A Preliminary Evaluation of Concentrations of Trace Gases in a Clay-Rich Yellow Latosol in the Tapajos National Forest

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INTRODUCTION

The soils of the humid tropics are a source and a sink for CH4 (Keller et al., 1990), but they represent the large global source of N2O (Keller et al., 1986; Bouwman & Taylor, 1996). Accurate measurements of CO2 emissions from soil are important for understanding the C cycle in forest systems. Soil-atmosphere fluxes of CO2, N2O, and CH4 depend upon the production and consumption of these gases and on gas transport. Gas transport may occur by gas diffusion and mass flow. When pressure differences are small, gas diffusion dominates over mass flow.

The objective of this study was to determine the concentration of greenhouse gases (CO2, N2O and CH4), in the dry and wet season, in depth, in Yellow Latosol and to verify the relationship between the soil moisture and the trace gases concentrations in the Tapajós National Forest - TNF. In the future, we intend to use this information and data on soil diffusivity to model the diffusive exchange of CO2, N2O and CH4 between the soil and the atmosphere.

METHODOLOGY

This study was conducted from August 2003 through August 2005, in the Tapajos National Forest, located in east-central Amazonian (2.89S, 54.95 W). This area receives 600–3000mm (Davidson et al., 2004) of rain each year, with a mean of 2000mm, most of which falls during the wet season from January to June. The soils are highly weathered, deep, well drained, kaolinitics, Yellow Latosol in the Brazilian soil classification system (Oxisols in the US system). The soils are acid (pH ~4.5) and they lack hard pans or lateritic concretions.

Stainless steel gas sampling tubes (3mm diameter) were installed in the walls of the three soil pits at depths of 0.05, 0.15, 0.30, 0.50, 1.0 and 2.0 m to collect soil trace gases (CO2, N2O, CH4). The tubes were placed into 0.5m long horizontal auger holes that were then backfilled. Quadruplicate gas samples of 20 ml were withdrawn from each tube through a septum and fitting on the exposed end in the soil pit using a nylon syringe. The N2O and CH4 concentrations were analyzed by ECD and FID gas chromatography. The CO2 concentrations in the soil profiles were sufficiently high that quantification could be achieved with the ECD despite its relatively poor sensitivity to CO2 (Fig. 1). For moisture measurements, we used a commercially available frequency domain reflectometery sensor (Campbell Scientific, CS615 version 8221-07). Soil moisture content was calculated based on gravimetric calibration curves that we established using undisturbed soil samples from the study site.

RESULTS

In the Figure 1A and 1B, we show the concentrations of the three gases during wet and dry seasons. N2O and CO2 concentrations are higher in the wet season than in the dry season in all depths. For CH4 the pattern is different. In the middle depths, CH4 has a higher concentration in the wet season than in the dry season.

Figure 1C, shows that at 30cm, the soil has higher volumetric water content than at other depths. This occurs principally because at these intermediate depths, the soil has higher bulk density and a higher proportion of micropores that hold water strongly in the soil matrix. Throughout the study period, the soil moisture was high with 40-45% of water filled pore space.

N2O and CO2 concentrations correlated with soil moisture especially at shallow depths (<30 cm) in the wet season but not in the dry season (Fig. 2; Table 1). In contrast, we find no correlation between CH4 concentration and soil moisture. Gas concentrations and soil moisture are not correlated in the deeper soil.

An analysis of the distribution of CH4 concentration at all depths data shows that during the wet season 59% of the samples are higher than atmospheric concentration (~ 2.0ppm), and during dry season this figure is 39% (Fig. 3). Methane concentrations above 2 ppm are correlated with soil moisture during the dry season but not during the wet season (Fig. 4)

DISCUSSION & CONCLUSION

Soil temperature and water content directly affect production and consumption of greenhouse gases through their effects on microorganism and root activity (Howard and Howard, 1993; Zak et al., 1999). Soil gas concentration in the soil is further moderated by transport. During the dry season macro-pores are mainly air-filled so relations between gas concentrations and soil moisture content is generally weak. However, during the wet season, we see a correlation between gas concentrations and moisture content suggesting that diffusive transport of gases out of the soil is limited by water filled pore space during this time of year.

The role of the distribution of soil porosity is seen clearly in the concentrations of CH4 and N2O. While CO2, a gas formed mainly by aerobic properties increases monotonically with depth, N2O and CH4 peak between 30and 50 cm. This zone has high bulk density and considerable microporosity that is permanently moist. It seems likely that there is always some anaerobic activity in this zone although that is minimized in the dry season.

The concentrations of CH4 are highly variable. There is a bimodal distribution of concentrations suggesting that the soil switches between states of CH4 consumption and production. Consumption dominates during the dry season but production dominates during the wet season.

The gas concentration raised according depth to N2O and CO2; to CH4 this do not happen. The gases concentrations show seasonal variation to all gases studied. The soil moisture at our site at Tapajos National Forest is high same in the dry season (40-45% wfps).

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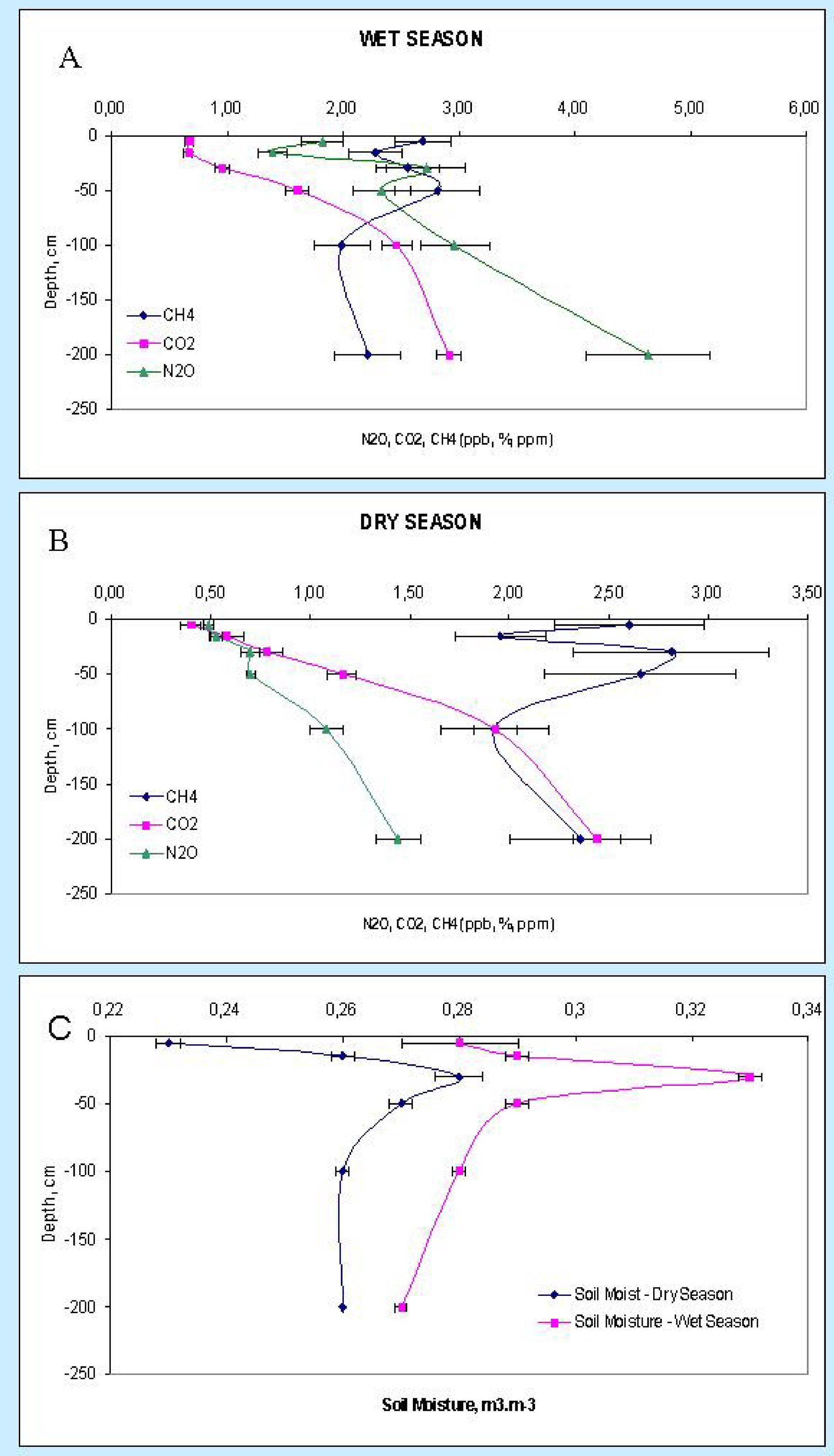

Figure 1. Trace gas concentration in wet (A) and dry (B) season in all depths Soil moisture (C) in all depths at wet and dry season.

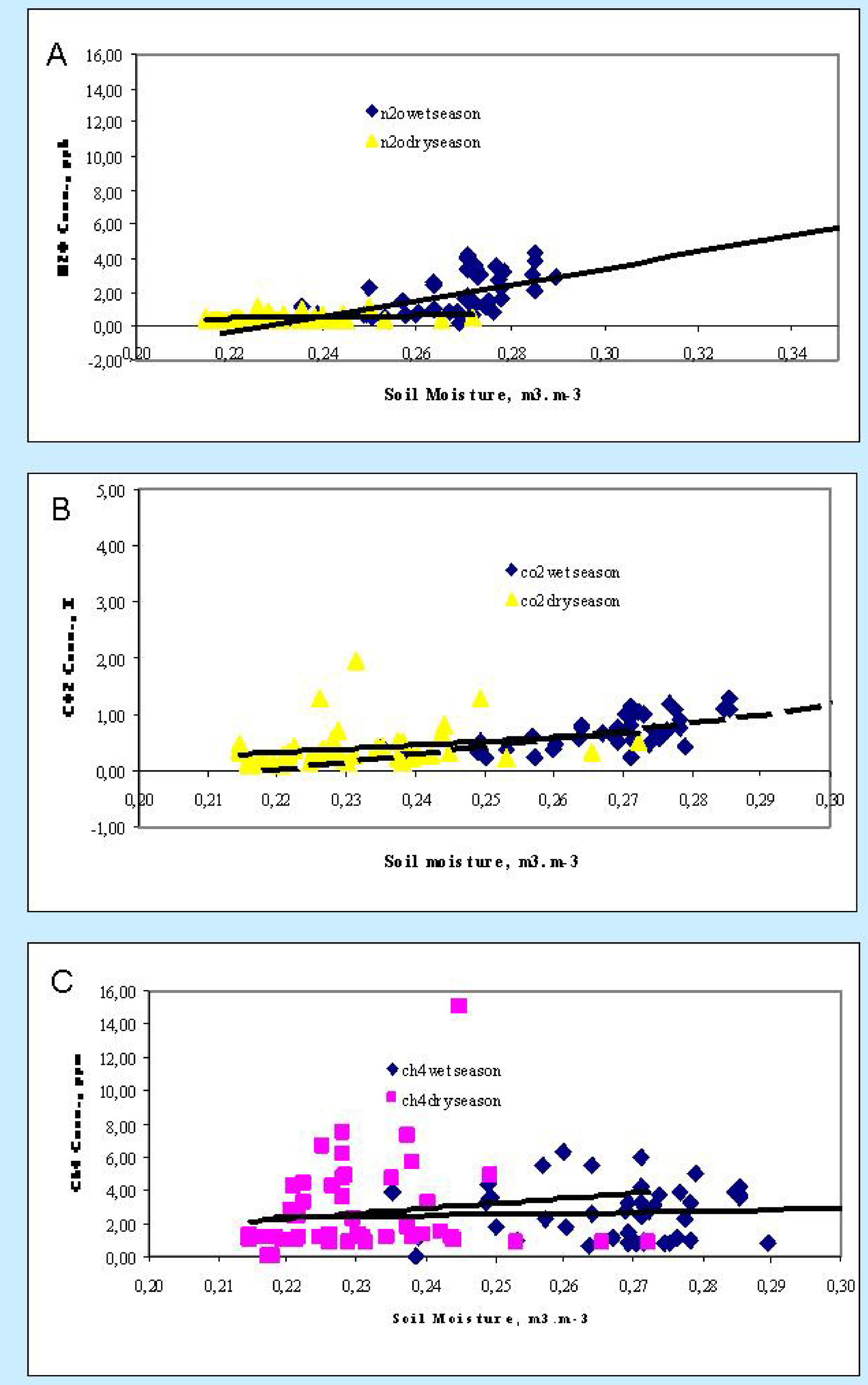

Figure 2. The relations between N_2O (A), CO_2 (B) and CH_4 (C) concentration with soil moisture in wet and dry season at 5cm depth.

	CO_2		N_2O		CH_4	
DEPTH (cm)	WET	DRY	WET	DRY	WET	DRY
5	0,33	0,08	0,48	0,06	0,002	0,02
15	0,14	0,00005	0,35	0,001	0,009	0,04
30	0,11	0,0007	0,11	0,28	0,04	0,01
50	0,08	0,05	0,03	0,01	0,03	0,01
100	0,01	0,02	0,01	0,0001	0,0002	0,004
200	0,02	0,13	0,01	0,03	0,0009	0,22

Table 1. Coefficients (r^2) among soil gases and soil moisture, in dry and wet season, by depth .

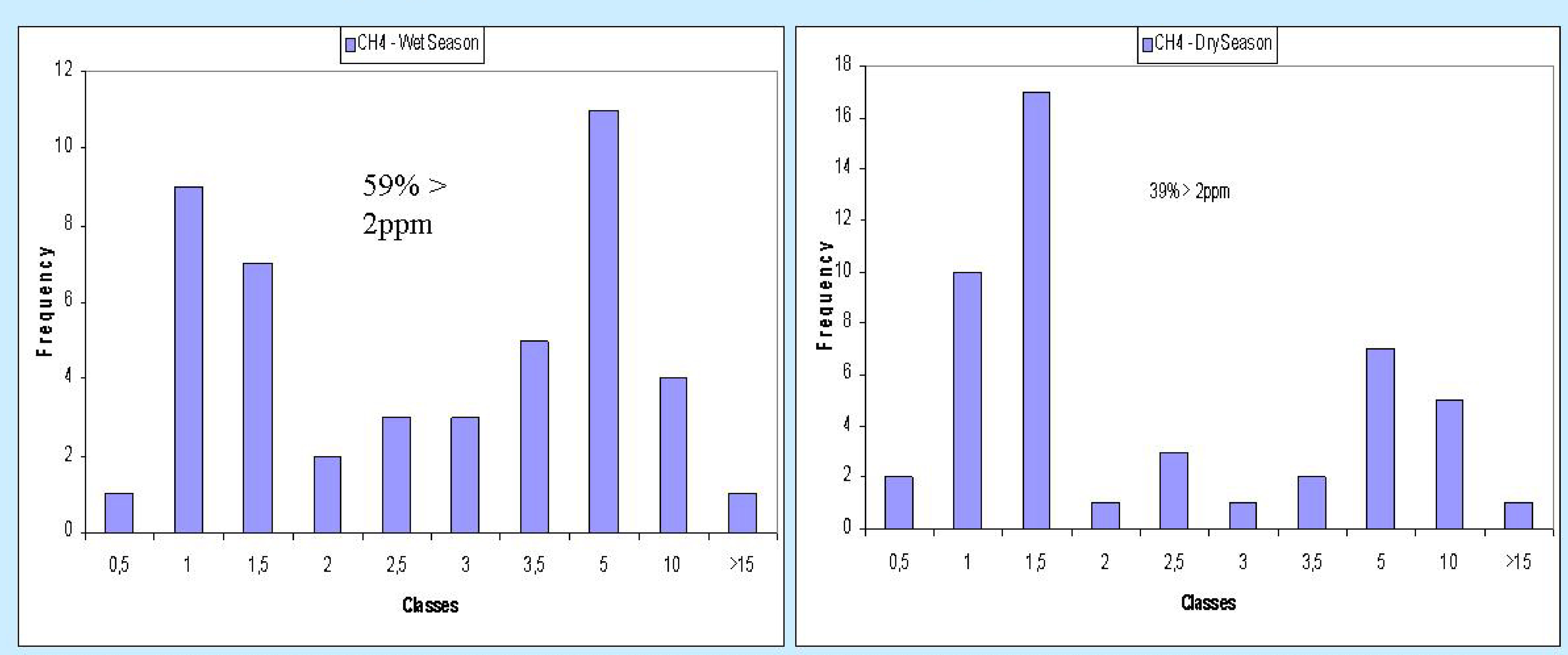

Figure 3. Frequency distribution of CH4 concentration in the wet and dry seasons. Note that there are many values above atmospheric background concentration (~2 ppm).

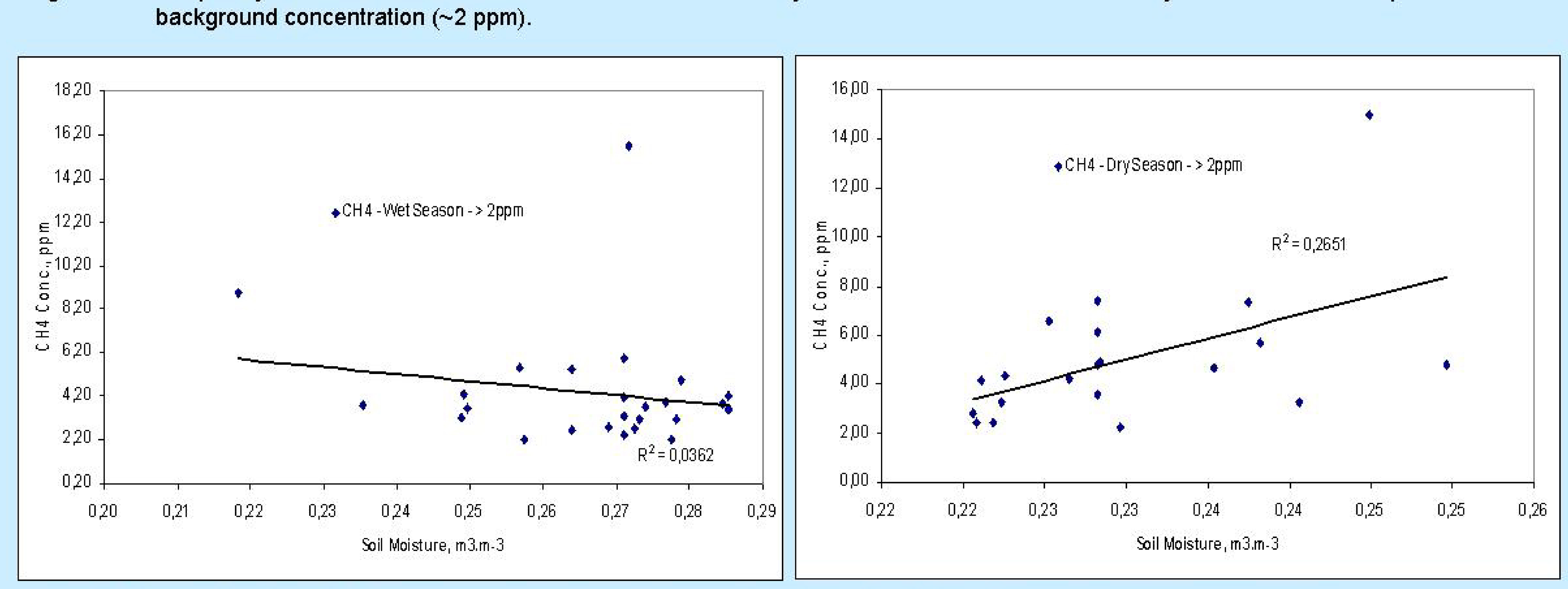

Figure 4. Relations between CH4 concentration and soil moisture using values above 2ppm. Dry season has higher correlations.