RESPONSE TO REVIEWER 3

We would like to thank the reviewer for the insightful and helpful comments and suggestions. The response to each comment is below in italics.

General comments :
This paper is indeed well in the scope of the journal, but needs to be improved before acceptance. The manuscript appears as not enough mature, missing frequently of accuracy with lack of definitions and arguments. Provide sections 3.2.1, 3.2.2 and 3.2.3 earlier in the manuscript because these informations should be available for the lidar when operated at l'Université de la Réunion.

Sections 3.2.1, 3.2.2 and 3.2.3 are now provided earlier in the manuscript.

Equation 6, correlated text and figures are unclear and I will not address any comments there, unfortunately a key point in your study. Improve Figures and to suppress the figures or table when not enough informative and avoid repetitions. Material should be valuable with a real effort and some work to reinforce the demonstration and the benefits/limits from this new instrumentation.

Equation 6 is now clarified and "not-usefull-enough" Figures and Tables are removed.

Specific comments (not extensive) :
Title should be revised discarding Part 1 which is not meaningful. I suggest : « Ozone profiles from a DIAL lidar at Maïdo Observatory (Reunion Island): instrumental description, instrumental performance, and result comparison with ozone external data set. »

This suggestion is taken into account in the new title. However, "Part 1" is kept because this paper is the companion article of an upcoming one dealing with stratospheric ozone measurements in Reunion Island, which will be the "Part 2".

Your paper is based on a DIAL instrument...but DIAL is nowhere defined as a Differencial Absorption Lidar. Please define this acronym at least once.

The DIAL acronym is now defined in the abstract and in Section 2.1.

This lidar technique is now well known and you refer to major technical points already published regarding your instrument (ex line 31 p3-line 1 p4) and data processing. Highlight what is new regarding LIO3T instrument and performance as compared to previous published papers.

This work mainly aims to validate the LIO3T measurements. As, indeed, technical description of the instrument can be found in previous published papers, we now refer to these previous papers and only state the most important features of the system.

Please discuss the uncertainty from your figure 2 versus figure 7 and explain why the results are

similar/different with respect to altitude.

There was a mistake in the uncertainty calculation due to the various valid ranges troughout the lidars datasets. It is now corrected and results are more consistant.

Homogenize your instrument labelling. Fix it once and make it consistent all along the text, including abstract, figures and tables. Along the text, you used : ozone lidar system (LIO3TUR), LIO3T, LIO3T O3, LIO3TUR, system, current system, current LIO3T system, LIO3T system, LIO3T lidar, LIO3T low and LIO3T high (this two latest are undefined elsewhere and used also in the abstract - unclear). For example I suggest to replace sentence starting line 10 page 3 by : "In the following, the lidar installed at the Université de la Réunion will be referred as LIO3TUR whereas the one installed at the Maïdo Observatory will be referred as LIO3T". Two labelling seems enough. If you need more, clearly explain.

Instrument labelling is now consistent. However, we did not change line 10 page 3 because we do not want the reader to believe that both system (LIO3TUR and LIO3T) are currently operating (only the LIO3T – at the Maïdo Observatory – operates). Regarding the "LIO3T low" and "LIO3T high", they are not labels, they indicate if LIO3T is in average higher or lower than the ancillary dataset. It is now made more explicit.

Revise and Clarify line 5 p2 : "Ozone is a major greenhouse gas in the upper troposphere and lower stratosphere". Insist on radiative forcing contribution and remove "major"...
Rephrase lines 14-15 p2 and justify "great interest" to document climate change.
Line 20 p2 : "To improve the operation of remote sensing instrument" remote sensing is imprecise. Do you refer to space-borne instrumentation?... and operation seems not appropriated. Replace "a 2160m-high atmospheric facility" by "a high atmospheric facility" to avoid repetition. You provide afterwards geographical coordinates and altitude.

Introduction is now revised and clarified with respect to these comments.

Figure 1 : Gillot in black is difficult to see and altitude would be here welcome (figure already published please provide reference).

Figure 1 is changed and coordinates (including altitudes) are given for each site on Table 1.

Additional general comment on altitude: mention once all altitudes in your manuscript will be provided in amsl and avoid to repeat latter.

Done on page 6 line 14.

Replace title section 2 by "Historical context of the lidar installed at the Université de la Réunion (LIO3TUR, 1998-2010)

The article outline is changed and we now describe the LIO3TUR and LIO3T in the same Section

(3.1).

Replace title section 2.1 by “Instrumental description” or “Instrumental characteristics”

Done.

Line 7 p4 : First sentence is really too short...Is that your result? Could you explain the altitude range limitation? Don’t forget your goal Line24 p3 is to provide data "over the entire tropospheric column...".

This range validity is now justified by the overlap factor and signal-to-ratio (page 6 lines 13-14). Moreover, the “over the entire tropospheric column” sentence is now removed and replaced by “In 1998, an extension was installed to the existing system to perform ozone measurements in the free troposphere, including the upper troposphere” (page 5 line 22).

Figure 2 : by “resolution” you mean “vertical resolution”...

Yes, X label is now clarified.

What is the criteria for uncertainty? It is defined lately for LIO3T.

The same criteria apply for the LIO3TUR uncertainty and the Data processing sections are now provided before.

It would be valuable in addition to have uncertainty expressed with the ozone unit provided. Explain why such a change in the uncertainty of LIO3TUR with respect to altitude. Please modify your X-axis (top and bottom) giving a more precise scaling (more minor ticks).

Done.

Line 9 p4 : “Temporal resolution... was chosen depending on atmospheric conditions”...Please justify what is your criteria.

The atmospheric conditions mentioned here are the cloud free sky duration. It is now clarified in the text (page 6 line 16).

Figure 3 and Figure 4 : please provide consistent figures. The number of profiles given per year is non adapted and consistent to support a monthly-averaged climatology. Note than < 10 profile per year is extremely low. Provide the monthly statistics for the ECC sondes, the LIO3TUR and LIO3T in a panel of your figure 4 , deep gaps within years could be specified in the text and you might suppress figure 3. Please replace figure 4 caption by “Monthly O3 climatology derived from ECC sondes over 2005-2015 at Gillot site between 0 and 19km (Top left panel), from LIO3TUR over 1998-2010 at Université de la Réunion campus site between X and XXkm (Top right panel) and

from LIO3T over 2013-2015 at Maïdo Observatory between X and XXkm (Bottom panel).".

Figure 10 now shows the monthly statistics for ECC, LIO3TUR and LIO3T and Figure 11 caption is changed.

Comparing the ECC sondes and LIO3TUR climatology, your figure 4 points out within 10-16km greater ozone concentrations from the ECC sondes...Explain, please.

The ECC climatology is now done with the reprocessed ECC database (Witte et al., 2017) and with a correction applied to take into account the non-standard ECC/solution pairing (cf. Section 4.1). As a result, these greater ozone concentrations between 10-16km previously pointed out by ECC do not appear anymore.

Replace title section 3 by "The lidar installed at the Maïdo Observatory (LIO3T, 2013-present)"

As LIO3TUR and LIO3T are now presented in the same Section (3.1), this section does not exist anymore.

Line 31 p4 : "Many instrument" is very imprecise.

The sentence is changed.

Line 32 p4 : "another lidar" is imprecise. Which one : the LI1200 ?

Right. It is now clarified in the text.

Replace 3.1 in title "current system". In this paragraph, a similar description has been provided in Baray et al. (2013) and citation is missing. Is there something new?

Yes, description of the system can be found in Baray et al. (2013) and there is nothing new on this system since 2013. We now only state the main important features of the system.

Suppress lines 18-20 from this paragraph, probably the right place would be in "conclusions and future plans".

Done.

Please consider Table 1 and Figure 5 and try to avoid repetition between both. Table 1 should be probably suppressed.

This is right ; Table 1 is suppressed.

Please modify in Figure 5 caption using “LIO3T instrumental schema” ... I expect you are referring here precisely to LIO3T at Maïdo Observatory???

Figure 2 caption is modified, and yes, we are refering to the LIO3T (at Maïdo Observatory).

Line 23 p5 : “two backscattered lidar signal at two different wavelength” Check if correct.

It is correct.

Line 24 p5 : be more concise. I suggest “...wavelength, at 289nm (lon) where ozone is strongly absorbed and at 316nm (loff) where ozone absorption is weaker”.

This sentence is now more concise.

Line 28 p5 to Line 7 p6 : please avoid repetitions. Fix once z as the altitude and l as the wavelength. Please provide the interfering gas.

Repetitions are now avoided. Regarding the interfering gases, according to Leblanc et al. (2016), the interfering gases to consider in practice are NO2, SO2, and O2. NO2 and SO2 are negligible in most cases of tropospheric ozone retrieval, except in heavy volcanic aerosols loading conditions. The absorption by O2 should be considered if any of the detection wavelength is shorter than 294nm (which is the case here as we use the 289nm wavelength). However, in our case, we do not take into account any interfering gases for the time being. It is part of our future plans to include them in the “DIAL” code. This is now stated page 4 lines 3-8.

Line 7 p6 : This last sentence introduces further 3.2.2, specify. Additionally replace “this” by the equation number to be precise.-

Done.

Replace 3.2.2 title I suggest to replace by Saturation, correction and consequences on the vertical resolution

Done.

Line 9 p6 : “Saturation” what is saturated and what is the cause and why below 7km.

The saturation is defined as a difference between the number of photons received by the detector and the number of photons acquired. It is a non-linear phenomenon, depending on the dead time of the detector. In the LIO3T case, due to the detector sensitivity and the geometry of the instrument, we found that saturation occurs only below 7km. This is now clarified page 4 lines 10 and 16.

Line 13 p6 : ‘etc’. Rephrase the sentence”...type of filter such as....

Done.

Line 14 p6 : replace “described” by extensively detailed.

Done.

Line 15-16 p6 : “we decide”...replace by we found and rephrase but add (not shown)

Done.

Line 18 p6 : “the resolution rises” Modify expression. Compare the vertical resolution to figure 2 and explain.

The sentence is corrected and the vertical resolutions are presented in Figure 3 and Section 3.2.

Figure 6 : Modify the resolution lines using dashed lines and modify caption on the figure in order to discriminate ozone profiles and the vertical resolution given with respect to integration time. In the figure caption, origin of data (LIO3T) is missing.

Figure 6 is suppressed it does not bring any information with respect to the scope of this article, which is not to analyse any case study.

Line 26 p6 : Please check here “to 5The”

Done.

Line 9-10 p7 : “new tropospheric ozone version...” the details on cross-sections and uncertainty you provide is not much informative and information seems different from line 25-26 p6.

This sentence is suppressed (not very usefull indeed).

Line 11-17 p7 : not at the right place, better place could be in conclusions and future plans

Done.

Line 25-26 p7 : explain why only at night.

Done page 6 line 13.

Explain why such integration time changes with respect to the data you compare to.

Done page 6 line 27 and page 8 line 6.

Line 28-30 p7. Please rephrase this sentence. “Notably” is imprecise, how much and where, but note the consistency within ~9-11,5km and explain.

We removed this figure as it does not bring any information with respect to the scope of this article, which is not to analyse any case study.

Line 4 p8 : “goes” replace by varies

Done.

Figure 7 : Why LIO3TUR uncertainty increases by a factor of 3 at least above 13km whilst the one of LIO3T decreases above 14km whatever the integration time by a factor of 2 at least.

There was a mistake in the uncertainty calculation due to the various valid ranges troughout the lidars datasets. It is now corrected and results are more consistant.

Revise section 4 title. Comparison is really too short here. What pieces are you comparing.

Section 4 title is now “Comparisons with ancillary data”.

Line 9 p8 ‘validate’ Do you compare, evaluate or validate?...Keep constant and take care when using validation concept. I would say here you evaluate...

One of the main goals of this paper is to validate the LIO3T measurements by comparing them to ECC soundings (which are commonly used for this purpose). We consider that this work is a validation of the LIO3T measurements.

Line 13p 8 add IASI after space-borne and replace instrument by data.

Done.

Line 14-16: This paragraph is absolutely obscure... I don’t understand at all what you are dealing with and description of the equation terms is hard to follow. Be clear, concise, avoid repetition and be simple, that will help. I can’t go further here... Explain clearly how can D be negative and give a clear definition for D ??? What is LIO3Tn? What is MCDn? What is D by the end?

We are very sorry that this "D" parameter confused you and hamper your reading of the manuscript. "D" definition is now clarified (page 7 equations 7 and 8). "r" is the relative difference between two observations, using the mean value of these 2 observations to not considere anyone as the reference one. "D" is the mean over the entire dataset of the absolute values of "r". We use the absolute values of "r" because positive and negative values can balance each other resulting in an erroneous "D" (which can not be negative indeed - X label of right panel plots of Figures 5 and 6 is now "r" instead of "D").

Line 17 p8 add sondes after ECC.

Done.

Line 23-28 p8 : For that reason I think you should use only 'evaluate' and not 'validate'...as mentioned above.

Following the work of Johnson et al. (2002, 2016) intercomparing various KI and buffer solutions, we found that this ENSCI/0.5% full buffer solution tends to overestimate the amount of ozone by 1.7% in the troposphere. Consequently, an adpated correction was applied on the ECC profiles during this period. This is stated page 7 line 28 and page 8 line 1. Having corrected these ECC observations, we consider we can use them to validate the LIO3T measurements.

Line 9 p9 "SO2 loading too strong" imprecise, please provide informations on the amount.

This aerosol enhancement is clearly visible on the 355nm channels of the stratospheric ozone and LI1200 lidars, and on the 532nm channel of the LIO3T (not shown), and back trajectories together with CALIOP observations (on board CALIPSO - not shown) show that the detected plume comes from the Calbuco volcano. Consequently, although we do not have any information on the corresponding aerosol and SO2 amount, we consider as a wise assumption that, in the layer where this volcanic plume lies (i.e. between 17 and 22km), the SO2 and aerosols loading is too strong to allow a correct O3 retrieval. The study of this volcanic plume crossing in the south-western Indian Ocean will be the subject of dedicated articles. These explanations are added page 8 lines 12-17.

Line 11 p9 : "mean D" see above comment and remove LIO3Tlow which is undefined and that I do not understand. Clear definition is mandatory.

D only gives an absolute relative difference between two datasets, without indicating which one is greater than the other. "LIO3T low" means that the LIO3T dataset gives lower values than the ancillary dataset. It is now made more explicit.

Line 15 p9: "Enhanced" by how much and provide a reference.

These sentences warn the reader about specific conditions that occurred during the MORGANE campaign, and introduce an ongoing work about these stratospheric intrusions above Reunion Island involving the Calbuco volcanic plume. Consequently, no reference is available. This paragraph is modified according to this answer.

Line18-19 p9: Not at the right place, move to conclusions and future plans.

Done.

Figure 8 and 9 : I am not able to make any comment at the moment. Please use different line thickness for the mean and standard deviation in the figures. Text of the figure caption might be improved. Use same Yaxis altitude range in both figures.

Figures 5 and 6 are now improved with respect to these comments.

Line 21-22 p9 : Replace 3PM by 15:00:00 LT, 7PM by 19:00:00 and 1AM by 01:00:00 LT

Done.

Line 25 p9 : replace "goes"

Done.

Line 29-30 p9: rephrase this sentence, unclear.

This sentence is suppressed because the ENSCI/0.5% full buffer solution effect is now corrected.

Line 2 p10 : This FTIR spectrometer should be added to the list of instruments operating at Maïdo Observatory and provided in introduction (line 26-27).

We talk in the introduction only about the "lidar systems that are permanently deployed and routinely operated at the Maïdo Observatory". As of this writing, 30 instruments are installed in the Maïdo Observatory, and this paper does not aim to list all of them. However, Figure 1 is changed and the FTIR appears on it, together with its location.

Line 19-20 p10 : improve text...both instrument are operating at the same place so their measurements are colocated...What has to be pointed out is the time window you consider for the comparison.

This sentence is made clearer.

Add "Thus, for the LIO3T comparison with FTIR, 114 LIO3T profiles are available".

114 FTIR-LIO3T pairs are available, because a single LIO3T profile can be linked to several FTIR measurements (within the time window).

Line 21 p10 : just mention the selected LIO3T profiles are regridded consistently to the FTIR.

Done.

Line 22 p10 How many FTIR data are averaged within 24h.

It depends on the measurement conditions (the FTIR only operates in clear daily skies).

Line 23-31 p10: Very very hard to follow...

Sorry about that !

Line 3 p11: replace “time series” by “available over the 01/2013-01/2015 period.”

Done.

Figure 11 : The caption is imprecise and bottom plot Y-axis text is not consistent with equation 6. Is it D???

Y label is now “r”.

Moreover, I found 12 symbols on this bottom plot ???

That is right. Number is changed page 10 line 4.

Figure 12 : I wonder if figure 10 and 12 should be gathered...

Good idea, Figure 10 and 12 are now gathered into Figure 7.

Provide minor ticks for the month on the Xaxis plots

Done.

Line 18 p11 : suppress “ hereabove for the comparison with the ground-based FTIR observations” and replace by “in section 4.2.1”.

Done.

Figure 13: refer to figure 11 comment

Done.

Line 27 p11 : I don't clearly see a seasonal cycle, I see an O3 increase particularly in 2013 and 2016 suggesting an impact of biomass burning...

This sentence is corrected (page 10 line 32).

Section 5 : Title is data set and times series... You are dealing here with data from Intensive period of observations during campaigns... I think it makes the difference with material in previous sections, if I well understood. Please provide a more explicit title. This section is lengthy.

In Section 4, we were dealing with comparison with ancillary data coming from both intensive (Maïdo ECC) and routine (Gillot ECC, FTIR and IASI) periods of observations. In Section 5, we present the full datasets and the resulting climatologies. Section 5 title is changed to "Dataset and climatologies". Moreover, this section is now shortened.

Line 30 p11 – line 3 p12 : You provide LIO3T results in this section...Thus other lidar and details not used further are out of the scope of your study. Thus suppress. This text is very long and the Figure 14 do not provide more informations with respect to the text and is difficult to read. Shorten and improve text.

Text is shorten and Figure 14 is removed because Figure 10 now shows the monthly total number of LIO3T profiles.

Figure 15 is not much informative and text seems to repeat what is given in Line19-21 p7.

Figure 15 is suppressed.

Figure 4 : Please specify in the caption of bottom panel what the LIO3T climatology includes (data routinely performed and from intensive period of observations ???).

It is now specified in the caption that the plot includes data routinely performed and from intensive period of observations

Figure 16 : please provide these informations (4 numbers) on Figure 17 and suppress Figure 16.

Figure 16 is suppressed and information are given in Figure 12 caption.

Line 16-20 p12 : bring in the light what are the benefits from your new lidar...For sure a better description from the upper-troposphere/lower-stratosphere than when located at UR.

Exactly. It is now stated in the text (page 12 lines 18-20).

Line 21-24 p12 : valuable comments and for such reasons I encourage authors to carefully and rigorously revised the manuscript. Take care to the ECC caveats already mentioned.

OK.

Figure 17 : I recommend to add informations on the seasonal sampling frequency with respect to altitude and this should be done here with an additional panel.

Done on Figure 12 (right panel).

Section 6 : bring more in the light the benefits provided from LIO3T...if monthly climatology from ECC is equivalent and to LIO3TUR and LIO3T (i.e. range of values and seasonal patterns). Could you reinforce you study here... Your goal was to describe the whole tropospheric column with LIO3T... What is your conclusion?

The move of this lidar from the Université de la Réunion campus site up to the Maïdo observatory allows it to document the UT/LS region and to follow stratospheric and tropospheric intrusions with relevant vertical and time resolutions together with a reasonable uncertainty (1.5km, 20min and 14%, respectively, at 18km). This tropospheric ozone data set covering the tropical free troposphere and UT/LS of a sparsely documented region (South Western Indian Ocean) constitutes an extremely valuable resource for the validation of satellite tropospheric ozone retrievals, analysis of the ozone variability and sources, dynamics analysis of case studies, and for long term atmospheric monitoring. This is now stated page 12 lines 18-23.

Line 15-20 p12 : specify altitude range here.

Done.

Line 29-32 p12 : suggestion : A DIAL tropospheric ozone lidar was operating on the Université de la Réunion campus site from 1998 to 2010, providing 427 ozone profiles.

OK.

Note that this information on 427 profiles was not mentioned before. Same remark for LIO3T profiles.

It was mentioned page 4 line 11 for the LIO3TUR and page 12 line 4 for LIO3T.

Replace “familly” by network.

Done.

Line 9 p13 : “we found a 7.7% D between”...revised with the D definition.

Done.