Physics Presentation – Mike Bush

for 30th EWGLAM and 15th SRNWP Annual Meeting 2008
6th – 9th October 2008 Madrid, Spain

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James Manners, Gabriel Rooney, Jonathan Wilkinson, Damian Wilson
et al.

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Talk Outline

- NAE Physics
- UK1.5 km results

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Talk Outline

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

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Creating a new murk aerosol source dataset

- GEMS-TNO emissions. These are in a latitude, longitude format with a resolution of 0.125˚ x 0.0625˚ (approx 5 km × 5 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 km × 50 km, covering almost all of the NAE domain. Emissions from shipping are included here.
- A nominal value of sea salt = 0.007 mg/m2s (all sea points)
- A nominal value of 0.021 mg/m2s 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.

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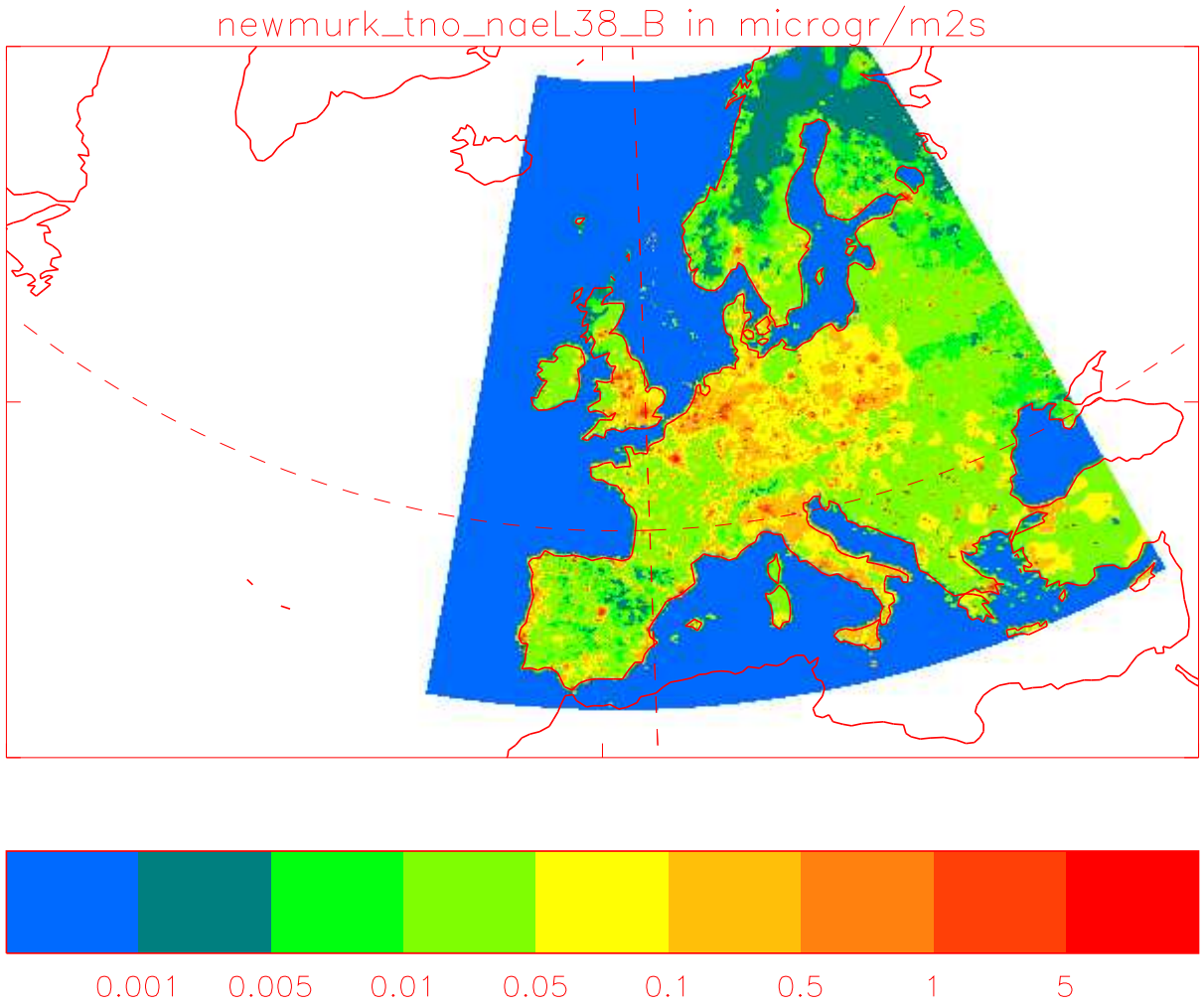
GEMS TNO dataset



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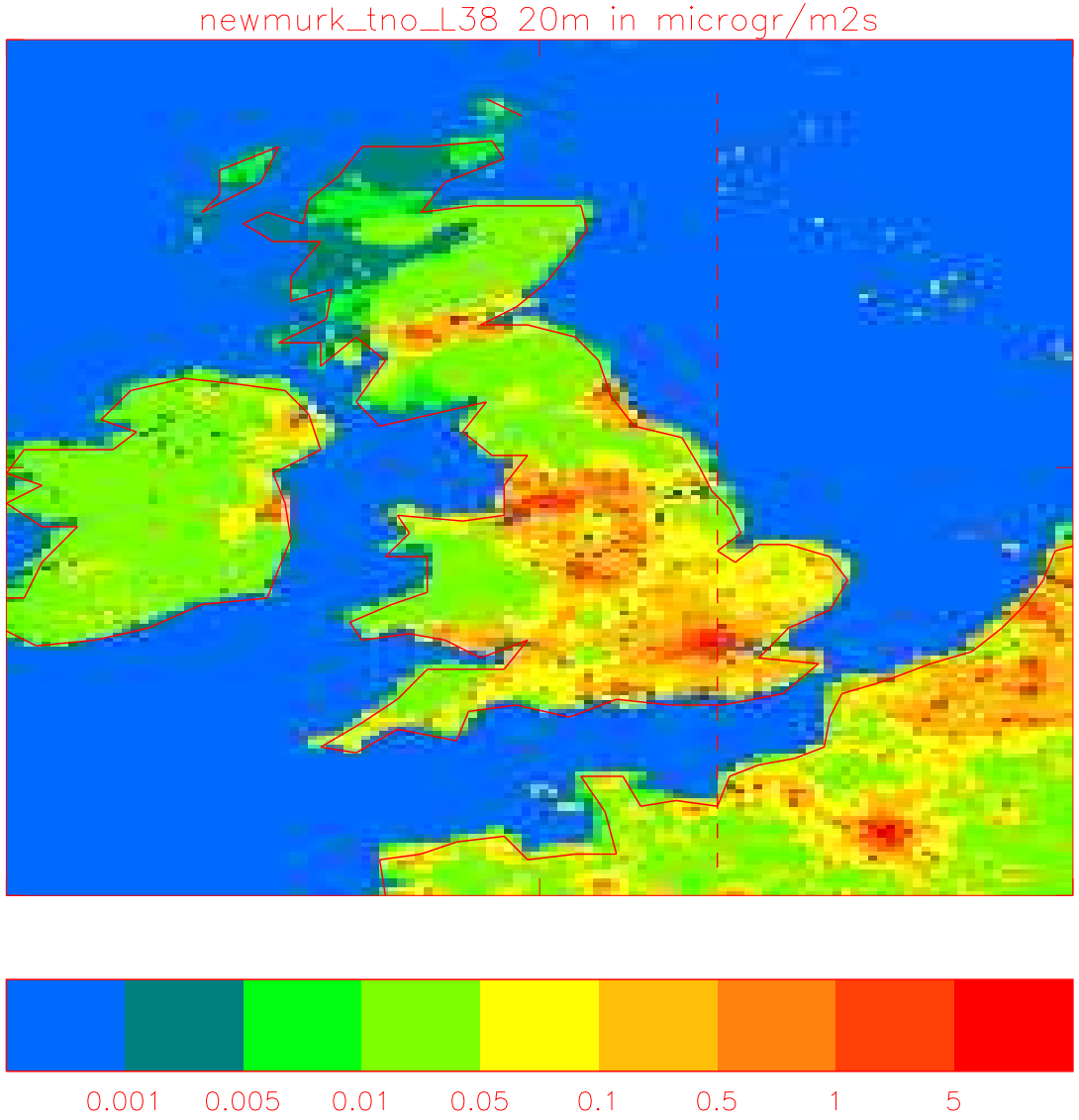
GEMS TNO dataset (zoom)



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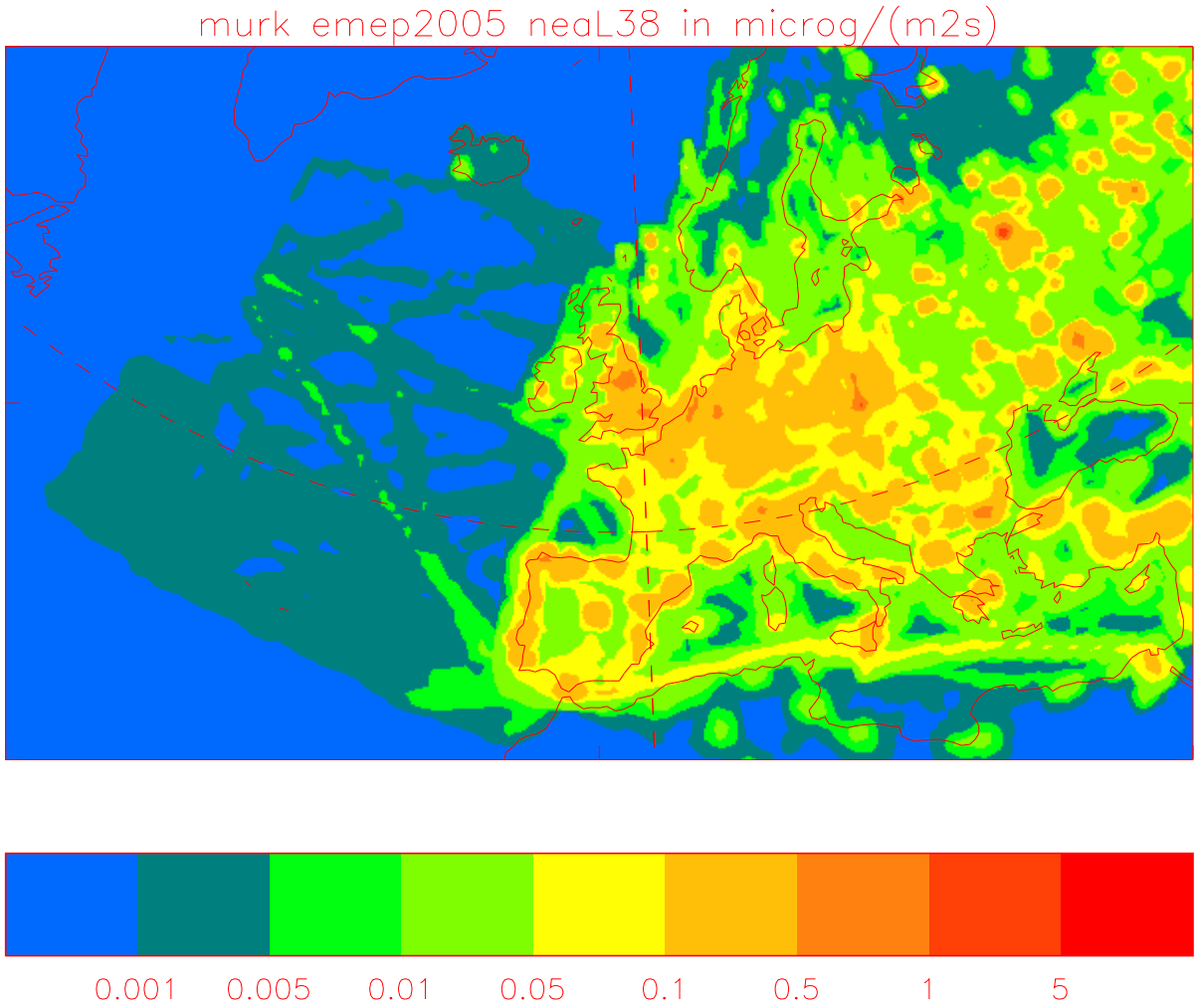
EMEP 2005 dataset



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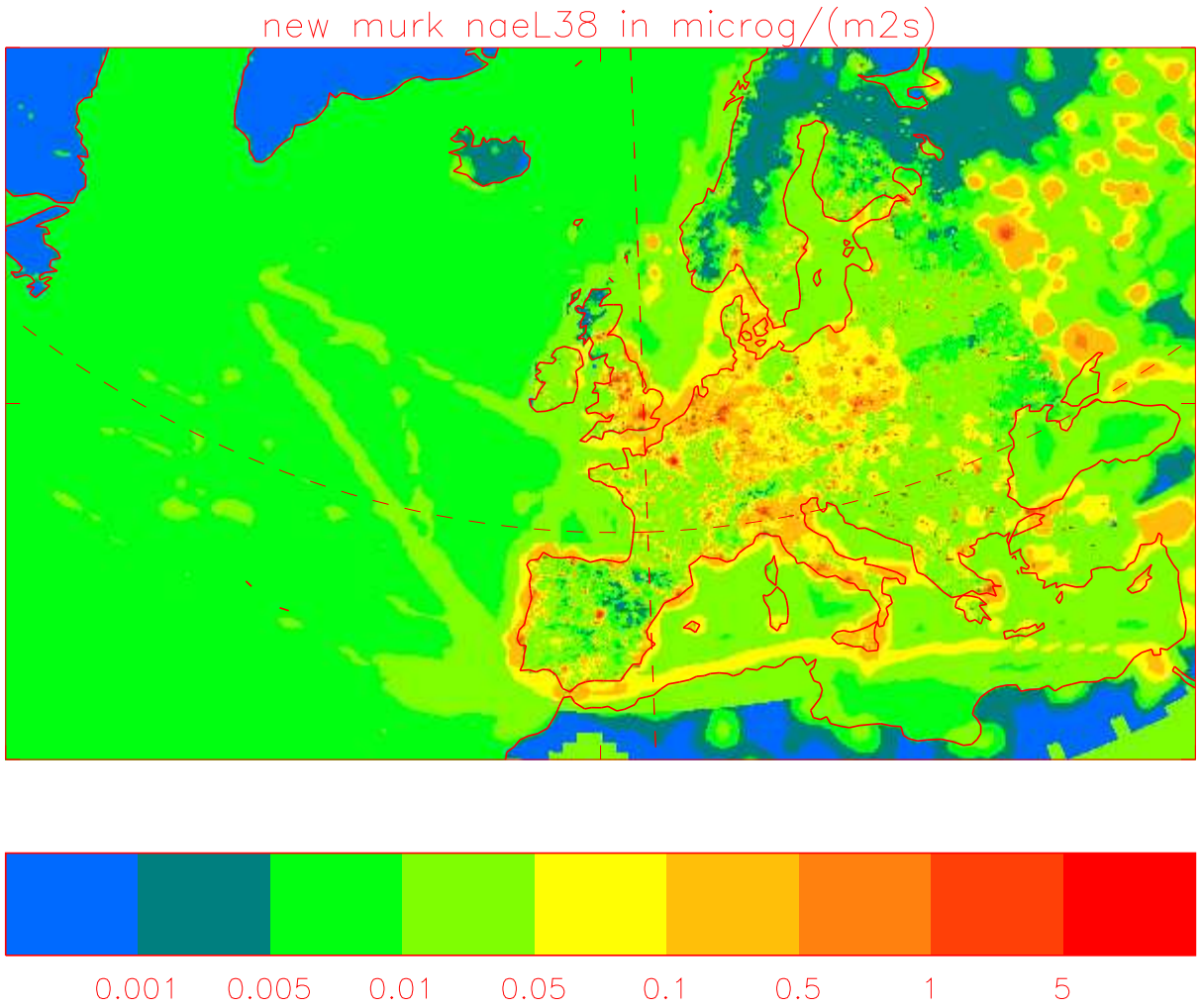
New Murk source dataset



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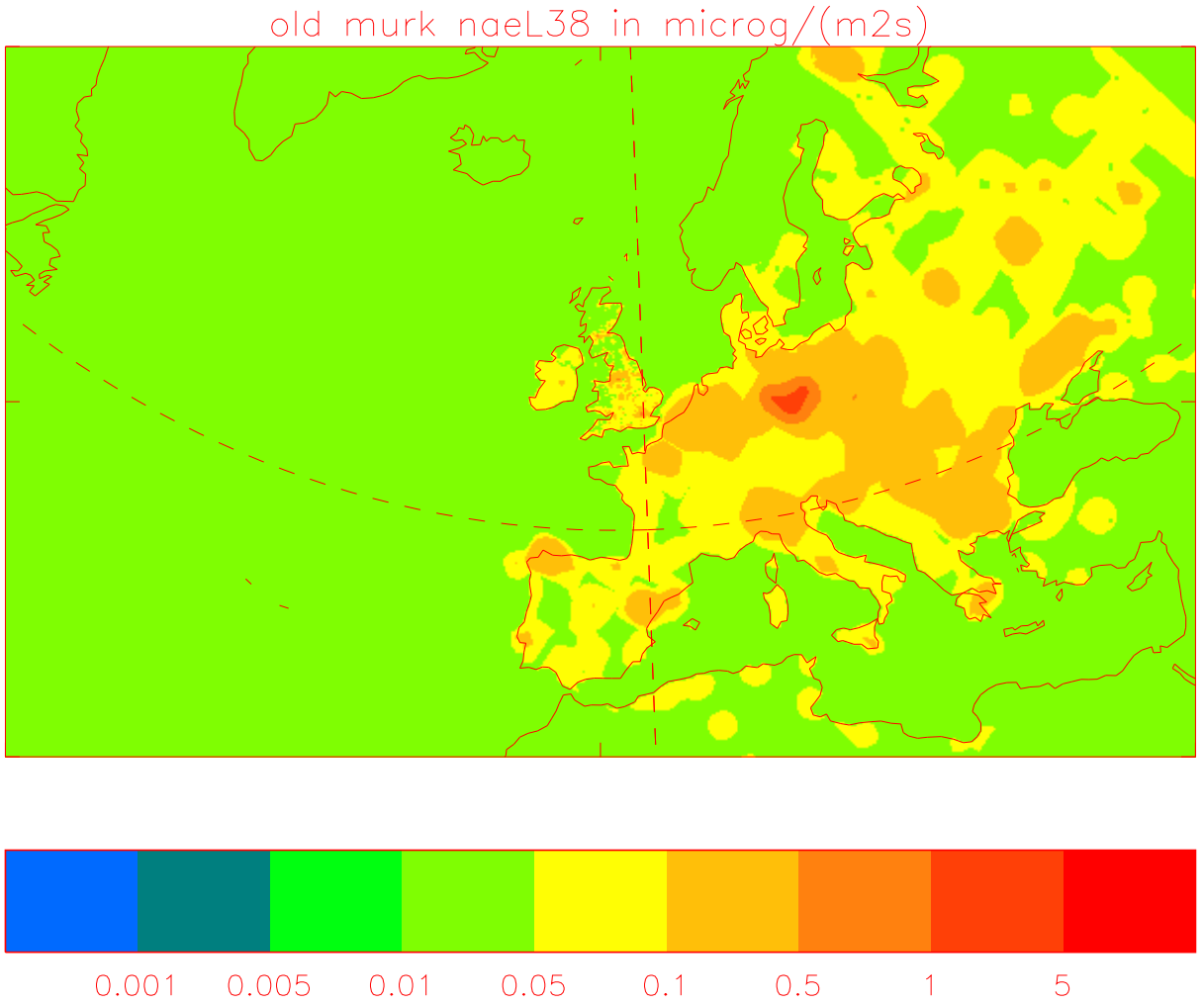
Current Murk source dataset



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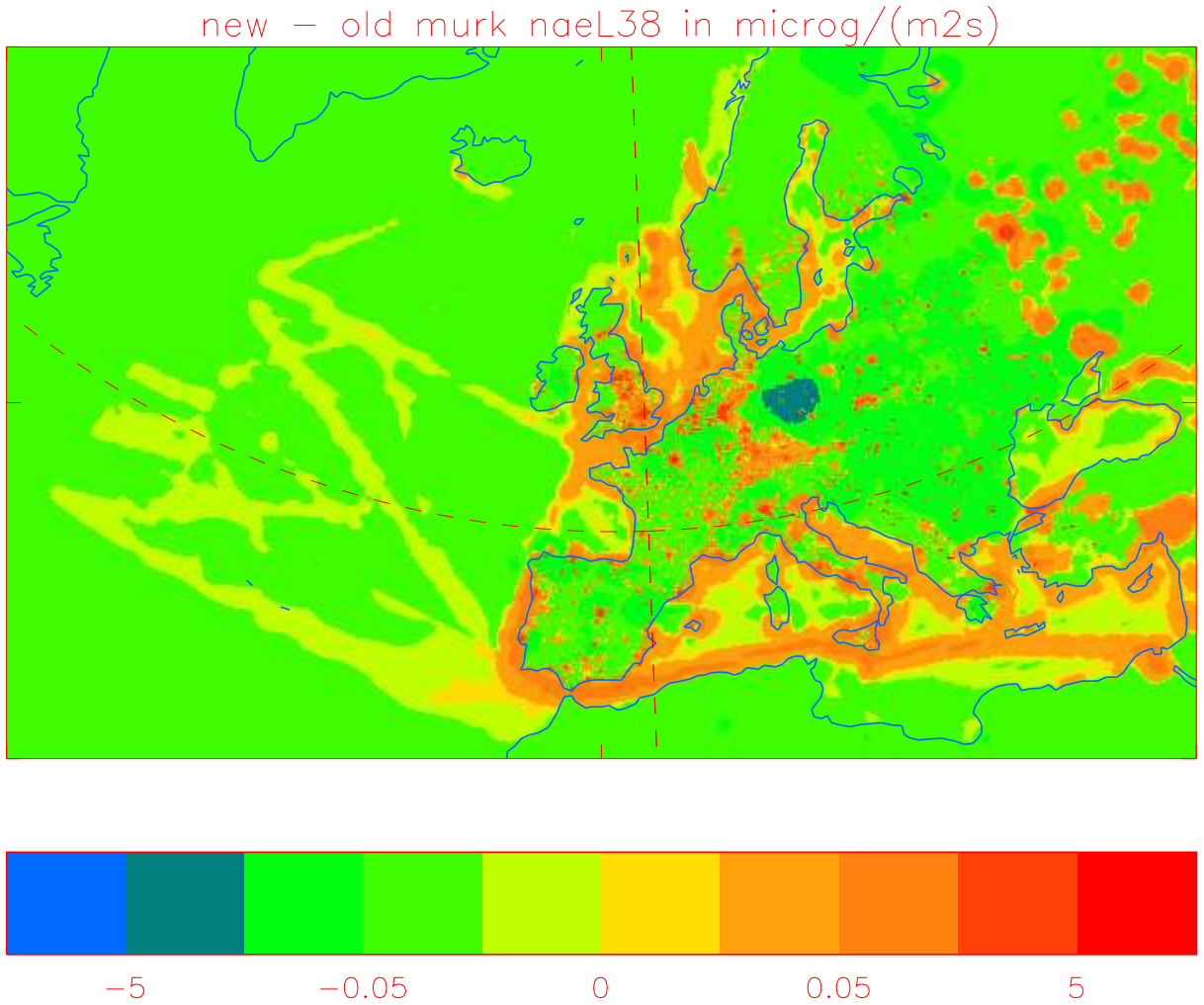
Difference (new – current)



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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.

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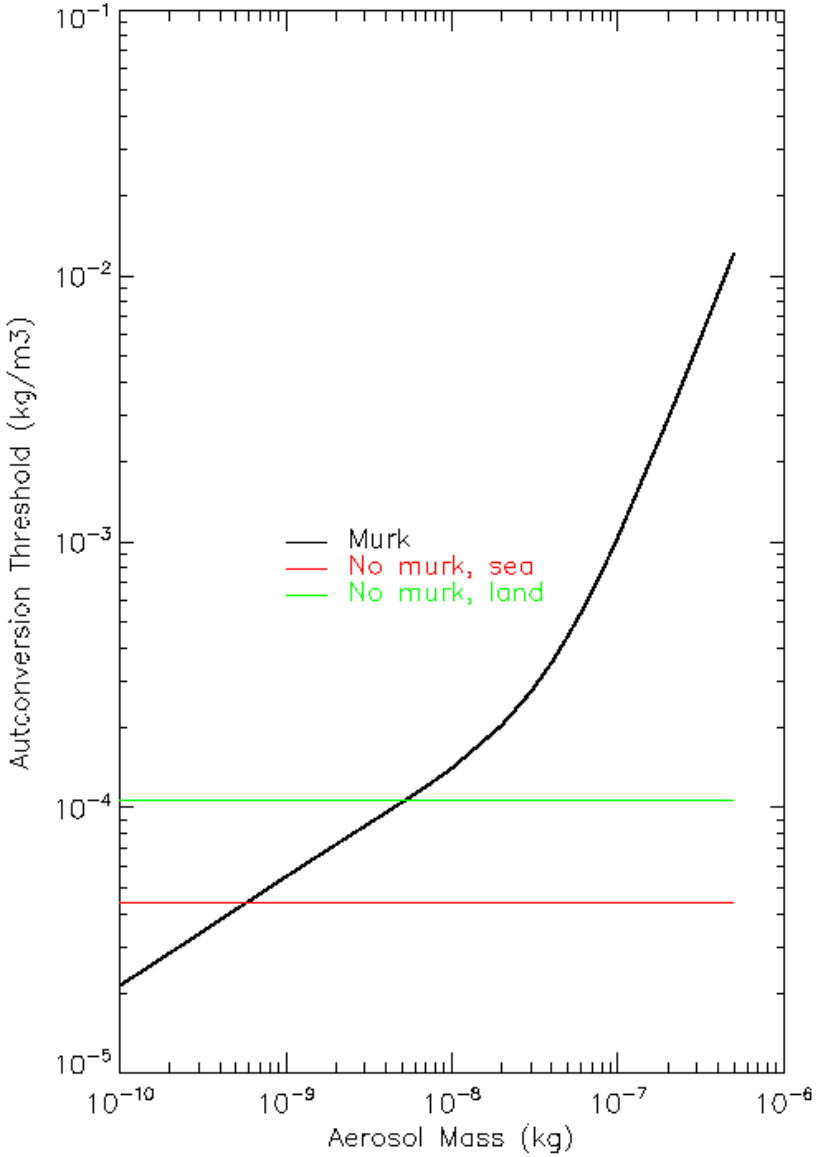
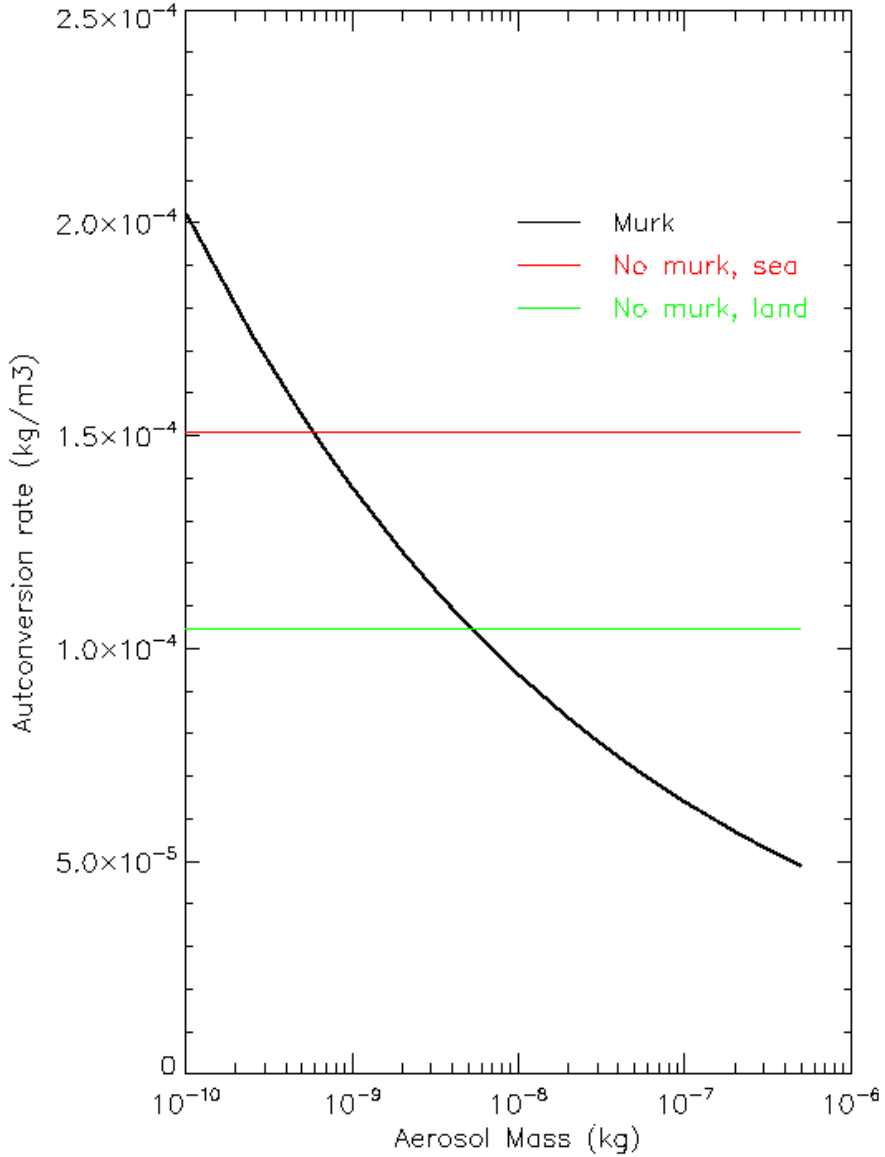
Murk link to autoconversion





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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).

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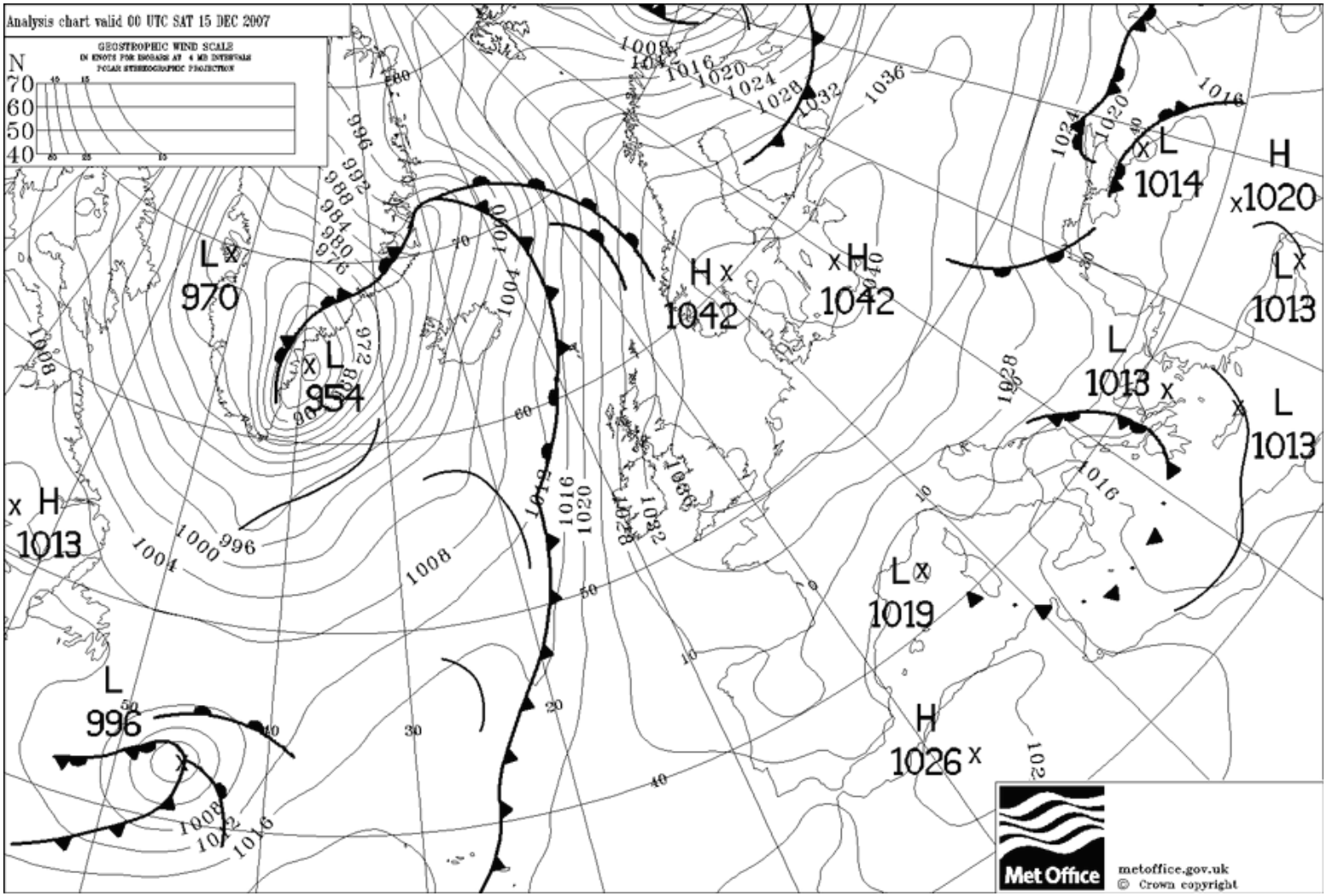
Case study – 15th December 2007



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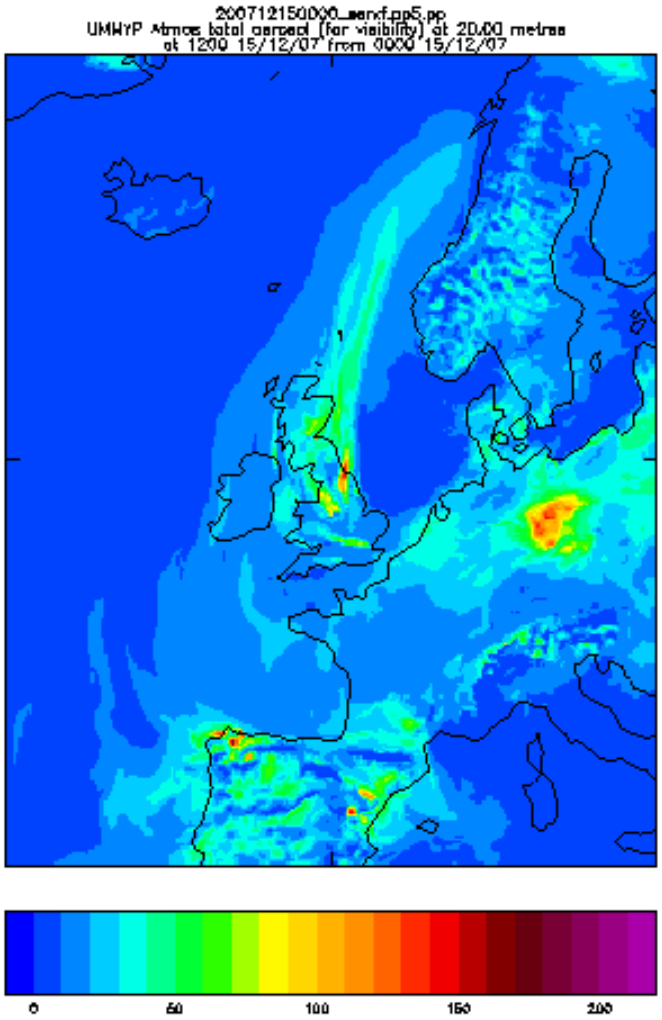
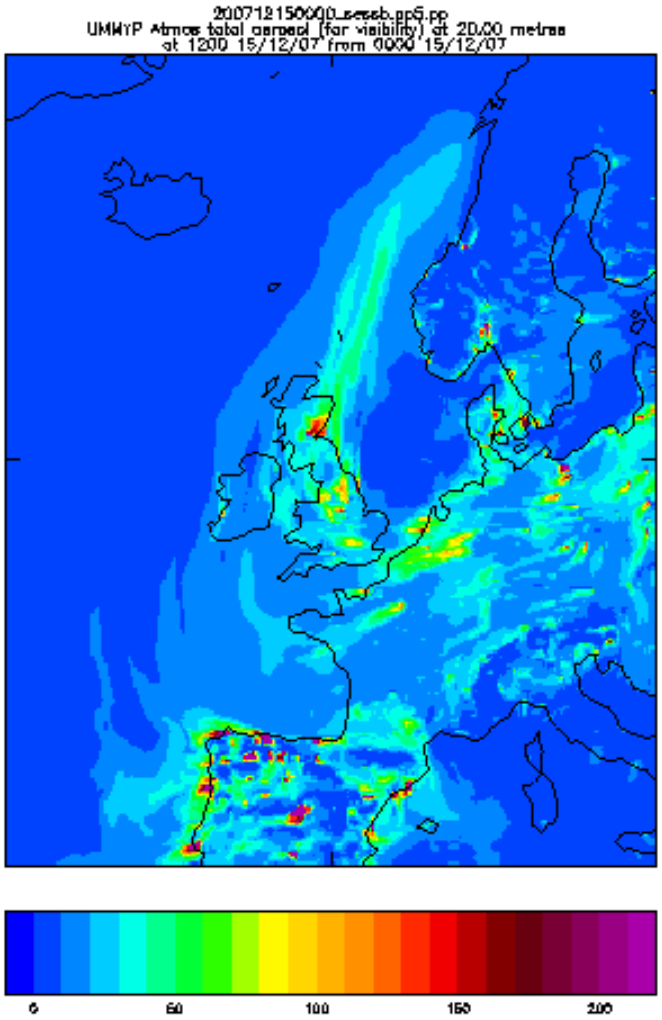
Impact of new murk sources





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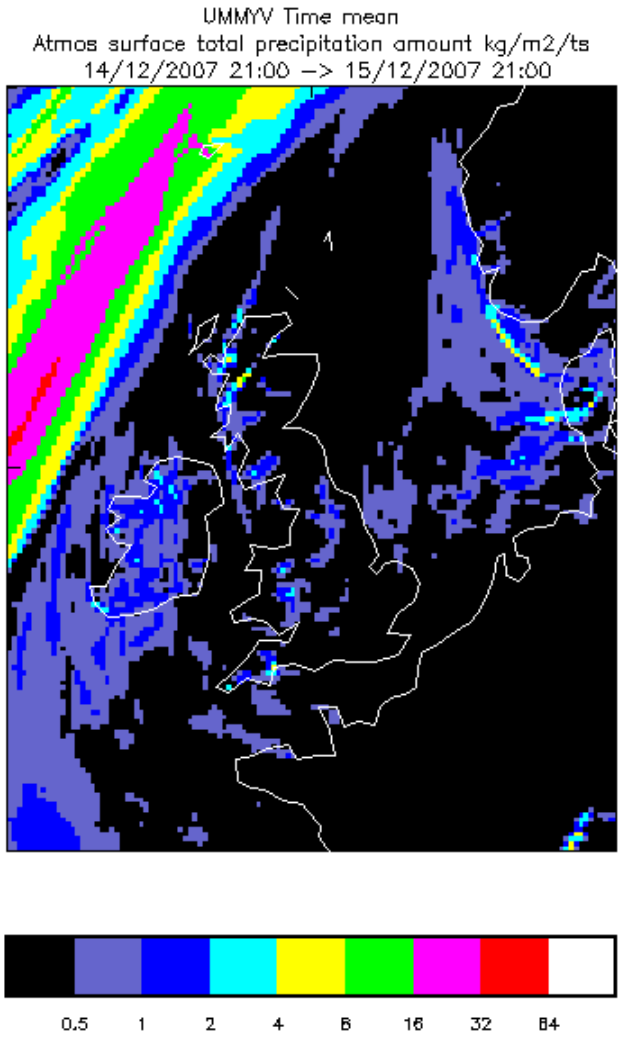
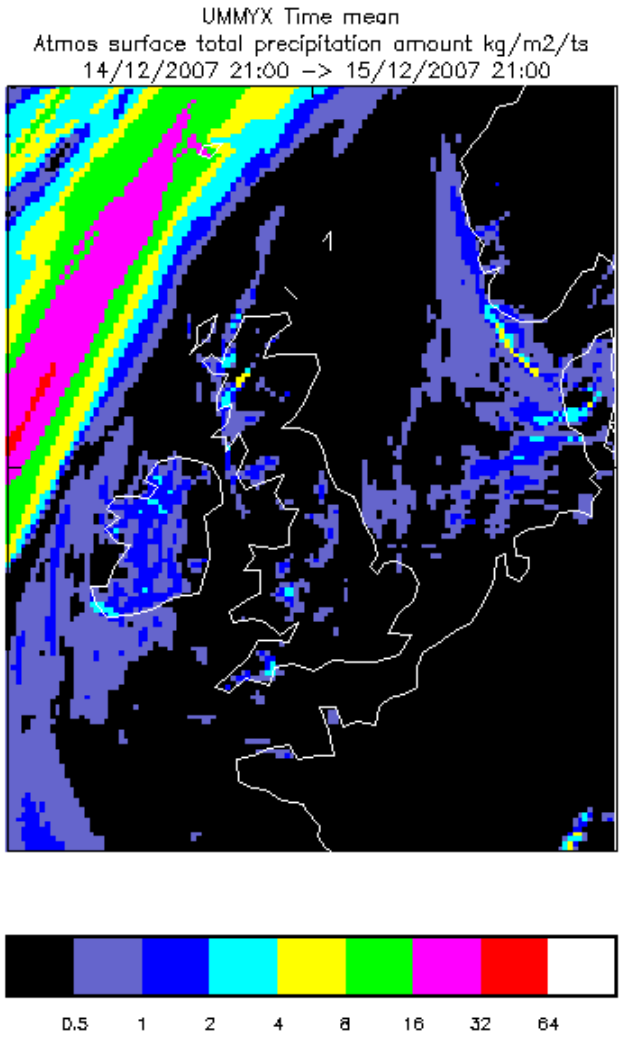
Impact of murk autoconversion





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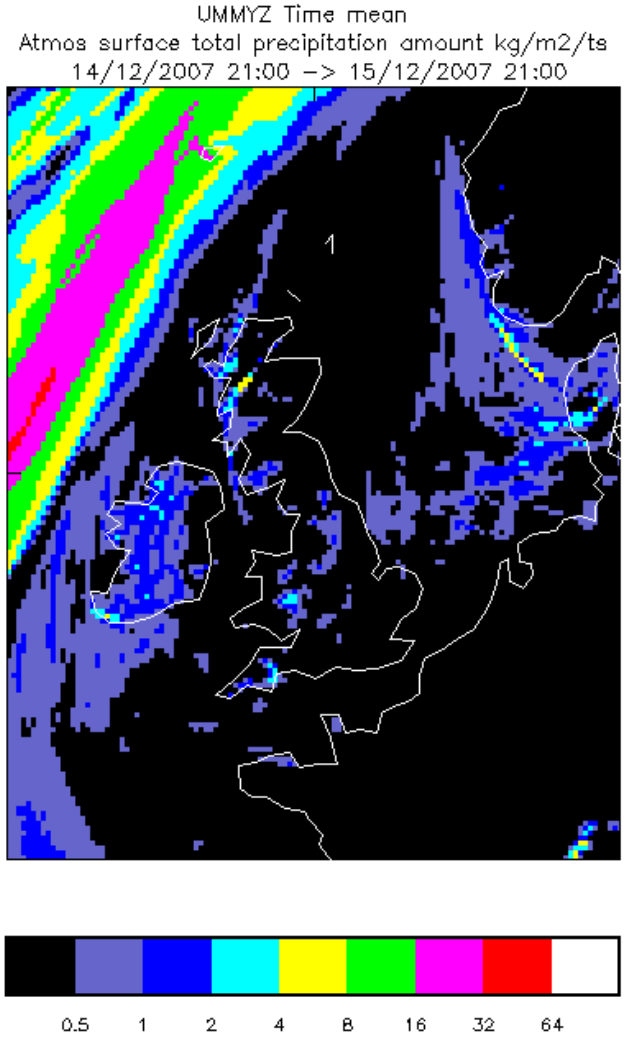
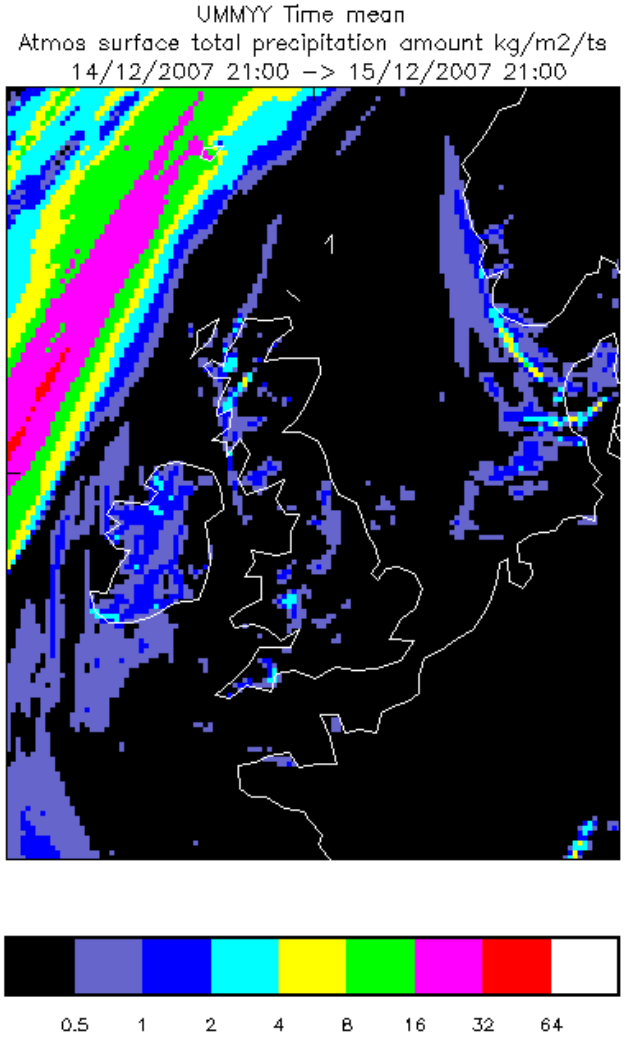
Impact of microphysics (numerics)





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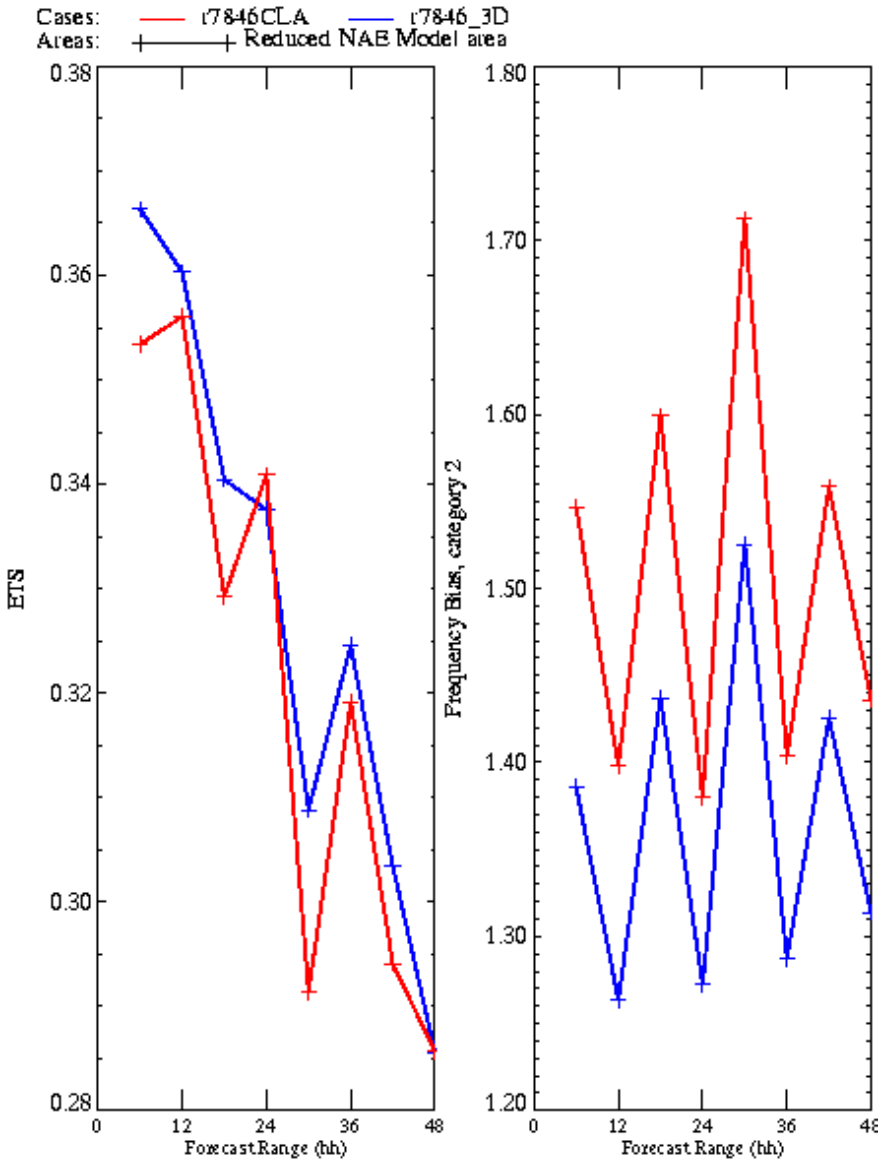
Impact of microphysics (numerics) on drizzle



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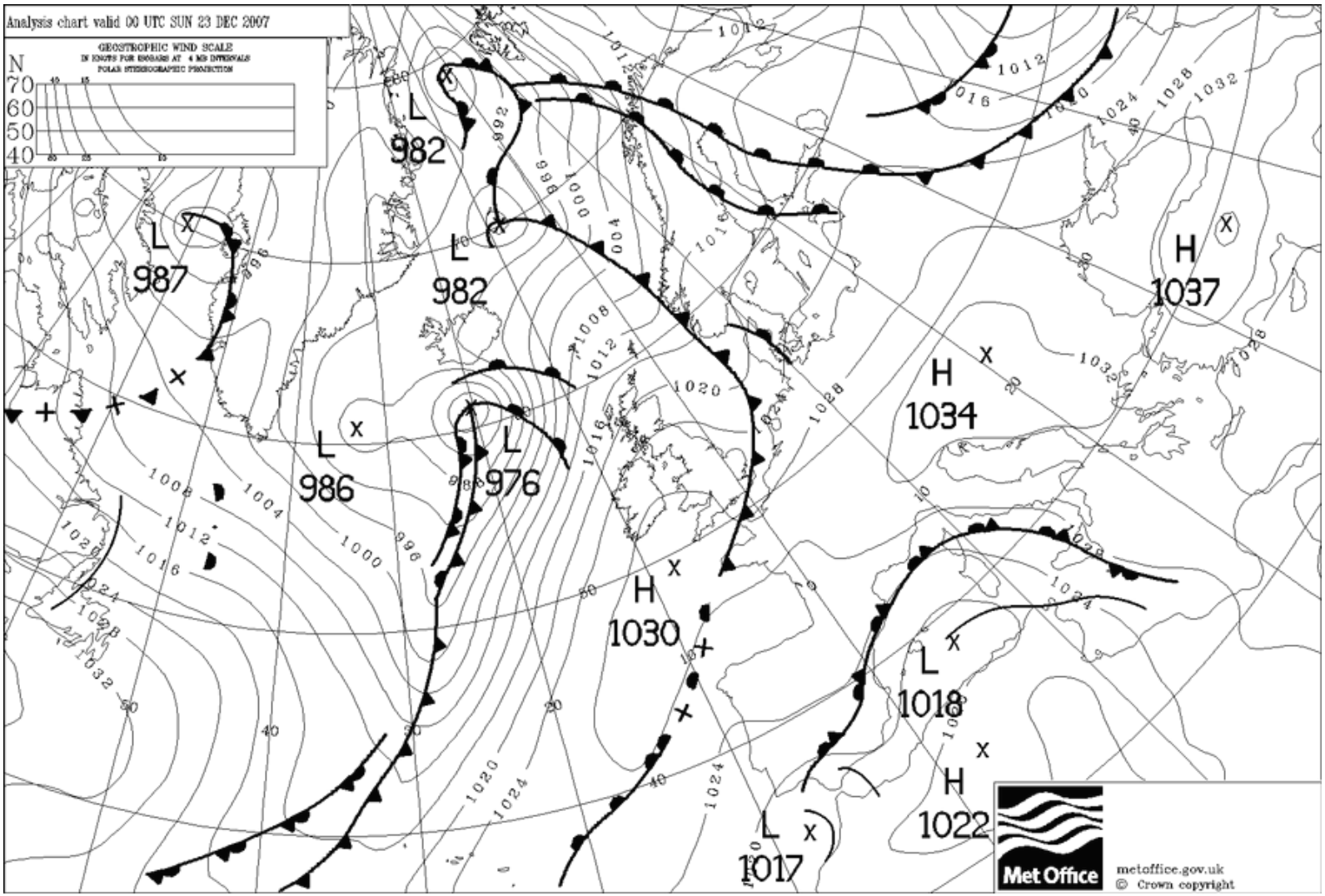
Case study – 23rd December 2007



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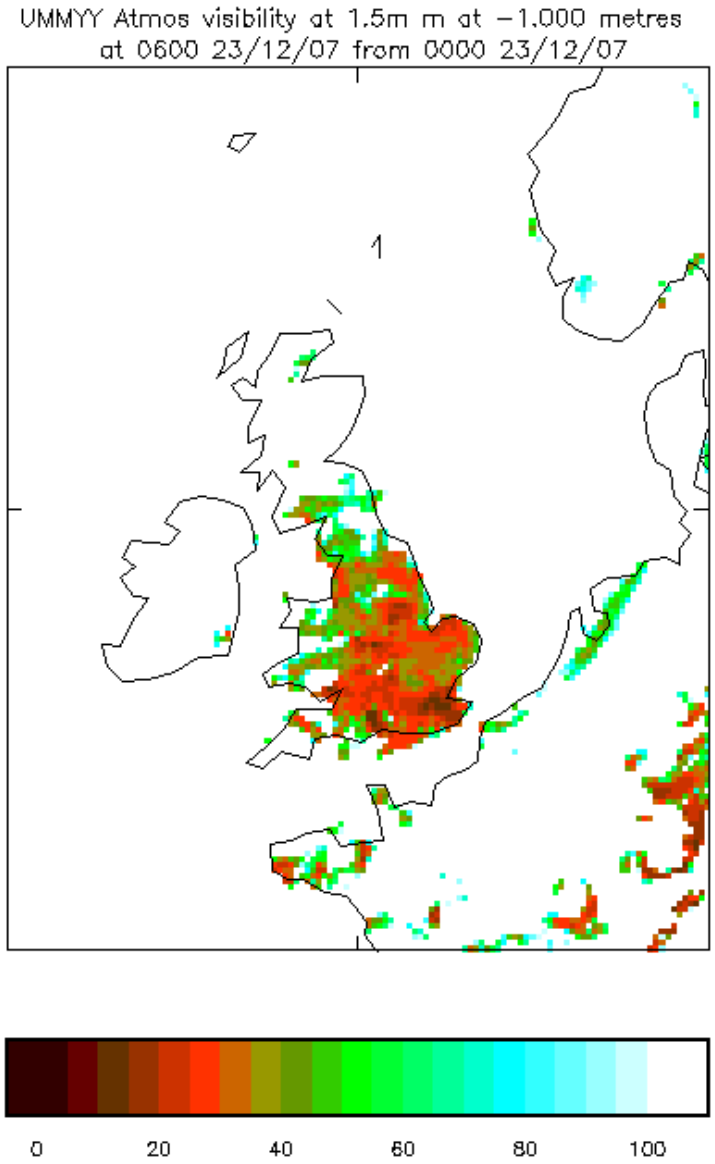
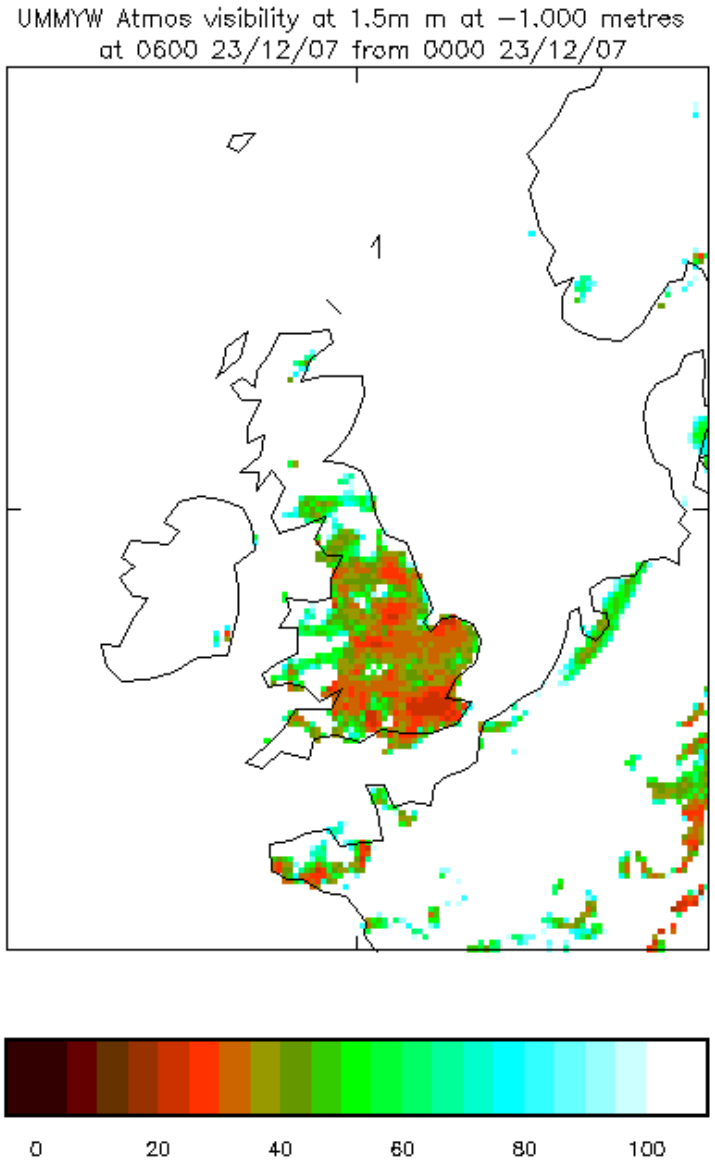
Impact of droplet settling on fog





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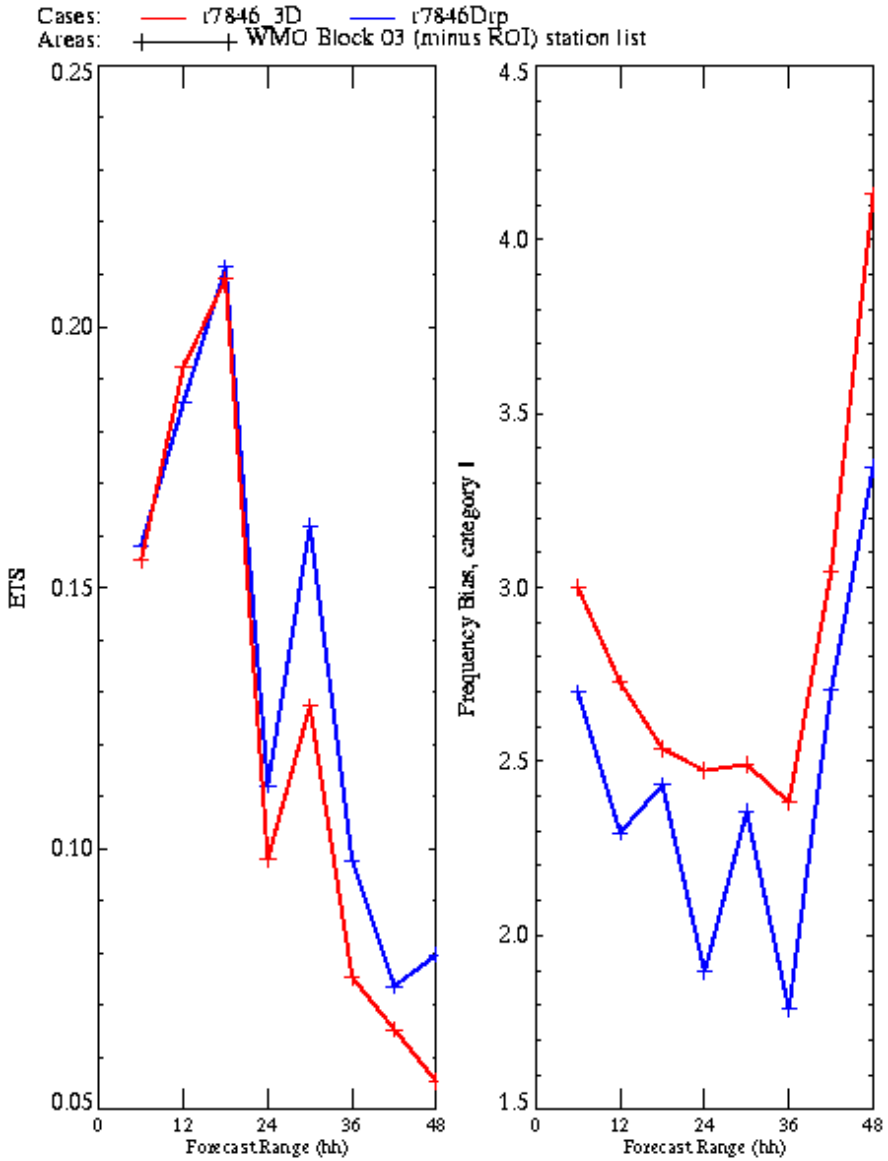
Impact of droplet settling on low visibility



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CLASSIC albedos

- This change uses date 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.

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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.

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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.

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Talk Outline

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

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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)	?

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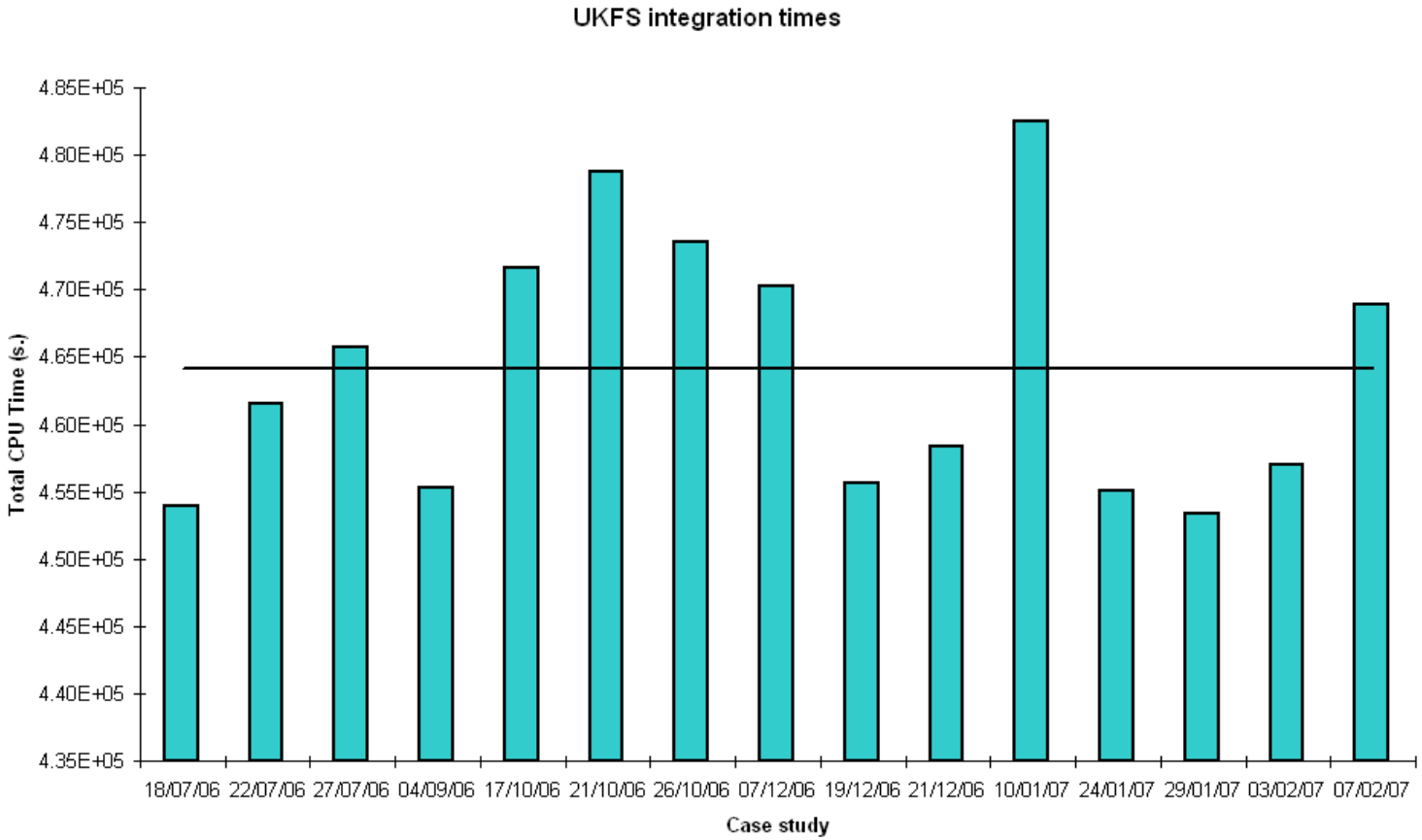
Integration Time (to T+36)

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.)



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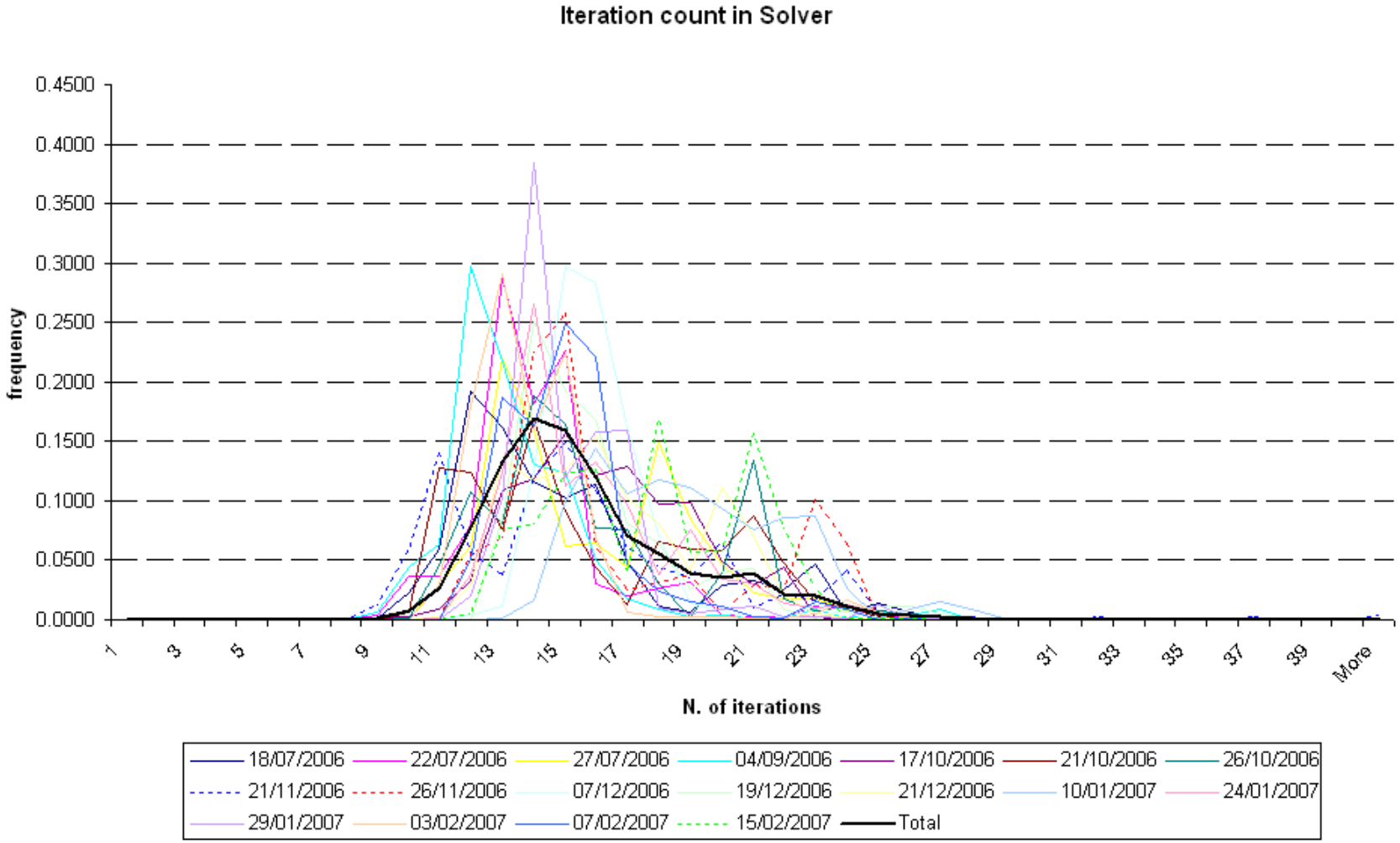
Iteration count

Typical iteration count 13-16



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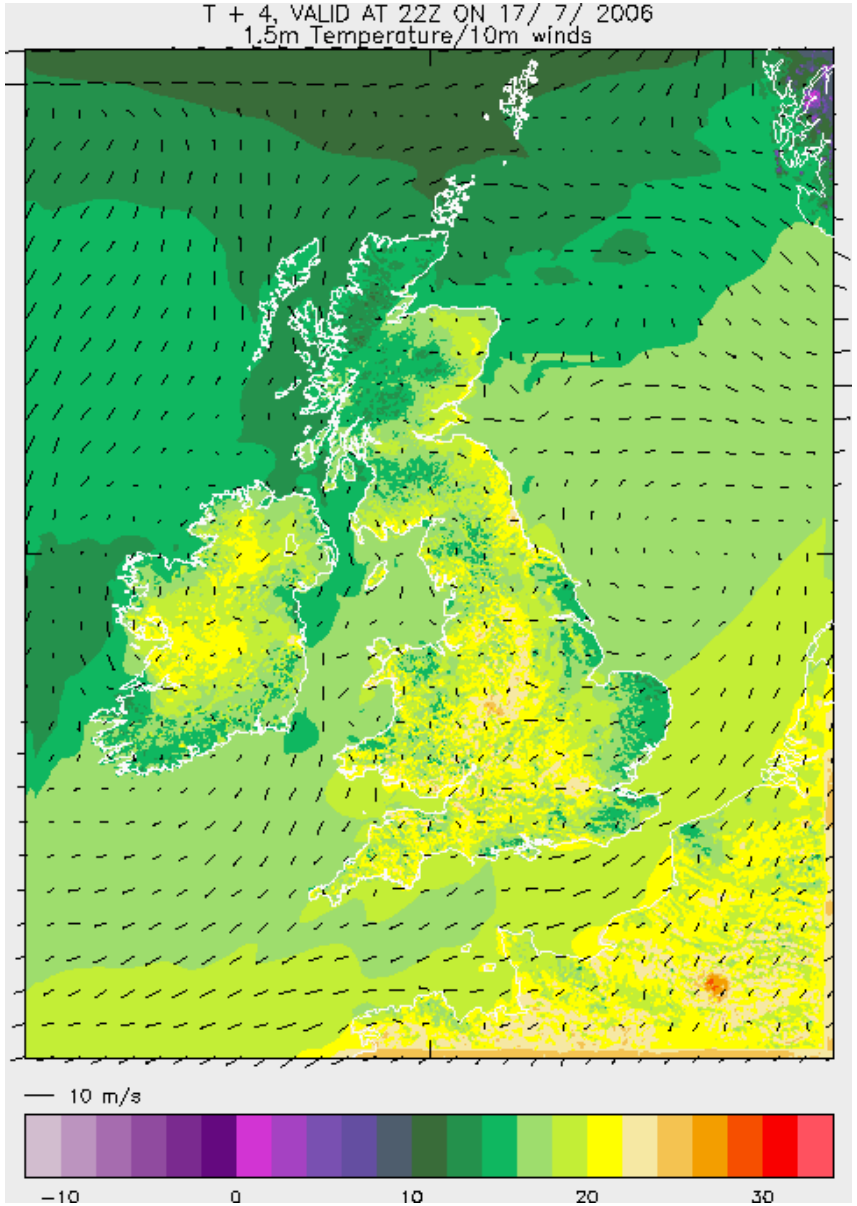
Case 18/07/2006. Heatwave



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

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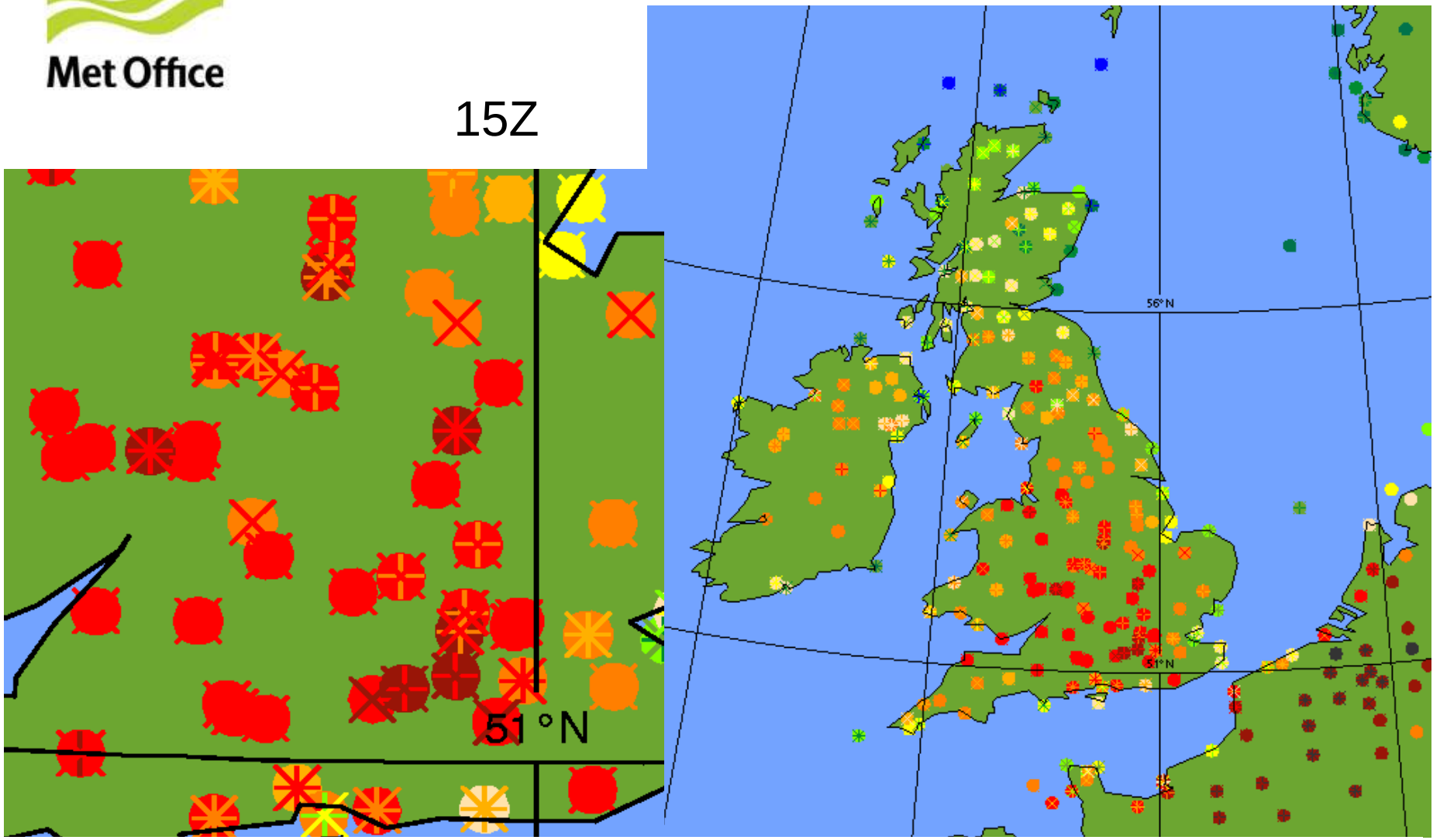
Case 18/07/2006. Heatwave

15Z



10 - 12 | 12 - 14 | 14 - 16 | 16 - 18 | 18 - 20 | 20 - 22 | 22 - 24 | 24 - 26 | 26 - 28 | 28 - 30 | 30 - 32 | 32 - 34 | 34 - 36

O Observations | + UKFS | X UK4 PS18

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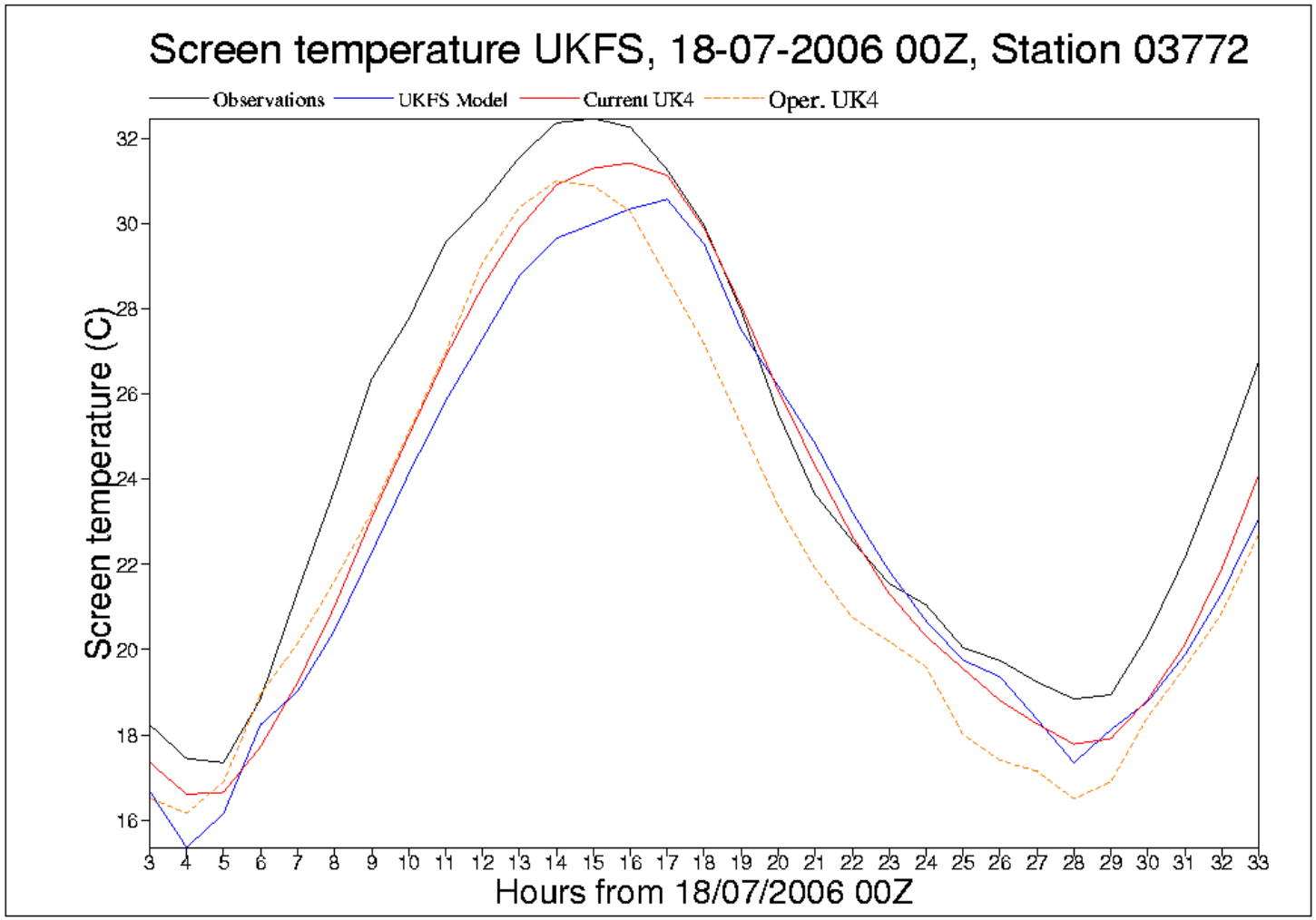
Case 18/07/2006. Heatwave

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



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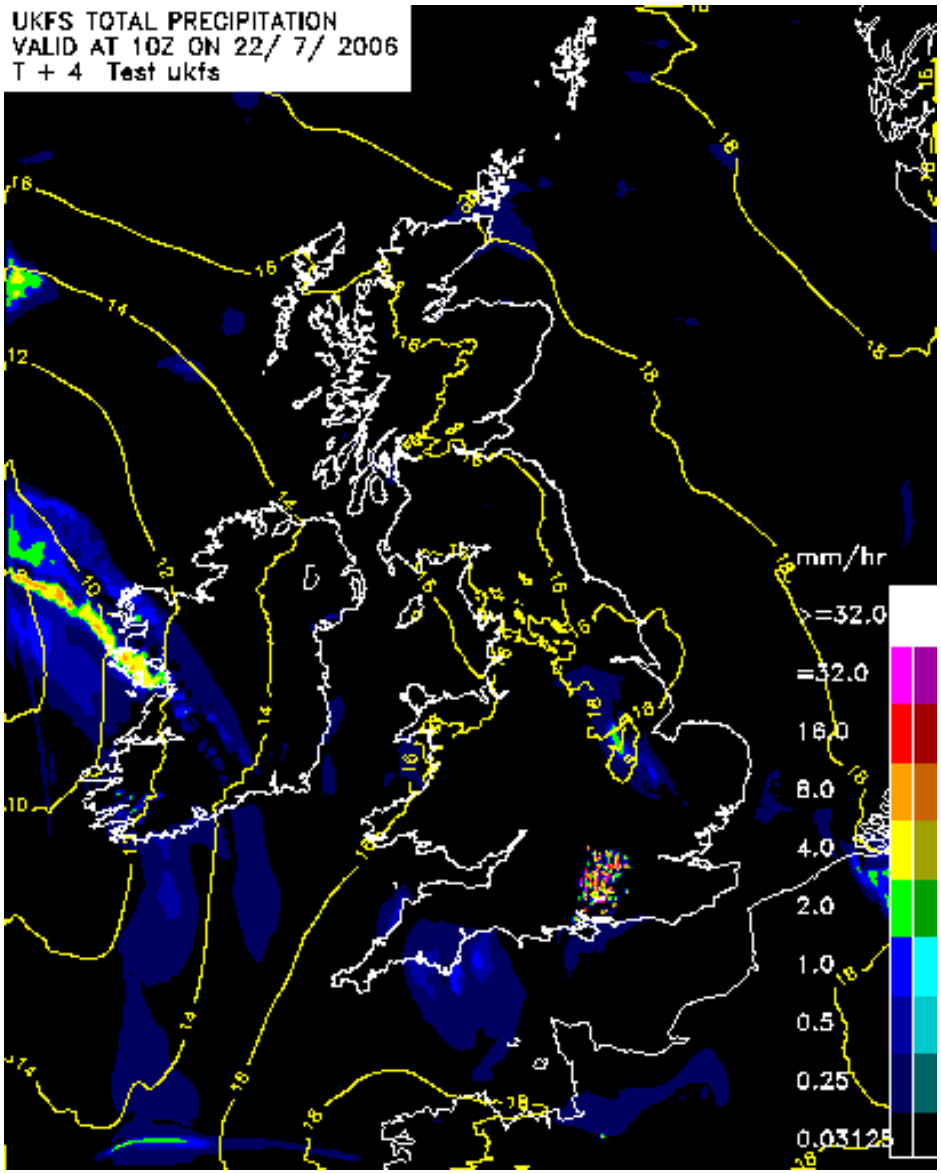
Case 22/07/2006. MCS

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



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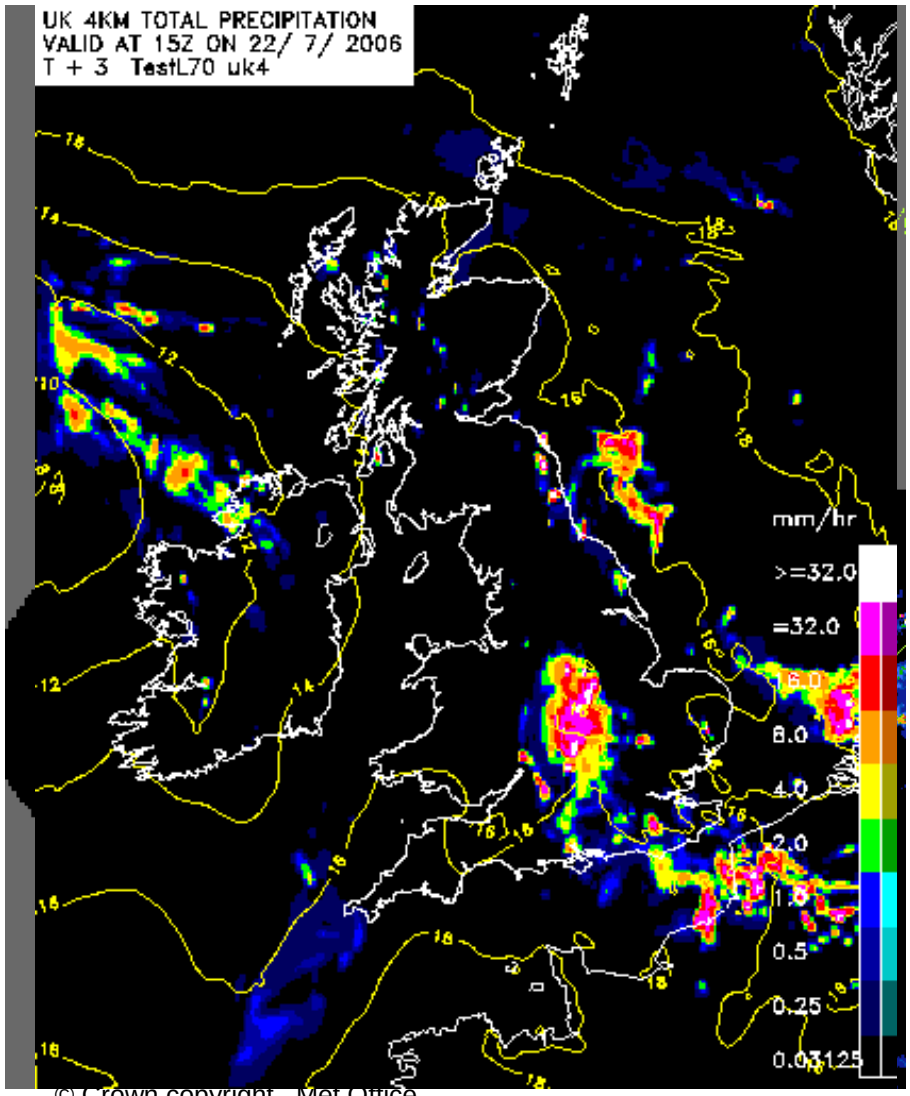
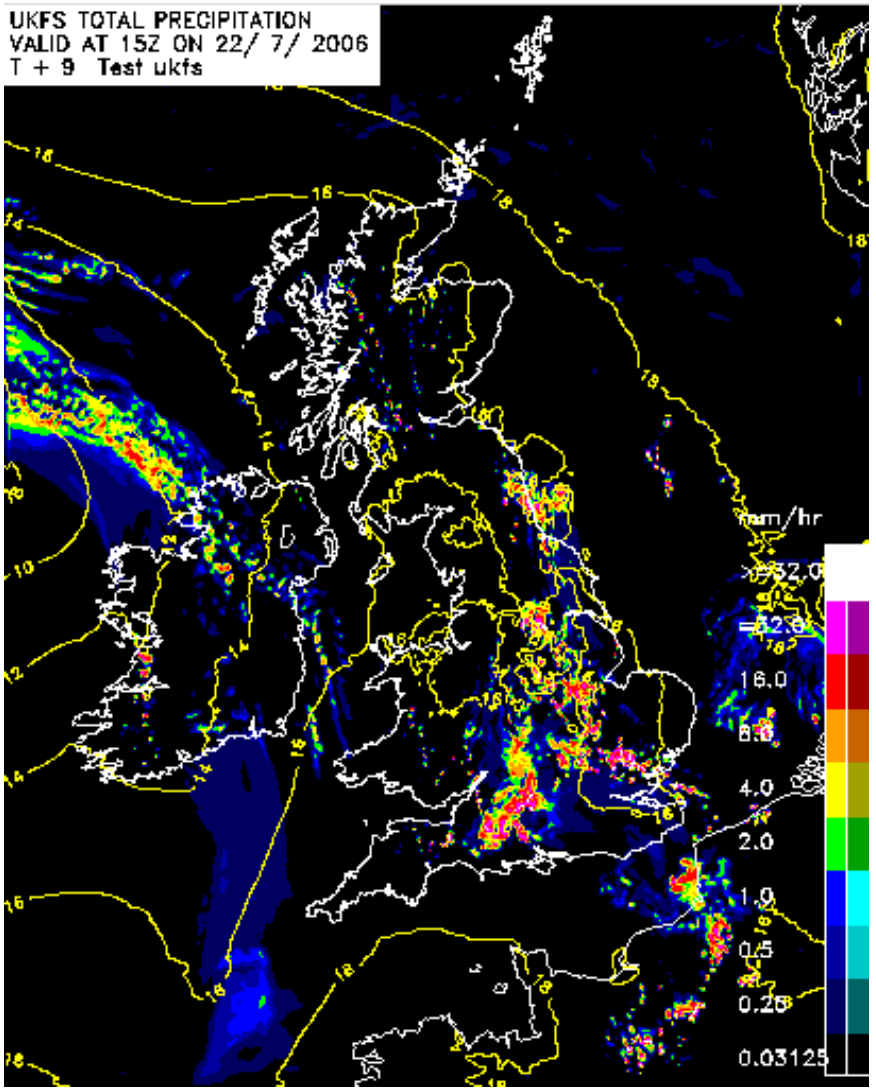
Case 22/07/2006. MCS





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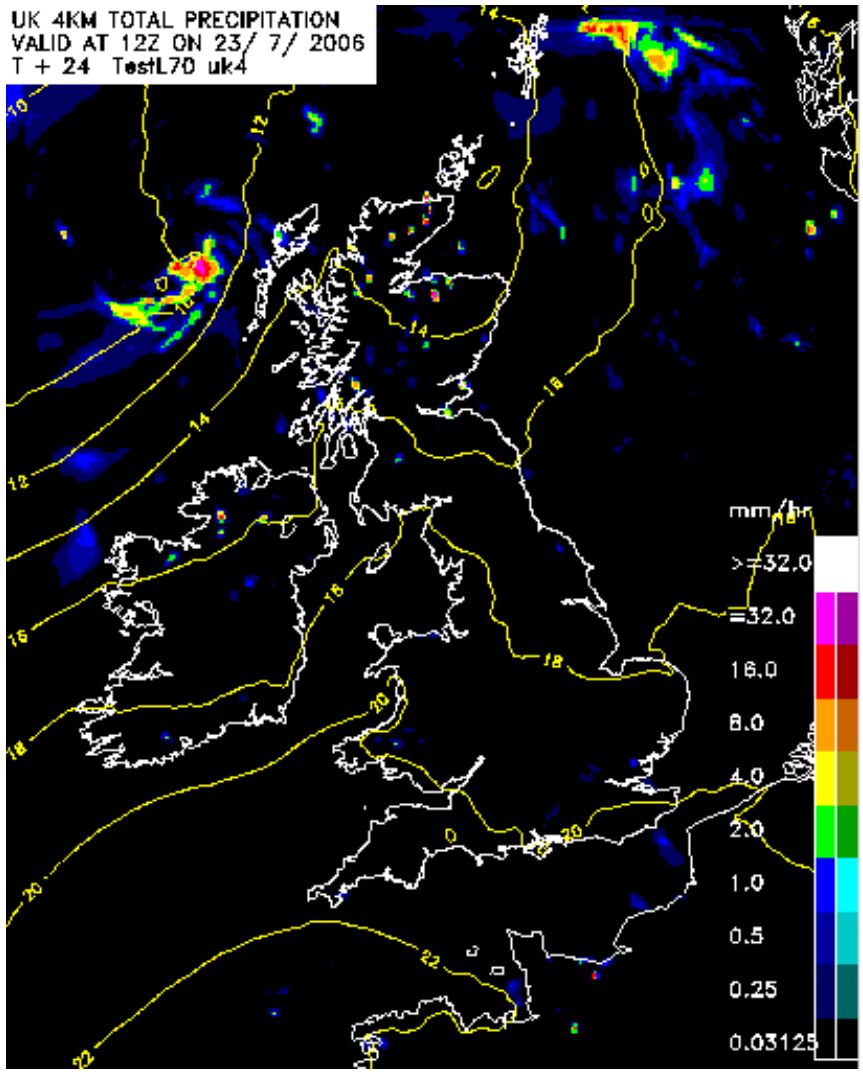
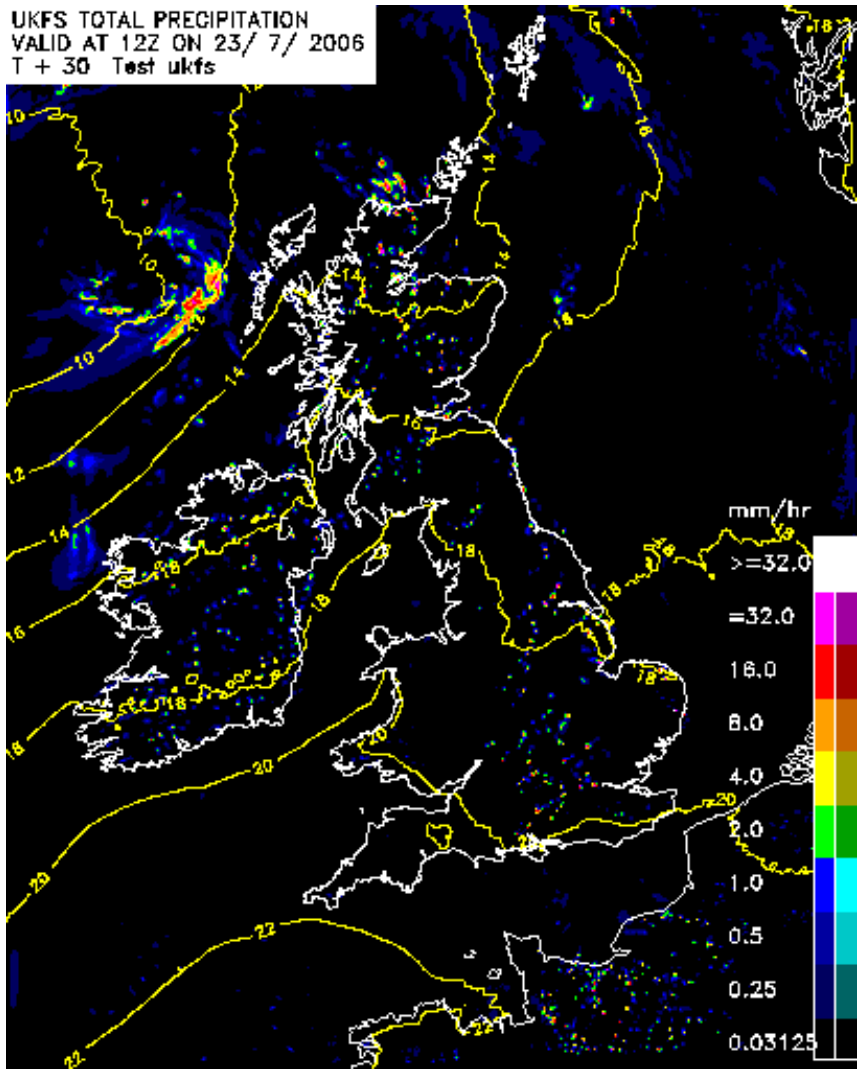
Case 22/07/2006. MCS





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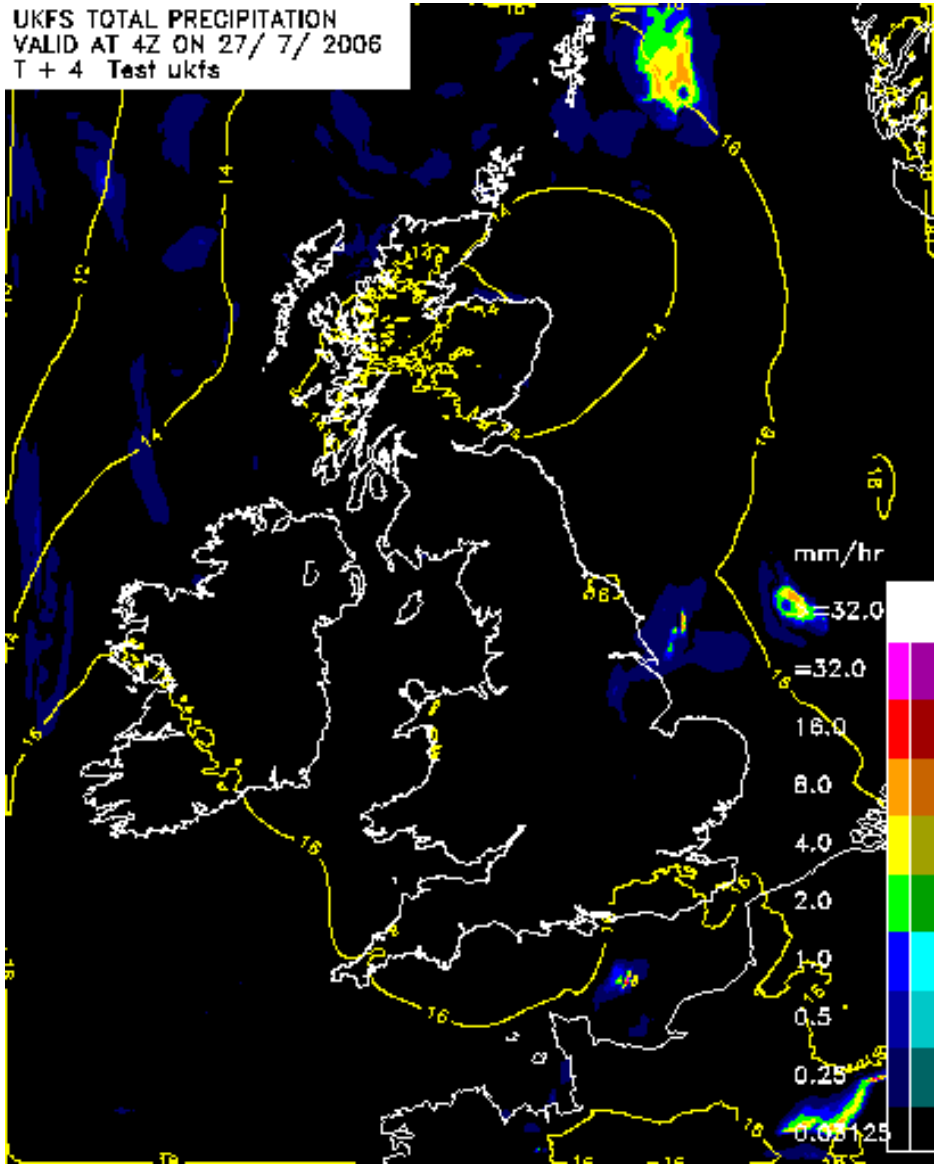
Case 27/07/2006. Thunderstorms



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

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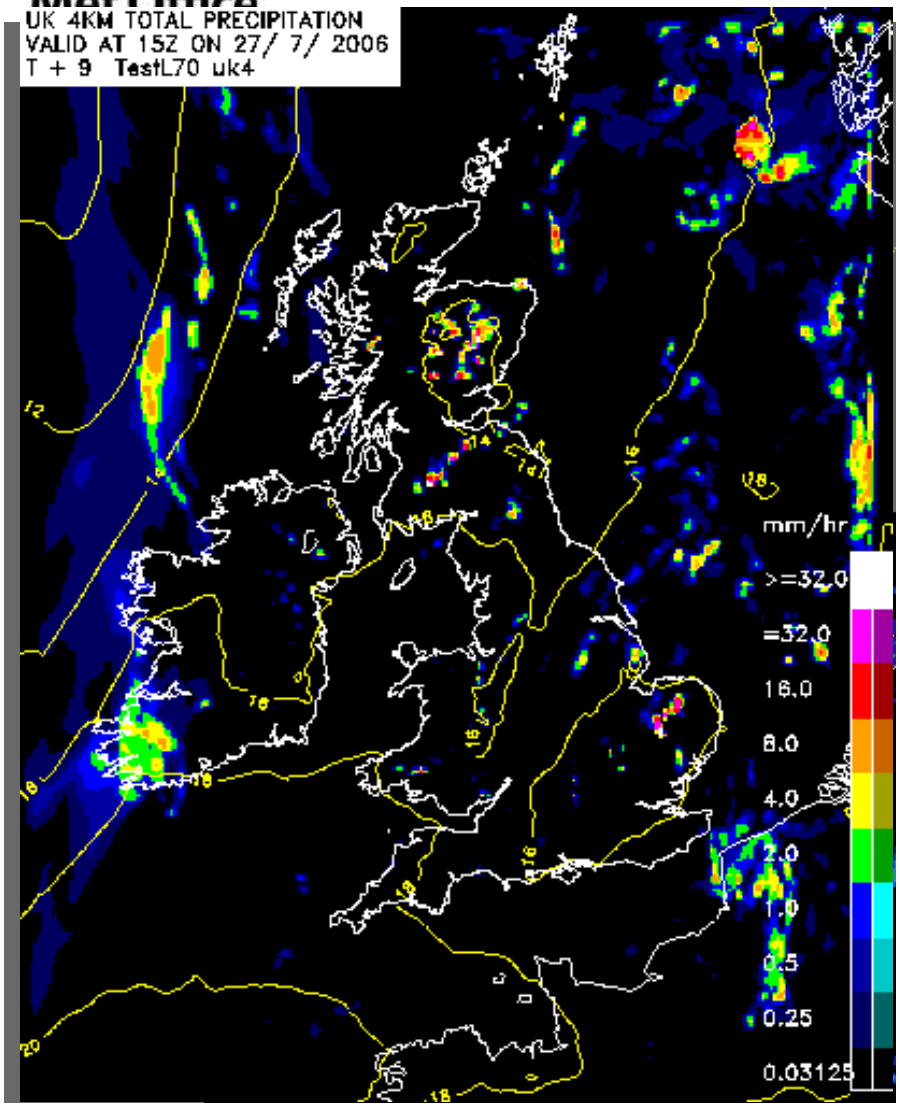
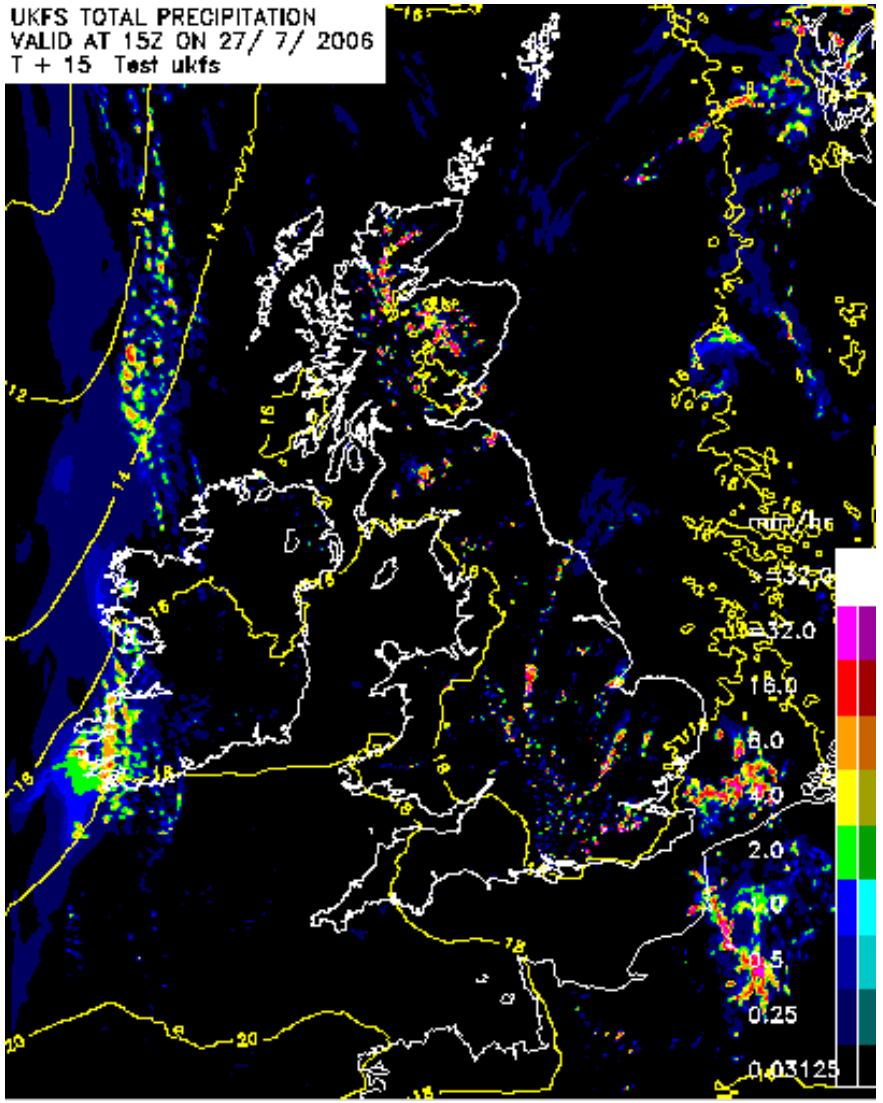
Case 27/07/2006. Thunderstorms





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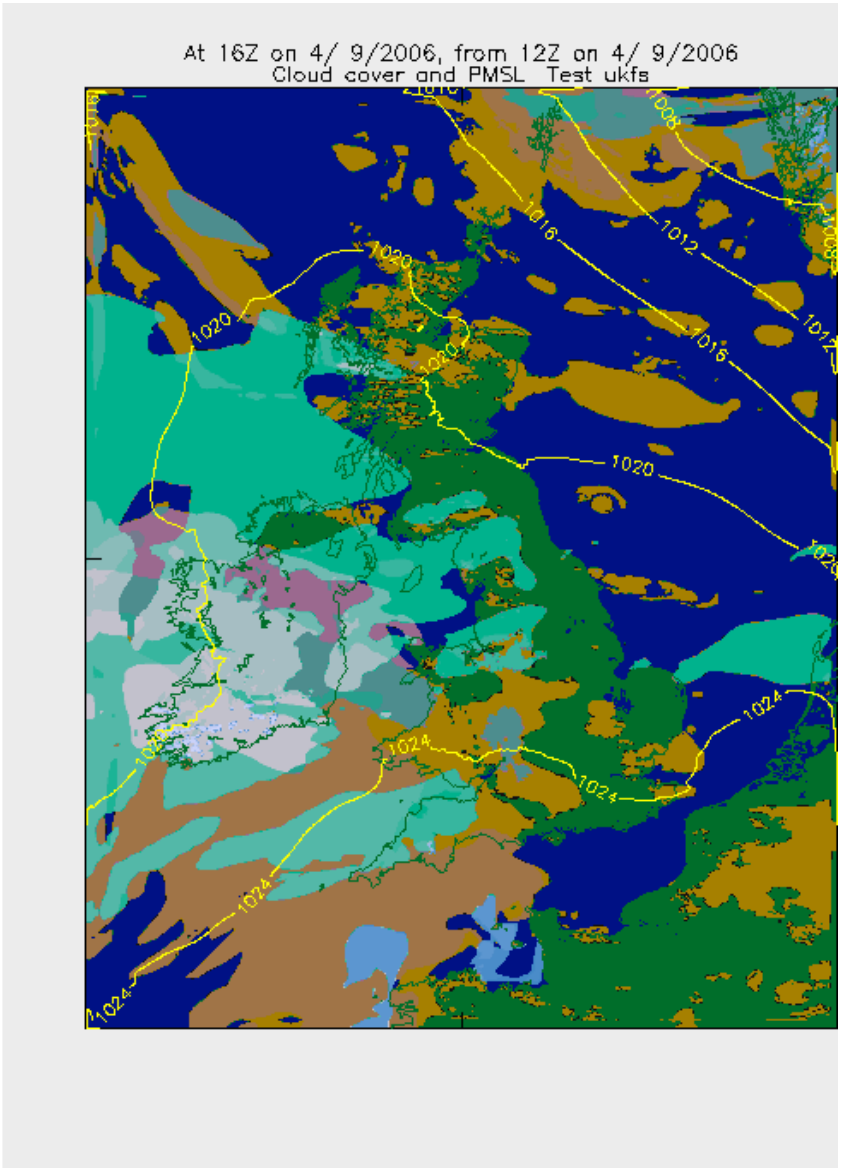
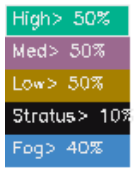
Case 04/09/2006. St/Sc





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

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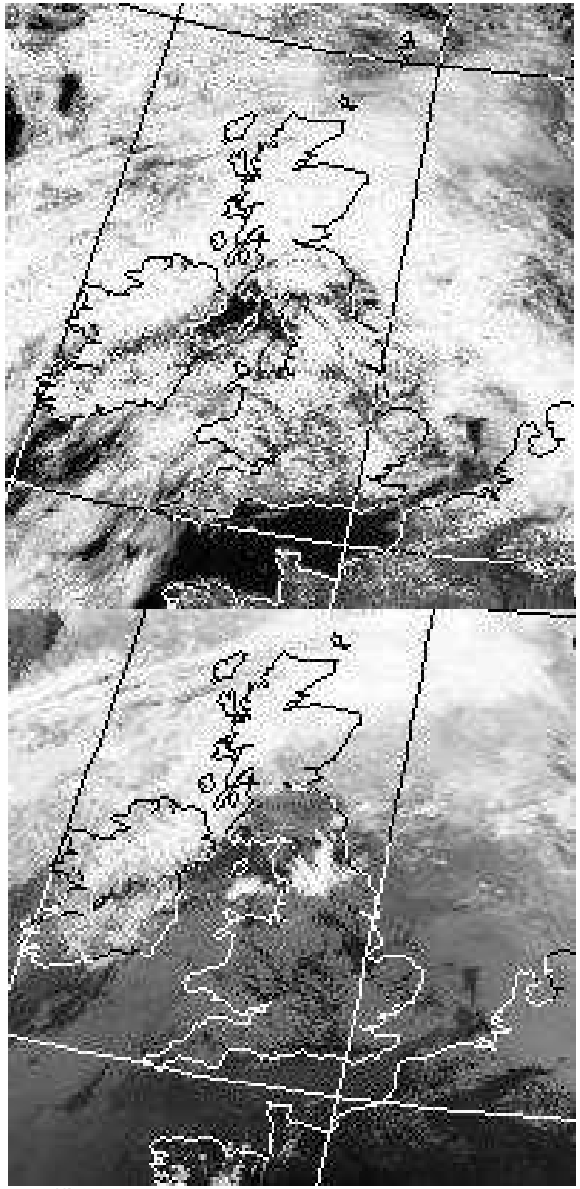
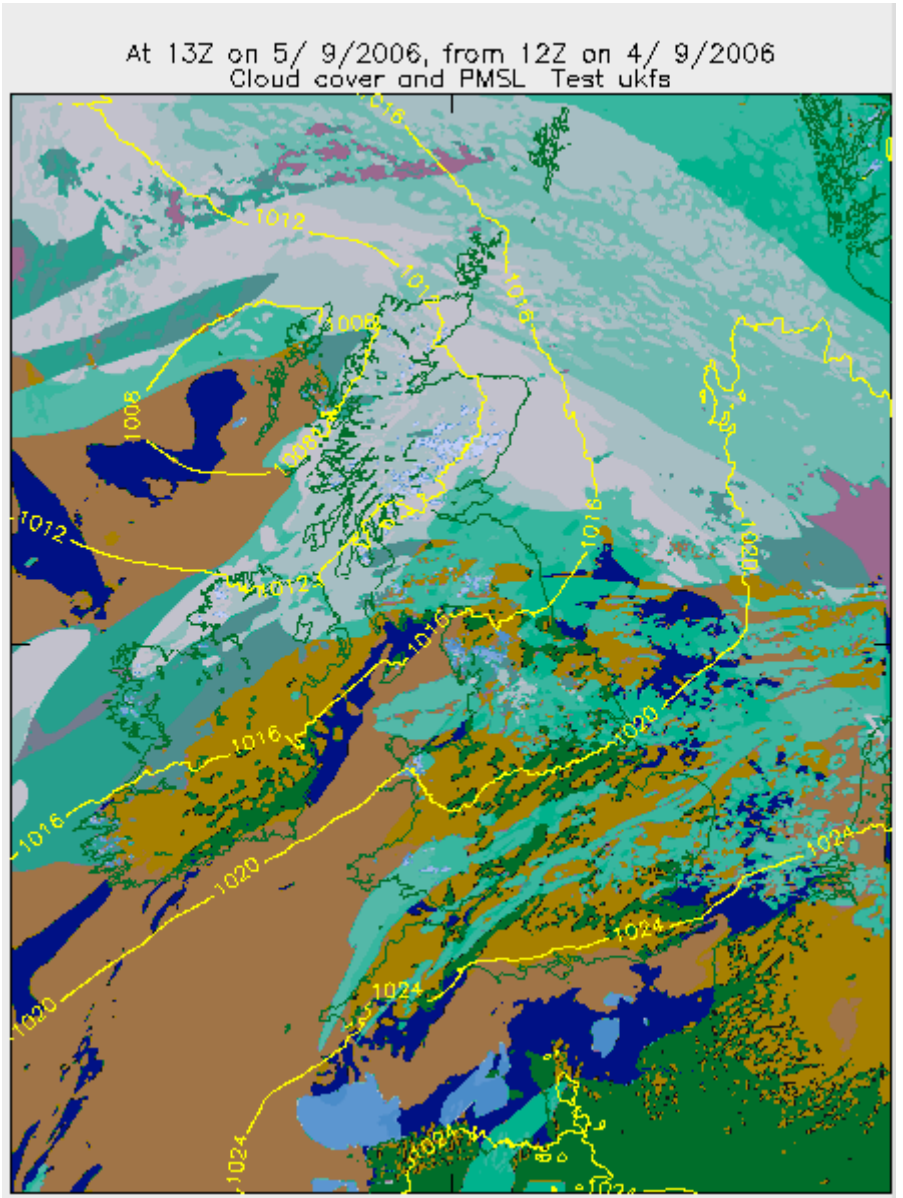
Case 04/09/2006. St/Sc

VIS

IR





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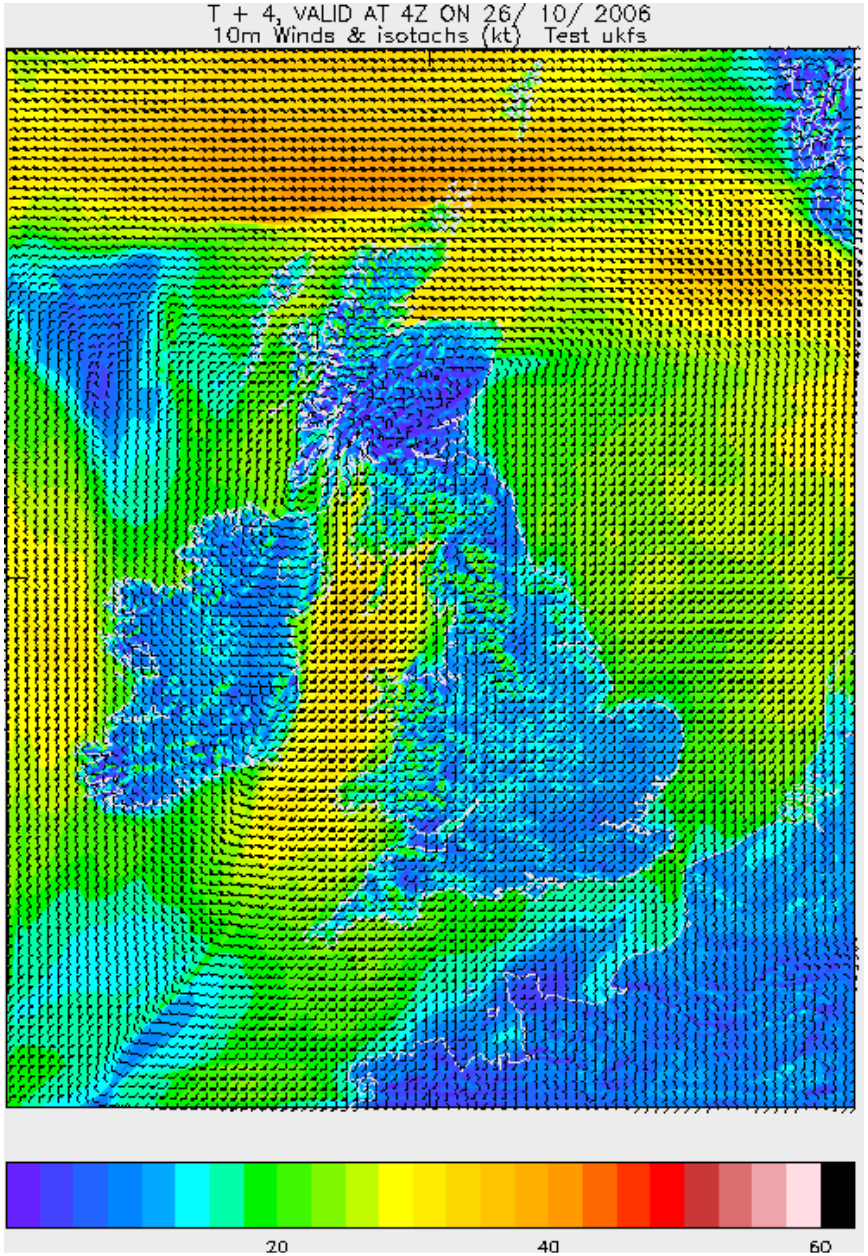
Case 26/10/2006. Gales



- Slightly stronger winds than UK4 over Sea.

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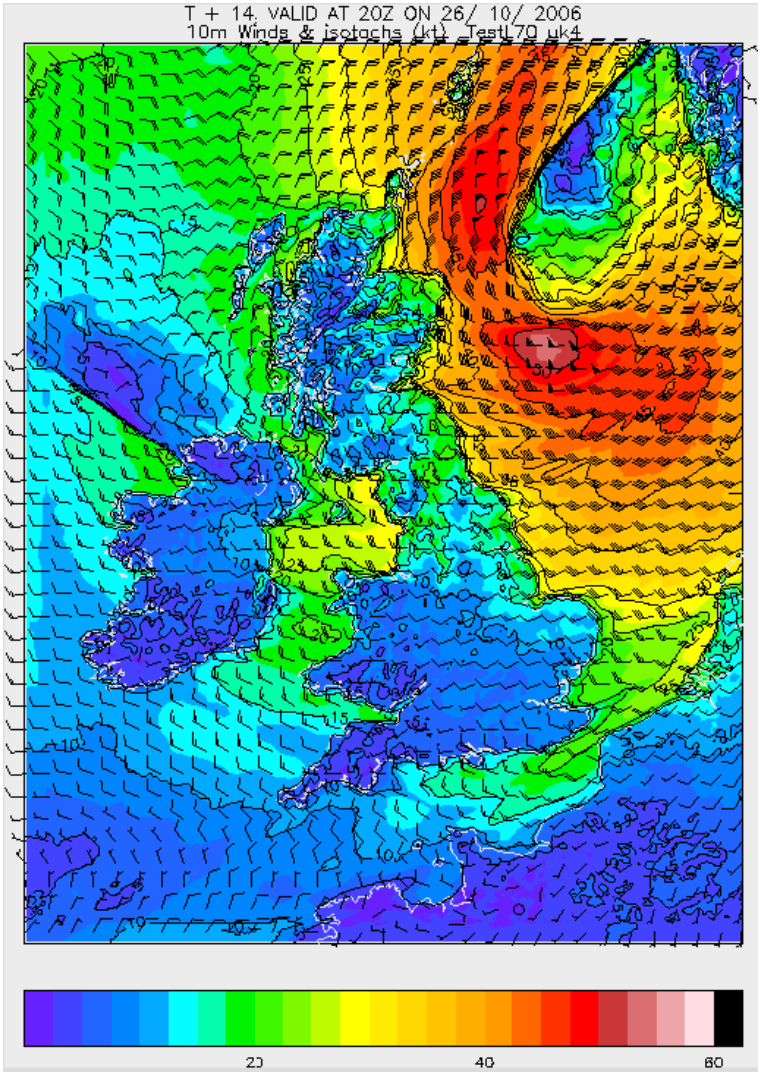
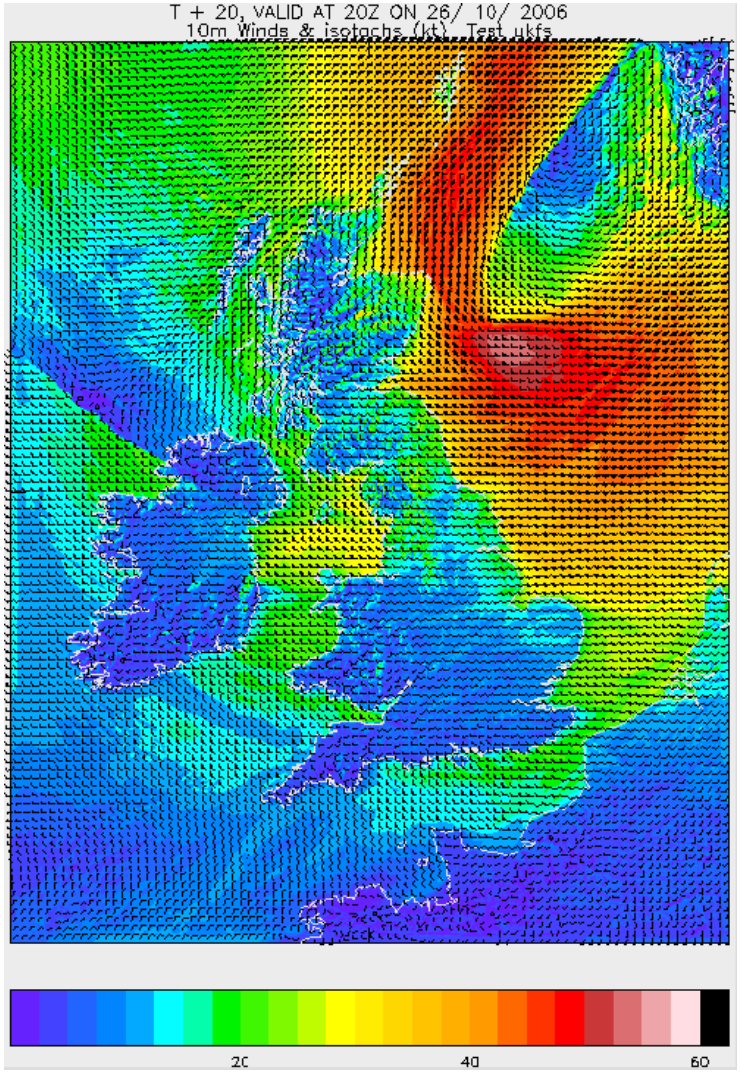
Case 26/10/2006. Gales





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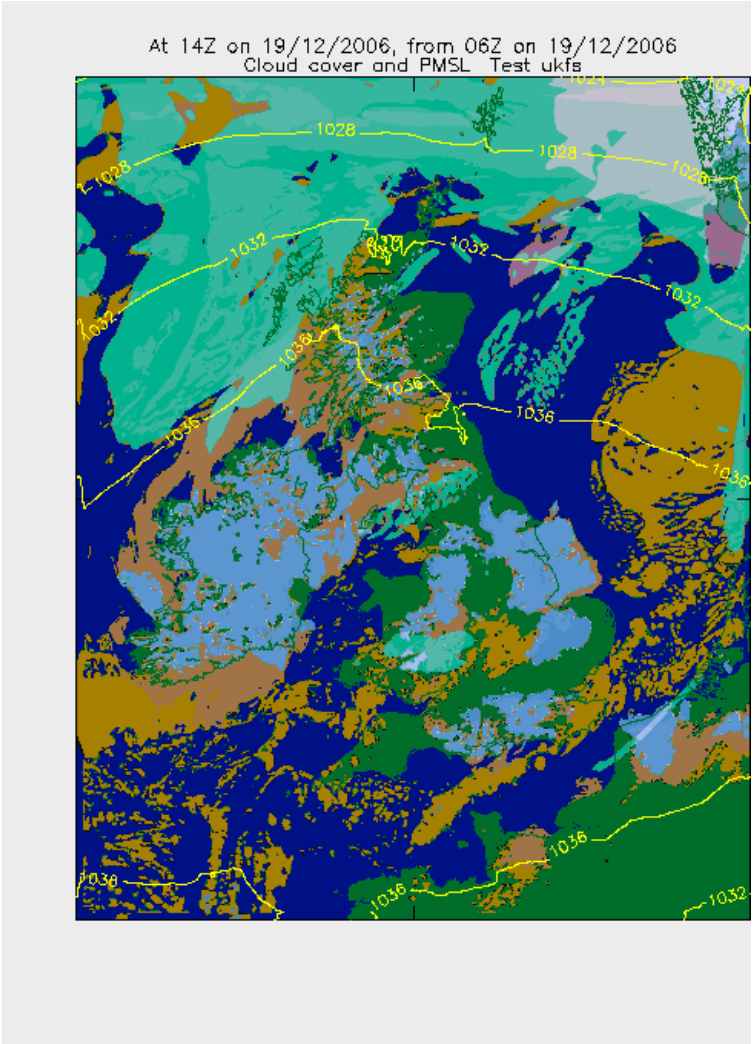
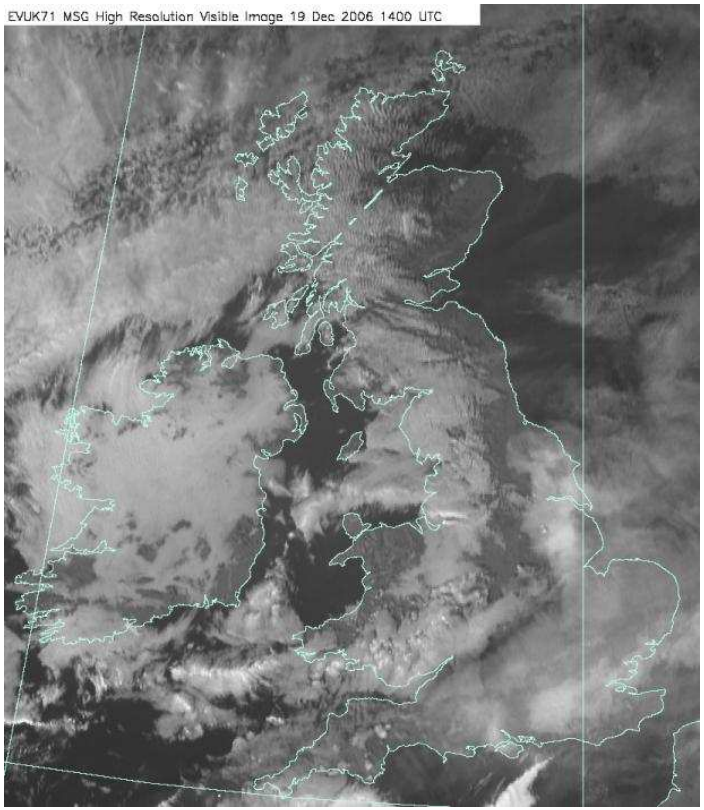
Case 19/12/2006. Fog

14:00 UTC. T+5





Good over Ireland.

Too little over SE England?

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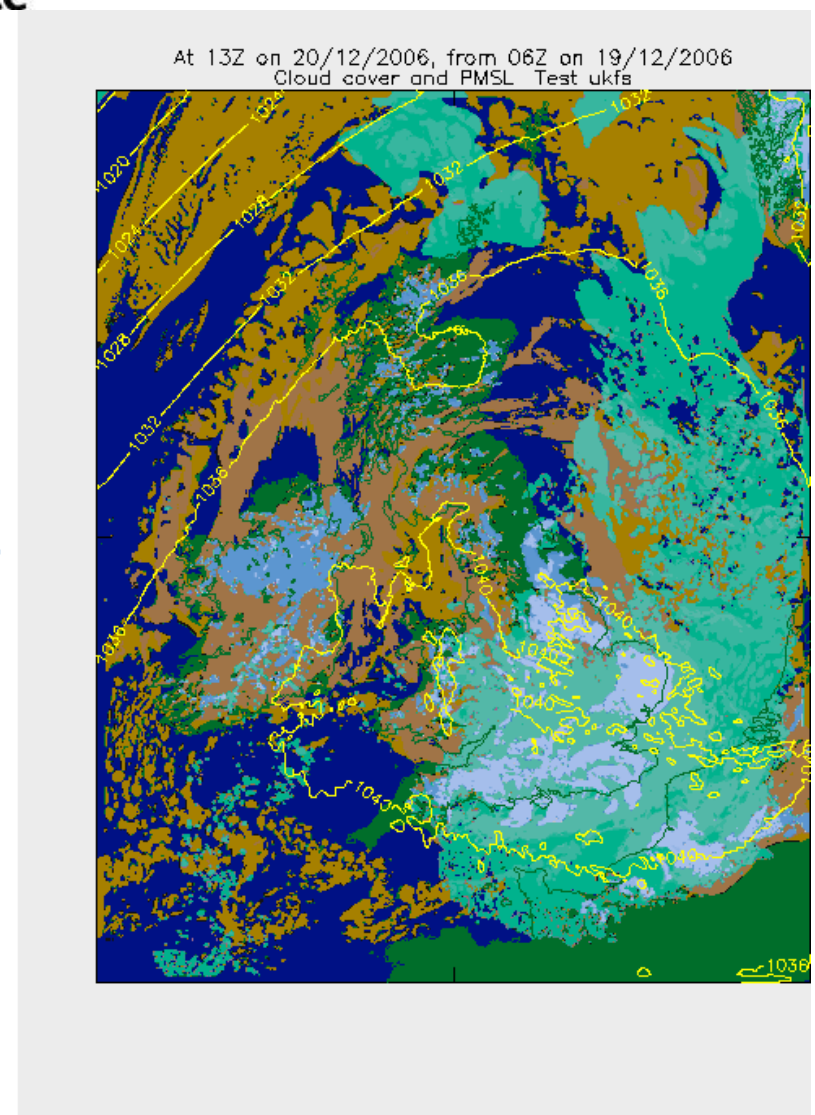
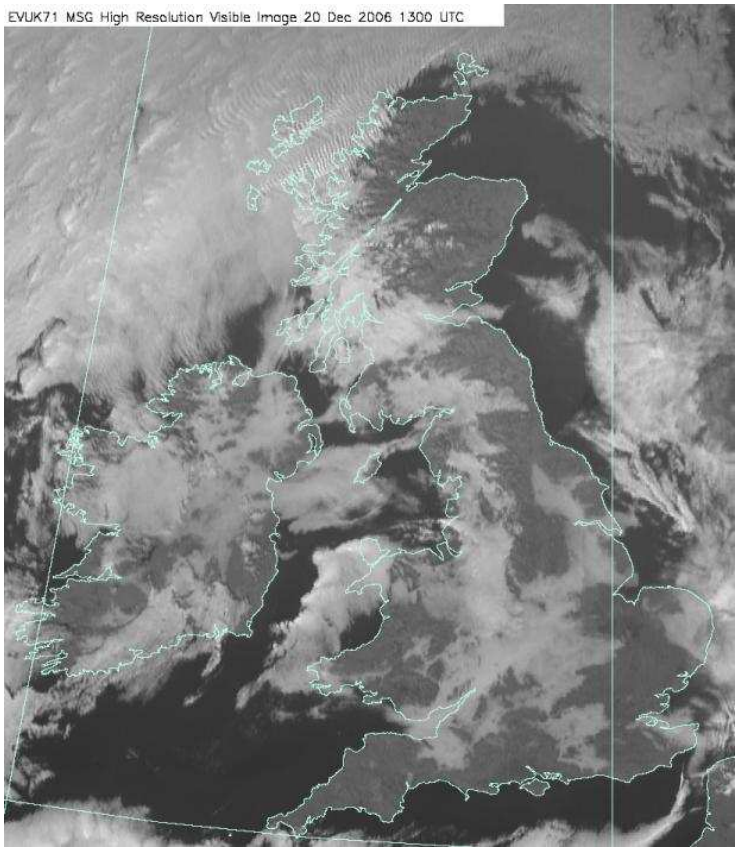
Case 19/12/2006. Fog

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





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

Positional errors of fog over England.

High Cloud far too West

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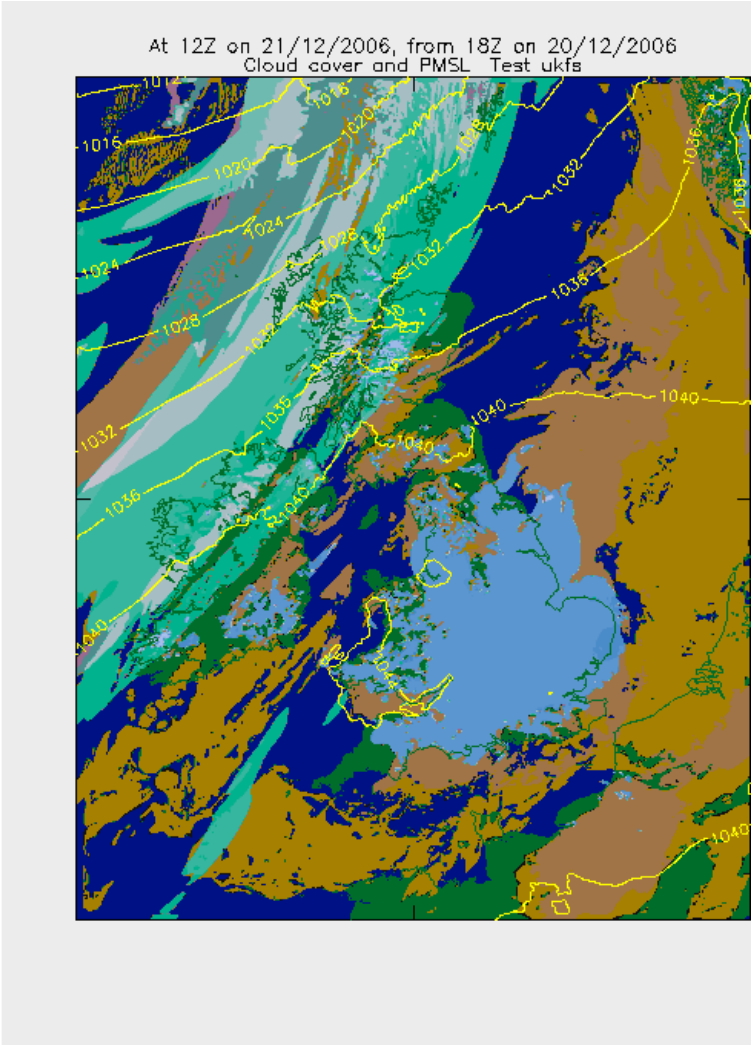
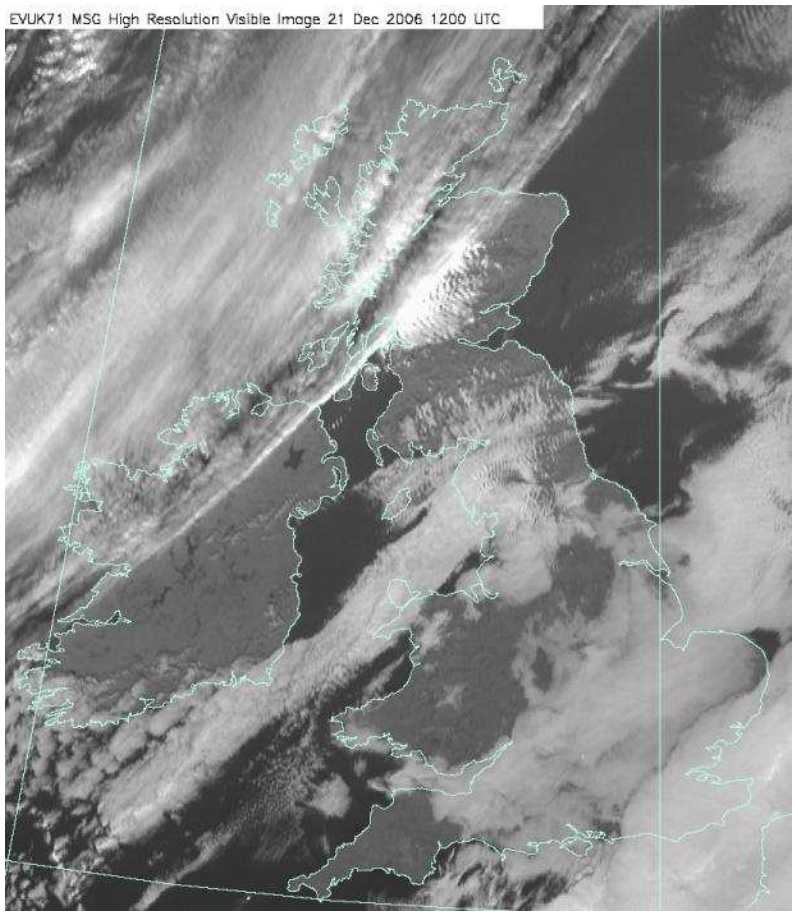
Case 21/12/2006. Fog

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





Too widespread fog in the model

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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.

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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.

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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.

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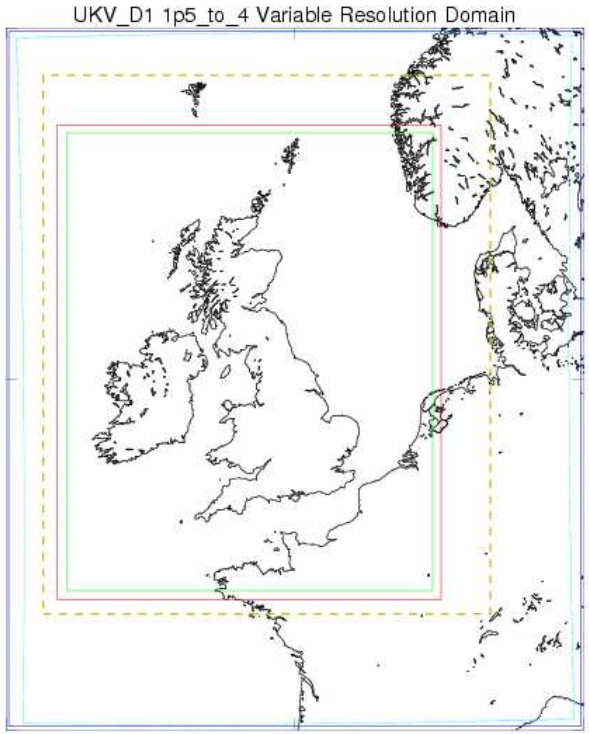
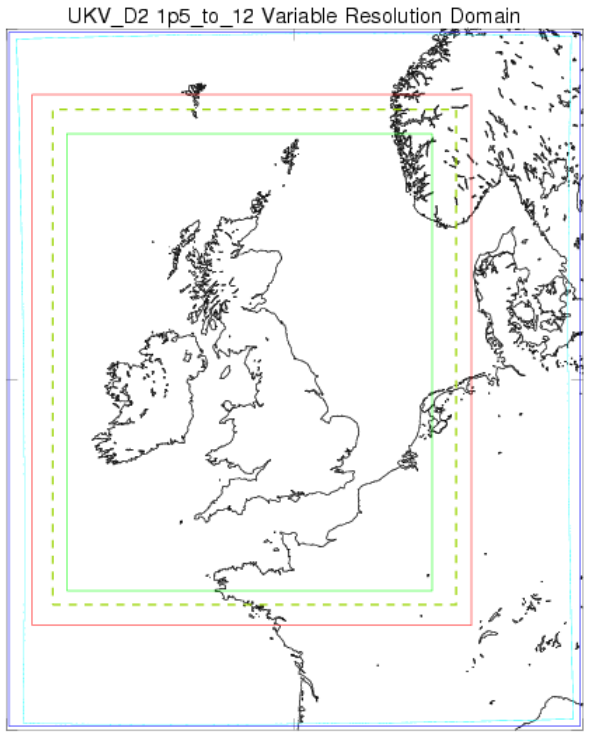
Some options for Variable resolution 1.5km model



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



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

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

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Questions and answers

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