Interactive comment on Comparison of two automated aerosol typing methods and their application on an EARLINET station" by Kalliopi Artemis Voudouri et al.

Anonymous Referee #2

We would like to thank the reviewer for his/her fruitful comments that led to the improvement of the manuscript. In the following, answers to comments are reported just below each related comment. When needed, the part of the manuscript we modified or added to the old version, is reported. In the revised version of the paper all comments have been extensively taken into account discussing more aspects of the comparison between the two typing techniques (motivation, agreement and disagreement of the methods). Some text has been added about this and it is reported below into the replies to specific comments.

1) Title 'Thessaloniki'

We keep the more generic title, since the concept of the paper is not to discuss explicitly the aerosol types observed in Thessaloniki, but is more about discussing an approach for evaluating the typing methods.

2) Line 13-14 ten : *marine, dust, polluted continental / smoke, clean continental, polluted dust, elevated smoke, dusty marine, PSC aerosol, volcanic ash, sulfate/other*

We thank the reviewer for his/her correction. The text has been modified to:

"The CALIPSO mission uses a decision-tree based on lidar profiles and external data (Omar et al., 2009) in order to classify the aerosol load in ten aerosol subtypes, i.e., marine, dust, polluted continental / smoke, clean continental, polluted dust, elevated smoke, dusty marine, PSC aerosol, volcanic ash, sulfate/other."

2) Line 6 page 3 You can also provide literature for other European countries (eg Greece)

The text has been modified to: "Simultaneous observations of desert dust and ash particles were made during the Eyjafjallajokull volcanic eruption in 2010 and the methodology for the type discrimination was presented by Papayannis et al. (2012); Mona et al. (2012); and Pappalardo et al. (2013)."

3) Line 10 page 3 in the abstract you are refer to: dust, maritime, polluted smoke and clean continental. Please be consistent.

The reviewer is right. The text has been modified to:
"The two automatic aerosol classification methods and the methodology used to characterize the layers in four basic aerosol types (i.e., Dust, PollutedSmoke, Maritime, CleanContinental) are presented in Sect. 3".

4) Line 24 page 3 Please provide a more recent paper that actually describe the recent status of THELISYS

The text has been modified to:
“A detailed description of THELISYS can be found in Siomos et al. (2018a) and Siomos (2018c).”

5) Line 2 page 4 Here you should explain the two different options of the aerosol typing algorithms (with and without δ)

Both automated algorithms can ingest depolarization information, however in our study we did not consider this possibility. The reason for this is the depolarization ratio unavailability. The next sentence text is changed to:

“The input module requires optical properties profiles as those measured by EARLINET stations, namely the aerosol extinction coefficient and the aerosol backscatter coefficient profile. Optionally, the linear particle depolarization profile at 532 nm can be provided, so as to allow a better classification and to increase the number of classified aerosols types.”

A complete description of the two different options of the aerosol typing algorithms (with and without δ), is given in Section 3.1 and Section 3.2. See below the paragraphs modified in the revised version:

“Depending on the availability of the particle linear depolarization ratio and the quality of the provided lidar profiles, the derived typing can be either of high resolution (AH), or low resolution with depolarization (AL) or low resolution without depolarization (BL). Pure aerosols categories, and even mixtures of three aerosols types can be obtained from the NATALI algorithm. In the high resolution typing, 14 aerosol types can be distinguished (i.e., Continental, ContinentalPolluted, Dust, Maritime/CC, Smoke, Volcanic, Coastal, CoastalPolluted, ContinentalDust, ContinentalSmoke, DustPolluted, MaritimeMineral, MixedDust and MixedSmoke) when the quality of the provided optical products is high enough. In the low resolution typing, 6 predominant aerosol types can be provided but with high uncertainty (i.e, Continental, Continental polluted, Smoke, Dust, Maritime and Volcanic). The low resolution typing provides 5 predominant aerosol types (Dust, ContinentalPolluted, Smoke, Continental, Maritime) either pure or mixed, when the depolarization information is not provided.”

“The algorithm applies the Mahalanobis distance classifier (Mahalanobis, 1936) to classify observations into maximum 8 (Dust, Volcanic, Mixed Dust, Polluted Dust, Clean Continental, Mixed Marine, Polluted Continental, Smoke) and minimum 4 (Dust, Maritime, PollutedSmoke, CleanContinental) aerosol classes, considering the needs of each user and the availability of the intensive properties.”

Also, the Table 2 added in the revised version, contains all the necessary information, describing both the high and low resolution aerosol typing provided by each algorithm and the low resolution that is used in our study.

6) Line 20 page 4 What about the particle depol?

The reviewer is right, therefore the following sentence is added in the revised manuscript:
“Optionally, the linear particle depolarization profile at 532 nm can be provided, so as to allow a better classification and to increase the number of classified aerosols types.”

7) Line 25page 4 In the previous paragraph you mention that only intensive optical properties are used, but here the backscatter is used for the identification of the layers

Yes, the reviewer is right. The intensive optical properties are used for the typing, but the backscatter at 1064 nm is used only for the identification of the aerosol layers.

8) Line 6 page 5 How is high enough defined?

We can talk about high quality of lidar products, when the values of the intensive optical parameters are between acceptable limits (see Table 1) and the relative error of each intensive optical parameter is lower than 50%.

9) Line 7 page 5 you mean low resolution with depol information

Yes, the reviewer is right. The low resolution (AL) typing corresponds to the low resolution with depolarization information.

The text is modified accordingly: In the low resolution typing (AL), 6 predominant aerosol types can be provided but with high uncertainty (i.e, Continental, ContinentalPolluted, Smoke, Dust, Maritime and Volcanic). The low resolution typing (BL) provides 5 predominant aerosol types (Dust, ContinentalPolluted, Smoke, Continental, Maritime) either pure or mixed, when the depolarization information is not provided.

10) Line 8-9 page 5 Here the types are 5, in the comparison you refer to 4 aerosol types…

The reviewer is right. The methodology section is changed accordingly:

“The NATALI typing was performed in the low resolution typing configuration (5 predominant aerosol types - Dust, Smoke, Continental Polluted, Continental and Maritime) since particle linear depolarization ratio measurements for Thessaloniki were not available for the study period. In what follows, we merged the output types from NATALI that tend to reflect the same aerosol characteristics, and hence we evaluate the corresponding effects on the prediction rate of the algorithms. Thus, the smoke and the polluted continental categories were grouped into the more generic type of small particles with high lidar ratio values. The selection of four main aerosol classes stems from the availability of intensive properties, the difficulty in deriving a confident classification without particle linear depolarization ratio and the difficulty in discriminating polluted continental and smoke particles that reveal the same type characteristics. Regardless, the aerosol classes describe the major aerosol components. The identified layer boundaries from NATALI are used as input in the EARLINET Mahalanobis distance-based typing algorithm. Considering the aforementioned typing merging, the EARLINET Mahalanobis distance-based typing algorithm was set to classify observations into 4 aerosol classes: CleanContinental, Dust, Maritime and PollutedSmoke.”

Also, the following sentence is added in the last paragraph of the methodology section:

“The idea here is to compromise: i) the resolution (low) of the automatic classification owing to the availability of the optical properties (i.e., 3+2 lidar configuration), and, ii) the type definition, which

does include the wide spectrum of the aerosol types provided by the two automated typing techniques."

Table 2 is added and lists the classified aerosol types of the above study.

11) Line 33 page 5 Here the classes are 8

The paragraph is reworded and reads as follows:

"Finally, the assessment of the predictive performance of the algorithm was tested on a testing dataset. For this purpose, EARLINET data collected during the ACTRIS Summer 2012 intensive measurements (Sicard et al., 2015; Granados-Muñoz et al., 2016b) were chosen to test the automatic typing algorithm. The testing dataset comprised of 47 layers, 21 of which yielded depolarization ratio values. The performance of the algorithm was checked for each of the grouping classes (i.e., 8,7,6,5,4) and the predictive accuracy of the algorithm increased up to 90% when the aerosol classes that tend to reflect the same optical properties values were combined into 4 (Dust, Maritime, Polluted Continental + Smoke, Clean Continental) without providing the information of the depolarization. The study concluded that the fewer aerosol classes (i.e., 4, 5, 6 classes) could provide a successful prediction accuracy, even without depolarization values, but, nonetheless, a coarser and less insightful classification."

12) Line 2 page 6 I don't understand. In this study? Increase to 90% compared to what? In general? please provide reference

Papagiannopoulos et al. (2018), checked the performance of the algorithm for each of the grouping classes and the predictive accuracy of the algorithm increased up to 90% (See Figure 10 in Papagiannopoulos et al., 2018) when the aerosol classes that tend to reflect the same optical properties were combined into 4 without providing the information of the depolarization (compared to 80% when depolarization ratio information was included). The study, also, showed that without depolarization ratio information, the accuracy of the model increases with decreasing number of classes, providing however a coarser classification. Instead, the training of the classification with depolarization measurements enhances the predictability strength and can provide finer aerosol classification (for 8 classes).

13) Line 3-5 page 6 So, you have 90% accuracy without using the depol information?

The reviewer is right. In general, the particle linear depolarization ratio increases the ability for correctly predicting the aerosol type. However, Papagiannopoulos et al. (2018) showed that (Figure 10), without depolarization ratio information, the accuracy of the model increases with decreasing number of classes (90% for the 4 classes), providing however a coarser classification.

14) Line 3-5 page 6 I understand that you have an accuracy of 90% for 4 classes. But fewer aerosol classes (I suppose fewer than 8..).

The reviewer is right. Papagiannopoulos et al. (2018) analyzed the predictive accuracy of the algorithm when compared to manually analyzed data for the different aerosol classes in both the cases in which

the depolarization information is available, for 8, 7, 6, 5 and 4 classes. This highlights that the typing in multiple classes and the typing accuracy are two conflicting aspects. The number of classes as well as the typing accuracy depends on the specific needs. This could be an approach for the specific user to select the appropriate balance each specific application. Another possibility is to find a compromise between degrading accuracy and gaining insight into the aerosol type.

15) Line 16 page 6 I suppose that you merged Smoke with Continental polluted. Please clarify this in the text

The reviewer is right. This type combination was not clearly stated clearly in the text. The selection of four aerosol classes stems from to the difficulty to distinguish aerosol types of aerosols that reflect the same aerosol characteristics. Besides, the particle depolarization ratio is not available for this study, which constitutes a powerful aerosol type discriminator. Therefore, we merged Smoke with Continental polluted. Following this comment, we added a table (Table 2) with the aerosol classes for both the High and Low resolution (without depolarization) mode for both automatic typing techniques and the aerosol types used in this study. Additionally, Papagiannopoulos et al. (2018) showed that in the testing phase of the algorithm, that the Dust classification showed a high success rate, whilst the aerosol types that performed worse were the smoke and polluted continental aerosol. However, when these two categories were combined into a single aerosol class, the correct prediction increased.

So, the following paragraph is added in the revised version of the text:

"In what follows, we merged the output types from NATALI that tend to reflect the same aerosol characteristics, and hence we evaluate the corresponding effects on the prediction rate of the algorithms. Thus, the smoke and the polluted continental categories were grouped into the more generic type of small particles with high lidar ratio values. The selection of four main aerosol classes stems from the availability of intensive properties, the difficulty in deriving a confident classification without particle linear depolarization ratio and the difficulty in discriminating polluted continental and smoke particles that reveal the same type characteristics. Regardless, the aerosol classes describe the major aerosol components. The identified layer boundaries from NATALI are used as input in the EARLINET Mahalanobis distance-based typing algorithm. Considering the aforementioned typing merging, the EARLINET Mahalanobis distance-based typing algorithm was set to classify observations into 4 aerosol classes: CleanContinental, Dust, Maritime and PollutedSmoke."

16) Line 21-28 page 6 Maybe a simple sketch is useful here.

We excluded this paragraph and instead section 3.1 was changed to the following one, in order to provide all the necessary information.

"The identification of the most probable aerosol type is then made through a voting procedure, using the results from the three ANNs interrogated. Over 50000 aerosol synthetic data have been used to train the ANN and identify the better ANNs to classify the aerosols type from multiwavelength lidar data. The capability of ANNs to resolve the overlapping clusters of the intensive optical parameters is used on NATALI algorithm. The answer is selected based on a statistical approach. The selected types

of ANNs classify the aerosols based on the response with high i) confidence (i.e. the probability of having one of the aerosol types) and ii) stability over the uncertainty range (i.e., the percentage of agreement for values between error limits). Therefore, answers with low confidence are filtered out and NATALI returns the 'Unknown' type. In this study, we select the confidence level for the output retrievals higher than 0.9 (minimum accepted confidence) and the minimum agreement threshold as default (i.e., 0.25), so as to make sure (as possible) that the output typing is trustworthy."

17) Line 31 page 6 you mean clean continental?

We thank the reviewer for his/her comment. The text has been modified to:
"and small particles with medium lidar ratios (i.e., clean continental particles, with mean lidar ratios, for 355 and 532 nm, 50 ± 8 and 41 ± 6 sr, respectively)."

18) Line 31 page 6 I think here is necessary to give number what is low / medium and high lidar ratios and what is large and small particles

Type specific values are added to the text.

"Consequently, the lidar classification scheme consists of the main classes: (i) large particles with medium lidar ratios (i.e., dust-like particles, with mean lidar ratios of 58 ± 7 and 48 ± 55 sr for 355 nm and 532 nm, respectively, Groß et al. (2013)), (ii) large particles with low lidar ratios (i.e., maritime particles, with mean lidar ratio at 355nm and 532nm of 18 ± 4 and 18 ± 2 sr, respectively, Groß et al. (2011)), (iii) small particles with high lidar ratios (i.e., pollution and/or smoke particles, the smoke mean lidar ratio values present values of 81±16 and 78±11 sr for 355 and 532 nm, respectively – and the polluted continental values succeed with 69±12 and 63± 13 sr for 355 and 532 nm, respectively, Amiridis et al., 2009; Baars et al., 2012) and (iv) small particles with medium lidar ratios (i.e., clean continental particles, with mean lidar ratios, for 355 and 532 nm, 50 ± 8 and 41 ± 6 sr, respectively). Generally, desert dust layers have optical properties that are considerably different from the other types, thus they are easily identified. Their big size leads to low Ångström exponent values and the reported lidar ratio at 355nm ranges from 47 to 58 sr for Thessaloniki (Siomos et. al., 2018). PollutedSmoke particles, are also easily identified, as they are highly absorbing particles, with high lidar ratio values. CleanContinental categorization is not completely straightforward, because the continental particles can be attributed to different subcategories (i.e., local, continental polluted or mixtures). In general, the CleanContinental cases are typically elevated layers, i.e. layers not related to the local atmospheric boundary layer where the pollution and anthropogenic contribution would mean more absorbing particles and therefore labeled as PollutedSmoke aerosol. Continental particles present low lidar ratio values, (i.e., 20–40 sr) and values of Ångström exponents around 1.0–2.5. The highest values appear during summer period in Thessaloniki (Siomos et al., 2018)."

19) Line 1 page 7 I would call this category Mixed Dust and not Dust

The reviewer is right. Dust category can be either pure dust, or mixed dust, or polluted, or volcanic. But, as mixed Dust and Polluted Dust are different definitions for NATALI typing scheme, we keep label

the category with the generic 'Dust'. This is specified in Table 2, which lists the classified aerosol types of the above study.

20) Line 2 page 7 So, is there any layer Clean Continental in the urban city of Thessaloniki?

Clean continental type is defined in the CALIPSO scheme background aerosol and as a consequence, deemed not to be influenced by urban pollution. However, these conditions are probably not realistic for the European continent. So, this category was revised for the applicability to Europe in the two typing schemes, as the clean continental aerosol over Europe is a mixture of anthropogenic pollution with particles from natural sources, but with a predominance of no-anthropogenic aerosol resulting a low lidar ratio observed value (Papagiannopoulus et al., 2018).

As reported in the text many layers were typed as Clean Continental over Thessaloniki and these are typically elevated layers (90% of the detected CleanContinental cases are found above 2km). This result is compliant with the CALIPSO scheme at global level and with results about Thessaloniki site characterization done by Siomos et. al (2018). In their paper Siomos et al. (2018b), used data from a double monochromator Brewer spectrophotometer and a sunphotometer in order to classify aerosol cases during the period 2007-2017 in Thessaloniki, in the following categories: Water soluble, Black Carbon, Dust, Sea Salt and mixed. They found that the pure Water Soluble category (which can be related to the Clean Continental consisting of mainly of water soluble particles) correspond to 29.1% of the cases, which is in fair agreement with results reported in Fig.3.

We added a sentence about this in the revised version of the paper:

"CleanContinental categorization is not completely straightforward, because the continental particles can be attributed to different subcategories (i.e., local, continental polluted or mixtures). In general, the CleanContinental cases are typically elevated layers, i.e. layers not related to the local atmospheric boundary layer where the pollution and anthropogenic contribution would mean more absorbing particles and therefore labeled as PollutedSmoke aerosol. Continental particles present low lidar ratio values, (i.e., 20–40 sr) and values of Ångström exponents around 1.0–2.5. The highest values appear during summer period in Thessaloniki (Siomos et al., 2018)."

21) Line 3 page 7 I suppose that this category is pure maritime+mixed maritime

True. For making clearer this point, we added a table (Table 2) describing each aerosol category.

22) Line 7 page 7 even without depolarization ratio?and even without back-trajectory analysis?

Usually dust can be identified, since the optical properties of dust particles are quite different from the other three classes. Even though we do not consider depolarization ratio information, the size information (i.e., Angstrom exponent) and physical and chemical properties (i.e., lidar ratio) are usually sufficient to discriminate Dust. Nicolae et al. (2018) and Papagiannopoulos et al. (2018) have demonstrated this possibility. Backward trajectory analysis is a well-established tool for the source identification, however automated classification algorithms for lidars, nowadays, can operate stand-alone and provide robust results (e.g., Omar et al., 2009; Burton et al., 2012; Nicolae et al., 2018;

Papagiannopoulos et al., 2018). Indeed, support from back-trajectory analysis and/or model simulations are necessary for an independent evaluation of the stand-alone typing algorithms and this is the reason we demonstrate in our paper certain case studies (section 4.1, 4.2, 4.3)

23) Line 7 page 7 Please provide numbers

Groß et al. (2011) for example reported values of 0.06 ± 0.21 and Tesche et al. (2009b) reported values of 0.19 ± 0.20. But, it should be pointed out that different values reported can be related to the different transportation paths of the load.

24) Line 10 page 7 Small? I suppose you are referring to aged smoke or polluted continental. Fresh smoke is not small

Yes, the reviewer is right. Smoke particles yield a wide range of optical properties. The transportation path, the aging, the burning material, the hygroscopic growth, and the height of injection are some of the parameters that can affect the observed optical properties. For instance, smoke layers observed by EARLINET systems over Europe in the summer of 2017 indicated high depolarization ratio (e.g., Haarig et al., 2018). The mechanisms for this are still yet to be understood. Here, we merged Smoke with Continental polluted, and the characteristics correspond to the merged class. We would like, also, to comment that we had to i) compromise the resolution of the automatic classification owing to the availability of the optical properties (i.e., 3+2 lidar configuration), and, ii) the type definition, which does include the wide spectrum of the aerosol types as stated above.

25) Line 32 page 7 Please correct the label of Natali in Figure 1, it should have run for 5 (merged to 4) classes

Following this comment, the plot is changed and the NATALI labels, now, are 5 (+ 2 categories of 'Unknown' and 'N/A' typing), corresponding to the categories of the low resolution typing.

26) Line 1 page 8 Please be consistent: use either Layer A, B or Layer 1, 2

The plot and the text is changed accordingly, using the labels of Layer 1, 2.

27) Line 2 page 8 'and Angstrom exponent'

Following this comment, the text is changed to: 'The stability of the lidar ratio and Ångström exponent values could be considered as an indicator of homogeneity and small variability of the aerosol type within the layer.'

28) Line 12 page 8 please present the fire spots in the trajectory already provided in Figure 2. Also give reference for the fires.

The fire spots are added in Figure 2. These values are in accordance with the typical biomass burning values observed over Thessaloniki. Giannakaki et al. (2010) report an annual mean lidar ratio at 355nm of 69 ± 17 sr and a mean BAE at 355-532nm of 1.7 ± 0.7, while Siomos et al. (2018a) found the lidar ratio at 355nm ranging from 51 to 73 sr for biomass burning events.

The paragraph is reworded and reads as follows:

“These values are in accordance with the typical biomass burning values observed over Thessaloniki. Giannakaki et al. (2010) reported an annual mean lidar ratio at 355nm of 69 ± 17 sr and a mean BAE at 355-532nm of 1.7 ± 0.7, while Siomos et al. (2018a) found lidar ratio at 355nm ranging from 51 to 73 sr for biomass burning events.”

29) Line 23 page 8 I would like to see, the application of the algorithms not only to pure dust and bb cases. To classify these pure cases is relative easy and there is not a need for aerosol classification algorithm. The authors should provide additional case studies with mixed aerosol types, or cases with complex aerosol structure and check the reliability of the algorithms.

The reviewer is right. A new plot and a paragraph (Section 4.3) is added in the revised version. The typing scheme selected and added is a more complex one and offers the opportunity to check the reliability of the algorithms in conditions where different aerosol types at different heights are observed.

30) Line 33 page 8 It is difficult to believe that the second aerosol type observed in Thessaloniki is clean continental. Have you also compared these results with satellite/model products? Clean continental is defined as 'background like' aerosols with a LR of about 30-35sr. I would speculate that the observed in this study layers would be small, non so absorbing aerosol.

See also our response to comment 20. Typically, the clean continental type presents the mixture of anthropogenic aerosols with natural sources. For instance, the manual typing made by Schwarz et. al. (2016) in the framework of EARLINET, assigns an aerosol layer as clean continental when the aerosol concentration is low by means of optical depth (the low values of lidar ratio). Based on this definition, the label “clean” can be taken literally. However, the automatic typing procedures do not take into account any extensive parameter, hence not “clean” aerosol layers might be classified as clean continental.

31) Line 3 page 9 We should talk for agreement only if the same layer is attributed to the same class. In such a figure we only new the statistical information of the occurrence of the layers, not if the classification is made right.

The reviewer is right. The paragraph is reworded and reads as follows:

“In particular, the agreement is reasonably close for the desert dust cases (10% and 17% for NATALI and EARLINET Mahalanobis distance-based typing algorithm, respectively), nevertheless, it becomes evident that the particle linear depolarization ratio could increase the ability for correctly predicting dust particles.”

32) Line 24 page 9 Please explain possible reasons for that

After the bug in the processing, the scores have changed to the following ones and the text has been modified to:
“For PollutedSmoke and CleanContinental the accuracy reached 88% and 65% respectively.”

In order to address the possible reasons of disagreement, we added the following paragraph in section 4.4 of the revised version of the manuscript and a summary table (Table 3) which provides mean aerosol optical properties of the reference aerosol types used on the two automated algorithms.

Overall, there were 15 cases (on Thessaloniki dataset) that the two methods provided different typing results. There are seven cases typed as CleanContinental aerosol by NATALI and PollutedSmoke or CleanContinental by EMD, five cases typed as PollutedSmoke by NATALI and Dust by EMD, 2 cases typed as Dust by NATALI and CleanContinental by EMD and one case type as Maritime by NATALI and CleanContinental by EMD. These mismatches are illustrated in Figure 7. In order to understand these differences we highlight some critical issues relevant the type definitions of the two methods, based on Nicolae et al., (2018) and Papagiannopoulos et al., (2018).

CleanContinental: The contribution of the Soot component in the chemical composition of the CleanContinental category, allows higher lidar ratio values at 532nm (52–53sr) in the NATALI scheme. Consequently, layers recognized by NATALI as CleanContinental ones, in the EARLINET Mahalanobis distance-based typing method are attributed as signature for PollutedSmoke or Dust (as it can be seen in the revised Figure 6 -now Figure 7).

Marine: As observations of pure maritime particles are quite scarce within EARLINET and, generally, when these particles are observed their characteristics are far from pristine, the Maritime category for the EARLINET Mahalanobis distance typing algorithm**,** corresponds to mixed maritime layers. This is different from the pure maritime category that NATALI identifies. Lower lidar ratio values for 532nm (19–25sr) are defined in the NATALI software for the identification for marine layers, in contrast to the higher ones (16-32sr) allowed in the EARLINET Mahalanobis distance typing algorithm.

Dust: Higher values of Lidar ratio at 532nm are allowed for EARLINET Mahalanobis distance typing algorithm in identifying dust particles (48-62sr), considering all dust-like aerosol types as one category, while NATALI allows values corresponding to more pure cases (44–49). Therefore, a number of Dust recognition are attributed to PollutedSmoke particles (6 cases) or CleanContinental particles (1 case) in the NATALI output.

PollutedSmoke: An almost perfect score was found for the PollutedSmoke category. This can be attributed to the similar reference values attributed by both typing algorithms. Higher values of Lidar ratio at 532nm are allowed for NATALI (62-92sr - ContinentalPolluted and Smoke), instead of the lower ones (52–89sr) allowed in the EARLINET Mahalanobis distance typing algorithm."

The paragraph describing the mismatches is reworded and reads as follows:

"Although, each automated classification algorithm has important differences acknowledged above, the comparison showed an overall good agreement for the four defined aerosol classes. The convergence of the two different methods on the same type can be regarded as a signature of reliability. An almost perfect score was found for the PollutedSmoke category, following by the Dust one, given that the dust class is well defined for both typing schemes, as the physical properties of dust particles differentiate from the other three classes. Considering the mismatches in the

CleanContinental category, the agreement is good enough. By contrast, the maritime category is defined in a different way for the two automated algorithms. The EARLINET Mahalanobis distance-based typing algorithm considers maritime layers mixed with other aerosol types, whereas for the NATALI the mixing is negligible and the aerosol type refers to pure maritime aerosol. The absence of measurements for such kind of particle also did not allowed a direct assessment of the pure marine particle synthetic data into NATALI algorithm itself. The case typed as Maritime by NATALI was identified as CleanContinental: this is because of the different lidar ratio at 532nm and backscatter Ångström related values allowed in the NATALI scheme which are recognized by the EARLINET Mahalanobis distance-based typing method as signature for CleanContinental types (Table 3)."

33) Line 12 page 10 case studies

The text has been modified to:
"The prediction of the automatic classification methods in the three case studies showed consistent results when compared against manually classified EARLINET data."

34) Figure 1

S stands for Pure smoke or general for the category: polluted continental + smoke?

The reviewer is right. The PS label is added to the plot, that corresponds to the category: polluted continental + smoke.

35) Figure 2

3rd, not 3th. please correct the label, only 4 types should be appear here.

The reviewer is right. The name of the layer is corrected (3rd was replaced with 3th).

Is it pure smoke?
please correct the label, only 4 types should be appear here. Is it pure smoke?

The reviewer is right. The PS label was added to the plot, that corresponds to the category: polluted continental + smoke.

The following references have been added in the revised manuscript

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