Application and verification of ECMWF products 2017

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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 preoperational on Cray supercomputer. Scheduling scripts for NMMB running on Cray were created in EcFlow last year and procedure for time critical application is almost finished in order to use products in operational weather forecast.

New products available in our service are derived fields of height of the tropopause and height of -10°C level prepared for Division for Aeronautical 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 Post-processing of model output

2.1.1 Statistical adaptation

2.1.2 Physical adaptation

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 since last year. Some verification results compared to ECMWF forecast are presented in chapter 3.1.2.

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

2.1.3 Derived fields

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 ECMWF products

2.2.1 Use of 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.

New products derived in RHMSS in operational use available on intranet:

- Horizontal fields

  EFI&SOT CAPE
  EFI&SOT CAPE/SHEAR
  HCCT Height of convective cloud top
  HWBT0 Height of zero-degree wet-bulb temperature
  CEIL Ceiling - Cloud-base height relative to the ground (at least 50% cloud in one layer)

- From **eccharts.ecmwf.int**

  Thickness 850/1000 hPa
  Bulk Shear 100m/300 hPa
  Bulk Shear 100m/500 hPa

- From **ecmwf.int**

  ENS meteograms for different places in Serbia

- Extended range forecast

  1. VI-ii-a Weekly mean anomalies of ensemble means - Single level:
  - 2TA (2 metre temperature anomaly) and 2TA (2m temperature significance)
  - TPARA (Total precipitation anomalous rate of accumulation) and 2TS (total precipitation significance)
  2. VI-vi-c Probabilities - Probability distributions:
  - 2T Quantile: 1:3, 1:5, 2:3, 3:3, 5:5
  - TP (tprate), Quantile: 1:3, 1:5, 2:3, 3:3, 5:5
  3. VI-vi-d Probabilities - Probability boundaries:
  - 2T, Quantile: 1:3, 1:5, 2:3, 4:5
  - TP (tprate), Quantile: 1:3, 1:5, 2:3, 4:5

2.2.2 *Product requests*

Some products that would benefit operational forecast at RHMSS include Temperature at 850 hPa on EPS meteograms and skew-T diagram with T, Td and wind from model levels from HRES.

3.   Verification of products

3.1   Objective verification

3.1.1 *Direct ECMWF model output (both HRES and EPS)*

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).
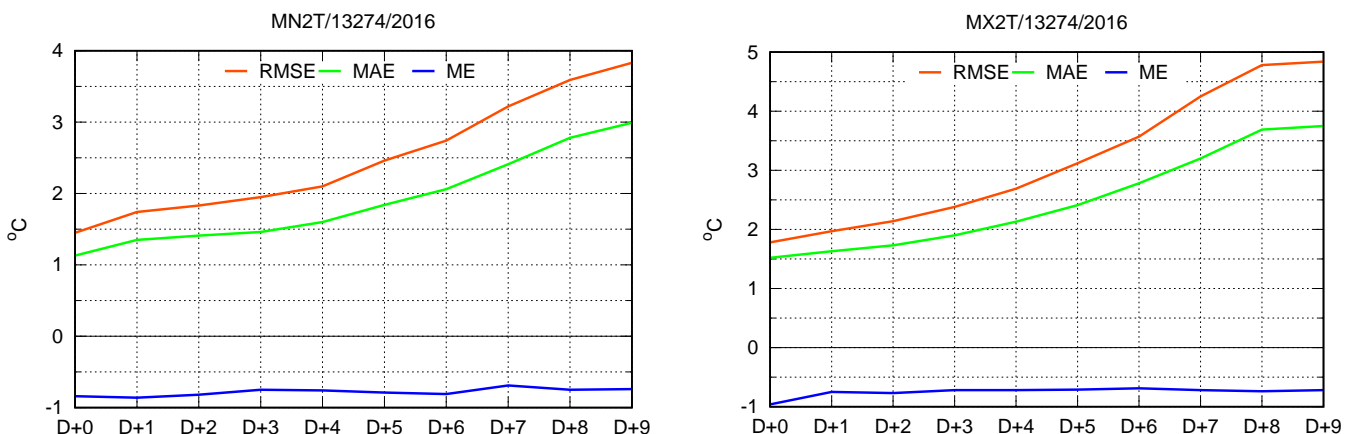

Fig.1-2   ME, MAE and RMSE of ECMWF 2 meter minimum and maximum temperature forecast (D+0 to D+9) as a function of forecast range (Beograd - Karađorđev park).

ME, MAE and RMSE of 2m minimum (18-06 UTC) temperature forecast (Fig. 1) show improvement compared to the previous year during the whole forecast range. These scores for maximum (06-18 UTC) temperature forecast (Fig. 2) are improved from D+4.
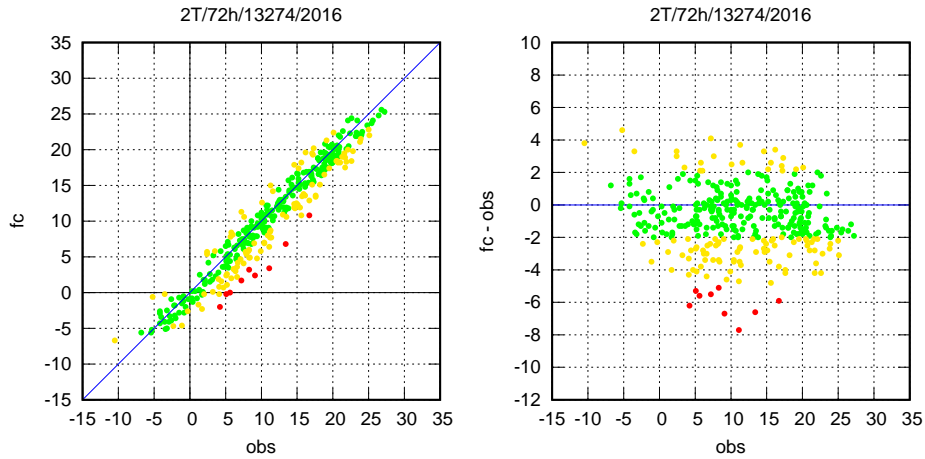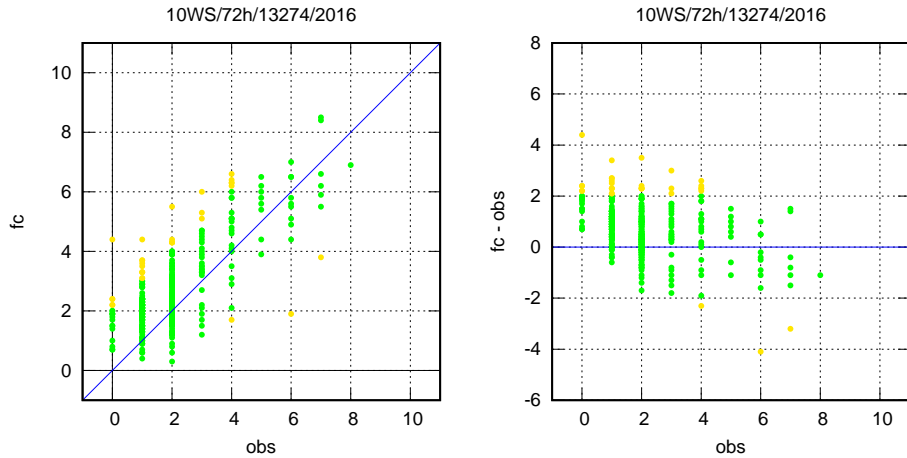
Fig.3   Scatterplot and forecast errors vs. observations of one year ECMWF t+72h (midnight) 2 meter temperature forecast for Beograd - Karađorđev park (13274).

Scatterplots (Fig. 3) show that there the underestimation for midnight (72h) 2 meter temperature is much less than previous year. The "percent correct" of the 2 meter temperature forecasts within ±2°C is 74% for midday (60h) and 70% for midnight (72h) forecast.

Fig.4   Scatterplot and forecast errors vs. observations of one year ECMWF t+72h (midnight) 10 meter wind speed forecast for Beograd - Karađorđev park (13274).

A slightly overestimation of 10 meter wind forecast can be seen in Fig. 4, for wind speed lower than 3 m/s. The "percent correct" of the 10 meter wind speed forecasts within ±2 m/s are similar as previous year, 91% for midday (60h) and 90% for midnight (72h) forecast.

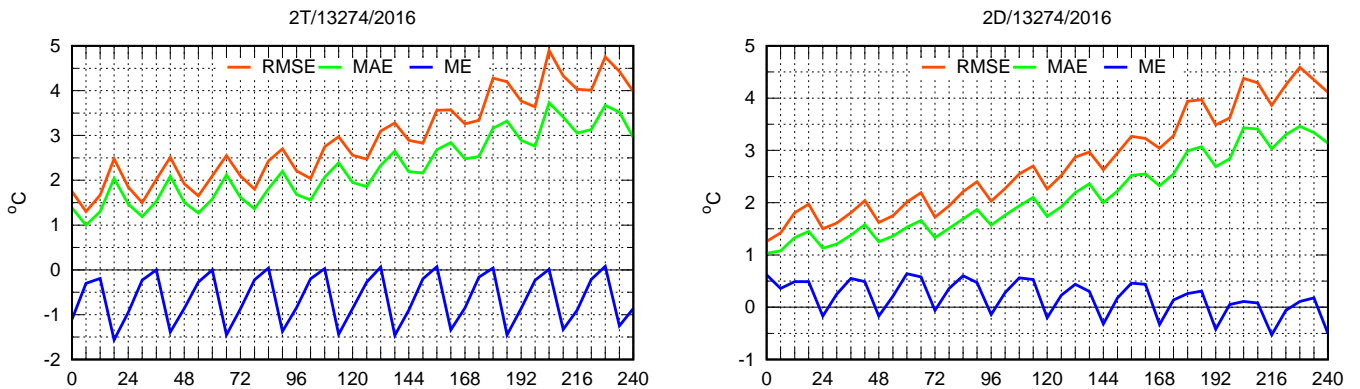Fig.5-6   ME, MAE and RMSE of ECMWF 2 meter temperature and 2 meter dew point temperature as a function of forecast range (Beograd - Karađorđev park).

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Figures 5 and 6 show scores for 2 meter temperature and 2 meter dew point temperature forecast. Diurnal cycles in forecast errors can be seen, stronger for 2 meter 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 almost the whole range. ME of 2 meter temperature is a bit smaller than during 2015 and also there is an improvement of MAE and RMSE from 72 to 240 hour. For 2 meter dew point temperature minimum of ME, MAE and RMSE is at midnight and scores are smaller than for 2 meter temperature.
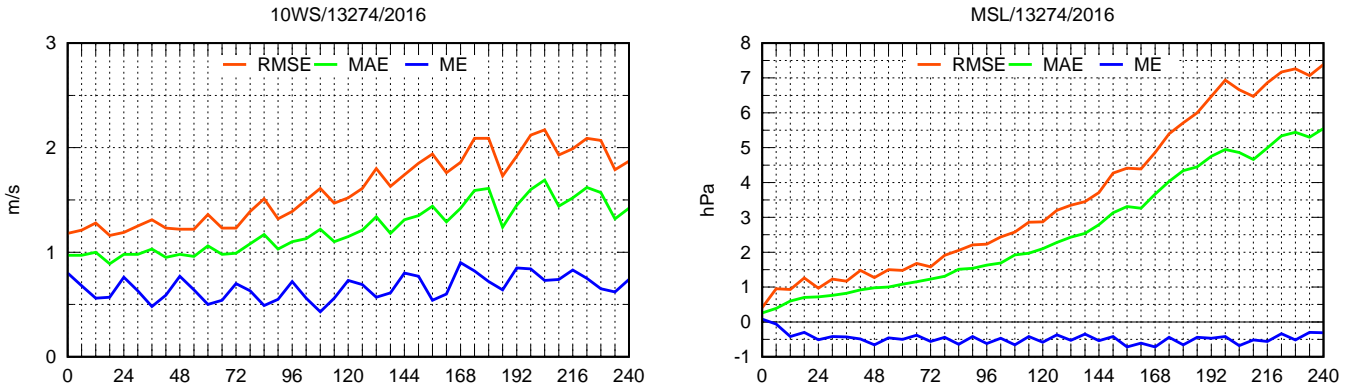

Fig.7-8   ME, MAE and RMSE of ECMWF 10 meter wind speed and mean sea level pressure forecast as a function of forecast range (Beograd - Karađorđev park).

Figures 7 and 8 show scores for 10 meter wind speed and mean sea level pressure forecast. All scores for 10 meter wind speed are a bit worse than last year with maximum error at 12 UTC. For mean sea level pressure a slight propagation of the errors with forecast time is evident.
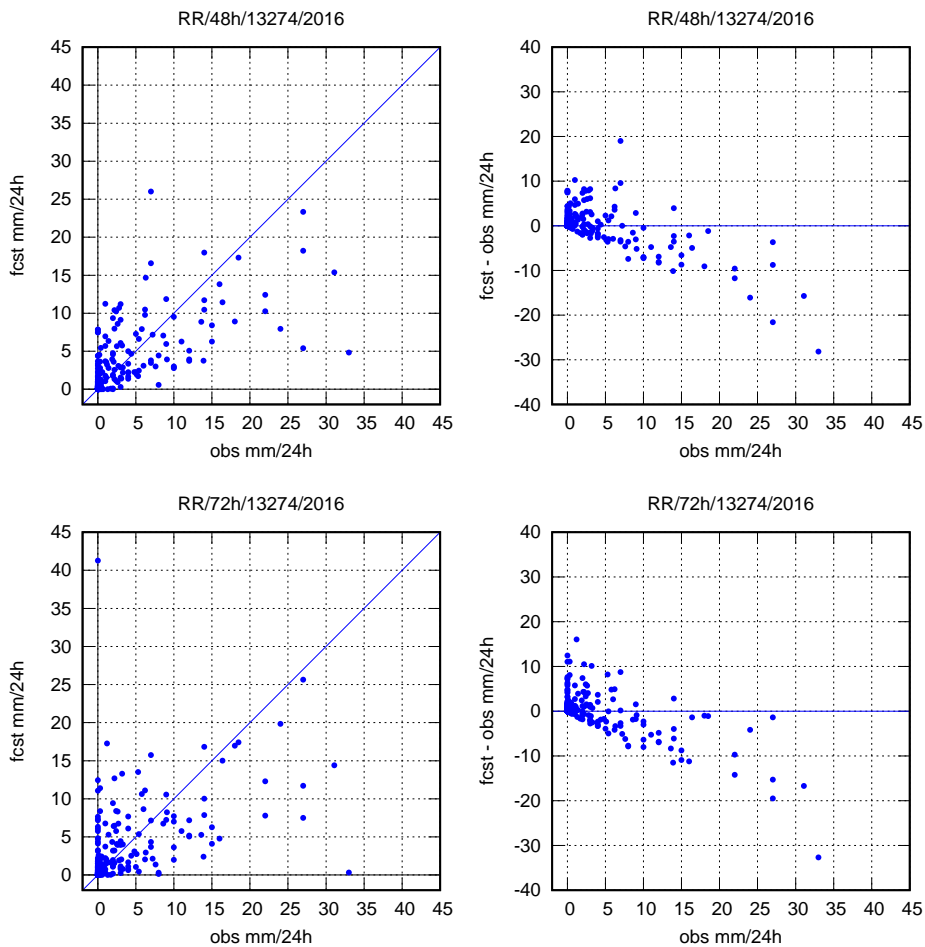

Fig.9-10   Scatterplots and forecast errors vs. observations of one year ECMWF 48h and 72h 24h precipitation forecast for Beograd - Karađorđev park (13274).

As previous years amounts of precipitation smaller than 5mm are overestimated and larger than 10mm are underestimated for both 48h and 72h precipitation forecast (Fig 9-10).

3.1.2 ECMWF model output compared to other NWP models

ECMWF model output is compared with several 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 48 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:
ECNMM4 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 running 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 operational NWP models is presented in figs. 11-18. 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.
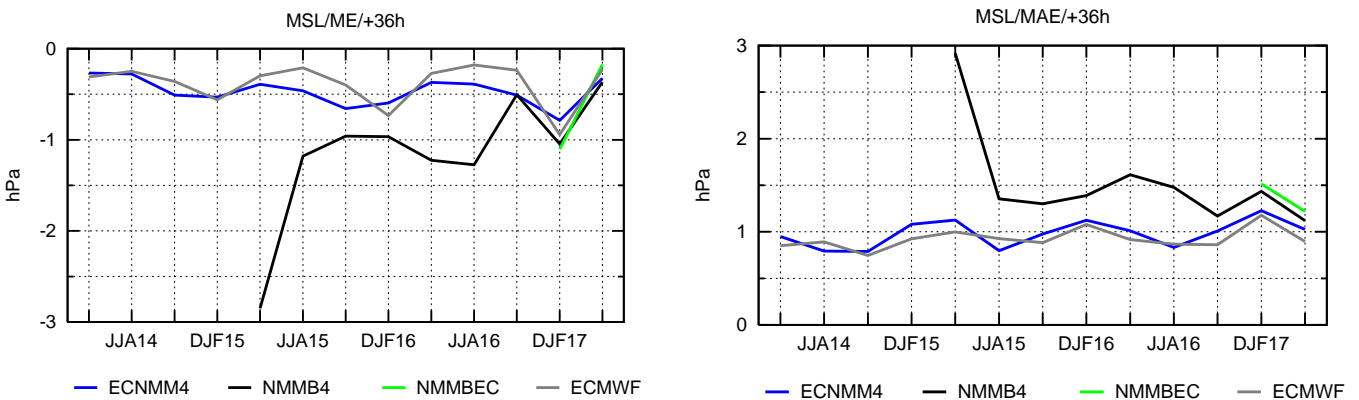

Fig.11-12 ME and MAE of ECMWF midday (36h) mean sea level pressure forecast for seasons MAM14 to MAM17. Comparison to operational NWP models forecast.

Values of ME and MAE for mean sea level pressure forecast of ECNMM4 are comparable with these values for ECMWF (Fig. 11-12).
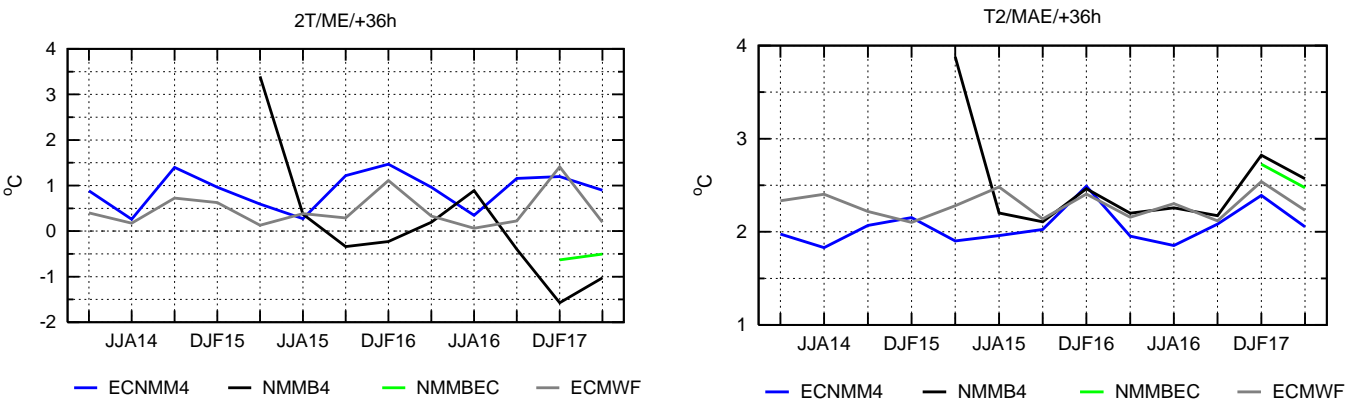

Fig.13-14 ME and MAE of ECMWF midday (36h) 2 meter temperature forecast for seasons MAM14 to MAM17. Comparison to operational NWP models forecast.

ME of ECMWF forecast for 2 metre temperature has the smallest amplitude among all other NWP models (Fig. 13). Values of MAE show advantage of ECNMM4 forecast for 2 metre temperature. Also, values of MAE score for NMMB4 model are comparable to values of MAE score of ECMWF and ECNMM4 since JJA15 (Fig. 14).
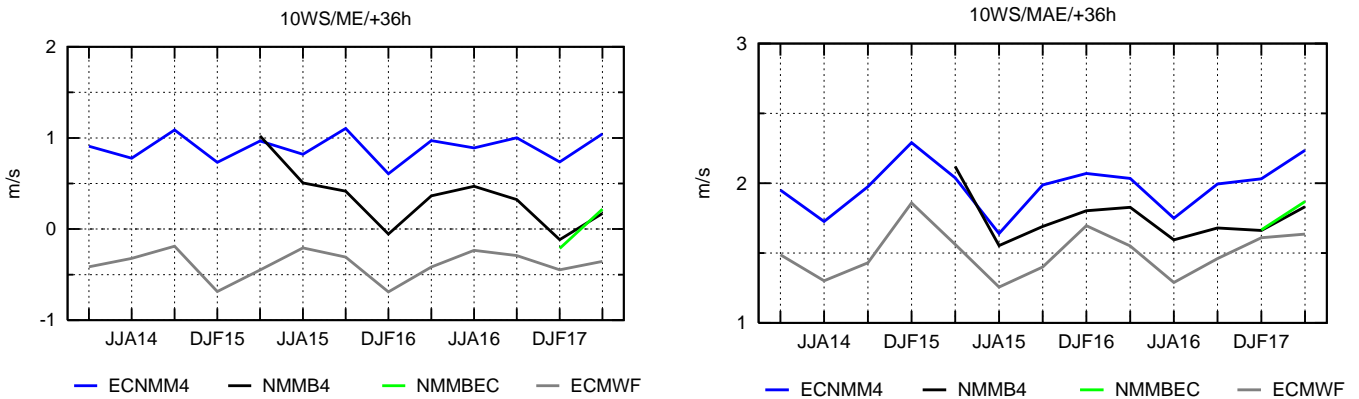

Fig.15-16 ME and MAE of ECMWF midday (36h) 10 meter wind speed forecast for seasons MAM14 to MAM17. Comparison to operational NWP models forecast.

ECMWF has best scores for 10 meter wind speed forecast compared to other models' scores during all seasons (Fig. 15-16).
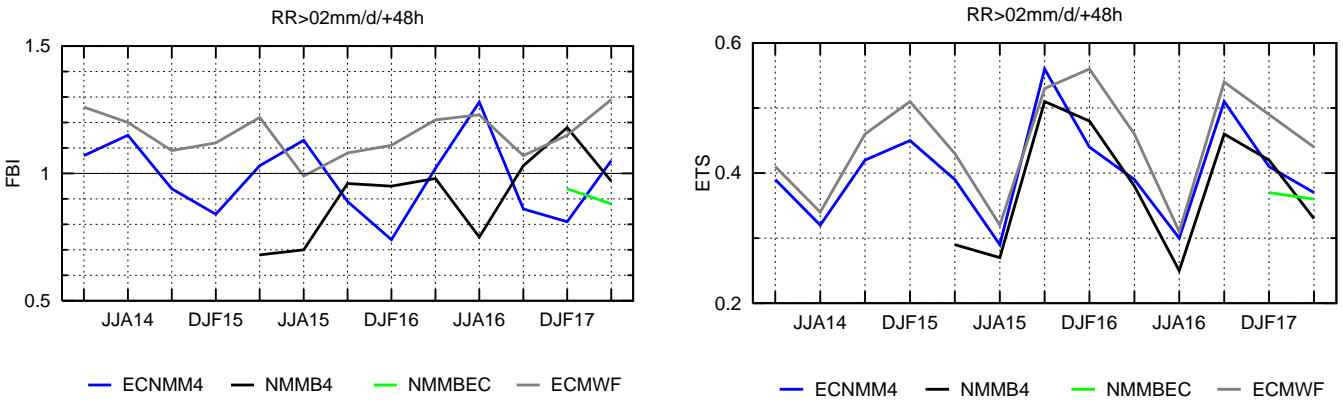

Fig.17-18 FBI and ETS of ECMWF 24h precipitation forecast (48h) for seasons MAM14 to MAM17. Threshold is 2mm/24h. Comparison to operational NWP models forecast

As for the ME of forecast for 2 metre temperature, 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. 17).

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. 18).
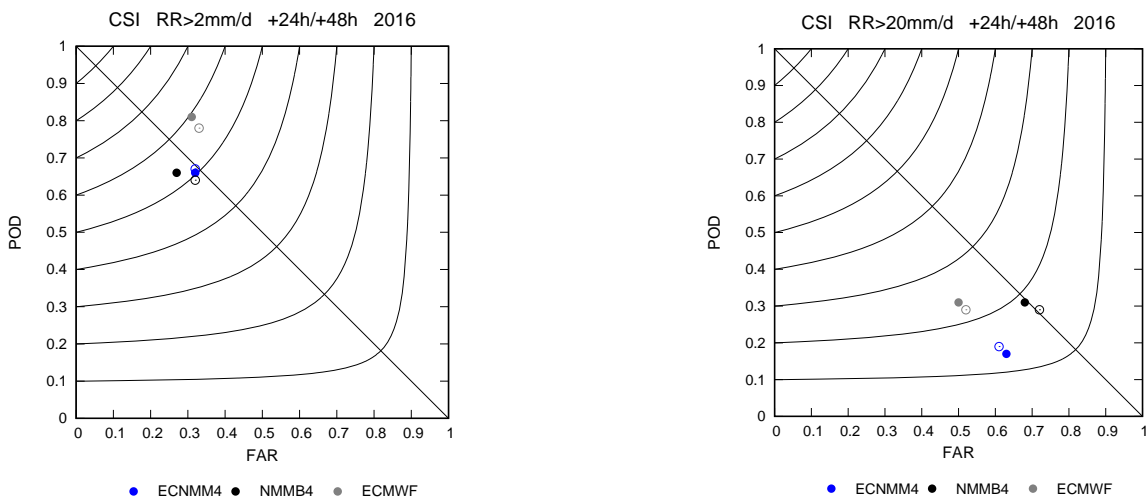

Fig.19-20 CSI contours as a function of FAR and POD for 24h/48h 24h precipitation forecast Thresholds are 2mm/24h and 20mm/24h. Comparison to operational NWP models forecast

ECMWF 24h precipitation forecast for 24h (dots) and 48h (circles) has the best results for CSI for both thresholds 2mm/24h and 20mm/24h. For the first case (2mm/24h) there is an overestimation of precipitation amount and for the second case (20mm/24h) an underestimation of precipitation amount. It should be pointed out that, for thresholds of 20mm, practically there is no BIAS for NMMB4.

3.1.3   Post-processed products

3.1.4   End products delivered to users

3.2   Subjective verification

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

3.2.2   Case studies

4.   Feedback on ECMWF "forecast user" initiatives

5.   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