Anonymous Referee #3

First, authors would like to thank the reviewer for his/her important comments and interesting suggestions. We bieleve they clearly helped highlighting the main conclusions of the paper and extend the interest to regional impacts of aerosol sources in South-America.

As recommend by all reviewers, layers have been renamed in order to justify that the method used only allows to differentiate atmospheric dynamic. Thus, Stable Layer (SC) and Turbulent Layer (TL) are replaced by Stable Condition (SC) and Turbulent Condition (TC).

In the following, authors answer to the reviewer and list modifications made to the paper.

Received and published: 10 September 2019

The paper by Aurelien et al. presents a detailed analysis of aerosol optical properties at a remote site of Andean mountains. The measurements are long-term and, therefore, certainly credible in terms of seasonal cycles, however, the novelty is mainly based on somewhat underexplored and sensitive region and that alone does not constitute scientific novelty. The authors make up for publishable results by careful and thorough data analysis separating dataset to represent stable and turbulent atmospheric layers alongside detailed trajectory analysis. The paper can be accepted for publication after addressing mainly minor comments. Last but not least English can be improved with the help of senior co-authors.

Conclusions could be more concise if a summarising diagram with the main transport patterns and corridors were presented. What matters is not a repeat of study results, but emphasising something about lasting regional impacts. Otherwise, it is just another study of optical properties at a different location.

Answer: Figure has been improved in order to illustrate the main airmasses transported to CHC station according seasons. The main influences for different seasons are discussed from l.274. As the RC3 suggests, this information gives interesting elements to discuss about regional impacts of the different aerosol sources in this particular region. Regional impacts have been highlighted in the final conclusion.

In addition, three tables have been added to summarize ranges of Angström exponent for the different aerosol types (Table 1), to detail the median values of the Angström exponent for each cluster, season and atmospheric stability measured at CHC station (Table 2), and suggest a new Angtsröm exponent definition for the different aerosol types (Table 3).

Modifications:

Figure 4 has been improved.

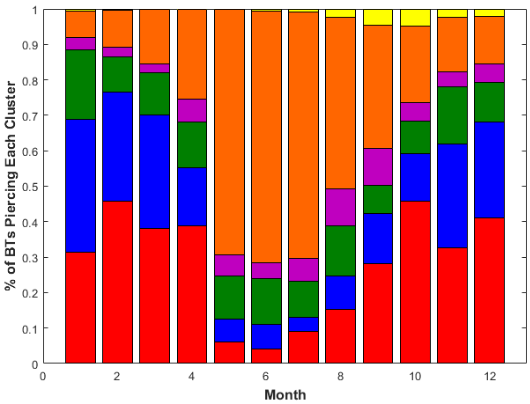

Figure 4: b. Monthly variation of the percentage of back-trajectories (BTs) for each cluster.

Table 1, 2 and 3 have been added.

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 particules 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.”

l.4503: “The present study clearly demonstrates the regional impacts of these activities.”

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).”

l.510: “One of the main aerosol sources in the Bolivian plateau is the urban area of La Paz / El Alto.”

l.520: “Finally, the arid plateau of the region has also demonstrated regional impact. 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.”

Minor comments

Line 31. Resulting in lower atmospheric...

Answer: In the final version, this sentence has been deleted.

Line 33. different aerosol sources.

Answer: In the final version, this sentence has been deleted.

Line 35. on average, instead of "in average".

Answer: Correction made.

Modification:

l.39: “[...] extinction coefficients are on average [...]”

Line 41. ...increase in the extinction...

Answer: Correction made.

Modification:

l.54: “28% to 80% increase in the extinction”

Line 44. How far away?

Answer: Scales still difficult to describe when only one in-situ station is used in addition to back-trajectories. In the present study, "long distance influences" is used for aerosol particles transported several hundreds of kilometres far from their sources whereas "local influence" is linked to aerosol particles transported less than 100 km from their sources. Additional ground based measurements could help to locate with more detail aerosol sources and satellite measurements could give more information on their long distance transport.

Modification:

l.46: "[...] far away from their sources [...]" is replaced by "[...] to a remote site [...]"

Is stable layer normally the upper layer above the boundary layer or is it free troposphere? I understand it is based on statistical treatment, but the abstract should convey the message without reading all the details.

Answer: From the method based on the local dynamic of the atmosphere and the impossibility to access to the vertical distribution of aerosol for the full period, stable and turbulent conditions are used in this study to differentiate atmospheric layers. Hence, it is not possible to attribute stable and turbulent conditions to unique common tropospheric layers. A sentence is added on the abstract to make this step clearer.

Modification:

l.58: "Results are also separated from distinct atmospheric conditions as stable and turbulent, with associated properties of the free troposphere and the planetary boundary layer"

Line 106-113. There have to be goals, not summary and justification of what and how the study has done.

Answer: The paragraph has been modified according to these suggestions.

Modification:

l.133: "Monthly and diurnal variations of extensive optical properties (related to particle concentration) and intensive optical properties (related to particle chemistry) are firstly shown. A robust method based on the measurement of the atmospheric stability is then applied to distinguish atmospheric conditions (stable and turbulent). Finally, back-trajectory analysis and optical wavelength dependences are presented to identify impacts of local and regional aerosol sources."

Figure 1. In insert would help to visualise in the larger region, especially tha the Figure covers only appr. 50x50km.

Answer: A larger view of the topography is added to figure 1.

Modification:

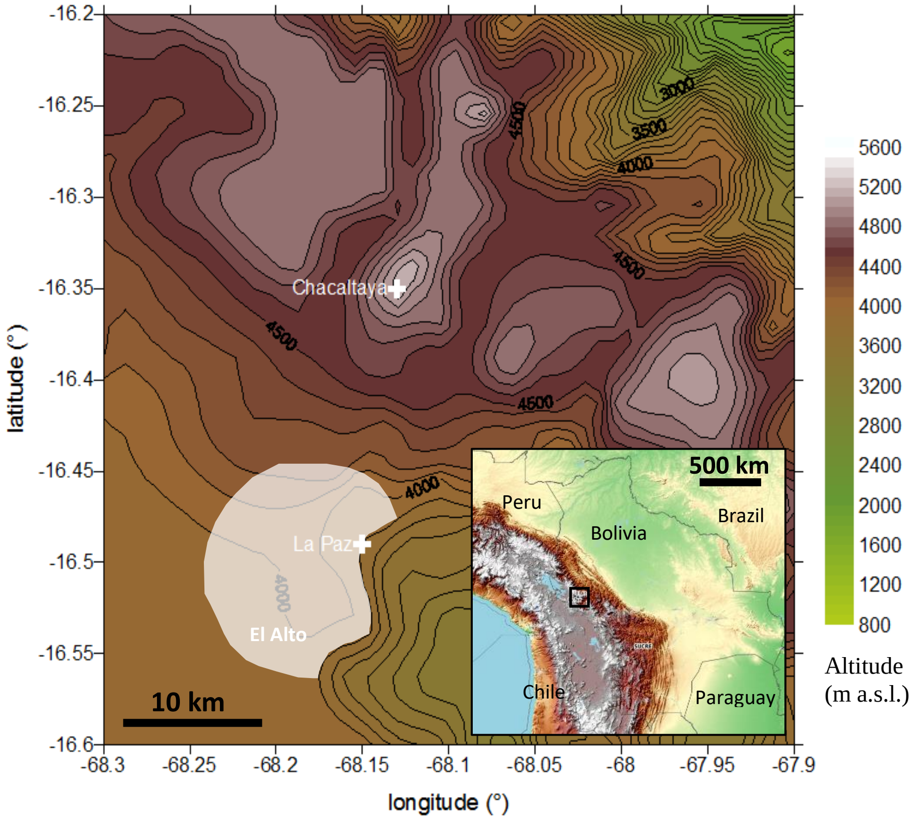

Figure 1: Topographic description of La Paz and Chacaltaya region, and Bolivia in the lower right panel. The black rectangle on the small panel represents La Paz region. The urban area of La Paz-El Alto (marked as white shading) lies in the Altiplano high-plateau at around 4000 m a.s.l..

Line 125. The papers deals with impacts over much larger region, therefore, it is important to describe that larger region, e.g. extending to 200km.

Answer: As discussed in previous remarks, long range transport is related to several hundreds of kilometres. Precisions have been added to the text.

Line 193. Use past tense as measurements represent the past not present day.

Answer: Correction made.

Modification:

l.250: “This 3-day example showed that [...]”

Line 276. Correlation is a scientific term, therefore, cannot "correlate to seasons". Use "...values exhibited typical seasonal variation".

Answer: Correction made.

Modification:

l.347: “[...] variations of AAE and SSAAE values exhibited typical seasonal variation.”

Line 327. I am not sure I follow why SL particles are aged longer and transported farther. Please elaborate.

Answer: Aerosol particles reaching high altitudes are subject to a more stable atmosphere with strong horizontal circulation and weak vertical motions. Hence, especially small particles (diameters around 1 µm) can be aged longer and transported farther.

Modification:

l.399: “[...] SC aerosol particles are aged longer and transported farther than TC particles due to less scavenging effects.”

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

References:

Clarke, A., McNaughton, C., Kapustin, V., Shinozuka, Y., Howell, S., Dibb, J., Zhou, J., Anderson, B., Brekhovskikh, V., Turner, H. and Pinkerton, M.: Biomass burning and pollution aerosol over North America: Organic components and their influence on spectral optical properties and humidification response, J. Geophys. Res. Atmospheres, 112(D12), D12S18, doi:10.1029/2006JD007777, 2007.

Collaud Coen, M., Weingartner, E., Apituley, A., Ceburnis, D., Fierz-Schmidhauser, R., Flentje, H., Henzing, J. S., Jennings, S. G., Moerman, M., Petzold, A., Schmid, O. and Baltensperger, U.: Minimizing light absorption measurement artifacts of the Aethalometer: evaluation of five correction algorithms, Atmospheric Measurement Techniques, 3(2), 457–474, doi:10.5194/amt-3-457-2010, 2010.

Dubovik, O., Holben, B., Eck, T. F., Smirnov, A., Kaufman, Y. J., King, M. D., Tanre, D. and Slutsker, I.: Variability of absorption and optical properties of key aerosol types observed in worldwide locations, J. Atmospheric Sci., 59, 590–608, doi:Review, 2002.Russell, P. B., Bergstrom, R. W., Shinozuka, Y., Clarke, A. D., DeCarlo, P. F., Jimenez, J. L., Livingston, J. M., Redemann, J., Dubovik, O. and Strawa, A.: Absorption Angstrom Exponent in AERONET and related data as an indicator of aerosol composition, Atmospheric Chem. Phys., 10, 1155–1169, doi:10.5194/acp-10-1155-2010, 2010.

Russell, P. B., Bergstrom, R. W., Shinozuka, Y., Clarke, A. D., DeCarlo, P. F., Jimenez, J. L., Livingston, J. M., Redemann, J., Dubovik, O. and Strawa, A.: Absorption Angstrom Exponent in AERONET and related data as an indicator of aerosol composition, Atmospheric Chem. Phys., 10, 1155–1169, doi:10.5194/acp-10-1155-2010, 2010.