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Geoscientific Model Development Discussions

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

H. Zhang et al.

jingxw@cma.gov.cn

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1. Reply to GENERAL COMMENTS

comments: This article describes the incorporation of a new radiative transfer scheme, BCCRAD, into the BCC_AGCM2.0.1 climate model. One of the main motivations for the new radiative transfer scheme is to allow a more sophisticated treatment of subgridscale cloud, using the Monte Carlo Independent Column Approximation (MCICA). BCC_AGCM2.0.1 climate simulations showing the impacts of the BCC-RAD scheme and subgrid-scale cloud structure changes are described. The article is generally very well presented and easy to follow. The writing is clear and concise, and the structure is logical. My main concern with this article relates to its scientific significance. McICA has already been incorporated in numerous other GCM radiative transfer schemes,

(e.g. Pincus et al., 2006; Barker et al., 2008; Räisänen and Järvinen, 2010; Hill et al., 2011) and, as far as I can tell, there is little novel in the way it is included in BCC-RAD. Moreover the impacts of changing the subgrid cloud structure in the manner described are obvious to anyone with a reasonable understanding of the topic and are well documented in the existing literature, albeit using different models and methods (e.g. Barker and Räisänen, 2005; Morcrette et al., 2008; Shonk et al., 2012; Oreopoulos et al., 2012). On the other hand, there are a number of other differences between the old radiation scheme and BCC-RAD, which is shown to perform significantly better. Moreover, if I understand the Geoscientific Model Development remit correctly, a more detailed description of these other changes would be more appropriate than the evaluation of the impacts of subgrid cloud structure. Consequently I'd suggest the paper is modified so that less emphasis is placed on McICA and the representation of subgrid cloud structure, and more on the other changes to the radiation scheme. Note that some of the comments below may become redundant if the paper is adapted as suggested.

Reply: The main purpose of this work is to show the improvement of the BCC_AGCM2.0.1 cloud-radiation process by including a various new schemes including BCC_RAD radiation scheme and McICA. It is true that McICA has already been incorporated in numeral other GCM and its physical impact has been explored. However, in most of other GCM simulations, the decorrelation length is set to be a constant of 2 km (global mean value), which does not represent the true cloud overlap behavior in reality. In our previous version, we have studied the different decorrelation length L=1, 2, and 3 Km as global mean values. Actually the decorrelation length is highly dependent on cloud types. Generally the convective cloud should have larger decorrelation length in contrast to other types of cloud. In the revised version, we have added a new experiment to address the cloud type dependent decorrelation length and the related radiative impact. We believe this is physically new results, which will remind the climate model community to pay more attention to apply more realistic decorrelation length in GCM simulations. This also is a topic for atmospheric observations.

Following the suggestion of anonymous referee #1, we have removed the NEW_GO1 and NEW_GO3 experiments and simplified the discussion for McICA. Therefore, more attention has been paid to the other changes to the radiation scheme.

2. Reply to SPECIFIC COMMENTS

1) comments: In the second paragraph on page 4936, the stochastic cloud generator (SCG) is presented as the only method for supplying the subcolumns required by McICA. While it is probably the most commonly used method, it is not the only method; other cloud generators or cloud resolving models may be used to supply the subcolumns (e.g. Räisänen and Barker, 2004; Hill, 2009). Please rephrase this paragraph to reflect this.

Reply: We have rephrased this sentence and referred the work of Räisänen and Barker (2004) and Hill (2009).

2) comments: I think the introduction is missing a discussion of the other studies that have examined the effect of changing assumptions about subgrid cloud structure. (See the previous section for some of the many examples.) This also applies to sections 4.2 and 4.3. How do these results compare to other studies?

Reply: We have mentioned various previous works on subgrid cloud structure in the revised version.

3) comments: Where do the SSTs used in the experiments come from?

Reply: The SST is from the global Hadley Centre Sea Ice and Sea Surface Temperature (HadISST) dataset (Rayner et al. 2003) for years up to 1981 and the Reynolds et al. (2002) for years after 1981. The details are shown in the revised version.

4) comments: Is equation (4) applied to vertically discontiguous clouds, or only vertically contiguous clouds? It is best to be precise about this, as it does make a (small) difference. When 'general overlap' was originally proposed (Hogan and Illingworth, 2000), it was applied to vertically contiguous cloud only, while random overlap was

applied to discontiguous cloud. Mace and Benson-Troth (2002) on the other hand, applied 'general overlap' to both discontiguous and contiguous cloud.

Reply: The "general overlap" algorithm is applied to both continuous and discontinuous clouds as stated in Mace and Benson-Troth (2002). More details are provided in the revised version.

5) comments: As noted in the previous section, I think the improvement due to the new radiation scheme is more interesting than the results concerning the impacts of subgrid cloud structure changes. Would it be possible to run further experiments to show what the individual impacts of the different changes are. E.g. what is the impact of changing just the ice cloud optical properties?

Reply: It is difficult to study the impact of each single element in the new radiation scheme, since the band structure is different from the old one. Thus it is not easy to replace the old ice cloud optical property in the new radiation scheme. There are many new elements in the new radiation scheme. Most of them have been studied in GCM simulations, including the ice cloud optical property. Also we hope to keep part of material for McICA, this is one of the most important issue for improving the climate simulation. As mentioned above, we have added the discussion on change of decorrelation length depending on cloud types in the revised version.

6) comments: It would be useful to add error bars to figure 1 to show uncertainty due to, for example, instrument error (e.g. Stephens et al., 2012), or interannual variability.

Reply: The error bars have been added to indicate the up and low extremes within the simulated decades to show interannual variability for all tests and observations.

7) comments: There are several sentences in the article that give the impression that the main reason for the improvement shown in section 4.1 is due to McICA. (E.g. first couple of sentences on page 4948), which need to be changed.

Reply: We have modified these sentences.

8) comments: I assume the zonal comparisons of surface temperature are over land only?

Reply: The zonal comparisons of surface temperature are over both ocean and land. In the revised version, we have replaced the plots with those for land only.

9) comments: Are the ERA40 temperatures averages over the whole dataset, or averages over the same decade as simulated?

Reply: The ERA40 data was averaged over the whole dataset. It is changed to average over the simulated decade, in the revised version. We have used the more recent and more accurate reanalysis ERA-INTERIM dataset. The change in result is very small.

10) comments: The final paragraph of section 4.1.2 notes that the changes to subgrid cloud structure are only applied to the radiation scheme. However, as I understand this section, each of the experiments uses the same subgrid cloud assumptions. I think this paragraph should be moved to section 4.2.3.

Reply: Changed accordingly.

11) comments: As mentioned in the previous section, I would argue that the impacts of changing cloud overlap and horizontal cloud variability are already well-understood. Consequently, I'd remove the NEW_GO1 and NEW_GO3 experiments and combine sections 4.2 and 4.3.

Reply: We have removed the tests of NEW_GO1 and NEW_GO3 and combine sections 4.2 and 4.3 to shorten the discussion on sub-grid cloud structures. As mentioned above we have added the study for cloud type related decorrelation length.

3. Reply to TECHNICAL CORRECTIONS

1) comments: Page 4935 line 12-14: Consider rewriting the sentence beginning 'However, both'; I found it a bit difficult to read.

Reply: This sentence is revised as: However, both PPH assumption and simplified

overlap treatments bring errors in calculated radiation fluxes and heating rates, affecting the accuracy of climate simulation.

2) comments: Page 4936 line 3: I think 'entanglement' is a more appropriate word than 'twisting' in this context.

Reply: 'Twisting' is used to replace 'entanglement'.

3) comments: Page 4936 line 14-15: I think this sentence should read 'The advantages of McICA are that it facilitates adjustment or alteration of both cloud structure and radiative transfer and thus accelerates future development of GCMs'.

Reply: This sentence is revised accordingly.

4) comments: Page 4937 line 1-3: I think this sentence should be rewritten as 'Second, the impacts of the changes to the cloud overlap assumption and cloud-water inhomogeneity in the radiation scheme on the radiation budget and simulated climate are discussed'

Reply: This sentence is revised accordingly.

5) comments: Page 4938 line 16: I think this should be 'Equation (3)'.

Reply: It should be equitation 3. We have corrected it.

6) comments: Page 4950 line 23: I think this should start 'The 3rd to 6th'.

Reply: Correct, it should be 3rd to 6th. As two tests are removed and a new test is added in the revised version, we correct this accordingly.

7) comments: Page 4952 line 21: This is the first time the SPCZ acronym is used, so it should be explained.

Reply: 'SPCZ' stands for South Pacific Convergence Zone. It is stated in the text.

8) comments: Page 4953 line 7: There's a '-' missing in 'NEWGO1NEWMRO'.

Reply: The missed '-' is added.

9) comments: Page 4956 line 5: Replace 'superior' with 'superiority'.

Reply: 'superior' is replaced with 'superiority'.

10) comments: Page 4956 line 18: I think this should be 'could lead to large biases in climate simulations.

Reply: This sentence is changed accordingly

We appreciate anonymous referee #1 very much for his/her constructive comment.

Interactive comment on Geosci. Model Dev. Discuss., 6, 4933, 2013.