Comparing COSMO-LEPS and COSMO-SREPS in the short-range.

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1 Introduction

Aiming at the development of an ensemble forecasting system for the short-range, the COSMO Consortium has chosen to explore the validity of a multi-model approach for providing initial and boundary conditions.

This approach has been tested in the experimental COSMO-SREPS system, which receives initial and boundary conditions by few state-of-the art operational deterministic runs. This ensemble has been compared with the operational COSMO-LEPS one, originally designed mainly for a 3-5 days forecast range, based on a dynamical downscaling of the global ensemble of ECMWF (EPS).

Both systems are made up by sixteen integrations of the COSMO model with 7 km horizontal mesh-size and they both benefit also of perturbations applied to the COSMO model itself.

In this paper, the impact of the two different perturbation strategies for boundaries on short-range forecast skill is assessed. This work is part of the COSMO Priority Project CONSENS, which aims at deciding which strategy is better to follow for short-range ensemble forecasting at the mesoscale. The impact of combining the two ensembles in different ways, for the aim of short-range forecasting, is also analysed. Results show that there is a positive effect in adding multi-model-driven members to the COSMO-LEPS ensemble, thus providing a hybrid solution to the problem.

2 Systems and methodology

COSMO-LEPS (COSMO Limited-area Ensemble Prediction System) is the mesoscale limited-area ensemble of the COSMO Consortium, developed by ARPA-SIMC, running since November 2002 (Montani et al., 2003). The ensemble is based on 16 runs of the COSMO model (Steppeler et al., 2003), the non-hydrostatic limited-area model of the COSMO Consortium.

The ensemble is generated as a downscaling of the global ECMWF EPS (Molteni et al., 2001; Marsigli et al., 2001). COSMO-LEPS is currently running at 7 km of horizontal resolution, on a domain covering central and southern Europe (Figure 1), with 40 levels in the vertical.

Being based on the EPS, COSMO-LEPS was designed for providing high resolution probabilistic forecast for the late-short to early-medium range, from day 3 to 5. The time window used for the cluster analysis (from +96 to +120 h) was selected to pursue this aim.

The experimental COSMO-SREPS system (Marsigli et al., 2009) receives initial and boundary conditions by a few state-of-the art operational deterministic runs (IFS, GME, GFS). The forecast range is 48 hours and resolution and domain are the same as for the COSMO-LEPS system.

Two different combinations of COSMO-LEPS and COSMO-SREPS have also been evaluated:

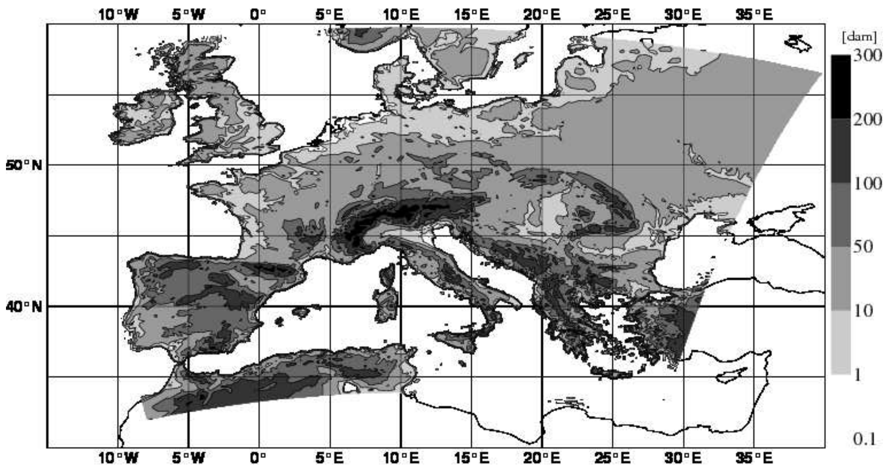

Figure 1: COSMO-LEPS and COSMO-SREPS orography, showing also the domain extension.

- a 20-member ensemble made up of the 16 COSMO-LEPS runs + 4 runs selected from COSMO-SREPS (here referred to as mix20)
- a 16-member ensemble made up by the first 12 COSMO-LEPS runs + 4 runs selected from COSMO-SREPS (here referred to as mix16)

The 4 runs selected from COSMO-SREPS are members 1, 6, 11, 16, which are nested on the 3 different global models (member 1 on IFS, member 6 on GME and member 11 on GFS) plus the control member (nested on IFS but with no physics perturbations). Hence, the maximum possible degree of diversity is allowed in these 4 COSMO-SREPS runs, to represent the impact of the multi-boundary approach.

The performance of the systems has been measured is terms of skill in PQPF (Probabilistic Quantitative Precipitation Forecasting). Verification of short-range precipitation was performed using a dense raingauge network covering northern Italy. This area includes the Italian part of the Alps and the Po Valley, enclosing in a small domain regions with different orography. The verification has been done following the "distributional method" (DIST), developed for the verification of COSMO-LEPS high-resolution precipitation forecasts (Marsigli et al., 2008). It consists of an upscaling of both forecasted and observed fields over boxes of selected size. The upscaling is performed by selecting some parameters of the precipitation distribution, providing a single forecast-observation pair for each box. In this work, only mean and maximum values of the distribution are evaluated and the size of the boxes is 0.5 x 0.5 degrees. If the number of observations in the box is below 5, the box is discarded.

Verification is performed over the winter season 2010/2011, specifically from 20 November 2010 to 28 February 2011.

3 Results

In Figure 2 the Brier Skill Score (left panel) and the area under the ROC Curve (right panel) are plotted as a function of the forecast range for the event "mean of the precipitation exceeding 1 mm/6h". Both score measures are positively oriented. For a description of the scores, the reader is referred to Wilks (2006).

The COSMO-LEPS score is represented by the solid thick line, while the COSMO-SREPS

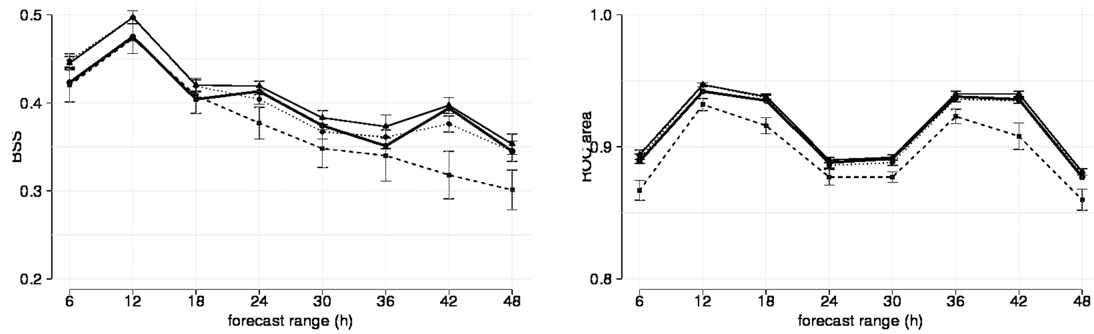

Figure 2: Brier Skill Score (left panel) and the area under the ROC Curve (right panel) are plotted as a function of the forecast range for the event "mean of the precipitation exceeding 1mm/6h". The solid thick line is for COSMO-LEPS, the dashed line is for COSMO-SREPS, the dotted line for mix16 and the solid thin line for mix20.

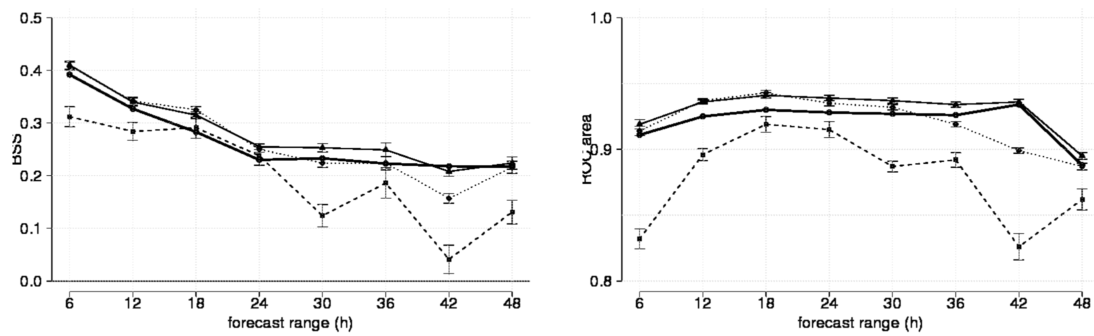

Figure 3: Same as in Figure 2 but for the event "mean of the precipitation exceeding 5mm/6h".

score is represented by the dashed line. The dotted and solid-thin lines refer to the mix16 and to the mix20 ensemble, respectively.

The first important finding is that COSMO-SREPS do not score better than COSMO-LEPS in the short-range. Both scores indicates a better performance of COSMO-LEPS for almost all the forecast ranges. The difference between the two ensembles is even more pronounced for a higher precipitation threshold, namely 5mm/6h, as shown in Figure 3.

The error bars around the red line are obtained with a testing, at 95% of confidence, that the COSMO-SREPS scores differ from the COSMO-LEPS one. The difference is always significant, except for a few forecast ranges for which the two BSS lines overlap.

An inspection of the scores in terms of maximum values of the precipitation distribution show the same behaviour, COSMO-LEPS performing better for (almost) all the forecast ranges (not shown).

The performance of the two combined systems, mix16 and mix20, are also shown in Figures 2 and 3. The mix16 ensemble can be regarded as a version of COSMO-LEPS where 4 members (randomly chosen) are substitute with 4 members driven by a small multi-model global ensemble (3 members + 1 control). Does the use of these 4 members in COSMO-LEPS provide additional skill with respect to using 4 more members driven by EPS?

For the lower threshold (Figure 2) the BSS of mix16 is significantly higher than that of COSMO-LEPS for the first 18 h, then it is comparable. In terms of ROC area, they are comparable from the beginning. For the higher threshold (Figure 3) mix 16 performs significantly better than COSMO-LEPS for the first 24 h in terms of both BSS and ROC area.

From an operational point of view it would be interesting also to quantify the impact to add these 4 multi-model-driven COSMO members to the operational COSMO-LEPS, thus increasing the ensemble size up to 20 members.

The mix20 ensemble performs better than COSMO-LEPS for almost the whole forecast range in terms of both BSS and ROC area for the higher precipitation threshold, and, to a lesser extent, also for the low precipitation threshold, but only in terms of BSS.

As a general result, there is a benefit in adding multi-model driven members for the first day of forecast and this holds even keeping fixed the number of ensemble members.

4 Summary and Outlook

A comparison has been presented between the performance for short-range QPF of two different ensembles based on the COSMO model.

COSMO-LEPS is driven by 16 selected members of the ECMWF EPS, while COSMO-SREPS is driven by 3 operational global model runs. Both initial and boundary conditions are provided by the driving runs. Both systems run at 7 km of horizontal resolution, on the same domain, and have perturbations in the physics parameters.

The main results are here listed:

- generally COSMO-LEPS outperforms COSMO-SREPS
- the multi-model approach for initial and boundary conditions proves valuable even if model with different qualities are used (not shown)
- combining the 16 COSMO-LEPS members with 4 COSMO-SREPS members this 20-member ensemble outperforms both systems
- combining 12 COSMO-LEPS members with 4 COSMO-SREPS members, this 16-member ensemble outperforms COSMO-LEPS for the first day (up to 18 - 30 h)

The multi-model in itself proved valuable, but the 3 IC-BCs perturbations available do not allow the COSMO-SREPS ensemble to get a performance better to a downscaling from a well constructed ensemble like the ECMWF EPS. A more detailed analysis will be presented as a Techical Report.

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