Probabilistic carbon flux upscaling in a complex northern forest ecoregion

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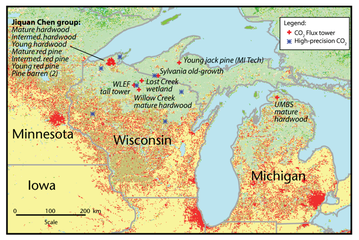
Project Objectives

Our overall project goal is to quantify the main sources of uncertainty associated with the light use efficiency approach to diagnosing net ecosystem-atmosphere exchange (NEE) of CO2 in northern temperate forest landscapes, In particular we will:

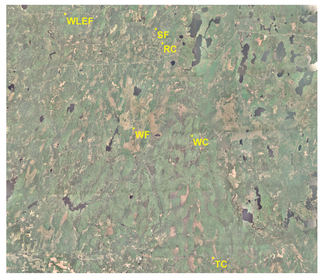
1) add flux tower assimilation and understanding of sub-MODIS-pixel complexity to the approach;
2) create probabilistic, gridded regional maps of NEE of CO2 and quantify the value of flux tower and sub-MODIS-pixel "special" data to the accuracy of this product;
3) evaluate this approach beyond the immediate study area and beyond the northern temperate forest ecoregion, and
4) evaluate the ability of predictive models to simulate regional NEE of CO2.

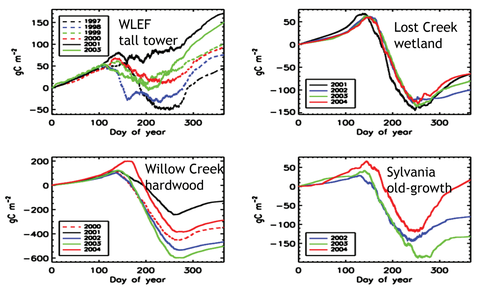
Background: Chequamegon Ecosystem-Atmosphere Study (ChEAS)

Larger study region

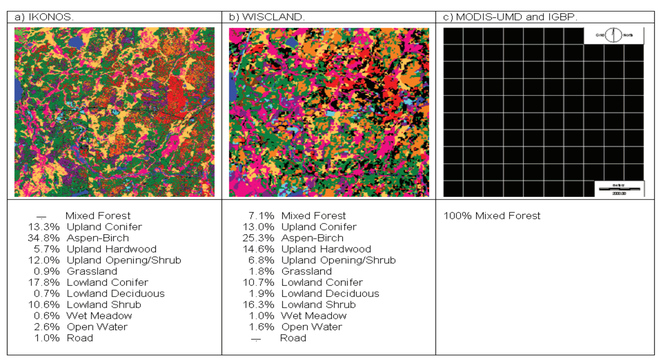


Intensive study region (approx 30x30 km2)



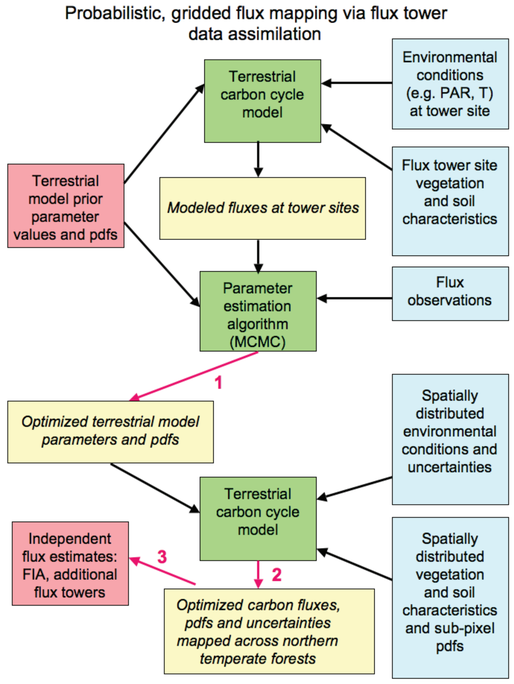


Motivating results: Simple flux tower upscaling effort fails. What is missing? Aspen? Wetlands? Stocking? What data inputs are needed for successful flux upscaling?



Complex, small scale land cover patterns are lost at the 1km spatial resolution used by standard MODIS products.
Are higher resolution remote sensing images required to create accurate regional flux estimates?

Methods



Model structure:
GPP=f(aPAR,ε)

R=f(carbon pools, T, moisture)

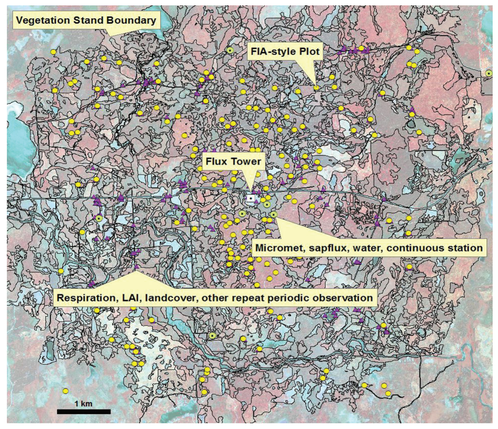
NEE=GPP-R

ε=εmax m(T) m(VPD) m(...)

Input data:
Land cover type
aPAR
Temperature
Carbon pool sizes

Sources of uncertainty:
Input data
model structure
model parameters.

ChEAS "special" data includes:
180 FIA-like sites
140 CWD and LAI plots
19 water table depth sites
26 soil and air T sites
8 flux towers close to WLEF
10 more distant flux tower sites
Quickbird imagery
MODIS imagery
Leaf-on and leaf-off lidar



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Results

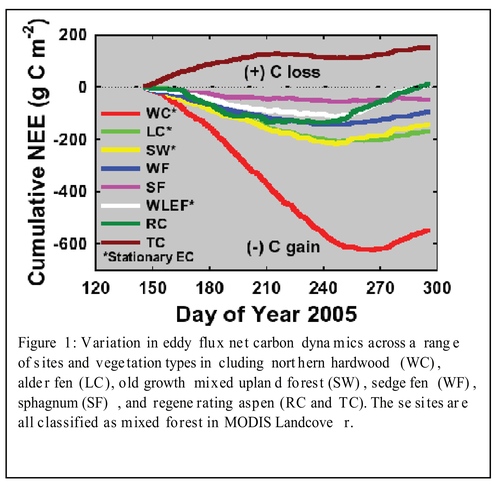

Figure 1: Variation in eddy flux net carbon dynamics across a range of sites and vegetation types including northern hardwood (WC), alder fen (LC), old growth mixed upland forest (SW), sedge fen (WF), sphagnum (SF), and regenerating aspen (RC and TC). The se sites are all classified as mixed forest in MODIS Landcover.

1) Wetland sites (LC, SF, WF) appear similar across the region.

2) Aspen sites appear to show the large respiration measured by the WLEF tall tower.

3) Landsat images capture regional complexity in land cover.

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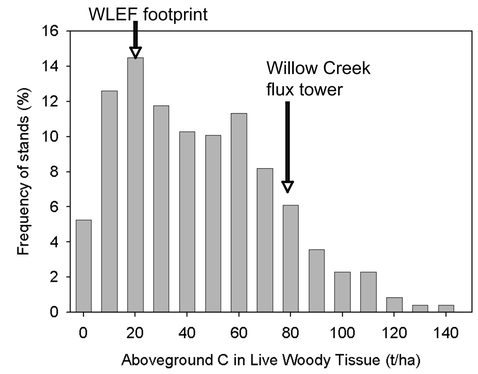
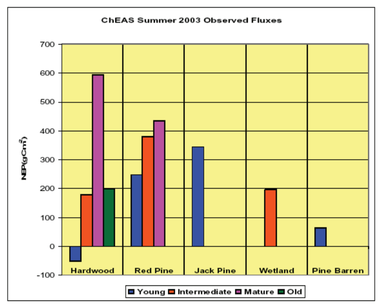


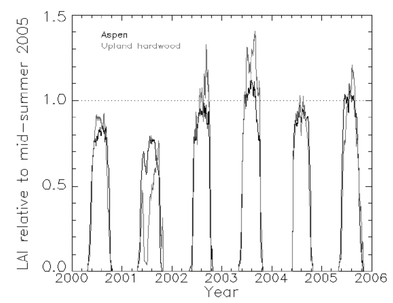
4) Above-ground biomass and LAI both vary considerably among hardwood stands.

5) The differences in aboveground C and LAI are captured by lidar.



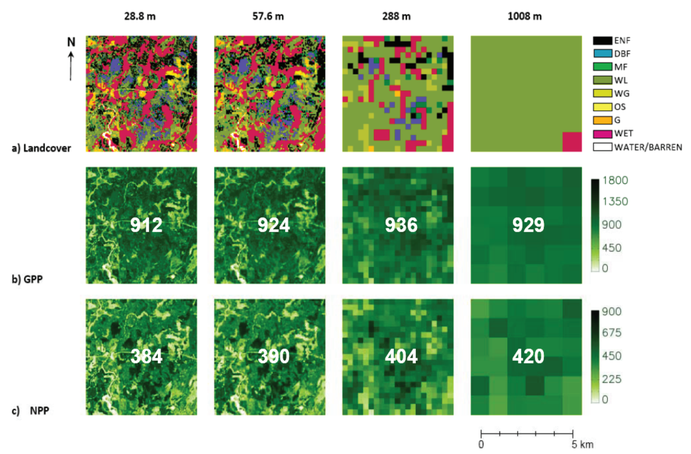
6) A "paint by numbers" assimilation of 12 flux towers with a simple "gap-filling" terrestrial carbon flux model yields regional fluxes consistent with the WLEF tall tower.

Quantity	Month	Tall tower observation	Footprint weighted decomposition	Multi-tower synthesis aggregation Method #1	Method #2
NEE (gC m-2)					
	Jun	-43 +/- 16	-95 +/- 20	-89 +/- 30	-122 +/- 20
	Jul	-40 +/- 9	-83 +/- 20	-112 +/- 35	-103 +/- 26
	Aug	7 +/- 10	-80 +/- 18	-89 +/- 35	-72 +/- 27
	Jun-Aug	-76 +/- 26	-258 +/- 56	-290 +/- 89	-298 +/- 72
ER (gC m-2)					
	Jun	175 +/- 8	130 +/- 11	108 +/- 14	112 +/- 13
	Jul	219 +/- 5	115 +/- 16	156 +/- 19	153 +/- 20
	Aug	207 +/- 6	130 +/- 12	144 +/- 20	162 +/- 21
	Jun-Aug	601 +/- 13	375 +/- 36	408 +/- 48	426 +/- 53
GEP (gC m-2)					
	Jun	218 +/- 8	225 +/- 20	198 +/- 26	234 +/- 6
	Jul	259 +/- 4	198 +/- 21	268 +/- 28	256 +/- 7
	Aug	200 +/- 4	210 +/- 18	233 +/- 26	235 +/- 6
	Jun-Aug	677 +/- 12	633 +/- 55	698 +/- 73	724 +/- 18



7) Leaf area index varies considerably from year to year and alters fluxes. LAI is correlated with water table in wetlands.

8) Area averaged flux estimates are fairly good even without high resolution land cover data.



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