

Dear Referee 1,

We thank you for careful reading of the manuscript and for your fruitful comments. Indeed, all comments have been extensively taken into account in the present form of the manuscript. In what follows, answers to comments are reported just below each related comment.

**This manuscript presents the results of fluorescence lidar measurements conducted over Thessaloniki. The fluorescence capacity and depolarization ratio are used as the basis for aerosol typing. Applying this classification scheme, the occurrence of different aerosol types at various altitudes during the 2024–2025 period is analyzed. The results of the fluorescence-based typing are also compared with those obtained using the EMD algorithm.**

**Overall, the manuscript is well written and suitable for publication in ACP, but several revisions are needed to address specific technical points and improve clarity.**

### **Detailed comments**

**Table 1. The filter width at 466 nm is likely 44 nm, not 50 nm—please verify and correct.**

Thank you for pointing this out. The filter width at 466 nm is indeed 44 nm. The value in Table 1 has been verified and corrected accordingly.

**Line 147. The text mentions “different PMT sensitivity, detector efficiency...”. Does the calibration constant account for both of these factors?**

We agree that the sentence “They include contributions from the optical throughput, IF transmission, different PMT sensitivity, detector efficiency, and electronic gain of each channel” may cause confusion regarding which factors are accounted for by the calibration constant. Therefore, we have removed this sentence from the manuscript. The following sentence in the manuscript already clarifies what the ratio represents “The calibration factors ratio therefore represents the relative calibration factor between the Raman and fluorescence channels; it corrects for their different instrumental efficiencies and is calculated following the calibration procedure described by Veselovskii et. al. (2020b) and analysed by Gast et. al. (2025)”.

**Table 2. The systematic biases are very low. However, it should be kept in mind that the smoke fluorescence spectrum depends on factors such as origin, altitude, etc. It is not entirely clear whether the authors corrected for differential Rayleigh extinction at the central wavelengths of the filters, or whether they accounted for spectral dependence within the filter transmission band. Ignoring this spectral dependence, especially for a 100 nm filter, could introduce a significant bias—this issue should be addressed.**

Thank you for raising this point. The biases reported in Table 2 account only for the effect of the interference-filter (IF) transmission band. We acknowledge that additional sources of uncertainty may affect the retrieved fluorescence spectrum, including the dependence of the fluorescence spectral shape on aerosol type, source region, and altitude, as well as the spectral dependence of the atmospheric transmission within the filter bandwidth. These effects are not included in the bias estimates presented in Table 2 and will be investigated in future work. Regarding differential Rayleigh extinction, the correction is currently calculated using the central wavelength of each filter, as described in Lines 143–145 of the preprint manuscript.

**Fig. 1. The labels in the figure also indicate the wavelengths corresponding to the spectral maxima. This information should be mentioned in the figure caption.**

Thank you for the suggestion. The sentence “Altitude and wavelength of the maximum of the fluorescence spectrum are indicated in the figures, and reference height is marked with an asterisk” has been added to the caption of Figure 1.

**Fig. 3g. Showing the fluorescence lidar signal is not very informative. Would it be possible to present the fluorescence backscattering coefficient instead?**

Thank you for the suggestion. The vertical profile of the fluorescence backscatter coefficient is already shown in the first panel for each case. The fluorescence lidar signal shown in Figure 3g is included to illustrate the temporal resolution of the fluorescence measurements. Therefore, we have retained the fluorescence lidar signal in this panel.

**Table 5. The values  $LR_{355} = 86$  sr and  $LR_{532} = 91$  sr are quite unusual for long-range transported smoke. Typically, such values are lower, and  $LR_{532}$  is usually greater than  $LR_{355}$ . This discrepancy should be discussed in the text.**

**Moreover, reporting values such as  $85.99 \pm 32$  is unnecessarily precise; it would be more appropriate to present them as  $86 \pm 32$ .**

The reviewer is right. Aged smoke shows a characteristic ratio of  $LR_{532}/LR_{355} > 1$  and this allows a clear identification of smoke layers after long-range transport. Specifically, three aspects of the retrieval procedure were reconsidered: (i) the alpha parameter used in the wavelet-based layer detection was adjusted, resulting in slight changes in the identified layer boundaries; (ii) the reference height was modified to improve the retrieval of the 532 nm particle backscatter coefficient; and (iii) additional smoothing was applied to the lidar-ratio profiles to reduce the influence of noise on the mean values within the aerosol layers. These changes resulted in revised lidar-ratio values that are more consistent with the expected values of aged smoke.

The revised Table 5 is provided below.

| Layer           | Layer<br>base (m) | Layer<br>top (m) | $G_F^{355}$<br>( $10^{-6} \text{ nm}^{-1}$ ) | PLDR <sub>532</sub> | BAE <sub>355/532</sub><br>(Å) | LR <sub>355</sub><br>(sr) | LR <sub>532</sub><br>(sr) | EMD |
|-----------------|-------------------|------------------|----------------------------------------------|---------------------|-------------------------------|---------------------------|---------------------------|-----|
| 1 <sup>st</sup> | 1642              | 2760             | $2.4 \pm 0.2$                                | $0.05 \pm 0.003$    | $1.81 \pm 0.22$               | $86 \pm 6$                | $73 \pm 4$                | PC  |
| 2 <sup>nd</sup> | 3180              | 3997             | $1.5 \pm 0.2$                                | $0.03 \pm 0.001$    | $1.74 \pm 0.17$               | $81 \pm 14$               | $84 \pm 7$                | PC  |
| 3 <sup>rd</sup> | 5190              | 5700             | $8.2 \pm 0.7$                                | $0.03 \pm 0.002$    | $1.90 \pm 0.17$               | $78 \pm 22$               | $75 \pm 11$               | PC  |
| 4 <sup>th</sup> | 6247              | 7357             | $9.2 \pm 0.9$                                | $0.03 \pm 0.004$    | $1.95 \pm 0.18$               | $49 \pm 19$               | $83 \pm 11$               | S   |

**Fig. 4e. Why the lidar ratio plot starts from –50 sr? Additionally, the uncertainty is not clear for me. For example, in the middle of the dust layer the lidar ratio appears to be about 20 sr—this is a very low value and needs explanation.**

Thank you for pointing this out. All the figures of the lidar ratios are from 0 to 120 sr on the revised manuscript.

The lidar ratio reaches relatively low values of approximately 25 sr in the central part of the identified dust layer, particularly below 2 km. We agree that these values are lower than the typical lidar ratios

reported for pure Saharan dust. This relatively low lidar ratio may be related to variations in the aerosol mixture, particularly at lower altitudes, where the dust layer may be mixed with local aerosol particles over Thessaloniki. Above 2 km, the lidar ratio is more stable, with values of approximately 50 sr, which are more consistent with the expected range for mineral dust. Nevertheless, the identification of the layer as dust is not based on the lidar ratio alone, but on the combined analysis of the retrieved aerosol properties, particularly the particle depolarization ratio and the other parameters used in the aerosol-typing procedure. This point has been clarified in the revised manuscript.

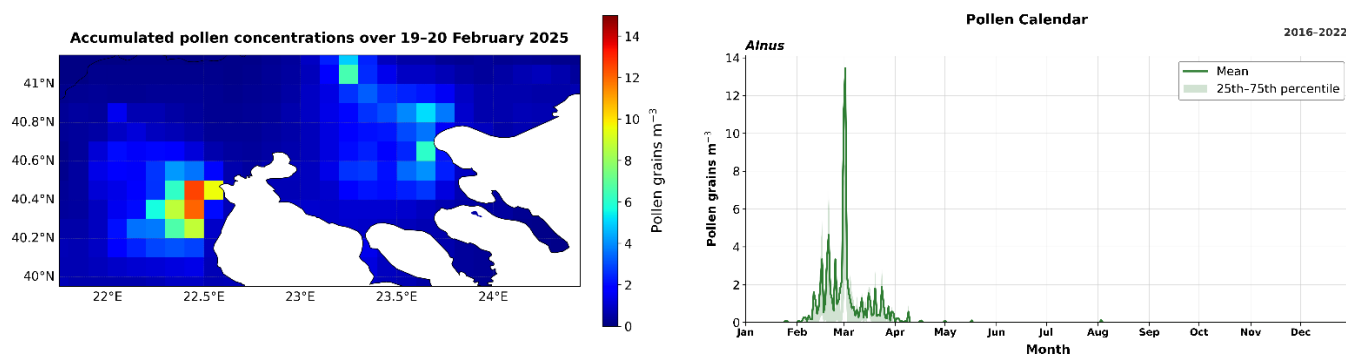
**Table 6. The depolarization ratio is 18%, which strongly suggests a mixture of dust with other aerosol types.**

Thank you for pointing this out. As discussed above, the lower part of the dust layer, below approximately 2 km, can be affected by the presence of local aerosol, resulting in a mixture of transported dust with other aerosol types. This mixing is reflected in the mean particle depolarization ratio of 18% reported in Table 6. Nevertheless, the particle depolarization ratio reaches a maximum value of approximately 23% within this layer, indicating the presence of strongly non-spherical particles and supporting the identification of mineral dust.

**Fig. 5c. A characteristic signature of pollen is a high depolarization ratio. However, the value shown in this figure is only about 2%, which is far too low. How can this be interpreted as pollen? The authors should justify this classification.**

According to the literature, pollen grains differ in size and morphology among taxa. *Alnus* and Cupressaceae pollen grains, that are present in Thessaloniki at the end of February, are approximately spherical and have characteristic diameters of around 20  $\mu\text{m}$ , which is consistent with the optical properties of the second layer. To provide additional supporting information for the typing of these layers, we have included in the revised manuscript independent information on the seasonal occurrence of pollen in the Thessaloniki region.

“During the end of February, Alder and Cupressaceae pollen are present in the atmosphere (Komnos et al., 2022). Figure 6 presents the mean and accumulated *Alnus* (alder) pollen concentrations simulated by the CAMS ensemble median model over the broader Thessaloniki area for 19-20 February 2025. The figure also includes the daily *Alnus* pollen concentrations measured with a Hirst-type pollen trap in Thessaloniki during 2016-2022 (Charalampopoulos et al. 2021), providing historical context for the seasonal occurrence of alder pollen. *Alnus* pollen grains are approximately spherical, with diameters of 20-30  $\mu\text{m}$  (Smith, 2000), and therefore fall within the coarse bioaerosol size range. Their presence could consequently have influenced the optical properties of the observed aerosol layer.



**Figure 6. Accumulated *Alnus* pollen concentrations over the broader Thessaloniki area during 19-20 February 2025 (left) and pollen calendar of daily *Alnus* pollen concentrations (right). The solid green line represents the calendar-day mean, while the shaded area indicates the interquartile range (25th–75th percentiles).”**

**Fig. 7. The dashed boxes are said to indicate results from Veselovskii et al. (2022b). However, the values shown in this figure do not appear to match those from the cited reference. For instance, dust depolarization should reach up to 35%, the maximum pollen capacity should be of  $3 \times 10^{-4}$ , etc.**

Thank you for pointing this out. Figure 7 was adapted from Miri et al. (2025), where it is stated that the figure is adapted from Veselovskii et al. (2022b). Therefore, the values shown in our Figure 7 correspond to the representation adopted by Miri et al. (2025). We have clarified the source and wording in the revised manuscript to avoid confusion.

**Finally, it should also be mentioned that the proposed typing scheme may be influenced by particle hygroscopic growth.**

Thank you for the suggestion. The sentence “It should also be noted that the proposed typing scheme may be influenced by particle hygroscopic growth, particularly under conditions of high relative humidity, as water uptake can modify particle size and consequently their optical properties, including the elastic backscatter coefficient and particle depolarization ratio (Miri et al., 2024).” has been added to the revised manuscript before the aerosol-typing figure.