COSMO Data Assimilation. Applications for Romanian Territory

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1 Introduction

In the context of numerical weather prediction, the requirements for a data assimilation system are dependent on the purpose and main characteristics of the numerical model for which they are used as initial conditions. The COSMO model in operational configuration is characterized by high resolution on a limited domain, with the main purpose of producing accurate short period numerical weather forecasts. One of the main concerns in improving the quality of numerical weather forecasts is the development of data assimilation techniques and proper usage of various types of observation data.

Data assimilation is an analysis technique in which the observed information is accumulated into the model state by taking advantage of consistency constraints with laws of time evolution and physical properties ([1]).

The purpose of this paper is the presentation of some results regarding the operational data assimilation in the numerical weather prediction model COSMO for the Romanian territory. Taking into account the availability of TEMP, PILOT and RADAR observation data, the necessary procedures to assimilate the data at both model resolutions ($7km$ and $2.8km$), for the Romanian territory were made.

In order to study the influence of assimilation for different observation types on the numerical weather forecast of the COSMO model for the domain of interest, the model was run in 4 different configurations using the available data.

Future plans include the usage in the operational activity of the data assimilation for TEMP, PILOT and RADAR observations in the COSMO model run for Romanian territory.

2 Methods and Data

The COSMO model is run operationally in the National Meteorological Administration since 2005, on a domain which covers the Romanian territory with 201×177 grid points for $7km$ horizontal resolution and 361×291 grid points for $2.8km$ horizontal resolution. Starting with 2009, data assimilation of SYNOP observations for all Romanian meteorological stations is run operationally.

For the assimilation of SYNOP, TEMP and PILOT observation, the nudging technique was used. The nudging scheme is based on the experimental nudging assimilation scheme developed for the former hydrostatic model DM and its Swiss version SM, and adapted, refined and extended in various aspects for the COSMO model. This technique is used in the COSMO model for the assimilation of most observation data (such as SYNOP, SHIP, RADAR Doppler, BUOY, AIRCRAFT and so on) except for RADAR observations ([2]).

For RADAR-derived precipitation rates, a Latent Heat Nudging scheme is used, which computes additional temperature and humidity increments at each model column independently from each other and is used only for convection-permitting model configurations (horizontal mesh width $\leq 3km$) ([2]).

Taking into account the data availability of TEMP, PILOT and RADAR observation data, a series of preprocessing procedures were made in order to assimilate the data for both horizontal resolutions ($7km$ and $2.8km$) of the COSMO model.

The TEMP and PILOT observation data for Romanian stations were obtained in BUFR format. The RADAR data were available in NetCDF format. TEMP and PILOT data for meteorological stations outside the Romanian territory (inside the COSMO domain, table 1) were received for the test case by courtesy of Davide Cesari from ARPA-SIMC (Agenzia Regionale per la Protezione Ambientale Emilia Romagna Servizio Idro Meteo Clima).

Station code	Location	Country
11035	Vienna / Hohe Warte	Austria
12425	Wroclaw / Maly Gad	Poland
13275	Belgrade Kosutnja	Serbia
14240	Zagreb/Maksimir	Croatia
16622	Thessaloniki	Greece
33393	L Viv	Ukraine

Table 1: Meteorological stations outside the Romanian territory (inside the COSMO domain).

The data format for the SYNOP, TEMP and PILOT observations required by the data assimilation nudging scheme is NetCDF. The necessary data format for the RADAR observation files is GRIB1.

For the conversion of the observation files from BUFR format to NetCDF format, the following additional software packages were used (by courtesy of Davide Cesari at ARPA-SIMC):

- wreport: a C++ library for decoding the BUFR data format;
- DB-all.e: utilities software for conversions from BUFR or NetCDF formats in WMO (World Meteorological Organization) standard format;
- bufr2netcdf: a library for conversions from standard BUFR to the NetCDF format required by the COSMO model.

For the conversion of the RADAR data from NetCDF to GRIB1 format and the interpolation in the COSMO grid at $2.8km$ resolution a procedure was developed based on the NCO (NetCDF Operator) software. The initial domain of the RADAR observations is 668×772 grid points, with a horizontal resolution of 0.0129316229208 degrees longitude and 0.00898306010458 degrees latitude. Observations are assimilated in the grid point closest to the location of the measurements. Observation processing includes (apart from the reading) spatial and temporal assignation of the observations to the model space, unifying TEMP (or PILOT) radiosonde parts in single complete profiles, applying bias corrections and so on ([2]).

3 Case Study

In order to analyze the influence of the data assimilation of TEMP, PILOT and RADAR observations, the COSMO model was run in various configurations for the 16^{th} of October $2012 - 00UTC$. The COSMO model was run in the following configurations:

- COSMO-RO-7km resolution with SYNOP data assimilation (C1);
- COSMO-RO-7km resolution with SYNOP-TEMP-PILOT data assimilation (C2);
- COSMO-RO-2.8km resolution with SYNOP-TEMP-PILOT and RADAR data assimilation (C3);
- COSMO-2.8km without data assimilation (C4).

The results of the COSMO model run in the 4 configurations mentioned before were compared as follows:

- the forecast from the COSMO-RO-7km with data assimilation for SYNOP observations against the forecast from the COSMO-RO-7km with the assimilation of the SYNOP, TEMP and PILOT data;
- the results from the COSMO-RO-2.8km without data assimilation against the forecast from the COSMO-RO-2.8km with the assimilation of the SYNOP, TEMP, PILOT and RADAR data.

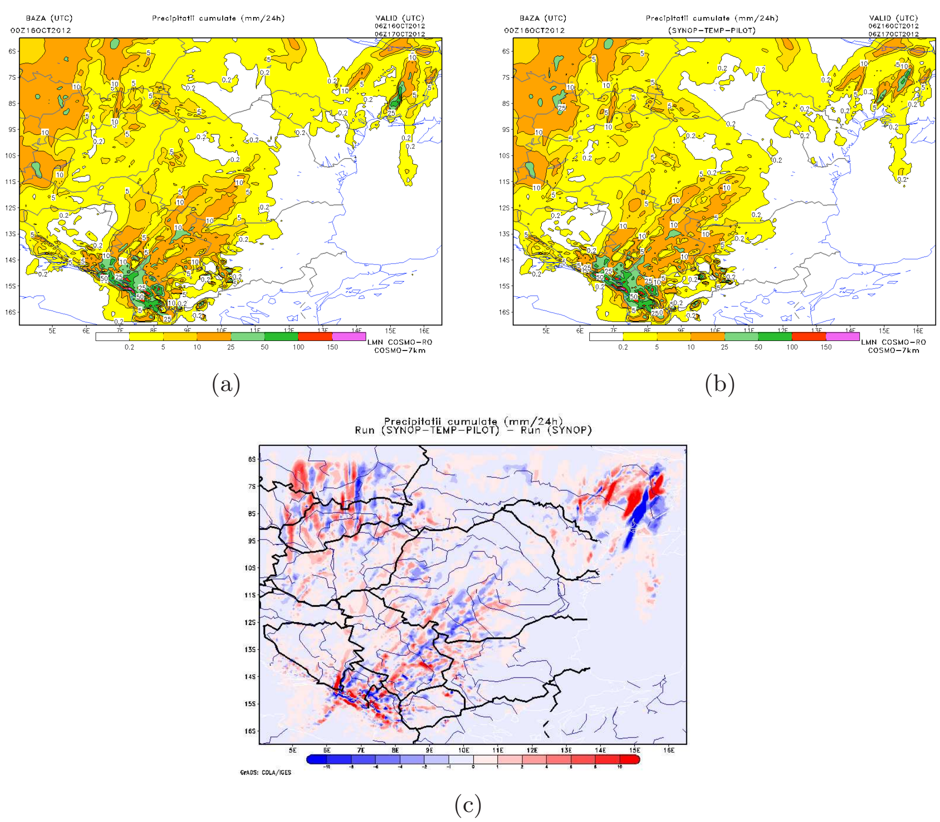


Figure 1: 16.10.2012 (00 UTC): COSMO-7km forecast for cumulated precipitation - 24h a) SYNOP; b) SYNOP, TEMP and PILOT; c) Difference (SYNOP-TEMP-PILOT) (SYNOP).

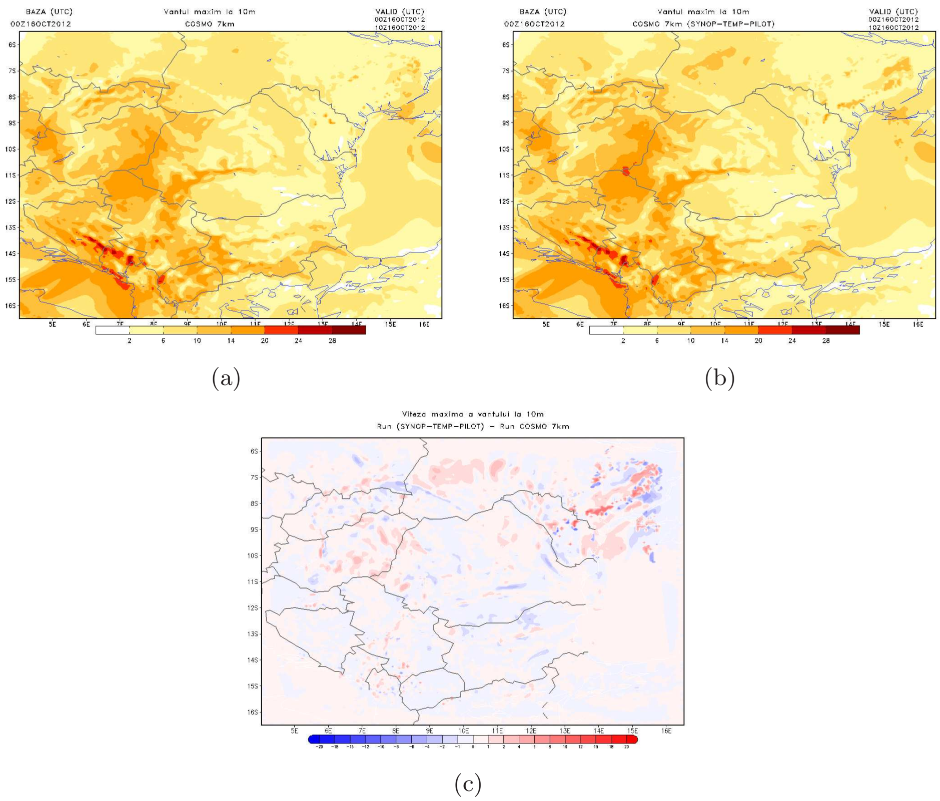


Figure 2: 16.10.2012 (00 UTC): COSMO-7km forecast for maximum wind speed - 10UTC a) SYNOP; b) SYNOP, TEMP and PILOT; c) Difference (SYNOP-TEMP-PILOT) (SYNOP).

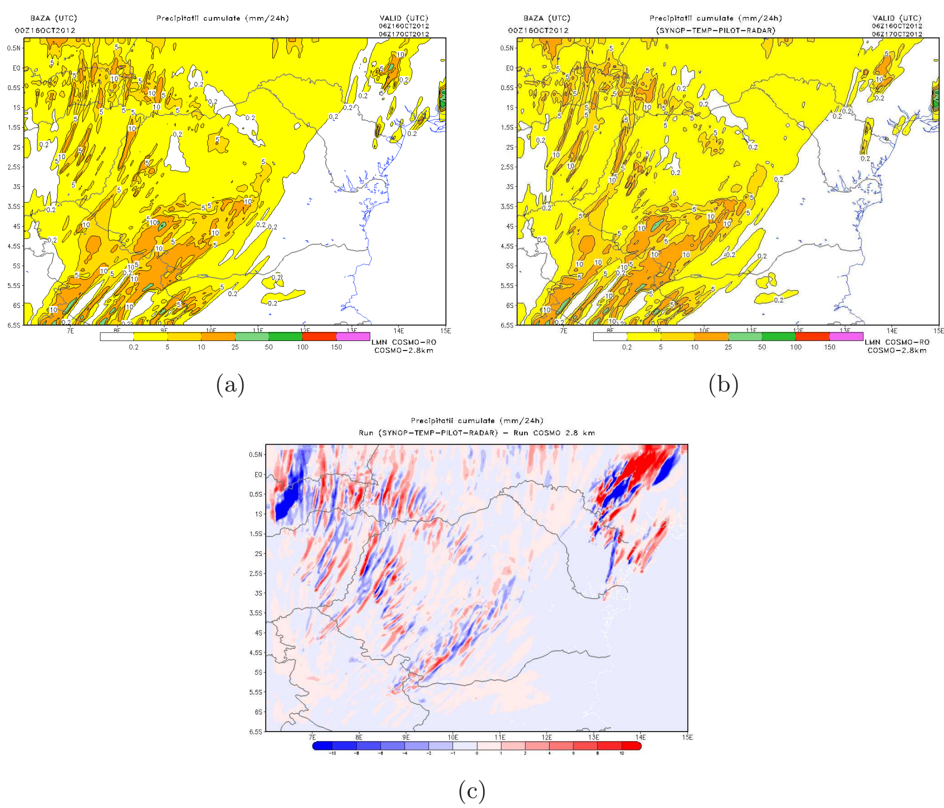
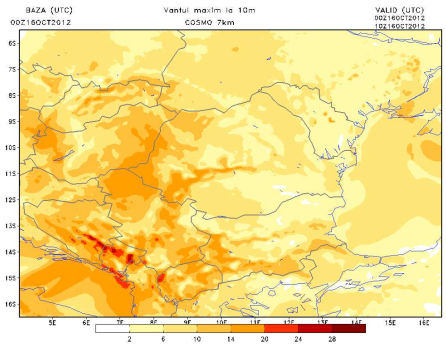
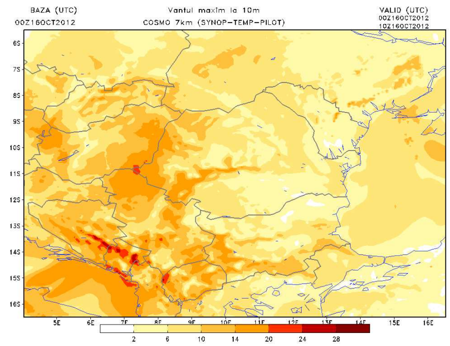


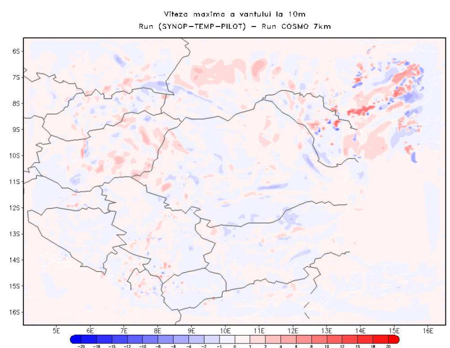
Figure 3: 16.10.2012 (00 UTC): COSMO-2.8km forecast for cumulated precipitation - 24h a) no data assimilation; b) SYNOP, TEMP, PILOT and RADAR; c) Difference (SYNOP-TEMP-PILOT-RADAR) - (COSMO-2.8km).



(a)



(b)



(c)

Figure 4: 16.10.2012 (00 UTC): COSMO-2.8km forecast for maximum wind speed - 07UTC a) no data assimilation; b) SYNOP, TEMP, PILOT and RADAR; c) Difference (SYNOP-TEMP-PILOT-RADAR) - (COSMO-2.8km).

By analyzing the results of the COSMO model run with the configurations mentioned before, we can especially notice the influence of the assimilation of the vertical soundings in the forecast of the precipitation parameter. This can be observed mostly in the areas surrounding the location of the vertical soundings (fig. 1-3).

From the previous examples, for the COSMO run (configuration C3) we can observe the tendency of the model to overestimate and redistribute spatially the precipitation parameter in the immediate vicinity of the location of the vertical soundings (fig. 3).

If we analyze the forecast of the maximum wind speed we see that the COSMO model in configuration C2 (with vertical soundings data assimilation) overestimates the values of this parameter compared to the model run in configuration C1 (only SYNOP data), again mostly in the areas closest to the location of the vertical soundings (fig. 2).

For the COSMO-2.8km model run, the values of the maximum wind speed parameter forecasted by the model in configuration C3 (with SYNOP, TEMP, PILOT and RADAR observations) are also overestimated compared to the values forecasted by running the model without any data assimilation, especially for the western and central areas of the domain (fig. 4).

4 Conclusions

Although the assimilation of various observation data in the COSMO numerical model can lead to significant improvement of the quality of forecasts, these adjustments cannot be analyzed and emphasized properly in just one case study.

Future plans include the usage in the operational activity of the data assimilation for TEMP, PILOT and RADAR observations in the COSMO model run for Romanian territory. The difficulties in concluding this task are mainly due to the difficult procedures necessary for the conversion of the observation data from the available data formats to the ones required by the model. Also, another inconvenient is the high computing time required for the preprocessing of the RADAR data to the model grid.

References

[1] Bouttier F., Courtier P. 1999: Data Assimilation Concepts and Methods. ECMWF Meteorological Training Course Lecture Series: 59

[2] Schraff C., Hess R. 2012: A Description of the Nonhydrostatic Regional COSMO Model. Part III: Data Assimilation. COSMO User Guide.