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EFFECTS OF LAND-USE CHANGE ON LOCAL ENERGY, WATER AND CARBON BALANCES IN AN AMAZONIAN PASTURE

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1. Introduction:

The interest of the impact of deforestation on climate in Amazon has been shown in the ABRACOS project (Gash et al., 1996). The Large scale Biosphere-Atmosphere experiment in Amazonia (LBA) is a continuing effort to understand the effects of deforestation with a more continuous data set. This study presents the preliminary results of turbulent flux measurements of carbon, heat, and moisture using the eddy correlation system over a pasture site in the Eastern Amazon region. The practicing of burning fields and changing landscape from a pasture to crop fields is also addressed.

2. Methodology:

Site location

The three LBA sites (Old growth forest, selective logging site, and pasture) in Santarem region are located in the Belterra city, at the confluence of the Tapajos and Amazon rivers. The pasture is about 12 years old, and the tower flux coordinates are 3.01190 S and 54.53652 W. At this site the topography presents a gentle slope from West to East. The principal type of vegetation is *Brachiara brizanta*.

Instruments

A 20 m tower was installed to monitor micrometeorological and trace gases measurements. An eddy covariance system was installed at 8.75 m,composed by a 3D sonic anemometer (SATI/3K), and a CO_2/H_2O gas analyzer (licor 6262). Wind (CATI/2 - 12.25, 5.73, and 3.12 m), temperature and humidity (Vaysala Humitter, CS500, at 6.09, 4.14, 2.20 m), and CO_2 (licor 6262 at 11.81, 5.29, 2.71, and 0.5 m) profiles have also been measured. At the top of the tower (17.76 m) upward and downward solar (Kipp and Zonen, CM11/14) and terrestrial (CG2) radiation is also collected. Soil temperatures (Campbell 108 at 0.10, 0.24, 0.50,1.50, and 2.0 m), soil heat flux (Campbell HFT3 at 0.30 m), and soil moisture (Campbell CS615 at 0.30 m) have also been installed. The site has been collecting data since September 2000.

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All instruments and data acquisition are powered by a solar panel that can provide, at least, continuous 500 W/m^2. Only two hours of the diesel generator was used during the 2000/2001 rainy period. The sonic anemometers and the IRGAs send a serial stream outputs, analog signals are digitalized by a datalogger (Campbell Sci., model 23x). In real time, a linux based computer synchronizes all serial streams, and process the data as well. Turbulent fluxes are calculated from deviations derived from a 30 minute running mean removal. A 3D wind rotation has been applied to the wind components, as well as the webb correction, and a tube attenuation correction.

3. Data Analysis:

Seasonal patterns:

Seasonal changes are presented in figure 1. The rainy season can be characterized by the increase of soil moisture content associated with frequent rainfalls. There is not a presence of seasonal changes in the net radiation. The albedo and PAR-albedo have an opposite pattern thorough the year, this has been observed in other canopies (Moore et al., 1996). Their magnitudes are comparable to the ones found in other pastures (Culf et al., 1996). The CO_2 uptake does not follow the soil moisture content at the beginning of the wet season, but it is "lagged" by 3 months, having its minimum during May. Nocturnal exchange of CO_2 does not present a strong seasonal variation, with the respiration rate about –0.02 mg CO_2/(m^2 s^{-1}).

On November 14, the pasture field was burnt (fig. 2), and after that the soil was plowed. Even though burning is a common practice in pasture fields, this one was part of a change of farming practice, from grazing to a rice and corn plantation. Even though there is not a dramatic change in the sensible and latent heat flux, it can be seen that there is an efflux of CO_2 during daytime. When grass was present, December 2001 to October 2002, the net exchange ecosystem (NEE) is –0.082 mg /(m^2 s^{-1}) and increases to –0.052 mg/(m^2 s^{-1}) if bare period is accounted.

Energy Budget:

Preliminary estimates of seasonal changes in the diurnal surface energy budget and carbon uptake (figure 3 and 4) are encouraging. At daytime there is a good agreement between the eddy correlation system and the net radiation measurements (figure 3). From figure 3, we can rely on our daytime eddy covariance measurements. We have still to understand a serious energy imbalance at nighttime (not shown here). One problem is the lack of the wind during this period for the entire stable boundary layer (Silva et al., 2002). This will not create enough mechanical turbulence that can be detected by the eddy correlation instruments. Also, there are several reports about the fog formation during nighttime. The presence of fog can affects the radiation instruments besides the fact that takes heat due to condensation of water vapor.

CO_2 exchange:

Hourly averaged curves for the several periods show that there is only a noticeable CO_2 flux from the eddy correlation system during the wet season at night (figure 4). During the daytime, there is a more uptake during the wet season. Since there is no detectable turbulence from the eddy correlation system, the assumption that only wind nights must be accounted (Goulden et al., 1996) is not attained. From our entire data set, only 12.5% of the night cases have $u^* > 0.2$ ms^{-1}, where u^* is the friction velocity. However, we note that sufficiently stable conditions occur regularly at this site that there is a morning "flush" of CO_2, a phenomenon previously thought to be most common in forest canopies.

4. Summary.

The wet season lasts from January to June and the dry season from July to December. The albedo and PAR-albedo curves have opposite behavior throughout the year. The maximum uptake occurs during May, and it seems that the uptake is delayed after the start of the rainy season. The NEE is about -0.083 mg CO_2 / ($m^{-2}s^{-1}$) from December, 2000 to September, 2001. After the pasture field was burnt and plowed, there is daytime efflux of efflux, increasing the NEE to -0.052 mg CO_2 ($m^{-2}s^{-1}$). The sum of sensible and latent heat flux, and the ground heat flux are within 92% of the net radiation during daytime. Our eddy correlation system seems not being able to measure fluxes. One alternative is using the accumulation method (Silva et al., 2002). A "morning flush" of CO_2, a common phenomenon over forest canopies, is also observed at this pasture site.

For future studies, we are going to compare the radon and the CO_2/H_2O profiles to determine the importance of the soil diffusivity. Also, we intend to measure the crop biomass to do the carbon budget.

5. Acknowledgements:

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6. References:

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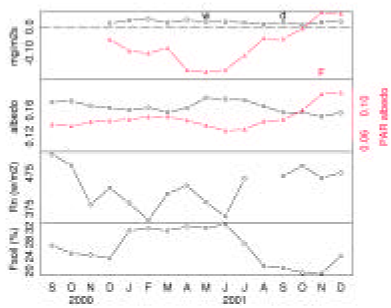


Figure 1: Monthly averaged values for (top) CO_2 uptake (triangles), and respiration (circles), (second panel), circles are albedo (Sup/Sdw), and triangles are PAR albedo (PARup/PARdw), (3rd panel), Net radiation (Rn=Sdw+Sup+Ldw+Lup), (4th panel), soil moisture content (Fsoil). "w" and "d", "F" correspond to the periods of wet, dry, and bare periods for the next graphs. Notice the increase of Fsoil during January to June 2001, associated with the rainy season. The CO_2 uptake minimum only occurred on May.

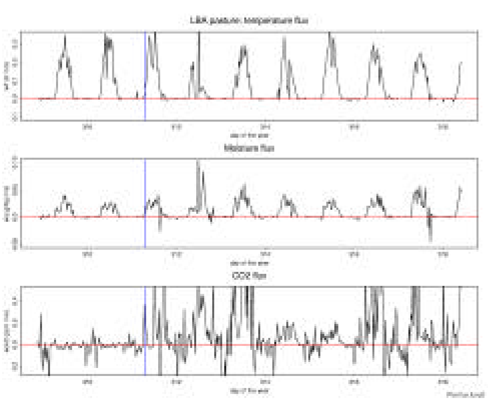


Figure 2: time series of heat, moisture, and CO_2 fluxes over the pasture site. The vertical line represents day November 14,2001. On this day the pasture field was burnt, and the soil was plowed. After this day, there is an efflux of CO_2 during daytime.

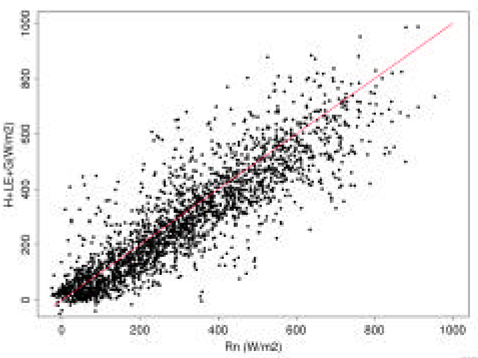
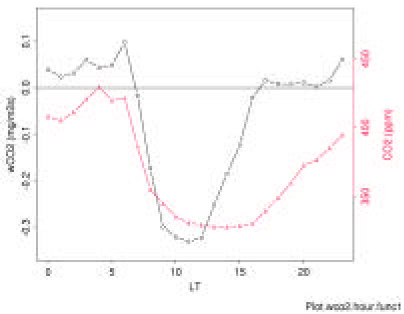
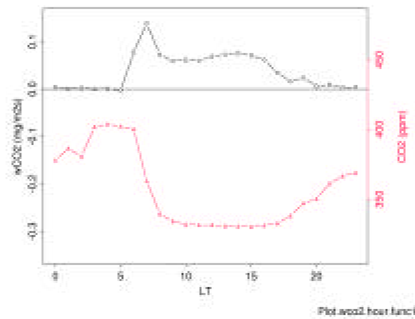


Figure 3: Scatter plot of the net radiation (Rn=Sdw+Sup+Ldw+Lup) versus the sum of the Sensible Heat Flux (H), Latent Heat Flux (LE), and the Ground Heat Flux (G) during daytime (Sdw > 10 W/m^2). The red line is the 1:1 line. The slope of the fitted line without intercept is 0.92 with r^2=0.85.

a)



c)



b)

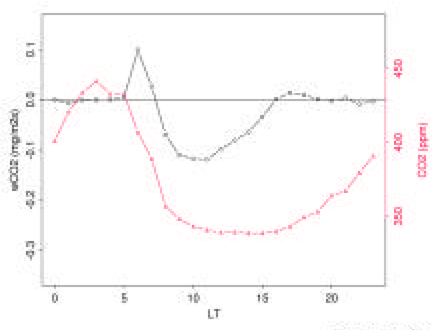


Figure 4: Hourly averages of CO2 concentration (triangles) and CO2 fluxes (wCO2 in circles) for (a) wet, (b) dry, (c) and bare periods.