

## **Review of manuscript ‘Validation of the TROPOMI/S5P Aerosol Layer Height using EARLINET lidars’, (acp-2022-412) by Michailidis et al. (2022)**

### **Summary**

This manuscript presents results of comparisons of aerosol layer height (ALH) derived from Oxygen-A-band ( $O_2A$ ) observations by the Sentinel5-Precursor Tropospheric Monitoring Instrument (TROPOMI) to ALH’s inferred from the vertical distribution of aerosols by European Aerosol Research Lidar Network (EARLINET). Lidar observations at seven EARLINET stations along the Northern Mediterranean coastline yielded 34 Lidar-TROPOMI coincidences. A coincidence defined as the averaged TROPOMI ALH inside 150 km radius circles centered at the EARLINET site within an 8-hr window ( $\pm 4\text{hr}$ ). The lidar inferred ALH is calculated as the 1064 nm backscatter-weighted aerosol altitude.

### **General Comments**

Although the authors have generally carried out a carefully planned validation analysis of TROPOMI ALH, a few details need additional explanation before the article is acceptable for publication.

-The 8-hour temporal window, dictated by the need of getting enough information for the analysis, is probably too long to capture the variability of the dust plumes’ structure. If the frequency of EARLINET observations allow it, I suggest adding a figure documenting the typical variability of aerosol load vertical structure during the passage of a dust storm at a representative site. This analysis could provide important information to characterize the uncertainty associated with the adopted ALH definition.

-The authors mentioned having considered the UVAI as an indicator of the presence of absorbing aerosols. Please explain the manner the UVAI was used considering the UVAI dependence on height, in addition to the known dependence on AOD and composition. Just having a positive UVAI value is not enough to assume aerosol presence because there are other non-aerosol related sources of positive UVAI values.

-Given the limited set of coincidences as well as the localized nature of the analysis, I disagree with the authors over-optimistic conclusion that the TROPOMI ALH product meets the expected 1 km threshold requirement of either accuracy or

precision. A previously published evaluation analysis (Nanda et al, 2020) demonstrated that the TROPOMI ALH product is systematically lower than CALIOP over both land and oceans.

-There was not mention of the possible role of calibration. It is well known that the calibration of the sensor has been drifting. The authors should address this issue and explain how calibration effects could (or could not) explain the observed level of disagreement in retrieved ALH.

## Specific Comments

Line 46. The statement ‘This work confirms that the TROPOMI ALH product is within the required threshold accuracy and precision requirements of 1 km’ should be removed. The temporarily and spatially limited analysis presented in this work does not provide any basis for such a general and over-reaching.

Line 75. Add TEMPO to the list of upcoming AQ satellites

Line 87 TROPOMI aerosol *height* products

Line 210 Over the oceans positive UVAI also result from non-aerosol sources such as sunglint and ocean color effects. Negative UVAI can also result from optically thin clouds and aerosols over both land and oceans. Ocean color effects associated with chlorophyll absorption yield negative values over the oceans. Surface spectral dependence over arid and semi-arid regions also generate non-aerosol related UVAI signal. Include original references [Herman et al., 1997; Torres et al 1998] and recent references documenting improvements in the treatment of water clouds in UVAI calculation [Torres et al, 2018]

Line 244 Elaborate on the cloud screening applied to TROPOMI observations for the comparison to EARLINET observations

Line 245 The term *real* aerosol height is not appropriate in this context. Perhaps *effective* is a better choice.

Line 246 Use ‘backscatter-weighted’ instead.

Line 445 Add the Torres et al [2018] reference that specifically addresses the treatment of clouds in the UVAI parameterization.

Line 538 It is reasonable to assume that the TROPOMI AER\_LH algorithm development team are familiar with the thermodynamic nature of the Earth's atmosphere. So, either remove the sentence '...The AER\_LH algorithm was not created to retrieve AER\_LH at such low air pressures' or add a specific reference in support of that statement.

Line 542 The analysis presented in this paper shows a real limitation of the TROPOMI AER\_LH algorithm, not just a *possible* one.

Line 578 Accuracy and precision are two different concepts. Based on the presented results, this reviewer is not convinced that the 1 km threshold requirement of either accuracy or precision has been met. I believe additional analyses are needed.

Line 579 The use of 'testify' is mainly a legal term. It is not appropriate in this scientific context. It could be replaced with 'show'.