COSMO-LEPS: a Limited-area Ensemble Prediction System

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THE LEPS APPROACH

The main purpose of the LEPS project is to introduce a probabilistic guidance to identify the possible occurrence of severe weather conditions in the time range

"late-short-range (>48h) - early-medium-range (120h)".

THE LEPS APPROACH

LEPS is designed to join

the ability of a global-ensemble prediction system to generate a satisfying set of larger scale evolution scenarios (through a good sampling of initial conditions phase-space)

with

the capability of LAM of detailing atmospheric phenomena on local scales, particularly in regions with complex orography

THE LEPS APPROACH

LAM is nested in only a limited number of members selected from global EPS

"Some" of the information from global EPS is lost

BUT

feasibility on an operational basis is gained

COSMO (COnsortium for Small-scale MOdelling)

Born in October 1998 and constituted by the national meteorological services of Germany **(DWD)**, Switzerland **(MeteoSchweiz)**, Italy **(UGM)**, Greece **(HNMS)** and Poland **(IMGW)**, the hydro-meteorological service of Emilia Romagna **ARPA-SIM** and the German Military Meteorological Service **AWGeophys**.

It aims at the development, improve and maintain the non-hydrostatic limited-area model **Lokal Modell**

www.cosmo-model.org

COSMO-LEPS

The computer resources needed by the COSMO-LEPS system (about 3250 BU per day) are provided by the ECWMF COSMO partners (Germany, Greece, Italy and Switzerland), whose contributions are joined into a unique "COSMO account".

The suite is run and maintained remotely by ARPA-SIM and the assistance and support from ECMWF is acknowledged.

Methodology

Super ensemble:
3 global ensembles EPS starting at different times (12 h lag)

Hierarchical Cluster Analysis
method: Complete Linkage
area (N/S/W/E): 60/30/-10/30
fields: Z,U,V,Q at 3 levels (500,700,850 hPa)
number of clusters: fixed to 5

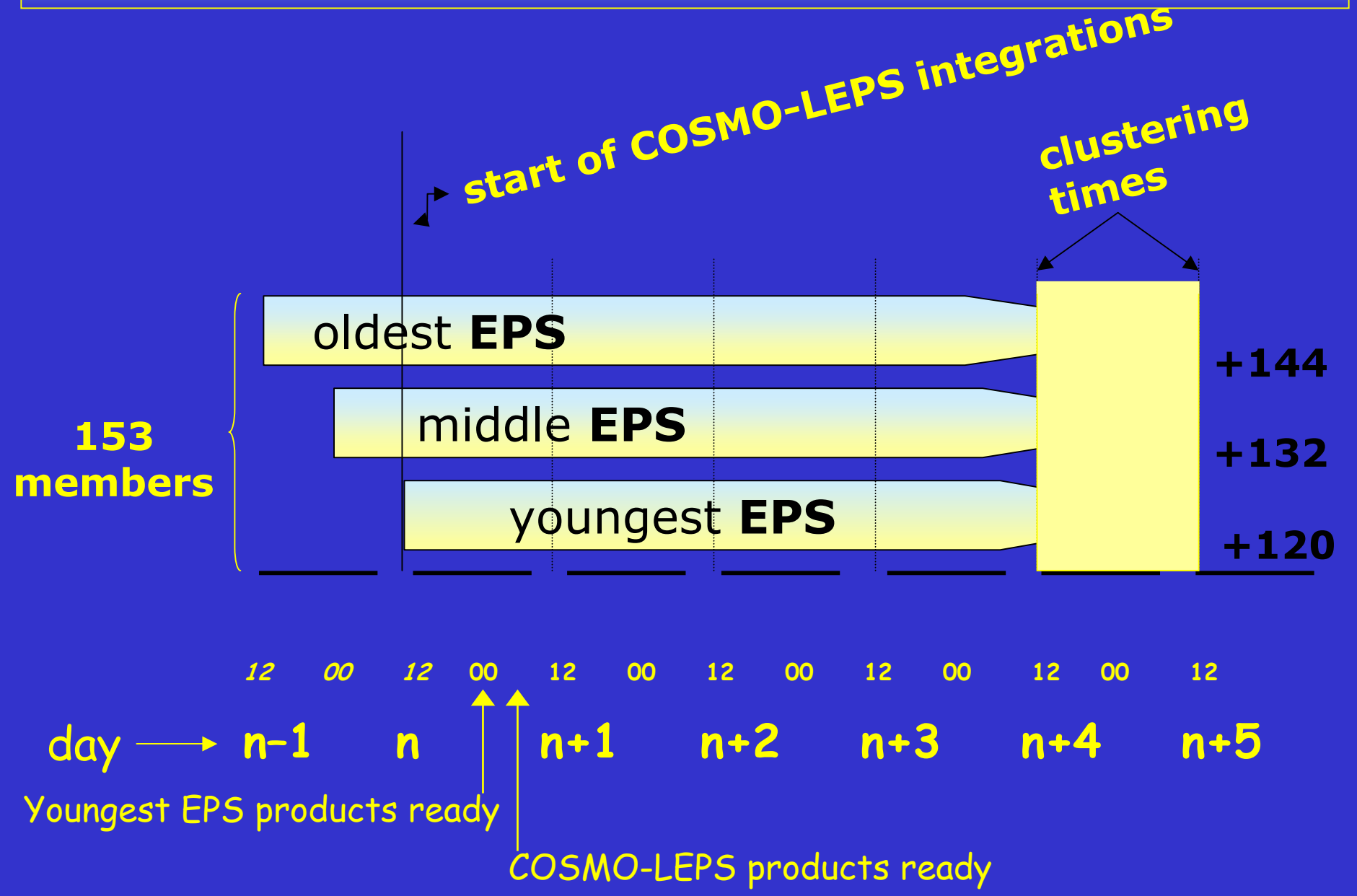
5 clusters

Representative Member Selection
- one per cluster
- the element closest (3D fields) to the members of its own cluster AND most distant from the other clusters' members

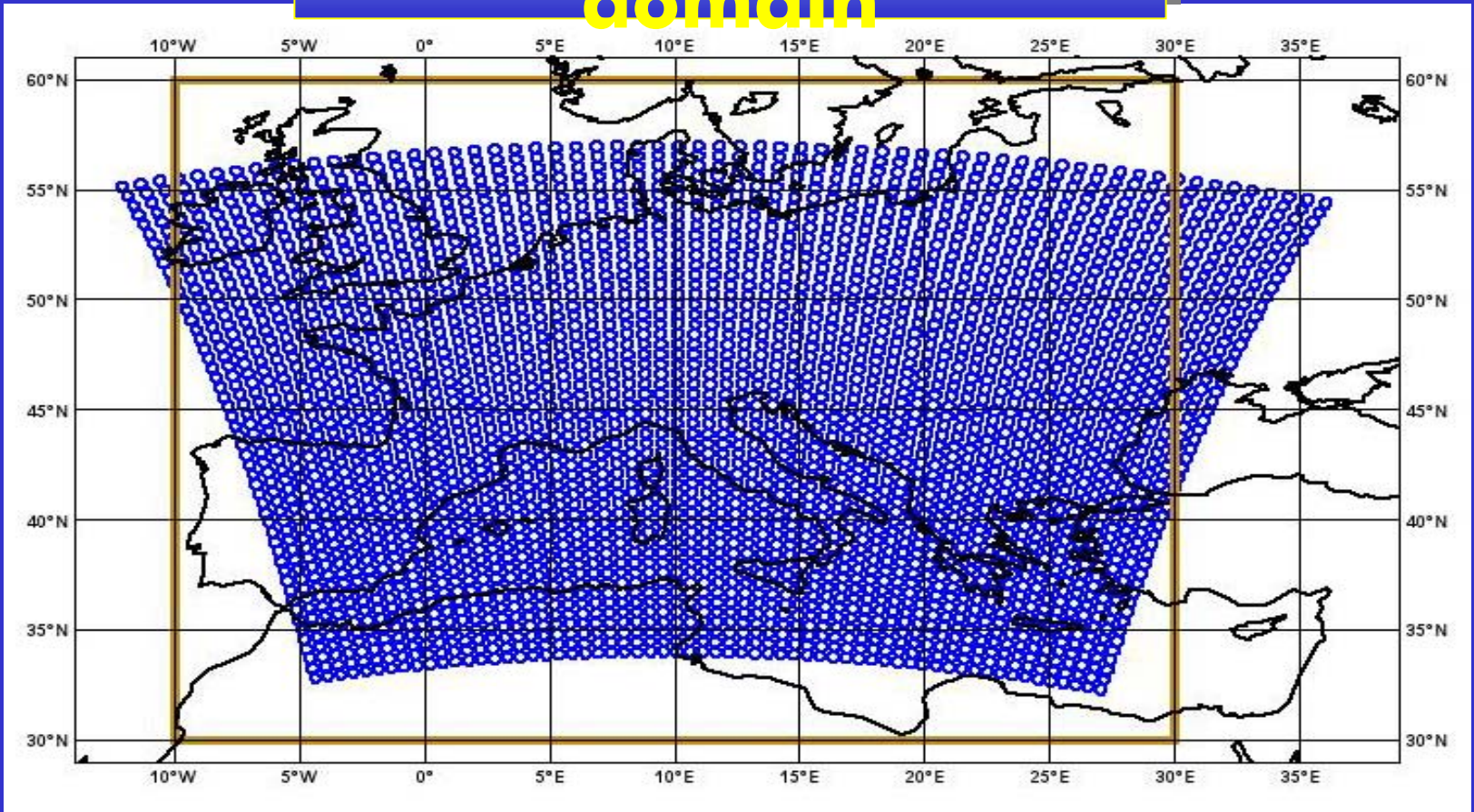
5 representative members (RMs)

5 LM integrations nested on 5 RMs:
COSMO-LEPS - Limited-area (High Resolution) Ensemble Prediction System

COSMO-LEPS suite: the superensemble

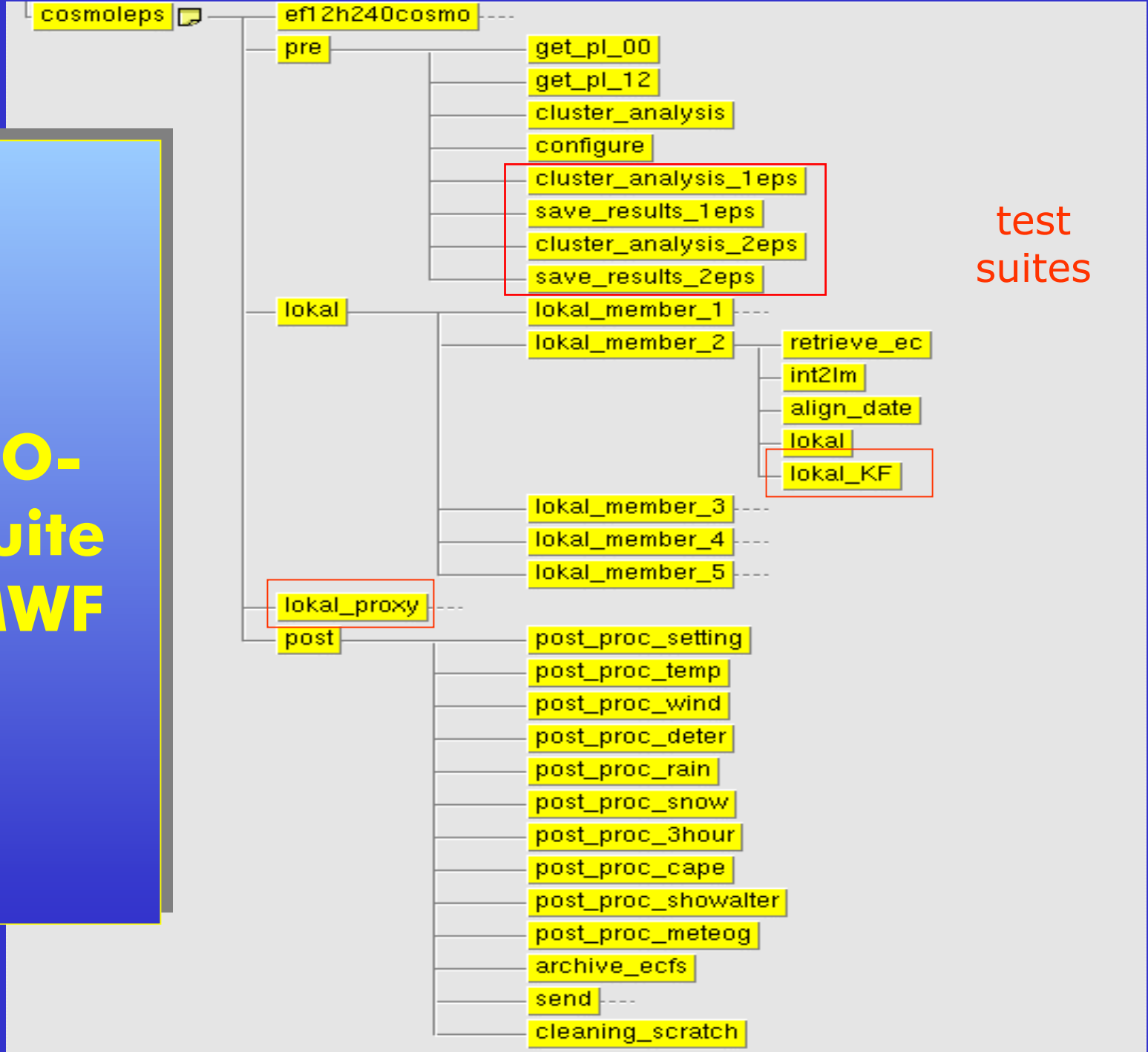


COSMO-LEPS domain



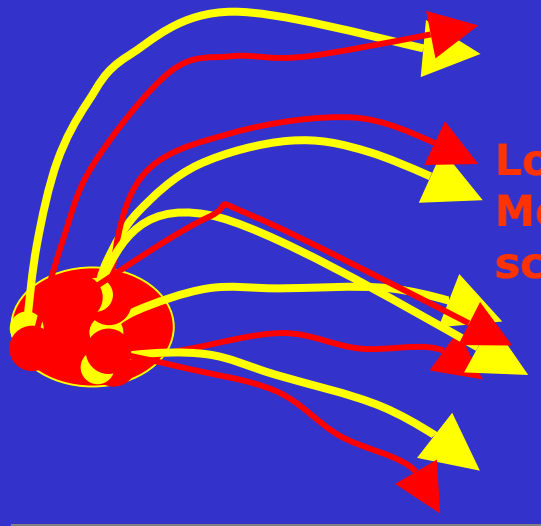
- **hor. res. 10 km (306 x 258 grid points); 32 vert. levels; time-step: 60 sec;**
- **forecast length: 120 h; elapsed time: 52 min (84 tasks of ECMWF IBM);**
- **for each LM run, CPU time = 73 h**

COSMO-LEPS suite at ECMWF



test suites

COSMO-LEPS



Lokal Model scenarios

Transfer to Cosmo Partners and other interested weather services

Deterministic products for each of the 5 LM runs:

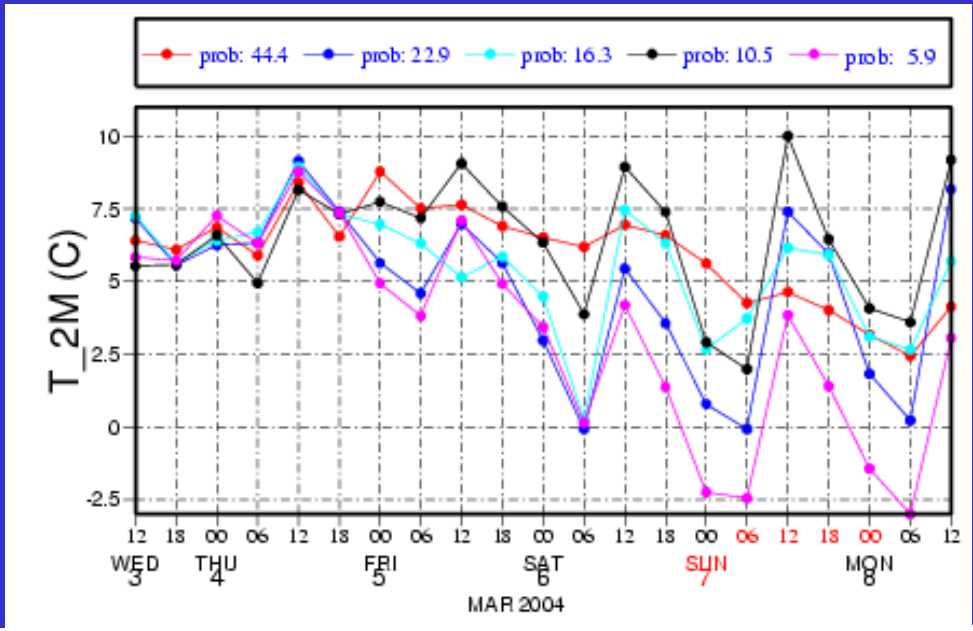
- Precipitation
- Mean Sea level pressure
- 700 hPa Geopotential
- 850 hPa Temperature

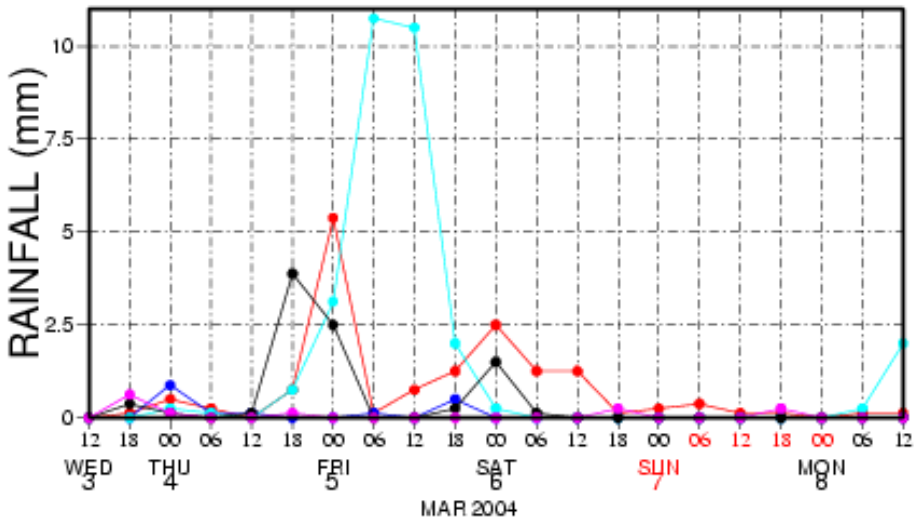
Probability Maps

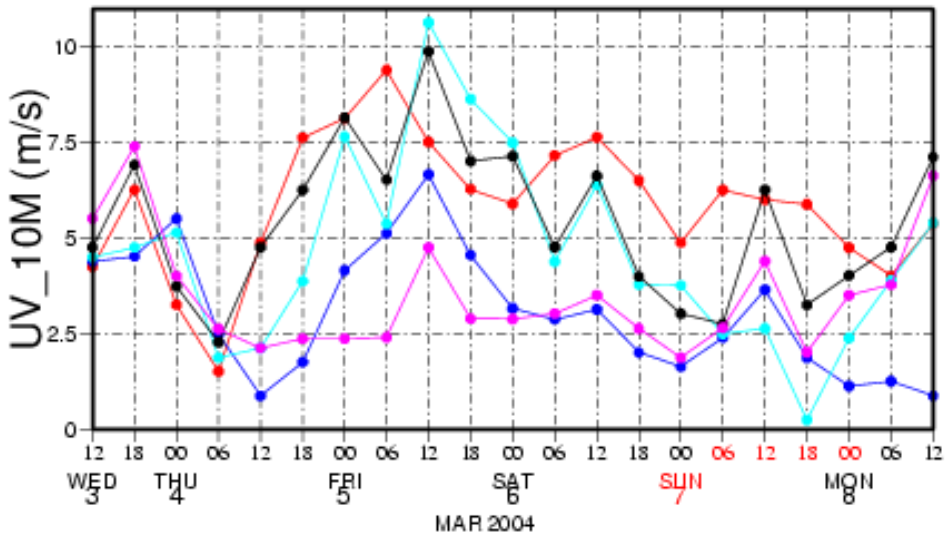
- prob of 24h rainfall exceeding 20,50,100,150 mm
- prob of 72h rainfall exceeding 50,100,150,250 mm
- prob of 24h Tmax exceeding 20,30,35,40 C
- prob of 24h Tmin below 5,0,-5,-10 C
- prob of 24h Vmax exceeding 10,15,20,25 m/s
- prob of 24h snowfall exceeding 1,5,10,20 cm
- prob of max in 24h CAPE exceeding 2000,2500,3000,3500 J/kg
- prob of min in 24h HZEROCL below 300 700 1000 1500 m

Meteograms over station points

Reading: 51.44N 0.94W

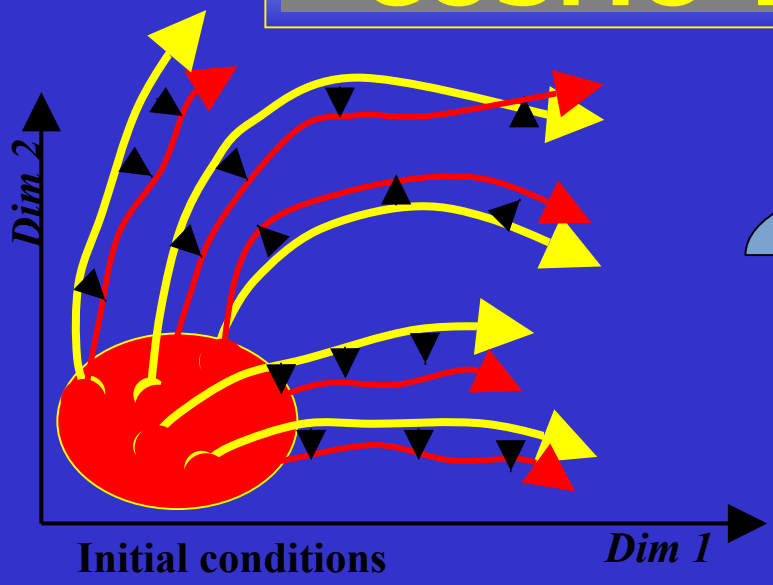


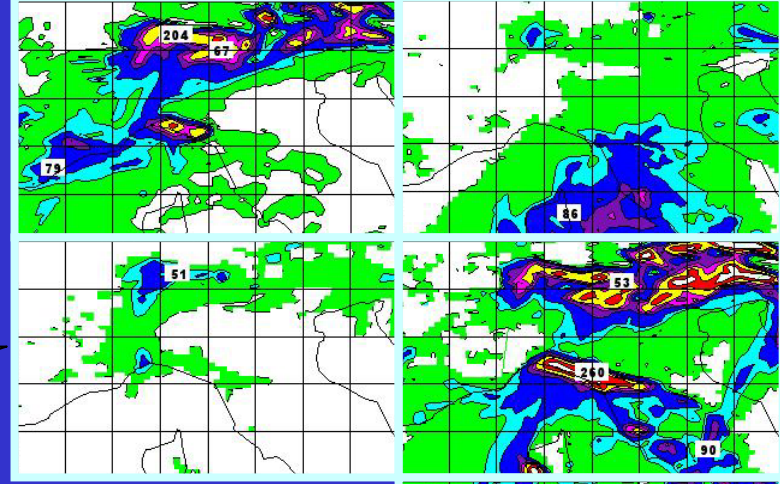




ECMWF
LM

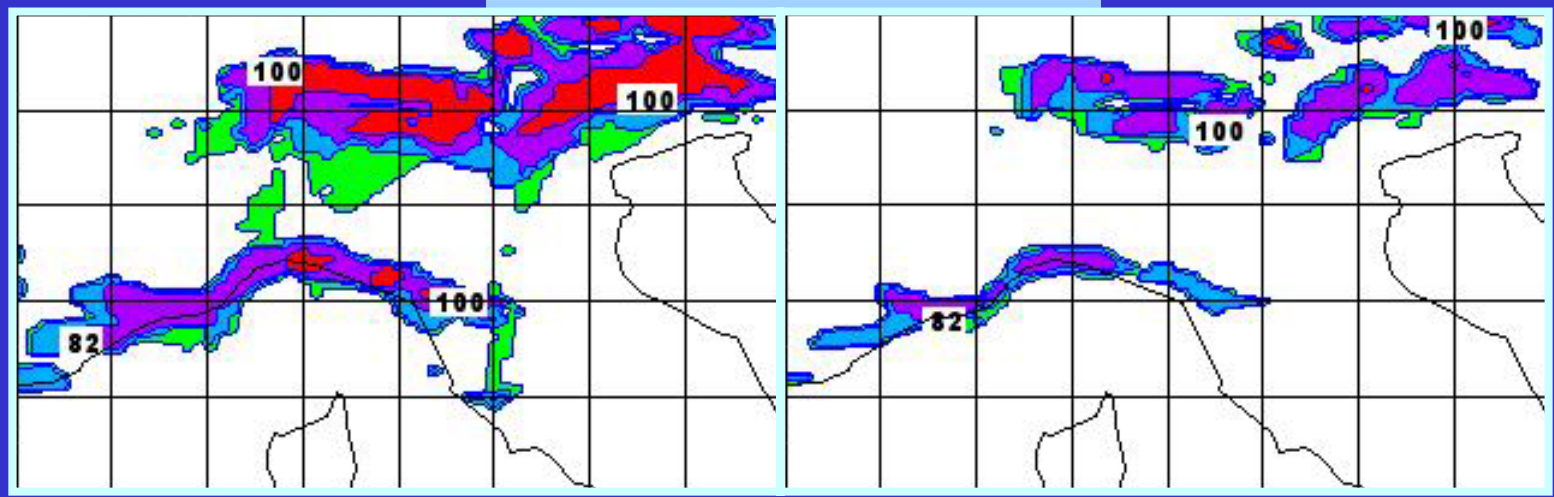
COSMO-LEPS





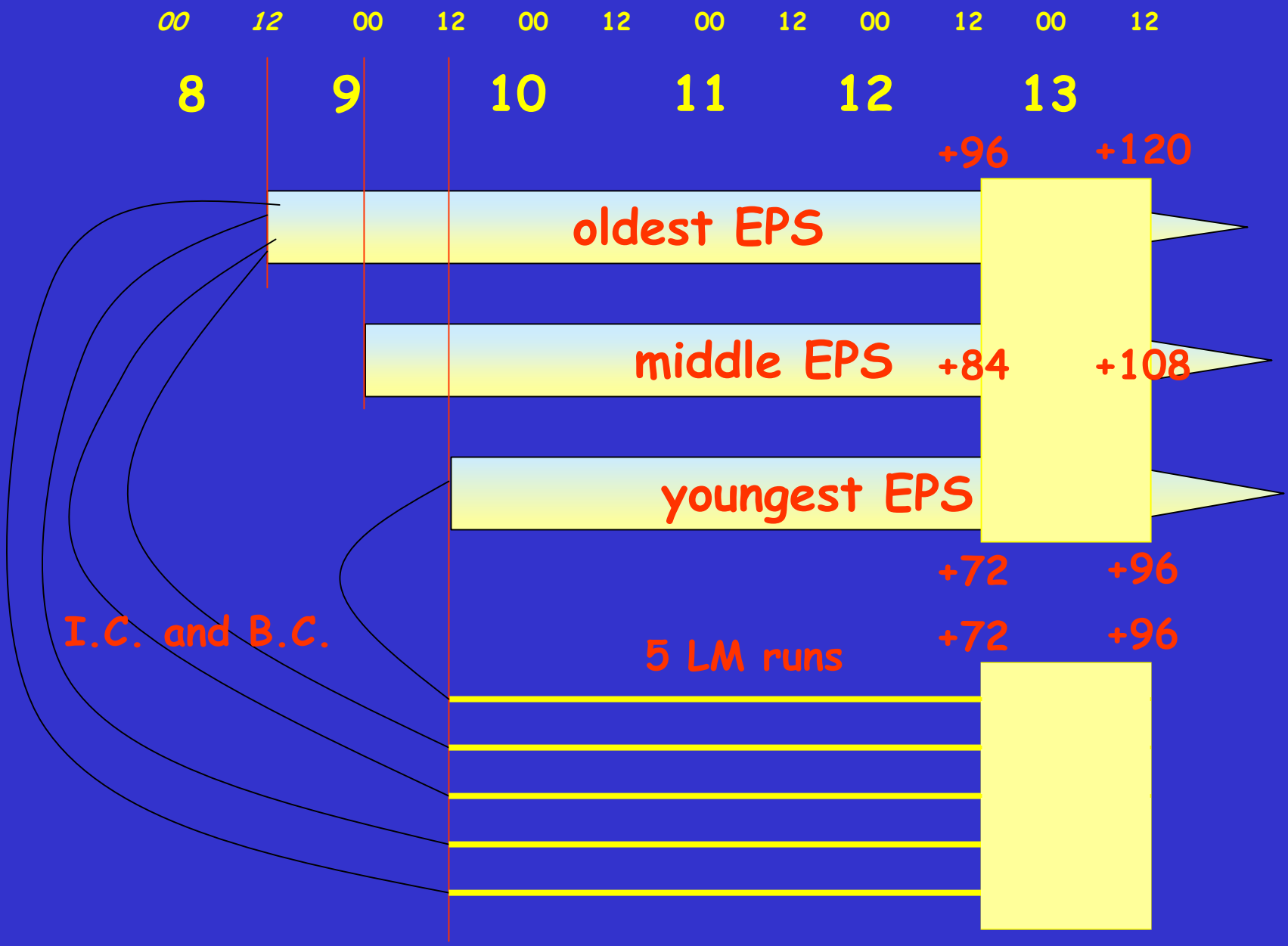
precipitation scenarios

PROBABILITY MAPS

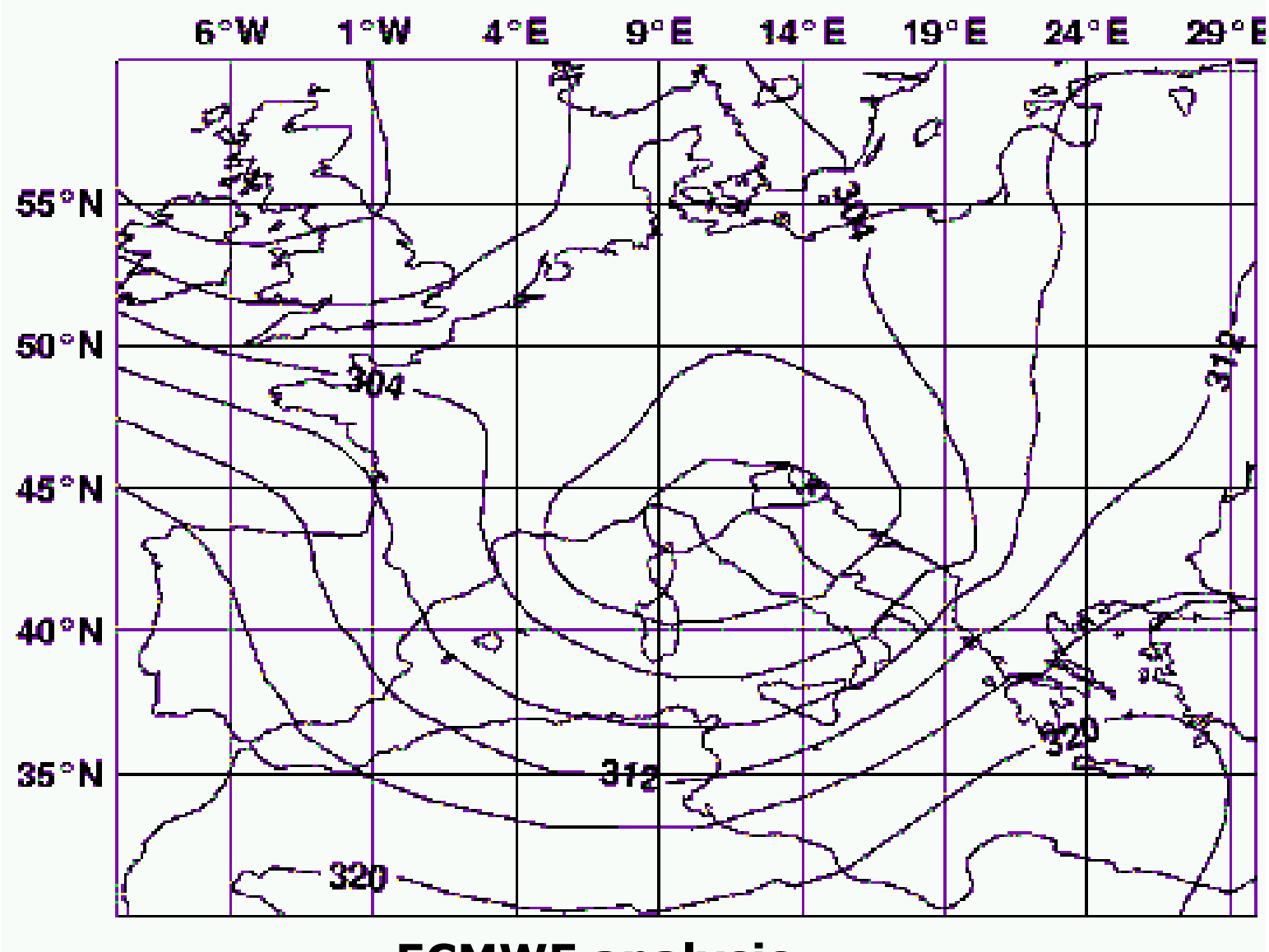


A hindcast case: the Elbe Flood

12-13 August 2002

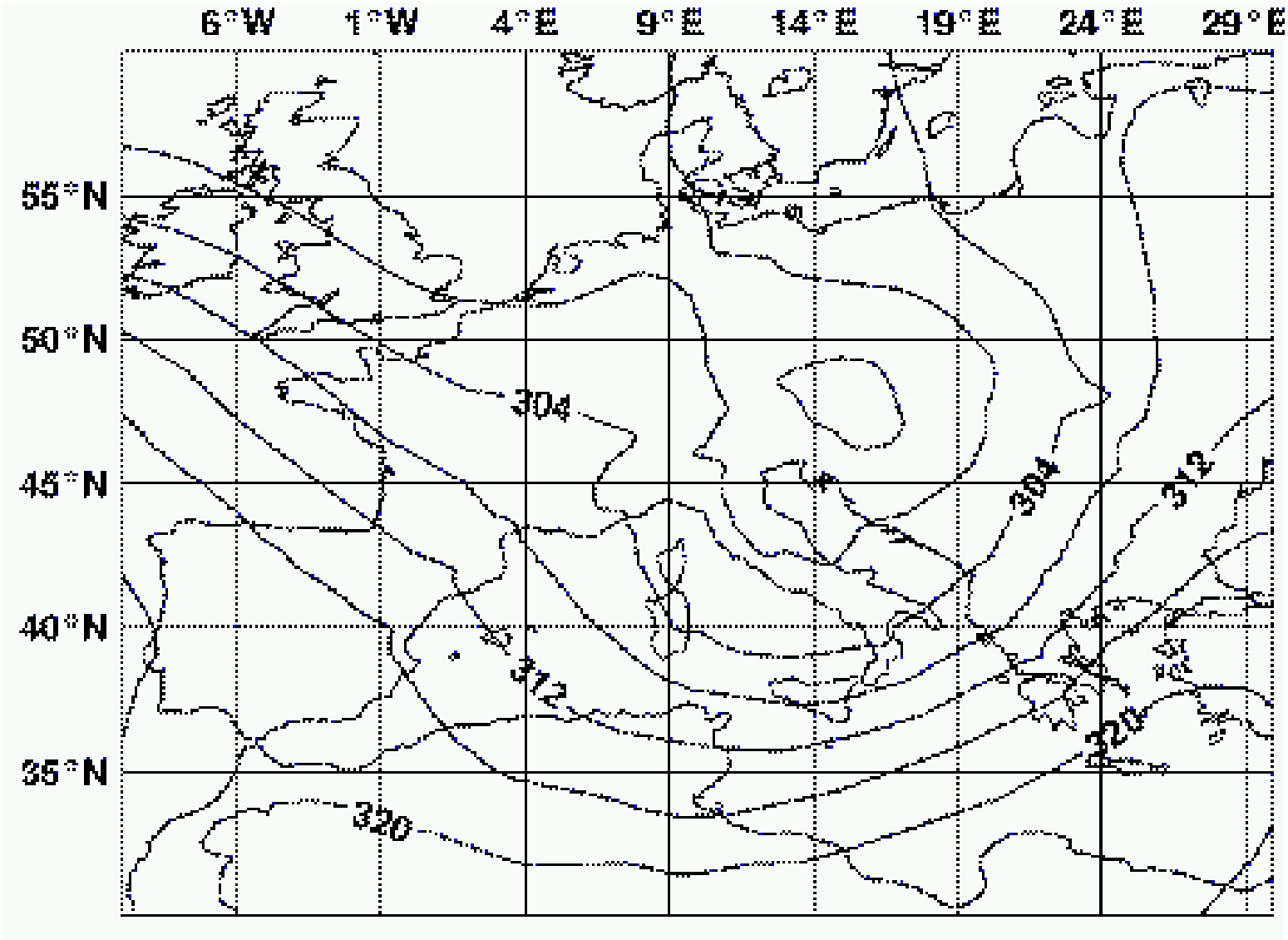

00 12 00 12 00 12 00 12 00 12 00 12
8 9 10 11 12 13
+96 +120
oldest EPS
middle EPS +84 +108
youngest EPS
+72 +96
I.C. and B.C.
+72 +96
5 LM runs

11/08 12UTC



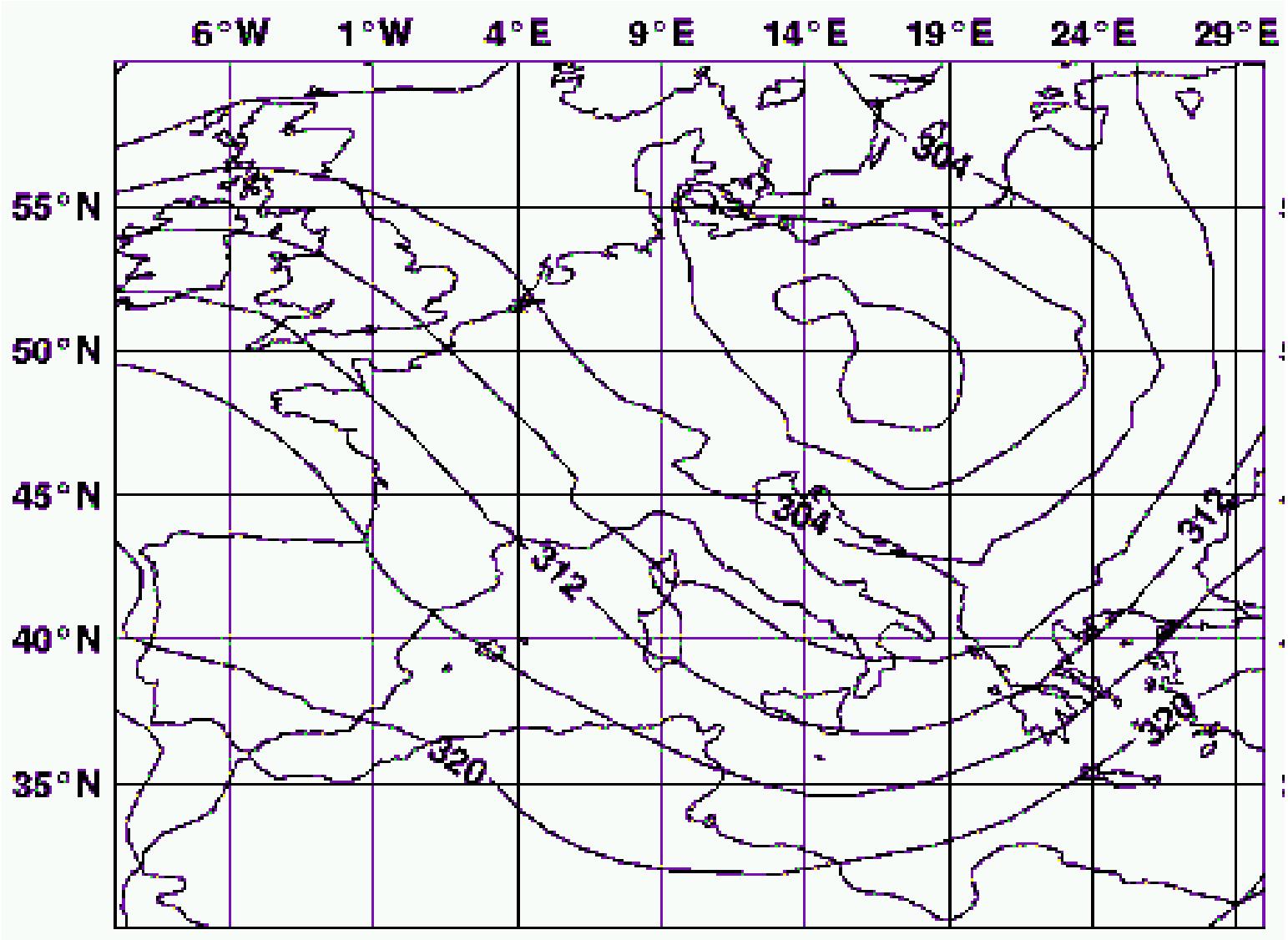
ECMWF analysis

12/08 00UTC



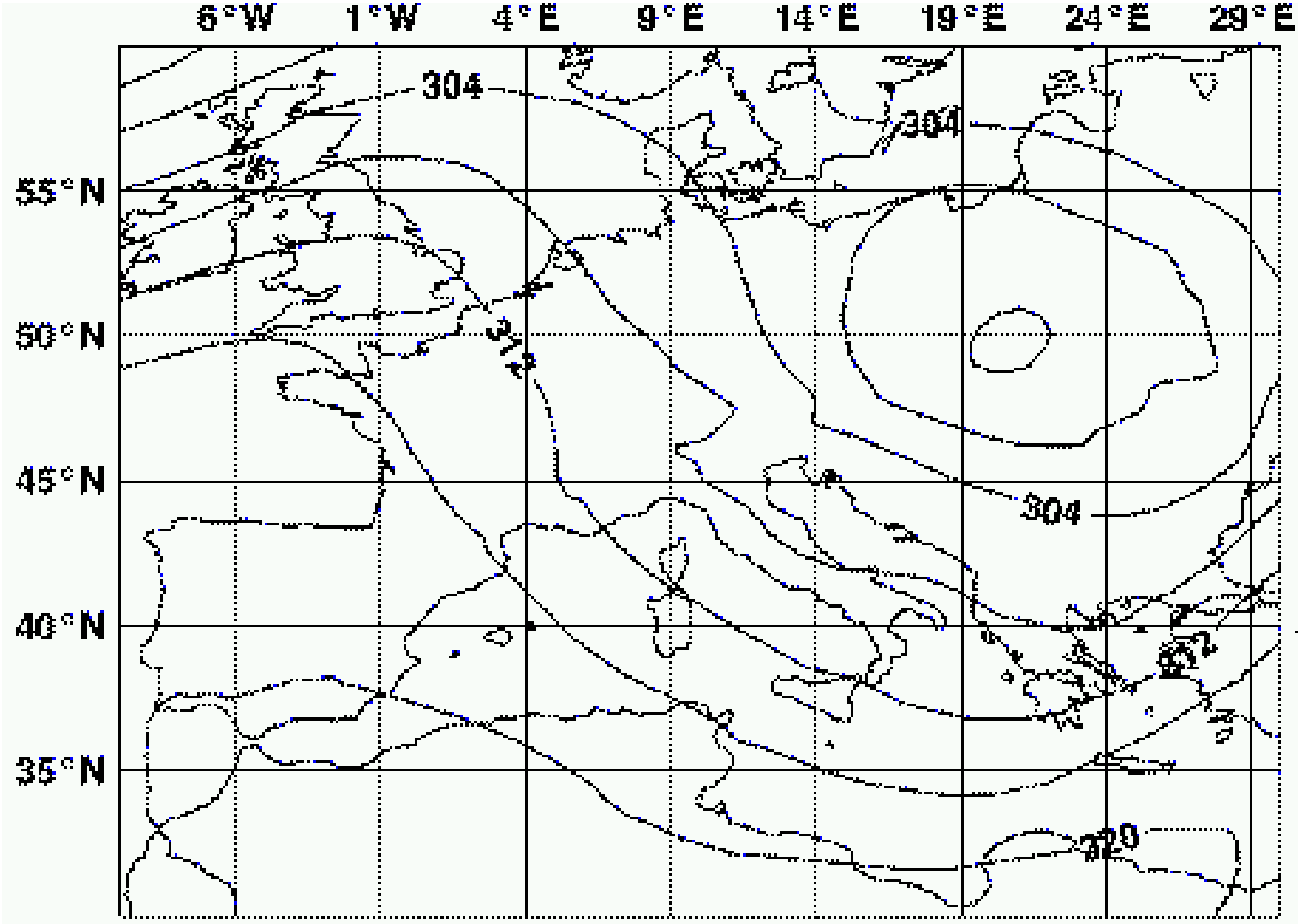
ECMWF analysis

12/08 12UTC



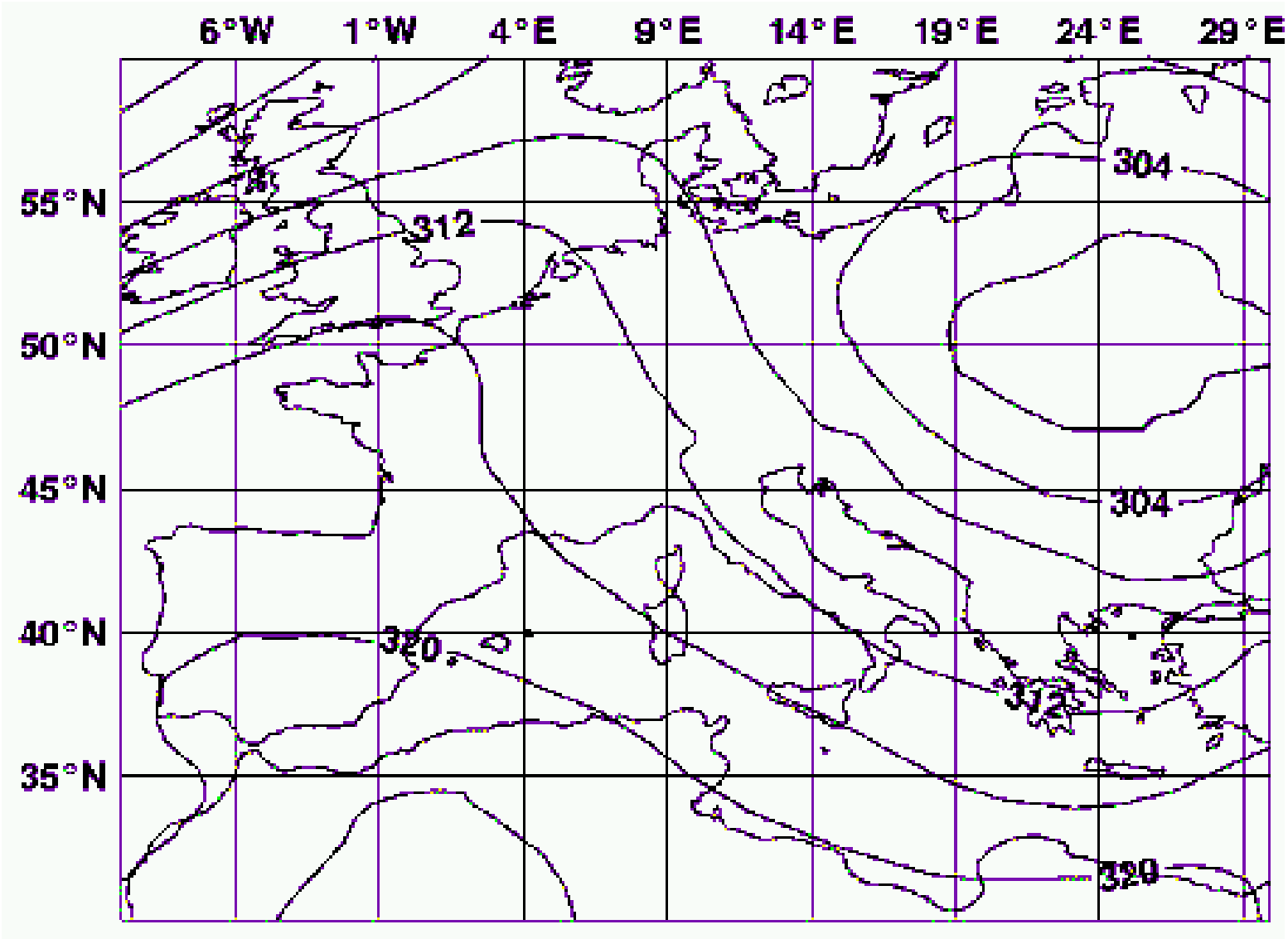
ECMWF analysis

13/08 00UTC



ECMWF analysis

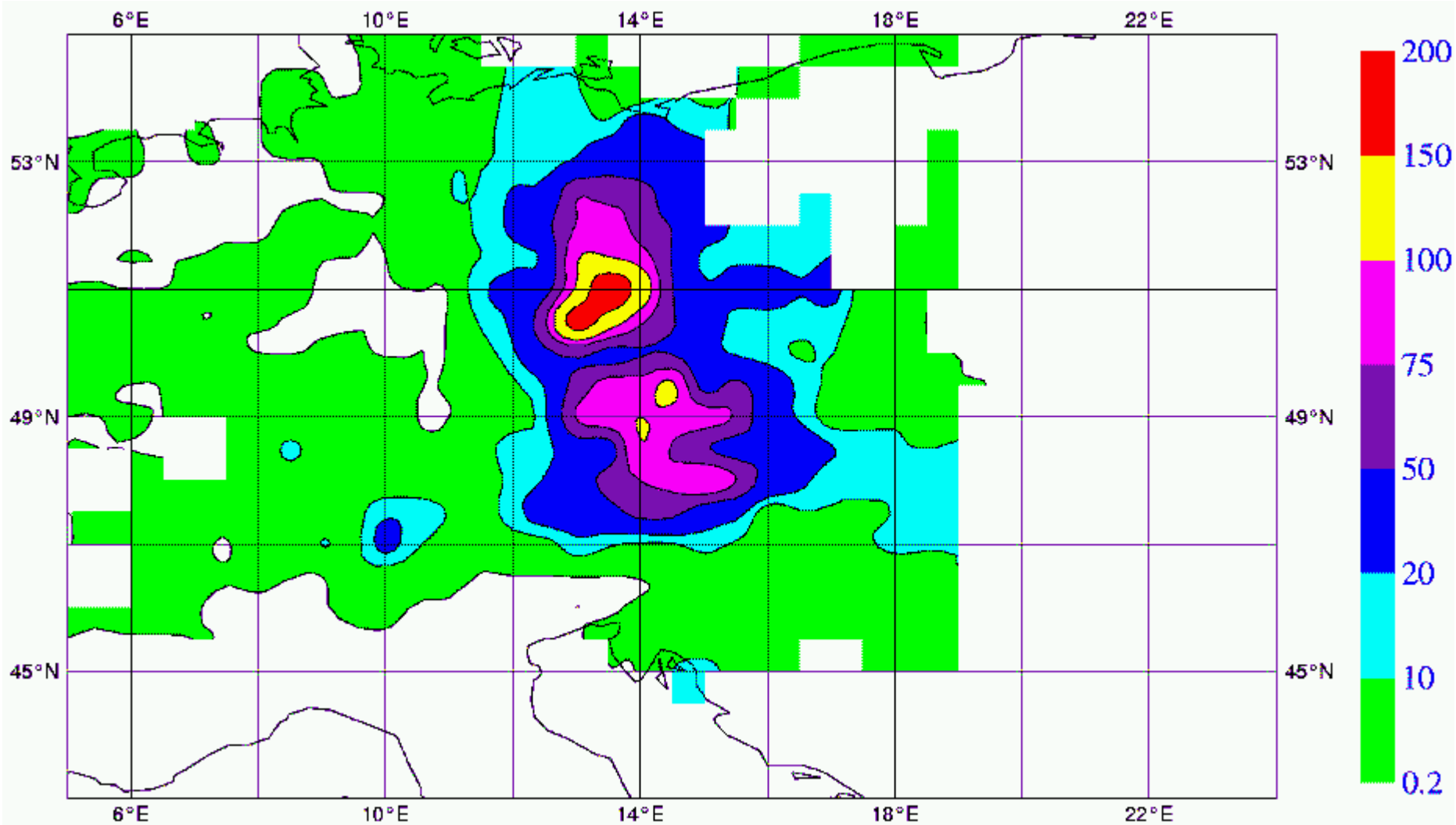
13/08 12UTC



ECMWF analysis

Observed precipitation

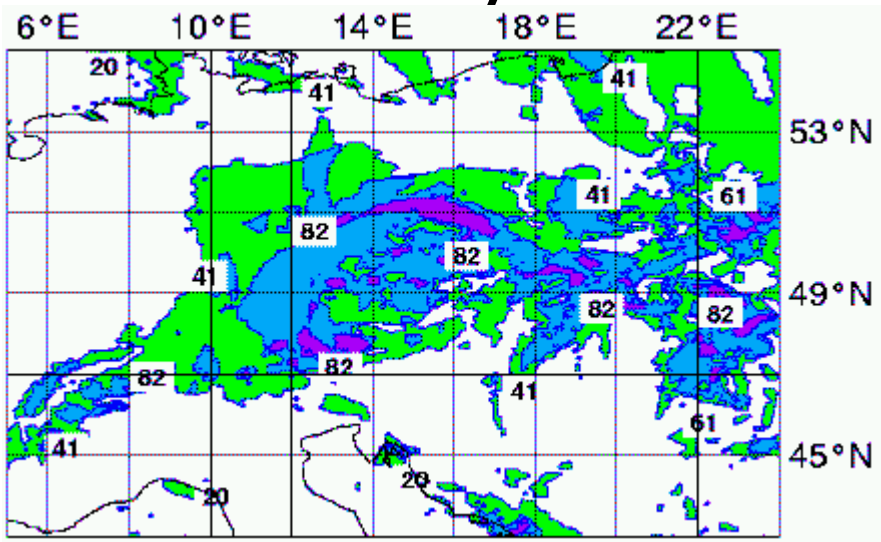
12/08 06UTC - 13/08 06 UTC



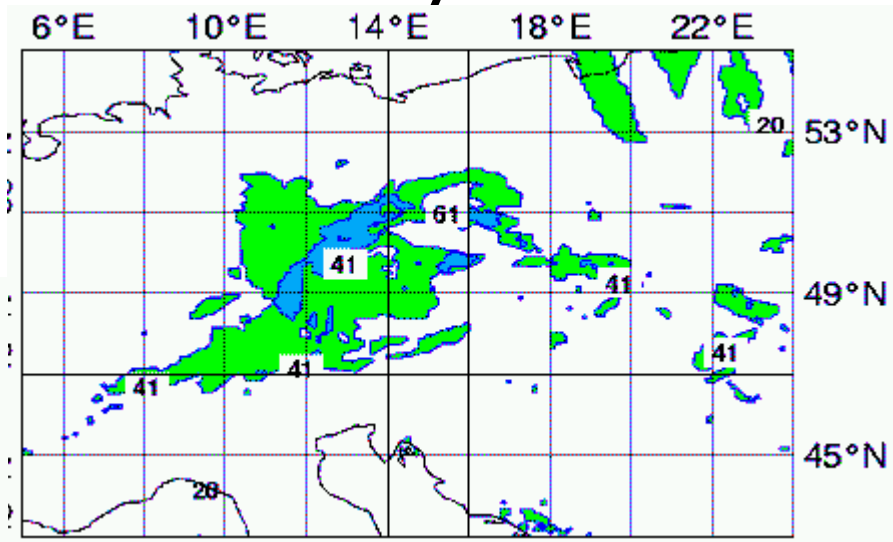
Courtesy of Ulrich Damrath

COSMO-LEPS probability of precipitation +4 days

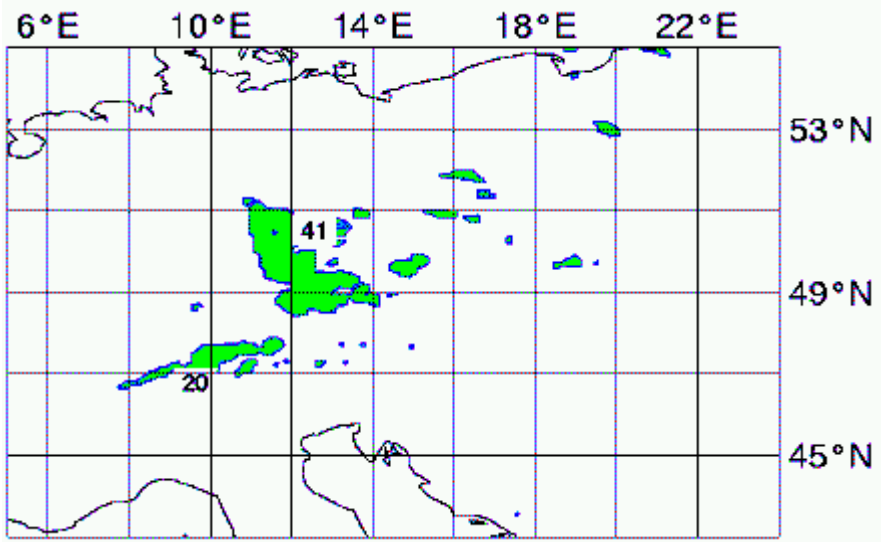
> 20mm/24h



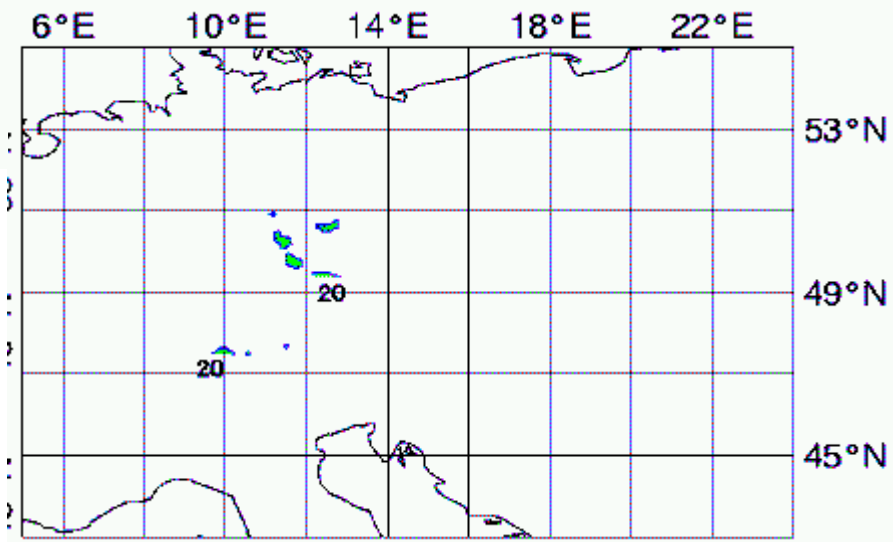
> 50mm/24h



> 100mm/24h



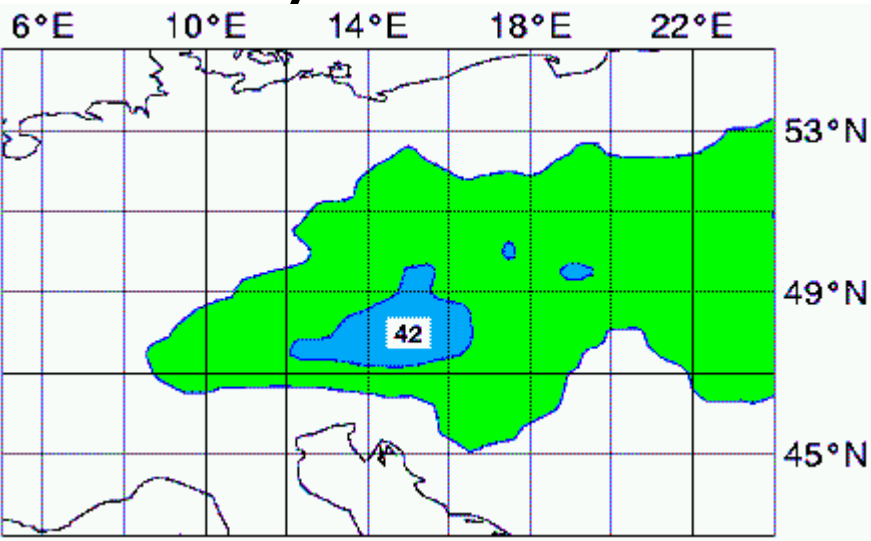
> 150mm/24h



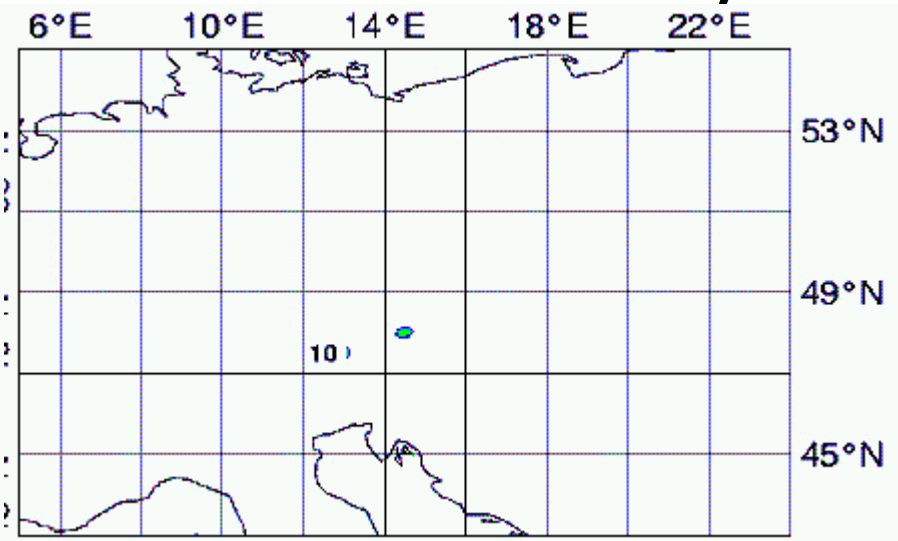
ECMWF EPS probability of precipitation +4 days

Super-ensemble

> 20mm/24h

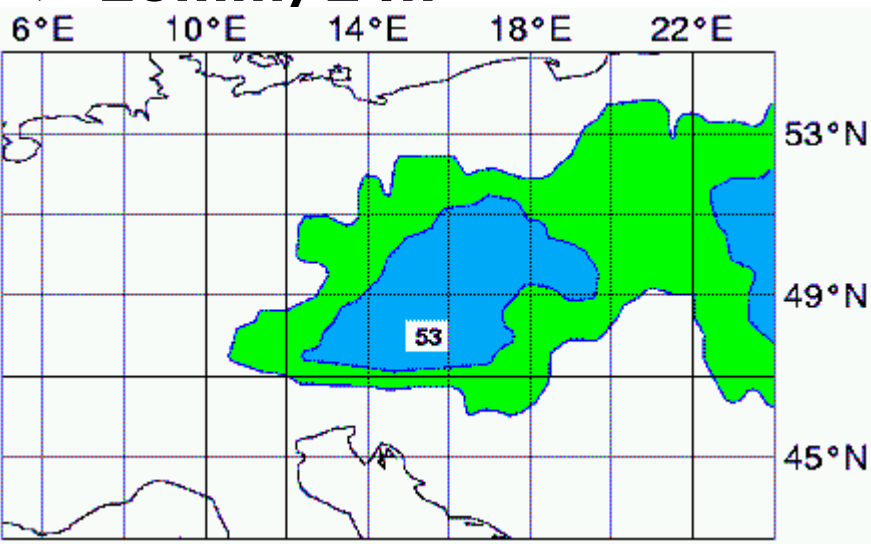


> 50mm/24h

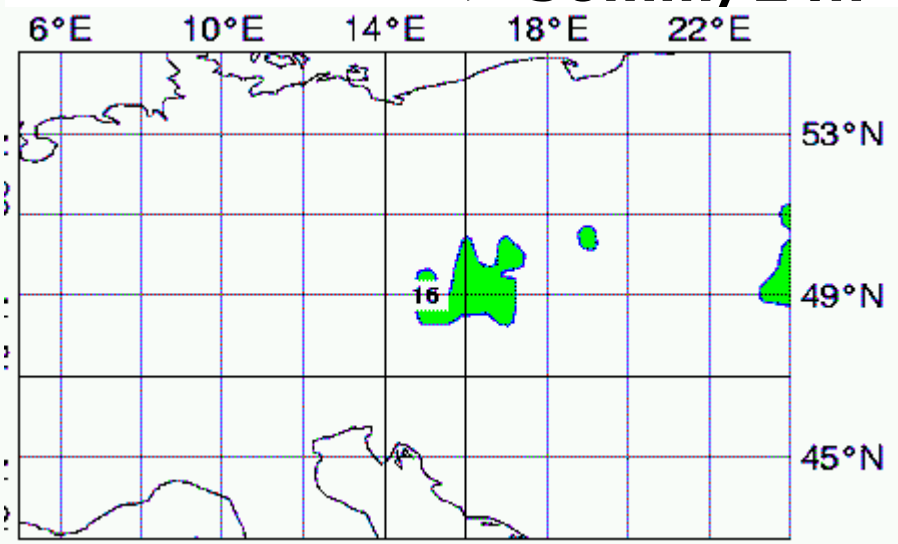


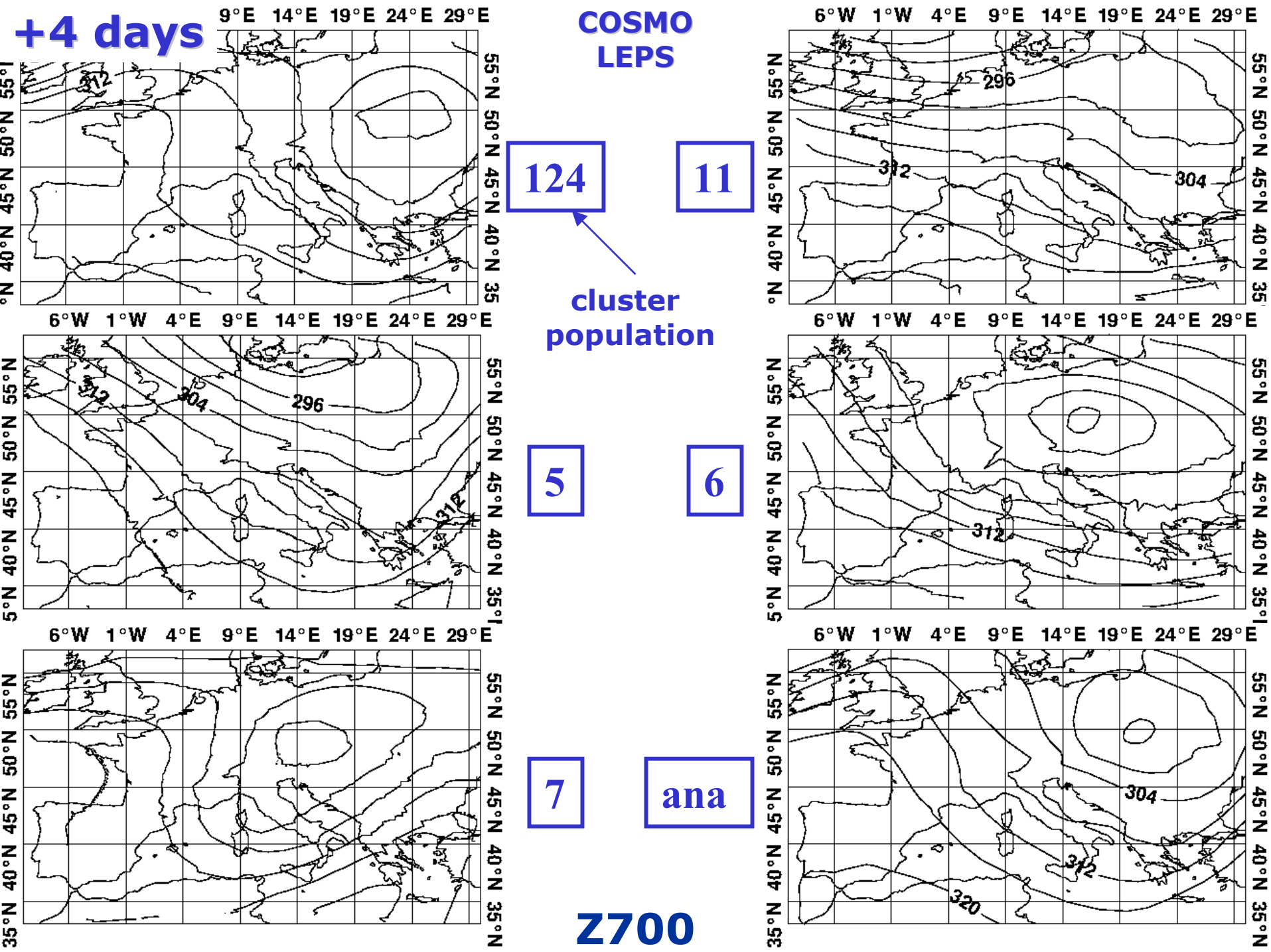
Youngest EPS

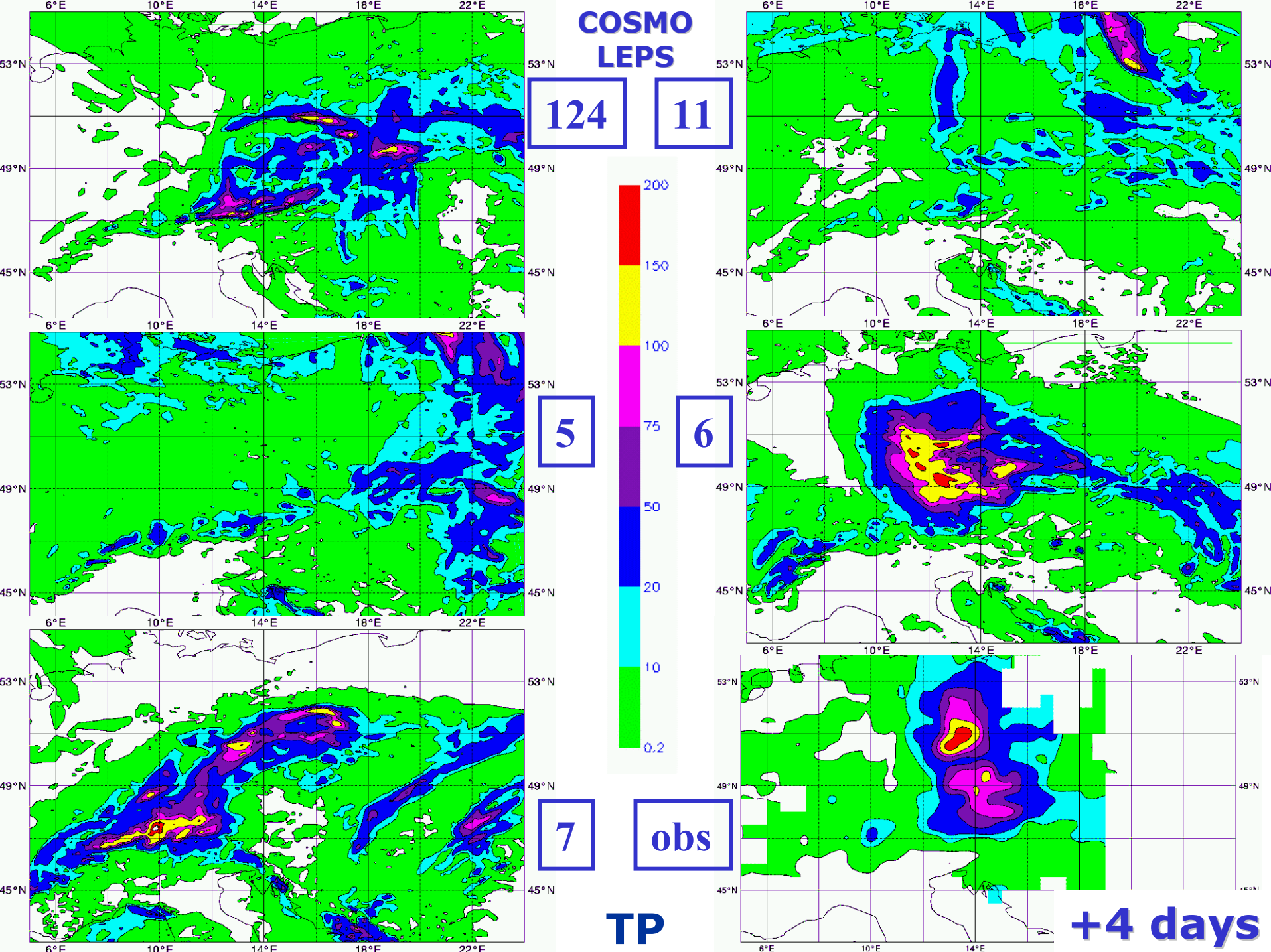
> 20mm/24h



> 50mm/24h

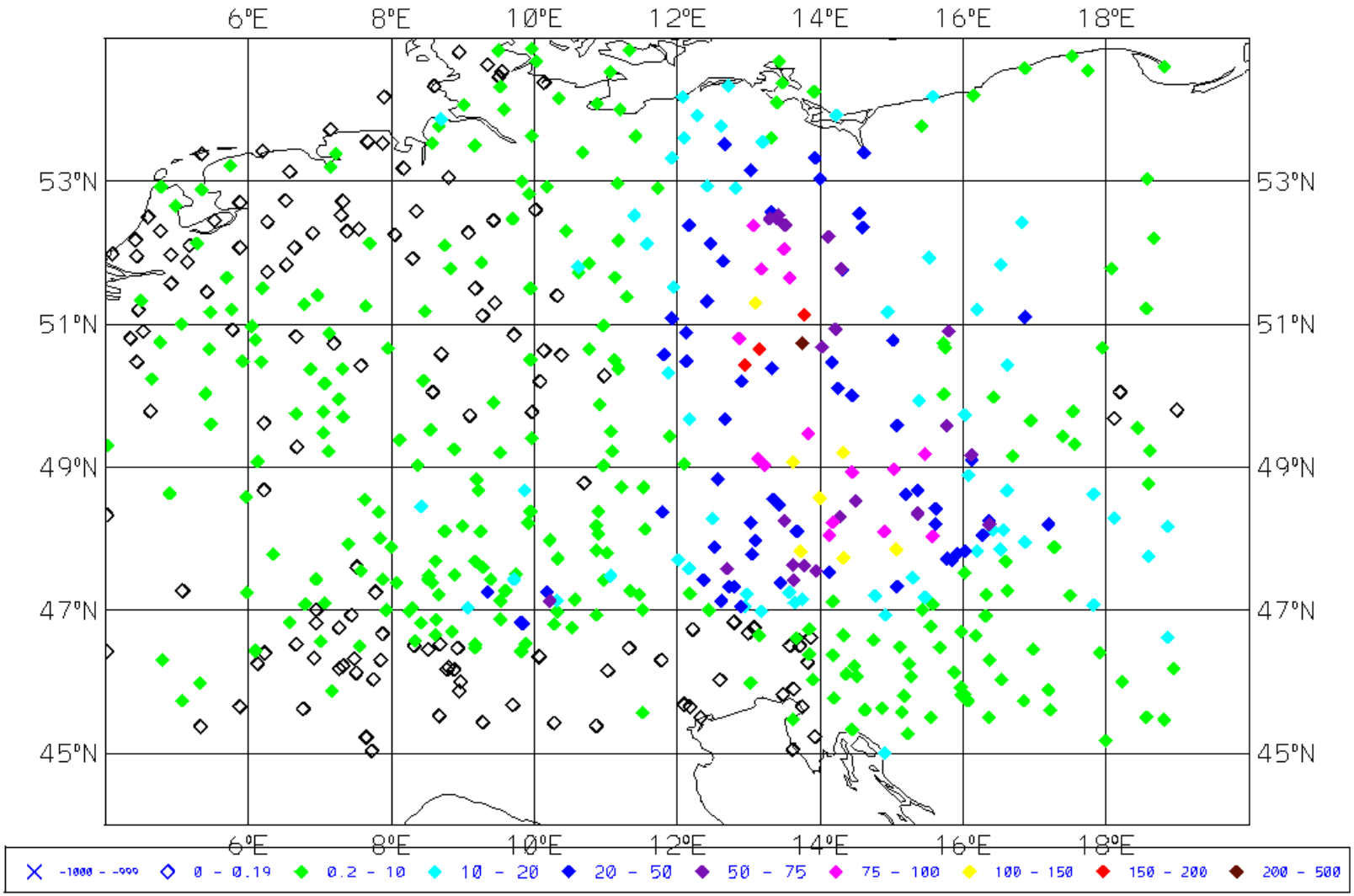



+4 days
COSMO
LEPS
124
11
cluster
population
5
6
7
ana
Z700
9°E 14°E 19°E 24°E 29°E
6°W 1°W 4°E 9°E 14°E 19°E 24°E 29°E
55°N 50°N 45°N 40°N 35°N
312
304
296
320


COSMO
LEPS
124
11
5
6
7
obs
TP
+4 days
200
150
100
75
50
20
10
0.2
6°E
10°E
14°E
18°E
22°E
53°N
49°N
45°N

Observed precipitation

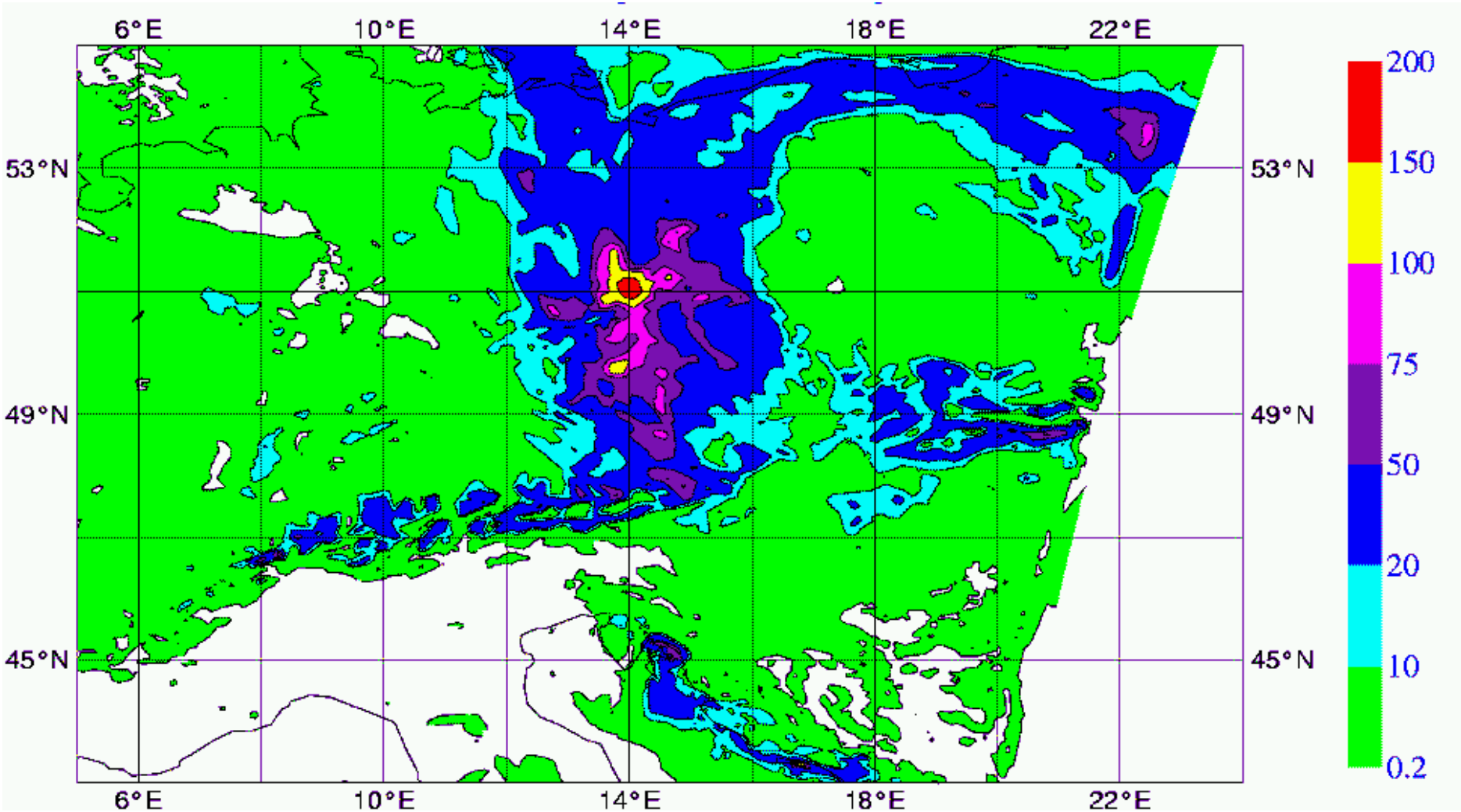
12/08 06UTC - 13/08 06 UTC



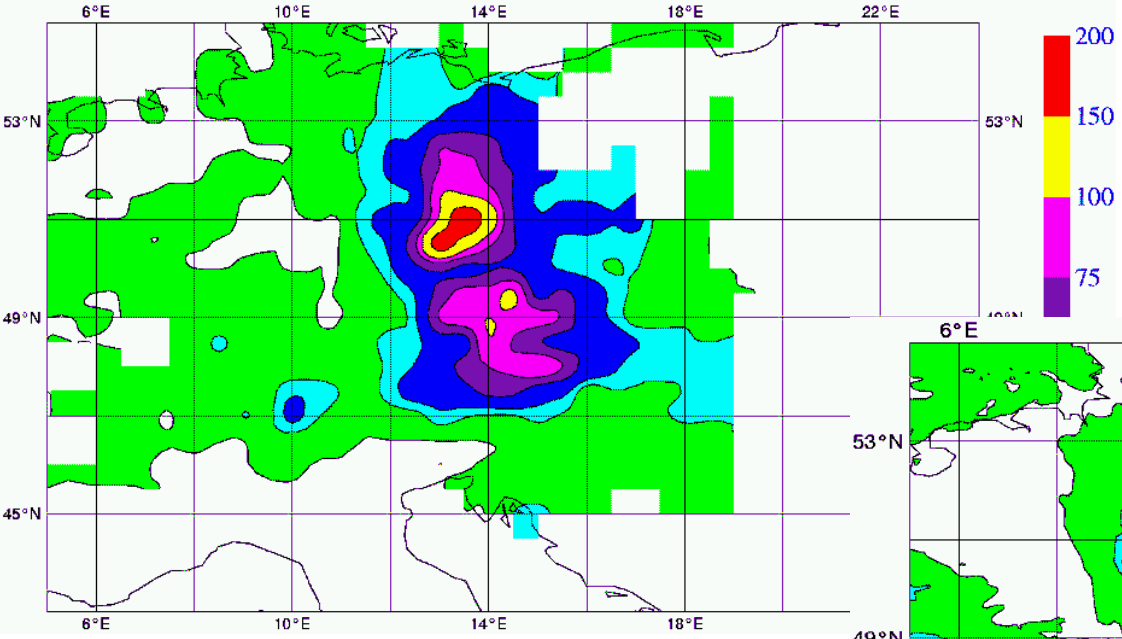
Courtesy of Ulrich Damrath

Lokal Modell deterministic run

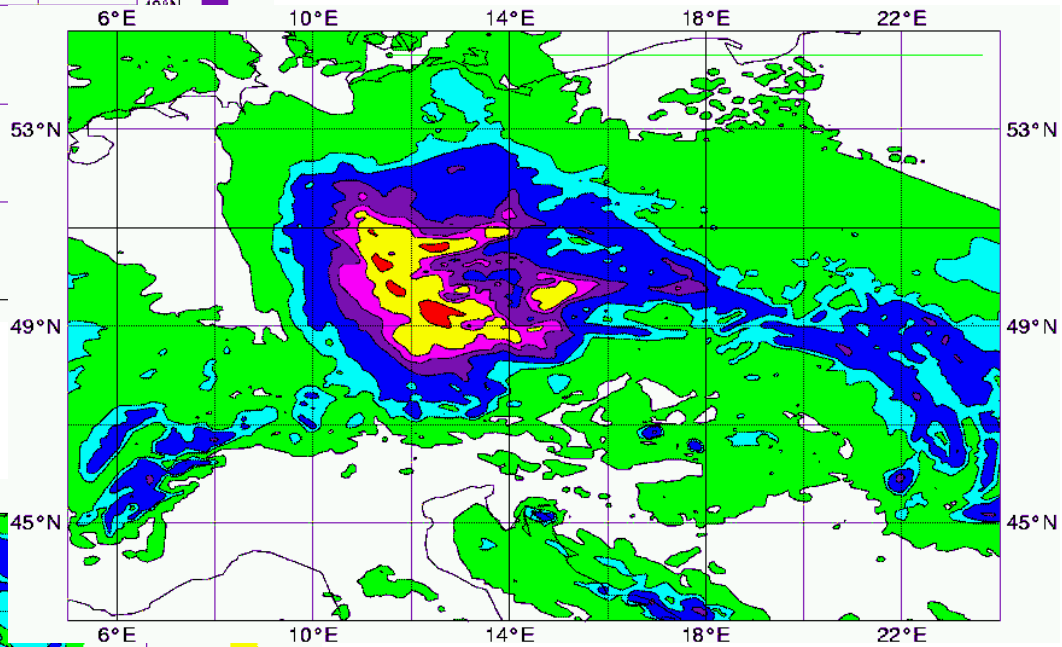
12/08 00UTC Fc +6 +30

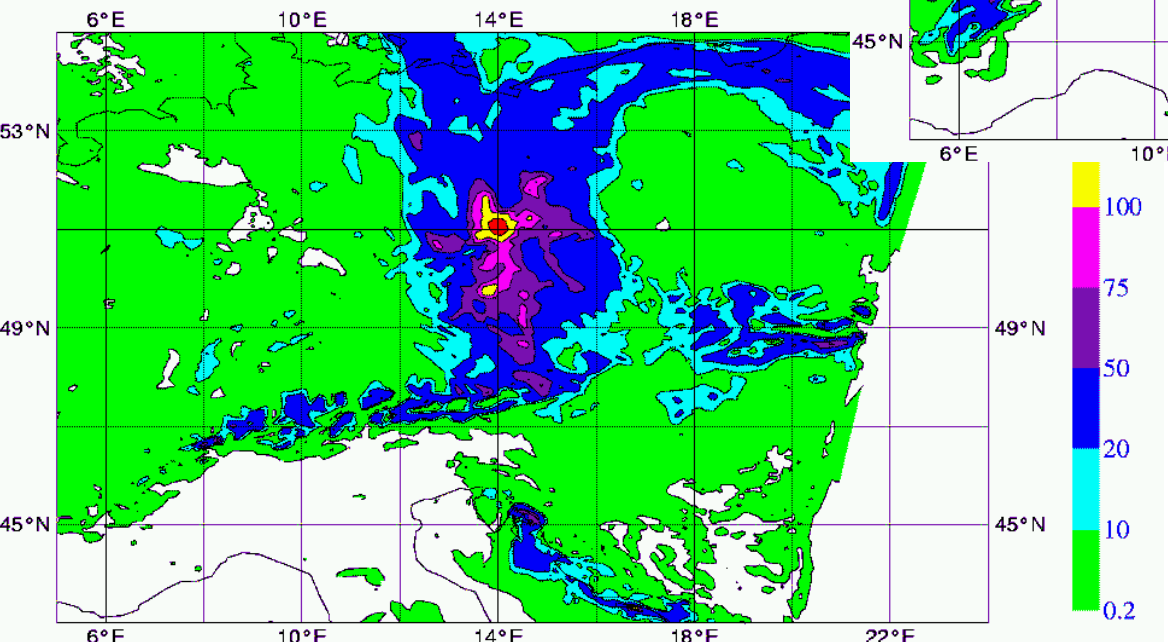


Courtesy of Ulrich Damrath



obs



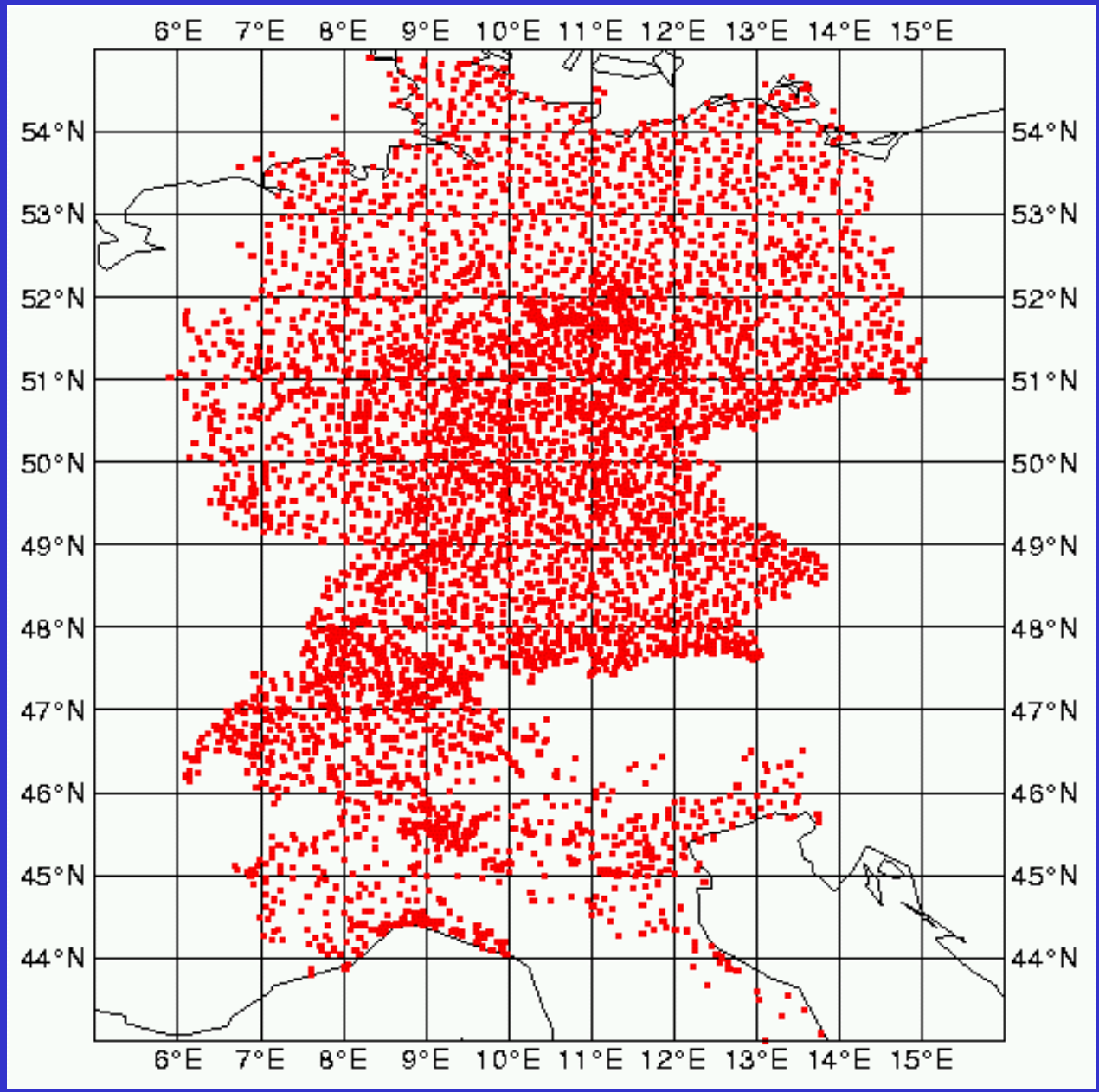


"best" COSMO-LEPS member

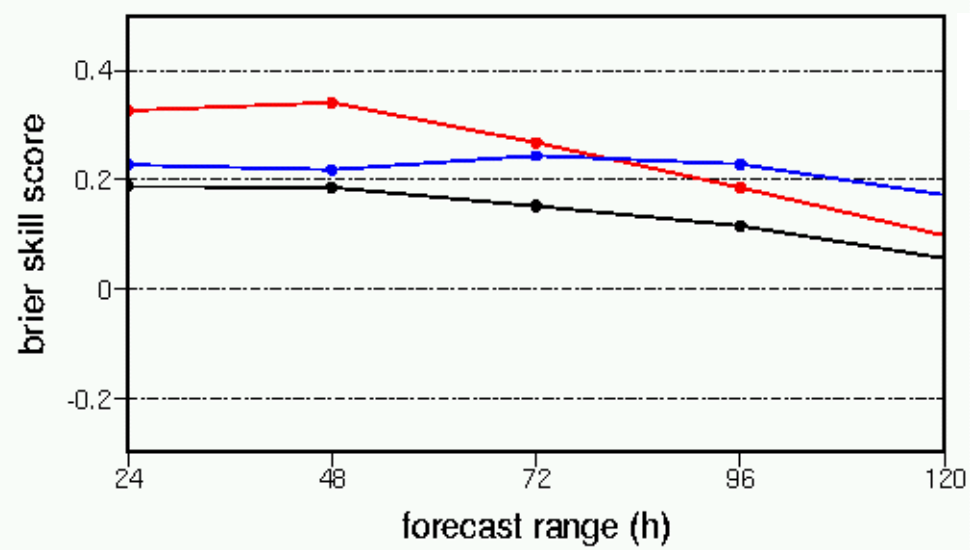
+4 days

LM ope +6 +30

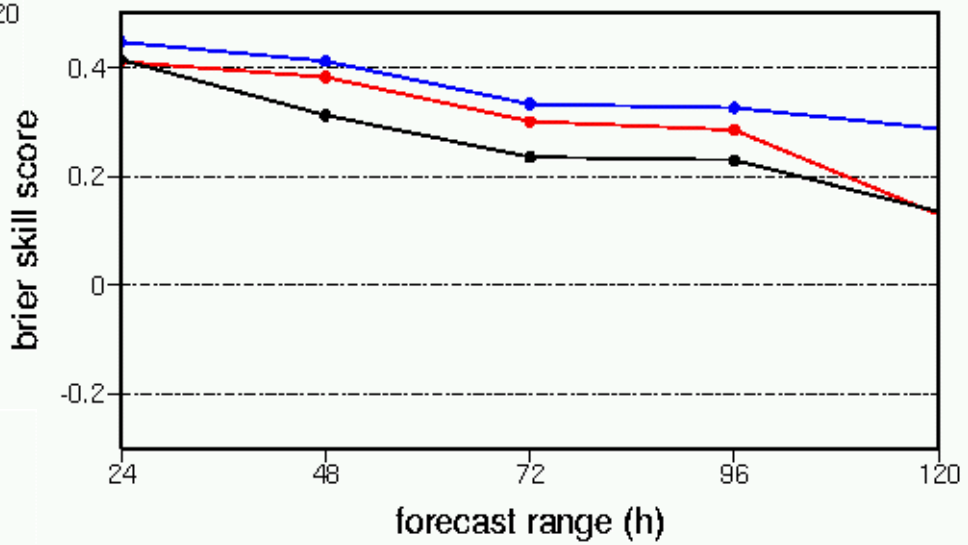
COSMO verification network



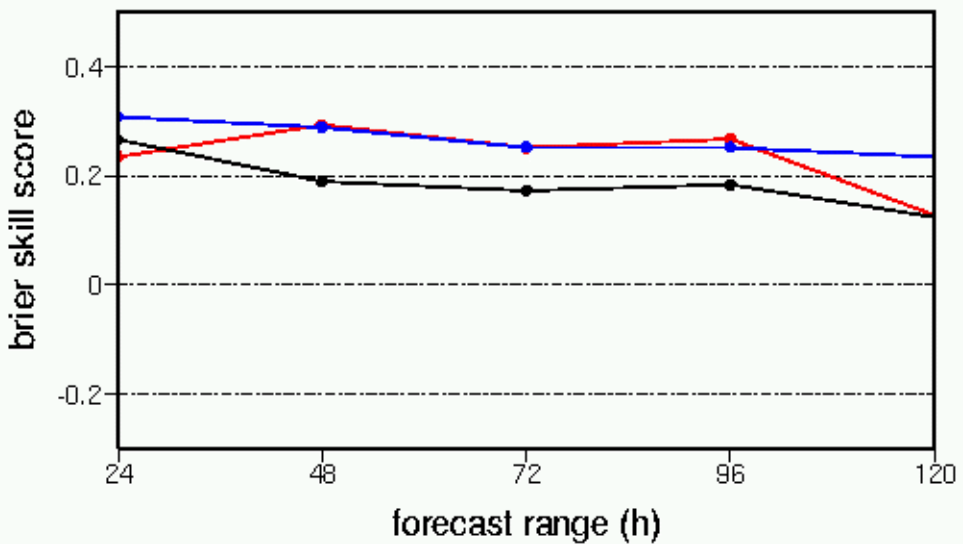
> 1mm/24h



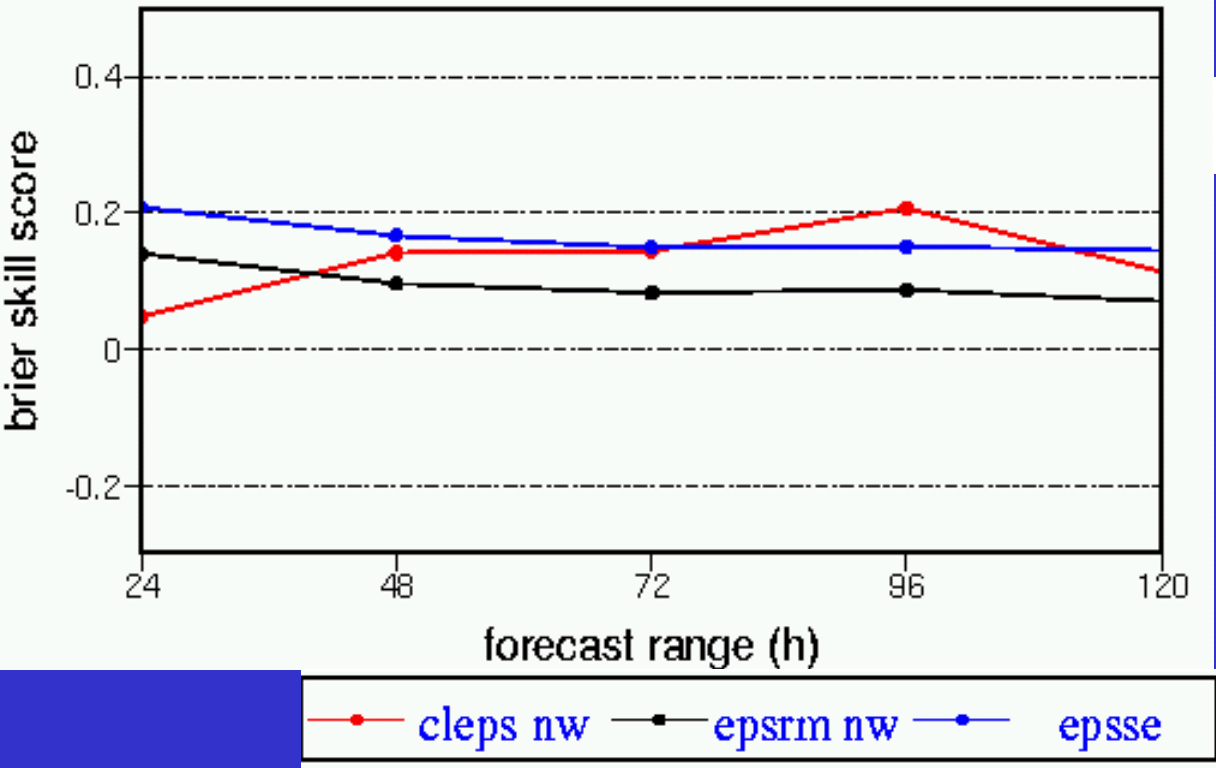
> 10mm/24h



cleps nw epsrm nw epsse

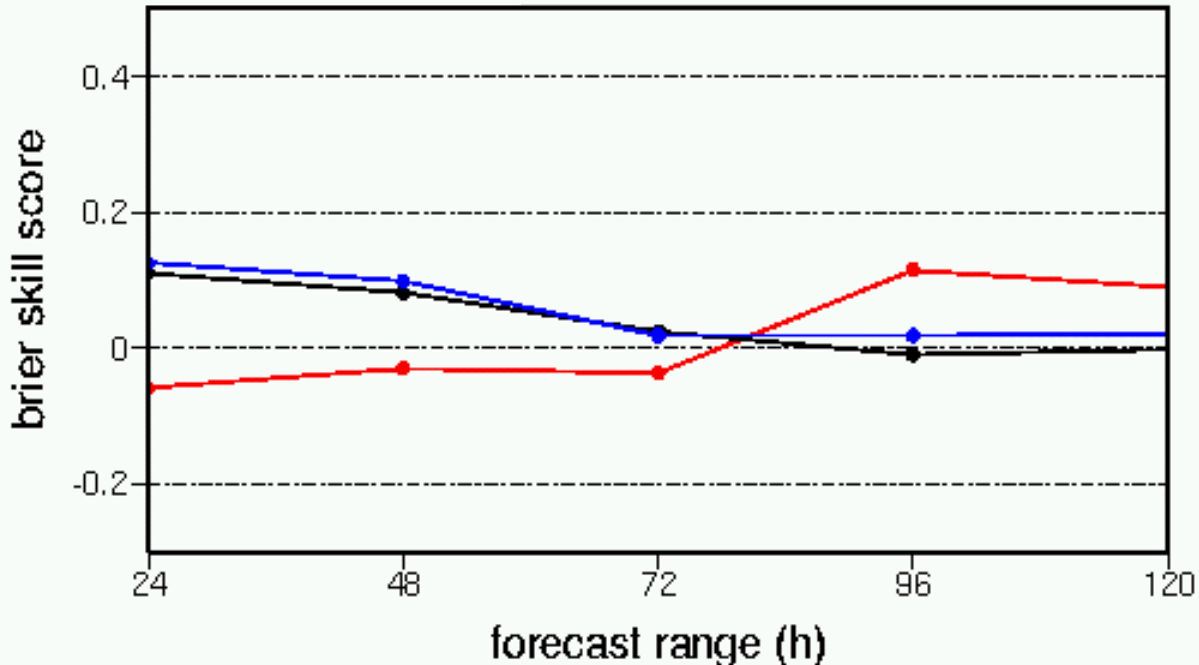


> 20mm/24h

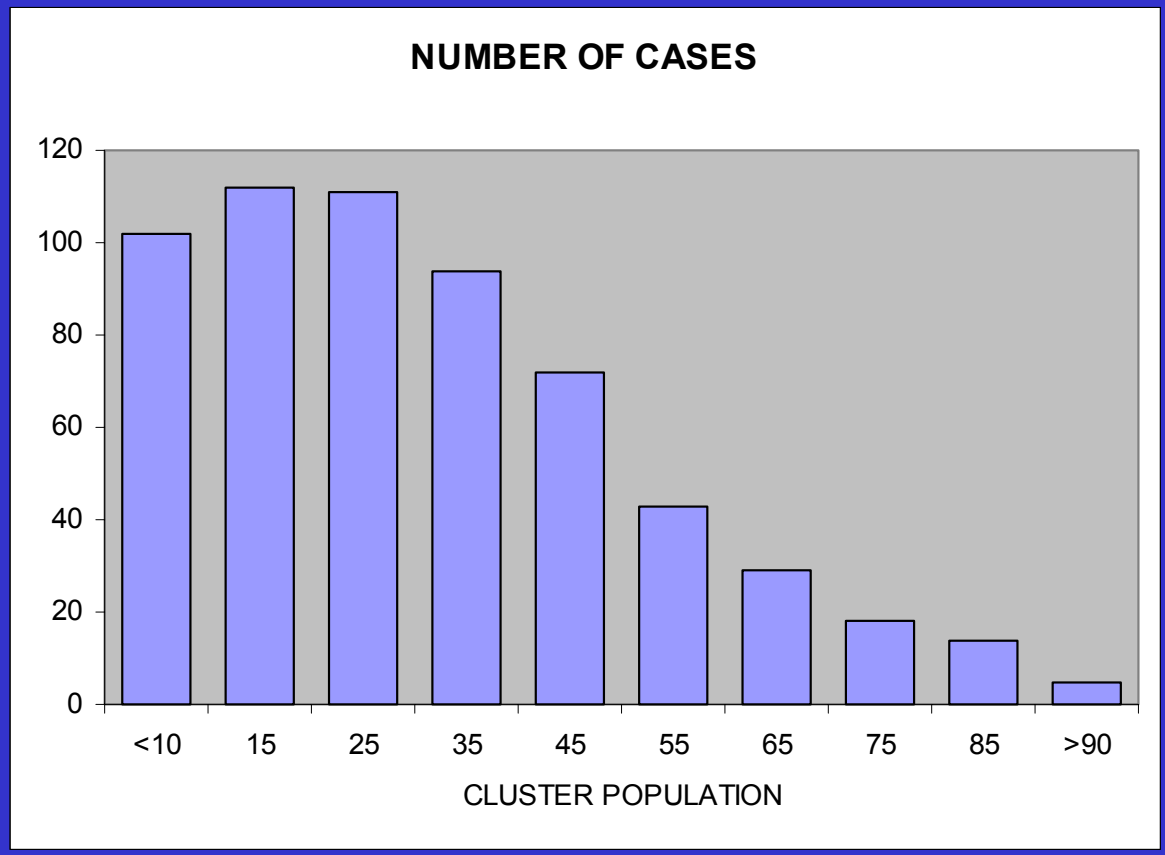


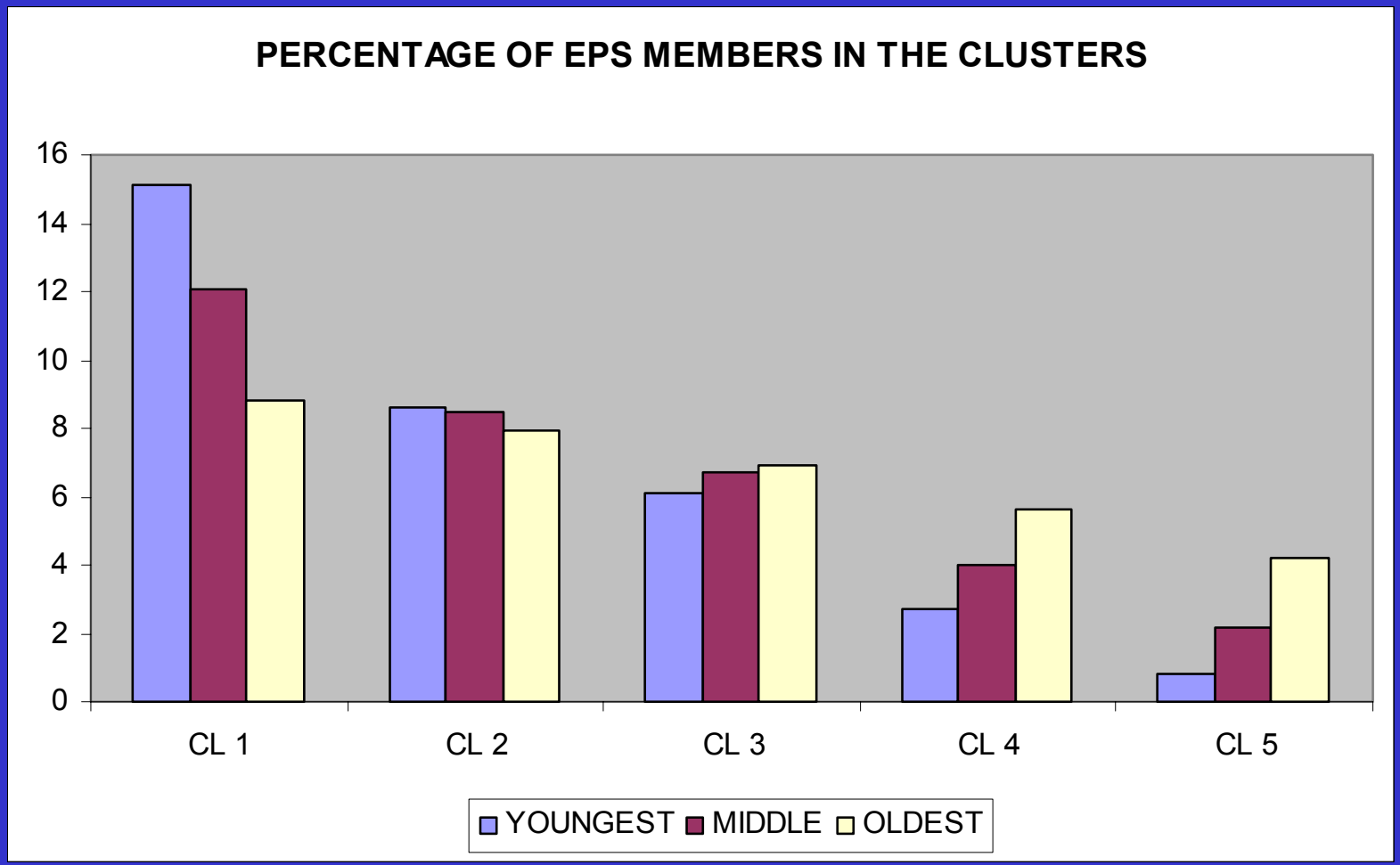
> 30mm/24h

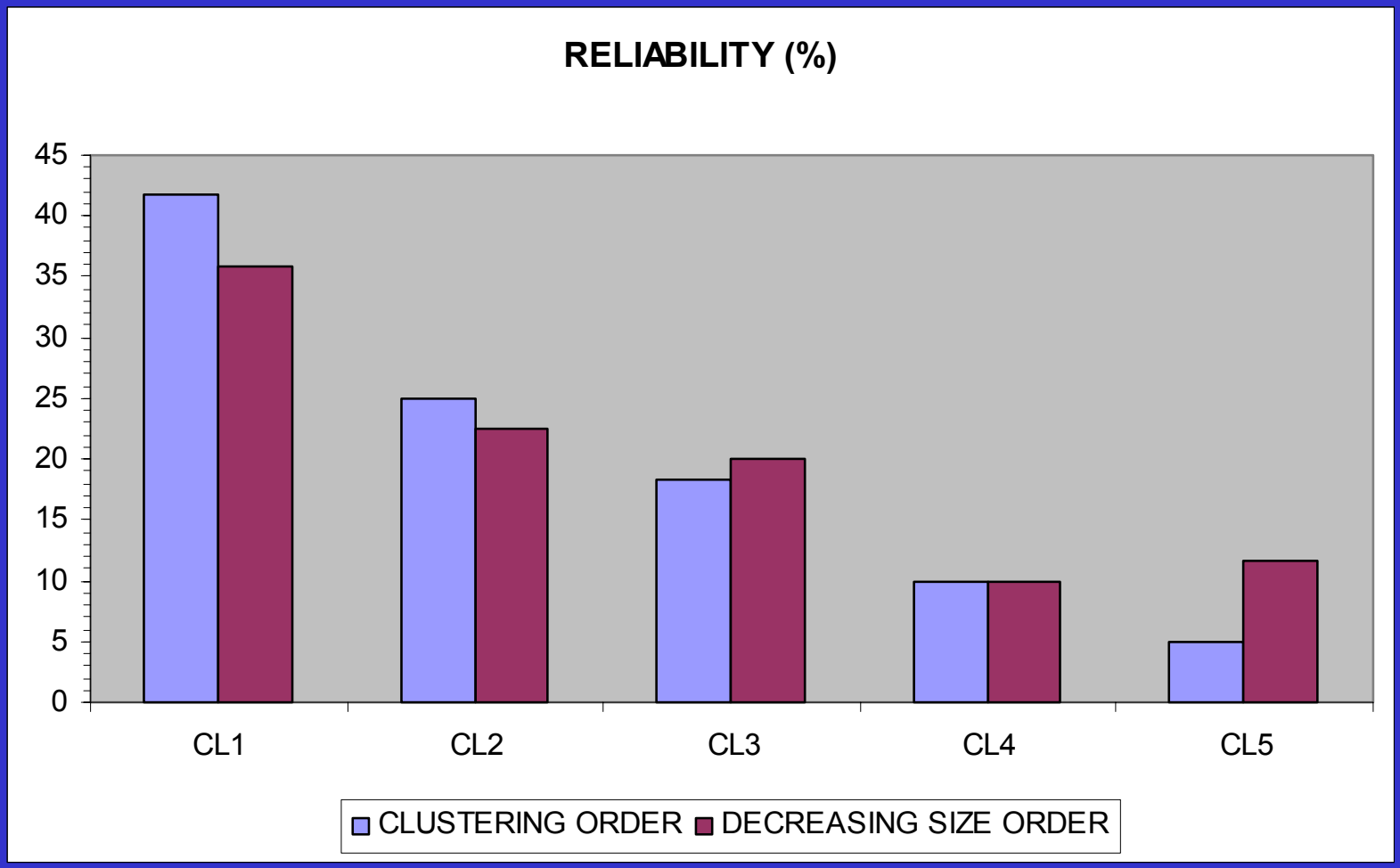
cleps nw — epsrm nw — epsse



> 50mm/24h


NUMBER OF CASES
120
100
80
60
40
20
0
<10
15
25
35
45
55
65
75
85
>90
CLUSTER POPULATION


PERCENTAGE OF EPS MEMBERS IN THE CLUSTERS
16
14
12
10
8
6
4
2
0
CL 1
CL 2
CL 3
CL 4
CL 5
YOUNGEST
MIDDLE
OLDEST


RELIABILITY (%)
45
40
35
30
25
20
15
10
5
0
CL1
CL2
CL3
CL4
CL5
CLUSTERING ORDER
DECREASING SIZE ORDER

ECMWF special project

In January 2004 the ECMWF special project **spcoleps** started between member states Italy and Switzerland, aiming at the improvement of COSMO limited-area ensemble forecasts.

- test different methodologies to select the Representative Members
- test of different member-sizes of the limited-area ensemble system to assess the dependence of forecast skill on the ensemble size
- test of the sensitivity of LEPS to model perturbations

Future development

- assess the impact of ensemble size on forecast accuracy; test 10-member COSMO-LEPS (from 1 September 2003);
- introduce model perturbations using different convection schemes (from 1 September 2003);
- test different combinations of clustering variables and different sizes of the super-ensemble;
- carry on COSMO-LEPS verification to get the evaluation of strength/shortcoming of the system. The verification activity will allow to answer the still open questions and will drive future developments.

Publications

Molteni F., R. Buizza, C.Marsigli, A.Montani, F.Nerozzi and T.Paccagnella, 2001: A strategy for high-resolution ensemble prediction. Part I: definition of representative members and global-model experiments. Q.J.R. Meteorol. Society, 127, 2069-2094.

Marsigli C., A.Montani, F.Nerozzi, T.Paccagnella, S. Tibaldi, F.Molteni and R. Buizza, 2001: A strategy for high-resolution ensemble prediction. Part II: limited area experiments in four alpine flood events. Q.J.R. Meteorol. Society, 127, 2095-2115.

Montani A., C. Marsigli, F. Nerozzi, T. Paccagnella and R. Buizza, 2001: Performance of the limited area ensemble prediction system for cases of heavy rainfall. Nonlinear Proc. in Geophys., 25, 123-135.

Montani A., C. Marsigli, F. Nerozzi, T. Paccagnella, S. Tibaldi and R. Buizza, 2003: The Soverato flood in Southern Italy: performance of global and limited-area ensemble forecasts. Nonlinear Proc. in Geophys., 10, 261-274.

Montani A., M. Capaldo, D. Cesari, C. Marsigli, U. Modigliani, F. Nerozzi, T. Paccagnella, P. Patruno and S. Tibaldi, 2003: Operational limited-area ensemble forecasts based on the Lokal Modell. ECMWF Newsletter Summer, 98, 2-7.

Marsigli C., A. Montani, F. Nerozzi, T. Paccagnella, 2004: Probabilistic high-resolution forecast of heavy precipitation over Central Europe. Natural Hazards and Hearth System Sciences, in press.

The end