Measuring the Effect of Selective Logging on Forest-Atmosphere Exchange

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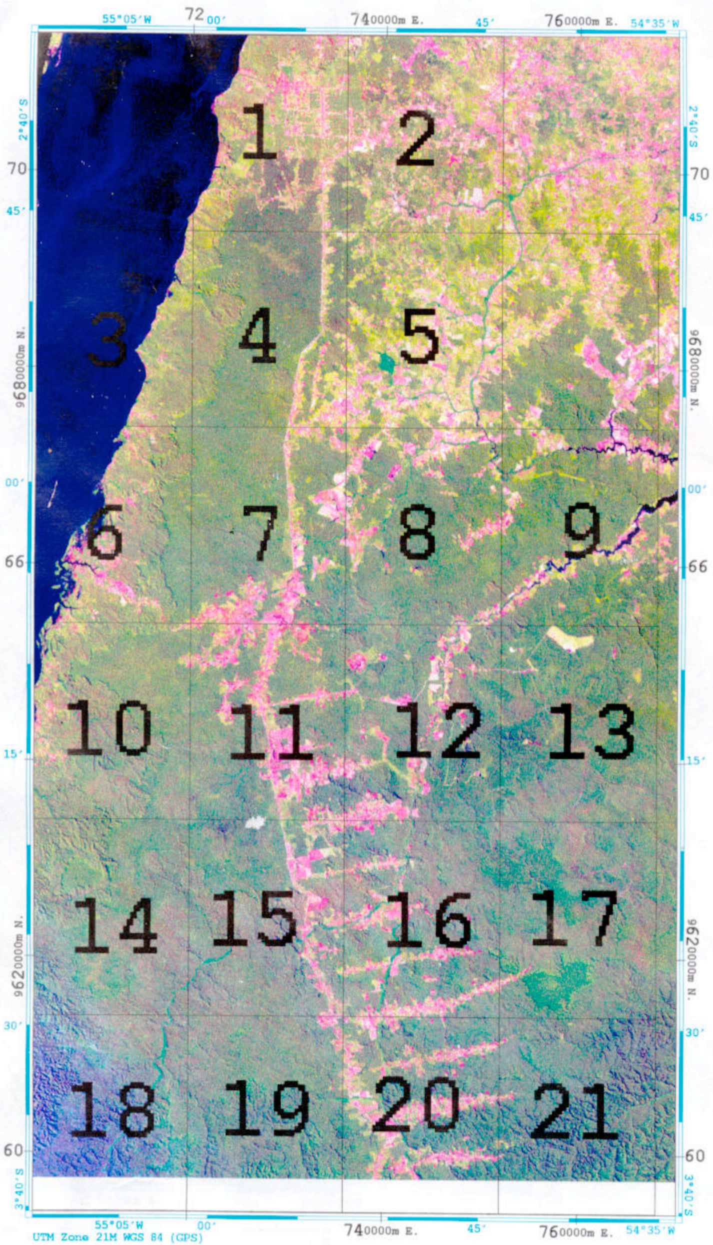
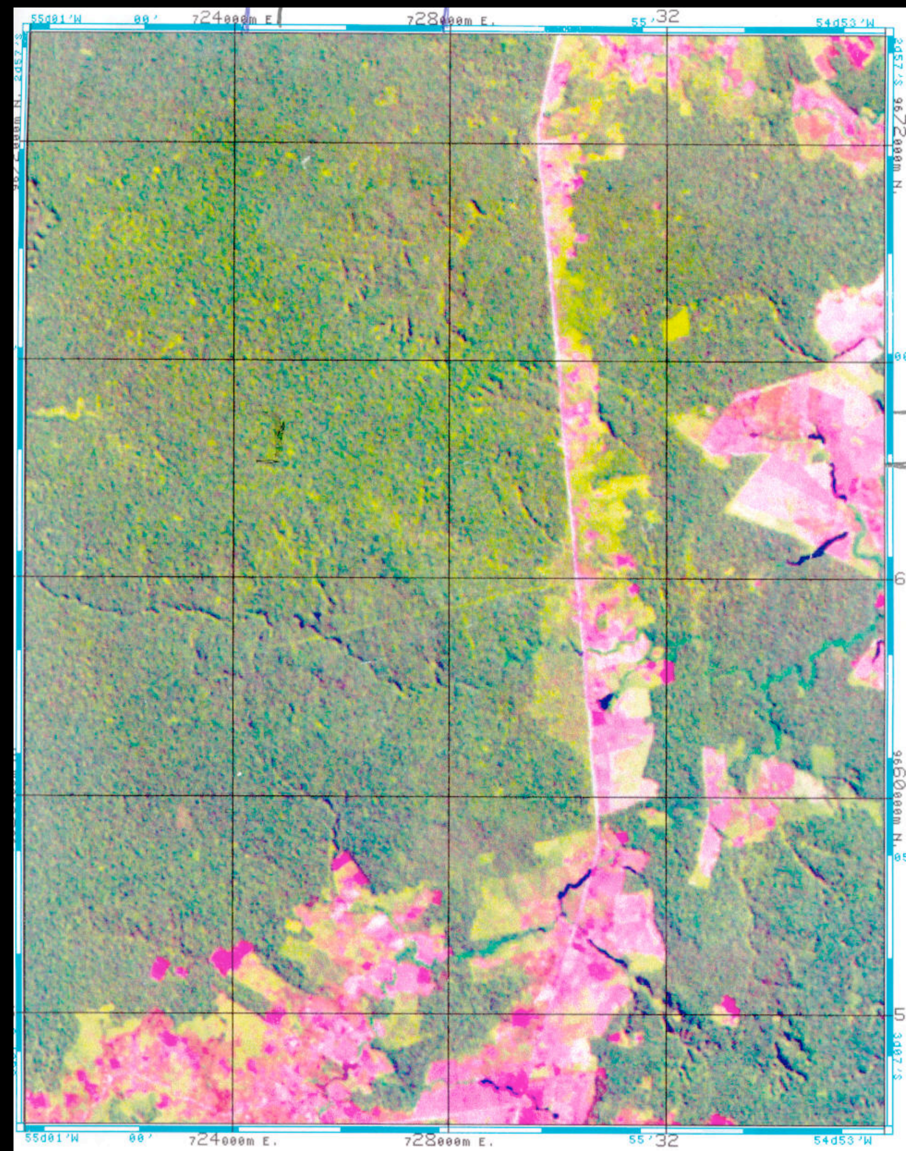
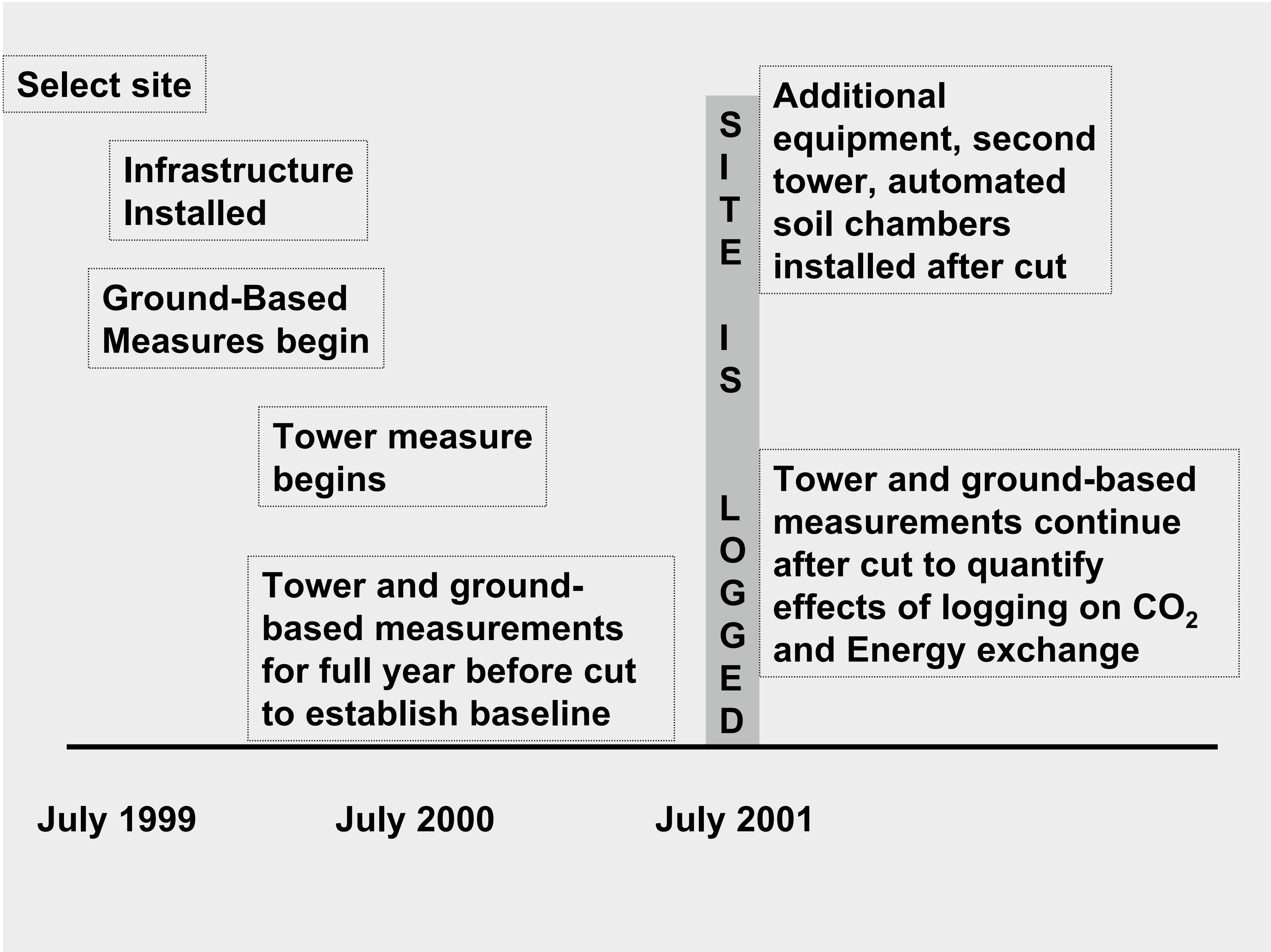
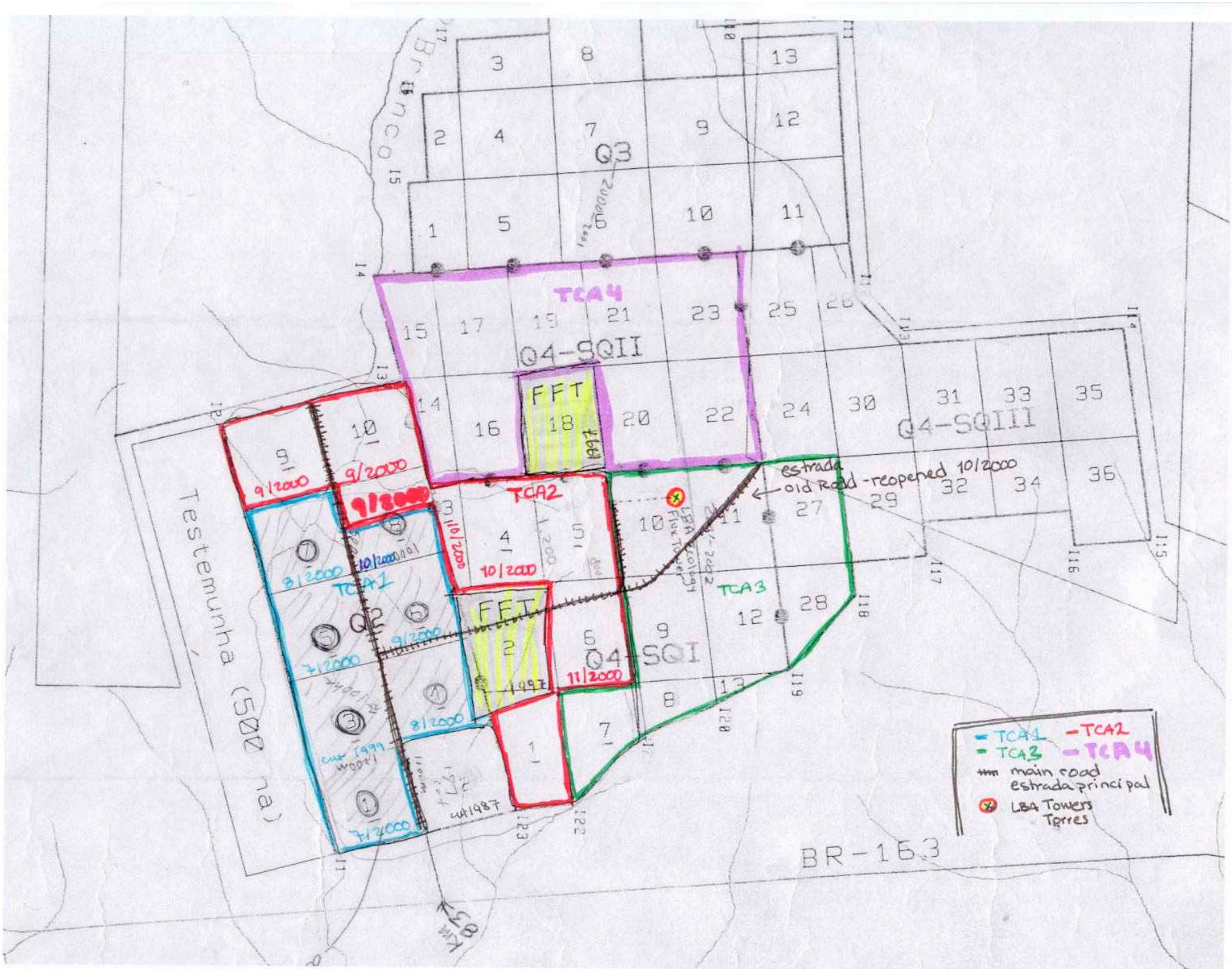


INDEX MAP

Santarem, PA




Select site
Infrastructure Installed
Ground-Based Measures begin
Tower measure begins
Tower and ground-based measurements for full year before cut to establish baseline
SITE IS LOGGED
Additional equipment, second tower, automated soil chambers installed after cut
Tower and ground-based measurements continue after cut to quantify effects of logging on CO_2 and Energy exchange
July 1999
July 2000
July 2001


Q3
TCA4
Q4-SQII
FFT
1997
Q4-SQIII
estrada
old Road - reopened 10/2000
TCA2
TCA1
Q2
TCA3
Q4-SQI
9/2000
10/2000
11/2000
8/2000
7/2000
cut 1999
cut 1987
Testemunha (500 ha)
BR-163
km 83
TCA1
TCA2
TCA3
TCA4
main road
estrada principal
LBA Towers
Torres

Ground-based measurements **MeasurementMethod** Above-ground BiomassAll trees > 30cm c

Challenges

Environment
Automation
Data Management

Tower Measurements

Since June 2000

METEOROLOGY

PAR (up/down)	LiCor Quantum Sensors
Solar	Kipp & Zonen
Net Radiation	REBS Q*7
Rain	Tipping Bucket

PROFILES

Wind (3 hts)	Cup anemometers
Temperature (4 hts)	Campbell 107
CO_2/H_2O (12 hts)	LI-7000 (Closed Path)

FLUXES

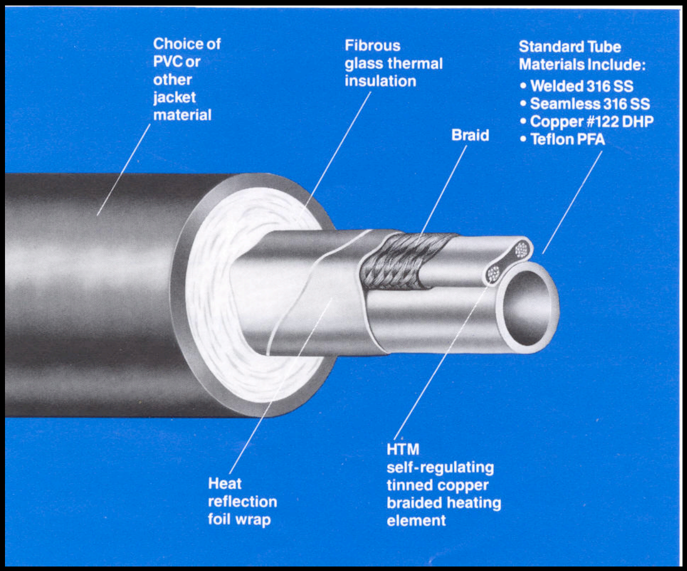
Momentum/Heat	Campbell CSAT3
1) CO_2/H_2O	LI-7500 (Open Path)
2) CO_2/H_2O	LI-7000 (Closed Path)

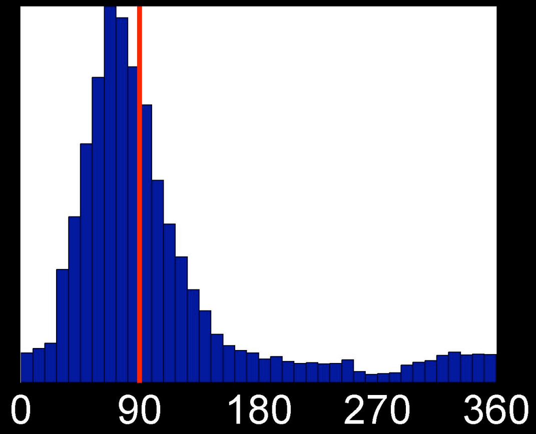
Air Inlet for Closed Path IRGA

Open Path IRGA

Heated Tubing

1) Fixed to tower
2) 300 ft ~ 300 lb
3) 10 W/m startup
4) Maintains T~64 C

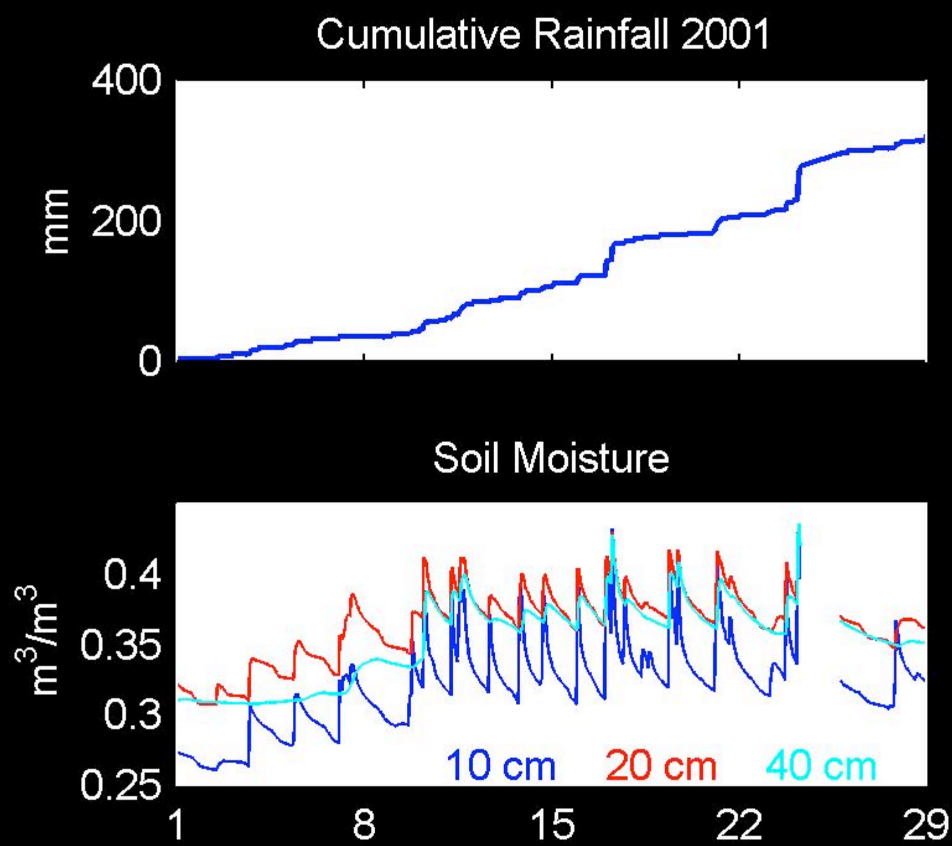




Sonic anemometer is looking East,
the most common wind direction

Elevator allows tower top instruments to be easily serviced.

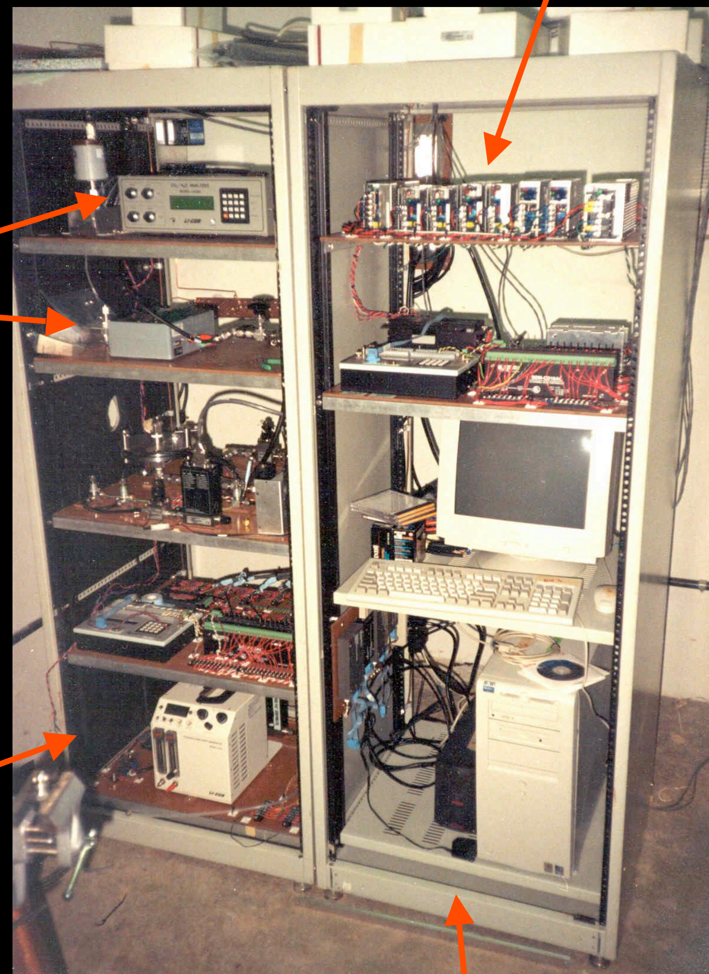
A soil pit has been instrumented to measure moisture and temperature profiles between 2 cm and 2.5 meter depth



Equipment Rack

Power Supplies

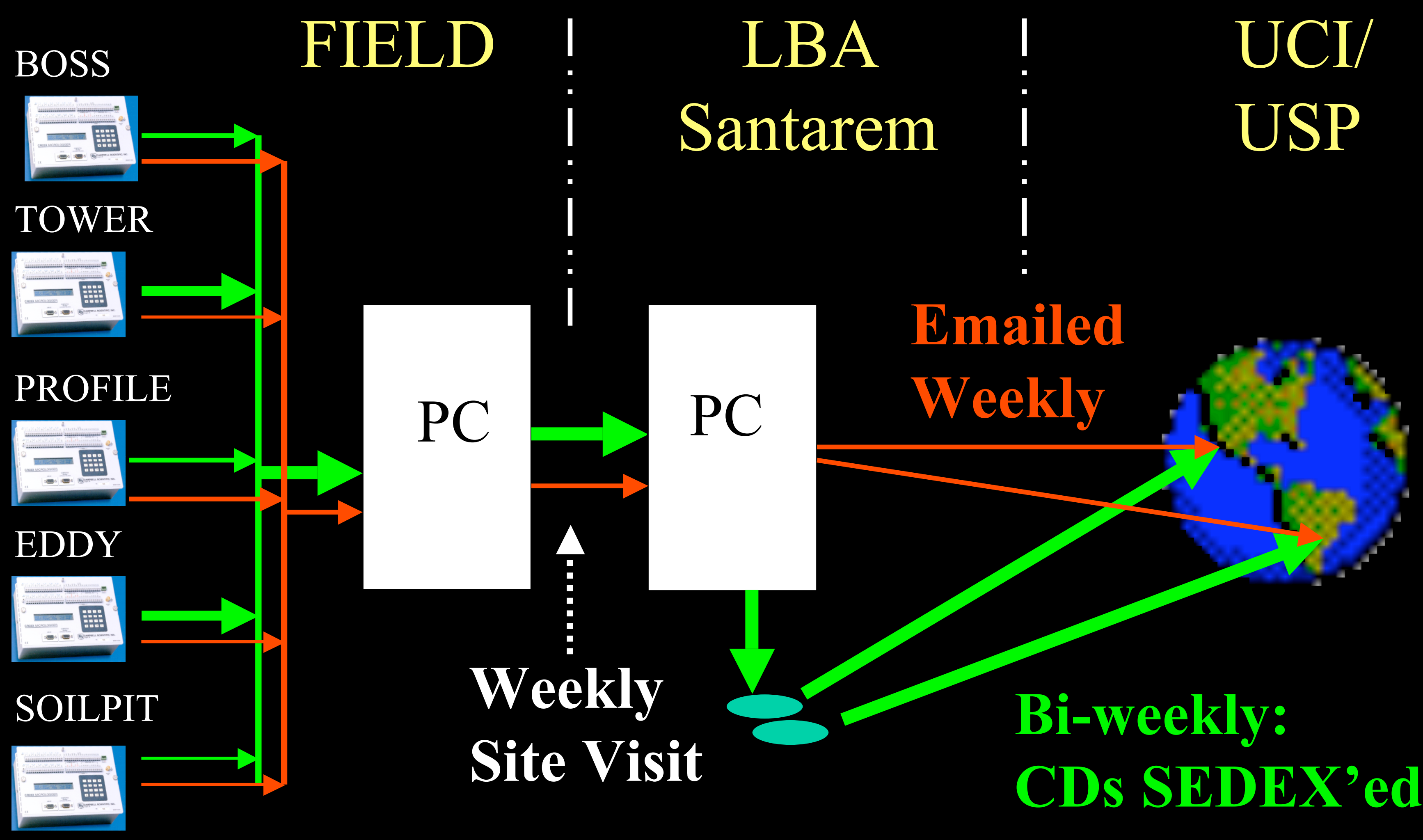
Closed Path IRGAS



Calibration Equipment

Data Acquisition Computer

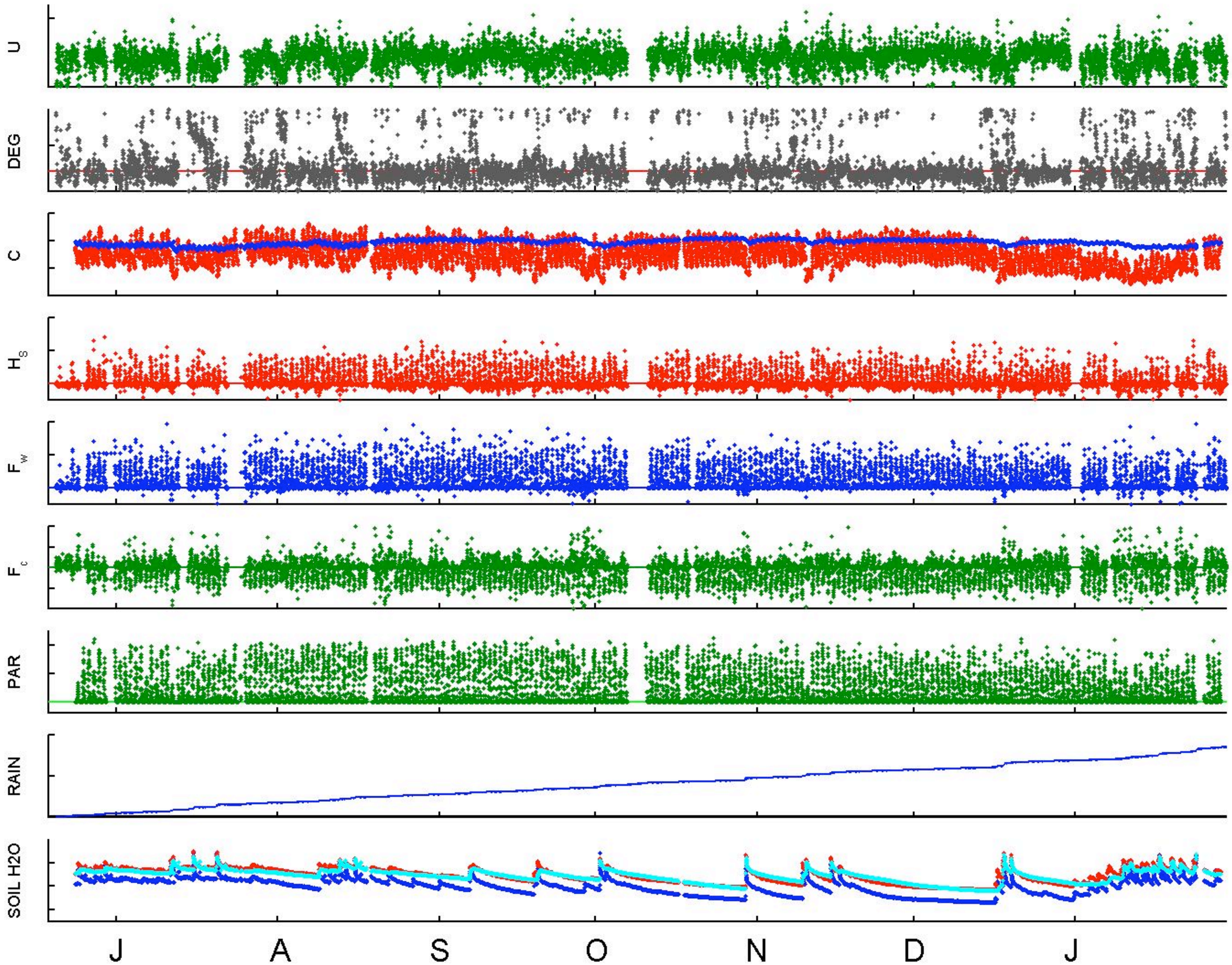
DATA MANAGEMENT



GREEN: Raw Data

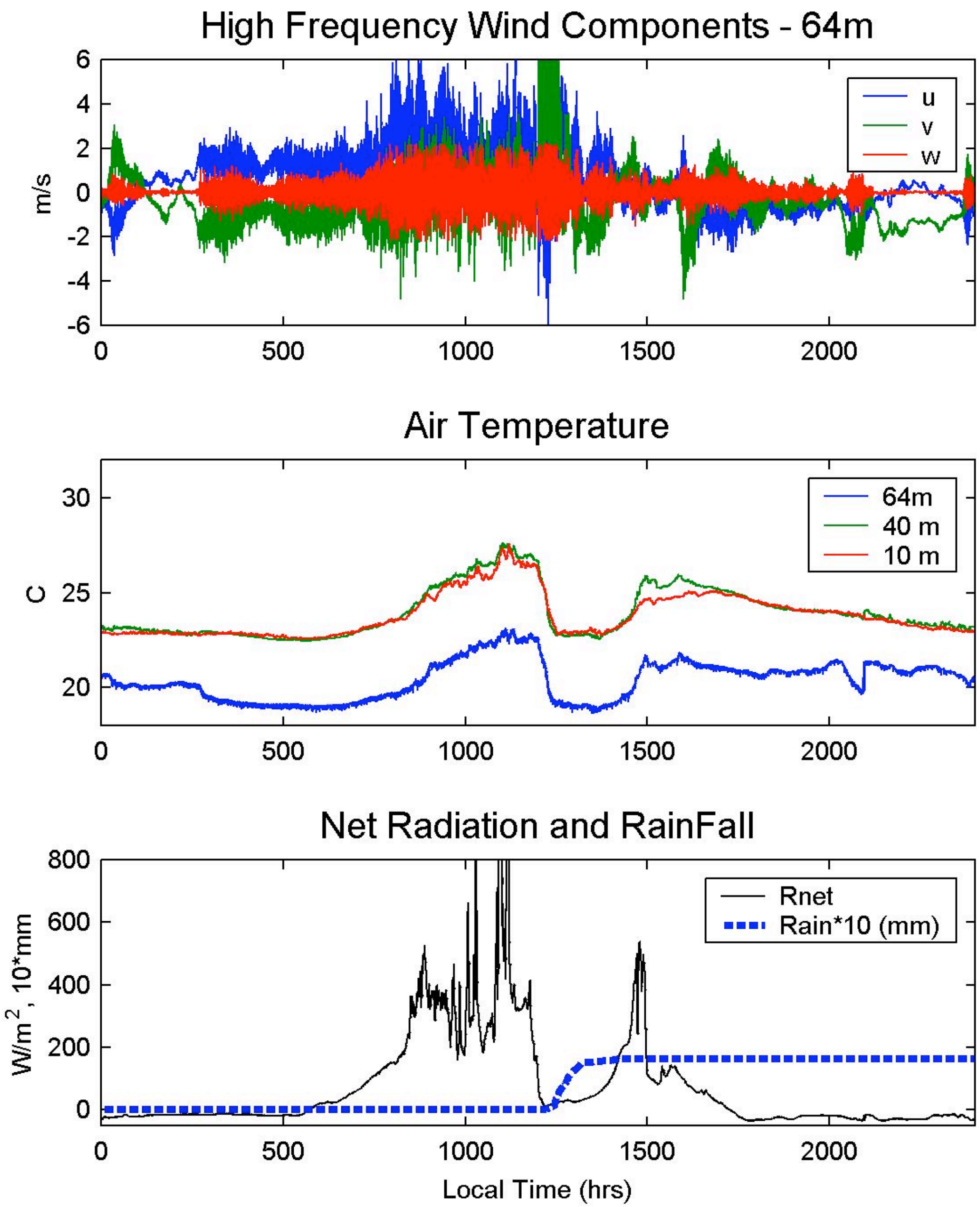
RED: Averaged Data

Data Summary

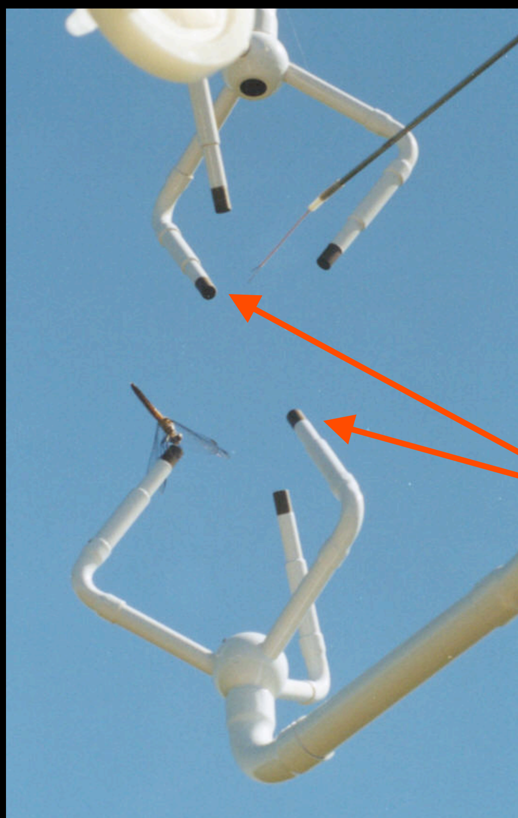


Data Processing

It is useful to have easy access to high frequency (raw) signals in addition to the processed data.

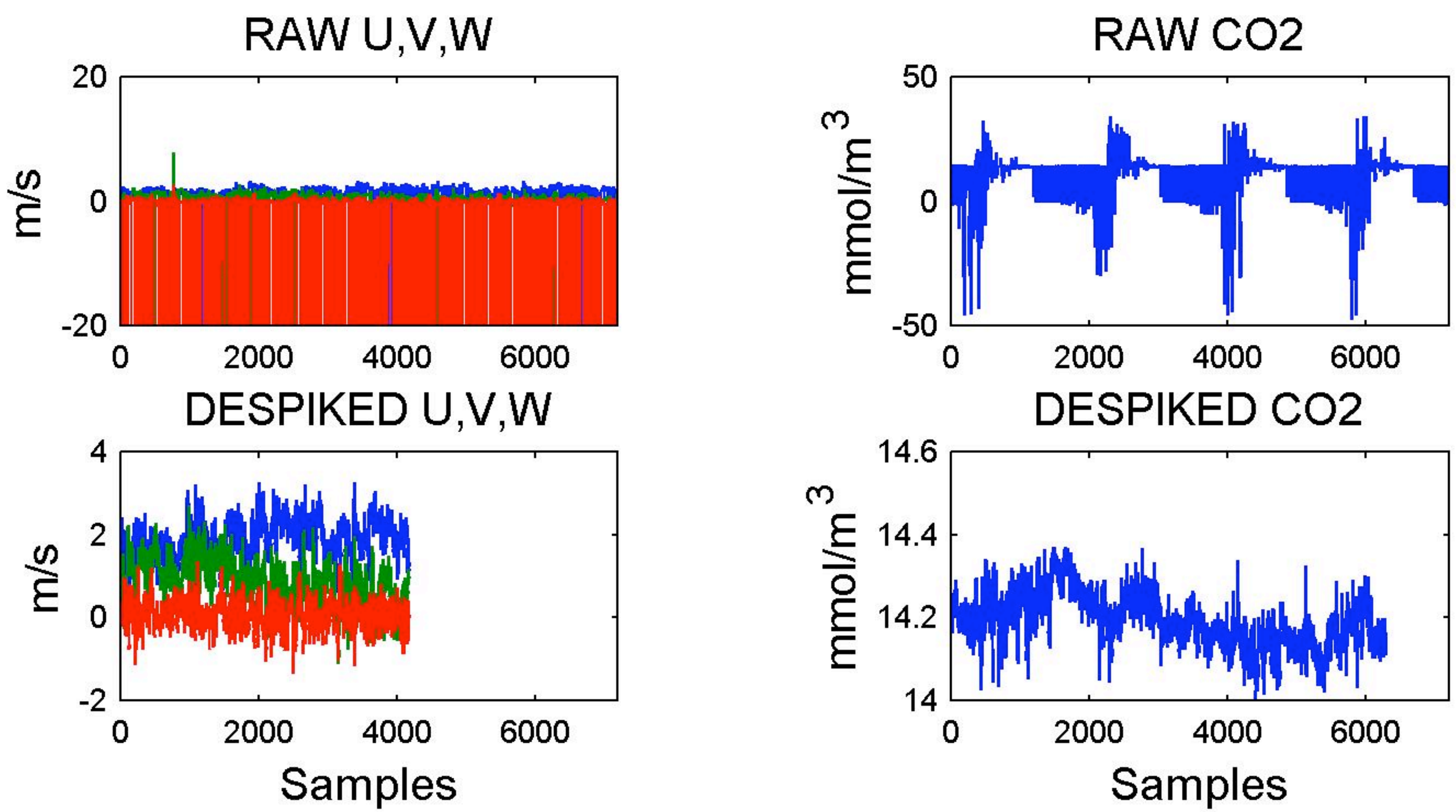


Is rain-induced spiking a problem?

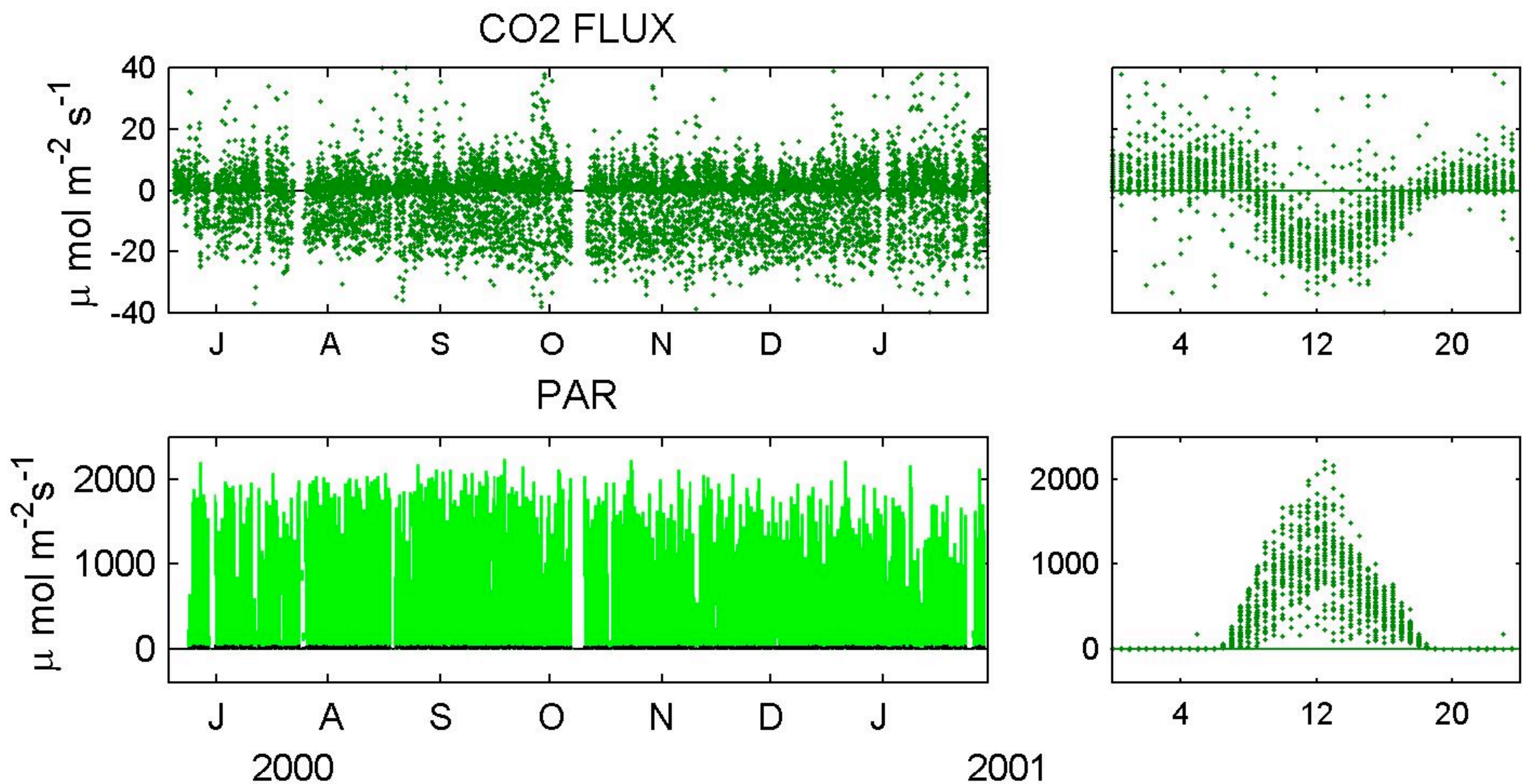


Sonic
Transducers

Moderate Instrument Spiking can be effectively removed by post-processing, allowing for calculation of fluxes



Continuous record of NEE is being assembled.



Annual Carbon Balance. We are using two indepe

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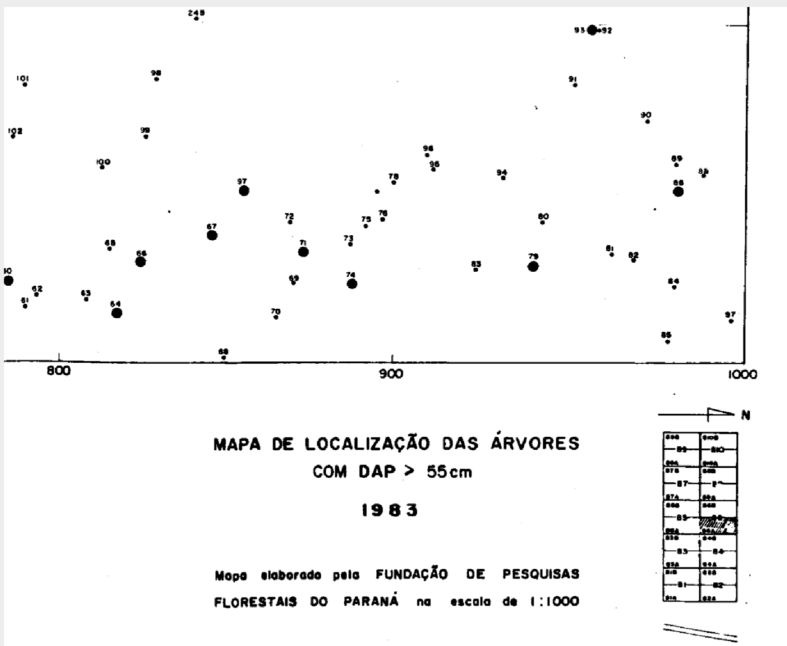
Ground based inventories

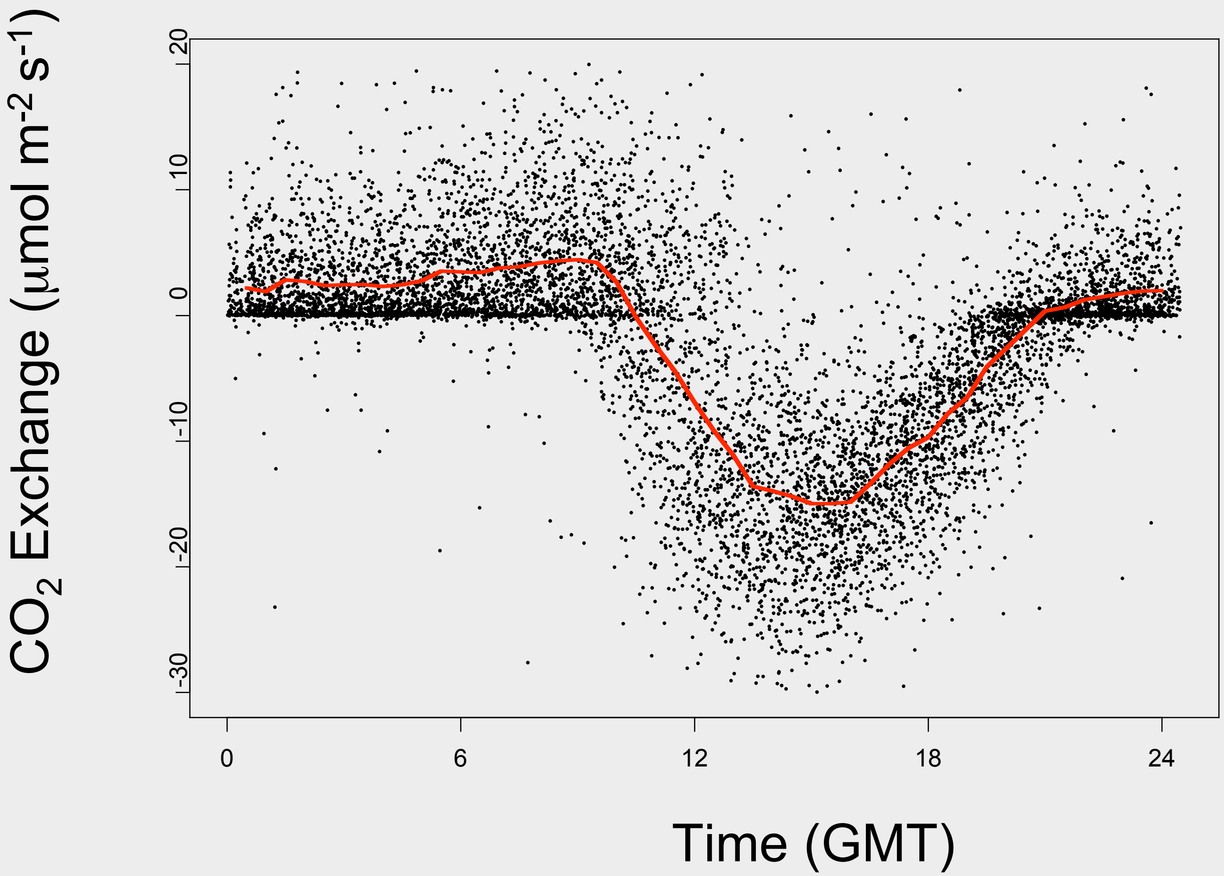
- The forest at km83 was inventoried in the mid 1980s and again in 2000.
- The difference between inventories indicates forest growth, with an uncertainty due to possible methodological differences.
- Geochemical analyses in other forests provides a bound on the change in soil carbon (S. Trumbore).



1983 Tree biomass	**105 tC ha^{-1}**
2000 Tree biomass	**106 tC ha^{-1}**
Net wood increment	**0 +- 1 tC ha^{-1}**
Probable Δ soil C	**0 +- 0.5 tC ha^{-1}**
Annual C balance	**0 +- 1.5 tC ha^{-1}**

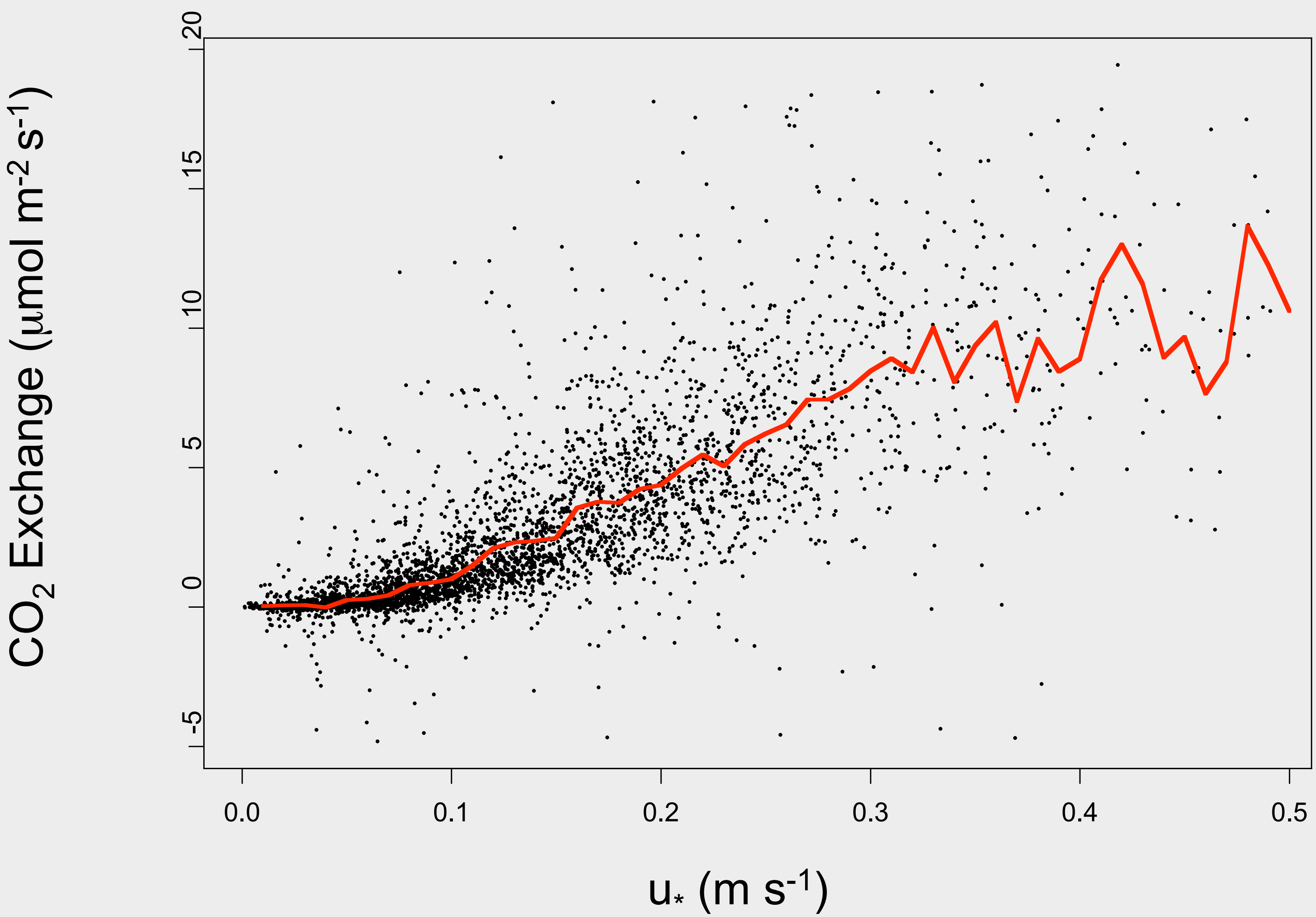
Annualized tower measurements

- NEP was calculated by averaging the flux measurements across time of day and summing all hours.
- The annualized flux using all the nocturnal data was -9.3 tC ha^{-1} yr^{-1}.



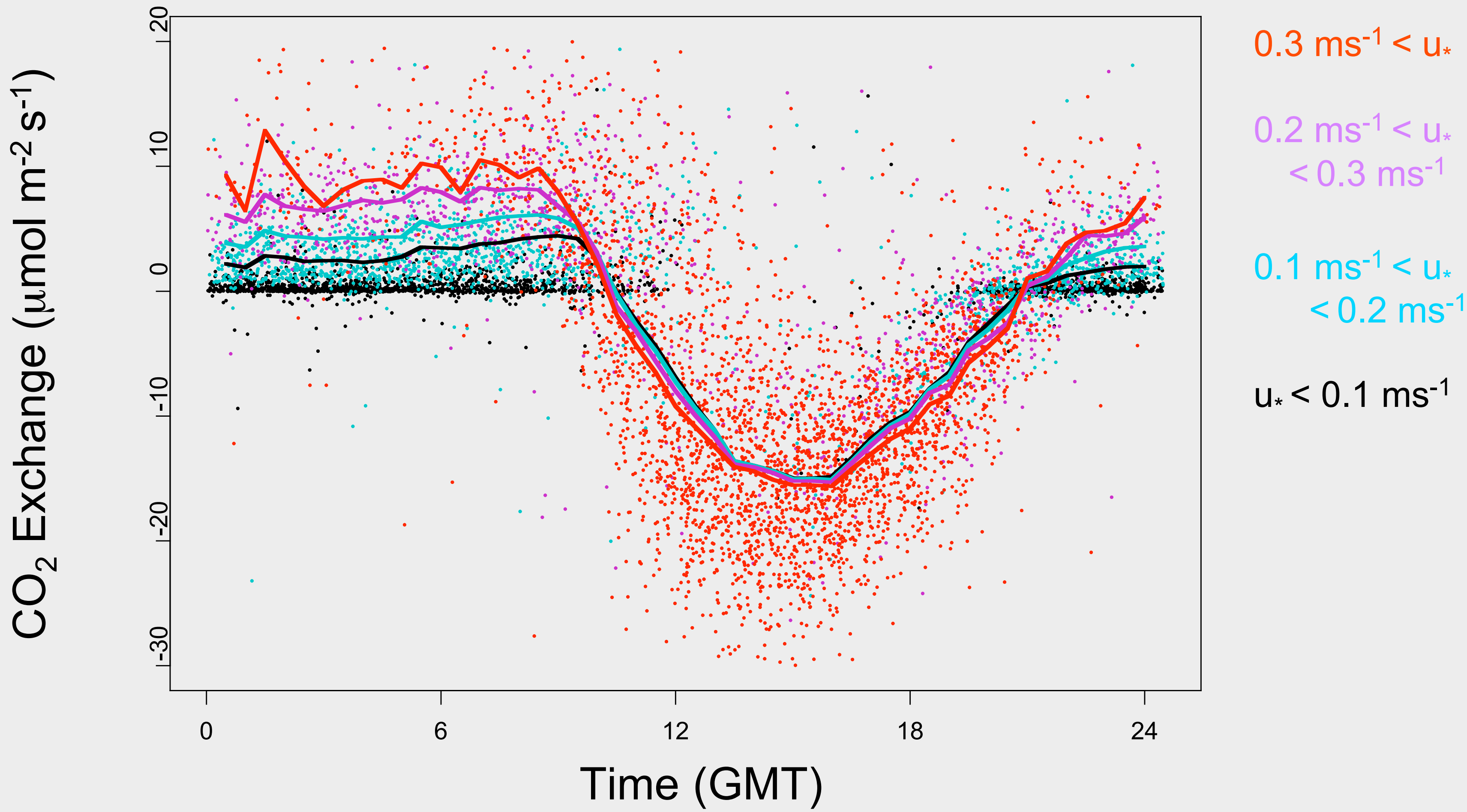
Effect of calm nights

- The annualized flux calculated with all the data likely overestimates C uptake since transport mechanisms during calm periods may remove CO_2 by routes that are not included in the covariance (e.g., drainage).



Recalculated flux using just windy periods

- The annualized efflux can be recalculated only considering periods windy periods.



Effect of calm nights on annualized CO^2 Flux:(June 2000 - Feb 2001)Th

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Why is annualized flux at km 83 so uncertain?

- This is a surprisingly large uncertainty, especially compared to the uncertainties reported for previous tower measurements. At the BOREAS Northern Old Black Spruce Site (NOBS) Goulden et al. reported an uncertainty of only +- 0.5 tC ha^{-1} yr^{-1}.

- The uncertainty at both NOBS and km83 is driven by the correction for calm nights. In both cases the uncertainty in annual NEP was calculated as half of this correction.

- The magnitude of this correction differs greatly between sites. The correction at NOBS was less than 1 tC ha^{-1} yr^{-1} whereas the correction at km83 was 8 tC ha^{-1} yr^{-1}. The uncertainty in NEP at km83 is therefore almost an order of magnitude greater than that at NOBS.

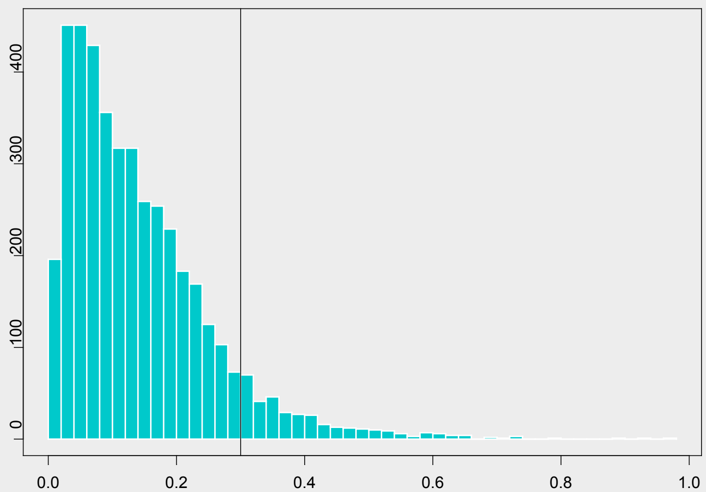
Why is the correction for calm nights so much at km83 ?

The annual calm night correction is a function of three things:

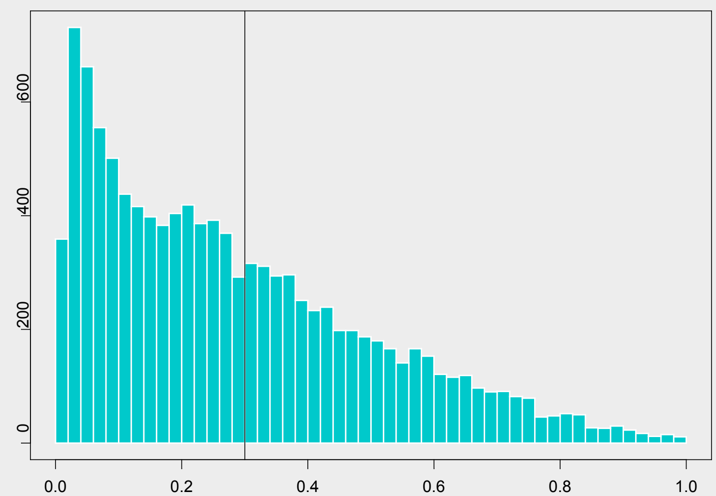
	Nocturnal hours with significant respiration ($T>0^oC$) (all hr yr^{-1})	X	Fraction of nocturnal hours with low wind ($u^*<0.3ms^{-1}$) (calm hr all hr^{-1})	X	Difference in CO_2 efflux high vs low wind (kg ha^{-1} hr^{-1})	=	Annual Correction (kg ha^{-1} yr^{-1})
NOBS	1400		0.54		0.5		400
km83	4000		0.92		2.5		9000

Most nights at km 83 are calm

km 83



NOBS



Incidence of nocturnal u*

Where does this leave us?

- The NEP base on inventories was 0+-1.5 tC ha^{-1}
  The NEP base on the tower was -1+-4 tC ha^{-1}

- We need to learn more about nocturnal CO_2 efflux.

- Tower data sets are rich. Hopefully analyses of these data will emphasize what towers do well (daytime exchange) rather than what towers do poorly.

- Our experimental design focuses on the **relative** carbon balance of the site before and after the cut. We are concerned about how the rates of daytime uptake and nocturnal efflux are changed by logging. Long-term precision is critical for our study; the absolute accuracy of NEP is less important.