Large Scale Experiment on the Atmosphere Biosphere in the Amazon Basin (LBA)

Reporting Period: January 2005-July 2006
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End Date: July 26 2006
URL: http://lba.inpa.gov.br/lba/
Chair: Jose Marengo

Overview:
The Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) is an international research initiative led by Brazil. LBA is designed to create the new knowledge needed to understand the climatological, ecological, biogeochemical, and hydrological functioning of Amazonia, the impact of land use change on these functions, and the interactions between Amazonia and the Earth system. LBA Phase 1 ended in December 2005 and LBA Phase 2 (LBA2) is now being organized and implemented.

Objective(s):
LBA is centered around two key questions that will be addressed through multi-disciplinary research, integrating studies in the physical, chemical, biological, and human sciences:

- How does Amazonia currently function as a regional entity?
- How will changes in land use and climate affect the biological, chemical and physical functions of Amazonia, including the sustainability of development in the region and the influence of Amazonia on global climate?

In LBA emphasis is given to observations and analysis which will enlarge the knowledge base for Amazonia in six general areas: Physical Climate, Carbon Storage and Exchange, Biogeochemistry, Atmospheric Chemistry, Hydrology, and Land Use and Land Cover. The program is designed to address major issues raised by the Climate Convention. It will help provide the basis for sustainable land use in Amazonia, using data and analysis to define the present state of the system and its response to observed perturbations, complemented by modelling to provide insight into possible changes in the future.

As relevant to GHP, we focus on two components of LBA:

a) The Physical Climate component, meteorological and hydrological studies will be conducted for nested spatial scales, from plots to the entire Amazonia, with focus on determining and understanding the spatial and temporal variations of energy and water fluxes. Variations of climate, and the responses of the Amazonian system to these variations, will be determined on daily to seasonal time scales. The data fields generated by a numerical weather prediction model will be stored and used in a four dimensional data assimilation scheme (4DDA) as a primary tool to analyze the observations. The duration of LBA should allow for direct observations of inter-annual climate variations, possibly including the effects of the El Niño-Southern Oscillation (ENSO) cycle. Data collected in the field program will be used to improve representation of key dynamical processes in meteorological models. The results will help to constrain the General Circulation Models used to examine interactions between climate and land cover changes in Amazonia.
b) The Hydrology component will consider issues related to both the quantity and the chemistry of water in the Amazon Basin. The stores and fluxes of water, and the controls on movement of water in soils and in streams, and the associated transport of constituents, will be determined for a nested suite of catchments representing a range of land use intensities. Forested and deforested catchments of several square kilometers will be instrumented to make measurements with high temporal resolution of discharge, rainfall, evaporation, interception, soil water storage, ground water leakage and export of sediment and nutrients. The data will be used to improve the capability of hydrometeorological models to assess the response of flows of the Amazon and its tributaries to changes in climate and changes in land use. Controls on the movement of materials from the upland through the riparian zone and into streams will be studied in small catchments drained by low order streams.

Status:
Some of the components of the LBA phase 1 have been integrated in new ones, with a different approach. The goal of the LBA2 chemical and physical multi-scale interactions between land and atmosphere in the Amazon component (combination of physical climate, atmospheric chemistry and human dimensions) will study the transport and transformation of water, energy, trace gases and aerosols in the atmosphere-land system and assess the effects of and impact on human activities in the region.

The scientific questions of this new component are:

- What are the biosphere-atmosphere fluxes of energy, water, trace gases and aerosols over the range of ecosystems in the Amazon and what is the effect of human activities in these fluxes?
- What are the sources of aerosol particles over the Amazon basin?
- What are the effects of aerosols over the Amazon Basin on cloud microphysics, convection dynamics, precipitation and energy transfer processes over Amazonia and how do they interact with climate in all scales?
- What processes regulate the atmospheric oxidant cycles in Amazonia and how are these affected by human activities?
- What is the role of volatile organic compounds in the carbon cycle?
- How the climate in Amazonia could change in response to vegetation dynamics caused by changes in vegetation and land use and the global climate forcing?
- What is the significance of regional and global teleconnections in the water, carbon and energy balance over the Amazon?
- How could a changing pattern of land use and precipitation in future climate scenarios affect the surface hydrological cycle and the fluxes of energy, carbon and trace gases in the Amazon?
- How does the climate system, including physical and vegetation dynamics, in Amazonia respond and feed back into man made land use change and global climate change?
- What is the impact of the high rate of urbanization in Amazonia and other human activities on air pollution and what are the health effects?
- What are the net transfers of trace gases and aerosols between Amazonia and surrounding regions, and how do they relate to trans-boundary pollution?

The combination of the LBA phase 1 human dimensions and land use changes components have giving place to a new LBA2 component which new science questions are:

- What is the impact of managed/degraded forests on the ecological functioning of the Amazonian system?
- What is the forest resilience to management?
- Is there a critical size for the forest patches (and matrix) to maintain their function within the system?
- Does the agrarian structure have impacts on the functioning of the Amazonian system? (B)
- How do the physical climate and land use affects disease “propagation”. (C)
- What is the value of the environmental services provided by Amazonian forests measured in terms of carbon? Scenarios of market options (second-growth, pasture management, avoided deforestation).

The LBA2 component on carbon and biogeochemistry has as scientific questions;

- How do the processes that control the stocks and fluxes of carbon [and nutrients, trace gases, water] in terrestrial and aquatic ecosystems respond to changes in: Land cover, Climate, Air quality, Agricultural intensification/diversification, Forest management, Urbanization, Biodiversity
- How do riparian zones and wetlands transform carbon, oxygen, and nutrients, thus affecting water quality, trace gas emissions, carbon cycling, and habitats?
- How do fluxes of energy, [water, carbon, and nutrients] [matter and information] [and commerce?] interact and integrate across landscapes that are composed of multiple land uses?
- In this context, a “landscape” can be defined as an area that is relevant to scales of local or regional planning.

Future: Next year foreseen activities*:*
Some “unfinished business” in LBA phase 1 has been identified, and they become the science questions of the future of LBA2:

- What are plausible scenarios for future land–cover change in Amazonia?
- How do biological processes such as mortality and recruitment or succession following land use change influence the net annual C balance for different land–cover/land use types
- What portion of the Amazonia–wide C flux is from fire? How do ecosystems recover from fire? What are the relations between land management and fire occurrence/frequency
- What are the processes and consequences of atmospheric horizontal transport of nutrients (wind) on the nutrient stocks and cycles of ecosystems within the Amazon basin at various spatial and temporal scales? (Saharan dust inputs, Losses and redistribution due to find, Links between physical climate models and nutrient cycling
- How will the composition and quantity of nutrients and organic matter entering and being processed within streams be altered under different land-use change scenarios?
- Are there unique signatures that can be traced downstream?
- To what extent do intact riparian zones buffer streams against changes due to anthropogenic activities in surrounding uplands?
- How are fluxes of trace gases and aerosols between ecosystems (both upland & wetland) and the atmosphere of Amazonia affected by land cover and land use change
- What is the (climatically driven) seasonal and inter-annual variability of trace gas and aerosol fluxes between the atmosphere and different land use/land cover types?

Key results:
Some of the main scientific results of the different field campaigns and LBA Phase 1 studies can be summarized as:

- The daily cycle of the energy budget at the pasture and forest shows differences between morning and afternoon behavior. Rn is larger at the forest in the morning and larger in the pasture in the afternoon. This would imply cloudier skies over forest in the afternoon. Would also mean lower cloud base in the morning over forest since LE is always larger at the forest while H is similar during the morning and larger over pasture in the afternoon.
- In a day that starts sunny and clear, the temperature evolution favors a faster evolution of the mixed layer over forest. After rains start at different times over forest and pasture this particular day, the continuous evolution is broken.
- The character of precipitation over Amazonia varies from a very continental behavior in the pre-rainy season to a more maritime regime during the rainy season. More important, during the rainy season there is an alternation between a more maritime and more continental regime associated with large scale controls, such as the presence or absence of large scale low-level convergence provided by approaching mid-latitude frontal boundaries or even the establishment of the South Atlantic Convergence Zone.
- Studies on the diurnal cycle of rainfall have shown that there is an apparent preference for maximum rainfall intensity to occur between 1200 and 1600 LST, and sometimes 1800 LST, while in some periods a second maximum shows up between 0000 and 0400 LST.
- Seasonal variability in the Amazon Basin has been observed for concentrations of aerosol particles, cloud condensation nuclei (CCN) and trace gases. This seasonal variability is mostly caused by biomass burning emissions in the dry season (July–October). In terms of aerosol optical depth measurements using a network of sun-photometers, background aerosol column amounts to 0.10–0.15 at 550 nanometers in the wet season. In the dry season, values of 2.5–3 are observed over large areas.
- The basic picture that puts together all the above features in the different wind regimes is based on two modes of convection. During the easterly regime, convective systems are more continental, with vigorous convective cells, more isolated with a well define mixed ice water region and frequent lightning. During the westerly phase, the systems are larger and more stratiform, no mixed ice water phase region almost no lightning. To incorporate the role of CCN into this picture involves looking also into the dynamic/thermodynamic forcing provided by different regimes.
- On the atmospheric water balance in the Amazon basin, based on rainfall observations in the region show that there is a seasonality and interannual variability of the water balance that varies across the basin. Because of its larger size, southern Amazonia dominates the seasonal cycle of the water balance of the entire region, while at interannual time scales rainfall anomalies in northern Amazonia

modulate the water budget of the entire basin. In the entire Amazonia, precipitation exceeds evaporation representing a sink of moisture (P>E). Our estimates of the Amazon region's water balance do not show a closure of the budget, with an average imbalance of almost 50%, meaning that some of the moisture that converges in the Amazon region is not unaccounted.

- A new version of the Hydro-NET (C.Vorosmarty, personal communication) or Hydrological Routing Network is being developed for the Amazon, which will simulate time-varying flow and storage of water in hydrological systems, including rivers, floodplains, wetlands, lakes, and human-made reservoirs.
- A hydrological model for Brazilian macro basin of the Igarape Asu is also being developed which will integrate existing meteorological, topographic, vegetation and pedological data, together with remote sensing derived products. The model will be used primarily as a real-time monitoring tool capable of providing updated information about soil moisture and river discharges to support several economic activities related to water management.
- Research is underway to understand and model the influence of land-cover change on the streamflow of Amazonian river basins with areas of approximately 10,000 km^2. To achieve that goal, the research will try to quantify the influence of both climate and land-cover change on river flow in mesoscale Amazonia to understand processes governing those influences, and to define the range of basin size over which land use affects the hydrology of rivers. The Experimental catchment is located nearby Manaus, and has been implemented close to Manaus to gain understanding of the carbon exchanges between soil vegetation and atmosphere on a pristine forest.
- Continuous activities such as the FLUX TOWER monitoring (started in 1999) and the SIVAM project (started in October 2002), are integral part of LBA and derived high quality observations needed in support of LBA studies in climate, Hydrology and ecology.
- In relation to LBA-DIS, during 2004 LBA experienced significant gains in both metadata and data submission.
- Although this growth is substantial, continued effort is made by LBA-DIS personnel to make sure that every byte of information collected by LBA research teams is cataloged (via metadata records) and stored at CPTEC.
- Modeling studies on the role of vegetation on climate and climate change indicate that the Amazon basin may become a savanna during middle 2050's, where temperatures may increase by up to 8C and rainfall during the summer and autumn seasons would decrease by almost 50%. The results obtained from the HadCM3 model with iterative vegetation are still uncertain and there is a need for similar experiences using other models.
- Studies on the Drought of Amazonia in 2005 have motivated initiatives linked to observational studies of this event, the ecological impacts on fire and sub surface hydrology, and the possibility that events like this could be more frequent in climate changes scenarios. The collaboration between CPTEC and the Hadley Centre has motivated at least 3 papers submitted and 3 others in preparation. The ecological aspects of drought-fire and the possible impact of El Nino (or El Nino like climate) have been considered.

Issues and Recommendations:

After few meetings among LBA scientists and the organized society and government, it was clear the need of a new formulation of a new LBA research agenda in accordance with the current state-of-the-art of knowledge in Amazon Basin processes and functioning of climate, hydrology, land use changes, biogeochemical cycles and human dimensions. An assessment of the Phase 1 of LBA has motivated to think on the new philosophy of LBA2 for the next 10 years. For the LBA2 Agenda the following aspects have been considered as key issues and the drivers for the LBA2 planning strategy:

- Should we develop plausible scenarios for the future of Amazonia? These would be critical for modeling exercises considering future conditions.
- Extension of the network of forest plots can have considerable long term value. Excellent opportunities exist to link these to remote sensing data for regional studies of forest dynamics.
- Regional studies of atmospheric composition should be fostered beyond BARCA and expanded.
- Continue and fortify the studies of smoke effects with a strengthening of the linkages between the atmospheric studies, ecological studies, and studies of social and economic controls on fire use.

- Take advantage of the strength of LBA in understanding of atmospheric transport to consider the role of atmospheric redistribution of nutrients.
- Collect and unify existing data to give a detailed regional picture of soil nutrients.
- Build on existing studies of river chemistry with increased attention to the riparian zone and continued attention to the tracers of downstream effects of land use change. How far can we go from the source?
- We are just getting hints of the role of the ecosystems in controlling atmospheric composition. What can we do to extend the point studies to the region?

List of key publications

Albrecht, R. I. & Silva-Dias, M. A. F. (2005) Microphysical evidence of the transition between predominant convective/stratiform rainfall associated with the intraseasonal oscillation in the Southwest Amazon., *Acta Amazonica. 35*, 175-184.

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Avissar, R. & Werth, D. (2005) Global hydroclimatological teleconnections resulting from tropical deforestation., *Journal of Hydrometeorology. 6*, 134 - 145.

Betts, A. K., Ball, J. H., Viterbo, P., Dai, A. & Marengo, J. A. (2005) Hydrometeorology of the Amazon in ERA-40., *Journal of Hydrometeorology. 6*, 764-774.

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Freitas, S., Longo, K. M., Silva-Dias, M. A. F. & Silva-Dias, P. L. (2005) Emissões de queimadas em ecossistemas da América do Sul: efeitos climáticos e biogoquímicos e distribuição regional da fumaça., *Estudos Avançados. 19*, 167-185.

Hutyra, L., Munger, J. W., Nobre, C. A., Saleska, S. R., Vieira, S. A. & Wofsy, S. C. (2005) Climatic variability and vegetation vulnerability in Amazonia, *Geophysical Research Letters. 32*, 1-4.

Lawford, R., R. Stewart, H. J. Isemer, M. Manton, J. Marengo, T. Yasunari, S. Benedict, J. Roads, P. Kabat, T. Koike, T. Lebel, P. Try, S. Williams, 2005: Advancing global and continental scale hydrometeorology: Contributions of the GEWEX hydrometeorology panel (GHP), *Bull. Amer. Met. Soc*. 85, 1917-1930.

Malhi, Y. & Phillips, O. (2005) *Tropical Forests and Global Atmospheric Change*, Oxford University Press, New York, USA.

Marengo. J. 2005: The chartacterisics and variability of the atmospheric water balance in the Amazon basin:Spatial and temporal variability. Climate Dynamics. 24, 11-22

Marengo, J, Nobre, C., Tomasella, J, Sampaio, G, Camargo H, 2006: The drought of Amazonia in 2005. Submitted, *J. Of Climate.*

Marengo, J. :2006 On the Hydrological Cycle of the Amazon Basin: A historical review and current State-of-the-art. Accepted, Revista Brasileira de Meteorologia.

Marengo, J (2004) Mudanças Climáticas Globais e Efeitos sobre a Biodiversidade-Caracterização do clima atual e definição das alterações climáticas para o território brasileiro ao longo do Século XXI: CREAS (Cenários REgionalizados de Clima para América do Sul). Encontro dos coordenadores dos subprojetos apoiados pelo PROBIO, Brasilia, DF, 27 a 29 de Outubro 2004.

Goncalves de Goncalves, J. Shuttleworth, B. Nijssen, E. Burke, *S.* Chou, J. Marengo, 2006: Evaluation of model-derived and remotely sensed precipitation products for South America. In Press, *J. Appl. Meteor*.

Vera C, W. Higgins, J. Gutzler, J. Marengo, R. Garreaud, J. Amador, D. Gochis, J. Nogues- Paegle, C. Zhang, T, Ambrizzi, C. Mechoso, D. Lettenmaier, 2006, A Unified Vision of the American Monsoon Systems, In press, *J. of Climate*.

Vera, C.; J. Baez; M. Douglas; C. B. Emmanuel; J. Marengo; J. Meitin; M. Nicolini; J. Nogues-Paegle; J. Paegle; O. Penalba; P. Salio; C. Saulo; M. A. Silva Dias; P. Silva Dias; and E. Zipser, 2006: THE SOUTH AMERICAN LOW-LEVEL JET EXPERIMENT (SALLJEX), In Press, Bull Am. Met Soc,

List of meetings, workshops

- -17th SSC meeting, Belem/PA, 2-4 June 2005.
- -Summer School on Environmental Modeling of Amazonia, Angra dos Reis/RJ, 10-15 April 2005.
- -18th SSC meeting, Sao Paulo/SP, Brazil, 14-15 November 2005.
- -VII Brazilian Congress of Ecology, Caxambu/MG, Brazil, 12-13 October 2005. -
- -III National Conference on Science and Technology and Innovatio, , Brasília/DF, Brazil, 12-14 March 2006
- -Meeting of the Brazilian Society for Progress in Science (SBPC), Belem/PA, Brazil, 2-3 Feb 2006.
- -Meeting of the LBA, GEOMA, PPBio and MpEG, São Paulo/SP, Brazil, 22 Feb 2006.
- -Meeting of the LBA Millenium Project, Belém/PA, Feb 23 2006.
- -Workshop LBA2 Science Agenda, Brasilia/DF, Brazil, 16-17 May 2006.
- -19th SSC Meeting, Brasília/DF, Brazil, 18-19 MAy 2006.vento: XIX Reunião SSC
- -Meeting LBA Council, Brasília/DF, Brazil, 30 June 2006.

Planned meetings, workshops

- Meeting of the LBA Superior Council, Brasília/DF, Brazil, Sep. 19, 2006.
- 10th LBA-ECO meeting, Brasília/DF, Brazil - October, 4-6, 2006.
- LBA Special Session at AGU**:** EUA, San Francisco/CA Dec. 11-15, 2006.
- Parallel Session at ESSP Conference: China, Beijing, Nov. 9-12, 2006
- Workshop LBA2 Agenda for the design of the LBA2 Scientific Agenda, Brazil, Manaus/AM, (data to be defined)
- 20th SSC meeting: Brazil, Manaus/AM, Feb. 07-08, 2007

List of SSC members and their term dates

1997 – present	Andreae, Meinrat O.
1997 – present	Artaxo, Paulo
1997 – present	Davidson, Eric
1997 – present	Gash, John H.C.
1997 – present	Kabat, Pavel
1997 – present	Krug, Thelma
1997 – present	Melack, John M.
1997 – present	Shuttleworth, James W.
1997 – present	Silva Dias, Maria Assuncao Faus da
1997 – present	Silva Dias, Pedro Leite da
1997 – present	Victória, Reynaldo Luiz
1997- present	Keller, Michael
1997- present	Nobre, Carlos Afonso
1999 – present	Avissar, Roni
1999 – present	Betts, Alan K.
1999 – present	Herrera, Rafael

1999 – present	Llerena, Carlos A.
1999 – present	Luizao, Flavio J.
1999 – present	Potter, Christopher
1999 – present	Richey, Jeffrey E.
1999 – present	Sá, Tatiana Deane de Abreu
1999 – present	Trumbore, Susan
2001 – present	Becker, Bertha Koiffmann
2001 – present	Dias, Maria Assunção Faus da Silva
2001 – present	Dias, Pedro Leite da Silva
2001 – present	Lloyd, Johnathan
2001 – present	Poveda, German
2001 – present	Vieira, Ima Célia G.
2001 – present	Viola, Eduardo
2002 - present	Alves, Diógenes Salas
2002 – present	Bustamante, Mercedes Ma.da C.
2002 – present	Malhi, Yadvinder S.
2002 – present	Mesquita, Rita de Cássia G.
2002 – present	Moore, Berrien
2002 – present	Moutinho, Paulo Roberto de S.
2002 – present	Piedade, Ma. Tereza F.
2003 - present	Asner, Gregory P.
2003 – present	Foley, Jonathan A.
2003 – present	Kruijt, Bart
2003 – present	Krusche, Alex V.
2003 – present	Martinelli, Luiz Antonio
2003 – present	Nobre, Antonio Donato
2003 – present	Reis, Eustáquio J
2004 - present	Batistella, Mateus
2004 - present	Figueiredo, Ricardo
2004 - present	Galarraga-Sanchez, Remigio H.
2004 - present	Palenque Vidaurre, Eduardo Rodrigo
2005 - present	Câmara, Gilberto
2005 - present	Carneiro Filho, Arnaldo
2005 - present	Cohen, Julia
2005 - present	Marengo, José Antônio
2005 - present	Novo, Evlyn Marcia Leão de Moraes
2005 - present	Santos Jr., Roberto Araújo de Oliveira