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Geoscientific Model Development Discussions
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Interactive comment on "Online dynamical downscaling of temperature and precipitation within the iLOVECLIM model (version 1.1)" *by* Aurélien Quiquet et al.

Anonymous Referee #1

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The article describes numerical methods that allow for temperature and precipitation downscaling within the iLOVECLIM model version in an online mode. There is a clear need for an improved spatial representation of these climate variables inside coarse-resolution EMIC models (Ice-sheet modeling is one aspect, but vegetation-climate interactions or forward proxy modeling will clearly benefit from such online downscaling scheme, too). The numerical methods are well-reasoned and certainly make sense within the iLOVECLIM model physical parameterizations. The authors describe their numerical scheme in detail so that it is transparent and can be reproduced or modified by others. The validation or model evaluation is sufficient, but I have a few suggestions to the authors to increase the value of the comparison with the observations (and to the standard model version). The discussion of the results, the improvements (and lack of) of the precipitation and temperature fields fell a little short, in my opinion. Another interesting aspect would be to discuss how the redistribution of precipitation inside the coarse resolution grid cell can affect the river routing runoff and if that affects in any way the ocean circulation. Therefore related to that question is, to what extent could this method be applied to tropical regions and Antarctica? This should at least be discussed since other users of the model may want a globally applicable downscaling scheme. Ideally this discussion should include a few sentences on the cost of adding additional regions to the downscaling process.

Before I will go into the specific comments and remarks I wanted to point out that the phrase 'dynamical downscaling' is very much restricted in use currently and applies to the application of regional climate models nested within a GCM and /or forced with boundary conditions. Therefore, I would argue against using the term in the title.

Introduction:

p. 1, l. 14-15: This could be extended to include many other applications of EMICs in process studies of the Earth System. Please add a few more examples (in connection with LOVECLIM, e.g. the research labs of Dr. Axel Timmermann, Dr. Hans Renssen, Dr. Andre Berger, and last but not least, Dr. Hugues Goosse have done extensive work with LOVECLIM (and your own research team, too). Likewise Dr. Ganopolski's work deserves to be mentioned, too, in connection with glacial cycles modeling. One could go one with the list, of course and include work of other research teams that apply other EMIC model like the climate modeling group (Dr. Andrew Weaver, Dr. Michael Eby) at University Victoria http://climate.uvic.ca/model/). I leave it to the authors to expand this paragraph in the introduction.

p.1 l. 21: "This has important . . ."

p.2. l.1-2: "high resolution is a particularly dire . . . require high spatial gridding" Aside from being a tautology this sentence needs to be revised carefully. (And note: avoid use of ‘dire’ in this context)

p.2 l.5: Your downscaling of temperature and precipitation are first and foremost important for the surface mass balance (SMB) of ice sheets. The grounding-line problem constitutes another ‘grid-resolution’ problem independent of the SMB. Please explain more carefully how the processes you discuss are physically connected and how your downscaling can help to address specific problems.

p.2. l.10 not sure if the journal has specific grammar rules but I would prefer “another” vs “an other” (here and in other sections of the text)

p.2 l.20 Consider to ‘relabel’ your downscaling, instead of using the dynamical downscaling, which is for many a term indicating the explicit use of a regional climate model.

2 Methodology

2.1 The iLOVECLIM model

The description should include some description of the 3-dim ocean model, which set’s iLOVECLIM apart from other EMICs that use a 2-dim oceans, or slab-ocean-type models. Also, in connection with my comments on discussing the effects of precipitation downscaling on river runoff and routing into the ocean, it would be good to give the reader some brief insight how the ocean is represented in iLOVECLIM.

p.4. l.8-11: Has there been made any attempt to validate this correction factor using ERA interim data, for example? Or could one use the reanalysis data to constrain the correction factor f_s?

p.4 l. 13 “[. . .] we derive several surface energy balance terms [. . .]”

p.4 l. 27 (last sentence) and p.6. l.3-4 and eqn. 5:

I had difficulties to follow the calculations of the moisture profile and the use of the relative humidity profile in the dynamic precipitation calculations. Is the relative humidity iteratively calculated starting with a constant profile in relative humidity? Are you then updating it to an actual profile that corresponds to the moisture profile after dynamic precipitation was calculated? On page 4 you say relative humidity is constant below 500hPa. On page 6 you diagnose the relative humidity on the virtual levels.

p. 5 l. 6 : write 'area' instead of 'surface': "Where [. . .] is the area of the sub-grid cell."

p.5. l. 16: "[. . .] this approach as computationally too expensive at this time."

p.5.l.18: "initialized with"

3 Application and validation:

3.1.1 Experimental design

p.7 last paragraph: 100 year simulations seem to be rather short for a coupled model. Can you explain what restart state was chosen, and was it really only a 100-yr integration, or did you have a longer spin-up simulation and only analyzed the last 100 model years?

p.8. l.4-5: Interesting point for the application: So right now you have perhaps downscaled less than 40% of the globe, and you have shown that it is most effective in proximity and over land with orographic features. Would it be possible to add more regions (e.g. Antarctica) in parallel and effectively keep the computational costs at similar loads?

p.9. l.17 and l.23: Reading the text up to line 17-18 one wonders what is the reason? Lines 23-24 seem to address the same issue. Consider rewriting this section and discuss the potential reasons.

p.9. l.25: "[. . .] precipitation decrease. Although the Northern [. . .]"

p.9. l.28-29: Please add an explanation. Is it because of your mass-conservation scheme or can in principle the coarse grid cells end up with significantly higher or lower precipitation after the downscaling? (Or did I overlook the text section where you discuss the how numerical downscaling scheme imposes certain constraints on the

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area-averaged rainfall).

p.10 line 13 "[. . .] performance on one specific metric but not the others": "others" or the "other one" In the Taylor diagram there are only two metrics combined.

p.10 l.16 "[. . .] range tested [not shown]. The real benefit of [. . .]"

p.10 l. 20-25: This deserves more discussion. How is the long-term simulation affected by the introduced downscaling scheme? In this regards I can think of the ocean-atmosphere interaction, in particular the river routing and runoff into the ocean. Some studies have shown that numerical models can be quite sensitive to a re-routing of freshwater into the ocean. Other implications worth to discuss: how does it affect vegetation cover in the VECODE, and could it potentially lead to feedbacks. Finally, since you started the introduction with references to ice-sheet modeling, it would actually be good to show some example perhaps from Greenland ice sheet model? There you have a significant improvement in the precipitation profile and an effect on the SMB should have an impact on the representation of Greenland's ice sheet.

Also notice that, in the summary on the same page you say "The scheme is conservative and, as such, is suitable for long-term integrations." (l. 31). So, in between these two statements (l.20-25 and l.31) there should be an extended discussion that leads to your concluding statement on l.31.

Figures:

Fig. 2, 5 I would have preferred if the figures showed the following difference maps:

X: stands for the climate variable

M: for model (M_CTLR, M_DOWN)

O: for observational data (reanalysis)

LR, HR: for low and high resolution respectively

Then arrange the figure in the follow 3x2 grid:

left column HR, right column LR

top row: observations O

middle row: M_DOWN

bottom row: M_CTRL

In addition then the corresponding difference maps in a 2x2 grid

left column HR, right column LR

top row: difference M_DOWN - O

bottom row: difference M_CTRL - O

Further suggestions:

Could you mention if/how the large-scale modes of variability in the Northern Hemisphere or the interannual variability are affected by the downscaling? There was only briefly mentioned that the effect on the circulation was small.

Is it worth to report on land model components, such as snow cover, vegetation cover or are there no significant changes?

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