La catena modellistica di previsione meteo-idrologica per il fiume Arno

Come operano i modelli per la previsione dell'esondazione dei fiumi.

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Regione Toscana

Centro Funzionale di Monitoraggio Meteo Idrologico - Idraulico
Settore Idrologico Regionale

LaMMA

La catena di previsione delle piene operativa presso il Centro Funzionale della Regione Toscana

Rete di monitoraggio

Previsioni meteo
'Multi-model'
a cura di LaMMA

Trasformazione afflussi-deflussi e idraulica del reticolo minore
Modello distribuito sviluppato da DICeA-UNIFI

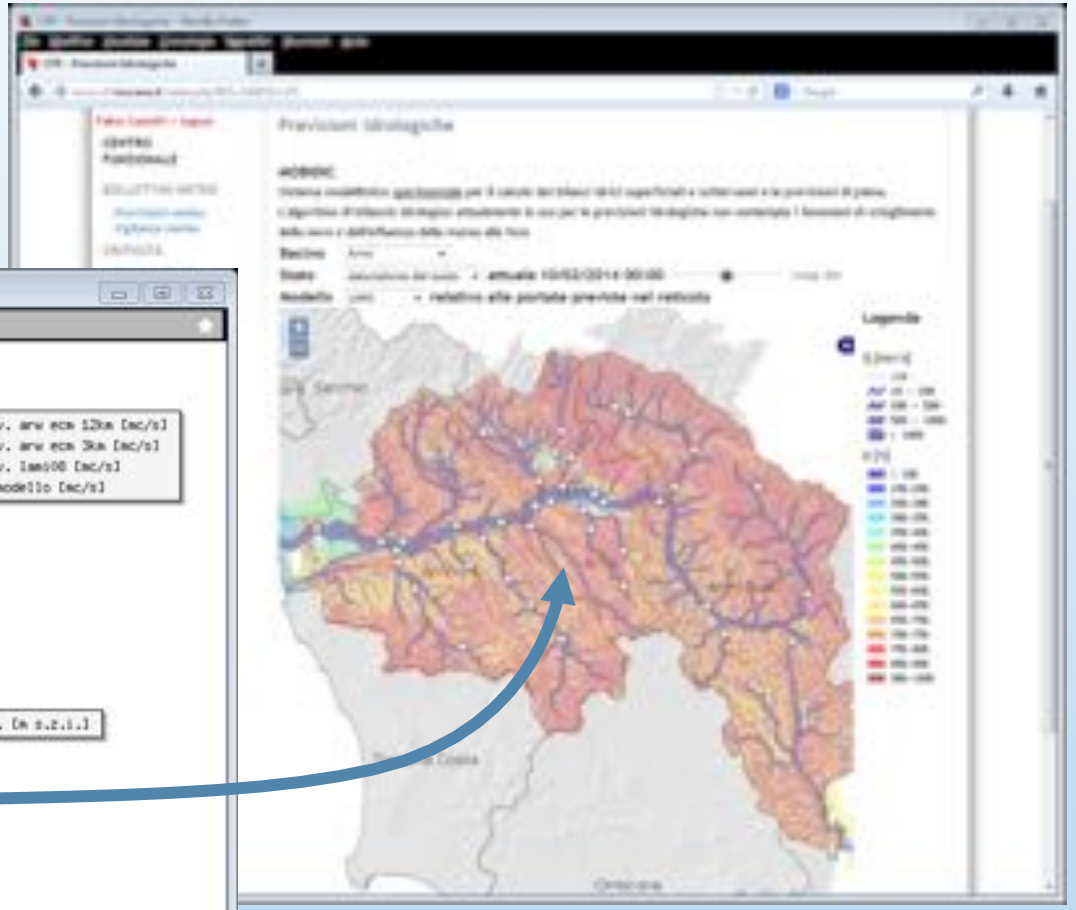
Idraulica dell'asta principale e delle esondazioni
Modello quasi-2D sviluppato da AdB-Arno

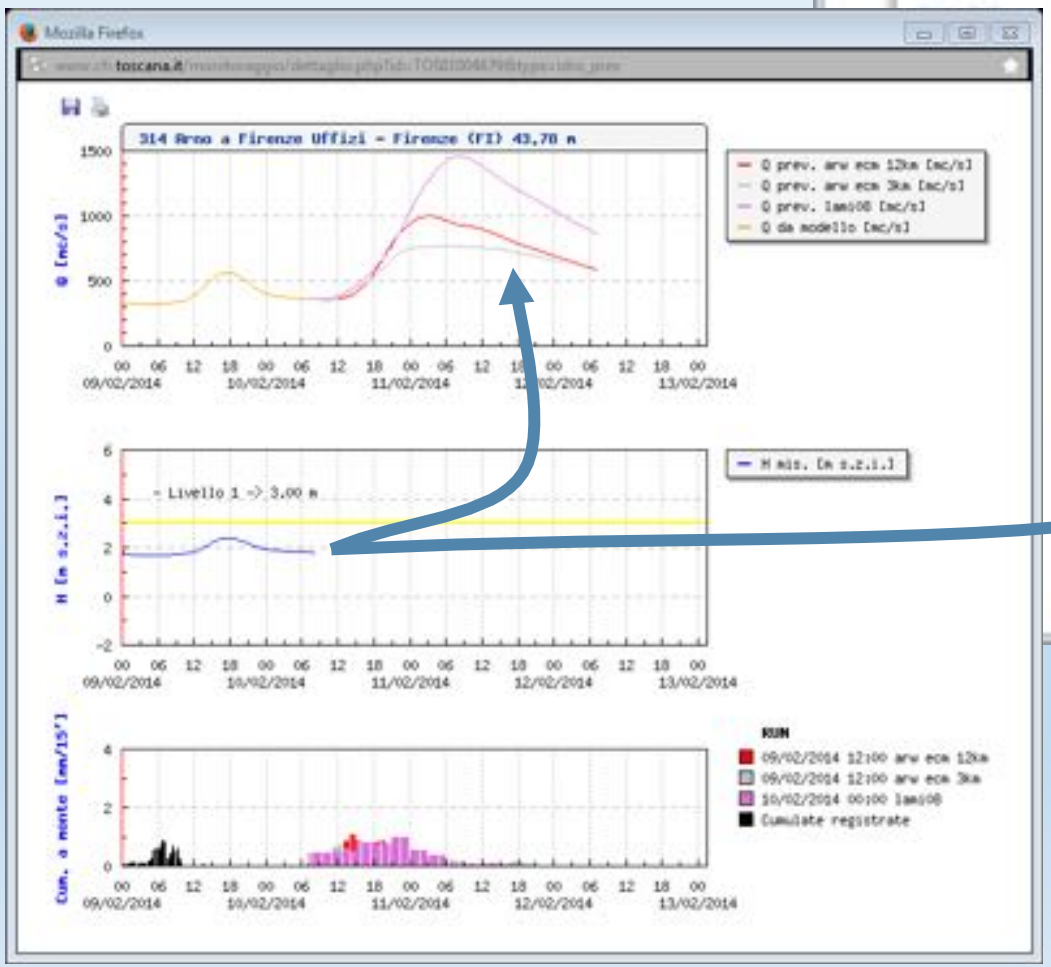
La previsione idrologica in Italia:
Un approccio 'locale', che nella caratteristica di un territorio fra i più antropizzati al mondo, nasce come estensione dell'ingegneria idraulica.

Regione Toscana

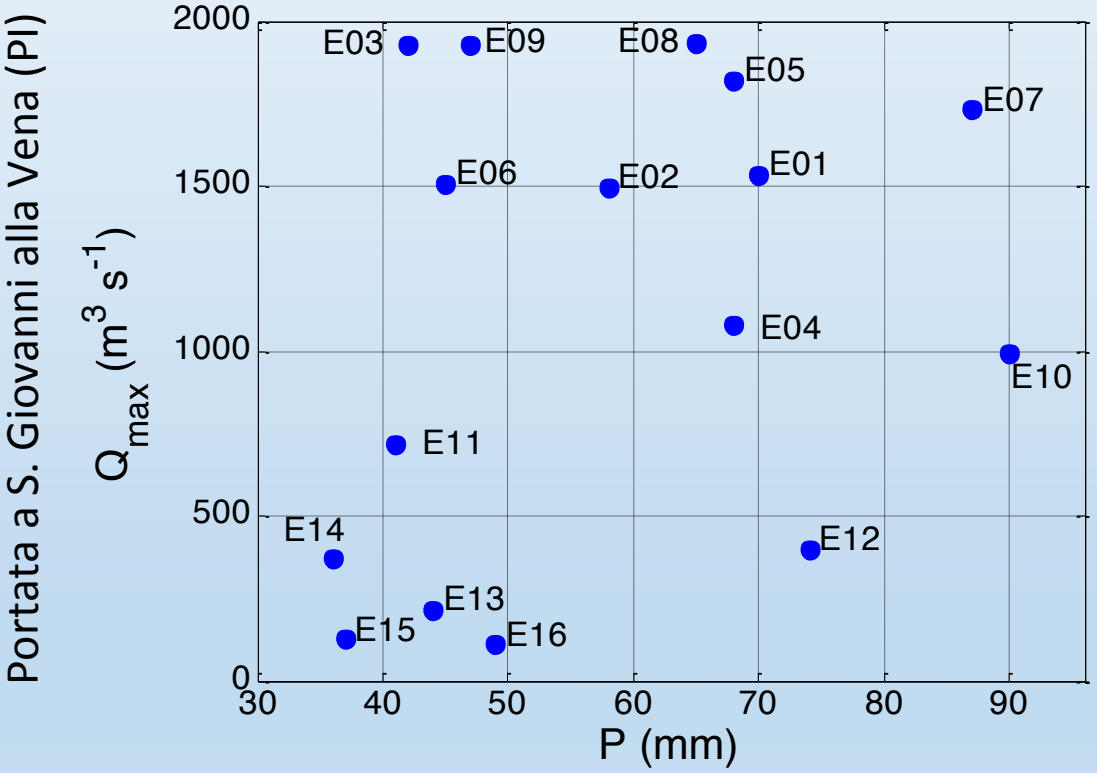
Diritti Valori Innovazione Sostenibilità

Regional flood forecasting setting





Recenti eventi con cumulate di pioggia 'importanti' sul Bacino dell'Arno



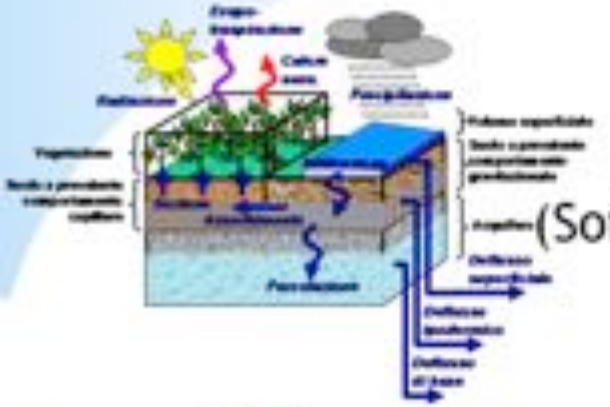
Cumulata di pioggia su 24 ore

- **16 events** in the period 2009-2014

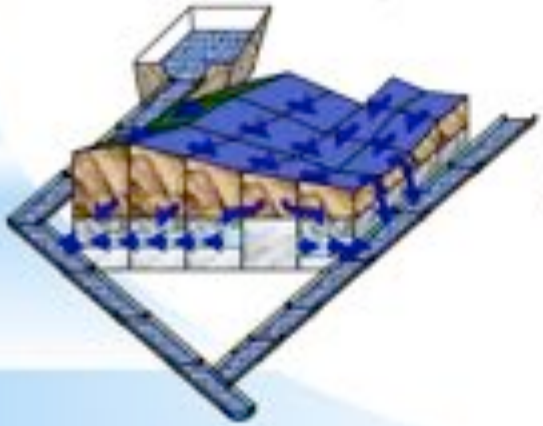
- Both high flow and false alarms (high rainfall but low rivers flow) cases

Flood prediction flow in a ‘physically based’ model

Precipitation



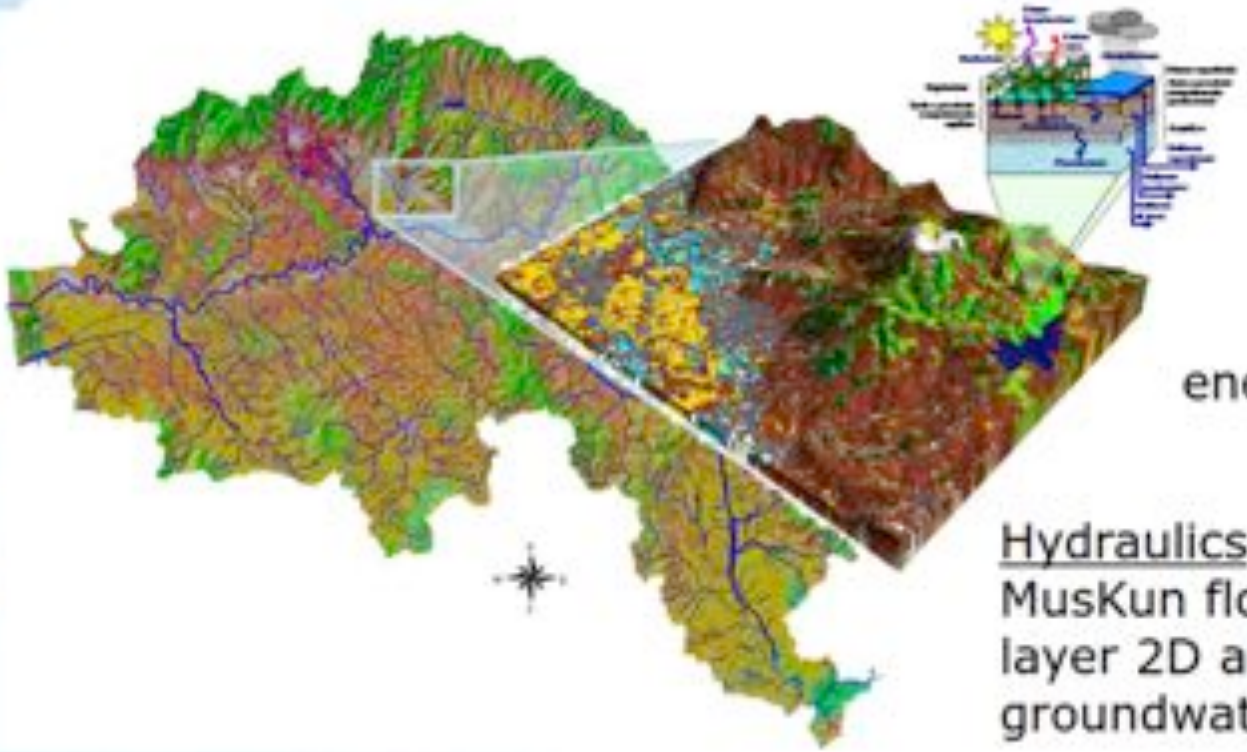
Runoff-formation
(Soil-Vegetation hydrology)



Flood wave dynamics
(River hydraulics)

Campo *et al.*, 2006, *Hydrol. Proc.*, 20, 2693-2712
Castelli *et al.*, 2009, *IAHS*, 327, 52-61
Yang *et al.*, 2014, *HESS*, 18, 4101-4112
Castillo *et al.*, 2015, *HESS*, 19, 1857-1869

MOBIDIC
MOdello **B**ilancio **I**drologico
DIstribuito e **C**ontinuo



<u>SVAT hydrology</u>:
Coupled mass and energy balance with heat diffusion into the soil

<u>Hydraulics</u>:
MusKun flood routing; multi-layer 2D aquifers; explicit groundwater-channel exchanges

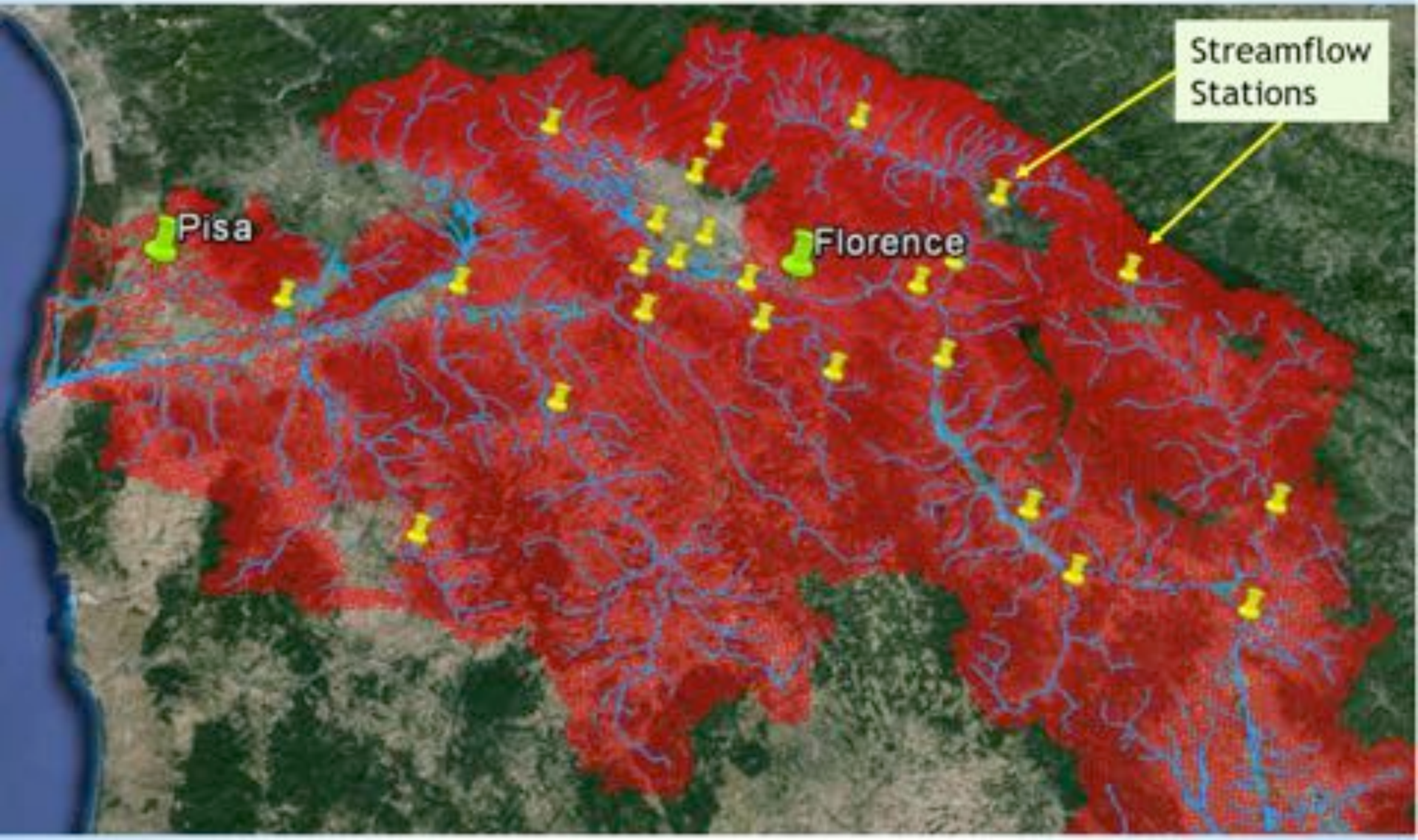
Model setup:

Total area: 9,374 km^2

Total river network length: 3,692 km

Cell size: 0.25 km^2

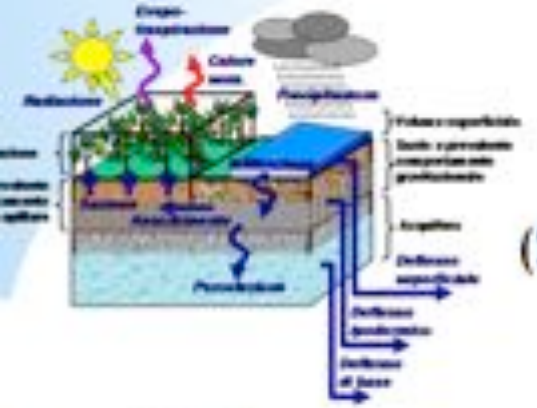
Drainage density: 0.394 km^{-1}




Google earth

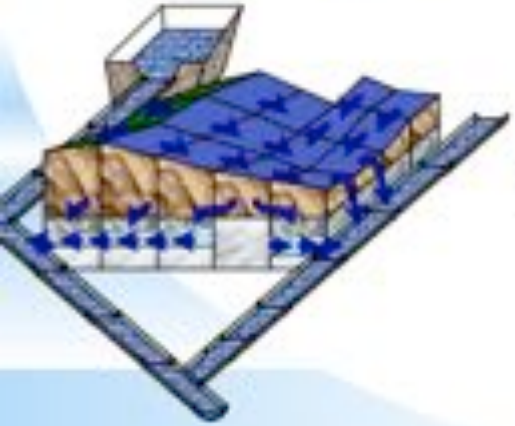

Google earth

Models and ‘routine’ observations



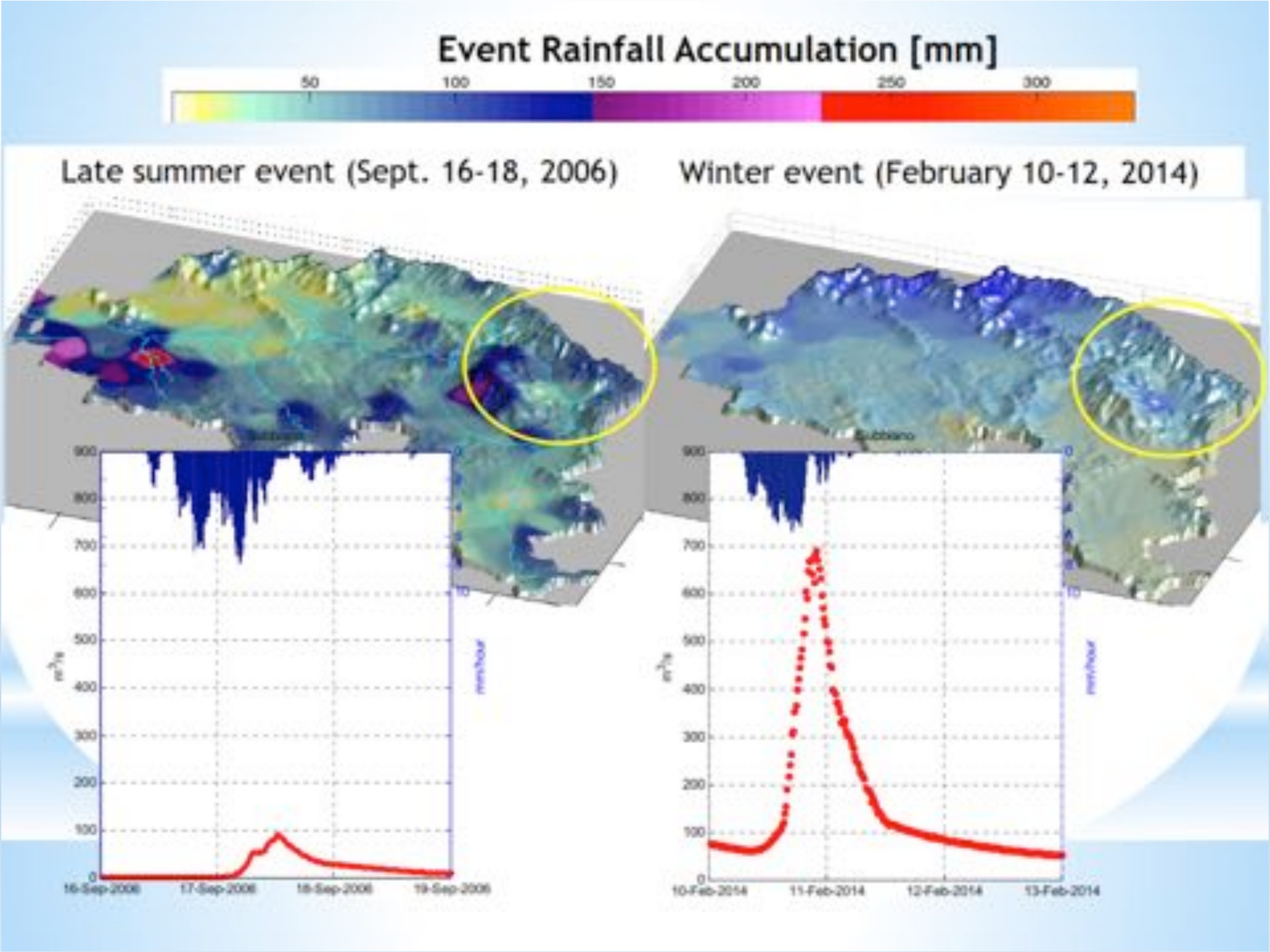
Precipitation

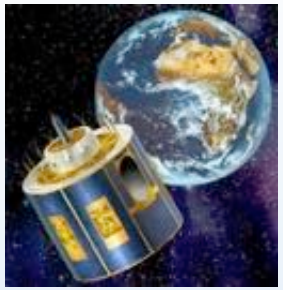
Runoff-formation
(Soil Moisture state)



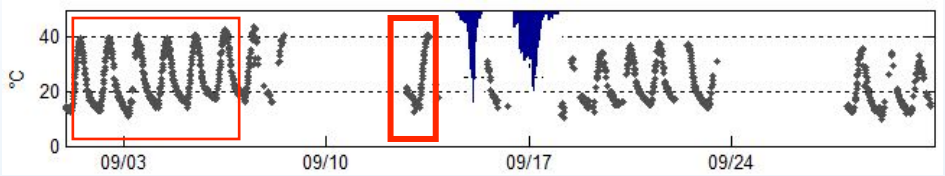
Flood wave dynamics
(River hydraulics)

How important is ‘guessing’ the right soil moisture condition?


Event Rainfall Accumulation [mm]
50
100
150
200
250
300
Late summer event (Sept. 16-18, 2006)
Winter event (February 10-12, 2014)
m³/s
mm/hour
16-Sep-2006
17-Sep-2006
18-Sep-2006
19-Sep-2006
10-Feb-2014
11-Feb-2014
12-Feb-2014
13-Feb-2014

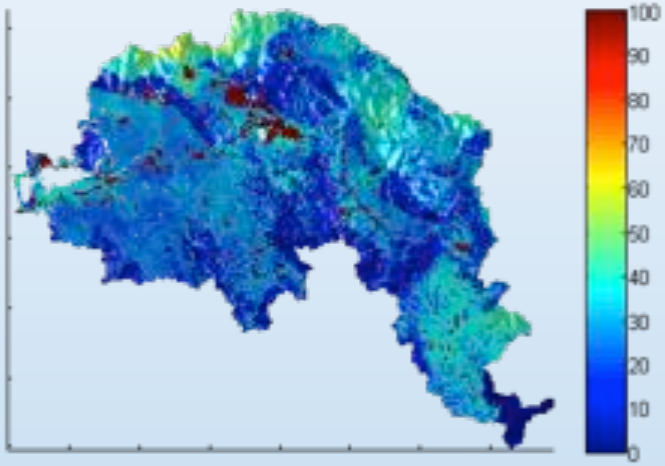


Assimilation of Meteosat LST

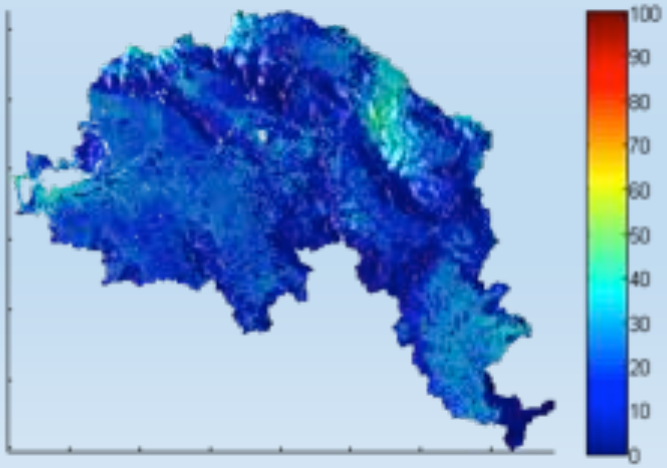


Soil saturation (%)

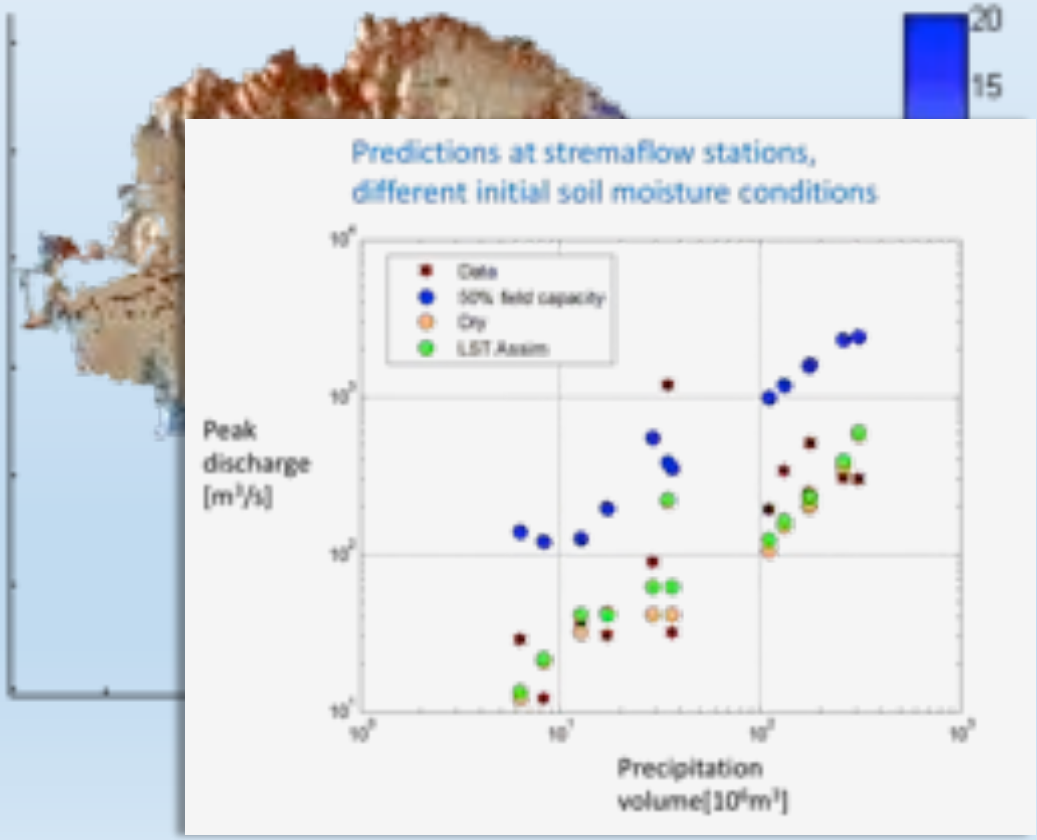
Background



Analysis

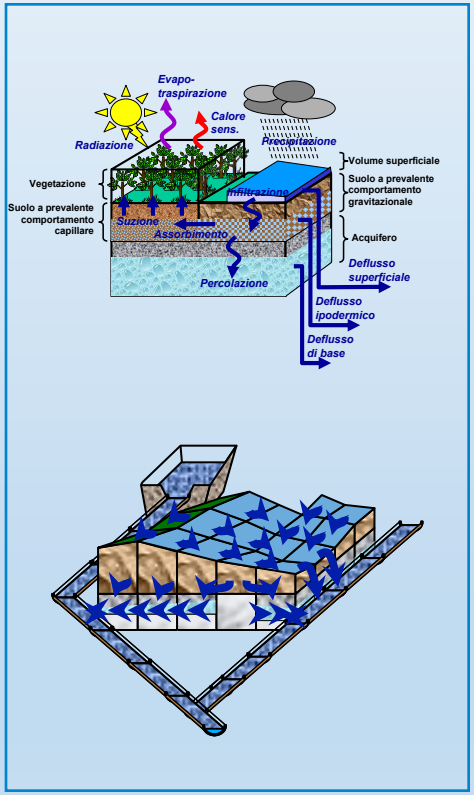


Analysis increment



Variational assimilation with an adjoint

Forward model



Precipitation

↓

Runoff-formation
(**Soil Moisture state**)

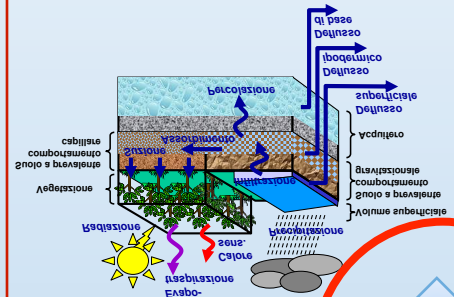
↓

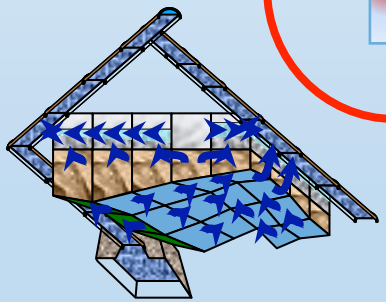
Flood wave dynamics
(**River hydraulics**)

↓

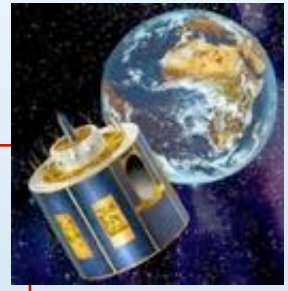
Streamflow

Adjoint sub-models

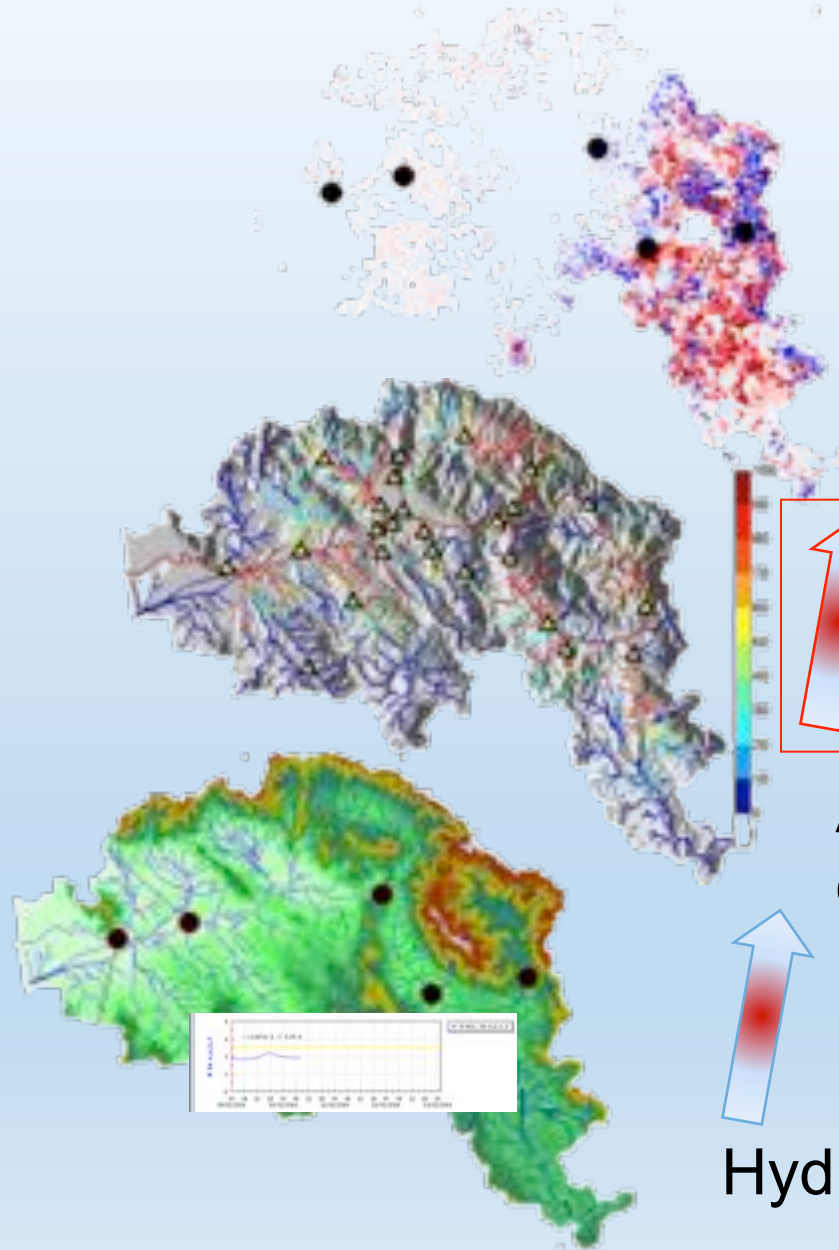




?



LST

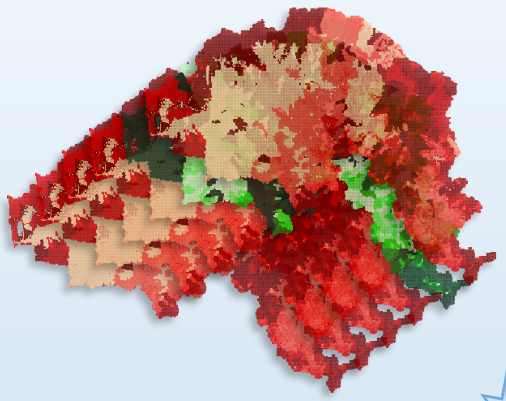


Analysis increment
of hillslope runoff

Difficult to adjoin, but at least mass conservation and rainfall distribution need to be maintained

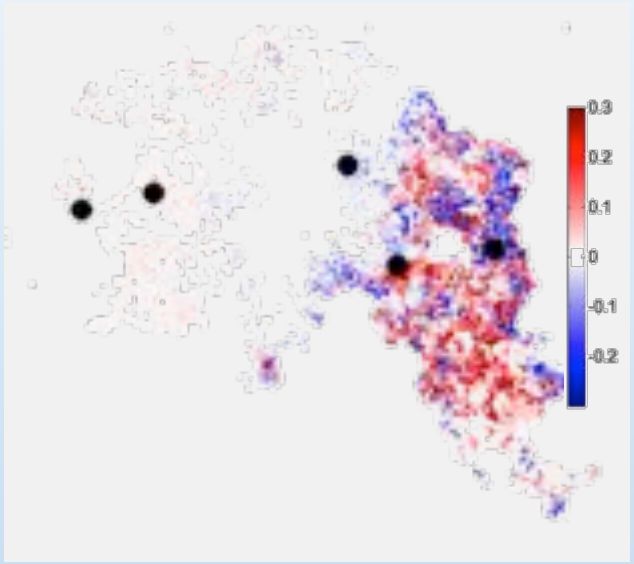
Analysis increment
of river flows

Hydrometric data

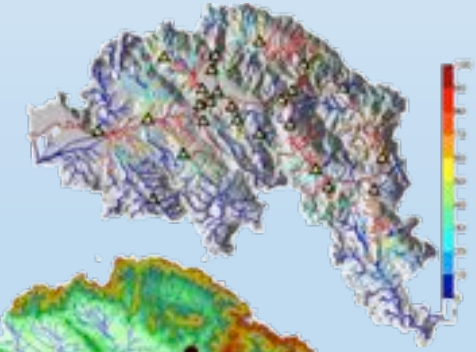


Montecarlo sampling of Antecedent Soil Moisture, rianfall interpolation

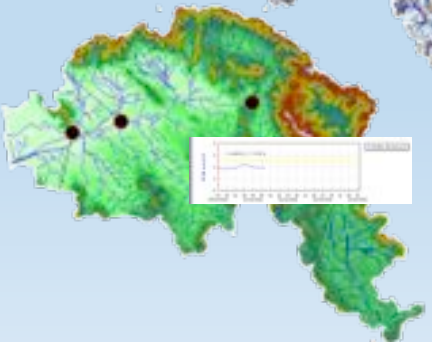
Likelyhood



Analysis increment of hillslope runoff and soil moisture



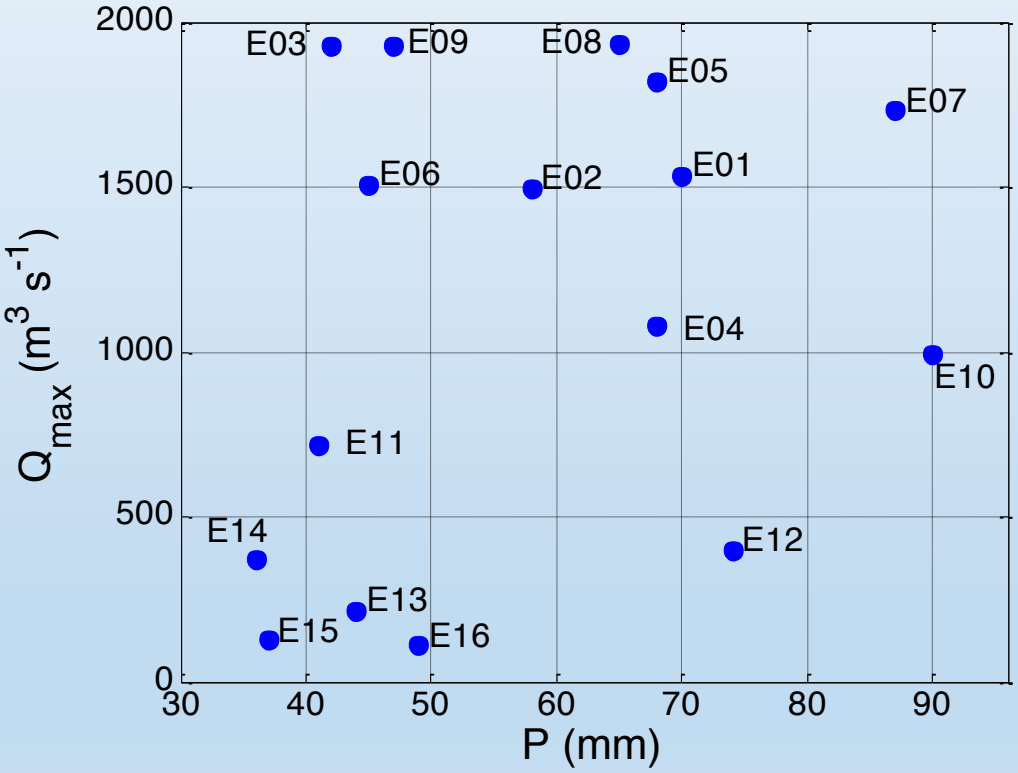
Analysis increment of river flows



Variational assimilation with an adjoint

Hydrometric data

Streamflow Assimilation



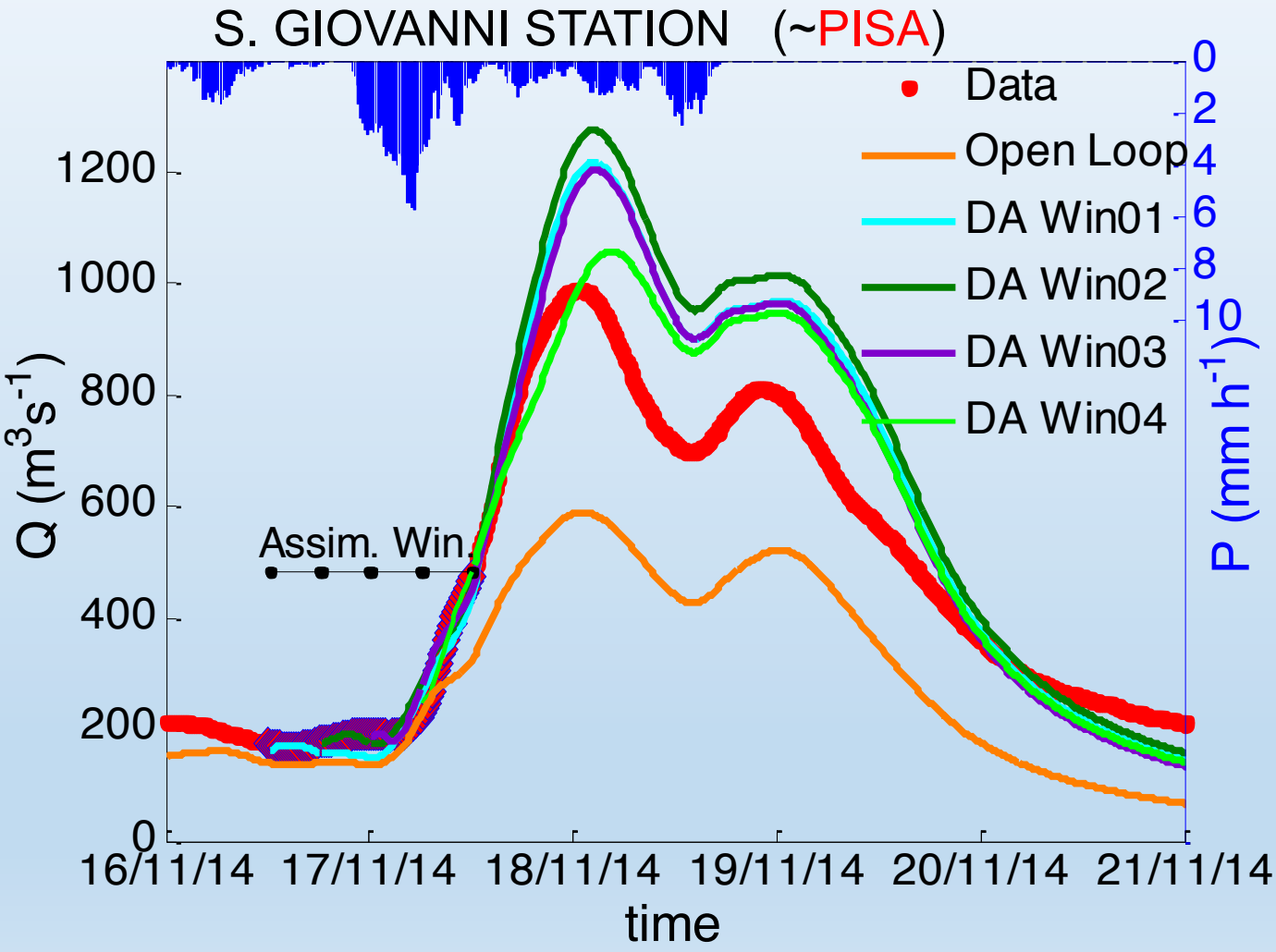
- **16 events** in the period 2009-2014

- Both high flow and false alarms (high rainfall but low rivers flow) cases

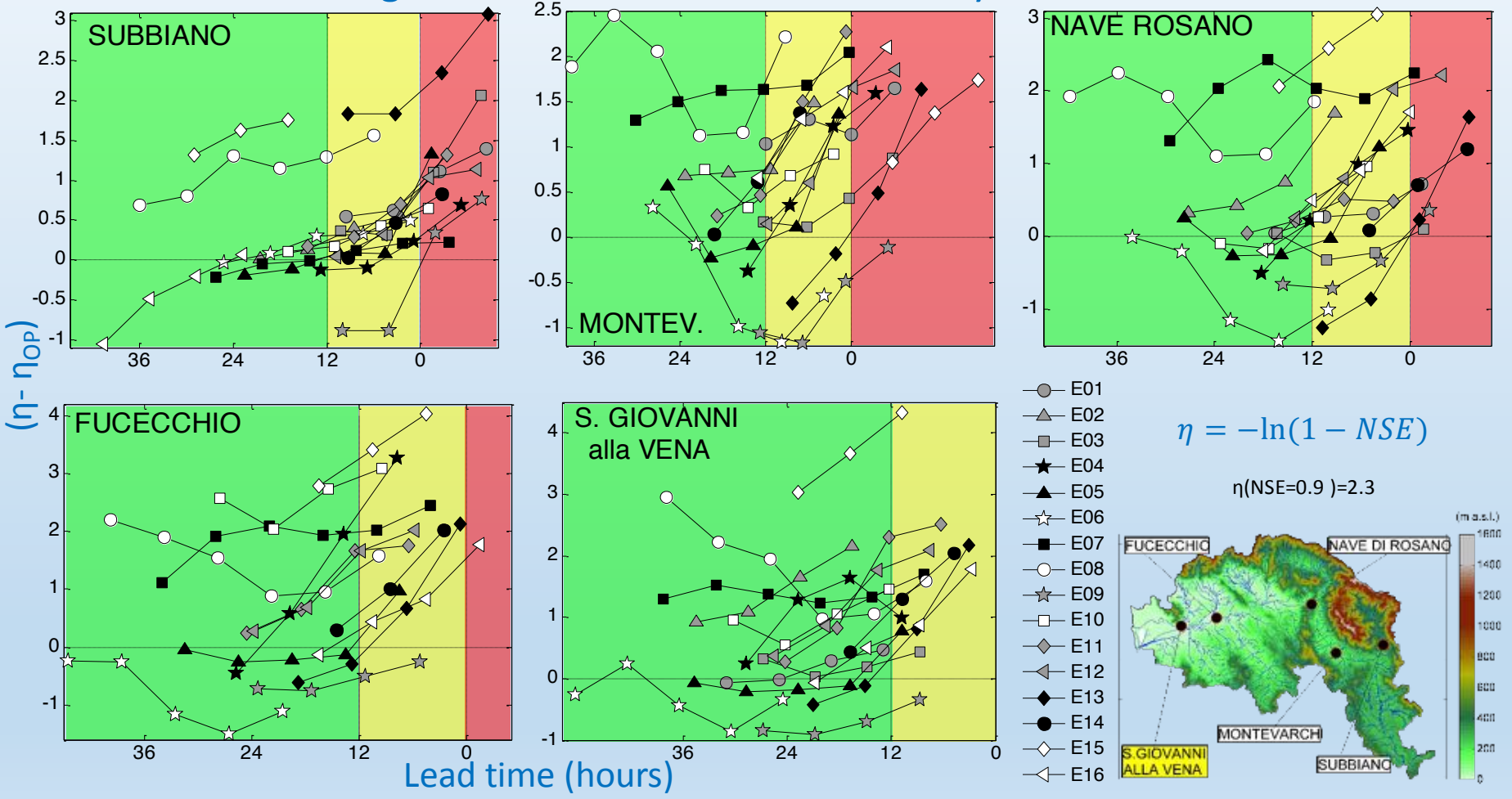
- Simultaneous assimilation of data from all the 5 available measurement stations

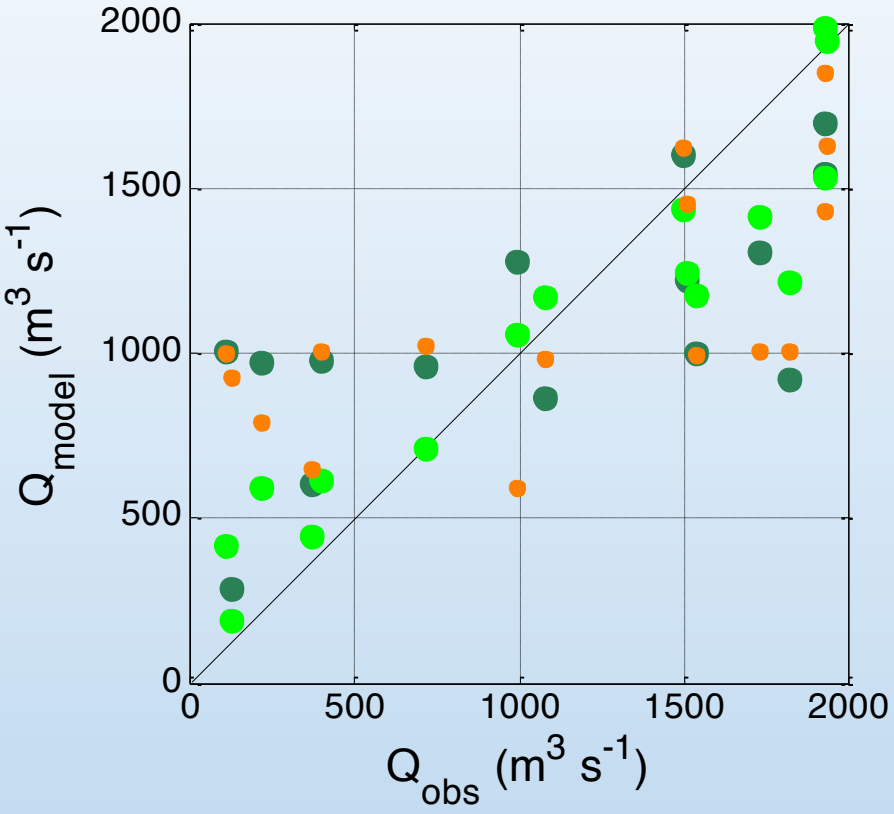
- Sequential assimilations on non-overlapping windows of 6 hours

High flow event E10



Increment of logarithmic Nash-Sutcliffe efficiency vs. Forecast Lead Time



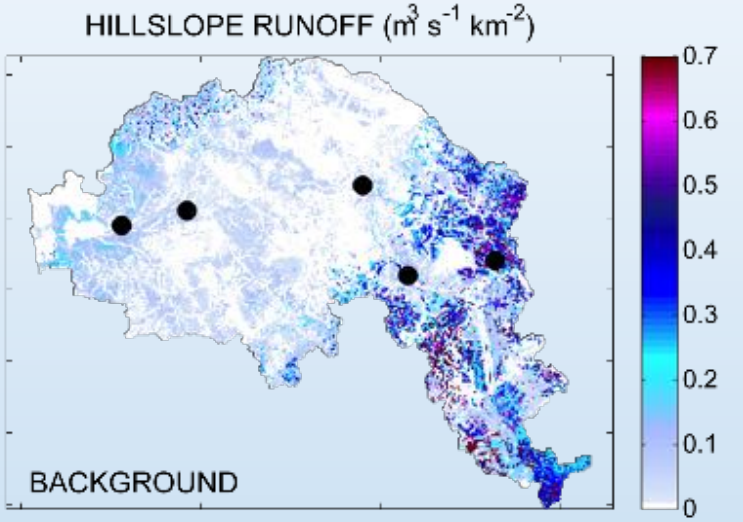


Peak flow scatter plot
S. Giovanni station
(all 16 events)

Open loop run $R^2 = 0.42$

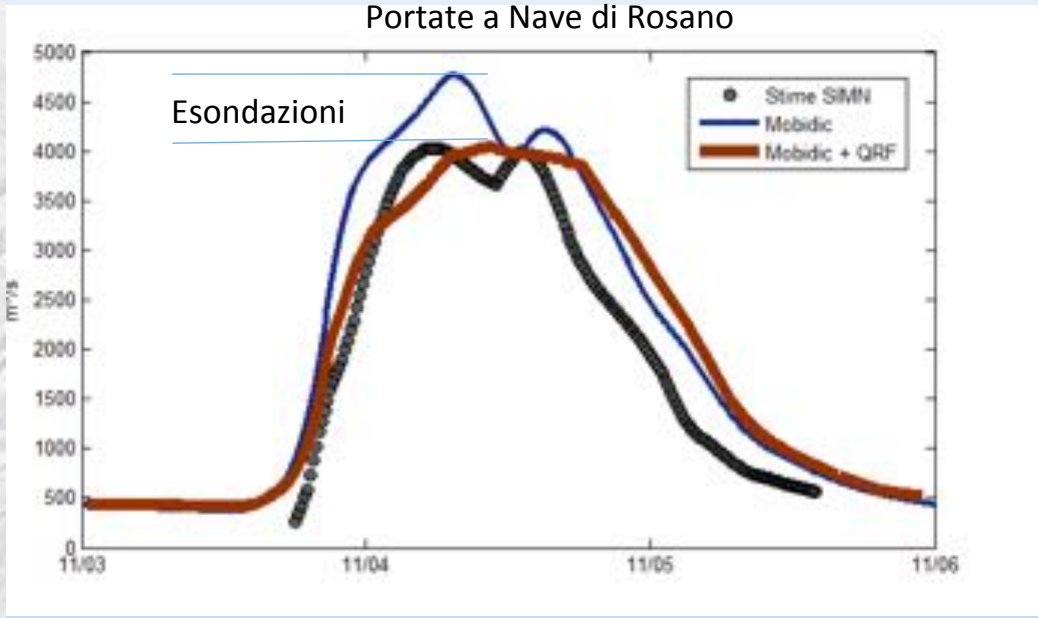
Run whose assimilation window DOES NOT include observations of peak flow at upstream locations (Subbiano and Montevarchi) $R^2 = 0.52$

Run whose assimilation window DOES include observations of peak flow at upstream locations (Subbiano and Montevarchi) $R^2 = 0.85$



HILLSLOPE RUNOFF ANALYSIS ($m^3 s^{-1} km^{-2}$) for EVENT E04

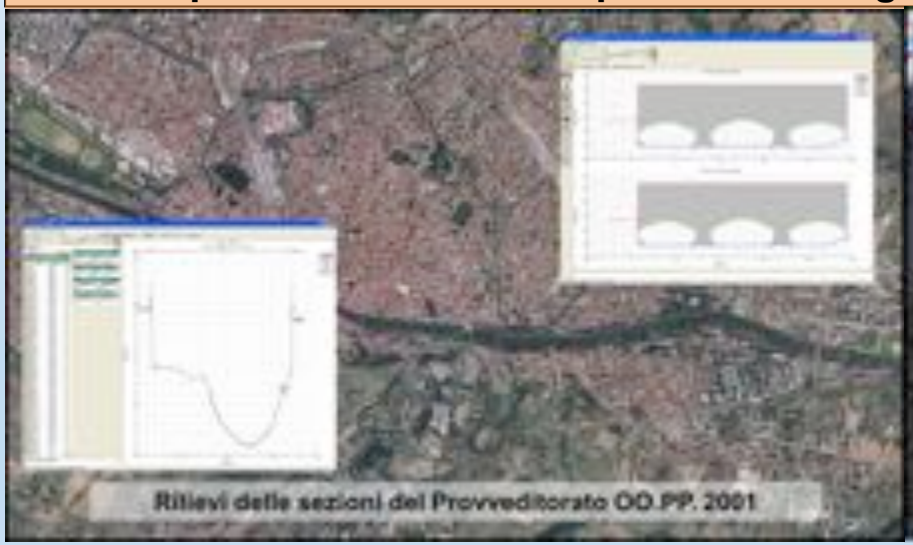
Stima idrologico-idraulica delle esondazioni

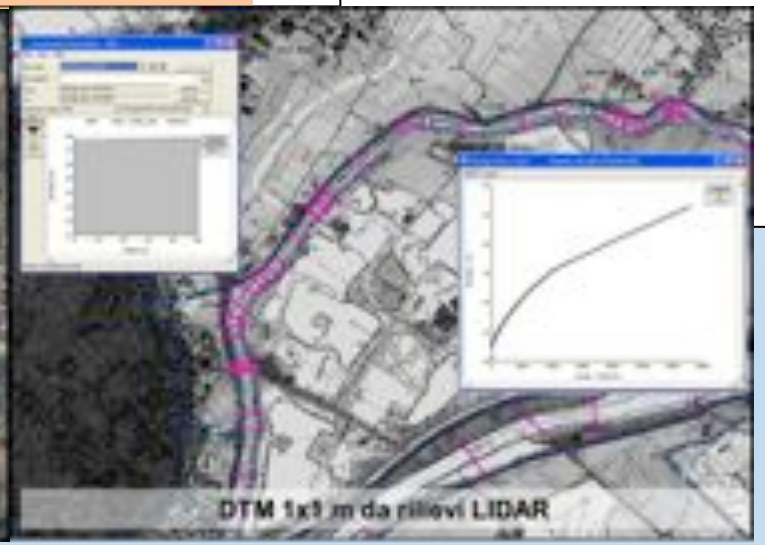


Sezioni Arno:

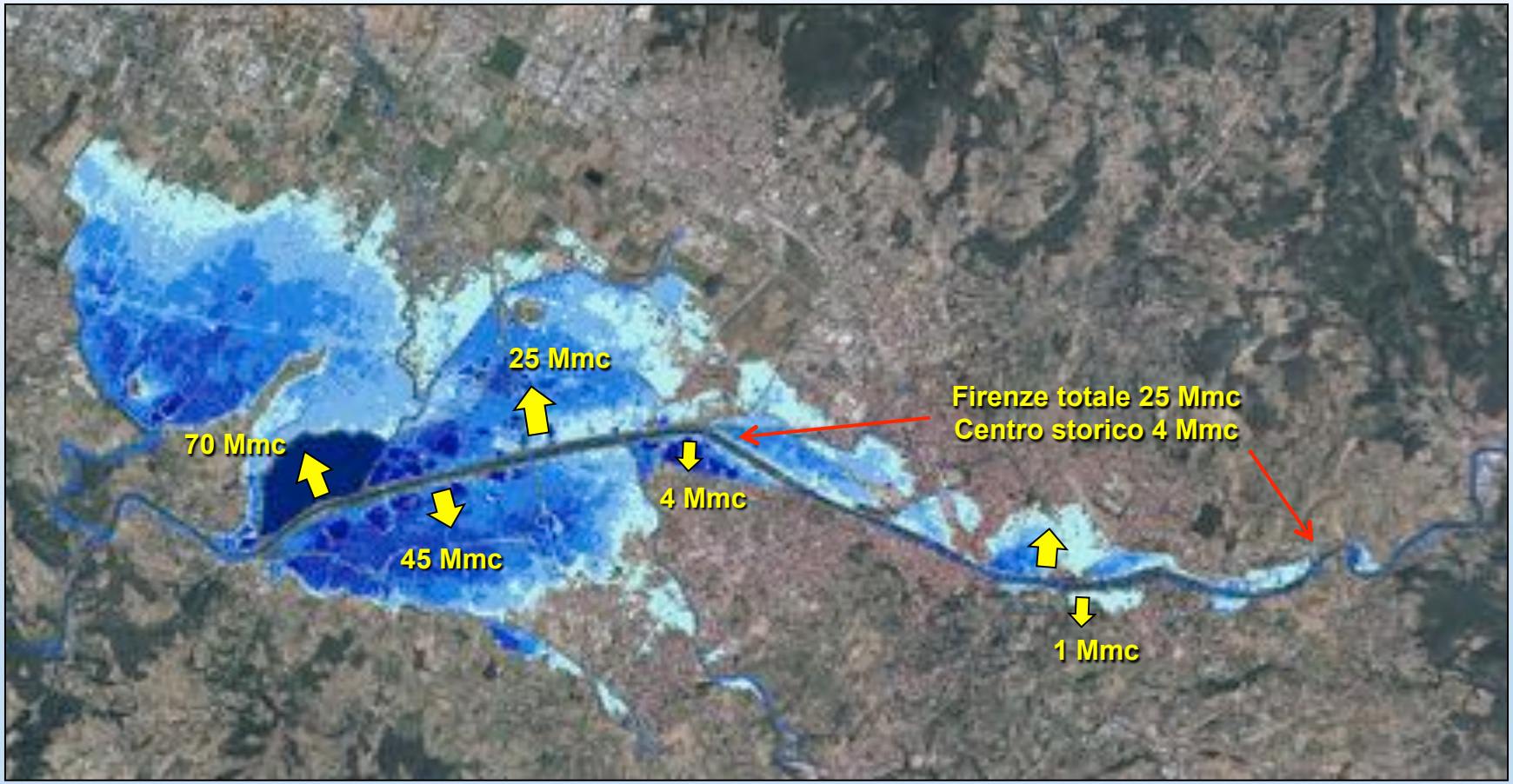
n. 307

schema di moto vario unidimensionale in alveo quasi-bidimensionale per le aree allagabili





Simulazione evento 1966 - Esondazioni



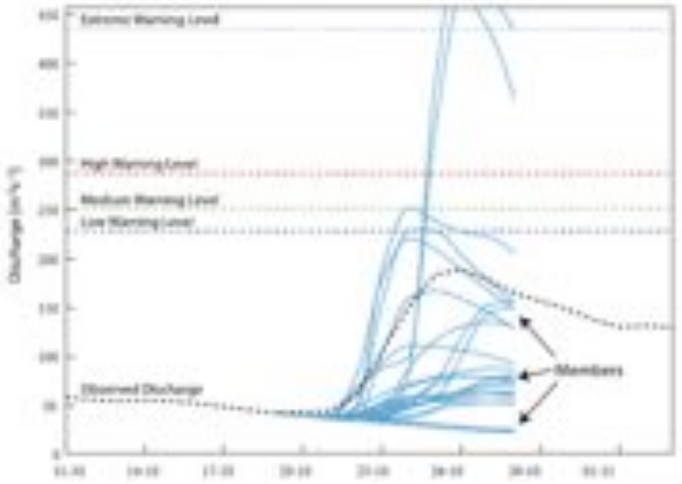
Contributo alla discussione

E' ammessa l'incertezza nella previsione meteo/idrologica?

Rimanda alle varie teorie sulla *decisione in condizioni di incertezza* e sulla necessità (o meno) di abbandonare il valore atteso in favore dell'*utilità attesa*

B. Pascal, *Pensées, 1670*

D. Bernoulli, *Exposition of a New Theory on the Measurement of Risk*, 1738



Hydrologic ensemble prediction

1° questione:

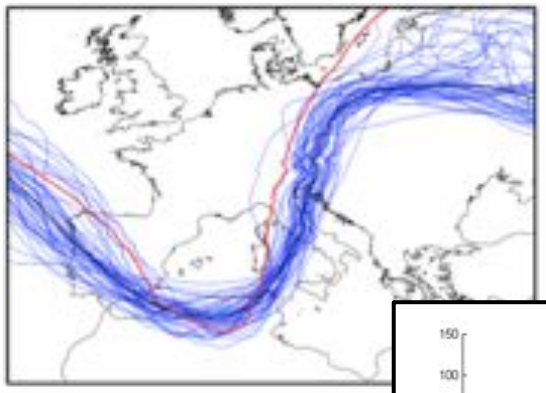
*Decisione in condizioni di **rischio** o di **incertezza**?*

Decisione in condizione di rischio: Sono quantificabili le probabilità dei singoli 'eventi' e i corrispondenti valori. È formalmente calcolabile il **valore monetario atteso**.

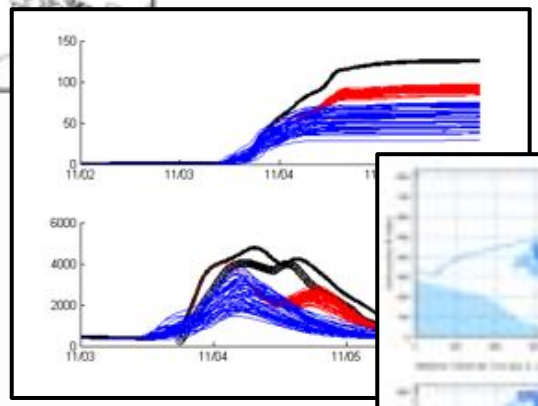
Decisione in condizione di incertezza: Non sono note le probabilità dei singoli 'eventi' e/o i corrispondenti valori. Deve essere introdotta una **funzione di utilità**.

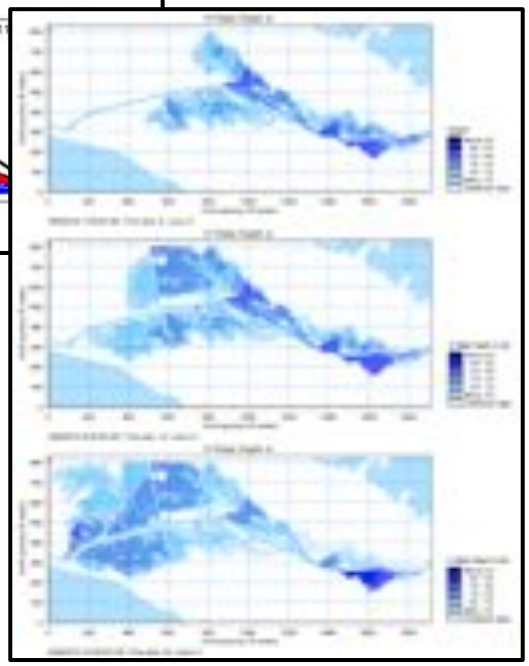
2° questione:

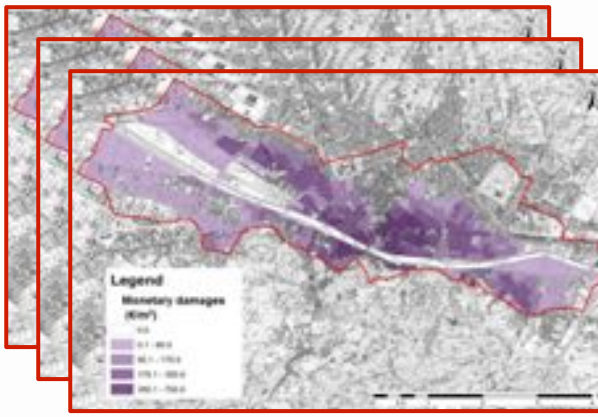
Cosa manca per 'decisioni in condizioni di rischio'?



Da 'ensemble prediction' a 'ensemble damage'
(*stima del rischio in tempo reale*)







$$\int_{\uparrow} D(h)dP(h)$$

Danno atteso in caso di decisione di 'non allarme'

3° questione:

*Esistono casi in cui la decisione è sempre in condizioni di **incertezza**?*

Rischio per le persone e/o beni culturali di pregio (valori non monetizzabili)

Curva di utilità di un allarme ?