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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Intercomparison of aerosol-cloud-precipitation interactions in stratiform orographic mixed-phase clouds" *by* A. Muhlbauer et al.

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On behalf of all contributing authors I would like to express my gratitude to the reviewer for the very useful and constructive comments that clearly helped to improve our manuscript. In response to the reviewer's suggestion we expanded our discussion on the compensation effects. Below is our item-by-item response to the comments and suggestions made by the reviewer with and a detailed description of how we addressed them. For convenience, the original comments of the reviewer are repeated in italic.

1. *There is a lack of description of the vertical coordinates, vertical grid spacing and model top of the models. Potentially, different vertical coordinates could have*

significant impact on the model results because the complex terrain is involved. Indeed, as shown in figures, the temperature fields, wind speed and vertical velocity predicted by the models vary substantially in a few hours. My feeling is that the fairly large model to model variability in aerosol effect on precipitation may not be just a reflection of differences in microphysics.

We clarified the model description section in this regard and added information on the vertical coordinate system used in WRF. All models use exactly the same vertical levels, grid spacings and model tops. We agree with the reviewer that dynamical differences attributable to different vertical coordinate systems or different dynamical cores may exist. However, the dynamical differences are rather small and occur predominantly in regions downwind of the mountain (e.g., in regions of wave breaking or downslope winds). Thus, there is no effect on the upstream cloud formation.

2. *Advection is known to be important in scalar transport and cloud-scale modeling of aerosol-cloud interactions. There are specific descriptions of advection scheme in the COSMO and UMNMS models, but not for the WRF model. Which advection scheme is used in the WRF model simulations?*

   The WRF model uses the Wang et al. (2009) advection scheme with monotonic flux limiter for all scalar quantities. The advection scheme is positive definite and shape preserving. For clarification, we added the following sentence to the model description section 2.2:

   "For the advection of scalar quantities the positive definite and shape preserving advection scheme of Wang et al. (2009) is employed"

3. *"Negative" distance is used in a few figures. It sounds rather odd to me. The horizontal "distance (km)" axes in figures can be simply replaced by something like "x (km)".*

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We agree and changed the notation in the plots accordingly.

4. *The aerosol size distributions (modes and mean size in particular) shown in Figure 2 don't match well with those summarized in Table 3. Please clarify. Did the bin-aerosol scheme in WRF take the same initial log-normal size distribution as the other bulk schemes?*

   The aerosol size distribution is calculated according to equation (3) with the values from table 3. Below is a figure that clarifies the location of the individual modes (dashed) and their contribution to the total size distributions (solid) shown in figure 2. The clean case is shown in blue and the polluted case is shown in red. As can be seen from this figure the size distributions do match with the values given in table 3. However, we realized that we have not been consistent with our notation for the count median radius in table 3 which may have lead to confusions and, thus, we corrected this error.
   The WRF model was initialized with the same aerosol spectrum than all the other models.

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figure-1.pdf

5. *Are there source terms in prognostic equations of CCN/IN number concentrations? More specifically, are aerosol particles recycled in the microphysics schemes after droplet/drop evaporation and ice sublimation?*

   The source terms in the prognostic equations for CCN/IN are the activation of aerosols and the nucleation of ice crystals. Recycling of aerosols is not yet taken into account. Thus, the aerosol size distribution does not change upon evaporation/sublimation of hydrometeors. However, current research in some of the participating modeling groups is heading in this direction and a paper including the effects of aerosol recycling is being published separately in Xue et al. (2010). We also plan to conduct intercomparison studies with aerosol recycling in the future.

6. *In Figs. 3 and 13, why the values of integrated water vapor are different between models even at time zero? Also, domain average vertical velocity is often very close to zero like the NWNMS model shows, but the other two models show quite a departure. Any explanation on this?*

   The subtle differences in integrated water vapor at initial time originate from slight differences in the sampling volume of each model. We compute the integrated values only for model levels below the Rayleigh damping layer and excluding the numerical relaxation zones. However, the height at which the numerical sponge layer starts as well as the width of the relaxation zones vary among the models depending on the numerical setup. Thus, slight differences in the integrated water vapor are to be expected. A short discussion on this issue can be found in section 4.1.1 of the manuscript:

   "Note that the slight differences in the domain integrated water vapour initially originate from differences in the model sampling volume. Since each model applies a different numerical setup (e.g., depth of the Rayleigh damping layer, width of the lateral relaxation zone) the model sampling volume varies slightly among the models. The maximum and domain integrated statistics are obtained for the entire model domain excluding relaxation and damping zones"

   Since the reviewer's second question in this item 6 is related to his/her first comment we refer to item 1 in our response.

7. *The terminology of "inverse/reverse sensitivity" of precipitation to change in aerosol number concentrations used in the manuscript is confusing. It's better*

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to be explicitly described in the text.

We agree and changed the text in order to be more specific.

8. *Some minor technical corrections:*
   10494.21-24: the model names are unnecessarily repeated.
   10505.3, 10514.22: change "negligible small" to "negligibly small"?
   10515.14: "decrease is riming" to "decrease in riming"?

   All technical corrections have been applied.

References

Wang, H., Skamarock, W. C., and Feingold, G.: Evaluation of Scalar Advection Schemes in the Advanced Research WRF Model using Large-Eddy Simulations of Aerosol-Cloud Interactions, Mon. Weather Rev., 137, 2547–2558.

Xue, L., Teller, A., Rasmussen, R., Geresdi, I., and Pan, Z.: Effects of aerosol solubility and regeneration on warm-phase orographic clouds and precipitation simulated by a detailed bin microphysical scheme , J. Atmos. Sci., in press.

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