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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observational analysis of the daily cycle of the planetary boundary layer in the central amazon during a typical year and under the influence of the ENSO (GoAmazon project 2014/5)" *by* Rayonil G. Carneiro and Gilberto Fisch

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Below are the answers to scientific community (SC)

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 abackscatter lidar, i.e., they follow the same physical principles.

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Discussion paper

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 lowpower ceilometer (CL31 compared to CL51 or Lufft ceilometers) is used. A briefoverview of the inherent pitfalls should be given: Signal artefacts (Kotthaus et al.,2016, AMT), overlap problems [relevant in particular for the NBL] and water vaporabsorption (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 signalsis 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 therefractive index? It could indeed be dependent on the relative humidity but Idoubt that this effect has a significant influence on the MLH-retrieval. Or is therelative humidity men-

tioned 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 sigamaw[2], 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 thesemeteorological conditions influence the number of MLH-retrievals? How many fulldiurnal cycles could be determined during the IOPs? In this context the "sporadicrainfall" (e.g., line 220) could be discussed in more detail.

According of the manufacturer's manual the Ceilometer operete in diferents enveiroment 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 thatthe 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 referee 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 isunrealistic. How is it determined: from the average over an IOP or from the meanof 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 verticalresolution 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 referees 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 represnt the hour on what occur erosion of nocturnal boundary layer.

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

Changed in the Figure

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