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Geoscientific Model Development Discussions

Interactive comment on "PMCAMx-2015 evaluation over Europe against AERONET and MODIS aerosol optical depth measurements" *by* Antigoni Panagiotopoulou et al.

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(1) *Remote sensing measurements of aerosols represent a valuable complementary to surface in-situ data for CTM evaluation. Indeed, satellite observations provide finely resolved in space AOD data with global coverage, though being of somewhat varying quality due to assumptions involved in the retrieval algorithms. AERONET sunphotometers provide directly measured AOD at high time-resolution. Therefore, last decades those data have been increasingly widely used for model evaluations. In this work, the authors make use of MODIS and AERONET measured AOD to compare with results from PMCAMx-2015 model in order to get better insight in the model performance with respect to aerosol loads. Thus, the paper addresses relevant to the*

scope of GMD issues.

The article is very neatly and clearly written, and the methods applied are valid, but it does not offer any substantial novelty regarding ideas, data or methodology. Some of the conclusions appear not to be satisfactorily well founded (i.e. regarding model performance with respect to the individual aerosol types based on AOD evaluation).

The title contain a proper reference to the model used, but does not indicate the short term (one month) and thus limited model evaluation. Besides, only levels of monthly mean AOD have been compared, rather than a complete evaluation. Therefore, I 'd suggest to use "comparison" instead of "evaluation". Also, I'd not advise to include rather hypothetical explanations (lines 22-25), but rather say that the probable reasons of disagreements are discussed in the paper.

In general, the paper is written in good language, the formulations are clear and the supplemented references are relevant and ample.

We do appreciate all the comments and suggestions of the referee. The major new methodological improvement in this work is the screening of the satellite retrievals for periods with high dust (or coarse particles in general) concentrations and the combination of the MODIS/AERONET datasets so that the conclusions can be more robust. This is now stressed in the revised manuscript.

We have followed the reviewer's suggestion and changed the word "evaluation" with "comparison" in the title of the paper.

It is clear that comparison of the predicted AOD with the MODIS/AERONET results can shed only limited light on the ability of a CTM to reproduce the composition of the aerosol. We have rephrased the corresponding sentences in the conclusions stressing that the performance of the model for AOD (combined with its performance for composition in the sites where there are ground and airborne PM composition measurements) can be used to derive some tentative conclusions about its composition performance.

These are clearly limited to the components dominating the AOD in each area and either suggest problems or lack of major errors.

Other Comments:

(2) *The considered period (May 2008) should be indicated in the Abstract and in Sections 2, 3.*

We have added the considered period of May 2008 (EUCAARI campaign) in the Abstract and in Sections 2 and 3.

(3) *I recommend to include a bit more complete summary of earlier evaluation of all aerosol components.*

We have followed the reviewer's suggestion and added a new section in which we provide a more extensive summary of the results of the earlier published evaluations of PMCAMx for the same period focusing on PM composition (see also Comment 2 of Referee 1).

(4) *Explain more clearly whether the model calculates size-resolved chemical composition or only size-resolved number density.*

We now explain in the revised section 2 that PMCAMx simulates the composition of each size section and therefore predicts the size-resolved PM composition using in this application 10 size bins. PMCAMx calculates the aerosol number from the corresponding mass distribution while its sister model, PMCAMx-UF, simulates both the aerosol number and mass distributions explicitly.

(5) *For comprehensive and robust model evaluation and better understanding model result more in-depth analysis should be performed, including spatial and temporal correlations, RMSE, STD etc.*

We have calculated additional performance metrics for the model including the RMSE and STD. These provide limited additional insights compared to the four metrics that are currently used in the paper. This information has been added to the Supplementary Material. We agree that the spatial dependence of the performance of the model is useful. We found that the separation of the model domain in areas, given our emphasis on secondary aerosol, was the best way to approach this issue. For the temporal performance we have added in the revised paper some discussion focusing mainly on the average diurnal profiles of the AERONET AOD.

(6) *I find the explanations of model vs observations AOD discrepancies by over/underestimation of a particular aerosol components a bit speculative. I would strongly recommend to also include (at least) aerosol evaluation with monitoring surface data in different regions (and airborne measurements if possible) to support the conclusions).*

We do agree that these explanations are necessarily speculative. The recommendation of the reviewer is very useful. We have combined the discussion of the AOD performance of the model with its composition performance for the areas (central Europe, United Kingdom and Ireland, North Atlantic, Mediterranean) in which there were PM composition measurements. Combining these date sources does strengthen our conclusions regarding the model performance in these areas.

(7) *P.2 lines 13-14: What is the temporal resolution of AERONET data?*

The AERONET measurements have a variable temporal resolution varying from 15 min when the sun is high up in the sky to higher values when the sun is closer to the horizon. Measurements start at sunrise when the sun is at approximately 7.5 degrees above the horizon and end at sundown when the sun is once more at approximately 7.5 degrees. This information has been added to Section 3 describing the AERONET data.

(8) *P.4 lines 13-16: provide biases for all aerosol species and even better for the regions included in your AOD discussion; only 4 sites with data for sulphates?*

We have added the biases for all aerosol species and analyzed them by region thus synthesizing the AOD and PM composition information. We have included the data from both the ground and the airborne measurements and therefore our comparison includes four regions and thousands of data points.

(9) *P.7 line 3: How is Mie theory applied for aerosol mass? line 10: Have you made tests on accounting for "brown carbon", i.e. absorbing OC (which is believed to make notable contribution)? Lines 19...Study period? time resolution of AERONET data? AOD at which wave length was used?*

We have added a paragraph and the corresponding references clarifying the application of Mie theory of the aerosol size composition distribution simulated by PMCAMx. We have tested in a sensitivity study the effect of the potential absorption enhancement of the BC due to coatings by the other PM components and the effect on AOD for this area and period has been found to be quite small. Given that the biomass burning emissions in Europe during that period were low and that biomass burning is expected to be one of the major sources of brown carbon the effect is also expected to be small. This is explained now in the revised paper. We also clarify in this page the study period (May 2008) and the AERONET AOD wavelength (550 nm). The variable AERONET data time resolution is discussed in our response to Comment 7 above.

(10) *P.8 line 7: location instead of part.*

We have replaced "part" with "location".

(11) *P.9 lines 4-6: I do not understand. Suggest to explain better, or just refer to the sources. Lines 22-23: times coinciding with the satellites' overpasses?*

We have rewritten this rather confusing sentence to explain better the binning of the data points for the comparison of the MODIS AOD with the AERONET AOD shown in Figure S1. The comparisons with the MODIS AOD retrievals correspond exactly in space and time, so the times coincide with the satellites' overpasses. We have made the corresponding clarification in the paper.

(12) *P.10 line 16: compared with.*

We have made the corresponding correction.

(13) *pp. 11 lines 10-18: Given rather poor quality of emission data for those regions, I feel rather skeptic and "alarmed" about good agreement between model and measurements.*

We were also expecting significant discrepancies between predicted and observed AOD over Russia given the uncertainty in the corresponding emissions. However, the agreement was quite good with both AERONET and MODIS. This rather surprising result clearly requires additional investigation and could be due to offsetting errors. This point is now stressed in the corresponding section.

(14) *p.13 line 4: Rather sloppy formulation.*

We have rewritten the corresponding sentence.

(15) *P.15 line 16-18: This is a rather unfair statement. MODIS data is particularly valuable due to its spatial coverage (besides the AOD errors are relatively small). Line 16: correct "complement" Line 21-22: please, elaborate, otherwise leave out. It's not needed unless model comparison with MODEI and AEROCOM lead to different conclusions.*

We agree with the reviewer about the value of the MODIS data and the enormous value of the spatial coverage of the corresponding dataset. This sentence has been rephrased. We have corrected the typo in Line 16 and have deleted the potentially confusing sentence in Lines 21-22.

(16) *P. 16 line 7: again "excellent" model performance using poor emission input is typically indicative of some kind of compensating errors. Lines 15-17: too speculative conclusion about model's excelling in calculating all of aerosol types.*

In the revised manuscript we repeat at this point the uncertainty of the emissions in this region and the potential existence of some form of compensating errors. We have rephrased the sentence in Lines 15-17 to avoid misinterpretation of the corresponding findings.

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