Application and verification of ECMWF products 2016

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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 HRES products. 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 140 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 have been made available on an internal website for over a year but EPS products on the ECMWF website are regularly consulted. 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

A simple bias correction filter for 2-m temperature is in a test phase. Preliminary results indicate that the scheme has the potential to significantly decrease mean error and mean absolute error at all forecasting steps (Fig 1).

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 66 hours.

Two dispersion models, Calpuff and NAME, are run operationally from ECWMF data for volcanic ash monitoring in case of an eruption. SURFEX CROCUS, single column, snow pack modelling using both ECMWF HRES and HARMONIE forcing data is run in research mode for several avalanche risk sites. The hydrological model Water Flow and Balance Simulation Model (WASIM) has been run in research mode using Harmonie reanalysis data as forcing data.

2.1.3 Derived fields

ECMWF EPS products, ensemble mean, standard deviation and probabilities, for 500 hPa geopotential height, mean sea level pressure, 850 hPa temperature, 10 m wind speed and precipitation, for an area covering Iceland and the surrounding seas, are visualised on an internal website.

Maps of several field of forecasted weekly anomalies, such as mean sea level pressure, 500-1000 hPa thickness and SST, are produced from ECMWF extended range forecasts.

2.2 Use of ECMWF products

The ECMWF products are vital for operational weather forecasting in Iceland. For general weather forecasting the ECMWF HRES forecasts are used along with other available short range forecasts as well as for day 3-7, updated twice a day. Medium range forecasts, week 1-3, that are produced for the hydro power energy sector are based on the ECMWF HRES 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.

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. Maps from the ECMWF HRES-WAM are produced internally and used by forecasters.

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 use and soil moisture may also play a part. This is illustrated in Fig 2 which shows the bias in July 1015 and January 2016. On average the bias is negative, -0.2°C in July 2015 and -1.6 in January 2016. During the summer month (as seen in previous reports) 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 slight negative bias by the coast, likely due to overestimation of the ocean cooling effect. In contrast during the winter month, some islands and points have a positive bias, likely due to poor representation of the orography at this scale. However, in general there is a negative bias during the winter month. Due to many periods of high pressure the bias due to the coarser grid of the radiation scheme, before the last upgrade, became extremely large, especially in peninsulas, and was noticed by media and the general public. An example of this extreme cooling is shown in Fig. 3.

Fig. 4 shows scatterplots for the same months. For the summer month the scatter is rather even and bias low. During the winter month the errors are larger. The largest errors are found for the coldest temperatures with frost between 5-15°C is sometimes overestimated but cooler temperatures, >-15°C, usually underestimated.

The 10-metre wind speed in in general underestimated.

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. However when high intensity convective precipitation occurs there have been cases of underestimation by the model.

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 likely due to soil moisture and slow development of shallow convection are known. By enlarging the domain shallow convection has been given more time to develop over the sea.

Fig. 5 shows a comparison of the models for 2-metre temperature in July 2015 and January 2016 for different forecast length. In July HARMONIE, closely followed by ECMWF, outperformed the HIRLAM models while in January 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.

With regards to 10-metre wind speed in January 2016, all the limited area models outperform ECMWF results, with ECMWF and the HIRLAM models having negative bias but Harmonie a smaller positive bias, see Fig. 6. As wintertime wind speed forecasts are vital in Iceland for warnings of high impact weather the performance of HARMONIE is appreciated by the forecasters.

Verification skill scores for 10-metre wind speed for January 2016 (Fig. 7) show that with regards to the probability of detection (POD) and Kuiper skill score (KSS) the ECMWF DMO is comparable to the HIRLAM DMO at 15 km resolution, while the ECMWF DMO has the lowest false alarm rate (FAR). HARMONIE DMO has by far the highest POD and KSS but also higher FAR, a result of a positive bias.

3.1.3 Post-processed products

New post-processing methods are currently in a test phase. Preliminary results are promising as mentioned earlier.

3.1.4 End products delivered to users

NA

3.2 Subjective verification

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

NA

3.2.2 Case studies

December 2015 was quite windy and there were several extreme wind events, the worst one in the evening of 7 December. Fig. 8 shows a HARMONIE wind forecast, valid close to the peak of the weather, as well as observations of wind speed and wind gust at two stations to the south of Iceland. The sonic anemometer at Stórhöfði couldn't measure during the height of the storm, most likely due to increased noise level, but both stations measured 30 m/s with gusts exceeding 45 m/s. Figure 9 shows a comparison of the observed wind speed in Iceland during December 2015 as well as forecasts by HARMONIE, HIRLAM 5 km and EC HRES, averaged over 139 weather stations. It is clear that HARMONIE outperforms the other models.

A flash flood incident occurred in Siglufjörður, North Iceland, on 26-28.08. 2015, due to extremely intensive rain falling onto a ground already saturated of water by melting and previous prevailing precipitation events in the area. The measured 48 hours accumulated precipitation from 26.08. 18 UTC to 28.08. 18 UTC was 145 mm. The return period of such a flash flood in Siglufjörður is estimated at 10-20 years. Comparison of measurements and forecasts show that only HARMONIE captured this precipitation event (140 mm/48 h), whereas both HIRLAM 5 km and ECMWF HRES greatly underestimating the precipitation, forecasting 35 mm/48 h and 60 mm/42 h respectively, see Fig. 10. It should be noted that Siglufjörður is located in a very orographically complex region and high resolution is thus needed to represent the orography.

4. Feedback on ECMWF “forecast user” initiatives

The “known IFS forecast issues” web site has been very useful in cases of systematic errors. It is valuable to know if an issue is known and what is being done to eliminate it, if possible. The “severe event catalogue” has not yet been used much.

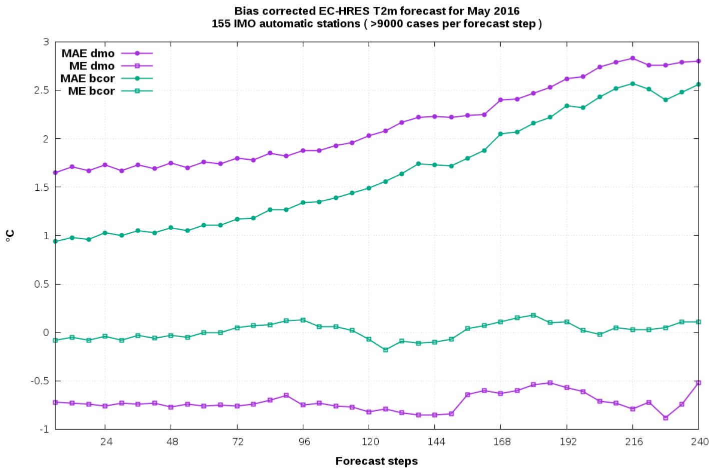


Fig. 1 Mean absolute error and mean error for ECMWF HRES DMO (purple) and bias corrected output for 2-metre temperature forecasts, May 2016. Averaged over 155 automatic stations.

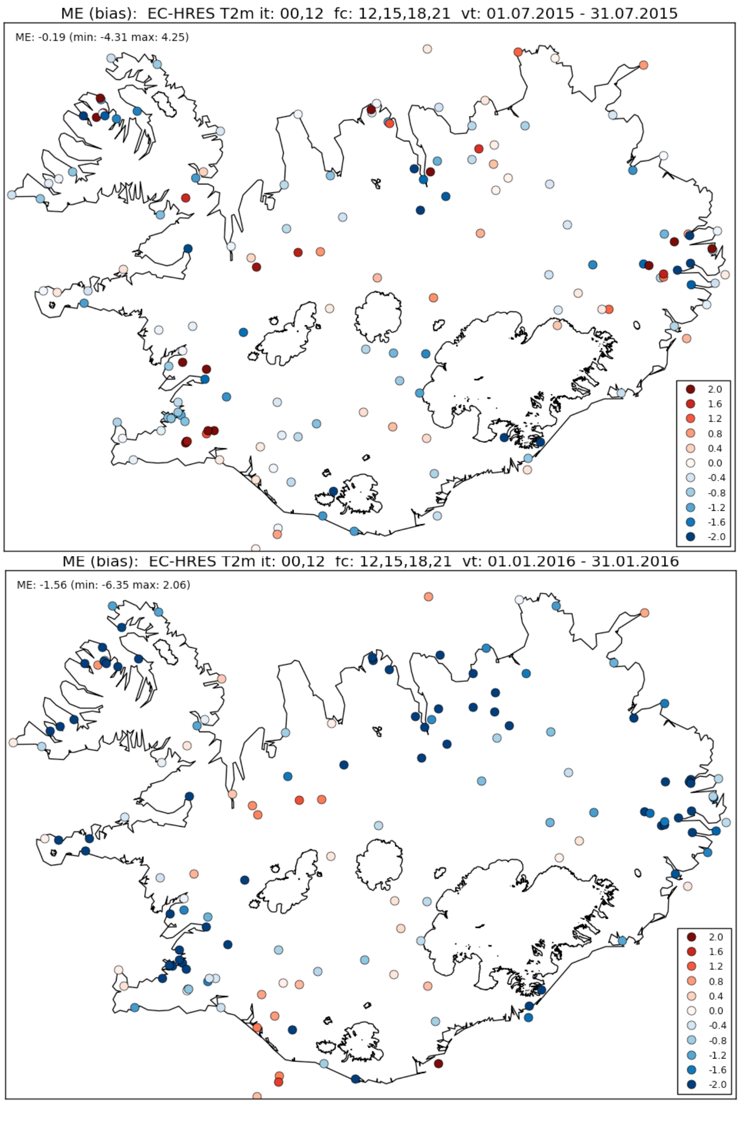


Fig. 2 Mean error (bias) of 2-metre temperature forecast (°C), forecast length 12, 15, 18 and 21 hours, initialized at 00 and 12 UTC, in July 2015 (top) and January 2016 (bottom). ECMWF HRES.

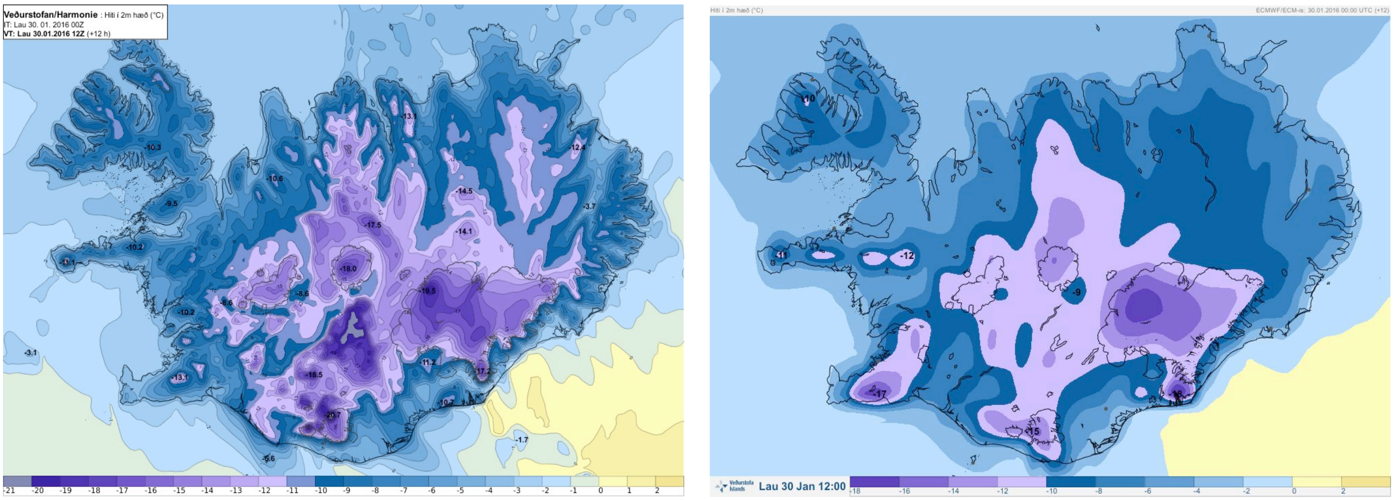


Fig. 3 2-metre temperature forecasts (°C), forecast length 12 hours, valid 30 January 2016 at 12 UTC from HARMONIE (left) and EC-HRES (right). ECMWF HRES.

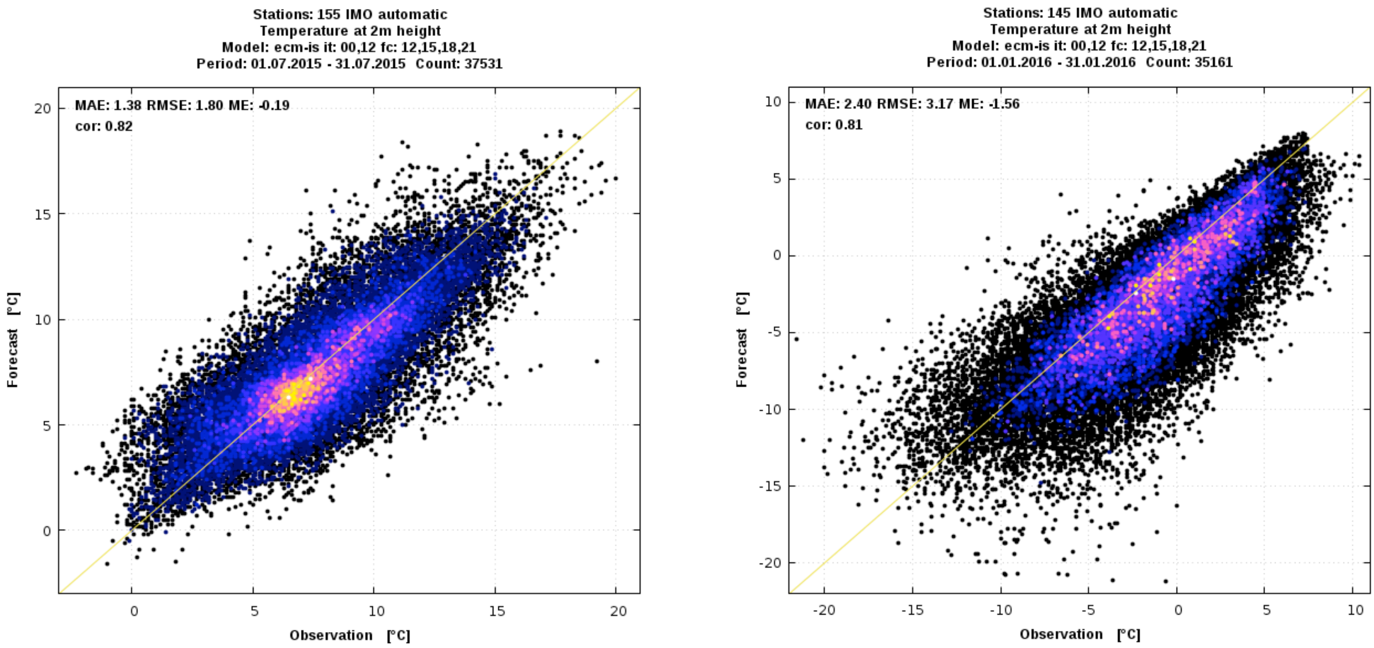


Fig. 4 Scatter plot of 2-metre temperature (°C) forecasts and observations for forecasts length 12, 15, 18 and 21 hours, initialized at 00 UTC and 12 UTC for July 2015 (left) and January 2016 (right). ECMWF HRES.

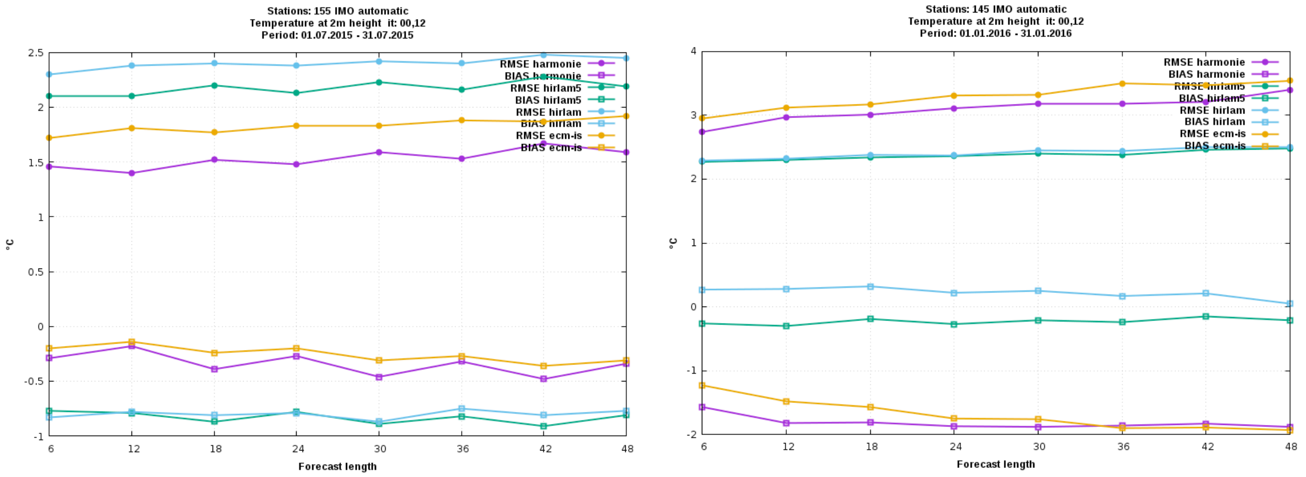


Fig. 5 RMSE and bias of 2-metre temperature forecasts for ECMWF HRES (yellow), HARMONIE (purple) and two HIRLAM model outputs (5 and 15 km horizontal resolution) as a function of forecast length. Left: July 2015 and right: January 2016.

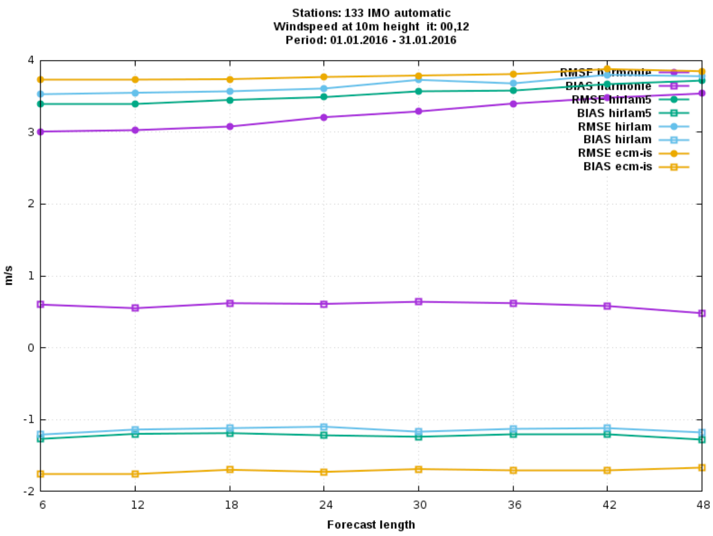


Fig. 6 RMSE and bias of 10-metre wind speed forecasts for ECMWF HRES (yellow), HARMONIE (purple) and two HIRLAM model outputs (5 and 15 km horizontal resolution) as a function of forecast length, for January 2016.

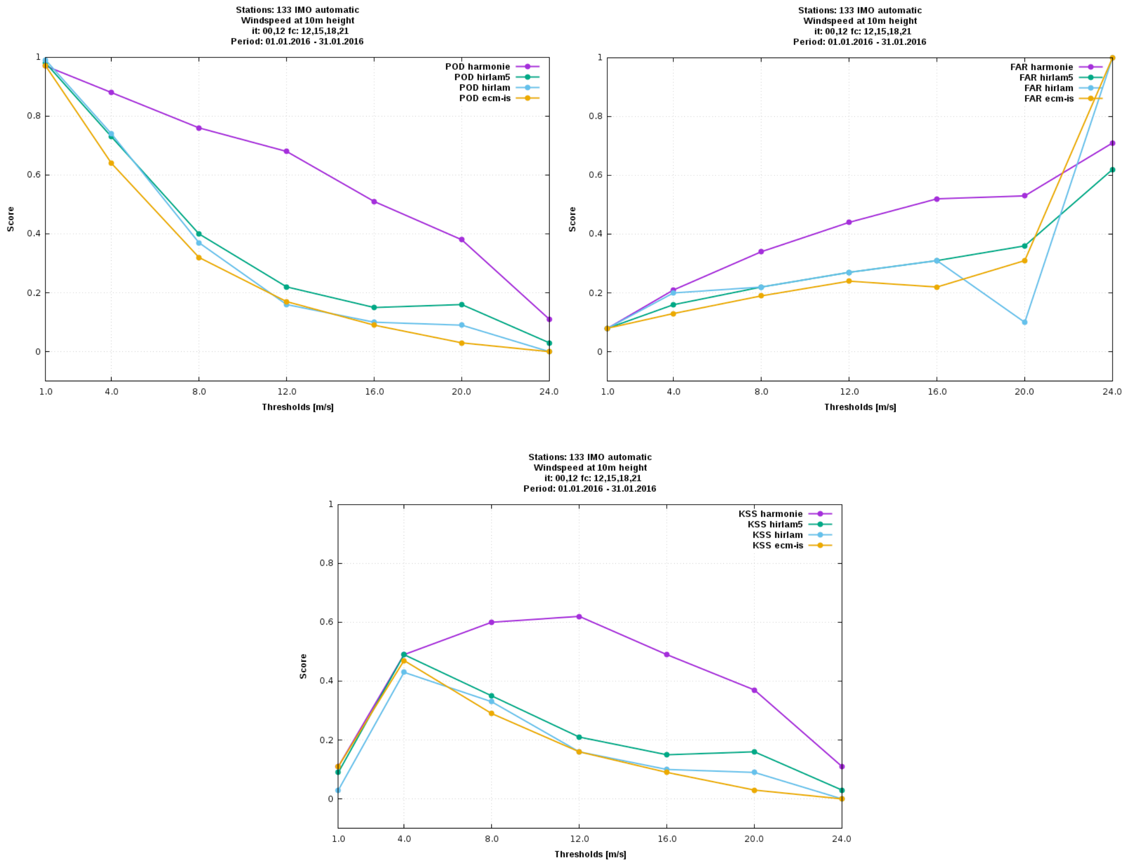


Fig. 7 Skill scores for DMO of 10-metre wind speed from HARMONIE (purple), HIRLAM (green, blue) and ECMWF HRES (yellow) for January 2016. Top left: POD, top right: FAR and bottom: KSS.

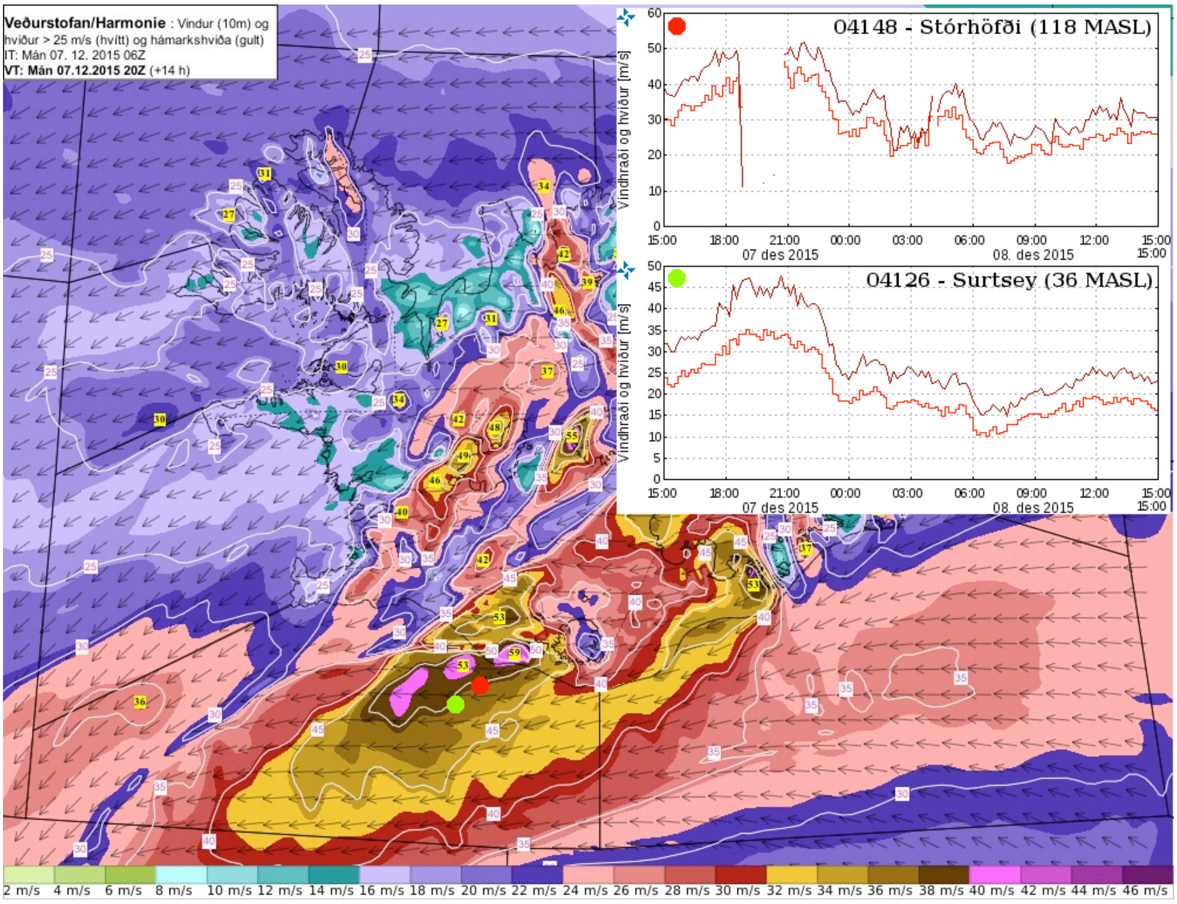


Fig. 8 HARMONIE wind speed forecast, forecast length 14 hours, valid 7 December 20 UTC. Inserted measurements of wind speed (red) and wind gust (brown) at two weather stations just south of Iceland.

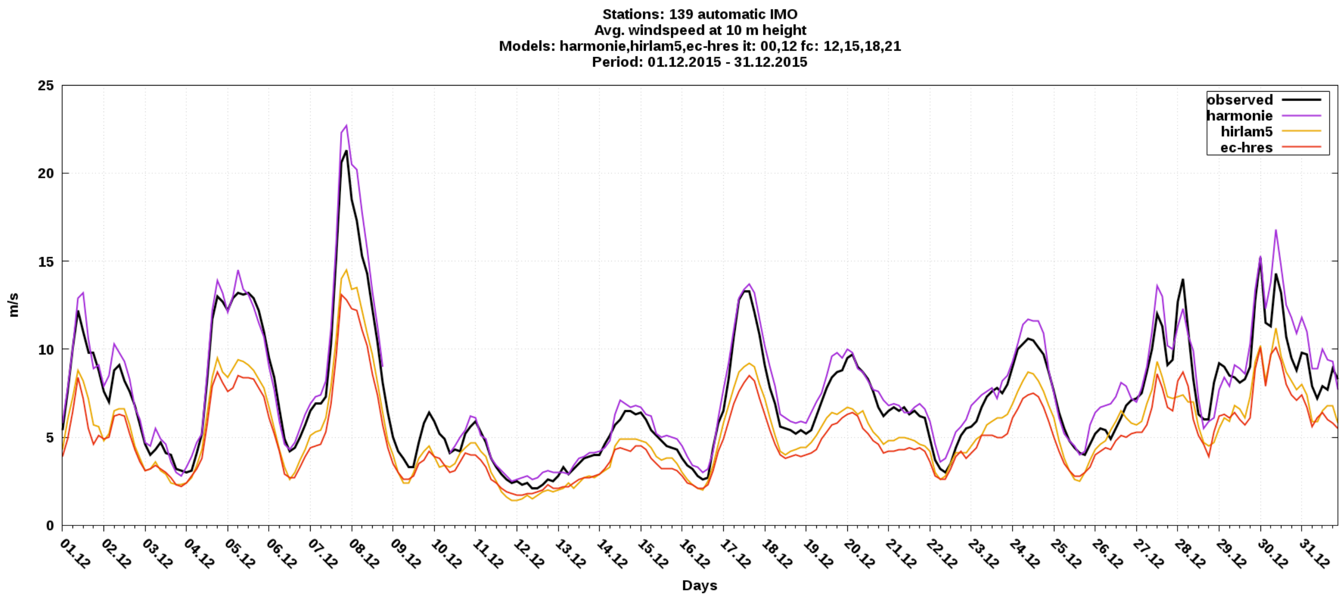
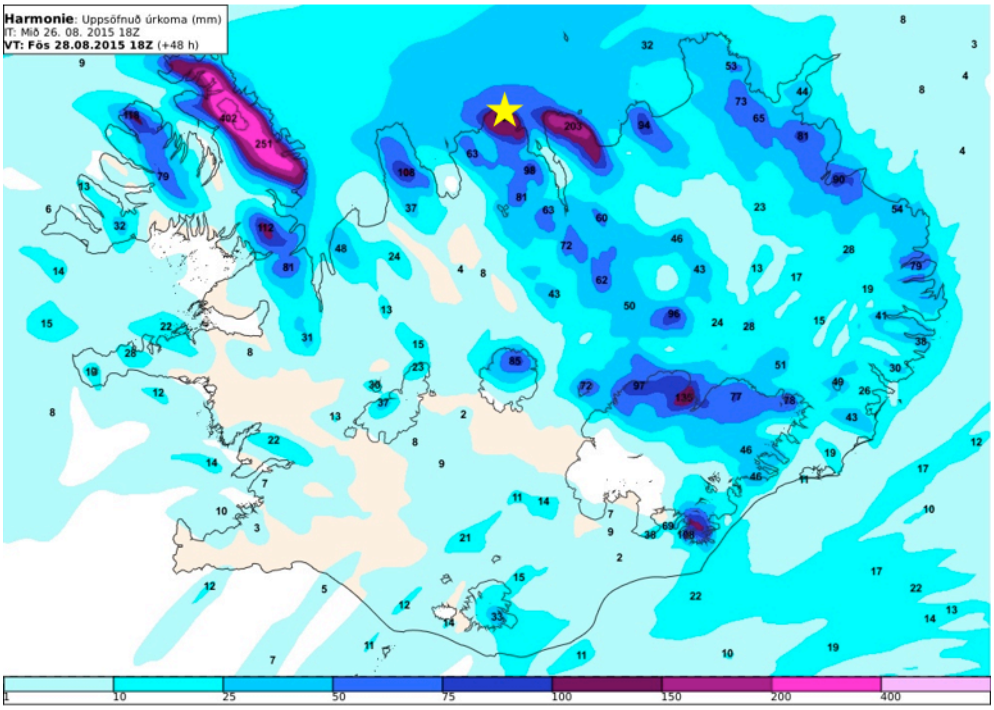


Fig. 9 Comparison of 10-metre wind speed observations (black) and forecasts from HARMONIE (purple), HIRLAM 5 km resolution (yellow) and ECMWF HRES (red) in December 2015. Forecast length 12, 15, 18 and 21 hours, initialized at 00 UTC and 12 UTC, averaged over 139 stations.



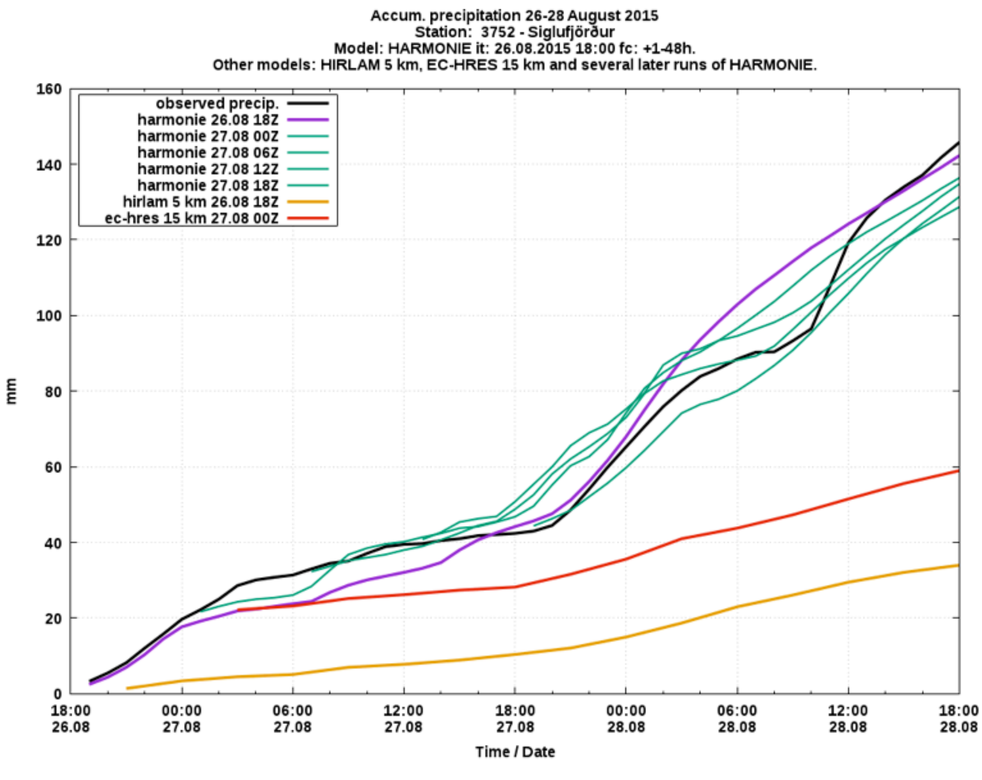


Fig. 10 Top: Accumulated precipitation, 48 hours HARMONIE forecast valid 28 August 2015 at 18 UTC. In Sigulfjörður, marked with a yellow star, the forecast was 140 mm in 48 hours. Bottom: Observed and forecasted accumulated precipitation for the period 26.08. 18UTC – 18.08. 18 UTC. Observations (black), HARMONIE forecasts initialized at different times (blue), HIRLAM 5 km resolution initialized 26.08. 18 UTC (yellow) and ECMWF HRES initialized 27. 08. 00 UTC (red).