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Geoscientific Model Development Discussions

Interactive comment on "Global aerosol modeling with MADE3 (v3.0) in EMAC (based on v2.53): model description and evaluation" *by* J. Christopher Kaiser et al.

Anonymous Referee #1

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General comments

The authors present the model description and evaluation of the global aerosol model MADE3 in the modelling framework EMAC. After a brief description of the modelling system and the chosen setup the authors compare a ten year simulation (1995-2005) in nudged mode to a range of aerosol observations. The observations include surface station measurements of number and mass concentrations, airborne measurements used to evaluate the vertical profile of aerosol concentrations, ground-based measurements of aerosol size distributions, aerosol composition data sampled from in-situ measurements, and remote sensing measurements (AOD). Finally, the evaluation results

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are compared to other widely used global aerosol models.

The paper is well structured and written. The authors do not miss on identifying model shortcomings in their evaluation and analyze the causes and reasons of model shortcomings in depth. The model setup, however, exhibits two major problems the authors themselves seem to struggle with in their evaluation at several places. Firstly, the model grid spacing is with 2.8 degree horizontal spacing and 19 vertical layers very coarse nowadays. Based on the publications that are cited, this setup seems to be in use by the EMAC community for more than ten years now. The choice of such a coarse resolution hinders comparability with in-situ measurements. Secondly, the time frame of the model simulation does not align with several of the observations that are used. As a result, temporal collocation is not possible further reducing the comparability.

Despite the shortcomings in the model setup the manuscript provides a thorough evaluation of the MADE3 aerosol scheme. I recommend it for publication after my comments are met. Nevertheless, the authors should consider a change in their setup for future studies.

Specific comments

For a manuscript bearing 'model description' in its title, the actual description of MADE3 is rather short. Only the adaptions that were made to the aerosol scavenging module are described in more detail. This is justified as MADE3 has already been described by Kaiser et al. 2014. The authors should think about removing 'model description' from the title, as the paper clearly focusses on evaluation of the model.

(P1 L16-17, P11 L22-24, P20 L22, P22 L27, P24 L28-29, P28 L3-4): Several sections are ended with an outlook and further plans. In my opinion this devaluates the results presented in the respective sections. Especially because this is done too frequently. These plans can be part of the summary section though.

(P2 L20): The formation efficiency of ice particles depends not only on size but also

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strongly on surface area (see Hoose and Möhler, 2012, which is cited in the same line).

(P2 L29): A two-moment aerosol microphysics scheme does not really 'explicitly simulate the size distribution'. The shortcomings of the approach with a fix standard deviation of the distribution are obvious in section 3.3.

(P3 L22): ECHAM5 seems to be a rather outdated version of this model. A more recent version might also be used easier at higher resolutions. Please comment.

(P3 L27): As I understand output was written in 12h intervalls. Depending on what exactly is written this can lead to a bias. For example, in one time zone the output is always written at 0 and 12 local time, in another one at 6 and 18 local time. Could the authors please clarify?

(P3 L31): Please add more information on the emission inventory, i.e. which one is used and at which resolution is the raw data.

(P5 L7): Please add a short description of the "big leaf" approach.

(P6 L8): From the text and also from Figure 1 it did not become clear to me how the authors are dealing with SOA in MADE3. Please extend!

(P6 L15): What does the neglection of POM mean for the diameters that are used to calculate the aging process?

(P6 L33): Are the ice nucleation scavenging ratio assumptions necessary because feedback is excluded? It could also be calculated explicitly by ice nucleation parameterizations.

(P7): Please provide some details on how the time integration of the aerosol dynamics equation is implemented.

(P11 L1): Aerosol optical properties and assumptions with respect to the mixing state are also important.

(P12 Table 3 description, L4): Why are there arithmetric averages in the inequation? Shouldn't the criterion apply to each single data point?

(P14 L4): With a high bias and a wrong gradient the distribution is not reproduced. Please weaken the statement.

(P14 L17): Do the authors have an idea why the simulation provides such a high bias for Spain and the western Mediterranean? Are misrepresentations of the land use in the emission data leading to too high precursor gas emissions?

(P16 L19): With the assumption of a homogeneous mixture between different particle sizes within one mode, you can calculate the modelled concentration below 2.6 microns. Did you try this?

(P17 L5): Please extent the findings of other studies.

(P22 L17): Although this is not a contradiction, it still means that the size distribution is not captured well.

(P22 L24): A possible reason could also be that upper tropospheric temperatures are not captured well by the model. As a result, nucleation rates are not represented well. As I understand, the nudging takes place only at the surface. Did you check for biases in the model climate? The rather low model top at roughly 30 km may also play a role.

(P24 L13): Did you check if the assumptions made in the SCAV module (with regard to the release of particles) are causing the unimodal size distributions?

(Section3.3): A high resolution implementation of MADE3 could provide valuable insight into the performance of the aerosol scheme with respect to the size distributions shown. If the authors see any chance to realize this with the available emission data, the manuscript could be substantially improved.

(P27 L22): Are there many particles? I would not expect too many particles in this region at this size range. An underestimation of small mineral dust particles could also

explain this behaviour.

(P29 Figure10): Please provide also relative differences plots.

(P30 L30): Please add sentences highlighting differences of MADE3 to its predecessors.

Technical corrections

(P3 L6): Please add turbulent to diffusion.

(P8 L22): leads

(P22 L2): There are some words missing in this sentence.

(P26 L33): be derived

(P27 L14): Please remove the word preliminary. If the results are preliminary you should not publish them.

(P32 L15): should

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