Application and verification of ECMWF products 2017

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1. Summary of major highlights

We started to validate some ECMWF parameters and other products for 15 locations in Slovenia and neighbouring countries.

Our operative visualisation systems has been upgraded to include also visualisation of ECMWF visibility fields, cloud ceiling fields and CB top fields (all used mostly for aviation meteorology).

2. Use and application of products

On operational level we use HRES and ENS forecasts (up to 15 days), monthly forecast and seasonal forecast are not used operationally yet.

We follow the results of monthly and seasonal forecast, but we do not issue any additional products for users based on those forecasts.

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

N/A

2.1.2 Physical adaptation

Model output of Boundary Conditions Optional Project is used as lateral boundary condition for ALADIN/ALARO limited area model forecasts. The fields are provided by ECMWF on a common LACE domain and then further interpolated onto 4.4 km model grid of ALADIN. The initial conditions for ALADIN are provided by 3D-Var assimilation. The 72 h production runs use ECMWF model fields with 6-hour time lag, while the underlying 3-hourly assimilation cycle uses ECMWF output without time lag.

The air temperature, precipitation and short-wave solar radiation fields from the ECMWF deterministic model runs are regularly used as input data in the rainfall-runoff model runs (NAM model) scheduled in several setups within the hydrological forecasting system. The latest available meteorological field data are spatially lumped on the river catchments (sizing between 50 and 1000 km2) in time series files. In the model simulations performed every hour the ECMWF time series are applied in the forecasting time interval that is not covered by the ALADIN limited area model forecasts (between +3 and +6 days).

Include limited-area models, hydrological models, dispersion models etc. that use ECMWF model data (HRES and/or ENS) as input (e.g. for initial conditions / boundary conditions / etc.)

2.1.3 Derived fields

N/A

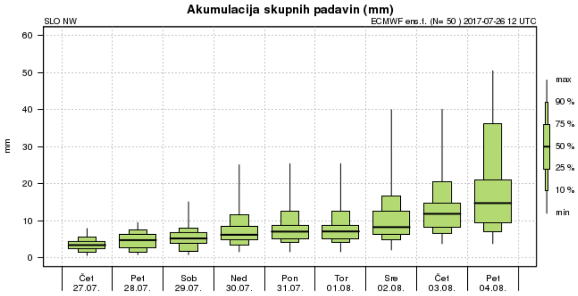
2.2 ECMWF products

2.2.1 Use of Products

ECMWF products are used as a main operative first guess for subjective mid-range weather forecast. Products are made available for forecasters on duty with a help of our visualisation software.

Precipitation fields are inputs to our hydrological models (see 2.1.2).

Our weather warning system produces weather alert levels (green, yellow, orange, red) for 5 days. For alert levels from day 2 ahead we use mostly ENS products. So our decisions are based on ECMWF probabilities for sever weather event. Thresholds are set on local criteria, we do not use ECMWF model climatology, EFI and similar products. Those products are used just as an additional information.



Example of cumulative precipitation based on ENS for NW region

2.2.2 Product requests

N/A

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS)

We verify HRES model morning and afternoon Tmin and Tmax (see 3.1.3), cloudiness, precipitation and wind. Verification was made for day 3 (D3) for 15 regions (Figure 1) in one year time period, which we divided in two seasons – »winter« from October to March and »summer« from April to September. For temperature verification we used MOS, but for other weather parameteres ECMWF 00 and 12 run.

For verification we used a bit modified and simplified version of MeteoSwiss MOVI method (Meteo Swiss Objective Verification Index), which verifies the general impression of weather (weighted sum of verified weather parameters).

To verify precipitation we used 4 classes (no precipitation, less than 5 mm of rain – one rain drop on graphics, more than 5 and less than 30 mm of rain – two rain drops on graphics, more than 30 mm of rain – three rain drops on graphics), for cloudiness 5 classes (clear – 0-10% of clouds, mostly clear – 10-35% of clouds, partly cloudy – 35-55% of clouds, mostly cloudy – 55-85% of clouds, cloudy – 85-100% of clouds) and for wind 3 classes (less than 5 m/s – one wind arrow on graphics, more than 5 and less than 15 m/s – two wind arrows on graphics, more than 15 m/s – three wind arrows on graphics).
Partial score for each weather parameter is from 0 to 100. If difference between model (minimum or maximum) and measured temperature is 2 °C or less, we get partial score for (minimum or maximum) temperature 100, if this difference is more than 4 °C, the partial score is 0. If the difference is somewhere in between 2 and 4 °C, the partial score is between 0 and 100.
Partial score for wind is 100, if measured average wind speed is in model forecasted wind interval, 50, if measured average wind speed is in neighbour interval of model forecasted wind interval and 0 if measured average wind speed is not in the same or neighbour interval.
The same is true for verification of precipitation with addition of partial score 0 in case, when model forecasted precipitation, but it is dry day and in the opposite case, when model did not forecast precipitation, but it is raining outside.
For verification of cloudiness is used equation

$$S_{RS}(f,o) = \begin{cases} 100, & if \;\; a \le o \le b \\ 100 \cdot \left(1 - \dfrac{o-b}{d}\right), & if \;\; 0 < o - b < d \\ 100 \cdot \left(1 - \dfrac{a-o}{d}\right), & if \;\; 0 < a - o < d \\ 0, & otherwise \end{cases}$$

where d is a constant with value 30, o is observed cloudiness, a and b are lower and upper value of forecasted interval for cloudiness.

Precipitation and cloudiness contribute each 30%, minimum and maximum temperature each 15% and wind 10% of value to total score – general impression of the weather. We determined, that weather forecast is accurate, if total score is 90 or more.

We calculated all partial and total scores for one year (divided in two seasons) for all 15 regions, then we calculated percent of accurate forecasts of every weather parameter and the whole forecast itself and also bias for cloudiness and temperature for every region.

As we can see from the graphs below, there are some differences between both EC runs.

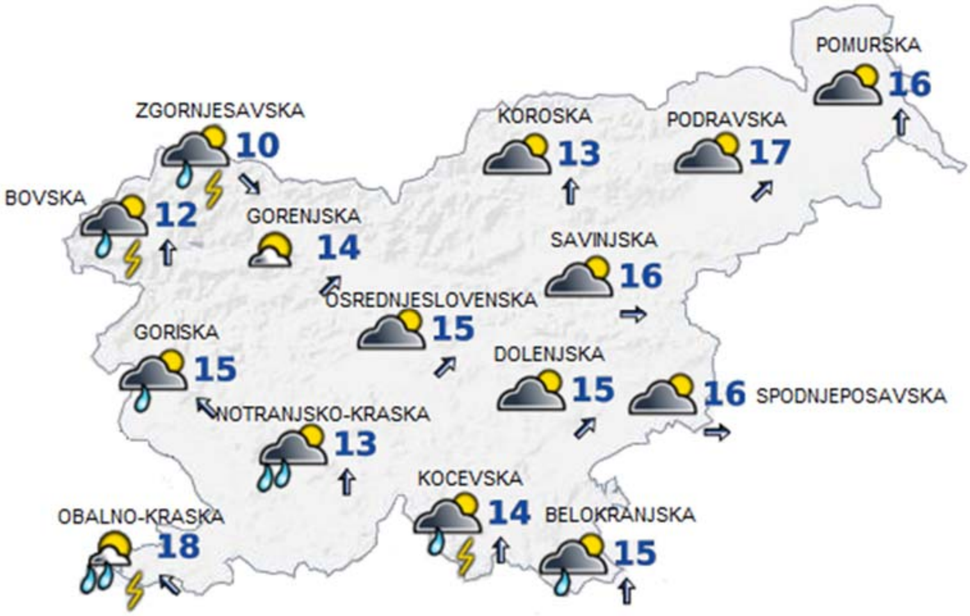


Figure 1: Example of morning model forecast for 15 regions.

<u>Results of verification</u>

Precipitation is better forecasted in winter than in summer season (Figure 4), the reason for this is still problematic forecasting of summer convective processes. Between 70 and 80% of accurate precipitation forecasts are in winter, but mostly between 50 and 60% of them in summer.

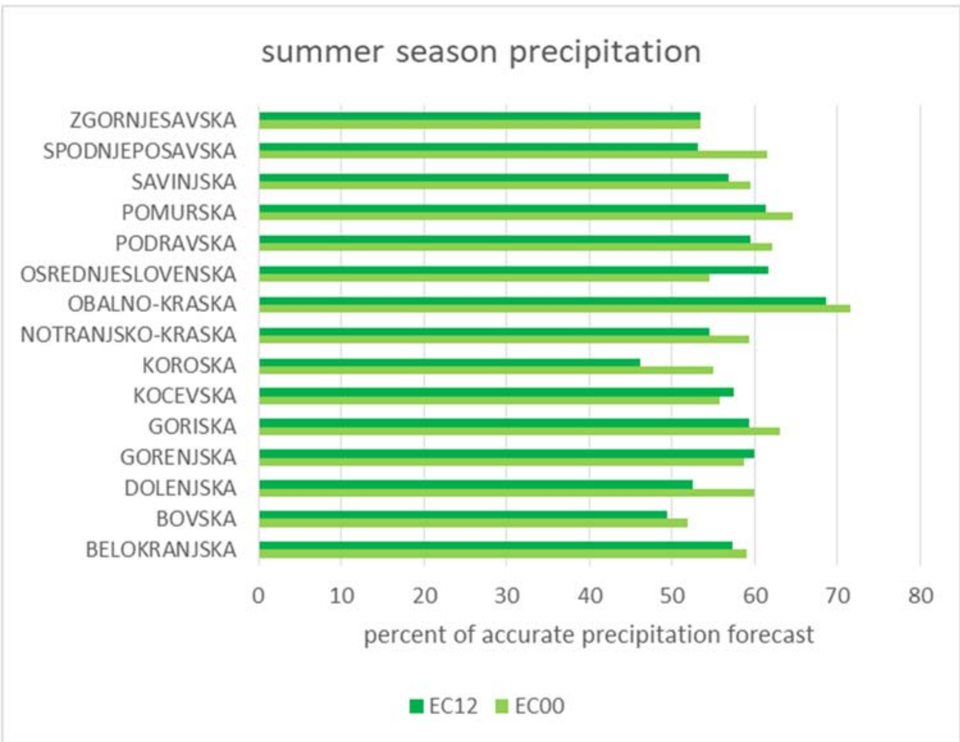
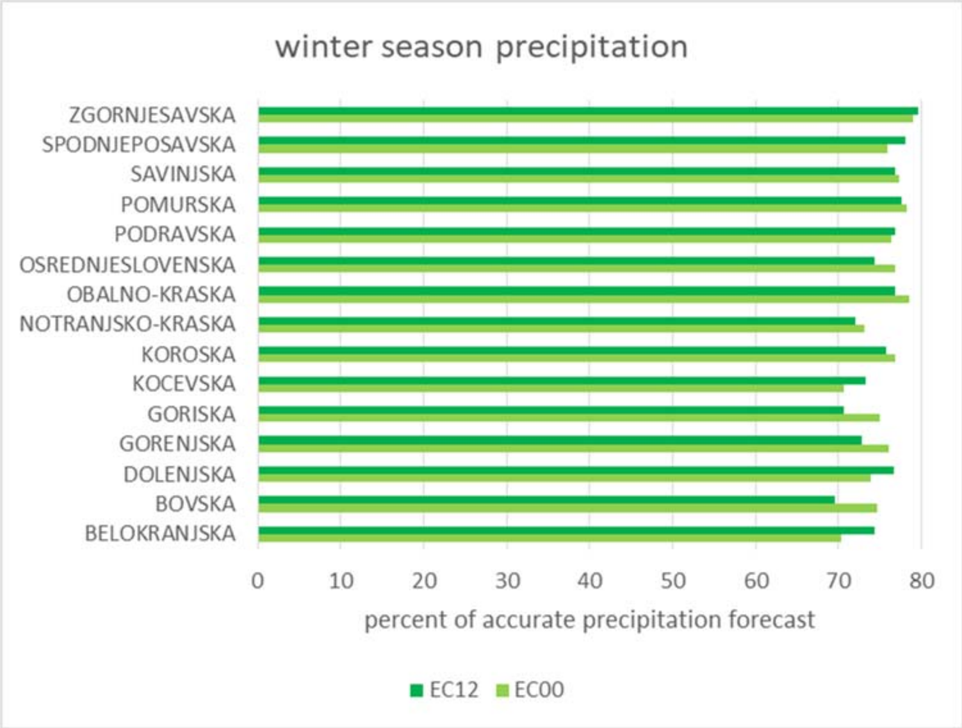


Figure 4: Percent of accurate precipitation forecasts for summer (above) and winter season (below).



The most problematic weather parameter to forecast is cloudiness (Figure 5). Percent of accurate cloudiness forecast is for winter and summer season less than 15, for summer season mostly even below 10%. Problem can be with interpretation of cloudiness, while presence of high clouds in model do not really mean cloudy weather. EC00 gives for Bovska region less than 5% of accurate cloudiness forecasts, similar is true for EC12 for Obalno-Kraska region.

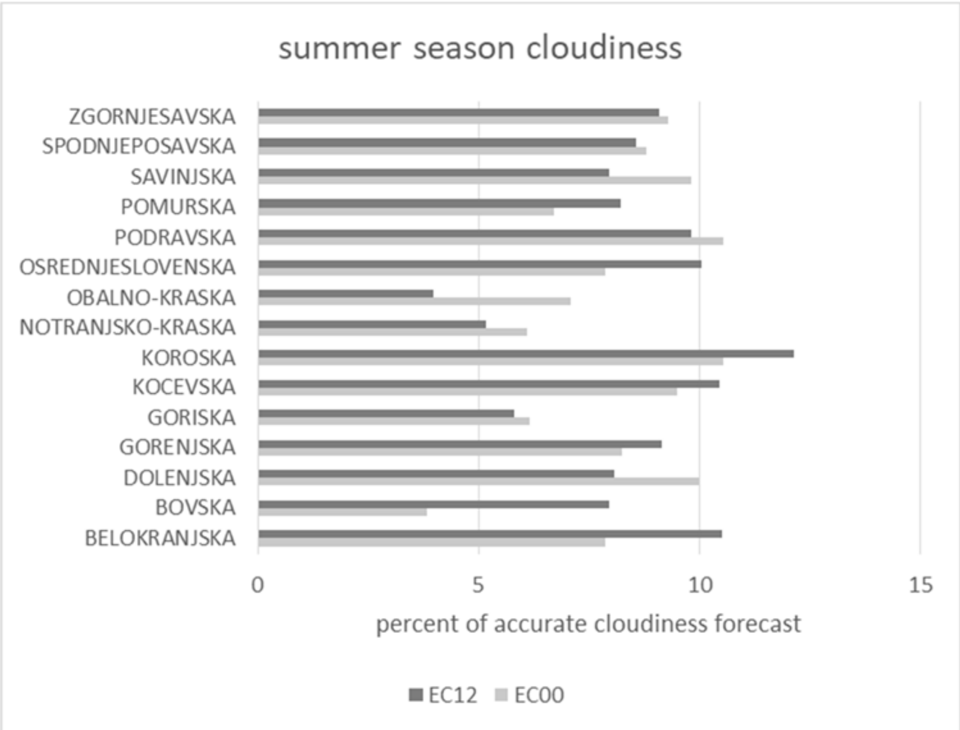
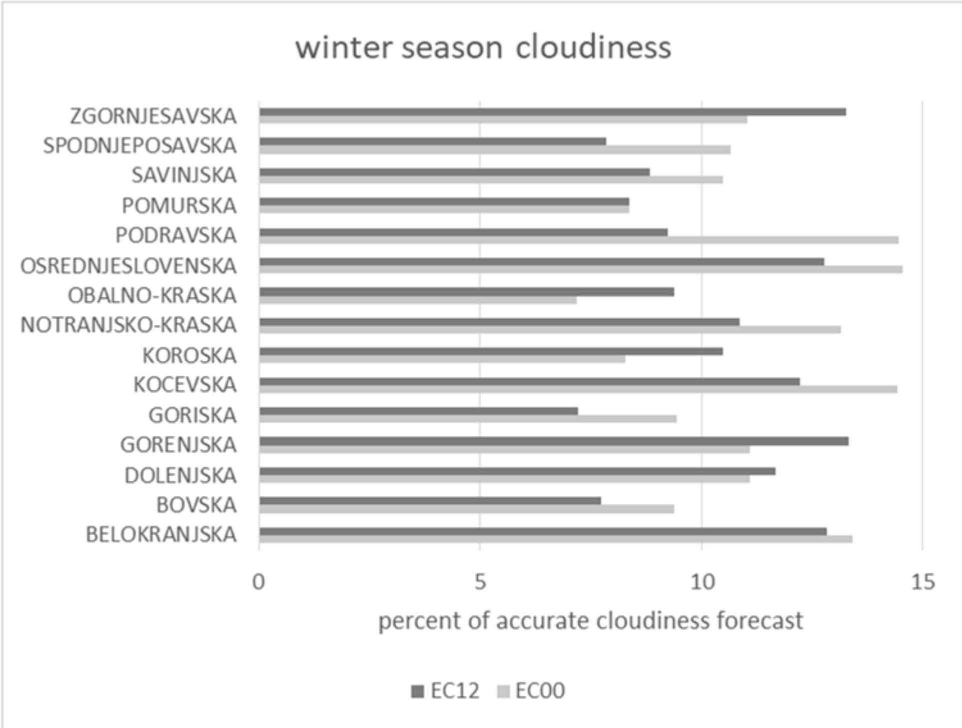


Figure 5: Percent of accurate cloudiness forecasts for summer (above) and winter season (below).



For most regions on average in the morning weather forecast is a bit sunnier (Figure 9) and in the afternoon is cloudier than observed (Figure 10). Afternoon forecasts are for summer season near 1 cloudiness interval cloudier.

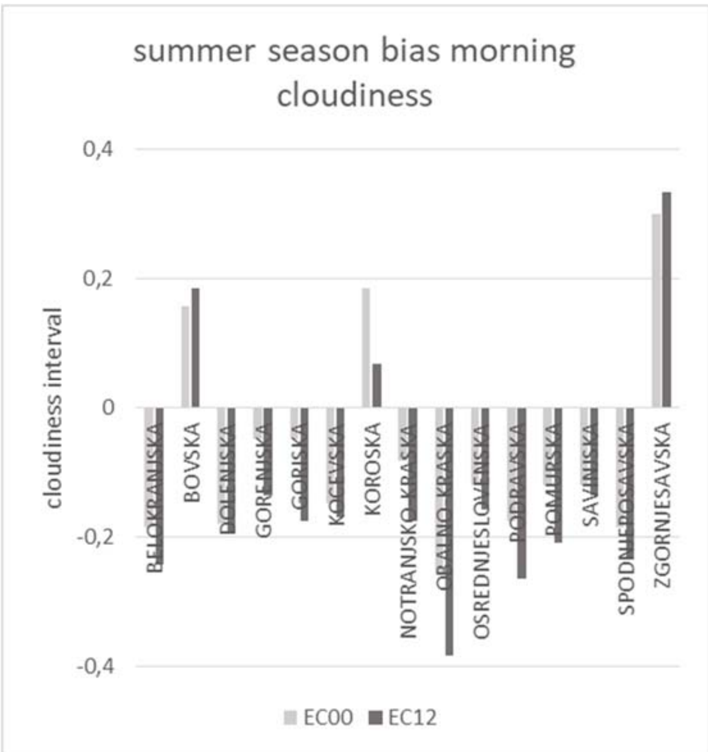
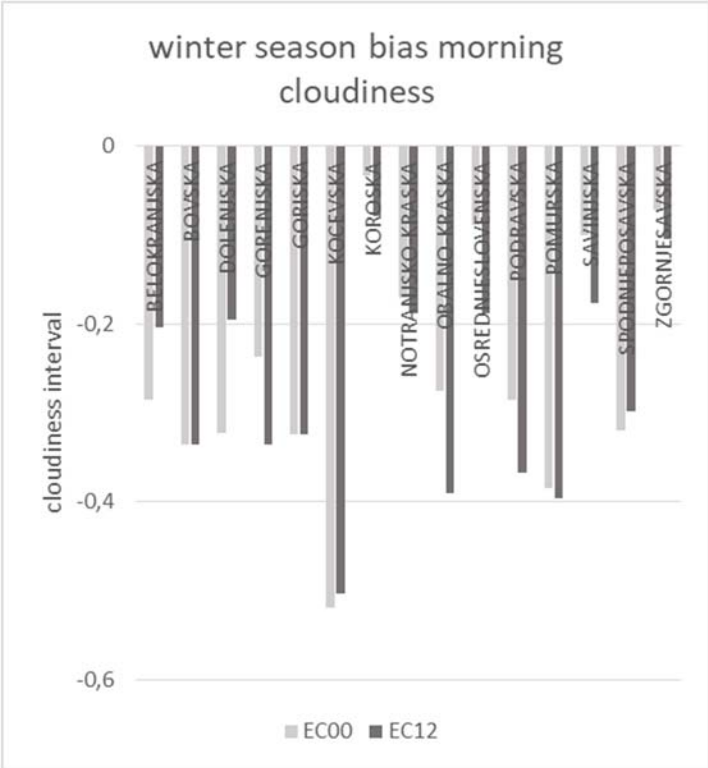


Figure 9: Bias of morning cloudiness forecasts for summer (above) and winter season (below).



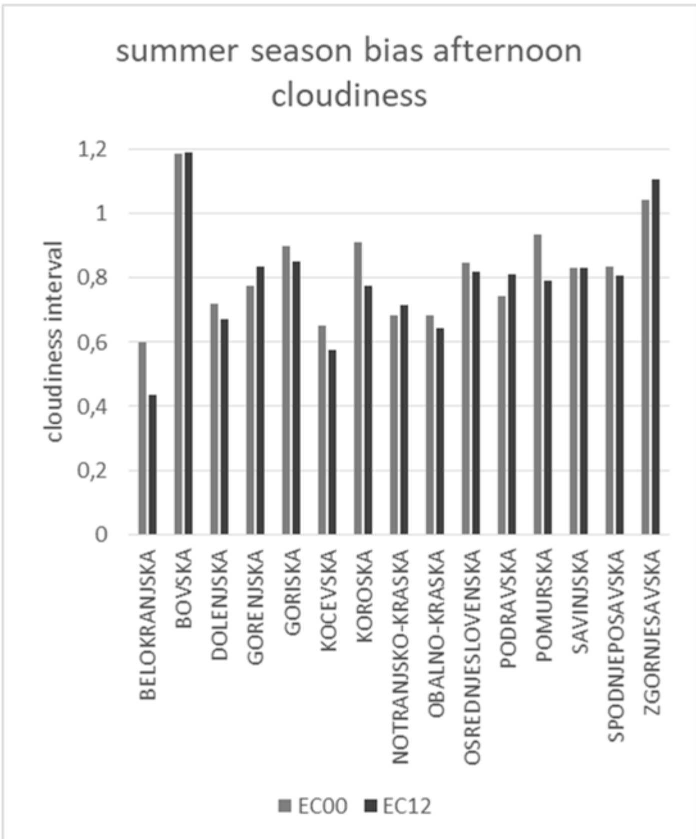
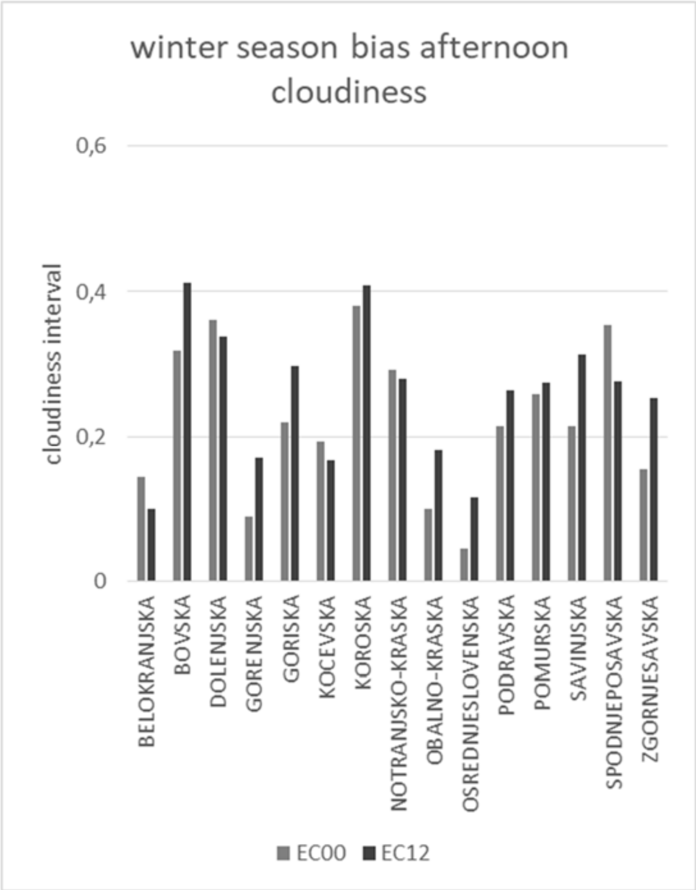


Figure 10: Bias of afternoon cloudiness forecasts for summer (above) and winter season (below).



Due to inaccurate cloudiness the percent of accurate forecasts is mostly below 25% (Figure 6).

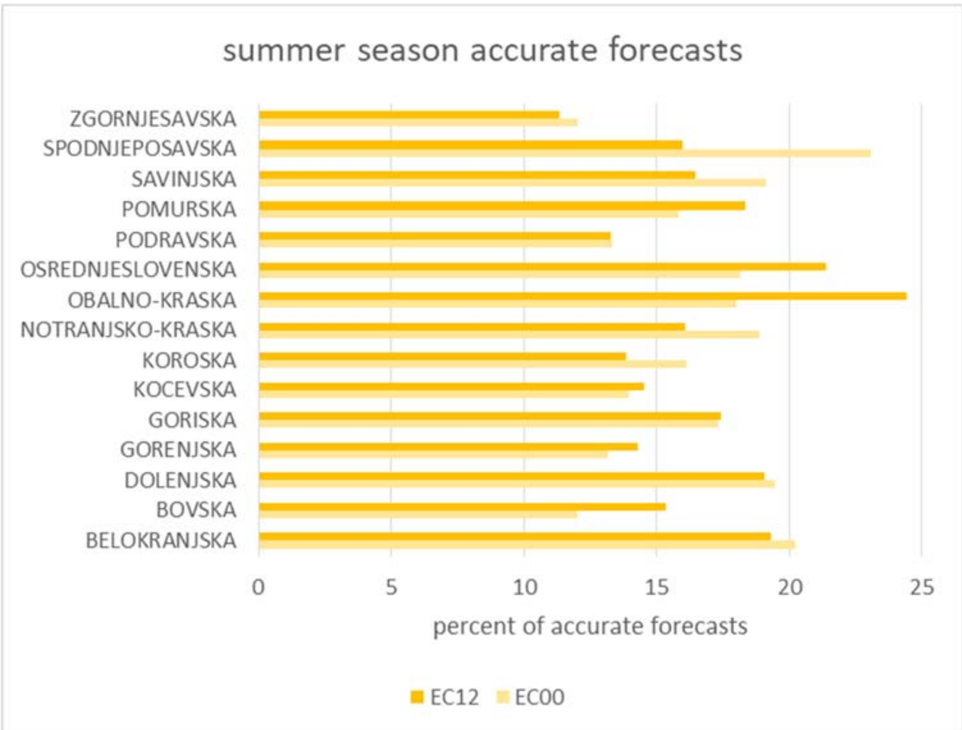
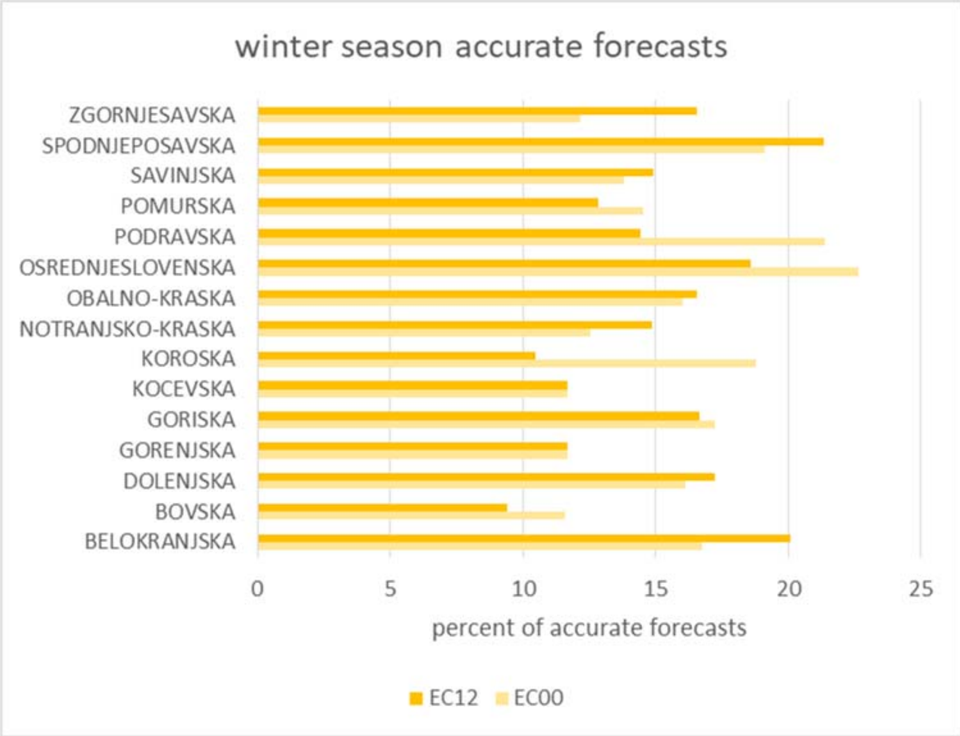


Figure 6: Percent of accurate forecasts for summer (above) and winter season (below).



3.1.2 ECMWF model output compared to other NWP models

N/A.

3.1.3 Post-processed products

We verified point weather forecasts for minimum and maximum temperature based on MOS (Model Output Statistic) results. The statistical metod for verification is described in 3.1.1.

Accuracy of minimum temperature forecasts is shown in Figure 2. In general, more common accurate minimum temperature forecasts are in summer. EC12 is in summer for all regions better than EC00, in most cases for 10%. Except for Gorenjska region, where is around 60%, in other regions are around 70 or even more than 80% of EC12 accurate minimum temperature forecasts. For winter region, the opposite is true, EC00 is better than EC12. In most cases are between 60 and 70% of accurate minimum temperature forecasts.

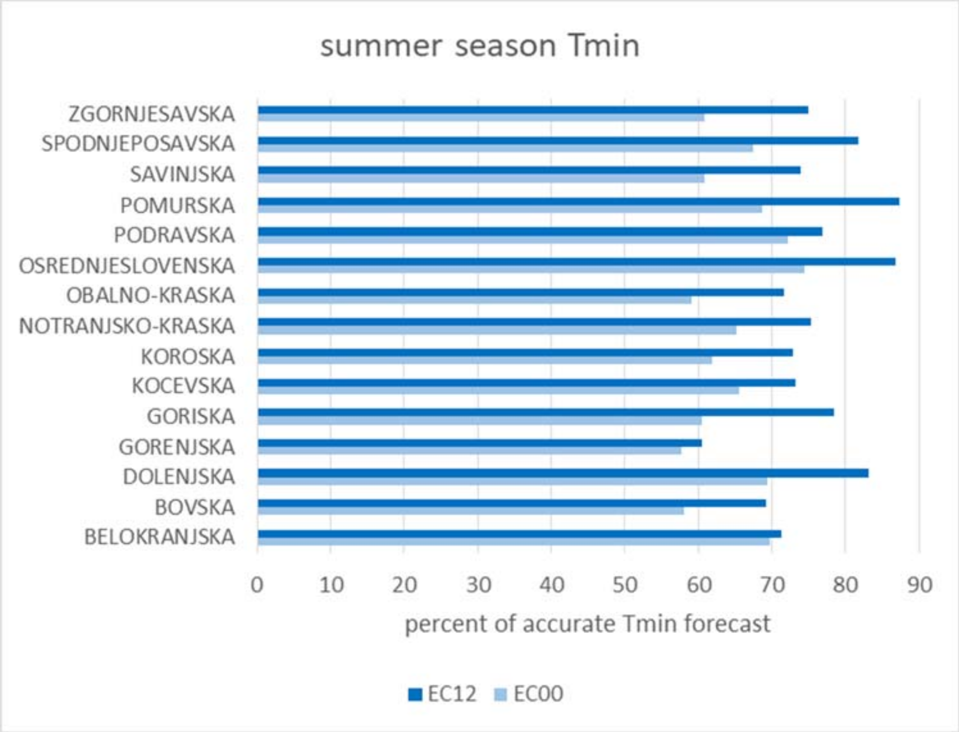
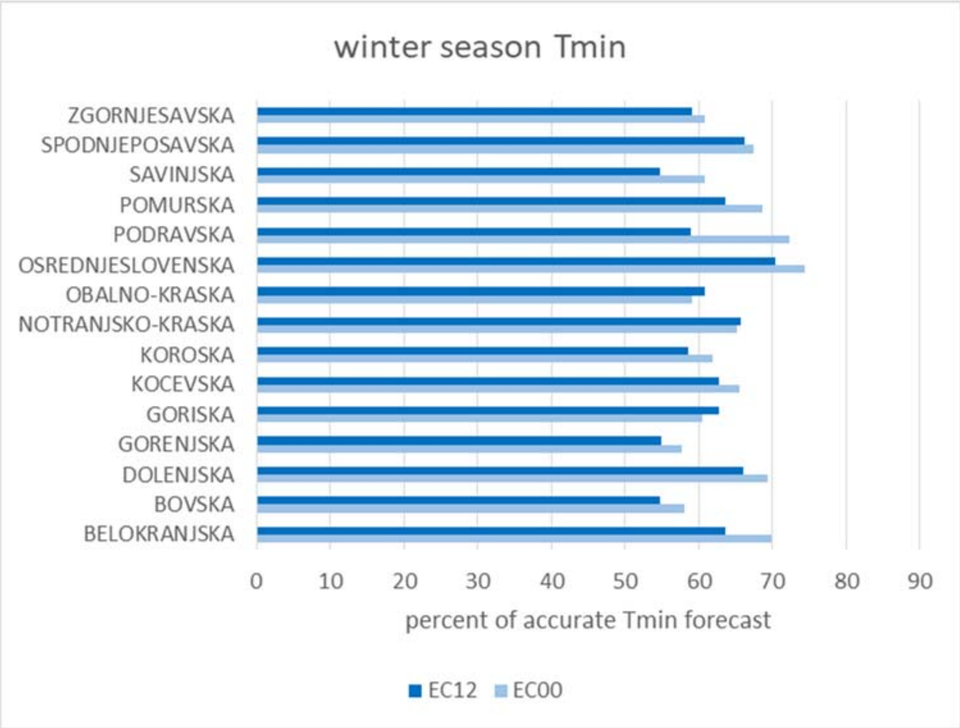


Figure 2: Percentage of accurate minimum temperature forecasts for summer (above) and winter season (below).



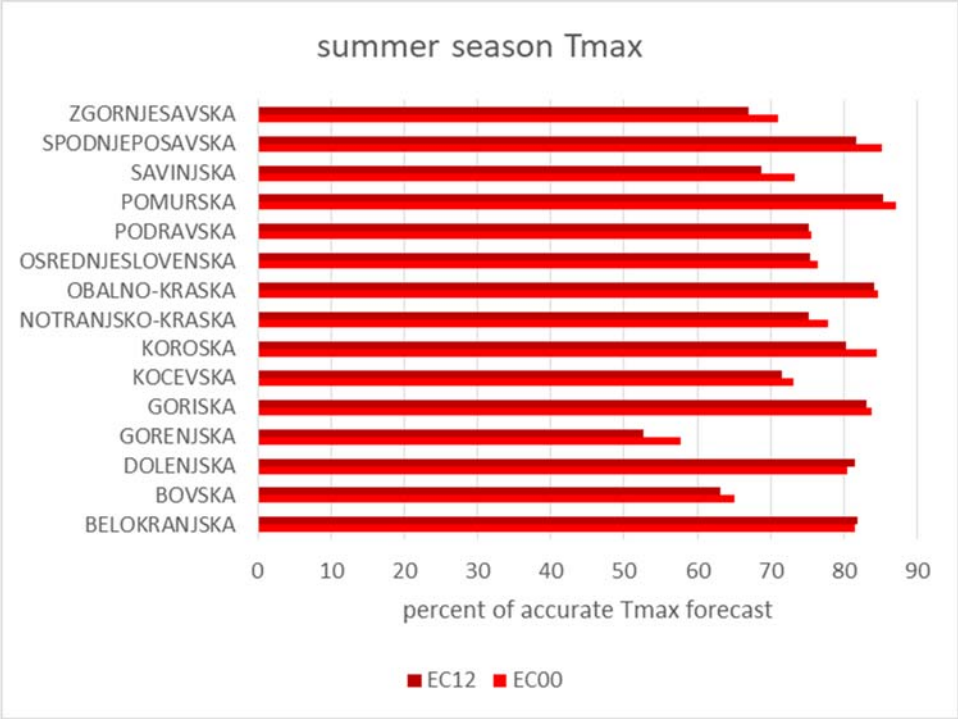
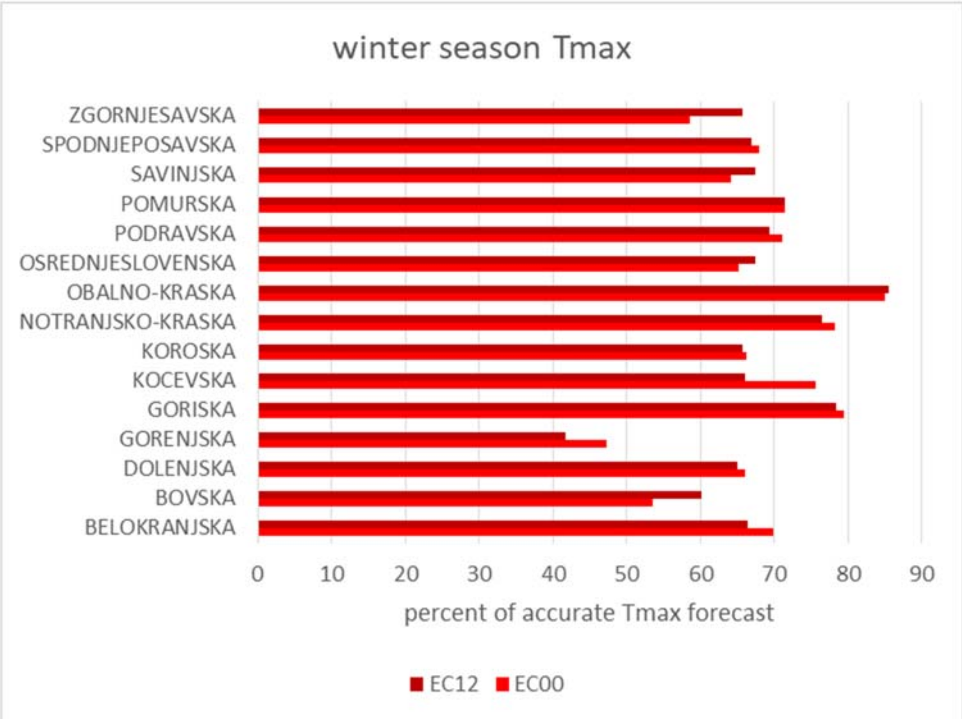


Figure 3: Percent of accurate maximum temperature forecasts for summer (above) and winter season (below).



Similar is true for accurate maximum temperature forecasts (Figure 3) – more common accurate forecasts are in summer than in winter season. There are not as big differences between EC00 and EC12 as they are at minimum temperature forecasts. Again, the smallest percent of accurate forecasts is for Gorenjska region – in summer season between 50 and 60% and in winter season only 40 to 50%. Maximum temperature is, if we compare it with precipitation, cloudiness and minimum temperature, best-forecasted weather parameter for almost all regions.

It is good to look at biases for minimum and maximum temperature forecasts to see, if on average model is forecasting higher or lower temperatures. Bias is calculated as an average difference of forecasted and observed values of weather parameter.

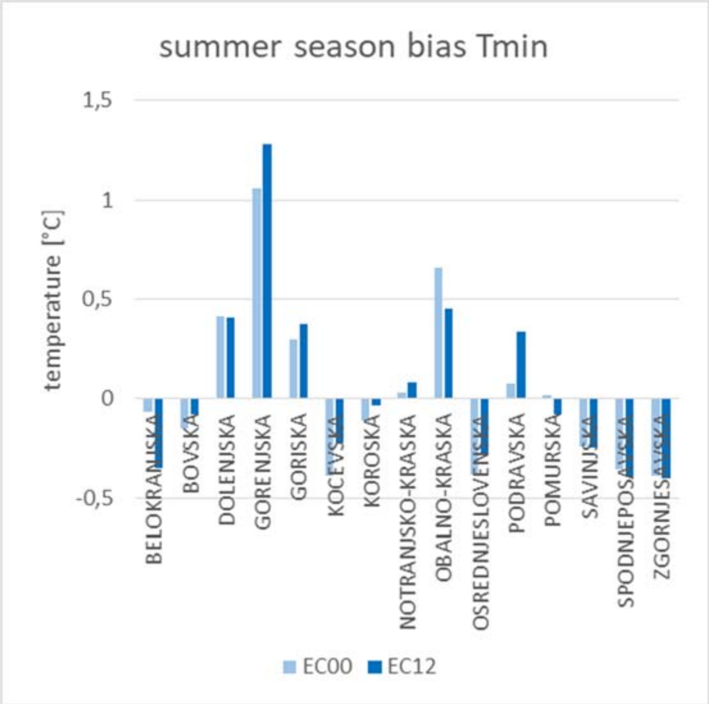
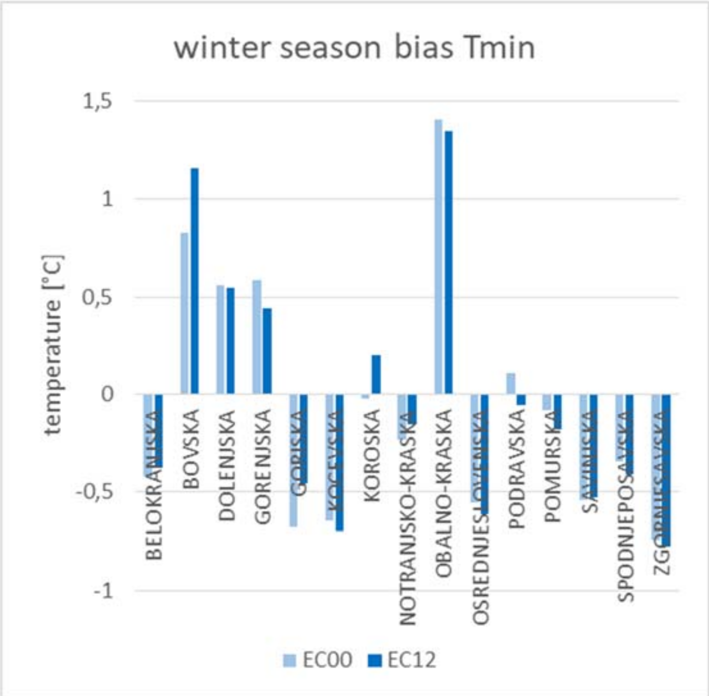


Figure 7: Bias of minimum temperature forecasts for summer (above) and winter season (below).



Bias of more than 1 °C is for summer season minimum temperature forecasts for Gorenjska region, and in winter season for Obalno-Kraska region for EC00 and EC12 and also for Bovska region for EC12 – forecasted values are higher than measured (Figure 7). Smallest bias (around zero) for summer season is for Bovska, Koroska, Notranjsko-Kraska, Pomurska region for both EC00 and EC12 and Belokranjska, Podravska region for EC00. Smallest bias for winter season is for Koroska, Notranjsko-Kraska, Podravska and Pomurska region for both EC00 and EC12.

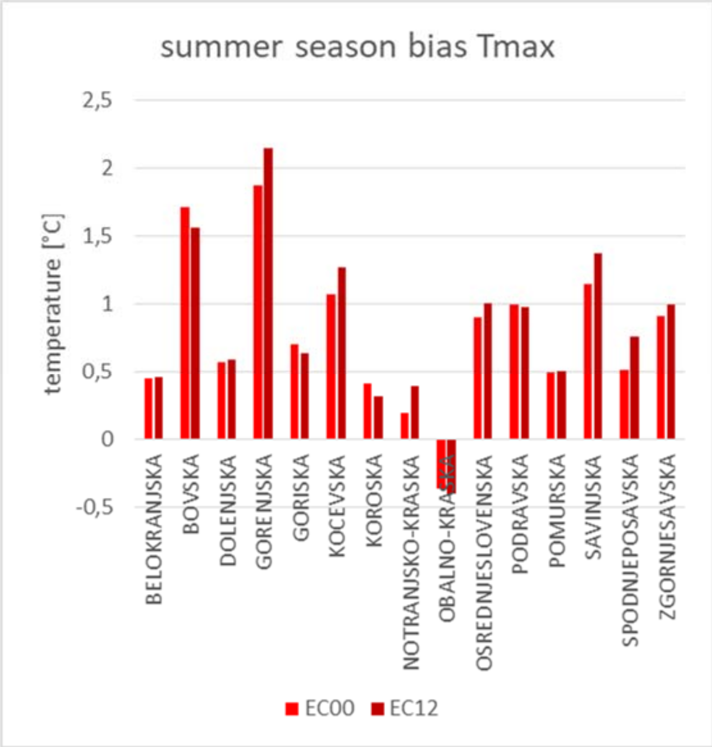
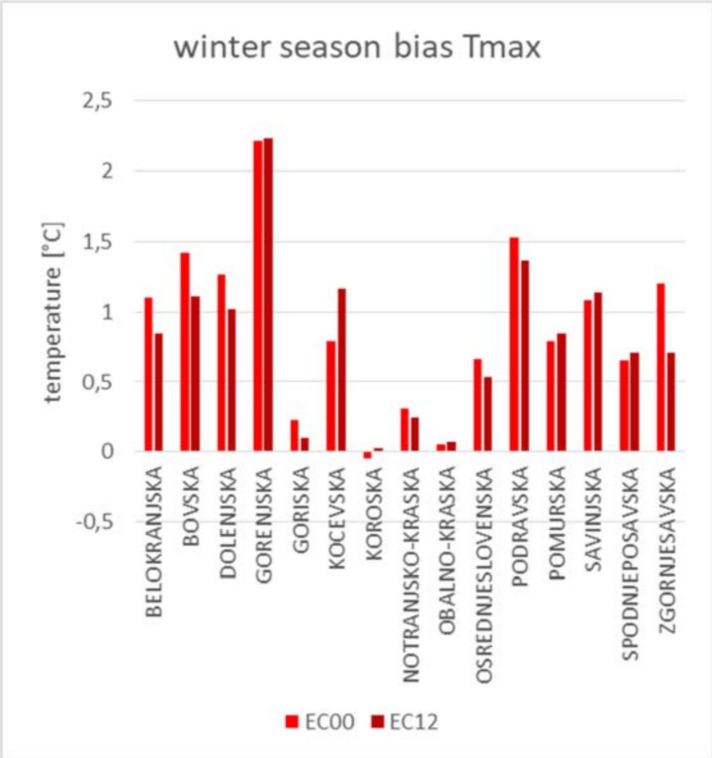


Figure 8: Bias of maximum temperature forecasts for summer (above) and winter season (below).



Biases for maximum temperature forecasts are bigger than biases for minimum temperature forecasts. In general, forecasted maximum temperatures are on average higher than observed (Figure 8). For both seasons there is around 2 °C of bias for Gorenjska region, but still a lot of other regions have bias around 1 °C. Smallest bias – around zero is for Koroska and Obalno-Kraska region.

3.1.4 End products delivered to users

N/A

3.2 Subjective verification

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

N/A

3.2.2 Case studies

N/A

4. Feedback on ECMWF “forecast user” initiatives

As last year we invite comment on whether you use the following, on how useful you find them, and on any changes you would like to see:

- “Known IFS forecast issues” page – (https://software.ecmwf.int/wiki/display/FCST/Known+IFS+forecasting+issues)
- “Severe event catalogue” (https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue).

5. References to relevant publications

Cattani D, Faes A, Giroud Gaillard M, Matter M: 2015, COMFORT: Continuous MeteoSwiss Forecast Quality Score, Scientific Report MeteoSwiss, 99, 45 pp