Answer to reviews for ms amt-2018-25 - Formenti et al., Aerosol optical properties derived from POLDER-3/PARASOL (2005-2013) over the western Mediterranean Sea: I. Quality assessment with AERONET and in situ airborne observations

We thank Referee #1 for evaluating the manuscript and providing us with feedback on its scientific content. Detailed responses are presented in the body of text here below in blue.

Anonymous Referee #1

The authors present a 2-part analysis of POLDER-3/PARASOL oceanic aerosol retrievals against ground-based AERONET validation (in the Mediterranean), as well as a comparison of different sub-orbital (in-situ) data taken in the region. For the former, the authors present compelling evidence of POLDER-3 sensitivity to aerosol size, fine/coarse mode discrimination, AOD, and non-sphericity (to some extent). For the latter, the authors compare results from different optical-particle counters, providing a nice summary of retrieved complex refractive index for different aerosol types. The authors have clearly performed a thorough literature review, and this work should be published after minor revisions.

General Comments:

I would strongly encourage the authors to convert AOD, fine-mode AOD, and coarse mode AOD to 550 nm rather than 865 nm. Many other retrieval algorithms provide AOD information (such as MODIS DT) at this wavelength (or at least near it), and solar irradiance is much higher (meaning absolute attenuation will be larger) at 550 nm. Fine-mode AOD is typically very small at 865 nm, which will result in a lower RMSE and correlation as compared to the coarse mode (which you see in Figures 4 and 5). I expect that your fine-mode AOD range will more than double by extrapolating to 550 nm, and I expect your RMSE to increase substantially too. Although the lack of absorption is probably not an issue because your retrieved fine-mode AODs are so low (and desert dust is non-absorbing in the red and NIR), you may see a low bias in AODf at 550 nm because the effects of absorption can lead to non-linear errors in retrieved AOD. As POLDER's sensitivity to sphericity is probably dependent on total aerosol loading, might it make sense to report non-spherical AOD rather than non-spherical AOD fraction?

We understand and appreciate the comments by Referee #1. It is true that the choice of wavelength is of importance: 865 nm results in small values of fine-mode AOD (compared to 550 nm), but it is a question of accuracy. The objective of the paper is the validation of the POLDER-3 retrievals at the wavelengths where the instrument made the measurements and the oceanic algorithm is applied. These are 865 and 670 nm, but not 550 nm. Converting all data to 550 nm would result in inducing an additional bias due to the limitations in the retrieval of the Angstrom exponent (AE). This is why, as a first step, it is of first importance to evaluate the retrieval at the instrument/algorithm wavelength. However, we will certainly consider the conversion for the second part of this paper, which will address the analysis of the AOD products for the investigation of the aerosol spatial distribution and temporal variability in the western Mediterranean. A sentence on this issue has been added in section 5.2.

I might be a bit biased towards the POLDER-3/AERONET analysis, but I think the paper might flow better if all of the in-situ analysis were moved to the supplemental (or into its own paper). It really seems like an add-on to the POLDER-3/AERONET work.

We considered in deep detail this suggestion by Referee #1. Our feeling, and the motivation behind the analysis, is that the comparison with the in situ data provides with additional information which augments the results obtained by the comparison with AERONET. In particular, they allow investigating the sensitivity to size of POLDER-3 retrievals. In this respect, we would prefer keeping them with the main text. This would imply keeping Figure 3, bottom panels of Figure 4, and Figure 7. The alternative suggestion by Referee #1 is that the in situ-POLDER comparison could make the object of a paper *per se*. Again, we felt that the complementary of AERONET and in situ is the added value of the paper. We prefer to gather the available information in a single paper, the approach is rather original and we believe it gives more value to our study. On the contrary, it seems to us that there is not enough supplementary material for writing a solid additional paper.

Specific Comments:

Line 255: Should read "can be calculated as".

Done

Line 365: Is this increased temporal window only for AODF and AODC, or for all measurements?

This was done only for AOD_F and AOD_C. To clarify the sentence has been changed from "Instead, the averaging temporal window was extended to the whole afternoon (that is, all data points later than 12:00 UTC) in order to allow for a significant dataset for comparison" to "For these two variables, the averaging temporal window was extended to the whole afternoon (that is, all data points later than 12:00 UTC) in order to allow for a significant dataset for comparison".

Line 452: I think this should read "retrieved" not "measured", as POLDER does not measure AOD.

Correct - Done

Line 580-582: At the risk of sounding like a broken record, I believe that this can be explained by your use of 865nm AOD rather than 550 nm AOD.

A sentence has been added.

Table 4: The uncertainties here do not make sense to me [maybe I am just missing something?]: 1. Your RMSE is substantially larger than the absolute term in your AOD uncertainty (which you have as an extremely low 0.003 [should this be 0.03?]) The 0.003 corresponds to Bias value reported in Figure 4.

2. AE uncertainty should be a function of AOD or just a flat envelope. The higher the AOD, the greater confidence you should have in particle properties.

The AE uncertainty is expressed as a function of AE from RMS and Bias values obtained in Figure 8, as done for AOD from Figure 4. The error is larger for larger AE which corresponds to lower AOD values.

3. Non-spherical AOD uncertainty makes a lot more sense than f_{NCS} uncertainty, as you can account for inherent bias at low AOD.

The POLDER-3 oceanic algorithm retrieves f_{NCS}, which can only assume fixed values (0, 25, 50, 75 and 100%), without interpolation, and not the AOD_{CNS}. In this methodological paper it is therefore logic to evaluate this quantity and not the AOD products. We agree with the reviewer that f_{NCS} poses problems when the AOD is low, that is why the product is provided only for AOD > 0.1.

Figure 2-3: I would move this to supplemental, but up to you.

We agree in moving Figure 2 but would prefer keeping Figure 3 in the main text as it is the parallel to Figure 1.

Figure 4: I would remove the bottom to panels, as you have too few data to provide anything of value from airborne. Maybe then merge Figure 4 with 5?

Again, we believe in the added values of the comparison to the in situ data, albeit based on a limited number of data points. The current representation is simple and easy to read. We would like to keep it as it is.

Figure 6: There appear to be a couple of issues with this figure: 1. Should the caption read "volume distribution at Dcut-off < 1.0 μm (left) and days with AERONET Dcut-off ≥ 1.0 μm (right)" or "volume distribution at Dcut-off < 1.0 μm (Top) and days with AERONET Dcut-off ≥ 1.0 μm (Bottom)" 2. Figure 6 reads as though retrieved fine-

mode AOD is the top plot, and coarse-mode AOD is the bottom plot. a. I assume that this is a mistake, and that the fine-mode retrievals are on the left, and the coarse-mode retrievals are on the right side. b. This should also be clarified in the caption.

The reviewer is correct: the fine-mode AOD is the top plot and the coarse-mode AOD is the bottom plot. This is now corrected. The caption should read "the caption read "volume distribution at Dcut-off < 1.0 μm (left) and days with AERONET Dcut- off ≥ 1.0 μm (right)"

Figure 7: I would move this to the supplemental as well.

See previous comments. We would like to leave this in the main text.

Figure 8: I would change this to being contingent on AERONET AOD > 0.1, but this is just my preference. I would also remove the airborne data, as there are too few data. Maybe instead you could have 3 plots of AE, with different AOD requirements for each (>0.05, >0.1, >0.2)? This would help demonstrate the dependence of AE errors on AOD.

The scope of this figure is not to show how the error on AE changes with increasing AOD bur rather how it compares to the AERONET retrieval when the right screening of AOD by POLDER-3 is done. Again the airborne data are few but illustrative.

Figure 10: Would it make sense to change this to AODNS vs AODCNS?

As we explained previously, the POLDER-3 oceanic algorithm retrieves f_{NCS}, which can only assume fixed values (0, 25, 50, 75 and 100%), without interpolation, and not the AOD_{CNS}. To clarify this, the text in lines 153-161 has been reworded. Because of that, we would like to keep the figure as it is. We have therefore added Figure 10 to show the scatterplot comparison between the POLDER-3 AODCNS and the AERONET AODNS. The 2 quantities are strongly correlated (R=0.87) but the POLDER-3 AOD_{CNS} is lower than the AERONET AOD_{NS}, as expected. Explaining text has been added in Section 4.4. Former Figure 10 is now included as Figure 9.b.