Dissolved CO_2 in Waters of the Amazon : Deconvolving Signals of Land-Water Coupling and In-Stream Processes as Indicative of Ecosystem Dynamics

Jeff Richy, Alex Krusche, Equipe Rede Beija Rio

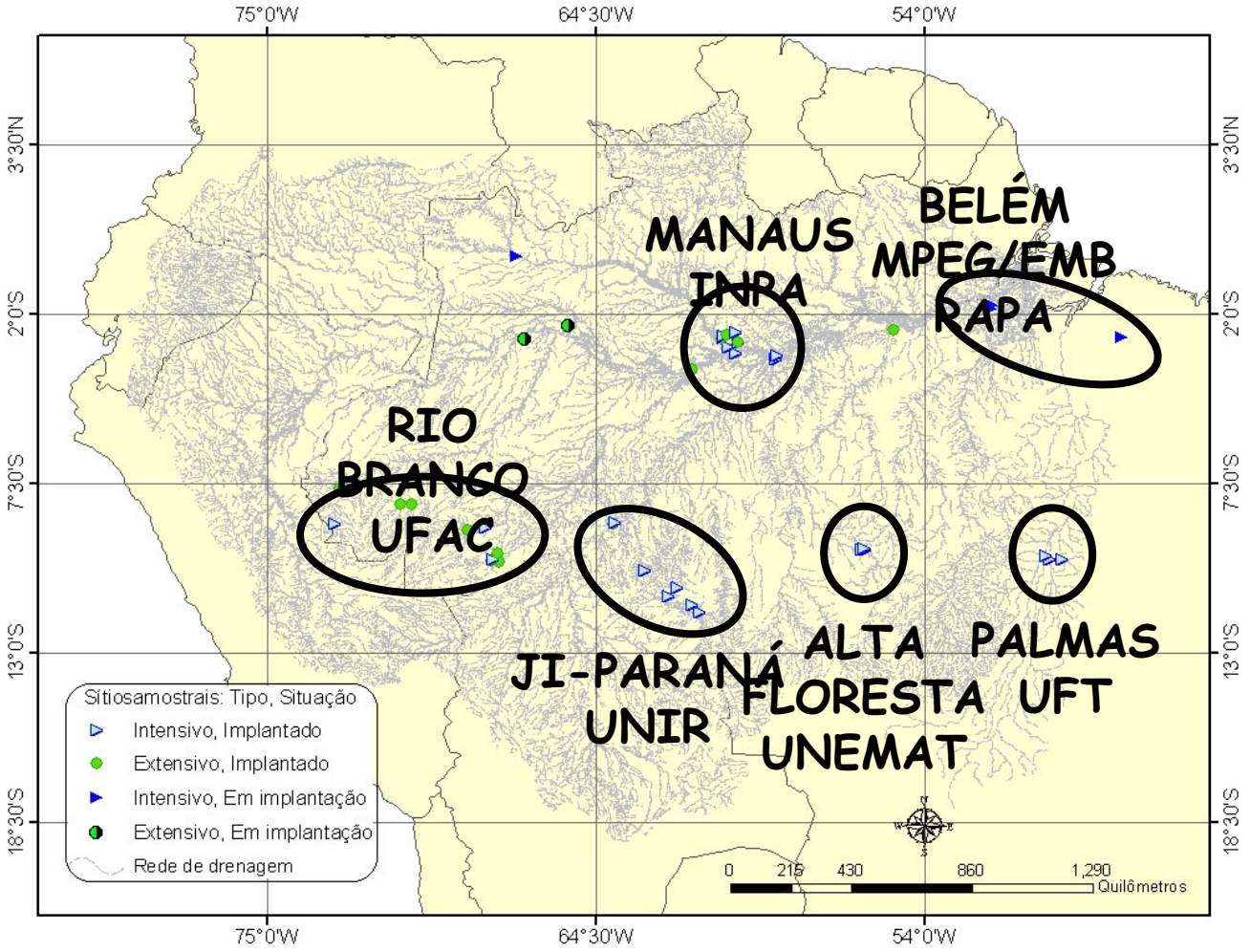
session "3A: Carbon, Rivers, and Wetlands"
Friday: Oct. 6, 2006 from 9:00 - 11:00.

Initial Working Hypothesis:

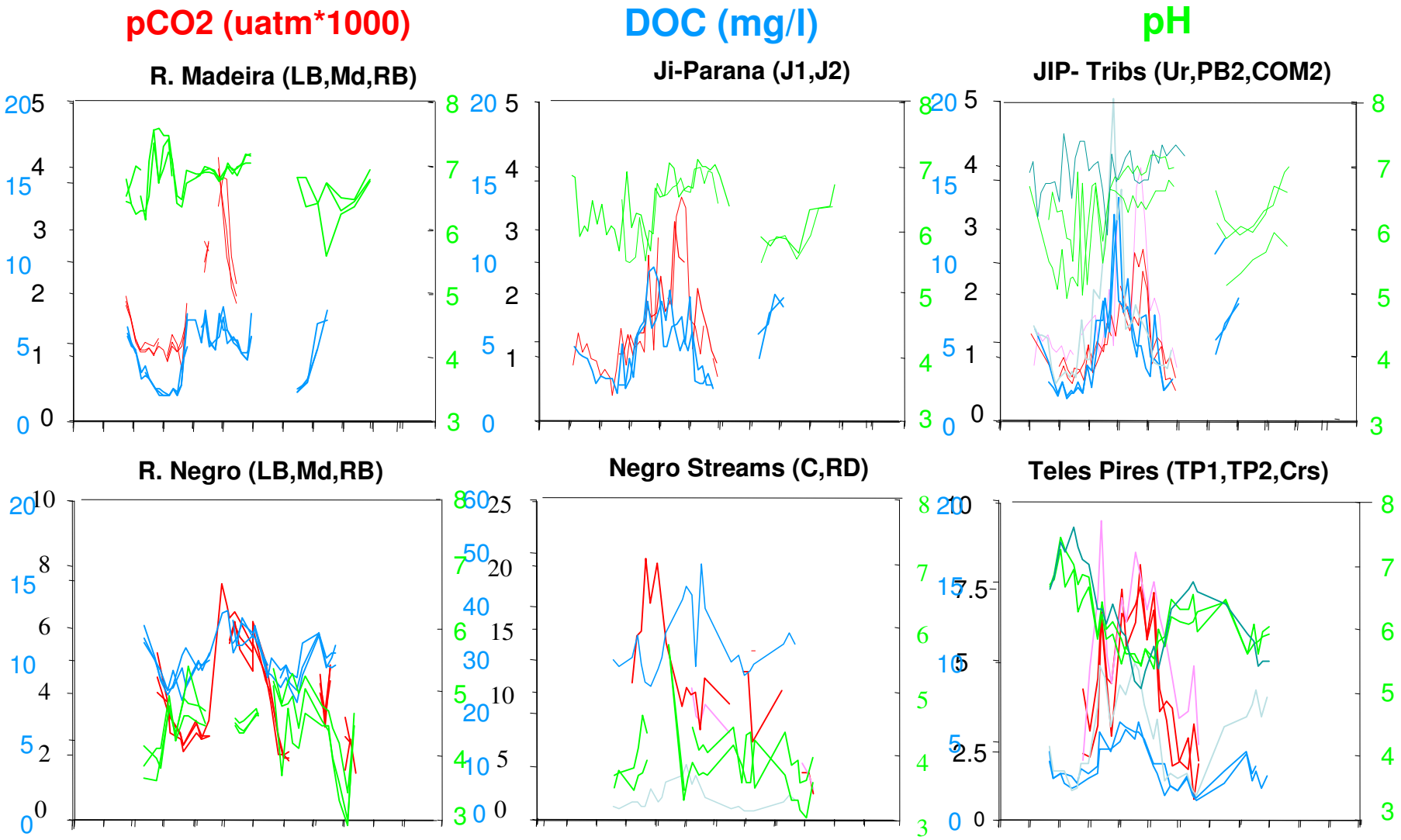
Outgassing of CO_2 returns as much carbon to the atmosphere as is sequestered in upland forests on an interannual basis. Export of organic material from upland forests to fluvial environments is the primary source of carbon that is eventually respired in rivers and evaded as CO_2.

REDE BEIJA-RIO

Maestro: Alex Krusche

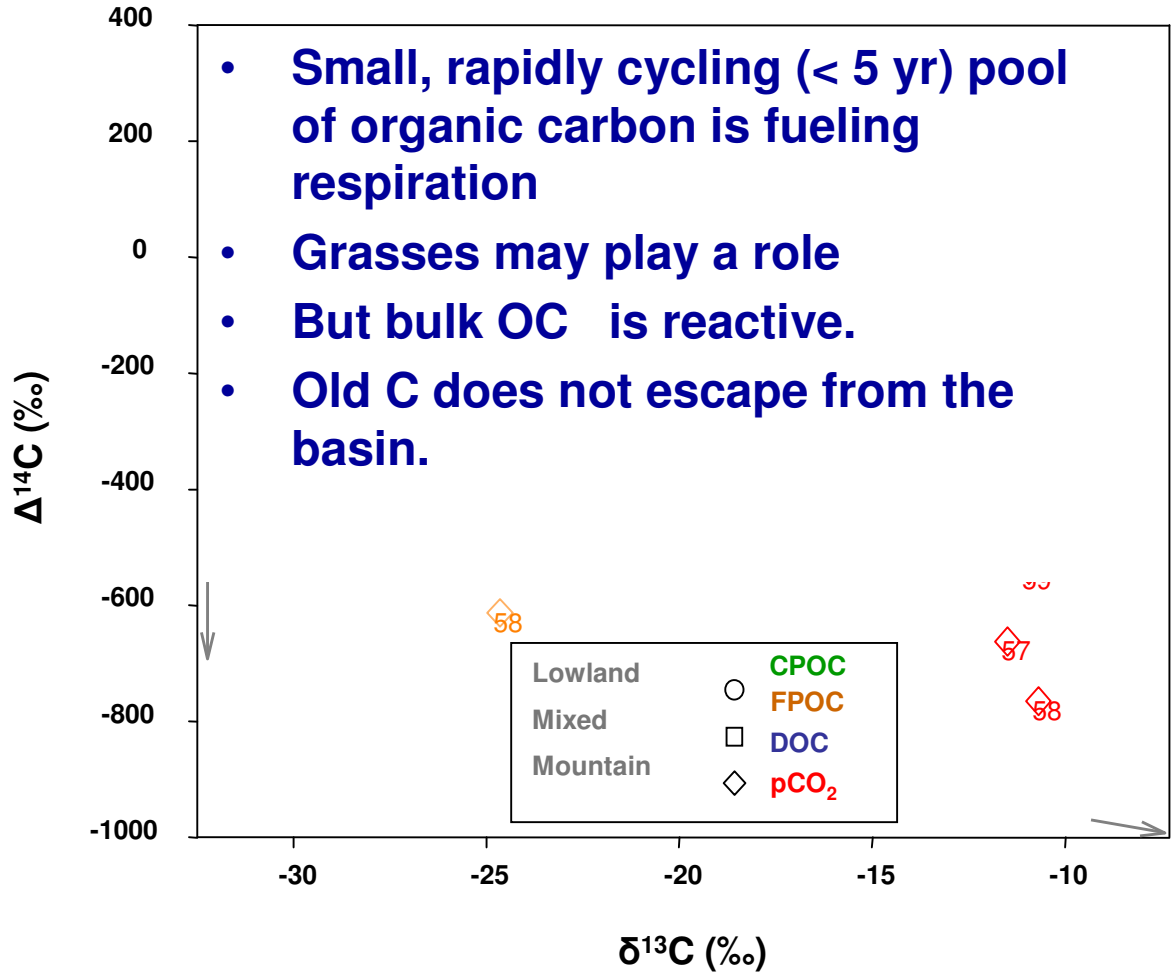


Distributions of pCO2 and Antecedent Chemistry



Time Jan 1, 2004 – Dec 31, 2006

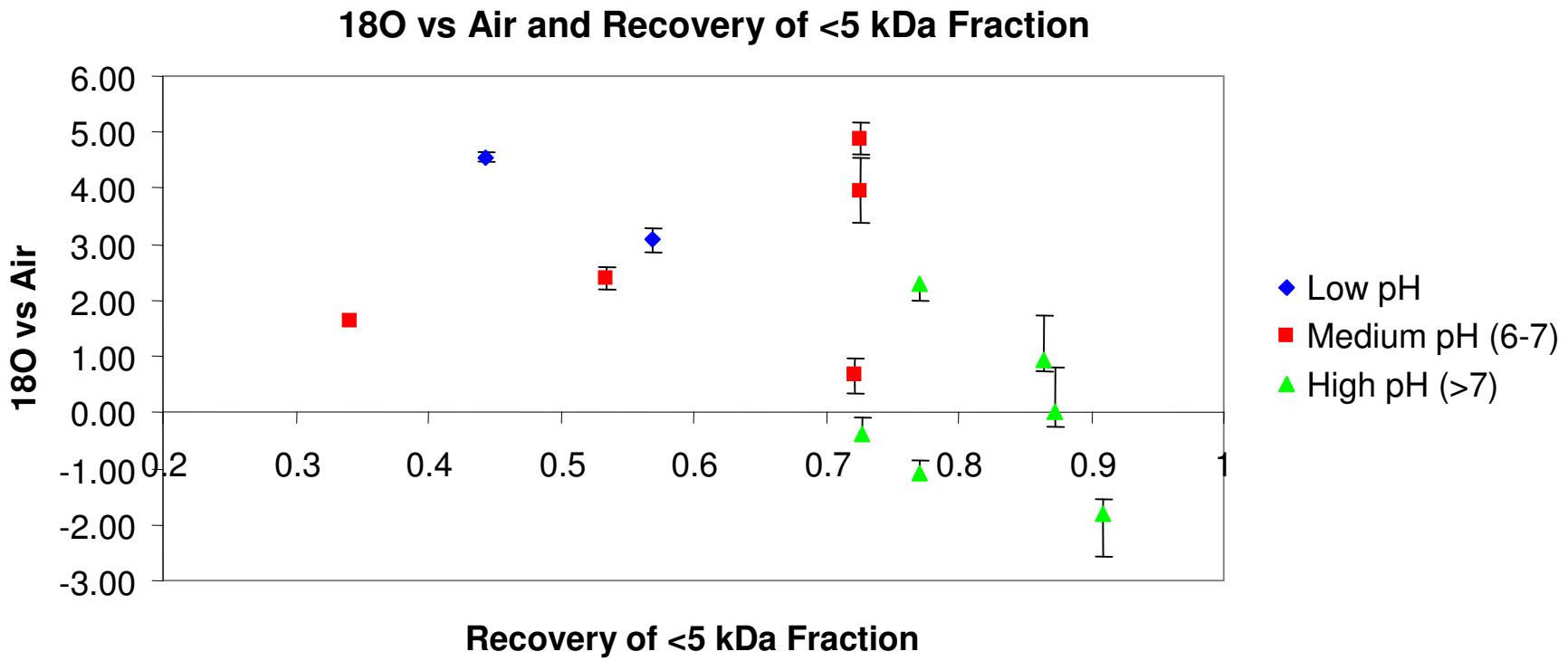
Processes Controlling pCO2: *Broad-Scale Tracers*



- Small, rapidly cycling (< 5 yr) pool of organic carbon is fueling respiration
- Grasses may play a role
- But bulk OC is reactive.
- Old C does not escape from the basin.

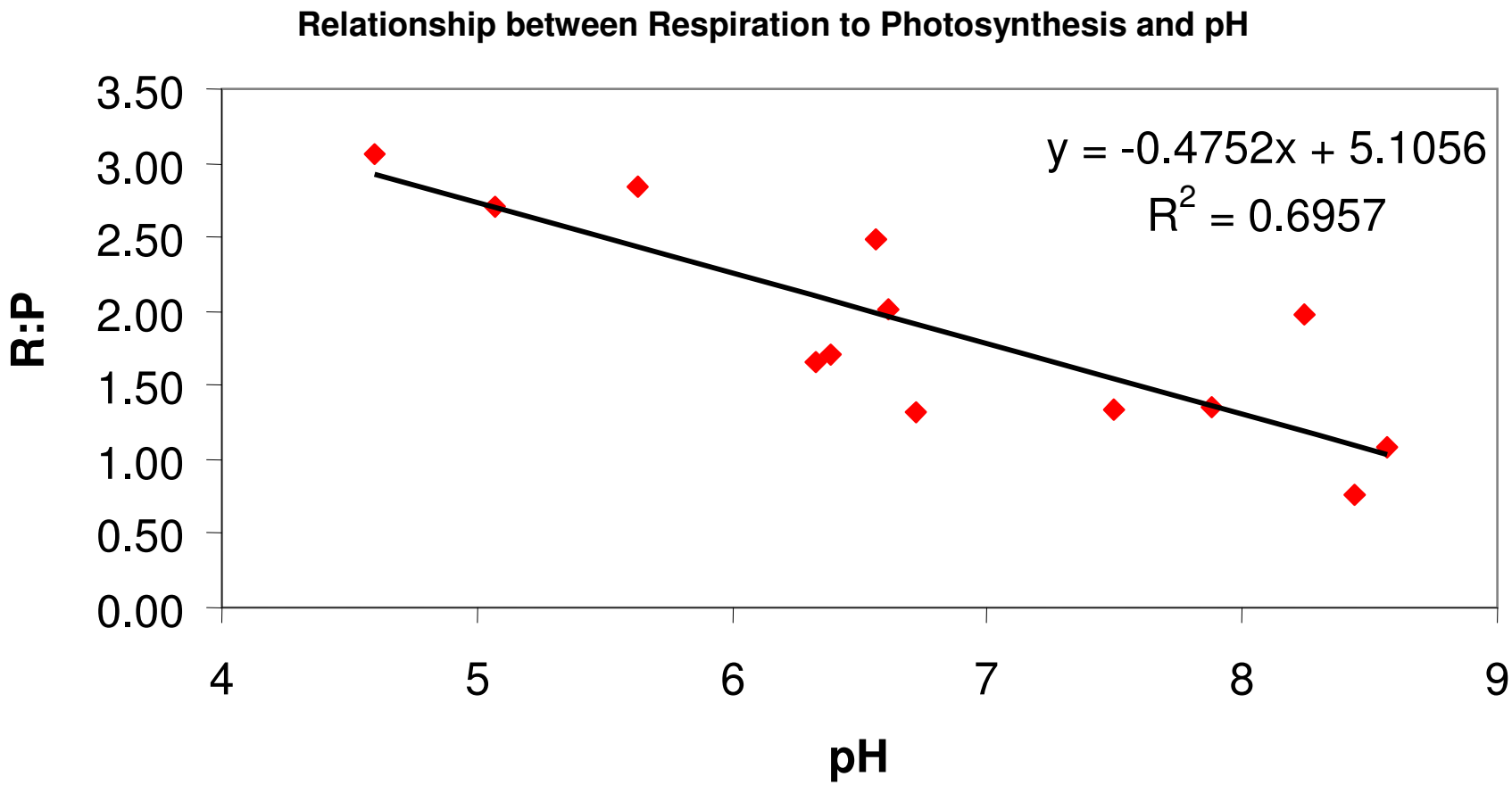
(Mayorga et al 2005; Isotopic Constraints on C Cycling

Processes Controlling pCO2 *In situ metabolism and organic matter reactivity*



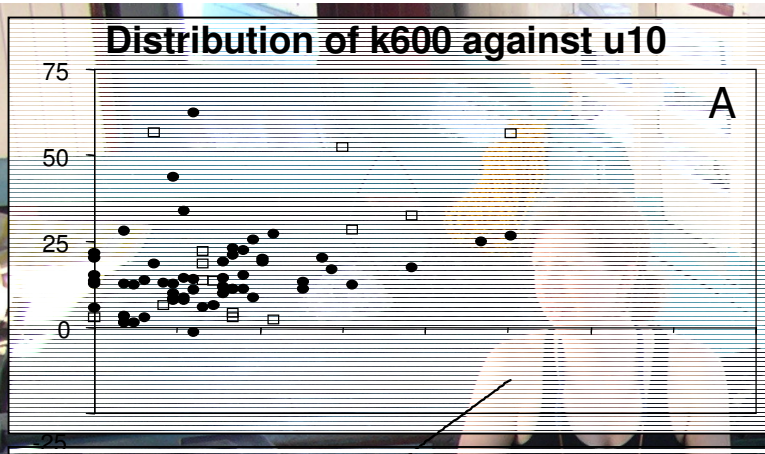
Erin Ellis

Processes Controlling pCO_2: Regional Patterns in R:P

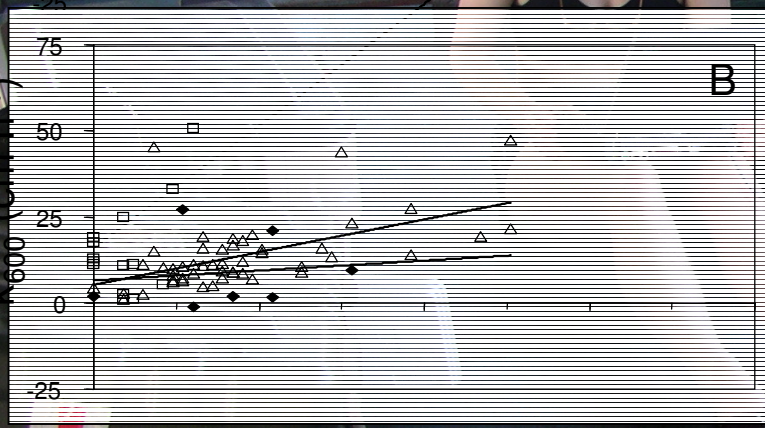


Erin Ellis

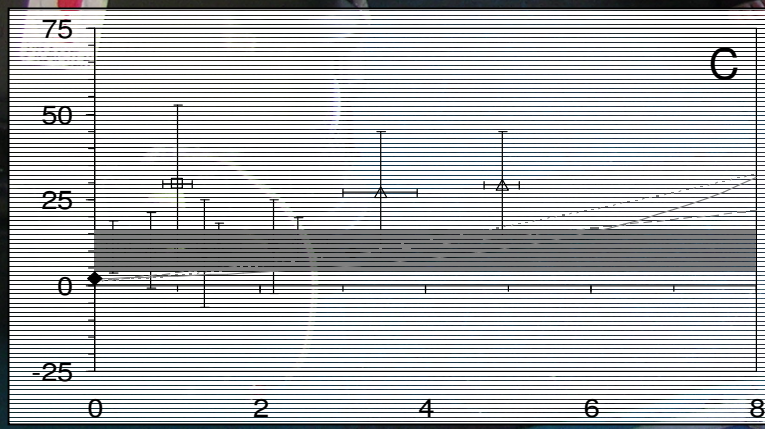
Processs Controlling pCO_2: Gas Exchange



Amazon (solid circles, n=14) vs. Mekong (open squares, n=14)



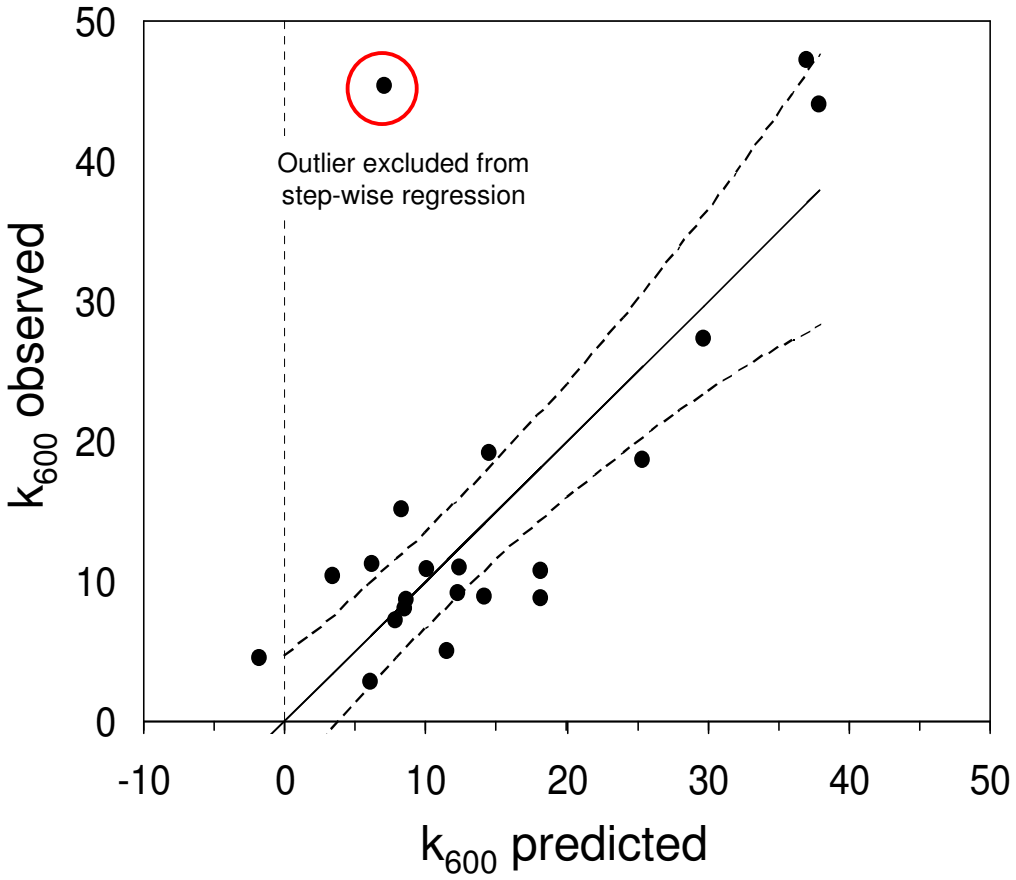
Streams and rivers <100 m wide (open squares,), rivers >100 m wide (open triangles), and lakes and bays (solid diamonds)



Data from B binned into 1 m s^{-1} u_{10} intervals for rivers >100 m wide and lakes and 0.75 m s^{-1} intervals for rivers <100 m wide (shown in relation to curves published for river and estuary systems and to Richey et al 2002)

Simone, Cleber, Fatima

Relation: k600:Wind Speed:Water Velocity:Depth



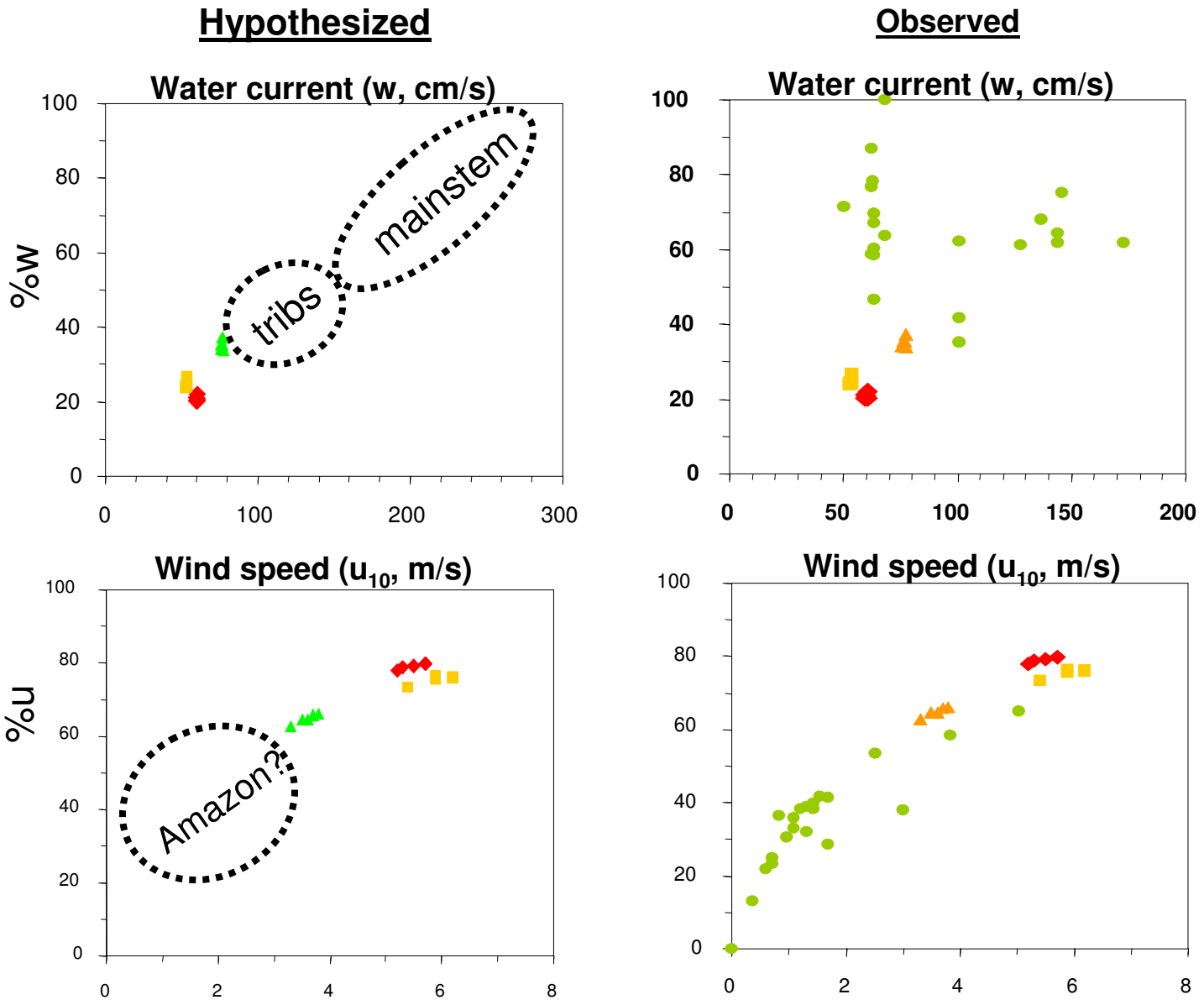
Step-wise regression model:

$$k_{600} = -10.8 + 6.2u_{10} + 52.2\sqrt{w/z}$$

where:
k_{600} is gas transfer velocity (cm h^{-1})
u_{10} is wind speed normalized to 10 m height (m s^{-1})
w is water current velocity (m s^{-1})
z is water depth (m)

Regression statistics:
$r^2 = 0.78$
RMSE = 5.99
F = 29.95
$p < 0.0001$

Relationships between water current, wind speed, and k_{600}



Evolving Working hypothesis.

Variability in the predictable annual regime of pCO_2 (essentially, increasing and decreasing in synchrony with the hydrograph) at any point in a river network across regions is functionally governed by the relative distributions of the ecosystem state variables controlling pH, water movement (infiltration and runoff on land, current velocity in channels), production and mobilization of LMW DOC fractions, and suspended sediment loads:

•With rising water, the primary source term for pCO2 in small streams is groundwater, but as that source degasses, in-river mineralization of (near-) contemporary low molecular weight (<5kDa) dissolved organic compounds derived from the local mix of terrestrial C3 and, preferentially, C4 plants becomes the dominant source. DOC export amount and composition by region is determined by soil type and flushing (which also drives pH).

•With falling water, depletion of terrestrial sources and reduction in sediment load promotes a higher ratio of aquatic primary productivity to respiration (to a greater extent than previously thought), leading to a sink of pCO_2 (but subsequent export of labile organic matter from in situ sources). pCO_2 during rising water is more aged and depleted in ^{13}C than during falling water, reflecting the greater terrestrial sources.

•Alternatively, pCO2 could be produced from DOC by other processes, such as photo-oxidation. The apparent importance of C4 materials may be reduced, if other sources of C13-enriched pCO2 were prominent (e.g., a greater legacy of weathering).

* pH, responding to the stage of the hydrograph and set initially by weathering and then with feedbacks from biological processes, affects not only the distribution of dissolved inorganic carbon among carbonate system species, but also the bioavailability of dissolved substrates for respiration, and thus is critical in controlling both the production term and the degree of supersaturation of CO_2.

* The primary pCO_2 sink term in flowing waters is outgassing, where
-scale of habitat and river current-induced turbulence are the primary controlling factors, and weather factors (wind speed, air-water temperature gradients) are secondary.
-Gas transfer velocity and variability scale roughly inversely to river size, with the highest rates and variability in the smallest.
-Floodplain lakes and slow “mouth-bays” have the lowest exchange rates, as only weather affects the controlling turbulence.