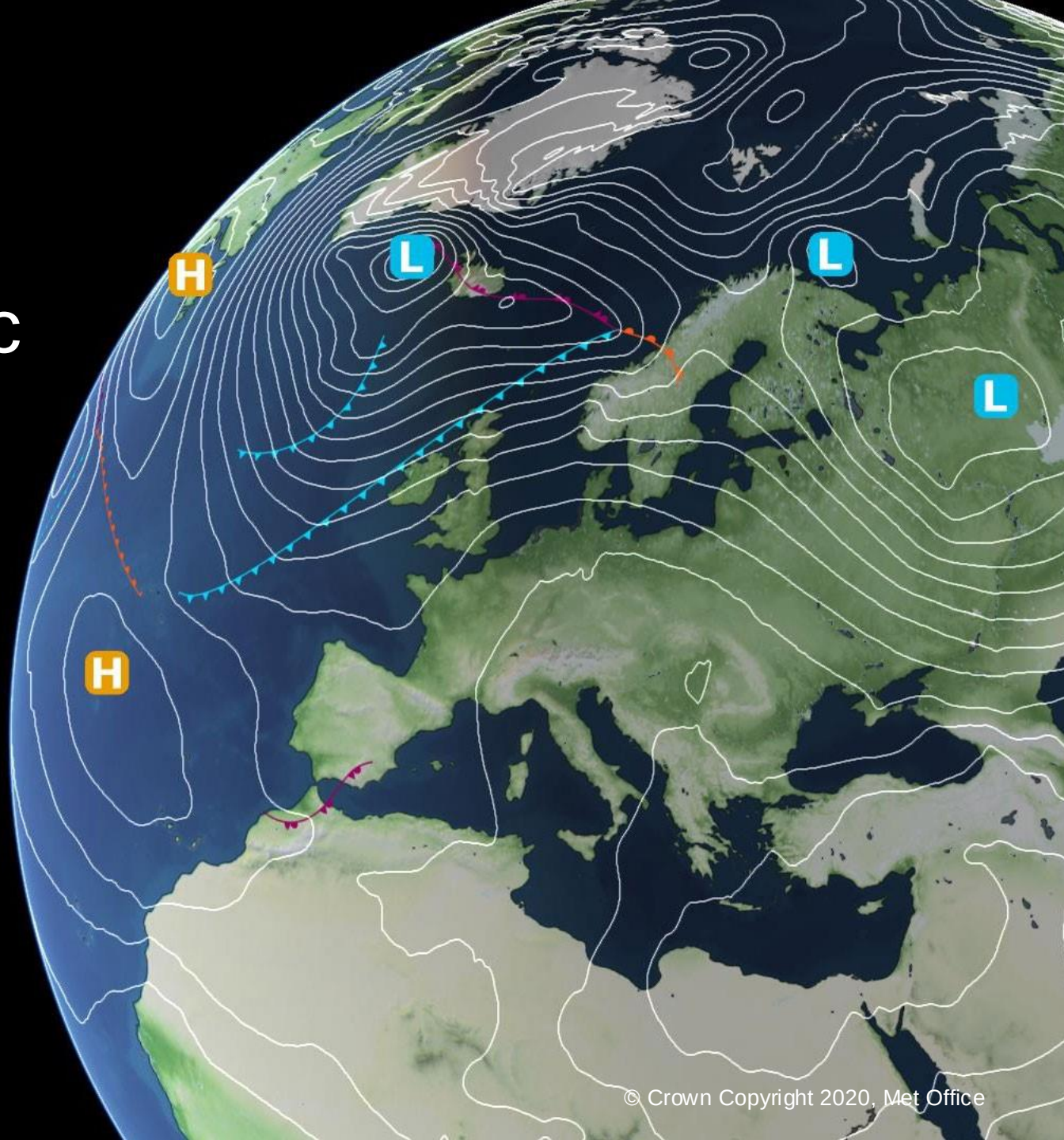
Introduction to RAL3-LFRic

Mike Bush and the RAL3-LFRic project team

Joint Annual R&D & 6th Momentum Partnership Convective Scale Workshop,
Melbourne, Australia

09th September 2024



Met Office

RAL3-LFRic project: Key aim

- The key aim of the RAL3-LFRic project is to deliver an LFRic-based RAL3 research configuration as a well-tested and understood baseline for future developments.

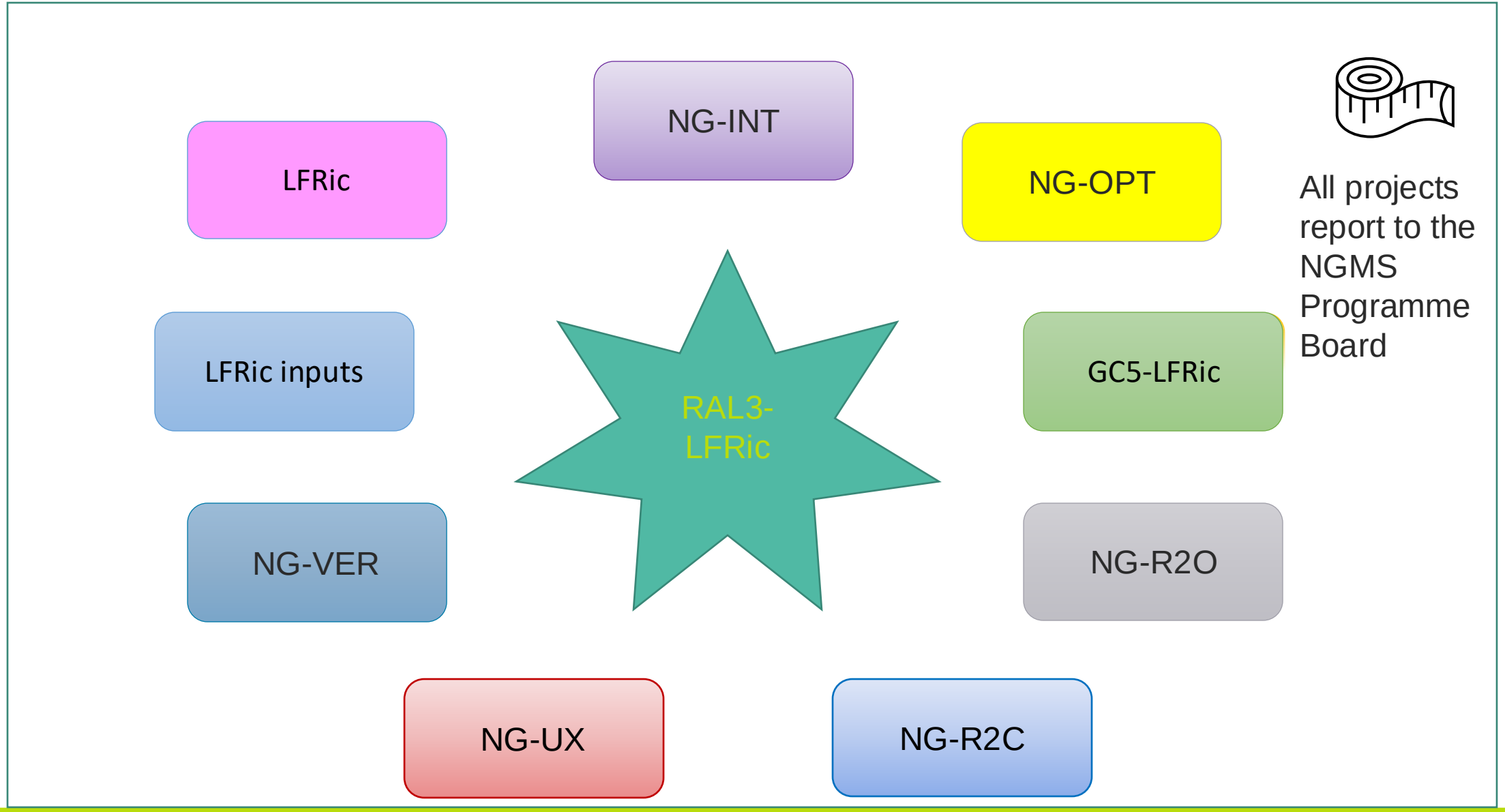
- It combines the new next generation atmospheric model (LFRic) infrastructure with the latest science configuration developed for regional modelling applications known as Regional Atmosphere and Land 3 (RAL3).

Met Office

RAL3-LFRic: Project organisational structure

Work Package	Focus	Lead
WP1	Evaluation tool and diagnostics development: Convective-Scale Evaluation Toolkit (CSET)	**Sylvia Bohnenstengel**
WP2	Suite/workflow development: RNS, ENS, RCS, RAS	**Anne Mccabe**
WP3	Acceptance criteria Testing and development strategy Characterization of RAL3-LFRic Evaluation and verification of RAL3-LFRic	**Anke Finnenkoetter**
WP4	Lagged orography, multigrid preconditioner, variable resolution and LBC meshes, new transport scheme, solver optimisation and LFRic2LFRic	**Christine Johnson**

Links to other NGMS projects



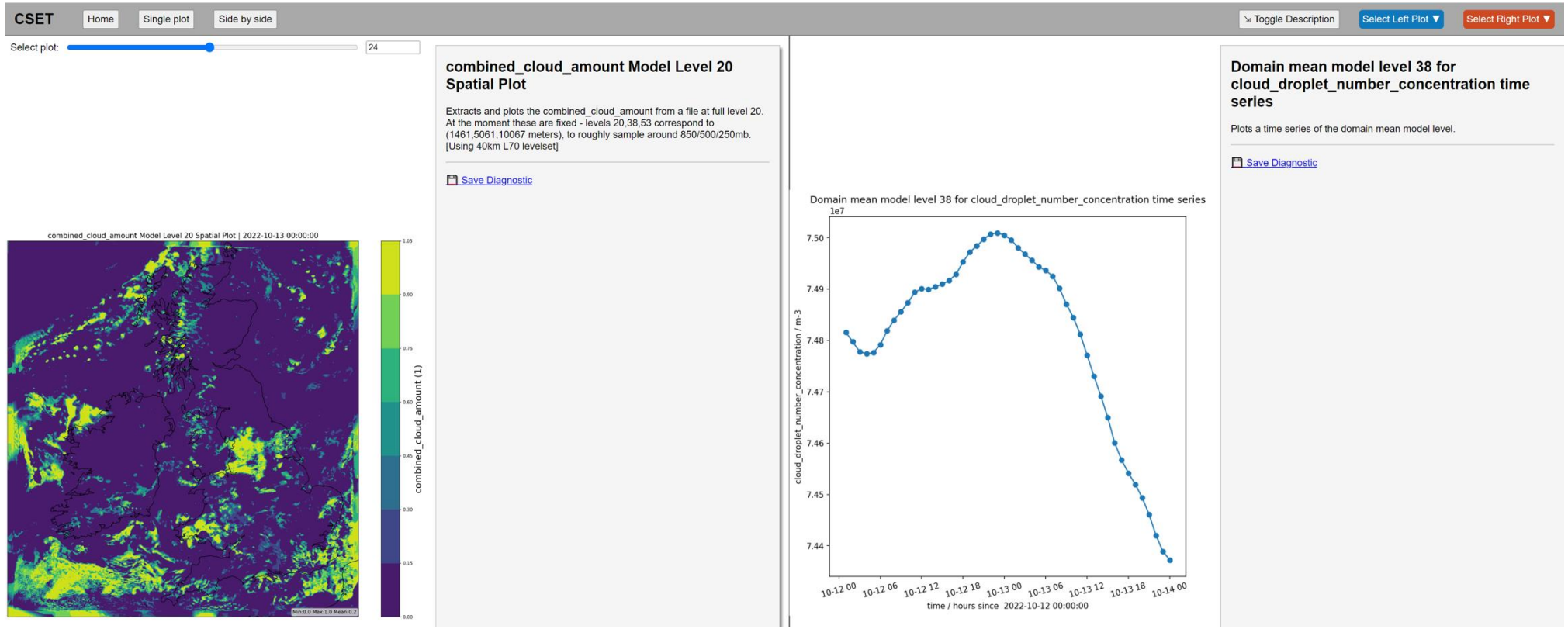
Met Office

Support evaluation and verification linked to RAL suites

CSET

Convective and Turbulence-scale evaluation toolkit

- Ensemble and deterministic
- UM and LFRic
- Focus on developing diagnostics for physical-process understanding
- Legacy for diagnostics incl observations
- Community tool development
- **Welcoming new users and developers**



Talks: Sylvia Bohnenstengel, James Frost Session 7, Day 2 Slide courtesy of Sylvia Bohnenstengel (Met Office)

UK case studies

- In March 2024, a set of UK case studies were successfully run using the Method of lines (MOL) transport scheme.

- These cases have now been re-run with the latest science, using lfric_apps vn1.0, including the Flux Form Semi-Lagrangian (FFSL) transport scheme.
- 72 cases have been run with 9 cases experiencing failures.

- #618 (Development of the RAL3-LFRic science configuration)
- #625 (u-dh663: RNS suite used for RAL3-LFRic case studies)
- #645 (UK Case studies: Characterization of RAL3-LFRic)

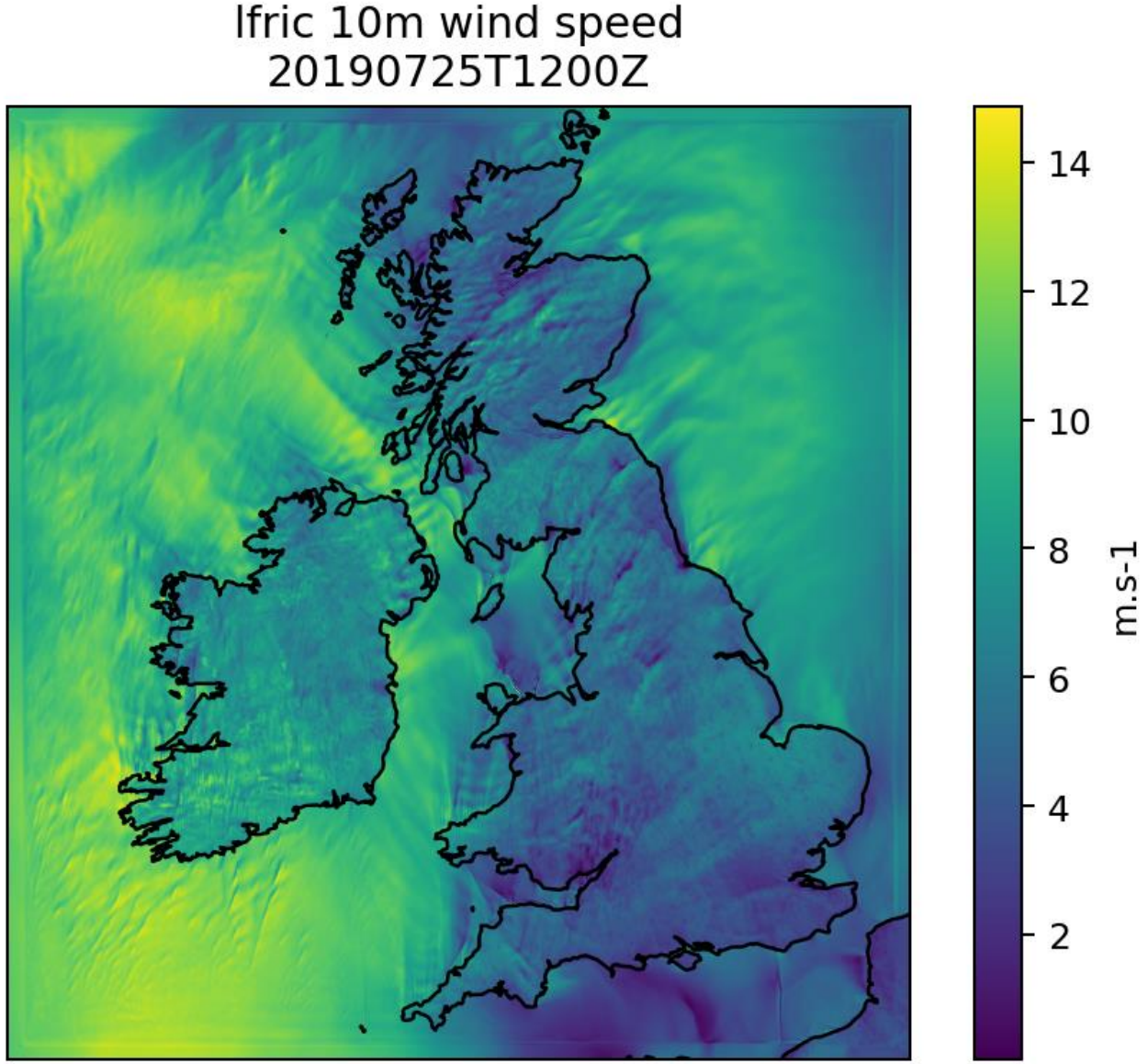


Image courtesy of Anke Finnenkoetter (Met Office)

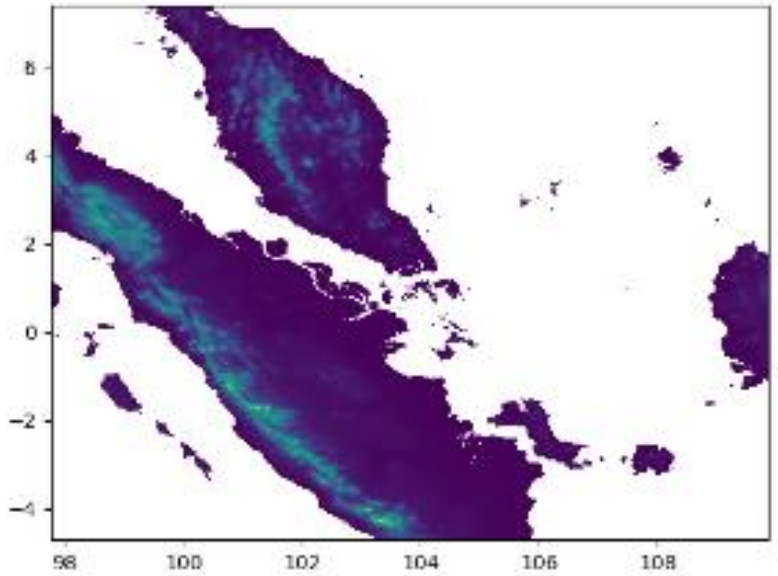
RAL3-LFRic at CCRS

Meteorological Service Singapore
Centre for Climate Research Singapore

Met Office | Momentum

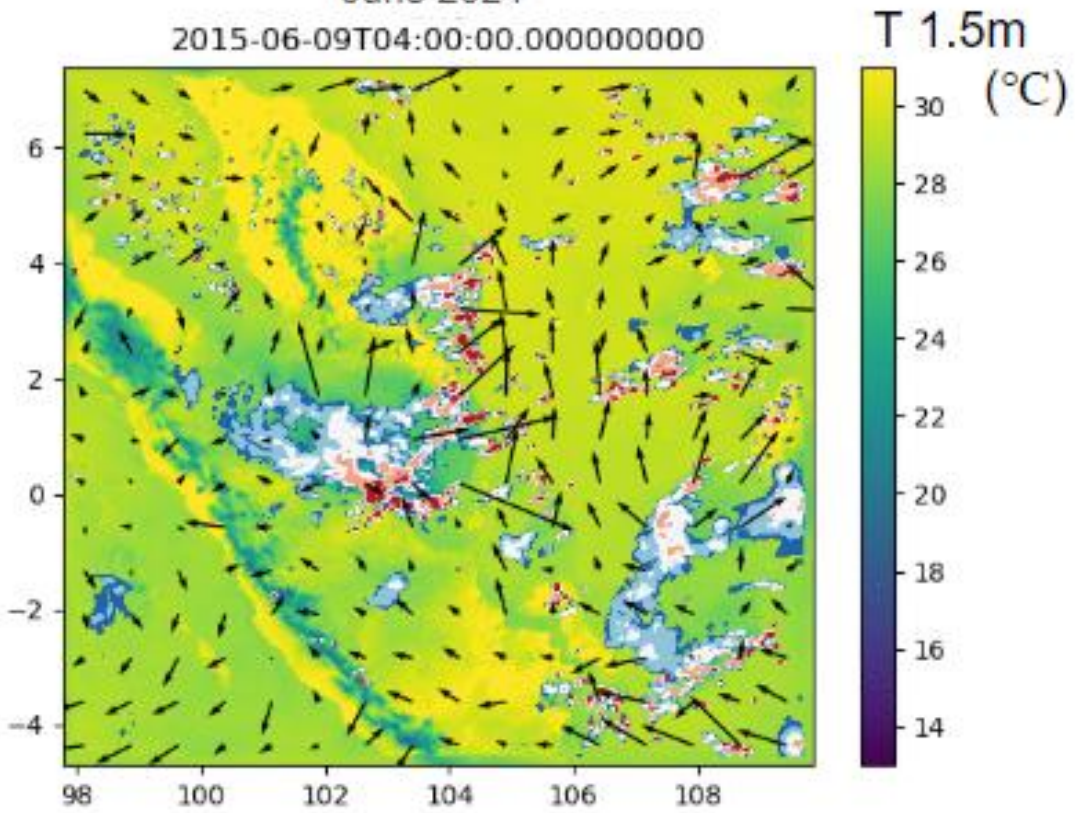
Next Generation Modelling System (NGMS, UK)

LFRic 1.5-km 896x896



- 1-month trial completed
- Evaluation & comparison to UM ongoing
- ***news*** 1024x1024 "SINGV" domain has also been generated …

48h forecast of a typical wet day during June 2024



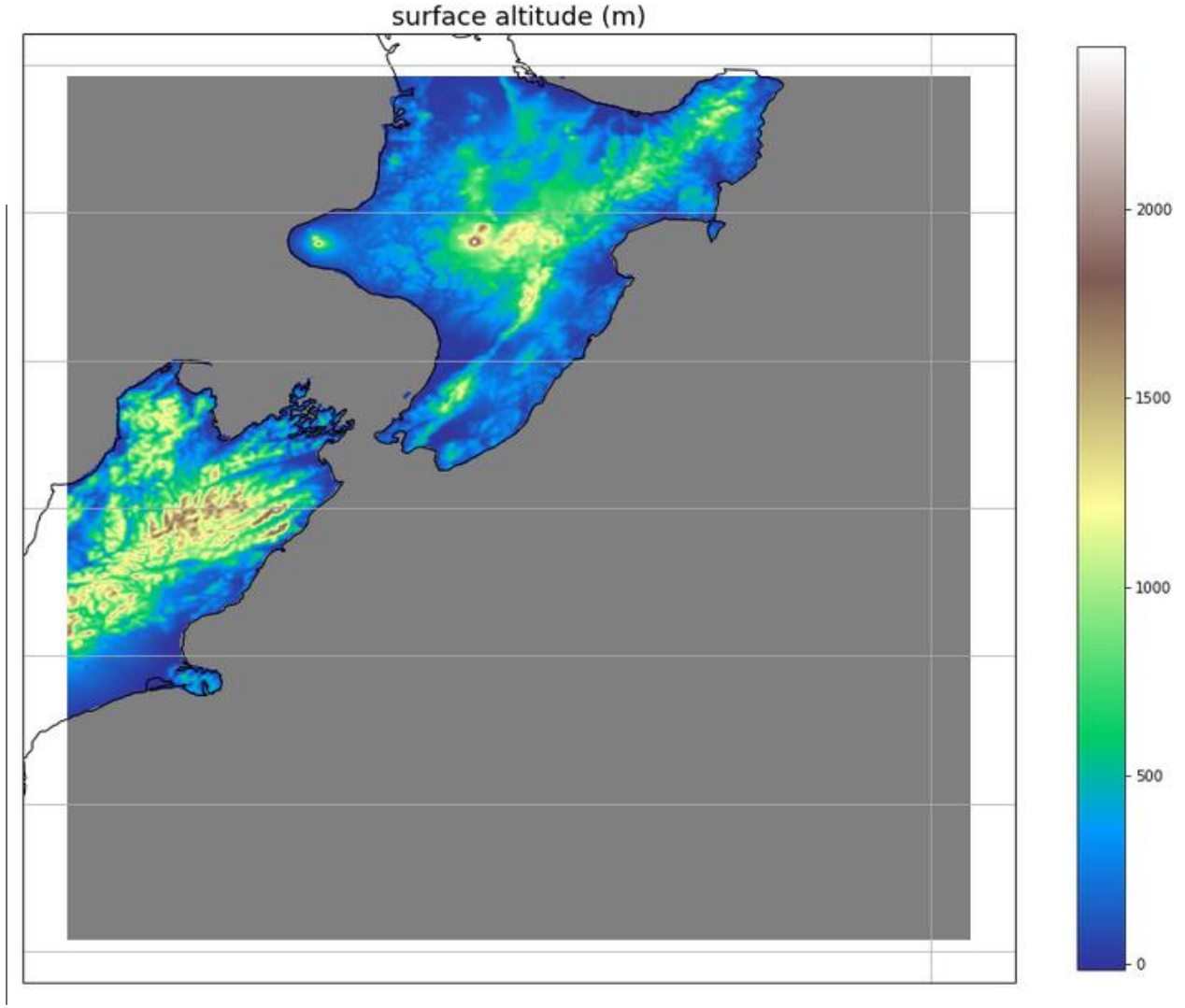
Air temperature, 10m winds, and precipitation

Slide courtesy of Kalli Furtado (MSS)

RAL3-LFRic at NIWA

- This is the first domain we're trying and is the largest (648x648 pts) we can run on our current HPC (not enough memory per node to go for a bigger domain).

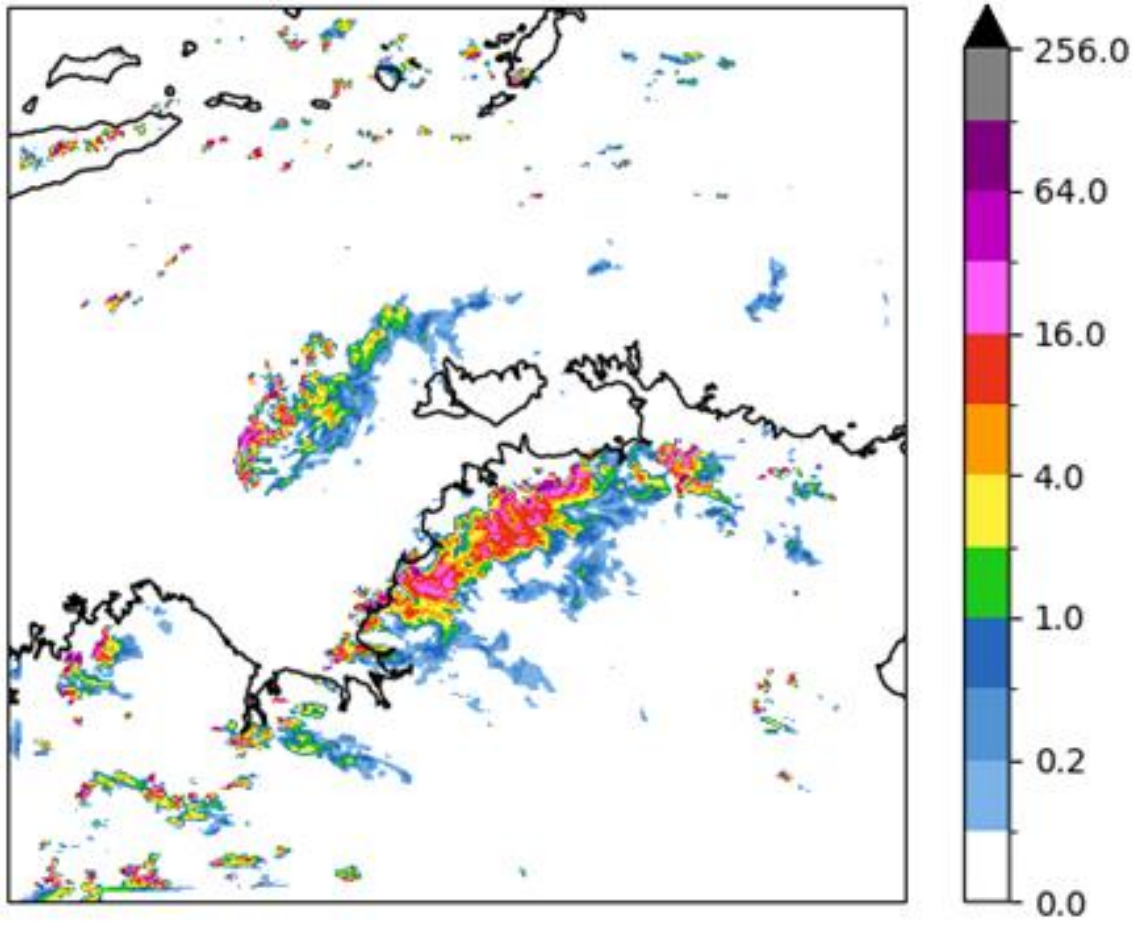
- We have a second domain set up to look more closely at LFRic performance for 2023's exTC Gabrielle, which is more focussed on the North Island.



Slide courtesy of Stuart Moore (NIWA)

Darwin case studies

- 768x768 grid point Darwin domain
- 14 case studies have been run so far.
- These are a mix of targeted and random cases.
- 4 of the 10 cases (20210105, 20210113, 20210204, 20221222) are targeted convective/tropical cyclone cases.
- There are some large rainfall totals (and high rates) within the Darwin domain.
- [#643 (RAL3-LFRic Darwin case studies)]

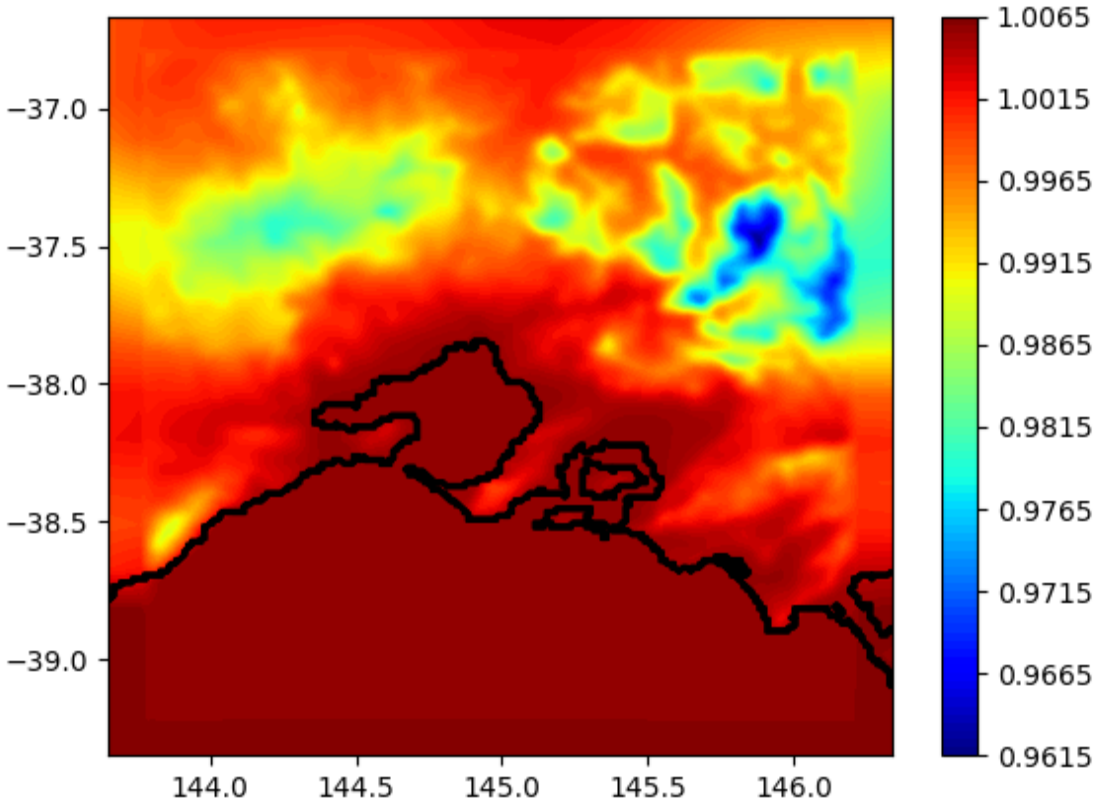


Example of precipitation from a Darwin case study

Image courtesy of Richard Jones (Met Office)

Melbourne case studies

- Dave Lee (BoM) has successfully run test Melbourne cases.
- Both Melbourne and Darwin cases are using the old transport scheme (mmol=true) and experimental w2v blending which extends further into the domain than for UK domains
- The key thing about the Melbourne domain is that there is steep orography in the LBC region. So likely this is a contributing factor to the problems that have been encountered.



Example of surface Exner pressure from a Melbourne case study

Image courtesy of Dave Lee (BoM)

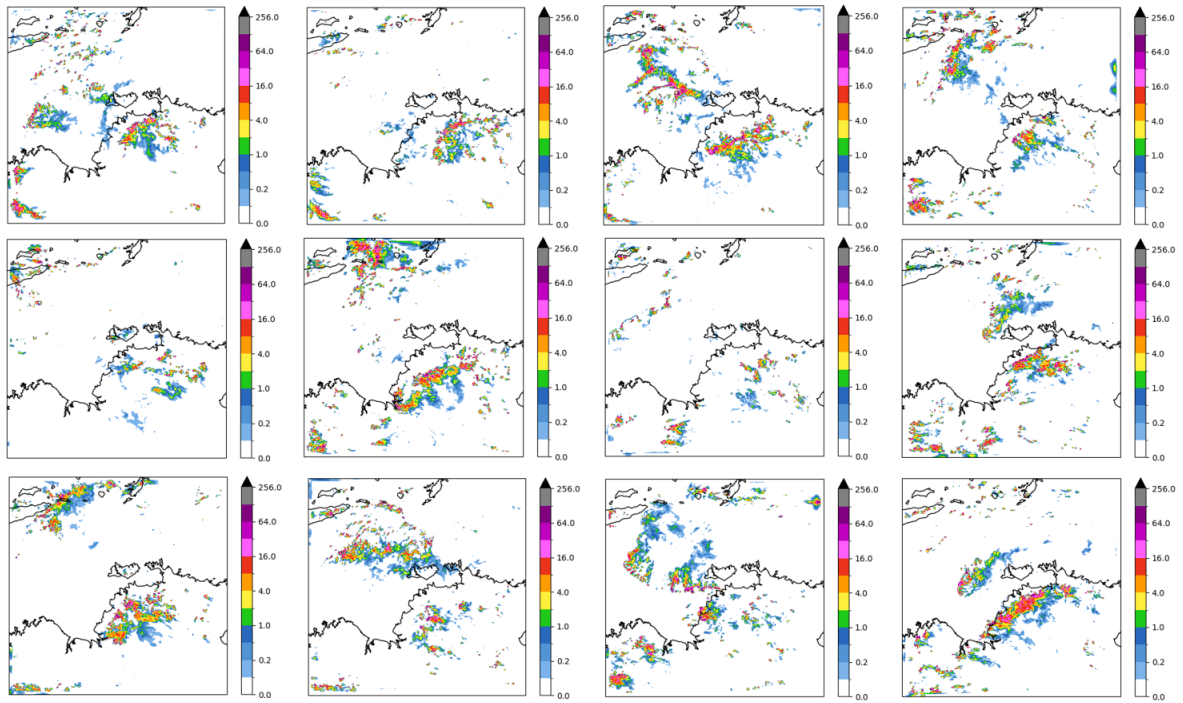
Ensemble model case studies and plans

- #595 (ENS: add capability to run an lfric lam nested inside the UM)

- Successfully run 3 targeted case studies focussing on impactful convective events in the vicinity of Darwin (2021/2022).

- 12-member ensembles for LFRic and UM run within a single workflow (copy of the ENS branch for ticket #595).

- Initial ensemble tests over the UK will start once #595 is lodged, focusing on checking that the functionality works.



Ensemble postage stamps

Image courtesy of Richard Jones (Met Office)

Climate simulations

- Calum Scullion and Simon Tucker have been setting up and running some longer LFRic tests.

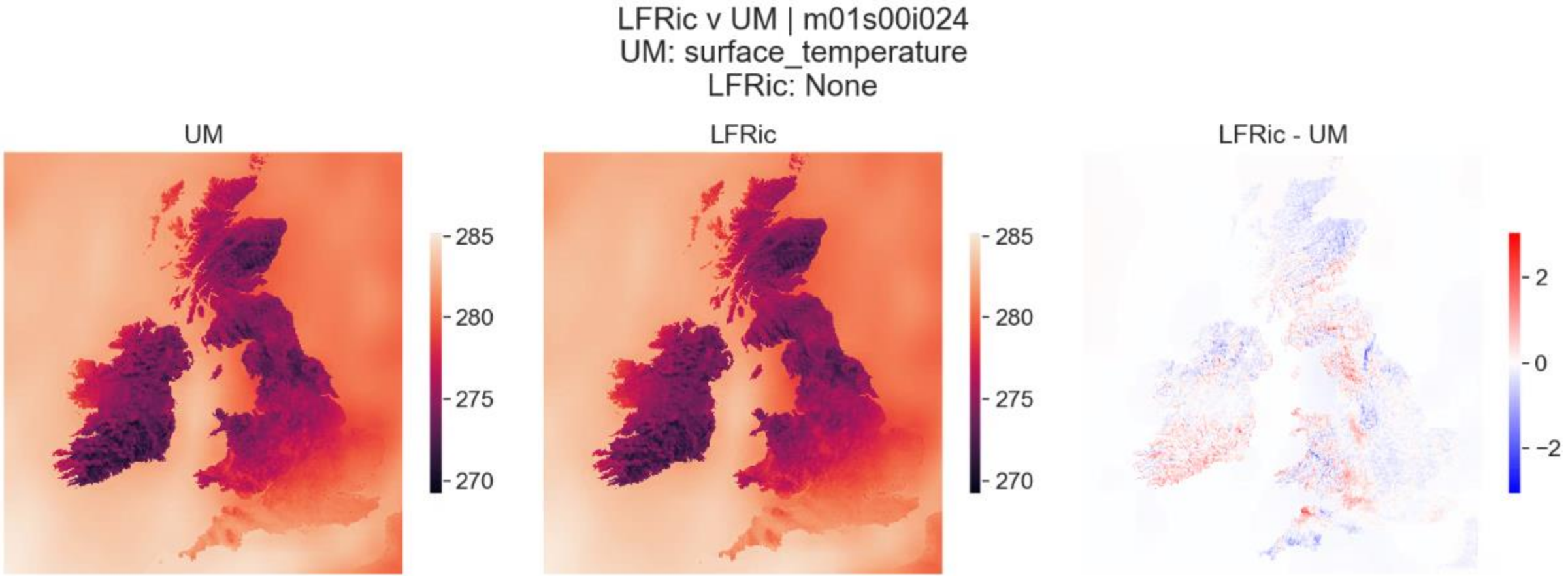
- We are currently focusing on the UK, using the same UK-like domain as used in the RNS LFRic case studies, and running both LFRic and UM LAMs with LBCs coming from ERA5 in both.

- The suite (u-di134) was actually adapted from a CP4Africa suite as the UKCP suite isn't set up to use ERA5. Easy aerosol is not included.

- The LFRic LAM has run nearly three weeks of Summer.

- The LFRic LAM runs a 6-hour CRUN forecast in 30-40 mins. This is approximately three times slower than the UM (24-hour CRUN in 50 mins) and mean that 1 year of simulation would take ~40 days on current HPC.

Climate simulations



Slide courtesy of Calum Scullion (Met Office)

UKV Data Assimilation plans

- Demonstrate capability to successfully run a UM driven LFRic LAM cycling DA (JOPA/VAR/LFRic) workflow, including successful observation ingestion into JOPA and successful creation and reading in of an analysis increment file to produce a modified model trajectory/forecast.

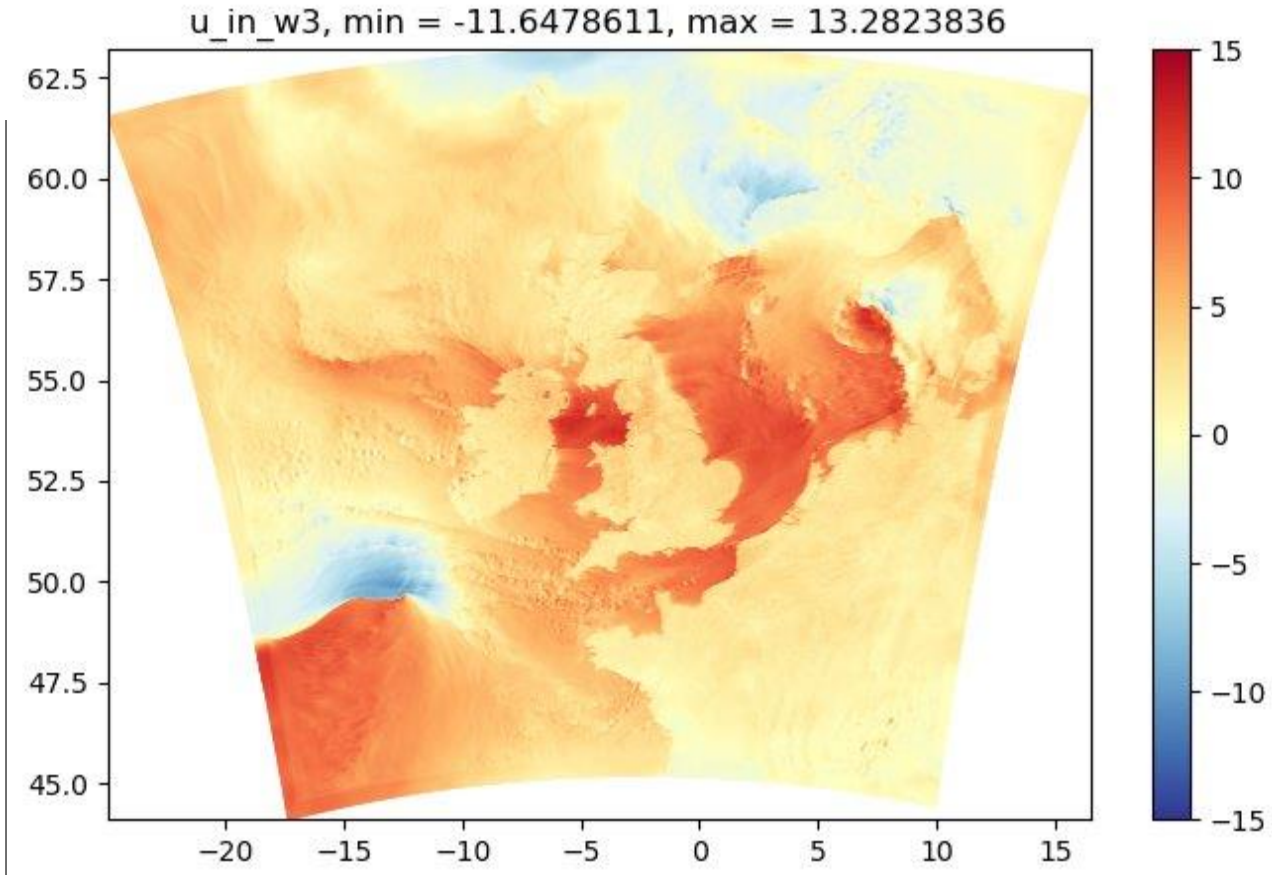
- *If sufficient observations exist within cycling DA capability, scientific evaluation indicates no significant degradation in verification relative to UM cycling DA with equivalent observation input*

Coupled model plans

- UM driven coupled LFRic model simulations will initially be atmosphere-ocean and later atmosphere-ocean-wave.
- Coupled simulations for at least one mid-latitude or one tropical domain of interest.
- Requires sufficient computational performance to enable the ability to run a CRUN segment (end-to-end simulation within single HPC submission) to at least 24 hours. This is how the RCS is set-up.
- This requirement has delayed the start of running coupled model simulations
- #591 (RCS: Addition of LFRic)

Variable resolution and urban-scale model plans

- #593 (RNS: Add Stretched Grid UK LFRic configurations (UKV))
- Variable resolution case studies – repeat cases already run with fixed resolution.
- Urban-scale case studies using London Model (LMV) and Paris Model (PMV) to test sub-km sensitivity to resolution and variable resolution for WesCon and Paris RDP cases.
- We will be interested in the behaviour of convection at 100m scales in LFric (which we know is very sensitive to turbulence in the model) and the representation of the convective boundary layer, in particular whether it is so keen to form rolls.

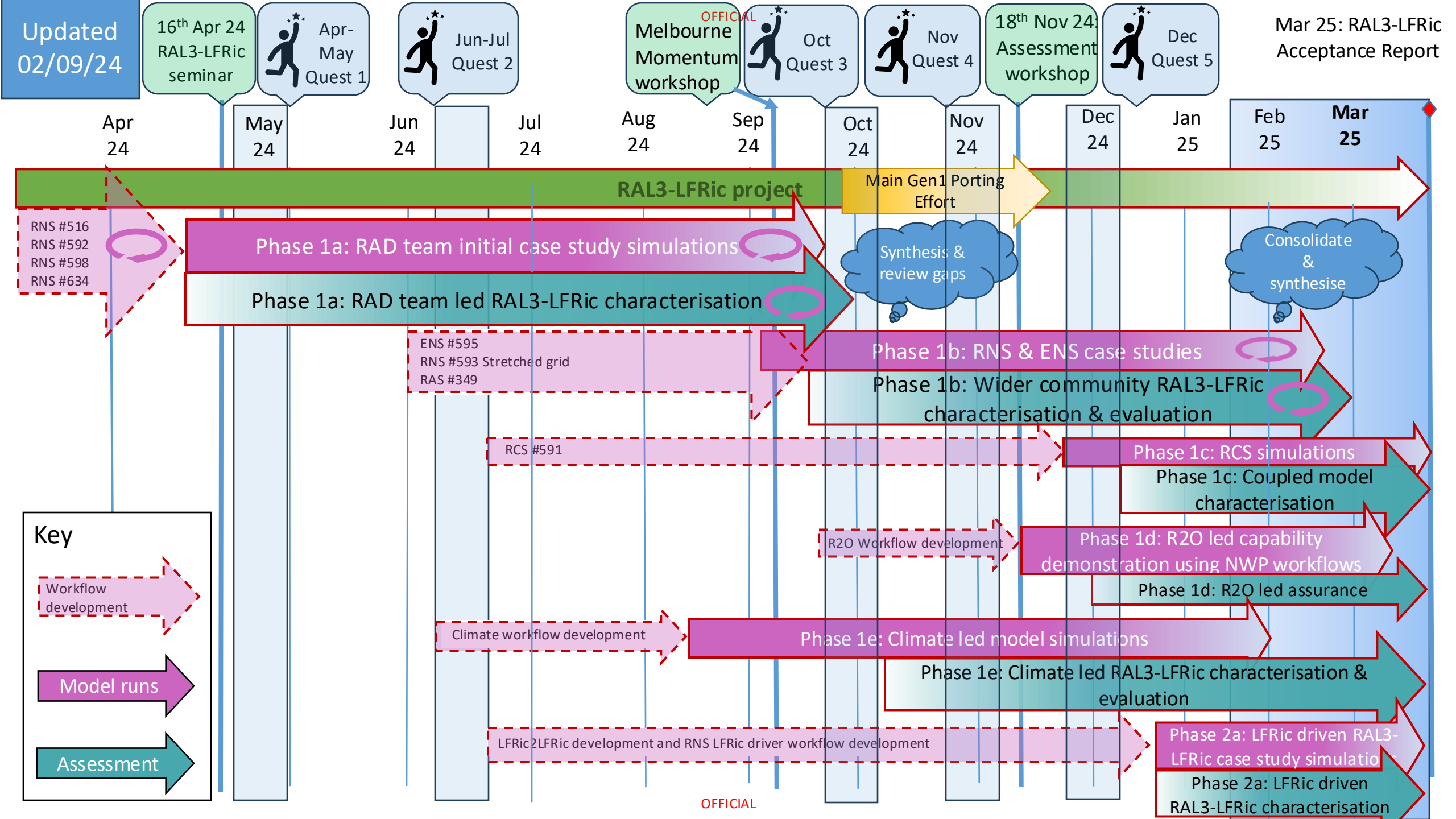


Eastward wind

Image courtesy of Christine Johnson (Met Office)

LFRic2LFRic plans

- Horizontal regridding
    - LFRic Inputs has developed a prototype for generalised horizontal regridding using the Oasis coupler
    - Start testing with 64x64 Point Nemo (Pacific ocean) domain – no orography
    - Move on to a larger domain (to test performance/scalability of prototype)
    - Introduce orography. This then leads us to:
- Vertical regridding
    - To be tested after the horizontal regridding
    - GAL has 80km model top. RAL has 40km top
    - UM reconfiguration is very poorly documented and this doesn’t help the development of new LFRic functionality


Updated 02/09/24
16th Apr 24 RAL3-LFRic seminar
Apr-May Quest 1
Jun-Jul Quest 2
Melbourne Momentum workshop
Oct Quest 3
Nov Quest 4
18th Nov 24: Assessment workshop
Dec Quest 5
Mar 25: RAL3-LFRic Acceptance Report
Apr 24
May 24
Jun 24
Jul 24
Aug 24
Sep 24
Oct 24
Nov 24
Dec 24
Jan 25
Feb 25
Mar 25
RAL3-LFRic project
Main Gen1 Porting Effort
RNS #516
RNS #592
RNS #598
RNS #634
Phase 1a: RAD team initial case study simulations
Phase 1a: RAD team led RAL3-LFRic characterisation
Synthesis & review gaps
Consolidate & synthesise
ENS #595
RNS #593 Stretched grid
RAS #349
Phase 1b: RNS & ENS case studies
Phase 1b: Wider community RAL3-LFRic characterisation & evaluation
RCS #591
Phase 1c: RCS simulations
Phase 1c: Coupled model characterisation
R2O Workflow development
Phase 1d: R2O led capability demonstration using NWP workflows
Phase 1d: R2O led assurance
Climate workflow development
Phase 1e: Climate led model simulations
Phase 1e: Climate led RAL3-LFRic characterisation & evaluation
LFRic2LFRic development and RNS LFRic driver workflow development
Phase 2a: LFRic driven RAL3-LFRic case study simulations
Phase 2a: LFRic driven RAL3-LFRic characterisation
Key
Workflow development
Model runs
Assessment

Met Office

Concluding thoughts

- Lots of exciting activity and great progress being made with the RAL3-LFRic project across the Momentum Partnership.
- You will see and hear much more detail in the upcoming talks today and tomorrow
- Lots more work still to do!
- We are already working on #634 (RNS: Upgrade to LFRic_apps version 1.1) and a new way of initialising PMSL, so the science is still very much in development!