Performance of COSMO–LEPS system during the D–PHASE Operations Period

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1 Introduction

COSMO–LEPS is the Limited–area Ensemble Prediction System developed and implemented by ARPA–SIM within COSMO (COnsortium for Small–scale MOdelling; the members of the Consortium are Germany, Greece, Italy, Poland, Romania and Switzerland). COSMO-LEPS project aims to generate "short to medium–range" (48–132 hours) probabilistic predictions of severe weather events based on the non–hydrostatic regional COSMO–model, nested on a number of ECMWF EPS members, chosen via a clustering selection technique (Marsigli et al., 2001).

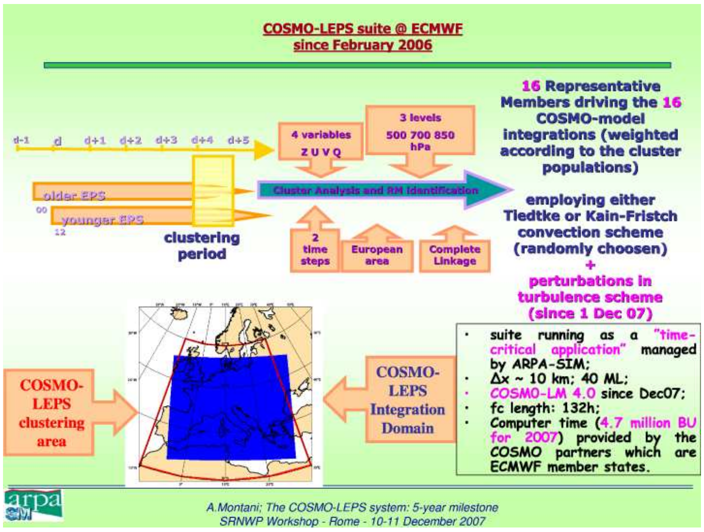

Figure 1: Present set–up of COSMO–LEPS operational suite.

The "experimental–operational" COSMO–LEPS suite (following the methodology described by Montani et al., 2003 and Marsigli et al., 2005) was set–up in November 2002 so as to produce probabilistic forecasts over a domain covering all countries involved in COSMO. After 6 years of activity, COSMO–LEPS application has become an "ECMWF member–state time–critical application" managed by ARPA–SIM and its present configuration in shown in Fig. 1. COSMO–LEPS is made up of 16 members, running at the horizontal resolution of 10 km with 40 model levels in the vertical. The computer–time to run COSMO-LEPS application on ECMWF supercomputers is provided from allocations to the ECMWF COSMO partners (i.e. Germany, Greece, Italy and Switzerland), whose contributions are joined into a unique "COSMO-account". Perturbations to the initial and boundary conditions are provided by the different EPS members driving the limited–area integrations. In addition to this, the following model perturbations are introduced:

- perturbations to the convection scheme: within each COSMO–LEPS integration, a random choice between Tiedtke or Kain–Fritsche convection scheme is made;
- perturbations in the maximal turbulent length scale;
- perturbations in the length scale of thermal surface patterns.

In this contribution, it is assessed the state–of–the–art of the system, showing its ability to provide warnings of severe weather events (e.g. heavy rainfall, strong winds, cold temperature anomalies).

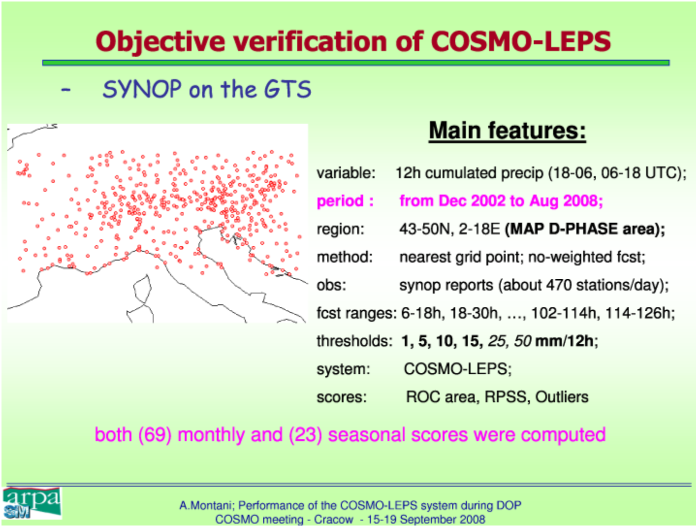

Figure 2: Main features of COSMO–LEPS verification.

2 Results of verification

As already mentioned, COSMO–LEPS has recently passed the 6–year milestone of activity. Therefore, a big verification effort was undertaken so as to assess objectively how the system changed in these years and the extent to which modifications have actually caused an improvement in terms of precipitation forecasts over mountainous areas.

In order to carry on this evaluation, a fix set of SYNOP stations (about 470) was selected, over an area covering the Alps (43-50N, 2-18E) and for the period ranging from December 2002 to August 2008. Precipitation accumulated over 12 hours (18-06 UTC and 06-18 UTC) was verified, comparing the values forecast on the grid–point nearest to each station against the observed values at that station. The other main features of the verification exercise are summarised in Fig. 2. Several probabilistic scores were used and the performance of the system was analysed both in terms of monthly and seasonal scores so as to identify the occurrence of possible seasonal variability.
As an example of the obtained results, Fig. 3 shows the performance of COSMO–LEPS in terms of the Relative Operating Characteristic (ROC) area, for 4 different thresholds (1, 5, 10, 15 mm/12h) at the 78–90h forecast range. Although the score is computed monthly, the 3–month running mean is actually shown in the plots to increase readability, due a marked month–to–month variability of the score itself. At the beginning of the verification period (early 2003), the ROC area scores (especially for high rainfall thresholds) were close to, or below, the 0.6 line, considered the discriminating value to detect between a useful and a useless forecast. Then, the scores increased for all thresholds starting from summer 2004.

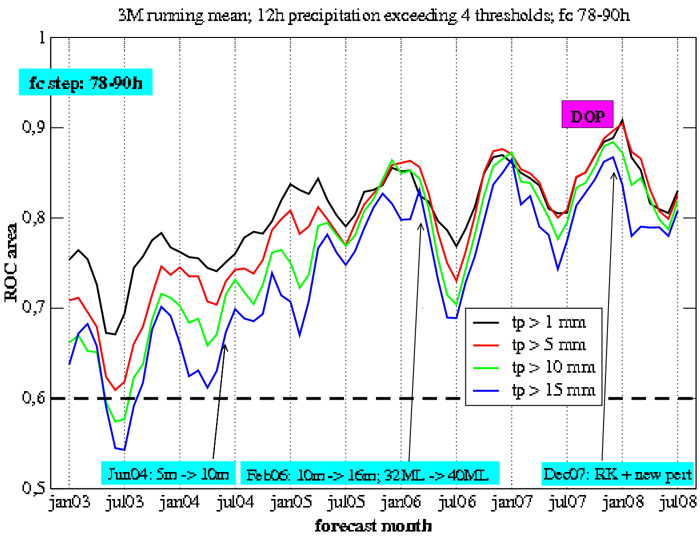

Figure 3: ROC area of COSMO–LEPS 12-hour precipitation forecasts for the forecast range 78–90h. The BSS was computed for each month, from January 2003 to July 2008. A 3-monthly running mean was applied to the scores to improve readability.

The ROC area has been well above 0.6 since spring 2004, for all the thresholds including the highest (15mm/12h). A different behaviour is exhibited in autumn 2006, which was a very dry season: COSMO–LEPS performance is not satisfactory. On the other hand, the ROC area is close to 0.8 during both 2007 and 2008, indicating a skillful system in the prediction of precipitation at the day–4 range. A marked seasonal variability is also evident, the system often performing better in the summer season.
In the overall evaluation of the system performance, it has to be kept in mind that, in addition to the upgrades in the COSMO–model itself, COSMO–LEPS configuration was subject to three major changes during the verification period:

- June 2004: the ensemble members were increased from 5 to 10 and only two EPS instead of three were considered to select the global–model members to drive the COSMO–LEPS integrations;
- February 2006: the ensemble members were increased from 10 to 16 and the vertical resolution of COSMO–LEPS integrations from 32 to 40 levels;
- December 2007: it was introduced the Runge–Kutta numerical scheme as well as new perturbations (in the maximal turbulent length scale and in the length scale of thermal surface patterns).

The former change seems to have led to better scores, since an improvement is evident from spring 2004. The impact of the latter change is more difficult to be judged, due to the already underlined problem in autumn 2006. Obn the other hand, a positive trend is well evident in the scores obtained in 2007, especially during the various meteorological experiments which took place during that year (e.g. COPS and MAP D-PHASE). This is also true if other scores, like the Brier Skill Score and the percentage of outliers, are considered (not shown).

As a final remark, it has to be pointed out that nowadays COSMO–LEPS forecast products are well–established in met–ops rooms across COSMO community. They have been recently used with success in EC projects (e.g. Windstorms PREVIEW) as well as in the field campaigns of the above–mentioned meteorological experiments. As future developments, it is planned to introduce more model perturbations, so as to improve the spread–skill relationship of the system, and to develop "calibrated" COSMO–LEPS forecasts.

References

Marsigli C., Montani A., Nerozzi F., Paccagnella T., Tibaldi S., Molteni, F., Buizza R., 2001: A strategy for high–resolution ensemble prediction. Part II: limited–area experiments in four Alpine flood events. *Quart. J. Roy. Meteor. Soc.*, **127**, 2095–2115.

Marsigli C., Boccanera F., Montani A., Paccagnella T., 2005: The COSMO-LEPS mesoscale ensemble system: validation of the methodology and verification. *Nonlin. Proc. Geophys.*, **12**, 527–536.

Montani A., Capaldo M., Cesari D., Marsigli C., Modigliani U., Nerozzi F., Paccagnella T., Tibaldi S., 2003: Operational limited–area ensemble forecasts based on the 'Lokal Modell'. *ECMWF Newsletter No. 98. Available from: ECMWF, Shinfield Park, Reading RG2 9AX, UK.*