# Application and verification of ECMWF products 2016 at the Finnish Meteorological Institute

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## 1. Summary of major highlights

FMI's forecasts are mainly based on ECMWF and we are generally very satisfied with ECMWF model and products. Still we do have some issues that are more or less persistent, many related to our northern location and our relatively cold climate. Two rather persistent problems with 2m temperature forecast that we have been reporting for several years are negative bias in spring especially in evenings and overforecasting during cold spells. This year we have noticed model having unrealistic sea surface temperatures and we also reported about cases of sea-ice in summertime, which is so unexpected that may be unnoticed by duty forecasters.

## 2. Use and application of products

FMI's forecasts are strongly based on ECMWF deterministic and ENS products. ECMWF data is also utilised as boundary conditions for HIRLAM/HARMONIE which are run at FMI. Usage and demand of monthly and seasonal forecasts is slowly increasing by energy customers, media and general public. ECMWF monthly and seasonal products have a crucial role in long range forecast production although some other sources are also used.

### 2.1 Post-processing of ECMWF model output

Manual editing done by forecasters (by choosing a model(s) to be used as a basis and making necessary adjustments to it) plays a crucial role in our production system concerning forecasts in Finland and Scandinavia. Global forecasts are fully automatic based on raw ECMWF data where 2m temperature is calibrated by height correction and land-sea interpolation. In addition some statistical adaptions are made which are explained in more detail below.

#### *2.1.1 Statistical adaptation*

FMI is strongly developing statistical calibration and post-processing systems. At the moment, ECMWF 2m temperature forecasts are operationally calibrated by using Kalman filtering and MOS in Scandinavia. MOS is still under development but we have already seen very good results. Post-processing is also done to improve wind gust forecasts.

#### *2.1.2 Physical adaptation*

ECMWF data is also utilised as boundary conditions for limited area models HIRLAM and HARMONIE which are run at FMI, dispersion and trajectory models, hydrological models (run by Finnish Environmental Institute), road condition models and wave models.

#### *2.1.3 Derived fields*

ECMWF data is used to calculate parameters that the model doesn't provide by itself e.g. probability of precipitation, probability of thunder and numerous parameters related to aviation weather.

### 2.2 Use of ECMWF products

In severe weather situations ECMWF deterministic model and ENS products are mainly used. EFI products are more widely used in monitoring global weather in situations where forecaster is less familiar with the local climate.

## 3. Verification of products

Verification information is used to monitor the quality of forecast and also to improve our forecasts.

### 3.1 Objective verification

The quality of FMI's weather forecasts are systematically validated. Official scores reported to the ministry of transport and communications are T2m forecast hit rate for one day and 2-5 days, predictability of precipitation based on SEEPS score and verification of wind warnings based on ROC. Besides the official scores, verification data from different data sources is widely used by weather forecasters. For instance, forecasters can easily find both near real time verification results or longer term verification scores and time series. FMI´s verification interface gives a possibility to assess the quality of different model data and further, compare different data sources with each other.

### 3.1.1 Direct ECMWF model output (both HRES and ENS)

In spring time ECMWF has negative bias in 2m temperature forecasts especially in the evenings (Fig. 1). This has been a long-standing challenge for several years which has also been noticed by end users. For example, Finnish Environmental Institute (SYKE) uses ECMWF products in their hydrological models to calculate flood risks. During spring time, when snow is melting, too cold evening temperatures significantly underestimates flood probabilities.

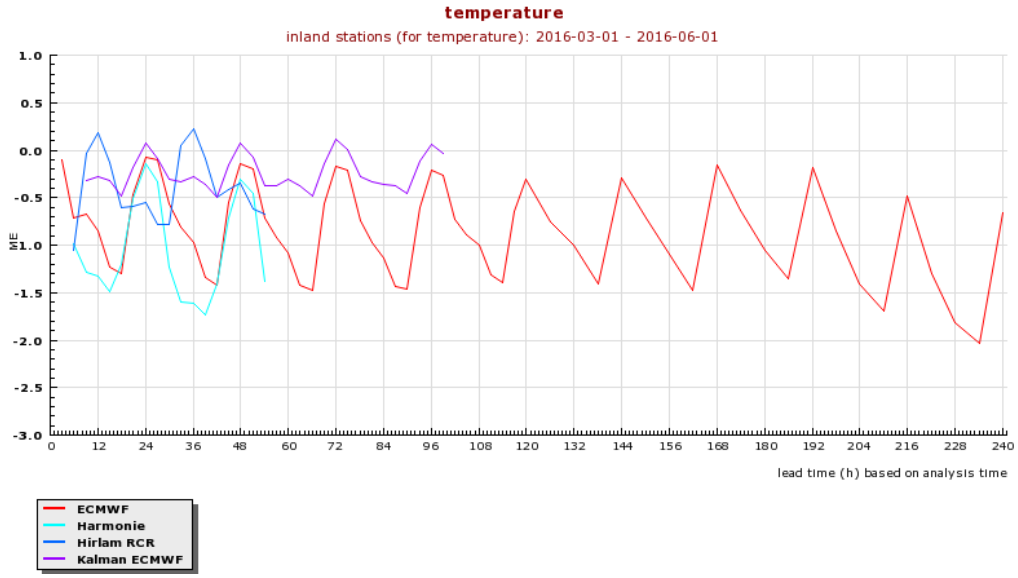



*Fig.1 Temperature forecast mean error in spring (MAM) 2016 for different models. HARMONIE and ECMWF have negative bias in the evening.*

During cold spells and stable conditions ECMWF has problems in forecasting surface inversion strong enough and thus overforecasts 2m temperatures (Fig. 2). This problem has been very persistent and we have already had good correspondence with ECMWF about this. We have understood that this problem is not easily fixed without causing problems in 2m temperature forecast in other parts of the world. Still this causes large forecasting errors in our climate.

We have also noticed model having rather unphysical behaviour in cases of not so cold temperatures with little snow/snowless ground, few clouds and low wind speeds when model forecasts near-neutral surface layer in model soundings and totally misses surface inversion altogether (Fig. 2). We have been thinking that this might be related to model having too much heat flux from the ground to air.

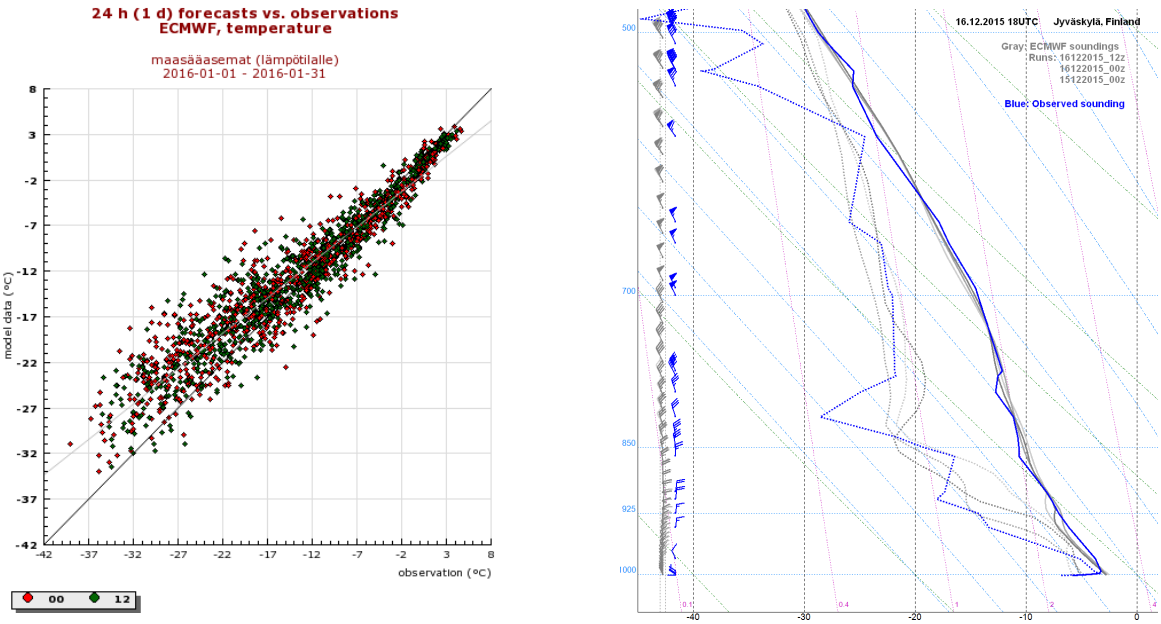
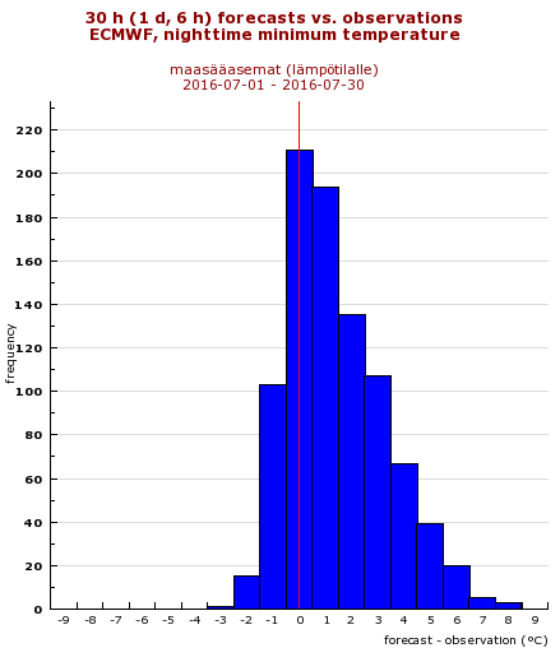



*Fig.2* ***Left:*** *Scatterplot of 24h 2m temperature forecasts vs. observations for Jan 2016 in 30 inland weather stations in Finland shows that ECMWF is overforecasting cold temperatures.* ***Right:*** *Observed sounding (blue curve) and ECMWF model soundings from multiple model runs (grey curves) in Jyväskylä 16th of Dec 2015 18UTC when snowless ground. There is a very shallow inversion near surface which ECMWF misses.*

In summertime ECMWF forecasted too warm minimum 2m temperatures (Fig. 3). This problem was evident in nights of clear skies and low wind speeds when ECMWF was unable to forecast low level inversion (Fig. 3)



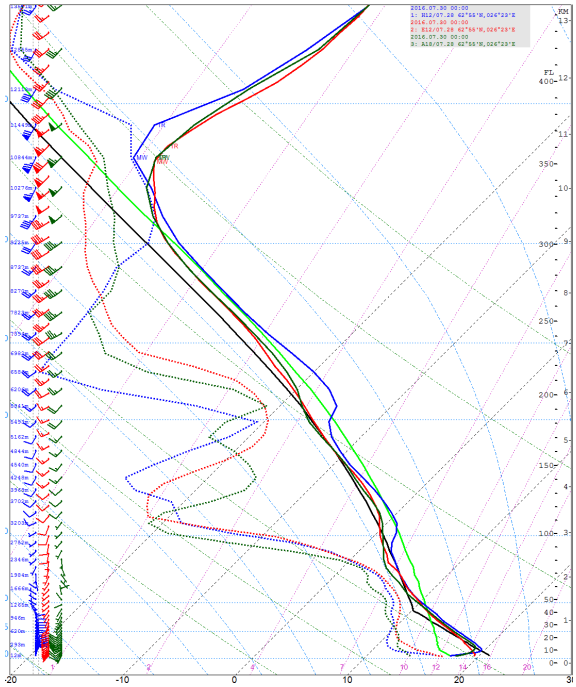
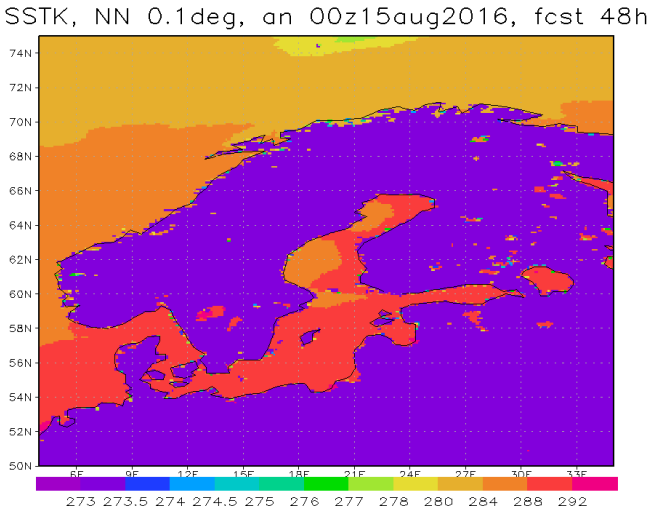



*Fig.3* ***Left:*** *Histogram of ECMWF forecast error of 2m temperature in July 2016 for 30 inland weather station shows that ECMWF is overforecasting minimum temperatures.* ***Right:*** *Nocturnal model soundings in 30th of July 2016 in case of low wind speeds and few clouds. Red curve is the ECMWF, blue curve HIRLAM and green curve HARMONIE in respectively. HIRLMAN and HARMONIE are forecasting low level inversion while in ECMWF the surface layer is almost well-mixed.*

We have noticed some problems in Sea surface temperatures (SSTK) near coastline. When land-sea mask is 100, SSTK seems to be set to 273K (Fig. 4). This seems to cause some gridpoints near coastline (and lakes) to get very cold values of SSTK, which affects larger areas when values are interpolated. This problem seems to have started this summer and is maybe related to IFS change from 40R1 to 41R1 when also land-sea mask changed.



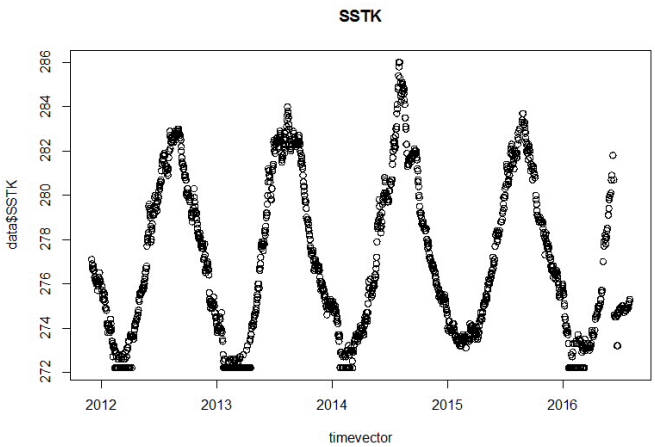




*Fig.4* ***Left:*** *Sea surface temperature in Kelvins (SSTK) over northern Europe shows cold gridpoints in coastline.* ***Right:*** *SSTK in Helsinki (Kaisaniemi) shows unrealistically cold temperatures for this summer.*

In previous year we noticed cases when ECMWF analysed sea ice in sea areas around Finland while in reality there was none (Fig. 5). This of course affected forecasts of 2m temperature. We have already had correspondence about this problem with ECMWF and hopefully we won't be seeing this again.

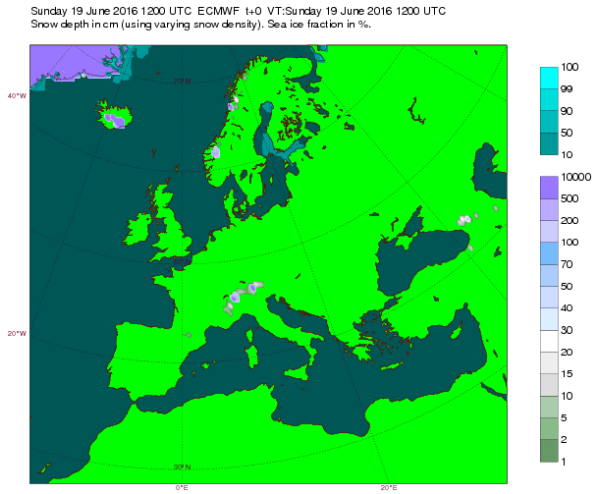



*Fig.5 ECMWF Snow depth and sea ice fraction in 19th of June 2016 shows erroneously sea ice in sea areas near Finland.*

### 3.2 Subjective verification

**Some comments from FMI´s duty forecasters:**

- We noticed some cases where the ECMWF model generated unrealistically rather long living rain showers over lakes, while the weather situation was more favourable to drizzle
- ECMWF is generally forecasting too little low level clouds, but it is most of the times the best model available.
- ECMWF seems to underestimate wind speeds in some smaller low pressure systems e.g. ECMWF may forecast a through passing Finland while in reality a slightly stronger center of low pressure passes Finland causing stronger winds than ECMWF forecasted.

## 4. Feedback on ECMWF "forecast user" initiatives

The "known IFS forecast issues" page is very useful, because it's important to know how well the model works in different weather situations.