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Interactive comment on "The Cloud_cci simulator for the ESA Cloud_cci climate data record and its application to a global and a regional climate model" *by* Salomon Eliasson et al.

Salomon Eliasson et al.

salomon.eliasson@smhi.se

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Firstly, we would like to thank the reviewers and the editor for their time spent assessing our manuscript, for the kind overall assessment and for providing valuable feedback and insightful questions. Following is a point by point response to the questions and comments posed by the reviewers.

1 Short comment

- In accordance to our Editorial v1.1, please add a version number for the Cloud_cci simulator in the title of your manuscript upon revision. As explained in `https://www.geoscientific-model-development.net/about/manuscript` GMD is encouraging that authors upload the program code of models (including relevant data sets) as a supplement or make the code and data or the exact model version C1

  We have now made the code available on github and added the address and the DIO to the code availability section

2 Reviewer 1

- P7,L10: Here you mention that you are using SCOPS to generate subcolumns. How many sub-columns are you breaking the domain into, for EC- EARTH, for the RCM? This leads me to my next question. Are you using SCOPS for the RCM? As this may not be necessary given the finer horizontal resolution.

  We are using 70 and 22 sub-columns per grid for EC Earth and RACMO respectively according to 100 sub-columns for a 1 degree grid. I have now added this to the text. The resolution of RACMO is still coarse enough that sub-columns are needed. In the text we write: The number of sub-columns per grid depends on the model's horizontal resolution assuming 100 sub-columns for a 1 degree grid. This version of EC Earth requires 70 sub-columns, and RACMO, which is still too coarse to not require the use of sub-columns, needs 22.

- P6,L34: replace "simulator For ERA. . ." with "simulator for ERA. . ." I'm not sure about this the capitol 'F' in For is the 'F' in the abbreviation SIMFERA

- P19,L13: replace "EC earth" with "EC-Earth" done
- P21,L10: Here "v2.0" is used which I assume you refer to "Cloud_cci AVHRR-PM v2.0 CDR"? Is there a reason for distinguishing the version here? Just a tad confusing as versions are not mentioned anywhere else when referencing the Cloud_cci CDR.

  We have now clarified that sentence somewhat to avoid confusion. We mentioned in the beginning of the article that the version used in this study is version 2, but what is not mentioned, and still not, is that there exists a version 3 of this CDR that has more reasonable microphysical retrievals, but is not yet published.

3 Reviewer 2

- However, if the authors can include a section where they would list or describe the known retrieval artifacts in AVHRR retrievals that would have an impact in CDR (apart from removing thin clouds. Its performance in high latitudes, heterogeneous cloud scenes, etc. It can have a reasonable impact on esp. daily composite). Expand the discussion on Page 6, Line 24-31.

  I agree that the further limitations of the CDR should be mentioned here. I made an subsubsection dedicated to these limitations and add this paragraph: However, there are several conditions that impact the performance of cloud detection for Cloud_cci (or any CDR) that are not replicated by simulators. A retrievals' sensitivity to clouds also depends on the underlying surface type and the illumination, temperature and humidity conditions.

  Karlsson & Håkansson (2018) showed that the cloud detection skill over mid-latitude oceans is in general much better than the global average whereas over the Polar regions during winter it is particularly difficult to retrieve clouds. They

  showed that in fact it is difficult to find a suitable optical depth limit for clouds in Polar regions (Fig. 13 in Karlsson & Håkansson, 2018) as other factors rather than cloud thickness may be equally important in determining whether or not a cloud is detected. Here the main problem arises during night time when the snow covered surface can have the same temperature as low clouds, rendering them indistinguishable from the surface at infrared frequencies. Also, broken clouds and fractional clouds, i.e., clouds that are smaller than the measurement footprints are very difficult to retrieve accurately (e.g., Karlsson & Håkansson, 2018). In these situations the measured radiance is a mixture of that from the cloud and the surface.

  For these reasons, in regions where these cloud situations are more common, the retrieval uncertainty is higher than in other places. The user should bare in mind the regionally varying skill of the CDR which is not handled by the simulator in their model evaluations.

- Similarly, describe EC-Earth's common issues.

  We have described some general climate model issues (underestimation of global cloudiness) and EC-Earth issues (overestimate of polar clouds) in section 4.1.

- I am also curious, does the vertical resolution of the global model plays a role in reduced LCF (and the reduced high-clouds you described in Page 16.) during the EOT due to coarser-vertical model resolution assigning low-cloud into mid-clouds? For example: in Figure 4, over Pacific cold tongue, simulated low-level clouds are underestimated but overestimated the mid clouds. Any thoughts on it apart from the discussion you have provided in Page 16, Line 18-23?

  It could possibly be as you point out a miss assignment for the cold tongue region. But it is a small signal in Figure 4 and not seen for DJF (Figure 5). We have preliminary evaluated high (137L) vertical resolution EC-Earth versions and noted that the main low cloud biases remains for the Pacific Ocean. We have clarified in the text in section 4.1 that the underestimate of low clouds we discuss are for certain regions.

- I am also curious, does the vertical resolution of the global model plays a role in reduced LCF (and the reduced high-clouds you described in Page 16.) during the EOT due to coarser-vertical model resolution assigning low-cloud into mid-clouds? For example: in Figure 4, over Pacific cold tongue, simulated low-level clouds are underestimated but overestimated the mid clouds. Any thoughts on it apart from the discussion you have provided in Page 16, Line 18-23? This has been considered, but we deem that the model vertical resolution is high enough that it does not have a big influence on low-middle-high cloud separation. We added something about this on the text

- Cloud_cci and CDR should be introduced in the Introduction section too. done

- Figure 3, left panel, clearly seems to have cloud regime dependent. The lower TCF values in the sampled model seem mainly over low-level stratiform dominant cloud regimes they have an explicit diurnal cycle. Have you checked the corresponding LCFs?

  Interesting point. The unsampled climate model does seem to have particularly higher cloud fractions over these areas and comparing the simulated LCF (which includes temporal sampling) to observations in figures 4 and 5, these are some of the key regions where EC Earth has less clouds than the observations suggest. I added this comment:

  ... Low clouds are also under-predicted in the storm track regions and mid-latitude oceans compared to Cloud_cci in respective winter hemispheres, as was also found in the EC-Earth to ISCCP comparison study (Lacagnina et al., 2014). For the polar regions, low clouds are overestimated compared to Cloud_cci as previously found in Koenigk et al., (2013). However, the size of the deficit seen

here may also be related to the temporal sampling of the model by the simulator. The left columns in Fig.3 indicate that the largest reductions in cloudiness when comparing non-sampled to sampled model TCF are in the subtropical marine Stratocumulus regions. This may indicate that on top of the general deficit in low clouds, a mismatch in the diurnal cycle between the model and observations may also play a role.

- Typo: Figure 11. Maps of 2011-2014? Yes, this is a typo. Will be corrected.

- Also, in Figure 11, τ is in-cloud or all-sky average? Clarify, please. As mentioned in the caption, τ is an all-sky average.

- Again Figure 11, regarding (n, r) and (o, s), have you checked if this is because Cloud_cci retrieval artifacts, underestimating τ and overestimating re retrievals. Have you looked at the results for different seasons? It would be good to discuss the LCF as well as mid-, and high cloud amounts?

  In general, we assume the retrievals to be correct, although artifacts cannot be excluded (see also the response to the first comment). We have looked at the results for different seasons. For two regions (Atlantic and North-West Europe) these are shown in Fig. 10. There are seasonal variations of the cloud properties and their difference between retrieval and simulator, but a full analysis of seasonal variations is beyond the scope of the paper. Similarly, there are many cloud properties that can be plotted. In Fig. 11 we have made a choice to show total cloud fraction and cloud-top pressure. The latter expresses the combined effect of low, middle and high cloud amounts.

- Have you run and check RACMO over other low latitude or stratocumulus domains? It would have been more interesting to see the results over such domain.

  No we have only run RACMO over the European domain, which we think is very interesting as it combines oceanic with continental areas as well as different climate zones. Analysis of other regions is definitely interesting but outside the scope of this paper. Note also that the global EC-Earth results do include the low latitude and stratocumulus domains.