High resolution model developments at the Met Office

Mike Bush

Thanks to Jorge Bornemann, Peter Lean,
Alison Eadie, Pete Francis, Martin Young and many others

for 31st EWGLAM and 16th SRNWP Annual Meeting 2009
28th September – 1st October 2009 Athens, Greece

Talk Outline

- What is the UKV convective scale model good at ? and what is it not good at ?
- L70 NAE - better cloud and inversions thanks to improved vertical resolution

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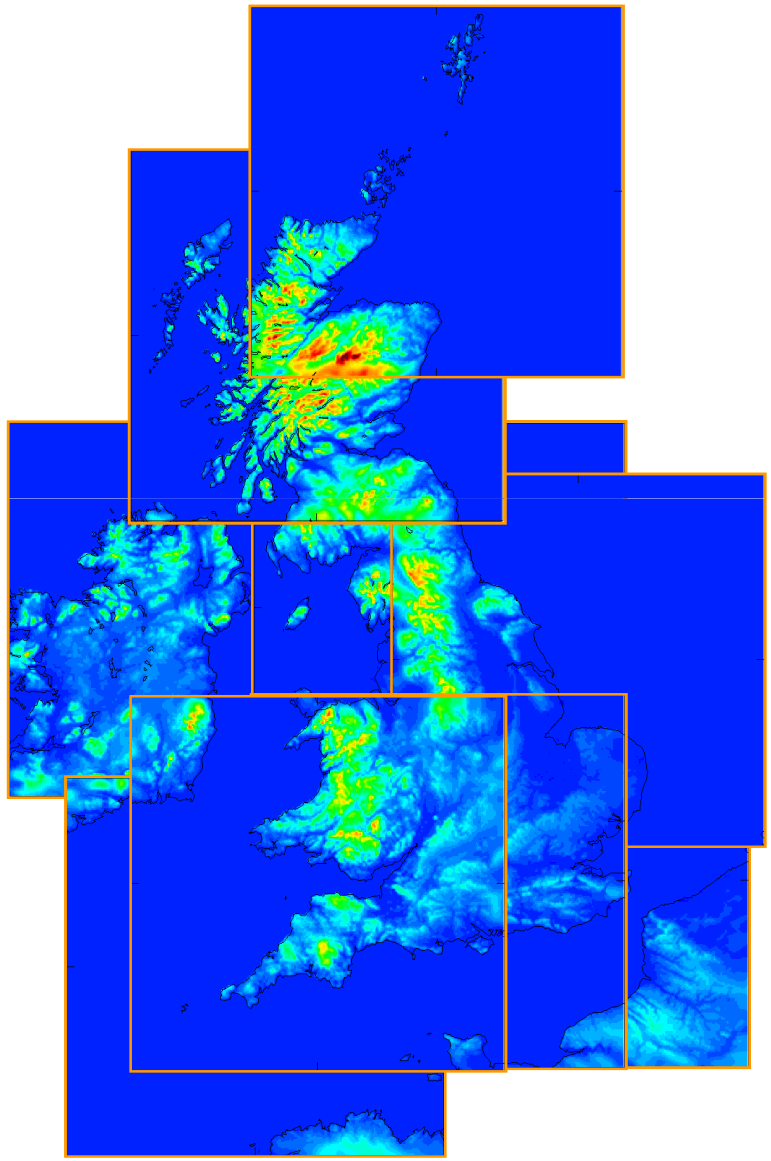
On Demand Model



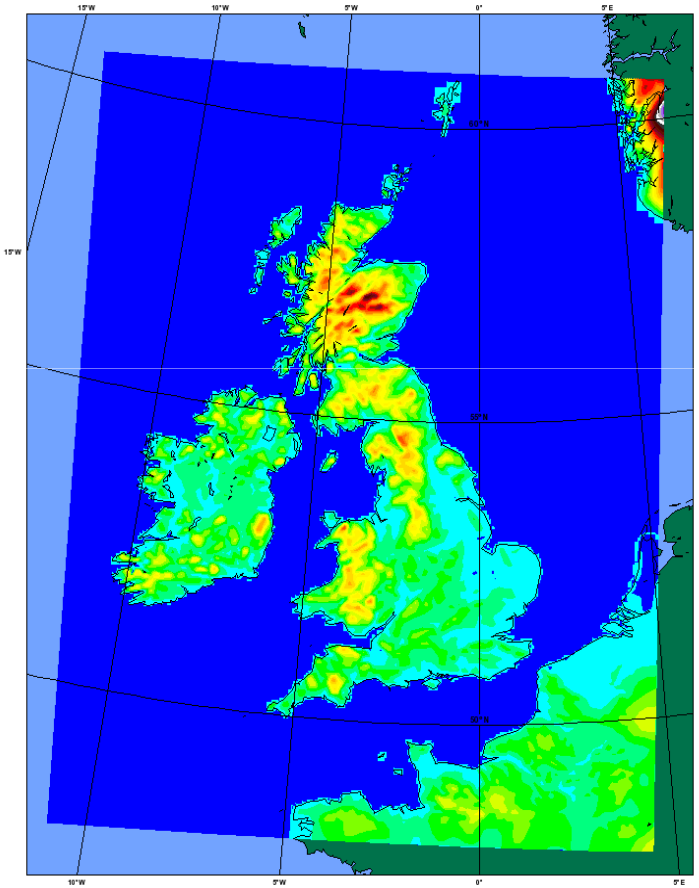
9 Domains

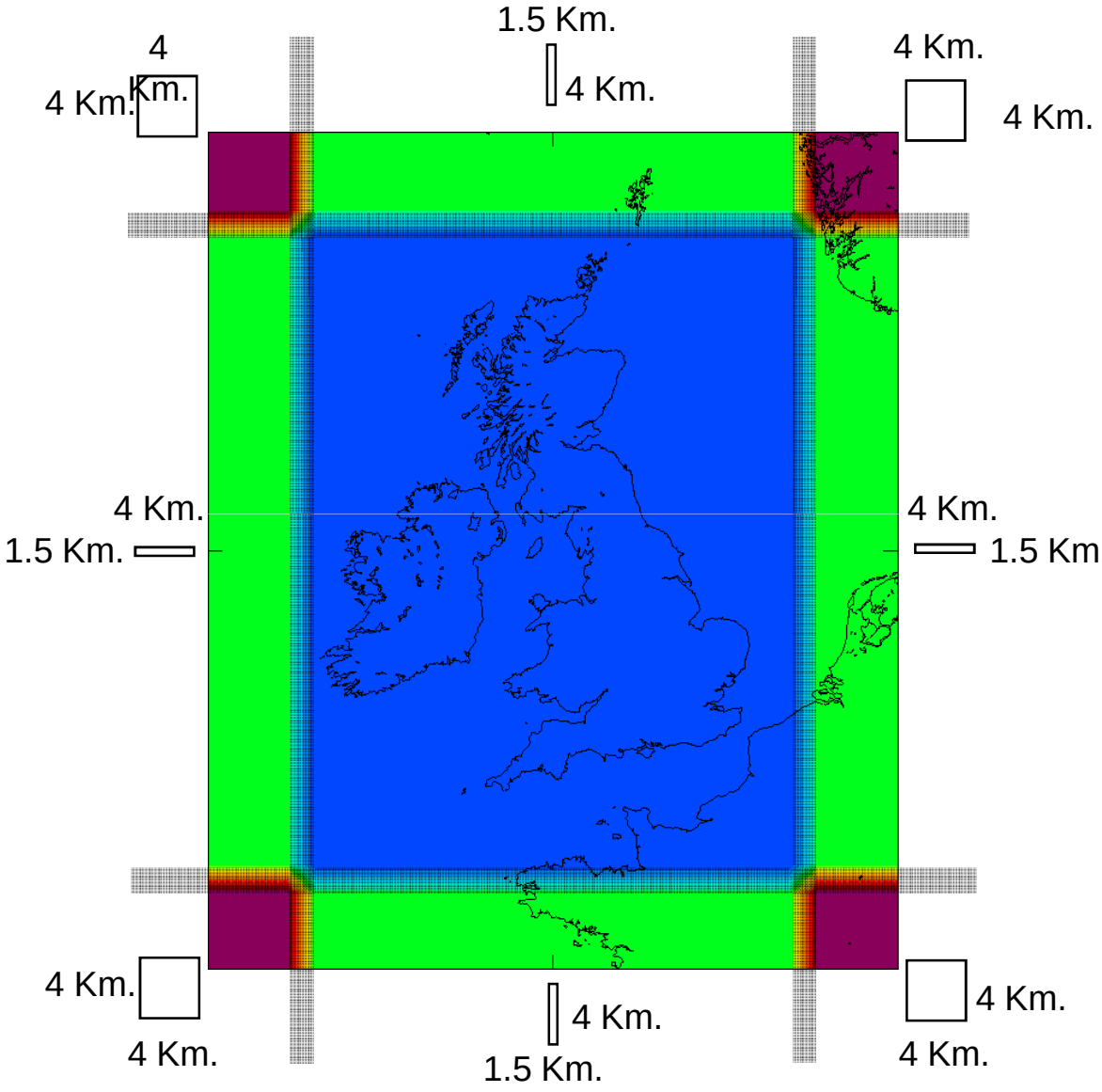
1. Far South West
2. South West
3. South
4. South East
5. Northern Ireland
6. Northern England
7. North Sea Coast
8. Scotland
9. Shetland

On Demand Model

- Nested in UK4.
- 300 x 300 gridboxes, approximately 450 km x 450 km.
- 1.5 Km gridbox length.
- 70 levels.
- Spin-up from UK4 T+1. Forecast length 18 hours.
- LBC update frequency: 30 min.
- Available after any main UK4 forecast.
- Discontinued 1st August 2009

UK4 vs UKV model domains





UKV Model

- Nested in NAE (12 Km gridlength)
- Variable Resolution. Outer rim 4 Km gridlength
- Inner area 1.5 Km gridlength
- Inner area size:
  - 622 gridboxes E-W
  - 810 gridboxesN-S
- Full area size:
  - 744 gridboxes E-W
  - 928 N-W
- LBC update frequency: 30 min.
- 70 vertical levels. Model top: 40000 m.
- Timestep: 50 sec.
- Forecast length: 24 hours

UKV vs UK4 science differences

- Convection scheme turned off in UKV model

- CAPE based CAPE timescale in UK4 model - shallow convection is still parametrized

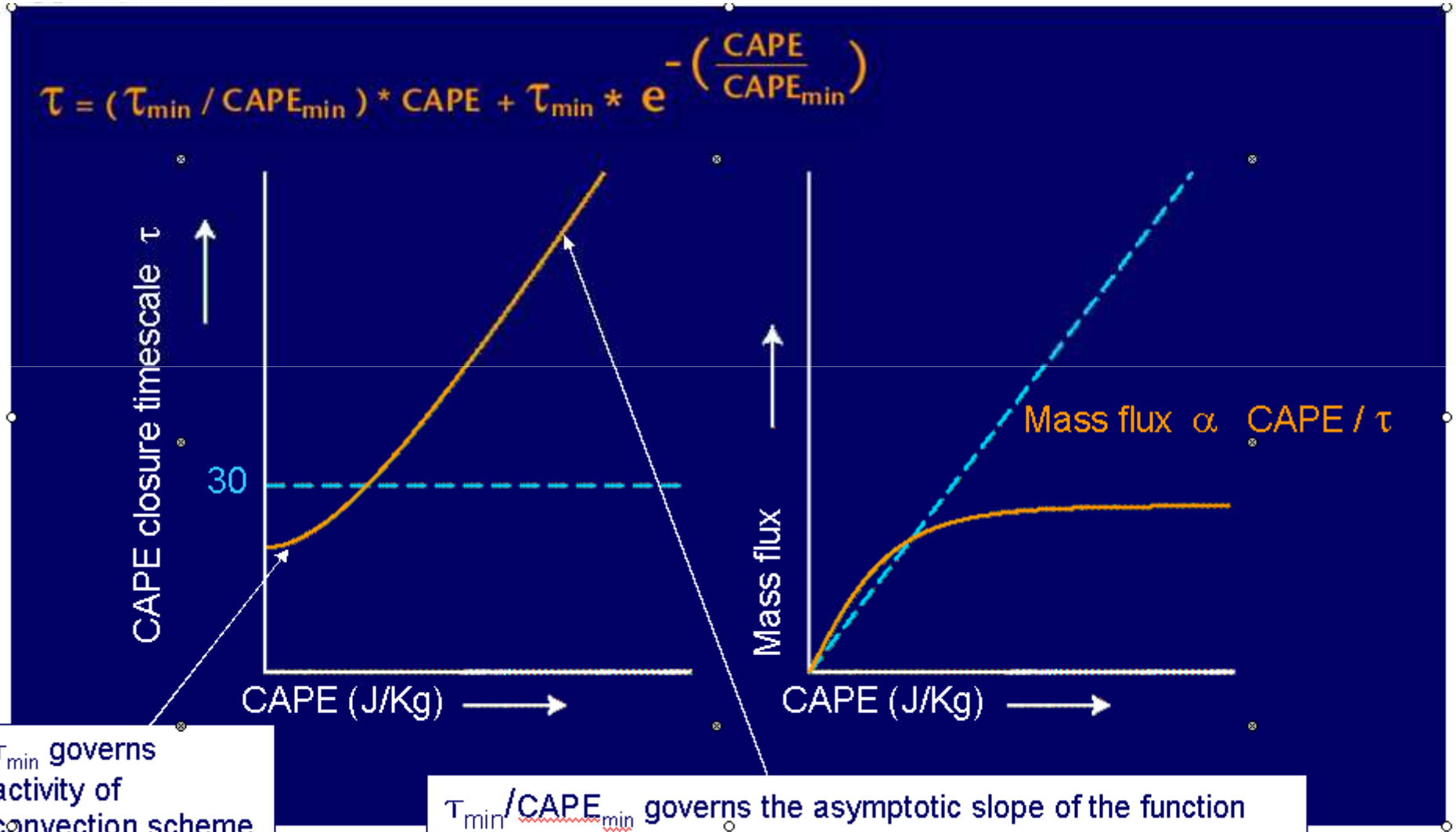
- Shallow convection partly resolved by UKV dynamics

- Boundary layer scheme allowed to work the full depth of the model to mitigate instabilities (see poster)

- 2D Smagorinsky- Lilley turbulence scheme replaces horizontal diffusion

- Orographic drag off in UKV model

UK4 CAPE based CAPE timescale



UKV does well at…

- **Spin up from boundaries**
- Orographically forced cloud/precip
- Inland penetration of marine showers/clouds
- Precipitation structure within fronts/line convection
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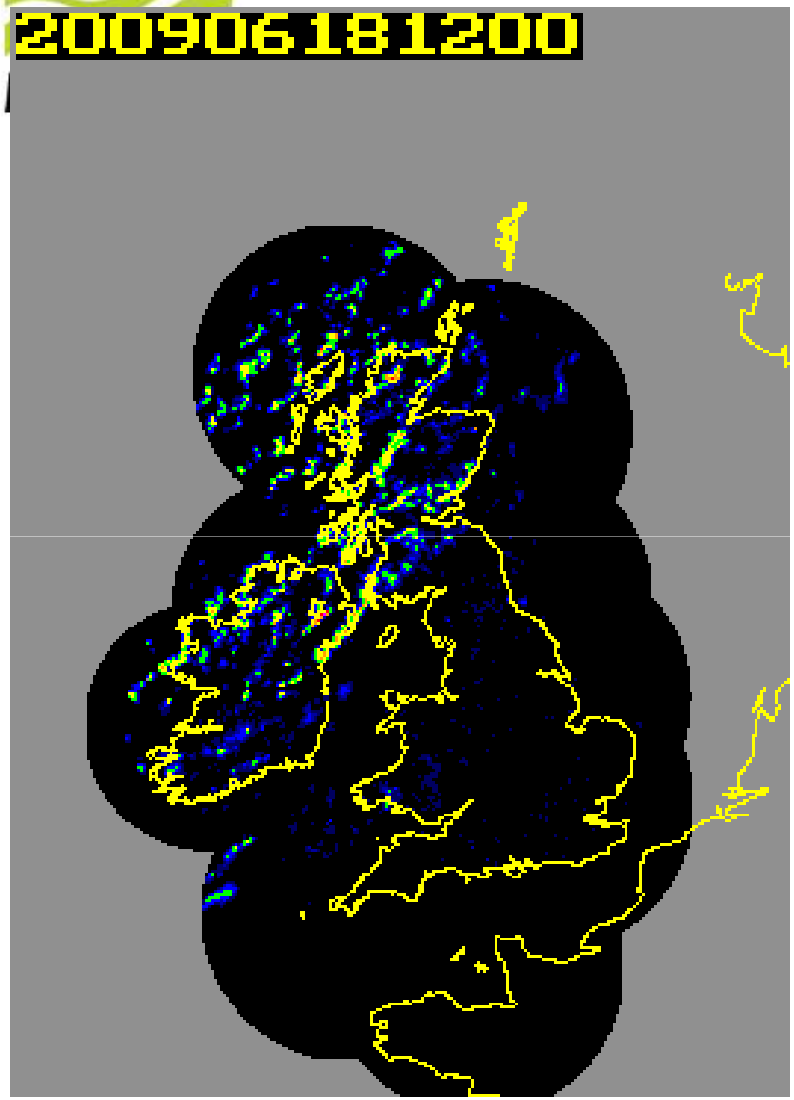
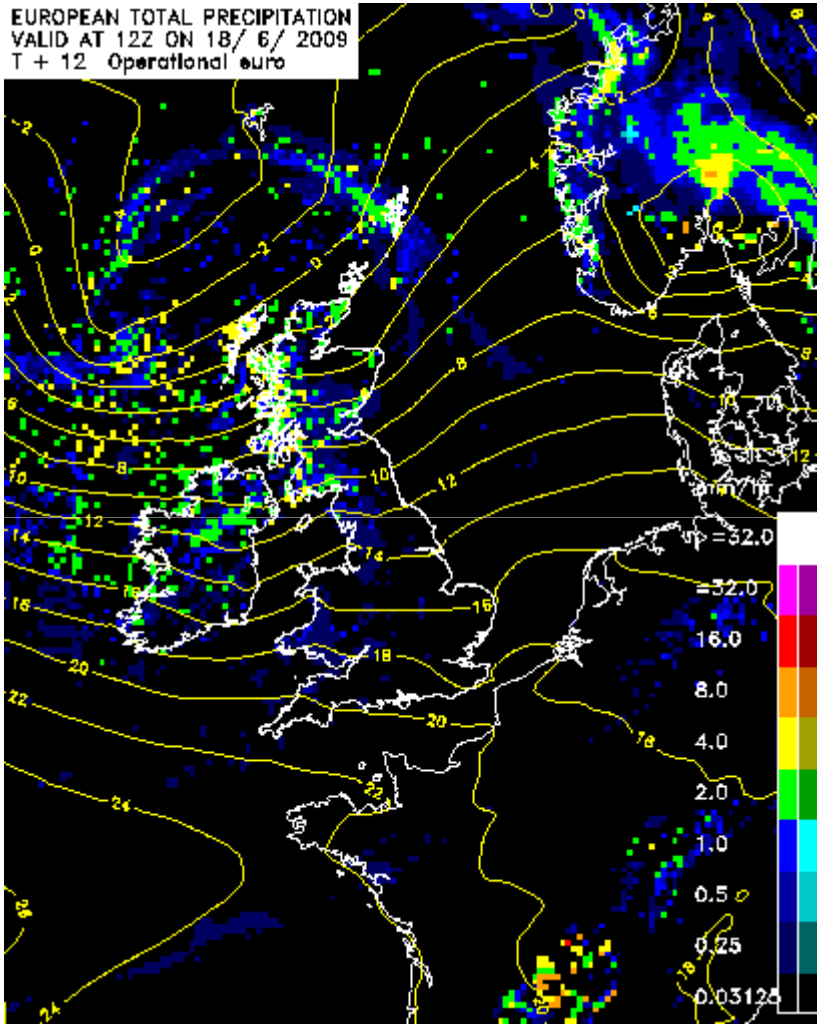
- Sea breezes

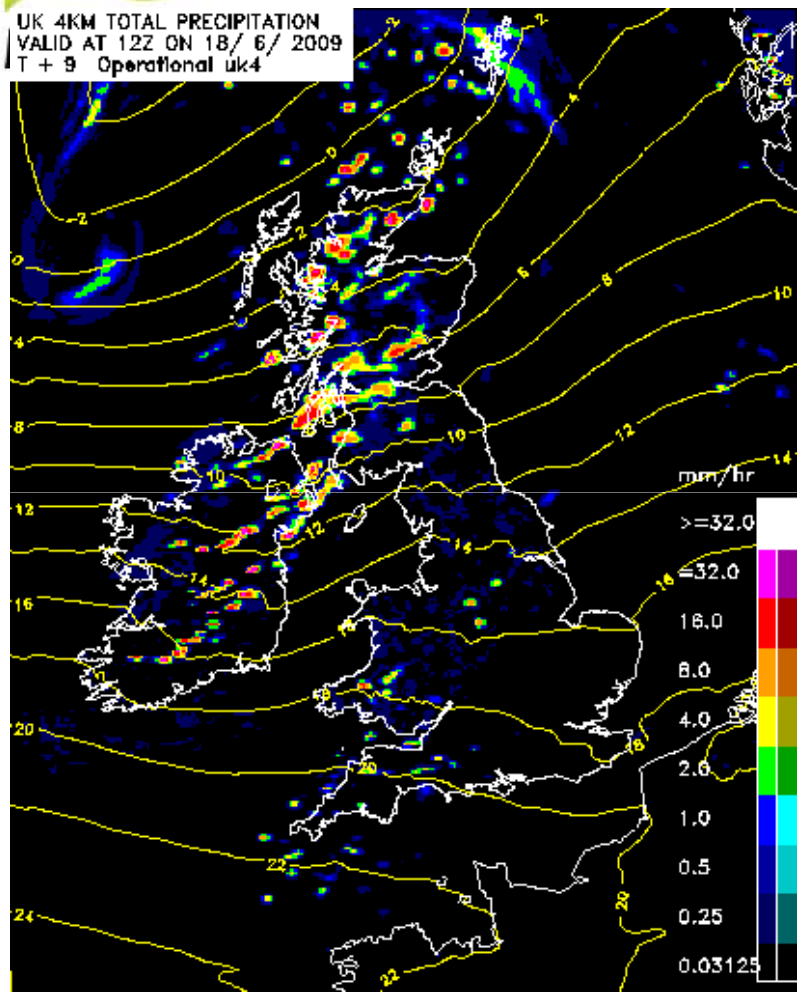
Shower spinup 12z 18/06/09

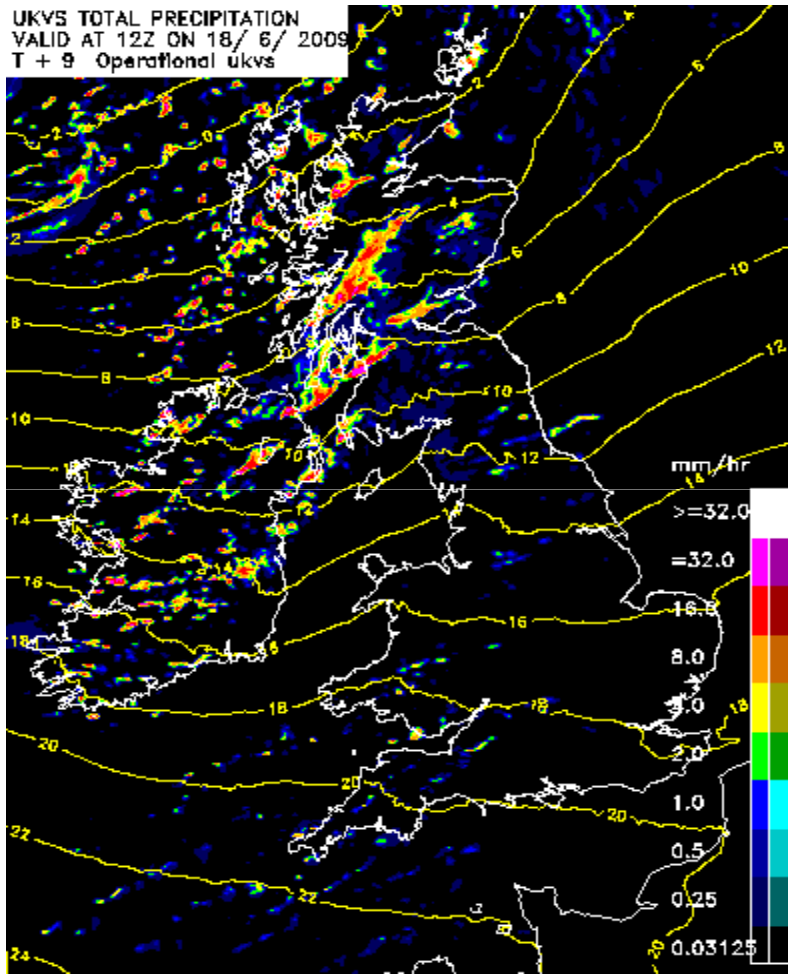




NAE has shower signal in the right place.

Shower spinup 12z 18/06/09





UKV shows more showers (i.e. less spin up) at W boundary.

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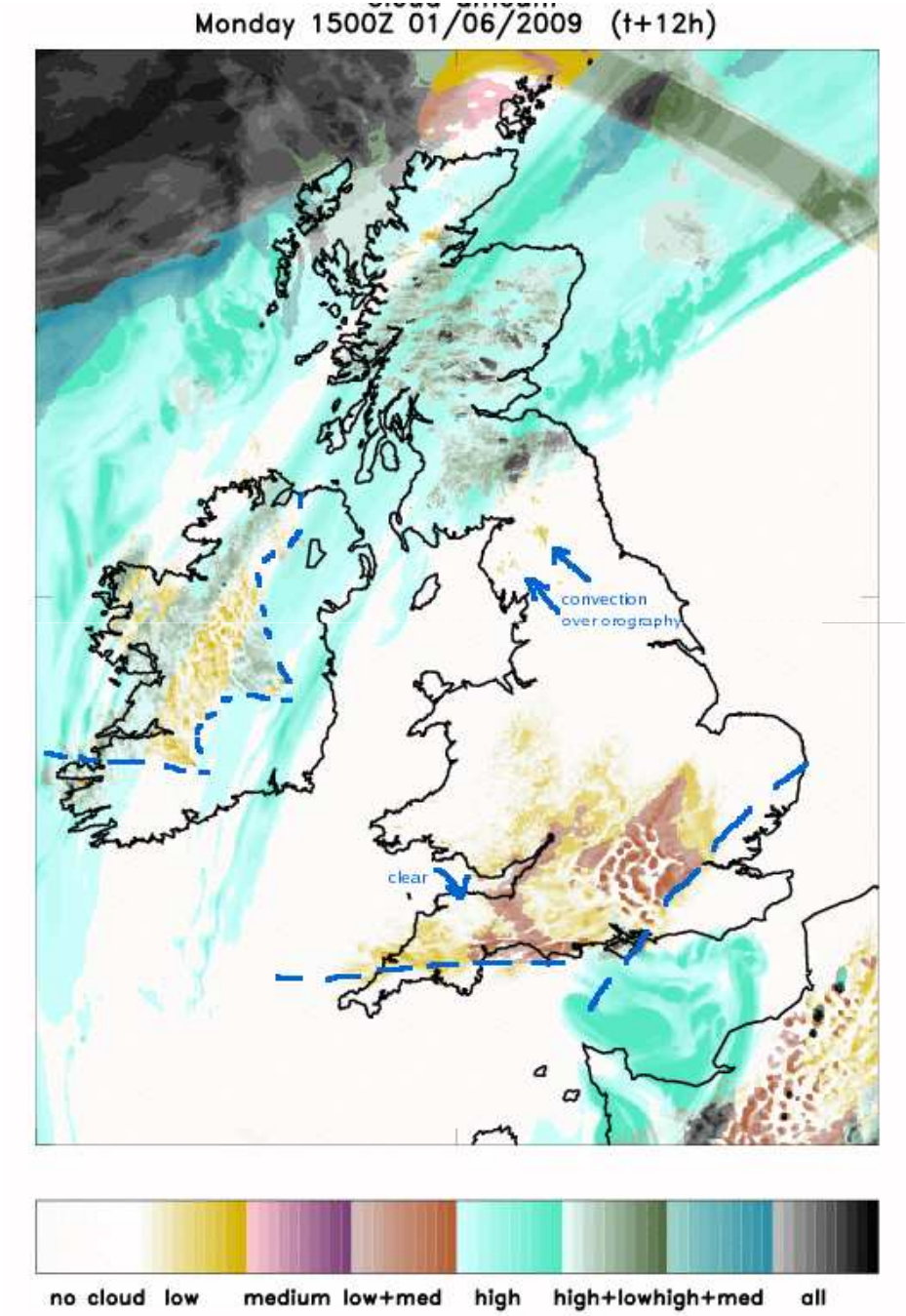
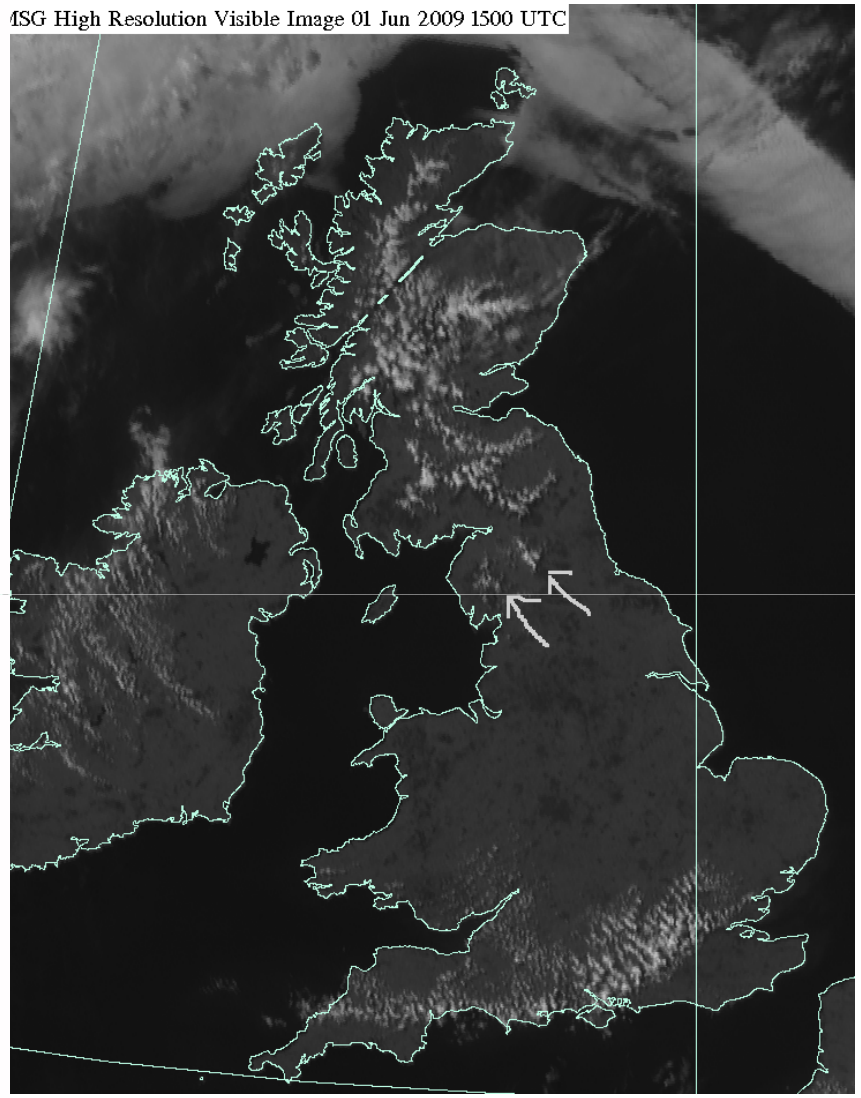
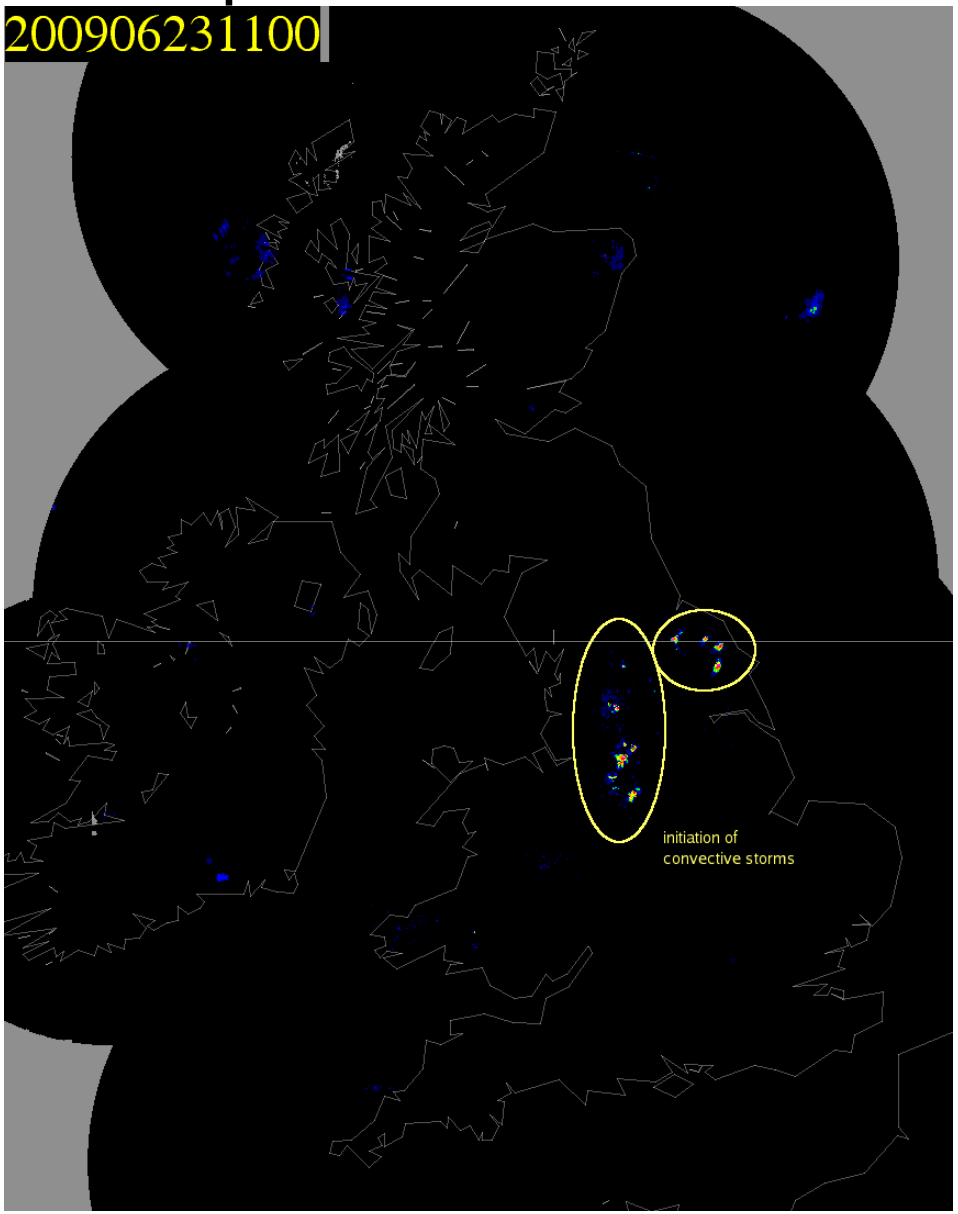
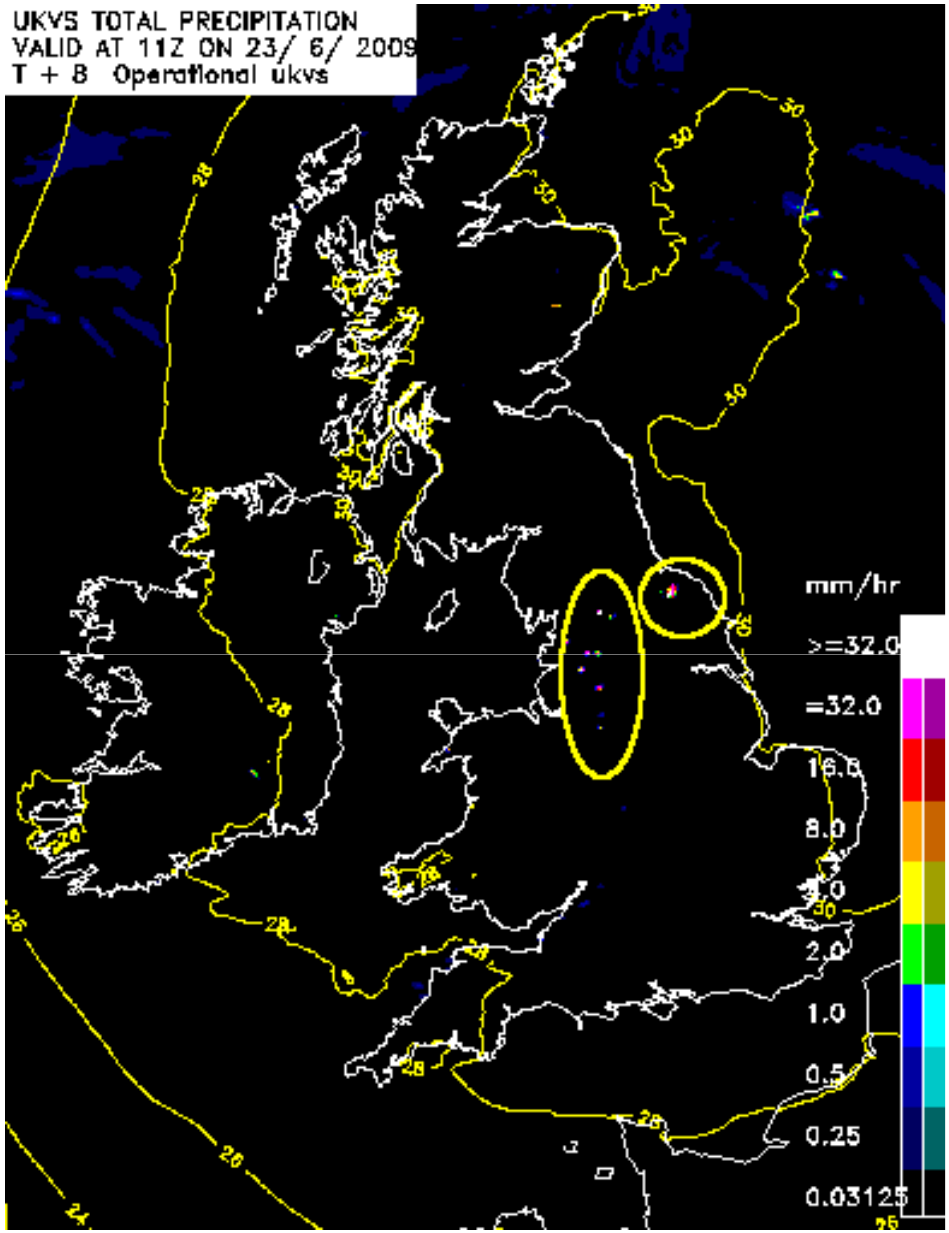




Convection over orography 01/06/09 15Z

Deep convection initiation





- RADAR

UKV

Ottery St Mary hailstorm 30/10/08

The exceptional Ottery hailstorm of 30th October 2008

- Pool of anomalously deep cold air transferred south across the U.K. in association with a marked trough extension at upper levels

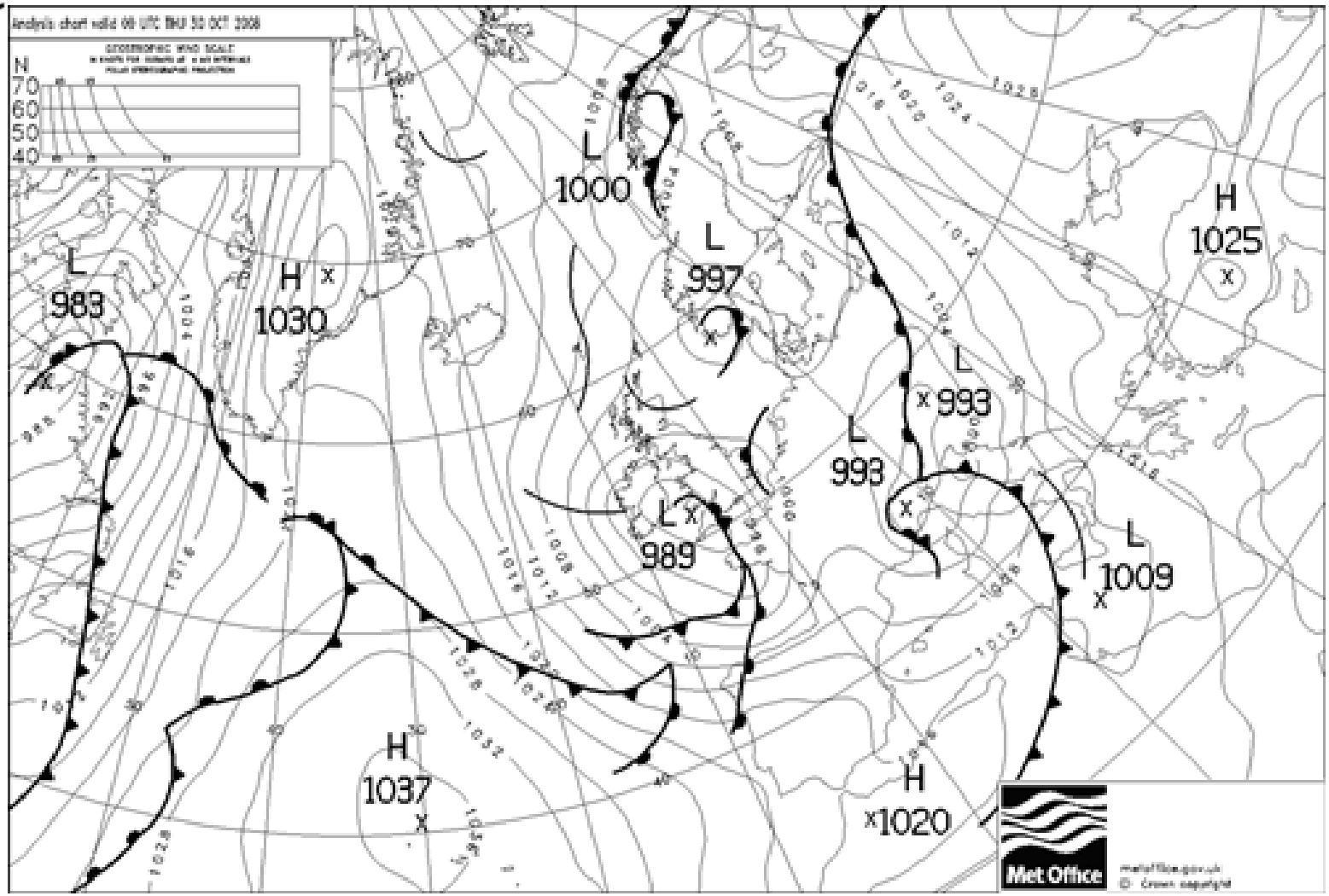
- Short wave upper trough developed upstream

- Low pressure area with occluded front crossed SW England. Low level southerly air was warm and moist

- First heavy rainfall cell location was determined by local convergence and uplift over Woodbury common

- Local topography played a significant role by funelling moist air up the Otter Valley

Analysis chart 30/10/08 00UTC



Observations and model guidance

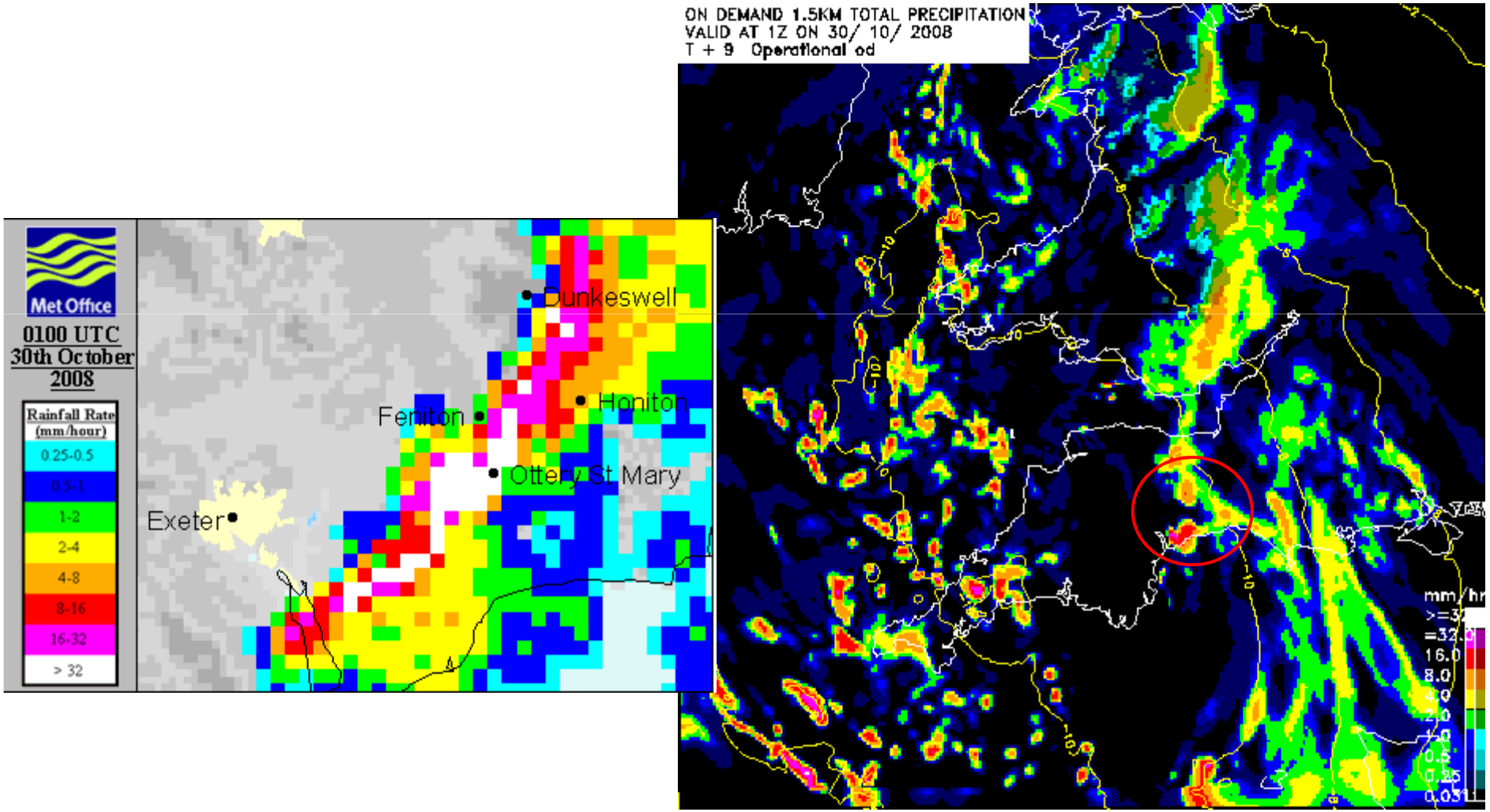
- Actual rainfall accumulations ~200mm, with 25cm of hail falling in 2 hours

- On Demand model forecast a 3 hour accumulation of 70-80mm in a 40km x 40km square containing Ottery and 80-90mm in a nearby square

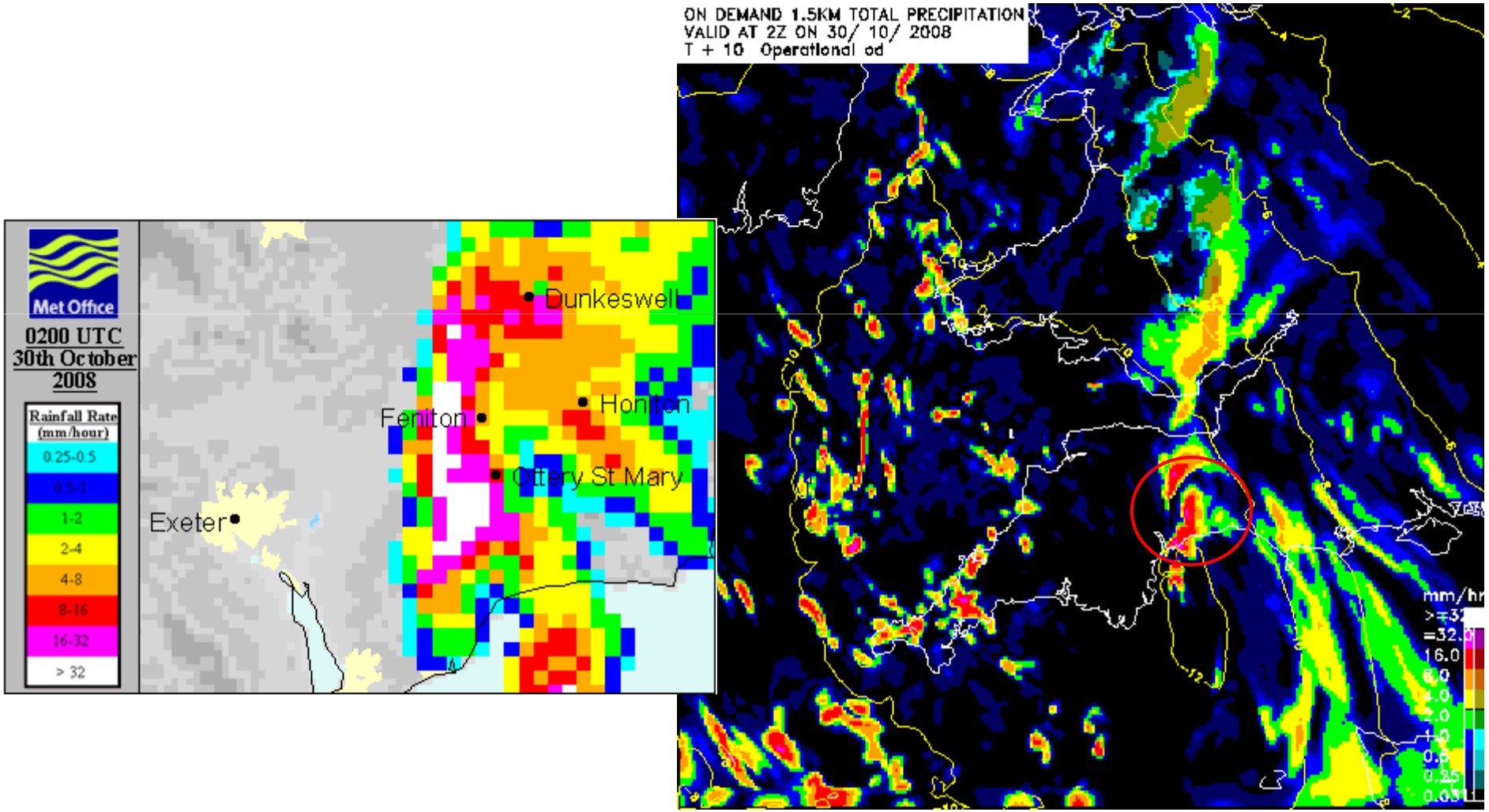
- The UK4 model had nothing in the 40km x 40km square containing Ottery and a 3 hour accumulation of 40-50mm in a nearby square

- Some MOGREPS-R members indicated heavy precipitation, but 24km resolution limits usefulness

Ottery Storm. Radar and On Demand Model 01UTC



Ottery Storm. Radar and On Demand Model 02UTC



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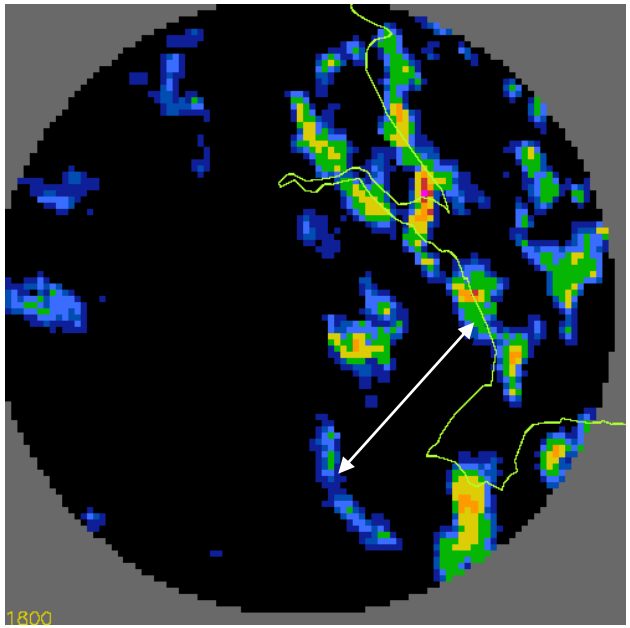
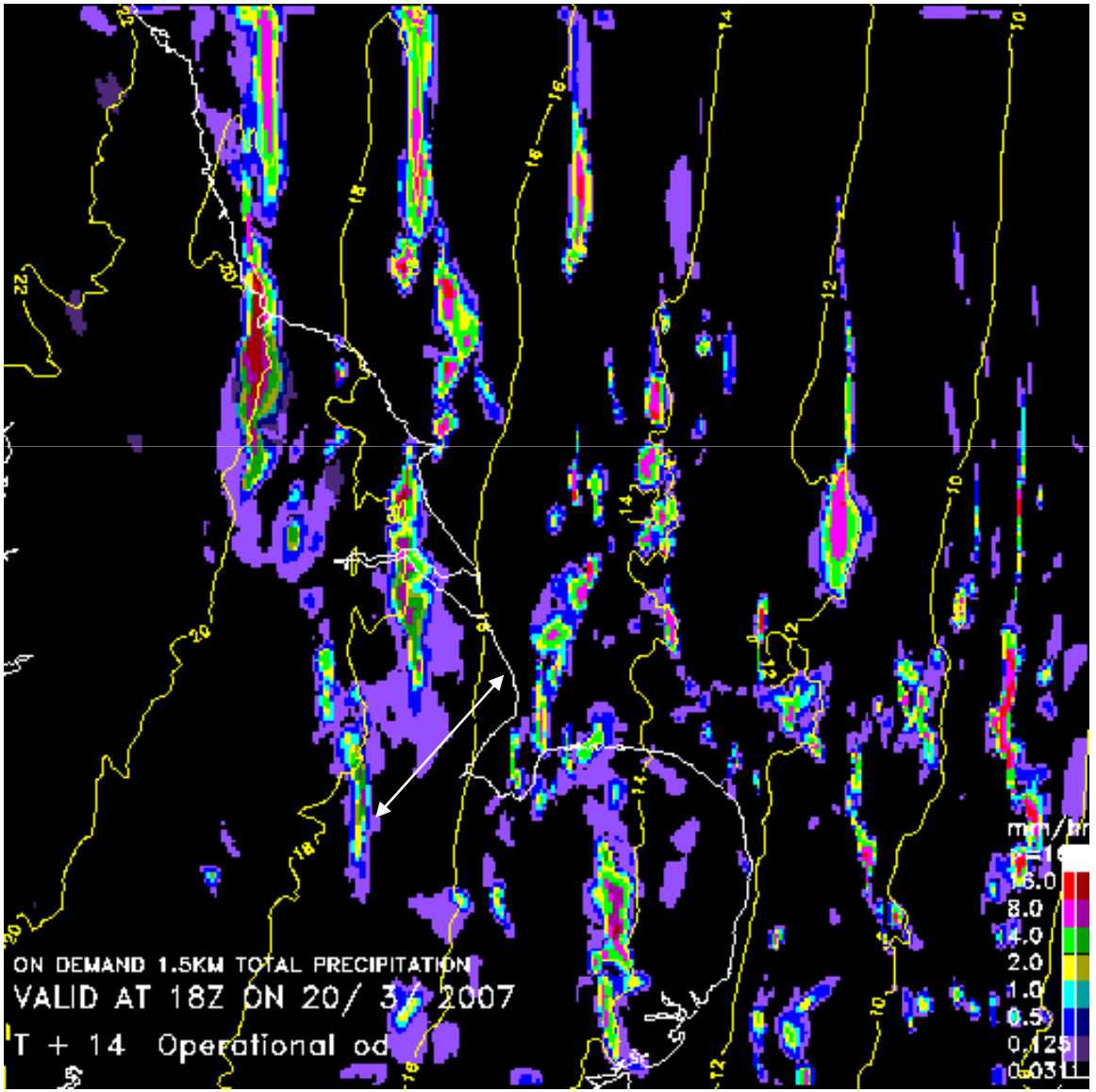
North Sea Wintry Showers

Inland penetration of showers is well represented.





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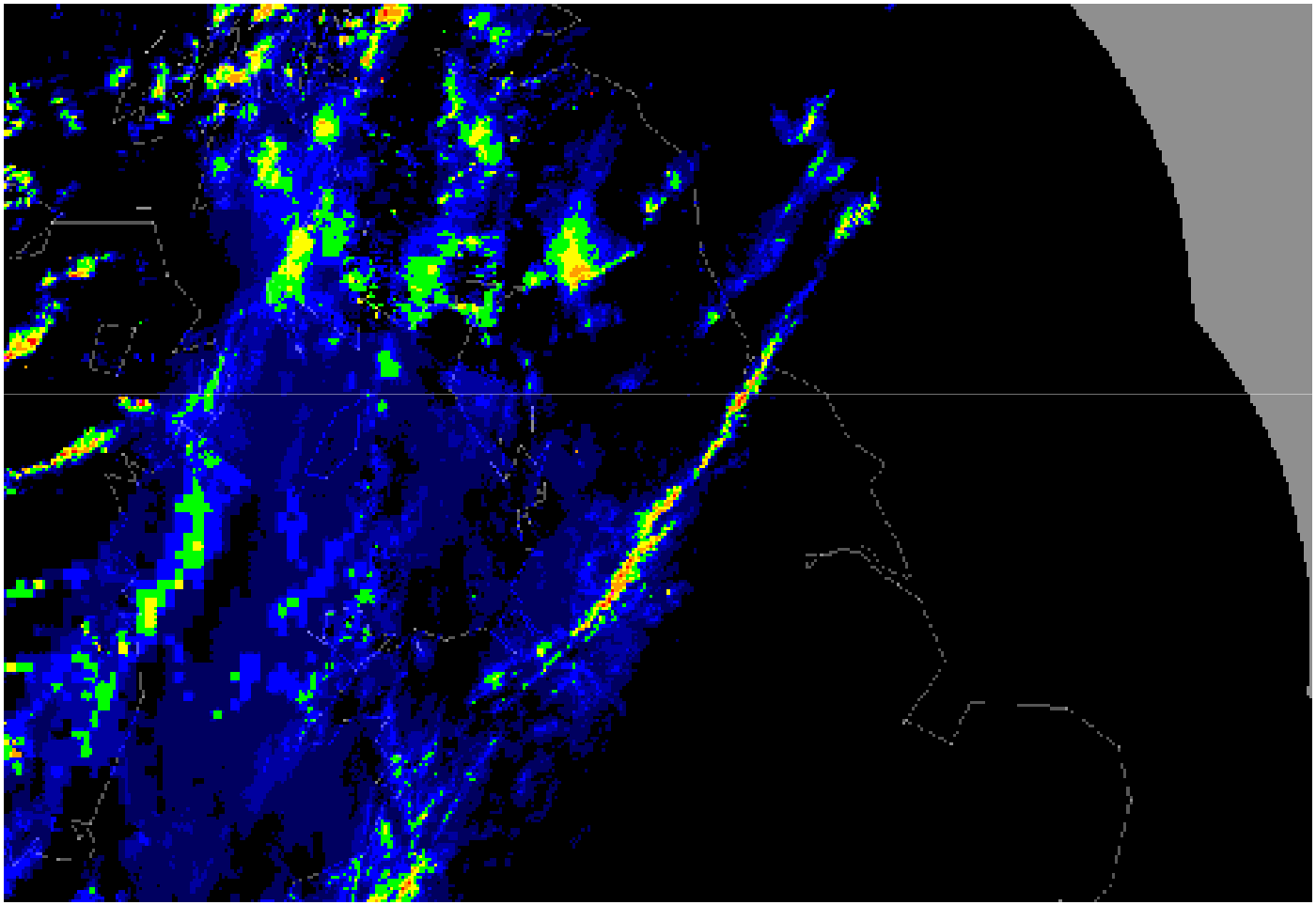
Line convection 08/09/09 17Z



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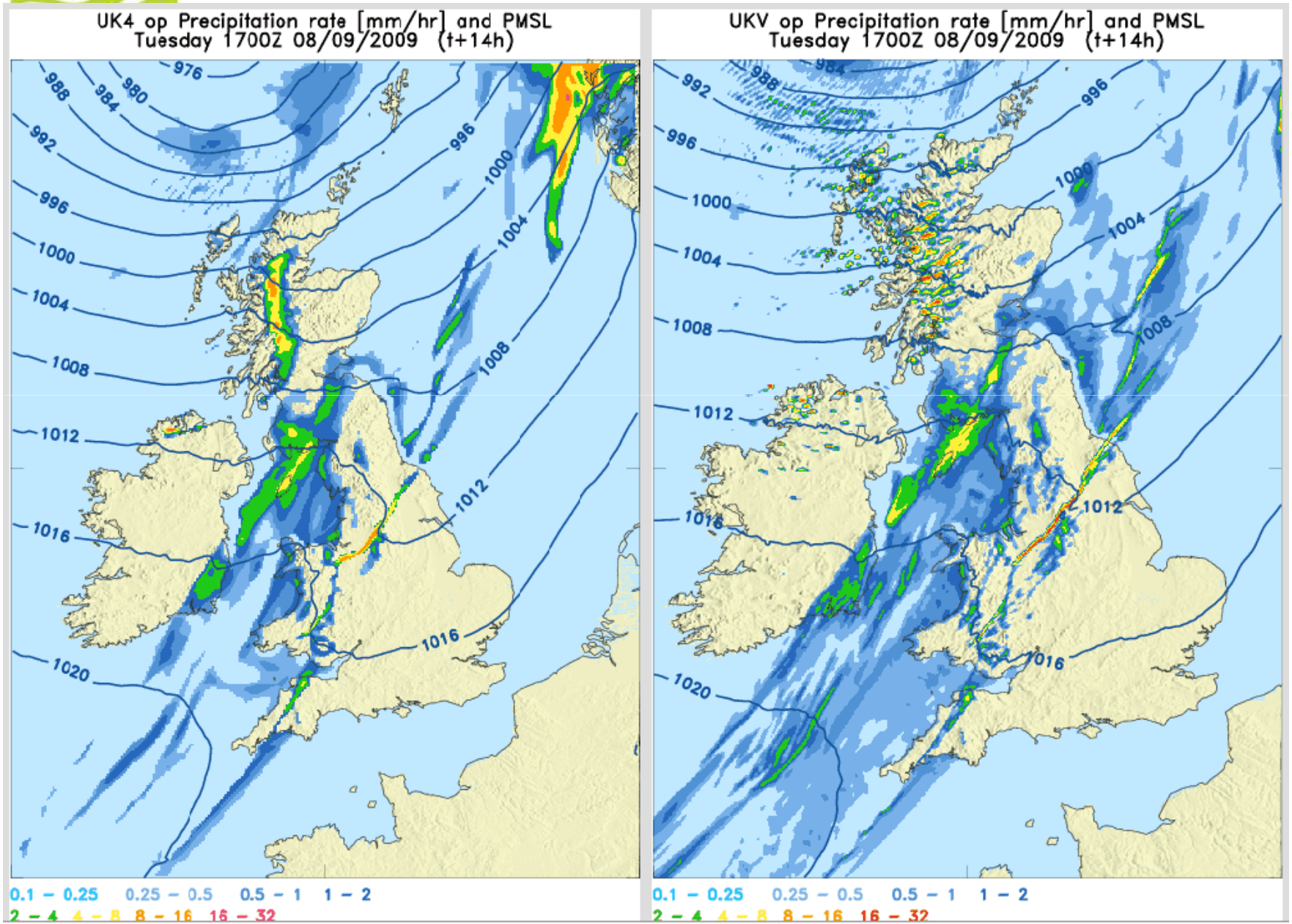

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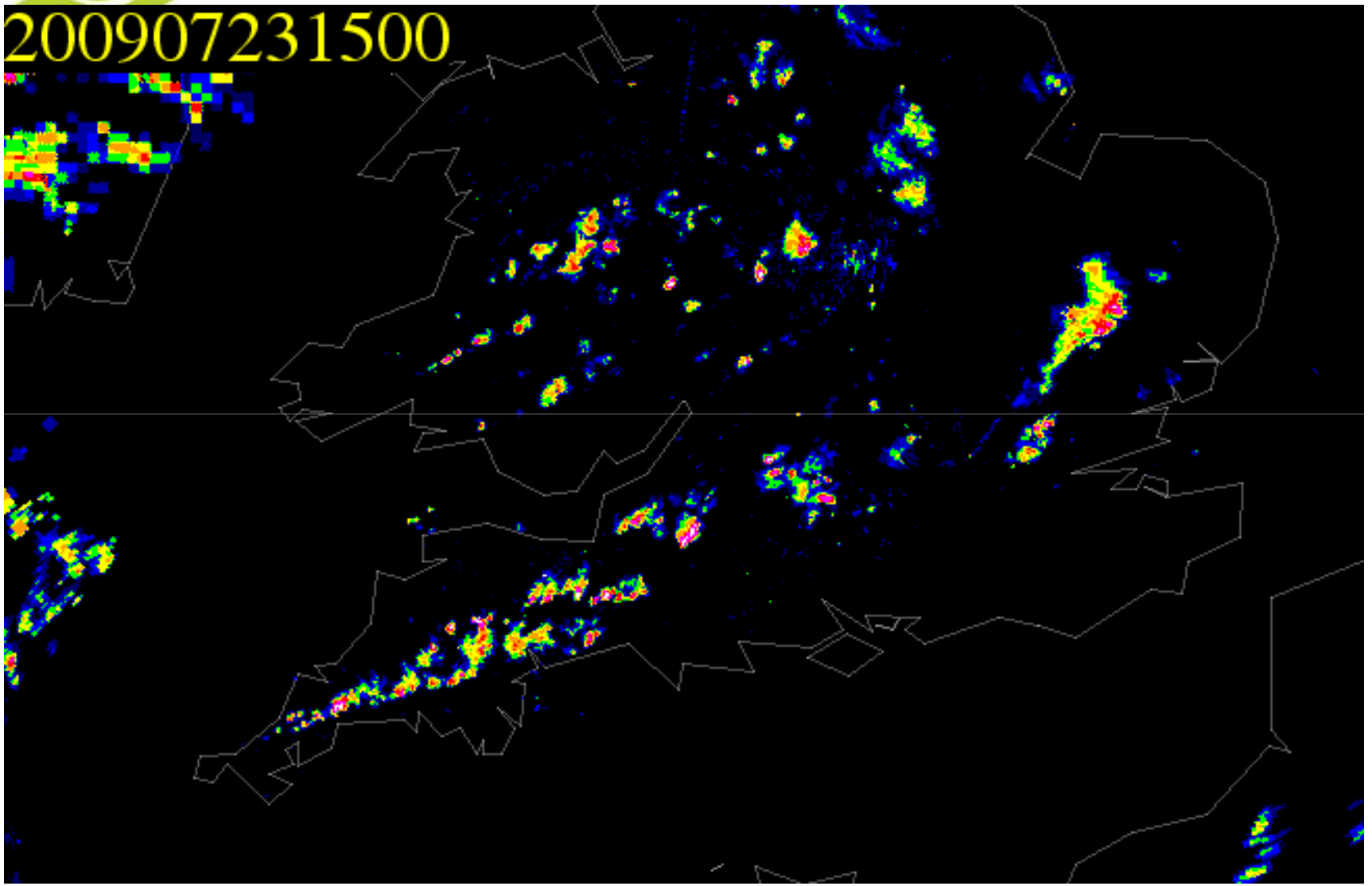
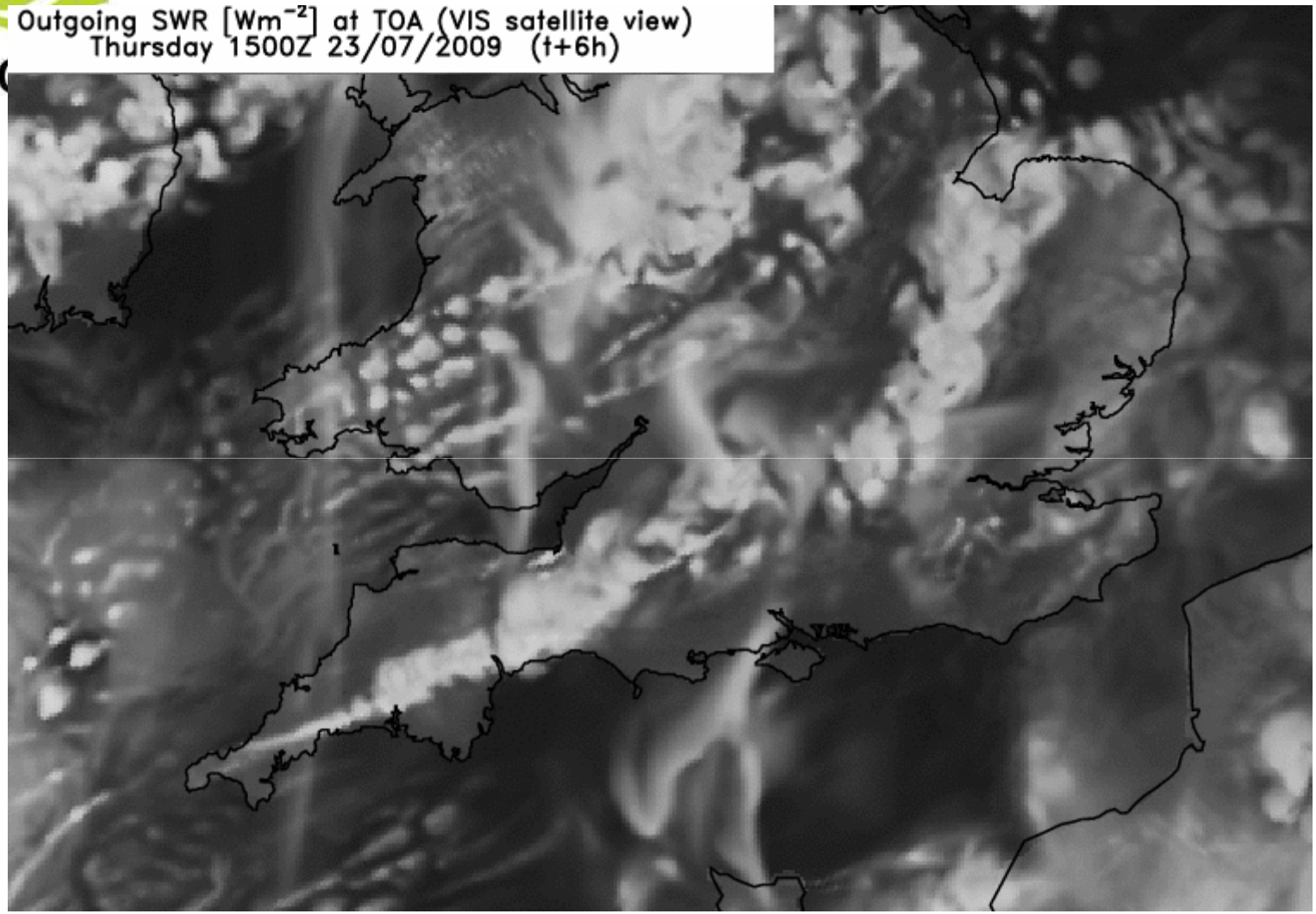
Convergence line 23/07/09 15Z



UKV ppn didn’t develop soon enough, but positioning is well handled

Convergence line 23/07/09 15Z



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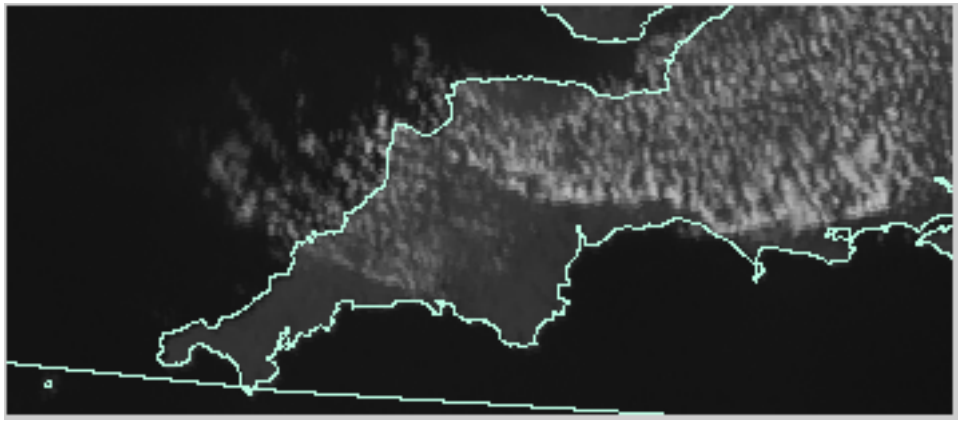
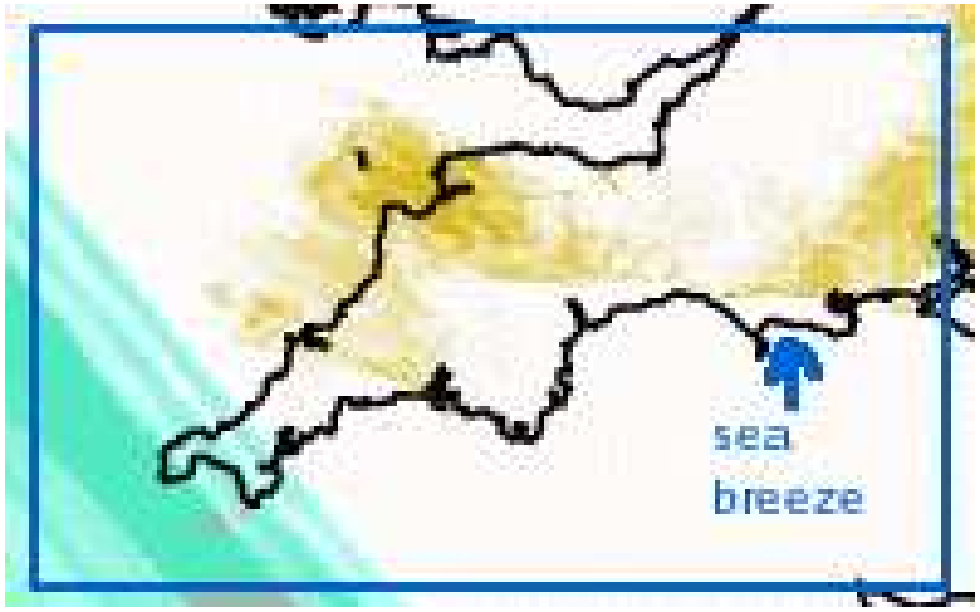
- **Sea breezes**

Shallow cumulus over land

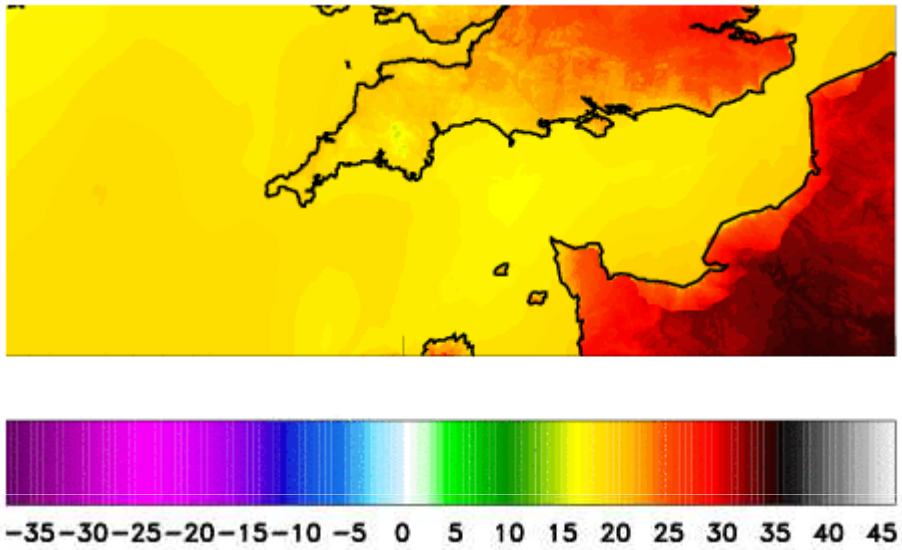
- 24/06/09 13Z
- Predictability arising from sea breezes and orography
- Brown shading indicates low cloud

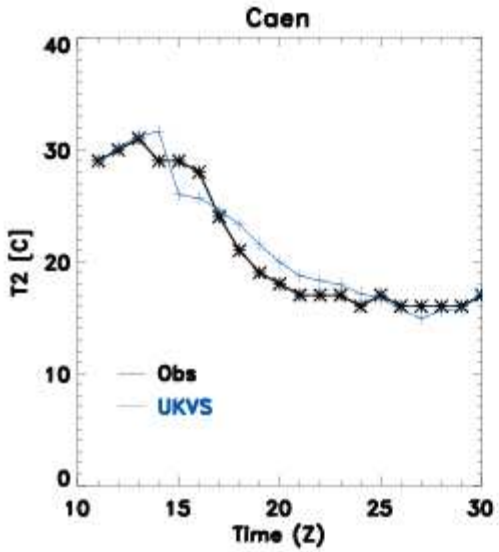


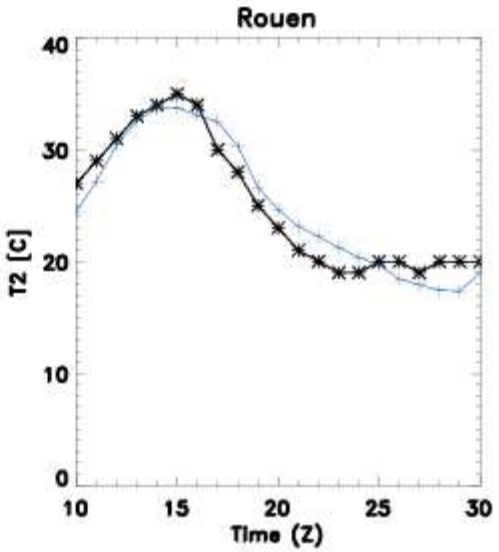


Sea breeze and temperatures

- 19/08/09
- Sea breeze moves inland through the afternoon







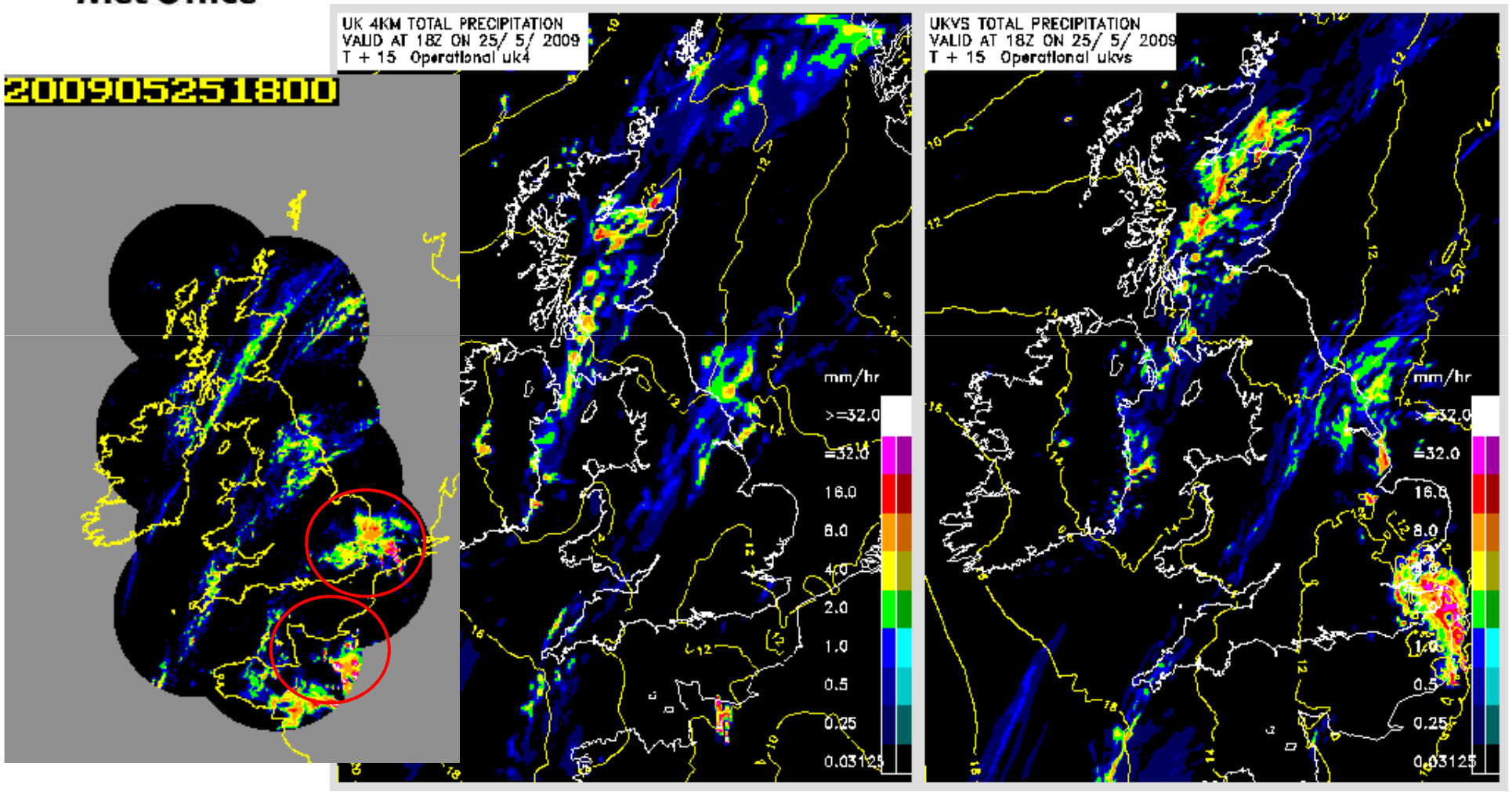
UKV doesn’t do so well at…

- **“Imported” convection (such as an MCS) that has naturally low predictability and is often poorly handled by the driving model.**

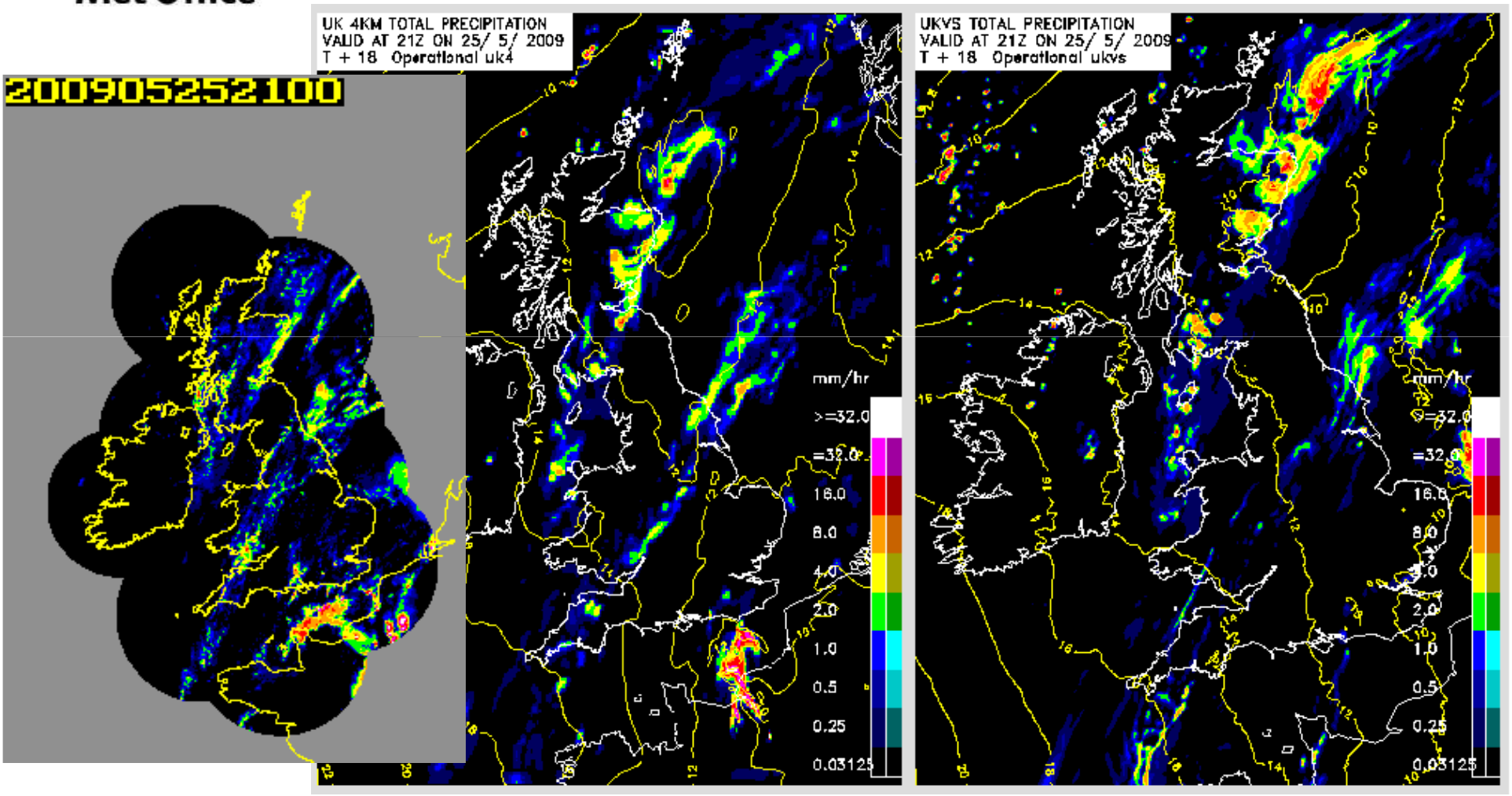
- Convection driven by upper level forcing

- Stratocumulus unless you have data assimilation

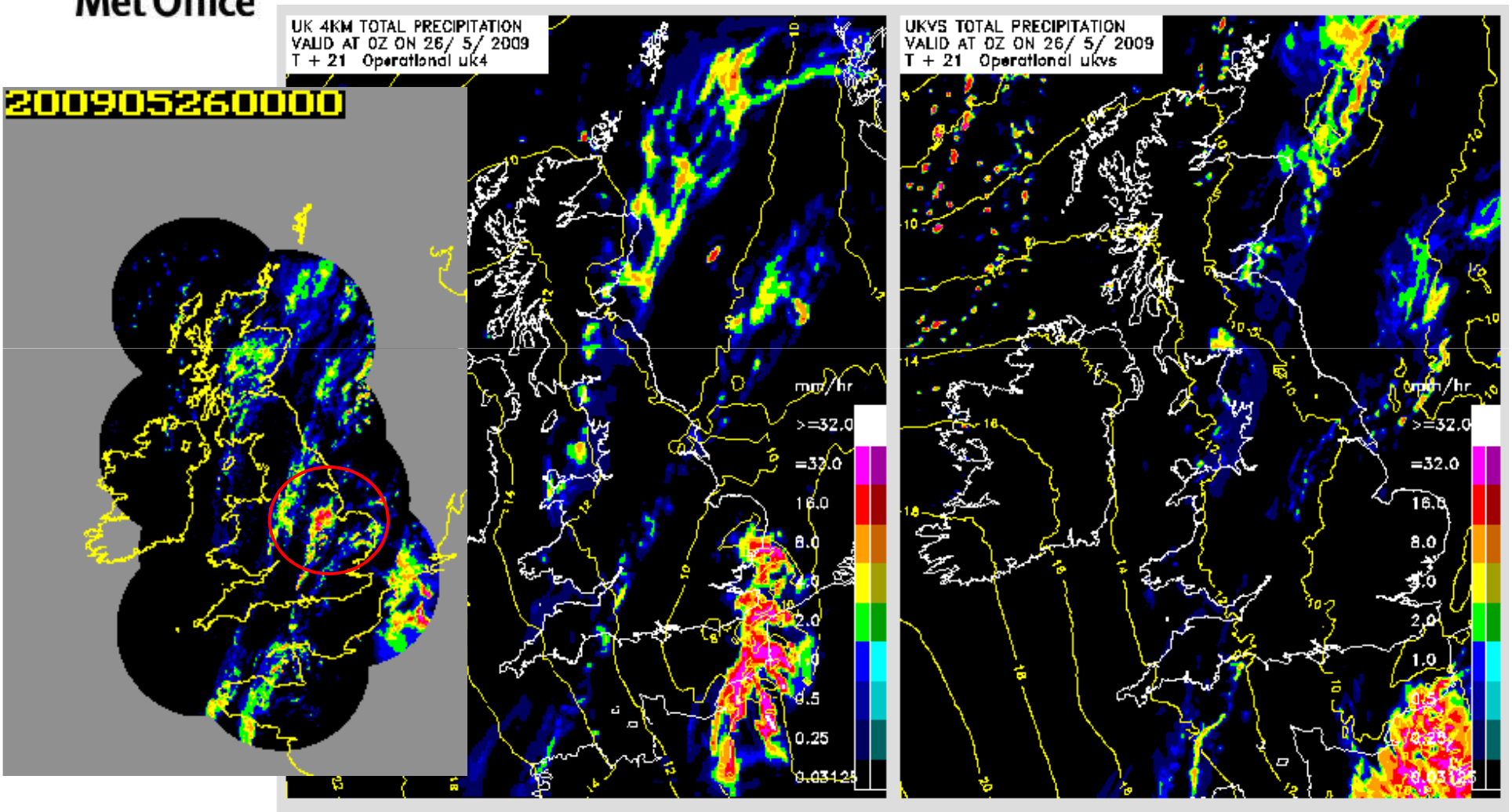
25/05/09 18Z – UK4 vs UKV



25/05/09 21Z – UK4 vs UKV



26/05/09 00Z – UK4 vs UKV



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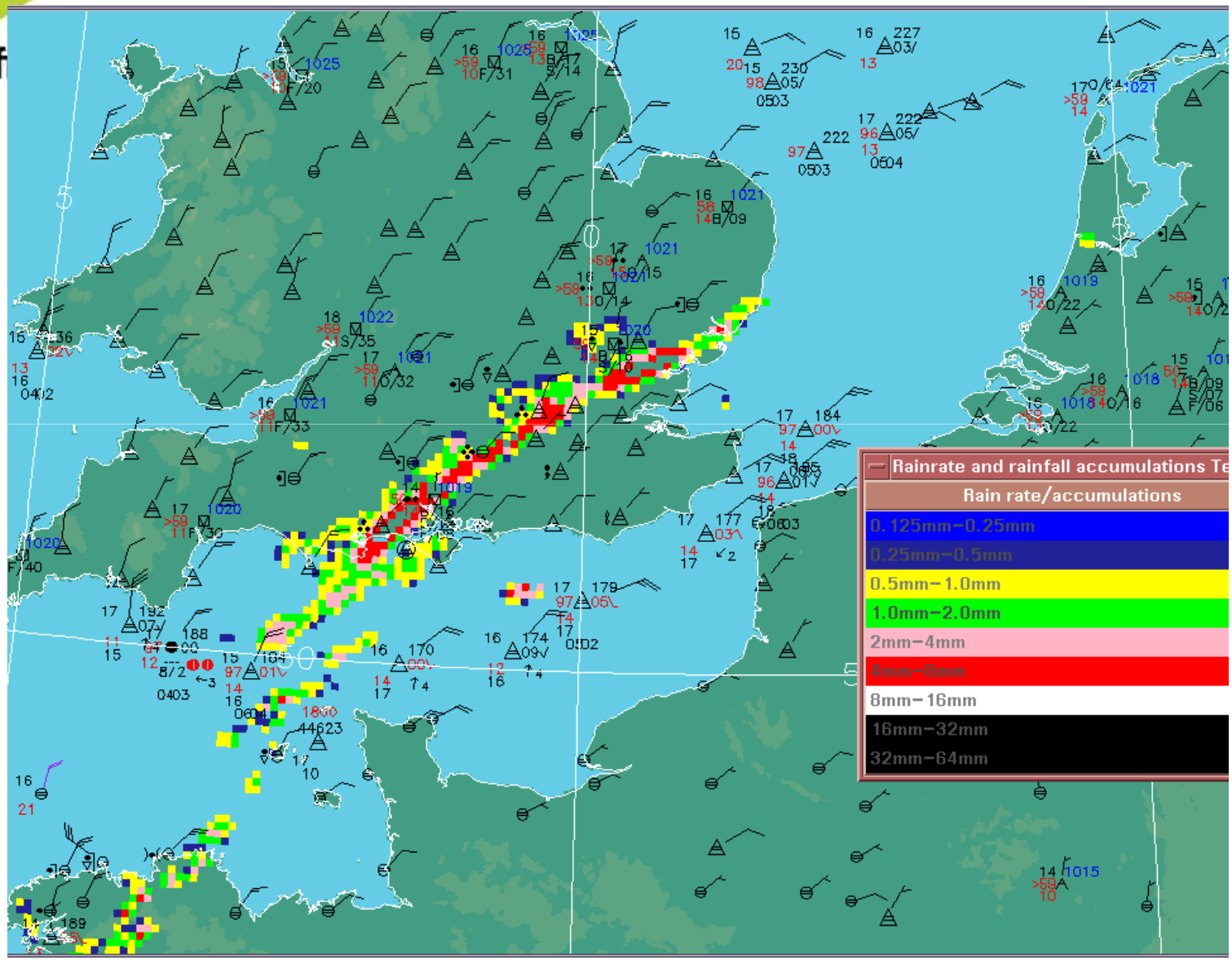
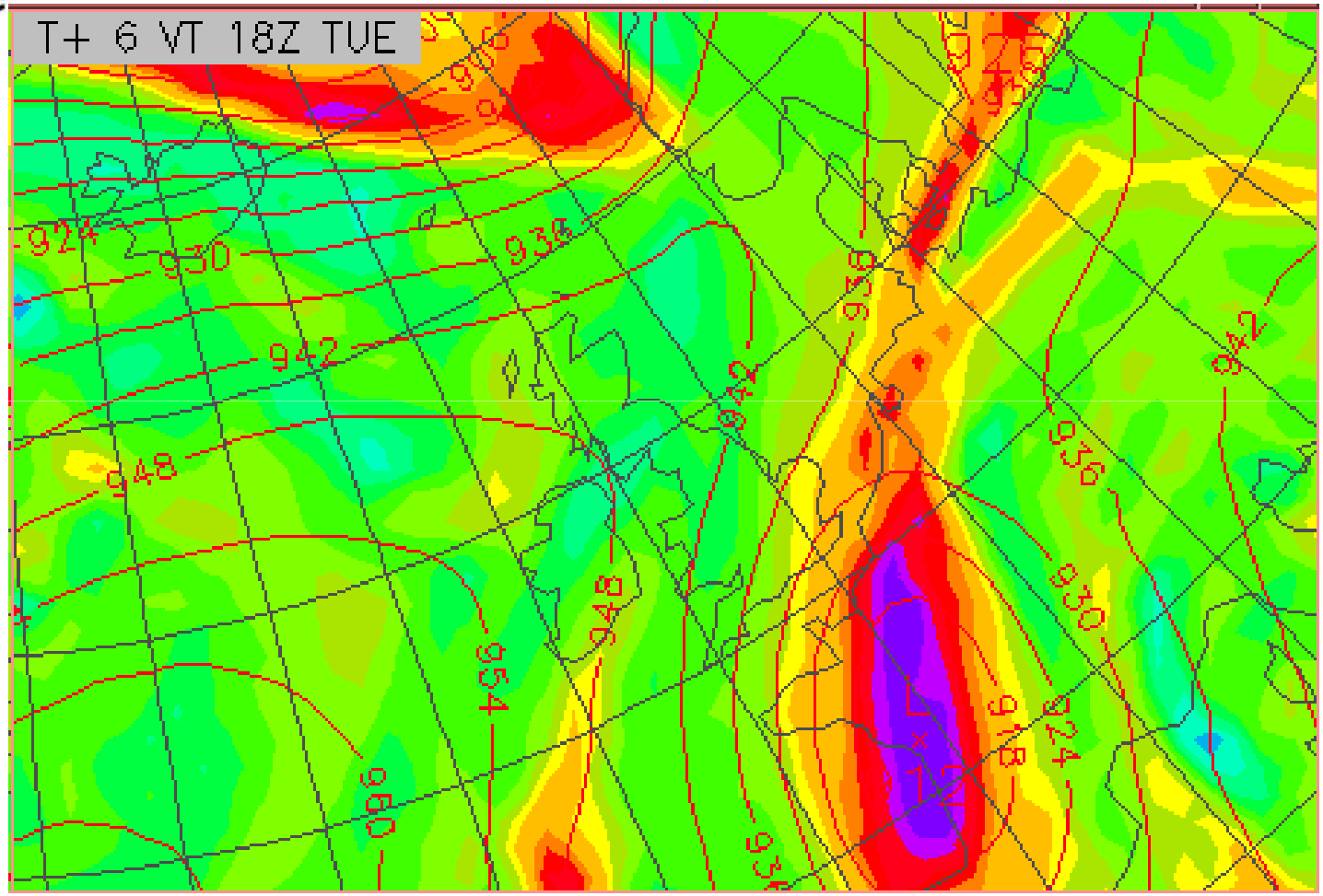
15/09/09 18Z radar and wind



15/09/09 18Z upper level forcing



15/09/09 case

- Upper vortex over near continent
- Occluded warm plume wrapped around northern flank
- Profile moist in depth and neutrally stratified
- Modest CAPE and updraught/downdraught strengths
- Efficient rainfall production as air parcels stay in cloud for a long time and original convergence zones are not destroyed by downdraughts
- Lack of surface convergence

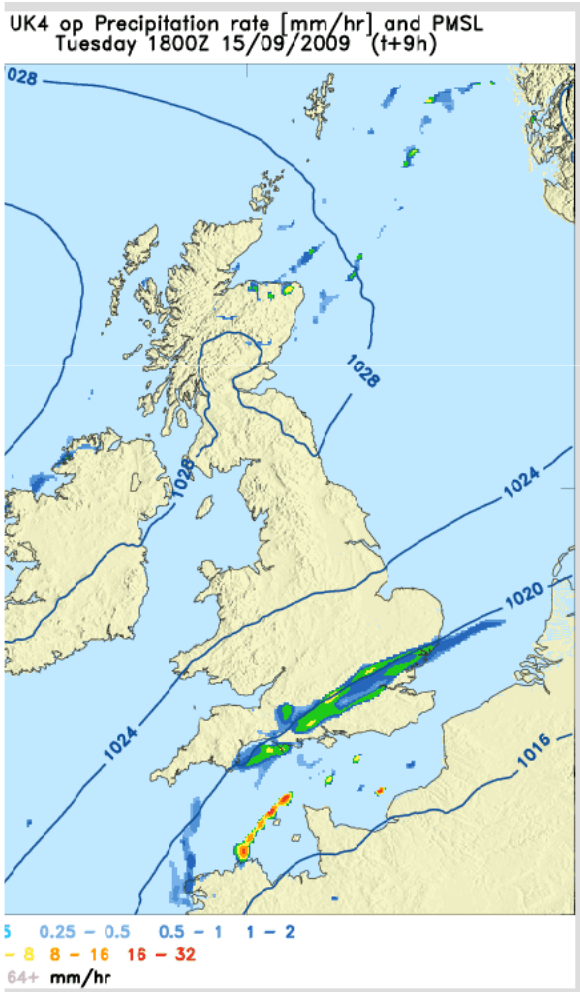
15/09/09 case

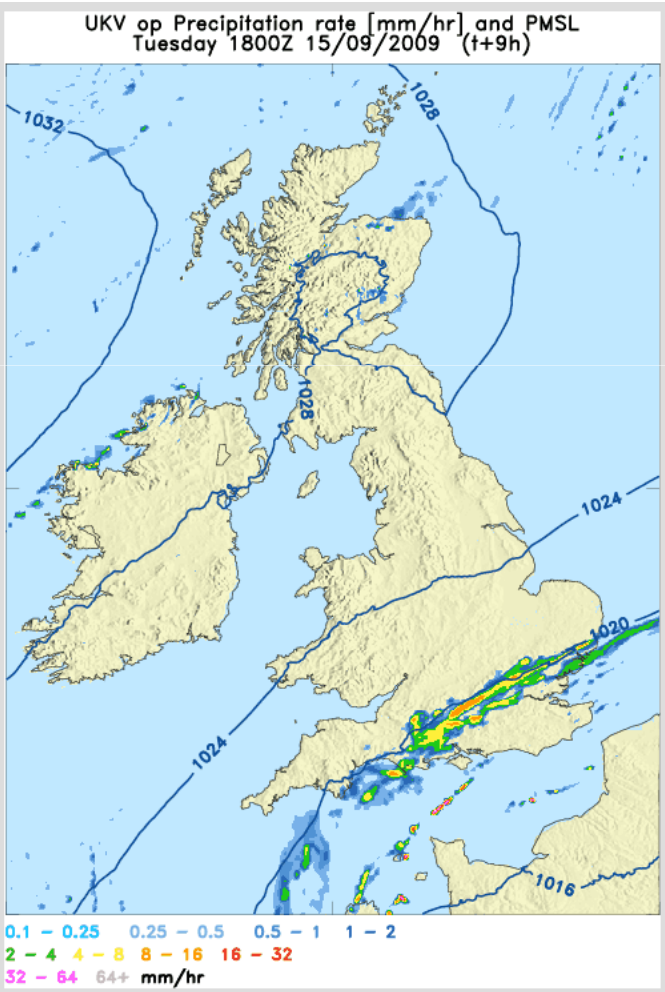
- Successive UKV (and also UK4) runs seriously underestimated the intensity of the rainfall band

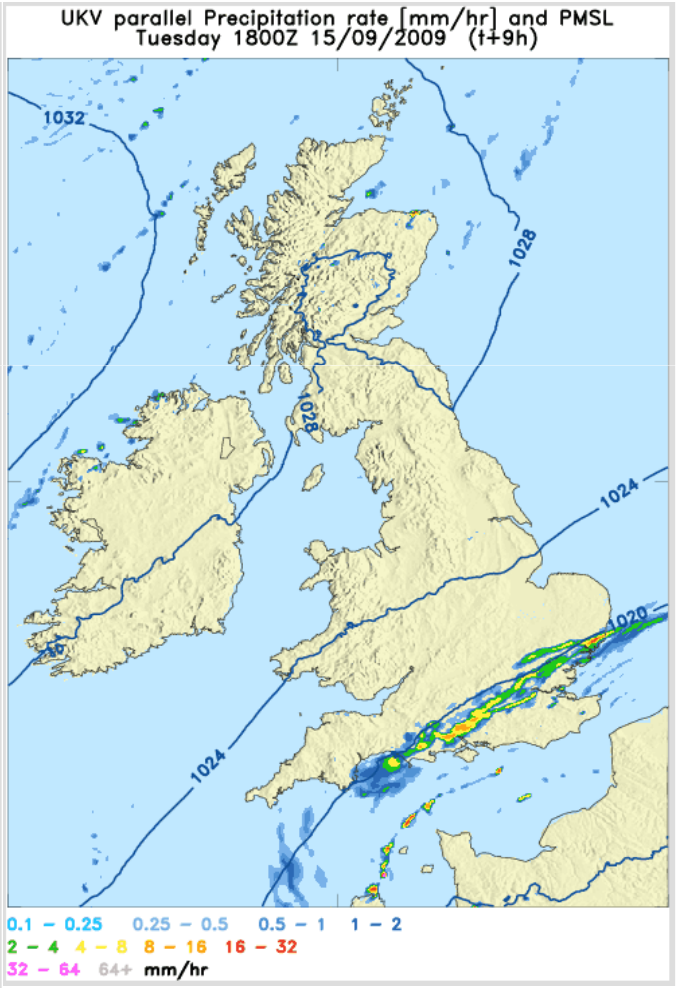
- 6hr rainfall totals to 21Z included 47mm at S Farnborough, 41mm at Odiham and 20mm at London W/C. Max hourly rates were 16 mm/hr – 20 mm/hr

- UKV had maximum rates of 8mm-16mm per hour and maximum 6hr accumulations of 16mm - 32mm

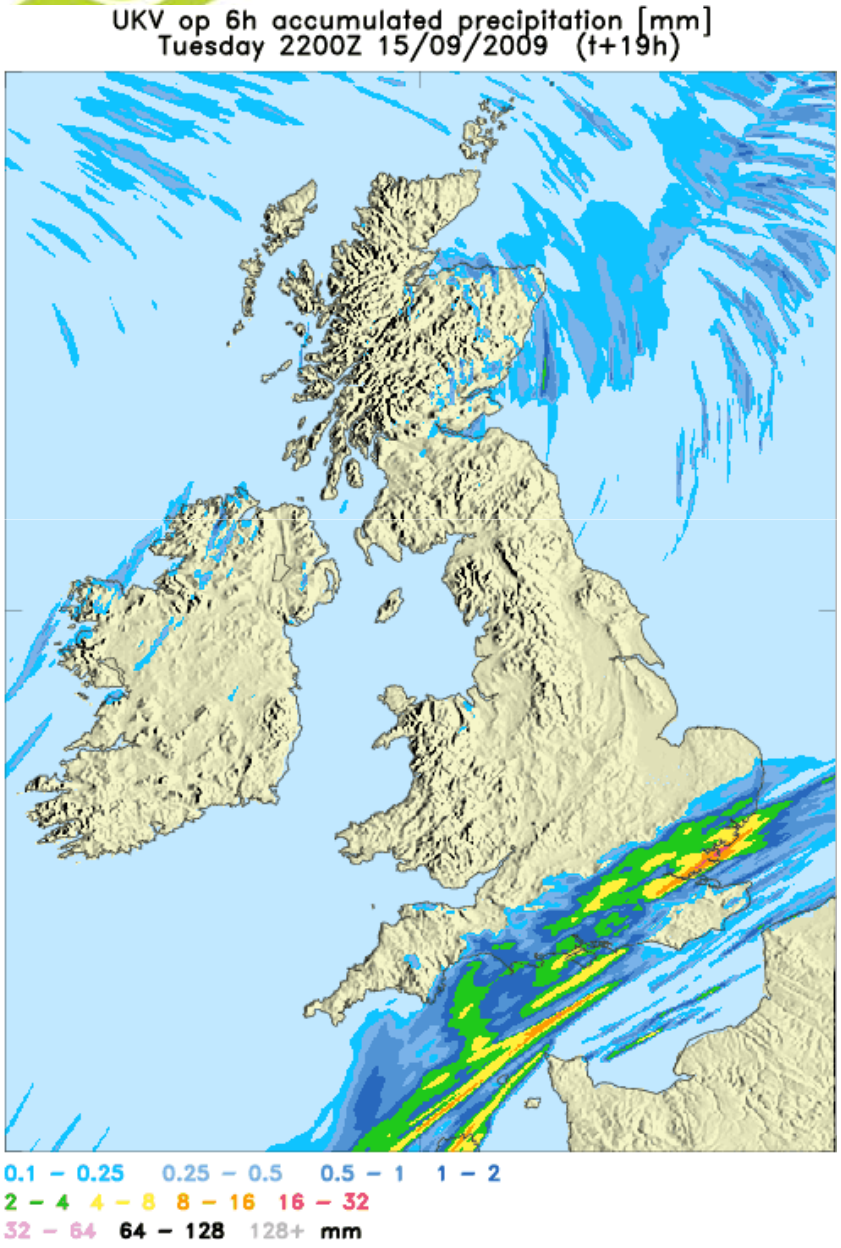
15/09/09 18Z
UK4 vs UKV (no DA) vs UKV with DA

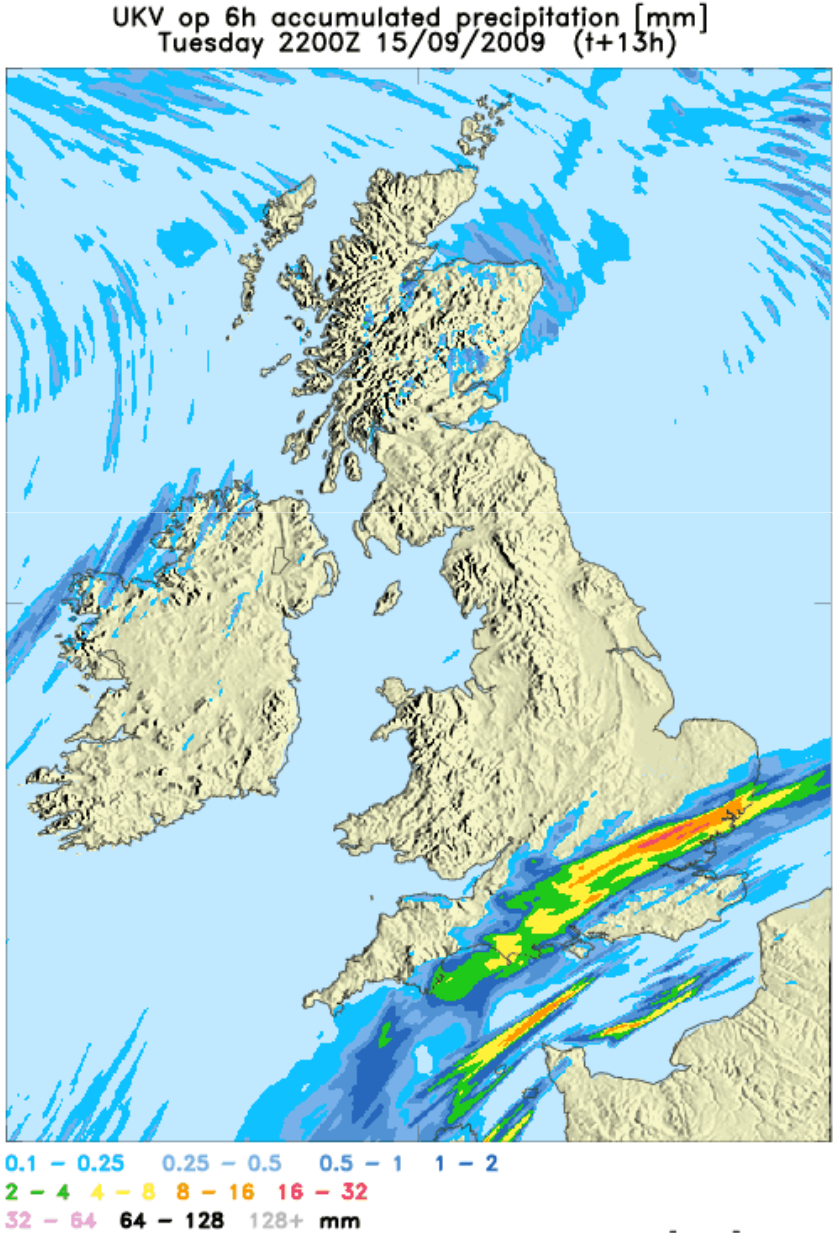






6 hourly accum from different UKV runs





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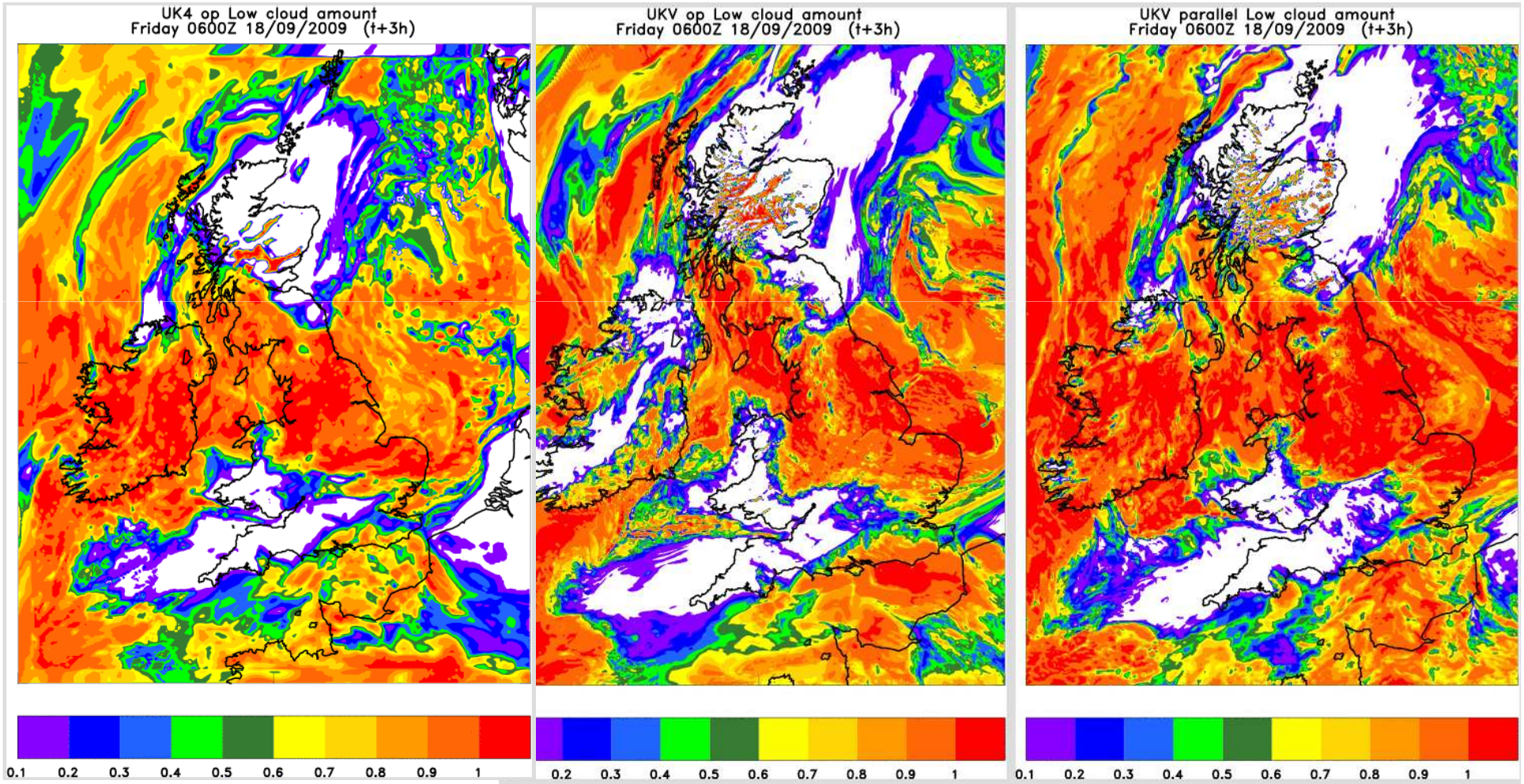
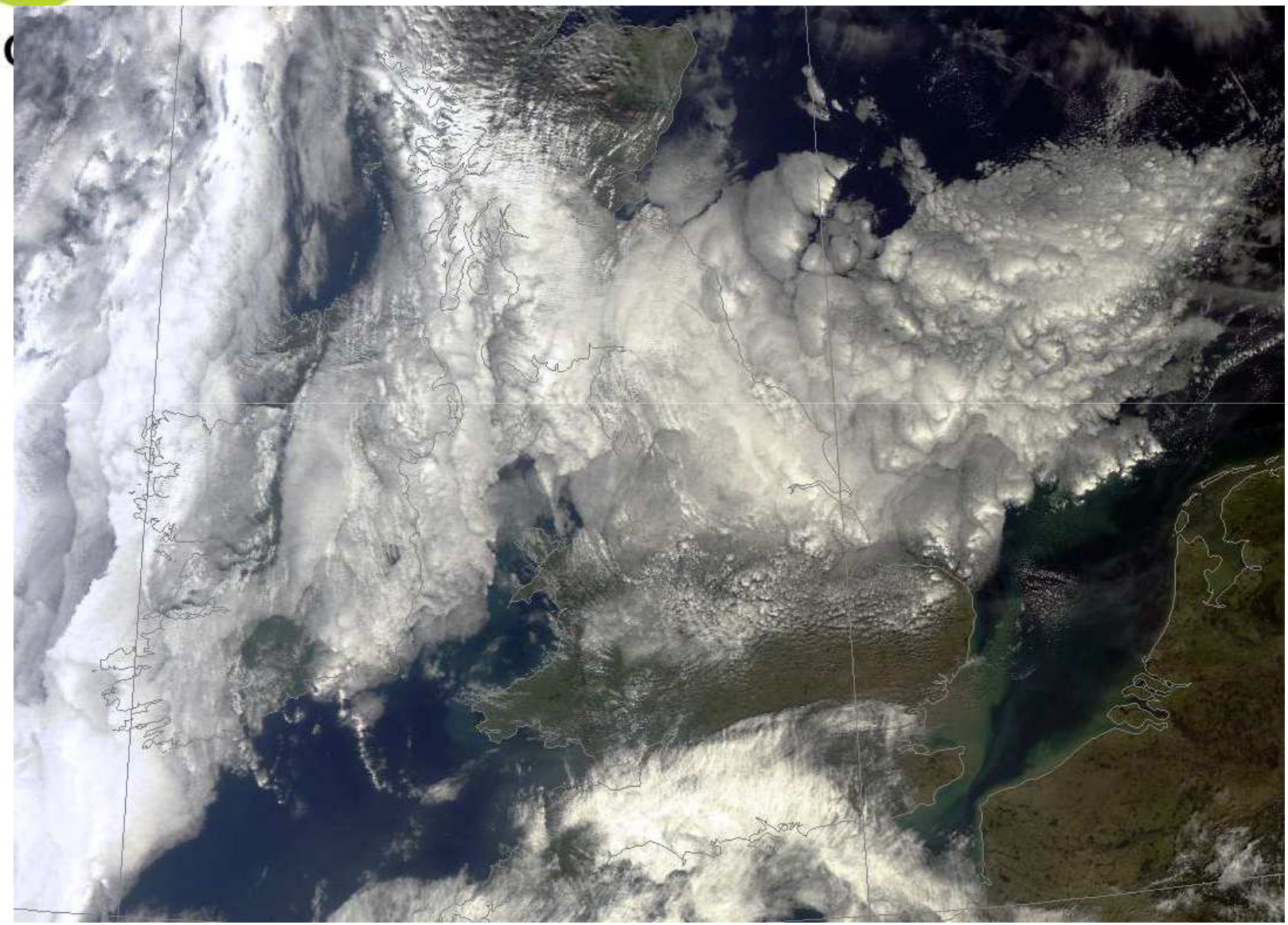
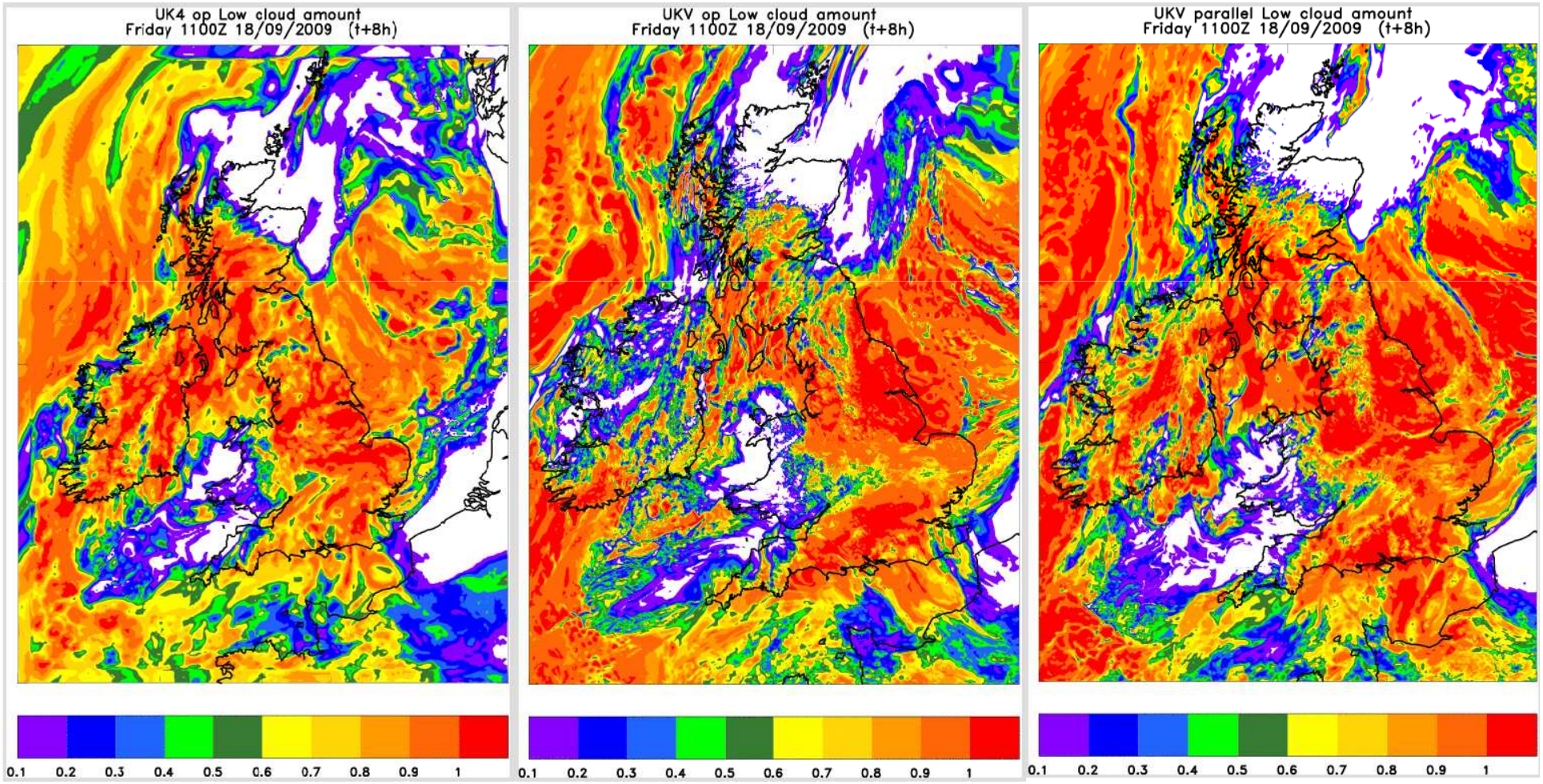
Low cloud 18/09/09 06UTC
UK4 vs UKV (no DA) vs UKV with DA



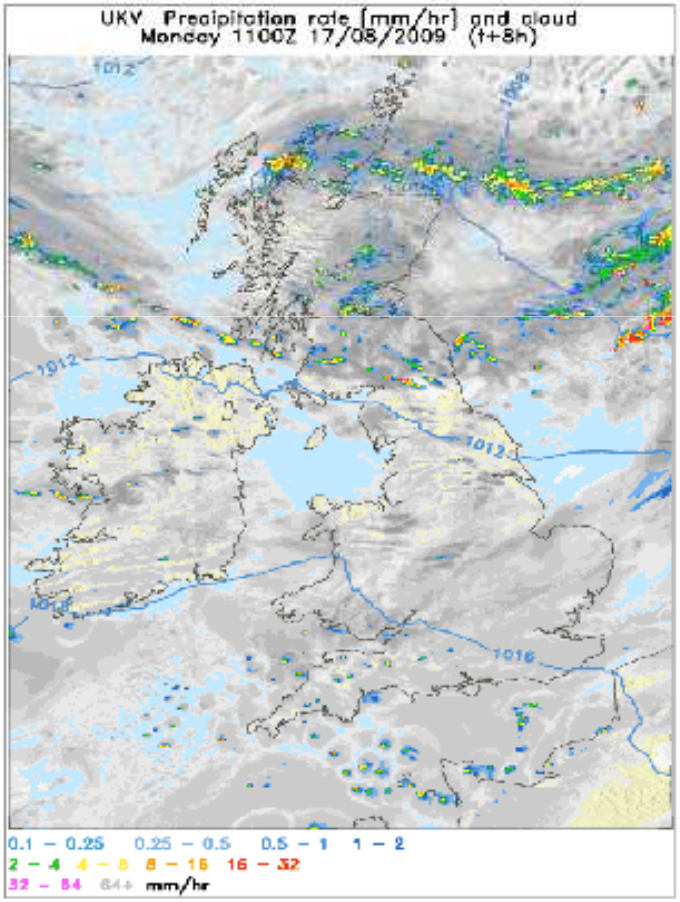
MODIS image 18/09/09 1056UTC

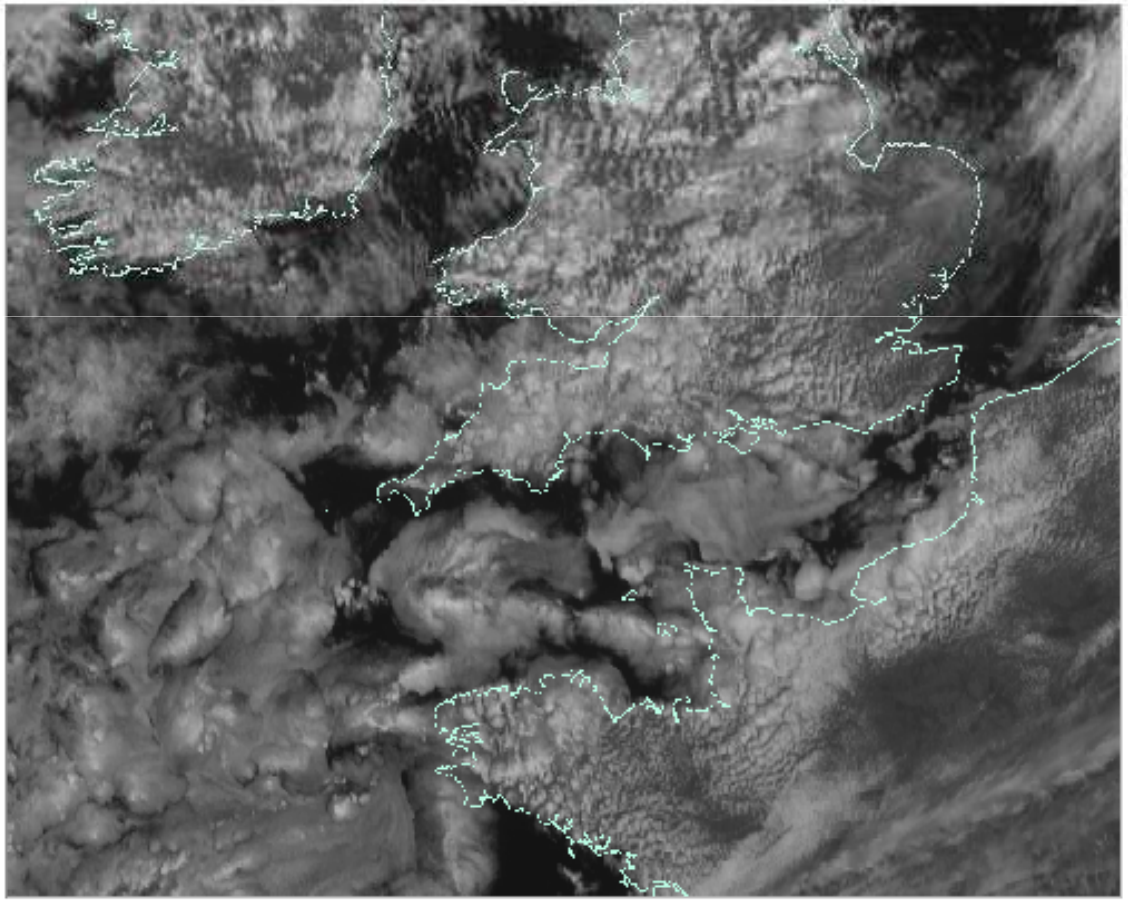


Low cloud 18/09/09 11UTC
UK4 vs UKV (no DA) vs UKV with DA



UKV cloud 17/08/09 11UTC
Mesoscale detail in UKV forecast?





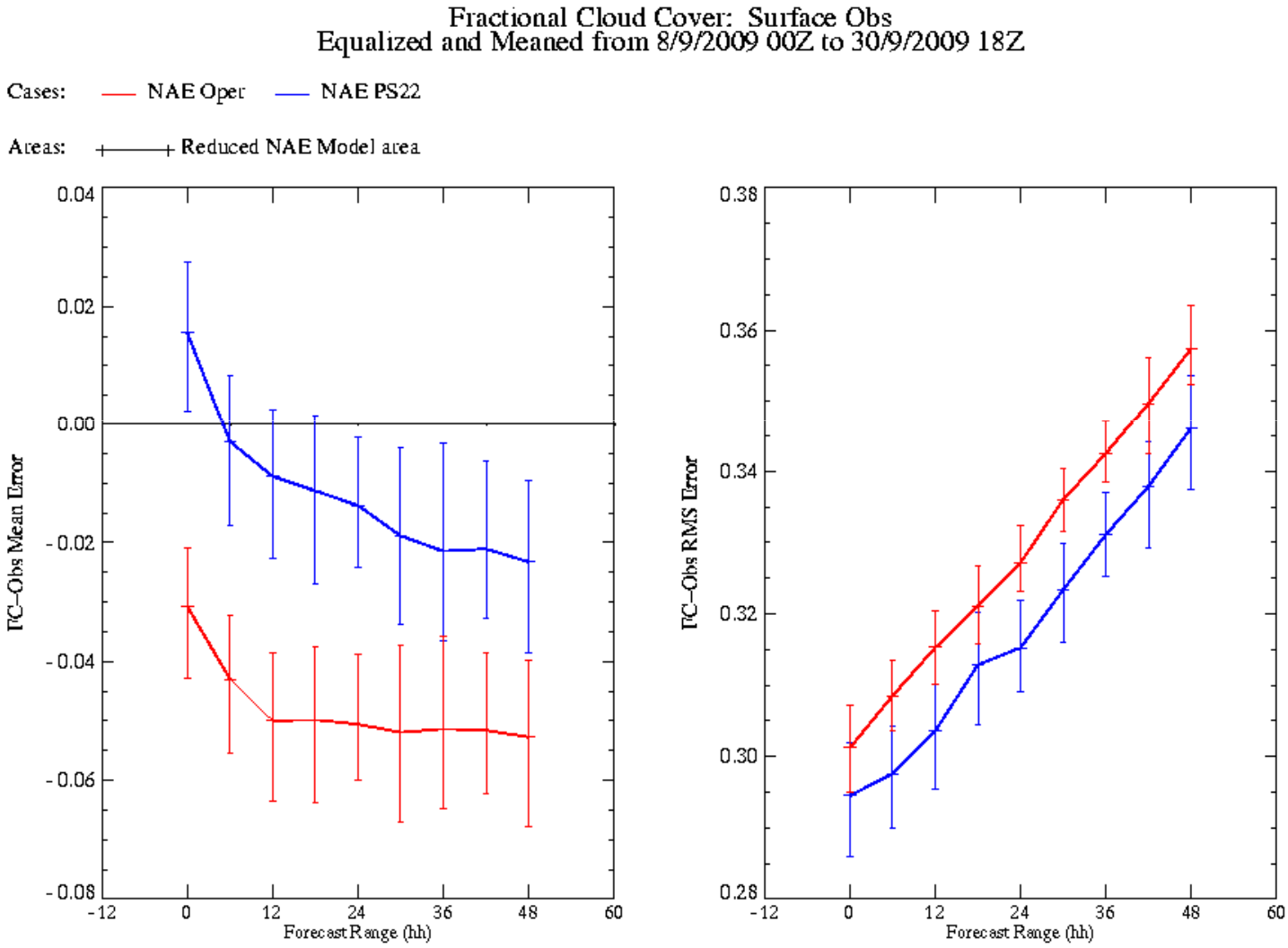
Talk Outline

- What is the UKV convective scale model good at ? and what is it not good at ?
- **L70 NAE - better cloud and inversions thanks to improved vertical resolution**

L70 compared with L38

- L70 has 21 levels in the boundary layer (bottom 3km) compared to 13 levels in L38.
- The greatest reduction in layer thicknesses of L70 versus L38 is at 10km where the resolution goes from 1km (L38) to 500m (L70).
- Lowest model level unchanged at 10m for u and v winds and 20m for theta
- L70 lid at 80km compared to 40km for L38.

Cloud cover verification from Parallel Suite



90% error bars calculated using Monte Carlo method

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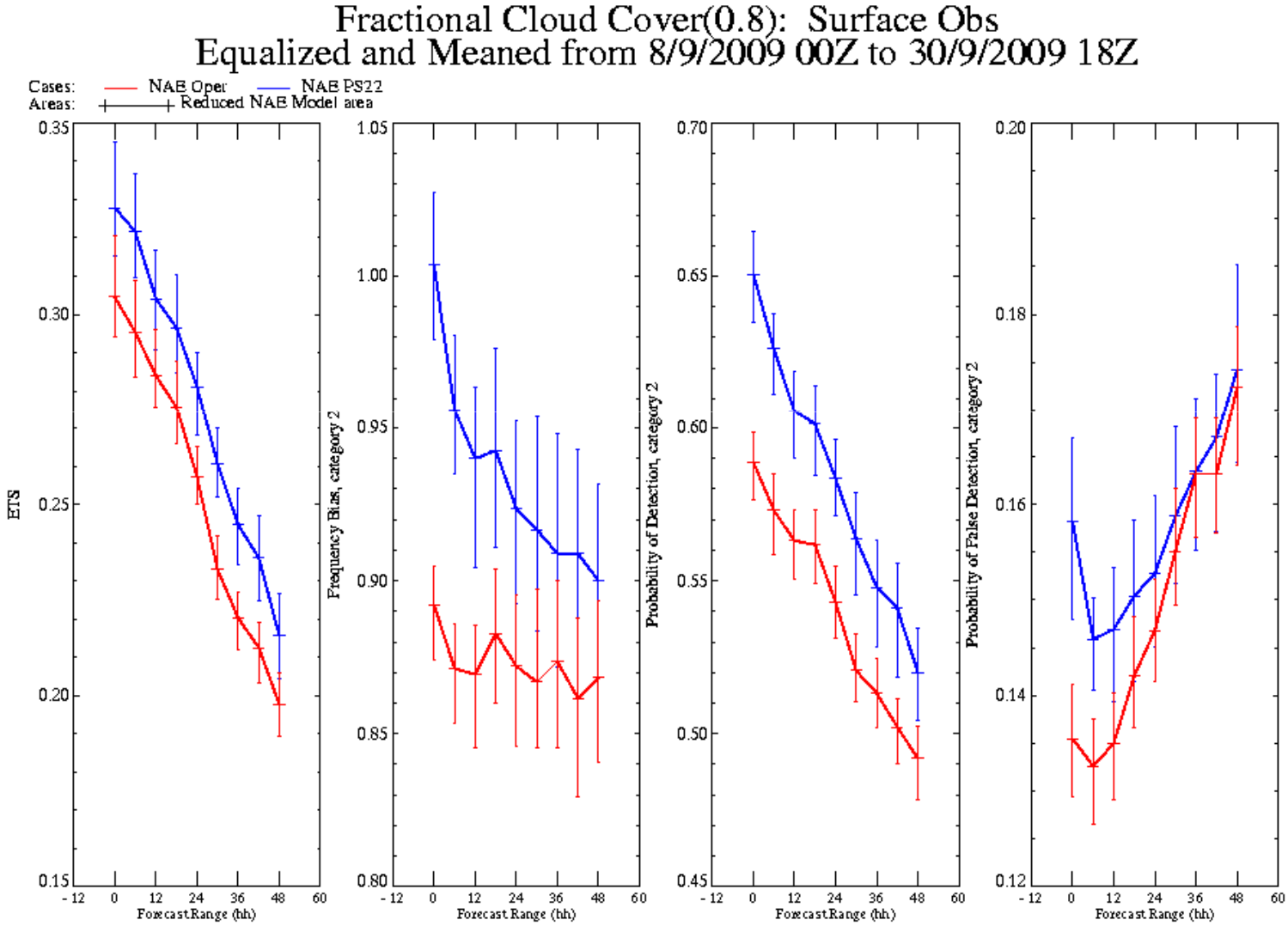
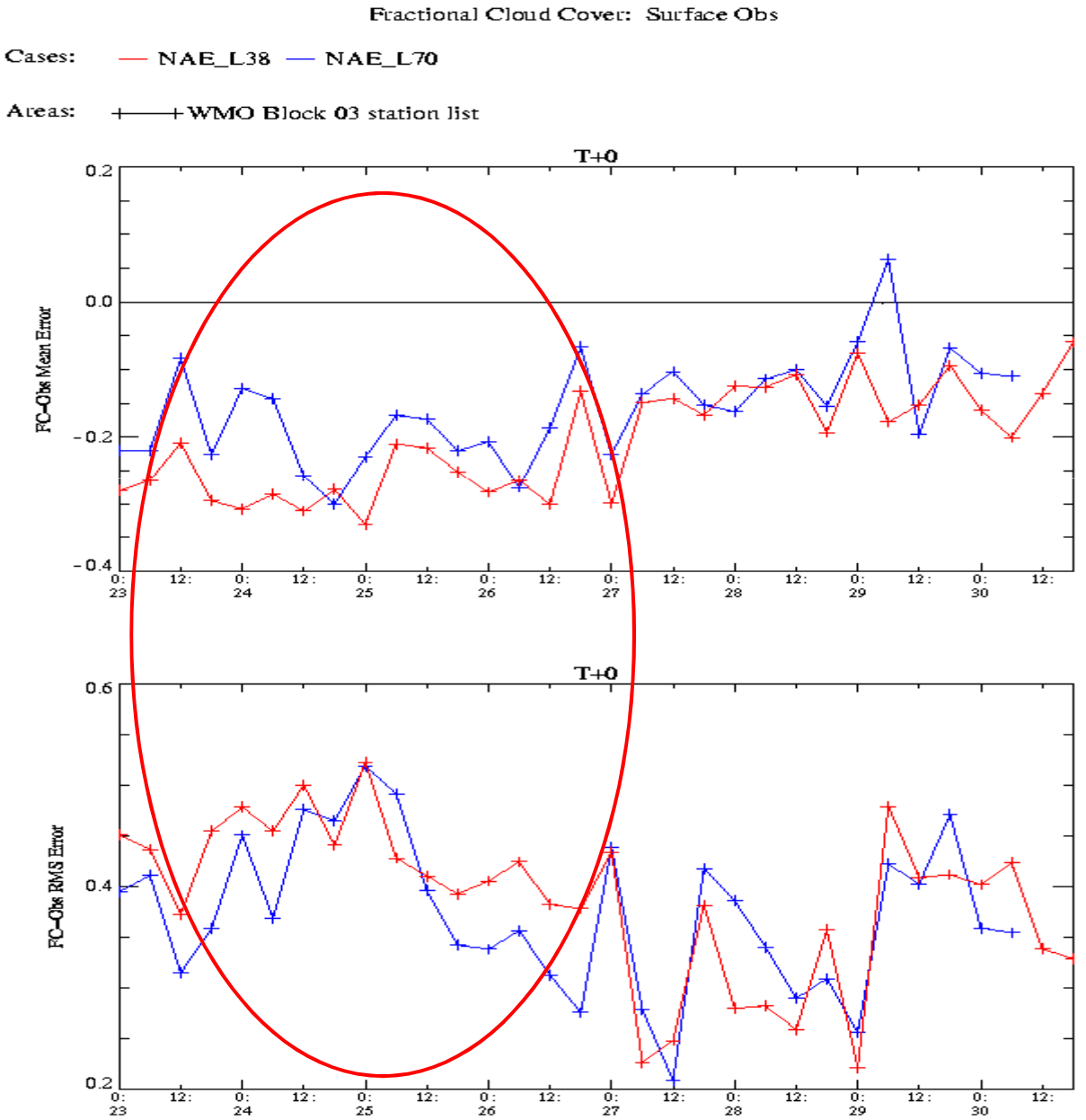


90% error bars calculated using Monte Carlo method

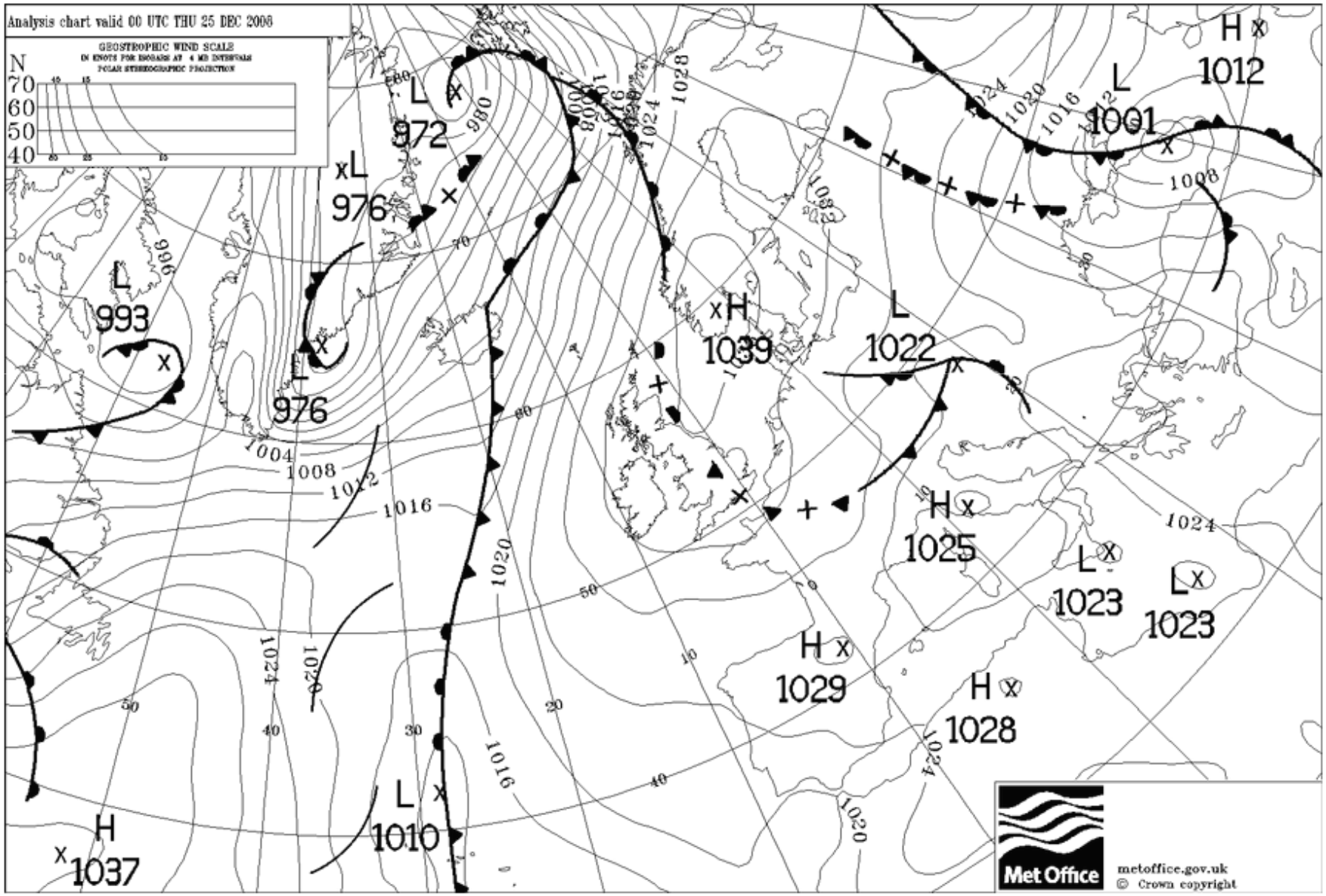
Cloud cover at T+0



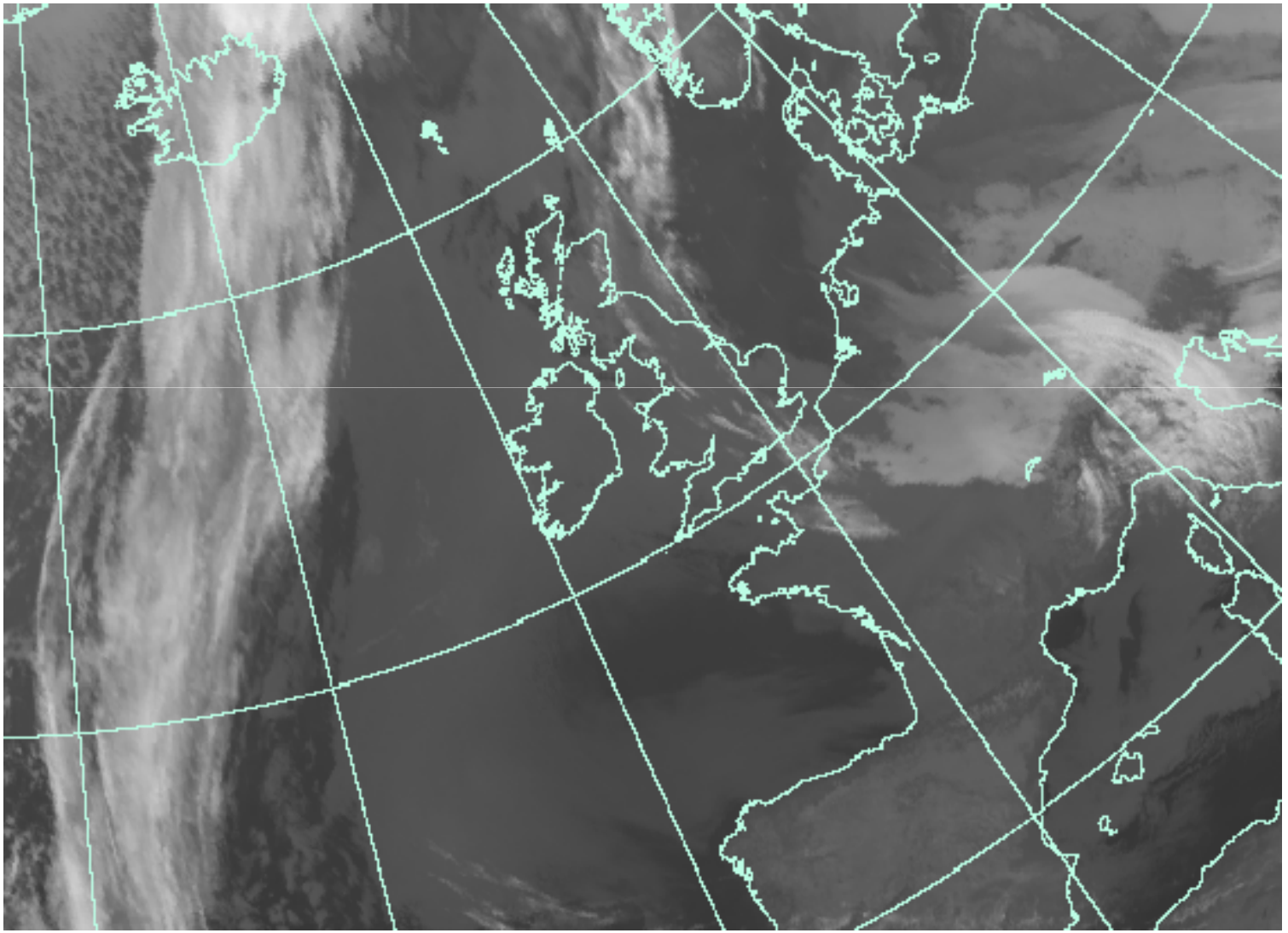
Model Assessment and emphasis

- NAE low cloud in initial conditions is even worse than background, with most of the British Isles cloud free (Eddy Carroll, 24/12/08).
- Fields modified again to increase cloud cover in a major way (Eddy Carroll, 25/12/08).
- 06Z NAE continues to struggle with low cloud assimilation across parts of the UK (Andy Page, 26/12/08).

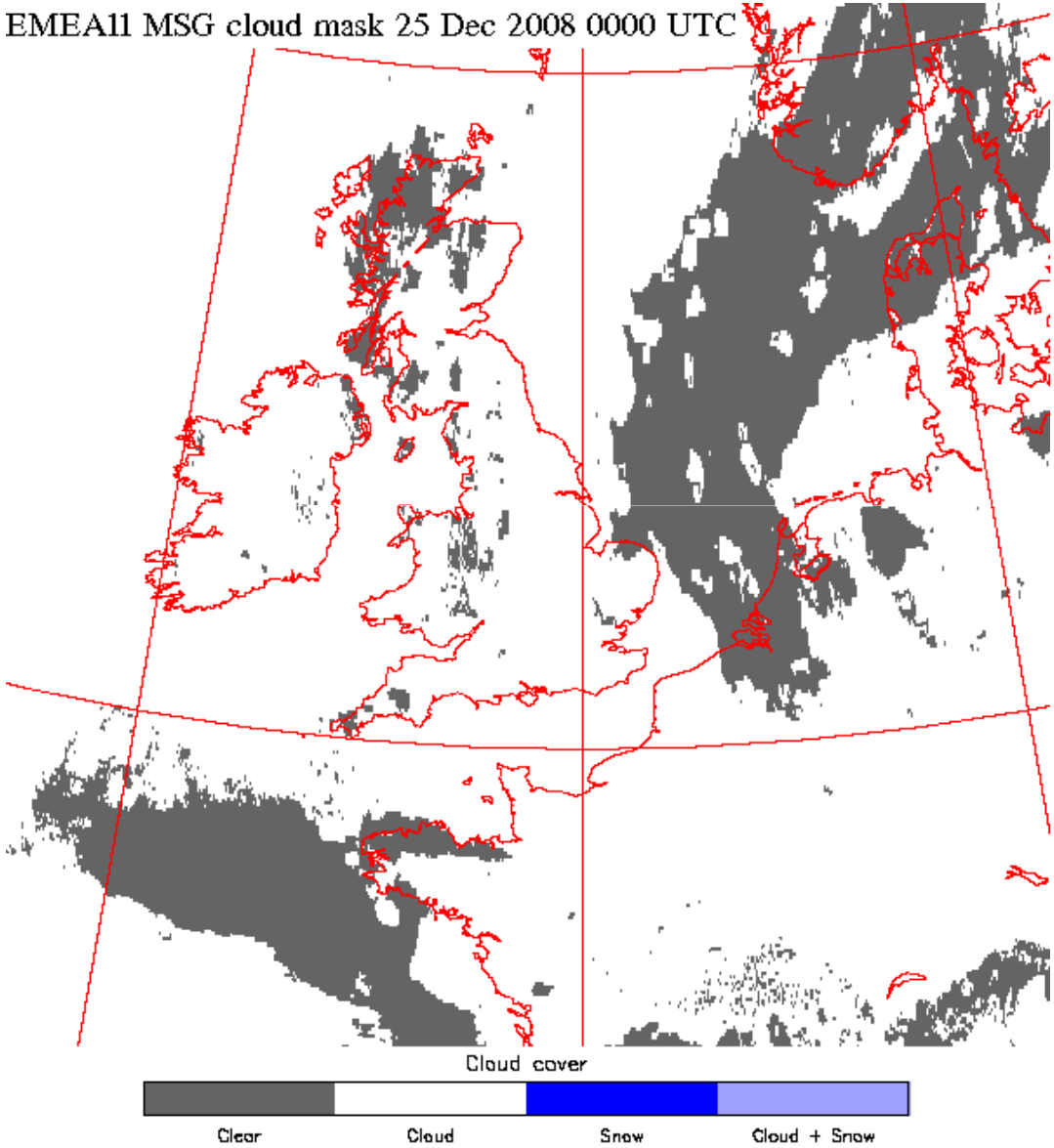
ASXX 00Z 25/12/08



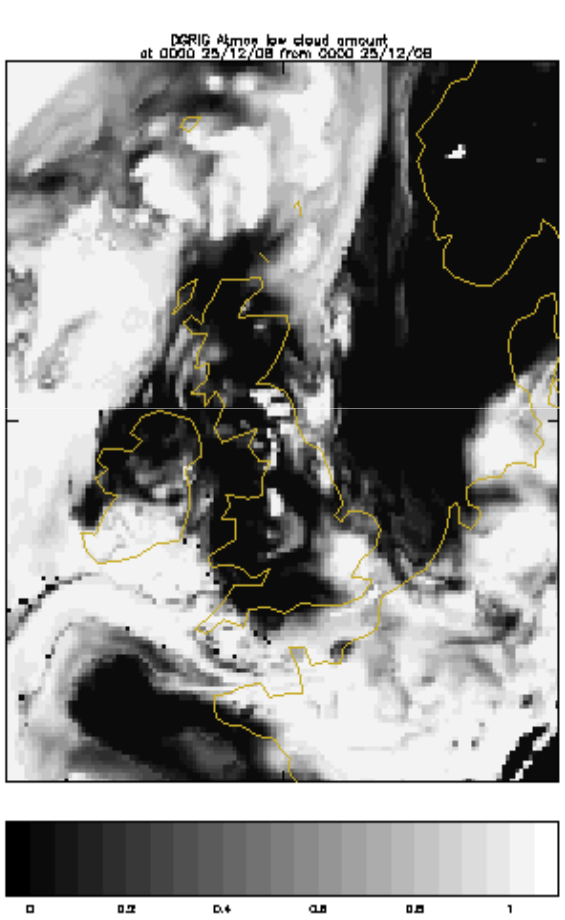
IR satellite image 00Z 25/12/08

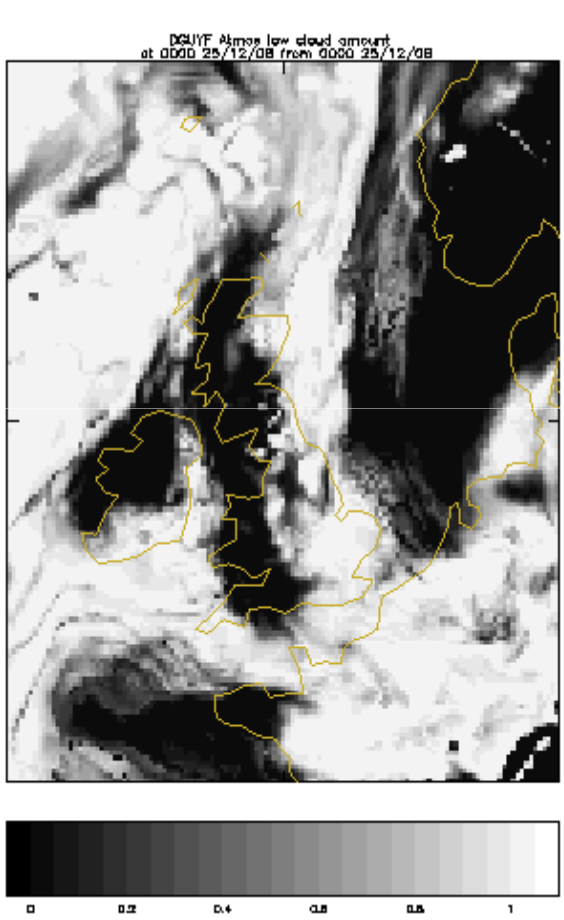


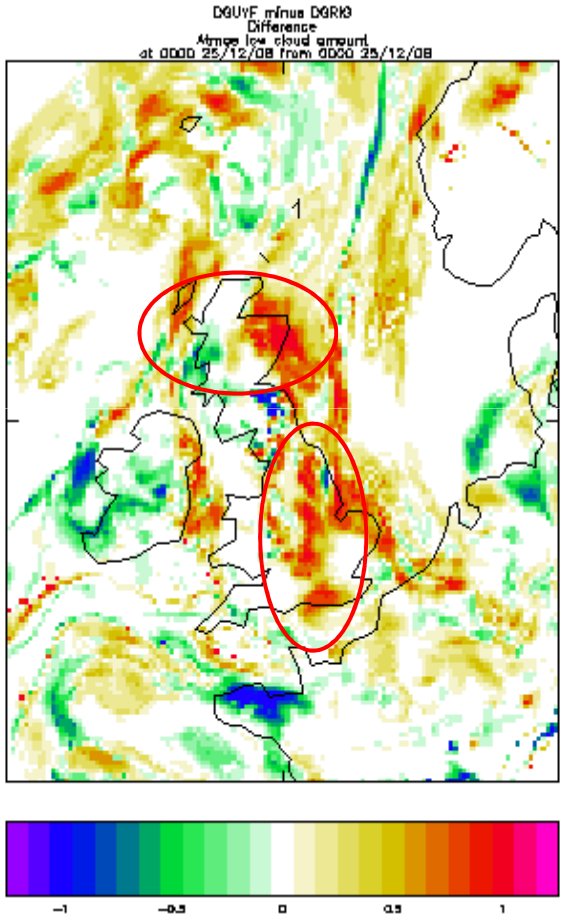
Derived cloud mask 00Z 25/12/08



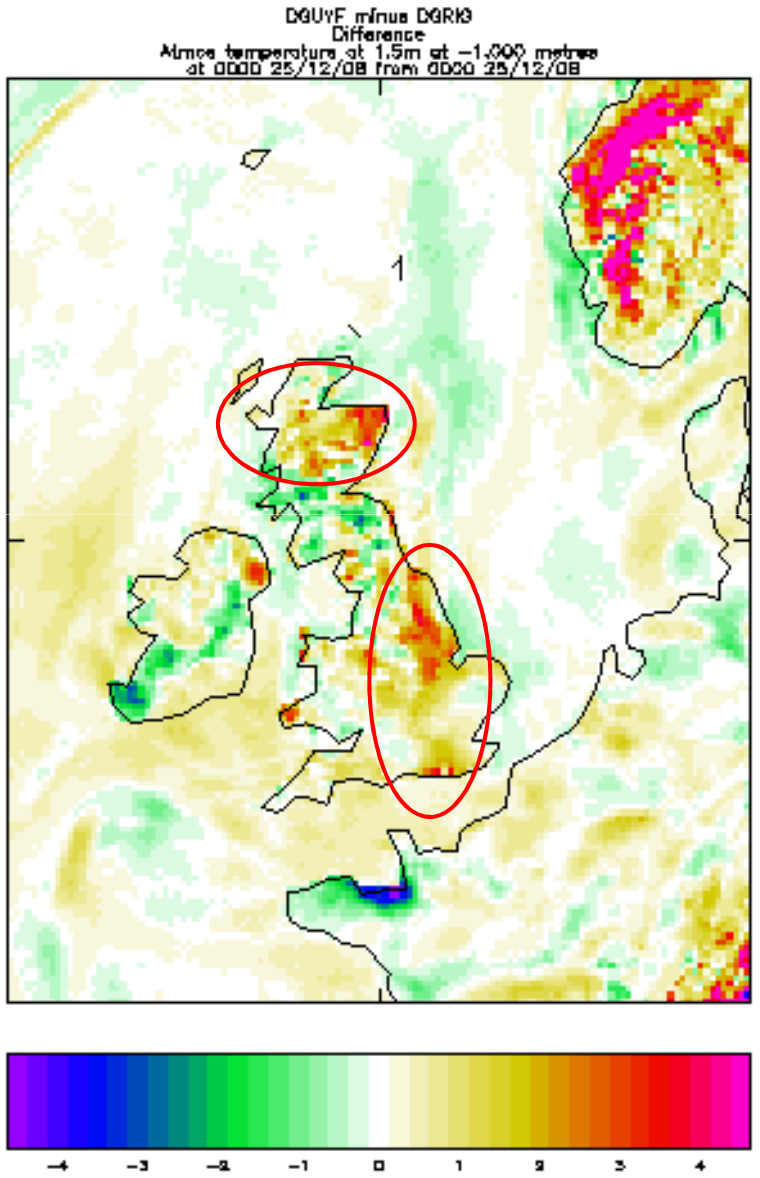
Low cloud L38, L70 and T+0 diff 00Z 25/12/08



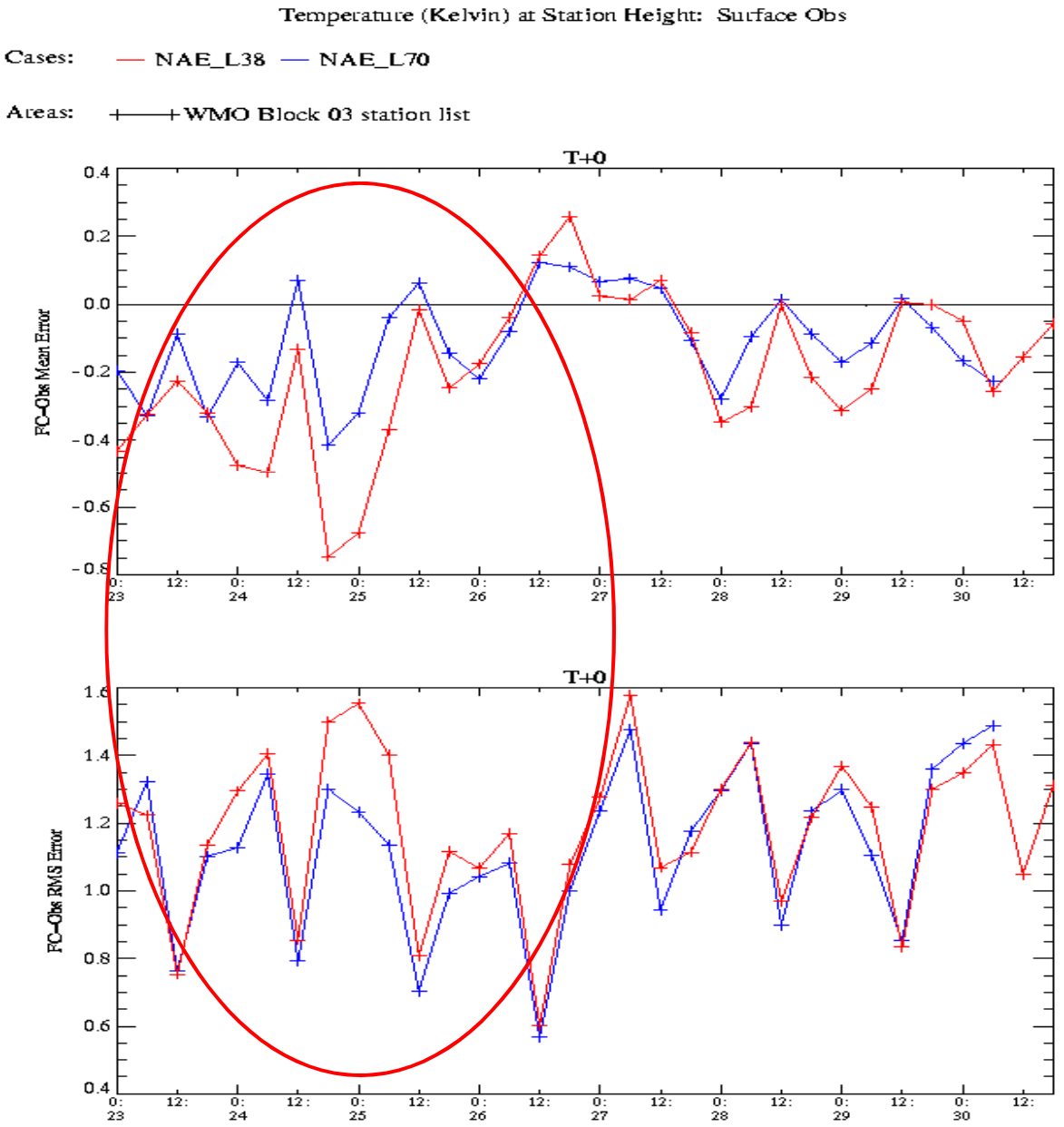




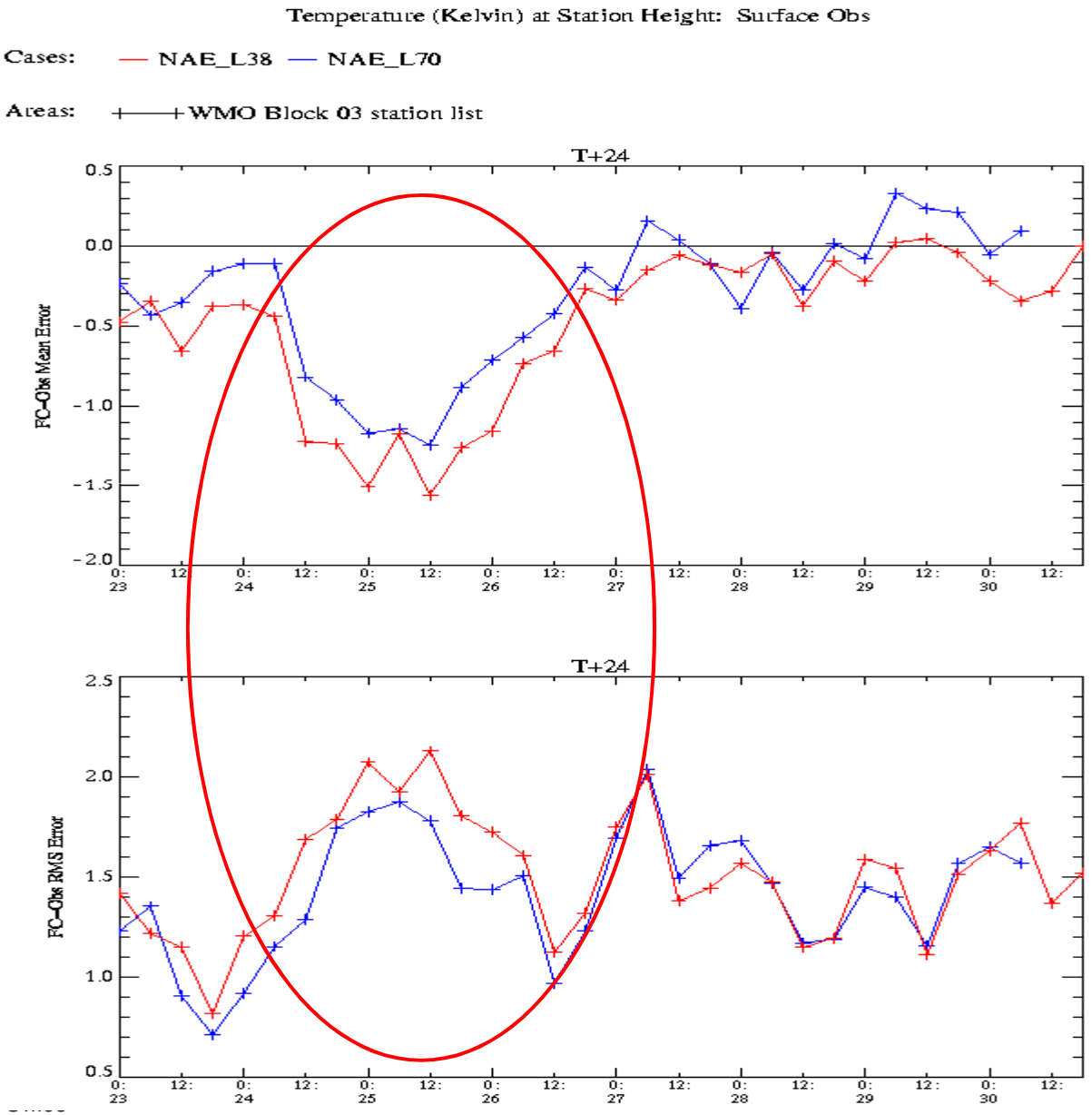
L70 – L38 T15 difference at T+00



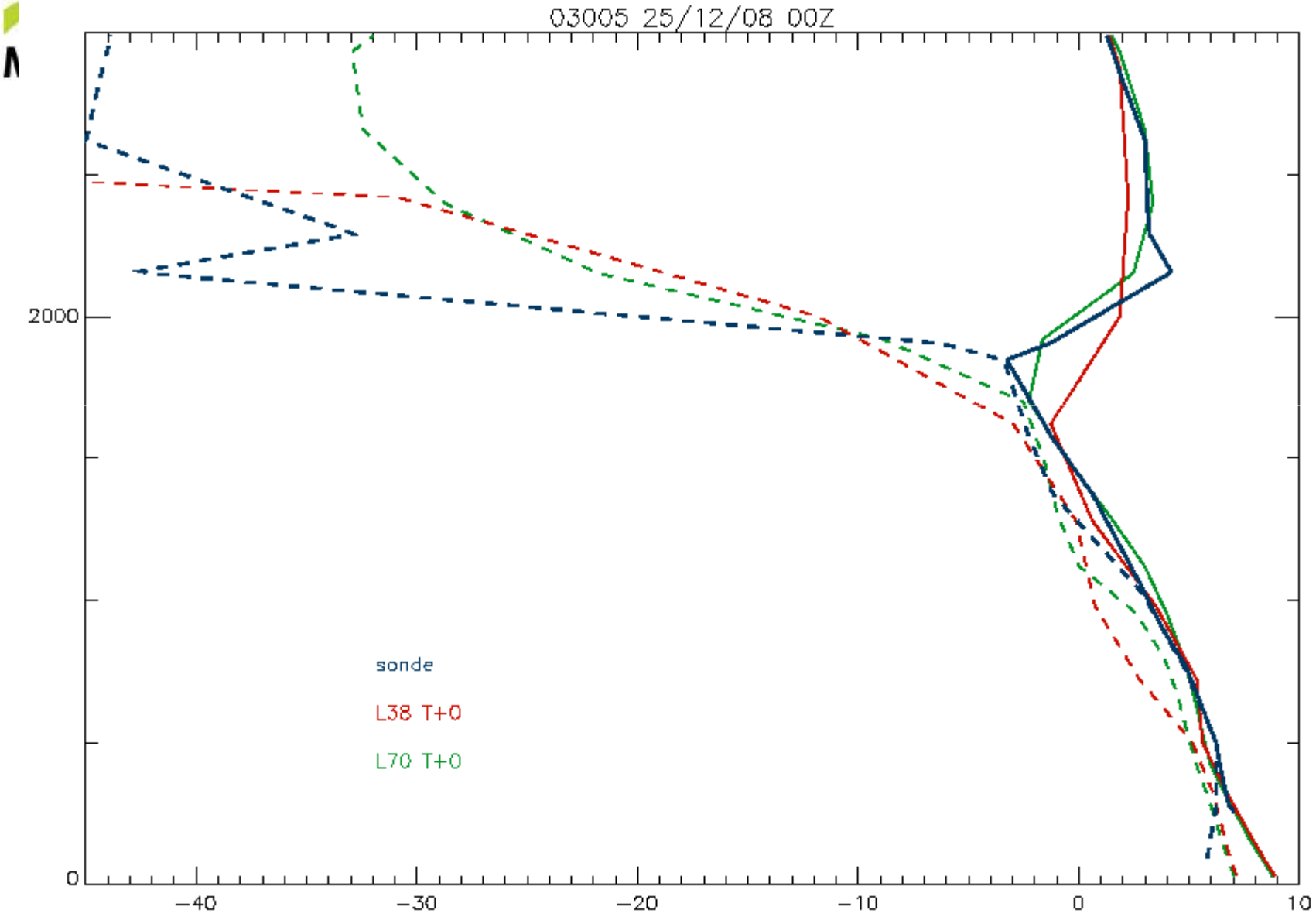
Screen Temperature at T+0



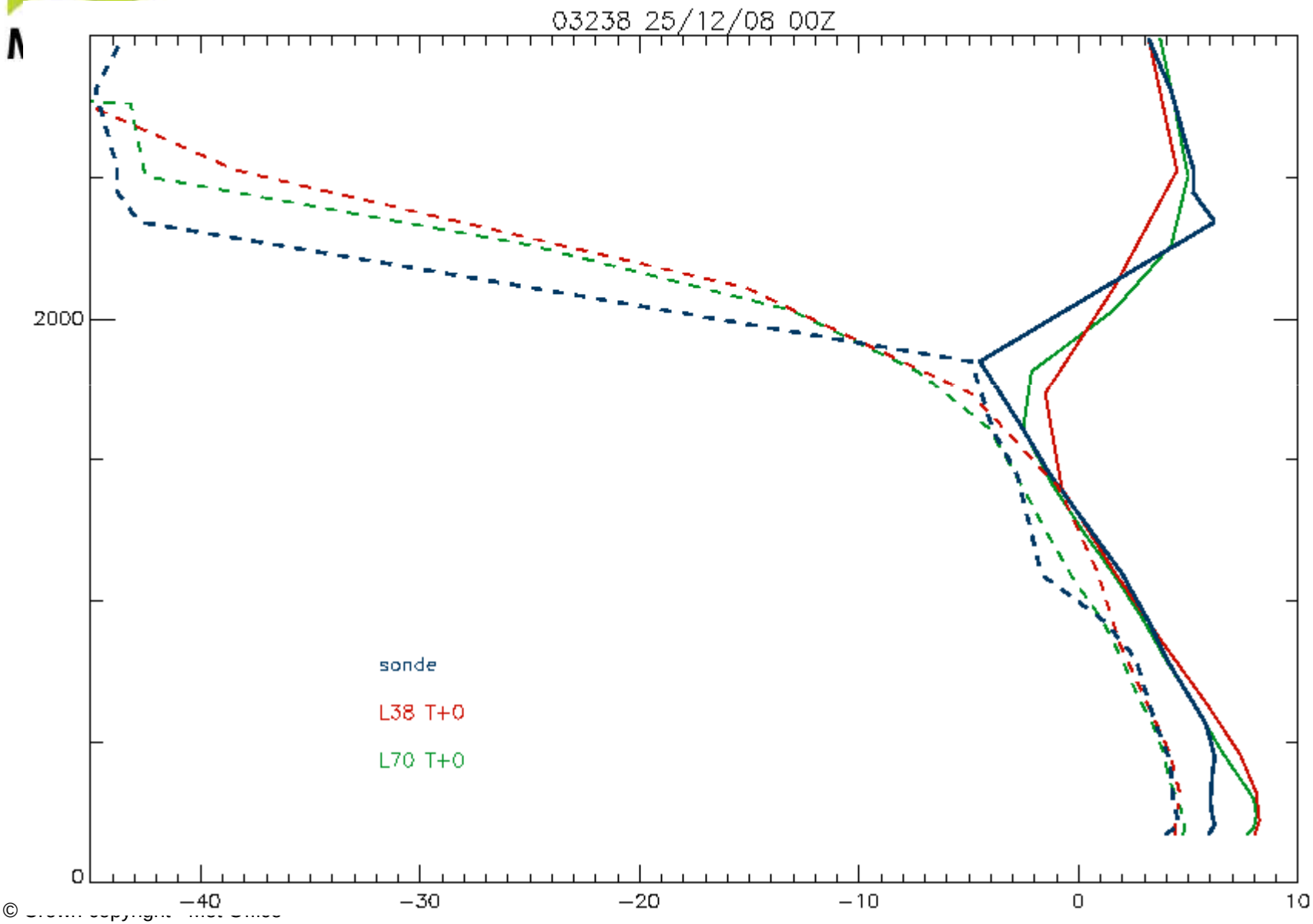
Screen Temperature at T+24



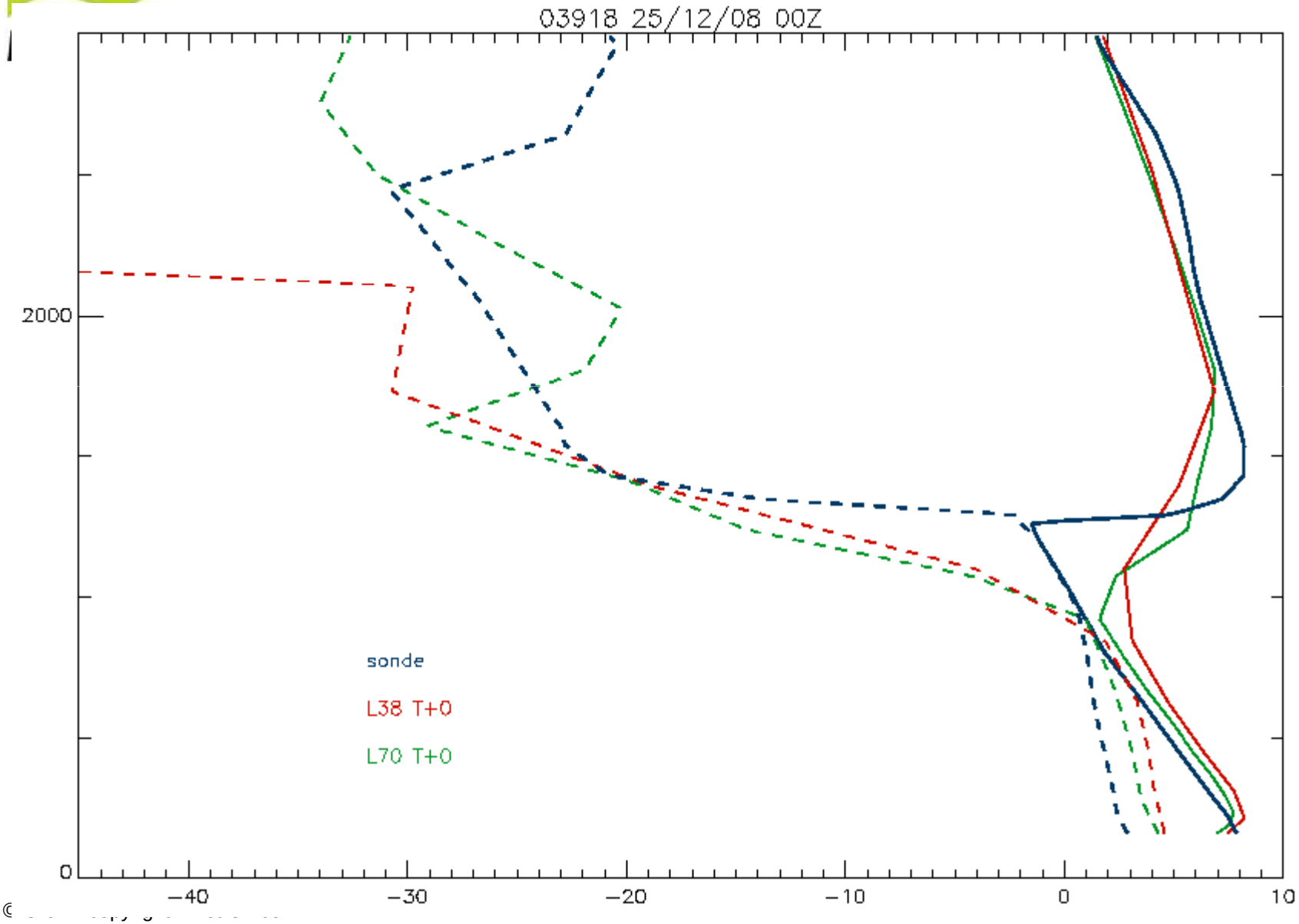
Lerwick (Shetland) 00Z 25/12/08



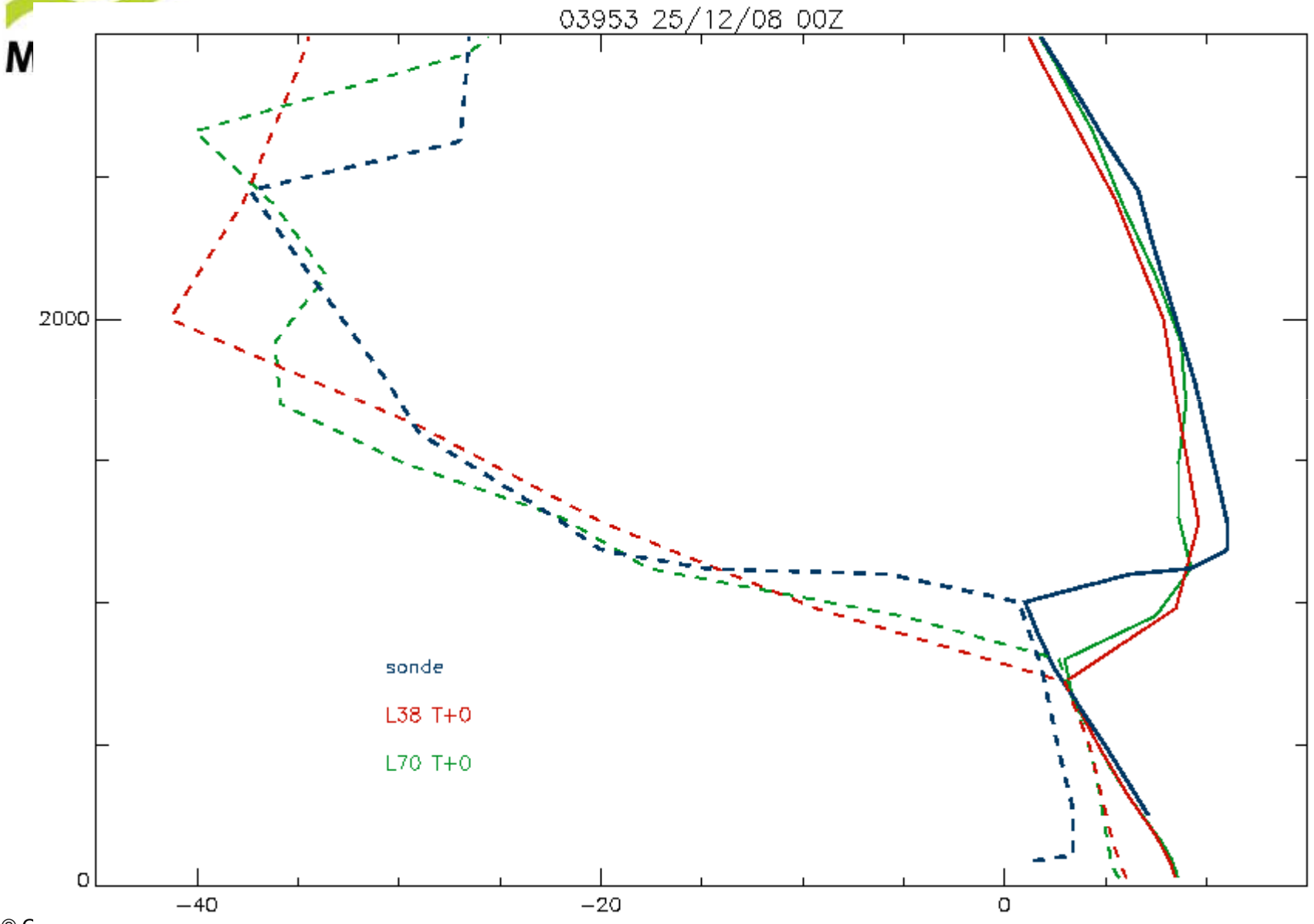
Albemarle (NE England) 00Z 25/12/08



Castor Bay (N Ireland) 00Z 25/12/08



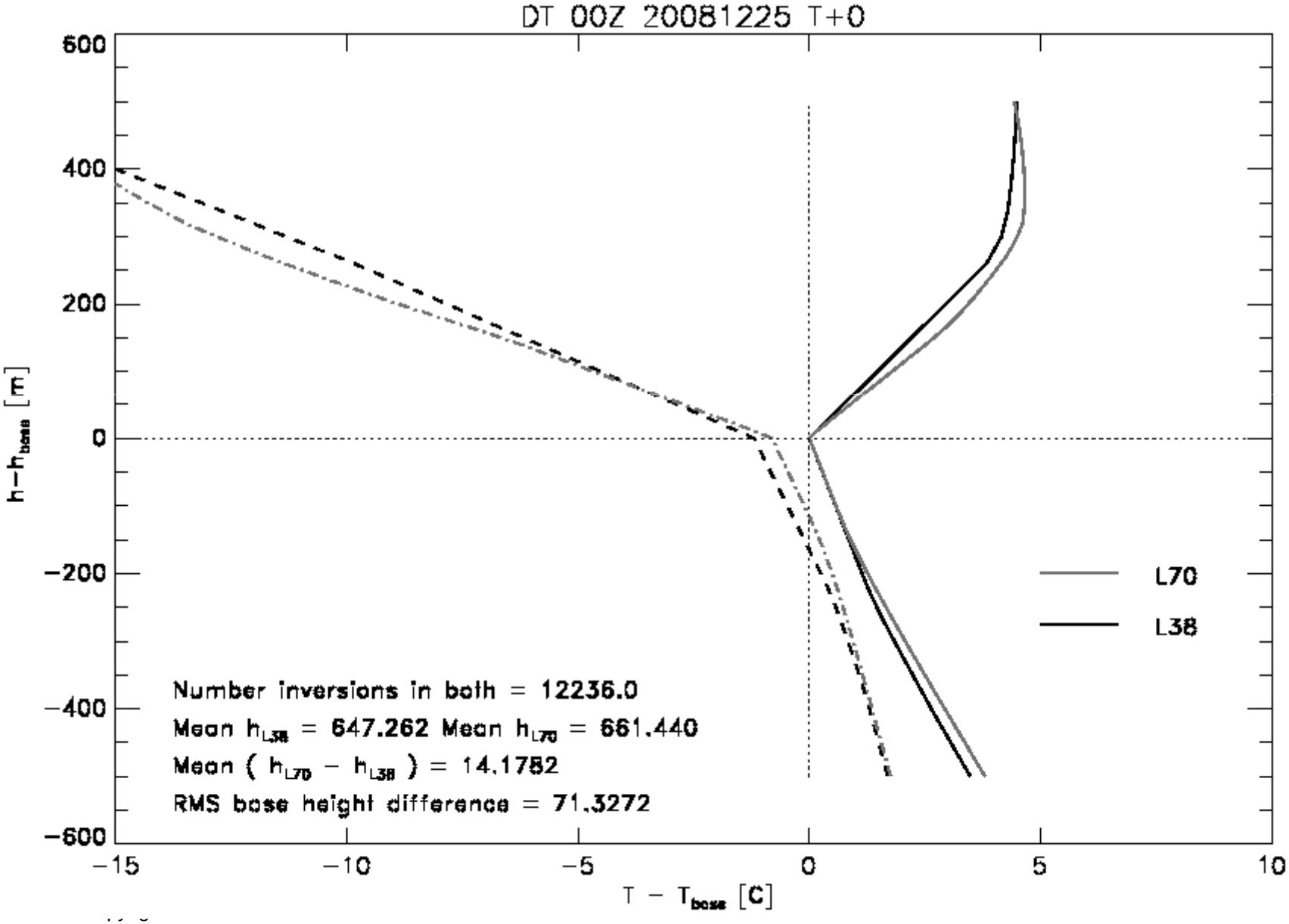
Valentia (Rep Ireland) 00Z 25/12/08



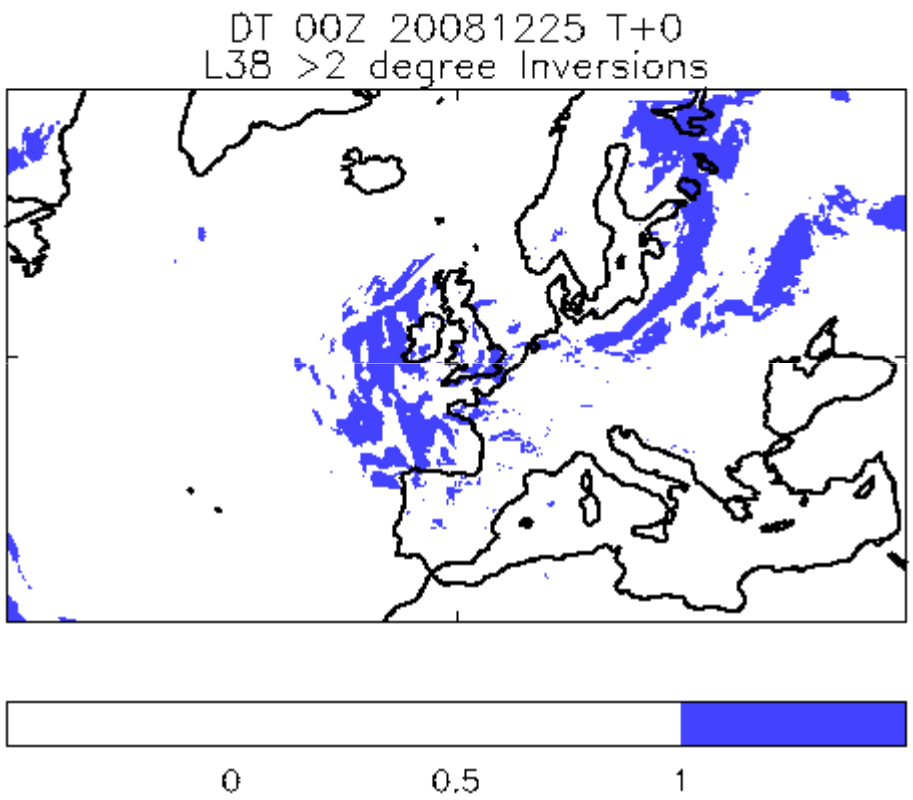
Model inversion comparison algorithm (Peter Lean)

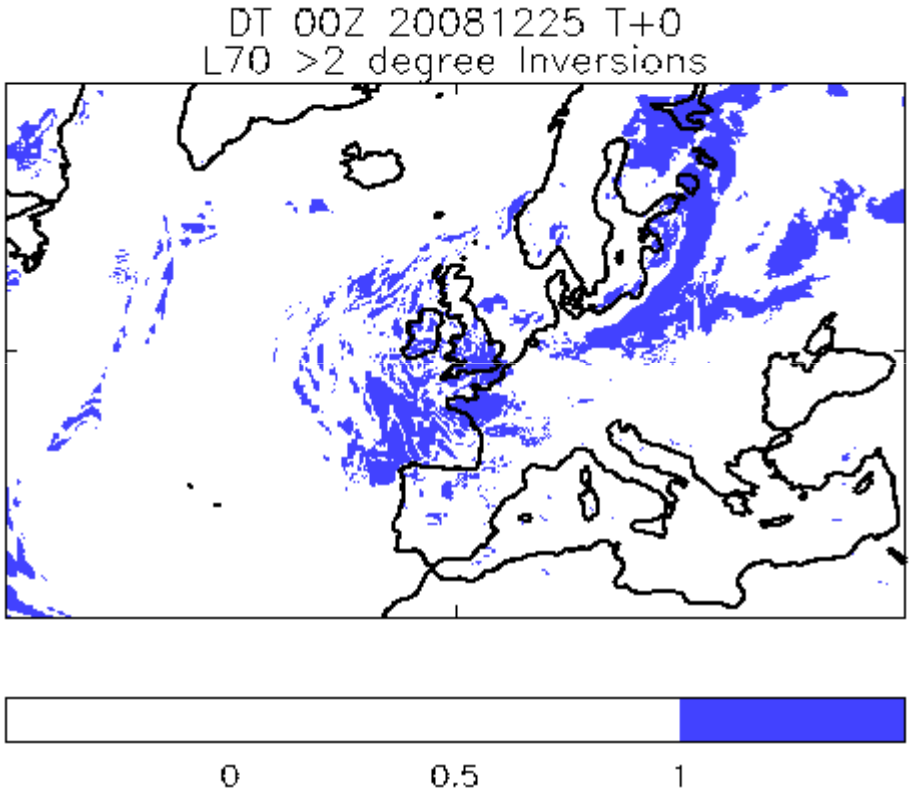
- L38 and L70 model level data are read in
- Data regridded to a common fine scale (10m) vertical grid
- Diagnoses columns where an inversion is present
- An inversion is defined as being a 2 degree temperature rise within 200m of base and between 470m and 3000m
- If an inversion is present in both runs, then the inversions in both L38 and L70 are averaged relative to the diagnosed inversion base
- This removes the smoothing that occurs if inversions at many different locations (and therefore with different heights) are just simply averaged

Averaged model profiles 00Z 25/12/08



Model inversions >2 degrees
00Z 25/12/08

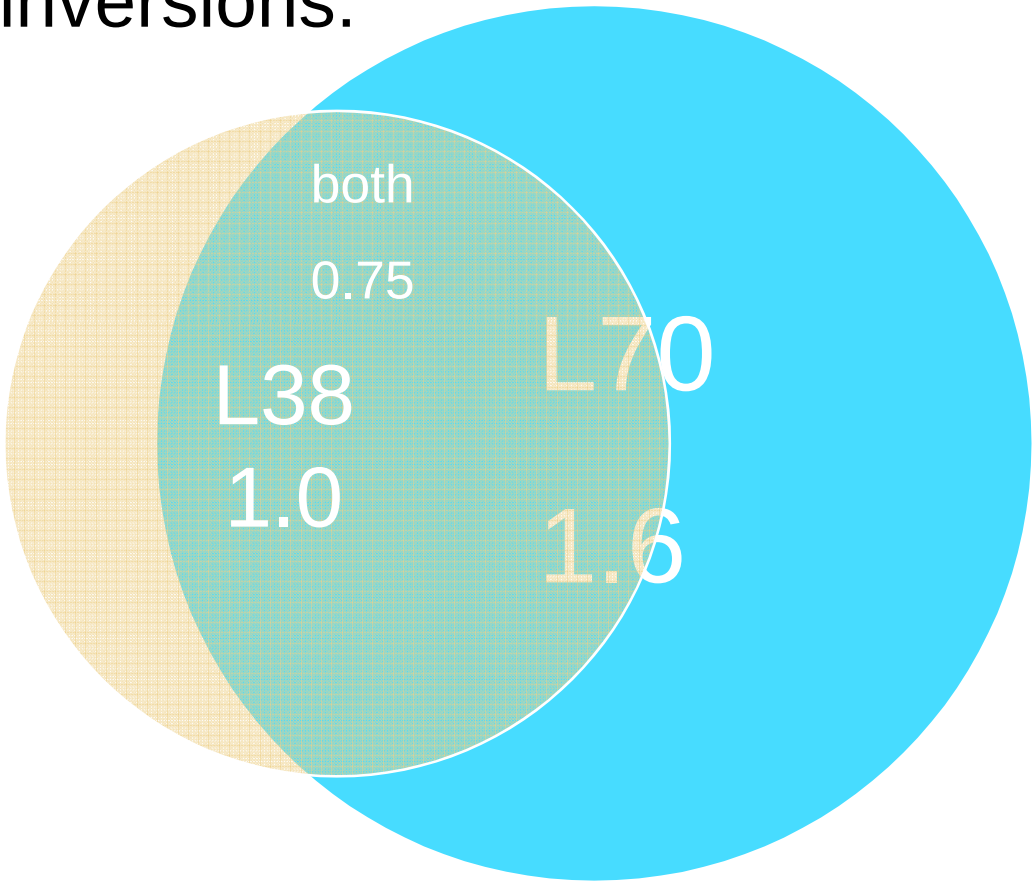




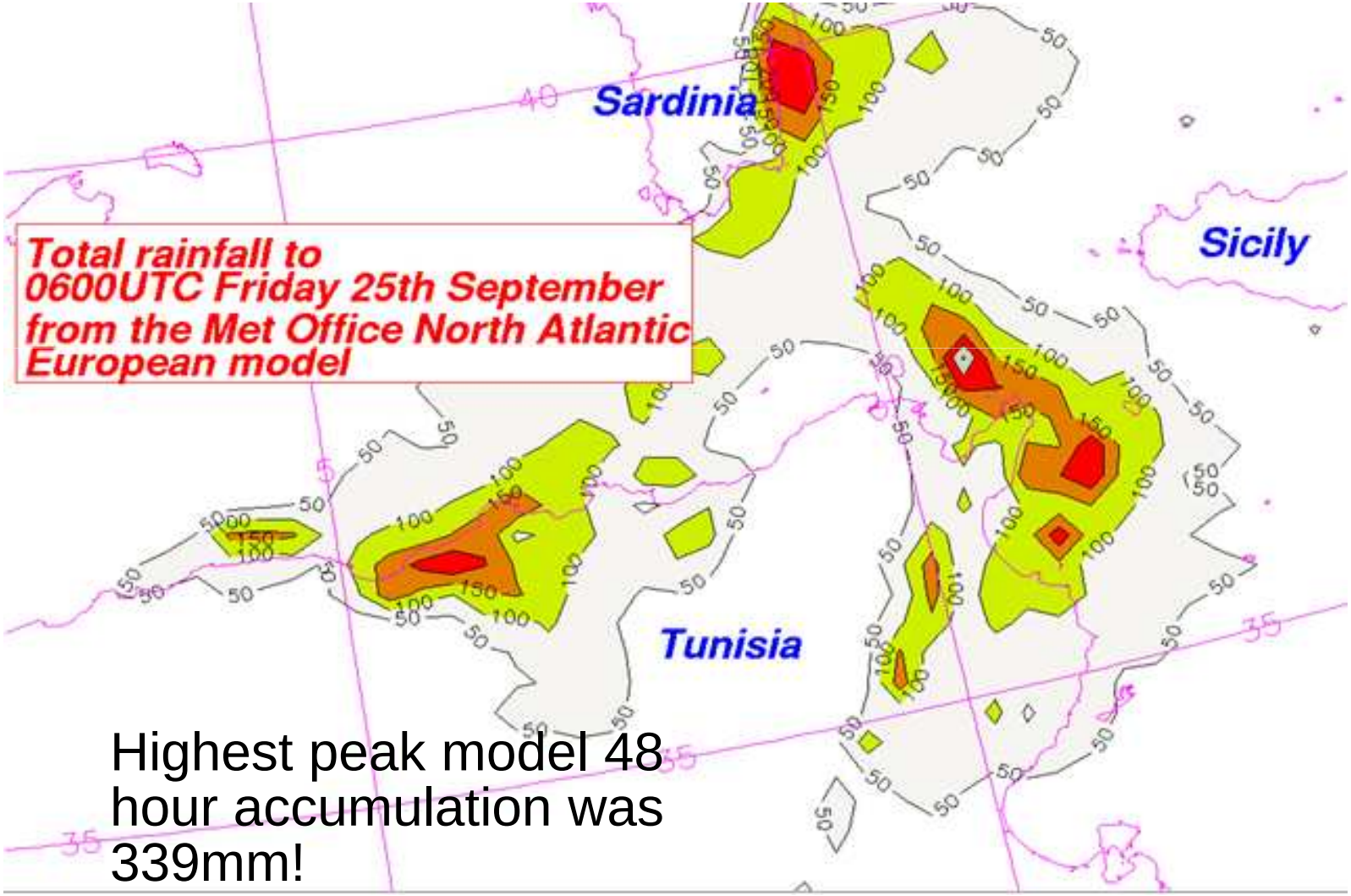
NAE L70 v L38 forecast-only cases

Area covered by inversions:

- More inversions in L70

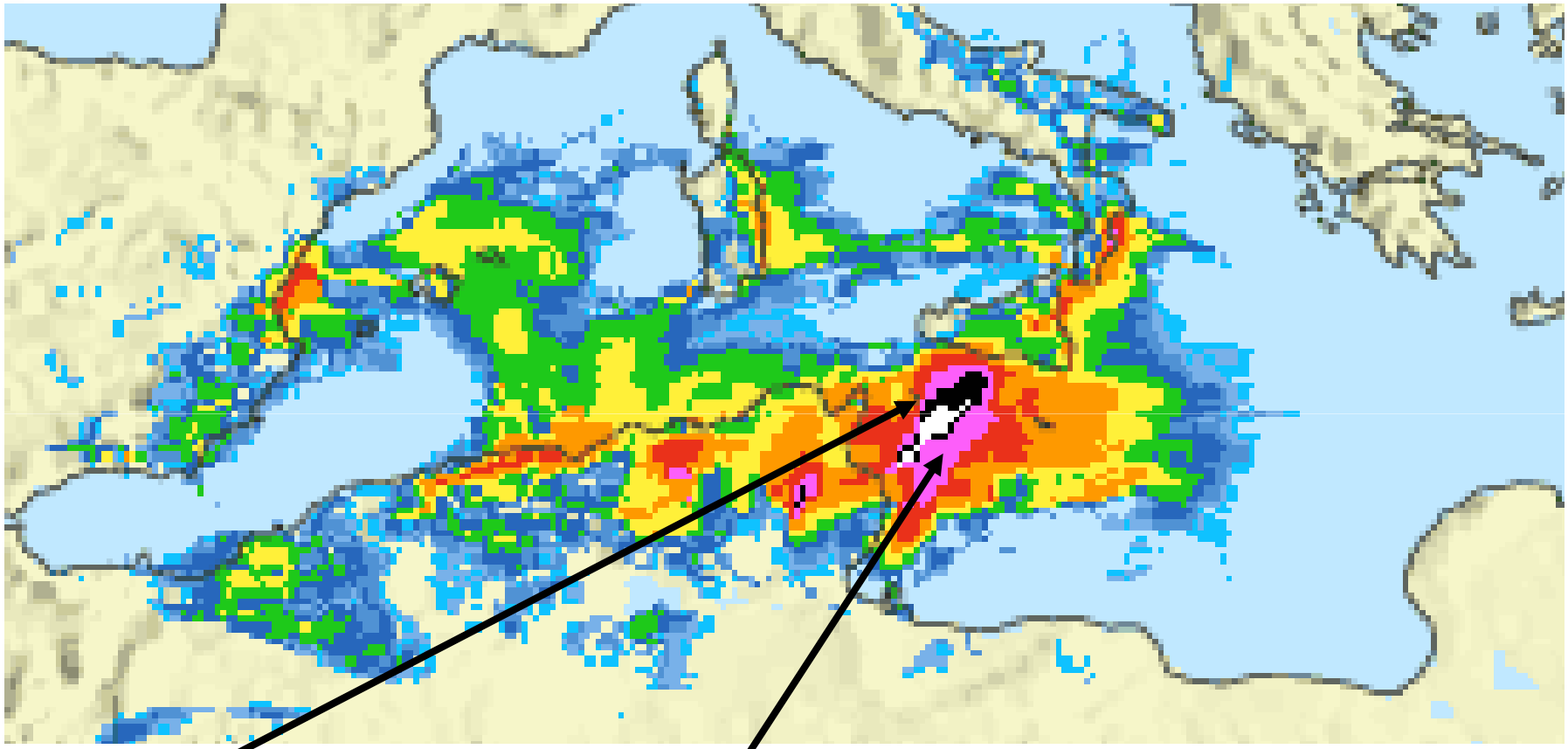


Guidance issued to Foreign and Commonwealth Office 10UTC 23/09/09



Highest peak model 48 hour accumulation was 339mm!

NAE 12 UTC run 23/09/09
6 hourly accumulation from 12UTC to 18UTC



Pantelleria 201mm
12 hours to 18UTC 23rd
Lampedusa 162mm
12 hours to 06 UTC 24th

Model ppn accumulations
Black = 64 -128mm
White = >128mm
Peak value was 206mm

Questions and answers