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Interactive comment on "Verification of the regional atmospheric model CCLM v5.0 with conventional data and Lidar measurements in Antarctica" *by* Rolf Zentek and Günther Heinemann

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Comment by referee #2

Response by authors

Changes in manuscript

In this paper the authors present an interesting series of climate simulations for the Weddell Sea region of Antarctica run using the CCLM model version 5. They test

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two different turbulence parameterisations and use observations from manned and automatic weather stations as well as radiosondes and Lidar measurements to assess how well the model downscales Antarctic climate and the potential uses of CCLM in modelling atmosphere sea ice and ocean interactions.

This is an interesting paper presenting solid work evaluating a regional climate model in Antarctica with a range of data sources. It is well written and easy to follow and is in fact a pretty good model of an evaluation paper for other groups who run climate simulations in the polar regions. I have a few comments that i think could help to improve the paper:

1) My main comment is the lack of detail in describing the model set-up. As one example, in section 2.1 (page 3 lines 6-11) the modifications to the turbulence parameterisation is discussed. The improvement in results shown in the figures is significant and it is therefore important, given also that this is a GMD paper, to be clear on exactly what was implemented.

We changed the paragraph:

Before: "In the T15 simulation, the minimal diffusion coefficients for heat and momentum were lowered (from 0.4 to 0.01 m2s−1) to allow for a very stable boundary layer over the Antarctic ice sheet during winter. Further, the parametrization of the impact of the inhomogeneity of the surface on the turbulent kinetic energy (TKE) was modified. These modifications are based on the studies of Cerenzia et al. (2014), Hebbinghaus and Heinemann (2006) and Souverijns et al. (2019)."

Now: "These modifications are based on the studies of Cerenzia et al. (2014), Hebbinghaus and Heinemann (2006) and Souverijns et al. (2019). In the standard version of CCLM, the diffusion coefficients for heat and momentum are restricted to the minimal value of 0.4 m2s−1. In the T15 simulation, these minimal diffusion coefficients were set to 0.01 m2s−1 to allow for a very stable boundary layer (SBL) over the Antarctic ice sheet during winter. Further, the standard setup of CCLM uses a parameterization of the impact of the inhomogeneity of the surface via the energy transfer from subgrid scale eddies on the turbulent kinetic energy (TKE). Since this leads to an overestimation of the TKE in the SBL (Cerenzia et al. 2014), this parameterization was removed in the T15 runs."

2) Similarly when looking at the results compared with the station data it is not really clear what surface scheme is being used here as this may also have an impact on the biases shown.

We added to section 2.1: "Over land, we use the standard land surface model of CCLM (TERRA, see archived documentation under zenodo (Zentek, 2019). The soil model has eight layers (down to 15 m) and allows for an additional snow layer on top of the soil, which varies with precipitation and sublimation. For the land ice regions, soil was replaced by snow using the parameters listed in Table 2."

3) The section on sea ice and SST setup is fairly clear but the authors do not mention if there is snow on sea ice and if/how this is dealt with in the model. Snow on sea ice can have important effects on the energy balance and it would be interesting to hear more abotu this aspect in CCLM.

We revised the section concerning the sea ice also with respect to the comments of referee #1.

Concerning this comment we added in section 2.1: "The snow temperature profile is initialized with the forcing data, then the snow temperatures freely evolve. The surface albedo for inland ice and ice shelves is kept constant and has no seasonal variations. The albedo of sea ice is parameterized as a function of ice thickness and temperature by a modified Køltzow scheme (Køltzow, 2007) as described in Gutjahr et al. (2016a)."

We also added in section 2.1.: "For grid points with a sea ice thickness of 0.1 m the modified Køltzow scheme yields an albedo of 0.07 and we assume no snow cover. For a thickness of 1 m the albedo is 0.84 (for temperatures lower than -2°C) and fixed snow

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layer of 10 cm snow cover (Schröder et al. 2011) is assumed."

4) It would similarly be useful to briefly discuss if/how similar this model version is with others that have been published recently such as by Gossart et al and Souverijns et al.

We added to section 2.1: "Lastly we want to point out some differences between the present model setup and the setup of Souverijns et al. (2019), as they also used the CCLM model for simulations in the Antarctic. Souverijns et al. (2019) use CCLM with the community land model CLM (van Kampenhout et al., 2017), while we use default land surface model of CCLM with the adaptions described above. While we use daily high-resolution (6 km) sea ice data from satellites, they use coarse resolution ERA-Interim data (80 km) for the sea ice. In addition, they use only the standard one-layer sea ice model of CCLM."

5) Is there nudging or relaxation in the domain or is forcing applied only on the boundaries? This has been shown by van Wessem to have a very significant affect on simulated Antarctic climate and details should be included if it is used

We appended another sentence to the last changes concerning the last comment: "They also ran CCLM in climate mode and applied spectral nudging, while we used forecast mode with a restart every day and applied forcing only at the boundaries."

6) Figures 3- 5 showing the bias with respect to the different reanalyses is very interesting, in particular because it seems clear then reanalyses themselves disagree substantially in some locations. This point is not however well expressed within the paper and should be brought to the fore as it makes it challenging to verify against a reanalysis product if the reanalysis itself has some issues.

We tried to take also the first comment from referee #1 into account and made an effort to express more clearly the issues of reanalyses and discuss the comparison in a way that gives it more importance on the one hand (e.g. by moving it to a new separate section of its own), but also raises awareness of the limits of such a comparison on the

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other hand.

We added “a short comparison to another model and reanalyses (section 3), then” to the introduction and renamed (and moved) the section to “Comparison with model and reanalyses”.

In this section we changed “bias” to “difference” added two paragraphs: “Although a verification with measurements is preferable, due to the small number of stations in polar regions this is not possible for the whole model domain. A comparison to other simulations is therefore an addition to the evaluation, although it has its limits. Gossart et al. (2019) found that in some respects different reanalyses (including ERA5 and ERA-Interim) differ greatly for Antarctica and thus comparisons of CCLM with simulations should not be seen as a validation.”

and “The study by Gossart et al. (2019) showed the largest differences in mean temperature between reanalyses over the interior Antarctica during winter (approx. 8 K) and that ERA and ERA-Interim are warmer than the observations. An evaluation of AMPS (Fig. A1 in Bromwich et al., 2005) showed only a small bias (down to -3 K) of AMPS in the interior Antarctica. Verifications using surface and radio sounding data (shown in section 4) confirm that C15 is too warm over the plateau and that this could be attributed to a too strong mixing in the surface boundary layer.”

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