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THE MET OFFICE'S NEW GLOBAL AND MESOSCALE NWP MODELS

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1. INTRODUCTION

The Met Office uses a single model code for its operational NWP and climate modelling, the Unified Model (UM), (Cullen, 1993). Several configurations are run routinely; global model at various resolutions and limited-area models for different regions. A major change to the Met Office models has been undergoing trials since 2001 and is due for implementation during the first half of 2002.

2. THE NEW MODEL CONFIGURATION

2.1 *New Dynamical core*

The current dynamics scheme, a split-explicit scheme consisting of a forward-backward scheme for the adjustment steps and a Heun scheme for advection, is now nearing the end of it's life span. A new dynamical core has been developed, with the aim of improving both the accuracy and stability of the numerics (Cullen et al, 1997).

The main features of the scheme are:

- Two time level semi-implicit Semi-Lagrangian scheme
- Non-hydrostatic model with height as the vertical co-ordinate.
- Charney-Philips grid staggering in the vertical, i.e. potential temperature is on the same levels as the vertical velocity including top and bottom boundaries where vertical velocity is zero.
- C grid staggering in the horizontal, i.e. u-component is east-west staggered from temperatures and v-component north-south staggered.

2.2 *Parametrizations*

Whereas most UM configurations use the same dynamics, there are currently a number of different physical parametrization versions available. It was decided that the new model would use the most up-to-date physics. Therefore the model is using the physics being developed for the latest UM climate model.

This consists of:

- Edward-Slingo radiation scheme with non-spherical ice (Edwards and Slingo, 1996). *
- Large scale precipitation with prognostic ice microphysics. *
- Vertical gradient area large-scale cloud scheme.
- Convection with CAPE closure, momentum transports and convective anvils.
- Boundary-layer scheme which is non-local in unstable regimes and includes BL entrainment (Lock et al, 1999). *
- Gravity-wave drag scheme which includes flow blocking.
- GLOBE orography dataset.
- MOSES (Met Office Surface Exchange Scheme) surface hydrology and soil model scheme (Cox et al, 1999). *

Those marked with an asterisk (*) are already operational in the Mesoscale model.

2.3 *Physics Coupling*

In the current UM, the physics parametrizations operate sequentially, with the updated values from one routine passing to the next. The input fields to the parametrizations are thus not well balanced. In the new model, this balance issue is addressed and the physics schemes are performed in a parallel manner. The increments from the cloud scheme, large-scale precipitation, radiation and gravity-wave drag are calculated at time level n and interpolated to departure points. For the boundary layer and convection, the calculations are made at the arrival points from the estimates to time-level n+1 but the exchange coefficients in the boundary layer scheme are calculated using (balanced) time level n fields.

3. PARALLEL TRIAL

The new dynamical core scheme is the most significant change to the Met Office numerical model for many years, so it has been put through rigorous pre-operational trials and case study tests. The configuration has been run in parallel with the operational (OP) global model since August 2001. This enabled weaknesses of the new model to be

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assessed and suitable changes to be made to enhance performance. During December and January the code was frozen and a further three trials were run alongside the parallel trial, covering Mar-Apr 2001, Jun-Jul 2001 and Sep-Oct 2001, each approximately 30 days long. In total all four trials amounting to a forecast sample of168 days.

4. RESULTS

4.1 *Objective Verification of Trials*

In general the Northern Hemisphere RMS errors are reduced by up to 5% against both observations and analyses. The Northern Hemisphere T+24 250hPa winds are also marginally better than OP (~0.5%), in all seasons except Sep-Oct, when verified against observations. While verification against analyses shows larger improvements of up to 5%. Tropical 850hPa winds are also improved for verification against analyses.

On the negative side Tropical 250hPa winds are currently worse (4%) when verified against observations. Secondly, Southern Hemisphere verification against analyses shows a deterioration in RMS error (>20%) during Dec-Jan and Mar-Apr. Initial diagnostics suggest a problem with the new model's analyses rather than the forecasts.

4.2 *Synoptic Case Studies*

An area of increasing focus for NWP forecast models is their ability to forecast extreme events successfully. A suitable test case study is the French storm of 27/12/1999 (Figure 1). The new model forecast cyclone at T+72 is significantly (8hPa) deeper than OP and has a structure more similar to analysis.

From September 2001 onwards all tropical cyclone forecasts produced by the parallel trial were studied. A homogeneous set of forecasts from both configurations has been verified for the period September 2001 to January 2002. It should be reiterated that the new model configuration was still under development during the course of this period. Even so, tropical cyclones are consistently improved with the new model. Verification (Figure 2) shows that the intensity of cyclones is better maintained over the forecast period, compared to OP. There is also on average a 5% improvement in skill of predicting the track of the tropical cyclones. These improvements may be attributed to the accuracy of the new model and the ability to run the model with less numerical diffusion.

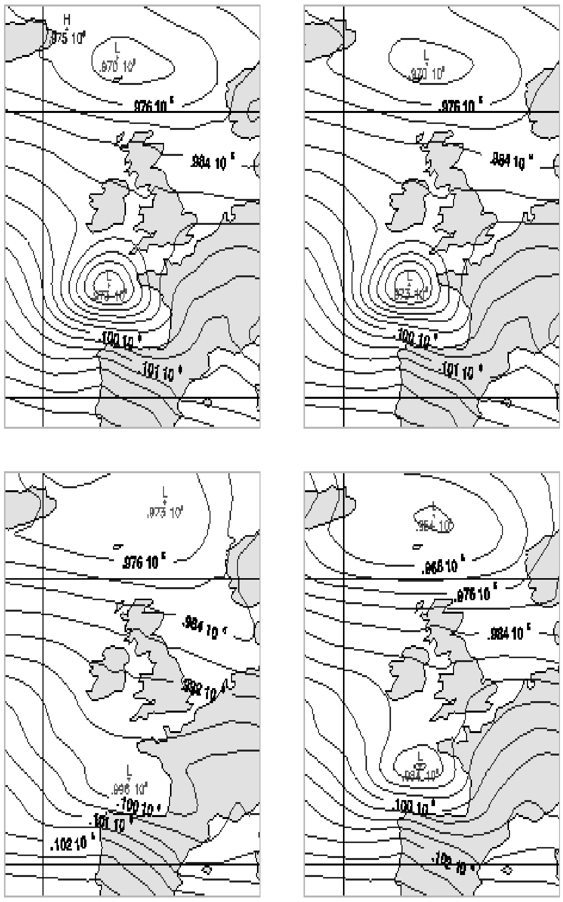

Figure 1: The French Storm of 12UTC 27/12/1999. Top left and right are the analyses from OP and ND respectively. Bottom left and right are the corresponding T+72 forecasts.

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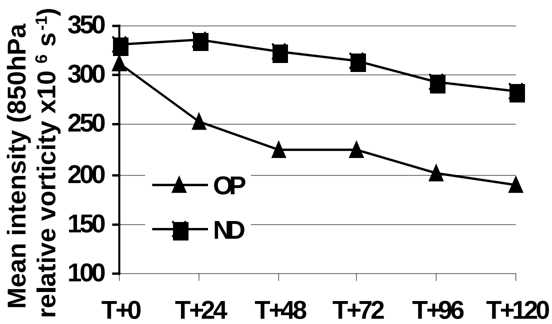
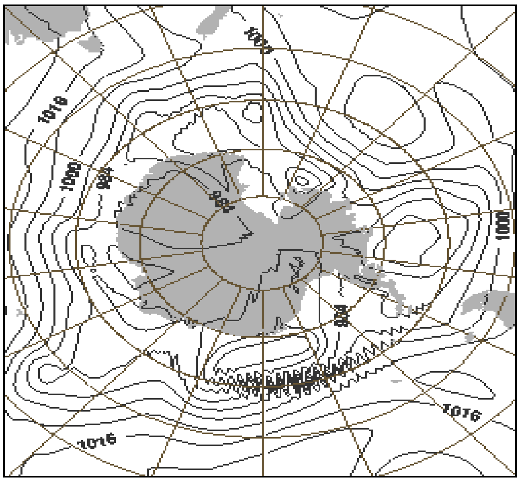


Figure 2: Tropical Cyclone verification for Sep 2001 to Jan 2002

4.3 *Systematic Model Errors*

The new model is generally warmer throughout the troposphere and stratosphere. This has a beneficial act on stratospheric temperatures, which were too cold in OP, but tends to increase the warm bias in the tropical mid-troposphere. The 1.5 metre temperature bias and RMS errors are significantly improved with the new model.

OP pmsl 2001-10-14 12h fc t+120



ND pmsl 2001-10-14 12h fc t+120

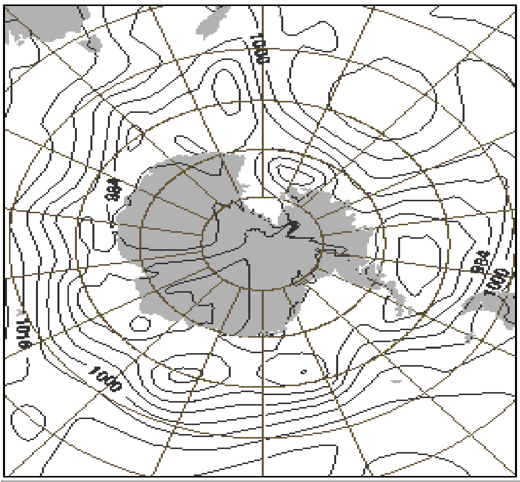


Figure 3: Noise in the OP (Top) PMSL field, is not apparent in the ND (bottom) field, T+120 forecast.

One of the expected benefits of the New Dynamical core (ND) semi-implicit, semi-lagrangian formulation is improved stability. A number of cases have been seen in the parallel trial where the current operational (OP) model produces noise but there is no evidence of noise in new model. For example, during October 2001 noise was seen in the OP PMSL field (Figure 3), which is not in the corresponding ND forecast.

5. CONCLUSIONS

The new model had to meet a number of strict criteria before getting the recommendation for operational use.

For example

- Overall the skill at least matches OP.
- WAFC products do not deteriorate.
- Extreme weather event performance
- Known systematic errors in OP should not be made worse by using the new model.

These criteria have largely been met. The only outstanding issue being the Southern Hemisphere RMS scores performance, investigations continue.

The new model is expected to go operational on June 18th 2002. A major benefit of the new model, for future developments, is that it is non-hydrostatic. This yields the ability to run the code at high resolutions. Initial 4km and 2km tests are promising.

6. REFERENCES

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