Application and verification of ECMWF products 2018

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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. The operational high resolution model of IMO is HARMONIE-AROME run at the Danish Meteorological Institute (DMI) for a join DMI-IMO domain covering Iceland and the southern part of Greenland, termed IGA. As a backup IMO runs the same model for a smaller domain. Both domains are initialised from HRES. Local weather forecasts are automatically generated for more than 140 locations in Iceland based on HARMONIE-AROME output for the first 66 hours and HRES output out to 168 hours. 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, based on ENS, have been made available on an internal website for a couple of years but ENS products on the ECMWF website are regularly consulted. ECMWF 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. HRES 10-metre wind speed forecasts have a negative bias which has been rather consistent for the last five 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.

2.1.2 Physical adaptation

The Danish Meteorological Institute (DMI) runs, in cooperation with IMO, HARMONIE-AROME for a large domain covering Iceland and South-Greenland, cycle 40h1.1, termed IGA (Iceland-Greenland A). IGA is run four times a day, forecasting range is 66 hours, using boundary data from HRES. The model has 2.5 km horizontal resolution and 65 vertical levels. In addition IMO runs HARMONIE-AROME operationally, also with boundary data from HRES, cycle 38h1.2 for a smaller domain, as a backup to the IGA run. A special run of the same model is used to monitor the conditions in water sheds important for hydro power. Furthermore, DMI has been running the model pre-operationally for a domain covering Iceland and the whole of Greenland, the IGB (Iceland-Greenland B) run. That run will become the operational run for Iceland and Greenland in the latter part of 2018.

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) is 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 produces charts of DMO 10-metre wind speed, 2-metre temperature and precipitation that are an intrinsic part of the official website (Fig. 1) as well as local weather forecasts for over 140 locations. HRES output is used for the forecasting range 75—168 hours. HRES output is also published in the IMO weather app. In addition 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 different models and different 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-metre wind speed and precipitation, for an area covering Iceland and the surrounding seas, are visualised on the internal website as well as the ECMWF clusters over the North Atlantic. Furthermore, meteograms for a few locations in Iceland and by the coast are produced.

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 concentrating on the area of interest.

IMO has developed end products of precipitation in water sheds for the national hydro-power company Landsvirkjun. These products are based on the HARMONIE-AROME runs and the Iceland reanalysis (ICRA). The model runs have the same setup as ICRA with HRES as boundary and are run four times a day. Fig. 2 shows an example of the end product.

2.2 ECMWF products

2.2.1 Use of Products

The ECMWF products are vital for operational weather forecasting in Iceland and HRES products are a part of the products ingested into the forecasters' workstations. EcCharts are sometimes used by the forecasters but for most purposes the internal chart website is favoured due to the slowness of the EcCharts and the good in-house chart library.

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 consulting 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. As most significant weather in Iceland is related to synoptic scale systems the cyclone tracks have been shown to be of helpful in assessing landfall of cyclones and thus the most affected areas. There is no experience in using the new precipitation type forecasting products.

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 consulted by forecasters.

In November 2017 IMO updated its natural hazard alert system from a threshold system to an impact-based system based on the Common Alerting Protocol (CAP). Weather alerts are published up to 5 days in advance of an expected event and are based on ENS products, in particular the shift of tails (SOT) and the extreme forecast index (EFI). Charts of both parameters are produced in-house for precipitation, 2-metre temperature and 10-metre wind gust.

2.2.2 Product requests

Icing on ships is a wintertime weather hazard on the North Atlantic, especially to the north of Iceland. An indicator of icing that took into account not only wind speed and wave activity but also the sea ice fraction would be helpful.

3. Verification of products

3.1 Objective verification

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. A comparison of scatter plots of observed and forecasted temperature and dew point, at 15—24 hours of forecasting, in August 2017 and January 2018 show that the bias was larger during the winter month than the summer month, the difference about 1°C for both parameters, see Fig. 3.

The 10-metre wind speed is in general underestimated, most likely due to ECMWF handling of the orography as well as an general overestimation of the surface roughness. In high wind speed events the forecasters often rely more on the forecasted 100-m wind speed than the 10-metre. Fig. 4 shows scatter plots of the forecasted wind speed at 10-metre and 100-metre, at 15—21 hours of forecasting, in December 2017 compared to observations at 10 metre. It is obvious that while stormy conditions were frequently measured the 10-metre forecast never exceeded 20 m/s. In fact, verification against observations has a larger mean error and lower correlation at 10-metre than at 100 metre. Fig. 5 shows monthly values of RMSE and bias for 10-metre wind forecasts, 48 and 120 hours, for the time period 2013—2017. The bias is similar but as expected the RMSE increases with forecast lengths. It is difficult to see any improvements during this time period, perhaps a slight improvement in bias and RMSE during winter.

3.1.2 ECMWF model output compared to other NWP models

In general HARMONIE-AROME outperforms HRES. Fig. 6 shows monthly values of RMSE and bias for 10-metre wind forecasts, 48 hours, for the time period 2013—2017 for HRES and HARMONIE-AROME. While it is difficult to see much improvement in the monthly values for HRES there are clear improvements for HARMONIE-AROME due to model improvements. In September 2013 the drag parametrization of sub-grid scale orography (SSO) was changed from the default of the model setup to a tuned value based on native conditions. The next major change was in September 2015 when the SSO was turned off as new state-of-the-art physiography was implemented with e.g. improved leaf area index (LAI) that improved the description of surface roughness. While HRES has a negative bias of up to -2.5 m/s HARMONIE-AROME has now a positive bias of up to 1 m/s.

Currently, IMO does not do much evaluation on humidity and visibility. However, an evaluation of visibility for a short period in June—July 2018 shows that HRES overpredicts low visibility more than HARMONIE-AROME (Fig. 7). Note though that this is a very short time period and verification at just a few stations.

3.1.3 Post-processed products

NA

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

NA

4. Feedback on ECMWF "forecast user" initiatives

We invite comments on how useful you find the information provided on ECMWF's "Forecast User Portal", see: (https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home), and on any changes you would like to see. A new web-based "Forecast User Guide" will be added soon (due May 2018) and we would particularly welcome initial comments on that.

Most of the forecasters have been introduced to the Forecast User Portal, mainly through the ECMWF training. However, the use of it is quite limited. The Known IFS forecasting issues page is greatly appreciated.

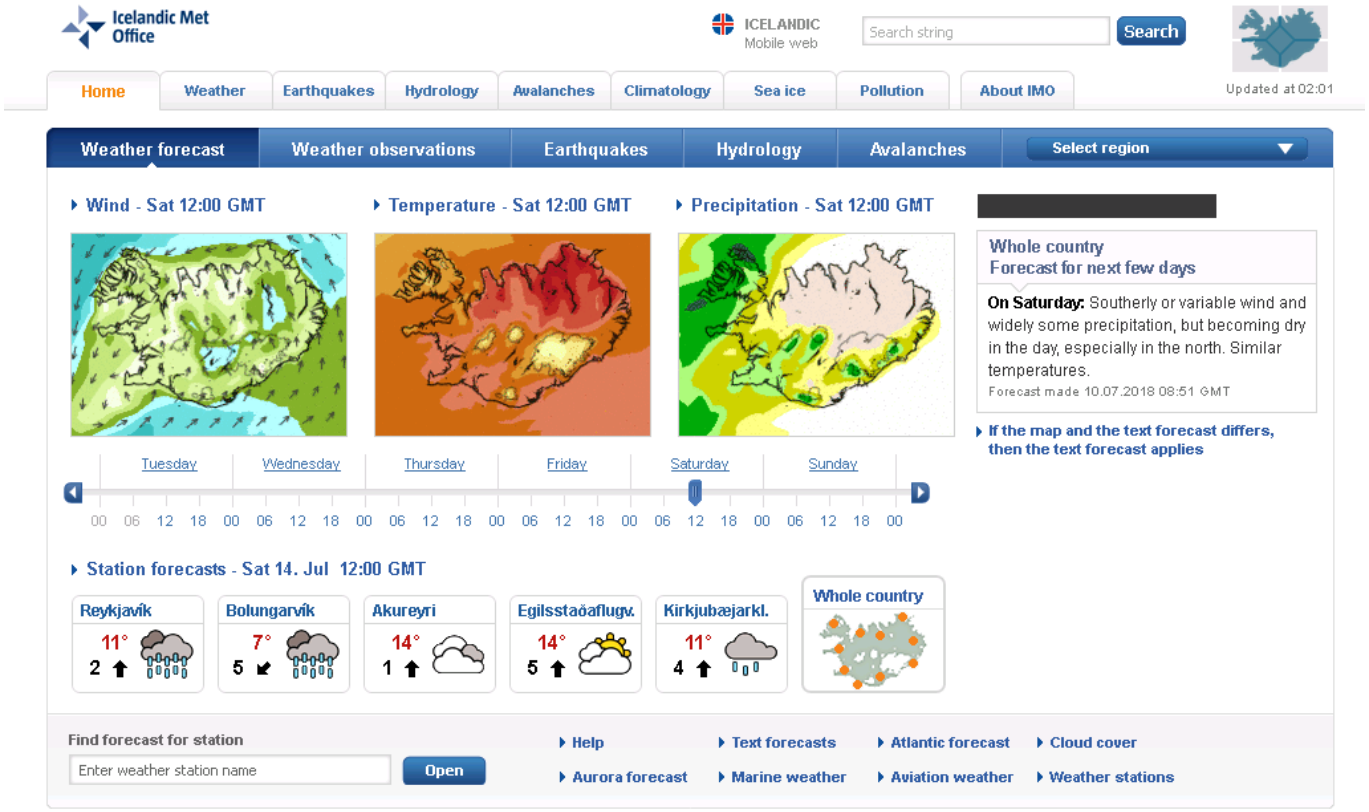

Fig. 1 The English front page of the IMO official website. Charts of wind speed, temperature and precipitation are based on HRES output for forecasting range 75—168 hours.

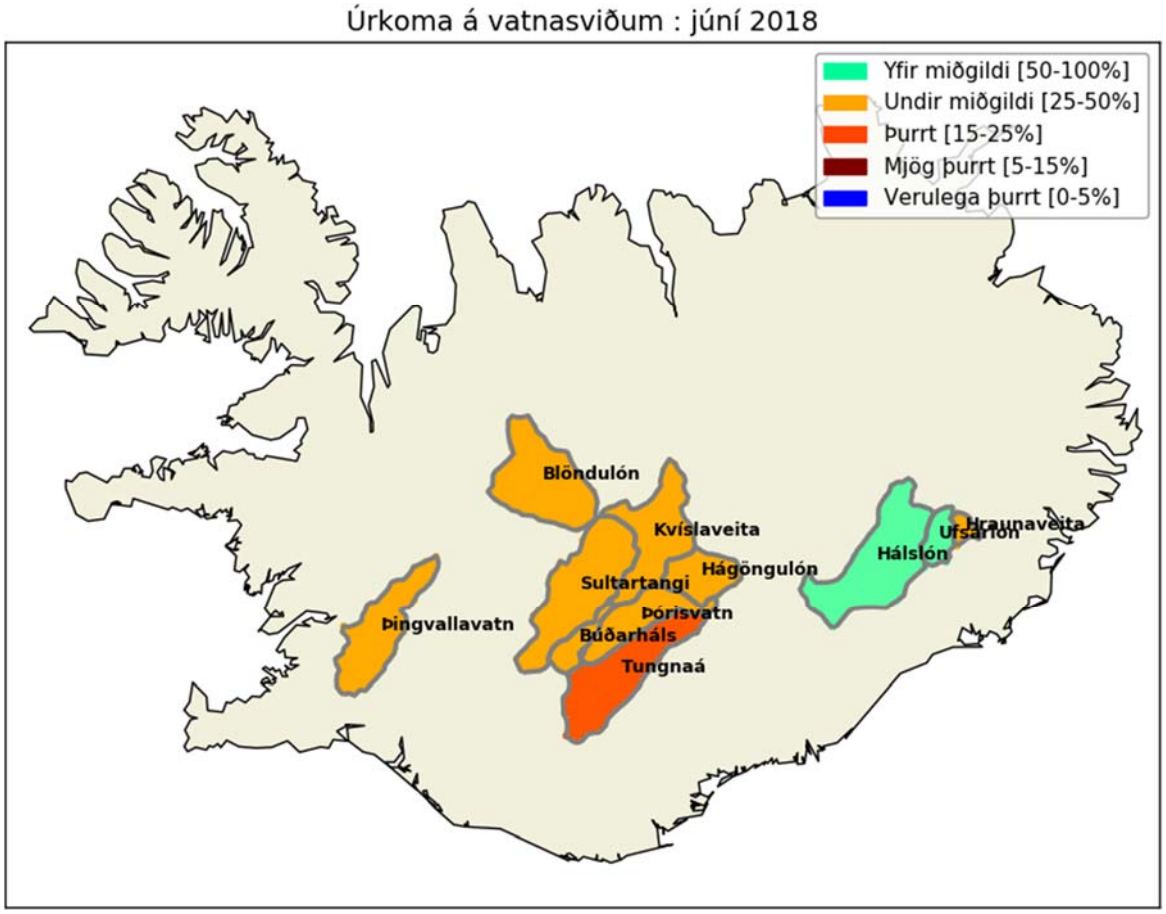

Fig. 2 Simulated precipitation in different water sheds in June 2018. The colour, top to bottom, represent over the mean value, below the mean value, dry, very dry and extremely dry. The figure is based on a comparison of short daily runs of HARMONIE-AROME and the Icelandic reanalysis (ICRA).

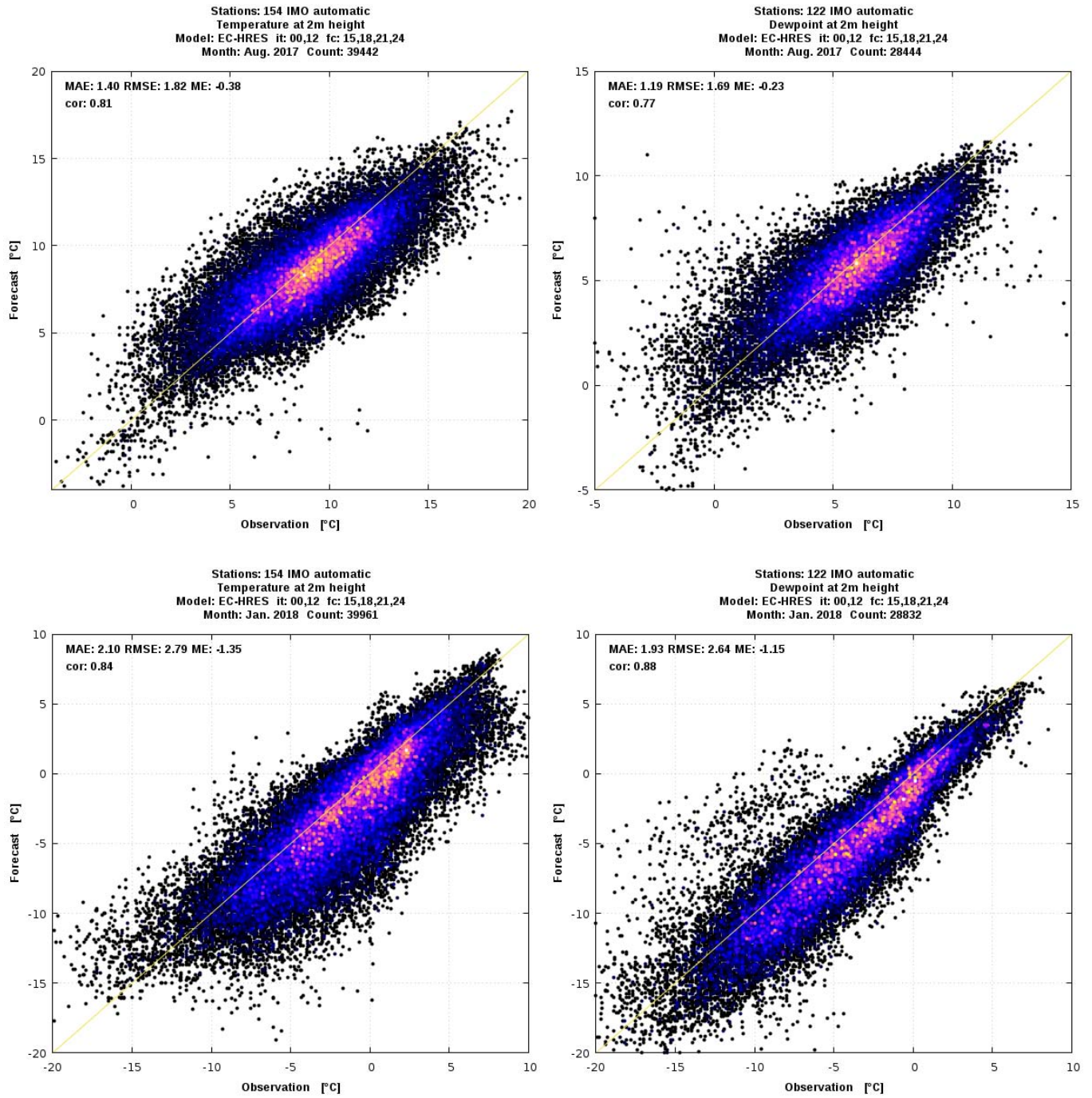

Fig. 3 Scatter plots of 2-metre temperature (°C, left) and dew point (°C, right) forecasts and observations for August 2017 (top) and January 2018 (bottom). ECMWF HRES forecast length 15, 18, 21 and 24 hours, initialized at 00 UTC and 12 UTC.

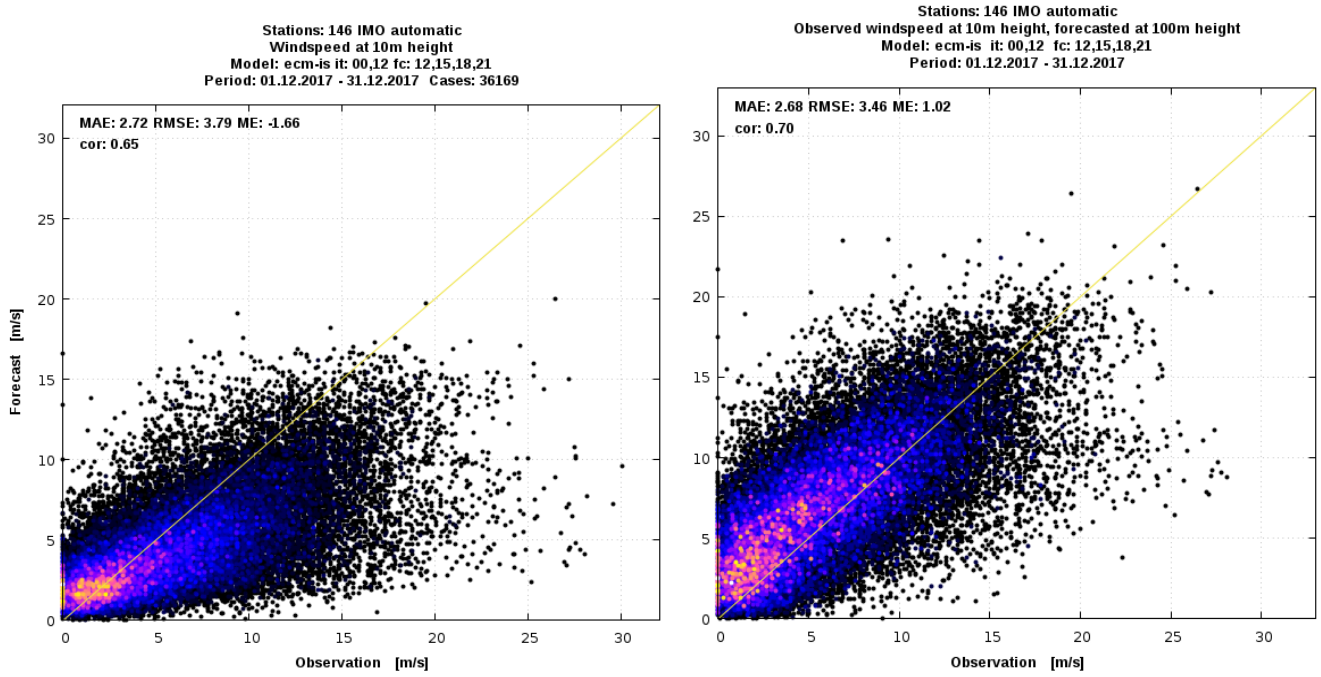

Fig. 4 Scatter plots of 10-metre wind speed (m/s, left) and 100-metre wind speed (m/s, right) forecasts and observed wind speed at 10 metre for December 2017. ECMWF HRES forecast length 12,15, 18, and 21, initialized at 00 UTC and 12 UTC.

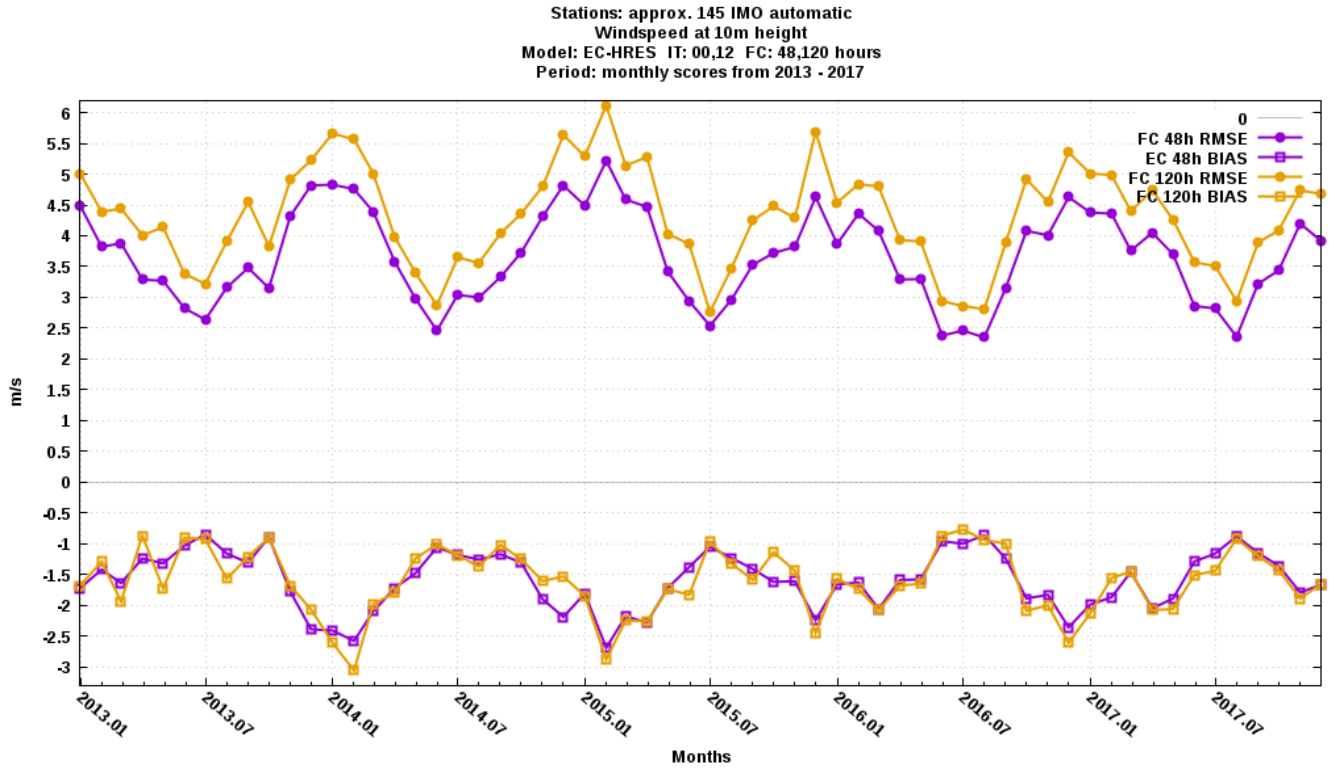

Fig. 5 Monthly values of RMSE and bias for forecasted 10-metre wind speed (m/s) for the time period 2013—2017. Forecast length of 48 hours (purple) and 120 hours (yellow), initialized at 00 UTC and 12 UTC.

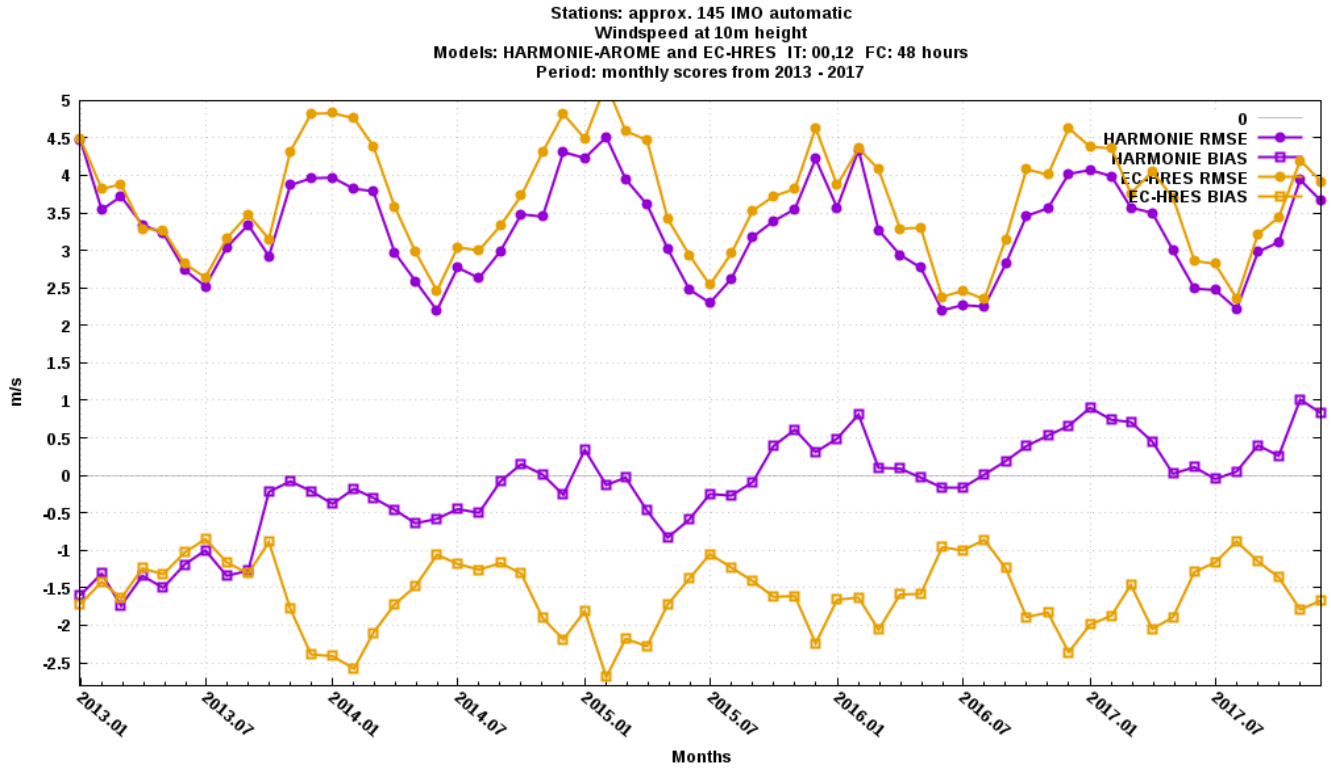

Fig. 6 Monthly values of RMSE and bias for forecasted 10-metre wind speed (m/s) for the time period 2013—2017. HARMONIE-AROME (purple) and HRES (yellow), forecast length of 48 hours, initialized at 00 UTC and 12 UTC.

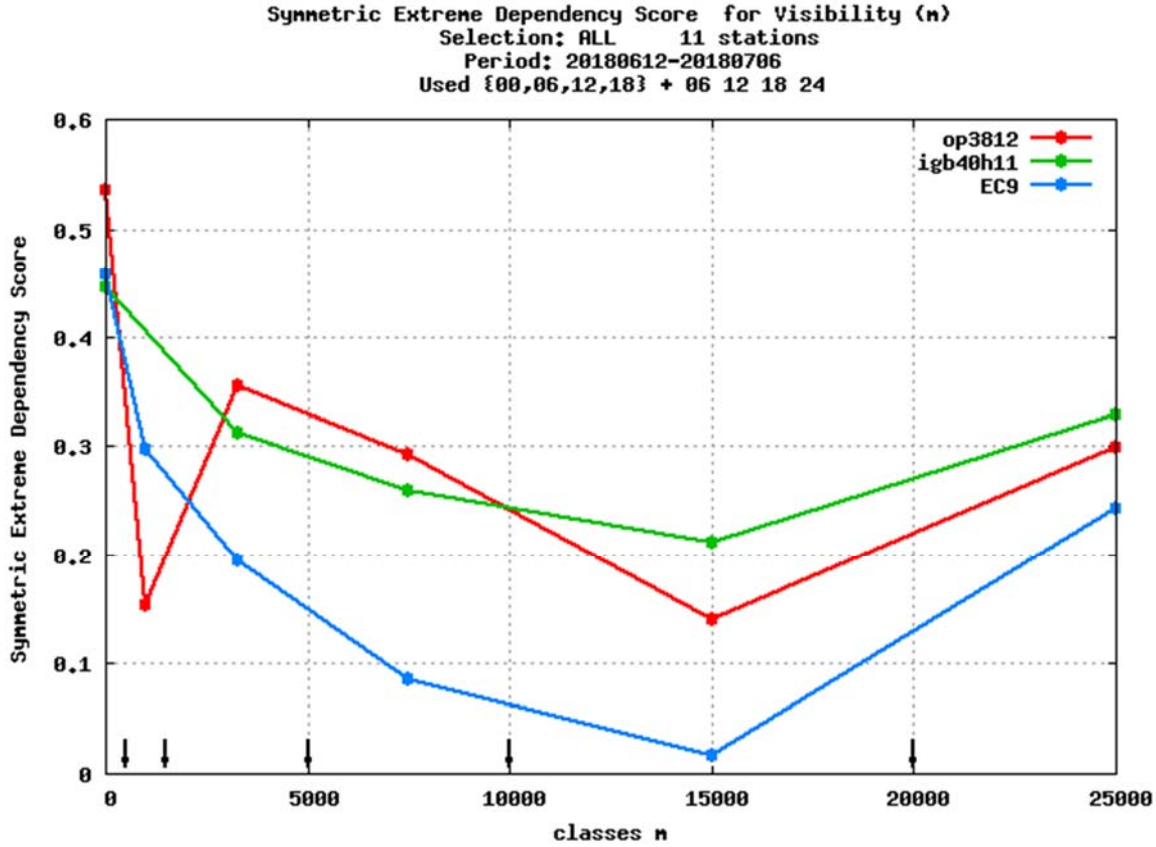

Fig. 7 The symmetric extreme dependency score (SEDS) of visibility for June and July 2018, forecast lengths 06, 12, 18 and 24 hours, for two versions of HARMONIE-AROME (op3812 and igb40h11, red and green respectively) and HRES (EC9, blue). Note that the verification is only for 11 stations and for a very short time interval.