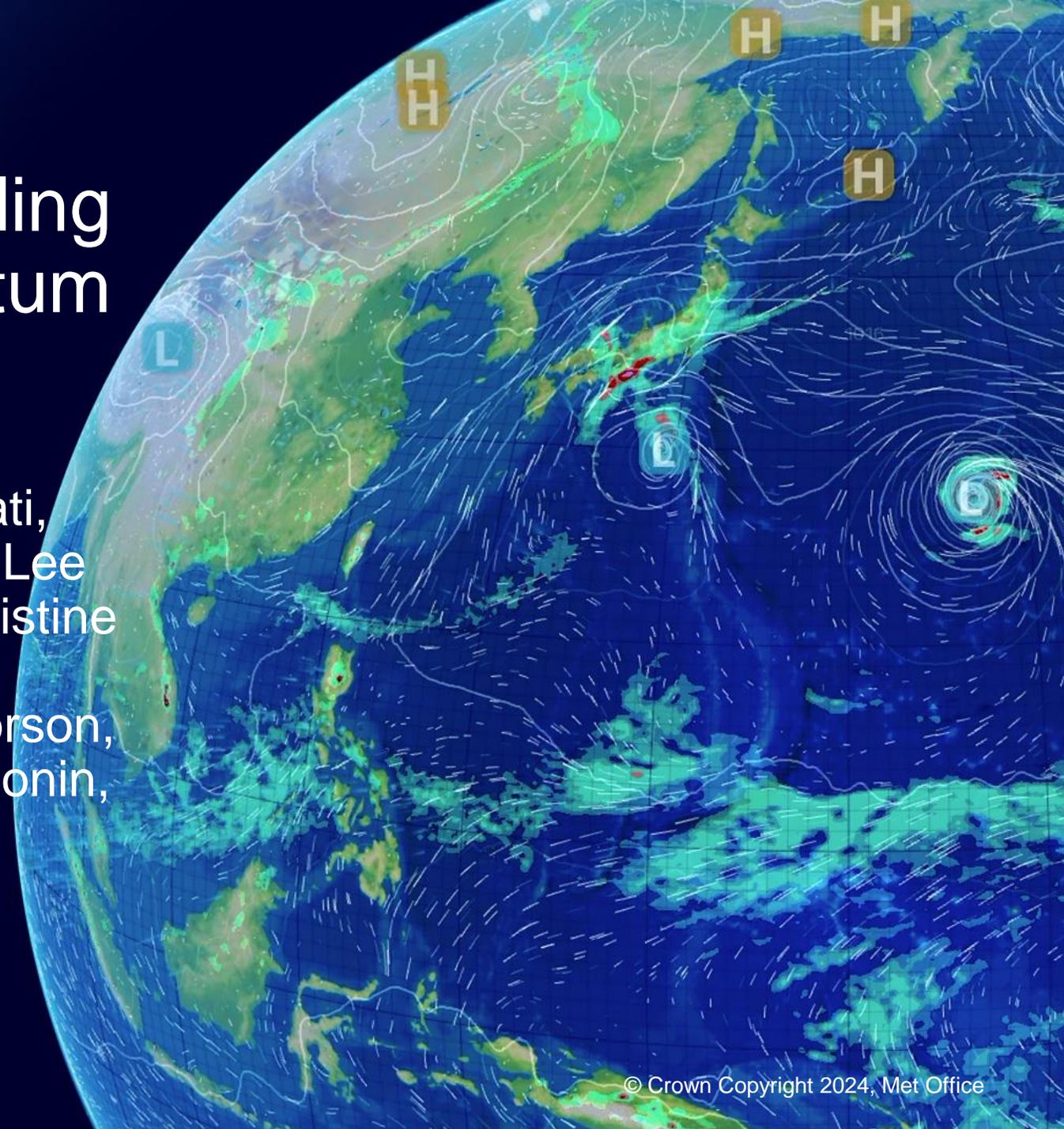


Latest Limited Area Modelling progress from the Momentum partnership

Marco Milan, Mike Bush, Fabien Carminati,
Gareth Dow, Tomos Evans, Chris Harris, Lee
Hawkness-Smith, Gordon Inverarity, Christine
Johnson, Peter Levens, Anne McCabe,
Adam Maycock, Rachel North, Aurore Porson,
David Rundle, Adrian Semple, David Simonin,
Dan Suri, Joao Texeira

30/09/2024



OUTLINE



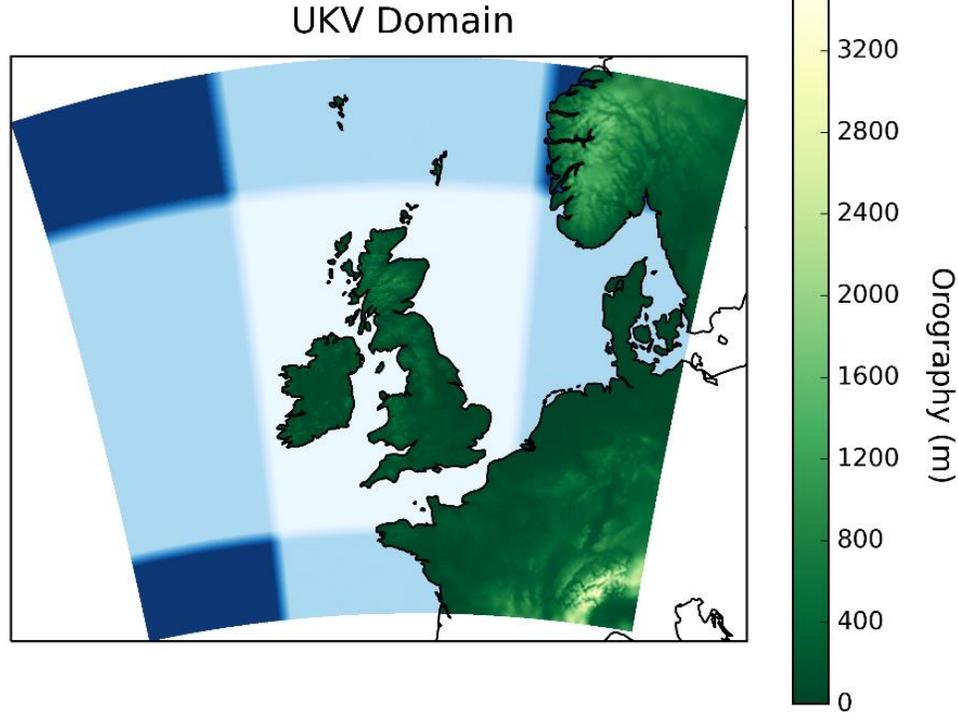
Work ongoing together with Met Office partners.

Introduction to the RAL3 model configuration.

RAL3 implementation in Met Office deterministic and ensemble models.

Journey to Next Generation Model System (NGMS).

DA changes in the deterministic system.



4DVar “deterministic” 1.5 km

- Hourly DA cycle
- Forecast up to T+120 on 03Z & 15Z cycles
- Forecast up to T+54 on 00Z, 06Z, 09Z, 12Z, 18Z, 21Z cycles. Other cycles T+12.
- Large-scale blending (LSB) – add filtered analysis increment from downscaler to UK background forecast. In the cost function and as increment at T+0.

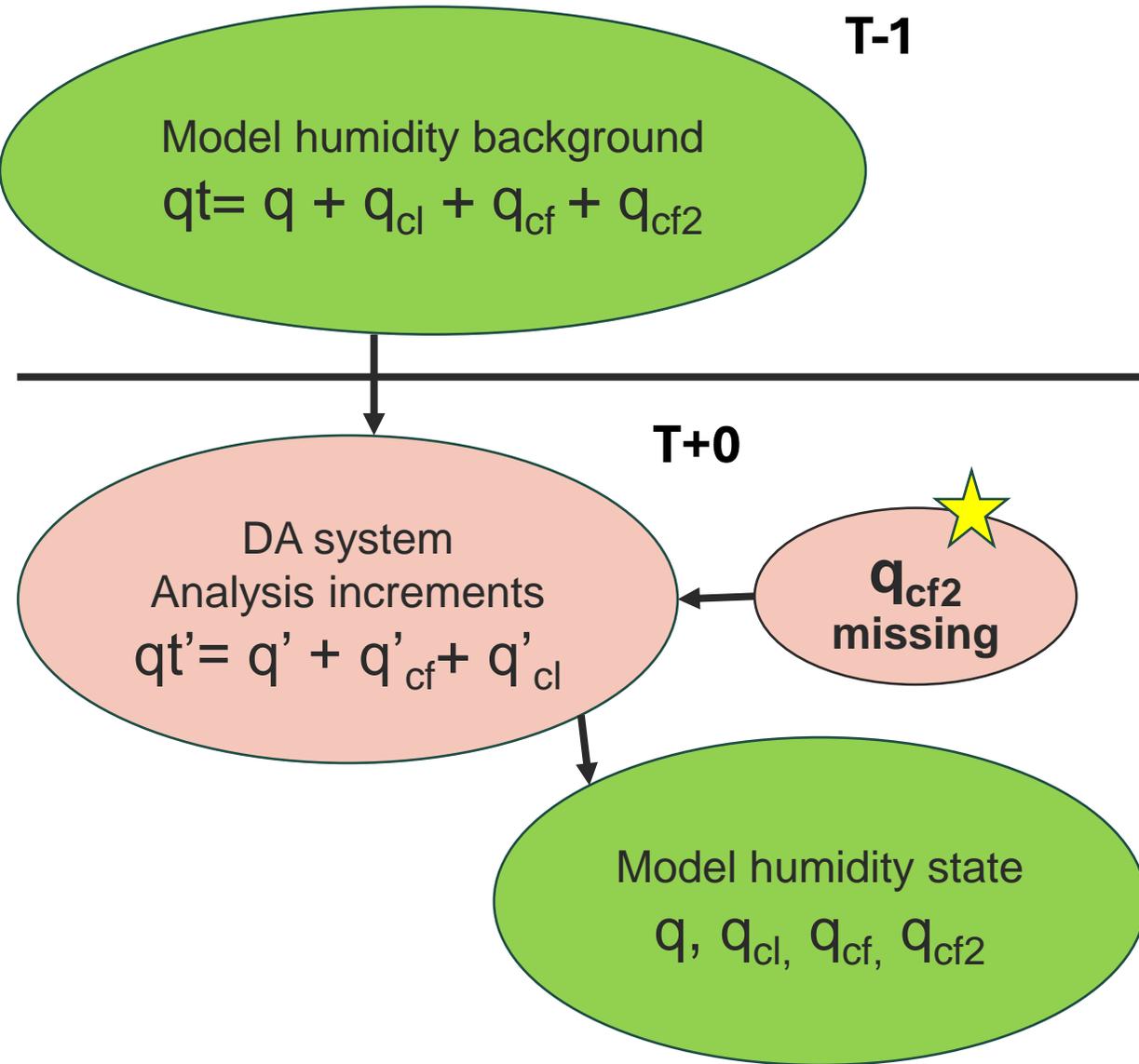
UK ensemble 2.2 km

- 3 members run every hour to T+120, with time lagging. 18 members hourly.
- UK analysis (using LSB) + global perturbations
- Dynamical downscaler of uncertainty
- Random Parameter (RP) scheme to represent model uncertainty.

Met Office **R**egional **A**tmosphere and **L**and configuration: **RAL3**

- The Met Office has two model configurations, RAL2M (mid-latitudes) and RAL2T (tropics).
- The **NEW** RAL3, will provide a single configuration.
 - Ensures a coherent programme of model development.
 - Removes stochastic boundary layer perturbations
 - Improvements to the land surface configuration.
 - Bi-modal cloud scheme (<https://doi.org/10.1175/MWR-D-20-0224.1>).
 - CASIM physical parameterization introduces a new type for cloud particle: ice (q_{cf2}) => more degree of freedom.
- Test phase for deterministic and ensemble RAL3 vs RAL2 show differences over UK, e.g.:
 - Produces more light rain and less intense heavy rain, introduces more coherent and realistic intensity distribution for precipitation.
 - Improves cloud cover and cloud base representation.
 - Better wind gust speed and better fog formation.
 - Generally cooler temperatures, degrades a pre-existing cold temperature bias.
- Final evaluations are taking place.

Physical consistency between CASIM and DA

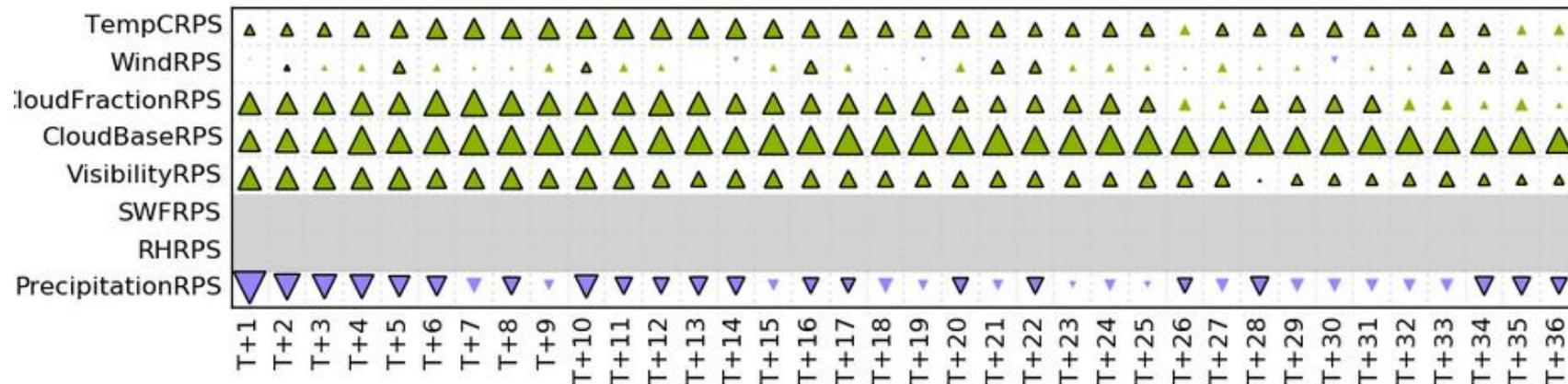


- RAL2: The DA increments of all humidity components (q' , q'_{cl} , q'_{cf}) are applied to the water vapour (q) on the model state.
- RAL3: the new microphysics CASIM splits frozen cloud particles into two, **snow** (q_{cf}) and **ice** (q_{cf2}).
- The DA system doesn't have the cloud ice particle coded in.
- To make DA physically consistent with CASIM the two cloud ice particles should ideally be present in the code.
- NGMS development, very different code => we use a different approach:
★ $(DA)q_{cf} = q_{cf} + q_{cf2}$ (*UM MODEL*)

INTRODUCTION OF RAL3 IN UKV

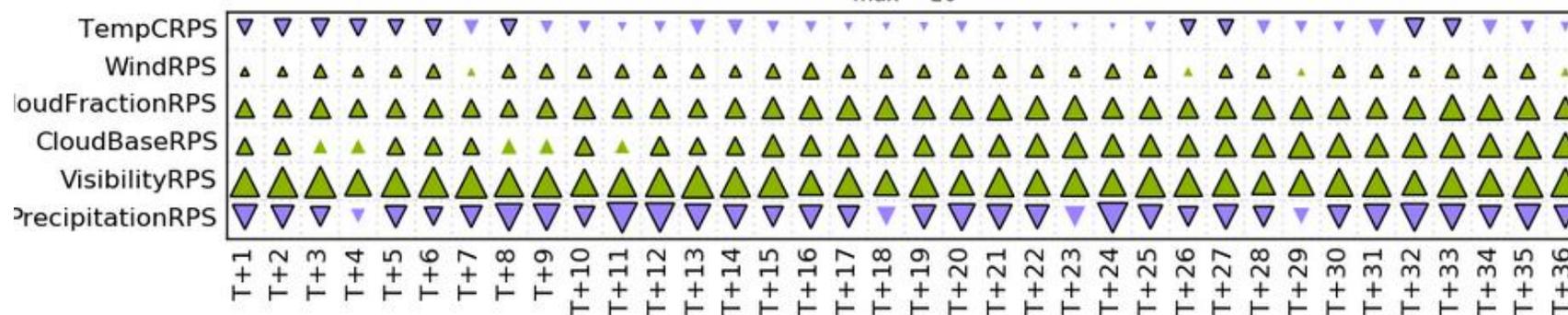
RAL3 vs RAL2M winter

7 grid lengths
max = 20



RAL3 vs RAL2M summer

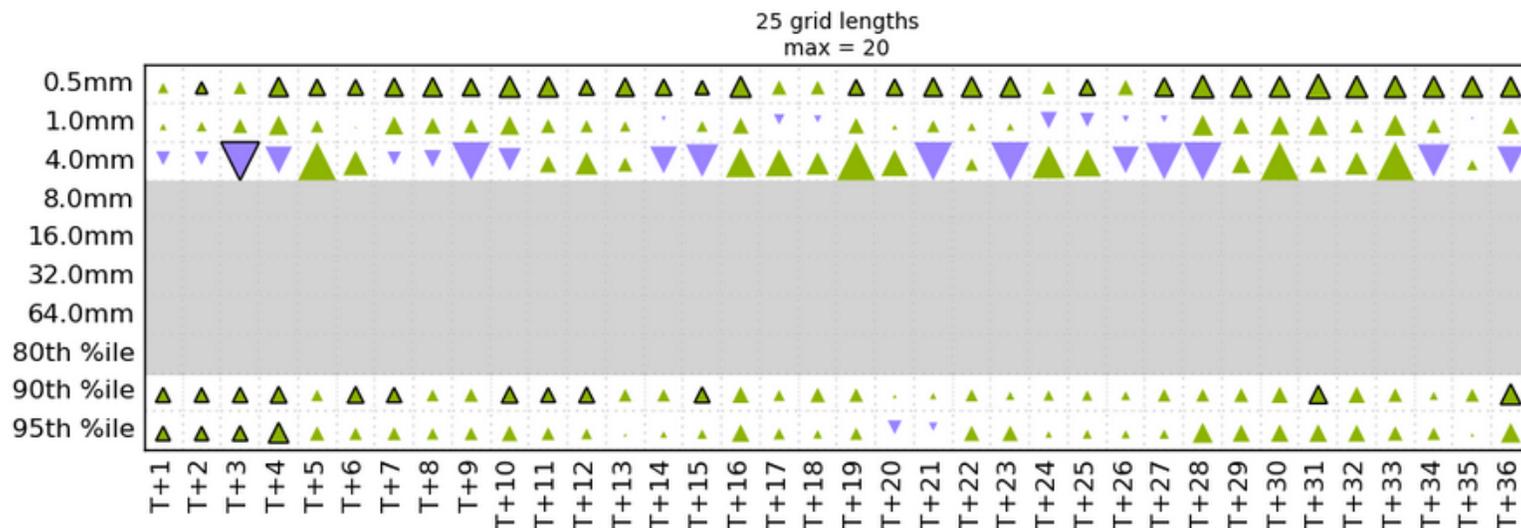
7 grid lengths
max = 20



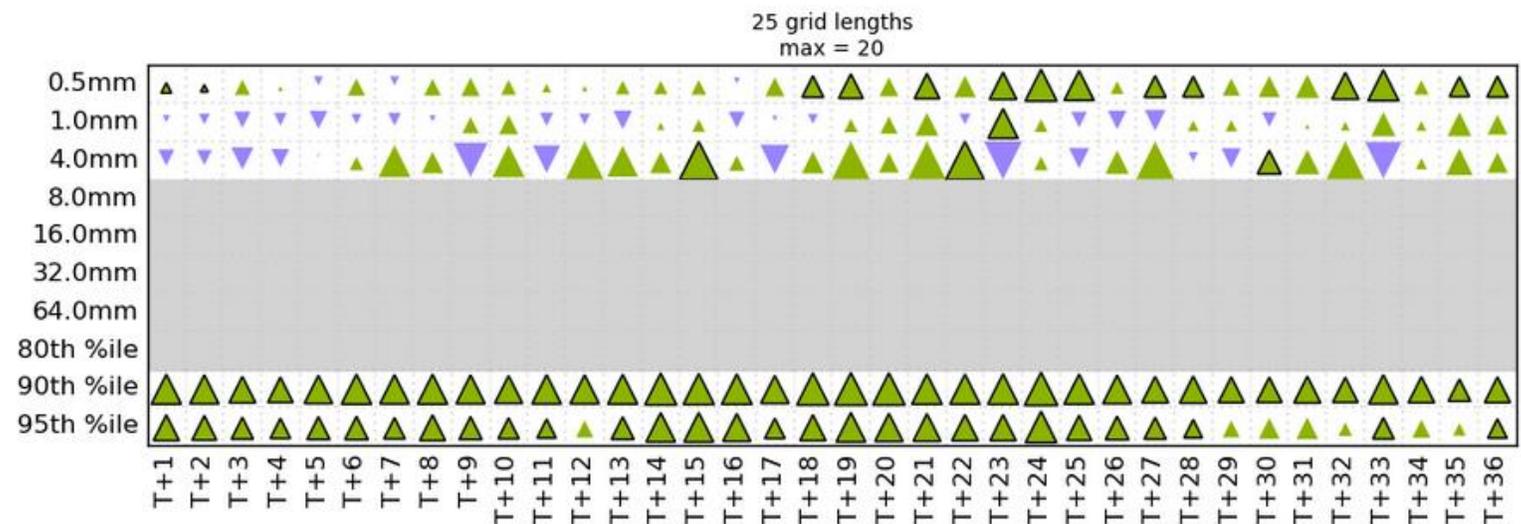
- **RAL3** with physically consistent DA, strong impact in many variables.
- One month of data for each season (summer/winter).
- Screen temperature positive in winter, neutral/slightly negative in summer.
- Precipitation RPS, negative impact.
- FSS strong positive improvement, especially in summer, and all over the forecast time.
- Sometimes, FSS and RPS are giving conflicting results. Our verification group is looking into this.

INTRODUCTION OF RAL3 IN UKV

RAL3 vs RAL2M winter

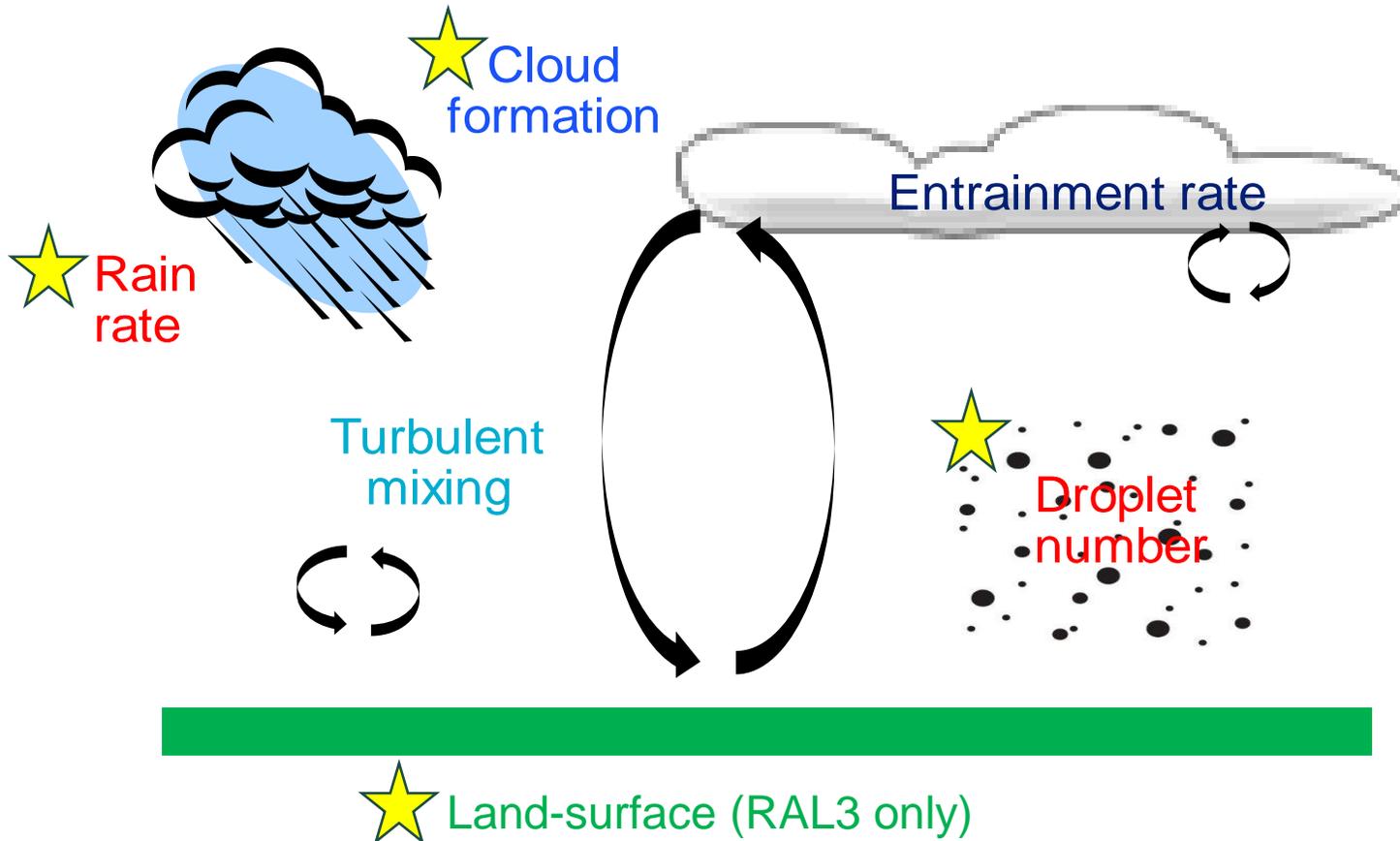


RAL3 vs RAL2M summer



- **RAL3** with physically consistent DA, strong impact in many variables.
- One month of data for each season (summer/winter).
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Updates to the Random Parameter (RP) Scheme for RAL3



- The RP scheme perturbs physics parameters throughout the forecast to represent the model uncertainty
- Microphysics parameters perturbed in current operational configuration have been removed in RAL3
- Updated RP scheme includes:
 - Additional parameters relevant to the new micro-physics and cloud scheme
 - Additional parameters in the land-surface scheme

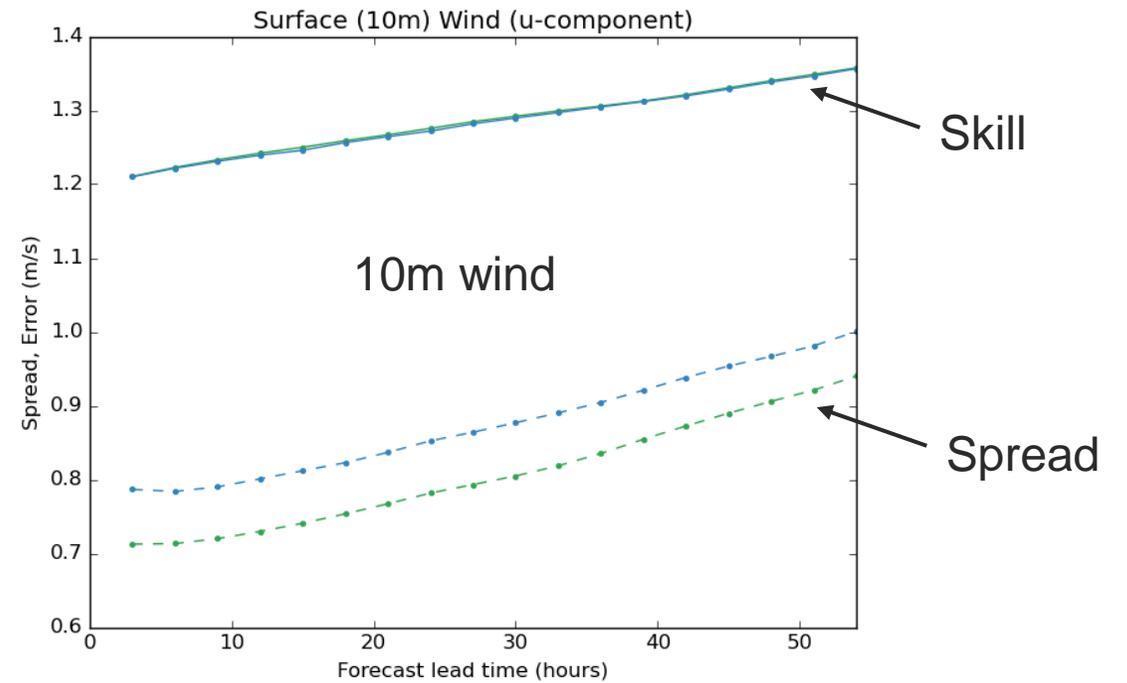
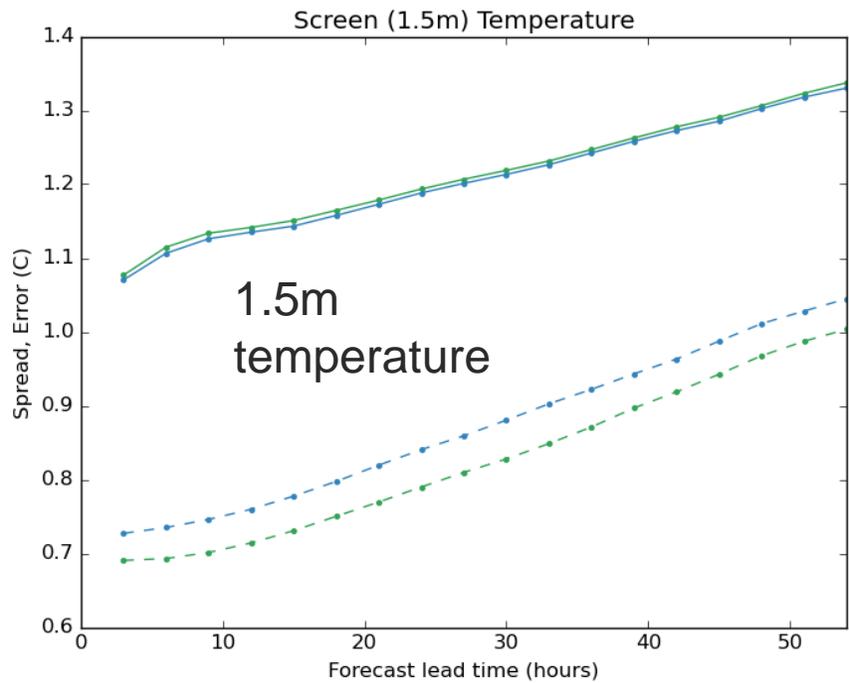
Early trial results of the updated RP scheme show increased ensemble spread in MOGREPS-UK.

The majority of the increase in spread comes from the new land-surface parameters

RAL3 + orig parameters

RAL3 + orig parameters + new RP

Similar results can be seen in winter trials



Month-long summer trial period

JOURNEY TO NGMS

LFRic (L. F. Richardson) : Infrastructure that allows **separation of concerns** – separating science code from computer optimization code.

using

GungHo:

A new dynamical core. **Finite-elements** give flexibility for the choice of mesh, **finite-volume transport** gives improved conservation.

Aim: Maintain the benefits of the current UM, whilst improving the scalability.

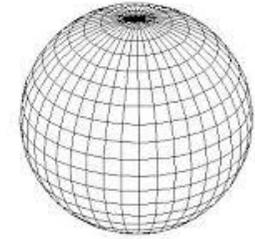
Work in progress LAM:

- Use the same rotated lat-lon grid/mesh as the UM.
- Lateral boundary conditions (LBCs) are provided by the UM driving model.
- Variable resolution in LFRic-LAM as in UKV.
- 1-to-1 mapping from the UM to LFRic.
- Tested on different domains.

LFRic global



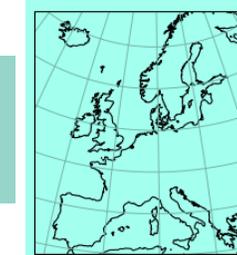
UM global



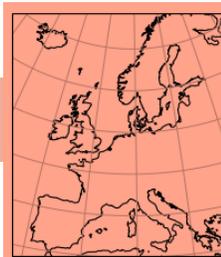
LBCs on UM grid

LBCs on LFRic mesh

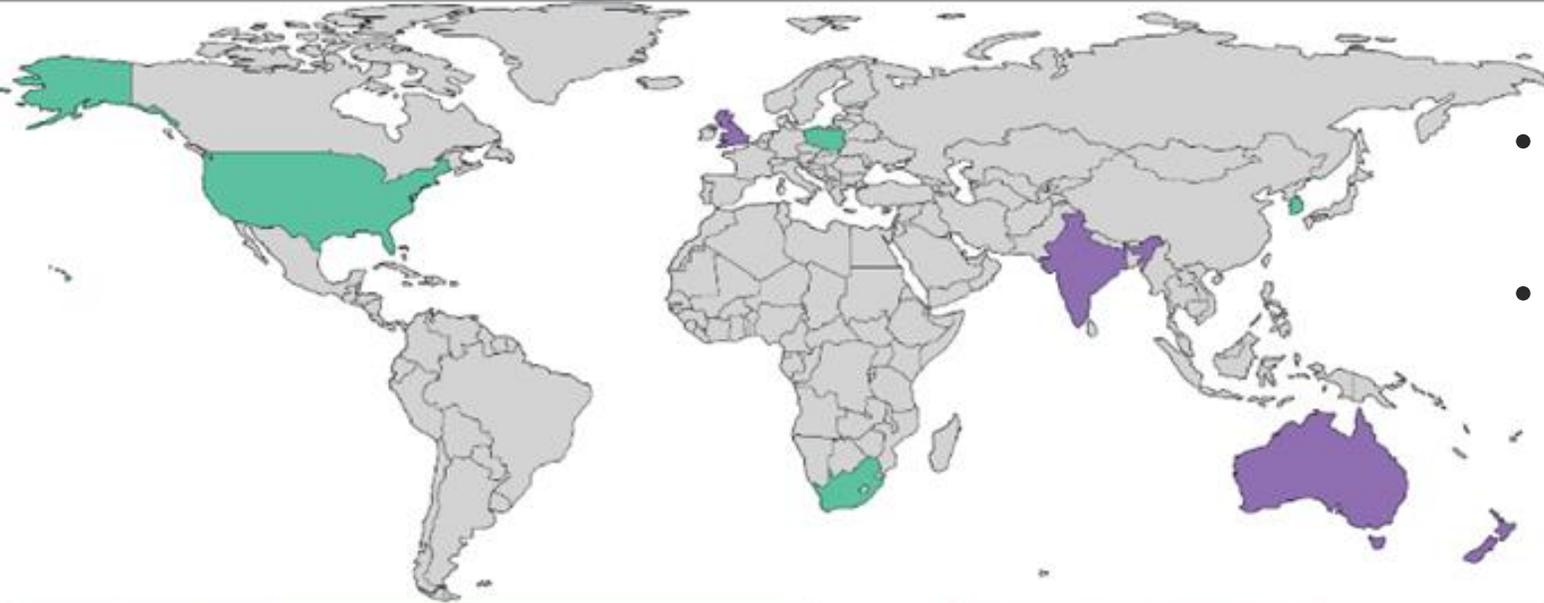
NEW
LFRic LAM



UM LAM



The Momentum® Partnership



CORE PARTNERS



ASSOCIATE PARTNERS



- I showed: collaborative work with international Met Office partners.

RAL3 introduction leads to retirement of RAL2M and RAL2T => easier collaboration.

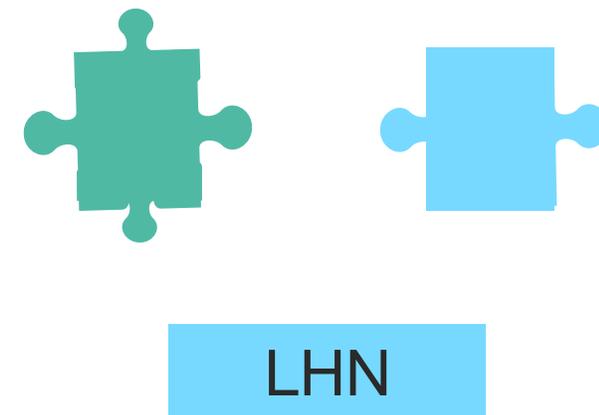
- Future direction LFRic => easier collaboration.

- Partner:

- Develops the same modelling framework between many institutions.
- Utilizes diverse strengths and expertise.
- Accelerates improvements of weather and climate models.
- Achieves more than any single organization alone.

Met Office DA changes with outlook to Next Generation system

- Radar reflectivity assimilation enhancements. Adjustment of observation error and adding radar data from Germany and France.
- Switch OFF of LHN (Latent Heat Nudging). Drives from the introduction of LFRic and NG-PAO (Next Generation Processing and Assimilation of Observations).
- Switch OFF of Adaptive Vertical Grid (AVG).
- Without AVG, the analysis increment is in hydrostatic and geostrophic balance.
- AVG adjusts the vertical position at which covariances are applied, disturbing the previous property.
- AVG => issues in humidity treatment in VAR.
- We are testing these changes on top of RAL3. The goal is to identify changes in our regional forecasts (improvement or deterioration) to better inform our end users before PS47 acceptance.



	Regional NWP	Comments	
Early 2025	Port to Gen1 supercomputer	Science-neutral change	Gen1
Late 2025	RAL3 physics + DA improvements	Package still being tested	
2026	JOPA, 1.5km ensemble, Retire UKV beyond T+12	Ensemble resolution increased from 2.2km at present	Gen2
2027 2029	UK LFRic ensemble Vertical level increase	Detailed plans on Gen2 still being developed	

- Start 4 QUAD **Gen1**
- Still in planning **Gen2**

- Many resources are involved in development of NGMS and of NG-PAO system.
- Introduction of new RAL3 physical parameterization led to significant improvement. In summer especially for precipitation, in winter for screen temperature.
- RAL3 also larger colder bias, potentially linked to the different representation of other variables.
- Physical consistency between RAL3 CASIM microphysics (2 frozen particles) and the DA.
- Some big changes for the DA system. Switch OFF AVG. Switch OFF LHN (driven by NG-PAO for LAM development requirements – which will likely be a very different system (Ensemble based)).
- Plan on the NG-PAO front: the first step will be to run a UM driven LFRic LAM cycling DA (JOPA/VAR/LFRic) workflow, including observation ingestion into JOPA (the “new OPS”) and creation and reading in of an analysis increment file to produce a modified model trajectory/forecast.
- The new supercomputer **is on its way.** 

THANK YOU

