GEOMORPHOLOGIC-MONTECARLO MODELS IN HYDROLOGY

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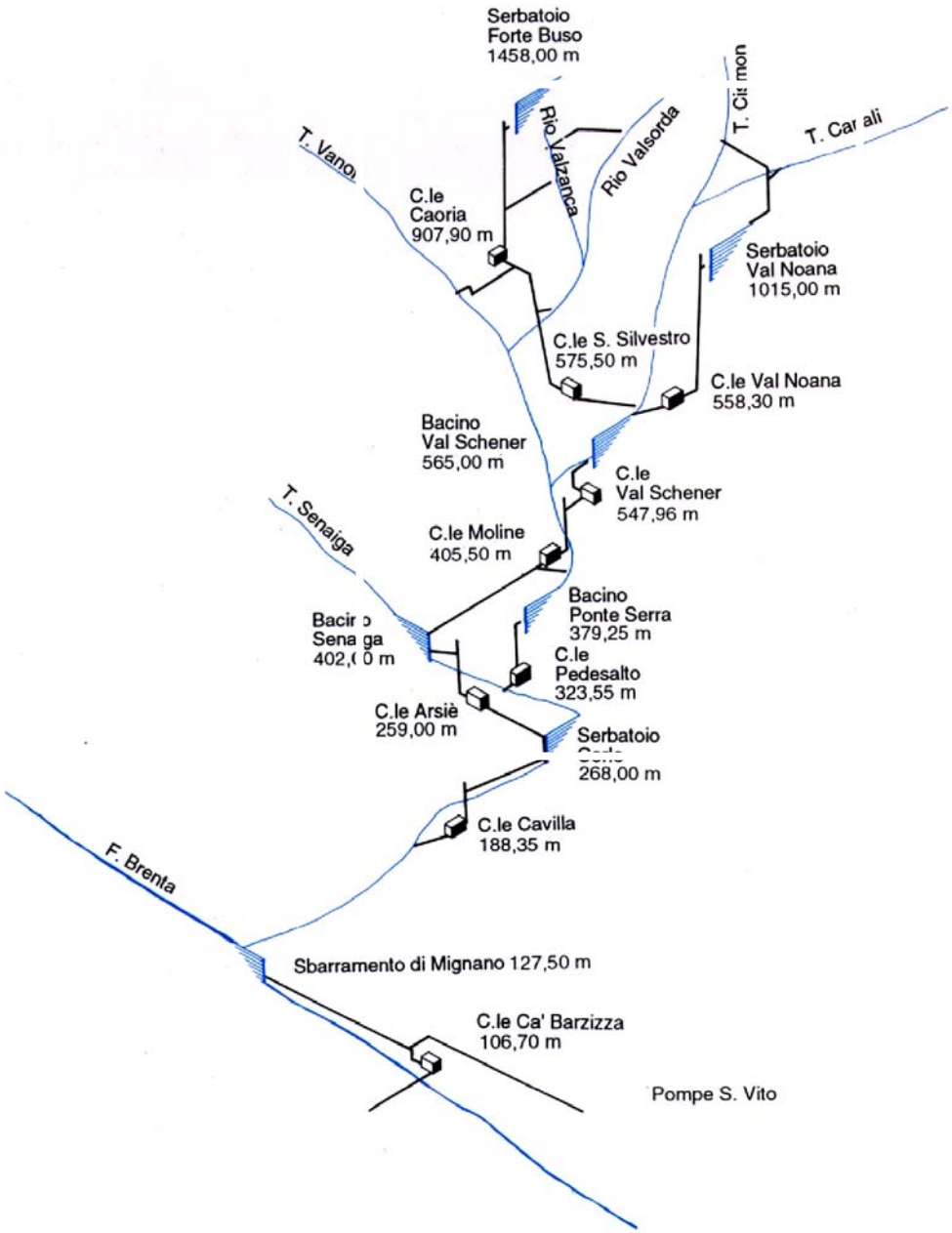
HEPEX
March 8-10, 2004, ECMWF, Reading

Brenta river at Bassano



$S = 1580\ km^2$

Water reservoir

Water reservoir model

$$Q_i - Q_u = S \cdot \frac{dh}{dt} = \frac{d}{dt}\left(\sum_{n=0}^{3} a_n \cdot h^n\right)$$

- Water discharged during real flood events

ENEL spa
Direzione Produzione e Trasmissione

Nucleo Idroelettrico di FELTRE

Diga di VAL SCHENER

MOD. 3 VAL SCHENER
Feltre li, 4/03/94

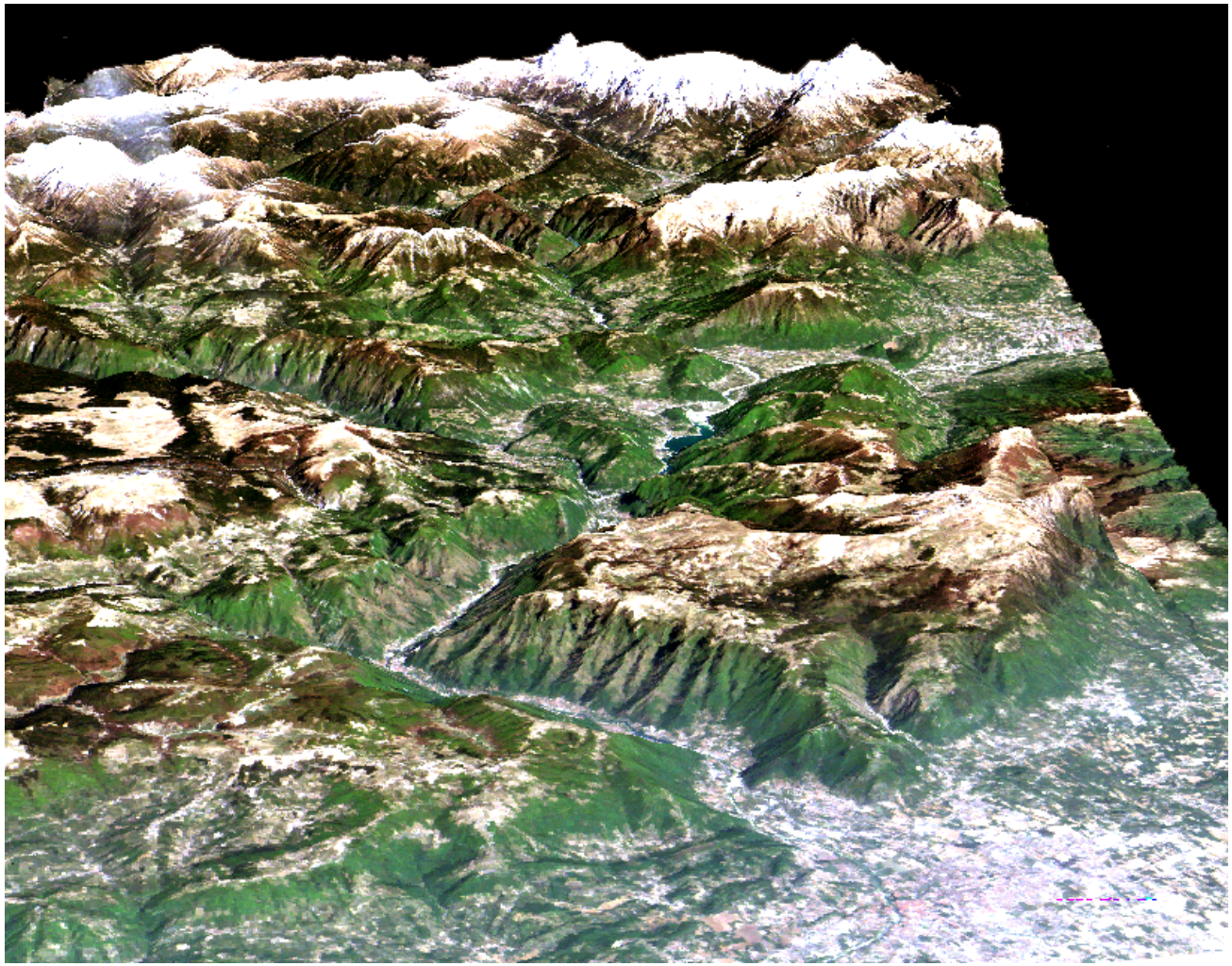
Rapporto del giorno 16.10.96 / Mencobeci

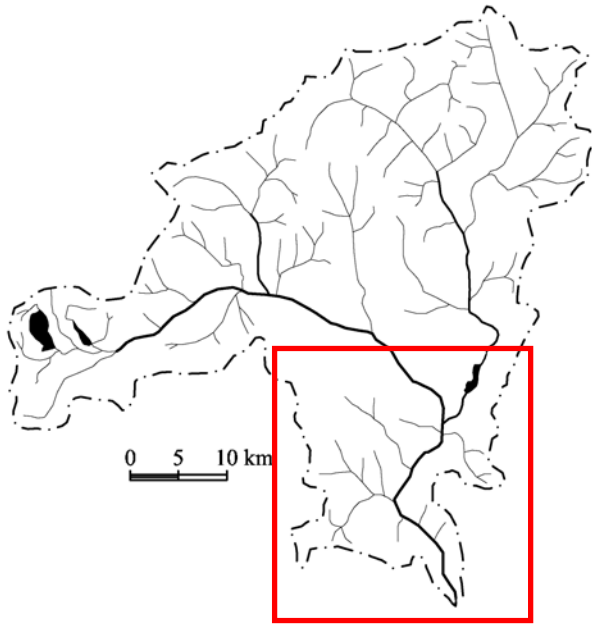
ABBATTIMENTO VENTOLE e/o APERTURA PARATOIE H (in cm) e PORTATE SCARICATE Q (in m³/s)

ORARIO	Precipitazioni Orarie mm/h	Precipitazioni Progressive mm	Temperatura aria °C	QUOTA INVASO (2)	ΔH +/− cm	SUPERFICIE: SFIORATORE FISSO (52) H	SFIORATORE FISSO (52) Q	VENTOLA: 1 - Sx (125) ▼ soglia 561,60 H	1 - Sx (125) ▼ soglia 561,60 Q	2 Cent - (125) ▼ soglia 561,60 H	2 Cent - (125) ▼ soglia 561,60 Q	1 - Dx (125) ▼ soglia 561,60 H	1 - Dx (125) ▼ soglia 561,60 Q	FONDO (193) (3) ▼ soglia 513,50 H	FONDO (193) (3) ▼ soglia 513,50 Q	PORTATE (in m³/s): Totale scaricate (620) A	Deflusso (18) B	Di Incremento +/− C	In arrivo A+B ±C D	NOTE
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16					
0	72.4	72.4	12,7°	564	60						120	10					10	15	—	25	ore 00.30 scarico
1	80.0	7.6			76	+16					150	20					20	15	+16	51	ore 01.00 V. Noana parte con 15 m³/s
2	90.0	10.0			97	+21					250	50					50	15	+21	86	
3	92.8	2.8			98	+1			130	20	250	50					70	15	+1	86	
4	94.8	2.0			98	—			130	20	250	50					70	15	—	85	
5	95.2	0.4			98	—			130	20	250	50					70	15	—	85	
6	98.0	3.6			98	—			130	20	250	50					70	15	—	85	
7	99.6	1.6			98	—			130	20	250	50					70	15	—	85	
8	100.4	0.8	10.4°		97	-1			0	0	250	50					50	15	-1	64	
9	0.4	0.4			97	—					250	50					50	15	—	65	
10	1.2	1.6			97	—					200	40					40	15	—	55	
11	—	1.6			97	—					200	40					40	15	—	55	
12	—	1.6	10.8°		97						200	40					40	15		55	
13		1.6			96						190	35					35	15	-1	49	
14		1.6			96						190	35					35	15		50	
15	0.8	2.4			96						190	35					35	15		50	
16	—	2.4			96						190	35					35	15		50	16.15 V. Noana riduce di 5 m³/s
17	1.2	3.6			96						190	35					35	15		50	17.00 " con 15 m³/s
18	—	3.6			96						190	35					35	15		50	
19	6.0	9.4			96						190	35					35	15		50	
20	6.6	16.0		564	95						190	35					35	15		50	
21	5.2	21.2			85						170	35					35	15	-	50	
22	0.4	21.6			85						170	35					35	15	-	50	
23	—	21.6			85						170	35					35	15		50	
24	—	21.6		563	84						150	35					35	15	-	50	

Methods

The model is aimed at incorporating state of art information, either from theory or remote sensing and ground measurements, to address,
in the framework of the formulation of transport by travel time distribution and of real and Montecarlo rainfall patterns in space and time, runoff production.





Brenta a Bassano

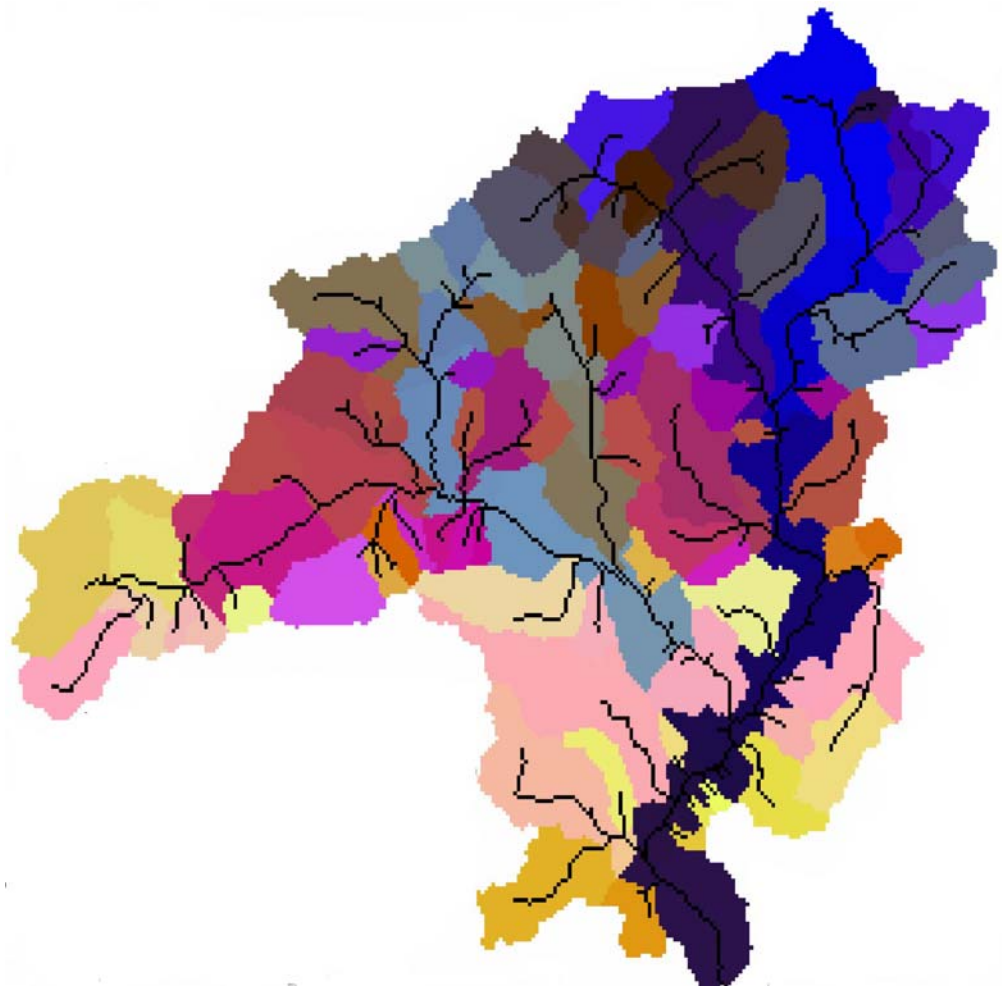
Network extraction

Channellized pixels:

$$\nabla^2 z > 0$$

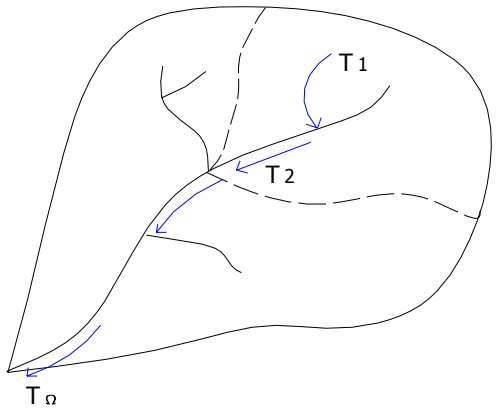
$$\nabla z \cdot A^{0.5} > threshold$$

[Montgomery and Dietrich, *Science*, 1992]



HYDROLOGIC MODEL

The geomorphologic theory of the hydrologic response is based on the definition of probability density function associated to travel time in different states, hillslopes and channels assuming that different states are statistically independent .



$$T_c = T_1 + T_2$$

$$f(t) = \sum_{\gamma \in \Gamma} p(\gamma)(f_{x_j} * \ldots * f_{x_w})(t)$$

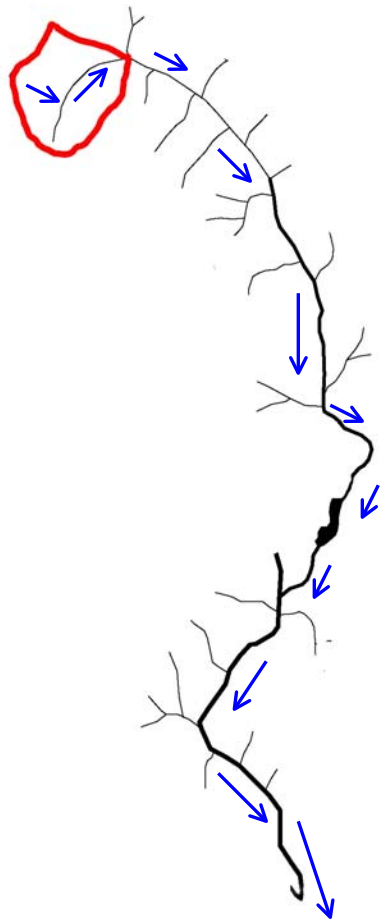
γ è il generico percorso formato dalla successione di stati $x_j \ldots x_w$

Travel time distribution in channel is derived from a parabolic scheme that includes both cinematic than storage effects

Geomorphological IUH

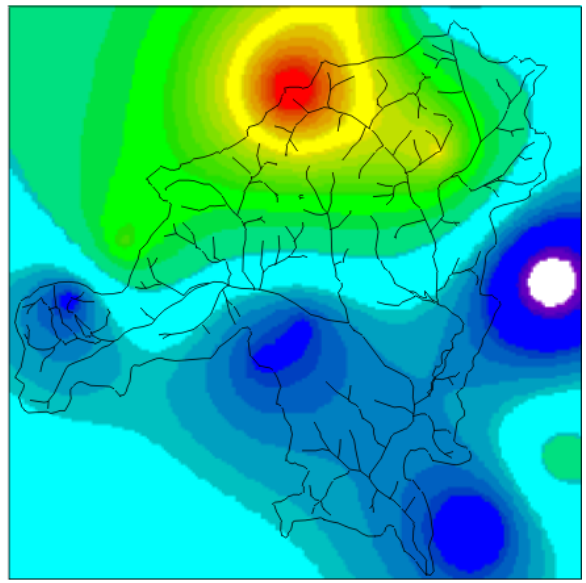
- Network/hillslope geometry
- Paths identification
- Residence time in available paths
- Stochastic transport models

Model which is lumped in the parameters but distributed in the description of the geometry



Kriging of precipitation

Optimal interpolator



Rainfall observations

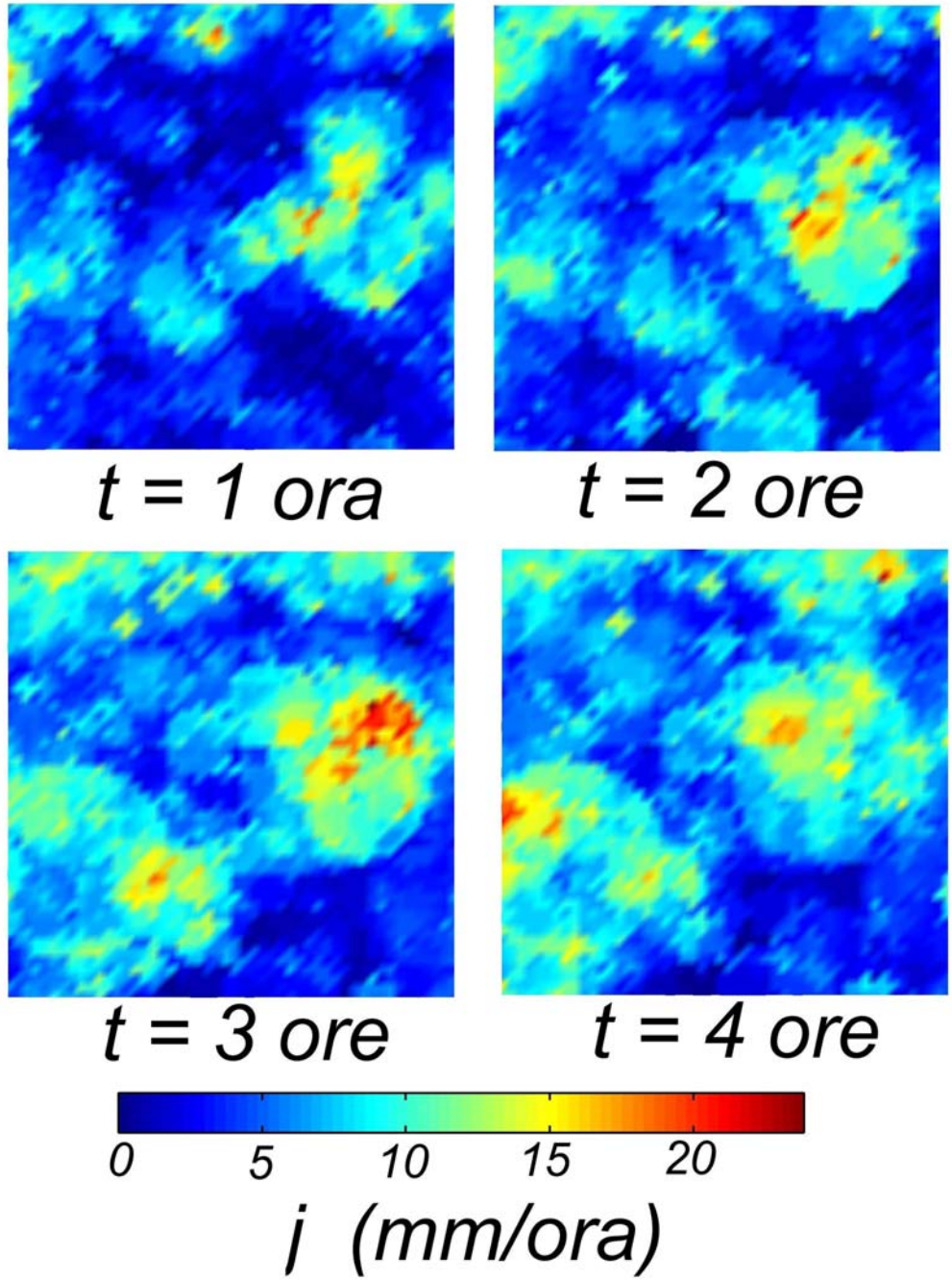
- Rainfall distribution
- Total rainfall volume

Stochastic model

- 5 parameters;

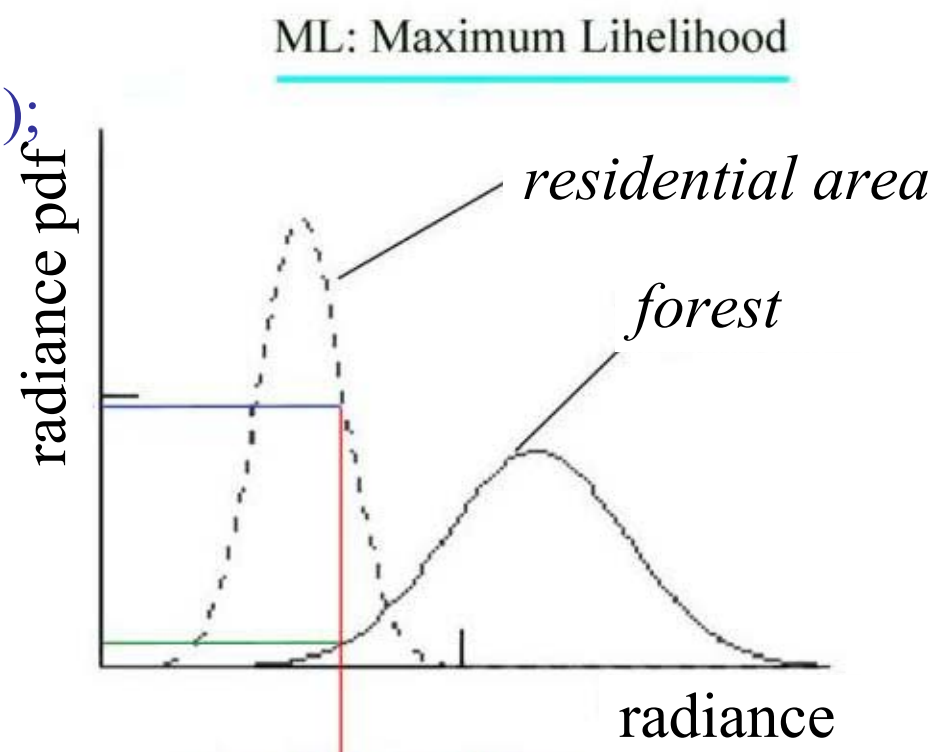
-Determined imposing:
  mean;
  variance;
  autocovariance (1 e 2 hrs);
  dry fraction;

200 events with duration
1 ÷ 7 days



Maximum likelihood algorithm

- Definition of relevant classes (residential areas, pasture, forest, etc.);
- Selection of reference areas for each class;
- Computation of radiance pdf for each class;
- Classification of unknown pixels;

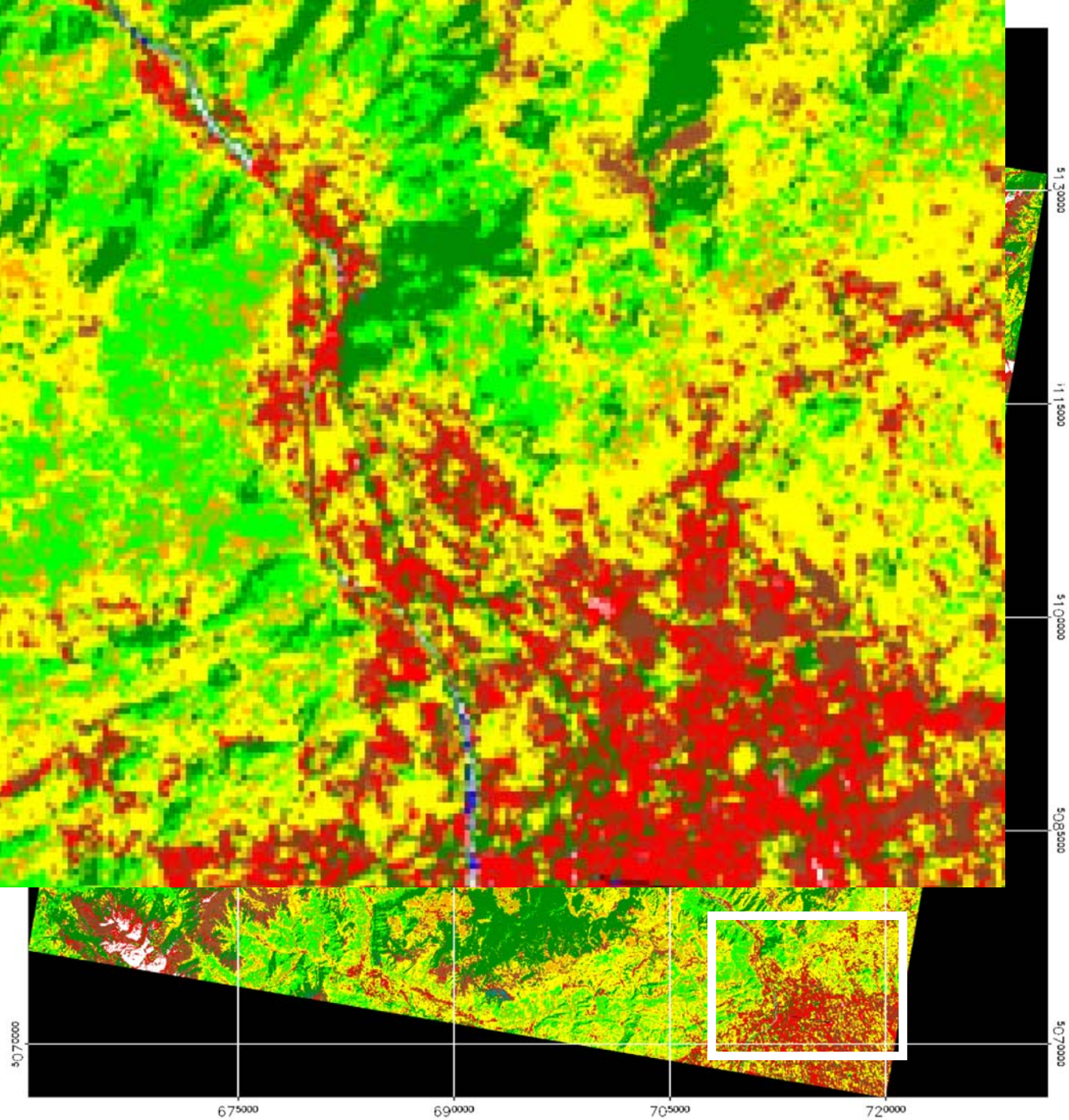


pixel classified as residential area


BASSANO

Classificazione LANDSAT

- max. verosimiglianza

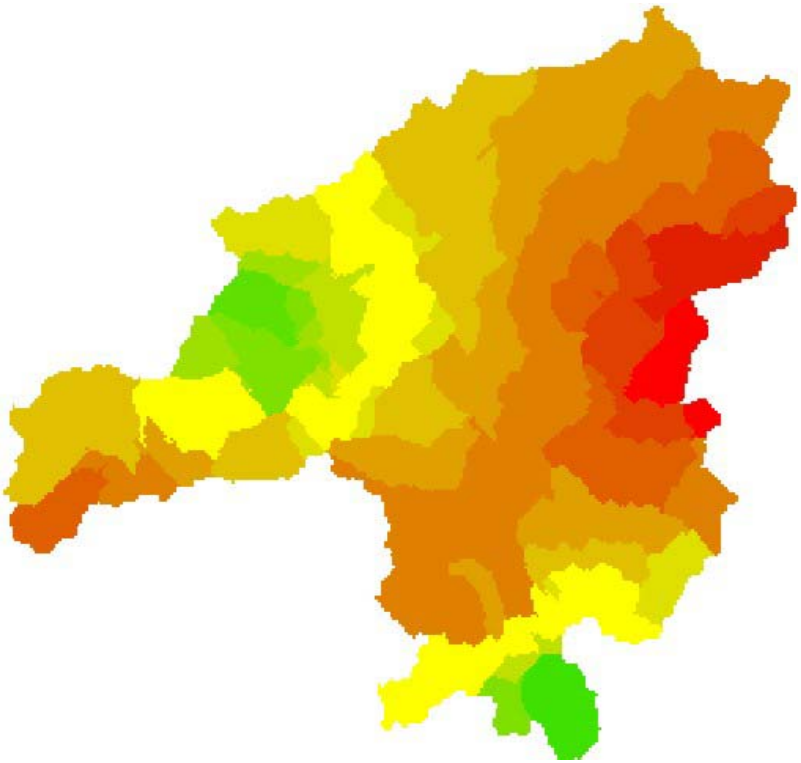


- Acqua
- Neve e ghiaccio
- Edificato/sup. imperm.
- Suolo nudo
- Pascolo
- Prato
- Territori agrari/naturali
- Bosco a latifoglie
- Bosco a conifere
- Bosco misto
- Non classificato

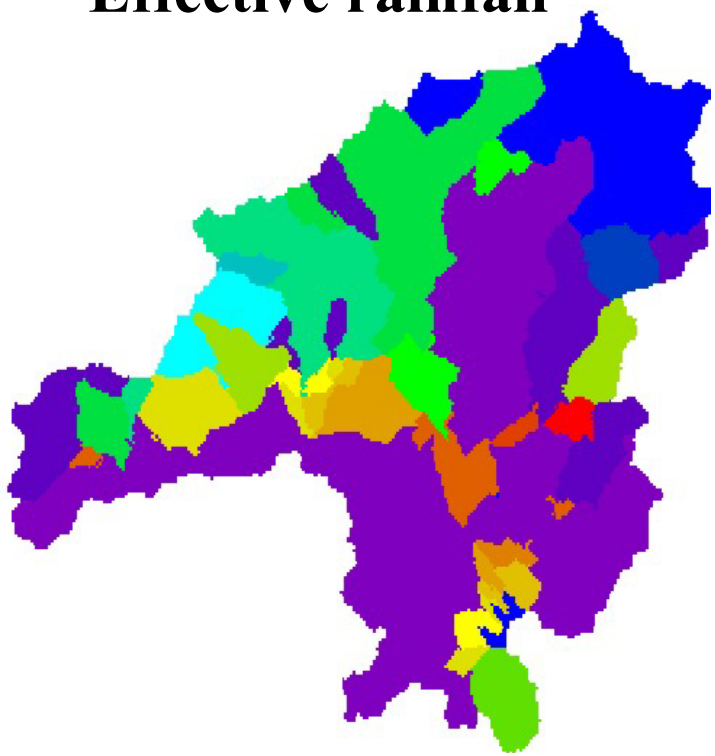
Effective rainfall (SCS/Green&Ampt)

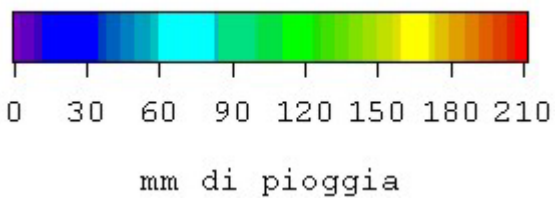
Observed rainfall

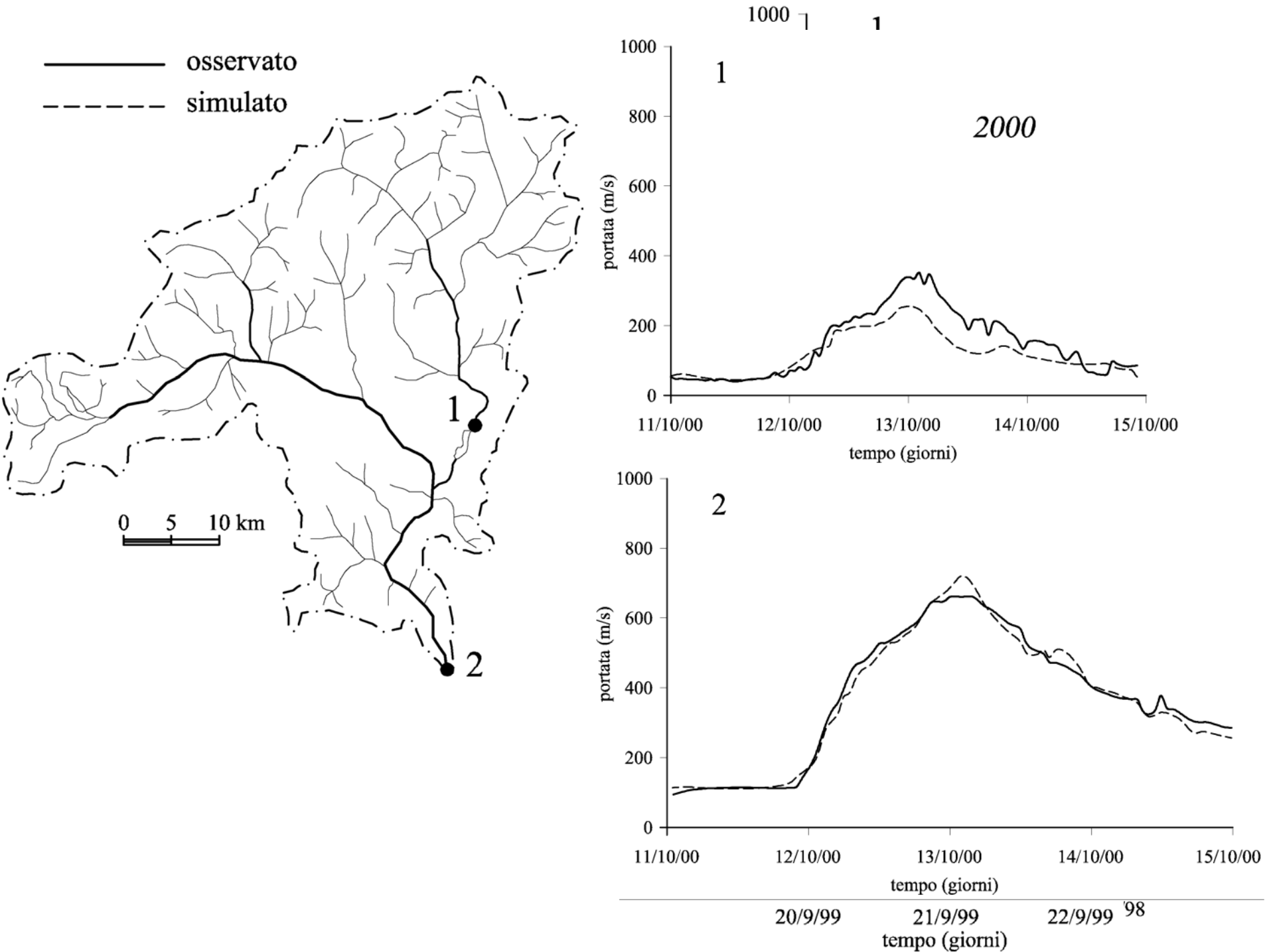
Effective rainfall



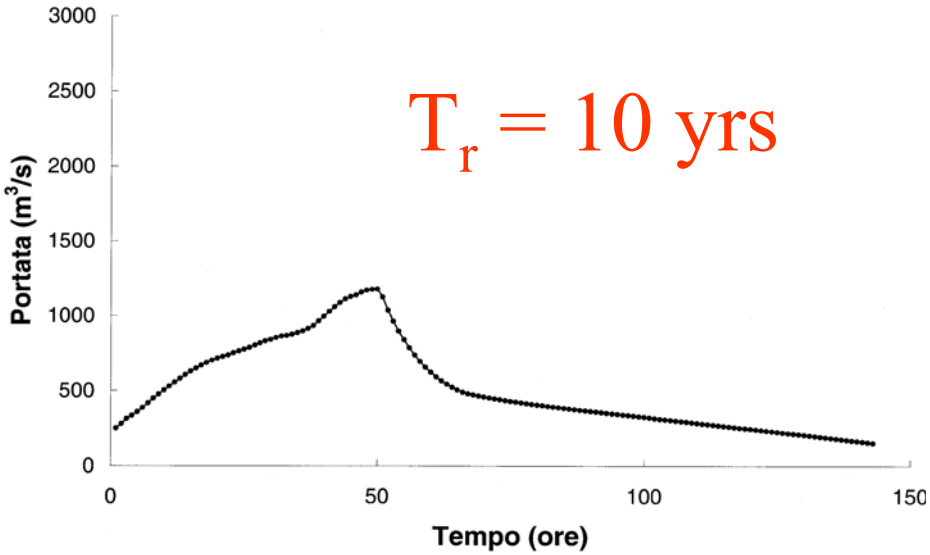
Pedology
Soil use

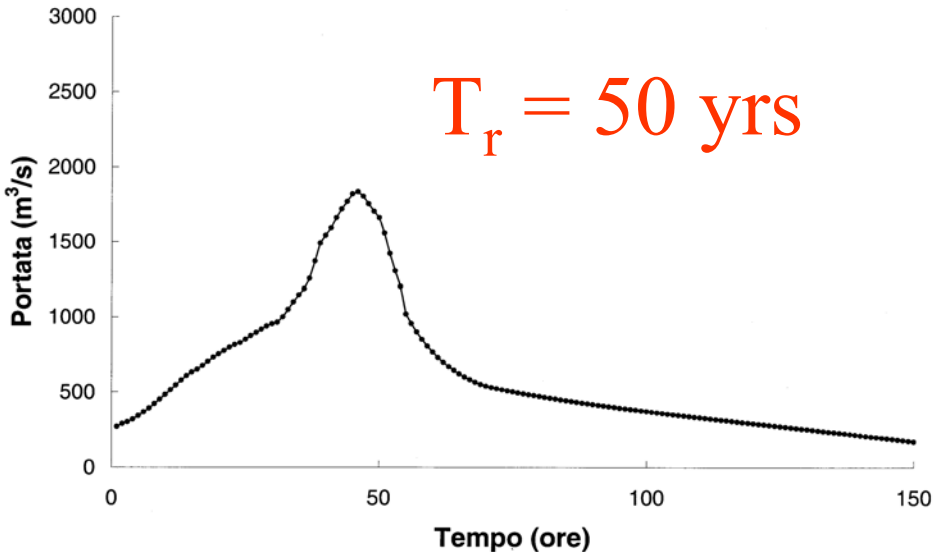


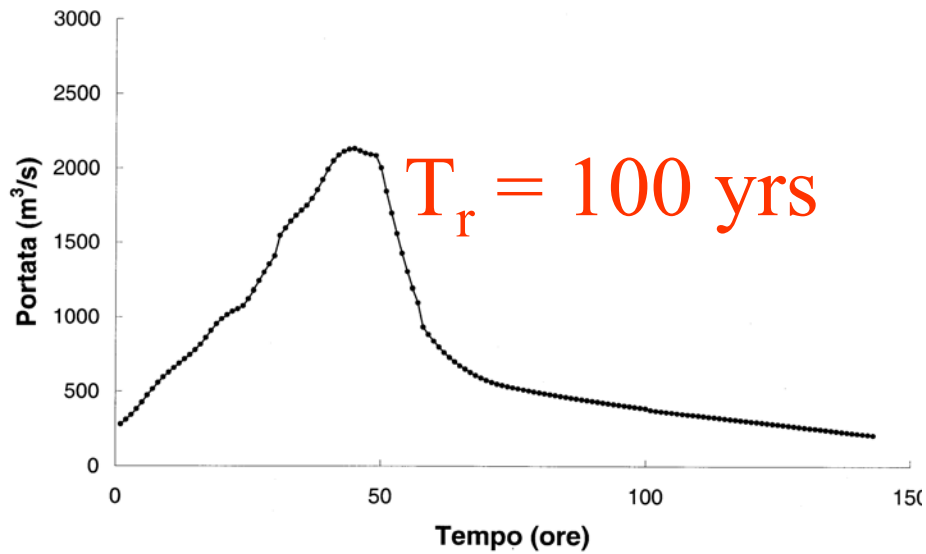


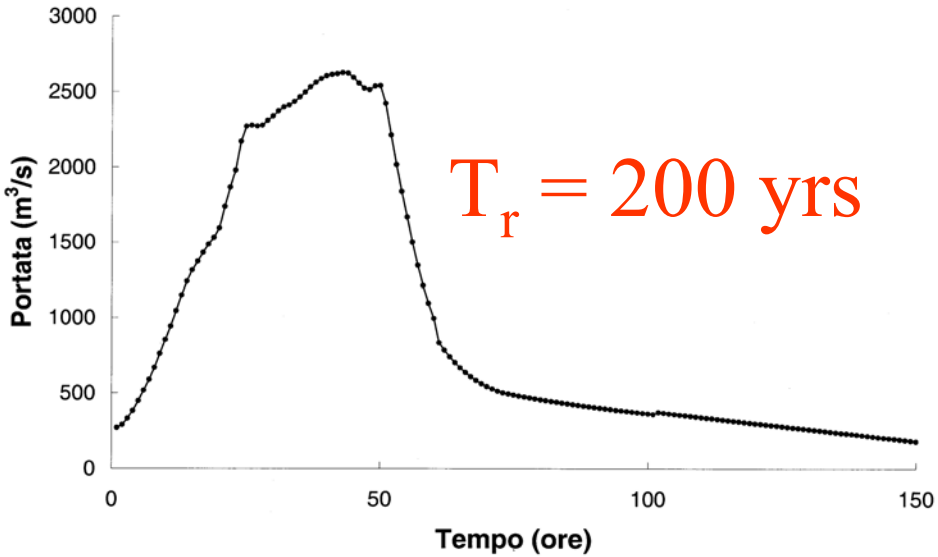

osservato
simulato
1
2
0 5 10 km
1000
1
1000
800
600
400
200
0
portata (m/s)
2000
11/10/00
12/10/00
13/10/00
14/10/00
15/10/00
tempo (giorni)
2
20/9/99
21/9/99
22/9/99
'98
tempo (giorni)

Flood hydrographs



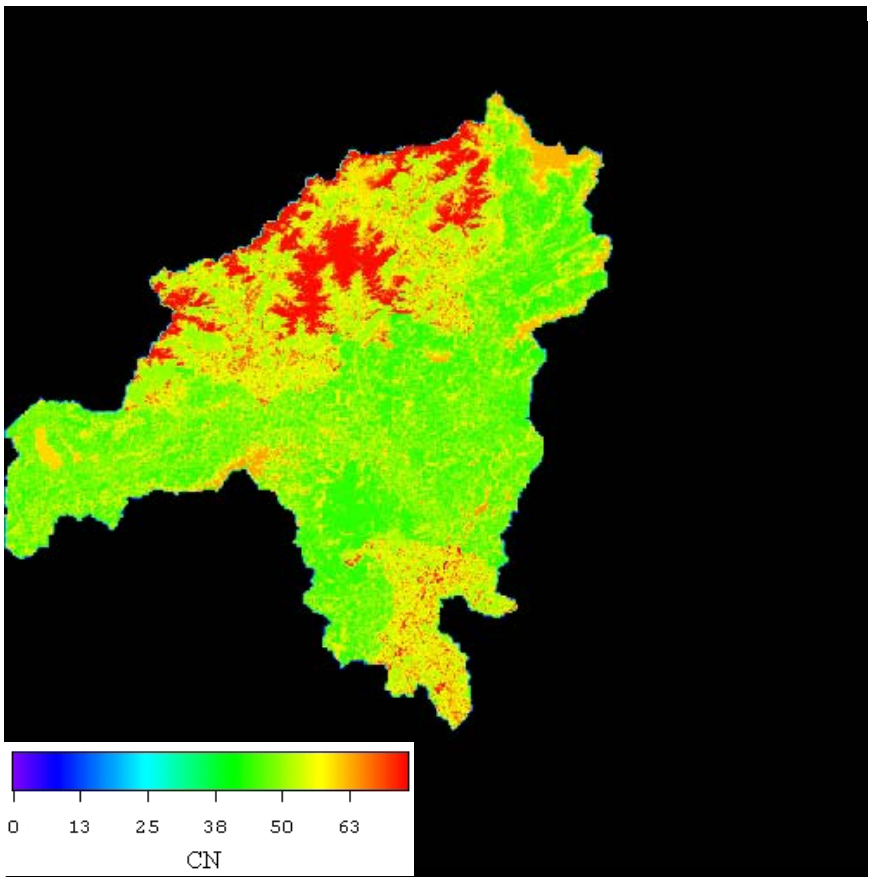


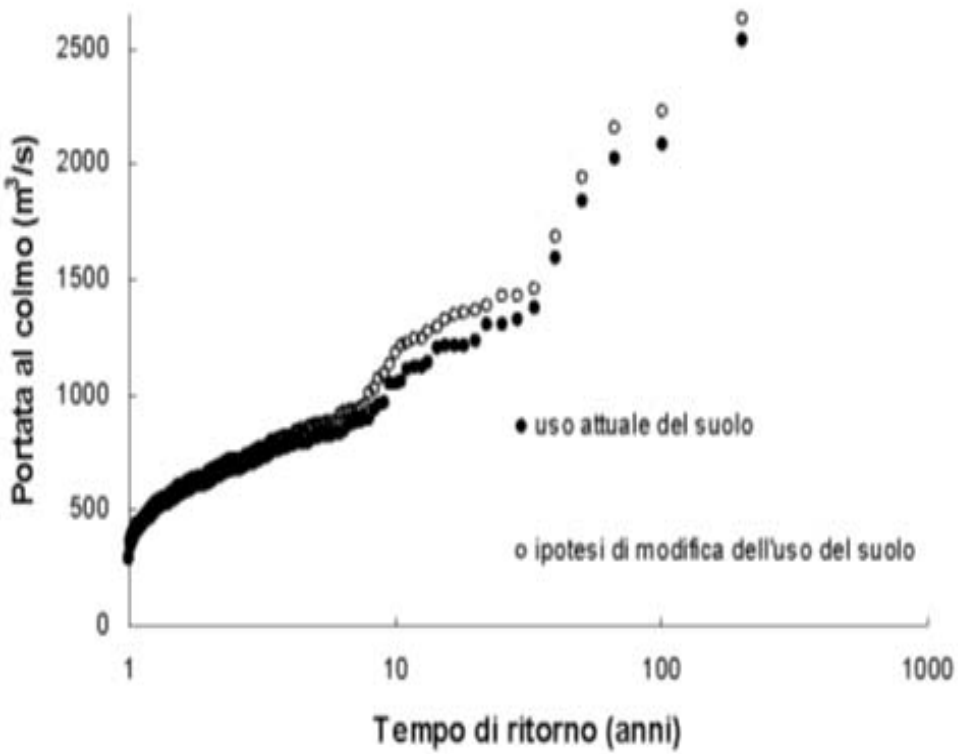




IMPACT OF SOIL USE

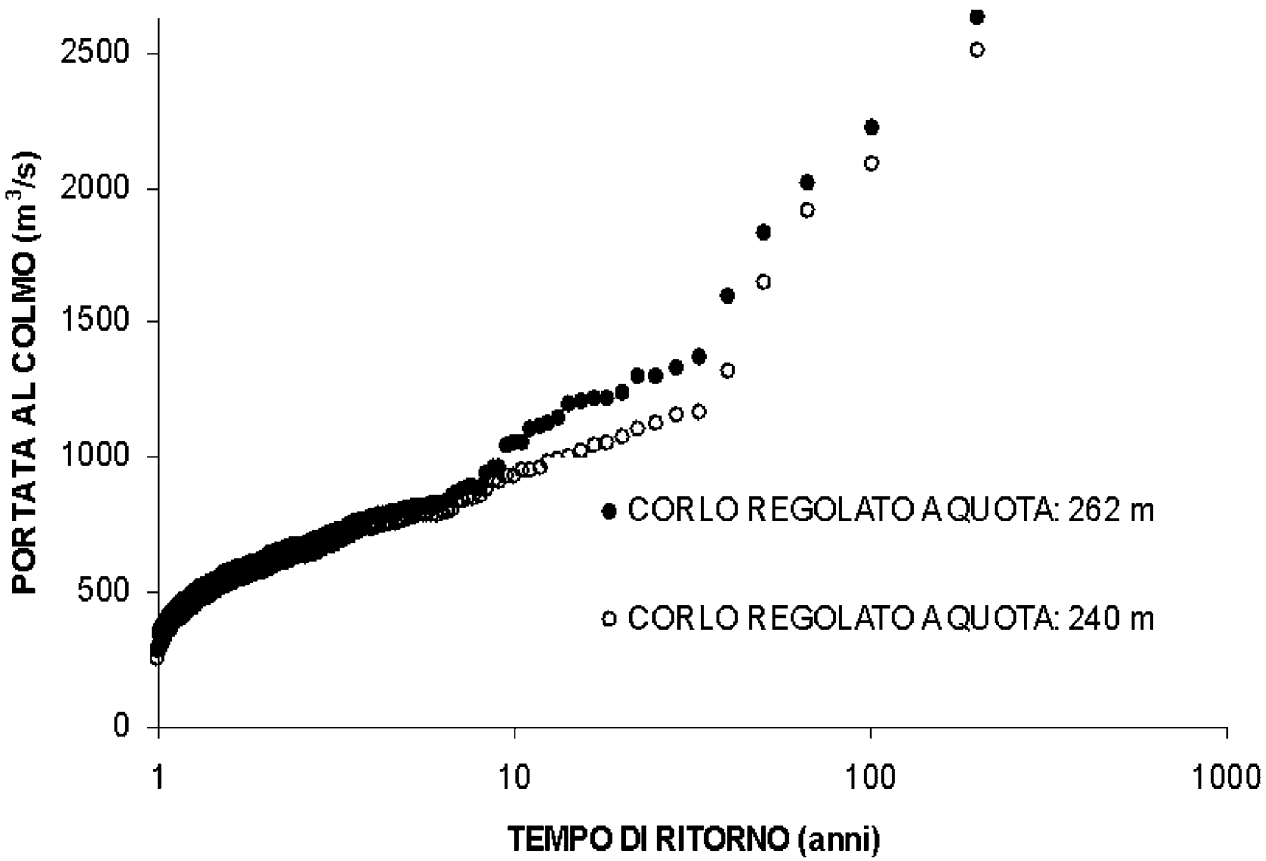
The model also allows the evaluation of the impact of soil use changes: in the following picture the effect of changing 20% of the forested area into bare soil, is shown.
Consequently the return periods of floods under the different land use scenarios may be evalueted





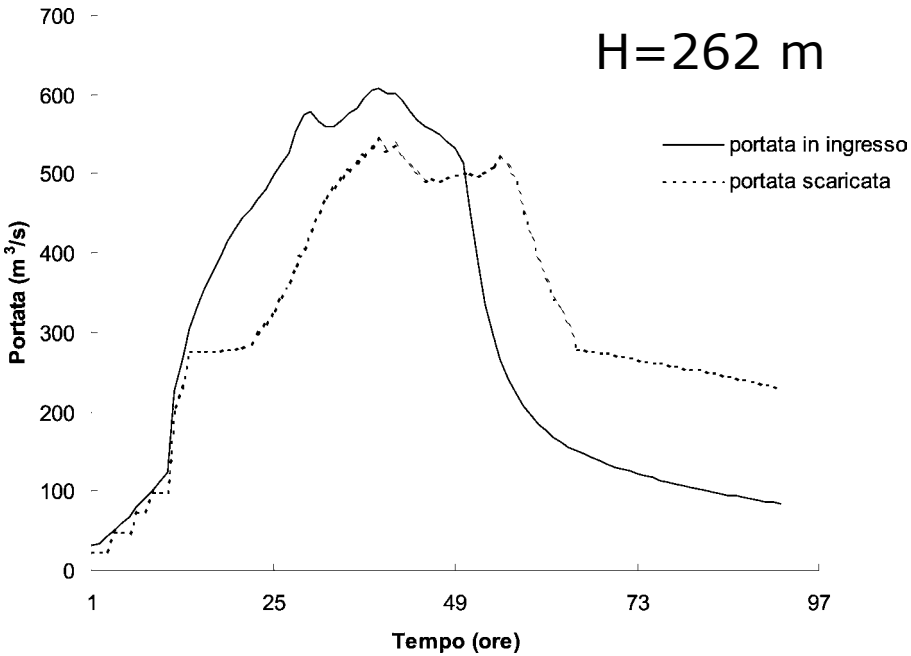
Flood mitigation obtainable from gate operations (I)

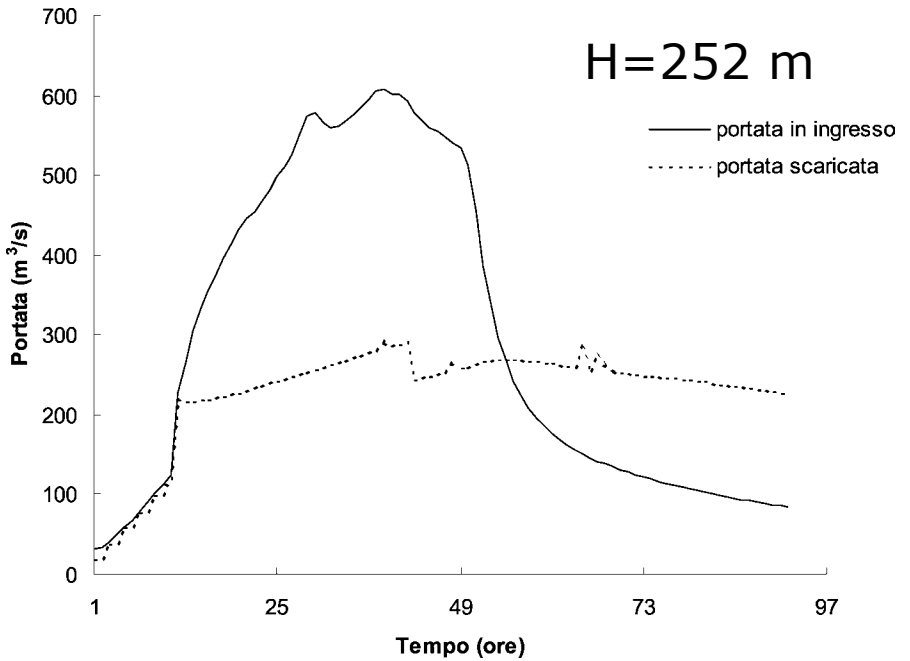
The following picture shows the filled effects produced by Corlo reservoir using its storage capacity without any other structural measure



Flood mitigation obtainable from gate operations (II)

Water Autority specifications impose that the Corlo water level be lower than 252 m.s.l.m. in the period 15 september –30 november

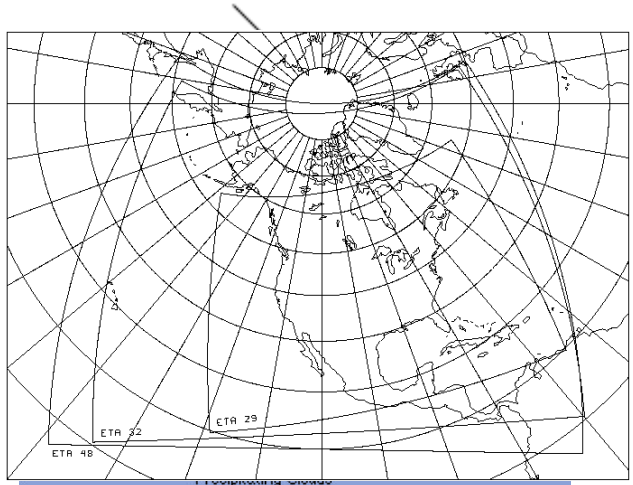


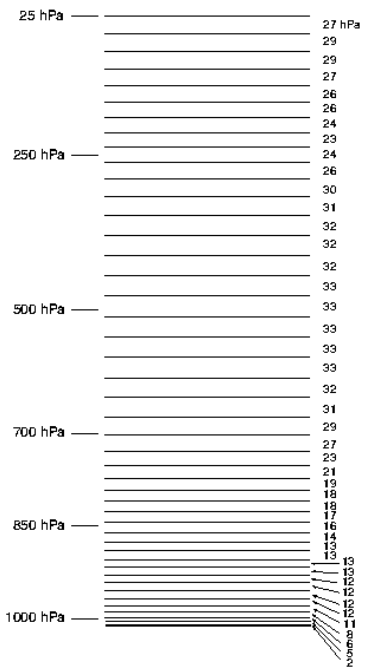


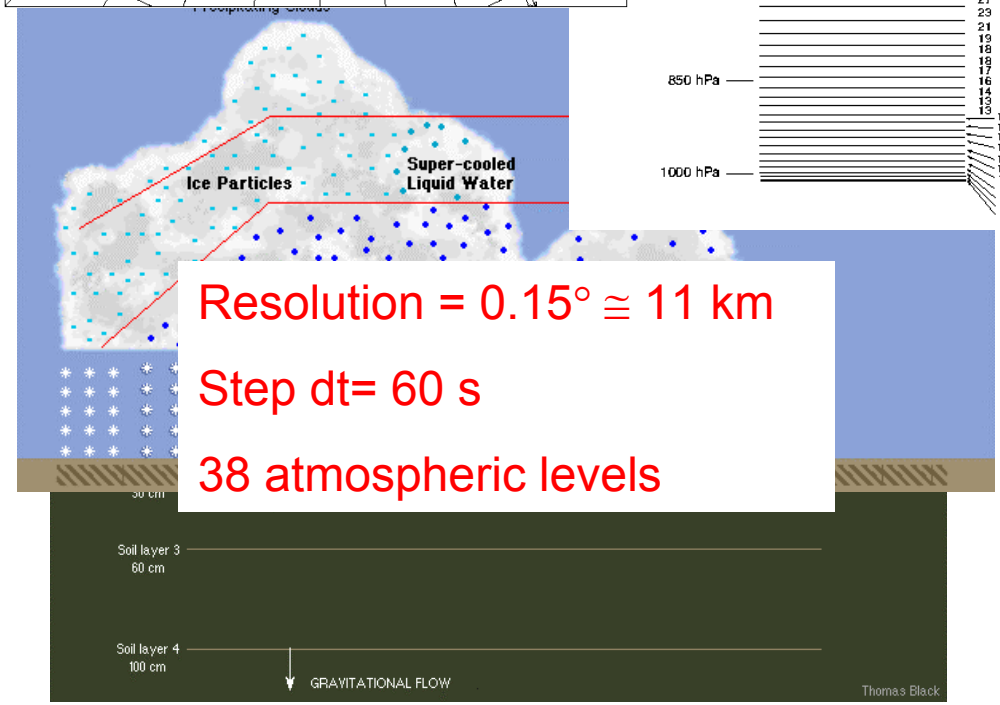
An improvement is observed when optimized gate operations are introduced: the availability of additional volumes in the reservoir, obtained by lowering the level in the lake before the flood allows the safe containment of the 50yrs flood event

ETA model (NCEP)

- Finite difference hydrostatic model;
- Radiative transfer model
- Convection parameterization (Betts-Miller-Jianic)
- Cloud model
- 4-layer model





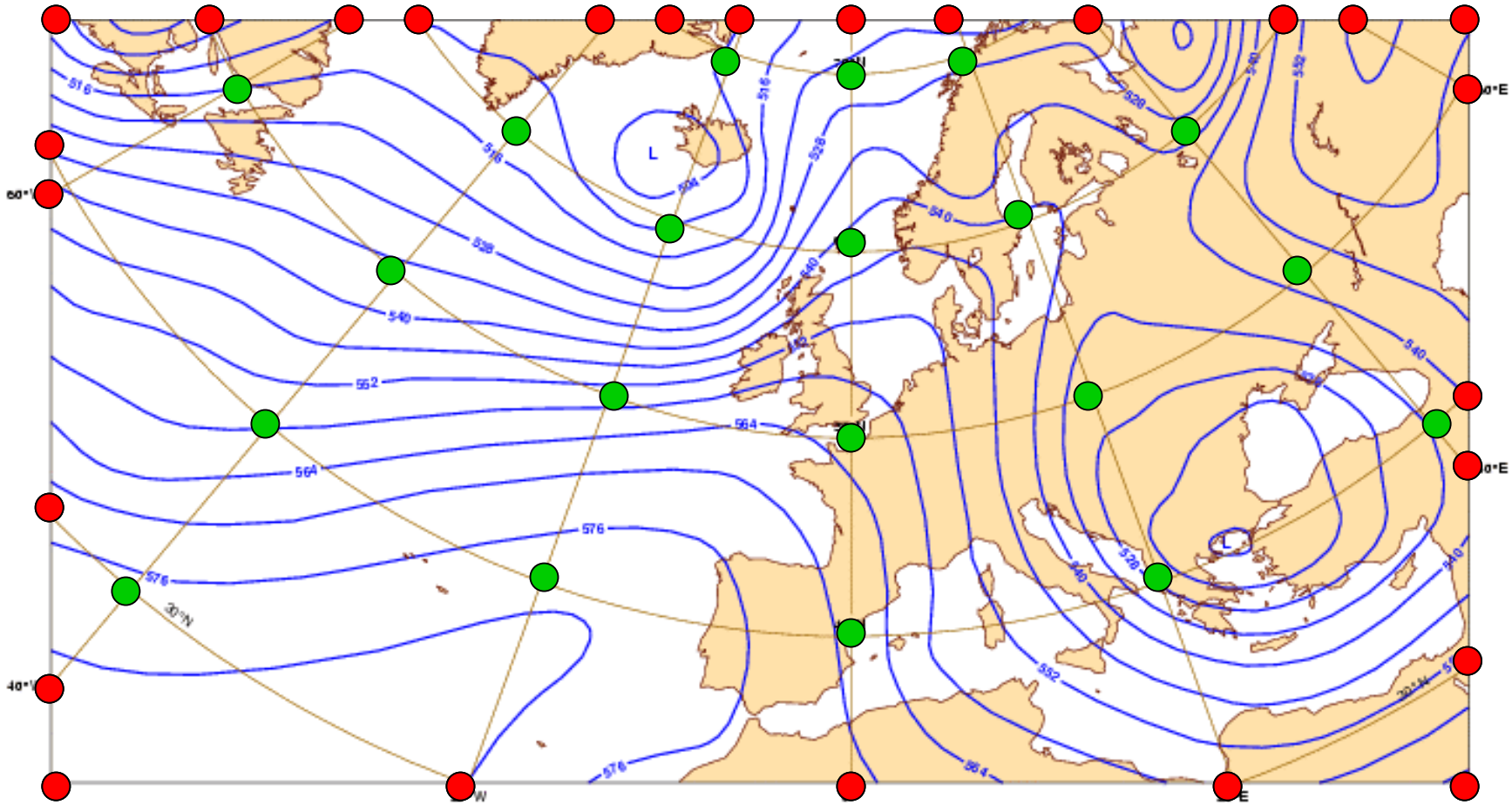


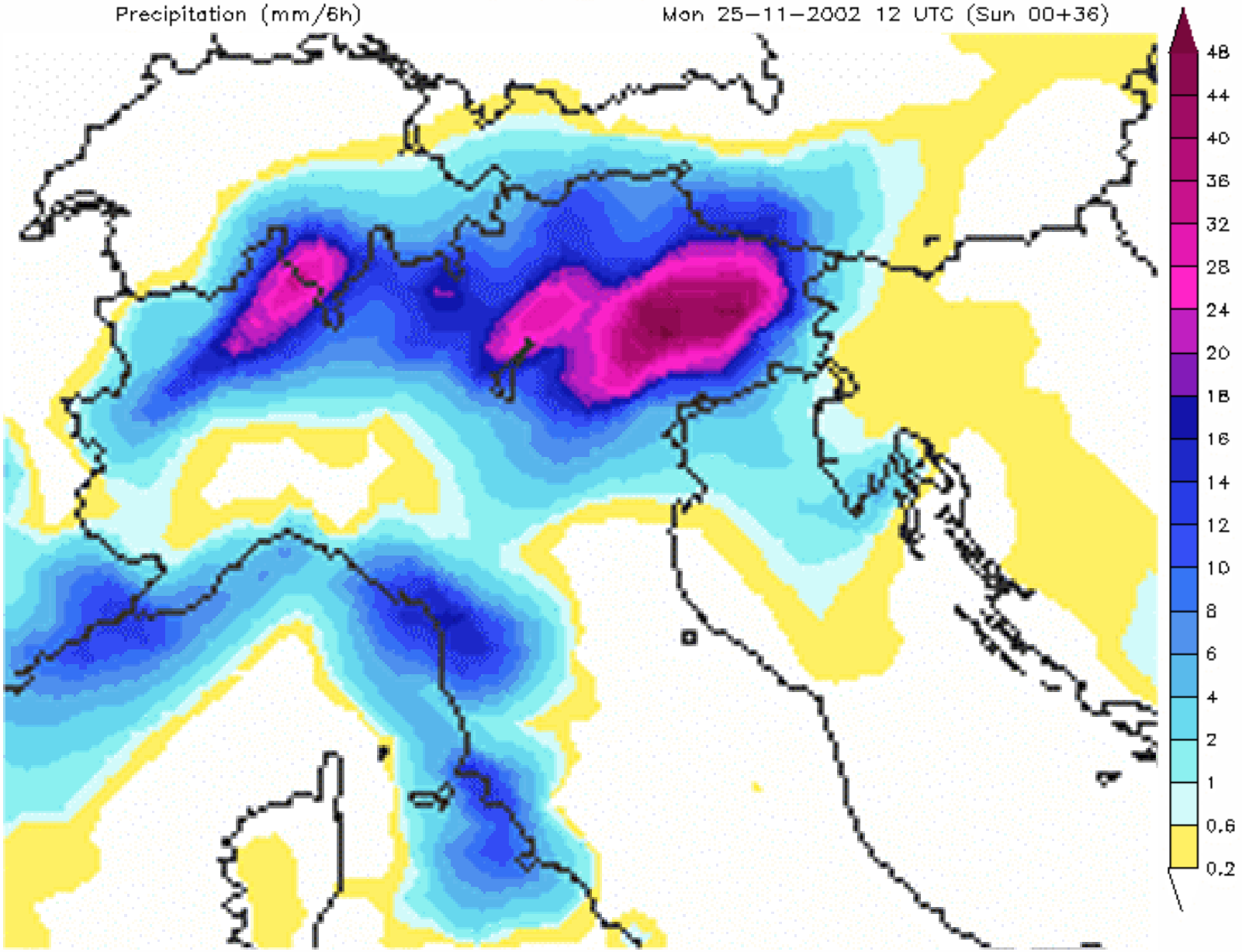
Resolution = 0.15° ≅ 11 km

Step dt= 60 s

38 atmospheric levels

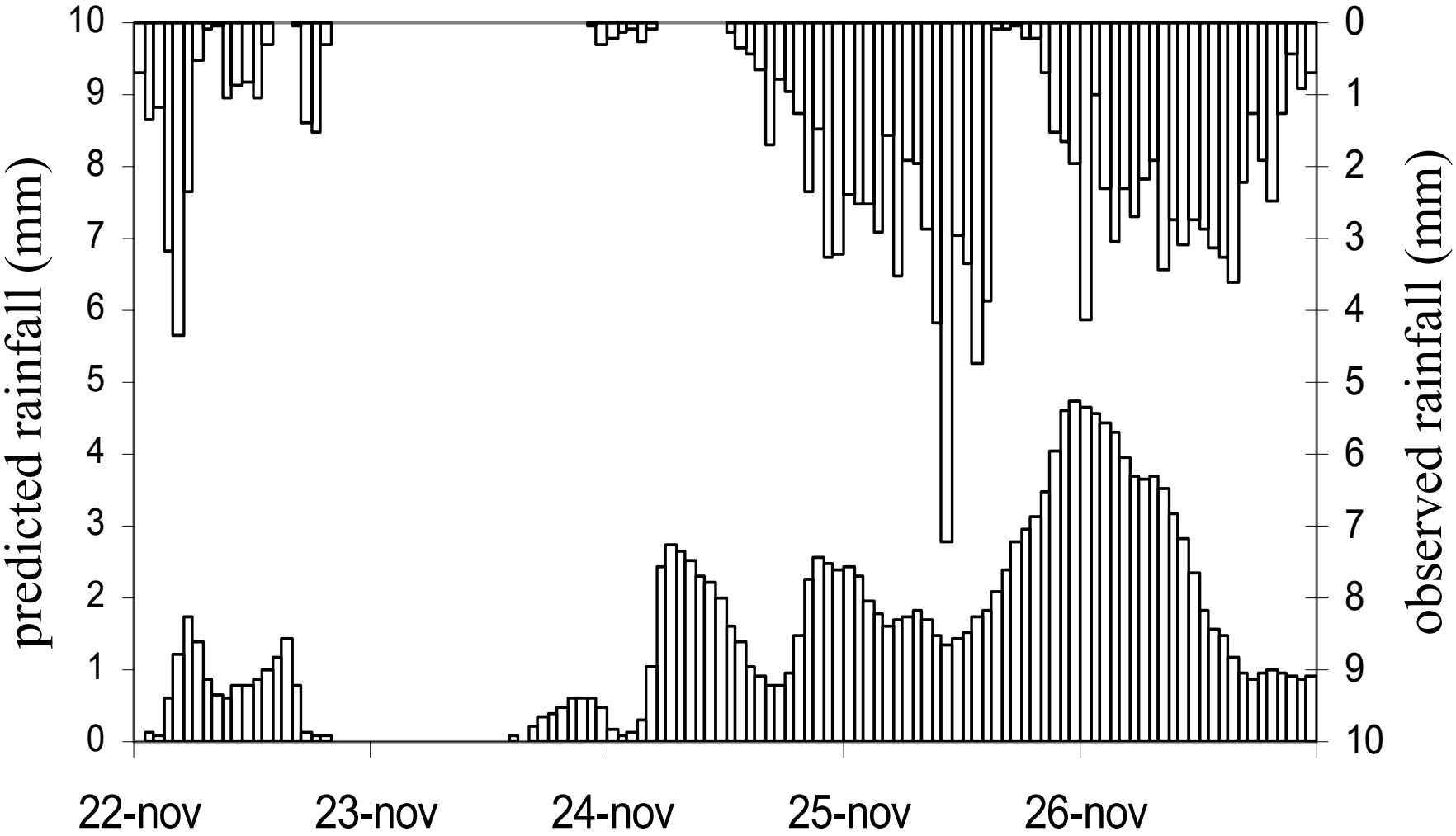
Initial ... and boundary conditions...





Fornito da: A. Sano', IlMeteo

Predicted vs. observed rainfall volumes



Forecasted hydrographs