Large CH_4 fluxes and seasonality from eastern and central Amazonia

John B. Miller[1,2], Luciana Vanni Gatti[3], Monica T. S. d'Amelio Felipe[3]

1. NOAA Earth System Research Laboratory, Boulder, CO 2. CIRES, U. Colorado, Boulder 3. Instituto de Pesquisas Energeticas e Nucleares, Sao Paulo

Contact: john.b.miller@noaa.gov

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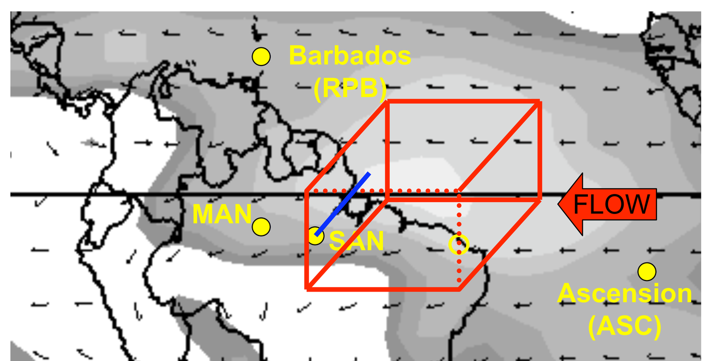
Introduction

- Recent findings in methane at a wide range of scales
  - •Laboratory measurements: show direct emissions from vegetation
  - •Field measurements: from Amazônia (and Venezuela) show methane emission from upland forests
  - •Satellite measurements: SCIAMACHY shows high methane over South America
- Here we use vertical profiles of methane mixing ratio above Santarem and Manaus, sampled aboard light aircraft, in order to derive regional scale fluxes for central and eastern Amazonia. To our knowledge, these fluxes are the first large-scale top-down estimates of Amazonian methane emissions.

Flux Calculation Method

1. A very large flux chamber

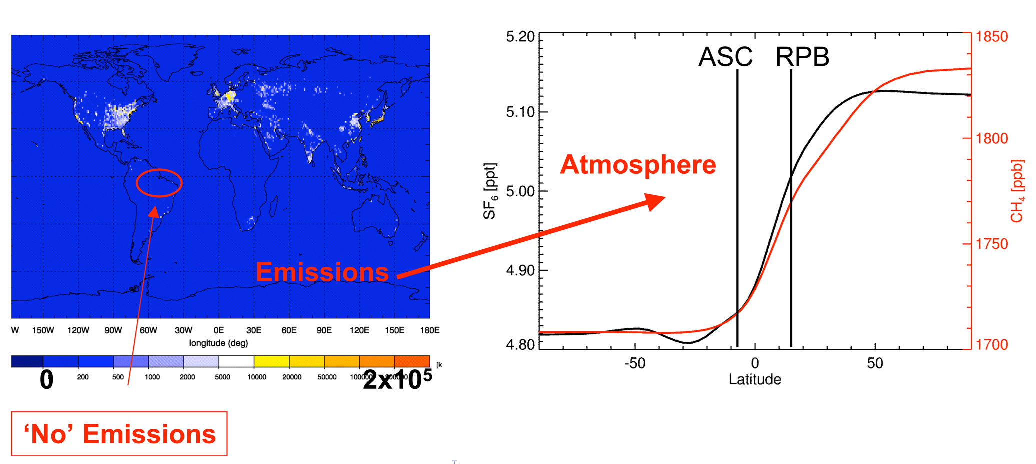


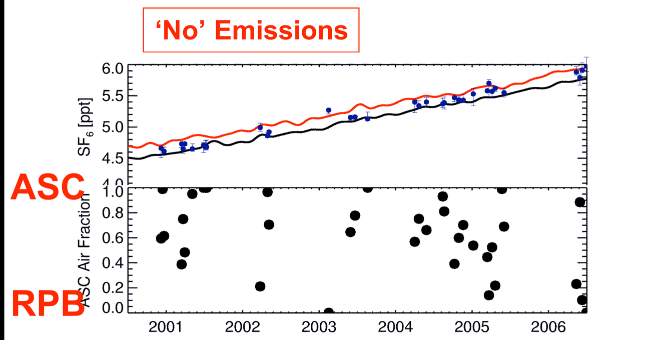
$$F_{CH_4} = \frac{\int_{z=0}^{4km}([CH_4]_{site} - [CH_4]_{bg})dz}{time} \quad (1)$$

Confluence of the Tapajos and Amazon rivers from 12 km. April, 2007.

1. We take advantage of persistent zonal trade wind flow from the Atlantic into the Amazon basin. Thus, aircraft vertical profile measurements of CH_4 represent the cummulative CH_4 flux between the coast and our sites: Santarem (SAN) and Manaus (MAN). In this way these are like chamber measurements, albeit with a leaky top.
2. We know the vertical integral of CH_4 at our measurement sites from direct measurement, but for the upwind CH_4 mixing ratio, we use an indirect technique based on the weighted average of the CH_4 mixing ratio at NOAA/ESRL Atlantic Ocean sites, RPB and ASC.

2. Determining the background



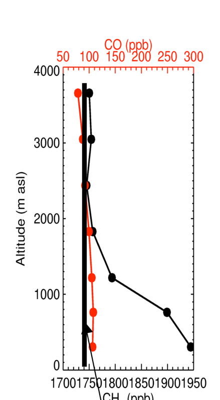


$$ASC_{site} = 1 - RPB_{site} = \frac{SF_{6site} - SF_{6RPB}}{SF_{6ASC} - SF_{6RPB}} \quad (2)$$

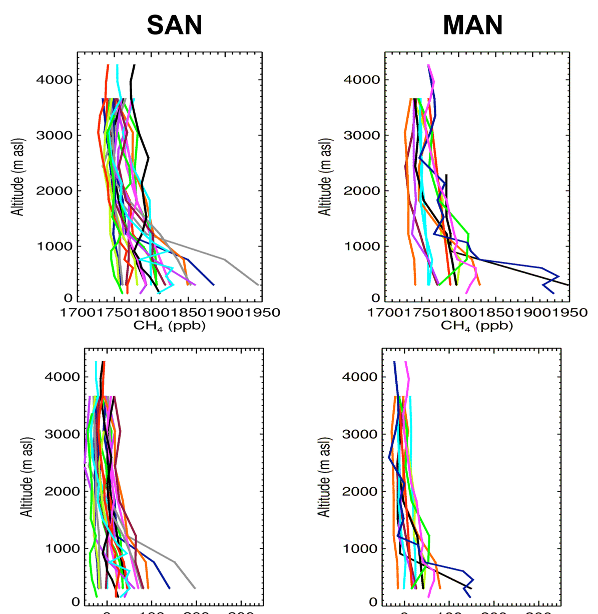
$$X_{bg} = ASC_{SAN} \times X_{ASC} + RPB_{SAN} \times X_{RPB} \quad (3)$$

1. We take advantage of the fact that CH_4 and SF_6 have very similar merdional gradients and that SF_6 has no local sources in Amazonia (see emissions map - right). The only reason for SF_6 variations in our site measurements should be related to the northerly or southerly origin of the air masses.
2. Thus, higher SF_6 indicates more northerly air and lower SF_6 more southerly air. The elevation or depletion of SF_6 can be translated to the background of CH_4 (or any other long-lived species) according to eqs. 2 and 3, where the CH_4 background (Xbg) is a weighted average of the CH_4 at ASC and RPB. We assume that all profiles start out as uniform, and are modified only by fluxes between the coast and the sites.

3. Calculating Flux



Weighted averages of ASC and RPB

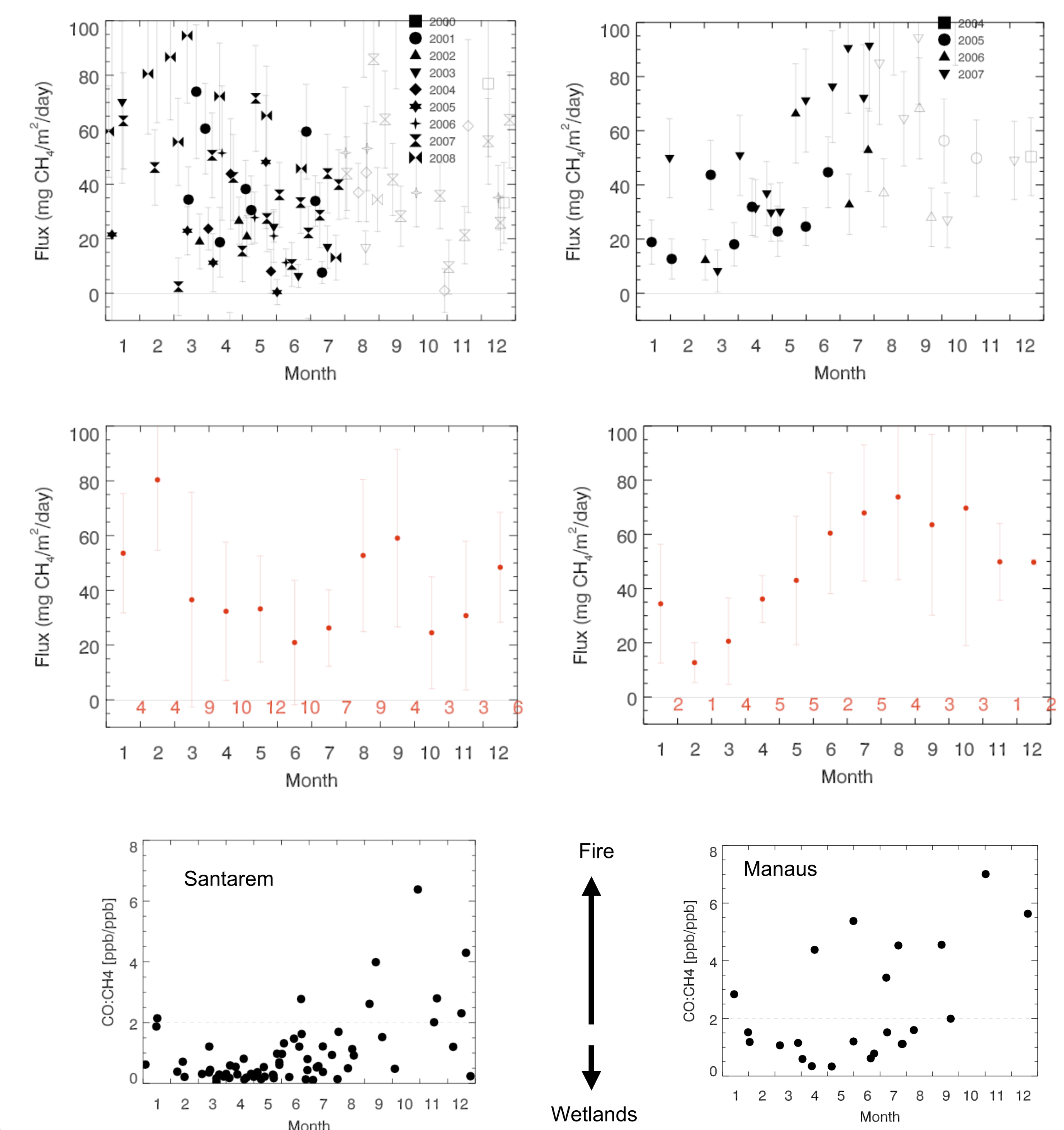


1. In order to calculate flux we subtract the background calculated in step 2 from the observed a vertical profile as shown in Fig. 3a,b,c.
2. These profiles are then vertically integrated, and the flux is then calculated by dividing the integral by an estimated time the air column has been over land, (eq. 1)
3. Based on clmatological wind speeds, we estimate 'time' as 2 days for SAN and 3 days for MAN. Analysis of back trajectories shows that these are reasonable averages, but we assign a 50% uncertainty to these nominal values in our error calculations.

Results

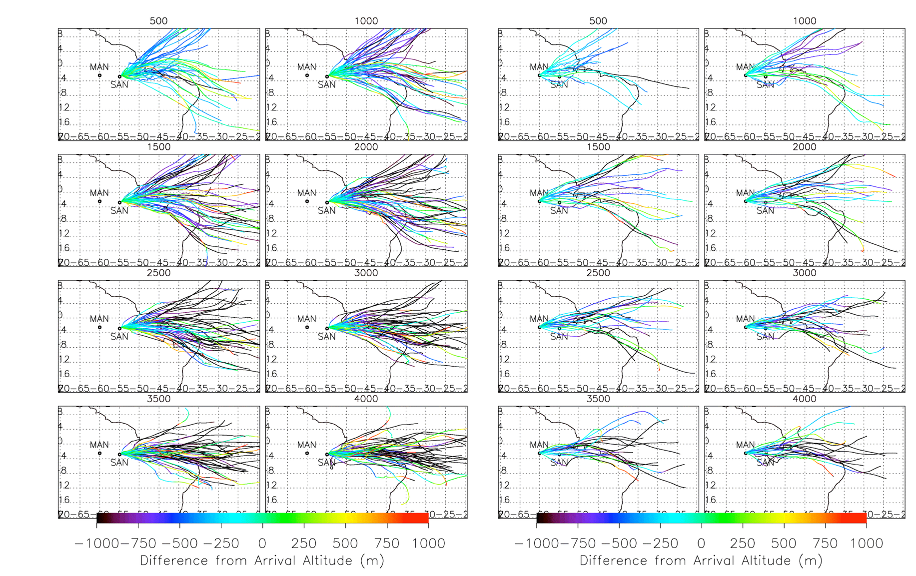
Fluxes and Ratios

SAN MAN

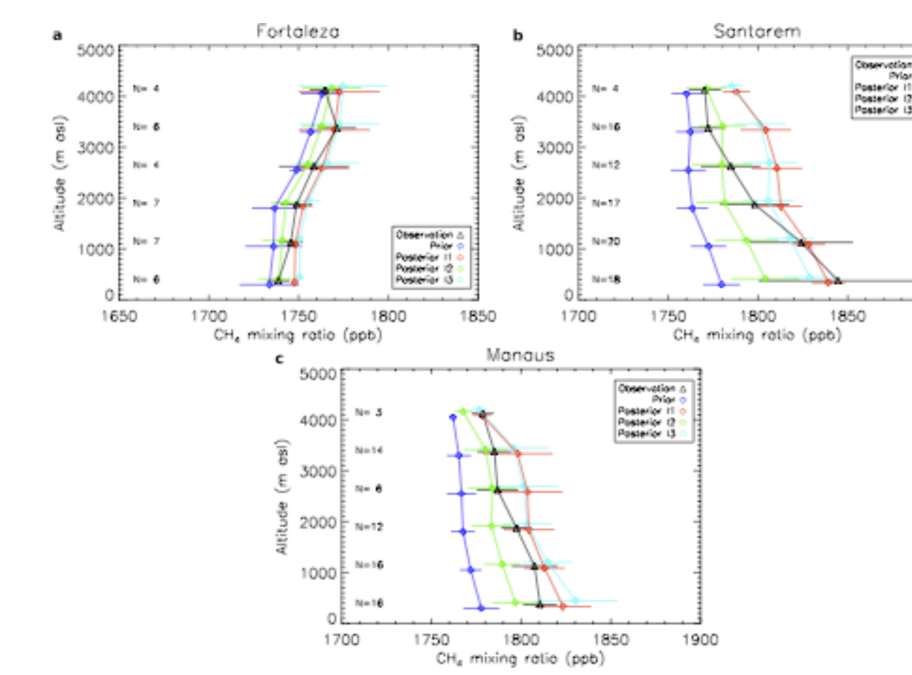


Origin of Air

SAN MAN



Comparison to Satellite data



Observations and simulated CH4 profiles derived from an inversion using SCIAMACY CH4 columns (Meirink et al).

Summary

1. East of Santarém: ~ 30 mg $CH_4/m^2/day$
2. (North)East of Manaus: ~ 40 mg $CH_4/m^2/day$

Source/Sink	Flux ($mg/m^2/day$)	Reference (note)
Fire	<1	van der Werf, p.c.
Wetlands	16	Melack (basin value/$5x10^6$ km2)
Plants	4	Keppler, 2006: 0.5 ng CH4/dry leaf biomass x 6.3 ton/ha (McWilliam, 1993)
?Canopy?	5	do Carmo, 2006
Termites	<1	Martius, 1993
OH	-3	Spivakovsky, 2000
Soil	>-1	Keller, 2005

- The size of emissions we infer are large and cannot be explained easily by bottom up estimates.
- Different seasonality at Manaus and Santarem:
  - -Origin of air is slightly different -- more northerly at MAN.
- CO:CH_4 ratios show influence of biomass burning on CH_4 profiles and fluxes.
- Future: regional inverse modeling-- will we get the same answers?
- Data have proven useful for validation of satellite-based CH_4 retrieval from SCIAMACHY

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