I Servizi per l'Idrologia Operativa tra Stato, Regioni e Sistema Nazionale per la Protezione dell'Ambiente

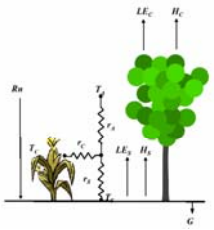
Sensori remoti misure al suolo e modellistica idrologica per la previsione delle piene e del fabbisogno idrico

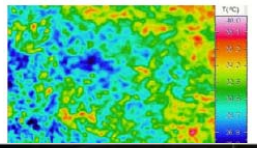
M. Mancini, *G. Becciu, A. Bianchi D. Bocchiola*, ***C. Corbari***, *C. Demichele , G. Menduni,* ***G. Ravazzani***, *R. Rosso, C. Rulli, U. Sanfilippo,* ***A Ceppi M. Feki***

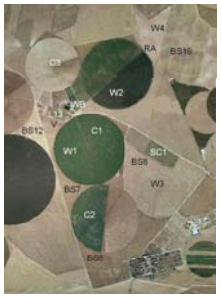
A. Raimondi, F Accattino, A Soncini, G Confortola , Van Thinh Le, C Dresti, F Avanzi, M Marchioni, F Scarpa, P Da Ronco, K Cugerone,, U Minora, Davide C, G De Carolis, ***I Ben Chafi, A Di Trapani G. Milleo*** *, I Colombo, R. Cantù.*

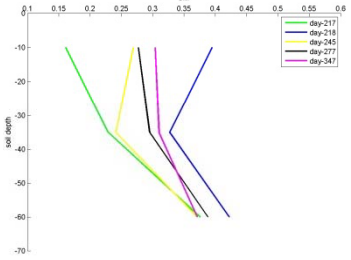
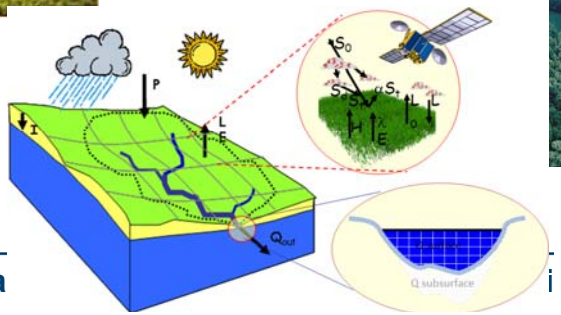
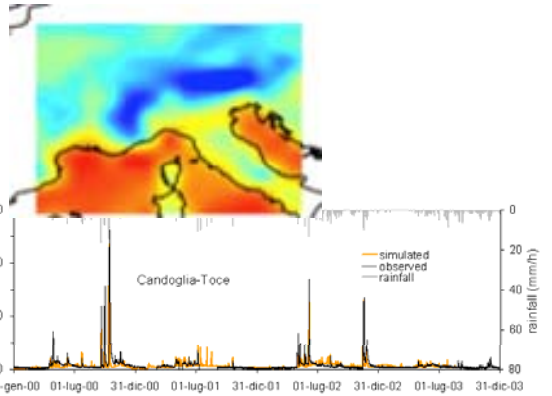
SCIENZE E INGEGNERIA DELL'ACQUA, ***D.I.C-A. POLIMI***









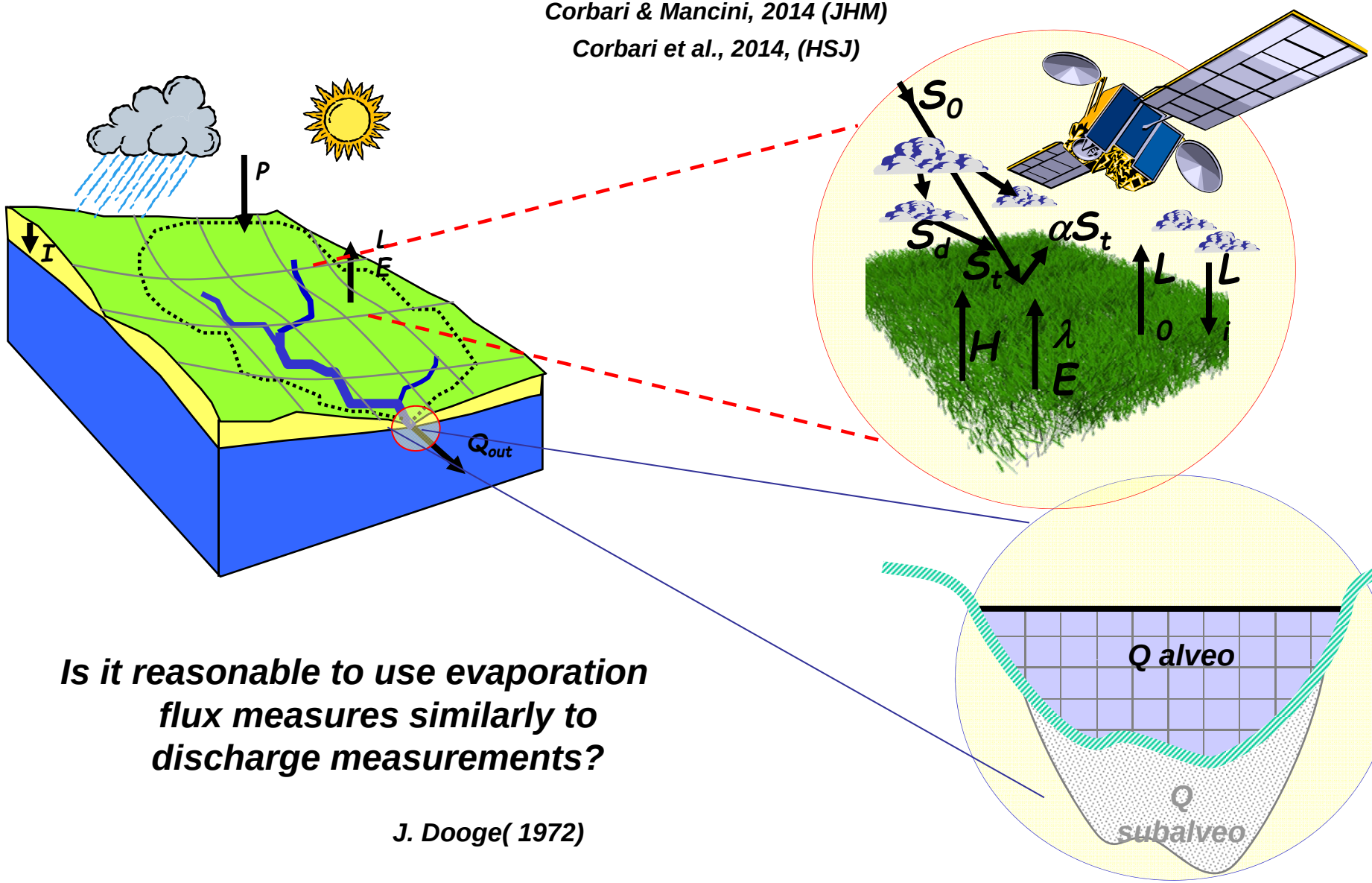

Roma Luglio 2015

POLITECNICO DI MILANO

Modellistica idrologica distribuita e dati satellitari: monitoraggio dei flussi evapotraspirativi dalla superficie di un bacino

Corbari & Mancini, 2014 (JHM)

Corbari et al., 2014, (HSJ)



Is it reasonable to use evaporation flux measures similarly to discharge measurements?

J. Dooge(1972)

The tools

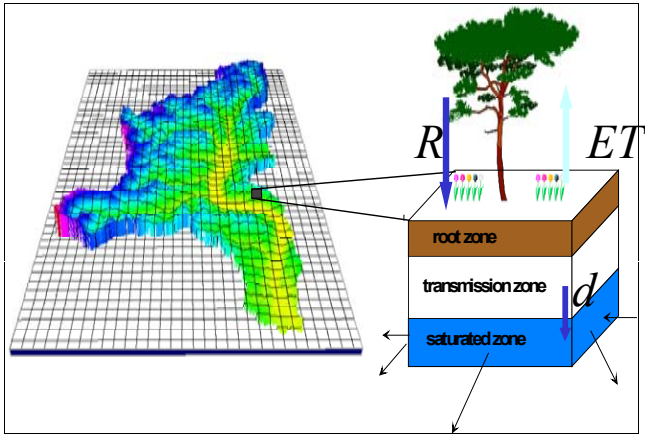
Soil water balance

Energy balance

$$P_{tot}=R+ET_{eff}+D+(\theta_{t+1}-\theta_t)*Z$$

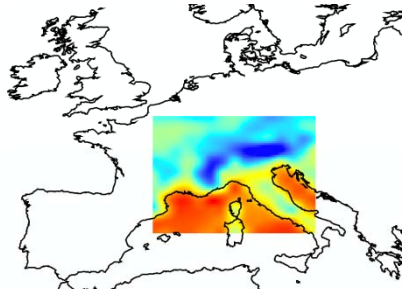
$$Rn-G-H-LE=\frac{dS}{dt} \qquad ETeff=\frac{LE}{\rho Cp}$$

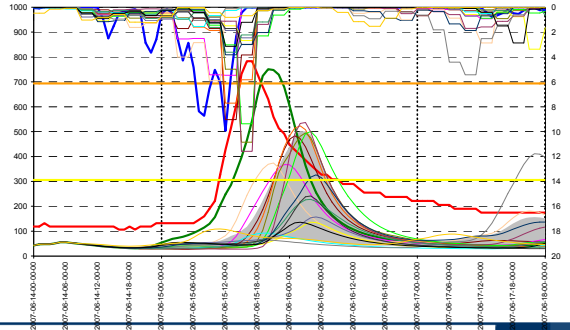
Distributed Hydological model



Misure al suolo

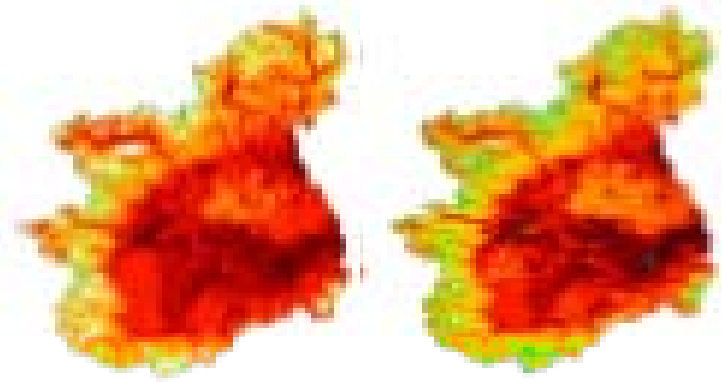
Previsioni meteorologiche





Immagini satellitari

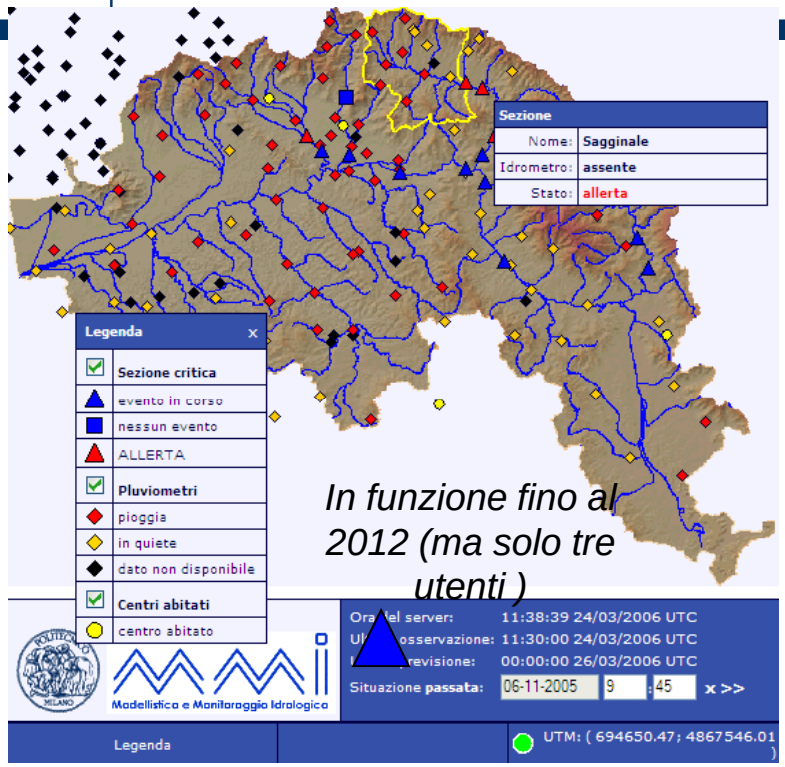
MODIS **FEST-EWB**



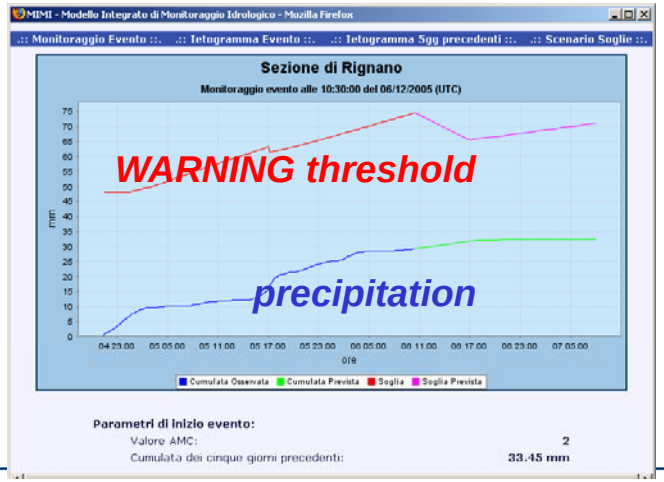
LST

Sistemi di allerta Meteo-Idrologica: soglie pluviometriche di allerta idrometrica

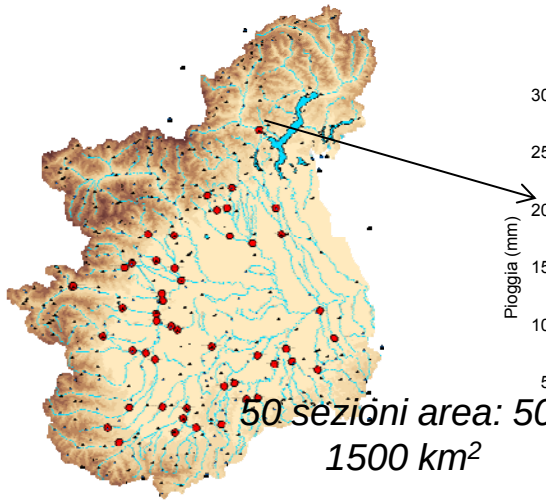
Centro Funzionale Regione Toscana

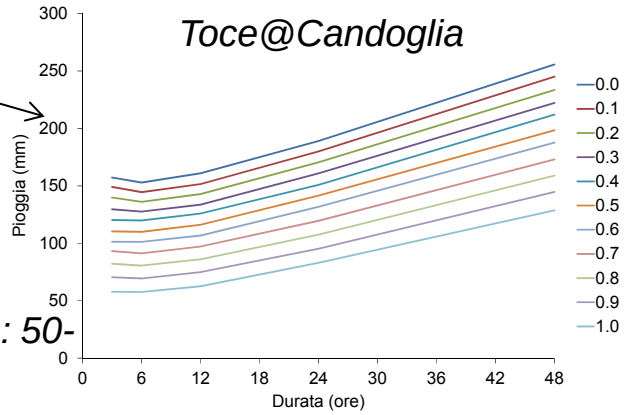


In funzione fino al 2012 (ma solo tre utenti)



Arpa Regione Piemonte

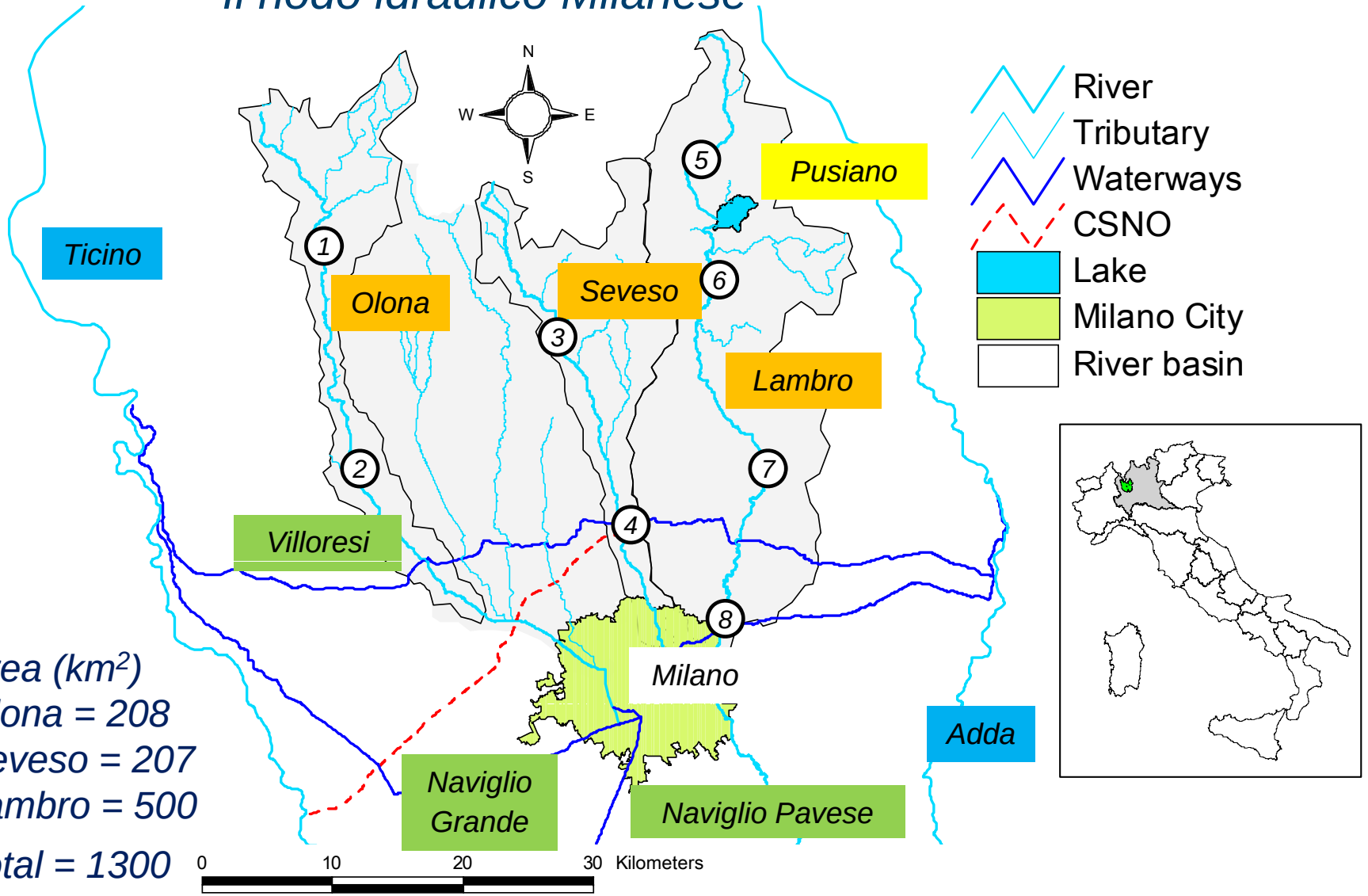




50 sezioni area: 50-1500 km²

Marco Mancini, marco.mancini@polimi.it,

Il nodo idraulico Milanese

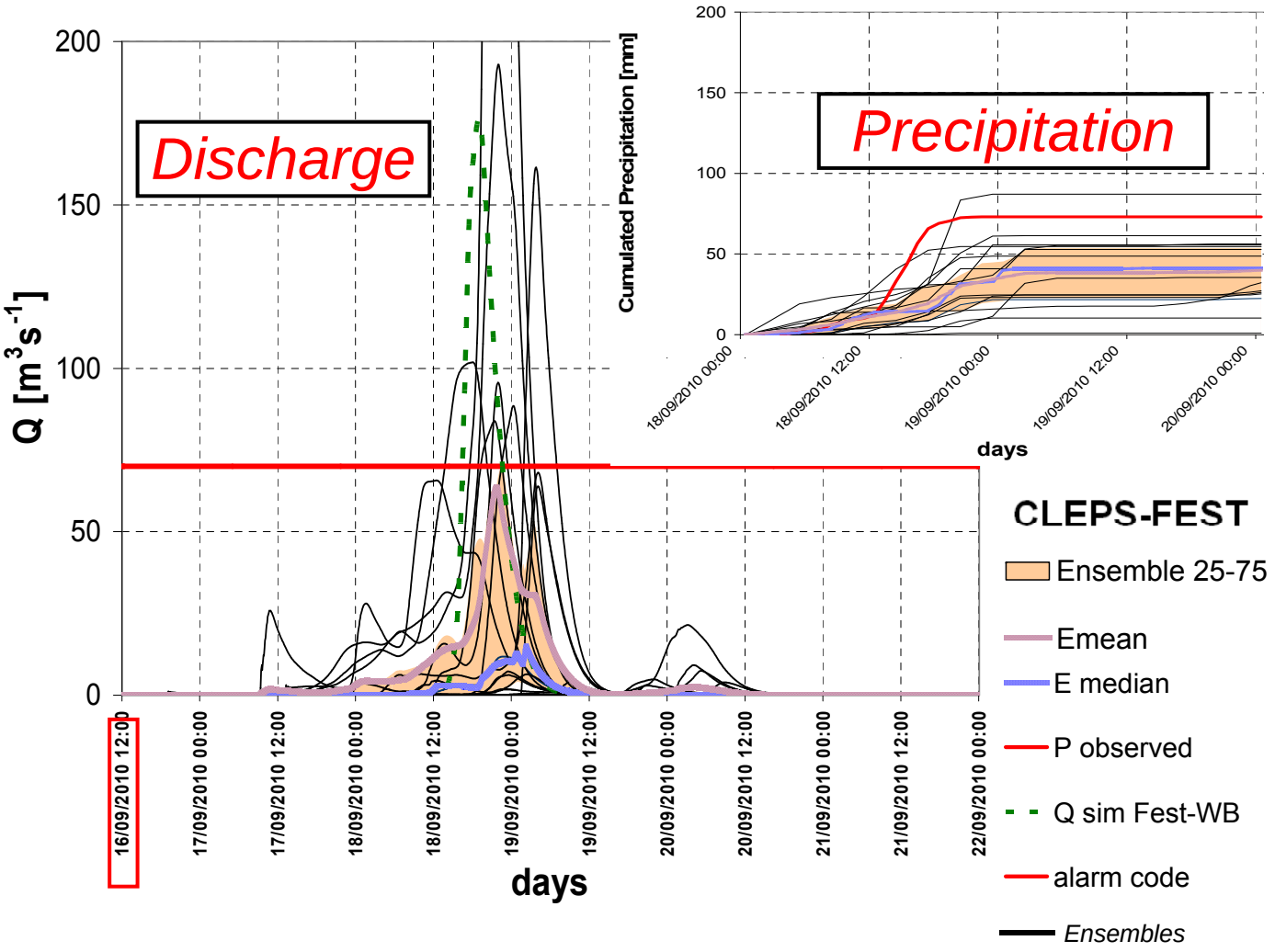


Area (km²)
Olona = 208
Seveso = 207
Lambro = 500

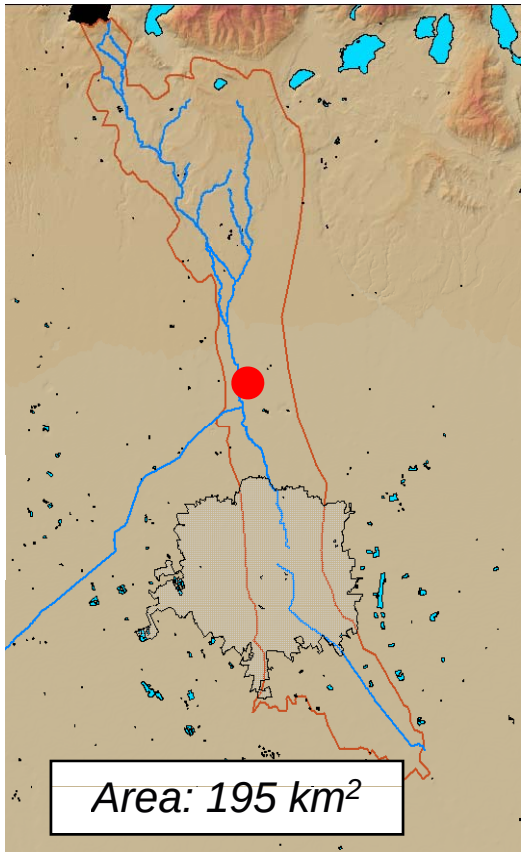
Total = 1300

16 September 2010 output run at 7 sqkm : 48 h before the main peak flow

Forecast Reliability: 37.5% about of 80 M € damages

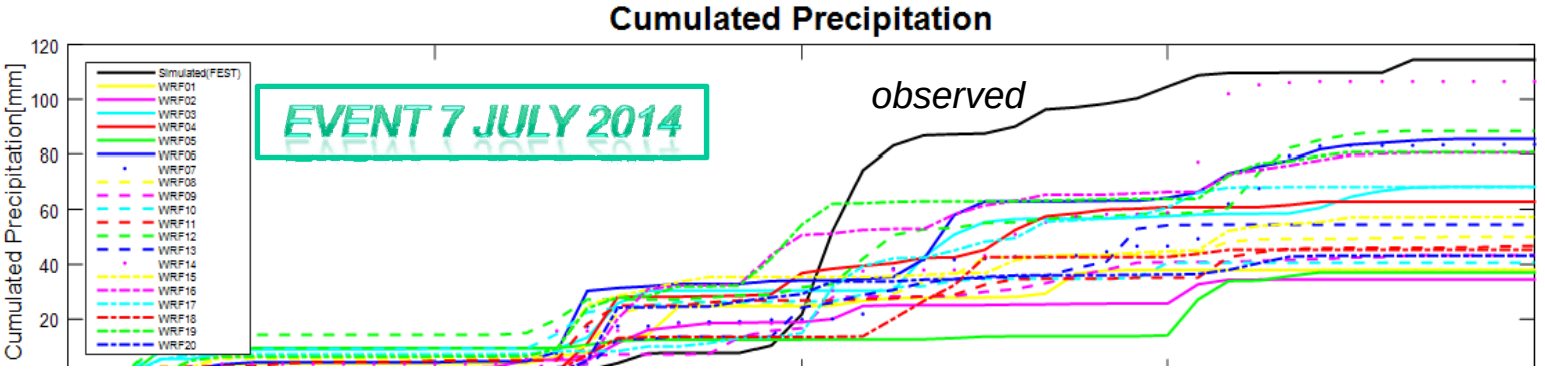


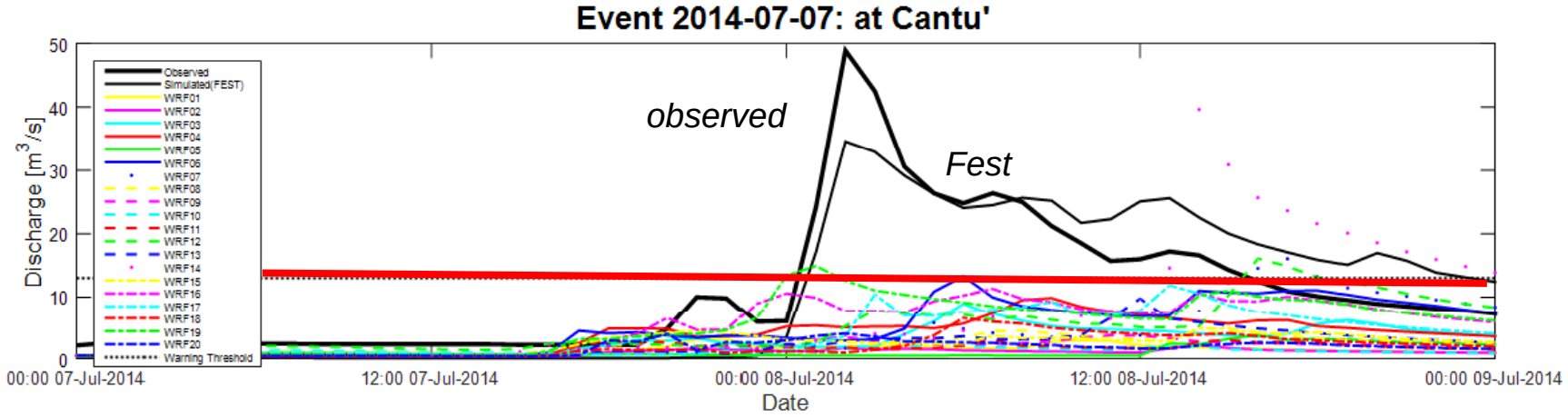
Seveso basin



Sistemi di Allerta Meteo Idrologica: Previsione dell'Idrogramma di Piena (PIP)

Seveso @ Cantu'





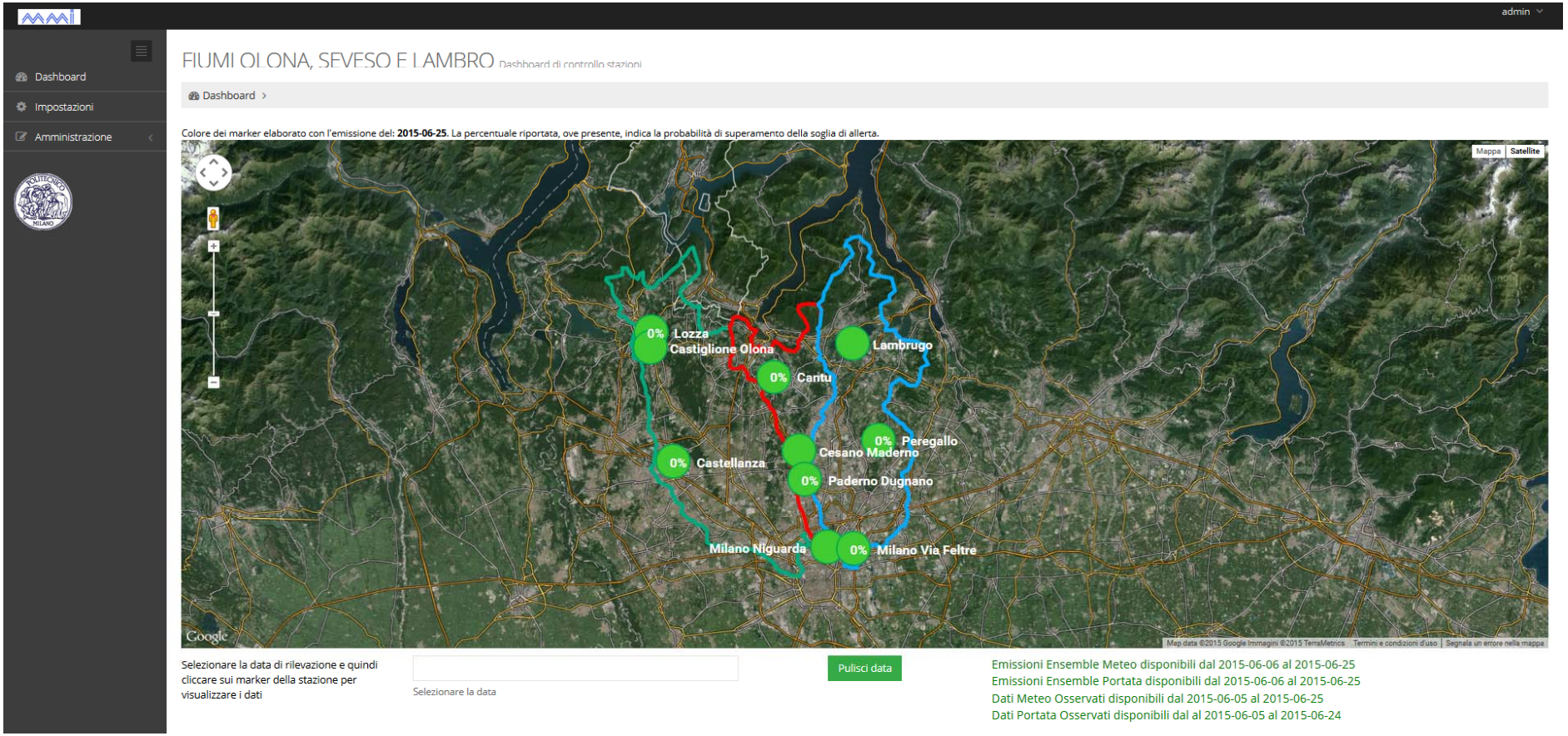
% di superamento della soglia di guardia per diversi schemi di previsione di pioggia

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

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

Meteo Model ensamble scheme (WRF dx=3km)		Seveso Cantu	Lambro Peregallo
7/7/2014	IC_1h	25.0%	50.0%
	Multiphysic_1h	25.0%	50.0%
	Multiphysic_3h	15.0%	55.0%

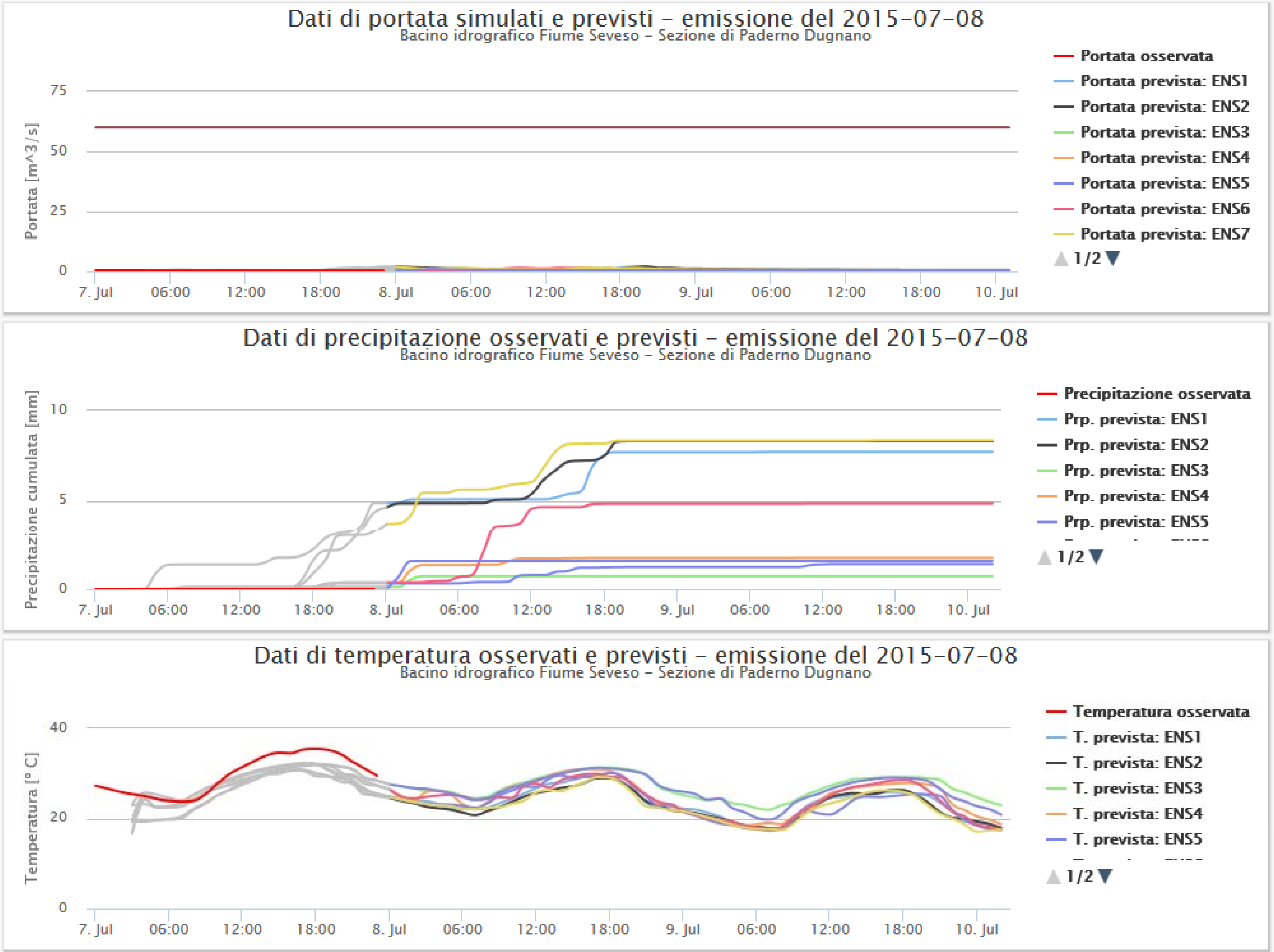
Real time forecasting system:, Seveso Olona Lambro (SOL)



Real time forecasting system:, Seveso Olona Lambro (SOL)

Grafici per l'emissione del 2015-07-08

Dati riportati in orario UTC +2



/isualizzazione nappe: Umidità | 24h | ✔ Visualizza Mappa | ✖ Pulisci Mappa

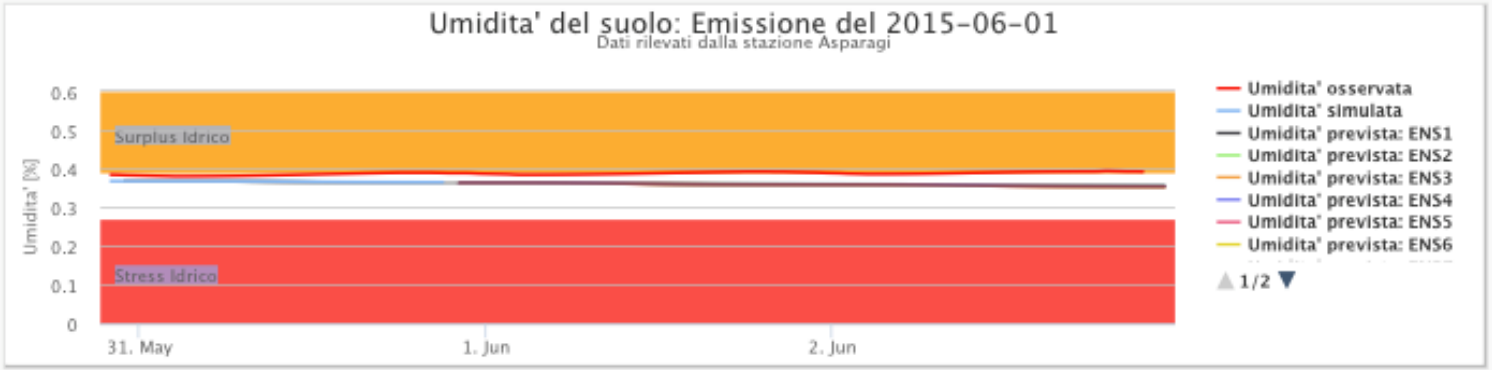
Situazione umidità terreno

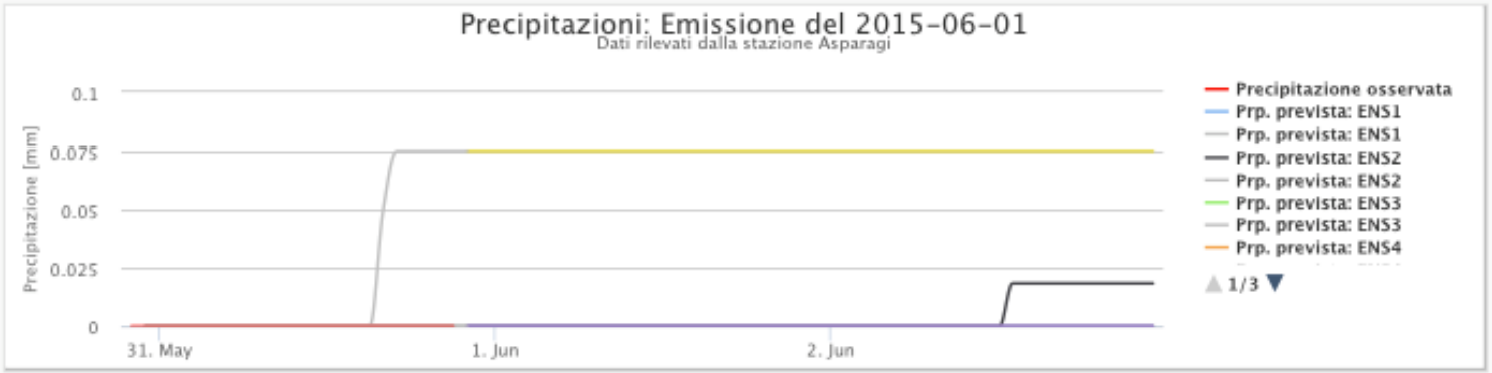
Umidita' del suolo prevista, Emissione del: 2015-06-18

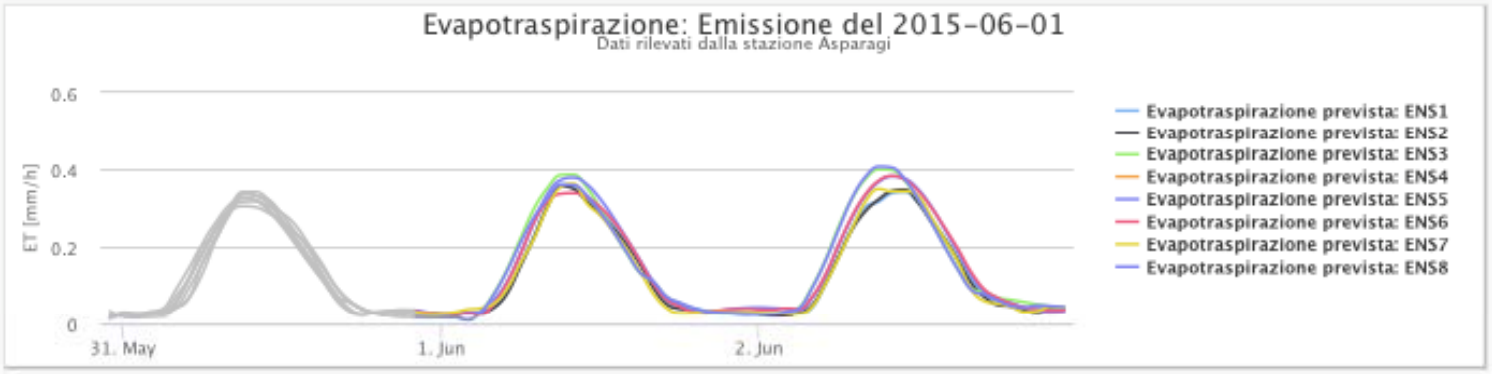
Media degli ensemble

Highcharts.c

Grafici per l'emissione del 2015-06-01





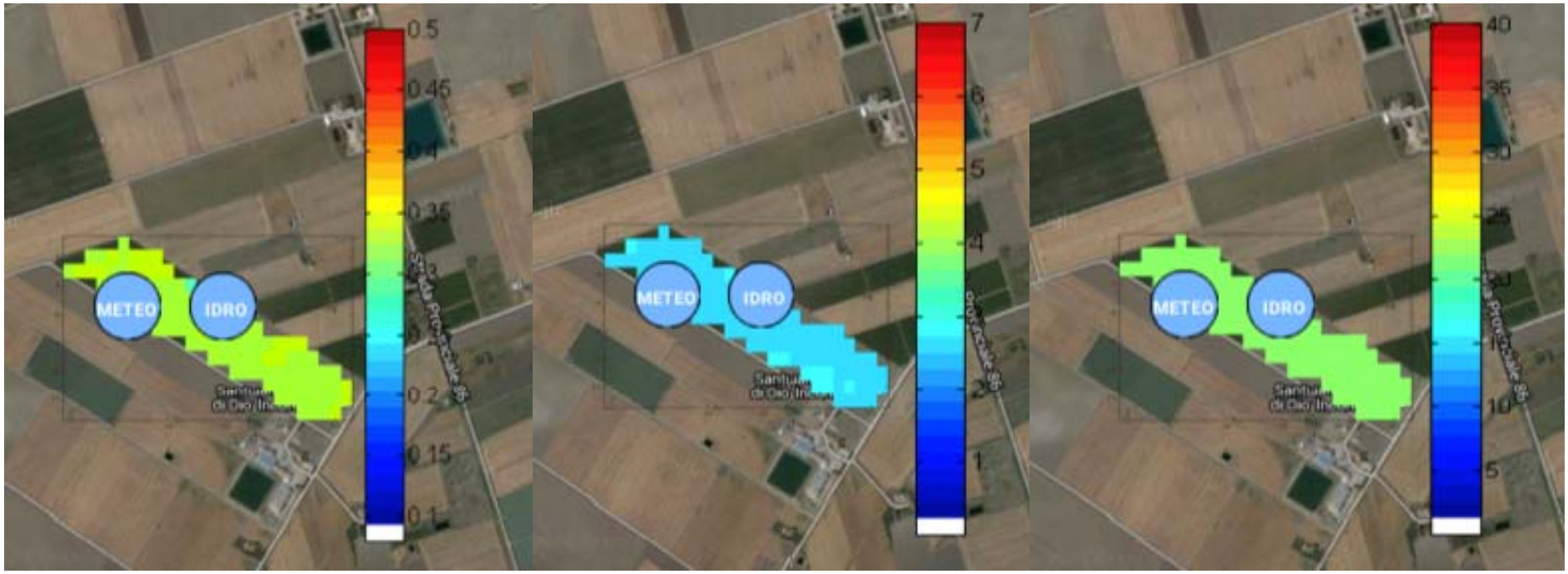


Il monitoraggio in tempo reale

Soil moisture

Evapotraspirazione giornaliera (mm/giorno)

Temperatura superficiale (° C)



Dati satellitari, Modellistica idrologica - idraulica distribuita, controlli al suolo, e previsioni metereologiche *sono oggi un formidabile strumento operativo* ***per il monitoraggio in tempo reale E PER LA PREVISIONE dei contenuti idrici del suolo*** *ai fini di un* ***irrigazione parsimoniosa e di una previsione di piena***

Il monitoraggio delle variabili idrologiche *affina le tecniche di modellazione, la sensibilità ai fenomeni e la progettazione.*

La previsione metereologica e la modellistica idrologica *permettono la previsione di soglie idrometriche di guardia .*

Maggiore attenzione alla modellazione del campo di precipitazione previsto è necessario per una previsione degli idrogrammi di piena.

Le Soglie pluviometrica *di allerta è' auspicabile considerino la capacità di smaltimento della rete idrografica e della condizione iniziale di umidità del suolo. Non una Linea di Possibilità Pluviometrica*

Il ruolo della ricerca e dello sviluppo tecnologico Italiano nel settore

va valorizzato e messo alla prova dalle Istituzioni !

ARTICOLI: WWW.FEST.POLIMI.IT

operative hydrology ground and satellite data:

THANKS TO:

Villa La Colombella, Perugia 1986

IRPI CNR ,
Arno Project 1987

Politecnico di Milano

experimental campaigns

Virginoiolo, 91-94-97,

Zwalm 94-97

Sele 94, EMSL 97, barrax 2012…..20.

Thesis students, Phd students

ADMINISTRATIVE STAFF

Projects

EC94_project
CNR grant
ASI Grant_2002
Radarsat 97
ENVISAT _2002_2005, CARIPLO, ENI,
ACQWA , PREGI, ACCA, SEGUICI , DRAGON

Princeton

MIT

Duke

Gent

Enskede

Wagenigen

Naples

Florence

Cosenza

Palermo

Genova

CRS4

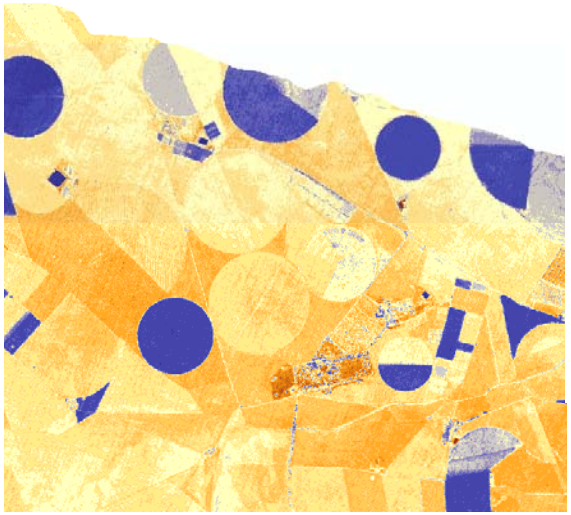
Cagliari …..

COLLABORATIONS

Remote Sensing Land Surface Temperature data (Barrax, Spain, Summer 2012)

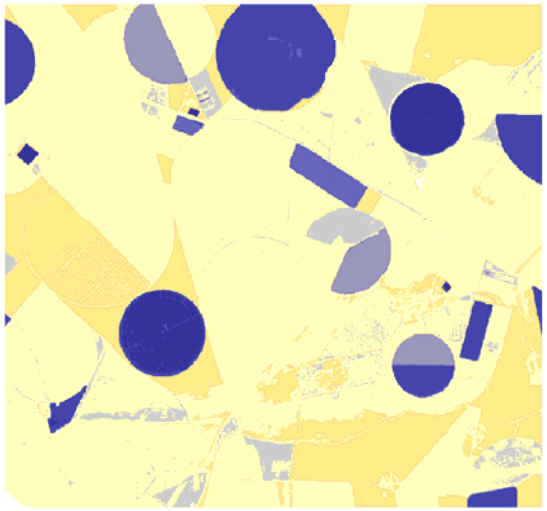
25 July 9:30 UTC *Δx= 5 m*

LST AHS



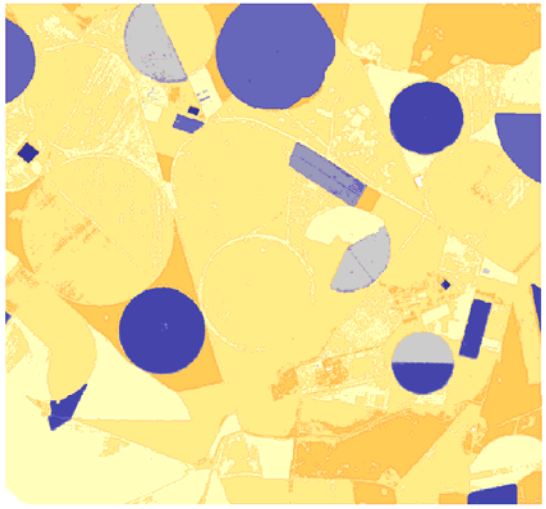
RET

FEST-EWB_not calibrated



RET

FEST-EWB calibrated



° C

22.00720025 - 25
25.00000001 - 28
28.00000001 - 31
31.00000001 - 34
34.00000001 - 37
37.00000001 - 40
40.00000001 - 43
43.00000001 - 46
46.00000001 - 49
49.00000001 - 52
52.00000001 - 55
55.00000001 - 58
58.00000001 - 61

Considering all the available images

Not calibrated				calibrated			
MAE (%)	MD(AHS - FEST-EWB) (° C)	MAD(° C)	RMSD	MAE (%)	MD(AHS - FEST-EWB) (° C)	MAD	RMSD
9.5	0.7	3.4	4.6	3.4	-0.9	1.5	2.1

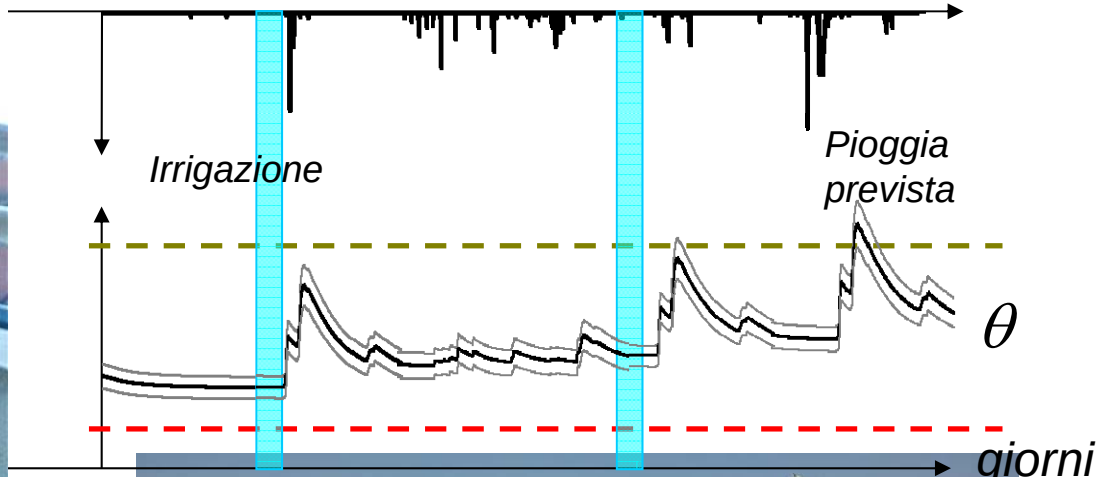
$$\Delta T(.) = Min(RET(.) - LST(.))$$

Corbari et al., 2013 (IJRS)

Corbari et al., 2014 (AG)

...testing different parameters configurations...

Crop irrigation water: synergism between soil water balance model and meteo forecast



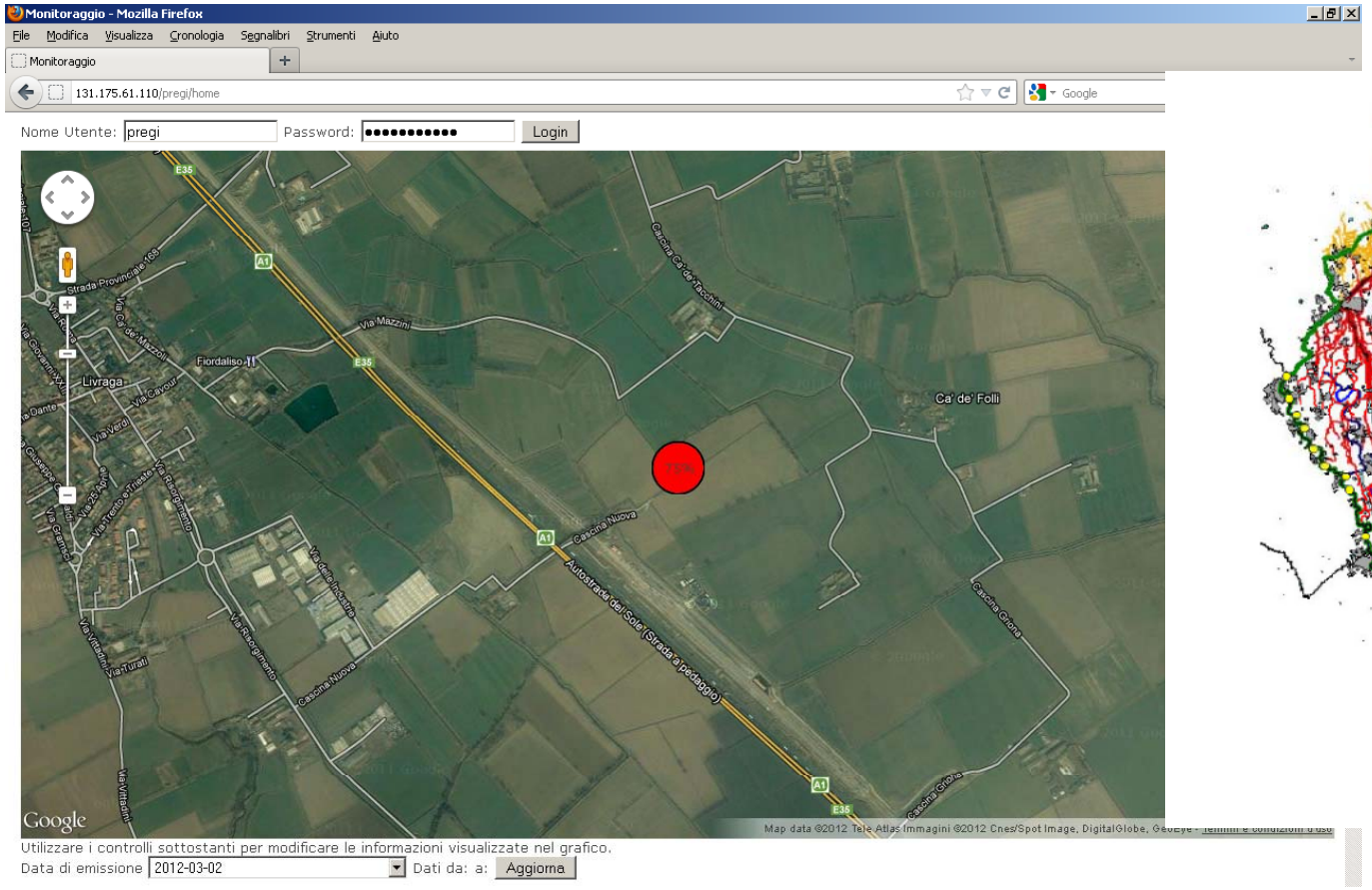
IL MODELLO PREVISIONE GESTIONE IRRIGUA (PREGI)

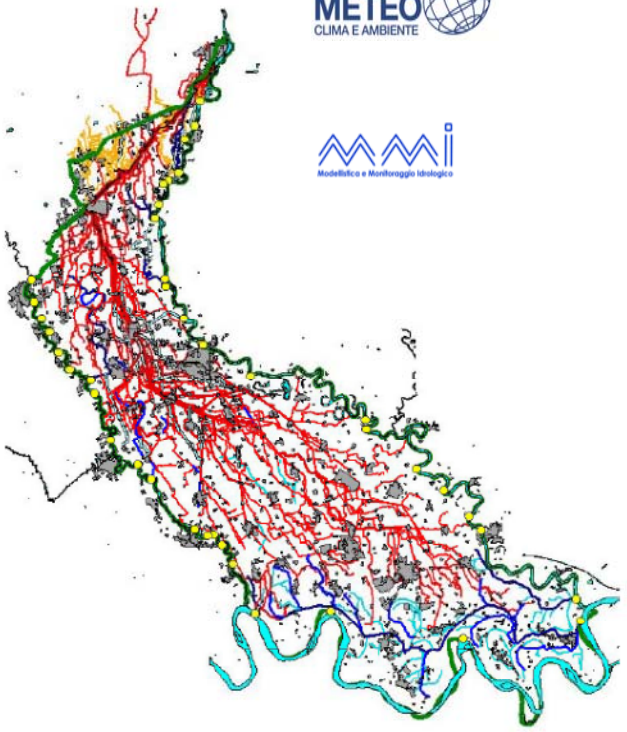
REAL TIME monitoring and forecasting of irrigation water demand

PREGI

Consorzio Muzza Lodigiana:

- 78 irrigation basin for 75’000 hectares
- 6500 km of channels length
- 15 days of scheduled irrigation





RegioneLombardia

MBL

EPSON METEO CLIMA E AMBIENTE

MMI Modellistica e Monitoraggio Idrologico

Marco Mancini, marco.mancini@polimi.it,

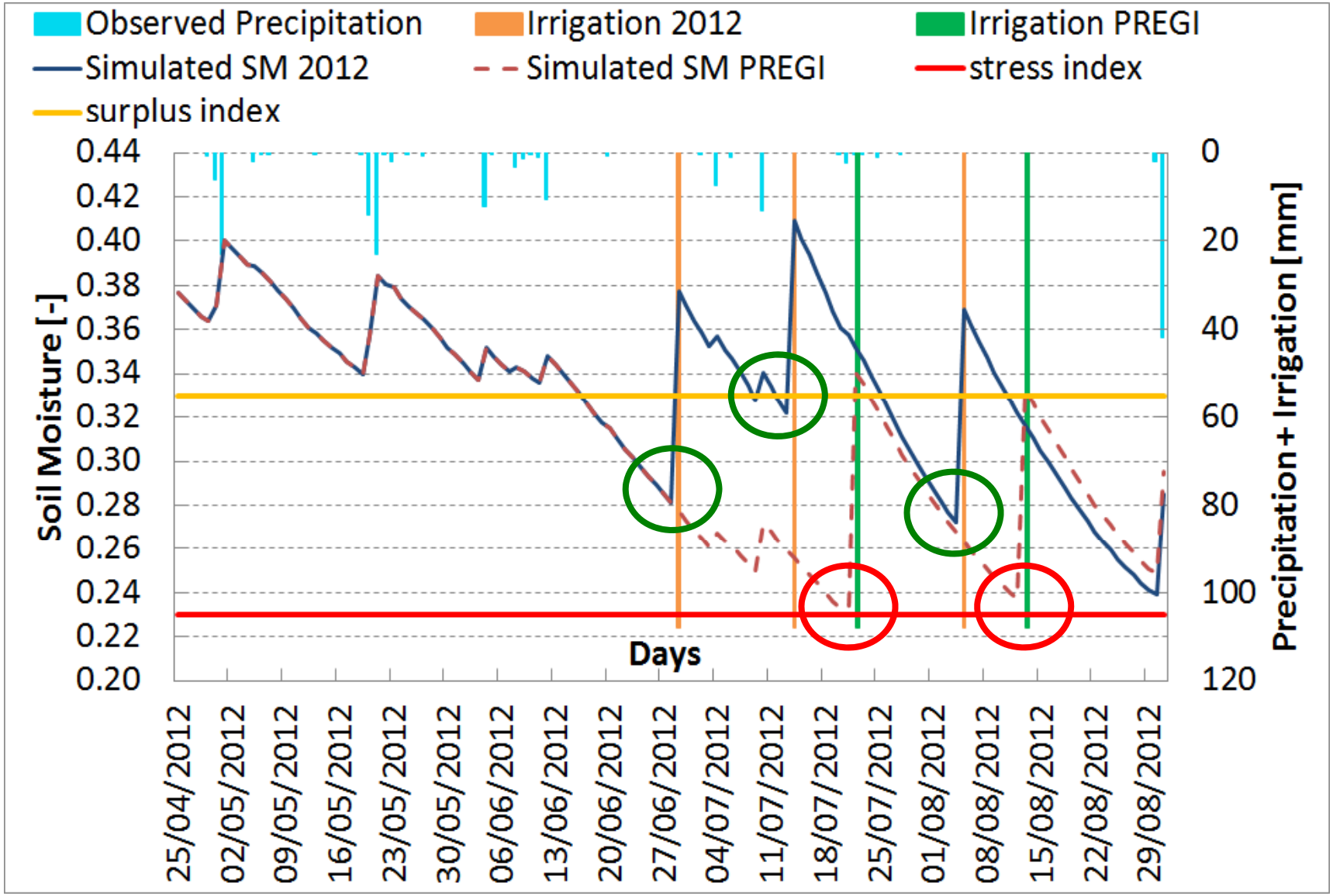
Il sistema irriguo MBL: digitalizzazione e modellazione in comizi

ESEMPIO: Bacino irriguo della coppa incassata e turno irriguo

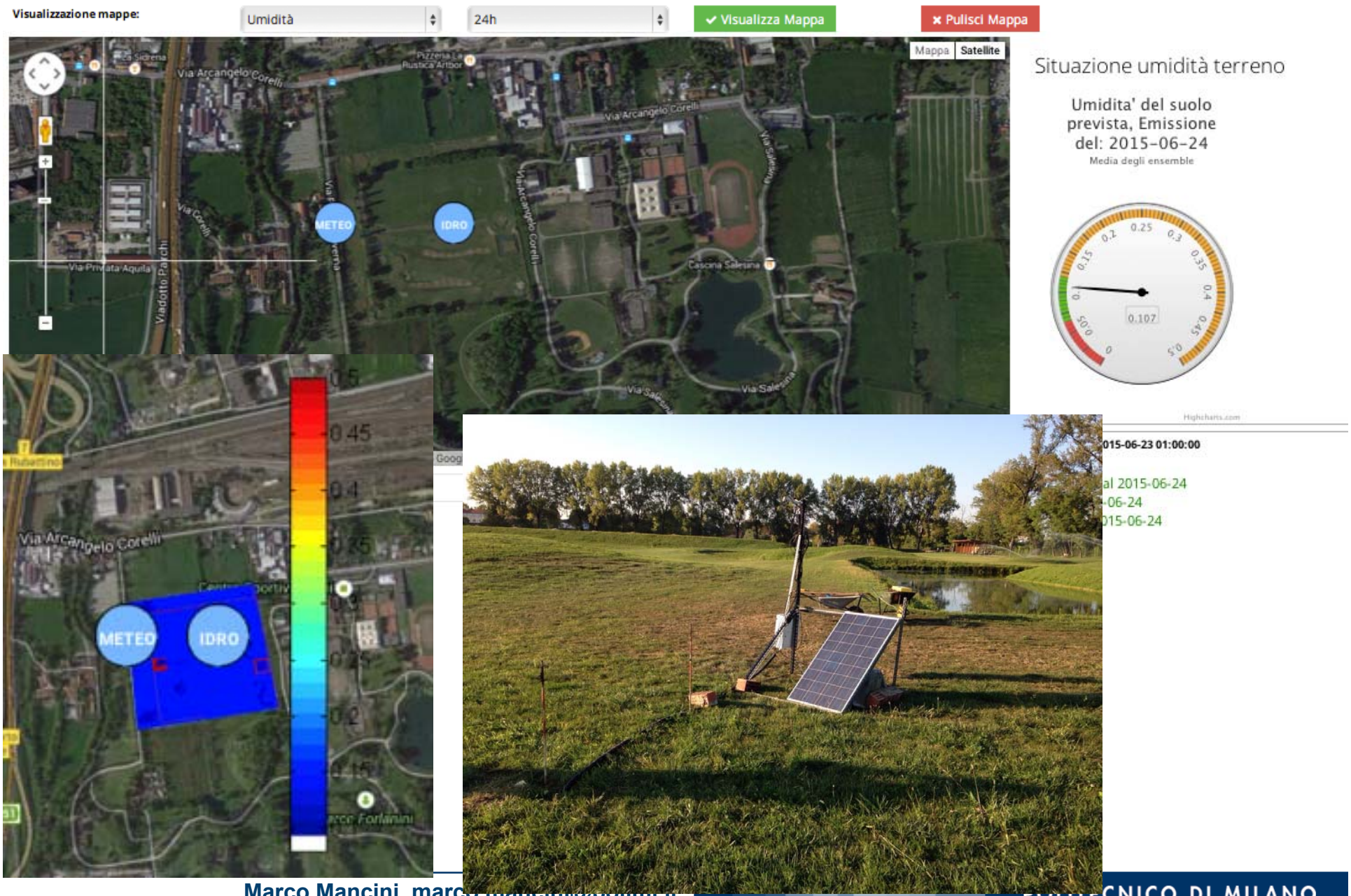
Ricostruzione della ruota irrigua

Digitalizzazione e modellazione del sistema irriguo

can we save irrigation water?

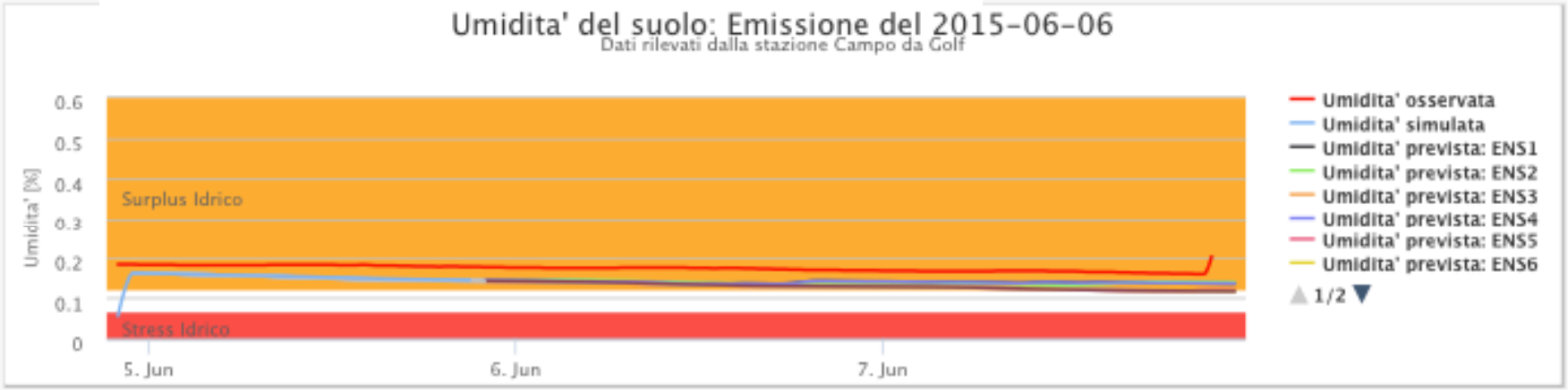


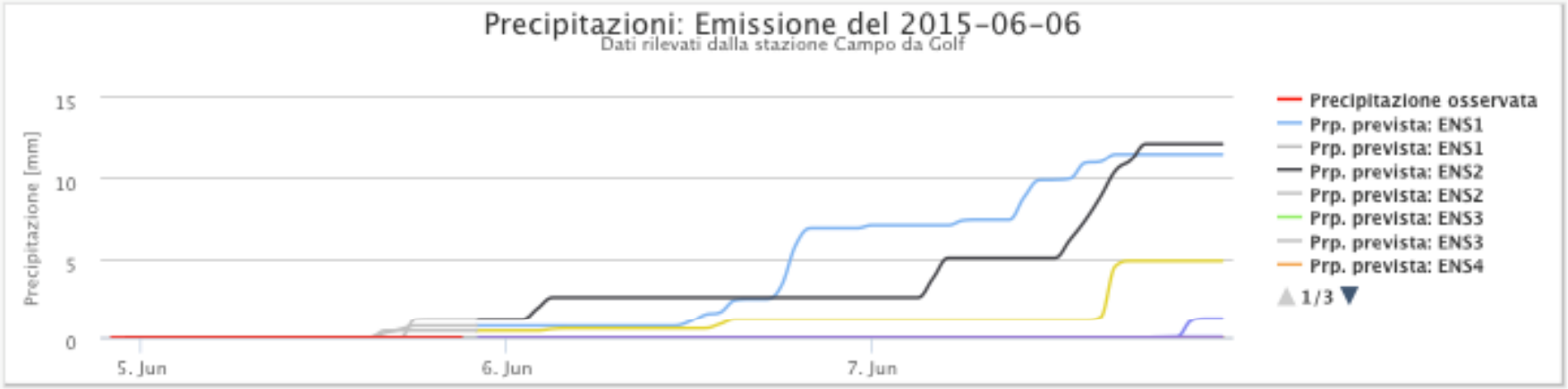
PREGI esempio: Milano, SCUOLA GOLF Forlanini

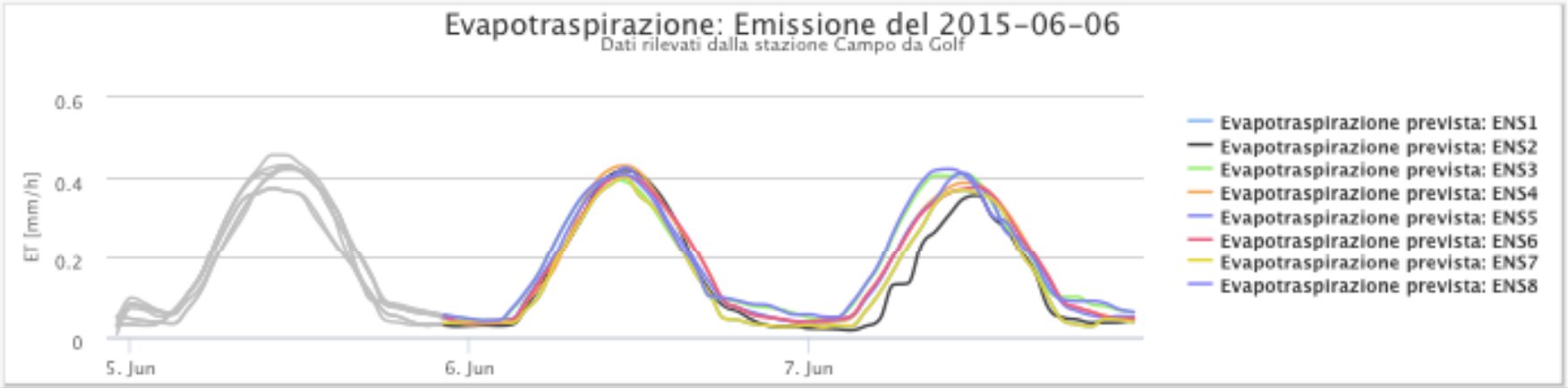


Grafic

PREGI esempio: Milano, SCUOLA GOLF Forlanini

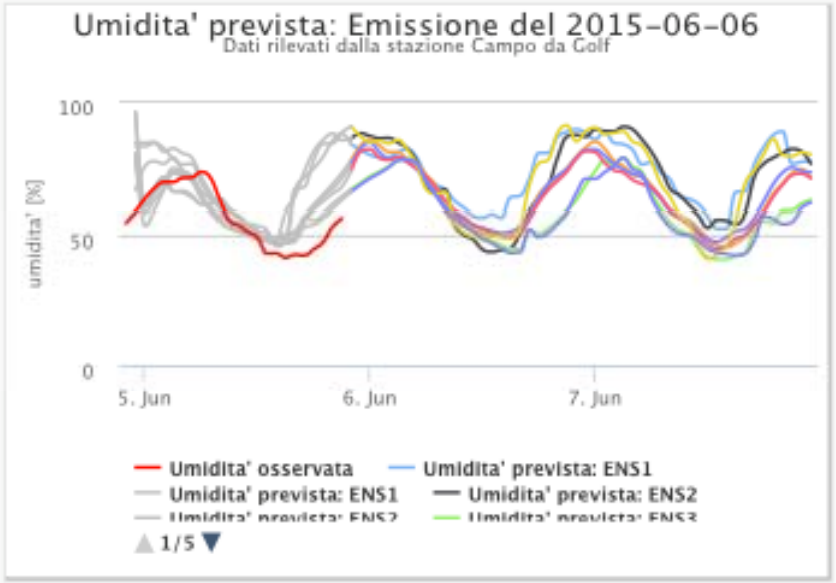


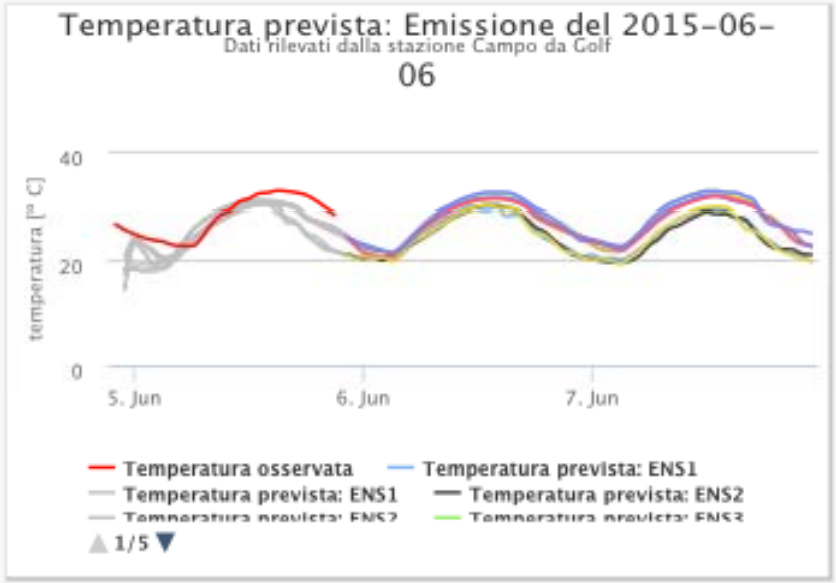


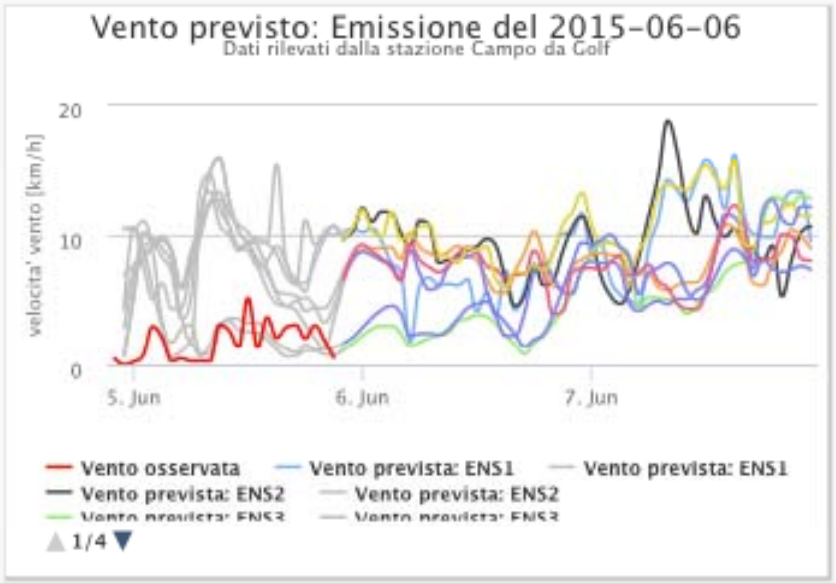


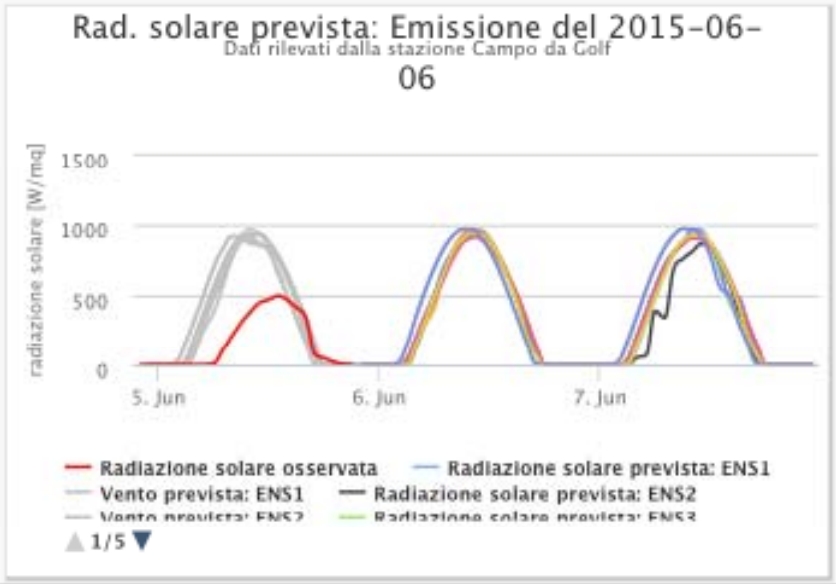
FORZANTI METEOROLOGICHE: oservate & previste

Grafici per l'emissione del 2015-06-06









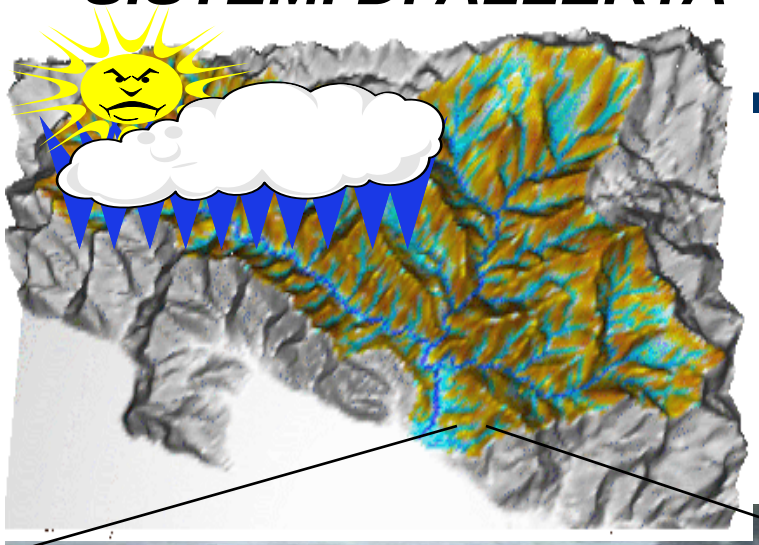
Progetto SEGUICI: *Smart tEcnologie per la Gestione delle risorse idriche ad Uso Irriguo e Civile [2014-2015]*

San Rocco al Porto

Secugnago

SISTEMI DI ALLERTA e MITIGAZIONE DEL DANNO

Riduzione di V ed E(beni mobili)

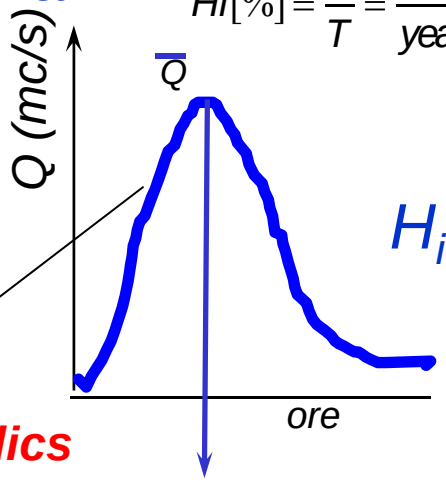


Rischio Idraulico Definizione

$$\textit{Hydraulic Risk} = \textit{Losses} = H_i * E * V$$

Hydrology

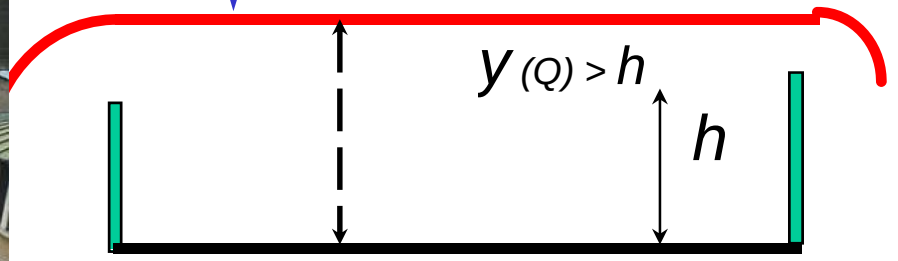
$$Hi[\%] = \frac{1}{T} = \frac{1}{\text{years between two exceedings events}}$$



$$H_i\,[\,\%] \Rightarrow Prob[Q > \overline{Q}]$$

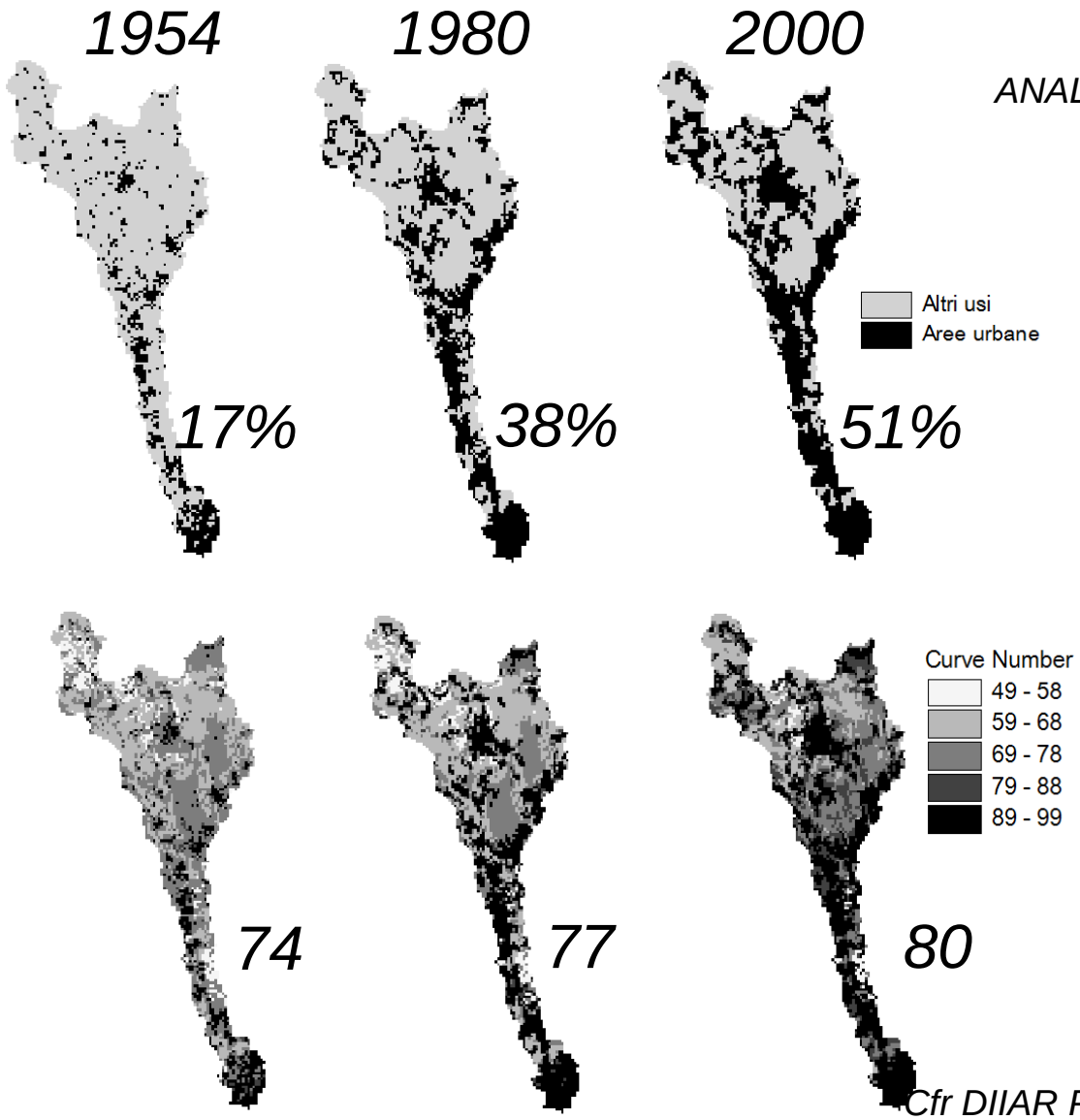
Prob[Q >Q] = Prob (y Ph)

ulics



chio V = Vulnerabilità di E

Effetti di cambiamento dell'uso del suolo sull'idrogramma di piena



ANALISi REGIONE LOMBARDIA

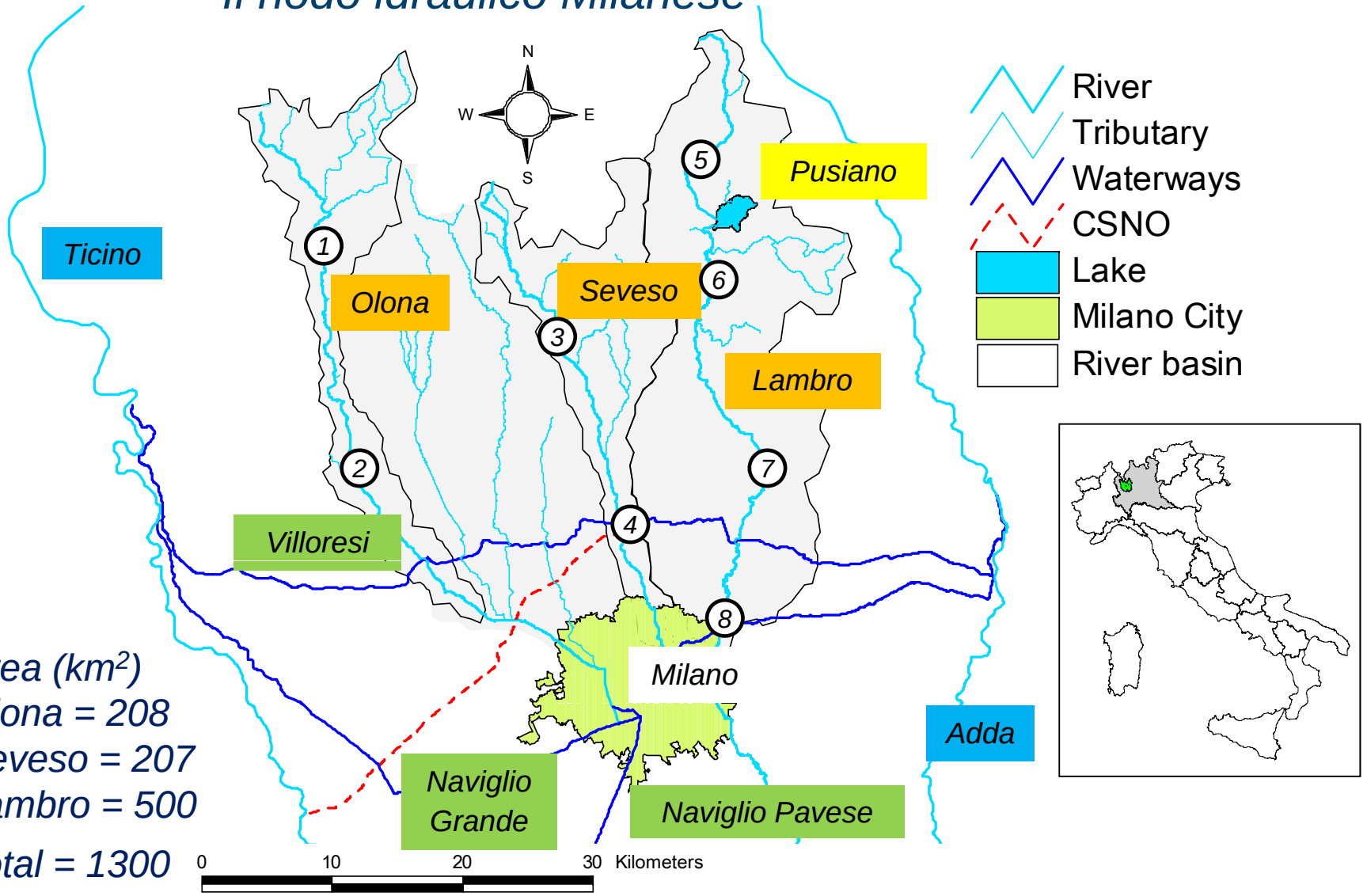
URBAN AREA

CURVE NUMBER

Cfr DIIAR PROGETTO FRAMEWORK 1994

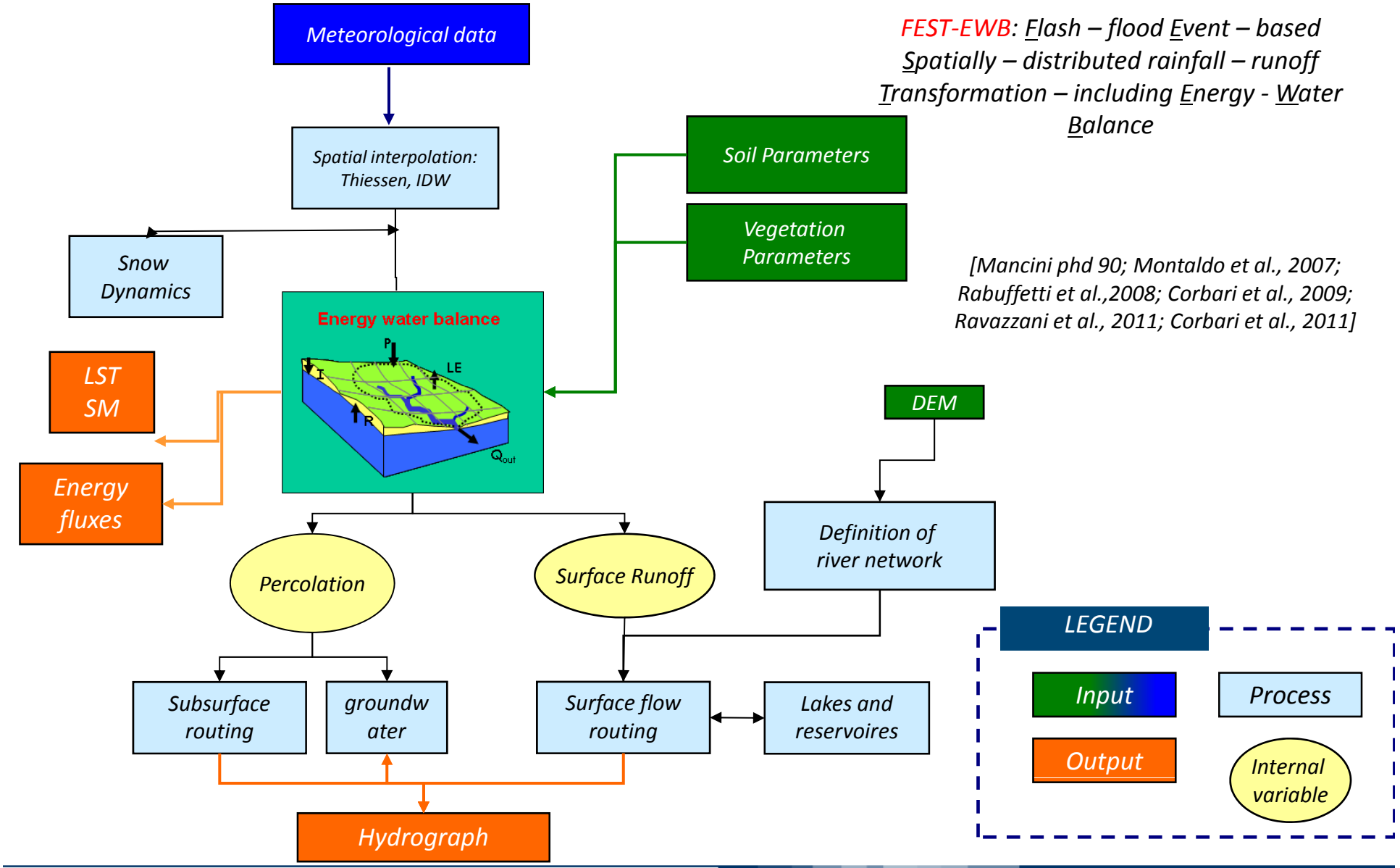
Interventi non strutturali di mitigazione: previsione integrata meteo idrologica con PREVISIONE DELL'IDROGRAMMA DI PIENA

Il nodo idraulico Milanese



Distributed hydrological model FEST-EWB - by POLIMI

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



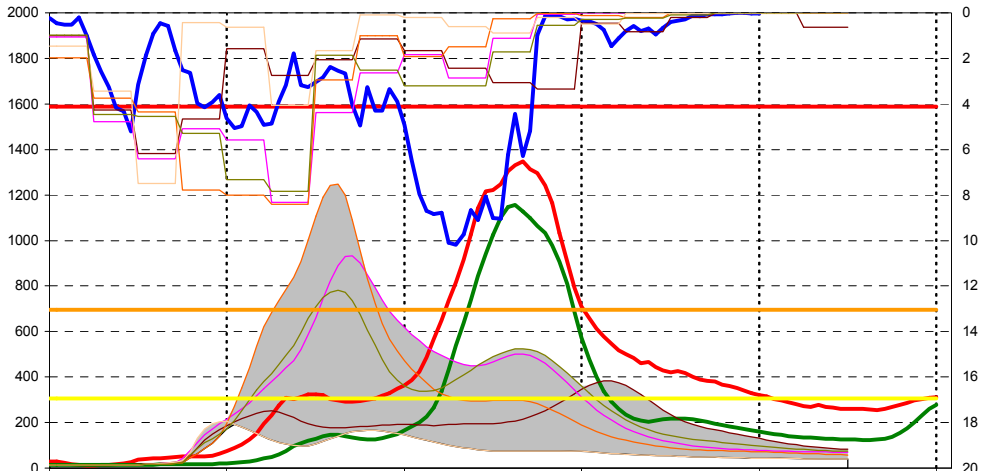
[Mancini phd 90; Montaldo et al., 2007; Rabuffetti et al.,2008; Corbari et al., 2009; Ravazzani et al., 2011; Corbari et al., 2011]

Interventi non strutturali di mitigazione: Sistemi di allerta Meteo Idrologica

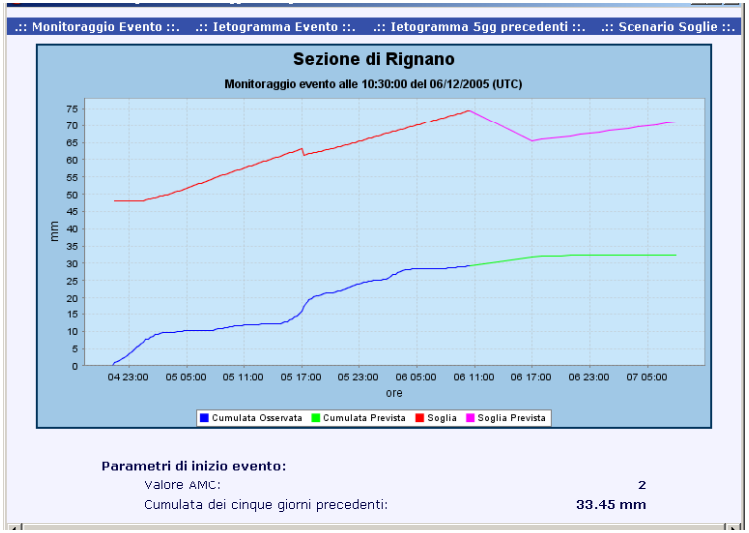
Prevedono un potenziale evento di piena pericoloso con un tempo sufficiente di preavviso a mettere in sicurezza le persone e le cose. (L. n 49/2010 da direttiva n. 2007/60/Ce "Valutazione e gestione dei rischi di alluvioni)

Piani di protezione civile

SISTEMI in tempo reale ***Modellistica di Evento Afflussi Deflussi*** *in tempo reale (**MEAD**)*



*SISTEMI in tempo reale SOGLIE PLUVIOMETRICHE di allerta Idrometrica precedntemente calcolate,(**SoPAI)***

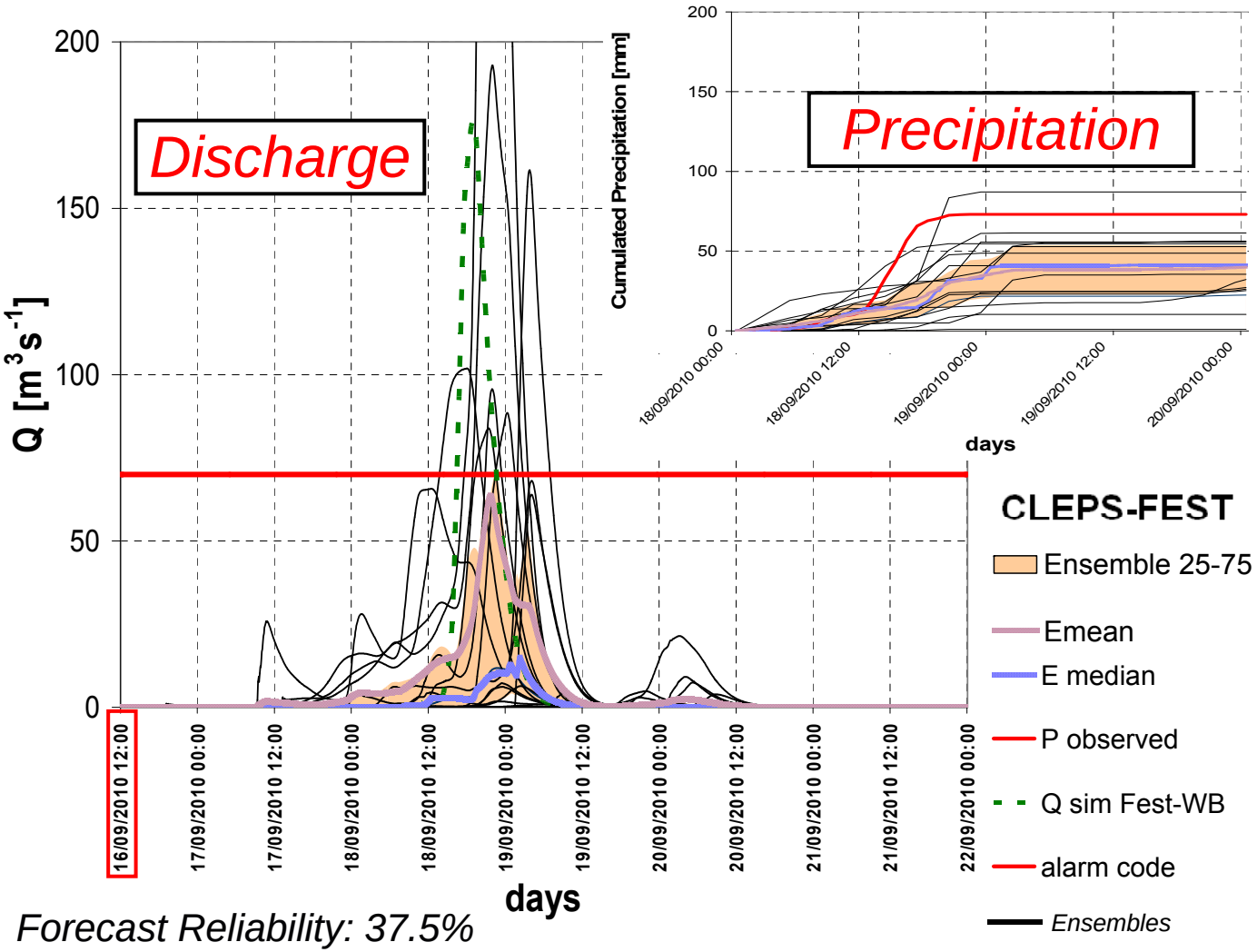


Marco Mancini, marco.mancini@polimi.it,

Hydrograph forecasting feeding the hydrological model with ensamble metereological model output

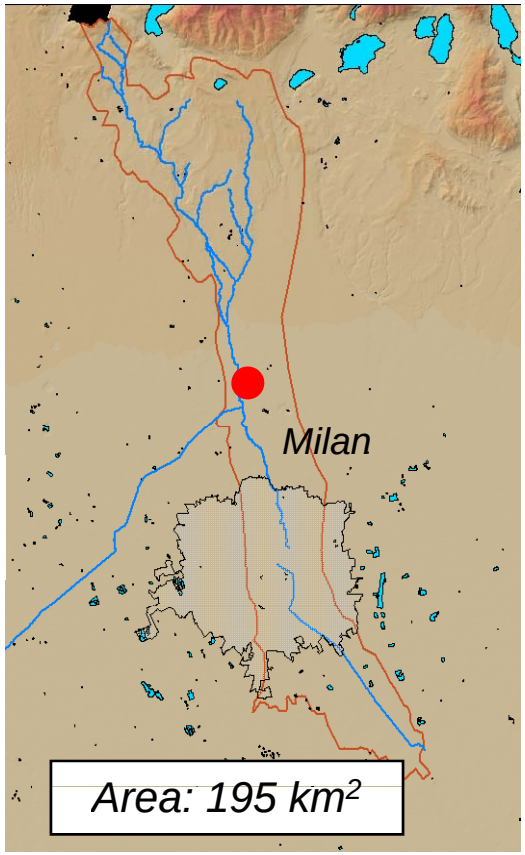
16 September 2010 output run:
36-48 h before the main peak flow

***Last flood in Milan urban area**: the river Seveso…*



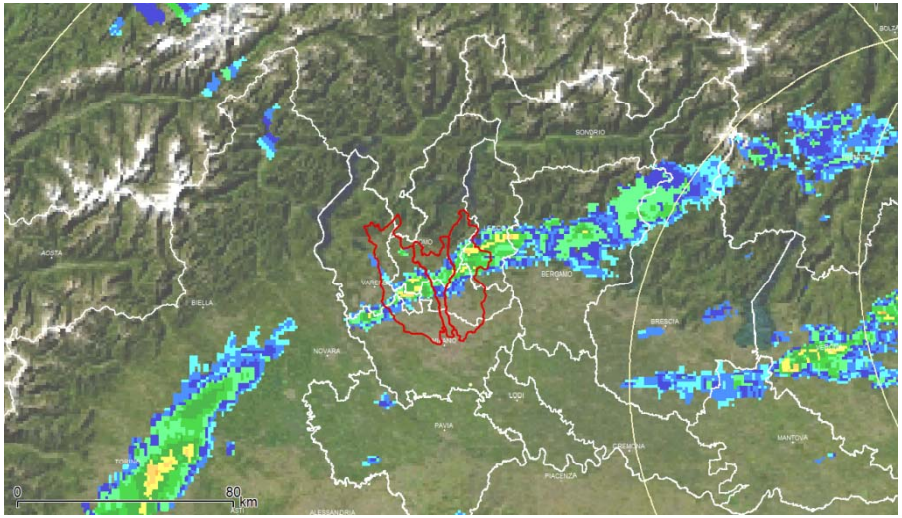
Forecast Reliability: 37.5%

Seveso basin

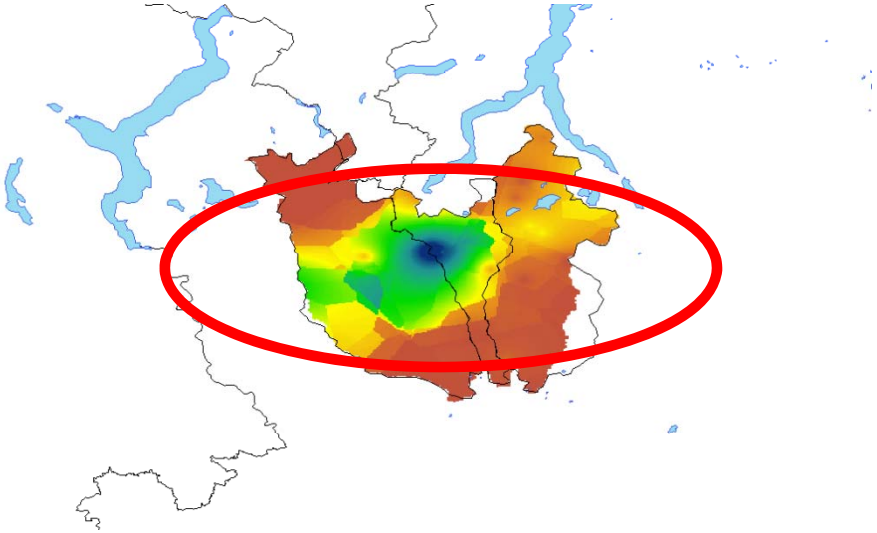


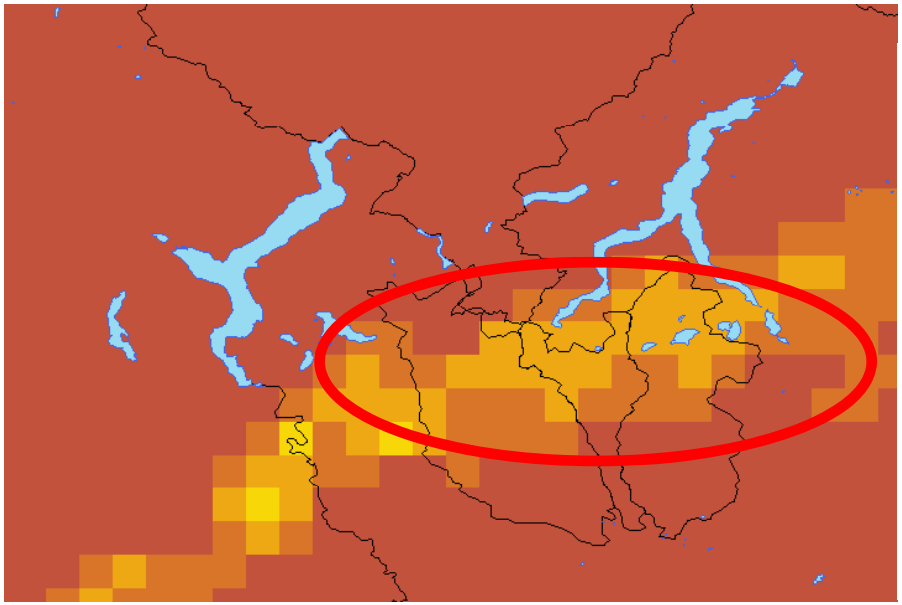
Event 2010-09-18: Seveso's Basin: precipitation target error

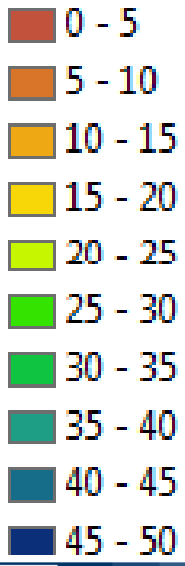
Observed by radar 08 UTC



Observed by rain gauge 08 UTC

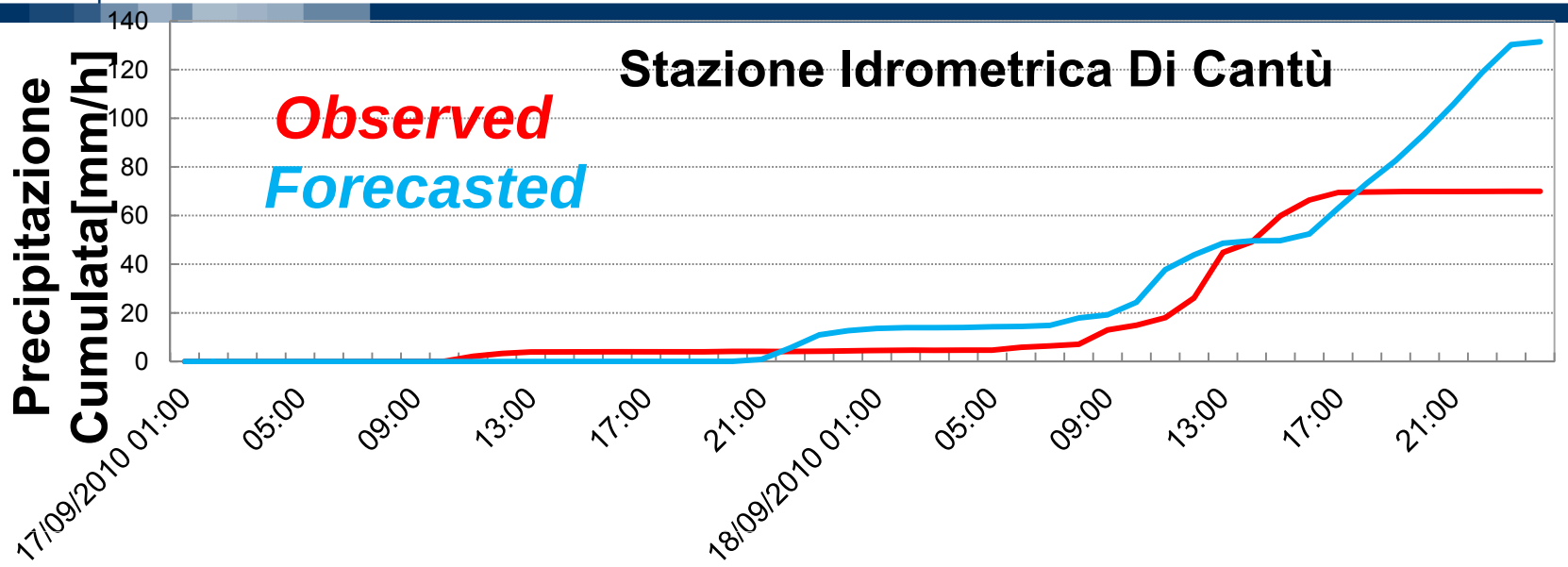


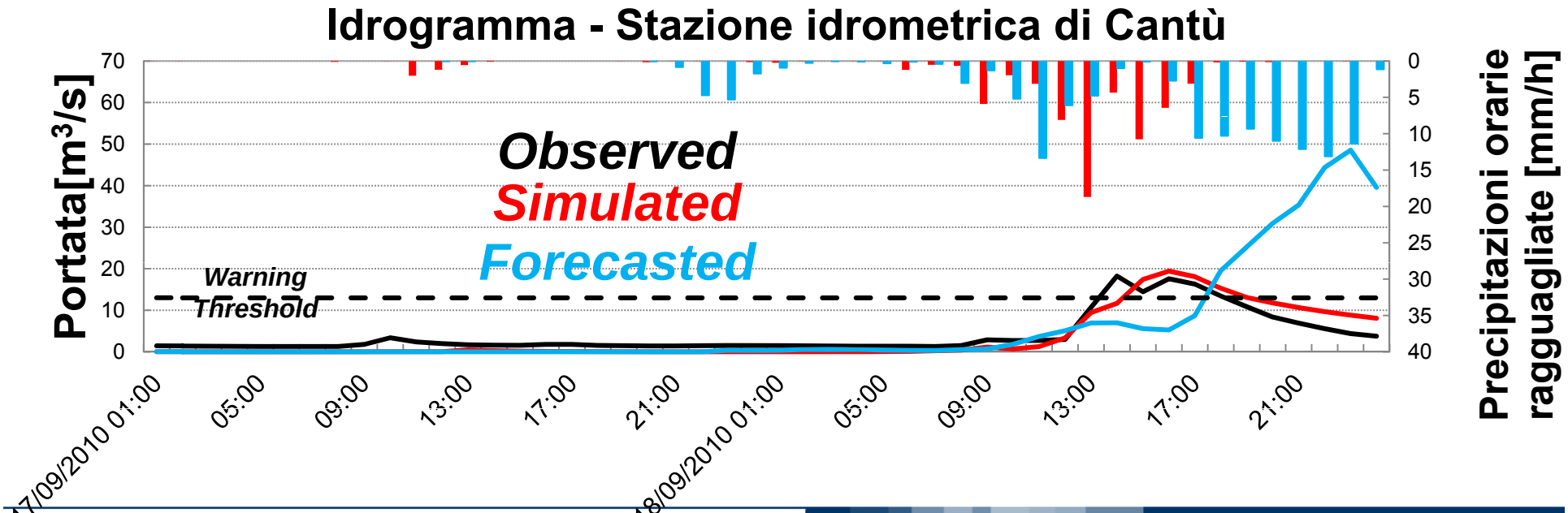




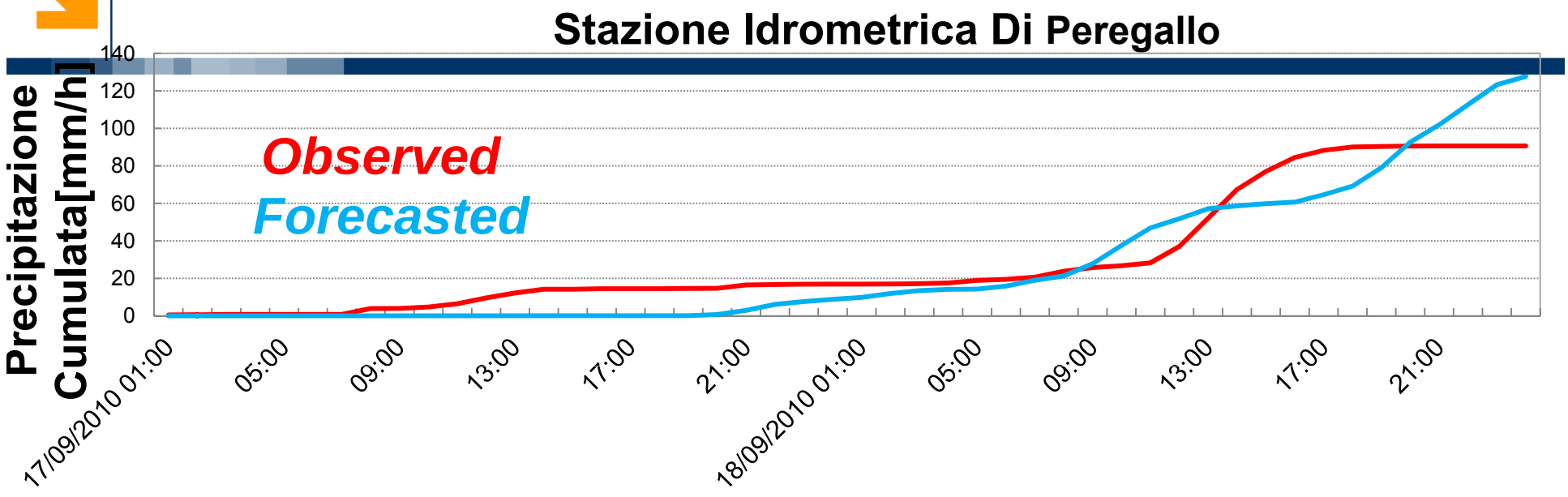
Forecasted by WRF 10 UTC

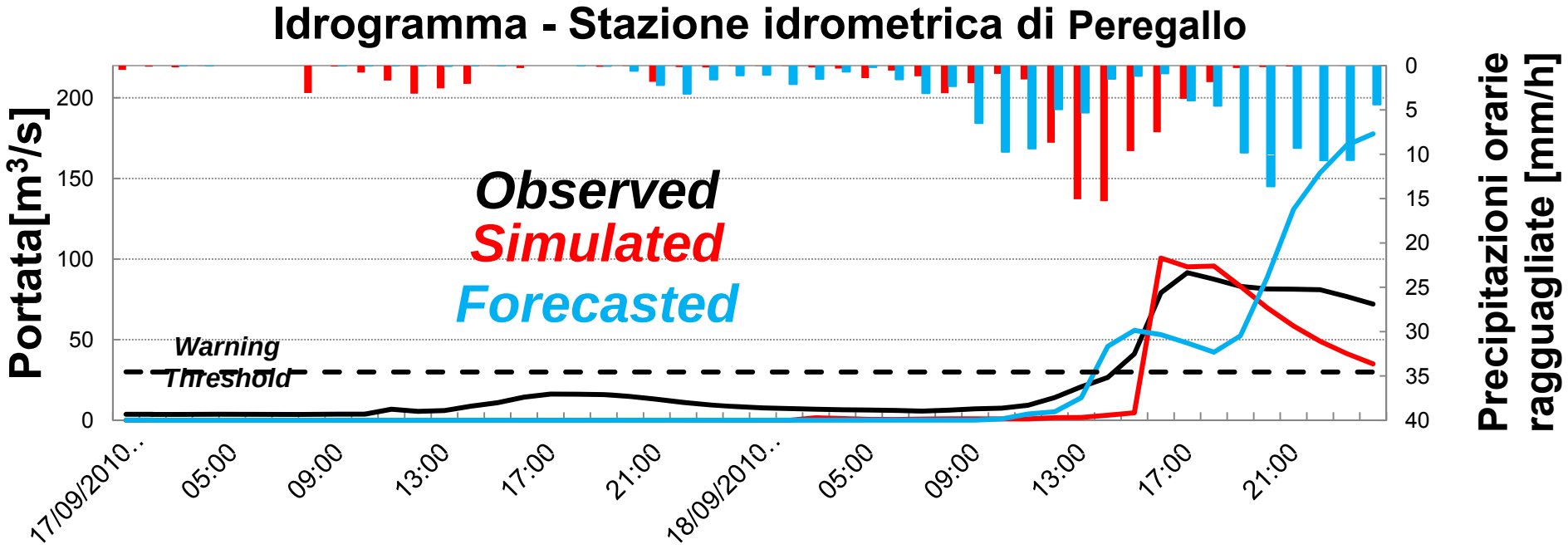
Event 2010-09-17: Seveso





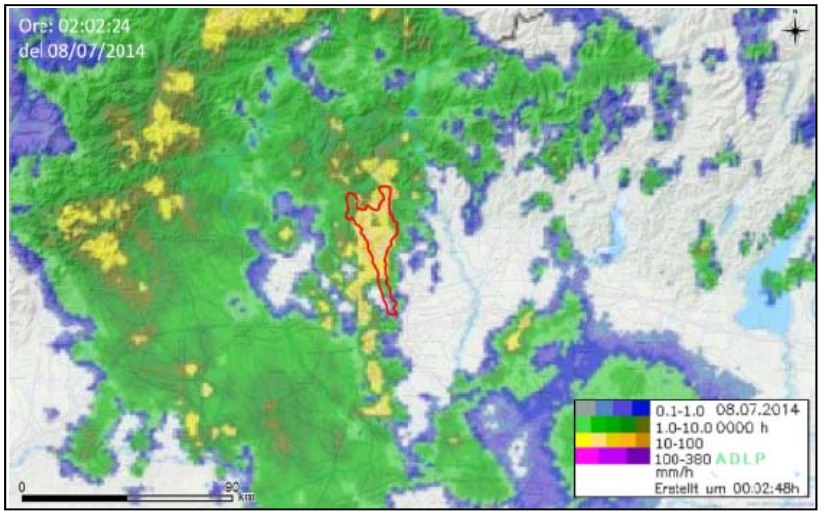
Eventi 2010-09-17: Lambro



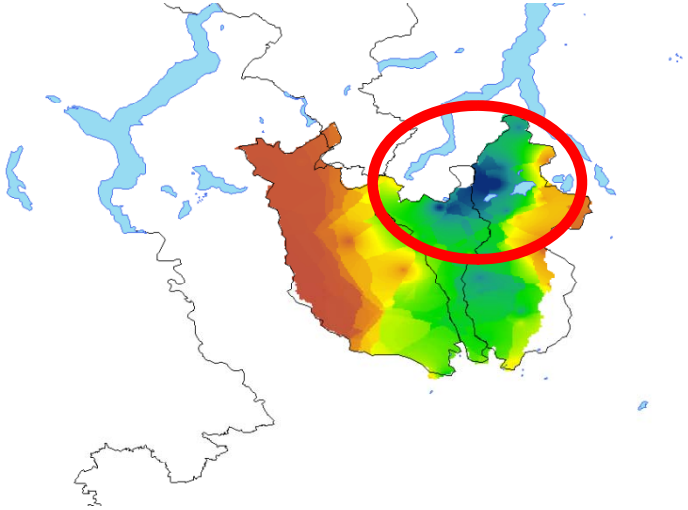


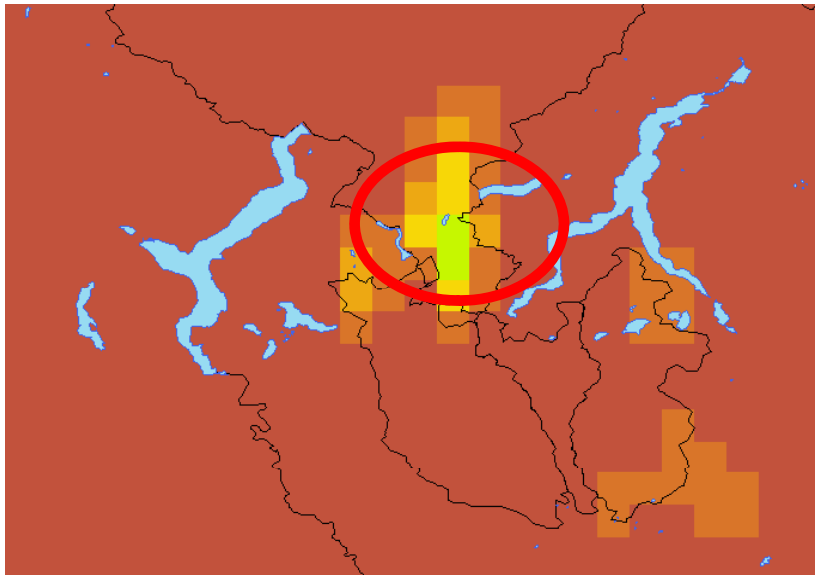
Event 2014-07-08: Seveso's Basin: precipitation target error

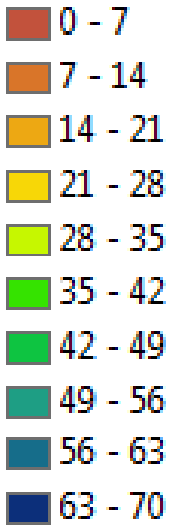
Observed by radar 00 UTC



Observed by rain gauge 00 UTC



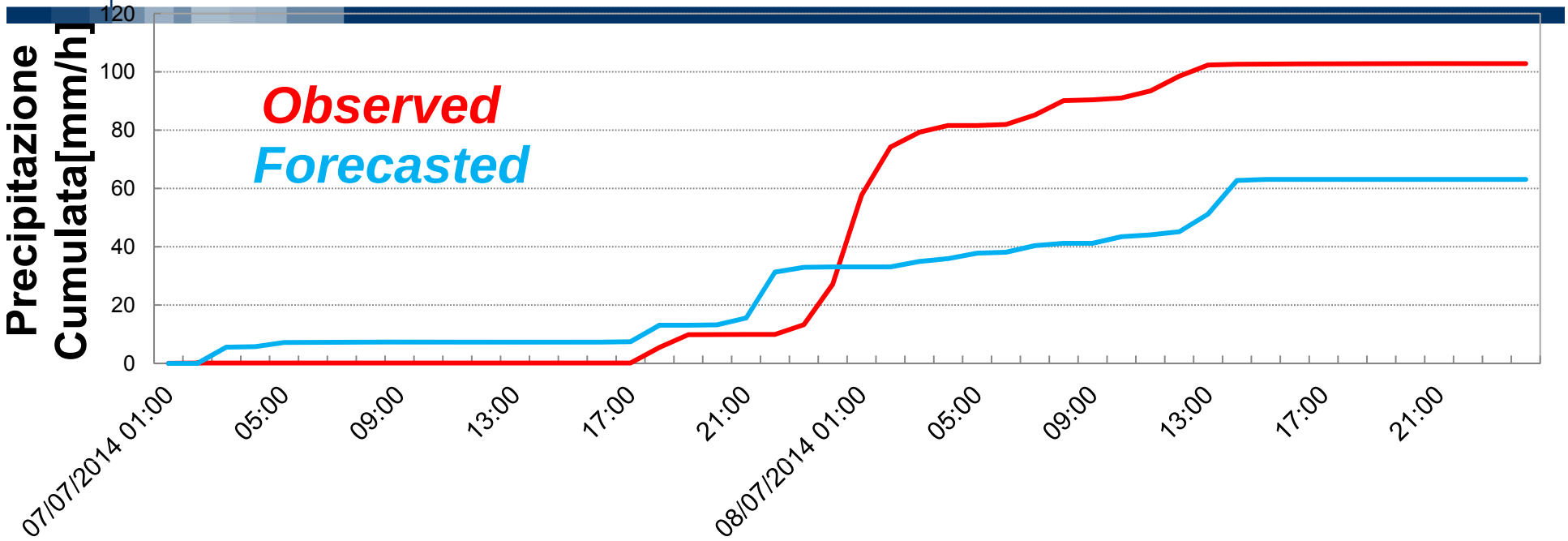




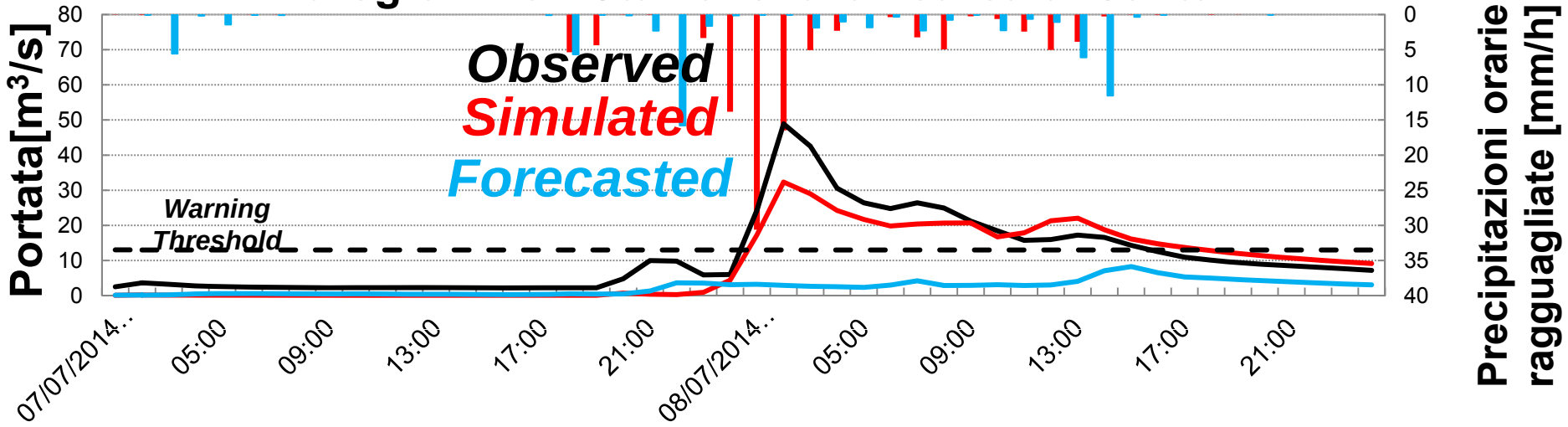
Forecasted by WRF 03 UTC

Event 2014-07-07: Seveso's Basin

Stazione Idrometrica Di Cantù

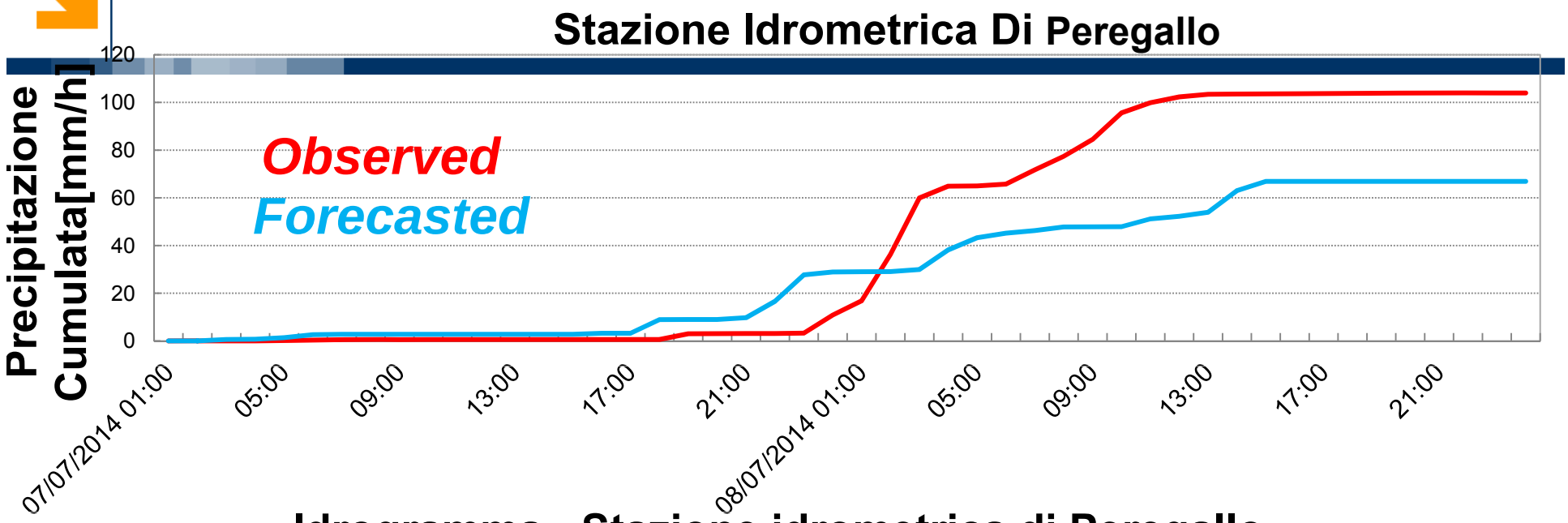


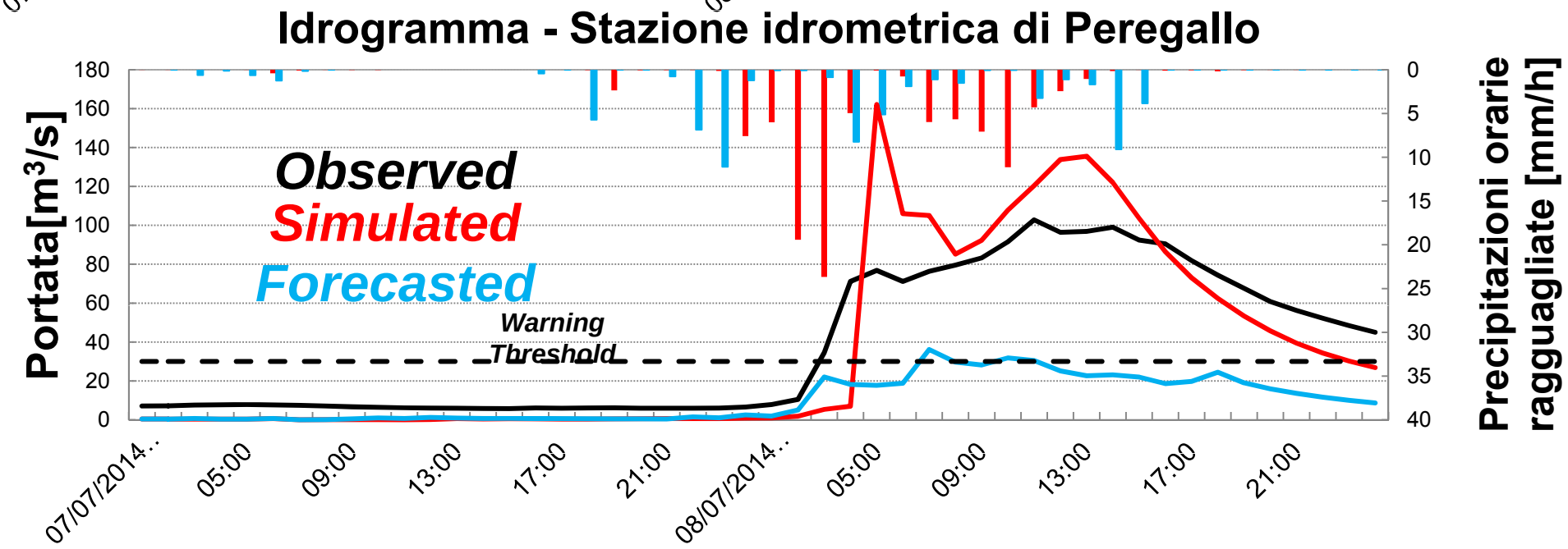
Idrogramma - Stazione idrometrica di Cantù



Marco Mancini, marco.mancini@polimi.it,

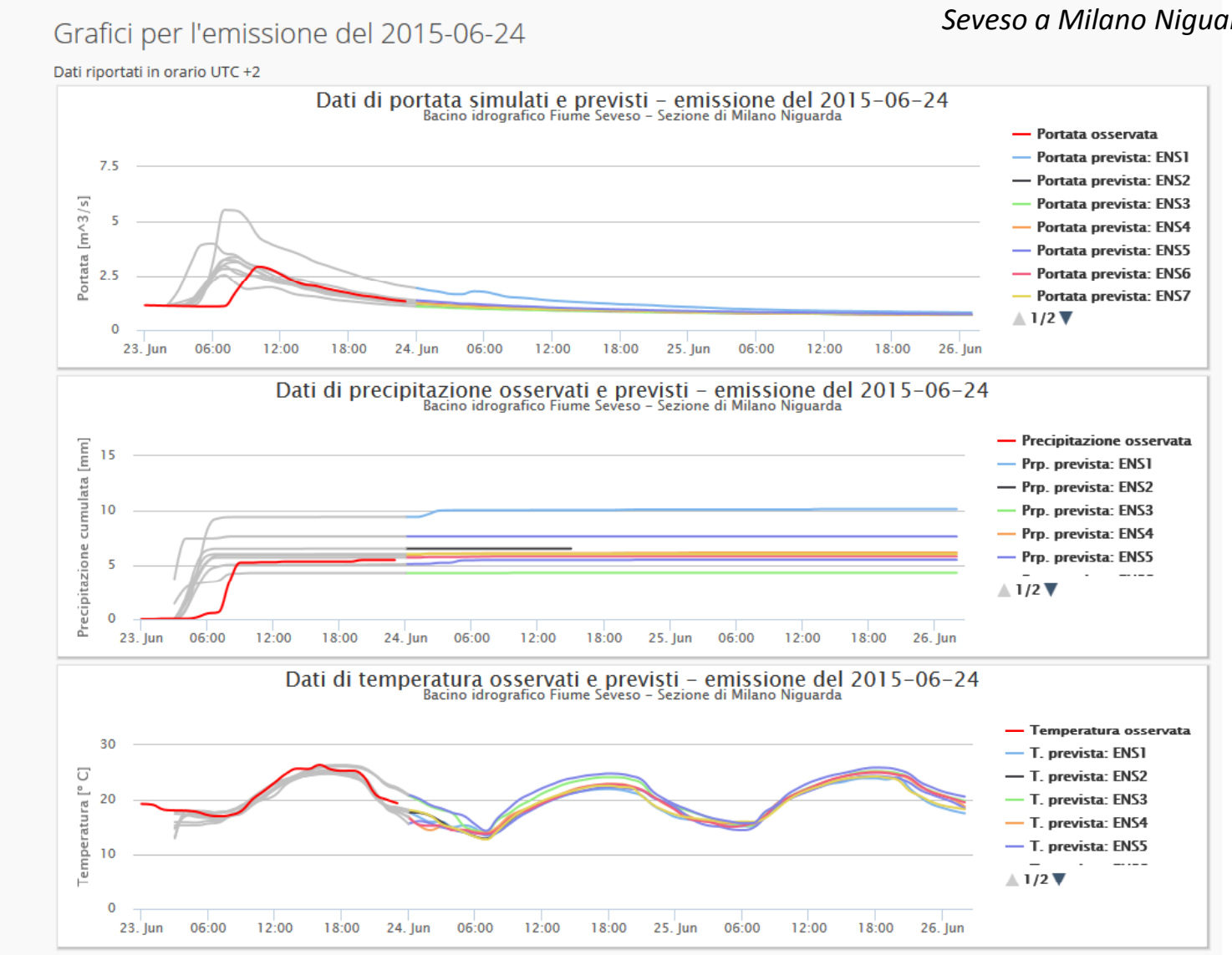
Event 2014-07-07: Lambro's Basin





Real time forecasting system:, Seveso Olona Lambro (SOL)

Seveso a Milano Niguarda



Interventi non strutturali di mitigazione: previsione integrata meteo idrologica con PREVISIONE DELL'IDROGRAMMA DI PIENA

JULY 2014

Seveso @ Cantu'

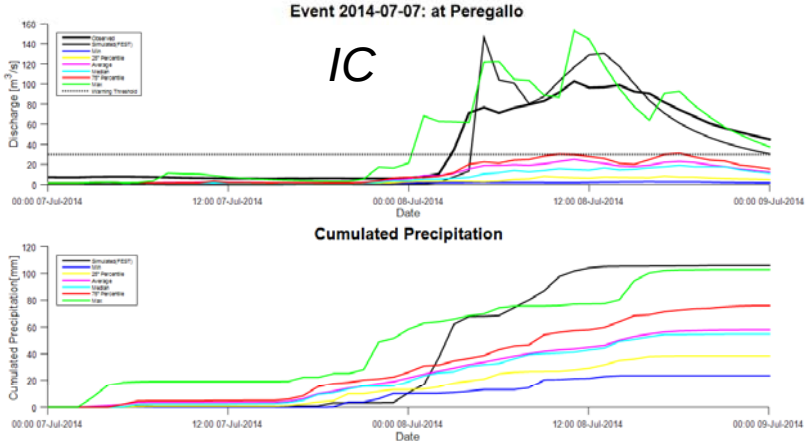
% di simulazioni eccedenti la soglia di guardia per diversi metodologie di previsione di pioggia

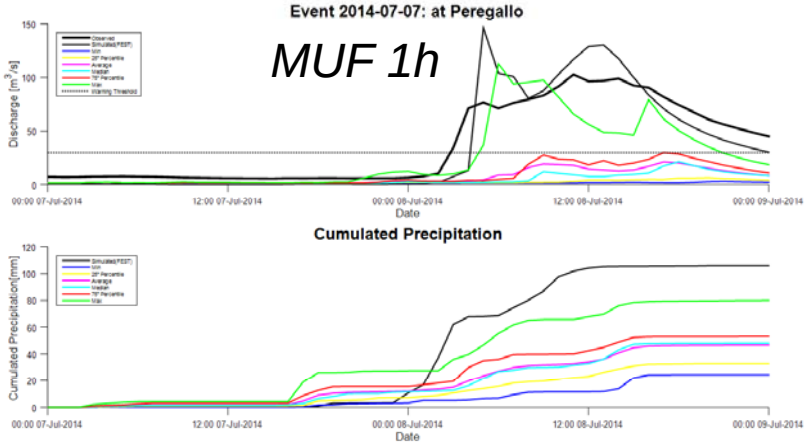
Exceeding Threshold		Seveso	Lambro	
		Cantu	Peregallo	Milano
7/7/2014	IC_1h	25.0%	50.0%	10.0%
	Multiphysic_1h	25.0%	50.0%	10.0%
	Multiphysic_3h	15.0%	55.0%	10.0%
	Lagged_1h	16.7%	25.0%	0.0%
	Lagged_3h	41.7%	41.7%	0.0%

In general IC and Multiphysic_1h have the best performance

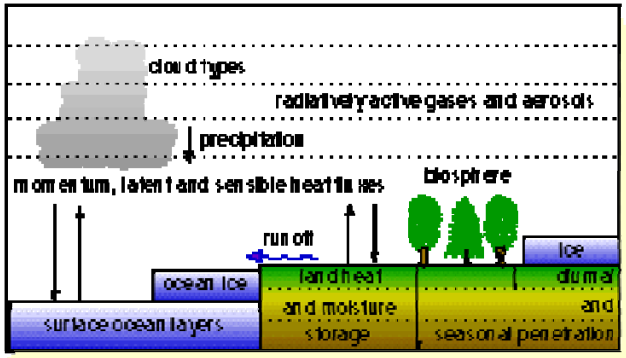
Multiphysic_1h is better than the Multiphysic _3h for the Seveso basin.

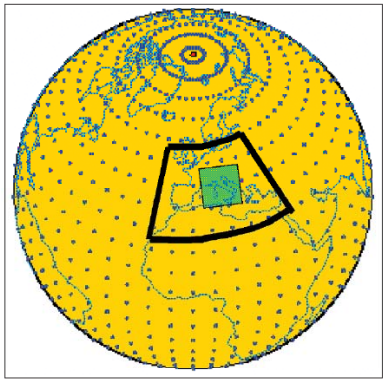
Multiphysic_3h is better than the Multiphysic _1h for the Lambro basin.



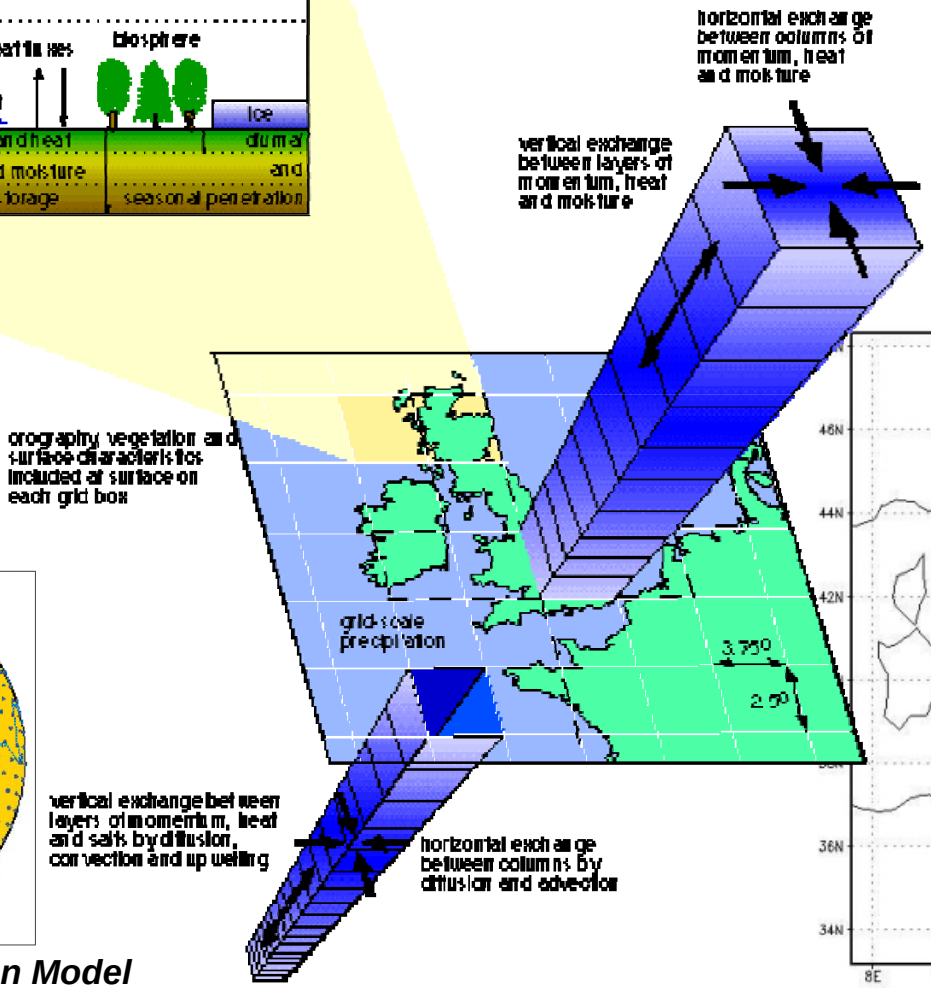


Meteorological FORECAST model



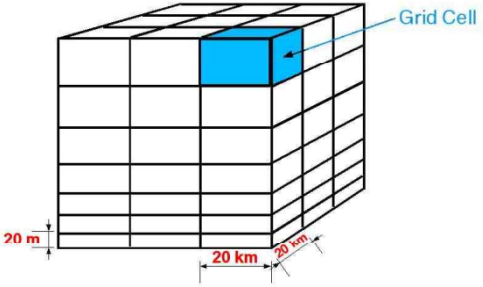


Global Circulation Model

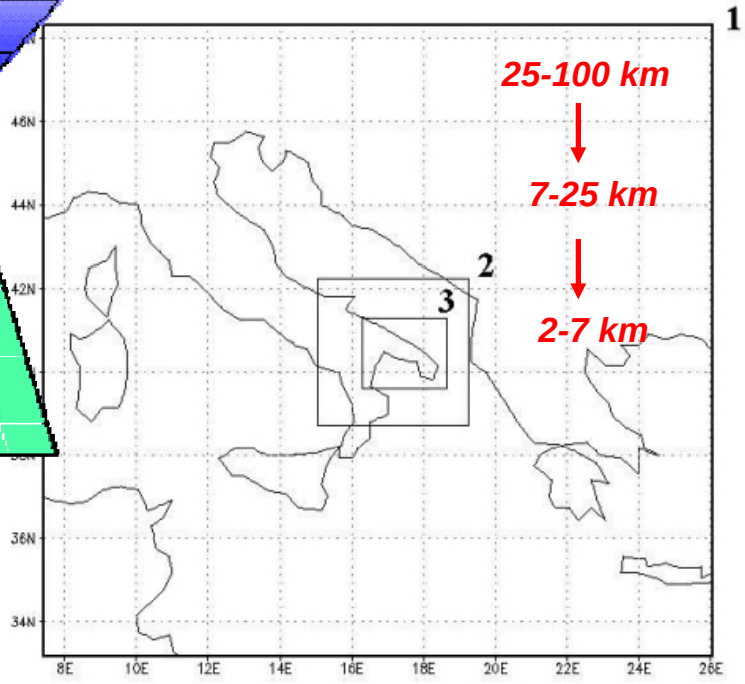


MODEL GRID RESOLUTION

Limits prediction precision – grid cell *average* predicted



Topography resolution effectively twice as coarse as grid resolution

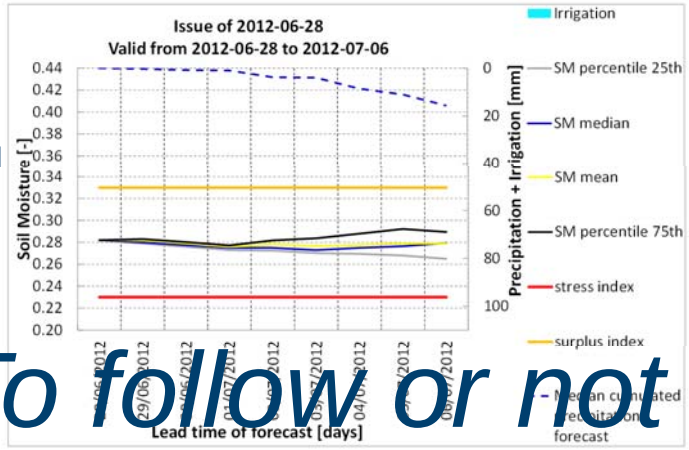


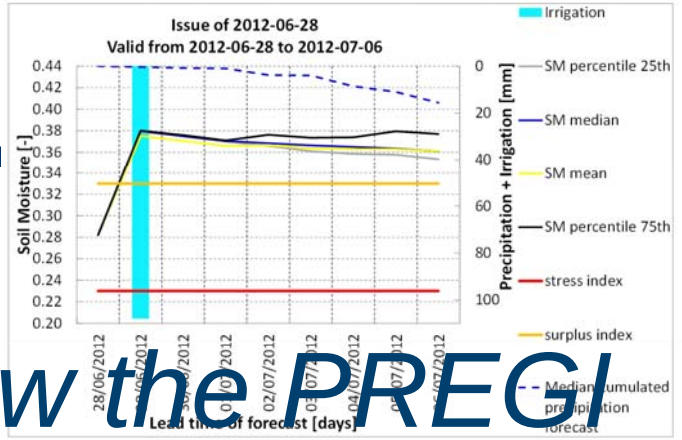
Limited Area Model

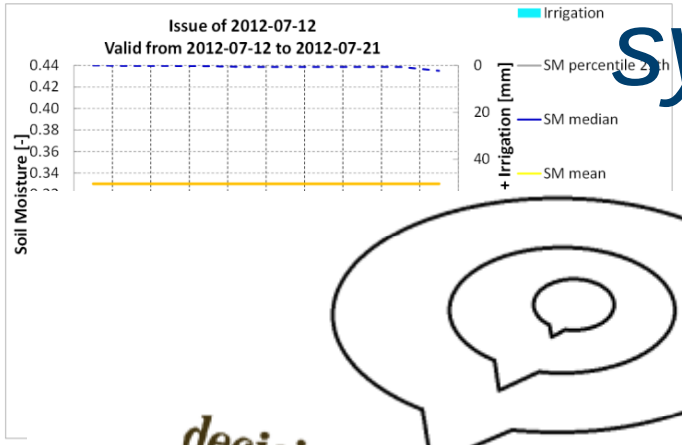
To follow or not to follow the PREGI system

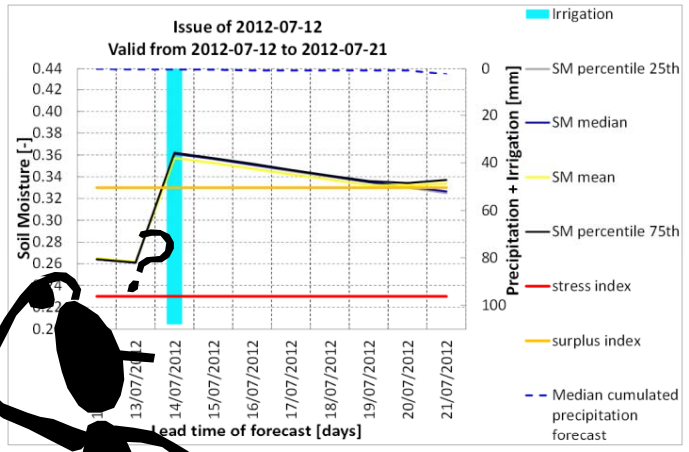
NO IRRIGATION

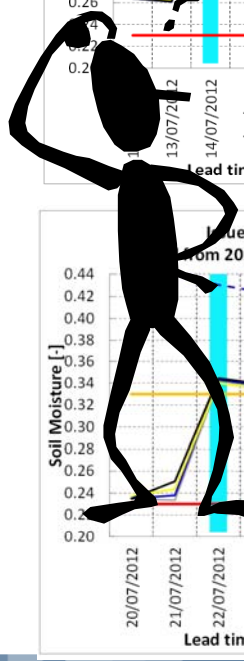
WITH IRRIGATION







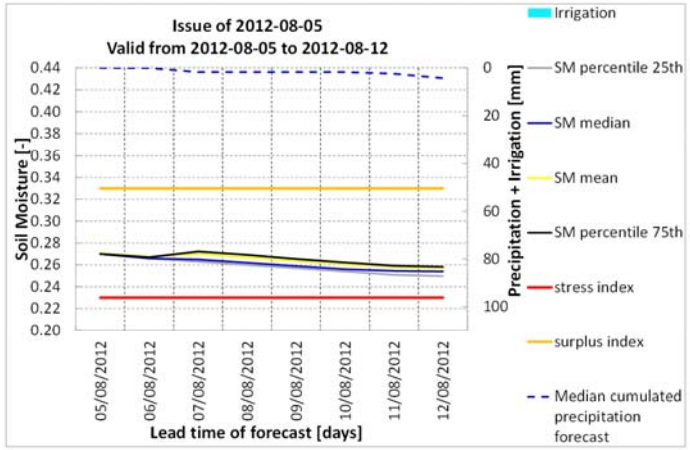


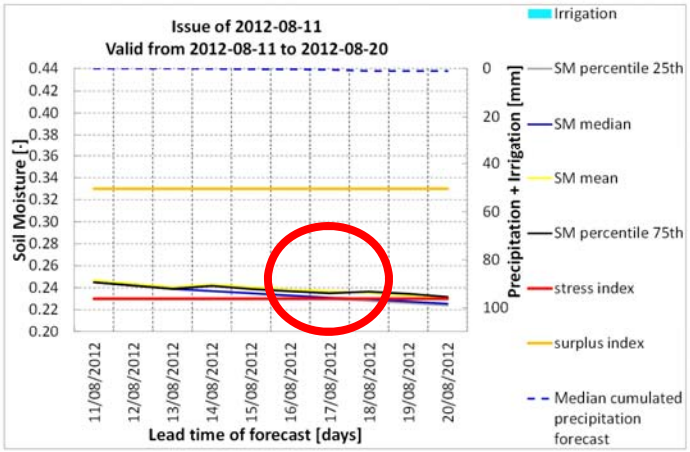


Marco Mancini, marco.mancini@polimi.it,

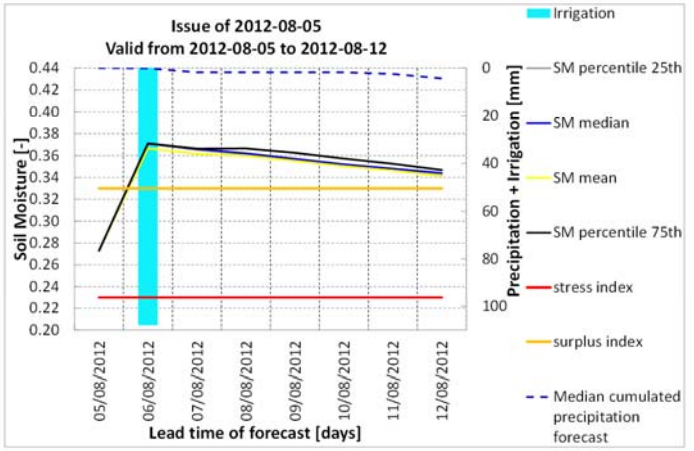
Soil Moisture Behaviour With and without Parsimonious irrigation

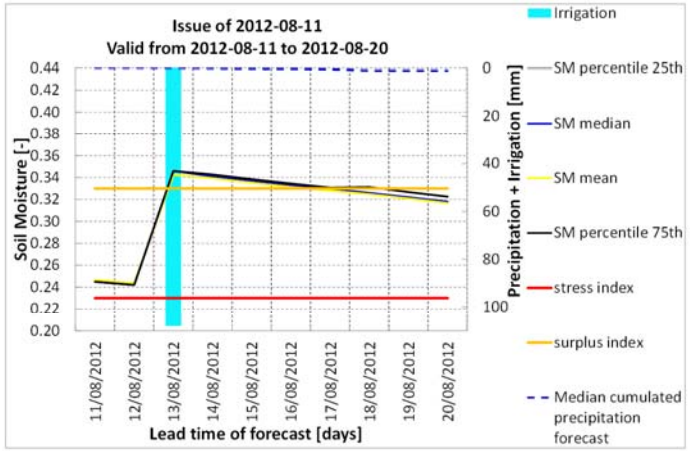
NO IRRIGATION





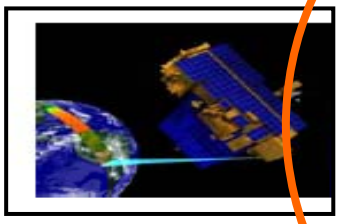
WITH IRRIGATION

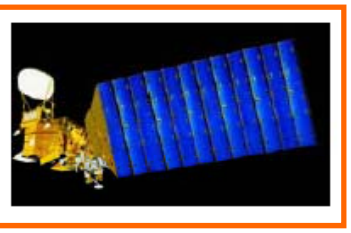


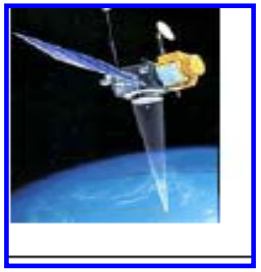


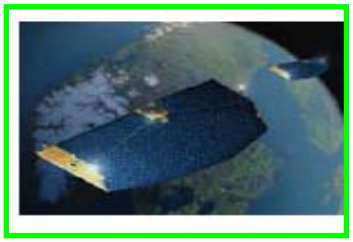
Bilancio idrologico: misure tradizionali ed innovative

$$P - E - Q = \frac{dS}{dt}$$



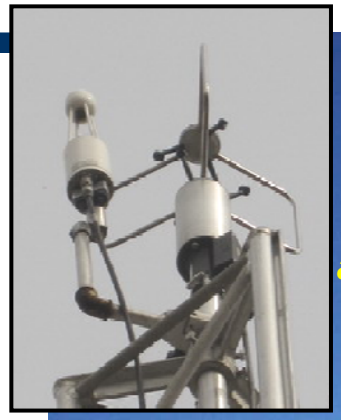






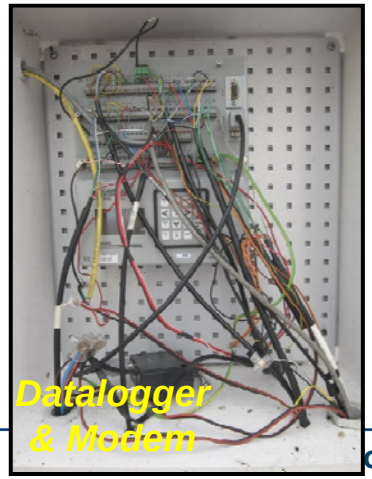
Il nostro contributo

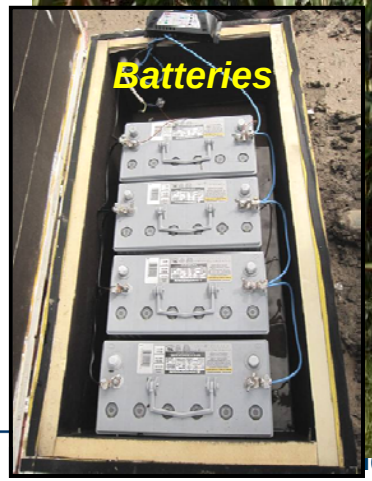
Ground Measurements : eddy covariance station

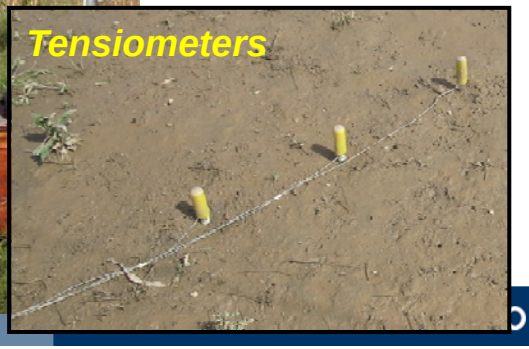


Gas analyser & Sonic anemometer

InfraRed Thermo Sensor

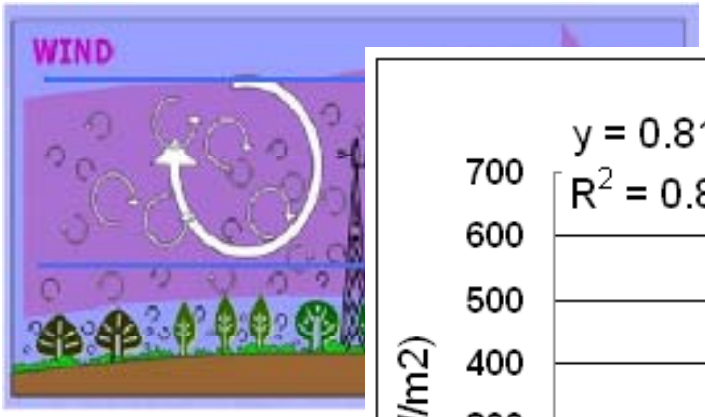


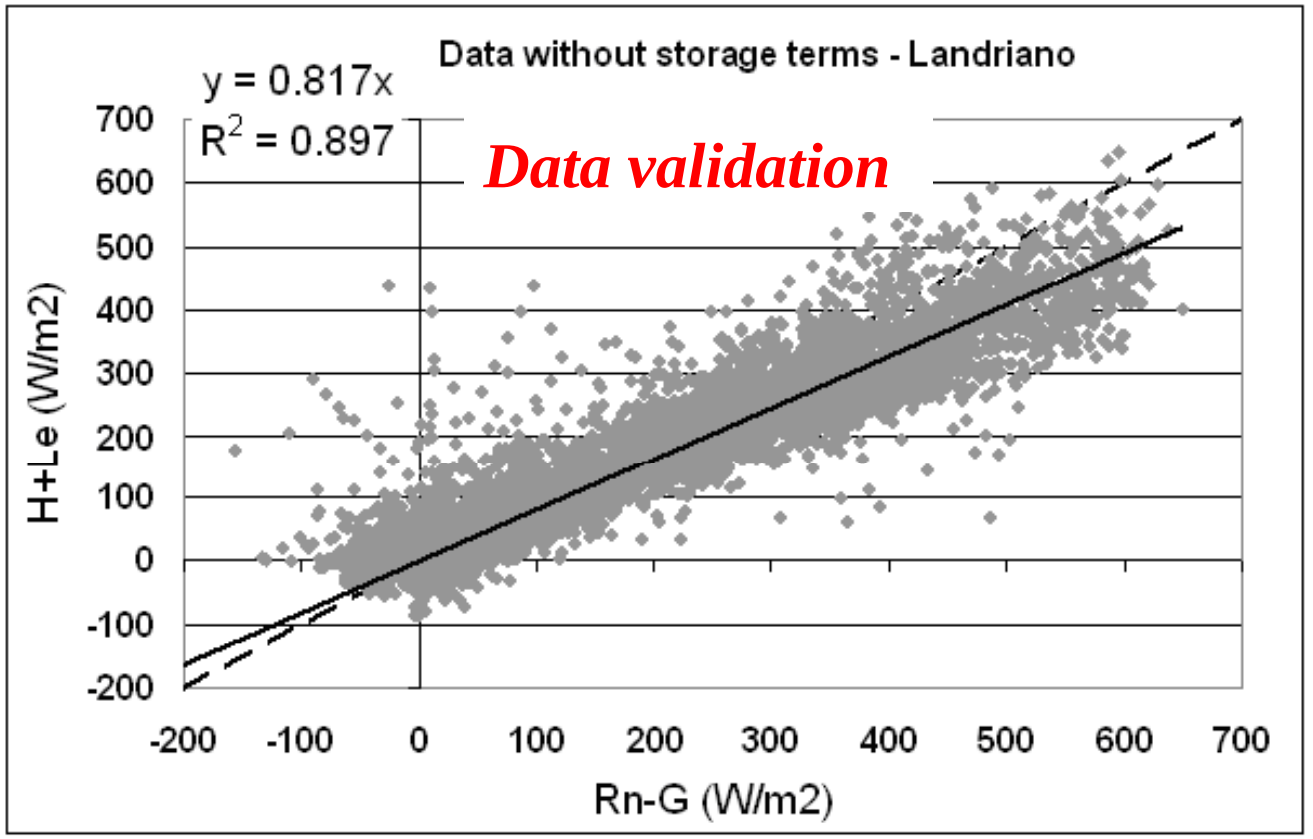




Eddy covariance station functioning

Costant Flux Layer (Elliot 1958)





$$\left(\frac{x}{z_{oD}}\right)^{0.8}$$

surface
hness

aize

$$LE = -K\frac{dq}{dz}$$

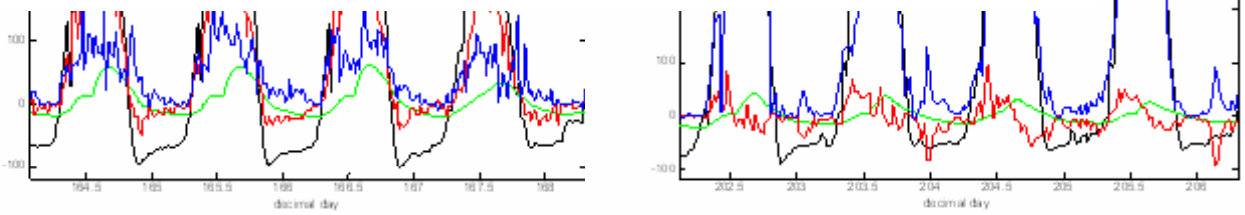
Th

$$LE = \lambda_v \rho \cdot \overline{w'q'}_v$$

$$H = -K\frac{dTa}{dz}$$

The

$$H = \rho C_p \cdot \overline{w'T'}$$



http://geoserver.iar.polimi.it

Eddy covariance data: real time monitoring →
http://geoserver.iar.polimi.it/

PEC software (Polimi Eddy Covariance)

Geoserver

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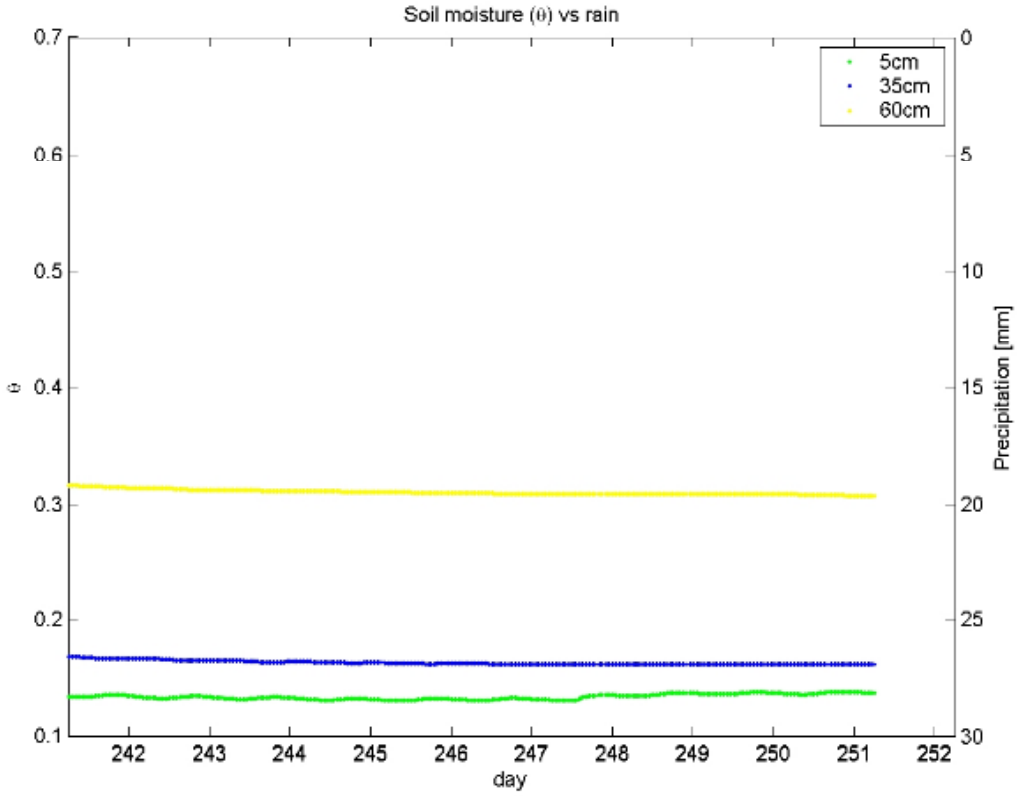
Precipitazione e Umidità del Suolo



RET Validation at local scale: comparison between observed ENERGY FLUXES and simulated from FEST-EWB (landriano 2006)

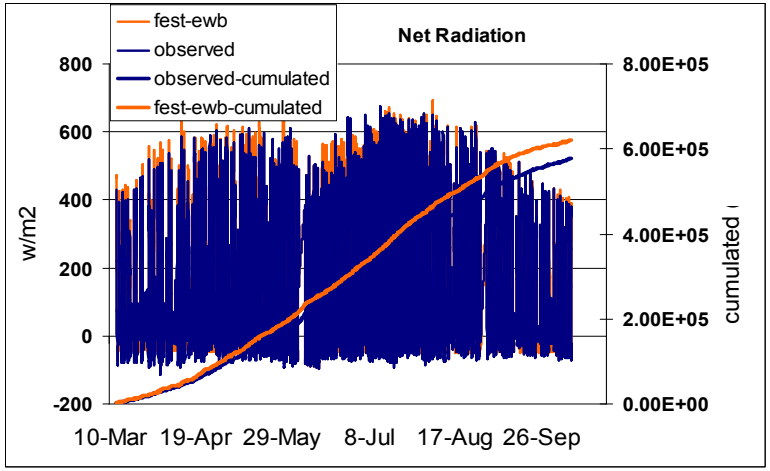
Indice di Nash

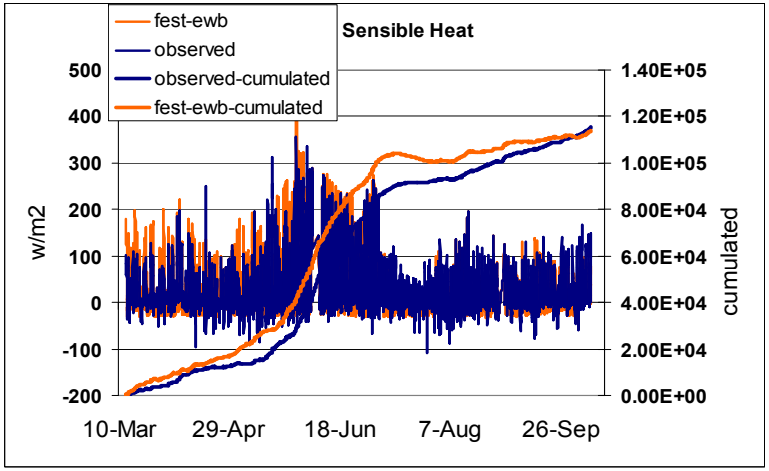
$$\eta = 1 - \frac{\sum_{i=1}^{n}\left(X_{oss,i} - X_{sim,i}\right)^2}{\sum_{i=1}^{n}\left(X_{oss,i} - \overline{X_{oss}}\right)^2}$$

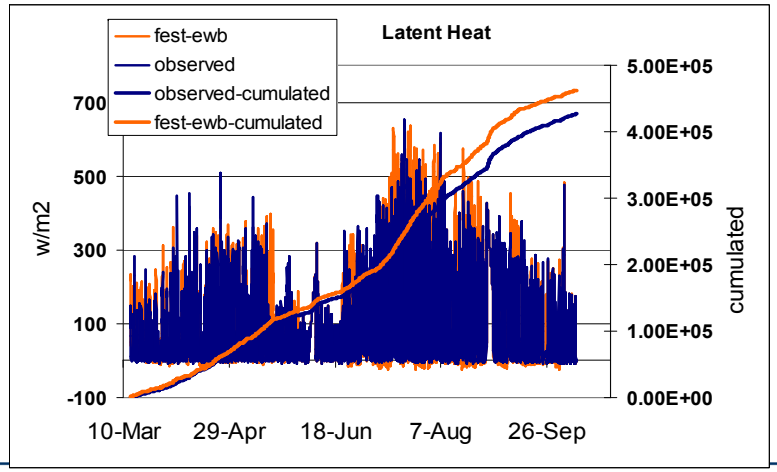
Root Mean Square Error

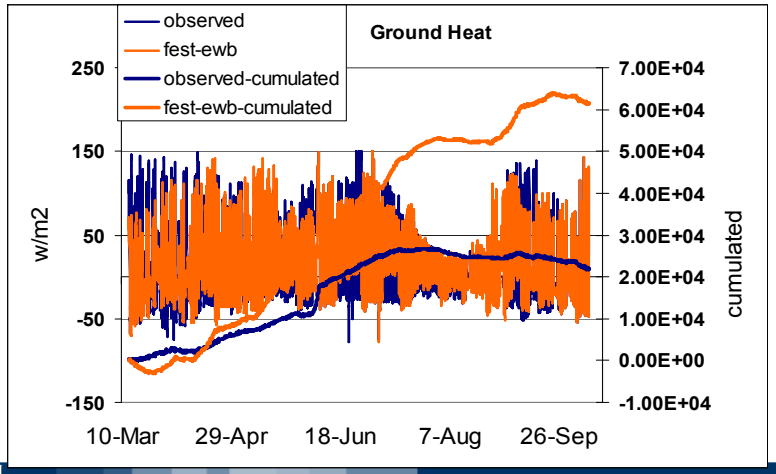
$$RMSE = \left(\frac{\sum_{i=1}^{n}\left(X_{sim,i} - X_{oss,i}\right)^2}{n} \right)^{1/2}$$

	η	RMSE (Wm^{-2})
Net Radiation	0.96	38.3
Latent Heat	0.75	54.8
Sensible Heat	0.71	29.6
Ground Heat	0.68	22.5

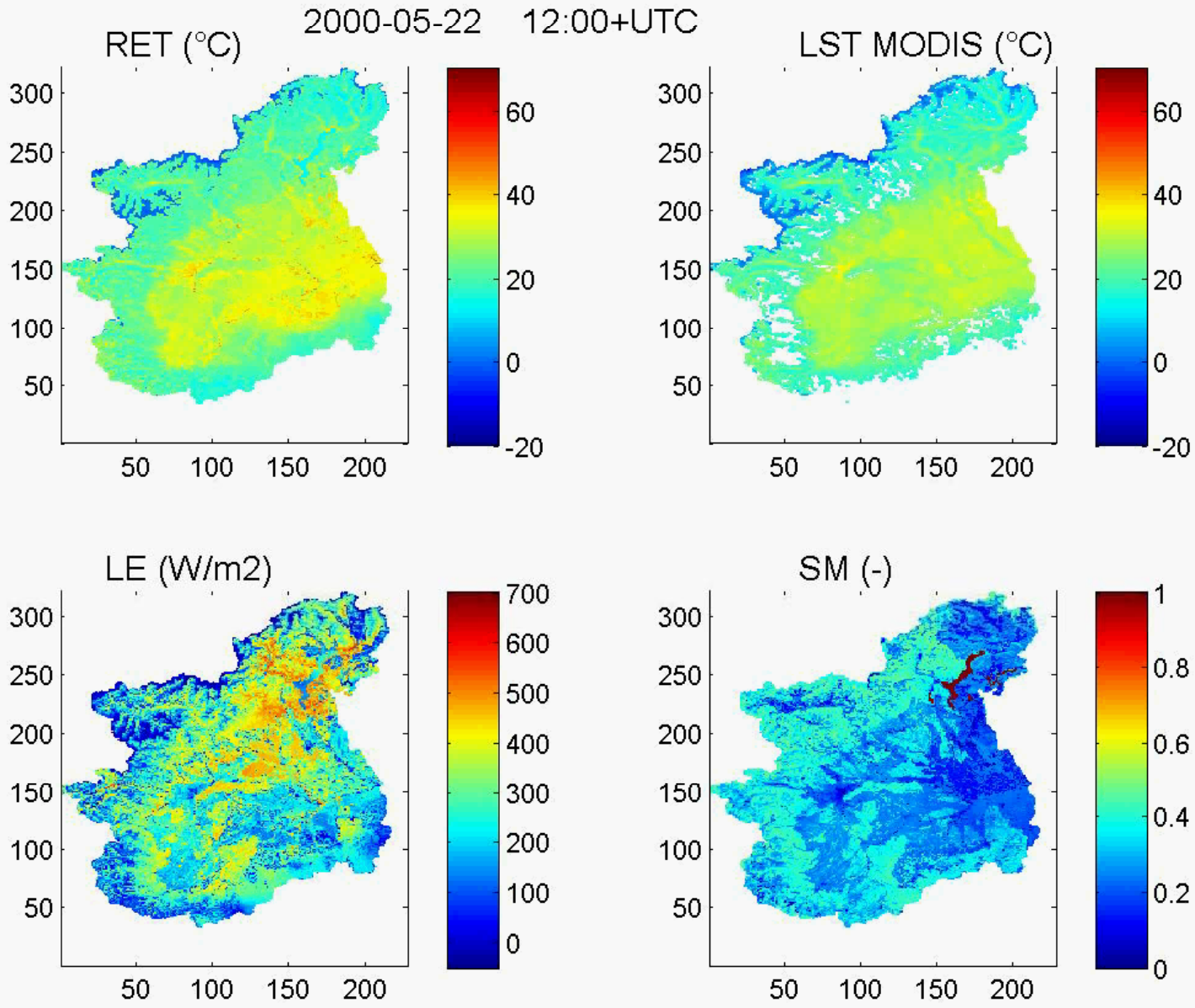








Validation at basin scale (Upper Po river basin, 2000-2003): land surface temperature, LE Fluxes and SOIL MOISTURE

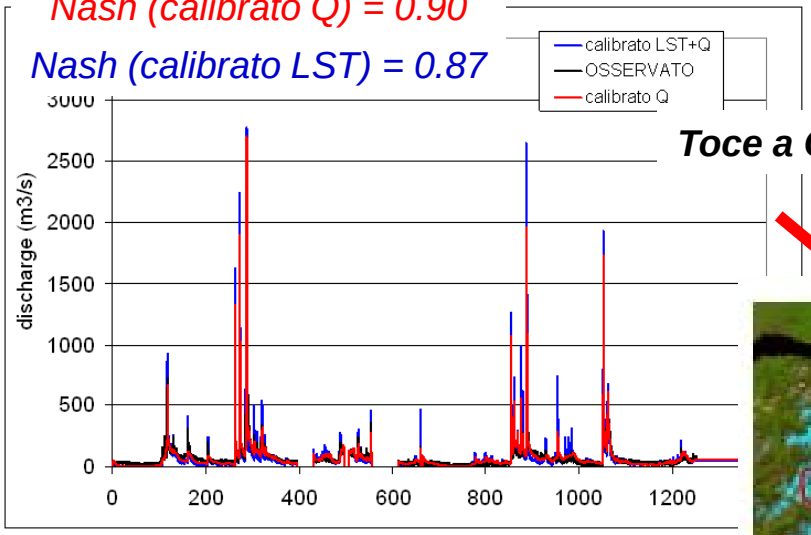


Corbari & Mancini, 2014 (UNIBO)

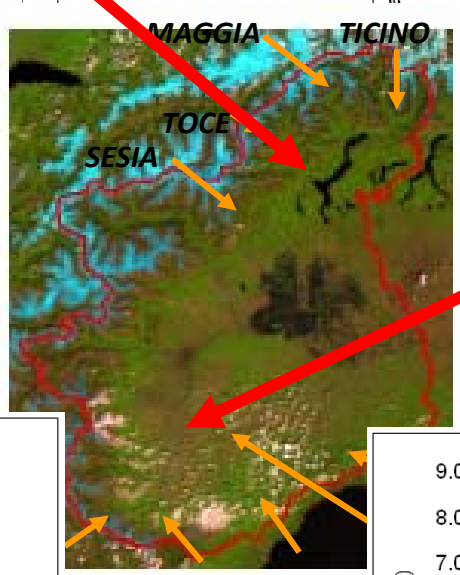
La calibrazione dei parametri del suolo su osservazioni distribuite e puntuali: confronto sui volumi cumulati e le portate

Nash (calibrato Q) = 0.90

Nash (calibrato LST) = 0.87

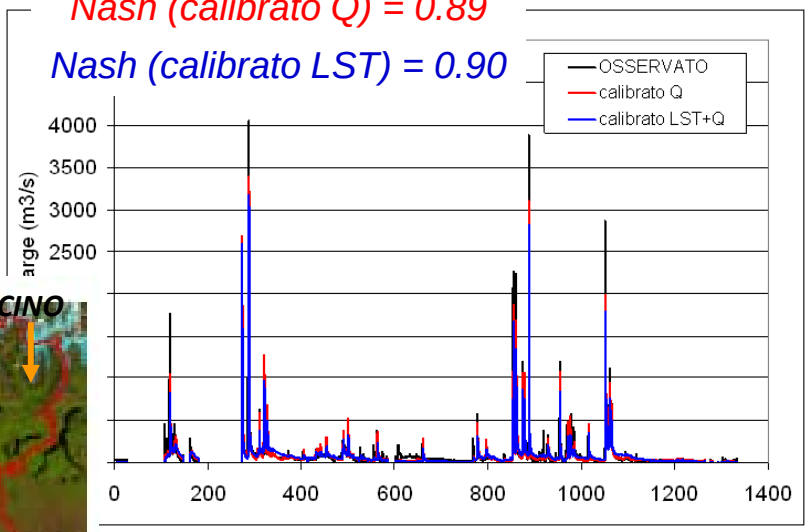


Toce a Candoglia



Nash (calibrato Q) = 0.89

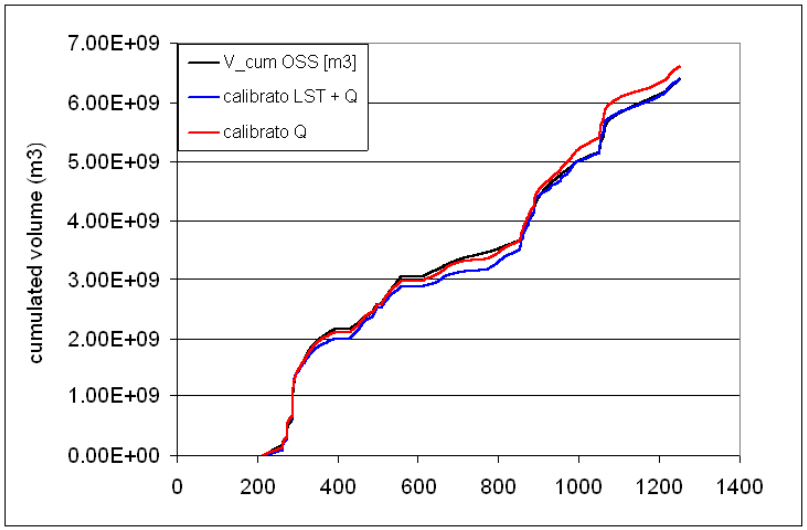
Nash (calibrato LST) = 0.90



Sesia a Palestro

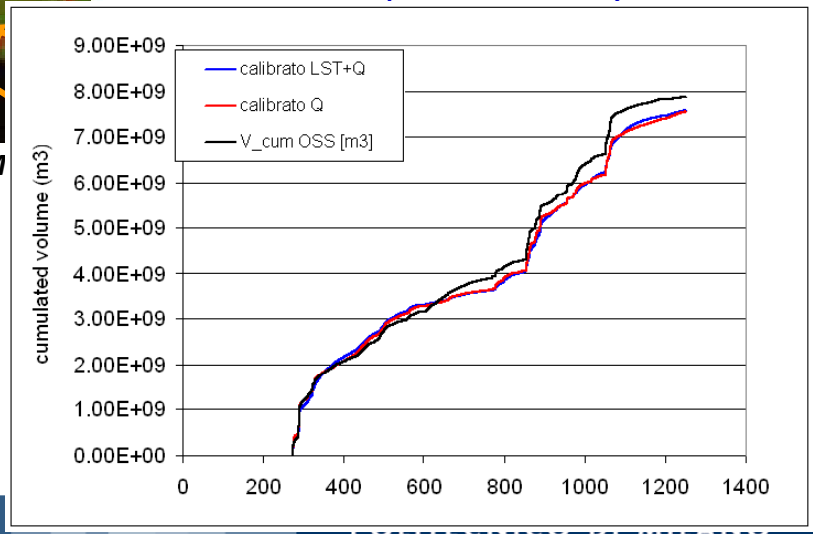
Errore volume (calibrato Q) = 3.2 %

Errore volume (calibrato LST) = -0.14 %



Errore volume (calibrato Q) = - 3.2 %

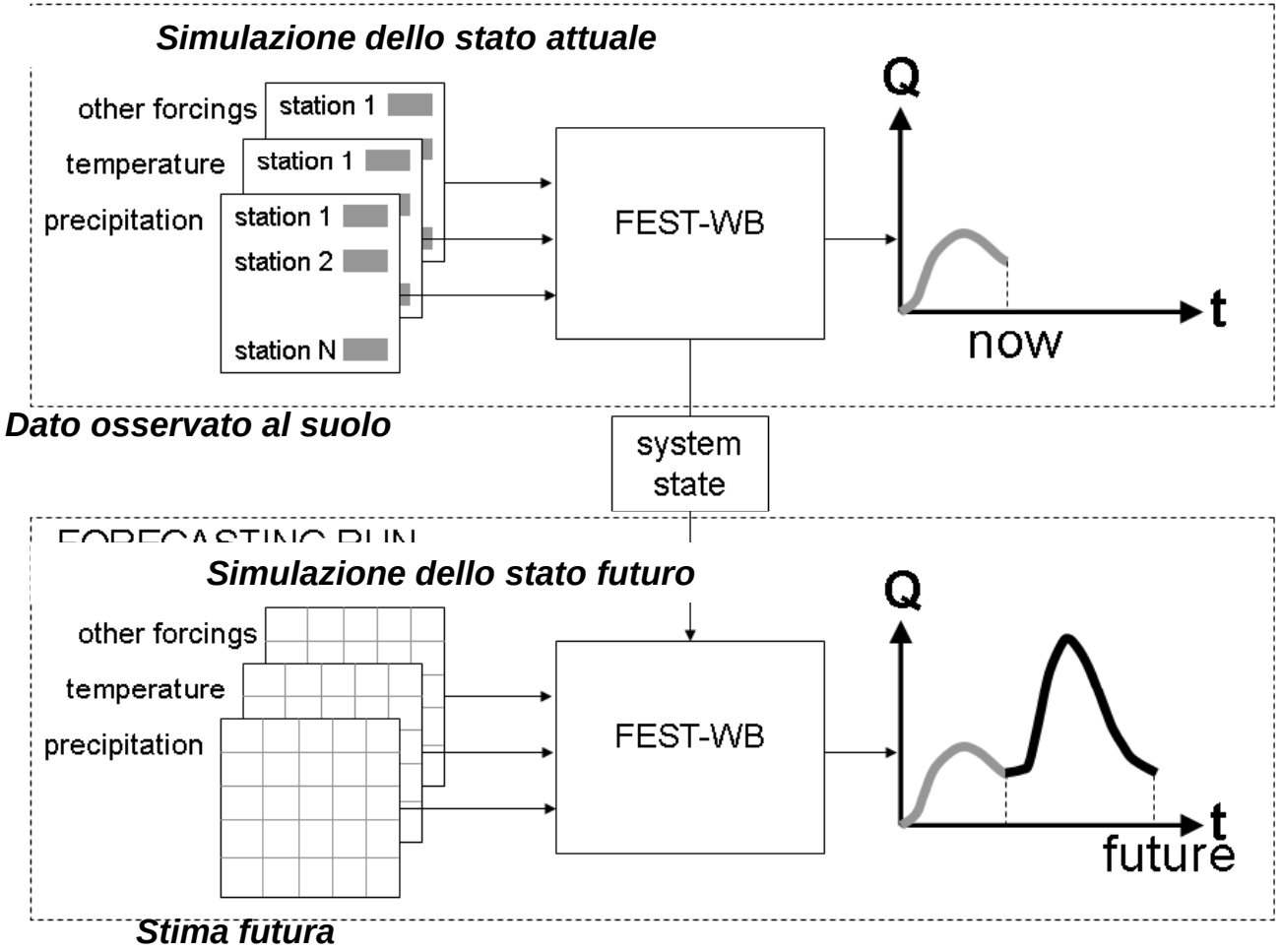
Errore volume (calibrato LST) = -2.9 %

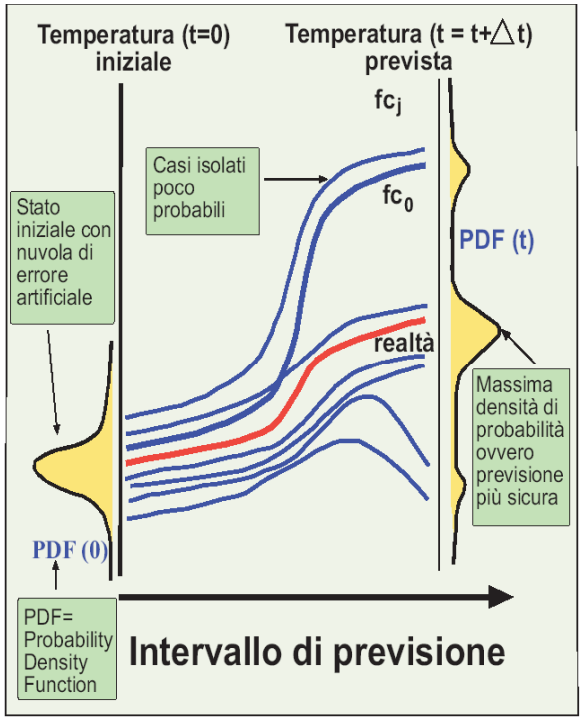


IL MODELLO PREVISIONE GESTIONE IRRIGUA (PREGI)

Metereological forecast and Hydrologic Hydraulic model

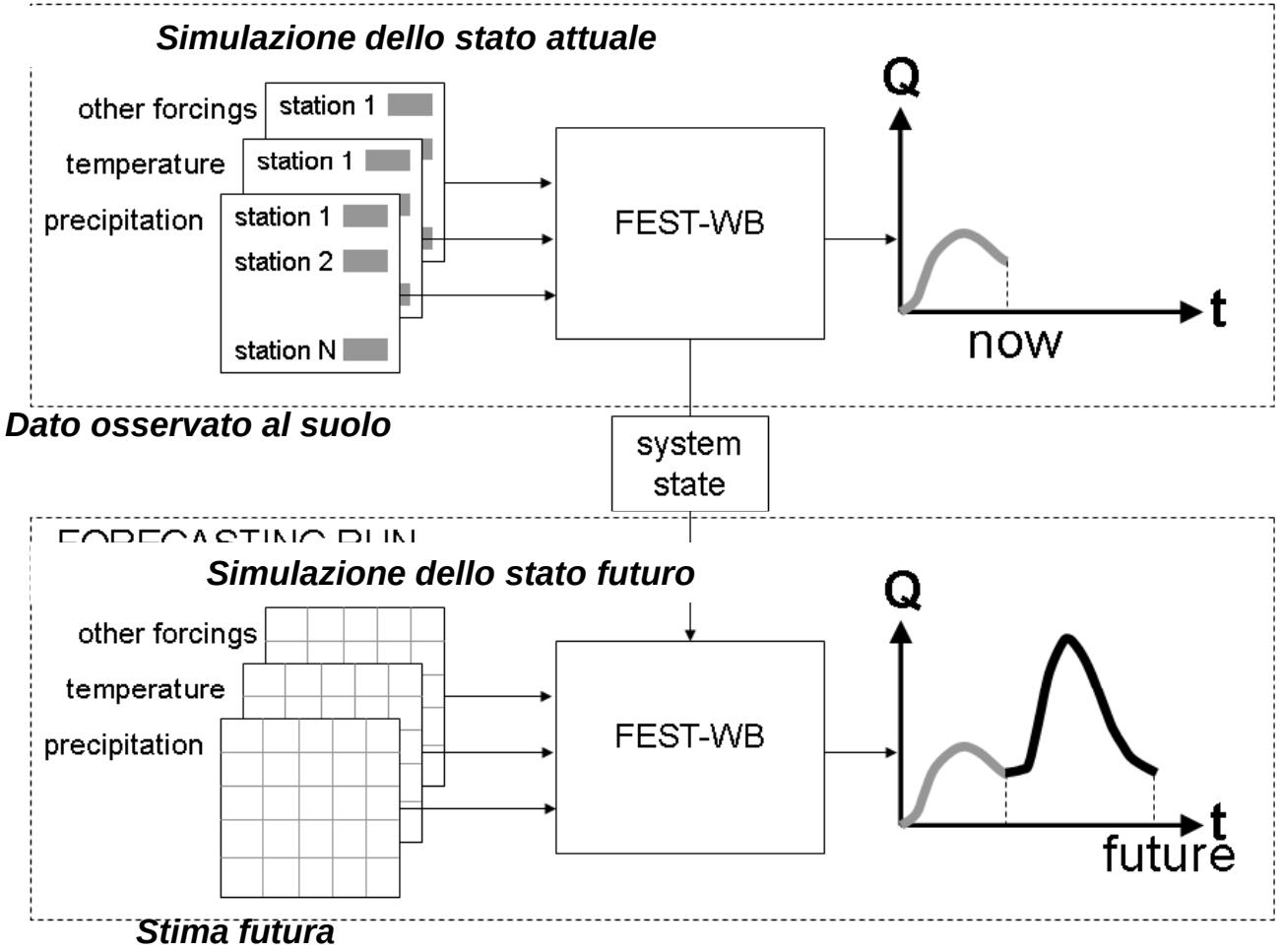
The Hydro-Meteorological chain → *Observations: Weather and Hydro data* → *Local M ~al Modelling* → *Basin H ~al Modelling*

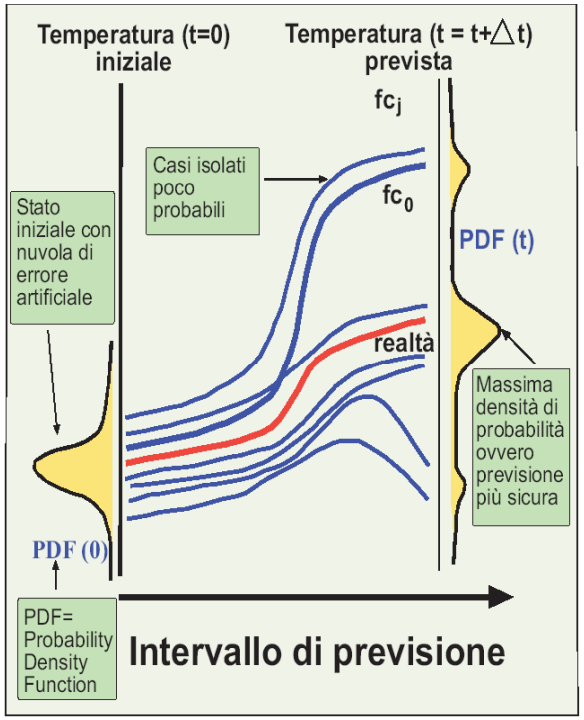




Interventi non strutturali di mitigazione: previsione integrata meteo idrologica con PREVISIONE DELL'IDROGRAMMA DI PIENA

The Hydro-Meteorological chain → *Observations: Weather and Hydro data* → *Local M ~al Modelling* → *Basin H ~al Modelling*





Analisi di affidabilità: Eventi Storici (1992-2002)

	ALTA VALDARNO		CASENTINO		SIEVE		BISENZIO		OMBRONE	
TIPO DI ALLARME	N° eventi	%	N° eventi	%	N° eventi	%	N° eventi	%	N° eventi	%
NO ALLARME	8	66.67	9	52.94	15	65.21	3	75	11	91.67
GIUSTO ALLARME	2	16.67	2	11.76	4	17.39	0	0	1	8.33
FALSO ALLARME	1	8.33	3	17.65	1	4.35	1	25	0	0
MANCATO ALLARME	1	8.33	1	5.88	1	4.35	0	0	0	0
ALLARME TARDIVO	0	0	2	11.76	2	8.70	0	0	0	0
N° eventi condizionati alla portata di	12		17		23		4		12	

BACINO	ALTA VAL D'ARNO	CASENTINO	SIEVE	BISENZIO	OMBRONE
Q*	900	350	300	300	200
BUON FUNZIONAMENTO	83.34 %	64.7 %	82.6 %	75 %	100 %

Analisi di affidabilità: Eventi Sintetici con 500 anni)

	ALTA VALDARNO		CASENTINO		SIEVE		BISENZIO		OMBRONE	
TIPO DI ALLARME	N° eventi	%	N° eventi	%	N° eventi	%	N° eventi	%	N° eventi	%
NO ALLARME	197	49.87	331	52.54	405	53.71	116	44.1	153	76.88
GIUSTO ALLARME	110	27.85	197	31.27	261	34.62	90	34.2	33	16.59
FALSO ALLARME	13	3.29	36	5.71	43	5.70	24	9.13	1	0.50
MANCATO ALLARME	56	14.18	56	8.89	40	5.31	29	11.0	11	5.53
ALLARME TARDIVO	19	4.81	10	1.59	5	0.66	4	1.52	1	0.50
N° eventi condizionati alla portata di Q>Q* m^3/sec	395		630		754		263		199	

BACINO	ALTA VAL D'ARNO	CASENTINO	SIEVE	BISENZIO	OMBRONE
Q*	900	350	300	300	200
BUON FUNZIONAMENTO	77.72 %	83.81 %	88.33 %	78.33 %	93.47 %

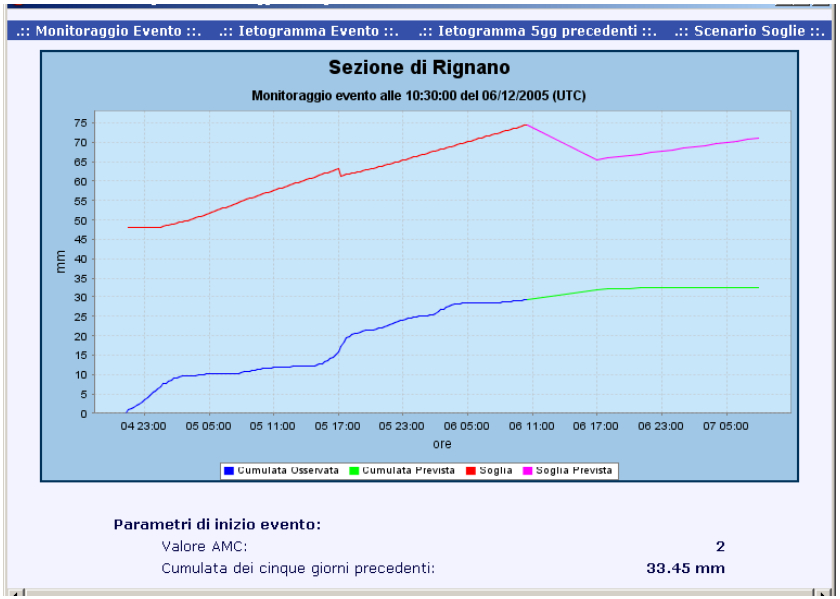
Simbolo azienda

Asparagi con sub irrigazione

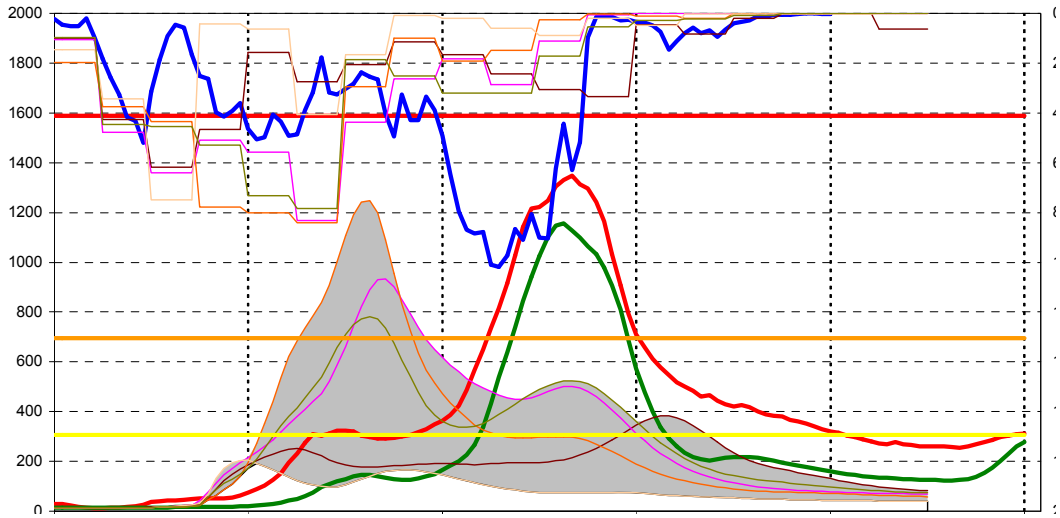
Finocchi con irrigazione a goccia

Prevedono un potenziale evento di piena pericoloso con un tempo sufficiente di preavviso a mettere in sicurezza le persone e le cose. (L. n 49/2010 da direttiva n. 2007/60/Ce "Valutazione e gestione dei rischi di alluvioni)

Soglie Pluviometriche di Allerta Idrometrica (,So PAI)



Previsione Idrogramma di Piena (PIP)



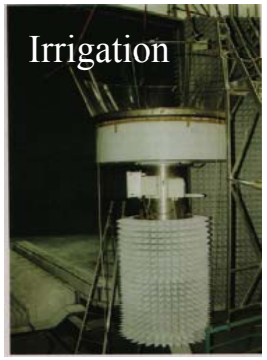
…..a supporto di Piani di protezione civile

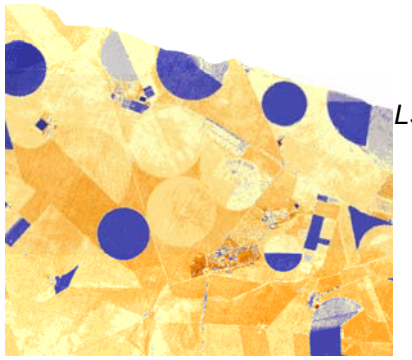
Marco Mancini, marco.mancini@polimi.it,

Remote sensing data and distributed hydrological models for water engineering

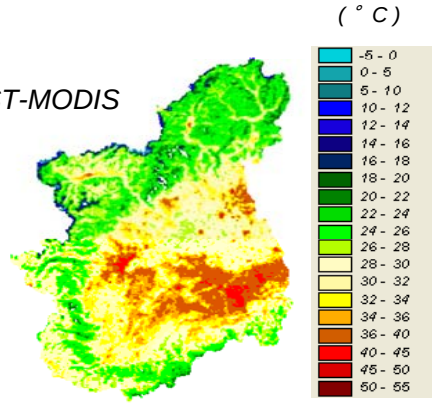
M. Mancini, C. Corbari, G. Ravazzani, A. Ceppi,

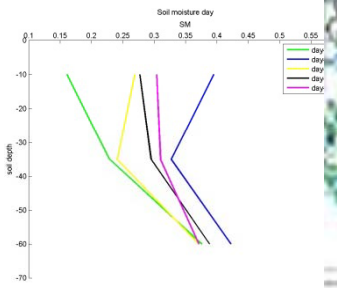
Politecnico di Milano (Italy)

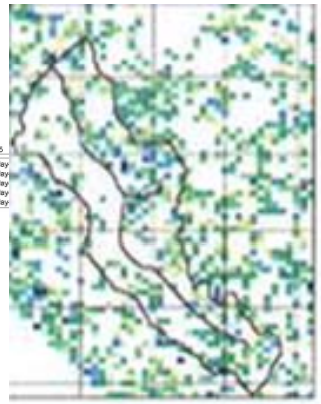


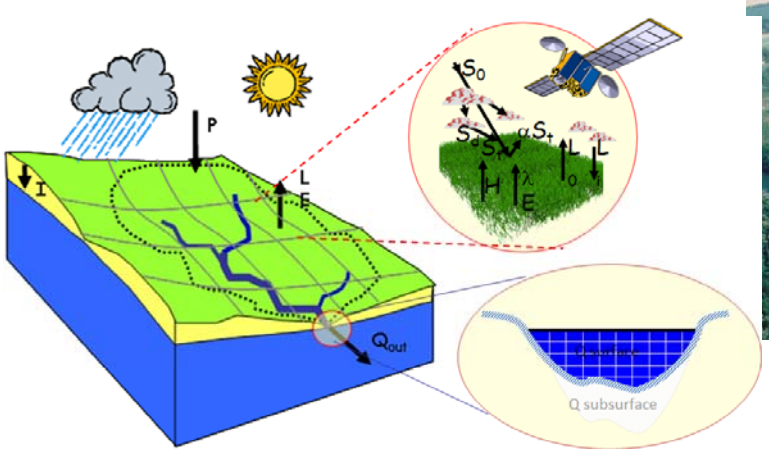


LST-MODIS









o.mancini@polimi.it,