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Interactive comment on "Application and evaluation of McICA scheme with new radiation code in BCC_AGCM2.0.1" *by* H. Zhang et al.

Anonymous Referee #2

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GENERAL COMMENTS

The authors report tests of a new radiation scheme in the climate model BCC_AGCM2.0.1, and evaluate its impacts in a series of atmosphere-only simulations (prescribed SSTs). The radiation scheme modifications include, in addition to McICA as mentioned in the title (i.e., treatment of subgrid-scale cloud structure), revised treatment of gaseous absorption and cloud optical properties.

The paper is well written and well organized. The single major concern I have regarding this paper is its somewhat limited scientific novelty. The McICA approach has been tested in several GCMs, and the radiave effects of changing subgrid-scale cloud structure are, at least qualitatively, well known before. Moreover, the results presented in the paper suggest that the other radiation scheme modifications actually have a bigger

effect than the introduction of McICA per se. Therefore, I suggest that more weight be put on these other modifications, and less on McICA. See specifically comment 4 below.

I don't object reporting the subgrid-scale cloud effects as such, but this part of the paper should be shortened, and some comparison to previous results be added. See comment 13 below.

SPECIFIC COMMENTS

1. p. 4934, lines 5-7: This sentence cannot be understood without reading the paper. It should be made clear that "consistent subgrid-scale structure" means here assumptions consistent with the original radiation scheme (maximum random, plane-parallel horizontally homogeneous), that the improvement in clear-sky radiative fluxes comes from the revised treatment of gaseous absorption, and that the improved cloud radiative forcing comes, presumably, from changes in cloud optics.

2. p. 4935, lines 17-18: To provide a balanced view, this sentence should be expanded, e.g.: Depending on the properties of the cloud field, the widely used maximum-random overlap assumption can yield even larger radiative flux errors than does PPH (Barker et al., 1999).

3. p. 4941, lines 21-23: What was assumed about greenhouse gases and aerosols?

4. p. 4942: As it seems that the largest effects on radiative fluxes and simulated climate actually do not come from the introduction of McICA, but rather from the new gas absorption scheme and the (ice?) cloud optics, the experimental setup should be extended so that it can also isolate the effect of these factors. The set of model runs (with either interactive or diagnostic radiation calculations) might include (e.g.) the following:

1. old radiation scheme 2. new gaseous absorption only 3. new gaseous absorption + water cloud optics 4. new gaseous absorption + water cloud + ice cloud optics 5.

new gaseous absorption + water cloud + ice cloud optics + McICA (with MRO-PPH) 6. new gaseous absorption + water cloud + ice cloud optics + McICA (with generalized overlap and/or inhomogeneous clouds)

Experiments 1, 5, 6 and six are already included in the paper, so only experiments 2-4 would need new simulations.

5. p. 4943, line 22: The cloud generator of Räisänen et al. (2004), which (if I interpreted it correctly) is used in the study, defines two decorrelation lengths: one for cloud fraction and another for condensate. Were both assumed the same in this study?

6. p. 4944, line 17: Loeb et al. (J. Climate 2009) should be cited here.

7. p. 4947, line 3: For a reminder to the reader, extend this sentence by "...when maximum-random overlap of plane-parallel horizontally homogeneous clouds is assumed".

8. p. 4947: What about SW heating rates? Presumably, the differences were smaller than in the LW, but they should be commented briefly (in text, figures not necessarily needed).

9. p. 4948, lines 1-3: Here, ít should be clear that the changes are not only due to the use of McICA, but more importantly, due to the other changes associated with the new radiation scheme.

10. p. 4948: Consider performing comparison with ECMWF's latest and, presumably, most accurate reanalysis ERA-INTERIM, instead of ERA40.

11. p. 4948, line 17: here, it would be useful to remind the reader of the fact that SSTs are presbribed, which limits substantially the climate response to changes in model parameterizations.

12. p. 4949, lines 3-8: What is said in this paragrapgh is true, but perhaps out of place. Note that the McICA experiments discussed until this point have assumed maximum-

random overlap and horizontally homogeneous clouds, as in the old radiation scheme.

13. Sections 4.2 and 4.3. As pointed out in the general comments, many of the results in these sections are qualitatively obvious and known from previous research. I therefore suggest (i) to shorten the discussion and (ii) add some comparison to previous results. For the latter, one could focus on the effects that assumptions about subgrid-scale cloud structure have on global mean radiative fluxes. Relevant studies include, at least, Barker and Räisänen (QJRMS 2005) and Oreopoulos et al. (ACP 2012), and to some extent, Räisänen et al. (J. Climate 2007), Morcrette et al. (MWR 2007), and Räisänen and Järvinen (QJRMS 2010).

14. p. 4951, line 6: Barker and Räisänen (2005) didn't use CAM3. Instead, they used some data produced in a superparametrization experiment with CCM3 (i.e., a predecessor of CAM3).

15. p. 4951: In comparing with ISCCP data in Figs. 11 and 12, it should be made clear whether or not the model results were processed with the ISCCP simulator. If not, the comparison should only be regarded as qualitative. For example, the overestimated total cloud fraction in the tropics could be a result of some of the model ice clouds being too thin to be detected by satellites.

16. p. 4951, lines 21-23: Please rephrase this. The use of larger L_cf in the tropics and smaller L_cf at midlatidues may well be warranted. However, the "correct" value of L_cf shouldn't be inferred from a comparison of GCM total cloud fraction with satellite data, as GCM layer cloud fractions may contain large biases.

17. p. 4955-57: The conclusions are totally focused on McICA and subgrid-scale cloud structure. What about the (often bigger) effects due to changed gaseous absorption and cloud optics?

18. In Table 2, it is curious that the simulated (SW CRF) / (LW CRF) ratio for both DJF and JJA is substantially more negative than the annual mean value (while there is little

difference in the observations). Check that these values are computed correctly.

19. In Fig. 3 and 4, you could add the average and RMS differences in the panel titles (you could make room for that by eliminating the variable name, which is the same for all panels). This would provide a quantitative measure of the model performance going beyond just the global-mean values.

20. The spatial maps in Figs. 13, 14 and 17 are quite noisy. I would recommend to show instead the zonal mean values, and perhaps for annual mean only. Figure 16 should be removed altogether. It would suffice to say that the precipitation differences are small.

TECHNICAL CORRECTIONS:

1. p. 4934, line 18, and elsewhere: "cloud condensation" should be "cloud condensate".

2. p. 4934, line 21: "prove the reliability". I suggest change this to "demonstrates the feasibility / viability", or something like this.

3. p. 4937, line 3: this should be "preceeding"

4. p. 4937, line 4: "document" better word than "archive"?

5. p. 4938, line 16. First Equation (2) should be Equation (3).

6. p. 4939, line 3: "Morcorette" should be "Morcrette", and "Jarvinen" should be "Järvinen".

7. p. 4946, lines 19-20: Replace the first part of this sentence e.g. with "As all these regions have abundant high-level ice clouds ..."

8. p. 4947, line 7 and elsewhere. I think that "ratio" would be a more appropriate term for (SW CRF) / (LW CRF) than "slope".

9. p. 4947, lines 21-22: "cooling trend", "heating trend". More rigorous wording would

be "increased radiative cooling", "reduced radiative cooling".

10. p. 4947, line 26: replace "final state" with "total difference", or "all-sky heating rate difference".

11. p. 4949, line 16: "middle troposphere" would be a more conventional term.

12. p. 4953, lines 10-13: This sentence is not clear. Rewrite or eliminate it.

13. p. 4953, line 7: this should be "NEW_GO1-NEW_MRO".

14. P. 4953, lines 19-20: more commonly "ocean-atmosphere interaction"

15. p. 4956, line 5: this should be "superiority"

16. P. 4957, lines 7: replace "is usually changeable" with "varies usually"

17. Fig. 2: consider using colours. The curves are close to each other, which makes it harder to distinguish them. The same also applies to Figs. 7, 8, 15 and 16.

18. Fig. 8: I find this figure difficult to read. Consider putting the differences in separate panels.

REFERENCES

Barker, H.W. and P. Räisänen, 2005: Radiative sensitivities for cloud structural properties that are unresolved by conventional GCMs. Quart. J. Roy. Meteor. Soc., 131, 3103-3122.

Loeb, N. G., B. A. Wielicki, D. R. Doelling, G. L. Smith, D. F. Keyes, S. Kato, N. Manalo-Smith, and T. Wong, 2009. Toward optimal closure of the Earth's top-of-atmosphere radiation budget. J. Climate, 22, 748-766.

Morcrette, J.-J., H. W. Barker, J. N. S. Cole, M. J. Iacono, and R. Pincus, 2008: Impact of a new radiation package, McRad, in the ECMWF integrated forecasting system. Mon. Wea. Rev., 136, 4773-4798.

Oreopoulos, L., D. Lee, Y. C. Sud, and M. J. Suarez, 2012: Radiative impacts of cloud heterogeneity and overlap in an atmospheric General Circulation Model. Atmos. Chem. Phys., 12, 9097-9111.

Räisänen, P., S. Järvenoja, H. Järvinen, M. Giorgetta, E. Roeckner, K. Jylhä and K. Ruosteenoja, 2007: Tests of Monte Carlo Independent Column Approximation in the ECHAM5 atmospheric GCM. J. Climate, 20, 4995-5011.

Räisänen, P., and H. Järvinen, 2010: Impact of cloud and radiation scheme modifications on climate simulated by the ECHAM5 atmospheric GCM. Quart. J. Roy. Meteor. Soc., 136, 1733-1752.

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