Geoscientific
Model Development
Discussions

Interactive comment on "Towards European-Scale Convection-Resolving Climate Simulations" *by* David Leutwyler et al.

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Received and published: 30 August 2016

Thank you for your detailed review of our manuscript and the very useful feedback. We appreciate the time you have invested in this review.

In the article "Towards European-Scale Convection-Resolving Climate Simulations present an adapted version of the COSMO-CLM model" Leutwyler et al. present a new version of the COSMO-CLM model that allows weather and climate simulations on GPUs. They impressively demonstrate the computational efficiency of this approach and the feasibility of the model to simulate processes from the mesoscale to the synoptic-scale by analyzing a strong, large-scale forced winter storm and weakly forced summertime convective storms. The article is well write well suited for publication in GMD. I have only minor comments that are listed below.

C1

Minor Comments:
L9: I suggest to replace demonstrate with e.g., present.

We changed the term according to your suggestion.

L9: continental-scales

This term consists of an adjective and a noun and does not constitute a compound adjective.

L12:There are several places in the manuscript where commas are missing (here after Furthermore,...". Please revise the document accordingly. Here are the locations where I found missing commas but there might be more. L61, 76, 122, 142, 200, 270, 301, 408, 460

Thanks for checking all those commas. We added an additional comma in L301. However, we prefer not to put commas after conjunctive adverbs, except if they imply contradiction.

L126: You already introduce the acronym COSMO in L109.

Good catch, thanks.

L149: I would suggest to make Figure 2 to Figure 1 since you mention it first in the text.

We switched them according to your suggestion.

L274-384: I suggest to shorten this section. For me, the basic message here is that the 12 km simulation performs very similar to the 2 km simulation in this kind of storm but the 2 km simulation is able to add some small-scale processes/details that are not present in the 12 km run. I think this can be communicated more concisely. As you mention at the end of this section, a real comparison and evaluation of the two models is not feasible and therefore the detailed description of the differences between the two models can be shortened.

Yes, the basic message is that the two models agree on the large and meso-alpha-scale. The important differences between the models for the storm case are pointed out later in the manuscript. As suggested, we substantially shortened this section (see revised manuscript) and removed a figure (former Figure 4).

L307: What do you mean with observational reference here? If you refer to ERA-Interim I would change observational to reanalysis.

The point is that we have tried to find station observations that would allow deriving the core pressure development of Kyrill II. However, we couldn't find enough stations that were located close enough to the storm core.

We have adapted the sentence. It now reads:

"It should be noted that the observational reference from measurement stations and balloon soundings is rather weak, as this was a rapidly developing small-scale cyclone."

L308: Should be ERA-Interim

Changed according to your suggestion.

L330: I cannot see that the band is much narrower in the 2 km model in Fig. 6. Also in the bottom panel I would argue that the 12 and 2 km simulation are remarkably similar and not that the differences are even more pronounced as you state in L303.

In our effort to shorten sections 3 and 4, we moved the first case displayed in Fig. 6 to the supplementary material. This action allowed providing an additional row of panels for the Kyrill II case. In the new panels, the differences in rainband width are more evident. Furthermore we estimated their width (counting gridpoints by hand).

We have added the following sentences in Section 3.1.2:

"In CTRL12, the front is split into successive precipitation bands with maximum precipitation rates up to 20 mm/h. CTRL2 additionally features small-scale embedded convection located in the vicinity and along the front, and a more coherent organiza-

C3

tion. The frontal rainbands (precipitation > 5 mm/h) are typically 30-40 km wide in CTRL12, and substantially narrower in CTRL2 (8-10 km).)"

Furthermore we expanded the discussion on the narrow frontal rainbands just below:

"The distinct narrow cold-frontal rainbands seen in the bottom-right panel of Figure 5 are of distinctly convective origin. They are associated with precipitation rates >20 mm/h, located on the leading edge of the fronts, and aligned with the cold front in an oblique angle. These systems have been extensively discussed in the literature (Houze, 2014), and studied using (airborne) radar (e. g. Jorgensen et al. 2003). We expect differences in location and intensity, due to the ability of CTRL2 to explicitly resolve the underlying dynamical processes"

The differences in physical behavior should now be more evident.

L340-1: In my printout it is very hard to see the difference between 20 mm/h and 50 mm/h. I have similar issues with Fig. 7, 10, and 11. Changing the color map might help to visualize the differences.

The main problem is that the grid spacing of CTRL2 is finer than the resolution of current computer screens (except for the really expensive ones) and standard printers. To increase the visibility of the details and small-scale structures, we have added another row of zoomed panels in Figure 5.

L350: "..., does not exhibit much similarity." I would change this to ", are different."

Changed according to your suggestions. The sentence now reads:

"However, while the geopotential height contours compare rather well, the associated precipitation pattern is different."

L387: I suggest to write "An over-prediction..."

Changed according to your suggestions. The sentence now reads: "An over prediction of summer temperature is a long standing issue for COSMO-CLM and other RCMs, ..."

C4

L389: Please add which version of E-OBS you used.

We have added the version according to your suggestion.

L397: You could add e.g., the pattern correlation coefficient here to quantify what you mean with well captured.

We would like to omit detailed statistical analysis (for now), since the simulated period is still rather short (3 months).

L398: Change observations to observed precipitation

Changed according to your suggestion.

L399: You could add Prein and Gobiet 2016 here who compared E-Obs precipitation with high-resolution observations in large areas of your simulation domain.

We were not aware that this paper got published by now. Added according to the suggestion.

L407: Replace: "is already at its peak around noon" with e.g., "has a precipitation peak at noon". In addition, you state that the convection is still building up in the 2 km model but you do not investigate convection here but only investigate precipitation.

We like the "is already at its peak around noon" formulation and would like to retain it. However, we changed the term "convection" to "precipitation".

L439: ...in the 900 hPa. . .

Thanks. Changed according to your suggestions.

L556: I would suggest to add that you are talking about AMIP style GCMs here.

Based on the suggestion of Reviewer 1, we have changed this sentence to: "What does this mean for global simulations."

L576-7: add – between the number and the km as you did in L581:

Changed according to your suggestions.

All Figures: I would suggest adding panel names to your figures (e.g., a,b,c...). It is sometimes hard to know which panel you are referring to in the text.

We've identified Figures 8 and 9 to be particularly confusing. We have added labels to these panels, according to your suggestion.

Figure 1: Add Southern to UK

We have added "Southern" according to your suggestion.

Figure 2: right column – Would it be possible to have the contour labels more similar to the other maps. There are only very few labels in these maps.

We guess you meant Figure 3 (Figure 2 in the initial manuscript doesn't have columns) in the original manuscript. Yes more labels could be helpful. We added more contour-labels in the revised version of Figure 3, according to your suggestion.

Figure 6: The embedded convection that you are talking about in the text is hard to see in my printouts. A way to visualize this more easily could be to show the vertical velocity (e.g., at 700 hPa) instead of the cloud field. However, I leave it up to you if you want to make this additional effort.

We moved the first case displayed in this panel to the supplementary material and added an additional zoom level for the remaining case. This allowed us to describe the remaining case with more detail. As an example for the convective motions associated with cold-fronts, we introduced reference to narrow cold frontal rain bands.

Figure 9 right panel: Shouldn't this be mm/d?

Yes it should. Changed accordingly.

Figure 10: I guess you mean Figure 12 instead of Figure 7 here? Looking at this snapshots it seems like that the largest differences are found over the Iberian Peninsula

and Eastern Europe. The cloud field in these regions look very different in the 2 km simulation.

We indeed caught the wrong labels. Good catch. Thanks.

Figure 11: These maps are too small. You might want to split them in two figures or move the maps from the right two columns beneath the left columns.

In our effort to shorten sections 3 and 4, we removed the panels displaying relative humidity. We hope that the remaining panels are now large enough.

Best regards, Andreas Prein
Literature: Prein, A. F. and Gobiet, A. (2016), Impacts of uncertainties in European gridded precipitation observations on regional climate analysis. Int. J. Climatol.. doi:10.1002/joc.4706