Application and verification of ECMWF products 2017

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1. Summary of major highlights

The ECMWF forecasts play an important role for SMHI, both for direct use and as provider of lateral boundary conditions for limited area (atmospheric) models and as upper boundary conditions for oceanographical models. The forecast quality is regarded as high or slightly higher than previous years. Especially the forecasts of low clouds are regarded as the best compared to other models.

2. Use and application of products

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

A Kalman filter is used for adjusting 2m- temperature and 10m-wind. The ensemble mean is, or has been used for products such forecast chart etc. The ensemble mean of cloud cover is found to be too smoothed, (too seldom near zero or eight octas) and thus being replaced by the median value of the ensembles. For similar reasons, the precipitation ensemble mean will perhaps be replaced by the median.

2.1.2 Physical adaptation

As for previous years, visibility is calculated by using an algorithm based on relative humidity, precipitation and latitude.

ECMWF provides model data for lateral conditions and other input data such as 'large scale mixing', (LSM). With LSM, the larger scale structures of the analysis or short forecast are used as input for the first guess field, but the finer ones are retrieved from the high resolution limited area models first guess. This technique is used for HIRLAM with 11 km resolution (this model is not in regular use any) and for AROME with 2.5 km resolution.

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.

In the beginning of November 2016, an ensemble system called MEPS became operational. It uses the difference between older and newer lateral boundaries from ECMWF to create perturbations (often refereed to as SLAF, Scaled Lagged Average Forecasting). The ensemble system has ten AROME members (AROME is a model set up within the HARMONIE system. The HARMONIE system is coupled to IFS.) All forecasts have the same forecast domain and horizontal resolution, 2.5 km and covers north-western Europe. In early September this year, the forecast domain was a little enlarged as Finland became a member in the MetCoOp cooperation, thus now consisting on Sweden,Finland and Norway. All three countries use the MEPS forecasts.

2.1.3 Derived fields

A smoothing technique is still used for all meteorological model outputs of cloud cover and precipitation, including ECMWF. 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 determined for all grid-points in an area covering north west Europe, basically that same area as AROME but with a slightly different grid. It is a rotated lat-lon grid of 0.025 degrees (2.75 km) Although this technique is also used for the ECMWF ensemble mean/median, the effect on the ECMWF ensemble parameters are very small since they are already smooth horizontally.

2.2 ECMWF products

2.2.1 Use of Products

2.2.2 Product requests

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS)

3.1.2 ECMWF model output compared to other NWP models

The general performance of the models mostly used by the institute is illustrated by the verification result for some near surface parameters, table 1:

Table 1:

Verification results for different models and seasons: 'HI 11 km' is HIRLAM with 11 km grid, 'HI 5.5 km' is HIRLAM with 5.5 km grid. 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 48 hours. Note that HIRLAM was switched off this spring.

Autumn: (September – November 2016)

parameter	Systematic error or bias				Mean absolute error			
model	HI 11 km	HI 5.5 km	ECMWF	AROME	HI 11 km	HI 5.5 km	ECMWF	AROME
10m wind	0.42	0.04	0.26	0.33	1.55	1.42	1.53	1.37
t2m	-0.13	-0.09	-0.21	-0.17	1.33	1.32	1.34	1.18
td2m	-0.35	-0.53	-0.36	-0.19	1.37	1.35	1.18	1.17

Winter: (December 2016 - February 2017)

parameter	Systematic error or bias				Mean absolute error			
model	HI 11 km	HI 5.5 km	ECMWF	AROME	HI 11 km	HI 5.5 km	ECMWF	AROME
10m wind	0.59	0.15	0.16	0.54	1.80	1.62	1.69	1.65
t2m	0.24	0.01	-0.33	-0.25	1.61	1.59	1.58	1.49
td2m	0.28	-0.60	-0.59	0.01	1.64	1.70	1.60	1.48

Spring: (March -May 2017)

parameter	Systematic error or bias				Mean absolute error			
model	HI 11 km	HI 5.5 km	ECMWF	AROME	HI 11 km	HI 5.5 km	ECMWF	AROME
10m wind	-	-	-0.04	0.16	-	-	1.46	1.40
t2m	-	-	-0.74	-0.64	-	-	1.52	1.39
td2m	-	-	-0.55	0.69	-	-	1.41	1.66

Summer (June – August 20 2017)

parameter	Systematic error or bias				Mean absolute error			
model	HI 11 km	HI 5.5 km	ECMWF	AROME	HI 11 km	HI 5.5 km	ECMWF	AROME
10m wind	-	-	0.19	0.00	-	-	1.36	1.24
t2m	-	-	-0.41	-0.26	-	-	1.31	1.22
td2m	-	-	-0.30	-0.14	-	-	1.18	1.26

ECMWF is a little too cold, especially in spring. Also AROME is a little too cold. An increased horizontal resolution is normally an advantage when traditional grid-point verification is used. Despite this, ECMWF performs best for 2m- dew-point temperate in spring and and in summer. One reason is that ECMWF has the most realistic diurnal cycle of 2m dew-point temperature in summer (Figure 1), with two peaks, one in the morning and one in the evening.

However, the summertime diurnal cycle of temperature and 10-meter wind are both too small, too cold during the day and too windy during the night. (not shown). The diurnal cycle of low clouds is too strong and the maximum comes a little too early (around 09 UTC in the ECMWF forecasts, but around 12 UTC in the observations. Not shown). Also the 3-hour precipitation daily cycle is too strong and the peak is too early (figure 2). AROME is very close to observations here, but one may keep in mind that observations (rain gauges) often underestimate precipitation somewhat.

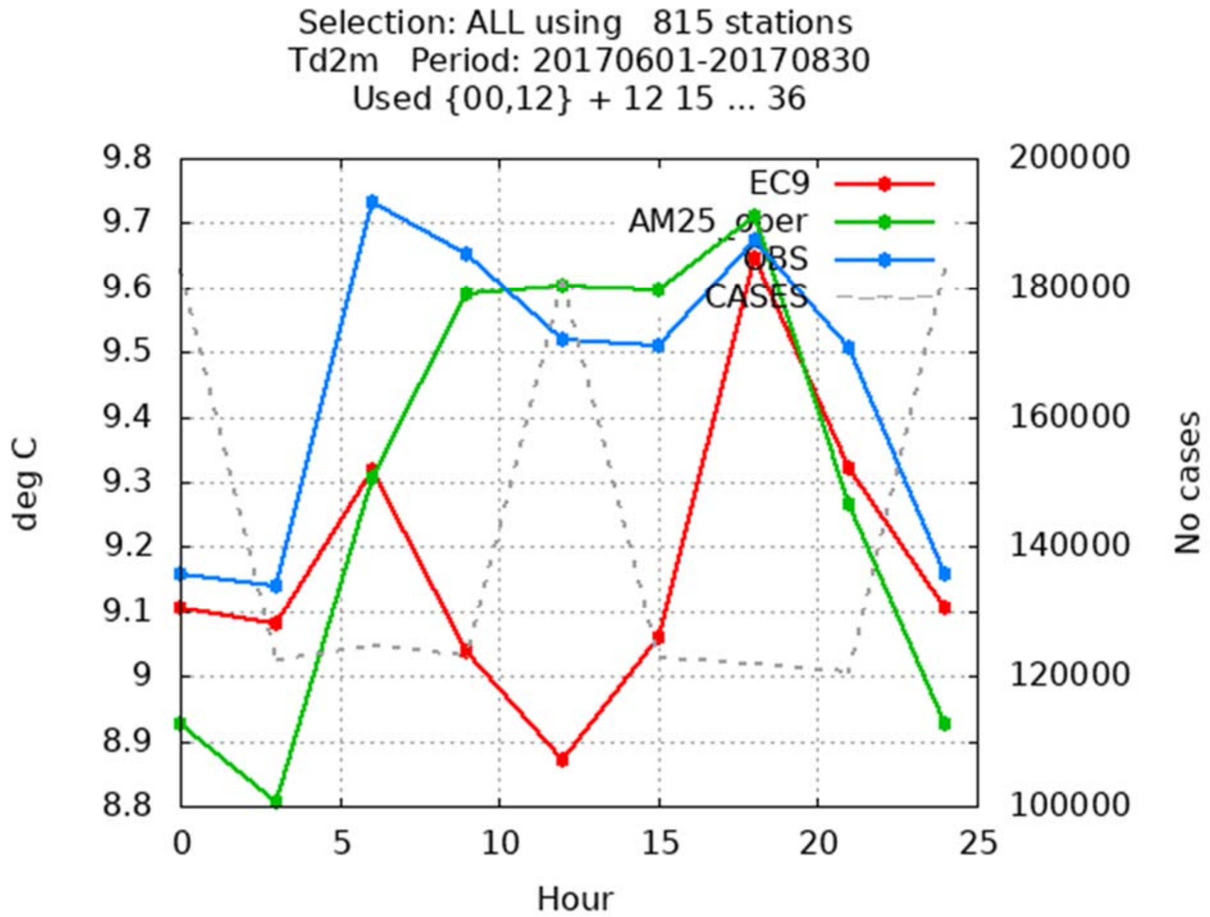

Figure 1: Diurnal cycle of dew-point temperature. Hours of the day on horizontal axis, temperature on vertical axis. Red: ECMWF, green: AROME and blue observations. Area: North-western Europe. Time period : June-August 2017. Forecast lengths: 12, 15, 18, 21, 24, 27, 30, 33 and 36 hours.

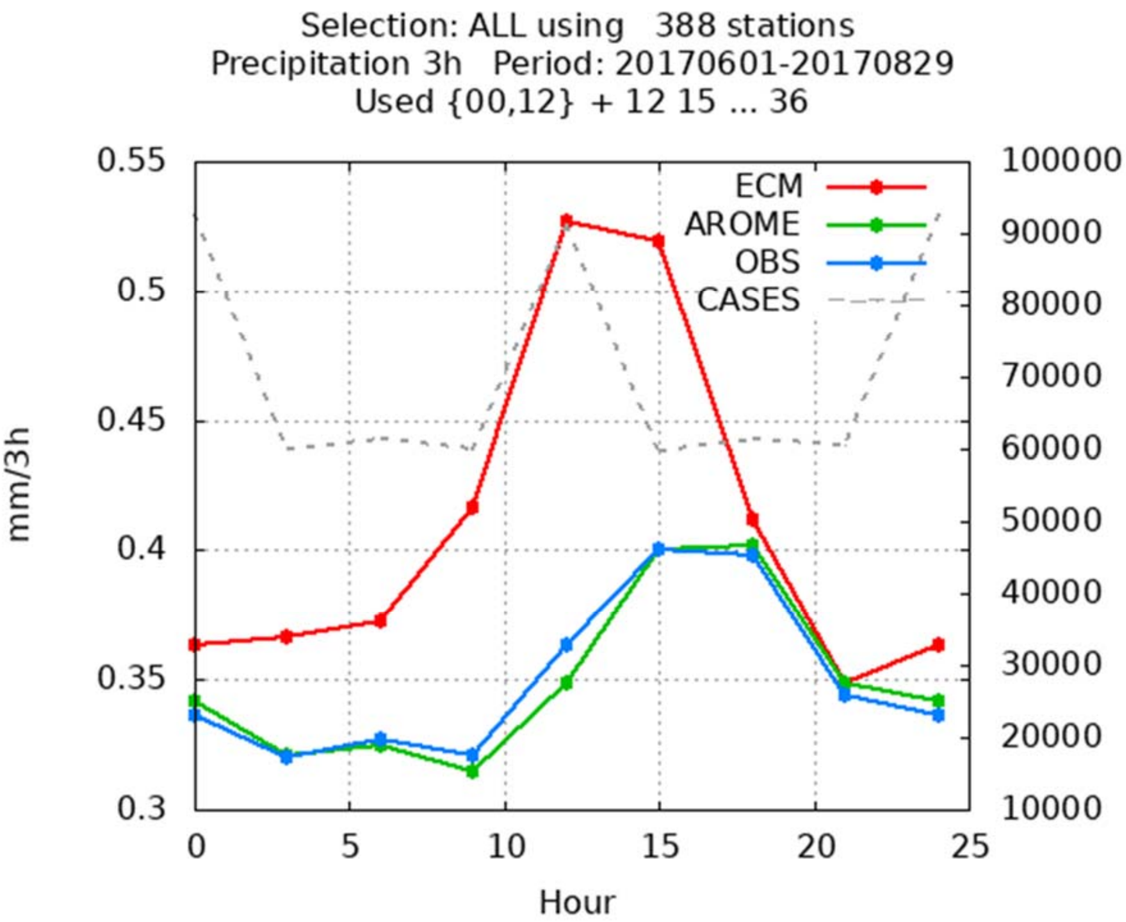

Figure 2: Diurnal cycle of 3-hour precipitation. Hours of the day on horizontal axis, precipitation on vertical axis. Red: ECMWF, green: AROME and blue observations. Area: North-western Europe. Time period : June-August 2017. Forecast lengths: 12, 15, 18, 21, 24, 27, 30, 33 and 36 hours.

24 hour precipitation has been verified against a dense network of climate stations, mainly over Sweden and some parts of northern Norway. It is short time forecasts (the 24 hour period starting at six- and ending at 30 hour forecast length) Fractions skill score is used with 'sample climate' as reference forecast. The period is July 2016 to June 2017. The result is seen in in figure 3.

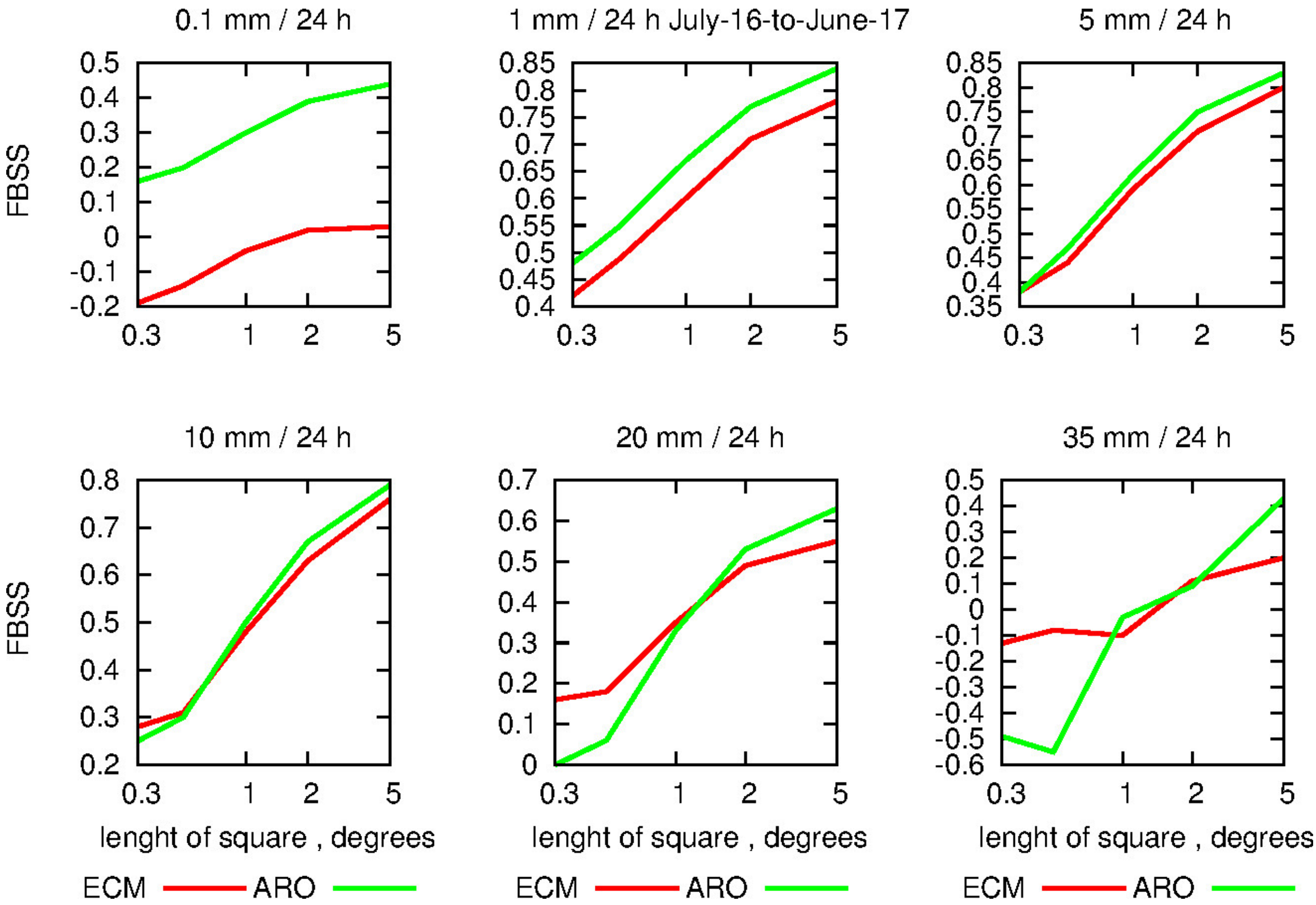

Figure 3: FBSS for different thresholds of precipitation. FBSS at the vertical axis and the size of different squares in degrees. There should be at least three observations in a square for being used in the verification. One degree is about 111 km. ECM (red) is ECMWF forecasts and ARO (green) is AROME with 2.5 km grid.

AROME has the highest score for all scales for precipitation thresholds up to 5 mm. For the 10 mm threshold, the results are mixed and rather similar. For 20mm and 35mm threshold, ECMWF is best with positive skill for the most valuable small scale features for the 20mm threshold. (below 100km). The low skill for ECMWF for 0.1mm threshold may partly be caused by that interpolated ECMWF fields are used.

3.1.3 Post-processed products

3.1.4 End products delivered to users

3.2 Subjective verification

3.2.1 Subjective comments etc

Duty forecasters have complained about over-prediction of high amounts of precipitation for the medium range forecasts, especially during this summer. There has not been possible to see such behaviour in the regular precipitation verification, except for the southernmost part of Sweden (Götaland), where there an over-prediction of precipitation for this summer (June-August) with up to about 50 %. The frequency biases for the higher amounts are also above unity for this area and period. Since this is a small area only and only seen for this summer, it may be a random effect, but will be investigated further anyway. It should be mentioned that forecasting high precipitation was of special interest over this area during this summer due to unusually dry conditions.

3.2.2 Case studies

Severe weather events/non-events are of particular interest. Include an evaluation of the behaviour of the model(s). Reference to major forecast errors, even if they are not in a "severe weather" category, are also very welcome.

4. Feedback on ECMWF "forecast user" initiatives

- "Known IFS forecast issues" page – (https://software.ecmwf.int/wiki/display/FCST/Known+IFS+forecasting+issues)
- "Severe event catalogue" (https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue).

5. References to relevant publications

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