Effect of the initial temperature field correction on weather parameters in the short-range numerical forecast

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Introduction

The purpose of this work is to test the technology of correction of initial fields of temperature of the near-surface air and upper soil levels in the COSMO-Ru7 configuration (grid spacing - 7 km, European Part of Russia and Eastern Europe) of COSMO model. This additional correction (imposed on the results of a global data assimilation system) is based on data of weather stations network (transferred in the SYNOP code).

There are several different configurations COSMO-Ru of the COSMO model in the COSMO-Ru weather forecasting system operated in the Hydrometcenter of Russia [Rivin et al., 2019]. Each configuration is characterized by its own integration domain, spatial and time steps, forecast length, etc. The examined technique is included only in the COSMO-Ru7 configuration. This work demonstrates how the correction affects the forecast of various meteorological parameters besides temperature, based on a comparison of the results of various configurations (operative runs for a full year are considered).

The correction algorithm

To perform the correction of initial fields, a specific module was developed, implemented, and tested. Based on the model initial data and 2m temperature (T2m) observations, the temperature on certain atmospheric and soil levels is refined and the updated initial data for a forecast is formed.

The general structure of the module is the following:

- Reading T2m observations at weather stations (available in the SYNOP code);
- Preparation of the first guess field T2m* at the COSMO-Ru7 grid using the initial data for starting the COSMO-Ru7 configuration;
- Interpolation of the T2m* field to the station locations;
- Calculation of increments Δt2m (observation - first guess);
- Data quality control of increments and rejection of erroneous data;
- Analysis of the increments Δt2m by a Cressman-like method, horizontal interpolation to the COSMO-Ru7 grid;
- Calculation of a refined field T2m** as a sum of T2m* and Δt2m;
- Calculation of new air temperature fields for 5 lower atmospheric levels by adding the increment Δt2m with a certain weight to the initial temperature values. The weight decays from unity at the lowest model level to zero at the sixth level from the bottom (stretching the temperature increments Δt2m to the overlying air);
- Calculation of new soil temperature fields for 5 levels below the land surface in the same manner as it was done for the atmospheric levels. The weight decays from unity at the surface soil level to zero at the sixth soil level (stretching the temperature increments Δt2m to the soil).

Methods

The impact of the 2m-temperature correction on short-range forecasts of surface air temperature, dew point temperature, wind gusts, cloudiness and precipitation is analyzed. The results were verified using the mean absolute error (MAE). The matching of stations and model grid nodes was carried out by interpolation for the nearest neighbor.

We evaluated the changes in the short- range forecast quality for winter (DJF) and summer (JJA) separately. The assessment was made for the following three domains: the Southern part of European Russia (with mountains), the Central part of European Russia (without mountains) and the entire European territory of Russia (ETR) for the forecasts started at four different times: 00, 06, 12, 18 UTC. Due to the limited size of the paper, we have to focus mostly on the results obtained for the European territory of Russia for the forecasts started at 00 UTC. In the figures below we show the results for three different model configurations: 1) COSMO-Ru7 (grid spacing - 7 km, [Rivin et al., 2015]), 2) COSMO-Ru6ENA (6.6 km, calculation domain is the entire Russia and the adjoining regions [Rivin et al., 2019]), 3) COSMO-Ru13ENA (13.2 km, the domain is the same as in COSMO-Ru6ENA) [Rivin et al., 2015]).

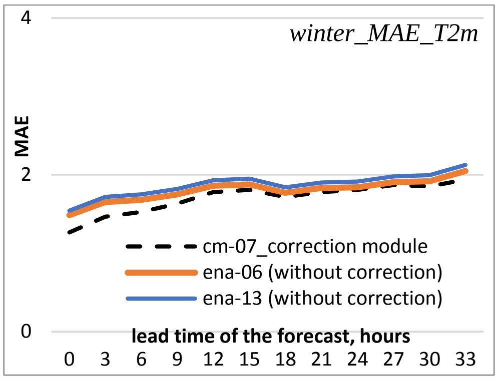
Results

The results based on seasonal averaging are summarized below for a set of key weather parameters:

- T2m: the positive effect of the temperature correction is more noticeable in winter than in summer (Fig.1a, b) and is observed during the entire short-range forecast.
- Td2m (dew point at 2m): As for T2m, the favorable effect is more noticeable in winter (Fig. 2a). COSMO-Ru7 with the correction module was almost always better than the other configurations primarily at the beginning of the forecast, the advantage becomes less pronounced later.
- Wind gusts: COSMO-Ru7 demonstrates better skill (smaller MAE) than the configuration COSMO-Ru6ENA characterized by the comparable resolution (7 km vs 6.6 km). The fields predicted by COSMO-Ru13ENA are smoother and this results in smaller MAE. Note that this fact does not permit us to conclude categorically that the forecasts of COSMO-Ru13ENA are better than much more detailed forecasts of COSMO-Ru7 and COSMO-Ru6ENA. Verification of highly variable fields like wind gusts cannot be based on MAE only, categorical and spatial scores should complement them. These scores will be considered in future research.

- Total Cloudiness: The effect was observed for the total cloudiness averaged within a 30-km radius around weather stations. Generally the cloudiness is better predicted with COSMO-Ru7 than with COSMO-Ru6ENA and COSMO-Ru13ENA (Fig. 3 *a*, *b*). The positive effect of the correction is evident during the whole forecast in the cold period (Fig. 3*a*). In summer, COSMO-Ru7 obviously wins only at the beginning of the forecast, later the resolution plays more important role and COSMO-Ru13ENA became the worst (Fig. 3b).

a)



b)

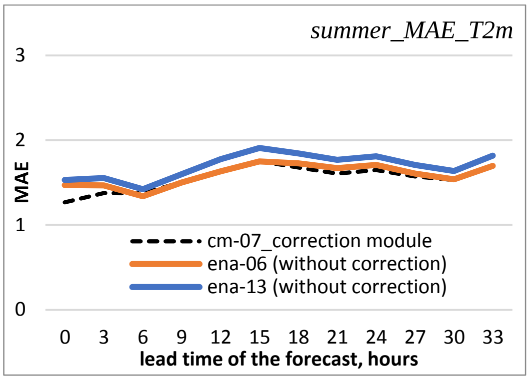
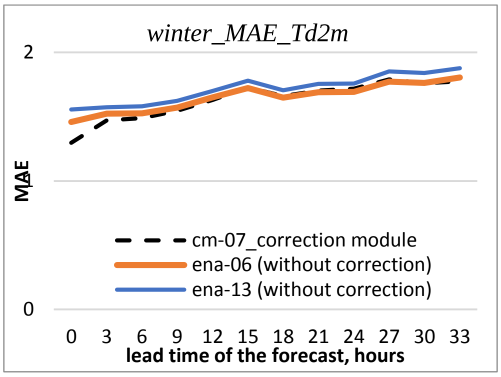


Figure 1. MAE for temperature at 2 meters(^{o} C): a) winter (DJF) and b) summer (JJA)

a)



b)

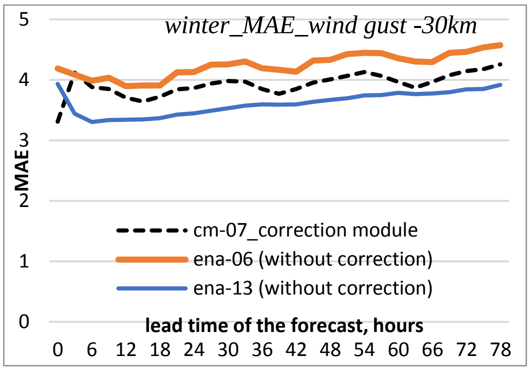
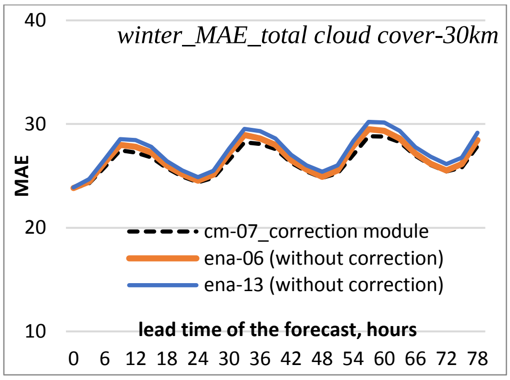


Figure 2. MAE for: a) dew point temperature at 2 meters(^{o} C), b) wind gust at 10 meters (maximum in the 30-km radious m/s).

a)



b)

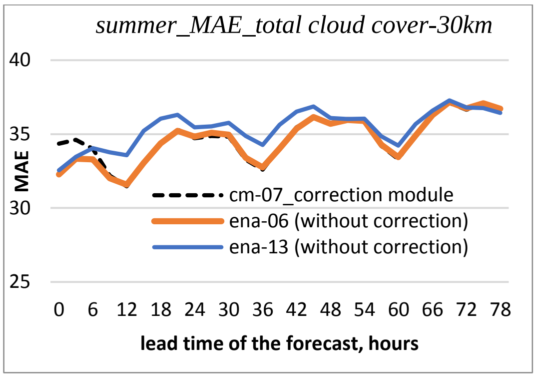


Figure 3. MAE for total cloud cover (mean in 30-km radious, %): a) winter (DJF);b) summer (JJA).

For two other domains considered in the study the results were mostly close to those presented above. However, in the southern regions of Russia COSMO-Ru7 & COSMO-Ru6ENA showed larger deviations wrt to COSMO-Ru13 ENA at the begining of the forecasts caused by the difference in resolution.

Our results show that the correction of temperature on the near-surface atmospheric model levels and on the upper soil levels based on T2m temperature measurements has positive influence to the forecasts of T2m, Td2m, cloudiness and wind gusts. The effect is uncertain for forecasts of other parameters. Probably, it can be found in some specific cases, but this was out of the scope of the present study.

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References

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