Variable resolution or lateral boundary conditions

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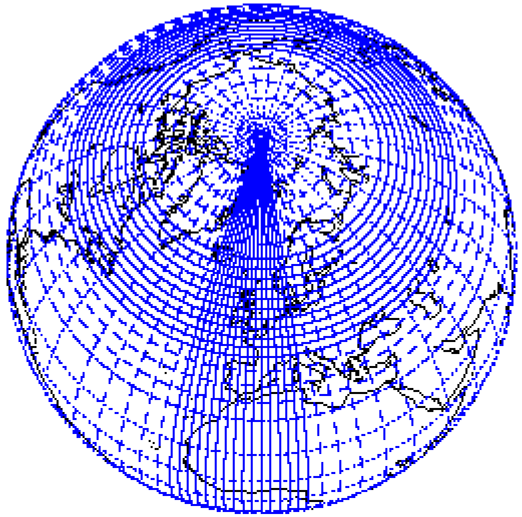
Convective scale NWP

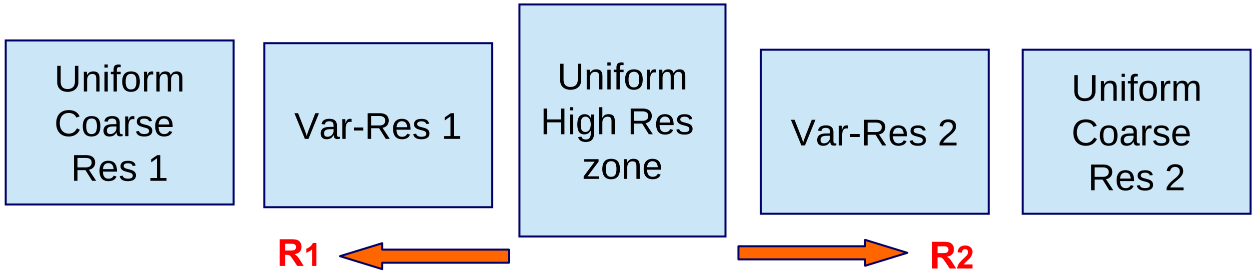
- Variable Resolution / Nested models
- Case Studies
  - with one-way nested UM NWP
  - with variable resolution UM

Variable Resolution



Grid Structure

Grid varies from coarse resolution at the outer boundaries smoothly to a uniform fine resolution in the interior of the domain



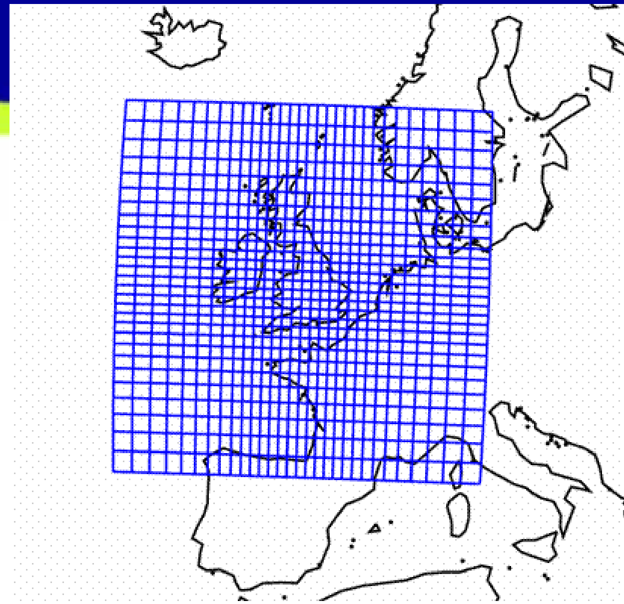
Typically, there are 3 regions, and *inflation ratio* $R_1 = R_2 = 5\sim10\%$

e.g. **= 1 km, $R_1 = R_2 = 10$ %**

N_vr = 34 / 24 / 15 points →

= 25 / 10 / 4 km

Variable Resolution



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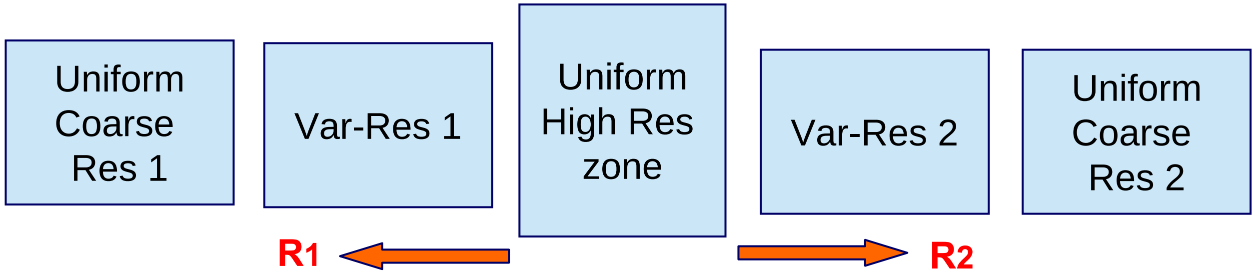

Typically, there are 3 regions, and ***inflation ratio R1 = R2 = 5~10%***

e.g. = 1 km, R1 = R2 = 10 %

N_vr = 34 / 24 / 15 points →

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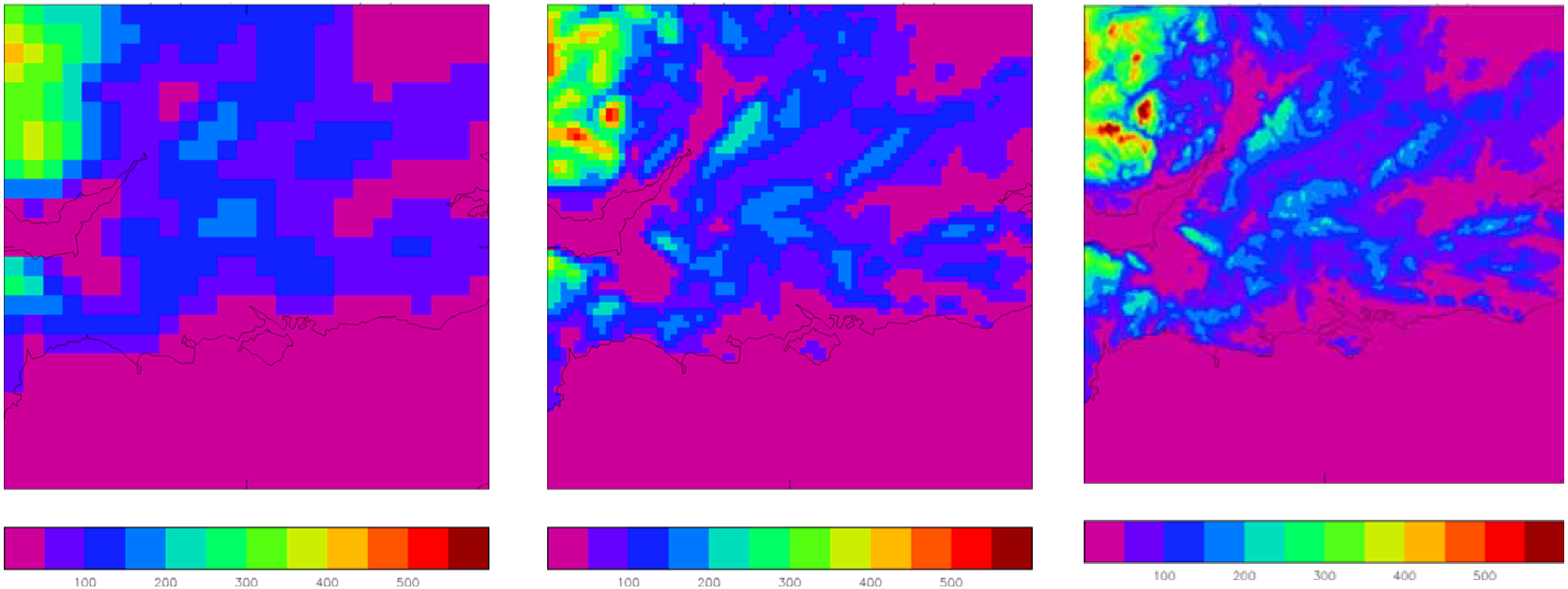
Forecasting precipitation from severe convection

- Parametrized convection – limited success
- Very high resolution models (over a small domain), with detailed controlling factors, such as surface forcing and orography – promising
- Nesting -- typically 3 - 5:1
  - Requires a smooth transition
  - Mismatch of grids and model physics (e.g. coarse resolution model does not explicitly represent convection).
  - Possible solution: variable resolution ?

NWP Model Orography

12 km | 4 km | 1 km



Height of model orography (m)

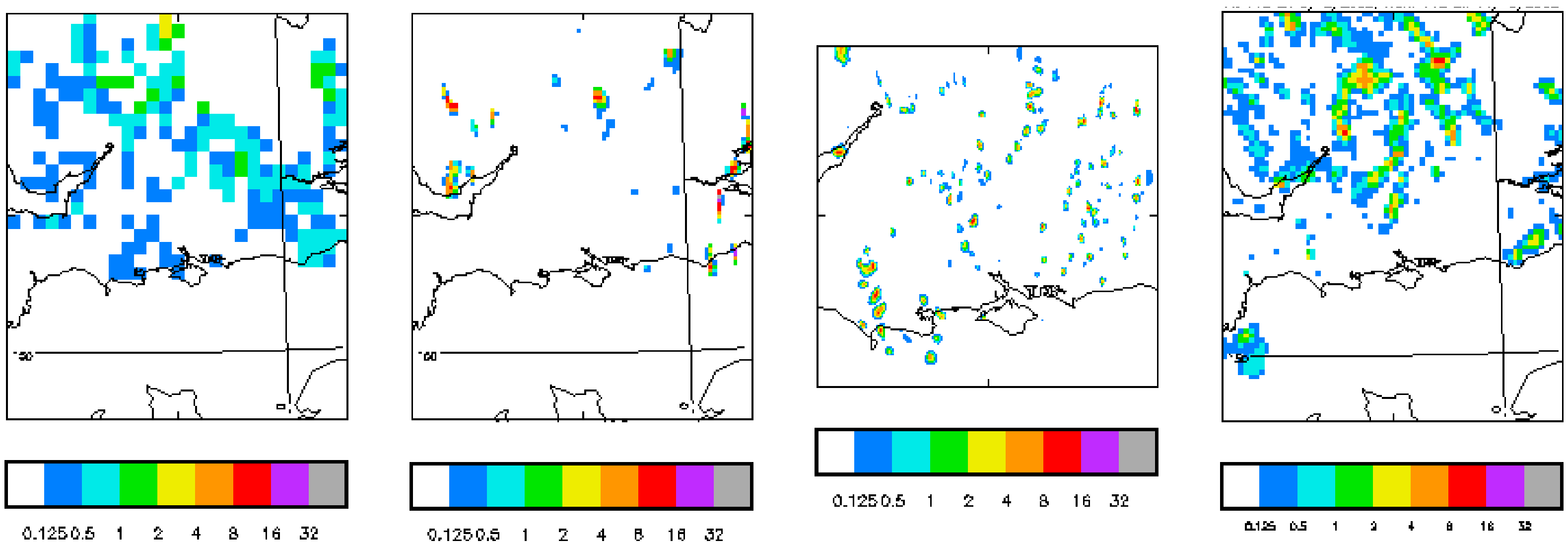
3rd May 2002 case

- **May 3 2002 case is a scattered convection case.**
- **To compare 1 km to 4 km variable resolution to a 1 km model nested inside a 4 km model .**

- **First, the conventional nested model.**

May 3 2002 Case
----- Nested model

12 km | 4 km | 1 km | Radar



1 km high resolution nested model and radar rainfall at 14 UTC

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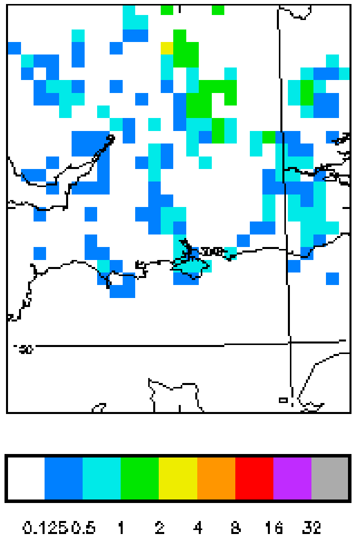
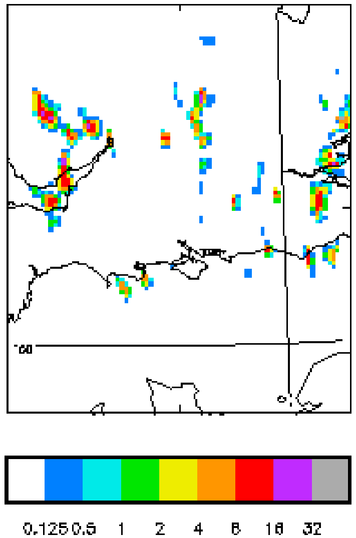
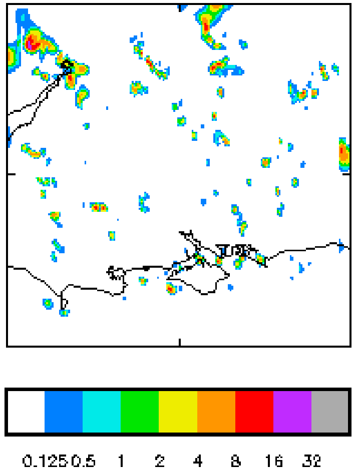
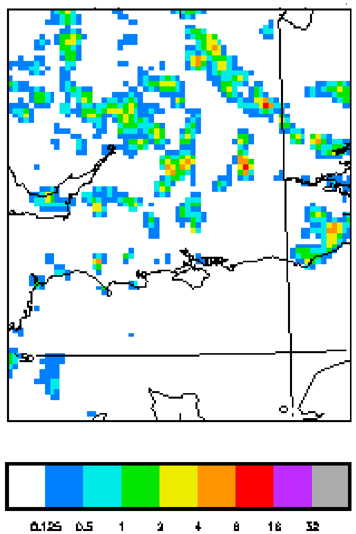
May 3 2002 Case
----- Nested model

12 km	4 km	1 km	Radar









1 km high resolution nested model and radar rainfall at 15 UTC

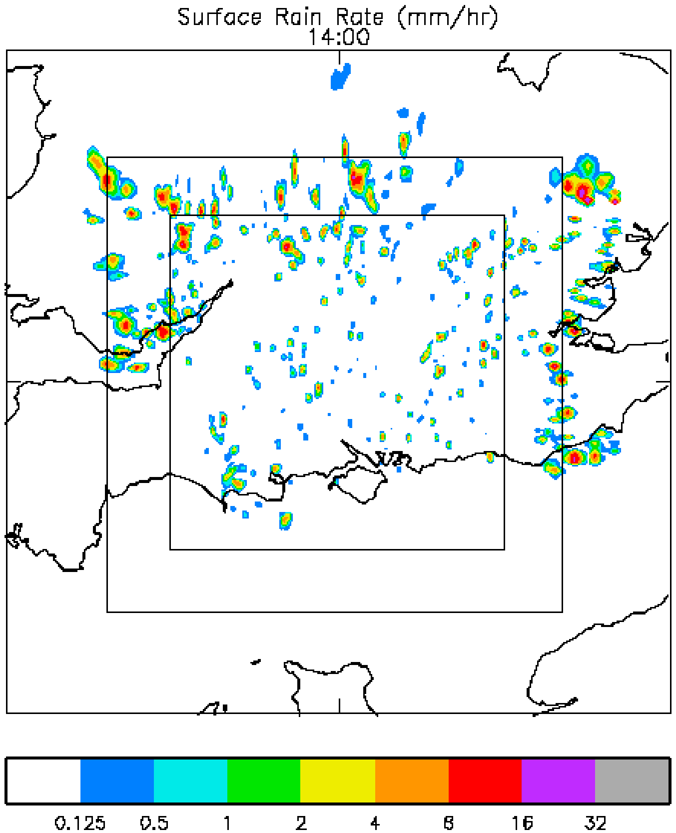
Summary of nested model result

3rd May 2002 case

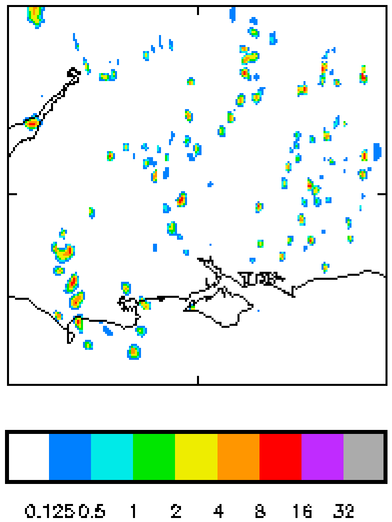
- Nested models suffered two major problems:
  - Spin up problem: at the inflow boundaries (northern) the nested model is too slow to produce convection.
  - Transition problem: at the end of the run when finally the large convection cells are being advected in from the 4 km model, they remain as large cells in the north.

- How well will variable resolution model do ?

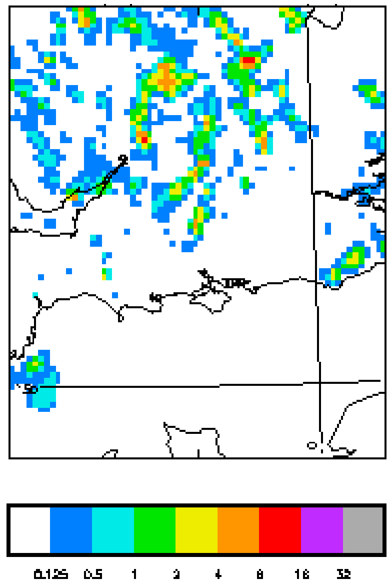
May 3 2002 Case
----- variable resolution model



1km

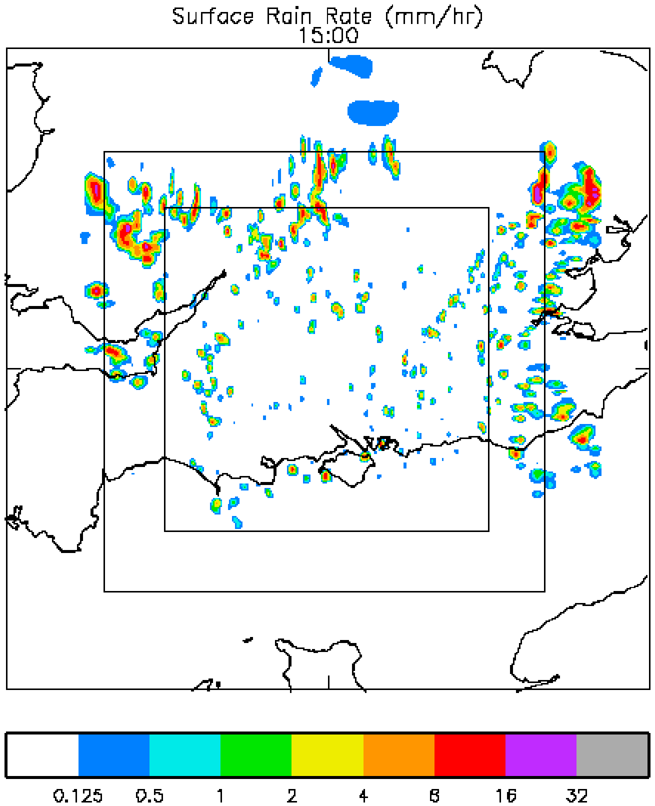


Radar

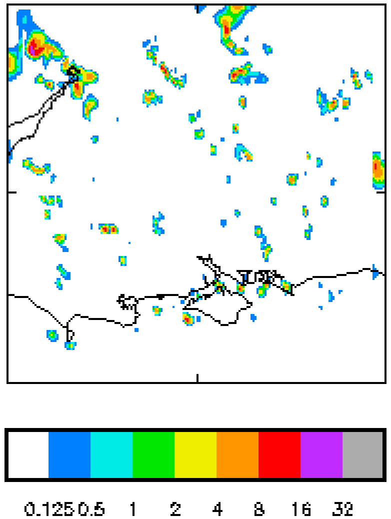


Rainfall at 14 UTC. The three regions of the variable resolution domain are also shown

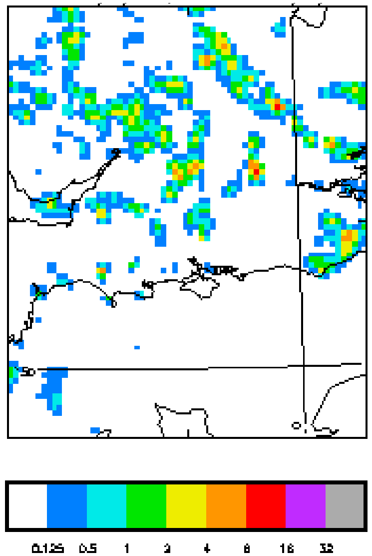
May 3 2002 Case
----- variable resolution model



1km



Radar



Rainfall at 15 UTC. The three regions of the variable resolution domain are also shown

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Summary

- **In the variable resolution model, when the ratio of the minimum and maximum grid is the same as a conventional nesting ratio of 1 : 4, it performs better in resolving convective scale storms. In particular it has overcome the problems of spin up and transition, highlighted in the nested model.**
- **Further study is needed on the physical parametrization schemes if ratio > 4.**
- **We are currently working on a grid-scale dependent convection scheme.**

Lateral boundaries

- To run variable resolution LAM will still need lbcs.
- Current lbcs use standard blending technique (Davies)
- Semi-Lagrangian predictor applies lbcs naturally using time level n
- Apply appropriate lbcs to Helmholtz equation
- Need to filter small-scale outflow information

Lateral boundaries

Semi-Lagrangian predictor applies lbcs naturally

- **Up-winding scheme so lbcs only applied at in-flow (if departure point is inside domain then lateral boundaries are not used)**
- **Departure points outside domain obtained from lateral boundaries but use time-level n information, not time-level n+1 (time-level n+1/2 used for trajectories)**

Lateral boundaries

- **Apply appropriate lbcs to Helmholtz equation**
- **LBC only applied to (Exner) pressure correction ($\Pi' = \Pi^{n+1} - \Pi^{n}$) at one point around edge of domain – well-posed Dirichlet problem**
- **For mpp, lateral boundary files do not need external halos – can use a rim (>1 to allow for flow Courant number >1) around inner edge of domain**

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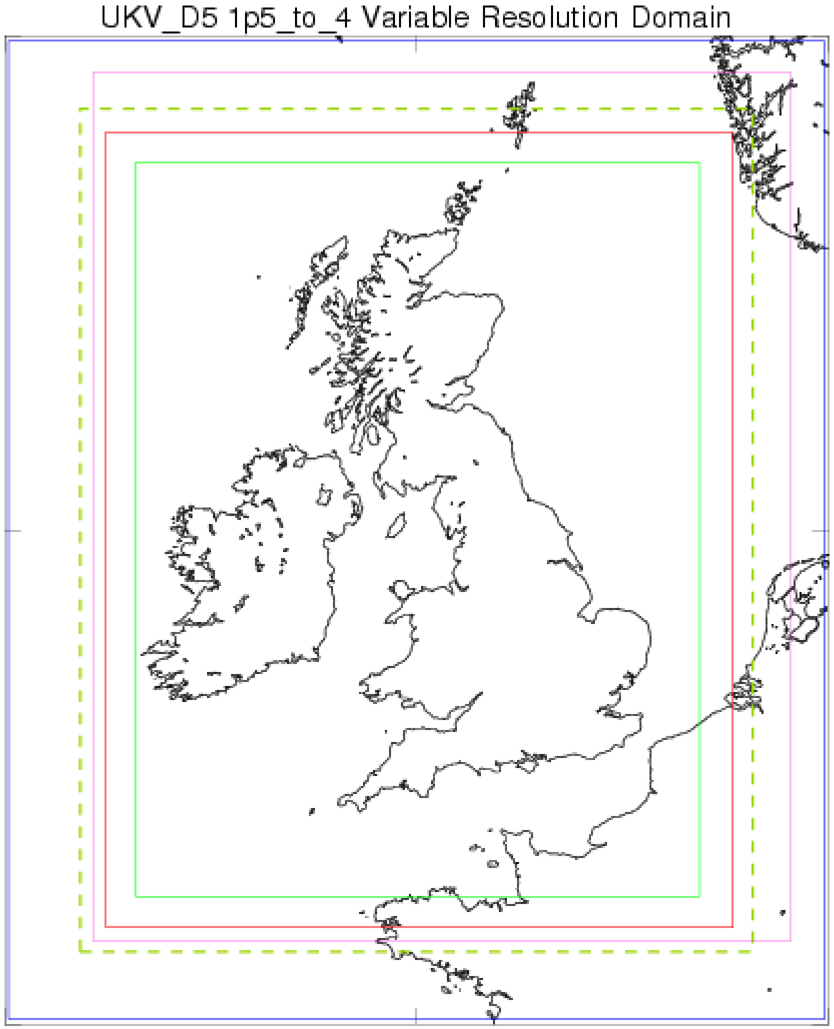
Lateral boundaries

- **Blending of lbcs still useful to match mass/pressure fields of driving and nested models**
- **Blending upsets geostrophic adjustment**
- **If no blending of lbcs then will need to filter small-scale outflow information otherwise reflection at the boundary (loss of transparency)**

UK 1.5 km domain



1.5km UK model plan

- **1.5km fixed resolution over UK with outer variable rim to 4km (perhaps 12km)**
- **3D VAR mainly over 1.5 km area**
- **Testing on new IBM starting January**
- **Parallel suite starts end of April**
- **Operational end-of-May**

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The End