Application and verification of ECMWF products 2015

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1. Summary of major highlights

Medium range weather forecasts issued at the Icelandic Meteorological Office (IMO) are mainly based on ECMWF deterministic products, at 0.125° horizontal resolution. IMO runs a high resolution model, HARMONIE, and short range forecasts are based on its output but are supported with products from the ECMWF as well as other numerical weather prediction models such as HIRLAM, WRF, GFS and the Unified Model. Local weather forecasts are automatically generated for more than 350 locations in Iceland based on HARMONIE and the ECWMF model output. Forecasts are made available to the general public and as special services to customers, e.g. the hydro-power energy sector. Locally generated EPS products are in a test phase and EPS products are 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.

2. Use and application of products

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

Post-processing with a Kalman filter is phasing out and a new simple bias correction filter for 2-metre temperature is in a test phase.

2.1.2 Physical adaptation

Harmonie is IMO's operational model and is run at 2.5 km horizontal resolution, with boundaries from ECMWF. It is run four times a day with a forecast range of 48 hours.
The surface model SURFEX is also run experimentally offline at a few sites, simulating the evolution of the snow pack.
Two dispersion models, Calpuff and NAME, are run operationally from ECWMF data for volcanic ash monitoring in case of an eruption.

2.1.3 Derived fields

ECMWF EPS products, ensemble mean, standard deviation and probabilities, for mean sea level pressure, 10 m wind speed, preciptation and 850 hPa temperature are plotted for Iceland and the surrounding seas.

2.2 Use of ECMWF 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 and landslides.

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 2-day and 6-day forecasts are 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 HRES and ENS)

Local direct model output (DMO) 2-metre temperature forecasts exhibit systematic errors at a large number of sites. This may be due to discrepancies between the model orography and the actual orography, as well as the horizontal resolution the output is retrieved at but representation of the land cover and soil moisture may also play a part. This is illustrated in Fig. 1 which shows the bias in July 1014 and January 2015. On average the bias is negative, -0.6°C in July 2014 and -1.5 in January 2015. However, during July 2014 there is a positive bias in mountainous regions, such as the mountain range to the southeast of Reykjavík, most likely due to poor representation of the mountain range, and in general a negative bias by the coast, likely due to overestimation of the ocean cooling effect. On the other hand during January 2015 some islands and points have a positive bias, likely due to the heating effect of the ocean being overestimated, while in general the temperature was too low.
Fig. 2 shows scatterplots for the same months. For the summer month temperatures above 20°C were never forecasted and for winter frost between 5-15°C is sometimes overestimated but cooler temperatures, >-15°C, usually underestimated.
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, see Fig. 3.
*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 precipitatio*n.

3.1.2 ECMWF model output compared to other NWP models

Comparisons of the ECMWF model output and HARMONIE and HIRLAM model output are made routinely at all verified locations for 2-metre temperature and 10-metre wind-speed. In general HARMONIE outperforms the other models, although systematic errors due to land use, soil moisture and slow development of shallow convection are known.
Fig. 4 shows a comparison of the models for 2-metre temperature in July 2014 and January 2015, for different forecast length. In July HARMONIE, closely followed by ECMWF, outperformed the HIRLAM models while in January 2015 the bias and RMSE were larger. Note that there seems to be a close relation between the results for ECMWF and HARMONIE. The latter is run for a small domain around Iceland with ECWMF output on the boundaries. Also note that the performance of the ECWMF model deteriorates with forecast length while the other model outputs show less deteriorating tendency. There is an increase in negative bias during winter.
With regards to 10-metre wind speed the results of ECMWF are similar to those of the HIRLAM models during July 2014 but worse during January 2015, see Fig. 5. HARMONIE outperforms the other models in both months, with ~0 m/s bias during winter. As wintertime

wind speed forecasts are vital in Iceland the performance of HARMONIE is appreciated by the forecasters.
Verification skill scores for the year 2014 (Fig. 6) show that with regards to the probability of detection (POD) and Kuiper skill score (KSS) the ECMWF DMO of 10-metre temperature is comparable to the Hirlam DMO while with the ECMWF DMO has the lowest false alarm rate (FAR). Harmonie output has the highest POD and KSS but also slightly higher FAR.

3.1.3 Post-processed products

New post-processing methods are currently in a test phase. Preliminary results are promising, see Fig. 7.

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)

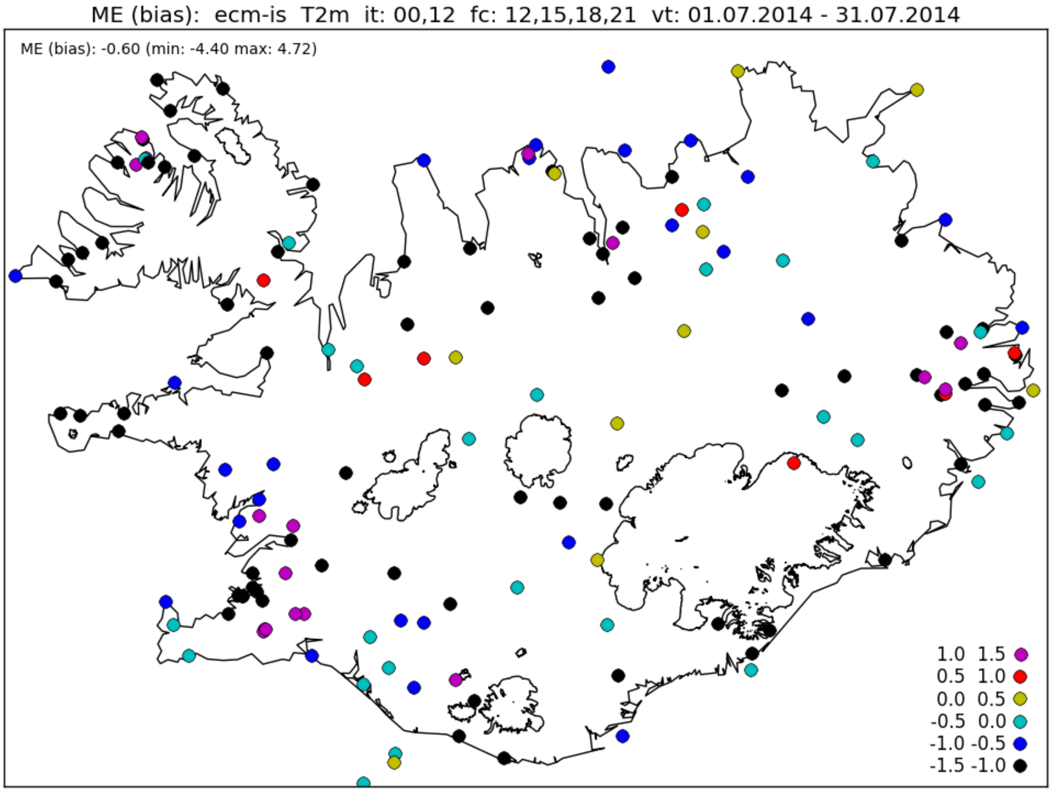
3.2.2 Case studies

A severe storm hit Iceland on the morning of 14 March 2015 with wind speed exceeding 25 m/s at several sites and wind gusts exceeding 40 m/s in near all parts of the country. Fig. 8 shows the observed mean wind speed from over 140 automatic weather stations compared to similar means for Harmonie and the ECMWF output at 10 m and 100 m, 13-24 hour forecasts. It is clear that while the ECMWF output at 10 m is underestimating the mean wind by up to 8 m/s, Harmonie is simulating the wind speed rather well. Also the 100 m wind speed from ECMWF shows a much better correlation with the observed wind than the one at 10 m. Fig. 9 shows scatter plot for ECMWF wind speed at 10 and 100 m altitude for the period 10-13 March. The wind speed at 10 m has a mean error -3.07 m/s and RMSE of 5.62 m/s while the wind speed at 10 m has a mean error of 0.88 m/s and RMSE of 4.42 m/s. The forecasters are aware of this and often disregard the 10-metre wind speed in high wind speed events and use the 100-metre wind speed instead.

4. References to relevant publications

NA.

a)



b)

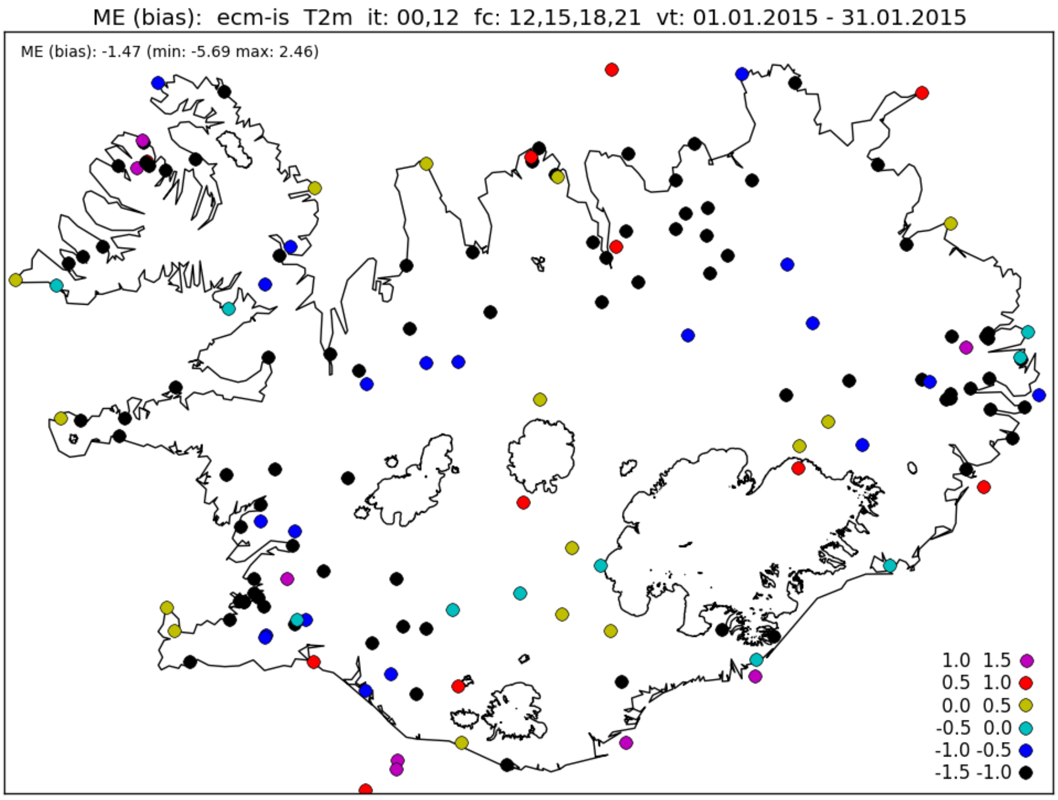


Fig.1 Bias of ECMWF 2-metre temperature forecasts (°C), forecast length 12, 15, 18 and 21 hours, initialized at 00 and 12 UTC, in a) July 2014 and b) January 2015.

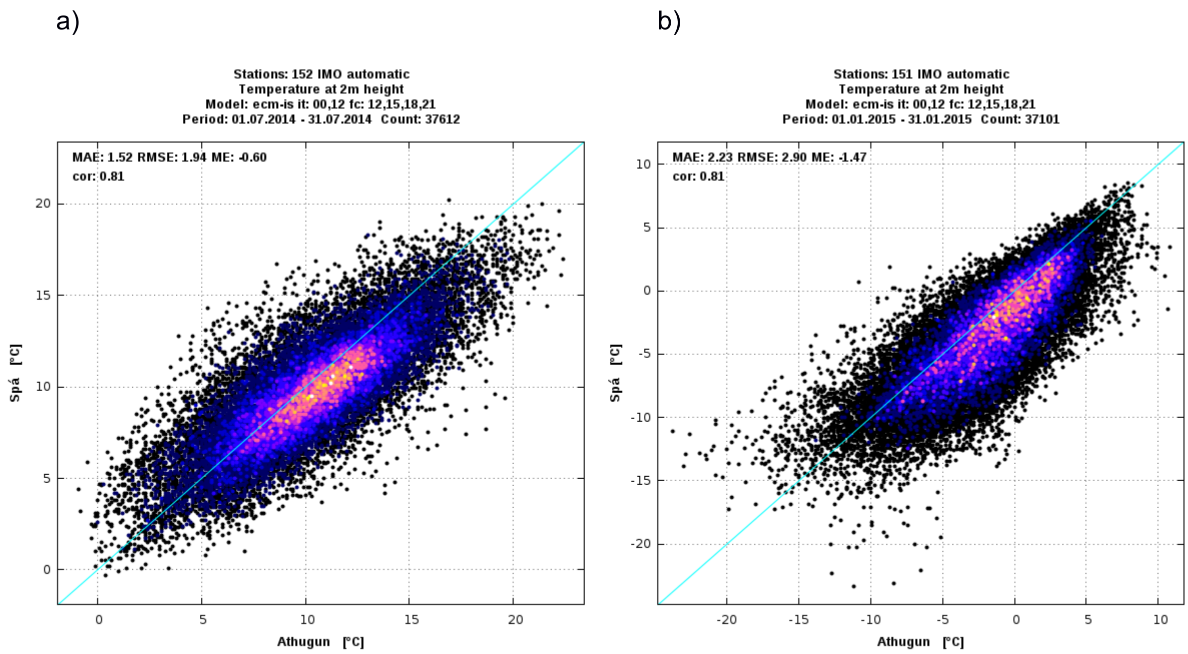


Fig.2 Scatter plots of 2-metre temperature forecasts (Spá, °C) and observation (Athugun, °C) for forecast length 12, 15, 18 and 21 hours, initialized at 00 and 12 UTC. a) July 2014 and b) January 2015.

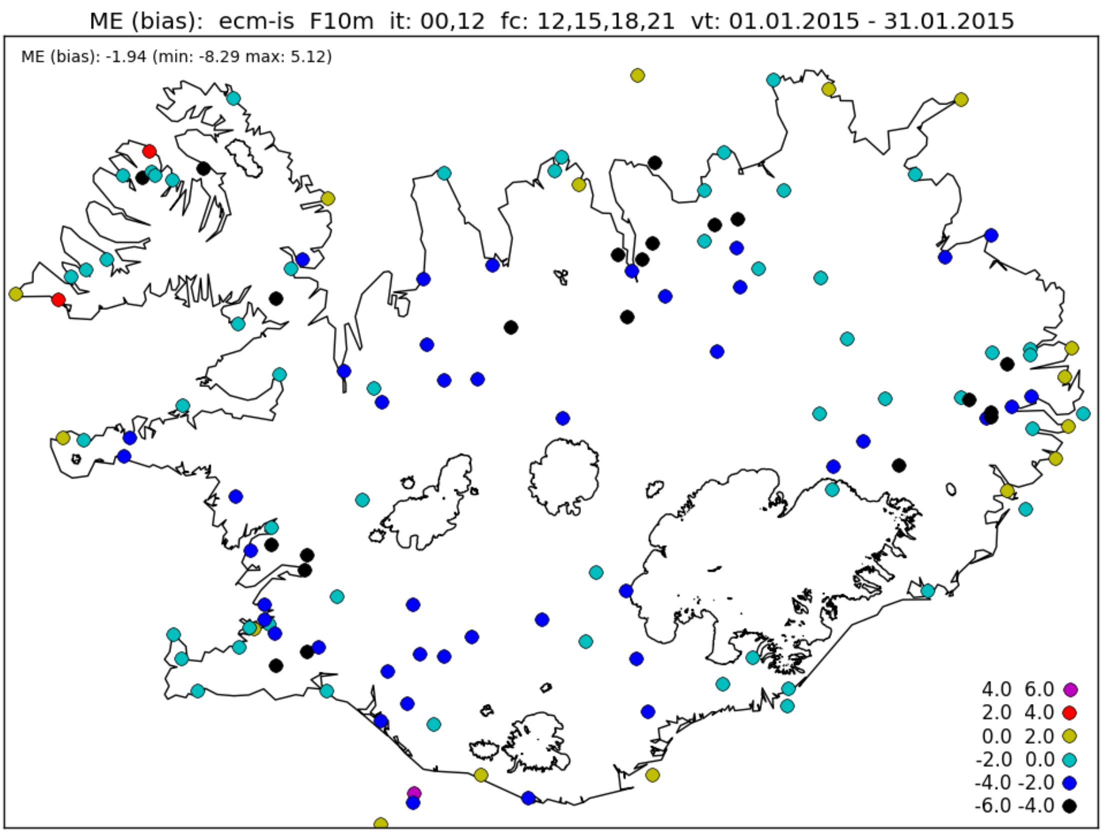
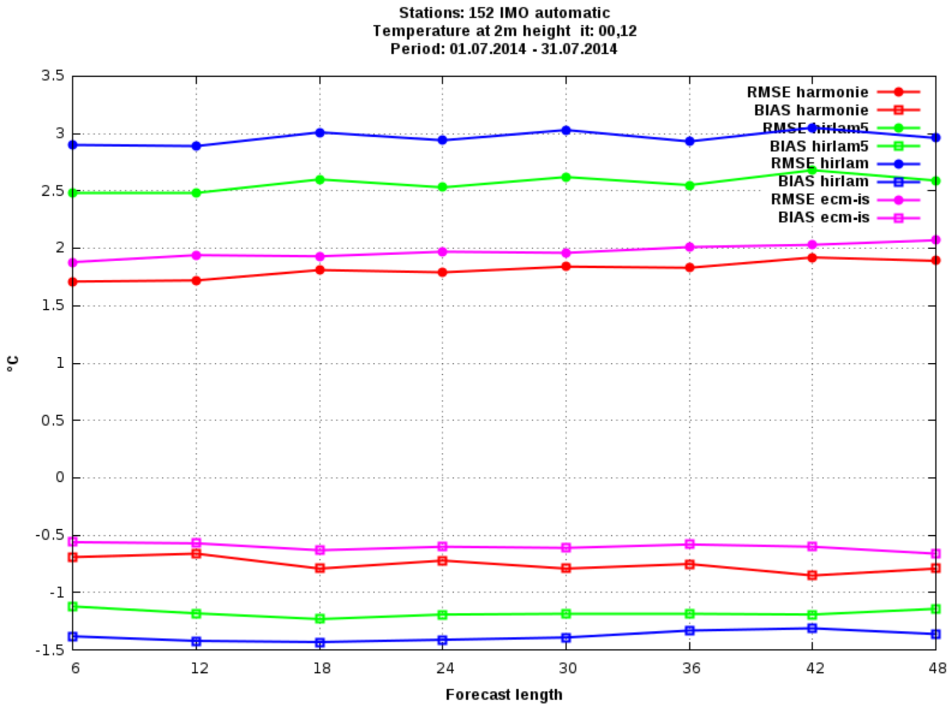


Fig.3 Bias of ECMWF 10-metre wind speed forecasts (°C), forecast length 12, 15, 18 and 21 hours, initialized at 00 and 12 UTC, in January 2015.

a)



b)

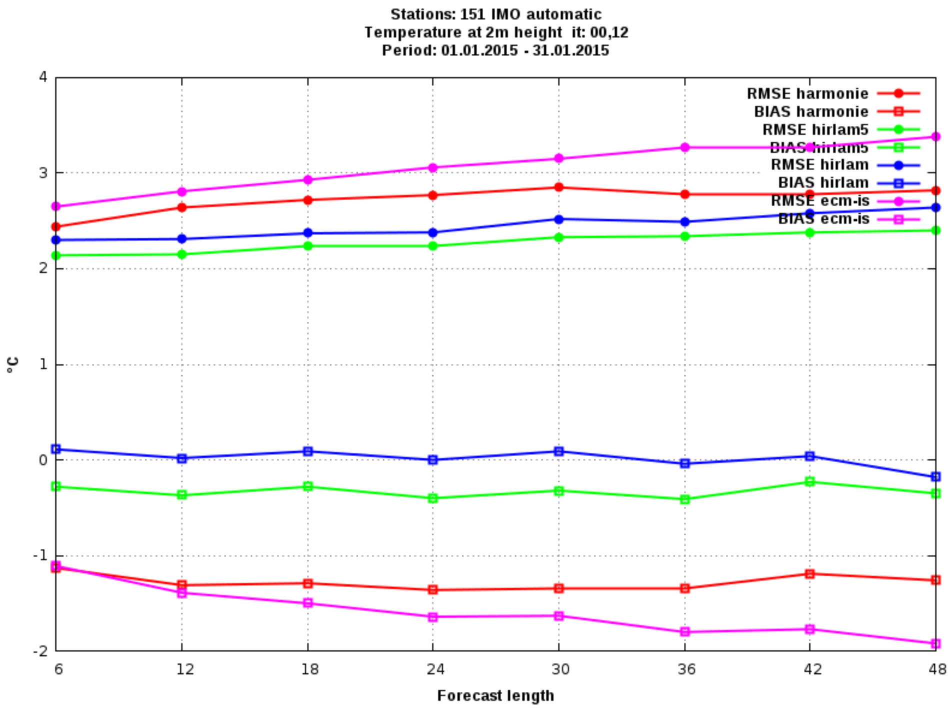


Fig.4 RMSE and bias (°C) of 2-metre temperature forecasts for ECMWF, HARMONIE and two HIRLAM model outputs (different resolution) as a function of forecast length. a) July 2014 and b) January 2015.

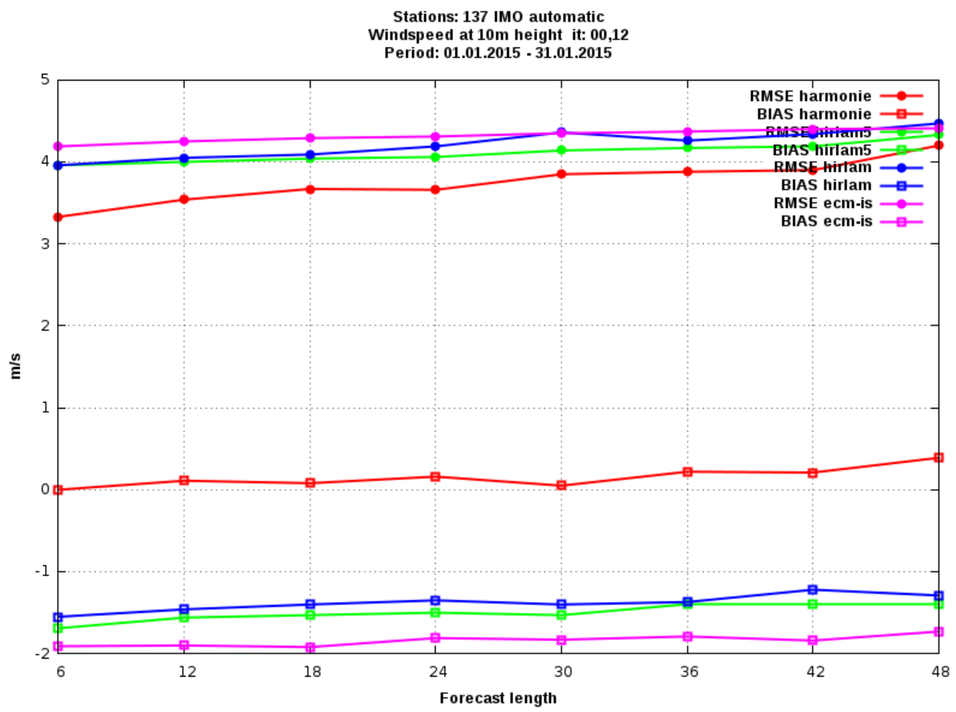


Fig.5 RMSE and bias (m/s) of 10-metre wind speed forecasts for ECMWF, HARMONIE and two HIRLAM model outputs (different resolution) as a function of forecast length for January 2015.

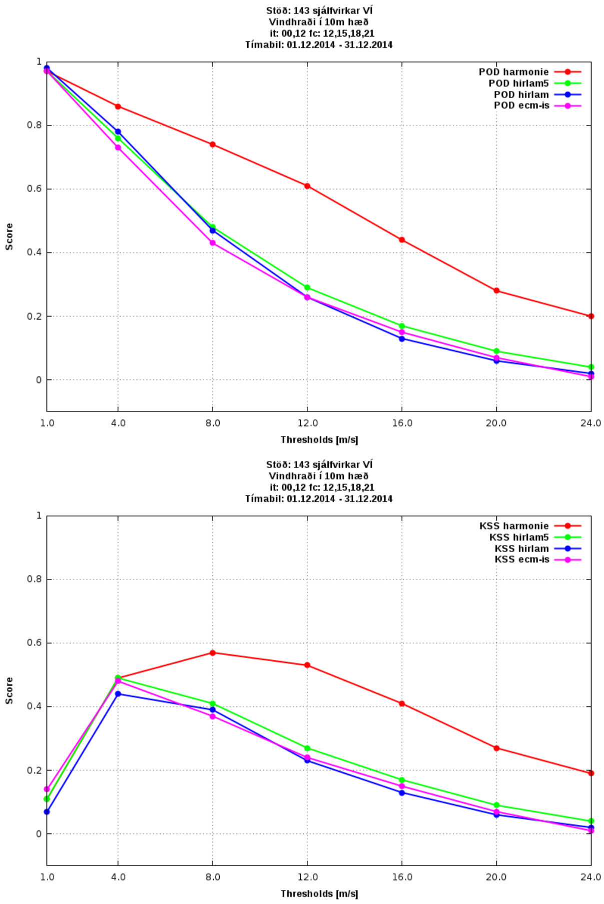


Fig.6 Skill scores for DMO of 10-metre wind speed from Harmonie (red), Hirlam (green, blue) and ECMWF (magenta) for the year 2014. Top left: POD, top right: FAR and bottom KSS.

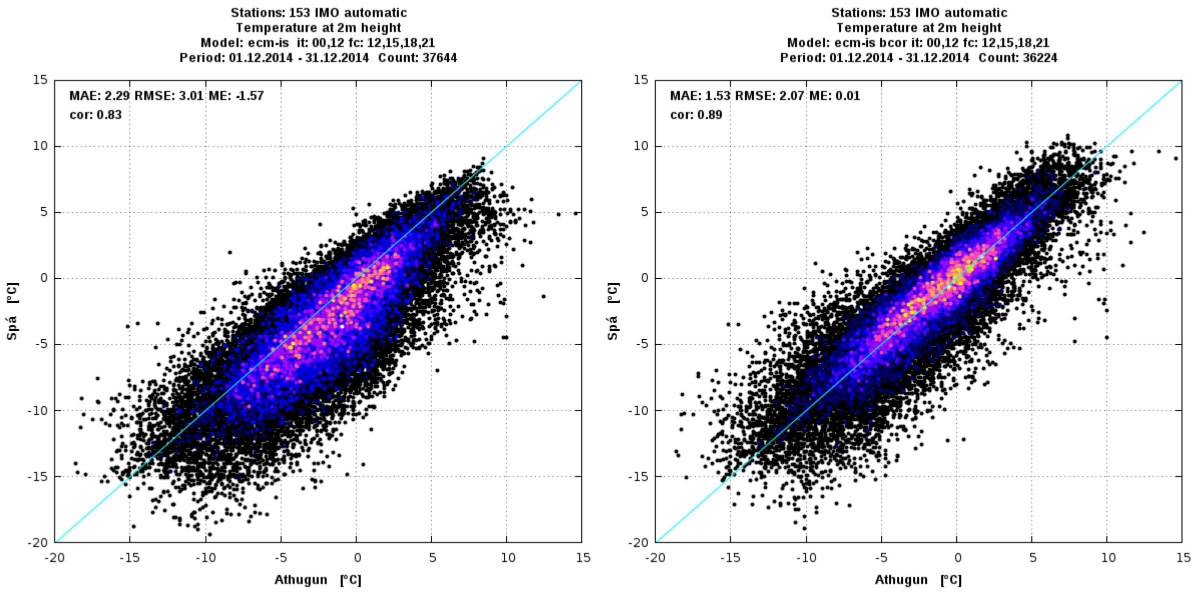


Fig.7 Scatter plot of 2-m temperature, observations and a) the ECMWF DMO and b) post-processed ECMWF forecasts. Time period December 2014, forecast length 12, 15, 18 and 21 hours.

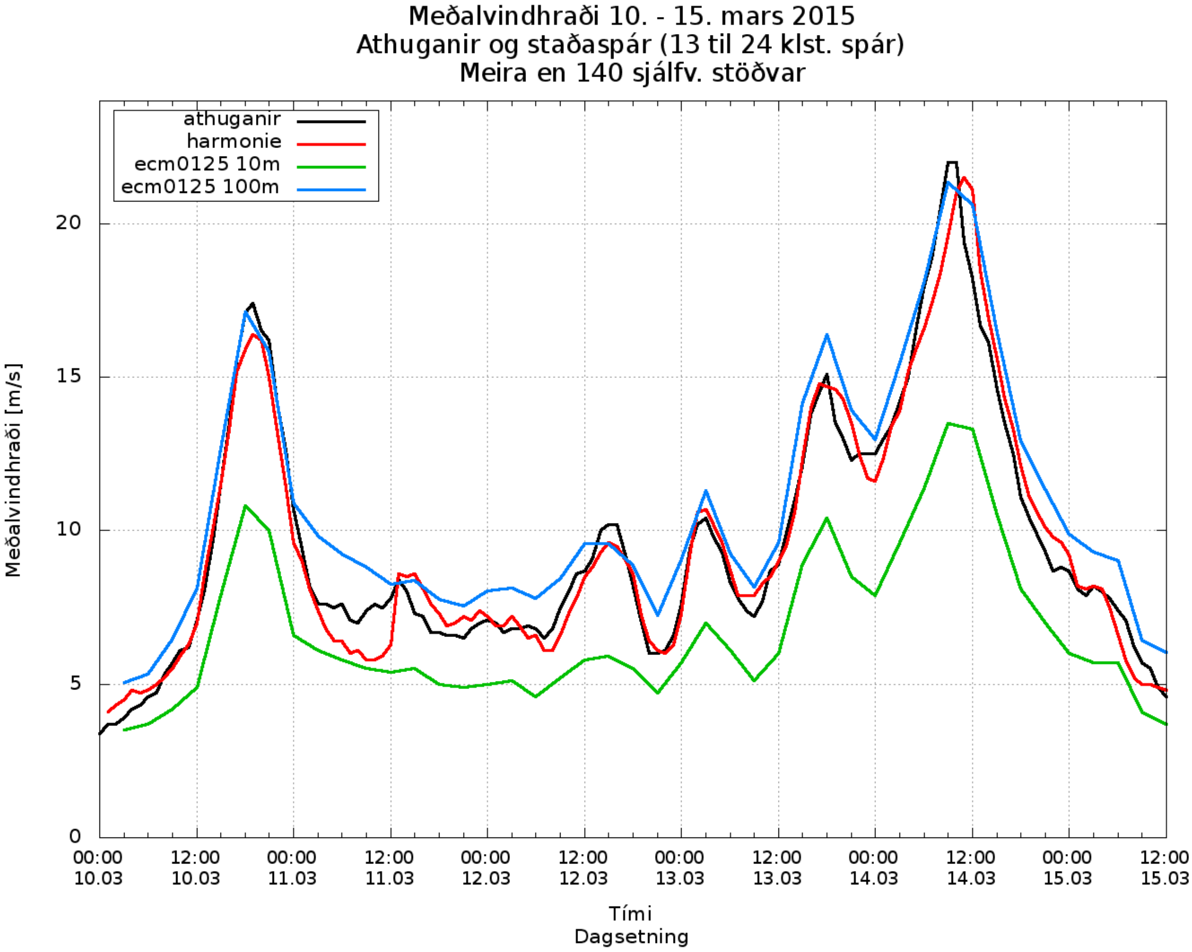


Fig.8 Wind speed on 10-15 March 2015, averaged over more than 140 automatic stations. Observations at 10 m a.g.l. (black) and 13-24 hour forecasts from Harmonie (10 m a.g.l., red) and the ECMWF system at 10 m a.g.l. (green) and at 100 m a.g.l. (blue).

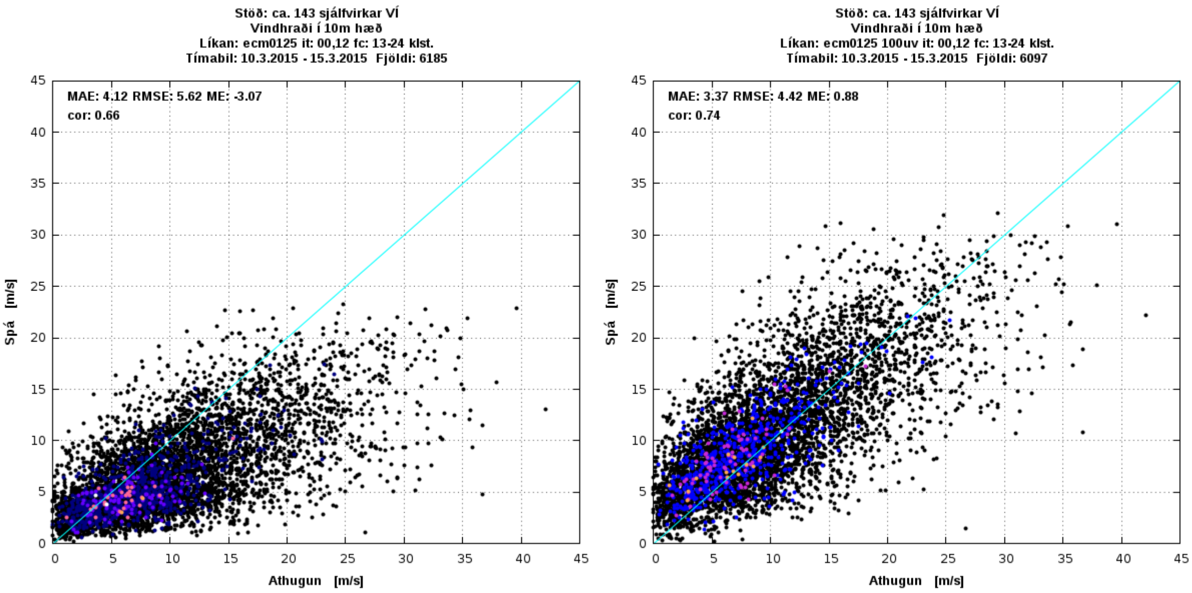


Fig.9 Scatter plot of observed 10-m wind speed and the ECMWF DMO at a) 10 m and b) 100 m. Time interval 10-15 March 2015, forecast length 13-24 hours.