Convective systems and surface processes in Amazonia during the WETAMC/LBA

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Goals of the WETAMC/LBA

The Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) is designed to generate new knowledge, essential to the understanding of the processes within the ecology, hydrology, biogeochemistry and climatology of Amazonia , the impacts of the different land uses on these processes and the interactions between Amazonia and the global biogeophysical system of the planet. To accomplish these goals, the LBA includes long term monitoring through several landscape transects of the biosphere-atmosphere interaction and intensive field campaigns during the wet season, the dry season and during the transition between them. From previous studies in the Amazon region (see *Amazonian Deforestation and Climate* J. Gash, C. Nobre, J. Roberts, R. Victoria, Eds., John Wiley & Sons, 1996) there are significant differences between surface fluxes of heat and moisture between forested and deforested areas in the dry season. This differences are small during the wet season. The differences in the surface fluxes lead to differences in boundary layer features such as the height of the mixed layer, which have an impact on the local concentrations and long range transport of aerosol, trace gases, greenhouse gases, and atmospheric constituents in general including the ones generated by the vegetation (e.g. volatile organic compounds - VOC).

The Wet Season Atmospheric Mesoscale Campaign - WETAMC/LBA - had a focus on the local effects of deforestation, with its different impacts, as well as on the regional response to the larger scale forcing, within the lines of the LBA. The WETAMC/LBA was a joint venture between including Brazilians and Europeans scientists who joined forces with NASA/TRMM scientists , whereby a major ground validation program within TRMM, known as TRMM/LBA, was collocated with the WETAMC/LBA. The field phase of this campaign took place in the state of Rondonia in Brazil (southwest Amazonia) during January and February 1999 and had about 250 participants. TRMM/LBA had a focus on the dynamical, microphysical, electrical and diabatic heating characteristics of tropical convection in the Amazon region and a major focus on the validation of the TRMM satellite experimental products.

Together, the WETAMC/LBA and TRMM/LBA campaigns represent an opportunity to study tropical convection in Amazonia and its relation to the underlying forested and deforested regions. For the long term objectives of LBA, the WETAMC and the other planned intensive field campaigns as the DRYAMC (planned for 2002), represent the means by which local measurements are integrated and related to the larger scale picture over the basin. Besides the physical climate intensive monitoring, the WETAMC included atmospheric chemistry measurements providing a complete data base to study in an integrated approach the impact of convective clouds on the atmospheric chemistry, over pasture and forest, and vice-versa, an integrated goal of LBA as whole.

Experimental Setup

The field campaign design included several activities listed in Table 1.

Table 1. Activities carried out during the WETAMC/LBA and TRMM/LBA and the temas responsible for the operation.

Activities	**Operated by**
4 radiosonde sites performing 6-8 soundings per day,	2 Brazil/Europe 2 Brazil/USA
3 tethered balloon sites.	1 Brazil/USA 2 Brazil/Europe
1 forest 60 m micrometeorological tower instrumented with 3 levels of eddy correlation measurements and vertical profiles of	Brazil

radiation, temperature, humidity and windspeed.	
1 forest 54 m tower instrumented for atmospheric chemistry measurements, including CO2 flux.	Brazil/Europe
forest and pasture arrays for temperature and soil moisture and set of rings for soil respiration.	Brazil/Europe
1 tethered balloon for atmospheric chemistry measurements,	USA
3 pasture towers with profiles, and eddy correlation measurements including CO2 flux.	1 USA 2 Brazil/Europe
1 pasture tower for atmospheric chemistry measurements and spectral radiation measurements.	Brazil/Europe
2 wind profiler sodars, 1 with RASS, at pasture sites,	1 USA 1 Europe
network of complete AWS.	Brazil/Europe/ USA
a four-station lightning detection network, a network of flat plate antennas.	USA
A dense raingage network.	Brazil/USA
5 disdrometers,	USA
2 Doppler radars (including the S-pol and the TOGA radar).	USA
1 dual-wavelength Doppler radar profiler	USA
Citation II Learjet for in-situ sampling of microphysical variables	USA
High altitude NASA ER-2 carrying the EDOP radar (ER-2 Doppler, X band radar) and AMPR (Airborne Microwave Profiling Radiometer), a multi-frequency radiometer similar to the SMI instrument on the TRMM satellite.	USA

The aircraft operations required also the functioning of a weather forecasting office at the city of Ji-Paraná with access to NWP products from CPTEC/INPE (global COLA/CPTEC and regional ETA models) and mesoscale NWP from USP (RAMS 20 km resolution model) used in conjunction with high resolution GOES images and airport data to plan the daily flights.

Preliminary results

The average accumulated rainfall for a network of raingages located in Rondonia may be seen in Figure 1 for January and February 1999. It may be seen that three periods are clearly defined: Period 1 - from January 4th until January 15th when rains were regular; Period 2 - January 16 up to February 15 when rainfall was more scattered; and Period 3 - February 16 up to February 25 when again the rains were regular. Although the total amount for the two months (420 mm) may be considered normal, the length of Period 2 with less regular rains is not typical of January and February. However, the more scattered nature of rainfall and the very pronounced daily cycle with clear mornings and rain showers in the afternoon provides a particularly good setup for studying the interaction between surface processes and convection.

As a highlight of preliminary results the 7 February 1999 case is an interesting example of the effect of surface features on convective processes, mainly at their start, i.e., during the morning hours. Figure 2 shows the area scanned by the S-Pol radar with the vegetation classification from Calvet et al (*Bulletin of the American Meteorological Society*, Vol. 78, No. 3, p. 413-423, March 1997.). Figure 3 shows the 1.1^{o} elevation angle S-Pol radar reflectivity at 13:25 UTC AND 15:01 UTC (for local time subtract 4 hours from UTC). At 13:25 UTC there is a large decaying mesoscale convective systems in the southwest quadrant. The NW and NE quadrants were clear of clouds since early in the morning and, at 13:25 UTC, scattered cumulus clouds may be seen mainly in the NE quadrant which, according to Figure 2, is the forested area. Later on, by 15:01 UTC, the forested area in the NE quadrant is seen covered by a large number of cumulus congestus while only a few isolated clouds are seen in the NW quadrant.

The surface temperature and 30 minutes accumulated rainfall at a pasture tower (Ouro Preto D’ Oeste) and above the canopy at the forest tower (Rebio Jaru) may be seen in Figure 4. Starting from warmer nighttime temperatures, the surface layer above the forest is warmer than over the pasture. Also, it rains sooner above the forest from locally originated rain showers. Several lines of convection developed and traveled from NE to SW over the radar scanning area during the afternoon. Figure 5 shows the time evolution of potential temperature in the boundary layer in the pasture and forest stations (from the radiosonde launches at Ouro Preto and Rebio Jaru, respectively) indicating that the mixed layer over pasture grows during a longer period and becomes deeper than over the forest where the early rain showers inhibited further growth. The downward transport of high potential temperatures associated with the convective downdrafts occurs first at the forest.

This example illustrates one of the potential impacts of the land cover on convection during the wet season in the Amazon basin, which is the timing of convection initiation. From a modeling perspective, the time of convection initiation is given as a result of the physical parameterizations of radiative transfer in the atmosphere, surface heat and moisture fluxes, boundary layer turbulence and convection and/or cloud microphysics. Thus, an adequate simulation of the time of convective initiation over different landscapes is a test not only of each parameterization but mainly of their adequate coupling. The reproduction of the observed thermodynamical structure and proper timing of convection over the WETAMC/LBA by the mesoscale numerical models has proved to be a major challenge.

The effect of the early start of convection over the forest on the further development of deep convection during the afternoon is under investigation. The possible effect may be a tendency to produce more rain over the forest than over the pasture, in the long run although in individual cases that may not be so.

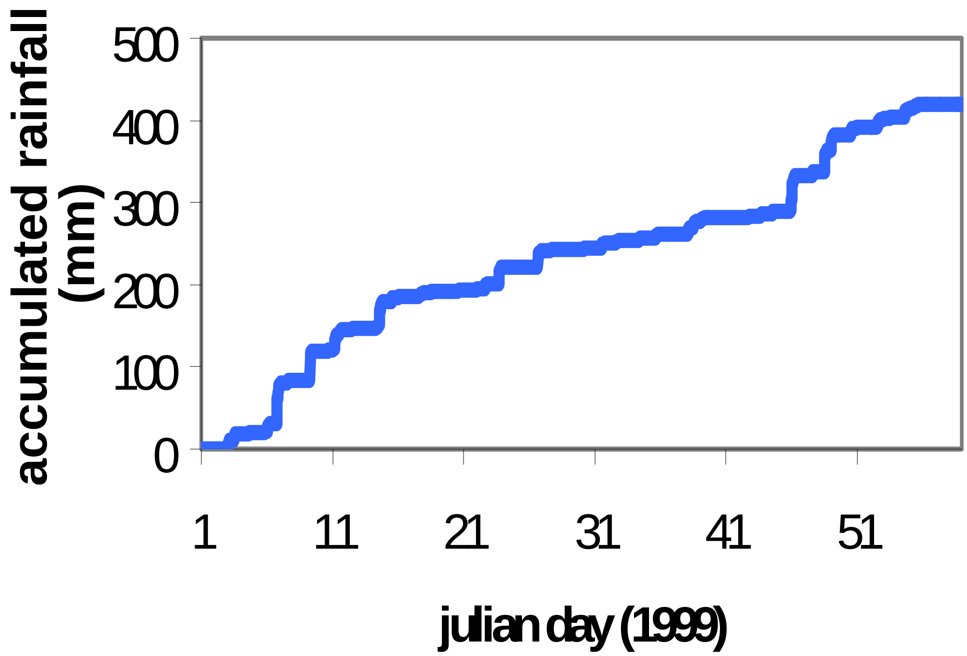
Figure 1. Average accumulated rainfall in mm for January and February 1999 for a network of 14 raingages located at about 60 km NW of the S-Pol radar location (one of the red marks in Figure 2)

Figure 2. S-pol radar scanning area. Circles are centered at the radar site located in Fazenda Jamaica and drawn at 20 km intervals. Yellow circles indicate the dual Doppler radar area. Blue indicates rivers, dark green is forest and light green is pasture or crops. In red, a few landmarks.

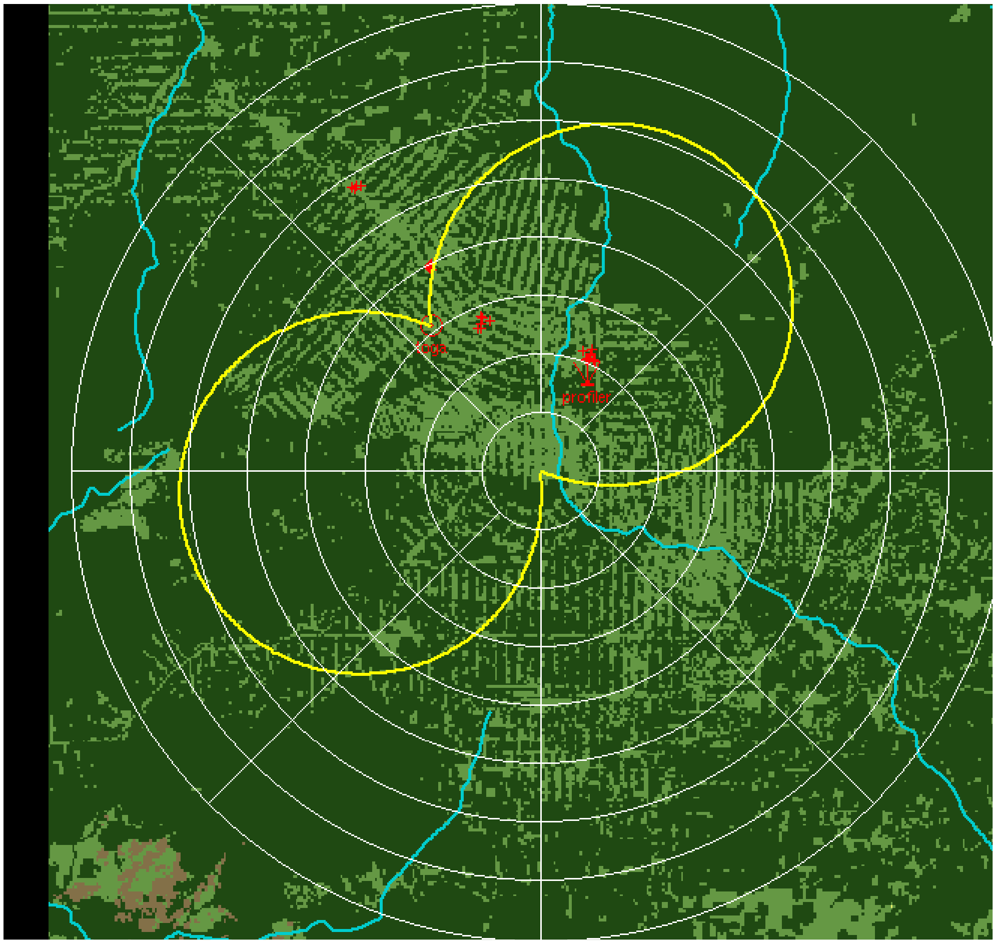
Figure 3. Reflectivity field in dbZ for elevation angle of 1.1 degrees from the S-pol radar for 7 February 1999 at 13:25 UTC and 15:01 UTC. Circles are drawn at every 40 km intervals.

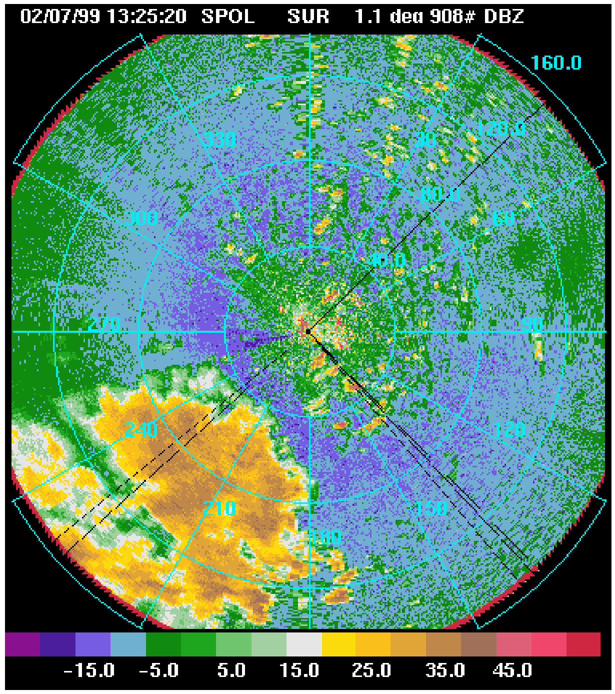
Figure 4. Surface temperature in ^{o}C and rainfall in mm accumulated in 30 minutes for the pasture (light green – Ouro Preto D'Oeste) and forest (dark green – Rebio Jaru) for 7 February 1999.

Figure 5. Height/time section of potential temperature in K from the radiosonde launches at the pasture station (Ouro Preto D'Oeste) and at the forest station (Rebio Jaru). The height in the ordinate is given in meters above sea level. Soundings operated every 3 hours.



accumulated rainfall (mm)
500
400
300
200
100
0
1
11
21
31
41
51
julian day (1999)


toga
profiler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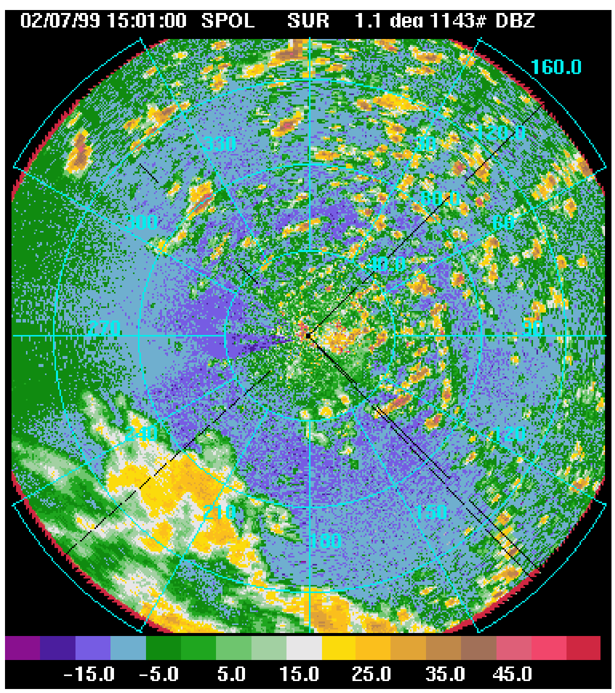
160.0
-15.0 -5.0 5.0 15.0 25.0 35.0 45.0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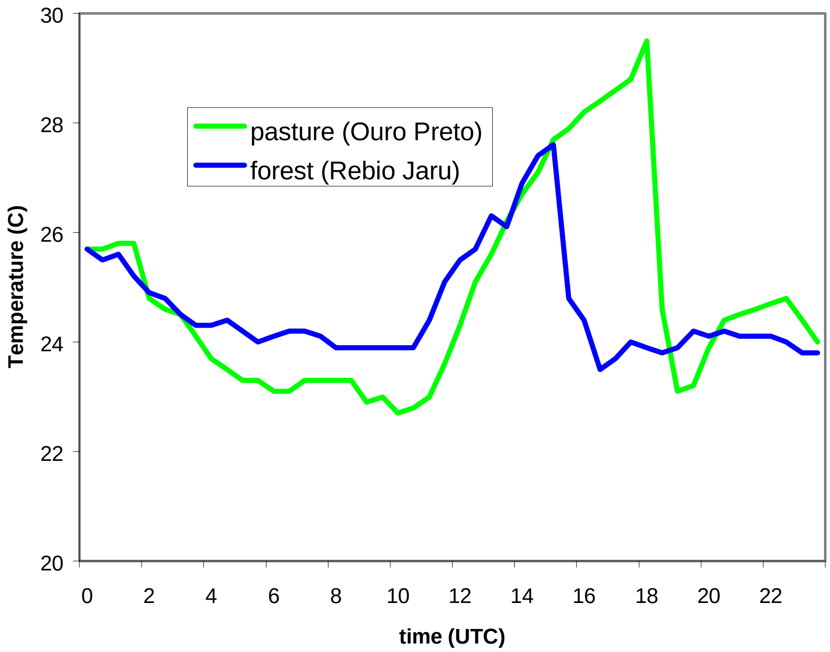
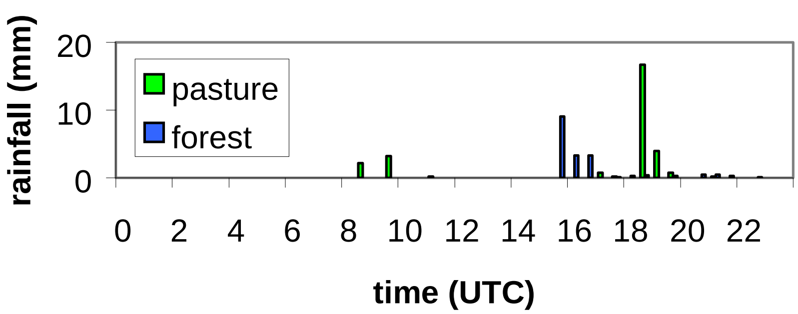
160.0
-15.0 -5.0 5.0 15.0 25.0 35.0 45.0

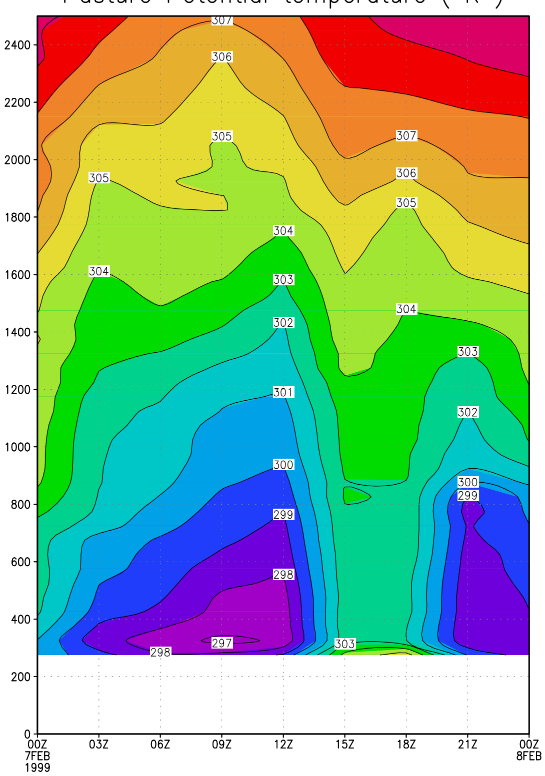


Temperature (C)
30
28
26
24
22
20
pasture (Ouro Preto)
forest (Rebio Jaru)
0
2
4
6
8
10
12
14
16
18
20
22
time (UTC)



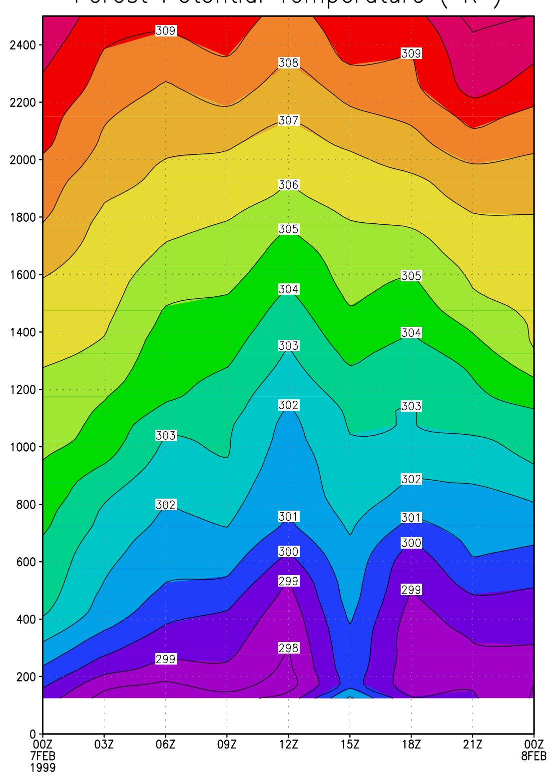
rainfall (mm)
20
10
0
pasture
forest
0
2
4
6
8
10
12
14
16
18
20
22
time (UTC)

Pasture Potential temperature (K)



GrADS: COLA/IGES 2000-02-11-13:53

Forest Potential Temperature (K)



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