# Application and verification of ECMWF products 2010

*Met Office – compiled by Marion Mittermaier*

## 1. Summary of major highlights

ECMWF products continue to be widely used across the Met Office. Input has been requested from many parts of the organisation: Forecast Service Delivery (Guidance Unit), decadal and seasonal forecast areas as well as model development groups for the short- and medium-range as well as ensembles.

## 2. Use and application of products

### 2.1 Post-processing of model output

#### *2.1.1 Statistical adaptation*

i) Statistical post-processing of site-specific forecasts (Anders Persson)

Figure 1 shows a comparison in terms of Mean Absolute Error of single and lagged ECMWF 2 m temperature forecasts for Heathrow winter 2009-10. The lagged forecasts for +120 are computed by a weighted average of the last +120, +144 and +168 h forecasts. The corresponding +144 h forecast, to which the jumpiness of the +120 h forecast is defined, is computed by a weighted average of the last +144, +168 and +192 h ECMWF forecasts. The reduction in jumpiness is much more profound than the reduction in error.

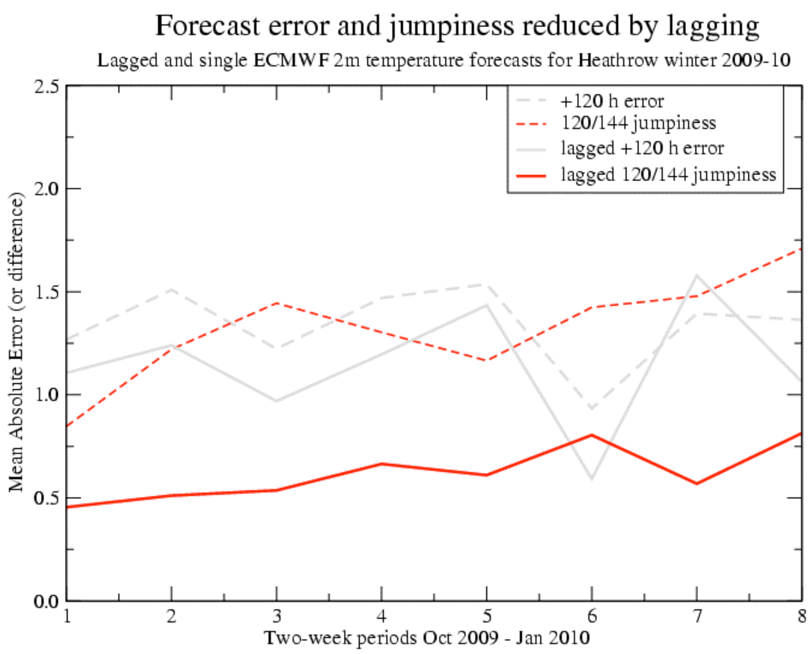



Fig.1 Figure illustrating the impact of post-processing on forecast jumpiness and MAE.

ii) Use of the monthly forecasting system (VarEPS) (Bernd Becker)

Extended-range forecast products are generated using output from the VarEPS system and used to provide services to a range of customers in government, public and business sectors.

Met Office post-processing is performed for mean, maximum and minimum temperature, precipitation and sunshine amount averaged/accumulated over three forecast periods: days 5-11 ahead, days 12-18 ahead, and 19-32 days ahead.

Products include global probability forecasts, forecasts for European weather regimes (Grosswetterlagen and Lamb weather types), and forecasts for the 10 UK climate districts. Global probability products are generated in the form of:

1) probability maps for tercile and outer-quintile categories, and
2) specific regions, probability histograms for quintile categories (well-below, below, near, above, and well-above the climate normal for the region and time of year).

For both these formats the forecast variables are temperature, precipitation and wind speed. Forecasts for the 10 UK climate districts are also presented in tercile and quintile formats. Population weighted probability products are also generated. The UK forecasts are expressed both in terms of the probability of each category and a deterministic forecast based on either the ensemble mean or the most probable quantile.

Met Office customer research revealed the public would like a monthly outlook. Therefore release of an UK 'seasonal forecast' four times a year was stopped and a monthly outlook, updated on a weekly basis is published instead. However, seasonal forecasts are freely available on the Met Office web site.

### *2.1.2 Physical adaptation*

### *2.1.3 Derived fields*

## 2.2 Use of products

Forecaster input has been solicited. Two questions were posed:
*1. What products have you started using in the last year in particular that you like and found really useful? Why?*
*2. Any specific aspects re the EC resolution upgrade that stand out for you, that you may want to comment on (subjective verification).*

The two responses have been copied here verbatim.

"1: a) Global Extreme forecast index temperature and rain and EFI interactive chart to help with provision for BBC world weather forecast for the next 5 days and potential severe weather in guidance. From EC Website.

b) as yet not operational but available feature tracking etc (provided by Tim Hewson)

c) EC ENS mean and spread from EC Website

2: Hurricane Alex well forecast with indications over a week ahead in Op and ENS (also picked out as easterly wave in the EFI in eastern Caribbean) - the spread of the ENS shown in the http://www.ecmwf.int/products/forecasts/d/charts/medium/eps/ensm/essential/
left hand figure also helpful to see variations in the ENS solutions over a period." - *Mike Trigger*

"1) (a) Tim Hewson has set up some stuff at EC which taps into his work into objective fronts etc (there's an article about what he's set up in ECMWF Newsletter no. 120, 121 or 122). The products he's set are very useful. My favourite is the Dalmatian plot of low pressure centre locations and intensities which can be very useful for assessing spread across the ensemble.
(b) The Extreme Forecast Index is also quite useful, though I need to find out a bit more about how the background climatology is calculated in order to make better use of the product. One of the things the Deputy Chief has to do is give the BBC some guidance about where potentially extreme weather will develop around the world during the next five days and the EFI is useful for that.

2) I've noticed that since the upgrade in resolution the cloud products highlight diurnal variation in convective cloud over land much better." – *Dan Suri*

Met Office also uses ECWMF's forecast of the number of tropical storms forming over the North Atlantic for the upcoming season as part of a multi-model ensemble, to create a tropical storm prediction for the public.

# 3. Verification of products

## 3.1 Objective verification

### *3.1.1 Direct ECMWF model output (both deterministic and EPS)*

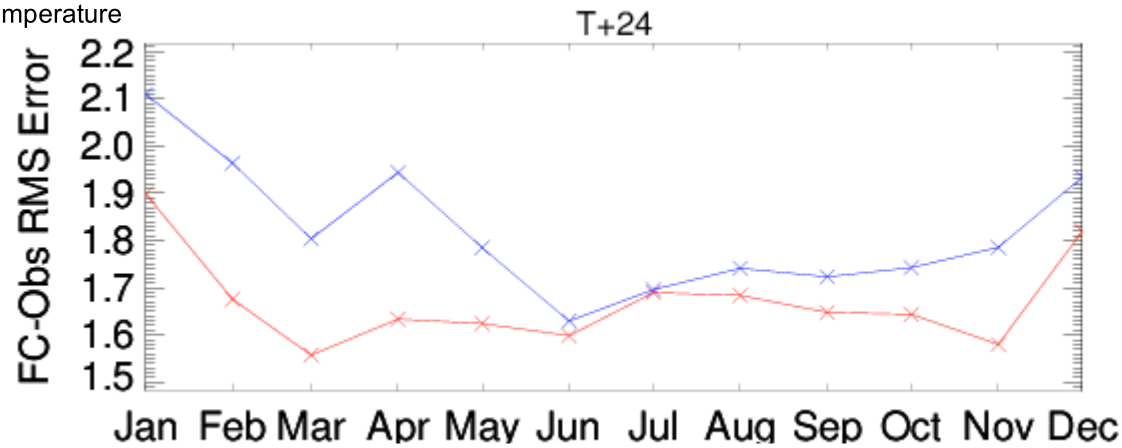
The Met Office is the lead centre in an SRNWP initiative to compare surface weather parameters from regional forecast models over Europe. The ECMWF deterministic forecast is included as an independent reference forecast. As ECMWF forecasts are assessed as part of a comparison results are shown in the next subsection.

### *3.1.2 ECMWF model output compared to other NWP models*

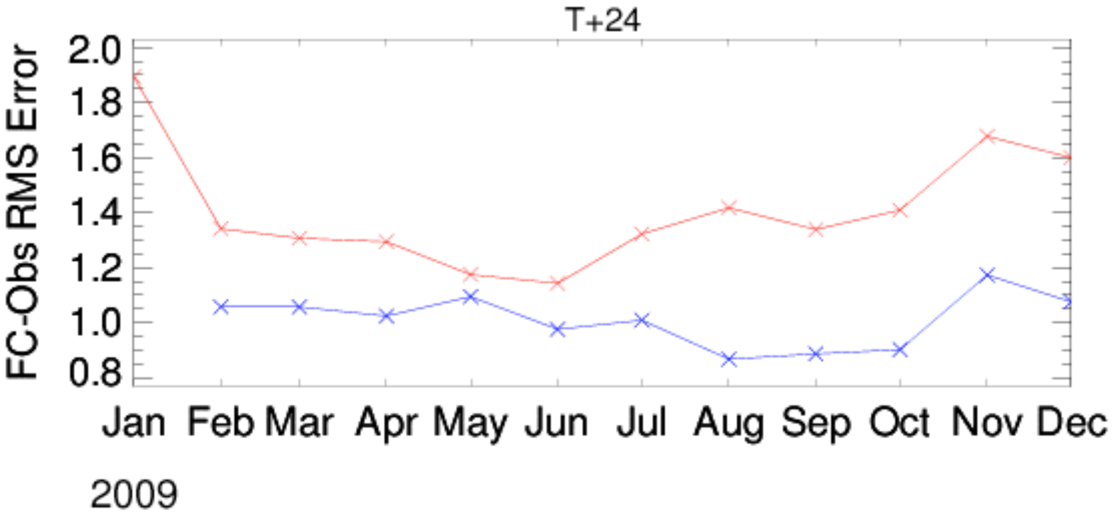
<u>i) Surface parameters</u> *(Clive Wilson)*

It is not appropriate that we show full SRNWP comparison results here, but restrict ourselves to showing monthly verification results of surface parameters between the 12 km Met Office North Atlantic European (NAE) Unified Model (UK-EU) and the equivalent area from the operational deterministic ECMWF forecast (EC-GM). Fig.5 shows the monthly *rmse* for 2 m temperature, pmsl and vector wind for the 00Z run only. The impact of lateral boundaries is clearly evident in the pmsl, where the NAE has a much degraded value compared to ECMWF which has no artificial boundaries.

(a) 2m Temperature




(b) PMSL



(c) Vector wind

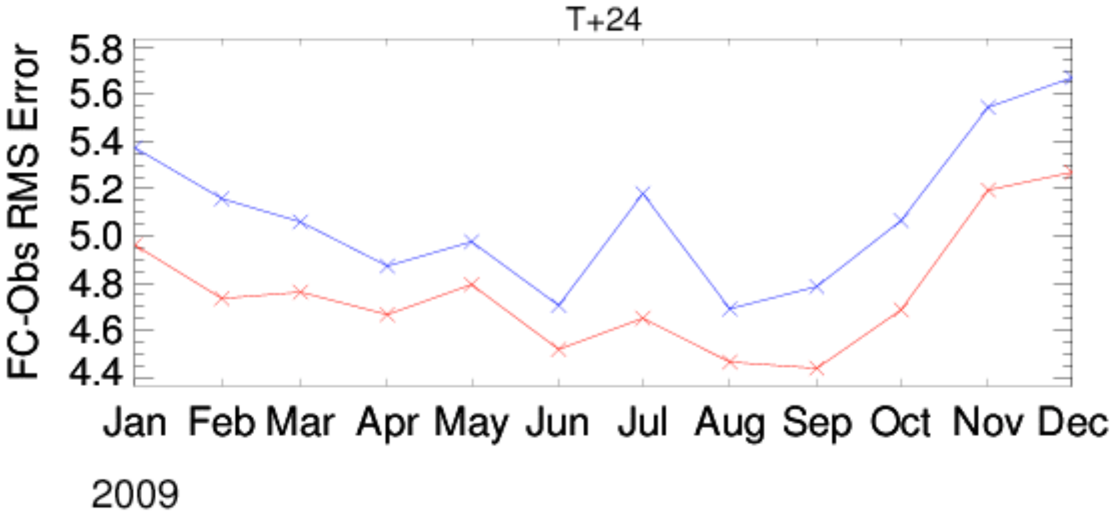



Fig.5 Comparison of a selection of surface parameters from the 00Z ECMWF deterministic and NAE forecasts at t+24h. **Red = NAE**, **blue = ECMWF**.

ii) Verification and intercomparison of ECMWF Tropical Cyclone Forecasts *(Julian Heming)*

The Met Office has objectively verified tropical cyclone (TC) forecast tracks from its global model since 1988. The verification scheme is described on the Met Office web site.

http://www.metoffice.gov.uk/weather/tropicalcyclone/method

This scheme has also been used to verify TC forecast tracks from the ECMWF model since 1994. This has enabled intercomparisons of the performance of the two models to be made since then. The first two figures show the differences between Met Office and ECMWF track forecast errors and skill scores against CLIPER. The graphs are for a global homogeneous sample of forecasts from the two models during the period 1994-2009. CLIPER is a benchmark statistical forecast based on a combination of climatology and persistence. In both graphs, positive values indicate the Met Office forecasts were better than ECMWF and vice versa for negative values.

Previous reports have shown how the ECMWF track errors have reduced markedly and skill scores increased markedly relative to the Met Office global model at short lead times since 2004 and at longer lead times since 2007. This was due to large reductions in ECMWF errors rather than increase in Met Office global model errors. The results for 2009 indicate a stabilisation in the gap in performance of the two models. For track errors (Figure 6) the gap in performance actually closed slightly at short lead times (24 to 72 hours). This is also reflected in the skill scores (Figure 7) which show a reduction in the gap in performance which had opened up in the previous few years.

Figure 8 shows the difference in analysis positional errors between the ECMWF and Met Office global models. Since the Met Office uses a TC initialisation procedure its analysis errors have always been smaller than ECMWF. The gap in analysis errors had been closing for many years such that by 2008 ECMWF analysis errors were only 18% larger than the Met Office. However, the gap suddenly widened again in 2009 with ECMWF analysis errors being more than twice as large as the Met Office. This was due to both a reduction in Met Office analysis errors and an increase in ECMWF analysis errors relative to previous years. This may explain why the gap in forecast errors has stabilised or even reduced in 2009.

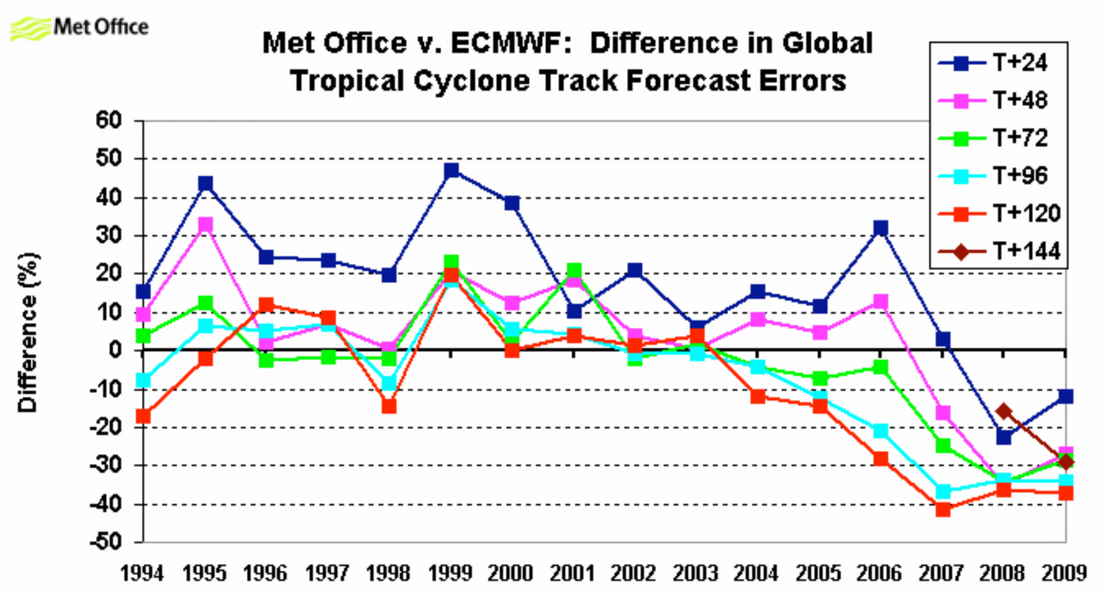



Fig.6 Comparison of TC track errors between the ECMWF and Met Office models.

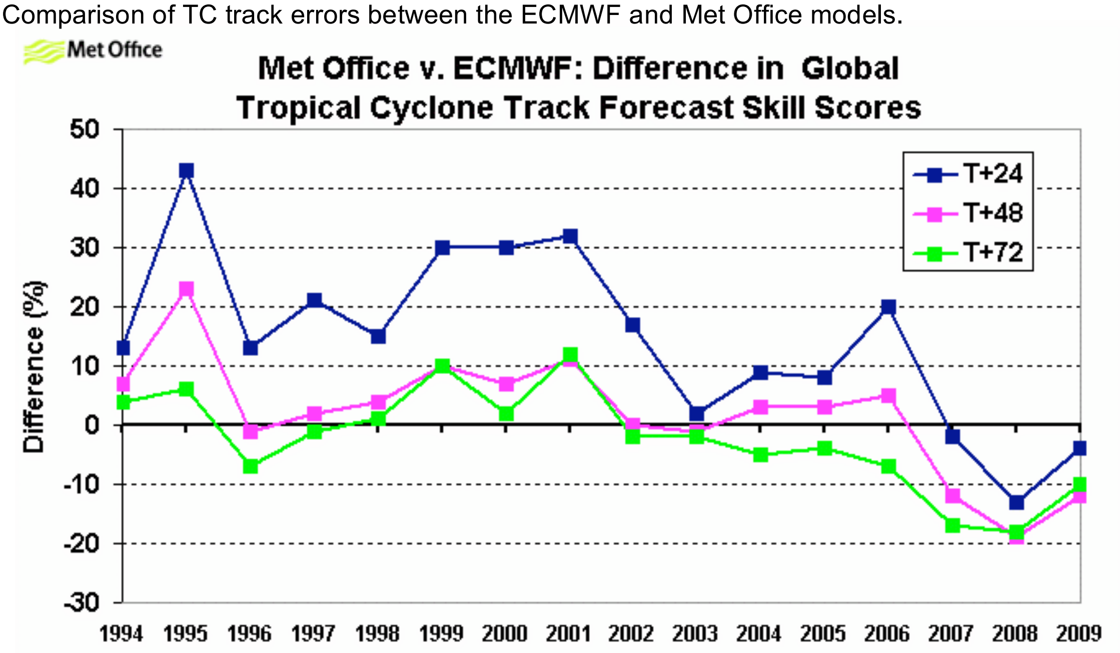



Fig.7 Comparison of TC track forecast skill scores between ECMWF and Met Office models.

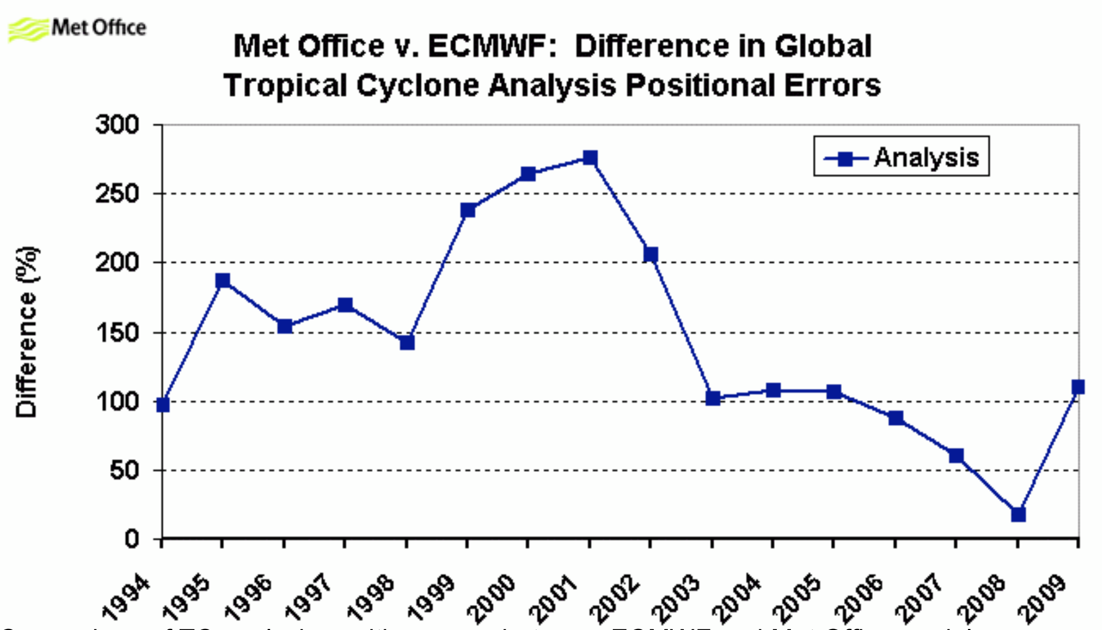


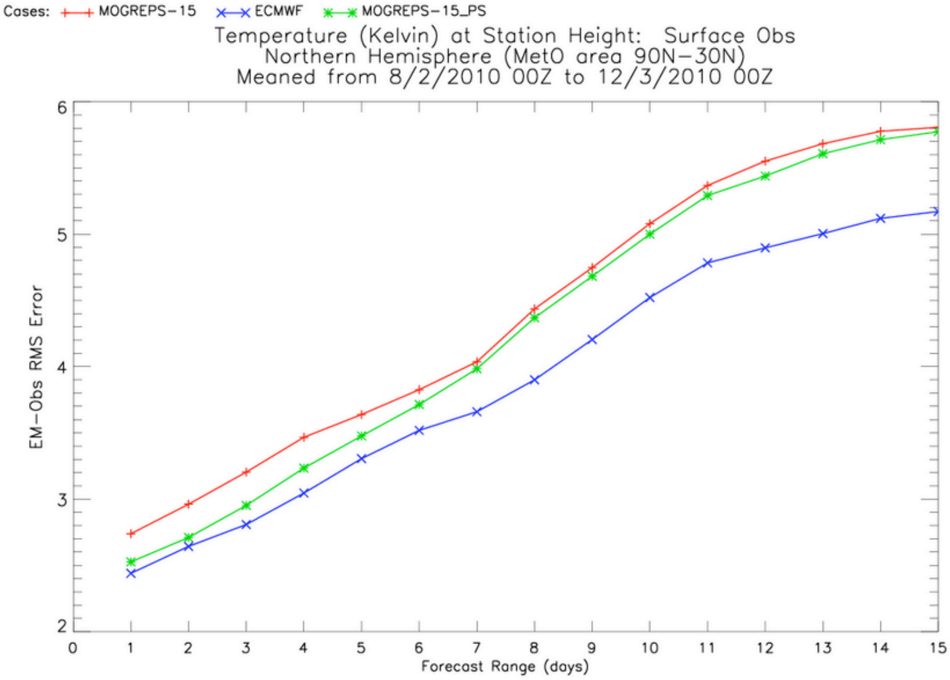

Fig.8 Comparison of TC analysis position errors between ECMWF and Met Office models.

iii) Comparison of MOGREPS-15 with ECMWF *(Simon Thompson)*

On March 9 2010, MOGREPS-15, the 24-member UK 15-day ensemble forecast system, underwent a significant upgrade. The resolution was increased from 90 km (nominally at mid-latitudes) to 60 km and the number of levels was increased from 38 to 70 with a 'top' at 80km. In the month prior to the implementation of the upgrade, a parallel trial was run to assess model performance, both in terms of a comparison with then operational MOGREPS-15, and a comparison with the recently upgraded ECMWF EPS.

Figure 9 shows that the combined impact of the horizontal and vertical resolution upgrades of MOGREPS-15 has made a significant difference to 2-m temperatures. There is a marked reduction in rmse of MOGREPS-15 in the tropics, further improving on the good performance. Reductions in rmse in the Northern Hemisphere were more muted but some appreciable improvements were made up to day 7.

(a)




(b)

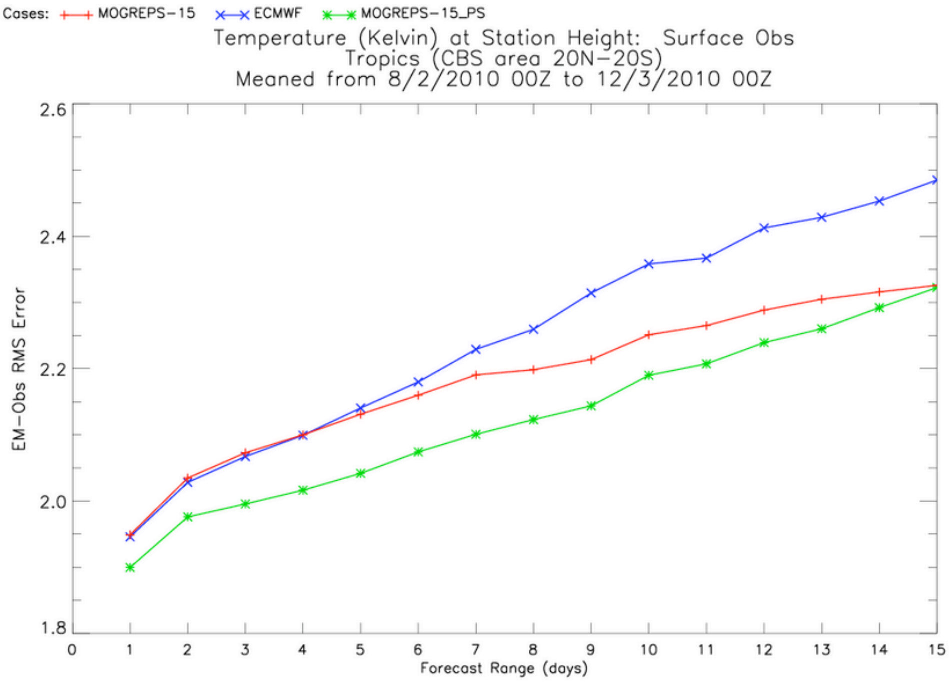



Fig.9 Comparison of 2 m temperature forecasts from MOGREPS-15 operational and parallel suites with ECMWF operational forecasts: (a) NH and (b) tropics.

### *3.1.3 Post-processed products (Marion Mittermaier)*

We use a Bayesian Update (BU) approach in the generation of our operational site-specific Probability of Precipitation (PoP) forecasts. ECMWF ensemble forecasts form a part of the update process. Extensive comparisons between ECMWF forecasts and the BU forecasts have been made in the last year to understand the behaviour. Figure 10 shows the comparison of combined (for 11 sites across the UK) "Day 1"12-month running means of the Brier Score, the reliability and resolution components of the Brier Score, as well as the Brier Skill Score for PoP forecasts, for precipitation exceeding 11.9 mm/24h. Also shown are 95% bootstrap confidence intervals. Five forecast flavours are compared: EC-RAW, EU-RAW (MOGREPS-R), EC-RECAL, EU-KF (MOGREPS-R Kalman filtered) and the BU operational version. The graphs reveal some interesting anomalies. The rather simplistic recalibration process (EC-RECAL) appears to provide the best reliability whilst most forms of post-processing appear to reduce the resolution of the forecast (most post-processing acts to smooth the forecast which reduces resolution).

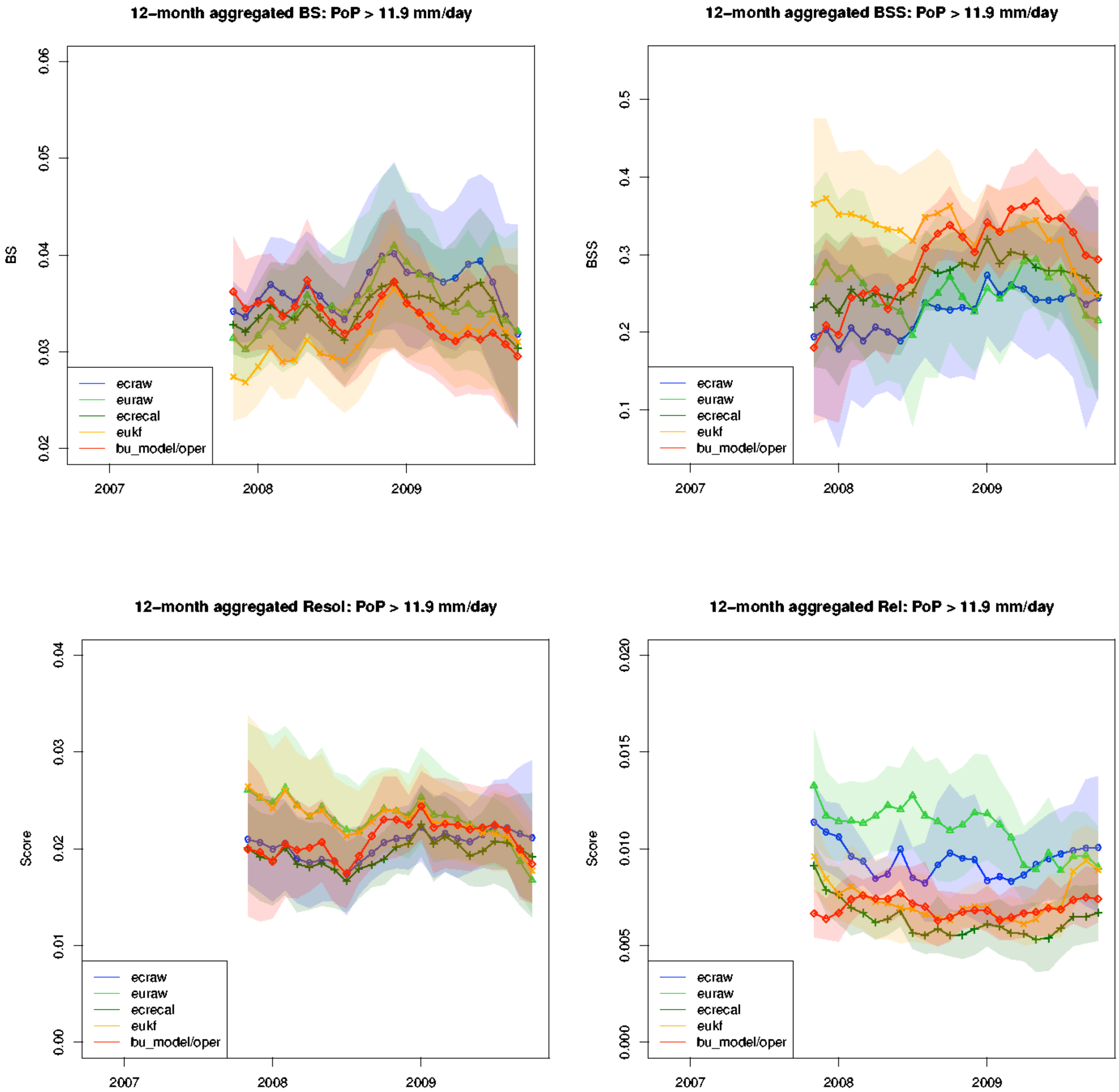



Fig.10 Comparison of 5 forecast "flavours" of site-specific PoP forecasts. Plot shows combined scores over 11 sites as a 12-month running mean. 95% bootstrap confidence intervals are also shown.

### *3.1.4 End products delivered to users*

i) Use of ECMWF seasonal forecasts at GHACOF *(Andrew Colman)*

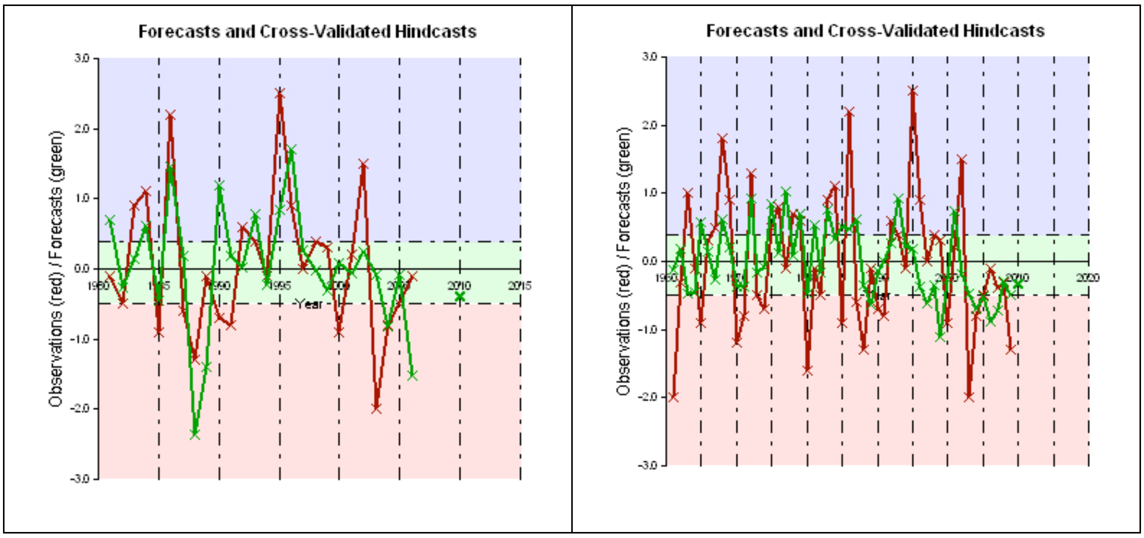
ECMWF seasonal forecast output was used to help produce a consensus forecast for the East African Long rains at the GHACOF25 meeting held in Nairobi in February.

A purpose of Regional Climate Outlook Fora (RCOF)s is to put together a seasonal forecast for the forthcoming rainfall season over a region of interest and convey it to users. The Greater Horn of Africa Climate Outlook Forum (GHACOF) covers the following east African countries; Burundi, Djibouti, Ethiopia, Eritrea, Kenya, Rwanda, Somalia, Sudan, Tanzania and Uganda.

The consensus forecast is usually produced as follows. Scientists from national meteorological services make forecasts for climatically defined zones within their respective countries. These forecasts are merged together to form forecasts for the countries and then a forecast for the Greater Horn region as a whole. Statistical methods using indices of observed sea temperatures and atmosphere prior to the rainfall season are mainly used to predict the climate zones from which the consensus forecast is derived. Dynamical methods are only considered at the latter stage when the forecast map for the region is checked against the output from global dynamical models such as the Met Office GloSea model or the ECMWF seasonal model.

At the GHACOF25 meeting held in February 2010 in Nairobi, Met Office Hadley Centre scientist Andrew Colman assisted scientists from national meteorological services in the region in developing prediction models for climatic zones within their countries. The objective was to try and make use of dynamical models in the forecast process right from the beginning. This is done by adding dynamical model output predictors to the currently used sea temperature and atmosphere predictors used to predict rainfall in the climate zones. Trial model forecasts produced as part of the ENSEMBLES project and corresponding rainfall observations are used to produce regression prediction models.

Dynamical skill is far from universal in this region, but useful skill was found for some climatic zones within the region. Figure 11 shows example forecasts for a zone in Tanzania using observed sea temperature predictors alone (right) and using observed sea temperature predictors combined with model output from the ECMWF model (left).



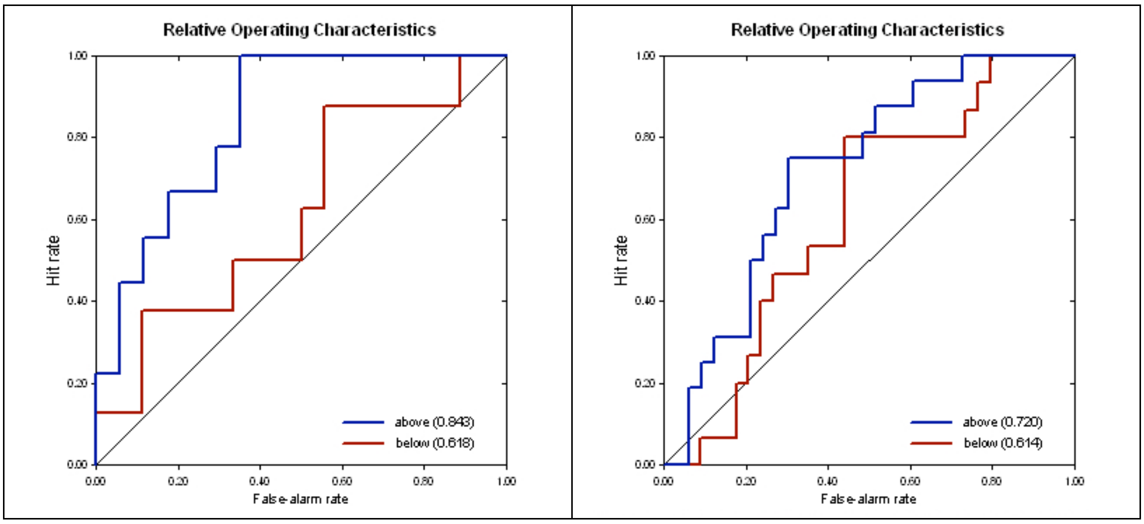



Fig.11 Forecasts for Zone 11 from Stats + Dynamical predictors (left, r=0.51), Stats predictors only (right, r=0.36).

### 3.2 Subjective verification

*3.2.1 Subjective scores (including evaluation of confidence indices when available)*

*3.2.2 Synoptic studies*

Some comments on subjective verification are included in the forecaster feedback listed in Section 2.2.

## 4. References to relevant publications