

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 #1

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1 General comments

This article describes the incorporation of a new radiative transfer scheme, BCC-RAD, 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 subgrid-scale 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.

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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.

2 Specific comments

1. 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.
2. I think the introduction is missing a discussion of the other studies that have ex-

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amined 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?

3. Where do the SSTs used in the experiments come from?
4. Is equation (4) applied to vertically discontinuous 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 discontinuous cloud. Mace and Benson-Troth (2002) on the other hand, applied 'general overlap' to both discontinuous and contiguous cloud.
5. 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?
6. 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.
7. 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.
8. I assume the zonal comparisons of surface temperature are over land only?
9. Are the ERA40 temperatures averages over the whole dataset, or averages over the same decade as simulated?

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10. 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.
11. 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.

3 Technical corrections

1. Page 4935 line 12-14: Consider rewriting the sentence beginning 'However, both'; I found it a bit difficult to read.
2. Page 4936 line 3: I think 'entanglement' is a more appropriate word than 'twisting' in this context.
3. 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'.
4. 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'
5. Page 4938 line 16: I think this should be 'Equation (3)'.
6. Page 4950 line 23: I think this should start 'The 3rd to 6th'.

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7. Page 4952 line 21: This is the first time the SPCZ acronym is used, so it should be explained.
8. Page 4953 line 7: There's a '-' missing in 'NEWGO1NEWMRO'.
9. Page 4956 line 5: Replace 'superior' with 'superiority'.
10. Page 4956 line 18: I think this should be 'could lead to large biases in climate simulations'.

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