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# ***Interactive comment on “Diagnosing the average spatio-temporal impact of convective systems – Part 1: A methodology for evaluating climate models” by M. S. Johnston et al.***

## **Anonymous Referee #2**

Received and published: 22 July 2013

### General Comments:

Building upon the work of Zelinka and Hartmann (2009) (ZH09 hereafter), this work demonstrates how satellite observations can be used to evaluate the representation of deep convective (DC) systems, as well as the mean response of the atmosphere to these systems, in general circulation models (GCMs). The method presented here could be used as a standard method of evaluating the effects of deep convection in GCMs.

One major point of clarification is required regarding the main purpose of this

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manuscript. It is stated the objective is to demonstrate that DC events in GCMs can be evaluated using the method presented in ZH09, however, it is explicitly stated that a discussion of the model's performance is left to part II. This is contradictory. A demonstration of the usefulness of this technique requires a full evaluation of the GCM as well as a listing of the limitations the authors encountered. In addition, the manuscript states "a deeper analysis into some of the findings are required". What aspects of the analysis must be examined further and how will a multi-model intercomparison, in Part II, help gain insight into EC-Earth's representation of DC events and aid in the ultimate goal of demonstrating the usefulness of the methodology? It is recommended that the authors provide a complete evaluation of one model, specifically EC-Earth, then expand the comparison to the multi-models to identify robust features. Can the authors elaborate on how one will move from the composites to individual parametrizations of EC-Earth?

Lastly, the manuscript would benefit from several minor edits focusing on clarity. Two key aspects are distinguishing the different instruments used in the work of ZH09 compared to that of this work; as well as concisely presenting all the different satellite observations with their resolutions and sampling times. This could be done with tables, which are a simple way to bring out the novelty of this work.

#### Specific Comments:

Throughout the article, figures are discussed without first introducing the intent of the figure nor the figure number. The latter is not elementary to deduce given the presentation/discussion of figures is not sequential. In that sense, the authors need to guide the reader better.

In addition, the domain size/resolution around DC events changes depending on the analysis made. Does the domain size affect the conclusions?

#### Technical Corrections:

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- Abstract: To avoid confusion, explicitly mention satellite observations are used to evaluate the GCM. This is not evident in the abstract.
- Abstract: Consolidate the last two paragraphs by describing the anomalies of EC-Earth in terms of the observations to avoid repetition. For example, "DC events are found to propagate westwards at  $\sim 4\text{ms}^{-1}$  in satellite observations whereas eastwards at  $\sim \text{ms}^{-1}$  in the EC-Earth model".
- Abstract: Why is the modelled albedo anomaly not mentioned (as it is one of the key variables compared with the observations)?
- Sec.1 Page 13657 Line 9: "... from sensors not considered by ZH09 ..." is too ambiguous. Specify which sensors used. Refer to comment 'Sec.3.3 Page 13664 Line 1' below.
- Sec.2.1 Page 13657/60: Consider including a table which shows the resolution and sampling time(?) of each satellite observation. Both these factors, and their differences, are important to the discussions presented later on.
- Sec.2.1.3 Page 13659 Line 18: "... while parts of the atmosphere ... only probed by CloudSat." may be misinterpreted as only cloudy scenes are probed by CloudSat. Reformulate this part of the sentence.
- Sec.2.1.3 Page 13659 Line 20: The last sentence of this paragraph presents more than one idea and is rather convoluted. Consider breaking it up into two separate sentences.
- Sec.3.1 Page 13662 Line 4: "ZH09 used data from polar orbiting satellites ..." is ambiguous. Which satellites? Be specific. - Sec.3.1 Page 13662 Line 24: Remove reference to Figure 1 because it is not discussed here. The fact that the discussion and interpretation of Figure 1 does not come till much later is confusing to the reader. Removal of this reference would also eliminate the 'jumping' nature in which the figures are presented and discussed.

- Sec.3.2 Page 13663 Line 1: "+/- 15o in latitude"... is this north/south or is this from a given latitude centred on New Guinea?
- Sec.3.3 Page 13664 Line 1: It would be useful if a list of the sensors used by ZH09 compared to those of the author was provided.
- Sec.3.3 Page 13664 Line 4: "Cloud interference" is an odd choice of words, particularly when one is studying deep convection. Consider rephrasing this.
- Sec.4 Page 13665 Line 3&8: How does 'extension back in time' and (backward) 'trajectory' analysis differ?
- Sec.4.1 Page 13665 Line 10: There is no mention of which figure the authors are referring to. A discussion of what the authors intend to show with the figure would be valuable, for example, "The time evolution of the PDF of precipitation shows ...". A discussion regarding the meaning, cause and consequence of having a 'flat' pdf would be helpful. It may help identify understand the processes behind the 4 modes of precipitation and what is missing/misrepresented in the model.
- Sec.4.1 Page 13665 Line 17: Alcalá and Dessler (2002, Fig.6). Consider rephrasing the reference to Fig.6 in their paper as someone may confuse this with Fig.6 of this manuscript.
- Sec.4.1 Page 13665 Line 24: Why are the consequences of the two missing modes not discussed here, but rather in Section4.3.2? Consider restructuring here.
- Sec.4.1 Page 13665 Line 25: "... most important points underscored by Fig.2 ... model and observations". Is Figure 2(Top) being discussed? If so, it should be stated explicitly. The bottom half of Fig.2 is for observations only so this sentence may be misleading for Fig. 2 in general.
- Sec.4.3 Page 13667 Line 11: "In this section, ..." move this sentence up to line 2 or combine it with the first sentence.

- Sec.4.3.1 Page 13667 Line 14: Give Figure number.
- Sec.4.3.1 Page 13667 Line 16: It would be best to move the analysis/references to Figure 4 to the section 4.3.2 where the model is discussed. This avoids 'jumping' topics.
- Sec.4.3.1 Page 13668 Line 19: "It is likely the reason why ..." Why is this only 'likely' given that the definition of DC events is based on maximum rain rate?
- Sec.4.3.2 Page 13669 Line 4: Can the rate of eastward propagation of DC events in the model be calculated? If so it would make for a better comparison to the observations. Also, how does a composite of DC events propagate given that it Eulerian by nature? Is the speed of propagation relevant relative to the speed of waves in the atmosphere?
- Sec.4.3.2 Page 13669 Line 23: Rephrase the sentence as it is rather confusing: "This results in a limitation of the probability that all time bins will occur during daylight hours ..."
- Sec.4.3.2 Page 13670 Line 15: Which Figure? Also, it is not clear that "the model is clearly showing ..."
- Sec.4.4 Page 13670 Line 23: Please reiterate that one changes from a 21x21o domain to 13x21o. It is easy to get confused since the frieze plots are for 12x12o and surface rain rate occasionally use 12x12o domains too.
- Sec.4.4.1 Page 13671 Line 14: Any mention of 'high correlation' should be followed by a value, otherwise it appears as speculation.
- Sec.4.4.2 Page 13662 Line 23: Discuss how cloud fraction and ice water content may be biased below the DC events within the observations because the 2C-ICE will not be able to account for properties below clouds with precipitation size hydrometers.
- Caption Fig 1: Rephrase "... passage times for (a) Aqua and (b) Terra are ..." to

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eliminate need for second sentence.

- Caption Fig 4: The caption can be written more concisely and accurately. For example: "Anomaly freezes from the top: surface rain rate (RR), ... . Anomalies are identified as the 11,000 strongest rain rates in each dataset".

- Caption Fig 5: Figure needs an x-axis label.

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