Geosci. Model Dev. Discuss.,
doi:10.5194/gmd-2016-313-AC2, 2017

Geoscientific Model Development Discussions

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 This article presents an assessment of the ability of the three-dimensional WRF-Chem model to simulate the transport of dust over the Mediterranean, for a set of dust parameterizations, and over several periods of spring and summer 2011. Model output data are evaluated in comparison with AOD measurements derived from satellite observations, ground-based AERONET stations and airborne lidar-derived extinction coefficient measurements. They focus on the main source area (North Africa, the Arabian Peninsula) and on the Eastern Mediterranean basin. The

impact -on this comparison- of the use of dust emission adjustment coefficients is also investigated. This topic is of major importance in the Mediterranean, an area which shores are highly populated, which is sensitive to climate change (partly due to atmospheric aerosols), and which is exposed to air quality degradation due to the recurring import of gaseous and particulate pollutants from the surrounding continents.

The model has previously been shown to correctly reproduce meteorological features. The work is of quite good scientific quality, and fits the GMD topics as it proposes a critical analysis of 3D dust emission and transport modelling and aims at the determination of an adequate model set-up.

- We would like to thank the Reviewer for his remarks and for this careful review. Please note that in this revised version of the article we performed new simulations, including wet removal of dust due to large scale precipitation (in addition to wet removal due to convective rainfall, used in the original submission of the article). The Figures have been redone, however the results were only slightly affected. 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 questions that arise are the following: How is the erodibility value obtained? Does the use of a dust flux coefficient aim at scaling this value to better represent dust release during ad hoc wind conditions? Or does it aim at correcting dust emission parameterizations?

- The erodibility field is defined in Ginoux et al, 2001 as a probability field of the areas having accumulated sediments. This is a constant input field to the model, available in a 1°x1° grid. The tuning coefficients that we use in this paper aim at adjusting the modeled dust emissions to a realistic level during ad hoc wind conditions which are identical to all simulations. In fact, only for GOCART and AFWA schemes, where emissions are scaled by the erodibility field, the application of a 0.5 coefficient could be interpreted as a uniform decrease of the erodibility field values by 50%. The relation of the erodibility field to the tuning coefficient is now added to the last paragraph of section 2.2:

"For each dust emission scheme, we perform four simulations where the dust emissions are multiplied by four different coefficients in order to increase or decrease the dust fluxes in the atmosphere. The erodibility field is used by the GOCART and the AFWA schemes as a scaling factor to dust emissions, meaning that emissions -parametrised as a function of atmospheric and soil physical properties- are scaled in each grid point with different values between 0 and 1. For these schemes the application of a tuning coefficient could be interpreted as a uniform decrease or increase of the erodibility field.Âă More generally, the tuning coefficients applied here aim at scaling the modeled dust emissions to be more realistic and would ideally -for all three schemes- compensate for any boundary conditions or processes that affect dust emission, but are not accounted for in the model. Preliminary tests showed that a coefficient equal to 1 for AFWA and GOCART resulted in disproportionally high AOD values over North Africa compared to the scheme of UoC. Consequently, we chose coefficients to be different for the four simulations when using the UoC scheme. Table 1 presents a summary of the 12 performed simulations set-up."

- §3.1 The authors largely describe the impact of dust flux coefficients on the model skills, in terms of under- or over- estimation. But the analysis of the results remains largely descriptive and not comprehensive. How do the authors explain the spatial heterogeneity in the skills when using the coefficients? Does it come from non-homogeneous quality in the erodibility field above the different areas? Or could it be explained by local soil features that are not all taken into account in the parameterizations? May this come from non-homogeneous local meteorological skills (wind speed restitution)? This issue is only slightly discussed in the conclusion.

- Thank you for this question. The spatial heterogeneity in model skill is likely dependent on the (spatially and temporally) variably accuracy of model input to the schemes, in particular for soil type and vegetation cover, as well as aspects that are not included

or sub-grid in the model, such as information about surface crusting and meteorological processes like dry and moist convection. The tuning constants applied here are only able to provide some insight into the amount of correction needed to compensate for systematic biases and how this amount varies when focusing on particular areas. A conclusive attribution of biases to one or more of the listed sources of error is, however, not possible within the framework of this paper. We have added a paragraph in section 3.1 discussing this issue:

"Figure 3 shows that the average spatial AOD patterns produced by the AFWA and GOCART schemes are similar and differ from those obtained using the UoC scheme. A main reason for this is the scaling of the calculated dust emission fluxes with estimated values for surface erodibility in the AFWA and GOCART implementations. Such empirical tuning is common and necessary in particular for (semi-)empirical parameterizations that do not explicitly describe the physical processes of dust emission at the surface. Physics-based parameterizations, such as the UoC implementation, aim to represent the physics of dust emission and would, if all processes were accounted for, not need empirical tuning. However, dust emission is a complex process including aspects that are not yet accounted for in the parameterizations because they are not yet fully understood and because model resolution limits the spatial representation of land-surface properties. Such aspects include, but are not limited to, surface crusting, particle supply, and intermittency. The spatial variability of model performance, both with and without tuning with constant coefficients, can thus likely be attributed to spatially and temporally varying accuracy of the model lower boundary conditions that are either constant, e.g. soil type, or follow a climatological cycle, e.g. vegetation cover. Surface crusting significantly affects dust emissions, but is to date not represented in any model. Meteorological processes that occur on sub-grid scales in the model, e.g. dry and moist convection, provide another source of uncertainty that can lead to model-observation biases. A conclusive determination of the origins of model over- and underestimations of AOD for the different areas is beyond the scope of this paper. However, an assessment of the tuning required for a particular parameterization to produce reasonable results can help to determine reasons for model-observation discrepancies."

- §3.4 It does not appear completely satisfactory that the evaluation of the model on the vertical is made using the simulations with the “best local” dust flux coefficients, which are not the same for all parts of the simulation domain. At least, the evaluation of relevance of the model output should thus be limited to the qualitative aspects (restitution of vertical shapes...), and not quantitative ones such as the restitution of the “magnitude of the extinction coefficients derived from lidar” (line 437).

- We agree with the Reviewer that quantifying the model bias in five vertical extinction coefficient profiles is not representative of the model performance. Our purpose here is to provide an insight into the model capacity to realistically reproduce the vertical profile of dust concentration as well as into the uncertainties when comparing model AOD to observations. Quantifying AOD in Fig. 11 we show that even if the model fails to represent the vertical variability of dust concentration, it might reproduce the AOD due to compensating biases. The quantification of AOD only aims to make this point. In section 3.4, we are now more precise on our motivation for presenting Fig. 11:

"Comparing model to observations in only five cases may not be enough to be used as a token of the model performance. On the other hand, Fig. 11 offers an insight into the model capacity to realistically reproduce the vertical variability of dust concentration."

In addition, we slightly changed the concluding remark of section 4.1 to:

"Here we presented only five profiles of extinction coefficient, but averaged over several hundreds of kilometres along the flight legs to average observed outliers, which are thought to be fairly indicative of the model capacity in reproducing vertical profiles of dust concentration."

Technical comments - Line 214 - Reference for AERONET should be given at the first mention of the network and not lately.

- Done.

Line 522 - “13” should be removed from the sentence.

- Done.

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