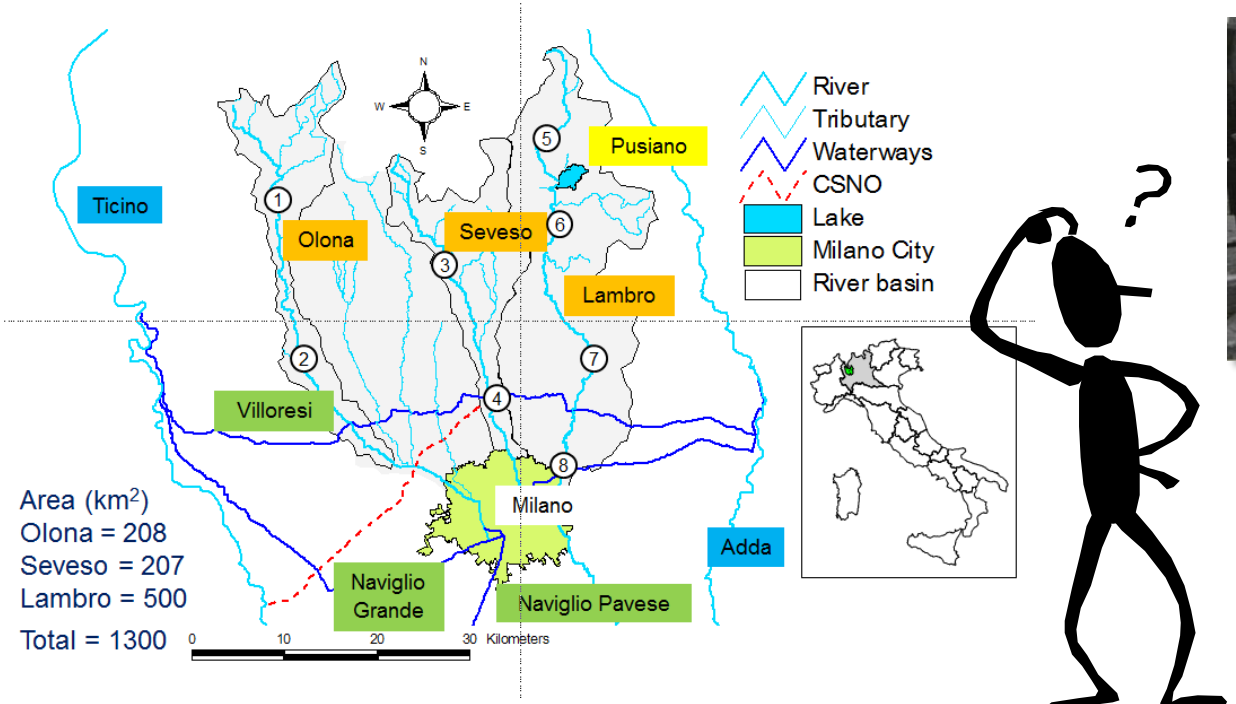
POLITECNICO DI MILANO

Un sistema di previsione delle piene sviluppato dal Politecnico di Milano

Ceppi A., Ravazzani G., Corbari C., Lombardi G., Cerri L., Mancini M.

Workshop 2019, Dissesto Idrogeologico, Milano, 22 Maggio 2019

The Milan urban basins: Seveso-Olona-Lambro (SOL)



Structural measures over the three basins:

- Olona → Ponte Gurone dam
- Seveso → CSNO filling channel
- Lambro → Pusiano Lake regulations

The Milan urban basins: Seveso-Olona-Olmabro (SOL), recent floods

15/07/2009

- The Olona flood (Varese): 30 milion €

18/09/2010

- The Seveso flood (Milan): 80 milion €

08/07/2014

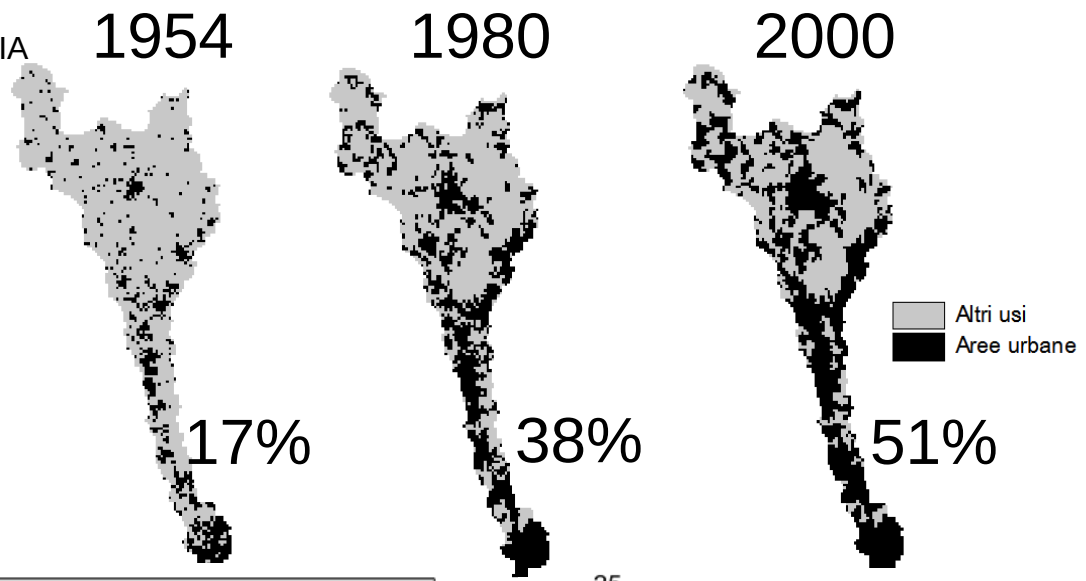
- The Seveso flood (Milan): 55 milion €

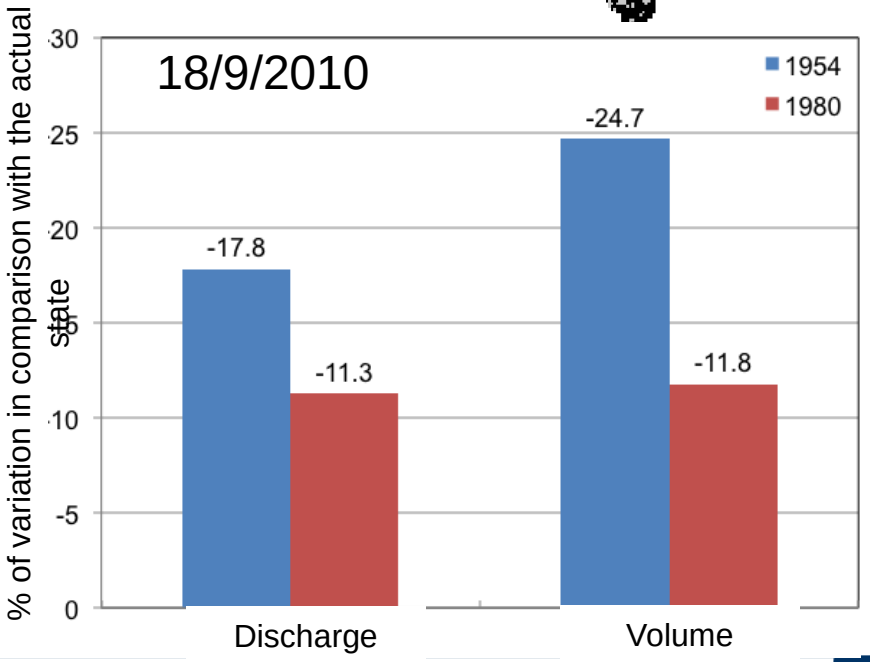
15/11/2014

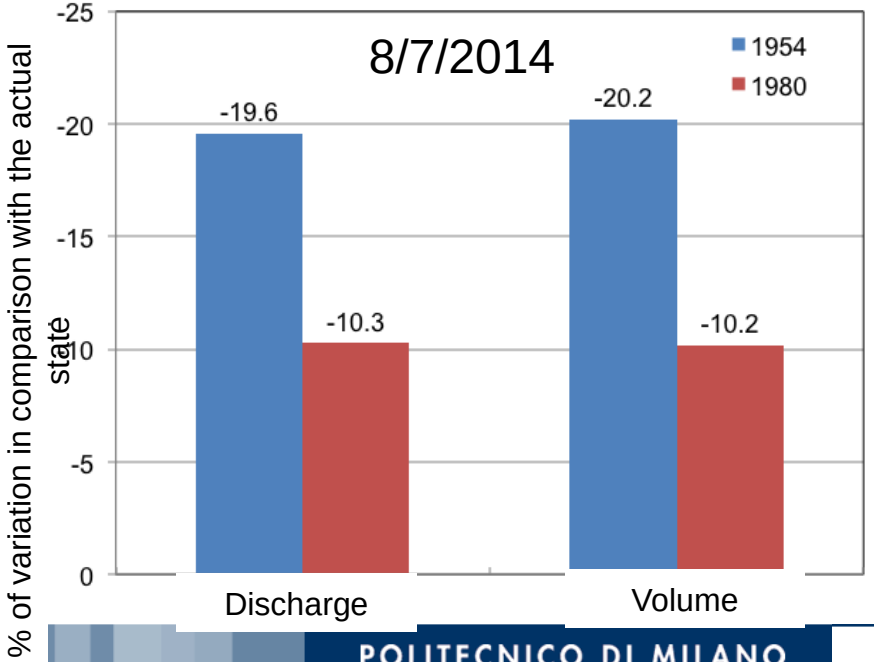
- The Lambro flood (Monza): 6 milion €

River Seveso: effects of land use change on discharge and volume

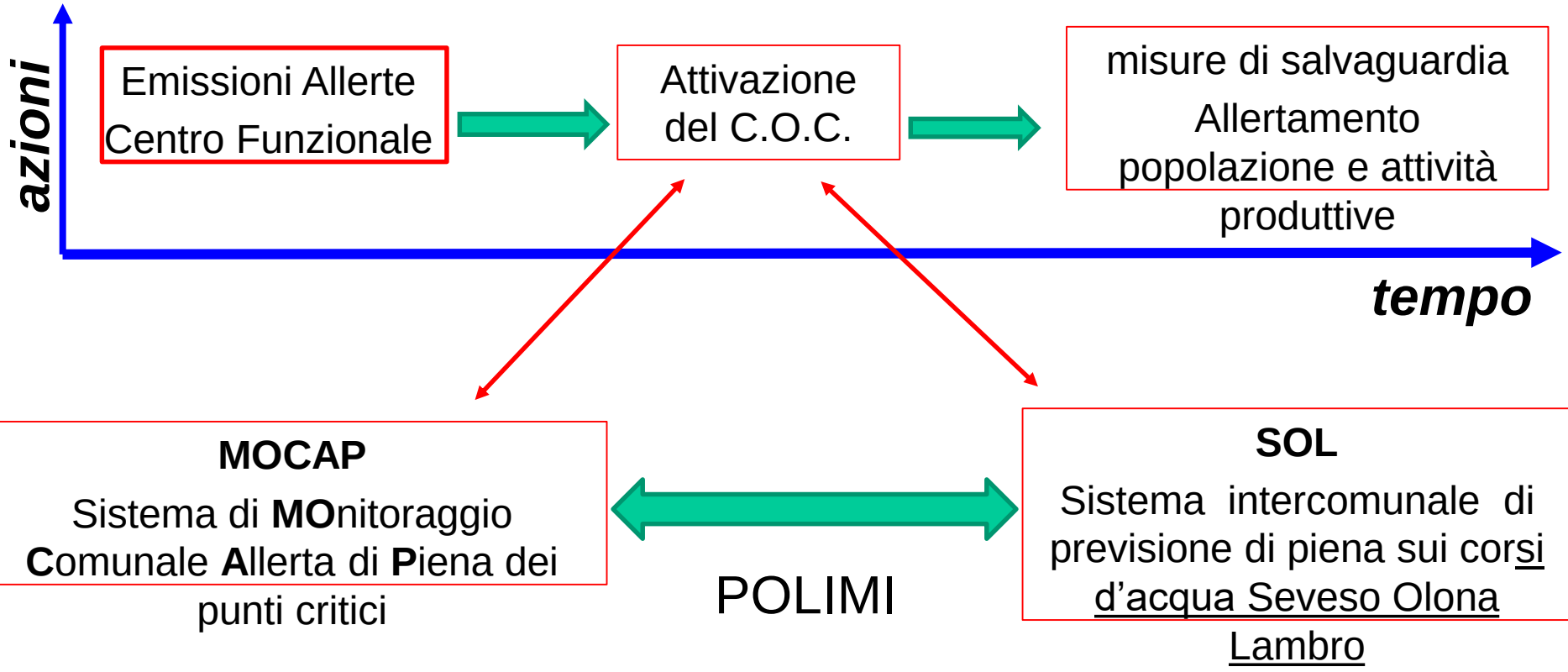
Source REGIONE LOMBARDIA



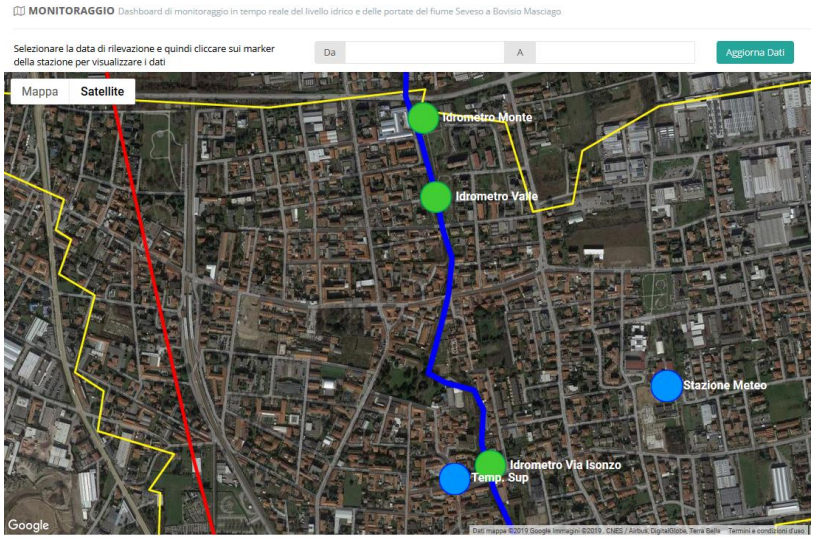




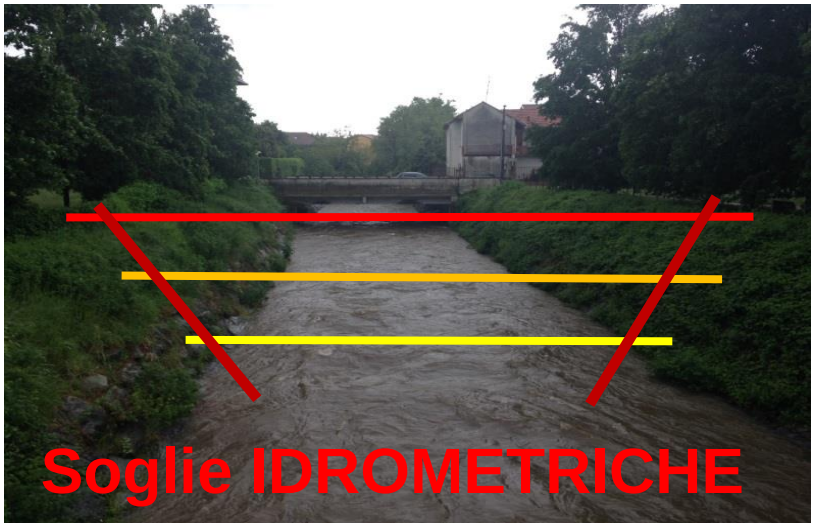
GLI STRUMENTI COMUNALI DI MONITORAGGIO E PREVISIONE: QUANDO e COME….



MOCAP, Monitoraggio Comunale Allerta di Piena
Fiume Seveso a Bovisio Masciago (MB)



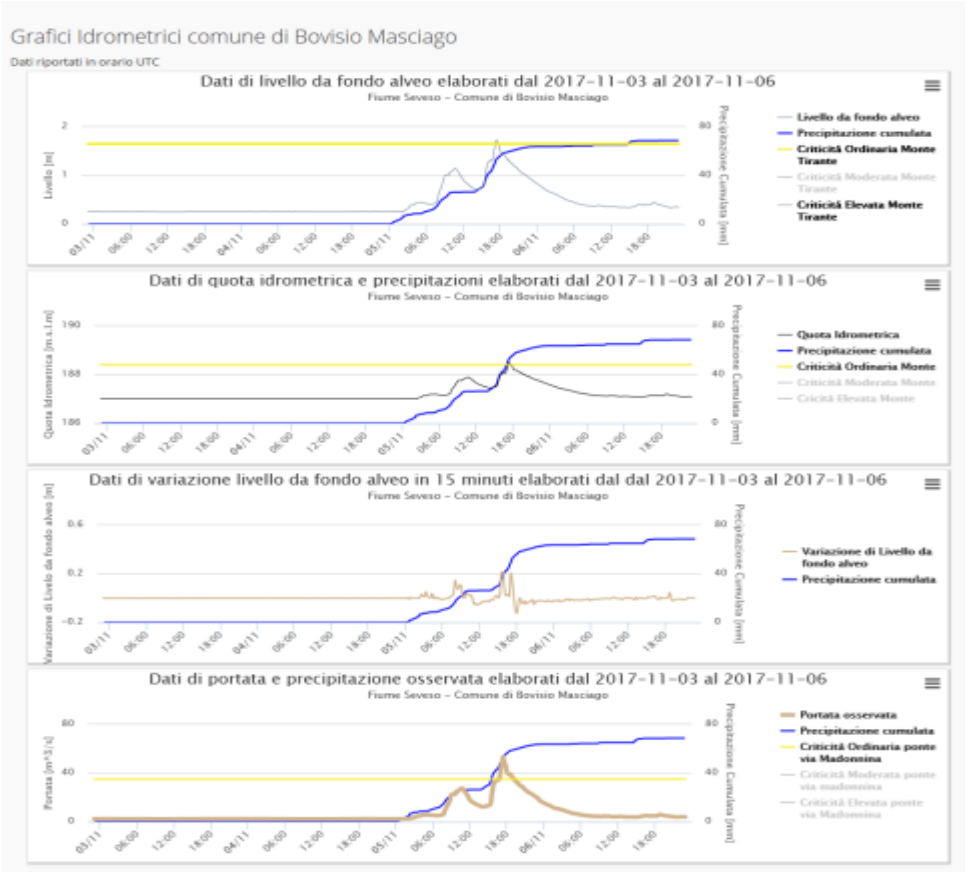
ANALISI IDRAULICA



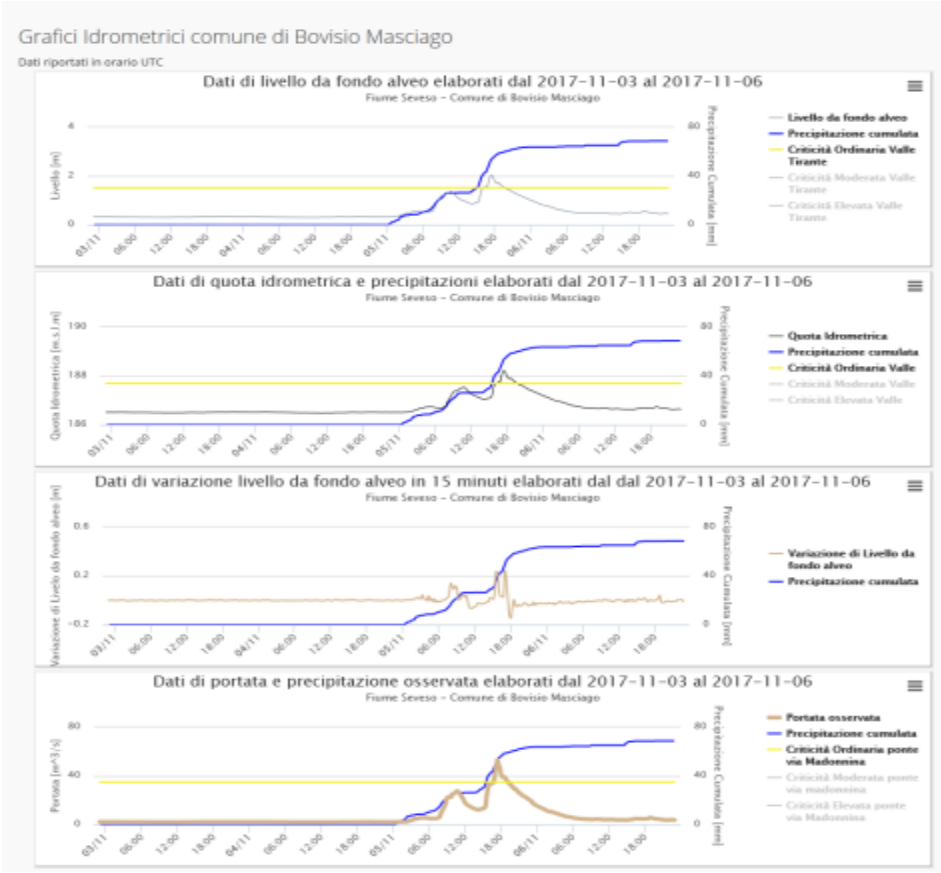
MOCAP, Monitoraggio Comunale Allerta di Piena
Fiume Seveso a Bovisio Masciago (MB)

Dalla dashboard è possibile consultare in tempo reale l'andamento della precipitazione, del livello idrico, della portata e della variazione di portata

SEZIONE DI MONTE

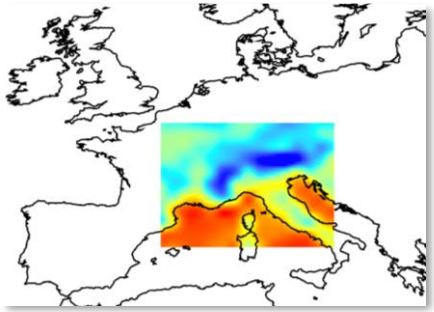


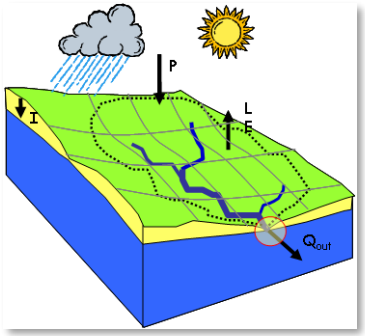
SEZIONE DI VALLE

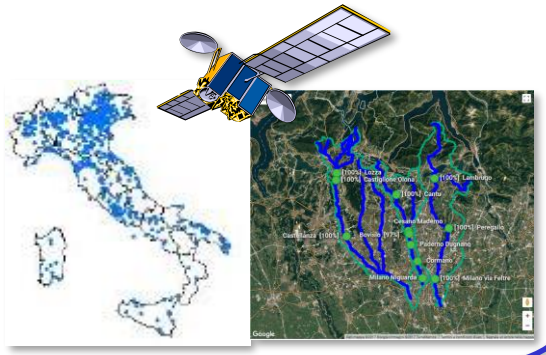


The SOL forecasting system

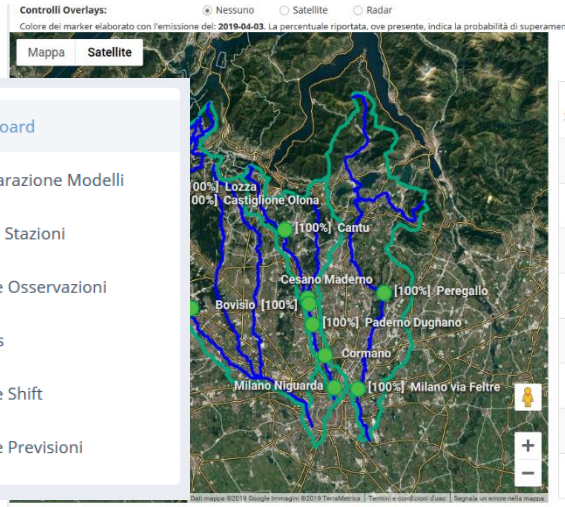
Meteorological forecasts + **Hydrological model** + **Land and satellite observations**







SOL free-access web dashboard: sol.mmidro.it = ***The flood forecasting system for Seveso, Olona and Lambro rivers***



nessuna criticità | criticità ordinaria | criticità moderata | criticità elevata

Stazione	03/04/2019	04/04/2019	Shift 04/04/2019	05/04/2019
Lozza	(100 %)	(4.3 %)		(100 %)
Castellanza	(100 %)	(4.3 %)		(100 %)
Cantu	(100 %)	(4.3 %)		(4.3 %)
Paderno Dugnano	(100 %)	(100 %)		(100 %)
Peregallo	(100 %)	(4.3 %)		(4.3 %)
Milano via Feltre	(100 %)	(4.3 %)		(4.3 %)
Bovisio	(100 %)	(4.3 %)		(100 %)
Castiglione Olona	(100 %)	(4.3 %)		(100 %)

Il premio "Italiadecide": SOL – Sistema di previsione di piena dei fiumi Seveso – Olona - Lambro

IL PROGETTO SOL
È UN'INIZIATIVA:

GRUPPO DI RICERCATORI
DELLA SEZIONE SCIENZE E INGEGNERIA DELL'ACQUA
DIPARTIMENTO DI INGEGNERIA CIVILE E AMBIENTALE
POLITECNICO DI MILANO

www.mmidro.it

SOL – SISTEMA DI PREVISIONE DI PIENA DEI FIUMI SEVESO - OLONA - LAMBRO

(sol.mmidro.it)

GRUPPO PROPONENTE

Marco Mancini, Giovanni Ravazzani, Chiara Corbari, Alessandro Ceppi (DICA PoliMi),
Stefania Meucci (MMI srl, startup PoliMi)

GRUPPO DI LAVORO

DICA POLIMI, MMI srl, EPSON Meteo MOPI srl, Meteonetwork,
ARPA Emilia Romagna, ISAC CNR.

Progetto vincitore del

PREMIO MIGLIOR PROGETTO/ATTIVITA' DI RICERCA APPLICATA INNOVATIVA O DI DIMOSTRAZIONE

in occasione del **Bando 2018 Italiadecide**
INNOVAZIONE TECNOLOGICA PER LO SVILUPPO SOSTENIBILE
(www.italiadecide.it)

Premio "Amministrazione, Cittadini, Imprese"
con il patrocinio del Ministro per la Semplificazione e la Pubblica Amministrazione e d'intesa e in collaborazione con il Ministero dell'Istruzione, dell'Università e della Ricerca

Consegnato in occasione del Rapporto Italiadecide 2018
"Civile e militare. Tecnologie duali per l'innovazione e la competitività"
Camera dei deputati, Sala della Regina – 12 febbraio 2018

Meteorological models for flood forecasts (multi-model approach)

Deterministic models

GFS	spatial resolution: 50 km, Δt 3h, forecast horizon +144h
Bolam	spatial resolution: 8.5 km, Δt 1h, forecast horizon +72h
Moloch	spatial resolution: 1.5 km, Δt 1h, forecast horizon +45h

Cosmo-i2	spatial resolution: 2 km, Δt 3h, forecast horizon +48h
Cosmo-i5	spatial resolution: 5 km, Δt 3h, forecast horizon +72h

Probabilistic models

COSMO-LEPS	spatial resolution: 7 km, Δt 3h, forecast horizon +132h 20 ensembles

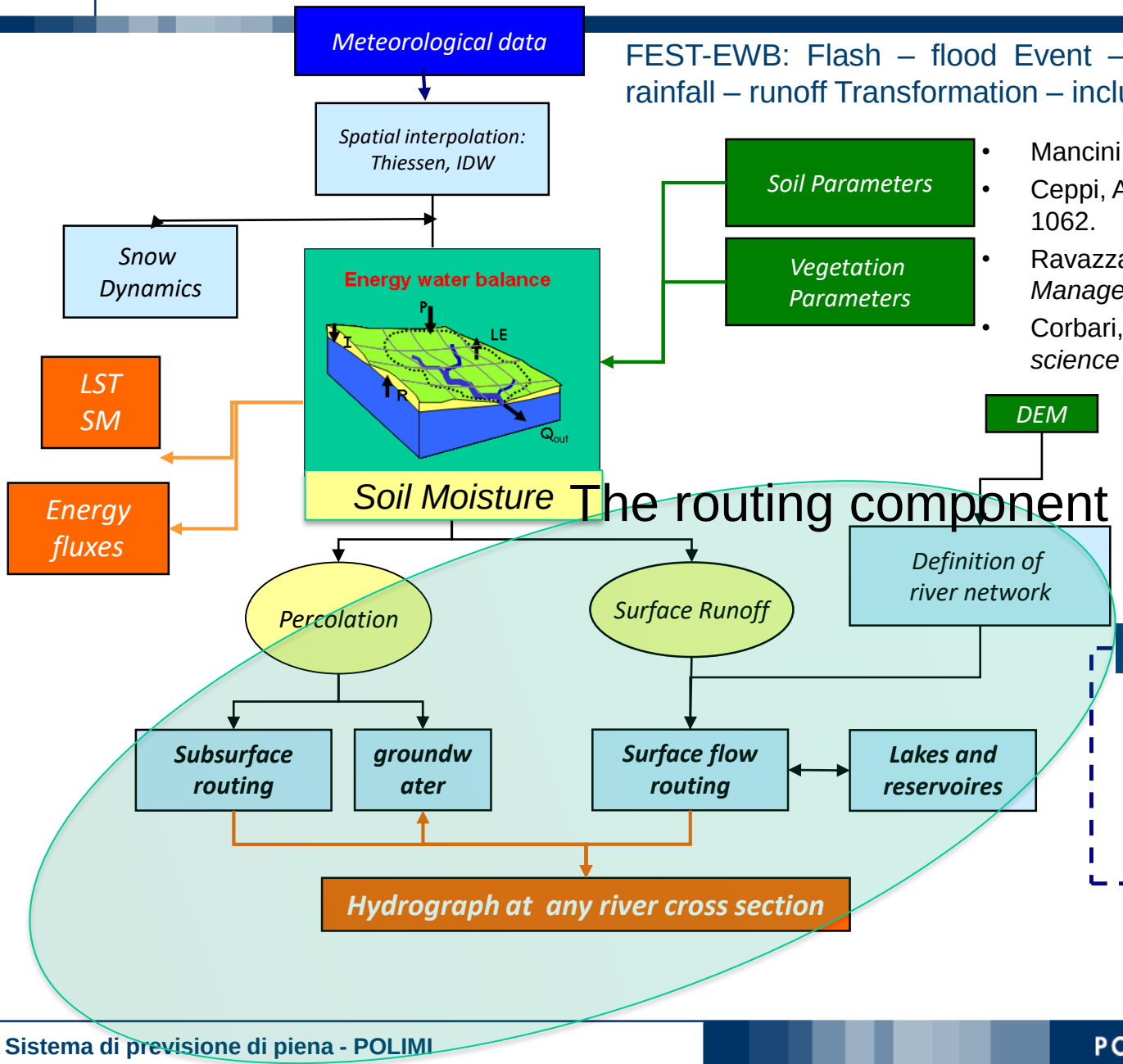
WRF	spatial resolution 5.5 km, Δt 1h, forecast horizon +72h 8 ensembles

The POLIMI hydrological model: FEST-EWB

www.fest.polimi.it

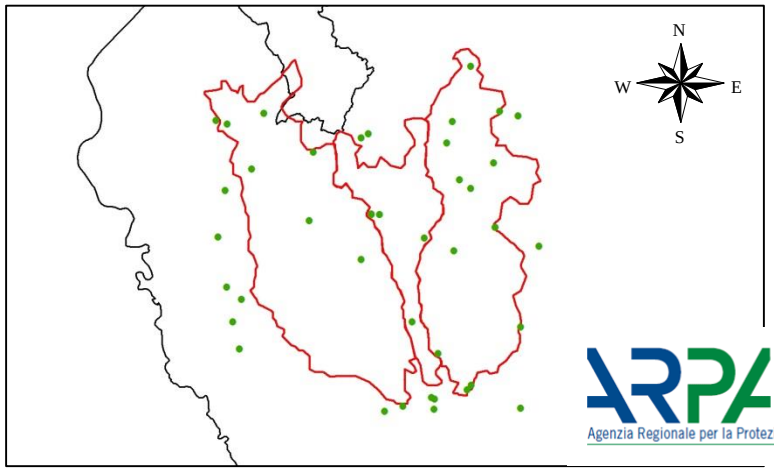
FEST-EWB: Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation – including Energy Water Balance

- Mancini, 1990: *PhD thesis*
- Ceppi, A., et al. 2013: *NHESS*, 13(4), 1051-1062.
- Ravazzani, G. et al., 2014: *Water Resources Management*, 28(4), 1033-1044
- Corbari, C., Mancini, M., 2014: *Hydrological science journal*, 59 (10), 1830-1843

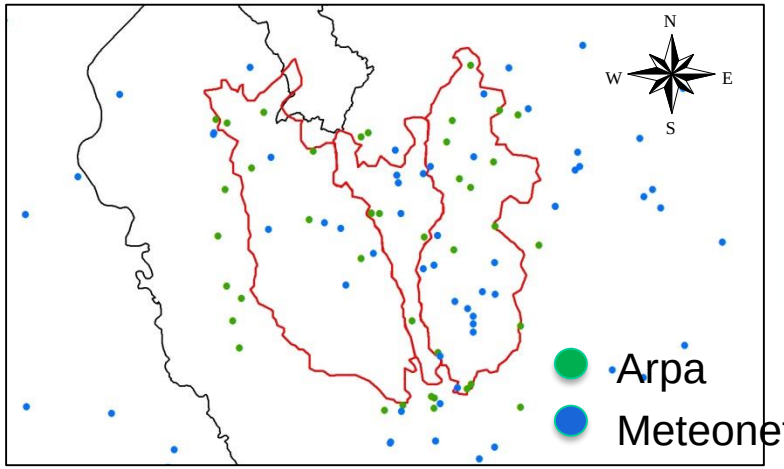


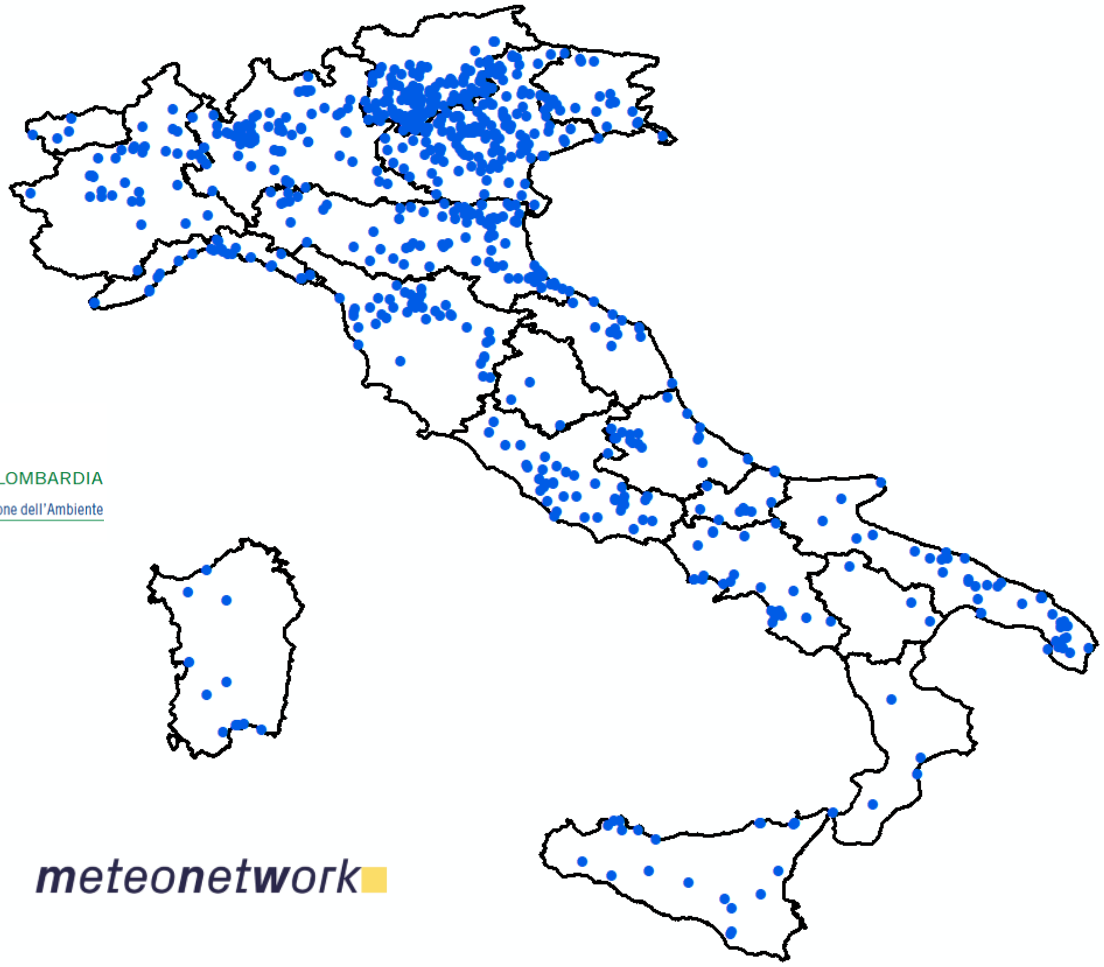
Observed weather data: official and *citizen scientist* stations

Official ARPA Lombardy stations



ARPA + Meteonetwork stations

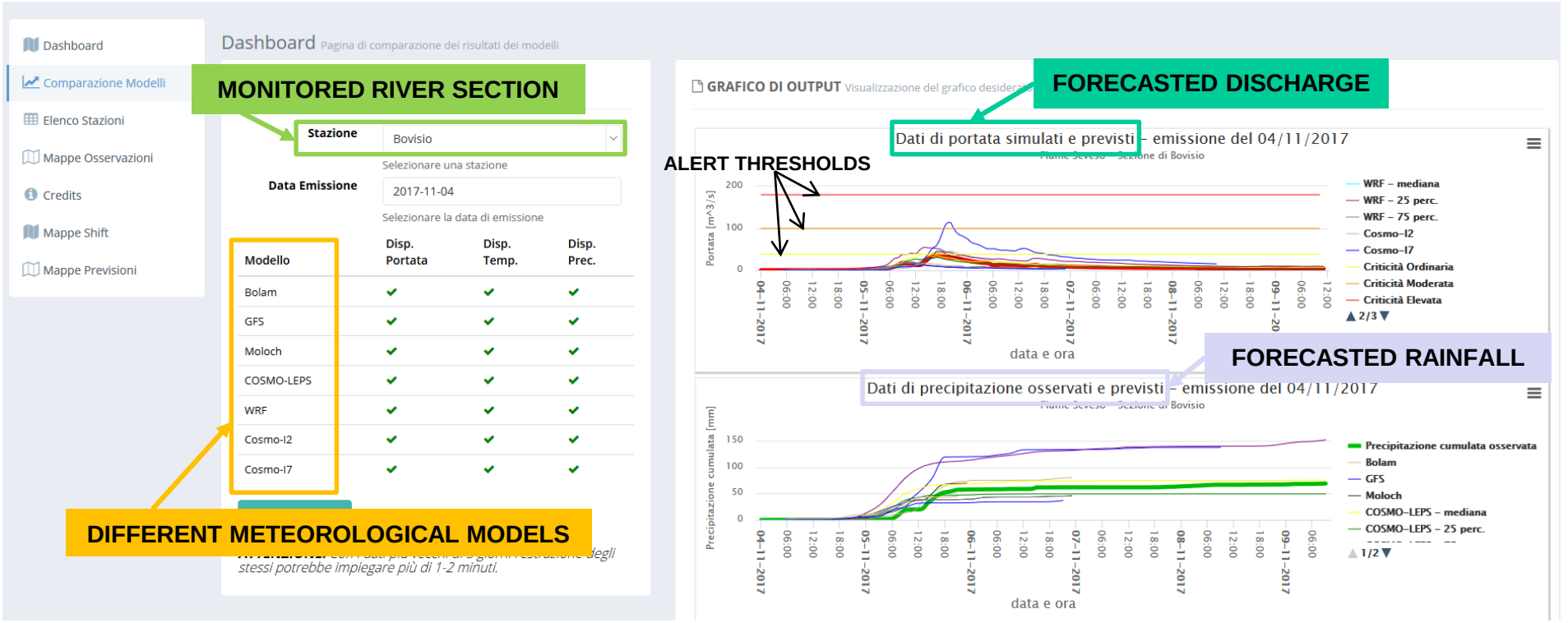




- + 700 weather stations
- real time data every 20 minutes

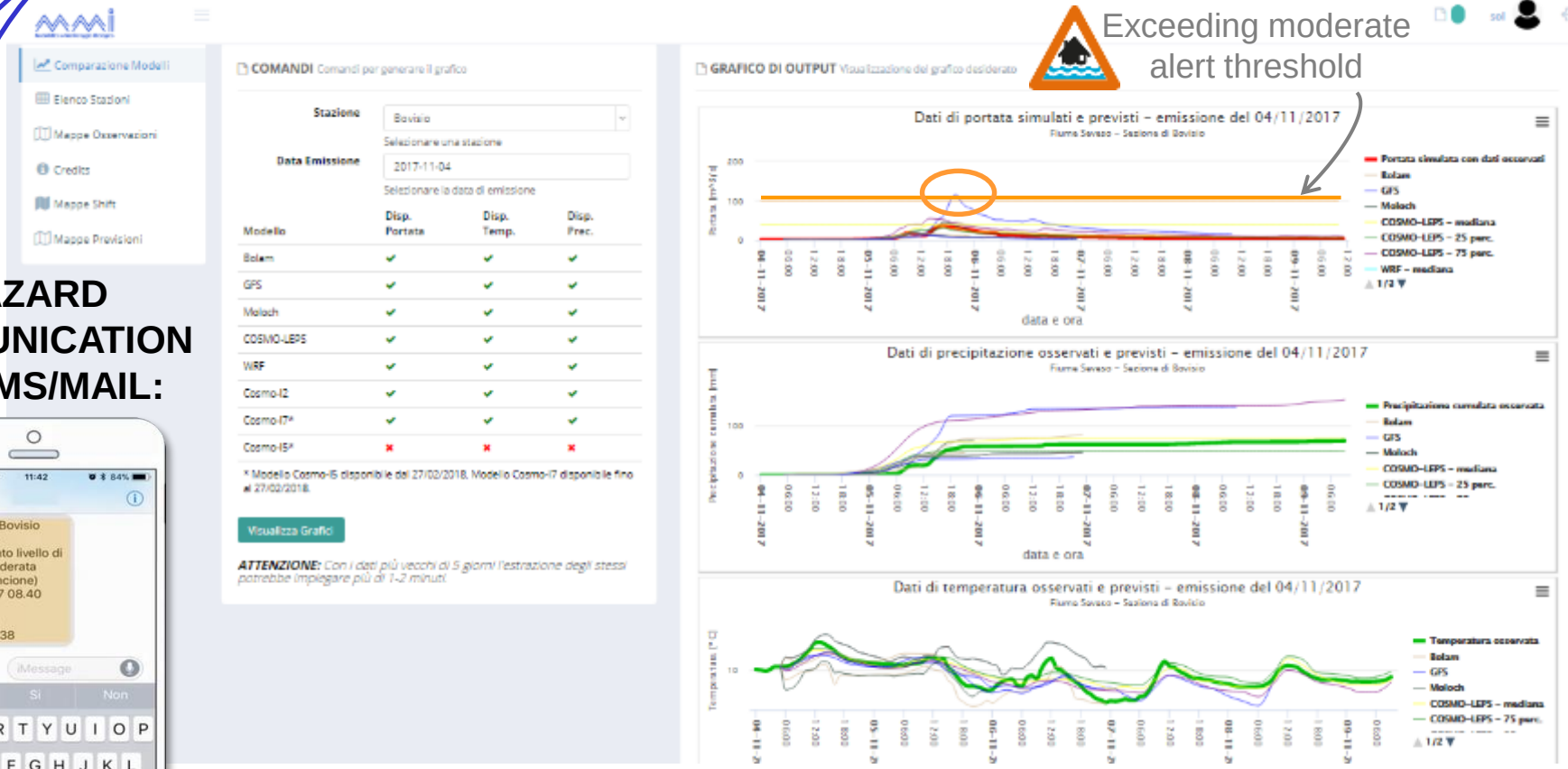
The SOL forecasting system: web dashboard

- SOL bases on a system of coupled limited area meteorological models and a physically-based/spatially-distributed hydrological model.
- The **meteorological models** output become the **hydrological model** input. Then, this model gives, considering the **soil moisture conditions** and the **river hydraulic structures**, the **forecast flood scenario** related to the next few hours and days**.**
- The forecasts are available for each **monitored river section.**



The SOL forecasting system: warnings

HYDRO-METEOROLOGICAL FORECASTS:



HAZARD COMMUNICATION VIA SMS/MAIL:

Il progetto SOL è un'iniziativa

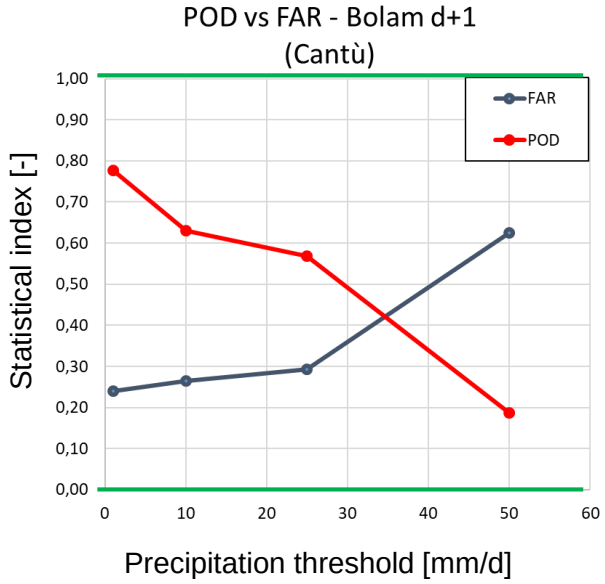
Gruppo di ricercatori della sezione Scienze e Ingegneria dell'Acqua Politecnico di Milano

Ravazzani, G., Amengual, A., Ceppi, A., Homar, V., Romero, R., Lombardi, G., Mancini, M. (2016). Potentialities of ensemble strategies for flood forecasting over the Milano urban area. Journal of Hydrology, 539, 237-253. doi: 10.1016/j.jhydrol.2016.05.023.

Performance analysis [years 2012-2016] for Bolam precipitation forecasts at Cantù (Seveso basin) gauge section

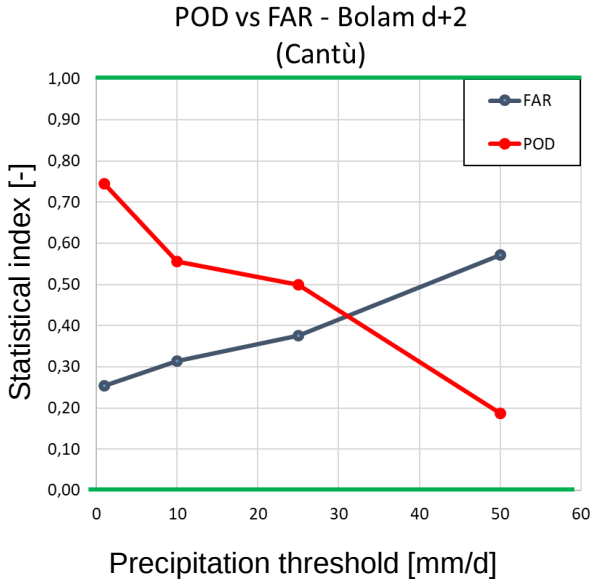
	Bolam d+1			
Threshold (mm/d)	1	10	25	50
POD	0.78	0.63	0.57	0.19
FAR	0.24	0.26	0.29	0.63
Bias Score	1.02	0.86	0.80	0.50
Accuracy	0.86	0.92	0.97	0.99
Brier Score	0.14	0.08	0.03	0.01
POFD	0.11	0.04	0.01	0.00
HK	0.67	0.59	0.56	0.18

	Bolam d+2			
Threshold (mm/d)	1	10	25	50
POD	0.74	0.56	0.50	0.19
FAR	0.25	0.31	0.38	0.57
Bias Score	1.00	0.81	0.80	0.44
Accuracy	0.84	0.90	0.96	0.99
Brier Score	0.16	0.10	0.04	0.01
POFD	0.11	0.04	0.02	0.00
HK	0.63	0.52	0.48	0.18



Best score POD

Best score FAR



Performance analysis [years 2012-2016] for Bolam and Moloch discharge forecasts

Bolam discharge forecast day+1 at Cantù (Seveso)

0-13 m³/s		FORECAST	
		YES	NO
SIMULATION	YES	1563	5
	NO	13	7

13-18.5 m³/s		FORECAST	
		YES	NO
SIMULATION	YES	0	11
	NO	3	1574

18.5-24.5 m³/s		FORECAST	
		YES	NO
SIMULATION	YES	1	2
	NO	4	1581

> 24.5 m³/s		FORECAST	
		YES	NO
SIMULATION	YES	1	5
	NO	3	1579

Moloch discharge forecast day+1 at Castiglione (Olona)

0-41 m³/s		FORECAST	
		YES	NO
SIMULATION	YES	1556	3
	NO	9	1

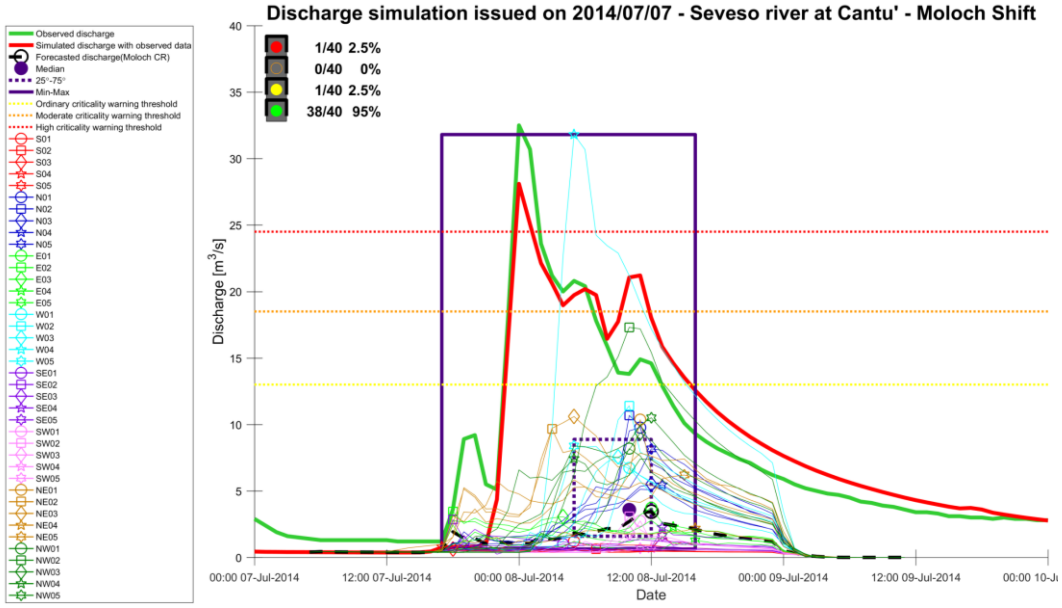
41-70.1 m³/s		FORECAST	
		YES	NO
SIMULATION	YES	0	5
	NO	2	1562

70.1-87.4 m³/s		FORECAST	
		YES	NO
SIMULATION	YES	0	2
	NO	1	1566

> 87.4 m³/s		FORECAST	
		YES	NO
SIMULATION	YES	0	4
	NO	0	1565

Shift Target (ST) ensemble: Union Jack plots, are they useful for civil protection purposes?

Forty discharge forecasts obtained by forty precipitation domain shifts issued on 7 July 2014 over the Seveso basin closed at Cantù gauge section.



North-West	-0.5LONG	-0.4LONG	-0.3LONG	-0.2LONG	-0.1LONG	North	+0.1LONG	+0.2LONG	+0.3LONG	+0.4LONG	+0.5LONG	North-East
+0.5LAT	10.5	Na	Na	Na	Na	8.2	Na	Na	Na	Na	6.2	+0.5LAT
+0.4LAT	Na	7.4	Na	Na	Na	5.5	Na	Na	Na	2.2	Na	+0.4LAT
+0.3LAT	Na	Na	9.4	Na	Na	5.5	Na	Na	10.6	Na	Na	+0.3LAT
+0.2LAT	Na	Na	Na	17.3	Na	10.7	Na	9.7	Na	Na	Na	+0.2LAT
+0.1LAT	Na	Na	Na	Na	8.2	9.8	10.4	Na	Na	Na	Na	+0.1LAT
West	8.4	31.8	7.6	11.4	6.7	3.4	3.7	3.5	3.1	2.3	1.3	East
-0.1LAT	Na	Na	Na	Na	2.7	1.2	1	Na	Na	Na	Na	-0.1LAT
-0.2LAT	Na	Na	Na	3.1	Na	0.63	Na	2.9	Na	Na	Na	-0.2LAT
-0.3LAT	Na	Na	1.8	Na	Na	0.63	Na	Na	1.1	Na	Na	-0.3LAT
-0.4LAT	Na	0.69	Na	Na	Na	0.8	Na	Na	Na	2.3	Na	-0.4LAT
-0.5LAT	0.69	Na	Na	Na	Na	1.6	Na	Na	Na	Na	1.6	-0.5LAT
South-West	-0.5LONG	-0.4LONG	-0.3LONG	-0.2LONG	-0.1LONG	South	+0.1LONG	+0.2LONG	+0.3LONG	+0.4LONG	+0.5LONG	South-East

Union Jack plot for the Cantù section issued on 7 July 2014: the forty values are the maximum discharge forecasts over the entire simulation horizon according to latitude and longitude shift from 0.1 to 0.5 degree which is approximately 10 to 50 km.

Conclusion: Flood monitoring and forecasting in real time, a tool and strategy to live in vulnerable areas

Not to keep the water away from the people…

….but the people away from the water (Nemec, 1986)

Do not reduce hazards, H…

…but reduce exposure (E) and vulnerability (V)

Milano, July 2014

Milano, November 2014

RISK = H*E*V

Forecasting a hazardous event (H) with a sufficient time to save people (V) and materials (E)

Commento conclusivo: Ricerca e Mitigazione del rischio

LA MITIGAZIONE DEL RISCHIO ALLUVIONALE RICHIEDE CONOSCENZA E ANALISI DELICATE **che devono essere riconosciute!**

Il ruolo della ricerca e dello sviluppo tecnologico italiano nel settore va valorizzato e messo alla prova dalle istituzioni e organizzazioni.

Spesso questo è solo in teoria…

Research team: POLIMI/MMI

POLITECNICO MILANO 1863

www.fest.polimi.it/

Modellistica e Monitoraggio Idrologico

www.mmidro.it

Thank you for your attention

alessandro.ceppi@polimi.it