Application and Verification of ECMWF Products 2021

Swedish Meteorological and Hydrological Institute (SMHI)

Karl-Ivar Ivarsson

1. Summary of major highlights

The ECMWF forecasts are of high value both for direct use and as input for other applications such as limited-area models and ocenographical models.

2. Use and application of products

2.1 Direct Use of ECMWF Products

Forecasts up to 10 days are regularly used by duty forecasters and for web- and mobile phone applications. Forecasts of precipitations and 10-metre wind, including gusts are of special interest for for severe weather situations. Probabilities derived from ENS are used for early warnings. “Open Charts” products has been used for testing. They give a good overview of the wide range of products available.

2.2 Other uses of ECMWF output

2.2.1 Post-processing

A Kalman filter is used for adjusting 2m- temperature and 10m-wind. The ensemble mean for different parameters (computed locally at the institute) is used for products such forecast chart etc.

2.2.2 Derived fields

A smoothing technique is used for all meteorological model outputs of cloud cover and precipitation, including ECMWF deterministic forecasts. The grid-point information from an area of 20 km radius is used to provide a mean value, a median value, a 90% percentile value and a 10% percentile value. Those values are calculated for all grid-points in an area covering north west Europe, basically that same area as the limited area model AROME, with 2.5 km resolution, but with a slightly different grid. Instead of a Lambert projection, a rotated lat-lon grid of 0.025 degrees (2.75 km) is used. The smoothing technique is not applied for ensemble mean values.

2.2.3 Modelling

ECMWF provides model data for lateral conditions and other input data such as 'large scale mixing', (LSM) and blending for the locally produced limited area model AROME. Thus, the larger scale structures of the analysis and short forecasts are used as input for the first guess field, but the finer ones are retrieved from the first guess of the high resolution limited area models.

ECMWF is also used for longer (up to ten days) oceanographical forecasts. (the NEMO model) Here, ECMWF meteorological input is used as upper boundary conditions.

IFS-ENS is used as lateral boundaries and for initial conditions for the MeCoOp-ENS (MEPS) system, which is an ensemble system based on five members with AROME physics at 2.5 km resolution. Since forecasts are produced every hour, it gives 15 members if the three latest forecasts are used as an ensemble. MEPS is a result of a collaboration between Sweden, Norway, Finland and Estonia.

3. Verification of ECMWF products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS), and other NWP models

Table 1:

Verification results for different models and seasons: AROME is the control run in the MEPS ensemble system. '10M wind' is 10 metre wind speed, 't2m' is 2 metre temperature and 'td2m' is 2 metre dew point temperature. The area for verification is north-western Europe and the forecast length ranges from 3 hours up to 66 hours.

Summer (June – August 2020)

parameter	Systematic error or bias		Mean absolute error	
model	ECMWF	AROME	ECMWF	AROME
10m wind	0.26	0.09	1.32	1.22
t2m	-0.14	0.04	1.35	1.30
td2m	-0.09	-0.22	1.27	1.34

Autumn (September – November 2020)

parameter	Systematic error or bias		Mean absolute error	
model	ECMWF	AROME	ECMWF	AROME
10m wind	0.43	0.21	1.50	1.32
t2m	-0.04	-0.08	1.17	1.04
td2m	-0.09	-0.26	1.06	1.08

winter (December 2020– February 2021)

parameter	Systematic error or bias		Mean absolute error	
model	ECMWF	AROME	ECMWF	AROME
10m wind	0.35	0.11	1.56	1.38
t2m	-0.17	-0.16	1.60	1.51
td2m	-0.28	-0.51	1.60	1.61

spring(March – May 2021)

parameter	Systematic error or bias		Mean absolute error	
model	ECMWF	AROME	ECMWF	AROME
10m wind	0.18	0.11	1.43	1.29
t2m	-0.63	-0.60	1.44	1.33
td2m	0.01	0.23	1.38	1.47

AROME has generally a lower absolute error for the near surface variables, mainly due to higher horizontal resolution, except for dew point. Here, ECMWF has the lowest error.

Both models are somewhat too cold during spring. In winter, ECMWF does not capture the lowest t2m below -35 C very well. Also AROME has a this problem, but it is less apparent. (Not shown) The frequency bias (FB) for latest winter (December to February) for t2m below -30 FB was 0.2 for ECMWF and 0.4 for AROME, but ECMWF was better for high winter temperatures, FB for 15 -20 degrees was 0.7 for ECMWF but 0.5 for AROME. In summer, ECMWF under-predicts high temperatures. For example, in June-August last year the FB was 0.6 for t2m above 30C. AROME had the opposite systematic error, a FB of around 1.3.

AROME is too dry (negative 2 metre dew point bias) in winter, but the opposite is seen in early spring. As for previous years, ECMWF forecasts of 2 metre dew point have small systematic errors for all seasons, and thus a valuable guidance for 2m forecast variables regarding moisture. (This means also the 2m relative humidity etc.) This is of great value for grass-fire forecasts in early spring.

Wind gusts are over predicted, with a typical bias of 1.5 m/s. (AROME 0.5 to 0.7 m/s) Despite this, ECMWF forecasts are valuable for the highest wind speeds, where the FB is of the order one or somewhat more and the different skill-scores shows similar values as AROME. Otherwise, the skill is higher for AROME.

The ECMWF forecasts of low clouds are generally somewhat better than those from AROME, but ECMWF tends to decrease the amount of low clouds too much in the evening. (During April to August). Fore example, the mean amount of observed low clouds during spring this year at 18 UTC was 3.1 octas, but 2.3 only for ECMWF. (AROME 3.2 octas) Low- and middle level clouds are over forecast during daytime in spring in case of light non precipitating convection, but the opposite is seen in the middle of the summer in case of deep convection.

The precipitation forecasts from ECMWF have a high quality, but two weak point are that the summertime convective precipitation over land areas starts too early and that the diurnal cycle is over-amplified. This has also been the case during previous years.

24 hour precipitation is regularly verified against a dense network of climate stations, mainly over Sweden and some parts of northern Norway. Only the short time forecasts (the 24 hour period starting at six- and ending at 30 hour forecast length) are verified. Fractions skill score (FBSS) is used with 'sample climate' as reference forecast. The period for verification is May 2020 to April 2021. The result is seen in in figure 1.

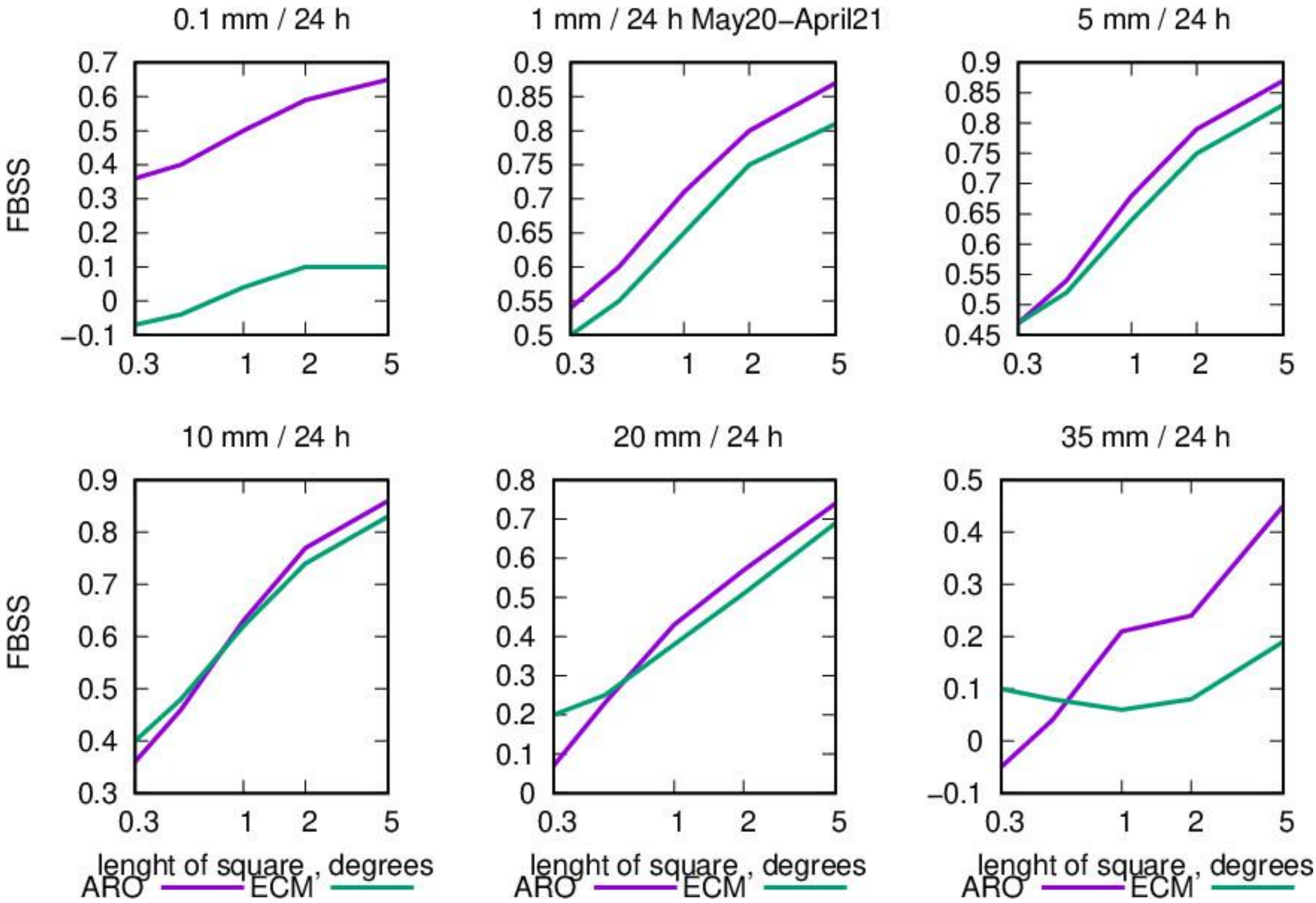
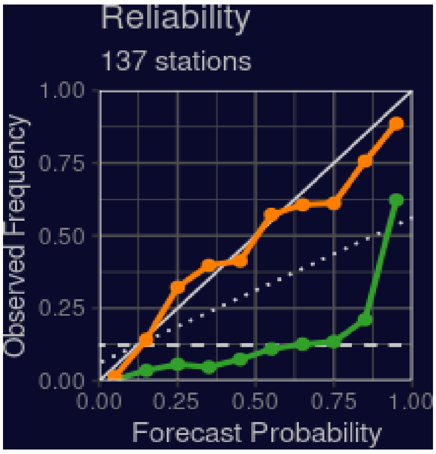


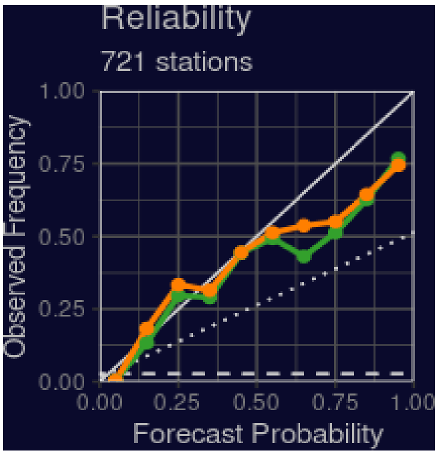
Figure 1: FBSS for different thresholds of precipitation. FBSS at the vertical axis and the size of different squares in degrees latitude. There should be at least three observations in a square for being used in the verification. One degree is about 111 km. ECM (green) is ECMWF forecasts and ARO (purple) is AROME.

AROME has the highest FBSS for all scales and thresholds up to 5mm/24h, For higher thresholds ECMWF is the best for the finest structures detectable by the rain gauge network, about 30 km. For the coarser structures, (larger squares), AROME is the best. The low skill for ECMWF for 0.1mm threshold may partly be caused by that interpolated ECMWF fields are used. The low skill for AROME for 30km squares may partly be caused by too spotty precipitation field.

MEPS probabilistic forecasts are verified regularly and compared with IFS-ENS, but currently most of the results are for single months only. The verification shows that 10 m wind is normally better with MEPS than with IFS-ENS. For other variables this is the often case for the shorter lead times only, up to 12-36 hours.

Some results are shown below. IFS-ENS often over-predicts the probability for low precipitation amounts, but is more reliable for higher ones. The risk of strong winds is often under-predicted.





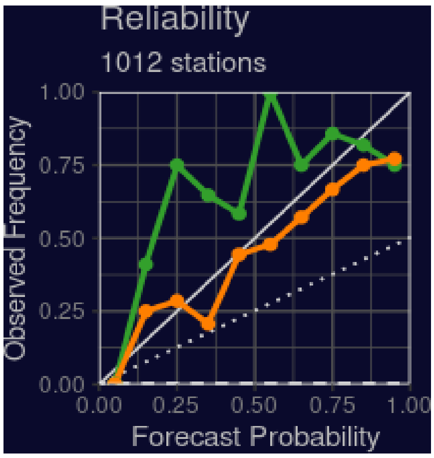
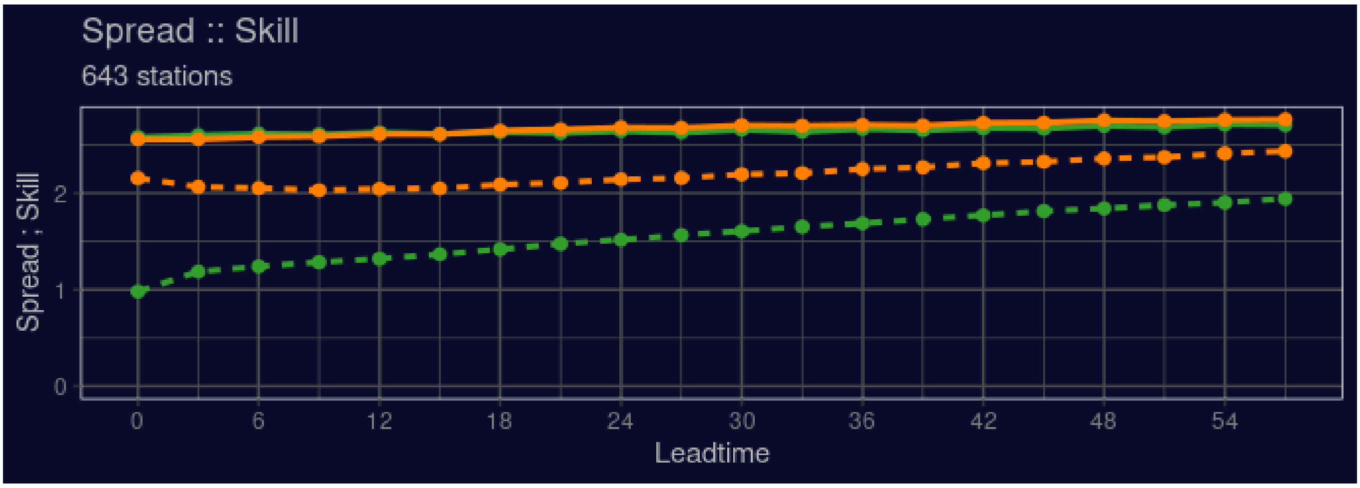


Figure 2: Reliability diagrams. Left: 12h precipitation more than 0.1 mm in April 2021. Middle: 12h precipitation more than 7mm in January 2021. Right: 10-m wind speed exceeding 15 m/s in May 2021.
Orange lines refers to MEPS and green ones to IFS-ENS.



Orange lines refers to MEPS and green ones to IFS-ENS.

Figure 3: Spread-Skill diagram: Spread in dash-dotted lines and RMSE in solid lines.

Period: March- May 2021. Forecast parameter: Low clouds.

Orange lines refers to MEPS and green ones to IFS-ENS

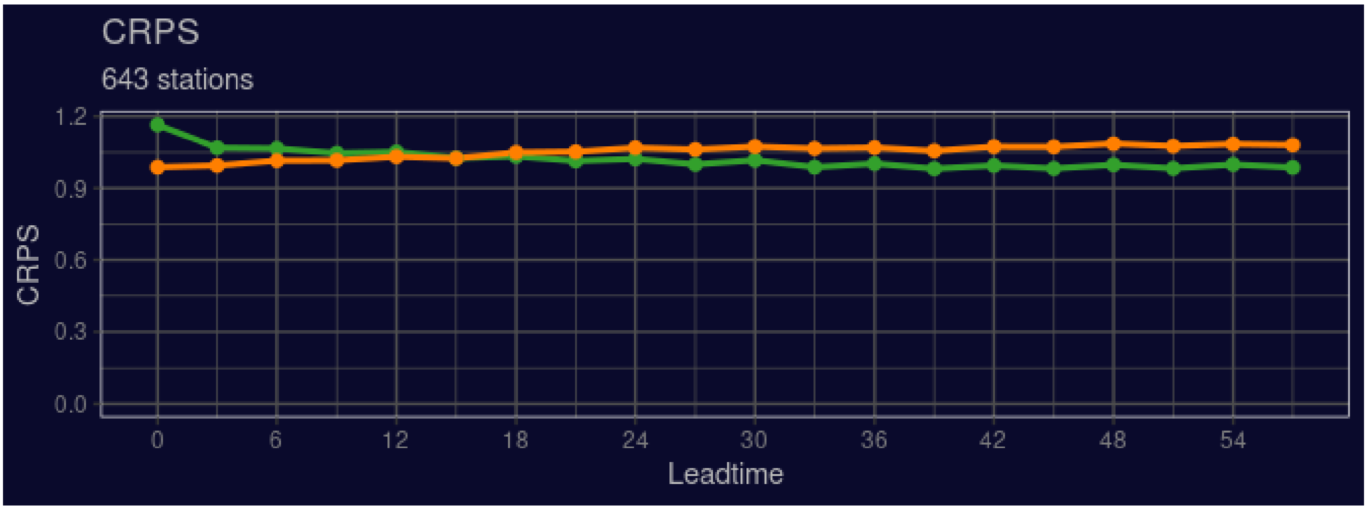


Figure 4: Continues Rank probability Score, CRPS:

Period: March- May 2021. Forecast parameter: Low clouds.

Orange lines refers to MEPS and green ones to IFS-ENS

The examples above show the verification result for the spring of low clouds. MEPS has better spread (=closer to the RMSE) than IFS-ENS, but the RMSE is a little worse, except in the beginning. The CRPS is better (lower) up the 12 hours lead time. Fore longer forecast lengths IFS-ENS is better.

3.1.3 Monthly and Seasonal forecasts

3.2 Subjective verification

3.2.1 Subjective scores

No subjective scores are available, but here follows some comments from duty forecasters:

The forecasts of the 00 UTC or the 12 UTC runs (24 hours difference in the time of issue) are often more similar to each other than when this difference is 12 hour only. It seems that the starting time of the day matters here.

ECMWF has difficulties in forecasting extreme temperatures, both high and low ones. Ensemble probabilistic forecasts do not help very much, since those difficulties are present among the members too. But the products in which the forecasts are compared with model climate is a good help here, since it gives a possibility to adapt to local biases, which is one reason for missing extreme events.

Convective clouds are sometimes over predicted. In those cases there may be overcast in the forecast, whereas the observed amount of cloud is typically only around 3/8. (This is also supported by objective scores)

4. Requests for additional output

Low-,middle- and high clouds closer to WHO definitions: 0-2000m, 2000-5000,m and >5000m above ground respectively, since this is closer both to observations and to locally produced forecasts. The automatic stations in Finland and Sweden only detects clouds up to approximately 7.5km. An additional forecast cloud cover that corresponds to those stations would be welcome.