

# Review for “Advancing the Capabilities for Efficient Hurricane-Centric Simulations with the Atmospheric Model ICON” by Senf and Cremer for GMD

## Summary

This study addresses the issue of performing high-resolution, global-storm resolving simulations while balancing computing resource and storage requirements. The authors propose a method to mimic Lagrangian-like simulations by shifting grids along the path of hurricanes, the phenomenon of interest in this study. The focus is on the efficiency gain as well as possible spin-up effects.

Dear Fabian and Roxana, it was a pleasure to read the manuscript. It is well structured, nicely written, and informative. The figures are clear and use appropriate colormaps. I believe the study should be published after considering my comments below, which are all of minor nature or editorial. Best, Nadja

## Minor comments

- Line 138: I do not understand what you mean by “ten revolutions”. Could you elaborate on that? That is mostly my ignorance and not being familiar with *tobac*. Also why, do you need to coarse-grain the vorticity field? What does the convolution filter exactly do?
- Line 224: In what way are these spin-up effects clearly visible? Did you perform a similar analysis as you did later for your inner nests?
- Line 228: What is the impact of having the daily-updated SST?
- Line 254: Do I understand correctly, that I as a user can specify the targeted grid resolutions? Or is it required to follow the halving of the resolution, as typical in an online nest? Could I perform a coarser simulation at 1.2 km and then immediately jump to 100 m, for example?
- Line 255: What is your estimated effort in making more than three nests possible? What is technical difficulty behind this? Also, is there a check, that the widths of the grids are not so large, that the inner grid would overlap with the nudging zone of LBCs of the outer grid? In your case, it is clear that this is not the case, assuming you are using the standard configuration of 14 grid cells as a nudging zone.
- Line 279: Is it correct, that the base runs were performed with ICON v2.6.6, while the grid segments were done with v2025-04-2. Do you expect any discrepancies between the two model versions that are important to your hurricanes?
- Line 282: What was the impact of adding graupel and ice number mixing ratios to the ICs? Did you see a reduction in spin-up?
- Figure 7: What is the temporal resolution of the output, as it seem quite noisy to me, especially in the maximum 10 m wind speed. Would a running mean help here? Can you also plot the maximum 10 m wind speed and minimum surface pressure of the base run, which is the white track?
- Figure 9: Could you be more specific regarding the discontinuous jumps in the subplots? I am not sure I fully see them, maybe highlighting them with some circles could help, or you point to them more explicitly in the figure caption.
- Line 323: Was the subtimestepping of the dynamical core changed in your grid setups? If so, why? Because of stability reasons?
- Line 336: Is your time step at 2.5 km grid resolution 6 seconds? If so, is this is because of stability reasons? I would have expected a higher time step.
- Line 343: I am convinced that your method is saving computing resources, and believing right now your numbers, this would lead to a substantial decrease in computing resources. However, I am wondering if this is true and not a slight overstatement, given that in your 3-nest setup + narrow width, the hurricane is cut off across all resolutions, but strongest in the case of 300 m naturally. My thinking here is, if your statement with a factor of up to 175 is a bit too strong, because coming from a scientific perspective, I am not sure how much we would gain from the innermost nest with the narrow width? Hence, I would be curious to hear “more realistic/applicable” numbers.

- Figure 10: Any idea what is happening to segment 02 and 03? Why are they behaving quite different to the other segments in your analysis? Why do you see for some segments and variables the zigzag pattern? What is your output frequency that your analysis is based on?
- Figure 11: So, blue represents the 10th percentile, while red the 90th? Could you specify this in the figure caption? Was the analysis here and Figure 10 also done for the higher resolutions? Are you changing vertical levels? This would also impact your spin-up. Have you looked at the cloud quantities vertically resolved before integrating them? I would be curious if you see some time dependence of the spin-up across the vertical dimension.

## Editorial comments

- Line 8: You usually refer to your tropical cyclones, as hurricanes, so to stay consistent I would also call them in this instance hurricanes instead of tropical cyclones.
- Line 45: add the reference to Zängl et al., 2014 after introducing ICON
- Line 55: I am being very picky here, but what do you define as “good”? Realistic? Accurate? Precise? In relation to what?
- Line 66/202: You introduced ICON already so I would omit the Earth system part / weather and climate model part.
- Line 107: Regarding the merging of ICs: Could you point to your extensive discussion later? I stumbled across this while reading and marked it hoping you would provide more details later, which you did. So, a simple reference to the section would already help.
- Figure 3: R02B10 should be explained in the figure caption, because this is only later used in the text. Same goes for Figure 4, and therein L70.
- Line 207: replace “times” by  $x$  and “km” should be  $\text{km}^2$ .
- Figure 5: The tiny world map in the upper right corner shows the extent of the shown reflect solar radiation flux, right? I was wondering, if you can add as well the nests described in Lines 207ff, such that it is clear how large these base runs are. Either for both R02B09 and R02B10, or at least for the latter.
- Line 307: there is a word missing in “must make between ...”.
- Line 372: Because you showcase a variety of resolutions, it would help to reiterate which resolution you are talking about in the case of the “outer nest”.