MEASURING THE EFFECT OF TROPICAL LOGGING ON FOREST-ATMOSPHERE EXCHANGE

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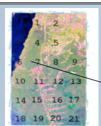
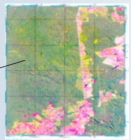
OVERVIEW

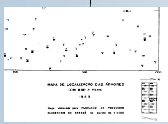
- Selective logging may involve cutting only a small fraction of the trees (e.g., less than 5 percent); however, collateral damage caused mainly by vines that adjoin adjacent crowns can reduce leaf area by as much as 30 percent.
- We aim to quantify the effects of selective logging on the energy and trace gas exchange of a primary tropical forest, using continuous, long-term eddy covariance measurements in a primary tropical forest (Tapajos National Forest, Para, Brazil, canopy height 35-40 meters) scheduled to be logged in August 2001. Eddy flux measurements began in June 2000, and are to continue several years following logging. A second eddy flux tower 16 km to the north in primary forest that will not be logged provides an experimental control.
- Intensive ground-based measurements have been established in a 600 m by 300 m permanent grid around the flux tower, including above-ground biomass, short-term wood increment, LAI, and litter fall.
- The reliability of eddy flux measurements during calm nights is uncertain. A comparison of year 2000 biomass inventory at this site with a detailed 1984 inventory provides an independent measure of the forest's recent carbon history, and a check on eddy flux results.



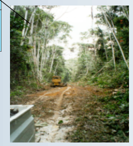
SATELLITE DETAILS



LOGGING PLAN MAP



PART OF 1984 STEM MAP



ROAD CLEARING

WHAT DOES GROUND-BASED SAMPLING TELL US?

- Long-term net wood increment - comparison between year 2000 inventory and detailed 1984 inventory of trees > 55 cm allows calculation of net wood increment over 16 years (with possible uncertainty due to methodological differences).
  - 1983 tree biomass was **105 tC ha^{-1}**
  - 2000 tree biomass was **106 tC ha^{-1}**
  - Net wood increment is then **0 +- 1 tC ha^{-1}yr^{-1}**
- Geochemical analyses (Trumbore) in tropical forests indicates soil carbon limit of
  - Probable Delta soil C is **0 +- 0.5 tC ha^{-1}yr^{-1}.**
- Independent of eddy-correlation, we therefore estimate the annual C balance to be

0 +- 1.5 tC ha^{-1}yr^{-1}

EXPERIMENTAL DESIGN AND DATA SET

CONTINUOUS, AUTOMATED MEASUREMENTS

TOWER TOP (64 m)

Momentum Flux and Heat Flux	Campbell CSAT3
CO_2/H_2O Flux (1)	LI-7500 (Open Path)
CO_2/H_2O Flux (2)	LI-7000 (Closed Path)
PAR (up/down)	LiCor
Solar Radiation	Kipp & Zonen
Net Radiation	REBS Q*7
Rain	Tipping Bucket

PROFILE

CO_2/H_2O	0.1m-64m	LI-7000 (12 hts)
Wind	40m-64m	Cup Anemometers (3 hts)
Temperature	2m-64m	Thermistors, (4 hts)

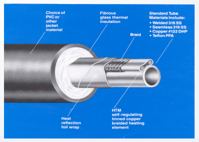
2.5m SOIL PIT

Temperature	-0.05m-2.5m	Thermocouples
Moisture	-0.05m-2.5m	Water Content Reflectometers
Soil Heat Flux		Rebs

EDDY FLUX: Instruments mounted at 64 meters, facing east, the most frequent wind direction.

ELEVATOR: Tower top instruments ride a carriage controlled by electric winch.

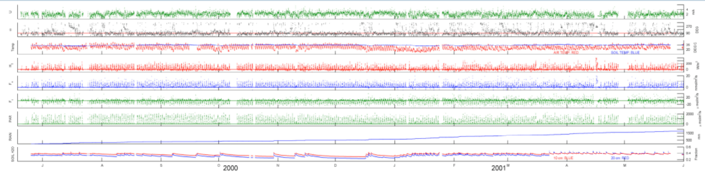
HEATED TUBING: Air is drawn to closed path IRGA through an 80m heated tubing bundle at 65 C to prevent water vapor retention.



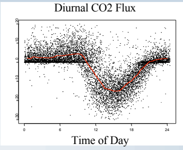
SOIL PIT: A 2.5m deep soil pit records continuous soil moisture and temperature profiles at 20 levels.

INSTRUMENT RACK: Closed-Path IRGAS, flow control and calibration equipment, power distribution and data acquisition computers are housed in air-conditioned shack at base of tower.

DATA: We have over 1 year of data, with few minor gaps.



WHAT DO THE EDDY FLUXES TELLUS?



Tower CO2 flux measurements can be annualized by summing all of the 30-minute eddy flux measurements of CO_2 exchange over the course of a year. From these measurements, the annualized flux using **all** the data was

-9.3 tC ha^{-1} yr^{-1}

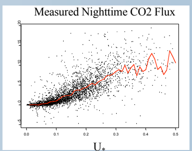
compared with the 16 year woody biomass increment based estimate of **0 +- 1.5 tC ha^{-1}!!**

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).

In some studies, the approach to this measurement problem has been to consider only measurements when turbulent mixing was active, expressed in terms of a u_* threshold. In the plot at the right, this would be the value of u_* at which the CO2 efflux levels off.

But, the rainforest is **extremely calm** at night, such that the high u_* events used to establish a turbulent mixing threshold are few and the statistics are poor. This works to decrease the objectivity of the data analysis.



SENSITIVITY OF ANNUALIZED FLUX TO u_* THRESHOLD
(June 2000 - Feb 2001)

Threshold	Annualized Flux
all nights	-9.3 tC ha^{-1} yr^{-1}
u_* > 0.1ms^{-1}	-6.4 tC ha^{-1} yr^{-1}
u_* > 0.2ms^{-1}	-3.1 tC ha^{-1} yr^{-1}
u_* > 0.3ms^{-1}	-1.3 tC ha^{-1} yr^{-1}

PRELIMINARY CONCLUSION

Using a threshold of u_* > 0.3 ms^{-1}, **our current best estimate of NEP based on the eddy flux data is**

-1 +- 4 tC ha^{-1} y^{-1}

This annualized flux represents an observed net movement of 9 tC ha^{-1} y^{-1} past our sensors minus a correction of 8 tC ha^{-1} y^{-1}. The selection of a threshold is subjective and potentially controversial. We therefore attach an uncertainty equal to 50% of this correction.

NEXT STEPS

We will continue to look into ways to effectively treat the nighttime data. This will include collaboration with the other tower flux groups working in the Amazon basin. One caveat to mention is that the nighttime problems do not concern the **precision** of the eddy flux measurement, but the **accuracy** of long-time averages. Fortunately, our primary goal in the LBA project (logging effects on fluxes) relies upon measurement precision, and not the absolute accuracy.

After logging, 15 automated, closed, soil respiration chambers will be installed. We expect these data will help us to understand the complex nighttime processes in the forest. Also, a second 65 meter tower will be installed at the logged forest sight, within ~200m of the original tower, and instrumented to assess the effect of gaps caused by the logging.