

***Interactive comment on “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”” by S. Roshny et al.***

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setspace color hyperref graphicx textcomp soul Response to the Reviewer’s Comments:  
NHES-2018-288

**Impact analysis of dynamical downscaling on the treatment  
of convection in a regional NWP model - COSMO: a case**  
C1

**study during the passage of a very severe cyclonic storm  
“OCKHI”**

By:

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and Radhika Ramachandran

Ms Reference No.:NHES-2018-288

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**Summary of Revision (to the Editorial Board, NHES)**

Dear Dr. Fabrizio Masci,

On behalf of myself and my co-authors, I would like to extend my sincere thanks to you and your supporting Editorial team for your efforts in evaluation of our manuscript. We would also like to place on records our sincere appreciation to Dr. Ronny Petrik and other anonymous reviewer for their valuable comments and suggestions, which have helped us in extending the scope of paper and improving the quality of scientific content of our manuscript. We have addressed almost all the suggestions/queries raised by both the reviewers and have made necessary modifications in the manuscript.

After incorporating reviewer’s suggestions, the revised manuscript includes fine-resolution (i.e., 0.25° grid spacing) ERA5 and NCEP FNL reanalysis fields for assessment of initial conditions and validation of CAPE and other meteorological fields simulated through different numerical experiments of COSMO. We have also

included satellite-based IMERG precipitation measurements (available at 0.10° horizontal resolution) for validation of rainfall simulations. As per the suggestions of both the reviewers, numerical experiments with COSMO model are also re-designed. For investigation of the vertical structure of cyclonic storm, a new figure of vertical cross section of equivalent potential temperature is also included in the Results and Discussion.

Having addressed most of the queries/suggestions pointed out by the reviewers, we are now quite optimistic that you will find the revised version of our manuscript acceptable for publication in NHSS Journal. Point-to-Point Response to the Reviewer's comments and summary of modifications carried out in the revised manuscript is attached as an Appendix to this letter.

Thanking You,

Dr. D. Bala Subrahmanyam  
Corresponding Author  
(On behalf of all the co-authors)

Dated: September 05, 2019.

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## **POINT-TO-POINT RESPONSE & SUMMARY OF REVISION**

### **REVIEWER#1**

#### **Comments from Referee**

*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.*

C4

## Author's Response

We would like to thank the reviewer for endorsing the potential relevance of our manuscript ("I found the study ...carefully written."), and also agree with the objections raised thereafter. During the revision of our manuscript, we have modified the numerical experiments with COSMO by replacing the DPC simulations with a new set of simulations, wherein the grid resolution of COSMO is kept at  $0.0625^\circ$  and convection parameterization scheme is switched off. Furthermore, for meteorological evaluation of our model simulations, we have now included fine-resolution ERA5 and NCEP FNL Reanalysis fields (available at a grid resolution of  $0.25^\circ$ ). For validation of rainfall simulations, we have made use of satellite-based IMERG (Integrated Multi-satellitE Retrievals for Global precipitation measurement) observations. Furthermore, the model domain of COSMO is also extended to a larger area over the Arabian Sea which covers the entire track of OCKHI storm, and all the simulations are carried out for new domain. After incorporation of new datasets, with re-designed numerical experiments, the Results and Discussions as well as our Conclusions are substantially improved.

## Author's changes in the manuscript

- **Introduction:** Scope of the manuscript is revised.
- **Data:** Details of ERA5, NCEP FNL Reanalysis and IMERG observations are added.
- **Numerical Experiments in the COSMO Model:** DPC Simulations are eliminated and are replaced with CNC simulations ( $0.0625^\circ$  grid resolution, and convection scheme switched off).
- **Figures:** Figure 5 and Figure 7 are eliminated. One new figure is included to show the sea level pressure and wind vectors from reanalysis fields and con-

C5

current simulations from COSMO. Furthermore, one more figure is added for representation of vertical cross section of equivalent potential temperature along the latitudes.

- As an outcome of the above-mentioned modifications in the manuscript, **Results and Discussion**, and **Conclusions** sections are also substantially revised.

## Comments from Referee

### 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.*

C6

#### Author's Response

We agree with the reviewer's suggestions about the "dynamical downscaling". In the revised manuscript, we have included meteorological fields of CAPE, sea level pressure and wind vectors from ICON global model. These fields are later compared with the COSMO simulations at dynamically downscaled finer grids. Furthermore, we have included satellite-based precipitation measurements for validation of rainfall simulations.

We also agree with the reviewer about rephrasing of sentences in Section 4 dealing with the dynamical downscaling. In this section, we have explicitly mentioned that the present work deals with the sensitivity of model's grid resolution to the convection parameterization scheme.

#### Author's changes in the manuscript

- **Data:** Details about ICON global model and other reanalysis fields are included.
- **Results and Discussions:** CAPE, sea level pressure and wind vectors extracted from global reanalysis fields are compared with COSMO model simulations. Similarly, rainfall simulations of COSMO are validated against the satellite-based IMERG observations.
- As an outcome of the above-mentioned modifications in the manuscript, **Results and Discussion**, and **Conclusions** sections are also substantially revised.

#### Comments from Referee

##### **2. Observations for model validation and comparison**

*The study uses the ERA-Interim data set from the ECMWF as a means to validate*

C7

*the COSMO model simulations. This approach is problematic since the ERA-Interim reanalysis is produced at a resolution of about  $0.7^\circ \times 0.7^\circ$ ; 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.*

#### Author's Response

AGREED AND IMPLEMENTED. CAPE measurements from fine-resolution global reanalysis fields (ERA5 and NCEP FNL, both with  $0.25^\circ$  grid resolution) are used in the revised figures. We also accept to make use of precipitation observation based on satellite estimates. In this regard, we would like to mention that TRMM observations over the oceanic regions for the period of OCKHI storm are not available. Hence, as an alternative option, we have used satellite-based IMERG precipitation measurements, which are available at  $0.10^\circ$  grid resolution and are widely used for the precipitation studies.

C8

Author's changes in the manuscript

- **Figures:** CAPE fields from ERA5 and NCEP FNL reanalysis are shown in the revised figures.
- Furthermore, IMERG satellite-based precipitation measurements are used for depicting the observed 24 h accumulated rainfall.
- Accordingly, the write-up describing the modified figures is also revised.

Comments from Referee

### **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.*

Author's Response

AGREED AND IMPLEMENTED.

C9

Author's changes in the manuscript

- COSMO domain is enlarged over the Arabian Sea (6.0° N to 22.0° N; and 66.0° E to 82.0° E).

Comments from Referee

### **4. Simulation experiments**

*The study uses three different simulation experiments; (1) with a grid spacing of 0.0625° (~ 7 km) and convection parameterized, (2) with a grid spacing of 0.025° (~ 3 km) and convection parameterized, and (3) with a grid spacing of 0.025° (~ 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 0.0625° (~ 7 km) and without the use of a convection scheme.*

Author's Response

AGREED AND IMPLEMENTED. DPC Simulations are replaced with CNC (Control simulations, with No Convection parameterization) simulations, wherein the grid resolution of COSMO is kept as 0.0625°, and the convection parameterization scheme is switched off.

C10

Author's changes in the manuscript

- **Numerical Experiments in the COSMO Model:** Necessary changes are made.

Comments from Referee

**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.*

Author's Response

AGREED AND IMPLEMENTED. Analysis of different meteorological fields is now extended to sea level pressure, wind vectors, and equivalent potential temperature. Contour maps of sea level pressure and wind vectors are used for the determination of cyclone track, whereas a vertical cross-section of equivalent potential temperature map across latitudes is included as a new figure for understanding the vertical structure of the cyclonic storm.

Author's changes in the manuscript

- **Figures:** New figures of sea level pressure, wind vectors, and vertical cross section of equivalent potential temperature are added.

C11

Comments from Referee

*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.*

Author's Response

AGREED. These figures are eliminated.

Author's changes in the manuscript

- Old Figure 5 and 7 are eliminated.

Comments from Referee (Minor Comments:)

Author's Response and Changes in the manuscript

Below we present a summary on all the minor comments raised by the reviewer (*Italic Letters*), and our response/changes in manuscript just beneath the reviewer's comments. Overall, we have taken care of all the minor comments in the revised version of manuscript.

- *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*

C12

*are found in the extratropics.*

AGREED AND REPLACED. Wherever relevant, we have replaced the word “cyclone” with “tropical cyclone” in respective sections.

- *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.*

AGREED AND CORRECTED. Necessary modifications are done in this sentence by incorporating the spatial and time-scales of convective processes.

- *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.*

AGREED AND OMITTED. The above sentence is omitted.

- *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.*

AGREED AND IMPLEMENTED. Above sentences are rephrased and corrected.

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

AGREED AND INCLUDED. Version 5.05 of COSMO is used for simulations in the present study.

- *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*

C13

*grid spacing of 3 km, convective processes may be largely resolved by the model.*

AGREED AND CORRECTED. Above sentences are rephrased and corrected.

- *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.*

AGREED AND INCLUDED. The standard version of the Community Atmosphere model Version 2 (CAM2) employs the deep convective scheme of Zhang and McFarlane (1995). The authors of the cited paper have used Tiedtke scheme (1989) revised by Nordeng (1994) for their study. These details are included in the revised manuscript.

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

AGREED AND INCLUDED. We have configured the COSMO model simulations with a total of 50 vertical levels. This information is included in the revised manuscript.

- *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.*

AGREED AND CORRECTED. Above sentences are rephrased and corrected.

- *Page 6, lines 13-18. Please, omit the technical description “COSMO model ... fine-grid resolution.”*

AGREED AND OMITTED. Above sentences are omitted, and we have included citation of the model’s users guide for further technical details.

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

C14

AGREED AND IMPLEMENTED. As mentioned above, now the revised manuscript include satellite-based IMERG precipitation measurements for validation. Hence, we are directly showing the precipitation measurements from IMERG rather than reanalysis or analysis fields.

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

AGREED AND IMPLEMENTED. The OCKHI cyclonic storm was categorized as a Very Severe Cyclonic Storm (VSCS), which was formed in the month of December. Historically speaking, none of the Depressions or Cyclonic Storms formed over the Comorin Sea in the month of December ever became a VSCS in the last 100 years or so. Secondly, this storm attained the status of a Cyclonic Storm from the stage of Depression within 6 h. Its rapid intensification was yet another rare event which was extremely unusual. These details are included in the revised manuscript.

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

AGREED AND INCLUDED. These observations were cited from the IMD report on OCKHI. Appropriate citations are included in the revised manuscript.

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

AGREED AND RE-NUMBERED. Section numbering is corrected accordingly.

- *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".*

AGREED AND REPLACED.

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

AGREED AND INCLUDED. CAPE fields are corresponding to 00 UTC of 03 December 2017.

C15

- *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.*

AGREED. We have included fine-resolution global data of ERA5 and NCEP FNL reanalysis with ERA-Interim data.

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

AGREED AND INCLUDED. Yes, these precipitation amounts are for 24 h between 00 UTC of 02 December 2017 to 00 UTC of 03 December 2017. These details are included in the revised manuscript.

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

AGREED AND REPHRASED. This sentence has been rephrased in the revised manuscript.

- *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.*

AGREED AND CORRECTED. We have included satellite-based IMERG precipitation measurements for validation of rainfall simulations. Thus, these points are

C16



well-addressed in the revised manuscript.

- *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.*  
AGREED AND REMOVED. The above sentence is removed.

Comments from Referee (Writing Comments:)

Below we present a summary on all the “Writing Comments” raised by the reviewer (*Italic Letters*), and our response/changes in manuscript just beneath the reviewer’s comments. Overall, we have taken care of all these comments in the revised version of manuscript.

- *Page 1, line 5. Please, consider to replace “inter-linking of” by “interplay between”.*  
AGREED AND REPLACED.
- *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.*  
AGREED AND CORRECTED.
- *Page 1, line 20 – Page 2, line 1. Please, replace “surface to the troposphere” by “surface to the upper troposphere”*  
AGREED AND REPLACED.
- *Page 2, line 3. Please, replace “Convection process” by “Convective processes” or “Convection”.*  
AGREED AND REPLACED.

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- *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.*  
AGREED AND REPHRASED.
- *Page 2, line 12. Please, replace “inter-linked” by “complex”.*  
AGREED AND REPLACED.
- *Page 2, line 13. Please, replace “Further” by “Furthermore, “.*  
AGREED AND REPLACED.
- *Page 2, line 16. Please, replace “is apparently inter-linked with” by “constrained by” or in a similar direction.*  
AGREED AND REPLACED.
- *Page 2, line 19. Please, replace “As on today” by “At present” or “Currently”.*  
AGREED AND REPLACED.
- *Page 2, line 26. Please, remove “physical and”.*  
AGREED AND REMOVED.
- *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 ...”.*  
AGREED AND CORRECTED.
- *Page 4, line 9. Please, replace “the conserved framework” by “the conservation of” and in line 10, replace “Different schemes” by “Schemes”.*

C18

AGREED AND REPLACED.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

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

NO CHANGES ARE MADE. We could not find the above mistake in original manuscript.

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

AGREED AND REPLACED.

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

NO CHANGES ARE MADE. The above sentence is correct to the best of our knowledge, and “form” is correctly used, hence no changes are made.

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

AGREED AND REMOVED.

C19

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

AGREED AND REPLACED.

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

AGREED AND IMPLEMENTED THROUGHOUT THE MANUSCRIPT.

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

AGREED AND IMPLEMENTED.

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

AGREED AND REMOVED.

- *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.*

AGREED AND RE-WRITTEN.

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

AGREED AND REPHRASED.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

C20

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

AGREED AND IMPLEMENTED THROUGHOUT THE MANUSCRIPT.

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

AGREED AND REPLACED.

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

AGREED AND CORRECTED. Sentence is rephrased and is rewritten as “landfall and final dissipation”.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

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

AGREED AND REMOVED.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

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

C21

AGREED AND CORRECTED.

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

AGREED AND REPLACED.

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

AGREED AND CORRECTED. All abbreviations are once again carefully checked.

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

AGREED AND REMOVED.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

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

AGREED AND REPLACED.

#### Comments from Referee (Figures and Tables)

- 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.

NECESSARY CORRECTIONS ARE DONE IN THE FIGURE CAPTION.

C22

- *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?*

AS THE MODEL DOMAIN IS EXPANDED, THIS FIGURE ITSELF IS REVISED.

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

FIGURE CAPTION IS CORRECTED AND ABOVE DETAILS ARE INCLUDED.

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

CPC SIMULATION DETAILS ARE ALSO INCLUDED IN THE TABLE.