



The Potential Influence of Fresh Water CO₂ Fluxes on Regional Carbon Balance in the Tapajos Region, Para, Brazil

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1. Abstract

Recent research have suggested that river and flooded land in Amazon basin are large sources of CO₂ to the atmosphere (Wofsy et al., 1988; Richey et al, 1990, 2001). The overall goal of this project is to explore the potential influence of CO₂ fluxes from river and inundated land on regional carbon balance in the Tapajos region. In addition to the prevailing trade wind regime, topographic and surface variations in the Tapajos region produce mesoscale circulations that have been documented from field data. These include a shallow diurnal river-breeze circulation forced by contrasts in sensible heat flux between the forest and the Tapajos and Amazon Rivers. We investigate this circulation using the CSU Regional Atmospheric Modeling System (RAMS). Several modifications have been made to RAMS Version 4.3: respiration rate and maximum photosynthesis are prescribed according to vegetation type; photosynthesis varies sinusoidally during daylight hours; Freitas et al (2000) convective transport scheme has been implemented to account for the deep tropical convections. A three month period (June-August, 2000) was simulated with two nested grids: The outer grid covers the northeastern part of Amazon and adjacent oceans at 100 km grid-spacing, and the inner grid covers an area of 1750 km x 1450 km, focusing on Santarem and adjacent area at 25 km grid-spacing. To investigate the effects of surface water CO₂ emission on the regional carbon balance, we performed these simulations with and without specifying the CO₂ fluxes from the river and inundated land. Smaller scale simulations that resolve the river breeze were performed for cases chosen from the regional simulations. These simulation reveal that heterogeneous vegetation produces easily detectable spatial structure in simulated CO₂ concentration. These gradients may be quantitatively interpreted to estimate area-averaged CO₂ fluxes under some circumstances, and form the basis of a field campaign using light aircraft which will be carried out in August of 2001. We found that surface water CO₂ flux modifies simulated CO₂ concentrations, especially at night. Experimental design for field campaign must treat trade wind and riverbreeze regime differently.

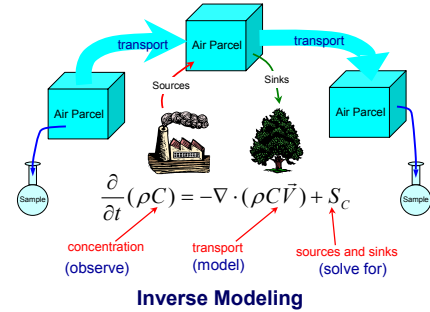
2. Objectives and tools

2.1 Objective



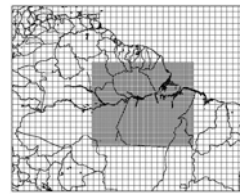
- Surface waters in the Amazon Basin are **supersaturated** with respect to atmospheric pCO₂ by as much as a **factor of 100**
- Organic matter produced by terrestrial uptake can be **transported in dissolved or particulate form** to the water, where it is decomposed by microbes
- A flux of 5 μMol m⁻² s⁻¹ from all surface water in the Basin would produce a **source of 0.4 to 0.7 GtC yr⁻¹**
- Experimental design must seek to **quantify this contribution** to the regional carbon budget

2.2 Methodology

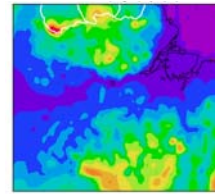


2.3 Model Grid Configuration

- **Model:** RAMS 4.3, with prescribed CO₂ fluxes
- **Control:** Forest and Pasture CO₂ fluxes
- **Experiment:** Surface water CO₂ flux = 5 μMol m⁻² s⁻¹
- **Modeled Period:** 07/30/2000 — 08/09/2000
- **Boundary Condition:** CPTEC Reanalysis
- **Grid Spacing:** Inner: 25-km Outer: 100-km



Inner and Outer Modeled Domain

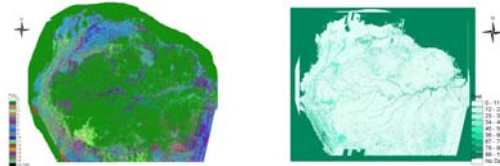


Topography for the fine-grid

2.4 Model Options

- Basic equations: Nonhydrostatic; Compressible
- Vertical coordinates: Terrain-following sigma z
- Horizontal coordinates: Oblique polar-stereographic projection
- Grid stagger and structure: Arakawa C grid, multiple nested
- Time differencing: Hybrid
- Large scale precipitation: Full microphysics
- Convective parameterization: Modified-Kuo, with convective transport (Freitas et al. 2000)
- Radiation: Mahrer-Pielke, and Harrington
- Cloud: Thompson, and level-3 moisture
- Surface layer: Louis, Prognostic soil, vegetation parameterization

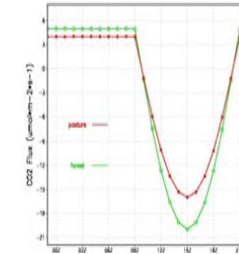
3. Observational Dataset



Land cover map of the Amazon basin (Saatchi, June 2001) Is generated from JERS-1 radar mosaic. The radar data was acquired in a single sweep during the generally low flood time of the Amazon River in September–December 1995, and again in May – August 1996 during a high flood period of Amazon river. The classification is performed using high & low water radar images and AVHRR 1995-1996 monthly averaged NDVI.

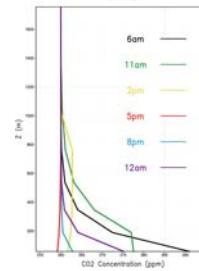
4. Numerical Experiment Design

- Respiration is constant in time
- Photosynthesis varies sinusoidally during daylight hours
- Max photosynthesis and respiration rate are prescribed separately by veg type
- Constant flux of 5 μMol m⁻² s⁻¹ over inland surface water



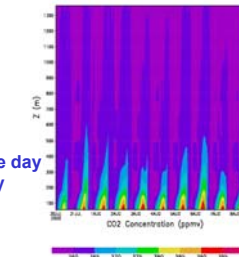
5. Results

5.1 Diurnal Evolution of PBL CO₂

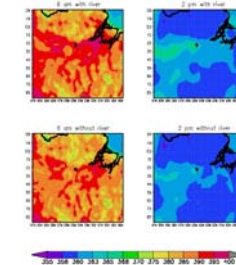


- CO₂ accumulates under **nocturnal inversion** due to respiration
- Turbulent **entrainment** in the morning dilutes CO₂
- Midday photosynthesis **depletes CO₂** but is **diluted** through a **deep PBL**

- Respiration elevates CO₂ at night
- Photosynthesis depletes CO₂ during the day
- Vertical mixing is deeper during the day



5.2 Spatial and Diurnal Patterns

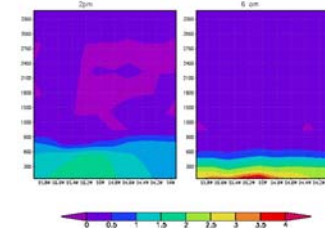


The figures show CO₂ spatial distribution at 57m:

- **Nocturnal accumulation is concentrated in lowlands** by drainage flow
- **Additional Efflux from surface waters** produces elevated concentrations, especially at 6Am

5.3 Effect of Surface Water CO₂ flux

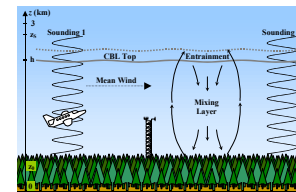
The figures plotted the difference of CO₂ field across the tapajos river. The vertical cross section is about 200 km wide and 3 km high. It shows CO₂ concentration difference between the two runs that with and without the surface water CO₂ fluxes at 2 pm and 6 am.



- **Impact of several ppm due to rivers**
- **The signals of river CO₂ fluxes are quite clear especially at night**

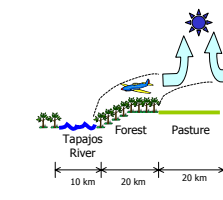
6. Field Experiment Design

- Estimation of **spatial average CO₂ fluxes** from airborne measurements
- **Continuous [CO₂]**, flasks for [CO], d¹³C, d¹⁸O, and other tracers
- **Two cases:**
 - **Trade Wind Experiment:** estimate average mid-day regional fluxes



d/dt of vertically integrated concentration, following an air parcel
Measure concentration and isotope ratios **four hours apart**,
Estimate area-average flux from **mass balance** of parcel

- **Riverbreeze experiment:** estimate separate flux components from forest, pasture, and river



Fly repeated grid pattern to quantify spatial patterns, invert for surface flux variations

- **Heterogeneous surface fluxes** produce mesoscale riverbreeze under light trade wind conditions
- Advection from river over forest and pasture produces **CO₂ gradients** in a shallow **internal boundary layer**
- Variations in **CO₂ flux** can be **quantified** from spatial gradients in [CO₂] and isotopic ratios

7. Summary and Conclusion

- **Heterogeneous vegetation** produces easily **detectable spatial structure** in simulated [CO₂]
- **Surface water CO₂ flux** modifies simulated concentrations, especially **at night**
- **Experimental design for field campaign** must **treat Trade Wind and Riverbreeze regimes differently**
- **IGBP 1-km land cover data** (both version 1.2 and 2.0) has some unrealistic vegetation types for Amazon basin. It is not suitable especially for high resolution simulations

On-going and Future Research Work

- **Perform 4-grid simulation with the finest-grid nested to 1-km grid spacing** so that the riverbreeze circulation can be adequately resolved.
- **use reliable and realistic land cover data set** for high resolution runs.
- **Validate model when tower and aircraft measurement data becomes available**

8. Reference

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