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Geoscientific Model Development Discussions

Interactive comment on "A simulator for the CLARA-A2 cloud climate data record and its application to assess EC-Earth polar cloudiness" *by* Salomon Eliasson et al.

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Dear referee#2,

Thank you for taking the time to review our paper for your overall supportive comments and useful suggestions about how to improve the article, and in particular, so that it may be more useful as a reference paper for the simulator. Following is a point by point response to each question/suggestion:

General comments

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Discussion paper

Given that this paper will become the main documentation reference for this simulator, we think it would benefit from some discussion and results on the impact of the different methods (mainly #1 vs #3) on other variables listed in Table 1, not only cloud fraction.

We agree that, since this will be the reference paper for the CLARA-A2 simulator, we should not only address the impact on cloud fraction of choosing the method of cloud cover simulation but also how the other cloud variables respond to the new method. We will add figures in a similar vein as the cloud fraction comparisons in figure 5 and fig 6 as well as an accompanying analysis.

The message regarding benefits of method #3 with respect to previous analyses needs to be more specific (e.g. in L385-390). The largest differences between methods occur in the polar regions, with much smaller differences in the rest of the globe. In some places, the paper gives the impression that previous studies where flawed, when in reality many of them did not use data polewards of 60 deg latitude to avoid large uncertainties.

Granted that, in this introductory paragraph in the conclusion section, we do not highlight the regionally variable impact of choosing a POD-approach (method 3) compared to using a static global optical depth threshold -approach (method 1). We will expand this paragraph to share the overall regional impacts, rather than just a global assessment as we do now.
We agree that the wording of this paragraph may also give the impression that there are many incorrect studies out there that have assessed simulated clouds in regions where it is inappropriate. This impression is not intentional, and we will make sure we are not implying this. We want to send the message that our approach can avoid sizable uncertainties.

We will mention that as long as model evaluations are carried out between +/- 60 degrees, and they usually are, the negative impact of using method one is not very large. However, we will also stress that by using a simulator that employs method 3, users need not limit their evaluation to +/- 60, especially not during the polar summer.

Section 4.2. The observational pattern of trends is regionally inhomogeneous, and therefore Figure 9 is not very informative. Does EC-Earth show smaller trends due to compensation of regional patterns? It would be interesting to show the regional patterns from EC-Earth, perhaps replacing Figure 9 by a figure like Figure 8 but for EC-Earth.

In the first version of the paper, we included the regional cloud trend patterns from EC Earth, but the results were tough to interpret. One of the problems is that we only have access to one realization of the model, and therefore no access to the model spread, which would be essential to assess cloud trends correctly here. Another, potentially worse problem is that the AMIP run of EC Earth used in this study, uses prescribed sea surface and ice cover surface conditions, and the sea-ice cover from ERA-Interim is fixed to 100% north of 80N for specific periods.
However, to make the comparisons of trends clearer, we will include the spatial distribution of cloud trends of EC-Earth trends instead of Figure 9. EC-Earth's trends also vary regionally; it is close to observations for some regions and not for others. We will comment on that in the text.

Specific Comments

L36-41. This sentence is hard to read, please rewrite.

We have split this super long sentence into several instead.

L141-142. What's the difference between gridbox size and area?

The Fibonacci grid is points spread approximately evenly over the globe, with the pixels matched to the closest point. The form is not quite round, nor is it a lat/long grid. To avoid confusion, we will remove the word 'size' and call it a "nearly equal-area grid".

L148-150. This statement is slightly optimistic. Only subtropical deserts show PODs below 0.4 like most of the Arctic region. Most of the continental regions show larger PODs than the Arctic, and comparable or larger than the Antarctic region.

We agree that the statement was too broad here. PODs in the polar regions are improving considerably during the polar summer (Day), but they are still not reaching values representative, e.g., most continental land surfaces. However, a strong point for the situation in the Polar summer is that if plotting a somewhat higher COT interval than shown here (e.g., 0.5-0.6), the differences decrease significantly between polar regions and most continental surfaces. This decrease is because of the higher skill in detecting liquid water clouds in the polar summer. The reason why this is not reflected in the current figure is that the very thin clouds in the COT interval 0.20-0.25 mostly consist of thin ice clouds, which are still difficult to detect over ice and snow surfaces in the polar summer.

Caption Table 1. Please can you clarify why the average cloud water phase is not a relevant quantity?

It may not be that the average cloud phase is irrelevant, but we have decided not to include this quantity. We suggest removing this confusing sentence.

- L174. its' → its.
OK

- L187-183. There is no need to give details of the methods here, all that information is given in the subsections below.

OK, we will remove this redundant text

- L200-205. It would be worth to point out that the COSP simulators only do the retrievals in sunlit conditions.

Thanks, we will point this out, and therefore also point out the advantage of this new simulator approach where the CLARA simulator can simulate cloud fraction and cloud top products all times of the year. We point out that the CLARA simulator does not produce COT, water path, or 2D CTP-COT histogram products during night time conditions

- Figure 2. The colour scale is very confusing, I would suggest a monotonic colour scale.

To us, the color scale is OK. However, we will change the top color from light pink to dark brown as a compromise, and hopefully, it will be less confusing

- Section 3.2. The POD maps used in method 3 depend on the distribution of clouds in the real world. These maps won't be optimal for models with cloud distributions that differ substantially from reality. It would be good to add a sentence mentioning this, and a brief discussion about the possibility of developing PODs that are not linked geographic positions.

We have to admit that we probably do not understand this question clearly. The CLARA-A2 simulator is a tool that should be used to facilitate model-to-satellite inter-comparisons and in this particular case, inter-comparisons with the results from the CLARA-A2 climate data record. So we are discussing clouds in the real world and not the cloud situation in a particular future or another scenario. If modeled clouds (channeled through the simulator) deviate from CLARA-A2 observations, it should be an indication of a model problem. This is the main goal for the simulator development. However, the reviewer is possibly asking how to interpret cases where models systematically place clouds incorrectly in space and then being subject to (potentially) other PODs than what they should have been in the CLARA-A2 simulator. The consequences here should not be large except for the extreme cases when a model place clouds over ice- and snow-covered areas in the polar night (with very low PODs) instead of over adjacent ice-free ocean areas (with very high PODs). Knowing about the unique problems over snow- and ice-covered regions (especially for the polar night) it will be hard to cover this situation adequately knowing about the specific cloud detection issues occurring over snow and ice during night conditions for AVHRR observations.
So, yes, under these particular circumstances, this might be a problem, and perhaps other observational datasets (e.g., from active sensors) would be more suitable to use here. However, for more normal situations, we do not believe this to be a big problem. Geographical mismatches between modeled and observed clouds should be possible to detect as long as the POD variability in the area of interest is not extreme.
We will add a brief discussion on this. We will use the example of the difficulties in

detecting clouds in the marginal ice zones and mention that as the ice margin moves in a warming climate, it will impact the POD geographical distributions. We plan on leaving the purely lat/long approach in future releases and base the PODs, preferably on something like climate zones or surface conditions.

- Figure 5 and 6. The labelling of the subplots is unusual. The top subplot should also have a label/letter so that it can be properly referenced.

Yes, the top subplot should be named (a). Also, subplot (d), soon to be (f), should be labeled “EC Earth (#1) - EC Earth (#3)” for clarity. We will change it accordingly.

L352. The trends calculated in this section are not decadal trends. I believe that what you are trying to say is that they are trends over the entire record, expressed in units of %/decade

Well, yes, this is what we are saying. We are using the wrong notation here and will fix it

- L354. Please use the correct units (%/decade). Same for figures 8 and 9. I would even suggest to change the units to 1/decade, as changes in % can lead to confusion in its interpretation (absolute percent change vs relative change).

We also accept to change the unit to 1/decade

- L366. is run → run is
OK