Application and Verification of ECMWF Products 2019

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1. Summary of major highlights

ECMWF forecast products have been the backbone in operational work during the last fifteen years. Starting from ten days deterministic forecast, amount of products in use is growing constantly including EPS, EFI, extended, seasonal forecast etc. Available ECMWF software like MetView and ecCodes are widely used.

Establishing of South East European Climate Change Centre started during 2008. In order to provide numerical background for seasonal forecast for the region, regional Eta model runs with 7 months EPS forecast as boundary conditions, every month. Also, WRF-NMM and NMMB use ERA fields for case studies and numerical tests for different regions.

Since last year regional NMMB model is running as time-critical on Cray supercomputer, using a suite under ecFlow. The products of the model are used in operational weather forecast.

2. Use and application of products

ECMWF products are used for short-range forecast for providing meteorological background for hail suppression activities.

Medium range forecast is mainly based on ECMWF products from deterministic model as well as EPS products.

Hydrometeorological Service of Serbia regularly issues monthly forecast for several places in Serbia. Statistical method by analogy is used together with EPS products from ECMWF. Also, for hydrological purposes, averaged weekly forecasts are issued once a week, with mean temperature and amount of precipitation for river catchments.

RHMS of Serbia has continued to use ECMWF's extended range forecasts as well as seasonal forecasts.

2.1 Direct Use of ECMWF Products

Some of ECMWF forecast products, like CAPE and EFI are widely used in every day work. Wind gusts, 2m minimum and maximum daily temperature forecast as well as daily amount of precipitation are used as a background in the severe weather warnings.

Prediction of the heat waves started operationally in August 2008. Maximum temperature predicted in deterministic model run and distributed as BUFR weather parameters is used as a first guess. During winter minimum temperature is used for prediction of the cold waves.

2.2 Other uses of ECMWF output

2.2.1 Post-processing

The HRES is used to produce some derived-processed fields such as Equivalent potential temperature, Positive vorticity advection and Temperature advection on several pressure levels. Height of the tropopause and height of -10°C level related to aviation weather are also calculated and presented.

Averaged daily 2 meter temperature and precipitation over several catchments are input fields for HBV model.

2.2.2 Derived fields

We built up flexible and modular system in Python for monthly (extended range) forecast, using ecCode and Magics based on ECMWF's monthly reforecast and forecast data in order to have more flexibility regarding different monthly forecast time periods, precise values in each grid point for climatological percentiles, possibility to extract values of different percentiles and forecast probabilities at any required point within area.

Methodology used for calculation of reforecast precentile values (10, 33, 50, 66, 90) and probabilities, is compatible with methodology used at ECMWF. We intend to add more graphics products and indices in the future.

2.2.3 Modelling

ECMWF's boundary conditions are used for WRF-NMM, a Non-hydrostatic Mesoscale Model, horizontal resolution about 4 km since 2009. Also, NMMB, a Non-hydrostatic Multiscale Model on the B-grid, horizontal resolution about 4 km, is using IFS and running on Centre's supercomputer. Some verification results compared to ECMWF forecast are presented in chapter 3.1.1.

For hydrological purposes IFS is used as input for hydrological model HBV run.

3. Verification of ECMWF products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS), and other NWP models

The 00 UTC run of ECMWF deterministic forecast is verified against SYNOP observations. Forecast data were taken from 0.1° x 0.1° grid, using grid points closest to chosen synoptic stations. Statistical scores presented here are related to station Beograd - Karađorđev park (13274).

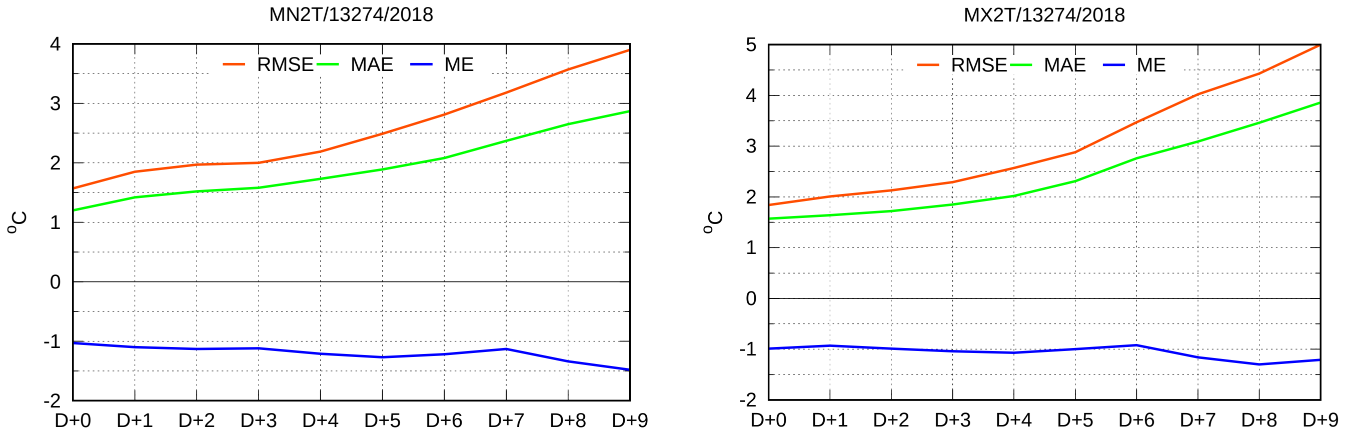


Fig.1-2 ME, MAE and RMSE of ECMWF 2 meter minimum and maximum temperature forecast (D+0 to D+9) as a function of forecast range (Beograd - Karađorđev park).

MAE and RMSE of 2m minimum (18-06 UTC) and maximum (06-18 UTC) temperature forecast (Fig.1-2) show an improvement compared to the previous year during almost the whole forecast range. Only for 2m maximum temperature forecast there is a slight worsening up to D+2. ME is around -1°C.

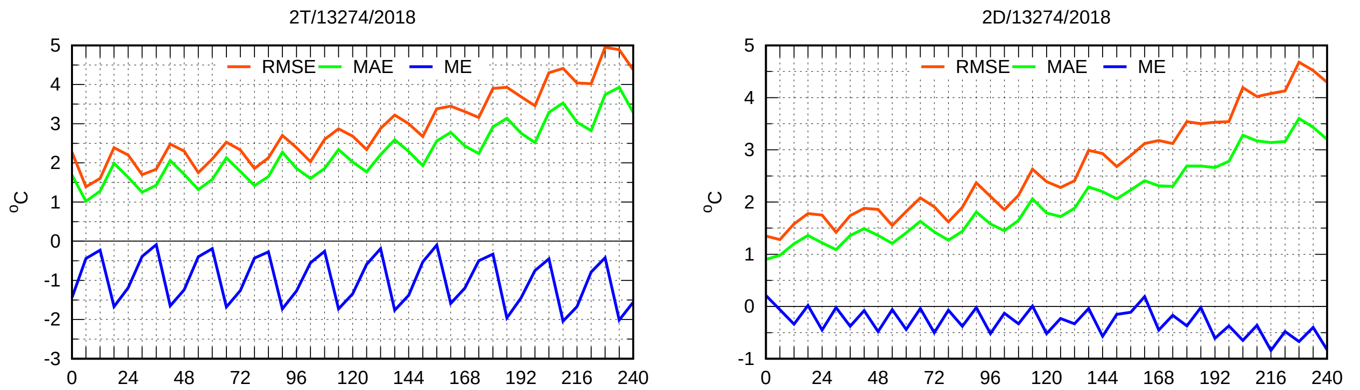
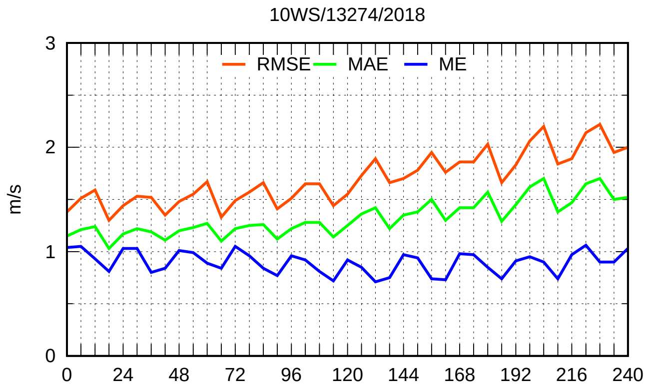


Fig.3-4 ME, MAE and RMSE of ECMWF 2 meter temperature and 2 meter dew point temperature as a function of forecast range (Beograd - Karađorđev park).

Figures 3 and 4 show scores for 2 meter temperature and 2 meter dew point temperature forecast. For 2 meter temperature forecast there are local minima of MAE and RMSE at 6 UTC and local maxima at 18 UTC during the whole forecast range. For 2 meter dew point temperature local maxima of ME is at midnight and local minima for MAE and RMSE is in the morning (6 UTC). Similar as for 2 meter minimum and maximum temperature forecast, MAE and RMSE for 2 meter temperature and 2 meter dew point temperature forecast and show an improvement comparing to 2017. Diurnal cycles are smoother than previous year and underestimation of both 2 meter temperature and dew point temperature forecast is present during whole forecast range.



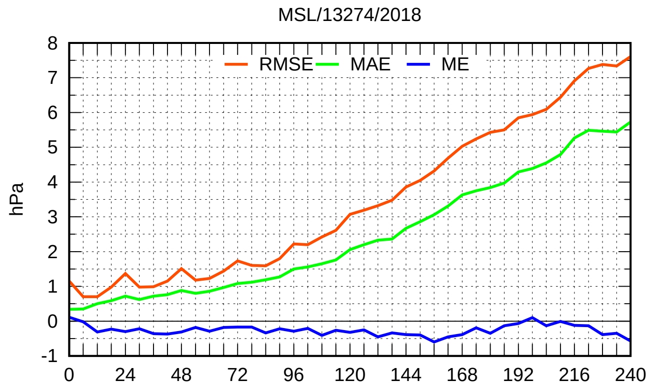


Fig.5-6 ME, MAE and RMSE of ECMWF 10 meter wind speed and mean sea level pressure forecast as a function of forecast range (Beograd - Karađorđev park).

Figures 5 and 6 show scores for 10 meter wind speed and mean sea level pressure forecast. All scores for 10 meter wind speed forecast are better than last year with local maxima at noon (12 UTC). For mean sea level pressure forecast a slight propagation of the errors with forecast time is evident. RMSE has local maxima at midnight. All scores show a slight improvement.

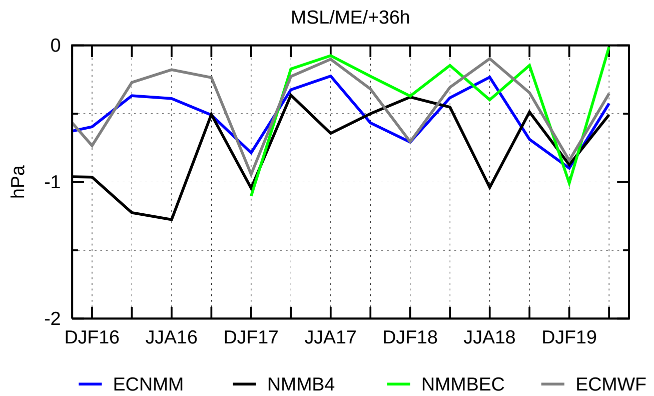
ECMWF model output is compared with regional NWP models operational in HMS of Serbia.

Verification of operational regional numerical weather prediction models started in 2007. As new regional models were included in operational run, verification of their products followed. Models are WRF-NMM and NMMB with different initial and boundary conditions (IFS, GFS). Meteorological variables verified every six hours are mean sea level pressure, temperature at 2m and wind speed at 10m. 24 hour precipitation amount and occurrence with different precipitation thresholds are verified too. Only the 00 UTC run is considered, up to 72 hours of forecast.

For model intercomparison, verification is done over the largest common domain of the participating models (47.38/10.65/40.37/25.25). 39 synoptic stations are chosen, 33 land and 6 mountain stations. Half of them are in Serbia. Observations are from BUFR data and the nearest grid point to the station is used. Height adjustment is not used.

Numerical weather prediction operational models intercompared here:
ECNMM WRF-NMM v3.5.1 with BC from IFS ECMWF. Horizontal resolution is about 4 km (0.05° x 0.05°).
NMMB4 NMMB nested in NMMB12 (with BC from NMMB global model with IC from GFS NCEP). Horizontal resolution is about 4 km (0.042° x 0.036°).
NMMBEC NMMB with BC from IFS ECMWF operational on CRAY. Horizontal resolution is about 4 km (0.042° x 0.036°).
ECMWF IFS model of ECMWF. Horizontal resolution is about 9 km (0.1° x 0.1°).

Comparison of the forecast quality of ECMWF model and our three operational NWP models is presented in figs. 7-16. Seasonal averaged values for mean sea level pressure, 2 meter temperature and 10 meter wind speed 36h (midday) forecast and 24 hour precipitation occurrence are taken in consideration.



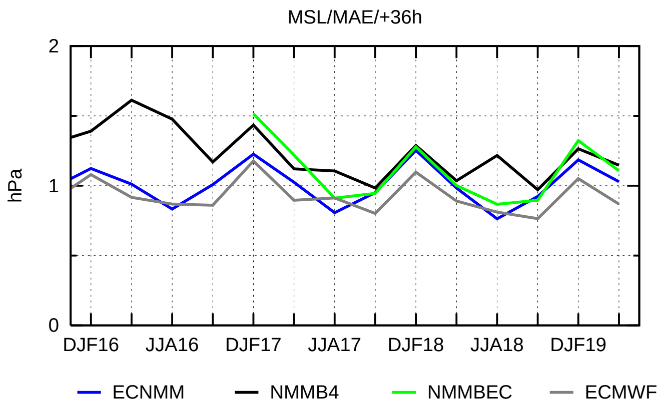


Fig.7-8 ME and MAE of ECMWF midday (36h) mean sea level pressure forecast for seasons DJF16 to MAM19. Comparison to operational NWP models forecast.

Values of ME and MAE for mean sea level pressure forecast of ECNMM are comparable with these values for ECMWF (Fig. 7-8).

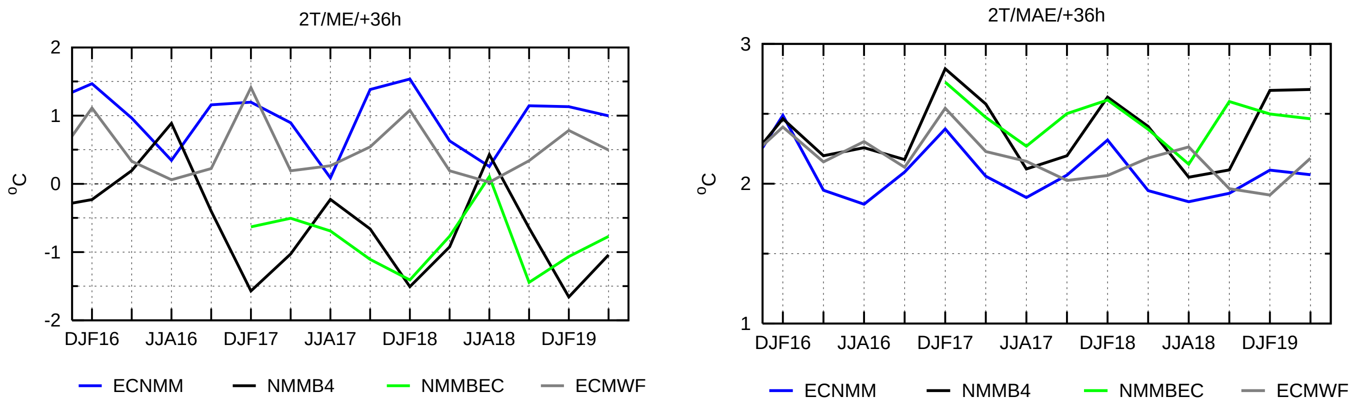


Fig.9-10 ME and MAE of ECMWF midday (36h) 2 meter temperature forecast for seasons DJF16 to MAM19. Comparison to operational NWP models forecast.

ME of ECMWF forecast for 2 metre temperature has the smallest amplitude among all other NWP models (Fig. 9). Values of MAE show advantage of ECNMM forecast for 2 metre temperature except during SON17, DJF18 and DJF19 (Fig. 10).

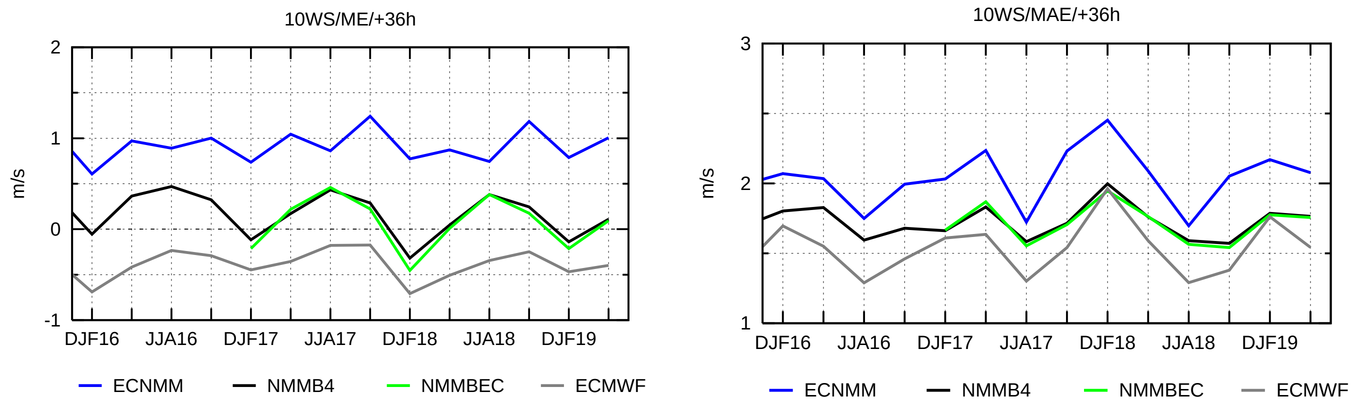


Fig.11-12 ME and MAE of ECMWF midday (36h) 10 meter wind speed forecast for seasons DJF16 to MAM19. Comparison to operational NWP models forecast.

ECMWF has best scores for 10 meter wind speed forecast compared to other models' scores during all seasons (Fig. 11-12).

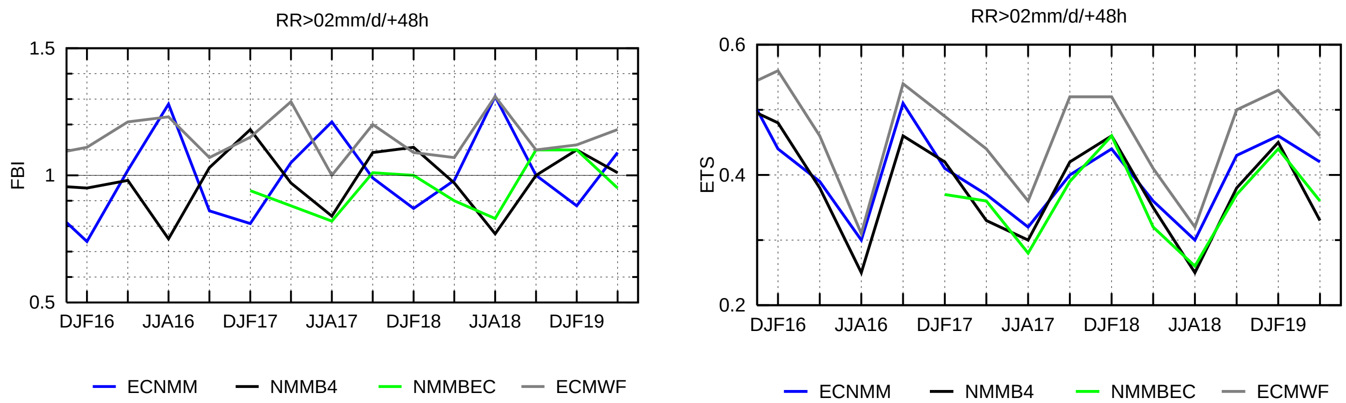


Fig.13-14 FBI and ETS of ECMWF 24h precipitation forecast (48h) for seasons DJF16 to MAM19. Threshold is 2mm/24h. Comparison to operational NWP models forecast

Values of ECMWF's FBI have the smallest amplitude but they are the largest for threshold of 2mm/24h among all other NWP models (Fig. 13) except in summer 2017.

Regarding ETS, evaluation of precipitation forecast is similar for all the models mostly with minimum skill in summer and maximum in autumn or winter. ECMWF's ETS score is better than the other models' ETS score (Fig. 14).

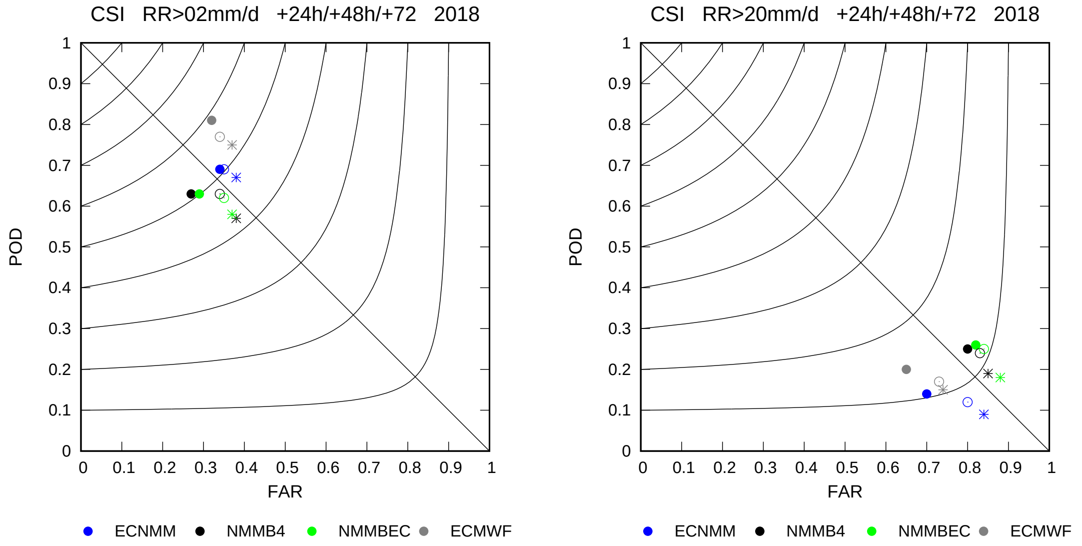


Fig.15-16 CSI contours as a function of FAR and POD for 24h/48h/72h 24h precipitation forecast. Thresholds are 2mm/24h and 20mm/24h. Comparison to operational NWP models forecast

ECMWF 24h precipitation forecast for 24h (dots), 48h (circles) and 72h (asterisks) has the best results for CSI for both thresholds 2mm/24h and 20mm/24h. For the first treshold (2mm/24h) there is an overestimation of precipitation amount and for the second treshold (20mm/24h) an underestimation of precipitation amount. Values of CSI for the second treshold (20mm/24h) are lower than they were previous year. Both NMMB4 and NMMBEC show overestimation of precipitation amount for threshold of 20mm.

3.1.2 Post-processed products and end products delivered to users

3.1.3 Monthly and Seasonal forecasts

3.2 Subjective verification

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

3.2.2 Case studies

4. Requests for additional output

5. Feedback on ECMWF “forecast user” initiatives

6. References to relevant publications

Nurmi, P., 2003: Recommendations on the verification of local weather forecasts, ECMWF Technical Memorandum No. 430

http://www.ecmwf.int/en/forecasts/quality-our-forecasts

(7. Structure of these Reports)

ECMWF is reviewing the way in which contributions such as these are gathered and collated. We have made some simple changes to the structure this year, as can be seen above. Please provide any comments you have on the whole process (e.g. schedule for collecting input, report content, report layout, TAC summary). Comments entered in this section will be examined and used by ECMWF, but will be removed prior to publishing your reports on the ECMWF website.