Resolving systematic errors in estimates of net ecosystem exchange of CO_2 and ecosystem respiration in a tropical forest

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In review Agricultural and Forest Meteorology

Not all Amazonian forest sites are equal!!

The LBA sites have different

- site histories and biophysical constraints (topography, soils, climate, etc)
- eddy flux site have different instrumentation, calibration systems, data gap frequencies, processing protocols, canopy storage, turbulence fields, etc.

Km 67 Measuring Flux

sonic anemometer (wind speed)

eddy flux inlet

Km 67 Measuring Storage

temp profile

CO_2 & H_2O profile inlets

What about 'lost flux' problems?

We expect total nighttime *NEE* to be largely *independent* of atmospheric turbulence *(other factors being equal)*.

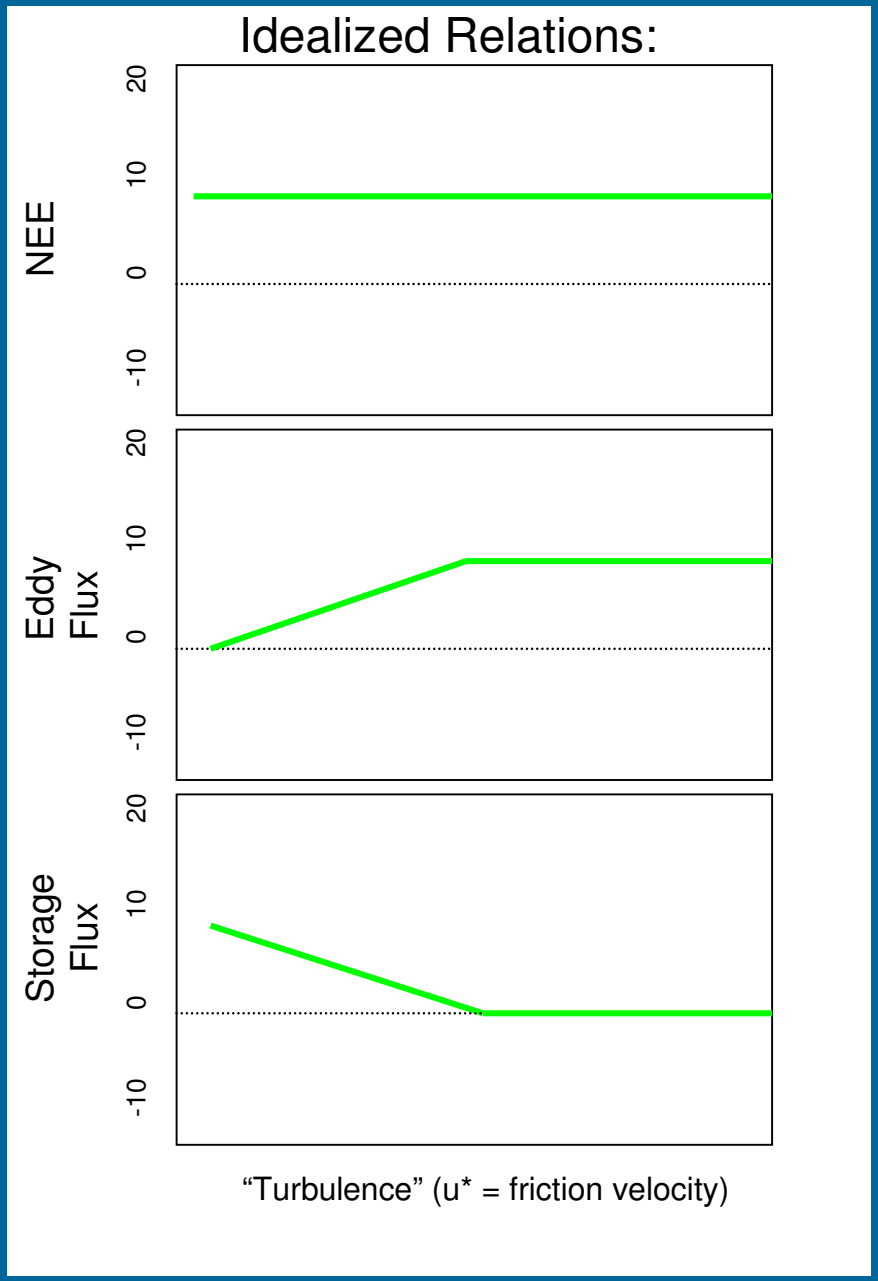
NEE components, however, are expected to depend on turbulence, but in opposite directions.

Definition: Net Ecosystem Exchange:

$$NEE = \text{Eddy Flux} + \frac{d}{dt}\langle \text{canopy storage} \rangle$$

Flux out the top

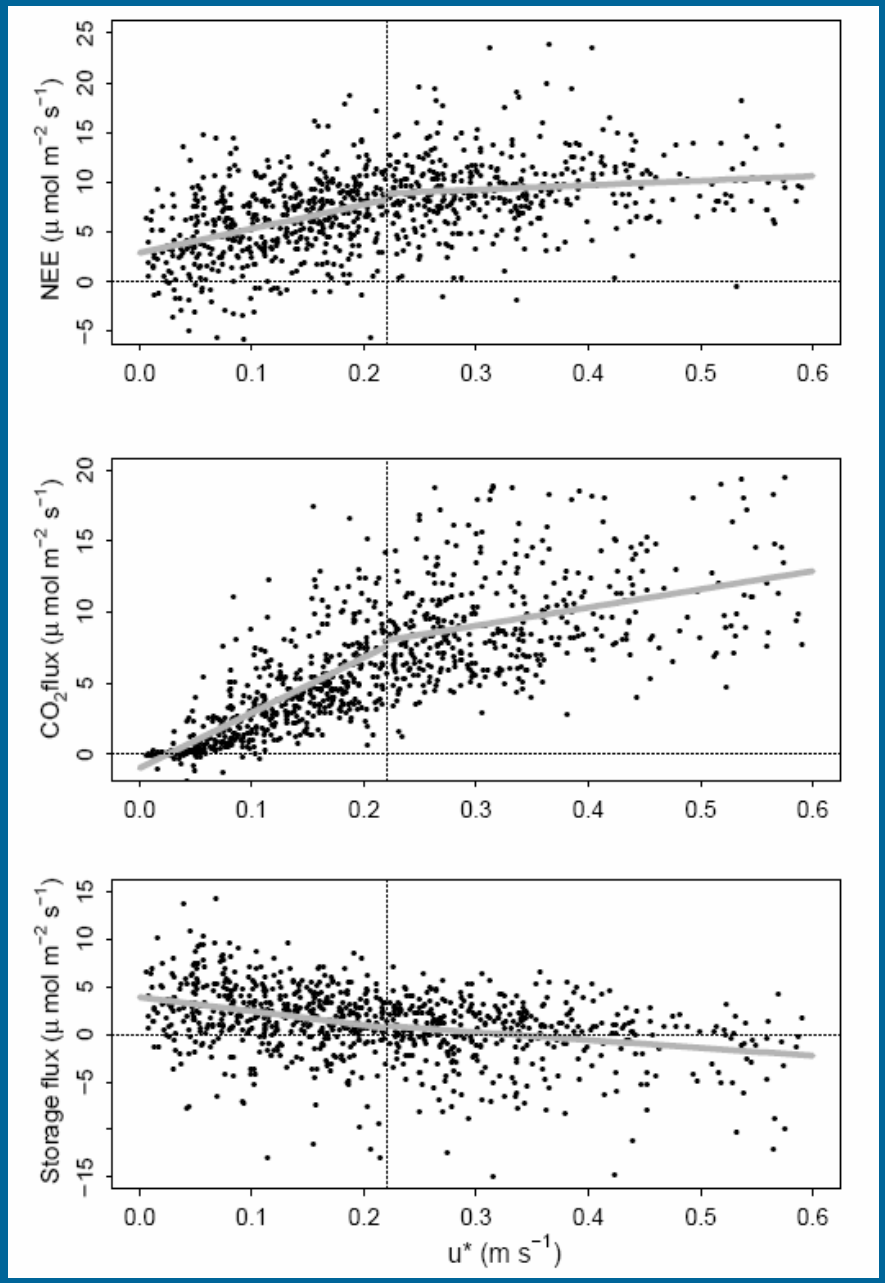
"Storage flux"



What about 'lost flux' problems?

As u* → 0, eddy flux decreases and storage flux increases as expected, but their sum (NEE) declines for u* < 0.22 m/sec:

We take this as evidence of *lost flux!*



Hutyra et al., *in review*

Correction Methods:

In order to correct for this lost flux (which is almost exclusively a nighttime problem), we apply a u* filter and remove NEE measurements during periods of low turbulence.

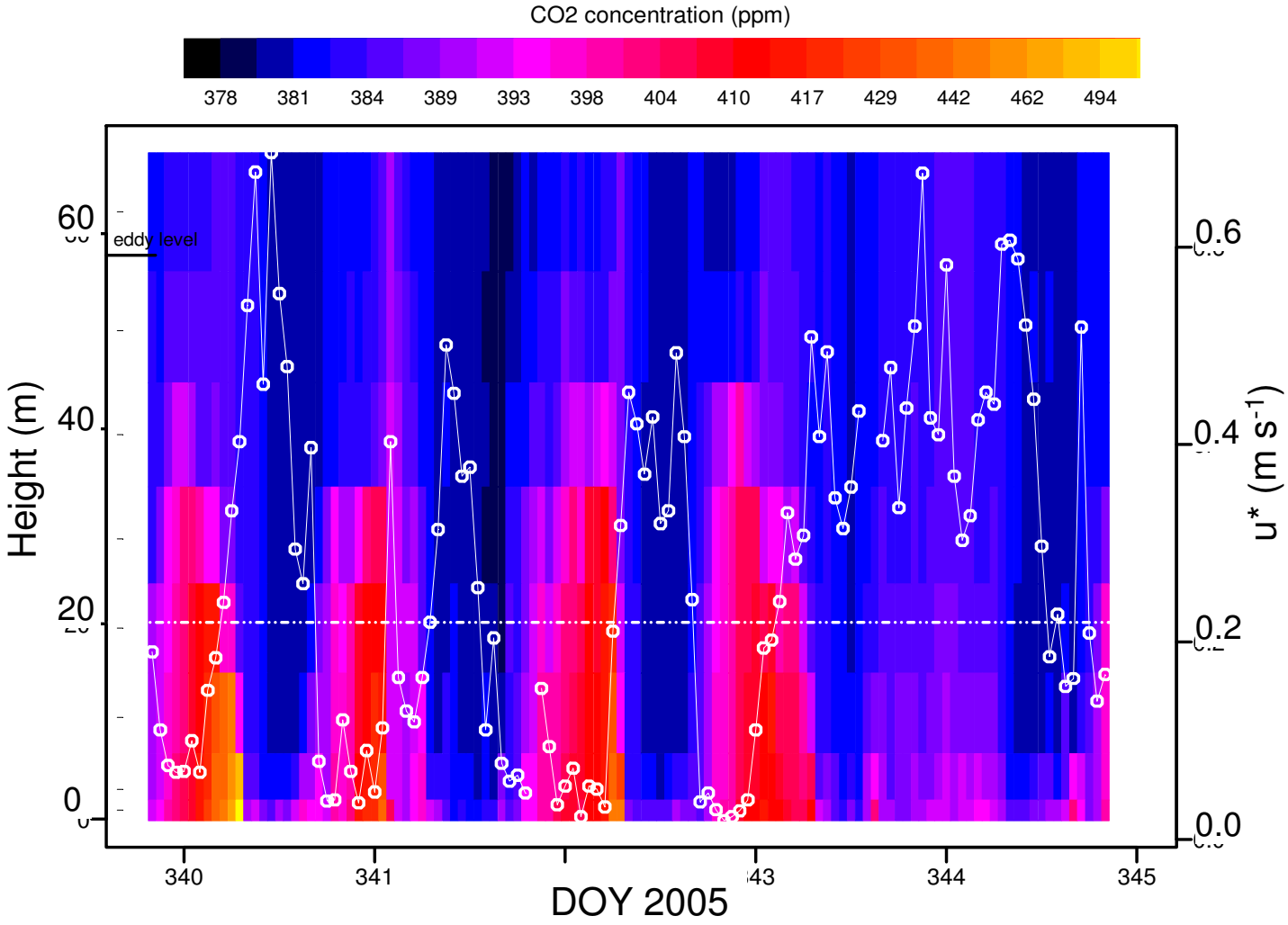
To created a continuous time series to estimate annual sums we have filled the NEE, R, & GEE time series.

- Missing R (due to filtering or data gaps) is filled over short time intervals (~15 days) using the median of the valid nighttime observations. No temperature corrections are applied because the data does not support a Q10 type relationship.
- GEE is inferred by difference from observed NEE and R (based on nighttime measurements). Gaps in the GEE time series were filled using light curve methods over short time intervals

What is the effect of the u* filter on canopy CO_2 storage?

Nighttime: $\overline{S} = 1.2 \pm 0.06$ μmol m^{-2} s^{-1}

$\overline{S_{u^*}} = -0.18 \pm 0.11$ μmol m^{-2} s^{-1}



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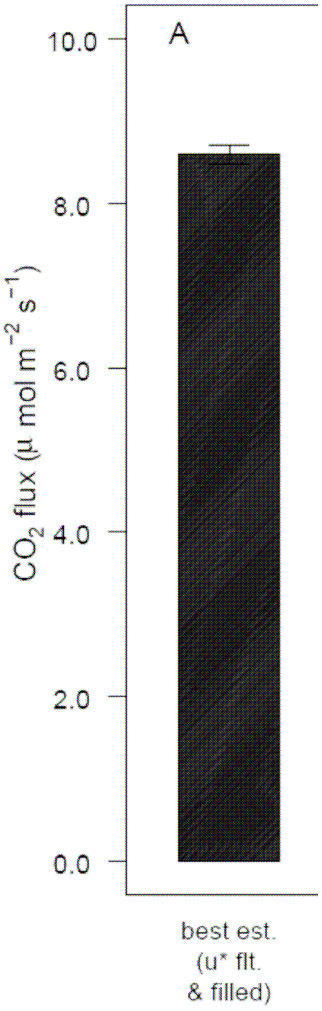
What is the influence of storage measurements and u* filtering on estimates of ecosystem Respiration?

Estimates of ecosystem respiration



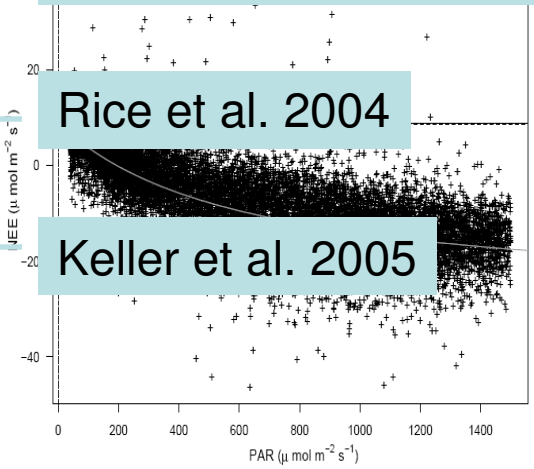
Martens et al., 2004

Nepstad et al. 2002

Chambers et al. 2004

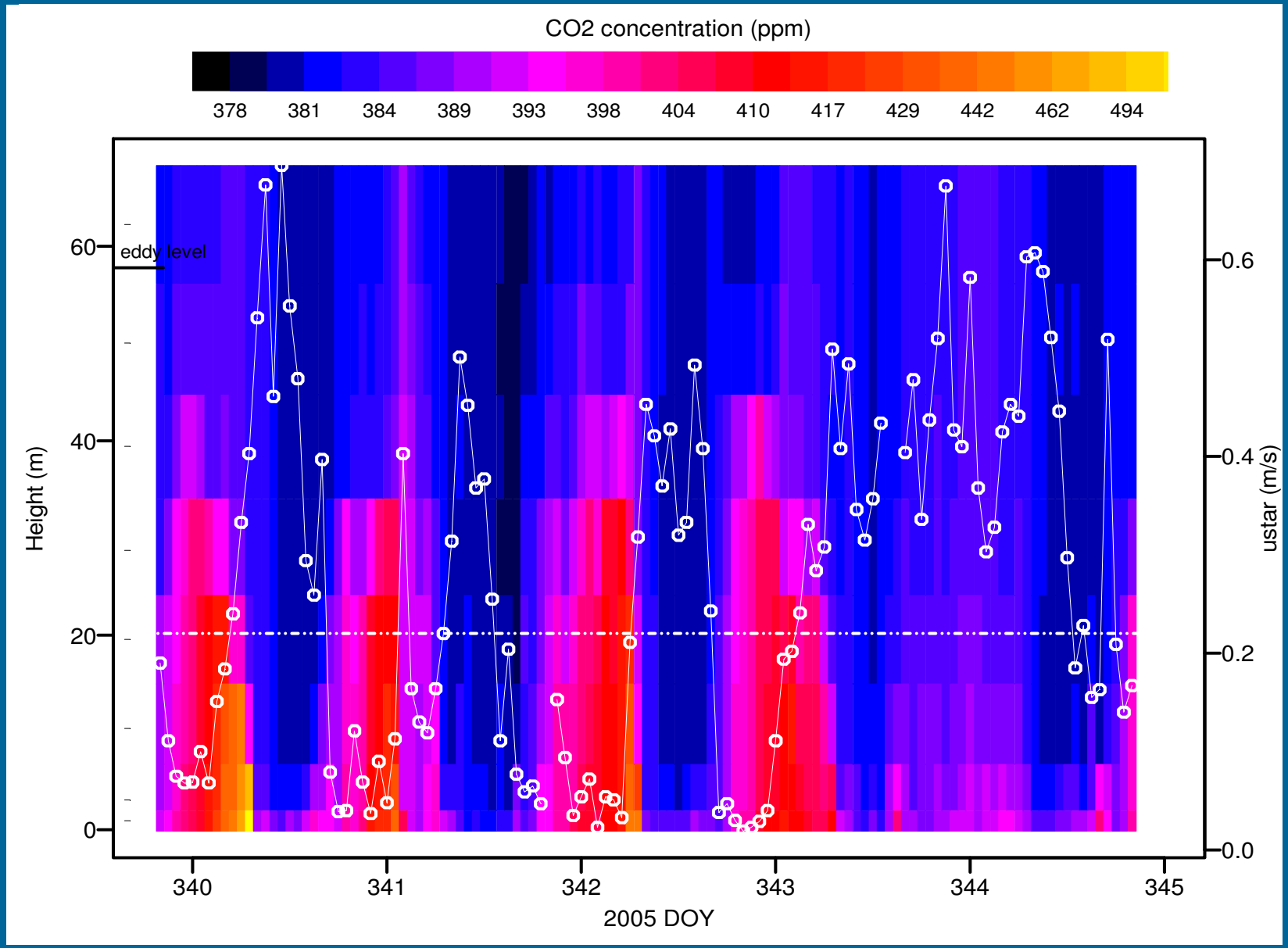
Rice et al. 2004

Keller et al. 2005

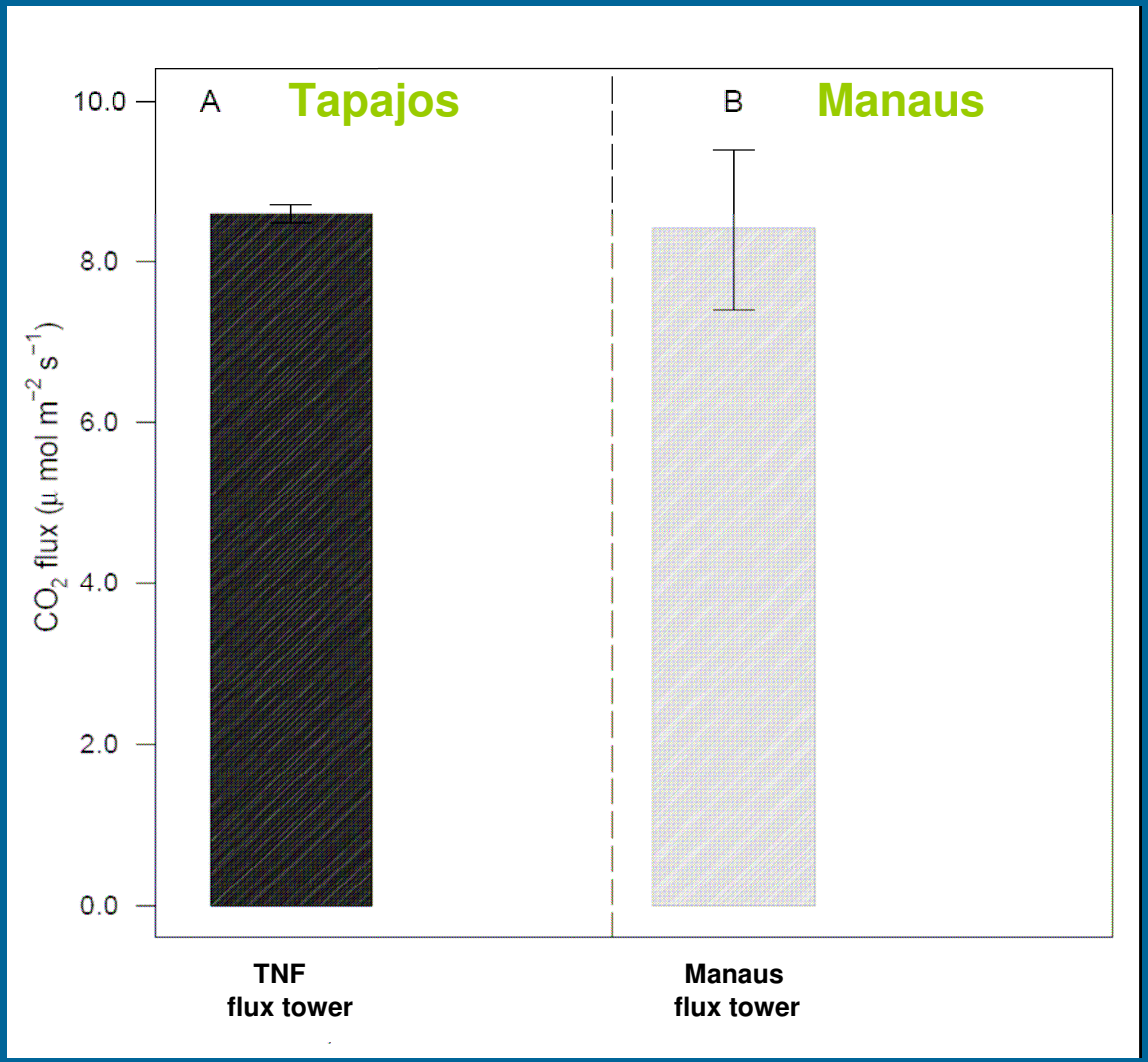


Hutyra et al. fig. 1

What is the influence of storage measurements and u* filtering on estimates of ecosystem Respiration?



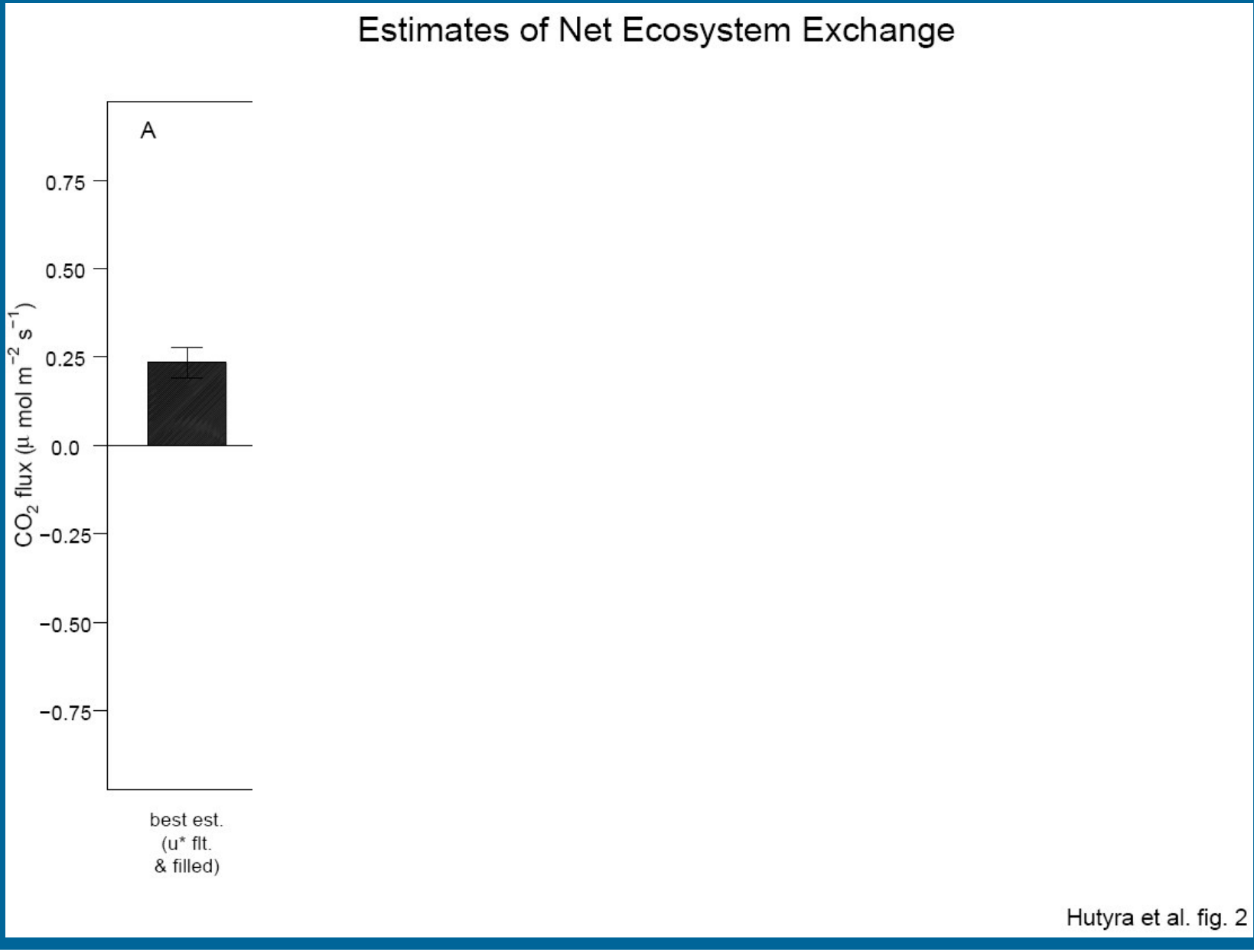
How do the Tapajos respiration estimates compare with Manaus?



Hutyra et al., in review

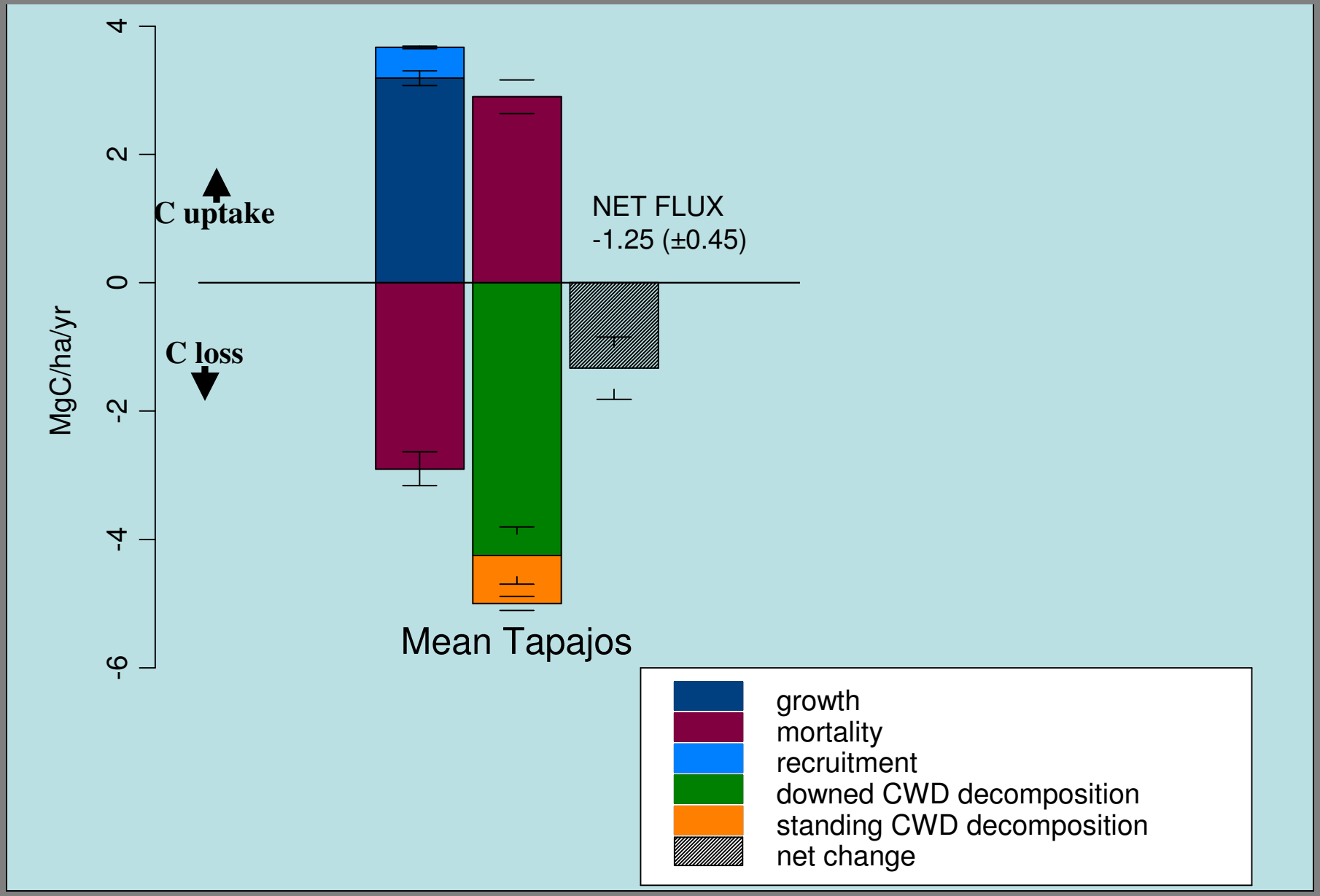
Chambers et al., 2004

What is the influence of storage measurements and u* filtering on estimates of the net ecosystem exchange?



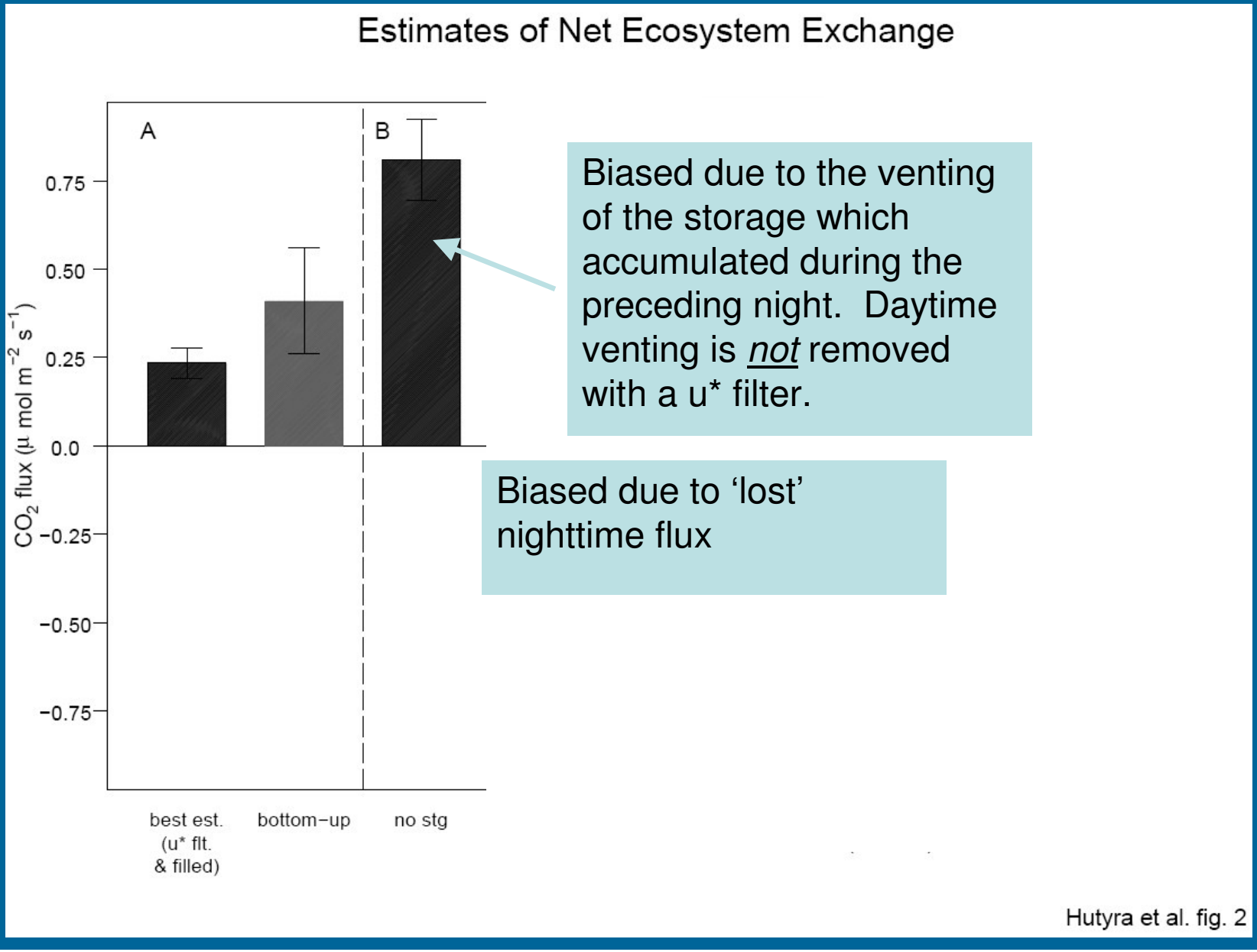
Hutyra et al. fig. 2

FLUXES IN LIVE AND DEAD BIOMASS (1)



Pyle et al. in review

What is the influence of storage measurements and u* filtering on estimates of the net ecosystem exchange?



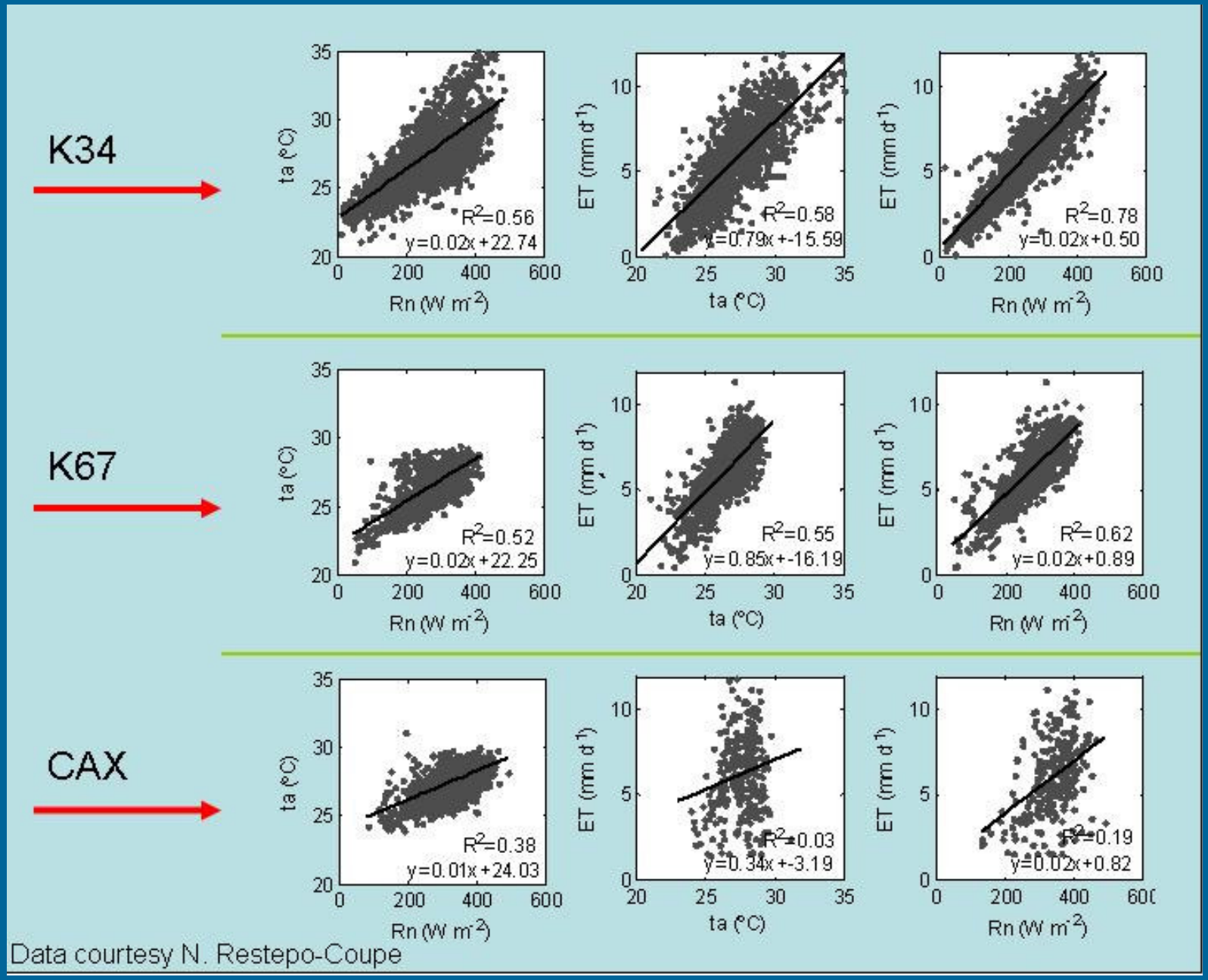
Summary & Conclusions:

- We derived and compiled 4 independent estimates for ecosystem respiration and the net ecosystem carbon exchange to validate our eddy flux measurements and data processing. The independent estimates confirmed our treatment of lost nocturnal flux, gap filling methods, and data separation.

- We tested and derived models for canopy storage and found that a simple model could allow for recovery of NEE data during periods of missing storage.

- It is crucial to assess and correct biases associated with lost nighttime flux and missing canopy storage measurements at all eddy sites, particular in the tropics.

Thank You!

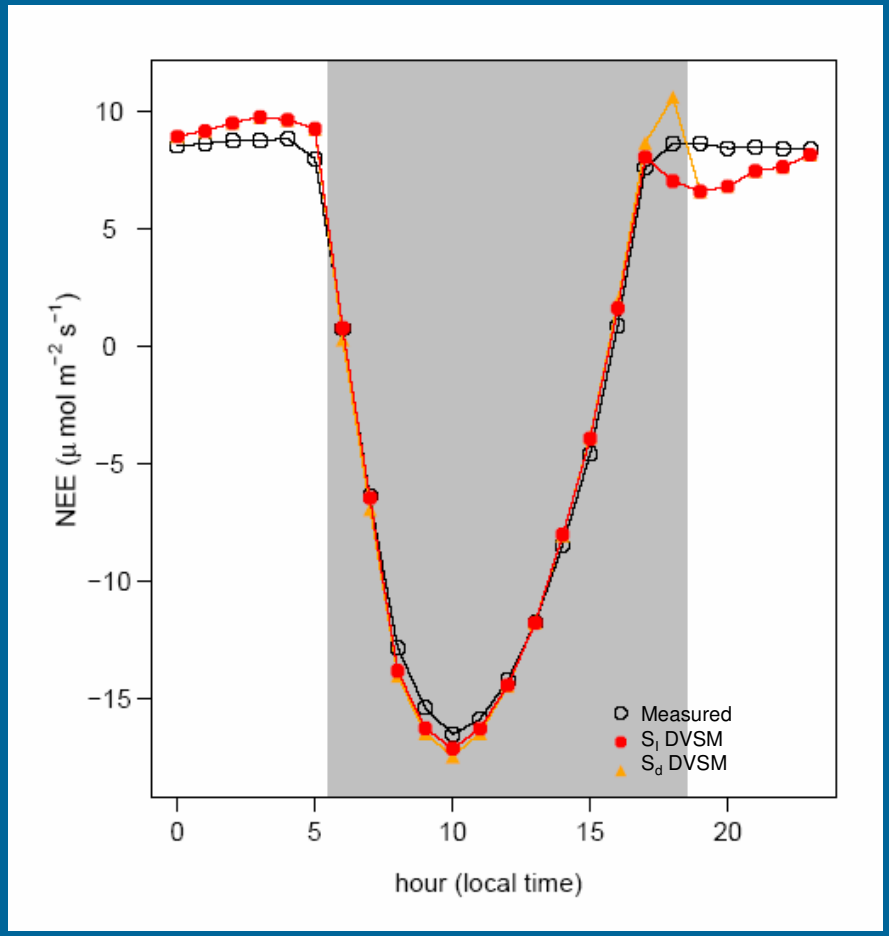


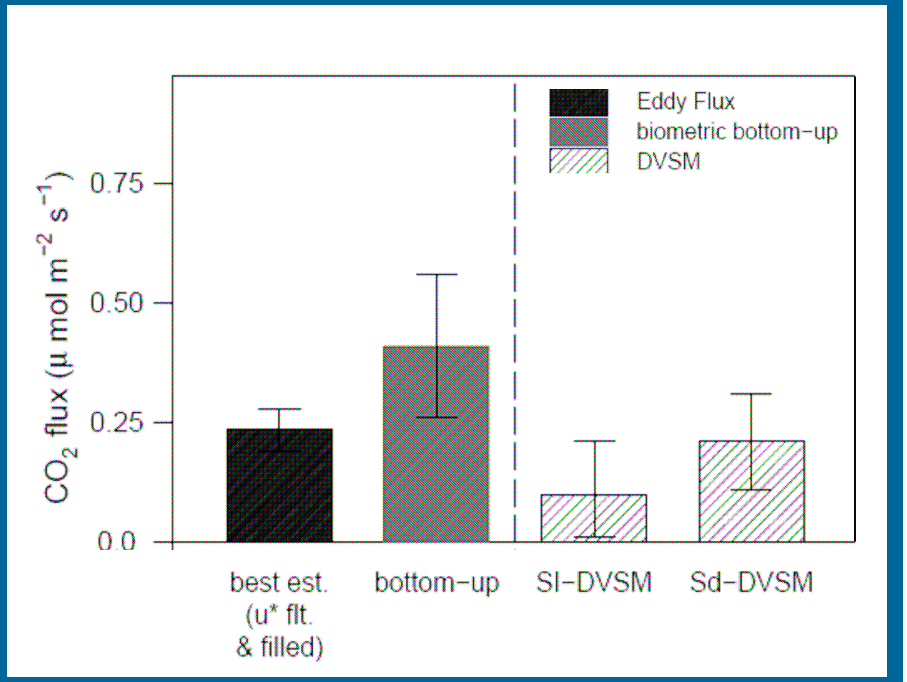
Data courtesy N. Restepo-Coupe

A diurnally varying storage model can capture the patterns in NEE

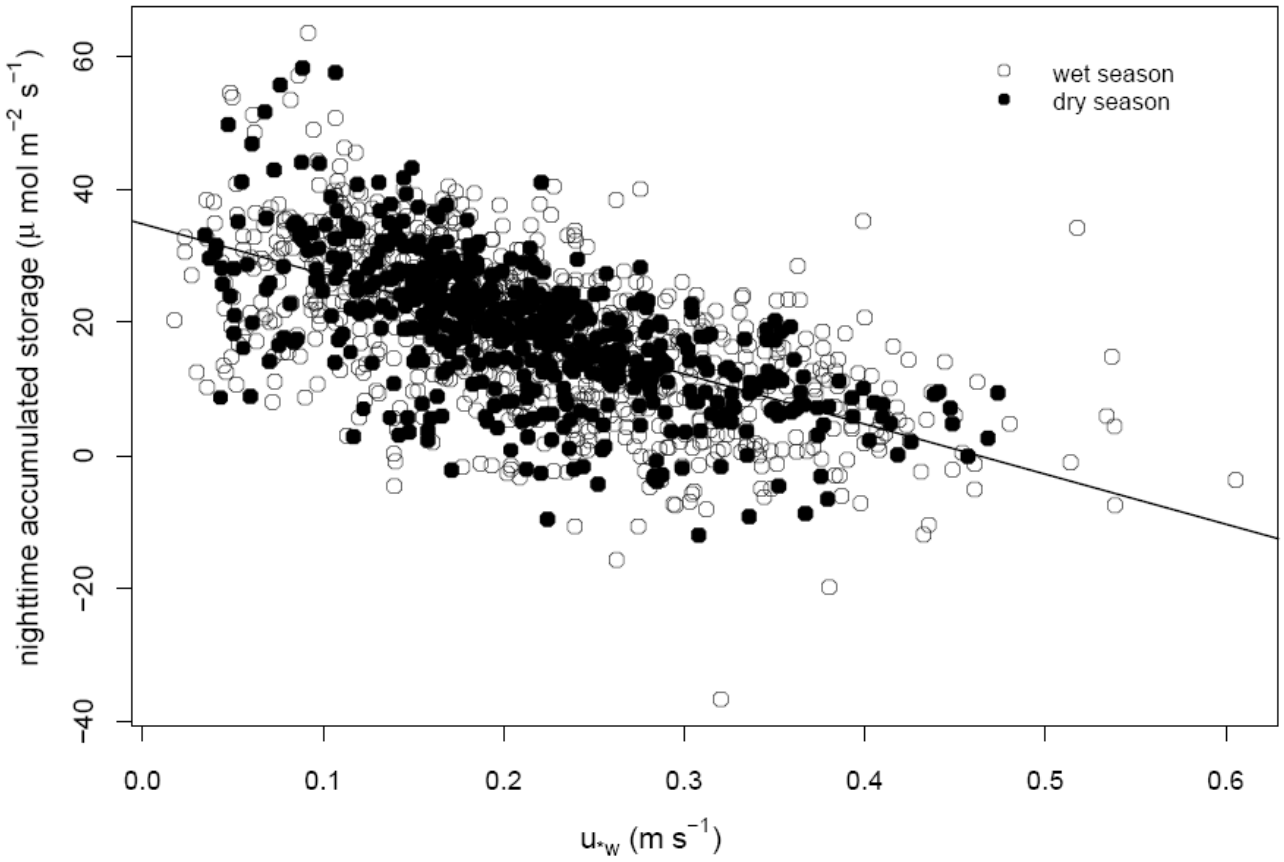
nighttime: use only u* filtered measured flux

daytime: use measured flux + the mean hourly daytime values.

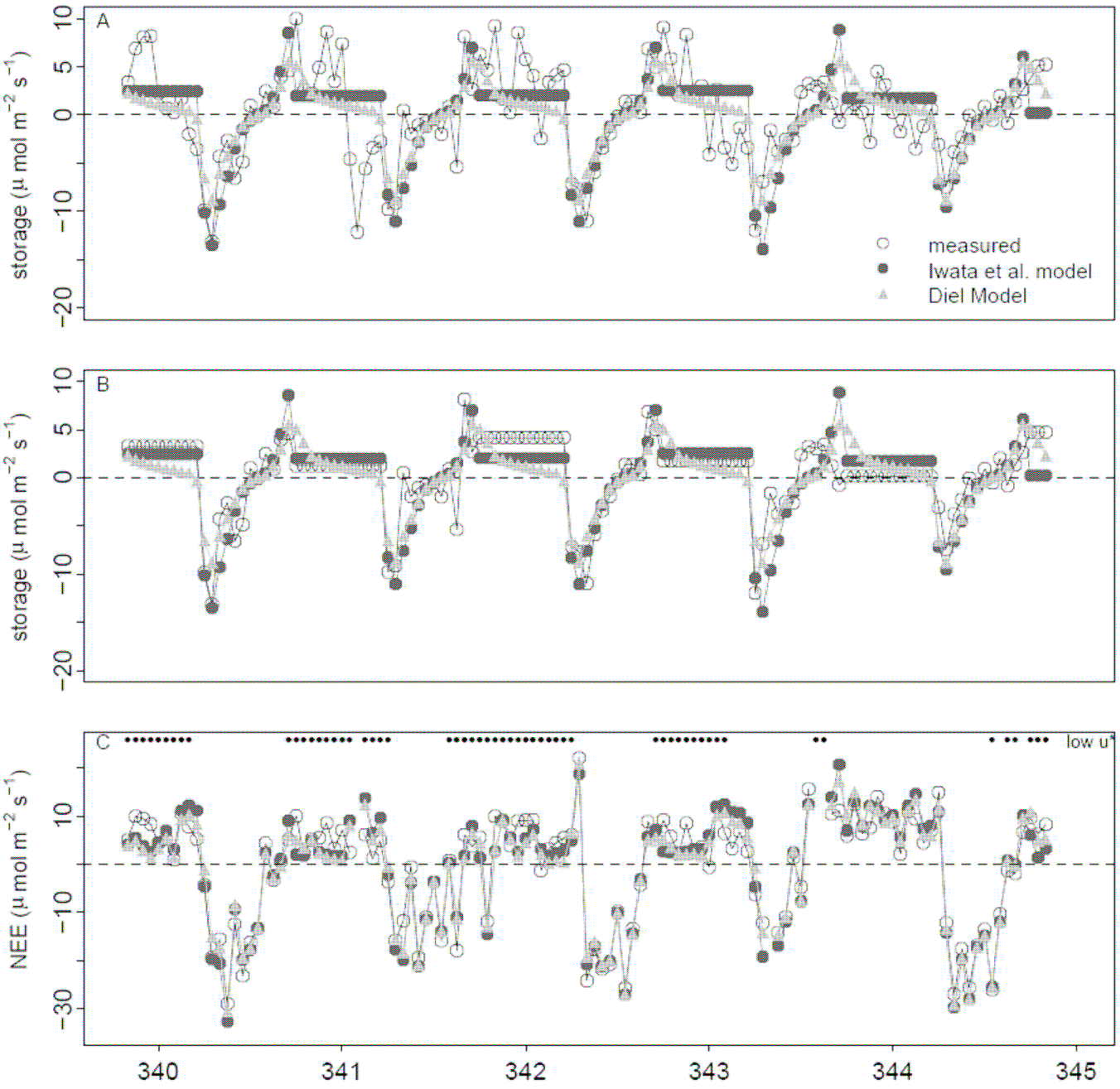




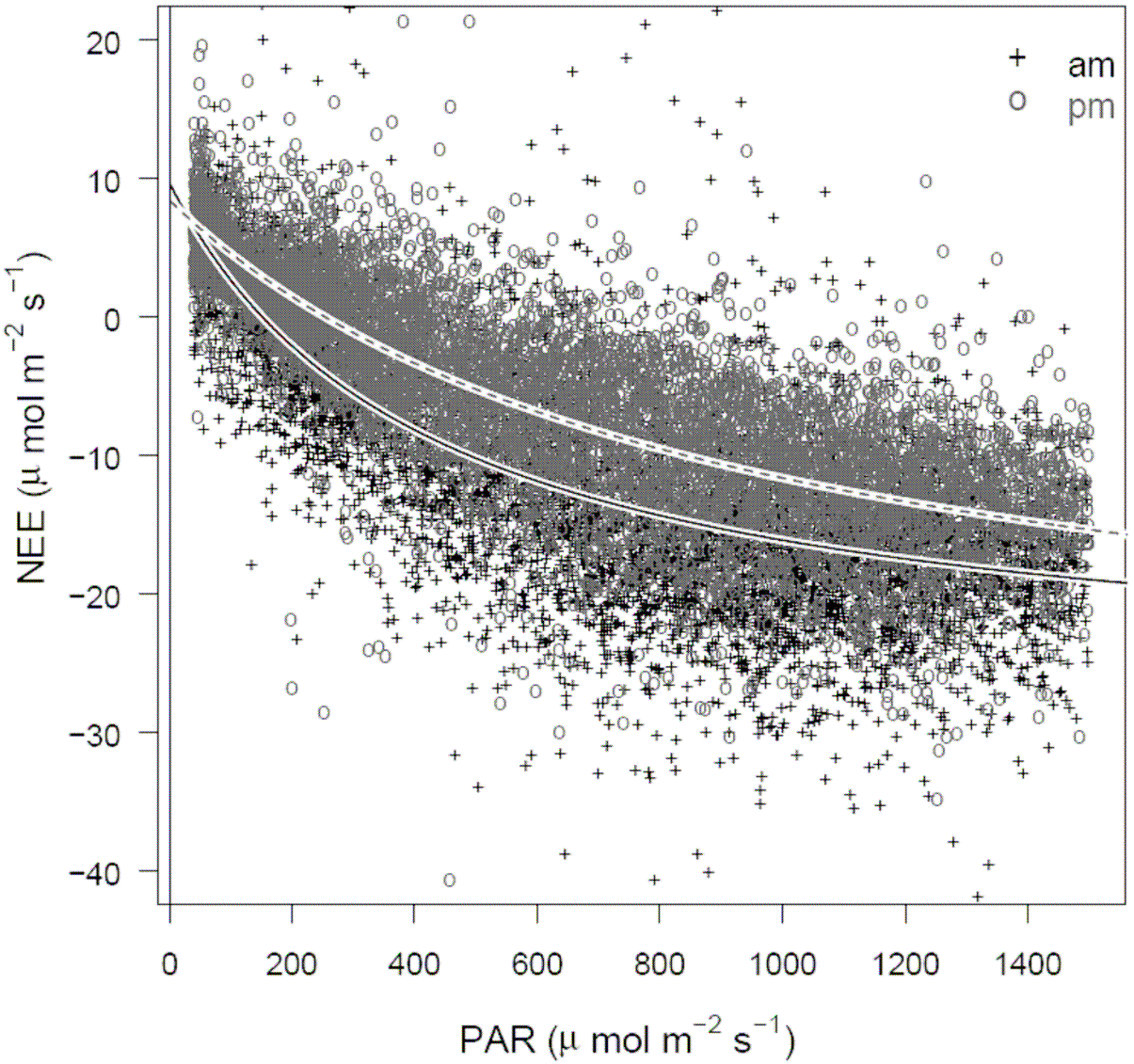
Hutyra et al., in review



Hutyra et al. fig. 7

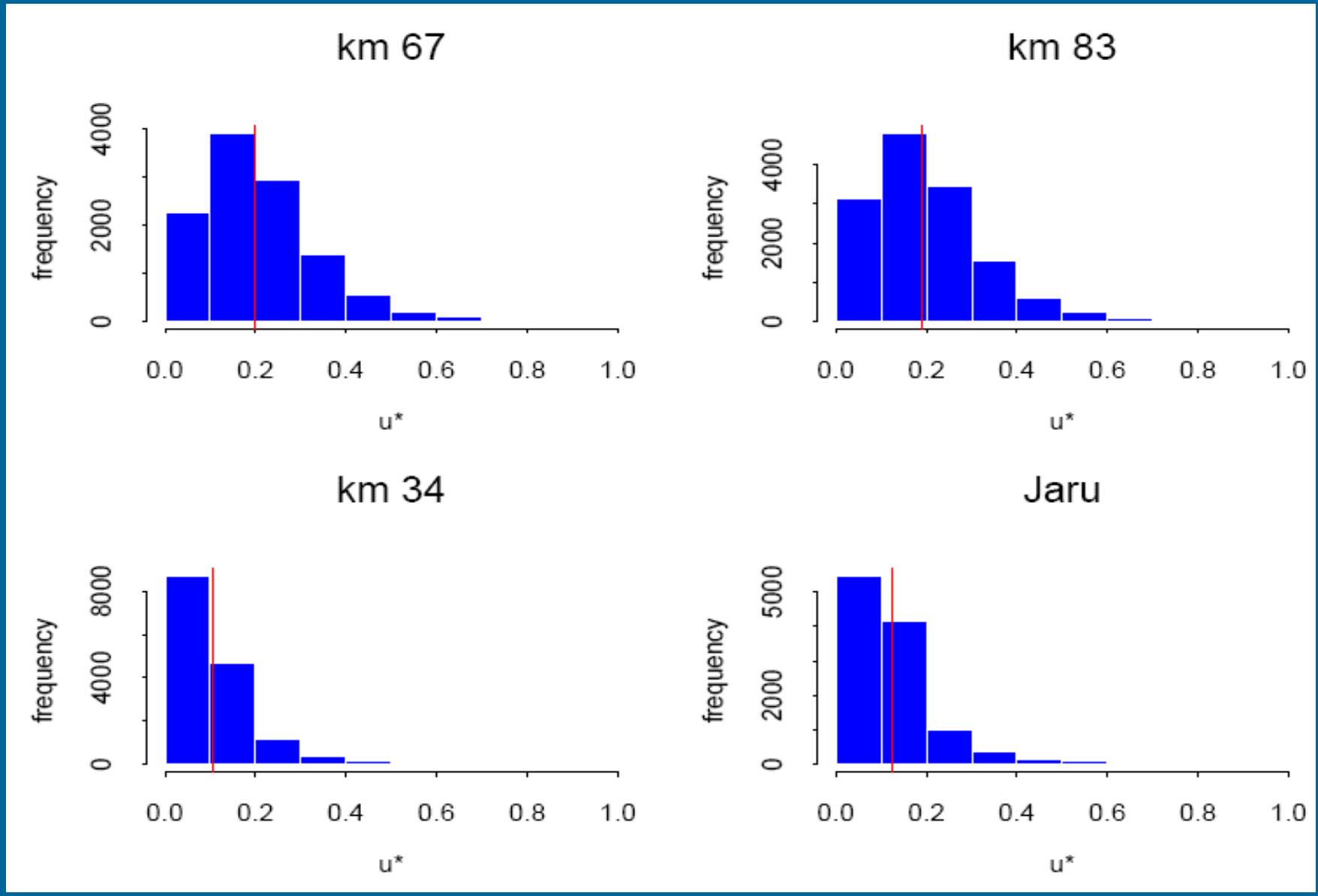


Hutyra et al. fig. 8



Hutyra et al. fig. 9

The distribution of nighttime u* is not uniform across sites in the Amazon.



Respiration:

$R = R_a + R_h$

Temperature and soil moisture typically vary inversely but both simultaneously influence R. At this site, we found *NO* significant relationship between temperature and R on short time scales.

Summary of explained variance (R^2) and best regression equations used to estimate R

	$\overline{T}_{daily\,\max}$ (°C)	$\sum P$ (mm)	$\overline{T}_{daily\,\max}$ & $\sum P$	Best Model
Hourly time scale	-	-	-	-
Daily time scale	0.05	-	-	-
Weekly time scale	0.12	0.06	-	-
14-day time scale	0.29	0.24	0.32	$R = 22.9 - 0.51*T_{max} + 0.05*P$
21-day time scale	0.45	0.32	0.47	$R = 25.1 - 0.58*T_{max} + 0.03*P$
Monthly time scale	0.67	0.54	0.72	$R = 26.1 - 0.62*T_{max} + 0.03*P$
Seasonal time scale	0.92	0.45	0.92	$R = 39.9 - 1.1*T_{max}$