Performance of the COSMO-based ensemble systems during Sochi-2014 pre-Olympics

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1 Introduction

A few month ago, the Winter Olympics and Paralympic Games took place in Sochi, Russia, from 7 to 23 February 2014 and from 7 to 16 March 2014. In the framework of these events, WMO WWRP initiated a dedicated blended Forecast Demonstration/Research and Development Project (FDP/RDP). **FROST-2014** (**F**orecast and **R**esearch in the **O**lympic **S**ochi **T**estbed; `http://frost2014.meteoinfo.ru/`) aimed at advancing the understanding of nowcasting and short-range prediction processes over complex terrain, since the region of Sochi is characterized by a complex topography, with the Caucasus mountains in the vicinity of the Black Sea (Kiktev, 2011), as shown in Fig. 1, where the main features of the Olympic venues are presented.

Figure 1: Main features of the Olympic venues for Sochi–2014.

Several activities were performed by the COSMO consortium (`http://www.cosmo-model.org`) to support NWP aspects of the FROST-2014 project. In the framework of probabilistic forecasting, the following actions were undertaken:

(1) FDP part: relocation of COSMO-LEPS (Montani et al., 2011) over the Sochi area, generating a new system named COSMO-S14-EPS ("S14" stands for Sochi2014);

(2) RDP part: development of a convective-scale ensemble system for the Sochi area, referred to as COSMO-Ru2-EPS ("Ru2" stands for Russian 2.2 km; Montani et al., 2014).

As for (1), COSMO-S14-EPS, the convection-parameterized ensemble prediction system based on COSMO model and targeted for the Sochi-area, was set-up, implemented and maintained throughtout the full pre-Olympic and Olympic periods. In addition to providing probabilistic guidance for the prediction of high-impact weather over the Olympic mountainous areas up to day 3, COSMO-S14-EPS also provided initial and boundary conditions for activity (2), linked to the generation of the convective-permitting ensemble, COSMO-Ru2-EPS, which ran on an experimental basis during the pre-Olympics season and on a quasi-operational basis during the Olympics.

2 Methodology and implementation

As previously mentioned, COSMO-S14-EPS is a relocation of COSMO-LEPS over the area interested by the Olympic competitions and COSMO-Ru2-EPS is a pure dynamical downscaling of COSMO-S14-EPS over a small domain centred on the Olympic venues. The main features of implmentation for both systems are described in Montani et al. (2014) and summarised in Table 1.

Table 1: Main characteristics of COSMO-S14-EPS and COSMO-Ru2-EPS.

	COSMO-S14-EPS	COSMO-Ru2-EPS
Horizontal resolution	7 km	2.2 km
Vertical resolution	40 ML	50 ML
Forecast length	72h	48h
Ensemble size	10	10
Initial time	00/12 UTC	00/12 UTC
Convection	Parameterized	Resolved
Running at	ECMWF	Roshydromet
ICs and BCs	from selected ECMWF-EPS members	from COSMO-S14-EPS members
Model perturbations	Physical parameterizations	

COSMO-S14-EPS was implemented on ECMWF super–computers in November 2011 and ran on a regular basis from 19 December 2011 to 30 April 2014 thanks to the billing units provided by the ECMWF Special Project SPCOFROST.
COSMO-S14-EPS forecasts were used to generate a set of standard probabilistic products, including probability of surpassing a threshold, ensemble mean and ensemble standard-deviation for several surface and upper-air variables. In addition to this, the individual forecast members for a specially defined sub-area were also transferred to the Hydrometcenter of Russia (Roshydromet) where the epsgrams for predetermined points (mainly, locations of outdoor and indoor competitions) were prepared. All these products, delivered in real time to Roshydromet, were used by the Sochi forecasters via the FROST-2014 Web-site (`http://frost2014.meteoinfo.ru/forecast/goomap` and `http://frost2014.meteoinfo.ru/forecast/arpa-new/`).
Apart from the ensemble products, COSMO-S14-EPS provided both initial and hourly-boundary conditions (up to t+48h) to Roshydromet for the experimentation with the convection-resolving ensemble COSMO-Ru2-EPS, which ran between January and February 2013 as well as from November 2013 to April 2014 and whose main features are also summarized in Table 1. Figure 2 provides a synthetic overview of the forecasting chain involving COSMO-S14-EPS and COSMO-Ru2-EPS during the Olympic Games.

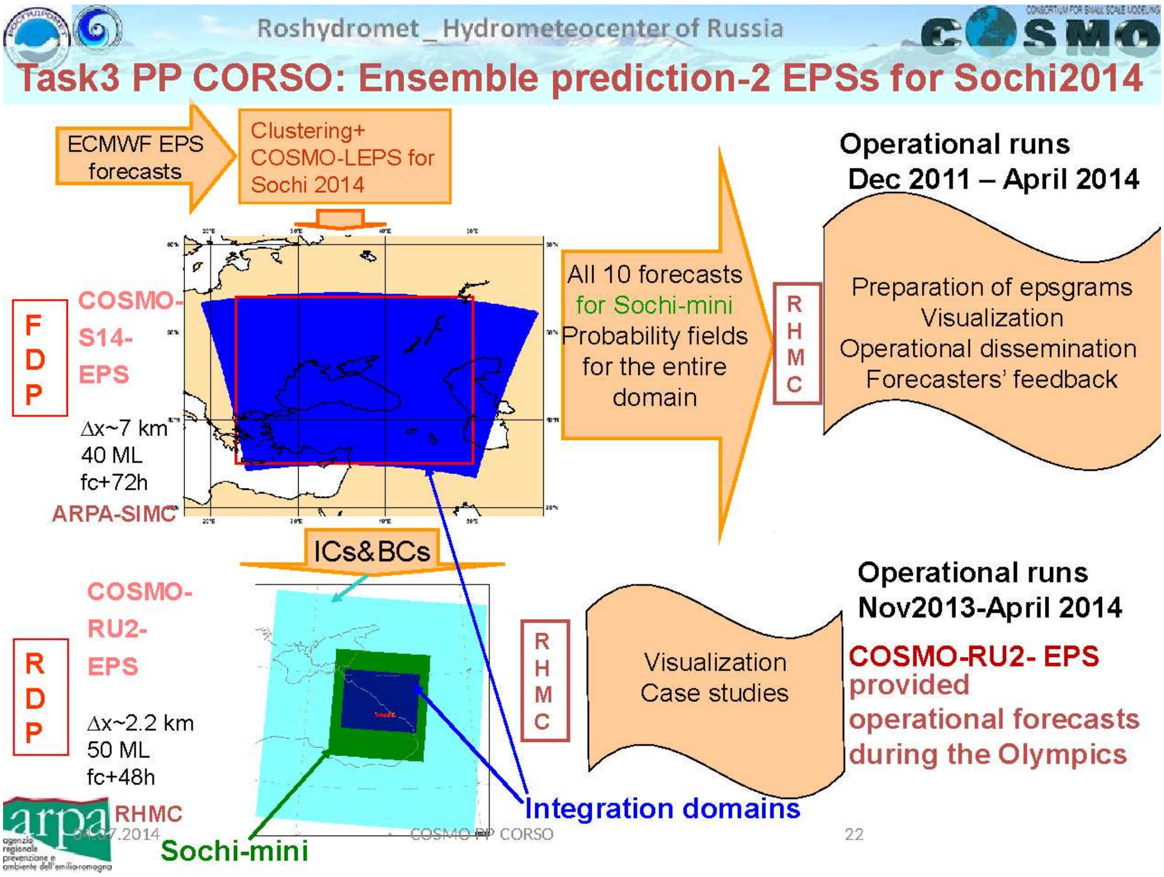

Figure 2: Illustration of the forecasting chain used during winter Olympic 2014.

In the next section, we present some preliminary results relative to the intercomparison between COSMO-S14-EPS and COSMO-Ru2-EPS in terms of 2-metre temperature relative to the pre-Olympics season. The investigation aims at highlighting the added value of enhanced horizontal resolution in the probabilisitc prediction of surface fields.

3 Verification results

In this section, the preliminary results of a verification exercise are presented; the skills of COSMO-S14-EPS and COSMO-Ru2-EPS are assessed over the period January-February 2013. For both systems, we considered the probabilistic prediction of 2-metre temperature exceeding a number of thresholds for several forecast ranges. As for observations, it was decided to use the data obtained from the SYNOP reports available on the Global Telecommunication System (GTS) as well as from a number of non-GTS local stations.

This enabled the possibility to assess the performance of the systems over a relatively dense observation dataset (69 stations), since the verification domain was restriced to an area centred over the Olympic venue (42.5-45N, 37.5-41.5E). As for the comparison of model forecasts against observations, we selected the grid–point closest (in 3D) to the observation.

The performance of both systems was examined for 4 different thresholds: -5, 0, +5 and +10 ^{o}C. Verification was performed using COSMO software VERSUS. The following probabilistic scores were computed: the Brier Skill Score (BSS) and the Relative Operating Characteristic (ROC) area. For a description of these scores, the reader is referred to Wilks (1995). The main features of the verification exercise are also summarised in Table 2.

The skill of the two systems in terms of probabilistic prediction of 2-metre temperature is summarised in Fig. 3, where the values of the ROC area are plotted against the forecast range for 4 different weather events: temperature below -5^{o}C (top-left), above 0^{o}C (top-right), above +5^{o}C (bottom-left) and above +10^{o}C (bottom-right). It can be noticed that the ROC area values are well above 0.8 for three out of the four thresholds, indicating that both COSMO-S14-EPS and COSMO-Ru2-EPS manage to discriminate these events. The performance of the two systems is quite similar, with a slight predominance of COSMO-Ru2-EPS which has higher scores for most of the thresholds/forecast ranges. Worse scores are obtained by both systems for the highest threshold

Table 2: Main features of the verification configuration.

variable:	2-metre temperature;
starting time:	12 UTC;
period:	from 1 January to 28 February 2013;
region:	42.5–45 N, 37.5–41.5 E;
method:	nearest 3D optimised grid–point;
observations:	SYNOP reports + local stations (69 in total);
fcst ranges:	from fc+3h to fc+72h every 3h;
thresholds:	-5, 0, +5, +10 ^{o}C;
scores:	ROC area, BSS.

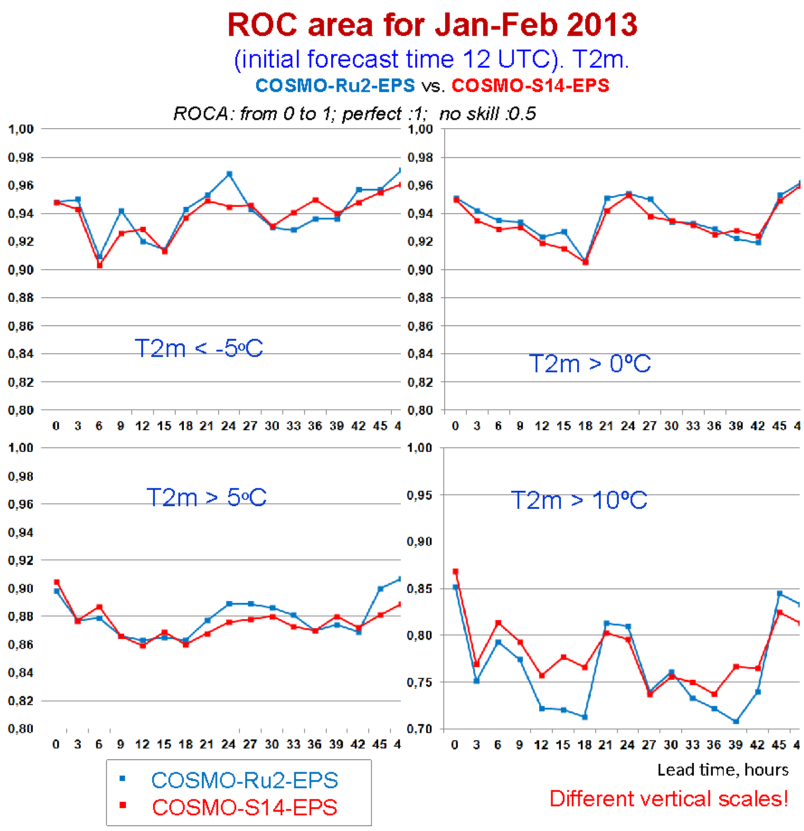

Figure 3: ROC area values as a function of forecast range for four different weather events: 2-metre temperature below -5^{o}C (top-left panel), above 0^{o}C (top right), above +5^{o}C (bottom left) and above +10^{o}C (bottom-right with different vertical scales). The scores are calculated over the period January-February 2013. Red (blue) lines refer to COSMO-S14-EPS (COSMO-Ru2-EPS).

(bottom-right panel), where COSMO-S14-EPS outperforms COSMO-Ru2-EPS. It is worth pointing out that this is the rarest event with few observations; therefore, the statistical significance of this result needs to be confirmed by a more detailed investigation over a longer verification period.

Similar results are obtained when the attention is focussed on the Brier Skill Score (BSS), shown in Fig. 4. Also with this score, the satisfactory performance of both systems is confirmed: the BSS is always positive for COSMO-S14-EPS and COSMO-Ru2-EPS, indicating an added value of both systems with respect to climatology as regards the probabilistic prediction of 2-metre temperature for the thresholds of Table 2. Similarly to Fig. 3, it can be noticed that COSMO-Ru2-EPS usually outperforms the lower-resolution ensemble, although the difference is not very marked. As for the +10^{o}C threshold (bottom-right panel of Fig. 4), the skill of the

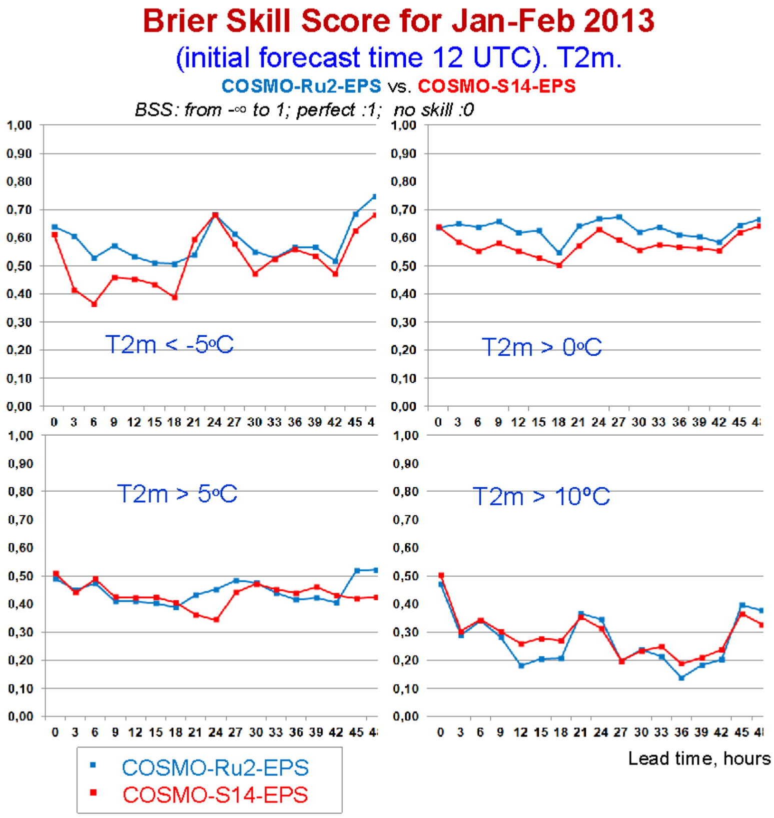

Figure 4: The same as Fig. 3 but for the Brier Skill Score. The vertical scale is the same in all panels.

two ensembles is almost identical, with slightly higher scores for COSMO-S14-EPS.

4 Summary and Outlook

The main results of the ensemble prediction system experimentation within FROST-2014 can be summarized as follows:

- two limited-area ensemble prediction systems, based on COSMO-model and referred to as COSMO-S14-EPS (convection-parameterised) and *COSMO-Ru2-EPS* (convection-permitting), were implemented and run on an operational/*quasi–operational* basis during the pre-Olympic and Olympic seasons;
- a preliminary verificationn exercise was undertaken by assessing the probabilistic skill of both systems in terms of 2-metre temperature during the pre-Olympic season (January-February 2013) over a region centred around Sochi;
- both COSMO-S14-EPS and COSMO-Ru2-EPS turned out to have an overall good performance with ability to discriminate different weather events;
- the added value of the higher resolution in COSMO-Ru2-EPS was confirmed by the better probabilistic scores obtained by this system.

As for the future, it is planned to consolidate the verification results, by considering the performance of both system for other variables (in particular, precipitation) and over a longer verification period which includes the Olympic season.

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