THE EFFECTS OF LAND USE CHANGE AND OF SEASONAL VARIATIONS IN CLIMATE ON GPP ACROSS THE AMAZON BASIN: AN ANALYSIS COMBINING DATA FROM MODIS SATELLITES AND FROM A NETWORK OF FLUX TOWERS

S. R. Saleska[1], M. Pathmadevan[2], A. Huete[3], F. Cardoso[4], H. da Rocha[5], K. Didan[3], D. Fitzjarrald[6], M. Goulden[7], B. Kruijt[8], A. Manzi[9], S. Miller[6], A. Nobre[9], C. von Randow[8], R. Sakai[6], J. Tota[9]

(1) Dept. of Ecology and Evolutionary Biology, University of Arizona, Tucson AZ, 85721 USA; saleska@email.arizona.edu
(2) Dept. of Earth & Planetary Sciences, Harvard University, Cambridge, MA 02139, USA; mahadev@fas.harvard.edu.
(3) Dept. of Soil, Water and Environmental Science, University of Arizona, Tucson AZ, 85721 USA; ahuete@Ag.arizona.edu and kamel@ag.arizona.edu.
(4) Fundação Universidade Federal de Rondonia, Ji-Parana, Rondonia, Brazil.
(5) Dept. of Atmospheric Sciences, Universidade de São Paulo, São Paulo, Brazil
(6) Atmospheric Sciences Research Center, State University of New York, Albany, NY USA.
(7) Dept. of Earth System Science, University of California, Irvine CA USA
(8) Alterra, Wageningen University and Research Centre, Wageningen, The Netherlands
(9) Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Brazil.

ABSTRACT
Amazonian forests play an important and complex role in the global carbon cycle, contributing substantially to increases (via land use change emissions) and possibly to net sequestration (in intact forests) of atmospheric CO_2. Predicting these processes of net carbon uptake and release depends crucially on understanding ecosystem response to both seasonal and interannual variations. However, prominent ecosystem modeling studies of the Amazonian carbon cycle [*Tian et al.*, 1998; *Botta* 2002] appear to make seasonal predictions (wet-season carbon uptake and dry-season loss) at odds with both some site-specific observations (which show the opposite pattern, *Saleska et al.*, [2003]) and basin-wide satellite observations (which imply large-scale increases in the activity of photosynthetic vegetation during the dry season, *Huete et al*., [2005]).

To better understand these discrepancies, we investigated the seasonal and spatial patterns of Amazonian forest photosynthetic activity, and the effects of land-use conversion thereon, by combining spatially continuous satellite data from the Terra- Moderate Resolution Imaging Spectroradiometer (MODIS) with data from a network of ground-based eddy flux towers. By using spectral information that minimizes cloud-contamination and that does not saturate at high leaf areas, MODIS-derived indices can detect seasonal patterns with high fidelity. Flux towers at 'Large-Scale Biosphere Atmosphere Experiment in Amazonia' (LBA) research sites have now produced multi-year datasets of seasonal patterns temporally coincident with MODIS data. Four years of MODIS-derived indices (enhanced vegetation index, EVI, and land-surface water index, LSWI) showed higher primary forest photosynthetic activity in the dry season than in the wet season, a broad pattern opposite to that predicted by prominent ecosystem models which simulate dry-season declines in primary forest photosynthetic activity due to water-limitation. A complete reversal in the primary forest EVI pattern was observed in areas converted to pasture, agriculture, or secondary forests, where the elimination of deep roots has likely reduced vegetation access to deep soil waters which often persist through the dry season. We used tower data over the same time period to test the satellite-observed seasonal pattern of dry-season "green up" at specific sites, and then used tower-derived GPP at those sites to calibrate a simple empirical model parameterized with MODIS data (adapted from the vegetation-photosynthesis model, VPM, see *Xiao et al.*, [2005]) to obtain basin-wide estimates of the seasonal trend of GPP carbon fluxes, and to estimate the effect of land use changes on these trends.

REFERENCES

Botta A, Ramankutty N, Foley JA. (2002) Long-term variations of climate and carbon fluxes over the Amazon basin. *Geophysical Research Letters*, **29**, Article-1319.

Huete, A., Didan, K., Shimabukuro, Y.E., Jacobson, A., Ratana, P., Nemani, R.R., Myneni, R., (2005), Amazon rainforests green up in the dry season, *Nature* (in second-round review, July 2005).

Saleska, S. R., Miller, S.D., Matross, D.M., Goulden, M.L., Wofsy, S.C., da Rocha, H.R., de Camargo, P.B., Crill, P., Daube, B.C., de Freitas, H.C., Hutyra, L., Keller, M., Kirchhoff, V., Menton, M., Munger, J.W., Pyle, E.H., Rice, A.H., Silva, H. (2003). "Carbon in Amazon forests: Unexpected seasonal fluxes and disturbance-induced losses." *Science* 302: 1554-1557.

Tian H, J.M. Melillo, DW. Kicklighter, AD McGuire, JVK. Helfrich, B Moore, CJ. Vorosmarty (1998). Effect of interannual climate variability on carbon storage in Amazonian Ecosystems. *Nature* 396: 664-667.

Xiao, X., Zhang, Q., Saleska, S., Hutyra, L., De Camargo, P., Wofsy, S., Frolking, S., Boles, S., Keller, M., and Moore III, B. (2005). "Satellite-based modeling of gross primary production in a sesonally moist tropical evergreen forest." Remote Sens. Environ. 94(1): 105-122.