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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Development of an aerosol chemical transport model RAQM2 and predictions of Northeast Asian aerosol mass, size, chemistry, and mixing type" *by* M. Kajino et al.

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Dear anonymous referee 2

We very much appreciate your constructive comments, useful information and your time. Thanks to your review, our manuscript was substantially improved. Point-by-point responses to your comments (in blue) are attached in this later.

We attached the revised manuscript with modifications highlighted in red as the supplement (only text and tables, no figures).

The usage of English of the current version was not checked yet but will be checked by

native English speakers at least once before publication.

Sincerely yours,

Mizuo Kajino

General comments and replies:

The authors describe the development of a simpliïňĄed version of the MADMS aerosol model and its incorporation into the chemical transport model RAQM. The new model, dubbed RAQM2, is then applied to an annual simulation for the year 2006 over a Northeast Asian domain with 60 km grid spacing. The model is evaluated by comparison with observational data from relatively remote sites in Japan. The RAQM2 aerosol model uses four log-normal modes. It does not assume that the gas and aerosol phases are in equilibrium, but instead simulates condensation and evaporation dynamically. RAQM2 also includes six parameterizations related to aerosol dynamics: (1) new particle formation, (2) CCN activation, (3) IN activation (4) explicit grid-scale cloud microphysics, (5) dry deposition, and (6) subgrid convection and scavenging. The model uses offline-coupled meteorology from the WRF model, so CCN and IN activation do not lead to differences in the meteorology, but are used to determine scavenging and wet deposition. The paper is well organized and for the most part the model is very well described. The model application and evaluation are reasonably rigorous and comprehensive: annual simulation period, hourly measurements of various gas-phase species and bulk PM2.5 and PM10 concentrations, weekly or biweekly filter pack measurements of gases and aerosol components, plus hourly AMS data at one site. I recommend publication in ACP if the minor points listed below are addressed.

Thank you for the evaluation.

Specific comments and replies:

- Please explain why the WRF-RAQM2 simulations were performed in monthly segments with two-week spin-up periods. Is this the case for both WRF and RAQM2, or

only WRF?

This is for RAQM2. It is due to the technical reason that boundary data sets such as the boundary concentrations, emission inventory, MODIS/LAI, TOMS-O3 are all on monthly basis, and in the program, read once and set constant during simulation. About 1-2 weeks of spin-up is needed for long-lived species such as ozone. It was more time consuming to make 12 save-and-restart runs with 30 days one after another, than parallel 12 runs at once with 44 (30+14) days. WRF is done for throughout a year at once with a spin-up period of 3 days. I changed the sentence to “The entire simulation period was 1 year, but each simulation was performed separately for each month (as most of boundary data sets are on monthly basis) with a spin-up period of 2 weeks for RAQM2. WRF simulation was done for 1 year at once with a spin-up period of 3 days.”

- The paper refers to four aerosol "categories": ATK, ACM, AGR, and COR. I believe these are synonymous with "modes" but the terminology was confusing to me. Please clarify.

“The aerosol sizes in each ‘category’ are assumed to be characterized by a ‘mode’” is the definition but there is the word “mode” in the name of “category” itself. This may be the cause of confusion. I tried to clearly distinguish the usage of the two terms in the revised manuscript: For example please see changes in Abstract as “a category approach was utilized, in which the aerosols were distributed into 4 categories: particles in Aitken mode (ATK), soot-free particles in accumulation mode (ACM), soot aggregates (AGR), and particles in coarse mode (COR). In the current setting, aerosol size distribution in each category is characterized by a single mode.” Substantial revision is done in Sect. 2.2, too. I changed the terms “intra-category” and “inter-category” to “intra-modal” and “inter-modal”, respectively, in most of cases (not all). I also changed to “all modes of the categories” from “all categories”, “each mode of categories” from “each category”.

- In a few places (e.g., pg 13413 lines 11 and 20) the phrase "fix the LNSD" is used.

I believe "characterize (or describe) the LNSD" is what is meant; "fix" sounds like the moment parameters are not varying in time.

I changed the term “fix” to “characterize”. Thank you.

- Within the aerosol code, what are the variables that describe each mode? On 13413 line 11 it says N, Dg, and sigma-g, but on line 25 it says M0, M2, and M3, or for coagulation M0, M3, and M6. A few additional equations showing the relationship between these sets of variables would be helpful so that the reader can understand how the code progresses along the aerosol subprocesses shown in Figure 2. What are the transported variables deïňĄning each LNSD? Is sigma-g calculated for each mode, or is it held constant, or not allowed to exceed some maximum value?

I changed the title of Table 2 to “transported species” instead of “tracers” and modified Sect. 2.2.1 accordingly. I added a flow chart to explain how moments and parameters are treated in the operators in Fig.2b and replaced the confusing statement in Sect. 2.2.1 by the sentence “how moments and the LNSD parameters are changed in the process operators are described later in Sect. 2.2.10 and Fig. 2b”, and made the new section 2.2.10, titled “Time evolution of the moments and the LNSD parameters in each process operator” After the explanation of all the equations and the flowchart, 2.2.10 would be the best place to explain this.

We set the minimum sigma value of 1.0 and the maximum values of 1.7 for ATK, ACM and AGR and 2.0 for COR to avoid unrealistic values. When sigma exceeds the either limits, sigma is adjusted to the limit values preserving M0 and M3 (thus M2 is changed accordingly).

The conclusion is a simple summary of the main points in the previous section. I encourage the authors to go beyond that restatement and make some additional remarks, such as the next two points below.

As noted in the introduction, in terms of complexity this model lies between the GATOR-

GCMOM of Jacobson and regulatory models such as CMAQ, which rely on assuming thermodynamic equilibrium for the ïňĄne aerosol modes. How computationally expensive is the new RAQM2 model, particularly the aerosol component? Is it feasible for urban airshed modeling?

Are there plans to make the coupling between WRF and RAQM2 a two-way coupling, so that the aerosol microphysics affects the clouds and/or radiation in the meteorology model?

To skip the restatement, we combined the first three paragraphs in Sect. 4 together, and simplified it. Your first comment (computational efficiency and feasibility) and the second one (online coupling) are discussed in the last and the second last paragraph, respectively.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/12/C7236/2012/acpd-12-C7236-2012-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 12, 13405, 2012.