Unified Model Developments 2005

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Configurations

The current NWP Model configurations are shown in figure 1.

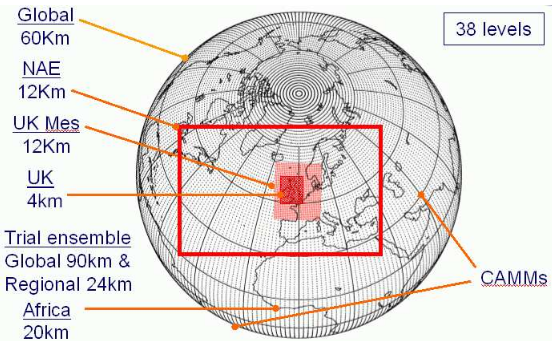

Figure 1: Current NWP Model configurations

Supercomputers for NWP and Climate

In April 2005, there was an upgrade to the twin 15 node NEC SX6 system that had been operational since April 2004. The addition of 4 SX6 nodes plus a 16 node NEC SX8 has given an increase in computing power from 1.86 TFlop to 4.08 TFlop, allowing the introduction of ensembles and increased resolution models (including those used in climate research).

Global model changes

Cycle	Date	Global Model Change
G33	5 Oct 04	Introduction of 4D-VAR
G34	18 Jan 05	HadGEM physics upgrade
G35	8 Feb 05	Data Assimilation upgrade
G36	14 June 05	DA and SA upgrade
G37	17 Aug 05	Implementation of a soil moisture nudging scheme

Introduction of HadGEM physics

An upgrade to the Global model physics was introduced in cycle G34. The package included improvements to the Large Scale precipitation (3C) and Boundary Layer (8B) schemes. There was also a change to the CAPE closure timescale and an increase in Saharan surface albedos. The main benefits were seen in the tropics with an improved circulation and winds. Precipitation over land was increased while precipitation over the ocean was decreased (figure 2). Elsewhere there were beneficial reductions in low cloud (e.g over Iraq) and improved 1.5m temperatures. The main drawback was an increase in the existing warm bias in the extratropics.

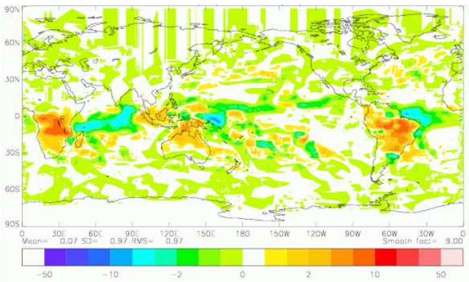

Figure 2: Convective rain amount: 30 min CAPE forecast - 1 hour CAPE forecast

Implementation of a soil moisture nudging scheme

A soil moisture nudging scheme was introduced in cycle G37, replacing the previous weekly reset to climatology. The nudging scheme uses errors in the 6 hour forecasts of screen temperature and humidity to infer (using the physics of the land surface model) corrections to the soil moisture field. Summer trials showed improvements to surface and boundary layer temperature forecasts whilst Winter results were close to neutral.

Planned Global Changes (2005-6)

- Increased horizontal (40km) and vertical (50 levels) resolution (December 2005)
- Convection and Boundary Layer tuning (Spring 2006)
- Introduction of improved AIRS (better humidity, esp SH) (Spring 2006)
- Introduce SSMIS (T only, back-up for N15 AMSU); SSMI introduce TCWV by using stricter thinning to only include cloud-free areas (Spring 2006)
- Upgrade to 4D-VAR including better incremental physics. (Summer 2006)
- Microwave cloudy radiances and less obs thinning (ATOVS) (Summer 2006)

Introduction of the Met Office Global and Regional Ensemble Prediction System (MOGREPS)

Cycle	Date	Ensemble model Change
MOGREPS_G1	14 June 05	Model introduced
MOGREPS_G2	11 Oct 05	Stochastic physics upgrade
MOGREPS_R1	17 Aug 05	Model introduced

Initially forecasters will view output on the internal web. There are also plans to engage in multi-model ensembles with USA and Canada (THORPEX).

Global Ensemble

- 24 member Global Ensemble at N144 (~90km) resolution
- Twice per day (00Z, 12Z) to T+72 hours
- ETKF perturbations, stochastic physics

Regional Ensemble

- 24 member North Atlantic/European Ensemble at 24km resolution
- Twice per day (06Z, 18Z) to T+36 hours
- IC perturbations taken directly from the Global model
- Nested within Global Ensemble for LBCs

NAE model Developments

Cycle	Date	NAE model Change
E5	18 Jan 05	Change in domain
E6	22 Feb 05	Horizontal resolution increased from 20km to 12km
E7	14 June 05	New surface soil moisture analysis
E8	17 Aug 05	Removal of truncation of vertical modes in VAR from 21 to full 38
E9	11 Oct 05	New CovStats based on Global model

New CovStats

New CovStats based on Global model CovStats (generated using the NMC method) replaced the use of U.K Mes covariances in cycle E9. The Global covariances fit less closely to obs but the horizontal length scales are longer and this leads to large improvements to the performance of the model. Ideally we would use NAE covariances but forecast differences are dominated by the use of different lateral boundary conditions.

Planned NAE Changes (2006)

- Upgrade to model physics (Spring 2006)
- Introduction of 4D-VAR (Spring 2006)
- More new satellite data e.g. full resolution AMSU-B, Assimilation of GPS data, MODIS winds etc. (Summer 2006)
- Increased vertical resolution (Autumn 2006)

Crisis Area Mesoscale Models (CAMM's)

Currently a 17km Southern Asia and a 12km Falklands model are run operationally. However new configurations can be set up rapidly as demonstrated by the Bay of Bengal CAMM in response to the 26th December 2004 Tsunami and the USA CAMM (Hurricanes). The extra resolution not only helps to deepen Hurricanes such as Rita but also gives the possibility of a different track forecast.

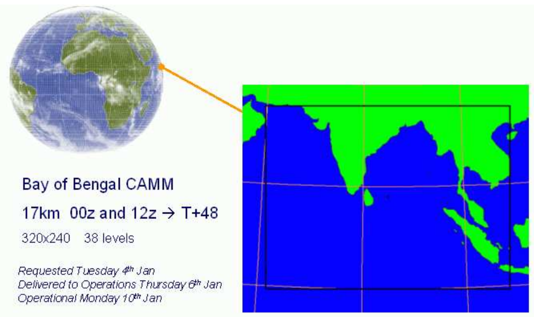

Figure 3: Bay of Bengal CAMM

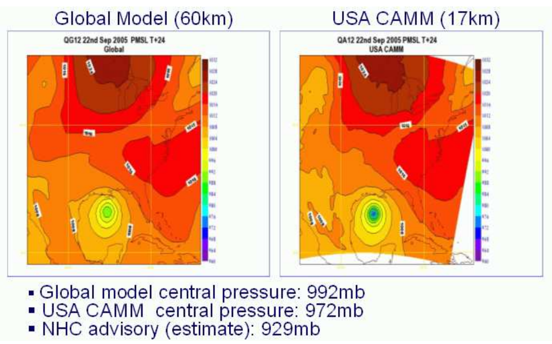

Figure 4: USA CAMM Hurricane Rita

African Model

The 20km resolution Africa model was introduced into the Operational Suite on 13th April 2005 as part of the Met Office vision of increased focus on assisting developing countries and disaster mitigation. Currently there is one forecast per day (00UTC) to T+48 hours, but this will change in early 2006 when data assimilation (6 hour cycle) is introduced. There are also plans for an increase in the model vertical resolution during 2006.

HRTM and UK4 models

The High Resolution Trial Model (HRTM) has been developed over a number of years and is the basis for the now operational UK4 model. However development of the HRTM has continued and it is used as a testbed for planned UK4 upgrades.

The UK4 model became operational in April 2005 and there have been encouraging results from both pre-operational tests and the first few operational months. Objective verification scores have been slightly worse than other operational models and some problems have been identified. Several upgrade packages are scheduled for implementation in the near future.

HRTM Scientific Options

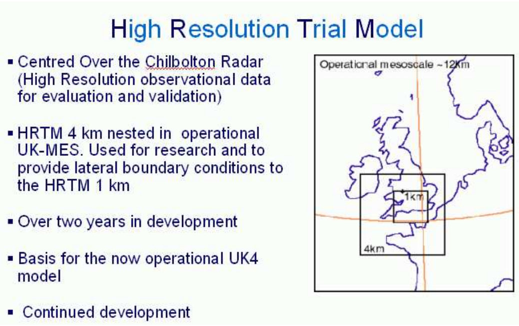

Figure 5: HRTM

Like other Met Office operational models, the HRTM has non hydrostatic dynamics with Semi-Lagrangian advection and Semi-Implicit time integration. The Boundary Layer scheme is a 1st order non-local K scheme with explicit entrainment and the radiation is a two stream scheme with 5 spectral bands for short wave and 5 for long wave. It differs from other models in that is uses a Del-4 operator in U,V,Q and Theta for Horizontal diffusion and a mixed phase scheme + 3D advection of precipitation products for the microphysics.

Convection: Deep convection explicitly resolved and shallow convection parametrised. Solution based on the operational mass flux scheme with CAPE closure. The CAPE reduction timescale is dependant on the CAPE such that for large values of CAPE, the CAPE timescale increases, reducing the activity of the convection scheme and allowing explicit deep convection. For small CAPE, a minimum CAPE timescale is fixed and shallow convection processes are taken into account. It has been seen that there is a delay in the onset of convection as the convection scheme is made less active.

UK4 model

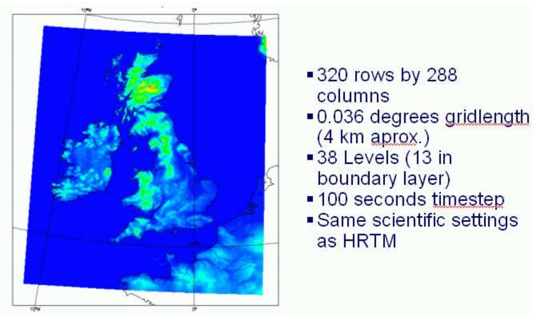

Figure 6: UK4 model

UK4 Model - Pre-operational tests

21 case studies were run covering of all the main weather regimes, (although biased towards severe weather events) with the lateral boundary conditions being provided by the UK Mesoscale model. A continuous trial was run from 1st March to 1st April 2005 with forecasts at 00UTC and 12UTC. There was varied weather through the period and this time the lateral boundary conditions were provided by the NAE model.

The model proved to be very robust and there were a number of positive points such as the better forecasting of fog than other coarser resolution operational models. However a number of problems were also identified. The 11th August 2004 organised convection case showed that although the banded structure in the 6hr precipitation accumulation compared well with the radar (figure 7), the small structure of precipitation was found to be too persistent (figure 8). There was better agreement when averaged to a 12km grid. The model also had unrealistically large row/point precipitation rates (grid point storms) as seen in the 03rd August 2004 Borders Grid Point Storm case (figure 9). A negative cloud bias (operational models use a cloud enhancement scheme) was found to be the cause of the diurnal cycle in the screen temperature bias (figure 10). Finally, PMSL errors were found to be strongly linked to errors in the driving model.

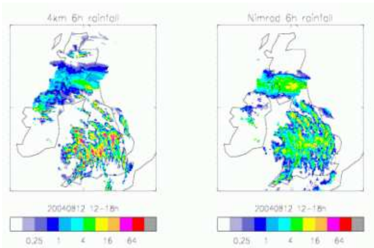

Figure 7: Banded structure in the 6hr precipitation accumulation (left) compares well with the radar (right).

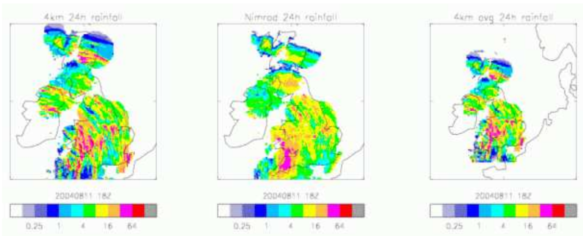

Figure 8: Small structure in 24hr precipitation accumulation (left) too persistent compared to radar (centre). Better agreement when averaged to a 12km grid (right).

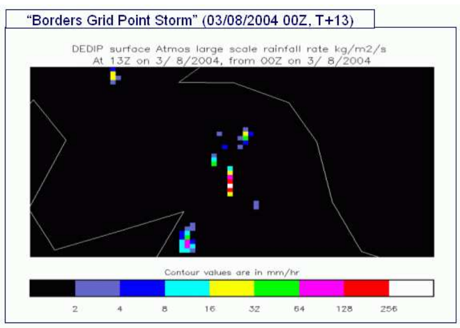

Figure 9: Borders Grid Point Storm - a row of unrealistically large precipitation rates at T+13 on 03rd August 2004.

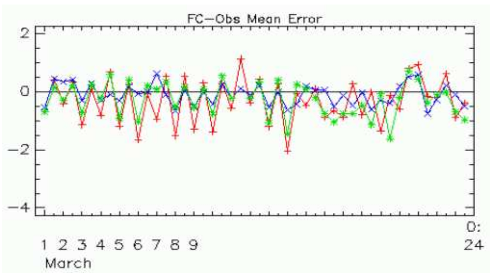

Figure 10: Diurnal cycle in screen temperature bias (UK4 in red,U.K Mes in blue and NAE in green) due to negative cloud bias.

UK4 Model - Introduction into operations

Cycle	Date	UK4 model Change
U4.01	13 April 2005	Model introduced. One forecast per day to T+36 at 00UTC
U4.02	14 June 2005	Extra T+36 forecast at 12UTC added
U4.03	11 October 2005	Upgrade to the model science.

The feedback from forecasters was generally positive although there was concern at the number of false alarms of heavy precipitation events and the excessive amount of light precipitation. There was a high profile severe weather event in North Yorkshire on the 19th July 2005. Intense precipitation caused flooding of the Rye Valley and the model gave good guidance in terms of timing, intensities and location (figure 11).

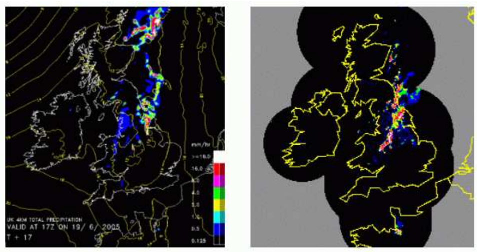

Figure 11: Rye Valley floods

Upgrade to the model science

A science package was implemented in cycle U4.03 of the UK4 model on 11th October 2005. The package included an upgrade of the convection scheme to the current operational version (4A), but keeping the CAPE dependent CAPE closure. The microphysics was tuned to reduce excessive light precipitation and the empirically adjusted cloud fraction was enabled to enhance cloud amounts. Finally the horizontal diffusion of moisture was replaced by the targeted diffusion of moisture.

Planned UK4 model Changes (2006)

- Introduce 3D-VAR assimilation system (plus Analysis Correction scheme for cloud and precipitation)
- Introduce orographic gravity wave drag parametrization
- Introduce anthropogenic urban heat source
- Introduce daily initialisation of soil moisture
- Increased vertical resolution
- Introduce seasonal variability into the Leaf Area Index
- Split urban tile type into rooftops and street canyons