Reply to Anonymous Referee #1:

Thanks to the reviewer for his/her helpful advice, please find our answers below:

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GENERAL COMMENT

The paper presents an interesting study on long-range transported smoke aerosols, originated in Canada wildfires, in the UTLS (Upper Troposphere/Lower Stratosphere) over Europe detected at several EARLINET stations in summer 2017 in combination with satellite observations. Optical depth at 532 nm from 0.05 to above 0.20 were detected, with very weak spectral dependence. Other particle microphysical properties like Lidar ratio and particle depolarization ratios suggest the presence of aged smoke likely with complicated morphology. The retrieved aerosol properties allowed the computation of the direct radiative forcing (DRF) effect originated in the UTLS aerosol layers and the radiative heating rates in this layers that are coherent with the observed radiosonde temperature profiles. The paper is worthy to be published in ACP having in mind that evidences the capabilities of a lidar network focused on tropospheric research in obtaining valuable information on the UTLS aerosols. For this purpose both the advanced instrumentation and the analytical tools used are crucial. The paper is well written and offers valuable information for the reader. Nevertheless the clarification of some points will enhance the quality of the paper.

PARTICULAR COMMENTS

In this work it is especially relevant to get information on the accuracy and uncertainties of the retrievals. The AOD retrievals and the lidar ratio retrievals are clearly related in the analysis procedure used. In this sense, the approach followed for the computation of the UTLS AOD and Lidar ratio with the fixed lidar systems is stated and details on the error propagation and discussion on the accuracy and uncertainty of the retrievals is presented. Nevertheless, some points require additional clarification.

1. Thus, concerning the discussion on the error propagation, in Page 7, I have a question: Are the authors assuming the absence of errors in the molecular part? Having in mind the impact of an accurate thermodynamic profile on this assumption I do not see any information on the thermal profile used. Furthermore, although the computation of the uncertainties is applied in the analysis sections, it would be worthy to include some quantitative information concerning the final uncertainties of the UTLS AOD and UTLS lidar ratio retrievals in the last paragraph in section 3.1.1.

A1: The temperature and pressure profiles are taken from radiosonde measurement in the closest stations: Trappes 20 km from Palaiseau and Beauvechain 120 km from Lille

station. Although the radiosonde stations are not exactly collocated with the lidar observations, we found the spatial variations are minor after exanimating the variability of the temperature and pressure profile in the two stations in August 2017. We think the errors resulting from molecular scattering are not significant, so it is not considered in the total error estimation of the optical depth.
The total error is calculated following Equation (4) and (5), and the calculation process is quite straightforward, we think that it is not necessary to present the calculation details in the paper.

2. In the case of the MAMS lidar retrievals there are additional limitations and the issue of accuracy and uncertainty is particularly relevant. Thus, in spite of the auxiliary use of its data, it is necessary to include additional discussion on the reduced accuracy of this retrieval.

A2: The limitation of MAMS lidar inversion is discussed in the 'Methodology' section before the MAMS results are presented. In the revised version, we mention when presenting MAMS results, that "the MAMS results are limited mainly by the difficulty of quantifying the errors resulting from the lidar signal at high altitude and the assumption of vertically constant lidar ratio".

3. Considering the uncertainty in the AOD retrievals the AOD spectral dependence will present a large uncertainty that requires additional discussion.

A3: The error of the Angstrom exponent Å is derived from the following equation:

$$(\Delta \text{Å})^2 = \left(\frac{1}{\log\left(\frac{\lambda 1}{\lambda 2}\right)}\right)^2 \left[\left(\frac{\Delta\tau_{\lambda 1}}{\tau_{\lambda 1}}\right)^2 + \left(\frac{\Delta\tau_{\lambda 2}}{\tau_{\lambda 2}}\right)^2\right]$$

Considering the error of the two selected cases, the error of optical depth is about 10%, the estimated error of the Angstrom exponent is about 0.3 (absolute value, unitless); and if the error of optical depth is 15%, the resulting error of Angstrom exponent is about 0.5(absolute value, unitless). Compared to the extinction coefficient, the backscatter coefficients we derived are more reliable because they are rather consistent with the results from Raman inversions, except the 1064 channel. The main error of regularization input comes from the error in the spectral AOD and the backscatter coefficient at 1064 nm.
The above information is reorganized and added into the revised version.

4. More details about the procedure used in GARRLIC for the computation of the

aerosol DRF and the UTLS, layer heating rates must be provided.

A4: More information has been added in the manuscript to describe the general strategy of GARRLiC /GRASP and the input parameters for the calculation procedure. The theories and methodology of GARRLiC/GRASP can hardly be well presented in a short section. So we suggest the readers to refer to previous publications about GARRLiC or GRASP. GRASP is an **open source algorithm**, anyone who is interested in using GRASP to reproduce the results in this paper or to invert their own measurements, is **very welcome** to download the algorithm here: https://www.grasp-open.com or contact us by email.

Minor changes

5. The references on the EARLINET network must include a recent reference that updates the features of the network: Pappalardo, G., Amodeo, A., Apituley, A., Comeron, A., Freudenthaler, V., Linné, H., Ansmann, A., Bösenberg, J., D'Amico, G., Mattis, I., Mona, L., Wandinger, U., Amiridis, V., Alados-Arboledas, L., Nicolae, D., and Wiegner, M.: EARLINET: towards an advanced sustainable European aerosol lidar network, Atmos. Meas. Tech., 7, 2389-2409, https://doi.org/10.5194/amt-7-2389-2014, 2014.

A5: It is added.

6. Please consider the following reformulation of the statement on Page 6 Line 2 "at this temperature clouds consist mainly of ice crystals" In order to increase the clarity of the test include the following changes in the first paragraph of section 3.1.1: Substitute:" The integral of the extinction coefficient over the UTLS layer, expressed below, is compared with the pre-calculated optical depth" by "The UTLS AOD is calculated by the integral of the extinction coefficient over the UTLS layer, expressed below". And after equation (2) reformulate the statements: "This pre-calculated optical depth is derived from the elastic channel at 355 and 532 nm. The method is widely used in cirrus clouds studies (Platt, 1973; Young, 1995). " as follows" by "This derived value of AOD is compared with the pre-calculated optical depth obtained from the elastic channel at 355 and 532 nm using a method widely used in cirrus clouds studies (Platt, 1973; Young, 1995)" In page 7 Line 7 change: "We calculate the signal mean within a window of 0.5 km..." by "We calculate the lidar signal mean within a window of 0.5 km. . ." In page 9 line 13 consider changing "intervals" by "periods".

A6: These statements are re-phrased; some are not exactly modified as suggested but in a similar manner.