Recent Improvements to the Met Office Global NWP Model *

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1 Introduction

In 2005, the Met Office made two major changes to the global Unified Model component of its operational NWP suite. In January, a package of improvements was made to the model physics[1], and in December, the resolution was enhanced in both the horizontal and the vertical directions[2].

2 HadGEM 1 Physics Package

The January physics package included revisions to the boundary layer parametrisation and large-scale precipitation scheme microphysics, a change to increase the Saharan albedo and some corrections and revisions to the convection scheme. Most of these changes were part of a physics package tested and successfully implemented in the latest climate version of the Unified Model, HadGEM1.

The boundary layer (BL) changes were mainly improvements to the diagnosis of mixed layer depths in the decoupled stratocumulus regime and the main change to the convection scheme was a reduction of the CAPE closure adjustment timescale from 1 hour to 30 minutes (not currently in HadGEM1). The main impacts from these two changes are in the tropics. There is reduced oceanic tropical precipitation and an increase in precipitation over tropical land masses, both of which correct known systematic errors in tropical precipitation. These changes in precipitation are accompanied by improvements in the tropical large-scale circulation. The new BL scheme (the 8B scheme) also reduces low cloud over subtropical oceans, which improves the radiation balance in comparisons with ERBE and GERB (Meteosat 8).

The changes to the microphysics scheme (the 3C scheme) were numerous. Increased autoconversion of liquid water to precipitation helps dissipate excessive low cloud in the model, with improvements in near surface temperatures. Also, an increased tendency to form ice means that it falls out more quickly, leading to a beneficial reduction in cloud over the poles. Finally, comparisons with ERBE and GERB top of atmosphere clear sky radiation budgets suggested that the Saharan surface albedo was previously underestimated, leading to excessive sensible heating of the surface. A change was made to increase Saharan albedo via the soil parameters, which gives an improvement to the radiation budget and reduces circulation errors over the region. The impact on RMS errors in parameters that make up the Met Office's "NWP index" skill-score are shown in Table 1.

3 40 km/50 Level Resolution

The resolution enhancement of the global NWP model was part of a wider project to increase model resolutions throughout the Met Office's NWP suite in 2005/6. The number of grid-points in the horizontal lat-lon grid was increased by about 48%, to 640(EW)× 481(NS); this gives a physical resolution of approximately 40km at mid-latitudes. A plot of the resulting orography over Europe, showing improved barrier

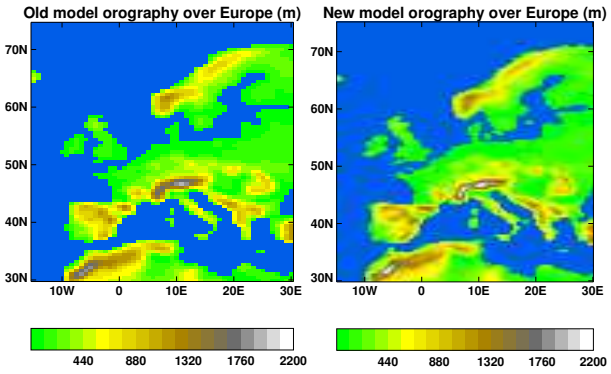

Figure 1: A comparison of the European orography in the old (left) and upgraded (right) global models, showing the improved resolution of coastlines and mountain ranges resulting from the finer horizontal grid.

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heights for the Alps and Pyrenees, is illustrated in Fig. 1. In the vertical, the number of model levels has been increased from 38 to 50. The main focus was a better representation of the upper atmosphere, with a finer level structure in the stratosphere and an increase in the height of the model lid from 39 km to 63 km, i.e. from the upper stratosphere to the lower mesosphere. This not only allows for the better assimilation of satellite data, but improves the Met Office's capability in stratospheric forecasting, by superseding the climate-resolution 50 level forecast model dedicated to this purpose. A comparison between the old and new level sets is made in Fig. 2. A further

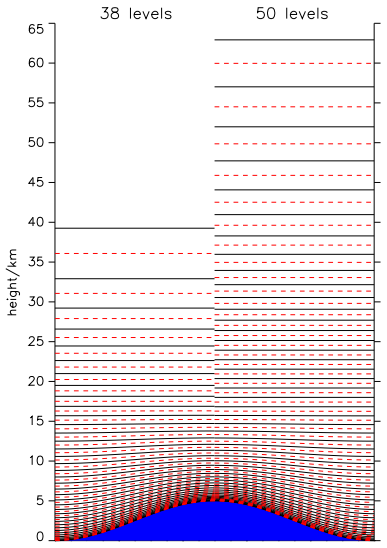

Figure 2: A comparison of the level sets in the old (left) and upgraded (right) global models. The majority of extra levels can be seen to be in the stratosphere.

increase to 70 levels in 2007 will focus on improvements to the representation of the boundary layer and the troposphere. Finally, to compliment these increases in spatial resolution, the model timestep was decreased from 20 to 15 minutes.

The main improvements in model performance come from the increased number of levels and the increase in the height of the model lid, with a decrease in both RMS errors and biases in geopotential heights, temperatures and winds at mid-to-upper levels. We also see a decrease of random error in lower-level fields such as PMSL in 1-3 day forecasts. Whilst the impact of the finer horizontal grid on the RMS-based NWP skill-scores is fairly modest, it does lead to some improvement in the tropics, including better wind forecasts, a weaker Hadley circulation and reduced precipitation over the oceans. More importantly, the increased resolution also allows for a better representation of small-scale features. This leads to a beneficial increase in eddy kinetic energy and to the development of systematically deeper tropical cyclones compared to the old 60km model. The impact on errors in components of the NWP index are shown in Table 1.

	RMSE Difference Test-Cont (%)	
Field	HadGEM Ph.[1]	40km 50L
T+24 NH PMSL	-1.0	0.12
T+48 NH PMSL	-1.1	-2.04
T+72 NH PMSL	-1.9	-1.31
T+96 NH PMSL	-0.7	0.23
T+120 NH PMSL	-0.9	2.80
T+24 NH 500 HGT	-1.0	-1.75
T+48 NH 500 HGT	-1.3	-2.69
T+72 NH 500 HGT	-0.7	-2.08
T+24 NH 250 Wind	-0.7	-0.59
T+24 Tr. 850 Wind	-2.3	-0.63
T+48 Tr. 850 Wind	-3.7	-0.41
T+72 Tr. 850 Wind	-4.7	-0.81
T+24 Tr. 250 Wind	-0.4	0.33
T+24 SH PMSL	-2.7	1.89
T+48 SH PMSL	-4.1	1.56
T+72 SH PMSL	-4.7	0.25
T+96 SH PMSL	-4.1	-2.02
T+120 SH PMSL	-3.4	-5.19
T+24 SH 500 HGT	-0.4	-1.13
T+48 SH 500 HGT	-1.3	-1.80
T+72 SH 500 HGT	-2.4	-6.08
T+24 SH 250 Wind	-1.0	1.31
ΔNWP index (points)	2.25	0.99

Table 1: Impact on RMSE for parameters that make up the NWP Index. Verification of the physics and resolution changes against observations are from 1 month trials in Winter 2003/4 and Winter 2004/5 respectively.

References

[1] Milton, S. *et al.* HadGEM1 physics for the global NWP model (cycle G34): Improvements to boundary layer, large scale precipitation, convection and saharan albedo. Technical Report 458, NWP, Met Office, UK (2005).

[2] Earnshaw, P., Milton, S. & Walters, D. Enhanced vertical and horizontal resolution in the global NWP model (cycle Gxx). Technical Report In Preparation, NWP, Met Office, UK (2006).

[1] Data only available to $\frac{1}{7}$% accuracy.