UNDERSTANDING THE RESPONSE OF PHOTOSYNTHETIC METABOLISM IN TROPICAL FORESTS TO SEASONAL CLIMATE VARIATION

Principal Investigator (PI): Luiz Eduardo Oliveira e Cruz de Aragão

Remote Sensing Division / National Institute For Space Research (INPE)

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US PI: Denis Gene Dye (Southwest Geographic Science Center

co-PIs: Liana O. Anderson e Yosio Edemir Shimabukuro (INPE), Luciana Alves (IAC), Rafael Oliveira (Unicamp)

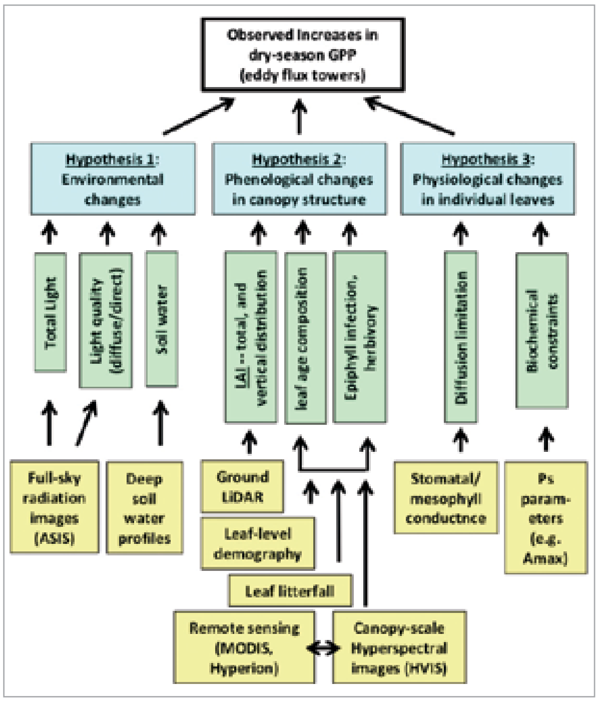


Figure 1. Three general hypotheses (blue boxes) for observed dry season increases in GPP, along with potential mechanisms underlying those hypotheses (green boxes). Yellow boxes show measurements that we will take as part of the research campaign

Tropical forests have a major influence on the global carbon cycle because of their high rates of primary productivity and large stocks of carbon in vegetation and soils. The response of tropical forest ecosystems to a variable and changing climate may introduce strong feedbacks to the global climate system. The response of photosynthetic metabolism to seasonal climate variations provides a first-order test of our understanding of how tropical forest carbon cycling interacts with climate, but there remains uncertainty and debate in the literature about even the basic seasonal patterns of tropical ecosystem photosynthesis, as well as the mechanistic constraints. Models disagree, as do remote sensing measurements: some models and remote sensing indices show widespread declines in photosynthetic metabolism during dry seasons, suggesting that Amazonian forests are driven by water availability, while others show the opposite, suggesting sunlight availability is a key limiting factor. What controls the response of photosynthesis in Amazonian forest to seasonal variations in climate? To answer this question, this project aims to guide improvements in earth system models of tropical forest photosynthesis by collecting and integrating a suite of observations to:
1) test several hypotheses (three core, conceptual hypotheses for explaining observed photosynthetic seasonality and a methodological hypotheses for scaling from leaves to canopy with hyperspectral cameras), and
2) perform a synthesis activity that applies empirical work to earth system models of terrestrial carbon cycling. The specific aim is to investigate through observations, analysis and modeling, two mechanistically related factors that control these patterns, leaf phenology and photosynthetically active radiation (PAR), and to identify opportunities for reducing uncertainties associated with these factors through model corrections or enhancements. Specifically:

i) What is the seasonal pattern of the display and properties of leaves in tropical forest canopies observed at tree-to-landscape scales?
ii) How do solar radiation and other climate factors control these patterns and what should be expect in the future?

To address these questions, it will be used field measurements, ground- and satellite-based remote sensing, and modelling at study sites near Manaus and Santarem in the Amazon region of Brazil. This study is linked to DOE's GoAmazon/ARM campaign, and will add substantial value to GoAmazon.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

This project envisages to provide an extensive suite of new and unique datasets that enable to fill, through advanced modelling techniques and analysis, critical knowledge gaps in current understanding of what controls the response of canopy photosynthesis and related functions in Amazonian forests to seasonal variation in climate. Three major types of datasets and data products will be delivered:

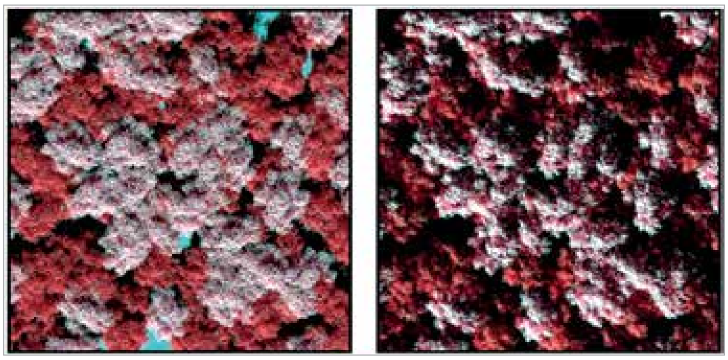
(1) *in situ* leaf and tree-scale measurements from intensive ecophysiological and ecohydrological field campaigns,

(2) time-series observations of leaf-to-crown scale forest reflectance properties and atmospheric radiation from two innovative, ground-based imaging sensors (respectively, the Hyperspectral Vegetation Imaging System and the High Dynamic Range All-Sky Imaging System), and

(3) results from state-of-the-art models (including DIRSIG model) of 3-dimensional canopy processes for radiative transfer and photosynthesis that integrate and link observations to tropical forest processes.

These data products and the improved knowledge achieve with them will contribute to testing and improving the treatment of tropical forest processes in earth system models. They will contribute data to and leverage related data from of the GOAmazon campaign, and make significant contributions to support the overall goals of GOAmazon. This work will also help establish a foundation for the Next Generation Ecosystem Experiments (NGEE) in the Tropics.

Figure 2. Nadir-view, false-colour composite images for Landsat-like green, red and NIR bands simulated by the DIRSIG model at solar zenith angles of 0 degrees (left) and 45 degrees (right) for a synthetic broadleaf forest with 2 tree species. The spatial extent of each image is ~100 m, with individual crowns and shadow effects visible



Luiz Eduardo Oliveira e Cruz de Aragão

Instituto Nacional de Pesquisas Espaciais
Divisão de Sensoriamento Remoto
Avenida dos Astronautas, 1.758 – Jd. Granja
CEP 12227-010 – São José dos Campos, SP – Brasil

+55-12-3208-6490
laragao@dsr.inpe.br