Carbon and Oxygen Isotope Ratio CO_2 Flux Analyses at the Soil, Canopy, and Landscape Scales

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CD-02

Abstract

We propose two areas of research emphasis to better understand and constrain estimates of carbon dynamics in Amazônia ecosystems, based on progress during Phase I of LBA-ECO.

(1) Stable isotope analyses of atmospheric CO_2 are one tool which scales processes from the soil and individual plant levels through to the troposphere. We will apply $^{13}C^{18}O^{16}O$ analyses as tools for better understanding gas exchange processes within ecosystems and regionally across ecosystems (forest, pasture, and river) in Manaus and Santarém. These data will also directly contribute to regional and aircraft studies which rely on ground observations for their data interpretation.

(2) Mechanistic leaf, canopy and site-scale canopy-scale models including isotope exchange are tools for extrapolating from local scale measurements towards understanding carbon cycling on an ecosystem and a basin-scale. Parameterized with leaf gas exchange characteristics (functional response curves, N values, $^{13}C^{18}O^{16}O$ and, canopy structure) and driven by meteorological inputs, these models will be used to understand how climate influences carbon gain at the canopy-ecosystem scale and will be used to link with eddy covariance studies (NEE estimates), atmospheric sampling programs and regional carbon cycle modeling efforts as part of our science integration.

The proposed study will make several key LBA-Ecology measurements at two primary regions: Manaus and Santarém:

- leaf-scale parameters to parameterize canopy photosynthesis models
- canopy scale photosynthesis models driven by climate data
- $\delta^{13}C$ and $\delta^{18}O$ values of stocks in forest and pastures: leaves and soils
- $\delta^{13}C$ and $\delta^{18}O$ values of CO_2 effluxing from soils and from the total ecosystem at forest and pasture sites
- $\delta^{13}C$ and $\delta^{18}O$ values of ecosystem photosynthetic discrimination in forests and pastures
- $\delta^{13}C$ and $\delta^{18}O$ values of landscape-level respiration (PBL)

Our studies will be conducted in close association with eddy covariance measurements, atmospheric CO_2 sampling, and regional carbon modeling groups. The leaf and canopy-level models of carbon gain and of isotope fractionation will linked directly with regional scale models. The information gathered using our isotope studies will help in determining the role of the Amazon Basin as a net sink or source of CO_2 to the atmosphere.

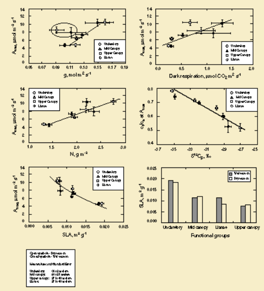
Scientific objectives

- to use carbon and oxygen isotopes of both atmospheric CO_2 and organic matter to provide integrated information about important plant physiological characteristics across both spatial and temporal scales
- to use isotopes as a tool for understanding the mechanistic factors contributing to changes in NEE in response to climate drivers
- at the landscape scale, to use C and O isotopes to partition the relative contributions of the forest, pasture, and river components to CO_2 fluxes
- to couple mechanistic gas exchange data with models to predict the changes in stand-level photosynthesis associated with seasonal dynamics and with changes in precipitation and humidity

Canopy modeling studies

What have we done?

Quantifying photosynthetic parameters



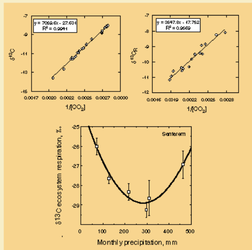
What are we planning to do next?

Leaf and canopy models

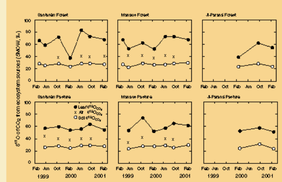
The initial focus of our modeling work will be at the leaf scale. Our approach of building up from leaves to a canopy will test scaling assumptions and should lead to improved canopy models for larger scale simulations. The models we will use are derived from the leaf models of Collatz et al. (1991, 1992) extended to simulate isotopic fractionation in transpiration and photosynthesis. We will use within canopy meteorology obtained from the flux sites to drive these models at various levels within the forest or pasture canopies. We propose to collaborate with Scott Dennings' group. They have developed a coupled model of physiology and turbulent transport within canopies, which provides a "bridge" to move from leaf-scale simulations to whole canopy simulations. The model will simulate within canopy gradients in CO2 and its isotopic composition and can be tested against observations made in the field. Simulations with this multilayered model will be compared with simplified canopy models like SiB. We plan to use a new soil model developed by Riley et al. (2002) to simulate CO2 and isotopic exchange associated with soil respiration and invasion of atmospheric CO2 into the soil.

Isotope field studies

What have we done?



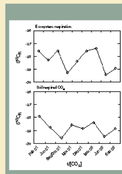
Isotopic composition of ecosystem respiration responds to environmental conditions, such as precipitation amount



Isotopic composition of daytime CO_2 reflects influence of both leaf (canopy) and soil sources

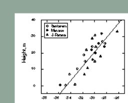
What are we planning to do next?

links to NEE through continuous observations

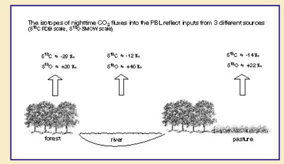


C and O isotopes in CO_2 of both the soil and total ecosystem show seasonal dynamics, which appear related to NEE and ecophysiology

Organic C and O isotopes show limited seasonal dynamics, but there are pronounced profiles associated with stand structure



regional studies - forest, pasture, and river



regional studies - boundary layer

- balloon sampler to measure in PBL
- ^{13}C and ^{18}O of CO_2 in PBL profile
- PBL keeling plots
- ^{13}C and ^{18}O of CO_2 in forests
- ecosystem $\delta^{13}C$ and $\delta^{18}O$ discrimination

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