Effects of soil moisture parameterization on a real- time flood forecasting system based on rainfall thresholds

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EARTH: OUR CHANGING PLANET

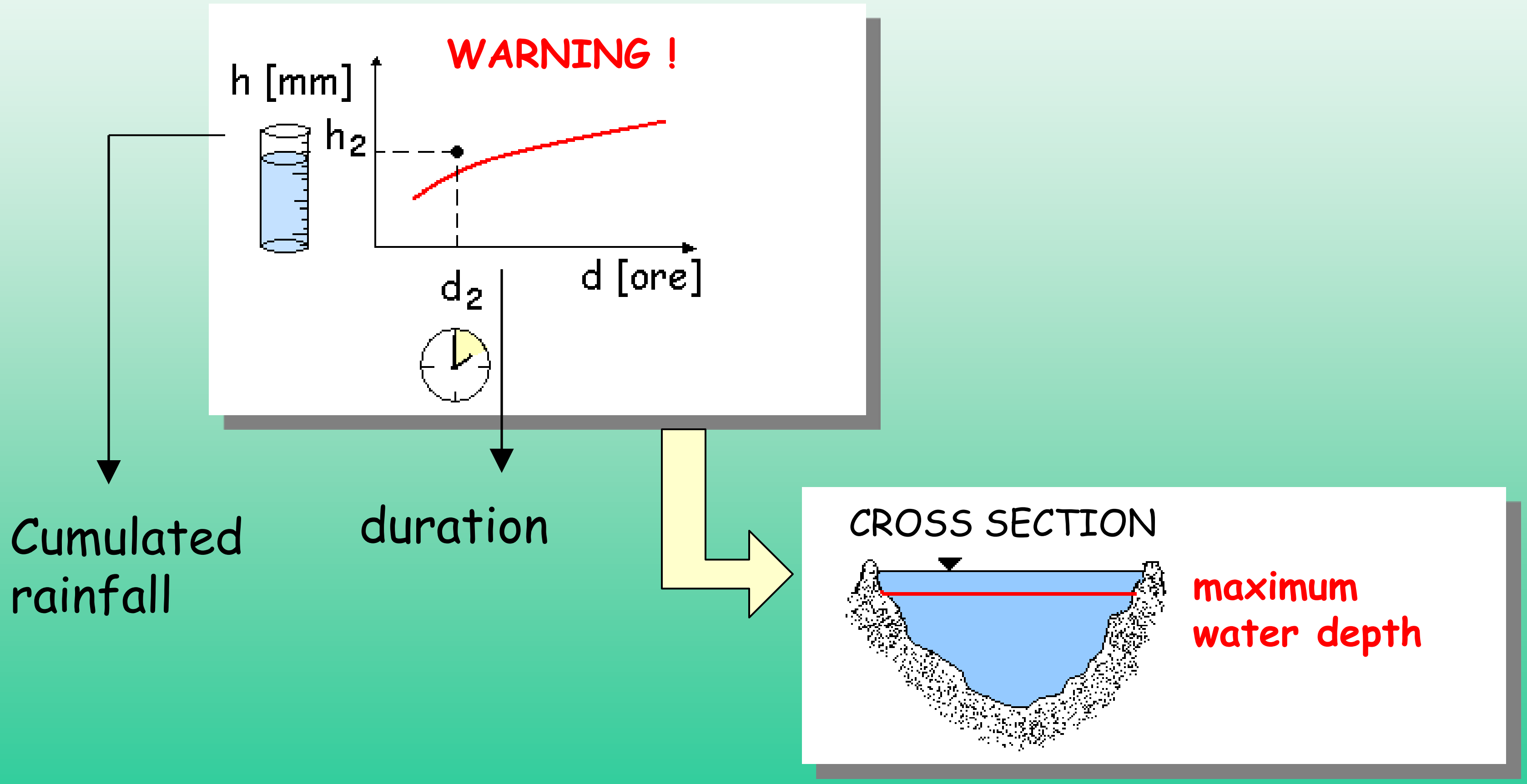
AIM OF THE WORK

Assess reliability analysis of a real time flood forecasting system based on rainfall thresholds in use on the Arno River, in Italy.

Verify the effect of the use of the actual soil moisture, instead of API, on a recent flood event

THRESHOLD DEFINITION

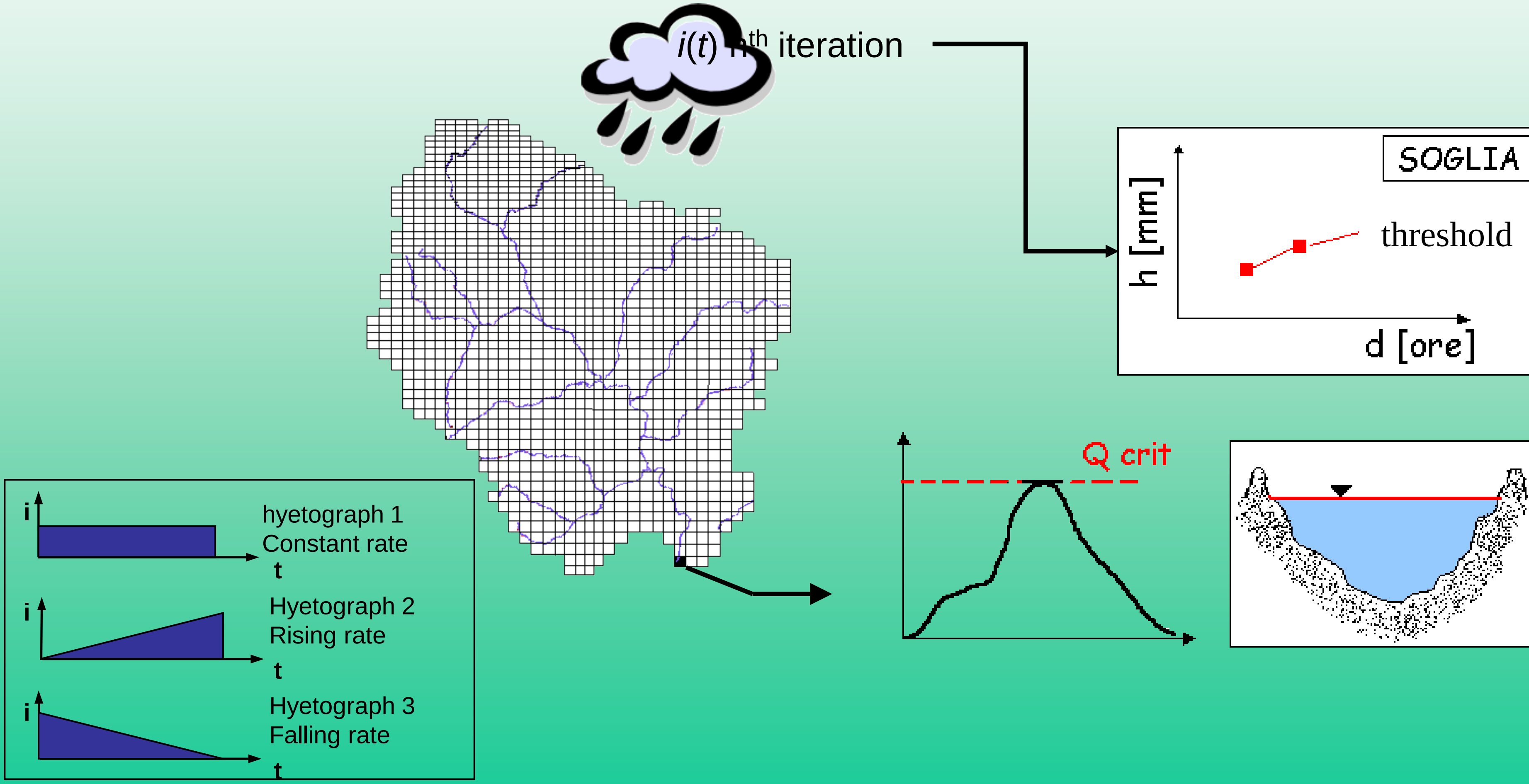
"The rainfall threshold for flood forecasting is defined as the cumulated rainfall depth causing flooding flow at the basin outlet"



SOLVER

… solution of the inverse hydrological problem (Rainfall-Runoff transformation) is needed

FEST Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation (Mancini, 2004)



SCS-CN method (1956)

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$$

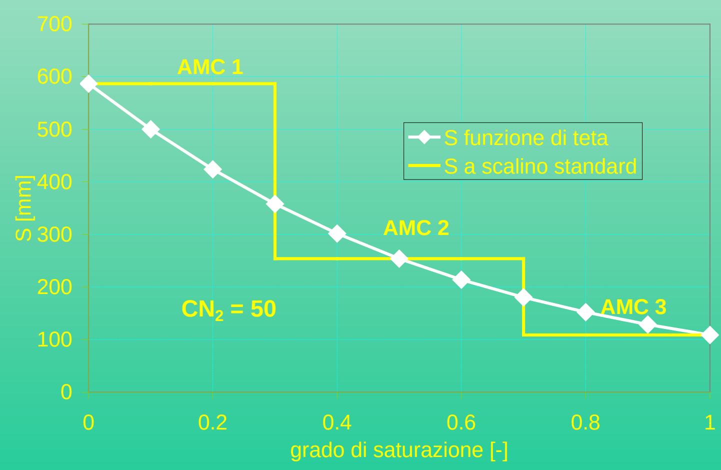
$Ia = 0{,}2\ S$

P = precipitation
R = runoff
Ia = initial abstraction

S (soil maximum retention capacity)

1

Past five days total precipitation [mm]		
AMC	DORMANT SEASON	GROWING SEASON
I II III	$P_a < 12.7$ $12.7 < P_a < 27.9$ $P_a > 27.9$	$P_a < 35.5$ $35.5 < P_a < 53.3$ $P_a > 53.3$



2

modified for continuous soil moisture accounting

$$S = S_I \cdot \left\{ 1 - \left[\frac{\varepsilon}{\varepsilon + \exp(W_I - W_{II} \cdot \varepsilon)} \right] \right\}$$

$$W_{II} = 2 \cdot \left[\ln\left(\frac{0.5}{1 - \frac{S_{II}}{S_I}} - 0.5 \right) - \ln\left(\frac{1}{1 - \frac{S_{III}}{S_I}} - 1 \right) \right]$$

function of the soil degree of saturation (ε)

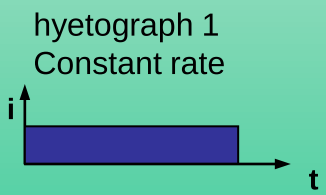
$$\varepsilon_t = \frac{\theta_t - \theta_{res}}{\theta_{sat} - \theta_{res}}$$

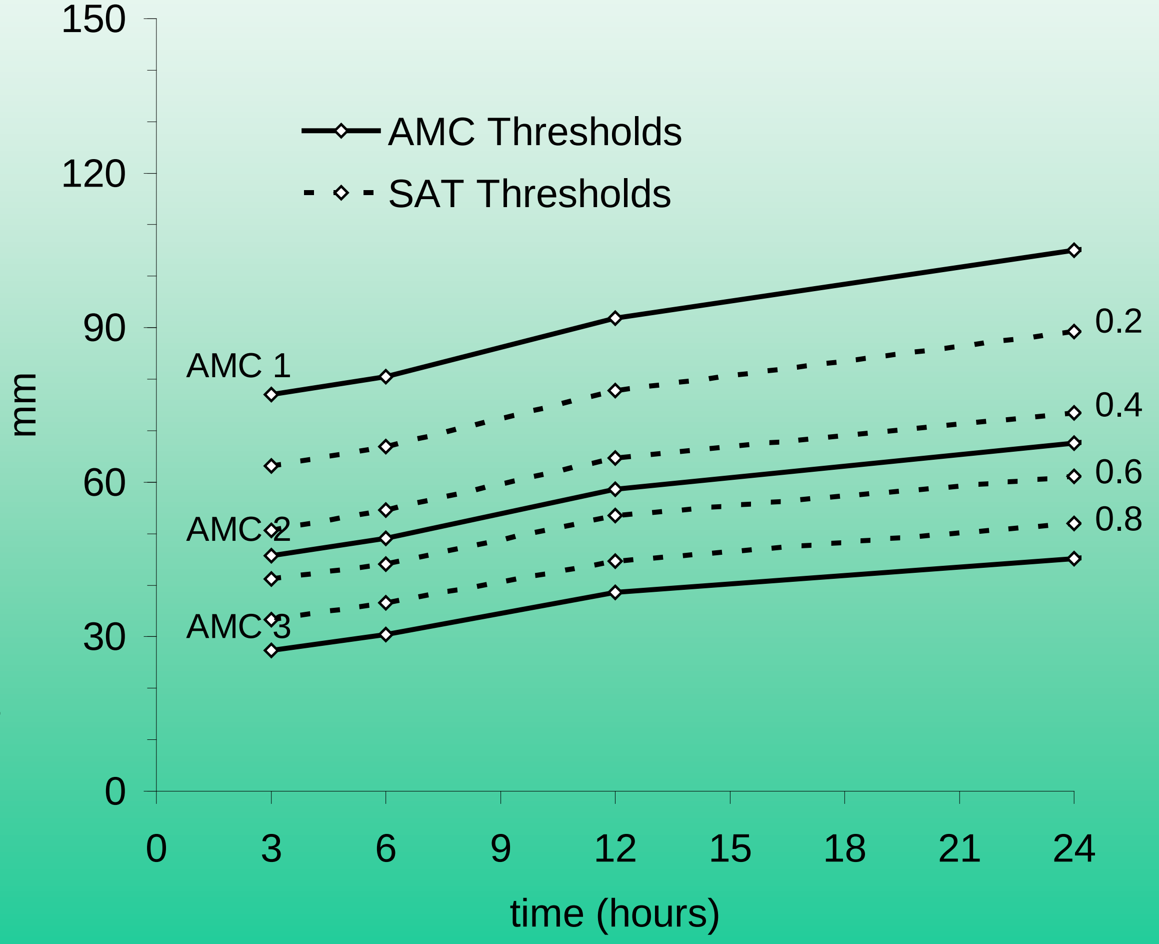
$$W_I = \ln\left[\frac{1}{1 - \left(\frac{S_{III}}{S_I} \right)} - 1 \right] + W_{II}$$

AnnAGNPS model (Bingner & Theurer, 2005).

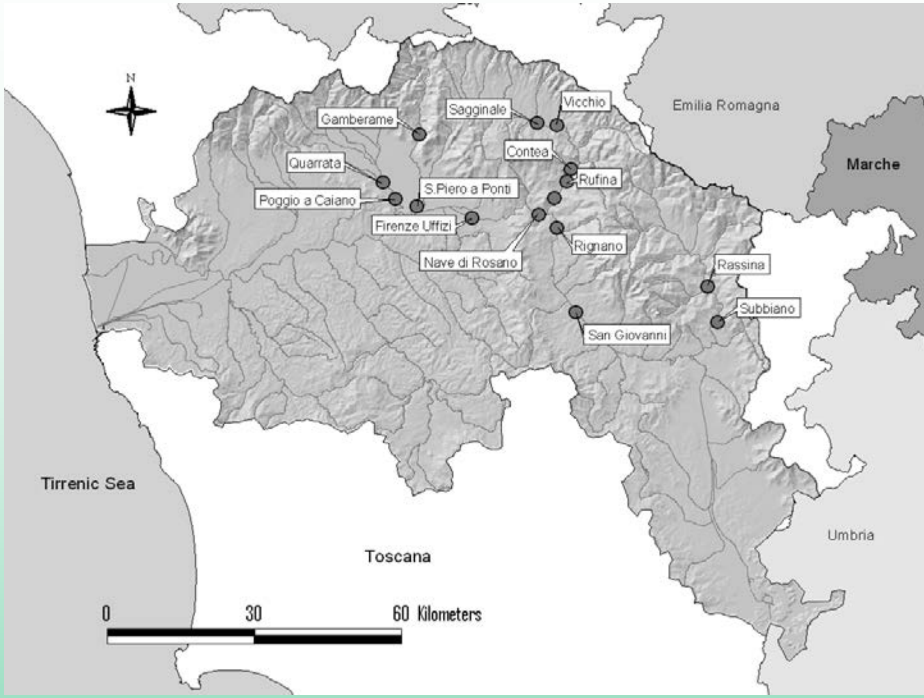
THRESHOLDS

Rainfall thresholds computed for the Rignano cross section, on the River Arno, Italy. Solid lines show thresholds estimated for the three levels of AMC following classical SCS-CN guidelines. Dotted lines show thresholds estimated according to the alternative approach as a function of the 0.2, 0.4, 0.6, 0.8 soil degree of saturation.



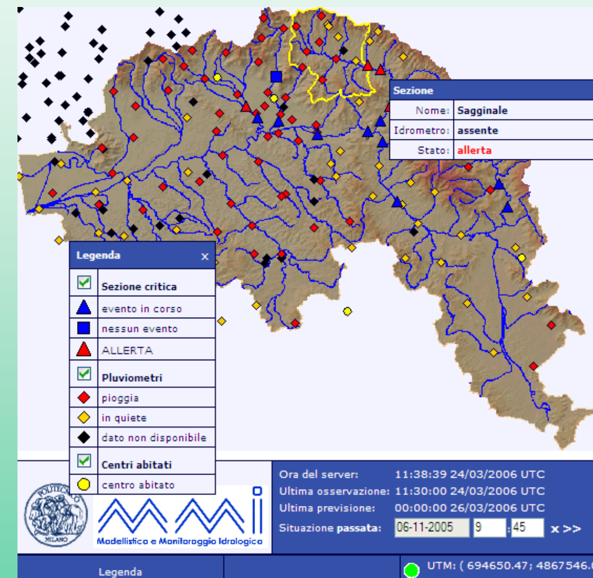


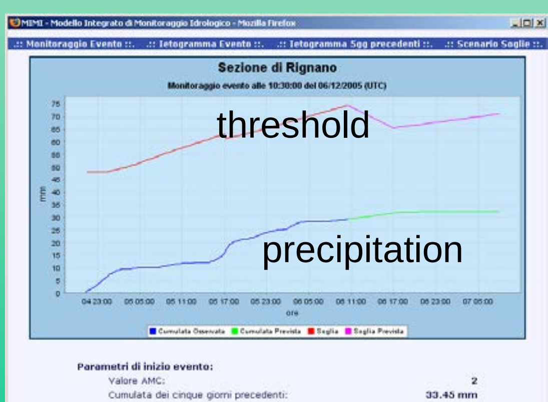
THE CASE STUDY

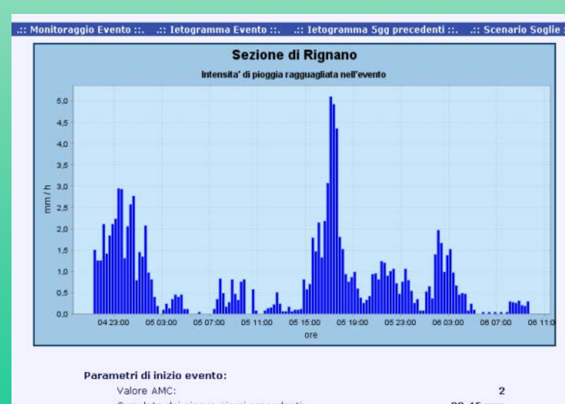


15 critical cross sections

Area: 151 – 4267 km^2







MIMI

Meteo Hydrological

Integrated Model

Reliability Analysis - 1

Based on contingency table, period 1992 – 2002, observed rainfall and discharge

(1) a **hit**, if an event occurred and the warning was provided (**h** is the number of hits);
(2) a **false alarm**, if an event did not occur but the warning was provided (**f** is the number of false alarms);
(3) a **miss**, if an event occurred but the warning was not provided (**m** is the number of misses);
(4) a **correct rejection**, if an event did not occur and the warning was not provided (**c** is the number of correct rejections);
(5) a **delayed hit**, if an event occurred and a warning was provided later (**d** is the number of delayed hits)

Outcome	River section: Nave di Rosano	Subbiano	Pontassieve	S. Piero a Ponti	Poggio a Caiano
Hit (*h*)	2	2	4	0	1
False alarm (*f*)	1	3	1	1	0
Miss (*m*)	1	1	1	0	0
Correct reject. (*c*)	8	9	15	3	11
Delayed hit (*d*)	0	2	2	0	0
Total (*n*)	12	17	23	4	12

Index	River section: Nave di Rosano	Subbiano	Pontassiev e	S. Piero a Ponti	Poggio a Caiano
POD	0.667	0.667	0.800	-	1
FAR	0.111	0.250	0.063	0.250	0
CSI	0.615	0.545	0.759	-	1
SS	0.556	0.417	0.738	-	1
CPI	0.833	0.647	0.826	0.750	1

0.647 → 0.765 0.826 → 0.913

Probability of detection *h/(h + m)*

False alarm rate *f/(f + c)*

Crit. Suc. I. *1/[1/(1 – FAR) + (1/POD) – 1]*

Skill Score. *POD – FAR*

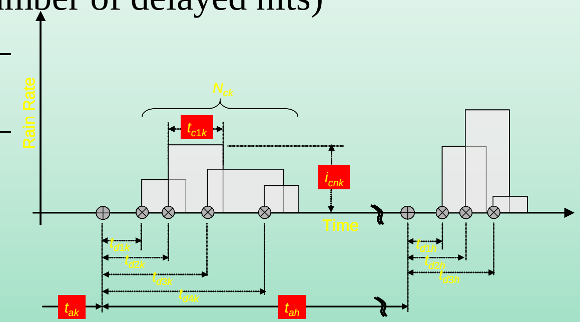
Correct performance index *(c + h)/n*

Reliability Analysis - 2

Based on contingency table, 500 years synthetic data

(1) a **hit**, if an event occurred and the warning was provided (**h** is the number of hits);
(2) a **false alarm**, if an event did not occur but the warning was provided (**f** is the number of false alarms);
(3) a **miss**, if an event occurred but the warning was not provided (**m** is the number of misses);
(4) a **correct rejection**, if an event did not occur and the warning was not provided (**c** is the number of correct rejections);
(5) a **delayed hit**, if an event occurred and a warning was provided later (**d** is the number of delayed hits)

Outcome	River section: Nave di Rosano	Subbiano	Pontassieve	S. Piero a Ponti	Poggio a Caiano
Hit (h)	164	224	289	90	33
False alarm (f)	24	47	53	24	1
Miss (m)	34	59	41	29	11
Correct reject. (c)	201	295	425	116	153
Delayed hit (d)	9	10	5	4	1
Total (n)	432	635	813	263	199



NEYMAN-SCOTT RECTANGULAR PULSES (NSRP), Burlando, 1997)

Index	River section: Nave di Rosano	Subbiano	Pontassieve	S. Piero a Ponti	Poggio a Caiano
POD	0.828	0.792	0.876	0.756	0.750
FAR	0.107	0.137	0.111	0.171	0.006
CSI	0.754	0.703	0.790	0.654	0.746
SS	0.722	0.654	0.765	0.585	0.744
CPI	0.845	0.817	0.878	0.783	0.935

Probability of detection $h/(h + m)$

False alarm rate $f/(f + c)$

Crit. Suc. I. $1/[1/(1 – FAR) + (1/POD) – 1]$

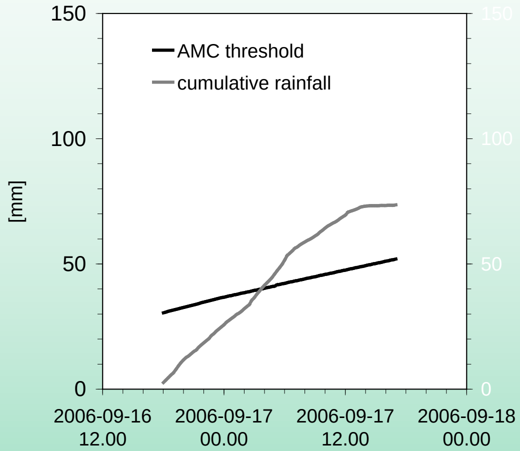
Skill Score. $POD – FAR$

Correct performance index $(c + h)/n$

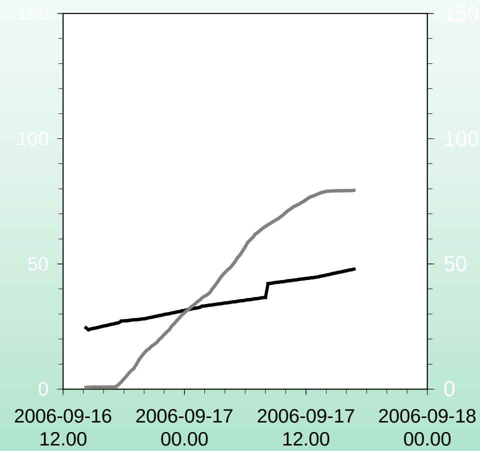
THE 17 SEPTEMBER 2006 FLOOD EVENT

WARNING !

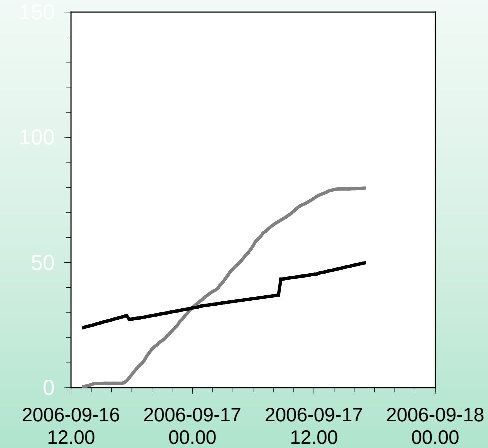
Nave di Rosano



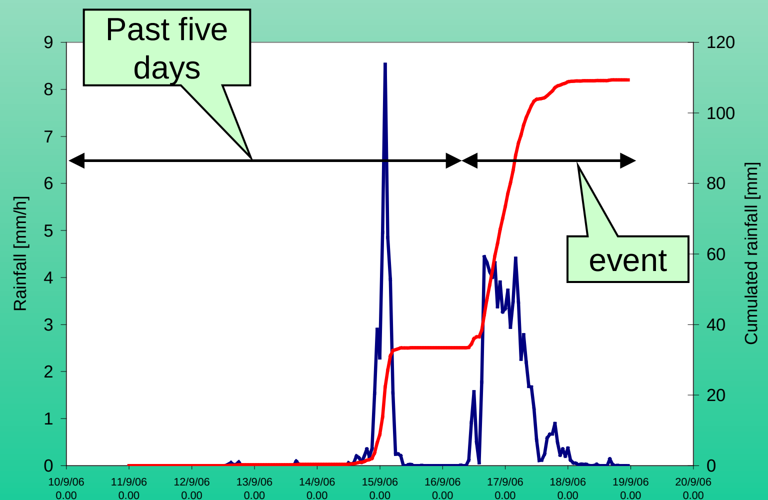
Rignano



S. Giovanni

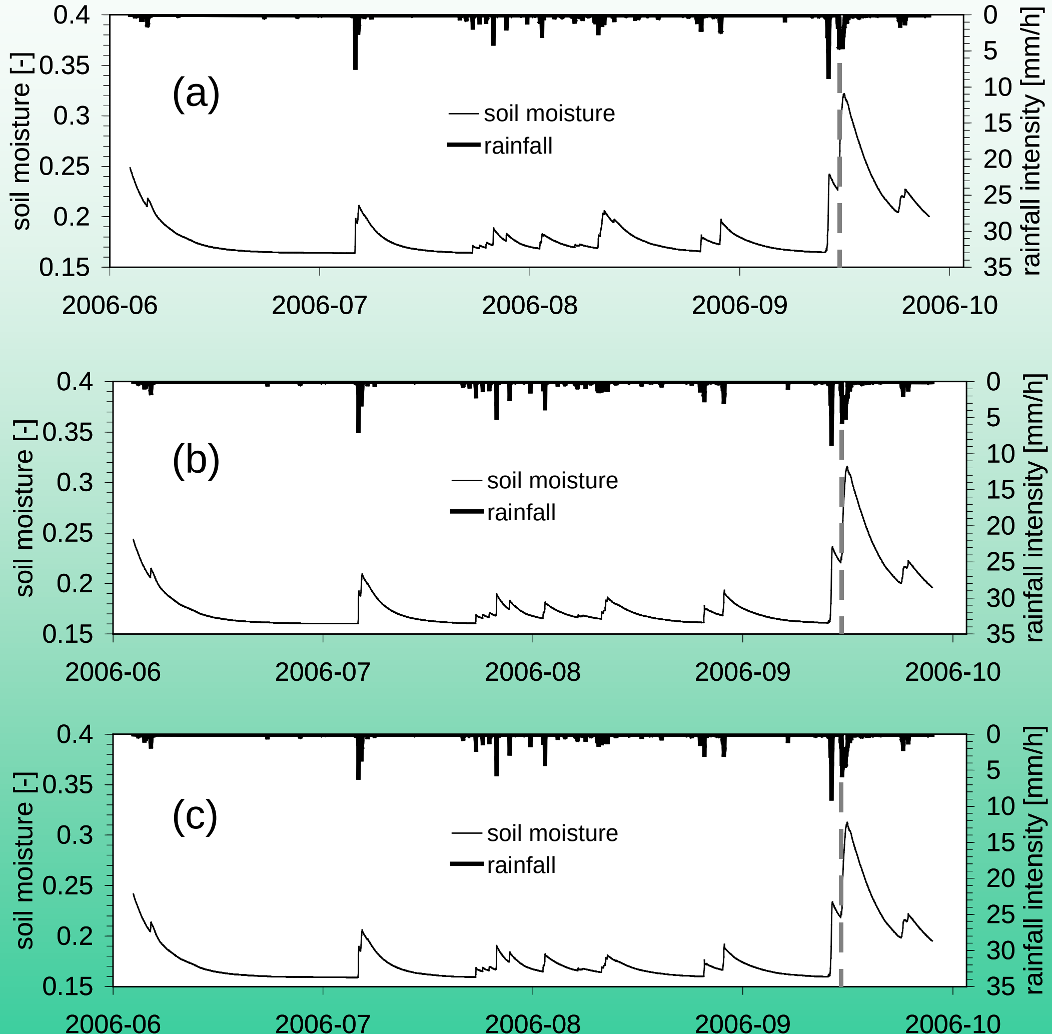


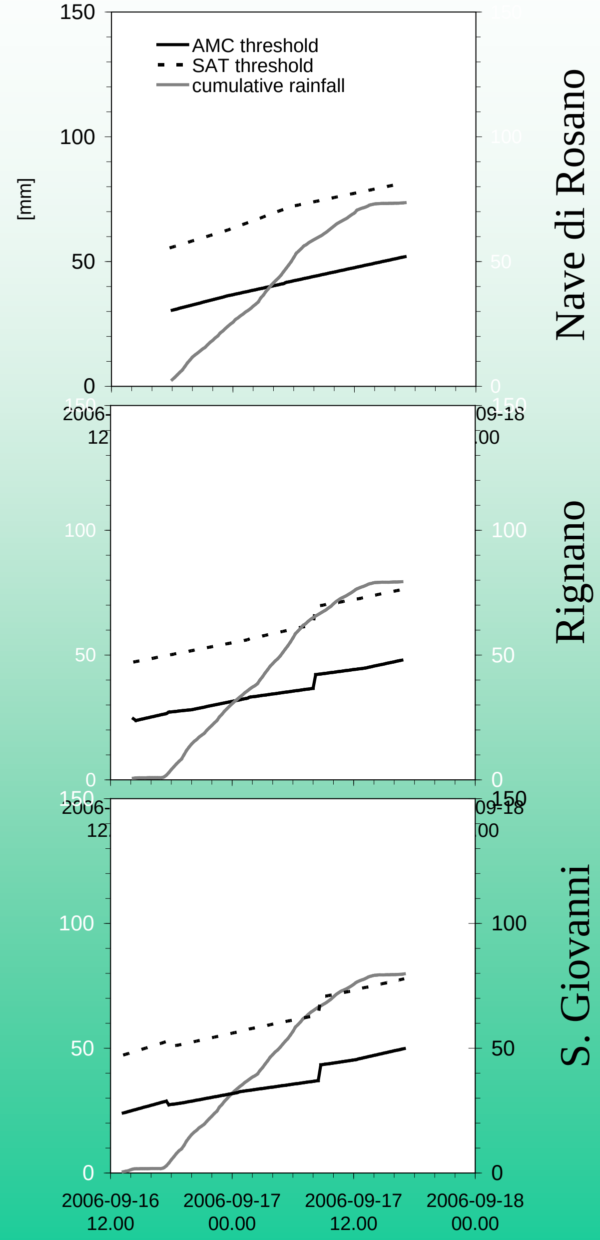
NO ANY BIG FLOOD ! FALSE ALARMS !



AMC 3: soil saturated

THE 17 SEPTEMBER 2006 FLOOD EVENT





CONCLUDING REMARKS

- The paper presents a method for the estimation of rainfall thresholds based on the solution of the inverse hydrological problem

- Application of the warning system to the historical and sysnthetic flood events on the Arno River basin showed a good degree of reliability.

- The use of actual soil moisture as a basin wetness index, in conjunction with a method for estimation of soil moisture at the beginning of the rainstorm, could improve the result.

Thank You for your attention !

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