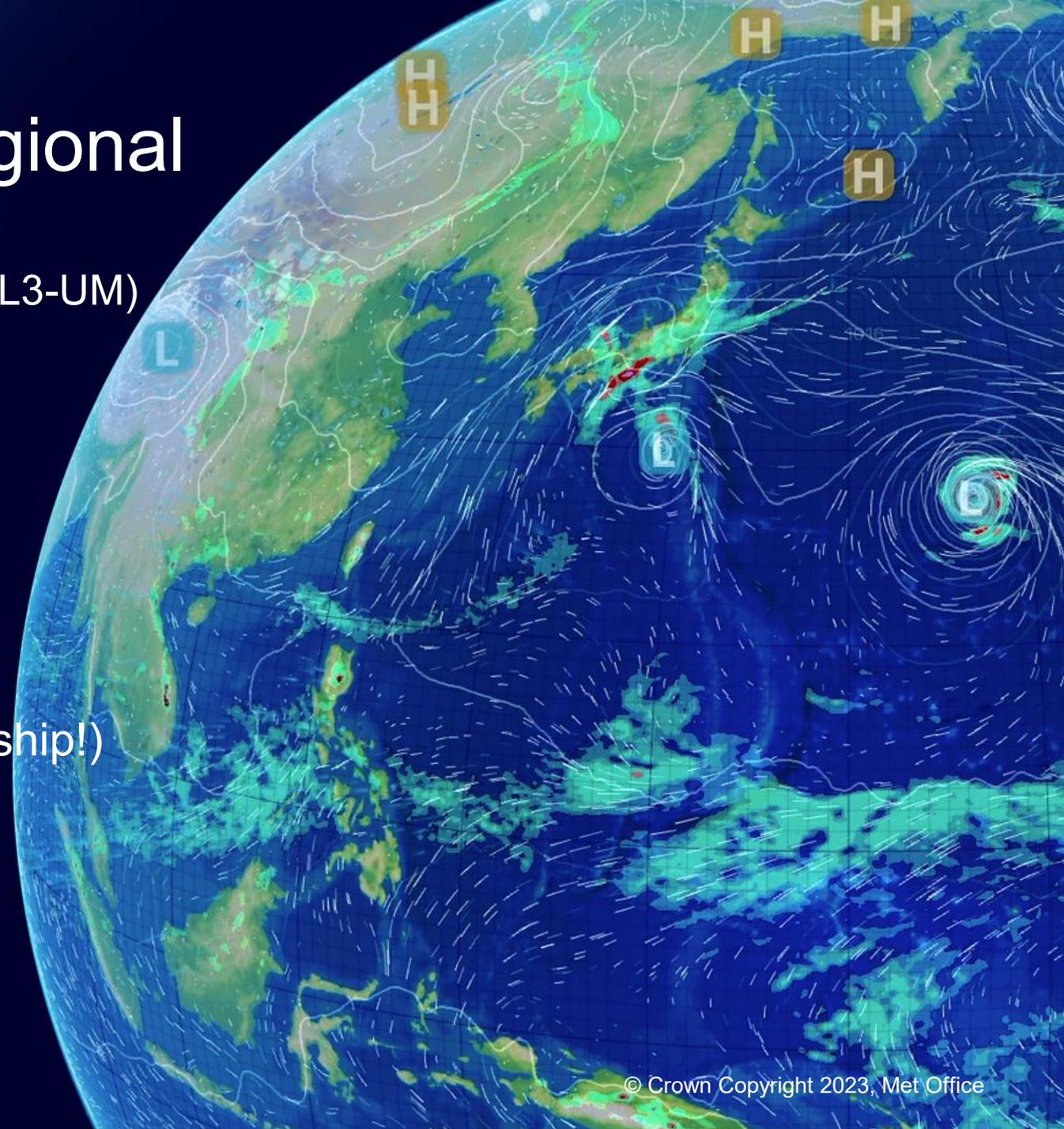


Latest updates to the UK regional modelling system

focusing on Regional Atmosphere and Land 3 (RAL3-UM) developments

EWGLAM 2025, Norrköping, Sweden
25th September 2025

Gareth Dow, Adrian Lock, Aurore Porson,
Paul Field, Anke Finnenkoetter et al
(=cast of dozens from around the MO partnership!)

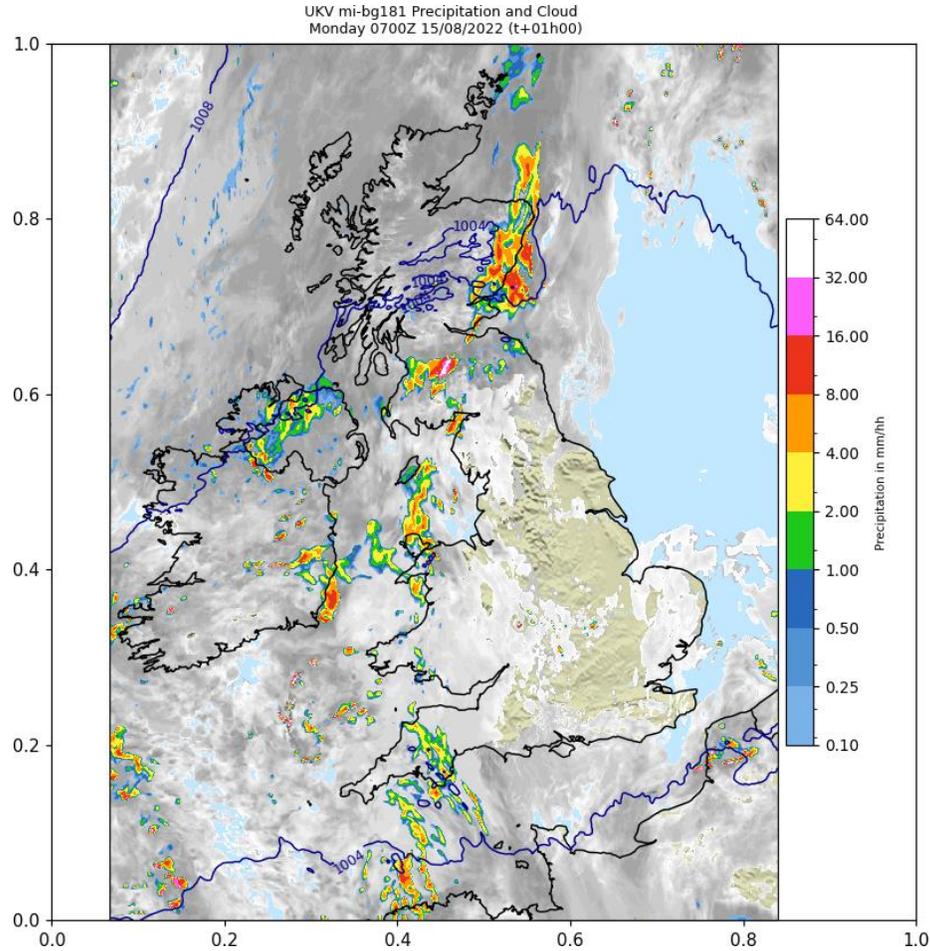


RAL - the “**Regional Atmosphere and Land**” configuration

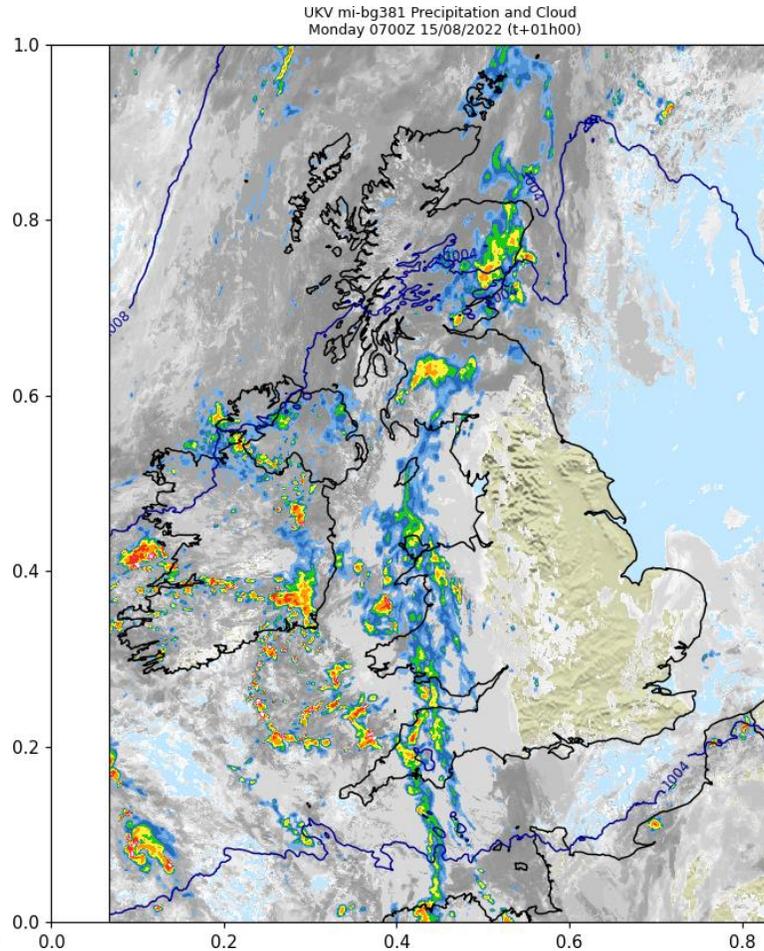
- **RAL** provides a single physics configuration for use in NWP operations, climate applications and research projects and ensures a coherent programme of regional model development
- **RAL2** used operationally since December 2019
- **RAL3** operational implementation planned for **January '26** as part of our PS47 update:
 - **Bi-modal cloud scheme**
 - **CASIM double moment microphysics**
 - Changes to land surface configuration
 - Unification of *mid-latitude* and *tropical* RAL configurations

RAL3 hallmark is much better envelope of light ppn (largely thanks to CASIM microphysics)

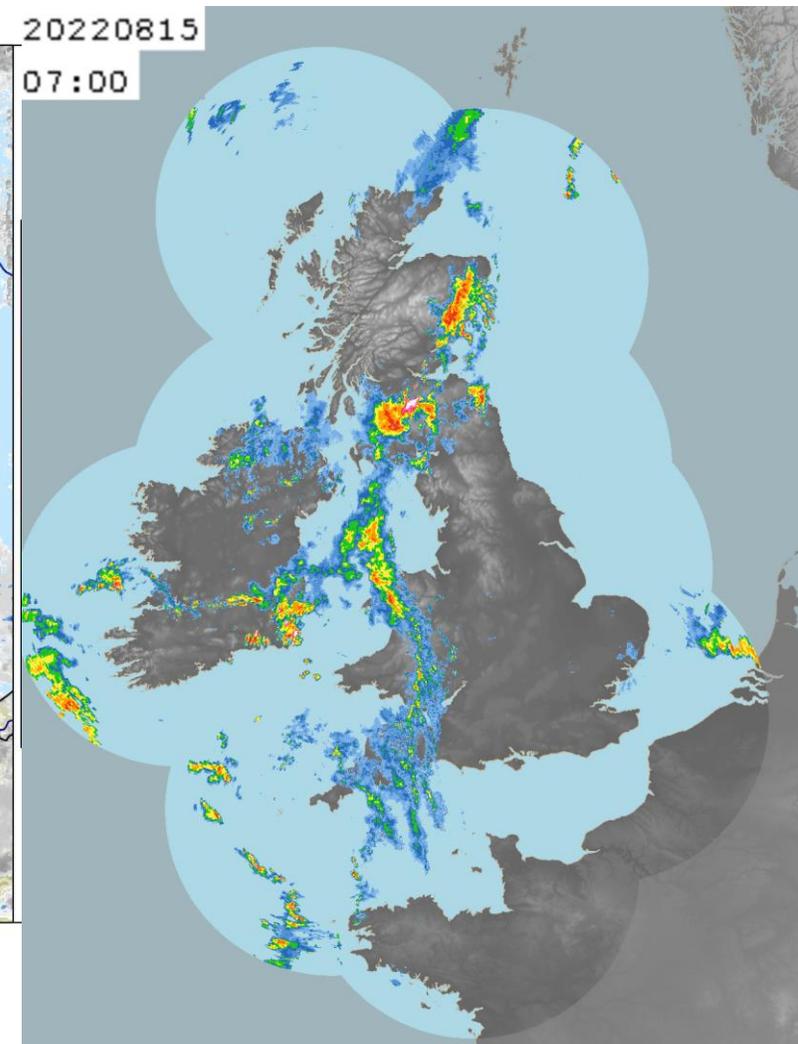
Control (RA2M)



RAL3



Radar composite

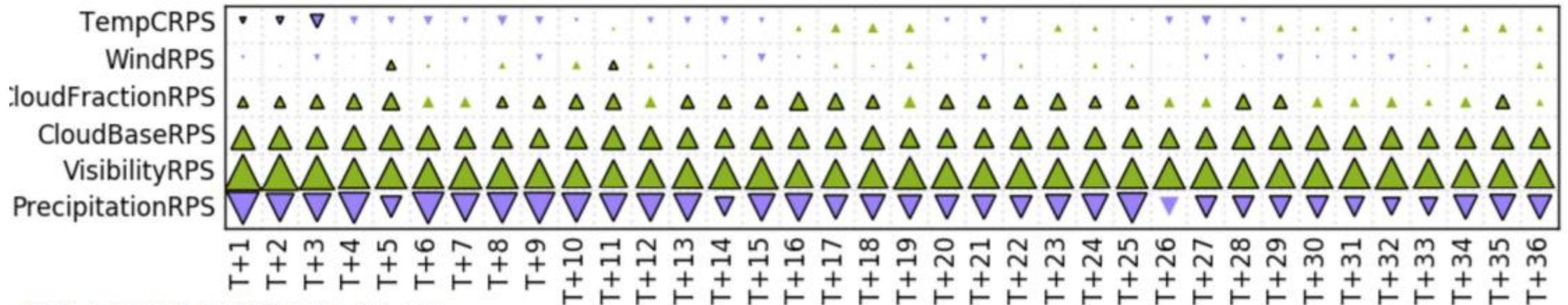


RAL3 was first released in August 2022 showing overall improvements over RA2M

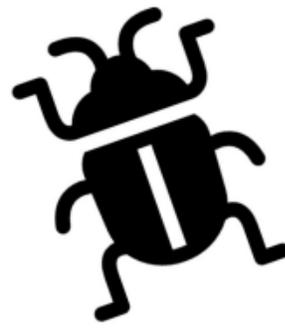
- Exacerbation of existing cold temperature bias
- Improved representation of clouds
- Improved visibility
- Precipitation worse against gauges, improved against radar. Distributions improved.
- Improved representation of convection

 RAL3 better
 RAL3 worse

7 grid lengths
max = 20

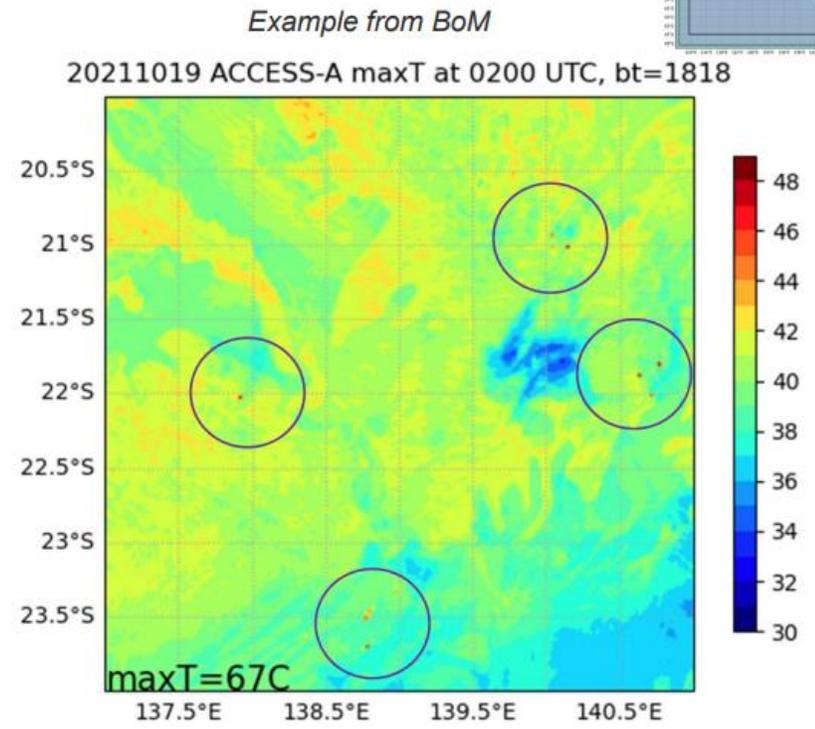
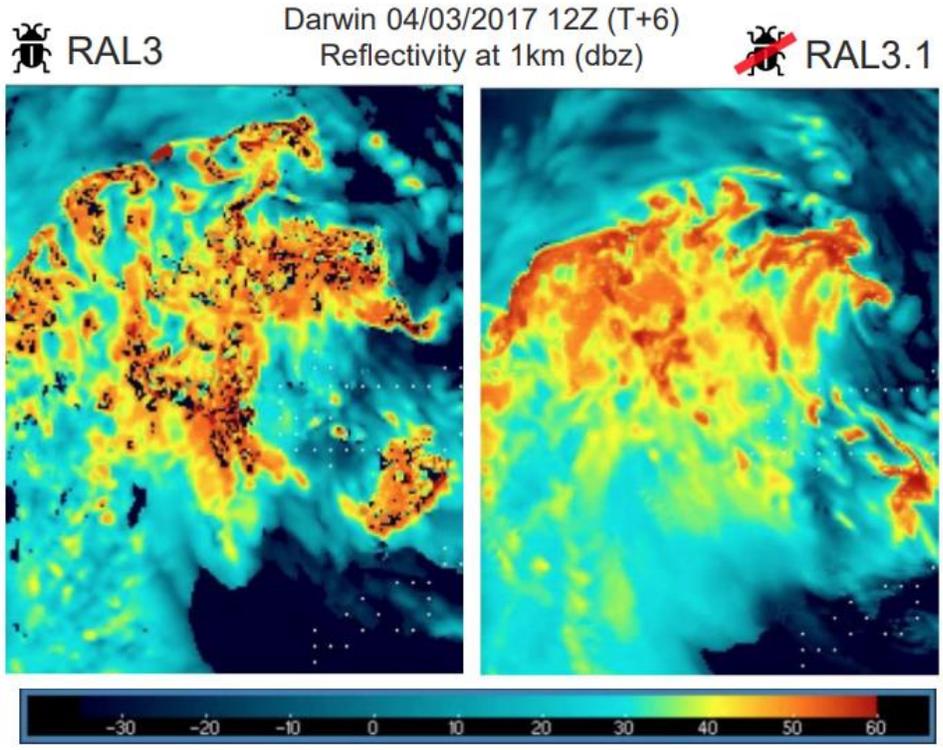


RAL3-RAL2-M UKV DA Trial Summer



 Radar Holes → RAL3.1

 Hot Spots → RAL3.2



RAL3

—

What happened next

	RAL3 Update	Rationale	Ticket
RAL3.1	Fix for radar holes	Bug Fix	#375
RAL3.2	Hot spot fix	Performance	#311
#504.1	Reconfiguration fix for qrain, qcf2 and qgraupel	Bug Fix	#479
#504.2	Rationalising choice of monotonicity schemes in ral3	Performance	#460
#504.3	Washout of MURK aerosol by CASIM	Performance	#471
#504.4	Radar holes part 2 + make ice-particle optical properties consistent with CASIM	Performance	#473
#504.5	Add stochastic perturbations near the boundaries	Performance	#531
#504.6	optimisation of visibility code	optimisation	#604
#504.6	Correction to the wind gust diagnostic	Bug Fix	#605
#504.7	Further revisions in ants to JULES ancillaries and LAI	Performance	#612
#504.8	correct the BiModal cloud scheme calculation of the 1st moment of the size distribution for CASIM ice and snow	Bug Fix	#640
#504.8	bug fix to pressure levels used in BiModal cloud scheme	Bug Fix	#639
#504.8	correction to calculation of frozen cloud fraction in BiModal cloud scheme	Performance +Bug Fix	#629
#504.8	retune of optical thresholding used in cloud-base and cloud-top height diagnostics, and low/medium/high cloud cover diagnostics	Performance	#637
#504.8	reduce bl_levels, turb_endlev_horiz, turb_endlev_vert from 69 to 60, to save 1-2% cpu time	Efficiency	#399

Post-RAL3.2 updates

Combo of performance, bug fix and optimisation issues

RAL3.3.1

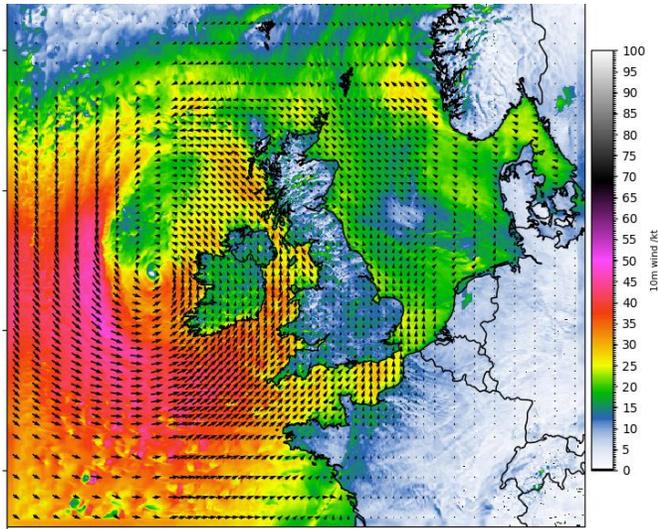
A look at some of the post- RAL3.2 updates:

- Correction to wind gust diagnostic (#605)
- Stochastic edge perturbations (#531)

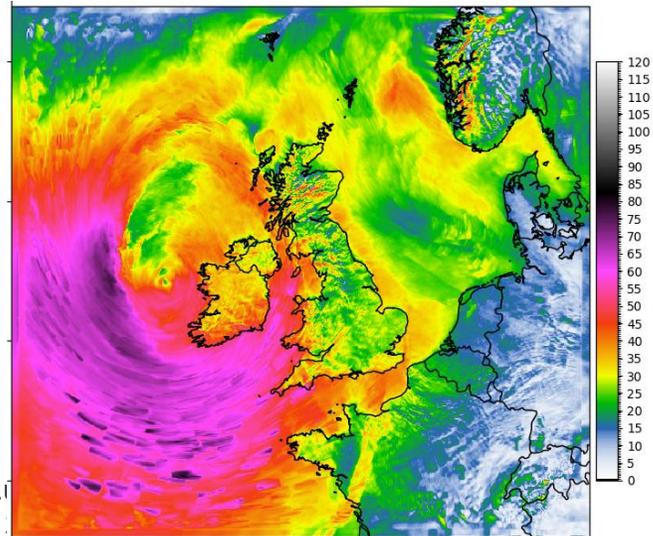
Correction to wind gust diagnostic (#605)

- Applies to RAL2M (operational) as much as to RAL3 (PS47)
 - Effectively a retune of empirical coefficient $c_{gust}=3.14$ # instead of 4.0
 - Weakens gust strength by around 10%
- Note RAL3 10m winds are also somewhat weaker than RAL2M - due to changes to surface drag over land and sea

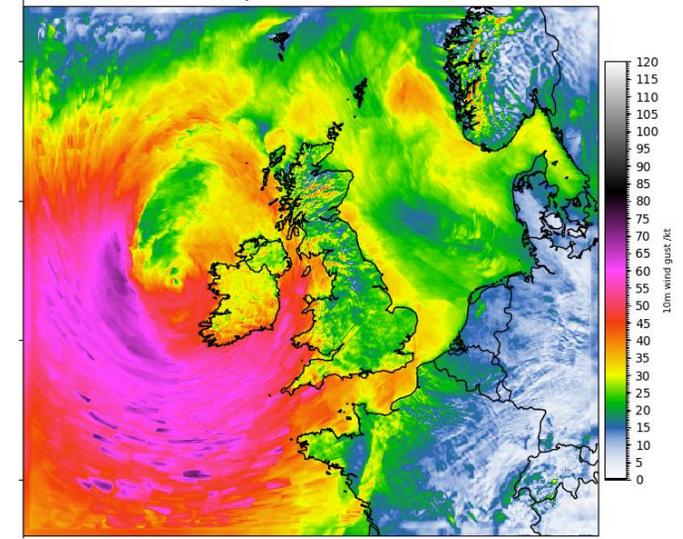
RAL3
10m wind speed



RAL3
10m wind gust



RAL3
10m wind gust corrected



12Z 19/10/2017
T+36

Stochastic edge perturbations (#531)

- In RA2M we apply stochastic BL perturbations over the whole domain

The stochastic perturbations make some buoyancy fluctuations in the boundary layer to drive resolved-scale ascent, as long as there is some static instability in the profile through which these incipient plumes can rise.

- They were removed with RAL3 because:

- (a) they can trigger spurious showers over the UK, eg in the morning of a somewhat suppressed convective regime
- (b) they can disrupt the model's dynamics from getting the convection organised (essentially by keeping on randomly triggering new convection)
- (c) of convergence of M and T (they weren't used in RA2T because (a) and (b) were even worse in the tropics)

- But they did promote the formation of showers from in-flow boundaries which now takes significantly longer in RAL3

Hence, we wish to reintroduce them around the boundaries of the domain, but it is important **not** to apply them over too large an area of the domain, where “too large” is not easy to be precise about. Essentially, we are looking for a “happy medium” – wide enough to be confident we'll give the dynamics enough variability to work with, but also narrow enough to avoid excessive triggering of small showers. 24 grid points is considered as a safe option.

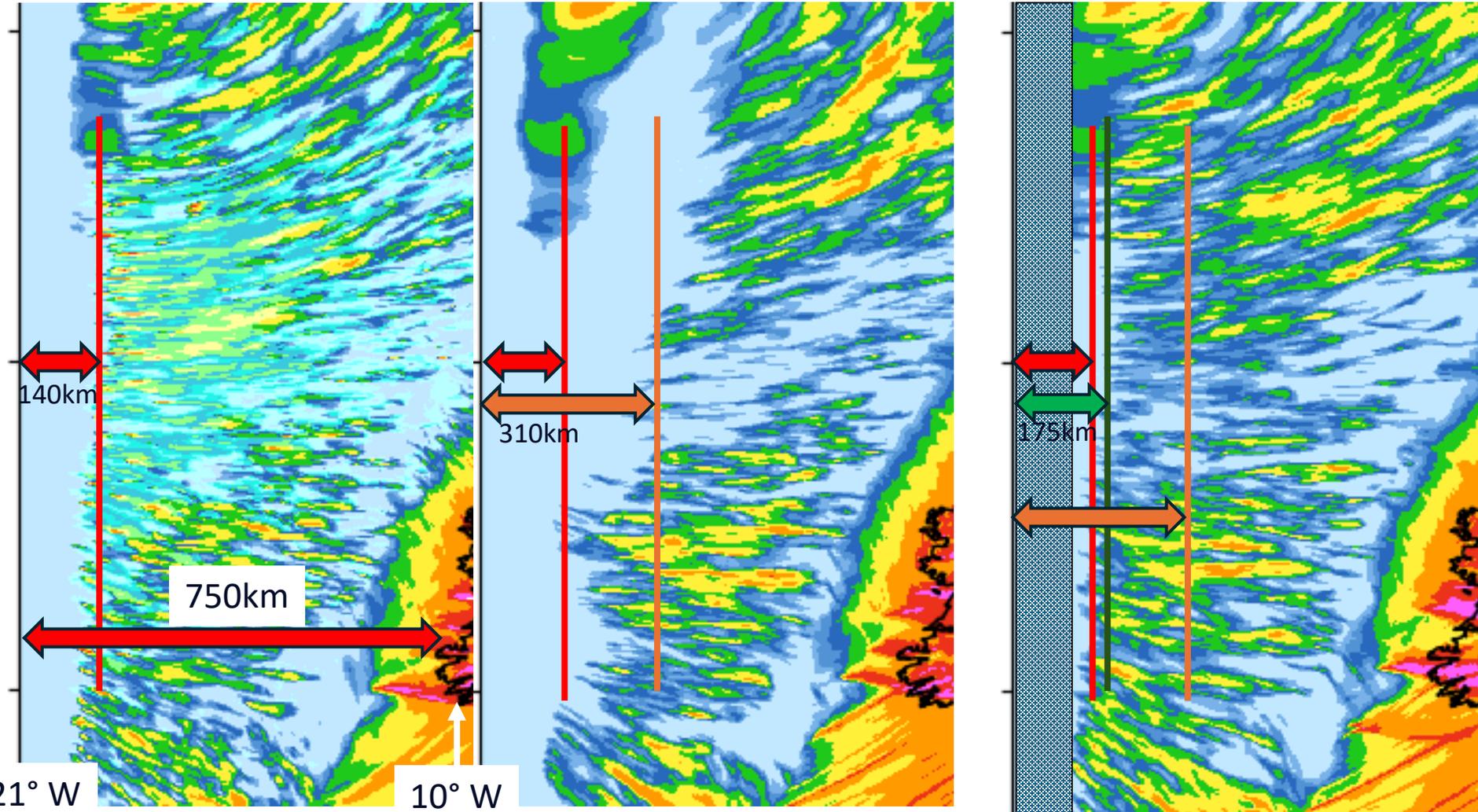
Comparing RA2M vs RAL3.2#504.4 with and without boundary perturbations

00z 7/11/2017 T+36

RA2M

RAL3.2#504.4

RAL3.2#504.4
+24 pt perturbations



Attempting to be quantitative about the spin-up distances:

- RA2M: 140km = 35pts
- RAL3: 310km = 77pts
- RAL3+perts: 175km = 43pts

Recall, outer UKV 4km zone is 165 points wide

Even with edge perturbations, RAL3 is a little slower to spin up than RA2M, but then the precip is qualitatively different

RAL3 is 80% slower to initiate precipitation without edge perturbations, than with

And some more:

Cold Wintry easterly:



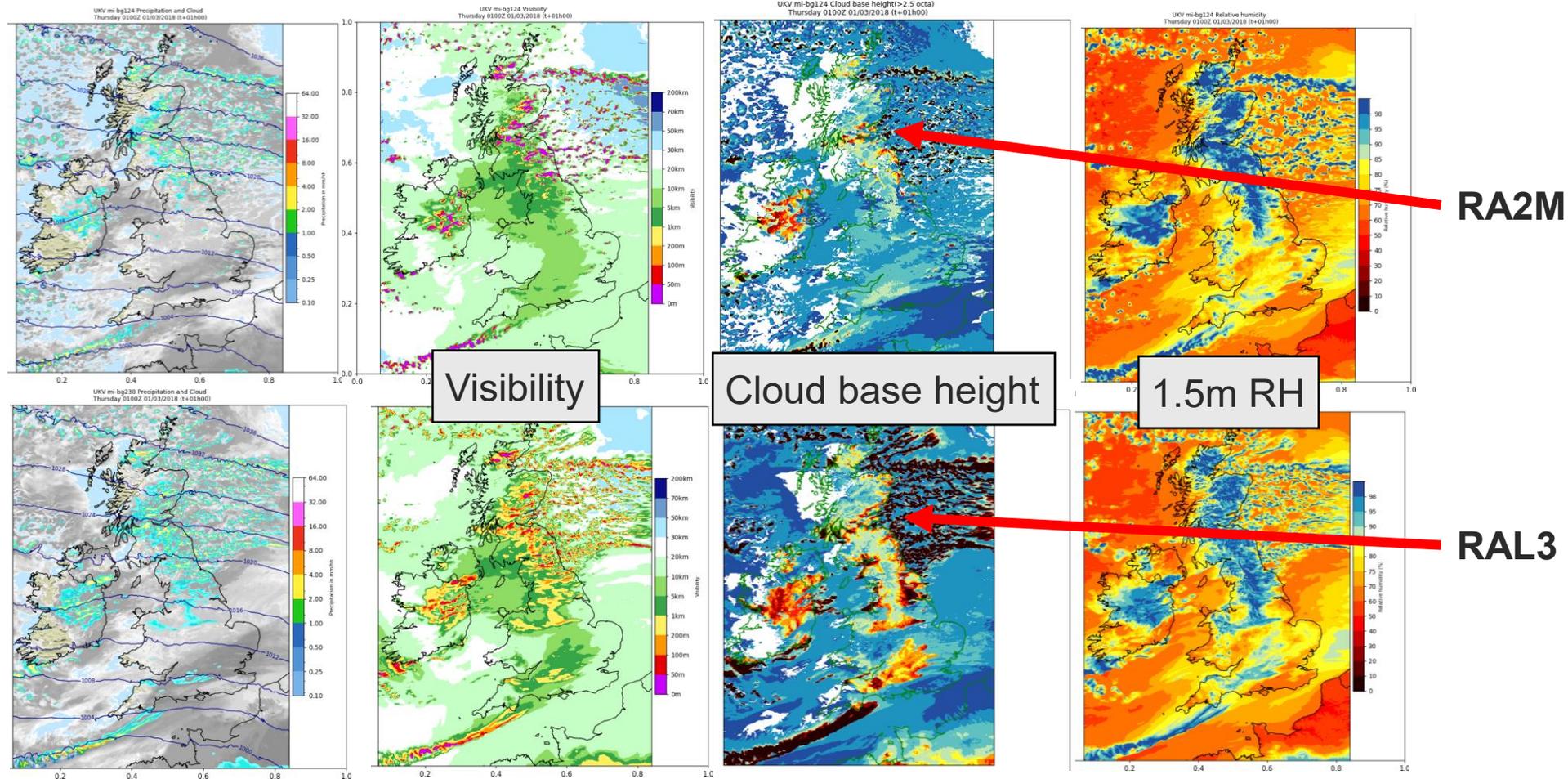
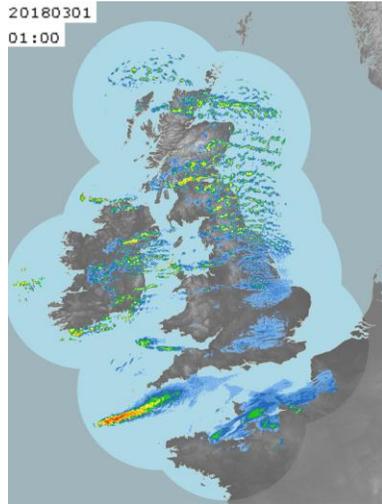
Cloud-base heights issues

- cflmax fix (#629)
- introduction of tau threshold (#637)

Overly widespread reduction of cloud height bases in cold showery easterlies

- During the course of PS47 assessments (actually to check boundary shower spin-up) we noticed that **the areal extent of reduced cloud base heights in association with wintry showers seemed to be excessive in cold easterly regimes** – certainly compared to RA2M.

1st Mar 2018 0z T+1



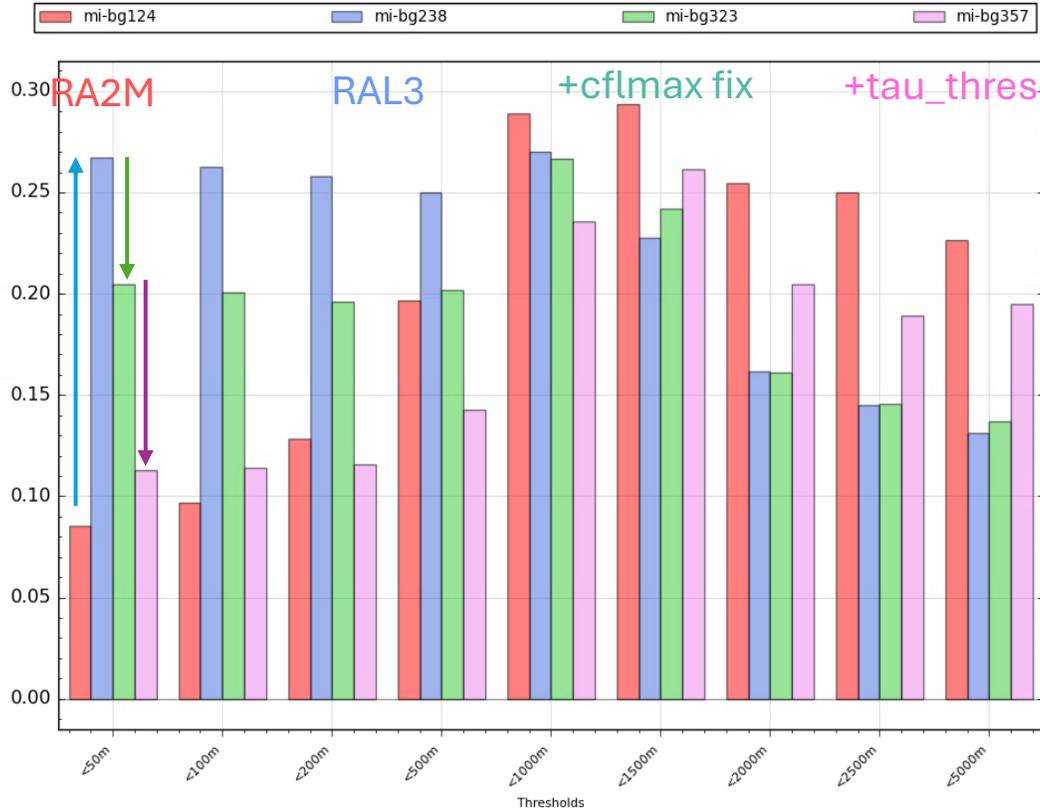
Concern over the more widespread 2-octa-CBH<100ft with RAL3 with RH<95%

- in RAL2M these correspond to areas with RH>98% (due to stronger snow evaporation)

- **The correction to the bimodal cloud scheme to obtain a more realistic frozen cloud cover (#629)** improves the scores for cloud base heights for the very low cloud base heights and does not affect the verification of the higher cloud base heights
- **The addition of the tau_threshold (#637)** further improves the very low cloud base heights issues (and also reduces the risks of having widespread sub-optical high clouds). However, the higher end of the cloud base heights, in terms of Brier Scores, does verify less well. Overall, the scores do now look similar to RA2M, both at the low end and higher end of cloud base heights.
- Also reassurance from case studies that the impact is negligible for the summer

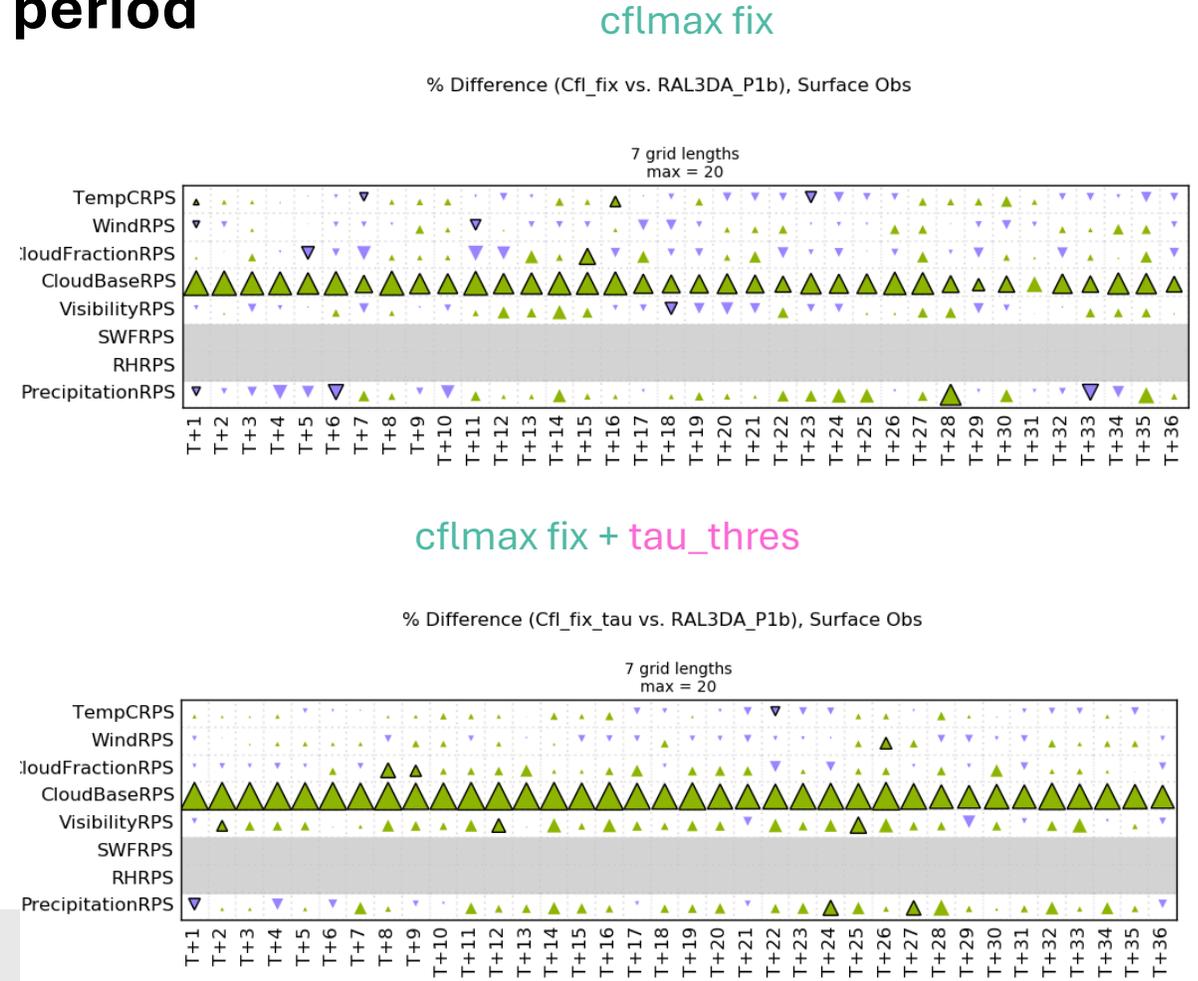
Cloud base heights improvements (cflmax bug #629 and tau_thresh #637)

Cloud Base Height (given 2.5 Oktas Cloud Cover),
 Brier Score (Ensemble FC(j) (Excluding Control)), Current UK Index station list, T+36,
 Meaned between 20180226 00:00 and 20180301 18:00, Surface Obs



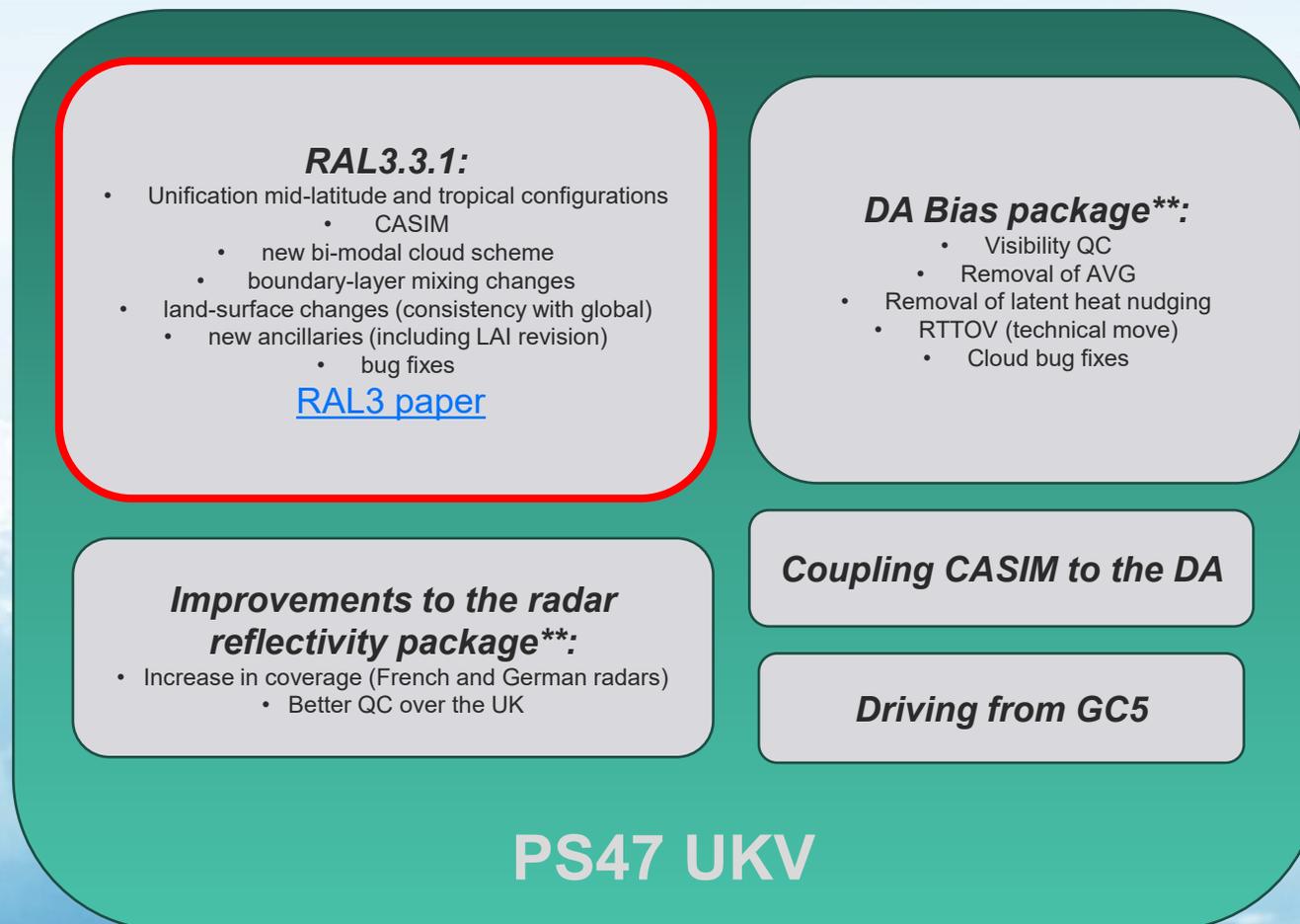
- Large benefit of cflmax and tau_thresh at lower cbh thresholds.
- Reduced benefits at higher thresholds.

Beast from the East (Feb/Mar 2018) period



cflmax fix + tau_thresh

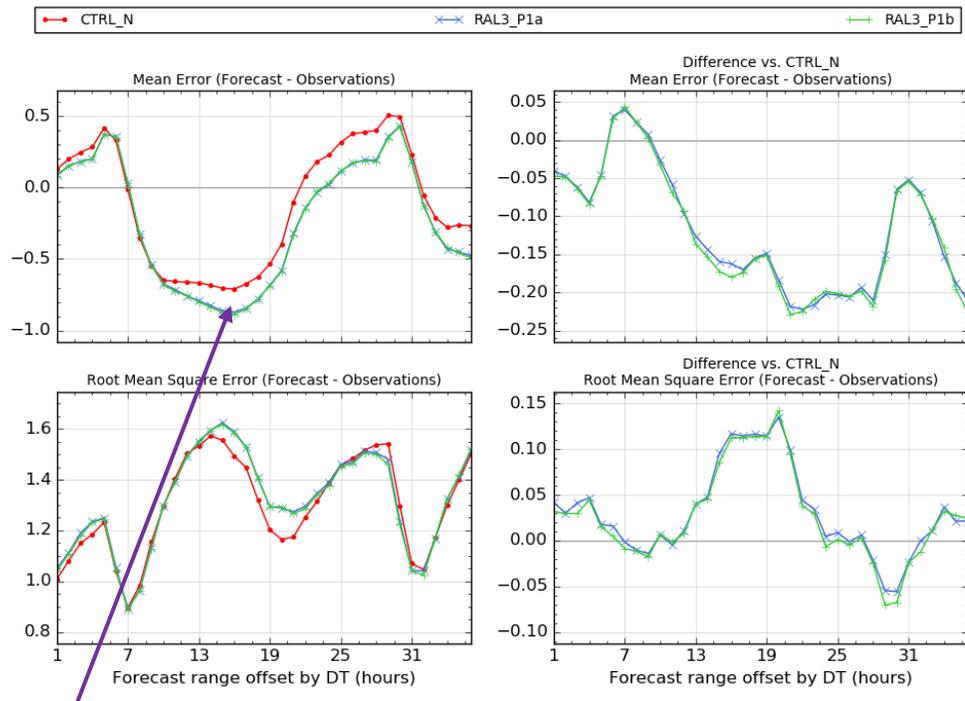
Final **RAL3.3.1** testing within our UKV PS47 testing framework



What's happening with the summer temperature?

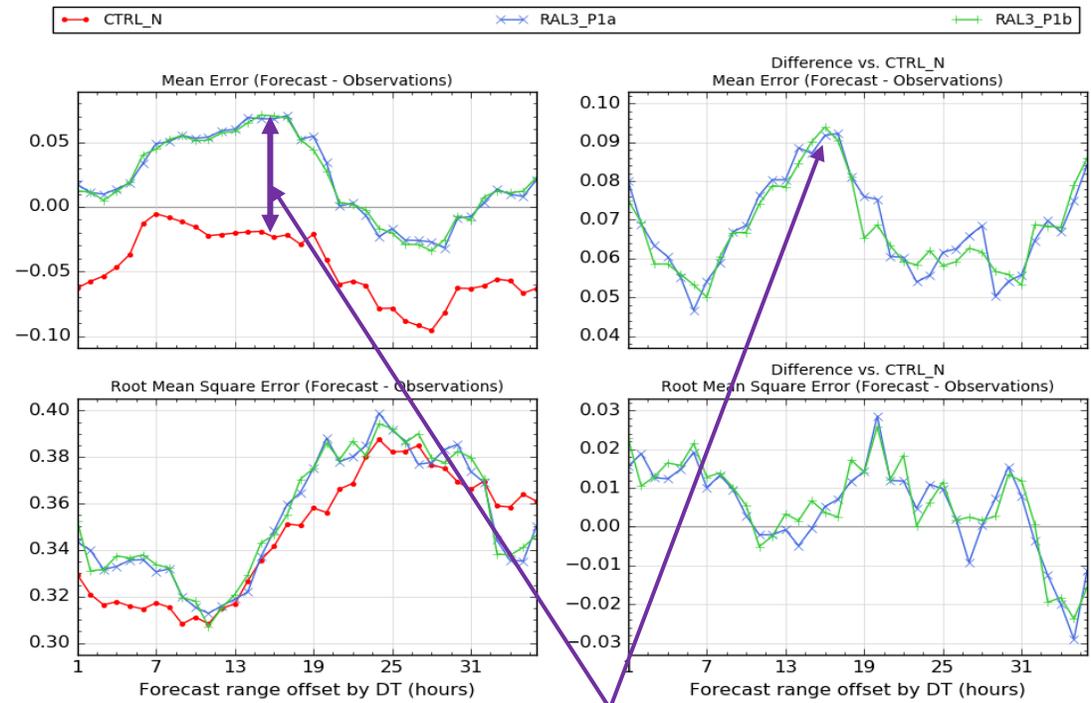
-> Poorer cold daytime bias -> further investigations with SW and cloud verification ongoing (RAL3 more low and medium clouds)

Surface (1.5m) Temperature (K), WMO Block 03 station list, 00Z DT, Equalized and Meaned between 20220708 00:00 and 20220808 00:00, Surface Obs



RAL3 colder in afternoon

Ceiliometer Cloud Amount, WMO Block 03 station list, 00Z DT, Equalized and Meaned between 20220708 00:00 and 20220808 00:00, LND SYN - Auto



Cloud bias gap greatest in afternoon ?

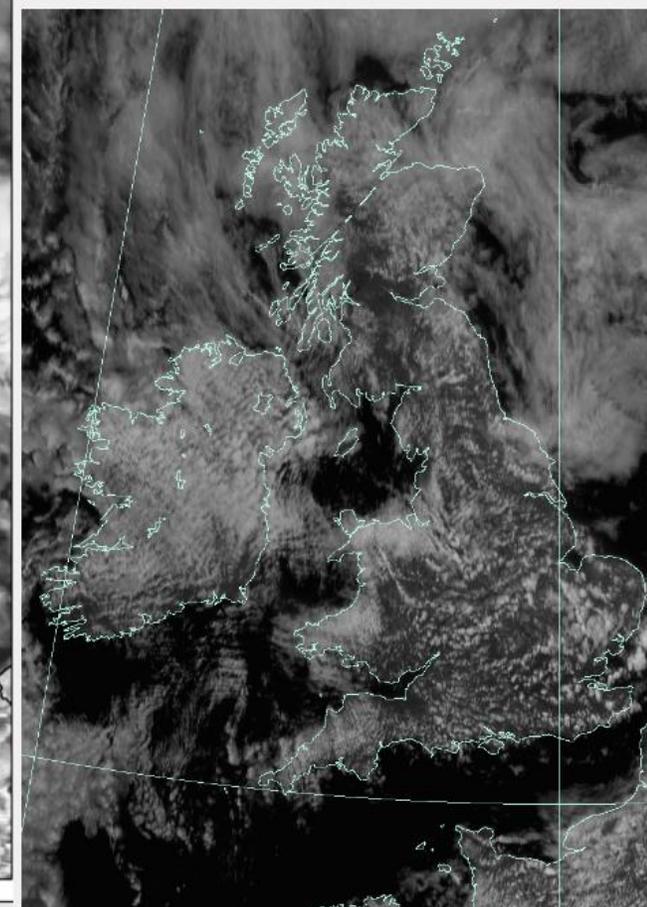
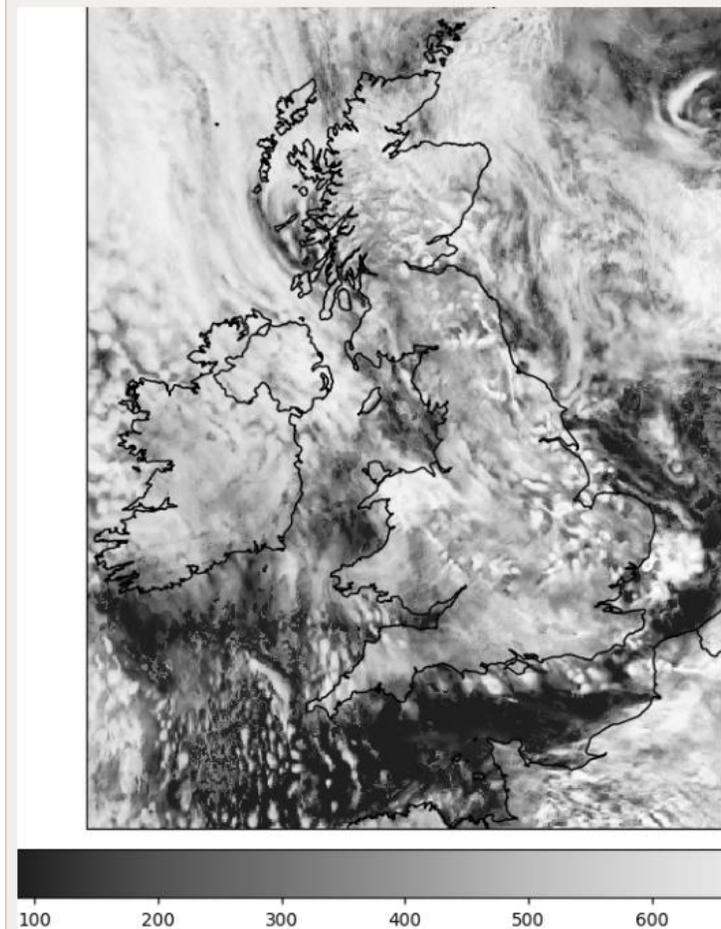
Diurnal spin-up of convective clouds June 'fairweather' cumulussubstantially contrasting cloud representations between the two models

RAL3

RA2M

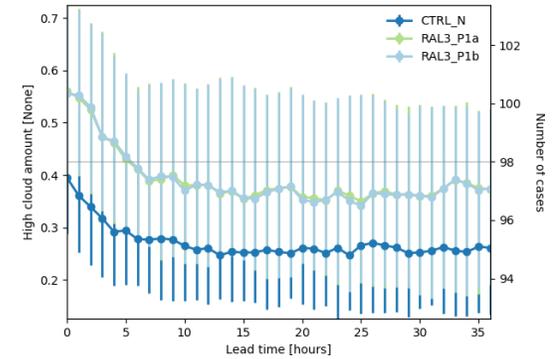
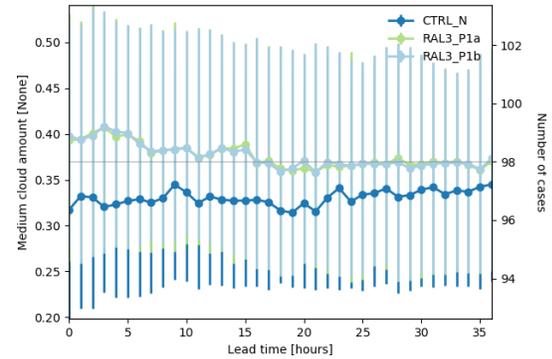
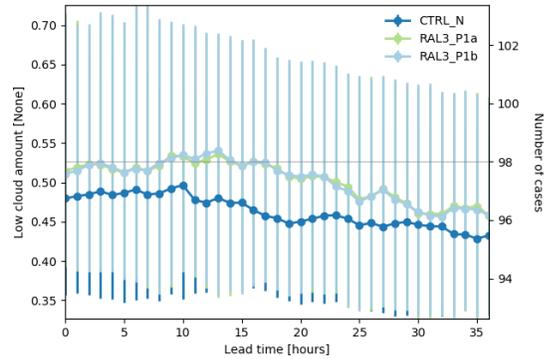
Satellite

Satellite observations: Visible light



RAL3 cloudier in general than RA2M

Summer

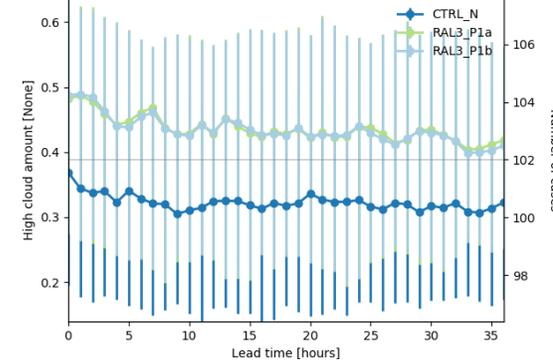
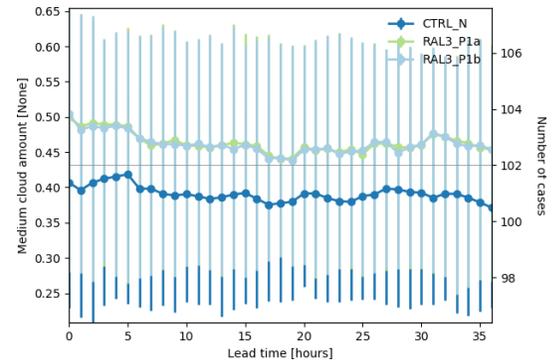
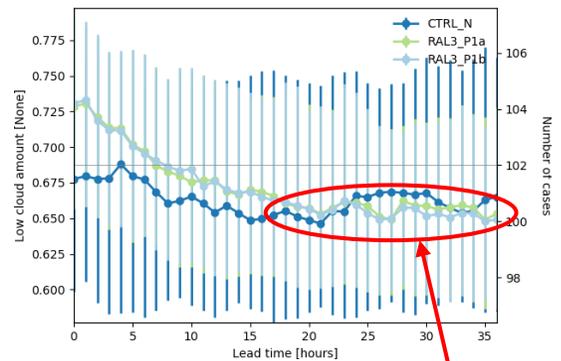


Low

Medium

High

Winter



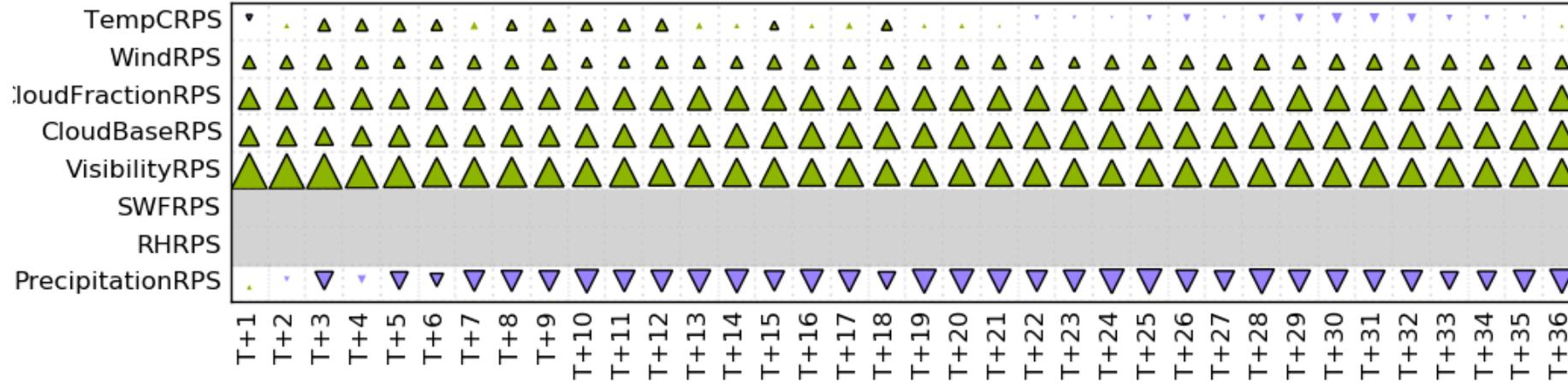
....although some loss of low cloud in winter, traced to anticyclonic regimes

Summer '22 (~10 weeks)

PS47 vs OS45

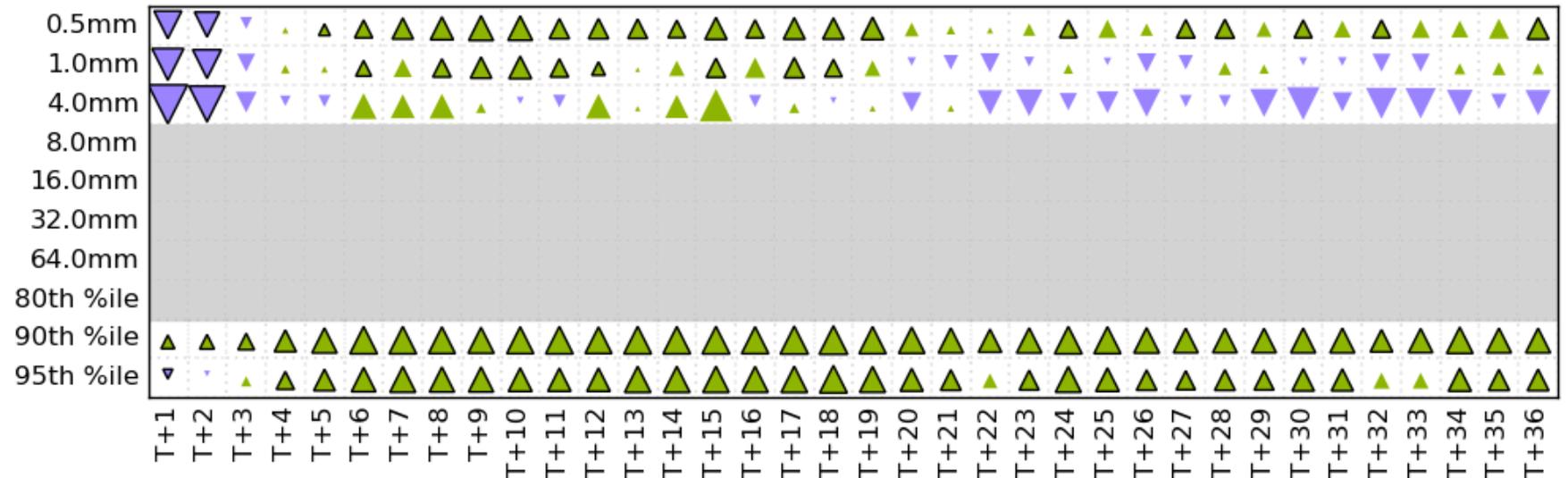
HiRA scorecard

7 grid lengths
max = 20



25 grid lengths
max = 20

FSS (ppn)



RAL 3.3.1 Summary

- Number of performance tweaks and minor bug fixes since original issue of RAL3 physics configuration
- Taken as a whole RAL3 outperforms RA2M across a range of parameters:
 - **Precipitation.** Improved precipitation envelopes and light rain.
 - **Cloud and cloud base heights.** Improved cloud cover. Significantly improved cloud base heights especially associated with fronts.
 - **Temperatures.** Winter cold bias reduced.
 - **Winds.** Improved surface winds over land and sea including gusts.
- In general RAL3 tends to be cloudier than RA2M
 - Good for UK winter T2m
 - Not quite as good for summer T2m as tends to (further) inhibit diurnal cycle
- RAL3 operational implementation as part of PS47 package expected in **Jan '26**