Carbon

Regional^Fluxes: Challenges and Opportunities

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Regional Fluxes?

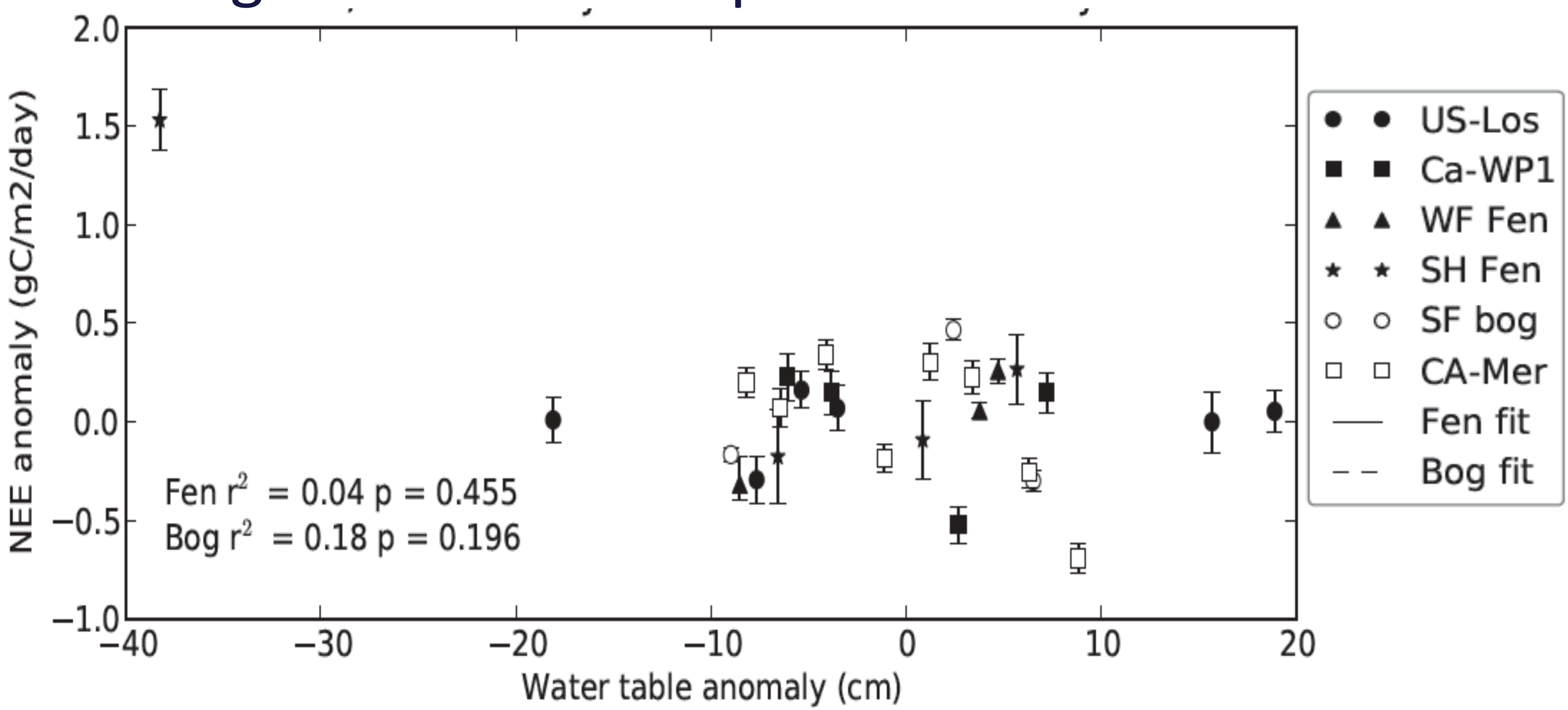
- Anthropogenic climate change has global forcing but regional impacts
- These impacts require assessment of response of **regional** surface-atmosphere **fluxes** of trace greenhouse gases, water, and energy to climate variability and change

So What?

- Fundamentals of ecology and micrometeorology have been mostly studied at the **plot** scale
- Fundamentals of surface-atmosphere flux influence on climate mostly studied **globally**
- **Regions** (landscapes, watersheds, continents) are where climate-ecosystem interactions are least understood and likely to hold the most surprises
  - It's also the relevant scale for ecosystem management
- A couple of examples in carbon cycling…

Example 1: Northern Wetlands

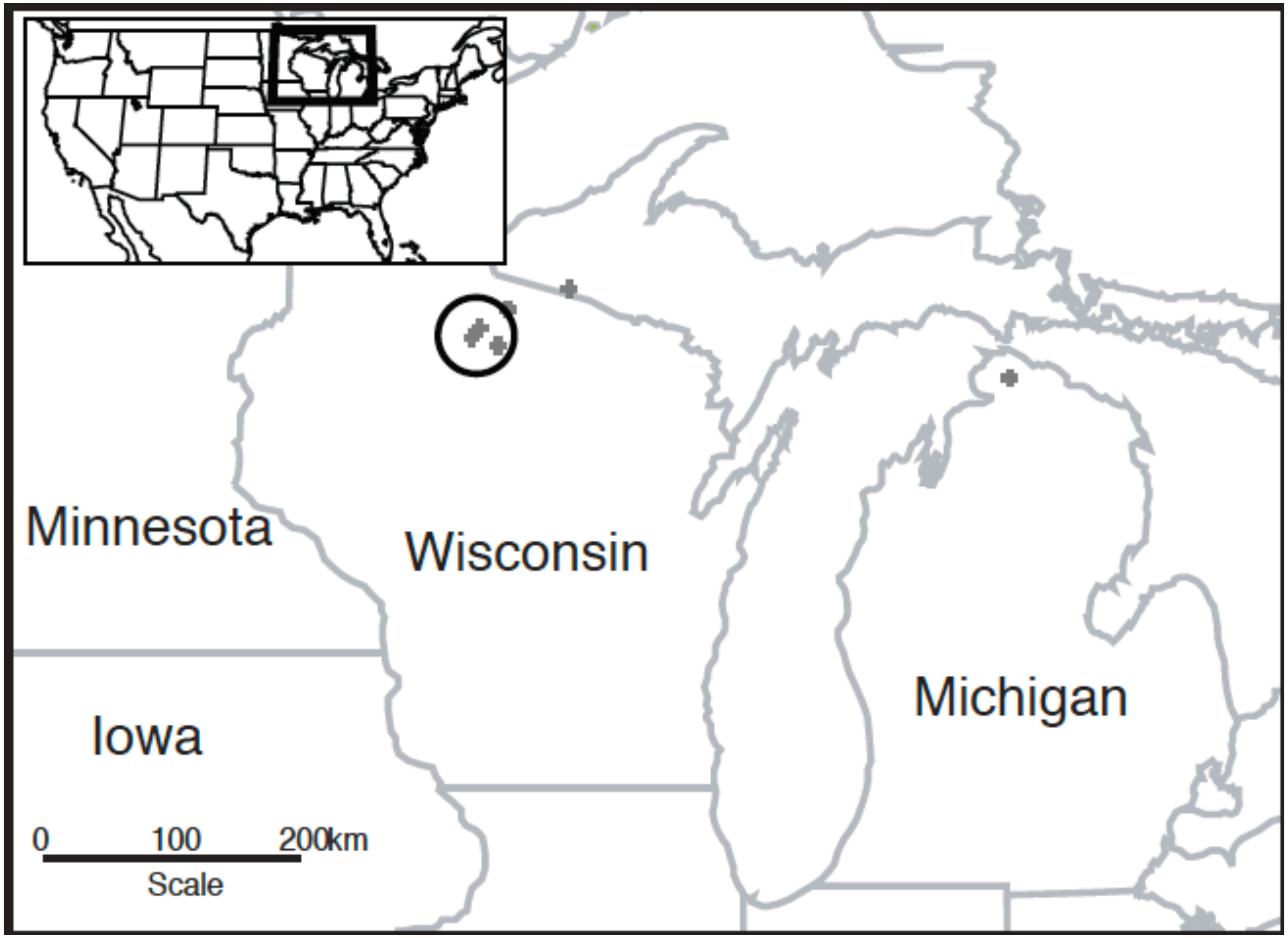
- NEE (Net Ecosystem Exchange of CO_2): negative = carbon uptake



Sulman et al. (2009) BG; Sulman et al. (in press) GRL

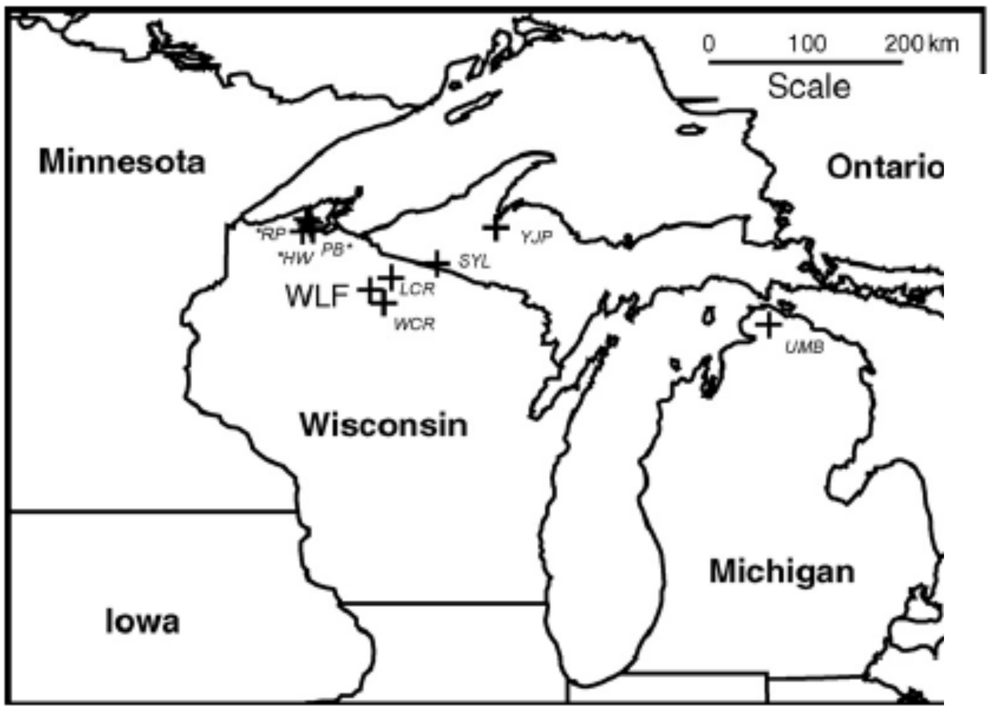
The Region

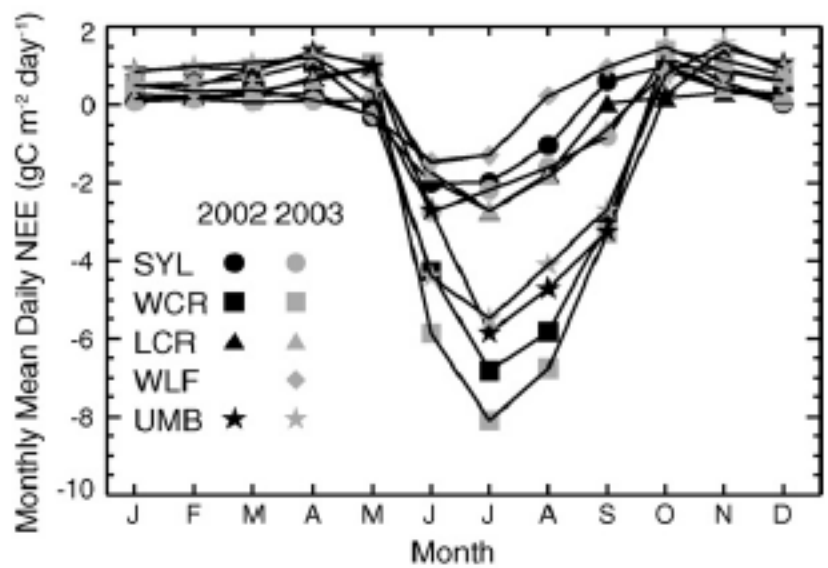
- Does the region respond similarly?



Methods

- Bottom-up (scaling)
  - **IFUSE – Interannual Flux-Tower Upscaling Experiment**
    - 12 regional flux tower upscaling using simple regional model and data assimilation (**Desai et al., 2008 AgForMet; accepted, JGR-G**)





Desai et al (2008) AgForMet; Desai, accepted, JGR-G

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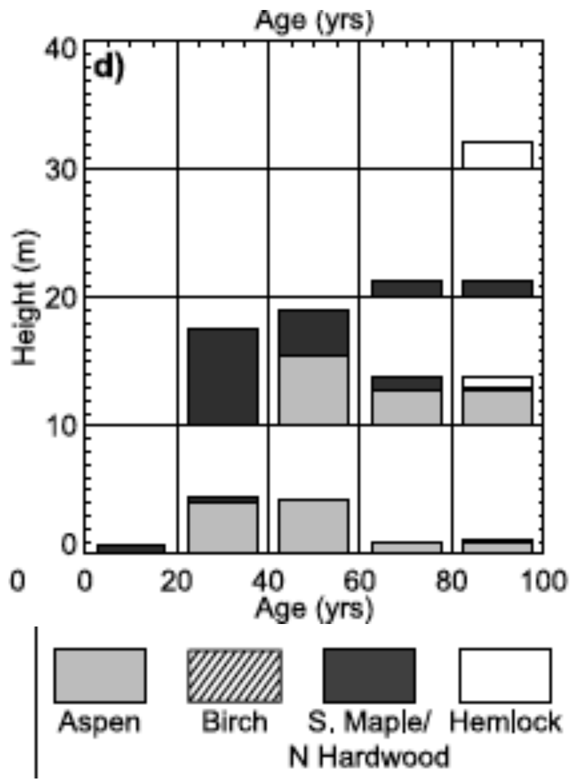
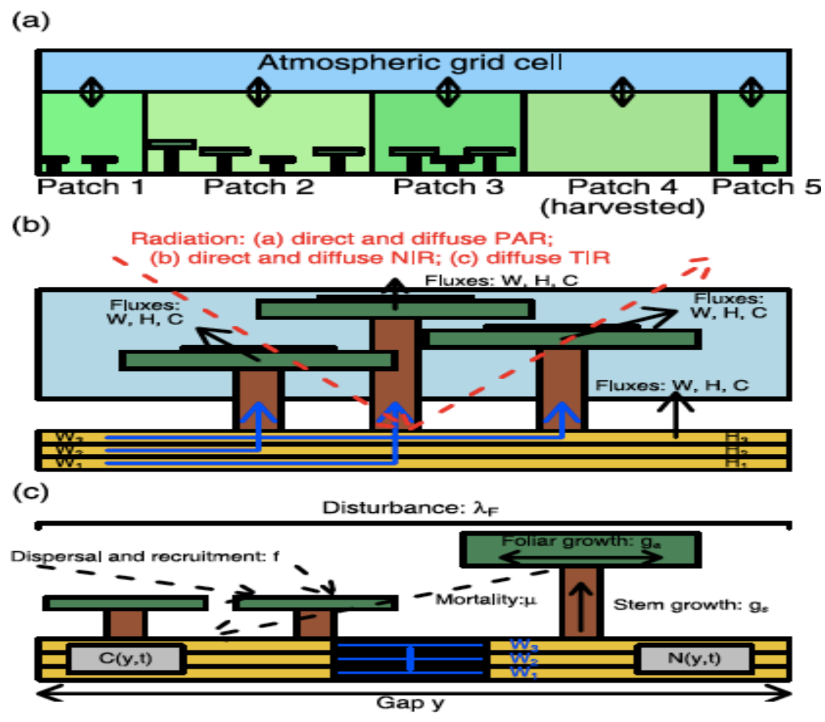
  - **ED – Ecosystem Demography Model v1.5**
    - Height-and-age cohort succession model tuned to Forest Inventory and Analysis (FIA) data (**Desai et al., 2007, JGR-G**)



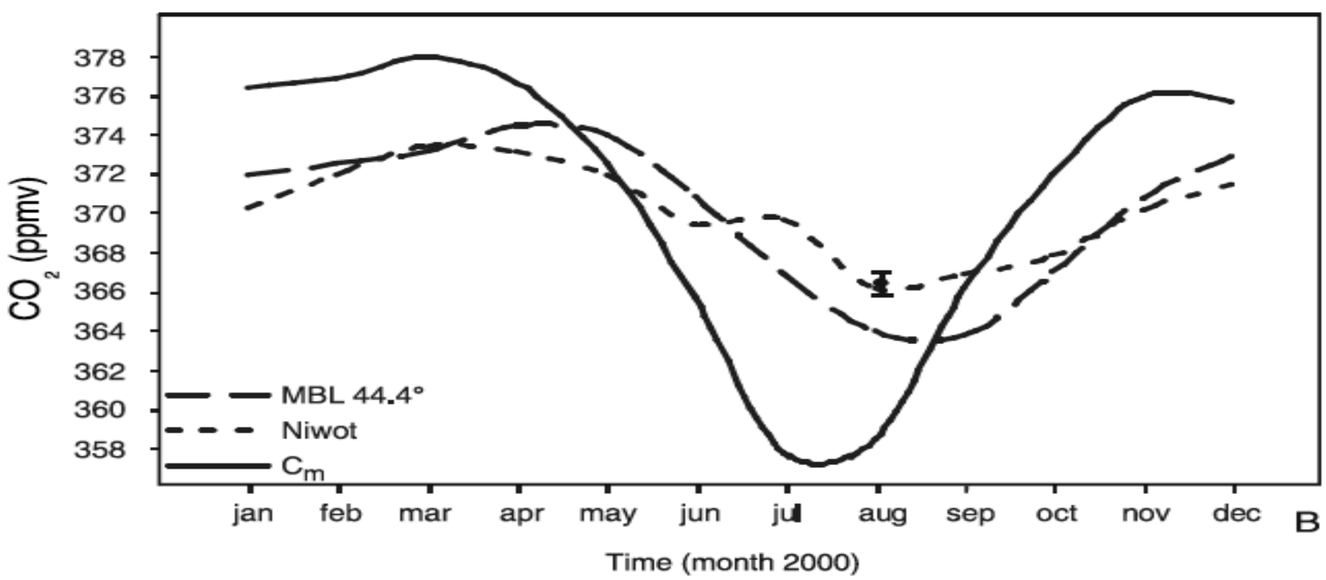


Desai et al (2007) JGR-G; Moorcroft et al (2001); Medvigy et al (2009)

Methods

- Bottom-up (scaling)
- Top-down (atmospheric budgets)
  - **EBL – Equilibrium Boundary Layer**
    - 1-D boundary layer budget inferred from tall tower CO_2 and reanalysis subsidence rates (**Helliker et al, 2004, JGR-D**)

$$NEE = \rho W(C_t - C_m) + \rho h \partial C_m / \partial t$$



Desai et al (2010) JGR-G; Helliker et al (2004) JGR-D

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  - **CT – CarbonTracker v2009**
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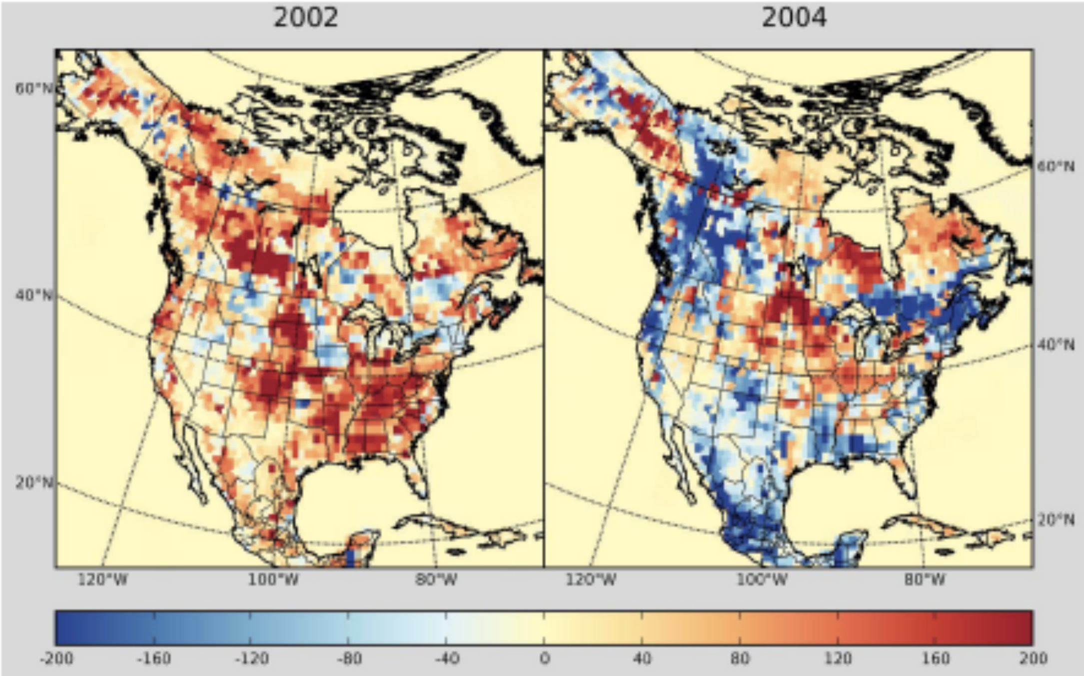

Desai et al (2010) JGR-G; Peters et al. (2007) PNAS

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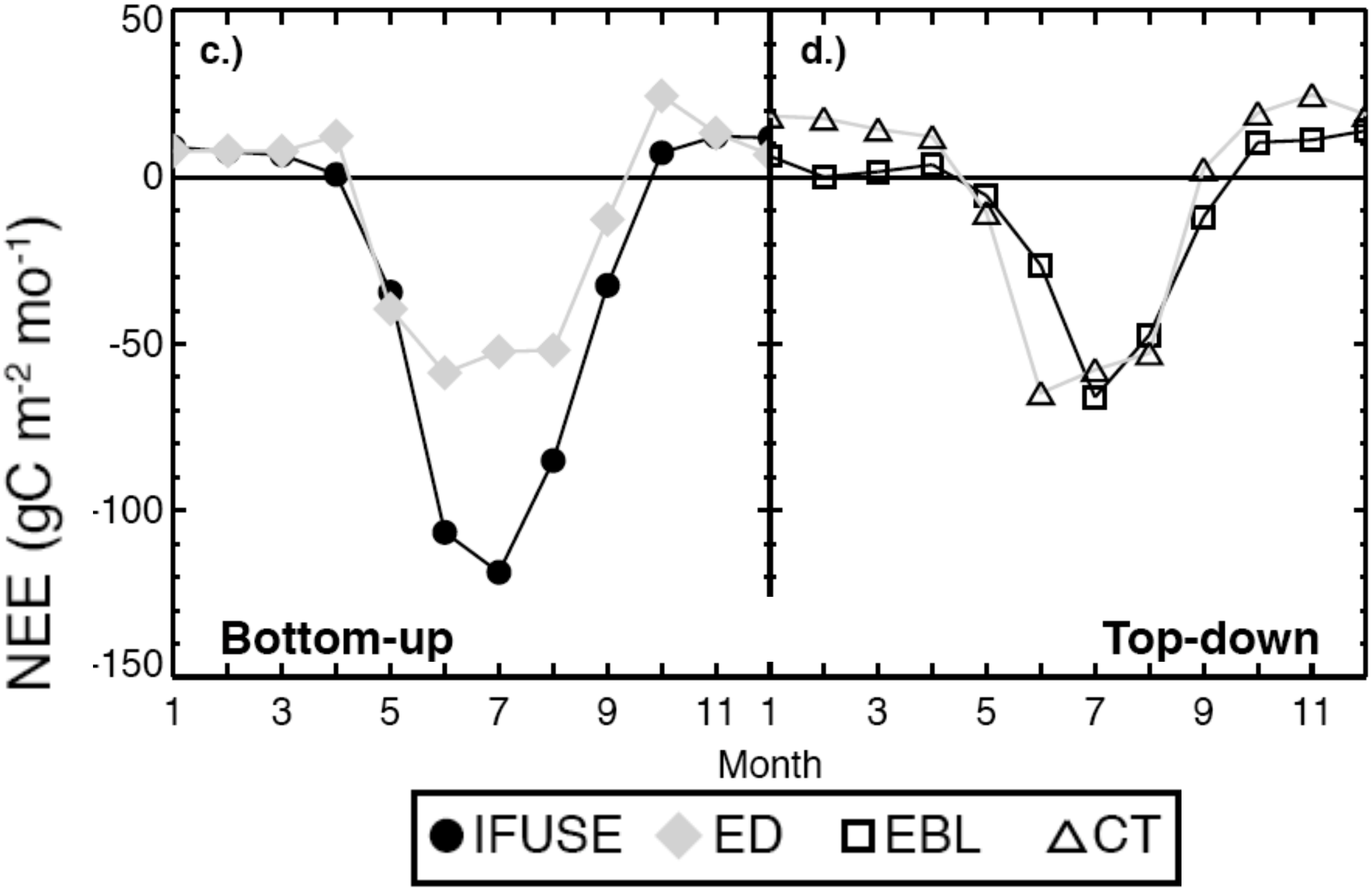
Desai et al (2010) JGR-G

Regional Flux

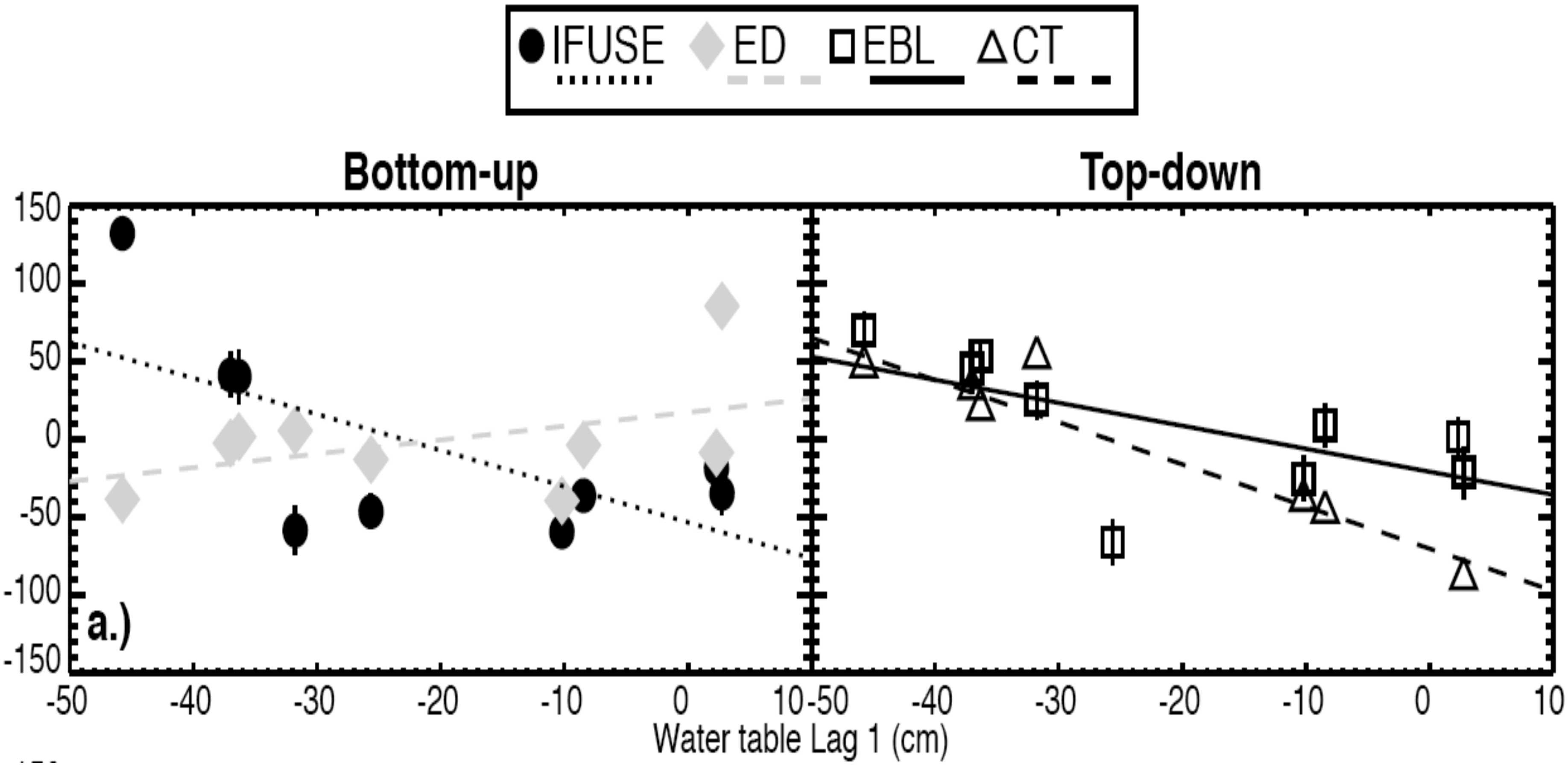
- Magnitudes vary, but variability is similar



Desai et al (2010) JGR-G

Regions and Water

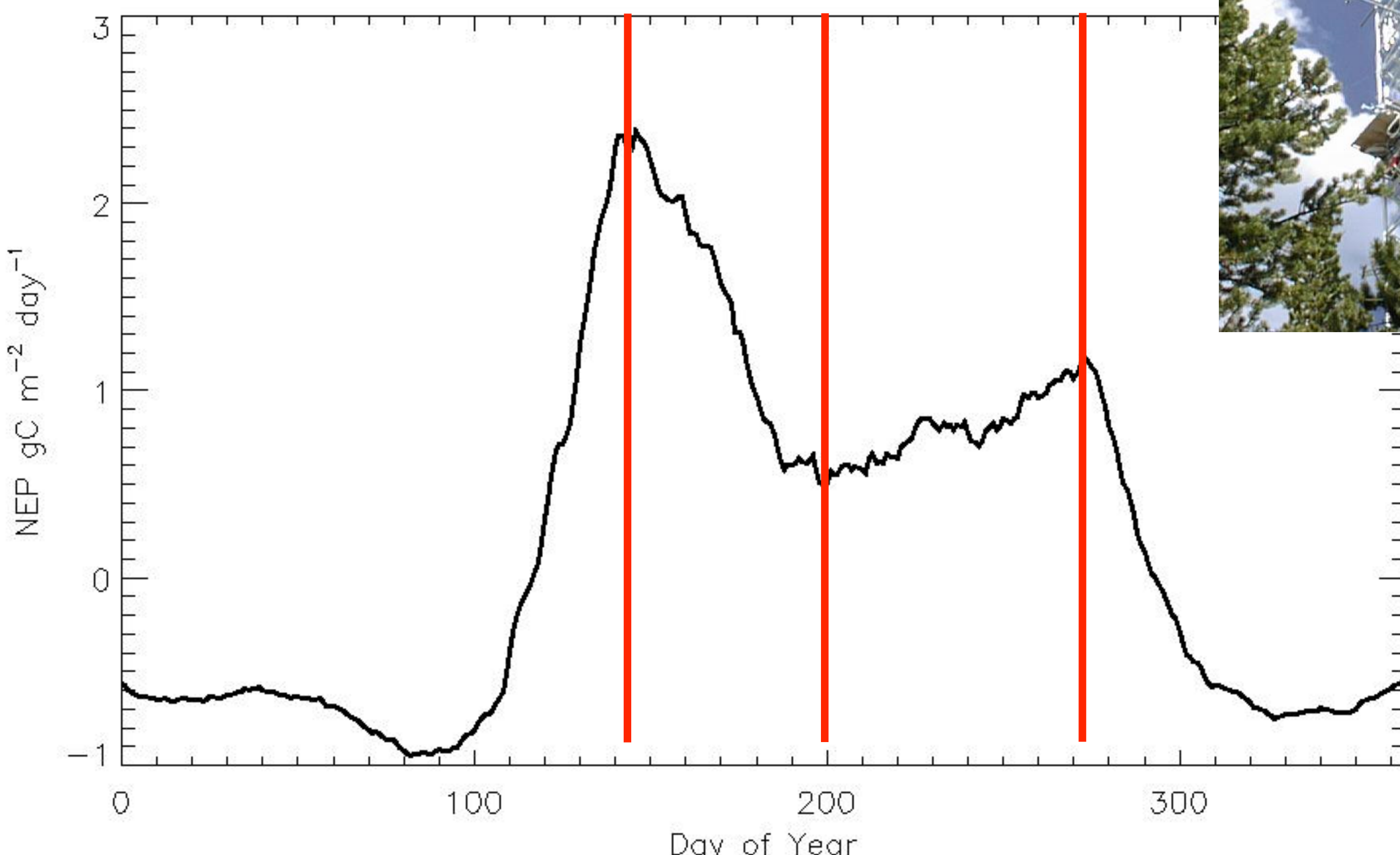
- Unlike wetland sites, water table strongly influences anomalies in regional NEE



Desai et al (2010) JGR-G

Example 2: Montaine Conifer Forests

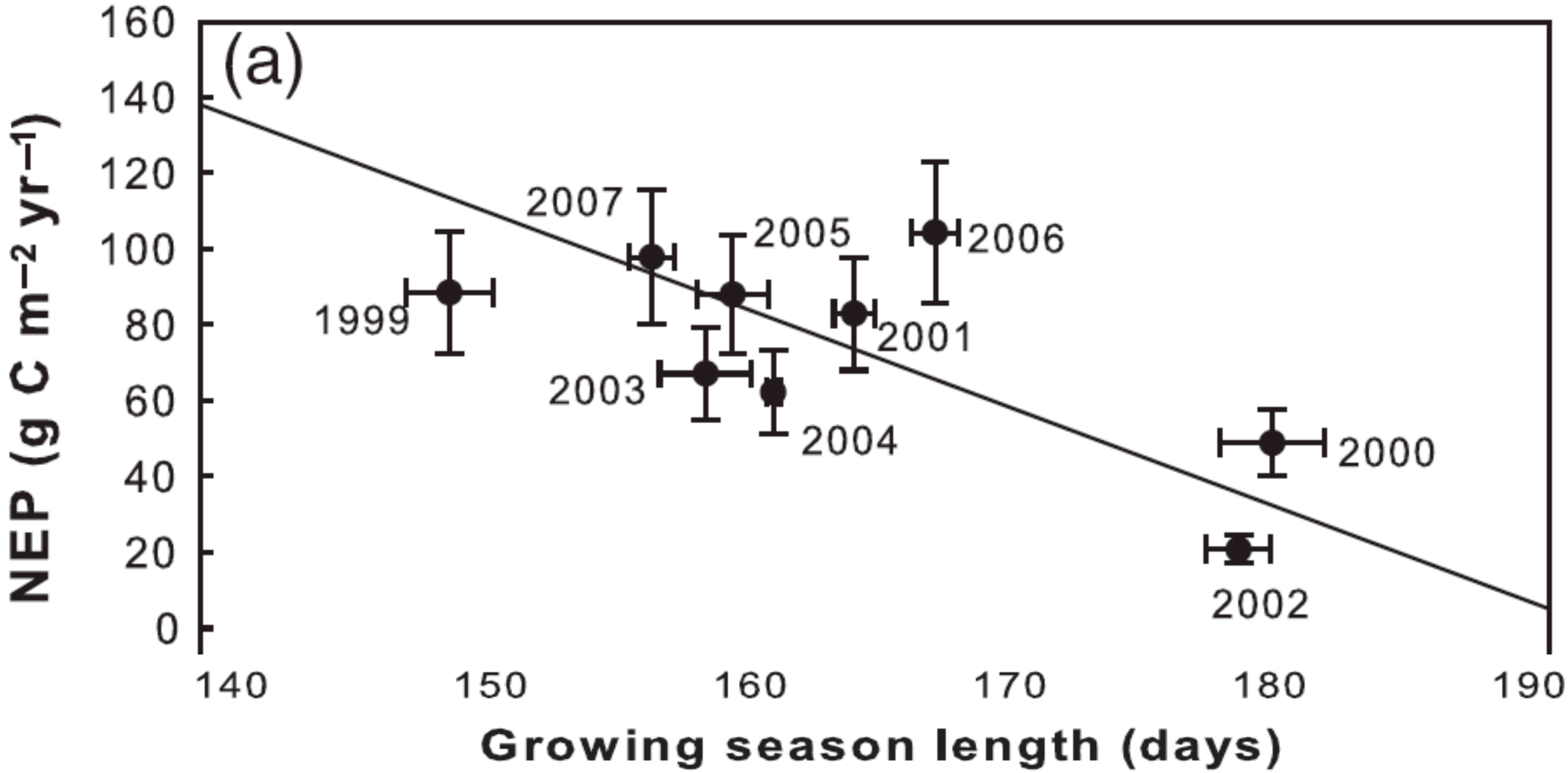
- NEP = Net Ecosystem Production
  - Positive = More productivity



Courtesy of R. Monson, CU-Boulder

Interannual Response

- Niwot Ridge Ameriflux subalpine fir/spruce
  - 3050m elevation

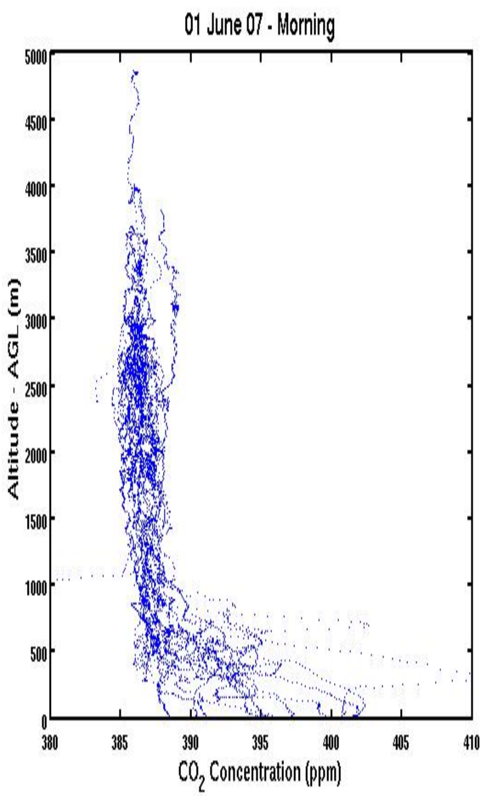


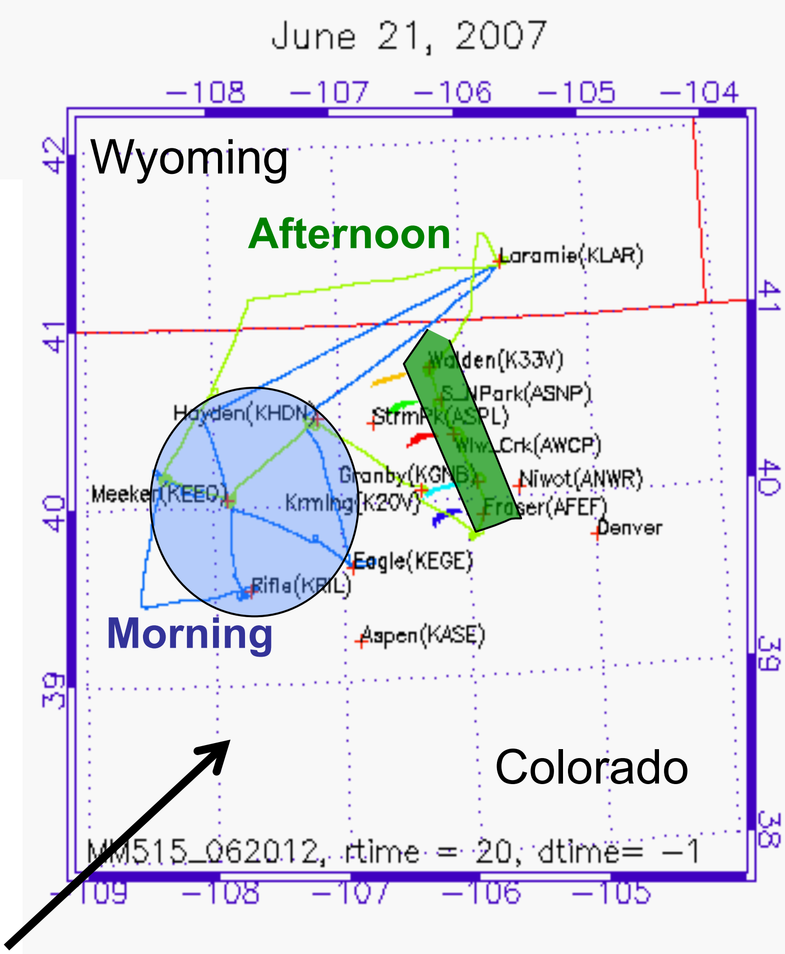
Hu et al. (2010) GCB, Sacks et al. (2006) GCB

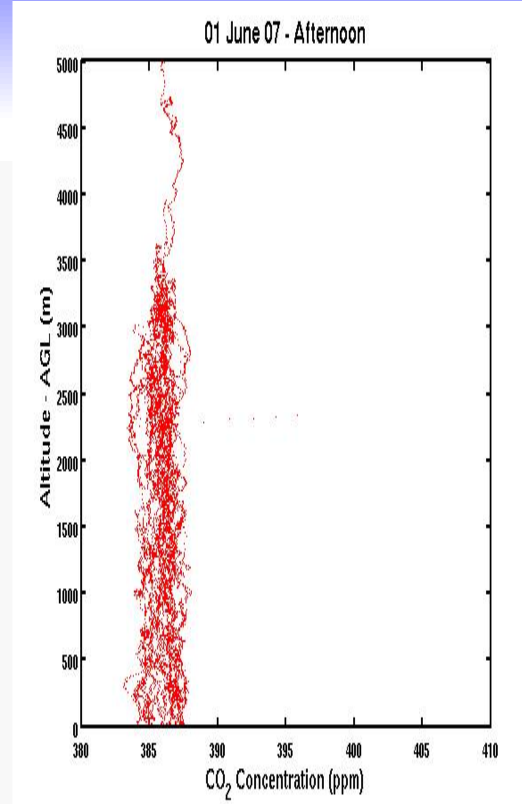
Is It Regional?

Airborne Carbon in the Mountains Experiment – ACME 2007

UPWIND



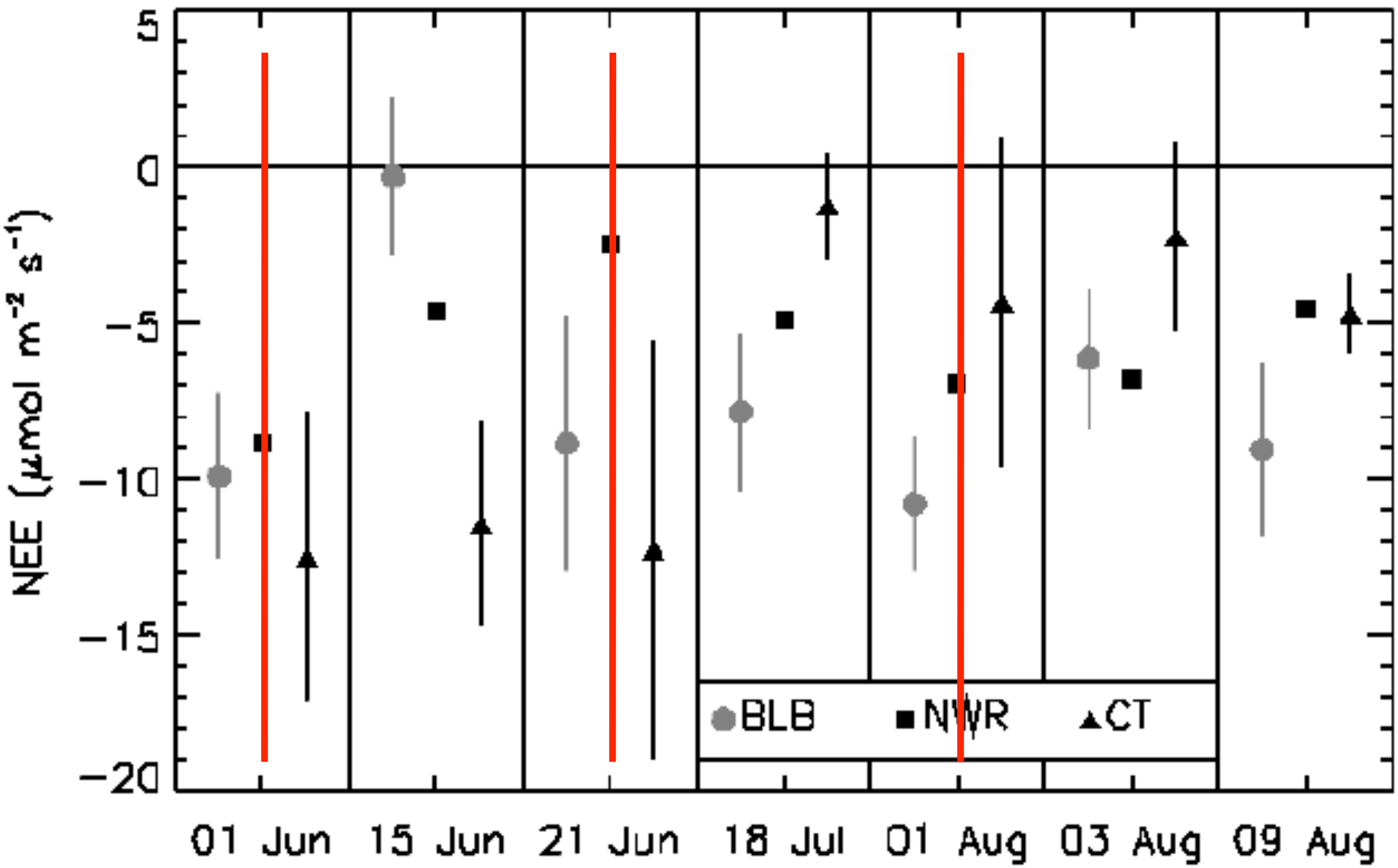




DOWNWIND

Ahue et al. (2010) M.S. thesis, Desai et al (in prep)

Is It Regional?



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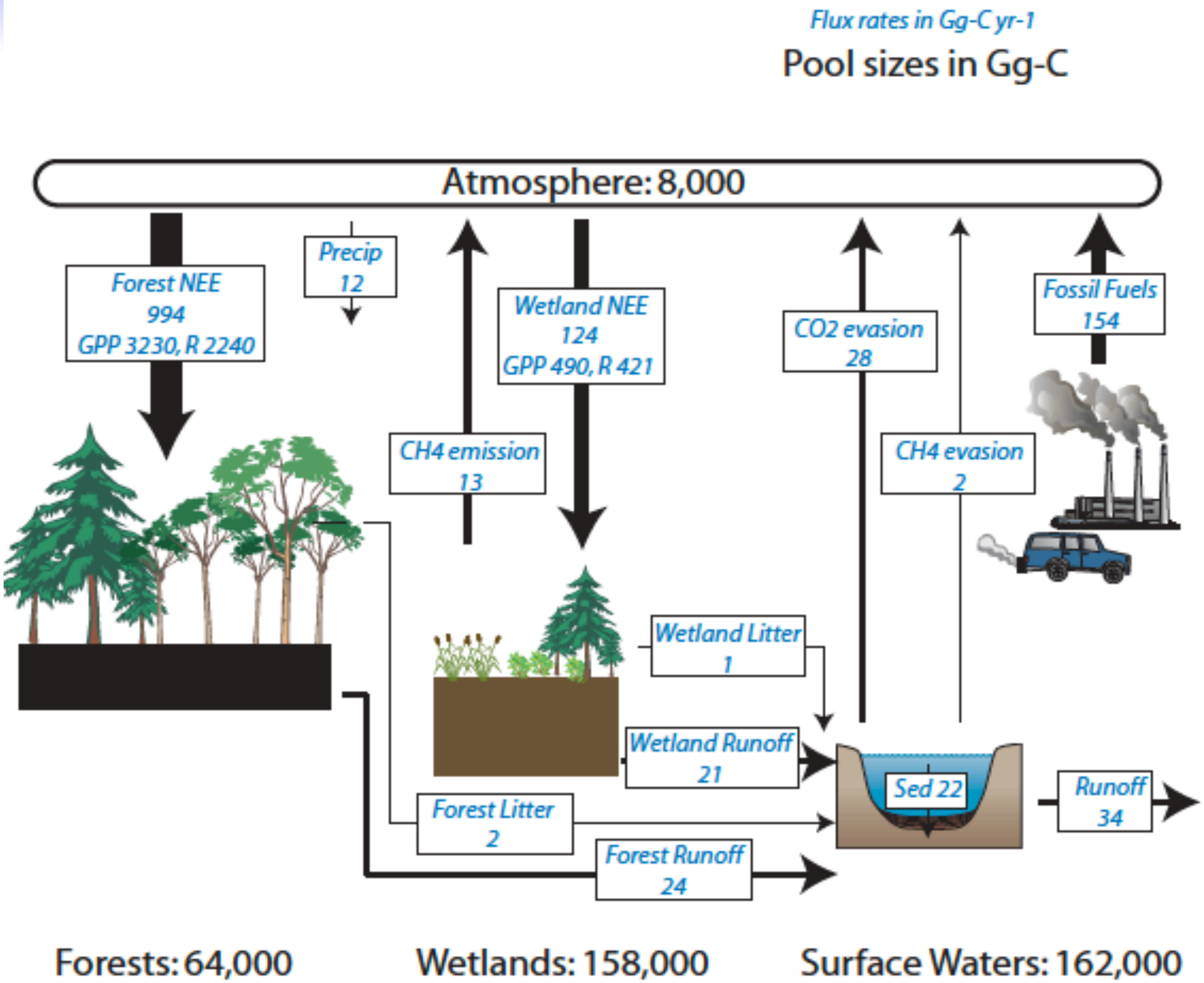
Summary

	Site Level	Regional
Temperate-boreal wetland/forest (WISCONSIN)	Wetland annual NEE weakly related to water table	Annual NEE strongly sensitive to water table and regional drying
	Large forest sinks	Moderate forest sinks
	Large interannual variability	Smaller interannual variability
Evergreen montaine forest (COLORADO)	Peak uptake after snowmelt (Apr-May)	Peak uptake in mid-June
	Drought stress 2 months later	Weaker drought stress response
	Weak secondary peak	Stronger secondary peak?

Challenges and Opportunities

- Methods to quantify regional fluxes require continued research
  - But rich networked datasets now allow us to test these
- Emergent climate-surface flux interactions are apparent at regional scale and call into question parameterizations from on site or global scale
  - But new model-data assimilation techniques allow us to develop regional assimilations
- Carbon and water cycling are intimately connected in multiple ways in regions
  - Ecosystem and climate model testbeds can test range of responses, level of complexity required

Challenges and Opportunities



Buffam et al (in press) GCB

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