IMPROVEMENTS TO MET OFFICE FIFTEEN DAY FORECASTS WITH REVISED PHYSICAL PARAMETERIZATIONS

Nicholas Savage, Sean Milton, David Walters, Julian Heming

Global Model Development and Diagnostics, Met Office, Exeter, UK
E-mail: *nicholas.savage@metoffice.gov.uk*

1. INTRODUCTION

The WMO project THORPEX is a ten-year international global atmospheric research and development project. Its aim is "to reduce and mitigate natural disasters by transforming timely and accurate weather forecasts into specific and definite information in support of decisions that produce the desired societal and economic outcomes". Swinbank et al (2007) describes the Met Office contribution to the THORPEX research program through the implementation of medium range global ensemble forecasts run on a regular basis. This paper describes work to evaluate systematic (model) error growth in the current model configuration and the impact on these errors of a package of improved physical parameterizations which were introduced into the operational 5-day global forecast model in March 2006.

2. UNIFIED MODEL CONFIGURATIONS AND EXPERIMENTS

This study uses the UK Met Office Unified Model (Davies et al, 2005) at a horizontal resolution of N144 (1.25° longitude by 0.83° latitude) with 38 levels in the vertical from the surface to 38 km. The first model formulation tested is very similar to the atmospheric part of the climate model configuration HadGEM1 (Martin et al, 2005) and is almost identical to the version of the model currently used for the medium range ensemble forecasts. The second model version includes a package of improvements to the physics recently introduced in the global forecast model. The package of improvements included changes to the boundary layer and convection parameterizations and the main aim was to improve the tropical performance of the model.

Boundary layer changes improved the rate of evaporation from the sea surface; over the sea, the model has been revised to have a more realistic decline in amount of turbulence as the stability of the atmosphere increases ('sharp tails') and a non-gradient parameterization of transport by turbulent eddies has been extended from temperature to wind fields which results in higher near surface wind speeds in convective boundary layers.

The major change to the convection scheme was the introduction of adaptive detrainment. Forced detrainment of air from a cloudy plume of ascending air occurs when the parcel's buoyancy falls below a critical threshold. The critical level has been changed from a fixed value of 0.2 K to a function of the parcel's local buoyancy gradient giving a more realistic detrainment profile. For more details of these changes to model physics and their impact on the short range forecasts see Willett (2006). In addition the new model formulation also had a restructured convection scheme, changes to the CAPE closure formulation and different values of sea surface temperature (SST), snow depth, soil moisture content, deep soil temperature and sea ice.

A set of twenty cases has been used to evaluate these two different model formulations: ten cases from two Northern Hemisphere summers (2003 and 2006) and ten cases from two Northern Hemisphere winters (2003/4 and 2005/6). Each fifteen day model run was initialised from analyses produced with the Met Office operational variational data assimilation system (3D Var before 10/2004 and 4D Var thereafter). The results from both model versions have been evaluated against UM operational analysis, surface and sonde data plus Global Precipitation Climatology Project (GPCP) data which is a global precipitation dataset based on a combination of rain gauge and satellite data.

3. RESULTS

With the revised physics, improvements in model performance for temperature, wind speeds, humidity and precipitation were observed for most regions. We found a much reduced Northern Hemisphere winter cold bias at 1000hPa (the initial runs had a bias of -8K whereas in the new configuration this is close to zero in many parts of this region, see Figure 1) possibly as a result of increased cloudiness reducing radiative cooling. A small reduction in temperature bias over tropical oceans can also be seen in Figure 1. In the tropics at 250hPa the cold bias is also reduced from -1K to near zero and there are beneficial changes in mid-latitude zonal wind speeds in response to these improvements in the temperatures via thermal wind balance. We also see a reduced dry bias (from over -12% to -8%) in the tropical upper troposphere, and large reduction of errors in tropical circulation due to an improved treatment of convective detrainment. In particular, errors in the Indian Ocean (with a low level convergent bias and an upper level divergent anomaly indicating too much ascent in this region) is much reduced.

Connected with this improved circulation in the Indian Ocean is a reduction in precipitation over the Indian Ocean giving better agreement with GPCP data. Although the revised model still does not do a very good job of representing the precipitation patterns associated with the Madden-Julian Oscillation (MJO) it does weaken significantly spurious westward propagating disturbances seen in the control and for some of the cases an improvement in the forecasts of the MJO index of Wheeler and Hendon (2004) is found. The new physics however does cause some detriments: in particular the summer warm bias over Asia and North American is made worse and a positive precipitation bias over Africa and the north of South America is worsened. Both these issues are also found with the operational model and work is ongoing to resolve them via modifications to cloud cover over land, changes to aerosol fields and other model changes.

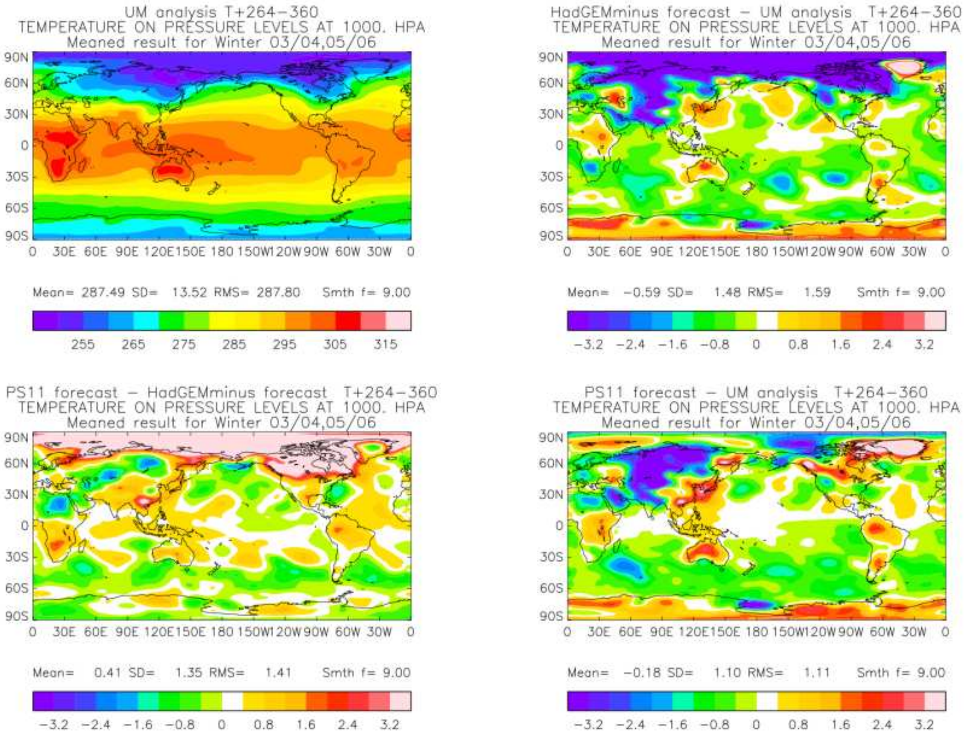

Figure 1. Differences in Temperature (K) at 1000 hPa between model runs averaged over days 10-15 of the 10 DJF cases. Top left: mean temperature in UM analyses from days 10-15 of forecasts. Top right: control (HadGEMminus) forecast minus analysis. Bottom left: new physics forecast (PS11) minus control. Bottom right: new physics minus analysis. The new model configuration shows a large reduction in the divergent anomaly over the Indian Ocean.

4. CONCLUSIONS

A set of improvements to model physics recently introduced to the Met Office global operational forecast model have been tested at the resolution now used for medium range ensemble forecasting. Substantial reductions in systematic errors have been found in most regions. Revised stochastic physics schemes have also been tested in the fifteen day forecasts and these improvements will shortly be implemented in the regular medium range forecasts.

REFERENCES

Davies, T., M.J.P. Cullen, A.J.P. Malcom, M.H. Mawson, A. Staniforth, A.A. White, and N. Wood, 2005, A new dynamical core for the Met Office's global and regional modelling of the atmosphere. Q. J. R. Meteorol. Soc., **131**, 1759 - 1782.

Martin, G.M., M.A. Ringer, V.D. Pope, A. Jones, C. Dearden, and T.J. Hinton, 2005, The physical properties of the atmosphere in the new Hadley Centre Global Environmental Model (HadGEM1). Part I: Model description and global climatology, J. Climate, **19,** 1274-1301.

Swinbank, R., H. Watkin, C. Johnson and S. Thompson, 2007: Medium-range ensemble forecasts at the Met Office, this volume.

Wheeler, M.C. and H.H. Hendon, 2004, An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, Mon. Wea. Rev., **132**, 1917-1932.

Willett M., 2006: Unified Model has improved physics, NWP Gazette, June 2006, http://www.metoffice.gov.uk/research/nwp/publications/nwp_gazette/jun06/um_imp_phys.html.