Review

ICON simulations of cloud diabatic processes in the warm conveyor belt of North Atlantic cyclone Vladiana

This manuscript contains a nice, detailed, and insightful analysis of 18 ICON simulations of cyclone Vladiana. The authors focus on the dynamics of the warm conveyor belt and on its relationship with model horizontal resolution, convection settings and microphysics scheme. This is a well-written piece of research that could surely be a welcome contribution to the field. However, I have some reservations on the application of the PTE method (see the two relevant comments at the end of this document) and, as such, I don't think the third research question (see Conclusions) has been fully answered as of now. Apart from this, all other comments are minor and, in some cases, I'm just requesting to expand some discussions and clarify some statements. Overall, I think this paper would be worth of publication once the comments are addressed.

Comments:

General:

- I find the title slightly vague and I don't think it does justice to the novelty of your analysis. I appreciate that for space reasons it won't be possible to explicitly mention model resolution, convective parameterisation and microphysics scheme, but I would suggest you try highlighting the analysis performed on these ICON simulations.

- I would consider replacing "higher/highest" and "lower/lowest" resolution with "smoother/smoothest" and "coarser/coarsest", respectively. Given that grid spacing decreases with finer ("higher") resolution, those two terms might be misleading (the same applies to all the "increasing/decreasing resolution" instances).

-DOIs seem to be missing from most of the references included in this manuscript. It would be helpful for reviewers & readers to add them, so the referenced research can be accessed more quickly.

Abstract:

- Lines 7-8: "the resolution" here could be replaced by "that" in both instances, making the sentence more concise.

- Lines 13: "With increasing resolution". I would specify exactly what are the two resolutions that show a 3-time increase in ascent velocity. Also, if there's space, I would include a brief statement on the saturation of those effects when moving to resolutions finer than 10 km.

- Lines 17-18: "on the one hand" and "on the other hand" are not really needed here.

Introduction:

- General: There is a sort of jump between the first two paragraphs, describing the WCB, and the following one, starting with “Despite decades of model development…”. I would suggest improving the link between the different topics presented and/or to try change the order of paragraphs and see if the readability improves.

- Lines 23-24: “Most of the diabatic processes occur within coherent streams of ascending air known as warm conveyor belts”. This is a bold claim and I don’t think the papers referenced justify it. I understand the reasoning behind it, but I would still like it to be rephrased (or properly justified) as substantial diabatic processes can be found in many other parts of the cyclone, even outside the warm sector.

- Lines 44-45: It might be better saying “.. in which horizontal grid spacing is reduced to a few kilometers..” (or something similar, should you prefer taking into account spectral models).

Method:

- Lines 89-90: Could you give some motivation as to why it is ok that the model follows a “ tropical Atlantic setup”?

- Line 91: Consider moving the domain description here (or motivate why it should stay at lines 106-107).

- Line 94: Did you consider running half-explicit convection (i.e., with only shallow or deep parameterisations disabled)? I’m not asking you to run anymore simulations, I was just wondering if you thought such as setup could be useful (possibly in future works?)

- Line 105: Could you briefly specify here how what the 18 simulations are? (I don’t think a table is needed, a sentence in the text should be enough).

- Figure 1: I would replace the PV colour scale with a more intuitive (and colour-blind friendly) one. I understand the emphasis on the 2 PVU value, but I think it could just by highlighted with a red contour line, while using a more logical colour scale for the shading. Also, I would replace ‘EQ’ with ‘0W’ on the x axis.

- Line 135-137: “from every grid point”: this would suggest that simulations with finer resolutions have more trajectory starting points, whereas line 137 indicates that this is not the case as “the seeding points are based on the 20 km simulation. For all resolutions….”. I assume the latter is true but a clarification is needed, for example moving this second quote up to line 135 (and, if my assumption is wrong, “number” needs to be replaced with “proportion” at line 9).

- Line 147: “As a result, …” could you clarify why this point about slantwise convection is a consequence of using off-line rather than on-line trajectories?

- 2.4 Diabatic Heating: Are these tendencies computed on-line by the model?

WCB trajectories:

- Lines 177-178: Is it possible to be more quantitative here? (giving more context to the following split into subsets, and Figure 4)

- Line 182: I would say “more” than 10 times, looking particularly at Figure 3.

- Lines 185-187: Again, could you make this statement more quantitative?

- Figure 4: How are the boundaries of the rectangular domains defined? Is there any motivation to not just stop at an “anticyclonic vs cyclonic” decomposition?

- Figure 5: I would consider changing this figure to a 4-panel one, to separate total and subclasses counts. other solutions are welcome, as long as they make it clearer to interpret (I find having all and subclasses together, and on two different scales, slightly confusing).

- Figure 6: I suggest making this a 2x2-panel figure (a similar consideration applies to Fig 8, which could become a 3x2 or 2x3 one). I think that using colours would help differentiating between the various points. Also, I suppose that “mean ascent height” indicates the mean pressure difference between beginning and end of the ascent, rather than the pressure value half-way through the ascent. I think a clearer name for this quantity might be needed (if instead it is the latter, the y-axis should be reversed).

- Lines 216-217: Based on this result, can we say that in coarser simulations we see fewer WCB trajectories because generally ascent is less vigorous? Or are there other factors at play?

- Line 221: Can you elaborate on the reasons behind this statement? (slower ascent because trajectories are off-line)

- Line 234: I would add a rough timing of the two main periods.

- Fig 7: Given that Δh is approximately proportional to $-\Delta(\log P)$, have you considered using log-scale in all panels (in Fig 7 elsewhere in the manuscript) where pressure is on the x or y axis?

- Line 239: I completely agree with you on the expected PV vertical profile, but this might not be familiar to all readers. Could you add a reference?

- Lines 249-250: I’m not sure I agree with this sentence. Even if the output of a 2.5km simulation is regridded to 40km, that simulation was run with the model being able to resolve processes well below 40km (although I appreciate that coarsening the output will smooth out the patterns).

- Figure 9: adding a line for the 2.5km simulation regridded at 40km and/or 80km would help the argument that horizontal resolution does not influence cyclone deepening.

- Section 4.1: Would it be possible to compute PTE in a storm-relative frame of reference or, even better, to use a fully Lagrangian perspective and trace the terms onto the trajectories computed? I'm saying this as I'm thinking at ways to reduce the impact of advection and the related cancellations between terms.

- Line 304: I find slightly surprising that the diabatic term is not calculated explicitly , but instead grouped with the residuals. Without knowing how big residuals are, I don't think it's possible making conclusions on the behaviour of the diabatic term.