Application and verification of ECMWF products 2017

Icelandic Meteorological Office (www.vedur.is) – Guðrún Nína Petersen

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-AROME, 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, GSM. The Danish Meteorological Institute runs HARMONIE-AROME over a domain covering Iceland and southern Greenland, the IGA setup, also initialised from HRES. Local weather forecasts are automatically generated for more than 140 locations in Iceland based on HARMONIE-AROME 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

Currently there is no statistical adaptation of ECMWF model output at IMO but there are plans to implement a simple bias correction filter for 2-m temperature.

2.1.2 Physical adaptation

IMO runs HARMONIE-AROME operationally four times a day, forecasting range 66 hours, using boundary data from ECMWF. The model has 2.5 km horizontal resolution and 65 vertical levels. The Danish Meteorological Institute (DMI) runs, in cooperation with IMO, the same model but a different version for a large domain covering Iceland and S-Greenland, termed IGA (Iceland-Greenland A). IGA is forced by ECMWF data.

Two dispersion models are run operationally at IMO for volcanic ash monitoring in case of an eruption: Calpuff and NAME. Both models are initialised with HRES data. SURFEX CROCUS, single column, snow pack modelling using both HRES and HARMONIE-AROME 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-AROME reanalysis data as forcing data. This reanalysis was obtained using ERA interim data on the boundary.

2.1.3 Derived fields

IMO has an extensive internal forecasting charts website where a number of fields from the available NWP models are visualised. It is easy to scroll through the forecasts as well as eyeball differences between models and model runs. Over 70 charts types are produced from HRES using a number of variables, varying from traditional surface parameters (e.g. mean sea level pressure) to surface fluxes, divergence and potential vorticity aloft, and for up to three map sizes. In addition, 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 the website. An additional product is the visualisation of the ECMWF clusters (Fig. 1).

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 ECMWF products

2.2.1 Use of Products

The ECMWF products are vital for operational weather forecasting in Iceland. For general weather forecasting the HRES forecasts are used along with other available short range forecasts for day 1-3. For day 3-7 the published forecasts are solely based on HRES, with the forecasters also using ENS and GSM for information on predictability. Medium range forecasts (week 1-3) that are produced for the hydro power sector are based on HRES and ENS products available internally at IMO as well as at ECMWF. 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, landslides and floods.

The ECMWF SST analysis and forecast are used by the forecasters. Charts of the analysed SST, 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.

2.2.2 Product requests

A few years ago the visualisation of the monthly forecast plumes was changed on the ECMWF websites. Although the new plume figures are easy on the eye, some information was lost in the process. In particular the old plume had accumulated precipitation, which is sorely missed by some of the meteorologists at IMO, showing how much precipitation could be expected in the next 30 days and the slope of the accumulation. Also, it would be informative to be able to see again what the different members are forecasting instead of only having the option of the median and quantiles.

3. Verification of products

3.1 Objective verification

Describe verification activities and show related scores.

3.1.1 Direct ECMWF model output (both HRES and ENS)

As previously reported HRES direct model output (DMO) 2-metre temperature forecasts exhibit systematic errors at large number of sites but there are indications that HRES is doing better at low winter temperatures than in previous years. Fig. 2 shows scatter plots of forecasts and observations in December 2015 and 2016.

The 10-metre wind speed is in general underestimated. However, when the stations are divided up by area (highland, inland, coastal) it can be seen that wind speed at coastal stations is better forecasted than at inland and highland stations (Fig. 3). This is most likely related to the surface roughness of the orography being too high which affects stations away from the coast but has less effect by the coast due to the wind frequently being off sea and thus less affected by the orographical properties.

3.1.2 ECMWF model output compared to other NWP models

Comparisons of the HRES output and HARMONIE-AROME, IGA and HIRLAM model outputs are made routinely at all verified locations for 2-metre temperature and 10-metre wind-speed. In general HARMONIE-AROME outperforms the other models, although systematic errors likely due to soil moisture and slow development of shallow convection are known errors.

Fig. 4 shows a comparison of the models for 2-metre temperature in August 2016 and January 2017 for different forecast length. In August 2016 HARMONIE-AROME, closely followed by HRES (ecm-is), outperformed the HIRLAM models. HRES has the smallest bias but in general there is not much difference in the bias of the models. In January 2017 the bias and RMSE are in general larger and HRES is outperformed by the other models. This performance is related to the fact that ECMWF initialised incorrectly with sea ice by the west coast of Iceland from November 2016 until 22 March 2017 that impacted sea surface temperature (SST) and thus surface temperature, see Section 3.2.2 for further information.

With regards to 10-metre wind speed in January 2017, all the limited area models outperform HRES results, with HRES, HIRLAM and IGA having negative bias but HARMONIE-AROME a smaller positive bias. As wintertime wind speed forecasts are vital in Iceland for warnings of high impact weather the performance of HARMONIE-AROME is appreciated by the forecasters, but they are aware of the positive bias. Skill scores for 10-metre wind speed for January 2017 (Fig. 5) show that with regards to the probability of detection (POD), false alarm ratio (FAR) and Kuiper skill score (KSS) the HRES performance is comparable to HIRLAM5 (DMI's HIRLAM run over Greenland, Iceland and the surrounding seas at 5 km horizontal resolution). The two HARMONIE-AROME setups, the IMO setup and the IGA setup, outperform ECMWF at all thresholds except the lowest. The HARMONIE-AROME setups however also have higher FAR, a result of a positive bias.

3.1.4 End products delivered to users

IMO is working with the national hydro power company Landsvirkjun on precipitation and water sheds products. These products are based on the HARMONIE-AROME operational model and reanalysis.

3.2 Subjective verification

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

NA

3.2.2 Case studies

Sea ice and SST

In November 2016 IMO became aware of the fact that 2-metre temperature forecasts by the west coast of Iceland were far too low, both HARMONIE-AROME and HRES. The reason for these erroneous forecasts turned out to be an incorrect sea ice cover by the west coast of Iceland in the HRES analysis, resulting from incorrect sea ice detection by the OSISAF product. This meant that while the SST around Iceland were high, 8-10°C, and to the north of Iceland more than 4°C above the 1981-2010 average, in fjords in west and north west Iceland the SST was below freezing. Consequently the 2-metre temperatures by the coast in these regions where forecasted far below realistic values. This was reported to the ECMWF which started looking into the problem. The hope was that the error would diminish with a new cycle (43r1) but that had almost no effect. While ECMWF worked on finding a permanent solution it became clear that IMO needed to find at least a short term solution for the operational simulation. Thus from 7 December 2016 the HARMONIE-AROME forecasts were initialised with sea ice and SST from the ocean model MyOcean. Fig. 6 shows a comparison of the ECMWF SSTs and MyOcean SSTs for the sea surrounding Iceland. Although the SST in the fjords are still lower than observed the values are closer to reality and the gradient to the open sea less. In March 2017 the UK Met Office updated the OSTIA SST data set with a new filtered product from OSISAF. ECMWF implemented this and the fictional sea ice cover disappeared from the ECMWF analysis on 22 March.

4. Feedback on ECMWF “forecast user” initiatives

- “Known IFS forecast issues” page – (https://software.ecmwf.int/wiki/display/FCST/Known+IFS+forecasting+issues)
  IMO is aware of this web site. It is especially useful to be able to see that ECMWF is aware of issues that come up, get an explanation for issues and if work is ongoing to solve them. IMO has used information from this site to inform when it was necessary to inform the general public of forecasting issues, e.g. the extremely low winter temperatures on peninsulas in 2015 due to the coarse resolution of the radiation scheme. IMO appreciates greatly the work ECMWF has put into informing the member states about known IFS forecasting issues.
- “Severe event catalogue” (https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue).
  IMO is aware of this web site but uses it little.

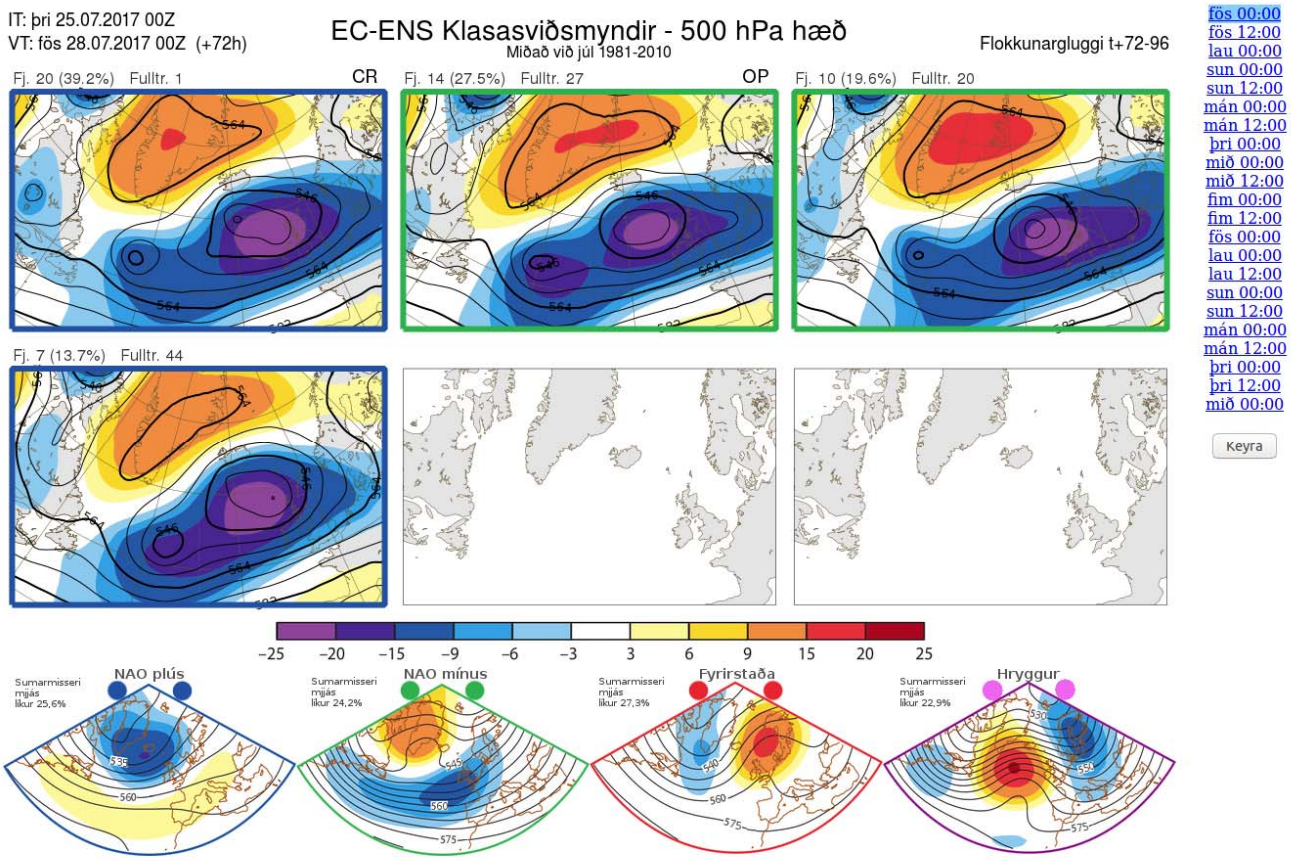

Fig.1 An example of the visualisation of the ECWMF clustering on IMO's internal forecasting chart website. It is easy to scroll through the lead times to get a good overview of the clustering scenarios.

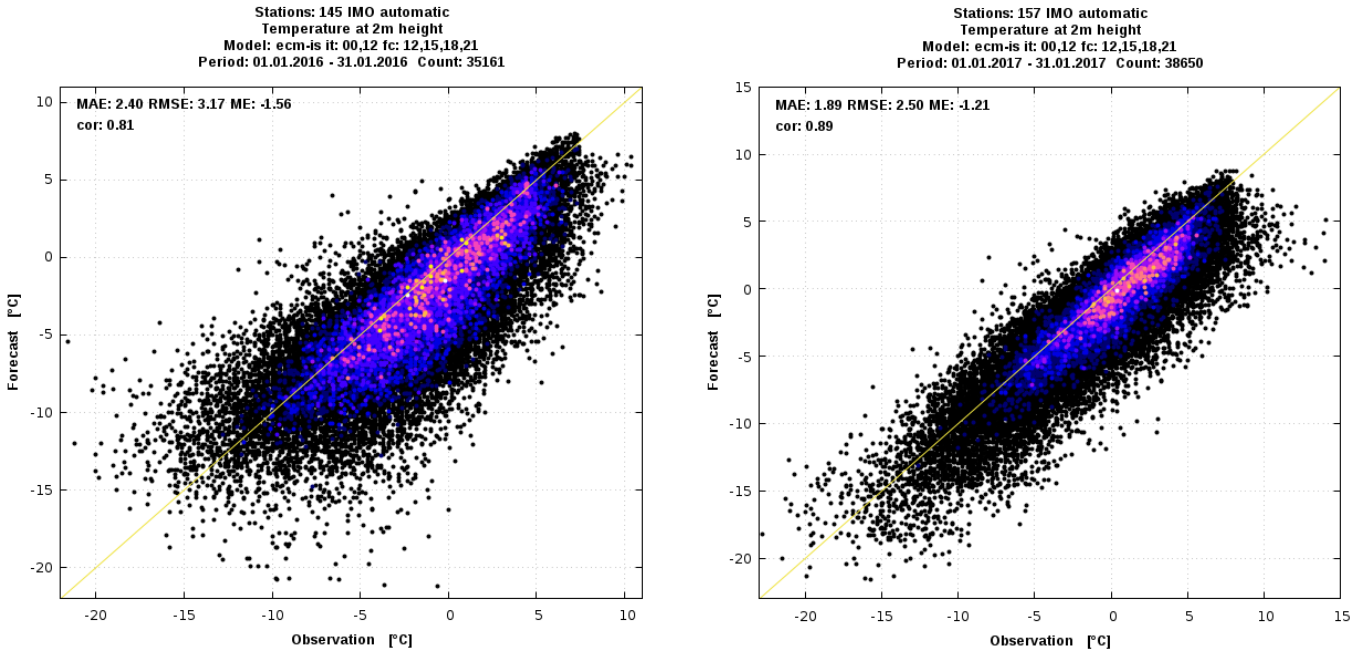

Fig. 2 Scatter plot of 2-metre temperature (°C) forecasts and observations for forecasts length 12, 15, 18 and 21 hours, initialized at 00 UTC and 12 UTC for January 2016 (left) and 2017 (right). ECMWF HRES.

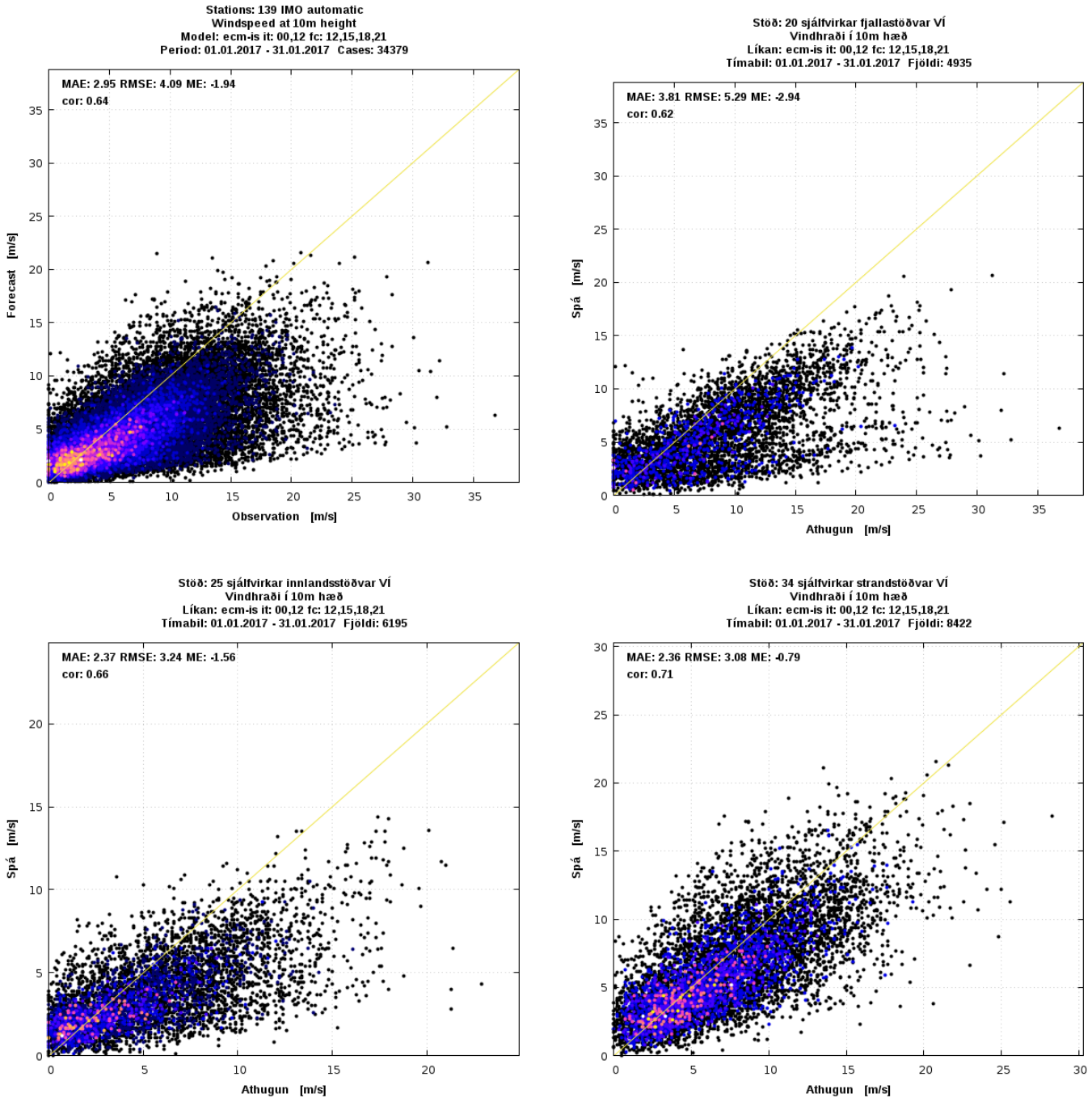

Fig. 3 Scatter plot of 10-metre wind speed (m/s) forecasts and observations for forecasts length 12, 15, 18 and 21 hours, initialized at 00 UTC and 12 UTC for all stations (top left), highland stations only (top right), inland stations only (bottom left) and coastal stations only (bottom right). January 2017 HRES.

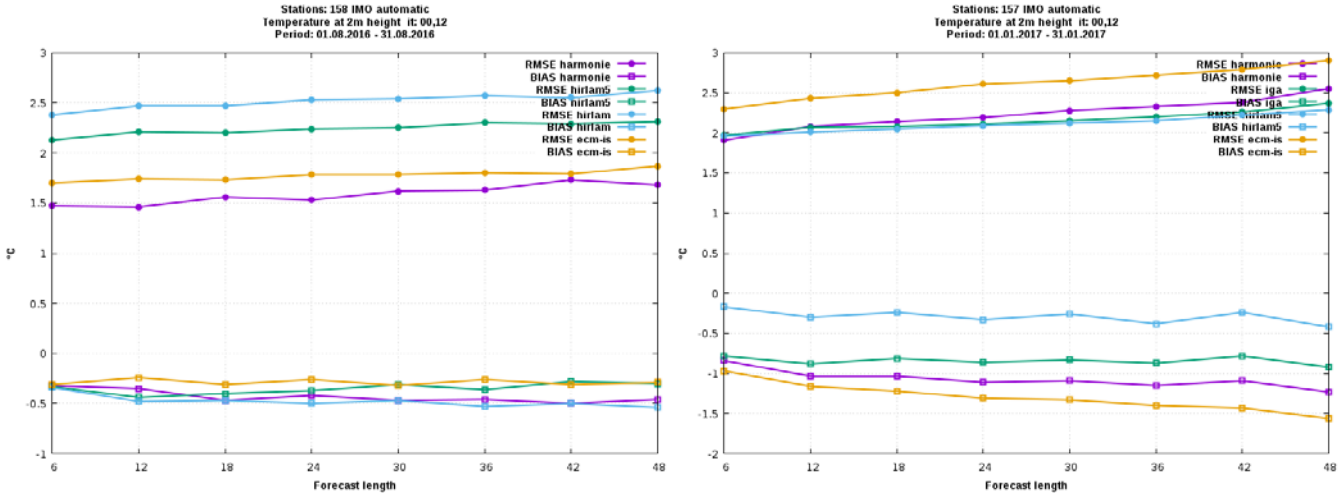

Fig. 4 RMSE and bias of 2-metre temperature forecasts, HRES (yellow), HIRLAM (blue: left panel), HIRLAM5 (green: left panel, blue: right panel), IGA (green: right panel) and HARMONIE-AROME (purple). Left: August 2016 and right: January 2017.

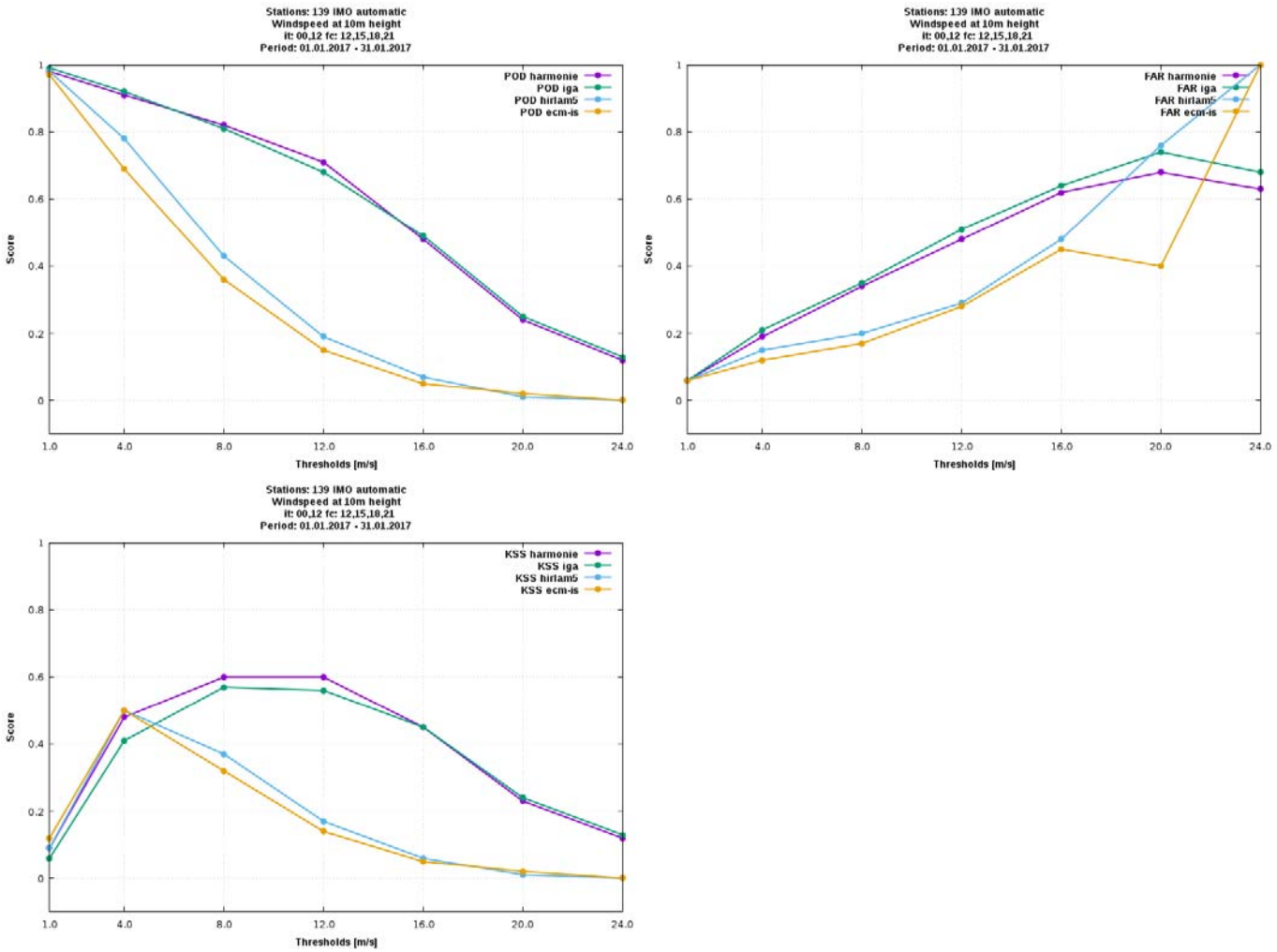

Fig. 5 Skill scores for 10-metre wind speed from HARMONIE-AROME (purple), IGA (green), HIRLAM5 (blue) and HRES (yellow) for January 2017. Top left: POD, top right: FAR and bottom: KSS.

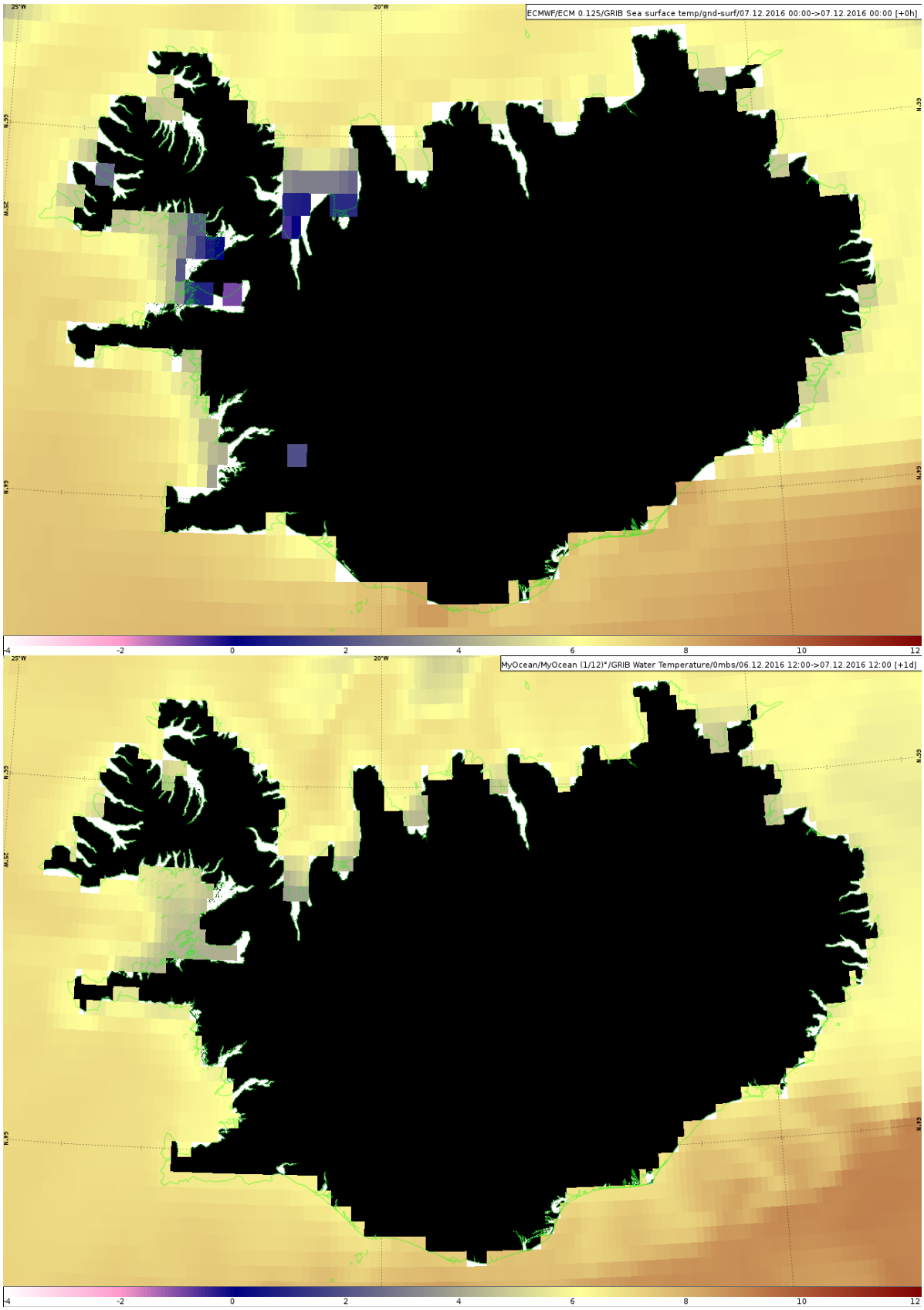

Fig. 6 Sea surface temperature (°C) around Iceland in ECMWF analysis on 7 December 2016 00 UTC (top) and MyOcean 24 hour forecast valid 7 December 2016 12 UTC. The sub-zero SSTs in the fjords in west and northwest Iceland in the ECMWF analysis are incorrect.