Application and verification of ECMWF products 2015

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1. Summary of major highlights

There are no notable change in the use of ECMWF products since last year. This means that short range ECMWF forecasts are used together with products from the limited area models HIRLAM and Harmonie. Harmonie is the ALADIN based limited area model linked to the IFS system. Harmonie is used with AROME physics at 2.5 km resolution and with 65 levels. HIRLAM forecasts have two different resolutions, 11km and 5.5 km. 60 or 65 levels are used. ECMWF provides boundaries for all runs. AROME uses a boundary update every hour, and the other models have a 3 hours boundary update. For the medium range, products from NCEP and UK Met Office are also used.

The ECMWF forecasts are continuously good and no large difference in forecast quality is seen since last year, including the effect of the new cycle introduced in spring. ECMWF has the best performance of the models for upper air parameters. This is also true for 2m dew-point temperature, expect in winter, when AROME is the best. The 2m-temperature from ECMWF suffers from some negative bias during winter, spring and early summer. AROME has the best forecasts of 10m-wind speed and 2m temperature in the summer and partly also in other seasons. AROME also preforms best for cloud base. The two HIRLAM versions has the best 2m temperature forecasts during spring. The result is mixed regarding total cloud cover and precipitation for all the models compared here.

2. Use and application of products

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

There are no new statistical adaptations during the recent years. A Kalman filter is used for adjusting 2 meter temperature and 10 meter wind speed forecasts. ECMWF data, (e.g. CAPE) is still used for creating thunderstorm probabilities.

2.1.2 Physical adaptation

The ECMWF model data is used to provide lateral boundary conditions and other input data for limited area modelling such as “large scale mixing” (=LSM), which means that the the larger scale features of the ECMWF analysis or short terms forecast are used as input for the first-guess field.

ECMWF data is used for both atmospheric and oceanographic models. The ECMWF data is used in the same way as previous years, but the LSM technique may be introduced also for HIRLAM with 5.5 km resolution. LSM has been used for HIRLAM with 11 km resolution and for AROME during recent years.

A smoothing technique is used for all model outputs of cloud cover and precipitation. (Including ECMWF) The grid-point information from an area of 20 km radius is used to create smoothed fields with a mean value for cloud cover and precipitation. Fields containing a median(=50 % percentile), a 'maximum' (=90 % percentile) and a 'minimum' (=10 % percentile) are created for precipitation. This additional information is used for e.g. mobile telephone applications.

2.1.3 Derived fields

2.2 Use of ECMWF products

Many ECMWF products are used for public warnings, e.g. wind gust forecasts. The use of ECMWF products in this context has not changed during the last year, compared to the previous years.

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 are seen in the following table.

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 2014)

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	0.44	-0.06	0.24	0.28	1.53	1.39	1.53	1.33
t2m	-0.03	-0.24	-0.31	-0.58	1.37	1.39	1.44	1.38
td2m	-0.33	-0.72	-0.40	-0.47	1.42	1.47	1.26	1.32

WINTER: (December 2014 – February 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	0.61	0.14	0.17	0.81	1.86	1.68	1.78	1.79
t2m	0.10	-0.08	-0.72	-0.36	1.62	1.60	1.78	1.51
td2m	0.10	-0.64	-0.82	-0.15	1.67	1.71	1.70	1.51

SPRING (March – May 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	0.34	-0.11	0.02	0.34	1.60	1.54	1.56	1.51
t2m	0.12	-0.32	-0.90	-0.72	1.34	1.38	1.56	1.37
td2m	0.31	-0.57	-0.27	0.54	1.62	1.49	1.34	1.56

SUMMER (June – August 22, 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	0.26	-0.14	0.17	0.09	1.39	1.38	1.38	1.26
t2m	0.28	-0.32	-0.32	-0.08	1.40	1.47	1.41	1.26
td2m	-0.47	-0.69	-0.09	0.01	1.54	1.59	1.21	1.32

ECMWF has the lowest mean absolute error for 2 metre dew-point temperature compared to the other models. ECMWF also competes well with the other models regarding relative humidity and specific humidity for most of the seasons and with respect to other verification measurements (not shown). The only exception is in winter, because the model is a little too dry during this season. ECMWF is also generally a little too cold, especially in winter and spring. But in late summer and early autumn, there is not any notable systematic error. (not shown)

10 metre wind and 2 metre temperature are usually best predicted with the model with the highest horizontal resolution, which is AROME. This is not only seen by considering mean absolute error, but also other scores such as ETS for different thresholds. (not shown) Winter is an exception for 10 metre wind speed, since AROME suffers from some over-prediction for snow covered forest. Spring is an exception regarding 2 metre temperature, since AROME is too cold and moist.

The precipitation in summer and its diurnal variation is of interest for agriculture and for people having their vacation. This summer it is also of interest since ECMWF is updated with a new cycle. The diurnal cycle of 3 hour precipitation is seen in figure 1.

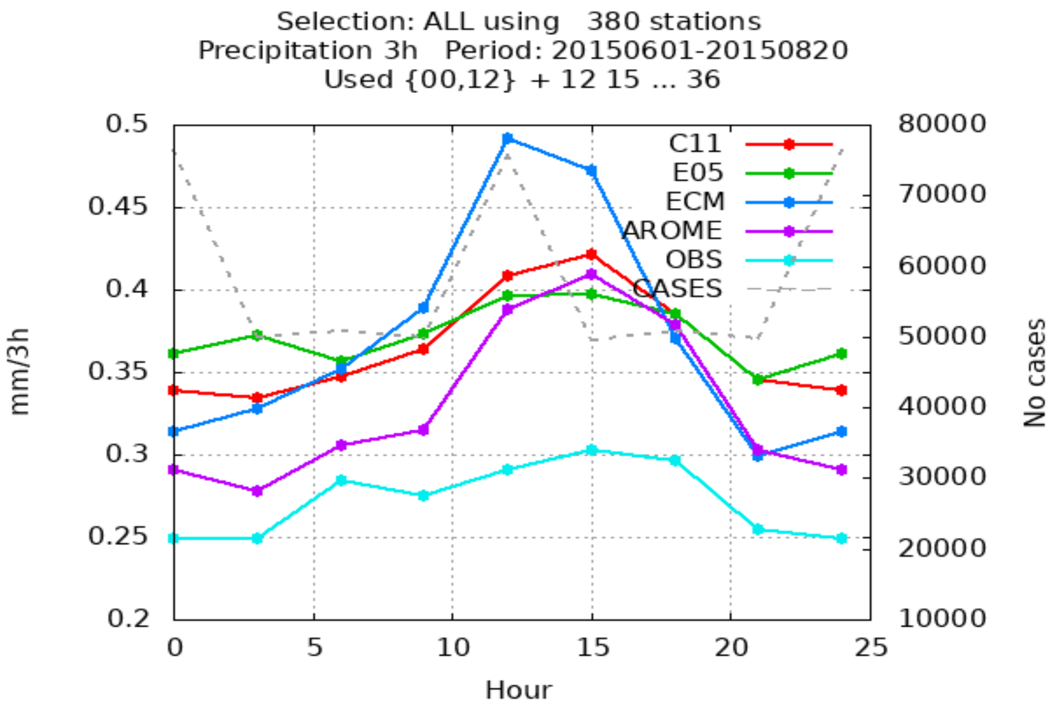

Figure 1: Time of the day in UTC on the horizontal axis and average precipitation during 3 hours on the vertical axis. The time is the end of the 3-hour period. The observed precipitation is in light blue, ECMWF forecasts in dark blue, HIRLAM forecasts with 11 km horizontal grid in red and HIRLAM 5.5km in green. AROME (2.5km grid) in purple. The verification area is mainly Norway and Sweden.

All models forecast more precipitation than observed, but the rain gauges may have some negative bias in the observations. ECMWF over-amplifies the diurnal variation and the precipitation also comes a little too early. The HIRLAM forecasts seems to be closest to observations, except for the over-prediction.

Low clouds have been verified against Swedish automatic stations. Those stations may give lower amount of cloud cover than manually observations due to different perspective effects and perhaps also because thin clouds are not always detected. The result is seen in figure 2.

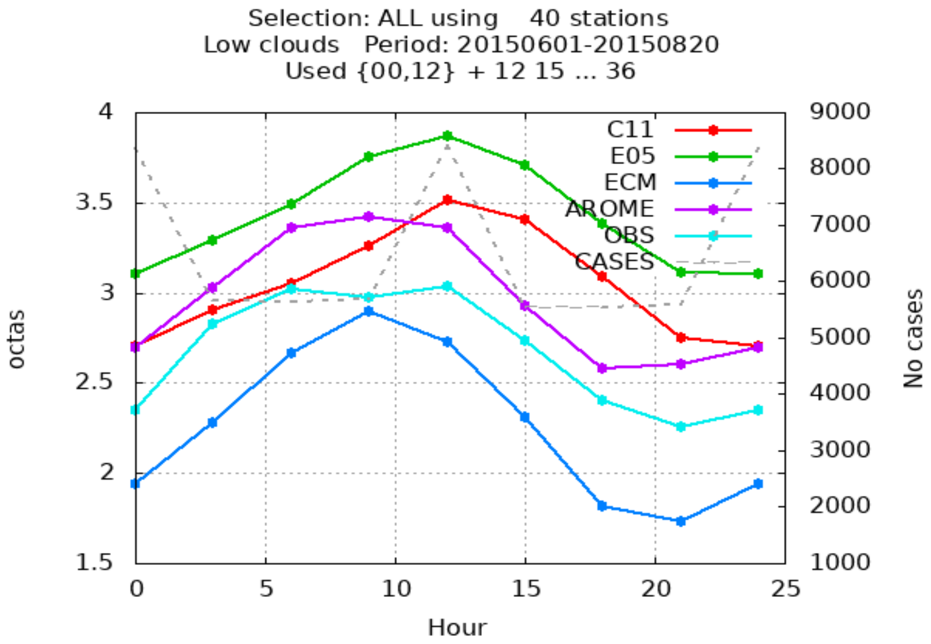

Figure 2: Time of the day in UTC on the horizontal axis and the average amount of low clouds in octas on the vertical axis. The observed cloud amount is in light blue, ECMWF forecasts in dark blue, HIRLAM forecast with 11 km horizontal grid in red and with 5.5 km in green. AROME (2.5km grid) in purple. The verification area is Sweden.

The phase of the diurnal cycle of low clouds are well predicted for this summer period in both ECMWF and AROME, but ECMWF generally has an under-prediction of low clouds, especially during the evening and night. HIRLAM has the diurnal maximum somewhat too late. The small dip of the observed cloud amount around 09 UTC was also present previous summer and may be related to a decrease of low stratus generated at night-time and to that the daytime convective cloudiness maximum is still not reached.

The Equitable Treat Score, (ETS) for different thresholds of low clouds show fairly the same value for ECMWF as for the other models used in the comparisons discussed here. (not shown)

The forecast of cloud base is of interest for aviation and many other activities. The ETS for different thresholds and and models for the short-range forecasts is seen in figure 3 and the frequency bias in figure 4. The result is based on data from this summer (June to late August)

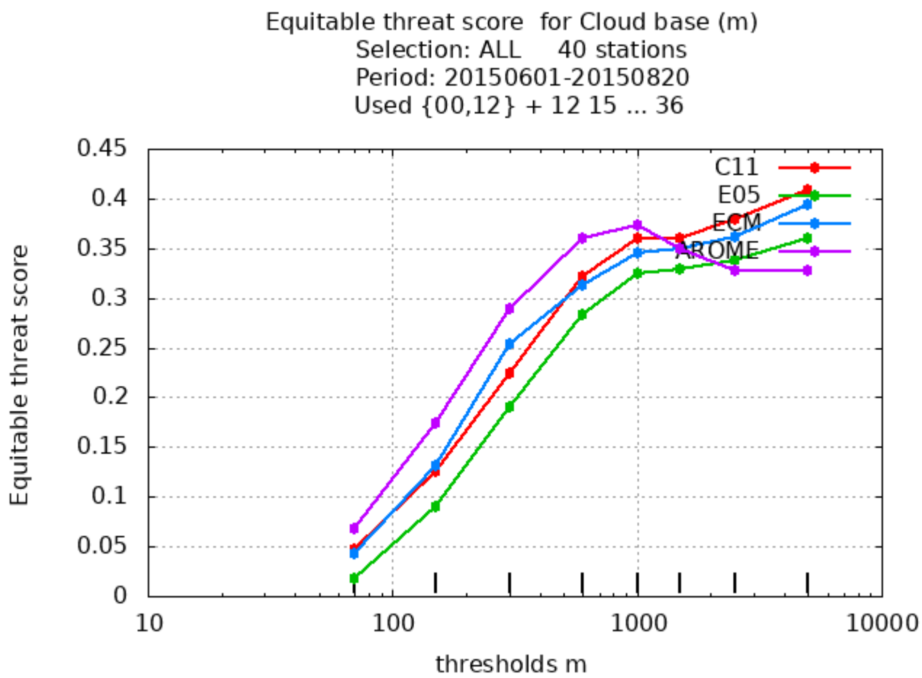

Figure 3 : Different thresholds of cloud base (3/8 cloud fraction or more) on the horizontal axis and ETS value on the vertical axis. ECMWF forecasts in dark blue, HIRLAM forecast with 11 km horizontal grid in red and with 5.5 km in green. AROME (2.5km grid) in purple. The verification area is Sweden.

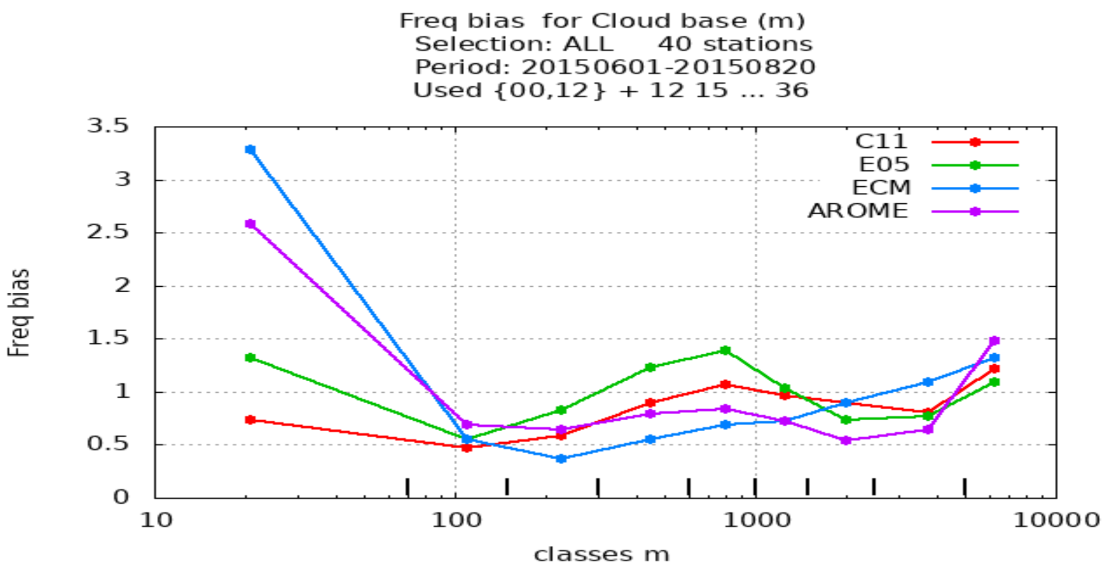

Figure 4 : Different classes of cloud base (3/8 cloud fraction or more) on the horizontal axis and the frequency bias on the vertical axis. ECMWF forecasts in dark blue, HIRLAM forecast with 11 km horizontal grid in red and with 5.5 km in green. AROME (2.5km grid) in purple. The verification area is Sweden.

The cloud base forecast has the highest ETS values for AROME, except for cloud base above about 2000m. ECMWF is at the same level as HIRLAM with 11 km resolution. Both ECMWF and AROME has to much of very lowest clouds including fog. ECMWF has too little of cloud base from about 200 m up to 1000m. It is not clear if this is due to over-prediction of the very lowest clouds or to under-prediction of clouds between 200 – 1000m.

24-hour precipitation has been verified against a dense network of climate-stations in (mainly) Sweden in order to examine the ability of the models to separate areas of different size with respect to different amounts of precipitation. Fractions Brier Skill-Score (FBSS) has been used for this purpose. The result is seen in figure 5.

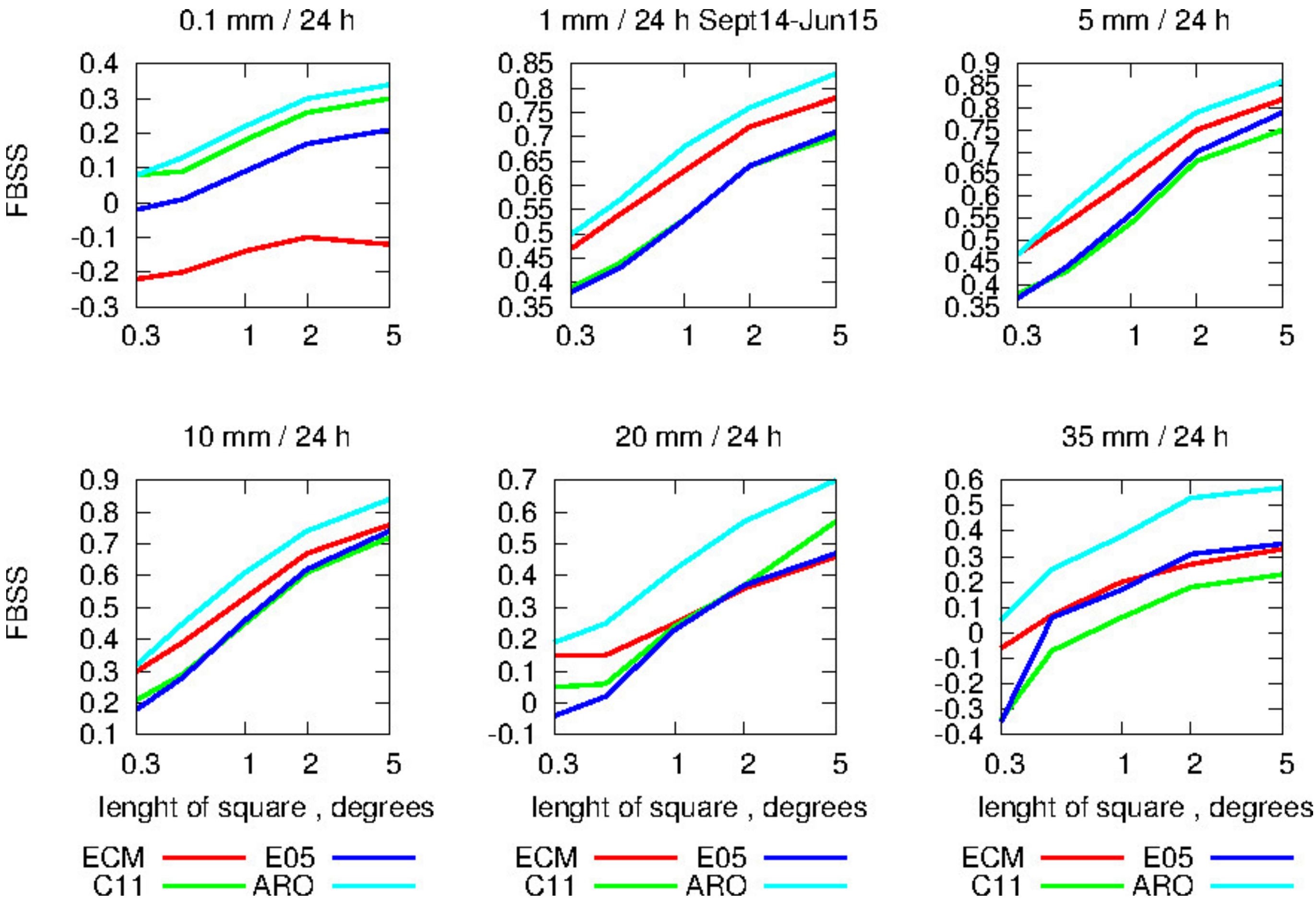

Figure 5: FBSS for different thresholds of precipitation FBSS values at the vertical axis and the size of different squares in degrees. The squares should have at least three observations on order to be included in the test. One degree is about 111 km. ECM (red) is ECMWF forecasts, C11 (green) is HIRLAM with 11km grid, E05 (blue) is HIRLAM with 5.5km grid and ARO (light blue) is AROME with 2.5 km grid. The reference forecast is sample climatology.

The model with the highest horizontal resolution, AROME has generally the highest FBSS, and the FBSS is also always positive for all thresholds and sizes of the squares in this test. Despite the coarse resolution, ECMWF has often the second best FBSS. The low ability for ECMWF forecasts to separate no precipitation from (at least) light precipitation has been seen for several years, but may partly be caused by that interpolated ECMWF fields are used.

3.2 Subjective verification

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

Below are some comments from the duty forecasters about the ECMWF forecasts:

- Perhaps a little too much of fog in the mountain-area of Sweden.
- In convective situations during summer, there seems to be situations in which the precipitation remains for some time, after the clouds have disappeared.
- The wind gusts are generally too strong in the model.
- Too much cooling (2m temperature) in case of precipitation in summer.

- Somewhat too much clouds (total cloud cover, not low clouds) except in spring. (supported by objective verification against observations)
- During convective situations in summer, low clouds too often seems to be forecast as middle level clouds (There are some uncertainness about this. It may at least partly be related to how different cloud types are presented in the forecast charts)
- The clouds disappear too quickly behind a weather system, such as a cold front etc.
- The spread of the ensembles seems to be too small for shorter forecast lengths than about day 5.

3.2.2 Case studies

4. References to relevant publications