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Interactive Comment

Interactive comment on "Introduction of prognostic rain in ECHAM5: design and Single Column Model simulations" *by* R. Posselt and U. Lohmann

R. Posselt and U. Lohmann

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The authors wish to thank the referee for the helpful comments on this manuscript. Below please find the point by point response to your comments.

Reply to "Specific comments":

p. 14679, l. 21: The reviewer is right by stating that a diagnostic treatment of snow is especially worrisome because of lower fall speed of snow and of the larger distances from the cloud to the surface. We are aware of that and the extension of the prognostic treatment to snow is work in progress. But as the current study focuses on warm rain processes and the effect of Giant CCN (like sea salt, presented in another publication)

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on it, we first limited ourself to rain. Thus, at this stage of the study we cannot make any statements about potential errors for the diagnostic treatment of snow.

p. 14682, l. 5: The maximum overlap assumption for precipitation fraction is consistent with the maximum cloud overlap assumption within the cloud microphysics routine. Thus, rainy and cloudy fractions overlap fully within the cloud microphysics. This is not very reasonable for large vertical distances between the cloud layers. Thus, the current treatment might overestimate the cloud microphysical processes. Radiation calculations assume a maximum random overlap for the cloud fraction but the precipitation fraction is not connected to the radiation (calculations). The inconsistency between cloud cover treatment in the microphysics and the radiation is an important issue that will be addressed in the future. The explanation of the precipitation fraction has been revised and extended.

p. 14682, l. 23: Following the suggestions of referee #1, a two-moment sedimentation velocity is now used for the simulations. That means, separate fall velocities for rain water mass and rain drop number are used. Using the two-moment approach (v_q for q and v_N for N) instead of the one-moment (v_m for q and N) leads to more RWP and slightly more rain. The mass is falling faster than the number which results in smaller drops in the atmosphere (compared to the one-moment approach) which subsequently have lower fall speeds. Thus in both considered case studies, rain water remains longer in the atmosphere resulting in a larger RWP (and lower TWP due to higher accretion rates) and slightly higher precipitation rates.

p. 14686, l. 6: Eq. (11) is directly applied into Eq. (3), already. The asymptotic solution are found because there is no a analytical solution of this integral. Sensitivity studies revealed that the model results do not depend on whether a gradual transition between the two asymptotic solutions is used or not. Hence, the piecewise linear approximation is used for simplicity.

p. 14687, l. 5: A section on that topic is included in the paper. This study showed that

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v_{max} is especially often reached in the lower levels (where the level thicknesses are decreasing). As expected, v_{max} is less often reached for a larger number of sub-time steps.

p. 14687, sect. 2.4: [Pruppacher and Klett(1997)] (section 15.4, p 646) stated that drops larger than $5\,mm$ in diameter get into the spontaneous break-up regime. The model results are insensitive to the chosen break-up size as obtained from sensitivity studies with varying diameters of 2, 5 and $10\,mm$ and to the chosen fraction of $1\,\%$ vs. $0.1\,\%$.

p. 14686, sect. 3.2: Additional information about the SCM set-up are included in the paper.
The SCM is initialized by the surface pressure and the thermodynamic profiles of temperature, specific humidity and horizontal wind. The large-scale advective tendency profiles of temperature and humidity are used to force the SCM for the EPIC case. Furthermore, the sea surface temperature is prescribed. For the ARM case, the SCM is forced with the large-scale humidity tendencies and divergence and temperature are prescribed. In both cases the surface energy balance is calculated within the model, i.e., the surface fluxes are not prescribed. No nudging is applied in these simulations.

p. 14690, l. 7: The differences between observed and simulated precipitation could have several reasons which are given in the paper. Due to some changes in the model setup (which includes the forcing with the advective tendencies of temperature and moisture instead of prescribing the thermodynamical profiles for each time step) the results for the EPIC case look now different to the ones presented in the original paper. Nevertheless, the precipitation is not captured in the first two days of the simulation because the model does not simulate a cloud during that time. Later on, the agreement gets better but still there are events that are either over- or underestimated. The most likely reason might be the advective tendencies as they are given only in the boundary layer and there they are set constant. Similar to the ARM case, the missing hydrometeor advection might also lead to discrepancies with the observed precipitation. The

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analysis of the moisture budget did not reveal any further insights that could help to verify the reasons for the discrepancies. We are not aware of other SCM studies of the EPIC case so that a comparison to other model simulations are not possible.

p. 14691, l.13-21: This part in the paper is revised.
Increasing sub-time step numbers lead to slower sedimentation and thus rain water is kept longer in the atmosphere and is maintained there for the next (model) time step (compared to a diagnostic scheme where all rain water is removed within one time step). Thus, there is generally more rain water in the atmosphere the larger the number of sub-time steps. And more rain water means higher accretion rates. As the accretion process also removes cloud water, less cloud water is available for the autoconversion. Therefore, the autoconversion rates decrease.

p. 14692, l. 2-5: Moisture budget consideration are now also included on page 14690.

p. 14692, sect. 3.3: see above (p. 14686, sect. 3.2)

The technical corrections have been included.

References

[Pruppacher and Klett(1997)] Pruppacher, H. R. and Klett, J. D.: Microphysics of Clouds and Precipitation, Kluwer Academic Publishers, 1997.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 14675, 2007.