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Interactive comment on "Evaluation of ice and snow content in the global numerical weather prediction model GME with CloudSat" *by* S. Eikenberg et al.

Anonymous Referee #2

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Evaluation of ice and snow content in the global numerical weather prediction model GME with CloudSat

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Summary:

In this article Eikenberg and coauthors present an evaluation of frozen hydrometeors in the global numerical weather prediction model GME against CloudSat datasets. The analysis uses both the operational CloudSat ice-water-content (IWC) product (in a traditional observation-to-model assessment) and the operation CloudSat reflectivity product (with reflectivity simulated from model output in a model-to-observation as-

sessment). The authors find the new prognostic precipitation scheme (GME 2007) is broadly able to capture the shape of the observed IWC and reflectivity distributions, although there is clearly need for further improvements. Perhaps most strikingly, the model appears to dramatically overestimate the to total amount of ice (i.e., the ice-water-path). The authors demonstrate this overestimate may be do primarily to an underestimated in snow fall speeds.

Assessment:

The article provides a nice evaluation of GME which both highlights the value of the new precipitation scheme and points towards areas where additional improvements are still needed. I recommend publication once the authors address a variety of comments given below. In particular, I was confused by the criteria used to filter both model and observations, which are a very important part of the analysis framework, and need to be better explained.

Major Comments:

1) The CloudSat IWC retrieval frequently fails to converge. In these situation a "fill value" is used. How do these fill values effect your results, especially with regard to Figure 4a ?

2) I'm am confused by several aspects of the matching/filtering. a) In section 4.1 you write "To account for instrument and retrieval algorithm sensitivities, only data which are firstly within the CloudSat CPR sensitivity range and secondly deemed trustworthy are included in the investigations, i.e., -26 dBz < Z < +29 dBz (no reflectivity factors below -26 dBz due to increased influence of noise) and 0.001 g/m-3 < IWC < 1 g m$-$3." By "data" do you mean both observational data and model output ? How are these limits applied with respect to Figure 4 ? Or do these limits only apply to Figures 2 and 3 ? Please clarify.

b) I am confused by the criteria discussed in section 4.3. Please expand further this material. In particular,

** How is criteria (2) applied to the observational data ? You write "Criteria (2) and (3), though diagnosed from model output, are assumed to be true for CloudSat." What does "assumed to be true" mean ? There is no filtering of the observational data ? If so, that would seem to invalidate any comparison. Also, if that is true how can the red-line in Figure 4a be different then the red line in 4d ?

** How is criteria (3) applied to the observational data ? Do you calculated cloud-fraction over some distance or a given latitude range ? It doesn't make any sense to me to remove IWC in the model with a cloud-fraction limit and yet take all observed IWC values (if that is what you did).

** Is criteria (4) only applied when comparing reflectivities ?

It clearly the values you produces in Figure 4b and thereafter are going to be a strong function of these criteria and you need to provide more details and explain why you implemented these specific values much more thoroughly. e.g. Why a cloud-fraction of 50%. Why not 33% or 66% ? It feels like you have somehow "picked" values that give you the result you wanted for Figure 4b .

3) In the introduction you write "Ice clouds have a large impact on the Earth's climate system due to their effects on the global radiation budget." I couldn't agree more. Can you say anything of top-of-atmosphere and surface radiative fluxes from the model ? In particular, when you increase the falls speeds (i.e. material associated with Figure 8) what happens ? Increasing fall speeds improved agreement with CloudSat but does this cause problems or improve the radiative fields ?

Minor comments:

1) In the introduction you write, "The CloudSat Cloud Profiling Radar (CPR) (Stephens et al., 2002) offers the so far unique opportunity to vertically resolve ice clouds from space snow content – in contrast to the numerous passive satellite-based sensors." A

somewhat similar comment is contain in the abstract. This is not strictly true in that there have been several lidar system that provide vertically resolved information on many ice clouds (including those "too thin" for CloudSat) and the PR on TRMM is able to see a lot of ice material – that someone looking up from the ground would likely call a cloud. Rather I would say CloudSat is the first millimeter-wavelength radar in space and provides sufficient sensitivity that it is able to vertically resolve most frozen hydrometeors.

2) In section 4.2 you write "The fuzziness of the Z-IWC relationships resulting from the two approaches becomes clear in Fig. 2." I'm not sure I understand "fuzziness". Do you mean the width of the distribution? Please rephrase.

3) In section 4.2 you write " Note firstly that the mean bin-temperature of the two Z-IWC relationships differs in the region of largest IWC and reflectivity factor values . . . ". I do not follow. Please rephrase and explain why it is an important observation.

4) In section 4.3 you write " . . . only temperatures lower than –10 âŮę C to avoid liquid and mixed phase . . .". Since there is liquid water below -10 C, you probably mean "most" mixed phase ?

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