Application and verification of ECMWF products 2011

National Meteorological Administration

1. Summary of major highlights

Medium range weather forecasts are primarily based on the results of ECMWF and ARPEGE deterministic models. In the short range, ECMWF and ARPGE models results are used in conjunction with those from: ALADIN, ALARO and COSMO_RO. The usage of those models combined with MOS systems continues to lead to a further increase in forecast accuracy.

The objective verification of all deterministic models forecasts in use have been continued on all time ranges as previous years. All MOS verification results and deterministic models verification results are presented on the specialised web-site. http://neptun.meteoromania.ro (access restricted upon request)

In **2010**, some important steps were performed:

- MOS_MIXTE model: - statistical MOS model using MES_ECMWF and MOS_ARPEGE
- improvement of daily direct model output verification

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

The MOS statistical models have been in operational use since 2004. No changes in basic models since that time. The models provide twice on a day, local forecasts up to 10 days, to 163 meteorological stations for the following main parameters: 2m temperatures, extreme temperatures, 10m wind speed and direction, total cloudiness(3 classes) and total precipitation. The results are plotted in map forms and displayed on the web site. A special selection is made for the end users in text format and also for the forecasters.

In 2008, the PseudoPP statistical model developed in cooperation with Meteo France, was implemented. The parameters are: 6h 2m spot temperatures and extremes temperatures, up to 15 days and up to 32 days. The disseminating formats are: maps, regional graphs, and stations graphs.

In 2010, a MOS_MIXTE model was developed, using MOS_ECMWF RUN 12 UTC and MOS_ARPEGE RUN 00, for extreme temperatures. The results are plotted in map forms:

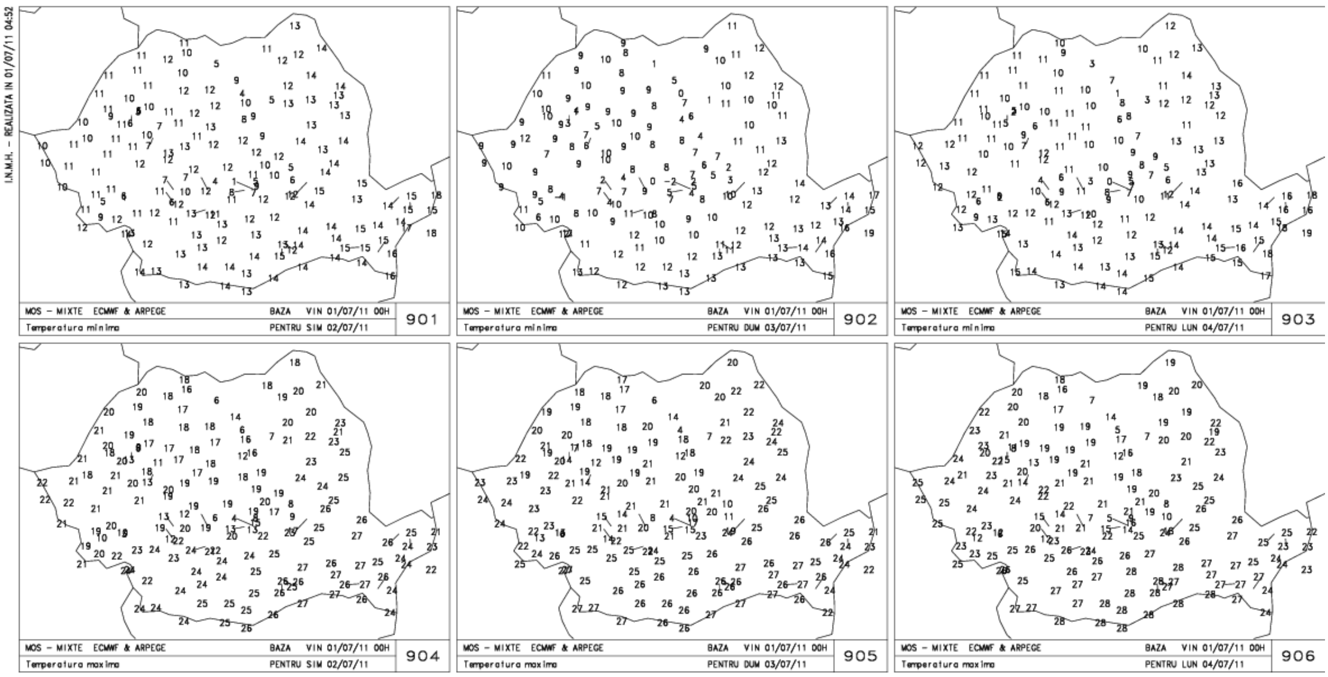


Fig. 1. *MOS_MIXTE extreme temperatures forecasts.*

2.1.2 Physical adaptation

2.1.3 Derived fields

During the summer the “Humidex” index is computed, using the ECMWF 2m temperature and humidity forecasts. During the winter season the “Wind Child” is calculated using 2m temperatures and wind speed forecasted by the ECMWF model, twice a day.

2.2 Use of products

The ECMWF products continued to form the basis of short and medium range forecasts, for public, customers and state authorities, and within the national warning system. A large number of new graphical products, generated through METVIEW and Magics are available on a dedicated Intranet site.

On the other hand, a few parameters from numerical models are plotted using “*ncl-ncar”* and displayed on the web site in such a way to be easily compared. Examples in Fig. 3.

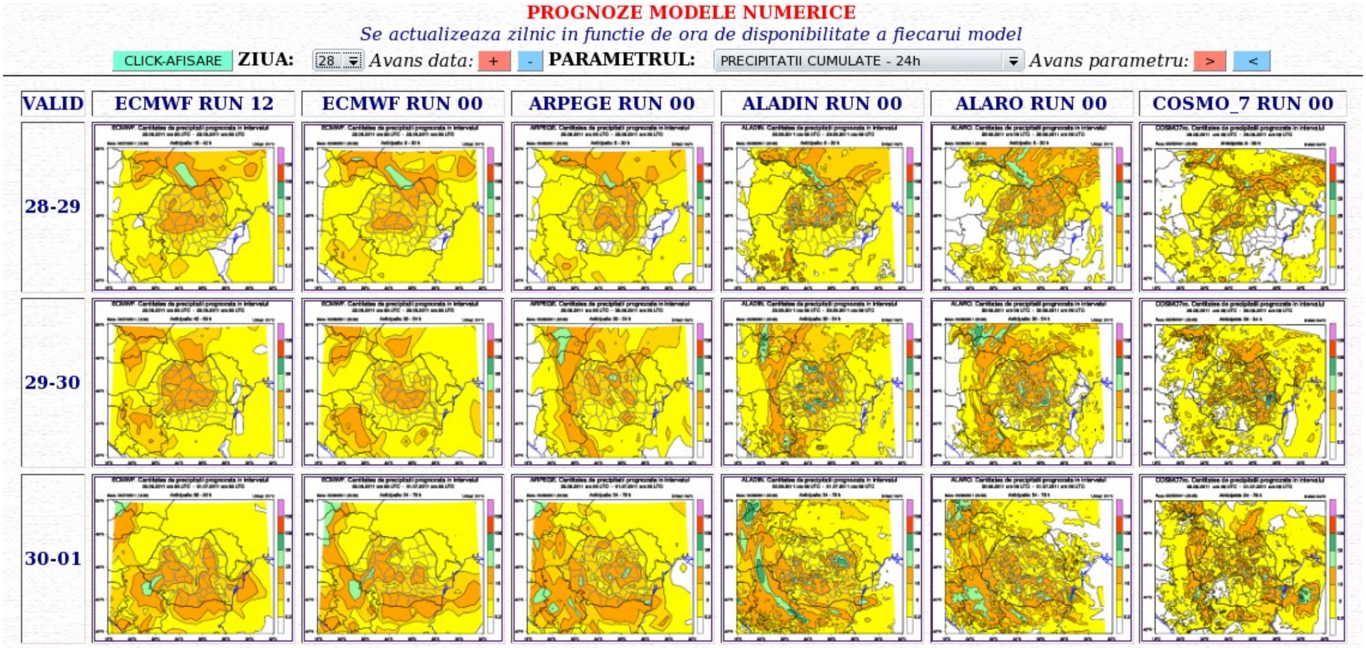


Fig. 3. *Example of daily total precipitation; Forecasts with different time lags from various models*

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

The objective verification has been continued in 2010, using the VERMOD - an unitary system for objective verification of all models used operationally by the National Meteorological Administration (NMA): ECMWF, ARPEGE, ALADIN, ALARO COSMO_RO. A wide range of statistical verification measures are computed daily and monthly. The results are disseminated via dedicated *statistical and verification* web-site. The results are averaged over different selections of stations.

In 2010, a new procedure was developed in order to perform daily verification of all models used in NMA. The parameters are : 2m temperature, total cloudiness, msl pressure, wind speed and 24 total precipitation. The results are displayed in map and graph forms, on the friendly web-page. The user can choose the parameters and can easily see the performance of one model on the specific day and the comparison between the models over the regions. The map formats for 2m temperature, wind speed, total cloudiness and msl pressure are the same (see examples below).

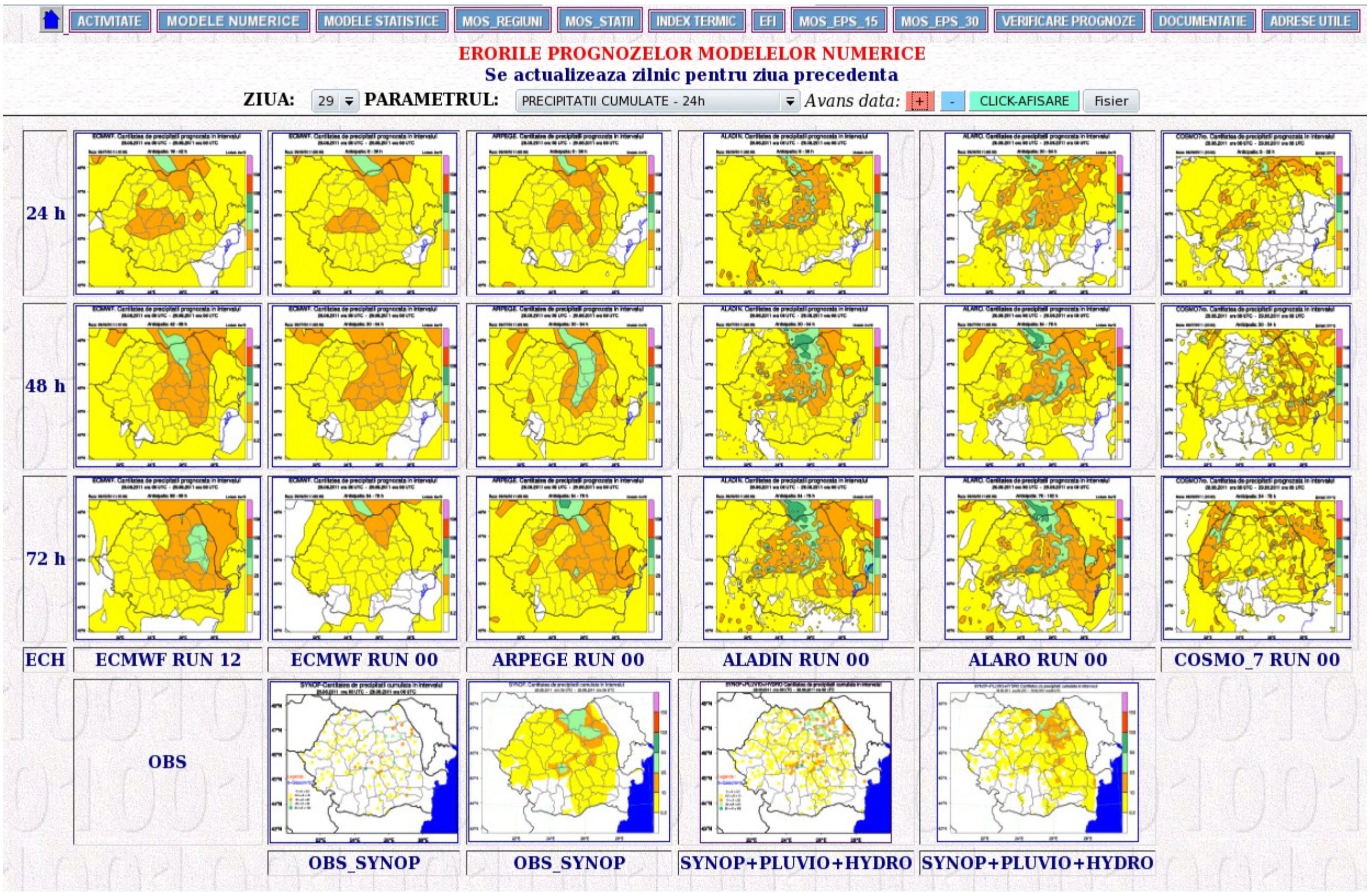


Fig. 4. *Example for 24 hours accumulated precipitation verification maps: Forecasts with different time lags and the corresponding observations*

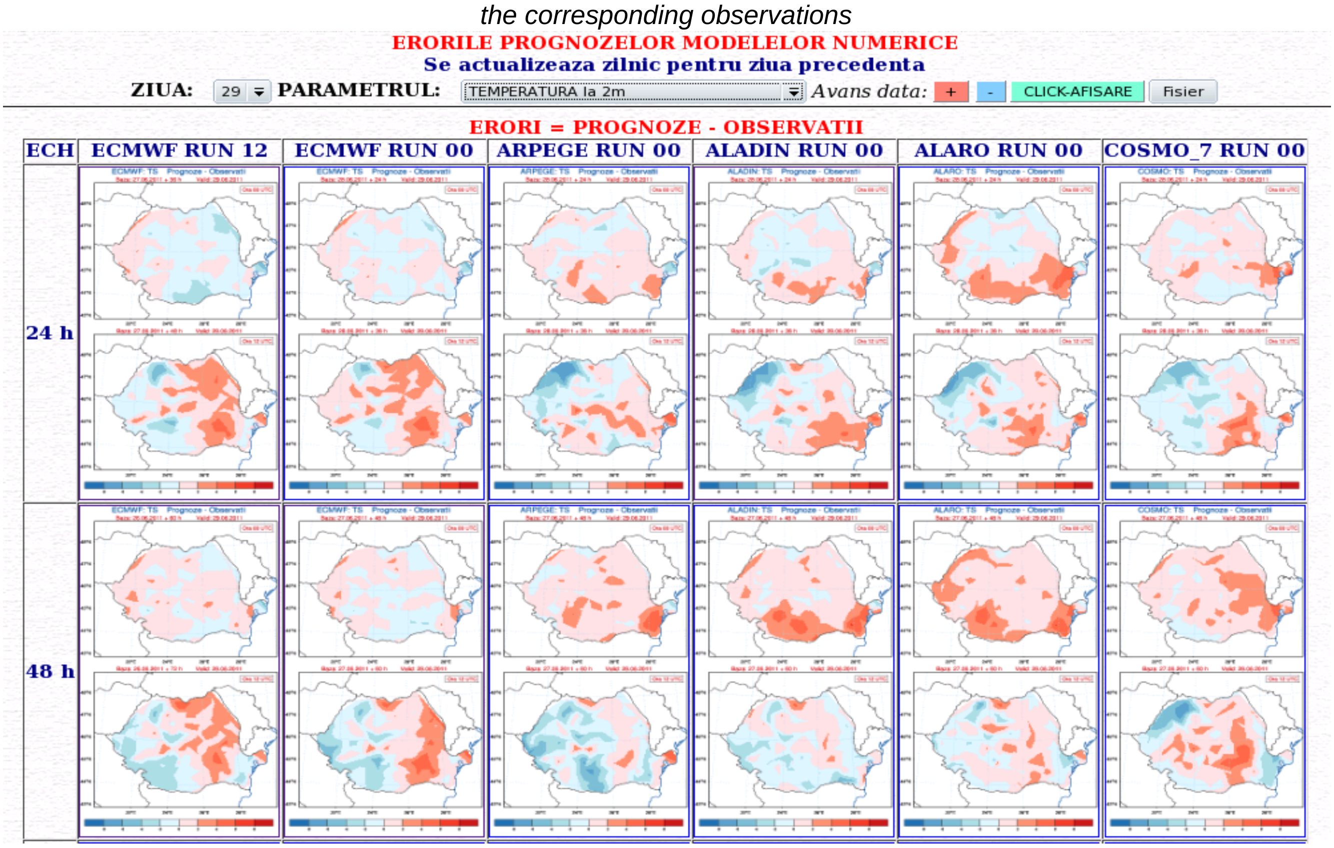


Fig. 5. *Example of daily temperatures verification maps: Forecasts errors with different time lags, against observations.*

3.1.2 ECMWF model output compared to other NWP models

Comparison of performance of ECMWF model to other NWP models used by NMA is performed daily and monthly, for the most important surface weather parameters: 2m temperature, 10m wind speed, total cloudiness, mslp pressure and 24 h total amount of precipitation. Graphs of the main verification scores are available on the web-site and also an overview of the performances of the models for all year. Examples of graphs are presented in Fig. 6 – 8.

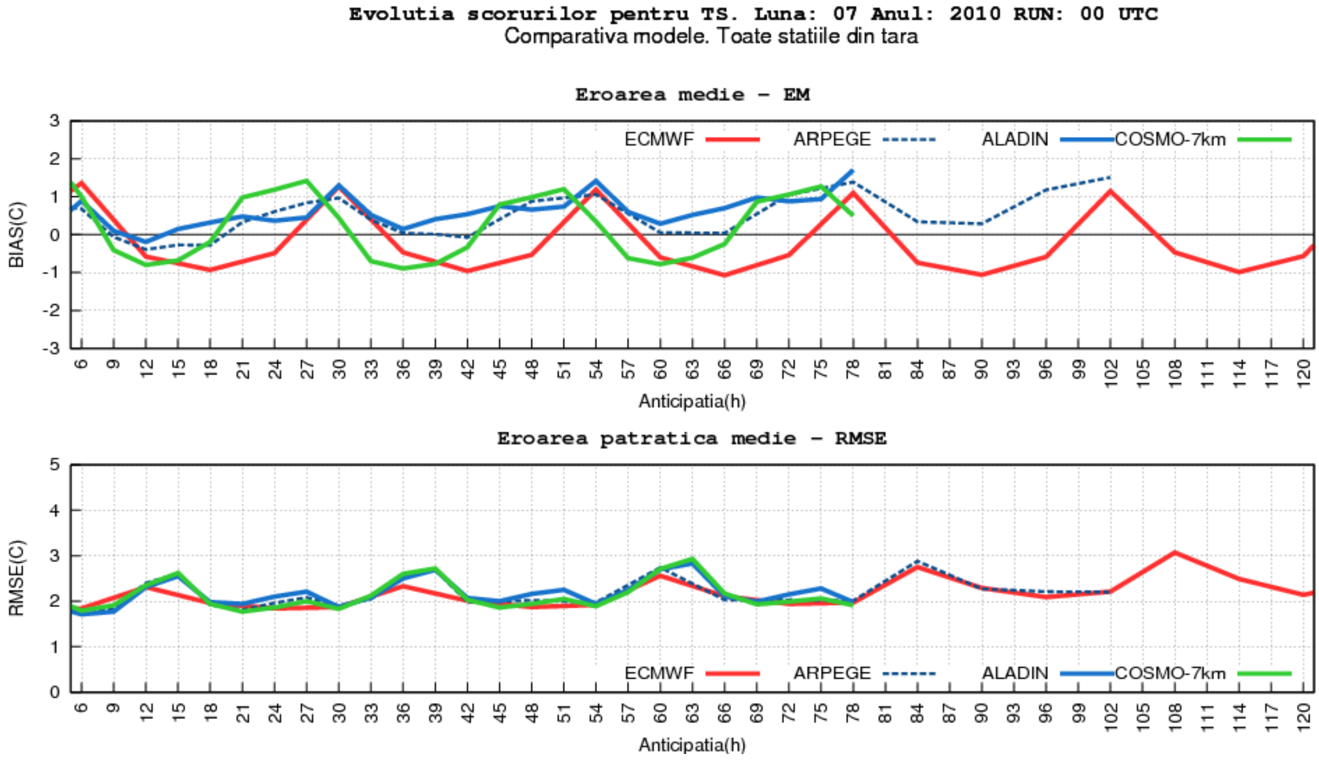


Fig 6. **2m Temperature**. *BIAS and RMSE scores distribution using all meteorological stations. Month of July 2010.*

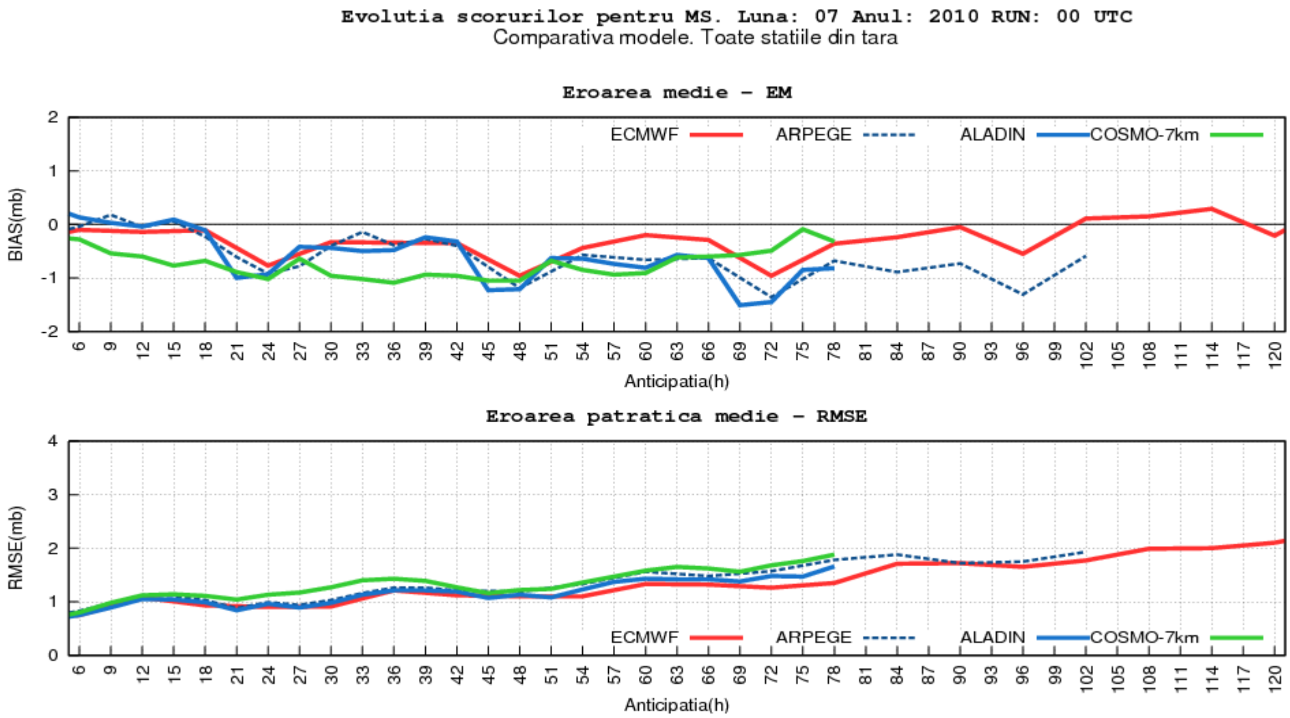


Fig. 7 **MSLP.** *BIAS and RMSE scores distribution using all meteorological stations. Month of July 2010.*

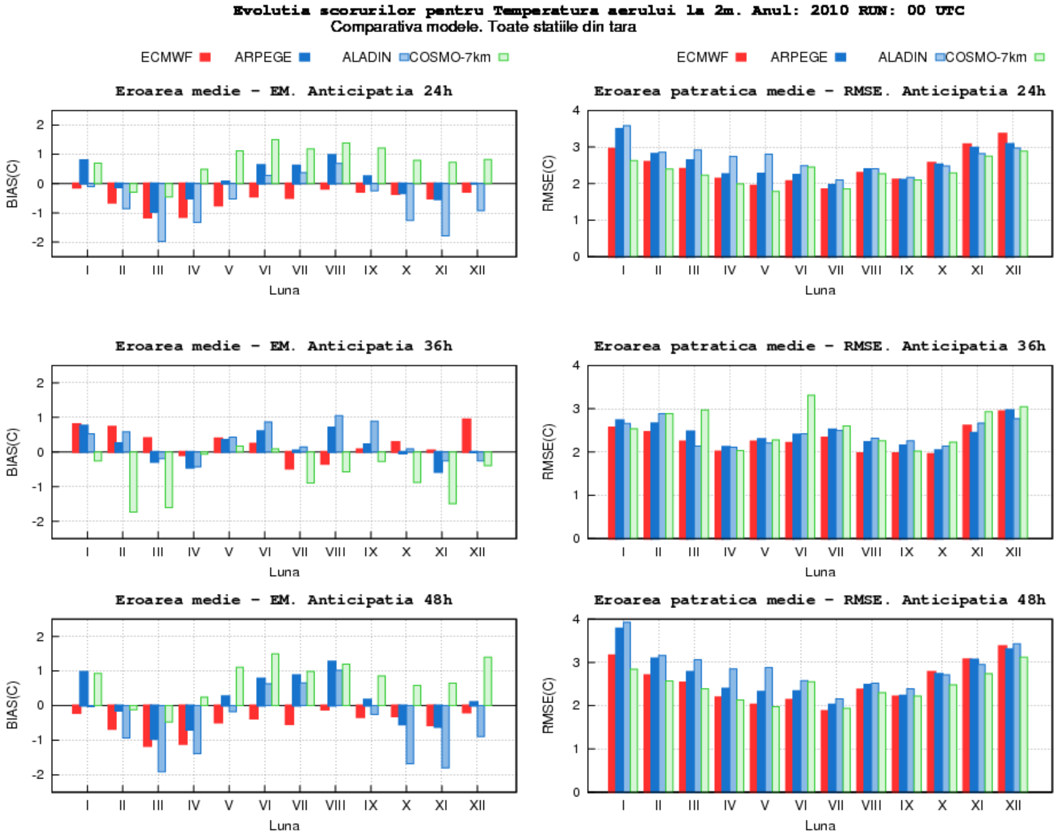


Fig 8. **2m Temperature**. *Mean monthly BIAS and RMSE scores distribution using all meteorological stations. Year – **2010***

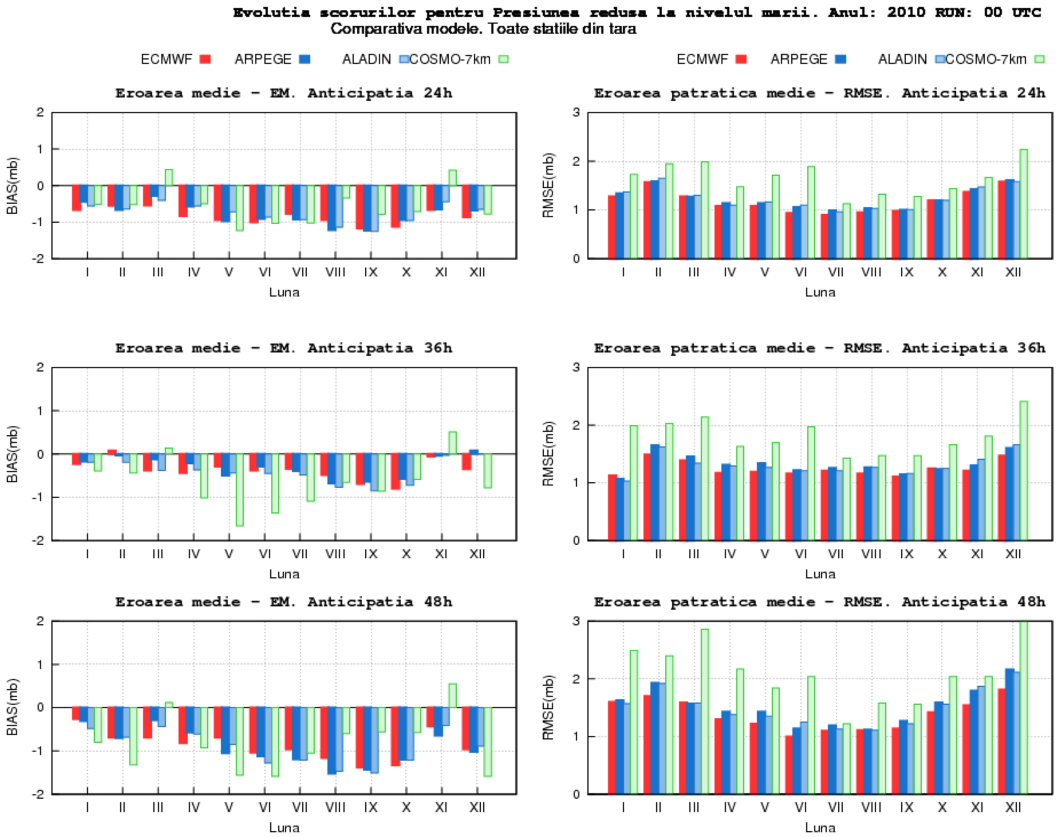


Fig 9. ***MSLP.*** *Mean monthly BIAS and RMSE scores distribution using all meteorological stations.*

3.1.3 Post-processed products

All MOS forecasts have been verified every month since 2004, and the results have been displayed on the web site. A comparison between MOS and meteorologist forecasts, for extreme temperatures is performed daily and monthly. The performances of all MOS systems – and "forecaster – (red bar)" for 21 meteorological stations from different regions is performed daily and monthly.

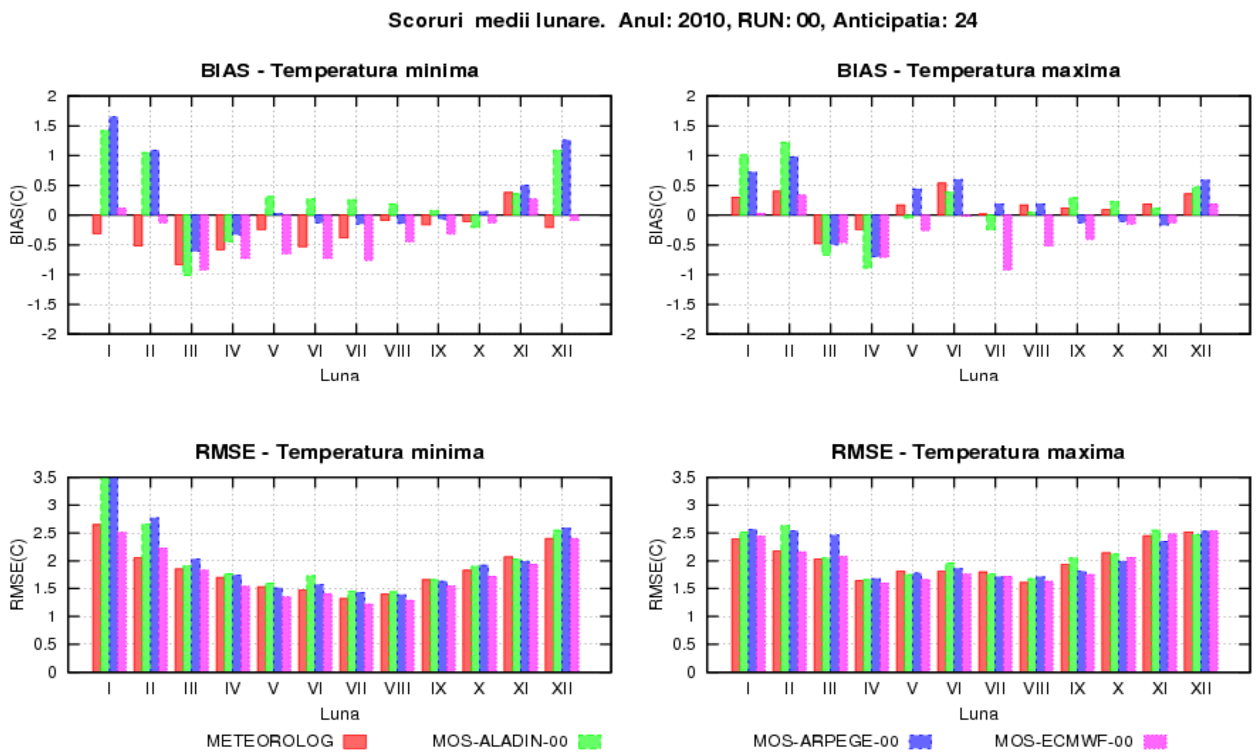


Fig. 10 **2010 -** *MOS_ECMWF, MOS_ALADIN and MOS_ARPEGE , compared with "subjective"-METEOROLOG forecasts Scores averaged on 21 stations –* ***minimum and maximum temperature.***

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 Synoptic studies

Use of ECMWF products in a severe convection situation

Precipitation forecasts supplied by ECMWF with 42, 30 and 18 hours ahead of the initiation of convective phenomena in Wallachia

In central Wallachia and in Bucharest, phenomena occurred, associated to the enhanced instability in the afternoon of 6 August 2009. It rained in one day more than it usually rains during the whole month of August – with accumulated amounts exceeding 50 mm over a wide area – 61 mm in Bucharest, and the largest amounts accumulated in 8 hours being 114 mm at Cornu in Dambovita County. Such amounts exceeded the mean monthly values for the whole month of August: nearly 55 mm in Bucharest, between 35 and 60 mm over the Romanian Plain and between 60 and 80 mm in the sub-Carpathian area.

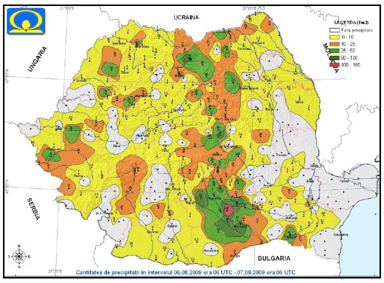
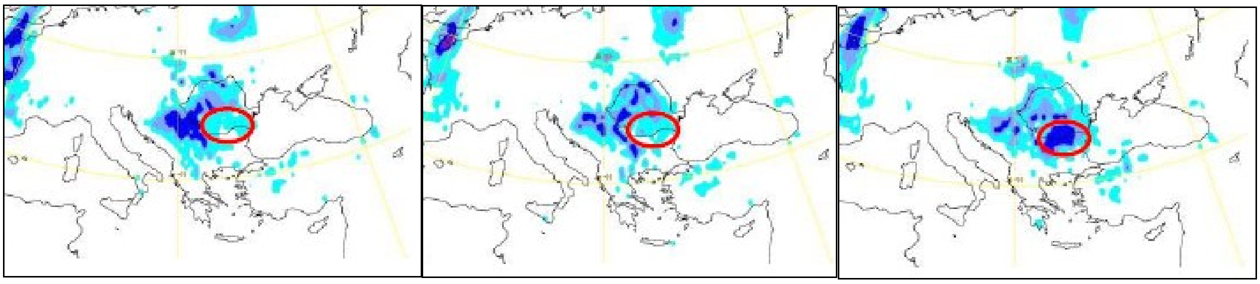


Fig. 11 Accumulated precipitation

As regards the precipitation forecasts, these ones were underestimated. 42 and 36 hours before, the forecast precipitation was under 2 mm in this part of the country and in the morning before those phenomena occurrence, the model detected the area with the largest precipitation amounts, however widely underestimated, just 10...15 mm in Wallachia.*(Fig 12, a-42 , b-30 and c-18 hour forecast before the event)*



The question is: why 42 and 36 hours before the phenomena the model forecasted almost no rain at all over the capital city and why in the morning of the same day things changed radically? Are there new elements parametrized by the model for lead times of up to 24 hours or did the model fail to detect certain elements in the vertical structure of the atmosphere?

- Precipitation forecast with various lead times (up to 10 days) yielded by the European Forecasting Centre.

It can be noticed how both the deterministic and the EPS control model forecasted 13 and 15 mm respectively for Bucharest one morning before the event. Besides, for longer anticipations, the model forecasted under 3 mm, with a first signal for larger amounts issued by the deterministic model 6 days before of the event, when it forecasted 10 mm.

- **Why the European Centre for Medium-Range Weather Forecasts failed to detect the very large precipitation amounts recorded in central Wallachia**
-

First analysis - sea-level pressure and temperature at 850 hPa – analysis and forecast. Synoptic circumstances were apparently unfavourable. As a rule, blocking structures and the north-easterly circulation at the level of our country created certain problems to forecasting temperature and assessing precipitation. Thus, in almost all cases, the Scandinavian High, expanded towards central Europe also, found favourable conditions to further expand towards our country and lobed upon a peri-Carpathian shape by the sides of the Tatra Mountains, the Eastern Beskids and the Eastern Carpathians, as facilitated by the relief and caused convergence lines to emerge in the south of the country and especially in the central part of the Romanian Plain.

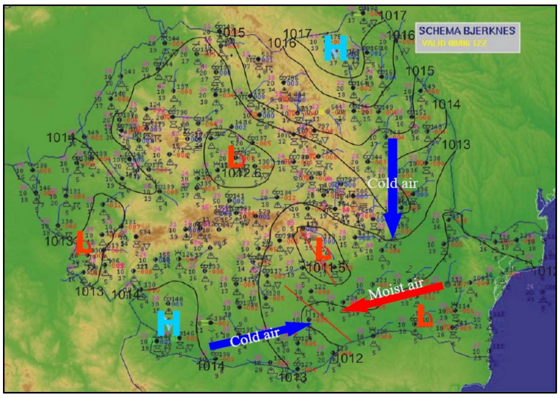


Fig 13 *Mesoscale sea level pressures (hPa) at 15 LT (12UTC) 6 August 2009 -Source: maps SIMIN – COF*

The model detected very accurately the ground pressure field, even the way how the Scandinavian High lobed upon the peri-Carpathian relief shape, but it underestimated the temperature values from the low troposphere in the south-east of our country (the influence of the warm, moist air from over the Black Sea*).*

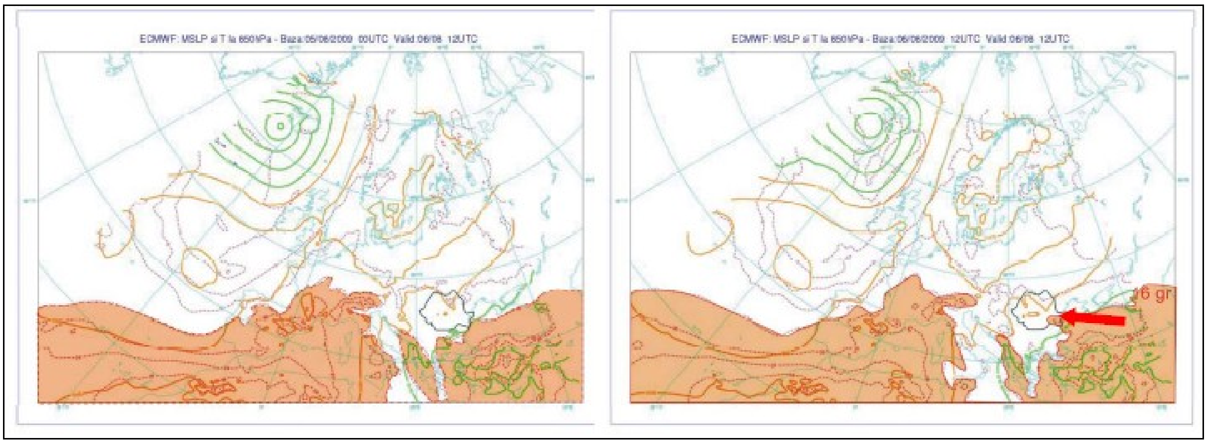


Fig 14, *a) - MSLP and 850 hPa temperature-36 hours forecast and b)b - MSLP and 850 hPa temperature-analysis)*

As can be noticed from the analysis performed at noon, on the image on the top, 16 degrees Celsius isotherm was in the south-east of our country, whereas the 36-hour anticipation expected the warm ridge to only affect the Black Sea.

- **The 24-hour lead time temperature forecast was largely underestimated; the deterministic model yielding 7.4 degrees less and the EPS control- 8.4 degrees less.** Implicitly the maximum temperature forecast was largely underestimated because of the thermal influence from the low-troposphere, and because of underestimating the insolation-owed daytime warming degree, taking into account that the are between the Carpathians and the Balkans displays types of active surfaces with a low albedo, which leads to the accumulation of heat in the area of the Romanian Plain.

Thus, the temperature forecast for Bucharest on that day was 24...25 degrees, much below the one recorded at Filaret station, which climbed to 32.4 degrees Celsius. Besides, the convective temperature estimated by the sounding at 31 degrees Celsius, essential to initiate convection, was reached as early as 13:00 LT.

- Deviations are small in anticipations of up to one week, therefore the model was stable – forecasts with up to 6 days lead time framed within the maximum 5 degrees error margin.

The exception was on 6 August, when both models, the deterministic and the ensemble one respectively, underestimated the maximum temperature value, even at the 24-hour anticipation.

However, as a rule, the August forecasts for the maximum temperature yielded by the two models (deterministic and ensemble ones) showed good results for anticipations of up to 6 days, as the maximum deviations did not exceed 5 degrees Celsius. The exception was exactly on 6 August.

- Assessment of the thermal and geopotential structure at the level of 500 hPa. On the one hand, the warming degree within the lower troposphere was underestimated, but what really happened in mid-troposphere? As can be noticed in the image on the bottom, a fresh cold air penetration affected our country. The thermal trough had expanded as far as towards the Aegean Sea.

The forecast did not anticipate this new refresh of the air mass at this level

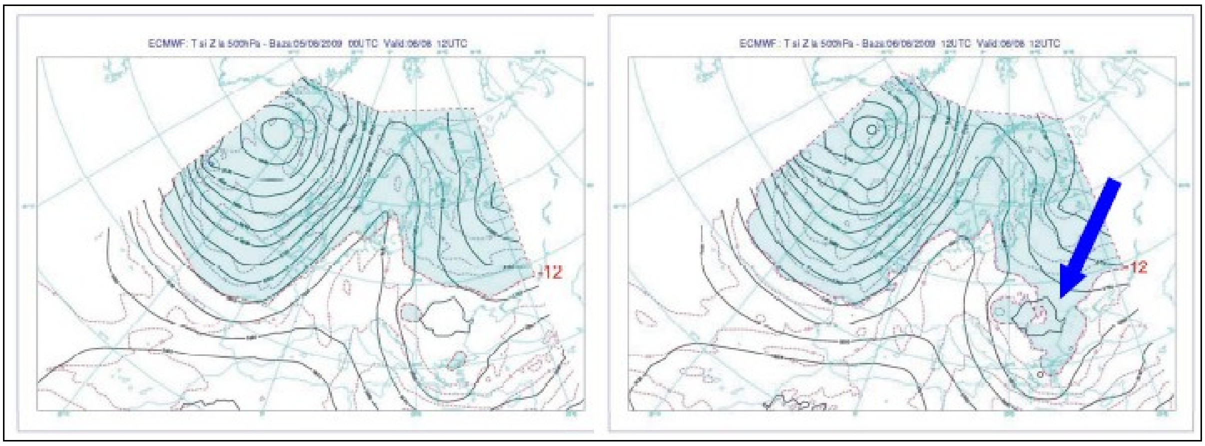


Fig 15 *a) - 500 mb geopotential height and temperatures-36 hours forecast, and b) - 500 mb geopotential height and temperatures—analysis)*

So these would be the two missing ingredients for a successful forecast: the preservation and contribution of warm air in the low troposphere and the influence of the polar air mass in the mid-troposphere.

- **Conclusions**

-The **blocking structure –** in many situations, such structures created problems to forecasting temperatures and assessing precipitation.

-An unfavourable synoptic circumstance – local air dynamics in the area encompassed by the Carpathians and the Balkans – was not detected.

-Convergence lines emerging in this area are favoured by the Scandinavian High lobed upon the peri-Carpathian relief shape – as facilitated by orography.

- The **atmospheric instability** factor – the model underestimated the ground-level warming degree and the cooling extent in the altitude.

- The **influence of the Black Sea** (moisture contribution) is underestimated in many cases

- The **excessive warming in the Romanian Plain**, attributed to the active surfaces with a low albedo.

- Problems with assessing the **thermal potential of the air masses** within the mid-troposphere reaching our country, by the front side of very strong ridges.

The model forecasted very accurately the major structure of geopotential and sea-level pressure, but it **underestimated the atmospheric instability degree**: only a few degrees Celsius more in the low troposphere and a few degrees less in mid-troposphere – made thermal gradients be high and the air mass very unstable - and consequences in the weather evolution - bad for many people in Bucharest.

The **mass transport from over the Black Sea was also underestimated** (the incoming moisture permanently supplied the convective moisture)- the air mass was set in motion by the occurrence of the thermo-dynamic depression occurrence in the central part of the Romanian Plain. There, air masses with different properties came in contact – moist, warm masses from above the Black Sea with cold and generally dry masses in the front flank of the Scandinavian High.

4. References to relevant publications

http://www.ecmwf.int/newsevents/meetings/forecast_products_user/Presentations2010/pdfs/Cristinel.pdf