Application and verification of ECMWF products 2012

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1. Summary of major highlights

ECMWF products are extensively used at SMHI for many years. For the short range, they 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. It is run with Alaro physics at 5.5 km resolution and non-hydrostatically with Arome physics at 2.5 km resolution. Both models with 65 levels. Hirlam runs with two different resolutions, 11km and 5.5 km. 60 or 65 levels are used. ECMWF provides boundaries for all runs except one, where Hirlam11km is used instead. The Harmonie (Alaro and Arome) models are run in pre-operational mode and not directly used in production yet.

The overall result for ECMWF forecast is continuously good. But some of the new models preform better for certain parameters. Fore instance, Arome is better for 10m wind over mountains and one of the new Hirlam versions with new physics has a better 2m temperature forecast. Cloud base is a new parameter being verified. Here, Arome shows good results for the lowest clouds compared with other models, including ECMWF.

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 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 for 2010, but the applications have increased slightly. New atmospheric models, e.g. Arome uses ECMWF boundaries and the oceanographic model Hiromb uses data from ECMWF for a 'time - lag' ensemble up to 15 days. The EPS has also been tested for this purpose, but the result seemed not to be better than the 'time-lag' approach. There are also experimental runs with oceanographic forecasts up to four weeks, using input data from ECMWF.

2.1.3 Derived fields

There are a lot of such products. New ones are cloud base and cloudiness between the second lowest level and 7500m. This cloudiness is used for comparison with automatic stations.

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. But one new type of warning is included this summer. It is the risk of high temperatures. Due to the weather conditions this summer, this warning has only very rarely been issued.

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

2 metre temperature

The quality of the ECMWF 2-metre temperature forecast is high and for the short range essentially the same as for the Hirlam model.

As can bee seen in figure 1 the mean absolute error (MAE) varies over the year in the same way for both Hirlam and ECMWF forecasts. Both models have the largest errors in the winter time. But if we are just looking at data from coastal stations (figure 1 right) the behaviour is quite different. Instead the smallest MAE is found during winter and it has a maximum in spring and early summer. During this period of the year the ECMWF forecast data has a rather large and systematic negative bias.

In figure 2 an example of a forecast for a coastal area is plotted together with observations. It can be seen that even if the observed temperatures vary a lot over sea it is almost always warmer than the corresponding forecast gridpoint values.

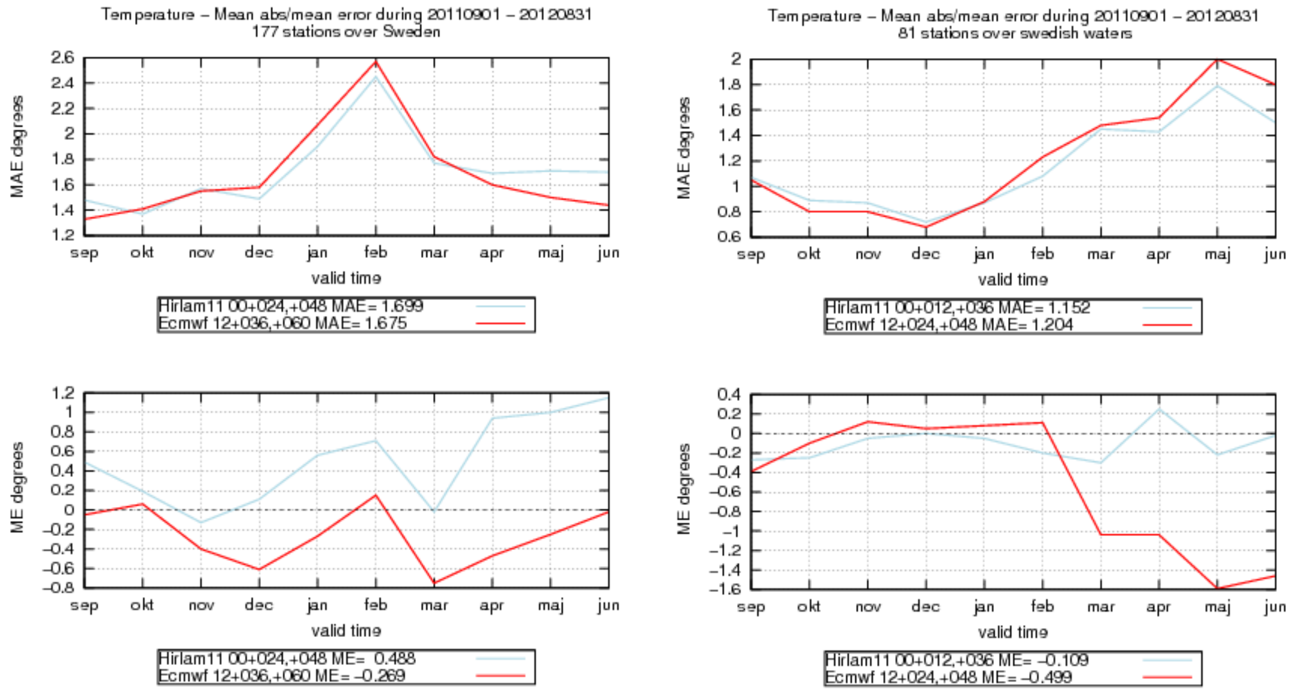

Figure 1 Left panels: MAE (top) and ME for 2 metre temperature over inland and valid at night. Right panels: As for left panels but for stations over Swedish waters and valid at noon.

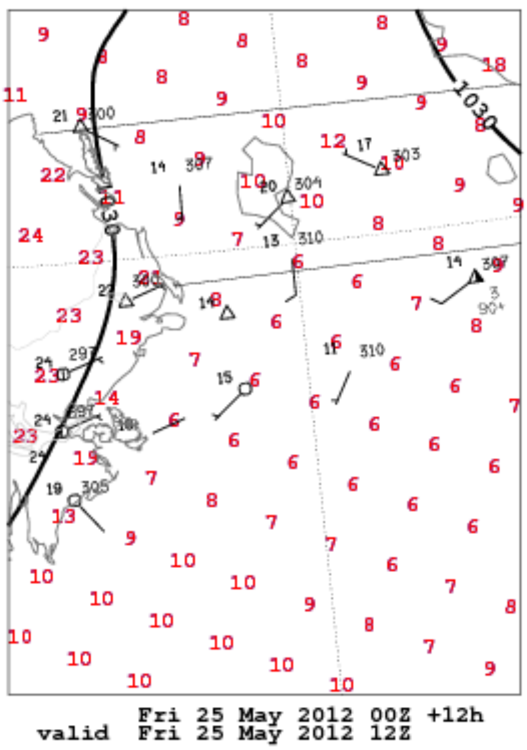

Figure 2 An example of to low forecast 2-metre temperature over sea. Red figures are 2-metre temperature grid point values.

Precipitation

The MAE for the short range precipitation forecasts are more or less the same for Hirlam and ECMWF (figure 3). Both models have a positive bias and Hirlam a somewhat larger. No significant difference in skill score was found between the model results (figure 4).

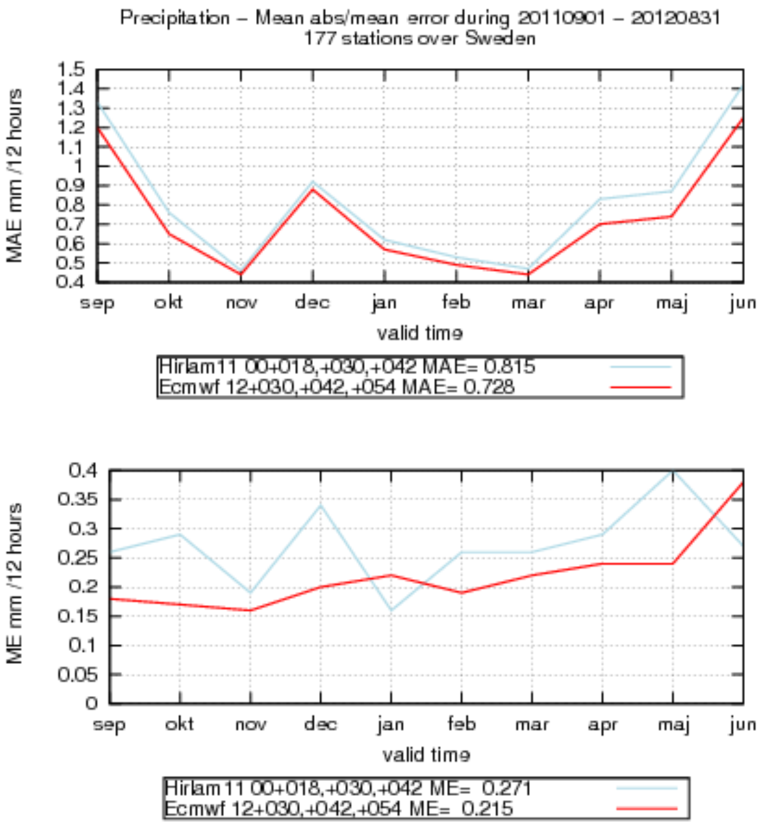

Figure 3 MAE (top) and ME for 12 hour accumulated precipitation forecasts up to 42 hours.

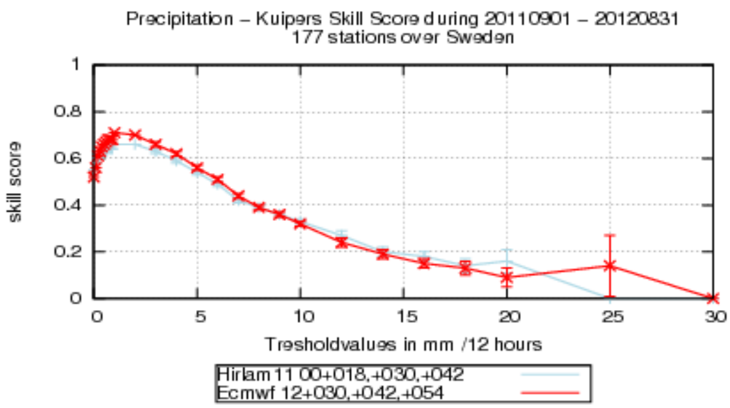

Figure 4 Kuiper's Skill Score (KSS) for 12 hours accumulated precipitation.

The diurnal cycle of precipitation is seen in figure 5.

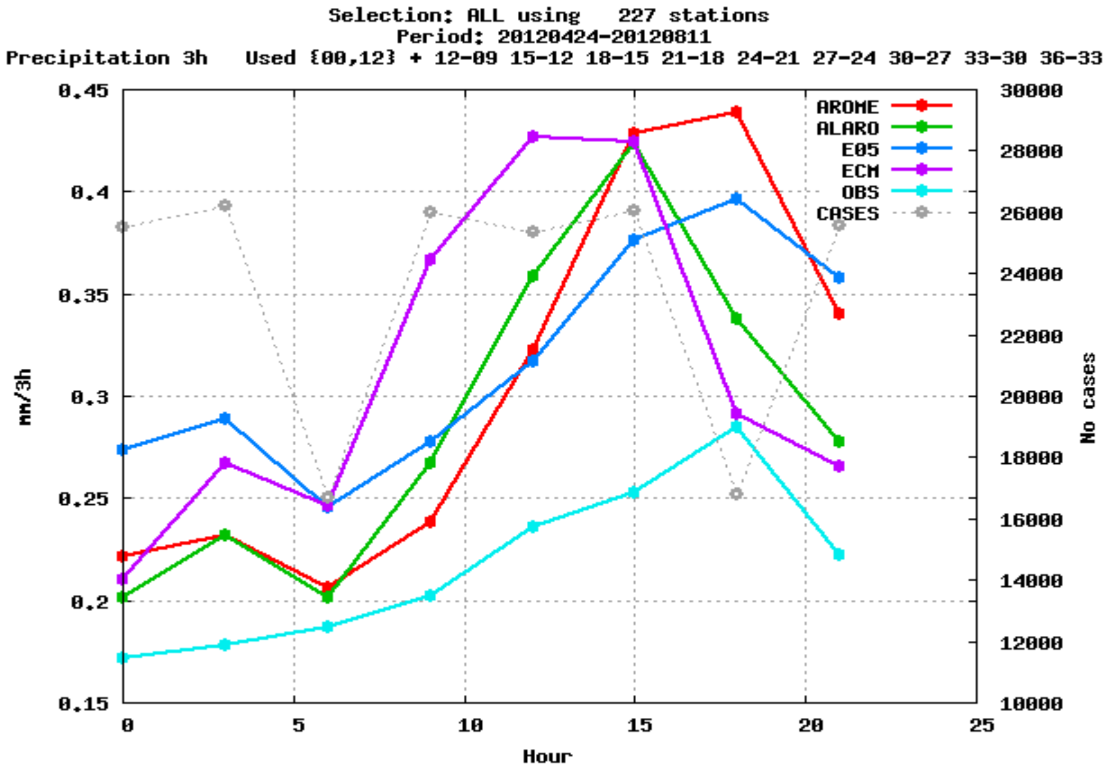

Figure 5 Diurnal cycle of 3 hours precipitation for ECMWF (violet) and some high resolution models run at SMHI. Arome (2.5 km, red) , Alaro (5.5 km, green) , Hirlam 5.5 km with new surface scheme (blue) and observation (light blue) for May, July and beginning of August 2012. (June missing due to technical reasons) The verification area is the northwestern part of Europe.

All models have more precipitation than the observation. It may at least partly be due to observation errors, such as precipitation blowing away from the rain gauges. Arome and Hirlam have the precipitation maximum and minimum mainly at the right position, but for ECMWF and Alaro it is too early.

Skill scores for different thresholds of precipitation show that ECMWF preforms well compared with the high resolution models, when model grid point values are compared with point observations (rain gauges). This is not a prefect way of comparing, but for the moment it is the only available. The result with Kuiper's skill score is seen in figure 6.

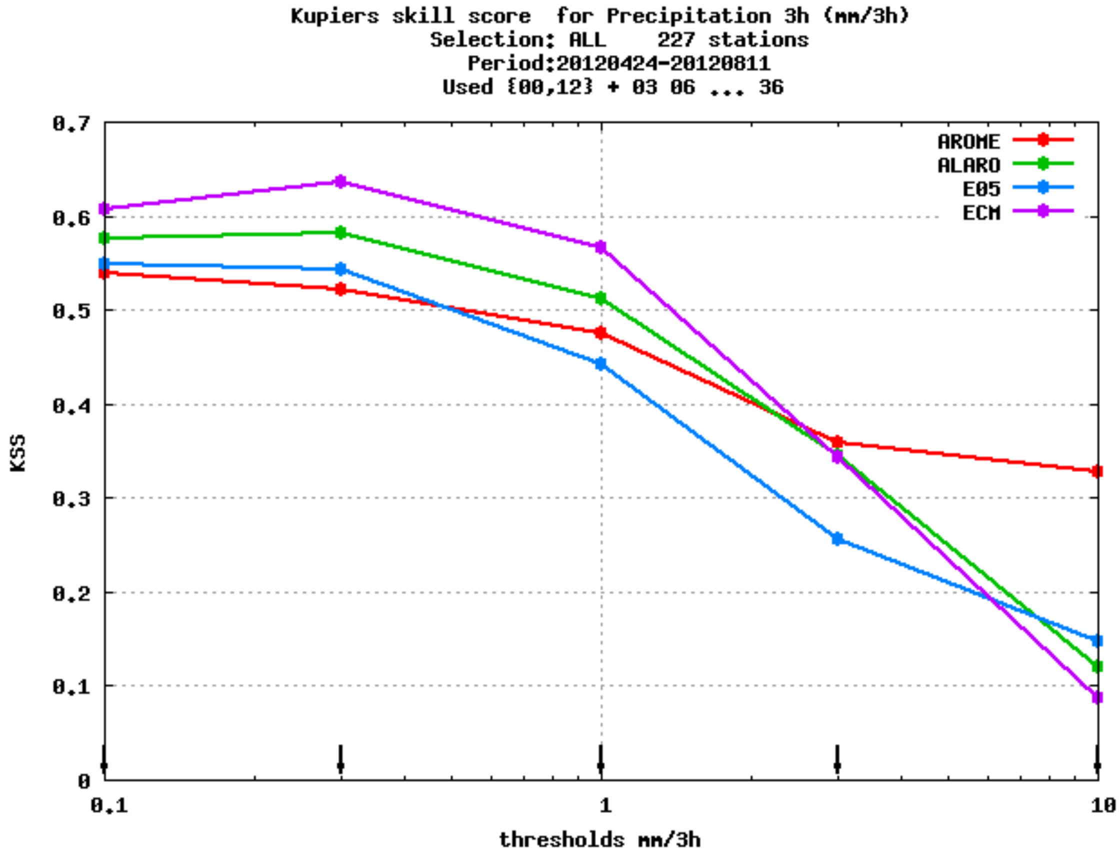

Figure 6 Kuiper's skill score for 3 hours precipitation. ECMWF as violet lines, Arome, red , Alaro green and Hirlam blue. The verification period is May, July and beginning of August 2012. The verification area is the northwestern part of Europe.

ECMWF has best score for the lower precipitation thresholds. For more than 10 mm in 3hours Arome is the best.

Cloud base

The cloud base has been verified against the automatic stations which are able to detect clouds up to 7.5 km. The frequencies of the mean cloud base (threshold 2 octas) is seen in figure 7.

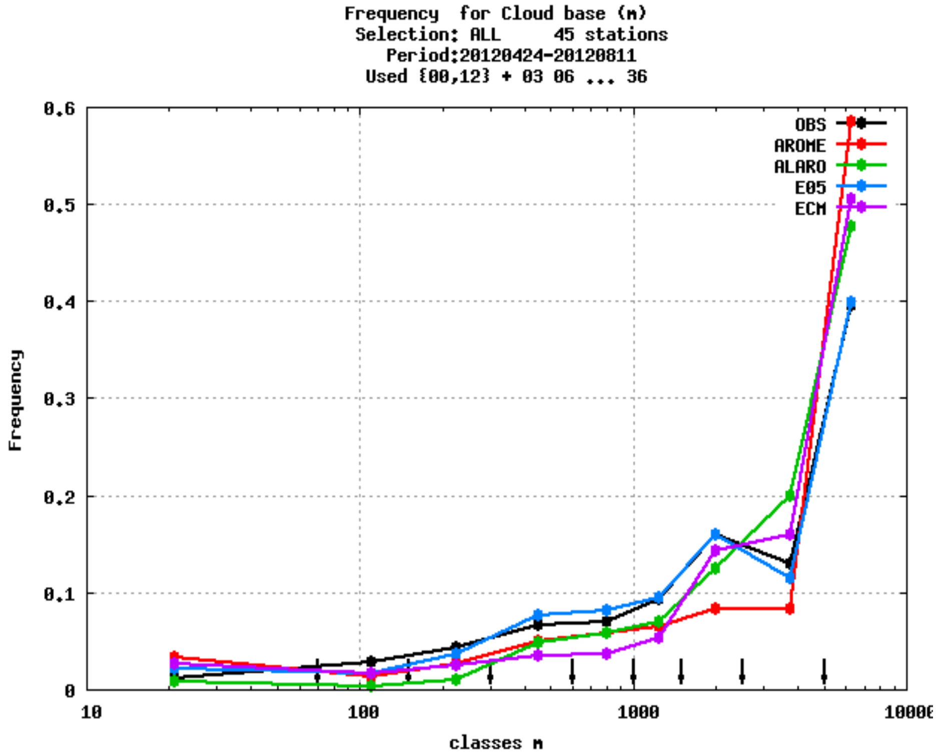

Figure 7 Relative frequency for cloudbase (at least 2 octas) ECMWF as violet lines, Arome, red , Alaro green and Hirlam blue. Observation is in black. The verification period is May, July and beginning of August 2012. The verification area is the northwestern part of Europe.

The lowest threshold is in practice fog or very low clouds. All models, except Alaro has a higher frequency of cloudbase for the lowest threshold than the observation. For ECMWF (and Arome) this is often seen over sea, and may lead to too low 2m-temperatures due to radiative cooling of the fog top. One example of that is in fact seen in figure 2. The area with the lowest temperature is covered by spurious fog. Between 100 and 2000m cloud base the ECMWF relative frequencies are below the observation. No large systematic error for Hirlam in this range.

The Kuiper´s skill score for the same verification statistics is shown in figure 8.

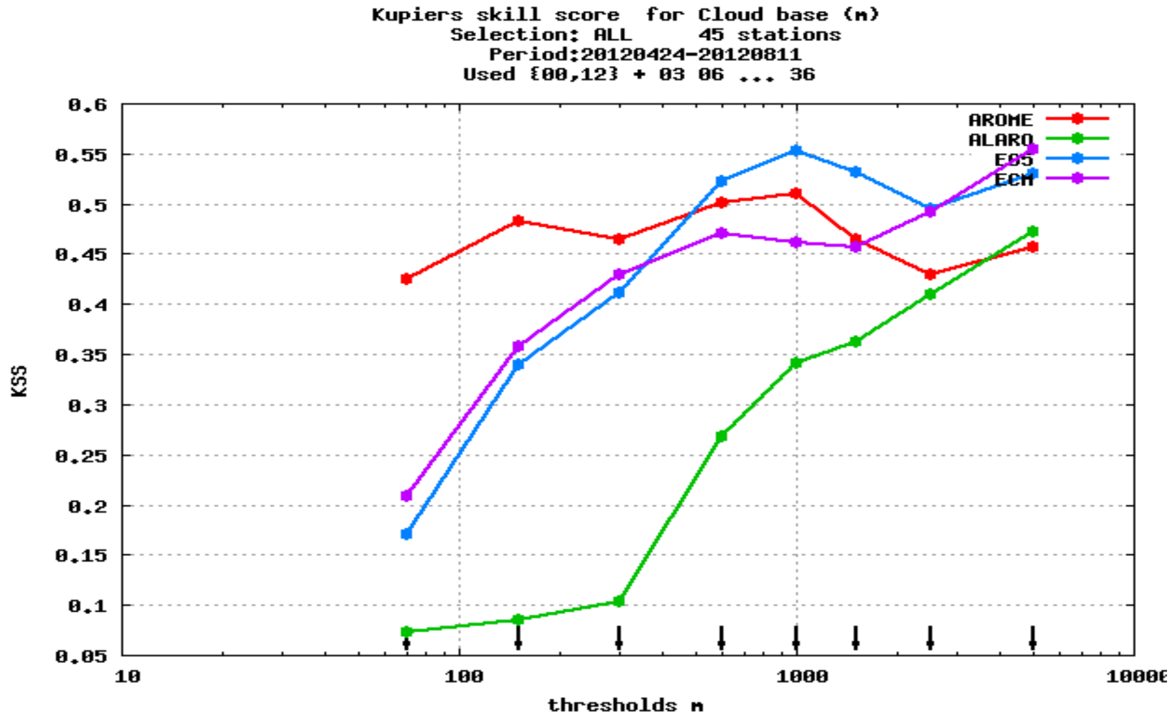

Figure 8 Kuiper's skill score for cloud base (at least 2 octas) ECMWF as violet lines, Arome red, Alaro green and Hirlam blue. The verification period is May, July and beginning of August 2012. The verification area is the north western part of Europe.

Arome is best for low cloud base, but ECMWF is best for the highest ones.

10 metre wind

Both Hirlam and ECMWF underestimate the frequencies of low wind speeds and also overestimates the occurrence of moderately strong winds. This is true, not only for coastal stations (figure 10) but also for inland stations (not shown). For wind speeds over 10 m/s the skill scores for Hirlam is somewhat higher than the ECMWF score values (figure 9).

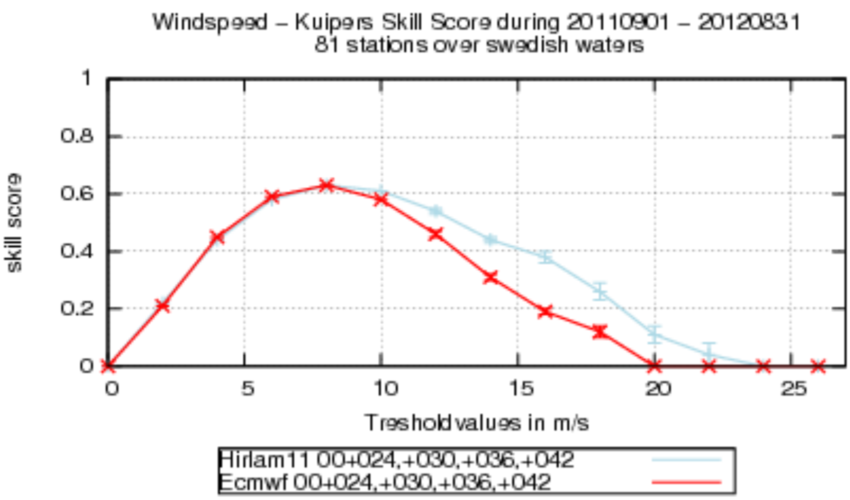

Figure 9 Kuiper's Skill Score (KSS) for Hirlam (blue) and ECMWF (red) for different threshold values. Forecast values are valid one or two days ahead.

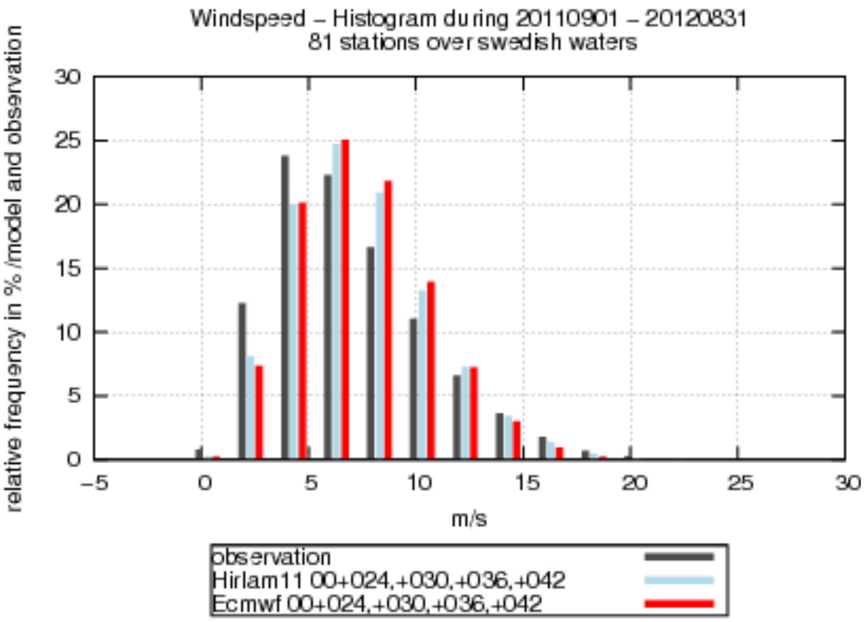

Figure 10 Observed and forecast frequencies of different wind speeds. Observations in black, Hirlam light blue, and ECMWF red.

3.1.3 Post-processed products

At SMHI a Kalman filtering technic is used for 2-metre temperature and 10 metre wind speed forecasts. The correction increments are derived station-wise and then interpolated to a grid using optimal interpolation and using the original forecast as a background field. The method has been in use for several years.

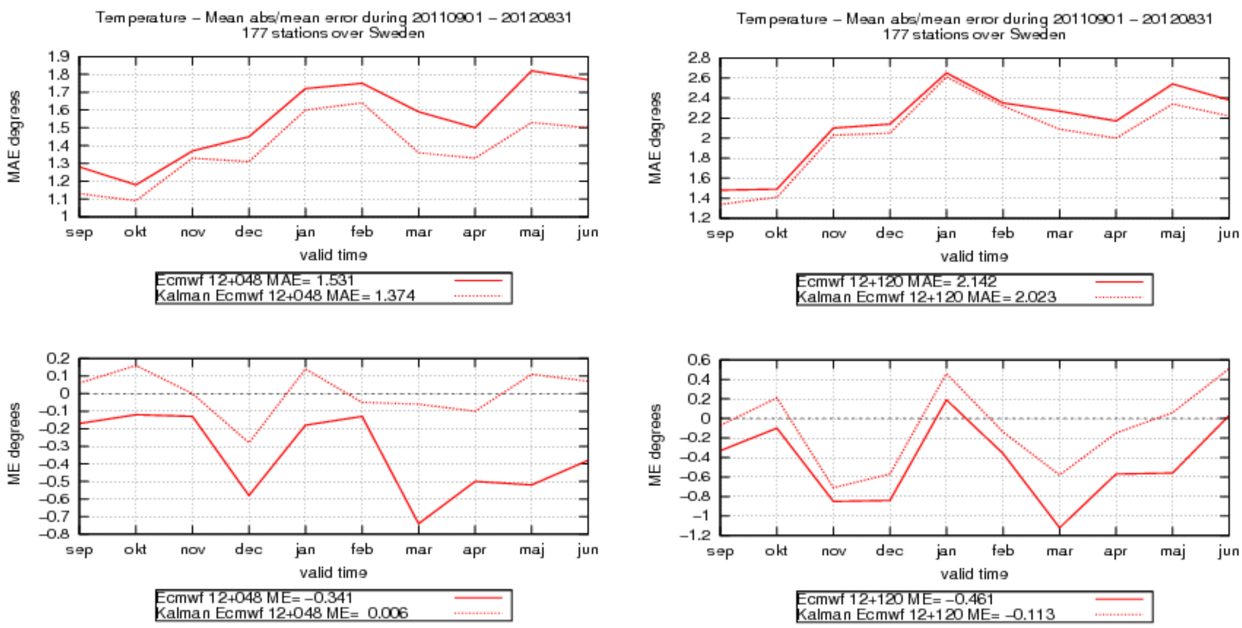

Figure 11 Bottom panels show mean errors and top panels mean absolute errors. The two panels to the left shows the results for a 2 day forecast and to the right for a 4 day forecast. Solid lines are results for the original forecast and dotted lines for Kalman-filtered values.

As can be seen from figure 11 the Kalman filter has a positive impact on forecast quality by reducing both the systematic error and the mean absolute error. The improvement is largest for forecasts valid the first couple of days and is thereafter decreasing.

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 Synoptic studies

4. References to relevant publications