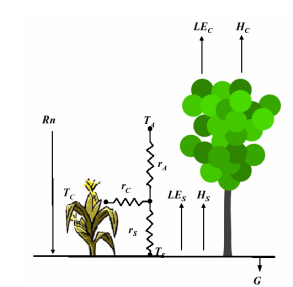
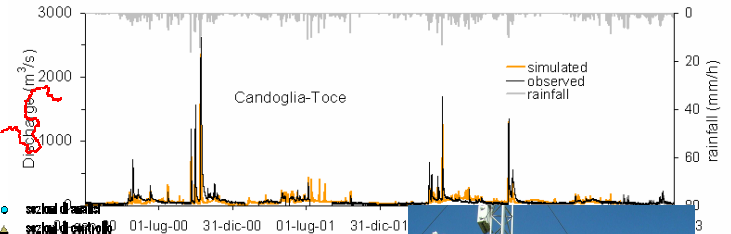
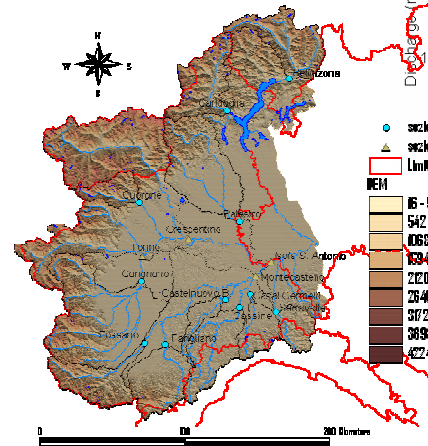
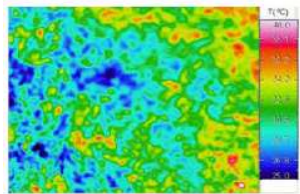


Misure tradizionali e innovative a supporto dell'ingegneria dell'acqua

M. Mancini, G. Ravazzani, C. Corbari, A. Ceppi, D. Masseroni, G. Milleo, L. Boscarello, G. Ercolani

DIAR Politecnico di Milano





Bilancio idrologico: misure tradizionali ed innovative



P

-

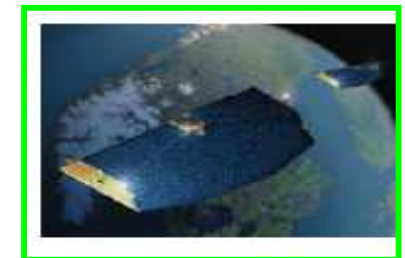
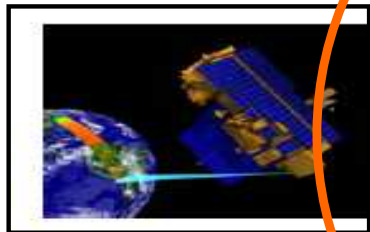
E

-

Q

=

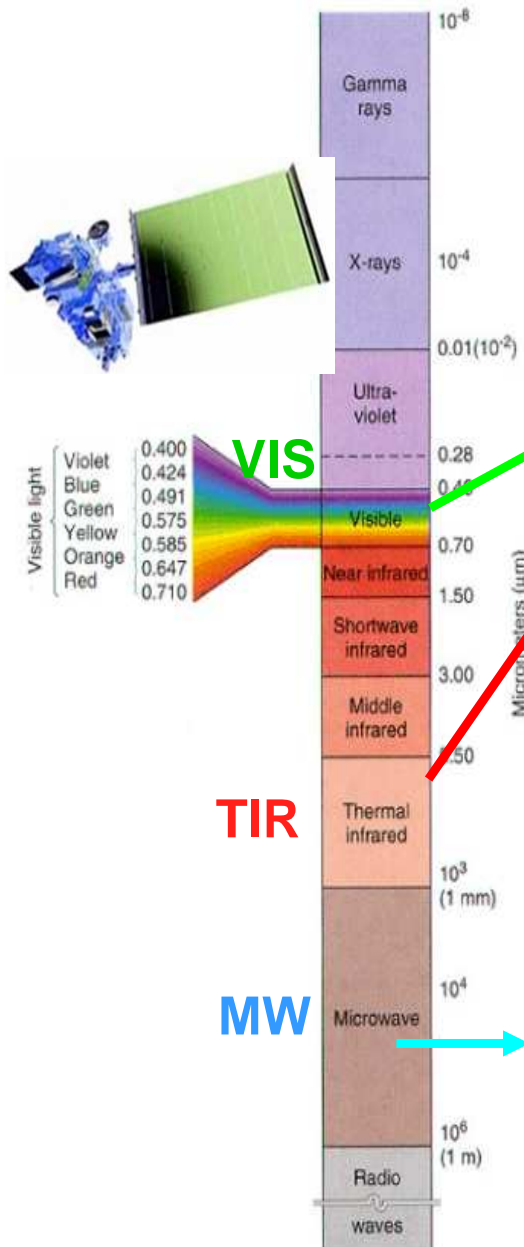
$$\frac{dS}{dt}$$



Il nostro contributo



Sensori satellitari: spettro elettromagnetico e variabili idrologiche e biologiche



- albedo **superficiale** (Knap, 1999)
- indici di vegetazione (Choudhury, 1987; Richter et 2009)
- indice di area fogliare (LAI) (Minacapilli et al., 2009)
- neve estensione areale (Ranzi 2010,)
- radiazione entrante (Bish et al.,2005; Niemela et al.,2001)
- temperatura dell'aria (Seemann et al.,2003)
- photosynthetically active radiation (Running et al., 2000)
- clorofilla (Abbott et al., 2002)

- LST (temperatura superficiale): (Sobrino 2007, Prata, Becker, Li, Menenti, Durso, La Loggia et al, Agnese et al. Corbari 2010)

- umidità del suolo: (Wagner (2007), Jackson(1990), Schmuggy (1994), Wood 1990, Mancini(1999) ,,,)
- soil water storage** (Ramillien 2006)
- pioggia (Heinemann et al., 2008; Huffman et al., 2010, La Barbera, Rudari(2006))
- altimetria (Berry et al., 2003;Frappart et al., 2006)
- topografia (space shuttle mission)
- Classificazione di vegetazione (Hllikainen, 1992, Anderson et al., 2004; Clevers, 1989)
- Frane analisi interferometrica, Rocca 2000)**
- copertura e spessore del ghiaccio

Radiometria Passiva

Radiometria attiva

source: Christopherson (2000) Geosystems

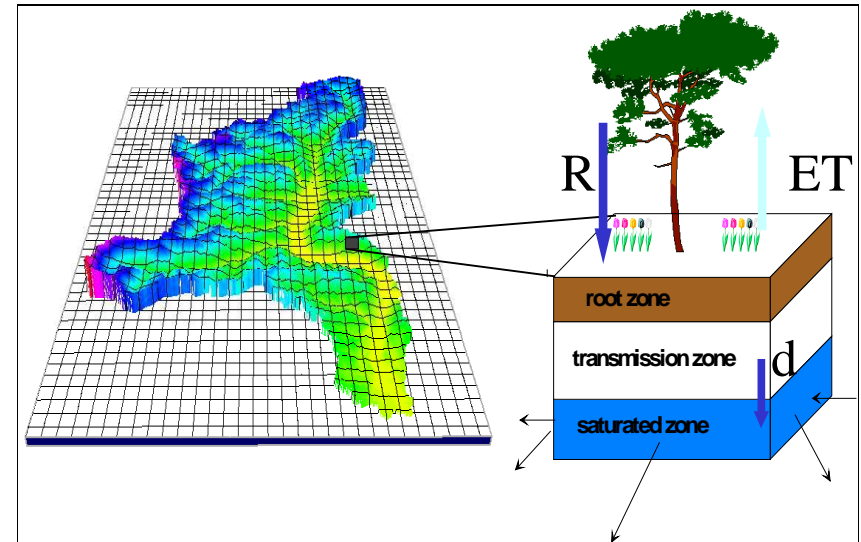
Soil water balance

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

Energy balance

$$Rn - G - H - LE = \frac{dS}{dt} \quad ET_{eff} = \frac{LE}{\rho C_p}$$

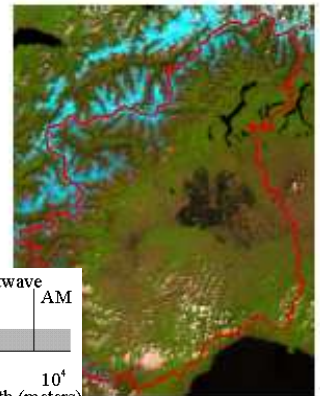
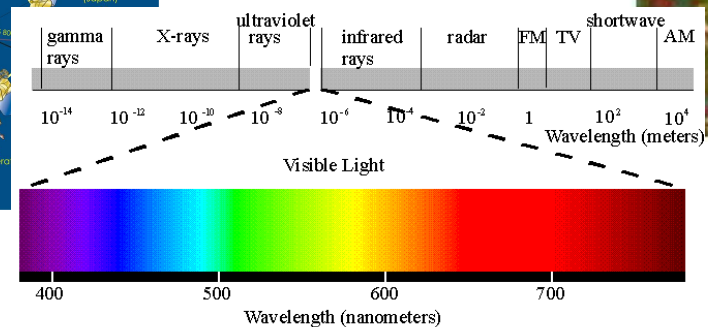
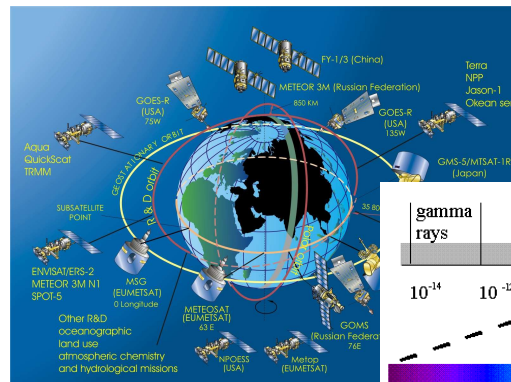
Modello idrologico distribuito



Misure al suolo



Immagini satellitari



Stazione micrometeorologica: eddy covariance station

<http://geoserver.iar.polimi.it>



Radiometer

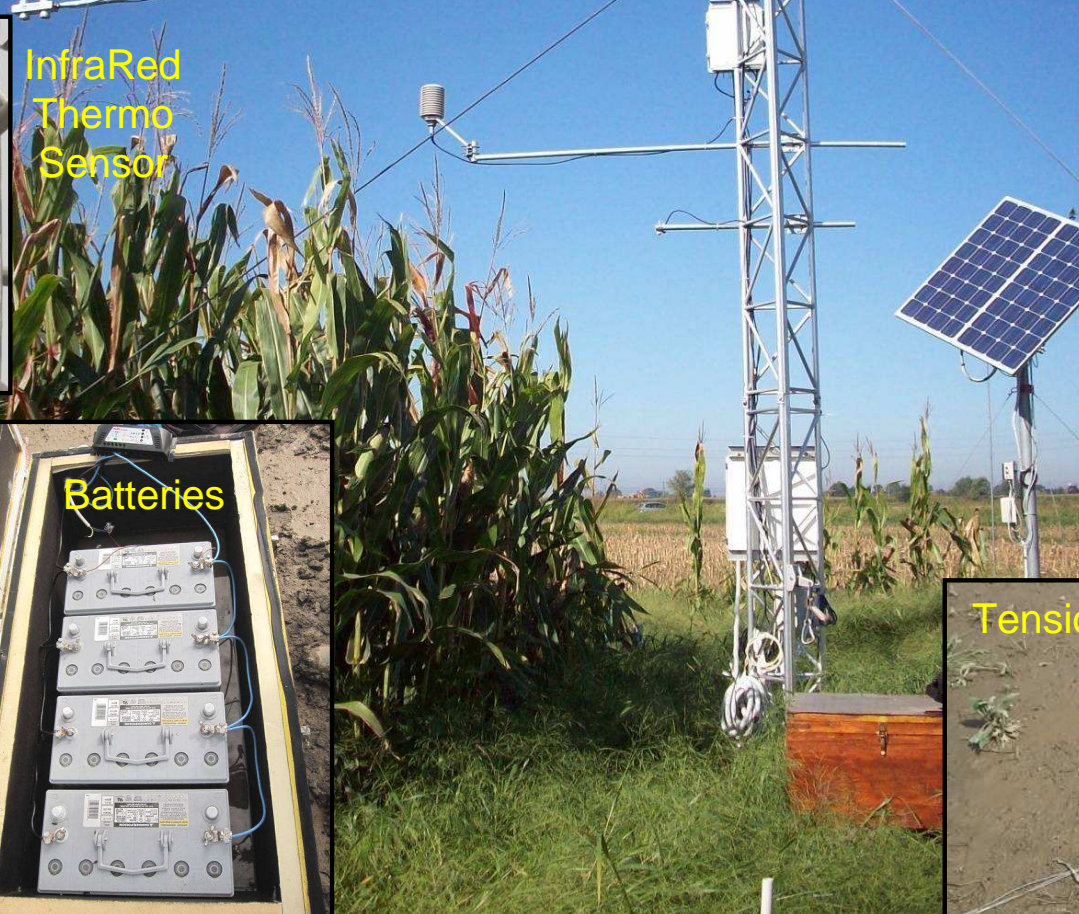


Gas analyser & Sonic anemometer

Davis Weather Station



InfraRed Thermo Sensor

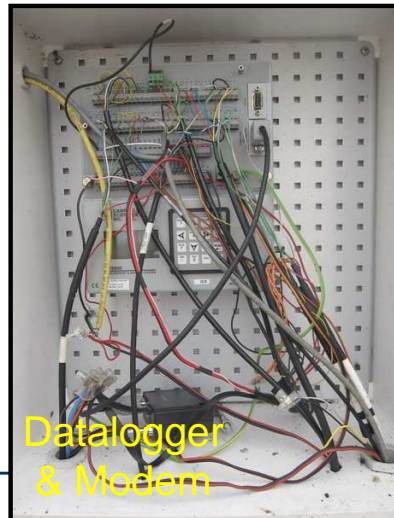


Thermo-Hygrometer

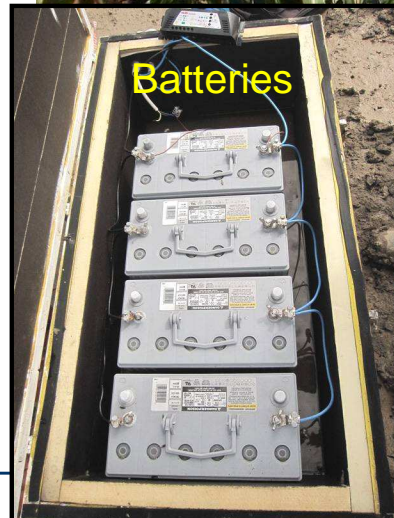


Raingauge

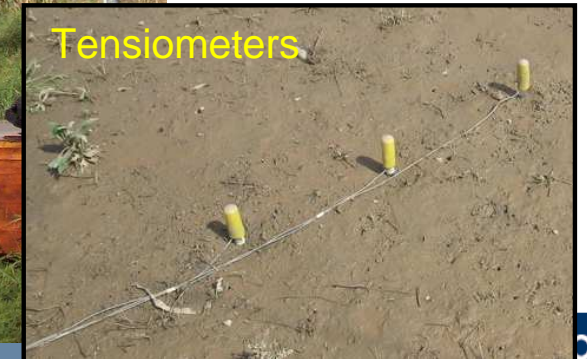
Datalogger & Modem



Batteries



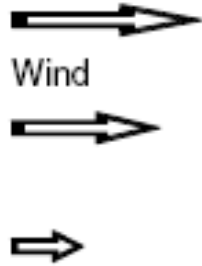
Tensiometers





Posizionamento della stazione eddy e misura dei flussi

COSTANT FLUX LAYER



Upwind surface roughness z_{0U}

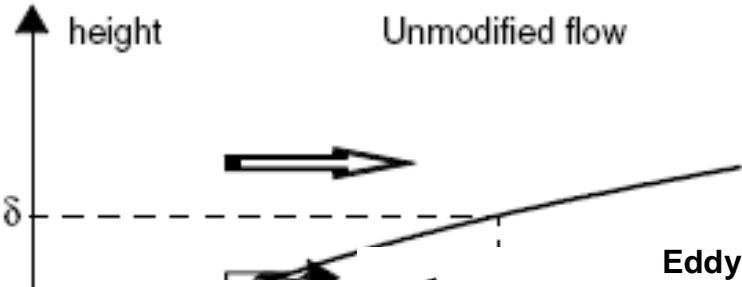
$$LE = -K \frac{dq}{dz}$$

$$Le = \lambda_v \rho \cdot \overline{Wq_v}$$

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

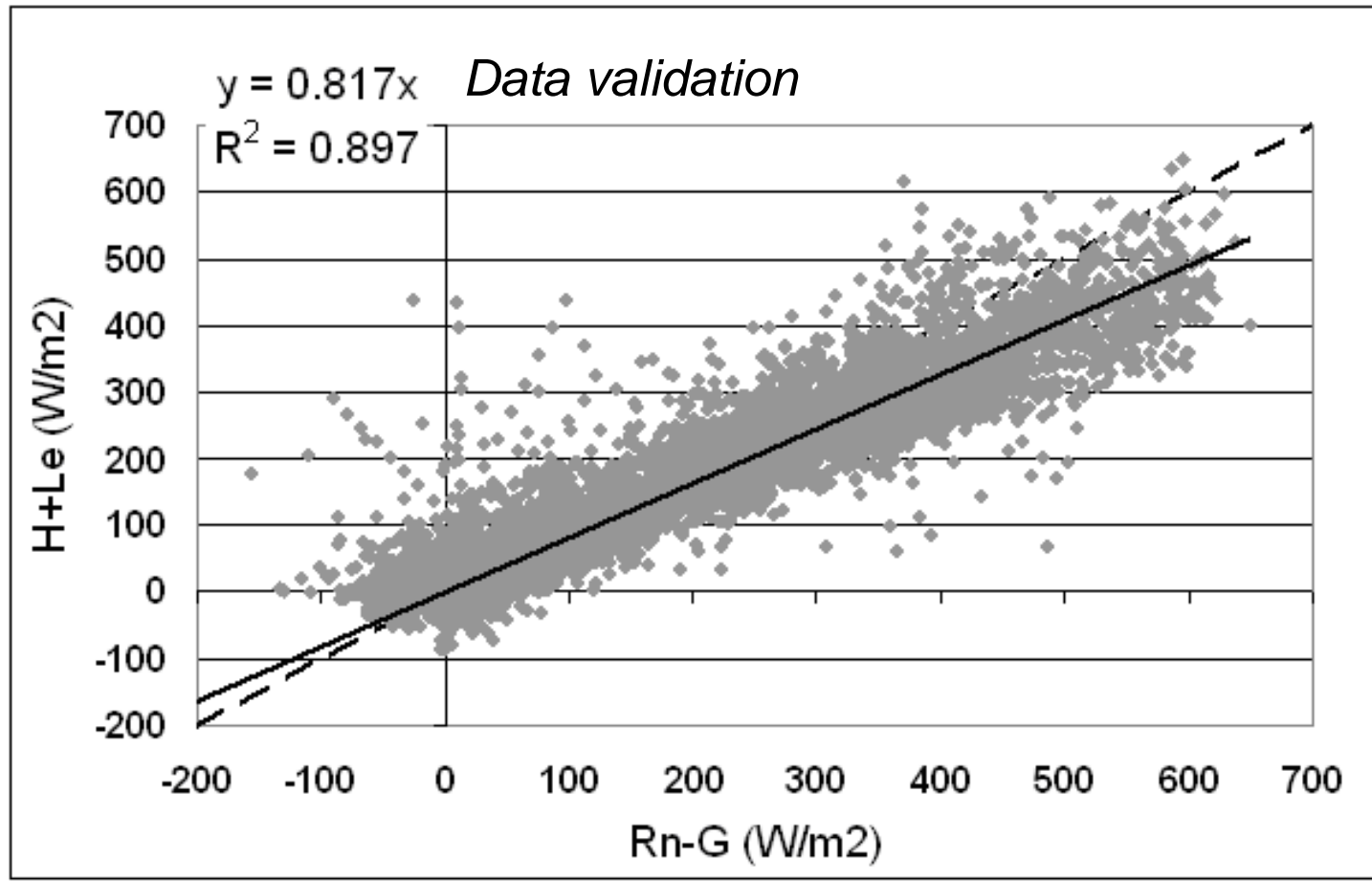
The F

$$H = \rho C_p \cdot \overline{WT}$$



Costant Flux Layer (Elliot 1958)

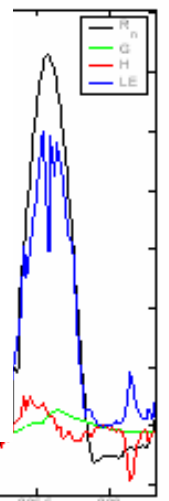
$$\frac{\delta}{z_{0D}} = (0.75 - 0.03M) \cdot \left(\frac{x}{z_{0D}} \right)^{0.8}$$



surface

rface

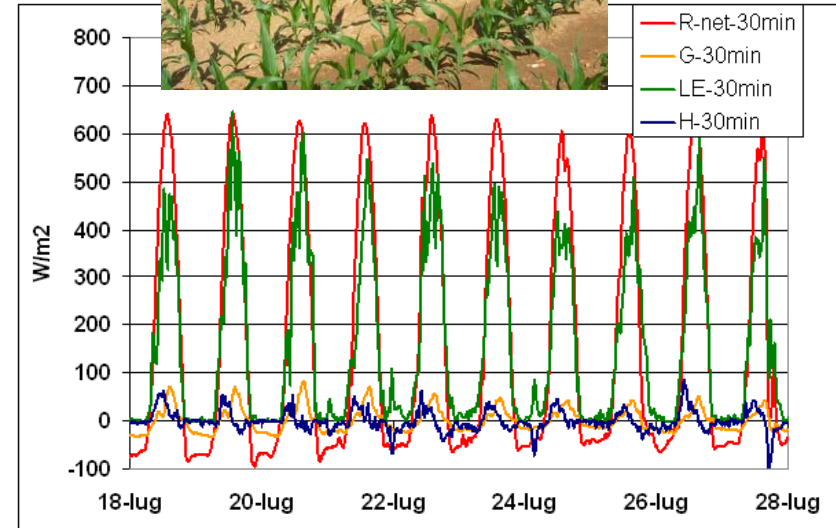
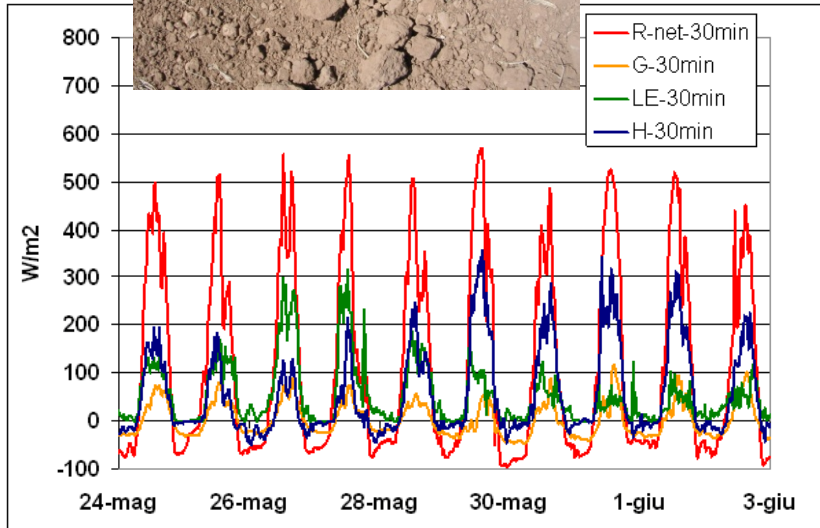
ze



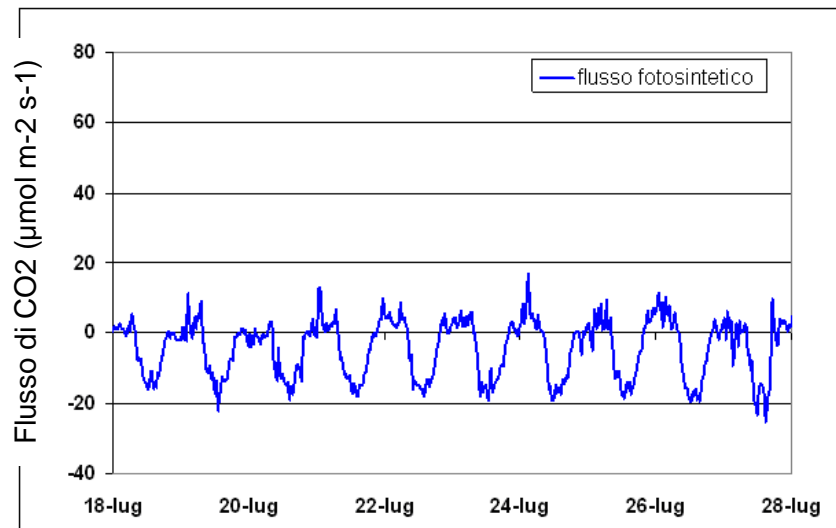
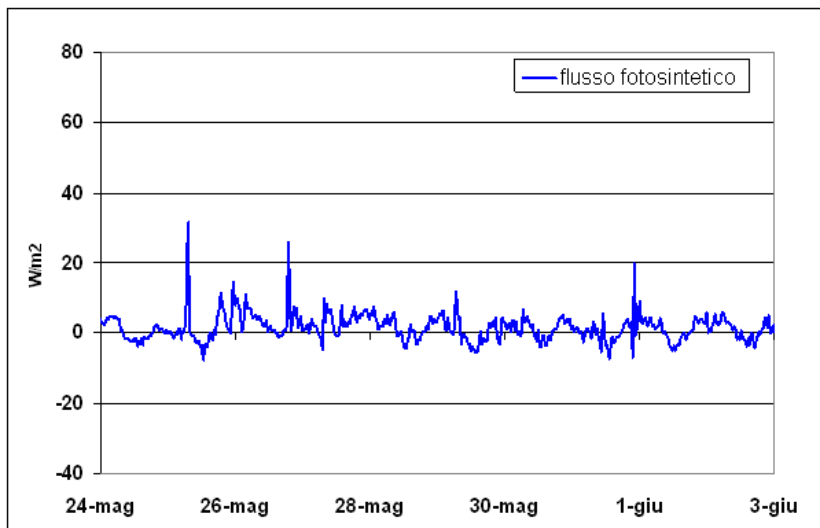


Landriano 2010: effetto della presenza di vegetazione sui flussi energetici

FLUSSI ENERGETICI

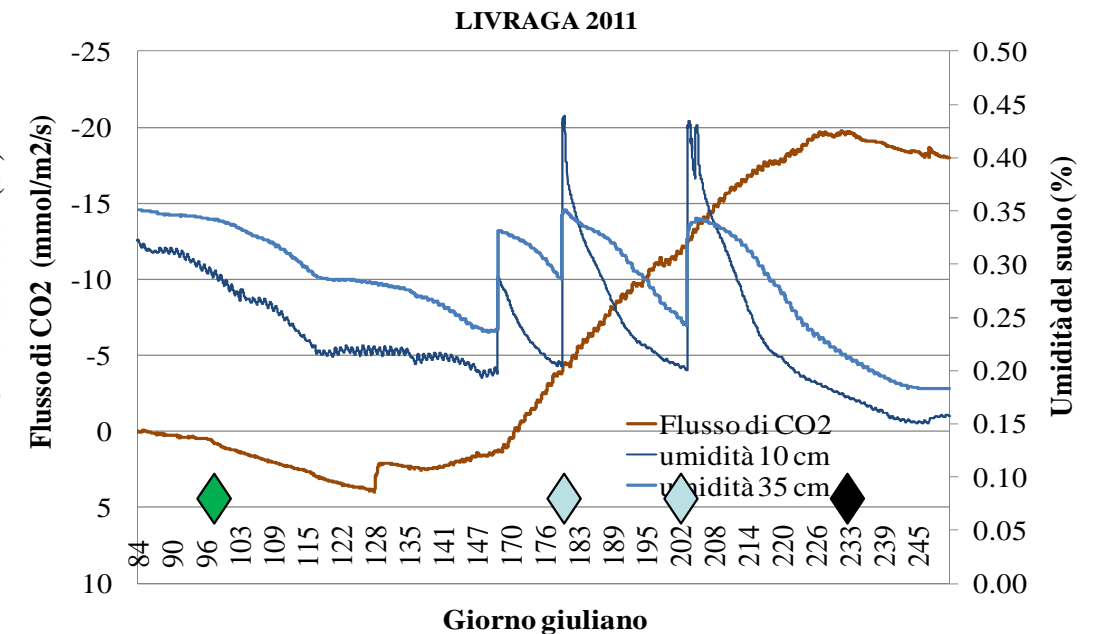
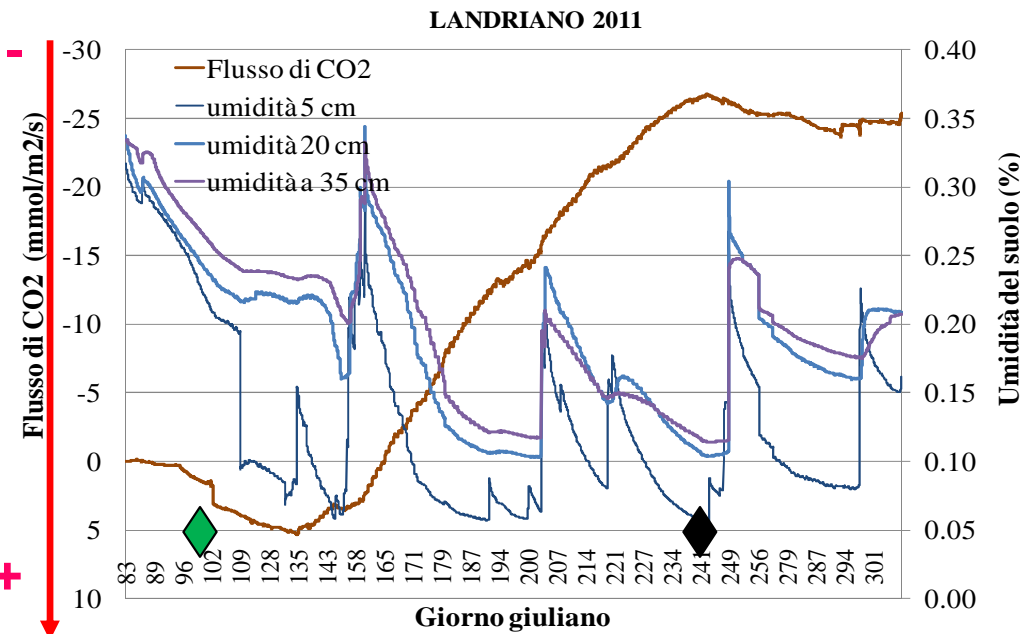
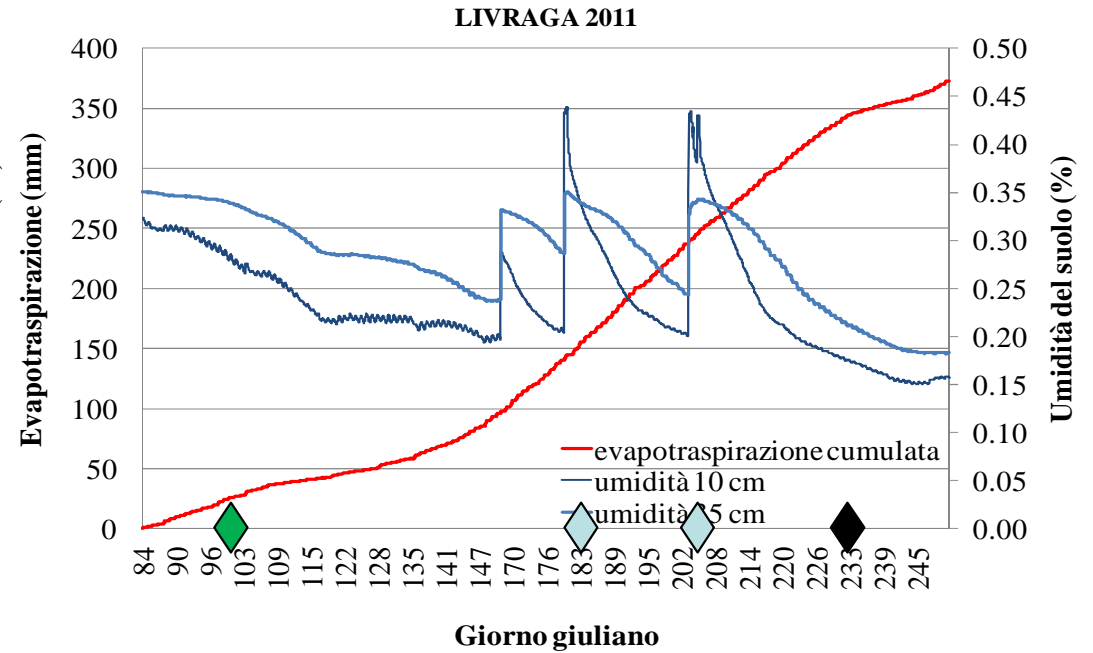
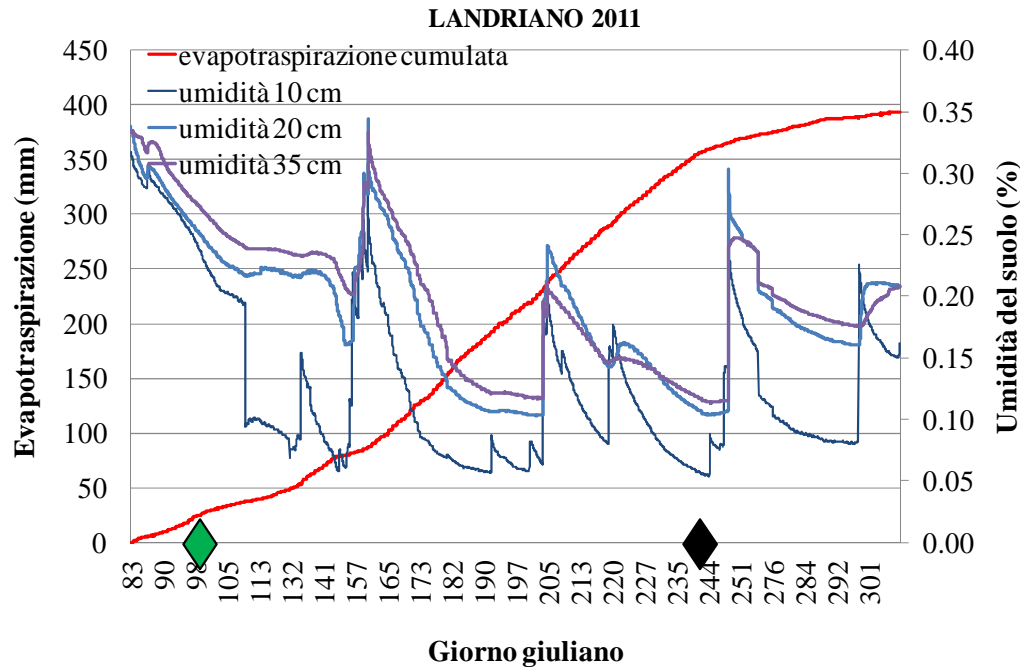


Flusso di CO2 ($\mu\text{mol m}^{-2} \text{s}^{-1}$)





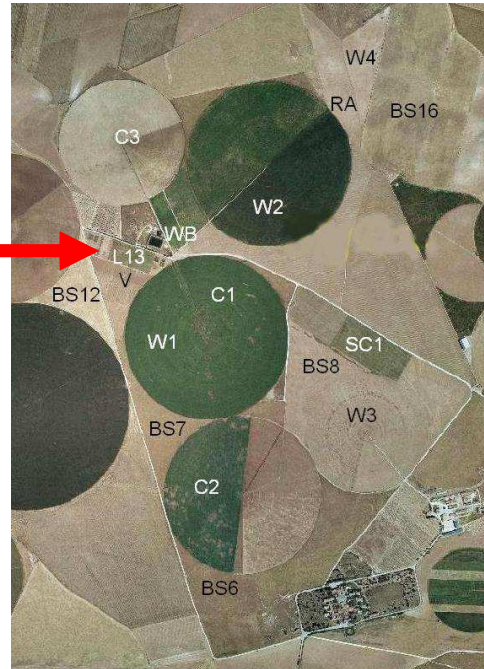
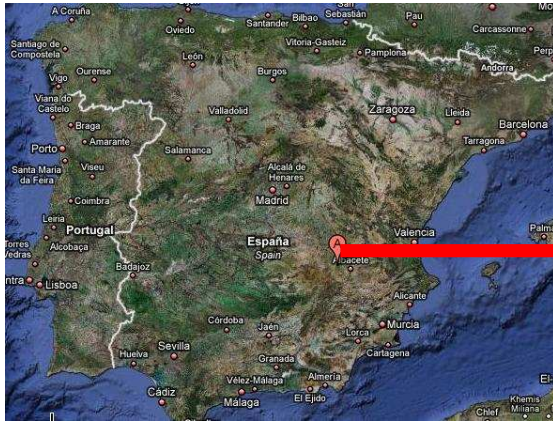
Misure di evapotraspirazione, anidride carbonica e umidità del suolo



◆ Irrigazione ◆ Semina ◆ Raccolto
ACCA - 31 Maggio 2012



Misure da aereo al suolo e modellistica idrologica (Barrax, 2005/ 2009 / 2011/ 2012 Spain)



The SENTinel-2/3 and FLuorescence EXperiment (**SEN2/3FLEX** field campaign - Luglio 2005 e Giugno 2009) è una nuova costellazione di satelliti ad orbita polare – **ESA** (<http://earth.esa.int/object/index.cfm/fobjectid=5658>)



AHS_050602_P01M

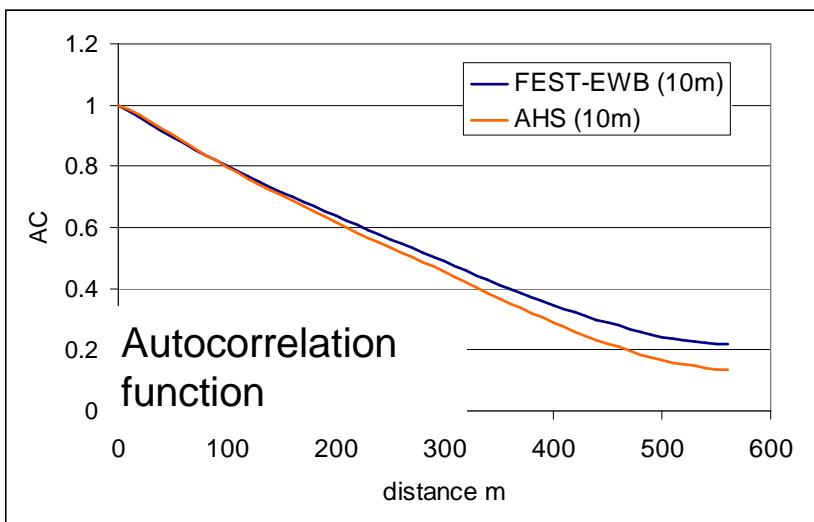
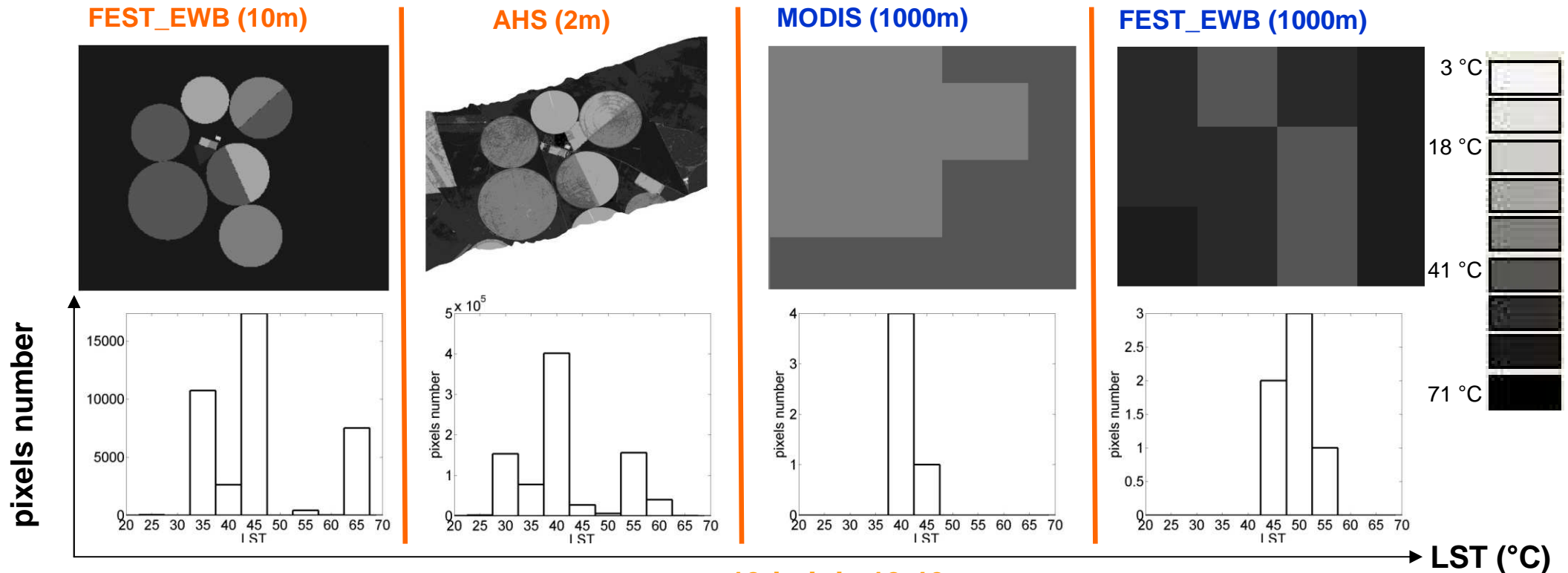
comparison between airborne infrared ground and modelling data

Heterogeneous area: irrigated fields (75% corn, 15% weath, 15% sunflower, 5% alfalfa, 5% other coltures) and drylands





BARRAX : Comparison between observed surface temperature from AHS and MODIS and simulated surface temperature from FEST-EWB

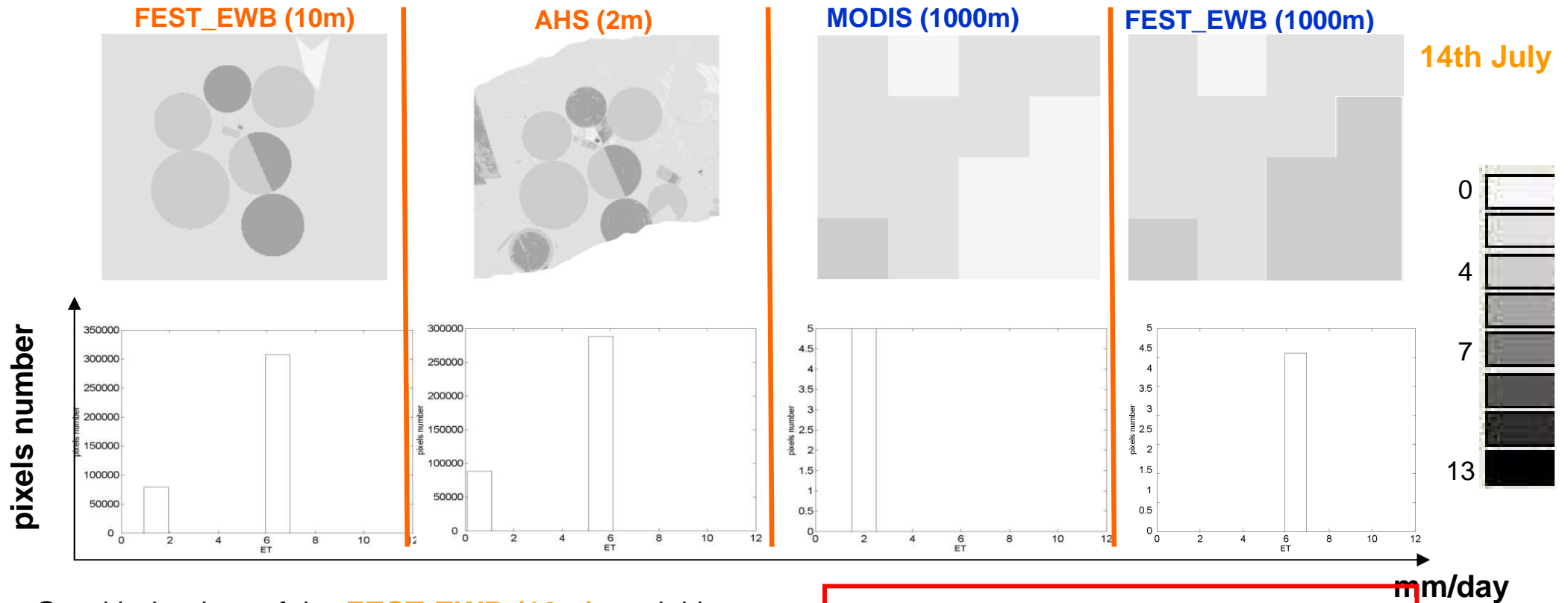


13th July 13.46

Spatial resolution at increasing scale offers the possibility to understand the ability of MODIS resolution to represent LST over extremely heterogeneous area

	AHS	FEST-EWB 10m	FEST-EWB 1000m	MODIS
Pixel n	967450	38698	5	5
Mean LST (°C)	42	42.9	44.8	41.4
St. Dev. (°C)	8.8	9.6	3.1	1.1

Barrax agricultural district: comparison between Evapotraspirazione retrieved from AHS and MODIS and simulated from FEST-EWB



Good behaviour of the **FEST-EWB (10m)** model in representing the **spatial heterogeneity** of ET images from **AHS**. Histograms: bimodal distribution due to the distinction between crops and bare soil



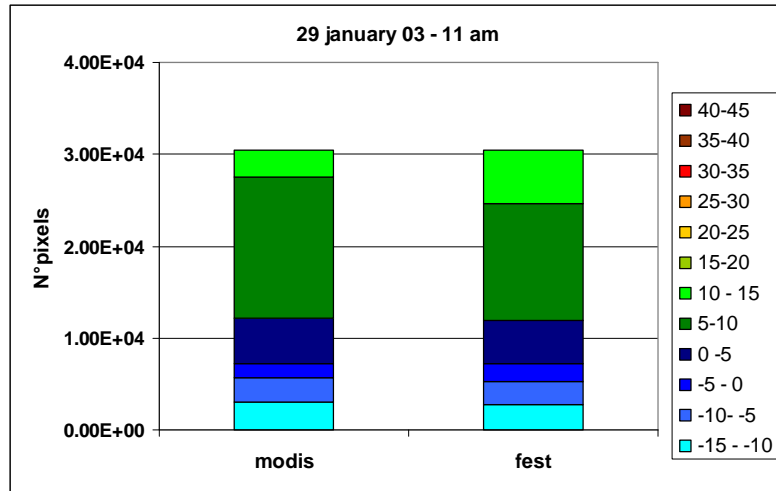
MODIS coarser images do not catch the strong spatial heterogeneity neither the mean value, **FEST-EWB (1000m)** catches the mean value

The influence of the LST **representativeness** on latent heat flux

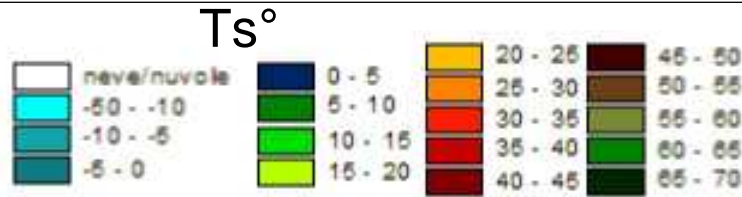
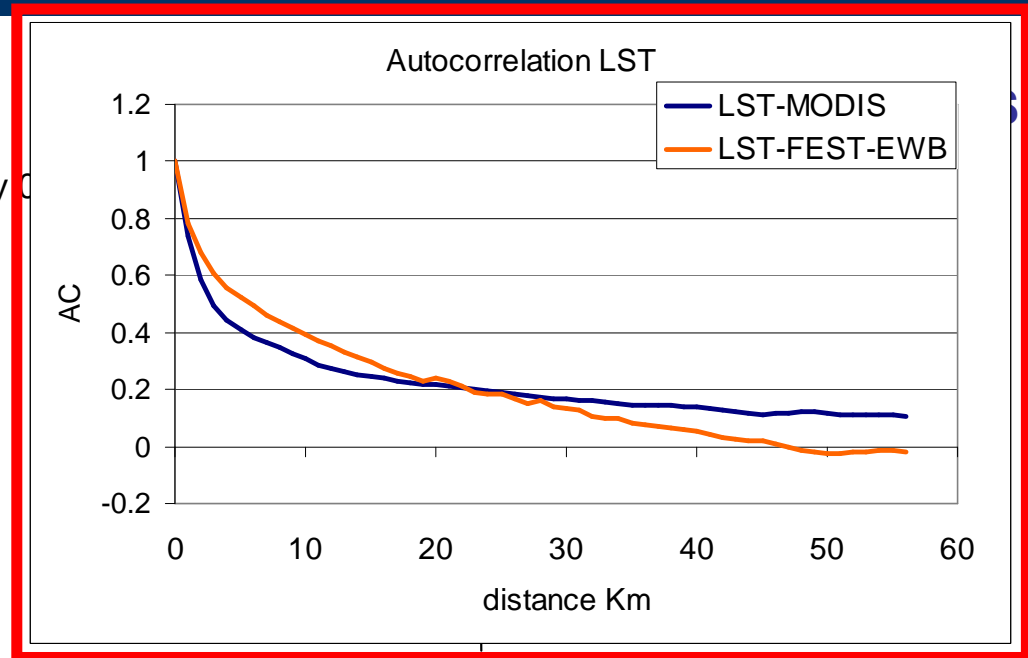
	AHS	FEST-EWB 10m	FEST-EWB 1000m	MODIS
Pixel n	967450	38698	12	5
Mean ET (mm/day)	4.1	4.8	5.1	2.3
St. Dev. (mm/day)	1.4	1.9	0.2	0.7



Misure Satellitari e modellistica idrologica: il bacino del Po piemontese



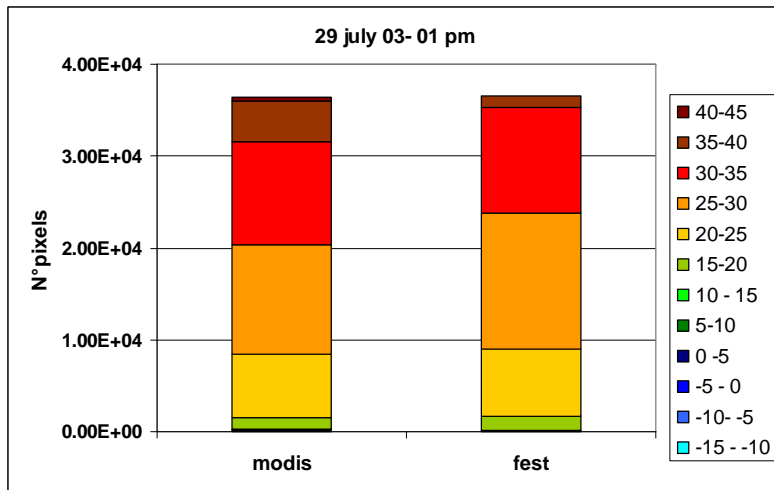
29 January 03



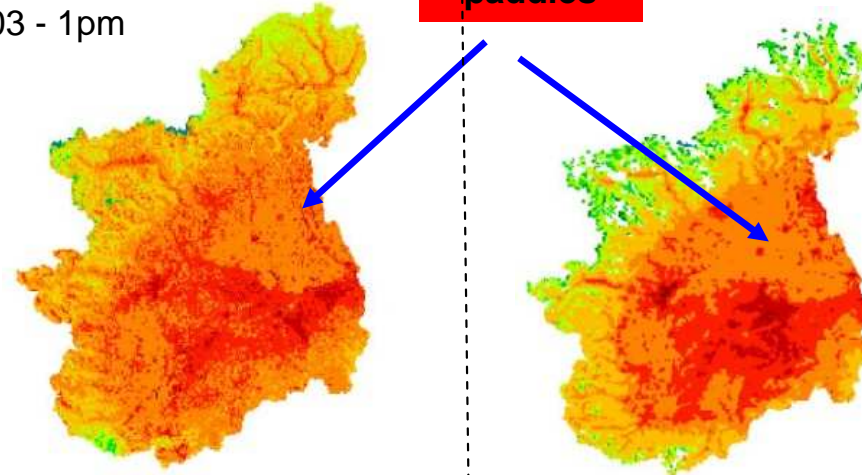
FEST-EWB

MODIS

paddies



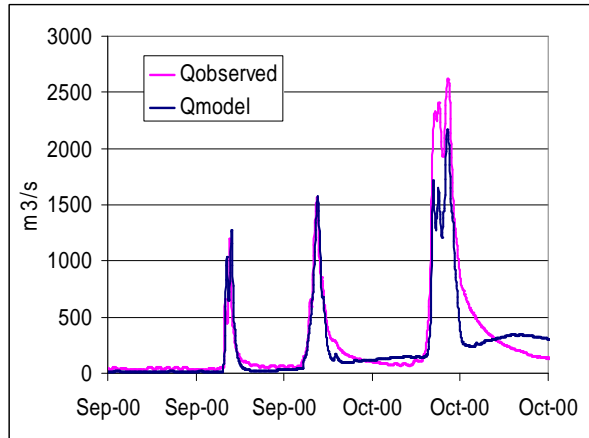
29 July 03 - 1pm





Local Outputs of the hydrological model: comparison between observed and simulated discharges

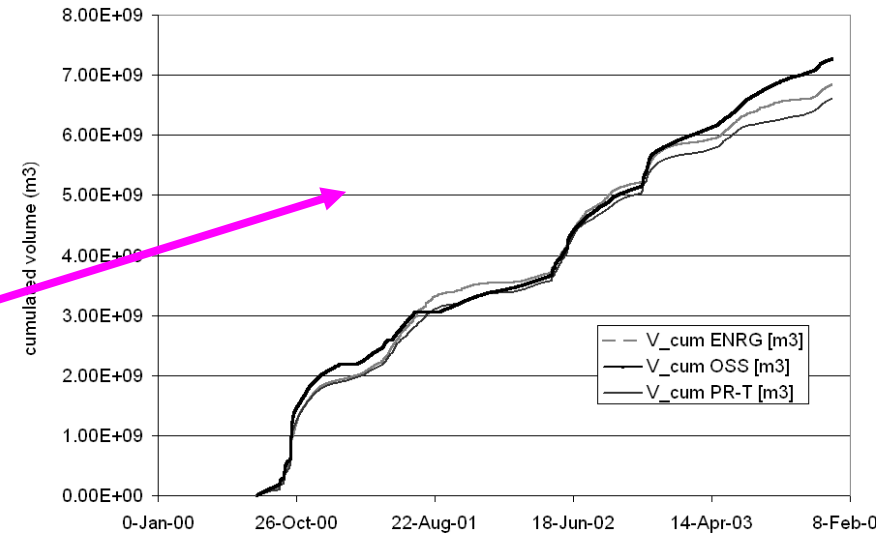
Toce a Candoglia



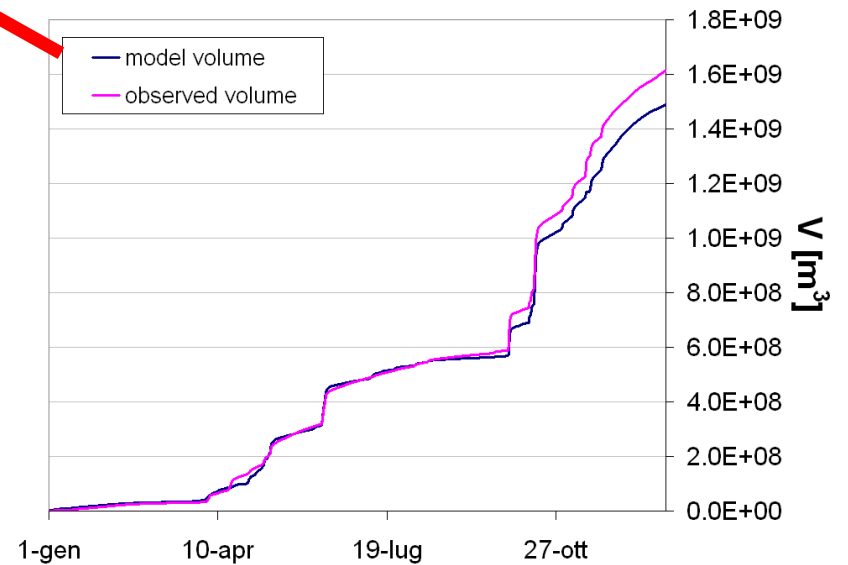
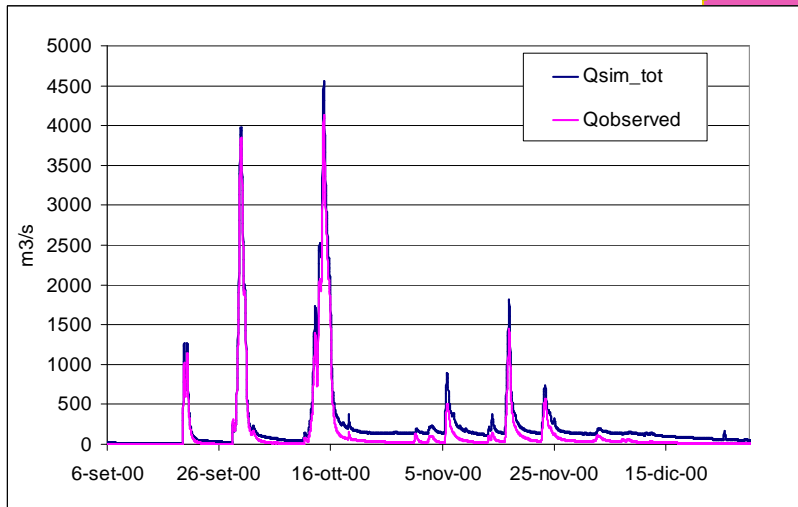
RMSE 120.1 m³/s
Nash = 0.65

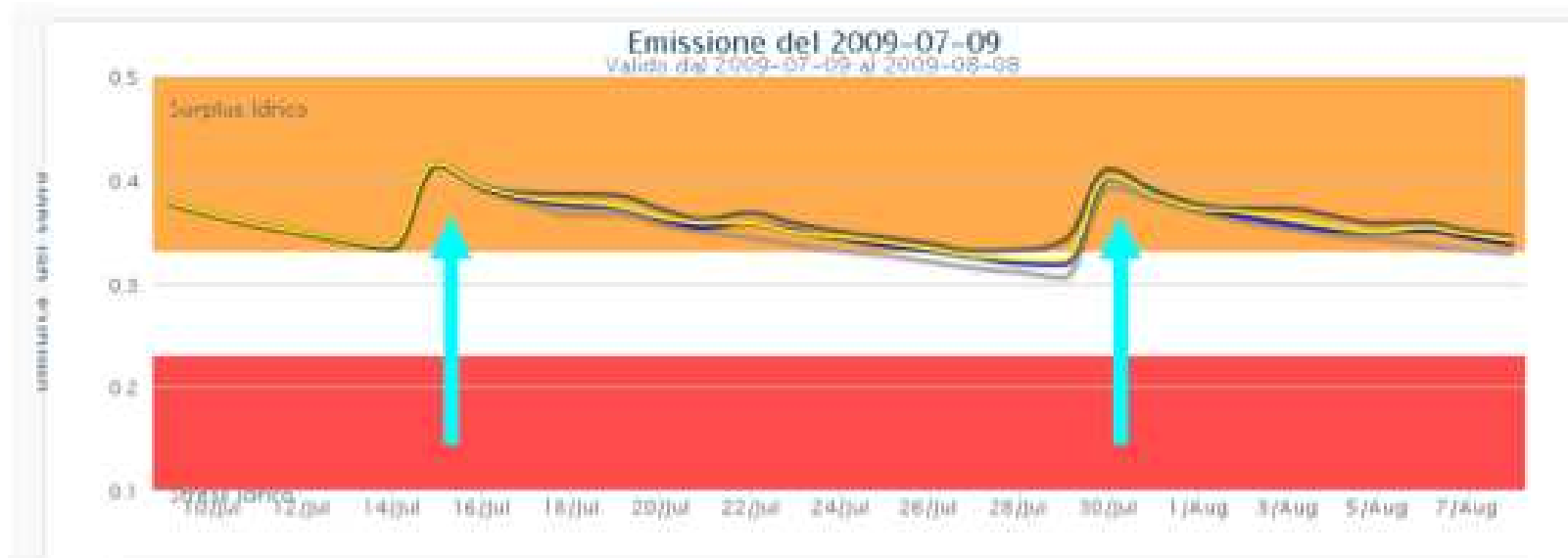
Po a Ponte della Becca (38'000) km²

Volume Error = -1.82 %



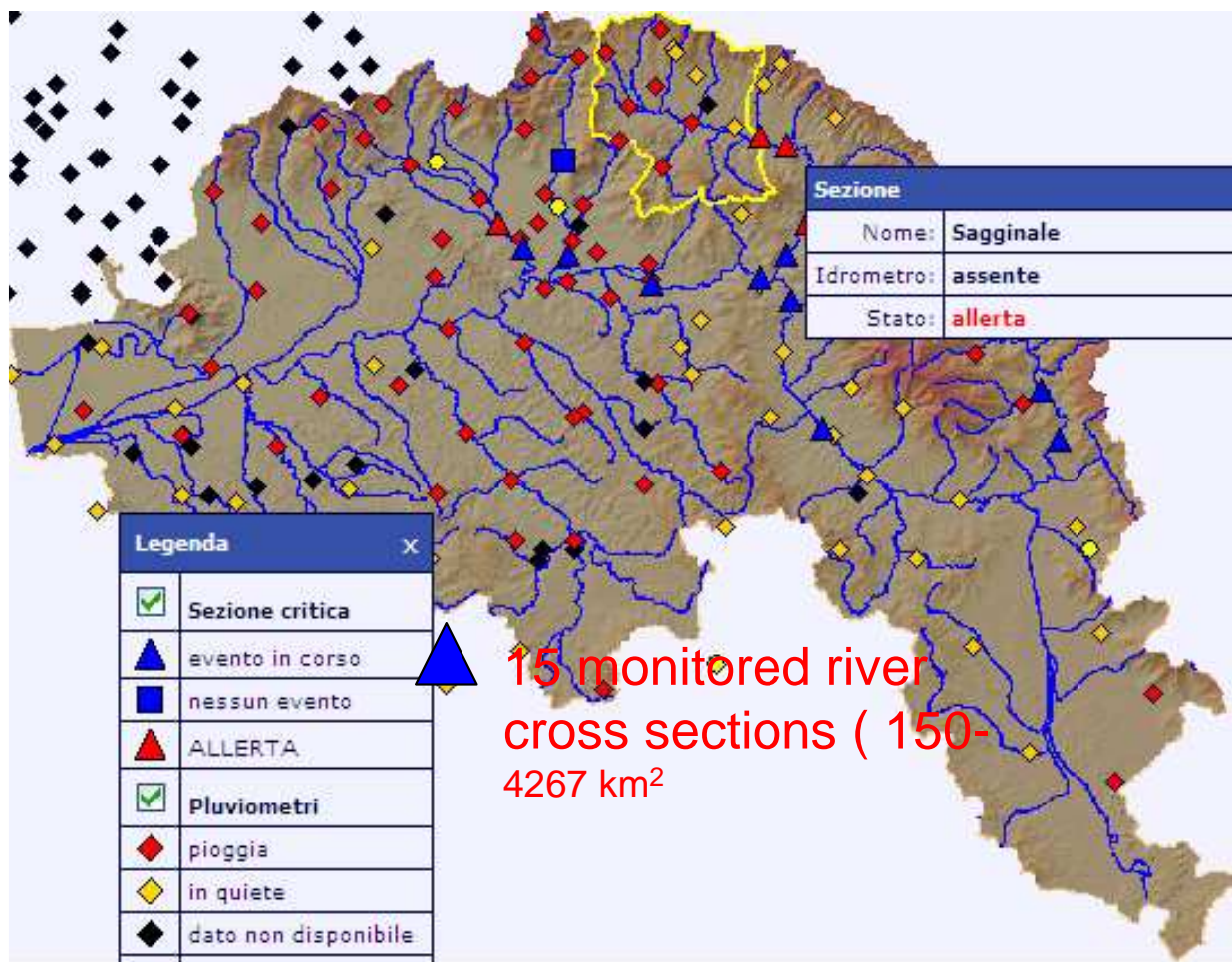
Sesia a Palestro







Applicazioni ingegneristiche: I sistemi di allerta meteo idrologici, le Soglie di precipitazione di allerta idrometrica fiume Arno (Firenze)



Sezione	
Nome:	Sagginale
Idrometro:	assente
Stato:	allerta

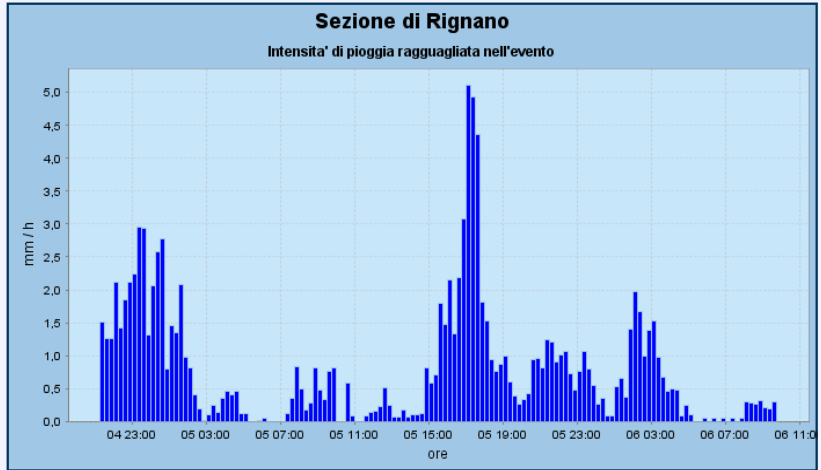
Legenda	
<input checked="" type="checkbox"/>	Sezione critica
	evento in corso
	nessun evento
	ALLERTA
<input checked="" type="checkbox"/>	Pluviometri
	pioggia
	in quiete
	dato non disponibile
<input checked="" type="checkbox"/>	Centri abitati
	centro abitato

15 monitored river cross sections (150-4267 km²)

Ora del server: 11:38:39 24/03/2006 UTC
 Ultima osservazione: 11:30:00 24/03/2006 UTC
 Ultima previsione: 00:00:00 26/03/2006 UTC
 Situazione passata: 06-11-2005 9 :45



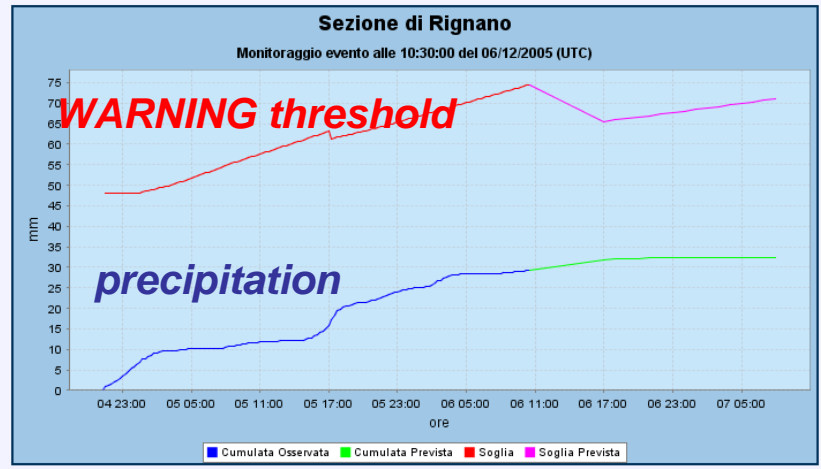
Monitoraggio Evento :: Ietogramma Evento :: Ietogramma 5gg precedenti :: Scenario Soglie ::



Parametri di inizio evento:
 Valore AMC: 2
 Cumulata dei cinque giorni precedenti: 33.45 mm

MIMI - Modello Integrato di Monitoraggio Idrologico - Mozilla Firefox

Monitoraggio Evento :: Ietogramma Evento :: Ietogramma 5gg precedenti :: Scenario Soglie ::



Parametri di inizio evento:
 Valore AMC: 2
 Cumulata dei cinque giorni precedenti: 33.45 mm

Centro Funzionale Regione Toscana

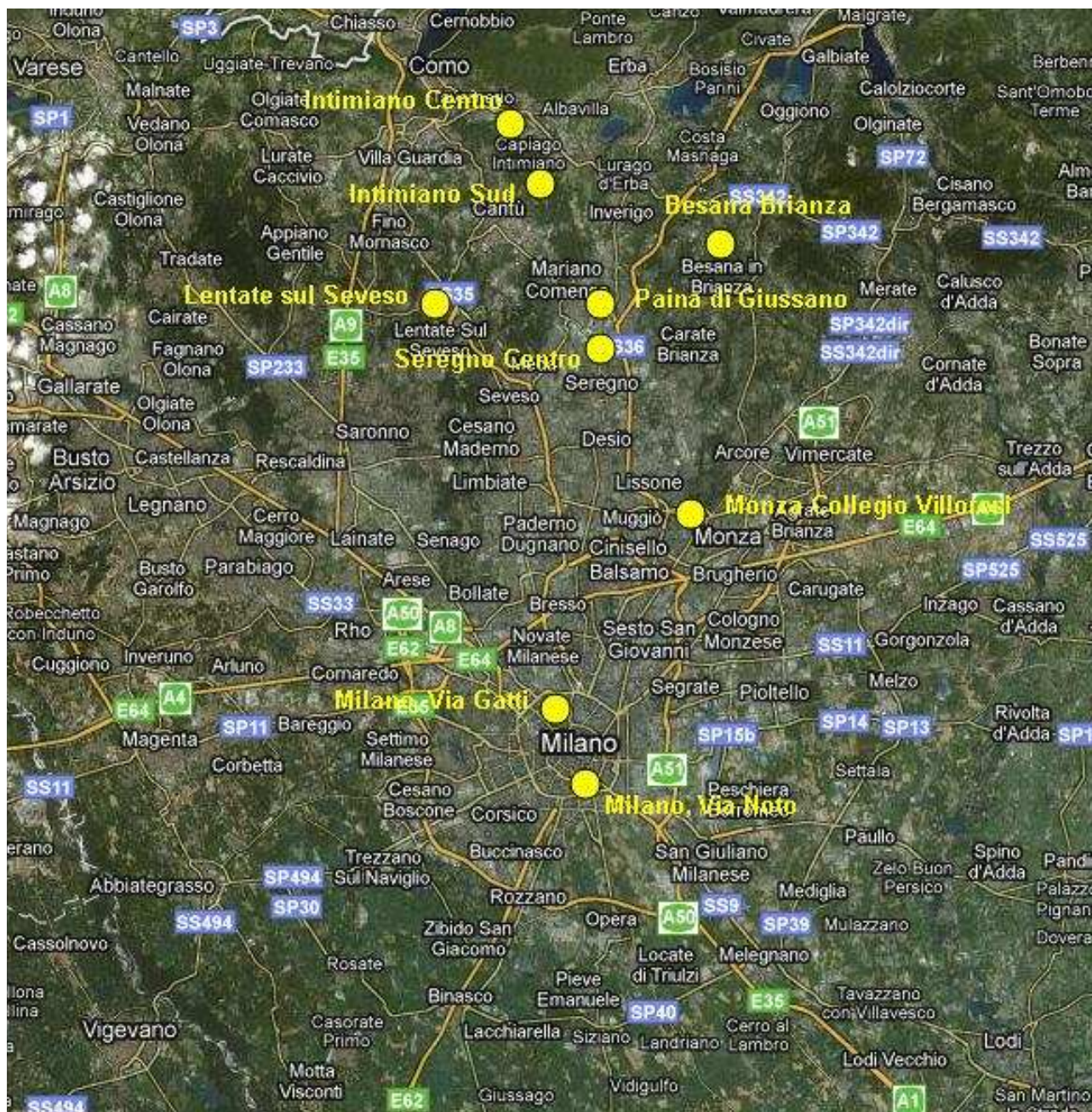


Applicazioni ingegneristiche : La previsione in tempo reale della piena del Seveso

Torrente SEVESO

Stazioni

Rete MNW



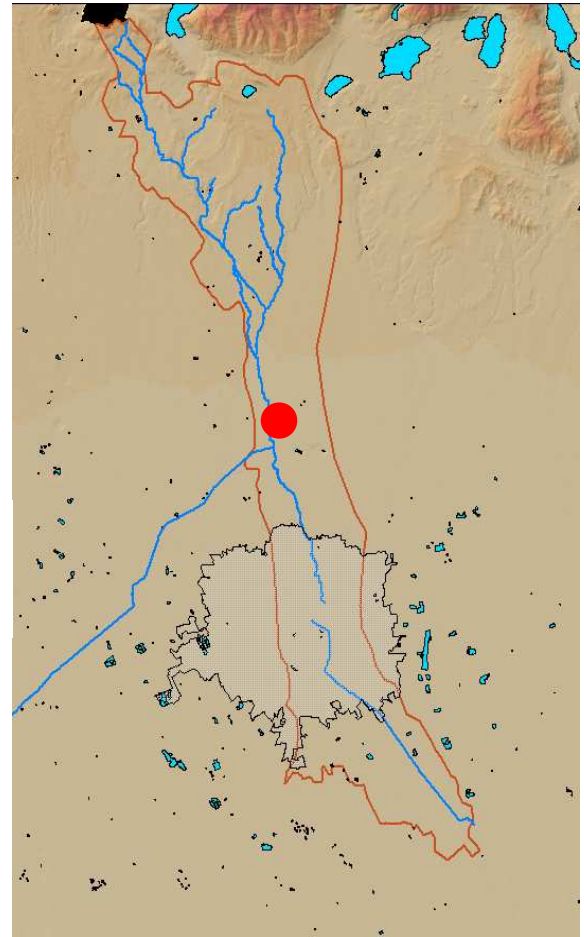
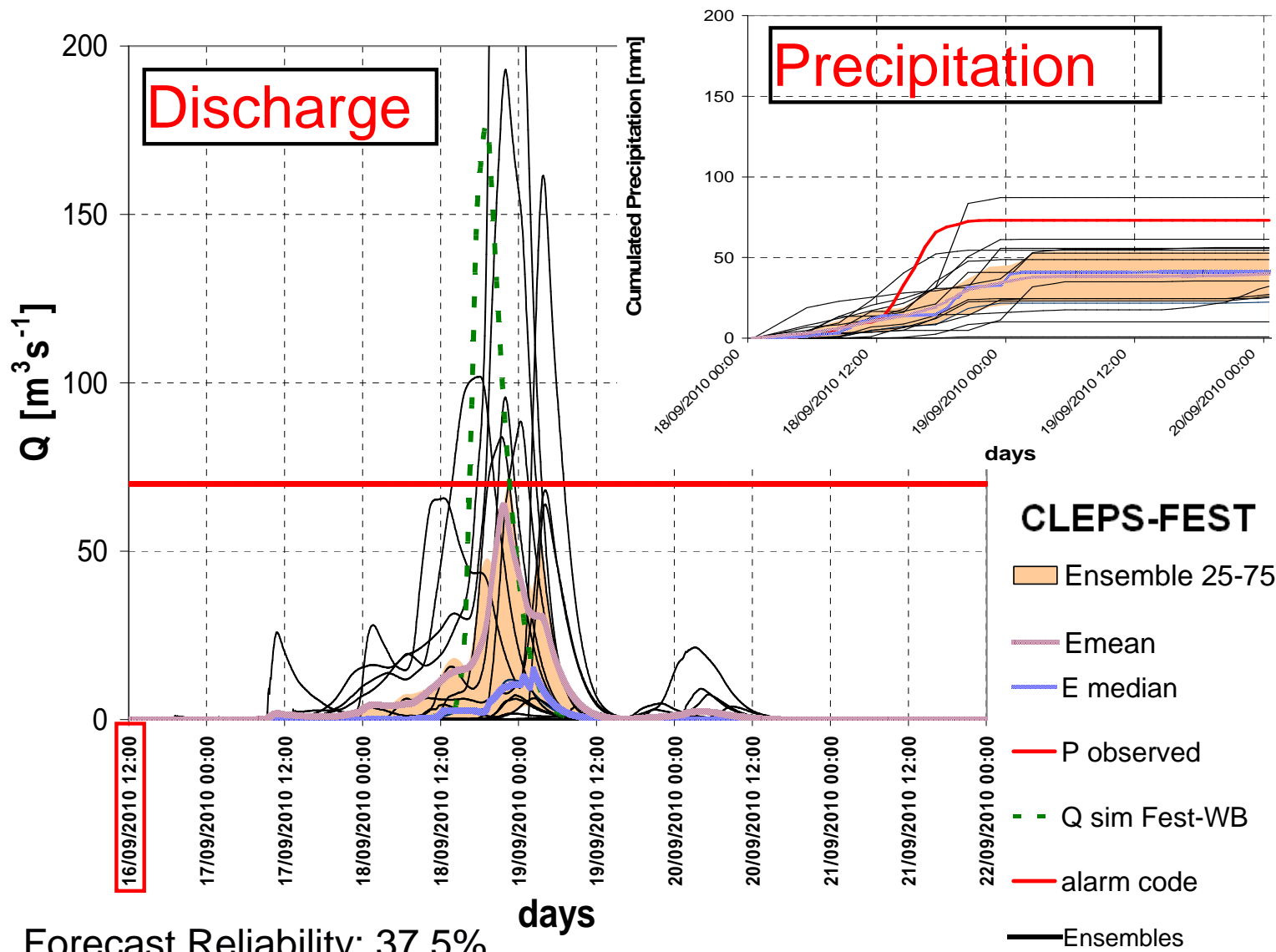


INTEGRAZIONE PREVISIONE METEOROLOGICA E MODELLISTICA IDROLOGICA

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

Area: 195 km²

Seveso basin

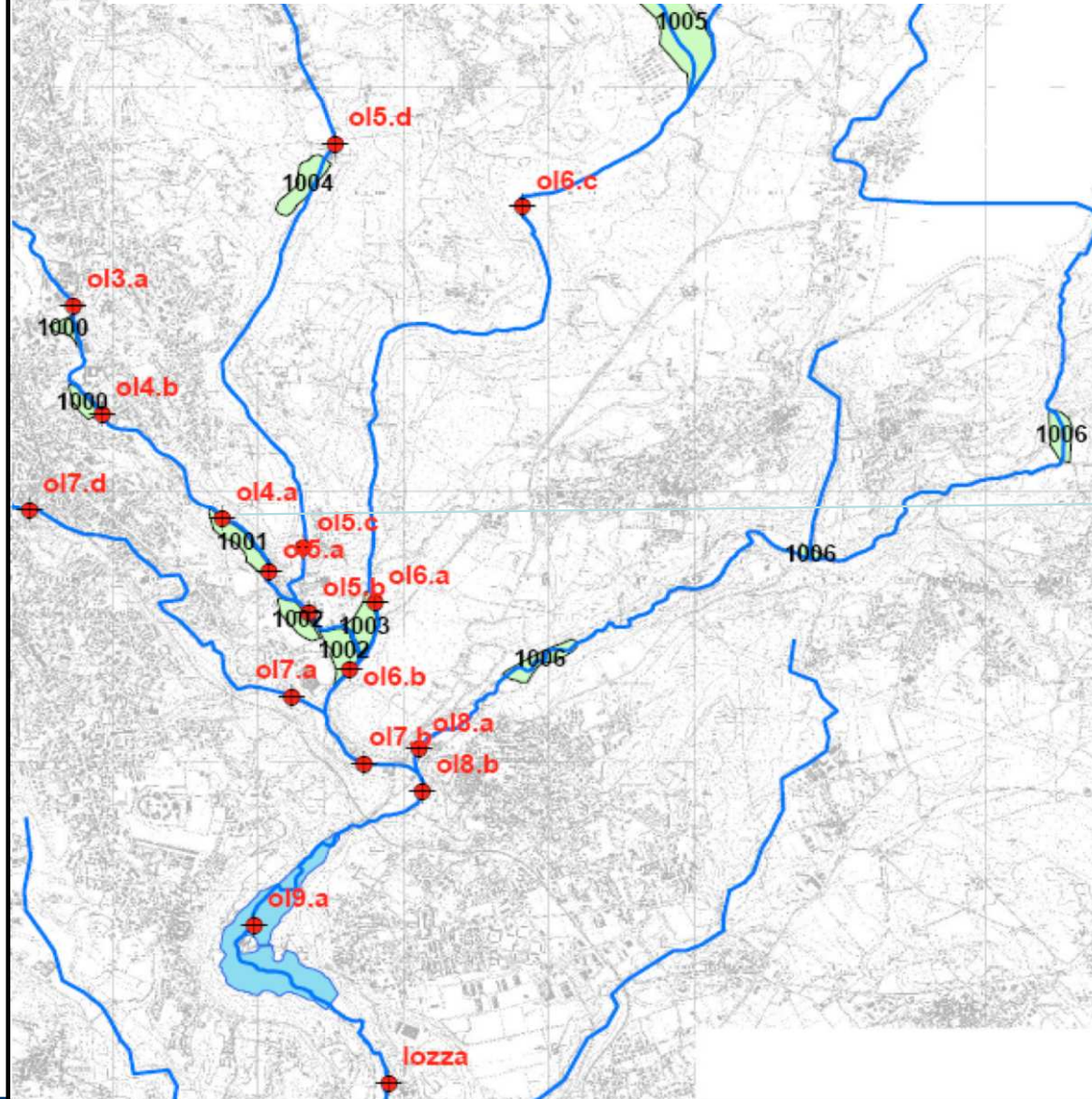


Forecast Reliability: 37.5%



Applicazioni ingegneristiche: la progettazione del sistema di difesa di Varese.

The effects of introducing artificial volumes along the river network on the design hydrograph of downstream dam



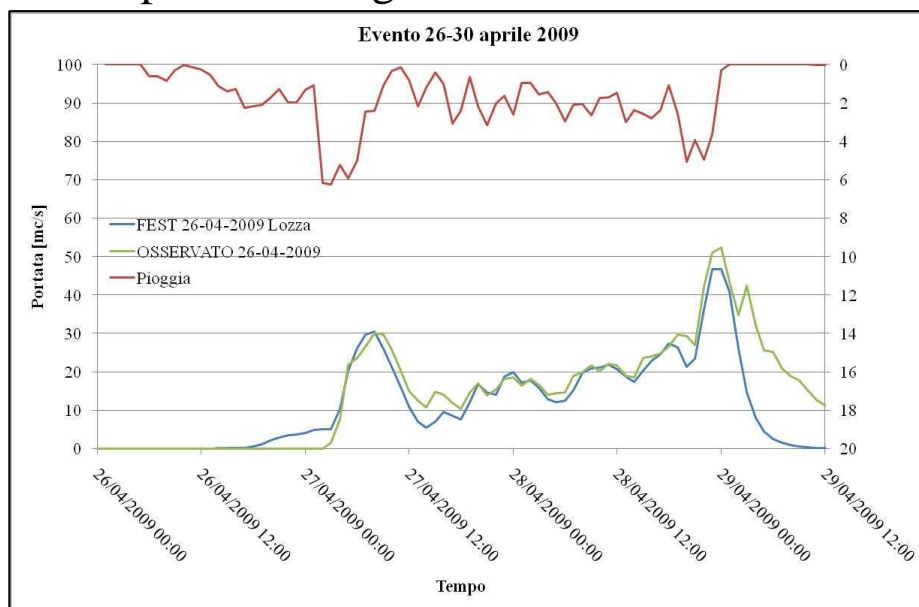
$$Q_T(d_c) = Si_T(d_c) \varphi(d_c) \varepsilon(d_c)$$



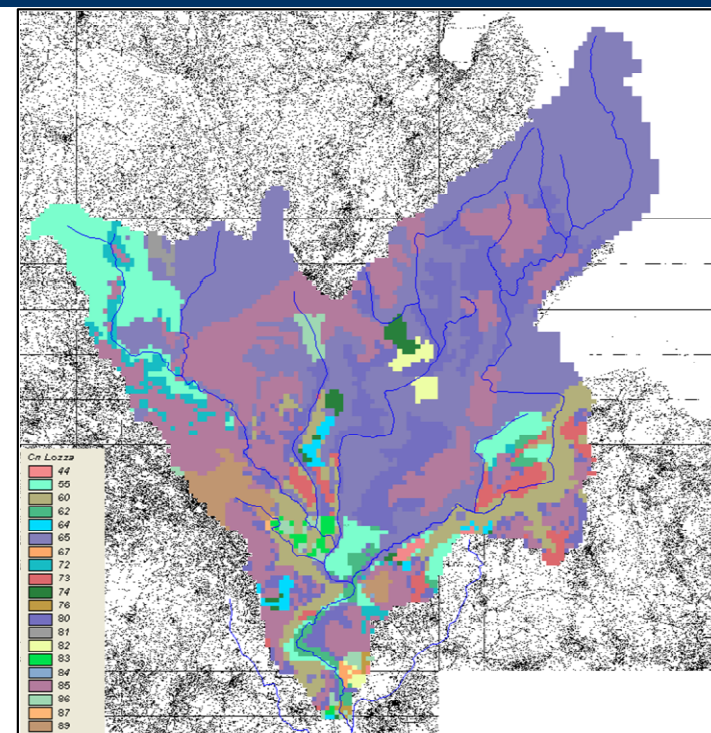
(Ravazzani, Gianoli, Meucci, Mancini, 2012 in prep)

Applicazioni ingegneristiche: la progettazione del sistema di difesa di Varese. Misure e calibrazione di modelli idrologici idraulici FEST-RS

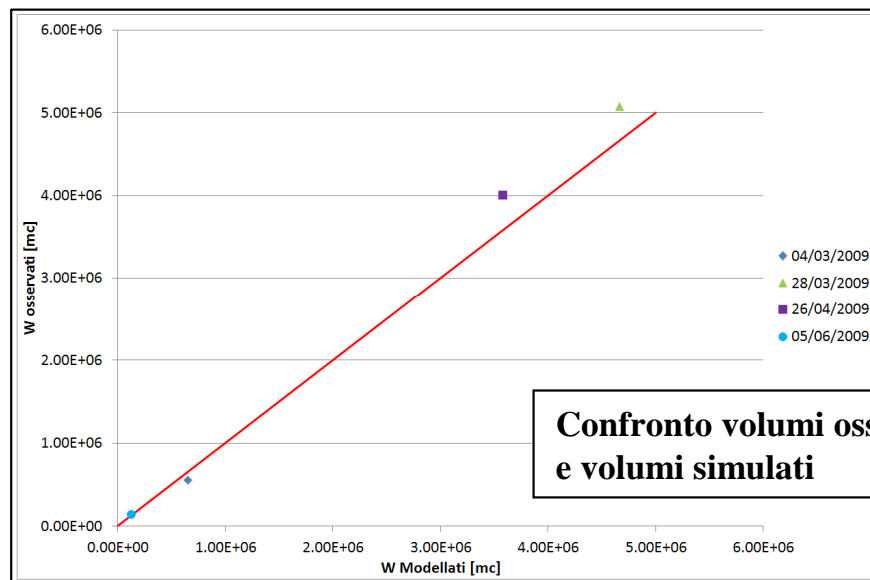
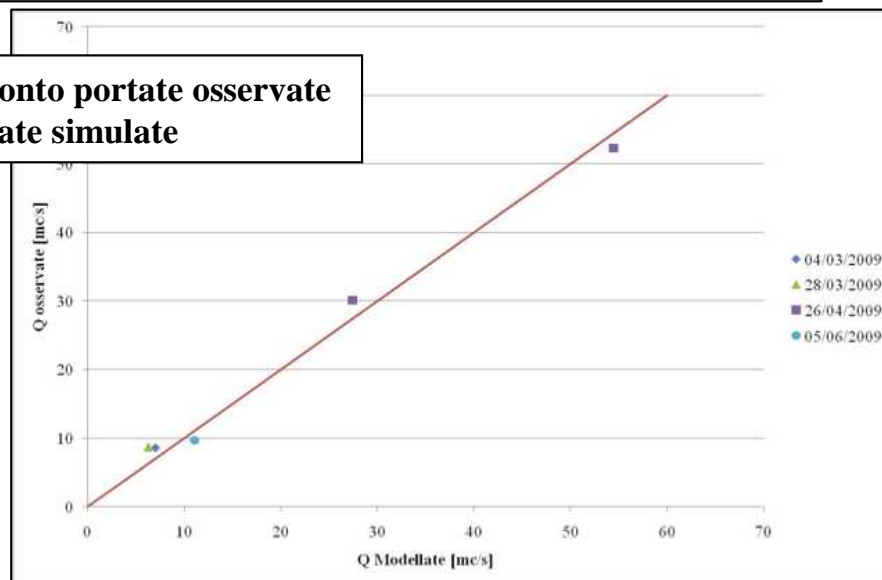
Calibrazione sulla base di eventi reali che non hanno provocato significative esondazioni



Calibrazione della matrice di assorbimento (valori di CN II)



Confronto portate osservate e portate simulate

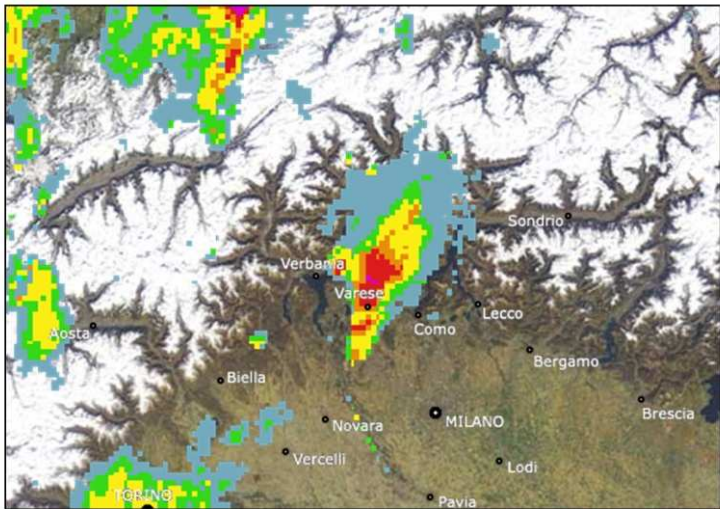


Confronto volumi osservati e volumi simulati

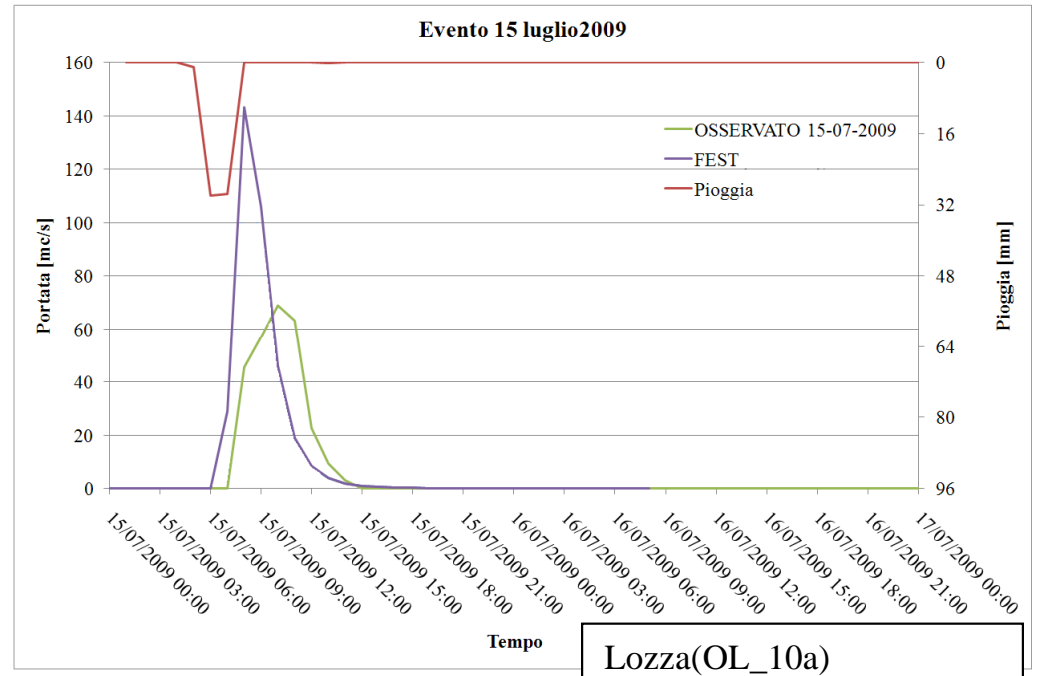
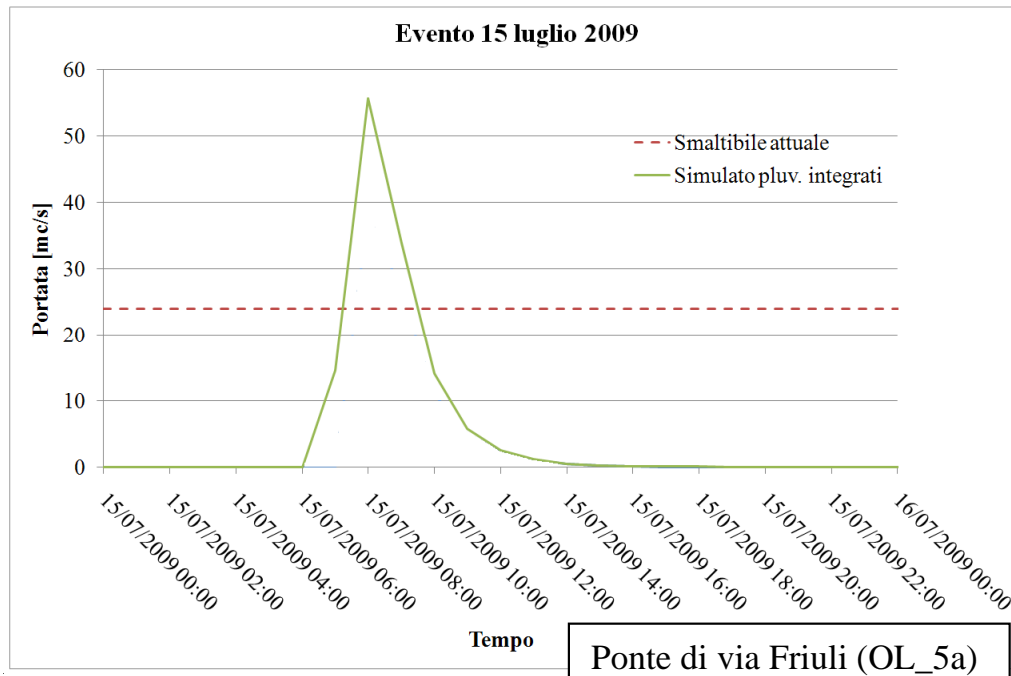


Applicazioni ingegneristiche: la progettazione del sistema di difesa di Varese. simulazione di evento FEST-RS: Evento del 15/7/2009 e verifica delle criticità

Intensità delle precipitazioni 15/7/2009 ore 7:30



Fonte: SF DRS - <http://www.sf.tv>





CONCLUSIONI

Le misure e le analisi dei processi idro meteorologici sono strumenti necessari all'ingegneria delle opere idrauliche e dei sistemi di gestione dell'acqua, per l'interazione continua che entrambi hanno con gli afflussi e i deflussi di un corso d'acqua.

In Italia ciò è stato spesso **disconosciuto e non apprezzato** dal pubblico e dal privato. **La conoscenza e l'innovazione** nel settore della risorsa idrica e del dissesto idrogeologico **sono spesso ritenuti un costo e una perdita di tempo.**

I risultati sono evidenti.



Il circolo prezioso tra misure e conoscenza nonché tra conoscenza e misure potrà contribuire a cambiare questo modo di pensare e operare.



“Nobody believes in simulation models except their developers...Everybody believes in experimental data except who collected them.”

Gaylon S. Campbell

La misura delle variabili per la conoscenza,
la conoscenza per le misure