Review of https://doi.org/10.5194/gmd-2020-196

Exploring the Parameters Space of the Regional Climate Model COSMO-CLM 5.0 for the CORDEX Central Asia Domain

by Emmanuele Russo et al.

General comments

After Russo et al. (2019) this is the second study with the overall goal to find a suitable setup for climate simulations, using the Regional Climate Model (RCM) COSMO-CLM (CCLM), for the CORDEX Central Asia Domain.

The present study creates and analyses a Perturbed Physics Ensemble to investigate the parameter space of CCLM for the Central Asia Domain in order to characterize the model parameter uncertainty and to determine the most sensitive parameters for the region, on which, and this seems to be the topic of a future study, the objective calibration method of Bellprat et al. (2012) will be apply.

Altogether, 26 parameters have been considered.

The study focuses on those model parameters that are essential for parameterized physical process, namely turbulence, land surface processes, convection, microphysics, radiation and process in the soil.

The study is carried out for the entire model domain but also for eleven sub-regions characterized by different climate conditions.

The model results are compared with observations for 2m temperature (T2M), precipitation (PRE), and total cloud cover (CLCT). The observational data are from three different sources for each variable. This allows taking into account the uncertainty of observations.

The analyses of parameter uncertainties have been conducted by a Performance Index (PI) metric. PI represents a normalized multivariate root-mean-square error (RMSE), weighted over different sources of uncertainties (the monthly standard deviation of the internal variability of the regional model, the monthly standard deviation of the interannual variations of observations, and the monthly standard deviation of the observational error derived from different reference datasets) and averaged over the model variables, the considered regions and the months of a selected year. Model sensitivity to the variations of parameter values is quantified by a positive definite Performance Score (PS), which can be calculated from PI. Improvements of worsening of the performance of the different experiments compared to a reference simulation is determined by a Skill Score (SS)

The results show that the variations of only a sub-set of the considered parameters are accompanied by relevant changes in model performances. But when considering

the different sub-regions these changes are not consistent; the model may show an opposite behaviour among different regions. A result, which could be expected considering the large size of the entire model domain and the different climate conditions prevailing in the sub-regions.

From this point of view the results of the transfer of the model setup to EURO-CORDEX region are also not surprising. They show that the sensitivity of the model to parameters perturbation for Central Asia is different than the one observed for Europe.

The present study is an important contribution demonstrating that an RCM has to be re-tuned, and its parameter uncertainty properly investigated, when setting up model experiments to different domains of study. As the authors emphasize, this is of importance in order to strengthen confidence in climate projections.

From this point of view, the study is scientifically significant.

I recommend the publication of the study after some revisions (see specific comments below)

Specific Comments:

Page 4 line 9: Panitz et al. (2014) describes an evaluation simulation forced by ERA-Interim, not a future projection study; cite Dosio et al. (2015) and/or Dosio and Panitz (2016) instead.

Dosio et al. (2015): Dynamical downscaling of CMIP5 global circulation models over CORDEX-Africa with COSMO-CLM: evaluation over the present climate and analysis of the added value. Clim Dyn 44, 2637–2661 (2015). https://doi.org/10.1007/s00382-014-2262-x

Dosio, A. and H.-J. Panitz (2016): Climate change projections for CORDEX-Africa with COSMO-CLM regional climate model and differences with the driving global climate models. Clim Dyn 46, 1599–1625 (2016). https://doi.org/10.1007/s00382-015-2664-4

Page 5, line 21: Zhang et al (2004) cited, but reference is missing

Pages 5 and 6, section 2.3: which spatial resolution did you use for the comparisons between model data and observations? I assume 0.5°. Please, mention it and say why you chose the specific spatial resolution and how you did the remapping.

Page 8, line 9: any idea why PS is lower for PRE than for T2M and CLCT? Just indicating this fact is not very satisfying.

Page 8, line 10: must be Tab. 2, not Tab. 3

Page 8, section 3.1: altogether, 9 parameters have been selected, which are recommended to conduct the objective calibration procedure following Bellprat et al

(2012). These 9 parameters are the 7 most sensitive parameters that show largest variation in PS, and in addition, two further, namely uc1 and soilhyd, which have been selected from the interpretation of PS dependency on each variable. Why not also rat_lam and tur_len being characterized, like uc1 and soilhyd, as “parameters with particularly small variations in PS calculated for single variables …” (see Page 8, line 5). To my opinion, especially the tur_len values ≥ 500 m are too high, and the smaller value shows slight improvements for CLCT and PRE. Baldauf et al. (2011) also demonstrated the sensitivity of results of NWP to the values of tur_len with improvements using smaller values, even smaller than the lower limit of 100 m used here.

I recommend considering at least also tur_len in a subsequent objective calibration study.

Page 9, line 13: must be “**c_lnd**”, not “c_land”; delete the “a”

Page 9, line 15: for example here the authors assign the model bias, here with respect to T2M, to “structural problems in the model formulation”. But what’s about the quality/reliability of observations in such sub-regions like those representing Siberia? I would expect at least a short paragraph in the manuscript discussing this aspect. I cite:

“As models are frequently tuned on the basis of observational data, misguided model development can easily result from not taking into account observational uncertainties. For example, tuning models to observations in regions where the mean model bias strongly depends on the selected observational data set (e.g. in Norway) can deteriorate the model performance.” These are the first two sentences of the Conclusions from a publication of Prein and Gobiet (2017) that perfectly describes the impacts of uncertainties in observations on regional climate analysis.

Page 11, section 3.4: I assume that the PS analysis has been performed for T2M, PRE, and CLCT together. This is not mentioned in the text.

Page 11, line 8: please explain why you only used the parameters e_surf, rlam_heat, rat_sea, and entr_sc for the transferability study. I would have expected that you would have considered also **qi0**, **uc1, fac_rootdp2.** With e_surf and qi0 you then would have considered the two parameters that you identified as those with “the largest effect on model performance”, as you state in your Conclusions. Furthermore, rlam_heat, rat_sea, entr_sc, qi0, uc1, and fac_rootdp2 are those parameters that had been considered by Bellprat et al (2012) in their objective calibration study. This would, perhaps, give the opportunity for some comparative discussions on the results achieved for corresponding parameters.

Comments Figures:

Figure 3: please, indicate in the caption that the red marker represent the PS values for the default values of the tested parameters (see also Table 2)

Figures 5, 6, and 7: it would be of advantage for the reader to group the experiments carried out in this study according to the physical processes the respective parameters are assigned to (as you did in in Table 2). It would be much easier for the reader to follow the discussions in the text also in the figures Example: on page 8, line 32, the authors describe, for T2M, changes in model performance over the Tibetian Plateau due to value variations of the surface parameters e_surf and pat_len. In Fig. 5 the reader finds the results for pat_len in the upper part, those for e_surf nearly at the end. This makes it hard to "synchronize" a discussion/interpretation in the text with the corresponding visualization in the figure.

Comments Tables:

Table 2: column "Description" for rlam_heat: missing "n" in the word "boundary"

Additional Recommendation: Russo et al (2019) investigated the sensitivity of CCLM results to different physical parameterizations. The simulations had been carried out also for the Central Asia Domain. The model version used (COSMO-CLM 5.0_clm9) offers the possibility to choose also different parameterization for bare soil evaporation. But this process had not been considered in Russo et al. (2019). But I could imagine that the process of bare soil evaporation could be important especially for a domain like Central Asia. Here I would like to refer to a study by Schulz and Vogel (2020) that demonstrated the positive impact of the resistance formulation of bare soil evaporation, which can also be chosen in COSMO-CLM 5.0_clm9. Therefore, I recommend that the authors repeat the simulation described in Russo et al (2019) with different parameterizations of bare soil evaporation, at least that one using the resistance formulation, analyse the results, and change their reference setup accordingly, if they find a positive impact, before they start with the actual objective calibration of model parameters.

Literature:

Baldauf et al. (2011): Operational Convective-Scale Numerical Weather Prediction with the COSMO Model: Description and Sensitivities. Monthly Weather Review, 139, 3387-3905, DOI: 10.1175/MWR-D-10-05013.1

Bellprat et al. (2012): Objective calibration of regional climate models. JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 117, D23115, doi:10.1029/2012JD018262, 2012

Dosio et al. (2015): Dynamical downscaling of CMIP5 global circulation models over CORDEX-Africa with COSMO-CLM: evaluation over the present climate and analysis of the added value. Clim Dyn 44, 2637–2661 (2015). https://doi.org/10.1007/s00382-014-2262-x

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Prein, A. and A. Gobiet (2017): Impacts of uncertainties in European gridded precipitation observations on regional climate analysis. Int. J. Climatol.37: 305–327 (2017), DOI: 10.1002/joc.4706.

Russo et al. (2019: Sensitivity studies with the Regional Climate Model COSMO-CLM 5.0 over the CORDEX Central Asia Domain. Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-22.

Schulz, J.-P.and g. Vogel (2020): Improving the Processes in the Land Surface Scheme TERRA: Bare Soil Evaporation and Skin Temperature. Atmosphere 2020, 11, 513; doi:10.3390/atmos11050513