gmd-2020-435 - Report - Revision June 2021

Non-Hydrostatic RegCM4 (RegCM4-NH): Model description and case studies over multiple domains

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Referee #1 (Citation: https://doi.org/10.5194/gmd-2020-435-RC1**)**

This paper introduces the development of RegCM4-NH, and shows three simulation cases. It is an important paper introducing a new member to the convection-permitting simulations. The manuscript is well organized and easy to follow. Before the paper can be accepted, more details should be further clarified.

Response: Thanks to the Reviewer for the time she/he dedicated to review our manuscript. Below our responses to the comments.

Major comments:

1. Authors state that the stability is a quite important factor to be considered when the RegCM4 is switched to NH core. Ten major modifications are implemented comparing to the original MM5 code. The explanations on why each modification is added should be provided. For example, the proper choice on the schemes of 0nd diffusion and their combination is quite important for the computational stability. The dynamical core used here relies on explicit numerical diffusion to be numerically stable. How the advection term chosen here considering both the stability and accuracy should be introduced more clearly, and the proper references are needed here.

Response: We accepted this suggestion and we have added references to the base finite differences technique used, along with a description of the adopted discretization for the advection equation. Herein, we provide to the reviewer a plot showing the result in a 1D case for a discontinuous signal advected along the equator with a perturbed velocity on a staggered $$X,U$$ grid for both the original MM5 discretization and the RegCM local Courant number weighted discretization. After 48 hours of integration, the resulting advected signal shows a halving of the computational mode noise generated by the CTCS scheme, even when applying to both numerical schemes the same Robert-Asselin filtering. Because the implemented interpolation cannot be considered a novel numerical scheme but a slight modification to well-consolidated methods, the authors do not deem necessary for this paper an in depth analysis of the scheme stability or accuracy, which are nevertheless second-order accurate in the model discretization parameters. The change of the Laplacian stencil in the explicit diffusion to reduce the computational cost of communications is now described in the manuscript. The other changes listed in the manuscript allow the user explicit namelist control over model parameters that in the MM5 are reported as configurable in the code. The top radiative boundary condition filter coefficients are computed every 24 hours integration time to adapt it to the model internal solution for a climate simulation period longer than the weeklong ones typical of the MM5 NWP code.

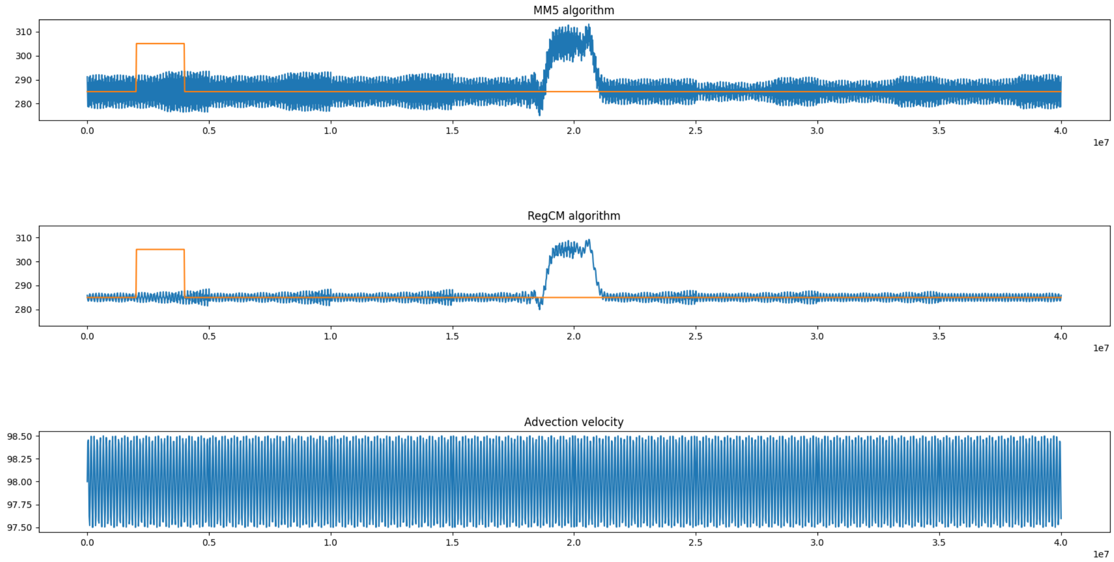

Figure R1. 1D case for a discontinuous signal advected along the equator with a perturbed velocity on a staggered $$X,U$$ grid for both the original MM5 discretization (top panel) and the RegCM local Courant number weighted discretization (middle panel).

2. Different observation datasets are chosen for three cases. But in fact, both the CHIRPS and CMORPH can cover all three cases, and the NCEP data can cover two US cases. It is necessary to use the same observation references to evaluate the simulations. Suggest to show all the observation data considering the uncertainties. Or necessary explanations on such choice are needed.

Response: Following the Reviewer remark we now use several and common observational dataset available for each area as suggested also by Prein and Gobiet (2017) findings . Figure 4 has been splitted in three different figures (figures 5, 7 ,11) and we describe each event separately. We also have added information about the observed dataset in the manuscript and summary table (Table 3). The discussion about each case study has been revised accordingly (changes are tracked in the manuscript).

3. In the case LKV, the proper simulation on the contrast between land temperature and lake temperature is important on reproducing the local circulations. So figures on surface temperature from both 3-km and 12-km simulations are necessary to check whether the underestimation on rainfall from 12-km simulation is induced by the biases in surface temperature. And similar figures based on 12-km simulation should be added in the Figure 7.

Response: Following the Reviewer remark we prepared a Longitude-time (hourly) Hovmöller diagram (Figure 10) of LKV domain surface temperature in order to evaluate the difference in terms of temperature gradient between the two simulations (tracked in *Lake Victoria* section***)***

Other comments:

1. The domains of 12-km simulations can be shown.

Response: done

2. The namelist files used for three cases should be included in the model codes, then the RegCM-NH can be easily used by the RegCM modeling community. And the choices on schemes of other physical processes should be introduced in the manuscript, such as the PBL.

Response: Namelist files are now available in **https://zenodo.org/record/5106399** and referenced in the manuscript.

3. L50: REGCM should be RegCM
4. L52: rcp should be RCP
5. Table 1: The year is missing in case 2
6. L319: Era should be ERA
7. It is hard to get the values from Figure 4 under the current color set.

Response: Unless differently indicated, the list above (3-7) has been fully considered and errors/typos/modifications have been implemented or revised in the manuscript.