Operational convective scale NWP in the Met Office

WSN09 Symposium. 18st of May 2011

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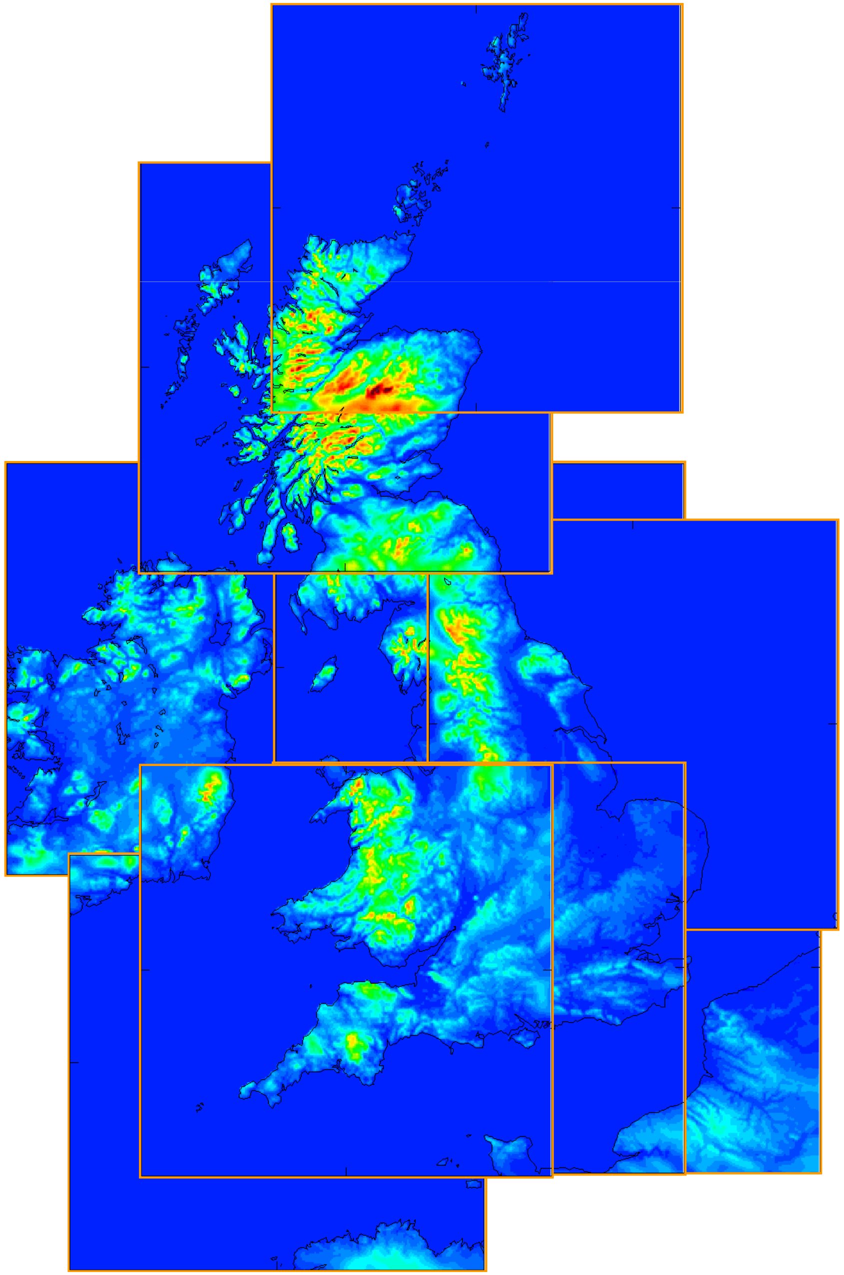
Contents

This presentation covers the following areas

Models description

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

- December 2007 – August 2009
- Downscaling model nested in UK4 (4 Km. grid).
- 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.

On Demand Model

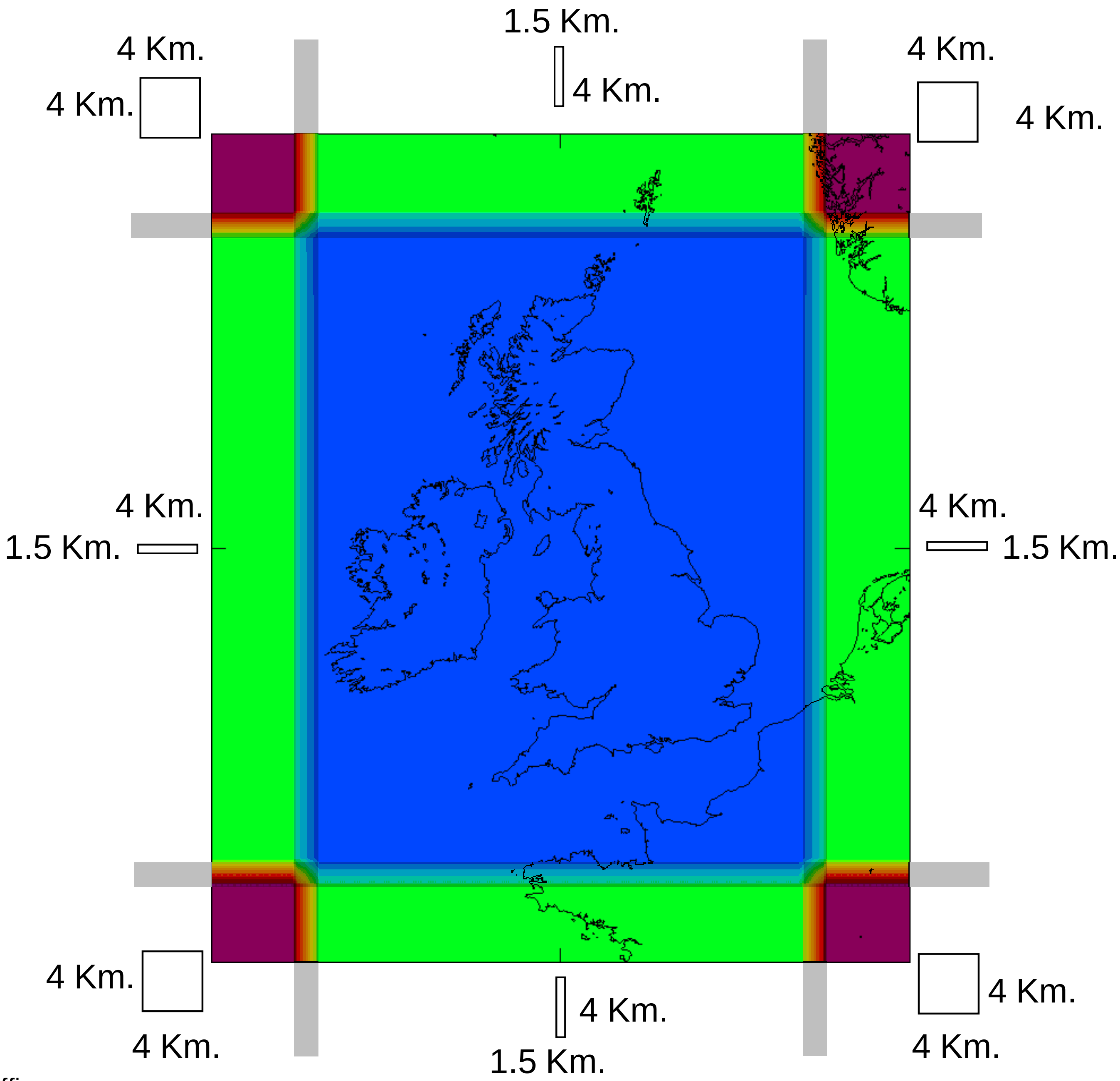
Limitations

- Short lead times.
- No possibility of DA.
- No possibility of objective verification.
- Limited spatial coverage.

Benefits

- Affordable.
- Added information to other models output.
- Forecasters had early access to convective scale models.

UKV Model



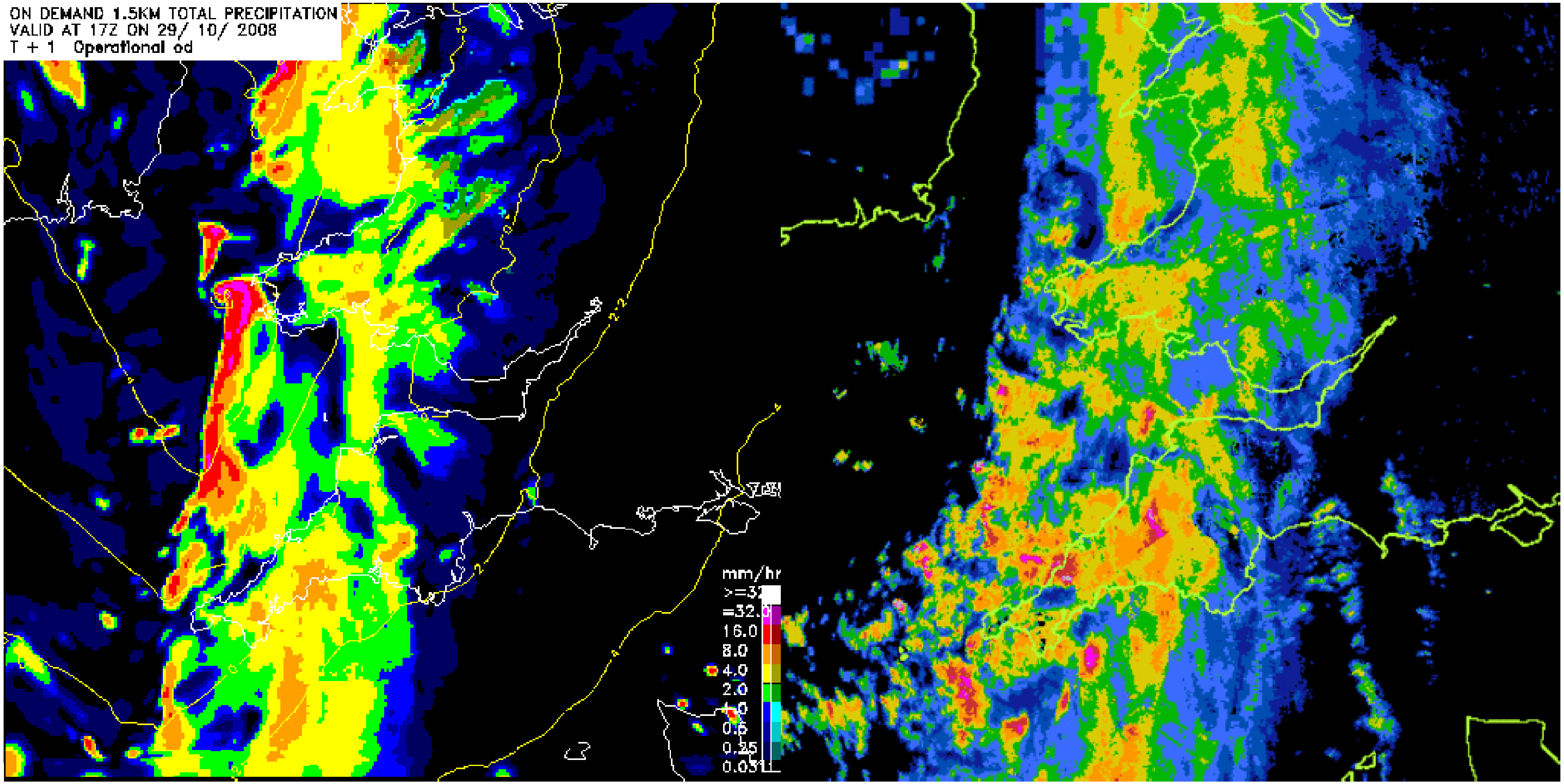
1.5 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
1.5 Km.
4 Km.
1.5 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
4 Km.
1.5 Km.

UKV Model

- Nested in NAE (12 Km gridlength)
- Variable Resolution. Outer rim 4 Km gridlenght
- Inner area 1.5 Km gridlength
- Inner area size:
  - 622 E-W x 810 N-S
- Full area size:
  - 744 E-W x 928 N-W
- LBC update frequency: 30 min.
- 70 vertical levels. Model top: 40000 m.
- Timestep: 50 sec.
- Forecast length: 36 hours
- No convective parametrization.
- Sub-grid turbulence scheme.

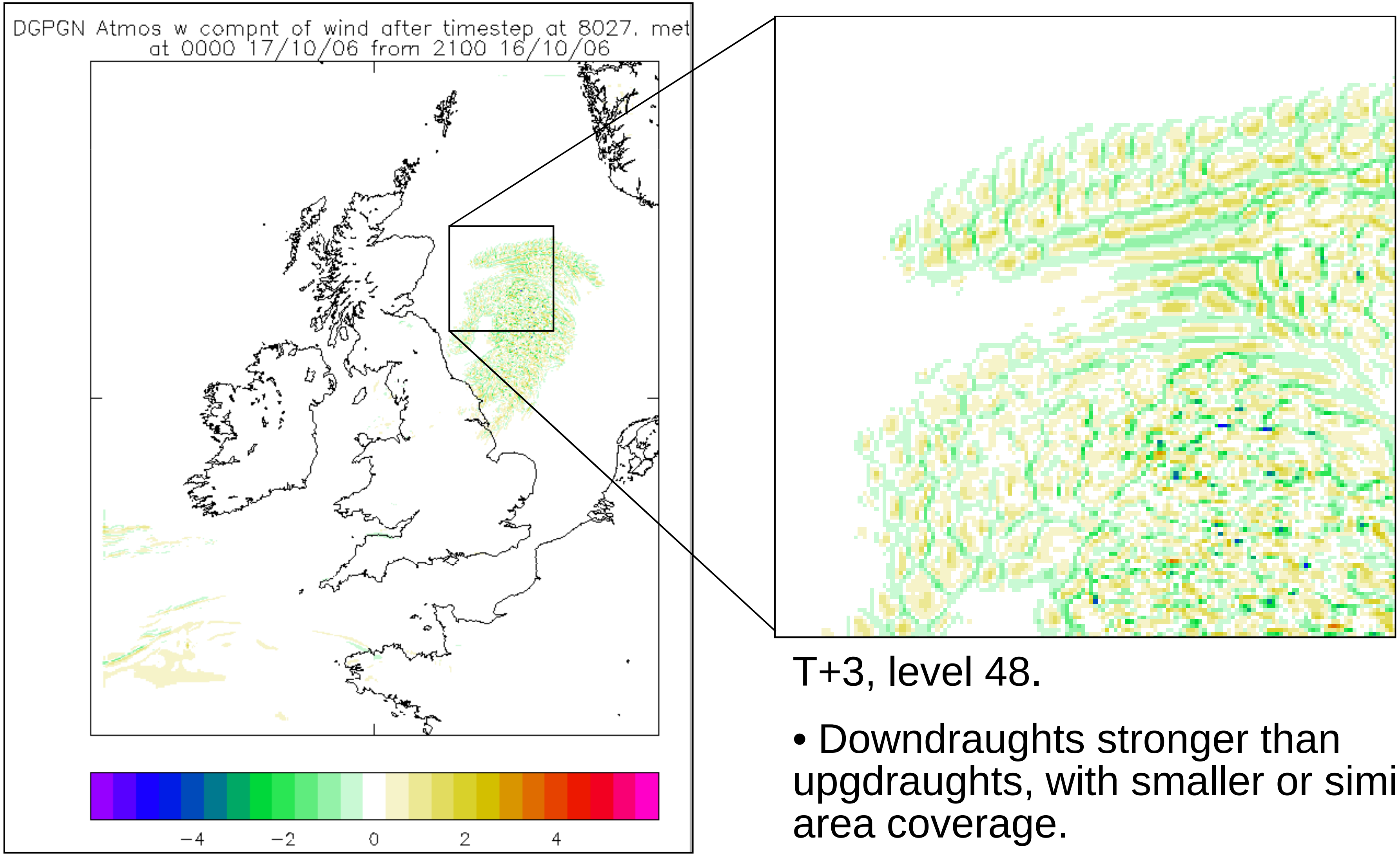
Examples

Ottery Storm. 29 October 2008
On Demand Model



Cirrus top Instability (UKV)

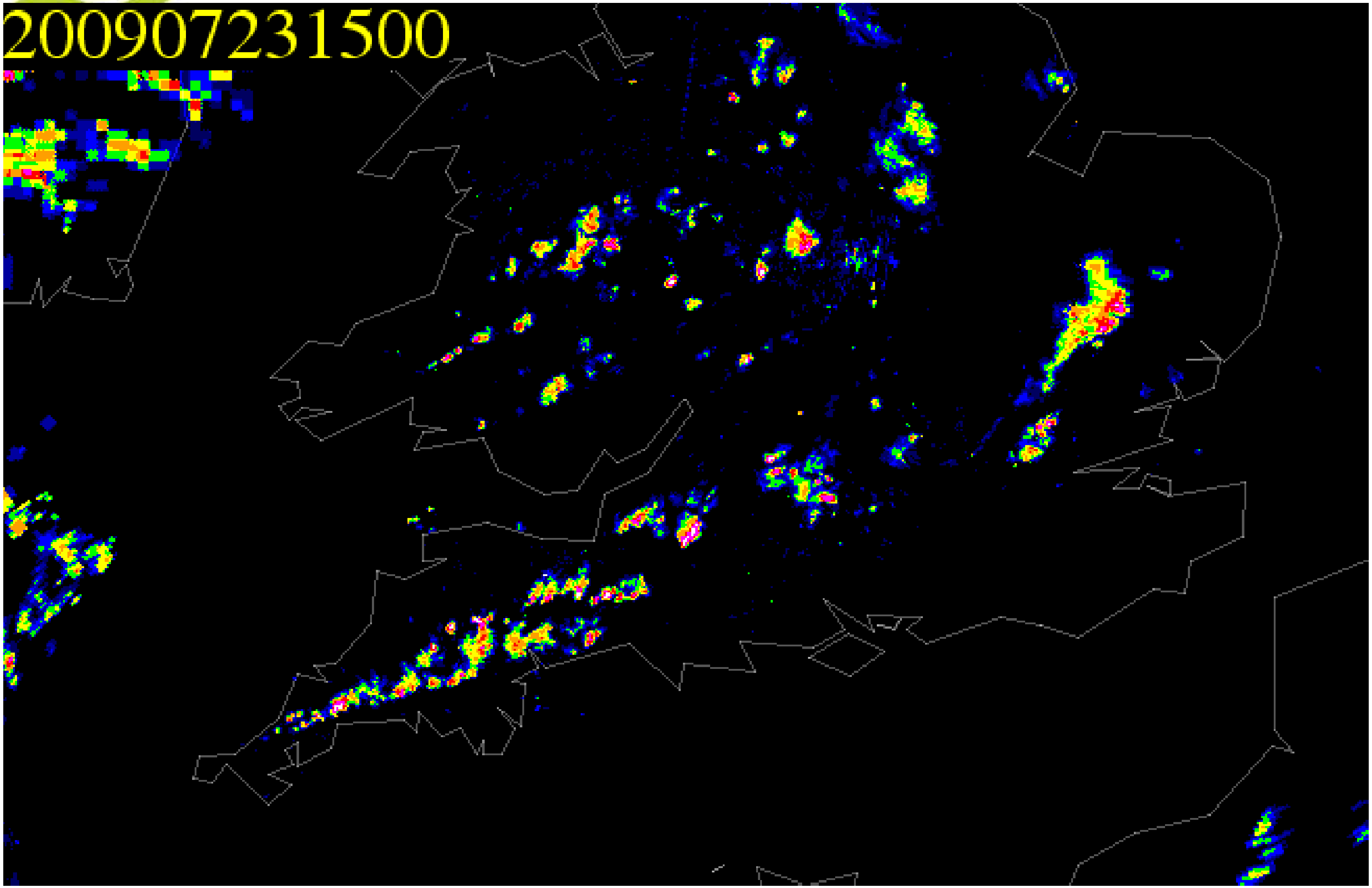
Vertical velocity 26th Oct. 2006



T+3, level 48.

- Downdraughts stronger than upgdraughts, with smaller or similar area coverage.
- High level of organisation.

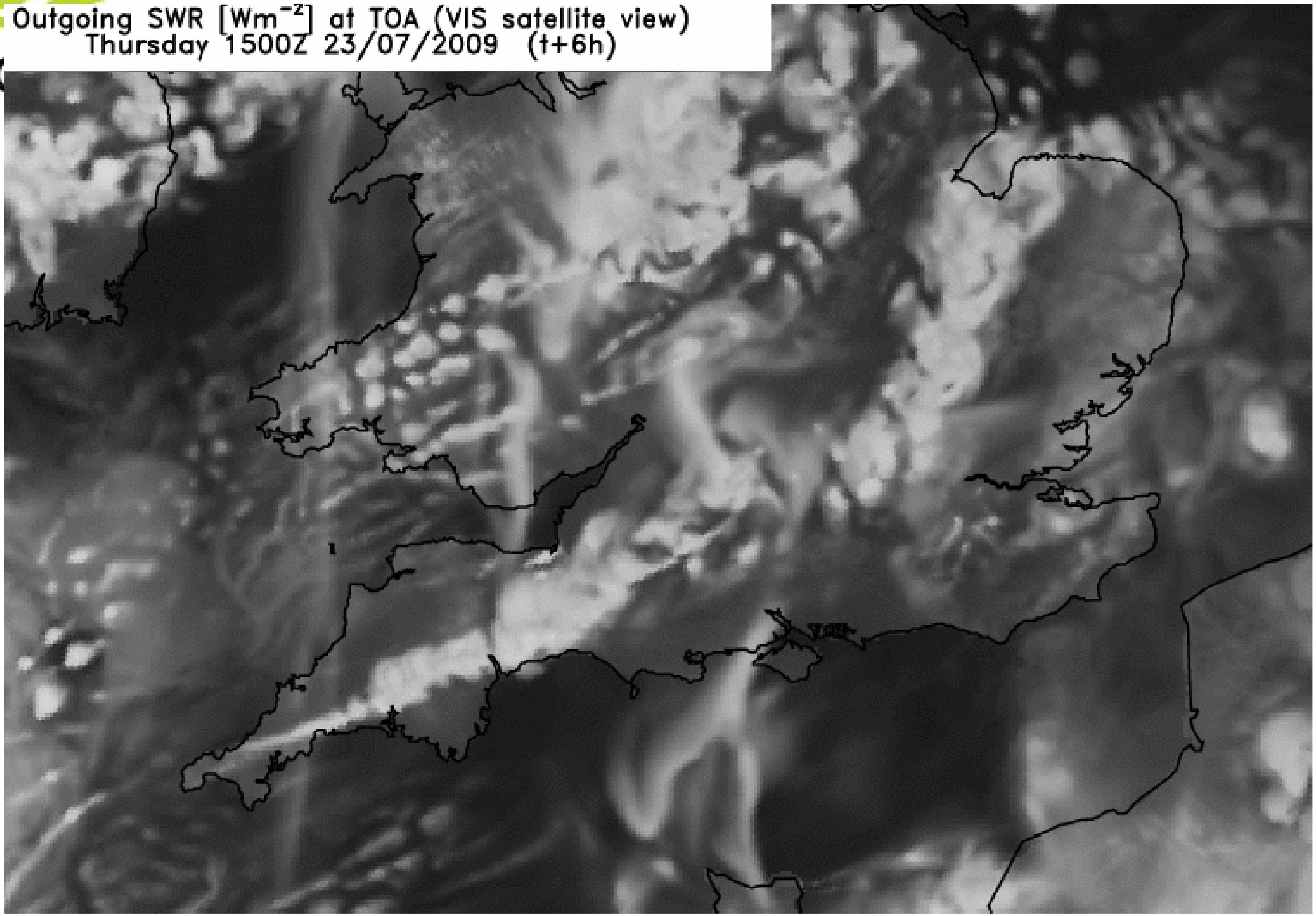
Convergence line 23/07/09 15Z



Radar

Peter Lean

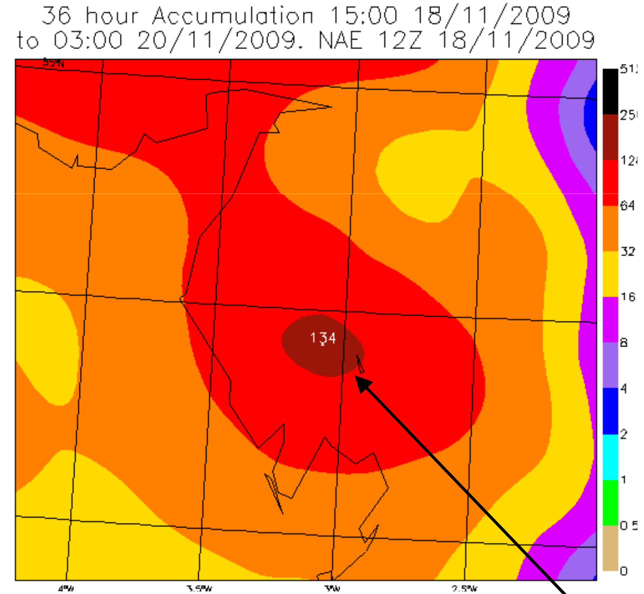
Convergence line 23/07/09 15Z

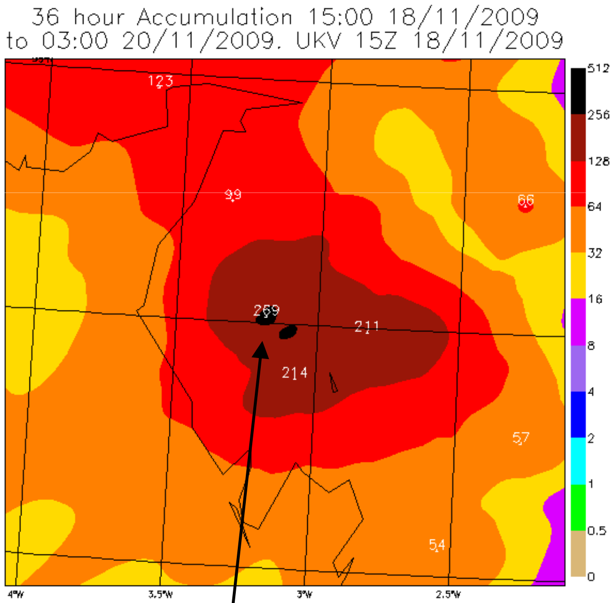


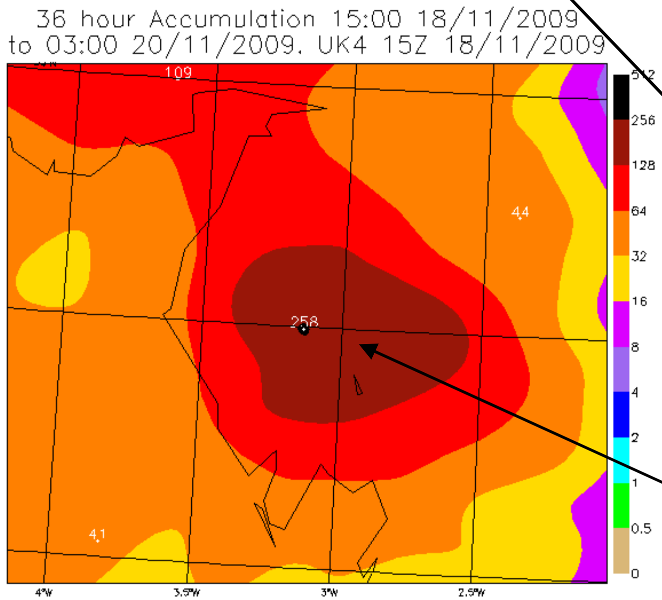
Model outgoing short wave radiation

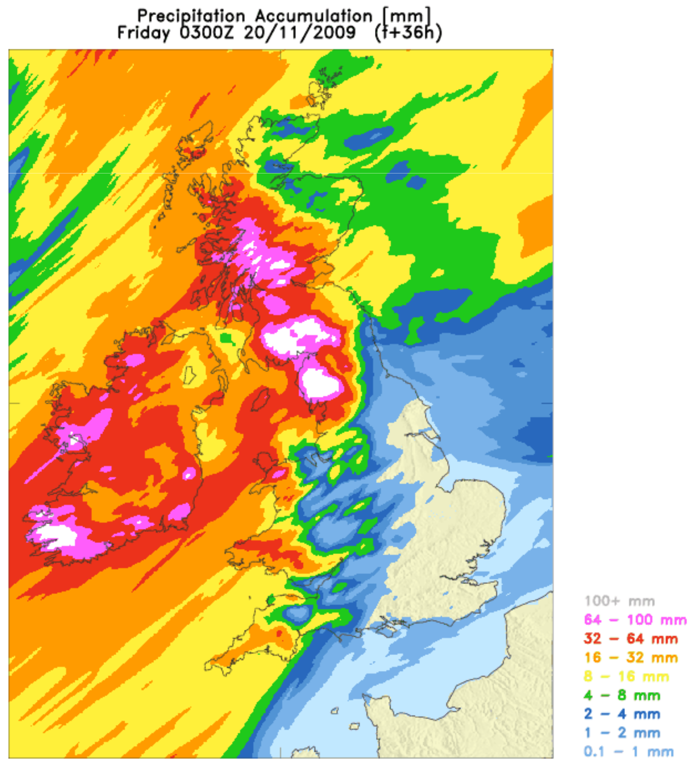
Peter Lean

Orographic precipitation Cumbria Floods (Nov 2009)









1.5 Km: 269 mm

12 Km: 134 mm

4Km: 258 mm

Seathwaite Farm

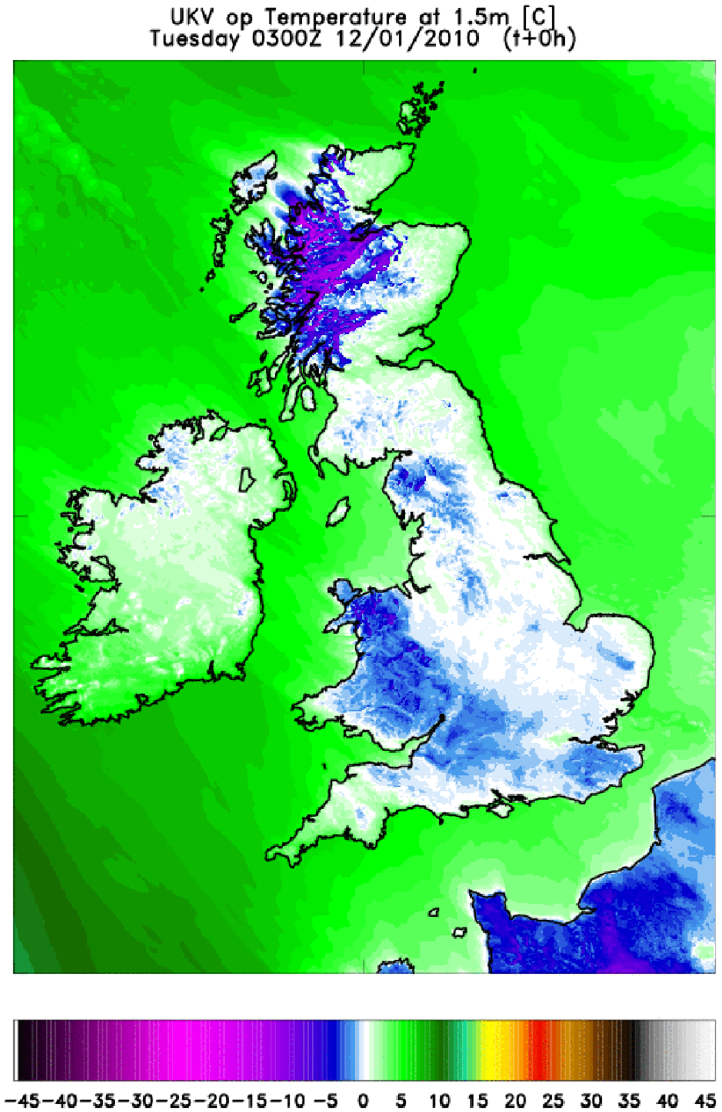
Max 24hr: 253mm

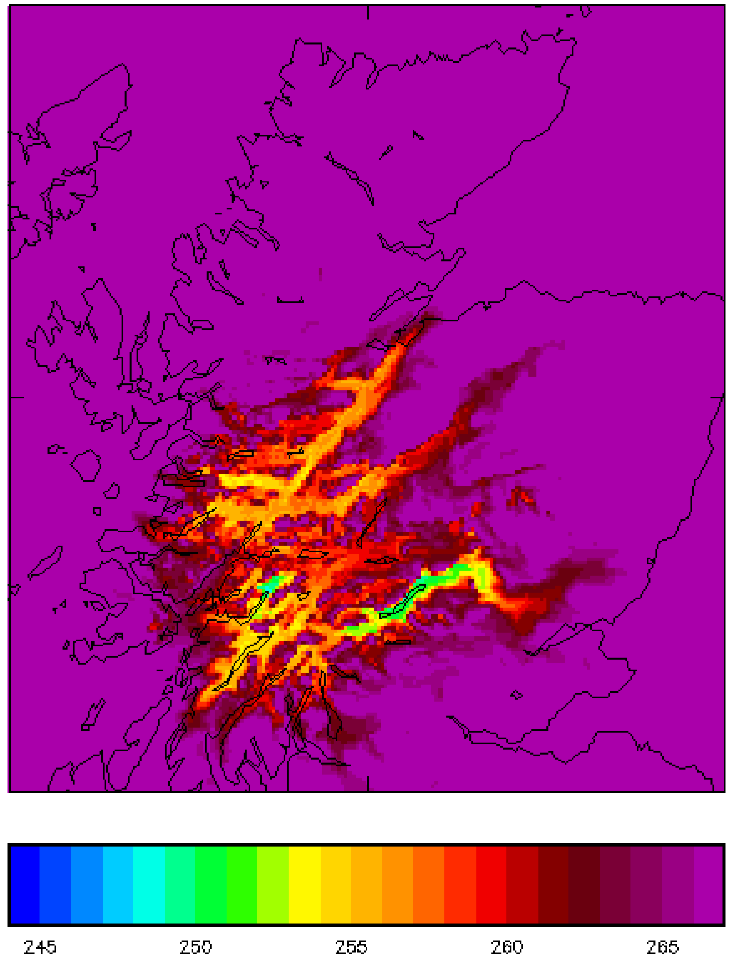
Max 48 hr: 395 mm

Valley Cooling (winter 2009-2010)

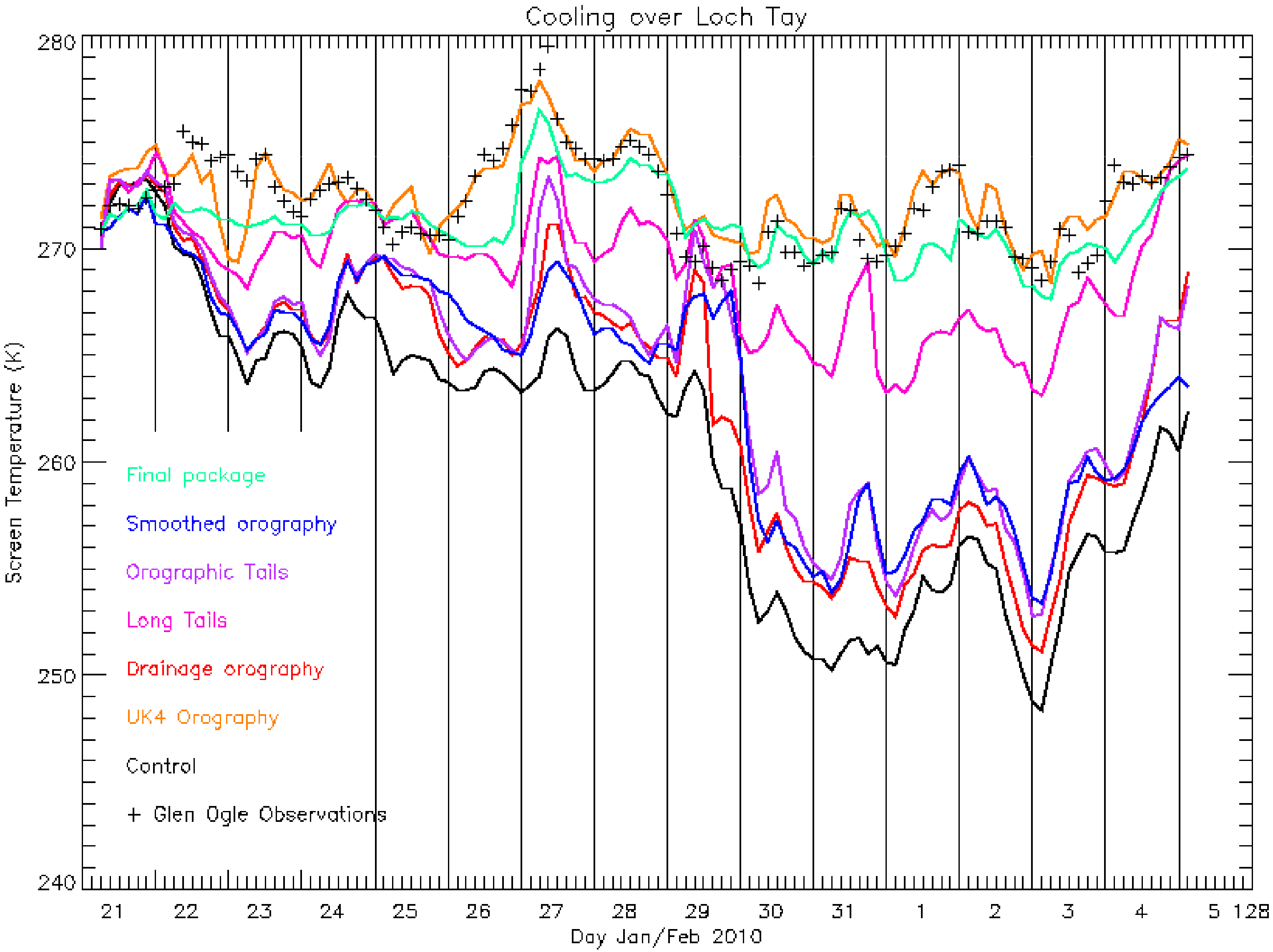
- Problem.
  - Katabatic flows compounded with unresolved mixing in the stable boundary layer make valleys unrealistically cold.
  - Eventually a cold drainage flow develops spilling out of the valleys, preventing failures but damaging forecasts in a wide area.
- Solution package.
  - Subgrid drainage shear (Adrian Lock).
    - Represents enhanced shear arising from small scale drainage flows.
  - Relax stability tails over land.
  - Change inland water characteristics (to represent deeper lakes).
  - Filtered orography.

Valley cooling





Valley cooling

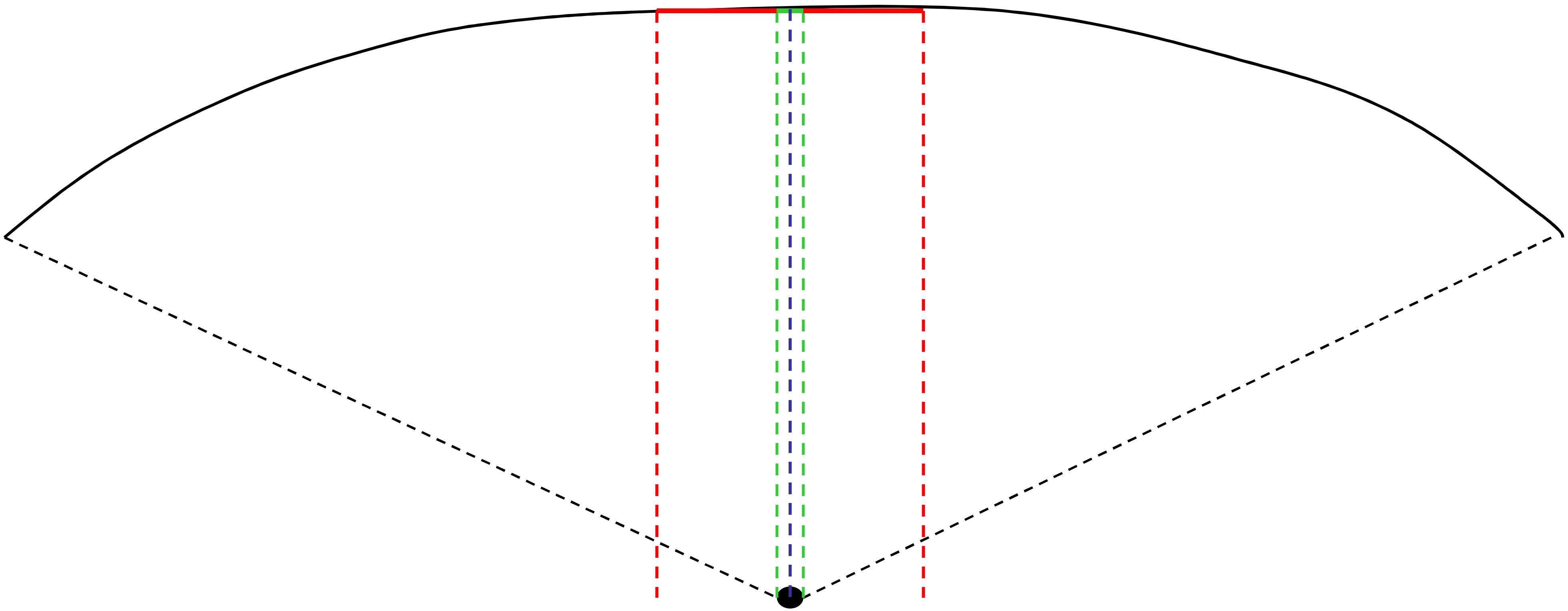


Verification

Verification

- Challenges:
  - Lack of predictability at small scales.
  - Representativeness/Double penalty.
  - Nature of observations.
- Approaches:
  - Fuzzy verification
  - SO-NF

Verification. Cloud cover.



Manual observations: Spatial average

GCM 25 Km.: Area fraction

UKV 1.5 Km.: Area fraction

Auto observation: Temporal average of point measurement.

Verification (FSS)

Fractions Skill Score:

Roberts, N. M., 2008: Assessing the spatial and temporal variation in the skill of precipitation forecasts from an NWP model. Meteor. Appl., 15, 163–169.

Comparison between models. Percentage of times that UKV has better FSS scores. Green cells give statistical significance.

Fractions Skill Score - 25km grid

UKV Vs. UK4:

FCR\Thr	0.5mm	1mm	4mm	8mm	16mm
[1]	16%	22%	18%	18%	14%
[2]	17%	18%	11%	11%	6%
[3]	12%	7%	4%	8%	3%
[4]	12%	13%	4%	5%	2%
[5]	16%	15%	15%	2%	3%

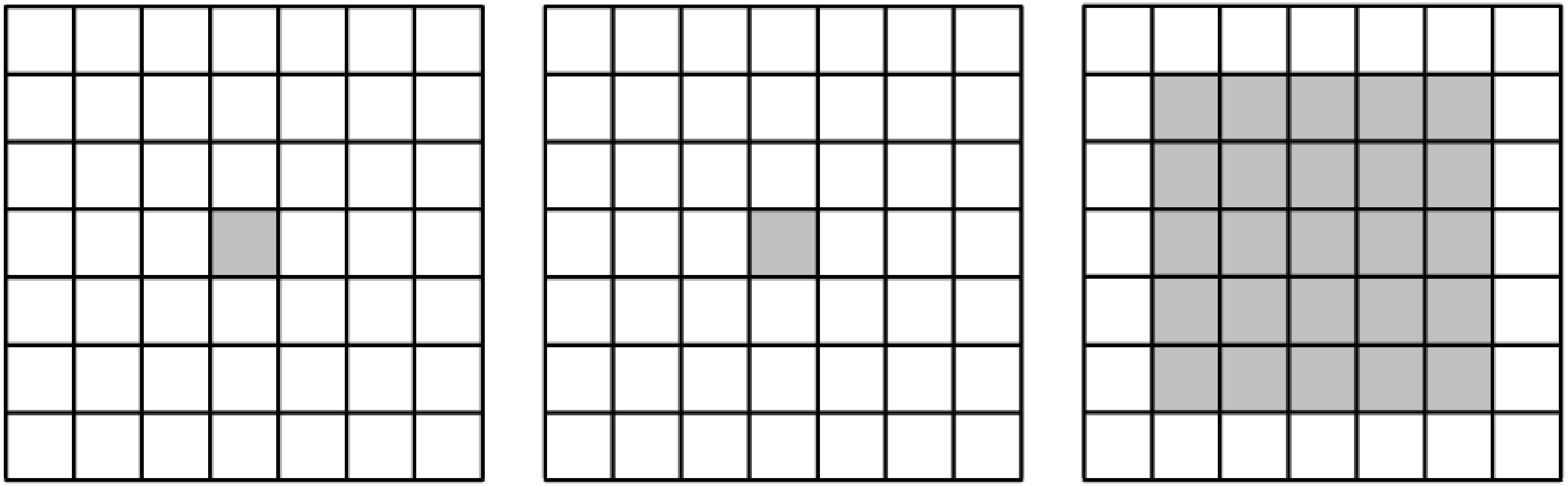
UKV Vs. NAE:

FCR\Thr	0.5mm	1mm	4mm	8mm	16mm
[1]	35%	30%	40%	41%	30%
[2]	33%	26%	35%	41%	26%
[3]	24%	28%	33%	36%	27%
[4]	30%	27%	37%	38%	23%
[5]	31%	28%	42%	39%	25%

What is SO-NF?

- It's a group of spatial verification methods which compare **single observations** to a **forecast neighbourhood around the observation location**.

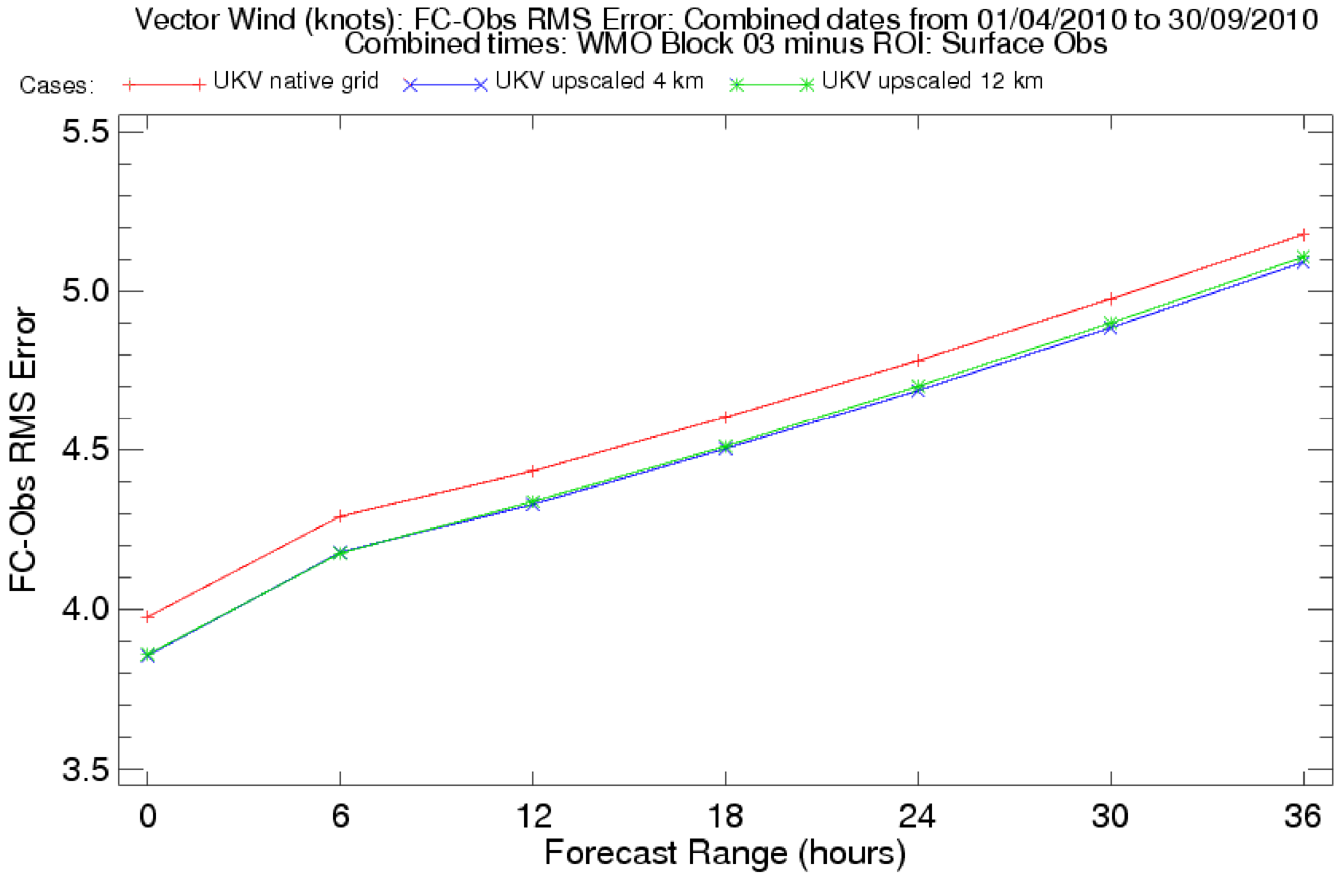
- Represents a **fundamental departure from our current verification system strategy** where the emphasis is on extracting the nearest GP or bilinear interpolation to get matched forecast-ob pair.



observation | matched forecast (traditional verification) | matched forecast (fuzzy verification)

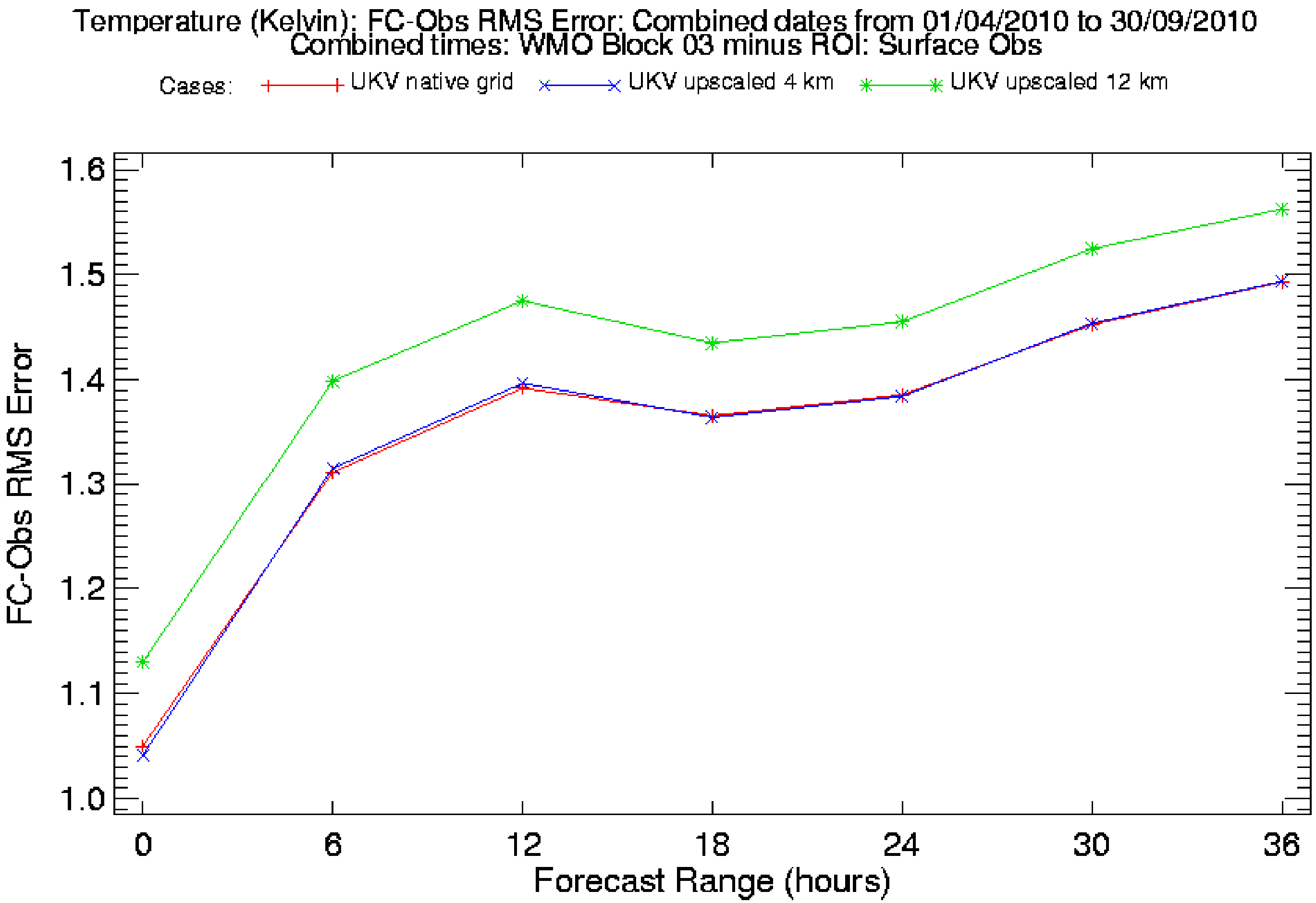
Verification (Upscaling)

- Local detail should improve wind forecast.
- Smoothing by upscaling benefits scores.
- Obs time averaged. Forecast instant value.



Verification (Upscaling)

- No improvements in temperature by upscaling to 4 Km.
- Further upscaling degrades the forecast.



Conclusions

Conclusions

- Convective scale models used operationally at the Met Office have proved significant benefits in several aspects (Initiation of convection, structure of precipitation, low cloud modulated by land-sea contrast and surface characteristics,…)

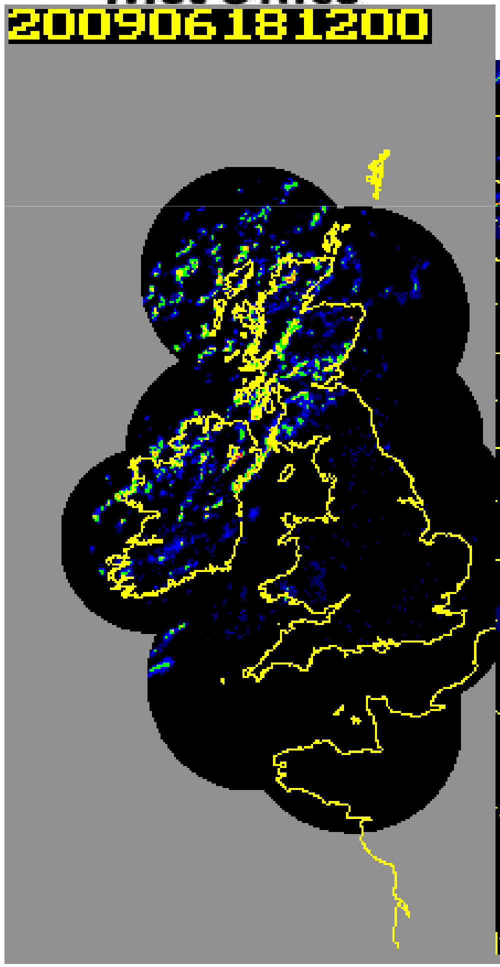
- Increase in computing resources have allowed full UK coverage. Variable resolution used to keep boundaries away from area of interest and mitigate Spin-up from the boundaries.

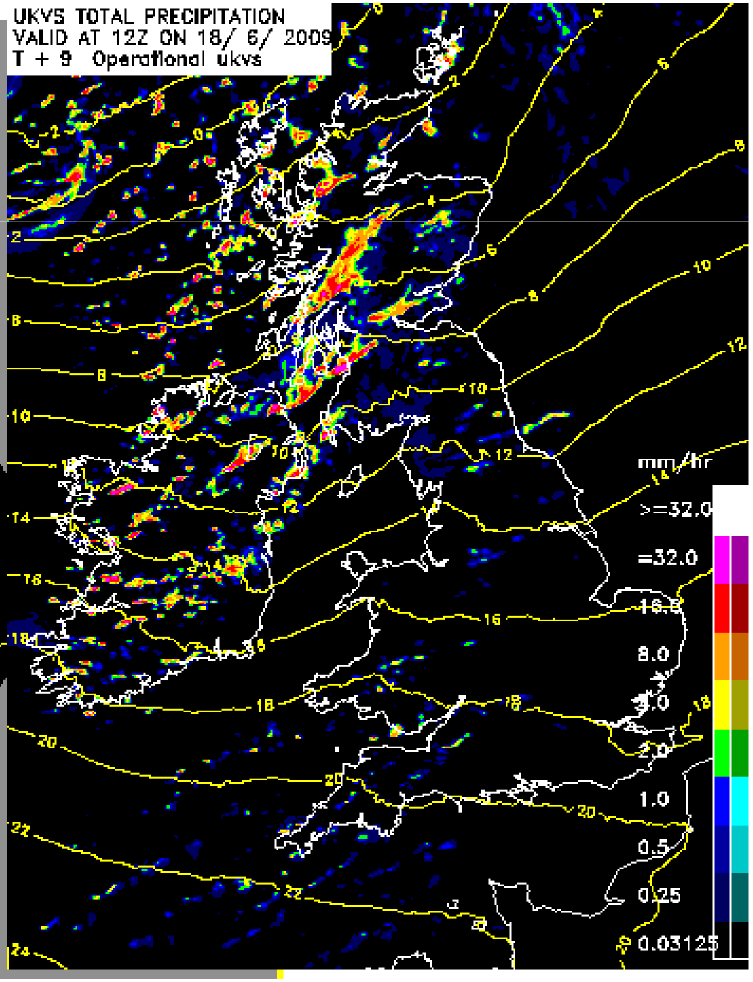
- Forecaster’s early access to convective NWP beneficial to get used of model characteristics ahead of operational implementation.

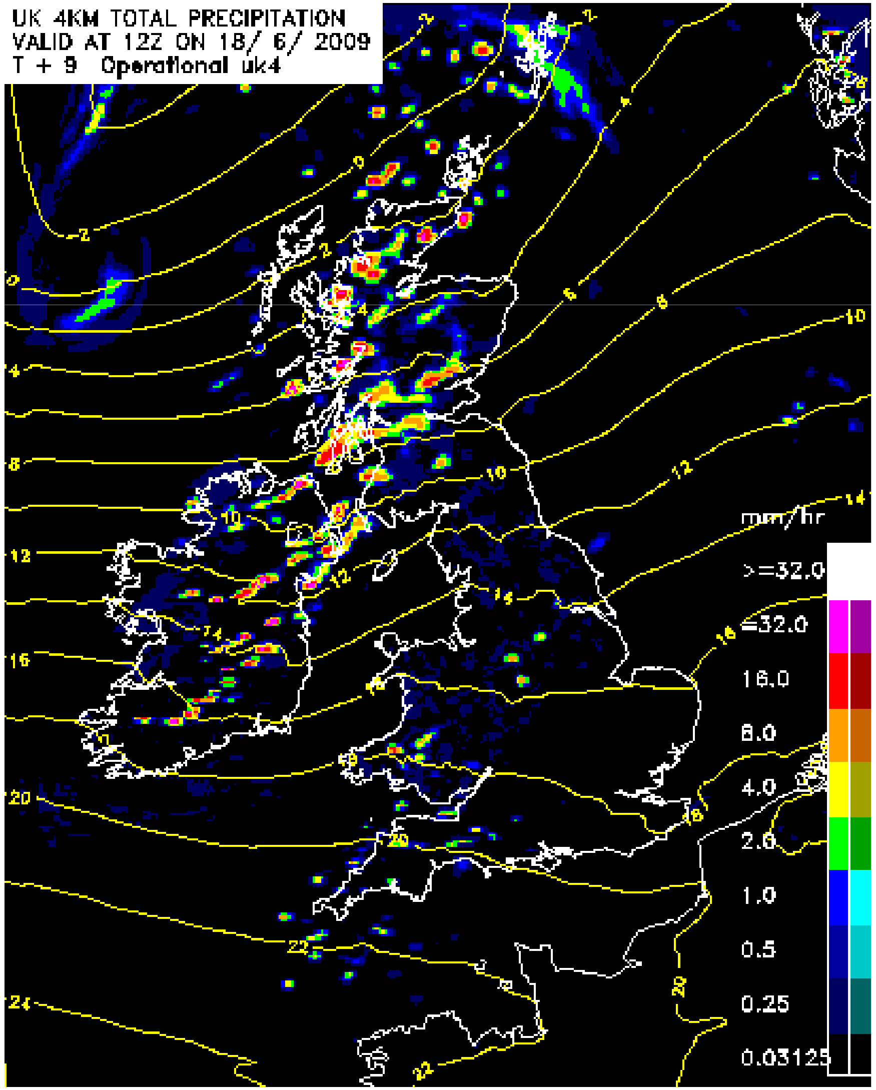
- Work ongoing on verification.

Questions and answers

Shower spinup 12z 18 June 2009

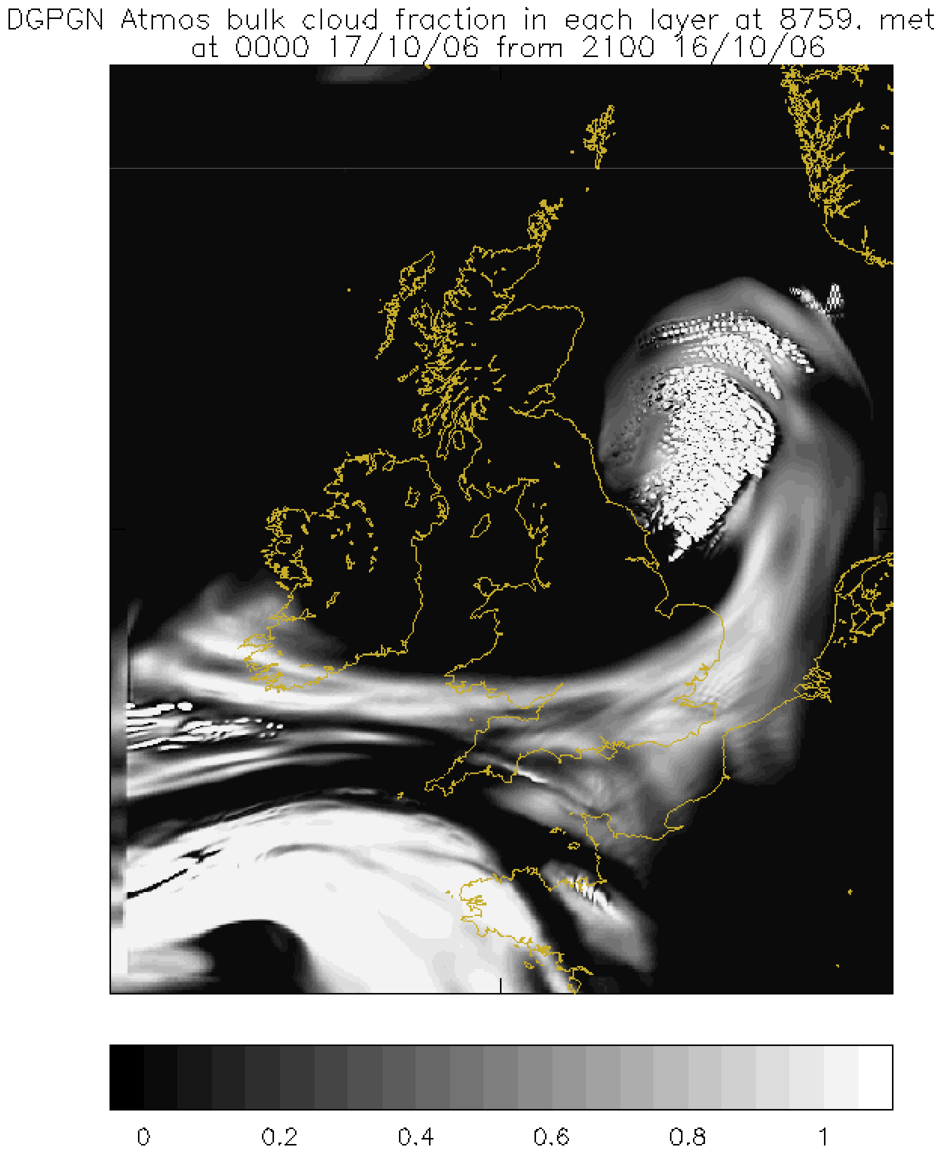


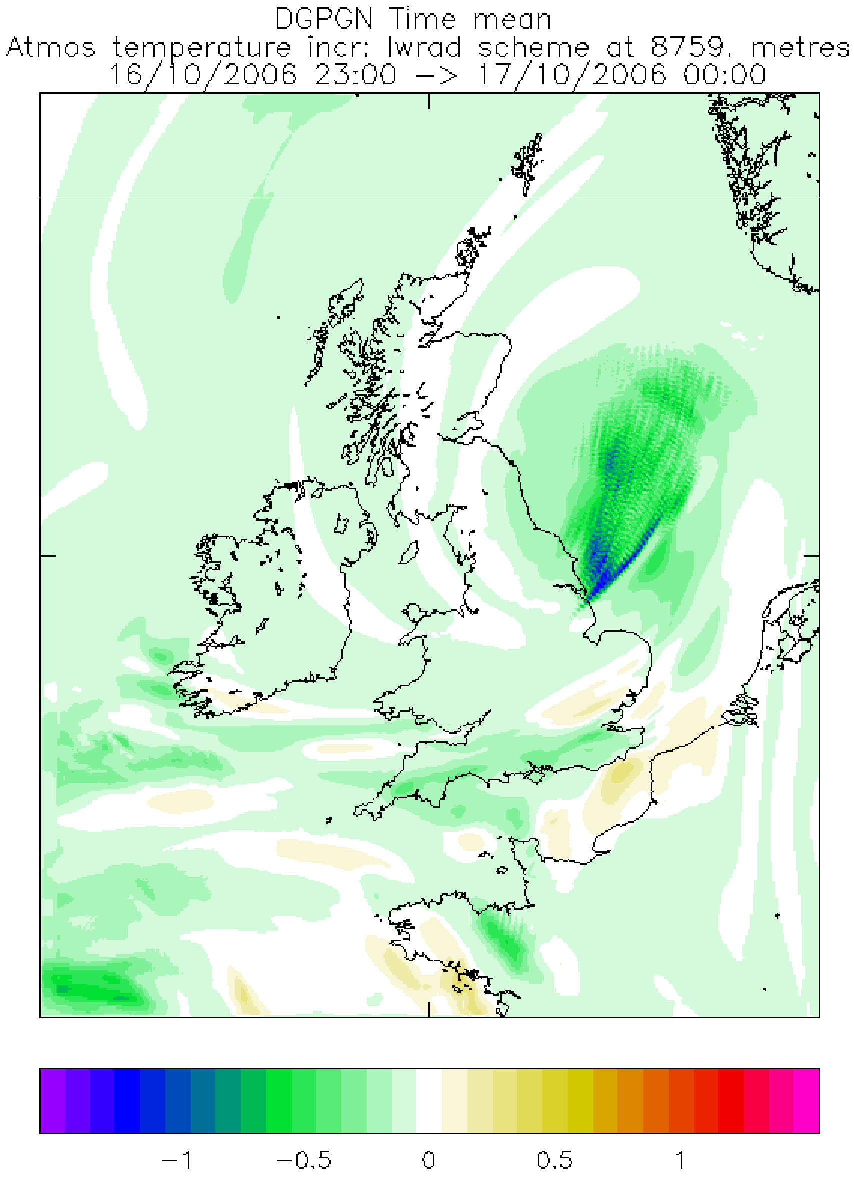




UKV shows more showers (i.e. less spin up) at W boundary.

Cirrus top Instability
(Radiative cooling 26th Oct. 2006)





Valley Cooling

Description of the Subgrid drainage shear solution

Previous research at the Met Office (McCabe and Brown, 2007) had demonstrated that area-averaging high resolution simulations of stable boundary layers in complex terrain can imply vertical mixing that is enhanced over what would be expected over a flat surface. Qualitatively this was attributed to the enhanced shear arising from small scale drainage flows but no quantitative parametrization was developed in that study.

Here, following Derbyshire and Wood (1994), we consider an idealised two-dimensional regime where uniform surface cooling under light winds leads to the generation of static stability (with buoyancy parameter N2) over a slope of gradient *α.* After a time *t,* the hydrostatic imbalance will generate a drainage flow with associated wind shear, *Sd*, given by:

$$S_d = N^2 \alpha t$$

In this initial implementation, *t* has been taken as a fixed timescale of 30 minutes, for simplicity. So, for example, taking typical values for the Scottish Glens of *N*2~1K/100m and *α*=0.15 gives *Sd*~ 0.1s-1, or a drainage flow of 2ms-1 at 20m.

Valley Cooling

For scales where the model does not explicitly resolve these flows, this wind shear should then appear in the turbulent mixing parametrization, as an enhancement to the resolved scale vertical shear, *S,* of the horizontal wind components. In addition, sensitivity to the surface slope will decrease with height so *Sd* is scaled by factor that reduces smoothly from 1 near the surface to zero by 1.5 standard deviations of the subgrid orographic height. Thus, the UM's 1st order closure for the turbulent diffusion coefficient becomes:

$$K = \lambda^2 (S + S_d) f(Ri) \quad \text{with} \quad Ri = N^2 / (S + S_d)^2$$

where *λ* is the mixing length and *f* the stability function. Importantly, the scales over which the model is known to underestimate the magnitude of local flows is of the order of six times the grid spacing. Hence in the UKV implementation, the slope is taken as the average slope over the surrounding 12km.

Derbyshire, S.H. and Wood, N. (1994): The sensitivity of stable boundary layers to small slopes and other influences. Pp.105-118, *Proc. 4th IMA Conf. Waves and Stably-stratified Turbulence*, ed. N.Rockliff and I.P.Castro. Clarendon Press, Oxford

McCabe, A. and Brown, A.R. (2007): The role of surface heterogeneity in modelling the stable boundary layer. *Boundary-Layer Meteorol.*, **122**, 517-534