Authors' response (in blue) to the Reviewer #2's comments (in black):

The authors thank Reviewer #2 for their comments and suggestions that definitely improved the manuscript. Required changes and modifications have been introduced in the text of the revised version of the manuscript by using the Word Track Changes tools.

In general, the title has been modified, and following some reviewer #2's suggestions, Sections 2.4.2 and 3.4 have been removed and the proposed changes as indicated in the Supplement by the reviewer #2 have been implemented as well. New references have been added and Figures 5 and 6 have been simplified, as well.

Next, the authors respond to the particular comments of the reviewer #2.

- Reviewer 2

The manuscript fits within the journal scope, as it describes the results from an intercomparison campaign in order to evaluate the Micro Pulse lidar overlap function taking EARLINET Martha and Polly systems as reference.

The manuscript is interesting, nevertheless some major changes are needed before publication.

R2C1. I understand that it is not very practical to find an horizontal line of sight free from obstacles with an homogenous atmosphere, but I think that this setup is way easier than organizing a measurement campaign on purpose. Moreover, shooting the lidar horizontally is more accurate than the proposed method.

Authors' response: The main goal of the campaign, indeed, was not the determination of the overlap (OVP) function for the P-MPL system; but, taking this advantage, part of the observational period during the campaign was devoted to obtain an accurate OVP correction for that P-MPL system. Although shooting the lidar horizontally seems to be a more accurate setup than other methods for OVP determination, it cannot be always viable under regular conditions, at least neither at El Arenosillo (Huelva) station, where our P-MPL is routinely in operation, and nor at Leipzig. Our experience tell us that horizontal pointing of the lidar to obtain the overlap profile is not an easy and simple approach. It sounds simple, but it isn't in many cases. The boundary layer is usually not well mixed (there are convective plumes and downdraft regions side by side) so that overlap determination remains a problem. On the other hand, the Polly beam was fixed to an off-zenith angle of 5 degrees. We think, it is always worthwhile to use the opportunity during lidar comparison studies to check the OVP functions of all involved lidars during their normal operation (that means when they look vertically). The proposed method is more easily applicable in our case, and it has been previously applied with accurate results (e.g., Guerrero-Rascado et al., 2010; Sicard et al., 2020).

R2C2. The manuscript needs a deep English editing, because some parts are not clear at all. I was editing some parts, but it is not a reviewer role.

Authors' response: We are sincerely grateful for the English editing of the manuscript as performed by the reviewer. An English revision in deep of the manuscript have been also done, and changes are shown in the revised version of the manuscript. But we think (as we know from former publications) that an AMT language editor will check the manuscript as well. Finally, several experienced co-authors will be forced to check the proof-readings and remove 'bad English' phrases.

R2C3. Some sections in the manuscript seem to be out of context. As stated in the title and mostly in the abstract, the main objective is to calibrate the MPL instruments with respect to the reference EARLINET lidars. The part where POLIPHON algorithm is applied is not adding value to the paper with respect to its main goal. I suggest to the authors to better contextualize it (maybe editing English will make it clearer) or delete it.

Authors' response: We decided to follow the reviewer #2' suggestion. Hence, corresponding sections (2.4.2 and 3.4), and related comments in the overall text, have been removed.

R2C4. Moreover, I think that the retrieval doesn't make so much sense. First, Leipzig is not the best spot to detect dust outbreaks, because the aerosol layer traveled so much before reaching the observation site. Then dividing the backscattering coefficient into those 3 categories is rather audacious and potentially wrong. There is not any information regarding the aerosol size distribution. Then Dc and Df how are assessed ? Just using the Particle Depol Ratio and the LR? In this case, no information is available on how the dust particles aged, i.e. if dust mixes up with urban or continental aerosol. Also, the used values are probably found for some specific measurement campaigns and cannot be assumed valid in general. For this reason, those values will show a very high variability making the error on retrieval huge. What if, during the advection, the dust particles mix with other aerosol particles? The LR changes, the depolarization changes...

Authors' response: We agree that Leipzig is not the best station to observe dust intrusions. However, dust air masses arrived to Leipzig on 29 and 30 June 2019. The dust case study selected in this work was examined in deep in Córdoba-Jabonero et al. (2021), where the arrival of dust particles to Leipzig on 29 and 30 June 2019 was confirmed and analysed by using aerosol travel and forecast modelling, AERONET data and lidar observations. POLIPHON algorithm allowed separating the optical properties of each Dc and Df components in aerosol mixed cases (in particular, see deleted Fig. 8, corresponding to a dust mixed scenario as observed on 30 June afternoon, and also Fig. 3 in Córdoba-Jabonero et al., 2021). POLIPHON is a depolarization-based method (i.e., Mamouri and Ansmann, 2017), which is well validated in a variety of field activities (e.g., Genz et al., 2011; Düsing et al., 2018; Mamali al., 2018; Haarig et al., 2019; Marinou et al., 2019) and applied in numerous studies (e.g., Córdoba-Jabonero et al., 2018; Ansmann et al., 2019; Baars et al., 2019; Marinou et al., 2019; Costa-Surós et al., 2020; Georgoulias et al., 2020; Hofer et al., 2020).

References

Ansmann, A., Mamouri, R.-E., Hofer, J., Baars, H., Althausen, D., and Abdullaev, S. F.: Dust mass, cloud condensation nuclei, and ice nucleating particle profiling with polarization lidar: updated POLIPHON conversion factors from global AERONET analysis, Atmos. Meas. Tech., 12, 4849–4865, https://doi.org/10.5194/amt-12-4849-2019, 2019.

Baars, H., Ansmann, A., Ohneiser, K., Haarig, M., Engelmann, R., Althausen, D., Hanssen, I., Gausa, M., Pietruczuk, A., Szkop, A., Stachlewska, I. S., Wang, D., Reichardt, J., Skupin, A., Mattis, I., Trickl, T., Vogelmann, H., Navas-Guzmán, F., Haefele, A., Acheson, K., Ruth, A. A., Tatarov, B., Müller, D., Hu, Q., Podvin, T., Goloub, P., Veselovskii, I., Pietras, C., Haeffelin, M., Fréville, P., Sicard, M., Comerón, A., Fernández García, A. J., Molero Menéndez, F., Córdoba-Jabonero, C., Guerrero-Rascado, J. L., Alados-Arboledas, L., Bortoli, D., Costa, M. J., Dionisi, D., Liberti, G. L., Wang, X., Sannino, A., Papagiannopoulos, N., Boselli, A., Mona, L., D'Amico, G., Romano, S., Perrone, M. R., Belegante, L., Nicolae, D., Grigorov, I., Gialitaki, A., Amiridis, V., Soupiona, O., Papayannis, A.,Mamouri, R.-E., Nisantzi, A., Heese, B., Hofer, J., Schechner, Y. Y., Wandinger, U., and Pappalardo, G.: The unprecedented 2017–2018 stratospheric smoke event: decay phase and aerosol properties observed with the EARLINET, Atmos. Chem. Phys., 19, 15183–15198, https://doi.org/10.5194/acp-19-15183-2019, 2019.

Córdoba-Jabonero, C., Sicard, M., Ansmann, A., del Águila, A., and Baars, H.: Separation of the optical and mass features of particle 30 components in different aerosol mixtures by using POLIPHON retrievals in synergy with continuous polarized Micro-Pulse Lidar (PMPL) measurements, Atmos. Meas. Tech., 11, 4775-4795, https://doi.org/10.5194/amt-11-4775-2018, 2018.

Córdoba-Jabonero, C., Sicard, M., López-Cayuela, M.-A., Ansmann, A., Comerón, A., Zorzano, M.-P., Rodríguez-Gómez, A., and Muñoz-Porcar, C.: Aerosol radiative impact during the summer 2019 heatwave produced partly by an inter-continental Saharan dust outbreak. Part 1. Shortwave dust direct radiative effect, Atmos. Chem. Phys., https://doi.org/10.5194/acp-2020-1013, accepted, 2021.

Costa-Surós, M., Sourdeval, O., Acquistapace, C., Baars, H., Carbajal Henken, C., Genz, C., Hesemann, J., Jimenez, C., König, M., Kretzschmar, J., Madenach, N., Meyer, C. I., Schrödner, R., Seifert, P., Senf, F., Brueck, M., Cioni, G., Engels, J. F., Fieg, K., Gorges, K., Heinze, R., Siligam, P. K., Burkhardt, U., Crewell, S., Hoose, C., Seifert, A., Tegen, I., and Quaas, J.: Detection and attribution of aerosol-cloud interactions in large-domain large-eddy simulations with the ICOsahedral Non-hydrostatic model, Atmos. Chem. Phys., 20, 5657–5678, https://doi.org/10.5194/acp-20-5657-2020, 2020.

Düsing, S., Wehner, B., Seifert, P., Ansmann, A., Baars, H., Ditas, F., Henning, S., Ma, N., Poulain, L., Siebert, H., Wiedensohler, A., and Macke, A.: Helicopter-borne observations of the continental background aerosol in combination with remote sensing and ground-based measurements, Atmos. Chem. Phys., 18, 1263-1290, https://doi.org/10.5194/acp-18-1263-2018, 2018.

Genz, C., Schrödner, R., Heinold, B., Henning, S., Baars, H., Spindler, G., and Tegen, I.: Estimation of cloud condensation nuclei number concentrations and comparison to in situ and lidar observations during the HOPE experiments, Atmos. Chem. Phys., 20, 8787–8806, https://doi.org/10.5194/acp-20-8787-2020, 2020.

Georgoulias, A. K., Marinou, E., Tsekeri, A., Proestakis, E., Akritidis, D., Alexandri, G., Zanis, P., Balis, D., Marenco, F., Tesche, M., and Amiridis, V.: A first case study of CCN concentrations from spaceborne lidar observations, Remote Sens.,12, 1557, https://doi.org/10.3390/rs12101557, 2020.

Haarig, M., Walser, A., Ansmann, A., Dollner, M., Althausen, D., Sauer, D., Farrell, D., and Weinzierl, B.: CCN concentration and INP relevant aerosol profiles in the Saharan Air Layer over Barbados from polarization lidar and airborne in situ measurements, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-466, in review, 2019.

Hofer, J., Ansmann, A., Althausen, D., Engelmann, R., Baars, H., Abdullaev, S. F., and Makhmudov, A. N.: Long-term profiling of aerosol light extinction, particle mass, cloud condensation nuclei, and ice-nucleating particle concentration over Dushanbe, Tajikistan, in Central Asia, Atmos. Chem. Phys., 20, 4695–4711, https://doi.org/10.5194/acp-20-4695-2020, 2020.

Mamali, D., Marinou, E., Sciare, J., Pikridas, M., Kokkalis, P., Kottas, M., Binietoglou, I., Tsekeri, A., Keleshis, C., Engelmann, R., Baars, H., Ansmann, A., Amiridis, V., Russchenberg, H., and Biskos, G.: Vertical profiles of aerosol mass concentration derived by unmanned 35 airborne in situ and remote sensing instruments during dust events, Atmos. Meas. Tech., 11, 2897-2910, https://doi.org/10.5194/amt-11-2897-2018, 2018.

Mamouri, R.-E. and Ansmann, A.: Potential of polarization/Raman lidar to separate fine dust, coarse dust, maritime, and anthropogenic aerosol profiles, Atmos. Meas. Tech., 10 (9), 3403-3427, https://doi.org/10.5194/amt-10-3403-2017, 2017.

Marinou, E., Tesche, M., Nenes, A., Ansmann, A., Schrod, J., Mamali, D., Tsekeri, A., Pikridas, M., Baars, H., Engelmann, R., Voudouri, K.-A., Solomos, S., Sciare, J., Groß, S., Ewald, F., and Amiridis, V.: Retrieval of ice-nucleating particle concentrations from lidar observations and comparison with UAV in situ measurements, Atmos. Chem. Phys., 19, 11315–11342, https://doi.org/10.5194/acp-19-11315-2019, 10 2019.

R2C5. Being the P-MPL a product commercially available, it is not possible to establish with precision which technology is used to detect the depolarized laser light, because, as stated on MPLNET website, there exist at least two different P-MPL models that depend on fabrication year. For the P-MPL models produced before 2013, the use of nematic liquid crystal polarizer introduces a delay in data rates. A new P-MPL model was developed around 2013 following Flynn et al 2007, but using a ferroelectric liquid crystal (FLC) for faster data rates and a slightly modified measurement strategy to accommodate the difference in polarizer properties. For this reason, as long as a proper instrument characterization and stability study of the polarized design and its calibration procedures will be not available, equation 4 and section 3.2 are based on speculations.

Authors' response: Sect. 2.2.1 in the Methodology Section has been modified in order to clarify up to some extent these issues. In particular, the P-MPL version of the 44245 unit uses a ferroelectric liquid crystal (FLC) with a switching time of ~ 100 μs. Besides, it was tested by the manufacturer, and a testing report was provided with the P-MPL system. Eq. 4 (now Eq. 2 or 6 in the revised version) is adapted from Flynn et al. (2007) and currently applied for providing the MPLNET version 3 data products (Welton et al., 2018), besides having been applicable in some particular studies (e.g., Sicard et al., 2016; Córdoba-Jabonero et al., 2018; Lewis et al., 2020; Lolli et al., 2020). Sect. 3.2 is based on the experimental analysis performed, indeed, in this work (see also references included).

R2C6. Specific comments are found in the attached files.

Authors' response is introduced in the attached supplement pdf file using the Adobe Acrobat tools. Corresponding changes have been also included in the revised version of the manuscript.