



Forecasting Convective Events with Kilometre Scale Versions of the Unified Model

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Introduction

- Requirement to improve forecasts of severe weather Particularly severe convective events
- General move towards NWP for short range nowcasting applications
- Higher resolution models being developed.
- Enabled by improving computing resources and non-hydrostatic version of Unified Model (UM)
- Currently highest resolution model run operationally by Met Office is 4km UK model. Expect order 1km gridlength model by ~2010.
- This poster describes work on "High Resolution Trial Model" (HRTM) system which includes models at 12km, 4km and 1km gridlengths.
- Two approaches:
 - Investigate model performance in particular cases
 - Aggregate statistics over a number of cases.

Unified model

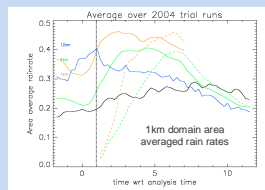
- Dynamics**
 - Non-hydrostatic with semi-Lagrangian advection and semi-implicit time integration. (Davies et al, 2005)
- Subgrid parametrizations**
 - Clouds and precipitation (Wilson and Ballard, 1999)
 - Radiation (Edwards and Slingo, 1990)
 - Surface exchange (MOSES II) (Cox et al, 1999)
 - Non-local boundary layer (Lock et al, 2000)
 - Convection (see table of configuration of different resolutions)

Configuration of different Resolutions

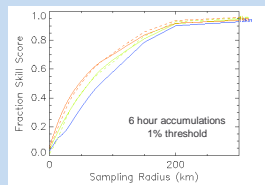
Model	12km	4km	1/1.5km
Timestep	5min	1min	30s
Levels	38	38/76	76
Nesting	1 way inside 60km global	1 way inside 12km	1 way inside 4km
Horizontal Diffusion	None (targeted diffusion)	8 tstep del-4	8 tstep del-4
Prognostic Rain	NO	YES	YES
Convection Scheme	Std Mass Flux	CAPE dependent CAPE closure timescale	NO
Assimilation	3D VAR MOPS/LHN	3D VAR MOPS/LHN	4km VAR incs MOPS/LHN

Differences between operational 12km and high resolution models

Statistics over a Number of Cases



- Have aggregated stats for 7 convective cases in summer 2004.
- Domain averaged rainrates show problem with over prediction particularly during assimilation cycle.
- Spin up runs show expected deficit early on followed by overshoot. Shows that assimilation essential for short range forecasts.
- Scale selective precipitation stats show benefits of high resolution models in spatial distribution of rain (the relative threshold eliminates effect of overall bias).

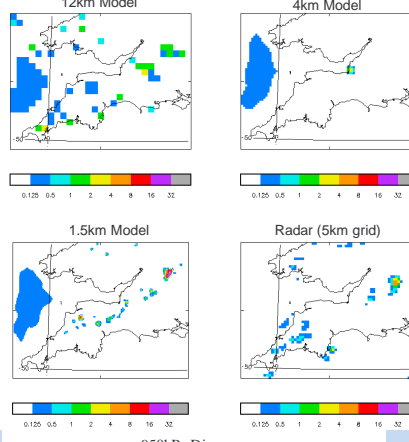


Key to both figs
 Red - 1km
 Green - 4km
 Blue - 12km
 Black - radar

Dotted spin-up
 Solid assimilation

CSIP IOP1 15th June 2005

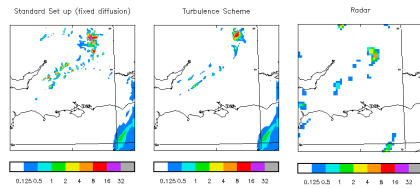
Rainfall Fields at 11:30 UTC (model runs initiated at 0:00 UTC)



- Convective Storms Initiation Project (CSIP) was large collaborative field project in S England in summer 2005.
- Intensive Observations Period (IOP) 1 was case of showers developing behind front in SW flow.
- Relatively simple case with only one heavy storm.
- Heavy storm at intersection of convergence line from SW peninsula with upper level feature.
- Two areas of interest: 1. Initiation of shower and 2. transition from shallow to deep.
- 12km model (parameterised convection) gives general idea of areas of rain but insufficient intensity.
- 4km model misses rain due to trying to produce convection explicitly on too large gridlength. Often see delay in initiation at 4km. (does produce shower in correct place two hours later).
- 1km model gives best representation. Tends to produce many small showers (insufficient diffusion/turbulence). Main shower too heavy and small for same reason.
- Comparison of low level divergence in 4km and 1.5km models shows much stronger and more coherent line in 1.5km.

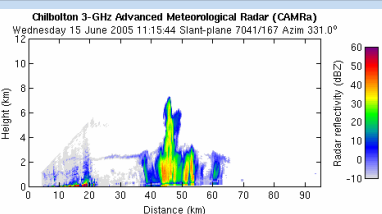
Tests of Turbulence Scheme

12:45 UTC 15th June 2005 0:00 UTC runs



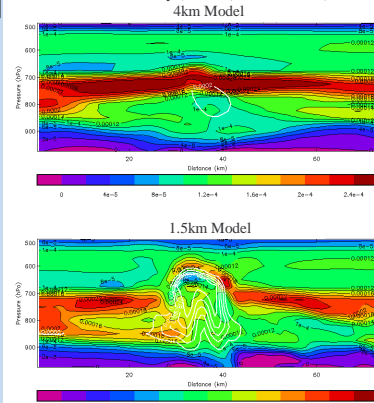
- Preliminary test of Smagorinsky turbulence scheme shows successful elimination of large numbers of small showers.
- This rerun of CSIP IOP1 (different from that shown above) shows more realistic rainfall distribution behind main shower.

Start of deep convection in CSIP IOP1



- Radar reflectivity data shows storm breaking through lid at around 11 UTC
- Picture above shows radar cross section taken across convergence line and through storm
- 1.5km model appears to capture this reasonably well.
- 4km model due to large gridlength does not generate enough vertical velocity to penetrate lid and give deep convection at this time (it does at later times),

11:00 UTC Static stability (colours) cloud water (contours)



Summary and Discussion

- Objective statistics show benefits of high resolution in terms of spatial distribution of precipitation. Problem with over prediction of precipitation.
- 4km and 1km models produce benefits over the 12km model from explicitly representing convection.
- 4km model suffers from trying to explicitly produce convection while under resolved - delay in the initiation of convection and unrealistically large and heavy cells too far apart.
- 1.5/1km models often produce significantly better forecasts than the 4km - better representation of mesoscale features.
- 1/1.5km models still suffer from a delay in initiation compared to parameterised models (although the latter often initiate too early). They also tend to incorrectly produce many very small showers which probably result from too little mixing in the model.
- Although further development is required order 1km gridlength models have the potential to improve forecasts of convective events.

References

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