Application and verification of ECMWF products 2018

Croatian Meteorological and Hydrological Service

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1. Summary of major highlights

At Croatian Meteorological and Hydrological Service, ECMWF products are considered as the main source in the operational forecast, particularly for the medium- and long-range. For short range, Aladin model is included also. Regular verification is usually done by the point-to-point method, with SYNOP data verified against nearest grid point of the model. The emphasis of the verification is on 2m-temperature and precipitation.

At the Service, ECMWF model is also widely used as input for running other hydro/meteorological forecasts, such as Aladin, WRF, RegCM4 and MIKE.

Although scores are periodically calculated also for the medium-range, the emphasis of this paper is put to long-range forecasts, that are comprehensively monitored. For the System 5 forecast, first scores are calculated, but it is still too early to make confident conclusions and comparison to System 4. Forecast generally exhibit better skill for temperature compared to precipitation. Although a positive aspect can be provided by observing success rate of positive/negative anomaly forecasts, long-range forecasts still represent a major challenge, particularly in reliable prediction of extreme events/anomalies (often missed by the forecast).

For subjective verification, results of a forecasters' survey are presented also, raising several comments/issues of the model: improvement of wind forecasts, very good experience with precipitation-type product, but some challenges also, such as model jumpiness, inversion situations, unrealistic CAPE forecast, visibility forecast etc.

2. Use and application of products

2.1 Post-processing of ECMWF model output

Describe the different ways in which you post-process ECMWF forecasts, in the following categories:

2.1.1 Statistical adaptation

2.1.2 Physical adaptation

ECMWF lateral boundary conditions (LBC) are used for running a 72hr forecast with ALADIN-HR8 (8km grid spacing) and ALADIN-HR4 (4km grid spacing) operational runs. Due to time constraints for availability of ALADIN 72hr forecast ECMWF LBCs in production are used in so-called lagged mode (ECMWF forecast initialized 6h earlier than ALADIN initial time is used as LBC). As no SST data assimilation is performed locally, the initial SST is taken by combining data from OSTIA analysis and ROMS model output. Since 6th Feb 2018, hourly LBCs are provided by ECMWF. The operational LBCs are currently provided in lower spatial resolution than the HRES model. The alternative setup is being developed and tested. Current operational procedure involves many interpolation steps. It is being investigated how to reduce this.

ECMFW initial and boundary conditions derived from operational analysis are used for running WRF (Weather Research and Forecasting) microscale simulations (hectoscale and large eddy) of wind events in Croatia. Results of these simulations are used in studies of wind conditions required for building major infrastructure, such as roads, bridges, wind farms on locations exposed to extreme and gusty bora downslope windstorms along the eastern Adriatic coast. Similar simulations are performed for process analysis of other meteorological events of interest (meteotsunami, hail etc.). It was noted that better results are achieved with the use of operational analysis than ERA-Interim reanalysis.

ERA-Interim reanalysis lateral boundary conditions (6 hourly) are used for performing dynamical downscaling with the regional climate model RegCM4. Two types of the simulations are performed. In the first group of runs, RegCM4 at the horizontal resolution of 12.5 km is directly nested into ERA-Interim. Typical experiments cover the 1979-2016 period. The same model version is then applied to the RegCM4 simulations forced by the CMIP5 GCMs. In the second group of runs, RegCM4 is run at the 3 km or 4 km horizontal resolutions. In this case double nesting is performed, where in the first nesting RegCM4 is run at 12.5 km using hydrostatic dynamical core, and in the second nesting at the higher horizontal resolution using the nonhydrostatic dynamical core. Typical experiments in this setup are currently for reduced periods of up to 1 year. This model version is still in the development phase, and the use of the ERA5 as the boundary data is planned. Both groups of simulations are done for the research purposes.

The Operational hydrological forecasting system with MIKE11 is based on real-time data received from available online stations in Croatia and Bosnia and Herzegovina, relevant online data received from Slovenia and temperature and precipitation FC from the meteorological models ALADIN (8 km resolution, lead time 0-71 h, 4 runs per day - 00, 06, 12 and 18 UTC) and ECMWF (16 km resolution at the moment, but within weeks 10 km, lead time 72-120 h, 2 runs per day - 00, 12 UTC). The forecasting model is mainly driven by precipitation input. The model has to deal with uncertainty in rainfall, which is usually the largest source of uncertainty in hydrological modelling. Preliminary test exhibit significant differences between 10 km and 16 km runs.

2.1.3 Derived fields

Some products are recently developed in the new operational workstation system, that allows easy combination/postprocessing of different meteorological parameters (e.g. probability of road icing, as a combination of temperature and precipitation, several instability diagnostics parameters etc.).

2.2 ECMWF products

2.2.1 Use of Products

A variety of products is used, and ensemble approach is constantly increasing with time. Experience and usage of new products, such as precipitation-type forecast, is described in Section 3.2.2.

2.2.2 Product requests

So far even the existing possibilities are not completely used in our new system. However, some derived products would be very welcome, such as long-range drought forecast (e.g. SPI, SPEI indices), and calibrated fire danger forecast as well (Fire Weather Index - FWI).

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS)

A periodical verification of surface parameters is carried out for the medium range, particularly for 2mT and precipitation. Several scores and features were presented and discussed in the previous reports (such as decrease of the skill for 2mT and 12-hour precipitation forecasts at the end of the forecasting period, daily variation of bias for the 12-hour precipitation forecast etc.), so they will not be presented in this paper (see previous reports).

A comprehensive periodical verification of seasonal forecast is carried out also.

Mean absolute error (MAE) of mean temperature anomaly for station Zagreb-Maksimir is relatively large, reaching about 1.5 °C. Furthermore, forecast rarely forecast negative anomalies, and even in those cases they are rarely accurate. Forecast skill – according to months – ranges from 0.1 to 0.17 (10 do 17 %), with respect to climatology (not shown). Taking into account 3-monthly periods, skill is significantly higher (24 to 27 %).

Another, more benevolent approach, is to observe realisations of positive/negative anomalies. According to this, skill of forecasts ranges between 68 and 77 % for monthly anomalies (Figure 1), and between 80 and 88 % for seasons. But one should notice that a dummy forecast - expecting all seasons to be warmer - would get even higher skill (between 78 and 90 %).

Performance of forecast skill with respect to forecast lead time did exhibit the expected decrease for System 4, but for System 5 they are still not clear, due to extreme observed anomalies in the period since System 5 started (characterized by transition from weak La Nina to neutral ENSO phase).

System still experiences large forecast errors (forecast „busts“), such as forecast for February 2018, which turned out to be significantly colder than predicted. This situation has expanded for March also. Synoptic analysis shows that this was caused by Sudden Stratospheric Warming that probably has low long-range predictability. In previous periods, we experienced large errors also, such as September 2017, being significantly colder and extremely rainier than predicted etc.

Additionally, a 'jump' in the seasonal forecast has been noticed with the start of System 5, with the strong increase of positive signal for June, and for the whole 2018 summer season. This has still to be verified.

As expected, precipitation forecasts exhibit significantly lower skill compared to temperature forecasts. Skill of forecasts is marginally higher than climatology (Figure 2). It is worth mentioning that from November 2017 skill has slightly increased, but this feature is still not undoubtedly associated to the introduction of System 5.

3.1.2 ECMWF model output compared to other NWP models

In the short range, performance of ECMWF model is periodically compared to Aladin (ALARO) Croatia model. Results (not presented in this paper) usually exhibit similar level of skill performed by the two models.

Another comparison of forecasts/models is delivered to the duty forecasters in real time, with daily visualisation of different forecasts compared to observations. In several previous reports the occasionally poor behaviour in winter stable situations has been analysed. On the contrary, an example of good 2m maximum temperature forecast in warm season is displayed in Figure 3. In period June-August, during a series of extreme heat spells, models performed well, so end-forecasts were accurate, as well as timely heat spell warnings issued by the Service.

3.1.3 Post-processed products

None.

3.1.4 End products delivered to users

Long range forecast are monitored with special attention, since the Service's monthly and seasonal end-product forecasts are based on ECMWF-DMO, visualized and interpreted. Classical scores are regularly calculated (see section 3.1.2, as well as previous reports).

3.2 Subjective verification

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

3.2.2 Case studies

For subjective evaluation purpose, a survey is being carried out in the Forecasting Department every year. Some topics are proposed to the forecasters to confirm/reject, but they are invited to raise their own topics, and others can join the discussion/voting.

Model jumpiness is a well-known issue in the medium range. It is sometimes present even in the ensemble members, such as in one episode this winter (mid-January), followed by unusually strong criticism in the media/public (7-day ECMWF DMO forecast is most visited content on DHMZ web page).

A jumpiness is reported in the long-range (particularly for 4-week monthly forecast) also. It is manifested as certain 'model momentum', i.e. model has difficulties to change positive/negative anomaly (regimes transition?), so usually it is affected by the existing anomaly which is often kept through the whole forecast range.

It is a general consensus that the wind forecast is improving constantly over the last years. This was particularly noticed by maritime forecasters, who have a major expertise in wind. This is especially stressed for the strong bora flow forecast (with strong influence by the complex orography at the Croatian coast), that was previously considered as inferior to the Aladin forecast.

Common praise has been won for the precipitation type (freezing rain) product. A case study of end Feb/ beginning March 2018 event has been carried out, when a large portion of Croatian inland was affected by supercooled rain. The forecast was generally very accurate in terms of time and intensity of the event. Several previous events also proved good reliability of the product, particularly if the signal is strong. For weak signal, forecasters suggest to take care and consider other sources as well. Usage of precip-type point meteograms is also encouraged, accompanied with standard spatial fields.

Strong criticism has again been reported for the CAPE forecast. Although there are some reports on slight improvement lately, it is still often regarded as not realistic, particularly over the sea, and even more in the warm season. Forecasters consider it should be used combined with other convection tools. Similar reviews are experienced for the visibility product, particularly by the marine and aviation forecasters. They use it in a more qualitative fashion (e.g. ensemble probability for visibility<1.5 km etc.)

Several other issues are also raised. Problems in stable/inversion situations are still excessively reported, particularly over the sea, but some forecaster consider a slight improvement in this area. A subjective impression about (too) extreme precipitation at the end of medium-range is constantly reported, but this was never confirmed with objective scores. For possible problems with snow cover/T2m minimum forecast, mixed reviews are delivered by the forecasters.

4. Feedback on ECMWF "forecast user" initiatives

We invite comments on how useful you find the information provided on ECMWF's "Forecast User Portal", see: (https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home), and on any changes you would like to see. A new web-based "Forecast User Guide" will be added soon (due May 2018) and we would particularly welcome initial comments on that.

Forecasters are invited to use those portals, but so far no systematic feed-back has been collected.

5. References to relevant publications

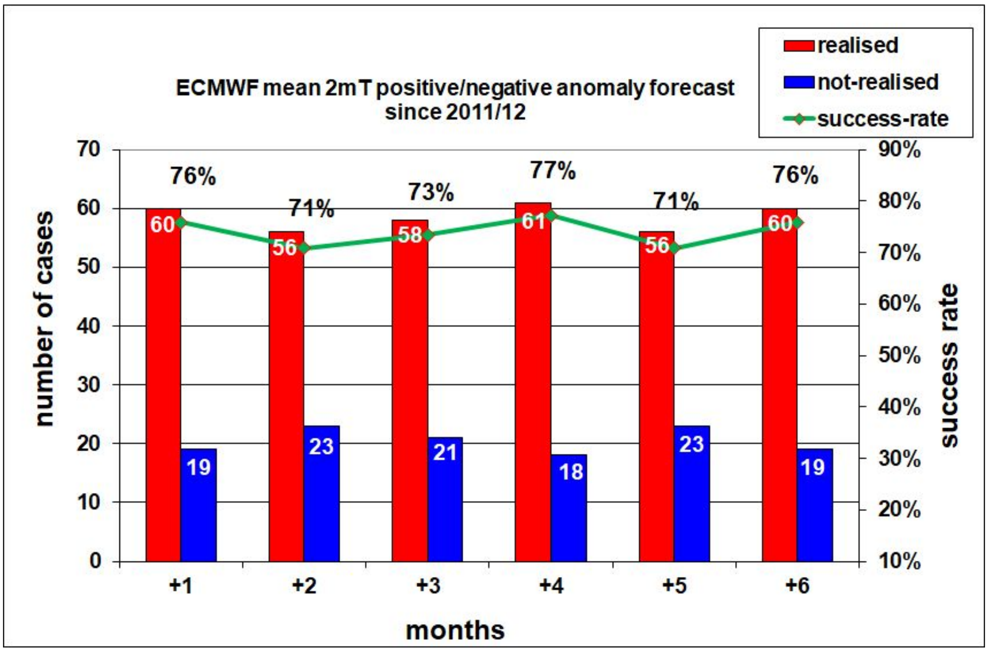

Figure 1. Number and percentage of successful forecasts of positive/negative monthly temperature anomaly (seasonal forecast), for different lead times, for station Zagreb Maksimir (climatology 1981-2010.)

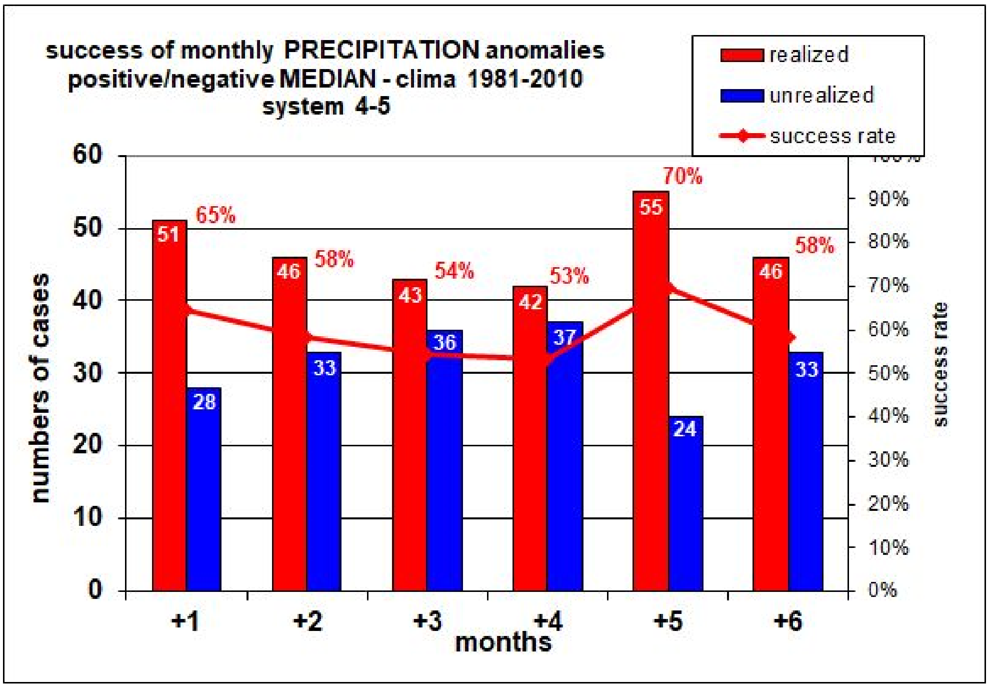

Figure 2. Number and percentage of successful forecasts of positive/negative monthly precipitation anomaly (seasonal forecast), for different lead times, for station Zagreb Maksimir (climatology 1981-2010.)

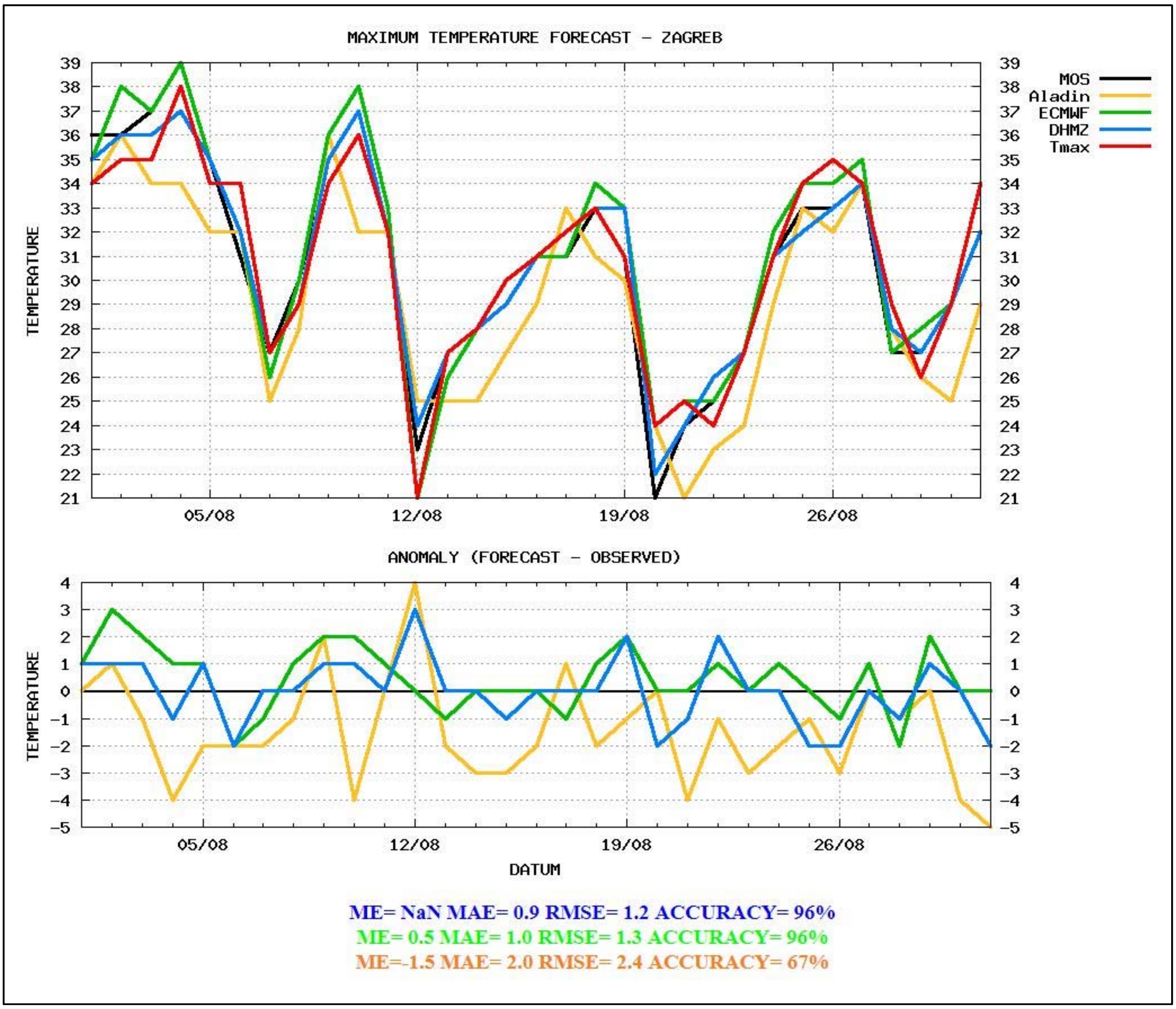

Figure 3. Maximum 2m-temperature forecast (for the following day) for station Zagreb Maksimir (14240) in August 2017. Aladin (yellow line), ECMWF (green line), DWD MOSMIX (black line), forecaster's prediction (blue line) and observed temperature (red line) are displayed. Anomalies are displayed in the lower panel: Mean error (ME), mean absolute error (MAE) and root mean square error (RMSE) are calculated. Accuracy is defined as the percentage of forecasts with error smaller than 2 degrees.