Review of "nhess-2018-288"

Title: Impact analysis of dynamical downscaling on the treatment of convection in a regional NWP model – COSMO: a case study during the passage of a very severe cyclonic storm "OCKHI"

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The study evaluates the representation of a cyclone over the Arabian Sea in COSMO model simulations at different horizontal resolutions and different treatments of convection. More specifically, the authors performed simulations at a grid spacing of (i) 0.0625° with a parameterized convection, (ii) 0.025° also with a convection scheme, and (iii) 0.025° with explicit convection. Precipitation and CAPE fields from COSMO are then compared to ERA-Interim reanalysis data in an attempt to evaluate which model configuration better represents the convection and precipitation during the passage of the cyclone over the Arabian Sea along the Indian Peninsula.

Overall, I found the study potentially relevant and the manuscript carefully written. However, there are several major flaws in the model setup of the experiments, the meteorological evaluation, and the choice of the data set that serves for the model evaluation. Therefore, a substantial part of the analysis is invalid and the conclusions remain unsubstantiated. In my view, the required corrections go beyond major revisions. However, the study has much potential when these major comments are accommodated. Tropical cyclones cause frequently severe socioeconomic impacts, and their simulation and predictability are of high interest to the scientific community and operational weather forecasting. Also, the model experiments with different representations of convection are relevant and deserve attention. Therefore, I would like to encourage the authors to implement these changes and to resubmit the manuscript.

Major comments

1. Dynamical downscaling

At several occasions, including the title, the abstract and the conclusions, the manuscript claims to assess the impact of dynamical downscaling on the representation of convection in the numerical weather prediction model COSMO. Dynamical downscaling refers to the use of a limited area model or regional climate model to provide more detailed information on weather or climate that cannot be provided by a global weather or climate model that typically has a relatively coarse model resolution. When claiming that the impact of dynamical downscaling is assessed, the study would need to show a comparison between the global data (from ICON) and the limited area model (COSMO), for example, for the simulation of precipitation and CAPE. The present manuscript does not show any data from the global model. In order to evaluate impacts of dynamical downscaling, as the manuscript claims to address, the authors would need to include a comparison between the ICON and COSMO data, and then to use observation-based data to show that the dynamical downscaling indeed leads to an improvement.

At other places in the manuscript, for example in Section 4, the text seems to imply that the use of different horizontal grid spacing aids the evaluation of the impacts of dynamical downscaling. This is incorrect as it can only help to investigate the sensitivity of convection to the model resolution. In other words, the use of different horizontal model resolutions is not the same as dynamics downscaling.

2 Observations for model validation and comparison

The study uses the ERA-Interim data set from the ECMWF as a means to validate the COSMO model simulations. This approach is problematic since the ERA-Interim reanalysis is produced at a resolution of about 0.7ºx0.7º, much coarser than the COSMO model simulations which use a horizontal grid space of about 3-7 km. Later, in the analysis it becomes indeed clear that the data is much coarser (e.g., page 8, lines 26-27) and that the center of the cyclone is more off in the ERA-Interim data than in the COSMO simulations. As a consequence, the comparison between the COSMO simulation experiments and ERA-Interim as shown in Figures 5 and 7 is not relevant. Therefore, the conclusions based on this comparison, as for example phrased in the last sentence of the abstract, are not supported by a valid analysis.

I highly recommend to use precipitation observations based on satellite estimates, for example TRMM (Huffmann et al., 2007) or any other satellite product, whereas CAPE fields from the operational IFS analysis from ECMWF may provide higher resolution data than the ERA-Interim reanalysis.

3. Model domain

The used model domain is very small with only 10 degrees / 1000 km in zonal and meridional direction. In fact, the cyclone is located near the boundary of the domain at the initial time of the simulations with a +48 and + 36 hour lead time, as shown in Figure 2. This model configuration is problematic for obtaining proper results. I recommend using a model domain that is sufficiently covers the tropical cyclone throughout the simulation. As also written in section 5.1.2 (page 11 and lines 30-32), it is understood that computational resources can be a limitation; however, this cannot justify a model simulation that does not support a valid study.

4 Simulation experiments

The study uses three different simulation experiments; (1) with a grid spacing of 0.0625º (~7 km) and convection parameterized, (2) with a grid spacing of 0.025º (~3 km) and convection parameterized, and (3) with a grid spacing of 0.025º (~3 km) and without convection scheme. Following previous studies, convection schemes can potentially be switched of at the order of a 7 km grid spacing, whereas convection may largely be resolved when using a grid spacing of 3 km (e.g., Marsham et al., 2013). This is also explicitly stated in the manuscript on page 7, lines 17-18. The results show that experiment (2) does not add much to experiment (1), whereas the convection-permitting simulation of experiment (3) shows a lot of details as compared to experiment (2). Therefore, I would recommend to replace experiment (2) by a simulation with a grid space of 0.0625º (~7 km) and without the use of a convection scheme.

5. Meteorological analysis.

The analysis in the manuscript is limited to CAPE and precipitation. In order to learn more about the representation of the tropical cyclone in the different model simulations, it may be helpful to extend the analysis with other meteorological variables, for example, sea level pressure and equivalent potential temperature. In particular, SLP can reveal information about the track of the cyclone, which can be compared to the observations and thus be a measure for the accuracy of the different model simulations.

In addition, the area averaged amounts of precipitation and CAPE, as shown in Figures 5 and 7, may not be appropriate for a comparison of the model simulations to observational data. The area averaging leads to a loss of detailed information and can be misleading as a comparison.

Minor comments

At several places (e.g., lines 2, 5 and 8 on page 3), the text speaks about a cyclone. Is there a specific reason why not to speak about a tropical cyclone? The term “cyclone” is a very general term that also covers extratropical cyclones that are found in the extratropics.

Page 1, lines 19-20. Instead of speaking about “the smallest and most compact weather processes”, please, speak in terms of spatial and time scales.

Please, omit lines 17-18 on page 2; “With the availability … becoming finer.”. The use of higher model resolutions is primarily limited by computational resources, not by the availability of observations.

At several places in the manuscript (e.g., page 3, lines 10-11, page 8, line 9, and page 12, lines 3-4) the text speaks about simulation experiments with different initial conditions. This can be understood by readers as use of slightly perturbed initial conditions at the same date, as for example used for ensemble simulations. Instead, the difference between the simulations are different forecast lead times with respect to the episode of interest. Please, rephrase the text where needed.

Section 2. Please, specify which COSMO version is used.

Page 4, lines 12-13 The phrase “Since the convective processes … … much smaller than those resolved by mesoscale and regional NWP models” is not entirely correct. In case of high-resolution simulations, for example, with a horizontal grid spacing of 3 km, convective processes may be largely resolved by the model.

Page 5, lines 8 “to the standard version of the model”; what is the standard version of the model in their study? Please, clarify in the text.

Section 3.1 Please, state in the text how many model levels are used for the model simulations.

Page 5, line 28 speaks about the use of ICON global model data for a period of 9 days. This is not consistent with the ICON model data that are used for four different time instances on 2 days as mentioned later in the text (Page 6, line 10). Please, correct.

Page 6, lines 13-18. Please, omit the technical description "COSMO model … … fine-grid resolution."

Page 7, lines 10-12. Why don't you show the precipitation from ICON? See also major comment number 1.

Page 7, line 26. In what way was the tropical cyclone rare? In its intensity, duration and / or socioeconomic impacts? Please, be specific.

Page 8, lines 12-13. Please, state the source of these precipitation observations.

I recommend to restructure sections 5.1.1 as 5.2 and 5.1.2 as 5.3.

Page 9, line 4. It is not only the state of the lower troposphere that defines CAPE. Please, replace "lower atmosphere" by "the thermodynamic conditions".

Page 9, lines 6-7. Please, clarify which forecast step is used from ERA-Interim.

Page 9, lines 13-14 "The ECMWF fields were almost off by more than 100 kms from ..."and page 10, lines 12-13 "… the CAPE magnitudes obtained from ECWMF fields were always overestimated … " and page 10, lines 24-29 "In this regard … … a smaller mesoscale region only". This shows that the ERA-Interim data is not suitable for validation of the model simulations, see also major comment number 2.

Page 10, line 32. Are these precipitation amounts per day?

Page 11, lines 2-3. I cannot follow the sentence "Even if … accumulated rainfall". Please, rephrase.

The conclusions at page 11, lines 19-20 "However, switching off … … rainfall over the Arabian Sea." and at page 12, lines 12-13 "Fine representation … … accumulated rainfall magnitudes." are invalid due to the comparison of COSMO simulations to ERA-Interim data. Satellite-based estimates may provide a base for a more realistic and useful comparison, see also major comment number 2. Moreover, Figure 6 shows that the DNC simulation has intense rainfall, although area-averaged amounts as in Figure 7 may be lower as compared to ERA-Interim.

Page 12, lines 30-31. The sentence "There is a visible increase … … over the tropical oceans" needs to be supported by references or otherwise be removed.

Writing comments

Page 1, line 5. Please, consider to replace "inter-linking of" by "interplay between".

Page 1, line 15. Please, replace "an NWP" by "a NWP" and write out NWP. Abbreviations used in the abstract need again to be defined within the text of the manuscript upon first use.

Page 1, line 20 – Page 2, line 1. Please, replace "surface to the troposphere" by "surface to the upper troposphere"

Page 2, line 3. Please, replace "Convection process" by "Convective processes" or "Convection".

Page 2, lines 9-10. Please, rephrase the sentence "However, the process of convection … interaction with radiation", for example, as "Moreover, convection involves complex interactions with cloud formation which influence the atmospheric circulation through radiative effects." or in a similar direction.

Page 2, line 12. Please, replace "inter-linked" by "complex".

Page 2, line 13. Please, replace "Further" by "Furthermore, ".

Page 2, line 16. Please, replace “is apparently inter-linked with” by “constrained by” or in a similar direction.

Page 2, line 19. Please, replace “As on today” by “At present” or “Currently”.

Page 2, line 26. Please, remove “physical and”.

Page 3, lines 16-17. Please, correct the sentence by writing “COSMO (formerly known as … …in Switzerland) is a non-hydrostatic … … model that was initially ...”.

Page 4, line 9. Please, replace “the conserved framework” by “the conservation of” and in line 10, replace “Different schemes” by “Schemes”.

Page 4, line 14. Please, replace “resolved” by “estimated” or “represented”.

Page 4, line 18. Please, replace “cumulus” by “convective”.

Page 4, line 21. Please, replace “the Convectively” by “Convective”.

Page 4, line 25. Please, replace “COSMO model” by “The COSMO model”.

Page 4, line 30. Please, replace “lies” by “lie”.

Page 5, line 12. Please, remove the comma after “that”.

Page 5, line 11. Please, replace “can provide improved” by “can improve”.

Page 5, line 31. Please, replace “form” by “from”.

Page 6, line 11. Please, remove “and meteorological”.

Page 6, line 27 as well as on page 7, line 8. Please, replace “under the framework of” by “using the” or “with the”.

Page 7, line 1, 10, and elsewhere in the manuscripts. Always, use a comma, before “respectively”.

Page 7, lines 2-3. Please, remove “to the COSMO model” and write “of the actual episode”.

Page 7, lines 6. Please, remove “to the COSMO model”.

Page 7, lines 15-17. Please, rewrite this long sentence. Stating that you switched off the convection scheme or use a convection-permitting simulation is sufficient.

Page 7, line 14. Please, rephrase “are treated directly” by “are explicitly simulated”, or “permitted” or in that direction.

Page 7, lines 26 and 31. Please, rephrase “residence time” by “life span” of “life cycle”.

Page 7, line 30. Replace “between” by “from”.

Page 7, line 30 and at many other places in the manuscript. Rewrite “01st December” and “5th December” as “1 December” and “5 December”.

Page 8, line 3. Please, replace “The CAPE” by “CAPE”.

Page 8, line 7. Please, reverse “final dissipation and landfall”.

Page 8, line 22. Please, replace “corresponding to” by “on”.

Page 9, line 5. Please, replace “proactive” by “conducive” or “favorable”.

Page 9, line 10. Please, remove “, and the category of storm was retained as VSCS.”.

Page 9, line 18. Please, replace “downscaling of” by “a higher”.

Page 9, line 20. Please, replace “which was actually not true for” by “occurred on”.

Page 9, lines 24. Please, write “Figures … depict...”.

Page 9, lines 27-28. Please, replace “was” by “were” and “activities” by “activity”.

Page 10, line 15. Define the abbreviation “CS” or write full out.

Page 10, line 18. Remove “got” and “it got”.

Page 10, line 19. Replace “reasonably” by “substantially”.

Page 11, lines 9-11. Please, replace “requirements” by “experiments”, “amount” by “amounts”, “is” by “are”, “least” by “shorter”.

Page 12, lines 4-5. Please, replace “in determination of” by “to determine”.

Figures & Table

Figure 1. Please, remove the words downscaling in the caption as all simulations are downscaled in the sense that the simulations are fed by global data. Instead, indicate the resolution of horizontal grid spacing of 7 and 3 km.

Figure 2. The caption speaks about CAPE from COSMO. CAPE fields extend outside the model domain that is indicated by the black box when I understand correctly. Is this perhaps CAPE from ERA-Interim?

Figure 6. Is this the accumulated rainfall in the 24 hours prior or after 00 UTC, 3 December 2017? Please, clarify.

Table A2. For the sake of consistency, I would recommend to also include the results from the CPC simulation.

References

Huffman GJ, Adler RF, Bolvin DT, Gu G, Nelkin EJ, Bowman KP, Hong Y, Stocker EF, Wolff DB. (2007), The TRMM multisatellite precipitation analysis (TMPA): Quasi-global, multiyear, combined-sensor precipitation estimates at fine scales. J. Hydrometeorol. 8: 38–55.

Marsham JH, Dixon NS, Garcia-Carreras L, Lister GMS, Parker DG, Knippertz P, and Birch CE. (2013), The role of moist convection in the West African monsoon system: Insights from continental-scale convection-permitting simulations. GRL, 40: 1843-1849.