Application and verification of ECMWF products 2010

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1. Summary of major highlights

Medium range weather forecasts issued at IMO are mainly based on ECMWF deterministic products. In the short range ECMWF products are used along with products from other models, mainly limitied area models. Local weather forecasts are automatically generated at more than 120 locations in Iceland and 30 foreign location. Forecasts for Icelandic locations are made available to the general public and as special services to customers. 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. A seasonal verification procedure, including precipitation and surface pressure, is run quarterly for forecasts valid up to T+168h. This procedure is also used for the annual verification over the calendar year. All the results can be consulted on the internal web pages. The ECMWF direct model output performance is poorer in 2009 than it was in 2008.

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

Kalman filtering is used to post-process local 2-metre temperature and 10-metre wind-speed forecasts from ECMWF 00 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 liner model, from D+1d to D+5d, using input from ECMWF 12 UTC deterministic run (Crochet, 2003).

ECWMF 00 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 4 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 4 times a day and the forecast range is 54 hours.

The climatic precipitation maps used to downscale precipitation forecasts have been derived from a 1-km gridded precipitation dataset made with an orographic precipitation model forced by ERA-40 fields for the period 1958-2001 and ECMWF analysis for the period 2002-2006 (Crochet et al., 2007; Jóhannesson et al., 2007). This gridded dataset has been placed in the public domain: http://www.vedur.is/vedur/vedurfar/kort

2.1.3 Derived fields

No fields are derived at IMO from ECMWF model output.

2.2 Use of products

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

During wintertime, ECMWF forecasts are used together with other NWP forecasts to assess the risk of weather conditions that could lead to snow avalanches.

The 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.

The ECMWF SST analysis and forecast are used by the forecasters. Charts of the analysed SST and the 5-day and 10-day forecasts are produced and published on the external web along with other marine weather forecasts.

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. In general the temperature is too low but at elevated sites the temperature is often too high. To illustrate this Figure 1 and Figure 2 show that there is about -2.2°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 +1.5°C.

For Reykjavík there is a large diurnal variations in the error statistics with the bias, MAE and RMSE all having larger values during night than during day, i.e. the 2-metre temperature is systematically underestimated more during the night than during the day, by the difference being about 0.5°C. At stations on small islands or close to the ocean the signal is reversed, i.e. the 2-metre temperature errors are systematically larger during the day than during the night, see Figure 3. This may be due to the grid point being located over sea and/or that the boundary layer scheme is not performing optimally at the boundaries between land and sea.

A comparison of statistical score for 2008 and 2009 shows that in general the ECMWF direct model output performance is poorer for 2009 than 2008. For example, for Reykjavík while the mean bias was about -1.9°C in 2008 it is closer to -2.2°C in 2009. Also the RMSE error increased with forecast range (+12h to +164h) from 2.4°C to 3.7°C in 2008 but from 2.4°C to 4.6°C in 2009.

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 because of well-known problems associated with rain-gauge measurements such as wind-loss, that is a common problem in Iceland. Thus, most sites in Iceland show a model overestimation of precipitation, see e.g. Figure 4 that shows a verification of the precipitation for Reykjavík, a site that is mainly located in a rain shadow. However, the false alarm rate (FAR) is slightly lower than for Akureyri (WMO 4063), that is located in a narrow fjord, see Figure 5.

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 to 3 show cases of the performance of the Kalman filtered forecasts exceeding the DMO in about 70% of cases for all forecast ranges, with the least number of improved cases at the mountain station (Bláfjöll). The prediction intervals are reliable at all ranges and most location, making the information useful to access the prediction uncertainty, even at sites where there are no systematic errors.

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)

None.

3.2.2 Synoptic studies

None.

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

Crochet, P., T. Jóhannesson, O. Sigurðsson, H. Björnsson, F. Pálsson and **I. Barstad,**2007: Estimating the Spatial Distribution of Precipitation in Iceland Using a Linear Model of Orographic Precipitation. *Journal of Hydrometeorol.* **8,** 1285-1306. DOI: 10.1175/2007JHM795.1

Jóhannesson, T., G. Aðalsteinsdóttir, H. Björnsson, P. Crochet, E.B. Elíasson, S. Guðmundsson, J.F. Jónsdóttir, H. Ólafsson, F. Pálsson, Ó. Rögnvaldsson, O. Sigurðsson, Á. Snorrason, O.G. Blöndal Sveinsson and **T. Thorssteinsson**, 2007: Effect of climate change on hydrology and hydro-resources in Iceland. Reykjavík, National Energy Authority, Rep. OS-2007/011. http://www.os.is/ces

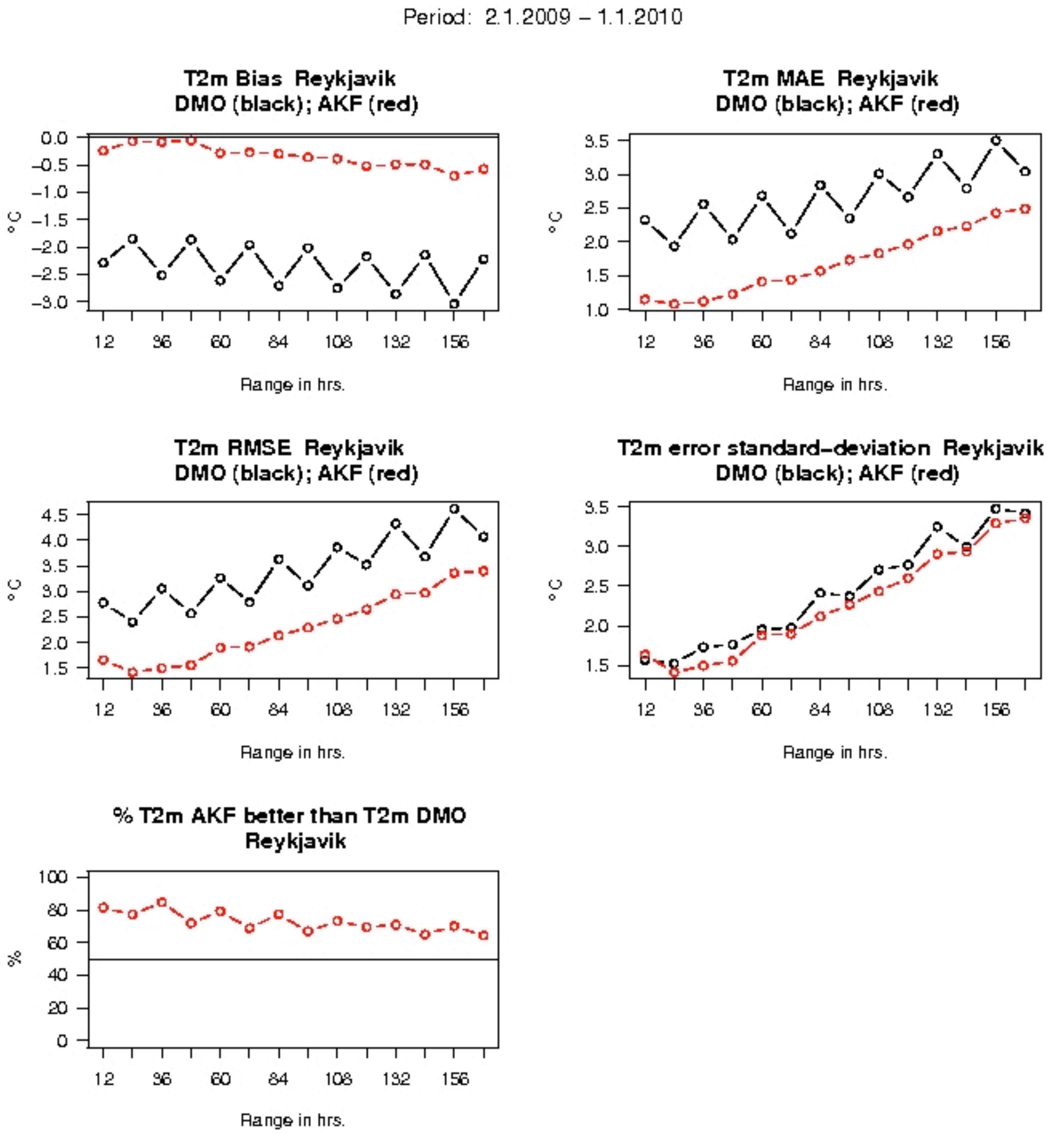

Fig.1 Verification of ECMWF (12 UTC run) DMO and Kalman filtered 2-metre temperature forecasts for Reykjavík (WMO 4030) in 2009. Statistical scores versus forecast range.

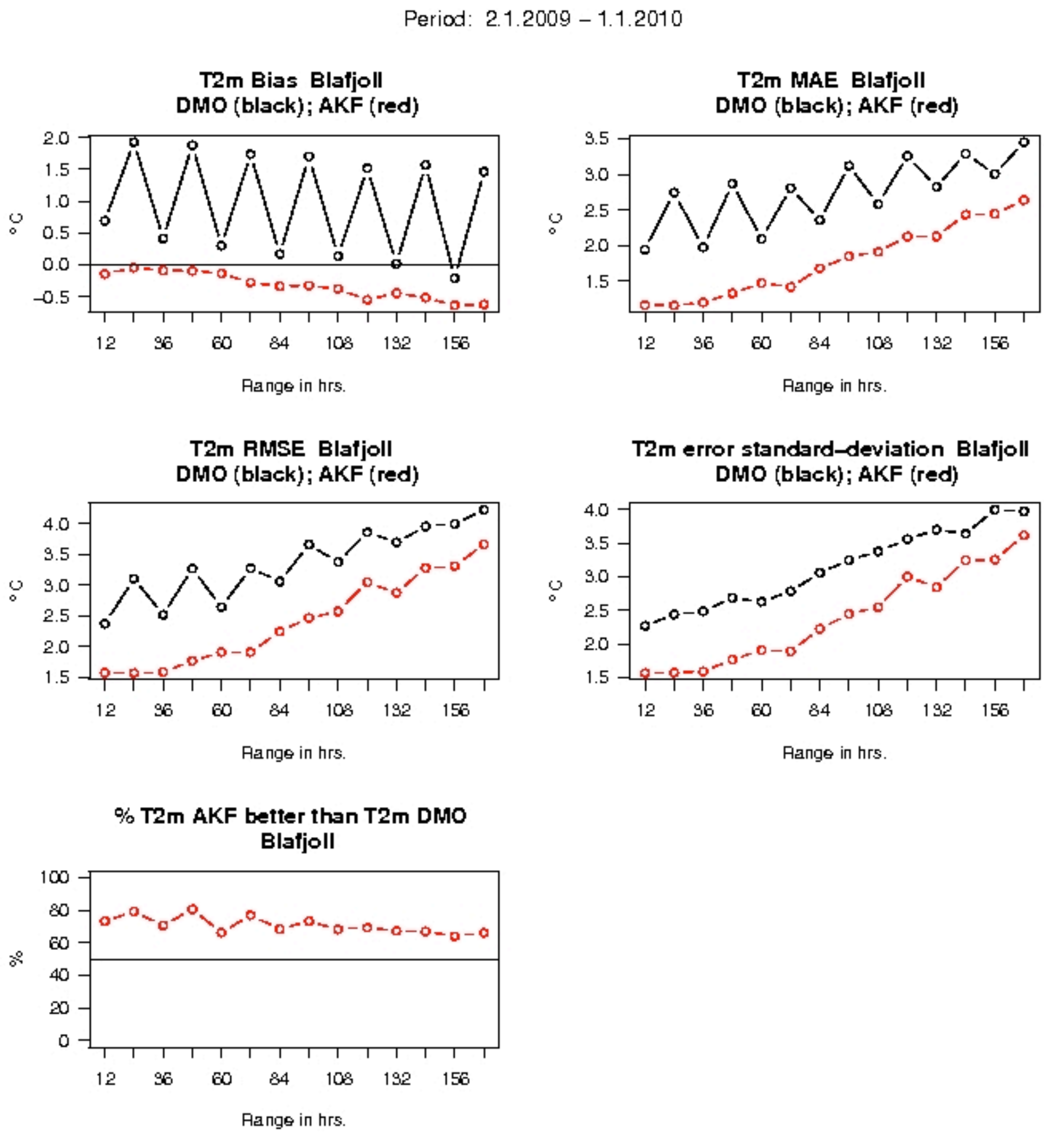

Fig.2 Verification of ECMWF (12 UTC run) DMO and Kalman filtered 2-metre temperature forecasts for Bláfjöll (WMO 4138) in 2009. Statistical scores versus forecast range.

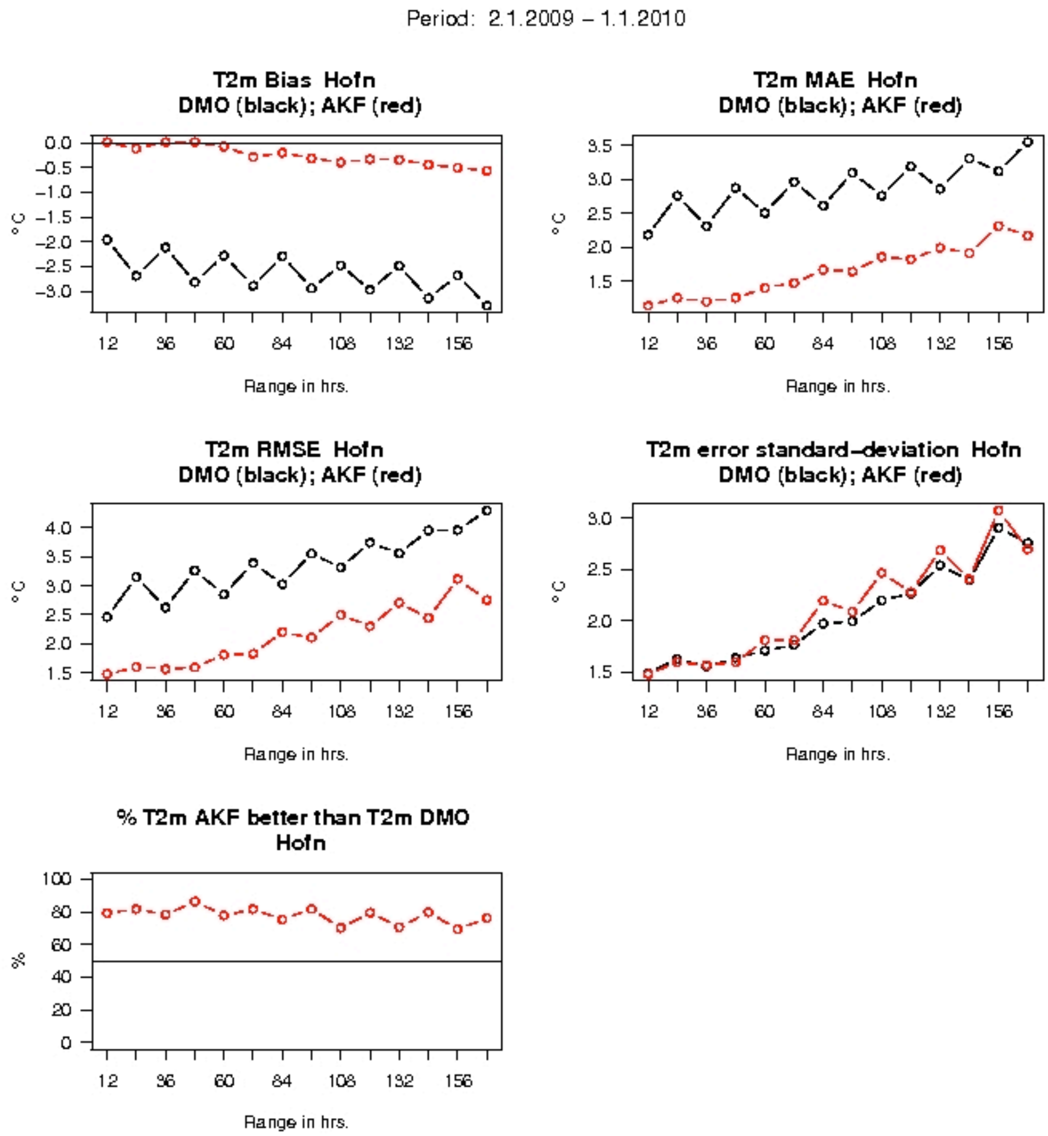

Fig.3 Verification of ECMWF (12 UTC run) DMO and Kalman filtered 2-metre temperature forecasts for Höfn (WMO 4192) in 2009. Statistical scores versus forecast range.

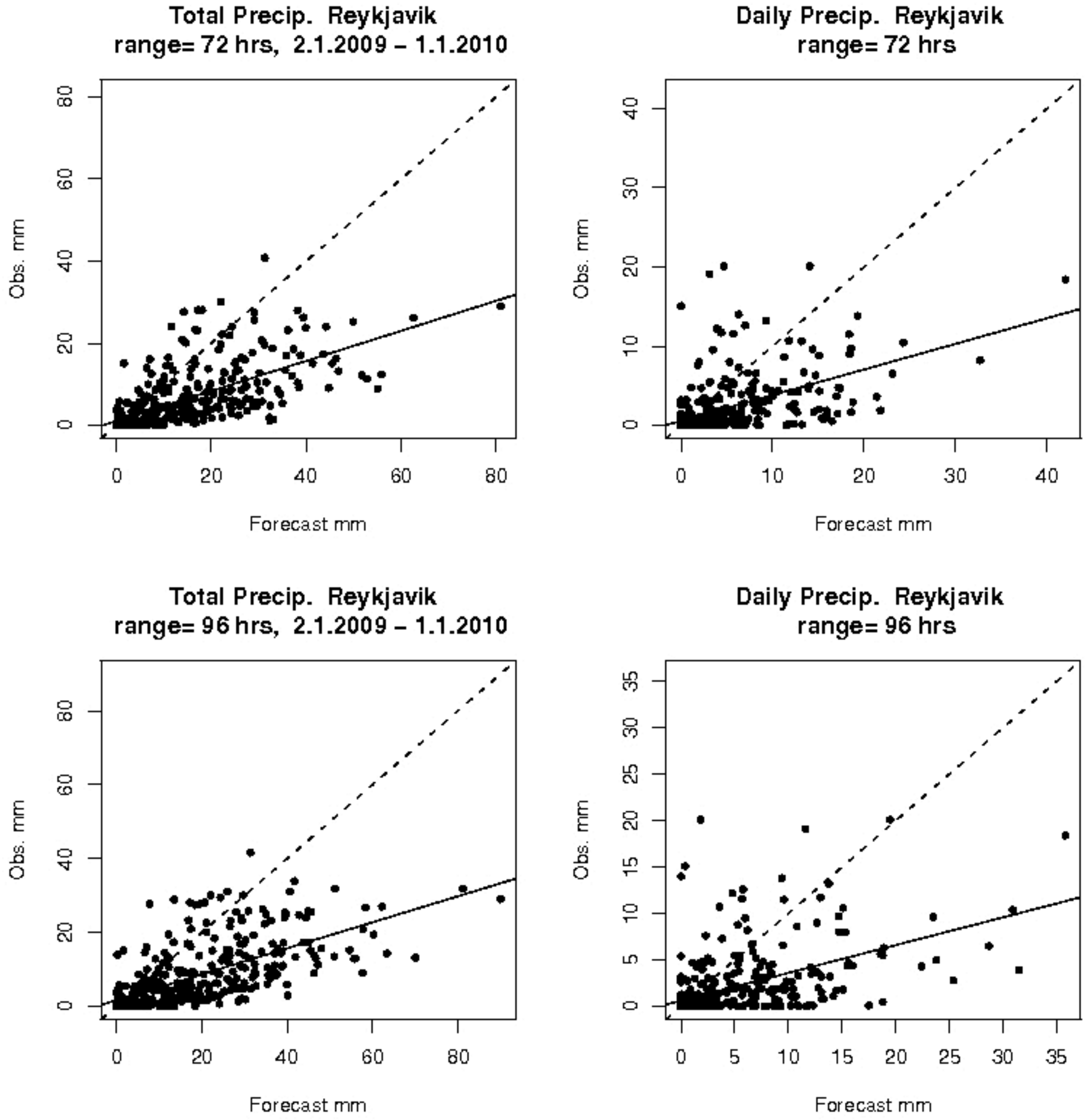

Fig.4 Verification of ECMWF precipitation forecasts (12 UTC run) for Reykjavík (WMO 4030) in 2009. Top left: accumulated precipitation in 72h valid at T+72h, top right: 24h accumulated precipitation valid at T+72h. Bottom left: accumulated precipitation in 96h valid at T+96h and bottom right: 24h accumulated precipitation valid at T+96h.

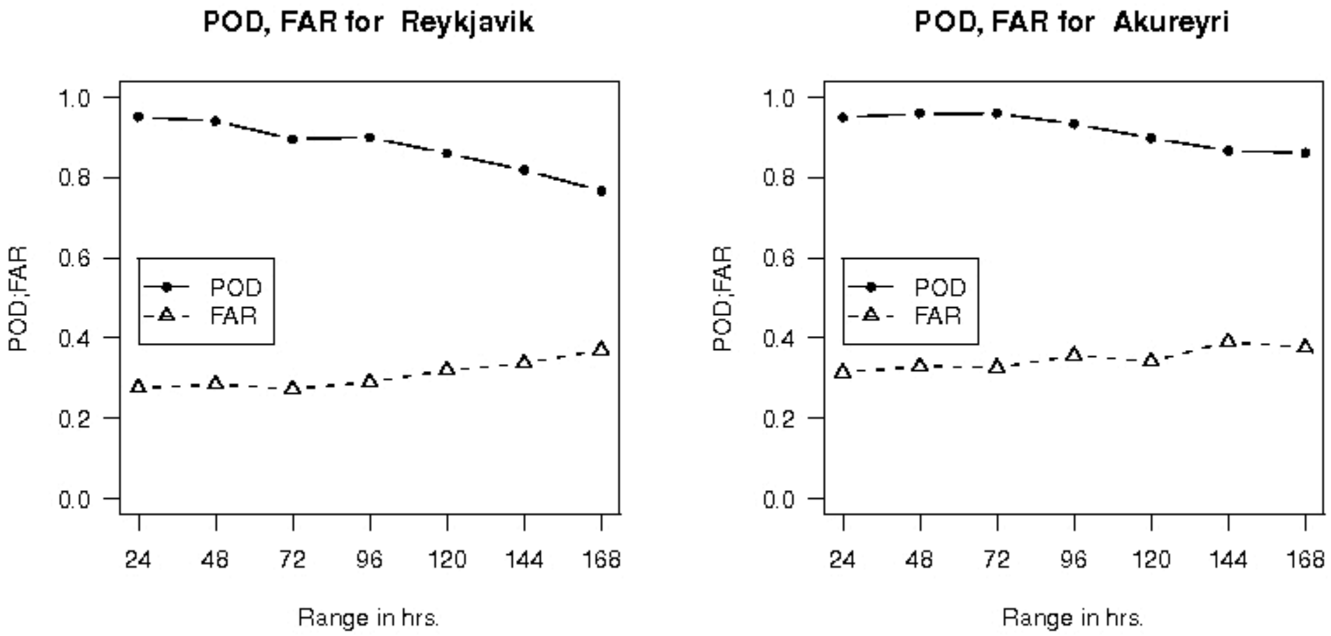

Fig.5 Probability of detection (POD) and False Alarm Rate (FAR) as a function of forcast range. Left: Reykjavík (WMO 4030) and right: Akureyri (WMO 4063) in 2009.