Boat-Based Eddy Covariance Measurements of CO_2 and H_2O Exchange Over Amazon and Tapajos Rivers and Lakes

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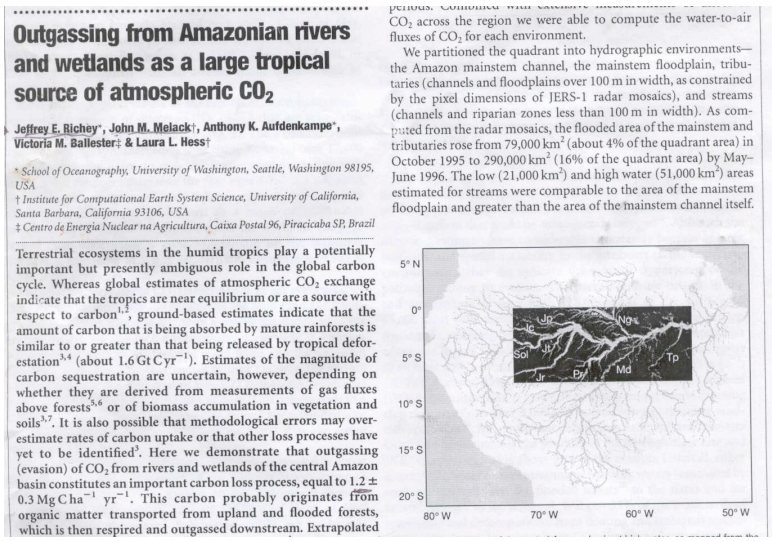
USP: HELBER FREITAS , HUMBERTO DA ROCHA

Motivation

Richey et al, Nature, April, 2002



Outgassing from Amazonian rivers and wetlands as a large tropical source of atmospheric CO_2

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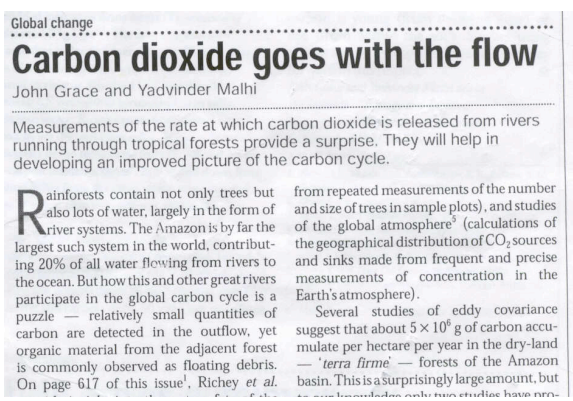
Terrestrial ecosystems in the humid tropics play a potentially important but presently ambiguous role in the global carbon cycle. Whereas global estimates of atmospheric CO_2 exchange indicate that the tropics are near equilibrium or are a source with respect to carbon[1,2], ground-based estimates indicate that the amount of carbon that is being absorbed by mature rainforests is similar to or greater than that being released by tropical deforestation[3,4] (about 1.6 Gt C yr^{-1}). Estimates of the magnitude of carbon sequestration are uncertain, however, depending on whether they are derived from measurements of gas fluxes above forests[5,6] or of biomass accumulation in vegetation and soils[3,7]. It is also possible that methodological errors may overestimate rates of carbon uptake or that other loss processes have yet to be identified[3]. Here we demonstrate that outgassing (evasion) of CO_2 from rivers and wetlands of the central Amazon basin constitutes an important carbon loss process, equal to 1.2 ± 0.3 Mg C ha^{-1} yr^{-1}. This carbon probably originates from organic matter transported from upland and flooded forests, which is then respired and outgassed downstream. Extrapolated

CO_2 across the region we were able to compute the water-to-air fluxes of CO_2 for each environment.

We partitioned the quadrant into hydrographic environments—the Amazon mainstem channel, the mainstem floodplain, tributaries (channels and floodplains over 100 m in width, as constrained by the pixel dimensions of JERS-1 radar mosaics), and streams (channels and riparian zones less than 100 m in width). As computed from the radar mosaics, the flooded area of the mainstem and tributaries rose from 79,000 km^2 (about 4% of the quadrant area) in October 1995 to 290,000 km^2 (16% of the quadrant area) by May–June 1996. The low (21,000 km^2) and high water (51,000 km^2) areas estimated for streams were comparable to the area of the mainstem floodplain and greater than the area of the mainstem channel itself.

Grace and Malhi



Global change

Carbon dioxide goes with the flow

John Grace and Yadvinder Malhi

Measurements of the rate at which carbon dioxide is released from rivers running through tropical forests provide a surprise. They will help in developing an improved picture of the carbon cycle.

Rainforests contain not only trees but also lots of water, largely in the form of river systems. The Amazon is by far the largest such system in the world, contributing 20% of all water flowing from rivers to the ocean. But how this and other great rivers participate in the global carbon cycle is a puzzle — relatively small quantities of carbon are detected in the outflow, yet organic material from the adjacent forest is commonly observed as floating debris. On page 617 of this issue[1], Richey *et al.*

from repeated measurements of the number and size of trees in sample plots), and studies of the global atmosphere[5] (calculations of the geographical distribution of CO_2 sources and sinks made from frequent and precise measurements of concentration in the Earth's atmosphere).

Several studies of eddy covariance suggest that about 5×10^6 g of carbon accumulate per hectare per year in the dry-land — '*terra firme*' — forests of the Amazon basin. This is a surprisingly large amount, but

$$F_c = k(c_w - \alpha c_a)$$

$$k = \text{piston velocity (cm hr}^{-1}\text{)}$$

piston velocity from chambers on Amazon and tributaries

Other approaches to measure k

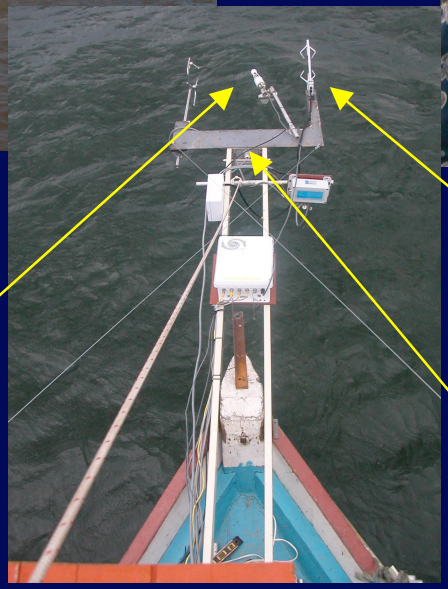
1. tracer techniques
2. eddy covariance

Goal: Direct measurement of CO_2/H_2O flux across air-river interface using eddy covariance

1. Compare eddy covariance and chamber techniques for measuring CO_2 flux

2. Calculate k from direct measurements on Amazon River and tributaries

Air-side CO_2 and H_2O Flux Measurement



sensor boom

CO_2/H_2O

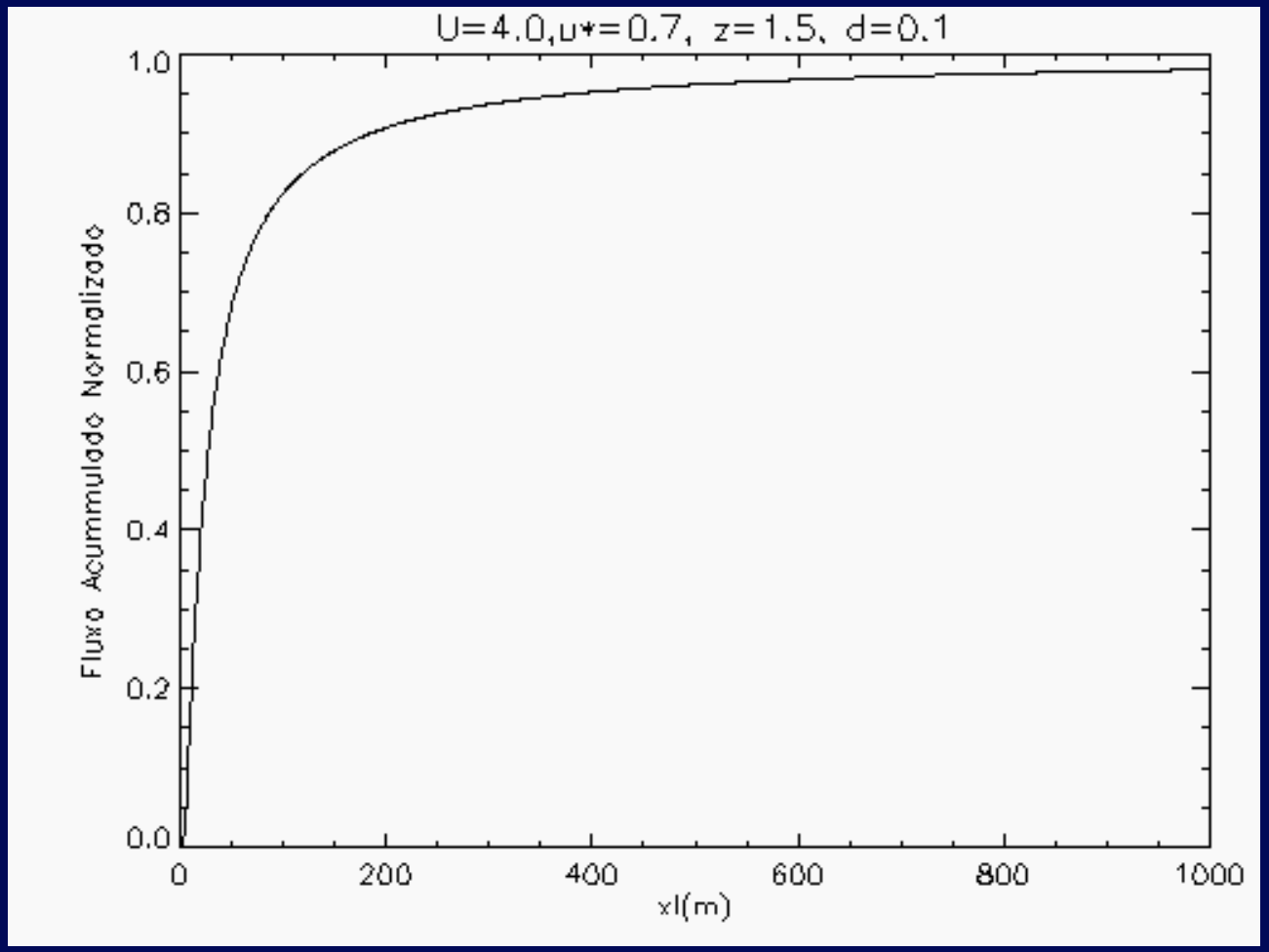
wind

motion

Flux Footprint

For U=4m/s, z=1.5 m, 90% of flux with 200m fetch.

flux accumulation



Upwind distance (fetch)

Water-side pCO_2 Measurement

Teflon tubing equilibrator

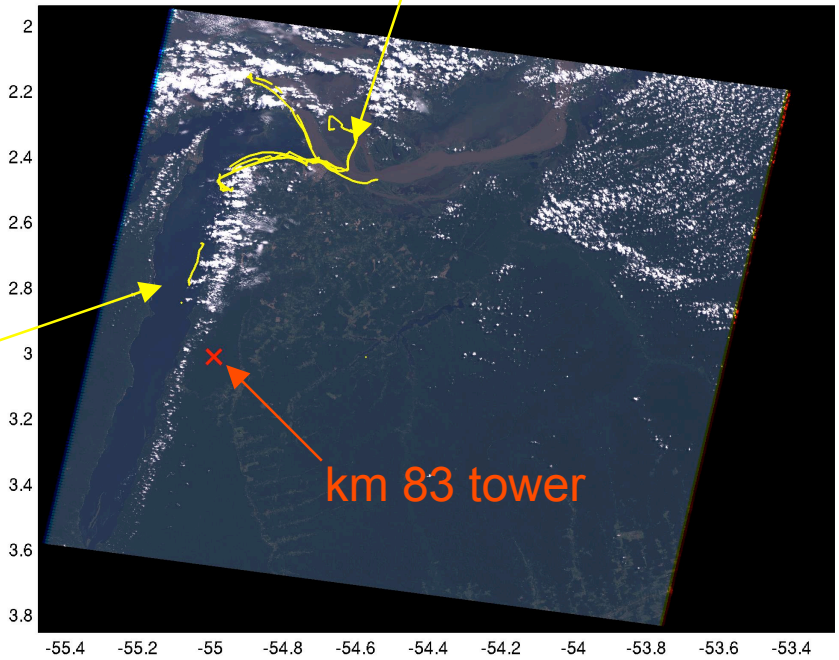
shower head equilibrator

Closed path IRGA

Sampling Strategy: Moving and Moored

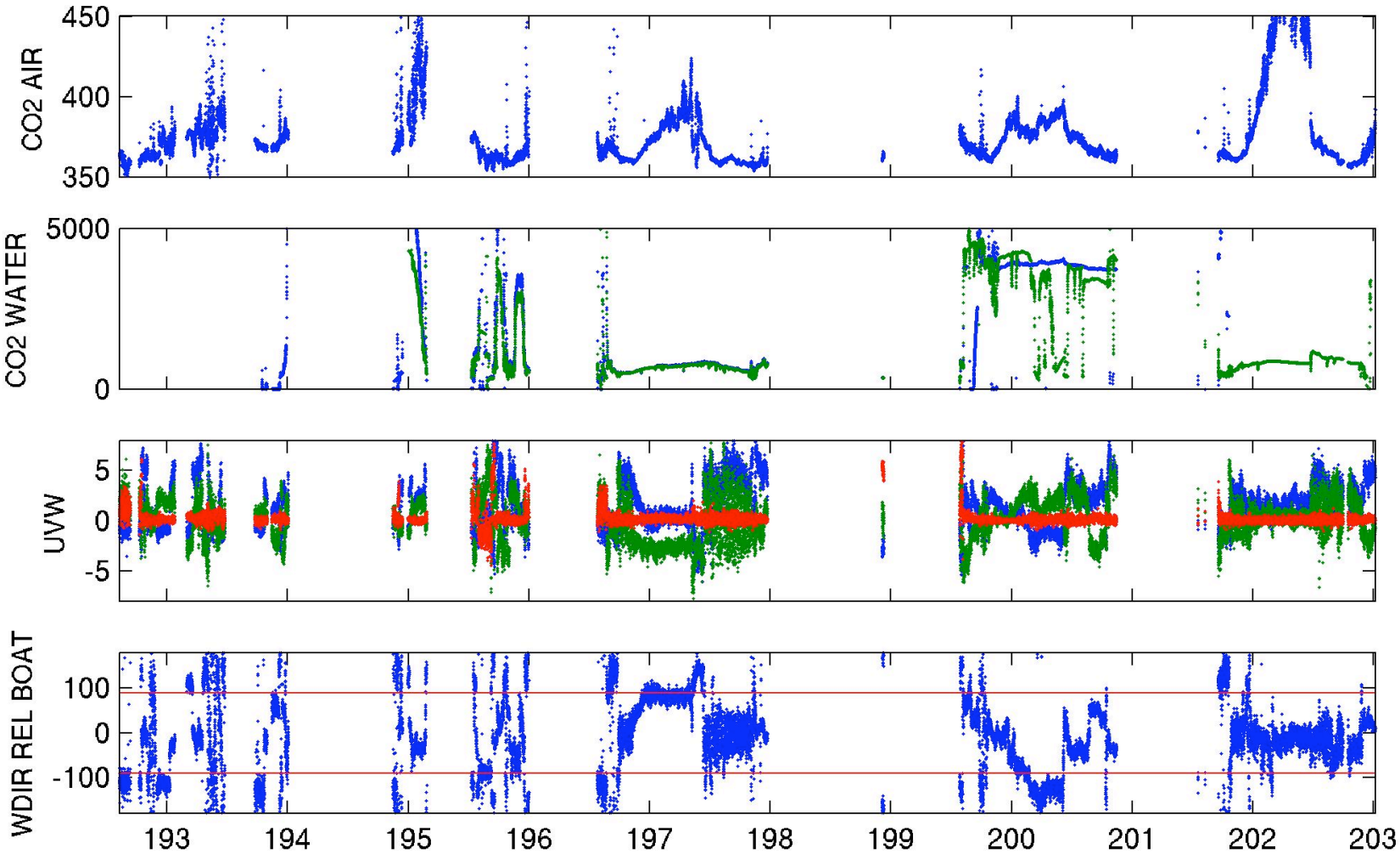
Amazon
~5000 ppm CO_2

10 day ship track

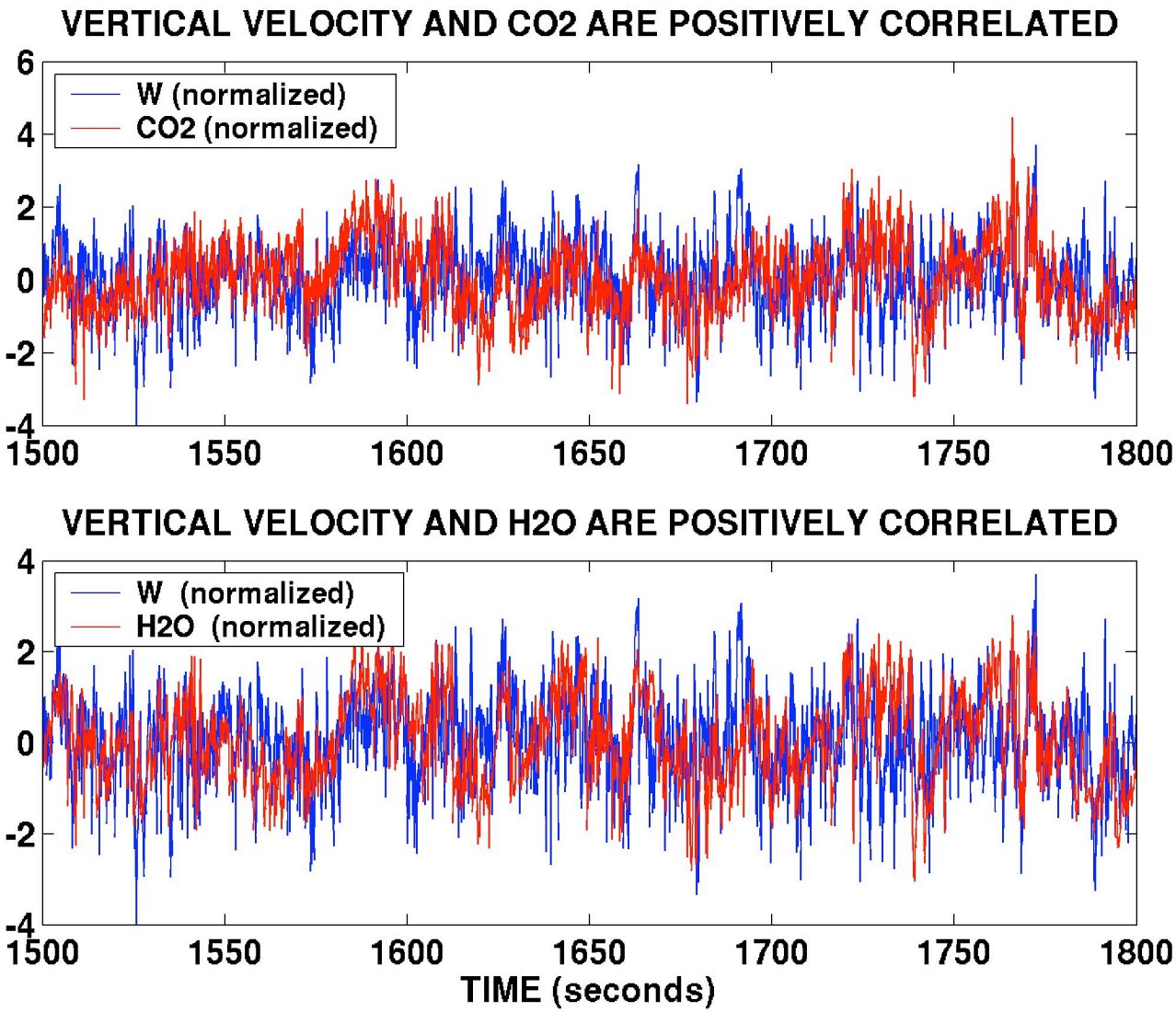


Tapajos
~1000 ppm CO_2

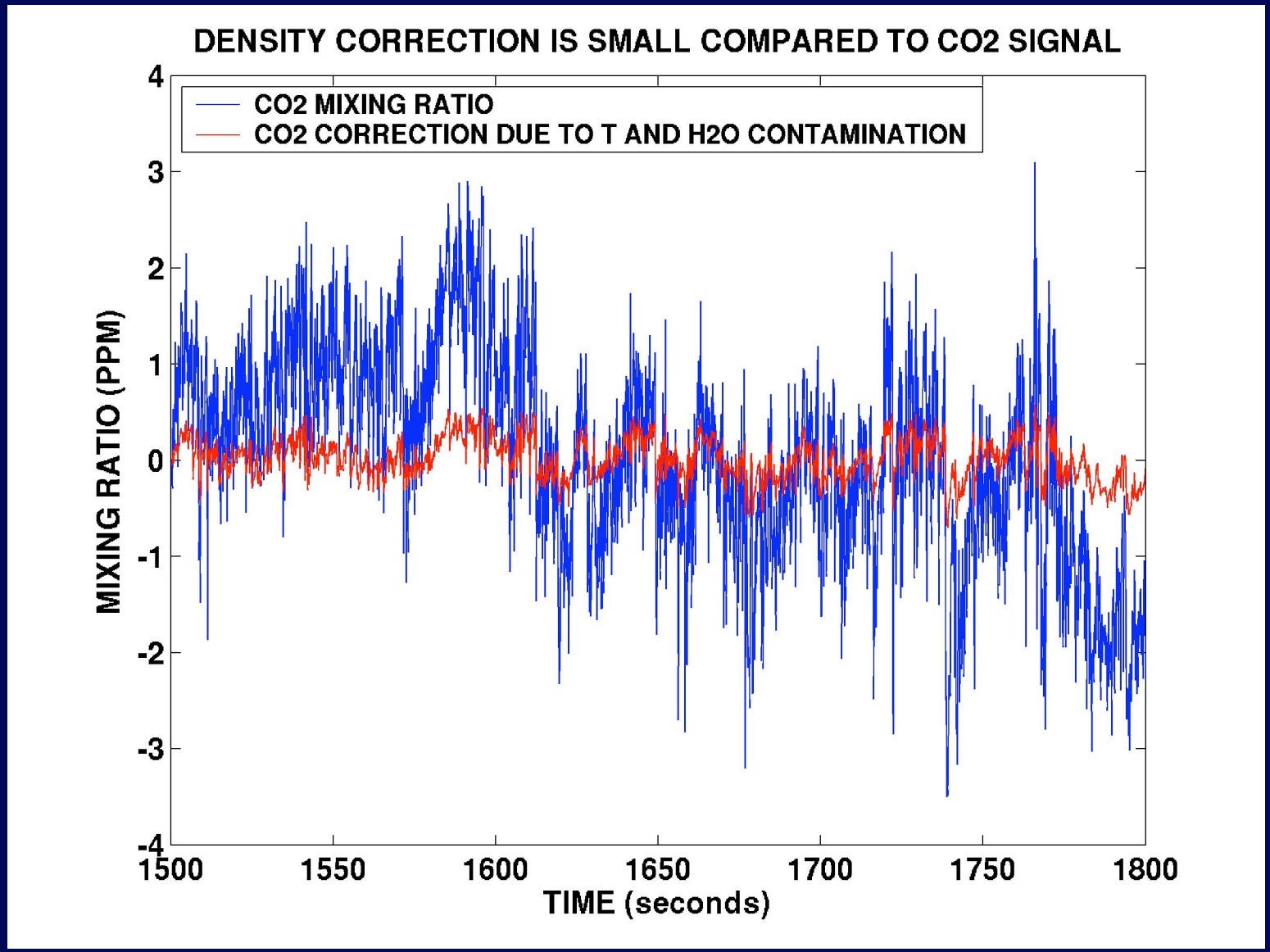
Data Set


CO2 AIR
450
400
350
CO2 WATER
5000
0
UVW
5
0
-5
WDIR REL BOAT
100
0
-100
193
194
195
196
197
198
199
200
201
202
203

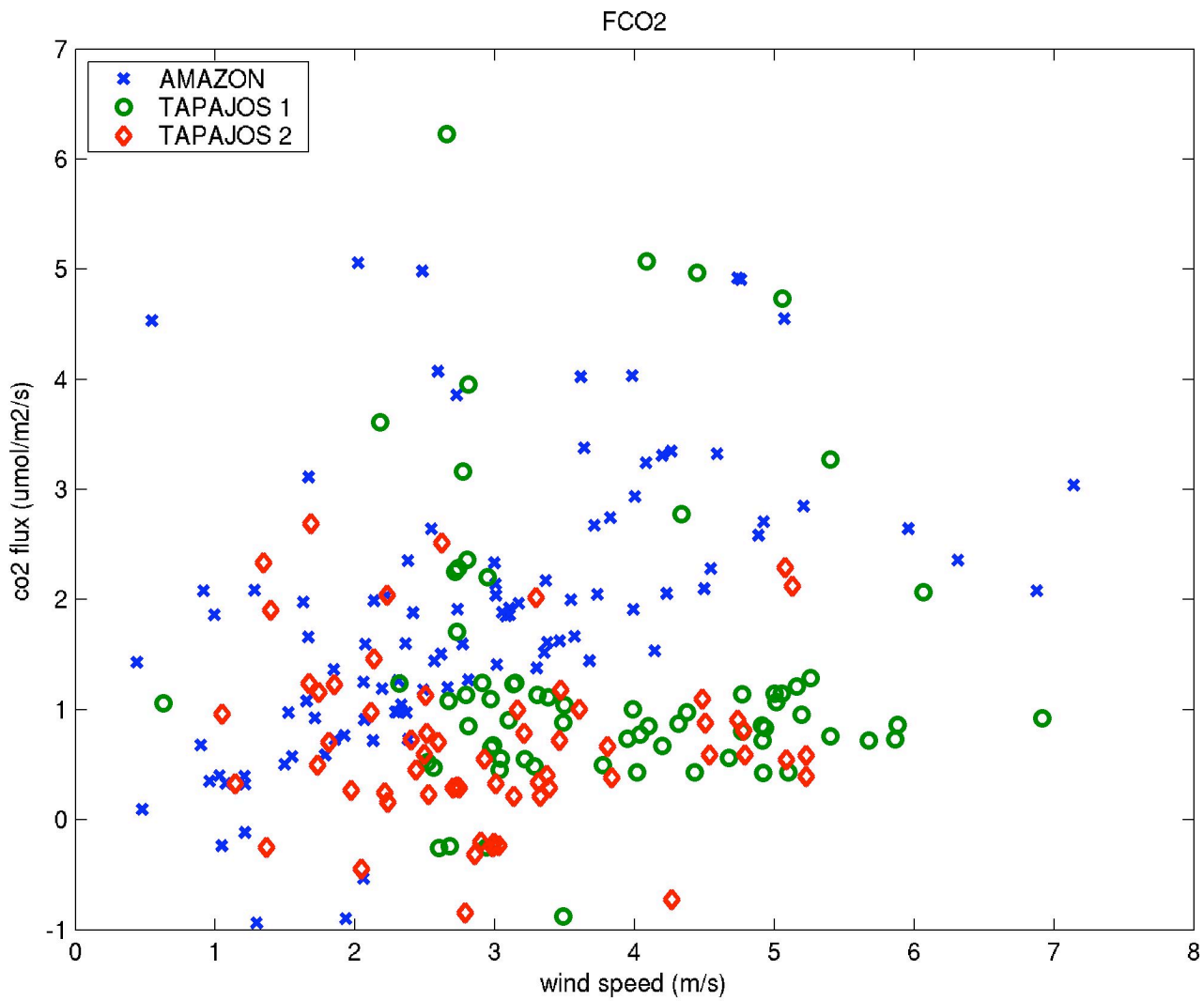
Raw Data


VERTICAL VELOCITY AND CO2 ARE POSITIVELY CORRELATED
W (normalized)
CO2 (normalized)
6
4
2
0
-2
-4
1500
1550
1600
1650
1700
1750
1800
VERTICAL VELOCITY AND H2O ARE POSITIVELY CORRELATED
W (normalized)
H2O (normalized)
4
2
0
-2
-4
1500
1550
1600
1650
1700
1750
1800
TIME (seconds)

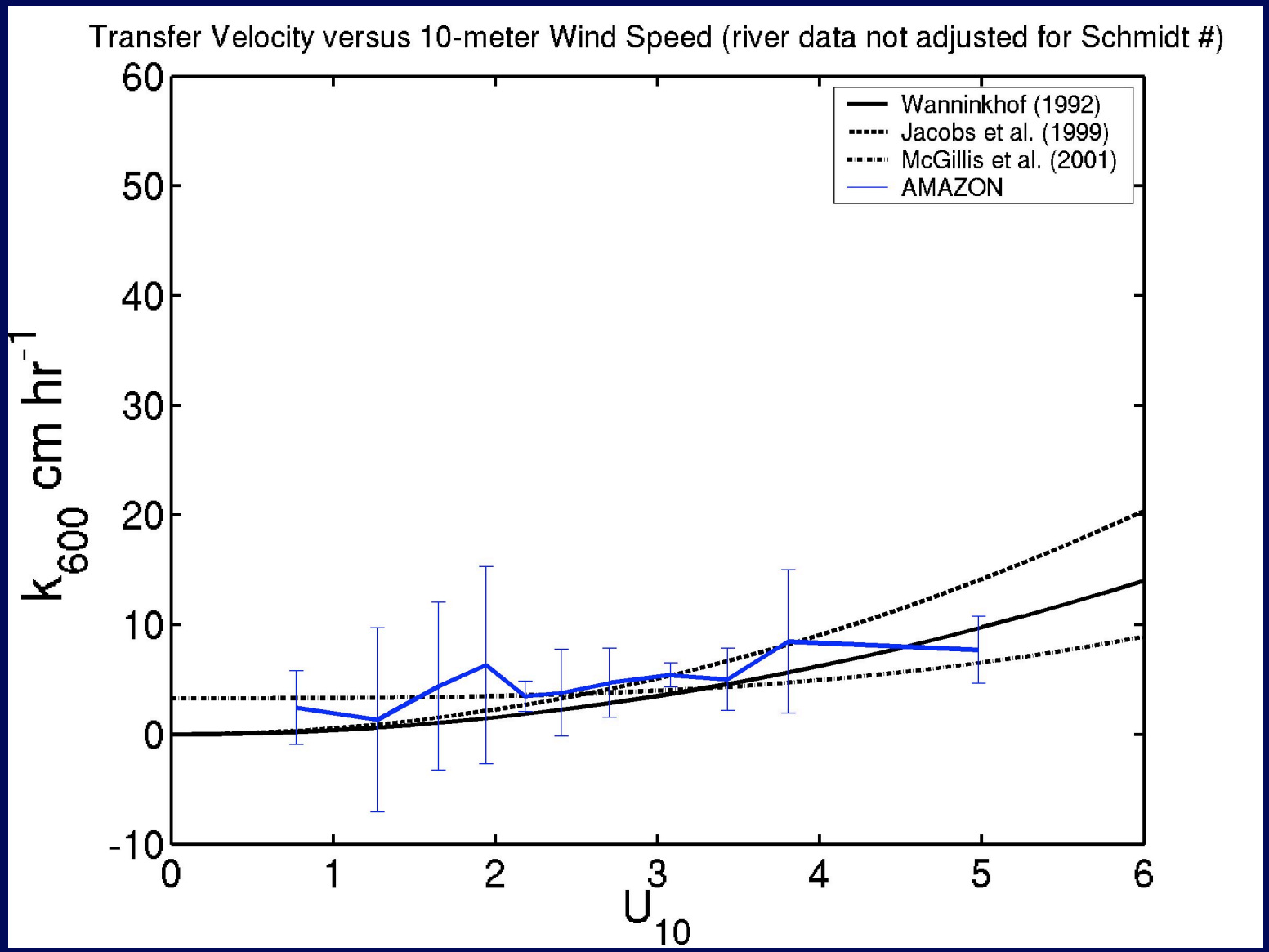
Flux Corrections



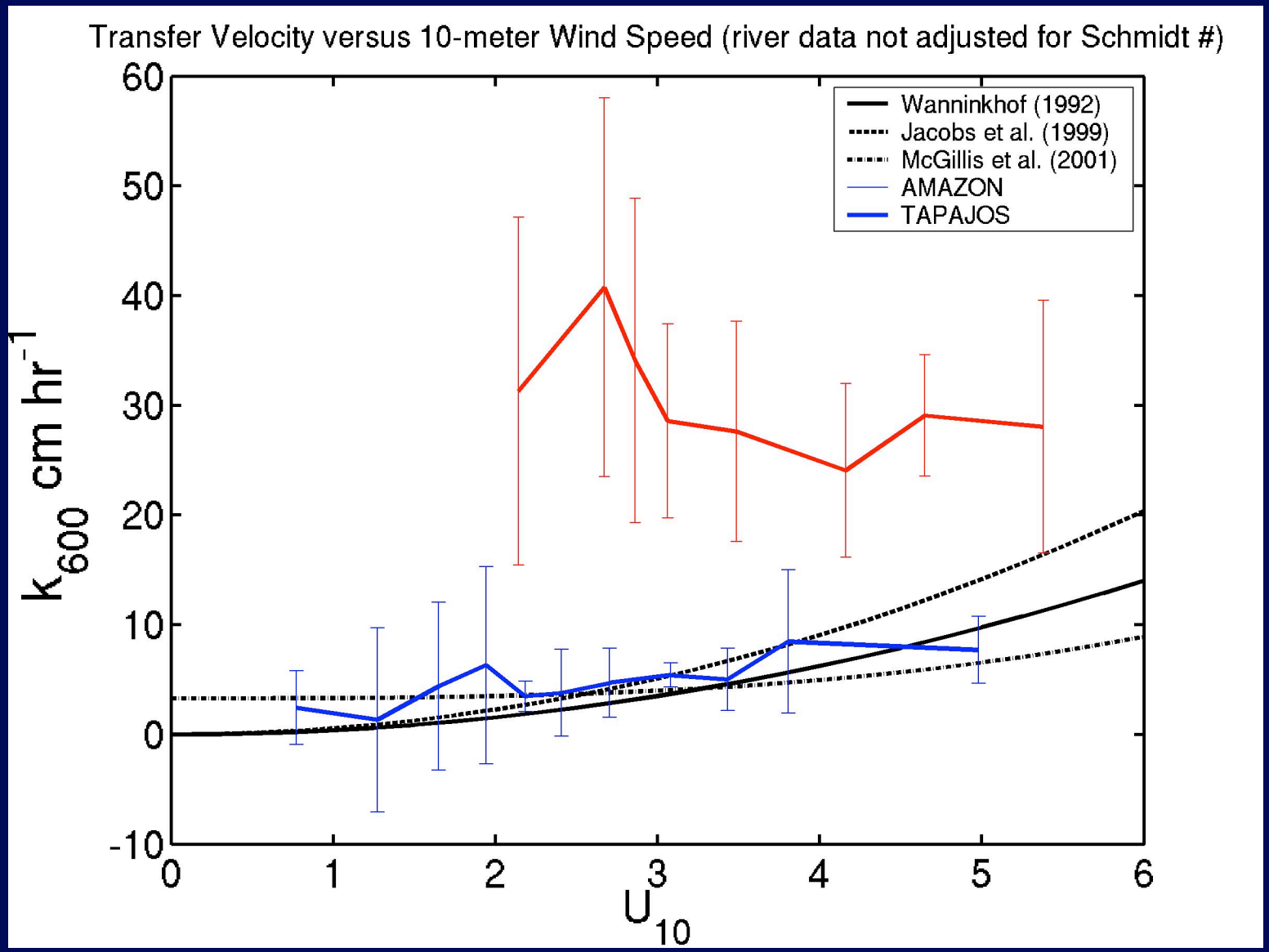
CO_2 Flux versus Wind Speed



Piston Velocity: Amazon only



Piston Velocity: Amazon & Tapajos



Next Steps

- Finish processing eddy flux data.
- Comparison with chamber measurements
- Additional measurements...

Conclusions

- Boat-based eddy covariance is facilitated by the high ΔpCO_2 across the air-water interface and large river size.

- Piston velocity for the Amazon consistent with other methods and environments.

Thanks: Boat Crew, Bethany Reed, Daniel Amarral.