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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A study of long-range transported smoke aerosols in the Upper Troposphere/Lower Stratosphere" *by* Qiaoyun Hu et al.

Anonymous Referee #2

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General assessment and major comments

This study provides lidar measurements from two sites in Northern France, showing long range transported smoke in the UTLS. The absorbing nature of smoke is crucial for the stratospheric height ranges, concerning both heating rates (HR) and direct radiative forcing (DRF). The authors try to estimate the DRF and HR and their results show decrease of the radiation reaching the surface and an increased HR due to the absorption of the solar radiation at TOA. In general, I find this study very interesting and of high value. It is a study that fits well in the EARLINET special issue, since it demonstrates the value of EARLINET lidars for atmospheric research in both troposphere and

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stratosphere. However, before proceeding with publication in ACP, I strongly suggest that the authors would revise the following points:

1. Page 11, Lines 18-27: "The spheroid model was used to retrieved dust properties (Dubovik et al., 2006; Mishchenko et al., 1997; Veselovskii et al., 2010). But it is not clear if this model is applicable to soot particles with complicated morphology. The size of smoke particles is expected not too big so that we choose to apply regluarization algorithm with sphere model." The retrieved microphysical properties seem to be associated with high uncertainties, since the shape used (spherical) does not reproduce the depolarization measurements and it should not reproduce accurately the backscattered light measurements either. The reported uncertainties in Table 2 refer to cases of spherical particles and are not representative. Please provide a better assessment of the retrieval uncertainties.

2. Regarding the DRF calculations: these are based on the retrieved microphysical (point 1) properties which, as discussed above, are derived from the 3b+2a regularization inversion and are associated with (most probably) high uncertainties. Especially for the imaginary part this uncertainty is expected to be the highest (Burton et al., 2016). Please provide a better assessment of the retrieved property uncertainties and quantify the uncertainties of the DRF calculations accordingly. If this is not possible, omit section 4.2.3 from the manuscript. This also applies to Page 14, Lines 9-13, where the derived complex refractive index is compared to other studies. Omitting 4.2.3 would not affect the quality of the paper, since the authors already provide important results on smoke optical properties and microphysical estimates.

3. Another issue addressed in this study is the increase in particle depolarization ratio at 532 nm which is attributed to the particle aging. The authors gathered observations of the particle linear depolarization at 532nm from previous studies and have also included the results obtained from the present study. Nevertheless, the only visible trend seen in Figure 11 results from CALIPSO measurements. From the ground-based lidars in Lille and Palaiseu, there is no obvious increase at 532nm. In conclusion, the

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phrase“we found an increase in depolarization versus transport time” in the manuscript abstract should be changed to “CALIPSO observations of the UTLS smoke layer suggest an increase in depolarization at 532nm versus transport time”.

Minor comments

Page1, Line 9: “Typical particle depolarization” the meaning of the word typical should be clarified by the authors, meaning what is the definition of linear particle depolarization ratio used? (is it the cross/parallel ratio or the cross/total ratio?)

Page 1, Line 10: “The relatively high depolarization ratios and such spectral dependence are an indication of a complicated morphology of aged smoke particles” The conclusion that the spectral dependence of the depolarization ratio is characteristic of aged smoke particles can be hardly drawn by two cases, i.e. the current one and the one reported in Burton et al. (2015). Please rephrase accordingly. Page2, Line 30: “We focus on the retrieval of the aerosol optical and microphysical properties from the Lidar measurements”. The authors should highlight that the depolarization ratio values are not reproduced in the retrieval of the microphysical properties. Page 4, Line 2: Please change the phrase “showed an increase of temperature in the stratospheric smoke layers” to “An increase of temperature due to the presence of smoke aerosols in this region” or something similar. Page 5, Line 3: Change the phrase “A plume with relatively high UVAI first occurred over the British Columbia on 11 August, and the intensity of the plume was moderate” to “a plume of moderate intensity and relatively high UVAI, first occurred over British Columbia on 11 August. Page 5, Line 4: Please change the phrase “and the UVAI in the center of the plume reached above 10” to “and the UVAI in the center of the plume reached above 10, as indicated by the grey area on the plot (Fig 4)” Page 6, Line 1: “We have examined the temperature profiles” Did you use radiosonde measurements? Please provide more info. Page 6, Line 2: “the temperature drops below -38_C, at which temperature the cloud droplets mostly turn to ice phase” Please provide relevant reference.

Page 6, Line 8: “The increasing trend of the depolarization ratio is probably due to aerosol aging” As discussed above, this is a hardly drawn conclusion. Please rephrase accordingly.

Page 7, Line 7: “we can calculate the optical depth of the cirrus cloud” Please change “cirrus cloud” to “UTLS aerosol layer” since this is what you refer to in this case.

Page 7, Line 12: change the phrase “are considered as the major error sources of the optical depth” to “are considered as the major error sources in the estimation of the optical depth”

Page 7, Line 13: “based on the statistical error of photon distributions” Please provide more info on the definition of the noise of your lidar measurements. Do you take into account the systematic errors?

Page 7, Line 22: change the phrase “of the error of optical depth” to “of the error of optical depth to the estimation of the Lidar ratio”

Page 10, Line 15: typing error, change volume depolarization ratio at 355 nm to molecular depolarization ratio at 355 nm.

Page 14, Line 14: “Smoke in dry conditions have higher refractive indices than that in wet condition” Provide relevant reference.

Figure 6: The x axes on CALIPSO plots should be the same in order to show the variation. Also the phrase in the caption “The profiles of backscatter coefficient and particle linear depolarization ratio (PLDR)” could be changed to “The profiles of backscatter coefficient and particle linear depolarization ratio (PLDR) at 532nm from CALIPSO” Figure 7: The points on this figure should be larger to be more visible. Also, it would be better if the colors of the points are different for the two lidar systems.

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