Towards RAL3 operationalisation at the Met Office

(focusing on more recent developments)

2024 Momentum®UK Partnership Convective Scale Workshop

12th September 2024

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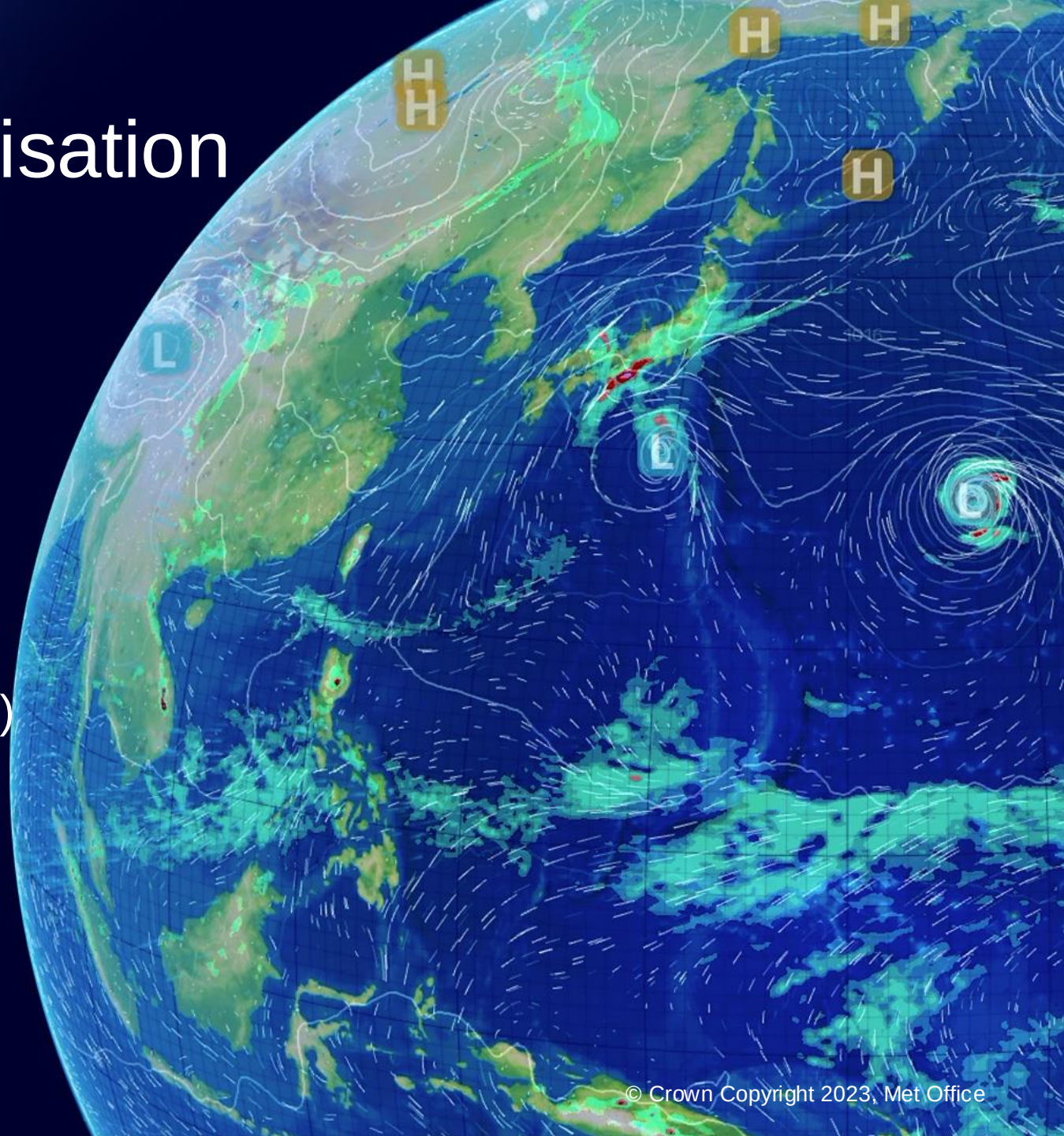
(=cast of dozens from around the partnership!)



Post-RAL3 updates

	UM Update	Rationale	Ticket	MSS / NCMRWF	RAL3 P1b (Conservative)	Stretch
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	correction to calculation of frozen cloud fraction in BiModal cloud scheme	Performance + Bug Fix	#629			✓
#504.8	bug fix to pressure levels used in BiModal cloud scheme	Bug Fix	#639			✓
#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	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			✓

RAL3 conservative package additions on top of #504.4

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

Optimisation of visibility code (#604)
Further revisions in ants to JULES ancillaries and LAI (#612)

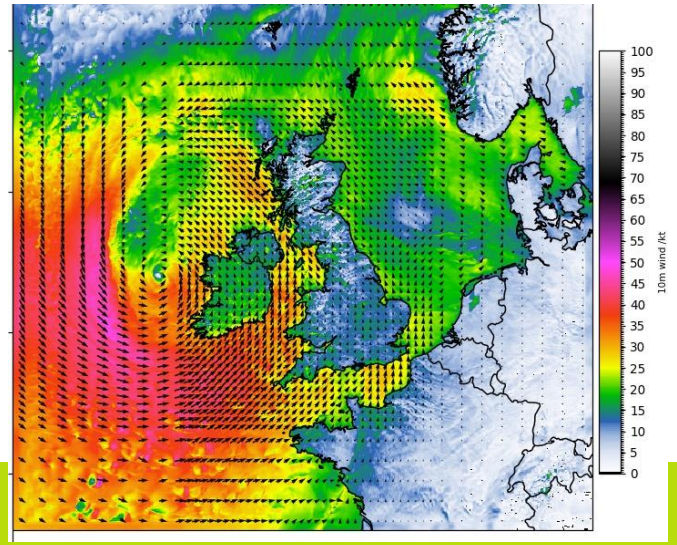
Correction to wind gust diagnostic (#605)

- 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%

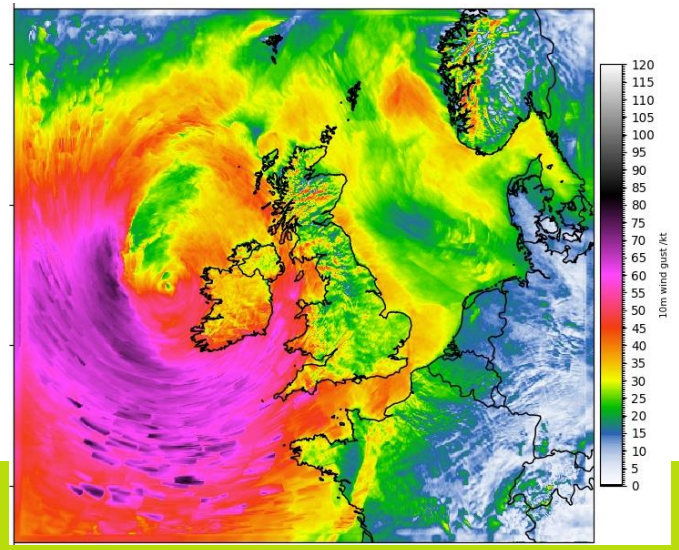
- Note RAL3 10m winds are also somewhat weaker than RAL2M - due to changes to surface drag over land and sea

12Z 19/10/2017
T+36

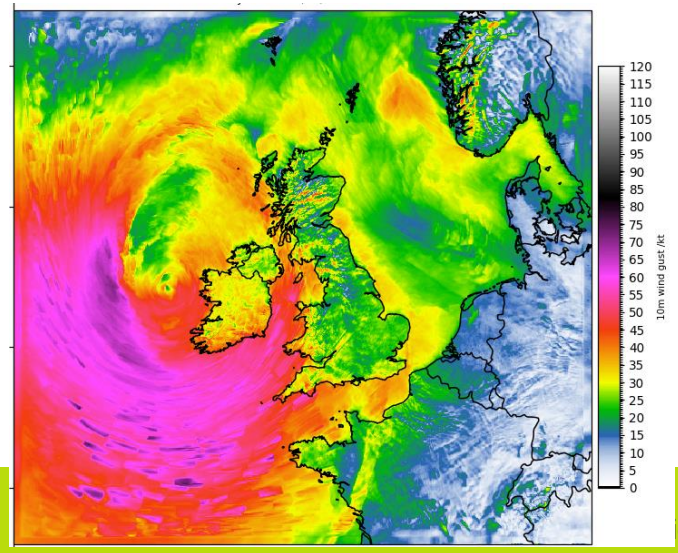
RAL3
10m wind speed



RAL3
10m wind gust



RAL3
10m wind gust corrected



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 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

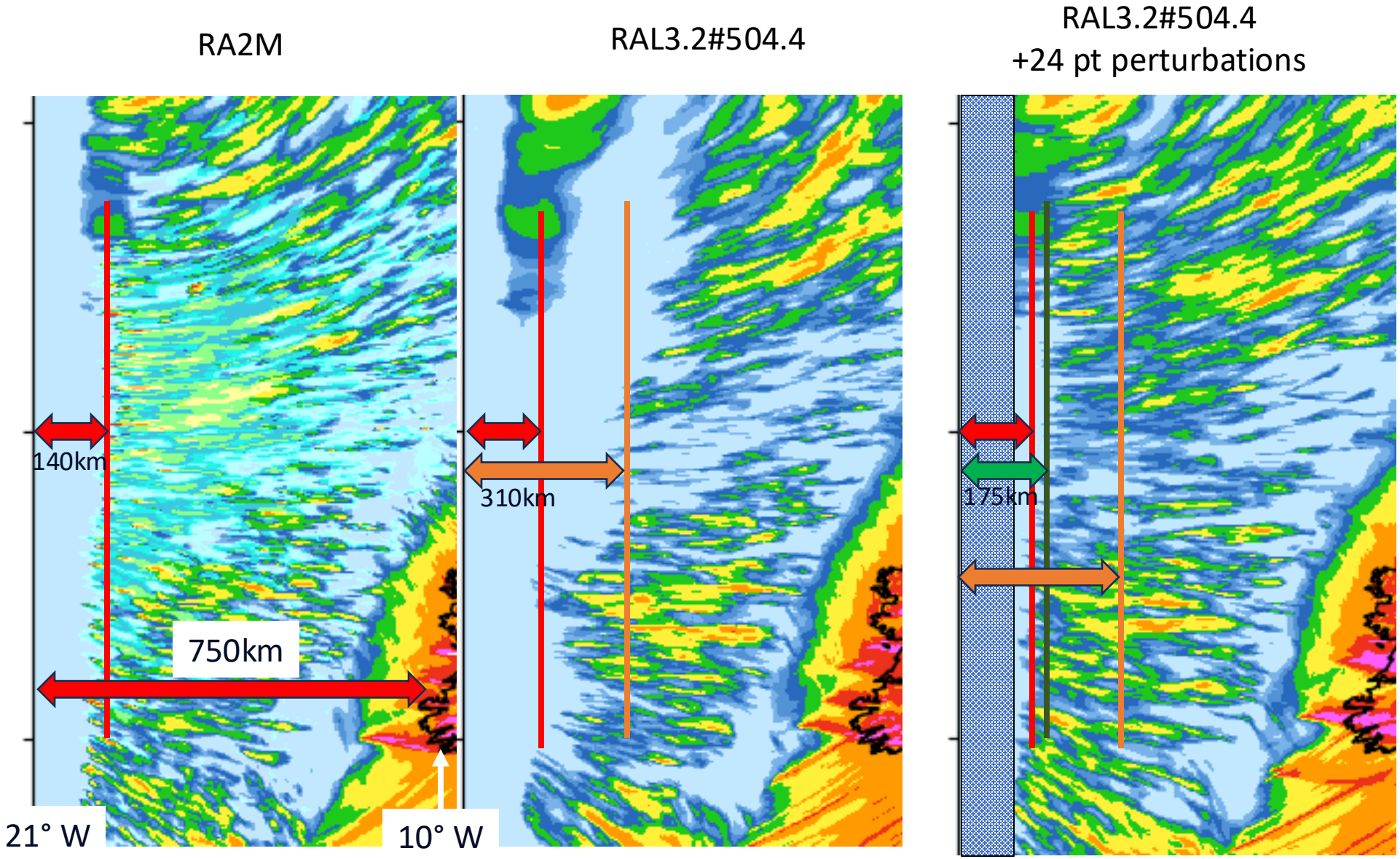
Attempting to be quantitative about the spin-up distances:

- 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



RAL3 stretch package additions

Winter easterly Cloud-base heights investigations

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

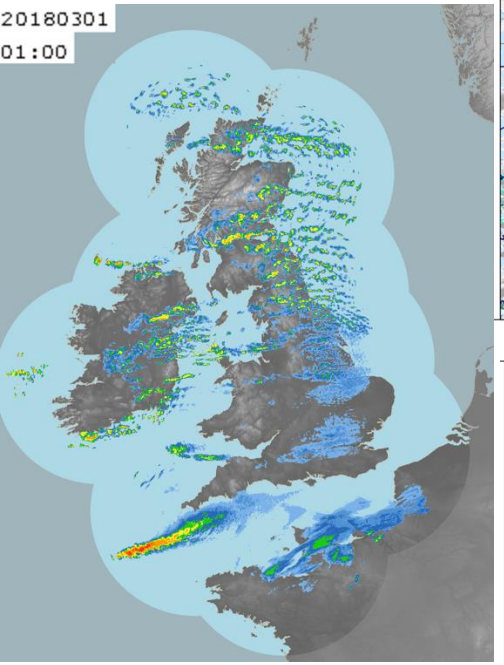
New physics bugs fixes and optimisation (#639,#640,#399)

1st Mar 2018 0z T+1

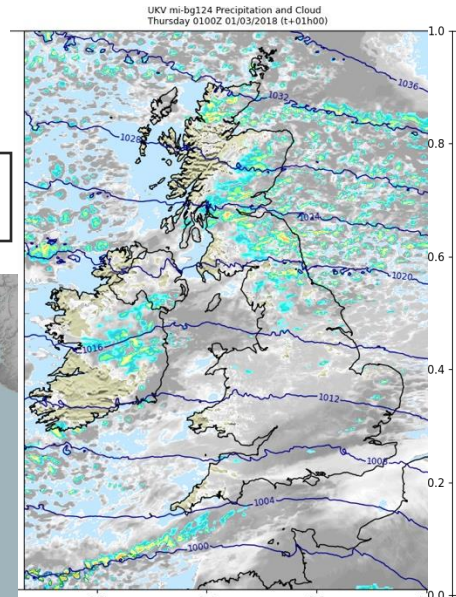
Concern over the more widespread 2-octa-CBH<100ft with RAL3 with RH<95%

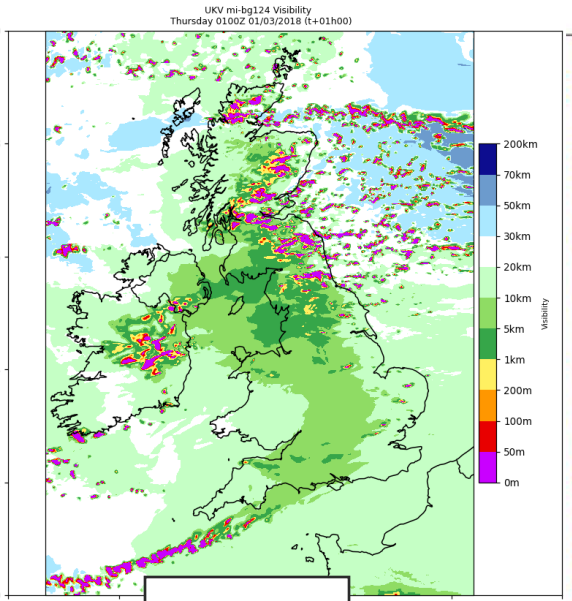
- in RAL2M these correspond to areas with RH>98% (due to stronger snow evaporation)

RAL2M

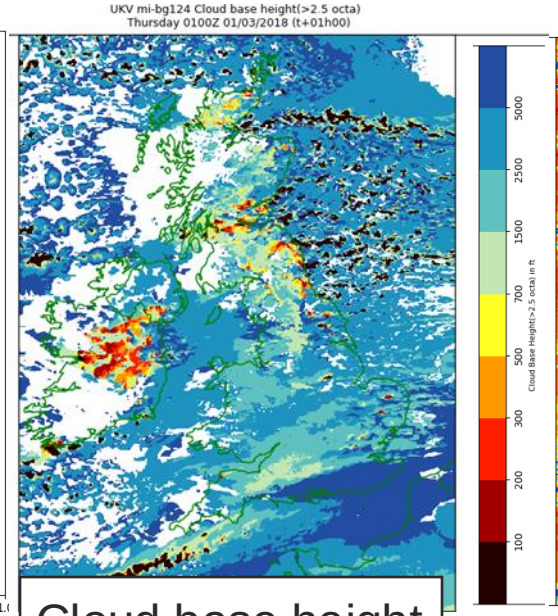


RAL3

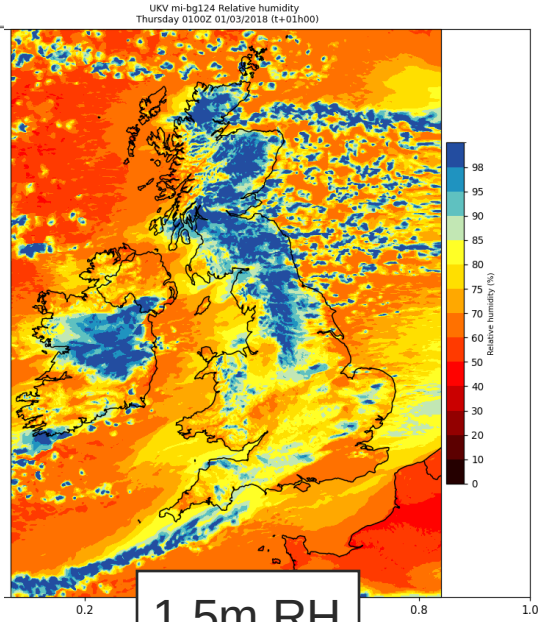




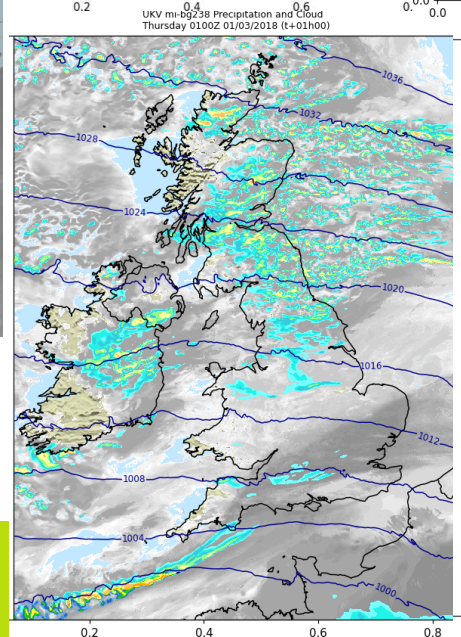
Visibility

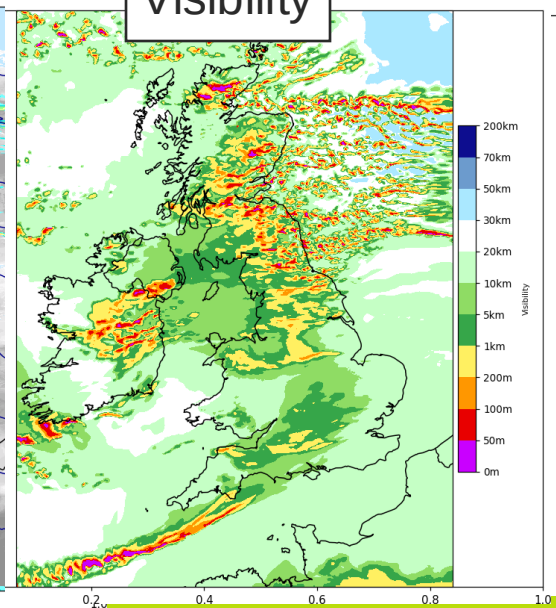


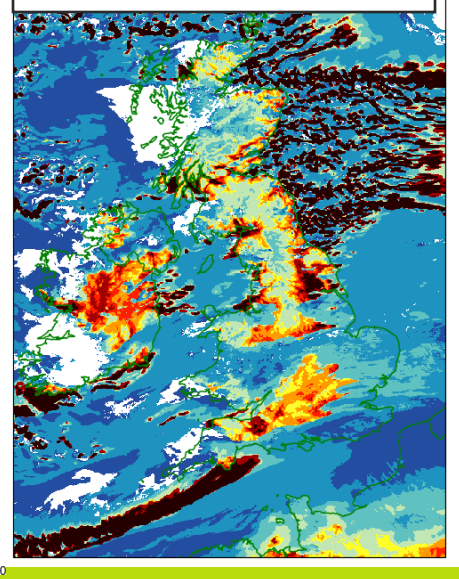
Cloud base height

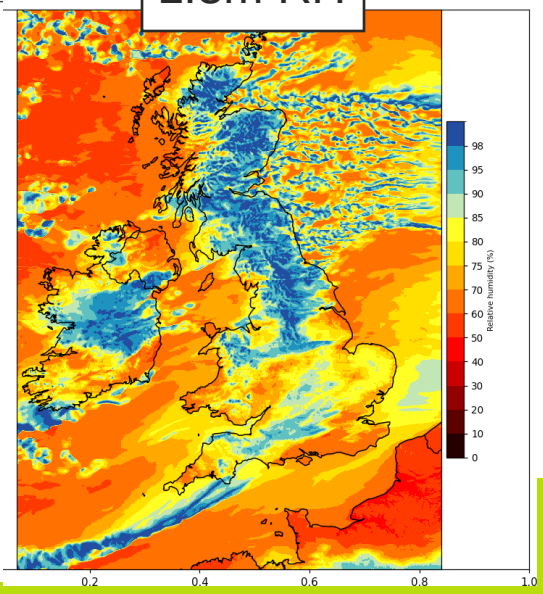


1.5m RH









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.

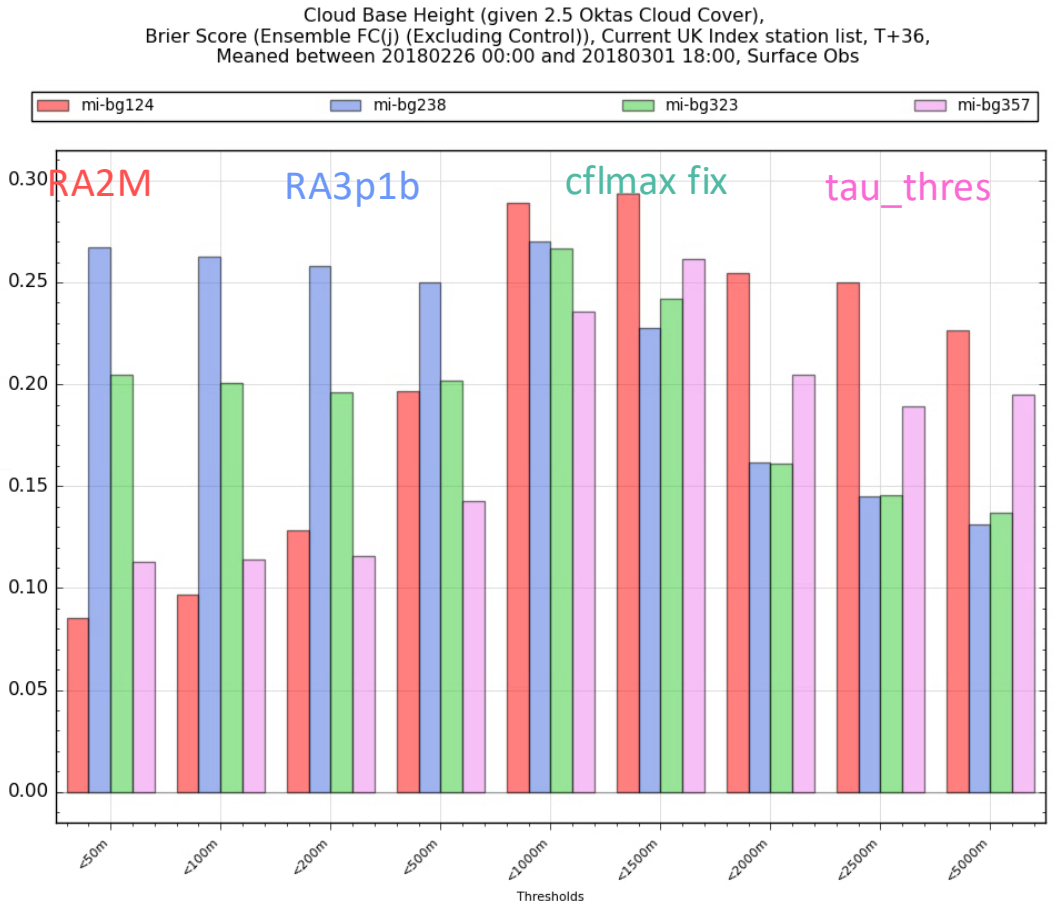
- The correction in the bimodal cloud scheme to obtain a more realistic frozen cloud cover (#629) improves the scores for cloud base heights for the very low cloud base heights and does not affect the verification of the higher cloud base heights

- 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 what we've had for 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

=> Strong candidate for stretch package

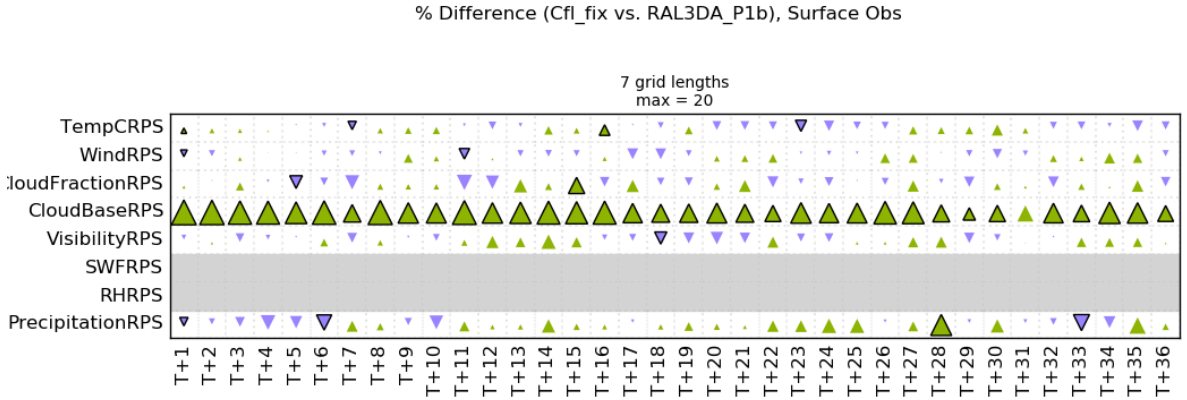
Cloud base heights improvements (cflmax bug #629 and tau_thresh #637)



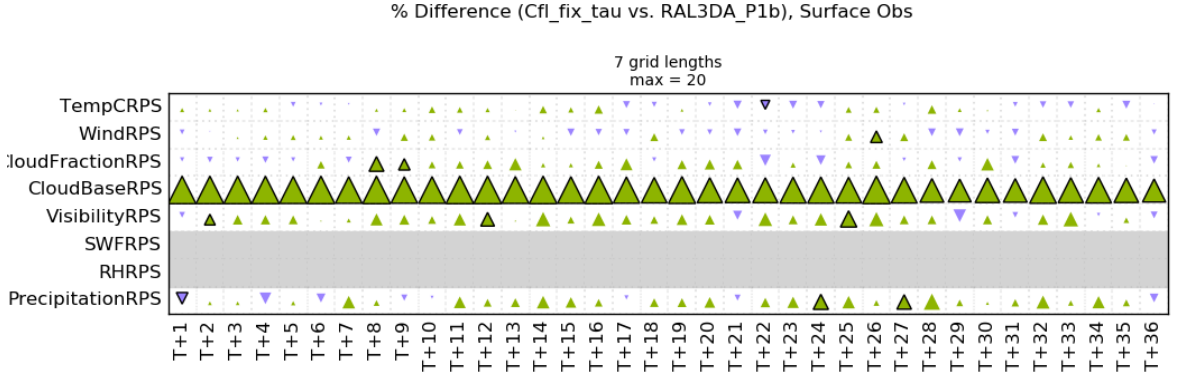
Improvements to cloud base heights slightly reduced, with the addition of the tau_threshold retune, in the RPS due to increase in Brier scores at the higher end of cloud base heights. However, larger benefits at the lower end of cloud base heights.

Beast from the East (Feb/Mar 2018) period

cflmax fix

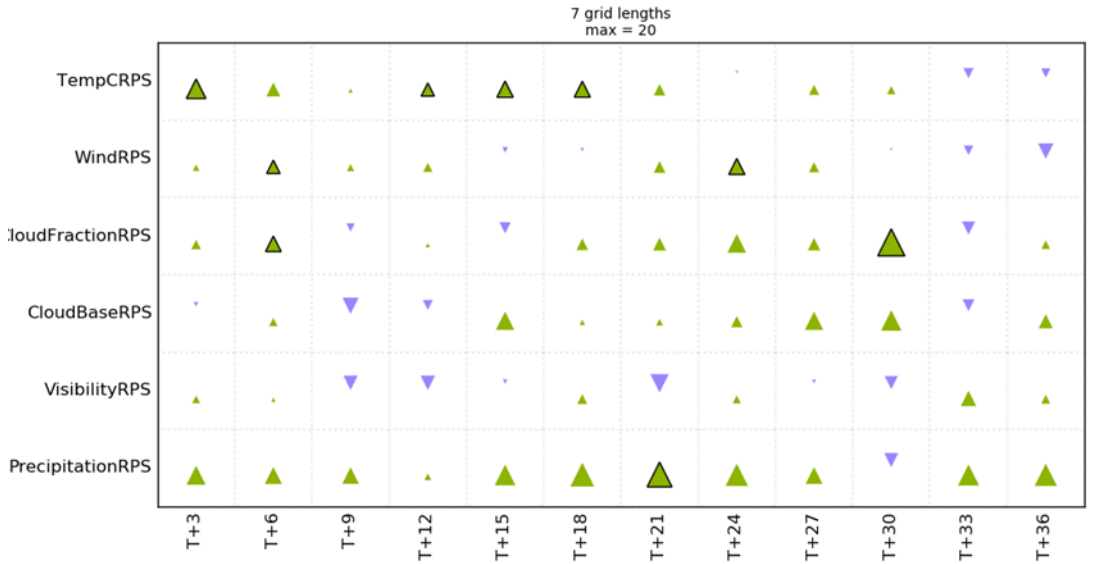


cflmax fix + tau_thres

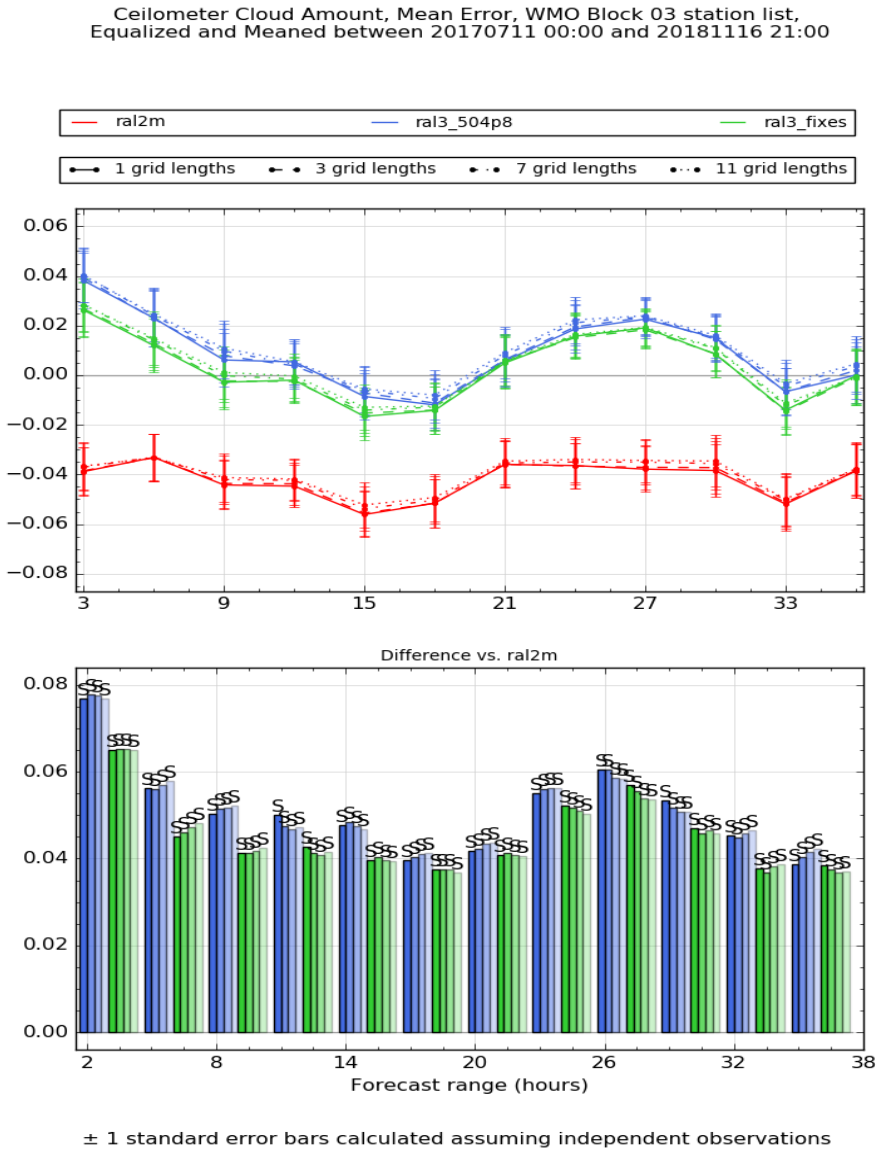


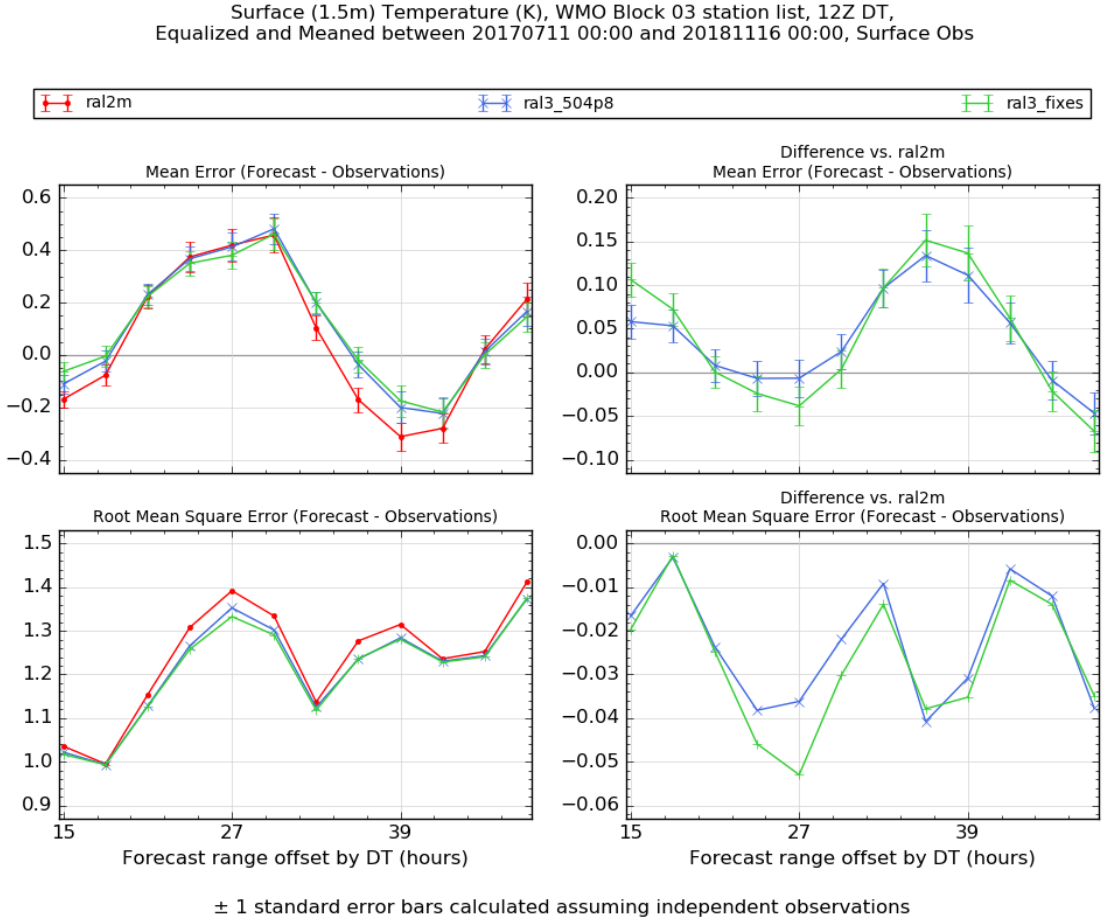
New physics bug fixes and optimisation

- Fix level pressure indexing in Bi-modal scheme #639
- Correction bimodal bm_calc_tau #640
- Optimisation of B-L levels #399 with bl_levs=60 with 1-2% cost saving and neutral verification from case study suite



Slight reduction in cloud cover and slight improvement in diurnal cycle





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Testing in pre-op PS47 trials

RAL3P1b vs RA2M Evaluation

(ie without stretch package changes).

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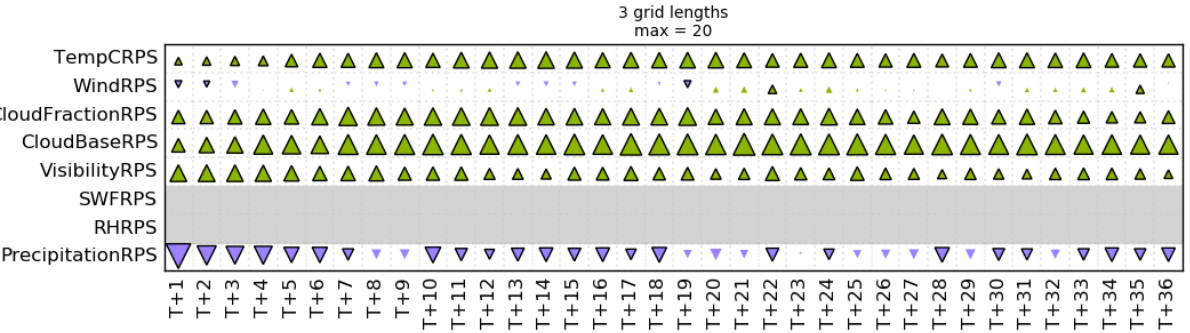
UKV PS47 Research Component Progress

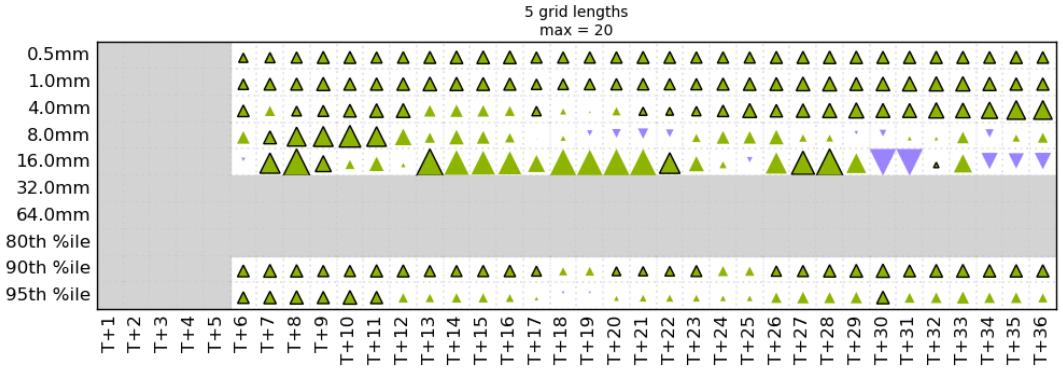
Package Name and Description	Progress	Periods
RA2M Control	Completed	**Summer 22, Winter 21-22**, Wet Week Aug 22, Winter Easterlies
RAL3 P1a (without CASIM DA)	Nearly completed	Summer 22, Winter 21-22, Wet Week Aug 22
RAL3 P1b (with CASIM DA)	Nearly completed	**Summer 22, Winter 21-22**, Wet Week Aug 22, Winter Easterlies
RAL3 P1b + DA Bias Package	Ongoing	Summer 22, Winter 21-22, Wet Week Aug 22
Reflectivity tuning -> definition final package	Completed	Wet week Aug 22
Final Conservative and Stretch Packages (driven by GC4)	Not long started	Summer 22, Winter 21-22
Final Stretch Package (driven by GC5)	Not long started	Summer 22, Winter 21-22

RAL3P1b vs RA2M

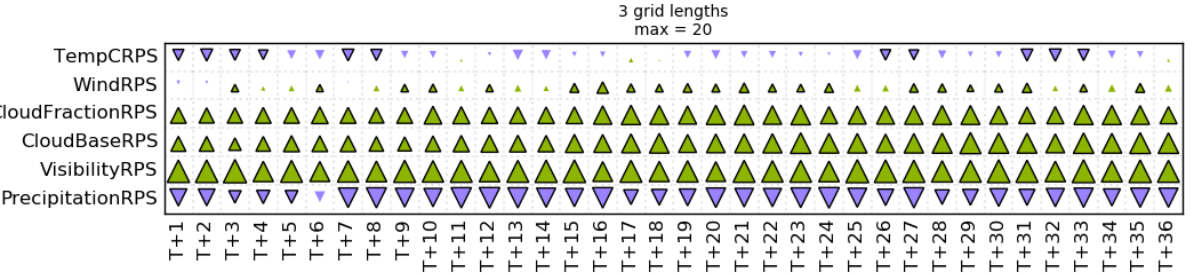
% Difference (RAL3_P1b vs. CTRL_N), Surface Obs

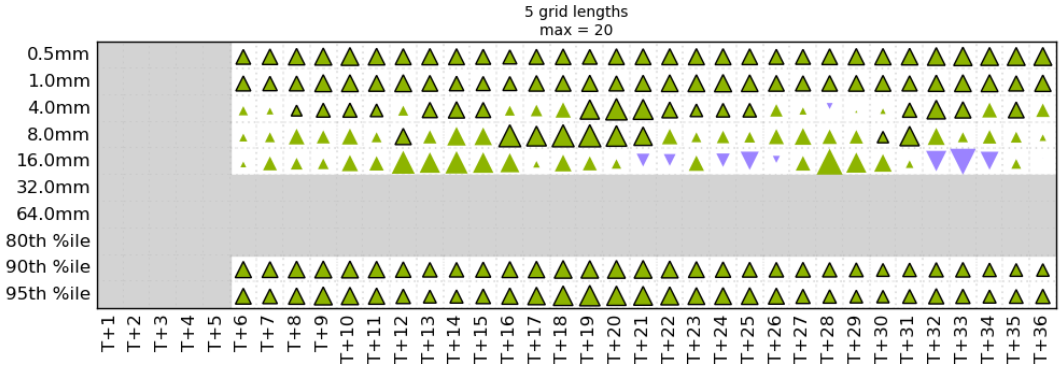
Winter stats ~ 7 weeks of data





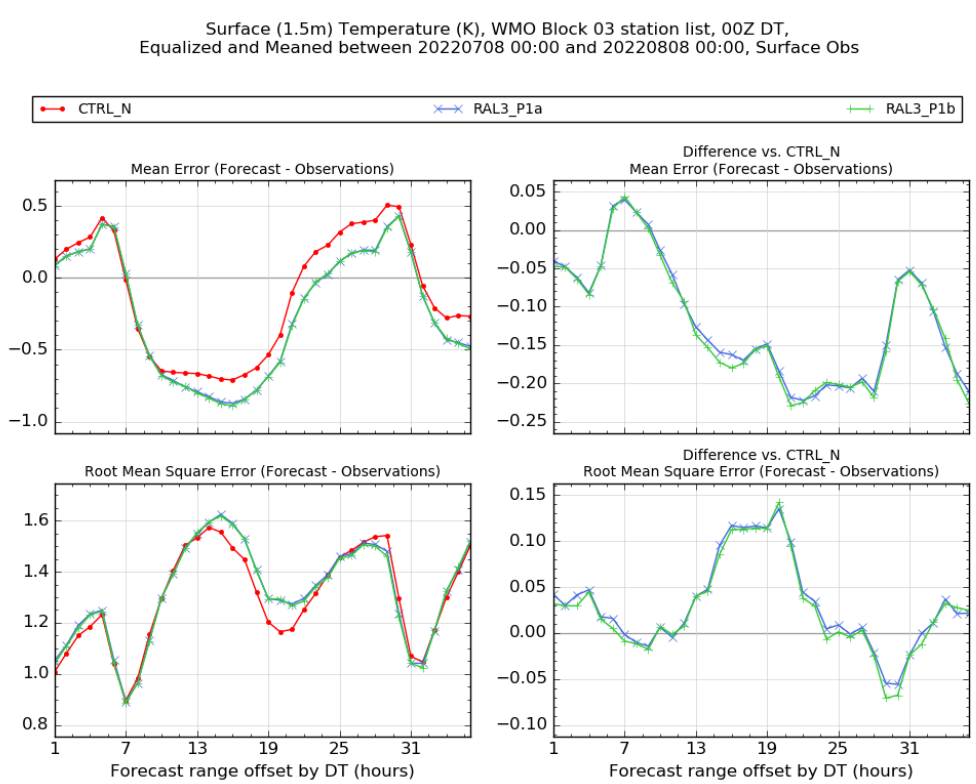
Summer stats ~ 7 weeks of data

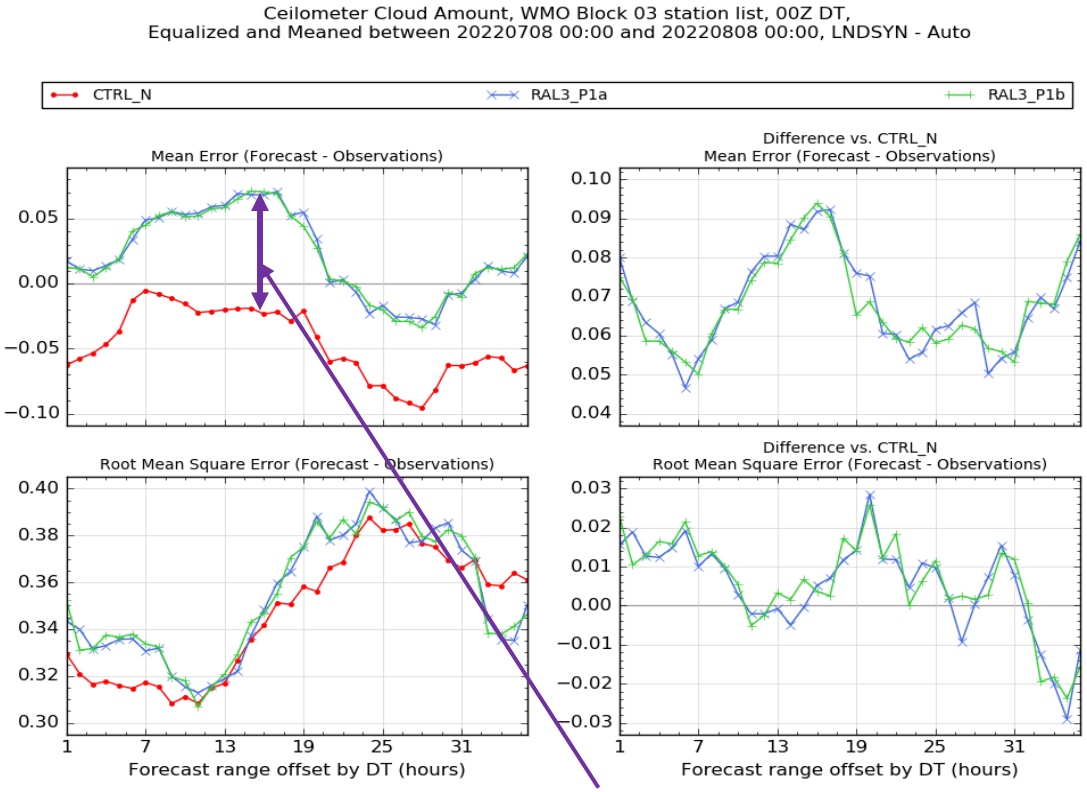




What's happening with the summer temperature?

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

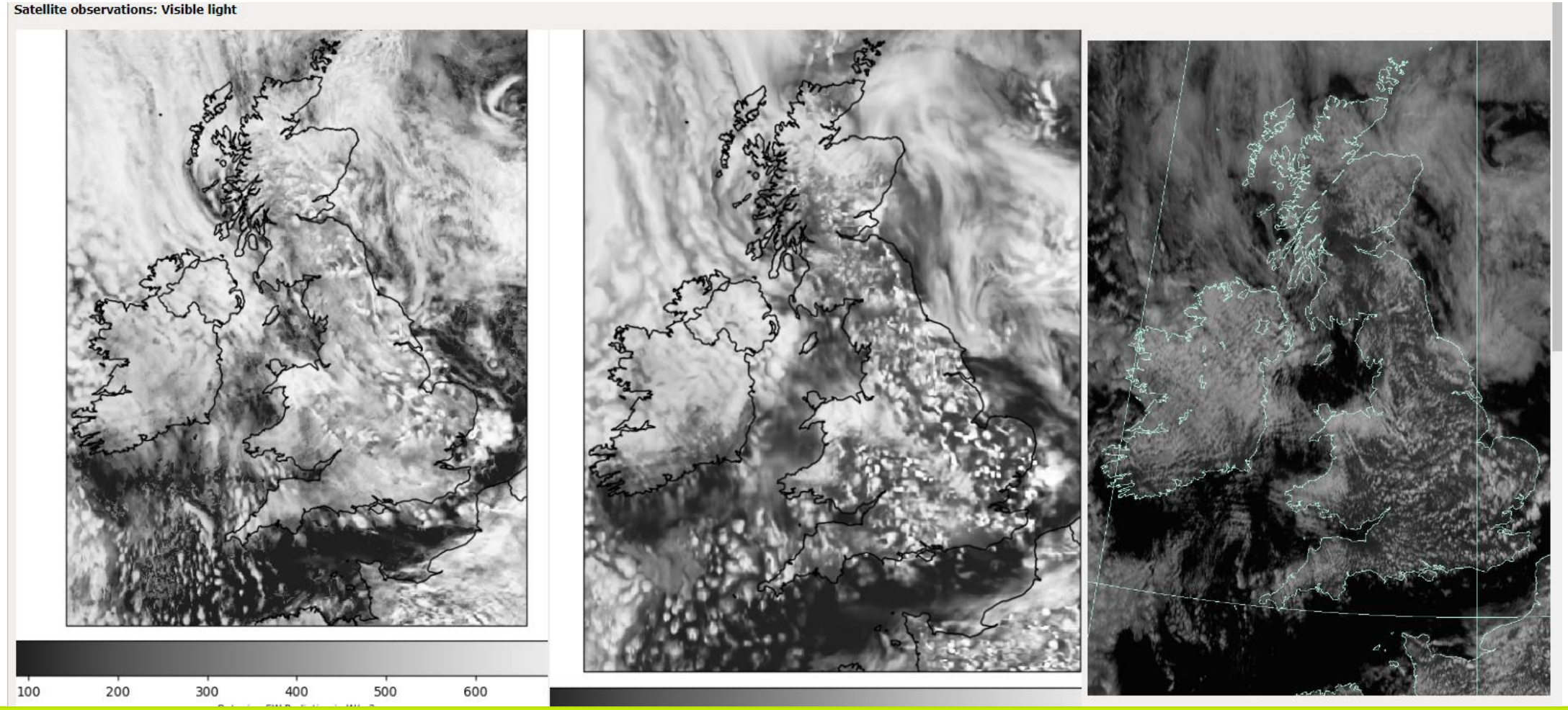




Cloud bias gap greatest in afternoon ?

Diurnal spin-up of convective clouds
June ‘fairweather’ cumulus
….substantially contrasting cloud representations between the two models

RAL3 | RA2M | Satellite



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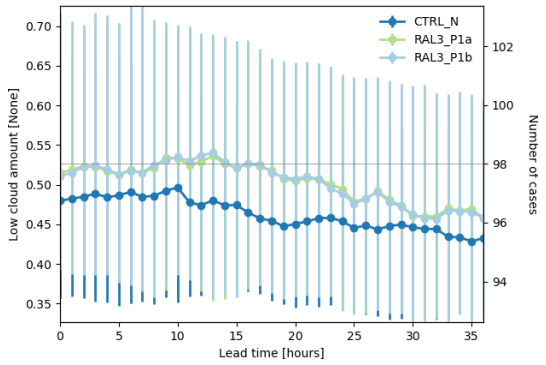
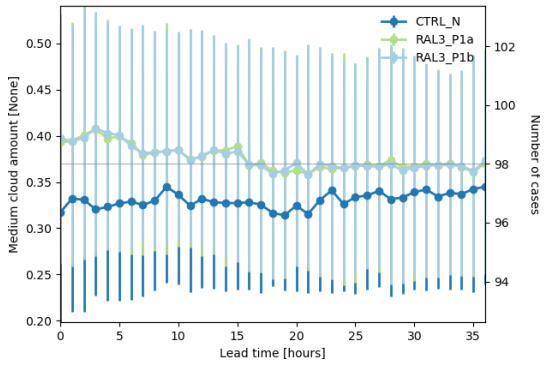
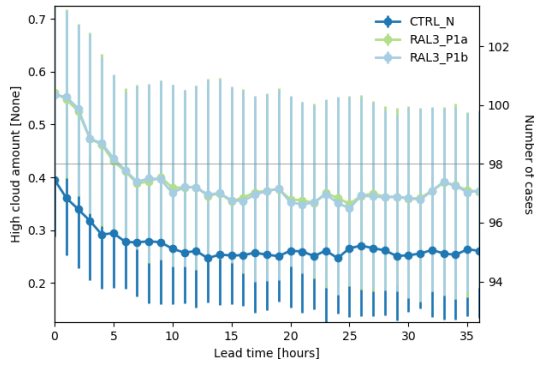
RAL3 cloudier in general than RA2M

Summer

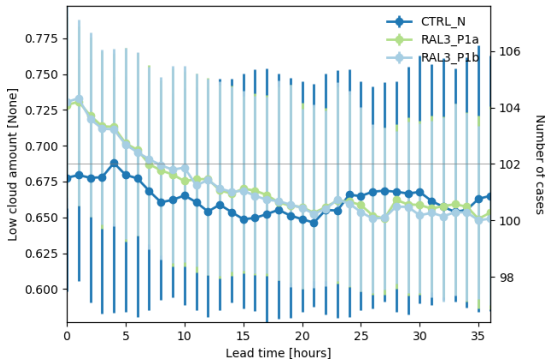


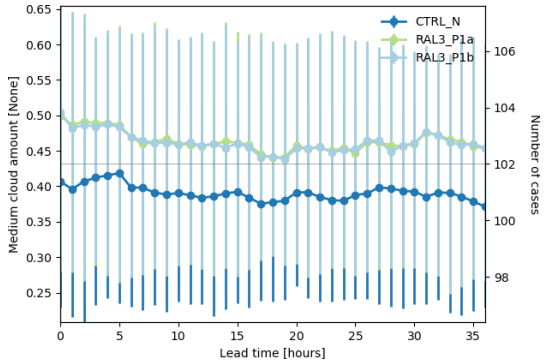


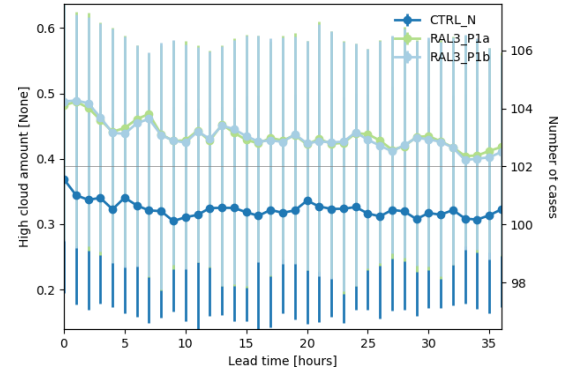


Low **Medium** **High**

Winter







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Summary

- Number of performance tweaks and minor bug fixes since original issue of RAL3 physics configuration
- Final evaluation underway within the PS47 testing framework
- Taken as a whole RAL3 outperforms RA2M across a range of parameters, especially precipitation.
- In general RAL3 tends to be cloudier than RA2M
  - Good for UK winter T2m
  - Not quite as good for summer T2m as tends to inhibit diurnal cycle
  - Ameliorated slightly in stretch package