Testing FEST-WB, a continuous distributed model for operational Quantitative Discharge Forecast in the upper Po River

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International Workshop on Hydrological Extremes

Analyses and images of hydrological extremes in Mediterranean environments

University of Calabria,
Soil Conservation Department,
10–12 July 2008

OBJECTS

To develop a distributed, grid, physically based hydrological model for continuous simulation (with soil moisture account)

To co-operate with the existing warning system of Regione Piemonte for real time flood forecasting in basins between 400 to 4000 km^2

Part of:

Application des méthodologies de prévisions hydro-météorologiques orientées aux risques environnementaux

https://amphore.medocc.org/

Demonstration of Probabilistic Hydrological and Atmospheric Simulation of flood Events in the Alpine region

http://www.map.meteoswiss.ch/map-doc/dphase/dphase_info.htm

OUTLINE OF PRESENTATION

1st SECTION

Presentation of the hydrological model and some results of calibration and validation activity

2nd SECTION

The hydrological model is coupled to meteorological models for the real time forecasting of one flood event on the River Toce

Nat. Hazards Earth Syst. Sci., 8, 161–173, 2008
www.nat-hazards-earth-syst-sci.net/8/161/2008/

Natural Hazards and Earth System Sciences

Verification of operational Quantitative Discharge Forecast (QDF) for a regional warning system – the AMPHORE case studies in the upper Po River

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THE DISTRIBUTED MODEL

Origin

FEST: *Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation*

CURVE NUMBER

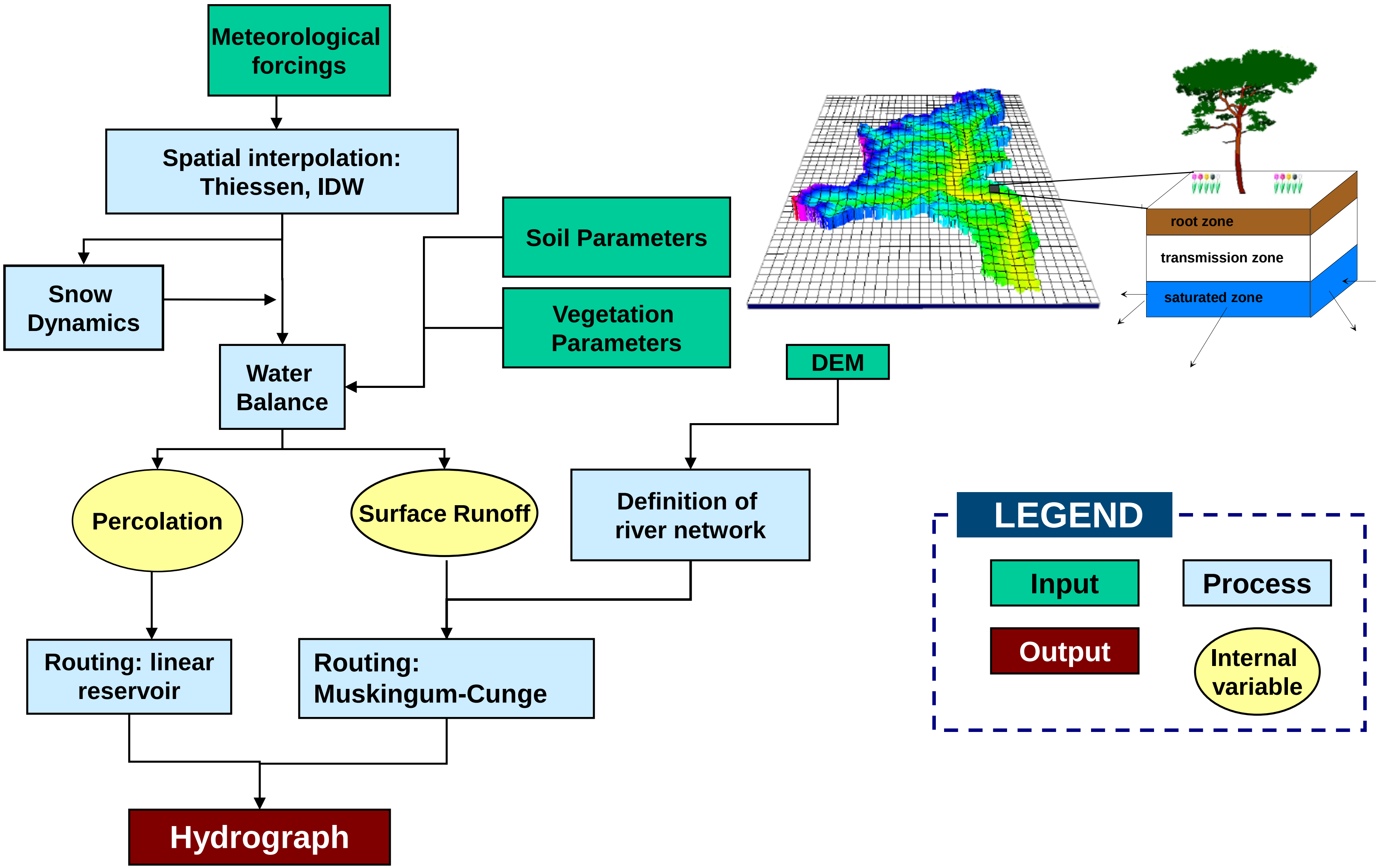
↓

SVAT

FEST-WB: *Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation –* ***including Water Balance***

THE FEST-WB MODEL

Flow-chart of main components



SCS-CN (1956) modified for continuous simulation

$$I = P_{TOT} - R$$

$Ia = 0{,}2\ S$

$$R = \frac{(P_{TOT} - Ia)^2}{P - Ia + S}$$

I = infiltration

P_{TOT} = precipitation

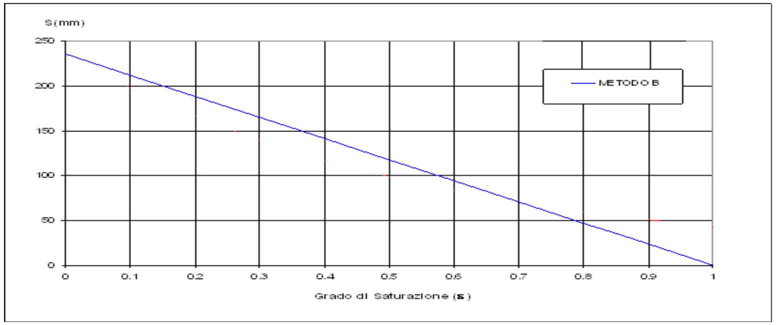
R = runoff

Ia = initial abstraction

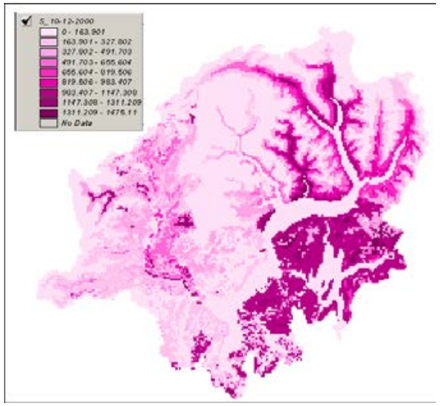
The soil maximum retention capacity, *S*, is a function of degree of saturation (ε)

$$\varepsilon_t = \frac{\theta_t - \theta_{res}}{\theta_{sat} - \theta_{res}}$$

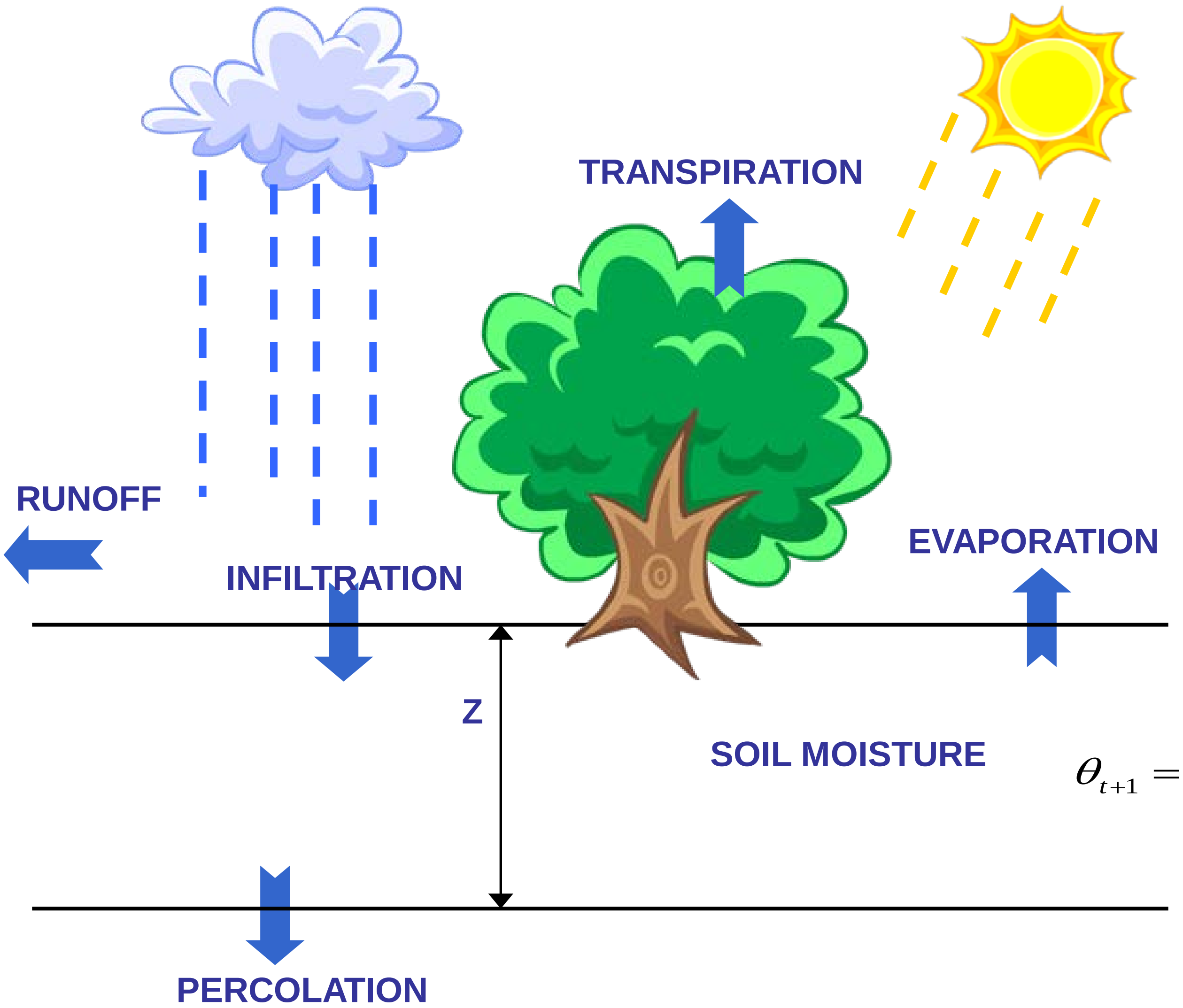
$$S_t = S_1 \cdot (1 - \varepsilon_t)$$



S at the beginning af a flood event



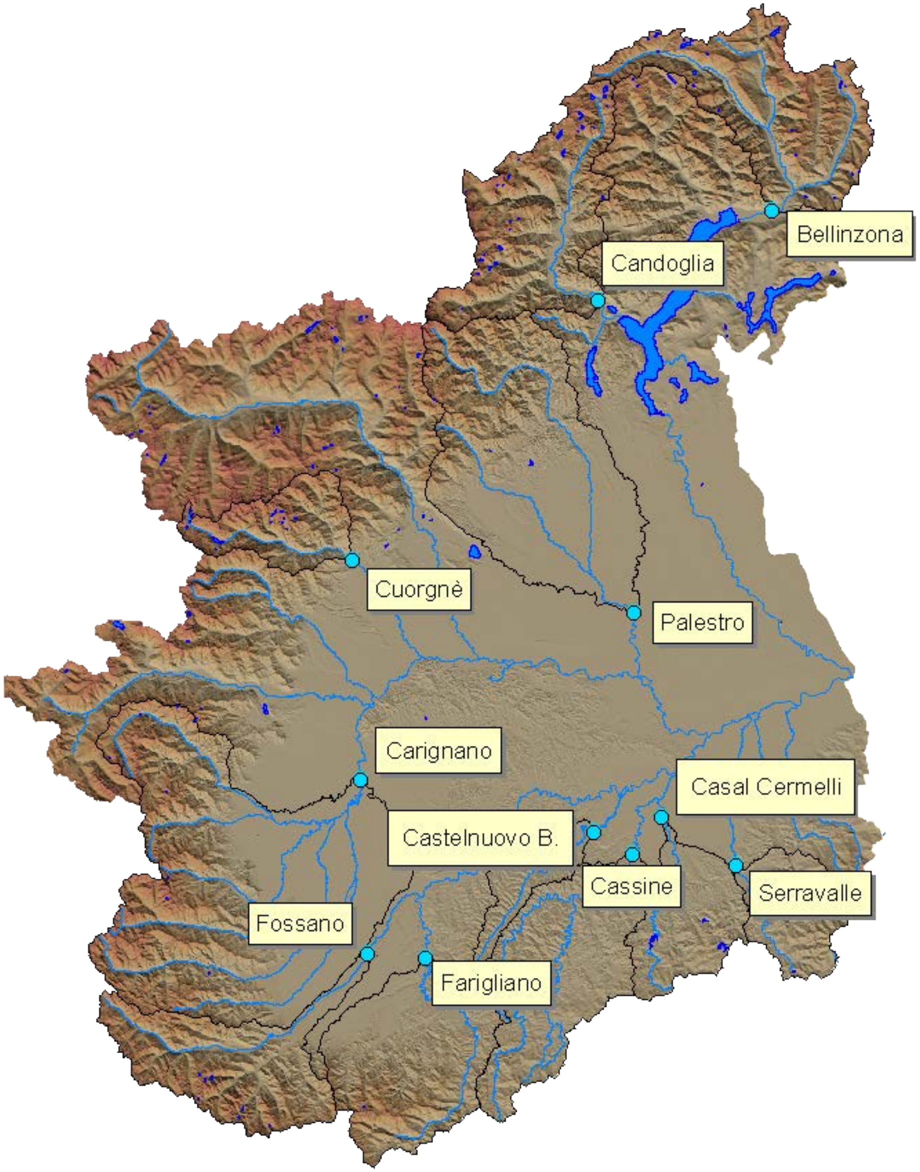
THE FEST-WB MODEL

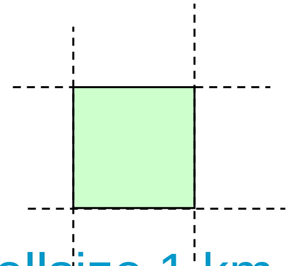


$$\theta_{t+1} = \theta_t + \frac{(I - PERC - ET)}{Z}$$

THE STUDY AREA

Cross sections

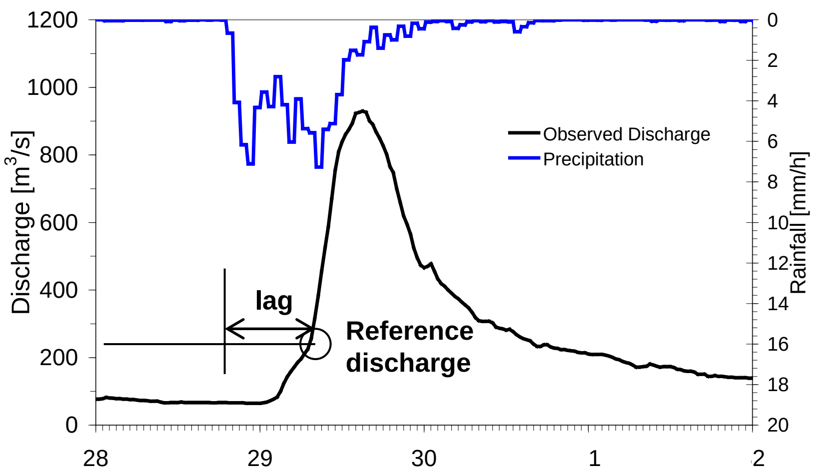




cellsize 1 km

Cross-section	River	Drained Area [km^2]
Bellinzona	Ticino	1624
Candoglia	Toce	1531
Carignano	Po	3976
Casalcermelli	Orba	798
Cassine	Bormida	1521
Castelnuovo Belbo	Belbo	422
Cuorgnè	Orco	630
Farigliano	Tanaro	1508
Fossano	Stura di Demonte	1249
Palestro	Sesia	2587
Serravalle	Scrivia	619

SELECTION OF EVENTS



Cross-section	Threshold dicharge [m³/s]	Lag time [h]
Bellinzona	337.65	10.2
Candoglia	263.86	9.0
Carignano	516.76	18.0
Casalcermelli	107.05	14.2
Cassine	120.92	23.2
Castelnuovo Belbo	34.71	15.1
Cuorgnè	168.11	5.8
Farigliano	263.57	14.8
Fossano	75.25	9.5
Palestro	1008.48	18.8
Serravalle	114.72	10.0

Flood events to be considered in the analysis are selected from the observed discharge time series. A flood event is selected when the discharge exceeds a reference value different for each river basin. The beginning of the storm event fixed exactly a lag time before the reference discharge is exceeded

CALIBRATION AND VALIDATION SET

Simulation period: 1st January 2000 – 31st December 2003.

Model calculation time step: 1 hour

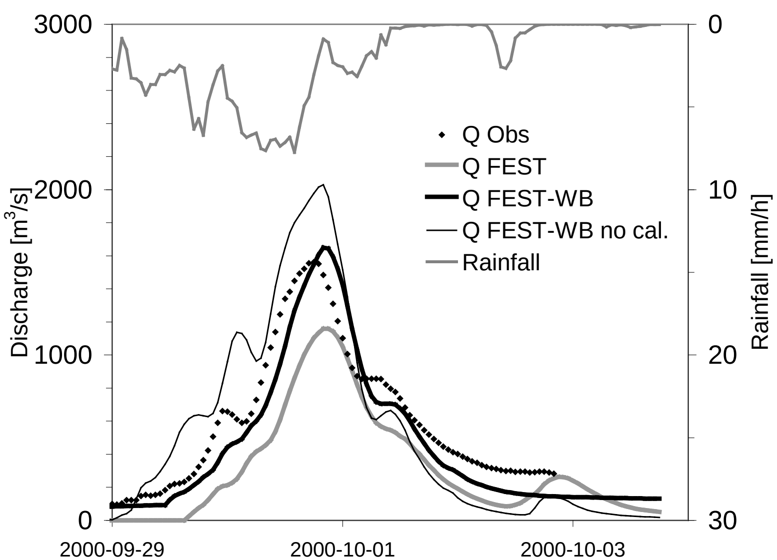
Cross-section	N calibration events	N validation events
Bellinzona	5	9
Candoglia	6	8
Carignano	3	4
Casalcermelli	8	8
Cassine	8	16
Castelnuovo Belbo	6	4
Cuorgnè	1	0
Farigliano	8	3
Fossano	2	11
Palestro	4	8
Serravalle	7	5

total number of flood events considered is 134

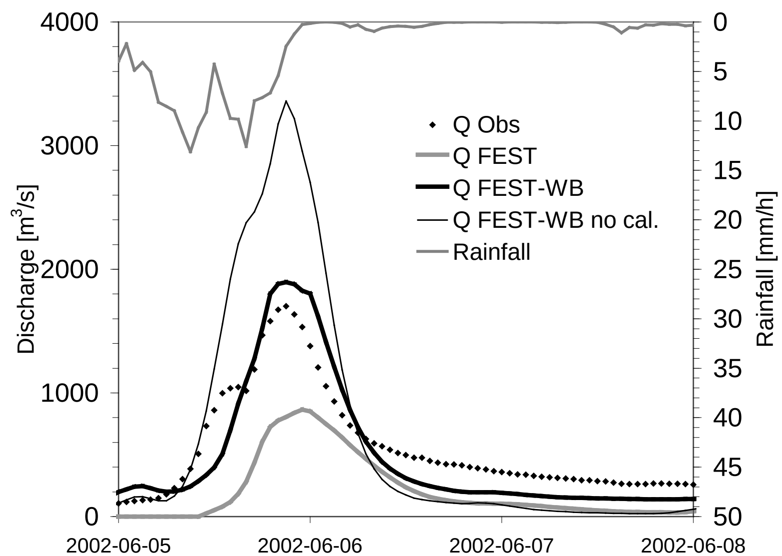
SIMULATION RESULTS

Toce @ Candoglia

CALIBRATION

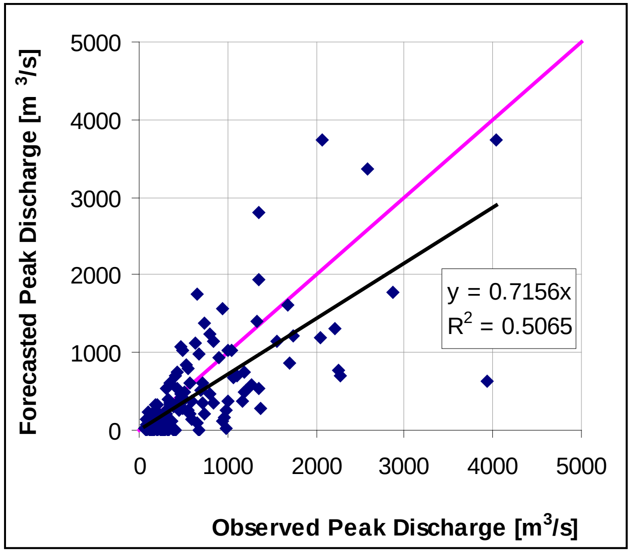


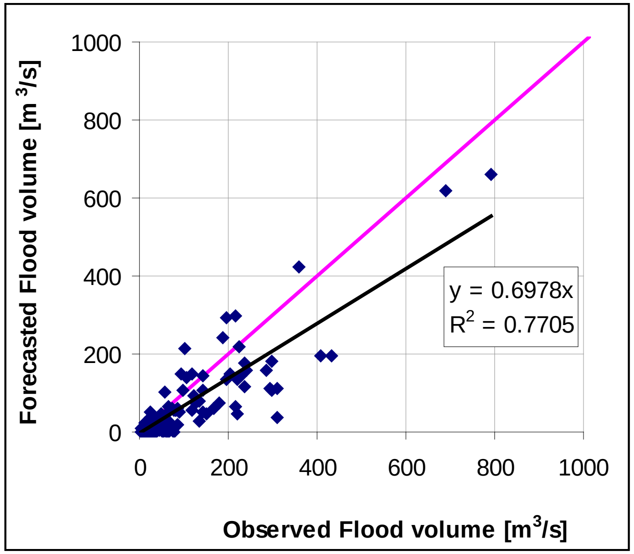
VALIDATION



SIMULATION RESULTS

FEST

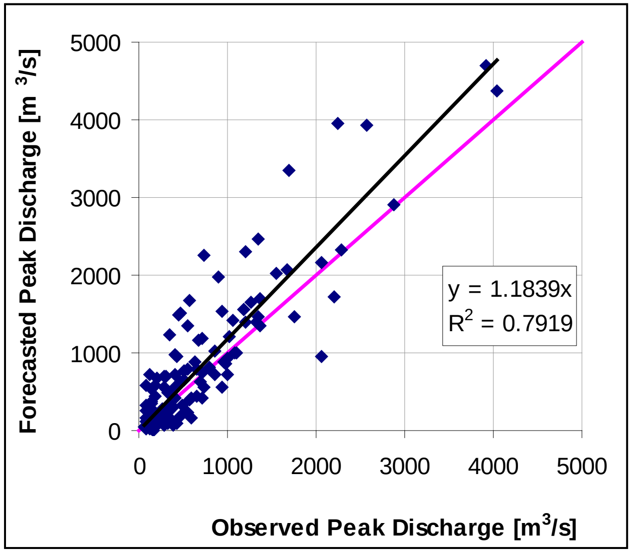


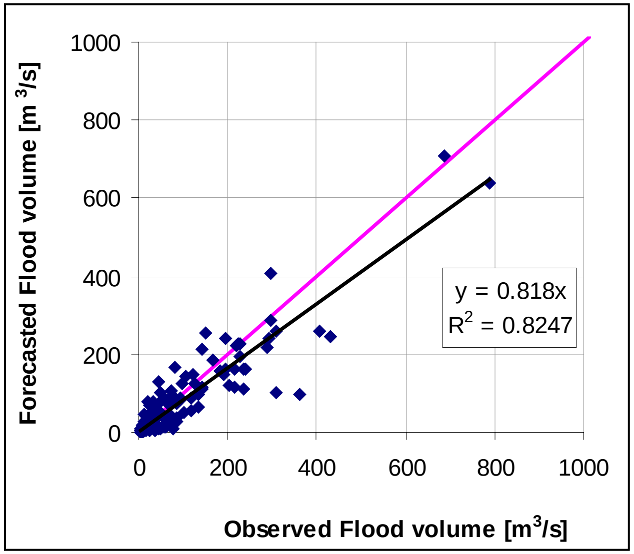


	Flood peak relative error [%]	Flood volume relative error [%]	Error in peak time [hours]
Mean	-32.21	-45.59	6.7
Standard deviation	61.57	47.59	15.0
CV	-1.91	-1.04	2.23
Absolute Mean	61.00	57.93	8.5
Standard deviation	32.97	31.27	14.1
CV	0.54	0.54	1.67

SIMULATION RESULTS

FEST-WB NOT CALIBRATED

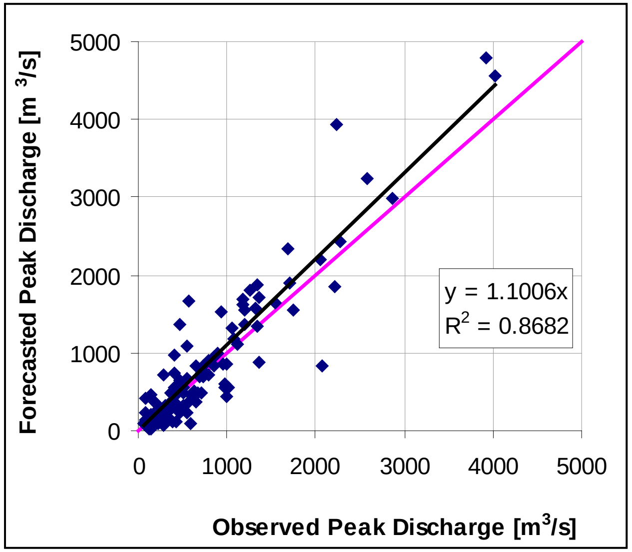


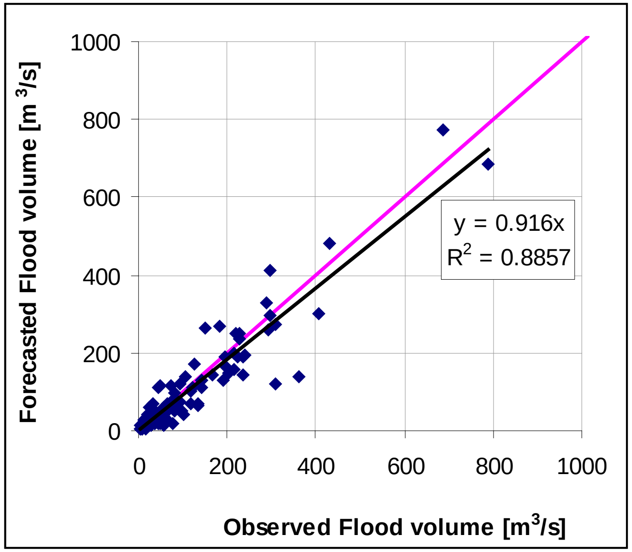


	Flood peak relative error [%]	Flood volume relative error [%]	Error in peak time [hours]
Mean	30.07	-1.69	0.31
Standard deviation	106.58	70.45	8.87
CV	3.54	-41.61	28.31
Absolute Mean	69.23	50.18	4.73
Standard deviation	86.26	49.30	7.50
CV	1.25	0.98	1.59

SIMULATION RESULTS

FEST-WB CALIBRATED

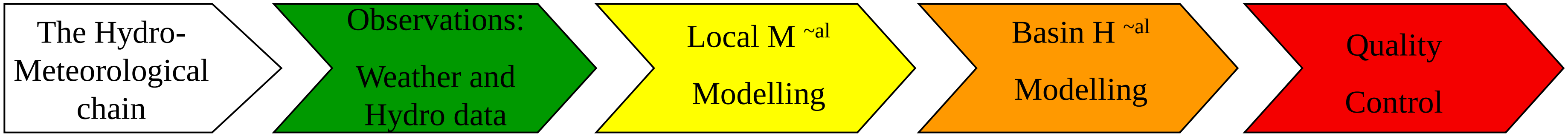




	Flood peak relative error [%]	**Flood volume relative error [%]**	**Error in peak time [hours]**
Mean	7.41	-0.89	0.63
Standard deviation	64.96	46.70	8.67
CV	8.77	-52.31	13.83
Absolute Mean	41.11	34.83	4.63
Standard deviation	50.71	31.49	7.35
CV	1.23	0.92	1.59

The hydro-meteorological chain

June – December 2007



•The analysis is focused on the River Toce, a middle-size alpine basin, in North-West of Italy.

•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.

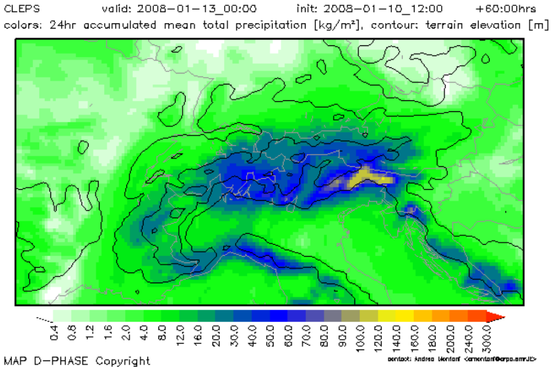
•The hydrological model used to generate the runoff simulations is the rainfall-runoff distributed FEST-WB model, developed at Politecnico di Milano. The initial hot start is sent daily by ARPA-Piemonte that runs the same model with weather observations.

•The only significant event during the MAP-DPHASE project in June 2007.

Meteorological models

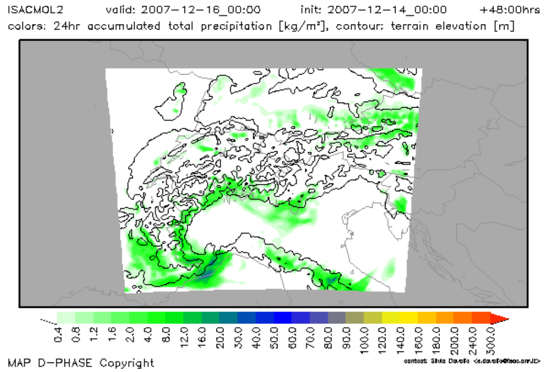
COSMO-LEPS Model

- **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

- **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



MAP-D-PHASE warning codes

Area mean precipitation sum in mm/accumulation time

	Σ03h	Σ06h	Σ12h	Σ24h	Σ48h	Σ72h
Yellow	10.9	15.5	22.4	31.9	42.3	49.8
Orange	24.6	35.2	50.7	72.4	96.1	113.3
Red	56.2	80.5	116.0	165.7	220.1	259.4

Meteorological alerts

Discharge in m^3/s

Yellow	306.0
Orange	694.0
Red	1588.0

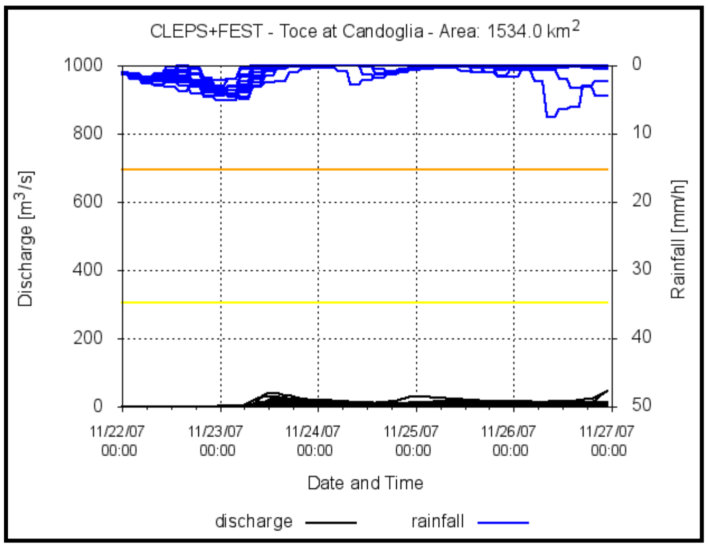
Hydrological alerts

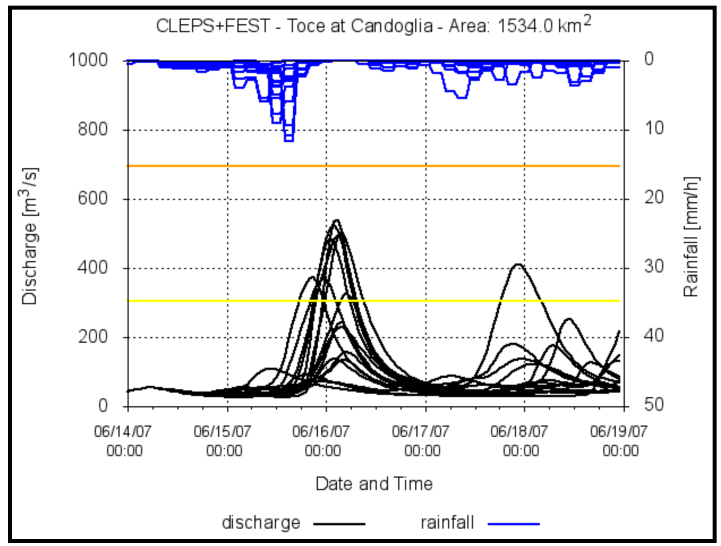
Return period of at least 60 days

Return period of at least 180 days

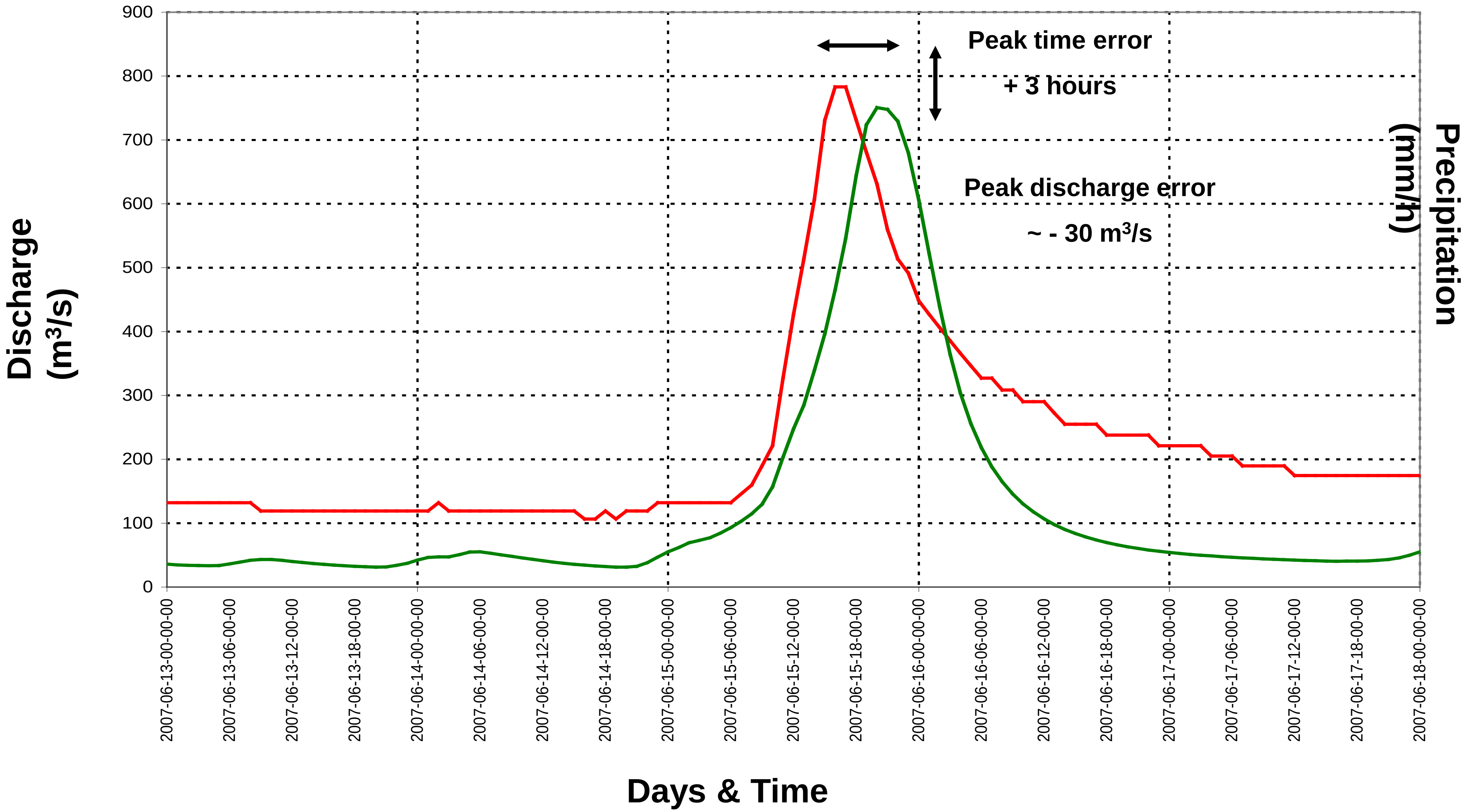
Return period of at least 10 years

The alert thresholds used for Toce basin at Candoglia

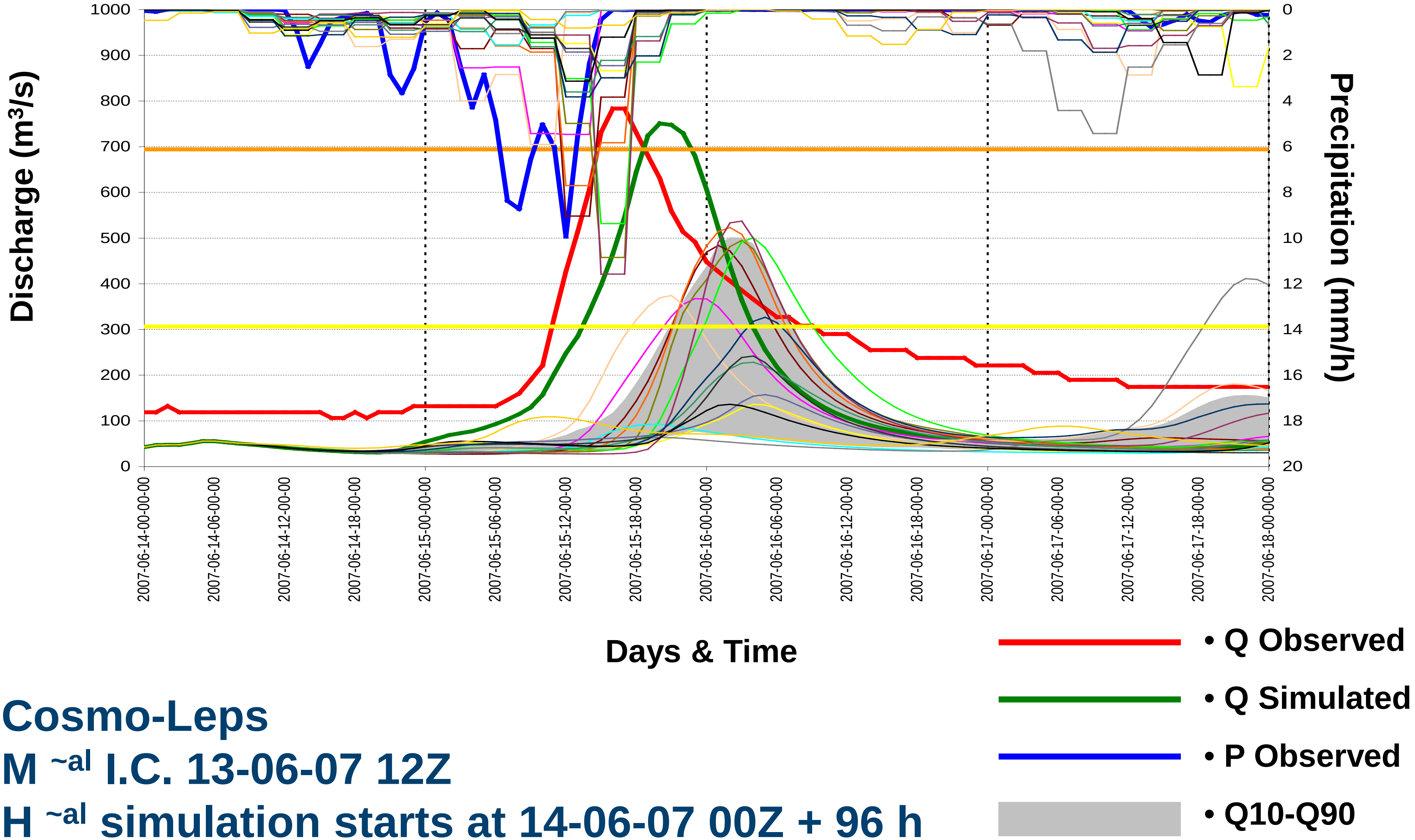




FEST-WB simulation with weather observations



Results: QDF, QPF from COSMO-LEPS the day before

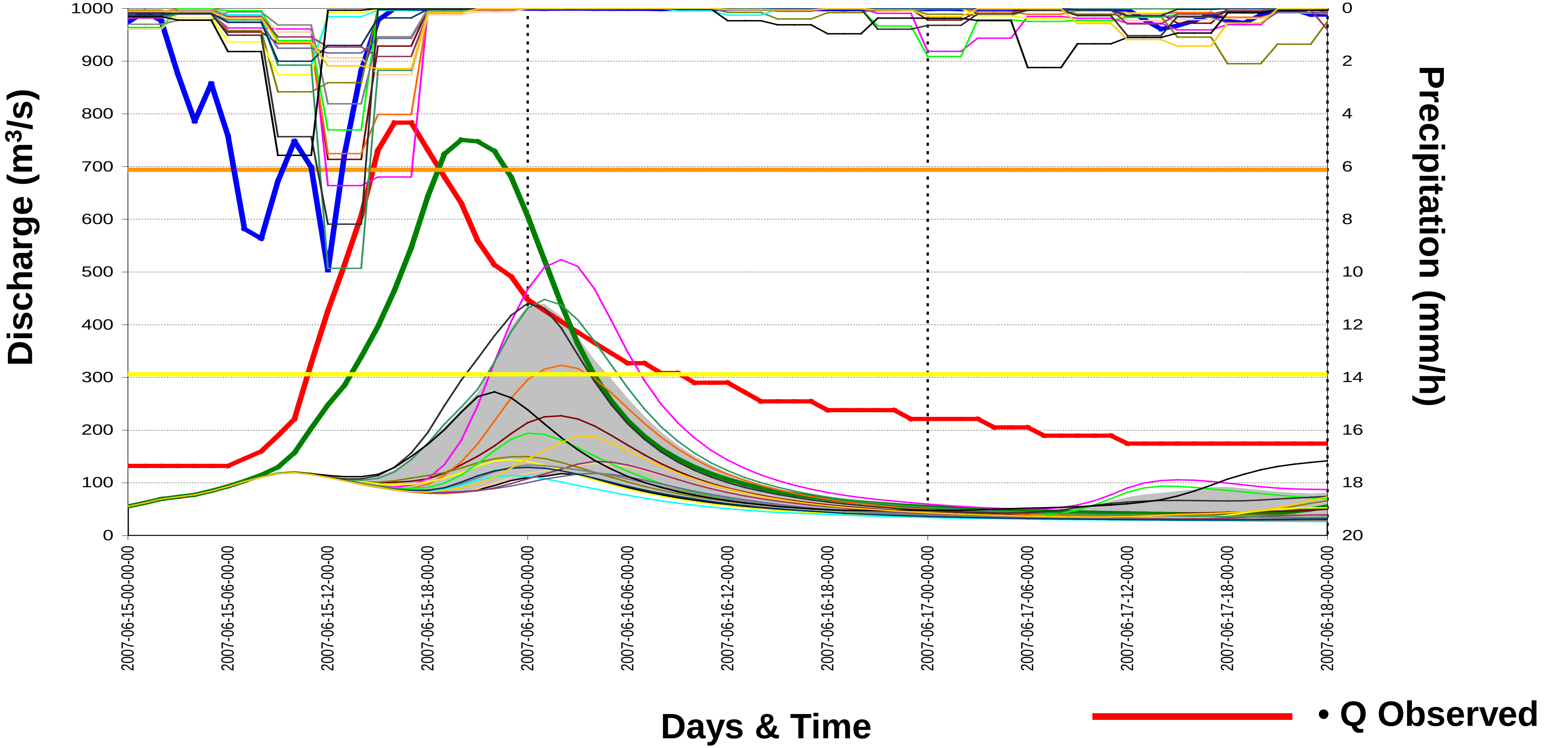


Cosmo-Leps

M ~al I.C. 13-06-07 12Z

H ~al simulation starts at 14-06-07 00Z + 96 h

Results: QDF, QPF from COSMO-LEPS the day of peak flow

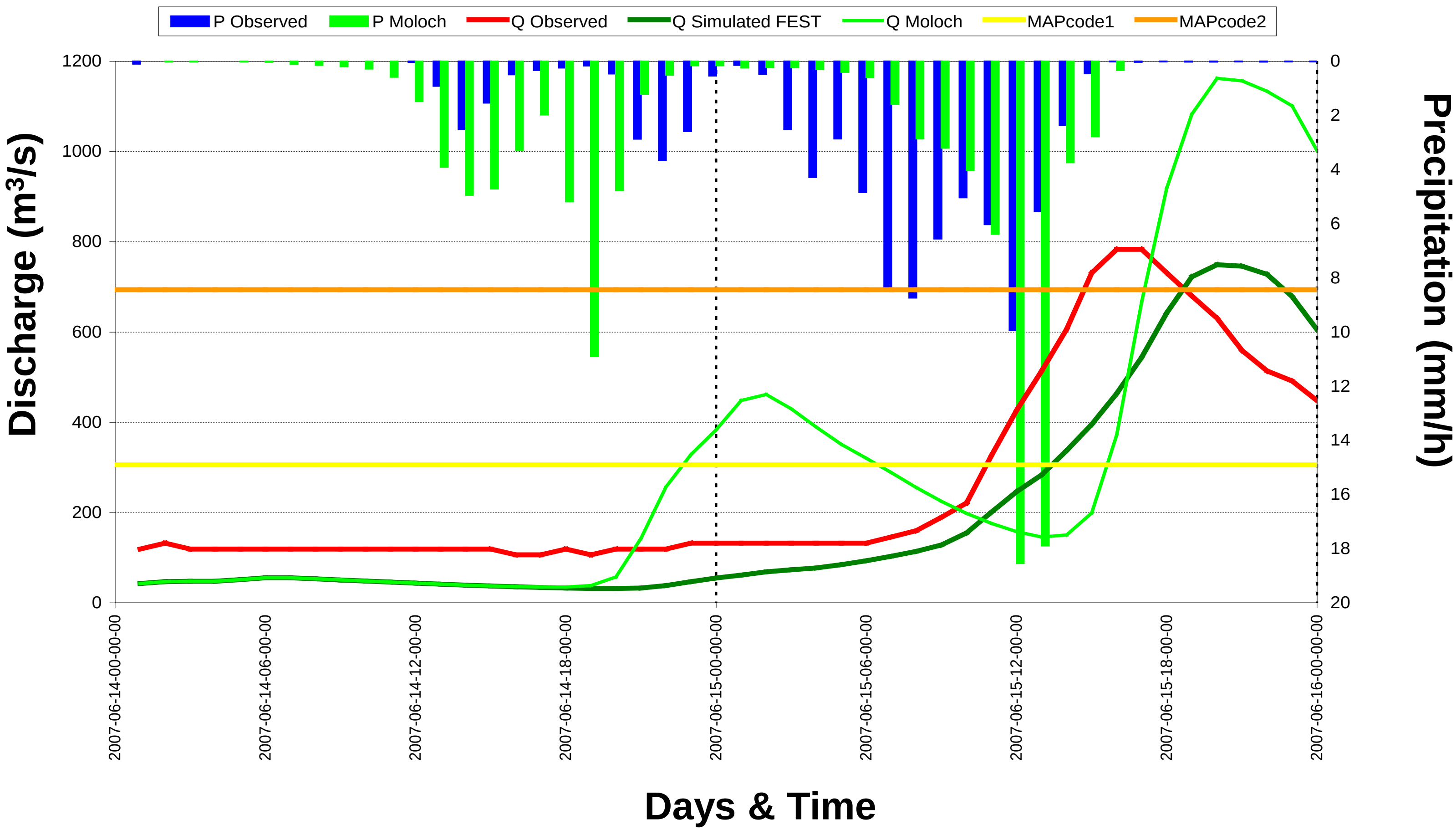


Cosmo-Leps

M ~al I.C. 14-06-07 12Z

H ~al simulation starts at 15-06-07 00Z + 72h

Results: QDF, QPF from MOLOCH the day before



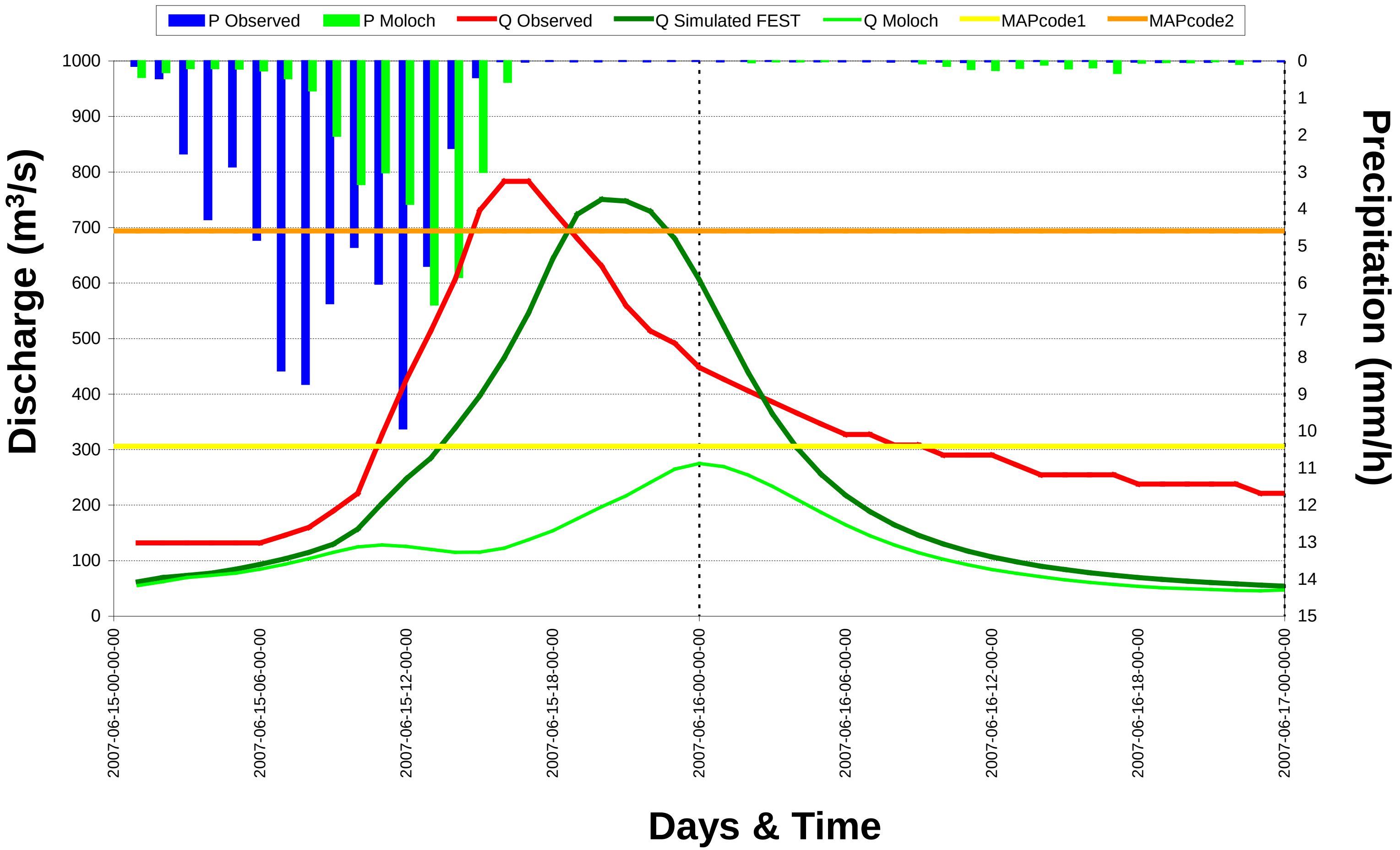
Days	Simulated Fest	Moloch	Observed
13/06/2007	55.4	328.4	132.1
14/06/2007	749.2	1162.3	783.2
Max Discharge (m^3/s)	749.2	1162.3	783.2

Moloch

M ~al I.C. 14-06-07 00Z

H ~al simulation starts at 14-06-07 00Z + 48h

Results: QDF, QPF from MOLOCH the day of peak flow



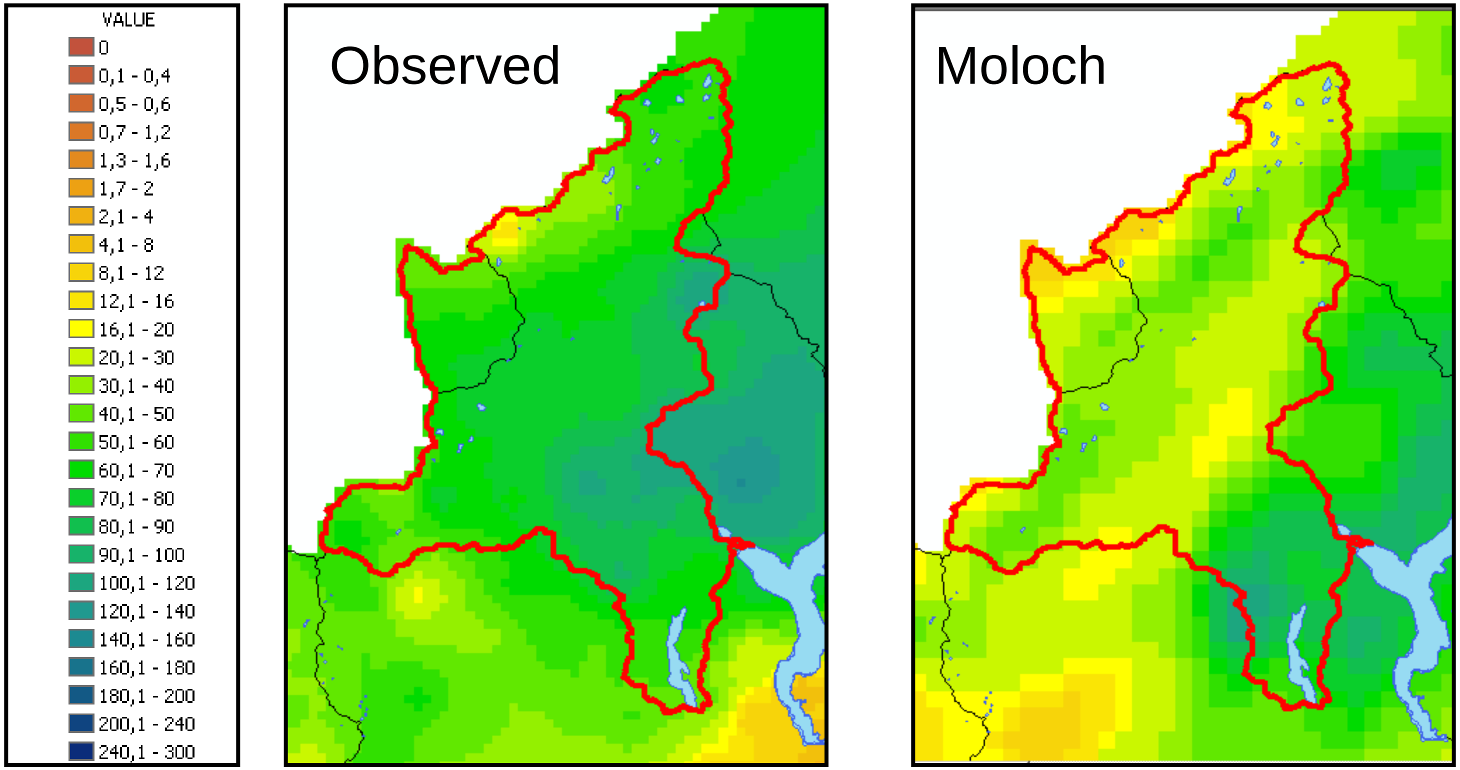
Days	Simulated Fest	Moloch	Observed
15/06/2007	750.7	265.0	783.2
16/06/2007	605.8	275.2	448.0
Max Discharge (m^3/s)	750.7	275.2	783.2

Moloch

M ~al I.C. 15-06-07 00Z

H ~al simulation starts at 15-06-07 00Z + 48h

MOLOCH: two days cumulated rainfall field



The spatial distribution of the 48 hours accumulated rainfall in Toce basin (15-16 June)

Days	Moloch	Observed
15/06/2007	31.1	68.2
16/06/2007	2.0	0.4
Precipitation (mm/d)	**33.1**	**68.6**

Conclusions

1st SECTION

•The distributed model with continuous soil moisture account performs better than flood event model based on standard Curve Number approach. However an accurate calibration is required

2nd SECTION

•For June event Moloch has predicted the peak discharge one day in advance, but it has shown a complete underestimation on the peak flow day. Cosmo-Leps has shown a global underestimation instead. The observed and simulated discharge has exceed the second thresholds (694 m^3/s): this was predicted by Moloch, but not by Cosmo-Leps model.

DESIDERATA

•Extend analysis on many other convective flood events on alpine basins

Thank you for your attention