Application and verification of ECMWF products 2008

National Meteorological Administration – ROMANIA

1. Summary of major highlights

- the ECMWF products – the basis of short and medium-range forecasts at the The National Meteorological Administration of Romania
- use and visualisation of products
- developing the MOS model and derived fields (wind chill and Humidex)
- use of ECMWF products for monthly and seasonal forecasts
- objective and subjective verification of ECMWF model

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

Using the Direct Model Output, there has been developed, in a bilateral cooperation with Meteo France, the MOS models on 163 meteorological stations, for the forecast of the following meteorological parameters:

- 2m temperature
- extreme temperatures (min/max)
- 10m wind (speed and direction)
- total cloudiness (3 classes: clear, partly cloudy, cloudy-covered)
- 6 hours total precipitations (3 classes: no precipitation, light precipitation, moderated-intense precipitation)

For the temperature and wind parameters, were used multiple linear regression models(RLM), and for the forecast of cloudiness and precipitation, the models used were the discriminant analysis ones. The results for the 2 RUNS of the models are presented in text format and also in graphical format. Example:

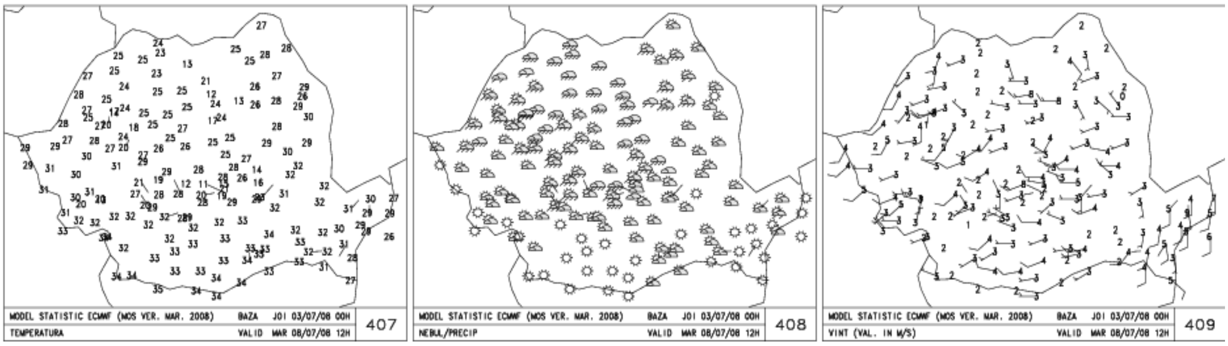


Fig. 1. Example of the MOS forecasts presentation in the operational activity

The system was implemented in the operational activity in 2004. The update on the equations was done in February 2008. An objective forecast verification system for MOS was implemented since 2005, and an update for it is scheduled in 2008.

2.1.2 Physical adaptation

The values of the monthly mean temperature and precipitation, resulting from the seasonal forecast are used in a model for the water soil balance developed by the National Meteorological Administration.

2.1.3 Derived fields

- There are operationally calculated, for the 2 RUNS of the model, during the cold period of the year, "Wind Chill", and in the warm period, "Humidex", using the forecast of ECMWF-DMO model (temperature and wind for Wind Chill, and temperature and humidity for Humidex).
- The results are disseminated in the operational activity in 2 types of format: distributions and values in meteorological stations. Examples in Fig 2 and Fig 3.

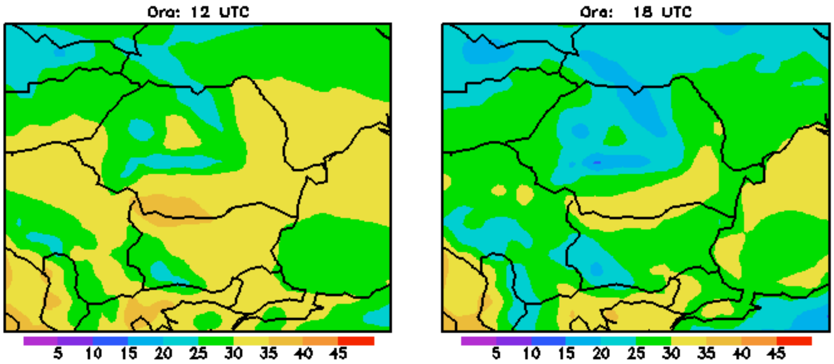


Fig. 2 Example of presentation of the Humidex forecast in the operational activity

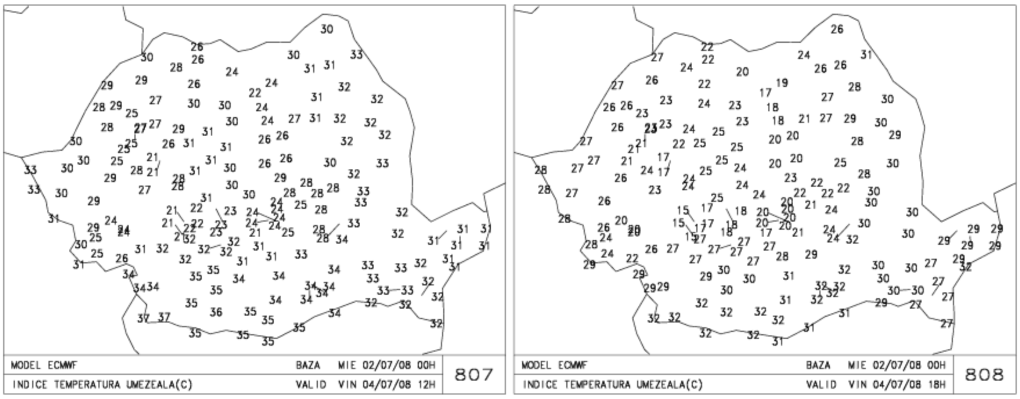


Fig. 3 Values in meteorological stations of the Humidex forecast for the operational activity

2.2 Use of products

In 2007, the ECMWF products formed the basis of short and medium-range forecasts (in the general weather forecasting for public, customers and state authorities and in the national warning system) at the The Bucharest National Weather Forecasting Centre and also at the Regional Weather Forecasting Centres of Romania. For the short range forecast, ECMWF products are used in conjunction with the outputs of high-resolution limited-area local models ALADIN, DWD-HRM and COSMO_RO. The ECMWF web site products are widely used by forecasters and became an integral part of the forecasters' daily routine (EPS esspecialy). The output fields are made available to the forecasters via Nex_REAP visualisation system, the ECMWF web site and also using the METVIEW tool on LINUX platform [6 hours forecast using METVIEW tool for accumuleted rainfall, snowfall, MSLP and 850 hPa temperature, relative humidity at 700 hPa, 2m temperature and dew point temperature, 10m wind, 10m wind gust, V300 hPa, V500 hPa, V700 hPa, V850 hPa, 700 hPa vorticity, Z-T 300 hPa, Z-T 500 hPa, Z-T 700 hPa, Z-T 850 hPa, Z-T 925 hPa, Z-T 1000 hPa, PV200 hPa, PV250 hPa, PV300 hPa, relative topography (thickness) 500-1000, relative topography 700-850, relative topography 700-1000, relative topography 850-1000, cloud cover (total, low, medium and high clouds)].

The ECMWF products (of the deterministic T799) are considered as the most important source of data used for operational weather forecast, both 00 and 12 RUN products beeing equally used and fully implemented in operational forecast. As warning system is becoming the most important component of our service, Extreme Forecast Index and other probabilistic products have been especially used in severe weather forecasting. The clusters, tubes, plumes and EPS-grams are considered for the evaluation of the credibility of the main deterministic forecast as well as to find possible scenarios in situations of low determinism. Both probabilistic products and extreme forecast index are used to issue warning information. Forecasters in The Bucharest National Weather Forecasting Centre mentioned the increasing use of the EPS meteograms and the VarEPS to predict in more details local weather conditions up to 10, even 15 days especialy to estimate the prospect for extreme weather events. ECMWF model output is used to pre-fill tables of weather of towns in global, European and local scale.

Monthly forecast – The monthly forecast has been operationally used at the National Meteorological Administration as in the previous year. Once a week, the ensemble means of 2m temperature, amounts of precipitation, pressure at sea level and 500 hPa geopotential are processed for days 5-11, days 12-18, days 19-25 and days 26-32. The weekly output fields are made available to the forecaster by mapping them on Romanian territory. A bulletin is made by a forecaster and used for internal purpose.

Seasonal forecast – ECMWF seasonal forecasts are used monthly to assess the confidence of our seasonal forecast which is performed through a method based on analogy criteria. The ensemble means for 2m temperature, amounts of precipitation, pressure at sea level and 500 hPa geopotential are checked each month for consecutive 7-months interval. The above-mentioned parameters are mapped on Romania in order to compare them to the output of the analogy method. The local weather parameters, like the temperature at 2 meter and the amount of precipitation are determined monthly at 39 Romanian stations by interpolating the surrounding four grid-points.

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output

An unitary system of objective verification of the Direct Model Output (deterministic) for all the models used operationally by NMA, has been started in 2007. Main characteristics of this system:

- uses for verification, all the available data from the national SYNOP stations –163
- the verified parameters are:
  - 2m temperature
  - mean sea level pressure (MSLP)
  - 10 m zonal and meridional wind components
  - 10m wind speed and direction
  - total cloudiness
  - total precipitation in 6 hours.
- it uses the same interpolation method (grid point to station): bilinear interpolation and/or the nearest grid point
- the descriptive diagrams are plotted for a number of reference stations from every geographical area.

The scores are stratified : meteorological stations, geographical areas and globally it uses the bootstrap method to compute the confidence interval associated with every score

- the verification is performed monthly, the scores are presented graphically on the intranet site of the Verification and Statistical Adaptation Group (GVPAS) from NMA.

The computed scores:

- for temperature, pressure and wind (components, speed and direction) are calculated:
- bias, absolute mean error, root mean square error, standard deviation, the variance reduction, correlation coefficient, covariance.
- the cloudiness and precipitation are treated as categorical parameters, using thresholds .The computed scores are: probability of detection, false alarm ratio, the percent correct , Heidke Skill Scores, Gillbert Scores, Threat Score.

We will present in the following a short description of the results for the 2007.

a) Descriptive diagrams:

Fig 4 and 5 presents two descriptive diagrams of the station 15420 - Bucuresti Baneasa, may 2007 for 2m temperature and mean sea level pressure. We consider the plot in this form as visually suggestive that allows a rapidly overview on the forecast/analysis data, used afterwards for computing scores. It also allows the identification of "outliers" , extremes, etc. Before computing the scores, we have taken the advice : .. "Always look at your data"

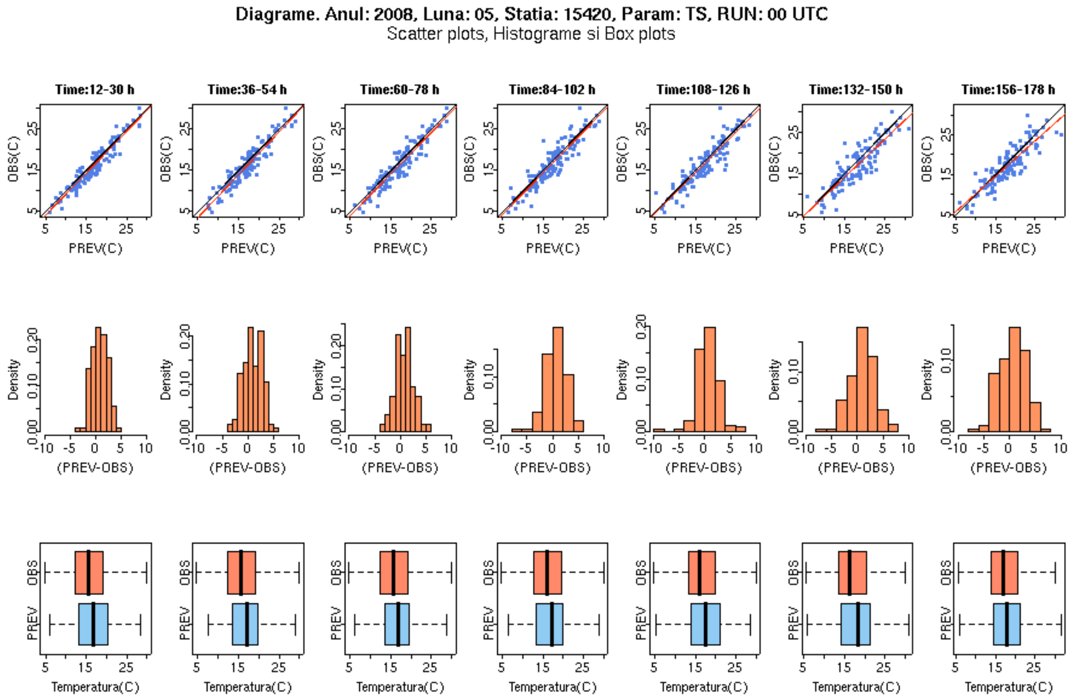


Fig. 4 Descriptive diagrams for 2m temperature, may 2008, Bucuresti Baneasa station

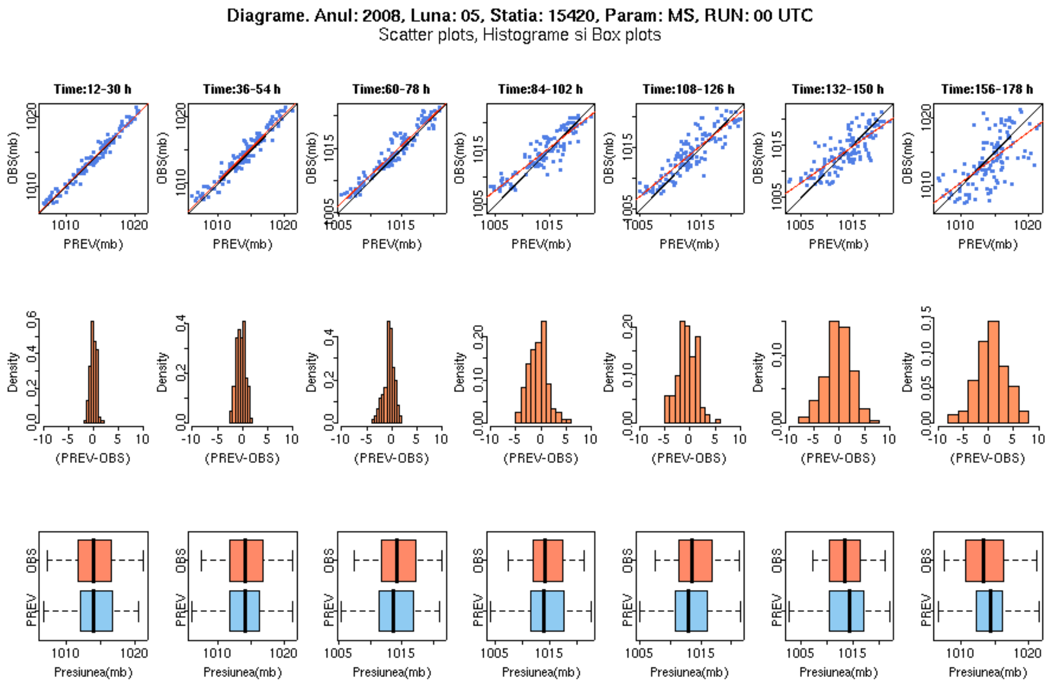


Fig. 5 Descriptive diagrams for MSLP, may 2008, Bucuresti Baneasa station

b) Scores on parameters:

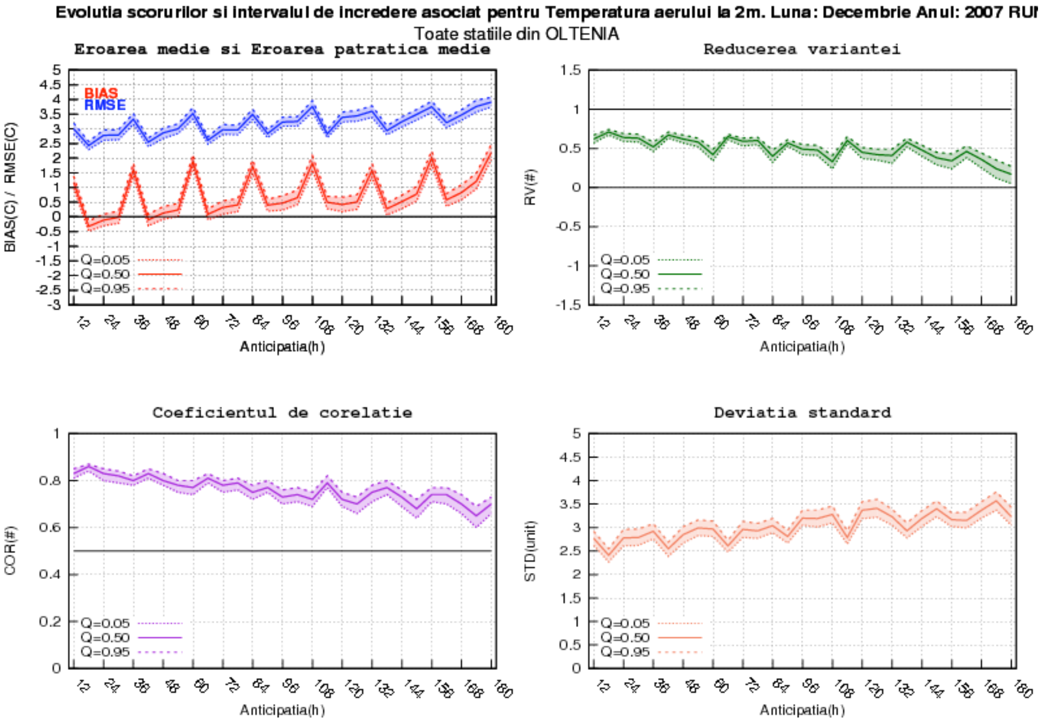


Fig. 6 Evolution of scores for 2m temperature, december 2007, Oltenia area

There are represented the quantile 0.05, 0.5 and 0.95 for each score, from 12 to 180 hours lead time, grouping the sinoptical stations from the same geographical region. The stability and the high information rate is relevant, but also the particularity of the forecast of 2m temperature (for Banat area in may 2007): a positive bias during day time and negative for the night-time.

2m temperature – The monthly average scores for all stations, computed for the year 2007 (Fig 7) shows the characteristic of the ECMWF model (Run 00) for Romania, namely: a positive bias, important in the summer season for the "night time", and also positive, but lower for the "day time". In December 2007, there was an important positive bias for the "day time" and an RMSE that surpassed 3 celsius degrees even from the 36 hours time lag. Comparing the scores of MOS and DMO for the year 2007 (Fig 8) (all months and all stations), it is noted the contribution of MOS in reducing the RMSE, by 0.5 - 1 C, in average. MOS has a different evolution in bias than the direct model, DMO has a positive bias for the moments corresponding to 06 UTC, and a negative one for 18 UTC. MOS reduces the bias, but it became in 2007, "colder" for the moments corresponding to 12 UTC, the bias growing to the 180 hour lead time. The update of MOS equation in 2008, we hope that it will correct this behaviour.

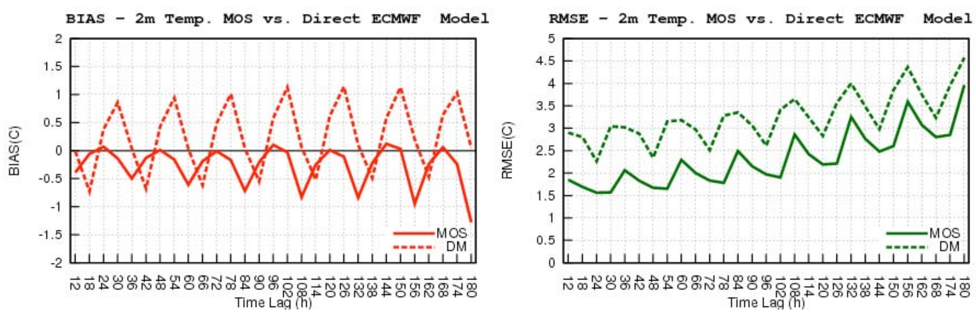


Fig. 7 ECMWF-comparison between MOS and DMO for 2m temperature, all stations, monthly average scores, year 2007

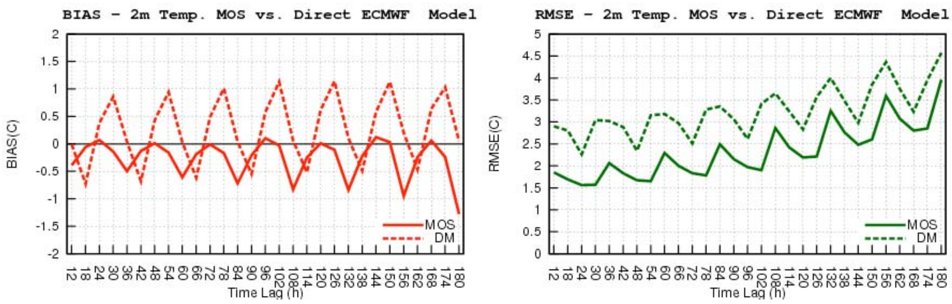


Fig. 8 ECMWF-comparison between MOS and DMO for 2m temperature, all stations, year 2007

Moreover, this behavior is not specific only to the ECMWF model, Fig 9 and 10 show similar graphics for the ARPEGE and ALADIN models. The ARPEGE-DMO has a negative bias of approximately 1 degree celsius for the 18 UTC hour, and a positive bias of the 06 UTC hour, is more reduced than the one of the ECMWF model. ALADIN has a small bias in the 18 and 42 hours time lag, but after 30 hours, it becomes likely ECMWF. The MOS developed on the two models reduces the RMSE, but especially for ARPEGE, it has been a "cold model", meaning a negative bias for all anticipations.

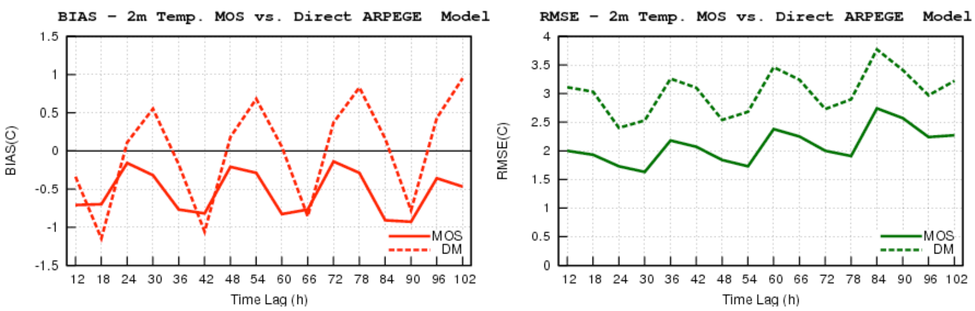


Fig. 9 ARPEGE-comparison between MOS and DMO for 2m temperature, all stations, year 2007

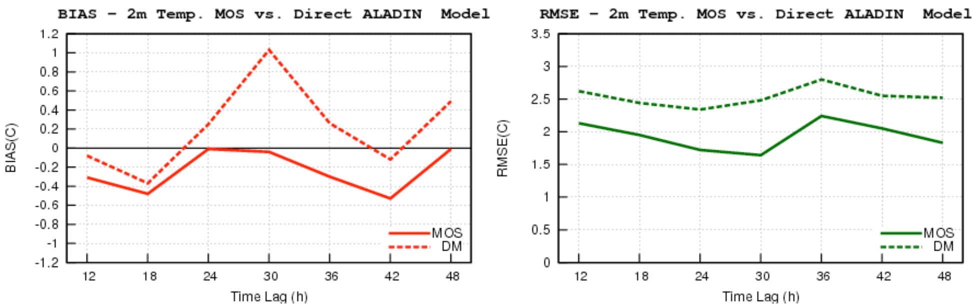


Fig. 10 ALADIN-comparison between MOS and DMO for 2m temperature, all stations, year 2007

Mean sea level pressure – we note a negative bias starting May, which has accentuated in December at time lags higher than 120 hours. October had the highest RMSE (T+120 h), and for T+132 hours, February had the same

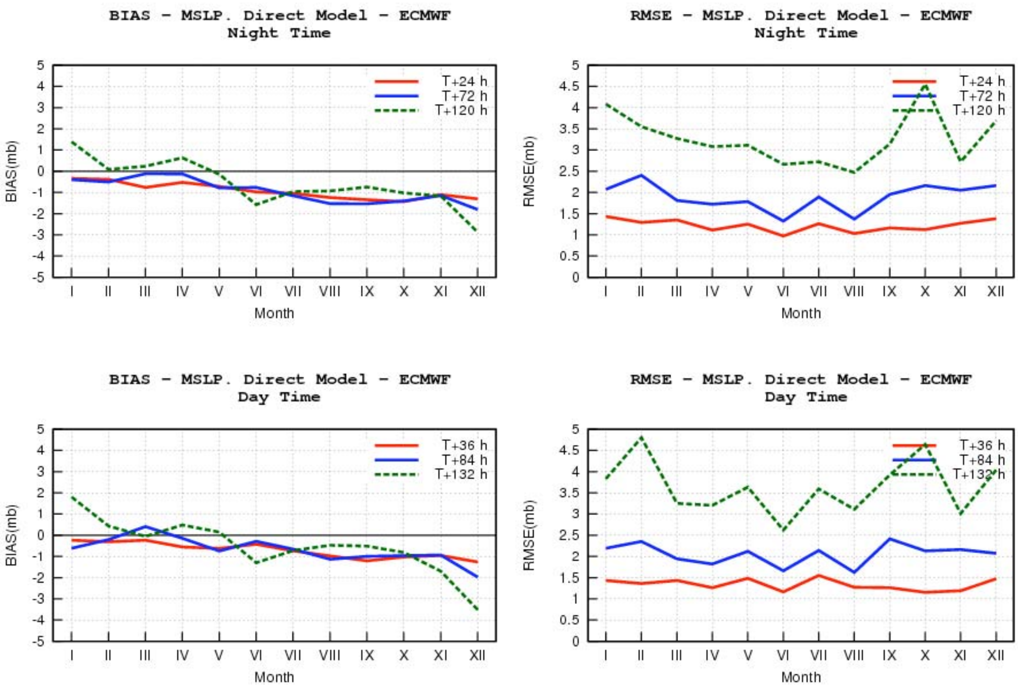


Fig 11. BIAS si RMSE for MSLP, day/night time, monthly scores computed for all romanian stations.

Wind speed – the characteristic scores for the wind speed higher than 4 m/s are presented in Fig 12, shows a positive bias, a little higher for the cold season, corresponding with a higher RMSE.

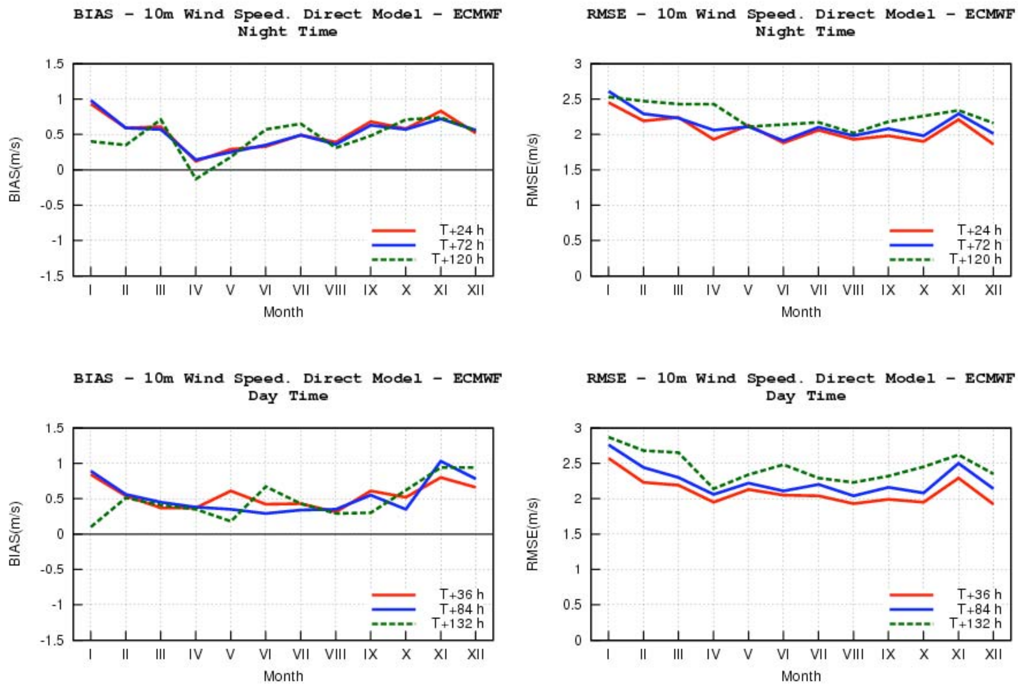


Fig. 12 BIAS si RMSE for 10m wind speed, day/night time, monthly scores computed for all romanian stations.

MOS comparated with DMO , for all months of this year, without imposing the 4m/s threshold , (Fig 13) shows a negative bias for both models (MOS and DMO), MOS accentuating the bias at time lags higher than 120 hours. Moreover, on these time lags, DMO is superior to MOS. (Fig 13)

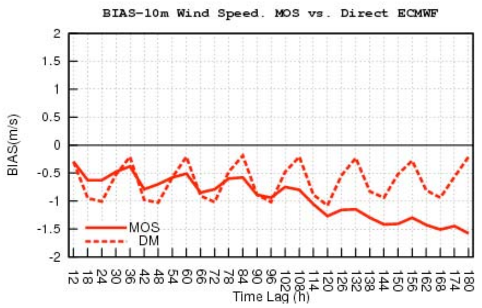


Fig. 13 MOS compared with DMO , all months of 2007, for 10 m wind speed.

6 hours precipitations – the verification of cumulated precipitation in 6 hours, is performed on the 3 classes: no precipitation, light precipitation and moderate to intense precipitation.

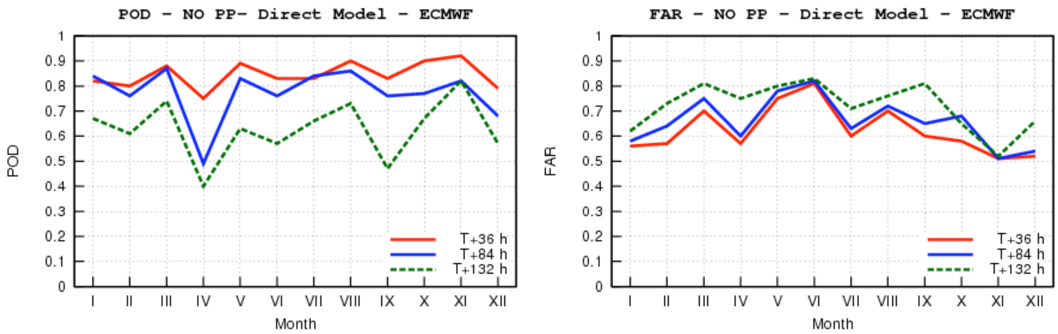


Fig. 14 Scores for cumulated precipitation , ECMWF-DMO, all months of 2007.

Fig 14 presents the scores for the non precipitation class. The POD of this class range between 80-90%, with a FAR less than 60% for lead times up to 120 hours. At 132 hours time lags, POD decreases and FAR increases. April 2007 had the smallest POD.

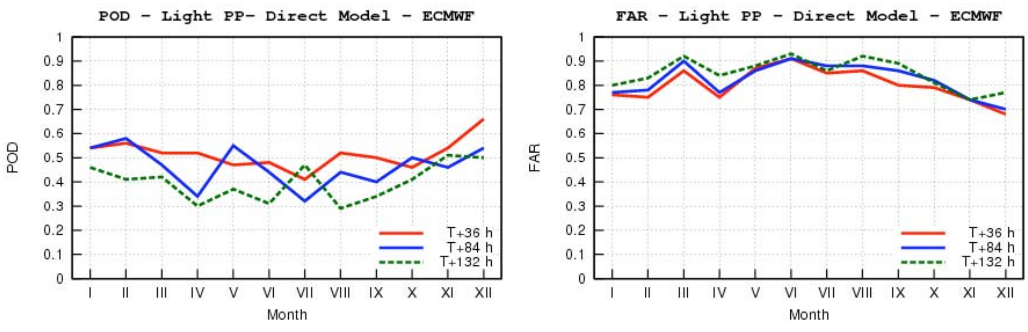


Fig. 15 Scores for light precipitation class , ECMWF-DMO, all months of 2007.

Fig 15 presents the same scores for light precipitation class. The scores are more reduced than on the 'no precipitation' class.

Comparing MOS with DMO for the first class (non precipitation), we note an inferior MOS to DMO for anticipation below 120 hours and little superior above this time lag. MOS, using discriminant analysis, doesn't seem to bring an important contribution in the forecast of precipitation. The verification of precipitation is a a difficult and complex task, so in this year we will develop more techniques of interpolation and precipitation verification, other than the basic ones.

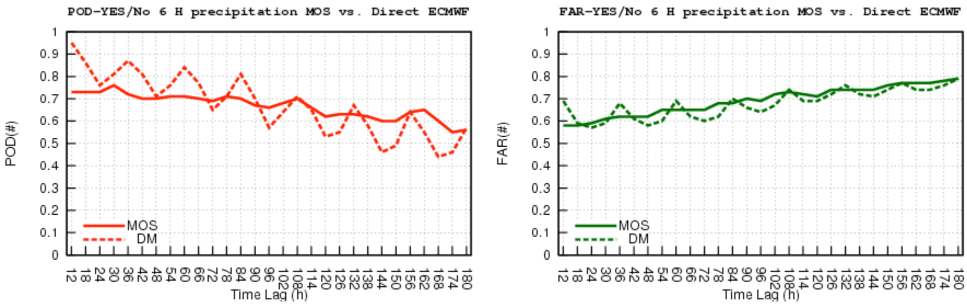


Fig. 16 Scores computed for appearance of 6 hours precipitation, MOS vs. DMO

3.1.2 ECMWF model output compared to other NWP models

Comparative verifications are developed, until now only for 2m temperature DMO and MOS.

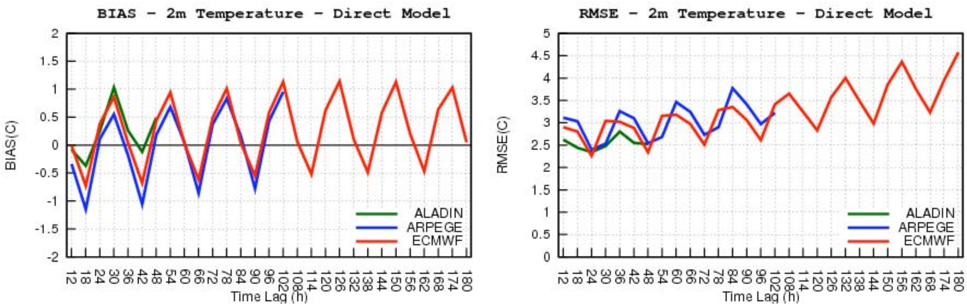


Fig. 18 Comparison between ALADIN, ARPEGE and ECMWF direct models, for 2m Temperature.

Fig 18 shows the same behavior of bias and RMSE for the 3 models, with small differences in the amplitude. RMSE for ALADIN is smaller than for the other 2 models. The diurnal cycle of RMSE - ARPEGE seems shifted with 6 hours, than the one of ECMWF.

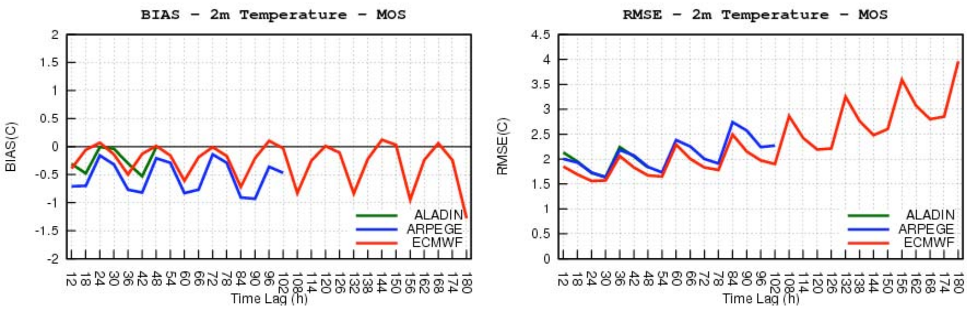
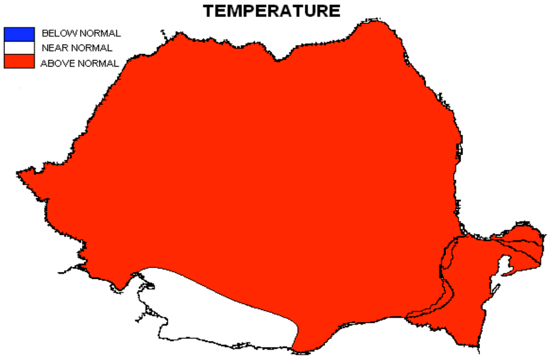


Fig. 19 Comparison between ALADIN, ARPEGE and ECMWF, MOS models, for 2M Temp

Fig 19 shows the same scores for MOS developed on the 3 models. MOS_ARPEGE has a negative bias higher than MOS_ECMWF and MOS_ALADIN. Regarding RMSE< MOS_ECMWF proves to be better than the other two models. The scores are gathered in suggestive graphical forms, an example of presentation being the one in Fig 6.

3.1.3 Post-processed products

The direct outputs of the ECMWF seasonal forecast model have been processed for the geographical region of Romania, in order to assess the forecasted meteorological fields at several Romanian stations. The forecast values were taken from a 2.5°x2.5° post-processing grid and interpolated at 39 stations. The monthly mean of 2 meter temperature forecasts and the amounts of monthly precipitation forecasts were verified using a method based on tercile categories: "above normal", "near normal", and "below normal" (figure 17).



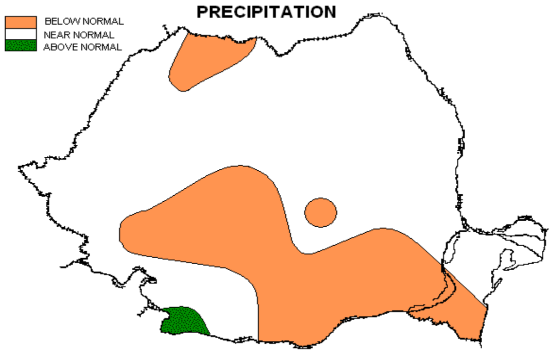


Fig. 17 Anomalies of the mean temperatures and amounts of precipitation in Romania – August 2008, issued July 2008

The ensemble seasonal forecasts of the above mentioned parameters were compared at each station to the boundaries of the tercile categories defined using the data observed in 1961-1990 period. The performance of the direct ECMWF model outputs was evaluated every month for all 7 forecasted months for both temperature and precipitation in order to set the expected quality of these forecasts. The skill score is obtained by using a method adapted from Preisendorfer and Mobley (1984). In the case of the mean temperature (table 1) the best result was found in the summer months 2007 and the worst one in May 2007. The precipitation forecast had the higher skill score in the fall months 2007 and in July 2007 and the lower skill score in April 2007 (table 2).

Month issued	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan	88	75	55	63	32	79						
Feb		82	71	55	55	81	89					
Mar			96	53	31	78	81	74	81			
Apr				53	32	65	81	78	55	79		
May					33	82	97	87	56	79	58	
Jun						96	99	95	42	83	59	43
Jul							97	91	54	79	58	36
Aug								71	53	81	54	54
Sep									82	76	55	51
Oct										74	76	57
Nov											88	62
Dec												53

Table 1. The skill score (%) of the monthly temperature anomalies in 2007

Month issued	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan	66	68	74	37	58	58						
Feb		76	78	26	69	48	73					
Mar			79	37	65	67	76	52	84			
Apr				54	63	63	69	47	64	78		
May					67	66	65	46	83	93	68	
Jun						70	67	14	65	85	68	56
Jul							76	33	85	88	68	56
Aug								60	79	91	67	62
Sep									88	95	71	56
Oct										99	68	58
Nov											82	60
Dec												65

Table 2. The skill score (%) of the monthly amounts of precipitation anomalies in 2007

3.1.4 End products delivered to users

The post-processed products – ECMWF_MOS (2m temperature, extreme temperatures, total cloudiness, 6h accumuleted precipitations, 10m wind) are automatically deliverd to some of our customers (service providers) and also represent the guidance for the 3day cities forecast issued by meteorologists.

3.2 Subjective verification

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

The team of forecasters in the NWFC subjectively express their confidence in the model's prediction. We continue the work in a subjective evaluation system (in finding confidence indices that we can rely on).

3.2.2 Synoptic studies

The case studies carried out by forecasters in 2007 using ECMWF deterministic T799 shown an improved accuracy in the position of the most significant low or high in the forecast area and the position of the atmospheric fronts associated with these systems. However, subjective impression is that the model often gave significantly different "scenarios", even for the range from D3 to D7, especially in the autumn (important differences between 12 and 00 UTC RUN).

Subjective evaluation for ECMWF products in forecasting and bringing up to date the heatwave of July 2007 in Romania has shown that:

- the weekly temperature anomaly and the 2m temperature EFI signal was a very good hint (first warning issued on 16 July);
- the 2mT direct output from ECMWF – very good for South-Western Romania, good enough for South-East;
- the ECMWF temperature field at TA850 – very good, especially for the SW;
- the ECMWF maps for TUI-humidex, post-processed by the GVPAS-NMA team – good all over the country as a hint, but underestimated values especially for Southern Romania.
- the ECMWF post-processed (MOS) for Tmax – the most accurate compared with the other operational models!

During the cold season, a lower forecast value for temperatures has been observed (analised on ECMWF T799 – 2mT direct output, post-processed Tmax – MOS, EPS temperature anomaly and the 2m temperature EFI, from EPS-grams) and an over-prediction of snow in marginal snow/rain situations.

4. References to relevant publications