Observational analysis of the daily cycle of the planetary boundary layer in the central Amazon during a non-El Nino year and El Nino year (GoAmazon project 2014/5)

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Second Review

Even though I do realize the authors put a strong effort to analyze the data, I do have some fundamental questions about this work. They were scattered in my previous review, and I will consolidate here (since I believe they have not been adequately addressed). My apologies for the long comments. However, I want to be thorough, since some of the responses from the 1st review might be due to a lack of explanation from my part.

Major Concerns:

1. The reason that I asked about the methods of the CBL/NBL height determination is because I do not understand figures 4 and 6: why the PBL is continuous? If one gets the PBL evolution in textbooks (e.g. Stull fig. 1.7), he/she will see that the CBL and NBL will start from the ground. So, there will be a discontinuity at 6am (formation of the CBL at surface), and 6pm (formation of NBL at surface). This continuous PBL might be due the lack of detection of the lidars (as someone noted the overlap problem), but it should not be a problem for the MWR, and RASS scalar profiles. The authors also might check the temperature and moisture profiles at the flux tower and see when the NBL starts. When the heat flux becomes negative at about 5pm (figs 3 and 5), the NBL will start to set at the ground (the temperature inversion at the ground), and the surface will be disconnected with the layer above. So, it is very hard to understand how the NBL will have a 300-500m inversion at 6pm. Unless, the NBL is generated by mechanical turbulence. However, this goes against the appearance of the LLJ, in which the stable layer is formed by radiative cooling (Greco et al, 1992, Boundary Layer Meteorology journal).
2. I do not understand the authors reasoning for the collapse of the CBL during the late afternoon hours: "The CBL measured by the instruments showed a decrease in its height around 16 LT. This collapse is associated with the lower intensity of the thermal convection. Although there are a reduction in H surface fluxes by this time, it is still positive (but weak). After 17 LT the H fluxes became negative and the PBL started its stable phase (NBL)". Maybe it is a problem of using aerosol backscatter as a proxy of the CBL. If not, then as stated in the previous review, H by itself does not contributes for the PBLH growth, or the rate of change of temperature, but it is its flux divergence. Using a box model frame, a positive sensible heat flux at the ground still contributes to the PBL growth. So, the collapse of the CBL during the late afternoon would be a positive entrainment flux at the top, or a horizontal divergence at the side of the box. I have not seen such CBL collapse (this is not a slow collapse, as the authors wrote in one the responses), unless there is some precipitation and/or an air mass modification. Can the authors provide the 8pm potential temperature and mixing ratio profiles from the 8pm soundings? So, one can see the height of the residual layer (RL), and a proof of such CBL collapse.

3. Also, I have some issues with the erosion of the NBL discussion during dawn period. I notice that Carneiro et al. (2019, C-19) has a very similar plot and analysis. Also, the fact that the remote sensing instruments do not capture the formation of the CBL at 6-8am does not mean that the CBL is not established during this period (as written in line 334-335). The CBL is being formed at 6-8LT because there is positive H. This positive H will erode the NBL residual layer. So, the PBL is defined by the CBL growth – that is not shown in figures 4 and 6. After the stable layer is dissipated, there is no reason to discuss the erosion of the NBL. Therefore, if the CBL starts to grow at 6am for IOP 2 and IOP 4, it means that the stable layer has already been dissipated (possibly because there is not a strong temperature gradient as depicted in C-19, figure 1).
Carneiro, R. G. et al. , 2019. Erosion of the nocturnal boundary layer in the central Amazon during the dry season. Acta Amazonica, http://dx.doi.org/10.1590/1809-4392201804453

Old Specific Comments (my comments in italic):

2. Methods

d. Radiosonde PBL estimation, it only shows for the procedure for the convective boundary layer (CBL), what are the criteria for the nocturnal boundary layer (NBL)?

The Radiosonde PBL estimation showed CBL and NBL the criteria was used two profile method used for CBL and NBL by Santos and Fisch, (2007), Seidel et al., (2010) and Wang et al. (2016).

d2. According to the authors "using the vertical profiles of θ and q the height of the PBL was calculated by identifying the vertical level 94 where there was a systematic increase in potential temperature and a sudden reduction in specific humidity". This seems criteria for the CBL height detection, but not the NBL. Citing Seidel et al. (2007): "The top of a surface-based inversion (SBI) [Bradley et al., 1993]. While the three methods above allow for the possibility of an unstable or neutral PBL, a surface-based T inversion is a clear indicator of a stable boundary layer, whose top can define a PBL height. If an SBI is found in a sounding, the other six methods are not evaluated, as they assume a different PBL structure."

3. Results, discussion, conclusion: there are some parts that needs some work and/or clarification.

a. There are several comparisons among several parameter (precipitation, H, LE, PBLH) for wet/dry season or El Nino/non-El Nino years. However, averages are presented without any uncertainties, so the authors cannot affirm that those averages are different.

The averages are presented with uncertainties, as the shading in figures 3 to 6 indicates the standard error of the instruments. Significant tests were made with average/standard deviations

between wet and dry periods. Which have been described in the captions of the respective figures.

a2. So, which tests were made? Are those statistical tests? If so, is there any significant levels? I believe the authors should incorporate these suggestions in the text. Just writing to reviewers does not clarify the manuscript and its future readers.

c. Are the CBL or residual layer (RL) shrinking for all remote sensing PBLHs during the afternoon? I wonder about this because H is still positive till about 16:30-17:00LT.

The CBL measured by the instruments showed a decrease in its height around 16 LT. This collapse is associated with the lower intensity of the thermal convection. Although there area reduction in H surface fluxes by this time, it is still positive (but weak). After 17 LT the H fluxes became negative and the PBL started its stable phase (NBL).

c2. The authors must be consistent! According to lines 251-252" "Diurnal (convective) and nocturnal (stable) conditions were separated by vertical lines at 06 and 18 LT". According to the authors' response, the 18LT is not the delimiter of convective conditions, and it should be 17 LT, or whenever H changes sign.

j. Lines 310-312: If one connects the red dots in figures 4,6, he/she can see a diurnal pattern in the RS PBLH time series.

I agree, there is a daytime cycle pattern of the PBL.

j2. Lines 357-359: "The RS, in spite of it being a proven high-precision method, it not captures the all daily cycle evolution of the height of the PBL, due to the long-time interval between launches" is not right, still. If the radiosonde has an upward velocity of 5 m/s, then one can launch a radiosonde every 30 minutes, or even, every 15 minutes – and will be able to probe the whole PBL for this site.

Minor Concerns:

a. *I am not familiar with the Vaisala RS92 SVG. However, how the radiosonde measures the dew point temperature (line 92)? I guess there is some confusion of what is measured and what is derived in this sentence.*

b. *The same can be written about ceilometer (line 147). As a colleague wrote, the BL-View is a software that estimates the mixing layer height (MLH), and not the PBL height. The ceilometer does not measure the MLH.*

c. *Lines 273-276: "*However, Acevedo et al. (2004), also studying in a pasture site in the Amazon (in Santarém-PA), observed lower NBL heights than those from the current study (between 50 to 150 m), and this difference occurs because of different geographic conditions (Santarém suffers the influence of river breeze) ". *However, Manaus is also influenced by the River Breeze circulation, no? According to Oliveira and Fitzjarrald (1992, Boundary Layer Meteorology journal), this circulation is responsible for the LLJ formation.*

d. *Figure captions: "*instrument error*" seems not accurate. For instance, which instrument measure turbulent fluxes? What is the error for the net radiometer? Probably much less than the Rn variation in 1 hour – principally during daytime. I believe should be "parameter uncertainties", or better, "standard deviation". No reason to let readers wondering about the meaning of "instrument error".*

e. *The standard deviations values from tables 2 and 3 seem too small for the shaded areas in figures 4 and 6, don't they?*