Unified Model Consortium Presentation

45th EWGLAM and 30th SRNWP meeting,
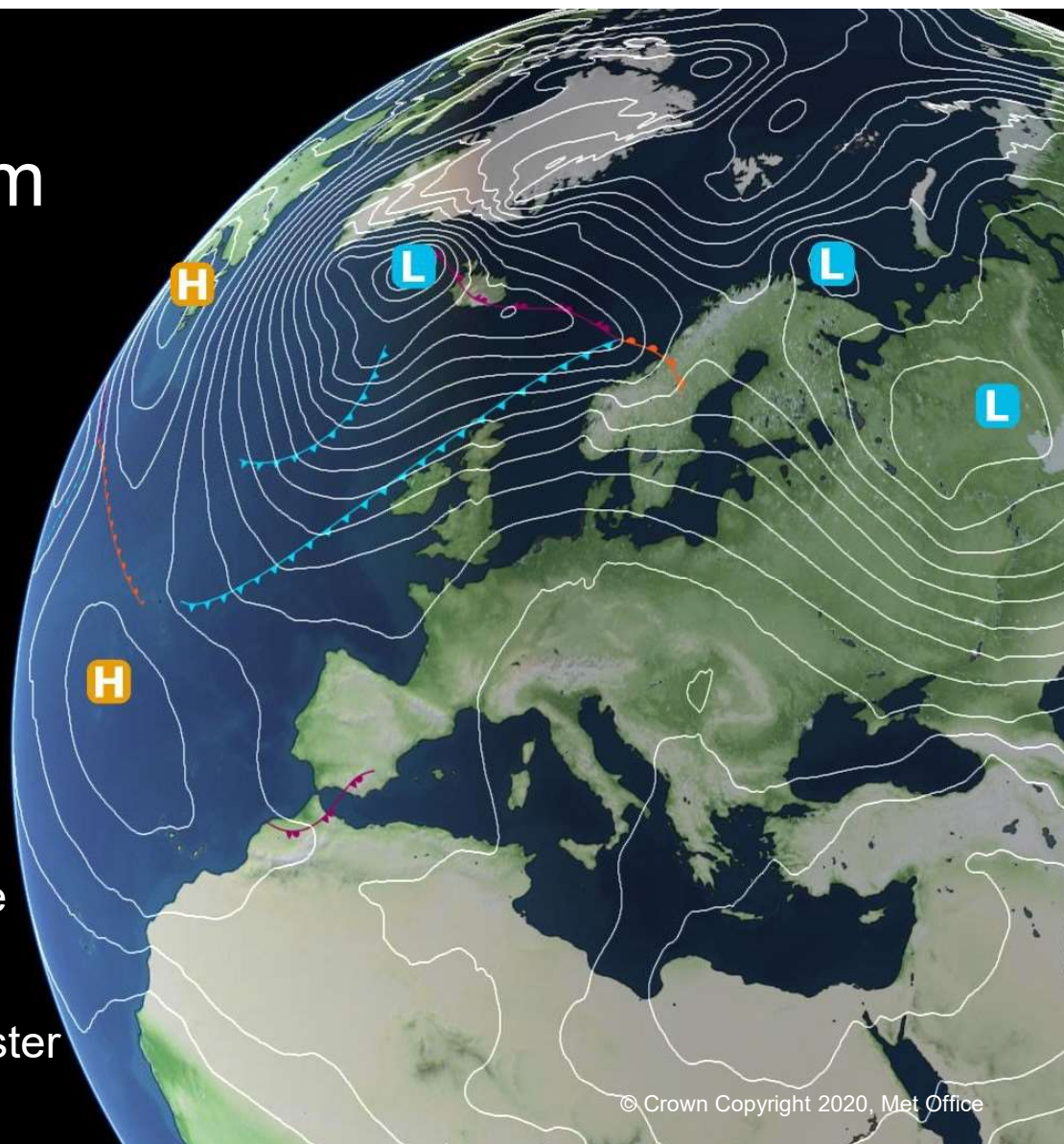Reykjavík, Iceland

25th September 2023

Mike Bush

With thanks to many colleagues including:

Paul Barrett, Ségolène Berthou, Charmaine
Franklin, Kirsty Hanley, Humphrey Lean,
Huw Lewis, Aurore Porson, Belinda Roux,
João Teixeira, David Walters & Stuart Webster

Met Office

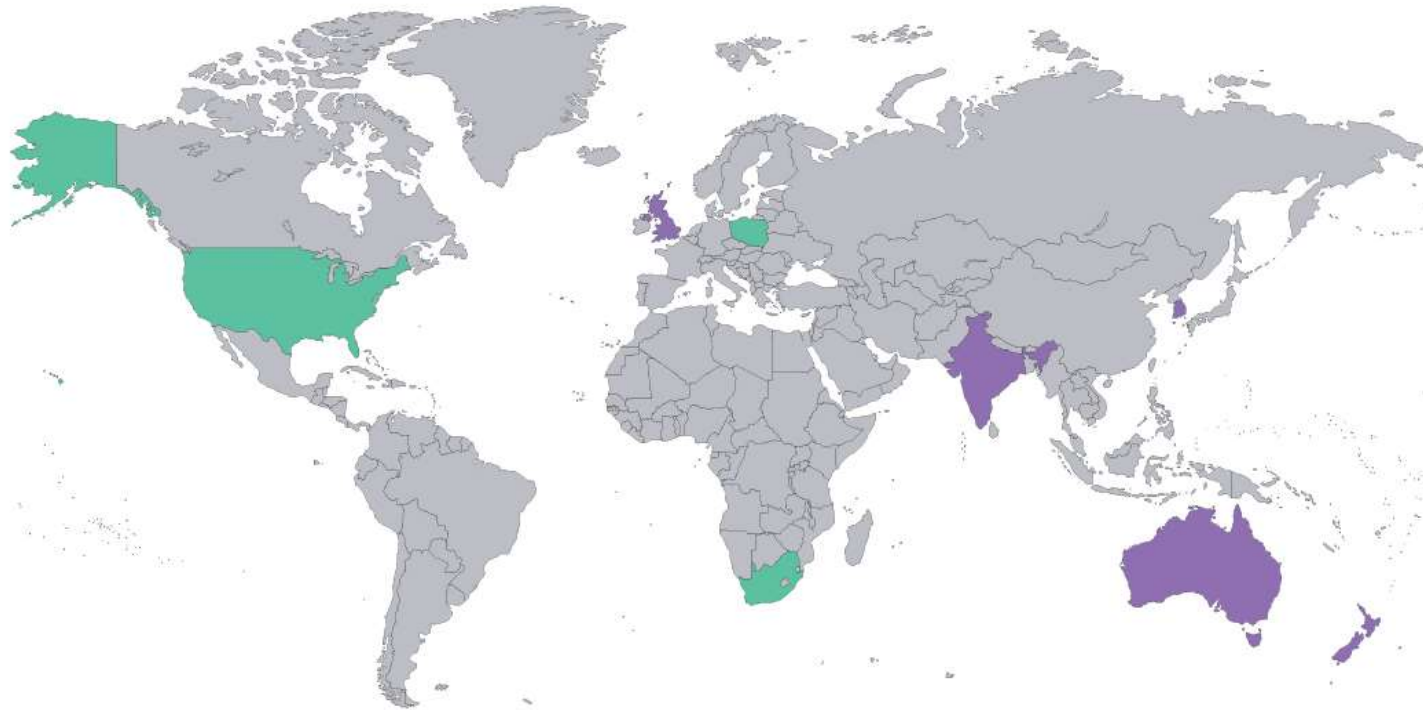# Talk structure

- Unified Model Partnership (consortium) status 2023
- WesCon (Wessex Convection) Field campaign
- UK Summer testbed
- Regional Environmental prediction (coupled-model development)
- Planned upgrades to Met Office and UM Partner operational systems
- Signposting other Met Office talks at EWGLAM giving more detail

The Unified Model Partnership

2023

CORE PARTNERS

Met Office · Australian Government Bureau of Meteorology · CSIRO · Korea Meteorological Administration · Ministry of Earth Sciences · NIWA Taihoro Nukurangi

ASSOCIATE PARTNERS

South African Weather Service · icm · United States Air Force · Meteorological Service Singapore

Momentum

The Unified Earth Environment Prediction Framework

Momentum is the collection of **Software** comprising the model codes and supporting infrastructure that provides the ability to run Earth Environment Prediction applications, together with the **Science Configurations** that define the way model codes are run for regional or global applications.
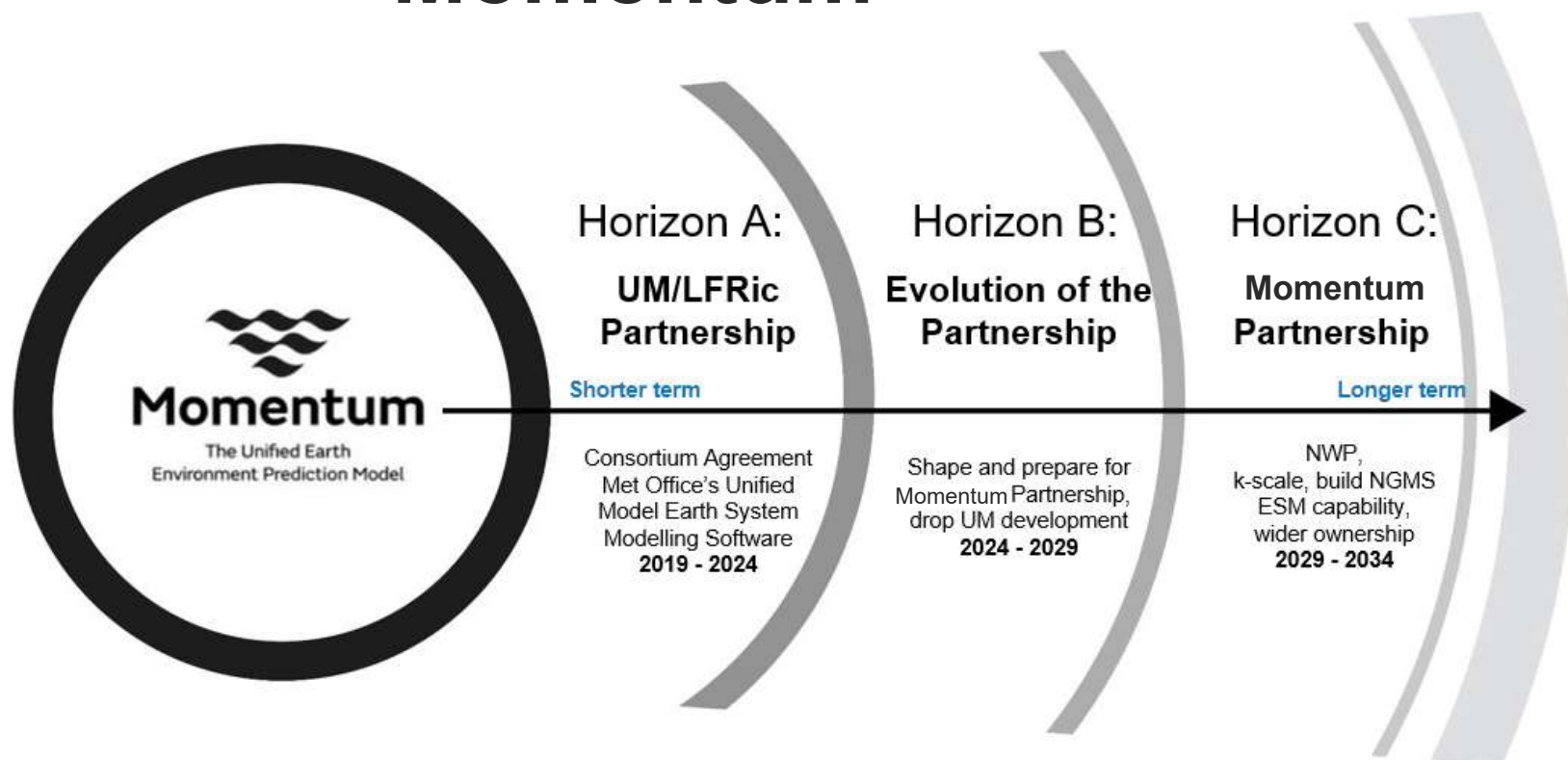
Partners using Momentum

Developing prediction systems that enable the delivery of forecasts and predictions

NZESM	MOGREPS	UKESM	GLOSEA	
	ACCESS	NCUM	GALWEM	K-ACE

Korea Meteorological Administration · National Centre for Atmospheric Science · National Oceanography Centre · UK Centre for Ecology & Hydrology · NIWA

British Geological Survey · British Antarctic Survey · National Centre for Earth Observation · PML · CSIRO · Ministry of Earth Sciences Government of India

South African Weather Service · icm · UK National Climate Science Partnership · Australian Government Bureau of Meteorology · Meteorological Service Singapore

Met Office · University of Birmingham · University of Bristol · University of Exeter · University of Leeds · Oxford · University of Reading · UCL

Prepared by Met Office, on behalf of Momentum partners © Crown Copyright 2023

Momentum

Slide courtesy of João Teixeira

WesCon WOEST 5th June - 25th August 2023

Met Office · UNIVERSITY OF LEEDS · Imperial College London · Menapia

National Centre for Atmospheric Science (NATURAL ENVIRONMENT RESEARCH COUNCIL) · UNIVERSITY OF EXETER · JADE HOCHSCHULE Wilhelmshaven Oldenburg Elsfleth · FAAM AIRBORNE LABORATORY

University of Reading · MANCHESTER 1824 The University of Manchester · AMOF
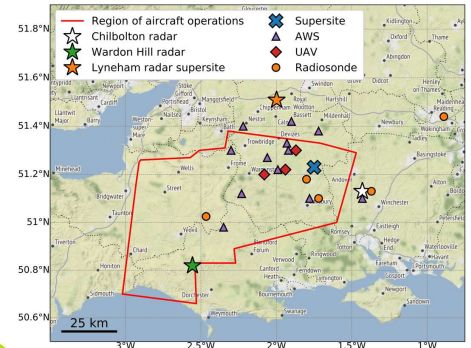
Aircraft
- FAAM - 12 flights, >70 hours
- DIMONA - 16 Flights, >45 hours

Radars
- CAMRa, Kepler, NXPol1 & 2,
- Chilbolton, Lyneham, Wardon Hill
- 25+ Days scanning

Radiosonde
- Larkhill, Chilbolton, Ash Farm, Spire View, Reading.
- Extras: Camborne, Herstmonceux, Aberporth
- >350 in total.

WxUAS
- Breach Hill, Heytesbury, Chilbolton, Wherwell Forest.
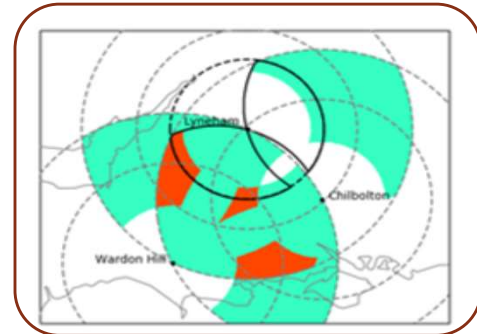- ~120 flight hours.
- ~700 flights.
- First 2 km BVLOS.

Supersites
- Netheravon, Lyneham, Chilbolton
- Lidars,
- wind profilers,
- microwave radiometers,
- stereo cameras
- Masts

AWS sites
- 12 stations 24/7 operation

Long term observations and 30 Intensive Observations Periods

Doppler Radar network
Lyneham, Chilbolton, Wardon Hill

#WesCon2023

WesCon Modelling

- The ultimate aim of WesCon is to improve km scale and sub-km models.

- As part of the campaign and to help kick start the subsequent work on models three experimental modelling systems were run routinely during the campaign:

- A 300m variable resolution ensemble over Wessex (the WMV) was run for every day of the campaign.

- A 2.2km regional coupled ensemble (including atmosphere, land, wave and ocean models) was run for 5 days starting each Monday of the campaign.

- A daily comparison of the RAL2-M and RAL3 configurations for the UKV model.

- Next steps: looking at vertical velocities from the observations and comparing them with the model

Slide courtesy of Paul Barrett

The UK Summer 2023 Testbed

Met Office

- Focus on the impact of our Scientific developments on downstream users and customers

- First hybrid testbed and wider involvement of MOAP (Met Office Academic Partnership)

- First international testbed with guests from NIWA, BoM, NEA and Met Eireann

- Six activities – major focus on ensembles and running in conjunction with WesCon

- About 100 people involved in this year's testbed

UK Testbed Summer 2023 (5 weeks from 19th June to 21st July)

Activity	Time
Main link: OpMet Brief #1: setting the scene/situational awareness	0910-0920
Separate link: Forecasting Denial Experiment: Ensemble vs Deterministic	0920-1020
Separate link: IMPROVER Forecasting	1040-1110
Main link: WesCon	1120-1200
Lunch	1200-1300
Main link: OpMet Brief #2: UKV/GM analysis	1300-1310
Main link: Post-Event: MOGREPS-UK & MOGREPS-G Evaluation	1310-1410
Main link: OpMet Brief #3: FDE Review	1410-1420
Separate link: Post-event Flooding: SWFHIM + FOREWARN Forecasts	1430-1530
Main link: OpMet Brief #4: UKV brief for Bristol and WesCon area	1540-1545
Main link: Post-Event: Sub-km Ensemble Convection & sub-km Bristol ASSURE	1545-1645

Break

Specific OpMet Briefs to introduce the activities

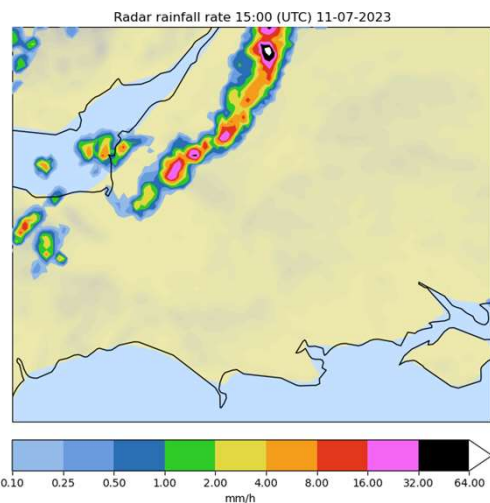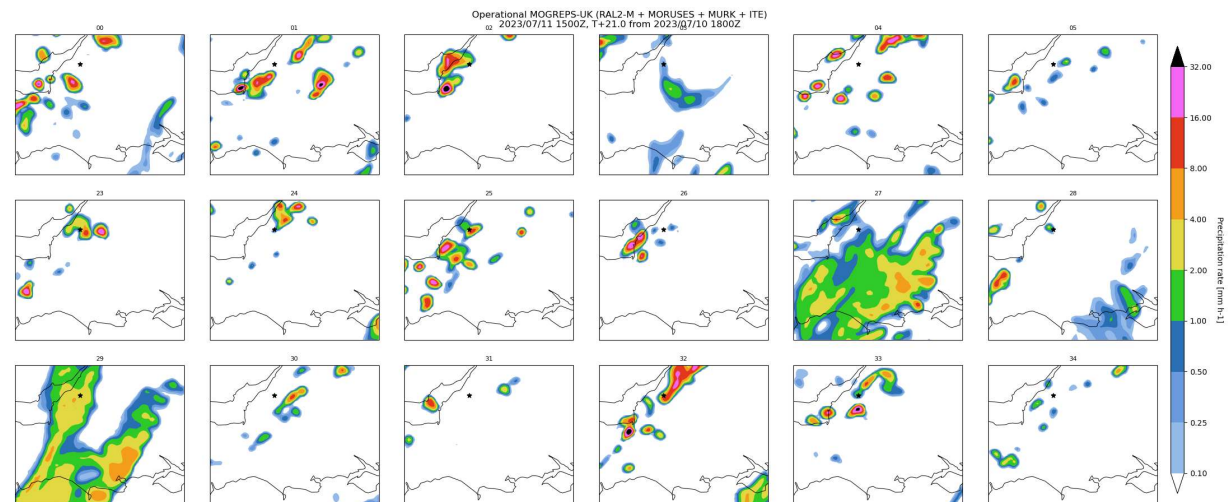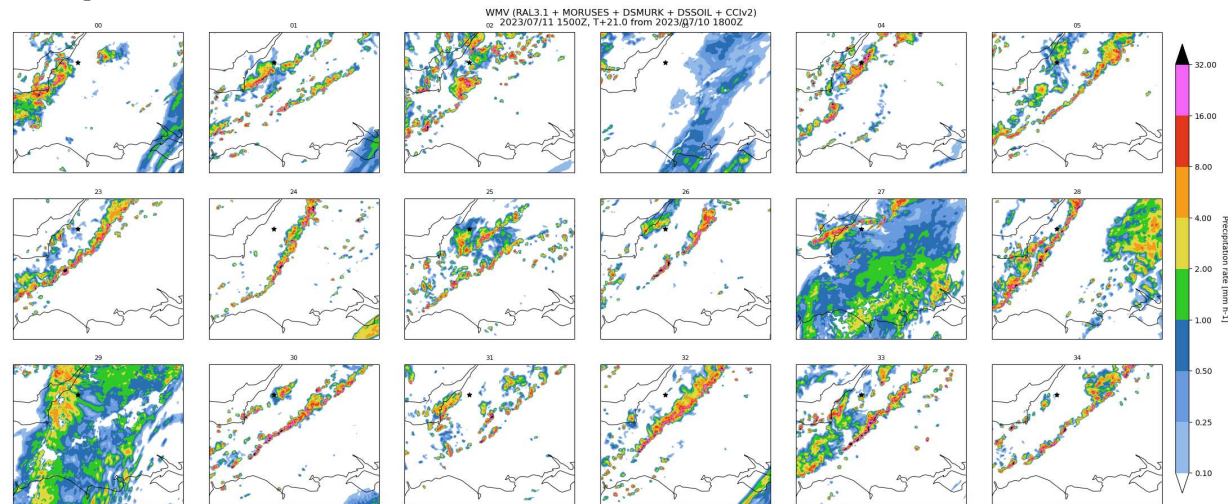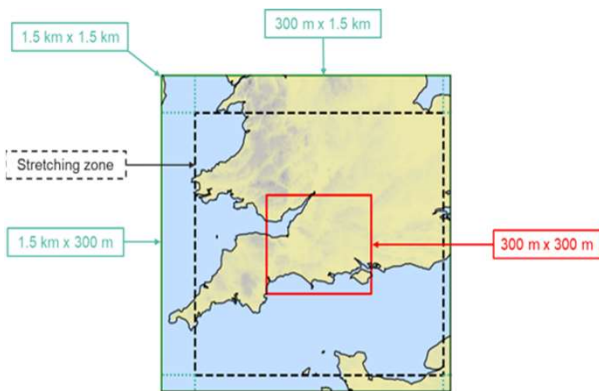Forecasting Activities in the mornings

Specific OpMet Briefs to introduce the activities

Post-Event Activities in the afternoons

Slide courtesy of Aurore Porson

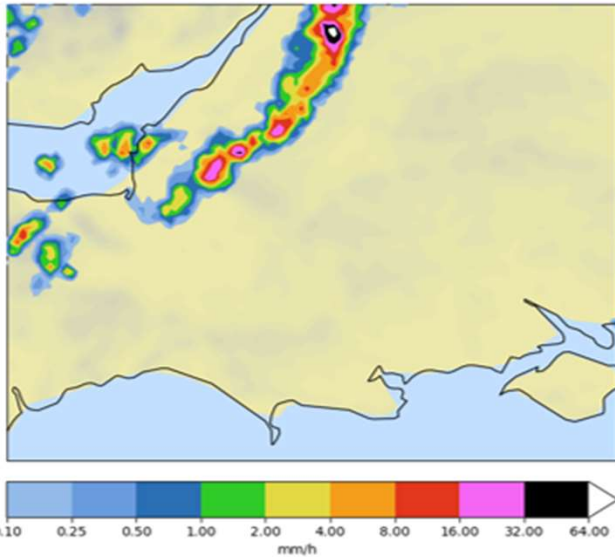**What value does a sub-km (300m) ensemble provide over the current km-scale operational ensemble MOGREPS-UK?**
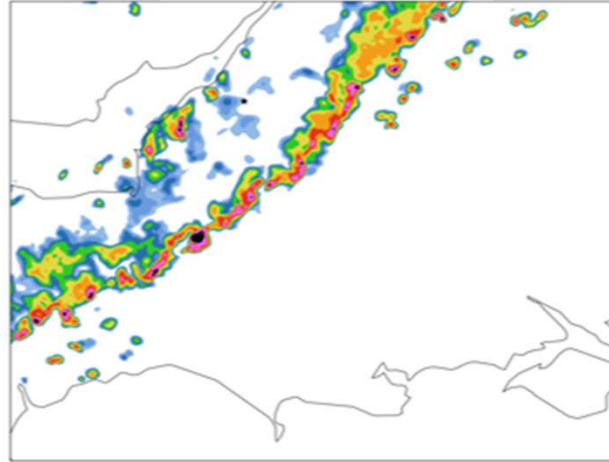
Met Office

WMV 300-m Ensemble

Current operational Ensemble 2.2 km MOGREPS-UK

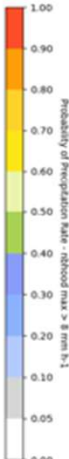Kirsty Hanley and Humphrey Lean

11 July 2023 15 UTC (T+21)
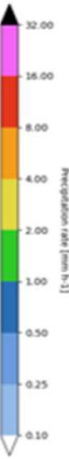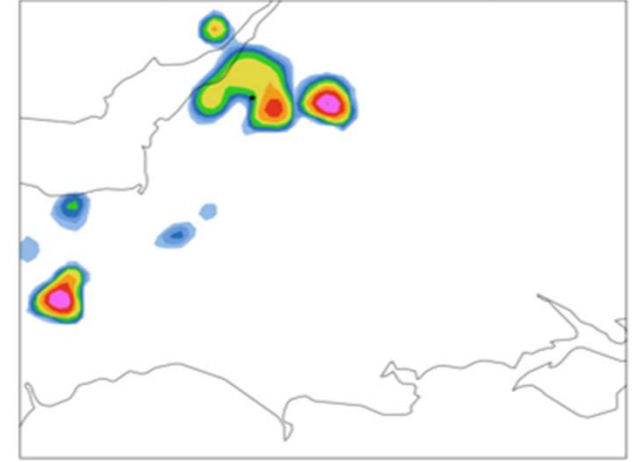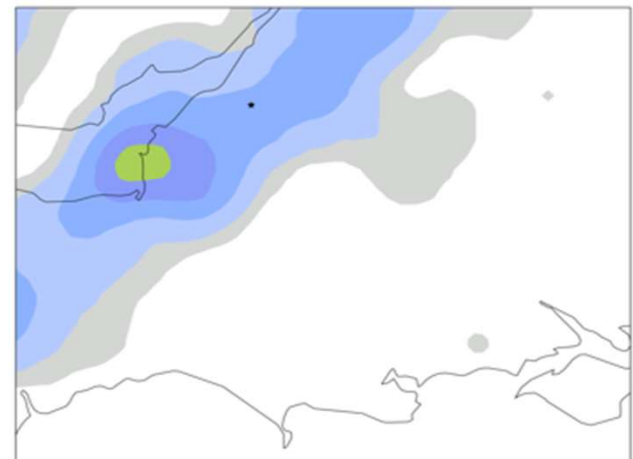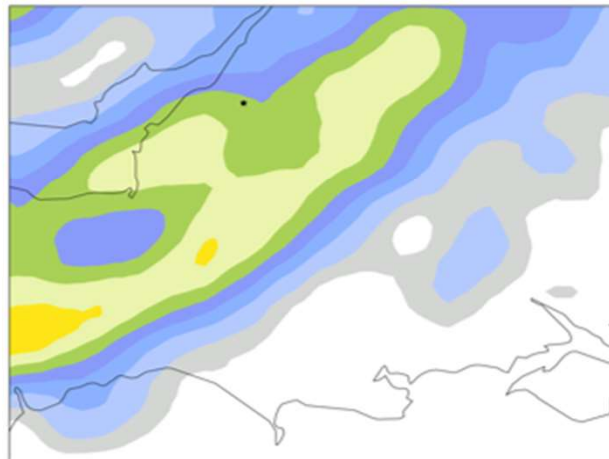
Slide courtesy of
Kirsty Hanley

Regional Environmental Prediction - UK

where it comes from, where it's going

Slide courtesy of Ségolène Berthou

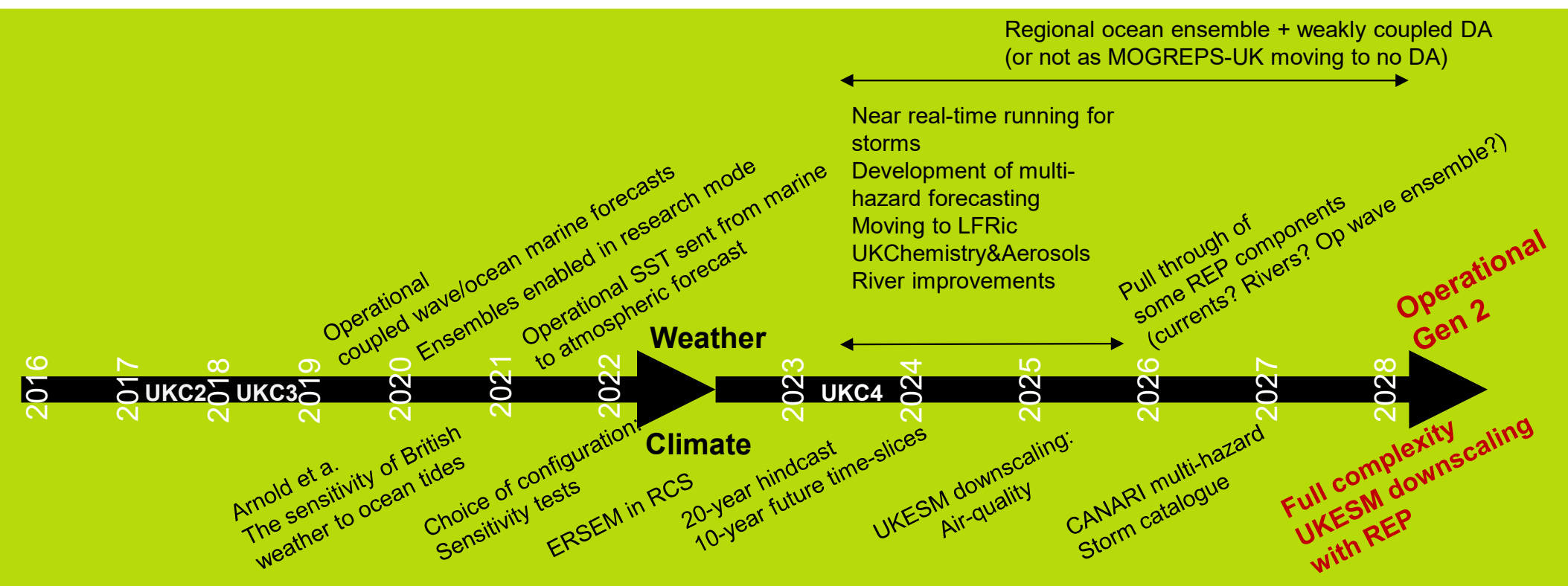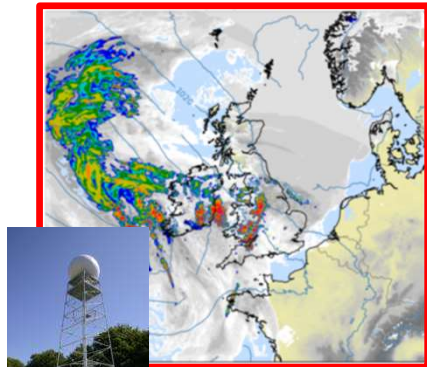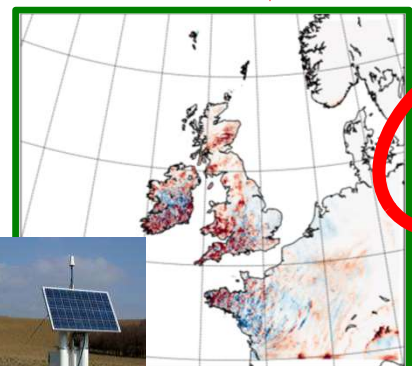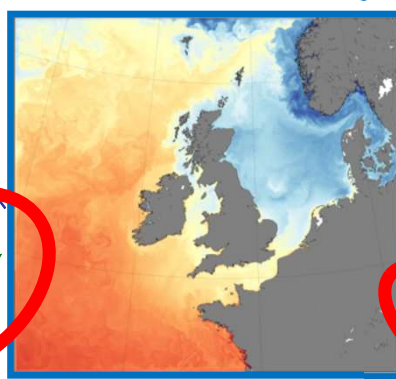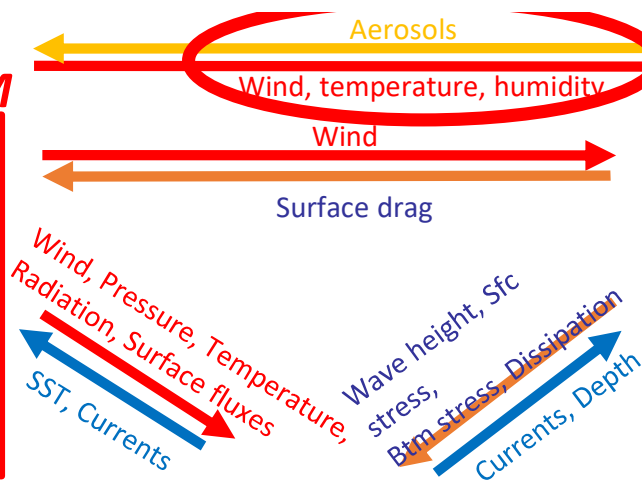Met Office | Centre for Ecology & Hydrology (NATURAL ENVIRONMENT RESEARCH COUNCIL) | National Oceanography Centre (NATURAL ENVIRONMENT RESEARCH COUNCIL) | PML | Plymouth Marine Laboratory

Regional ocean ensemble + weakly coupled DA
(or not as MOGREPS-UK moving to no DA)

Near real-time running for storms
Development of multi-hazard forecasting
Moving to LFRic
UKChemistry&Aerosols
River improvements

Pull through of some REP components
(currents? Rivers? Op wave ensemble?)

Operational coupled wave/ocean marine forecasts

Ensembles enabled in research mode

Operational SST sent from marine to atmospheric forecast

Weather

Operational Gen 2

2016 2017 **UKC2** 2018 **UKC3** 2019 2020 2021 2022 **Weather** / **Climate** 2023 **UKC4** 2024 2025 2026 2027 2028

Full complexity UKESM downscaling with REP

Arnold et a.
The sensitivity of British weather to ocean tides

Choice of configuration?
Sensitivity tests

Climate

ERSEM in RCS

20-year hindcast
10-year future time-slices

UKESM downscaling:
Air-quality

CANARI multi-hazard
Storm catalogue

ATMOSPHERE: UM

Aerosols

Wind, temperature, humidity

Wind

Surface drag

WAVES: WaveWatch III

Wind, Pressure, Temperature, Radiation, Surface fluxes

SST, Currents

Wave height, Sfc stress, Dissipation

Btm stress, Currents, Depth

Surface fluxes

Radiation, Temp, Precip, Evap

Bottom stress

NaCl, DMS

N, Fe

CHEMISTRY &AEROSOLS: UKCA

Inundation

Freshwater

Water Colour

T, S, u, v

Bottom stress

OCEAN: NEMO

Slide courtesy of Ségolène Berthou

Riv. Nutrients, Riv. Temperature
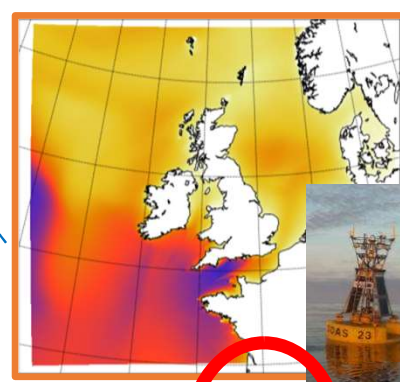
LAND SURFACE: JULES
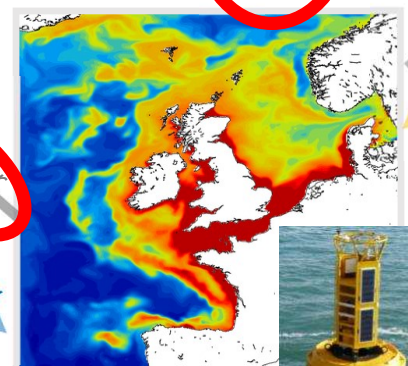
SEDIMENTS/BIOGEOCHEM: ERSEM

Met Office | Centre for Ecology & Hydrology NATURAL ENVIRONMENT RESEARCH COUNCIL | National Oceanography Centre NATURAL ENVIRONMENT RESEARCH COUNCIL | PML | Plymouth Marine Laboratory | UK Environmental Prediction research
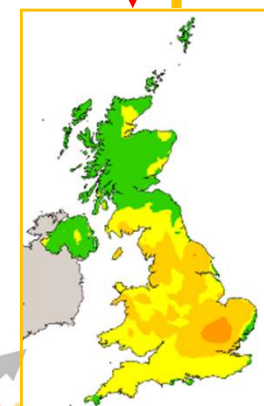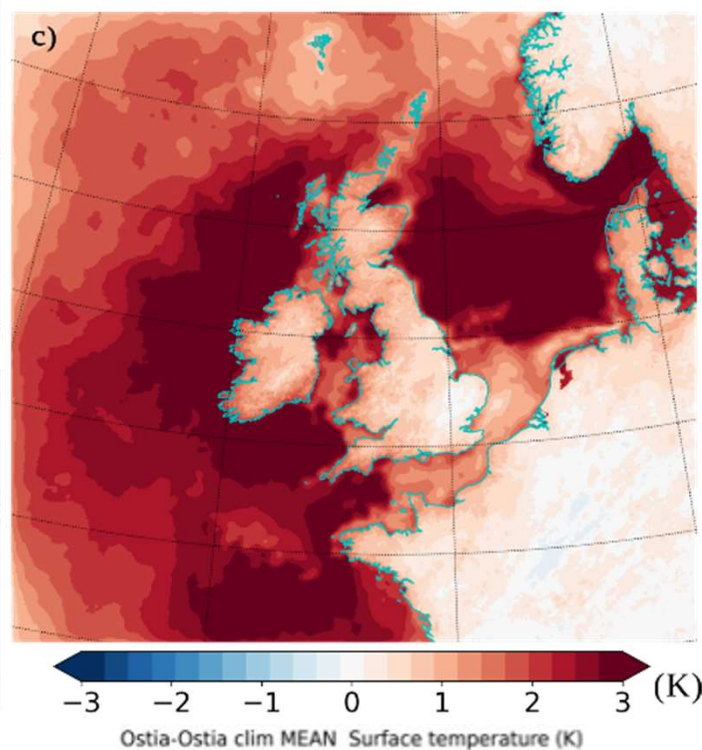
Slide courtesy of Ségolène Berthou

June 2023 Marine heatwave: feedbacks on the weather

British Isles 1K warmer in second half of June because of marine heatwave, advected in-land by sea breezes.
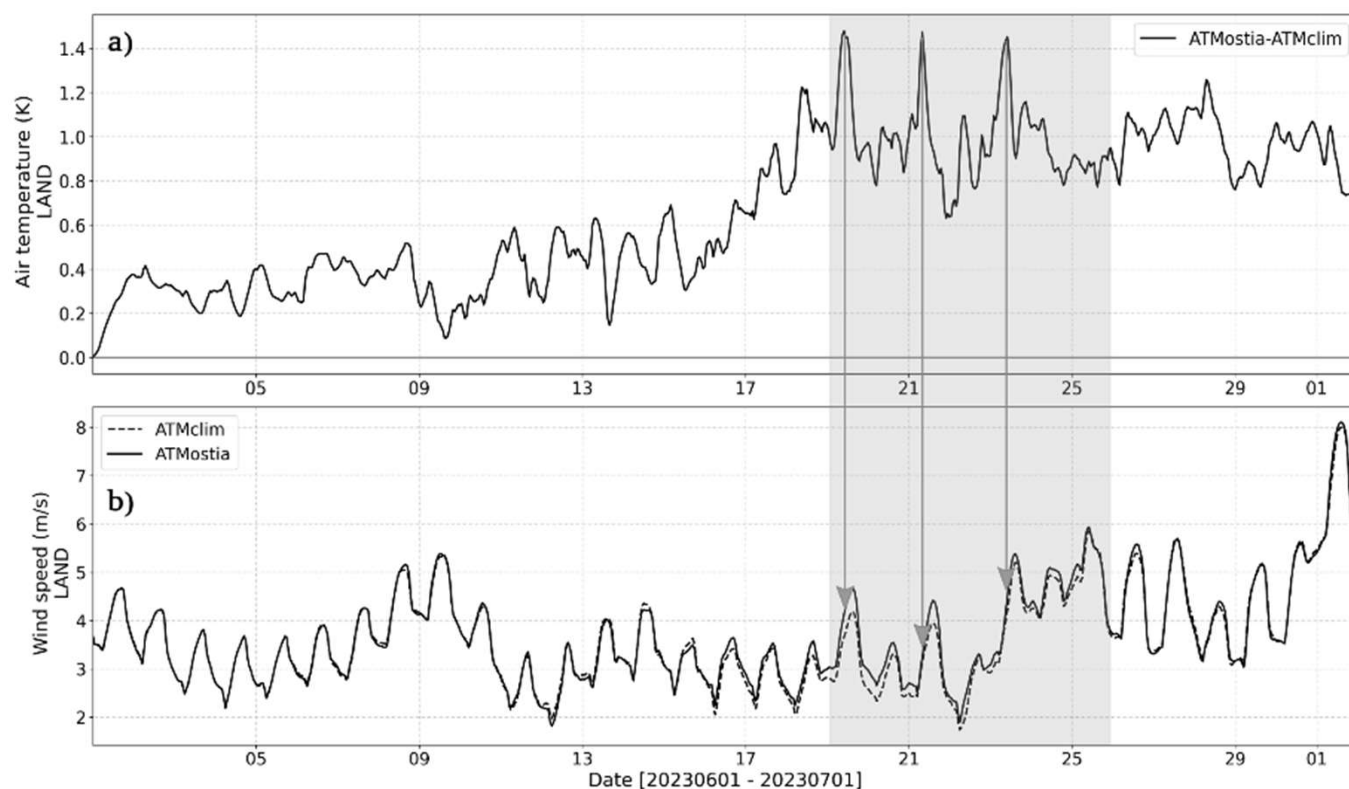
19th – 25th June average, air temperature

Berthou et al. (in prep) Unprecedented June 2023 marine heatwave over the Northwest European shelf: origins, feedback on weather and future recurrence

Met Office — Our future supercomputing capability

STRATEGIC ACTION
Delivering our future supercomputing capability

10 year strategic collaboration
Met Office

Microsoft

Full service supplied though a single provider
Service contract
- Hosting
- Supercomputing
- Networking
- Data storage
- Scientific compute
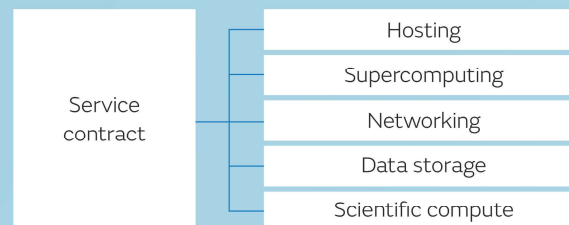
2 generations of supercomputing refreshed after 5 years
Generation 1 — 2023
Generation 2 — 2027
2032

Generation 1
6x
Phased introduction of capability

Phase 1	Phase 2
6 x increased capacity	

Generation 2
~18x
increase over current capability

Phase 1	Phase 2
3 x increased capacity	

Creating one of the world's most environmentally sustainable supercomputing capabilities

Powered entirely by sustainable energy

Entirely UK based

Investment will deliver many £ billions of socio-economic benefits to the UK over 10 years

# Planned upgrades to Met Office operational systems in 2024/2025

PS46: to go operational in Jun 2024

- Port models to new Met Office/Microsoft supercomputer

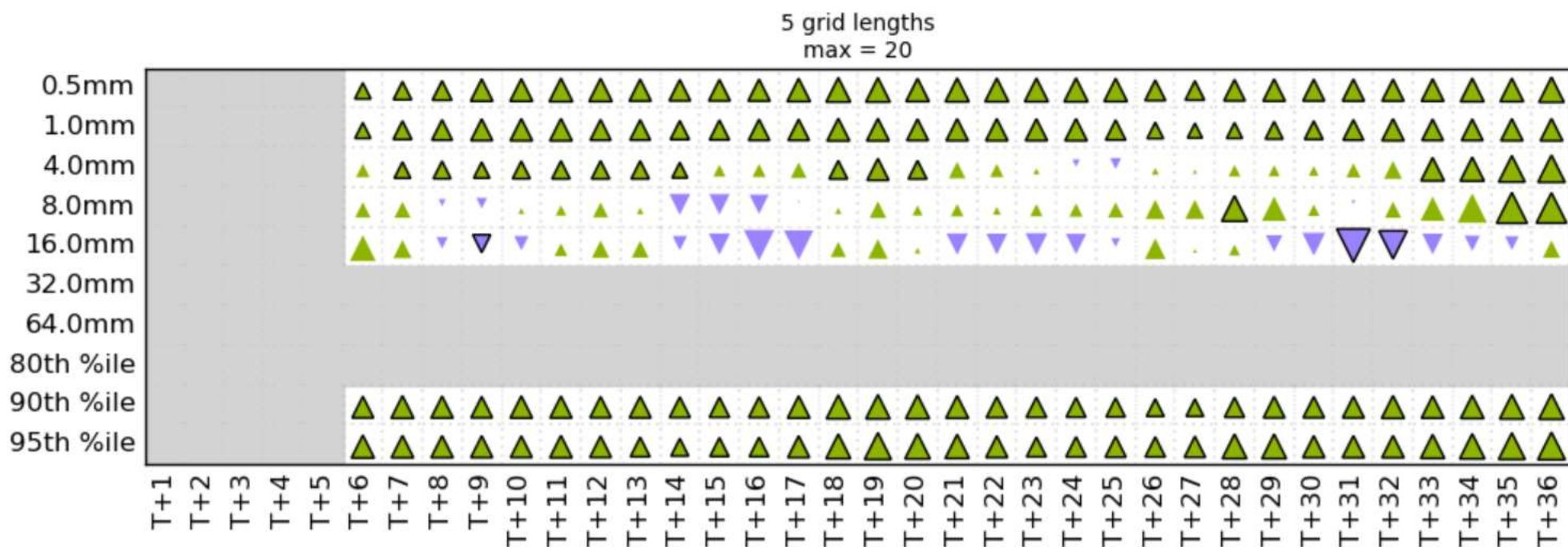**PS47:** June 2024 to January 2025

- Final OPS changes to be ready for JOPA in PS48
- New Moisture Incrementing Operator
- Regional Atmosphere/Land 3 (RAL3) Science Configuration
- Vertical resolution increase to 90 or 120 levels
- MET (Next-Gen verification)

Impact of changing science configuration and resolution on UK forecasts
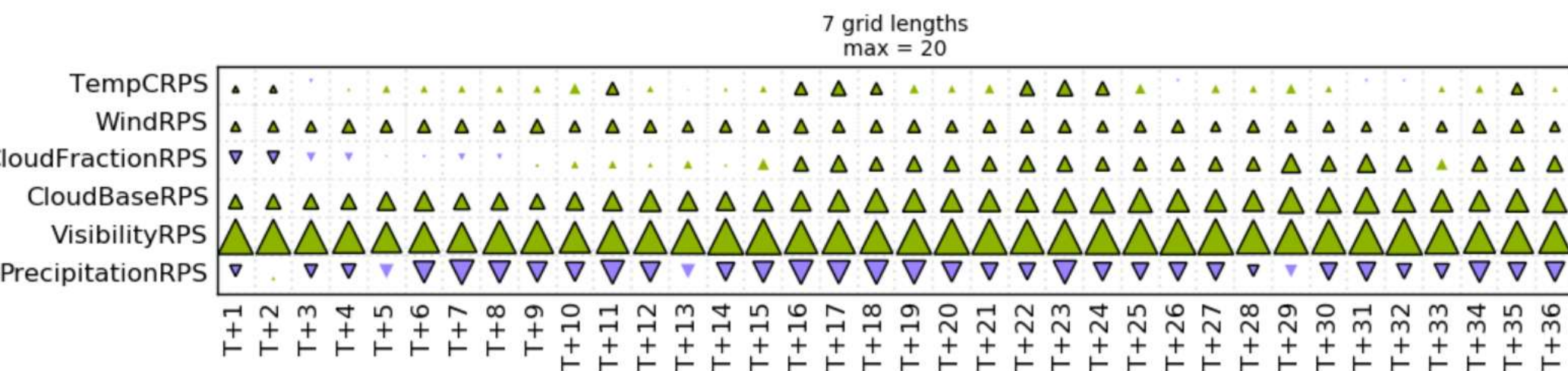
L120 RAL3.1 vs L70 RAL2-M. Summer trial at 15km spatial scale, model dx=2.2km

Stu Webster

Impact of changing science configuration and resolution on precipitation FSS for UK forecasts

L120 RAL3.1 vs L70 RAL2-M. Summer trial at 5km spatial scale, model dx=2.2km.

Stu Webster

Met Office

Planned upgrades to Met Office operational systems in 2025/2026

PS48: June 2025 to January 2026

- JOPA (JEDI* based observation processing)

- **Transition to ensemble-based forecasting systems**

- Retire UKV forecasts beyond the T+12 "NWP nowcast". Use the control member of MOGREPS-UK instead

- Upgrade to 1.5km resolution UK ensemble forecasts.

- Introduce 300m resolution "trailblazer" regional ensemble(s).

PS49: June 2026 to January 2027

- Pull-through of some Regional Env. Prediction components
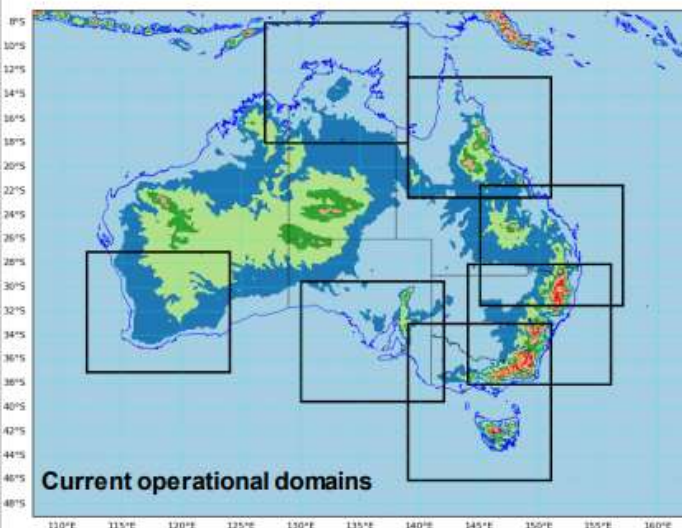
Planned upgrades to UM Partner operational systems

Met Office

UM Partner	Operational RAL	Expected date for RAL3 operational
NCMRWF (India)	RAL3	Already operational km-scale (Oct 2022) Delhi (Nov 2022)
MSS (Singapore)	RAL1-T	September 2023
ICM (Poland)	-	End of year 2023
NIWA (New Zealand)	UKV PS38 RAL2-M PS44 due soon	Late 2023/early 2024
BoM (Australia)	RAL1-M/T	January 2025
Met Office (UK)	RAL2-M/T	January 2025
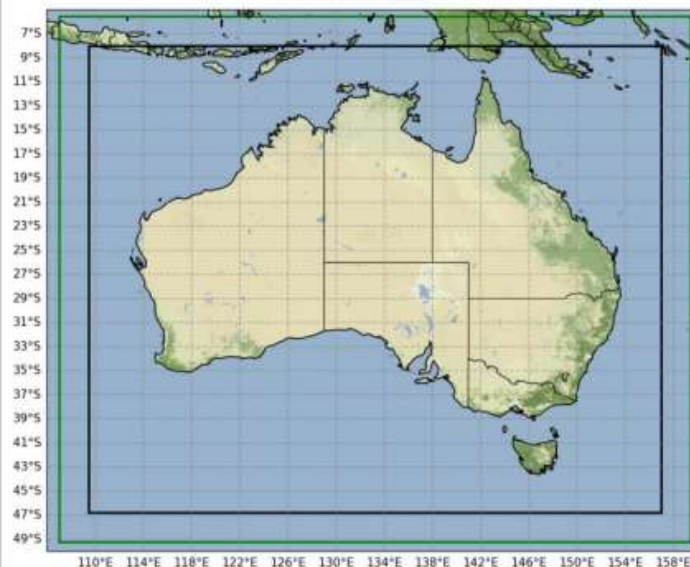
ACCESS-A Background

- Nationally consistent high-resolution forecasts
- RAL3.1 configuration, including MORUSES urban scheme
- 1.5 km horizontal grid spacing, 90 vertical levels
- Variable res grid to deal with spin up effects at boundaries
- 48-hour lead time
- Full domain: 3690 x 3045 x 90 points > billion
- Updated surface ancils
- ACCESS-AE - 2.2km, 12 members lagged ensemble

Slide courtesy of Belinda Roux and Charmaine Franklin

Monday	Consortia presentation		Session on Verification			Poster session
	Mike Bush	Marion Mittermaier	Nigel Roberts		Sebastian Cole	Marco Milan
	Consortia talk	Update on METplus implementation at the Met Office	Outcomes from the Met Office ensemble verification workshop		Use of MET verification to study and test Machine learning developments in emulating NWP global deterministic forecasts	National poster introduction
Tuesday	**Session on Upper-Air Physics**					
	Anke Finnenkoetter					
	Update on the Met Office Regional Atmosphere and Land configuration (RAL3)					
Wednesday	Parallel session on verification			Parallel session on DA	Predictability	Parallel session on predictability
	Marion Mittermaier	Roger Harbord	M. Mittermaier, Nigel Roberts, Rachel North	Marco Milan	Nigel Roberts David Walters	Stuart Webster + Carlo Cafaro
	Localised FSS with a new factorization to diagnose skill and skill improvements over time	Application of fair scores to lagged and unlagged ensembles from hourly-cycling MOGREPS-UK	Neighbourhood-based metrics investigation at the Met Office **1** FSS/RPS comparison **2** Using RPS with neighbourhoods **3** Impact on interpretation of RAL3 UK trial results	Ensemble-based methods	Ensemble NWP plans, the ensemble exploitation strategic action and ensemble use cases	Results from new configurations of MOGREPS-UK
Thursday	**Session on Dynamics**					
	Christine Johnson					
	Improving the solver efficiency in the LFRic LAM					

Thank you for listening!

Any questions?