SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	Experimentation of different strategies to generate a limited-area ensemble system over the Mediterranean region
Computer Project Account:	spitlaef
Start Year - End Year :	2012- 2014
Principal Investigator(s)	Andrea Montani , Lucio Torrisi
Affiliation/Address:	ARPA-SIMC Viale Silvani 6 40122 Bologna – ITALY CNMCA Centro Nazionale di Meteorologia e Climatologia Aeronautica Aeroporto 'De Bernardi' Via Pratica di Mare, 45 00040 Pomezia (Roma) - ITALY
Other Researchers (Name/Affiliation):	Chiara Marsigli (ARPA-SIMC), Francesca Marcucci (CNMCA)

The following should cover the entire project duration.

Summary of project objectives

(10 lines max)

This special project aims at the development of a number of limited-area ensemble initiatives carried out jointly by ARPA-SIMC and CNMCA, including the generation of an Italian-targeted limited-area ensemble system and the tests of dynamical donwcaling of COSMO-LEPS to 2.8 km in the framework of HyMeX field campaign (http://www.hymex.org).

Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

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Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

Progress reporting is often a nuisance, but I perfectly understand that ECMWF needs to have some form of control on how the computer time is used.
It is not clear how the final report should differentiate from the sum of the yearly reports ECMWF has already received. An explanation would be welcome.

Summary of results

(This section should comprise up to 10 pages and can be replaced by a short summary plus an existing scientific report on the project.)
The billing units of the project were used for a number of tests; the scientific results relative to the experimentation within HyMeX framework are summarised in the attached report.

List of publications/reports from the project with complete references

Davolio S., Diomede T., Marsigli C., Miglietta M.M., Montani A., Morgillo A., 2012. Comparing different meteorological ensemble approaches: hydrological predictions for a flood episode in Northern Italy Adv. Sci. Res., 8, 33–37. DOI:10.5194/asr-8-33-2012.

Ducrocq V., and co-authors, 2014. HyMeX-SOP1: The Field Campaign Dedicated to Heavy Precipitation and Flash Flooding in the Northwestern Mediterranean Bull. Amer. Meteor. Soc, 95, 1083-1100, DOI:http://dx.doi.org/10.1175/bams-d-12-00244.1.

Future plans

(Please let us know of any imminent plans regarding a continuation of this research activity, in particular if they are linked to another/new Special Project.)

No imminent plans envisaged at the moment.

Experimentation of different strategies to generate a limited-area ensemble system over the Mediterranean region

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1 Introduction

The HYdrological cycle in the Mediterranean Experiment (HyMeX, http://www.hymex.org) is an international experimental programme that aims at advancing the scientific knowledge of the water cycle variability in the Mediterranean basin. This purpose is pursued through monitoring, analysis and modelling of the regional hydrological cycle in a seamless approach. Given the central position of Italy in the Mediterranean basin, particularly affected by severe weather phenomena and to the consequent hydro-geological effects, the interest in improving knowledge and forecasting of disastrous severe weather events is clearly evident, for both the scientific research and the operational activity. Consistently with the HyMeX programme, within the Western Mediterranean target area (TA), three hydro-meteorological sites were identified over Italy (Fig. 1 red boxes): Liguria-Tuscany (LT), North-Eastern Italy (NEI) and Central Italy (CI). These sites were selected because they are representative of the mechanisms responsible of a large part of heavy precipitation and flood events affecting the Italian territory, which can be related to specific large scale patterns.

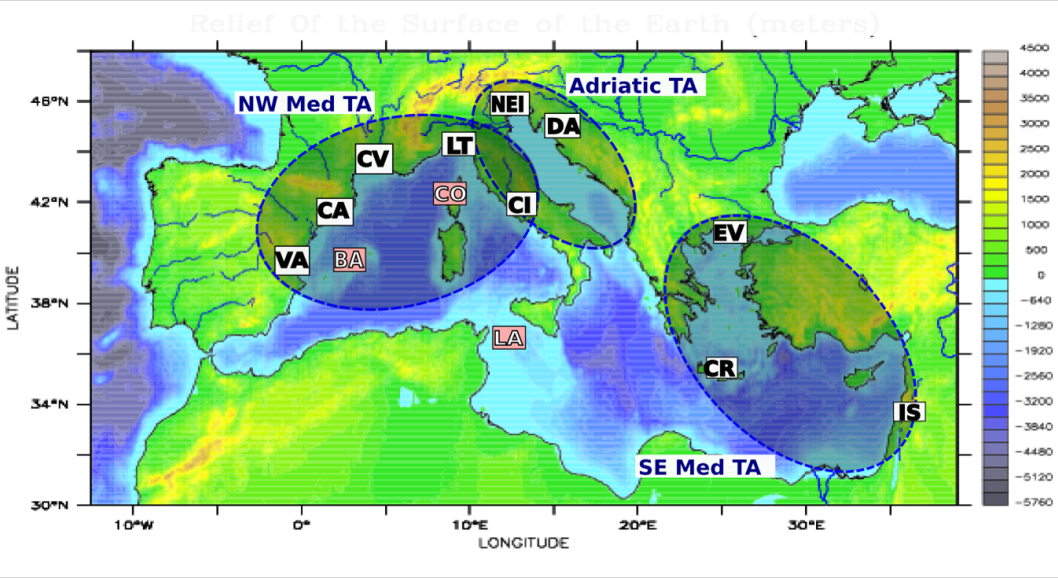

Figure 1: Target areas for the SOP1. The red boxes indicate the Italian ones

A key component of HyMeX is the experimental activity based on atmospheric, oceanic and hydrological monitoring for a period of ten years, from 2010 to 2020. Within this time frame, shorter periods of intensive monitoring, named Special Observation Periods (SOPs) are planned. The first field campaign, SOP1, dedicated to heavy precipitations and flash-floods, took place in autumn 2012 (5 September - 6 November) over the western Mediterranean area. It was characterized by an extraordinary deployment of advanced instrumentation, including instrumented aircrafts. In order to prevent or reduce the damages

that may result to society and territory, progresses in monitoring and in the predictive capability of these severe events are needed. This requirement represented the strong motivation that resulted in a large and active participation of the Italian community to the first HyMeX SOP.

2 HyMeX activity: numerical weather prediction models

In the framework of the HyMeX SOP1 a common platform has been implemented to upload products from different numerical weather prediction (NWP) models (available online at http://sop.hymex.org). These have been a fundamental mean for the forecasting activity during the campaign, allowing for planning with adequate advance the observation strategy of the events of interest. The following NWP models were actually available: the Advanced Research version of the Weather Research and Forecasting (WRF-ARW) by CETEMPS (WRF-CETEMPS), by CNR ISAC (WRF-ISAC) and by LaMMA (WRF-LaMMA), the BOlogna Limited Area Model (BOLAM) by CNR ISAC (BOLAM-ISAC), by ISPRA (BOLAM-ISPRA) and by ARPA Liguria, the MOLOCH model by CNR ISAC (MOLOCH-ISAC), by ISPRA (MOLOCH-ISPRA) and by ARPA Liguria, the COSMO model by ARPA–SIMC. COSMO is the limited-area model used by COSMO consortium (http://www.cosmo-model.org) and is based on the primitive hydro-thermodynamical equations for a compressible non-hydrostatic flow in a moist atmosphere with no scale approximations (for an overview of COSMO, the reader is referred to Steppeler et al., 2003).

In the framework of HyMeX, two ensemble systems based on COSMO model were provided:

- COSMO-LEPS (COSMO Limited-area Ensemble Prediction System) is the operational limited-area ensemble prediction system of the COSMO consortium, running on a daily basis since 2002 (Montani et al., 2011). It is a convective-parameterized ensemble and is run twice a day (starting at 0000 and 1200 UTC) at 7 km, with 40 vertical levels and a forecast range of 132 hours. It is composed of 16 members, with initial and boundary conditions taken from elements of ECMWF EPS selected via a clustering analysis-selection technique.
- COSMO-H2-EPS (COSMO HyMeX 2.8 km Ensemble Prediction System) is a research ensemble system, designed for the HyMeX program; COSMO-H2-EPS is an atmospheric convection-permitting ensemble and is run once a day (starting at 1200 UTC) at 2.8 km, with 50 vertical levels and a forecast range of 36 hours. It is composed of 10 members, which take initial and boundary conditions from the first 10 COSMO-LEPS members (Marsigli et al., 2013). COSMO-H2-EPS was run partly using SPITLAEF billing units.

Both COSMO-LEPS and COSMO-H2-EPS benefit also of model perturbations applied by varying few parameters of the COSMO physics schemes. The main features of the two systems are summarized in Table 1

3 Case sstudy: IOP 13

The IOP13 occurred on 15-16 October 2012. The weather system involved all the three Italian target areas: LT, NEI and CI (a detailed description of the event is reported in Ducrocq et al., 2013). Fig. 2 shows the 24-hour accumulated precipitation on 15 October

Table 1: Summary of the main characteristics of the COSMO-based ensemble systems used during SOP1. The COSMO ensemble size is denoted in brackets. The last column indicates whether or no the model calculates explicitly convection physics.

Model	Grid spacing (km)	Vertical levels	Initial conditions	Boundary conditions	Forecast range (h)	Convection permitting
COSMO–LEPS (size: 16)	7	40	ECMWF-EPS members	ECMWF-EPS members	132	No
COSMO–H2–EPS (size: 10)	2.8	50	CLEPS members	CLEPS members	36	Yes

obtained from the Italian regional rain gauge networks; the maximum reached 60 mm/24h. The inset of the figure shows the hourly precipitation recorded by one of the rain-gauges located north of Rome (Formello). Clearly, almost all of the precipitation occurred in the late afternoon (from 1700 to 1900 UTC) with a remarkable maximum of rainfall rate of 35 mm h1 at 1800 UTC, whereas little precipitation amounts were recorded at night and in the morning. For this event both deterministic and ensemble forecast were available, such richness of products eased the forecaster work.

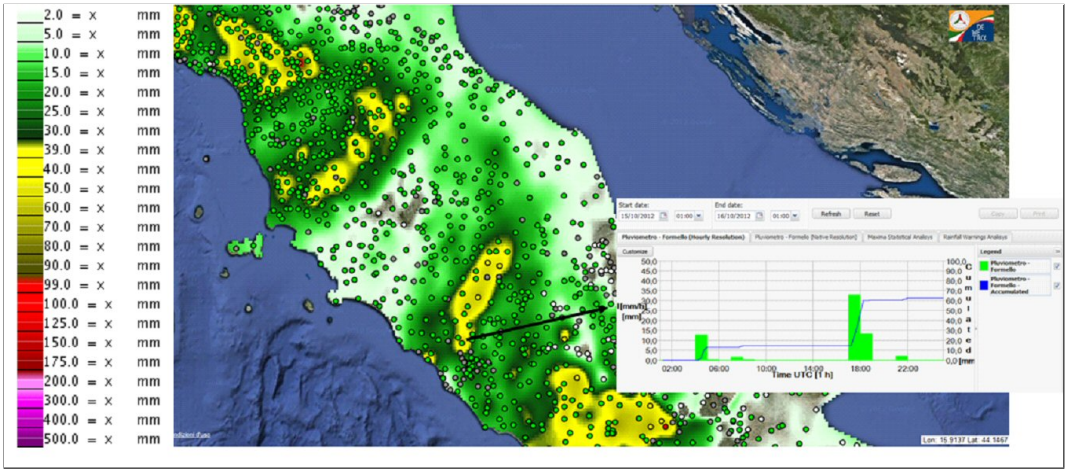

Figure 2: Daily accumulated rainfall recorded by rain-gauges (green dots on the map) on 15 October; the inset shows the hourly accumulated precipitation for the station of Formello (North of Rome). Courtesy of DPC (DEWETRA system).

As for the probabilistic prediction of this event, COSMO–LEPS provides an early indication of the possible occurrence of a HPE over the CI area.

Fig. 3 shows the 24-hour precipitation for the 16 COSMO-LEPS members (emission time: 00UTC of 13 October 2012). At the 72-hour forecast range, the possibility of a heavy precipitation scenario is shown by some ensemble members (e.g. members 3, 7 and 8) with a good prediction in terms of amount and, to a lesser extent, location. In fact, some COSMO-LEPS members tend to predict too much precipitation on the coast and to underestimate the amount of rainfall more inland.

The probability maps of precipitation exceeding 10 and 50 mm in 24 hours (left and right panel of Fig. 4, respectively) clearly highlight CI as an area possible affected by moderate-

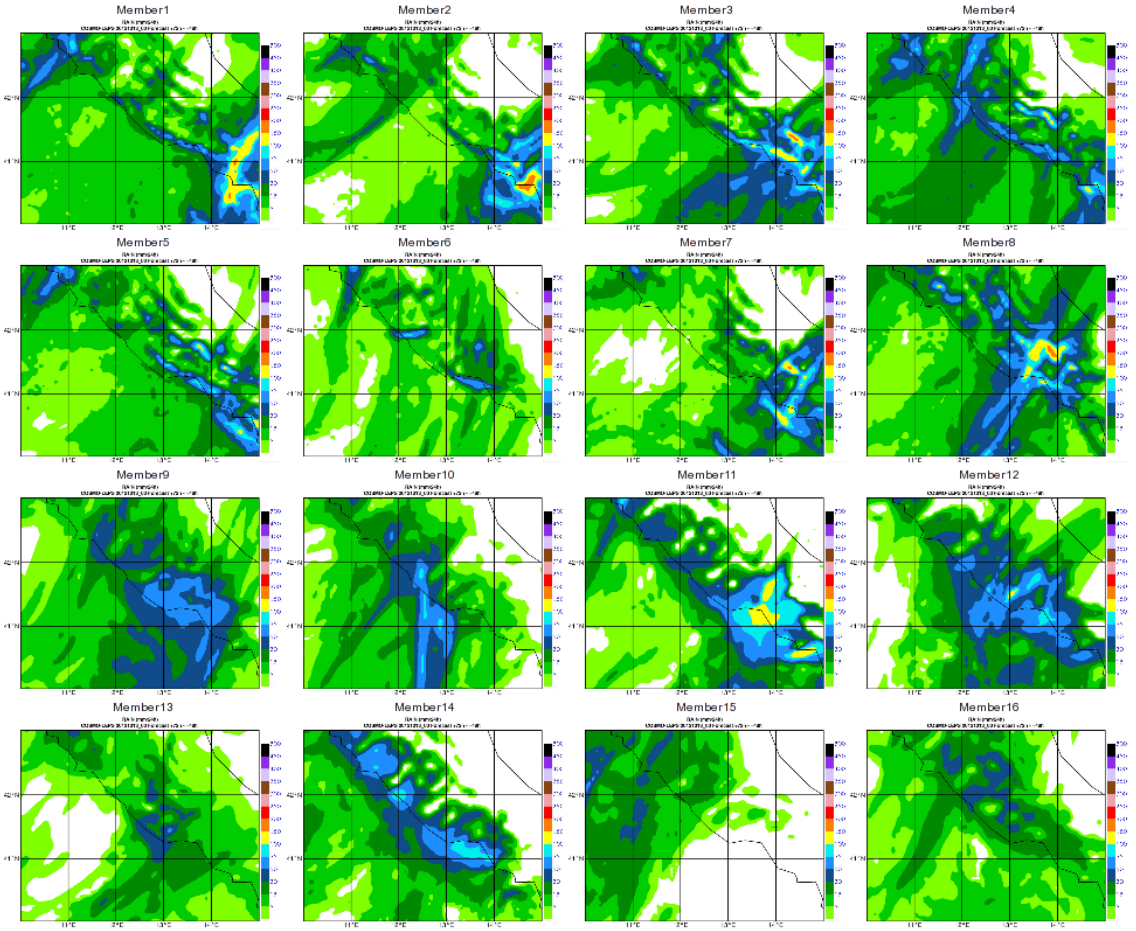

Figure 3: 24-hour precipitation maps from COSMO-LEPS members (emission time: 00UTC of 13/10/2012, fcst +48-72h).

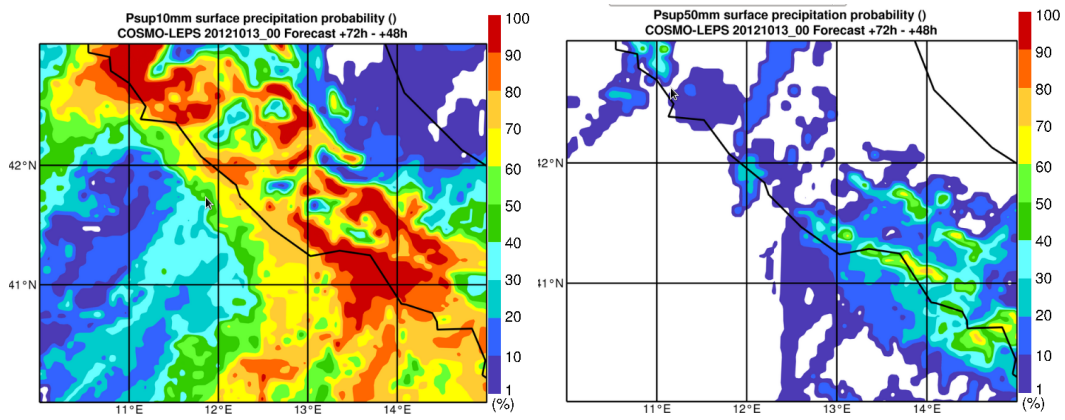

Figure 4: Probability maps of 24-hour precipitation exceeding 10 mm and 50 mm (left and right panel, respectively) from COSMO-LEPS (emission time: 00UTC of 13/10/2012, fcst +48-72h).

to-intense precipitation with probability peaks of 70% for the higher threshold. This type of information can contribute to the decision of booking or not a flight slot with the research aircrafts, which have to be alerted and prepared in advance.

At shorter time ranges, the high-resolution information conveyed by COSMO-H2-EPS is shown in Fig. 5 with the 24-hour predicted precipitation by the 10 ensemble members. The area possibly affected by heavy rain seems better localized: some ensemble members predict

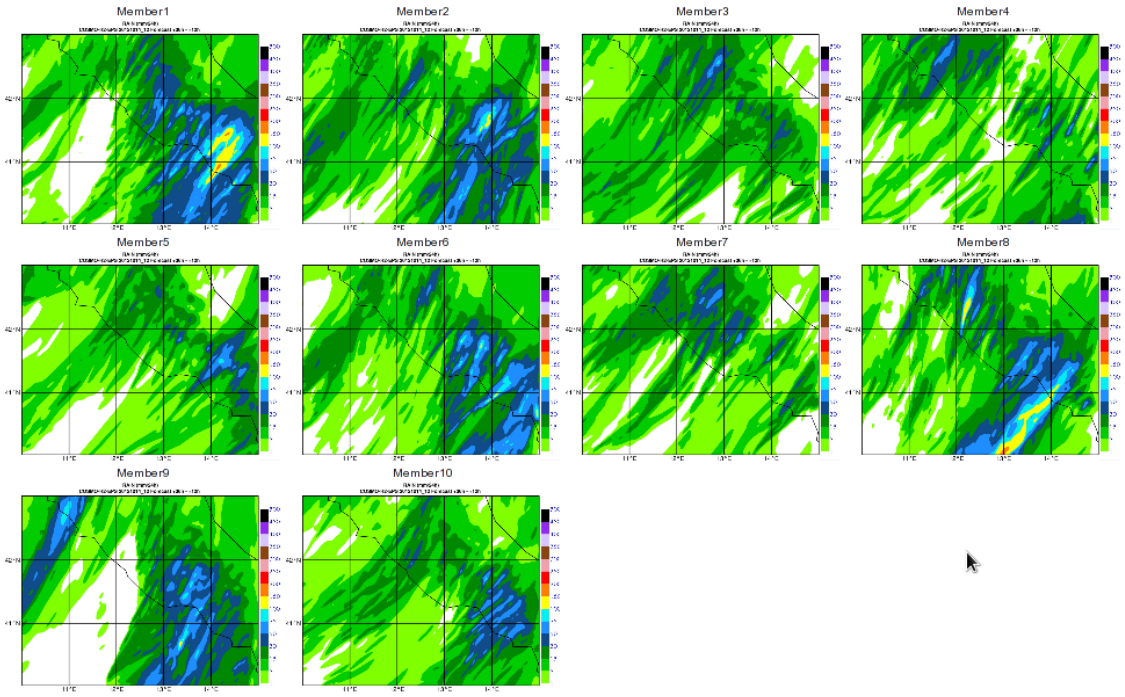

Figure 5: 24-hour precipitation maps from COSMO-H2-EPS members (emission time: 12UTC of 14/10/2012, fcst +12-36h).

the occurrence of precipitation above 50 mm in the region 41-42N 13-14E. The probability maps for 24-hour precipitation above 10 and 50 mm (Fig. 6) indicate that the area most likely affected by the weather events is located more inland rather than near the coast, confirming the information provided by the other deterministic systems (not shown).

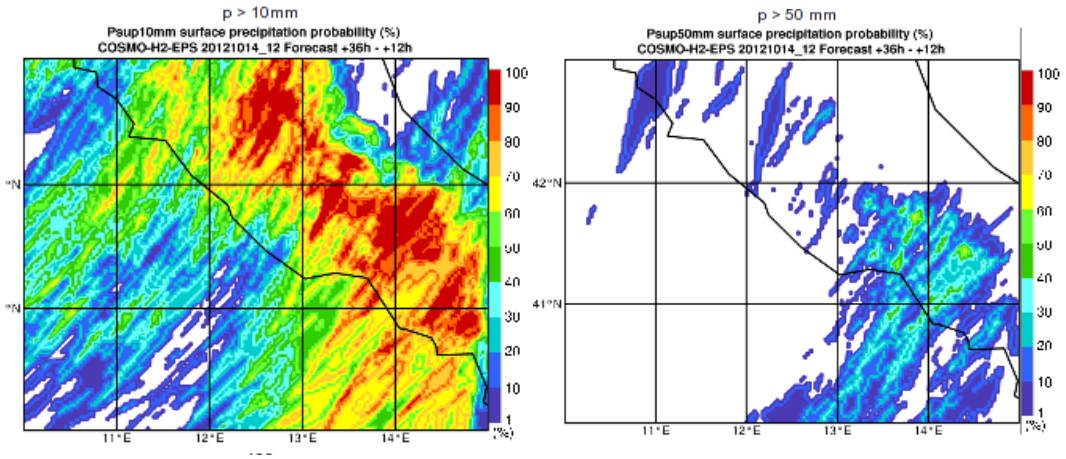

Figure 6: Probability maps of 24-hour precipitation exceeding 10 mm and 50 mm (left and right panel, respectively) from COSMO-H2-EPS (emission time: 12UTC of 14/10/2012, fcst +12-36h).

4 Discussion of results

From the previous section, it looks as if the coarser-resolution ensemble is able to provide an early indication of the occurrence of intense precipitation over Central Italy, with some uncertainty in the localization. The higher-resolution ensemble confirms the scenarios pro-

vided by the other deterministic models, with a good localization of the heavy rainfall. It is worth pointing out that these results obtained for this IOP cannot be generalised, but just show the potential of the synergy of the two ensemble systems. In addition to that, it is worth mentioning the attempt of a combined use of deterministic and probabilistic information, which took place during HyMeX for some IOPs affecting the Italian Target areas. This approach can really provide forecasters with added-value information from NWP systems and assist them in taking decisions in field campaigns as well as in operational forecasting activities.

References

Marsigli, C., Montani, A., and Paccagnella, T, 2013. Test of a COSMO-based convection-permitting ensemble in the Hymex framework. COSMO Newsletter, no 14, 100-104. Available at http://www.cosmo-model.org .

Montani, A., Cesari, D., Marsigli, C., and Paccagnella, T., 2011. Seven years of activity in the field of mesoscale ensemble forecasting by the COSMO-LEPS system: main achievements and open challenges. Tellus, 63A, 605624.

Steppeler, J., Doms, G., Schttler, U., Bitzer, H. W., Gassmann, A., Damrath, U., and Gregoric, G., 2003. Meso-gamma scale forecasts using nonhydrostatic model LM. Meteorol. Atmos. Phys., 82, 7596.