Geosci. Model Dev. Discuss.,
doi:10.5194/gmd-2016-313-AC1, 2017

Geoscientific Model Development Discussions
Open Access
EGU

Interactive comment on "Sensitivity of the WRF-Chem (V3.6.1) model to different dust emission parametrisation: Assessment in the broader Mediterranean region" *by* Emmanouil Flaounas et al.

Emmanouil Flaounas et al.

flaounas@noa.gr

Received and published: 31 May 2017

General Comments: The authors evaluated the performance and biases of three different dust emission schemes (GOCART, AFWA, and UoC) available in WRF-Chem. For each scheme, they conducted four different experiments by multiplying various coefficients to the dust emission flux. They also conducted two additional sensitivity experiments, one adding finer dust-size bins and the other changing the mass fraction of each bin, using the GOCART scheme. For each experiment the model was integrated for six months and during the integration the simulation was nudged toward reanalysis.

Dust was treated as passive tracer and thus all simulations use the same meteorological conditions. Model results were evaluated through comparison with observations from MODIS AOD, AERONET AOD, and airborne lidar-derived extinction coefficients. Their evaluation focused on three regions: North Africa and the Arabian Peninsula for dust emission and the eastern Mediterranean for dust transport.

The results show that compared to observations all three schemes perform differently with different multiplication coefficients over dust source regions versus over ocean after transport. However, for the same dust emission scheme, simulations with different multiplication coefficients have similar correlation coefficients with MODIS observations. Results at the simulation domain, regional scale, and local scale (vertical profiles) were also evaluated. They concluded that among the three schemes evaluated none is optimal. However, the multiplication coefficient of 0.5 gave the most reasonable trade-off option between model AOD at both the source regions and transport regions. This work is interesting and the results can be useful to dust modeling and forecasts. The control of the same meteorological conditions, with the use of FDDA, is a good strategy for the evaluation of the dust schemes. The manuscript could be published in GMD after a major revision.

- We would like to thank the Reviewer for carefully reading our manuscript and for his/her positive review. Please note that in this revised version of the article, all simulations have been redone calculating wet removal by large scale precipitation (in addition to convective rainfall removal, activated in the original submission). Finally, we corrected a minor mistake to the calculation of the vertical profiles of extinction coefficient in Fig. 11 that did not significantly affect our results. The text has been adapted to these changes.

Specific comments:

1. For each dust emission scheme, the differences in performance over the three regions evaluated may not only be due to the scheme itself (i.e., mass fraction, sizes, etc.)

but also the quality of observations that are used for comparison. There are common patterns of biases over land versus over ocean and over desert versus over non-desert regions. These systematic biases over different regions might be related to the quality or bias of observations, in addition to the emission schemes themselves. Thus, the authors need to compare observations from different sources and evaluate AOD retrievals from different algorithms (i.e., the deep blue versus dark target algorithms) using another observation (e.g., AERONET). Then observation analyses should be used to help interpret model results with different multiplication coefficients.

- Thank you for pointing this out. We have investigated the quality or bias of MODIS observations in the different regions of interest.

First, we would like to point out that the Deep Blue AOD retrievals (obtained over bright arid land surfaces, such as deserts) are meant to complement the existing Dark Target land and ocean retrievals. Henceforth, there is generally very little geographical overlap between the two retrievals and a comparison between the Deep Blue and Dark Target products is difficult to undertake, and definitely beyond the scope of the present study.

We then have compared AERONET and MODIS Deep blue AODs over Africa (3 stations; Zouerate, Tamanrasset and Oujda) and the Arabian Peninsula (1 station, Solar Village) over the six months of the simulations. We also have compared AERONET and MODIS Dark Target over the Mediterranean for the same period (2 stations: Lampedusa and Crete). The comparisons are shown in Figure A1, together with some relevant indicators such as the absolute bias, root mean square error (RMSE) and correlation. The 1 to 1 line is also shown. Generally speaking, we find very good agreement between AODs in the Mediterranean region (i.e. Dark Target Vs AERONET) with high correlations (0.84 or higher), low RMSE (0.05) and low bias (0.04). On the other hand, the comparison between Deep Blue and AERONET AODs exhibits correlations ranging from 0.39 (Oujda) and 0.83 (Tamanrasset), RMSEs between 0.26 (Zouerate) and 0.55 (Oujda) and biases between 0.19 (Zouerate) and 0.26 (Oujda). These numbers consistently indicate better agreement between Dark Target AODs and AERONET AODs.

Hence, as pointed out by the referee, it is likely that the systematic biases over different regions might be related to the quality or bias of observations, in addition to the emission schemes themselves. It turns out that over Africa and the Middle-East a non-negligible part of the systematic bias observed between MODIS and the WRF simulations may be due to poorer quality of Deep Blue retrievals with respect to the Dark Target ones when compared to the standardized AERONET retrievals. Consistently with our analysis, the additional systematic bias linked to the use of Deep Blue products may be on the order of $\sim$0.18 (on average for the 4 stations in Africa and in the Middle-East). This is now discussed in the text:

In section 2.3:

"The quality of MODIS observations has been investigated in the different regions of interest. For this reason, MODIS and AERONET observations were compared for the whole six month period of the simulations (March-August, 2011). Deep blue AODs have been evaluated over Africa and the Arabian Peninsula using the four AERONET stations of Zouerate, Tamanrasset, Oujda and Solar Village, while MODIS Dark Target AODs have been evaluated over the Mediterranean using the two AERONET stations of Lampedusa and Crete. Results showed a good agreement between AODs in the Mediterranean region (i.e. Dark Target vs AERONET) with high correlations (0.84 for Crete and 0.95 for Lampedusa), low root mean square errors (RMSEs; 0.05 for both stations) and low absolute bias (0.04 for both stations). On the other hand, the comparison between Deep Blue and AERONET AODs exhibits correlations ranging from 0.39 (Oujda) and 0.83 (Tamanrasset), RMSEs between 0.26 (Zouerate) and 0.55 (Oujda) and biases between 0.19 (Zouerate) and 0.26 (Oujda). These numbers indicate better agreement between Dark Target AODs and AERONET AODs. Consistently with our analysis, the additional systematic bias of AOD linked to the use of Deep Blue products may be on the order of $\sim$0.18 (on average for the four stations in Africa and in the Middle-East)."

In section 3.1:

"In addition to the emission schemes themselves, the model bias over the dust source regions might be also related to the quality of observations, where MODIS uncertainties over North Africa and Middle-East might be of the order of $\sim$0.18 (section 2.3)."

2. Sedimentation and wet scavenging are other potential factors that can impact model performance, in particular for the evaluation of dust transport results. The former seems to be included but not the latter. The wet scavenging should be included in model simulations since it has an impact on long-range dust transport.

- In the original submission, all simulations were performed with wet removal for convective rain (cumulus scheme). We missed to include this information in the original version of the paper. In this revised version of the paper, simulations and figures have been redone also including wet removal from large scale precipitation (rain due to microphysics scheme).

We now mention that the model treats wet removal explicitly, however the impact of including aerosol removal due to large-scale precipitation on our results was rather insignificant.

3. Does the inclusion of additional finer dust-size bins improve the background values (AOD=0.2)?

- This is an insightful comment. In Figure A2, we present the comparison of EXP1 (red line) and EXP2 (green line) to AERONET observations (similar to Fig. 9 of the article). The model skill in reproducing the background values of AOD does not improve in EXP1 and EXP2. This is clear during June in the AERONET station, located into Crete (panel f).

4. Figure 14a shows that the dust concentration using GOCART-0.5 has a higher value than that in EXP1 near ground. Since EXP1 includes finer bins (thus smaller sedimentation), one would expect to have more dust suspended in the air. If that is the case then results at a higher level, where more dust is expected in EXP1, should be

presented as well.

- Thank you for this comment. Indeed, the vertical profile of dust concentrations in EXP1 and EXP2 are different from GOCART-0.5. We addressed this issue in Fig. 11, where we now include both EXP1 and EXP2. Indeed, the vertical profiles of the two simulations show that dust might reach higher altitudes. We added the following in section 4.2:

"....However, when comparing the vertical profiles of extinction coefficient between the simulations EXP1 and EXP2 with the other simulations (Fig. 11), differences are observed at higher altitudes. For instance, in Fig. 11a the sharp decrease of dust concentration in EXP1 and EXP2 takes place at around 5.5 km with respect to 5 km in the other simulations. In fact, the addition of finer dust sizes suggests a lower rate of sedimentation and therefore differences to the in-column transport of dust. ..."

Technical corrections: 1. Line 415: “all models seem to capture...” should read “all experiments seem to capture . . .” since there is only one model (WRF-Chem) used.

- Done.

2. Line 522: Delete “13” in front of “each”.

- Done.

3. Line 523: Should 0.25 be 0.225?

- According to Ginoux et al. (2001), the total size fraction should be equal to 1.1. The total of clay particles should be equal to 0.1 (i.e. 0.025 for each of the four first bins) and equal to 1 for silt (i.e. 0.25 for each of the four last bins).

4. Caption 14 needs attention. (should be (a), (b), . . ., instead of A, B, . . .)

- Caption is now corrected

Interactive comment on Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-313, 2017.

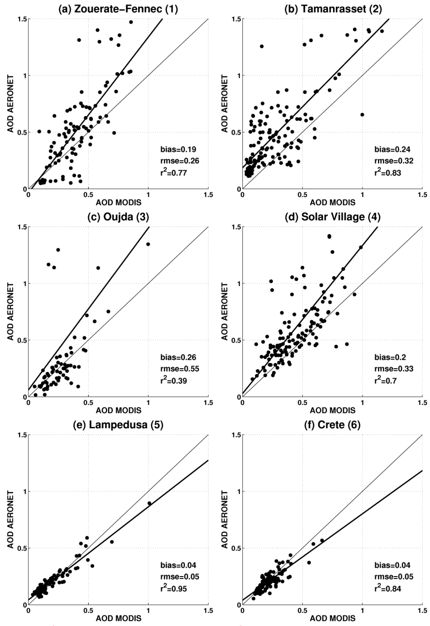

Figure A1 : Scatter plot of MODIS AODs Vs AERONET AODs for (a) Zouerate, Mauritania, (b) Tamanrasset, Algeria, (c) Oujda, Morocco, (d) Solar Village, Saudi Arabia, (e) Lampedusa, Italy and (f) Crete, Greece. The think black line is the 1-to-1 line, while the thick line shows the best linear regression. Absolute bias, RMSE and correclation coefficients (r^2) are also indicated in each panel.

Fig. 1.

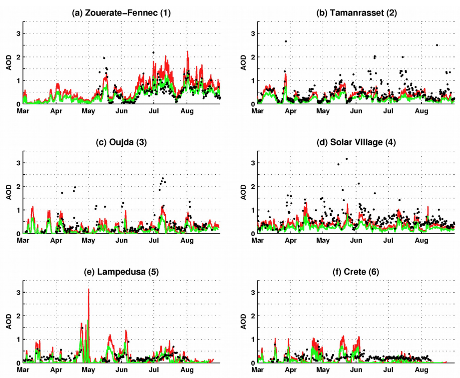

Figure A2: Time series of AOD for the EXP1 (red) and EXP2 (green) simulations and AERONET (black) observations during the whole six-month period.

Fig. 2.