**Atmospheric
Measurement
Techniques
Discussions**

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.

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We would like to thank the Anonymous Referee #1 for the extensive and constructive comments to improve our manuscript. The manuscript was revised based on them:

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

- Use of MODIS and AERONET parameters were clarified throughout the paper.

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.

- A detailed description of the MODIS retrieval algorithm was added to section 3-3.2. NDVI, slope and AE are also discussed there.

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".

- "pure fine dominated model" was changed to "unmixed fine model" throughout the paper.

Specific comments: Abstract (P. 3427) Line 7: "GSFC (USA)" – for consistency, change to: "USA (GSFC)"

- Done.

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".

- Done. The whole abstract was revised.

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.

- Done.

L. 11: "predicted" – replace by "retrieved"

- Done.

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

- Done.

1. Introduction (P.3429) L. 12: "It's" – replace by "Its"

- Done.

L. 23: "chooses dust model" – replace by "chooses the dust model"

- Done.

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.

- This analysis was done at an early stage of this study in order to be sure that we are looking at dust free cases. However, to minimize confusion the sentence was rephrased.

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."

- Done.

2. Data and methodology (P. 3430) L. 12: Quote Holben et al. here

- Done.

L. 24: "We used AOD data with best quality" – and at which spatial resolution? This is

only mentioned later, in Sect. 2.4

- Information on the resolution added to the text.

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"

- Done.

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

- Done.

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.

- Done.

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

- Done.

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"

- In our opinion, the expression with "one hour window" is more specific than the expression with "within one hour", thus we decided not to change it.

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."

- Done.

L. 8-11: "In addition, the dataset (...) five-year climatology." – change to "In addition,

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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."

- Done.

L. 20: "The overall accuracy" – change to "The overall absolute accuracy"

- Done.

2. Data and methodology (P. 3435) L. 1: Please deïňÃ ne NDVI and NDVI(SWIR)

- NDVI and NDVI(SWIR) defined in sections 3 and 3.2.

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 <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).

- Use of the slopes in the algorithm are explained in section 3.

3. Results (P. 3436) L. 20: "measured SSA spectra" – change to "SSA spectra measured by AERONET". See also General comment 1 for this whole chapter.

- Done.

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"

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- Done.

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."

- Done.

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."

- Done.

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."

- Done.

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

- This was shown in Figure 3 where the normalized surface reflectance for the MODIS measurements with AE > 1 stay almost constant as a function of AERONET AE.

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

- Done.

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 reïnĆectance at 660 nm kept constant? Or that at 2130 nm?

- The slope is a parameter in the retrieval algorithm thus we were able to multiply the value of the parameter with 0.9 or 1.1 within the algorithm. Modification of the slope

does not affect the surface reflectance at 2.13 μm, whereas an increase of 10 % in the slope increases surface reflectance at 660 nm and 470 nm by 10 %. The text was clarified.

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

- The retrieval procedure has been explained in more detail in section 3.

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

- Done. This was rephrased as "unmixed fine model".

L. 9: "in the Fig. 4" – change to "in Fig. 4"

- Done.

L. 11.: "under investigation." change to "under investigation very accurately."

- Done.

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

- The retrieval procedure has been explained in more detail in section 3.

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).

- Several ecotypes have been included in each of the subplots, thus the slope-NDVI relationship for specific ecotypes is hard to see. Therefore, we did linear fits for each

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ecotype and although there are large differences between the ecotypes, each of them had negative slopes indicating smaller slopes for larger NDVI values.

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

- Done.

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

- The text has been clarified.

3. Results (P. 3439) L. 5-6: "The number of the usable measurement (...) changes" – change to "The number of usable measurements (...) varies"

- Done.

L. 6: "changes for the different cases" – what different cases? Be more speciïňAc

- "Different cases" refer to the modified retrievals discussed in this section. The text was clarified.

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

- Negative surface reflectance values are possible because the calculation of the surface reflectance at 2.13 μm is based on the measured TOA reflectance and fixed AOD values from lookup tables. If the path radiance (function of AOD) in the lookup table is larger than the measured TOA reflectance, the surface reflectance becomes negative.

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

- Done.

L. 11: "inverse relationship" – change to "inverse of that relationship"

- Done.

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.

- The text was clarified: "where the fine model was assigned to be either absorbing or nonabsorbing regardless of the fine model originally assigned for the location."

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

- Yes.

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

- The text has been clarified.

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

- Done.

L. 29: "and mean difference" – change to "and mean AOD difference"

- Done.

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.

- The AOD difference tells us something about the bias between the MODIS AOD and AERONET AOD whereas R^2 provides a measure of how well the AERONET AODs are likely to be predicted by the MODIS AODs. Even though both parameters are indicators of correspondence, they represent different things. This means that the R^2 values can be good even though there is systematic bias and vice versa. Therefore,

these parameters a complementary.

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

- Done.

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.

- The following text was added to the manuscript for clarification: "The results in Mexico City and Rome are poor in all the cases because they are urban sites with bright surfaces. Therefore, we studied how much the slope660/2130 should be increased at these two sites in order to improve the AE and AOD retrievals. We did the retrievals several times and for each new run we increased the slope by 10 % . Then we compared these new retrieval values with AERONET measurements and found that in Mexico City the slope660/2130 should be as much as 1.6 times larger than the original to introduce significant improvements into the AE (AE agreement fraction 0.80) and AOD ($R2 = 0.56$ and mean(gb-M) = -0.03) agreements. In Rome, the best AE (AE agreement fraction 0.95) and AOD agreement ($R2 = 0.57$ and mean(gb-M) = -0.01) is achieved with 30 % larger slope660/2130"

4. Discussion (P.3440) L. 10: "mixing" – what is meant here? Be more clear

- "Mixing" refers to the combining of the fine-mode and dust models. The text was clarified.

L. 11: "fine dominated" – "fine-mode dominated"

- Done.

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.

- As we mentioned above (comment at P.3429, L.24), the information was used, however, it's not very important. Therefore, we decided to remove the text.

L. 17: "fine dominated" – "fine-mode dominated"

- Done.

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"

- Done.

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

- We decided not to change this because in our opinion the term "combining" describes better the actual mixing of the fine-mode and dust models in the algorithm. "Selection", on the other hand, sounds like we are choosing one model from a group of different models (e.g. non-absorbing, neutral, absorbing).

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

- Done.

L. 26: "fine dominated" – "fine-mode dominated"

- Done

5. Conclusions (P.3441) L. 9: "selected often" – "often selected"

- Done.

L. 16: "unphysical" – "inaccurate" or "incorrect"

- Done.

L. 17: "combining" – "selection"

- Again, we would like to keep this unchanged. See reply to comment P.3440, L. 24.

L. 26: "for all the ecotypes" – "for many ecotypes"

- See reply to comment P. 3438, L.22.

5. Conclusions (P. 3442) L. 5: "fine dominated" – "fine-mode dominated"

- Done.

Tables Table 3: – A better name for the quantity "agree" might be "fraction of AE agreement"

- For the plot, the name "fraction of AE agreement" is a bit too long, thus we changed it to "AE agreement". In the text we clarified that the parameter is the 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 Rˆ2. 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)

- This was a really good idea! We turned the Table into Figure 6. In addition, we decided to keep the Table 3 and made it more readable.

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

- Done.

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

- Done.

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

- Done.

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

- The legend and the figure caption was clarified.

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.

- The solid line for the MODIS retrieval is directly from the equation 9 given in section 3 (previously 2.4.3). The slope(660/2130) depends linearly on NDVI for 0.25<NDVI<0.75 as shown in the plot. For smaller NDVI values the slope(660/2130) is 0.48 and for larger NDVIs it is 0.58.

I think the slope and NDVI should both be explained in much more detail, in particular why they should be related and how exactly.

-This has been clarified in section 3 and 3.2: "Basically, the surface parameterization assumes that the slope increases as a function of surface-greenness."

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