“Convection permitting models” – setting the scene

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The elephant in the corner – convective storms

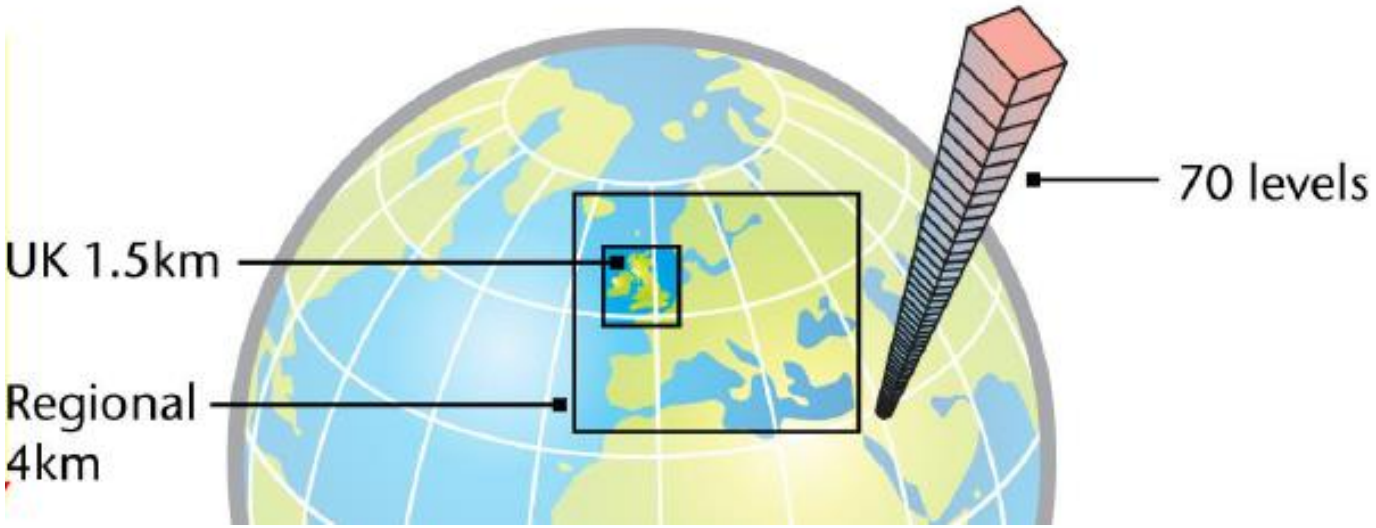
Hand et al 2004 examined UK 20th century extreme flood events and found that "more than half of the 50 events identified were short-period convective storms." We've seen plenty in recent years!

Regional Climate Models (100 – 12km grid) can't represent convective storms, therefore we can't really say anything useful about possible future changes in rainfall produced by convective storms.
That's a big omission.

Now we have the capability to do what is now done in weather forecasting and run so called "convection permitting" or "kilometre scale" models for climate studies

What benefit does this give us ? Take a look at the weather forecasting experience.

Operational “convection permitting” forecast models



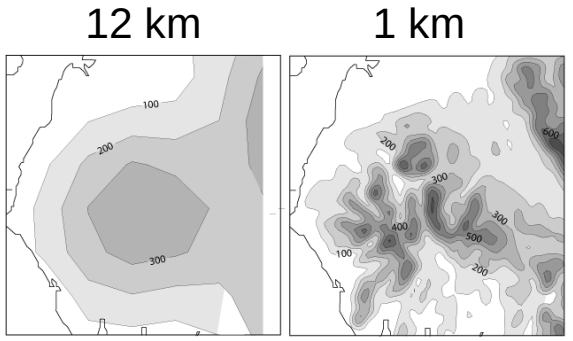
Simulate the atmosphere by splitting it into chunks – the smaller the chunks the greater the precision

Computer power has allowed this – more difficult for long climate simulations of course

What does a kilometre scale model do that a 12 km model can't ?

Much more detailed topography and land surface characteristics

Much better representation of local storm triggers – e.g. uplift from flow associated with hills, coasts and air-mass boundaries



Cumbria

Ability to represent the evolution, structure and secondary development of convective storms

More accurate orographic rainfall

Convection-permitting model development

2003 *Non-hydrostatic Unified Model – allows convection-permitting resolutions*

2005 *4 km UK model*

2009 *1.5 km UK model (UKV)*

CONVEX

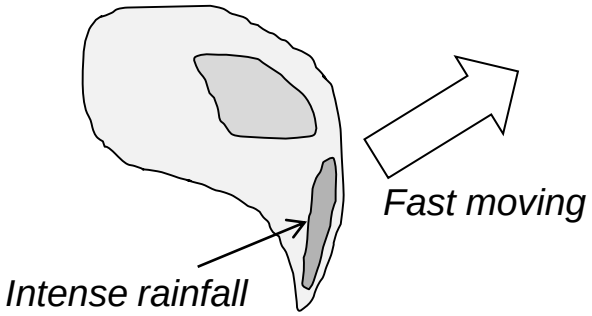
2012 *2.2 km UK ensemble system (MOGREPS-UK)*

Davies et al , A new dynamical core for the Met Office's global and regional modelling of the atmosphere. Quart.J.Roy.Meteor.Soc.,(2005) 608,1759-1782

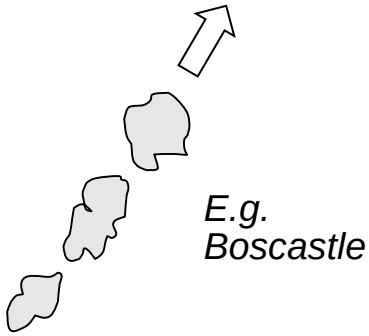
Lean et al 'Characterstics of High Resolution Versions of the Met Office Unified Model for Forecasting Convection over the UK', Mon. Wea. Rev. (2008) 136 3408-3424

Types of convective storm organisation
Heavy rain x long duration = high total

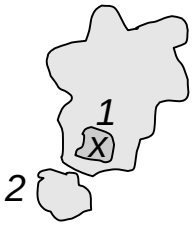
Mesoscale Convective System



Repeating storms



Back building



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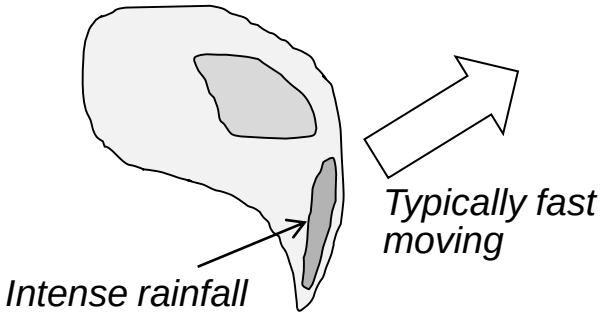

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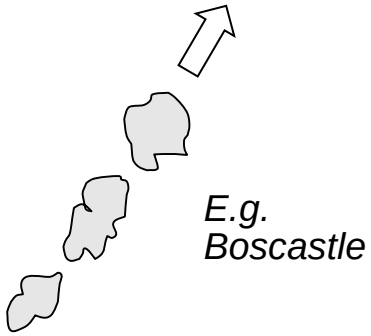

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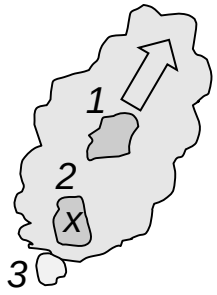
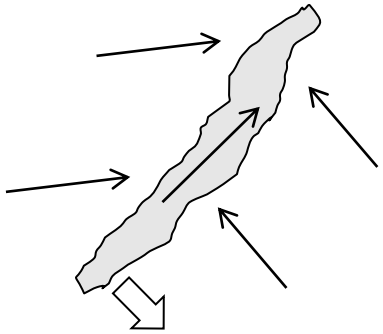
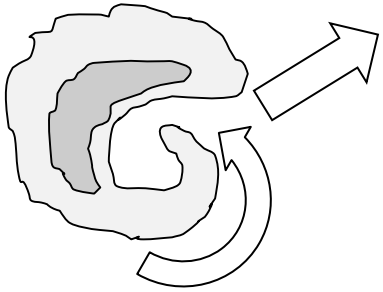


Near stationary bands



Slow progression

More exotic storms



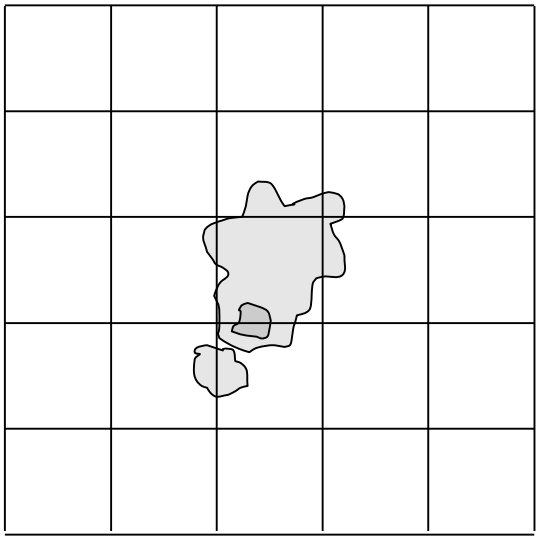
E.g. rotating Supercell

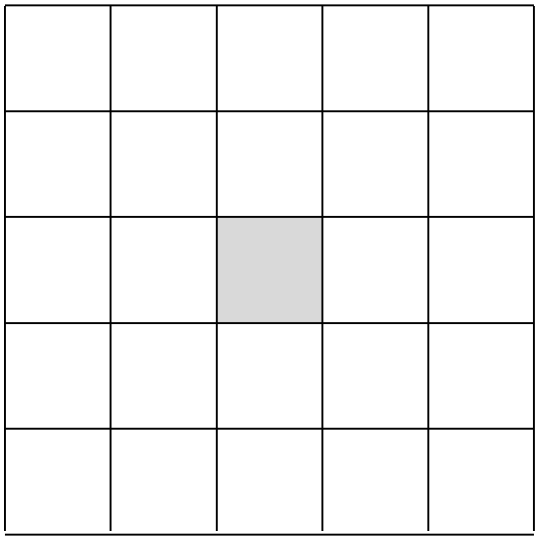
A combination

E.g.
Back-building Mesoscale convective system

Partly broken stationary band ….

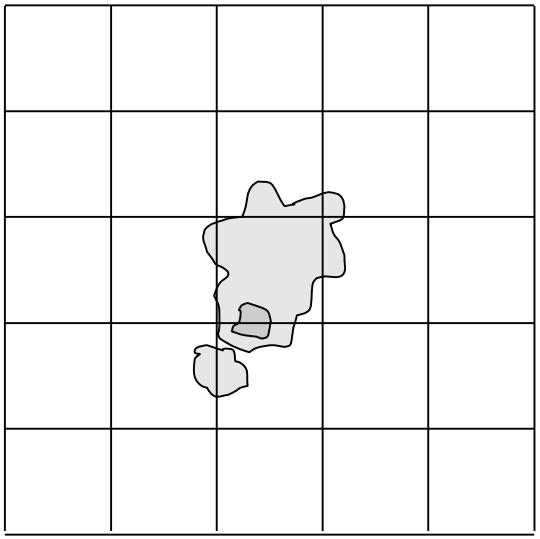
More pixels = more realism !

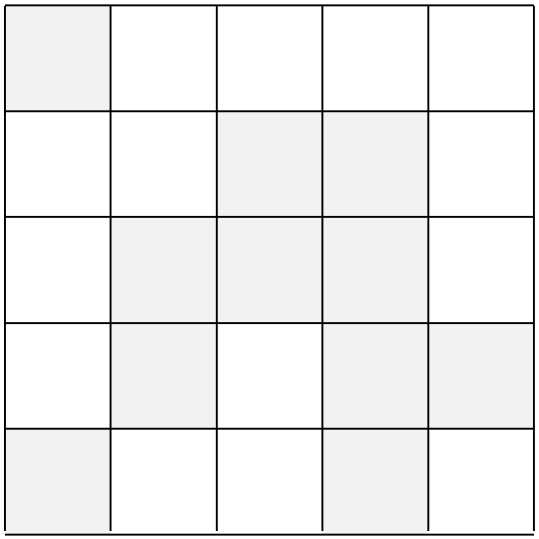




Grid point storm
Not good !

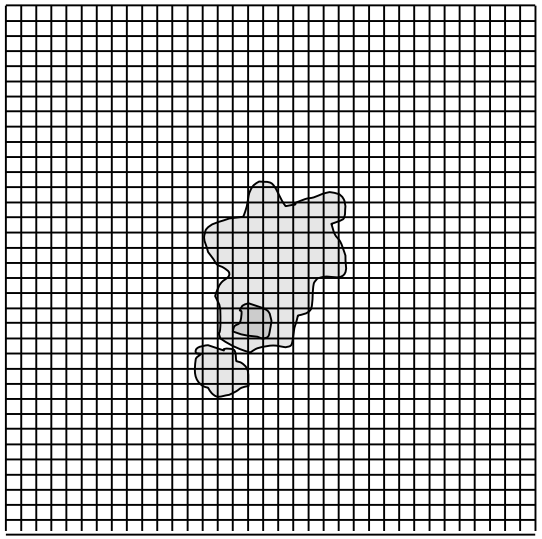
More pixels = more realism !

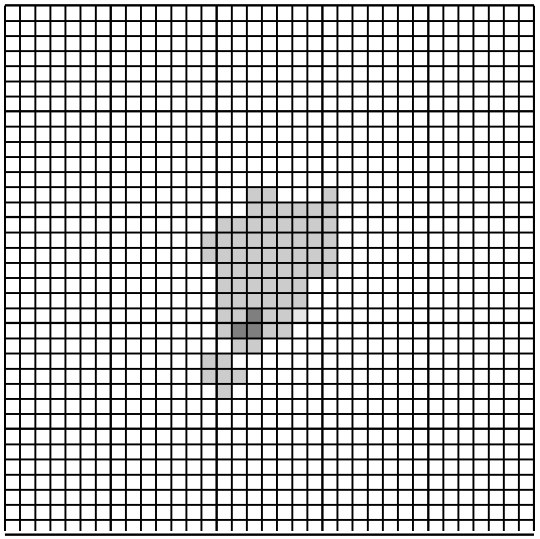




Convection scheme
Bit of rain everywhere !

More pixels = more realism !

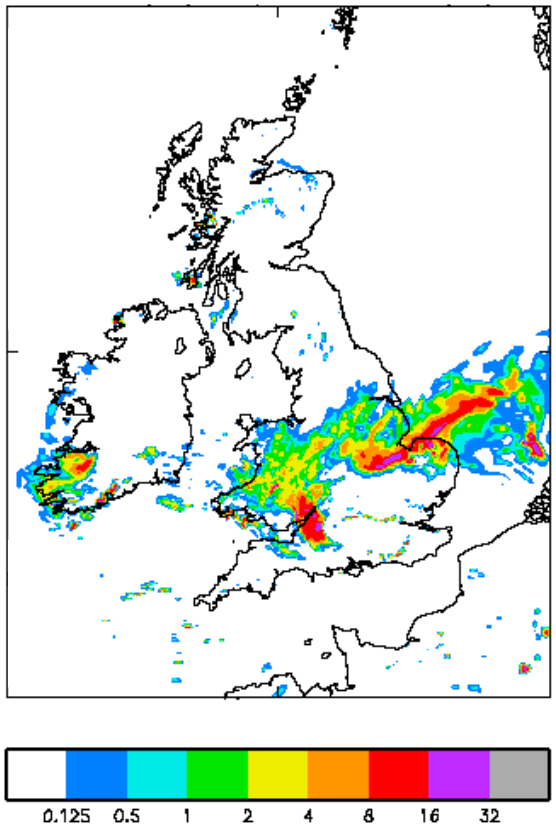


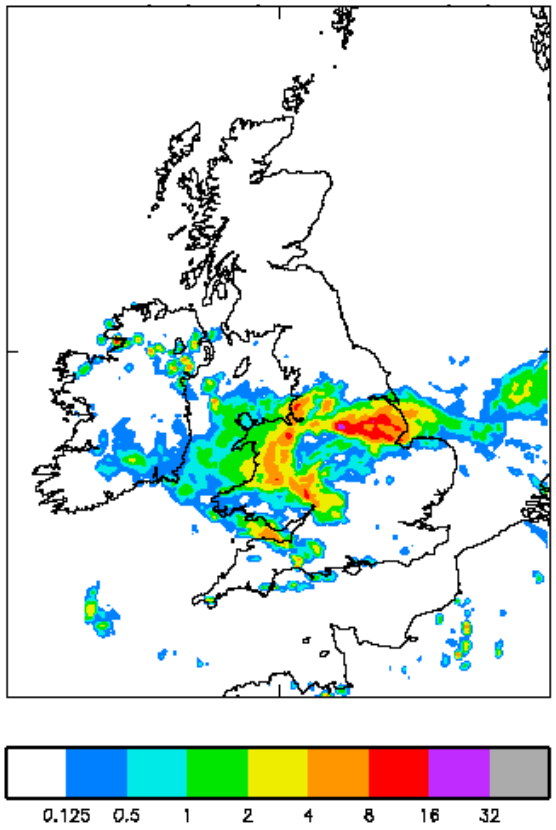


Dynamical structure represented

1.5 km forecast from 06 UTC for 20th July 2007

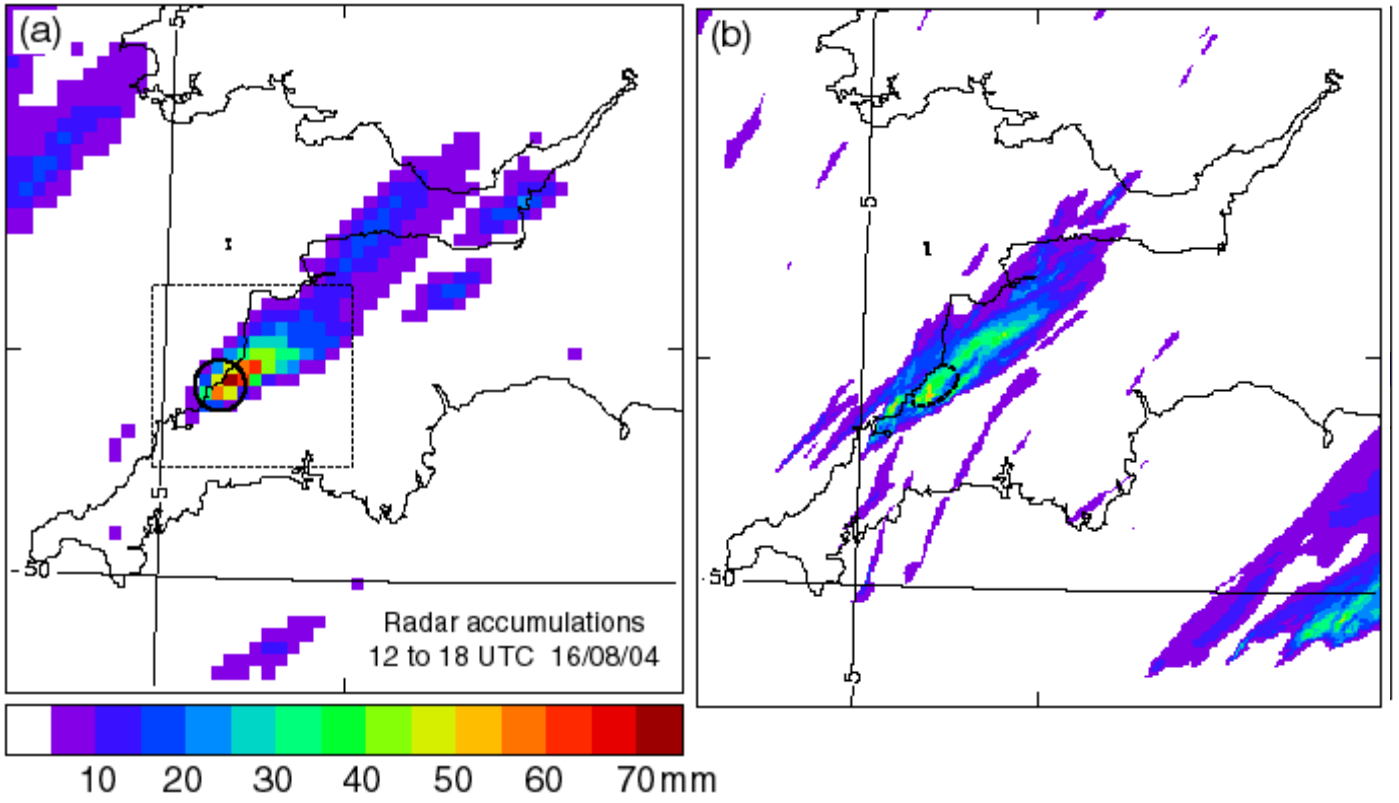
Which is radar and which is the forecast?





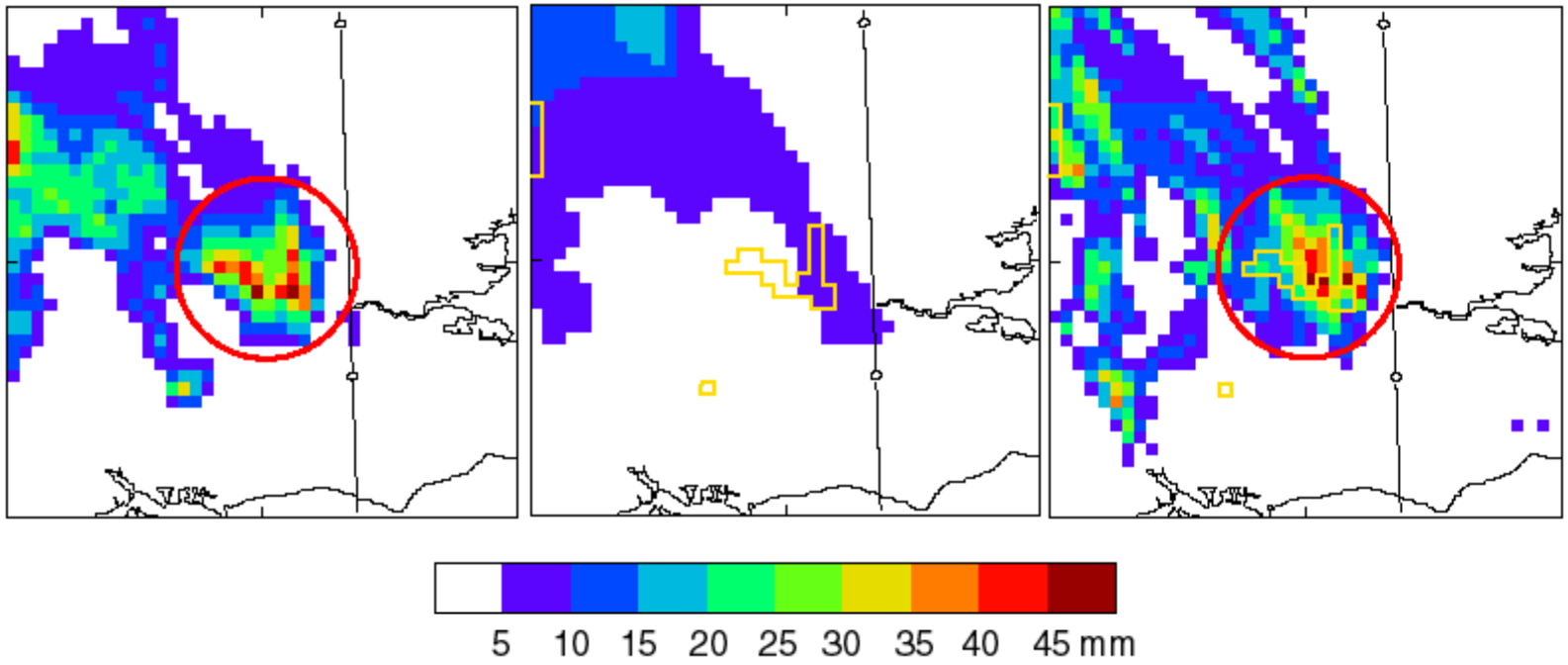
Simulation courtesy of Peter Clark

The Boscastle flood
16th August 2004



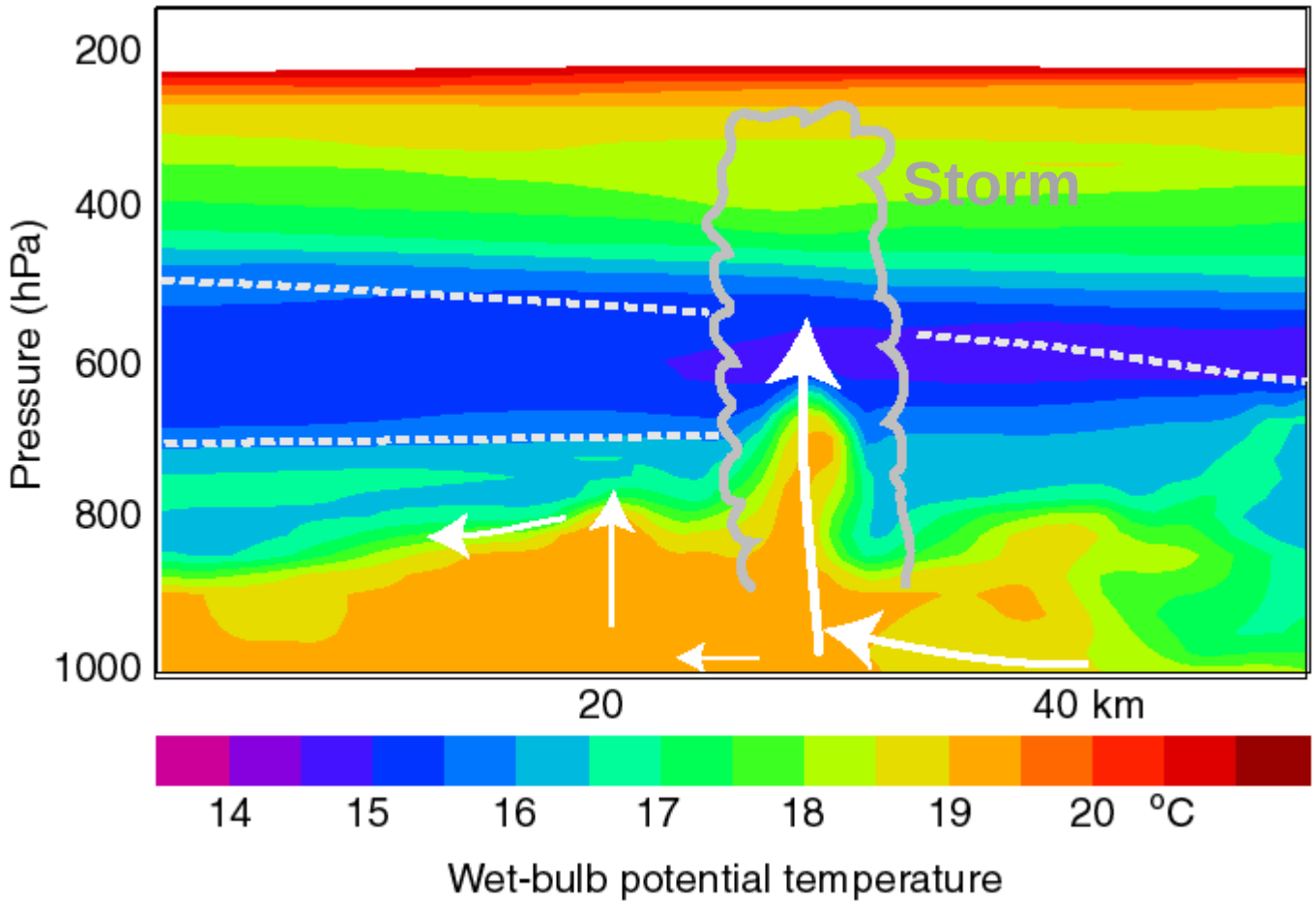
Flooding in London
3rd August 2004

radar *12km* *1km*

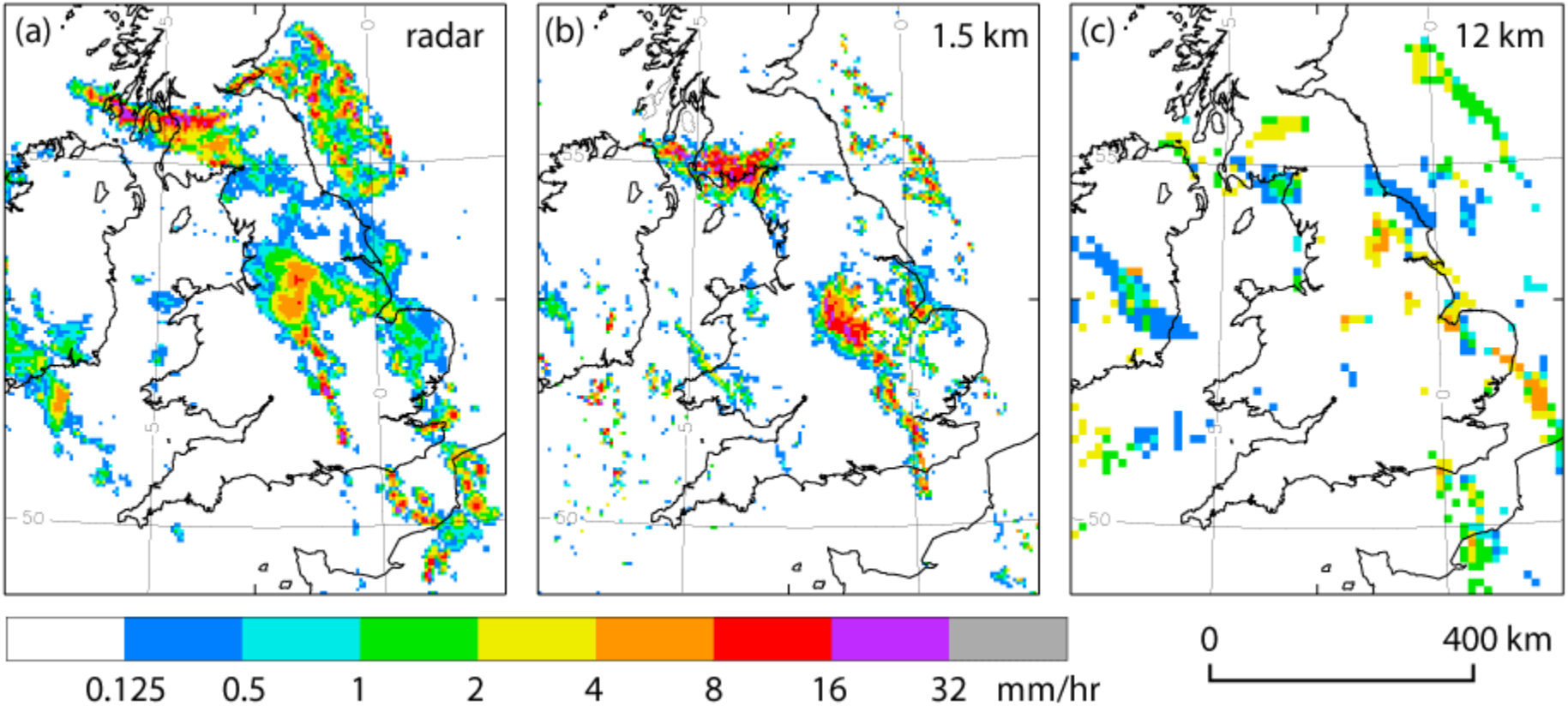


Displayed on a 5 km grid

Flooding in London
3rd August 2004

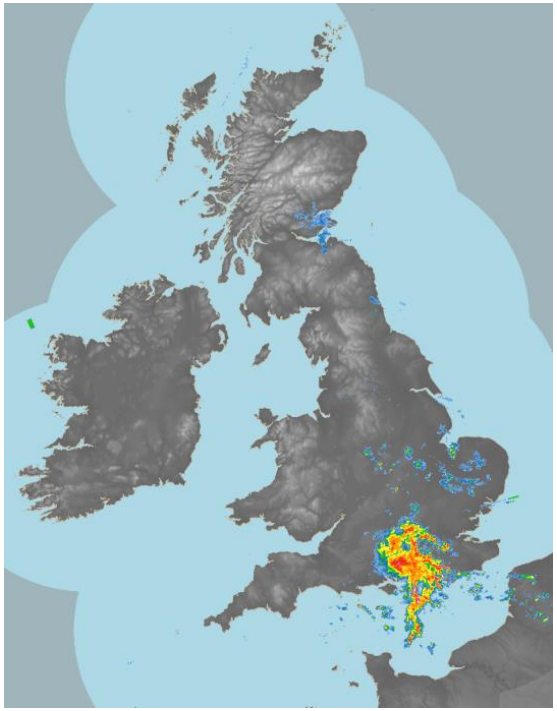


23rd July 2014

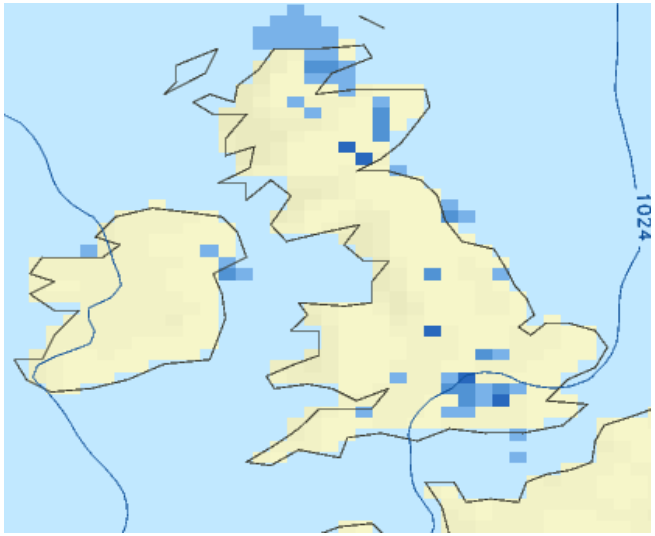


14th June 2014

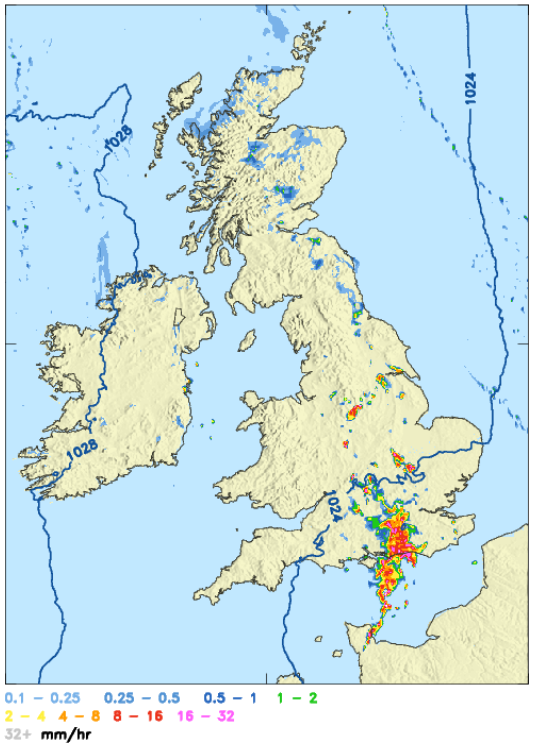
radar



Global model ~25 km grid



UKV model 1.5 km grid



Summary

Convection-permitting models have brought a step change in forecasting capability (greater realism & skill, new products)

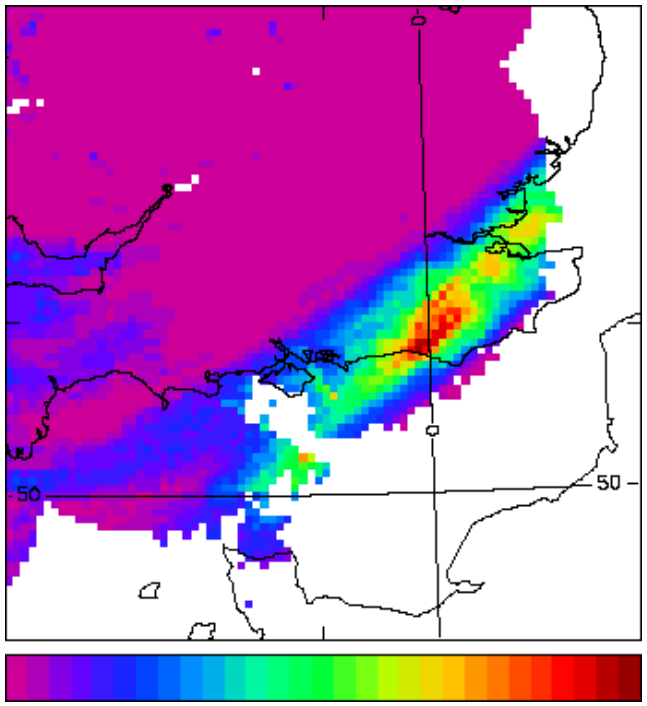
Storm structures, evolution and rainfall amounts can be represented with remarkable realism

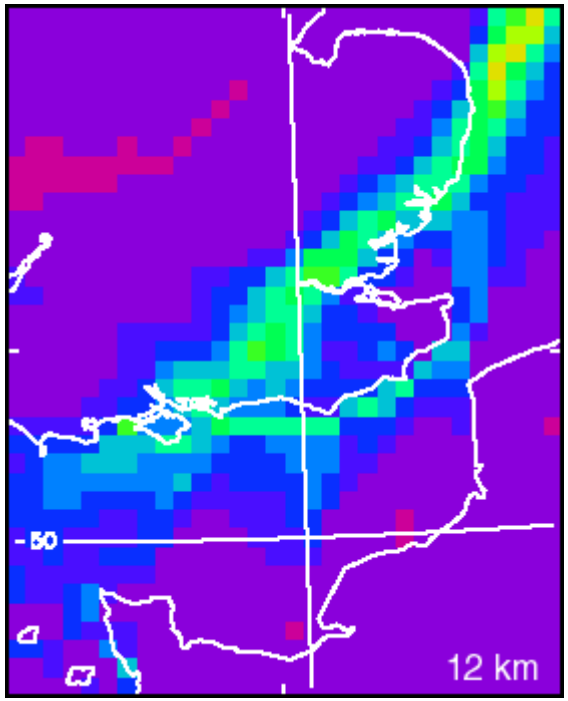
Realism is vital, but is only part of the picture for climate modelling – also need to test for statistical agreement with observed rainfall

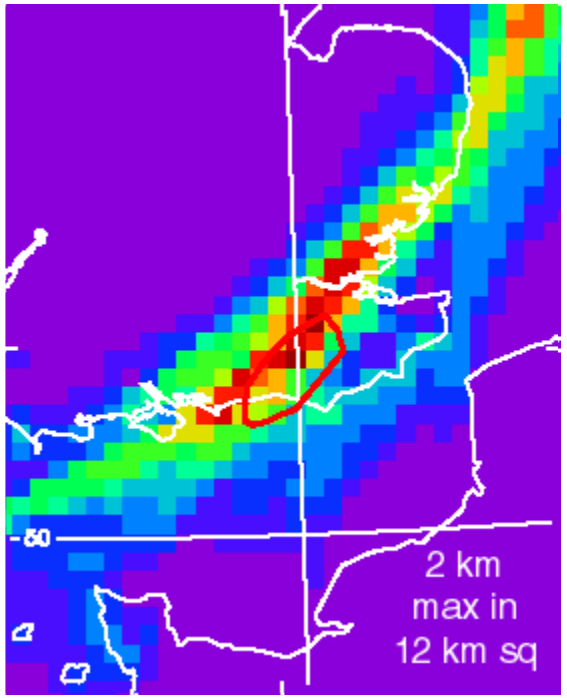
Note of caution – these models are impressive but are far from perfect. Some processes are still not properly resolved and any RCM also depends on the quality of the driving GCM. Further R&D is essential.

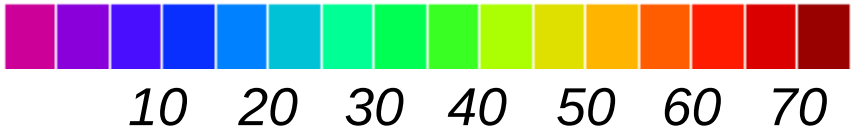
11-12th October 2000

Forecasts of 16-hour rainfall accumulations

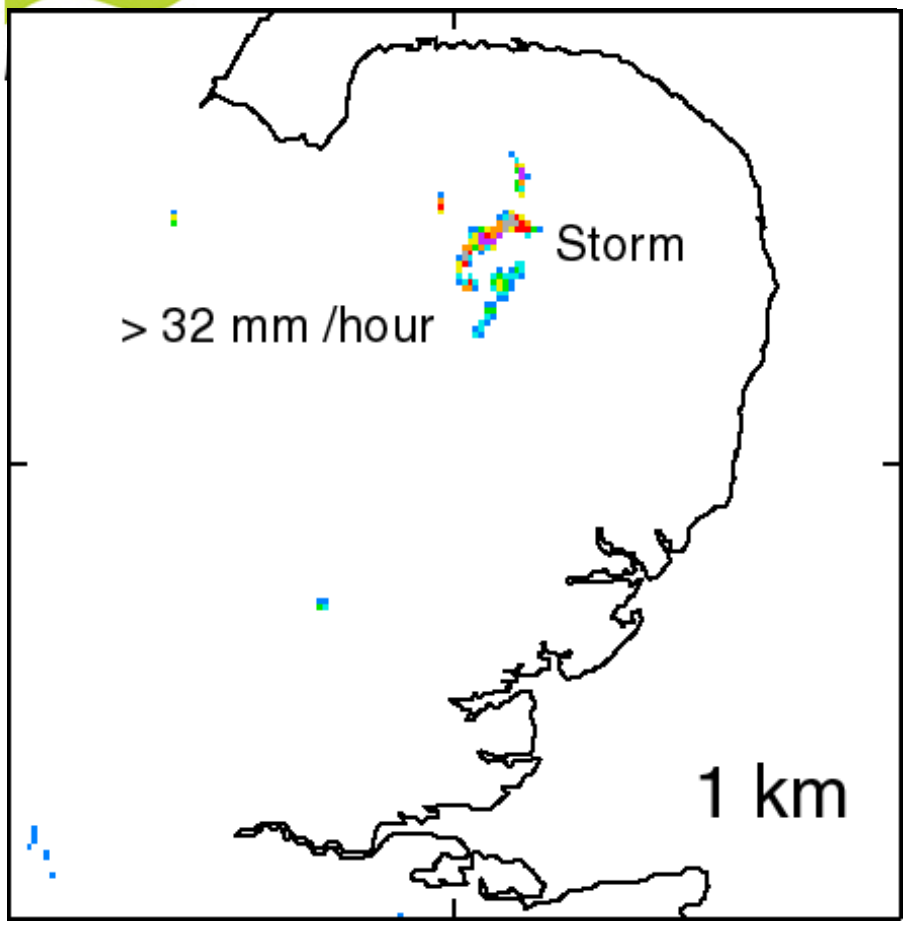


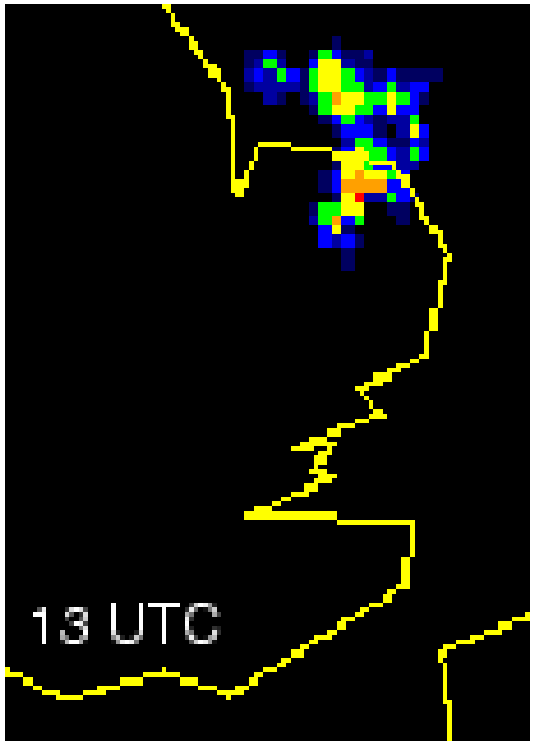




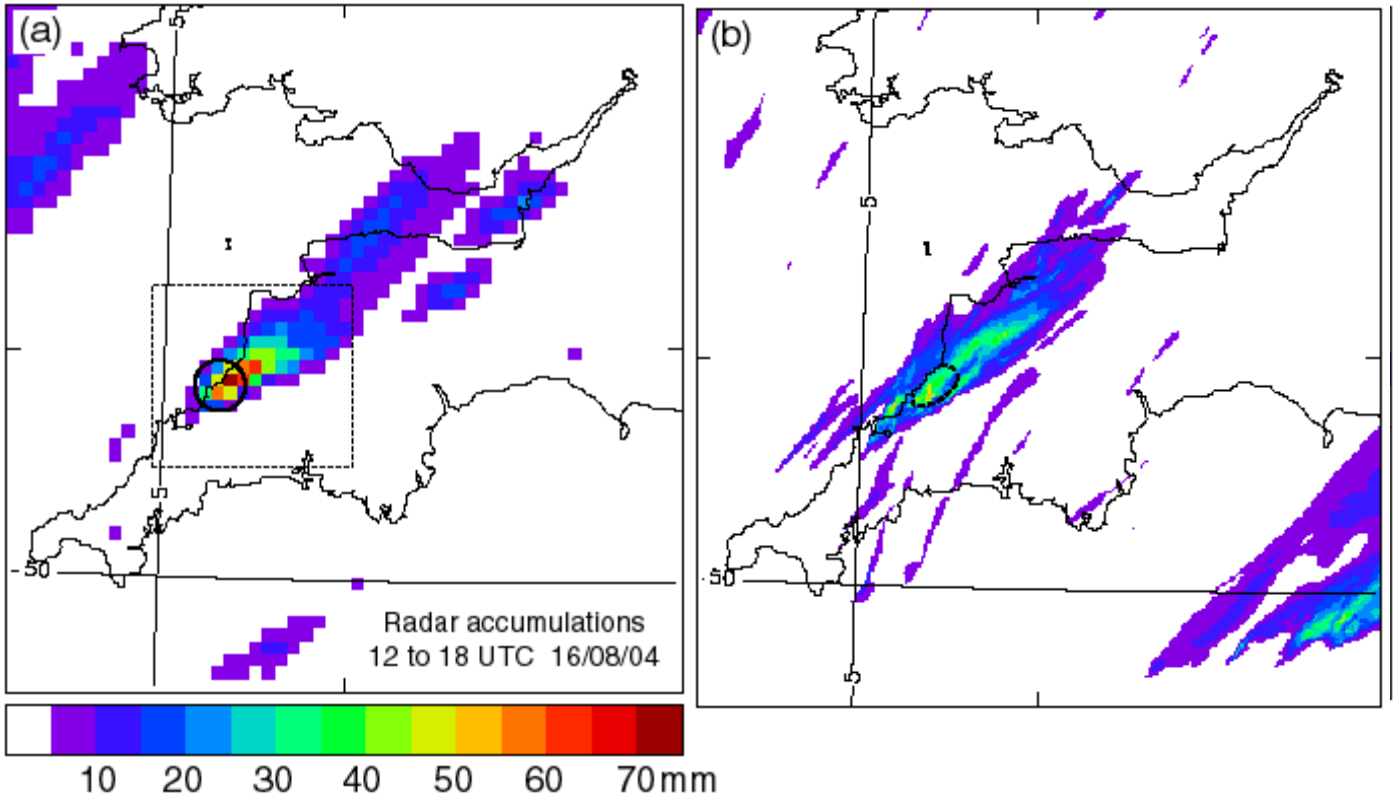


13 UTC 29th July 2002

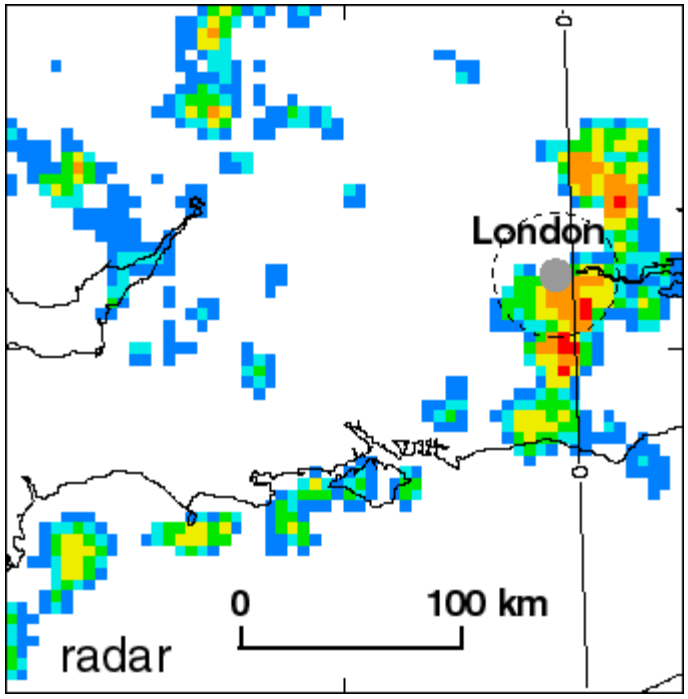


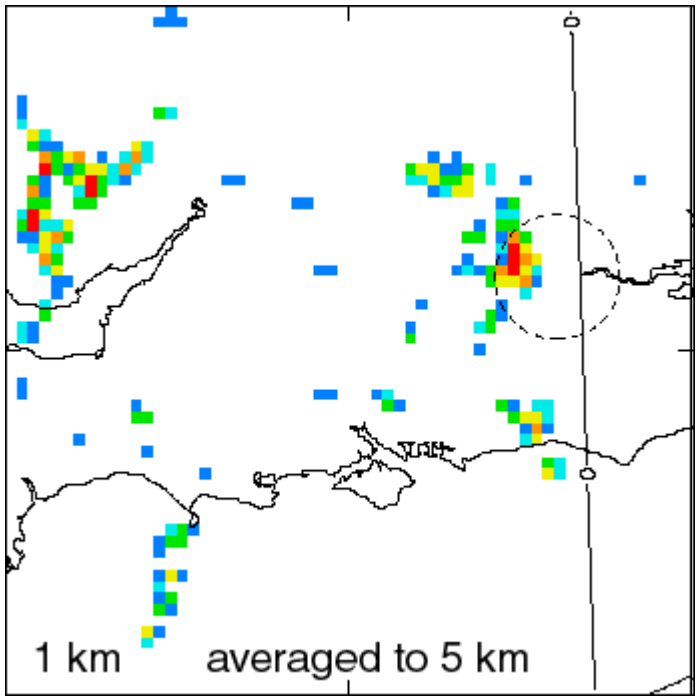


The Boscastle flood
16th August 2004



3rd May 2002 18 UTC





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