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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cloud-Aerosol-Radiation (CAR) ensemble modeling system" *by* X.-Z. Liang and F. Zhang

Anonymous Referee #1

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I am very impressed on how much work the authors have done to put together all those physical schemes and develop the CAR system. Although called Cloud-Aerosol-Radiation system, the CAR is basically still a radiation system, in which the original radiation schemes have been decoupled so that the parameterizations for single-scattering properties of gas, clouds, and aerosols, and the parameterizations for cloud subgrid scale structures, including vertical overlap and horizontal inhomogeneity, etc. are modularized. The original radiation schemes now mainly consist of the solver of the radiation transfer, say, two-stream or four-stream, in the CAR system. The CAR system will be a very useful tool to help identify and reduce model discrepancies in terms of the representations of some physical processes, including cloud, aerosol, and radiation. Extensive experiments have been carried out to evaluate the performance of

the system.

The manuscript is overall well-written and delivers the necessary information concisely. Some revisions are needed to address the following questions before the acceptance of this manuscript:

1. It is well-known and proved again by this study that the model simulations are very sensitive to the numerical representations of the cloud-aerosol-radiation processes in the models. It is also known that the most physically based schemes may not necessarily generate the best model simulation results due to the complicated interactions among the physical processes. The ultimate goal of the model development, however, is to have the most physically based representations for all the physical processes in the atmosphere. I am curious whether it is possible for the authors to provide a benchmark simulation using the most physically based parameterization among the available schemes for each physical process. It is likely that this combination wouldn't necessarily produce the best performance, but it may be able to provide some information or clues on what could possibly be the reasons.

2. One important usage of the CAR system is to find out the optimal combination of the existing radiation transfer schemes with cloud and aerosol parameterizations, which would be technically useful for the climate simulations. It is my understanding that the combination could be very case dependent and therefore I am not convinced if this could be practical. Nevertheless, for the cases used in this study, do the authors find out any combinations that work the best for certain cases? Before we can get the exact solutions for the radiative transfer, it could be statistically meaningful and useful if one can use the CAR system to find out the optimal combinations under certain atmospheric conditions.

3. I believe that another intended application of the CAR system is to couple it to climate models (similar to the development of WRF) and provide the users with the freedom to choose the parameterizations they want to use. However, given so many

possible combinations, I guess it would be very difficult for the users, who normally only know some parts of the model system and treat the other parts as black boxes, to choose among the numerous schemes. Do the authors plan to provide the CAR system as a research tool for experts in the cloud-aerosol-radiation field or for a wider community use? If the purpose is for wider community use (such as WRF), it would be very important to identify a few default options and/or combinations that work the best for certain cases. Or would the authors suggest using ensemble modeling, which could be very time consuming?

4. Page 10194, line 4: What does the "geometry" in the cloud properties mean? Seems to me, the authors were talking about cloud vertical overlap as shown in Table 3.

5. Page 10204, lines 11-13: It is my understanding that McICA does not employ any particular overlap assumption.

6. Page 10205, lines 1-11: 1) The aerosol vertical profiles play very important roles in the determination of the radiation budget and TOA and surface, as well as the heating profiles within the atmosphere. What are the built-in options for the aerosol vertical profiles included in the CAR system? 2) Do any of the experiments include the 1st indirect effect mentioned in this paragraph? 3) Semi-direct effect, by definition, is to describe the aerosol absorption of sunlight which heats the lower troposphere and reduces large-scale cloud cover (Hansen et al. 1997). In the designed experiment (page 10210, lines 23-25), the authors examined the semi-direct effect without changing the cloud cover. In that case, the semi-direct effect can not be investigated. I wish to point out that the semi-direct parameterization (Li et al. 2011) that the authors adopted is on the change of water cloud optical properties due to the internal mixture of black carbon. By commonly used definition, it is more related to 1st indirect effect.

7. Page 10213, line 15: I guess 2125 W m-2 should be 21.25 W m-2.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 10193, 2013.