Application and verification of ECMWF products 2016

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1. Summary of major highlights

The introduction of the higher resolution version of ECMWF in spring had a slightly positive impact of the subjectively experienced forecast quality. The forecasts became better due the to the increased horizontal resolution, which is rather trivial, but besides that, forecasts of low clouds are generally a little better after the update.

The ensemble products became more frequently used after the update.

ECMWF is still a very important provider of lateral boundaries for our regional models, and will probably soon also be used for a regional ensemble system based on the regional model AROME.

2. Use and application of products

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

There is no new statistical adaptations introduced. A Kalman filter is still used for adjusting 2m- temperature and 10m-wind.

2.1.2 Physical adaptation

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, and the finer ones are taken from the high resolution limited area mode used. This technique is used for HIRLAM with 11 km resolution and AROME with 2.5 km resolution.

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

Since this spring, an ensemble system called MEPS has been tested. It uses the difference between older and newer lateral boundaries from ECMWF to create perturbations (SLAF, Scaled Lagged Average Forecasting). The ensemble system has 9 AROME members and one ALARO member. ALARO also runs within the HARMONIE system which is coupled to IFS, but the physics in ALARO is different from that in AROME. All forecasts have the same forecast domain and horizontal resolution, 2.5 km covering north-western Europe. It is intended to become operational within our bilateral MetCoOp cooperation during this autumn.

2.1.3 Derived fields

A smoothing technique is used for all meteorological model outputs of cloudcover 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 0.025degrees (2.75 km)

2.2 Use of ECMWF products

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 for some near surface parameters is seen in 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. '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.

Autumn: (September – November 2015)

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	0.50	0.04	0.32	0.38	1.61	1.46	1.60	1.43
t2m	-0.15	-0.18	-0.35	-0.38	1.32	1.33	1.39	1.22
td2m	-0.36	-0.59	-0.32	-0.36	1.35	1.34	1.18	1.18

Winter: (January - February 2016, December fell out due to technical problems)

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	0.24	0.27	0.75	1.73	1.58	1.66	1.66
t2m	0.21	0.15	-0.41	-0.40	1.89	1.82	1.96	1.77
td2m	0.16	-0.40	-0.60	-0.36	1.95	1.95	1.99	1.86

Spring: (March -May 2016)

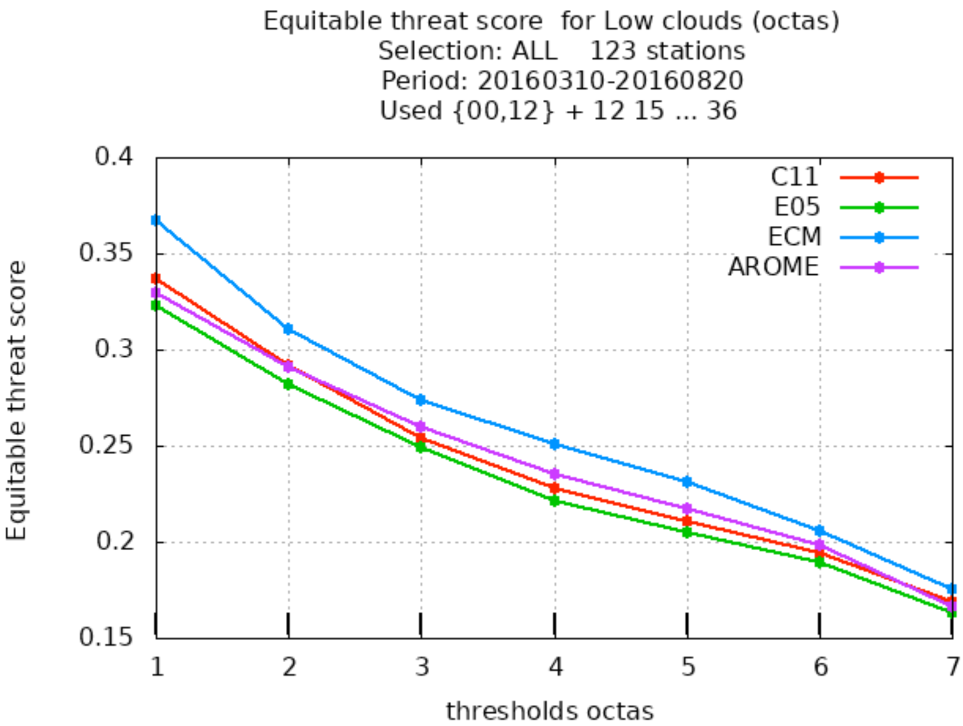
parameter	Systematic error or bias				Mean absolute error			
model	HI 11 km	HI 5.5 km	ECMWF	AROME	HI 11 km	HI 5.5 km	ECMWF	AROME
10m wind	0.31	-0.06	-0.03	0.24	1.47	1.41	1.40	1.35
t2m	0.14	-0.30	-0.93	-0.79	1.50	1.50	1.65	1.51
td2m	0.53	-0.53	-0.28	0.80	1.71	1.57	1.39	1.71

Summer (June – August 20 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	0.27	-0.12	0.14	0.12	1.43	1.38	1.39	1.29
t2m	0.18	-0.27	-0.40	-0.06	1.43	1.42	1.41	1.24
td2m	-0.48	-0.71	-0.35	0.08	1.54	1.51	1.22	1.26

These three parameters are all such that increased horizontal resolution normally is an advantage when traditional grid-point verification is used. Despite this, ECMWF often performs best for 2m- dew-point temperate (winter is the exception). AROME has the highest horizontal resolution and has also the lowest absolute error for 2m -temperature and 10m wind speed forecasts. One exception is seen in winter where HIRLAM with 5.5 km resolution has the lowest absolute error of 10m wind speed. ECMWF is a little too cold in winter and in spring.

From a subjectively point out view, the forecasts of low level clouds seem to have improved somewhat after the introduction of the new cycle in March this year. (According to duty forecasts.) In figure 1 the ETS (Equitable Treat Score) for different thresholds of low clouds is shown to be a little higher for ECMWF than the regional models, but for cloud base, AROME has the highest score. (figure 2) There is still some over prediction of the lowest cloud clouds, including fog. (not shown)



3.1.3 Post-processed products

Figure 1 ETS values for different thresholds of cloud cover in octals. ECMWF in blue, AROME in purple, HIRLAM 11 km in red and HIRLAM 5.5km in green. The observations used here are Swedish automatic stations. The verification period is March 10 to August 20 2016

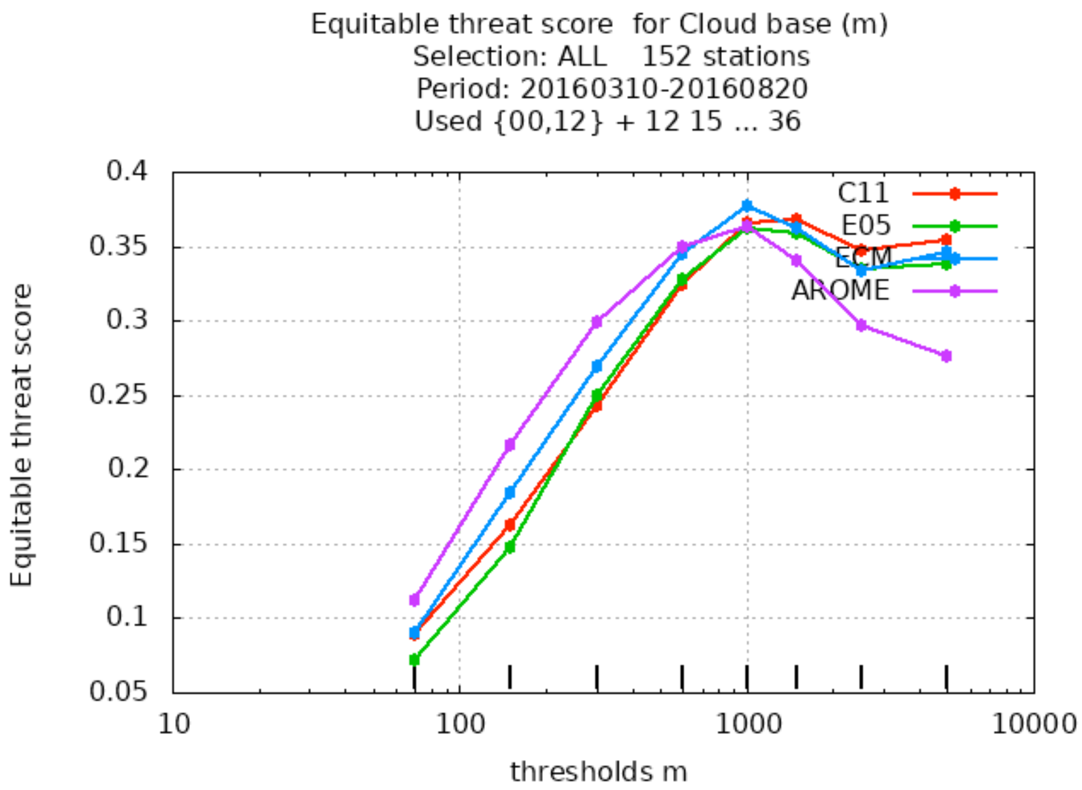


Figure 2 ETS values for different thresholds of cloud base height (at least 3/8 cloud cover) ECMWF in blue, AROME in purple, HIRLAM 11 km in red and HIRLAM 5.5km in green. The observations used here are Swedish automatic stations.

Verification of 3-hours precipitation for this summer period shows basically the same result as the previous summer. ECMWF has nearly the the same results in terms of ETS (or other similar scores) as our regional models. But the daily maximum is still a little too early and over-amplified with ECMWF. (not shown) Those biases are not seen with our regional HIRLAM models.

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 from six up to 30 hour forecast length) Fractions skill score is used with 'sample climate' as reference forecast. The period is July 2015 to June 2016. The result is seen in in figure 3

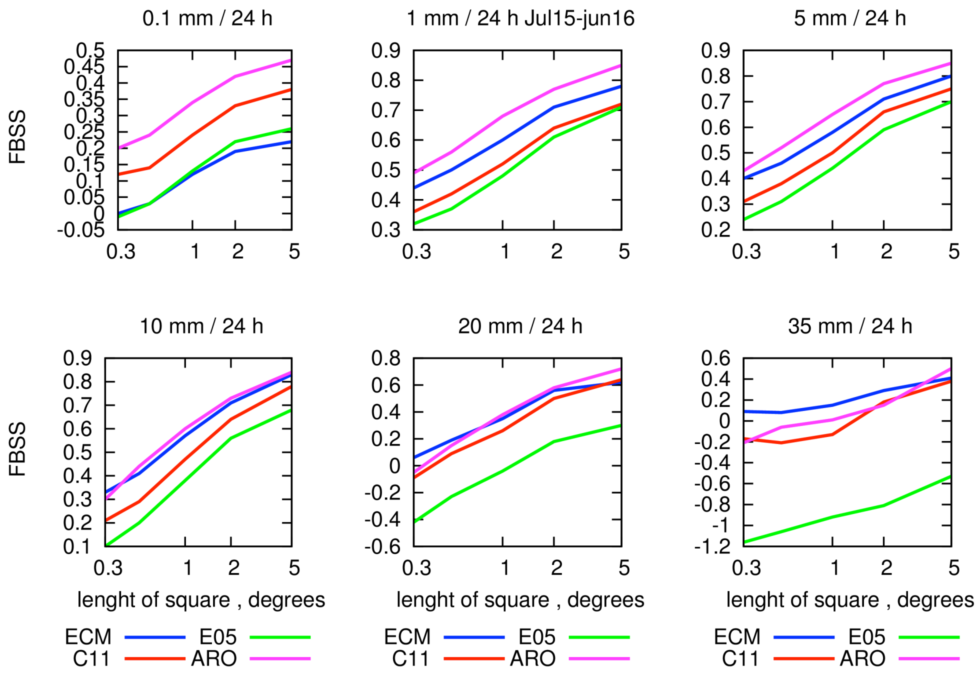


Figure 3: FBSS for different thresholds of precipitation. FBSS at the vertical axis and the size of different squares in degrees. There should be at least three observations in a square for being used in the verification. One degree is about 111 km. ECM (blue) is ECMWF forecasts, C11 (red) is HIRLAM with 11 km grid, E05 (green) is HIRLAM with 5.5 km grid, and ARO (purple) is AROME with 2.5 km grid.

AROME has the highest score for all scales for precipitation thresholds up to 5 mm. For 10 and 20 mm the results are mixed. For 35mm, threshold, ECMWF is best with positive skill for all scales. The low skill for ECMWF for 0.1mm threshold may partly be caused by that interpolated ECMWF fields are used. During summer and early autumn 2015 there where some technical problems with the analyses for HIRLAM 5.5 km and AROME. This reduced the performance of those models during the period. Occasionally during this summer, we have experienced some technical problems with getting lateral boundaries to AROME, and thus older boundaries where used in those cases. This may also have had some negative impact.

3.1.4 End products delivered to users

3.2 Subjective verification

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

3.2.2 Case studies

Although the new cycle introduced in March seems to have improved the forecasts of low clouds somewhat, one exception is seen in summer in case of windy conditions, where there is too little of low clouds. One example of this is seen in figure 4

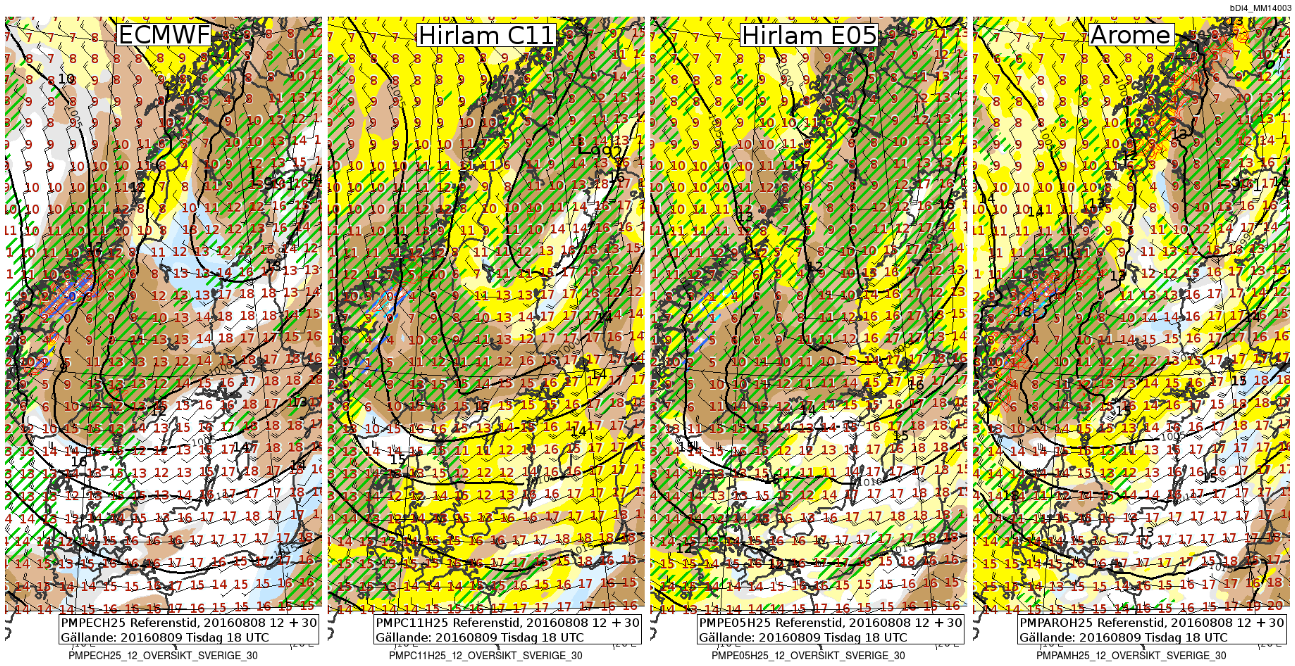
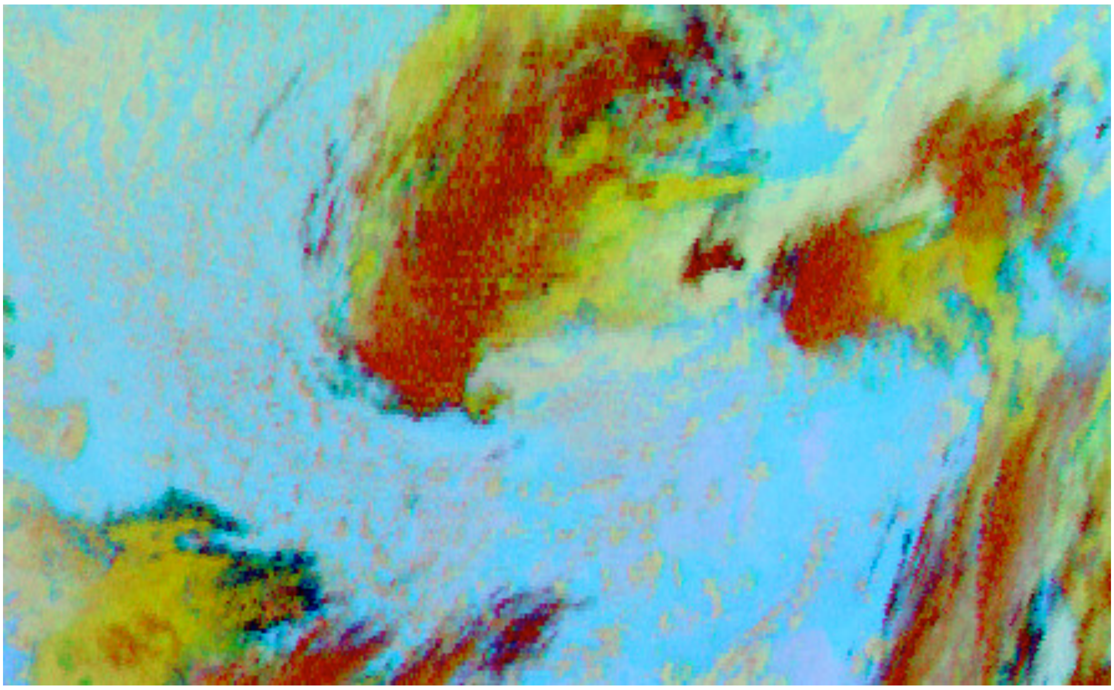


Figure 4 Forecasts 2016-08-08-12 UTC + 30 H valid 2016-08-09 18 UTC. From left to right is ECMWF forecast, HIRLAM with 11 km grid, HIRLAM with 5.5km grid and AROME with 2.5 km grid. Low cloud in yellow, middle level clouds in brown and high clouds in blue. Three hour precipitation in green.

The forecasts in Figure 4 is to be compared with the satellite picture in figure 5 valid at 2016-08-09 18UTC. The low clouds are missing or have a very low fraction in the ECMWF forecasts. But the satellite picture shows a lot of low clouds and also some deeper convective clouds. HIRLAM 11km has too much low clouds instead, but HIRLAM with 5.5 km resolution and AROME has fairly the same amount of low clouds as in the satellite picture, although some are misplaced.



Satellite picture valid at 2016-08-09-18. In the middle is Denmark and Southern Sweden. Land is purple, whereas sea is light blue. Low cloud is yellow, middle- and high clouds including deeper convective clouds are brown or dark red.