LBA-Model Intercomparison Project: Scientific Issues and Initial Results

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Introduction

The main goal of the LBA-DMIP is to understand how the different land-surface models (LSM) simulate the biogeochemical processes in the Amazon. Moreover, LBA-MIP is designed to research the land-surface processes over tropical and temperate regions of South America.

Data analysis of carbon, energy and water fluxes measured by flux towers and resulting from models produce a consistent analysis of land surface budget. We integrate such information to evaluate a suite of land surface models over the Amazon and study the effects of land cover conversion from forest to savannah in that region.

To accomplish these goals, LBA-MIP requires a data management system that will enable researches to access, understand, use and analyze large amount of diverse variables at multiple temporal and spatial scales. Based on the LBA-MIP goals, we have made an effort to make available drivers and ancillary information at the best quality possible for the modeling groups. Some of the issues with the data included time-shifting, unrealistic precipitation and downward radiation among other problems that are now resolved.

Scientific questions

1. *When do different LSMs produce better simulations when subject to he same drivers?*
2. *How models with different complexities reproduce diurnal, seasonality and annual cycles of surface fluxes? What are the magnitudes of uncertainties?*
3. *How are the land surface process controlled by water, energy and carbon fluxes.*
4. *What is the partitioning, variance, spatial distribution, and interannual variability of water and energy fluxes in response to atmospheric drivers?*
5. *What are the links between soil processes and drier climate over Amazon?*
6. *What can we learn from LSMs simulations about the interactions among water, energy and carbon in the forest-savannah-pasture ecosystem?*

Atmospheric Drivers

Drivers are observations over unique ecosystems made during LBA at eight flux tower sites across the Amazon.

The datasets are available for periods from 1999 to 2006 (multi-year) in UTC time.

The drivers comprise air temperature, specific humidity, module of wind speed downward long wave radiation at the surface, surface pressure, precipitation, shortwave downward radiation at the surface and CO2 will be set to 375 ppm.

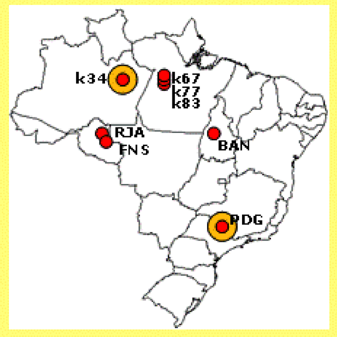


Figure 1. LBA-MIP Flux sites.

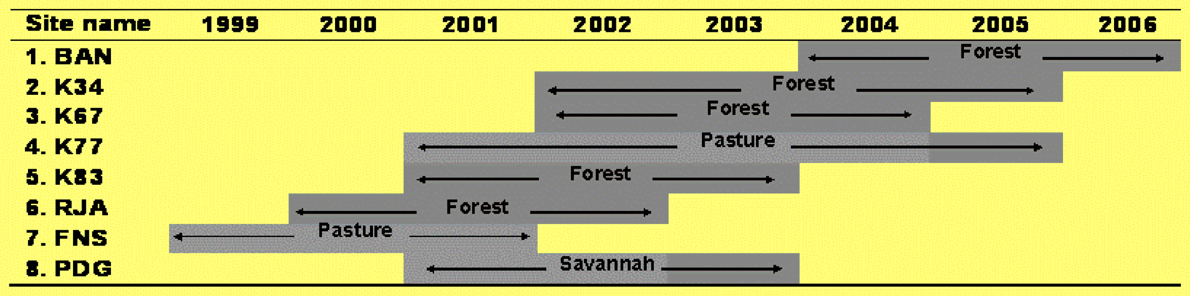


Figure 2. Site-specific availability of continuously filled driver data and your respective biome type.

Long Wave Calculation Methods

Three different methods for downward longwave radiation (LWdown) calculations were available in reason of observations gap-filling. Those methods are:

Kruk et al (2009) use Stefan-Boltzmann law, but there are differences between clear sky conditions and cloud cover, which is calculated through observed downward shortwave radiation.

Idso (1981) also use the Stefan-Boltzmann law. There is a special consideration to BAN and K67, where has missing measurements.

LWnet is based on net LW (incoming LW minus outgoing LW) observations through small changes on LWnet daily cycle from day to day at each of the sites. This method resulted of a complex and intelligent algorithm as procedure to calculate LW, which has been implemented and proposed in the LBA-MIP.

LBA-DMI Participants

	Model	Affiliation
1	ISBA	GAME/CNRM, France
2	ORCHIDEE HYBRID	LSCE, France
3	SPA	Edinburgh U, United Kingdom
4	LPJ (DGVM)	Postdam
5	CLM3 and CLMDVGM	U Arizona, United States
6	modified SiB2	USP, Brazil
7	CASA	NASA/Ames, CA, United States
8	HYLAND	Edinburgh U, United Kingdom
9	SIB2	UFSM, Brazil
10	LEAF-3	CPTEC, Brazil
11	LMBV	WHRC, MA, United States
12	LMBV	U of Arizona, Princeton U
13	IBIS	CPTEC, Brazil
14	DLEM	Auburn U, United States
15	ORCHIDEE	Ghent U, Belgium
16	IBIS and SITE	UFV, Brazil
17	SSiB2	UCLA, CA, United States
18	SIB3	Colorado State U, United States
19	FUN	U Oxford, United Kingdom
20	CoLM & UVA	INPA, Brazil
21	Biome BGC	NASA/Ames, CA, United States
22	SiBCASA	U Colorado at Boulder, United States
23	SoilCover	INPE, Brazil
24	Noah*; CLM3*	U Texas, United States
25	Biome-BGC	Boston U, United States
26	5PM	Vrije U, Netherlands
27	ED2/RAMS	Harvard U, United States

Driver Evaluation

The three LWdown drivers for the eight LBA sites were investigated regarding their frequency distribution in each month such as median, lower (25th), and upper quartiles, the interquartile range, and maximum and minimum LWdown. For K34 site, the three methods show similar results, except for OLD (Fig. 3). LWnet had median and interquartile range shifted to larger LW during the wet season (FEB to MAY) whereas Kruk and Idso showed more outliers and extremes than LWnet. The calculated average among the three methods, shows a more uniform distribution when comparing with each individual method. The previous method used in the prior analyses is also evaluated and presented the largest amplitude. We noticed however that the others have similar distribution in the forest sites.

The distribution for the PDG site, which is located in a savannah ecosystem, shows distinct characteristic for Lwnet when compared to Kruk and Idso (Fig. 4). The interquartile range and the maximum LWdown obtained from the LWnet method are shifted toward smaller values, which is related with decrease of thermal response to this region.

In the Figure 5, we see monthly mean diurnal composites for the K34 site (i.e. from 2002 to 2005). There is also the mean among Kruk, Idso and LWnet and the "OLD" LWdown. We observed that the maximum of diurnal cycle for K34 is almost the same during the wet (MAR to MAY) and dry (JUL to NOV) seasons, where the maximum was observed around 450 W/m2. However, the larger reduction in radiation night is larger during the dry season than the wet season. In the PDG site, we observed a larger variation of the diurnal cycle in the dry season with respect to the wet season (Nov to Mar) (Fig. 6). We also evaluated each of the three methods against the standard deviation (STD) of the mean temporal series among three methods. We observed the differences among three methods are not larger than the STD of the LWdown data itself. Based on preliminary analyses, we consider the LWnet as driver datasets to run the models.

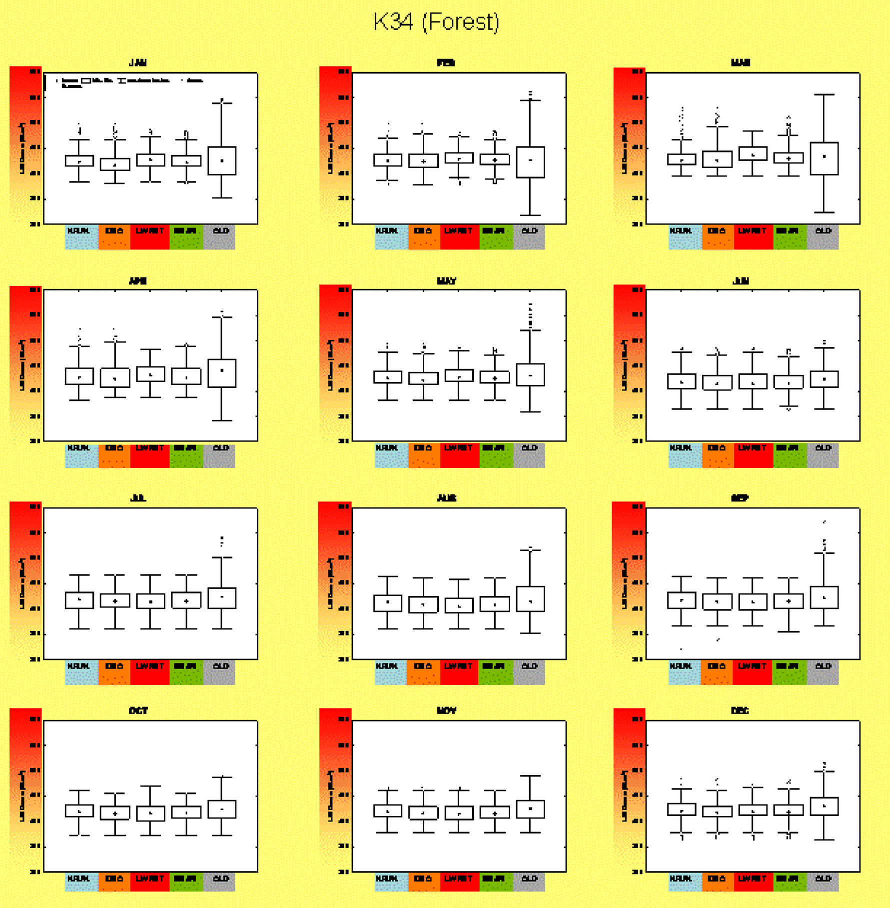


Fig. 3. Box-plot diagram illustrating the median, upper, lower quartiles and the interquartile-range of the distributions of LWdown driver datasets for each month. The limits of the boxes represent the interquartile range. Outliers are data values = 2 times the inter-quartile range and extremes are below 5% or above 95% of the distribution. For example, in JAN (a) the median is equal to all 3 drivers datasets, but maximum and minimum (no outlier) range is difference. Moreover, LWnet shows values outliers, but Kruk and Idso not, indicating that there are differences in the tails of the distribution.

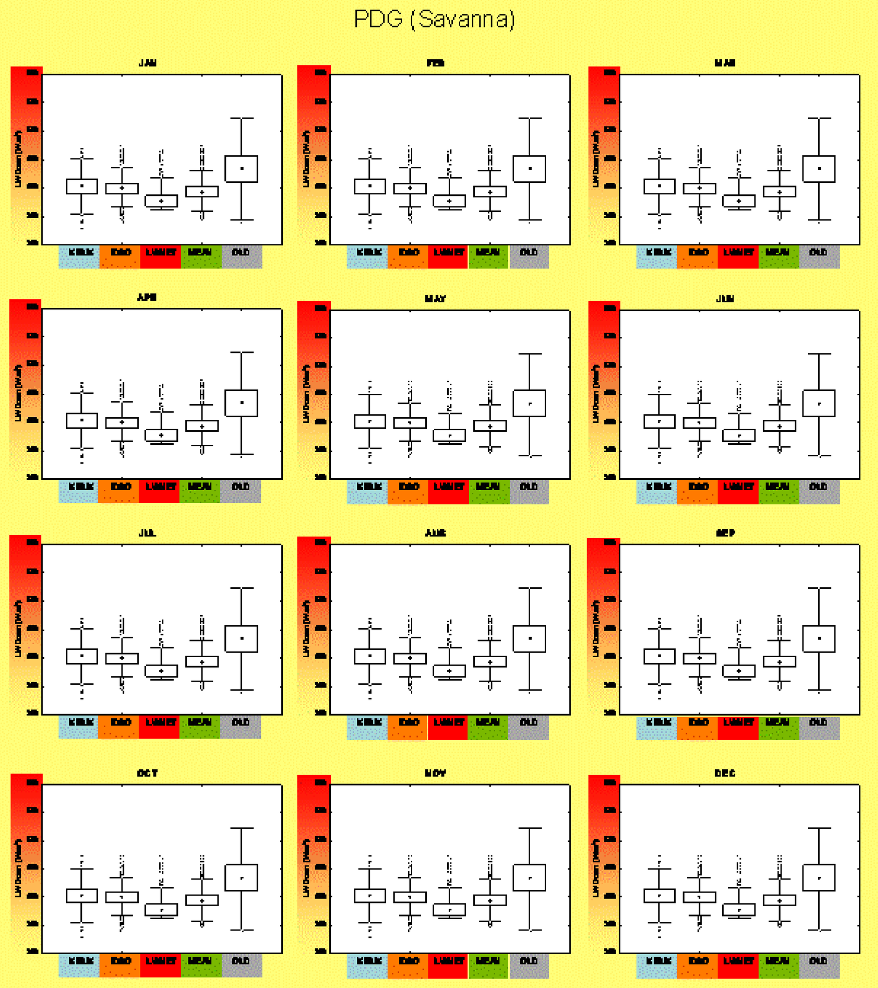


Fig. 4. Same as in Fig. 3, but for PGD.

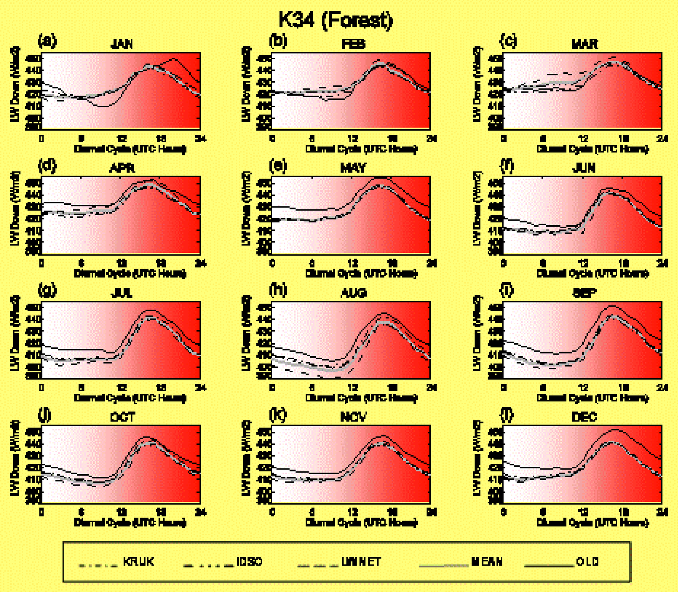


Fig. 5. Monthly mean diurnal composites 2002 to 2005 in K34 site.

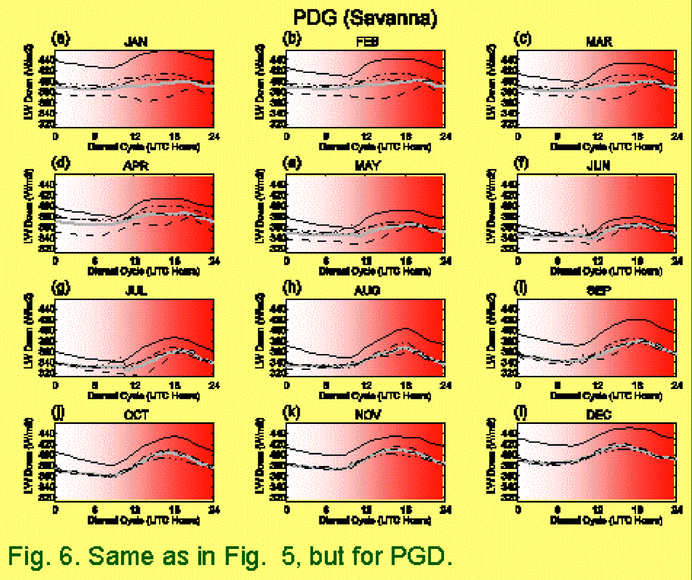


Fig. 6. Same as in Fig. 5, but for PGD.

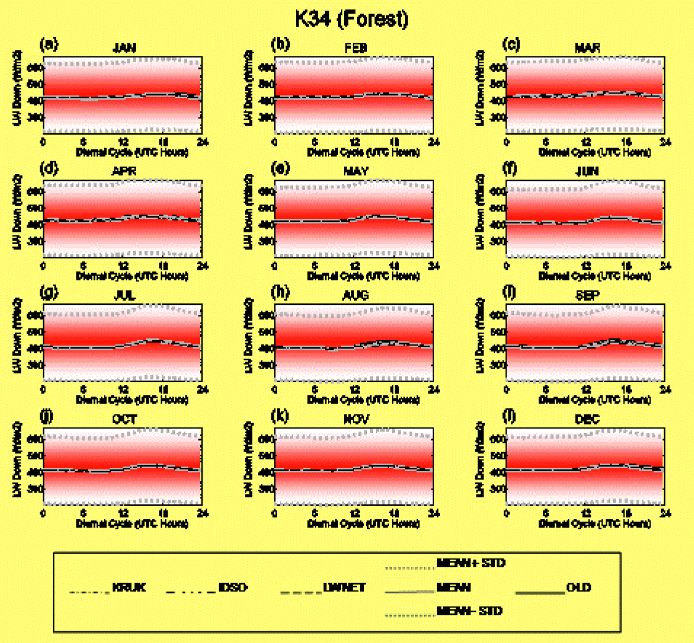


Fig. 7. Monthly RMS standardized and correlation between LWnet and others methods calculates for K34 site.

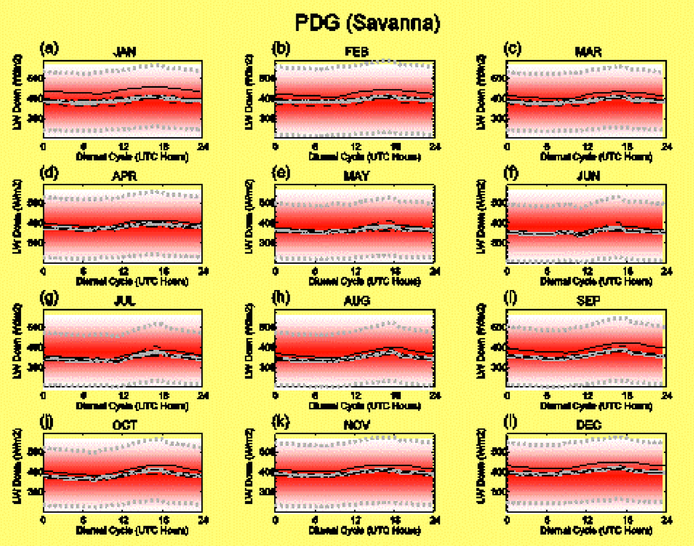


Fig. 8. Same as in Fig. 7, but for PDG.

Planning for the First Year.

We have investigated and improved drivers datasets to be released for the broad modeling community. A workshop is also being planned to ensure the analysis of the results will have maximum participation from the modeling groups. An important step to discuss and prepare the synthesis of the results. An effort was also made to adapt the initial protocol to be compatible with the North America Carbon Project (NACP) protocol. As a result, the individuals from the NACP Synthesis community are also participating in the LBA-DMIP.

Metrics for LBA-MIP

Standard Deviation (STD): Standardized indices based mean and standard deviation each model. We can have standardization based on the ensemble. STD or variance indicates if the diurnal, seasonal and inter-annual variability have right amplitude.

Bias: To examine model capabilities to reproduce the diurnal, seasonal and (mean) annual cycle.

RMS standardized: Difference between the two fields (which is normalized by the standard deviation of the ensemble).

$$SRMS_{\alpha} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i - \bar{x}_{ensemble}}{\sigma_{ensemble}}\right)^2}$$

where α is each model, n is sample size.

Correlation: To indicate whether the fields have similar variation patterns, regardless the difference amplitudes. Cross validation (for short sample data)

Space-time diagram (Taylor diagram): To compare many aspects of models or in gauging the relative skill of many different models. It is useful to provide a way of graphically summarizing as close as possible a pattern (or a set of patterns) matches observations (or ensemble). To synthesize information about skill of many different models or different initial conditions. The similarity is quantified by: Correlation, Centered RMS difference and STD

Reproducibility: The aim is to measure the ability model to respond consistently to the imposed boundary forcing. It is a measure of the unpredictability of the signal. It is useful to verification tool model-model or same model with difference in the specification of initial conditions.

- Standardized models
- Calculate the ensemble indexes
- Variance of the ensemble
- Reproducibility numerator: variance of the ensemble
- Denominator: average of the variance estimates from each i (year or season) based on m prognostics.
- E.g.: denominator equals zero, simulation has exact replica and the reproducibility is infinite.
- This measure could be used for groups of models with similar initial conditions (1xCO2, 2xCO2)

$$\langle y_i \rangle = \frac{1}{m}\sum_{\alpha=1}^{m} y_{i\alpha}$$

$$\sigma^2_{ensemble} = \frac{1}{m-1}\sum_{\alpha=1}^{m}\langle y_i \rangle^2$$

$$\overline{\sigma^2_{noise}} = \frac{1}{m}\sum_{i=1}^{m}\left[\frac{1}{m-1}\sum_{\alpha=1}^{m}\left(y_{i\alpha} - \langle y_i \rangle\right)^2\right]$$

$$\mathrm{Re}\,producibity = \frac{\sigma^2_{ensemble}}{\sigma^2_{noise}}$$

Brier score: The aim is to measure performance

- CS fraction of correct sign of the simulation models during year i (or wet/dry season).
- IS fraction of incorrect sign of the simulation models during year i (or wet/dry season).
- IS=(1-CS)

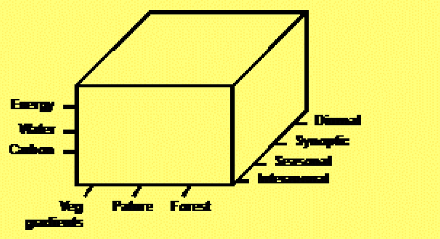
$$\overline{Bs} = \frac{1}{n}\sum_{i=1}^{n}(1-CS_i)^2.(0-IS_i)^2$$

$$\overline{Bs} = \frac{1}{n}\sum_{i=1}^{n}2(IS_i)^2$$

Bs = 0 (perfect score) to 2 (total disagreement with observation)

Synthesis

The final goal is to compare the ecosystem models that simulate energy, water and carbon fluxes over the LBA area and understand the land-atmosphere interactions from diurnal to interannual timescales. It also presents the opportunity to improve the representation of the Amazon region dynamics within the global and regional climatological frameworks. There are many ways model's simulations can be evaluated.



Conceptual diagram suggested by Dr. Ian Baker (Colorado State University)

The box to the right is a tri-dimensional representation of the multiple choices to cross-compare the results. One, for instance, might be interested on looking at Forest sites only across different timescales whereas another might be interested on fix its referential framework on interannual variability.

Acknowledgments

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