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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Two-moment bulk stratiform cloud microphysics in the GFDL AM3 GCM: description, evaluation, and sensitivity tests" *by* M. Salzmann et al.

Anonymous Referee #1

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General comments

This article describes the implementation of a 2-moment liquid and ice cloud microphysics scheme into the GFDL AM3 model, and compares it to the previously implemented scheme. The new scheme is based on the Morrison & Gettelman scheme from the NCAR CAM model, but also the cloud cover and ice nucleation parameterizations are modified and described in detail. A weakness of the 'NEW' model is the imbalance between a highly complex cloud microphysics scheme and a rather crude (1-moment) aerosol scheme. Still, the NEW scheme in the GFDL model is one of the most advanced treatments of aerosol-cloud interactions in global models. I recommend this

article to be published in ACP after minor revisions.

The model description is exceptionally clear and it is appreciated that the authors discuss details related to the implementation, which is often neglected in the peer-reviewed literature. However, this makes the paper quite lengthy, and I recommend to shorten it by taking out some unnecessary repetitions.

What I find somewhat problematic is that the two major references for the new GFDL AM3 model (Donner et al and Golaz et al) are not submitted yet. What if they undergo major future changes such that the citations in Salzmann et al. are not accurate anymore? At least, unsubmitted papers should be cited as (in preparation) instead of (2010).

Detailed comments

- The section titles do not make it easy to attribute the model description to the BASE and NEW simulations. I suggest to add 'BASE' and 'NEW' in the titles of sections 2.1 and 2.2, respectively, and to take section 2.3 to 2.5 as subsections to section 2.2.
- p. 6381, l. 6: Where does the Δz-term come from? It's rather unfortunate to make a physical parameter explicitly resolution-dependent.
- p. 6382, l. 1: Different coefficients are used over land and ocean. Do you apply any interpolation between these two values for near-coast gridcells?
- p. 6382, l. 4 / Table 2: How well balanced is the simulation, i.e. how large is netTOA? This could be added to Table 2.
- I did not find any mention of how radiative balance was achieved in simulation NEW. Please mention which are the critical parameters.

- There is no mention of a lower droplet concentration limiter, which presumably implies that it was not used here. In view of the recent discussions in Quaas et al (ACP 2009) and Hoose et al (GRL 2009), this should be mentioned.
- p. 6384, l. 4-9: Is the size adjustment term only for ice or also for liquid hydrometeors? What is the upper size limit?
- p. 6384, l. 13: Brownian diffusion should be very small for particles $> 0.1\mu$m, what about phoretic processes?
- p. 6384, l. 6 / p. 6388, l. 3: Now I'm confused. Is one of the two a typo or do you allow on overlap of the two regimes? If so, why?
- p. 6384, l. 10 / p. 6390, l. 11: It is inconsistent to combine the original Bigg et al immersion freezing and the modified Meyers et al deposition/condensation nucleation parameterizations. First of all, why scale the Meyer formula with the dust concentration but not the Bigg et al? Second, it is not clear whether the two parameterizations really describe two different processes which can be added. Condensation freezing and immersion freezing is difficult to separate.
- p. 6384, l. 21: In general, 'immersion nucleation' should act on pre-existing droplets. In the current implementation, it cannot because it is parameterized only below the homogeneous freezing threshold. Please clarify this.
- p. 6385, l. 9: Is there a physical reason for the decrease of this parameter, or is this pure tuning? How often is the lower limit of 0.7 m/s hit in BASE? If often, this adjustment might significantly contribute to the lower droplet number in NEW compared to BASE.
- p. 6388, l. 17: The uncertainty about soot immersion freezing and the Kärcher et al (2007) paper are mentioned three times. Please avoid such repetitions.

- p. 6390, l. 19: Why $20\ \mu$g/m^3? How often is DU$_{2.5}$ higher/lower than this?
- p. 6407, l. 7: As the Haywood et al (2009) article is difficult to obtain (book chapter), I suggest to add a reference to Lohmann et al (ACP 10, 3235-3246, 2010), which also contains a definition of the RFP.
- p. 6429, Table 1: More information could be moved from the footnotes into the table. For ice nucleation, Liu & Penner (2005) is not a complete description of the treatment in 'NEW'
- How do the model versions described here relate to the one contributing to Quaas et al (ACP 2009)?
- p. 6433, Figure 2: explain dashed blue and red lines in (b) in the caption. The red dashed line should also show up in the legend.
- p. 6434, Figure 3(a): The red dashed line should also show up in the legend.

Technical comments

- p. 6383, l. 33: two trailing commas at the end of equation (6)
- p. 6390, l. 11: temperature range **between**

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 6375, 2010.