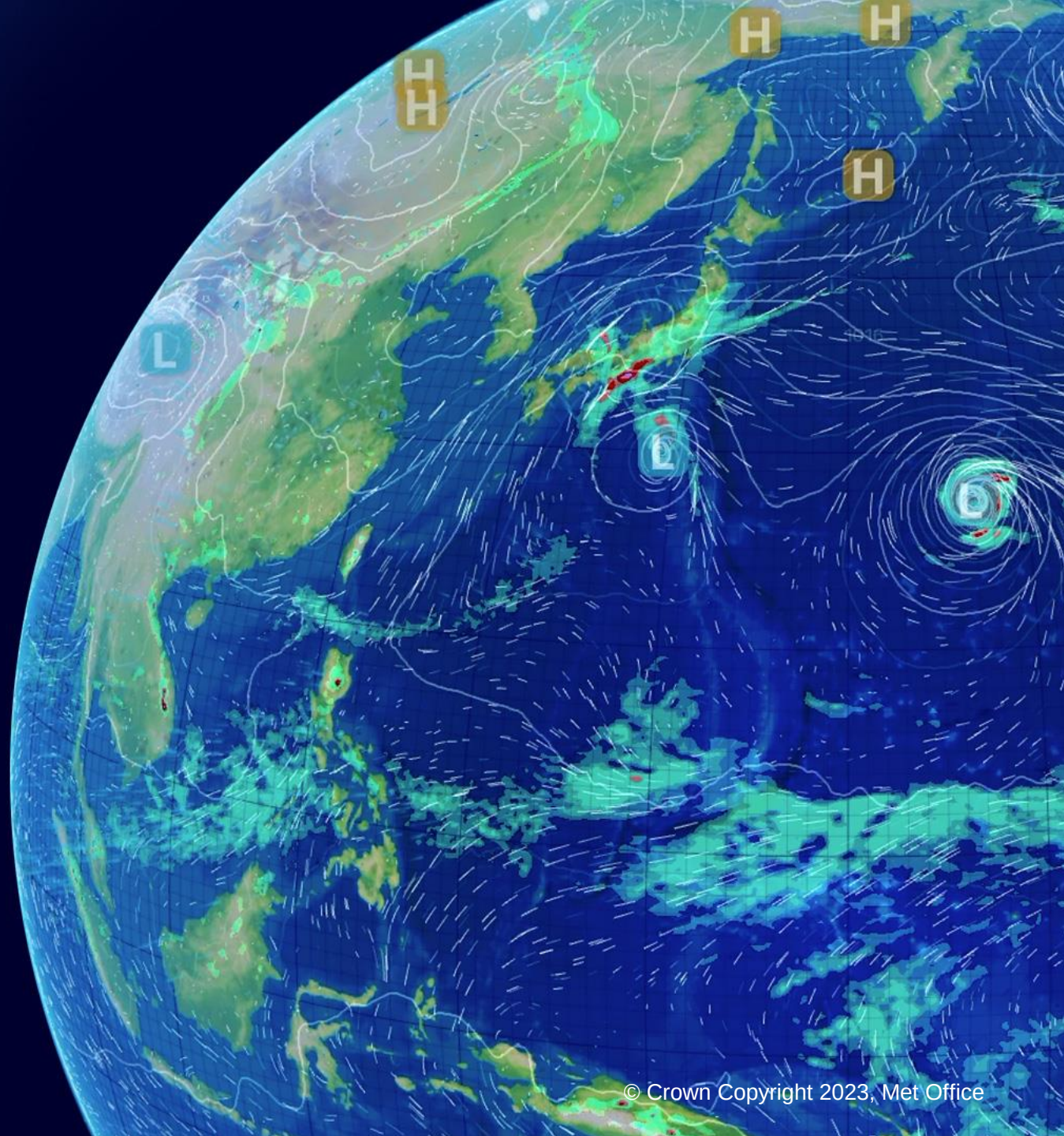
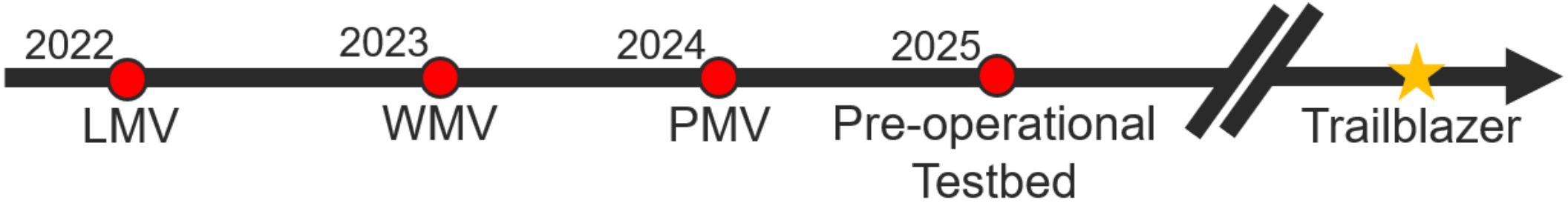
Experiences running an Urban-scale ensemble during summer 2023

Kirsty Hanley, Humphrey Lean



Towards an Urban-scale Trailblazer ensemble

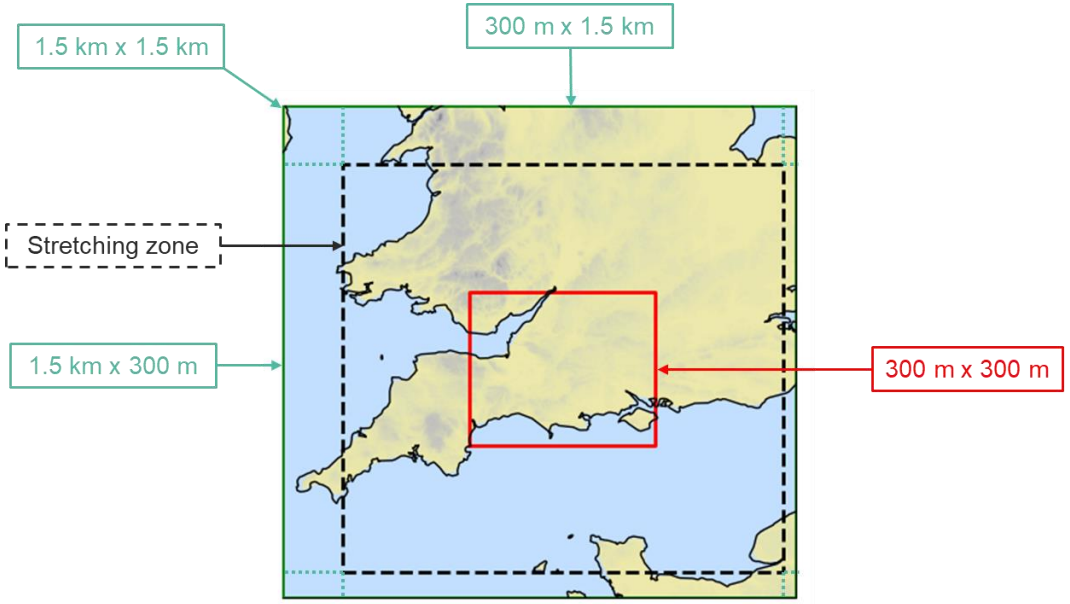
- The Met Office is working towards implementing an urban-scale “Trailblazer” system (300m variable resolution London ensemble) in 2026.



- Summer 2022: 300m variable resolution London (LMV) ensemble – see talk at Nov 2022 RDP General Assembly
- Summer 2023: 300m variable resolution Wessex (WMV) ensemble
- Summer 2024: 300m variable resolution Paris (PMV) ensemble

Sub-km “WMV” ensemble

Variable resolution 300m Wessex model (WMV):



Time-lagged WMV ensemble:

- 18 member WMV ensemble (RAL3.1) run once per day during Summer 2023 with ICs and LBCs provided by the operational 2.2km gridlength MOGREPS-UK ensemble (RAL2-M).
- Initialised from the 18Z MOGREPS-UK cycle:
  - 3 members run at 13, 14, 15, 16, 17 and 18 UTC
- MURK aerosol and soil moisture both downscaled from the MOGREPS-UK analysis

Differences between the WMV ensemble and MOGREPS-UK:

Model	Inner gridlength	Vertical levels	Timestep	Physics	Random parameters?	MORUSES urban scheme?	Land use
MOGREPS-UK	2.2km	70	100 s	RAL2-M	Yes	Yes	ITE
WMV	300m	70	12 s	RAL3.1	No	Yes	CCIv2

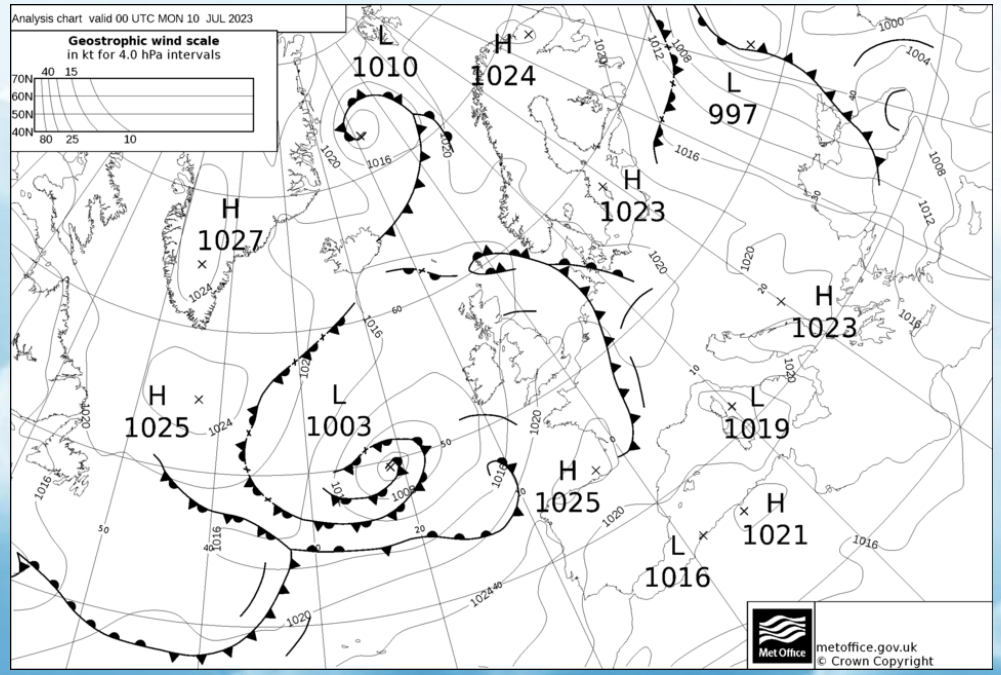
What value does the 300m WMV ensemble provide over MOGREPS-UK?

RAL3.1 Science Changes

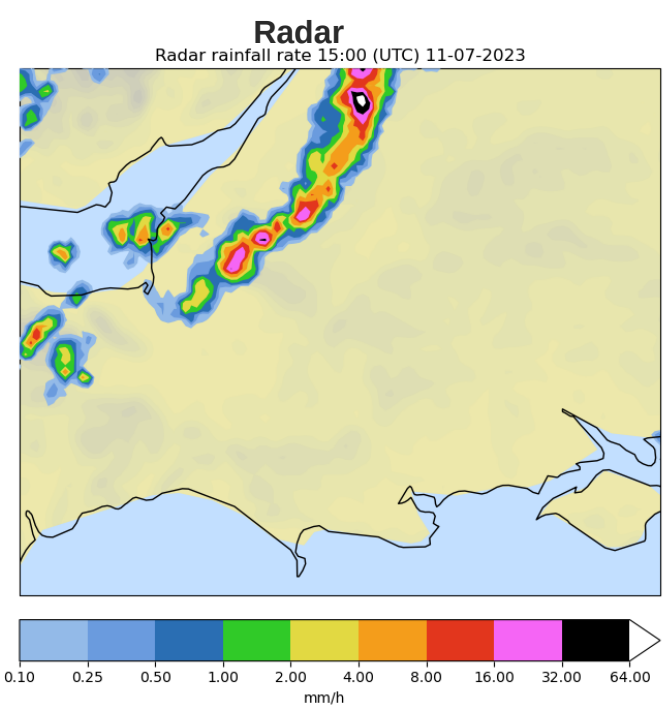
- Bi-modal cloud scheme (*Kwinten van Weverberg*)
  - Based on Smith cloud scheme used in mid-latitude RAL
  - Replaces Smith scheme in RAL2-M
- CASIM multi-moment cloud microphysics scheme (*Adrian Hill, Paul Field, Kalli Furtado*)
  - Permits the UM to have single or double moment microphysical capability
  - RAL3.1 uses double-moment CASIM
  - Replaces single-moment Wilson-Ballard scheme in RAL2-M
- Changes to the land surface configuration (*Martin Best*)
  - Consolidation of global and regional model land surface settings
- Stochastic boundary layer perturbations used in RAL2-M no longer needed (*Adrian Lock*)
- Corrections to thunderstorm electrification scheme (*Jonathan Wilkinson*)
- And many more…

Case of interest: 11th July 2023 (IOP 11)
Forecast start date: 18Z 10th July 2023

Brief summary of weather: Cold front clearing overnight, intense band of slow-moving precipitation during afternoon/evening.

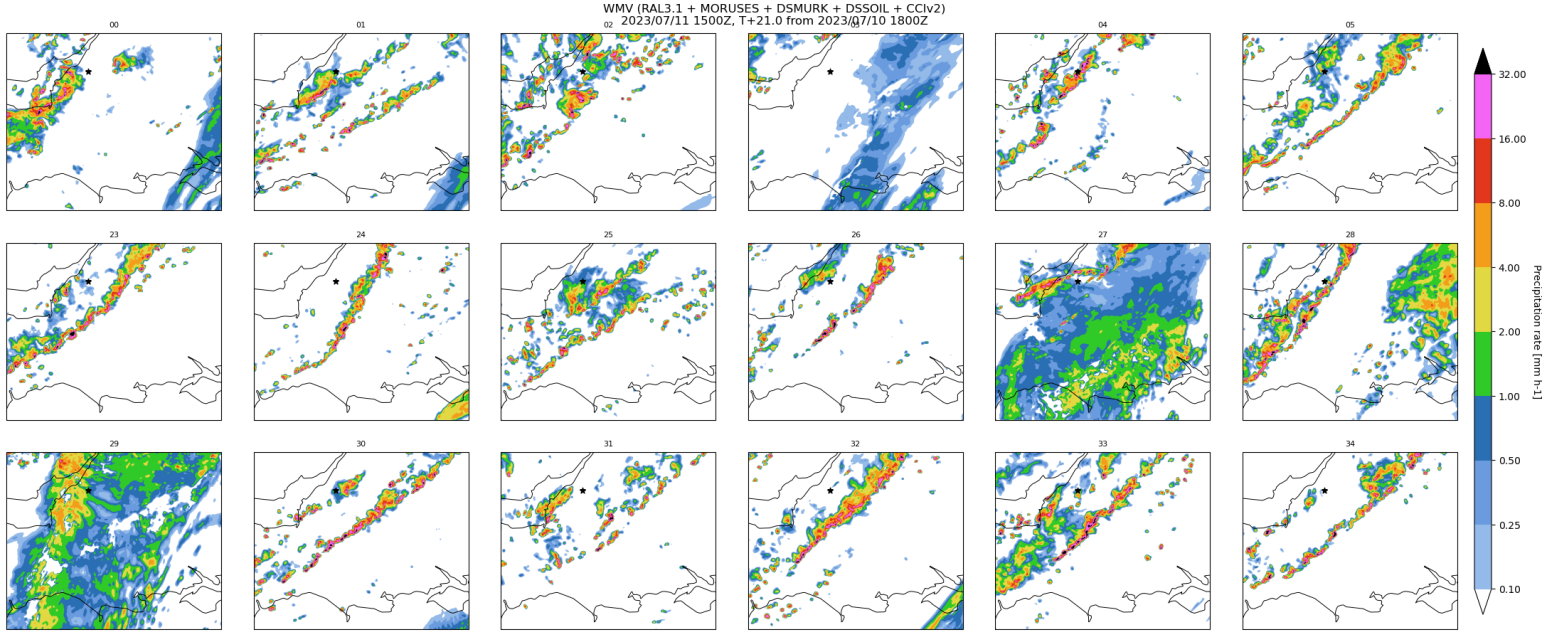


Time: 15 UTC Leadtime: T+21

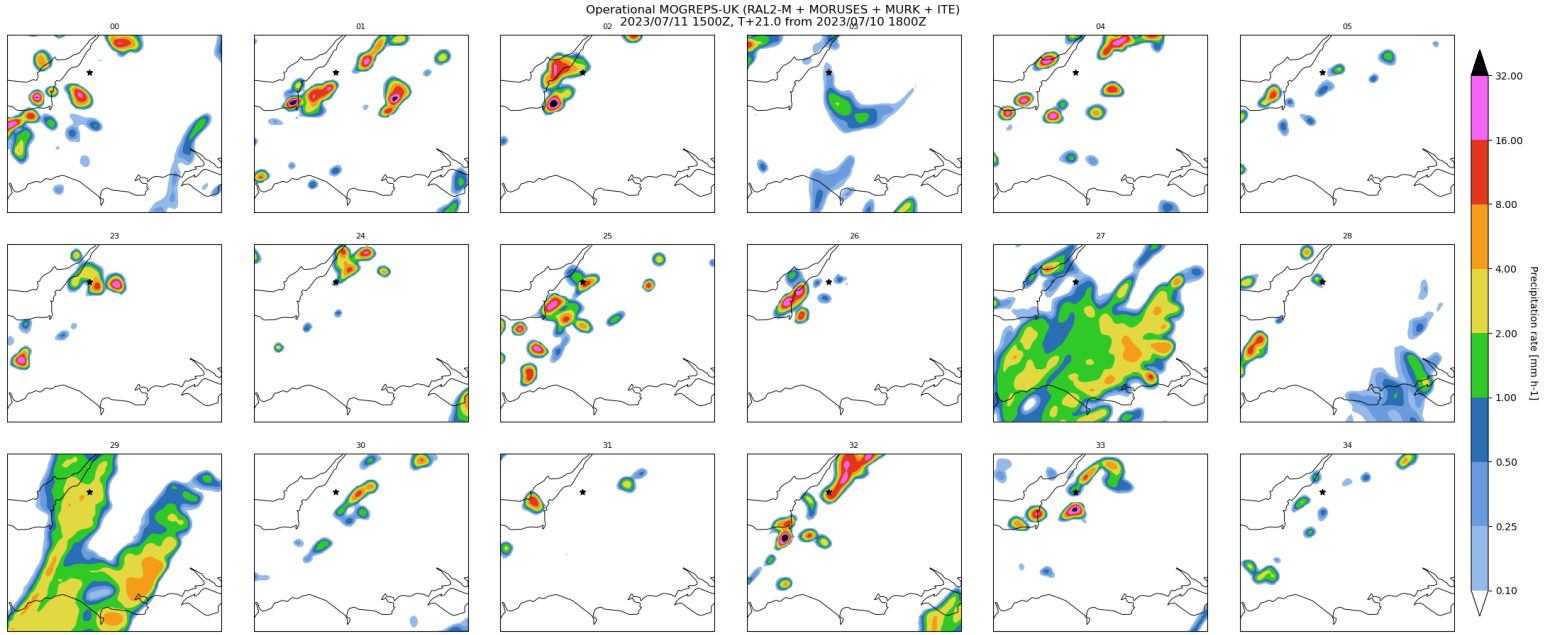


About half the WMV members have an organised band of convection

M-UK misses the organisation of the band and has mostly isolated, blobby cells



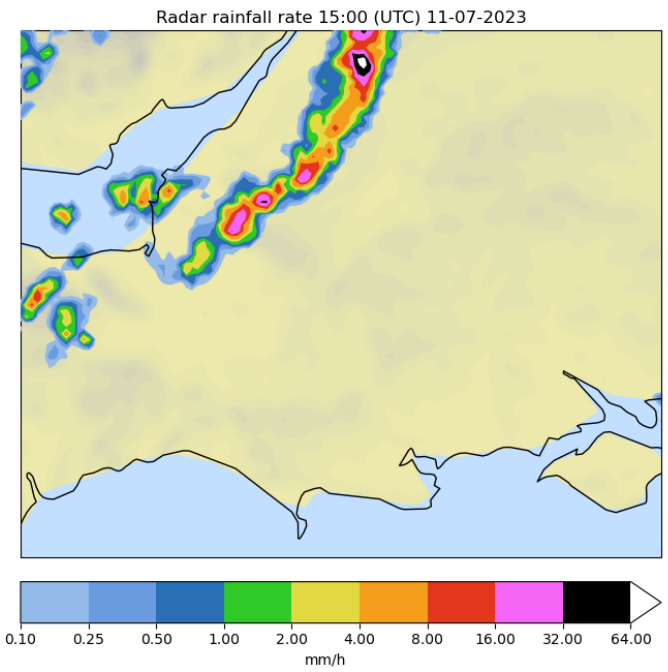
WMV



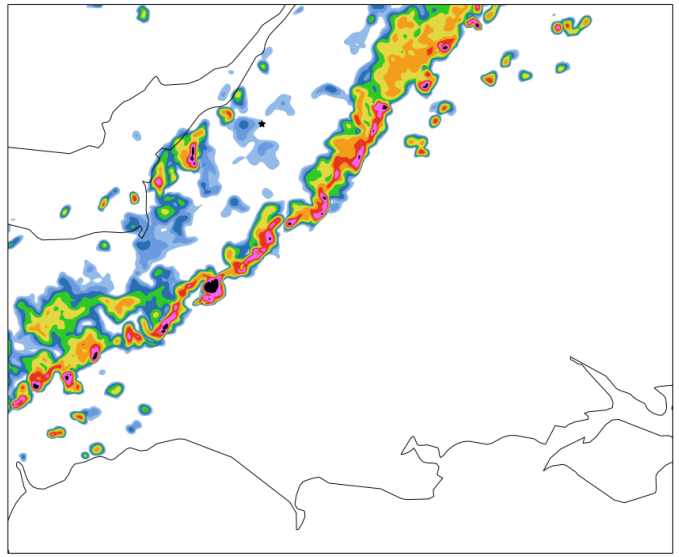
M-UK

Time: 15 UTC Leadtime: T+21

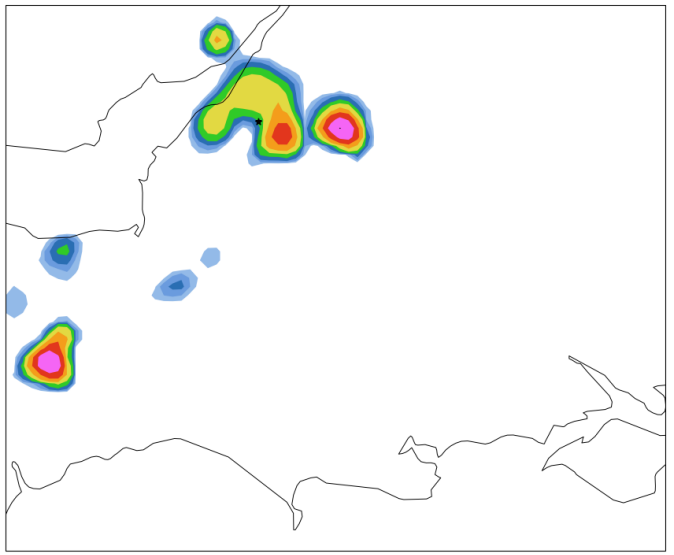
Radar



WMV member 23

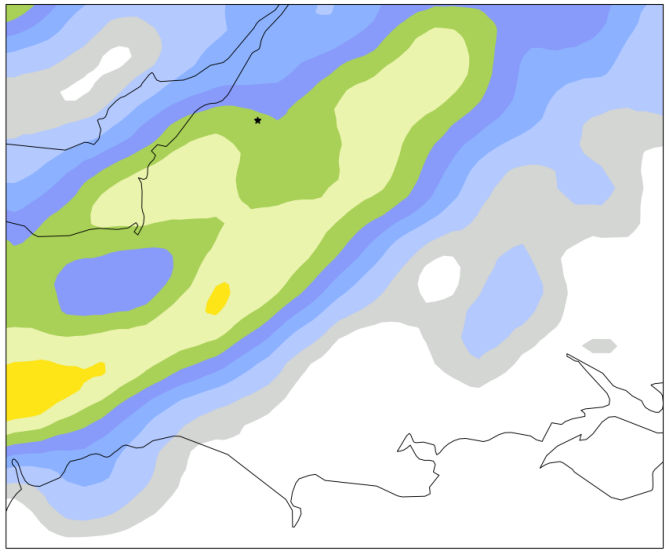


M-UK member 23

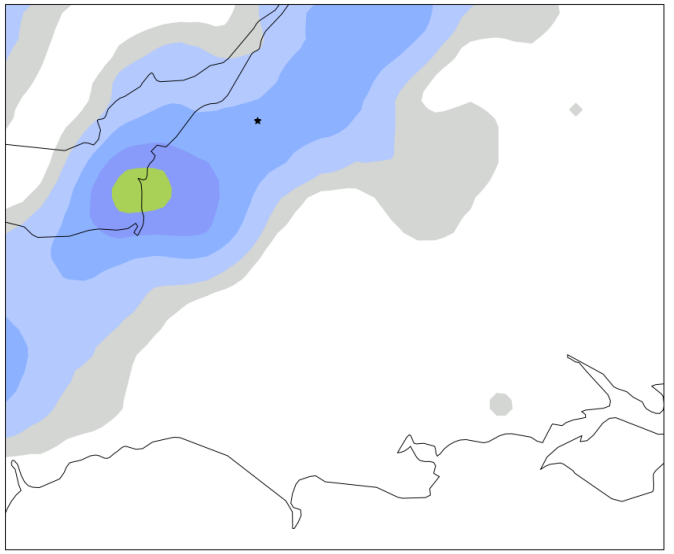


Neighbourhood max probability of ppn > 8 mm/hr

WMV



M-UK

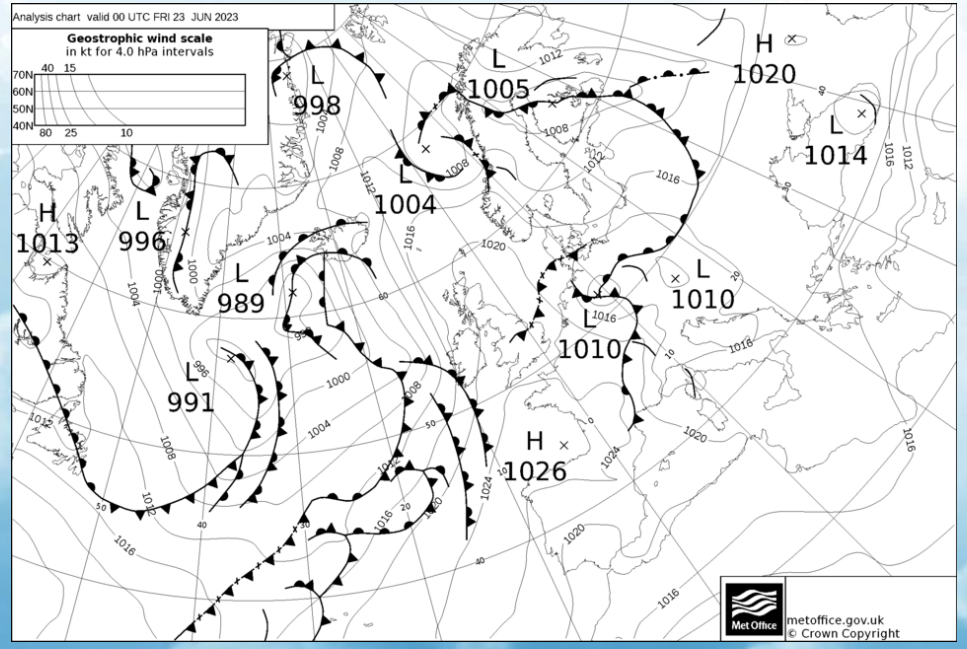


WMV better captured high intensity ppn and has more extensive and greater probs of ppn > 8 mm/hr, also more indication of there being a band of heavy ppn in the WMV

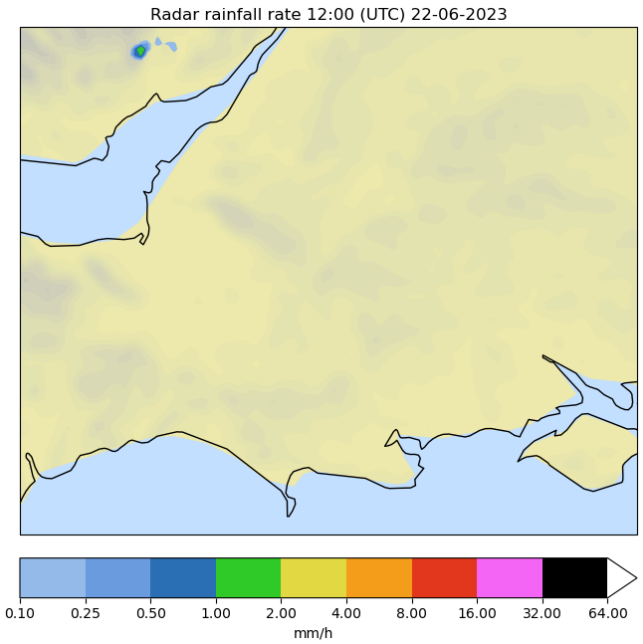
Probabilities are calculated using a neighbourhood length scale of 17.5 km.

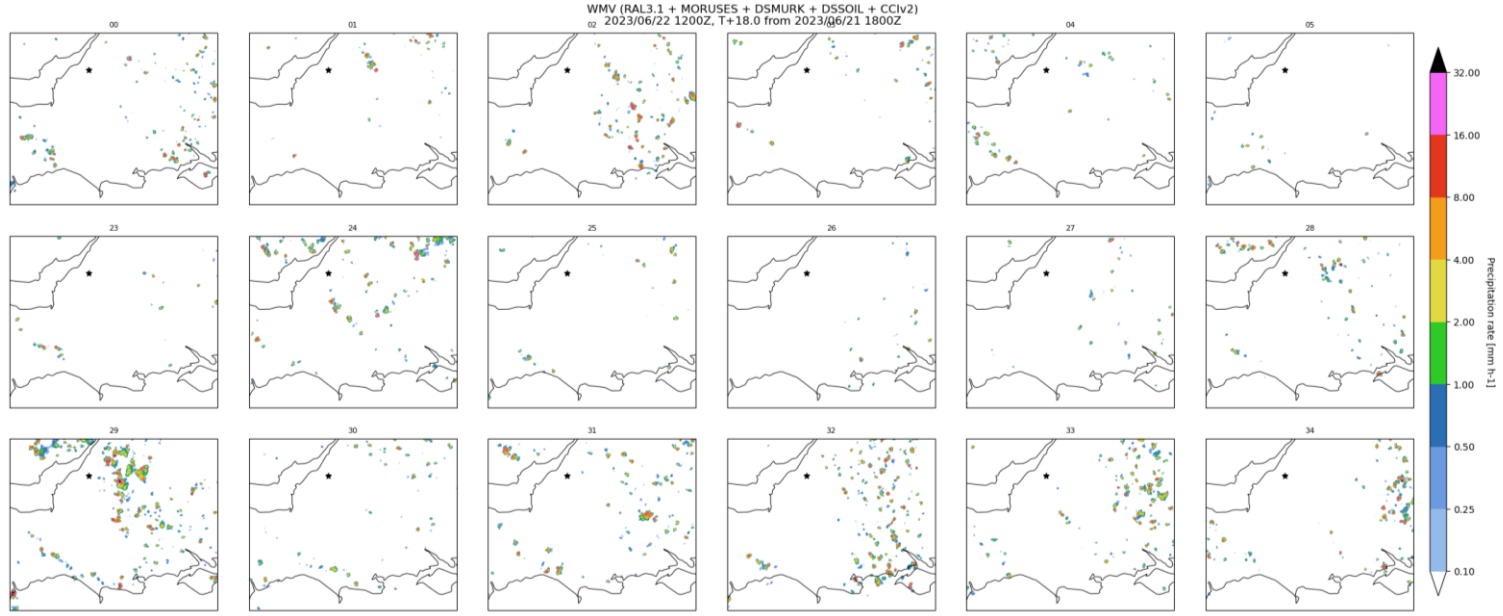
Case of interest: 22nd June 2023 (IOP 6)
Forecast start date: 18Z 21st June 2023

Brief summary of weather: Approaching fronts, a few isolated, heavy showers developed in the WesCon region during the afternoon

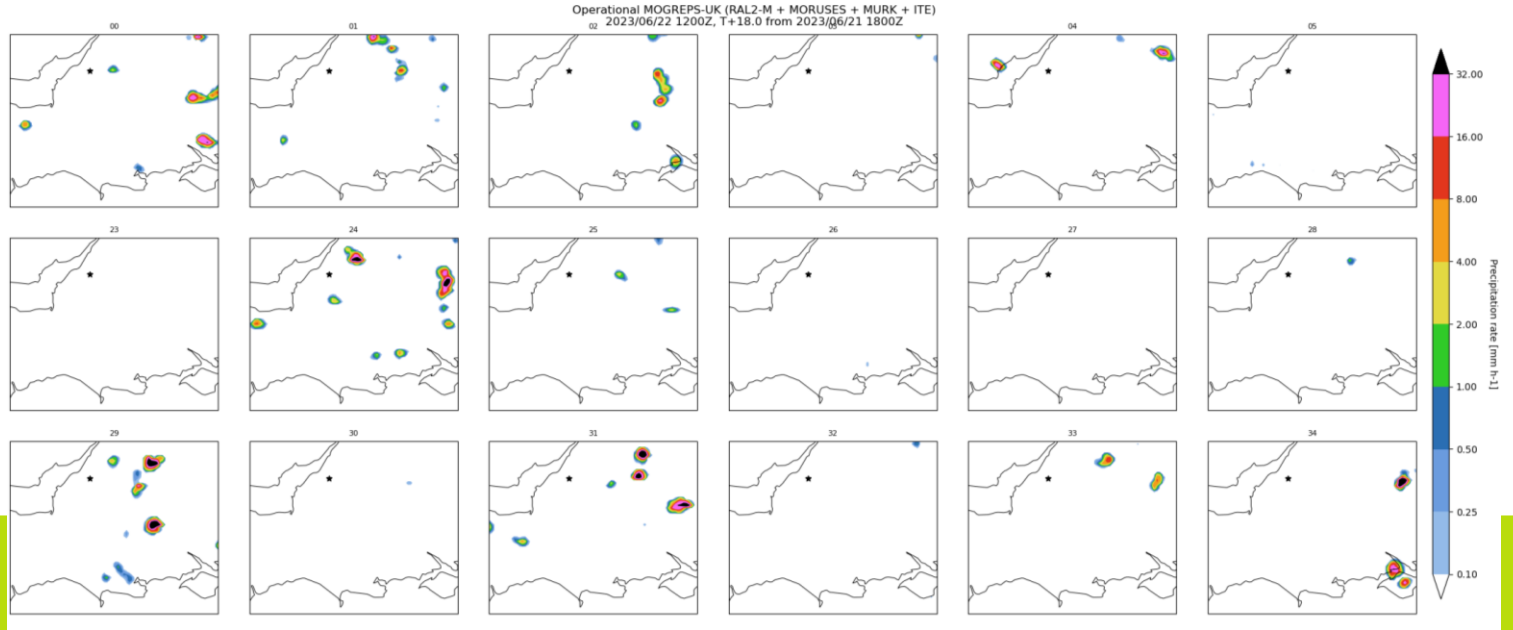


Time: 1200 UTC Leadtime: T+18





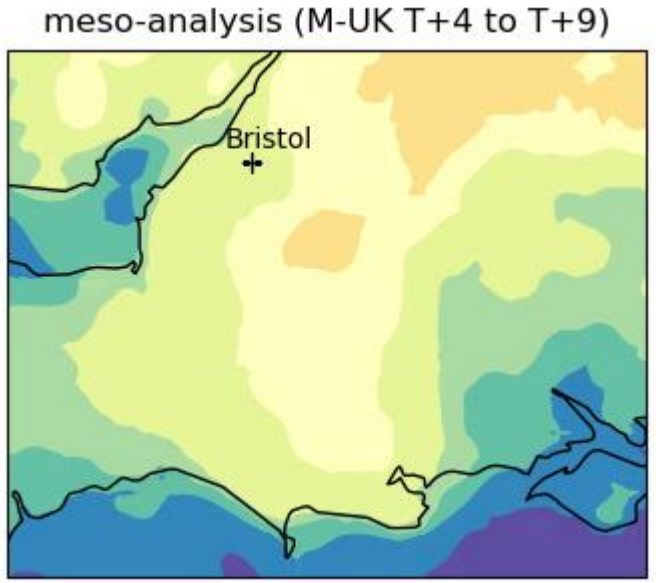
WMV

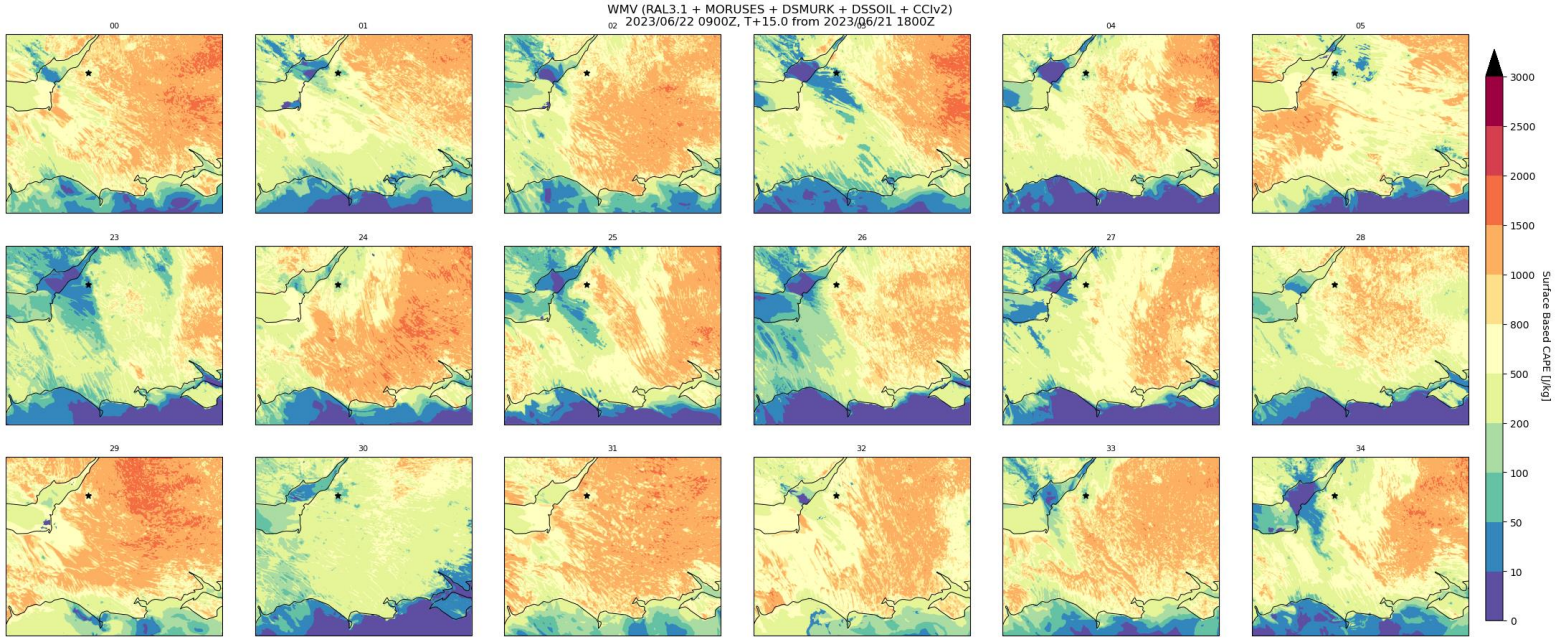


M-UK

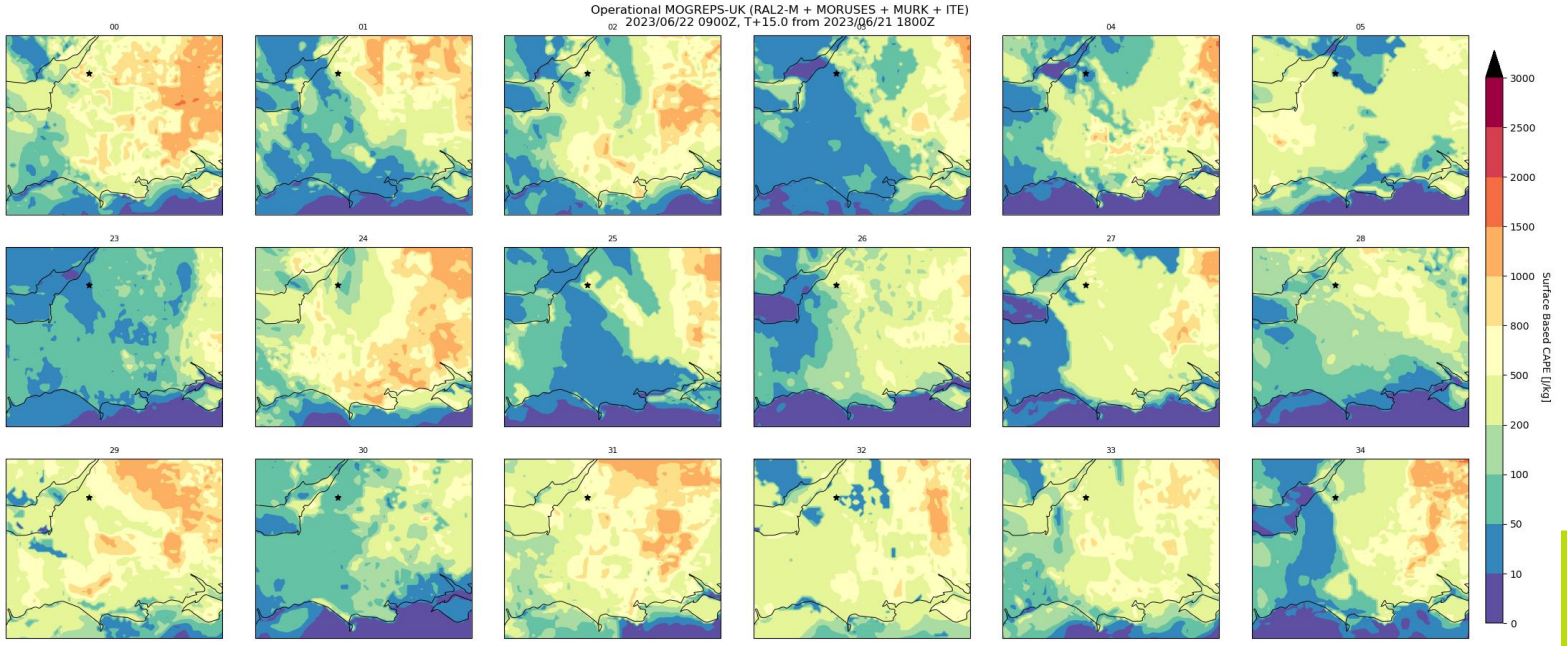
Both ensembles initiated too early. The WMV had too many small showers, M-UK had blobby, too intense showers.

Time: 0900 UTC Leadtime: T+15





WMV

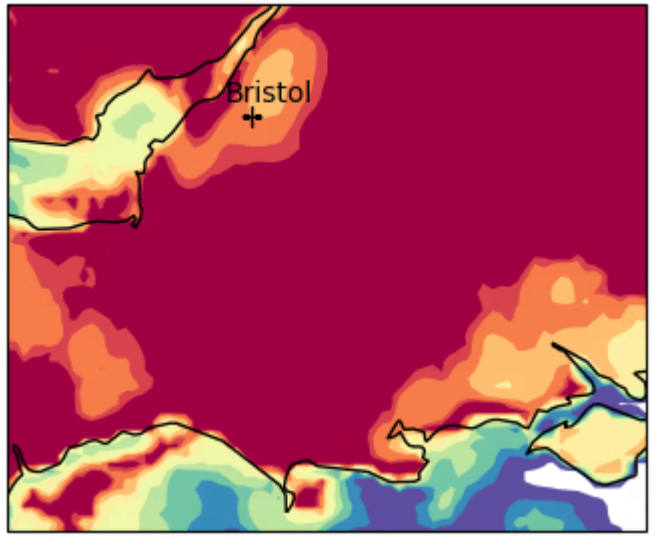


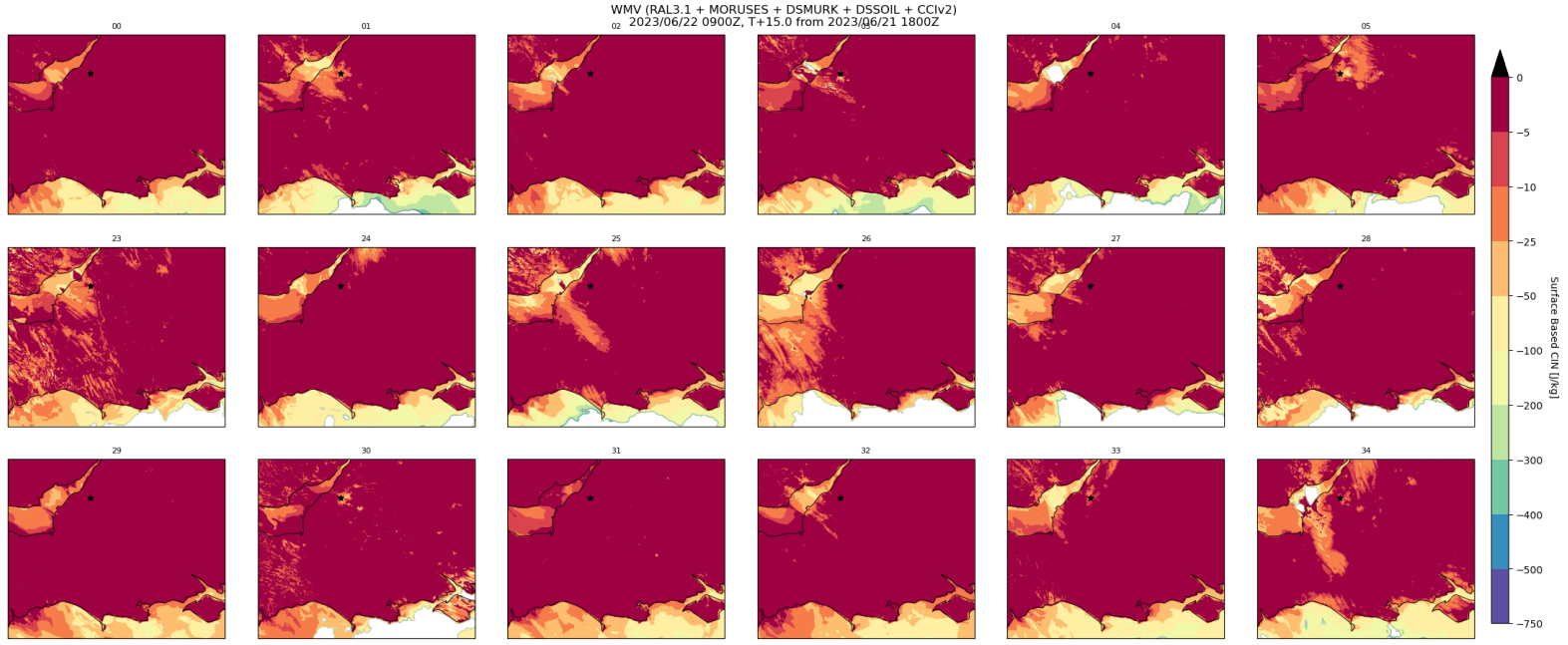
M-UK

Before convection initiates, WMV members have more CAPE than equivalent M-UK members and more than the mesoanalysis.

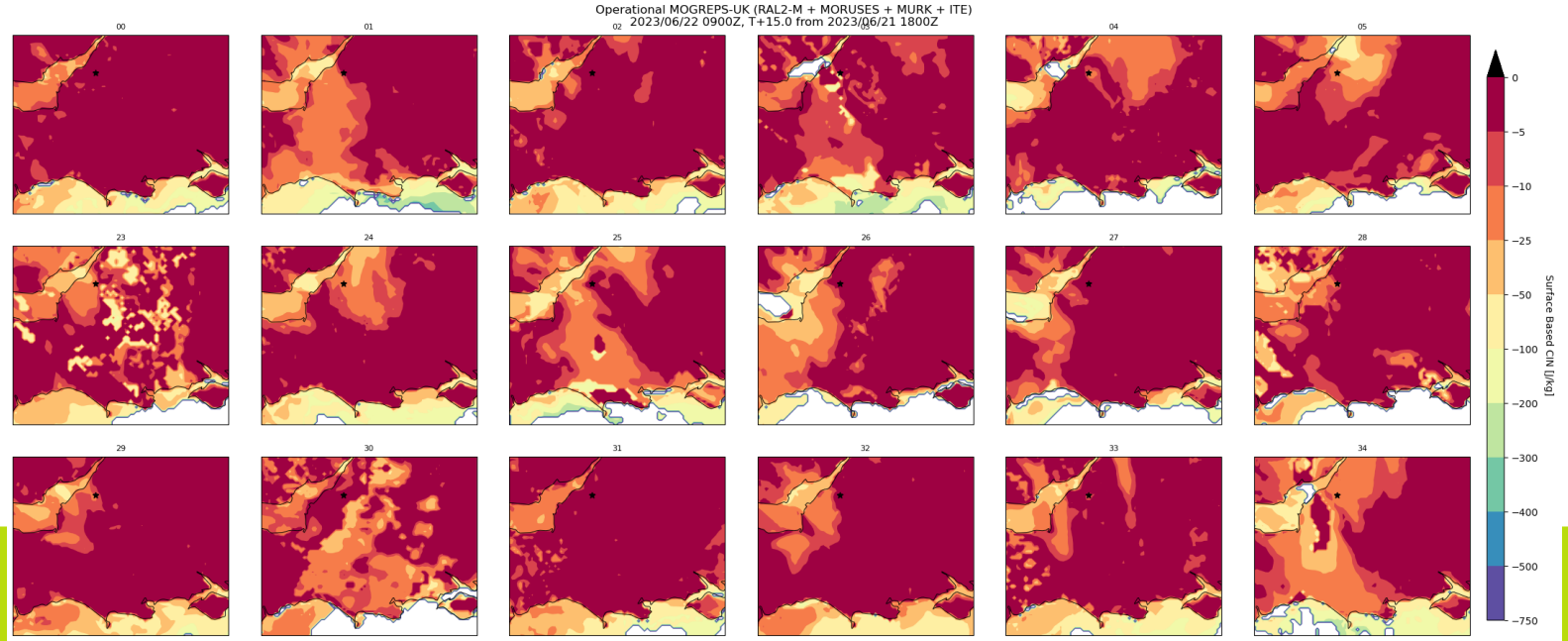
Time: 0900 UTC Leadtime: T+15

meso-analysis (M-UK T+4 to T+9)





WMV

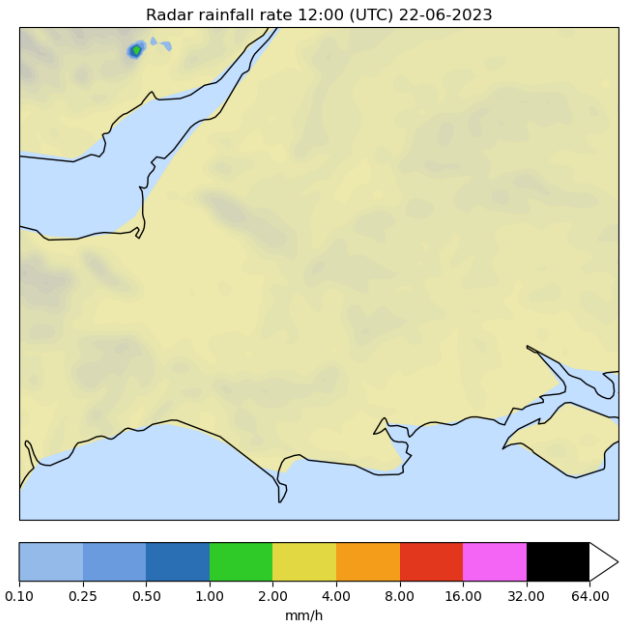


M-UK

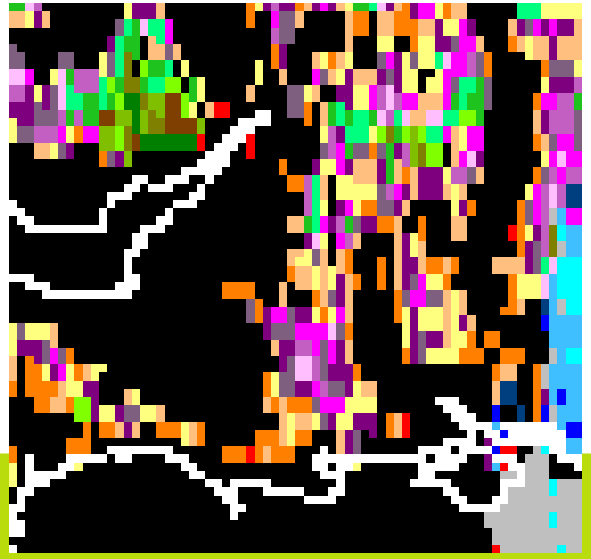
Before convection initiates, WMV members have less CIN than equivalent M-UK members and less than the mesoanalysis.

Time: 1200 UTC Leadtime: T+18

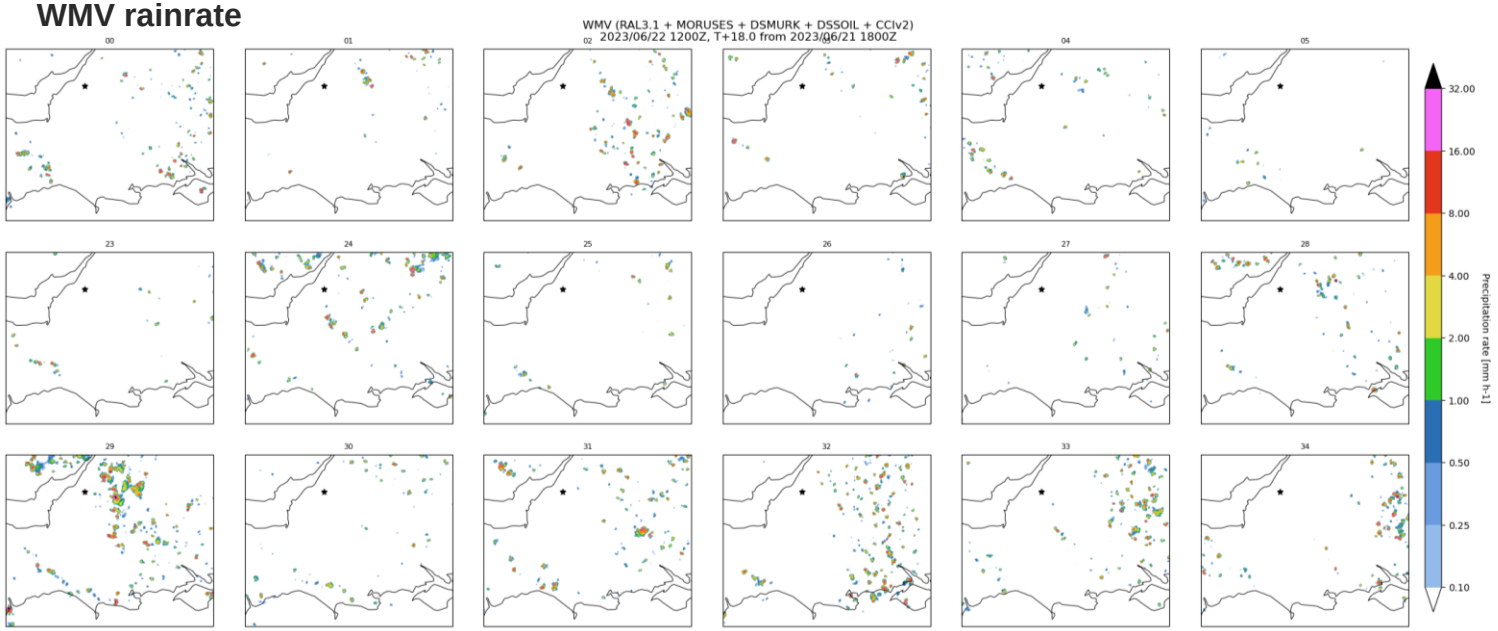
Radar



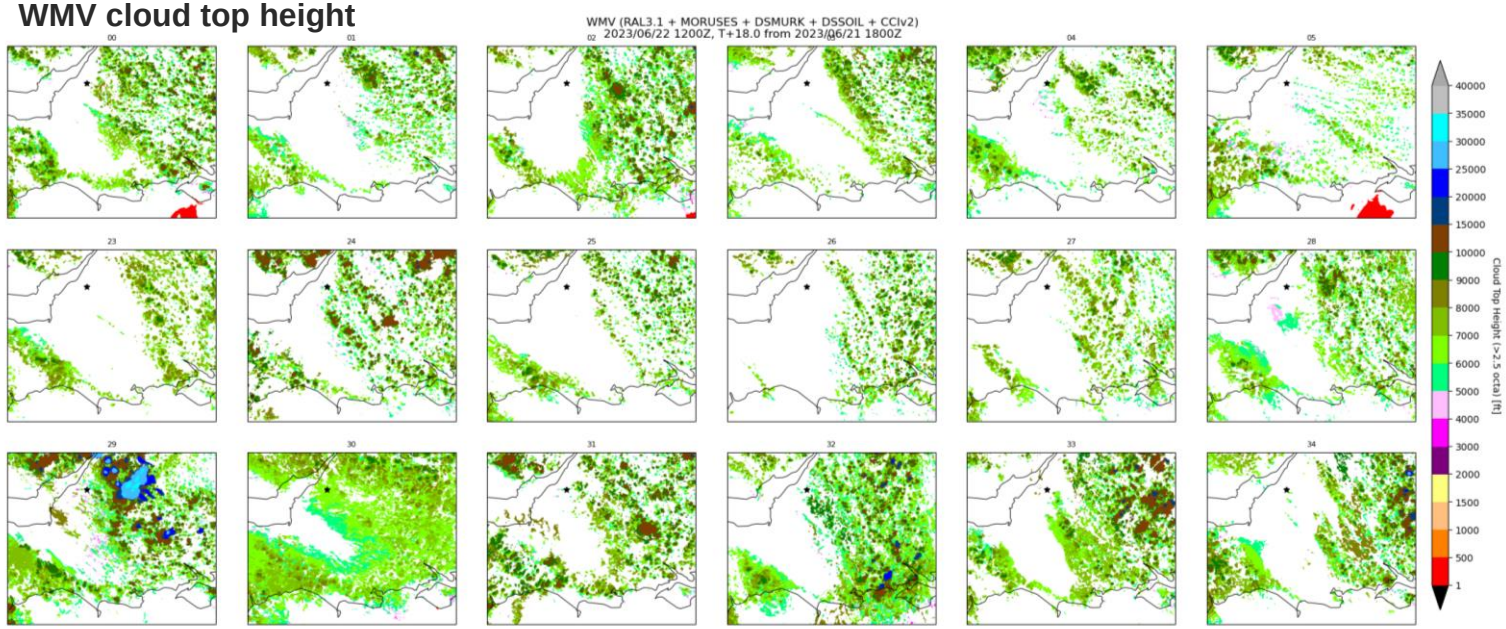
MSG cloud top height



WMV rainrate



WMV cloud top height



WMV precipitating showers getting too deep (tops above 10 kft) whereas observed clouds were only shallow (tops below 7 kft).

Verification:
Fraction Skill Score (Roberts & Lean, 2008)

The FSS is a neighbourhood-based verification metric. It is computed by first converting each grid point of the observed and simulated precipitation field to binary, depending on whether they exceed a chosen precipitation threshold.

Then for each grid square, comparing how many simulated points and observed points exceed the threshold in the surrounding area as defined by a “neighbourhood size” (e.g., a neighbourhood size of 3 refers to the nine grid squares centred on the square of interest).

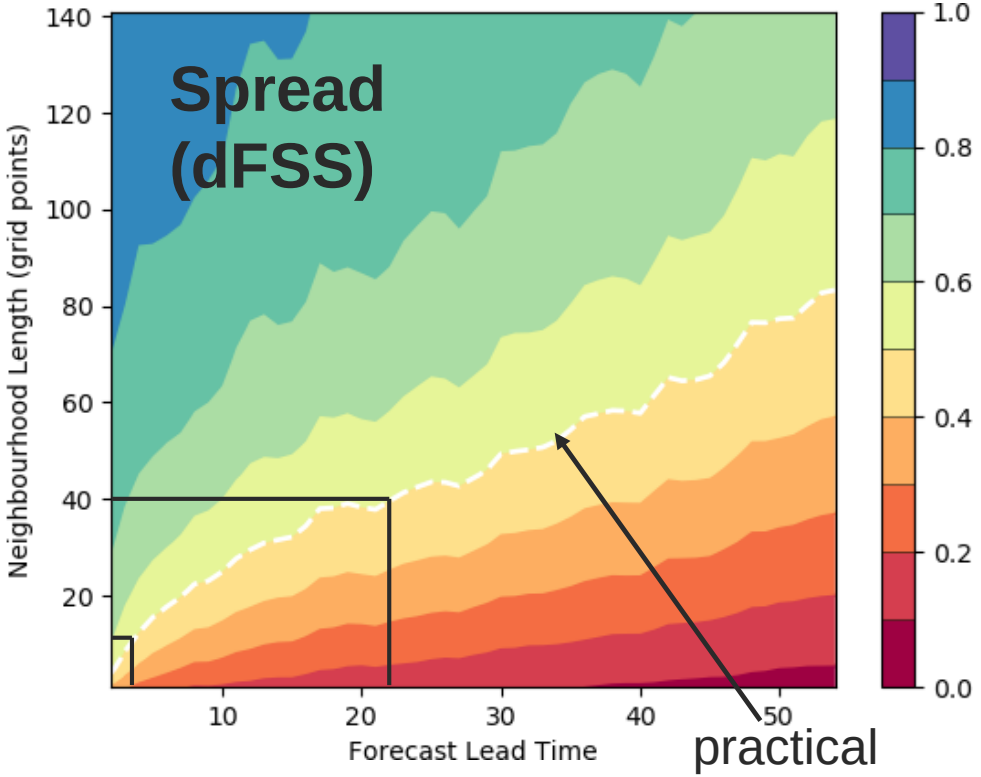
If fewer than 0.2% of the model or observed grid points in the domain exceed the threshold, then FSS=NaN. Only consider lead times when all ensemble members are available (so T+0=18 UTC).

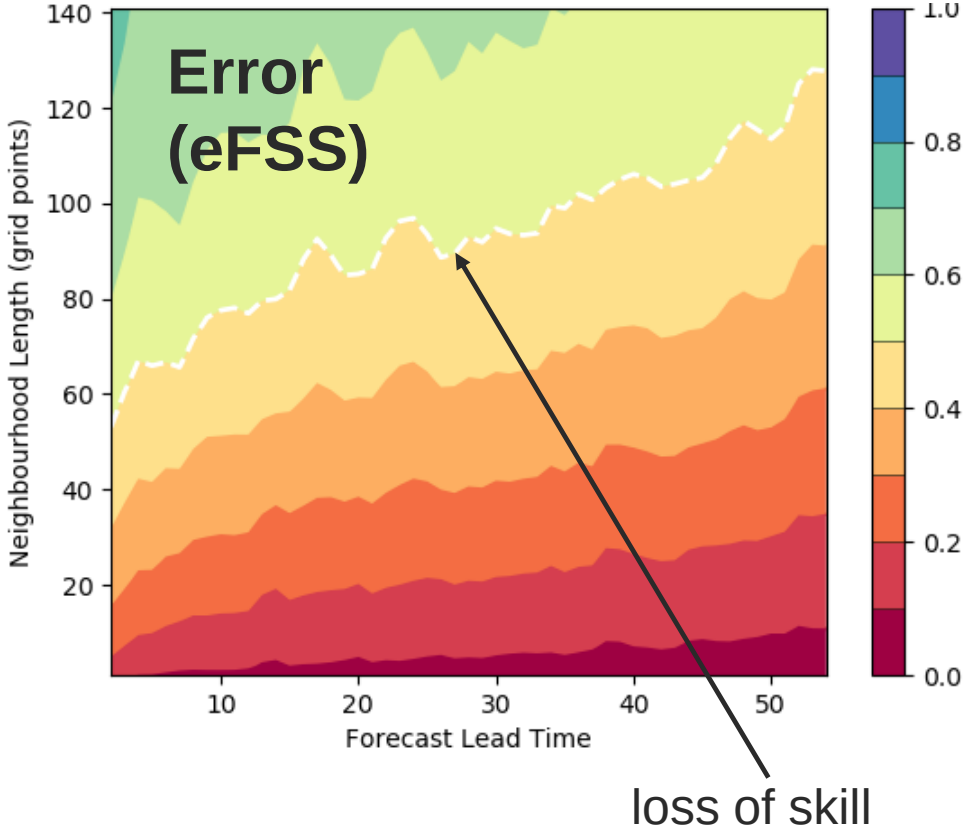
Spatial spread/skill relationship: dFSS/eFSS

- **Error FSS (eFSS)** is calculated to measure the **skill**, for each **member-obs** pair and then averaged.
- **Dispersion FSS (dFSS)** is calculated to measure the spatial agreement (or the **spread**) of the members, for each **member-member** pair and then averaged

eFSS and **dFSS** both range from 0-1.

Ideally, we want eFSS=dFSS=1 (high skill, low spread), or at least eFSS=dFSS.



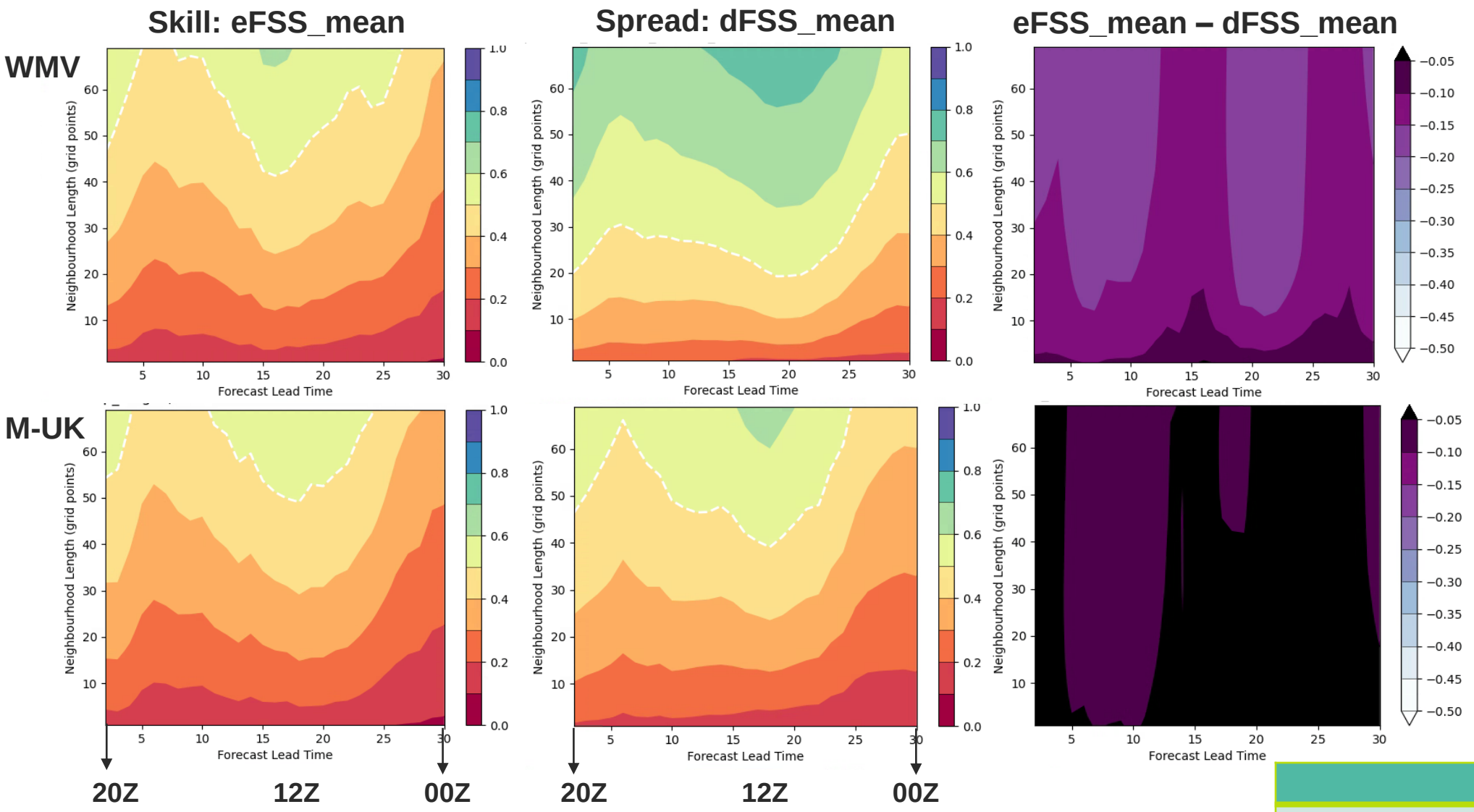


Lower values correspond to ***larger*** spread and ***larger*** error

Courtesy of Anne Mccabe

Ensemble application of FSS: Dey et al (2014, 2016)

Met Office eFSS/dFSS: 95th percentile of hourly rainfall



WMV compares better to obs (eFSS closer to 1) but is under-spread (dFSS>eFSS)

95th percentile of hourly rainfall accumulation:

	Mean (mm)	Max (mm)
Radar	0.467	5.875
WMV member 0	0.521	5.684
M-UK member 0	0.489	6.138

Dates: 14 June 2023 – 25 August 2023 (excluding 30/7-6/8)
All data regridded to 2.2km grid, extracted over full WMV domain

Conclusions & Future work

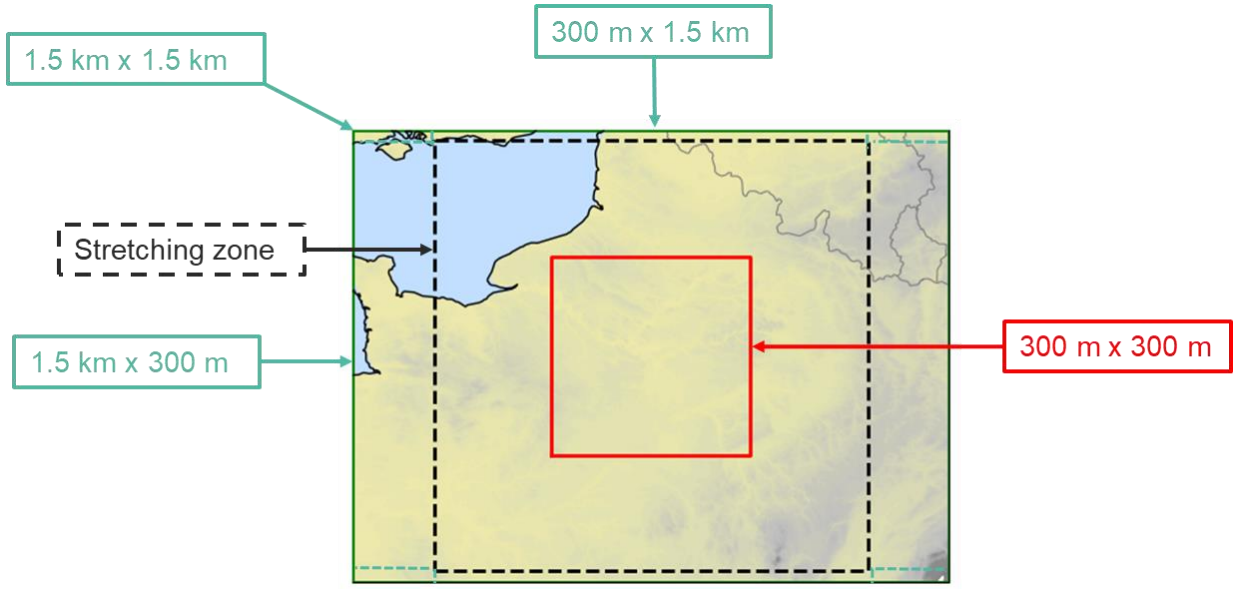
- The WMV looks promising for deep convection. It is better able to organise convection into lines or larger storms whereas MOGREPS-UK tends to simulate isolated, circular storms. This often leads to the probabilities of exceeding a particular precipitation threshold being greater in the WMV ensemble compared to MOGREPS-UK.

- FSS verification shows that the WMV ensemble compares better to radar observations than MOGREPS-UK (eFSS is closer to 1, dis_FSS is lower) but it is more underspread (dFSS>eFSS).

- However, there is an issue with the WMV producing too many small precipitating showers in situations where there should only be shallow clouds. This is thought to be a result of shallow clouds getting too deep in the model and precipitating erroneously. Plan to use WesCon observations of vertical velocity and vertical profiles to better understand this issue.

Summer 2024: Sub-km “PMV” ensemble

Variable resolution 300m Paris model (PMV):



PMV ensemble:

- Plan to run an 18 member PMV ensemble (RAL3.2) once per day during Summer 2024 with ICs and LBCs provided by a 2.2km gridlength ensemble nested inside the operational ~20km gridlength MOGREPS-G ensemble (GA7.2).
- Initialised from the 18Z MOGREPS-G cycle
- Lewis has recently generated the PMV domain and is planning to run the ensemble for a few 2023 cases

Differences between the kilometre-scale and urban-scale ensembles:

Model	Gridlength	Vertical levels	Timestep	Physics	Random parameters?	MORUSES urban scheme?	Land use
PM2	4.4km -> 2.2km	70	100 s	RAL3.2	Yes	Yes	CCIv2
PMV	1.5km -> 300m	70	12 s	RAL3.2	No	Yes	CCIv2

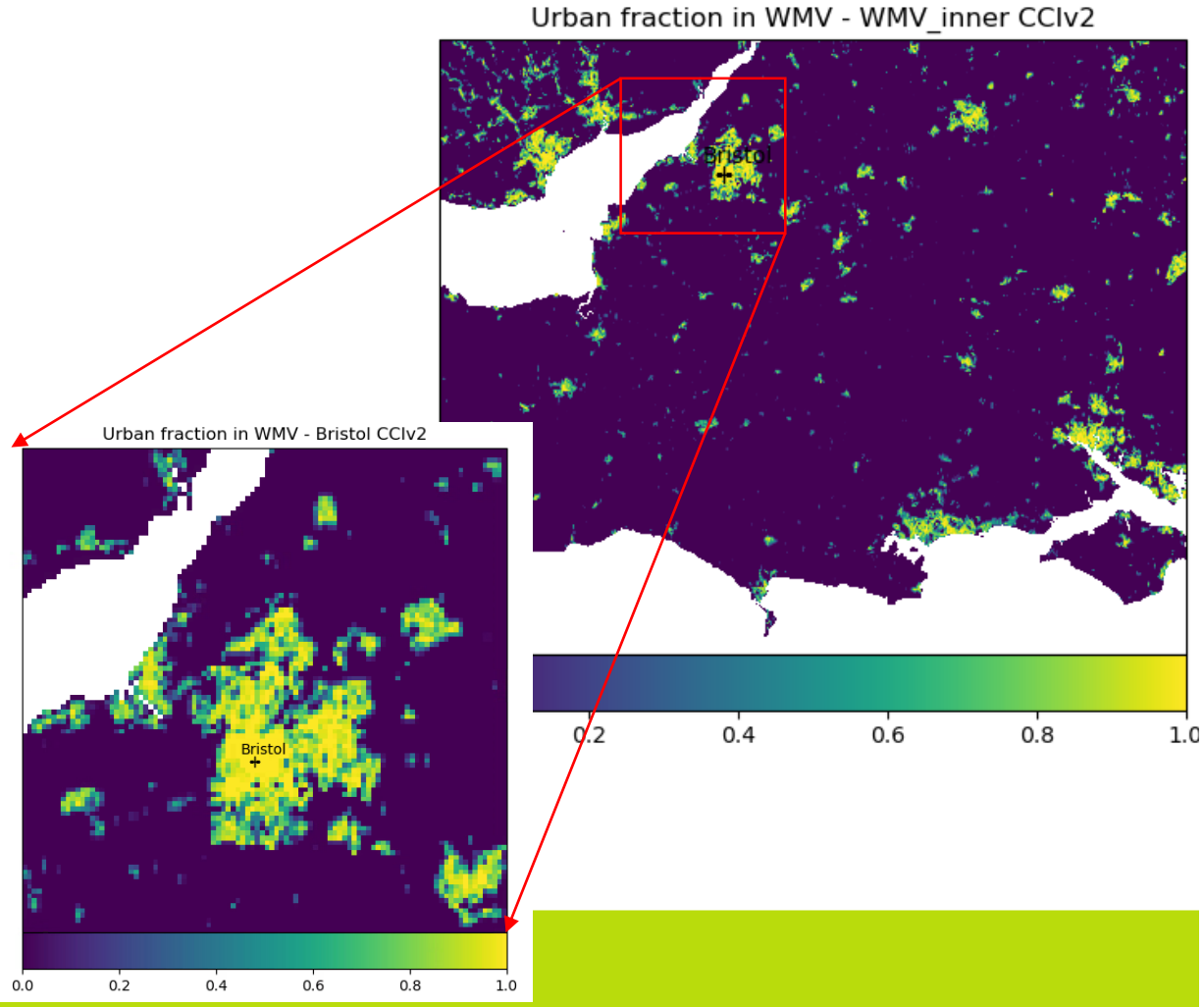
What value does the 300m PMV ensemble provide over the 2.2km ensemble?

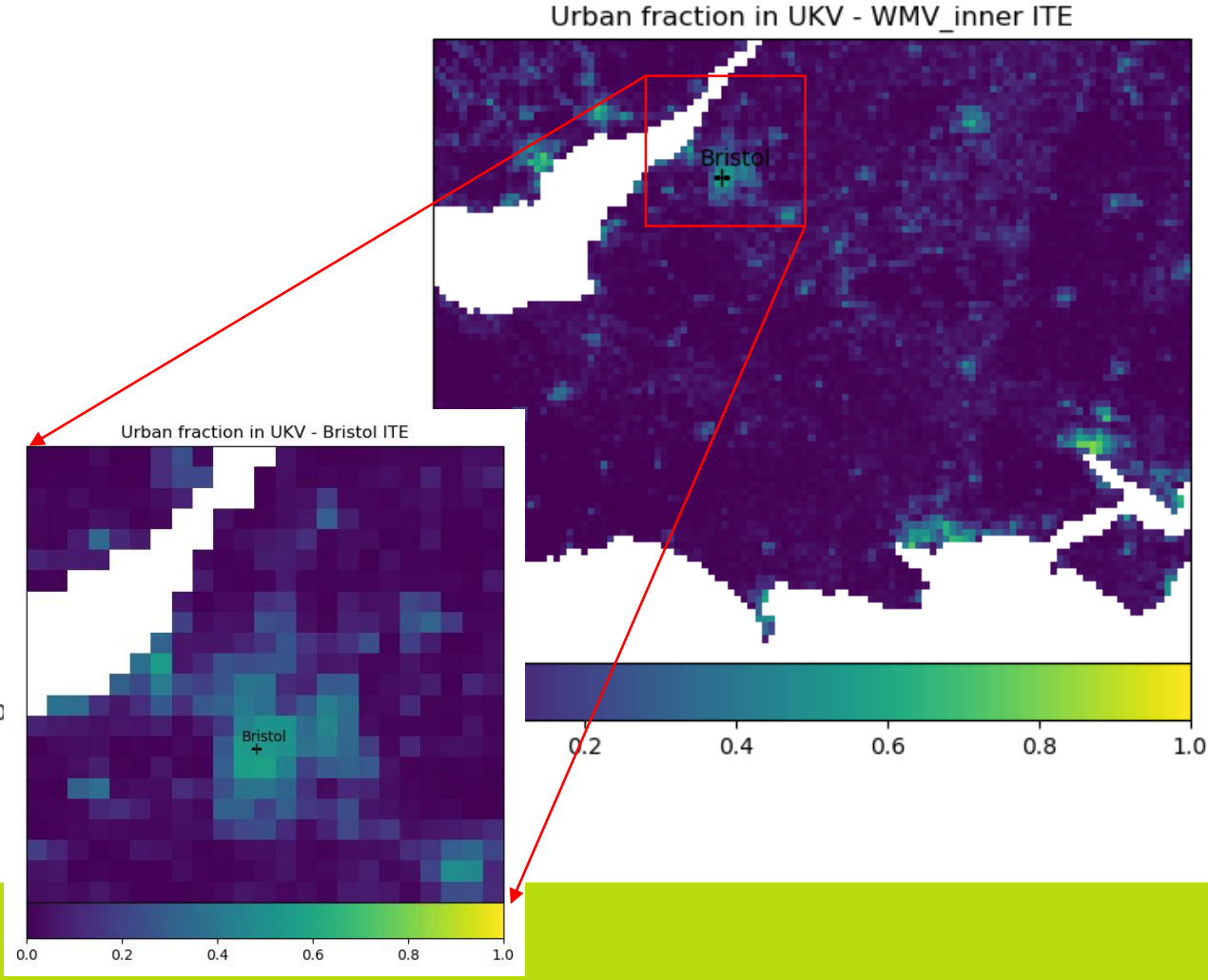
Met Office

For more information please contact

Land use datasets

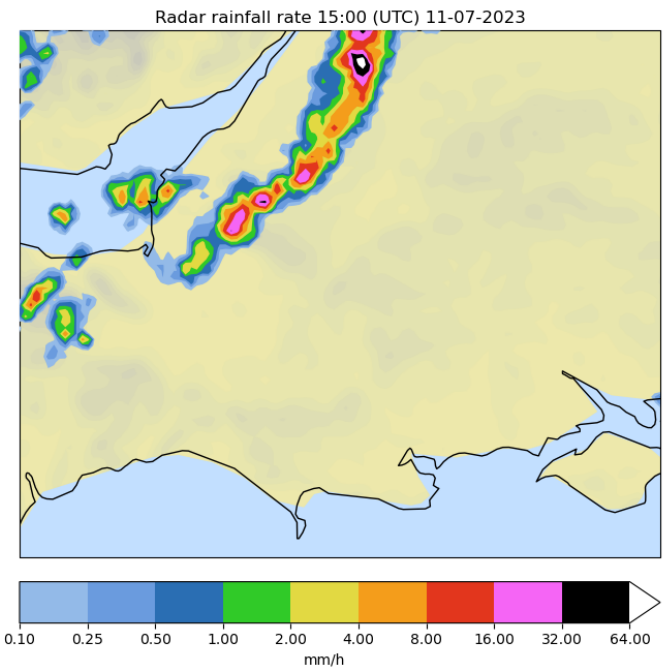
- MOGREPS-UK and the UKV use the 25m resolution 1990 ITE land-use dataset.
- The WMV uses the 300m resolution CCIv2 dataset – although lower resolution than ITE, it is much newer so includes recent urban developments.



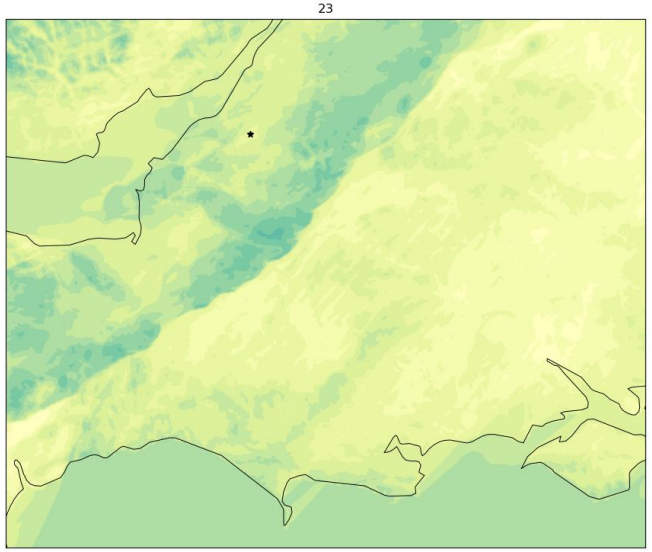


Time: 15 UTC Leadtime: T+21

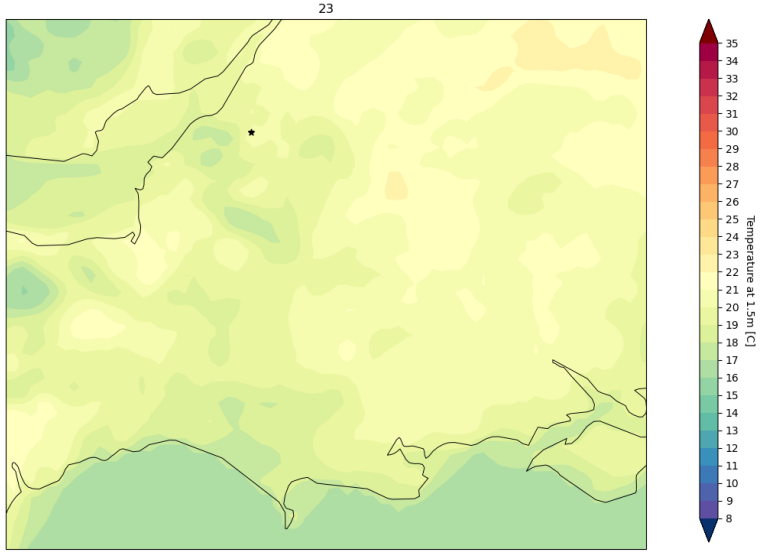
Radar



WMV member 23



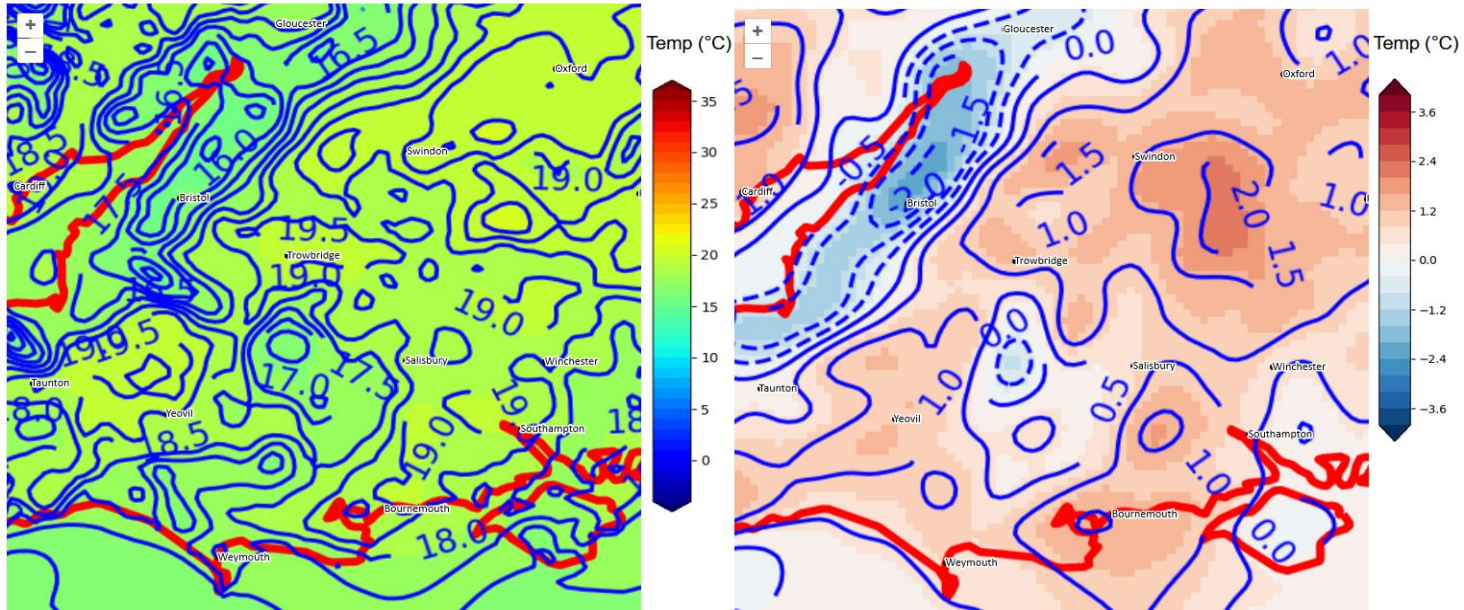
M-UK member 23



Cold pool of ~3-4 C observed in the mesoanalysis which is well captured by WMV
By missing the organisation, M-UK also misses the cold pool

Analysis : 20230711T1500Z (MOGREPS-UK T+4 to T+9) **Mesoanalysis**

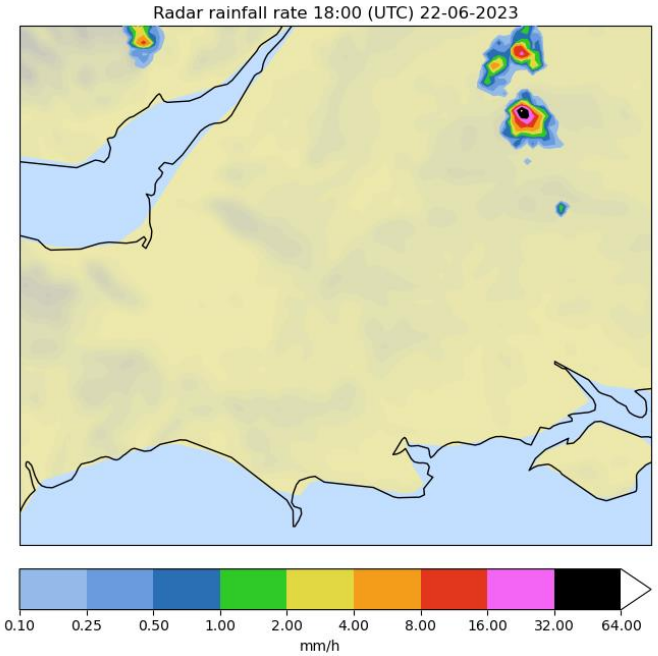
Background | Increment | Tendency



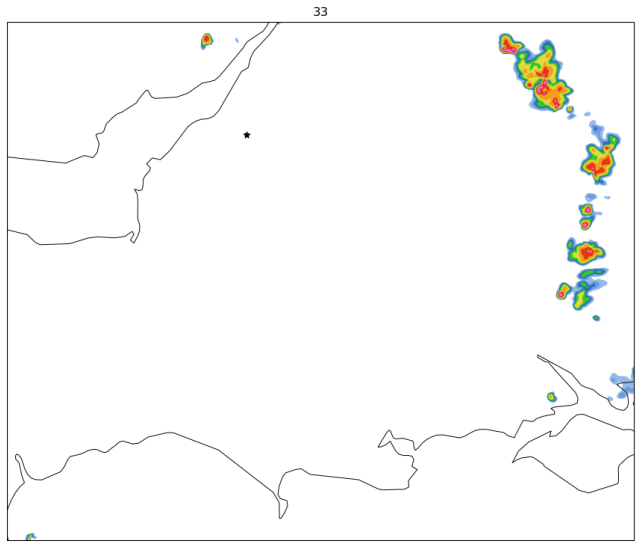
Increment = analysis – ensemble mean (M-UK)

Time: 1800 UTC Leadtime: T+ 24

Radar



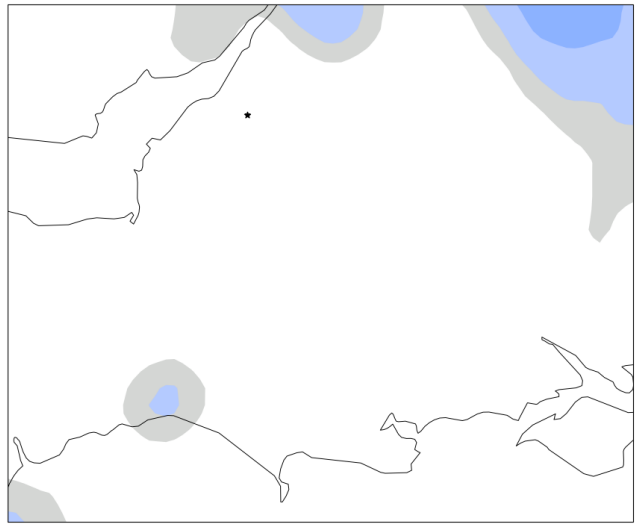
WMV member 33



M-UK member 33

Neighbourhood max probability of ppn > 4 mm/hr

WMV



M-UK

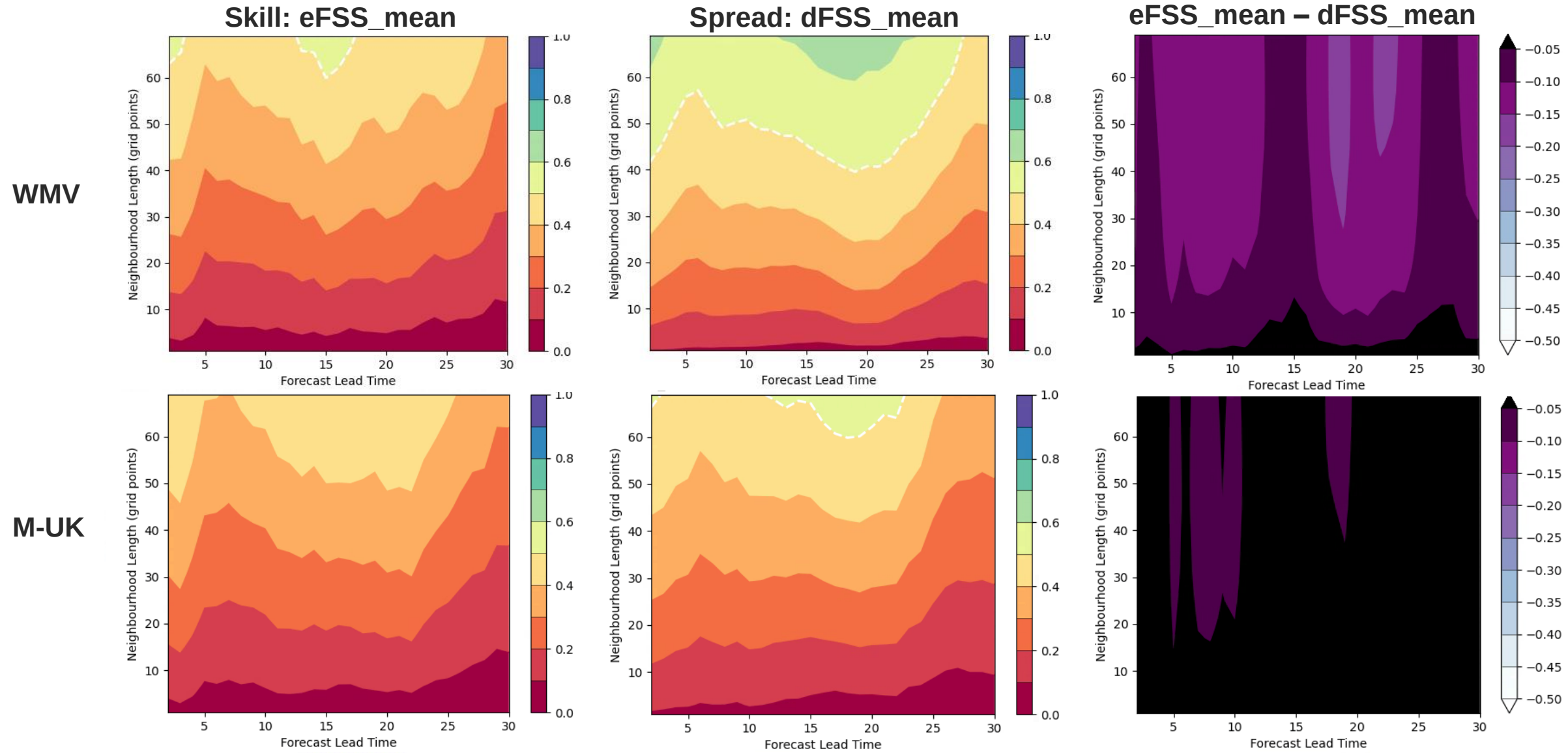
WMV did better with the larger more intense showers during early evening – M-UK convection died out too soon.

WMV probs of exceeding 8 mm/hr were more extensive and higher than M-UK – although note false alarm in Devon/Dorset.

Dan Suri (Chief Operational Meteorologist): "*If I was on shift this day, I'd prefer to have the WMV*"

Probabilities are calculated using a neighbourhood length scale of 17.5 km.

Met Office eFSS/dFSS: 99th percentile of hourly rainfall



Dates: 14 June 2023 – 25 August 2023 (excluding 30/7-6/8)
All data regridded to 2.2km grid, extracted over full WMV domain

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but is under-spread (dFSS>eFSS)