LFA Journal Club (April 04, 2018)
by: Theotonio Pauliquevis

The convective boundary layer over pasture and forest in Amazonia

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With 9 Figures

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ABL - definition

“Energy, momentum and scalar properties are transported to and from the land surface through the Atmospheric Boundary Layer (ABL), the lower part of the atmosphere which acts as the link between the surface and the large-scale circulation above”

Why to address it?

- How changes in the land surface will translate into changes in the dynamics and thermodynamics of the large-scale circulation and, in the other direction, how changes in the atmospheric circulation will modify the surface climate and in turn the surface fluxes?

CBL studies in Amazonia

- Atmospheric Boundary Layer Experiment – ABLE-2 (July and August 1985, and April and May 1987)
- Anglo-Brazilian Amazonian Climate Observational Study – ABRACOS (1990 + 4 anos)

The question: how evolves CBL throughout the day for dry/wet seasons, in forested/deforested areas?

The site

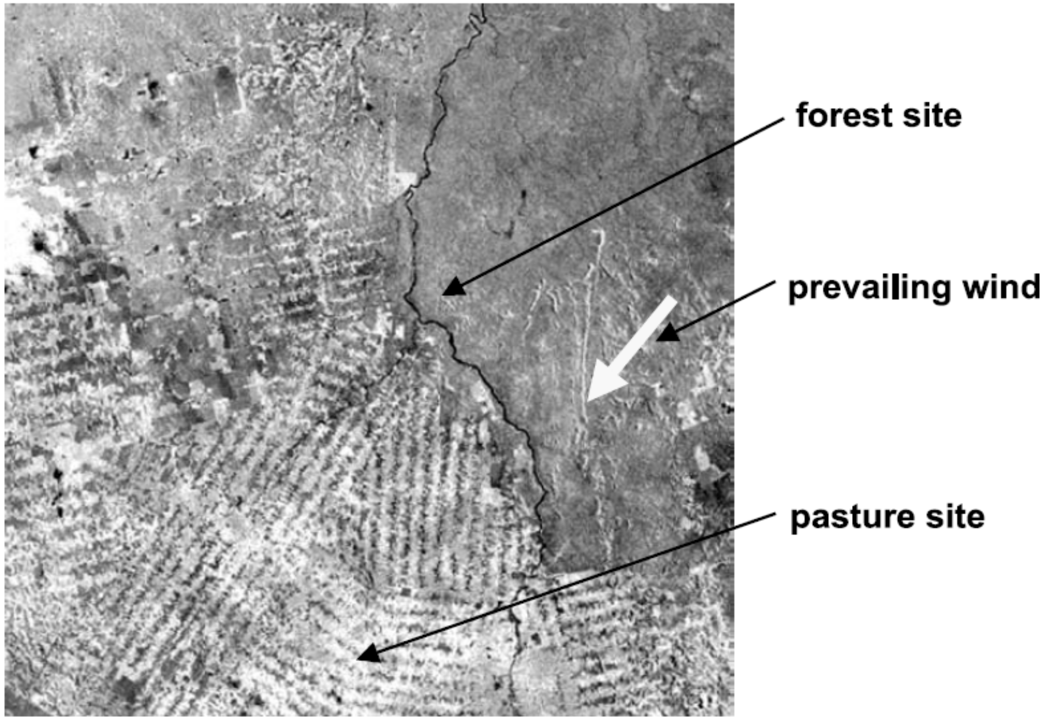

Fig. 1. The location of the forest and the pasture experimental sites. The distance between forest and pasture site is 80 km

- Wet Season Atmospheric Mesoscale Campaign (WETAMC-LBA)
- The ground validation of the Tropical Rainfall Measuring Mission (TRMM) in a tropical region

Reference: Silva Dias et al., 2002

Data

DRY PERIOD: 14 and 25 August 1994 at Rebio Jaru and Fazenda N. S. Aparecida (simultaneous soundings in forest/pasture points)

WET PERIOD: January and February 1999 (WET-AMC campaign)

➔ <u>08:00, 11:00, 14:00 and 17:00 Local Time (LT)</u>

Conditions during LBA/WET-AMC

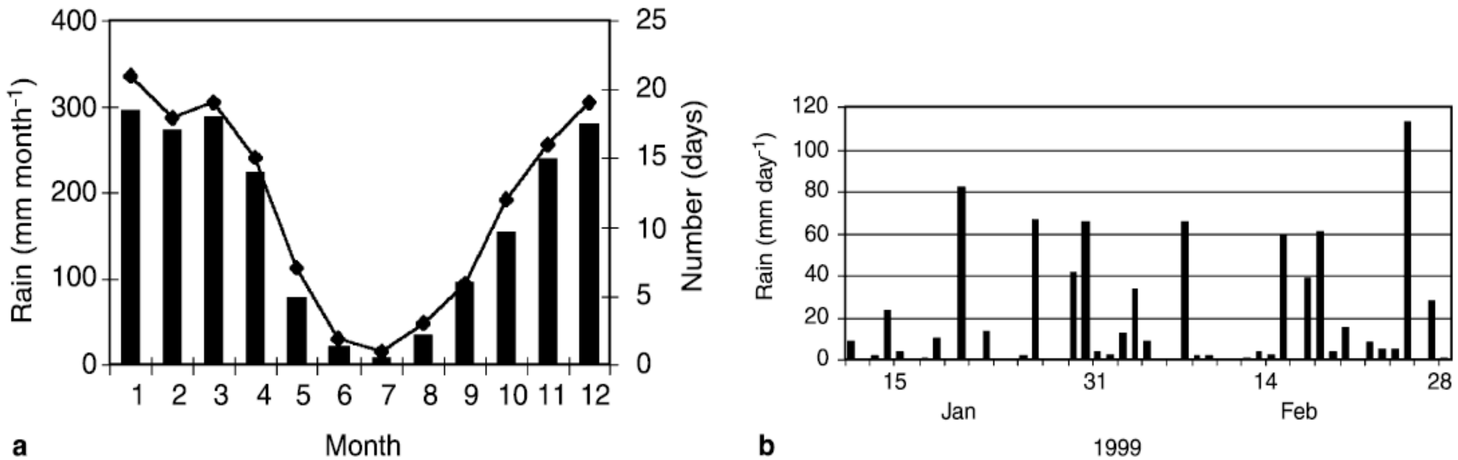

Fig. 2. Climatology of the rainfall for the Ji-Paraná area (left) and the time series of the rainfall during the LBA/TRMM (right)

- Precipitation slightly above average: 300 mm/month
- Most of the rainfall is due to convective systems (both local and mesoscale)

CBL height determination

- Computed as the height of the inversion layer,
- Estimated as the first point where the gradient of potential temperature is positive instead of zero

$$|\partial\theta/\partial z| \geq 2\,\mathrm{K\,km}^{-1}$$

This value takes into account

- Error in the temperature sensor (0.1 K)
- Vertical resolution (50 m),
- Visual inspection of the ABRACOS=RBLE dataset

Results

Table 1. The height (m) statistics (average values and standard deviation) of the CBL over the pasture and the forest sites during the dry and wet season

Local time	Pasture		Forest	
	Dry	Wet	Dry	Wet
08:00	62 ± 31 (10)	94 ± 29 (25)	75 ± 28 (12)	124 ± 50 (16)
11:00	517 ± 241 (13)	475 ± 99 (26)	267 ± 114 (13)	491 ± 133 (26)
14:00	1471 ± 479 (13)	775 ± 127 (28)	902 ± 307 (13)	813 ± 128 (19)
17:00	1641 ± 595 (13)	927 ± 166 (12)	1094 ± 385 (13)	1002 ± 195 (16)

The numbers in brackets represent the number of profiles used to compute the height

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TAXAS DE CRESCIMENTO		
HORARIO	cm/s	
8-11	4.2	3.5
11-14	8.8	2.8
14-17	1.6	1.4

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11-14	5.9	3.0
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No paper:

- m/s,
- 1.2 m/s for wet season.
- Não consegui explicar a discrepância

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?

<u>In the paper ("vertical scale"):</u>

- m/s,
- 1.2 m/s for wet season.
- Could not understand the discrepancy

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My point: different years

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SH fluxes (W/m2)		
	DRY	WET
FOREST	80-110	70-80
PASTURE	150-180	80-100

Results

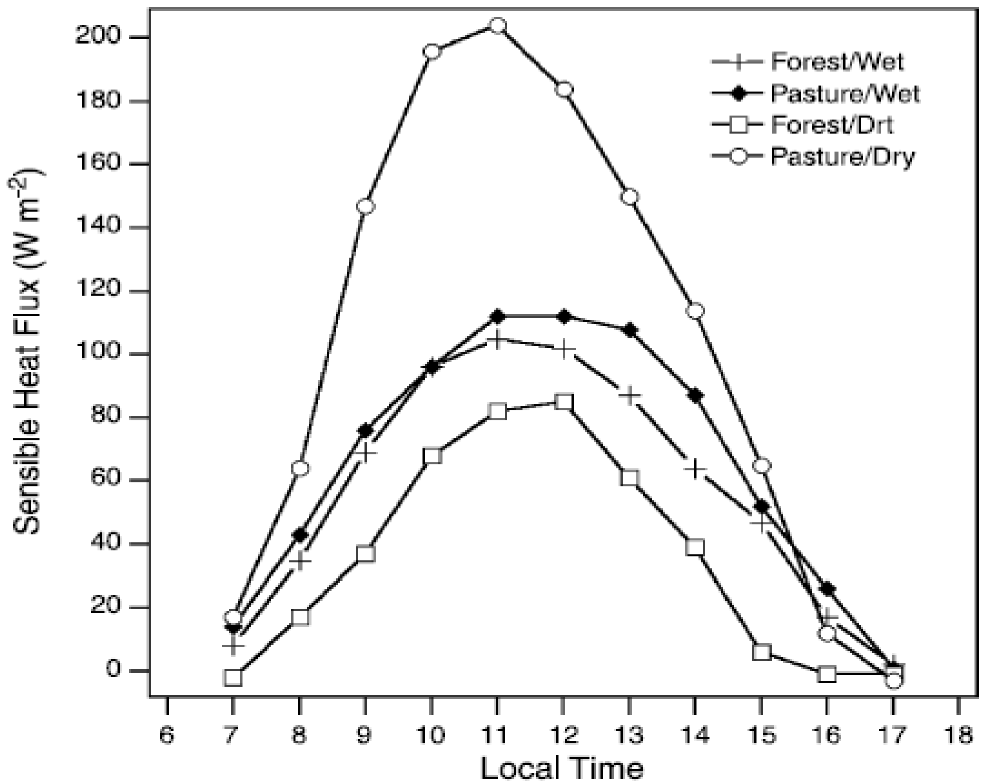

Fig. 3. The time evolution of the sensible heat flux over forest and pasture for dry and wet periods. Legend: forest/wet (cross), forest/dry (squares), pasture/wet (diamond) and pasture/dry (circles)

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	DRY	WET
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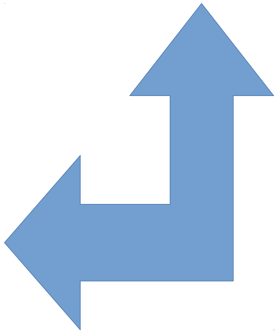


?

Results

<u>Explaining the reason:</u>

During wet to the dry of 1993, soil moisture content (down to 2.0m depth):

- 650mm to 580mm – forest
- 650mm to 450mm – pasture

→ **<u>In pasture the soil dries faster than the forest</u>**

Galvao (1999)

Summary of Thermodynamic Parameters

Table 2. Moist thermodynamics variables computed over the pasture and forest for both dry and wet periods

	Pasture		Forest	
	Dry	Wet	Dry	Wet
LCL (hPa)	841.1	927.1	898.9	942.8
Q ($g\,kg^{-1}$)	12.4	17.1	14.5	17.2
Temperature (°C)	27.0	24.9	26.4	25.1
CAPE ($J\,kg^{-1}$)	180	1194	571	1084
CAPE 14:00 LT ($J\,kg^{-1}$)	31	1205	734	1487

Results

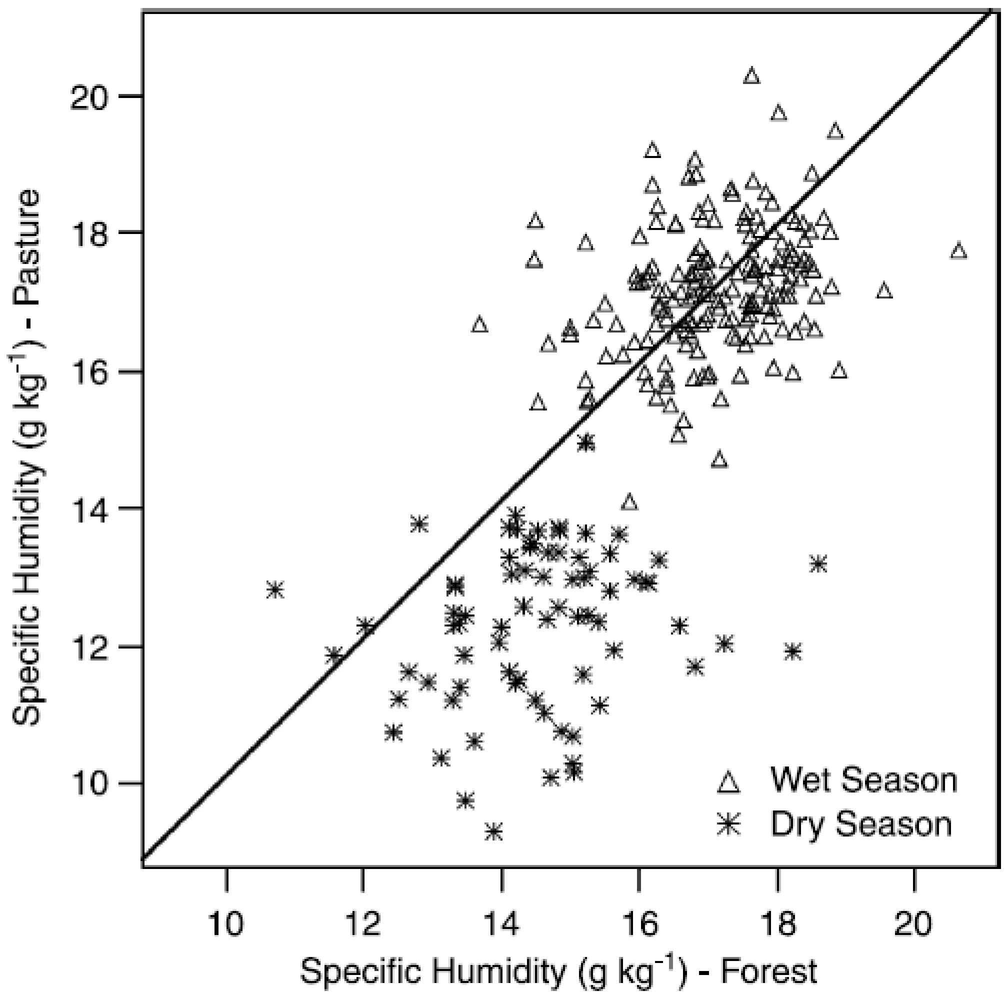


Fig. 5. The scatter plot between the specific humidity from forest and pasture sites and for wet and dry seasons

Wet season:

there is no difference between the sites;

Dry season:

the air over the forest is moister

Results

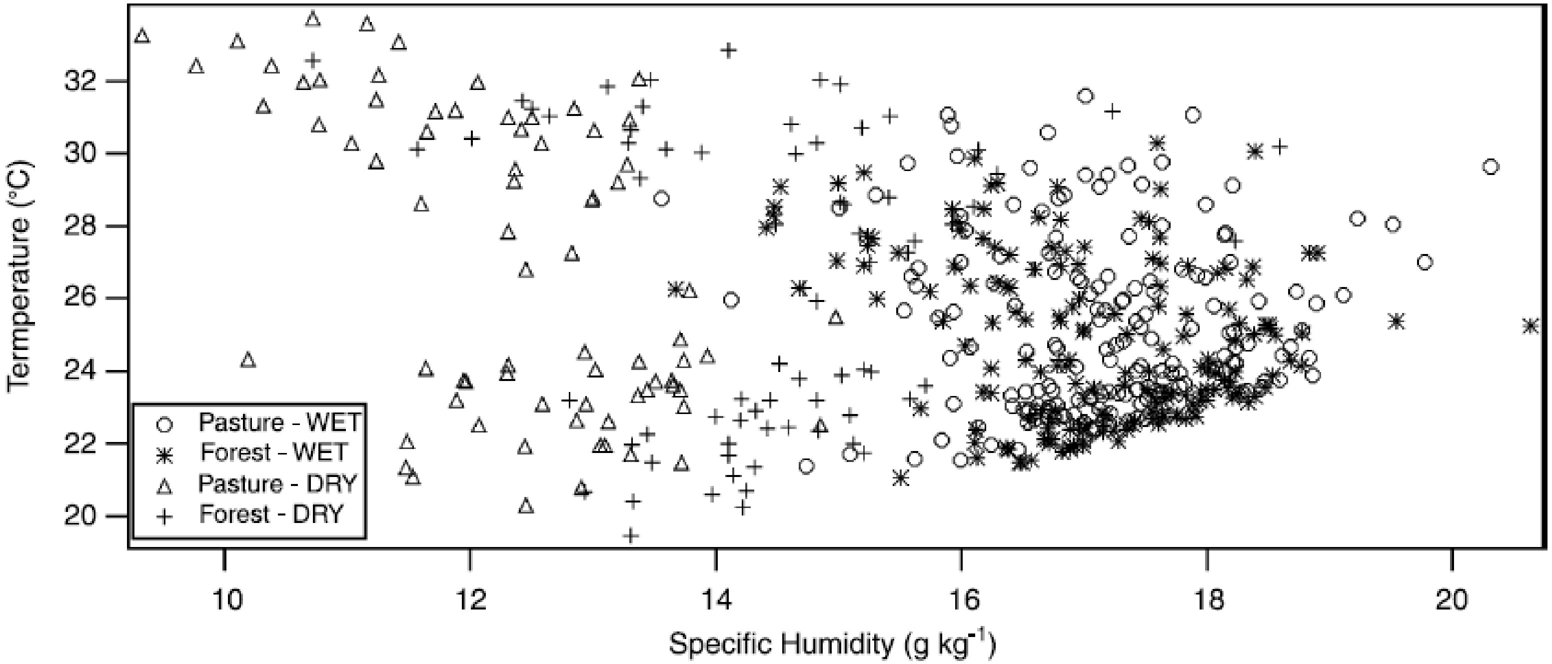


Fig. 6. The correlation between specific humidity and temperature for both sites (forest and pasture) for wet and dry seasons

<u>Another viewpoint: humidity and temperature relationship</u>

- Wet season: forest and pasture data are difficult to separate
- Dry period: clear separation between the characteristics from forest and pasture.

PROFILES

Wet season

5 February 1999
(uncommon dry day)

SUNNY

18 February 1999
(wet day, squall line)

CLOUDY

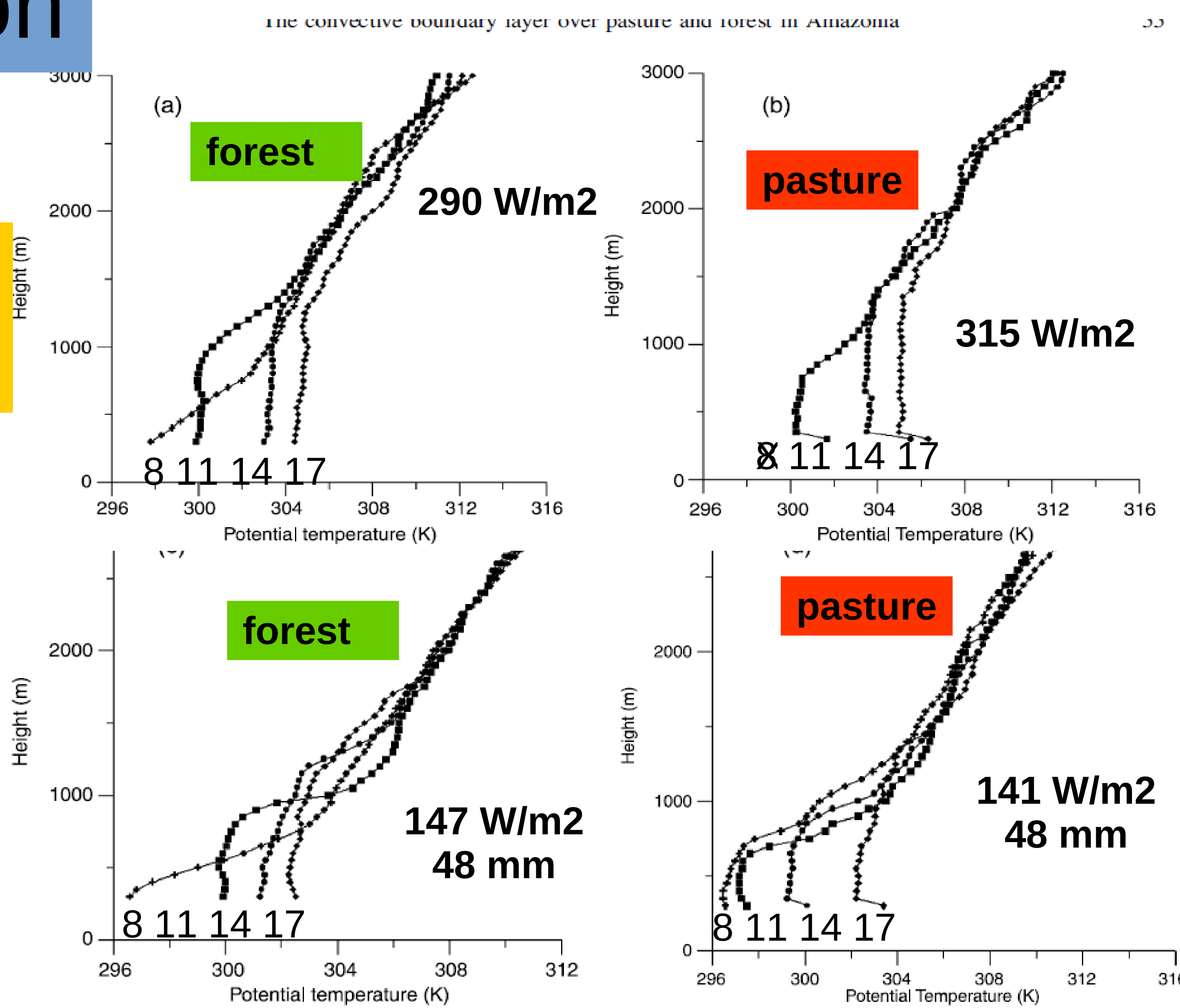
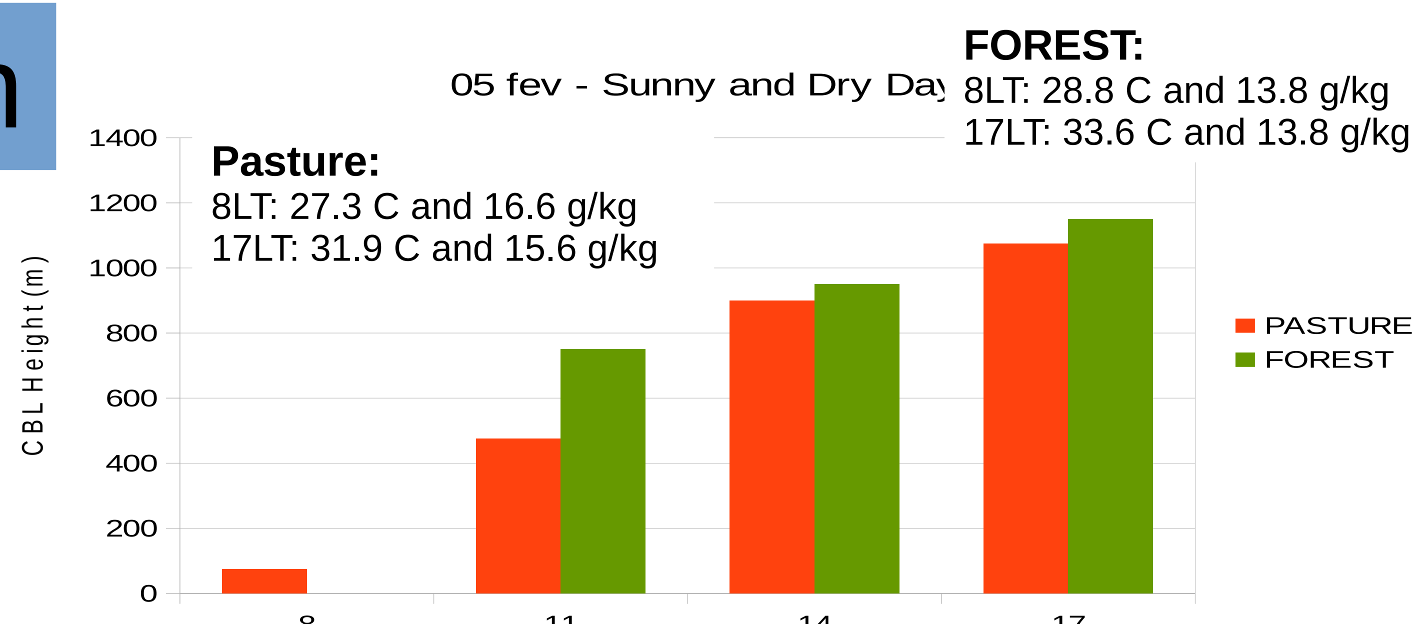


Fig. 7. Typical development of the CBL over the forest and the pasture for two representative days during the LBA/TRMM at 08:00 LT (cross), 11:00 LT (square), 14:00 LT (circles) and 17:00 LT (diamond) over the forest (a, c) and the pasture (b, d)

Wet season

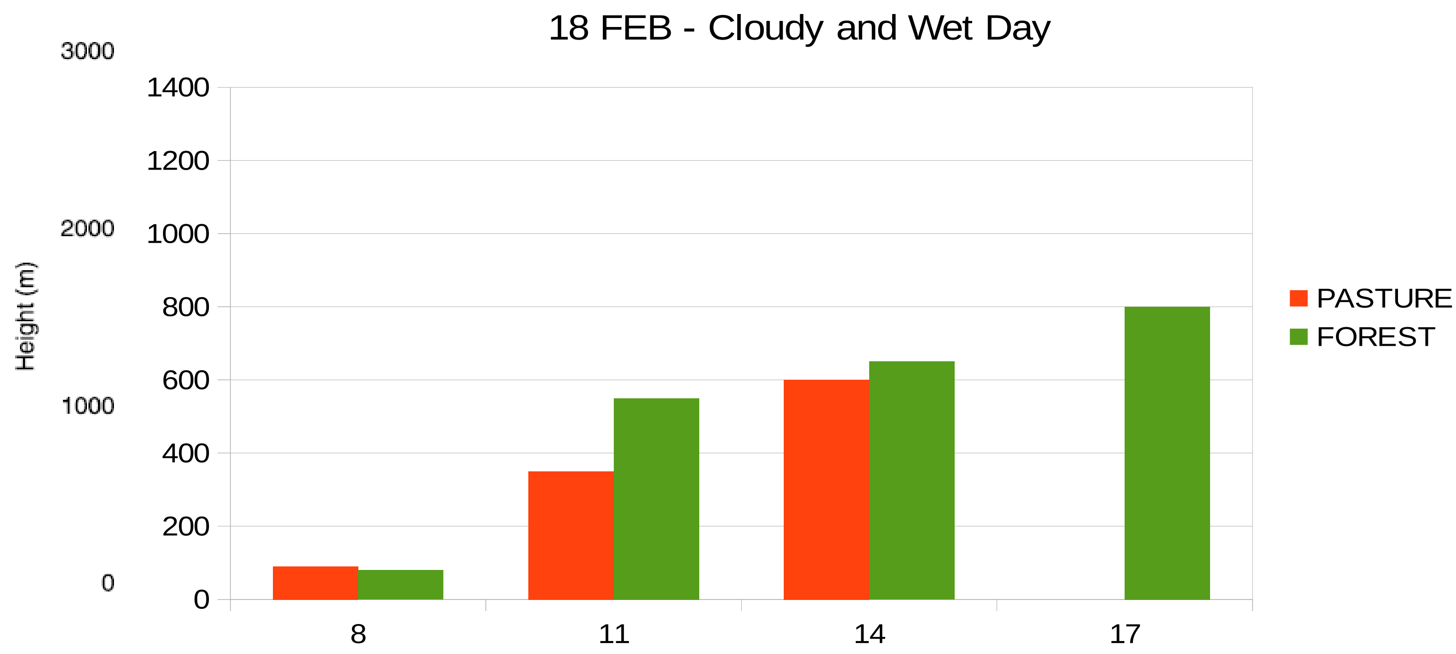
5 February 1999
(uncommon dry day)

SUNNY



18 February 1999
(wet day, squall line)

CLOUDY



The less energy is available, the lower is CBL height!

Dry season

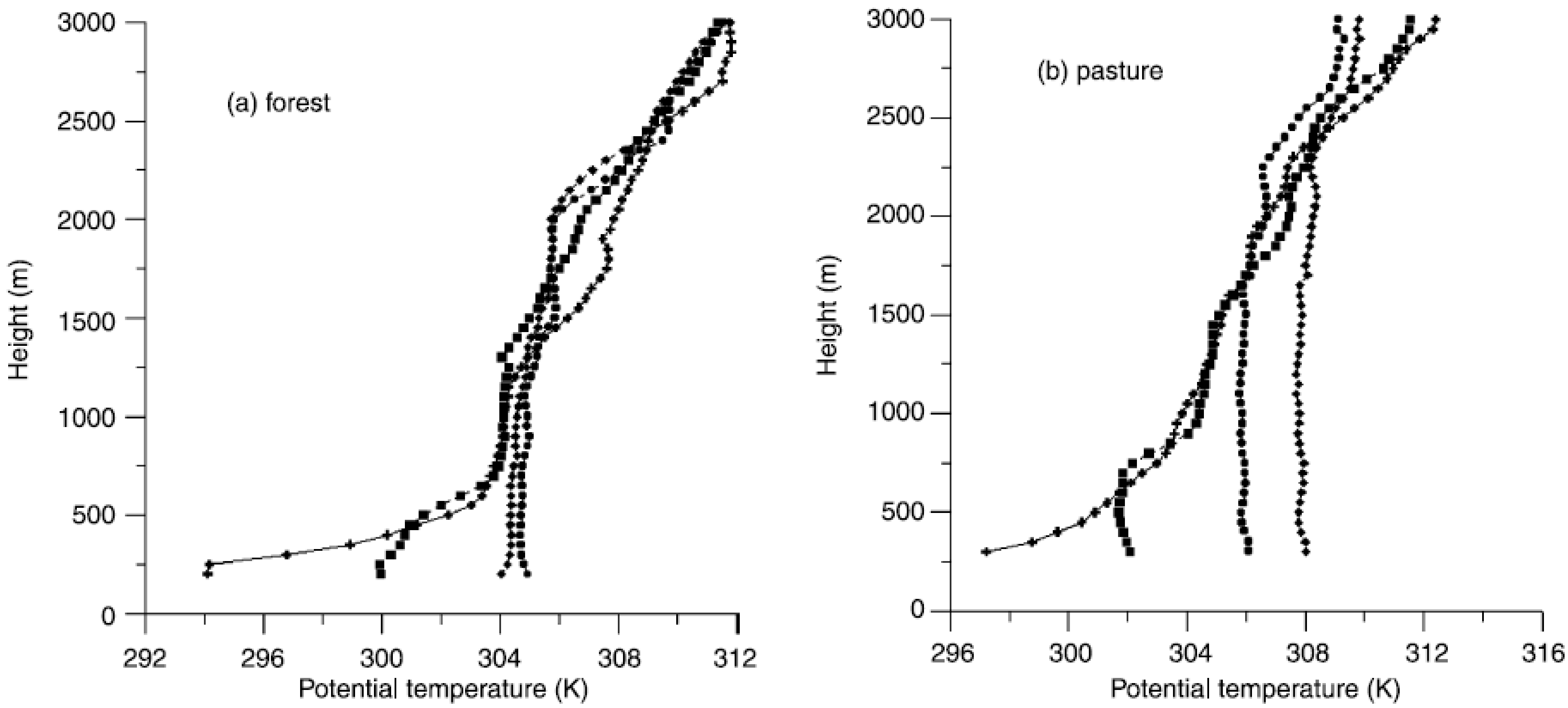
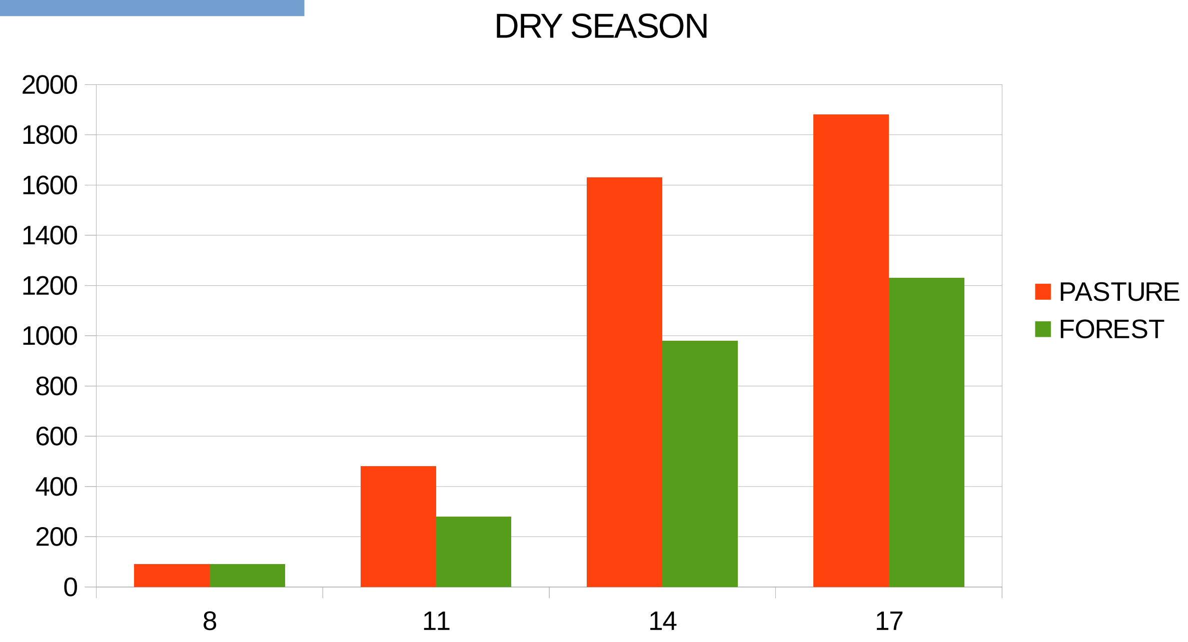


Fig. 8. Typical development of the CBL over the forest (**a**) and the pasture (**b**) for a representative day during the ABRACOS/RBLE at 08:00 LT (cross), 11:00 LT (square), 14:00 LT (circles) and 17:00 LT (diamond) over the forest (**a**) and the pasture (**b**)

Dry season



Solar radiation fluxes are almost the same:

- Pasture (206 W/m2)/Forest (208 W/m2)

Energy differently partitioned:

- Pasture SH = 49 W/m2, Bowen ratio = 0.93
- Forest SH = 22 W/m2 , Bowen ratio = 0.23

It explains why the CBL is deeper over pasture than over forest.

Conclusion

- The CBL development shows different patterns for different surface wetness conditions
- Forest site grows up to approximately 1000m, independent of the season (dry or wet).
- In contrast, the CBL at the pasture site shows strong seasonality with heights of 1650m during the dry season and around 1000m in the wet season.

Conclusion

- The soil moisture conditions in these situations determine the partitioning of surface energy and hence the sensible heat fluxes.
- This feature has a strong effect on the cloud formation regime and also for the energy budget.
- There is evidence from previous studies (Silva Dias and Regnier, 1996; Fisch, 1995) that during the dry season the land-use=land cover (forest versus pasture) can determine the structure of the CBL.
- In this situation, the synoptic situation is very weak and the surface is strongly coupled with the ABL.

Conclusion

- Conversely, for the wet season the large-scale convection seems to be the dominant factor in shaping the development of the CBL, as both surfaces have similar characteristics (height and growth of the CBL, convection properties, etc).

Thank you for your attention!