

Geosci. Model Dev. Discuss., author comment AC1
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Reply on RC1

Mike Bush et al.

Author comment on "The second Met Office Unified Model–JULES Regional Atmosphere and Land configuration, RAL2" by Mike Bush et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2022-209-AC1>, 2022

Thank you very much for your comments. Corrections have now been made to the manuscript. My replies to each of the specific comments are in **bold**.

Specific comments

- p.4, lines 20-27 – The overlap between liquid water and ice phases is "limited" but you don't describe how. Is there a cap on the percent overlap? Is this documented elsewhere and could be referenced?

see Appendix of Abel et al. (2017) for more details of the modification to the cloud scheme.

- p.5, lines 12-14 – since you show results for addition of the Leonard terms in Figs. 5 and 6, it would be good to give more explanation here of what the Leonard terms actually refer to. **The "Leonard term" is an extra subgrid vertical flux that accounts 15 for the tilting of horizontal flux into the vertical by horizontal gradients in vertical velocity. Hanley et al. (2019) found that including this extra term in the Met Office UKV model reduces the peak vertical velocity within updrafts, leading to a reduction in condensation. As a result, the number of grid points with moderate to high rainfall rates, which are overrepresented by the UKV, are also reduced.**
- Table 2 – what are b_{LEM} and c_{LEM} ?

Replaced Stability function definitions involving b_{LEM} and c_{LEM} in Table2 with "conventional" and "standard". Text now reads: There are two differences in the representation of turbulence between RAL2-M and RAL2-T, namely in the form of the unstable stability functions and in the free-atmospheric mixing length. Both give enhanced turbulent mixing in RAL2-T compared to RAL2-M. RAL2-M uses the Brown (1999) "conventional" function, the same as GA7, while RAL2-T uses the Brown (1999) "standard" function.

- p.6, line 12 – seems odd to have "(no reference)" – consider omitting

omitted

- p.6, eq.(1) – what is Γ ?

Equation deleted and text rewritten as there is a very small impact in RAL2. We don't have a convection scheme, so the parametrized downdraught gustiness velocity scale, w_c is zero (and so γ is irrelevant). Text now reads: For lower mean wind speeds, the effect of subgrid convective boundary layer gusts on the surface turbulent fluxes is included via a term proportional to the convective velocity scale in the calculation of the friction velocity. For RAL2 we reduce the strength of that term by a half, to then match GL7.0.

- p.6, lines 24-25 – why does fixing the multilayer snow scheme allow reintroduction of graupel? Does it form on the snow surface?

Improvements to the treatment of lying snow in RAL2 are achieved by introducing a representation of melting of the snow pack from the base over warm ground, as the original code in JULES allows melting only from the surface. Previously it was necessary to remove graupel from the precipitation reaching the surface as the omission of melting from the base resulted in unrealistically prolonged retention of thin layers of frozen precipitation. This modification allows the reintroduction of graupel into the precipitation reaching the surface.

- p.7, bottom – the scorecards in the figures use 10.5 km scale (7 grid-lengths). It would be good to explain why this particular scale was chosen for evaluation.

This particular scale was chosen for evaluation as Mittermaier and Csima (2017) showed that all variables benefited from the use of at least a 3 x 3 neighbourhood, whilst neighbourhoods which are too large may be detrimental for some variables, including temperature.

▪

p.7, line 18 – define GPM **Global Precipitation Measurement (GPM) IMERG satellite data based product (Huffman, 2015, 2017), Skofronick-Jackson et al., (2017) is used.**

- p.10, line 1 – this should be “the improvement in performance in Winter is much better than the improvement in performance in Summer”. **Corrected.**
- p.10, lines 13-14 and Fig. 12 – do the model results in Fig. 12 correspond to the large rectangular domain over Darwin or for the circular domain of the radar? Please clarify, including in the caption for Fig. 2. If the model results are for the larger domain, how much difference from the radar could be explained by sampling different areas?

Figure 2 caption now reads: The CPOL radar location is denoted by the black triangle and its coverage by the area within the circle of dashed lines, which is the area used for the analysis presented in Figure 12.

- p.11, lines 4, 9, 10, 14 – define GWP, LMI, ENLS, QCF

ENLS : Earth Networks Lightning Sensor; QCF: Cloud Frozen ice content; GWP:

Graupel Water Path; LMI : Lightning Mapping Image

- p.11, lines 17-18 – readers may not know where these regions are – it would be better to say what part of India (northern, etc.)

Bihar and Uttar Pradesh (Eastern India) and also very few flash strikes over the Rajasthan-Madhya Pradesh border (north-west India).

- p.12, lines 6-10 – do you think the implementation of RAL2 in operations with only 70 levels rather than 90 levels (as shown in the results in this paper) has much effect on the improvements over RAL1? If this has been tested it would be good to say a bit more about it.

Both level sets have a very similar number of near-surface levels with both having 28 levels below 3km and L90(67t,23s)40 only having one extra level by 10km asl. As a consequence of this, the impact of 10 L90(67t,23s)40 was found to be very small for this UK specific application.

- p.A table of acronyms is provided in Appendix 2 but never referred to in the text.

Now referenced at the beginning of chapter 2

Technical corrections

All technical corrections have been made.

- p.1, line 18 and elsewhere – There are too many parentheses in the in-line citations. This should be (e.g. Baldauf et al., 2011; Brousseau et al., 2016; Bengtsson et al., 2017; Klasa et al., 2018).
- p.2, line 6 – Fix spelling of 'the'
- p.2, line 16 – RAL has not yet been defined in the body of the paper
- p.2, lines 30, 32 and elsewhere – Instead of "Sect" write "Section"
- p.4, line 10 – fix "but extensively modified is used"
- p.4, line 20 – do you mean "a change in RAL2-M"?
- p.5, line 21 – change "RAL2 to use" to "RAL2 uses"
- Tables – remove "%" from captions
- p.9, line 6 and 8, and elsewhere in case studies – remove the "0" from "04th December 2019"
- Results sections – no need to capitalise Winter and Summer
- p.9, line 23 – should be "Figure 11 shows RAL2 outperforms RAL1..."
- p.10, line 20 – rather than "in the longer time" give the hours for which RAL2-T performance is better than RAL1-T