The Large Scale Biosphere-Atmosphere Experiment in Amazônia, Model Intercomparison Project (LBA-MIP) protocol

LBA-MIP website: http://www.climatemodeling.org/lba-mip/

Luis Gustavo G. de Goncalves (primary contact: gustavo@hsb.gsfc.nasa.gov)
Natalia Restrepo-Coupe (ncoupe@email.arizona.edu)
Humberto da Rocha (humberto@model.iag.usp.br)
Scott Saleska (saleska@email.arizona.edu)
Reto Stockli (stockli@atmos.colostate.edu)

February 06, 2008

1. Summary

A. Motivation

The importance of the land-surface dynamics of the Amazon region to the global and regional climates, including water, heat and carbon exchanges between land and atmosphere, has motivated an evaluation of the performance of the land surface models by the LBA community. During the workshop *Integrating eddy flux tower sites, remote sensing, and models to understand Amazonian carbon dynamics*, which was held in Brasilia, Brazil in October 2006 in parallel with the 10th LBA-ECO Science Meeting, a small working group was established to plan an LBA Model Intercomparison Project (LBA-MIP). The working group recognizes that by comparing the ecosystem models that simulate terrestrial energy, water and CO_2 fluxes with the continuous observations of these quantities over the LBA area will provide understanding on how well the models quantify the land surface process and define any deficiencies in the models and how they can be improved. As such, LBA-MIP will further the goals of the phase III of LBA which is focused on synthesis and analysis.

Similar studies have been conducted in the past. The well known Project for Intercomparison of Land-surface Schemes (PILPS; Pitman et al. 1993, Henderson-Sellers et al. 1993, Henderson-Sellers et al. 1995) led to a distinct improvement in the understanding of the exchanges of water and energy between land surface and atmosphere. More recently, model intercomparison projects with specific objectives have focused on particular climatic conditions (e.g. SNOWMIP-2, PILPS-urban, PILPS semi arid and PILPS C-1). LBA now provides a unique data source for extending process-based understanding of the coupled terrestrial carbon and water cycle in the Amazon. The LBA-MIP initiative has the potential to lead to an improved representation of seasonal-decadal land-atmosphere interactions in tropical climates of global climate simulations.

B. Objectives.

The goal is to gain comparative understanding of ecosystem models that simulate energy, water and CO_2 fluxes over the LBA area. **The task** is to subject all the models to the same forcing and experimental protocol, and compare the output. **The protocol** presented below proposes the model intercomparison to be executed in two major steps. The first step is to run models at eight individual LBA tower sites using the most up-to-date available atmospheric forcing and validation data. The second step is will then be to make gridded simulations with the models using the South American LDAS (SALDAS) atmospheric forcing dataset, which is based on the new CPTEC regional reanalysis and surface observations within the LBA region. Initial results from the first phase are expected to be generated in advance of an LBA-MIP workshop to be held on 24-25 September, 2007, adjacent to the 10th LBA-ECO Science Team meeting in Salvador, Brazil. These results will lay ground for more detailed subsequent analysis and simulations suitable for comparison with field data.

2. Data protocols

2.1 Sites description and driver data availability

Available sites range across a variety of land classes and soil types as documented in Tables 1A, 1B, 1C, 1D, and 1E. Each group may prescribe additional soil characteristics (rooting depth, depth-to-bedrock, among others) that better suits its model requirements. Therefore, it is required to report the parameters table used for each site and run, as well, as other model assumptions. Crop growth history for the two converted sites (Santarém K77 and FNS) and flooding history at Bananal Island (BAN), are expanded at Tables 1E and 1D, respectively:

Table 1A. Eddy covariance tower sites providing driver data for LBA-MIP

ID	Short Code	Site Name	Longitude [deg]	Latitude [deg]	Elev. [m]	Tower Height [m]	Biome Type	IGBP Link
1	BAN	Javaes River- Bananal Island	-50.159111	-09.824417	120	40	Forest-Savanna	4
2	K34	Manaus Km34	-60.209297	-02.609097	130	50	Tropical rainforest	2
3	K67	Santarém Km67	-54.958889	-02.856667	130	63	Moist tropical forest	2
4	K77	Santarém Km77	-54.536520	-03.011896	130	18	Pasture-Agriculture	12
5	K83	Santarém Km83	-54.971435	-03.018029	130	64	Selectively logged moist tropical forest	2
6	RJA	Reserva Jarú	-61.930903	-10.083194	191	60	Tropical dry forest	2
7	FNS	Fazenda Nossa Senhora	-62.357222	-10.761806	306	8.5	Pasture	12
8	PDG	Reserva Pe-de-Gigante	-47.649889	-21.619472	690	21	Savanna	9

Principle Investigators and data references for these tower sites are as follows. Please see "Important Note on Data-Use policy," at the end of this section:

- K34: Manzi, A., Nobre, A. (INPA, Brazil) [*Araujo et al.*, 2002]
- K67: Wofsy, S. (Harvard University, USA), Saleska, S. (UofA, USA), Camargo, A. CENA/USP, Brazil). [*Hutyra et al.*, 2007; *Saleska et al.*, 2003]
- K83: Goulden M. (UC Irvine, USA), Miller, S. (SUNY, Albany, USA), da Rocha, H. (USP, Brazil). [*da Rocha et al.*, 2004; *Goulden et al.*, 2004; *Miller et al.*, 2004]
- K77: Fitzjarrald, D. (SUNY, Albany , USA) [*Sakai et al.*, 2003]
- RJA: Manzi, A. (INPA, Brasil), Cardoso, F. (UFR, Brazil.) [*Kruijt et al.*, 2004; *von Randow*, 2004].
- FNS: Waterloo, M.(Vrije Universiteit Amsterdam, The Netherlands), Manzi, A. (INPA, Brazil) [*von Randow*, 2004]
- JAV: da Rocha, H. (USP, Brazil) [*Borma et al.*, submitted]
- PEG: da Rocha, H. (USP, Brazil)

Table 1B. Site characterization

ID	Short	Soil Type	USDA texture classes	Vegetation cover fraction	Canopy height [m]
1	BAN	Loamy sand	2	0.98	16
2	K34	clay latosol	8	0.98	35
3	K67	clay latosol	8	0.98	35
4	K77	clay latosol	8	0 to 0.8	0 to 0.6
5	K83	clay latosol	8	0.98	35
6	RJA	Sandy podsol	10	0.98	30
7	FNS	Sandy podsol	10	0.85	0.2 to 0.5
8	PDG	silty sand latosol	2	0.80	12

Table 1C. USDA soil texture classes

Soil No.	Name	Sand (%)	Silt (%)	Clay (%)
1	Sand	5	92	3
2	Loamy sand	12	82	6
3	Sandy loam	32	58	10
4	Silt loam	70	17	13
5	Silt	94	3	3
6	Loam	39	43	18
7	Sandy clay loam	15	58	27
8	Sandy clay	6	52	42
9	Clay loam	34	32	34
10	Silty clay loam	56	10	34
11	Silty clay	47	6	47
12	Clay	20	22	58

Percentage as mid-point value within each soil texture class [*Cosby et al.*, 1984]

Table 1D. IGBP biome classification

No.	Class name
0	Water
1	Evergreen Needleleaf Forest
2	Evergreen Broadleaf Forest
3	Deciduous Needleleaf Forest
4	Deciduous Broadleaf Forest
5	Mixed Forests
6	Closed Shrublands
7	Open Shrublands
8	Woody Savannas
9	Savannas
10	Grasslands
11	Permanent Wetlands
12	Croplands
13	Urban and Built-Up
14	Cropland/Natural Vegetation Mosaic
15	Snow and Ice
16	Barren or Sparsely Vegetated

Table 1Ea. K77 Crop growth history

Date	Cover Type K77 [*Sakai et al.*, 2003]
Before ~Nov 1990	Moist tropical forest
Jan 2000 Sep 2000 (start EC) - Nov 14,2001	Grassland (pasture)
Nov 14, 2001–Feb 24, 2001	Barren (pasture was burned and plowed)
Feb 24, 2001–Jun 13–14, 2002	Cropland (non-irrigated rice)
Jun 13–14, 2002–Jan, 2003	Barren (after harvest spontaneous re-growth of rice)

Table 1Eb. FNS Crop growth history

Date	Cover Type FNS [*von Randow*, 2004]
Before ~1977	Tropical dry forest
1977	Deforested by fire
Since 1991	Pasture (cattle ranch)

Table 1D. BAN flooding schedule*

Year	Flooding starts	Flooding ends
2004	02-Feb-2004 **	10-Jun-2004
2005	12-Feb-2005	06-Jun-2005
2006	12-Dec-2005	17-Jun-2006

*: Based on soil moisture reaching saturation, approximated dates
**: Missing data

Site-specific driver data will be available in ALMA-compliant NetCDF and ASCII formats via ftp at ftp://ezdods.ethz.ch/pub_read/stockli/lba_mip/driver/ or at the LBA-MIP website: http://www.climatemodeling.org/lba-mip/

Available data includes:

- general site-specific information (see Table 1, above), in ASCII format only from ftp://ezdods.ethz.ch/pub_read/stockli/lba_mip/vegsoil.lbamip.txt.
- Atmospheric forcing data (see Section 2.2, below)
- MODIS-derived vegetation phenological data (LAI, NDVI, EVI and FPAR), available for those models which cannot simulate fully dynamic vegetation prognostically (see Section 2.3, below).

Important Note on Data-Use policy

In accordance with LBA data sharing policy this data is freely available to all LBA researchers (http://www.lbaeco.org/lbaeco/data/data_poldoc.htm; see policy #2). Note, in particular, that policy #7 states that:

7. Where data are used for modeling or integrating studies, the scientist collecting the data will be credited appropriately, either by co-authorship or by citation. The data collectors should be informed of publication plans well in advance of submission of a paper, given an opportunity to read the manuscript, and be offered co-authorship. In cases where data from other investigators are a minor contribution to a paper, the data should be referenced by a citation. Users of the data will always have to state the source of the data

Please note that, notwithstanding the availability of this common driver dataset, the LBA data sharing policy still requires any author or presenter of this data to contact and appropriately credit PIs from individual projects that generated the data used. The necessary contact information is given in the Table 1.

2.2 Atmospheric Forcing Datasets

The forcing data are ALMA-compliant, multi-year driving data are consistently-filled meteorological observations from selected LBA flux towers (brasil flux network), including boundary conditions (site location, biome type, soil type and initial data). The data are for periods between 1999 and 2006, the exact time coverage being determined by site-specific data availability (see table below). Forcing datasets include:

a. air temperature
b. specific humidity
c. module of wind speed
d. downward long wave radiation at the surface
e. surface pressure
f. precipitation
g. shortwave downward radiation at the surface
h. CO2 will be set to 375 ppm.

These atmospheric drivers are provided at 1 hour time-step as ALMA-compliant ASCII and NetCDF format files (see http://www.lmd.jussieu.fr/~polcher/ALMA/). Models should use linear interpolation (except for solar radiation, where zenithal angle would be more appropriate) if they are run at shorter than a 1 hour time step. These data are available from the LBA-MIP website http://www.climatemodeling.org/lba-mip/ or ftp://ezdods.ethz.ch/pub_read/stockli/lba_mip/

The drivers will be distributed with leap year; groups are free to decide on the approach for leap year.

Table 2. Site-specific Availability of continuously filled driver data

<table>
<tr><th></th><th>1999</th><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th></tr>
<tr><td>1. BAN</td><td></td><td></td><td></td><td></td><td></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td></tr>
<tr><td>2. K34</td><td></td><td></td><td></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td></td></tr>
<tr><td>3. K67</td><td></td><td></td><td></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td></td><td></td></tr>
<tr><td>4. K77</td><td></td><td></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td></td><td></td></tr>
<tr><td>5. K83</td><td></td><td></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td></td><td></td><td></td></tr>
<tr><td>6. RJA</td><td></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>7. FNS</td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>8. PDG</td><td></td><td></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td style="background:#aaa"></td><td></td><td></td><td></td></tr>
</table>

2.3 Phenological information

Models with dynamic vegetation (DVMs) should be run in the mode in which they generate their own phenology (e.g., Leaf Area Index, LAI). To facilitate inclusion of those models which cannot prognostically simulate dynamic vegetation structure and phenology, a standard set of monthly LAI values derived by a phenology model [*Stöckli et al.*, in preparation] or MODIS-derived phenological information are provided (Tables 3a-c). It should be recognized that known remote sensing technical and physical uncertainties mean these data may be unreliable. However, to minimized these defects, aggregations of the best quality filtered satellite phenological information were derived for each tower site.

To facilitate comparison between models and to explore the effect of differences between dynamic vegetation model-derived and MODIS-derived vegetation phenologies, DVM's should be run in two modes if possible: i.e. in prognostic mode (in which leaf phenology is simulated) and in forced mode (in which model phenology is forced by the MODIS or phenology-model [*Stöckli et al.*, in preparation] derived). As not all sites allow for constant LAI values (e.g.: PDG or FNS), participants are encouraged to use LAI values in the following priority: modeled LAI (Table 3a), MODIS-derived monthly LAI (Table 3b) then MODIS-derived constant LAI (Table 3c). It is required to report the source of the selected LAI.

Table 3a. Modeled monthly LAI [*Stöckli et al.*, in preparation]

ID	Short	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1	BAN	5.27	5.05	4.99	4.99	5	5.14	5.24	5.26	5.26	5.27	5.31	5.32
2	K34	6.03	5.96	5.91	5.88	5.81	5.8	5.88	5.98	6.01	6.04	6.07	6.07
3	K67	5.77	5.71	5.67	5.62	5.63	5.63	5.7	5.8	5.82	5.82	5.82	5.81
4	K77[1]	2.04	1.28	0.72	0.81	0.91	1.24	2.59	2.85	2.76	2.32	2.10	2.54
5	K83	5.59	5.39	5.36	5.41	5.48	5.53	5.67	5.76	5.75	5.75	5.76	5.76
6	RJA	5.64	5.64	5.64	5.65	5.63	5.63	5.63	5.63	5.63	5.64	5.64	5.64
7	PDG	3.41	3.56	3.54	3.5	3.21	2.9	2.49	2.21	2.13	2.29	2.48	2.98
8	FNS	5.56	5.6	5.63	5.61	5.46	4.74	3.77	3.15	3.34	4.13	4.95	5.43

Table 3b. MODIS-derived monthly LAI

ID	Short	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1	BAN	5.35	4.58	4.63	4.71	4.77	4.51	4.88	4.86	4.81	4.9	4.24	5.6
2	K34	5.6	4.97	5.37	4.94	4.78	4.94	5.37	5.96	6.05	5.91	5.81	5.75
3	K67	5.08	5.43	5.58	5.19	4.93	5.33	5.22	5.56	5.15	5.55	5.5	5.73
4	K77[1]	2.04	1.28	0.72	0.81	0.91	1.24	2.59	2.85	2.76	2.32	2.10	2.54
5	K83	5.13	4.1	5.24	4.89	4.66	4.96	5	4.9	4.86	4.93	5.42	5.01
6	RJA	4.81	5.7	5.23	4.64	5.15	4.62	3.38	3.27	2.1	3.82	3.98	4.82
7	PDG	5.35	4.58	4.63	4.71	4.77	4.51	4.88	4.86	4.81	4.9	4.24	5.6
8	FNS	5.6	4.97	5.37	4.94	4.78	4.94	5.37	5.96	6.05	5.91	5.81	5.75

Table 3c. MODIS-derived average LAI

ID	1	2	3	4	5	6	7	8
Short	BAN	K34	K67	K77[1]	K83	RJA	PDG	FNS
LAI	4.8	5.5	5.4	1.85	4.9	5.1	2.4	4.3

[1] *Site history combined to LAI-2000 in-situ measurements at a similar site Santarém Km69 (18 July 2002) [Huete et al., 2007]*

2.4 Initialization and spin-up

Model physics and biophysics should be initialized as follows:

a) Soil moisture in all layers set to 0.95 of saturation (porosity)
b) Soil temperature in all layers set to the mean of the yearly air temperature
c) Because reliable carbon and nitrogen pools observations are not available, soil carbon, living biomass, etc should be spun up according to

the best practices for each model, but the spin up procedure used should be documented.

d) Initial CO_2 values will also be assumed as steady-state solution

Spin-up for model physics and biogeochemistry should use one of the following procedures:

a) Replicate the driving dataset to achieve a 10-15 year simulation run
b) Replicating the driver dataset until the mean monthly soil moisture does not deviate by more than 0.1% from the previous year.

2.5 Model output

Model outputs should be uploaded at the LBA-MIP website: http://www.climatemodeling.org/lba-mip/

The first phase of the LBA-MIP will focus on model simulations at eight individual towers using the meteorological forcing data from the LBA project. Participating models should be able to provide the defined set of variables in the ALMA-compliant format (please see ALMA website http://www.lmd.jussieu.fr/~polcher/ALMA/convention_3.html for units and details). This will allow compatibility among all the models and simplify comparisons. Output should be provided at 1-hour time-step in NetCDF for the variables listed below. The values of state variables should be given at the end of each time-step, fluxes should be averaged values over a time-step, and storage change variables should be accumulated over each time-step.

a. Model states and outputs
    i. *Carbon fluxes*: GPP, NPP, and Re.
    ii. *Energy balance and hydrology*: sensible and latent heat flux, net radiation for short and long wave, and runoff
    iii. Surface soil temperature and soil temperature by layer,
    iv. Soil moisture at the surface and soil moisture by layer
    v. Soil carbon (total, and by pools if possible, including separate litter pool)
    vi. Input parameters, re-output at the time resolution to simplify analysis
    vii. Parameters table used for soil description at each site and run, as well as other model assumptions should be reported (e.g. rooting depth).
b. Vegetation dynamics (if applicable);
    i. vegetation carbon (total, leaves, roots, woods etc. if possible)
    ii. Tree mortality, recruitment, and growth (in carbon flux and as annual rates) (broken down by components if possible: total, leaves, roots, wood)

Table 4 shows the list of ALMA variables that each modeling group should return. If a variable is not deliverable, it should be replaced by the value of -999.99 that will represent either undefined or missing value. Please note the desired sign convention for flux directionality is specified in column five of the table. Because it may vary from model to model, reporting by model preference the analysis would complicate the future comparative model analysis.

Model diagnostic variables should comply with the following radiation energy and water conservation equations. Participants are advised to check against these before submitting their results. This will ensure that diagnostics, units and timings of the submitted results are appropriate for the analysis:

Energy balance (residual at all times should be smaller than 1 W m-2):

$$SWnet + LWnet - Qh - Qle - Qg = DelCanh /dt$$

Water balance (residual at all times should be smaller than $1x10^{-6}$ $kg/m^2/s$):

$$Rainf + Snowf - Evap - Qs - Qsb + Qrec = (DelIntercept + DelSrfStor + DelSoilMoist) /dt$$

For the LBA towers neither snow nor ice is separately diagnosed since these states are not likely to occur. If this is a problem for closing the energy and water balance above, please add snow states and fluxes to respective water state and flux variables. If the model needs additional diagnostic radiation, heat and water storage terms (e.g. canopy air space water and heat storage) on the right hand side of the above equations, please add those to the diagnostic output and let us know.

Table 4A. General energy balance components:

Variable	Description	Definition	Units	Positive Dir. (Traditional)	Priority
SWnet	Net shortwave radiation	Incoming solar radiation less the simulated outgoing shortwave radiation, averaged over a grid cell	W/m^2	Downward	Mandatory
LWnet	Net long wave radiation	Incident long wave radiation less the simulated outgoing long wave radiation, averaged over a grid cell	W/m^2	Downward	Mandatory
Qle	Latent heat flux	Energy of evaporation, averaged over a grid cell	W/m^2	Upward	Mandatory
Qh	Sensible heat flux	Sensible energy, averaged over a grid cell	W/m^2	Upward	Mandatory
Qg	Ground heat flux	Heat flux into the ground, averaged over a grid cell	W/m^2	Downward	Mandatory
DelCanHeat	Change in canopy heat storage	Change in canopy heat storage	J/m^2	Increase	Mandatory
DelSurfHeat	Change in surface heat storage	Change in heat storage over the soil layer and the vegetation for which the energy balance is calculated, accumulated over the sampling time interval.	J/m^2	Increase	Recommended

Table 4B. General water balance components:

Variable	Description	Definition	Units	Positive Dir. (Traditional)	Priority
Rainf	Rainfall rate	Average of the total rainfall over a time step and grid cell.	$kg/m^2/s$	Downward	Mandatory
Evap	Total Evapotranspiration	Sum of all evaporation sources, averaged over a grid cell	$kg/m^2/s$	Upward	Mandatory
Qs	Surface runoff	Runoff from the land surface and/or subsurface stormflow	$kg/m^2/s$	Out of gridcell	Mandatory
Qrec	Recharge	Recharge from river to the flood plain	$kg/m^2/s$	Into gridcell	Optional
Qsb	Subsurface runoff	Gravity drainage and/or slow response lateral flow. Ground water recharge will have the opposite sign.	$kg/m^2/s$	Out of gridcell	Mandatory
DelSoilMoist	Change in soil moisture	Change in the simulated vertically integrated soil water volume, averaged over a grid cell, accumulated over the sampling time interval.	kg/m^2	Increase	Mandatory
DelSurfStor	Change in Surface Water Storage	Change in vertically integrated liquid water storage, other than soil, snow or interception (lake, depression and river channel etc.), accumulated over the sampling time interval.	kg/m^2	Increase	Recommended
DelIntercept	Change in interception storage	Change in the total liquid water storage in the canopy, accumulated over the sampling time interval.	kg/m^2	Increase	Recommended

Table 4C. Surface state variables:

Variable	Description	Definition	Units	Positive Dir. (Traditional)	Priority
VegT	Vegetation Canopy Temperature	Vegetation temperature, averaged over all vegetation types	K	-	Mandatory
BaresoilT	Temperature of bare soil	Surface bare soil temperature	K	-	Mandatory
AvgSurfT	Average surface temperature	Average of all vegetation, bare soil and snow skin temperatures	K	-	Mandatory
Albedo	Surface Albedo	Grid cell average albedo for all wavelengths.	-	-	Mandatory
SurfStor	Surface Water Storage	Total liquid water storage, other than soil, snow or interception storage (i.e. lakes, river channel or depression storage).	kg/m^2	-	Mandatory

Table 4D. Subsurface State Variables

Variable	Description	Definition	Units	Positive Dir. (Traditional)	Priority
SoilMoist	Average layer soil moisture	Soil water content in each user-defined soil layer (3D variable). Includes the liquid, vapor and solid phases of water in the soil.	kg/m^2	-	Mandatory
SoilTemp	Average layer soil temperature	Average soil temperature in each user-defined soil layer (3D variable)	K	-	Recommended
SoilWet	Total Soil Wetness	Vertically integrated soil moisture divided by maximum allowable soil moisture above wilting point.	-	-	Mandatory

Table 4E. Evaporation components:

Variable	Description	Definition	Units	Positive Dir. (Traditional)	Priority
ECanop	Interception evaporation	Evaporation from canopy interception, averaged over all vegetation types within a grid cell.	$kg/m^2/s$	Upward	Recommended
TVeg	Vegetation transpiration	Transpiration from canopy, averaged over all vegetation types within a grid cell.	$kg/m^2/s$	Upward	Mandatory
ESoil	Bare soil evaporation	Evaporation from bare soil.	$kg/m^2/s$	Upward	Mandatory
EWater	Open water evaporation	Evaporation from surface water storage.	$kg/m^2/s$	Upward	Recommended
RootMoist	Root zone soil moisture	Total simulated soil moisture available for evapotranspiration.	$kg/m^2/s$	-	Mandatory
CanopInt	Total canopy water storage	Total canopy interception, averaged over all vegetation types within a grid cell.	$kg/m^2/s$	-	Recommended

Table 4F. Carbon Budget:

Variable	Description	Definition	Units	Positive Dir. (Traditional)	Priority
GPP	Gross Primary Production	Net assimilation of carbon by the vegetation	$Kg/m^2/s^2$	Downward	Mandatory
NPP	Net Primary Production	Carbon assimilation by photosynthesis	$Kg/m^2/s^2$	Downward	Mandatory
NEE	Net Ecosystem Exchange	Sum of all carbon fluxes exchanged between the surface and the atmosphere	$Kg/m^2/s^2$	Upward	Mandatory
AutoResp	Autotrophic Respiration	Autotrophic respiration includes maintenance respiration and growth respiration	$Kg/m^2/s^2$	Upward	Recommended
HeteroResp	Heterotrophic Respiration	Total flux from decomposition of organic matter	$Kg/m^2/s^2$	Upward	Recommended
TotSoilCarb	Total Soil Carbon	Total soil and litter carbon content integrated over the entire soil profile	Kg/m^2	-	Recommended
TotLivBiom	Total Living Biomass	Total carbon content of the living biomass	Kg/m^2	-	Recommended

3. Intercomparison Methods and Analysis

The models compared will be divided in two categories, i.e. models that simulate carbon (C) and models that do not simulate carbon (NC). Models that simulate carbon may also participate in the simulations for group NC with their carbon component disabled. Models that simulate carbon will further be divided into fully dynamic vegetation models (which prognostically simulate vegetation phenology) and those that require phenological driving data.

The evaluation will include comparison between the model output and measured fluxes and state variables, at the different sites, namely:

a. Latent heat flux
b. Sensible heat flux
c. Ground heat flux
d. Carbon flux (NEE – Net Ecosystem Exchange)
e. Soil moisture
f. Soil temperature
g. Net short wave radiation
h. Net long wave radiation

The proposed evaluation will also be performed at different time-scales:

a. Daily mean
b. Monthly mean
c. Annual mean
d. Seasonal (dry and wet seasons analyzed separately)
e. Hourly
f. Diurnal cycle (amplitude and phase)
g. Daytime and nighttime carbon

Sensitivity analysis

A minimal standard set of sensitivity analyses are recommended for all model participants, with focus on sensitivity to precipitation and to vegetation phenology: In the case of p*henology,* in addition to runs in which MODIS phenology is used, a sensitivity run in which models use their own default phenology prescription (i.e. model calculated or from lookup tables). The following relevant driving data are available:

- Vegetation and Soil Characteristics
- ALMA NetCDF forcing data
- ASCII forcing data
- Plots of driver variables
- Annual and monthly mean LAI fields

4. Files and datasets name conventions

The file naming will follow the PILPS convention:

[modelname].[simulationcode].[sitename].lbamip.nc

where:

- [modelname] is the name of the model used;
- [simulationcode] is the convention used to identify the experiment: "c" or "nc" for carbon or non carbon, respectively, followed by the experiment number;
- [sitename] is the name of the site, for example, "ban" or "fns" or "k83" or "k77" or etc.

For example, the file "sib.nc1.k83.lbamip.nc" includes all the output for the first experiment using the sib model, without carbon at the K83 site. Files with additional information such as set of parameters used at a specific experiment or initial states should follow similar convention, respectively, e.g.:

[modelname].[simulationcode].[sitename].lbamip.par
[modelname].[simulationcode].[sitename].lbamip.ini

5. Participant Models Registration

A list of participating modeling groups is being maintained and the latest available version is given below. Groups that have not yet registered their model should provide the following information:

a. A short model description including model structure
b. A description of land surface that can be represented (topography? Land cover (plant functional types? Or biomes?, rooting depth, soil texture etc.) Although some parameters will be provided (i.e. vegetation cover, LAI, height of canopy, etc.) for LBA-MIP, the default set of parameters for the given soil and vegetation types for each site should be reported.
c. A description of the external forcing required (not calculated by the model) such as time variant and time invariant parameters, atmospheric forcing, etc.
d. Description of the "default" parameters used based on the different towers characteristics and, if any calibration is used, description of the calibration procedure and parameters affected.
e. Groups may upload models source code if desired.

6. LBA- MIP Timeframe and Deadlines

June 8, 2007:	Driver datasets at individual tower sites made available (downloadable at: http://www.climatemodeling.org/lba-mip/ and ftp://ezdods.ethz.ch/pub_read/stockli/lba_mip/)
Jun 8–Jul 10, 2007:	Initial simulation runs conducted
July 15, 2007:	Target for preliminary model outputs made available by participants
Jul 15–Sep 10, 2008:	Analysis and intercomparison of initial model outputs
Sep 24-25, 2007:	Workshop meeting to present/discuss the LBA/MIP preliminary results – Hotel Fiesta, Salvador, Brazil (just prior to the LBA-ECO 11th Science Team Meeting)
Dec 12, 2007:	Meeting at AGU, San Francisco, USA
Jan 2008:	Release updated drivers
April-May, 2008:	**Meeting at University of Arizona (proposed)**

References:

Araujo, A.C., A.D. Nobre, B. Kruijt, J.A. Elbers, R. Dallarosa, P. Stefani, C. von Randow, A.O. Manzi, A.D. Culf, J.H.C. Gash, R. Valentini, and P. Kabat, Comparative measurements of carbon dioxide fluxes from two nearby towers in a central Amazonian rainforest: The Manaus LBA site, Journal of Geophysical Research, 107 (D20), doi:10.1029/2001JD000676, 2002.

Borma, L.S., H.R. da Rocha, and O.M.R. Cabral, The effect of seasonal flooding on the surface energy and water fluxes over an ecotone in Bananal Island, Brasil, Journal of Geophysical Research - Biogeosciences, submitted.

Cosby, B.J., G.M. Hornberger, R.B. Clapp., and T.R. Ginn, A statistical exploration of the relationships of soil moisture characteristics to the physical properties of soils, Water Resources Research, 20, 682-690, 1984.

da Rocha, H.R., M.L. Goulden, S.D. Miller, M.C. Menton, L.D.V.O. Pinto, H.C. Freitas, and A.M.S. Figueira, Seasonality of water and heat fluxes over a tropical forest in eastern Amazonia, Ecological Applications, 14 (4), S22-S32, 2004.

Goulden, M.L., S.D. Miller, H.R. da Rocha, M.C. Menton, H.C. de Freitas, A.M.E.S. Figueira, and C.A.D. de Sousa, Diel and seasonal patterns of tropical forest CO2 exchange, Ecological Applications, 14 (4), S42-55, 2004.

Huete, A.R., L.G. Ferreira, T. Miura, P. Ratana, H. Yoshioka, E.E. Sano, K. Didan, T. Miura, E.P. Rodriguez, and X. Gao, LBA-ECO LC-19 Field Measurements 2002: Biophysical & Soil Parameters., edited by N.I.f.S.R.I.C. Data Set. Available on-line [http://lba.cptec.inpe.br/] from

LBA Data and Information System, Cachoeira Paulista, Sao Paulo, Brazil., 2007.

Hutyra, L.R., J.W. Munger, S.R. Saleska, E. Gottlieb, B.C. Daube, A.L. Dunn, D.F. Amaral, P.B.d. Camargo, and S.C. Wofsy, Seasonal controls on the exchange of carbon and water in an Amazonian rain forest, Journal of Geophysical Research, 112, G03008, 2007.

Kruijt, B., J.A. Elbers, C. von Randow, A.C. Araújo, P.J. Oliveira, A. Culf, A.O. Manzi, A.D. Nobre, P. Kabat, and E.J. Moors, The robustness of eddy correlation fluxes for Amazon rain forest conditions, Ecological Applications, 14 (sp4), 101–113, 2004.

Miller, S.D., M.L. Goulden, M.C. Menton, H.R.d. Rocha, H.C. Freitas, A.M.S. Figueira, and C.A.D. Sousa, Biometric and micrometeorological measurements of tropical forest carbon balance, Ecological Applications, 14 (4), S114-S126, 2004.

Sakai, R.K., D.R. Fitzjarrald, O.L.L. Moraes, R.M. Staebler, O.C. Acevedo, M.J. Czikowsky, R. Silva, E. Brait, and V. Miranda, Land-use change effects on local energy, water and carbon balances in an Amazonian agricultural field, Global Change Biology, 10 (5), 895-907, 2003.

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

Stöckli, R.C., T. Rutishauser, P.E. Thornton, L. Lu, and A.S. Denning, Remote sensing data assimilation for a prognostic phenology model, Journal of Geophysical Research, in preparation.

von Randow, C., A.O. Manzi, B. Kruijt, P.J. de Oliveira, F.B. Zanchi, R.L. Silva, M.G. Hodnett, J.H.C. Gash, J.A. Elbers, M.J. Waterloo, F.L. Cardoso, and P. Kabat, Comparative measurements and seasonal variations in energy and carbon exchange over forest and pasture in South West Amazonia, Theoretical and Applied Climatology, 78 (1-3), 5-26, 2004.