# Recent developments and plans for the COSMO-LEPS system

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# Outline

- **Recent upgrades of COSMO-LEPS:**
  - use of soil-moisture analysis fields from COSMO-EU.
- **Performance of the system:**
  - time-series verification of COSMO-LEPS using SYNOP;
  - reliability of COSMO-LEPS forecasts;
  - case study: the Liguria flood.
- **Implementation of a 2014 Winter-Olympics ensemble.**
- **Summary of results and future plans.**

# COSMO-LEPS (developed at ARPA-SIMC)

- What is it?

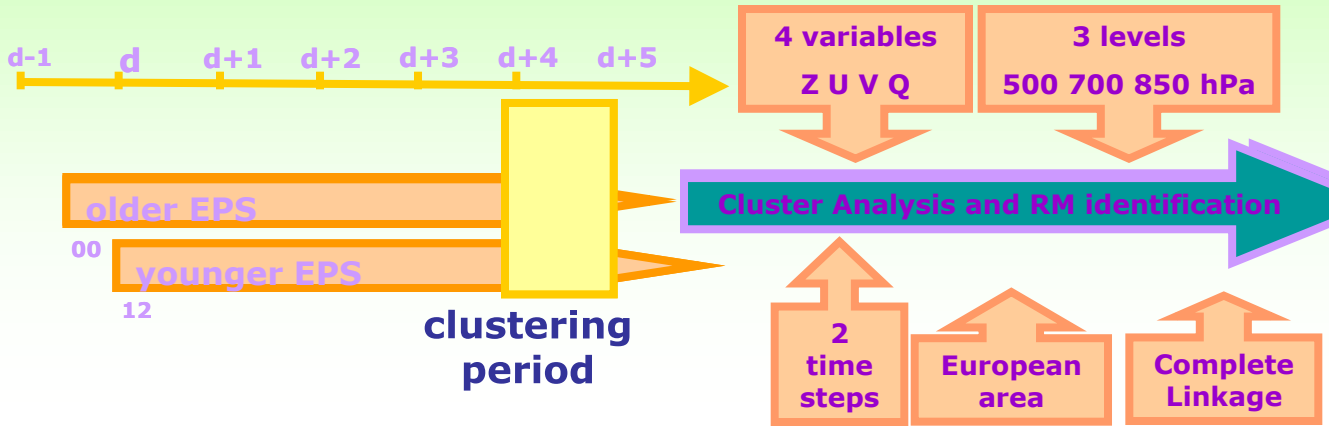
It is a **L**imited-area **E**nsemble **P**rediction **S**ystem (**LEPS**), based on COSMO-model and implemented within **COSMO** (**CO**nsortium for **S**mall-scale **Mo**delling, including Germany, Greece, Italy, Poland, Romania, Russia, Switzerland).

- Why?

It was developed to combine the advantages of global-model ensembles with the high-resolution details gained by the LAMs, so as to identify the possible occurrence of **high-impact** and **localised** weather events (heavy rainfall, strong winds, temperature anomalies, snowfall, …)

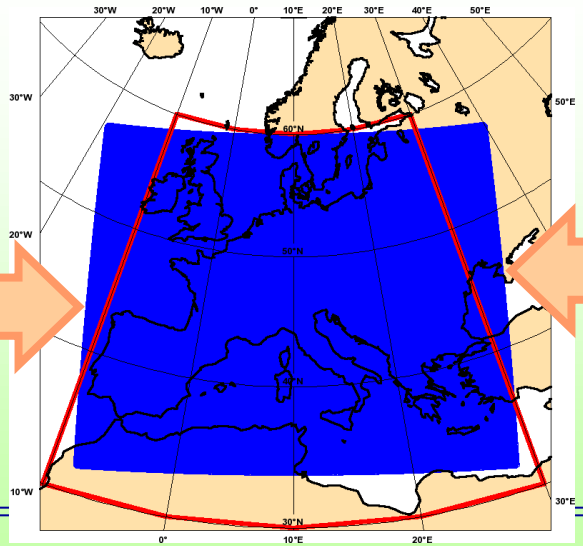
➔ **generation of COSMO-LEPS to improve the forecast of high-impact weather in the short and early-medium range (up to fc+132h)**

# COSMO-LEPS suite @ ECMWF: present status




**16 Representative Members driving the 16 COSMO-model integrations (weighted according to the cluster populations)**

**employing either Tiedtke or Kain-Fristch convection scheme (randomly choosen) + perturbations in turbulence scheme and in physical parameterisations**




**COSMO-LEPS clustering area**

**COSMO-LEPS Integration Domain**

- suite runs as a "time-critical application" managed by ARPA-SIMC;
- Δx ~ 7 km; 40 ML; fc+132h;
- COSMO v4.12 since July 2010;
- computer time (20 million BUs for 2011) provided by the COSMO partners which are ECMWF member states.

# Operational products

- 16 **perturbed** COSMO-model runs (ICs and 3-hourly BCs from 16 selected EPS members) to generate probabilistic output: start at 12UTC; $\Delta t = 132h$;
- 1 *deterministic* run (ICs and 3-hourly BCs from the high-resolution deterministic ECMWF forecast): starts at 12UTC; $\Delta t = 132h$.
- 1 *hindcast* (or *proxy*) run (ICs and 3-hourly BCs from ECMWF analyses) to "downscale" ECMWF information: starts at 00UTC; $\Delta t = 36h$.
- 1 *reforecast* run every 3rd day (IC and 6-hourly BCs from ERA-interim reanalyses) over a period of 20 years (1989-2008): starts at 12UTC; $\Delta t = 90h$.

# Outline

- **Recent upgrades of COSMO-LEPS:**
  - use of soil-moisture analysis fields from COSMO-EU.

# COSMO-LEPS with soil-moisture fields from COSMO-EU

## Oper system (interp)

$\Delta x$ = 7 km

fcst range = 132h

initial conditions: interpolated from EPS members;

perturbations: type of convection scheme; tur_len; pat_len; crsmin; rat_sea; rlam_heat.

## Test system (merge)

$\Delta x$ = 7 km

**fcst range = 48h**

initial conditions: interpolated from EPS members **merged with surface and soil-layer fields from COSMO-EU** (soil temperature, soil moisture, soil ice, snow water equivalent, interception water, snow density, fresh snow) **by DWD.**

perturbations: type of convection scheme; tur_len; pat_len; crsmin; rat_sea; rlam_heat; **mu_rain; cloud_num.**

**"Oper" and "Test" were run in parallel from 1/12/2010 to 15/3/2011 (> 100 cases).**

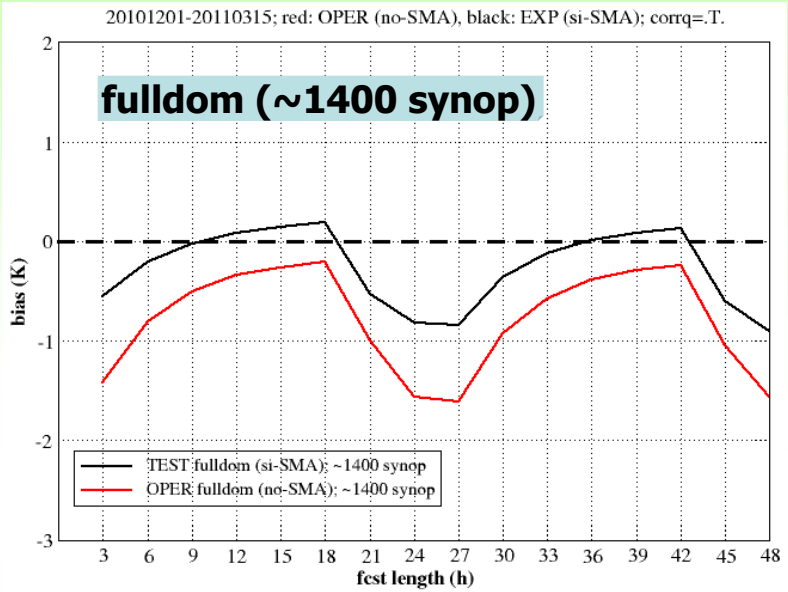
oper (interp)

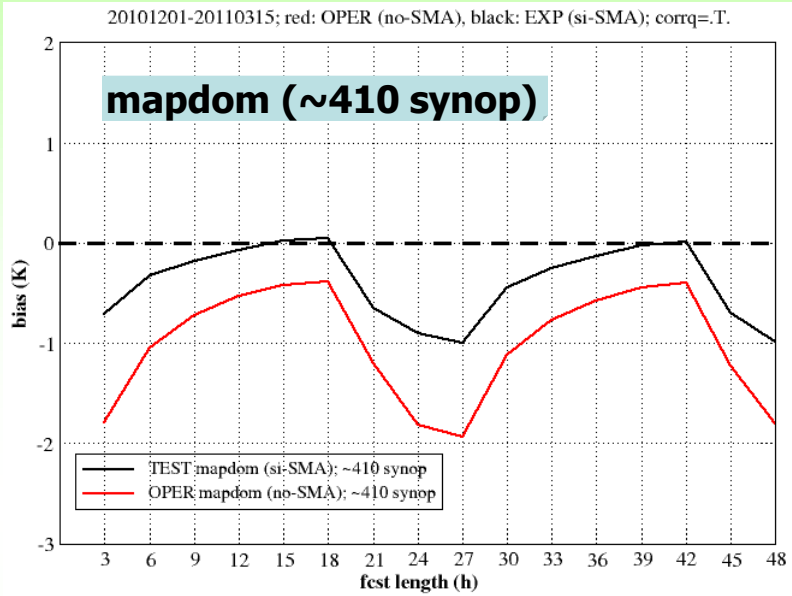
test (merge)

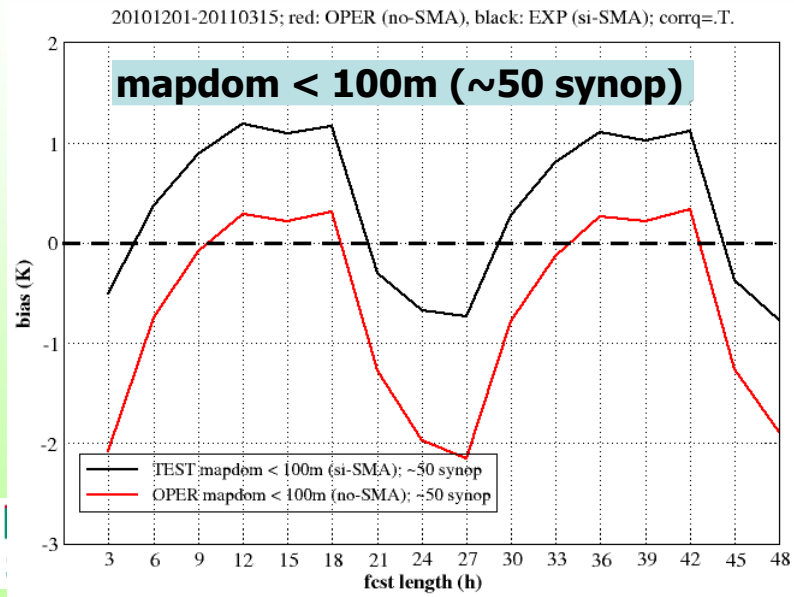
# BIAS of T2M Ensemble Mean

**T2m forecasts are corrected with height**

➢ bias computed over 3 different domains for the period **1/12/2010 → 15/3/2011** (> 100 cases).




➢ **Bias closer to zero for "test" ensemble, which uses the soil moisture fields from COSMO-EU.**

➢ Smaller amplitude in bias oscillations for "test".

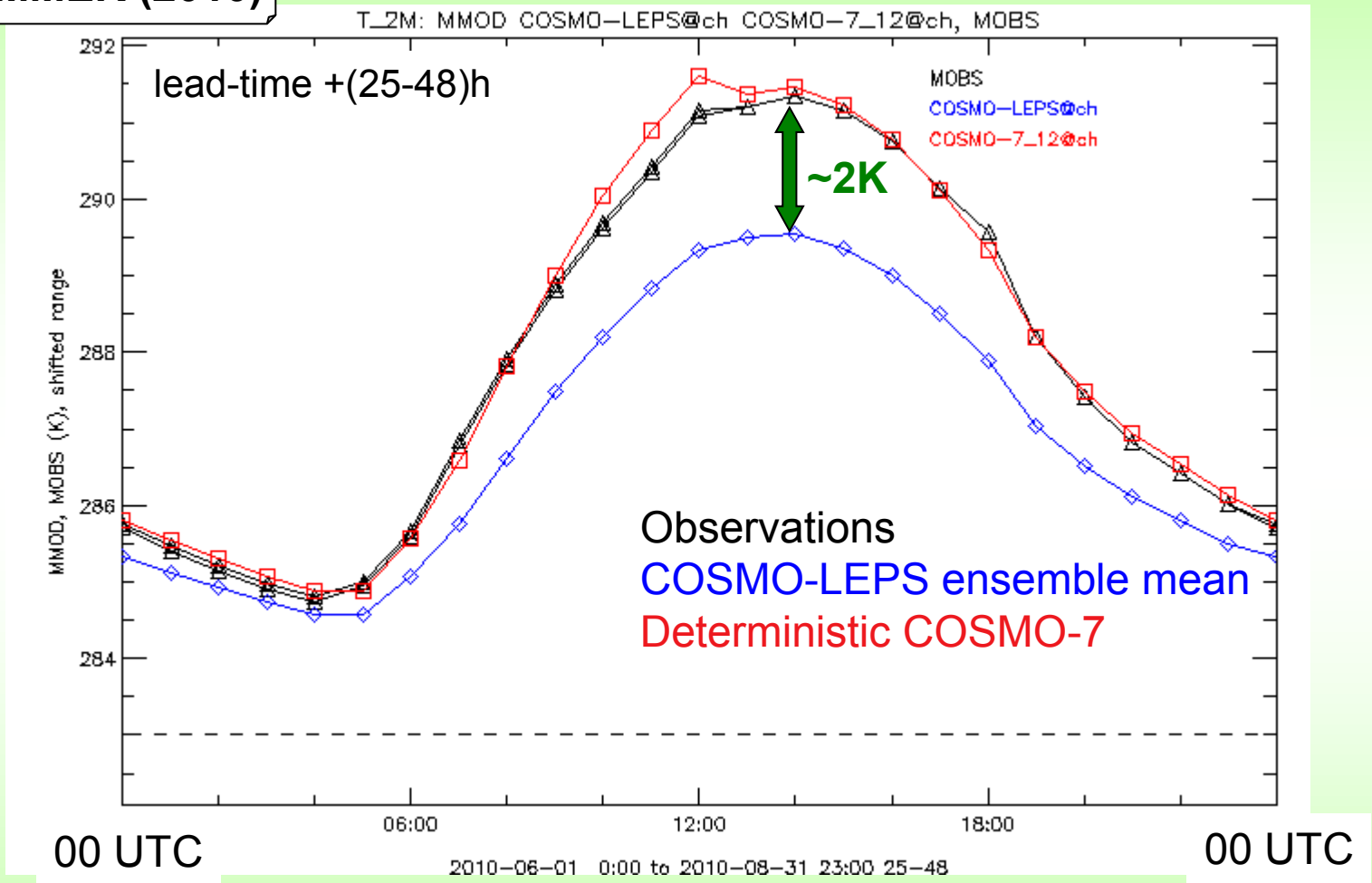
➢ **fulldom** and **mapdom:** the **improvement is systematic** for all forecast ranges; the cold bias of "oper" is reduced.

➢ **mapdom < 100m**: large reduction of bias for day-time verification; increase of the bias for night-time verification.

*…ni; The COSMO-LEPS system.*

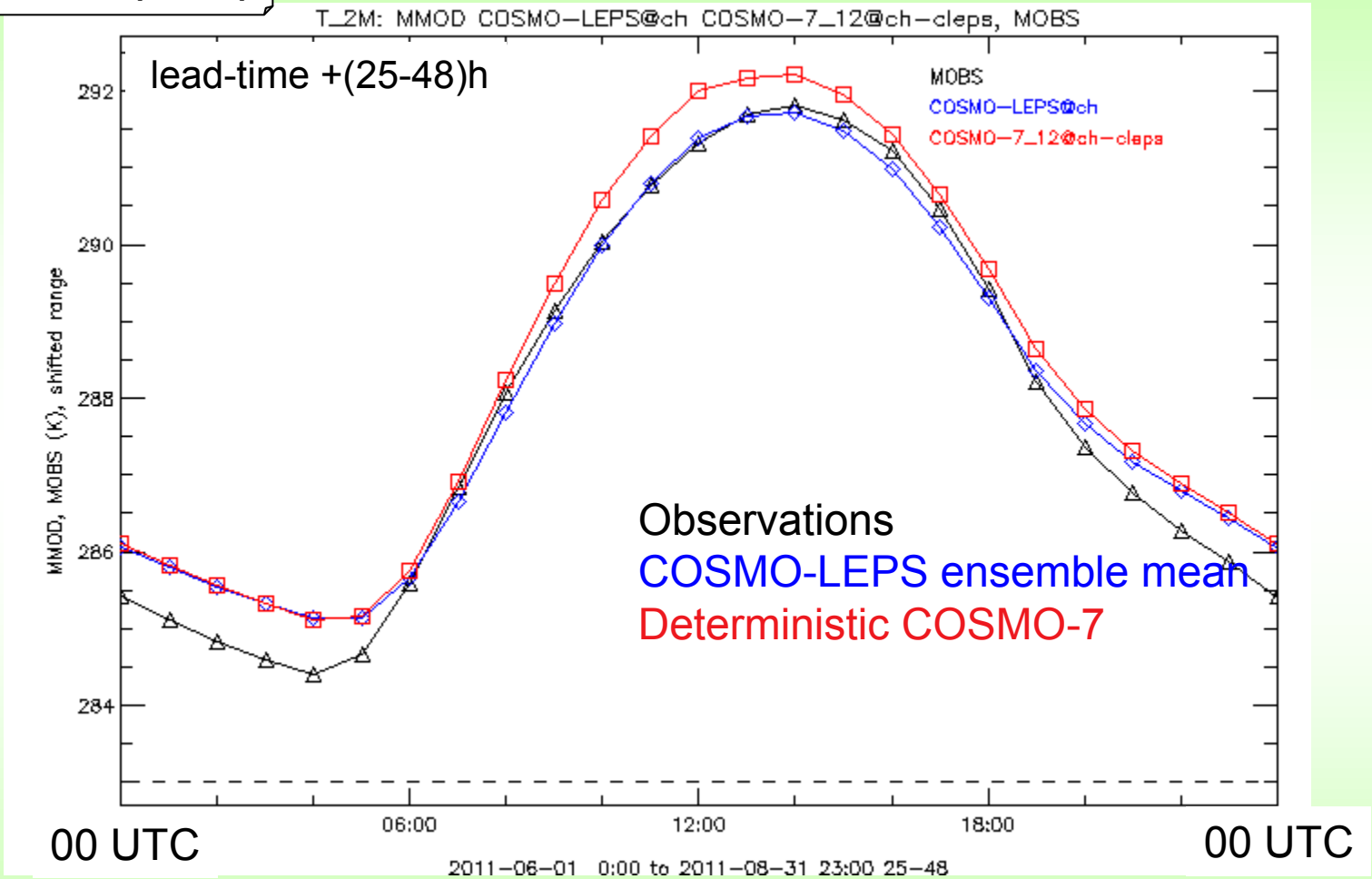
# SYNOP verif T_2M CH JJA2010

**PAST SUMMER (2010)**



# SYNOP verif T_2M CH JJA2011

**THIS SUMMER (2011)**



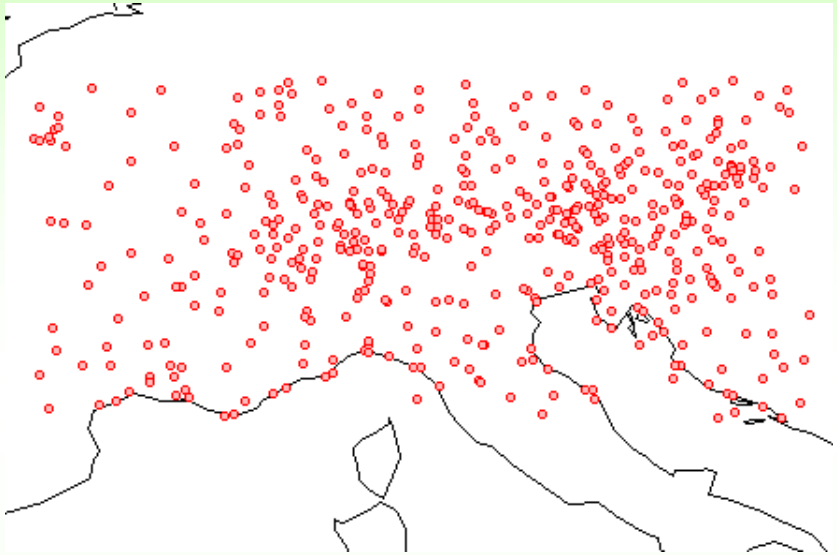

COSMO-LEPS ensemble mean outperforms COSMO-7 for all lead-times

# Outline

- **Performance of the system:**
  - time-series verification of COSMO-LEPS using SYNOP;

# Time-series verification of COSMO-LEPS

- SYNOP on the GTS



## Main features:

variable: 12h cumulated precip (18-06, 06-18 UTC);

**period : from Dec 2002 to Jul 2011;**

region: 43-50N, 2-18E **(MAP D-PHASE area);**

method: nearest grid point; no-weighted fcst;

obs: synop reports (about 470 stations/day);

fcst ranges: 6-18h, 18-30h, …, 102-114h, 114-126h;

thresholds: **1, 5, 10, 15,** *25, 50* **mm/12h**;

system: COSMO-LEPS;

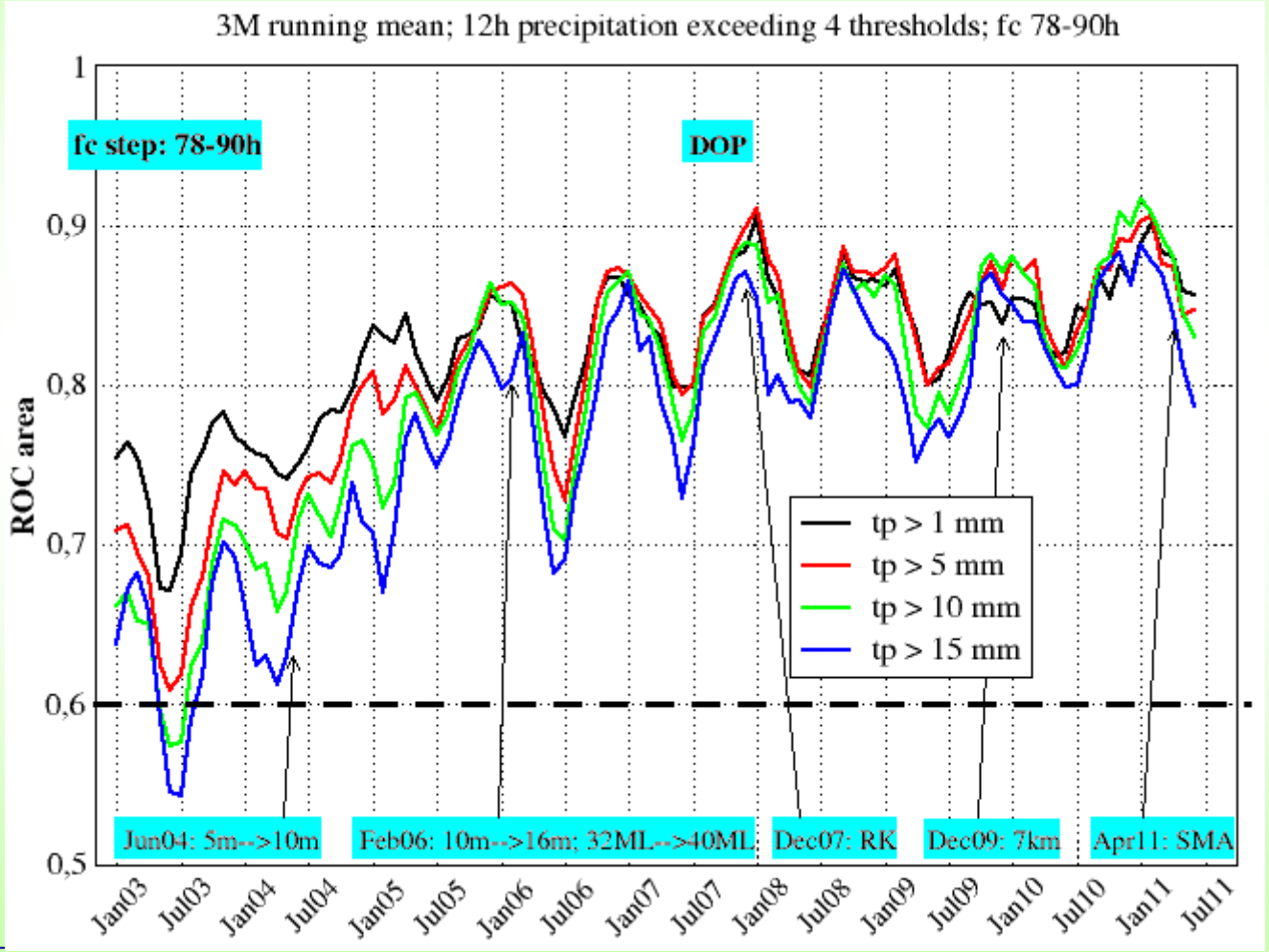
scores: **ROC area,** BSS, RPSS, Outliers, …

both monthly and seasonal scores were computed

# Time series of ROC area

- Area under the curve in the HIT rate vs FAR diagram; the higher, the better …
- Valuable forecast systems have ROC area values > 0.6.

- Improvement of skill detectable in the last 12 months for all but the highest threshold.
- In the last months, few events with heavy precipitation: possible lack of significance of the results for the 15mm threshold.
- ROC area values show little dependence on the threshold.



# Outline

- **Performance of the system:**
  - reliability of COSMO-LEPS forecasts.

# Reliability of COSMO-LEPS forecasts

## Combined use of EDA- and SV-based perturbations in the EPS

ROBERTO BUIZZA, MARTIN LEUTBECHER, LARS ISAKSEN, JAN HASELER

This article briefly describes the new EDA-SVINI implementation and discusses some results.

THE SIMULATION of initial
aspects in ensemble predicti
mentation of the first versic
System (EPS) in 1992, these
lated with singular vectors (S
by the fastest growth, measu
over a finite time interval.

With the forthcoming implementation in cycle 36r2 of an Ensemble of Data Assimilations (EDA, see the companion article in this edition of the *ECMWF Newsletter*, pages 17 to 21), the methodology used to generate the EPS initial perturbations will be changed. EDA-based perturbations will replace evolved singular vectors in the generation of the EPS initial conditions. Following this change, the EPS initial perturbations will have a better geographical and vertical coverage than in the earlier system. This results in a better spread-skill relationship in the early forecast range over the extra-tropics, and for the whole forecast range over the tropics. Limited-area ensemble prediction systems (e.g. COSMO-LEPS) that use EPS initial and boundary conditions will benefit from this improvement. Over the tropics the substantial increase of the EPS spread leads to much smaller spread under-dispersion. In terms of skill, the EDA-SVINI configuration of the EPS has a higher skill than the earlier SV-based system everywhere.

hours of the forecast (SVINI) sample directions in phase space likely to contribute most to forecast uncertainty. Practically, the SVs are computed separately over the northern and the southern hemisphere extra-tropics, and for up to six local regions in the tropics to improve the geographical sampling of the initial uncertainties. The initial-time and evolved SVs for the different areas are re-scaled to have initial amplitude comparable to the analysis error estimate given by the hi
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**Replacement perturbation**

*Buizza et al.* (2
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the tropics. Limited-area ensemble prediction systems (e.g. COSMO-LEPS) that use EPS initial and boundary conditions will benefit from this improvement. Over the tropics the

ECMWF Newsletter 123
(Spring 2010)
**EDA implemented on 24/6/2010**

## But is that true?

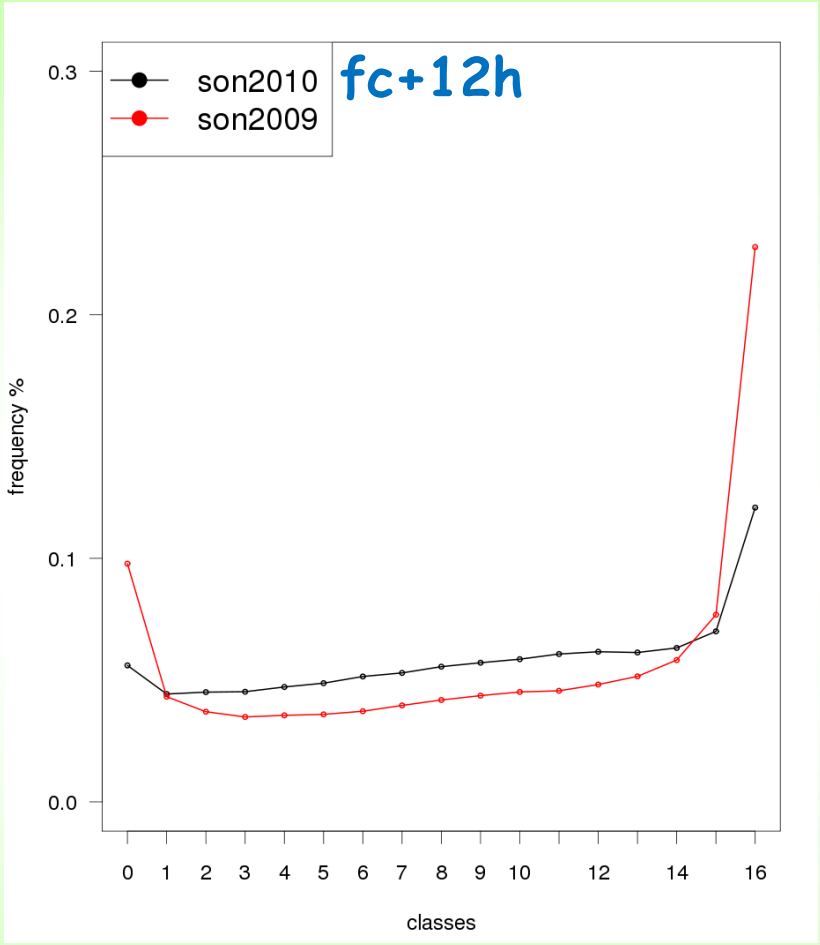
Consider COSMO-LEPS spread-skill for a few seasons:

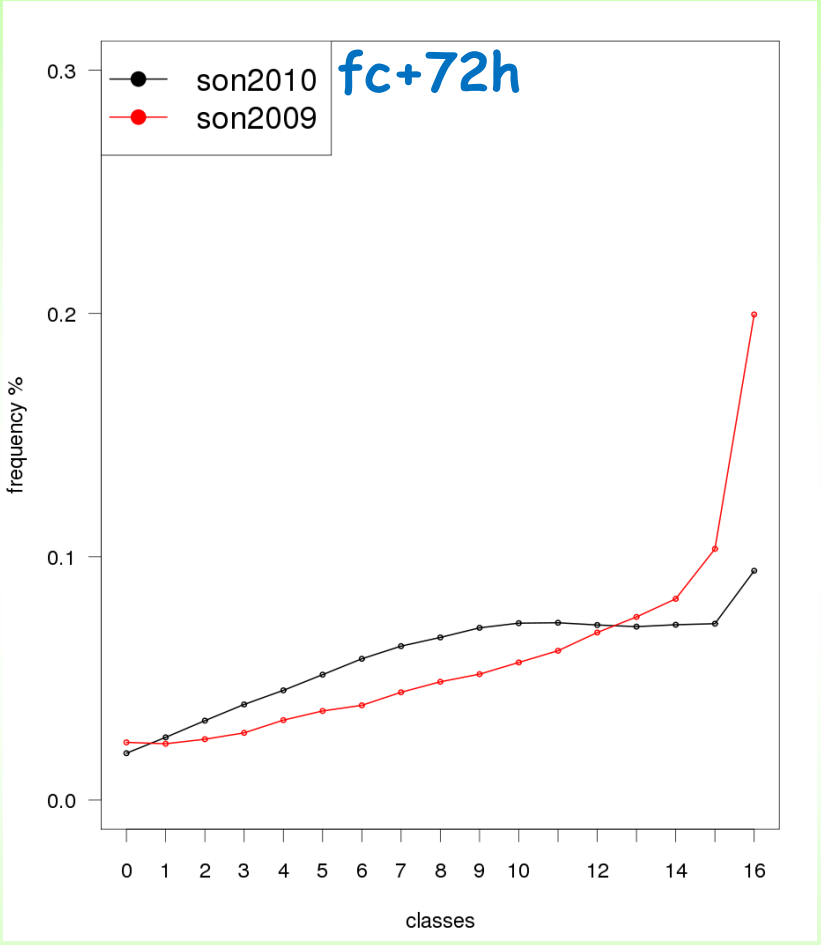
**SON 2009** - MAM 2010 *before* 24/6/2010

**SON 2010** - MAM 2011 *after* 24/6/2010

Verification against ECMWF analysis (0.5x0.5); **T850**

# Rank histogram (T850)



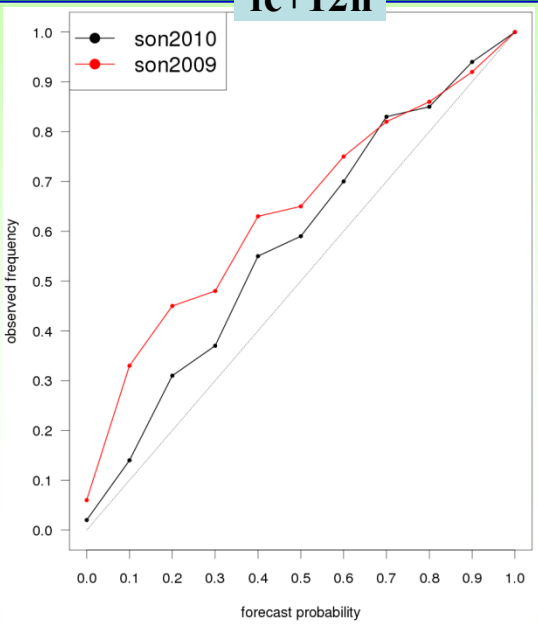



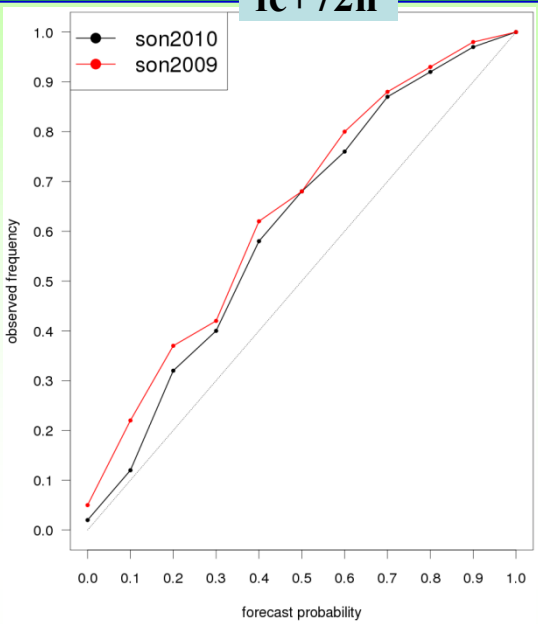

A cold bias persists in COSMO-LEPS forecasts (more outliers "to the right"), but the short-range spread is increased from **2009 (before EDA)** to **2010 (after EDA)**.

# Reliability diagram (T850)

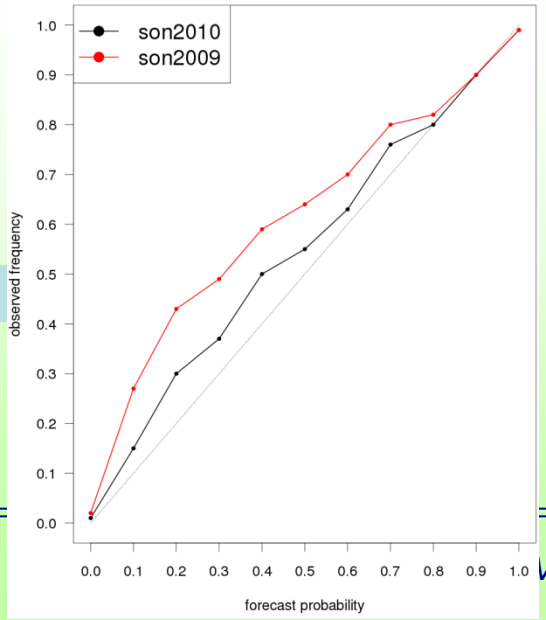
**fc+12h** | **fc+72h**

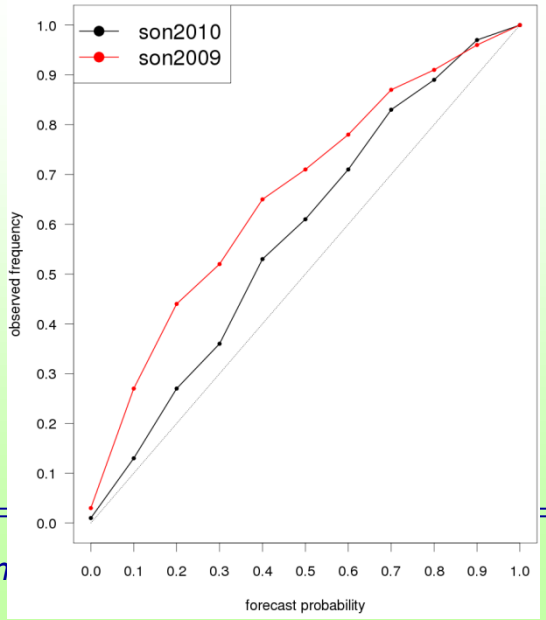
**T > 0 °C**




**T > 10 °C**




For both events and forecast ranges, COSMO-LEPS is under-confident ("above" the diagonal), but the reliability is increased from **2009 (before EDA)** to **2010 (after EDA)**.

Need to study **more seasons and more variables** to confirm these results.

# Outline

- **Performance of the system:**

  - case study: the Liguria flood.

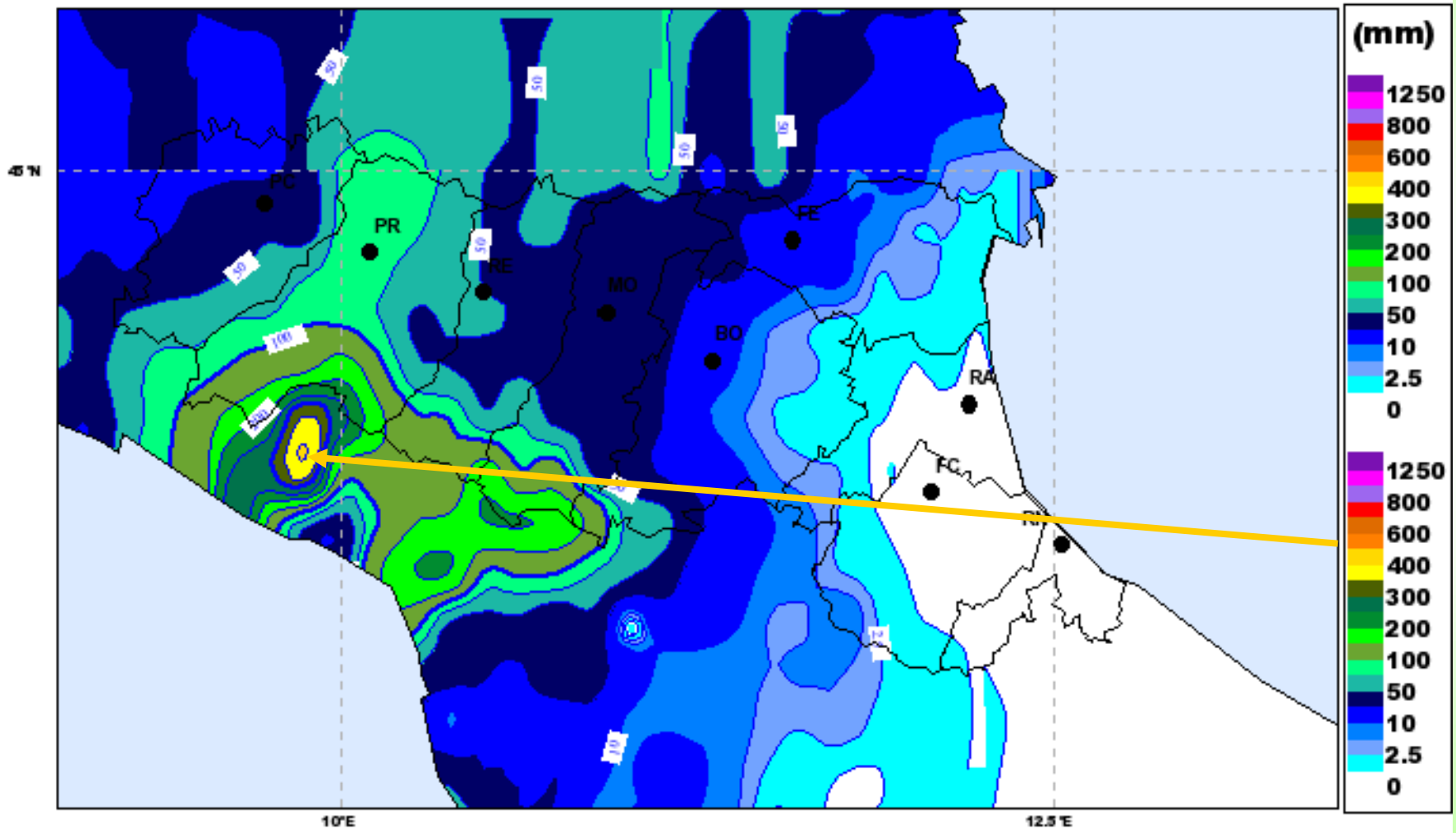
# Liguria and Tuscany flood event

**10 casualties, 3 missing people.**

Damages for about 1 million euro; and more rainfall is coming next week-end…

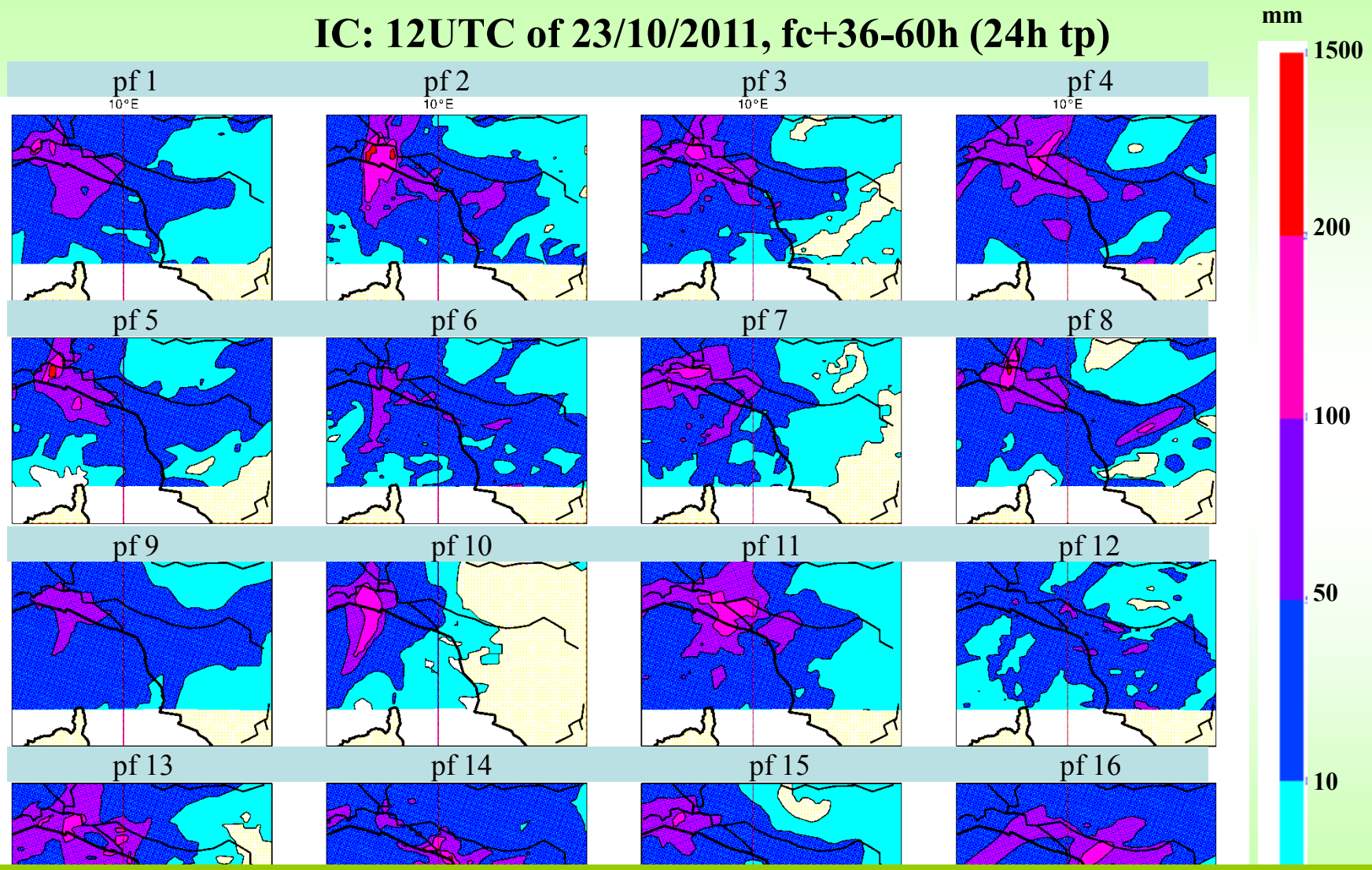

# Liguria flood: observations

24-hour cumulated precipitation from 00UTC to 24UTC of 25/10/2011




Courtesy of F. Grazzini

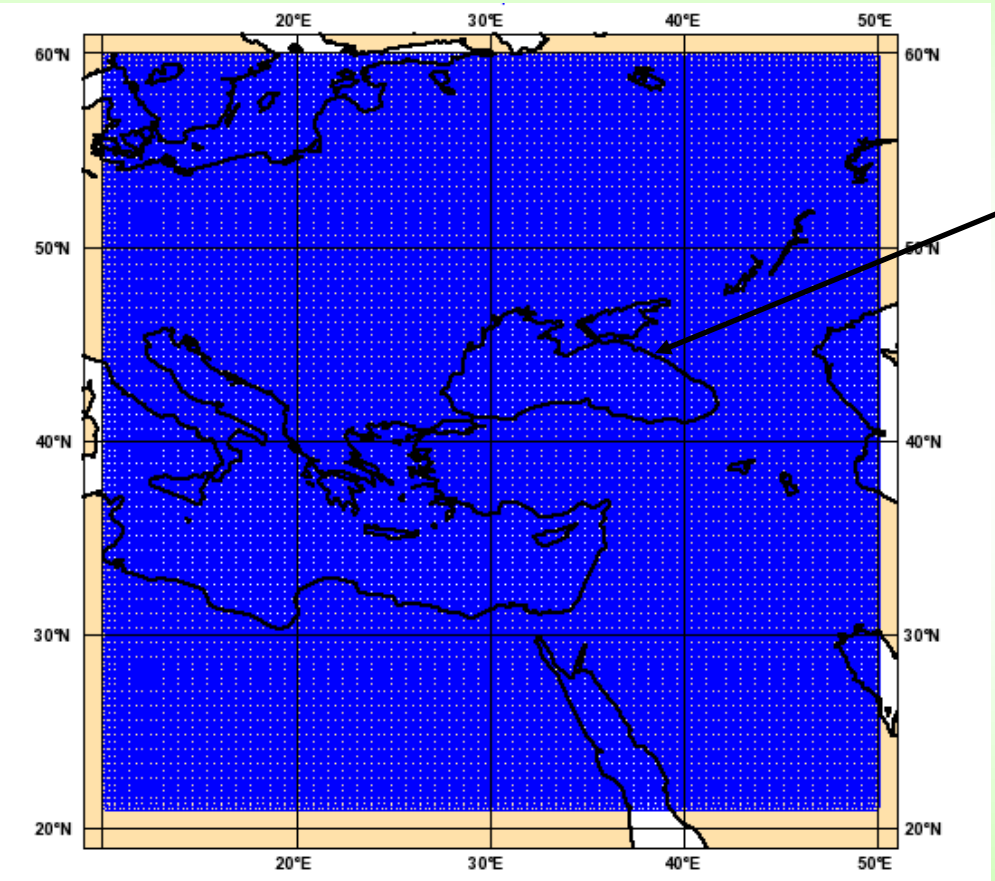
# Liguria flood: performance of COSMO-LEPS




**Several COSMO-LEPS members suggest a heavy precipitation event, although some underestimation is present.**

# Outline

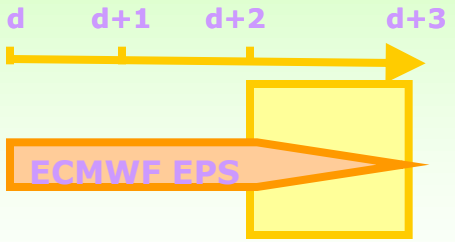
- Implement ensemble.



# SOCHi-targeted Mesoscale EnsembLe system

1) **Next Olympics and Paralympics Winter Games will take place in Sochi, Russia (7-23 February and 7-16 March 2014).**
2) For this event, WMO launched a WWRP RDP/FDP initiative, named **FROST-2014** (**F**orecasting and **R**esearch: the **O**lympic **S**ochi **T**estbed)
3) COSMO consortium will perform a number of activities related to Sochi-2014 WWRP RDP/FDP:
   a) deterministic forecasting,
   **b) probabilistic forecasting:**
      **b1) FDP initiatives** ("clone" of COSMO-LEPS over the Sochi area),
      b2) RDP initiatives (development of a convective-scale ensemble system for the Sochi area).
   c) post-processing and product generation,
   d) verification.

# SOCHI suite @ ECMWF: present status




clustering interval

4 variables
Z U V Q

3 levels
500 700 850 hPa

Cluster Analysis and RM identification

2 time steps

Black-Sea area

Complete Linkage

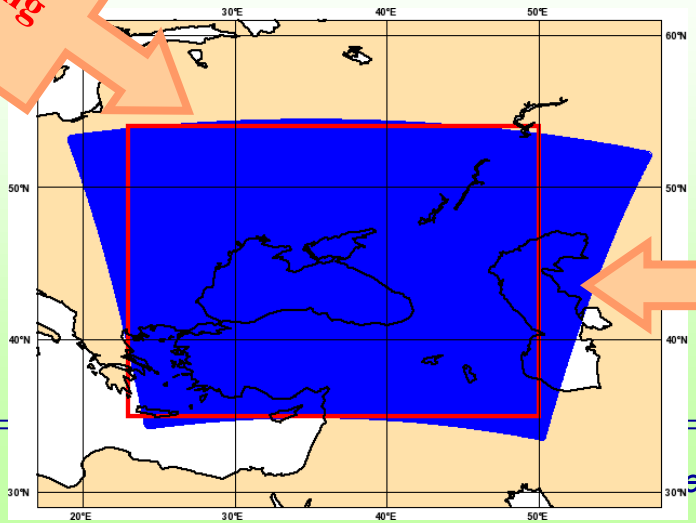
**10 Representative Members driving the 10 COSMO-model integrations (weighted according to the cluster populations)**

**employing either Tiedtke or Kain-Fristch convection scheme (randomly choosen)**

**+**

**perturbations in turbulence scheme and in physical parameterisations**

SOCHMEL clustering area




SOCHMEL Integration Domain

- Δx ~ 7 km; 40 ML; fc+72h;
- initial time: 00UTC, 12UTC;
- for the moment, computer time (10 million BU for 2012) is provided by an ECMWF Special Project;
- suite managed by ARPA-SIMC;
- contributions from ECMWF member states could be needed in the future.

*e COSMO-LEPS system.*

# Summary of results

## 11 April 2011: operational implementation of the soil-merge

- This should guarantee lower bias and mae for both T2M and TD2M in short range COSMO-LEPS forecasts.

## Performance of the system

- ECMWF EPS changed substantially in the last months (introduction of EDA-based perturbations) and it is hard to disentangle improvements related to COSMO-LEPS upgrades from those due to better boundaries; nevertheless:
  - time-series scores indicate higher values of ROC area for the probabilistic prediction of 12-h precipitation,
  - lower outliers and higher reliability for T850.

## SOCHi-targeted Mesoscale EnsembLe system

- The system runs “on demand”.
- Develop a full prototype (inclusive of post-processing and dissemination) by December 2011.

# Future plans

- Due to the increasing use and interest in COSMO-LEPS products, **COSMO-LEPS** will be implemented **also at 00UTC** by the end of the year.
- Test modifications to the clustering methodology: consider shorter forecast ranges for clustering intervals and/or select the Representative Members from only one EPS.
- Develop soil perturbations.
- Disseminate calibrated products over specific regions.
- COSMO-LEPS for TIGGE-LAM (GRIB2 encoding).
- LAMEPS_BC project → consider possible modifications to COSMO-LEPS suite.
- Carry on collaboration within research project (e.g. EFAS, SAFEWIND, IMPRINTS, NURC, …).

# Thank you !