Anonymous Referee #4

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First, authors would like to thank the reviewer for his/her constructive and detailed suggestions. Their additions to the paper helping us to improve significantly the clarity and the precision of the method used and the robustness of the results.

The atmospheric stability is used as a tracer to differentiate the atmospheric layers. As recommended, Stable Layer (SC) and Turbulent Layer (TL) are have been replaced by Stable Conditions (SC) and Turbulent Conditions (TC). This was also requested by other 2 reviewers.

In the following, we provide answers to the reviewer's comments and list modifications made in the manuscript.

This paper provides an interesting overview of the aerosol particle properties observed at the high mountain station Chacaltaya in the South America (Cordillera Real). The topic is of interest for ACP and the paper is generally well written. The scientific approach is sufficiently robust and the presentation of data and results is fair. Nevertheless, some points should be better addressed before publications. In particular, the authors should better discuss the caveats related with the back-trajectories analysis as well as provide more details and information about the experimental methodologies (e.g., no information about data generation, uncertainty characterization are provided).

In the following you can find my specific comments. ———————————————— ———————
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Abstract. In the last sentence, the authors claimed that "CHC provides first evidences of impact of emission from Amazonian basin far away from their source". Be more specific. Which "far away" means? Please, in the site description provide distance of CHC from Amazonian basin.

Answer: The CHC station is described as a background GAW site and is located 17 km from the first urban area, and around 300 km from fire area in Bolivia (Carmona-Moreno et al. 2005, Giglio et. al 2013). The Rondonia region where a significate deforestation process is reported every year is located 800 km from CHC station. In addition, CHC is the highest GAW station in the world and unique free tropospheric conditions can be obtained in the region where particles and gases have residence time of several months and be transported over large distances.

Modifications:

l.56: "From this analysis, long-term observations at CHC provides the first direct evidence of the impact of Biomass Burning emissions of the Amazonian basin and urban emissions from La Paz area on atmospheric optical properties to a remote site all the way to the free troposphere."

l.148: "[...] (Carmona-Moreno et al. 2005, Giglio et. al 2013). Indeed, the closest region where large areas are affected by biomass burning activities is the Bolivian Amazonia (Beni, Santa Cruz, north of La Paz departments) located ca. 300 km from the station, north and eastward from the Andes mountain range."

Line 71: please provide wavelengths.

Answer: Husar et al., (2000) reports aerosol extinction coefficients values related to visibility. Their values are representative of the integrated visible range. In this condition, it may not be reliable to compare those aerosol extinction coefficients with the Chacaltaya measurements. However, the study gives an interesting analysis of the impact of Amazonian fires at different altitudes and different distances to the main fire activities.

Modifications:

l.84: "Between the wet season and the biomass burning season, Schafer et al. (2008) show an increase of Aerosol Optical Depth by a factor of 10 from AERONET sites in southern forest region and the Cerrado region and, by a factor of 4 in the northern forest region."

l.88: "The study reports a spatial pattern of the visibility between 100 and 200 Mm-1 over the Amazon Basin. However, values can reach 600 Mm-1 at Sucre station (2903 m above sea level, hereafter abbreviated as "a.s.l."), 1000 Mm-1 at Vallegrande (1998m a.s.l.) and 2000 Mm-1 at Camiri (792 m a.s.l.) during BB period. Even the study clearly shows impacts of Amazonian activities at different altitudes and long distances, only few studies report long time period of aerosol optical properties."

l.96: "These extremely high coefficients are due to the proximity to BB sources for FNSA station and its very low altitude."

Line 92 – 105: this section ̀is hard to follow. I would recommend to add a table with the different threshold values for each type of particles (dust, pollution, biomass burning) for the different Angstrom exponents (AAE, SAE, SSAE).

Answer: Three tables have been added to the text which summarize information from the text. The Table 1 summarizes ranges of Angström exponent for the different aerosol types. Table 2 details the median values of the Angström exponent for each cluster, season and atmospheric stability. Table 3, on the conclusion, suggests a new Angtsröm exponent definition for the different aerosol types.

Modifications:

Aerosol type	SAE	AAE	SSAAE
Dust	Close to 1	Close to 1	Below 0
Urban pollution	Close to 2	Close to 1	Higher than 0
Biomass burning		Close to 2,1	

Table 1: Expected aerosol type and their optical properties for each cluster according season and atmospheric stability.

Cluster	season	SAE	AAE	SSAAE	Aerosol types
NA	WET	2,04 (1,42)	0,58 (0,56)	0,18 (0,15)	urban (dust/urban)
	DRY	1,91 (1,80)	1,00 (1,01)	0,01 (0,004)	urban (dust)
	BB	1,92 (1,87)	1,10 (1,26)	0,03 (0,02)	dust/BB (dust/BB)
SA	WET	1,2 (1,40)	0,74 (0,68)	0,11 (0,11)	urban (urban)
	DRY	1,69 (1,70)	1,04 (0,96)	0,02 (0,03)	dust (dust)
	BB	2,16 (2,02)	1,23 (1,20)	0,005 (0,01)	BB (BB)
LP	WET	1,71 (2,09)	0,86 (0,82)	0,08 (0,10)	urban (urban)
	DRY	1,64 (1,74)	1,05 (1,07)	0,02 (-0,01)	urban (dust/urban)
	BB	1,49 (1,93)	1,09 (1,29)	-0,02 (-0,02)	dust (dust/BB)
ATL	WET	1,93 (2,11)	0,75 (0,65)	0,11 (0,15)	urban (urban)
	DRY	1,77 (1,94)	1,00 (1,05)	-0,001 (0,006)	dust (dust/urban)
	BB	1,80 (1,81)	1,23 (1,08)	0,008 (0,01)	dust/BB (urban)
APO	WET	2,15 (2,04)	0,84 (0,82)	0,11 (0,10)	urban (urban)
	DRY	1,39 (1,38)	1,06 (1,10)	0,006 (-0,02)	dust (dust)
	BB	1,56 (1,61)	1,14 (1,20)	-0,008 (-0,01)	dust/BB (dust/BB)
NES	WET	2,05 (1,67)	0,72 (0,66)	0,13 (0,12)	urban (urban)
	DRY	1,74 (1,83)	1,06 (1,09)	-0,008 (0,003)	dust/urban (dust)
	BB	1,89 (1,80)	0,95 (1,07)	0,002 (0,02)	dust/urban (urban)

Table 2: Median aerosol Angström exponents of turbulent condition (stable condition) for each cluster and seasons measured at the CHC station and resulting aerosol types.

Aerosol type	SAE	AAE	SSAAE
Dust	-	> 0,9	[-0,05 ; 0,05]
Urban pollution	> 1,4	< 0,9	> 0,05
Biomass burning	-	> 1,1	[-0,05 ; 0,05]

Table 3: Updated Angström exponent values expected for aerosol types at the CHC station.

l.127: “As a summary, Table 1 shows expected Angström exponent for dust, urban pollution and Biomass Burning particles according the different referenced works (Dubovik et al., 2002 ; Collaud Coen et al., 2004 ; Clarke et al., 2007 ; Russel et al., 2010). This information has to be taken with caution since source influences are expected homogeneous and have been reported from several regions.”

l.482: “Table 2 summarizes the median Angström exponents measured at the CHC station for turbulent conditions (stable conditions in parenthesis). According to these values and as discussed above, aerosol types for the turbulent conditions (and stable conditions in parenthesis) are given.”

l.525: “A new Angtsröm exponent classification can then be defined for measurement at the CHC station and is reported Table 3. Thresholds are close to the ones proposed by previous works (Dubovik et al., 2002 ; Collaud Coen et al., 2004 ; Clarke et al., 2007 ; Russel et al., 2010) but adapted to CHC’s instruments and particular atmospheric conditions.”

Line 103: please correct "bellow"

Modifications: “bellow” has been corrected by “below”

Line 135: please clearly state which kind of compensation must be applied to aethalometer data.

Answer: Weingartner et al. (2003) correction is applied in order to compensate the multi-scattering effects and the loading effects on the aethalometer’s filters. The correction is performed by adjusting the f factor showed in equation 3.

Modifications:

l.170:“Aethalometer measurements were compensated for multi-scattering effects and loading effects (or shadowing effects) following the method described by Weingartner et al. (2003) briefly explained below.”

Line 140. was the mass coefficient provided by the manufacturer independently assessed and validated by others? If yes, provide references, if not, provide adequate comments

Answer: The mass coefficient given by the manufacturer allows us to convert BC concentrations to attenuation coefficients as derived from the Mie theory for small uniform spheres. Hence, the mass coefficient is inversely proportional to the optical wavelength as follow: $\sigma = 14625 / \lambda$, which corresponds to sigma values between 15 and 40 $m^2\ g^{-1}$ for wavelengths between 370 and 950 nm. Liousse et al. (1993) demonstrated highly variable mass coefficients depending on aerosol type and age. Saturno et al. (2017) recently demonstrate agreement between aethalometer corrections using manufacturer’s sigma coefficients and other instruments as MAAP and a multiple-wavelength absorbance analyser (MWAA). Collaud Coen et al. (2010) also demonstrate Weingartner’s correction as a good compromise comparing to Schmid’s et al. (2006) correction and Arnott’s et al. (2005) correction.

Modifications:

l.176: “with σm the mass coefficients given by the instrument’s instructions (The Aethalometer, A.D.A. Hansen, Magee Scientific Company, Berkley, California, USA) and based on the Mie theory. σm strongly depends on the aerosol type and age (from 5 to 20 m² g-1, Liousse et al., 1993). However, the manufacturer values (14625 nm m2 g-1 λ-1) have been recently validated in a comparison study between ifferent aethalometer corrections (Collaud Coen et al. 2010 ; Saturno et al., 2017).”

The method for deriving the absorption coefficient it is not clear. Equation 2, what is C.R(ïA˛ˇn)?. Equation 3 it is also not clear: please describe the contribution of each member/factor. What ln(10%) and ln(50%) represent? Why the factor R should be adjusted? What do you mean for "spot" change? Why the absorption coefficient should be the same before and after the spot change?

Answer: “C.R(ïA˛ˇn)” is probably due to format issues and should be C.R(λ). Then, C is defined as the calibration factor constant with wavelength, and R another calibration factor which does depend on the wavelength.

The aethalometer instrument permits to obtain aerosol absorption coefficients from optical measurement of aerosol trapped on a filter. Every 5 minutes, the spot on the filter band is changed in order to reduce loading effects. Hence, absorption coefficients from one spot to the other should not change significantly, then the median ratio between two successive absorption retrievals should be less than 1.

The method to derive absorption coefficients and correct data from aethalometer issues (multi-scattering and loading effect) is briefly described in this paper. However, the method is described in details in Weingartner et al. (2003) and largely used in other several studies (Bond et al., 2006, 2013 ; Rose et al., 2015 ; Andreae and Gelencsér, 2006 ; Zotter et al., 2017 ; Rajesh and Ramachandran, 2018). If C allows to correct multi-scattering effects linked to filter properties, R has to be adjusted in order to correct the loading effect and is related to wavelength and aerosol properties trapped on the filter. In Weingartner et al. (2003), we can find the description of every member. f is the filter loading effect compensation parameter and represents the slope of the curve of R as function of $\ln(\sigma_{atn})$ for a σ_{atn} change from 10% to 50%.

Modifications:

l.167: "Every 5 minutes, the spot on the filter band is changed in order to reduce loading effects."

l.170: "Aethalometer measurements were compensated for multi-scattering effects and loading effects (or shadowing effects) with the method described by Weingartner et al. (2003) and briefly explained below."

l.176: "with σ_m the mass coefficients given by the instrument's instructions (The Aethalometer, A.D.A. Hansen, Magee Scientific Company, Berkley, California, USA) and based on the Mie theory. σ_m strongly depends on the aerosol type and age (from 5 to 20 m² g-1, Liousse et al., 1993). However, the manufacturer values (14625 nm m2 g-1 λ-1) have been recently validated in a comparison study between aethalometer corrections (Collaud Coen et al., 2010 ; Saturno et al., 2017)."

l.182: "with C = 3.5 a calibration factor linked to multiple-scattering and assumed constant according wavelengths (GAW Report No. 227), and R, a calibration factor which depends on aerosol loading on the filter and aerosol optical properties, calculated as: [...]"

l.186: "where f is the filter loading effect compensation parameter and represents the slope of the curve of R as function of $\ln(\sigma_{atn})$ for a σ_{atn} change from 10% to 50%"

Equation 4: what "mEBC" is? Does QEBC is equal to QBC reported by line 148?

Answer: EBC corresponds to Equivalent Black Carbon. Because Black Carbon concentrations are obtained from optical measurements, and assumptions on mass absorption cross-section coefficients have to be included, it seems more appropriate to use Equivalent Black Carbon. Q_{BC} should be Q_{EBC} everywhere in the manuscript.

Modifications:

l.191: "A mass absorption cross-section Q_{EBC} = 6.6 $m^2.g^{-1}$ at 670 nm is used to determine Equivalent Black Carbon mass concentrations"

Line 155: the authors stated that the aethalometer measurement at 635 mm is unstable. Quantitatively, what does this mean? Do you are able to provide threshold value that other users can apply to evaluate if their own measurements are unstable? In general, which QA/QC framework/procedures did you apply to all the suite of measurement discussed in this work? Please describe air inlet system and calibration strategies for the considered instrumentations (i.e. nephelometer, aethalometr, MAAP). Please quantify uncertainties related to each of these measurements.

Answer:

Indeed, nephelometer measurements at 635 nm do show unstable values during several days. The figure below shows an example of these unstable periods, here for the scattering coefficients at 450, 525 and 635 nm between the 7th of September to the 9th of September 2012. The wavelength dependence of the scattering coefficients suddenly changes the 7th of September around 6 pm and the 635 nm channel keeps high values for several months. Level 2 data used in this work are in the EBAS database and consequently these data are controlled and opportunely flagged when issues were observed. The authors decided to only use unchanged 450 and 525 nm channels to analyse aerosol optical properties at Chacalataya.

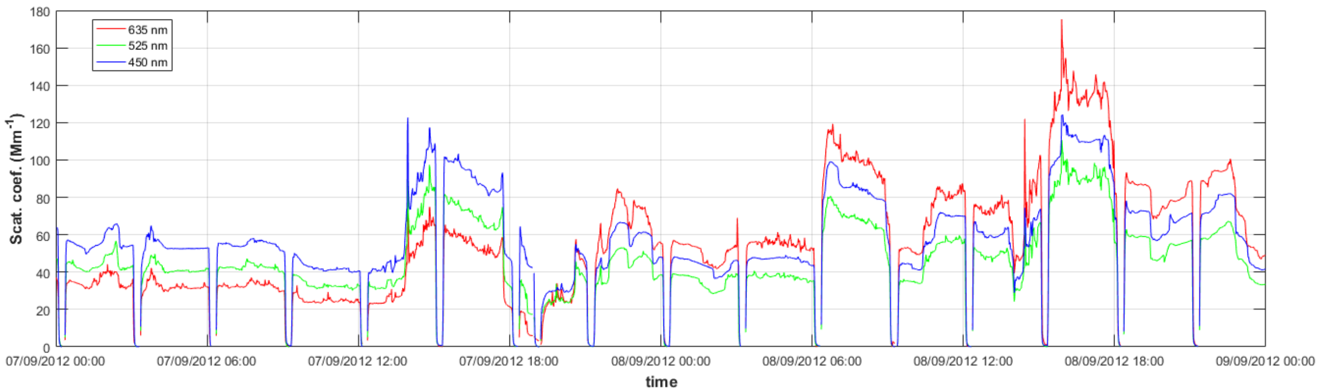

Figure 1: Temporal serie of the scattering coefficients at 450, 525 and 635 nm retrieved from the nephelometer at Chacaltaya station between the 7th of September at 00 am to 9th of September 2012 at 00 am.

From optical property measurements, the full dataset between the 3rd of January 2012 to 30th of November 2015 has been used. Every in-situ instruments of the station are located downstream a Whole Air Inlet and a dryer.

The nephelometer instrument was periodically calibrated using CO_2 as span gas and frequent zero adjusts were performed, following the procedure described in Ecotech manual (2009). The uncertainty of the Aurora 3000 is given in the user manual to be 2,5 %.

The air-flow and the absorption cross-section of the aethalometer instrument are calibrated. The method is detailed on the Magee Scientific manual (REF). Accuracy of attenuation coefficients are around 5%.

The MAAP instrument is automatically calibrated for air-flow, temperature and pressure according to the instruction manual (Model 5012 Instruction Manual) and described in Petzold and Schönlinner, 2004). According to them, uncertainty of the absorbance is 12%.

Modifications:

l.156: "In-situ instruments of the station operated behind a Whole Air Inlet equipped with an automatic dryer (activated above 90% RH) ."

l.158: “In the current study, the full dataset of in-situ optical measurements has been used between January 2012 and December 2015.”

l.169: “Sensor calibration is performed automatically and an uncertainty of 5 % on attenuation coefficients is given by the constructor.”

l.190: “According to Petzold and Schönlinner (2004), uncertainty of the absorbance is 12%.”

l.198: “The nephelometer instrument is calibrated using CO_2 as span gas and frequent zero adjusts were performed, following the procedure described in Ecotech manual (2009). The uncertainty of the Aurora 3000 is given in the user manual to be 2,5 %.”

Also equation 10 is not clear: what σÏt’2 (x) with X=12,30,45,60 represent? I think that the vocabulary used by the authors can be misleading. More than layers this methodology can be able to discriminate turbulent versus stable (or more stable) conditions at the measurement site. Please change nomenclature.

Answer: $\sigma^2_{\theta(15)}$ corresponds to the squared standard deviation of the horizontal wind direction calculated every 15 minutes. Hence, the standard deviation of the horizontal wind direction is calculated every 15 minutes and then hourly averaged.

Indeed, atmospheric layer definitions are largely discussed on aerosol and dynamic studies, and according to the method used, the definitions of the layers are slightly different. In addition, a residual layer can also be present at CHC station during nightime, resulting from low dispersion of the daytime convection. In the present study, because we use atmospheric stability as tracer for atmospheric layers, it is more appropriate to use the two different regime “stable conditions” and “turbulent conditions”.

Modifications:

In the full document, “layer” has been replaced by “condition” when needed, and SL – TL has been replaced by SC – TC (Stable and Turbulent Conditions).

l.220: “In addition, a residual layer can also be present at CHC station during nightime, resulting from low dispersion of the daytime convection. Because no clear distinctions between the mixing, the free tropospheric, and the residual layers can be strictly obtained from in-situ measurements only, the present dataset recorded at Chacaltaya station is separated in terms of stability conditions (turbulent and stable).”

l.227: “This method is based on the hourly averaged value of the standard deviation of the horizontal wind direction (σ_θ in Eq. 10) calculated every 15 minutes”

l.229: “with $\sigma_{\theta(15)}$ the standard deviation of the horizontal wind direction calculated on the first 15 minutes of every hour, and $\sigma_{\theta(60)}$ the last 15 minutes of every hour.”

Line 189: why was the residual layer excluded by the analysis? Does this mean that the residual layer conditions are embedded in what the author defined as "stable" layers? Please, better specify this point since this can have implications for the interpretation of results.

Answer: The residual layer is finally reported as stable condition. Hence, the interface cases do not take into account the residual layer but cases which cannot be attributed to stable or turbulent conditions. Indeed, these cases correspond to unclear dynamical conditions with high variability of the standard deviation of the horizontal wind direction. In order to analyse aerosol properties in stable and turbulent conditions only, the interface measurements have to be excluded.

Modifications:

l.220: “In addition, a residual layer can also be present at CHC station during nightime, resulting from low dispersion of the daytime convection. Because no clear distinctions between the mixing, the free tropospheric, and the residual layers can be strictly obtained from in-situ measurements only, the present dataset recorded at Chacaltaya station is separated in terms of stability conditions (turbulent and stable).”

l.236: “Interface cases correspond to unclassified data which mainly show high variability of the standard deviation between the two categories of dynamic. As described in Rose et al. (2017), the classification depends also on the σ_θ value in the 4-hour time interval across the time of interest. Interface cases correspond to unclassified data which mainly show a high variability of the standard deviation between the two categories of dynamic. For clarity, the interface cases are excluded from the dataset in the rest of the paper.”

l.249: “Black spots represent undefined cases (or interface) due to a fluctuating classification within the 1-hour time window.”

l.500: “Even TC is usually attributed to mixing layer, SC can be undoubtedly attributed to free tropospheric or residual layers.”

Line 193: I think that "morning" must be changed by "night"

Answer: True.

Modifications:

l.250: “This 3-day example shows that SLSC conditions are mostly observed during night when the convective effect of the previous day is already dissipated and no convective effect of the current day is present.”

Line 204: what BT set is used for the cluster analysis (12 hours or 96 hours)? Why different TRJ lengths were considered/calculated? Is the trajectory calculation set-up changing for the 12 and the 96 hours BTs? The authors did not provide any indication about the meteorological files (which are? Which horizontal and vertical resolution?) used for BT calculation nor about calculation set-up (which starting heights? single or multiple starting points around the station locations). The resolution of the input metro files is particularly important in this mountain region, I guess. Please comment on that and provide caveats about the effective reliability of trajectories in this region. This point is critical for interpretation of results.

Answer:

Indeed, only 96 hours back-trajectories are used in cluster analysis. 96-hours BTs are more appropriate in this region to analyse long range transports in particular from the Amazonian forest.

Hysplit trajectories has been generated using WRFd04 data and the kinematic method with ERA-interim data as boundary conditions. This dataset presents the best topographic resolution for this region with spatial resolution of 1.06x1.06 km and give an altitude of Chacaltaya station of 5058 m a.s.l. (true altitude 5240 m a.s.l.). The WRF dataset presents 28 atmospheric levels of pressure given every 6 hours. For this study, 96-hours BTs are generated every hour starting at 9 locations around the Chacaltaya station (Table 4 below).

Latitude (degrees)	Longitude (degrees)	Altitude (m a.s.l.)
-16,36	-68,14	4852
-16,35	-68,14	4918
-16,34	-68,14	4883
-16,36	-68,13	5000
-16,35	**-68,13**	**5058**
-16,34	-68,13	4965
-16,36	-68,12	5042
-16,35	-68,12	5043
-16,34	-68,12	4936

Table 4: Positions of the 9 stating location of BTs calculations. Chacaltaya station is bolded.

Modifications:

l.264: "WRFd04 dataset has been used to generate BTs every hour, starting at nine locations at less than 1 km around the Chacaltaya station (within a square of 2x2 km around the station). This dataset presents the best topographic resolution for this region with spatial resolution of 1.06x1.06 km, and 28 pressure levels."

Figure 4a is hard to understand and the comparison among the different cluster is challenging. Maybe, it can help to use a stack bar plot with 1 bar for each single month composed by the contribution from each different single cluster.

Also Figure 4b is difficult. The geographical boundaries are not clear at all. The same is true for the topographic features. Most of the locations listed in the legend are meaningfulness for readers not used with the region (are these villages, cities, regions?). For these reasons, it should be strongly improved.

Answer: Figures 4a and 4b have been improved. Indeed, stack bars allow to compare contribution of each cluster every month and is better appropriate to details given in the text. As recommended by RC1, trajectories of each cluster have also been added to Appendix A to illustrate results of the cluster analysis method.

Modifications:

Figure 4a and 1b have been improved.

legend Figure 4: "a. Trajectory frequency plot in La Paz region in Bolivia, centered on Chacaltaya station. ba. Monthly variation of the percentage of back-trajectories (BTs) for each cluster."

Appendix A added with the 10% first BTs more representative of each cluster.

Line 212: sentence starting with "Thus, for each cluster,..." isnt.t clear: what do you mean for "events"? " When the cluster have the most influence": what does it mean?

Answer: In order to obtain aerosol optical properties of each cluster, only a part of the back-trajectories have been selected. One BT is selected if its contribution to one cluster is high enough.

Hence, this can be obtained by selecting the first 10% of the BTs which are the most representative of each cluster. The describing paragraph has been improved to explain this selection of BTs.

Modifications:

l.268: "The Cluster Analysis method used in this study is described in Borge et al. (2007) and based on the Euclidean geographical coordinates distance and given time intervals. Figure (4a) shows the trajectory frequency plot. The opacity of each pixel is proportional to the number of BTs passing through each grid cell. Clusters are defined by using a two-stage technique (based on the non-hierarchical K-means algorithm). Six clusters have been found around the Chacaltaya station. Hence, a fraction of each cluster is assigned to each BT, and is calculated according the residence time in each cluster and their distance from the reference location (the Chacaltaya station). In order to obtain aerosol optical properties of each cluster, only a part of the back-trajectories have been selected. One BT is selected if its contribution to one cluster is high enough. For each cluster, the first 10% of the BTs have been selected by demonstrating the highest contribution to one any cluster. This firsts 10% of BTs related to each clusters and their mean paths are shown in Appendix A1

Line 263: Since the extinction is the sum of absorption and scattering, and scattering » absorption, the similarity between extinction and scattering is trivial.

Answer: This sentence permits to show that the extinction coefficient is mainly driven by the scattering property. This is regularly the case and can be deleted here.

Modifications:

l.333: "[...] and follows a seasonal variation that is very similar to the one of the scattering coefficient" has been deleted.

Line 377 - 376: please better explain. in which way the AAE values are impacted by the aethalometer variability. Do you mean that the uncertainty of aethalometer is enhanced during wet season? For which reason? How this impact results robustness (please discuss in the conclusions)?

Answer: The absorption Angtström exponent is calculated according equation 7 by using wavelength dependency of the absorption coefficients measured by the Aethalometer. As described in the description of the Aethalometer correction, absorption measurements can be biased by an important aerosol loading on filters and multi-scattering effects. However, two physical ways can explain these low AAE values: a reduction of dust and less biomass burning particles due to more efficient removal (higher hygroscopicity of BB particles). The Figure shows the frequency plot of the AAE for the entire period. Results are centered around 1 but vary from -0.5 to 2.

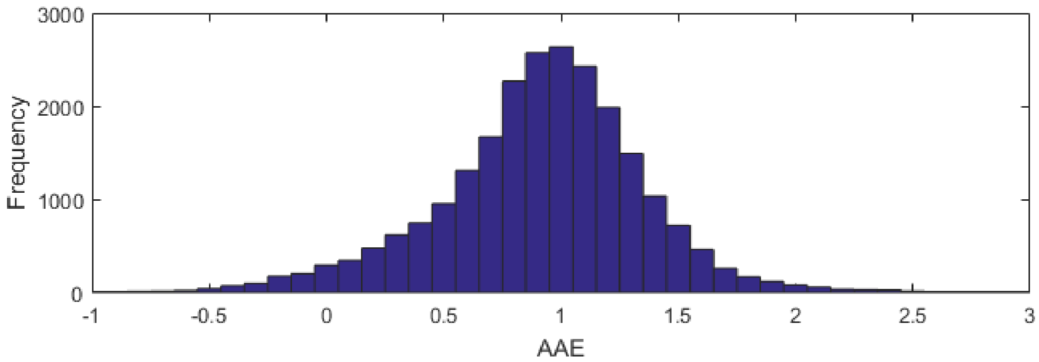

Figure 2 : Frequency plot of the Absorption Angström Exponent for the full period of the study.

Modifications:

l.445: “As shown in Fig. 5, low AAE values, especially during the wet season, can be explained by important reduction of dust and less biomass burning particles due to more efficient removal.”

Line 401: the decrease of urban particle influence within air-masses from LaPaz during "turbulent" conditions (in which I expect more efficient transport from the lower layers to CHC) is rather surprising. Does this indicate some inaccuracies in the local TRJ calculation or in the turbulent conditions identification?

Answer: Capturing the local atmospheric stability is still highly challenging in this region due to the complex topography and high altitude. In addition to these inaccuracies, and as mentioned in the text, dust particles largely generated in this region can also affect measurements in turbulent conditions measured at Chacaltaya station and thus, decrease SAE values. It can also be noticed that SSAAE are still representative of urban influences with values above 0. This indicates the main influence of urban particles from LP cluster in both stability conditions but with a moderate addition of dust influence in the turbulent condition cases.

Modifications:

l.474: “In addition to urban influences, during the BB period and the wet season, LP air masses are also affected by dust particles, especially in the TC, with significantly lower SAE values in the TL.”

Line 421:I agree that the transport to higher troposphere layers was supported but the spread over long-range (please, quantitatively specify what do you mean for longrange) is more a (reliable) hypothesis.

Answer: The long-range transport from the aerosol sources still a challenge to define since no detailed analysis is available about aerosol source locations. However, for BB emissions, the first intensive biomass burning source is located at 300 km fare from Chacaltaya station.

Modifications:

l.148: “[...] (Carmona-Moreno et al. 2005, Giglio et. al 2013). Indeed, the closest region where large areas are affected by biomass burning activities is the Bolivian Amazonia (Beni, Santa Cruz, north of La Paz departments) located ca. 300 km from the station, north and eastward from the Andes mountain range.”

l.505: "The present study has hence demonstrated that BB particles are efficiently transported to the higher part of the troposphere (Stable conditions) and over long distances (more than 300 km long)."

Line 435: the authors concluded that an effect of dust is visible during the entre dry season. However, looking at figure 9, SSAAE is mostly >0 during the dry season which contradict this (see also line 103). Please comment and/or rephrase.

Answer: In this arid region, dust sources have a significant impact on ground based measurements especially when the station is in turbulent conditions which tend SSAAE values to be below 0. However, air masses are not purely influenced by dust particles and are always slightly impacted by urban or BB emissions. In these conditions, SSAAE values are close to 0. In addition, Figure 7 shows the large variability of SSAAE values for every season and atmospheric condition due to the complexity of the different contribution of each type of aerosol measured at CHC. Ealo et al. (2016) have also shown that SSAAE performance in detecting dust is related to the amount of fine particles.

Modifications:

l.521: "In addition to urban and BB influences, the wavelength dependence of the single scattering albedo (SSAAE) measured at CHC highlights a main dust influence during the entire dry season with SSAAE values close to 0."

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-510, 2019.

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