The COSMO-LEPS system at ECMWF:

present status and plans

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Reading, 14-18 November 2005

Outline

- Introduction

- Present status of the COSMO-LEPS suite

- Related projects

- Performance during August 2005

- Verification results: COSMO-LEPS vs EPS
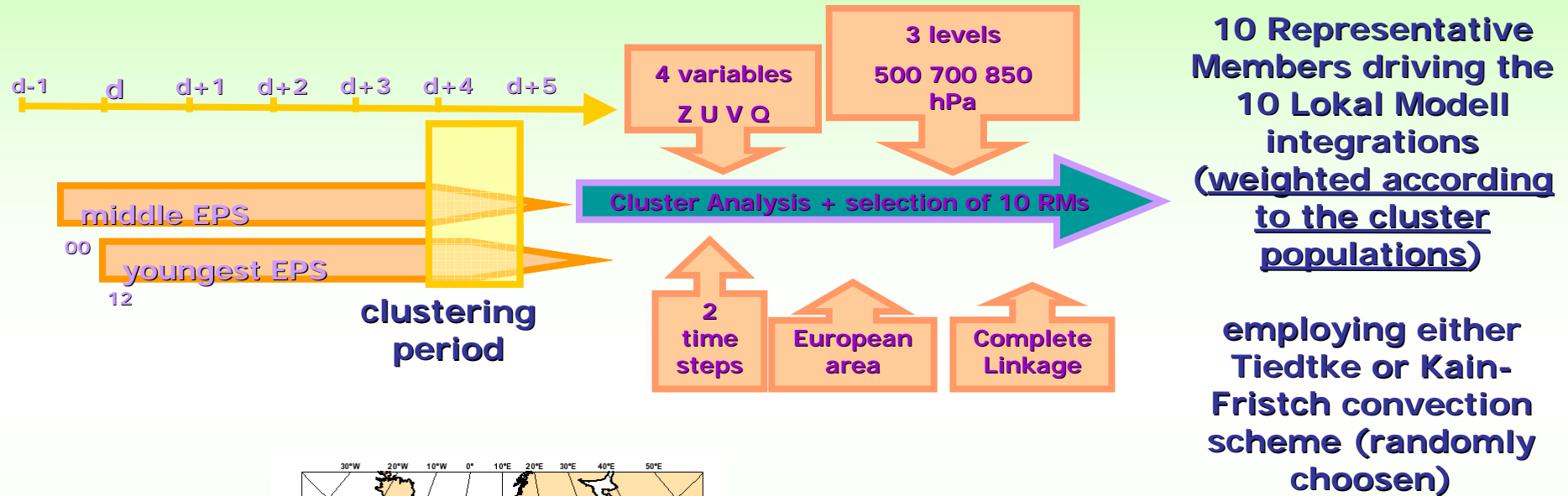
- Conclusions and future plans

Introduction

- **What is it?** It is a **L**imited-area **E**nsemble **P**rediction **S**ystem (**LEPS**), based on Lokal Modell (non-hydrostatic limited-area model) and developed within **COSMO** (**CO**nsortium for **S**mall-scale **MO**delling, which includes Germany, Greece, Italy, Poland and Switzerland).

- **Why?** The horizontal resolution of global-model ensemble forecast systems is limited by computer time constraints and does not allow a detailed description of mesoscale and orographic-related processes.

➔ **COSMO-LEPS project:** combine the advantages of global-model ensembles with the high-resolution details gained by the LAMs, so as to identify the possible occurrence of **intense** and **localised** weather events (heavy rainfall, strong winds, temperature anomalies, ...);
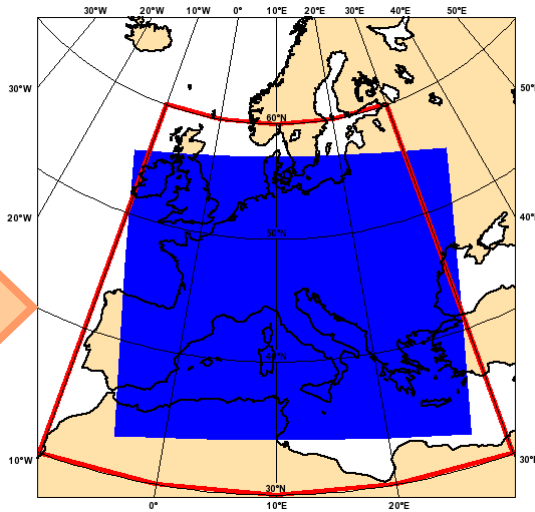
COSMO-LEPS forecasts to improve short to medium-range forecasts (48h < Δt < 120h) of the so-called "severe weather events".

The COSMO-LEPS suite @ ECMWF

d-1   d   d+1   d+2   d+3   d+4   d+5

middle EPS

00

youngest EPS

12

clustering period

4 variables

Z U V Q

3 levels

500 700 850 hPa

Cluster Analysis + selection of 10 RMs

2 time steps

European area

Complete Linkage

10 Representative Members driving the 10 Lokal Modell integrations (weighted according to the cluster populations)

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

COSMO-LEPS clustering area

COSMO-LEPS Integration Domain

- suite running daily at ECMWF managed by ARPA-SIM;
- Δx = 10 km; 32 ML;
- fc length: 132h;
- computer time (2 million BU for 2005) provided by the COSMO partners which are ECMWF member states.

arpa SIM

Operational set-up

Core products:

➔ 10 *perturbed* LM runs to generate probabilistic output (start at 12UTC; Δt = 132h); ICs and **3-hourly** BCs are provided by 10 selected EPS members (all EPS members post-processed also on model levels).

Additional products:

➔ 1 *deterministic* LM run to assess the relative merits between deterministic and probabilistic approach (start at 12UTC; Δt = 132h); ICs and 6-hourly BCs from the high-resolution deterministic ECMWF forecast).

➔ 1 *proxy* run to "downscale" ECMWF information (start at 00UTC; Δt = 36h); (ICs and 3-hourly BCs from ECMWF analyses).

Dissemination to the COSMO community (+ Hungary)

Products disseminated to the COSMO–countries

probabilistic products:

- 24h rainfall exceeding 20, 50, 100, 150 mm;
- 72h rainfall exceeding 50, 100, 150, 250 mm;
- 24h snowfall exceeding 1, 5, 10, 20 "**cm**";
- $UVmax_{10m}$ in 24h above 10, 15, 20, 25 m/s;
- $Tmax_{2m}$ in 24h above 20, 30, 35, 40 ^{0}C;
- $Tmin_{2m}$ in 24h below -10, -5, 0, +5 ^{0}C;
- min height of 0 ^{0}C isotherm in 24h below 1500, 1000, 700, 300 m
- max–CAPE in 24h above 2000, 2500, 3000, 3500 J/kg;
- min Showalter Index in 24h below 0, -2, -4, -6;

deterministic products (for each LM run):

- 24–hour cumulated rainfall; mean–sea–level pressure, Z700, T850;

meteograms (over a number of station points):

- T_{2m}, rainfall, 10m wind speed.
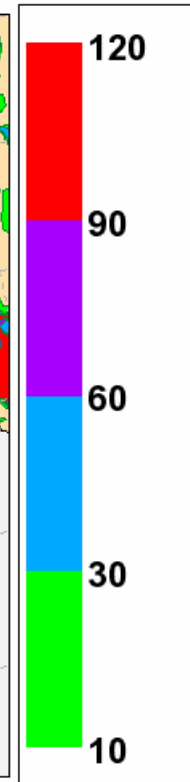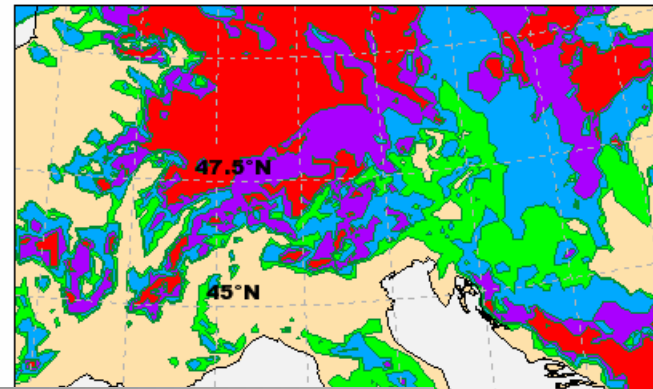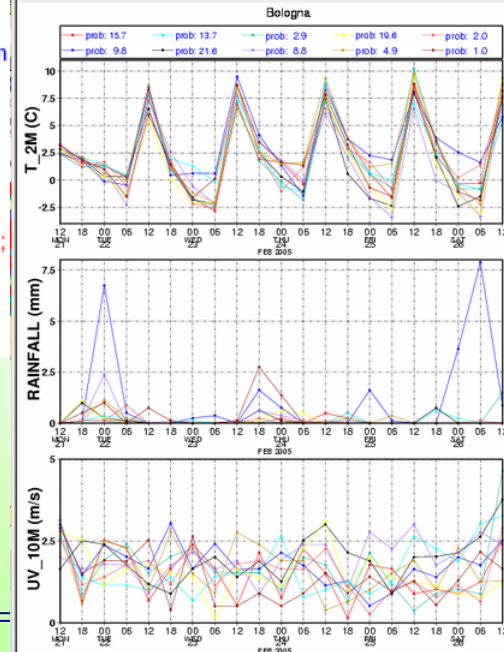
Archiving of COSMO-LEPS products at ECMWF

From 1 July 2005, COSMO-LEPS forecasts are archived on MARS (class=co; localdef=28).

➔ **Deterministic run** *(fc+0h to fc+132h every 3h).*

➔ **Ensemble Prediction System:**

  ➔ **10 perturbed forecasts** *(fc+0h to fc+132h every 3h)*:

   PLEV (500, 700, 850 hPa): Z, RH, T.

   SURF: albedo, LCC, MCC, TCC, SW radiation flux, CAPE, hzerocl, snowlmt, mslp, T_2m, Td_2m, TMAX_2m, TMIN_2m, U_10m, V_10m, UVMAX_10m, large-scale rain, convective rain, large-scale snow, TP.

  ➔ **Forecast probability** *(various intervals and thresholds)*:

   SURF: CAPE, hzerocl, TMAX_2m, TMIN_2m, UVMAX_10m, TP, snowfall, showalter index.

➔ **Clustering info** *(population, clustering variables used, ...).*

About 2.2GB per day

Related projects

• **SPITLAEF** (Italian ECMWF special project) to perform studies on limited-area ensemble size, clustering methodologies, model perturbations, EPS reruns, …

• **SPCOLEPS (joint Italy and Switzerland ECMWF special project) to study possible modifications of the operational suite.**

• **SPCOWIND** (joint Italy and Great Britain): new ECMWF special project so as to have the computer resources to run a limited-area ensemble system over North-Western Europe (within the EC project PREVIEW, WP: Windstorms).

ALPINE suite (running on SPCOLEPS billing units)
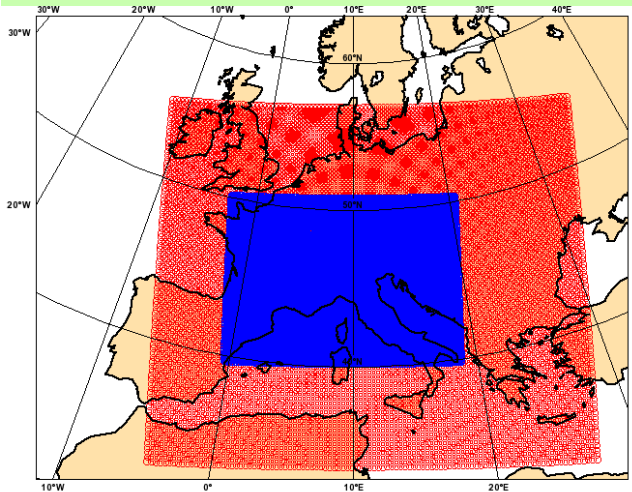
> Experimental suite running daily from 15 July 2005.

> Same configuration as the operational COSMO-LEPS (red), but both clustering and integration domain are centred over the Alps (blue).

> Products not yet disseminated, but saved on ECFS.

> On single events, differences between the 2 suites can be noticeable:

Prob maps of 3-day rainfall exceeding 50 and 100 mm (fc24-96h); forecast starting at 20050905 12UTC

➔   **In this case, more helpful maps from the Alpine suite**

ope   **alp**
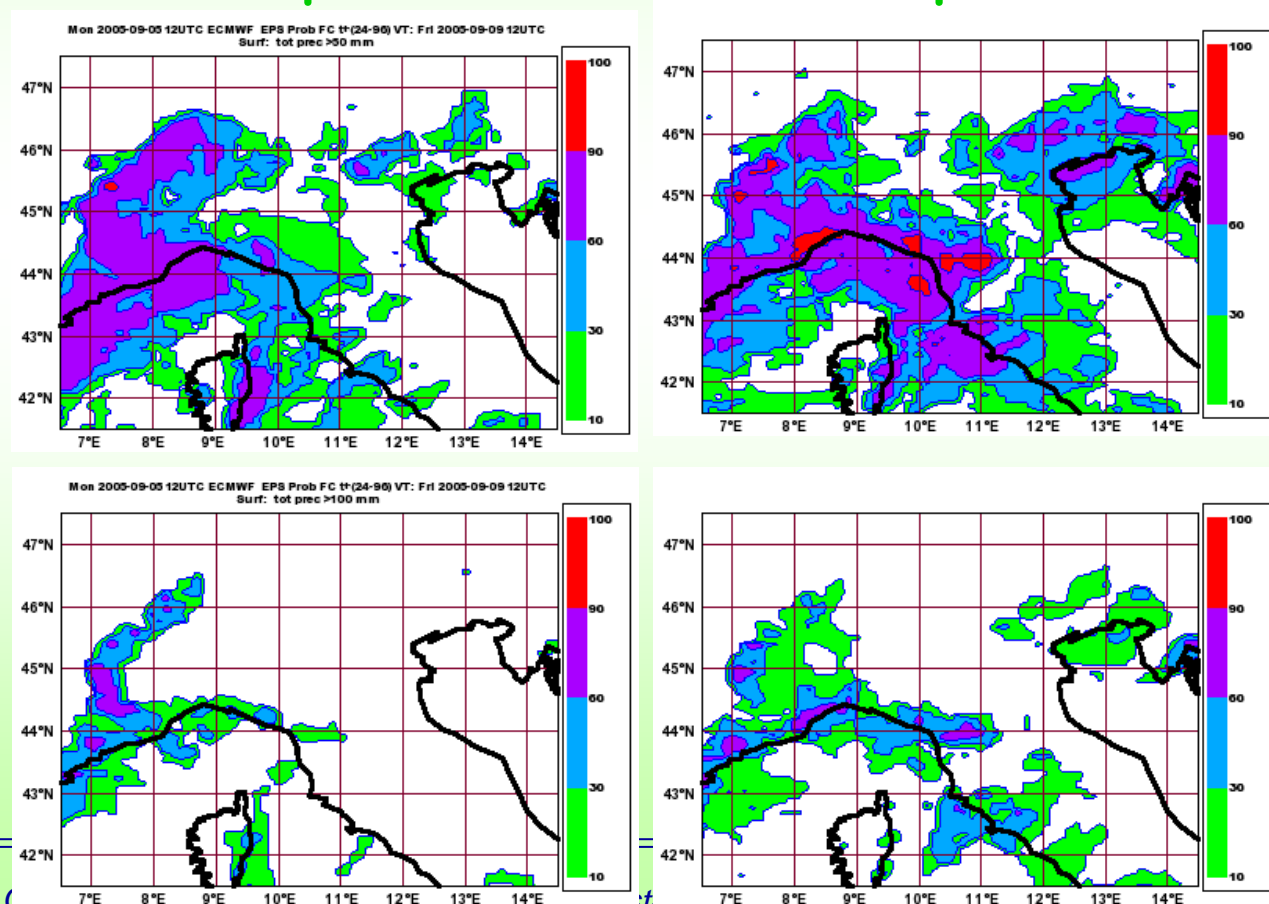
Case study: flood events in Switzerland in August 2005

Photos:Tages-Anzeiger

Synoptic overview: 22 August 2005

Temperature 850 hPa and geopotential 500 hPa:
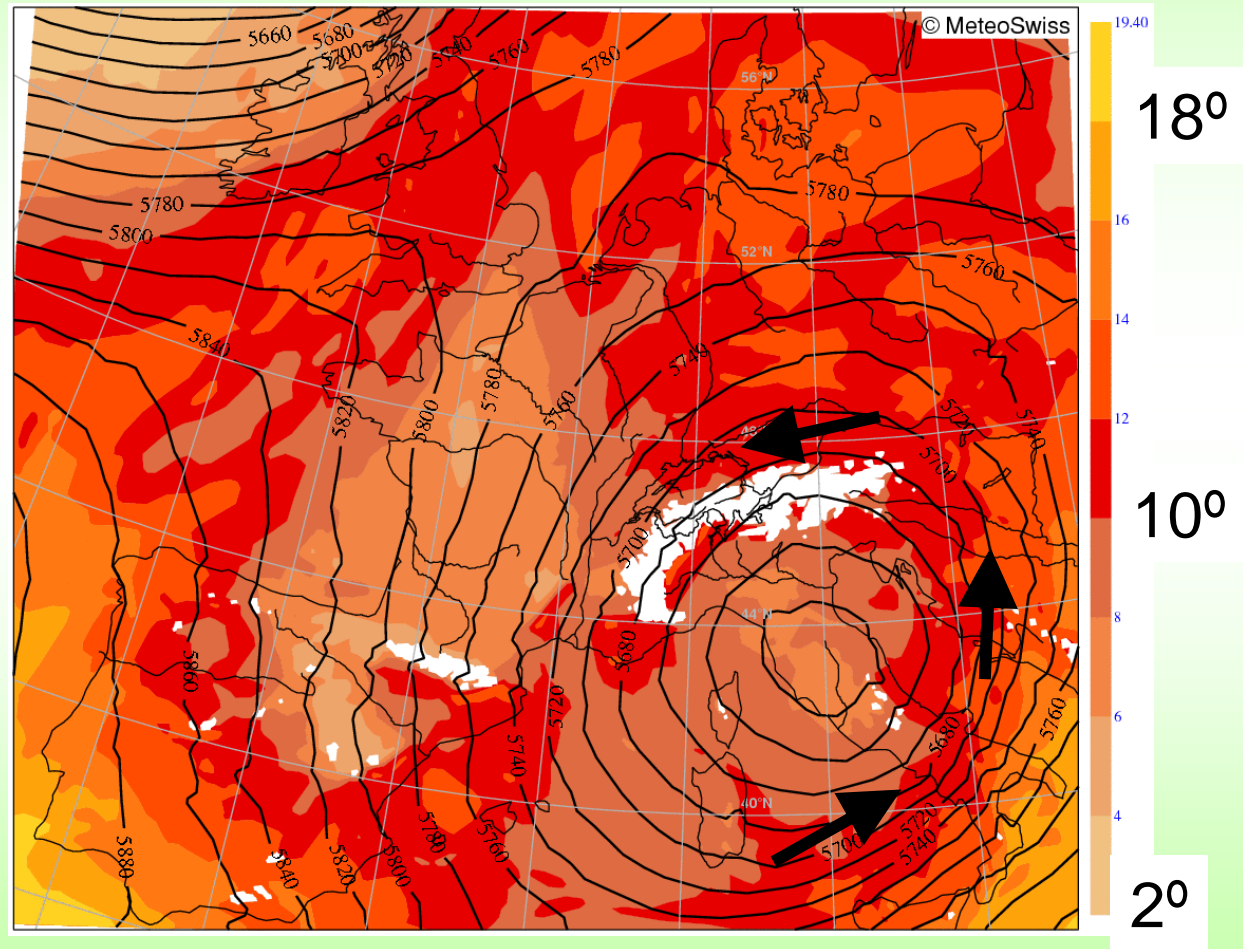
Total precipitation over 3 days (20/8 – 23/8)

Niederschlag 72h–Summe (mm) 20 - 23. 08. 2005 (06 - 06 UTC)

Datenstand 2005–09–08

250
200
160
130
100
80
60
40
20

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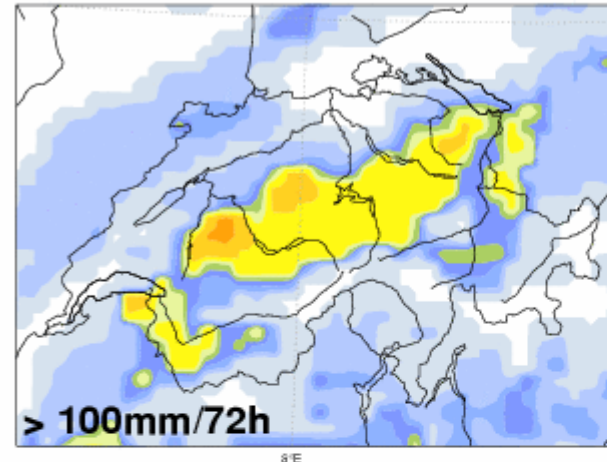© MeteoSchweiz
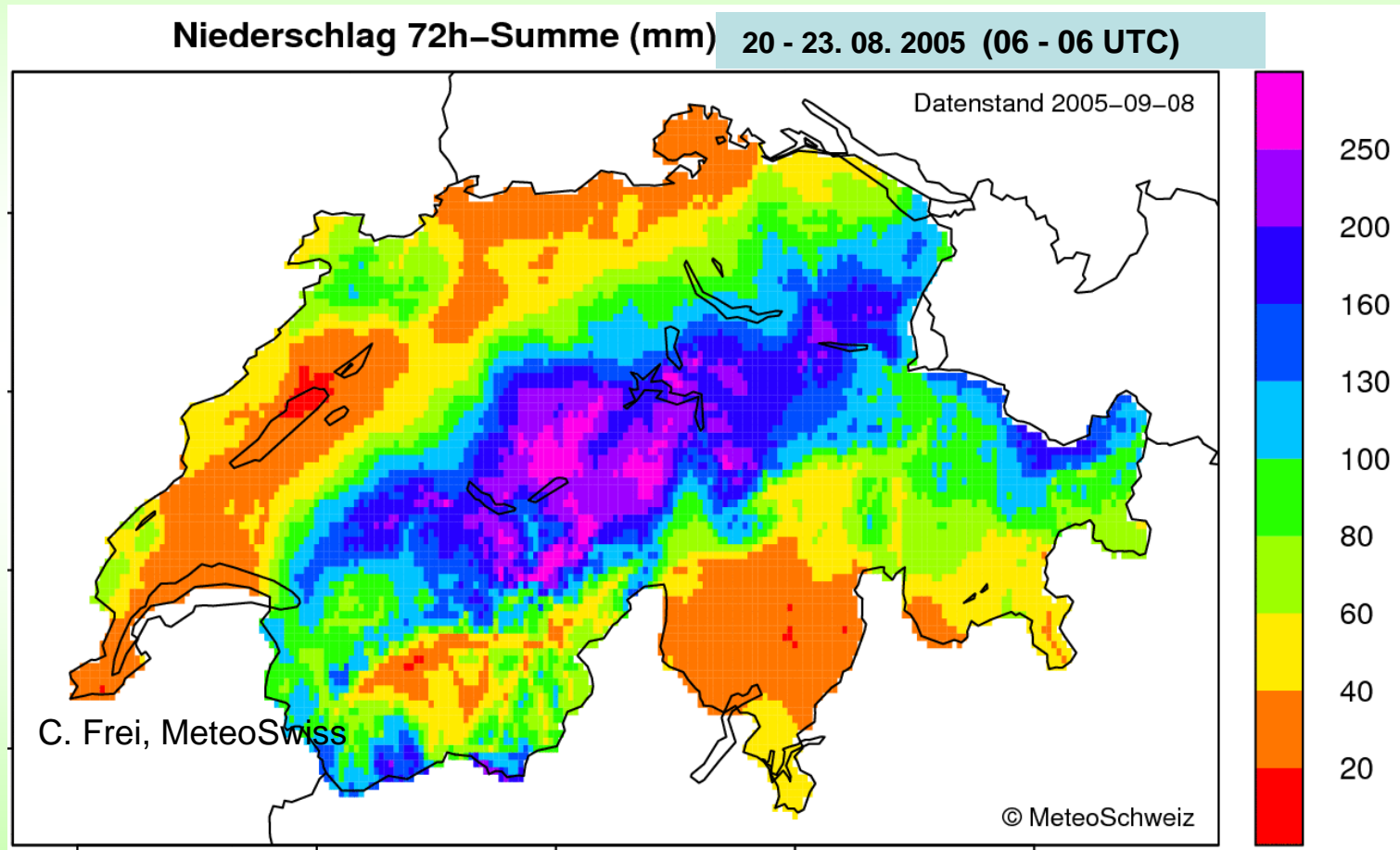
About 400 stations, precipitation sum locally over 300 mm!

COSMO-LEPS forecast for 72h precipitation

COSMO-LEPS probability forecast: 72h sum of total precipitation
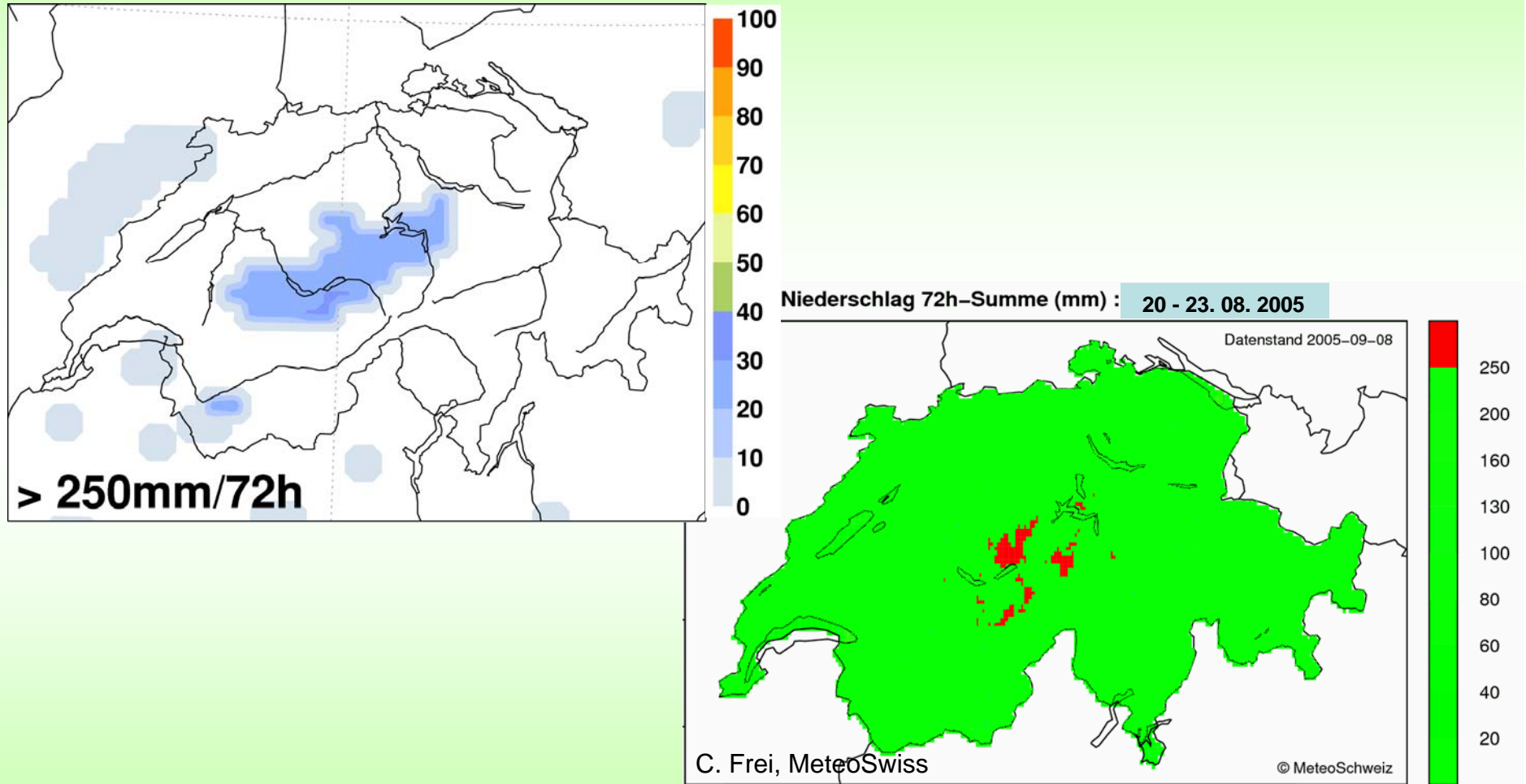18 Aug 2005 12UTC, t+(36-108), VT: Tuesday 23 Aug 2005 00UTC
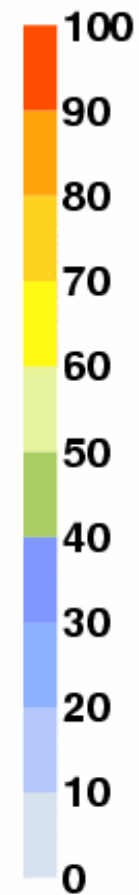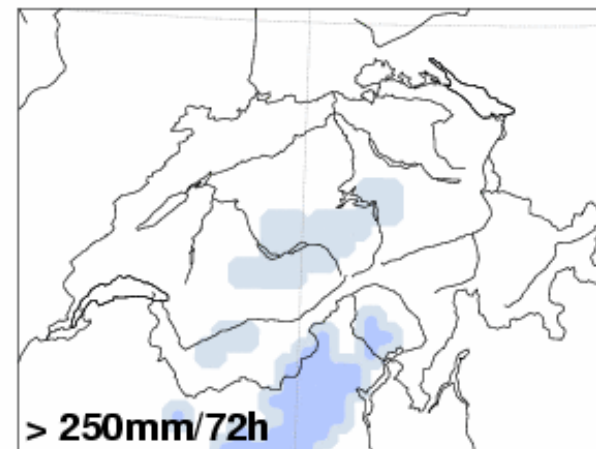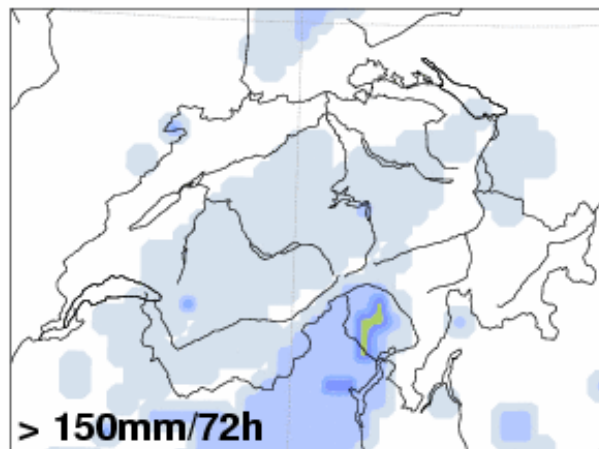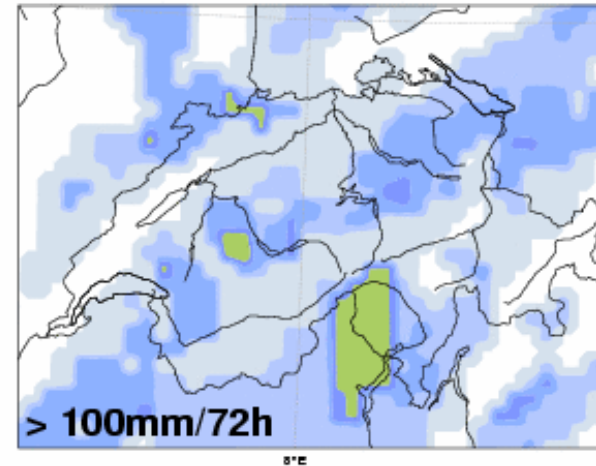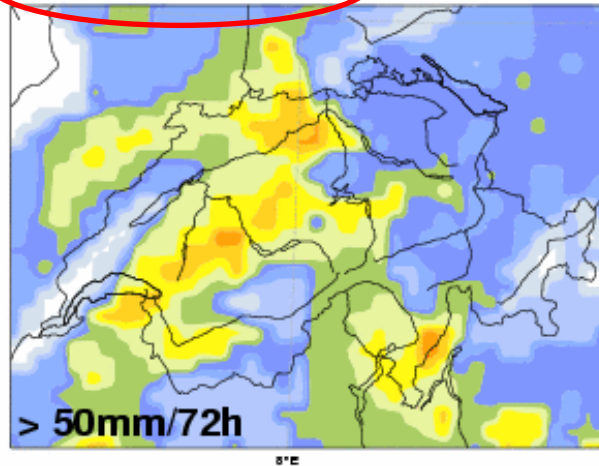
> 50mm/72h
> 100mm/72h
> 150mm/72h
> 250mm/72h

COSMO-LEPS forecast for 72h precipitation

COSMO-LEPS probability forecast: 72h sum of total precipitation
19 Aug 2005 12UTC, t+(18-90), VT: Tuesday 23 Aug 2005 06UTC
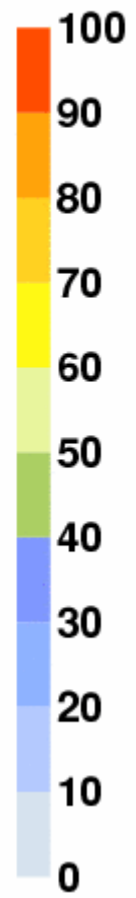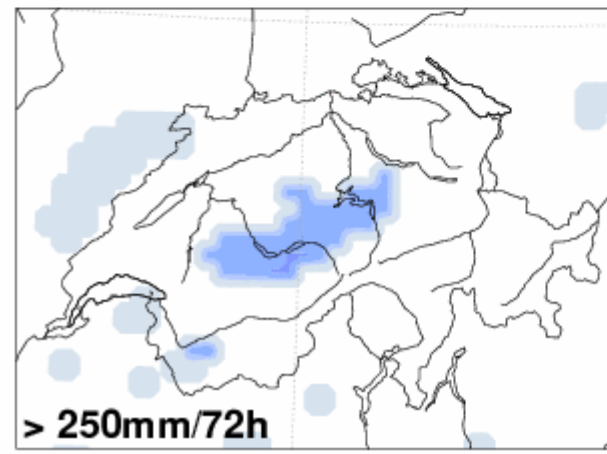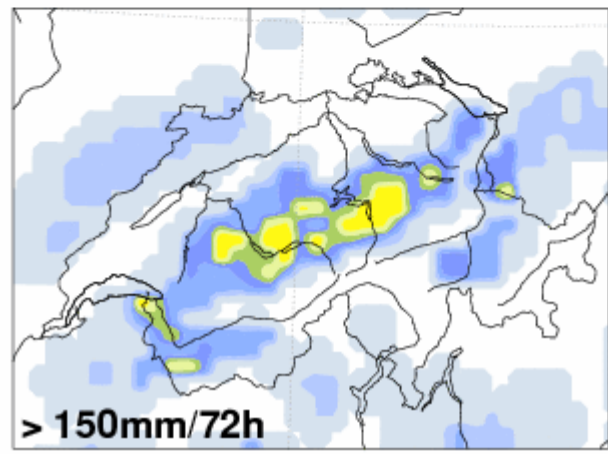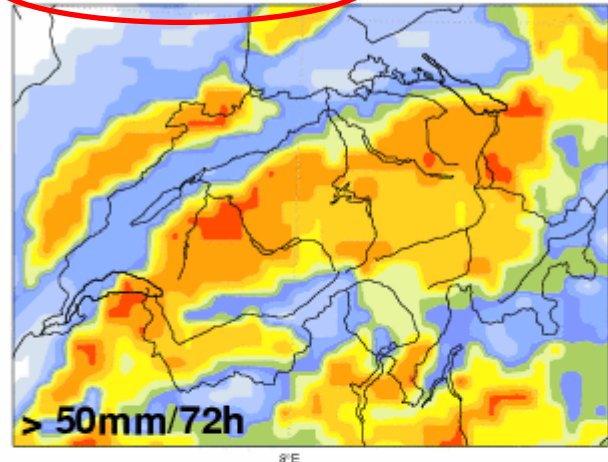
> 50mm/72h

> 100mm/72h

> 150mm/72h

> 250mm/72h

Probability precipitation > 100mm/72h   t+(18-90)

> 100mm/72h

Niederschlag 72h–Summe (mm) : 20 - 23. 08. 2005

Datenstand 2005-09-08

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Probability precipitation > 100mm/72h   t+(18-90)

> 100mm/72h

Niederschlag 72h–Summe (mm) : 20 - 23. 08. 2005

Datenstand 2005–09–08

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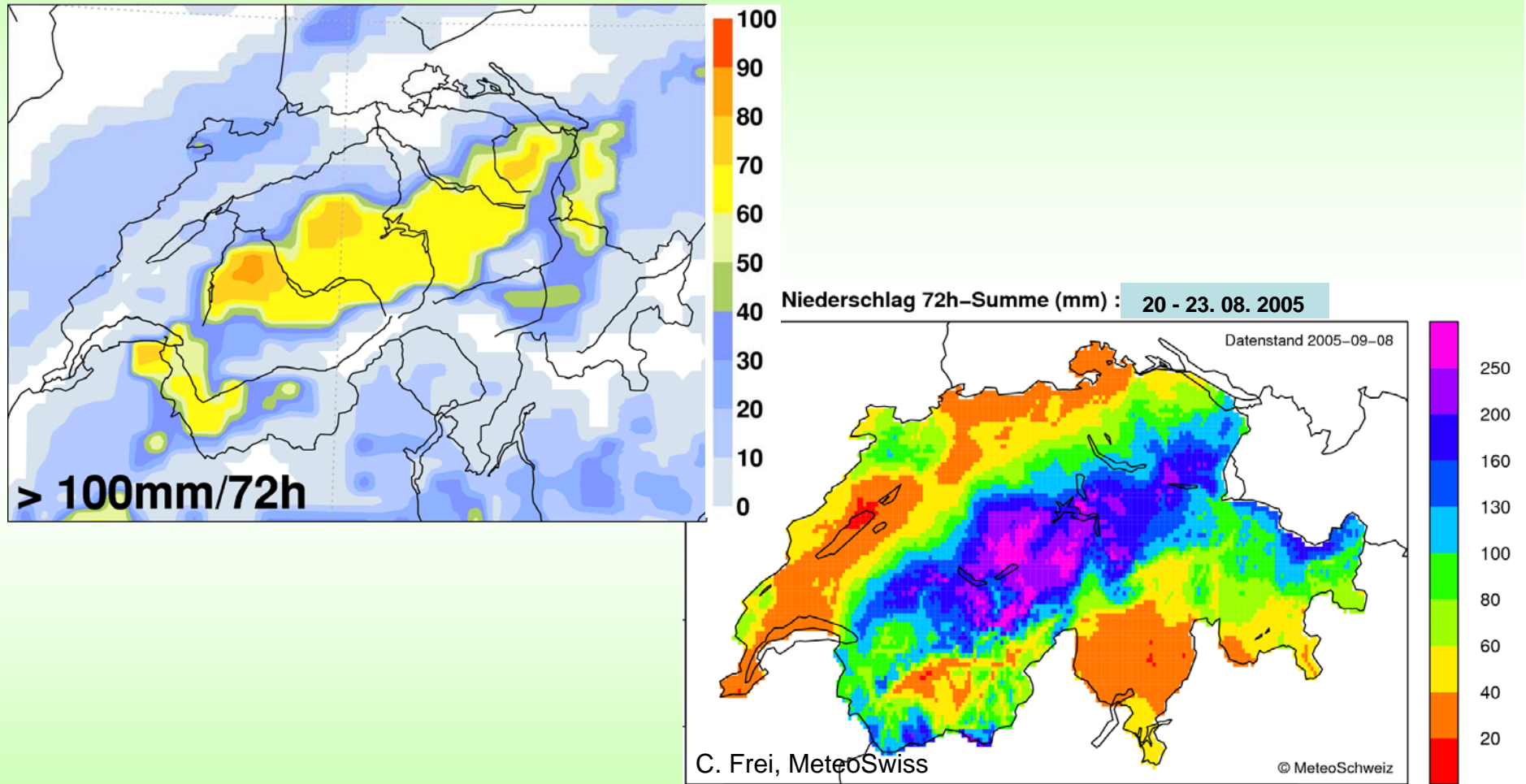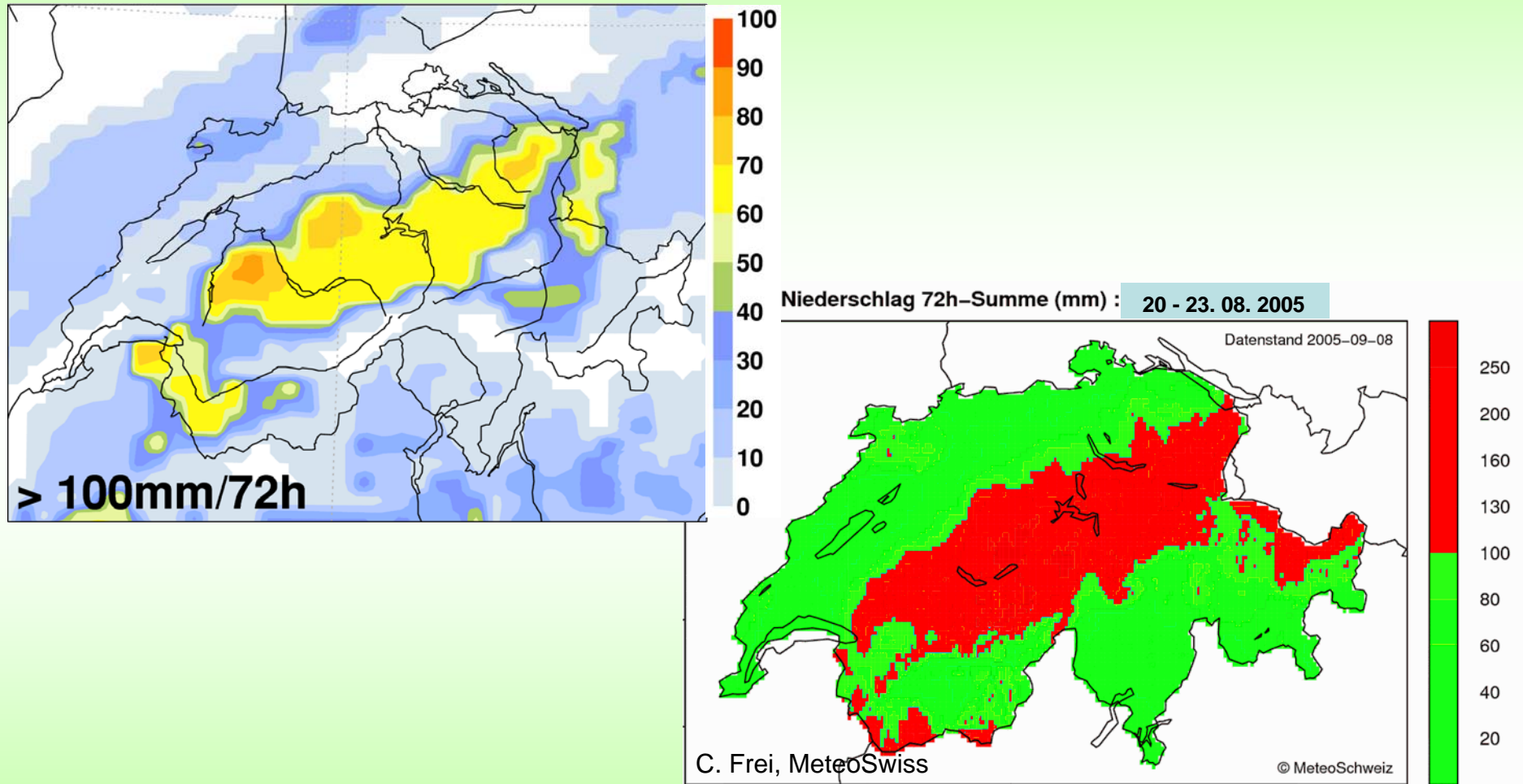
Probability precipitation > 250mm/72h   t+(18-90)

> 250mm/72h

Niederschlag 72h–Summe (mm) : 20 - 23. 08. 2005

Datenstand 2005-09-08

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Synop-Verification: COSMO-LEPS & aLMo

aLMo: - deterministic model (7 km; 45 levels) of MeteoSwiss for 72h forecasts
 - same code (LM) as COSMO-LEPS (10 km; 32 levels)

Common
verification
domain,
about 1000
synop stations

aLMo domain
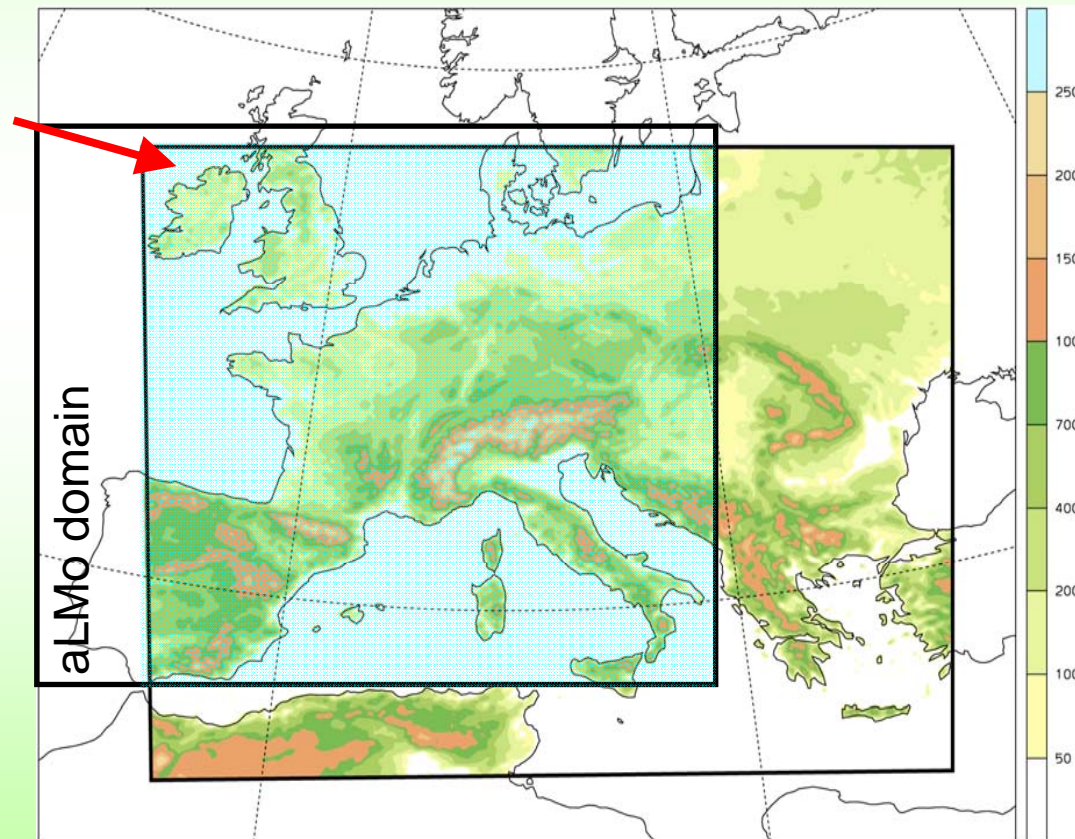
Standard deviation: 2m temperature 00UTC

DJF 2004/2005

Legend: aLMo, CLEPS mean uw, CLEPS mean w

JJA 2005

Legend: aLMo, CLEPS mean uw, CLEPS mean w
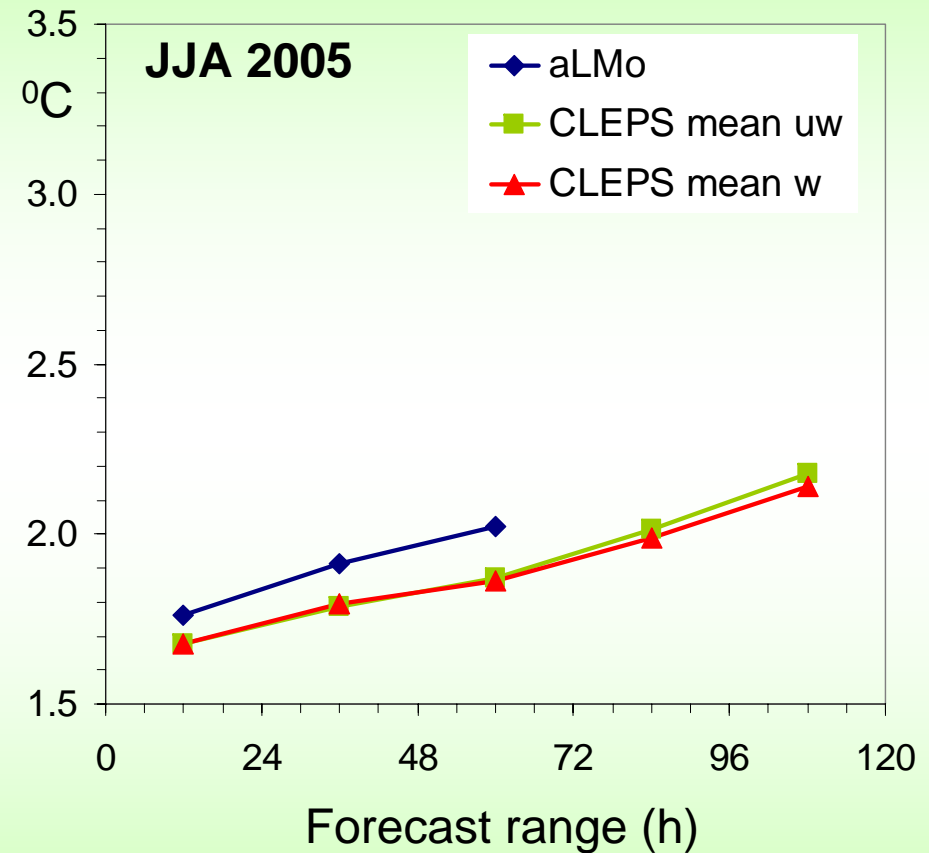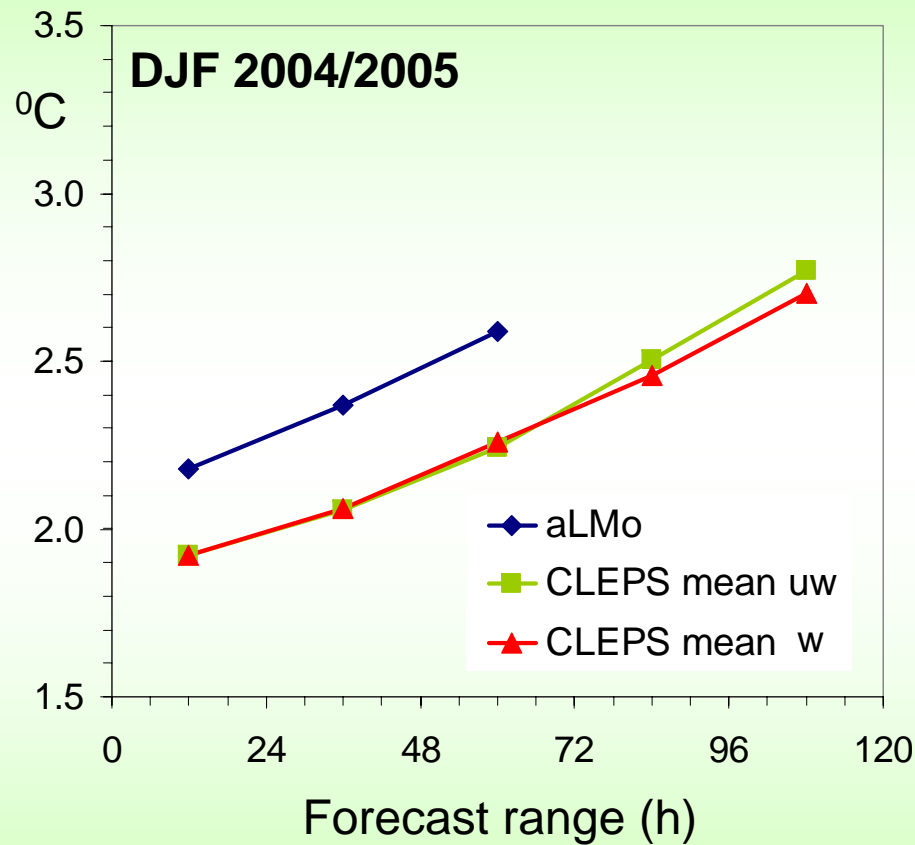
$$STD^2 = RMS^2 - BIAS^2$$

uw: unweighted / w: weighted according to cluster population

COSMO–LEPS verification (SON 2004)

Verification grid

COSMO-LEPS (10 km) vs EPS (80 km)

over 4500 stations

box included in scores if at least 10 obs fall in the box
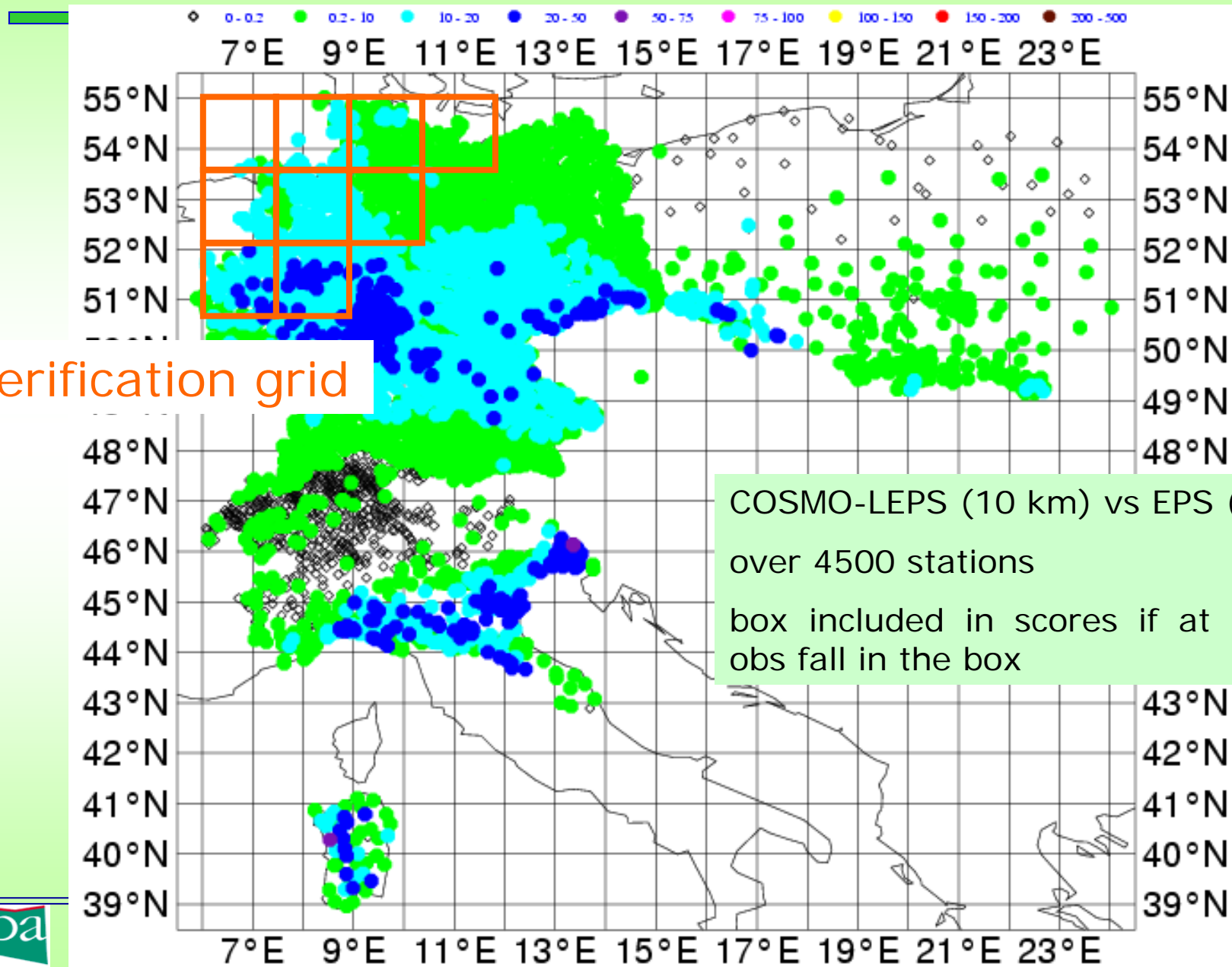
Verification of the distributions

The verification has been performed in terms of:

- **Average value**

- **Maximum value**

- 50th percentile (Median)

- 90th percentile

in a box

+ Station observation

● Grid point forecast
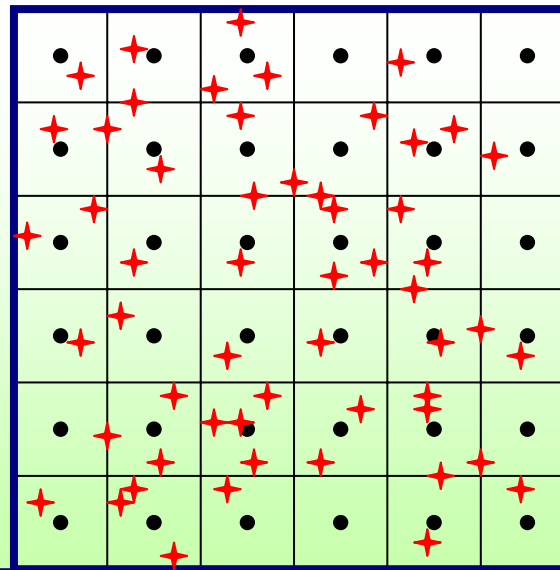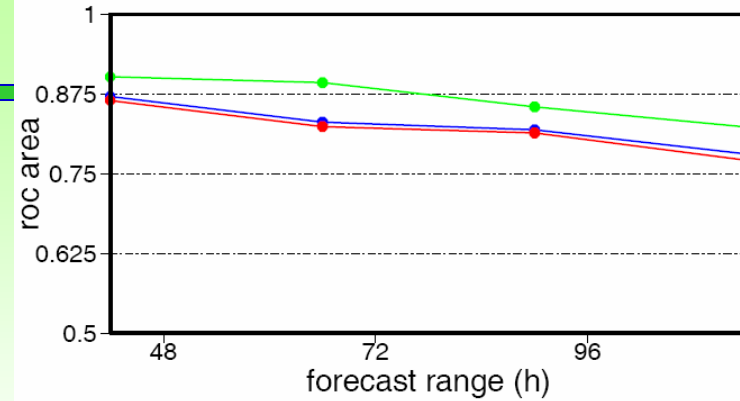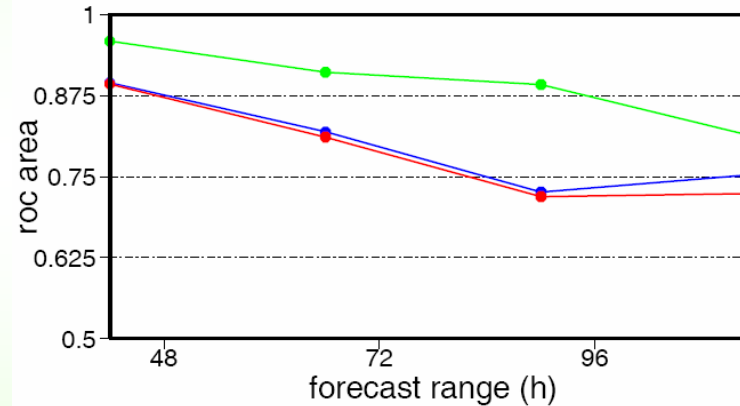
Average values
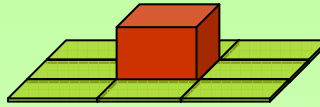
boxes 1.5x1.5 deg
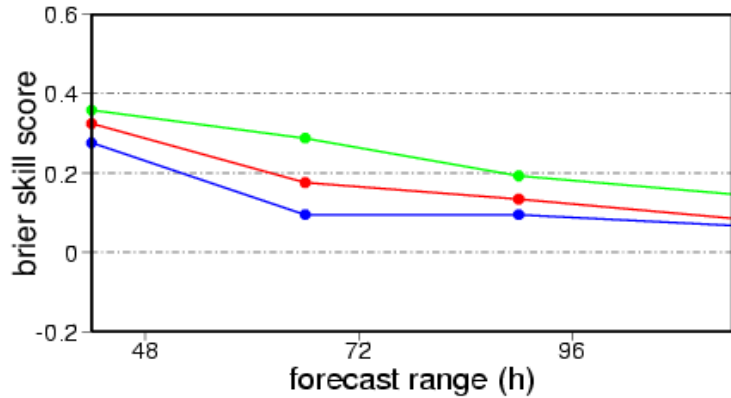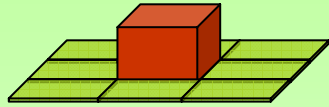
tp > 10mm/24h
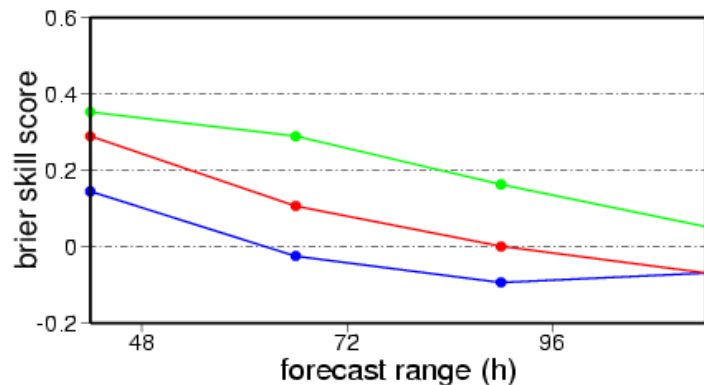
tp > 20mm/24h

tp > 10mm/24h

tp > 20mm/24h

➢ As regards AVERAGE precipitation above these two thresholds, EPS is the best.

➢ Worsening due to the ensemble reduction.

➢ Not clear positive impact of LM downscaling.
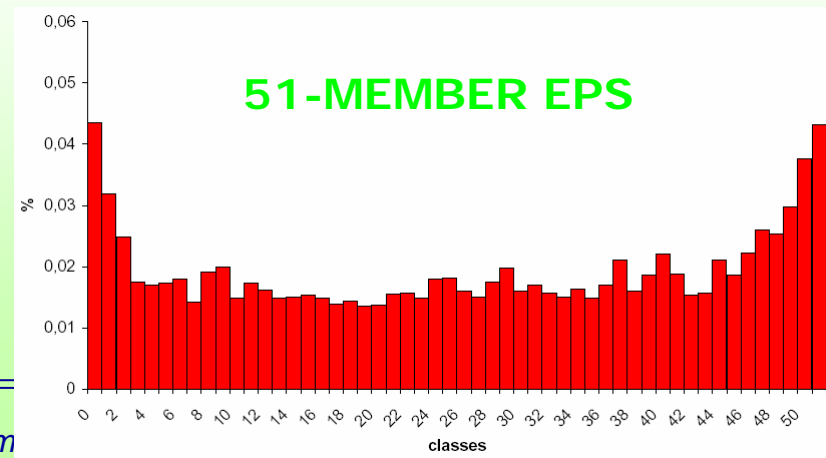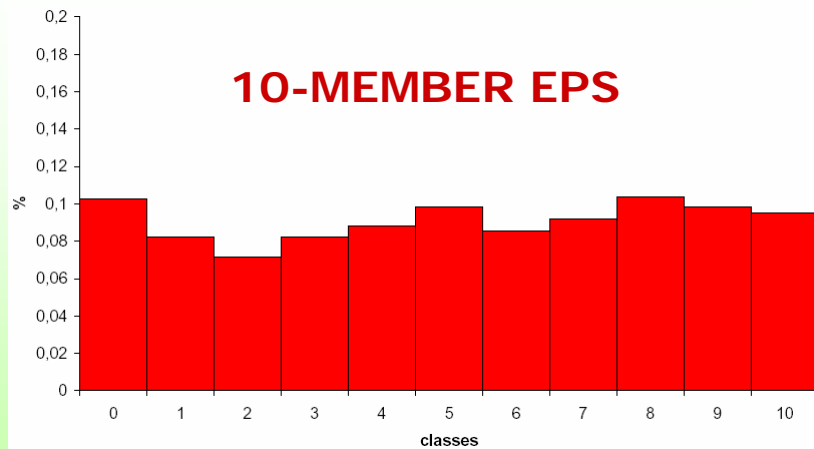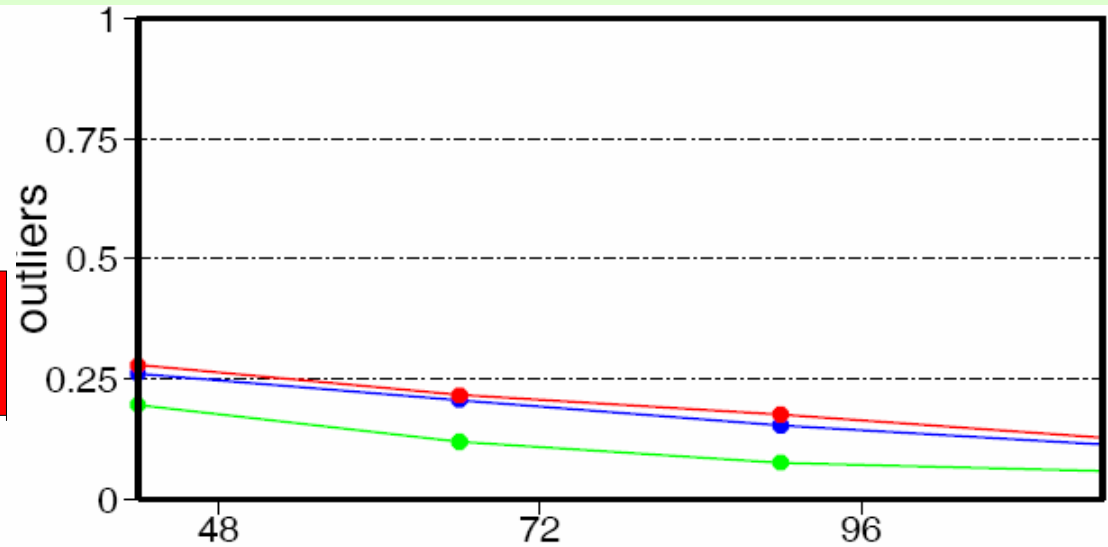
COSMO-LEPS ——————

10-MEMBER EPS ——————

51-MEMBER EPS ——————

Average values

COSMO-LEPS ————

10-MEMBER EPS ————

51-MEMBER EPS ————

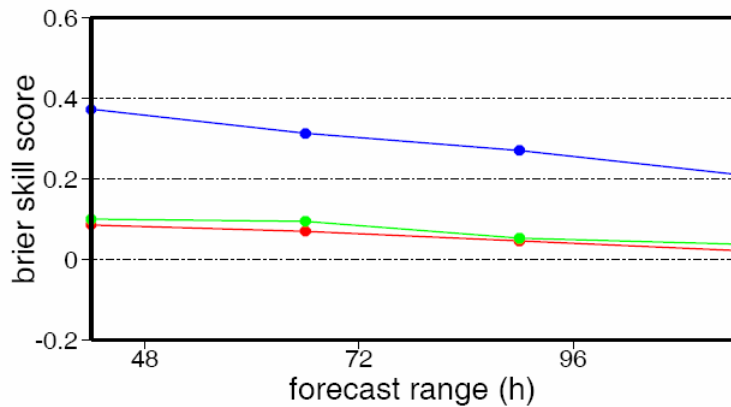## boxes 1.5x1.5 deg

Talagrand diagram (fc+90h)
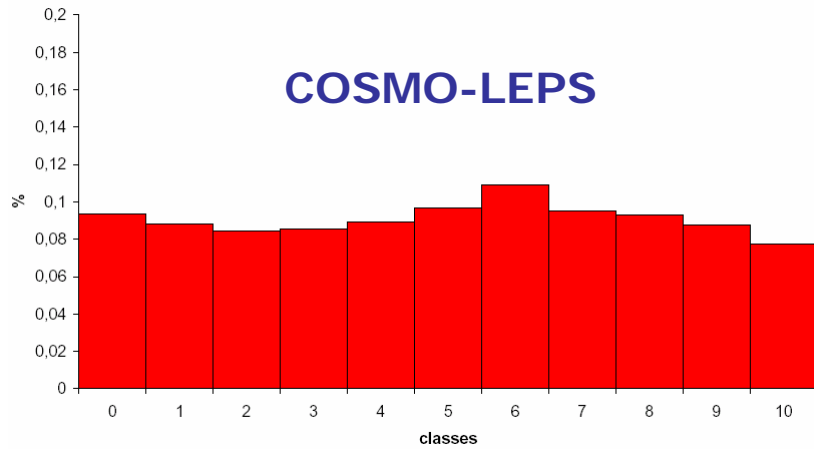
Maximum values
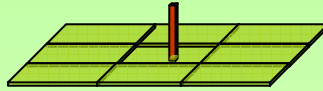
boxes 1.5x1.5 deg

tp > 10mm/24h
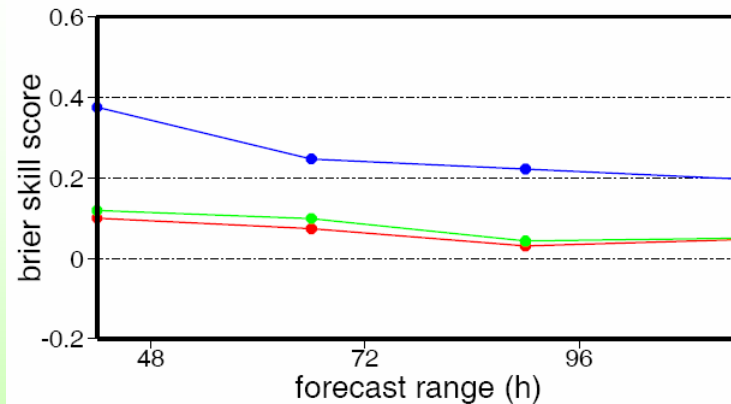
tp > 20mm/24h

tp > 10mm/24h
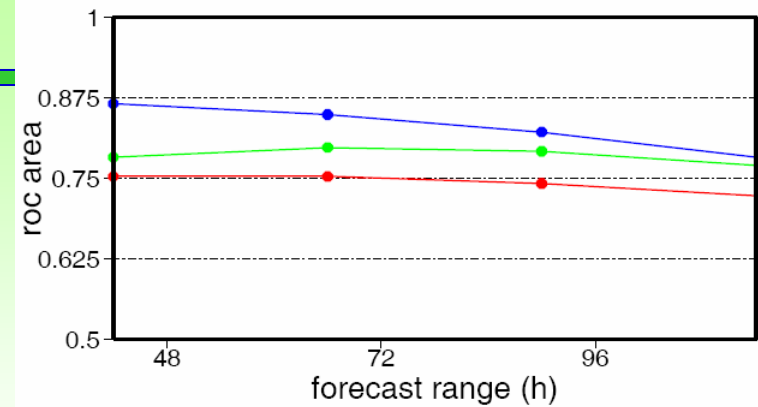
tp > 20mm/24h
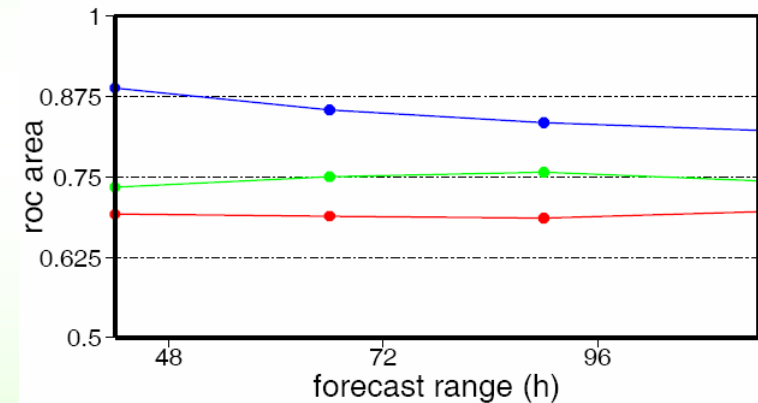
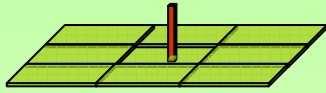**COSMO-LEPS** ——————

10-MEMBER EPS ——————

51-MEMBER EPS ——————

➢COSMO-LEPS is more skilful in forecasting correctly high precipitation values over a rather large area.

➢ **Few occurrences**: about 300 and 80 events for the 10 and 20 mm thresholds, respectively.

Maximum values
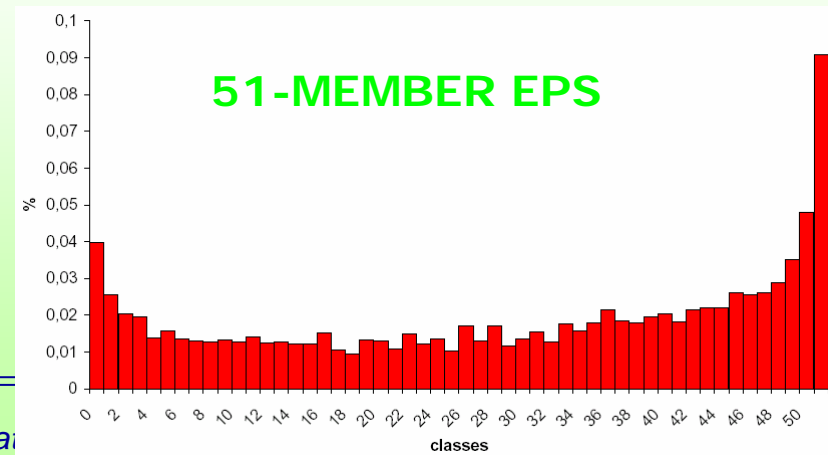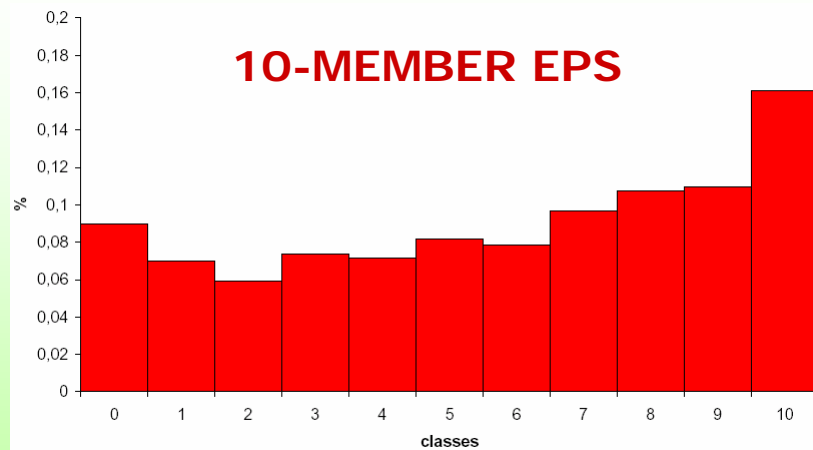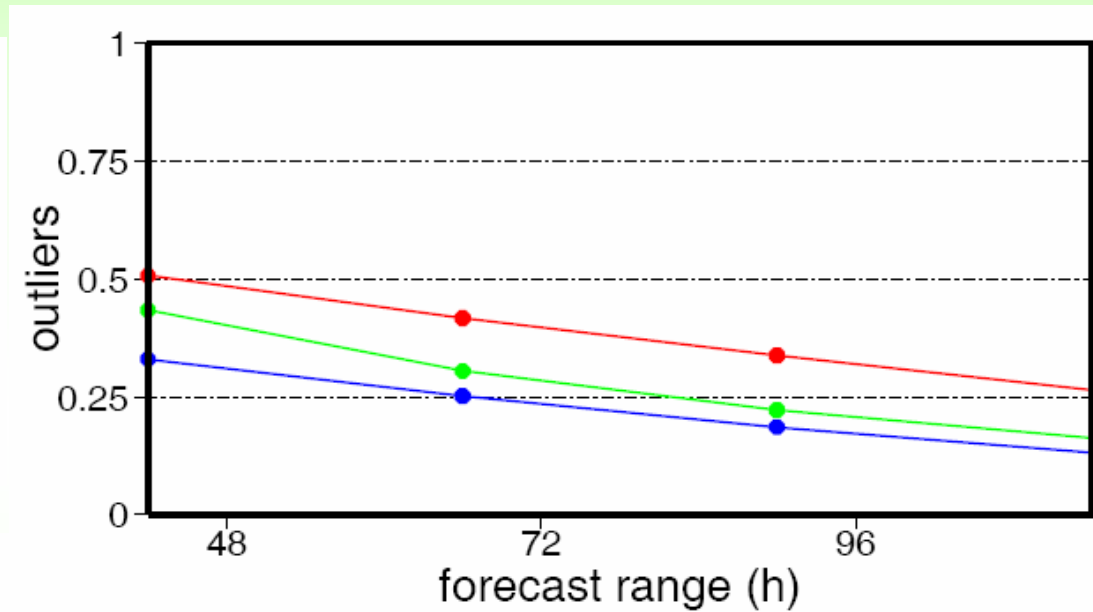
boxes 1.5x1.5 deg
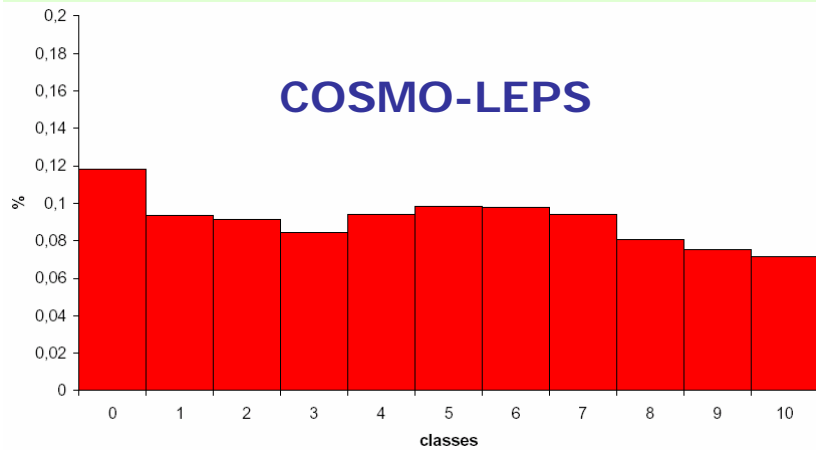
COSMO-LEPS ————

10-MEMBER EPS ————

51-MEMBER EPS ————

Talagrand diagram (fc+90h)

Summary

- Experimental-operational suite running at ECMWF since November 2002 over Central and Southern Europe (5 failures in more than 3 years of activity).

- Products delivered on a daily basis to National and Regional Weather centres (delivery time: ~ 22UTC).

- COSMO-LEPS forecasts for the flood cases of August 2005 provides warnings for extreme events.

- COSMO-LEPS ensemble mean for 2m temperature has better skill (lower standard deviation to observations) with weighting the ensemble members according to cluster populations compared to the mean with unweighted members.

- Positive impact of COSMO-LEPS with respect to EPS in forecasting precipitation maxima.

Future plans

- **COSMO-LEPS suite is becoming a "time-critical" application monitored by ECMWF:**
  - involvement of ECMWF operators in the handling of the suite;
  - file system dedicated and priority in job scheduling.

- **Back archiving on MARS of past runs (from 5/11/2002 onwards).**

- **Modify the operational configuration to "contrast" EPS upgrade:**
  - EPS will be soon upgraded to $T_L399L62$ with 56 model levels between 40 hPa (approximate top-level height of LM) and the surface;
  - EPS will have HIGHER vertical resolution than COSMO-LEPS; is this a problem???
  - increase the COSMO-LEPS **vertical resolution to 40 layers**;
  - increase COSMO-LEPS **ensemble size to 16 members** (how?).

- **Think about "dressing" COSMO-LEPS forecasts.**

- **Develop EFI index.**

- **Study CAREFULLY the outcome of the Alpine suite.**

Thank you !