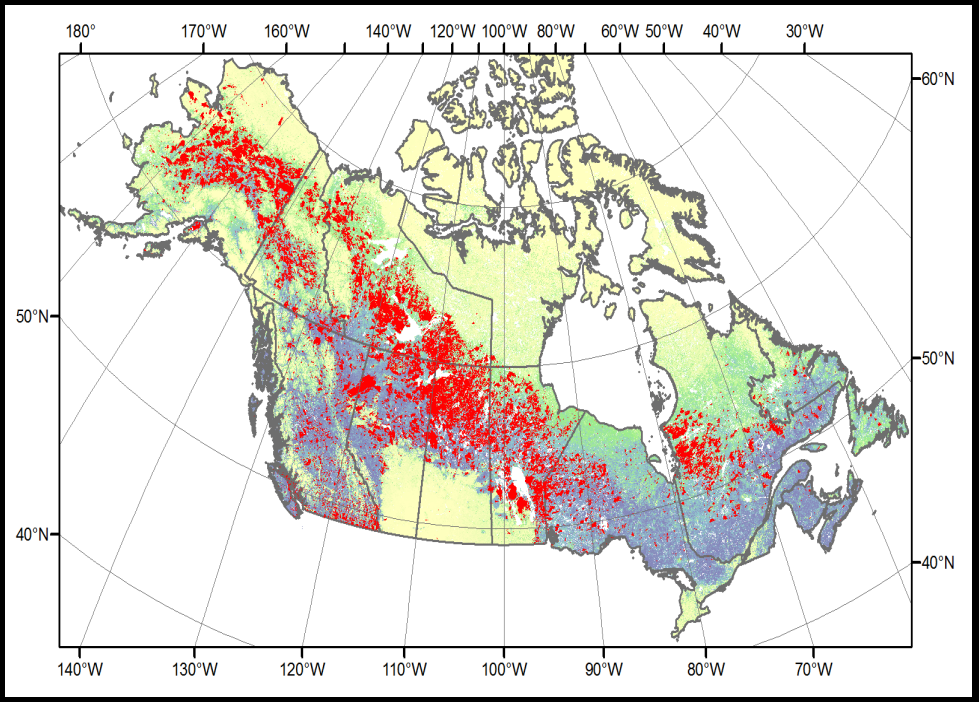

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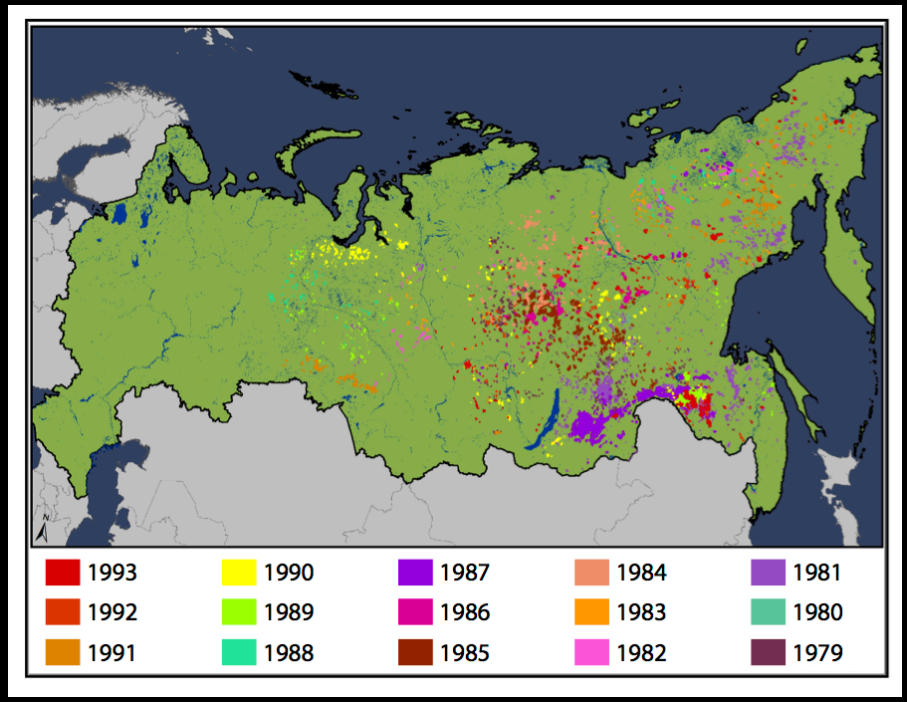
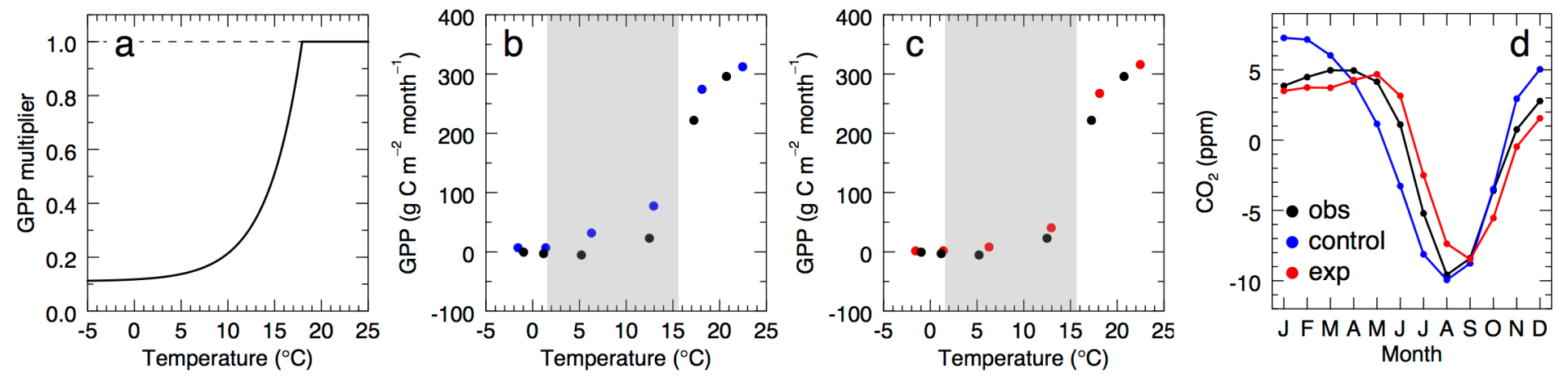


- New AVHRR-based continuous fields (0.05°, 1981-present, Hansen) = changing PFTs
- Burned area + PFTs = severity, mortality, succession trajectories, and evolving stand age
- Additional constraints on changing productivity vs. vegetation structure from $GIMMS_{3g}$ products
- Regional validation with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



Model experiments

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Permafrost (plant-available N & H_2O)	

We're looking for good postdocs!!

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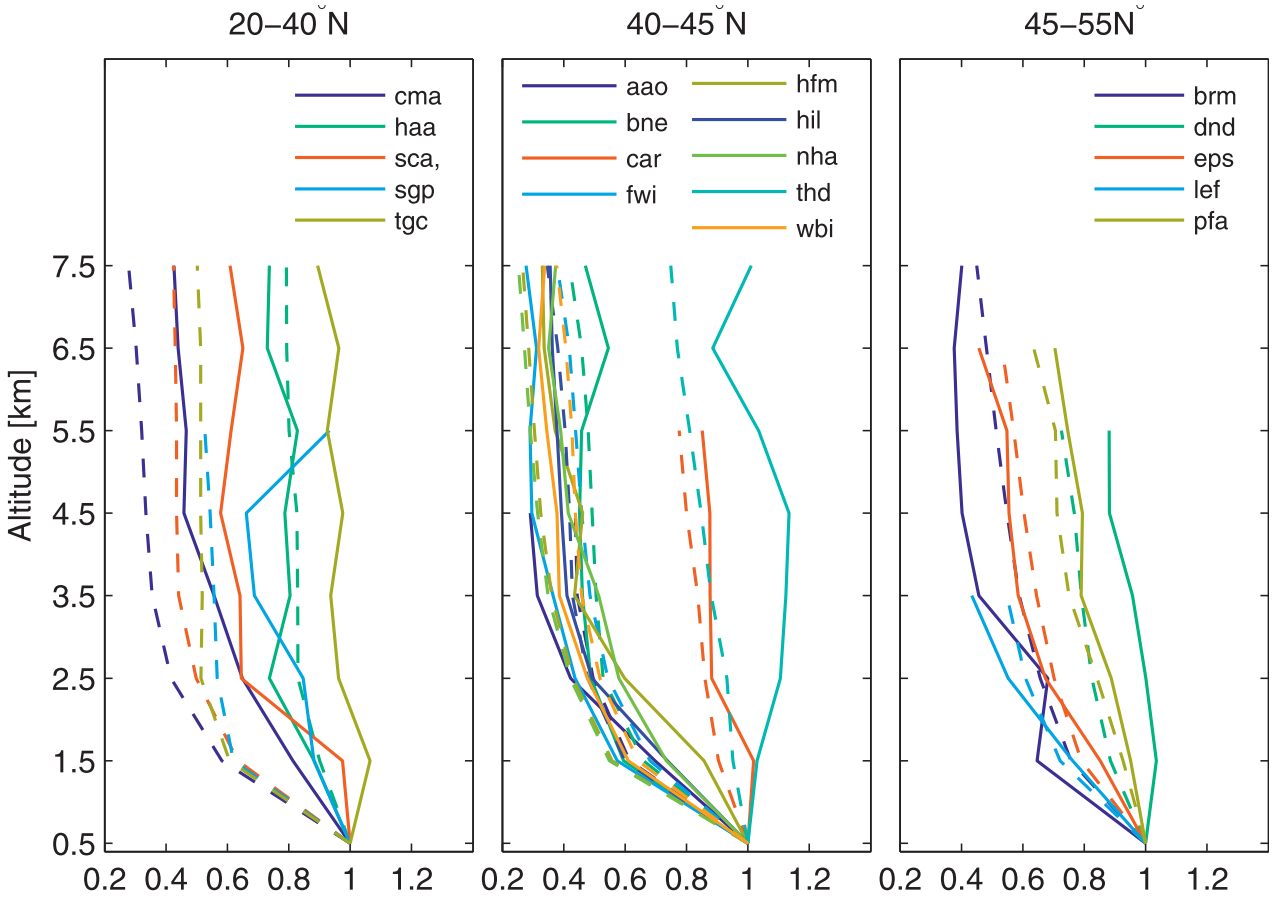

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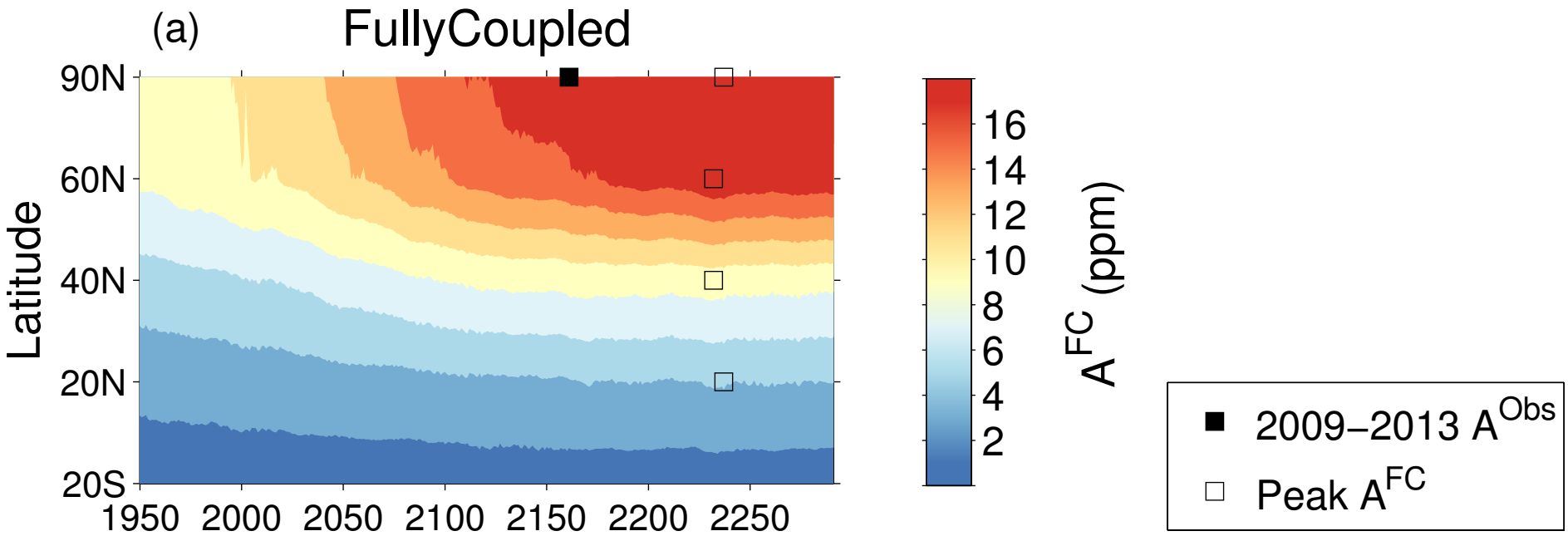

(Liptak et al., in press)

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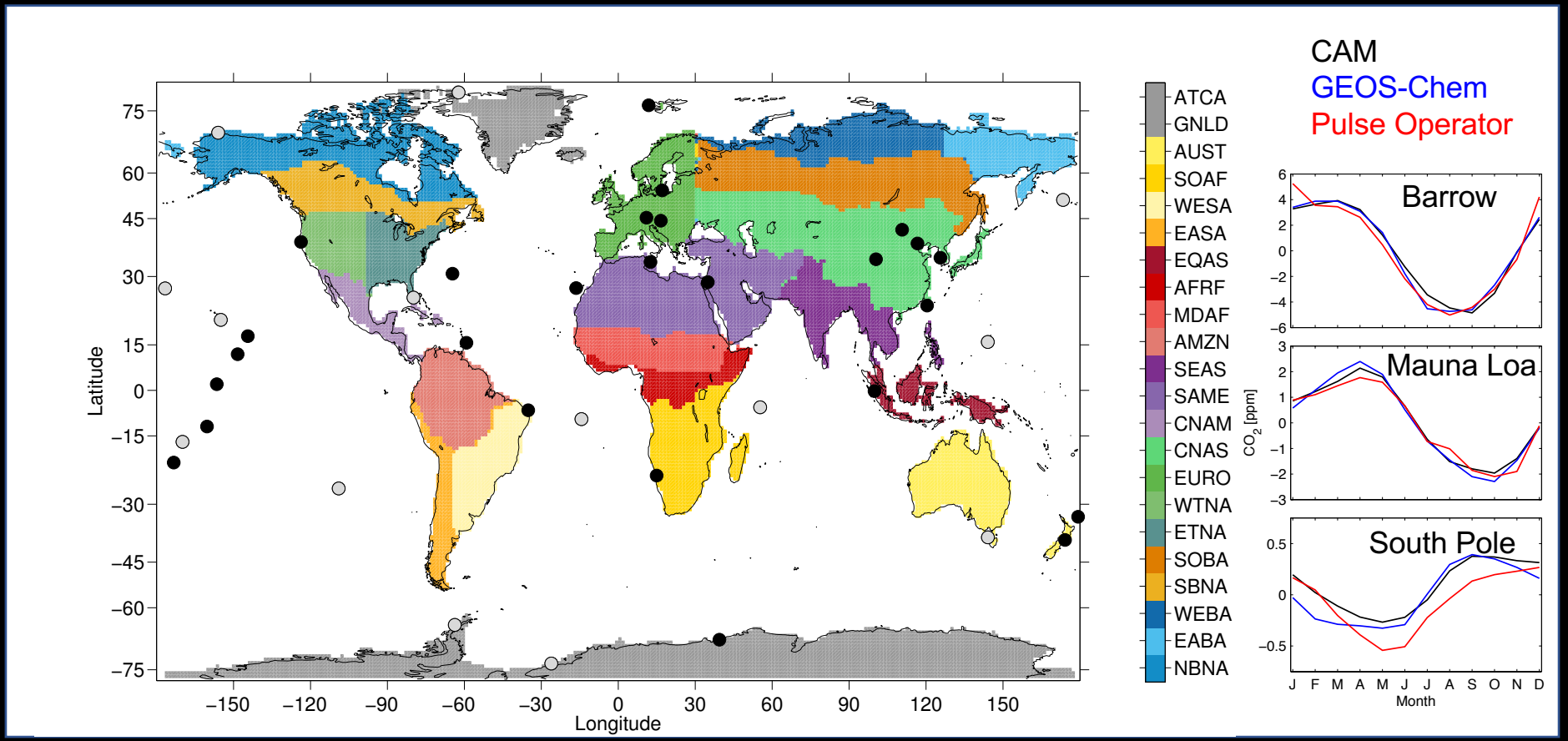

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