Reviewer 2:

The paper by Papetta et al. analyses four major dust outbreaks affecting the Mediterranean Basin during 2021–2022, using AERONET observations, satellite dust products from two passive sensors, HYSPLIT trajectories, lidar measurements , in situ aerosol measurements in Cyprus, UAV-based chemical observations, and METAL-WRF mineralogical simulations. This is a unique combination of available information to characterize mineral dust in the area and this multi-platform approach allows to connect optical properties, dust fraction, transport pathways, and mineralogical composition. The paper should be considered for publication in Atmospheric Chemistry and Physics after taking into account the following comments.

General comments

#1. *The paper presents a very large amount of material, but the way it is written and presented, e.g. large descriptive sections, makes it difficult for the reader to identify, what are the main messages and findings.*

We agree with the reviewer that some sections were lengthy, which could make the main findings difficult to identify. To improve clarity, we revised the manuscript structure by dividing Sections 4.1, 4.3, and 4.4 into more focused subsections and renaming several subsection titles to better reflect their scientific content. We also added a dedicated Discussion section that synthesizes the principal findings, of the comparison of the events.

#2. *The fact that the authors present in detail four cases, requires a discussion for the representativeness of them, otherwise the authors should avoid over-generalizing source-dependent conclusions. The classification of events by source region should be supported more quantitatively, e.g by adding source-region maps, or a clearer explanation of how mixed-source cases are interpreted.*

We thank the reviewer for this comment, which help us clarify the representativeness of the selected cases. The four events reveal substantial variability in dust loading, particle-size characteristics, absorption and vertical structure. The specific events were selected because they had a significant impact over different parts of the Mediterranean with sufficient observational coverage across several platforms. We agree that these events should not be interpreted as a climatological representation of Saharan and Middle Eastern dust. We have therefore revised the manuscript throughout to avoid over-generalized source-dependent statements and now frame the conclusions explicitly in relation to the four analysed events. We also added a dedicated Discussion subsection addressing the representativeness and limitations of the case-study approach, including which findings are robust within the selected episodes and which require confirmation using a larger multi-year event climatology.

In addition we added Fig. F2 in the Appendix, showing major natural aerosol source regions together with the locations of important fossil-fuel-related facilities in the Eastern Mediterranean and Middle East.

***#3**. The mineralogical part seems somewhat underdeveloped relative to the strength of the conclusions. More particular the conclusion that mineralogical differences are small while optical variability is mainly driven by dust fraction and mixing state is important, but it should be supported in more detail.*

We thank the reviewer for this comment. This comment was also addressed by Comment 1 of Reviewer 1. To support our statement for the small contribution of mineralogical variability during the selected events the revised manuscript now presents a table the simulated mineral composition together with the DOD-to-AOD ratio, FMF, SSA, and ASY for each event, allowing the compositional and optical characteristics to be compared more directly.

We have in addition revised the strength of our conclusions on the interpretation of the mineralogical results. We agree that the limited number of simulated events does not support a general conclusion that mineralogical differences are small across all four outbreaks, nor does it allow their optical influence to be quantitatively separated from the effects of dust fraction and mixing state. This limitation is now added in the manuscript (lines 469–470), and the conclusions have been revised accordingly (lines 609–617).

***#4**. The comparison between METAL-WRF and UAV observations which is performed for one even is more a first evaluation attempt rather than a broad model validation. The discrepancies for Al, Si, and Mg deserve more discussion, including possible causes (e.g. source mineralogy, size distribution, vertical sampling, model resolution, measurement uncertainties).*

We thank the reviewer for this important clarification. We agree that the comparison presented in the manuscript should be interpreted as a first, case-specific evaluation of the simulated dust composition rather than as a comprehensive validation of METAL-WRF. Based on this we revised the description of Figure 16 in the text (See lines: 475-476).

In response to this comment, we also refined the comparison workflow, including the conversion of simulated mineral concentrations to elemental composition and the choice of the quantity used for the model-observation comparison. As noted in our response to Reviewer 1, Comment 6, Fig.~16 now compares elemental mass fractions rather than absolute elemental concentrations. This approach reduces the influence of differences in the estimated total dust loading and allows a more direct comparison of the relative composition derived from the two approaches. The figure and its corresponding description and interpretation have therefore been updated throughout the manuscript.

We have also expanded the discussion of the discrepancies observed between UAV-based observations and METAL-WRF simulations. Several factors may contribute to these differences, amongst which the deviations in spatial sampling of the two methods and uncertainties related to the soil mineralogy databases used by METAL-WRF as noted also in Solomos et al. 2013. These and other factors are now explained in the discussions Section 5.2.

***#5.** Some figures are dense and difficult to read, particularly the trajectory and multi-panel optical-property plots.*

We thank the reviewer for this helpful comment. To improve the readability of the trajectory analysis, we separated the original multi-panel trajectory figure into individual figures for each event, allowing the transport pathways and station information to be displayed more clearly. For the multi-panel optical-property figures, we keep the events within the same figures because their common layout and consistent axes facilitate direct inter-event comparison.