Dear Mr ACP Editor

Firstly, I would like to thank the scientific reviews made, which contribute to a better article. Below I describe item by item, the questions of the Reviewers (RCs) and scientific community (SC). I am sending as a supplementary material a version of the article where the changes made are marked in the text.

RC1

1. The results are shown only in terms of typical daily cycles, which are important. However, it would be very nice to know the ranges of variabilities provided by each instrument. It could be done by adding error bars to the plots, but that would possibly make them "dirty". Another option would be to include additional plots of daily cycle of standard deviations for each platform used. This plot would tell the readers whether any of the platforms is more susceptible to errors that could just average out in the plots shown. Besides, that would give the readers an idea of the inherent variability observed for the PBL thickness in the region;

I agree that inserting the error bars in the plots would make the figure "dirty", so the standard error was represented by shading (Fig. 4 and 6). However for the RS measurements the error bar was used as requested by RC2.

Therefore, I have also included two tables that show the standard deviation for 4 intervals of the daily cycle of PBL at each IOP. If you deem it necessary, I will add them in the final version.

2. Along the same line of the previous comment, it would be very nice if the authors could go a step further and identify for the same years what drives deeper or shallower PBLs. This suggestion might be a bit more complex to address, so it may be done at a later study;

In the present work, some forcing factors that influenced the deepening of PBL (Rn, H, etc.) were discussed. However, the reviewer suggestion is very reliable and , it will be included in a new study, comparing observations and modeling for a specific number of days (8 days for each IOPs).

3. I would like to see case studies comparing the PBL thickness found by each method, for both a diurnal and a nocturnal event. This comparison would give the community a clear idea of what each method is capable of doing. I think this would be specially good *for the nocturnal case, where there are still large uncertainties in the determination of the PBL thickness;*

As previously answered (question 2), another article is under developing , which will analyze 8 typical days at each IOP during the transition between the night (NBL) and daytime (CBL) PBL periods.

4. Is it possible to provide scatterplots comparing the thickness found by the radiosondes to those from other methods? In that case, I am assuming the radiosonde would be the "truth" and the comparison would be limited to the periods when radiosondes are available. Nevertheless, given the long temporal coverage of the dataset, there may be enough points for this analysis which would, again, provide important insights on the quality of the PBL estimation provided by each platform.

The scatter plot suggestion is quite valid, but the temporal coverage of IOP data is restricted to only 45 days and not a full year, thus making the sample with low representativeness.

RC 2

1. I wonder what the meaning of a "typical year" is in the title. If ENSO correlates well with Amazon rainfall, then it is not an anomaly. I believe, the authors mean non-El Nino year (instead of typical year), and El Nino year (instead of ENSO).

Yes, we have accepted this suggestion and we have changed the title of the paper to " ….for an El Nino and a non El Nino years"

2. Methods

a. Some instruments do not have the maker and/or model (SODAR, Lidar, EC, solar and terrestrial, soil heat flux)

The manufactures and/or models for all instruments were added in the methodology section

b. How high are the radiation and flux measurements? What is the landscape of the study area, and what is the landscape composition of the flux and radiation footprint?

The height the radiation and flux measurements and landscape scenarios description were added in the new version of the document

c. Is there any data filtering, or all data were considered (clear, cloudy/rainy days)? What are the data sample size in figures 3 to 6?

We did not splitted (or filtered) the days between clear/cloud days. The goal was to present typical values for each season (that will include clear/cloudy day). Moreover, we have assumed that during the wet season, mostly of the days have rains/clouds, so they are cloudy. For the dry period, although there are small and isolated clouds, the situation represents clear conditions. The data sample size in figures 3 to 6 was 45 days, which corresponds to the intense observation period of the GoAmazon project (Lines 79-81).

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).

e. For the other remote sensing instrumentation, but SODAR. It seems that only the CBL detection are being shown. Do these methods also apply to the NBL?

The SODAR only was used for the NBL, because the vertical measurements were restricted only from the surface up to 500 m.

f. Also, I believe that PBLH from MWR should be explained in more detail. Is this a novel method or is it based on previous studies? I wonder, because, from my experience, temperature profiles from the MWR do not show sharp gradients at the top of the CBL. Also, I am not sure how this interpolation works during the transition periods (mornings, and early night).

The method is based on previous study, like Fisch (2012). Basically, it is a creation of a potential temperature profile using specific channels of MWR and then used the profile method to determine the height of the PBL.

FISCH, G. . The heights of the atmospheric boundary layer at a coastal region using remote sensing and in situ measurements. In: 16th Int Symp for the Advancements of Boundary Layer Remote Sensing, 2012, Boulder, USA. Proceedings of the 16th ISARS 2012. Boulder, USA: ISARS, 2012. p. 135-137.

g. NBL detection from SODAR: The use of the maximum of the wind profile is associated with the lower level jet. Have the authors consistently observed LLJ at the study site? If so, this should be written.

The height where the maximum wind value was observed was considered the height of the NBL, according to Stull's definition, 1988 and applied in the Amazon by previous study (Neves and Fisch,2015). Not all times this maximum windspeed can be considered as a low level jet, so this occurrence was not described in the document.

h. Why not use the temperature profile from WP to estimate the NBL?

Because our decision was to estimate the NBL and CBL by the same method in WP.

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.

b. I do not understand the PBLH time series for the ceilometer. According to the methods, the PBLH is the cloud base, not the aerosol mixing layer estimated from the aerosol backscatter profile. Thus, are the black lines shown in figures 4 and 6 the cloudbase diurnal variation? I do not believe that there will be boundary layer clouds during night time at such lower height (maybe fog – but not the cloud base). Also, there is a sharp drop during the afternoon, are the PBL clouds descending?

The Ceilometer PBLH time series does not refer to cloud base heights, but rather to measurements of boundary layer heights. During daytime (not nighttime and transitions time), the PBLH and the cloud base are coincidents. Thus the black lines shown in figures 4 and 6 are the daytime variation of the height of the PBL. Since the Ceilometer provides the height of the cloud base, the retrieval of the particle backscatters coefficient and PBL height (Wiegner et. Al., 2014; Shukla et al., 2014; Morris, 2016; Carneiro et al., 2016 Geiß et al., 2017). Thus, to improve the reader's understanding of this description, a new paragraph was included in the new version (P4, L 118-129, text below).

"The PBL was also monitored using a Ceilometer model CL31 from Vaisala Inc. (Finland). Ceilometers are a type LIDAR remote sensing instruments that operating through a maximum vertical range of 7700 m and register the intensity of optical backscattering at the near infrared wavelength between 900 and 1100 nm through an emission of a vertical pulse that is autonomously executed. The Ceilometer provide information about the height of the cloud base, the retrieval of the particle backscatter coefficient and PBL height (Wiegner et. al., 2014; Shukla et al., 2014; Morris, 2016; Carneiro et al., 2016; Geiß et al. 2017) for daytime conditions (not nighttime and/or transitions periods).

The ceilometer is a high-frequency instrument with a measurement interval of 2 s, and a sampling rate of 16 s and is a powerful tool for measuring the height of the PBL during its daytime to a high level of detail. The intensity of backscattering depends on the concentration of particles in the air, but also depends on the reflexive properties of the atmosphere, which are related to its level of humidity. Therefore, this instrument is useful for creating a tridimensional map of aerosols, air pollutants, and industrial and natural emissions of particles."

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).

d. Lines 205-206: The authors claim that there is no ground water at the root level. Is it a shallow root or deep root vegetation? Depending of the type of vegetation, this might not be the reason for lower evapotranspiration.
The T3 area was located was cover by shallow vegetation (pasture) with shallow root depth. This info was added in the description of the area in Material and Methods P2, L 72-73, text below).

"In order to conduct this observational study, data from the GOAmazon project 2014/5 were used. The article by Martin et al. (2016) describes the details of the experiment wherein these data were collected, its principal objectives, and some results. These data were collected using the structure that was installed at a research station called T3 (03º 12' 36" S; 60º 36' 00" W), located north of the municipality of Manacapuru in the State of Amazonas, about 9.5 km from the urban area, and about 11.5 km from the left bank of the Solimões River, at the confluence of the mouth of the Manacapuru River (Figure 1) in the central region of the Amazon basin. The T3 station is collocated in an area of pasture (with shallow depth roots water extraction), surrounded by native forest with about 35 m of canopy height (Martin et al. 2016)."

e. Lines 208-211: Groundwater stress are not be the only reason for low evapotranspiration.

Indeed, the Groundwater stress is not the only reason. Thus a new was included (P6, L211-215, text below).

“The latent heat flux (LE) showed that the majority of the available net radiation (daytime conditions) was used for this flux. Both periods had similar maximum values, with 355.9 (IOP1) and 350 W m^{-2} (IOP2) at 12 LT. However, there was a reduction of net radiation converted into LE (evaporative fraction) between the periods: it was 75% in IOP1 and 66% in IOP2. Since IOP2 refers to the dry season in the region, there are a lower soil water availability, which resulted in lower LE/Rn partition in comparison IOP1.”

f. Lines 223-230: So, how mechanical turbulence will affect the NBL for some instruments, and not for others? I believe a more in-depth analysis should be performed. If there is a presence of LLJ, then more likely there will not be too much turbulent mixing, and the NBL is going to grow due to radiative cooling. Also, usually the local maxima of the LLJ is not co-located with the bottom of the residual layer, so using the level of maxima wind speed will underestimate the NBL. Last, but not least, if there is rain, then most likely the remote sensing instruments do not work properly, and they will be unable to detect any mixing height.

Mechanical turbulence affected all instruments, however, each instrument has different measurement techniques, thus presenting differences in PBL height measurements at this range (00 - 60 LT). The study in question evaluated different PBLH measurement instruments, so the underestimation found for the NBL of the instruments that used the maximum wind speed level to estimate the height (SODAR, WP) showed that these sensors have limitations for measuring the NBL under mechanical turbulence.

g. The “erosion” of NBL discussion seems confusing and does not make any sense to me. Looking at figures 4 and 6, if the PBL is growing above 250m after 6am, thenit means that there is no more a stable layer. If not, then how the PBL is growing? Iguess the authors can check that looking at the SODAR RASS data: : :

According to Stull (1988), during the early morning the PBL is shallow. Its depth increases slowly at first because of the strong nocturnal stable layer that caps the young

CBL. This first phase is sometimes referred to as the erosion of the NBL, which begins after sunrise and the complete erosion occurs when the PBL has a growth rate above 100 m h^{-1}.

The text in question has been changed for readers' better understanding (P7, L248-253, text below).

"The phase of the erosion of the NBL according to Stull (1988) begins after sunrise (at 06 LT in Amazon) and the complete erosion occurs when the PBL has a growth rate above 100 m h^{-1}. In the IOP1 (Figure 4A), the erosion phase was occurred 3 hours after sunrise. only after 08 LT has occurred an increase in PBL heights (average rate of 22.8 m h^{-1}). This occurs due to a lower H flux (Figure 3A), which causes the erosion of the NBL to progress slowly, and total erosion occurs only at 09 LT when average rate is 102 m h^{-1}."

h. Lines 254-255, 300-302: H by itself does not contributes for the PBLH growth, or the rate of change of temperature.

Positive sensitive heat flux (H) heats the air near the surface and by convection will rise, generating turbulent movements within the PBL which increases its depth. According to standard literature on studies of PBL (Stull, 1998; Holtslag, 1987; Foken, 2008), described below:

"*During the daytime when H>0 the atmosphere is heated from below, while for H<0 the atmosphere near the surface is cooled (nighttime). This leads to unstable (daytime) and stable (nighttime) stratifications of the PBL. The magnitude and the diurnal cycle of H has important consequences on the height and the structure of PBL. During unstable conditions the air adjacent to the surface is heated and will rise. This rise continues as long as the air is warmer then the surroundings (up to an inversion layer). This process is know as convection, which is accompanied with the production of convective turbulence in the PBL.*"(Holtslag, 1987).

"*The daily cycle is highly variable, after sunrise, the atmosphere is warmed by turbulence flux H from the ground surface, and the inversion layer formed during the night brakes up (erosion phase). The new layer is very turbulent, well mixed (mixed layer), and bounded above by an entrainment zone.*"(Foken, 2008; Stull, 1998).

i. Lines 255-257: Not sure about that a small H will decrease the PBLH. According to the theory, if there is negative flux-divergence, the PBLH will increase. Also, how the entrainment at the top was calculated?

As H is reduced at late afternoon, then the thermal convection is not so active anymore and the PBLH starts to collapse slowly. The entrainment rate was not calculated but is is out of the goal of this analysis.

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.

Some Minor Concerns:

Lines 81-82: Wind Profiler, ceilometer, SODAR, MWP, and Lidar are not remote sensing estimation methods, but the instruments that probe the lower troposphere.

Thanks for the observation, it was changed in the text

Table 1: Ceilometer vertical resolution is missing. I believe some of the instrumentation measure more than reported in row 3.

This info was included in the Table 1

Figure 1: What is the location of the site? There are 2 red squares and red dots, are they the instrument location of Manacapuru site? If so, where are the location of the instrumentation? If now, what are they?

Figure 1 has been modified to better present the location of the site.

Figures 3 and 5: What are the error bars for the measurements?

The figures has been modified to improve comprehension.

Figures 4 and 6: What is the shaded area? The errors? If so, how the errors are estimated? Why RS points do not have error bars?

The shaded area is errors and they have been estimated by the standard deviation of the measurements All errors/uncertainties were included in the Figure and Table X

SC1

Comments on the ceilometer part:

Sections 2.4 and 2.6: as far as the same methodology is used (exploitation of a backscatter signal) the explanations can be combined: a ceilometer is a backscatter lidar, i.e., they follow the same physical principles.

I agree with your observation, but one of the objectives of the paper was to compare different PBLH estimation techniques / instruments and we chose to leave the sections of the instruments separate. However, the sections have been reorganized (LIDAR - Section 2.4 and Ceilometer - Section 2.5).

line 120: what is meant with "high frequency instrument"? As this could be misleading I suggest to write that the "temporal resolution is high" or something similar.

It's ok. The text has been changed (L 144).

lines 121ff: "powerful tool ... high level of detail": This is quite a general statement that neglects the problems of retrieving the MLH, in particular when a low power ceilometer (CL31 compared to CL51 or Lufft ceilometers) is used. A brief overview of the inherent pitfalls should be given: Signal artefacts (Kotthaus et al.,2016, AMT), overlap problems [relevant in particular for the NBL] and water vapor absorption (Wiegner et al., 2019, AMT), or wrong attribution of detected layers (Geiß et al., 2017, AMT).

The description of the instrument was more detailed in the text due to yours contributions and the indicated articles.

Section 2.4: The description how the MLH is determined from the CL31 signals is missing. Is the proprietary software BL-VIEW used? How is it applied (compare Geiß et al., 2017)? A brief outline is strongly recommended as it help to understand the accuracy of the retrieval.

Your suggestion has been added to the text. (P4, L151-152, text below).

“The standard procedure for the PBL heights determination from Vaisala ceilometers is the software package BL-VIEW developed by the manufacturer (see more details in Morris, 2016; Geiß et al. 2017).”

line 123: What is meant by "reflexive properties"? Do the authors mean the refractive index? It could indeed be dependent on the relative humidity but I doubt that this effect has a significant influence on the MLH-retrieval. Or is the relative humidity mentioned because of potential water vapor absorption? Again, it is unlikely that this effect is relevant for the MLH-retrieval (Wiegner et al., 2014,AMT).

line 124: "creating a tridimensional map": What does "tridimensional" mean? Iassume that the ceilometer provides MLH as a function of time, or the particlebackscatter coefficient as a function of time and height. Moreover, mentioning"aerosols, air pollutants, and industrial and natural emissions" might be misleading if it is interpreted as the potential to discriminate between different types ofaerosol particles; this is impossible by a simple single-wavelength backscatterlidar (ceilometer).

line 125: what is a "retro diffusion" laser? Just skip this word. The expressions "coefficient of the attenuated portion" and "coefficients for aerosols" arenot clear/known: do you mean "attenuated backscatter" or "particle backscatter coefficient"?

line 126: "subsequently the heights of ... the PBL are calculated". See my previous comment. Please outline how this has been done.

We agree that with the changes suggested by SC-1 regarding lines 123 to 126 were necessary, and to improve the reader's understanding, they have been restructured in paragraph (P4, L144-152, text below).

“The ceilometer is a high temporal resolution instrument with a measurement interval of 2 s, and a sampling rate of 16 s and is a powerful tool for measuring the height of the PBL during its daily cycle (day and night phases) to a high level of detail. The ceilometer signal is resulting over backscattering light by particles at atmosphere, then intensity of backscattering depends on the concentration of particles in the air (Morris, 2016). Ceilometers use a retrodiffusion laser to determine the attenuated backscatter, and the particle backscatter coefficient are obtained from these data, and subsequently

the heights of the cloud base and the PBL are calculated (Wiegner et. al., 2014; Kotthaus et al., 2016; Geiß et al. 2017).
The standard procedure for the PBL heights determination from Vaisala ceilometers is the software package BL-VIEW developed by the manufacturer (see more details in Morris, 2016; Geiß et al. 2017)."

line 145: Similar to the ceilometer-section: What is a "retro-diffused signal"?
Text has been improved as suggested by SC1 (P4, L122-126, text below).

"These instruments employ an laser transmitter operating at a wavelength of 1.5 µm, low pulse energy (~100 µJ), and high pulse repetition frequency (15 kHz). These instruments have full upper hemispherical scanning capability and provide range-resolved measurements of attenuated particle backscatter coefficient and radial velocity. The fundamentals of its operation are similar to those of radar in which pulses of energy are transmitted to the atmosphere, the energy that is bounced back to the receiver is collected and measured as a resolved signal in time (Newsom, 2012)."

Section 2.6: The authors mention "attenuated backscattering" (this means they use the lidar as an "elastic backscatter lidar") but do not use this quantity for the MLH-retrieval (why?)? Do I understand this correctly?
Since the objective of this work is to estimate the height of the PBL by different methodologies for Amazonia, the calculation of the PBLH with the Lidar data was performed using the methodology of Huang et al. (2017), based on sigamaw², whose applicability was proved another location (such ..artigo! ..).

General comments:
The authors should explain in detail how they determine the diurnal cycles of theMLH (for each instrument): which days are considered (only if full diurnal cyclescan be determined)? Are the sample of days the same/similar for the differentapproaches? If not, is a bias expected? Did any instrument failures occur? Whatare the reasons for the gaps of some curves?

The description of the methodologies used to obtain the PBLH of each instrument is in the text. Every day was used, the data were verified and gap fillings was performed

Nearest-neighbor. Each IOP corresponds to 45 days of observations, as described in Table 1. The gaps in the SODAR data are due to the instrument not capturing the CBLH, and Lidar showed many gaps in the NBL.

The authors emphasize that the precipitation is quite high at the site. When itis raining the retrieval of the MLH by a ceilometer is not possible. How do these meteorological conditions influence the number of MLH-retrievals? How many full diurnal cycles could be determined during the IOPs? In this context the "sporadic rainfall" (e.g., line 220) could be discussed in more detail.

According of the manufacturer's manual the Ceilometer operate in different environment and weather conditions (fog, precipitation and etc.) as described to Moris, 2016 (text below).

“These instruments employ pulsed diode laser lidar (light detection and ranging) technology, where short, powerful laser pulses are sent out in a vertical or slanted direction. The directly backscattered light caused by haze, fog, mist, virga, precipitation, and clouds is measured as the laser pulses traverse the sky. This is an elastic backscatter system, and the return signal is measured at the same wavelength as the transmitted beam.”

The authors consider the MLH derived from radiosondes as truth. This is a frequently made assumption. However, the authors should explicitly mention that the methodologies (radiosonde vs. ceilometer/lidar) are based on different physical concepts.

According to the literature, RS data are taken as reference values for PBL height studies. The other methodologies/techniques used in this study were described in the following lines:

RS (L 91-95); WP (L 104-107); SODAR (L 109-112); Deal (L 122-126); Ceilometer (L 144-150); MWR (L 154-159).

According to the shaded areas (not explained!) in Fig. 4 the variation/uncertainty(or whatever it indicates) is so large that the rapid growth/decrease of the MLHas discussed in lines 221ff is not significant.

The shaded represents the instrument error (changed in figures). The variation discussed in line 221 refers to the temporal variation of PBL height and not to the instrument error.
However, to improve interpretation, a table of the standard deviation of the instruments was attached, as suggested by the reviewer 1.

MLHs of 50 − 150 m (line 234, Acevedo's results) can hardly be retrieved by aceilometer (in particular when the overlap correction function is not very accurate). So it might be possible that the NBL is at 50 m at the authors' site but notdetectable by the ceilometer. This fact is not covered by the discussion.
The present study is not only focused on the Ceilometer, RS and the other instruments also show ceilometer equivalent heights, as well as the study by Neves and Fisch (2011) in the Amazon region of similar environmental/climatic conditions to the area of this study.

Mentioning growth rates of e.g. 22.8 m/h (line 243) pretends an accuracy that is unrealistic. How is it determined: from the average over an IOP or from the mean of all individual diurnal cycles during the IOP (in the latter case the uncertainty can be estimated)? How is such a "precision" justified in view of the vertical resolution of the ceilometer? Please explain.
The growth rate that I refer to in the text is calculated for each phase time interval (NBL, NBL erosion, CBL growth) of the PBL, not the daily cycle average or the IOP period average.

The limited temporal coverage of the lidar (compared to the ceilometer) retrievals should be explained.
Lidar's night time coverage was not displayed by many gaps.

A comment on the availability of the different methodologies should be given: How many retrievals (obviously hourly averages) from the ceilometer, the lidar, and so on, are used for Figs. 4 and 6, (see also my first comment).
As modified in the text in response to reviewers 1 and 2, for each instrument 45 days of observation were used for each IOP.

Minor/technical comments:

Table 1: The vertical resolution of the ceilometer is given as "X". Please change.

Changed in the Table

Figs. 4 and 6: Explain in the caption what the dashed line means? Instead of (A) and (B) one might also use "left" and "right".

The vertical lines represent sunrise (06 LT), sunset (18 LT) (full line) and the dashed line represent the hour on what occur erosion of nocturnal boundary layer.

Fig. 6: panel B refers to IOP4 not IOP3.

Changed in the Figure