Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2019-130-AC2, 2019

Geoscientific Model Development Discussions
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Interactive comment on "The first Met Office Unified Model/JULES Regional Atmosphere and Land configuration, RAL1" *by* Mike Bush et al.

Mike Bush et al.

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Received and published: 24 October 2019

SpeciïňĄc comments

âĂć 1. It would be good to specify in section 1 that the Met OfïňĄce you're referring to is the UK Met OfïňĄce.

Response: "Met Office Unified Model" is the name of the model and "Met Office" is the correct name for the organization that was once known as the UK Met OfïňĄce. Whilst I understand (and have some sympathy) with the point the reviewer is making, I am unable to change this. I have slightly changed the word order at the beginning of the second paragraph of the Introduction to perhaps make this more obvious.

âĂć 2. In section 2.6 where you discussed the Smith cloud scheme you give

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RHt=(qv+qcl)/qsat. Could you deïňĄne qv, qcl and qsat to make it unambiguous? Also, RHc is not deïňĄned, is it RHcrit?.

Response: I have amended the text to read: RHt=(qv+qcl)/qsat (where qv is the vapour, qcl is the liquid content and qsat is the saturation specific humidities) reaches 100% and that the grid-box only becomes overcast when RHt>=2-RHcrit.

âĂć 3. The tickets discussed in Section 3 aren't sequential. It is understood that only the most important tickets are discussed and arranged per topic, but it would be useful to have a complete list of the tickets that documents all the changes to the model.

Response: I have added Table 6.

âĂć 4. In section 3.5 "CCI" and "IGBP" is not deïňĄned. I like the description of the physical effects of the changes in the last paragraph of section 3.5 as it makes it more tangible.

Response: I have added a reference to table 4.

âĂć 5. The second paragraph in section 4 is a bit ambiguous. The ïňĄrst sentence on p15 talks about "several aspects" but then name two. Maybe the use of "such as" instead of "namely" would be better in that case? And in the following sentence about the differences in the representation of turbulence between RAL1-M and RAL1-T it would be good to speciïňĄcally note that the values given there is for RA1L-T, or state the opposing values for RAL1-M as well.

Response: I have amended the text to read: In order to cope with this, RAL1-M, has relatively weak turbulent mixing and stochastic perturbations to encourage the model fields to be less uniform and help convection initiate. If the model is run with these in the tropics the model initiates too early and convective cells tend to be too small.

Representation of turbulence (RMED tickets #12 and #26) and BL stochastic perturbations (RMED ticket #25)

There are two differences in the representation of turbulence between RAL1-M and RAL1-T, namely in the form of the stability functions and in the free-atmospheric mixing length. Both give enhanced turbulent mixing in RAL1-T compared to RAL1-M. RAL1-T uses the Brown (1999) "standard" model whilst RAL1-M uses the Brown (1999) "conventional" model. RAL1-T retains RAL0's interactive free-atmospheric mixing length, whilst RAL1-M uses a value of 40m. The other related change is that RAL1-T does not use the stochastic boundary layer perturbations. For more details and a summary of differences between RAL1-T and RAL1-M, see Table 2.

âĂć 6. GPM in section 4 and IMERG in section 5 is not deïňĄned in the text.

Response: There are references to these in sections 5 and 5.1

âĂć 7. When you explain the "scorecard" in section 5.1, you should also indicate which direction of arrows indicate improvement/decline. Something along the lines of "triangles pointing upward (green) are indicating that model A is better than B and downward "blue" triangles indicating model B is better" showing whether the model version being tested is better or worse than a previous incarnation.

Response: I have amended the text to read: Triangles pointing upward (green) indicate that the test model is better than the control and downward (purple) triangles indicate the control model is better.

âĂć 8. The legends in Figure 13 are not legible.

Response: Figure 13 has had its legends made legible.

âĂć 9. In section 5.5 it is stated that a total of 130 TC forecasts were produced, and only storm cases appearing in both RA1L-M and RAL1-T were kept. However, in Figure 19 the number of cases are up to 140 with a 0-hour lead time. Does that mean that some simulations had more than one TC at the same time?

Is the mean bias for model-obs?

Also, it would have been interesting to know how often storm cases appeared only in one of the experiments. Which conïňĄguration was more likely to form storms?

Response: The answer to the first two points is yes and I have slightly amended the text. 130 TC forecasts were run. When the storm sample was homogenised across the two experiments (RAL1M/T), there were 126 initialisation times remaining, i.e. some forecasts were discarded because either no storm was found in either experiment, or a storm was found in one experiment but not the other. This sort of thing can happen if the storm is weak and drops below one of the pre-defined thresholds used in the tracker code.Âă Âă In Fig 19 the number of cases at T+0 is 144. This is because there were 18 forecasts where two storms were present in the domain at the initialisation time (and 126 + 18 = 144). In 9 of these forecasts TCs Chan-Hom and Linfa were both present at T+0, and in the other 9 it was TCs Koppu and Champi.

Yes the mean bias is for model-obs.

The TC verification software we use (see Heming 2017 for details, reference below) only tracks and verifies storms that were observed to exist at the model analysis time so we do not have any statistics regarding TC genesis at present. In principle this is something we could look at in the future, but we suspect there would be little difference in genesis statistics between RAL1M/T. Âă Heming, J. T. (2017), Tropical cyclone tracking and verification techniques for Met Office numerical weather prediction models. Met. Apps, 24: 1-8. doi:10.1002/met.1599Âă Âă âĂć 10. Is there a reference for the Random Parameter scheme mentioned in section 5.6? Response: Added McCabe et al. (2016).

âĂć Technical corrections

P3 line 2: "added to the RAL0 base to deïňĄne RAL1-M" P7 line15: Maybe start "This represents" as a new sentence. P9 line 5: "Ri is less"? P10 line 9: Remove "Therefore" P14 line 29: There is an extra "reason" P16 line 18: "most" should be "must" P17 line 25: 3-hour or 3-hourly? P17 line 32: "can lead to difïňĄcult to interpret veriïňĄcation

scores" rather "can lead to veriïňĄcation scores that are difiňĄcult to interpret". P20 line 3: "reduces signiïňĄcantly the ability" change to "signiïňĄcantly reduces the ability" P23 line 5: "evaluate its performance"

Response: All technical corrections have been made.

Please also note the supplement to this comment:
https://www.geosci-model-dev-discuss.net/gmd-2019-130/gmd-2019-130-AC2-supplement.pdf

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Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-130, 2019.

Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2019-130-AC3, 2019

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Interactive comment on "The first Met Office Unified Model/JULES Regional Atmosphere and Land configuration, RAL1" *by* Mike Bush et al.

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Received and published: 25 October 2019

1. Need to indicate that this is the UK Met Office in the title.

Response: "Met Office Unified Model" is the name of the model and "Met Office" is the correct name for the organization that was once known as the UK Met Office. Whilst I understand (and have some sympathy) with the point the reviewer is making, I am unable to change this. I have slightly changed the word order at the beginning of the second paragraph of the Introduction to perhaps make the UK more obvious. Please note that the analogous Global Atmosphere series of papers in GMD (Walters et al, 2011, 2014, 2017) also have a title beginning "The Met Office Unified Model Global Atmosphere..."

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2. It would be nice to have a list of acronyms in an appendix. There are a lot of them!

Response: I have added Table 5 containing a list of acronyms.

3. Define UM and JULES at the first use (in the abstract as far as I can tell.).

Response: I have modified the abstract to read: In this paper we define the first "Regional Atmosphere and Land" (RAL) science configuration for kilometre scale modelling using the Unified Model (UM) as the basis for the atmosphere and the Joint UK Land Environment Simulator (JULES) for the land.

4. Is there an internal report that this paper could reference?

Response: Nothing that is of direct relevance.

5. While Kendon et al. 2017 is a good reference for km scale modeling, there are a lot more that could be given. General comment: There are a lot of UK Met Office references in the paper. It would make the paper more relevant if more of the communities efforts in these same areas are also referenced. Otherwise this reads as a UK Met Office report.

Response: I have added three more relevant references (Baldauf et al. (2011), Brousseau et al. (2016) and Bengtsson et al. (2017)).

6. Page3, line22. Suggest that say the “ENDGame” is the dynamical core used in the RAL1.

Response: This section deals with RAL0. I have amended the text to say that RAL0 uses the UM’s ENDGame dynamical core. Also the new Table 5 explicitly notes that RAL1 also uses the ENDGame dynamical core.

7. Page3, line14. A reference to the hybrid height coordinate used would be appropriate here.

Response: I have amended the text to say: "A terrain-following hybrid height coordinate

is used that it is a mix of both pure height (i.e. flat levels) and terrain following levels (Davies et al., 2005)."

8. Page 6, line 12. Why has a scaling of 0.333 been applied to the Cusack et al. (1998) climatology?

Response: I have amended the text to say "and the contribution from dust has been scaled by 0.3333 compared to the original climatology of Cusack (1998) as the dust loading of the basic climatology over land (which includes arid areas) is too high for the UK."

9. Page 6, line 25. How is the surface albedo set?

Response: I have amended the text to say "The emissivity and the albedo of the surface are set by the JULES land surface model (see Section 2.8). A single frequency-averaged emissivity is specified for each surface type (see Walters et al. (2014) for the numerical values). For the surface albedo, the radiative transfer in plant canopies uses the two-stream radiation scheme and spectral parameters of Sellers (1985)."

10. Page 7, lines 14 – 23. Why isn't the CASIM microphysical parameterization developed by the Met Office not used instead of the Ballard scheme?

Response: CASIM is being actively developed and the intention is that it will be incorporated into a future RAL version. At the time that RAL1 was released, the code wasn't yet ready for operational use because it was slower and didn't contain the necessary coupling to the boundary layer scheme for forecasting of foggy cases (essential for the UK in the winter). Both of these issues are in the process of being addressed. We haven't mentioned CASIM in the paper as we want the manuscript to contain details of parametrizations included in RAL1 rather than digressing into details of parametrizations which were not included, potentially confusing the reader.

11. Page 8, line 7. Can you give the RH function for cloud fraction?

Response: The equation is given below. I don't feel it is necessary to include it in

the paper as it is quite long and doesn't really add much. However if the editor feels strongly that we should include it, then we can.

In the Smith scheme, the cloud fraction c is calculated from qn using: if qn < -1 c=0; elseif qn<0 c=0.5*((1+qn)^2); elseif qn<1 c=1-(0.5*((1-qn)^2)); else c=1; end

where qn=(rht-1)/(1-rhc) and rht=(qv+qcl)/qsat.

When using the EACF we use the same formulation but instead of c being calculated from qn it is calculated from qn' where qn'=(qn+0.184)/(1-0.184); where the 0.184 has been determined from trying to better match the observations of Wood and Field and while also improving model performance.

General comment: I would suggest a table giving the changes from RAL0 to RAL1. Response: I have added Table 6.

12. Page 16. I can't find Table 1 in my version of the paper.

Response: Table 1 (model timesteps) is at the bottom of page 4. Table 2 (M&T diffs) is at the top of page 16.

13. Page 17. Is the size of the "triangles" in the "scorecard" proportional to a relative or absolute improvement/degradation of the model?

Response: I have amended the text to say: "The area of the triangles is proportional to the absolute improvement (or deterioration) of the model and the triangles are outlined in black if the change is statistically significant, at the 0.05 level determined using the Wilcoxon signed-rank test."

14. Page 18. How were the 100 cases used to verify the model chosen?

Response: I have significantly added to the text to say: "The UK evaluation consisted of a hierarchy of testing. Firstly, individual science changes (RMED tickets) were tested by running 100 case studies with a 1.5km horizontal grid-length, using the same domain as the Operational UKV model (Figure 3). These were simple downscaling runs

(from the Met Office Global model) with no data assimilation. The cases sampled a wide range of meteorological conditions from the period July 2014 to April 2017 and comprised roughly equal numbers from each season. The cases were a mixture of poor forecasts (as identified by forecasters), high impact weather and normal everyday weather. The verification results from this stage of testing were used in the decision making process of whether individual science changes were performing well enough to progress to the next round of testing. Secondly, the tickets were packaged up into a "proto-RAL1" package and the same case study tests repeated. Typically there may be several "proto" packages trialled before a preferred package is chosen. Thirdly to test the impact of including data assimilation in RAL1, one month long UKV 3D-VAR Data Assimilation trials were run for Summer and Winter 2016. The exact choice of dates for the case studies (and indeed the data assimilation trials) can obviously affect the results, but the reason for running the case studies is to provide a relatively cheap and quick test of model changes before moving on to the more expensive data assimilation trials."

15. Page 18. What do you mean by “mixture of 00Z and 12Z runs of the Met Office global model?

Response: See response to 14.

16. Page 18, line 10. Suggest “By far the” instead of “One of the”.

Response: I have amended the text to read "By far the most significant improvement in RAL1 is the surface temperature".

17. Page 18. Paragraph breaks are not consistent with the flow of the paper.

Response: I have slightly changed the paragraph breaks.

18. Page 18. It is interesting that the major improvement is the land surface. I wonder how dependent this is on the choice of the dates chosen to analyze? I assume there was a reason for choosing the specific 100 cases. I am wondering if this isn’t biasing

the results somehow.

Response: See response to 14. I have also added some more text: "Figure 4 shows the HiRA scorecard comparing RAL1 performance with RAL0 for the 100 case studies and Figure 5 shows the results for the 3D-Var Winter and Summer trials. The first thing to note is that there is remarkably good agreement between the case study and the 3D-Var trial results. This shows that the case studies can give a good indication of likely performance in data assimilation trials and that the exact choice of dates is not crucial to the results provided enough cases are run."

19. Page 19. Lines 10-15. You can show anything with one case study. How robust is this result? I would suggest deleting this section.

Response: I have decided to keep this section, but have amended the text to read: "Overall RAL1 shows statistically significant degradation to cloud fraction RPS at most lead times in both case study (Figure 4) and 3D-Var Winter trials (Figure 5 left panel). Subjective assessment of RAL1 by forecasters found that whilst largely very similar to RAL0, RAL1 tends to break up lower cloud faster than RAL0, especially where that cloud is fragmented. Whilst on average the reduction in cloud amounts verifies worse, in some cases it is good. Figure 13 shows a stratocumulus case from 23rd June 2015."

20. Page 19. The fog “taper” is an interesting result I would like to learn more about. Why does the model produce too much fog near the surface, is dew deposition not considered?

Response: I have amended the text to read: "RAL1 reduces the optical depth of fog as a result of the droplet taper change (ticket 1) and further discussion of fog processes and model performance can be found in Boutle et al. (2018)."

There definitely is dew deposition in the model, although fog is very sensitive to exactly how this is represented, hence the importance of the drop number in the taper since that governs the cloud droplet sedimentation rate onto the surface.

21. Page 20, lines 13 – 16. The result described in this section needs to be expanded and explained better.

Response: I have expanded the text significantly to read: "The impact of PC2 is to increase light rain amounts and decrease very heavy rain amounts compared to the Smith scheme. Effectively this makes the model more dissipative and this leads to a reduction of small-scale structure which enables the large-scale envelope of features like Sumatran Squalls to be better handled and hence to propagate more realistically. The increased free-atmospheric mixing further increases the dissipation, and the two together were found to improve the ability of the model to propagate Sumatran Squalls faster and further, rather than have them not develop or dissipate prematurely."

22. Page 21. Line 16. How does the storm initiation time and strength compare to observations?

Response: Figure 19 answers the strength compared to observations question. As for the storm initiation time (when genesis occurs), the TC verification software we use (see Heming 2017 for details, reference below) only tracks and verifies storms that were observed to exist at the model analysis time so we do not have any statistics regarding TC genesis at present. In principle this is something we could look at in the future, but we suspect there would be little difference in genesis statistics between RAL1M/T.

Heming, J. T. (2017), Tropical cyclone tracking and verification techniques for Met Office numerical weather prediction models. Met. Apps, 24: 1-8. doi:10.1002/met.1599

General comments on figures: 1. The figures need more explanatory labels. 2. What is the verification data used for figures 4, 5,14,?

Response: Added that "HiRA uses synoptic observations (see section 5) to the captions for figures 4 and 5. Figure 14 already says that 3 hourly GPM is used.

Please also note the supplement to this comment:
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