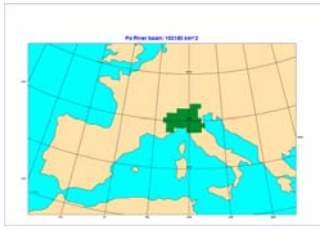
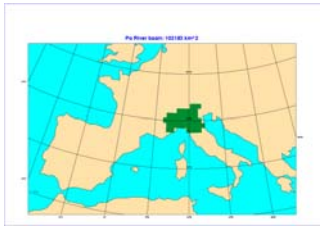


Ensemble forecasts for the Po-basin flood of 2000

Pedro Viterbo

Tony Hollingsworth

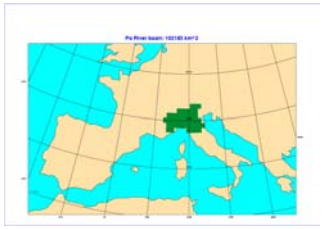
ECMWF



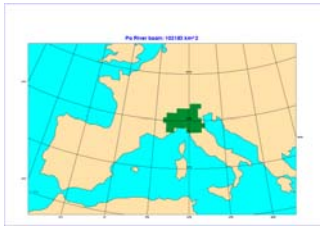
Overview

- **Heavy precipitation events caused exceptional flood situations in Northern Italy in October 2000**
- **Time integrated precipitation from the ECMWF forecasting system are illustrated here:**
  - **Deterministic forecasts (t511; 40 km)**
  - **Ensemble forecasts (50 perturbed + control) (t255; 80 km)**
  - **24 hr forecasts (t511; 40 km) are taken as a proxy for truth**
- **Results are spatially integrated for the Po River Basin (catchment area 102 183 km^2), represented at 0.5x0.5 degrees (Fekete et al 2000)**
- **The importance of model resolution (40, 60, 80 and 110 km)**
- **Verification issues**

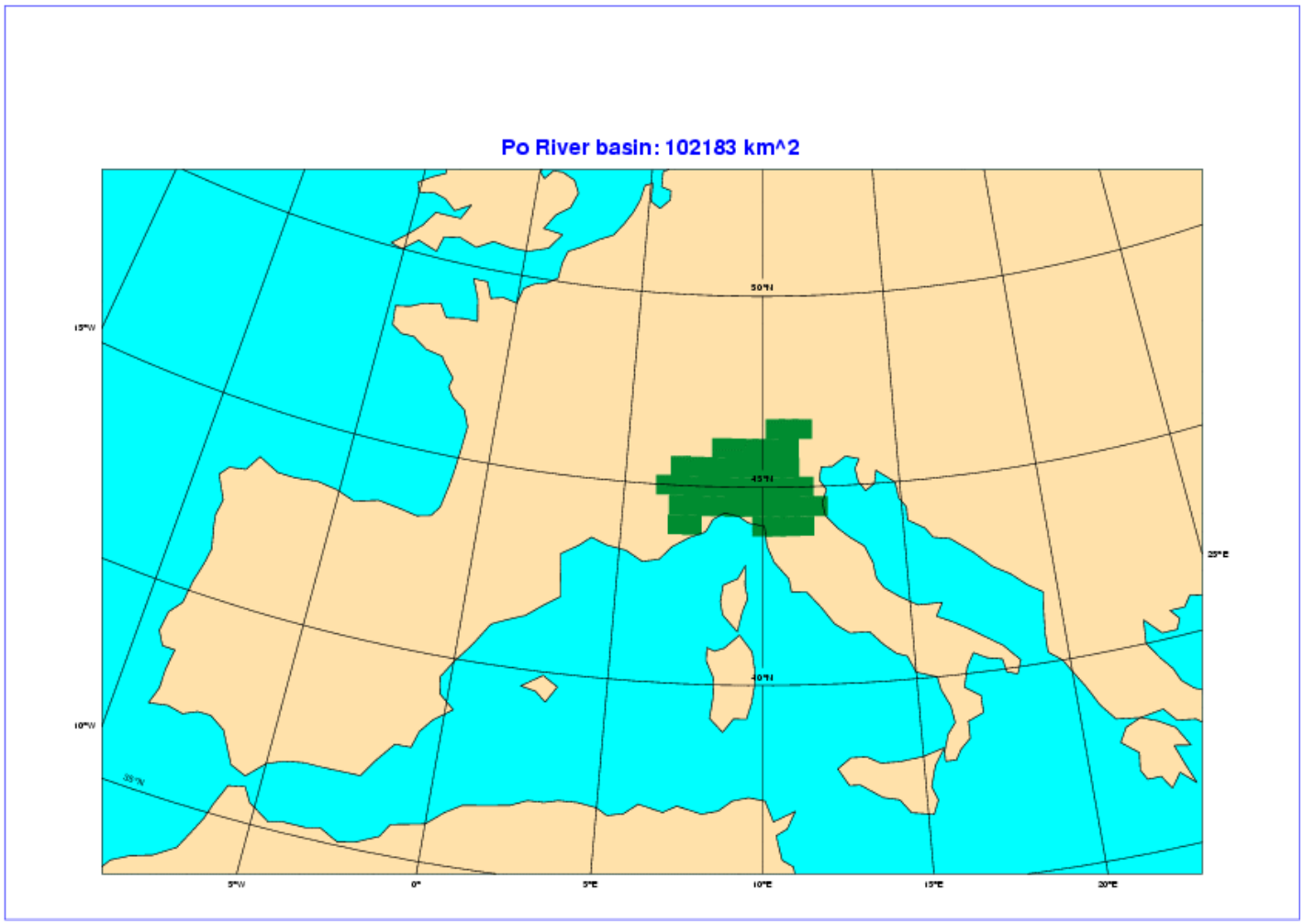
Hollingsworth, Viterbo, and Simmons, 2003: The relevance of …. A *Half Century of Progress in Meteorology: A Tribute to Richard J. Reed*, AMS *Meteorological Monographs*, 31, 109-129.

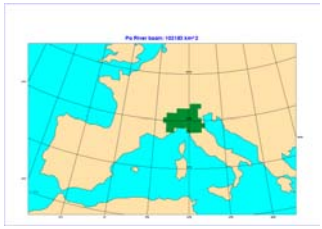


The Po floods, NW Italy



The Po River basin



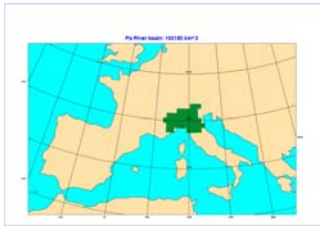


Model(s) running in October

- **High resolution system with (40/80)**
  - **Deterministic forecasts (t511; 40 km)**
  - **Ensemble forecasts (50 perturbed + control) (t255; 80 km)**

in parallel with

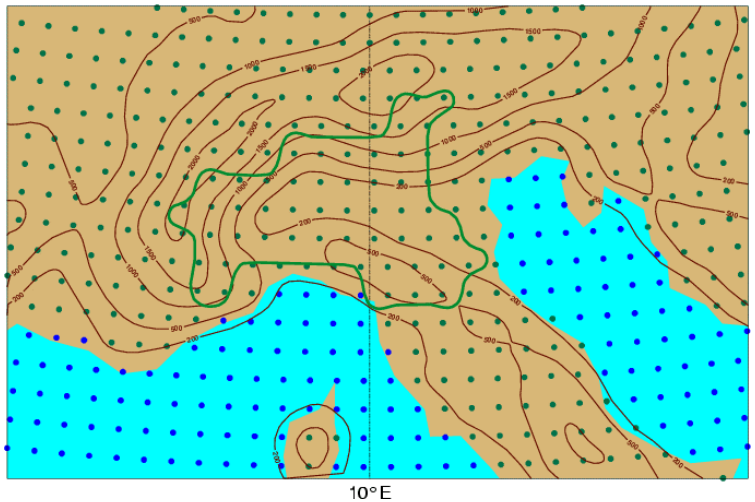
- **Lower resolution system with (60/125)**
  - **Deterministic forecasts (t319; 60 km)**
  - **Ensemble forecasts (50 perturbed + control) (t159; 125 km)**
- **Methodology**
  - **Precipitation is aggregated over Po River basin and time integrated for each forecast**
  - **24 hour forecasts of precipitation (at 40 km) will be taken as proxy for truth**

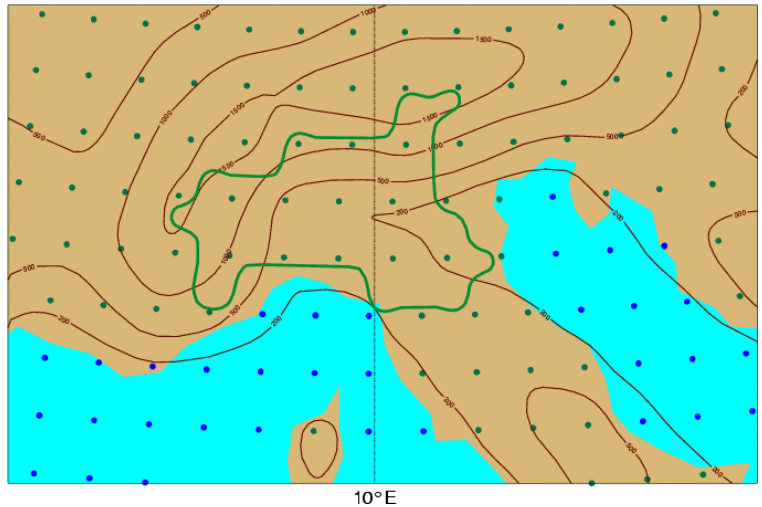


Model resolution

- **Deterministic**
- **Ensemble prediction (50+1 members)**

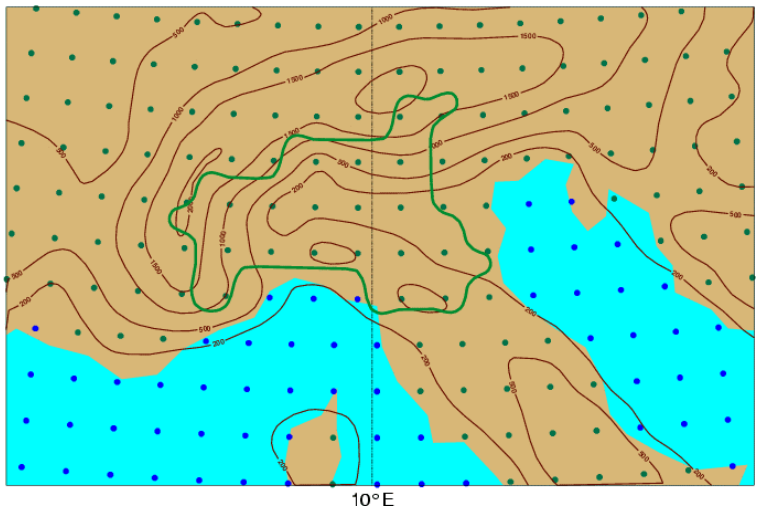
T511
40 km

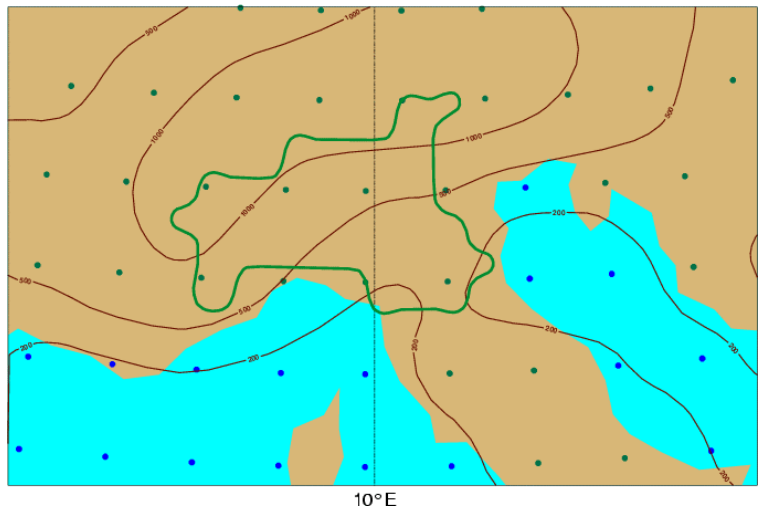




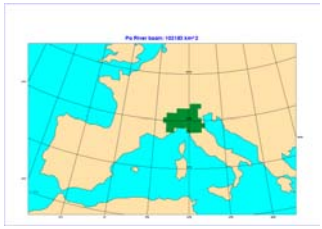
T255
80 km

T319
60 km



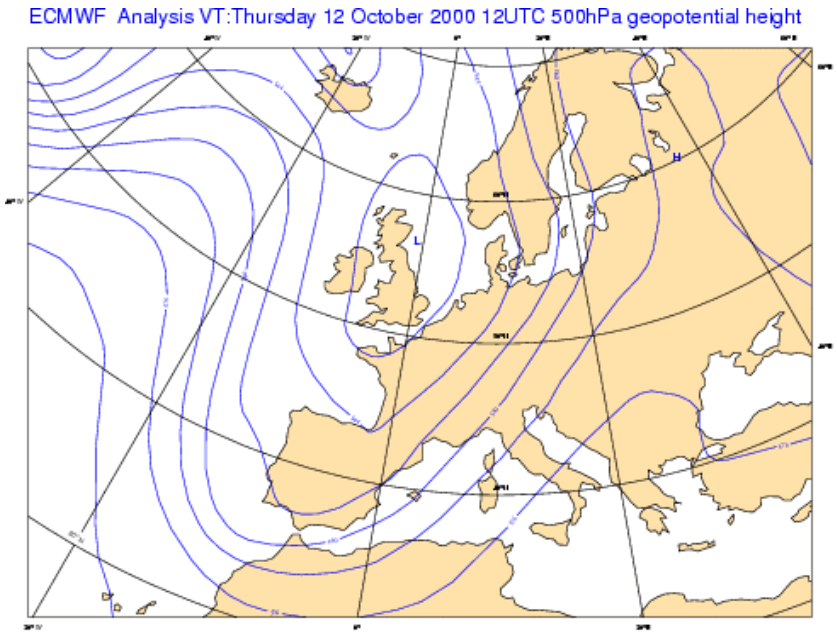


T159
125 km

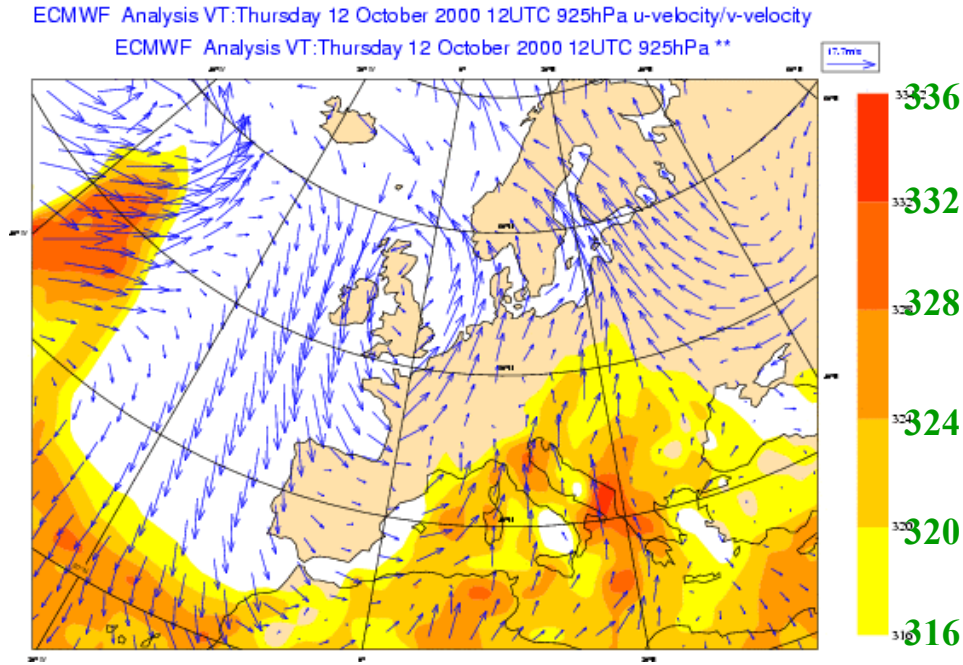


The synoptic situation (1)

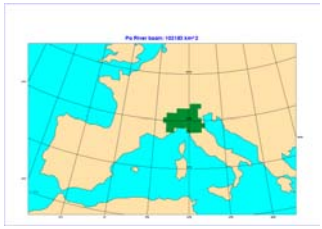
12 October



500 hPa geopotential

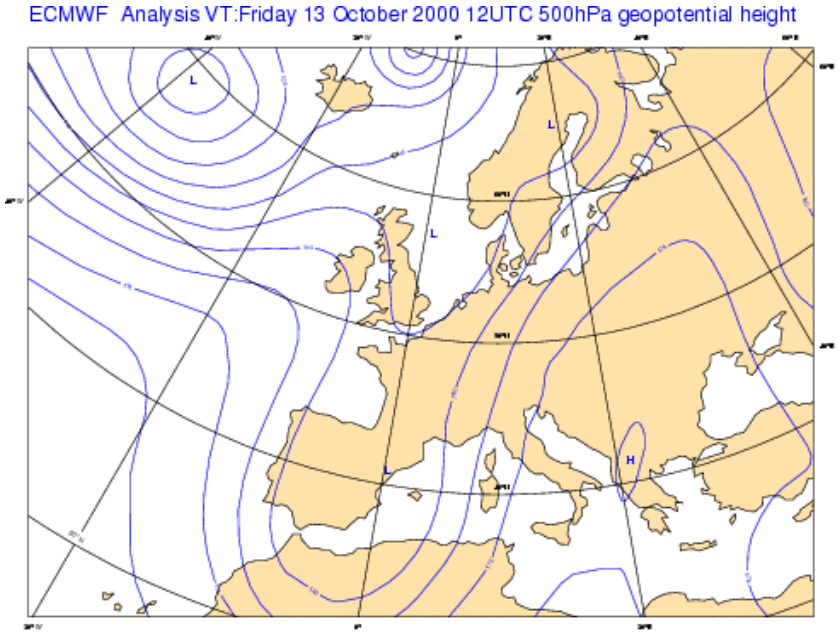


925 hPa winds/equivalent potential temperature

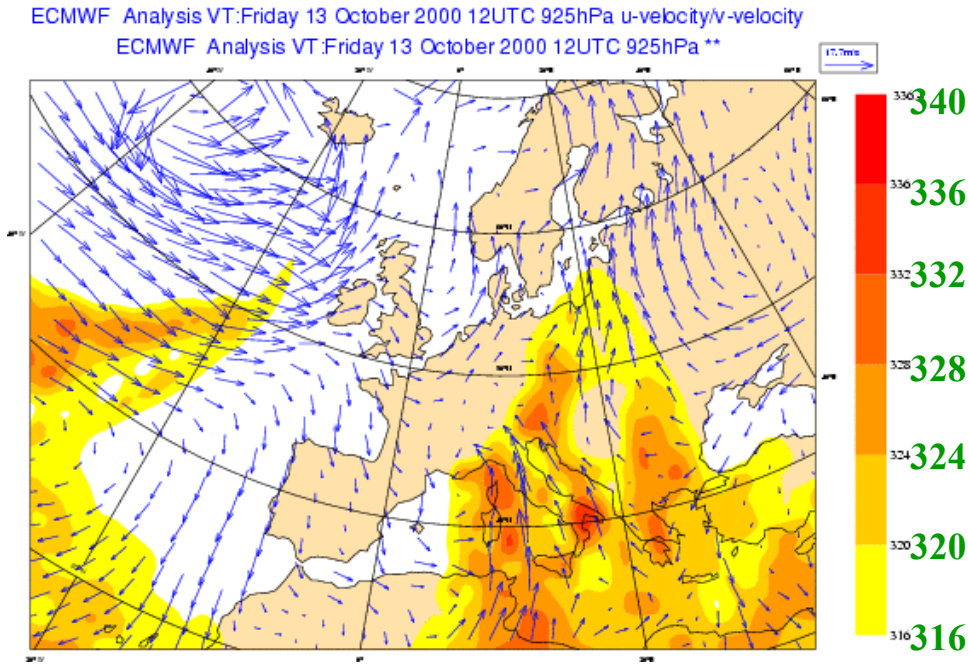


The synoptic situation (2)

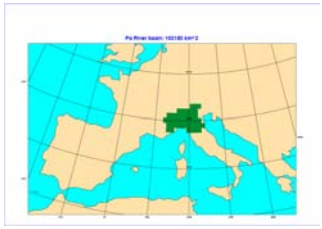
13 October



500 hPa geopotential

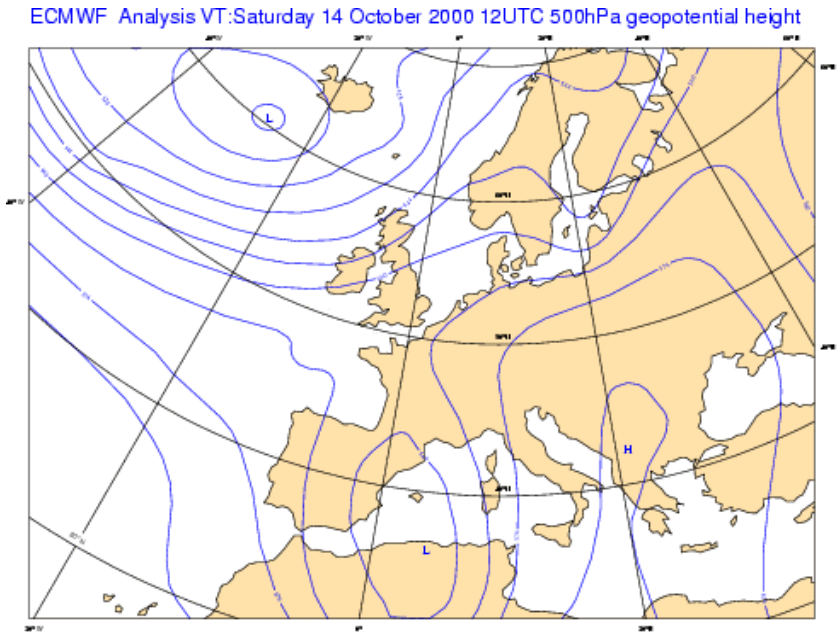


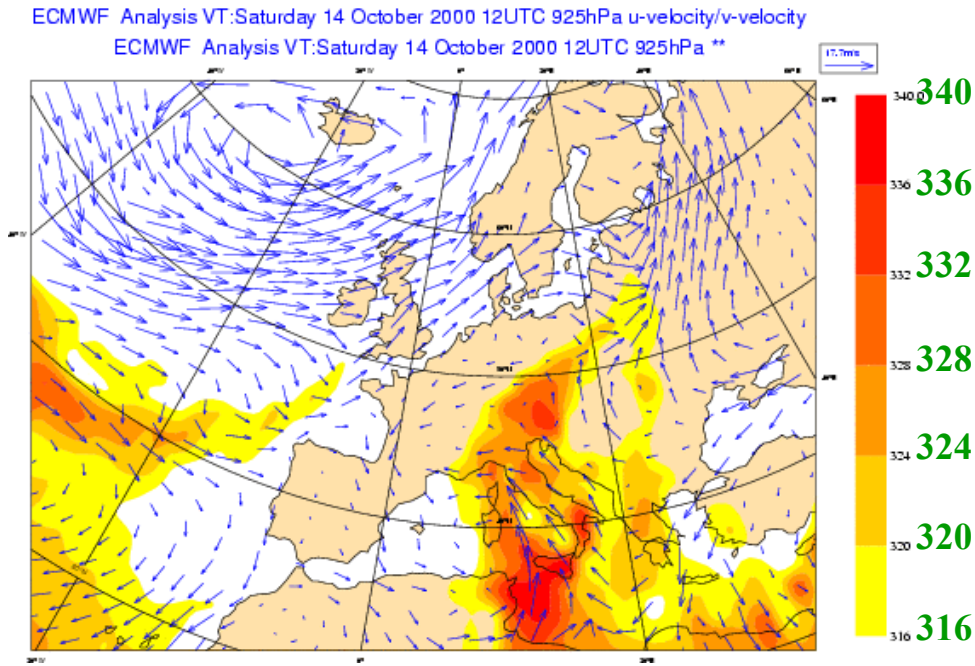
925 hPa winds/equivalent potential temperature



The synoptic situation (3)

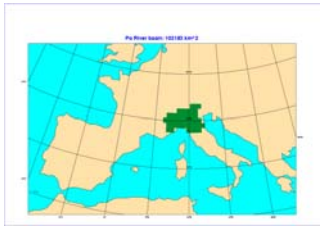
14 October



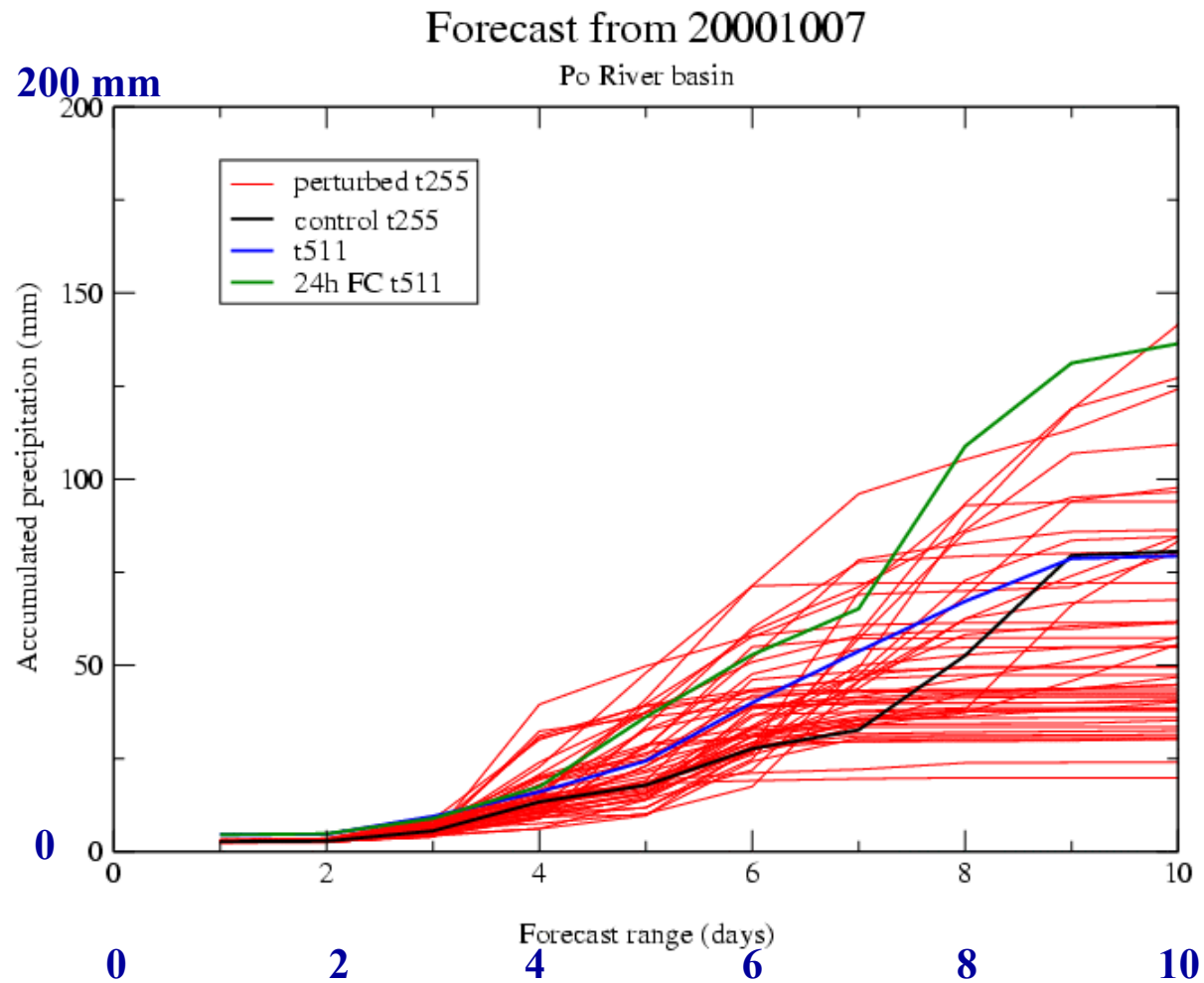


500 hPa geopotential

925 hPa winds/equivalent potential temperature

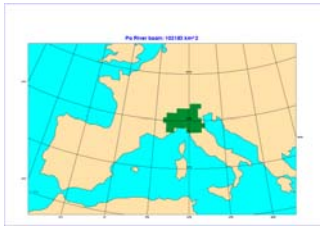


Forecast from 20001007 (40 km/80 km)



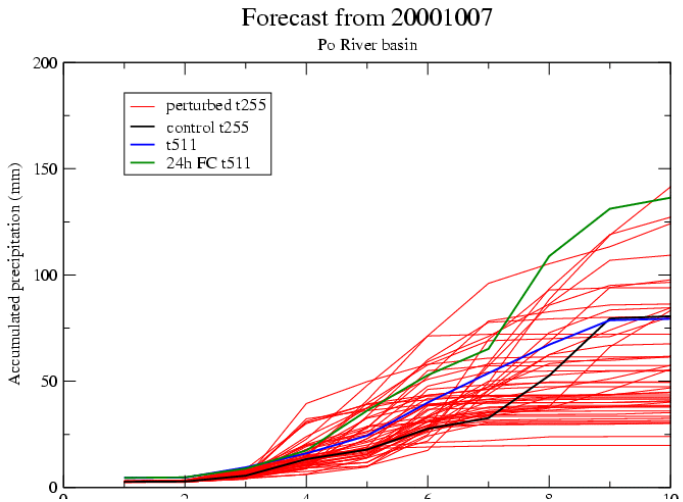
perturbed t255
control t255
t511
24h FC t511

1 member (2%) above 140 mm
4 (8%) above 100 mm
12 (26%) above 75 mm
23 (46 % above 45 mm

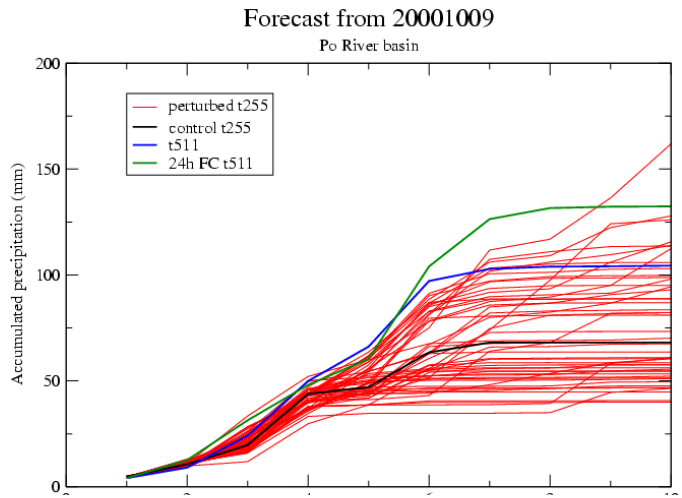


Synopsis 20001007-20001013 (40 km/80 km)

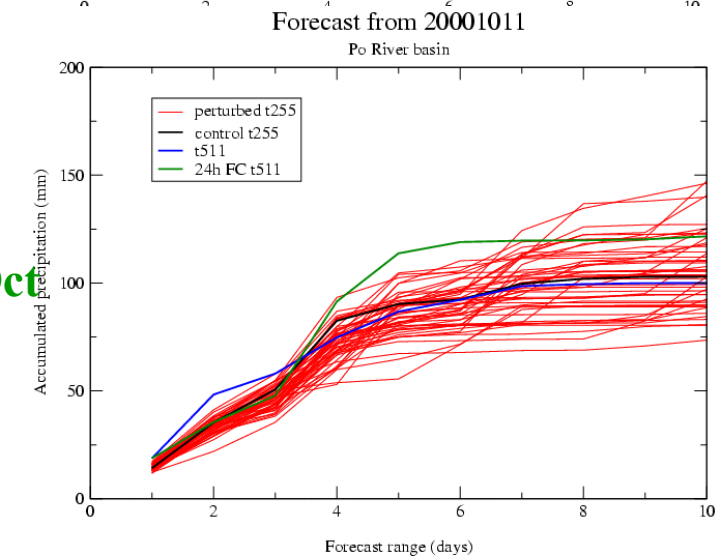
7 Oct



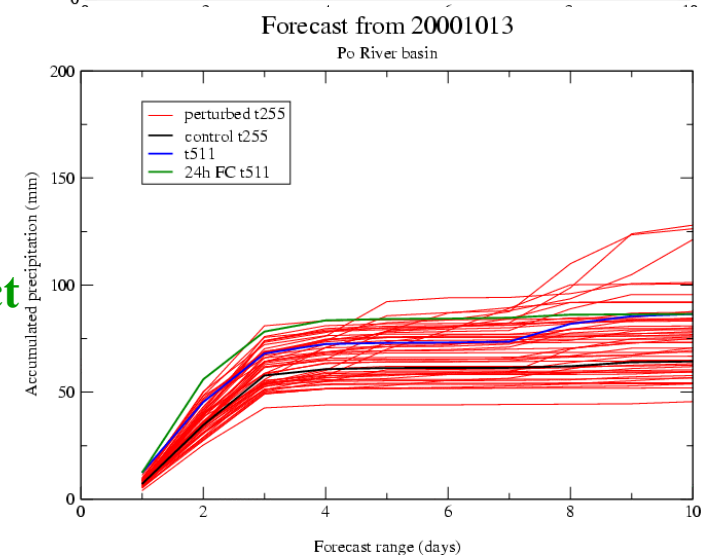
9 Oct

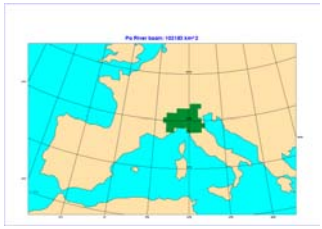


11 Oct

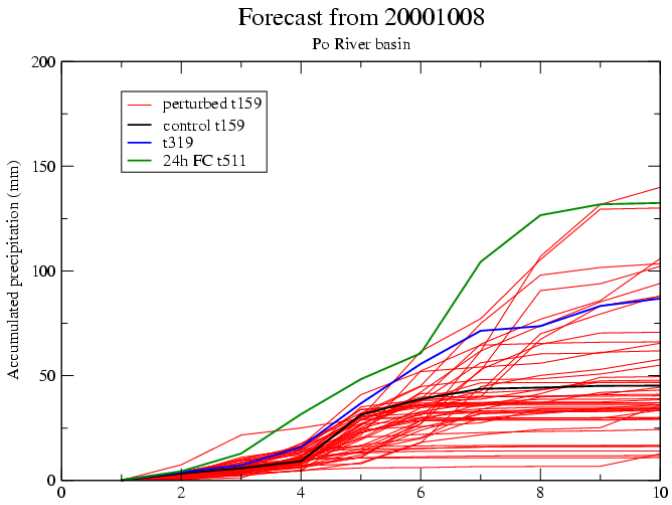


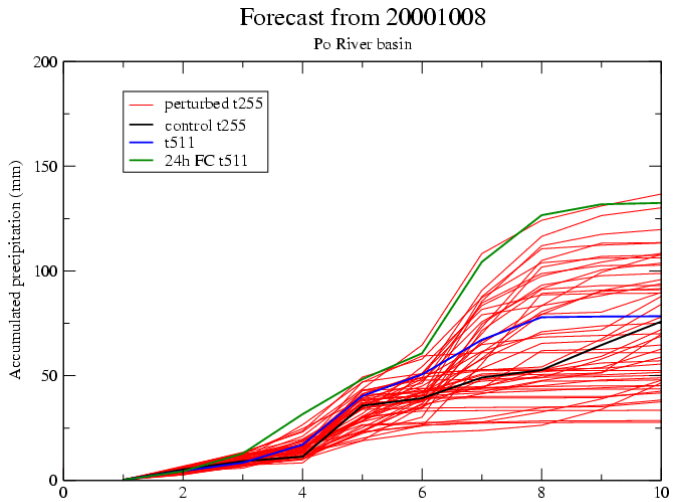
13 Oct



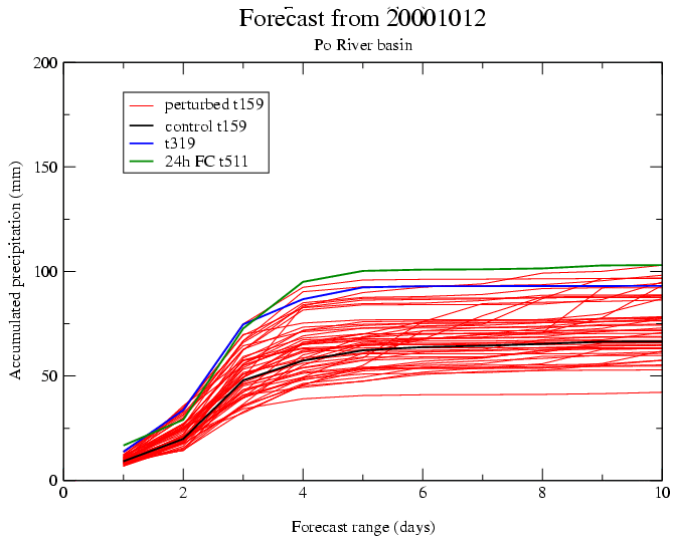


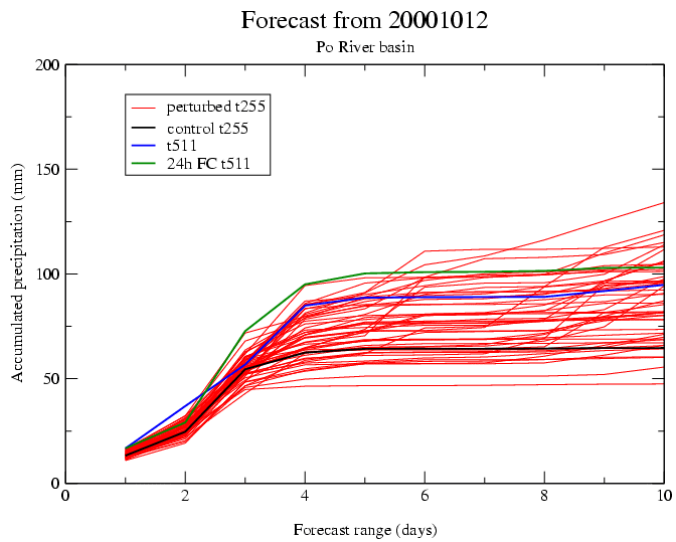
Impact of resolution





8 October

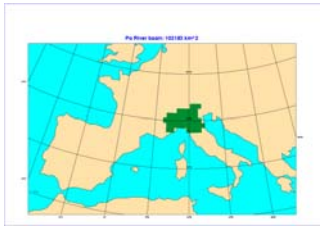




12 October

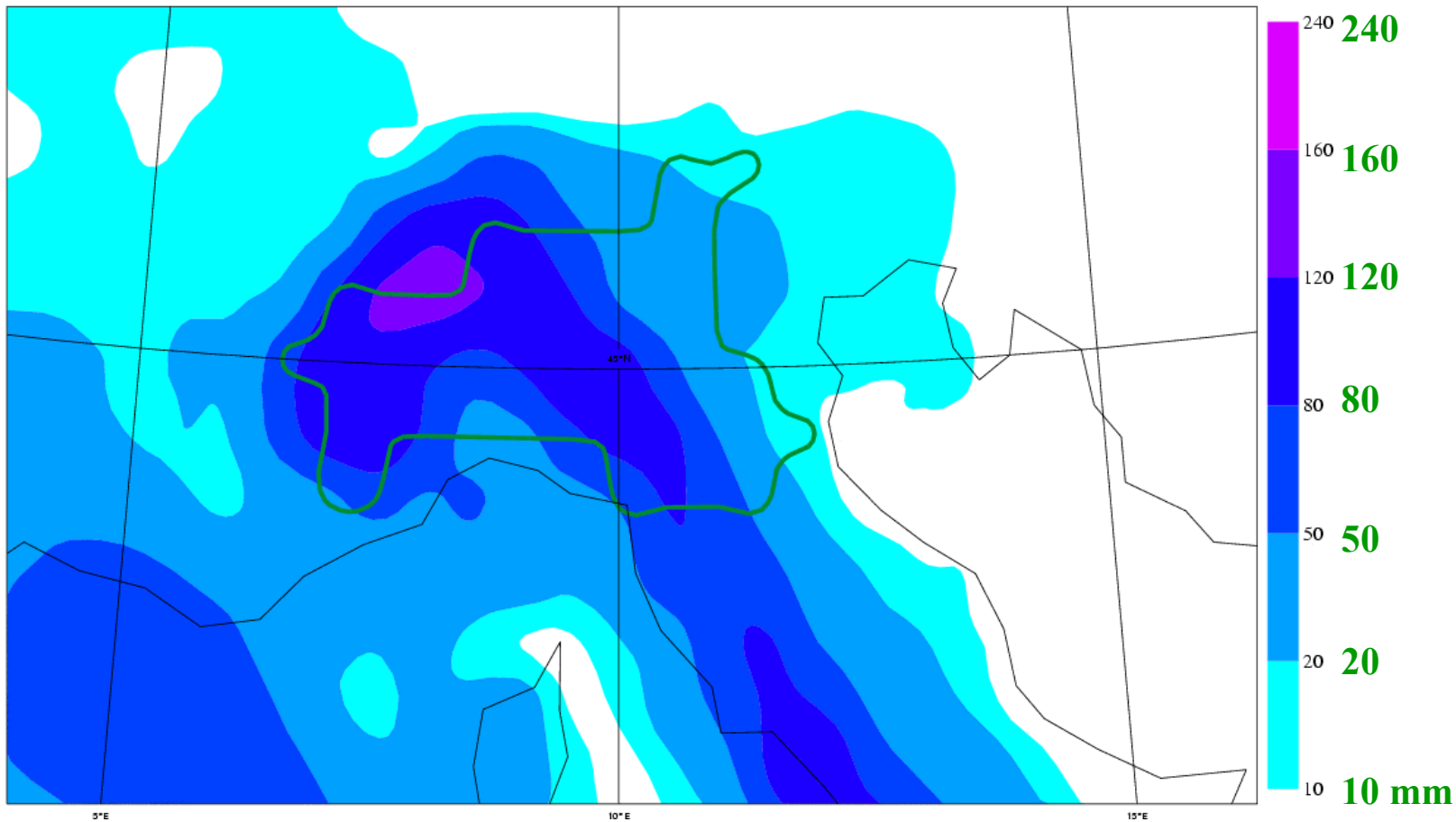
60 km/125 km

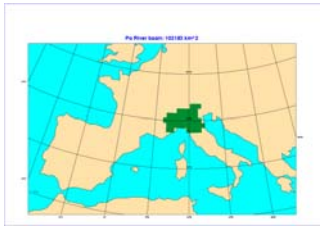
40 km/80 km



Rainfall 14-15 October: "truth" (40 km)

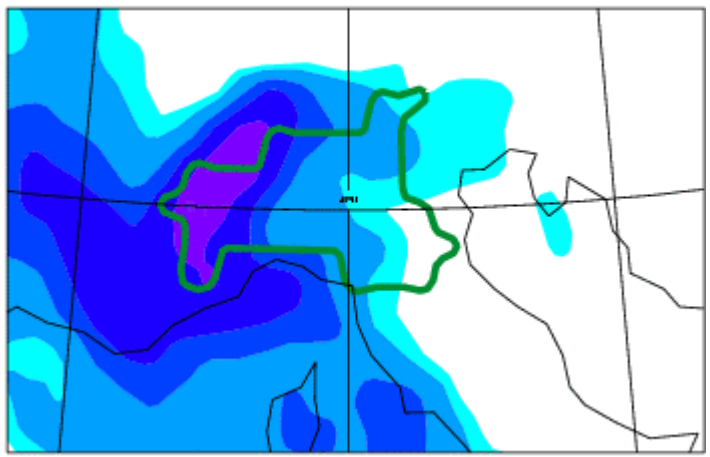
20000114-15 + 0-24 H





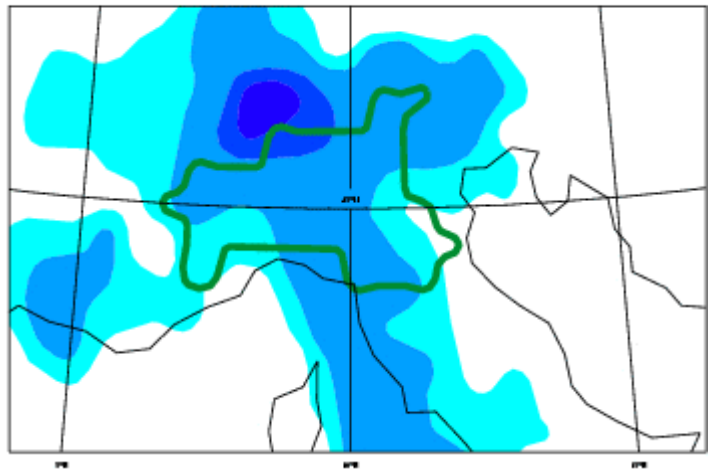
Rainfall forecast (40 km)

20000113 + 24-72 H



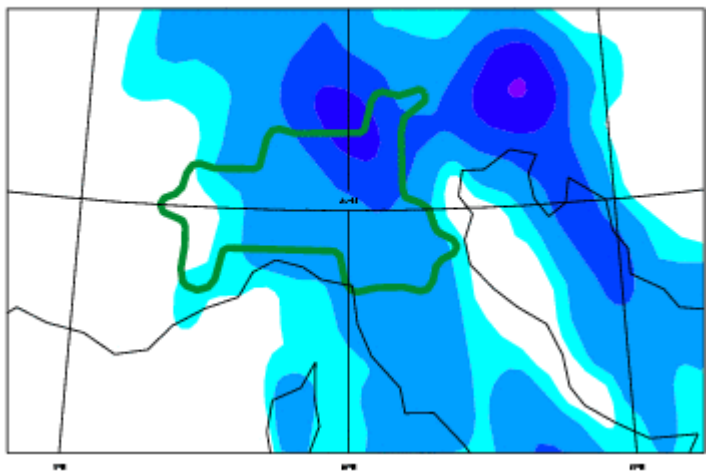
day 2

20000111 + 72-120 H



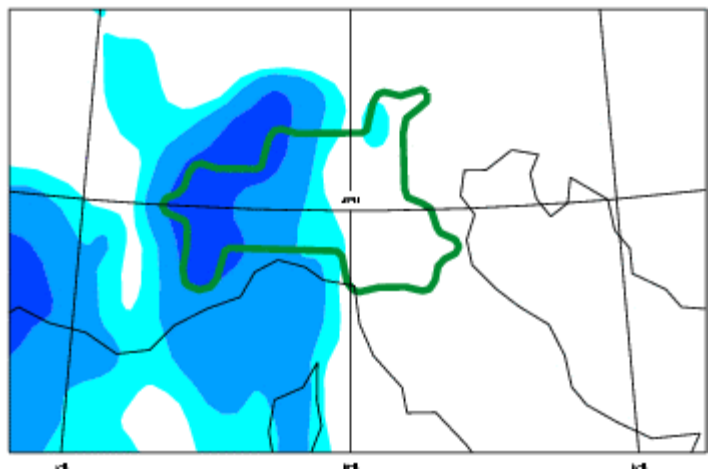
day 4

20000109 + 120-168 H



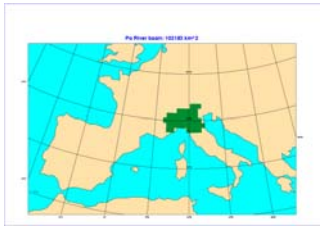
day 6

20000107 + 168-216 H



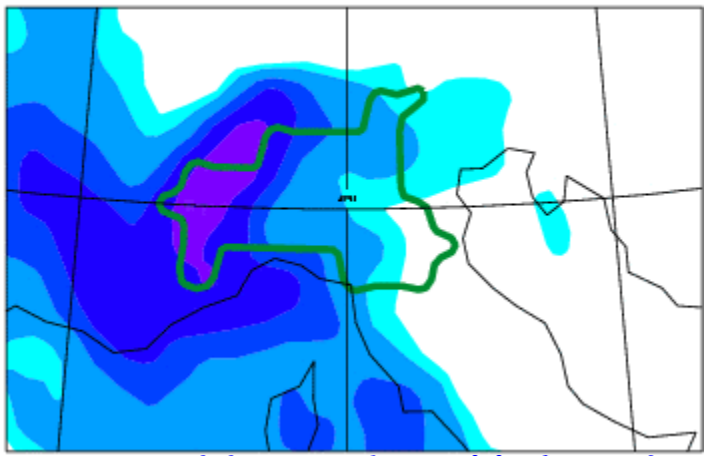
day 8

10 mm 20 50 80 120 160 240



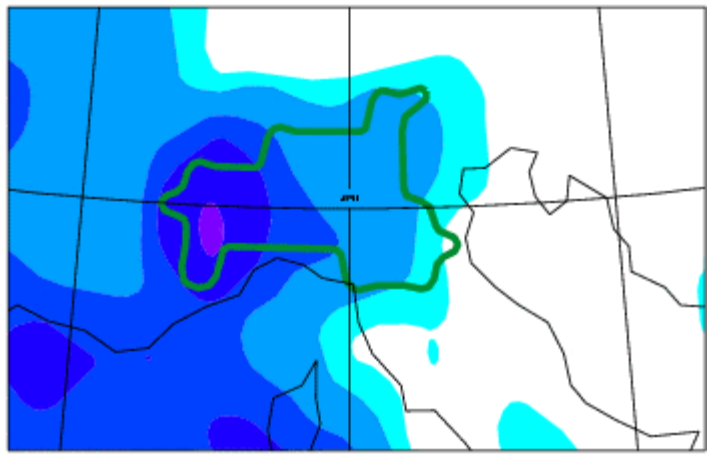
Impact of resolution on day 2 forecasts

20000113 + 24-72 H



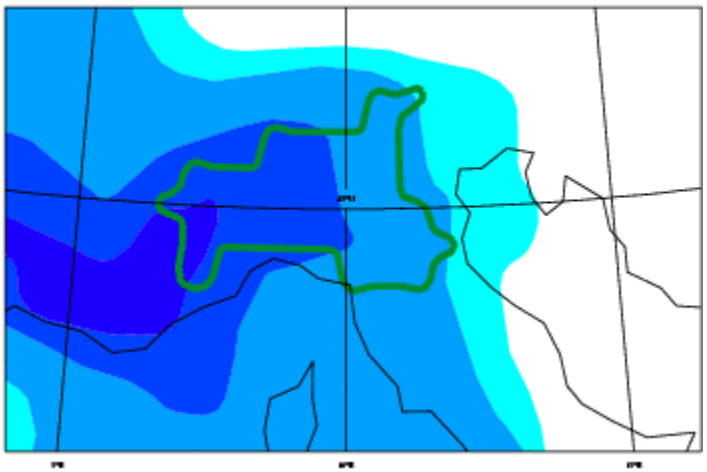
40 km

20000113 + 24-72 H (t319)



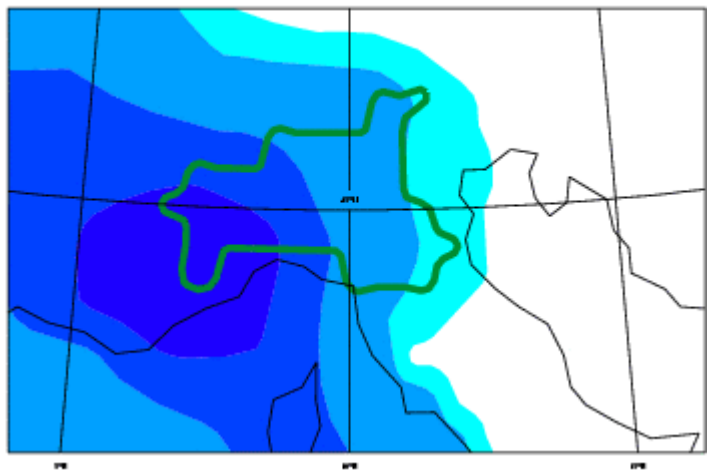
60 km

20000113 + 24-72 H (t255)



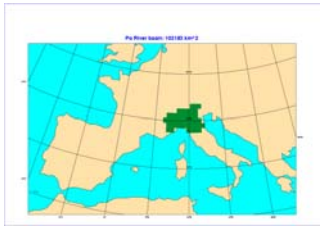
80 km

20000113 + 24-72 H (t159)

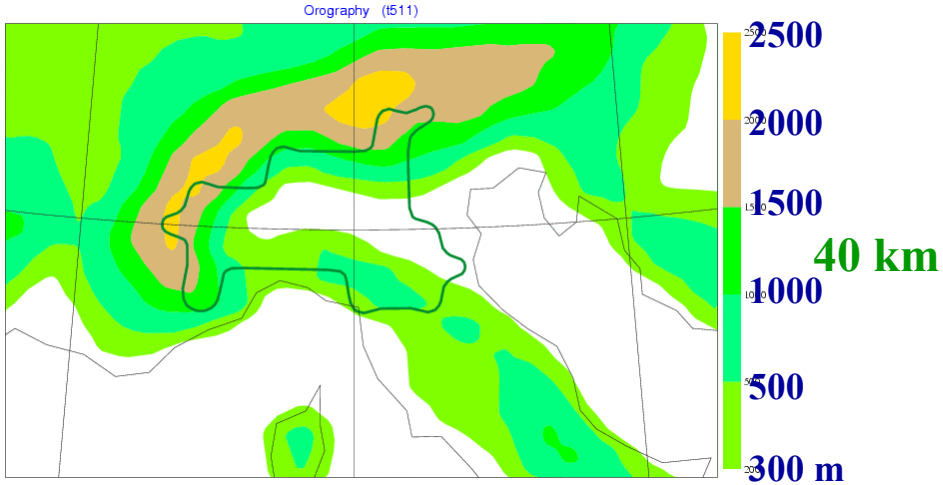


125 km

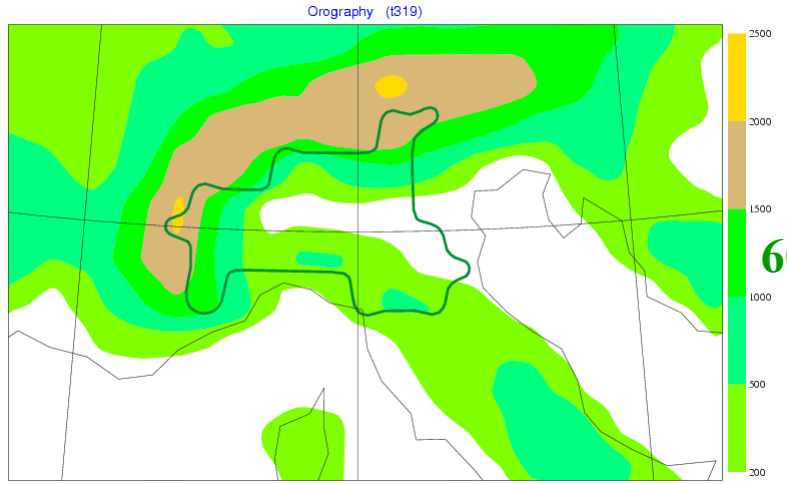
10 mm 20 50 80 120 160 240



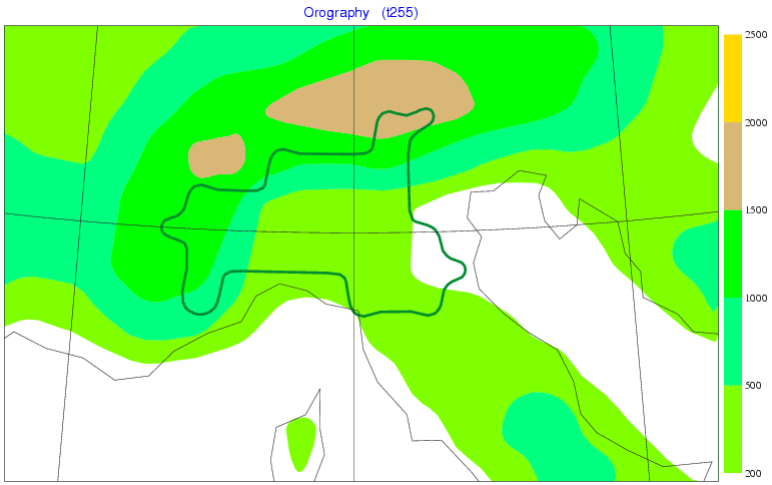
Orography and resolution



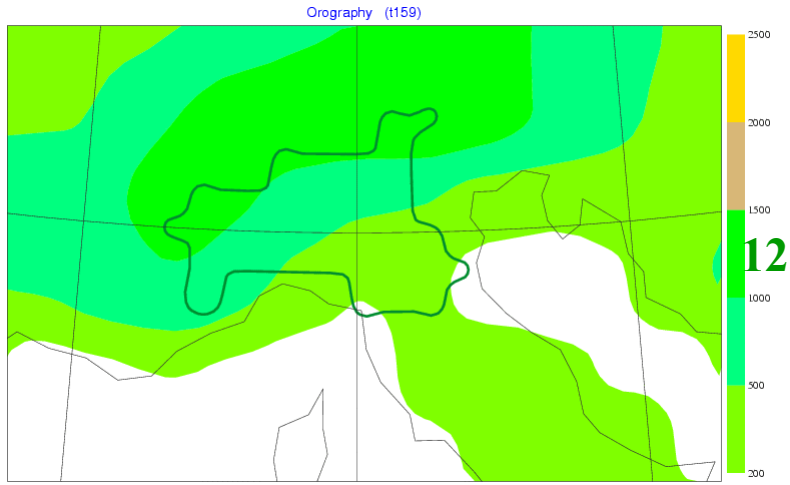
40 km



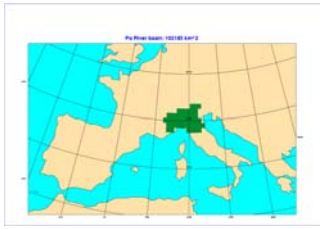
60 km



80 km



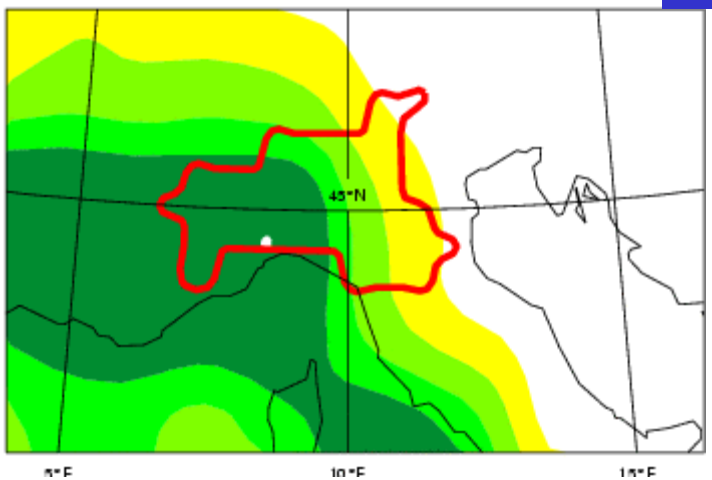
125 km



14th October: Probability of precipitation > 20 mm

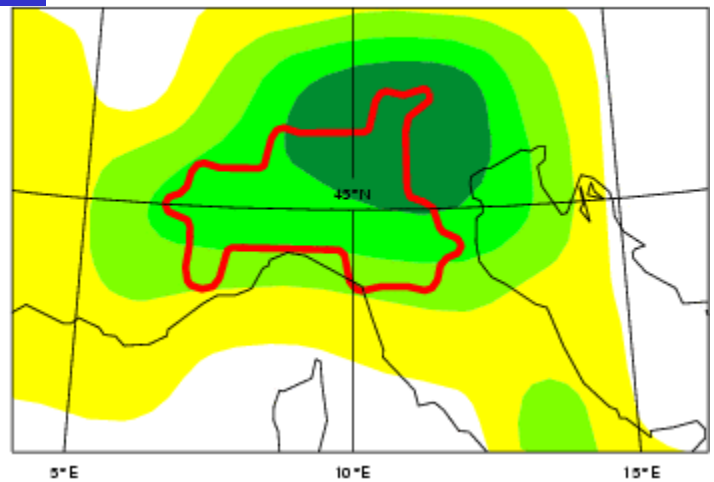
80 km

20000113 + 24-48 H precipitation exceeding 20 m



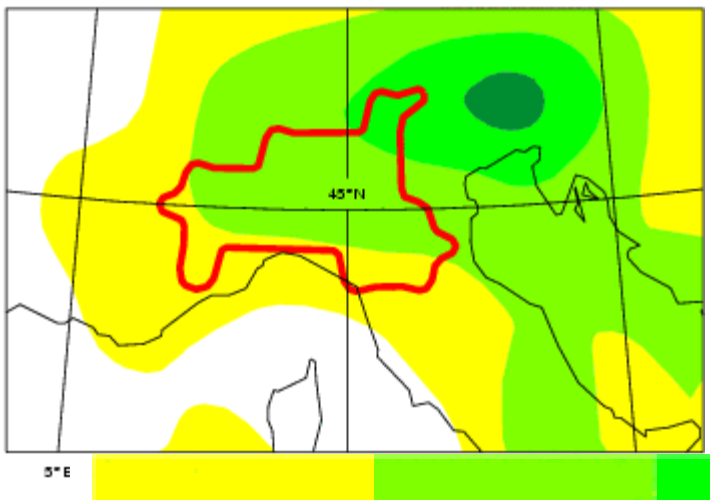
day 1

000111 + 72-96 H precipitation exceeding 20 mm



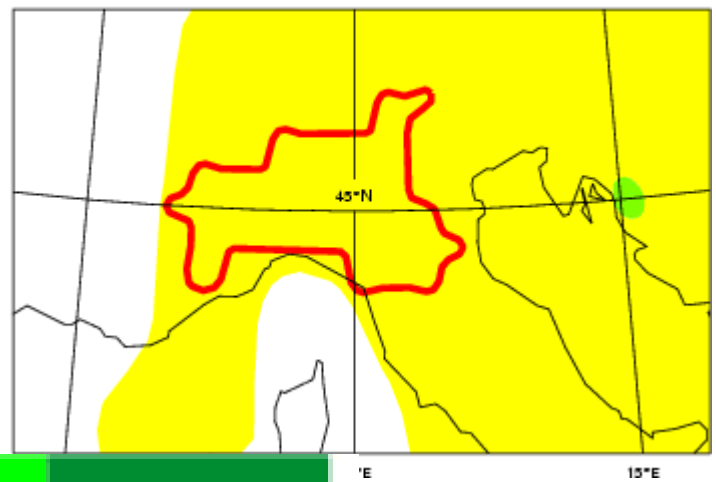
day 3

20000109 + 120-144 H precipitation exceeding 20 mm



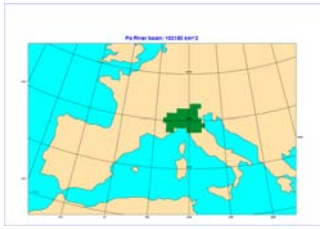
day 5

20000107 + 168-192 H precipitation exceeding 20 mm



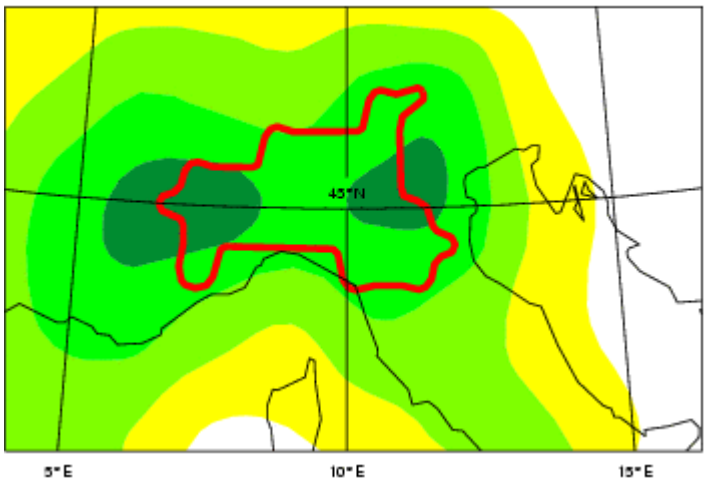
day 7

5% **25** **50** **75** **100%**

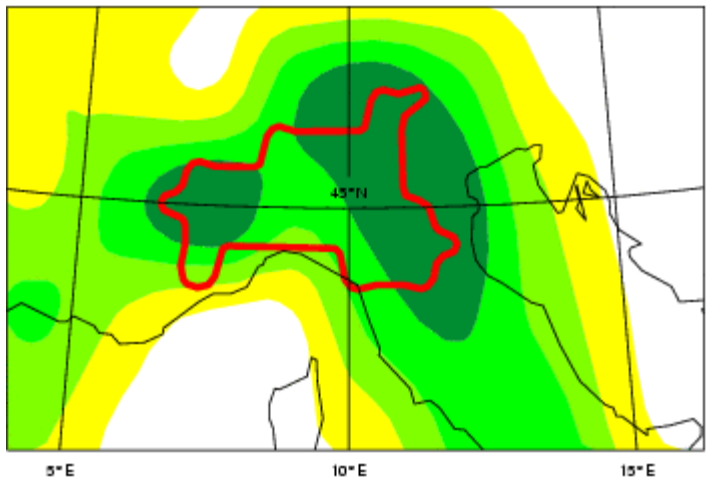


14th October: Resolution and precipitation probability (P > 20 mm)

20000112 + 48-72 H precipitation exceeding 20 mm (t159)

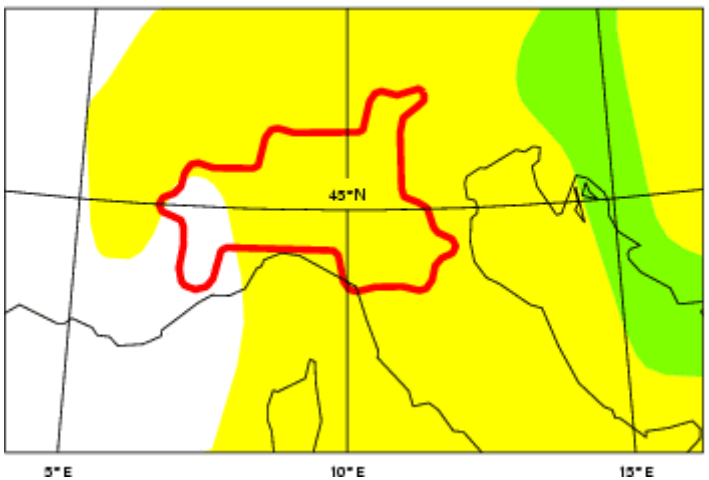


20000112 + 48-72 H precipitation exceeding 20 mm

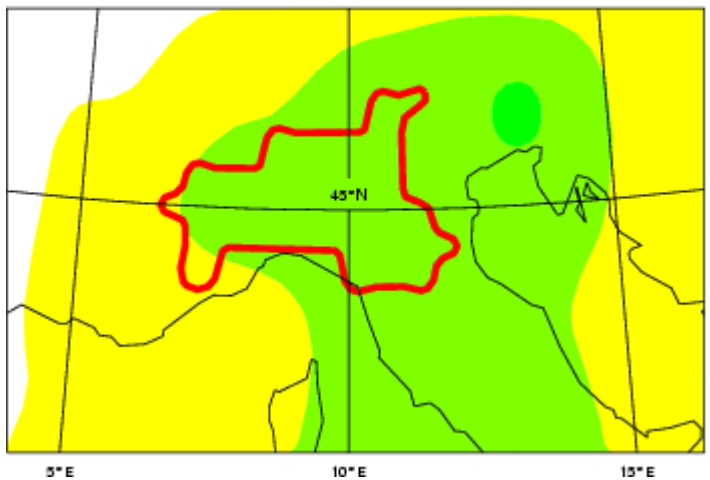


day 2

20000108 + 144-168 H precipitation exceeding 20 mm (t159)



20000108 + 144-168 H precipitation exceeding 20 mm

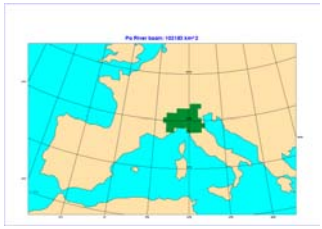


day 6

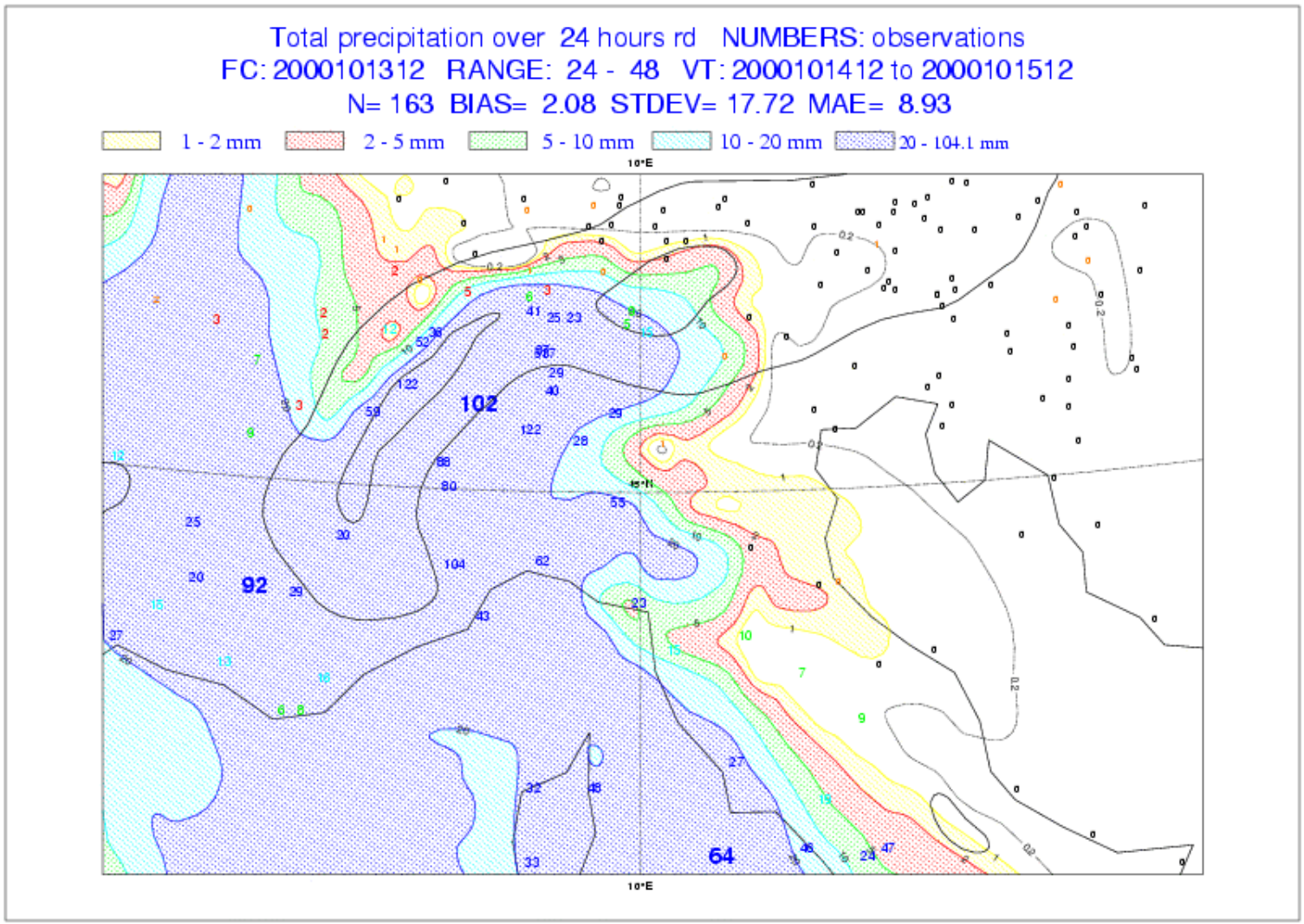
125 km

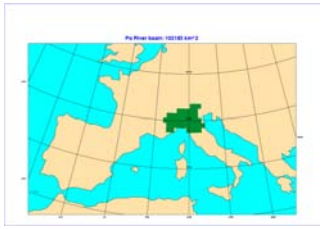
80 km

5% 25 50 75 100%



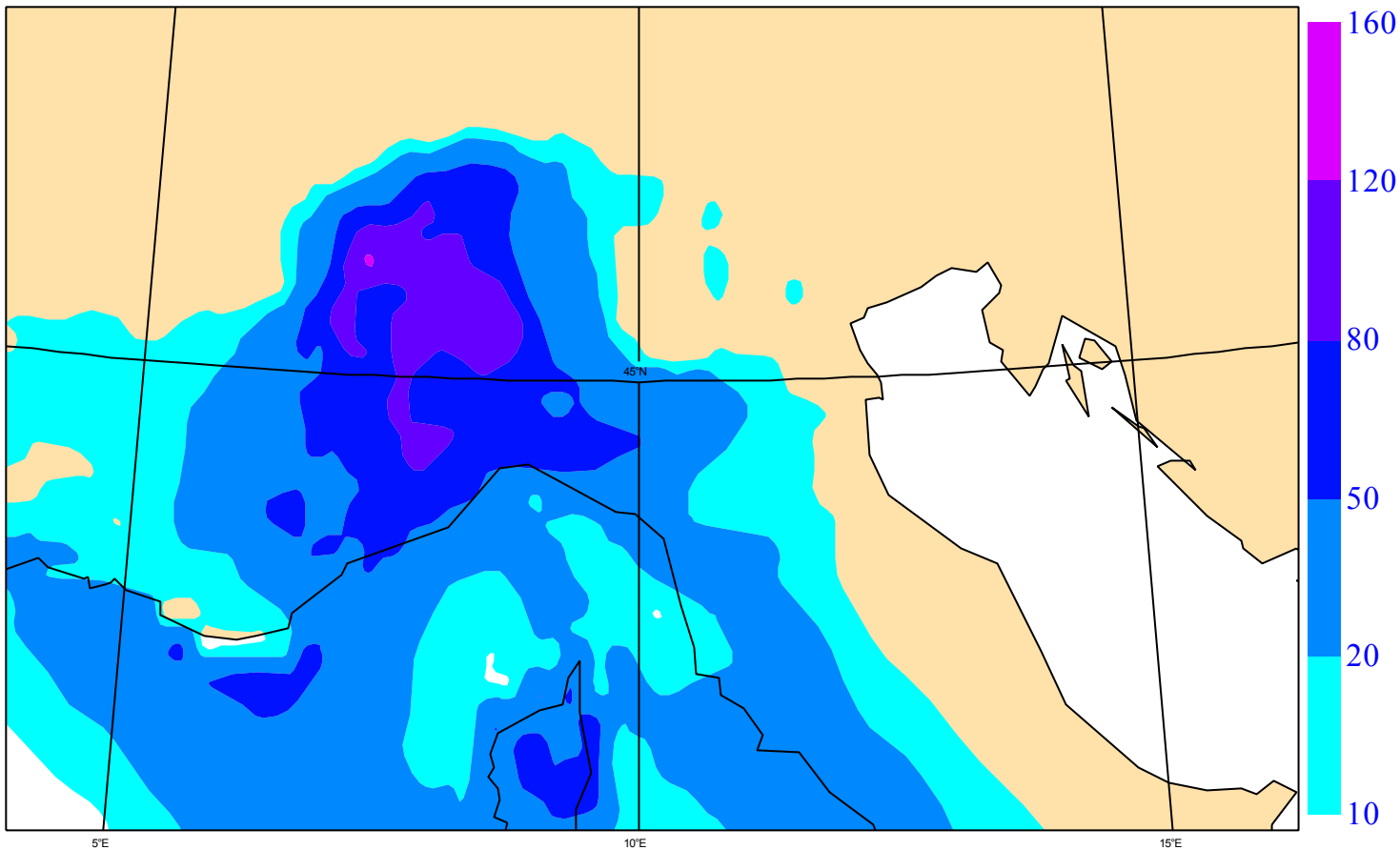
Verification



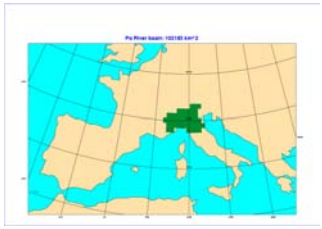


Verification (Precipitation analysis)

Precipitation analysis (ELDAS high-density gauge) 2000101412-1512

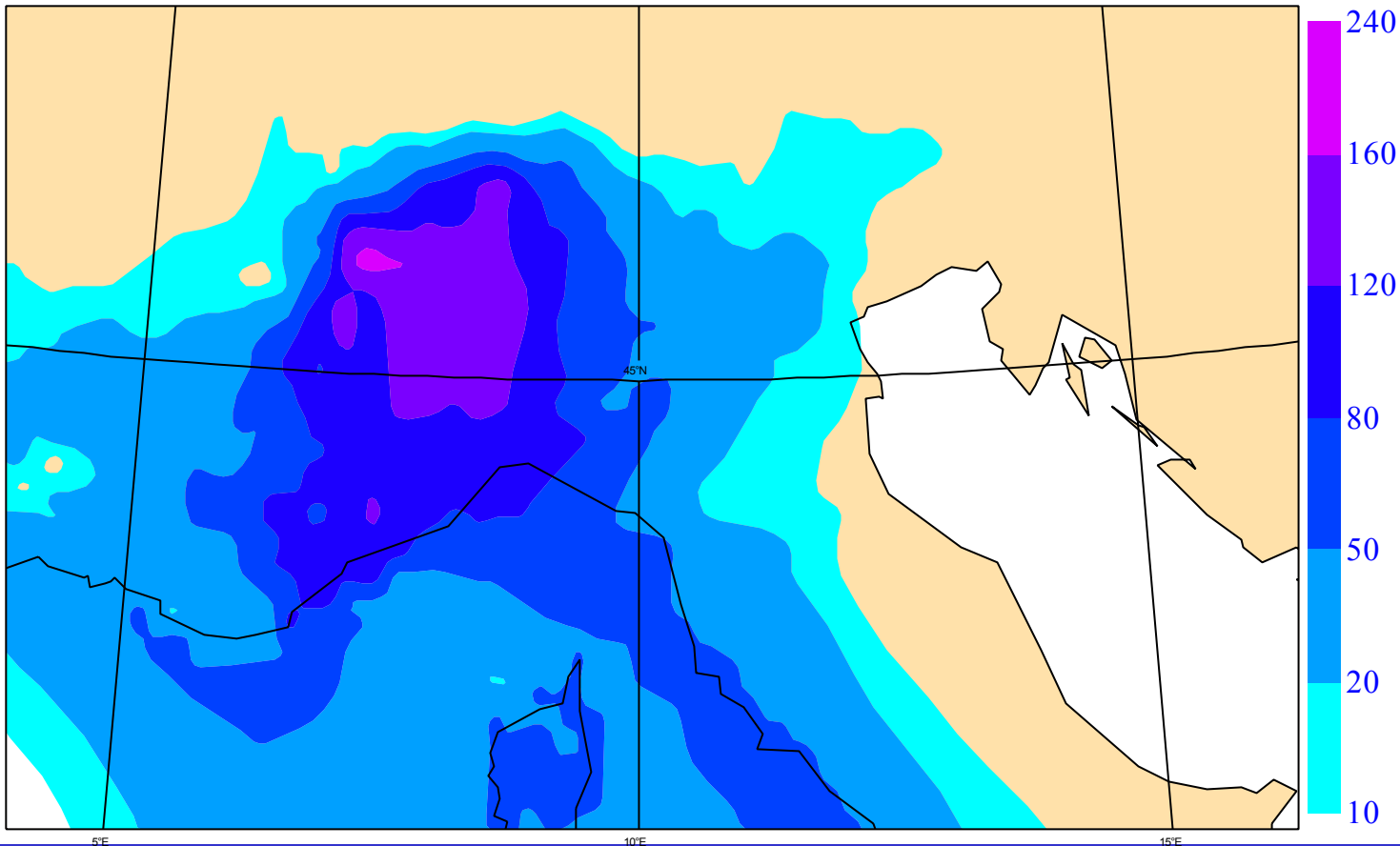


•**ELDAS (European Land Data Assimilation System) precipitation analysis: 0.2x0.2 deg, 3-hourly for the period 199910-200012**

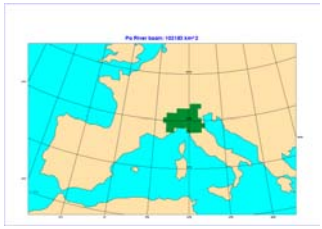


Verification (Precipitation analysis)

Precipitation analysis (ELDAS high-density gauge) 2000101412-1612



- **ELDAS (European Land Data Assimilation System) precipitation analysis: 0.2x0.2 deg, 3-hourly for the period 199910-200012**



Conclusions

- ECMWF forecasts of the Po events gave early warning (up to 8 days ahead) of heavy precipitation and flood risk
- The timing of the onset and tailing off of the main event (over the weekend 14-15 Oct) was well predicted up to 6-7 days in advance
- Spatial aggregation over basins and time integration improves reliability of results; Does it meet the demands of hydrologists and water managers?
- The use of the ensemble is crucial to attach a confidence to early warnings
- Resolution is essential to capture the timing, magnitude and spatial distribution of precipitation; It is also the key ingredient on the performance of the ensemble system
- Meaningful verification of precipitation is very difficult and, at the moment, impossible at the European scale, with no routine precipitation analysis available