A hydro-meteorological ensemble prediction system for real-time flood forecasting purposes in the Milano area

POLITECNICO DI MILANO

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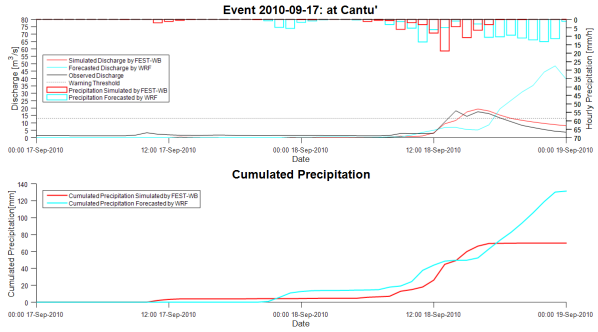
Flash floods, hydro-geomorphic response, forecasting and risk management

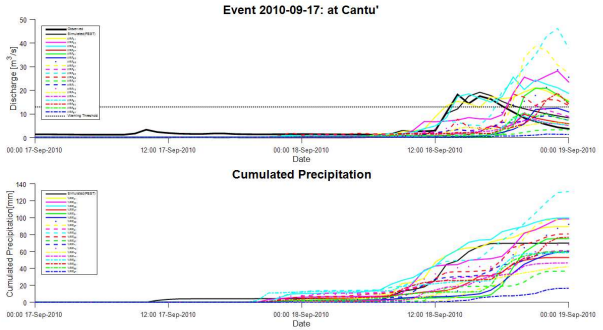
Objectives

Milan is a flood prone area that was frequently flooded in the last years.

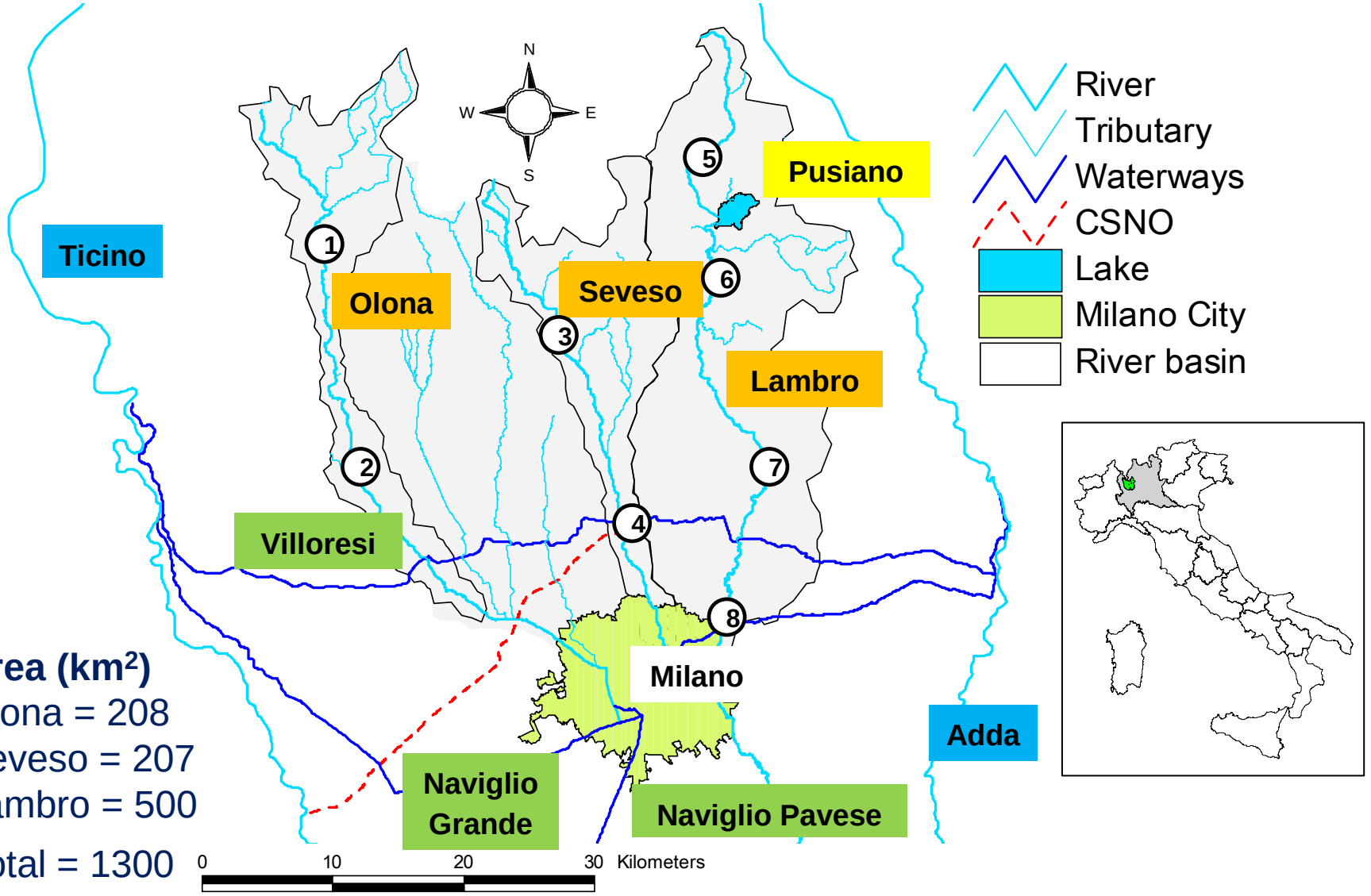
Previous study showed that deterministic simulation may not properly forecast flood severity of convective events mainly due to difficulties in correct localizing rainfall peaks



Explore different setups of ENSEMBLE simulation to detect what is the most reliable for real time flood forecasting of convective events in Milan



Water courses network in Milan



Area (km²)

Olona = 208

Seveso = 207

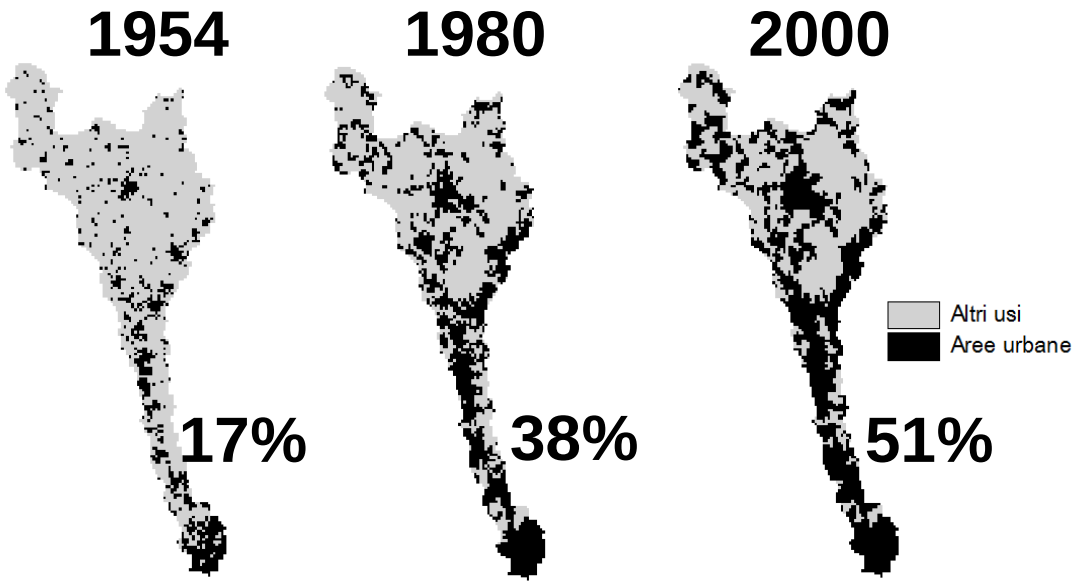
Lambro = 500

Total = 1300

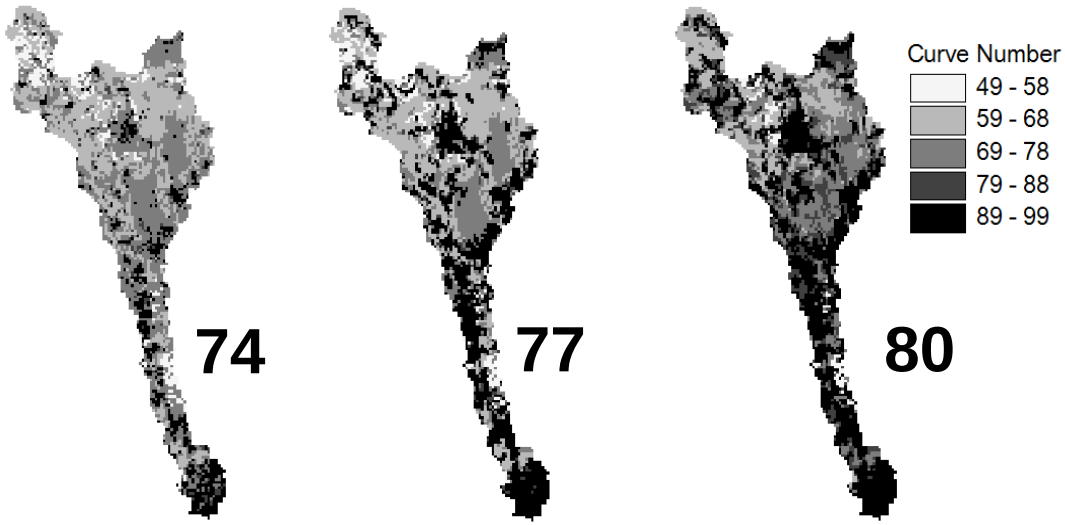
Existing structural measure

Bypass channel (CSNO, acronym from Italian “Canale Scolmatore di Nord Ovest”).
Built from 1954 to 1980.
Discharge capacity 30 m^3/s

Land use change



URBAN AREA



CURVE NUMBER

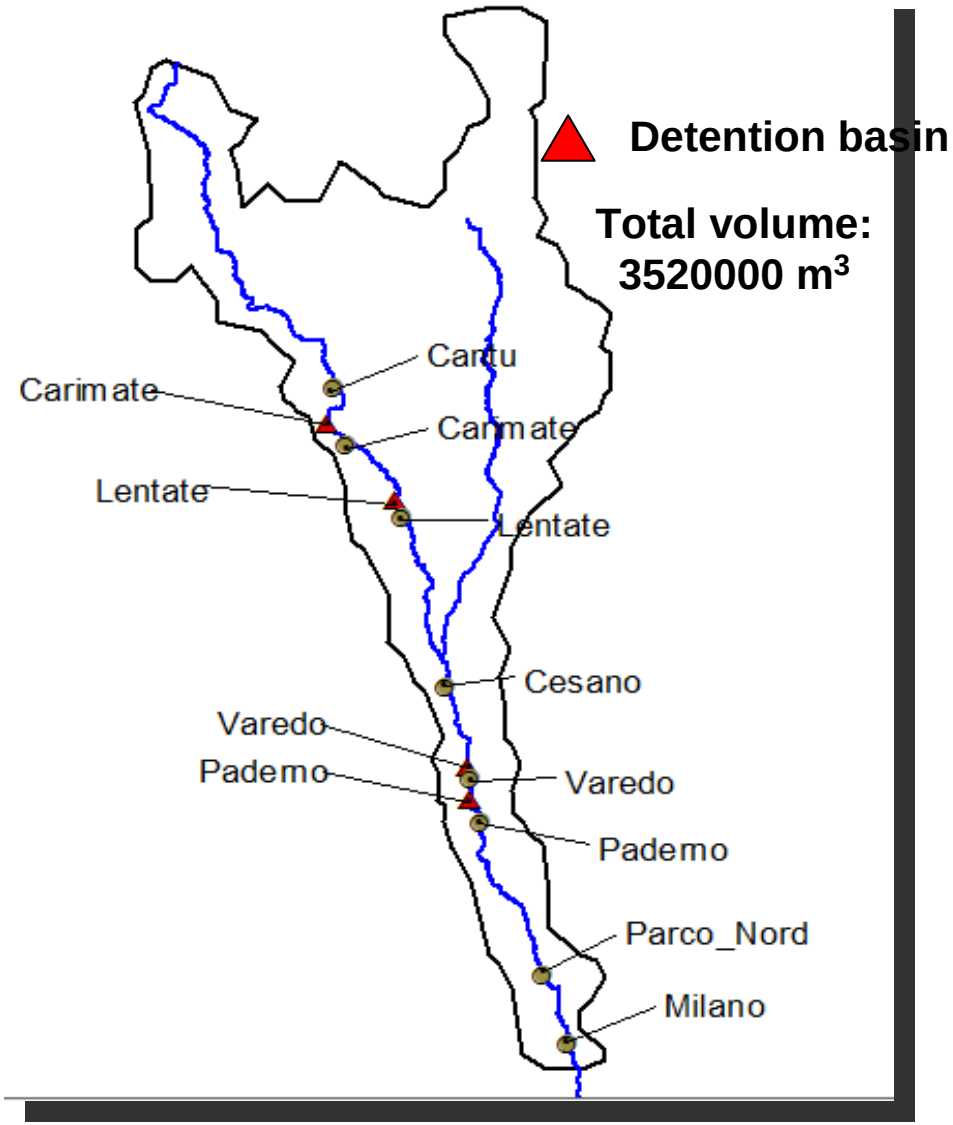
Recent floods

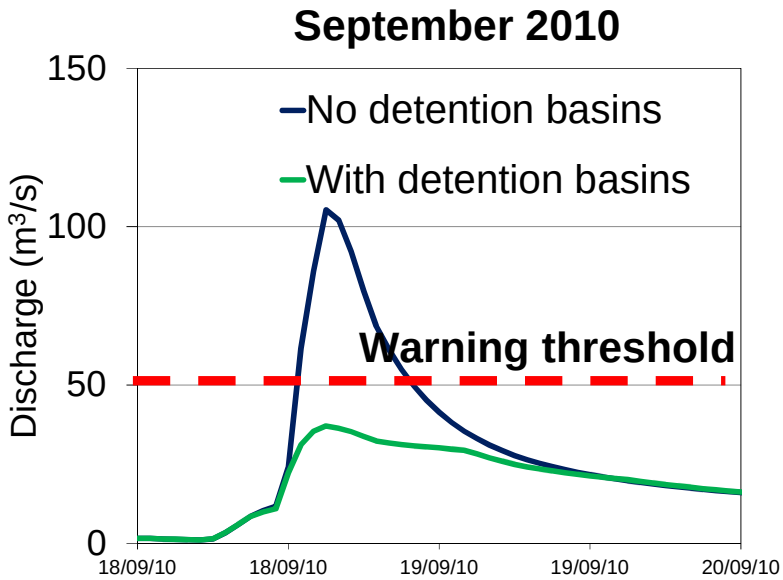
Seveso flood, 18 September 2010

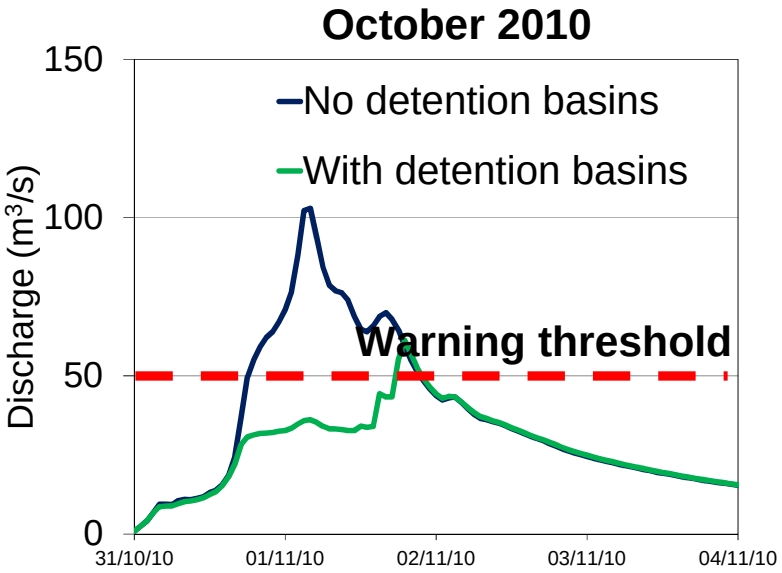
80 milion Euro as total damage!

Seveso flood, 8 July 2014

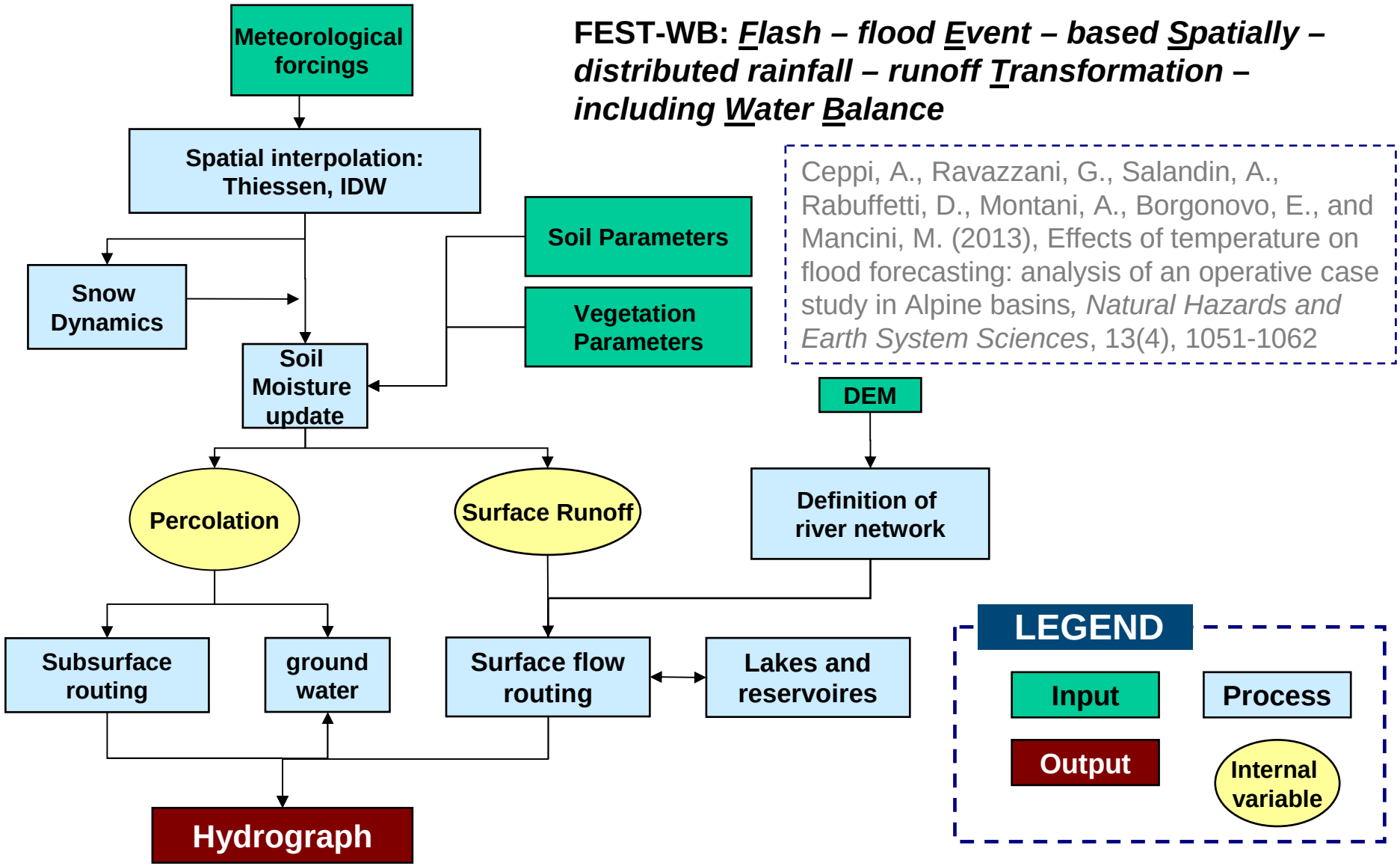
Planned structural measure







FEST-WB hydrological model

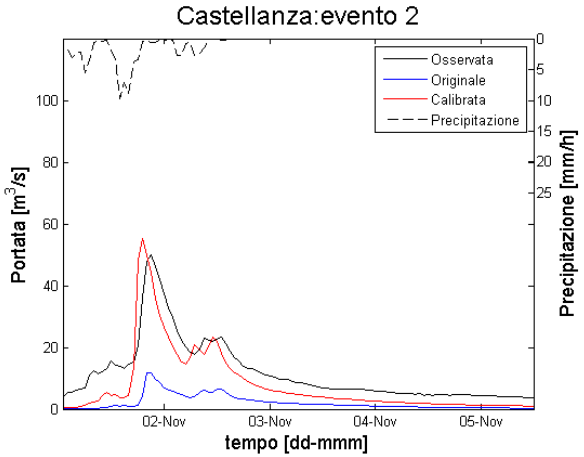


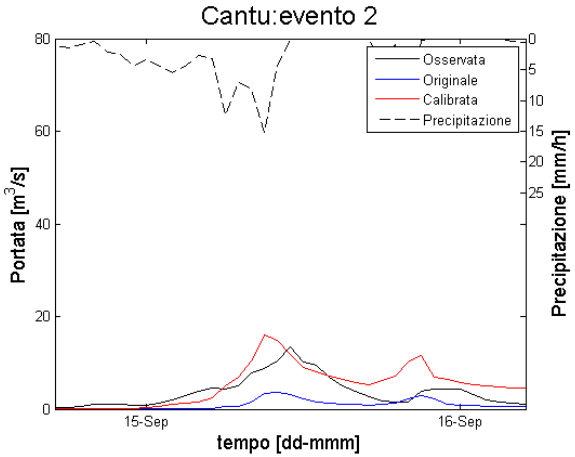
FEST-WB: *Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation – including Water Balance*

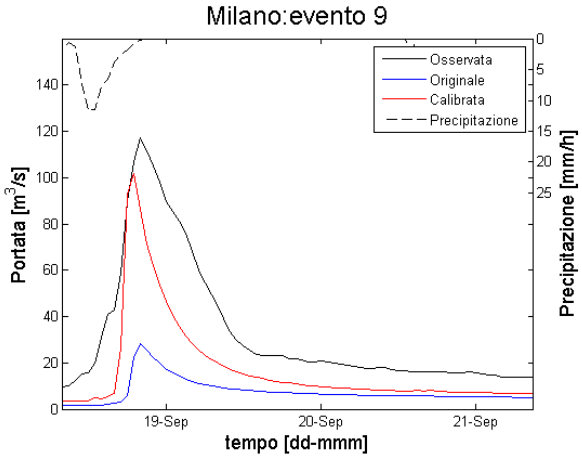
Ceppi, A., Ravazzani, G., Salandin, A., Rabuffetti, D., Montani, A., Borgonovo, E., and Mancini, M. (2013), Effects of temperature on flood forecasting: analysis of an operative case study in Alpine basins, *Natural Hazards and Earth System Sciences*, 13(4), 1051-1062

Calibration of the FEST-WB model (2003-2010 events)

Basin	Gauging Station	err Q_{max} [%]	
		Before	After
Olona	Lozza	**-50.7**	**0.27**
	Castellanza	**-51.8**	**0.12**
Seveso	Cantù	**-65.5**	**-10.9**
Lambro	Caslino	**78.4**	**0.57**
	Peregallo	**-72.1**	**1.5**
	Milano	**-74.8**	**-3.54**





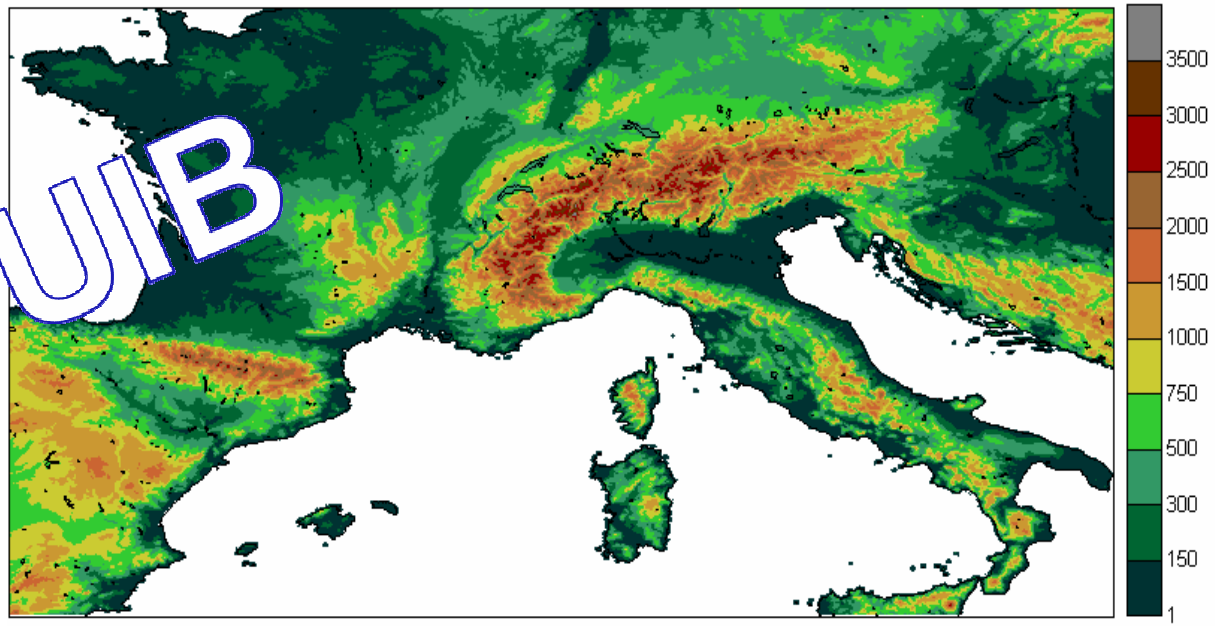


The WRF computational domain

Dynamical downscaling performed with WRF 3.4 with: 2.5 km grid spacing and 28 vertical levels.

IC: Data coming from the global ECMWF EPS , aiming at sampling the distribution of plausible atmospheric states. ECMWF-EPS generated by perturbing an analysis with the singular vector technique.

We generate a high-resolution EPS by selecting members exhibiting the most large spread to encompass better any possible issues of underdispersion.



run by UIB

ENSEMBLE setup

- **MUF (Multi Physics forecast 20 members)** : uncertainties in model physical parameterizations. Combinations of different planetary boundary layer (PBL) and moist microphysical (MP) parameterizations:
  - MP schemes: Lin, Eta (Ferrier), WRF single-moment 6-class (WSM6); Goddard; and New Thompson
  - PBL schemes: Yonsei University (YSU); 1.5-order Mellor-Yamada-Janjic (MYJ); Mellor-Yamada Nakanishi Niino (MYNN) level 2.5; and asymmetric convection model 2 (ACM2)
- **IC (20 members)**: uncertainties in the initial and lateral boundary conditions
- **LAF (lagged average forecast 12 members)**: Mimics ensemble systems, but at low computational cost. LAF ensembles reflect flow-dependent forecast errors

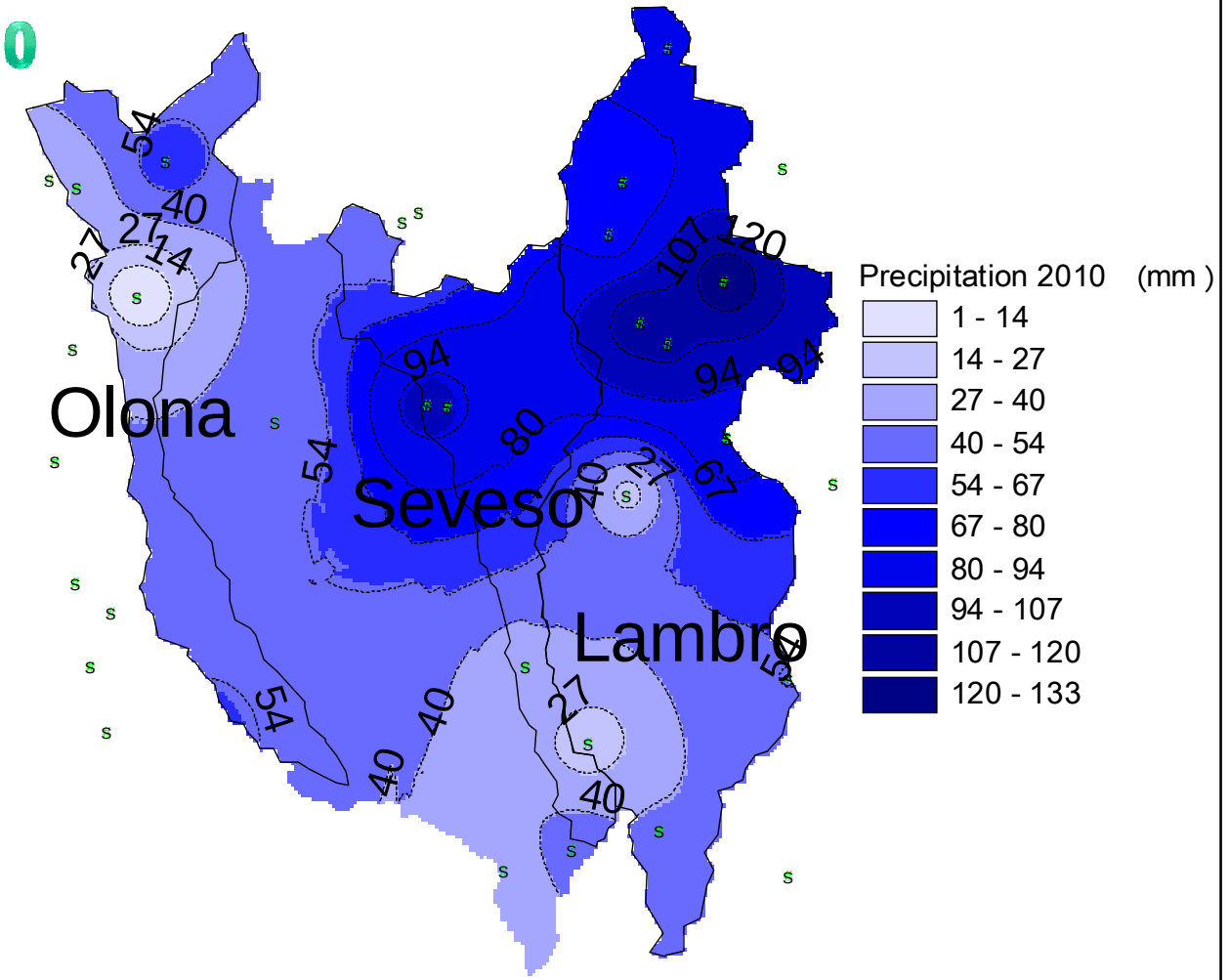
LAF: Reference (*unperturbed*) global ECMWF forecasts at each lead-time

Reference physical parameterizations for all the IC and LAF members:

the *WSM6* microphysical scheme and the *MYJ* PBL scheme.

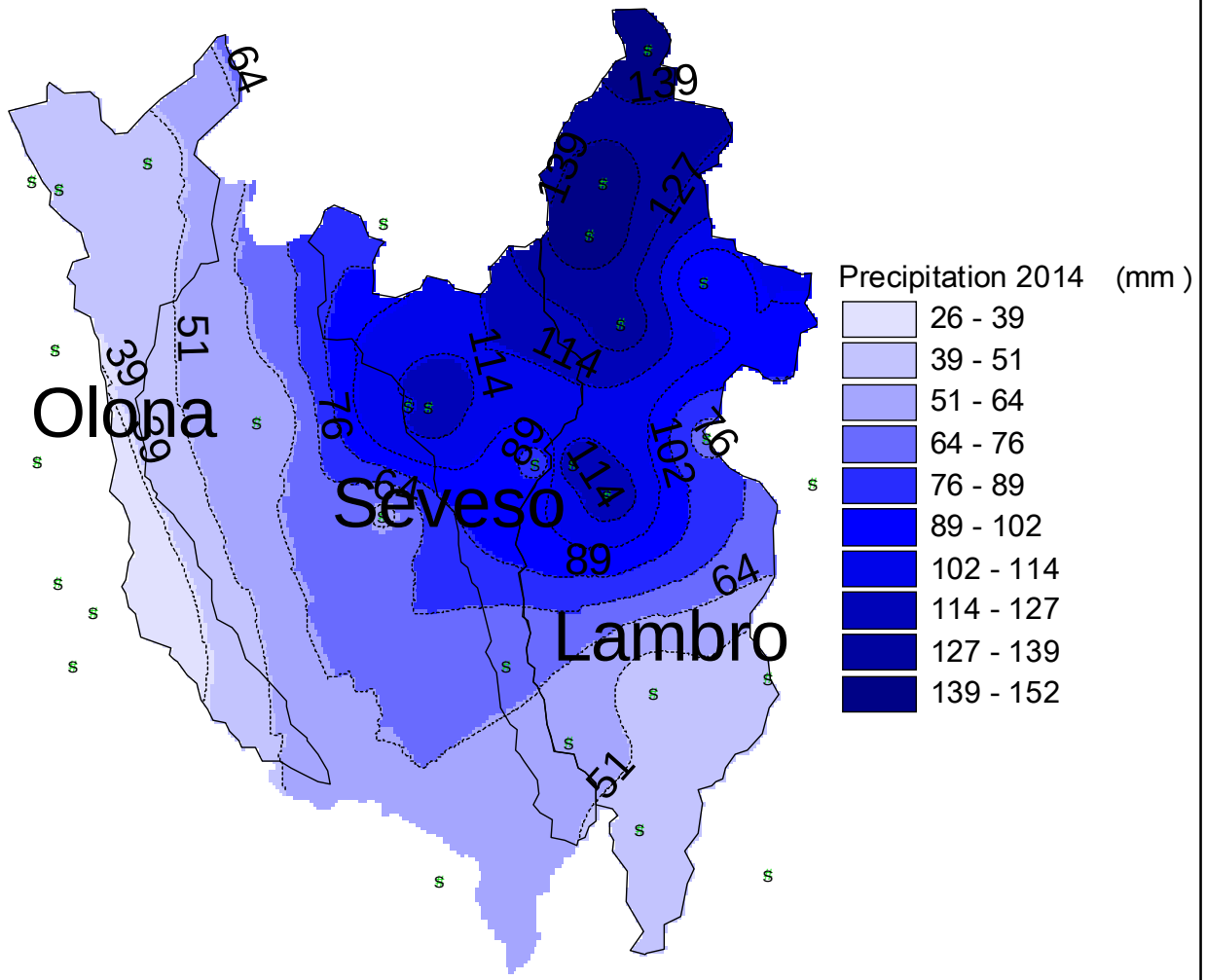
Re-analysis of two major convective flood events

SEPTEMBER 2010



Re-analysis of two major convective flood events

JULY 2014



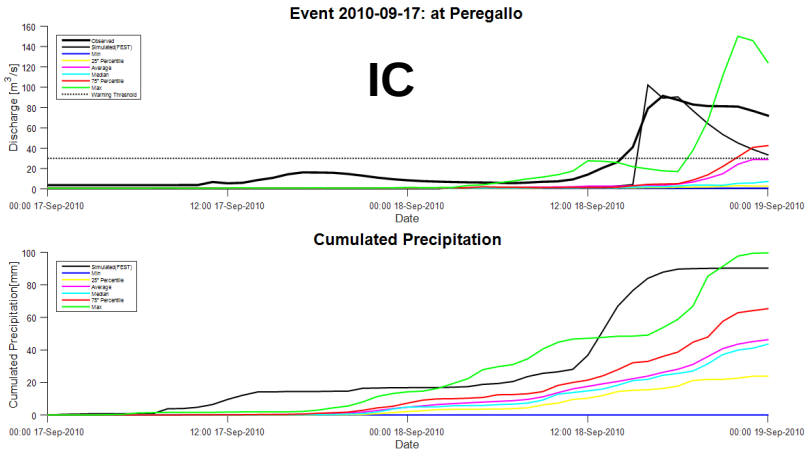
Performance 1/2

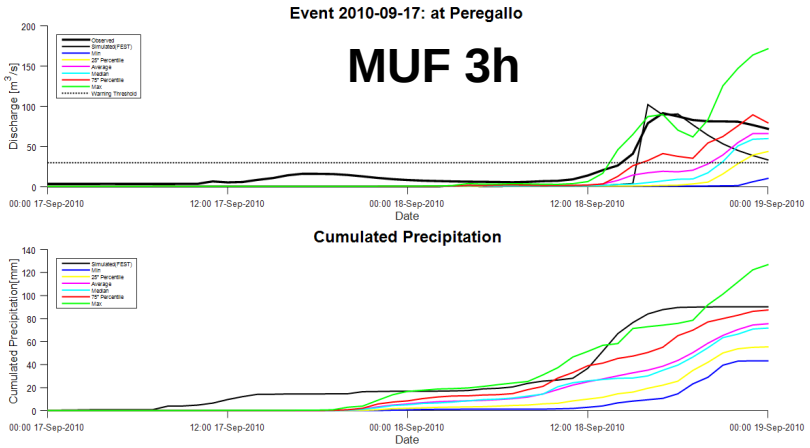
SEPTEMBER 2010

percentage of ensemble members exceeding threshold

Exceeding Threshold		Seveso	Lambro	
		Cantu	Peregallo	Milano
9/17/2010	IC	20.0%	35.0%	10.0%
	Multiphysic_3h	50.0%	85.0%	40.0%
	Lagged	18.2%	54.5%	27.3%

Multiphysic have the best performance, Initial Condition the worst





Performance 2/2

JULY 2014

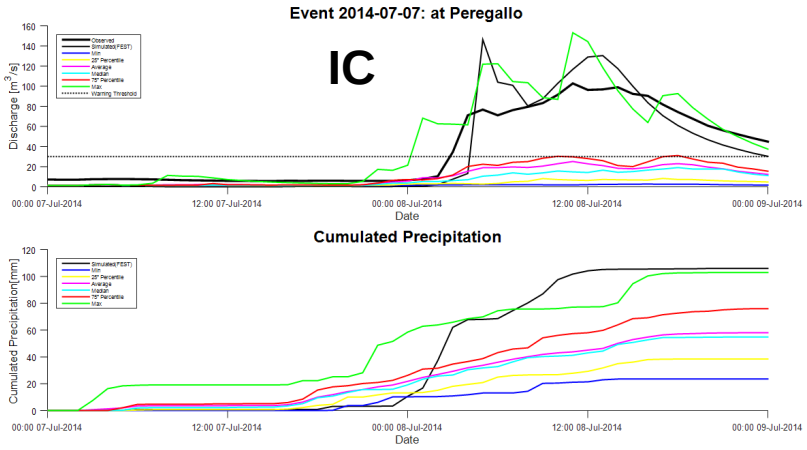
percentage of ensemble members exceeding threshold

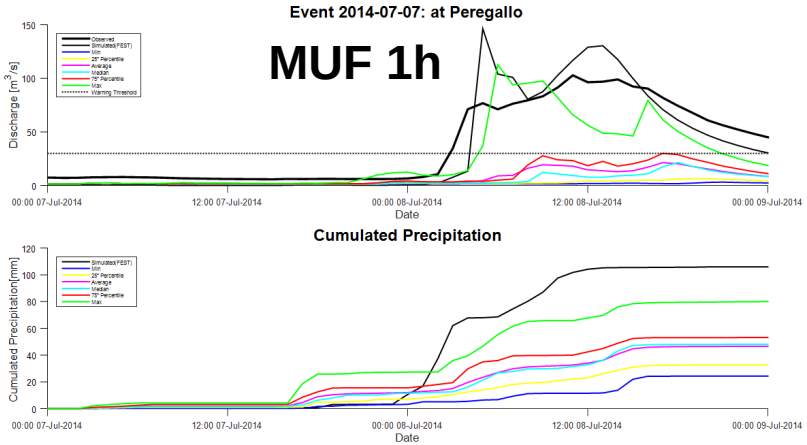
Exceeding Threshold		Seveso	Lambro	
		Cantu	Peregallo	Milano
7/7/2014	IC	25.0%	50.0%	10.0%
	Multiphysic_1h	25.0%	50.0%	10.0%
	Multiphysic_3h	15.0%	55.0%	10.0%
	Lagged_1h	16.7%	25.0%	0.0%
	Lagged_3h	41.7%	41.7%	0.0%

In general IC and Multiphysic_1h have the best performance

Multiphysic_1h is better than the Multiphysic _3h for the Seveso basin.

Multiphysic_3h is better than the Multiphysic _1h for the Lambro basin.





Conclusions and future developments

1) Despite structural measures, flood residual risk in Milan is still very high due to land use change in the past years that lead to an increase of flood frequency

2) A spatially distributed hydrological model can be effectively used to simulate flood events

3) The multiphysics forecast gave better or equal performance to classical IC ensemble

4) The LUF is a method that requires far less resources than a real ensemble system but it proved to give not so bad results.

5) Future developments involve the analysis of more events in order to confirm the good performance achieved by the MUF and to detect if there are some physical schemes more capable than the others in simulating convective events in Milan area .

Ravazzani., G., Amengual, A., Ceppi, A., Romero, R., Homar, V., Mancini, M. A hydro-meteorological ensemble prediction system for real-time flood forecasting purposes in the Milano area. Journal of hydrology ***Special issue "Flash floods, hydro-geomorphic response and risk management"***

THANK YOU FOR YOUR ATTENTION