Experiments with stochastic perturbation of physical tendencies in the mesoscale convection-resolving ensemble COSMO-Ru2-EPS

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Introduction

Insufficient ensemble spread is a well-known problem in ensemble forecasting. Various methods have been developed to account for model-related uncertainty in global and regional ensemble prediction systems (EPS) which benefit from their usage. The applicability and efficiency of these methods for convective-resolving EPSs are under research. This paper analyses how the introduction of stochastic perturbations of physical tendencies (SPPT scheme) [1] affects the spread and performance of a convective-resolving EPS based on COSMO model.

Experiment setup

In our experiments, we used the COSMO-Ru2-EPS system with a 2.2 km resolution that had been previously developed within the framework of the COSMO Priority project CORSO [6] and WWRP FDP/RDP FROST-2014 [2] for the Sochi region. The system provided a dynamical downscaling of COSMO-S14-EPS, the 7-km Italian ensemble prediction system for the Sochi-2014 Olympics. In turn, COSMO-S14-EPS was a clone of COSMO-LEPS [3] moved to the Sochi region. The systems are described in detail in [4, 5]. Both COSMO-S14-EPS and COSMO-Ru2-EPS ran operationally during the Olympic Games 2014 providing probabilistic products to Sochi forecasters. The ensemble size was 10 in both systems. SPPT scheme was not included. The operational COSMO-Ru2-EPS forecasts for February 2014 starting at 00 and 12 UTC were used as a reference in the study.

SPPT scheme was adapted to the COSMO model by Lucio Torrisi and introduced to the official COSMO code in 2014 [7]. To test the SPPT scheme and to assess its effect on the forecast spread and skill, numerical experiments were carried out with COSMO-Ru2-EPS for the same period, initial and boundary conditions as operational forecasts of 2014. Additionally, sensitivity to SPPT parameters, governing the perturbation size and spatiotemporal correlations, as well as to the selection of various humidity perturbations, was examined.

Both case studies and verification of monthly series of forecasts were carried out.

Results and conclusions

Case studies demonstrated that SPPT could be useful for precipitation forecasts improving the description of the rain location and start. The analysis of T_{2m} predictions in the tropospheric Foehn case (February 7, 2014) revealed the correlation between the T_{2m} ensemble spread and the model orography (see Fig.1). Also the coincidence between high-spread areas and the areas of less skillful forecast was found.

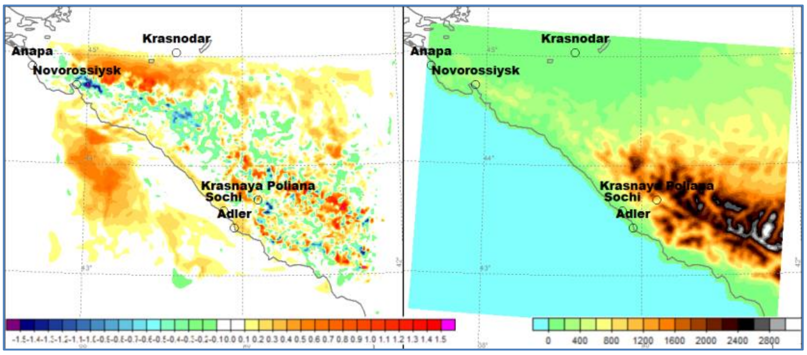

Fig.1. The difference between the T_{2m} ensemble spread in experiments with and without SPPT (left) and the COSMO model orography (right).

30h forecast starting at 00UTC on February 6, 2014.

For probabilistic verification, the Brier score, the Brier skill score and the area under the ROC curve were calculated for the monthly series of COSMO-Ru2-EPS forecasts (56 in total).

Some positive effect of using SPPT was found for precipitation forecasts, especially for the event “3-h precipitation is greater than 1 mm”. Variations in the SPPT parameters did not influence the results much.

SPPT does not improve the skill of 2-m temperature forecasts. At the same time, the eyeball analysis shows that introduction of SPPT makes the predicted T_{2m} distribution more realistic. This is supported by comparing the distribution histograms for forecasts with and without SPPT and observations (Fig. 2). Thus, SPPT did not add value to temperature forecasts, but can sometimes improve the representation of its distribution.

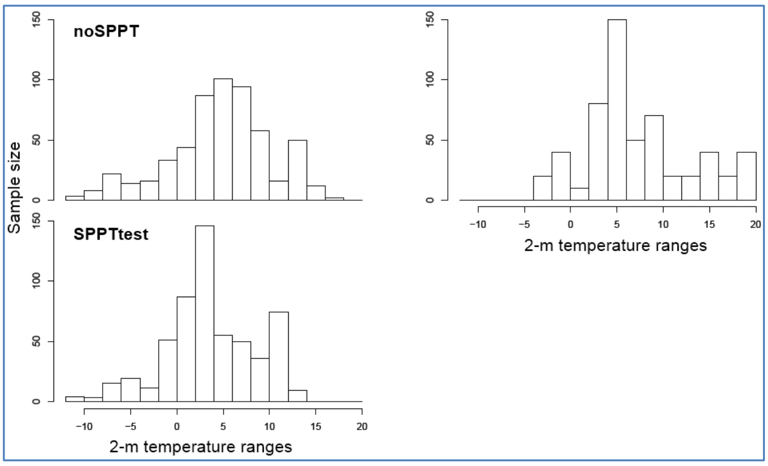

Fig.2. 2-m temperature distribution histograms for 48-h forecasts with and without SPPT (left) and for observations (right). February 2014.

At the same time, the verification scores for 2-m temperature forecasts showed rather large sensitivity to variation of SPPT parameters. It was found that the 2-m temperature forecasts can be improved by adjusting the SPPT parameters. For example, perturbing all hydrometeor tendencies in most cases leads to better results than perturbing only specific water content tendency. Increasing the range of standard deviation for the Gaussian distribution of random numbers and using the higher upper limit imposed to the absolute value of random numbers also positively contributed to the results.

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