Application and verification of ECMWF products 2012

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1. Summary of major highlights

Medium range weather forecasts issued at IMO are mainly based on ECMWF deterministic products, at 0.125° horizontal resolution. In the short range ECMWF products are used along with products from other models such as MM5, HIRLAM, HARMONIE and the UK Unified Model. Local weather forecasts are automatically generated for more than 120 locations in Iceland. Forecasts are made available to the general public and as special services to customers, e.g. the hydro-power energy sector. The EPS products are not received at IMO but regularly consulted on the ECMWF web page. Monthly and seasonal forecasts are also consulted and used to provide guidance to the energy sector. Short and medium range local weather forecasts are verified as in previous years. The verification is performed individually at each station where local forecasts are automatically generated. A daily verification is run and used to appreciate the quality of 2-metre temperature and 10-metre wind-speed forecasts valid from T+12h to T+48h over a 10-day window. An annual verification procedure for each calendar year, including precipitation and surface pressure, is run for forecasts valid up to T+168h. Most of the results can be consulted on the internal web pages.

2. Use and application of products

Include medium-range deterministic and ensemble forecasts, monthly forecast, seasonal forecast

2.1 Post-processing of model output

2.1.1 Statistical adaptation

Currently all statistical adaptation of ECMWF deterministic products is based on output at 0.5° horizontal resolution. Kalman filtering is used to post-process local 2-metre temperature and 10-metre wind-speed forecasts from ECMWF 00 UTC and 12 UTC deterministic runs, up to T+168h (Crochet, 2004).

The probability of precipitation (PoP) in 24h is predicted at 11 locations with a generalized linear model, from D+1d to D+5d, using input from ECMWF 12 UTC deterministic run (Crochet, 2003).

ECWMF 00 UTC and 12 UTC deterministic precipitation forecasts are downscaled using high resolution climatic precipitation maps and taking into account the terrain complexity. The resulting maps are derived for precipitation accumulated in 6h, 12h, 24h and 48h up to T+96h.

2.1.2 Physical adaptation

The MM5 NWP model, which forecast is received operationally at IMO with horizontal resolution of 9 and 3 km, is run with boundaries from ECMWF. The MM5 is run at 9 km resolution four times a day with the forecast range being 72 hours but extending to 168 hours at 00 and 12 UTC. The lateral boundaries for the 3 km resolution simulation are provided by the 9 km resolution simulation. The MM5 is run at 3 km resolution four times a day and the forecast range is 54 hours.

HARMONIE is currently run in a test phase at a 2.5 km horizontal resolution with boundaries from ECMWF. It is run four times a day with a 48 hours forecasting range.

2.1.3 Derived fields

A vessel icing forecast chart based on the Overland algorithm (Overland et al., 1986; Overland, 1990) for vessel icing is derived from ECMWF model wind ground speed, 2-metre temperature and sea surface temperature. These forecasts are used internally by forecasters to evaluate and forecast the risk of vessel icing as a part of the textual shipping forecast.

2.2 Use of products

The ECMWF products are vital for operational weather forecasting in Iceland. For general weather forecasting the ECMWF short range forecasts are used along with other available short range forecasts while the medium range forecasts updated daily, day 3-7, are primarily based on the ECMWF medium range forecast. The medium range forecasts, week 1-3, that are produced for the hydro power energy sector are based on the ECMWF deterministic forecast and the EPS products.

ECMWF forecasts are used together with other NWP forecasts to assess the risk of weather conditions that could lead to natural hazards, such as snow avalanches.

Downscaled precipitation maps are used to assess the rainfall-triggered landslide risk by comparison to critical values that depend on the accumulation time and the mean annual precipitation. Additional emphasis has been on this feature for the last two years due to volcanic ash deposited on glaciers in southern Iceland as a result of the recent volcanic eruptions.

The ECMWF SST analysis and forecast are used by the forecasters. Charts of the analysed SST and the 2-day and 5-day forecasts are produced and published on the external web along with other marine weather forecasts. There are plans to increase the range of marine forecast products in the near future.

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

Local direct model output (DMO) 2-metre temperature forecasts exhibit systematic errors at a large number of sites resulting mainly from discrepancies between the model orography and the actual orography, as well as the horizontal resolution the output is retrieved at. In general the temperature is too low but at mountainous sites the temperature is often too high. To illustrate this Figure 1 and Figure 2 show that there is about -2^{o}C bias for Reykjavík (WMO 4030, station height 52 m a.s.l.) while for Bláfjöll (WMO 4138, station height 530 m.a.s.l.), located on a nearby mountain ridge, the bias is about +1.3^{o}C. There is a systematic under-prediction of temperature in the highlands, especially during the summer. This is evident in Figure 3 which shows scatter plots of 2-metre temperature forecast error as a function of observed temperature for the station Veiðivatnahraun (WMO 4162, station height 647 m a.s.l.) both DMO and post-processed. At this station the forecasted 2-metre temperature is seldom above 5°C and for the warmest observed temperatures, ~10°C, the error is 6-8°C. This is related to the description of glaciers used in the ECMWF runs, but the glacier cover is unrealistic and needs to be updated as soon as possible, see Figure 4. This erroneous glacier cover has large impact on the 2-metre temperature in the interior and Northeast-Iceland. HARMONIE simulations are much improved when not applying ECWMF glacier cover.

For most stations there is a diurnal variation in the error statistics. For Reykjavík the bias, MAE and RMSE all have larger values during night than day, i.e. the 2-metre temperature is systematically underestimated more during the night than during the day, the difference being about 1^{o}C. However, most stations show larger absolute bias during day than night. This may be related to the coastal boundary layer in Reykjavík but this is currently not entirely understood as not all stations at the coast have larger error statistics during night.

An underestimation of 10-metre wind speed dominates, especially inland. However, along the coast, especially where orography is complex, there is a tendency towards a positive bias.

The verification of precipitation is difficult due to well-known problems associated with rain-gauge measurements, such as wind-loss that is a common problem in Iceland. Thus, as reported in previous reports most sites in Iceland show a model overestimation of precipitation.

It is likely that forecast error statistics, of especially 2-metre temperature and 10-metre wind speed, will improve when IMO upgrades the horizontal resolution of the ECMWF model output applied. However, until ECMWF updates the glacier cover 2-metre temperature forecasts over the interior will have a large error.

3.1.2 ECMWF model output compared to other NWP models

Comparisons of the ECMWF model output and HIRLAM model output are made routinely at all verified locations for 2-metre temperature and 10-metre wind-speed. These comparisons apply to both DMO and post-processed predictions. The comparisons are presented as time series plots and error statistics, as well as maps showing the model giving the best prediction over a 5-day window according to some criteria.

3.1.3 Post-processed products

The Kalman filter procedure reduces systematic errors, especially in the case of 2-metre temperature forecasts. Figure 1 and 2 show cases of the performance of the Kalman filtered forecasts exceeding the DMO in about 60-80% of cases for Reykjavík but decreasing down to 50% of cases for longer forecast range for the mountain station Bláfjöll. Figure 3 shows that the Kalman filter is capable of correcting for the erroneous glacier gover. Although in general the Kalman filter procedure removes systematic bias and slope errors there are cases with sudden weather change where the procedure adds to the error.

In the case of 10-metre wind speed the results are more complicated. In general the Kalman filter procedure reduces wind speed forecast errors and improves forecast error statistics. For Stórhöfði, an island station from which weather information is important for fishing vessels, the Kalman filter procedure decreases number of cases with underestimated high wind speeds, see figure 5. However, it also increases cases of forecasted wind exceeding observed wind for low wind speed cases. This may have implications for the smallest fishing vessels that only sail in very light winds.

3.1.4 End products delivered to users

None.

3.2 Subjective verification

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

The forecasters are aware of the erroneous glacier cover and the implication for especially 2-metre temperature of both ECMWF direct model output and HARMONIE. Steps are being taken to sidestep the use of ECMWF glacier data to avoid this problem.

3.2.2 Synoptic studies

Some of the forecasters have grown accustomed to use the web based visualisation tool wrep.ecmwf.int and find it very useful.

4. References to relevant publications

Crochet, P., 2003: A statistical model for predicting the probability of precipitation in Iceland. IMO report, 03028. http://www.vedur.is/um-vi/utgafa/greinargerdir/nr/03028.pdf

Crochet, P., 2004: Adaptive Kalman filtering of 2-metre temperature and 10-metre wind-speed forecasts in Iceland. *Meteorol. Appl*. 11, 173-187. DOI: 10.1017/S1350482704001252

Overland, J.E., C.H. Pease, R.W. Preisendorfer and **A.L. Comiskey**, 1986: Prediction of vessel icing. *Journal of Climate and Applied Meteorology*, **25**, 1793-1806.

Overland, J.E., 1990: Prediction of vessel icing for near-freezing sea temperatures, *Weather and Forecasting*, **5**, 62-77.

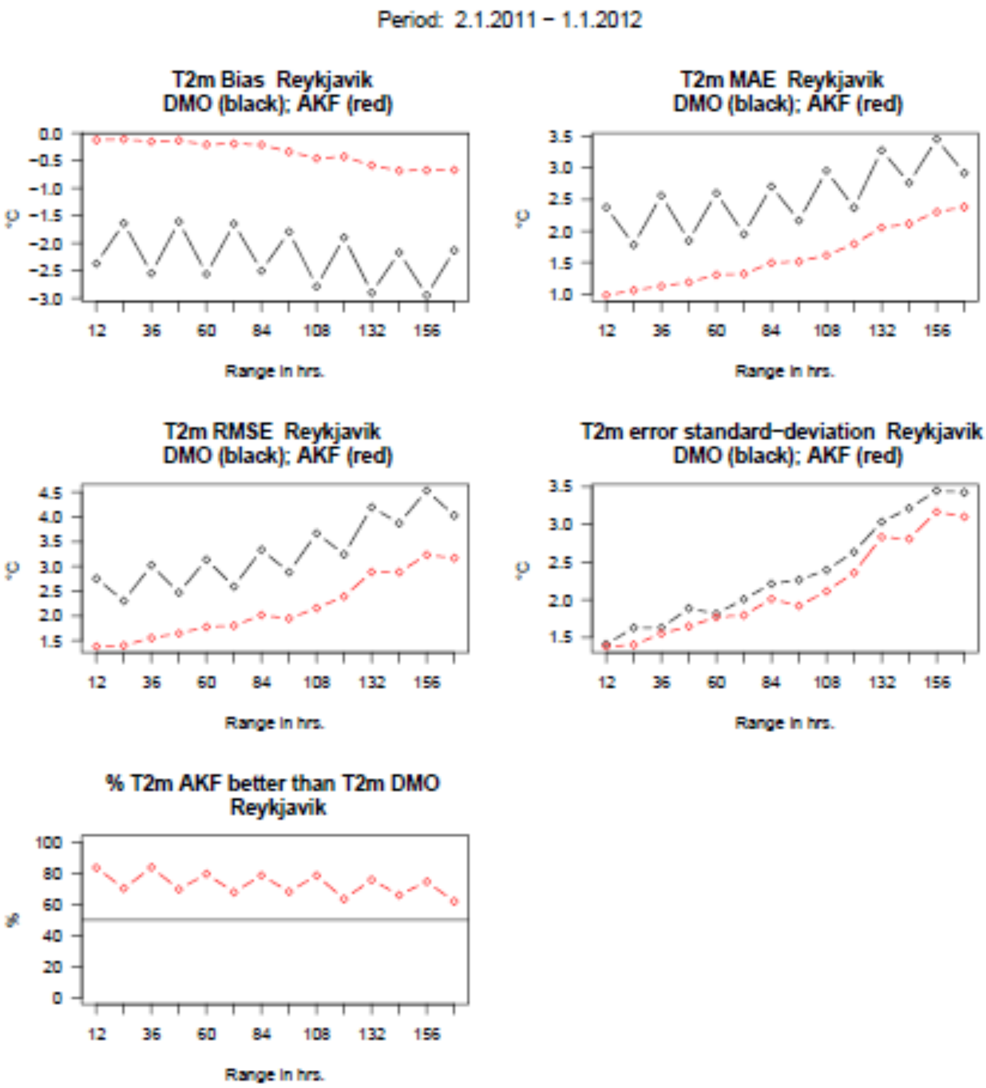

Figure 1 Verification of ECMWF (initiated at 12 UTC) DMO and Kalman filtered 2-metre temperature forecasts for Reykjavík (WMO 4030) for the year 2011. Statistical scores versus forecast range.

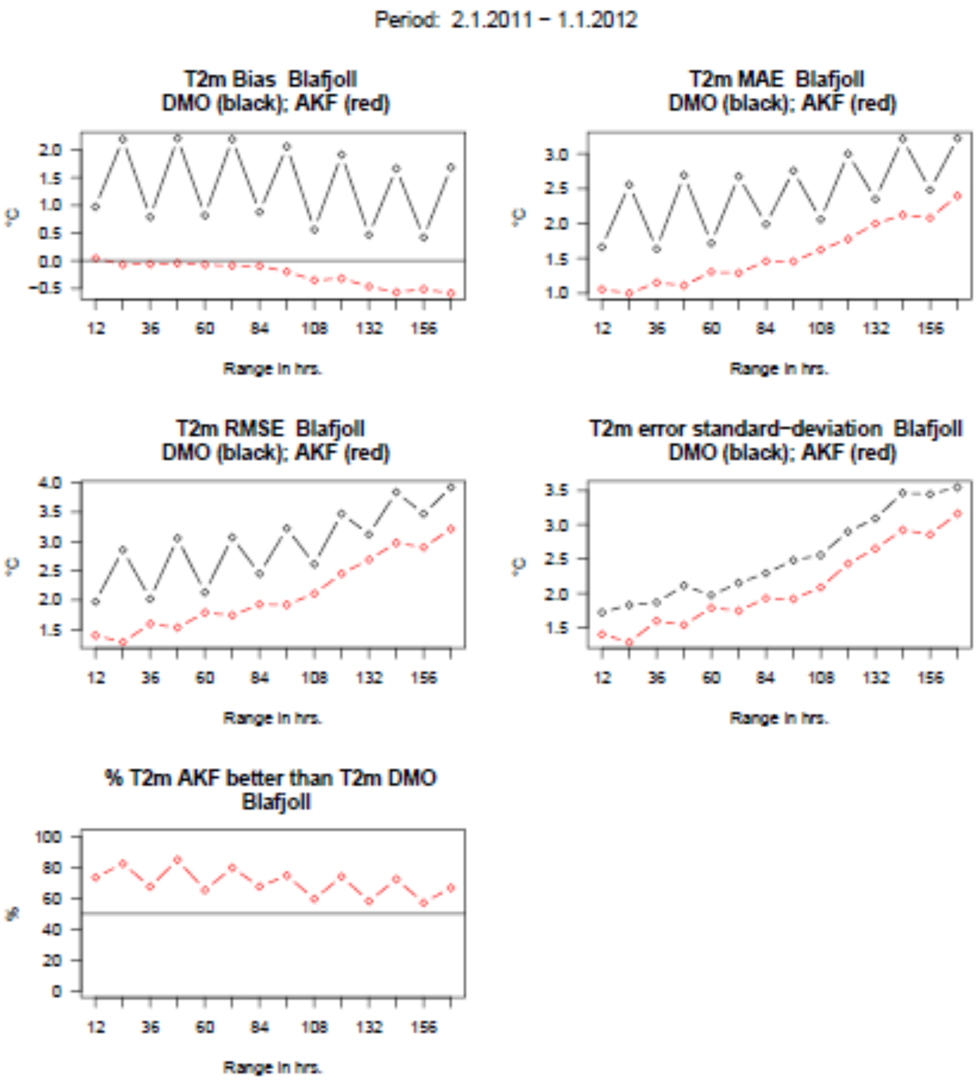

Figure 2 Verification of ECMWF (initiated at 12 UTC) DMO and Kalman filtered 2-metre temperature forecasts for Bláfjöll (WMO 4138) for the year 2011. Statistical scores versus forecast range.

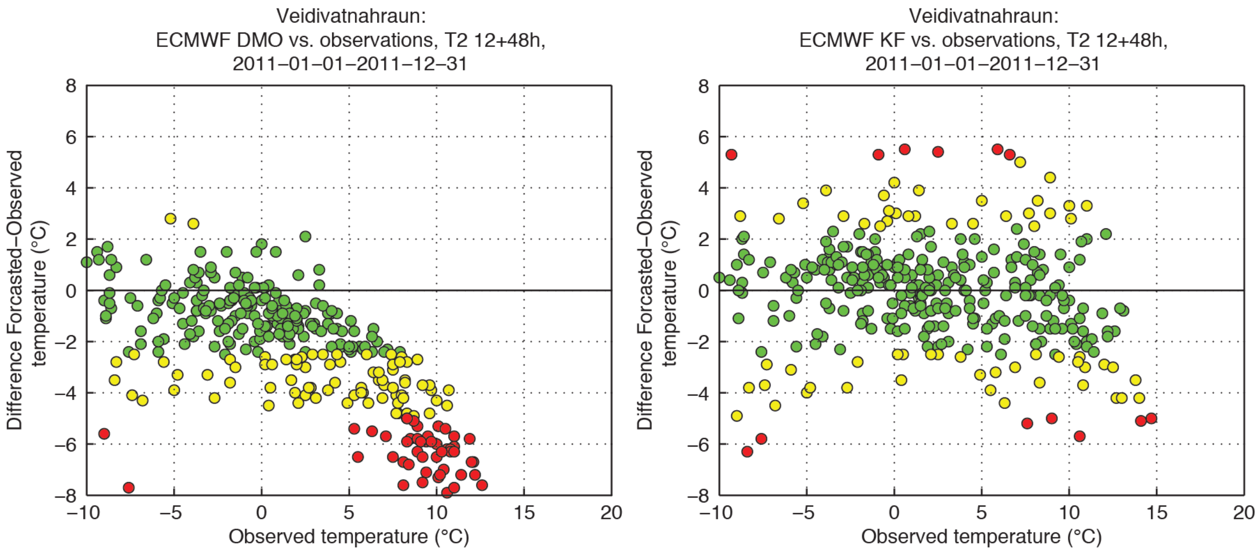

Figure 3 Scatter plots of (left) DMO and (right) Kalman filtered 2-metre temperature forecast errors versus observations at Veiðivatnahraun (WMO 4162). Green dots: absolute forecast error less than 2.5°C, yellow dots: absolute forecast error in the range 2.5-5 °C and red: absolute forecast error exceeding 5 °C. Forecast range 72 hours and initial time 12 UTC.

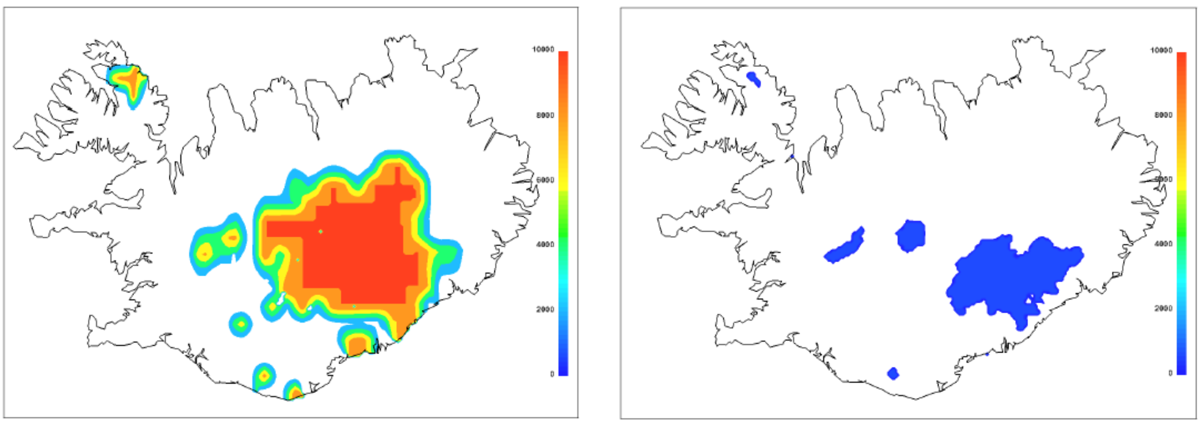

Figure 4 Left: The glacier cover of Iceland as described by the ECMWF model. Right: The much more correct glacier cover of Iceland as described by HARMONIE.

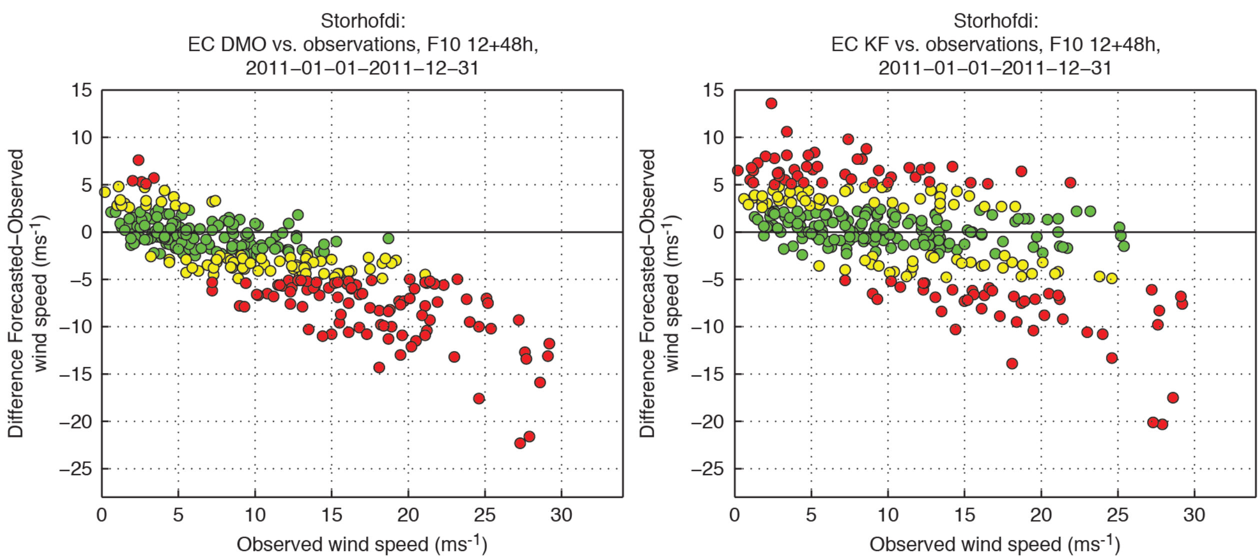

Figure 5 Scatter plots of (left) DMO and (right) Kalman filtered 10-metre wind speed forecast errors versus observations at Stórhöfði (WMO 4048). Green dots: absolute forecast error less than 2.5 m/s, yellow dots: absolute forecast error in the range 2.5-5 m/s and red: absolute forecast error exceeding 5 m/s. Forecast range 72 hours and initial time 12 UTC.