

***Interactive comment on “Evaluating the assumptions of surface reflectance and aerosol type selection within the MODIS aerosol retrieval over land: the problem of dust type selection” by T. Mielonen et al.***

**Anonymous Referee #1**

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The paper by Mielonen et al. presents a detailed study of the discrepancies between aerosol optical depth measurements from MODIS and AERONET that are found at specific AERONET sites. The authors find that errors in surface reflectance assumptions in some cases lead to the inappropriate selection of the dust aerosol type by the MODIS algorithm. This significantly affects the accuracy of the aerosol optical depth retrieval from MODIS data. The study represents an important step in the process of further improving the MODIS aerosol retrieval algorithm.

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Although I have only minor comments, I strongly recommend that they be taken seriously to improve the readability and clarity of the manuscript.

General comments: 1. A clearer distinction should be made between what is measured by MODIS and what by AERONET (especially in Sect. 3.1)

2. It should be more clearly explained how the MODIS aerosol retrieval algorithm functions, in particular those steps that are of importance to the manuscript: the selection of the aerosol model. It is not sufficient to cite the literature in this case. It should also be explained how AE is determined and what the slope(660/2130) is, what NDVI is, and how and why they should be related.

3. The phrase “pure fine dominated model” is used several times. It should be changed to “pure fine-mode model” or something similar, since the word “dominated” indicates a mixture, which cannot be “pure”.

Specific comments:

Abstract (P. 3427)

Line 7: “GSFC (USA)” – for consistency, change to: “USA (GSFC)”

L. 16-23: “Our study suggests (...) relationship is used.” – This needs to be rephrased, because the paragraph is confusing to the uninitiated reader. For example, instead of “aerosol model combining” use “selection of aerosol model(s)” and be more specific in the rest of the paragraph, avoiding vague terms like “these two parameters”.

1. Introduction (P.3428)

L. 5-9: “Even though (...) top of the atmosphere.” – Please remove or change the start of the sentence, because the fact that aerosols are ubiquitous has nothing to do with the difficulties of aerosol retrieval. The sentence would also be a lot clearer if it were split in two shorter sentences.

L. 11: “predicted” – replace by “retrieved”

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L. 21: “simultaneous inversion for three channels” – replace by “simultaneous inversion of reflectances from three channels”

1. Introduction (P.3429)

L. 12: “It’s” – replace by “Its”

L. 23: “chooses dust model” – replace by “chooses the dust model”

L. 24: “(climatology, backtrajectory analysis, etc.)” – this is mentioned again later in the manuscript, but it is not clear why it is mentioned, since this analysis was apparently not done in this study. Maybe the complete second part of the sentence (starting with “when there is much evidence (...)”) should be replaced by “where no significant amount of dust is expected.” In my opinion, there is no need to provide evidence.

L. 25: “The question is (...) dust model?” – Replace by “This study addresses the question why the MODIS algorithm wrongly selects the dust model in such cases.”

2. Data and methodology (P. 3430)

L. 12: Quote Holben et al. here

L. 24: “We used AOD data with best quality” – and at which spatial resolution? This is only mentioned later, in Sect. 2.4

2. Data and methodology (P. 3431)

L. 6: “The uncertainty of the PFR instrument” – change to “The absolute uncertainty in AOD of the PFR instrument”

L. 7-8: “the PFR measurement at 500 nm was interpolated” – change to “the AOD measured by the PFR at 500 nm was interpolated”

L. 19: “The spectral AOD from AERONET” – change to “The direct-sun AOD from AERONET” to distinguish this AOD value from the AOD value retrieved from the almucantar measurements.

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L. 22-23: “the AERONET measurement at 500 nm was interpolated” – change to “the AOD measured by AERONET at 500 nm was interpolated”

2. Data and methodology (P. 3432)

L. 3: “made within an one hour window centered at the MODIS overpass” – replace by “made within one hour of MODIS overpass”

2. Data and methodology (P. 3434)

L. 7-8: “in order to provide (...) average year” – replace by “which is assumed to be representative of an average year.”

L. 8-11: “In addition, the dataset (...) five-year climatology.” – change to “In addition, the dataset contains surface albedo statistics (average and standard deviation) sorted by ecosystems. These are available at various resolutions of each 16-day time period’s snow-free filled albedo maps for each separate year as well as for the five-year climatology.”

L. 20: “The overall accuracy” – change to “The overall absolute accuracy”

2. Data and methodology (P. 3435)

L. 1: Please define NDVI and NDVI(SWIR)

L. 1-9: “These parameters (...) model combination.” – This section is not quite clear to me. In the given equation for slope(660/2130) the slope depends linearly on NDVI (at least for  $0.25 < \text{NDVI} < 0.75$ ), but later it is mentioned that “The slope (660/2130) also depends on the scattering angle, however, it does not have as large effect as the NDVI.” That is somewhat contradictory. I think this section needs to be rephrased, and the use of the slopes in the aerosol retrieval algorithm needs to be explained in detail somewhere else (General comment 2).

3. Results (P. 3436)

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L. 20: “measured SSA spectra” – change to “SSA spectra measured by AERONET”. See also General comment 1 for this whole chapter.

L. 23-24: “For small particles the SSA (...), while for larger particles” – It is not clear if these are really small and large particles, because MODIS might have misinterpreted the data. It would be better to write “When MODIS measures  $AE > 1$ , the SSA (...), whereas when MODIS measures  $AE < 1$ ”

L. 26: “aerosols which absorb more than assumed in the model.” – replace this by “aerosols with a different absorption behavior than that assumed in the model.”

L. 27-28: “on average the dust measurements are associated with slightly smaller SSA values.” – replace by “on average, the measurements where MODIS detects  $AE < 1$  are associated with smaller SSA values.”

### 3. Results (P. 3437)

L. 1: “whether absorption capacity of the fine dominated aerosols could affect the combination of the aerosol models in the MODIS aerosol retrieval?” – change this to “whether the absorption characteristics of the fine-mode dominated aerosols affect the selection of the aerosol model combination in the MODIS aerosol retrieval.”

L. 15: “Surface reflectance (...) AE data shows.” – How and where is this shown?

L. 22: “Figure 4 shows an typical” – should read “Figure 4 shows a typical”

L. 26: “retrievals where the slope(660/2130) has been multiplied by 0.9 and 1.1, respectively.” – what, exactly, does this mean? How did you change the slope? Was the surface reflectance at 660 nm kept constant? Or that at 2130 nm?

### 3. Results (P. 3438)

L. 1: “error bar” – if I understand correctly, the error bar contains all possible aerosol types and all possible AOD values when the reflectances at other wavelengths (e.g., 470 nm) are taken into account in the retrieval. This procedure should probably be

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explained in some detail in the methods section (see General comment 2).

L. 1: “pure fine dominated model” – change to “pure fine-mode model”, see General comment 3.

L. 9: “in the Fig. 4” – change to “in Fig. 4”

L. 11.: “under investigation.” – change to “under investigation very accurately.”

L. 11-12: “The MODIS AOD retrieval (...) and scattering angle.” – This needs to be explained more clearly somewhere, see General comment 2.

L. 22: “However, for all the ecotypes” – this is not apparent to me. There are some ecotypes that clearly exhibit a somewhat linear relationship (especially in Fig. 5b), but many ecotypes do not at all (most green dots don't, neither do many red dots).

L. 28: “inverse relationship that better fits the data” – change to “inverse relationship that fits the data slightly better”

L. 28-29 and next page, L. 1-2: As an attempt (...) thought to disagree.” – rephrase these sentences to make them more clear.

### 3. Results (P. 3439)

L. 5-6: “The number of the usable measurement (...) changes” – change to “The number of usable measurements (...) varies”

L. 6: “changes for the different cases” – what different cases? Be more specific

L. 7: “negative surface reflectance” – where does this come from? It looks rather worrying.

L. 9-10: “original C5 slope-NDVI relationship” – change to “original slope-NDVI relationship as used in the C5 MODIS aerosol retrieval”

L. 11: “inverse relationship” – change to “inverse of that relationship”

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L. 12: “where the aerosol model was forced to be either absorbing or non-absorbing.” – what does this mean? Please explain this in more detail.

L. 16-17: “agreement” – So does the agreement value give the fraction of measurements that agree?

L. 27-28: “two AOD correspondence parameters” – what are these? Be more specific.

L. 28: “the inversion slope” – to avoid confusion, it’s better to change this to “the inverted slope-NDVI relationship”

L. 29: “and mean difference” – change to “and mean AOD difference”

### 3. Results (P. 3440)

L. 1: “ $R^2$  indicates best AOD correspondence” – I am confused by the fact that mean AOD difference gives a different result than  $R^2$ : they are related quantities and should, at least, point in the same direction. Please explain this apparent contradiction.

L. 2: “The absorptivity the fine dominated aerosol model” – change to “The absorption of the fine-mode aerosol model”

L. 6: “as much as 1.6 times larger” – where does this number come from? There should also be a comment on the very small values of agreement for Rome and Mexico City.

### 4. Discussion (P.3440)

L. 10: “mixing” – what is meant here? Be more clear

L. 11: “fine dominated” – “fine-mode dominated”

L. 13: “other observations (AERONET AE, (...) satellite images)” – Why do you mention this here (see also comment at P.3429, L.24 above)? Was this information used? It is not discussed in this manuscript. It doesn’t appear to be very important.

L. 17: “fine dominated” – “fine-mode dominated”

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L. 21-22: “show clearly that the combination of the models usually results as either pure fine dominated aerosols” – change to “show clearly that the retrieval algorithm usually selects either pure fine-mode aerosols”

L. 24: “combining is extremely sensitive” – change to “selection of aerosol models is extremely sensitive”

L. 25: “the absorption capacity of the fine dominated aerosol models” – change to “the absorption characteristics of the fine-mode aerosol models”

L. 26: “fine dominated” – “fine-mode dominated”

### 5. Conclusions (P.3441)

L. 9: “selected often” – “often selected”

L. 16: “unphysical” – “inaccurate” or “incorrect”

L. 17: “combining” – “selection”

L. 26: “for all the ecotypes” – “for many ecotypes”

### 5. Conclusions (P. 3442)

L. 5: “fine dominated” – “fine-mode dominated”

### Tables

#### Table 3:

– A better name for the quantity “agree” might be “fraction of AE agreement”

– Table 3 would be much easier to read and more informative in the form of bar graphs, where original, inverted, abs and nonabs are shown in different colors at each AERONET site, for agreement, mean, and  $R^2$ .  $n_{all}$  can be written near the plot,  $n_{diff}$  and  $n_{same}$  are not needed (because they can be calculated from  $n_{all}$  and agreement)

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## Figures

Figure 1: Make the legend more clear by changing “AE over/under 1” to “MODIS AE over/under 1”

Figure 2: Make the legend more clear by changing “AE over/under 1” to “AERONET; MODIS AE over/under 1”

Figure 3. Make the legend more clear by changing “AE over/under 1” to “MODIS AE over/under 1”

Figure 4: Improve the legend, the current one is not very understandable.

Figure 5: These results are a little puzzling, or at least the lines for the MODIS retrieval are. Where do they come from? And what value is taken for the slope when  $NDVI > 0.6$ , or when  $NDVI < 0.4$ ? What does the equation given in Sect. 2.4.3 have to do with this figure, because the relationship is very different from the lines shown in the figure. I think the slope and NDVI should both be explained in much more detail, in particular why they should be related and how exactly.

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