POLITECNICO DI MILANO

An operational hydro-meteorological chain to evaluate the uncertainty in runoff forecasting over the Maggiore Lake basin

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Barcelona, 9 September 2009

Aim of the work

•Analysis of the performance of hydro-meteorological chain for flood forecasting on Maggiore Lake area (Italy)

• Check of the weather forecast errors (QPF)

• Check of the under/overestimation in the hydrological discharge forecasts (QDF)

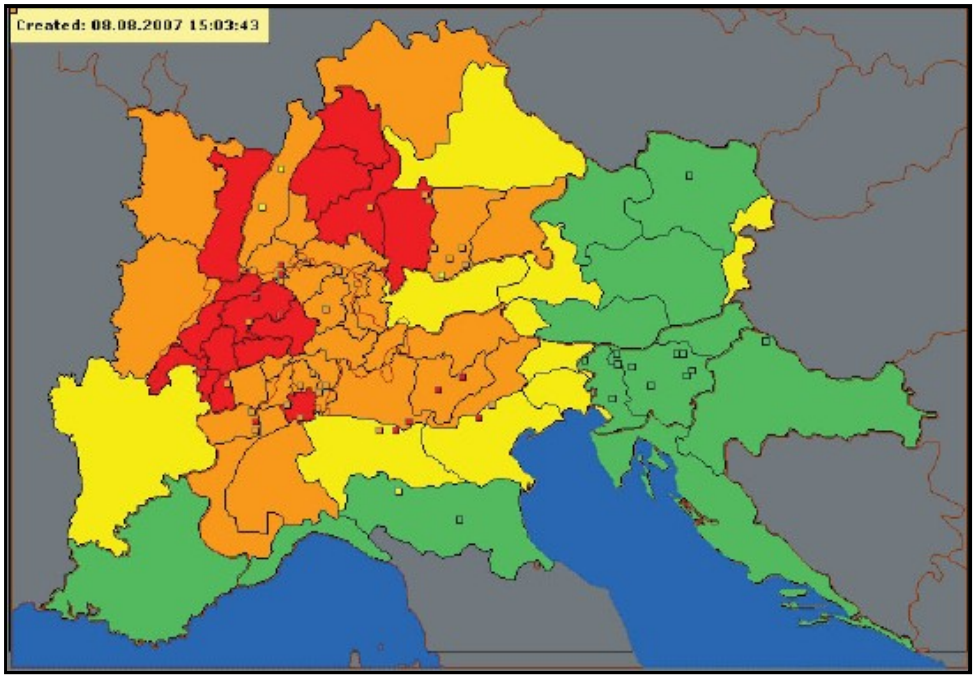
• Analysis at **different basin area**:
  - total precipitation
  - infiltrable water
  - runoff
  - **temperature**

MAP-D-PHASE Project

D-PHASE
a WWRP Forecast Demonstration Project

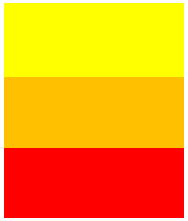
Mesoscale **A**lpine **P**rogramme - **D**emostration of **P**robabilistic **H**ydrological and **A**tmospheric **S**imulation of flood **E**vents in the Alpine region (Zappa et al. 2008, Rotach et al. 2009)

- Forecast and alert support decision system (experimental test)



Visualisation platform during the Map-D-Phase

Hydro-meteorological alert codes



→ Return period at least 60 days

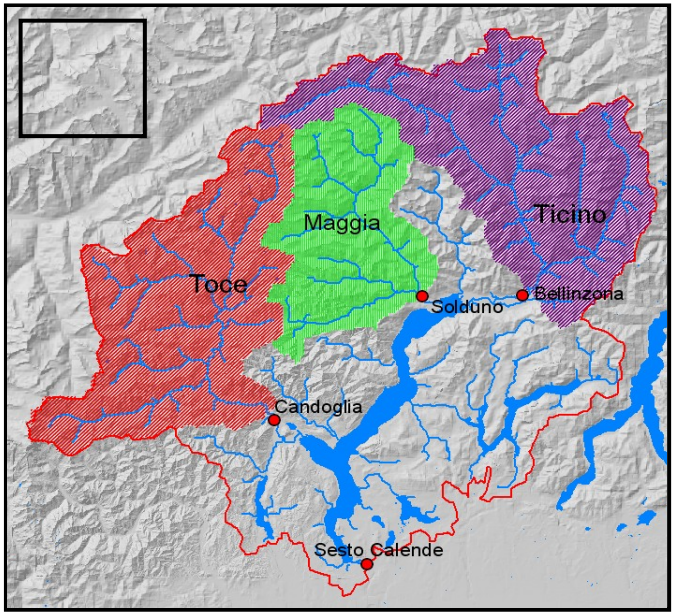
→ Return period at least 180 days

→ Return period at least 10 years

Simulation period

Period	Analysis type
June - September 2007	Post Processing
October - December 2007	Real Time
Now	Real Time

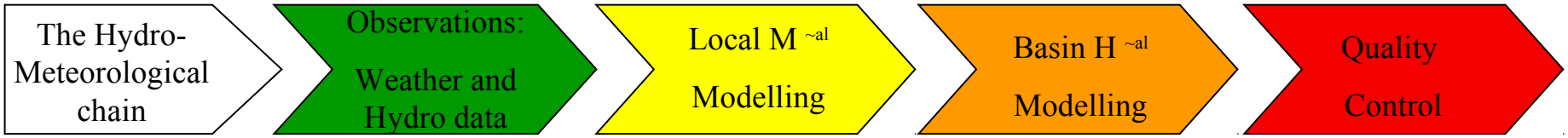
Area of study



MAGGIORE LAKE WATERSHED

Ticino basin: area (closed at Bellinzona)	1537 km^2
Toce basin: area (closed at Candoglia)	1534 km^2
Maggia basin: area (closed at Solduno)	902 km^2
Total area (Ticino, Toce, Maggia)	3983 km^2
Total Maggiore Lake: area (closed at Sesto Calende)	6598 km^2

The hydro-meteorological chain



• The hydro-meteorological chain includes both **probabilistic** forecasting based on ensemble prediction systems with lead time of a few days and short-range forecasts based on high resolution **deterministic** atmospheric models.

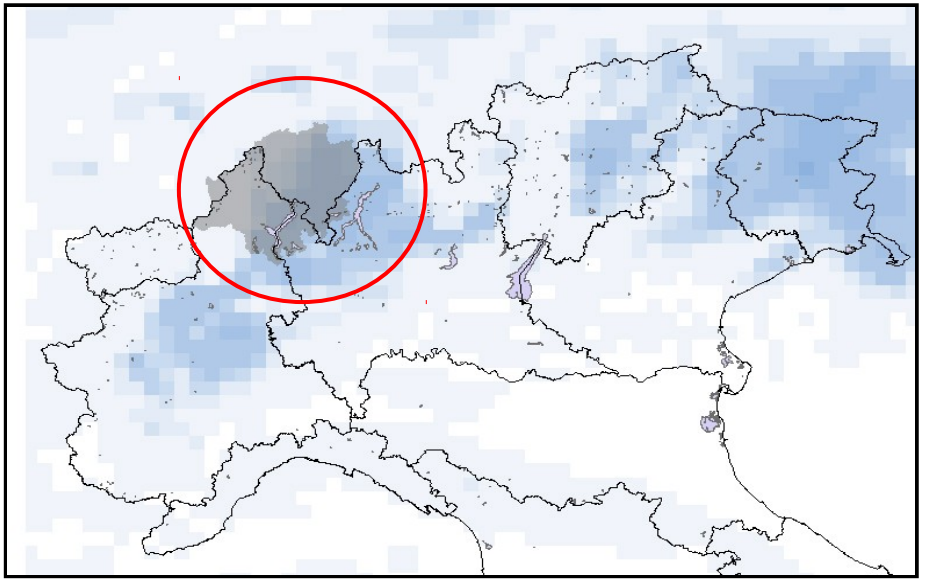
• The hydrological model used to generate the runoff simulations is the rainfall-runoff distributed **FEST-WB** model, developed at Politecnico di Milano. The initial hot start is sent daily by ARPA-Piemonte that runs the same model with weather observations.

• The analyzed events are: one moderate in the middle of **June** and one light at the end of **November 2007**.

Meteorological models

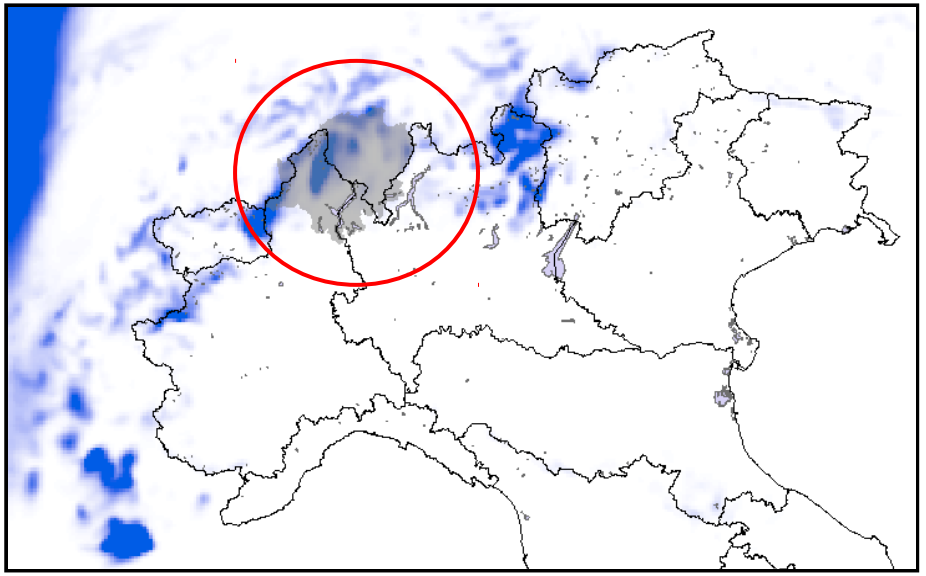
COSMO-LEPS Model (Marsigli et al. 2005)

- **Spatial Resolution:** 10.0 km (0.09°)
- **Temporal Resolution:** 3 h
- **Vertical levels:** 40 (non-hydrostatic)
- **Ensemble members: 16** nested on ECMWF EPS
- **Forecast range:** +132 h
- **Run starting at:** 12:00 Z
- **Owner:** ARPA Emilia-Romagna

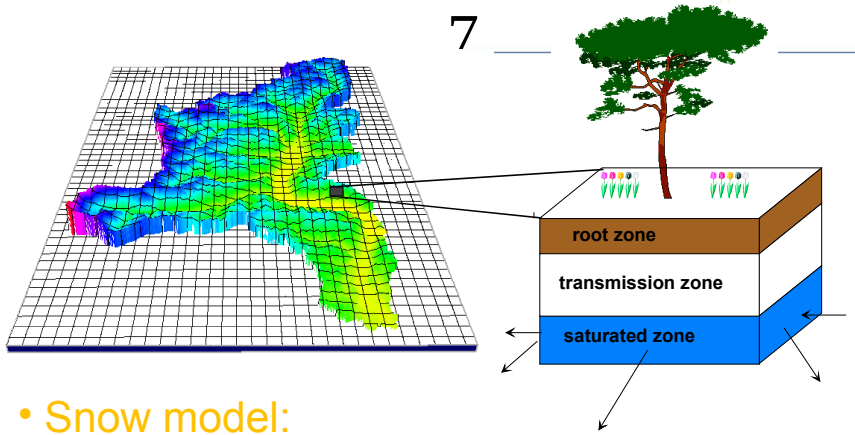


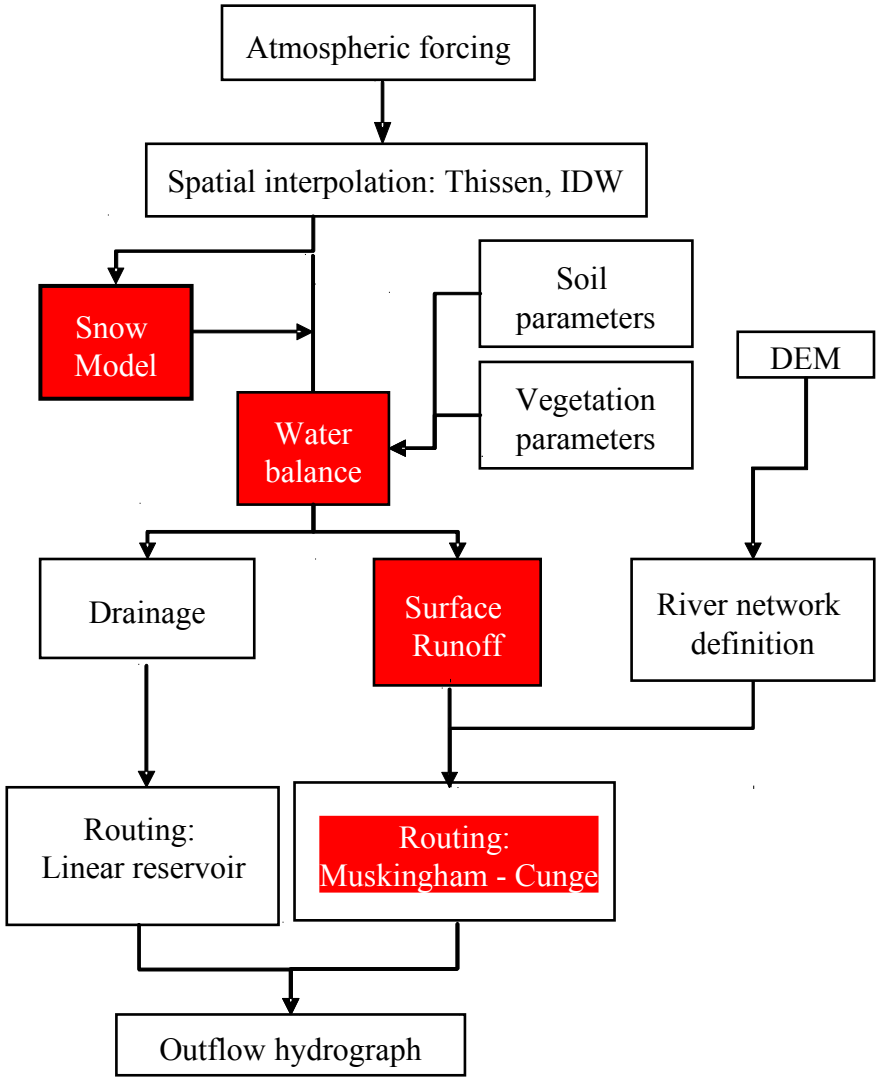
MOLOCH Model (Davolio et al. 2007)

- **Spatial Resolution:** 2.2 km (0.02°)
- **Temporal Resolution:** 1 h
- **Vertical levels:** 50 (non-hydrostatic)
- **Deterministic model,** nested on BOLAM, nested on ECMWF
- **Forecast range:** +48 h
- **Run starting at:** 00:00 Z
- **Owner:** ISAC-CNR



Hydrological model: FEST-WB





Full scheme of the rainfall-runoff distributed hydrological model FEST-WB, physically based (Rabuffetti et al., 2008)

- Snow model:
  - snow accumulation dynamics

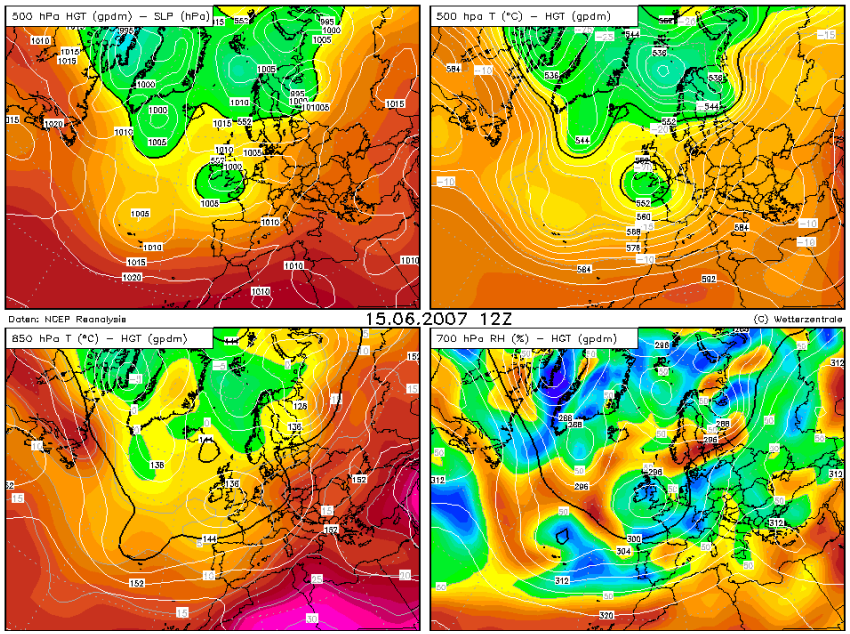
$$\begin{cases} P_L = \alpha P \\ P_S = (1-\alpha) P \end{cases} \qquad \begin{aligned} \alpha_p &= 0 && T_a < T_{\inf} \\ \alpha_p &= \frac{T_a - T_{\inf}}{T_{\sup} - T_{\inf}} && T_{\inf} < T_a < T_{\sup} \\ \alpha_p &= 1 && T_a > T_{\sup} \end{aligned}$$

  - melting model

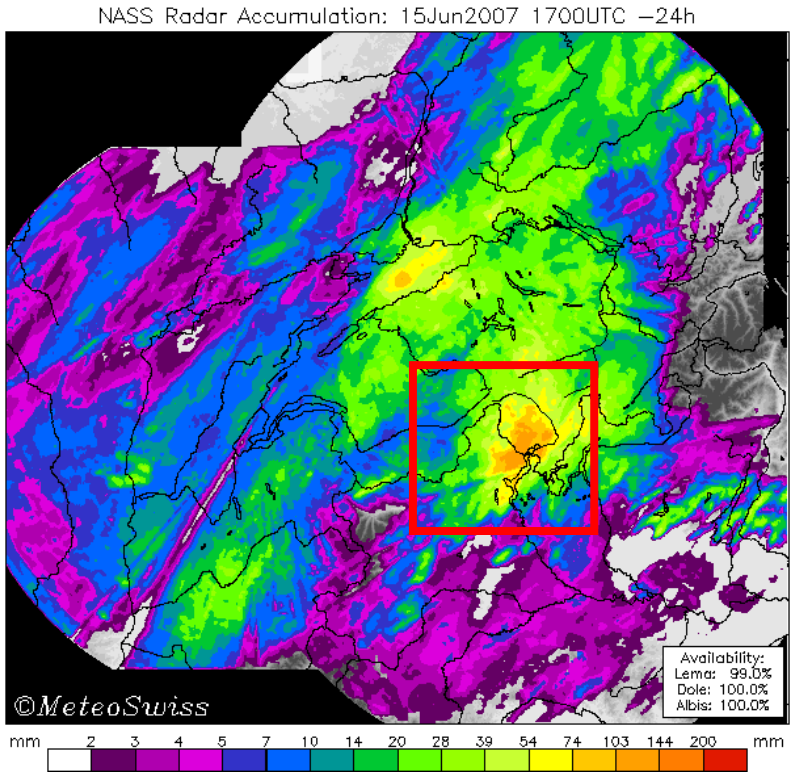
$$M_s = C_m (T_a - T_b)$$

- Water balance: estimation of ET_P with Priestley-Taylor empirical formula
- Surface runoff: Runoff is computed according to a modified SCS-CN method extended for continuous simulation (Ravazzani et al., 2007)
- Routing: The surface flow routing is based on the Muskingum-Cunge method in its non-linear form with the time variable celerity (Montaldo et al. 2007)

13-15 June 2007 event



Synoptic analysis over Europe: 15 June



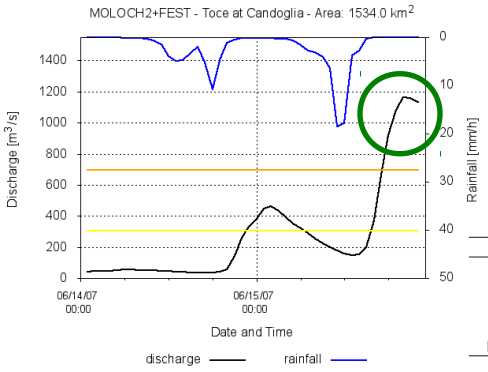
Radar accumulation over Maggiore Lake basin: 14-15 June

Day	Toce	Ticino	Maggia
13 June 2007	4.9	7.4	6.9
14 June 2007	16.3	24.6	20.6
15 June 2007	68.2	72.7	82.1
Total	**89.4**	**104.7**	**109.6**

Basin mean rainfall (mm) over Toce, Ticino and Maggia basins

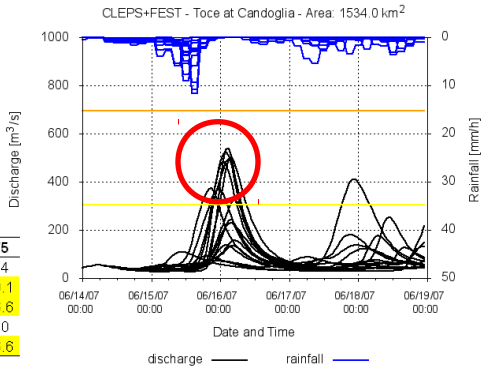
H ~al simulations start at 14-06-07 00UTC

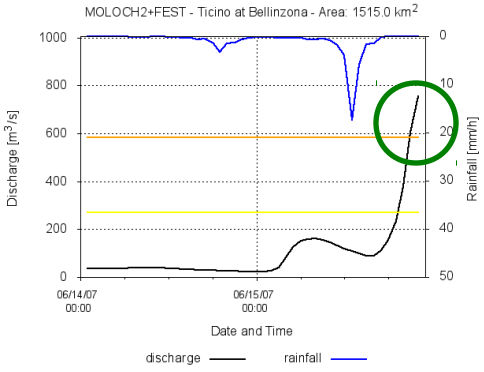
13-15 June 2007 event



Toce basin

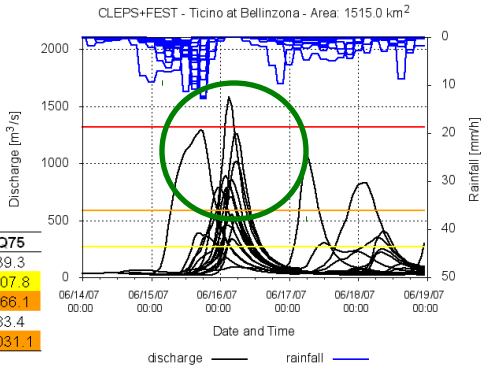
Days	Observed	Simulated Fest	Moloch2	Ensemble Min	Max	Mean	Median	St. Dev.	Q25	Q75
14/06/2007	132.1	55.4	328.4	55.4	55.5	55.4	55.4	0.0	55.4	55.4
15/06/2007	783.2	750.7	1162.3	63.5	437.0	219.5	153.0	138.8	103.4	369.1
16/06/2007	448.0	605.8		57.4	537.1	288.4	259.9	176.1	136.0	486.6
17/06/2007	221.3	54.2		41.2	410.9	95.7	63.1	92.3	51.6	94.0
Max Discharge (m3/s)	783.2	750.7	1162.3	92.5	537.1	319.9	347.0	162.7	151.8	486.6

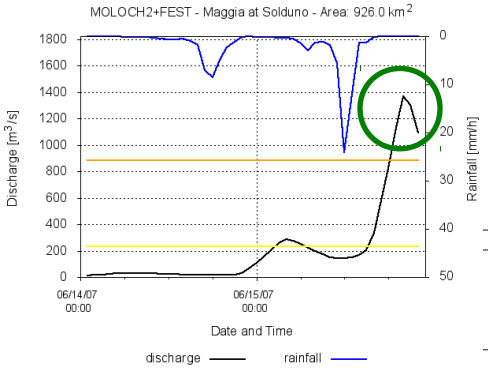




Ticino basin

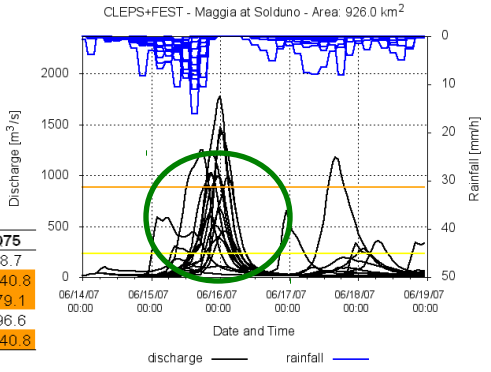
Days	Observed	Simulated Fest	Moloch2	Ensemble Min	Max	Mean	Median	St. Dev.	Q25	Q75
14/06/2007	124.5	39.1	39.2	39.1	65.1	40.9	39.2	6.5	39.2	39.3
15/06/2007	761.5	1210.4	753.9	41.4	1289.1	344.2	223.7	338.6	97.7	507.8
16/06/2007	440.5	1037.1		95.3	1580.1	705.7	629.2	368.1	466.8	866.1
17/06/2007	154.3	59.1		48.6	1073.1	154.1	79.7	254.5	59.5	83.4
Max Discharge	761.5	1210.4	753.9	335.9	1580.1	823.8	793.9	347.8	529.2	1031.1



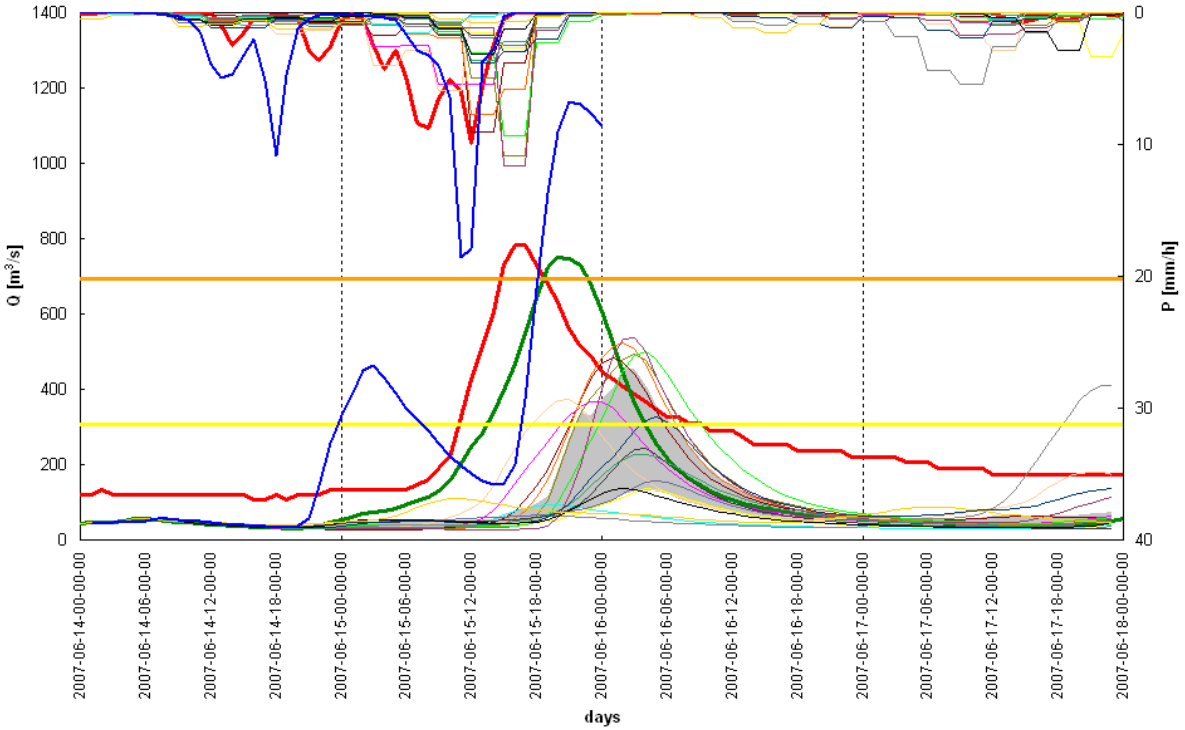


Maggia basin

Days	Observed	Simulated Fest	Moloch2	Ensemble Min	Max	Mean	Median	St. Dev.	Q25	Q75
14/06/2007	11.2	24.3	63.5	38.4	102.6	42.7	38.5	16.0	38.5	38.7
15/06/2007	941.7	956.4	1366.1	110.7	1737.1	841.1	830.7	464.7	540.5	1240.8
16/06/2007	446.4	325.6		28.3	1775.9	733.4	623.0	499.4	436.0	979.1
17/06/2007	91.0	14.8		14.1	1182.4	180.4	51.7	306.5	19.9	196.6
Max Discharge (m3/s	941.7	956.4	1366.1	110.7	1775.9	917.0	988.5	448.5	617.1	1240.8



Toce basin



Q&P Observed

Q Simulated

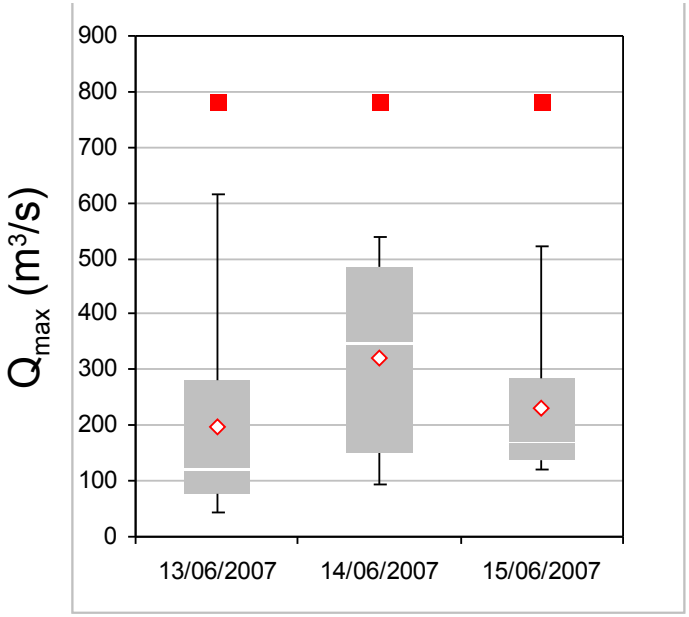
Q&P Moloch

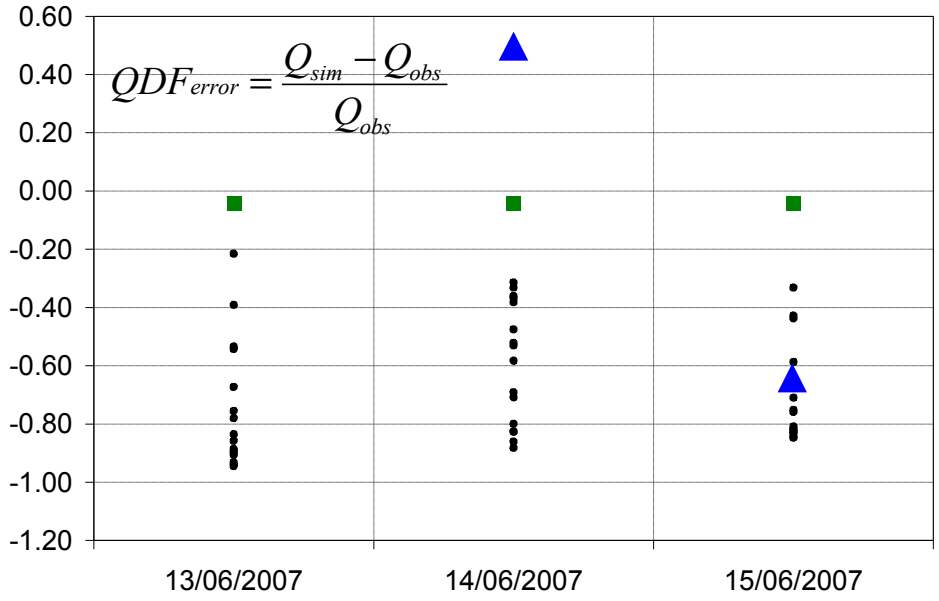
Q25th-Q75th

Mean

Median

Min-Max





Toce subbasins

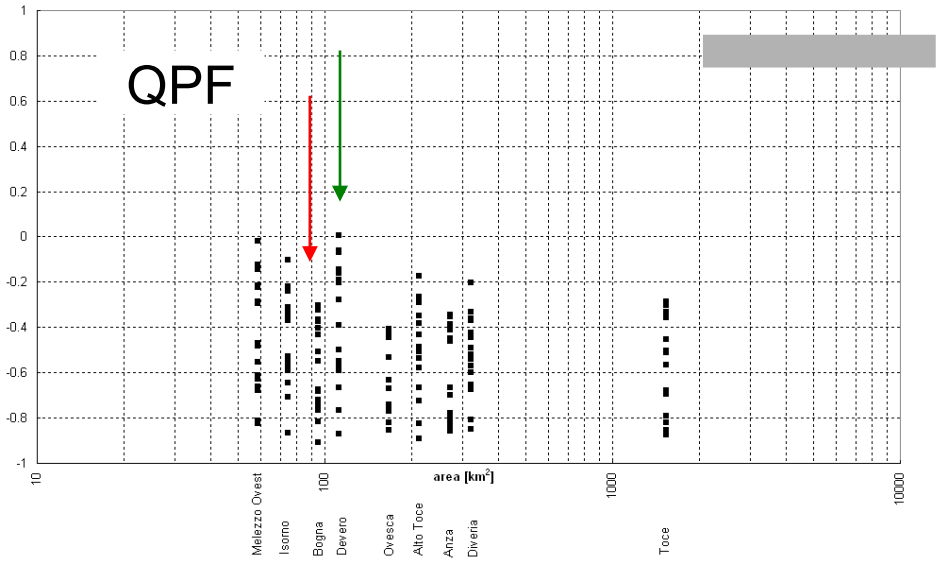
Q&P Observed

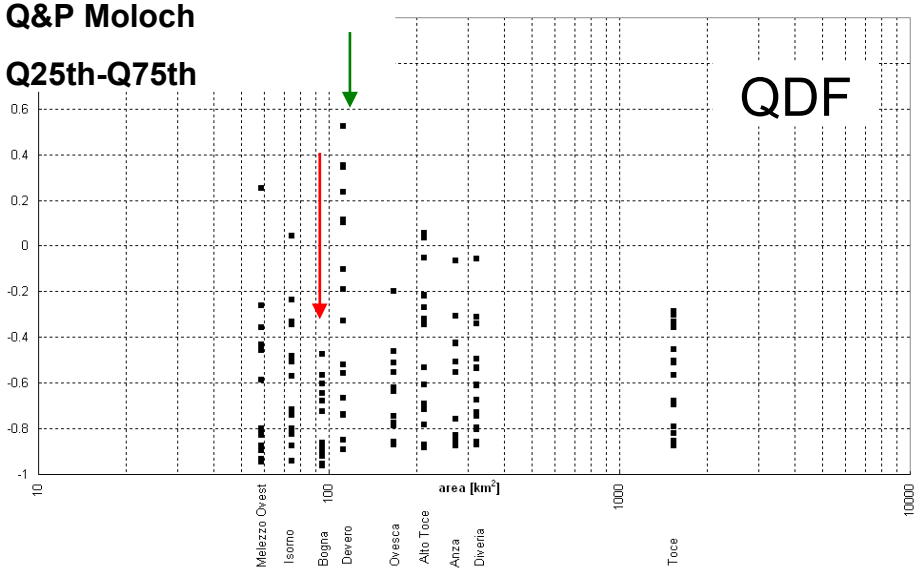
Q&P Ensemble median

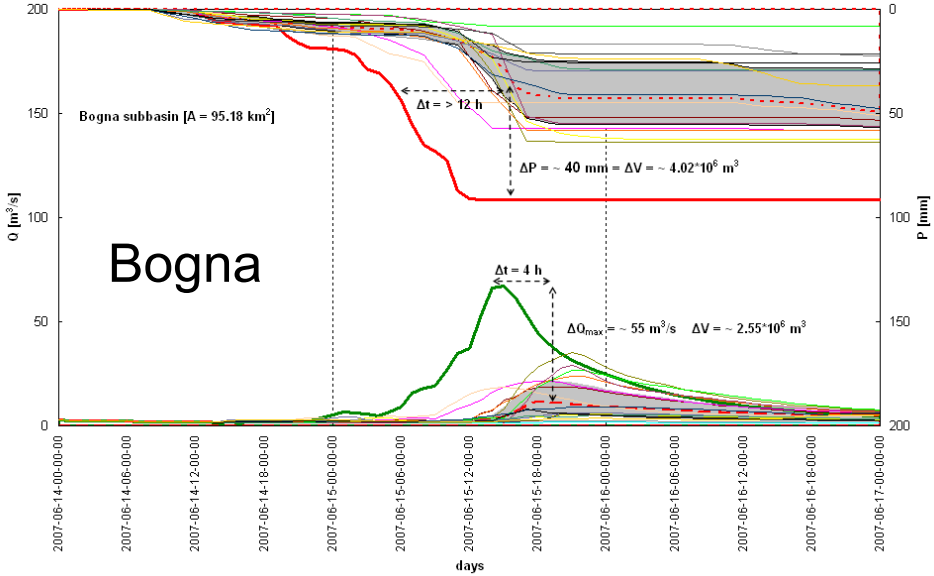
Q Simulated by FEST-WB

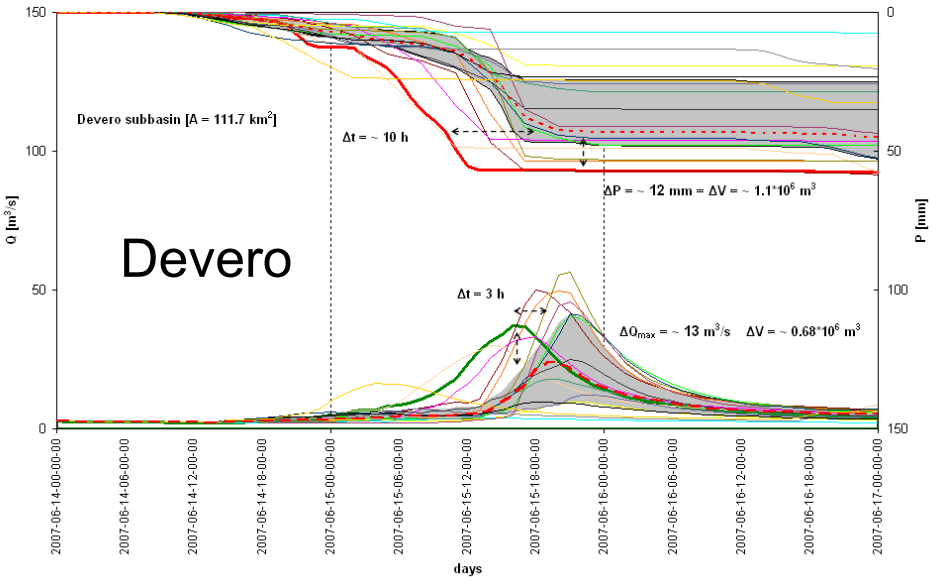
Q&P Moloch

Q25th-Q75th

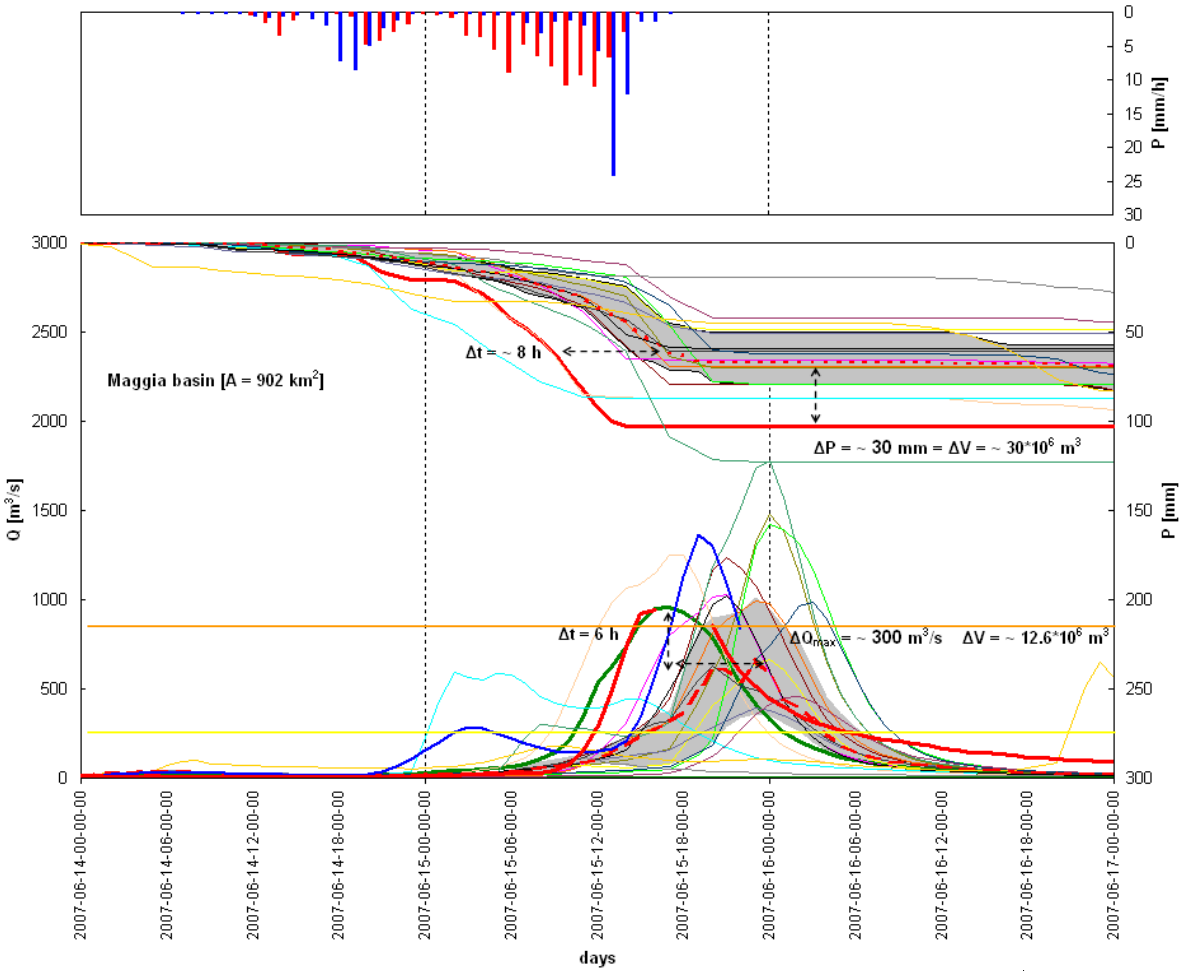








Maggia basin



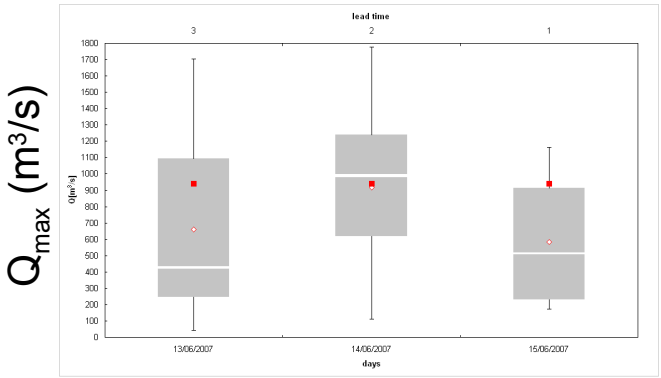
Q&P Observed

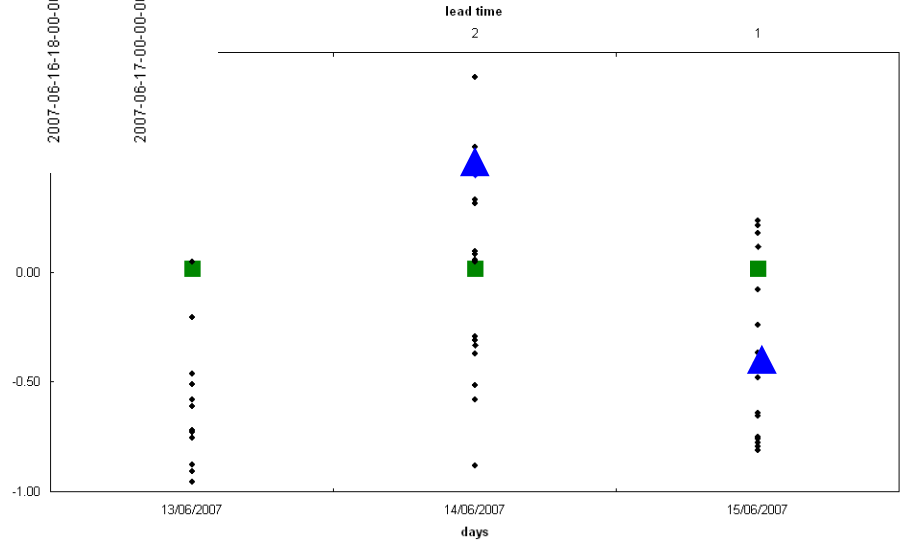
Q&P ensemble median

Q Simulated by FEST-WB

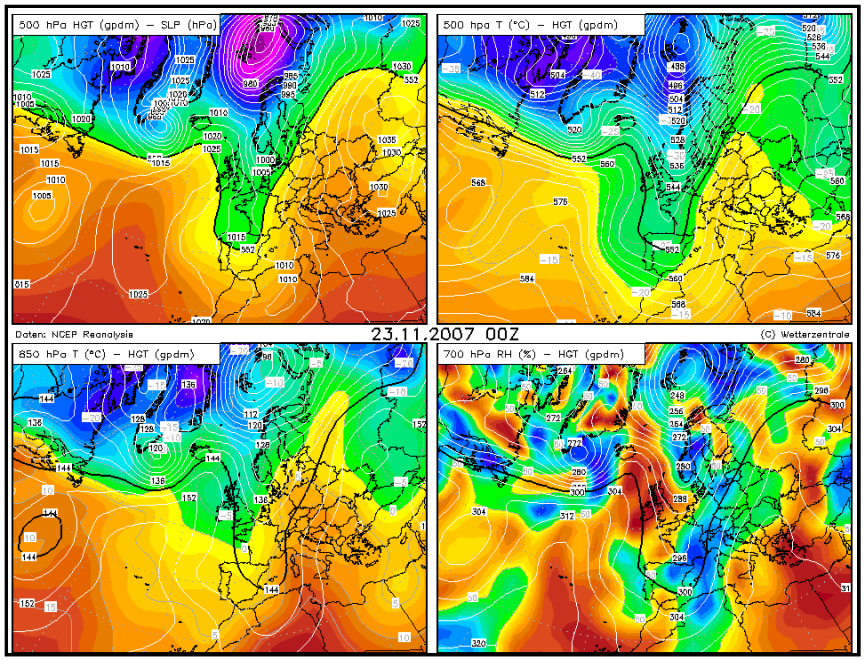
Q&P Moloch

Q25th-Q75th



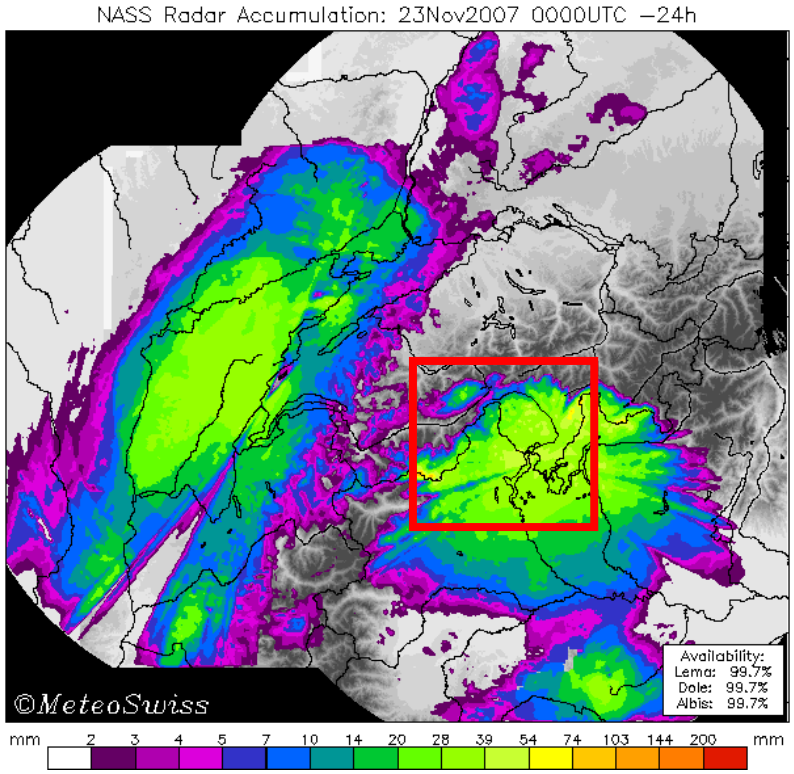


21-23 November 2007 event



Synoptic analysis over Europe: 23 November

Day	Toce	Ticino	Maggia
13 November 2007	5.3	3.3	7.1
14 November 2007	27.7	27.6	37.0
15 November 2007	37.1	37.0	42.3
Total	**70.1**	**67.9**	**86.4**

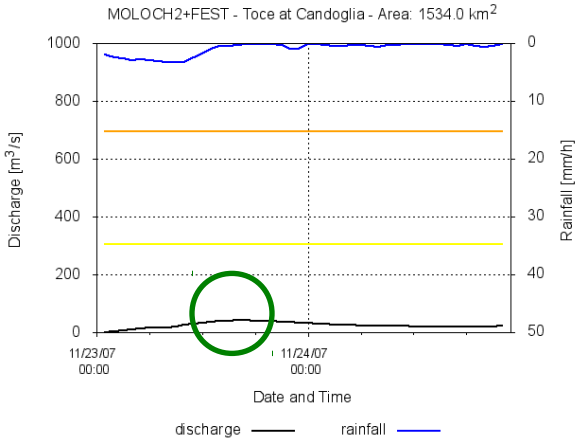


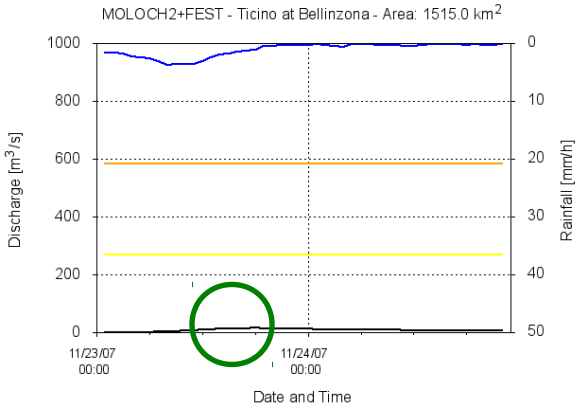
Radar accumulation over Maggiore Lake basin: 22-23 November

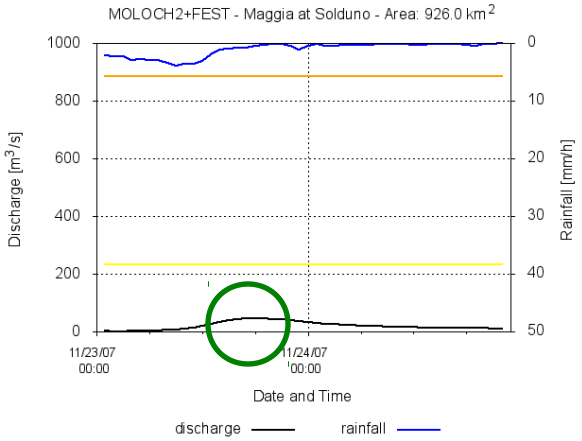
Basin mean precipitation (mm) over Toce, Ticino and Maggia basins

H ~al simulations start at 23-11-07 00UTC

21-23 November 2007 event





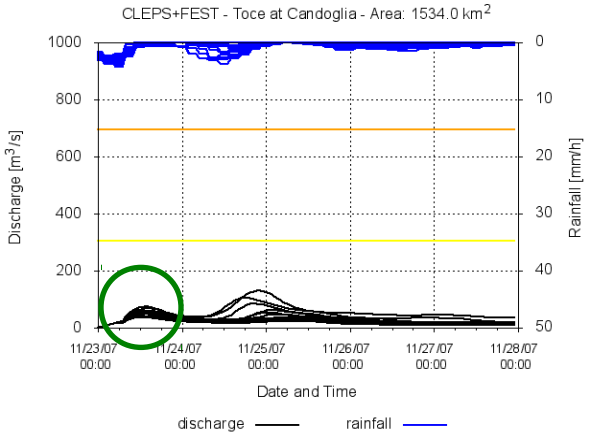


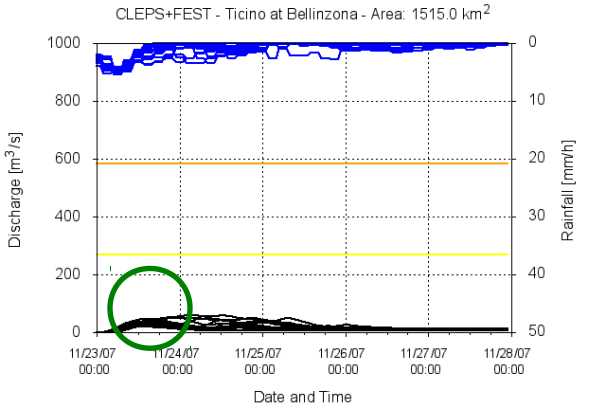
Toce basin

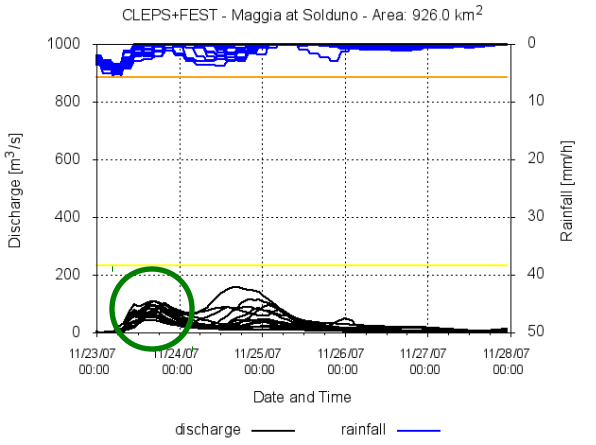
Ticino basin

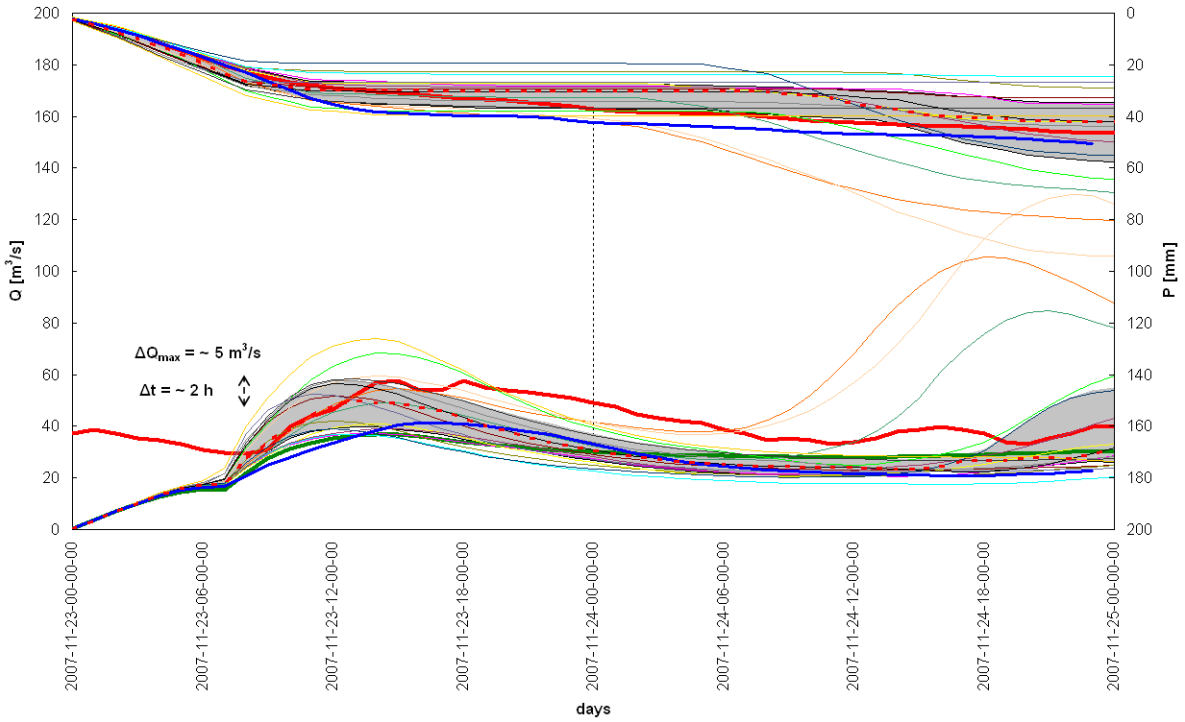
Maggia basin

NO ALERT



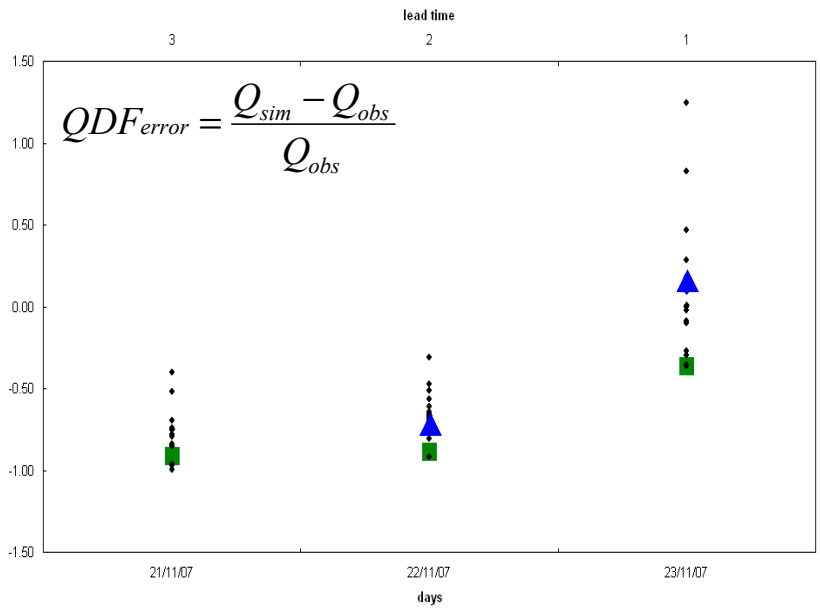


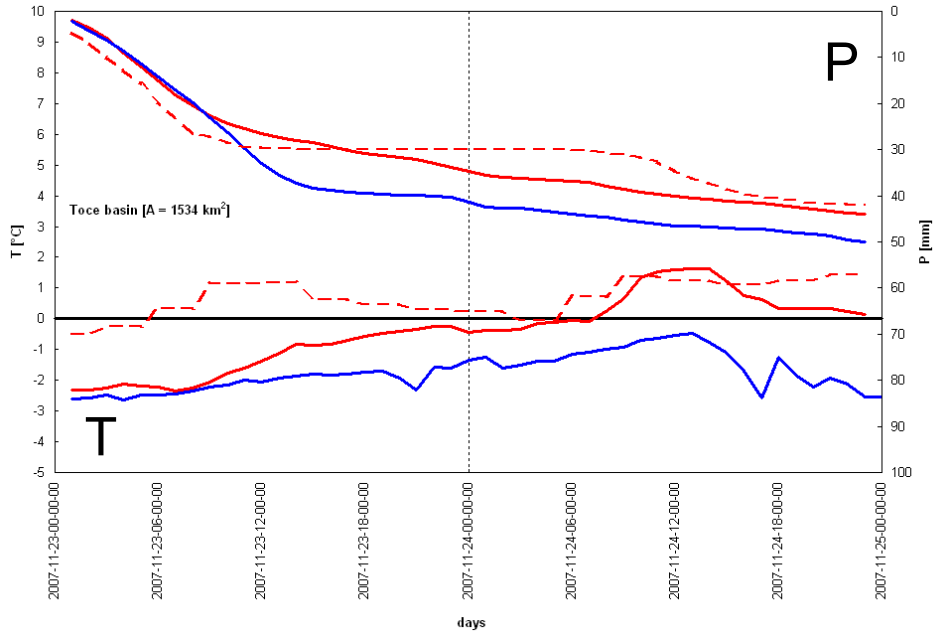


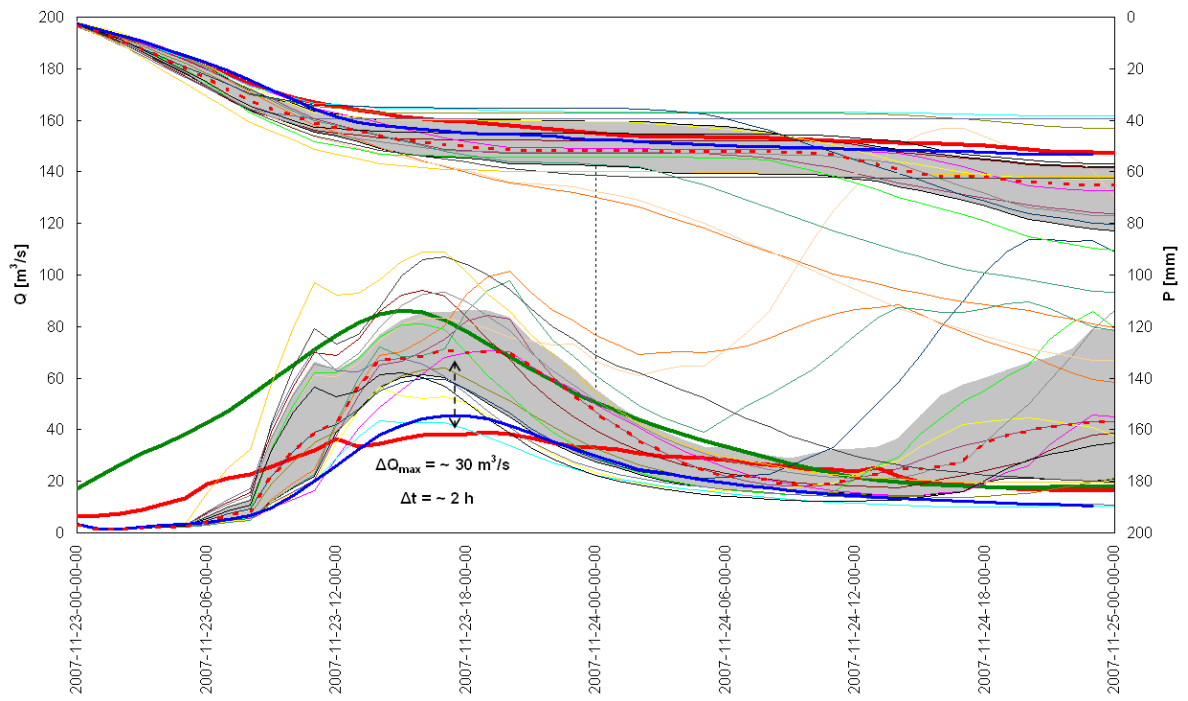


Toce basin

- Q,P,T Observed
- Q,P,T Ensemble median
- Q Simulated by FEST-WB
- Q,P,T Moloch
- Q25th-Q75th

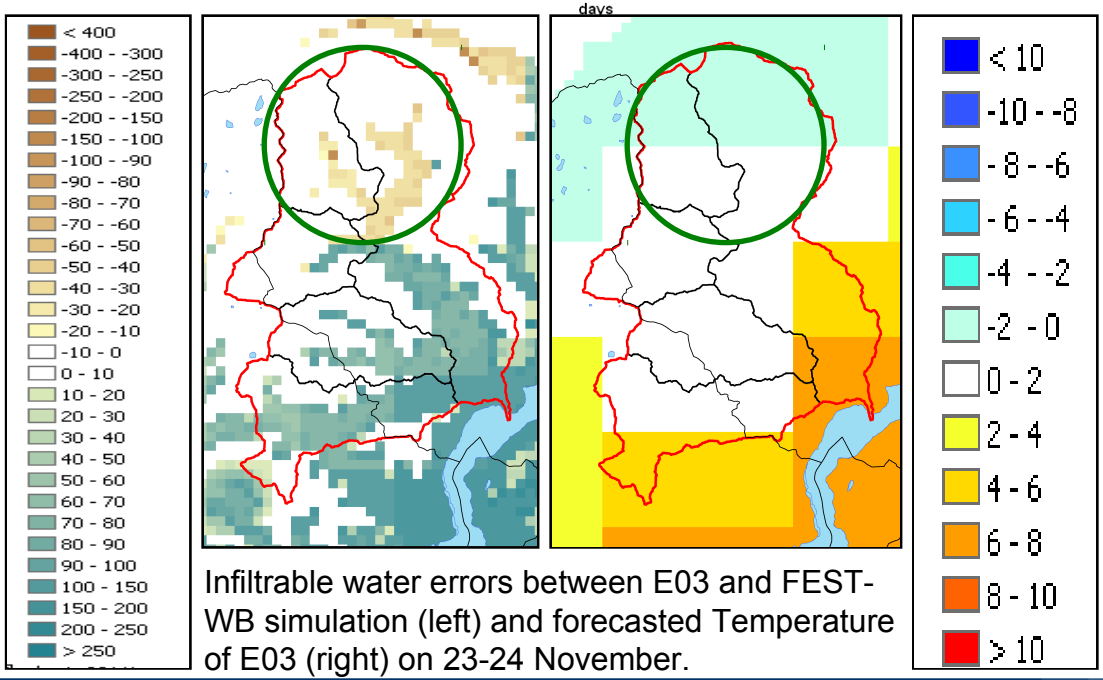




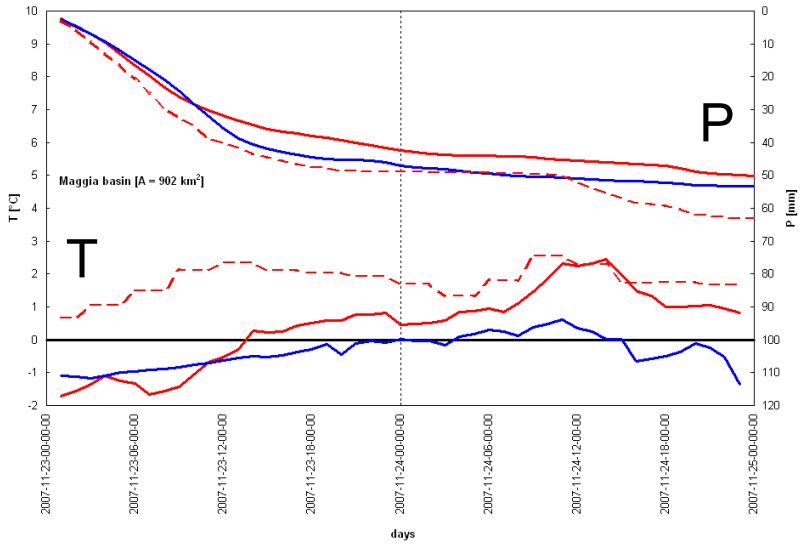


Maggia basin

- Q,P,T Observed
- Q,P,T Ensemble median
- Q Simulated by FEST-WB
- Q,P,T Moloch
- Q25th-Q75th



Infiltrable water errors between E03 and FEST-WB simulation (left) and forecasted Temperature of E03 (right) on 23-24 November.



Concluding Remarks

• Two issues that, in our opinion, emerge from the work and that are important to be better investigated for applications in flood prediction in mountain basins

1) Analyse flood prediction at different spatial scale, important to manage alert for small scale basins.

2) Investigate air temperature forecasted by meteorological models and its effect on the simulation of big floods.

Necessity to extend analysis to a significant number of events (ongoing)

Acknowledgments

•Thanks to ARPA Emilia-Romagna (A. Montani) for its contribute in providing COSMO-LEPS model data…

•…to ISAC-CNR (S. Davolio) for MOLOCH model data…

•…and to ARPA Piemonte for weather and hydrological observation data.

Thanks for your attention

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