Application and verification of ECMWF products 2013-14

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1. Summary of major highlights

ECMWF products have extensively being used at SMHI for many years. 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 use a boundary update every hour, and the other models have a 3 hours boundary update.

The overall result for ECMWF forecast is continuously good, and the best one for upper air parameters and 2m dew-point temperature. But some of the new models preform better for certain parameters. Fore instance, AROME has better forecasts of 10m-wind speed and 2m temperature in the summer. HIRLAM with 5.5km resolution has better 2m temperature forecasts and also of 10m-wind speed during winter. ECMWF seems to have improved the forecasts of cloud base, low clouds and 3h precipitation compared to last year, at least when comparing with other models.

2. Use and application of products

2.1 Post-processing of 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 wind gust forecasts and 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. This includes both atmospheric and oceanographic models. The ECMWF data is used in the same way as previous years.

When the new high-resolution model, AROME became operational within the MeCoOp project in March this year, a smoothing technique was introduced for all model outputs of cloud cover and precipitation. (Including output from ECMWF.) The grid-point information from an area of 20 km radius is used to create new smoothed field with a mean value for cloud cover and precipitation. For precipitation fields containing a median (=50 % percentile), a max (=90 % percentile) and a min (=10 % percentile) are also created. This additional information is used for e.g. mobile telephone applications. All verification results presented here are based on the mean values.

2.1.3 Derived fields

There are a lot of such products, but no new ones have be implemented during the last year, except the ones presented in 2.1.2.

2.2 Use of products

Many ECMWF products are used for public warnings. ECMWF forecasts have a good reputation as a guideline for those warnings for many years, and the use of ECMWF has not changed during the last year, compared with previous years.

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

3.1.2 ECMWF model output compared to other NWP models

Winter 2013-14 (2m-temperature and 10m wind speed)

The result from routine verification is seen in figure 1

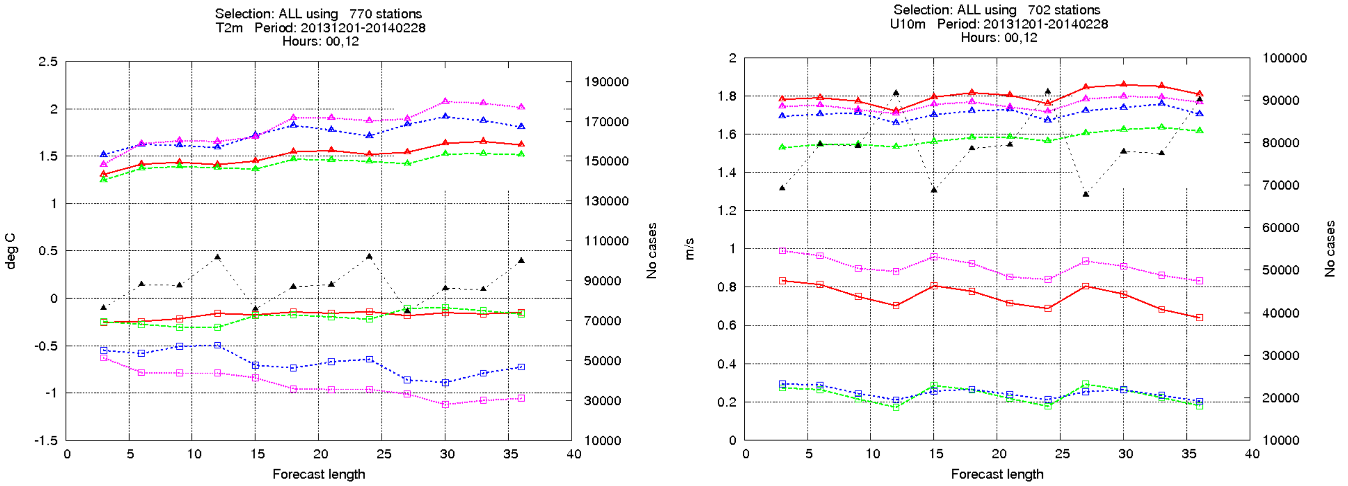

Figure 1: To the left: 2m temperature and 10 metre wind speed to the right. Mean absolute error as triangles and mean error as squares. Hirlam with 11km grid in red, Hirlam with 5.5km grid in green, ECMWF in blue and AROME (2.5km grid) in purple. The number of cases used is plotted as black dotted lines. The area for verification is north-western Europe and the period is December 2013 to February 2014.

AROME and ECMWF are a little too cold. All models are a little to 'windy', especially AROME and ECMWF. Note that most synop stations are over land. Hirlam with 5.5 km resolution has the lowest absolute error of 2m-temperature and 10m wind speed.

During spring, the ECMWF 2m-temperatures are generally a little too cold (not shown)

For this summer, the result is a little different, see figure 2:

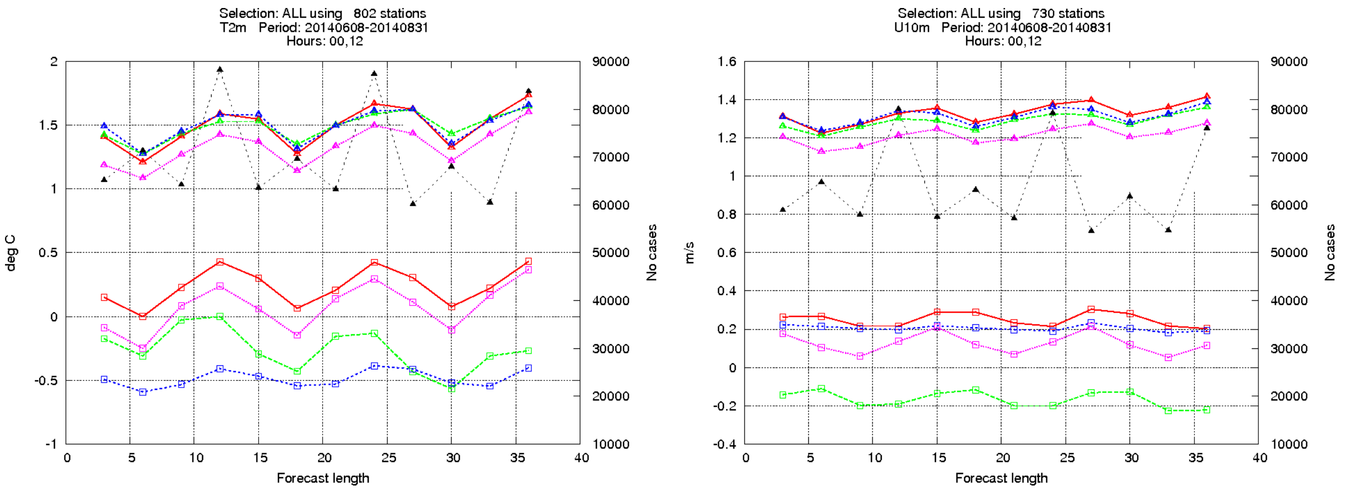

Figure 2: Verification result for summer (June to August 2014) For explanation, see figure 1.

ECMWF is a little too cold also in summer. The bias of the 10m wind speed is generally quite small in summer. AROME has the lowest absolute error of 2m- temperature and 10m-wind speed.

Verification against a database created by smoothing of data and further manual post-processing by duty forecasters (spring and summer 2014)

This database, called 'PMP' is produced at SMHI and has a smoothed field for cloud cover and precipitation. Duty forecasters choose the most reliable model for input to the database. It is often a limited area model for the first 48 hours, but ECMWF is used for the longer forecasts. It is possible to use a previous forecast, if it is regarded as more reliable. It is possible to edit the fields and to use Kalman filtered forecasts of 2m-temperature. Only near surface forecast fields are used in the database. This smoothing technique became operational in late March 2014.

The result for short-range forecasts of cloud and precipitation (which are the two parameters that have been smoothed) are seen in figures 3 and 4 The database issued at 03 UTC is compared with the available numerical forecasts when producing the database. It is previous days 12 UTC ECMWF (15 hours earlier) forecast and 00 UTC (3 hours earlier) forecasts of the other models. The verification area is Sweden and the verification period is April -August 2014.

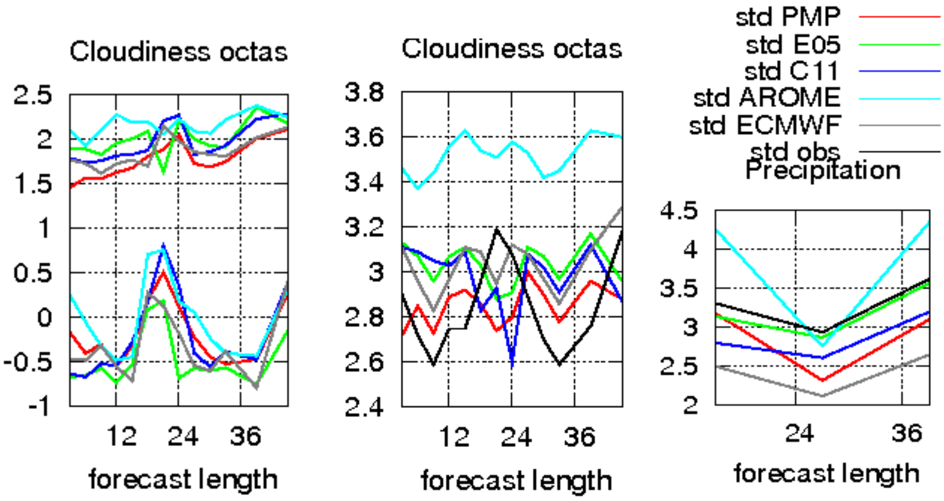

Figure 3: To the left: Mean absolute error and mean error of total cloud cover. In the middle: Standard deviation of total cloud cover. To the right: Standard deviation of 12-hour precipitation. The PMP database in red, HIRLAM with 5.5 km grid in green, HIRLAM with 11 km grid in deep blue, AROME (2.5 grid) in light blue, ECMWF in grey and observed standard deviation in black. Forecast length in hours at the horizontal axis and verification measures at the vertical axis.

The mean absolute error of the PMP database is is little lower than for the other models, despite that the other models are used as input. The spread of the total cloudcover and of precipitation seems to be fairly realistic too. This indicates that the smoothing technique, together with model choices and editing works reasonable well. The ETS (Equitable Treat Score) for different thresholds of clouds and precipitation is seen in figure 4.

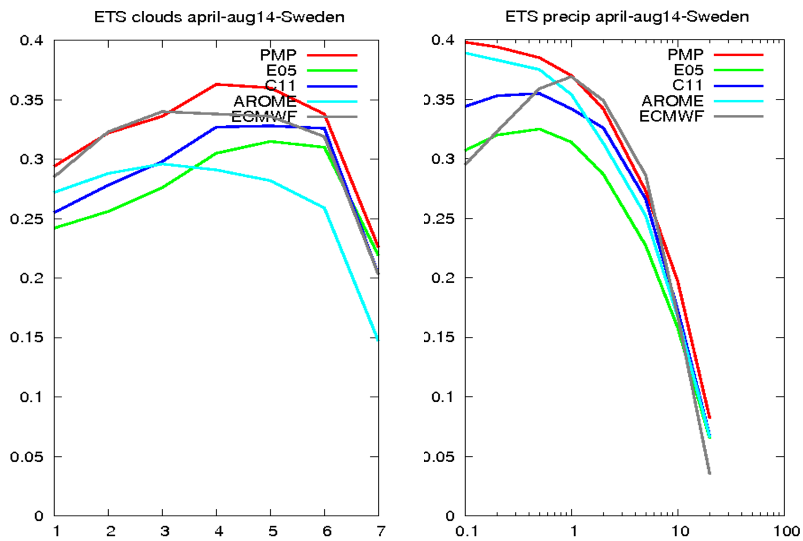

Figure 4: ETS for total cloudcover (left) and 12 hours precipitation (right) ETS values are at the vertical axis and thresholds at the horizontal axis. The PMP database in red, HIRLAM with 5.5 km grid in green, HIRLAM with 11 km grid in deep blue, AROME (2.5 grid) in light blue and ECMWF in grey.

The PMP products have generally the highest ETS values. ECMWF forecasts are among the best of the possible forecasts for input to the database.

The smoothing procedure is intended for the high resolution forecasts used for short-range, but it is used for all models, including the medium range ECMWF forecasts. The result for medium range forecasts (2-10 days ahead) are seen in the following two figures.

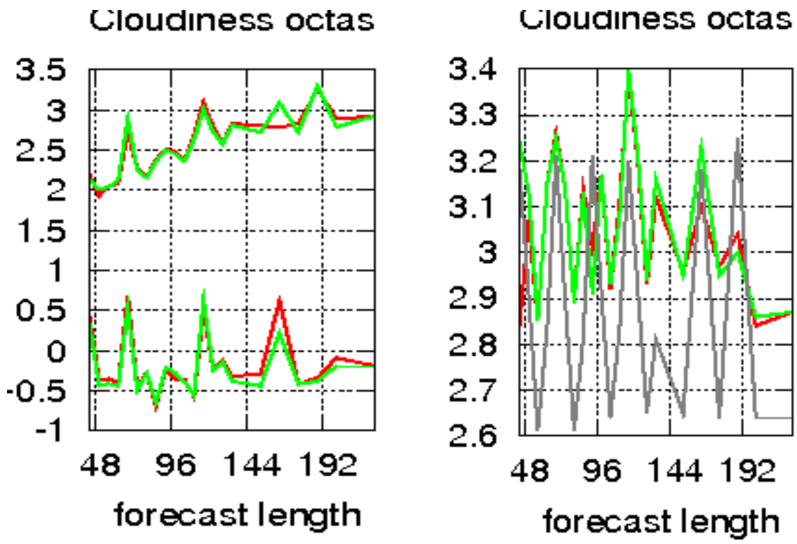

Figure 5: To the left: Mean absolute error and mean error of total cloud cover. In the middle: Standard deviation of total cloud cover. To the right: Standard deviation of 12-hour precipitation. The PMP database in red and ECMWF in green. Observed standard deviation in grey. Forecast length in hours at the horizontal axis and verification measures at the vertical axis.

ECMWF is the only source for input to the PMP database for medium range forecasts. The smoothing seems to have little effect on total cloud cover, whereas a little reducing in spread is seen for precipitation.

The corresponding ETS values are plotted in figure 6

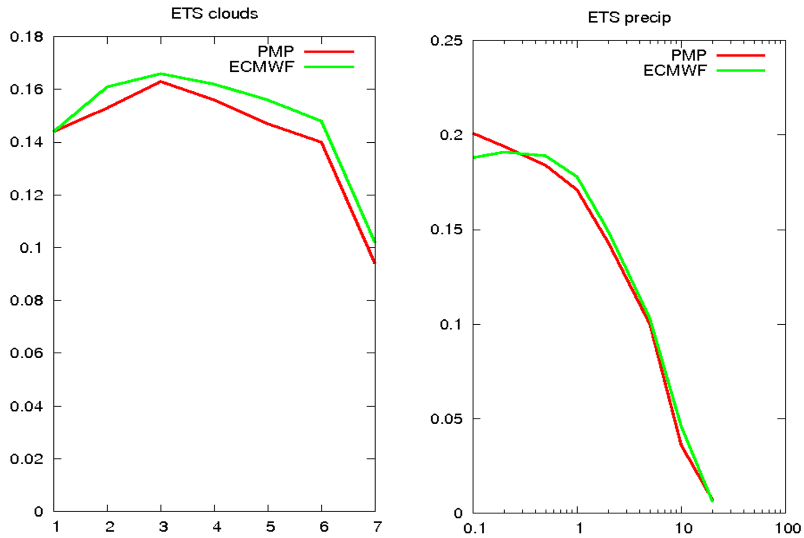

Figure 6: ETS for total cloudcover (left) and 12 hours precipitation (right) ETS values are at the vertical axis and thresholds at the horizontal axis. The PMP database in red and ECMWF in green.

A minor degradation is seen for total cloudcover for the PMP database, compared to the 'original' ECMWF forecasts. The effect on precipitation forecasts is mainly neutral.

3-hour precipitation in summer

The precipitation in summer and its diurnal variation is of particular interest for agriculture and for people having their vacation. The diurnal variation of precipitation is seen in figure 7.

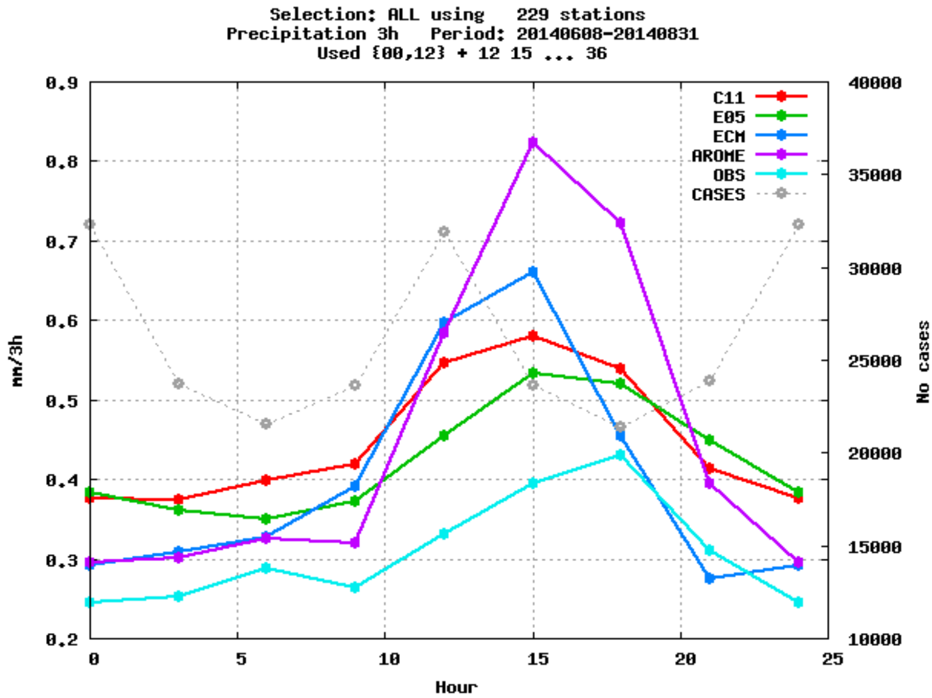

Figure 7: Time of the day in UTC on the horizontal axis and average precipitation during 3 hours on the vertical axis. The time is the end of the 3-hour period. The observed precipitation is in light blue, ECMWF forecasts in dark blue, HIRLAM forecasts with 11 km horizontal grid in red and HIRLAM 5.5km in green. AROME (2.5km grid) in purple. The verification area is the mainly Norway and Sweden.

The minimum of precipitation during 21- and 00 UTC is well captured by all models in this verification. The observed maximum is at 15 UTC, but all models have the maximum at 12 UTC including ECMWF. The maximums for AROME and ECMWF are a little over-amplified.

The equitable treat score (ETS) for the 3-hours precipitation is seen in figure 8.

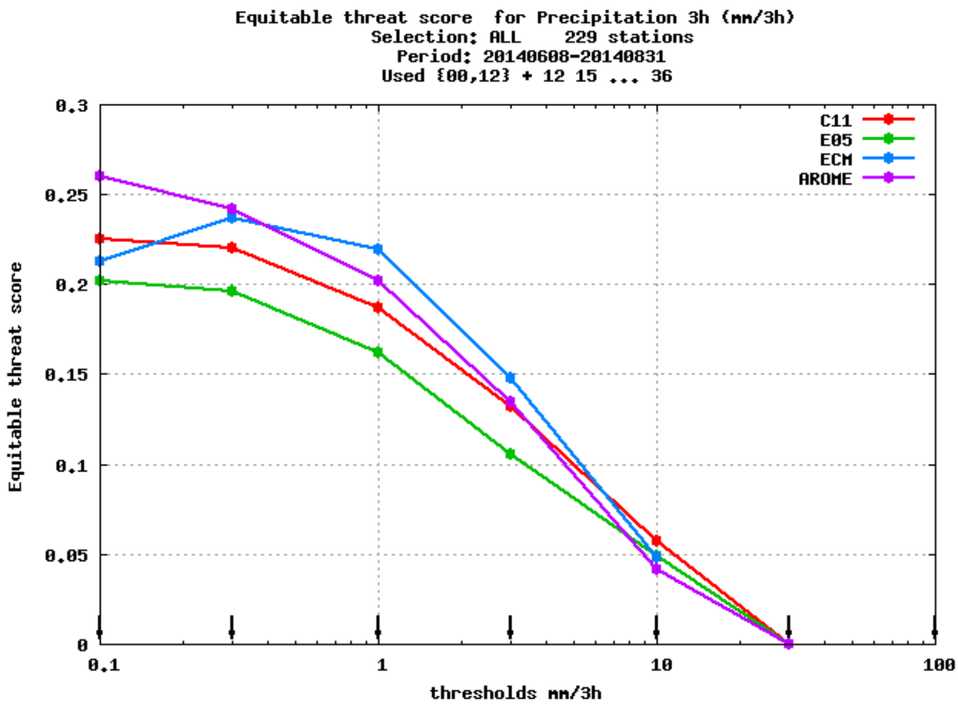

Figure 8: Different thresholds of precipitation on the horizontal axis, and ETS value on the vertical axis. ECMWF forecasts in blue, two different HIRLAM forecast with 11 km, and 5.5km horizontal grid in red and green respectively. AROME (2.5km grid) in purple. The verification area is the mainly Norway and Sweden.

The highest (=best) value is seen for the ECMWF forecasts regarding 1mm and 3mm thresholds. AROME is better fore the lower thresholds, whereas HIRLAM with 11km resolution is a little bit better for 10mm.

Low clouds

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 diurnal cycle of low clouds in summer is seen i figure 9.

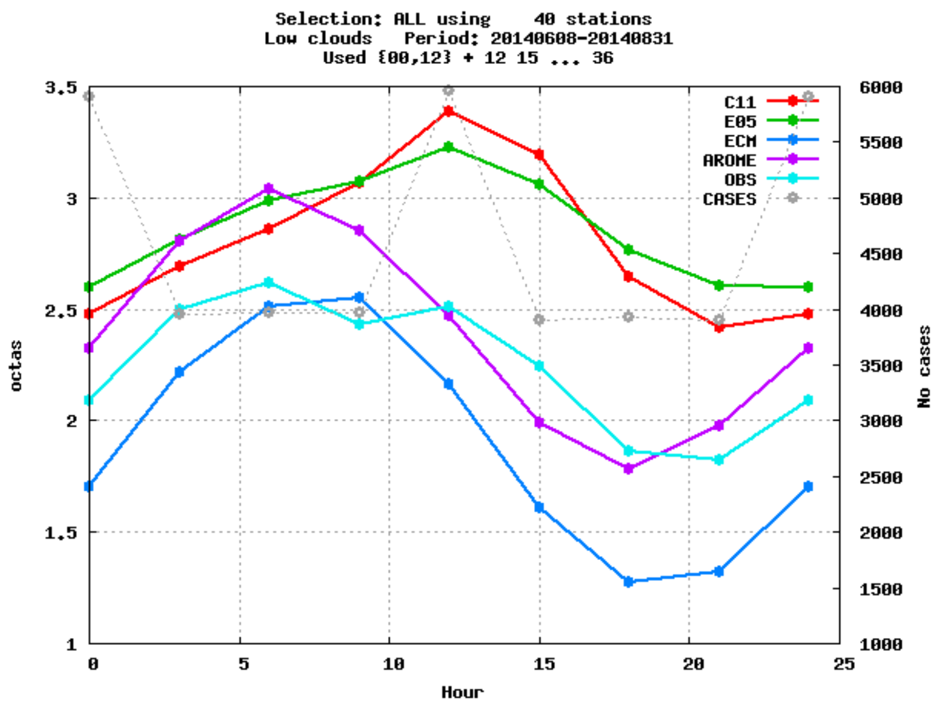

Figure 9: Time of the day in UTC on the horizontal axis and the average amount of low clouds in octas on the vertical axis. The observed cloud amount is in light blue, ECMWF forecasts in dark blue, HIRLAM forecast with 11 km horizontal grid in red and with 5.5 km in green. AROME (2.5km grid) in purple. The verification area is Sweden.

Despite the possible underestimation of low clouds compared to manual observations, ECMWF has less amount of low clouds than the observations. It may partly be an effect of that the postprocessing of low clouds at ECMWF does not exactly correspond to the definition of low clouds according to the WMO standard, which is clouds up to 2.5 km. The low clouds disappears too early in the ECMWF forecasts and AROME but too late in the HIRLAM forecasts.

The mean absolute error for low clouds verified this way is lowest for the ECMWF forecasts, but it may partly be an effect a too low variability of the ECMWF forecasts. (Not shown.) The ETS values for different octas are seen in figure 10.

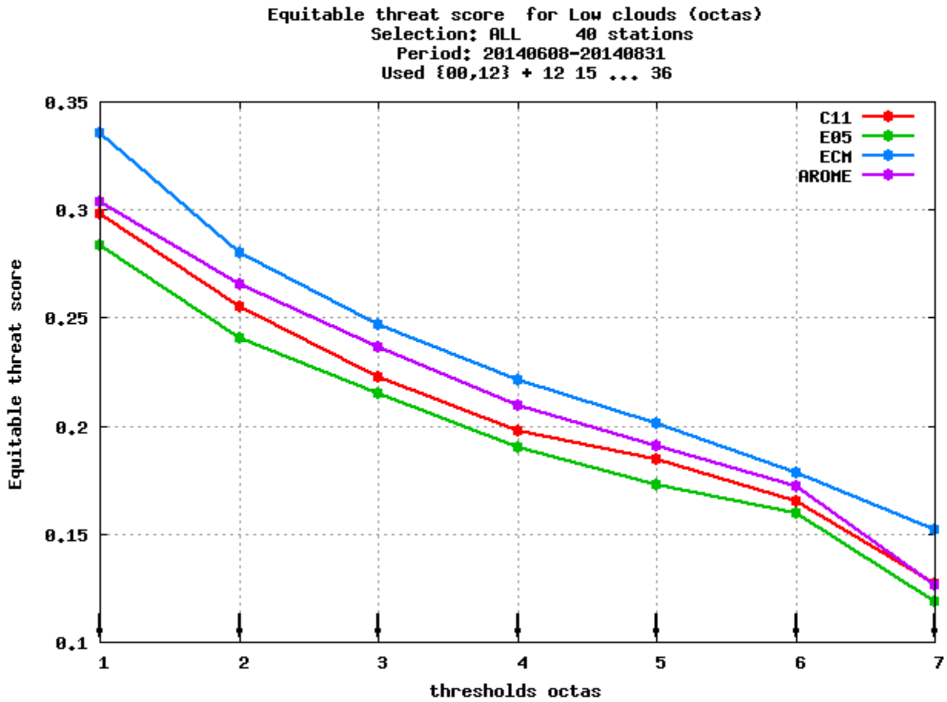

Figure 10: Different thresholds of cloudiness in octas on the horizontal axis and ETS value on the vertical axis. ECMWF forecasts in dark blue, HIRLAM forecast with 11 km horizontal grid in red and with 5.5 km in green. AROME (2.5km grid) in purple. The verification area is Sweden.

ECMWF is the best forecast, but AROME is almost as good as ECMWF.

3.1.3 Post-processed products

3.1.4 End products delivered to users

3.2 Subjective verification

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

Duty forecasters are generally satisfied with the forecasts. But fog over sea seems to be somewhat to frequent during summer. Convective clouds over land in summer are well predicted, but disappears a little to quickly in the evenings. The wind speed over sea seems to be a little under-predicted. (But the pressure field is OK) Wind gust are well predicted in case of severe weather, but is generally somewhat over-predicted, so there are too many false alarms for high wind gusts.

3.2.2 Synoptic studies

There have been several events with heavy rain causing damage this summer. One example is August 30 -31 over southernmost Sweden (Malmoe-region). Several models indicated a lot of rain, but only AROME came close to what was observed, see figure 11.

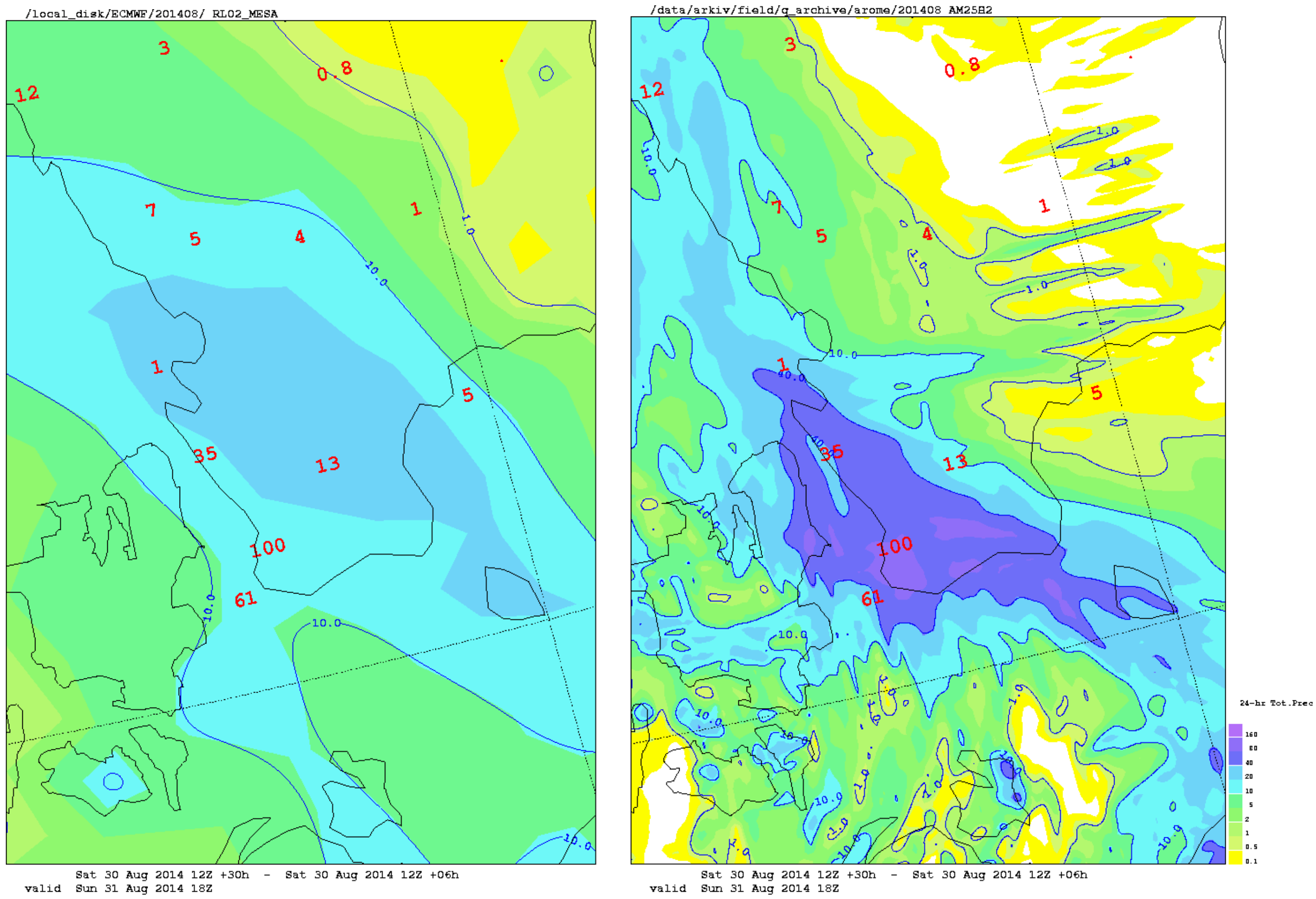

Figure 11: 24 hours precipitation in different colours over southernmost Sweden and surrounding areas. To the left ECMWF forecast, to the right AROME forecast. Observed precipitation in red (mm / 24 h)

4. References to relevant publications