Dear Mr

ACP Editor

Firstly, I would like to thank the new scientific review, which contributes to a better article for sure. Below I describe item by item, the questions of the referee. My answers are in blue and the changes in the text also are in blue color.

Below are the responses to referee

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).

The reviewer´s observation is correct. However, the continuous measurements (like ceilometer) of the sensors during the hours of 17 to 18 HL capture the CBL (in its decay phase forming RL) and the NBL begins to form (from the surface), as shown in Figure S1 of the supplementary document (figure below). This figure shows the measurements at 16 second intervals. As one of the objectives of the paper is to have a complete daily cycle of PBL (including CBL and NBL), we decide to leave the continuous line. However, this observation was indicated in the text.

Remote sensors capture multi-layers from the heights of the PBL in the transition interval (day-night, between 17 and 18 LT). Figure S1 (presented at the supplementary material) shows the heights obtained through the ceilometer every 16 s, where the blue points represent the CBL (that is in its decay phase or Residual Layer) and the red points the NBL that is forming from the surface. However, as the one of the goal of this paper is to have a complete picture of the PBL cycle, the NBL heights were neglected in Figures 4 and 6, in order to show only the decay of the CBL convection.

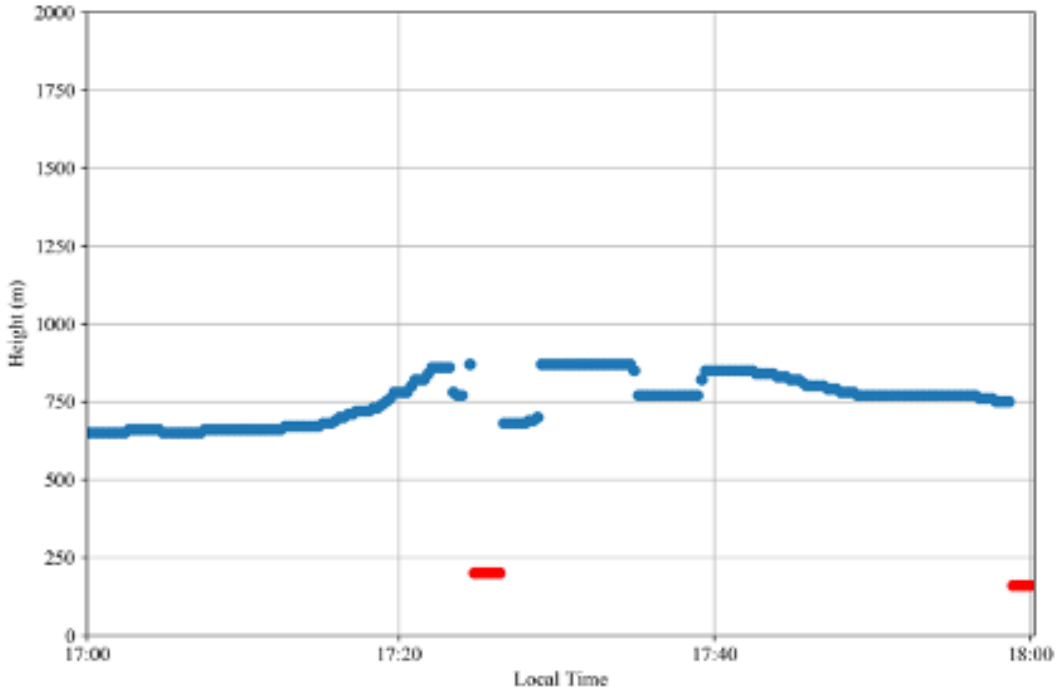

Figure S1 Height of the PBL for the sunset transition, with the blue dots referring to CBL and the red dots referring to NBL.

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.

As requested by the reviewer in order to answer the question were made the potential temperature and specific humidity profiles of the IOPS at 20 LT (Figures 2 below). Additional figures for wind u* and windspeed were also added in the range of 16 to 06 LT (Figures 3 and 4 below).

The vertical profile of potential temperature (Figure 2 A) and specific humidity (Figure 2 B) made with the radiosonde launched at 20 LT also showed this residual layer. In complement, the temporal variation of the u* and windspeed (Figures 3 and 4, respectively) showed that the collapse of the CBL is reduced by the mechanical turbulence that occurs near the sunset transition.

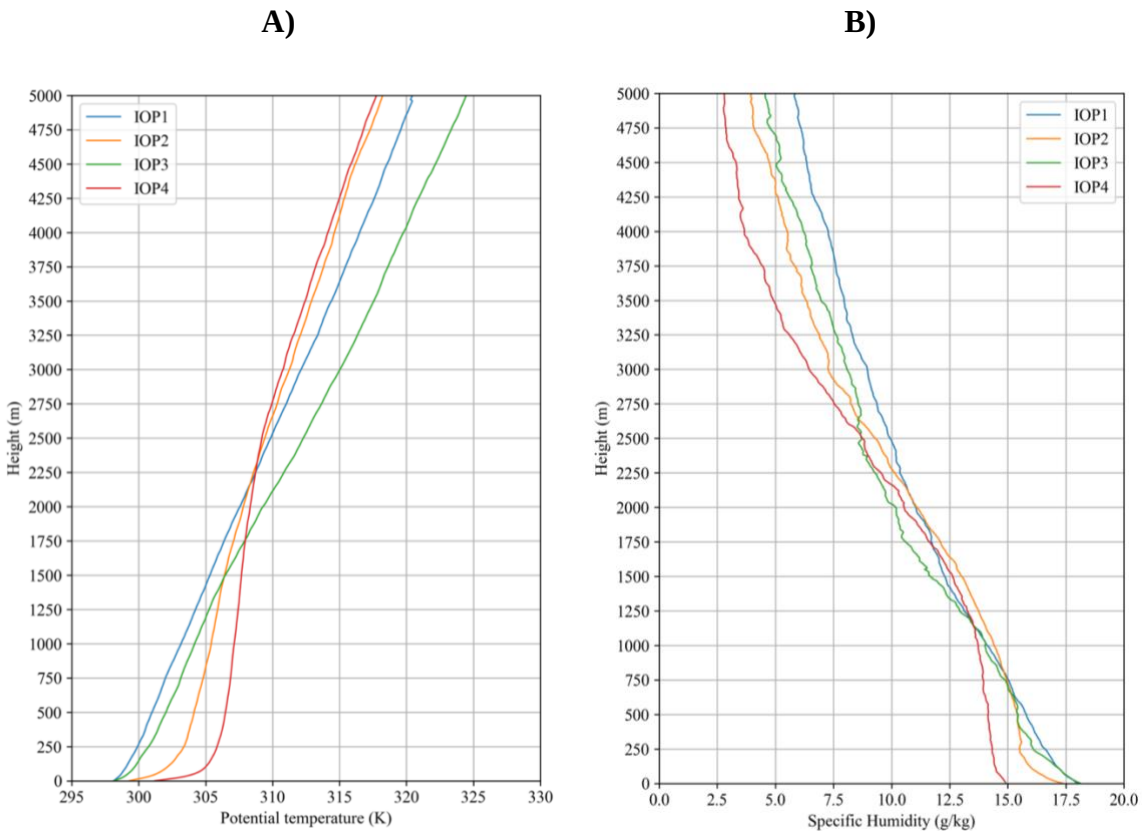

Figure 2 Vertical profile of potential temperature (A) specific humidity (B) at 20 local time of the 4 IOPs

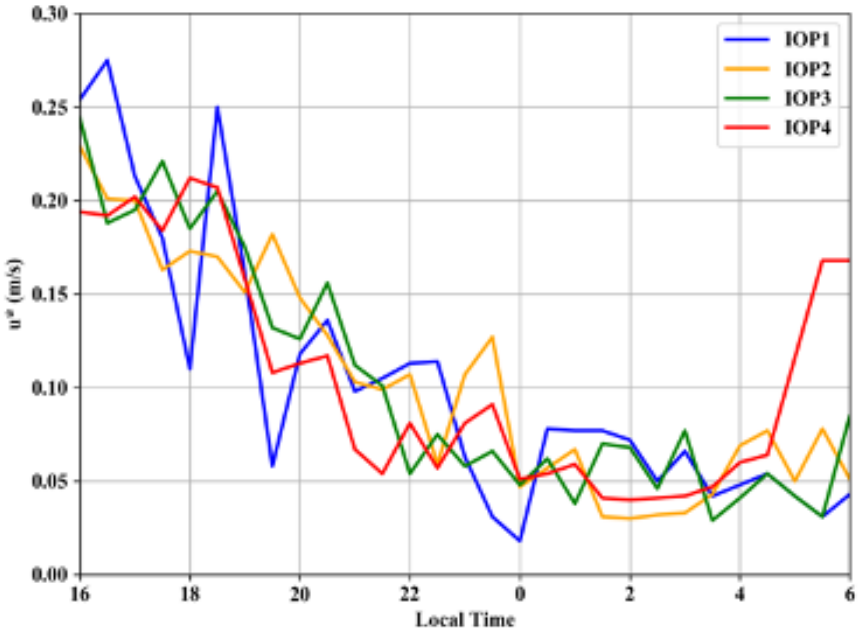

Figure S3 Average of the u* (m/s) during transition from night to day of the 4 IOPs.

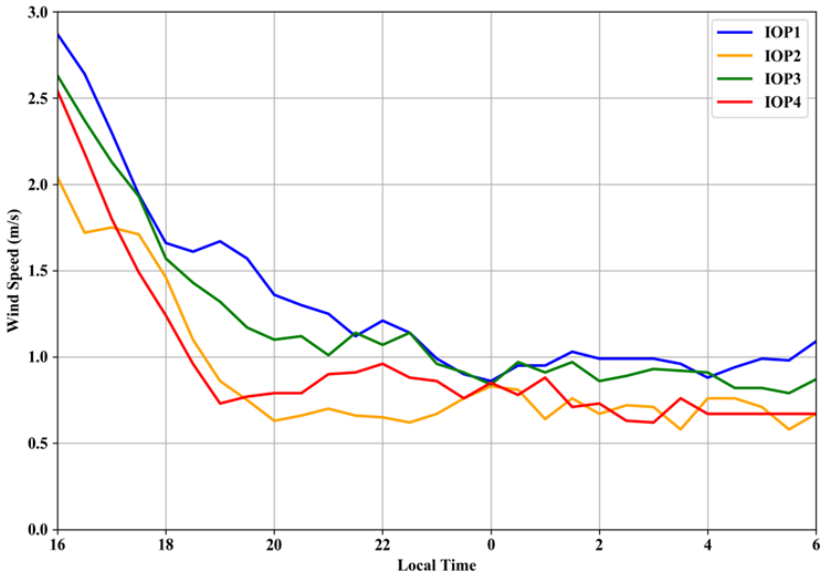

Figure S4 Average of the wind speed (m/s) during transition from night to day of the 4 IOPs.

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

According to Stull (1988), the complete erosion of the NBL occurs when the whole layer is mixed, the potential vertical gradient is almost null and as a consequence there is a high growth rate (like 100 m h^{-1}). So, before (say 2-3 hours) after sunrise, there are still several layers (see Figure 1.7 and the S4 point in a Figures 1.11 from Stull, 1988, figures below). In order to be more elucidated, a figure of the PBL heights was added to the supplementary document every 10 minutes of the day-night transition period (Figure S3) and the H flux in the same interval (Figure S4) (figures below). Nevertheless, we have included a statement to clarify this point (text below).

The transition from nighttime to daytime is very complex. Although the H has become positive (so heating the atmosphere), this amount of energy did not completely warm the atmosphere, eroding the previous (or old) NBL. So, the height of PBL was considered to be (still) NBL (see Figures S3 and S4 in the supplementary material). The PBL height will be CBL only when the NBL is completely eroded.

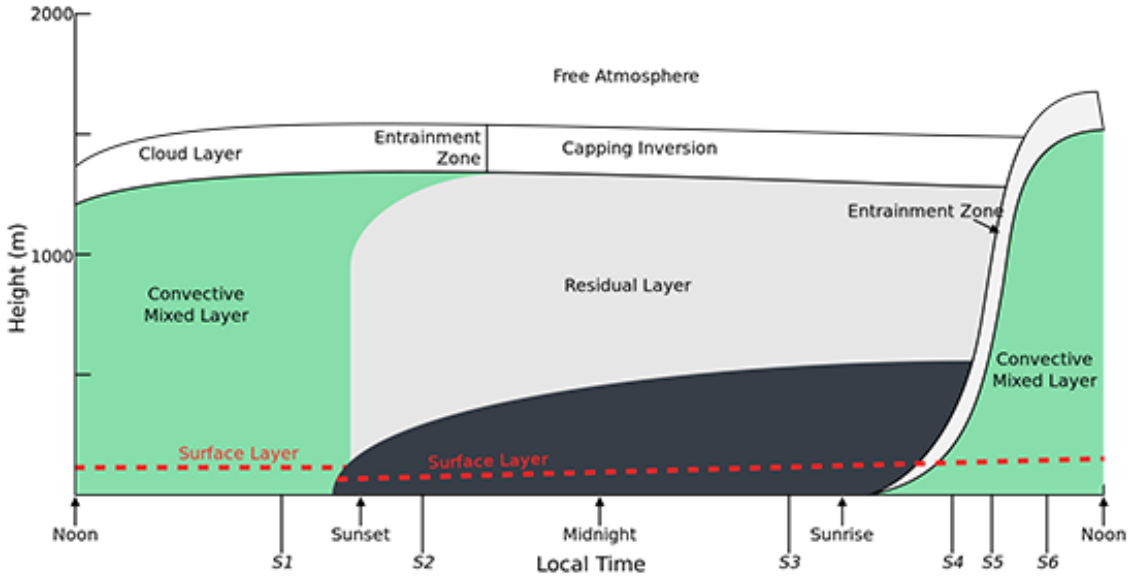

Figure 1.7 The boundary layer height consists of three major parts: a very turbulent mixed layer; a less-turbulent residual layer containing former mixed-layer air; and a nocturnal stable boundary layer of sporadic turbulence.

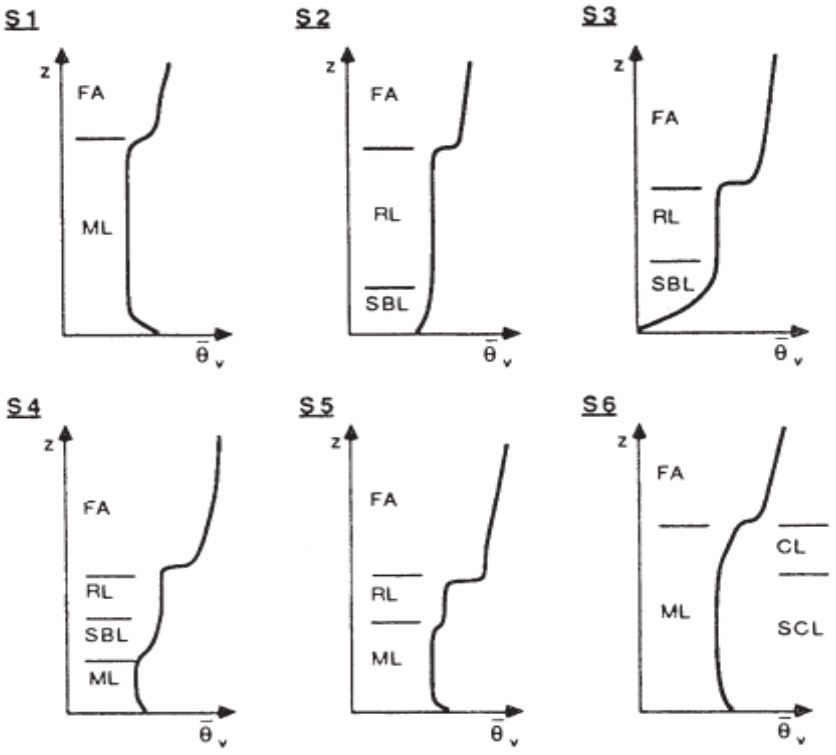

Figure 1.12 Profiles of mean virtual potential temperature θv, showing the boundary-layer evolution during a diurnal cycle starting at about 16 local time identify each sounding with an associated launch time indicated in Figure 1.7.

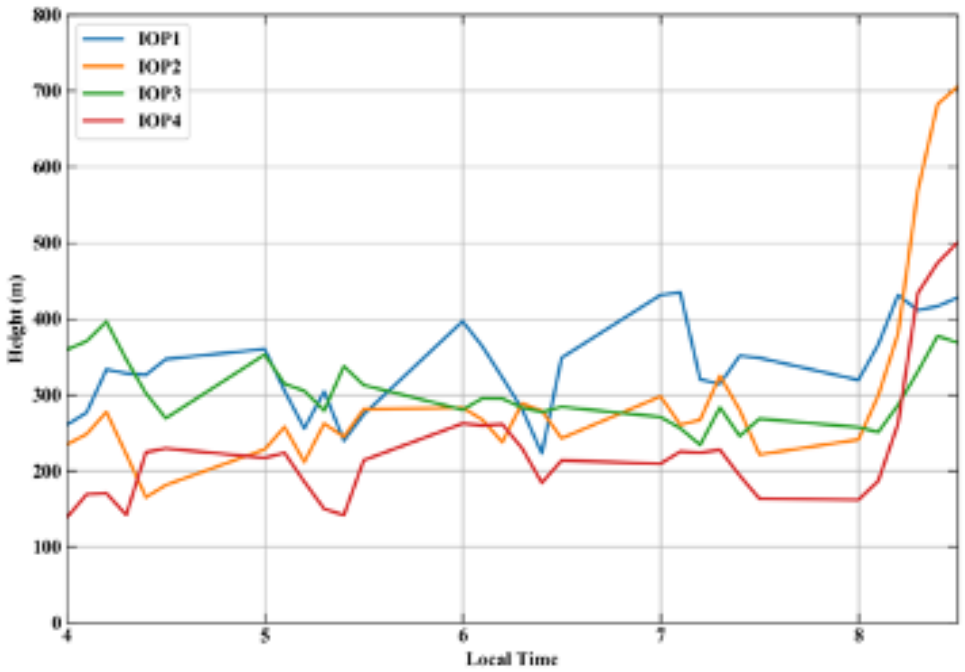

Figure S3 Transition from night to day PBL of the ceilometer for 4 IOPs, averaging every 10 minutes.

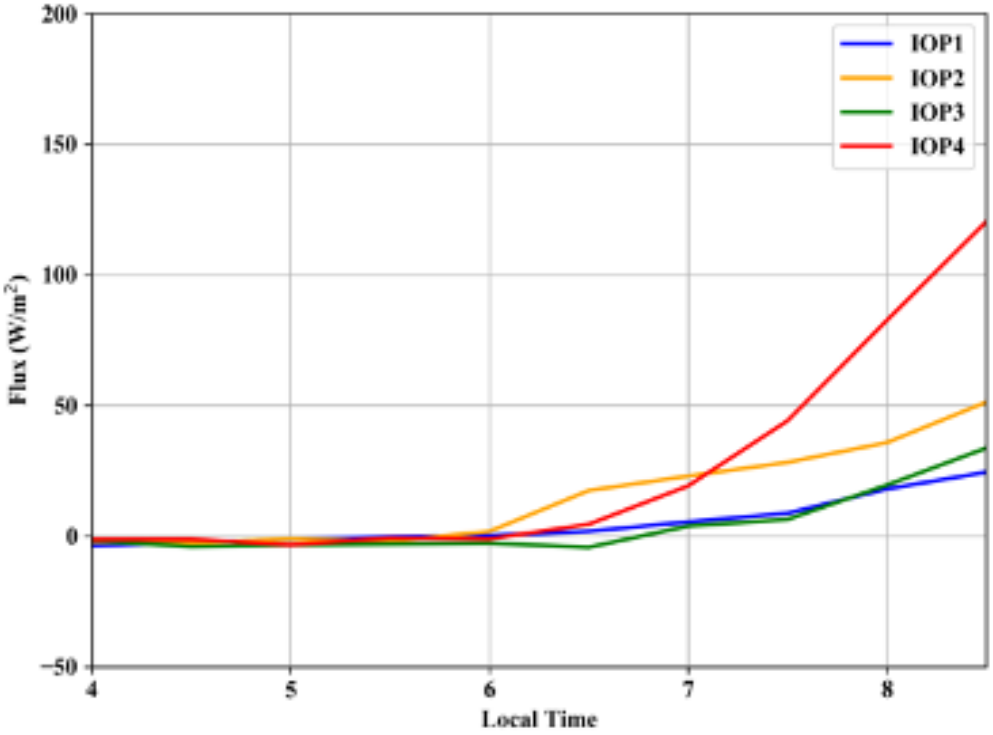

Figure S4 Average of the sensible heat flux (H) (W m-2) during transition from night to day of the 4 IOPs.

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."

Good point. I agree that the profile method is only applied for CBL. And, the text did not make it clear to readers that the method used for NBL was different. Therefore, this part of the text has been rewritten, detailing the methods for the two phases of the PBL (text below).

From these data, the potential temperature (θ) and specific humidity (q) were extrapolated and their vertical profiles were used for the determination of e height of the PBL. At the CBL phase, the heights were identified by the vertical level where there was a systematic increase in potential temperature and a sudden reduction in specific humidity, and this method is called the profile method, as described in detail by Santos and Fisch, (2007), Seidel et al., (2010) and Wang et al. (2016). However, at the NBL phase, the heights were determined by the height where the vertical θ gradient was null or less than a defined number (0.01 K m^{-1}) starting from the surface. This statement relates the maximum distance from the surface where the radioactive night cooling operates, as described in detail by Santos and Fisch (2007), Neves and Fisch (2011).

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.

We performed a statistical test (test t), comparing the sensors data with the RS (defined as true data). In this way, following the suggestion given by the reviewer, it was incorporated into the text (text below) and all test tables are in the supplementary document (Table S1 to S4).

In the results obtained, the average and standard deviations values were computed for different time intervals along the PBL daily cycle (Tables 2 and 3). Also, a significant test (Test t-Student) was applied to assess the significance of the correlation coefficients amongst the remote sensors compared to the RS (Tables S1 to S4 in the supplementary material).

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.

I thank you for the observation because the text was confusing. The vertical lines were chosen to delimit the time of sunrise and sunset, which does not vary much between the

periods as the site is near the Equator. Hence, the text was corrected to make it consistent for readers (text below).

In which, the sunrise and sunset times were marked by the vertical lines of 06 and 18 LT respectively, since the study area is near to the equator line and there are not changes at these times.

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.

I agree that with launches every 30 minutes of RS it would be possible to probe the entire PBL cycle. However, GoAmazon launched only during synoptic times, and it is not possible to obtain the daily cycle through RS. We are focusing on the high temporal resolution (say 10-15 min) from the remote sensors instruments. Even so, the text was changed to show the limitation due to the number of launches per day (text below).

The RS, in spite of it being a proven high-precision method, in this experiment it was launched only on synoptic times plus an extra at 15 UTC. Hence, it did not capture a high temporal resolution (like the remote sensors) daily cycle evolution of the height of the PBL, due to the long time interval between launches (each 6 h).

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.

Good point. The text really confuses the readers. The dew point temperature is a derived variable from the humidity sensor. Thus, the text has been corrected to improve the reader's understanding (text below).

From the RS measurements, the following data were measured as functions of time during a free-balloon ascent: pressure (hPa), air temperature (dry bulb) (ºC), relative humidity (%), wind velocity (m s^{-1}) and wind direction (deg). With these measurements, others derived quantities were computed and used in this study: altitude (m), geographic position (latitude and longitude), dew point temperature (ºC), u-component of wind velocity (m s^{-1}) and v-component of wind velocity (m s^{-1}).

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

According to the Ceilometer´s Handbook (Morris, 2016) used in the GOAmazon experiment, the height of the PBL is estimated through the optical backscattering of the instrument. As the MLH is the major part of the diurnal PBL, it may be a misunderstanding issue. Thus the text has been modified to improve comprehension (see the new text below).

These measurements are used to produce derived products that are recorded: the height of the cloud base, the retrieval of the particle backscatter coefficient and PBL height. Although the ceilometer measures the reflection of the aerosols layer (so the mixing layer height), it was assumed as the diurnal PBL height) as the entrainment zone is very shallow. So, during all manuscript, this information (backscatter aerosols) was assumed as PBL height.

*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.*

I agree with your observation. Manacapuru (T3 site during GOAmazon experiment) can also be influenced by the river breeze, but not as strong as Manaus or Santarém. So the text was changed.

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 (influence of river breeze, fog formation, etc). An example of these influences, in the Santarém region the authors related several cases of formation of fog during the night, which was not observed at the pasture site in Rondônia (see Neves and Fisch, 2015) nor at T3 site.

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".

Good point. The "instrument error" can leave the reader with doubts, so following your suggestion I changed the terms to "***standard deviation***" in all manuscript.

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?

Your observation is correct. The values have been revised in the text. But tables 2, 3 showed the average of the standard deviations for different intervals from PBL daily cycle, whereas the shaded areas in Figure 4 and 6 are related on average every 30 min.

The shaded area for Figure 3 which represented the standard deviations values, were computed for each 30 min time interval. It is also shown in the following Figures 4 to 6.