



Physics Presentation – Mike Bush

for 30th EWGLAM and 15th SRNWP Annual Meeting 2008
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et al.



Talk Outline

- NAE Physics
- UK1.5 km results



Talk Outline

- **NAE Physics**
- UK1.5 km results

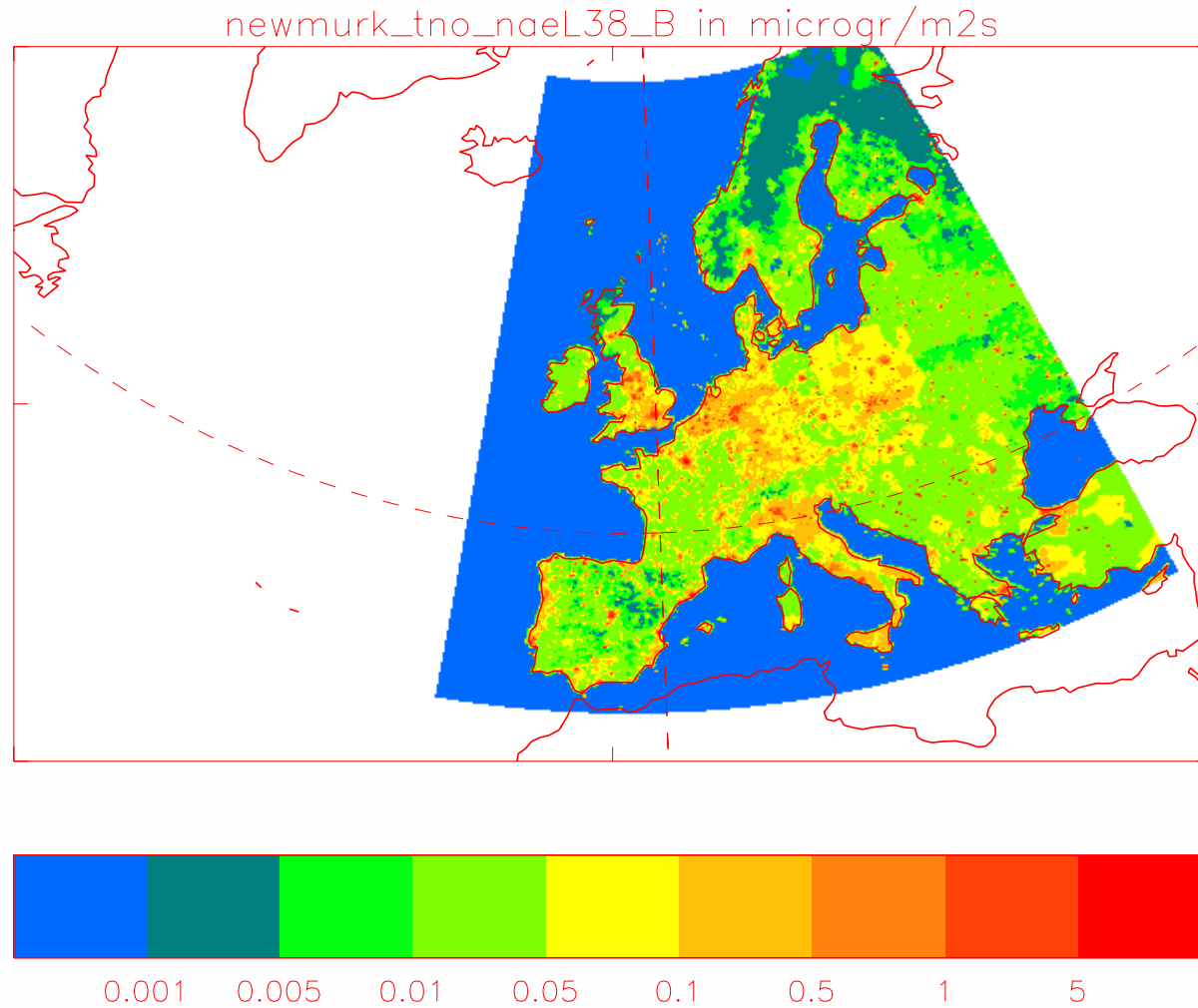


Creating a new murk aerosol source dataset

- GEMS-TNO emissions. These are in a latitude, longitude format with a resolution of $0.125^\circ \times 0.0625^\circ$ (approx $5 \text{ km} \times 5 \text{ km}$). They cover the GEMS domain (15° W to 35° W and 15° N to 70° N) but not all of the NAE domain.
- Emep 2005, in a resolution of $50 \text{ km} \times 50 \text{ km}$, covering almost all of the NAE domain. Emissions from shipping are included here.
- A nominal value of sea salt = $0.007 \text{ mg/m}^2\text{s}$ (all sea points)
- A nominal value of $0.021 \text{ mg/m}^2\text{s}$ over N. Africa where there are no emissions.
- Over the UK only, where stack heights from point sources are known, GEMS-TNO emissions from grid points corresponding to elevated point sources have been moved from the surface to the appropriate model level.



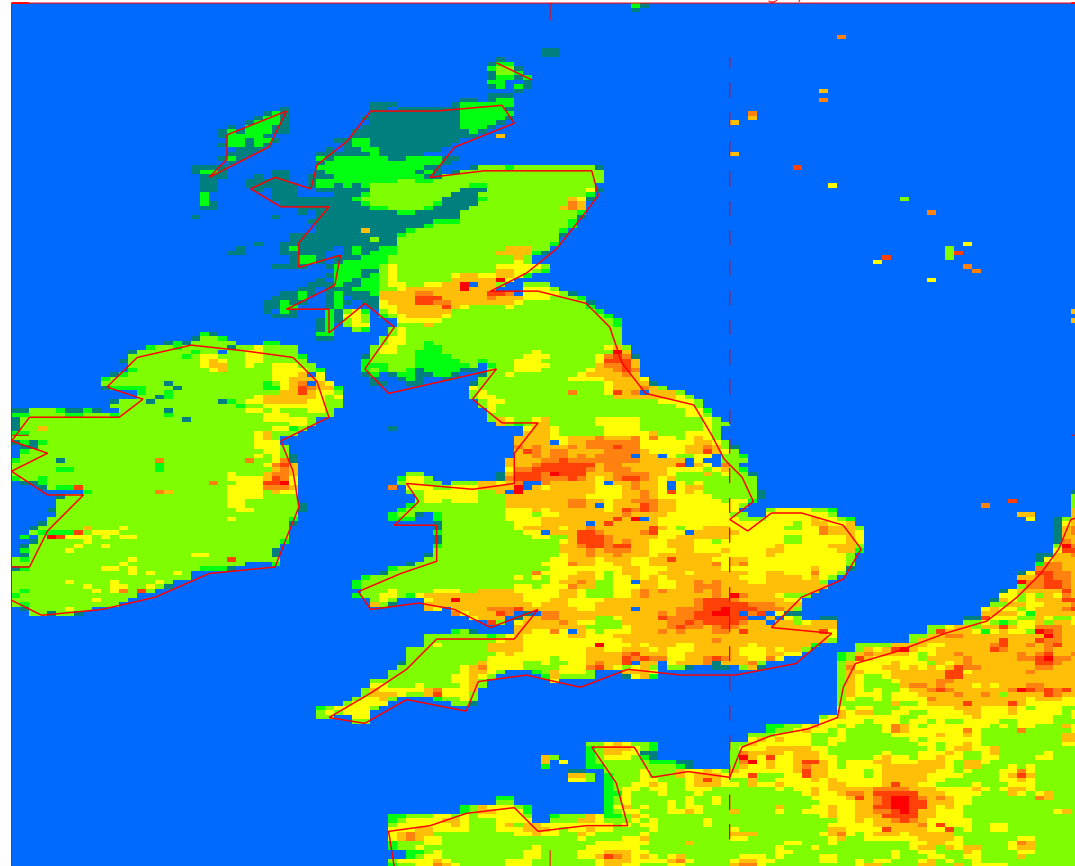
GEMS TNO dataset





GEMS TNO dataset (zoom)

newmurk_tno_L38 20m in microgr/m2s

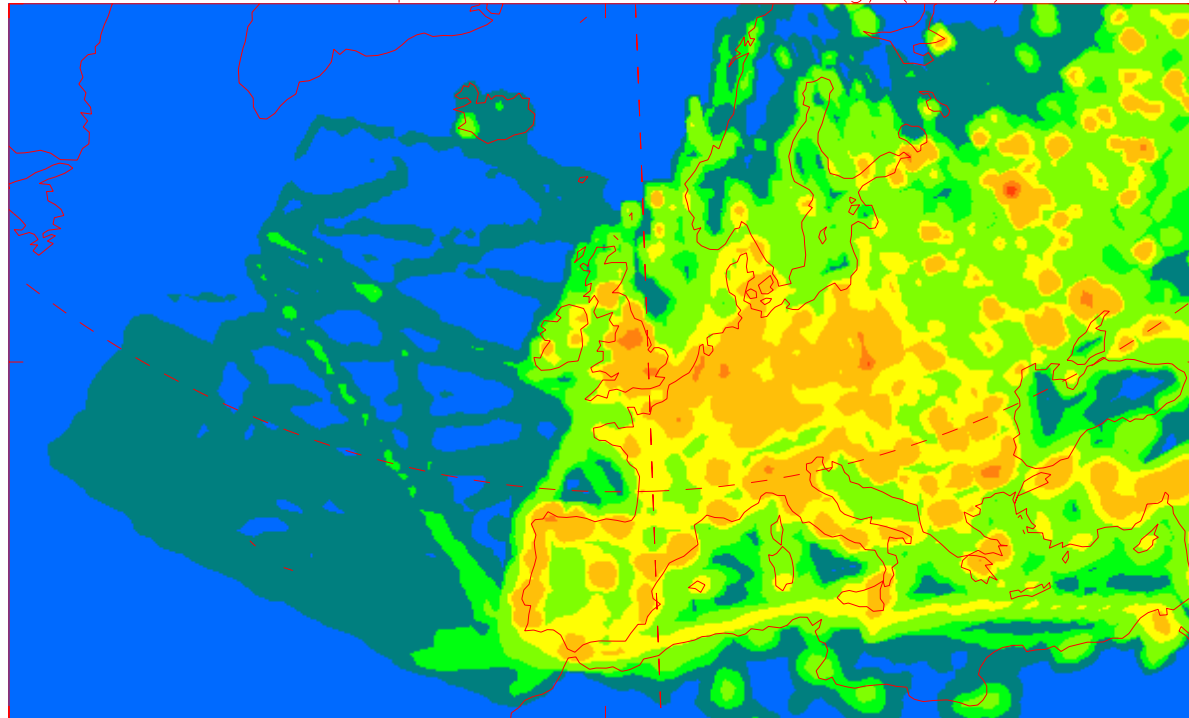


0.001 0.005 0.01 0.05 0.1 0.5 1 5



EMEP 2005 dataset

murk emep2005 neaL38 in microg/(m2s)

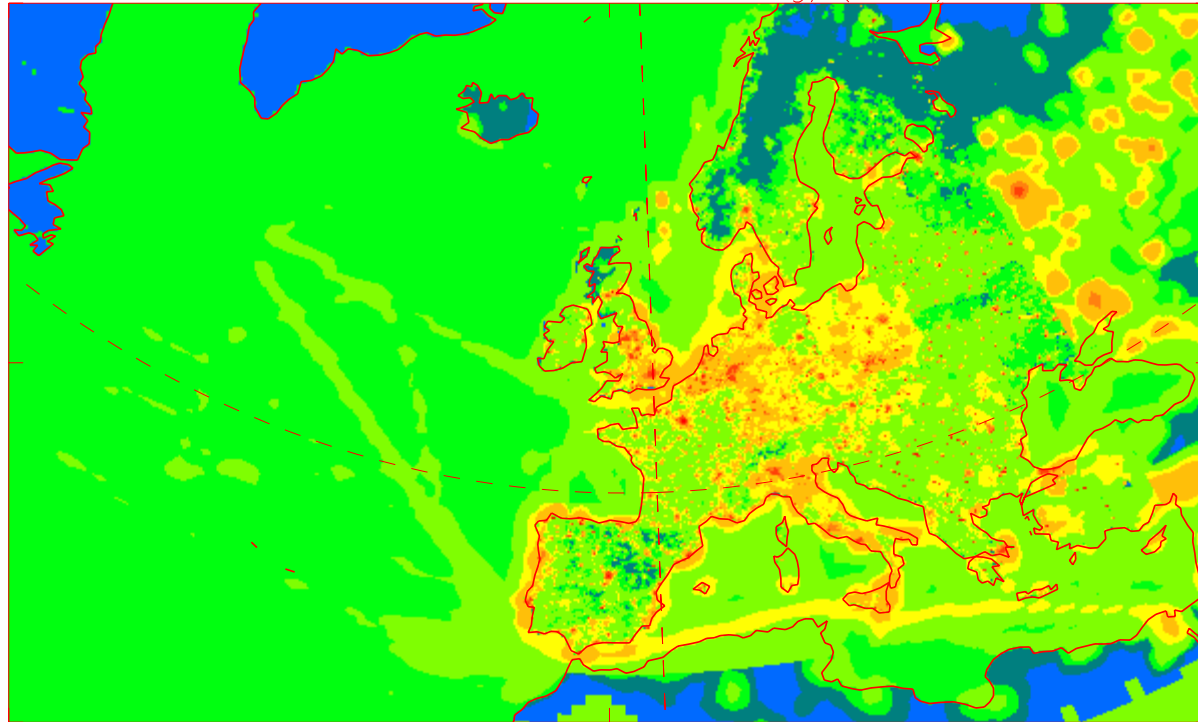


0.001 0.005 0.01 0.05 0.1 0.5 1 5



New Murk source dataset

new murk naeL38 in microg/(m2s)

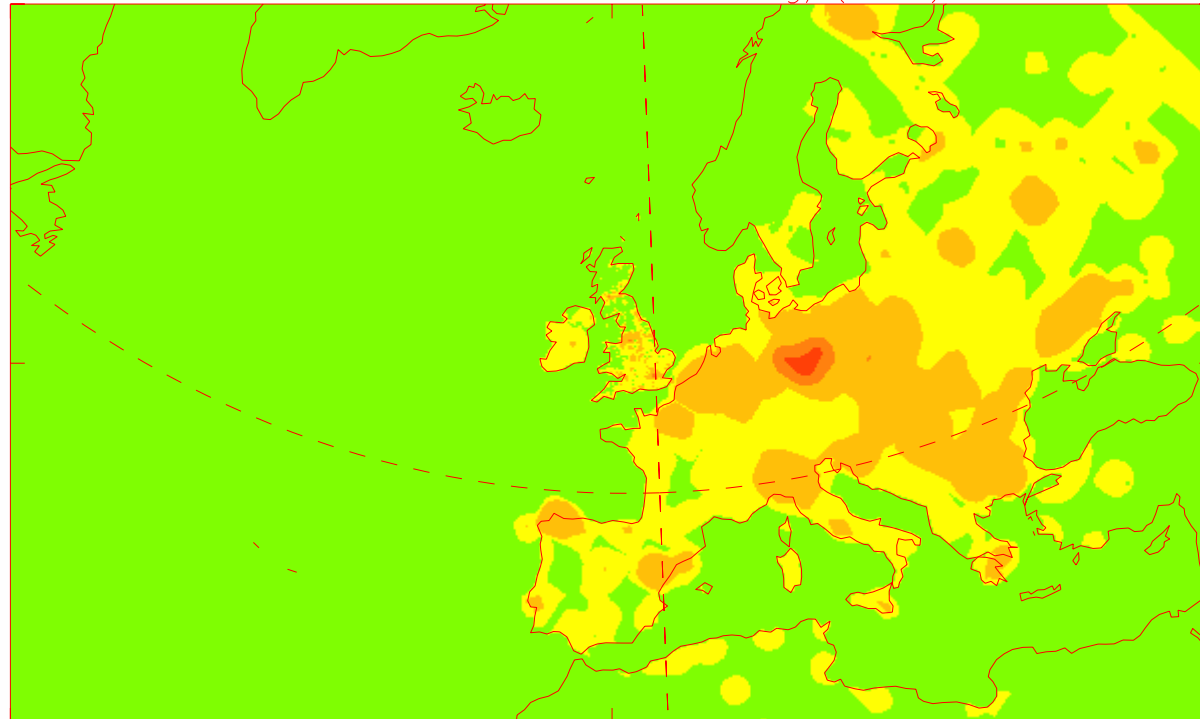


0.001 0.005 0.01 0.05 0.1 0.5 1 5



Current Murk source dataset

old murk naeL38 in microg/(m2s)

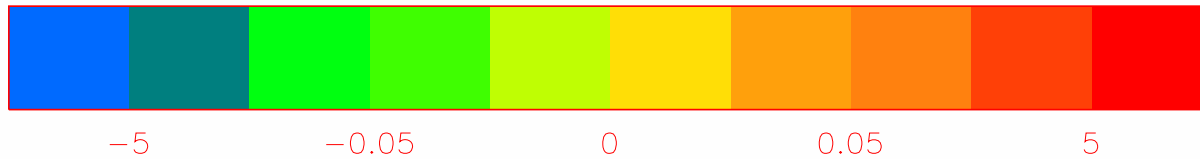
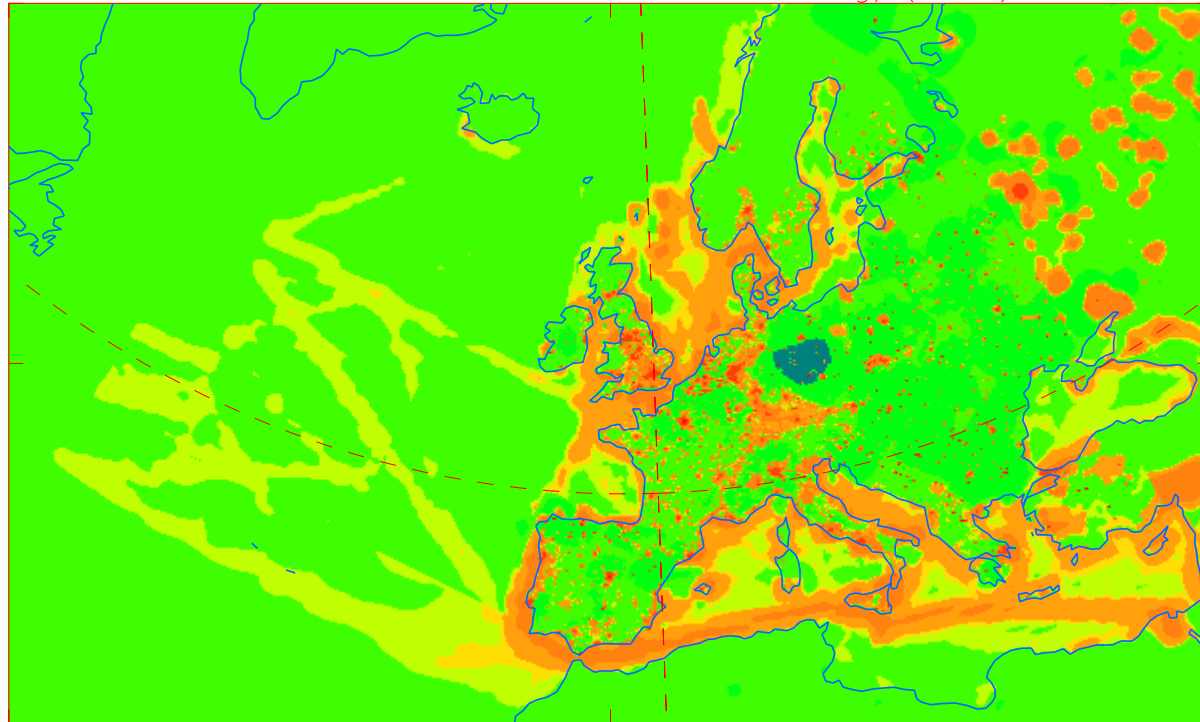


0.001 0.005 0.01 0.05 0.1 0.5 1 5



Difference (new – current)

new – old murk naeL38 in microg/(m2s)



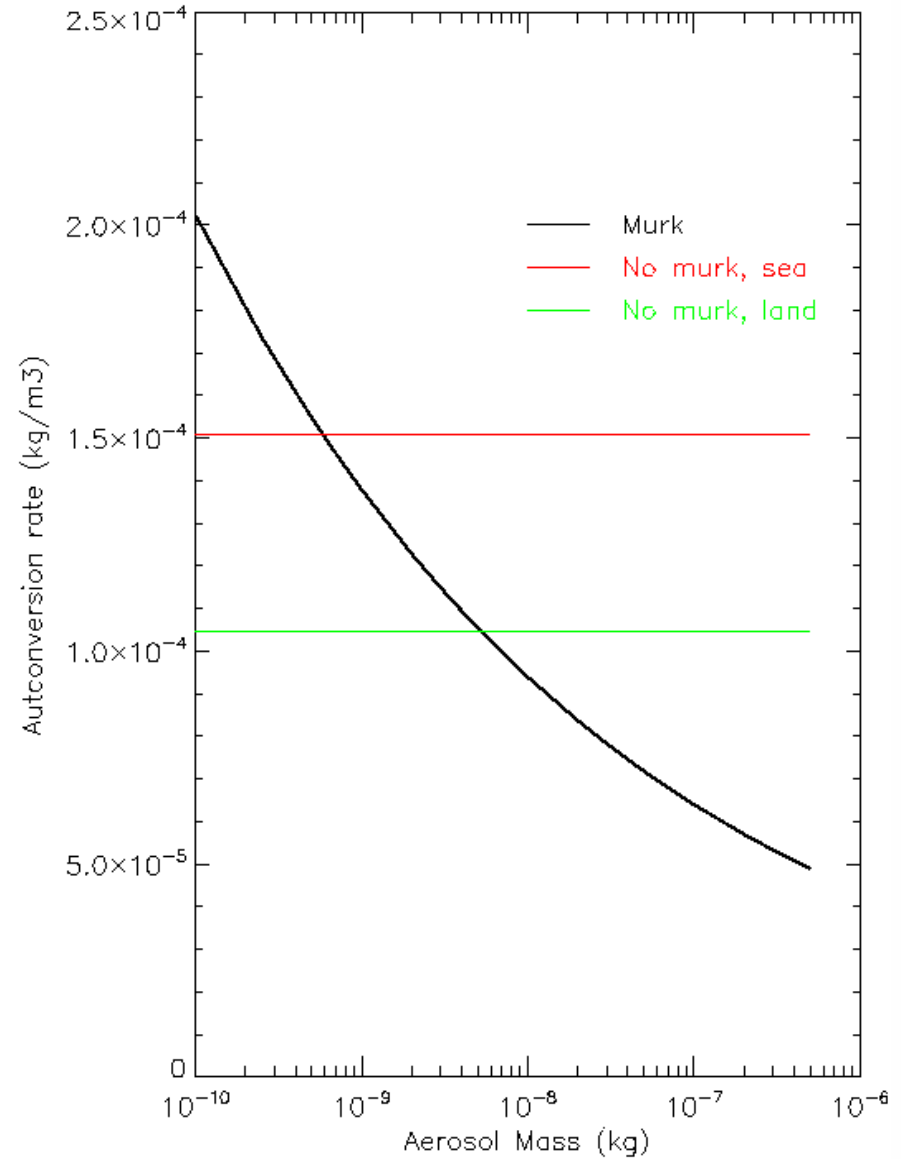
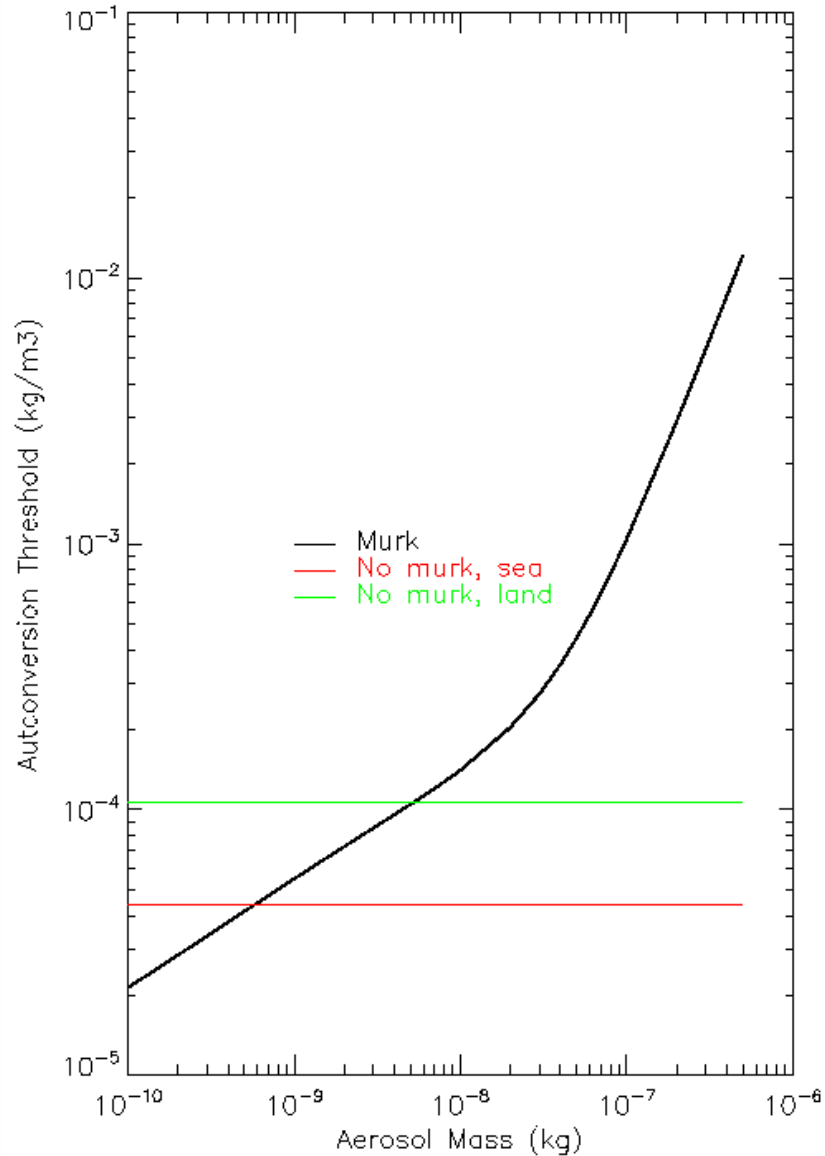


Murk link to autoconversion

- Autoconversion from cloud droplets to drizzle uses some assumption of cloud droplet size.
- At present this is a fixed value for land and another fixed value for sea, resulting in a unrealistic land-sea split in drizzle rates.
- Linking MURK to autoconversion rates removes this tendency and should produce more realistic drizzle patterns for example reducing some of the more spurious drizzle that occurs in cloudy anticyclonic conditions.



Murk link to autoconversion



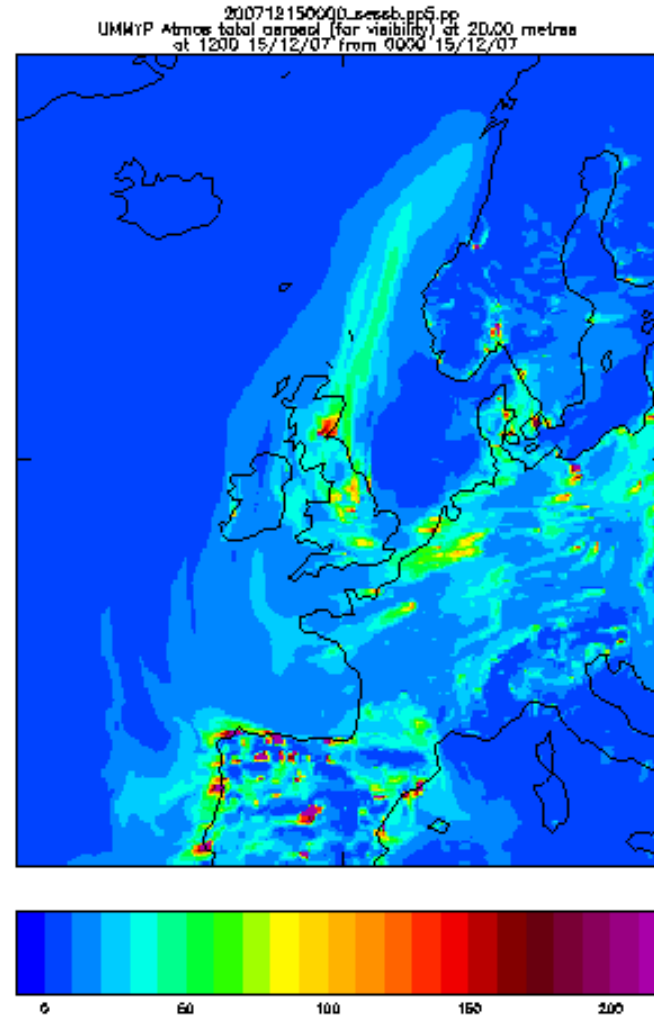
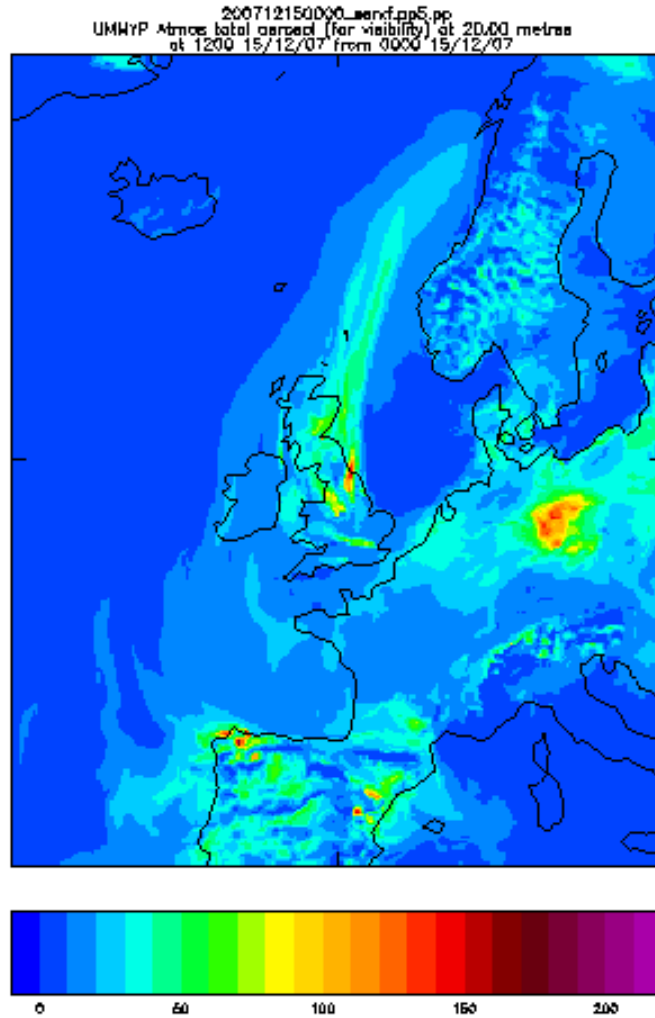


Other microphysics changes

- Brown and Francis Ice Particle Densities
- There is evidence from radar data that the density relationship used within the UM is too large, causing thick ice cloud to develop in the model. This new relationship gives a more realistic ice particle size to density relationship.
- Mitchells 2nd Re-X Relationship
- Changing the density relationship for calculating ice crystal fall speeds will hence alter the fall speed of the ice crystals. This change should be run in conjunction with Brown and Francis to prevent this happening.
- Droplet settling allows the cloud droplets to fall out slowly (typical velocities of ~ 1 m/s).
- This has very little effect on cloud or surface rain rates, but has been shown to be rather good at removing persistent fog (e.g. Christmas Fog 2006).

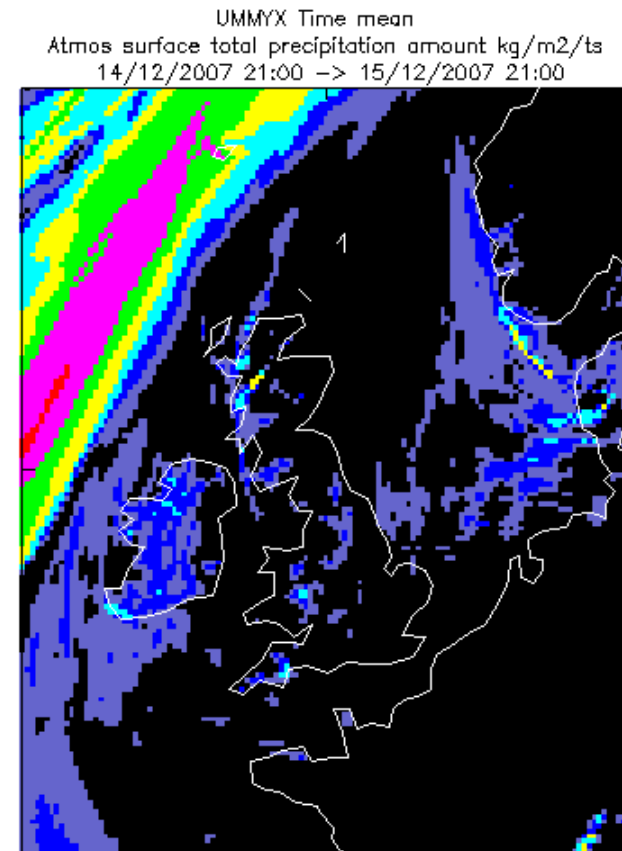
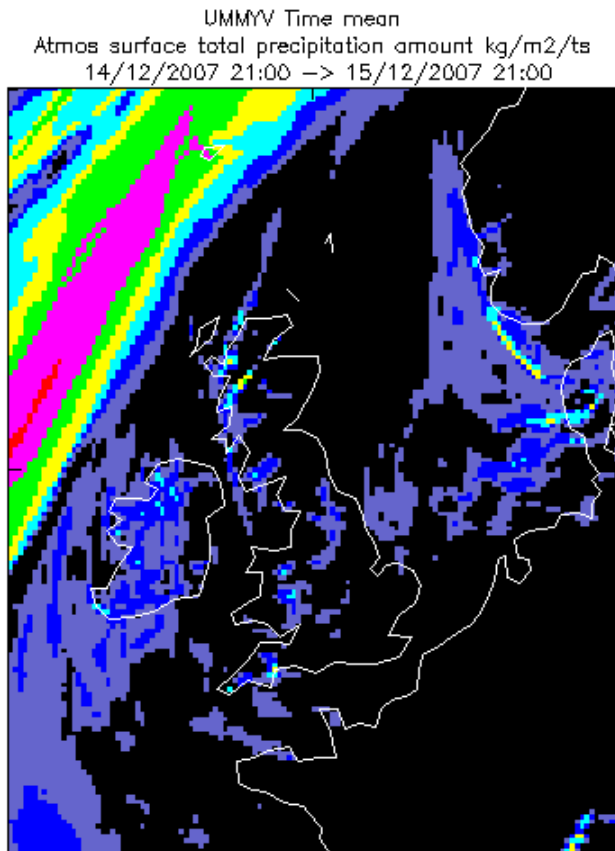


Impact of new murk sources





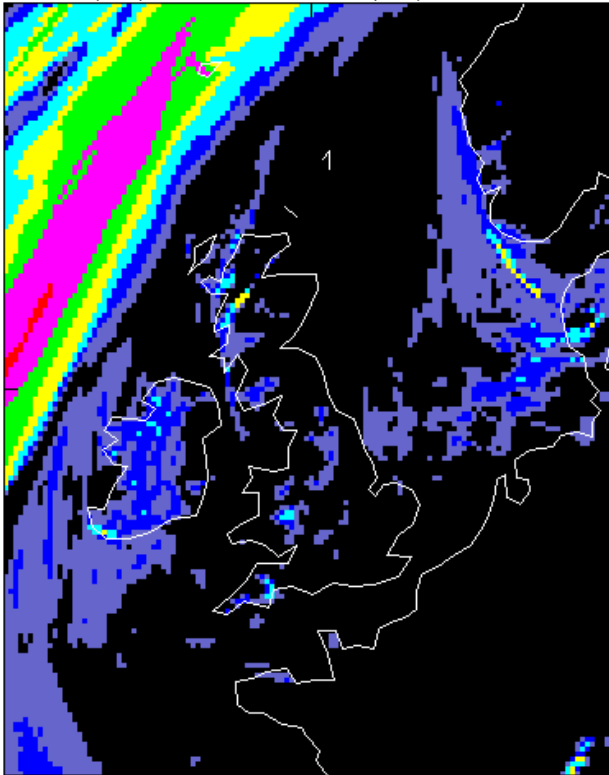
Impact of murk autoconversion





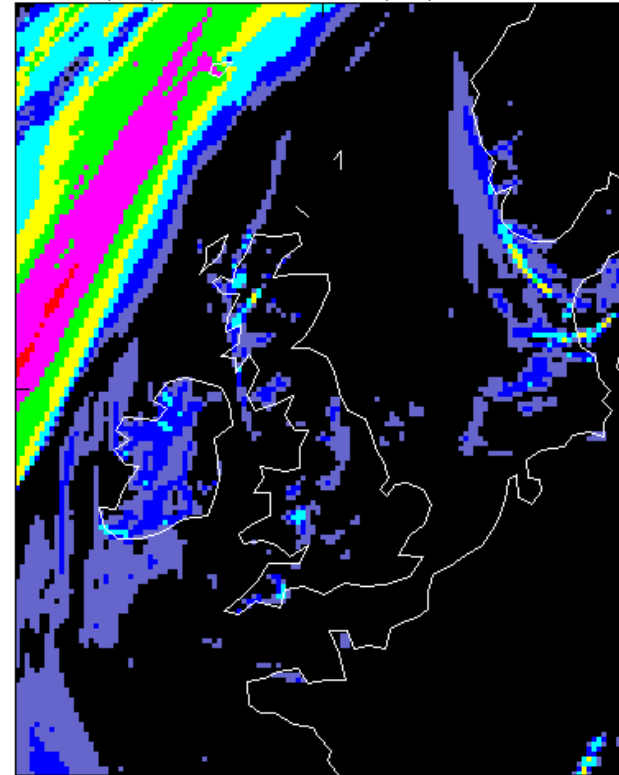
Impact of microphysics (numerics)

UMMYZ Time mean
Atmos surface total precipitation amount kg/m²/ts
14/12/2007 21:00 -> 15/12/2007 21:00



0.5 1 2 4 8 16 32 64

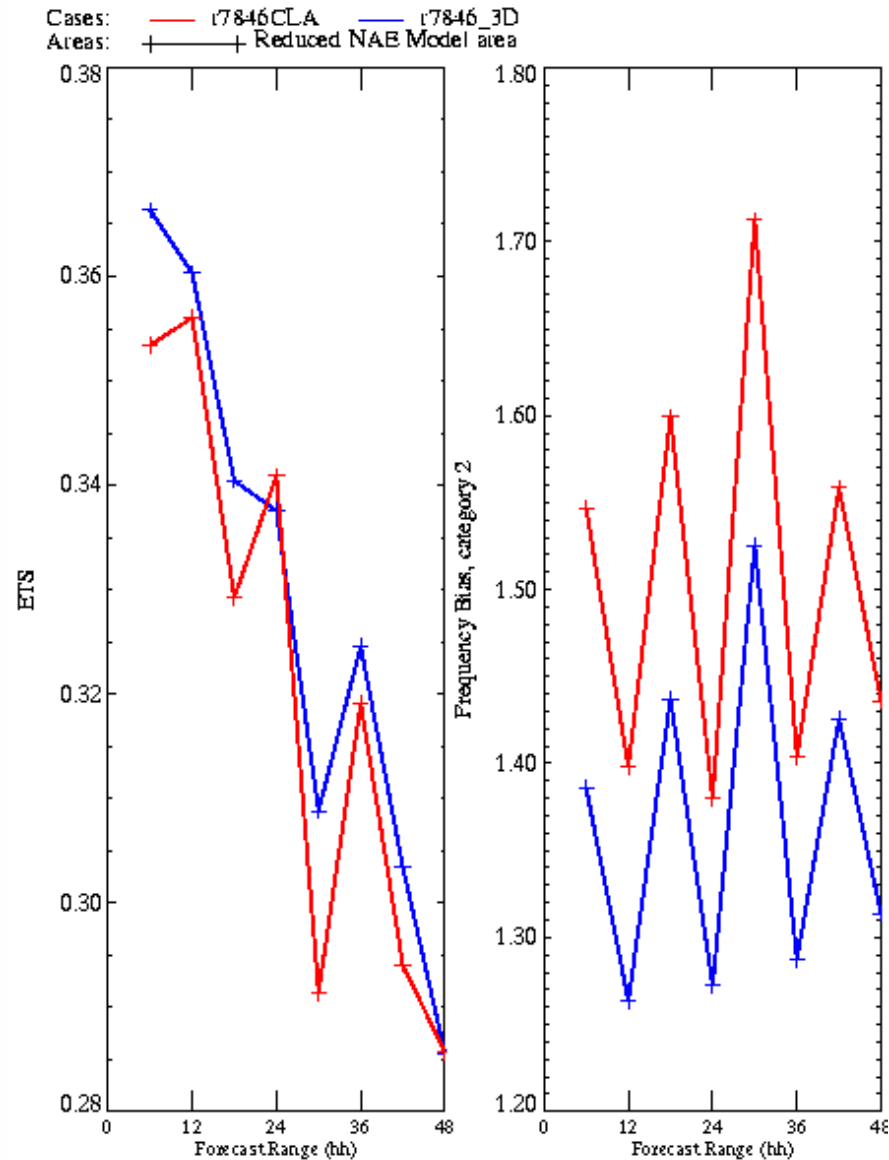
UMMYT Time mean
Atmos surface total precipitation amount kg/m²/ts
14/12/2007 21:00 -> 15/12/2007 21:00



0.5 1 2 4 8 16 32 64

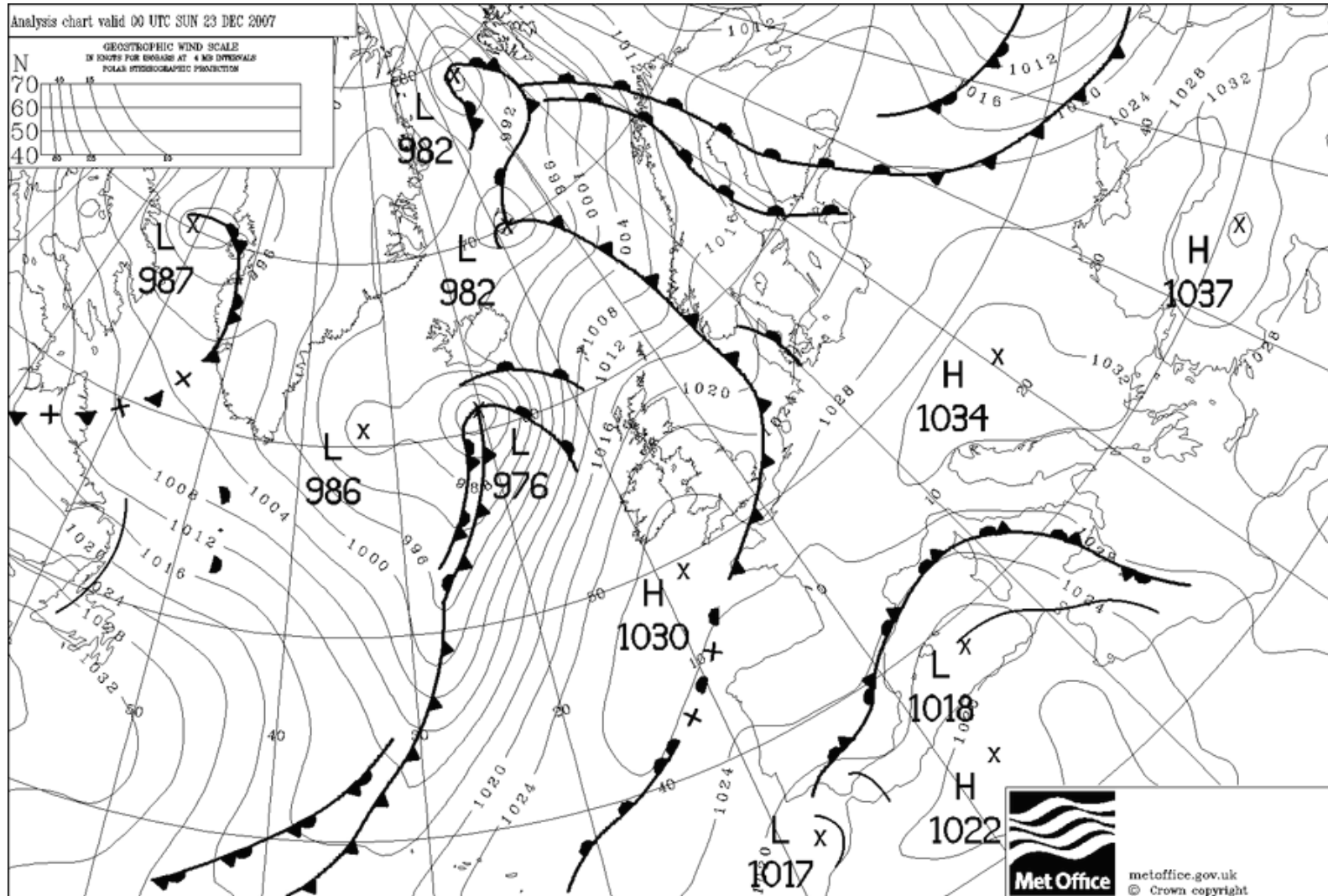


Impact of microphysics (numerics) on drizzle





Case study – 23rd December 2007

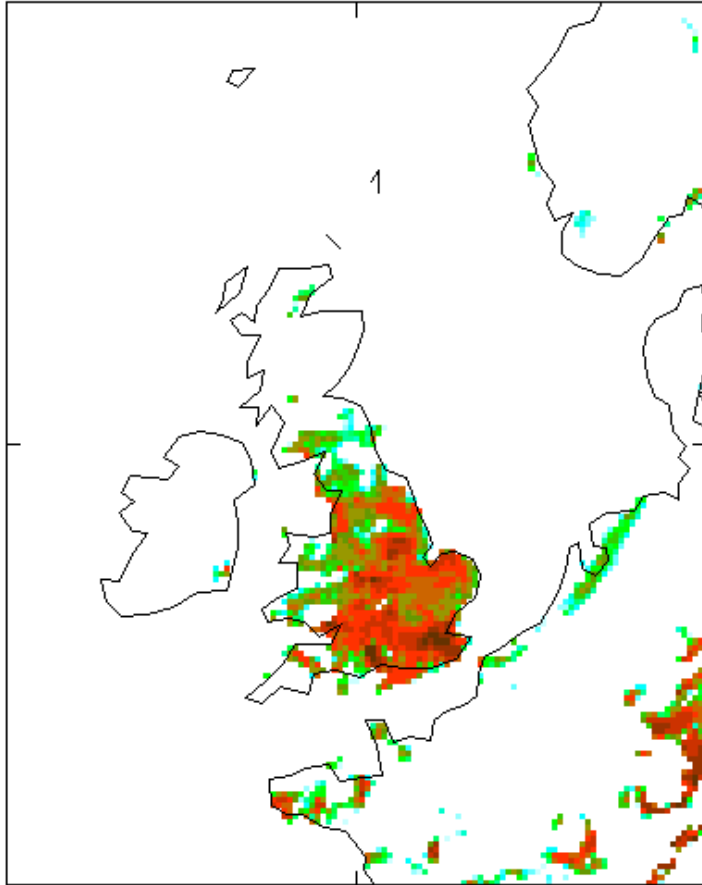




Impact of droplet settling on fog

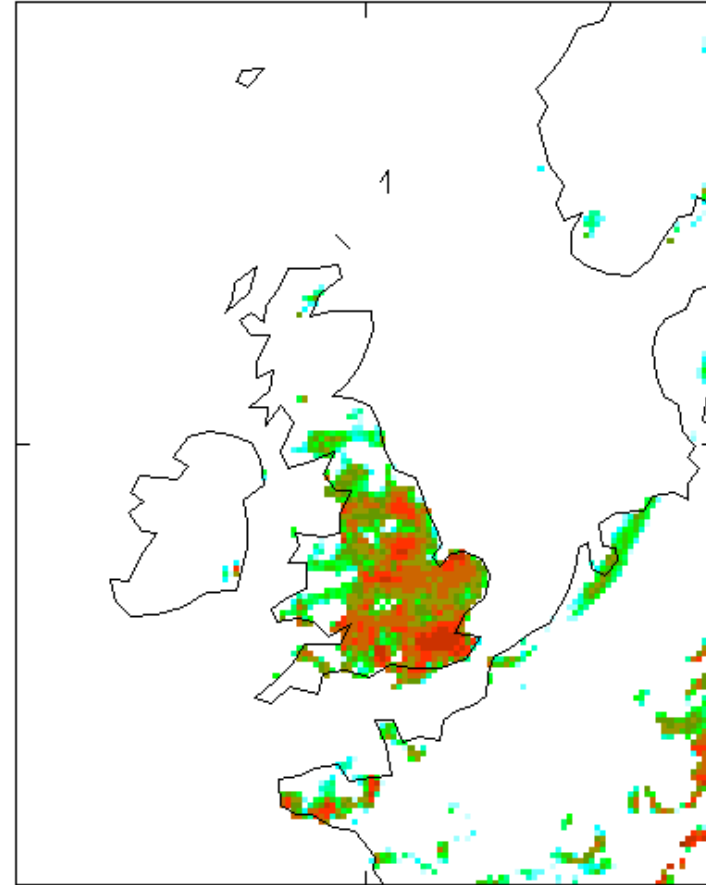
Met

UMMY Atmos visibility at 1.5m m at -1.000 metres
at 0600 23/12/07 from 0000 23/12/07



0 20 40 60 80 100

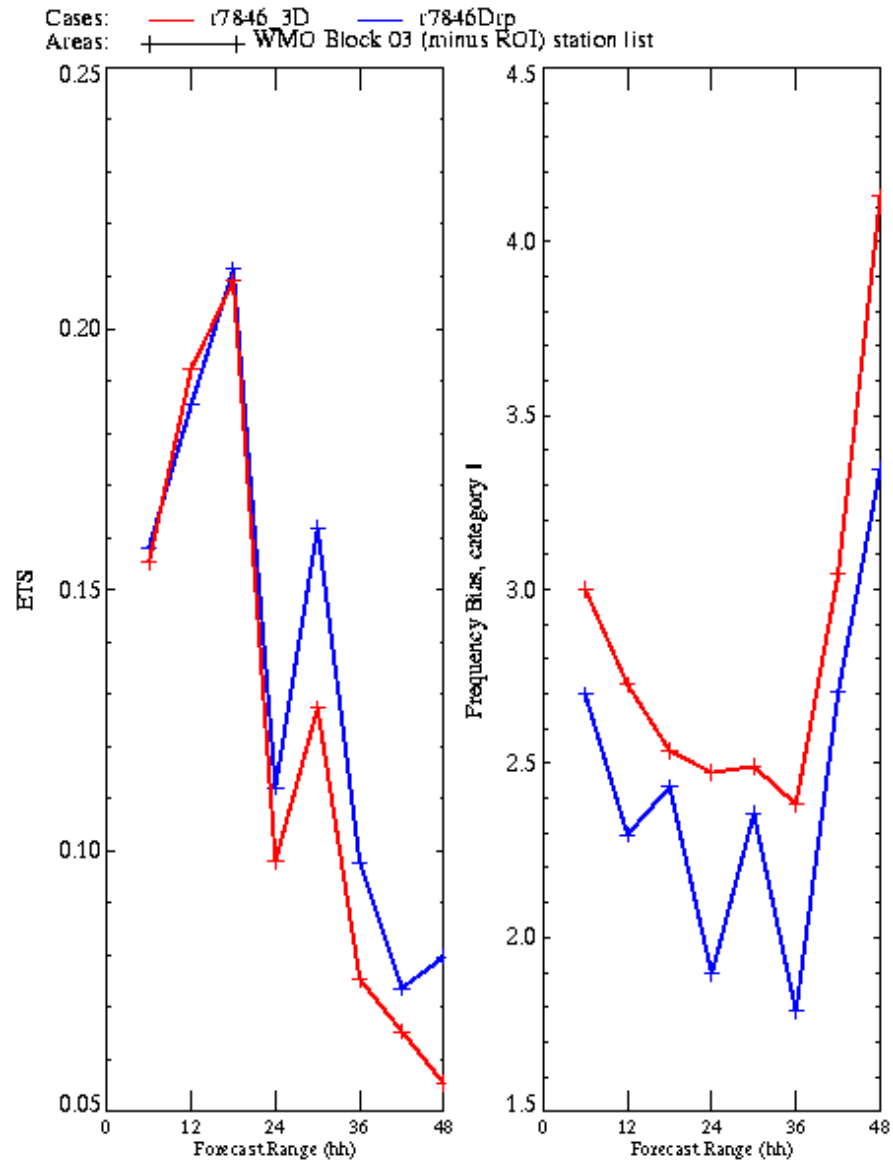
UMMYW Atmos visibility at 1.5m m at -1.000 metres
at 0600 23/12/07 from 0000 23/12/07



0 20 40 60 80 100



Impact of droplet settling on low visibility





CLASSIC albedos

- This change uses data provided by the Climate and Land-Surface Systems Interaction Centre (CLASSIC).
- Based on MODIS observations this gives a much more accurate specification of albedo of the MOSES vegetated tiles and of the underlying bare soil, particularly in partially vegetated areas.



Snow canopy

- This option allows snow to reside under, as well as on top of, needle-leaf trees, with a calculation made for the rate of transfer between the two stores.
- The result is reduced sublimation of the snow, warmer surface temperatures and snow can persist for longer under the trees.



Radiation changes

- The concentrations of CO₂ and other trace gases needs to be updated as the previous concentrations were consistent with the observations in 1985 and so do not account for the continued increases in the concentration of these gases.
- Update Meso Spectral Files to remove bug in ice processes. The LW ice parametrisation contained an error that significantly overestimated the extinction due to ice.
- Rayleigh Scattering: A long standing error has been found in the code which produces the part of the spectral files which describe the Rayleigh scattering properties of dry air.
- Correcting this error slightly increases the scattering of solar radiation in clear skies but has a minimal impact on the quality of the forecast.



Talk Outline

- NAE Physics
- **UK1.5 km results**



Case studies

| Date/Time | Description | Ts. (s) |
|----------------|--------------------------------------------------------------------------------|---------|
| 18/07/2006 00Z | Clear Summer Day (Heatwave) | 50 |
| 22/07/2006 12Z | MCS with local flooding | 50 |
| 27/07/2006 06Z | Thunderstorms (fog following morning) | 50 |
| 04/09/2006 18Z | Cu Sc under inversion | 50 |
| 17/10/2006 00Z | Dense fog clearing with front passage (*) | 50 |
| 21/10/2006 12Z | Bands of rain (*) | 50 |
| 26/10/2006 06Z | Gales | 50 |
| 21/11/2006 18Z | Gales (failed in ls_cld after 447 ts) | 40 |
| 26/11/2006 06Z | Band convection (failed in mono_enforce after 1796 ts) | ? |
| 07/12/2006 06Z | Squall line (London Tornado) | 50 |
| 19/12/2006 12Z | Onset of Fog Spell | 50 |
| 21/12/2006 00Z | Peak of Fog Spell | 50 |
| 10/01/2007 12Z | Organised convection | 50 |
| 24/01/2007 18Z | Frost | 50 |
| 29/01/2007 00Z | Sc | 50 |
| 03/02/2007 06Z | Clear skies | 50 |
| 07/02/2007 12Z | Snow | 50 |
| 15/02/2007 00Z | Frontal system with embedded convection (failed in mono_enforce after 1316 ts) | ? |

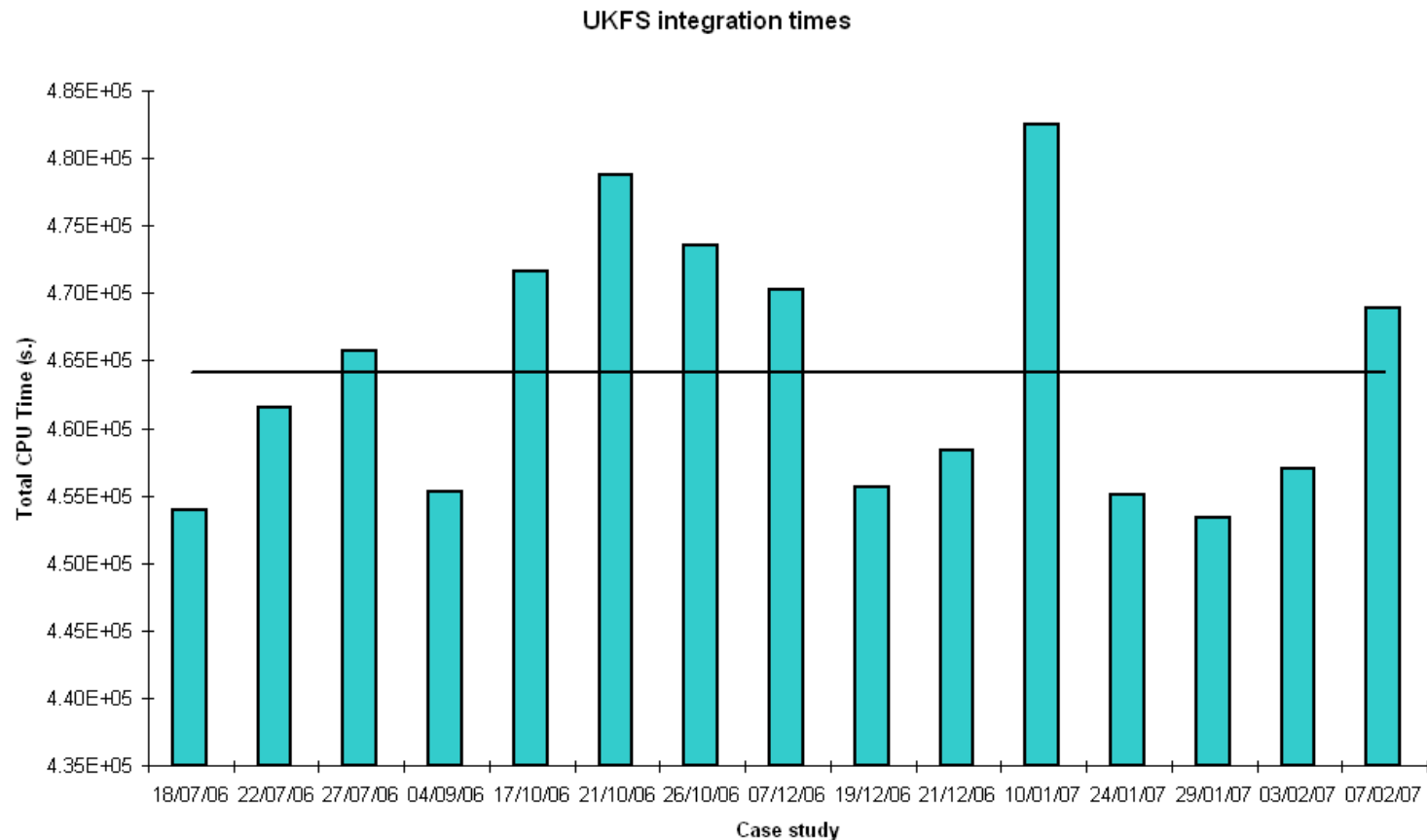


Integration Time (to T+36)

Avg Elapsed = 33446 s. (9.30 hr.). In 3 nodes (6.10 hr.)

Min Elapsed = 32612 s. (9.05 hr.)

Max Elapsed = 34667 s. (9.63 hr.)

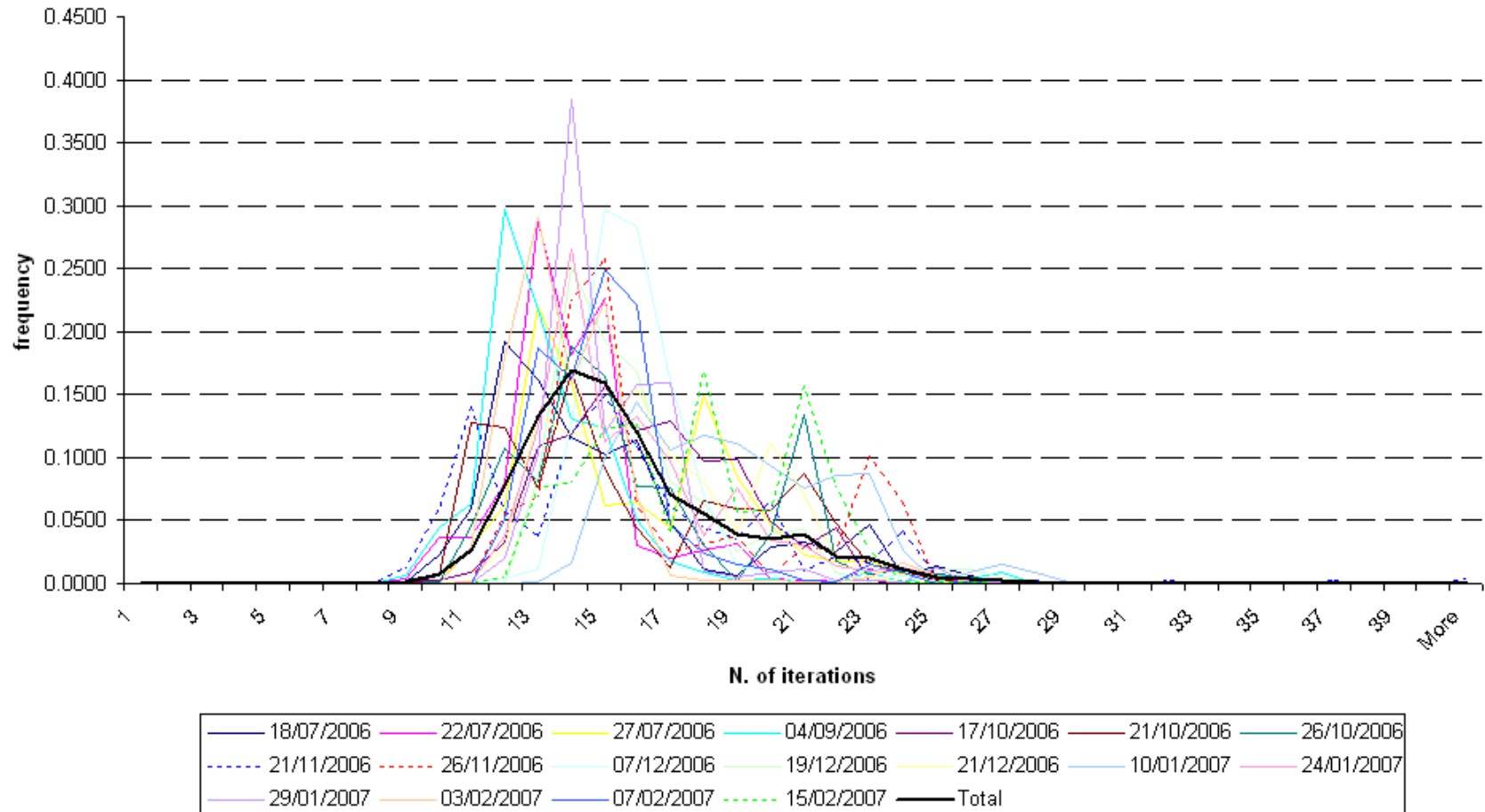




Iteration count

Typical iteration count 13-16

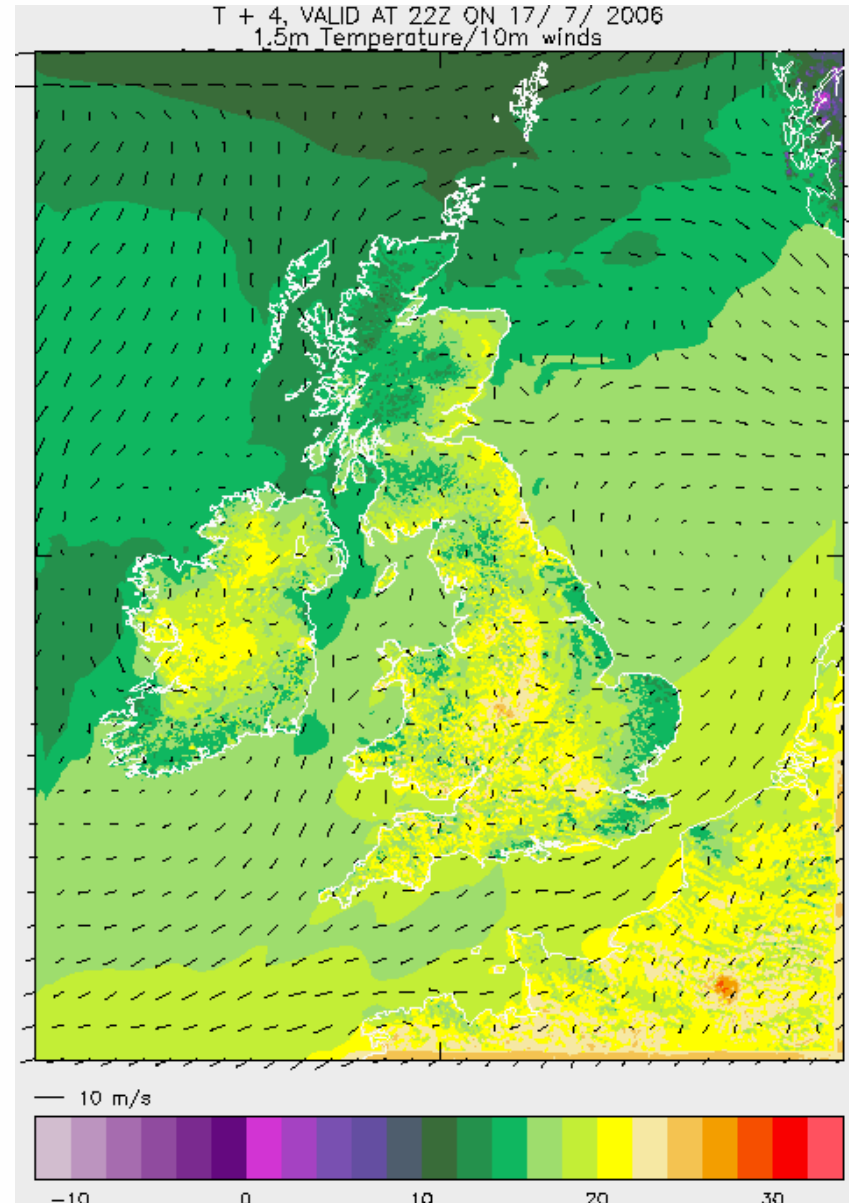
Iteration count in Solver





Case 18/07/2006. Heatwave

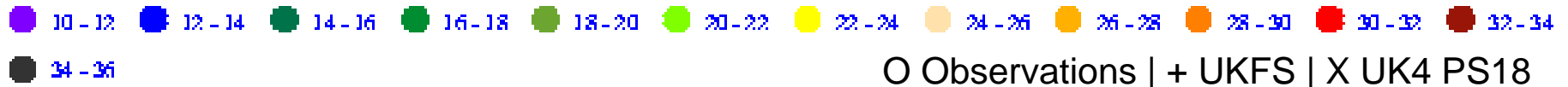
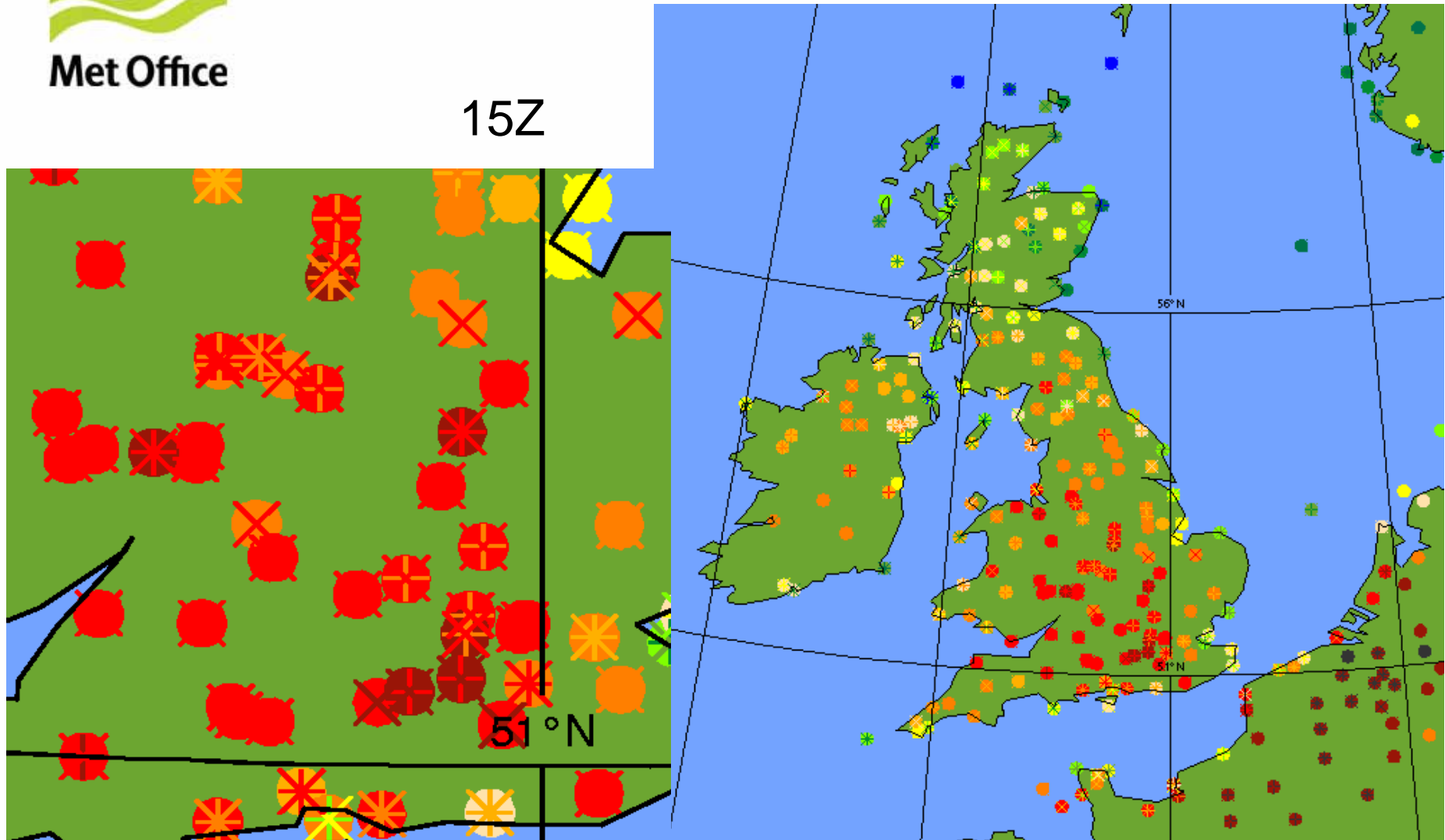
- Captures high temperatures well.
- Model too cold (by up to 2 degrees) at a few locations
- UK4 (after PS18) more accurate





Case 18/07/2006. Heatwave

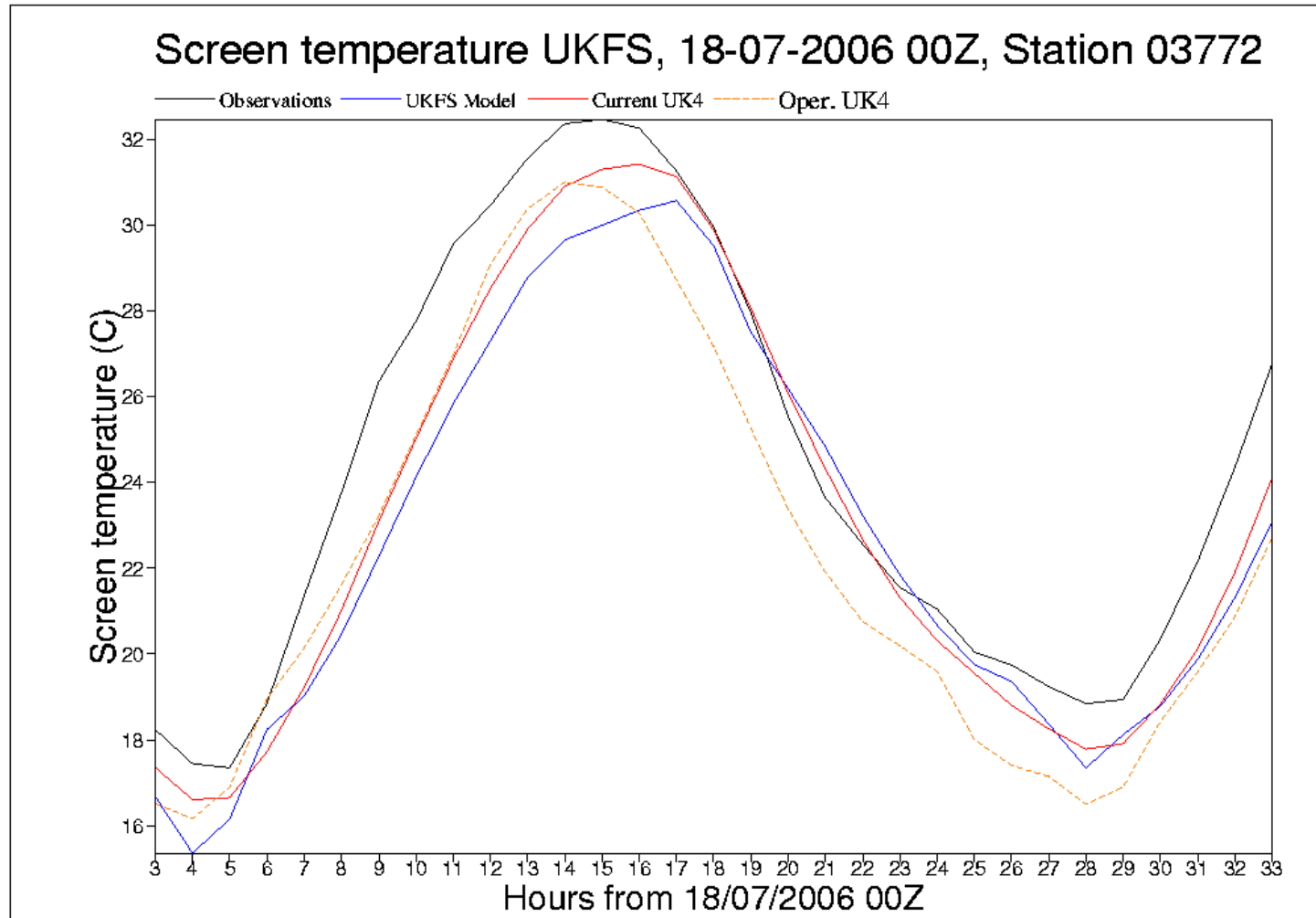
15Z





Case 18/07/2006. Heatwave

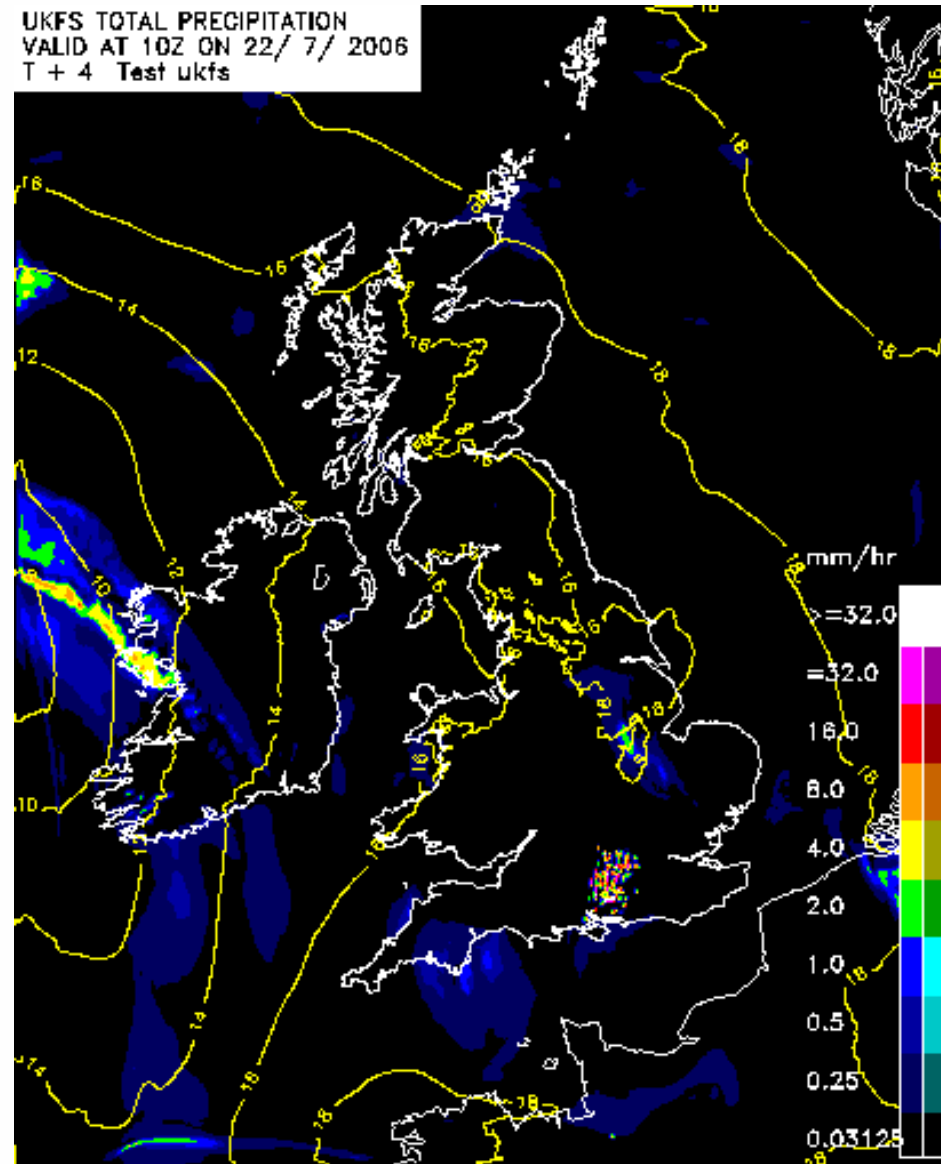
Delayed diurnal cycle, captures the evening cooling but model too cold in the early morning





Case 22/07/2006. MCS

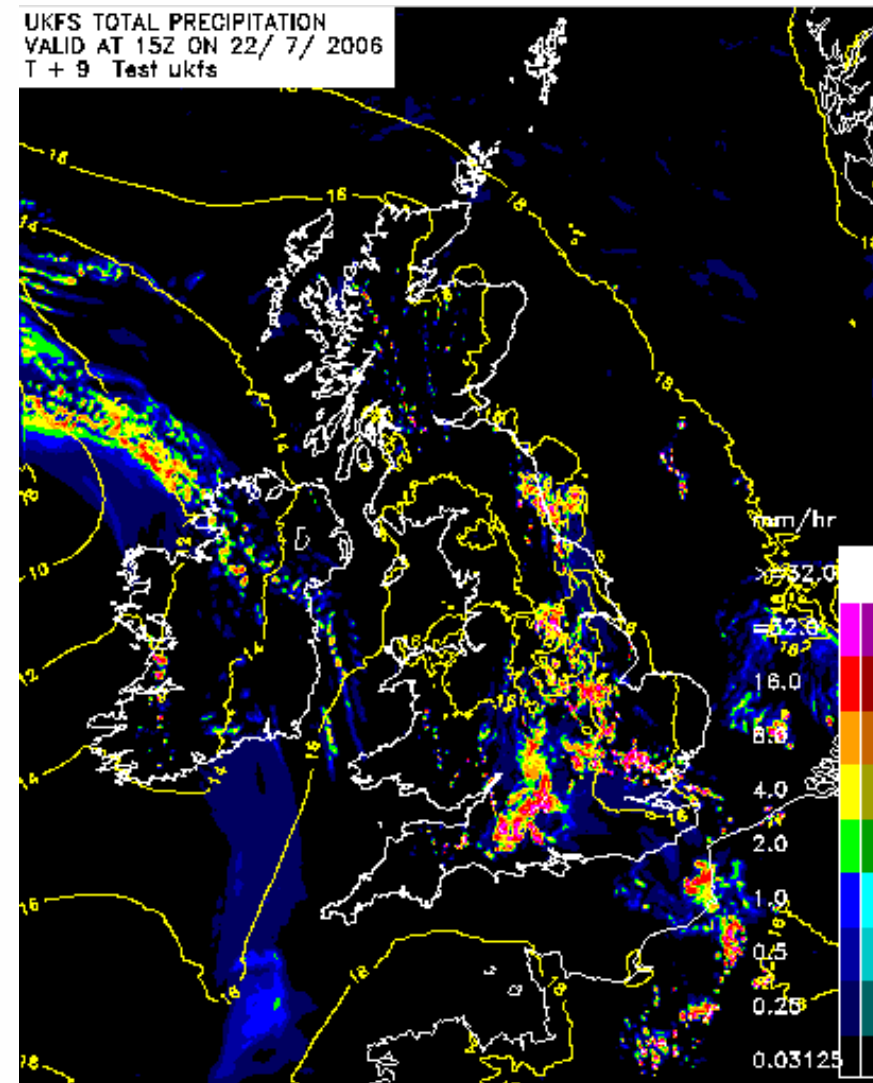
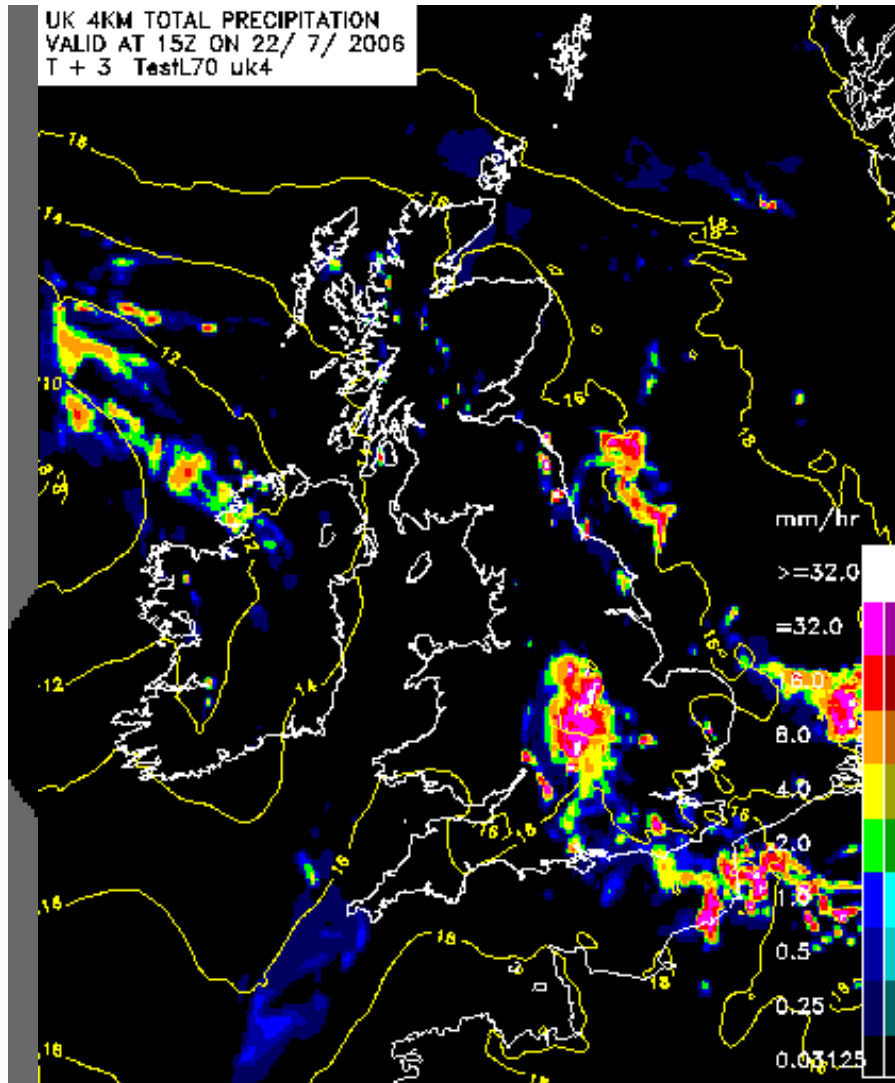
- Captures MCS.
- Short forecast range positional errors.
- Long forecast range light showers agree better with radar





Met Office

Case 22/07/2006. MCS

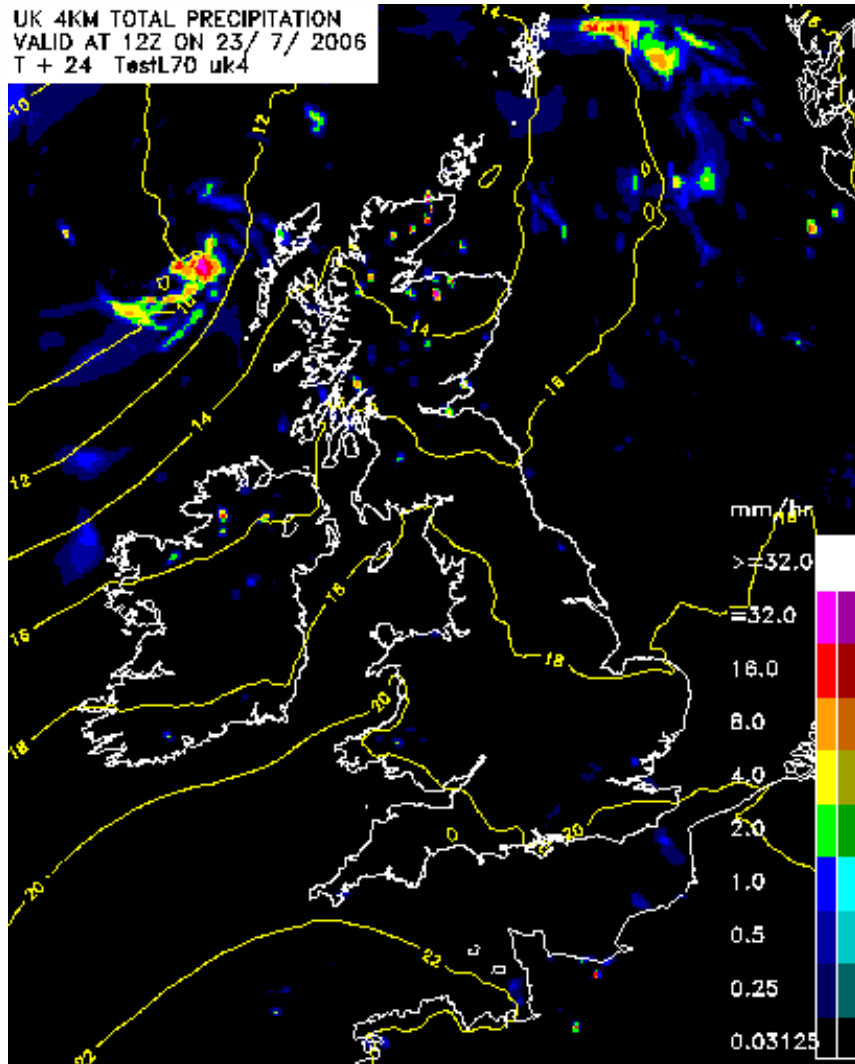




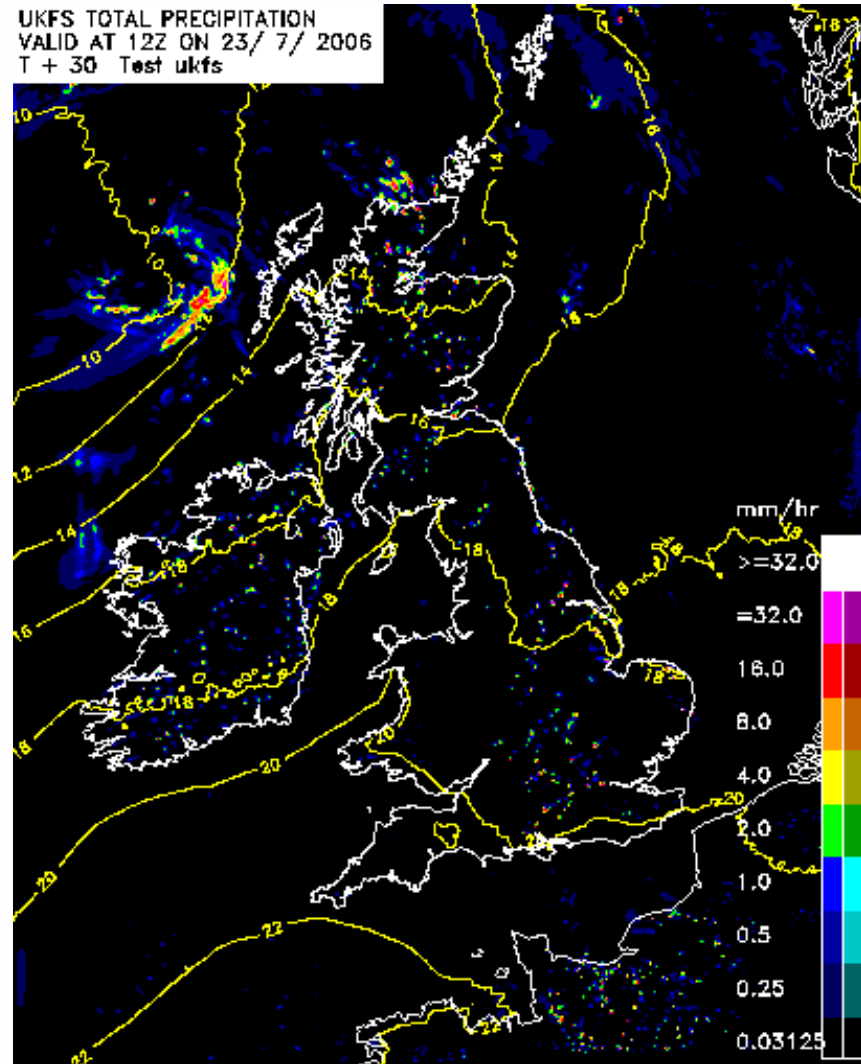
Met Office

Case 22/07/2006. MCS

UK 4KM TOTAL PRECIPITATION
VALID AT 12Z ON 23/ 7/ 2006
T + 24 TestL7D uk4

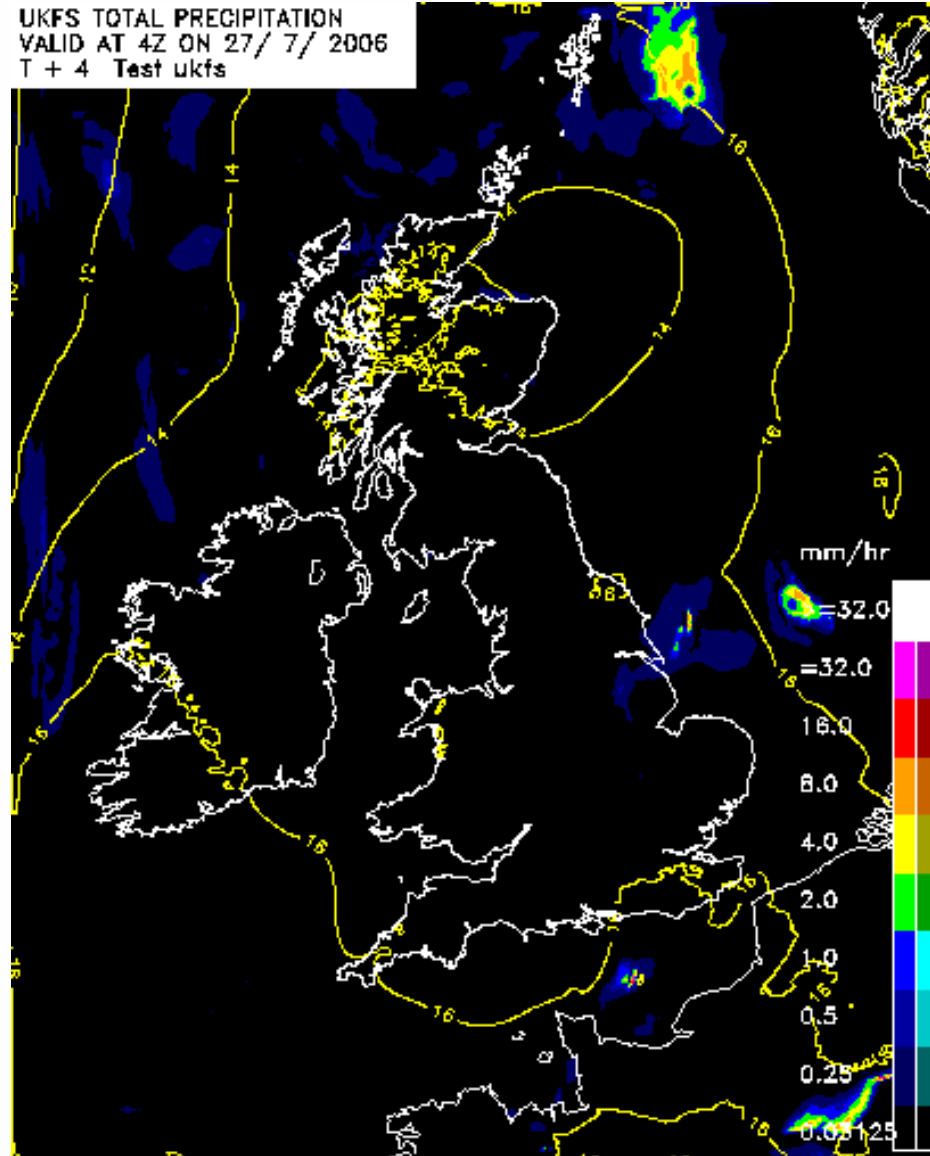


UKFS TOTAL PRECIPITATION
VALID AT 12Z ON 23/ 7/ 2006
T + 30 Test ukfs





Case 27/07/2006. Thunderstorms



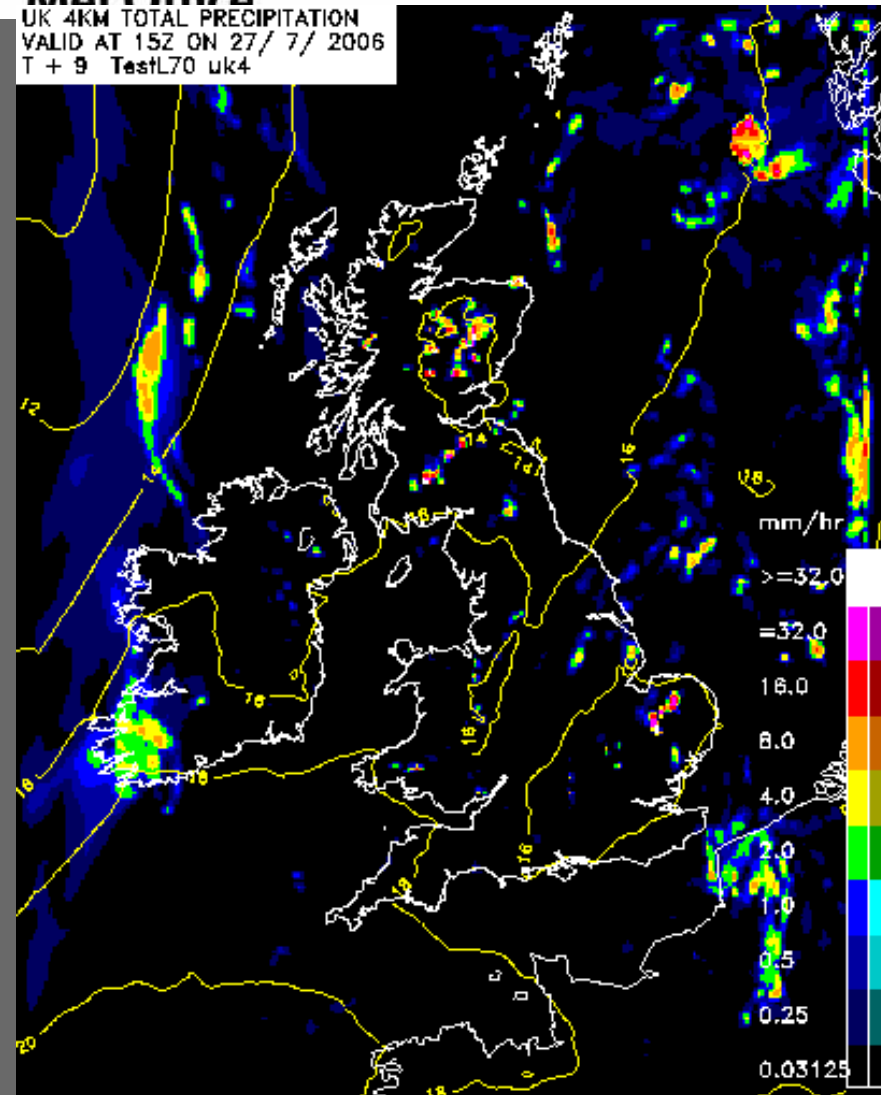
- Main showers represented, but with positional errors.
- Overforecasting of small showers.



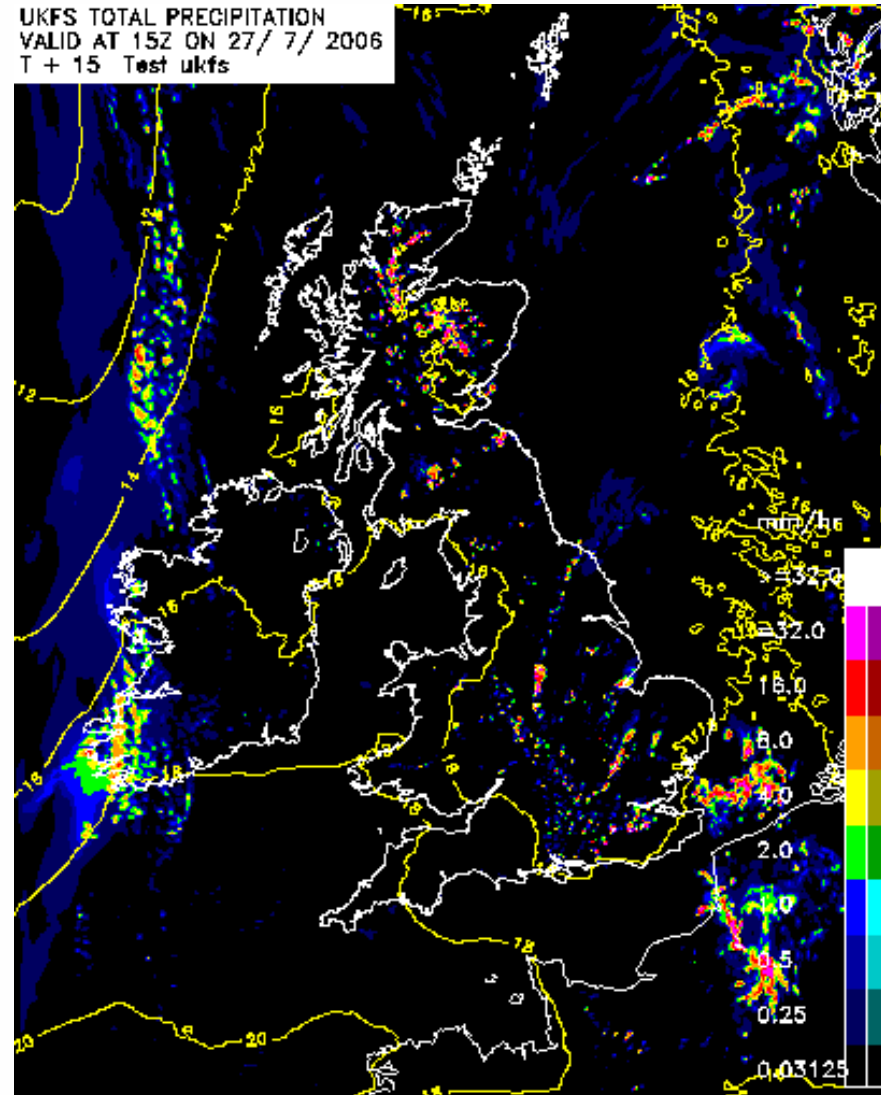
Case 27/07/2006. Thunderstorms

Met Office

UK 4KM TOTAL PRECIPITATION
VALID AT 15Z ON 27/ 7/ 2006
T + 9 TestL70 uk4



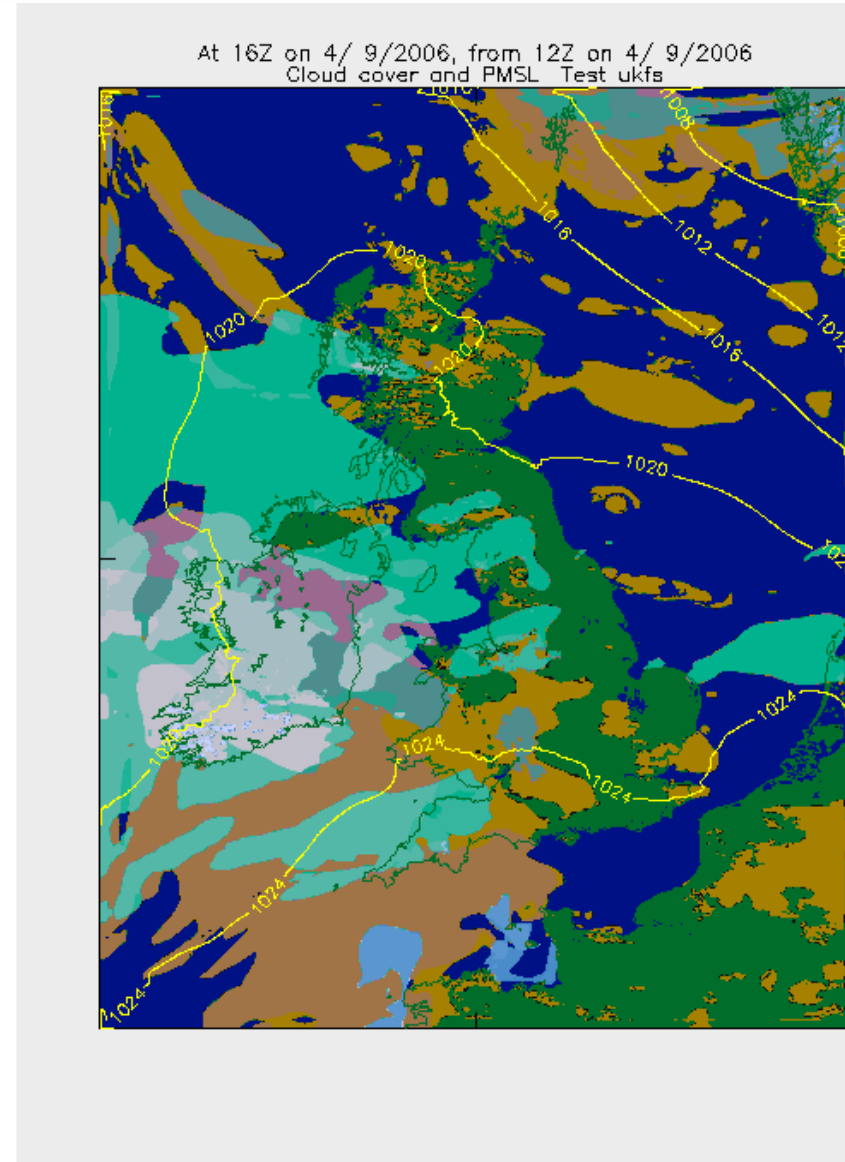
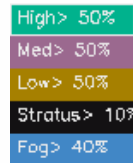
UKFS TOTAL PRECIPITATION
VALID AT 15Z ON 27/ 7/ 2006
T + 15 Test ukfs





Case 04/09/2006. St/Sc

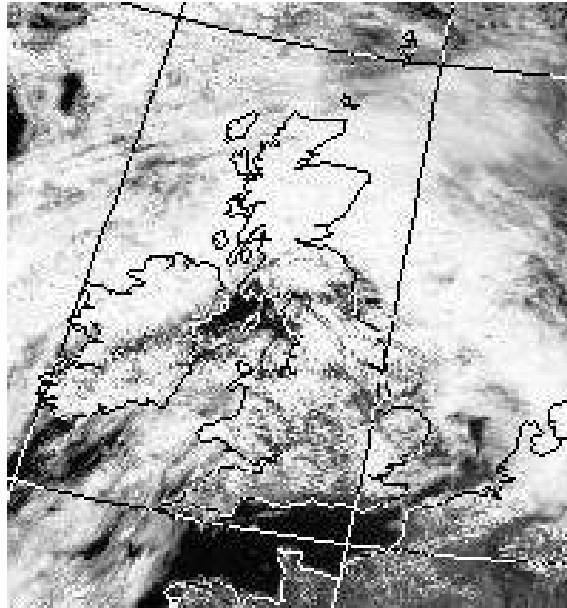
- Compares well with satellite imagery.
- Small scale detail.



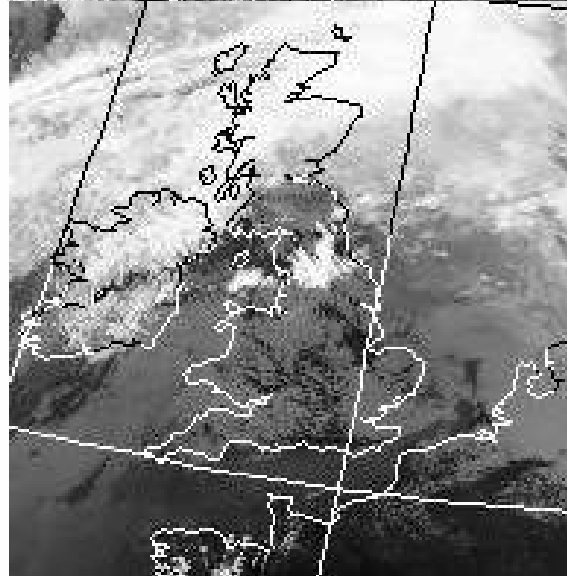


Case 04/09/2006. St/Sc

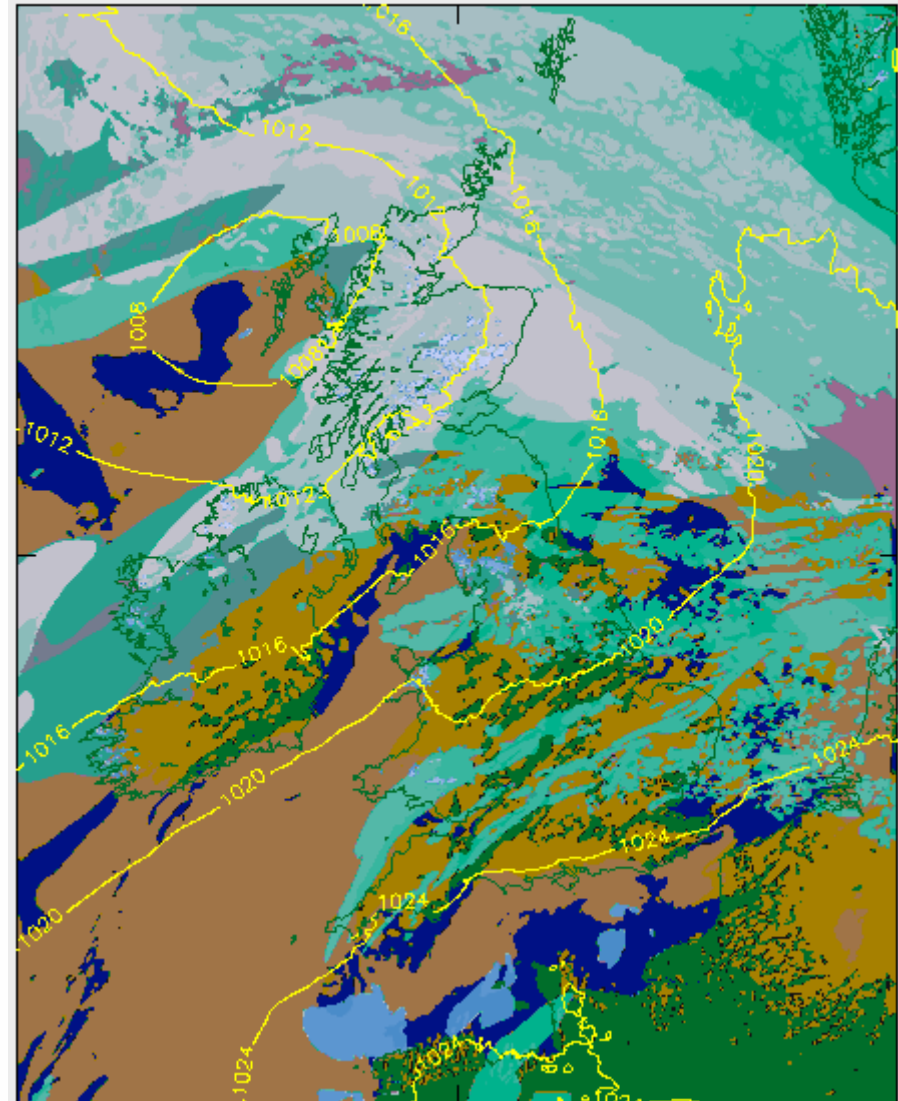
VIS



IR

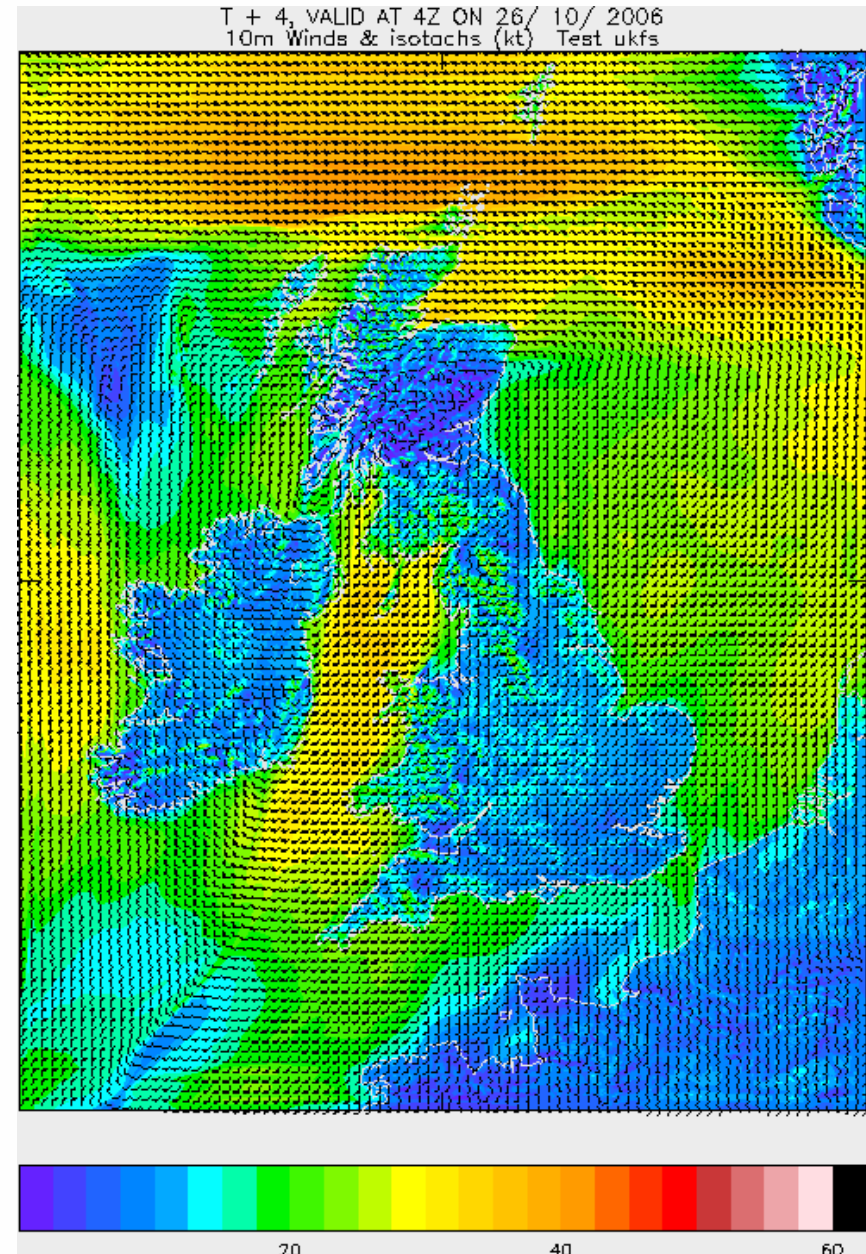


At 13Z on 5/ 9/2006, from 12Z on 4/ 9/2006
Cloud cover and PMSL Test ukfs





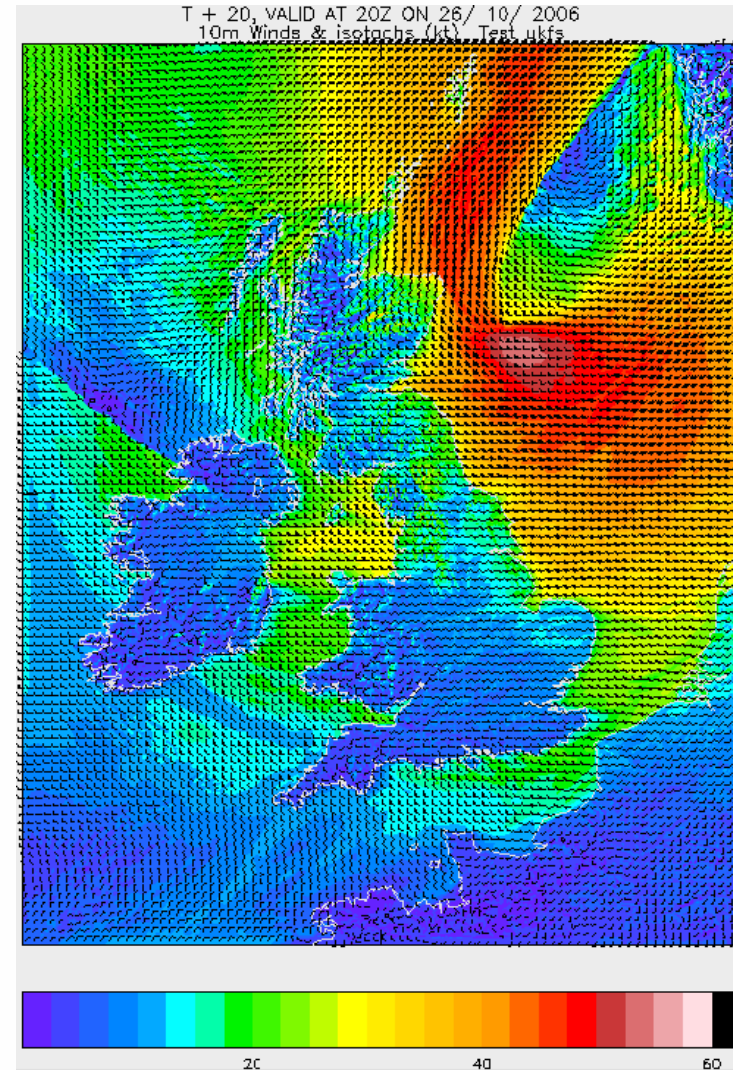
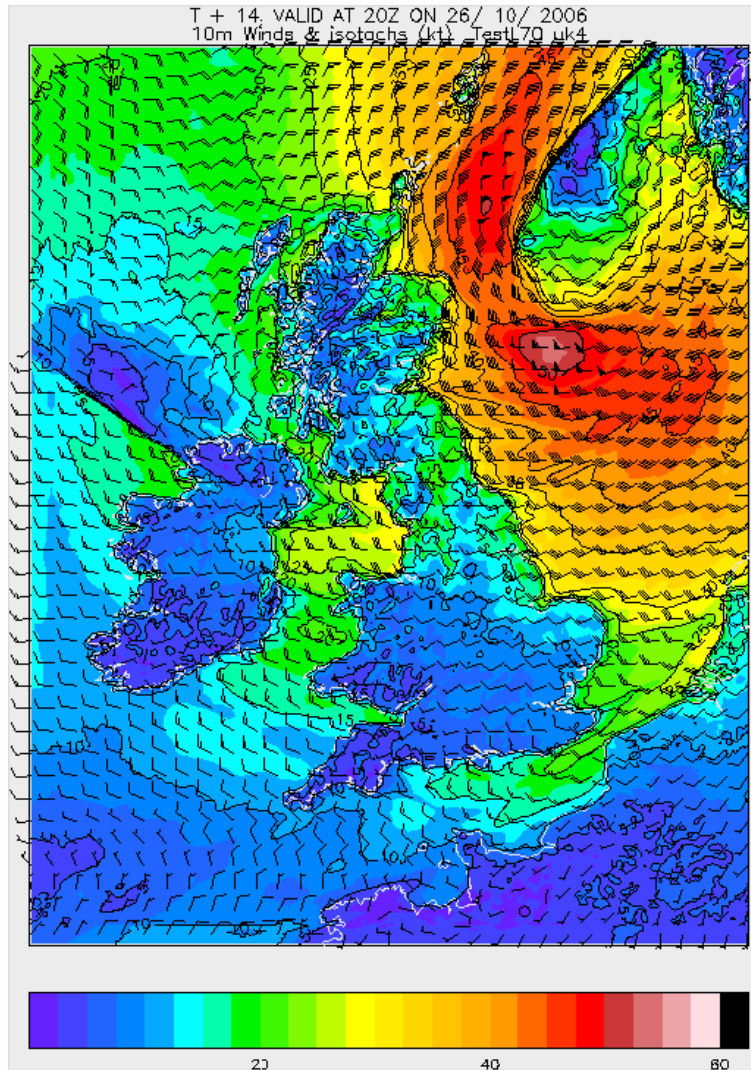
Case 26/10/2006. Gales



- Slightly stronger winds than UK4 over Sea.



Case 26/10/2006. Gales

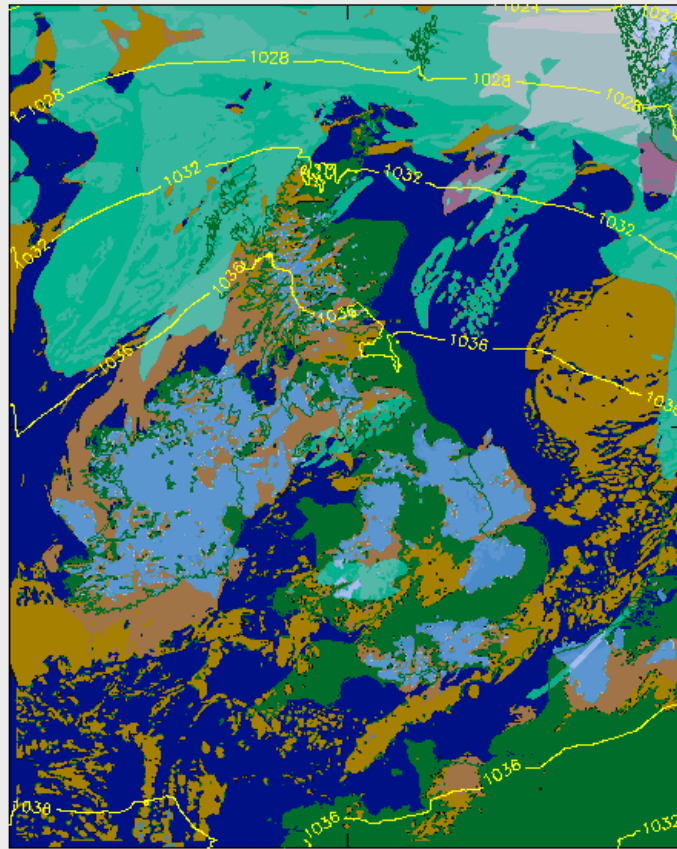




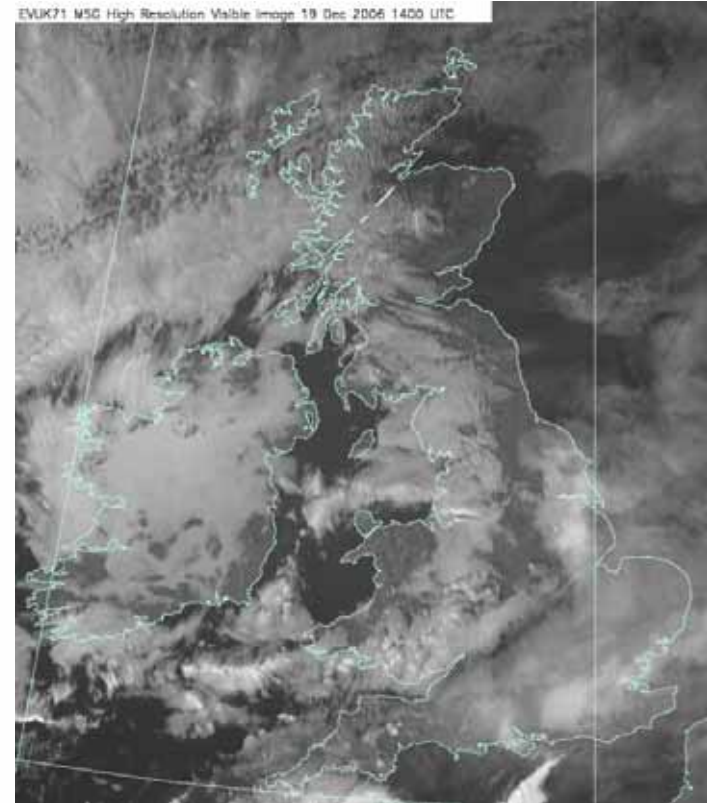
Case 19/12/2006. Fog

14:00 UTC. T+5

At 14Z on 19/12/2006, from 06Z on 19/12/2006
Cloud cover and PMSL Test ukfs



- High > 50%
- Med > 50%
- Low > 50%
- Stratus > 10%
- Fog > 40%



Good over Ireland.

Too little over SE England?



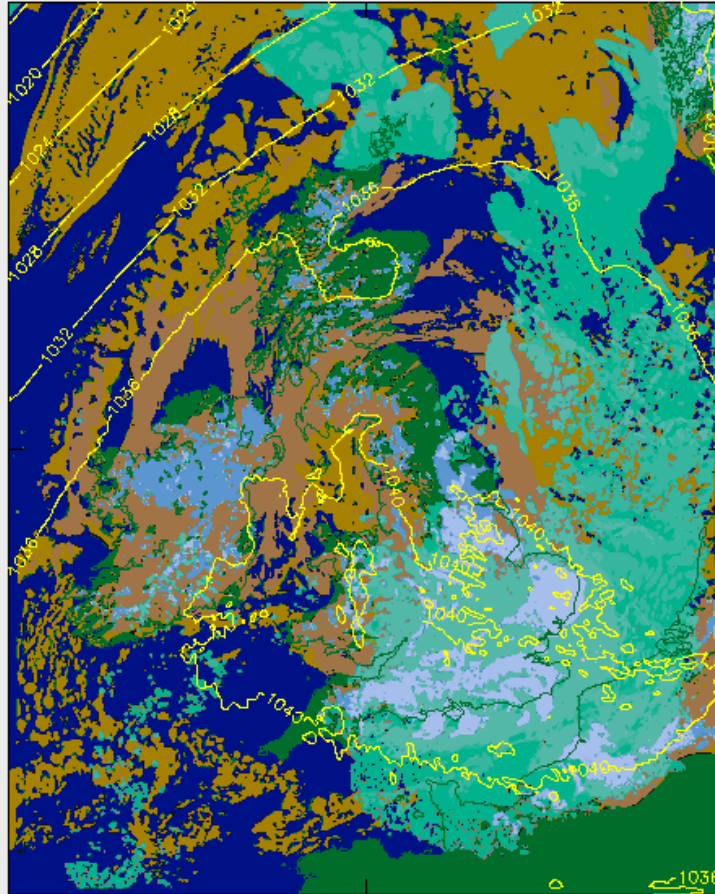
Case 19/12/2006. Fog

20/12/2006 13:00 UTC. T+28

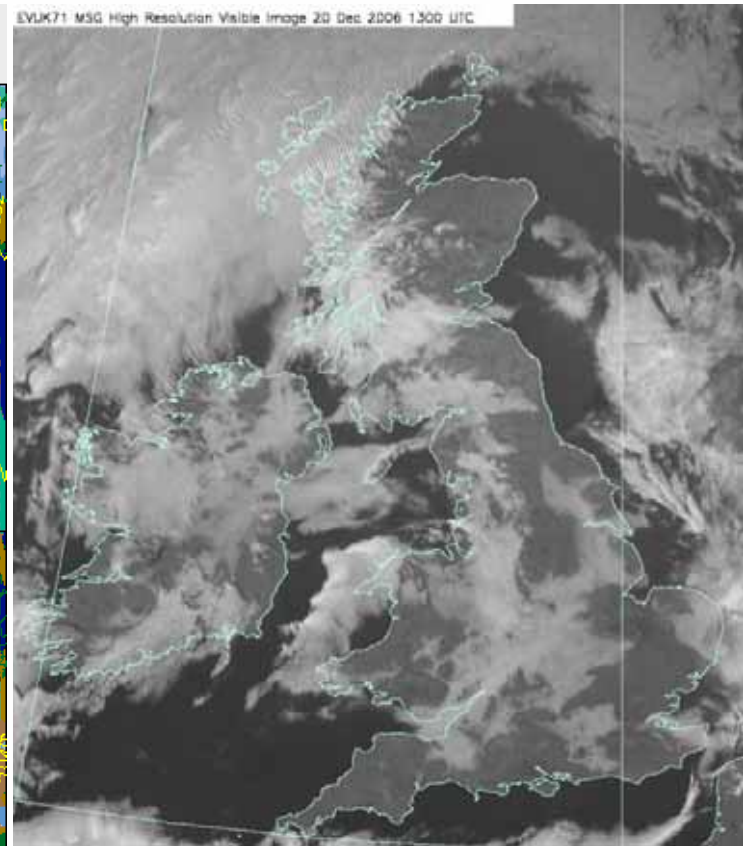


- High > 50%
- Med > 50%
- Low > 50%
- Stratus > 10%
- Fog > 40%

At 13Z on 20/12/2006, from 06Z on 19/12/2006
Cloud cover and PMSL Test ukfs



EVJK71 MSG High Resolution Visible Image 20 Dec 2006 1300 UTC



Positional errors of fog
over England.

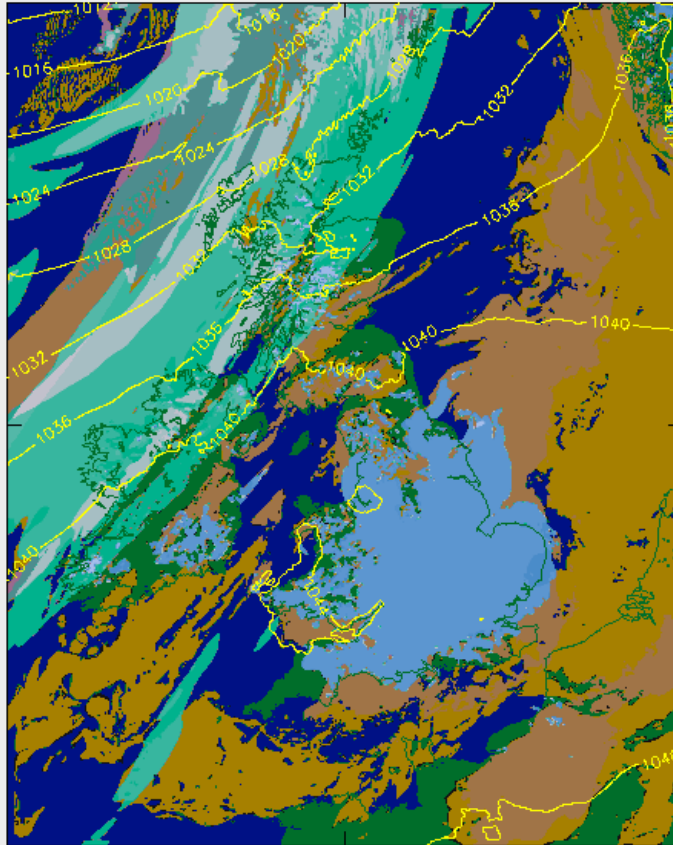
High Cloud far too West



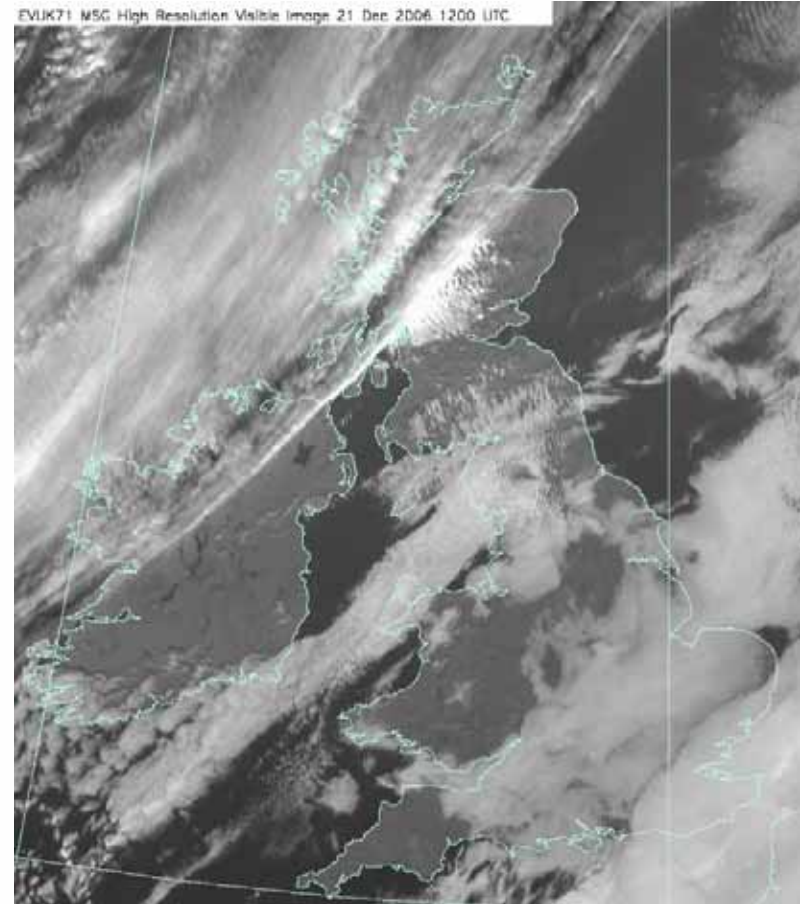
Case 21/12/2006. Fog

21/12/2006 12:00 UTC. T+15

At 12Z on 21/12/2006, from 18Z on 20/12/2006
Cloud cover and PMSL Test ukfa



High > 50%
Med > 50%
Low > 50%
Stratus > 10%
Fog > 40%



Too widespread fog in the model



Summary of UKFS case studies

- Fairly stable model
- No gross errors identified
- Tuning of the model physics has yet to be done
- Difference in resolution between the driving model (12km NAE) and the 1.5km UKFS does not cause a noticeable deterioration in forecast quality.
- Shortcomings are more likely to come from Initial Conditions.



Implementation strategy

- UKFS is fixed resolution and spins up from a 12km NAE
- UKFS is only a stepping stone to what we plan to implement.
- The plan is to introduce a variable resolution model with 3D-VAR (3 hour cycle)
- Purpose of variable resolution is to move 'spin-up' domain away from product area AND improve stability by reducing boundary mismatch.



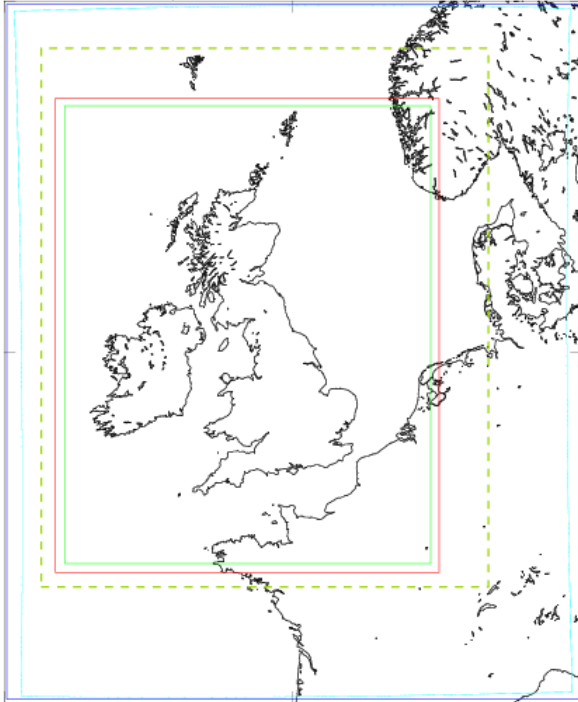
Issues for variable resolution

- Variable resolution code on NEC is as fast (CPU/point/timestep) as original fixed-resolution code.
- In addition, new pre-conditioner saves ~5% and may improve scalability.
- Best judgement is Variable resolution code same speed as benchmark. +/- 20% certainly plausible.
- 1.5-4 km runs have always been at least as good as 4 km in variable zone, 1.5 in fixed.
- We have little experience 1.5-12 km – transition from parametrized to resolved is more of an issue. We have methods which work reasonably well in idealised studies, but no proof that they work in real cases.



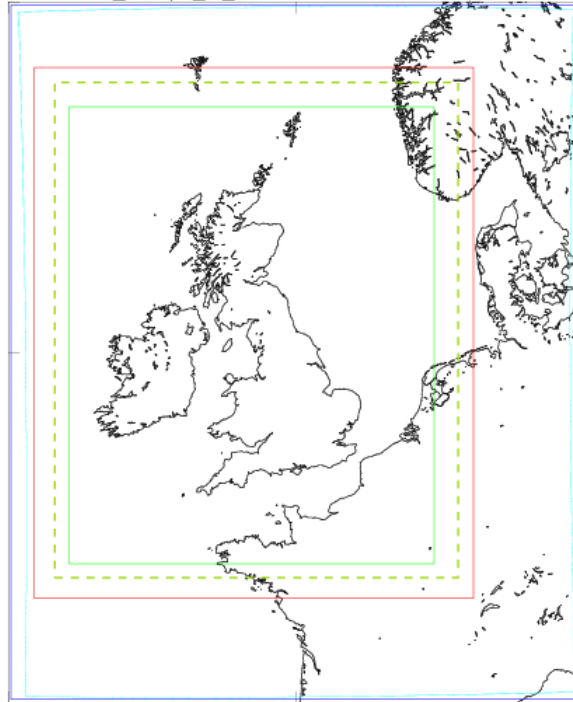
Some options for Variable resolution 1.5km model

UKV_D1 1p5_to_4 Variable Resolution Domain



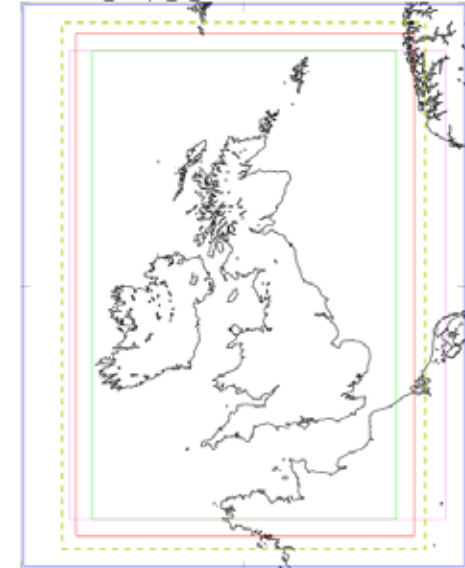
1.5-4 km 6-9%
1.57x Benchmark
~63 min

UKV_D2 1p5_to_12 Variable Resolution Domain



1.5-12 km 8-10%
1.28x Benchmark
~51 min

UKV_D4 1p5_to_4 Variable Resolution Domain



1.5-4 km 4-5%
1.12x Benchmark
~45 min



Met Office



Questions and answers