Application and verification of ECMWF products 2011

SMH I– Karl-Ivar Ivarsson

1. Summary of major highlights

ECMWF products are extensively used at SMHI. For the short range, they are used together with products from the limited area models Hirlam and Alaro. Alaro is used with 5.5 km resolution and 60 levels. The Hirlam model is used with two different resolutions, 11km and 5.5 km. 60 levels are used for both resolutions. ECMWF provides boundaries for the 11 km runs while Hirlam 11 provides boundaries for the operational Hirlam with 5.5 km resolution. Hirlam with the resolution of 5.5 km is also running semi-operational with a larger domain than the operational version and has boundaries from ECMWF. ECMWF boundaries are also used for Alaro.

Surface parameter verifications of ECMWF forecasts from July 2010 to July 2011 show good results for 2 meter temperature, 10 meter wind speed and precipitation, but different from for previous years, a more pronounced negative bias of t2m temperature have be noticed this winter and spring. The verification results will be presented in more detail below. The quality of the 2-metre temperature and 10-metre wind speed is further increased by a statistical adoption with a Kalman filtering technique.

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

A Kalman filter is used for adjusting 2 meter temperature and 10 meter wind speed forecasts. The correction increments are derived station-wise and then interpolated to a grid in the forecast database using optimal interpolation and utilizing the original forecast as a background field. This method has been used for several years.

ECMWF data is used for creating wind gust forecasts and thunderstorm probabilities. The wind gust forecasts are used together with wind gust forecasts provided as DMO by ECMWF. The thunderstorm probabilities are valid for forecast length up to five days.

2.1.2 Physical adaptation

The ECMWF model data is used to provide lateral boundary conditions for limited area modelling. There are two different areas. The larger area has a horizontal resolution of 11km and covers Europe and the north Atlantic and the smaller area covers northern Europe with 11 km or 5.5 km resolution. The purpose of the small area is to provide a somewhat more detailed forecast than from ECMWF for the short range and a smooth transition to ECMWF forecasts for the medium range.

HIROMB is an oceanographic circulation model including ice. This model is forced by model data from ECMWF and Hirlam and is run up to 15 days. Hydrological models, dispersion models etc. are also using ECMWF model data as input.

2.1.3 Derived fields

There are a lot of such products. The most important ones are probabilities for thunderstorms, near gale, storm and hurricane force winds. Those probabilities are derived from deterministic ECMWF forecasts.

2.2 Use of products

Many ECMWF products are used for public warnings. The deterministic runs from 00 UTC and 12UTC are used for our quality controlled forecast database, which covers forecast lengths from 0 to 240 hours. The deterministic runs from 06UTC are used experientially for evaluation.

Normally, the deterministic forecasts from ECMWF are used for forecast lengths exceeding 30 – 42 hours and limited area models are used for the shorter forecast lengths. Sometimes ECMWF is selected already from 6 hours. If the ECMWF forecasts show a large degree of 'jumpiness', a 12 hour older ECMWF forecast may be considered as more reliable and may be used instead. An important application is warnings for severe weather for both short and medium range forecasts. ECMWF forecasts have a good reputation as a guideline for those warnings since many years.

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (short-range deterministic)

2 metre temperature

The quality of the ECMWF 2-metre forecast is high and for the short range essentially the same as for the Hirlam model (figure 1). The largest errors occurred during winter which is caused by the difficulty to forecast low temperatures in case of clear sky and snow cover. ECMWF has a negative bias during spring this year which is larger than a year ago. This is seen in figure 1.

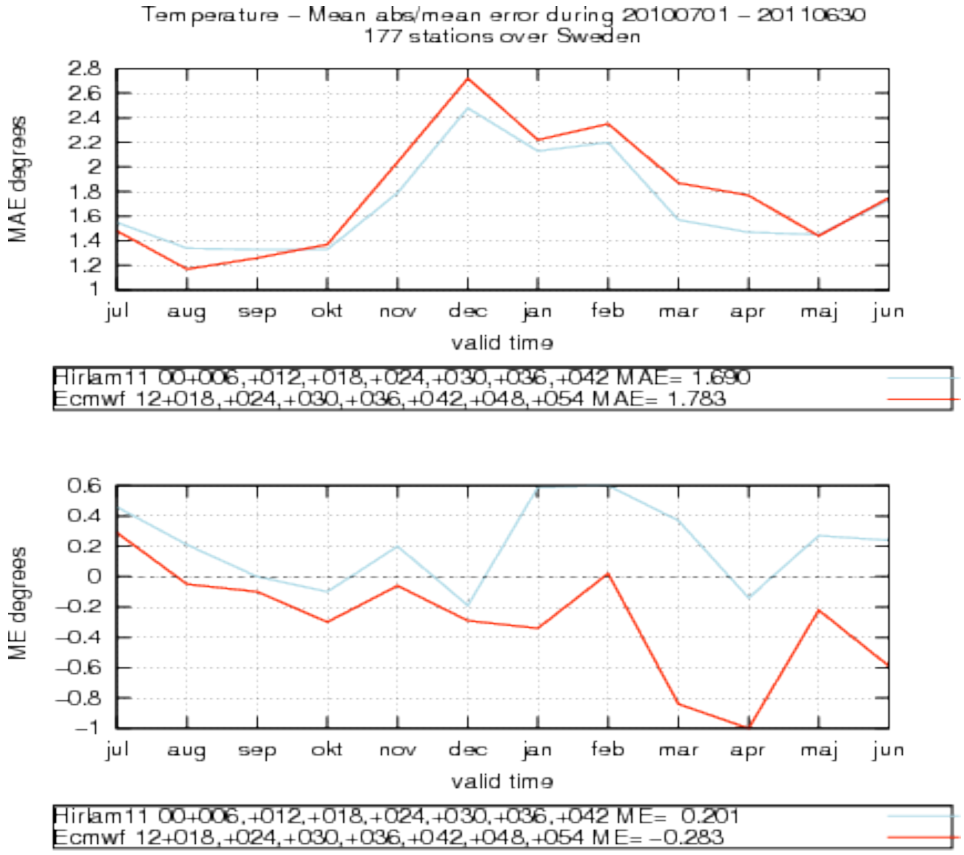

Figure 1 Mean absolute error (top) and bias or mean error, (bottom) for ECMWF (red) and for HIRLAM (light blue) for different months. Note that “operational” verification is used here, which accounts for when the forecasts normally arrive. Only short range forecasts (“ Day 1”) are verified.

SWEDEN

10 metre wind

The verification result of 10 metre wind over Sweden is seen in figure 2.

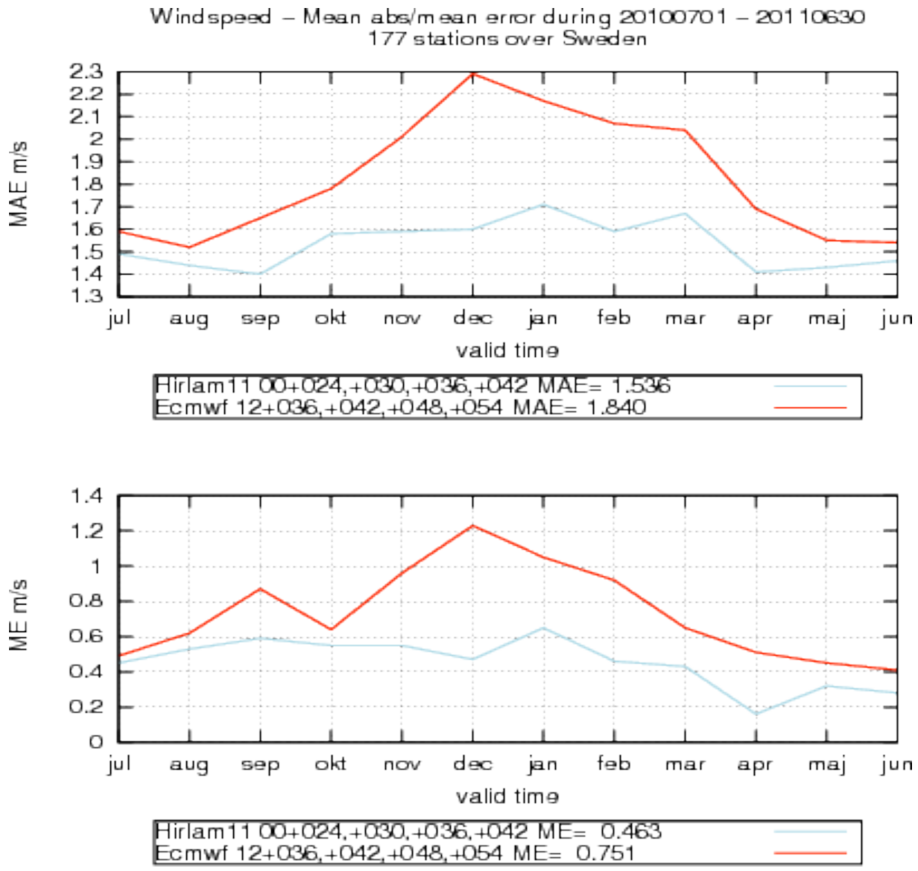

Figure 2 ECMWF (red) and Hirlam (light blue) mean 10-metre wind speed for Swedish stations and for different months. Above is the mean absolute error and below the mean error (bias). Note that "operational" verification is used here, which accounts for when the forecasts normally arrive. Only short-range forecasts (" Day 1") are verified.

There is still an overestimation of the 10 metre wind with up 1 m/s (figure 2) for inland stations, most clearly seen in winter. (inland stations are the most common stations in this verification.) But over ocean there is probably an underestimation instead, but this is hard to verify due to absence of observations.

Total cloud cover

The forecasts of total cloud cover and of clouds at different levels are generally of a high quality. But the diurnal cycle of total cloud cover is a little over-predicted, except in winter. One example of this is seen in figure 3.

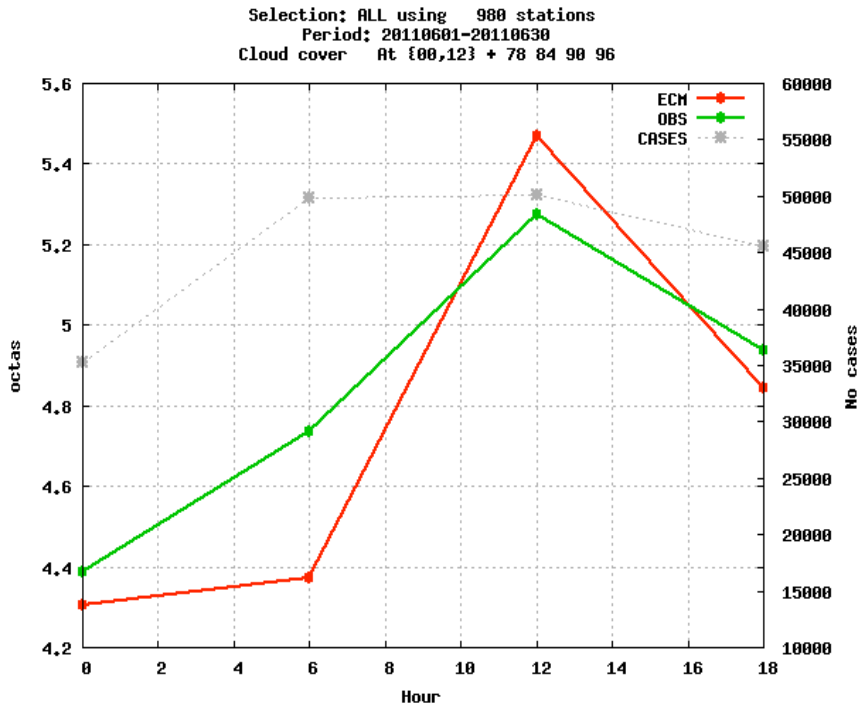

Figure 3 Mean ECMWF forecasts of total cloud cover for different time of the day in UTC for northern Europe in June 2011. Forecasts for day 4 (78 to 96 hours forecast time) in red. Corresponding mean observations in green.

For 12 UTC there is too much cloud cover in the model, the opposite is seen for other times of the day.

Verification against soundings

The verifications against soundings show that the ECMWF forecasts are generally have a higher quality than our limited area models, and with no notable systematic errors, except for that ECMWF seems to be too dry in some parts of troposphere during winter. One example of this is seen in figure 4. But one has to keep in mind that humidity is not easy the measure at low temperatures.

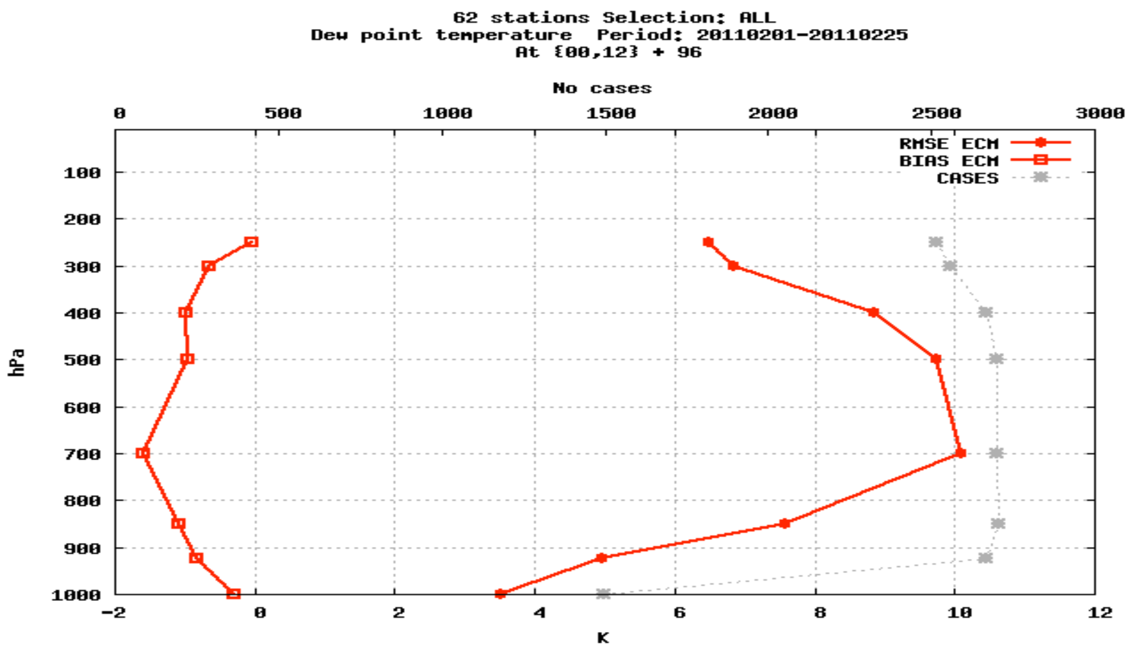

Figure 4 The systematic error or bias (to the right) and RMS error (to the left) for ECMWF forecasts for dew point temperatures for day 4 and different pressure levels. Verification is done against soundings over northern part of Europe during February 2011.

Precipitation

The capability of different models to predict the probability of precipitation over certain threshold values and for different areal sizes can be monitored by using the Fractional Brier Skill-Score (FBSS). The observed and predicted 24 hour precipitations in this study are from April 2010 to March 2011. Observations from the Swedish climate station network (770 stations) have been used. The models are ECMWF, Hirlam with 11 km horizontal resolution, Unified Model with 4 km horizontal resolution (produced by Met.no.), Hirlam with 5.5 km horizontal resolution, and Alaro , also with 5.5 km horizontal resolution. The sample climatology has been used as reference forecast. It is the observed relative frequencies of precipitation during this test period.

Sweden is divided into areas of different sizes. The fraction of observations over a threshold value and corresponding forecast fractions were calculated for each area. Areas with less then 3 observations are not considered. The results for different threshold values and area sizes are seen in Figure 5.

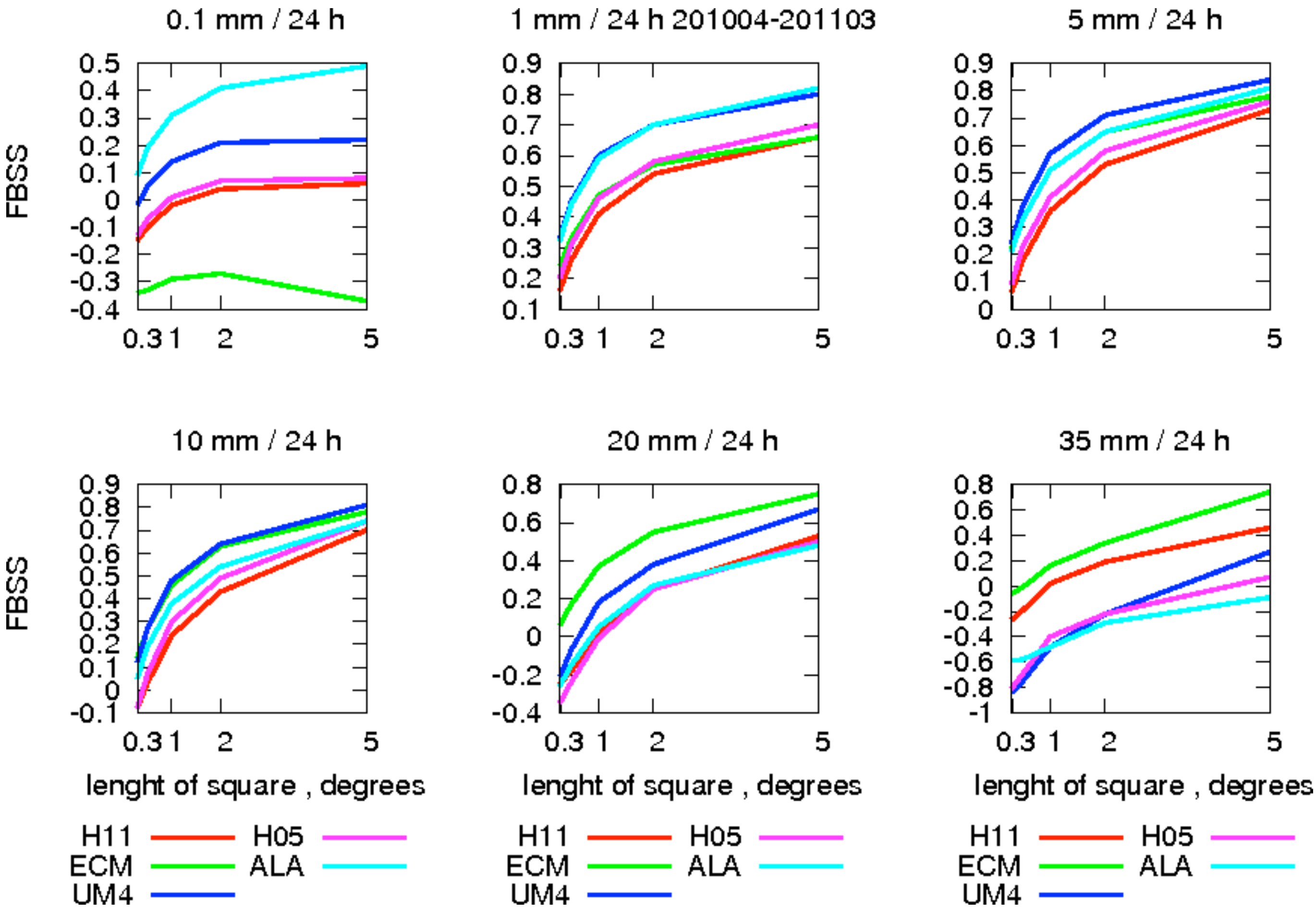

Figure 5 FBSS for different precipitation thresholds and areas. Hirlam 11 km in red, ECMWF in green, Unified model 4km in blue, Hirlam 5.5 km in rose-red and Alaro 5.5 km in light blue. The forecast length is 30 hours and 24 hours precipitation is verified.

ECMWF has the highest skill for most of the area sizes for 35mm, followed by the limited area model with the most coarse resolution, Hirlam 11km. The fine scale models all have problems with forecasting precipitation for that high threshold. For the smallest area, (square of 0.29 degrees, about 32 km) all models have negative skill. But for smaller threshold amounts, Alaro and the UM-model have the best result. As for previous years, ECMWF forecasts are not that skilful for small amounts of precipitation.

3.1.4 End products delivered to users

3.2 Subjective verification

One important forecast variable is the amount of low clouds. Generally, the quality of the low cloud forecast from ECMWF is good, especially in winter. But in very cold conditions, (2-metre temperatures being -25 C or lower) low clouds are over predicted. In spring there is some under prediction. There is often too little of clouds, especially low clouds after passing frontal systems. Those errors have been seen for several years.

The wind gust speed is over-predicted over land. This may be good as a warning in some cases, for instance June 4 this year over northern Sweden when strong gusts occurred in connection with a passing cold front. However, the over prediction leads to an excess of false alarms of severe gusts.

Snow showers generated over the Baltic Sea disappear too quickly when reaching land. This is only a problem in cold winter conditions. One example can be seen in figure 6

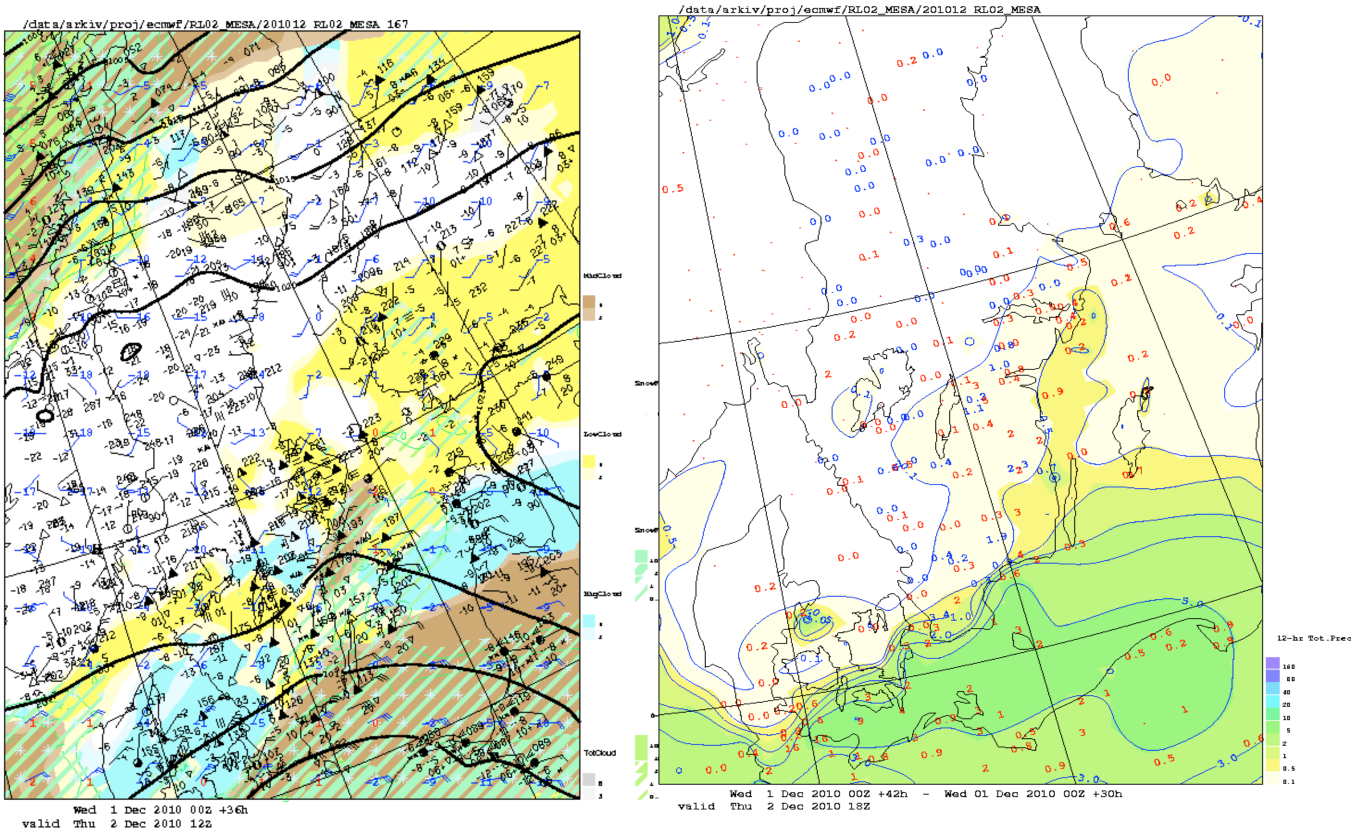

Figure 6 To the left: The figure shows the weather situation with easterly winds over southern Sweden. Thick lines are isobars, precipitation in green, low cloud in yellows, middle level cloud in brown and high clouds in blue. To the right: Precipitation amounts (contour lines) from ECMWF compared with observations (red and blue numbers)

In this case, snow showers appear over the open water in the Baltic Sea. The snow showers move to the west and disappear rather late after reaching the coast, but in the model they disappear to quickly. The precipitation field may also contain local “spots” with high precipitation. It is not known if this is due to the interpolation from Gaussian grid to rotated lat- lon grid or if is originating from the Gaussian grid. Those local “spots” seem not to be present at summertime.