University of Basilicata (Potenza)

Dept. of Environmental Engineering and Physics (DIFA)

SWAT2003
2nd
International SWAT Conference
July 1-4 2003
Bari, Italy

A comparison between Swat and a distributed hydrologic and water quality model for the Camastra basin (Southern Italy).

Aurelia Sole
Donatella Caniani
Ignazio Mancini

Objectives

- ✓ Use a distributed hydrologic model to improve understanding of the hydrology, water balance and water quality in the Camastra river basin (southern Italy).
- ✓ Make a comparison between Swat and the distributed hydrologic model results
- ✓ Test and validate model results.

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Overview

- ✓ THE DISTRIBUTED MODEL
  - Input data
  - Theory
- ✓ SWAT MODEL
  - Input data
- ✓ RESULTS AND DISCUSSION
  - Comparison among SWAT, distributed model and observed daily discharge for 4 years of simulation

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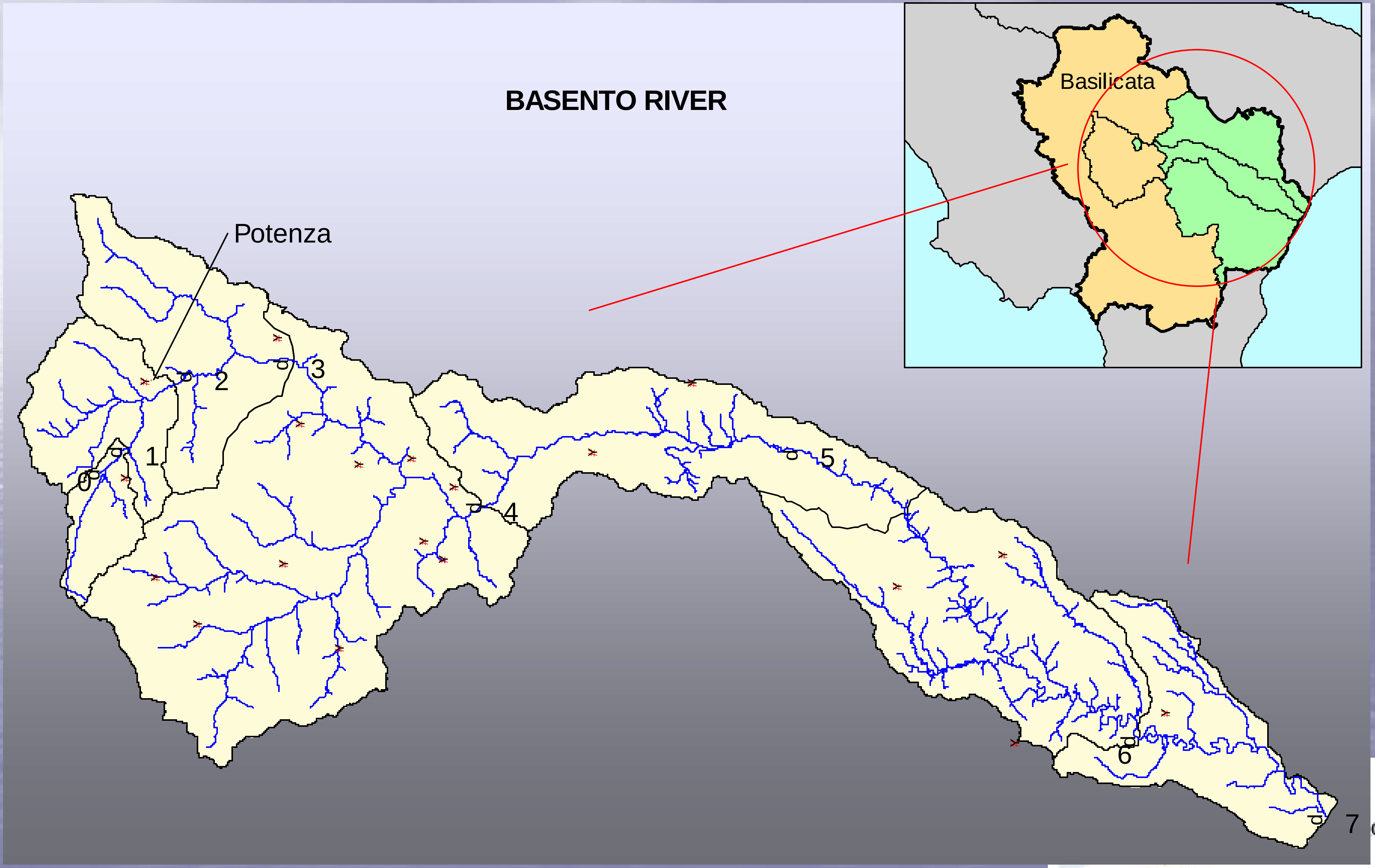
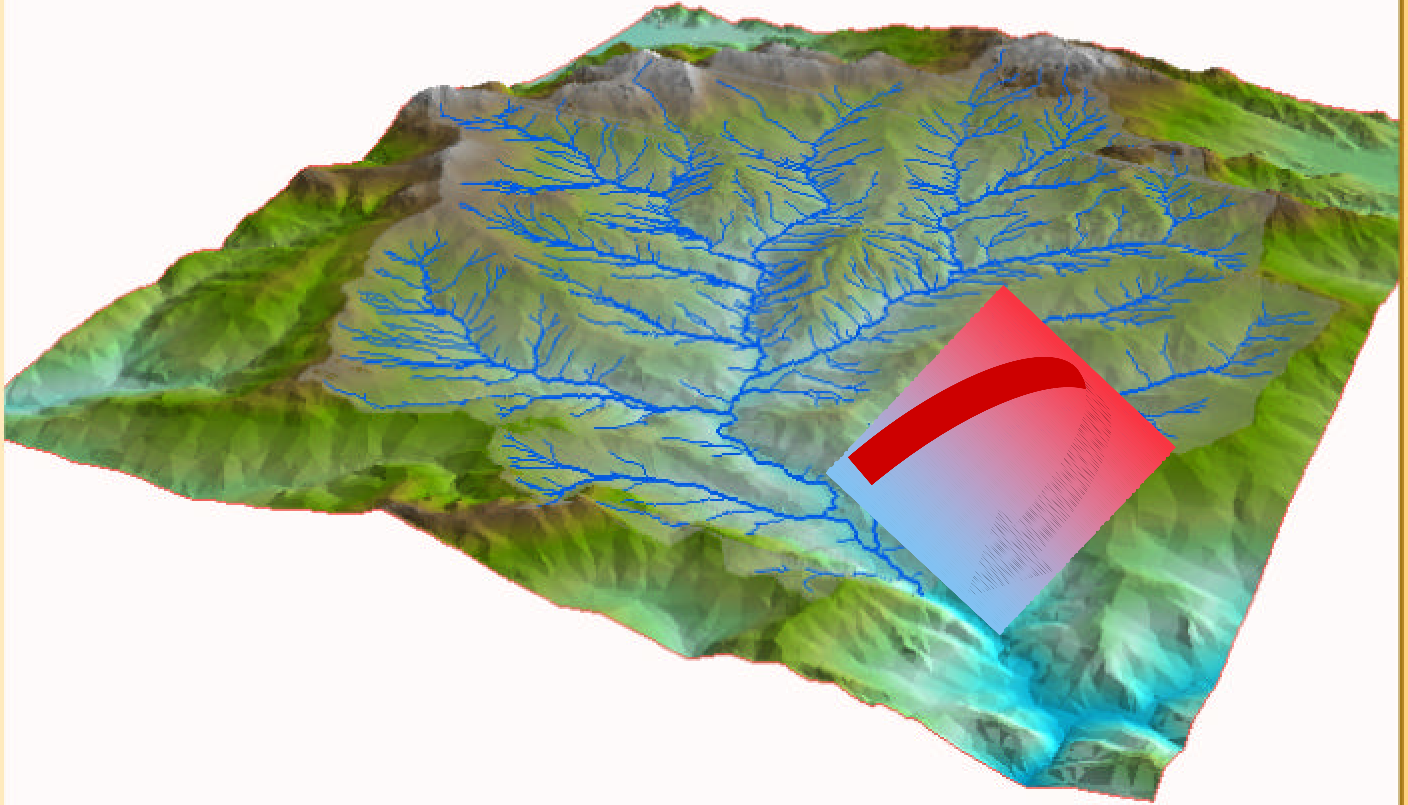
Distributed model



Bacino idrografico del torrente Camastra



Modello tridimensionale e reticolo idrografico

Input data

Input data for hydrologic distributed model

DEM

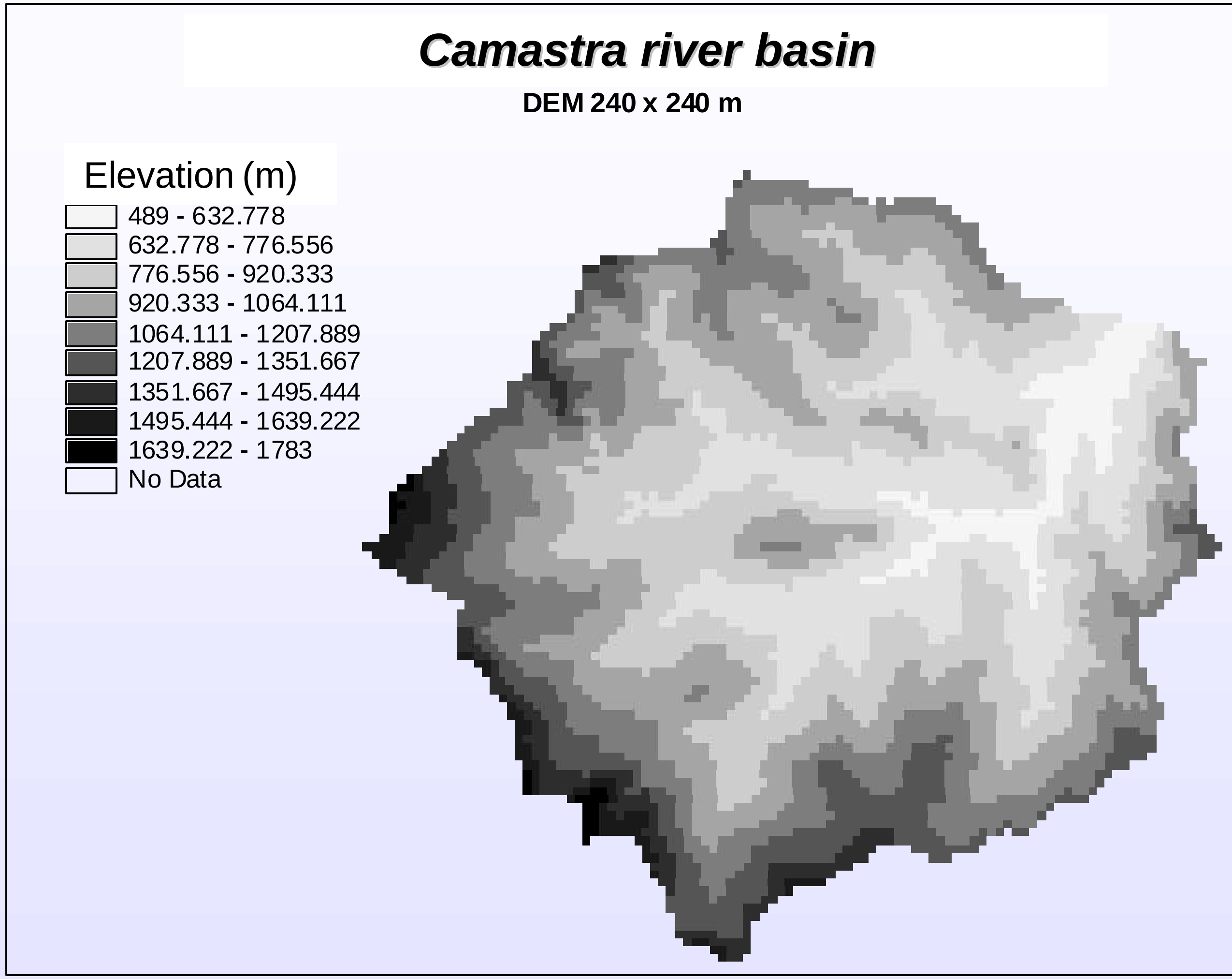
- ✓ Flow direction grid
- ✓ Flow accumulation grid
- ✓ Streams
- ✓ Basin

Burning in procedure

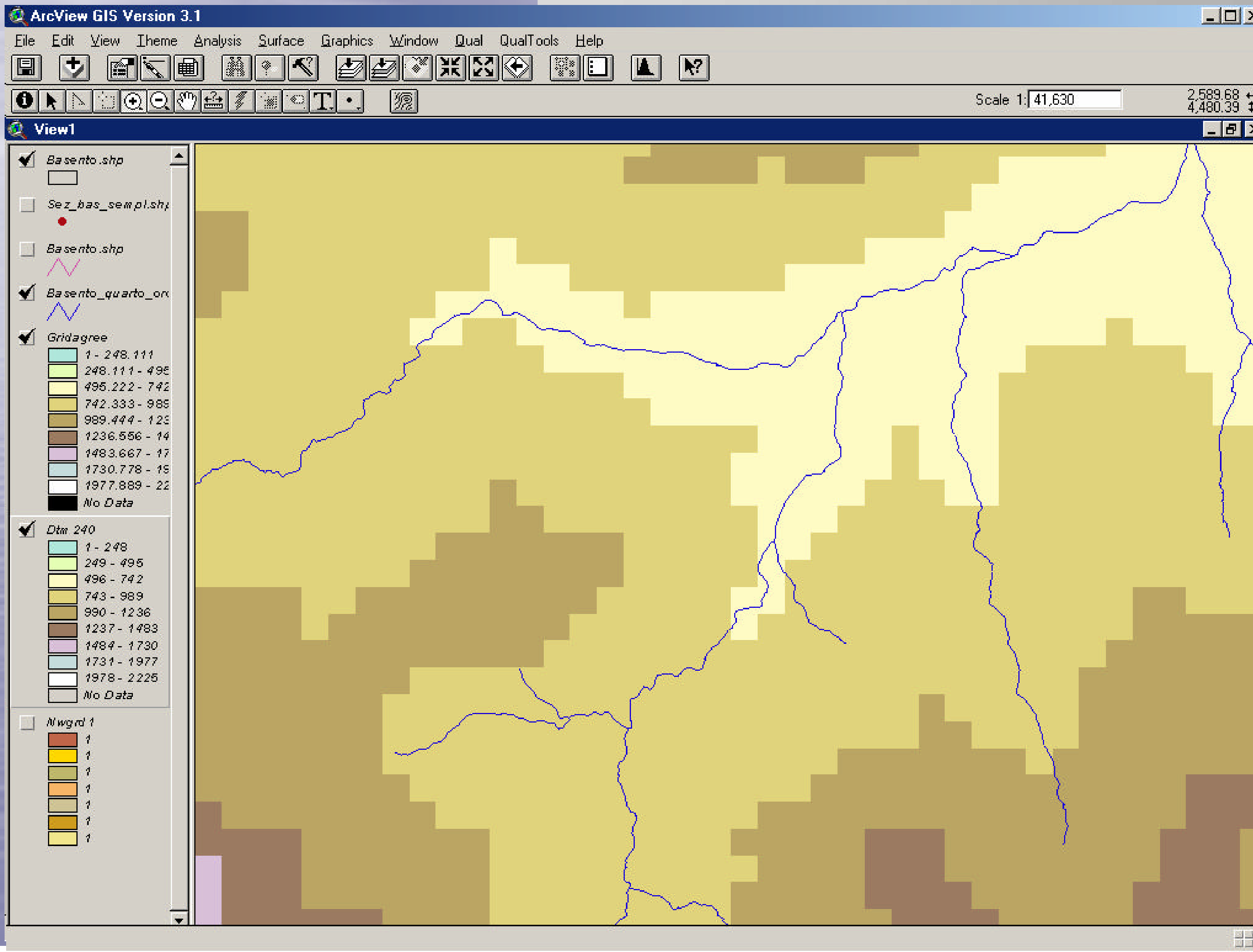
Land use map

Digital Elevation Model

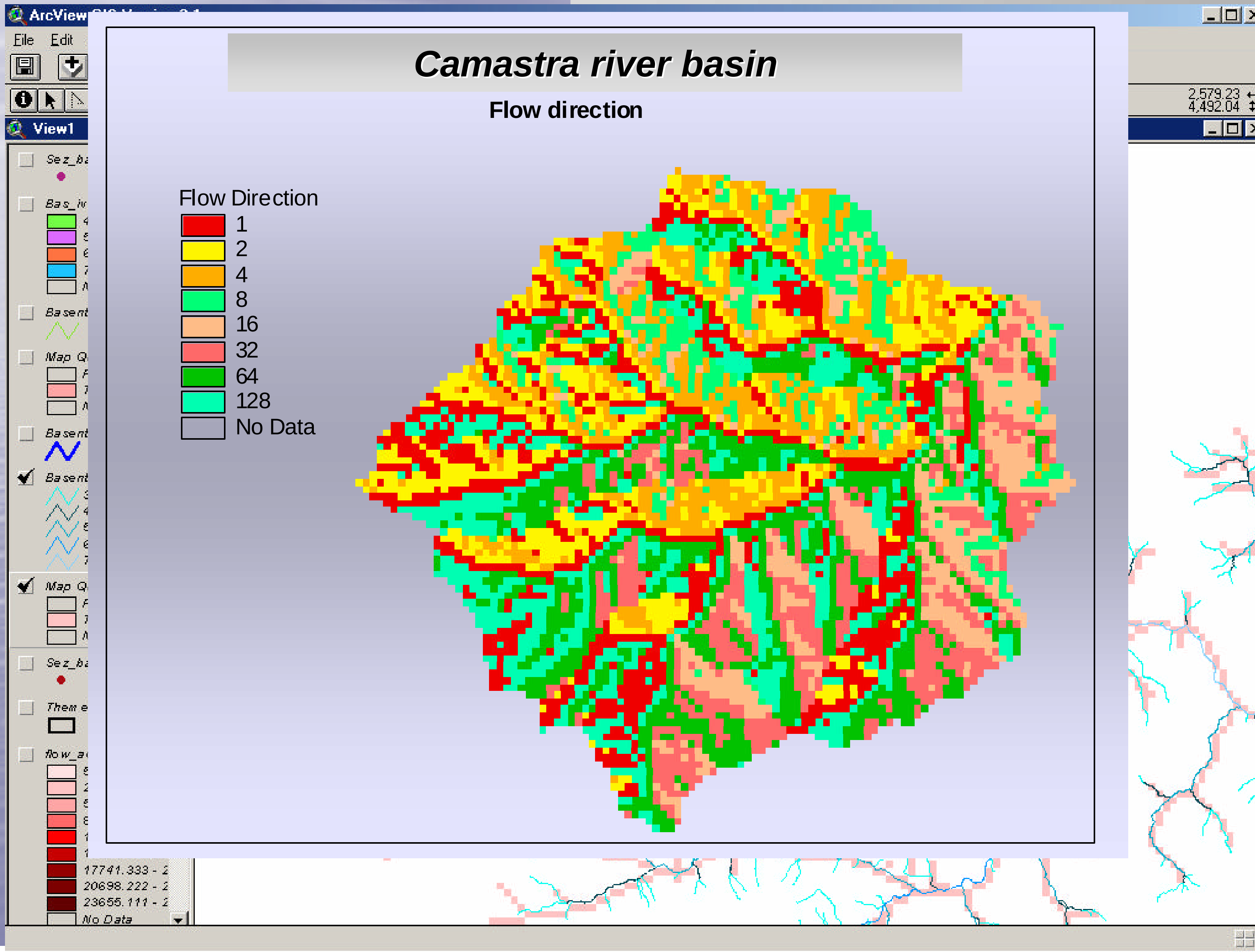
- ✓ Basin Area: 350 km^2
- ✓ 94 rows
- ✓ 102 columns
- ✓ 240 m grid



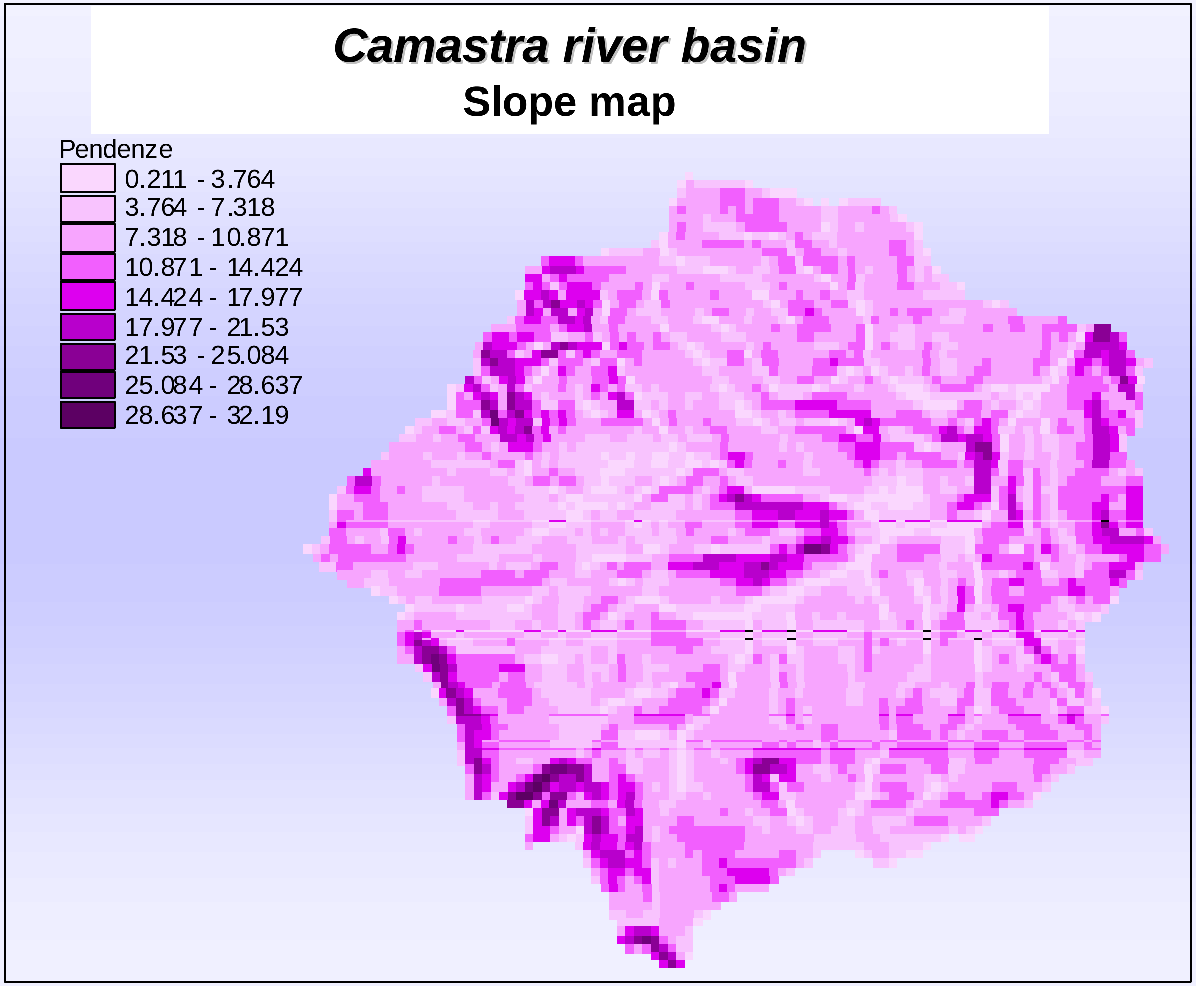
Dem recoditioning



Stream network extraction and basin delineation

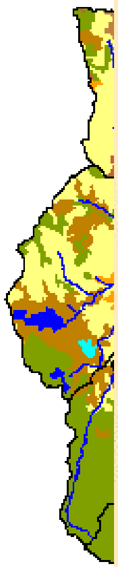


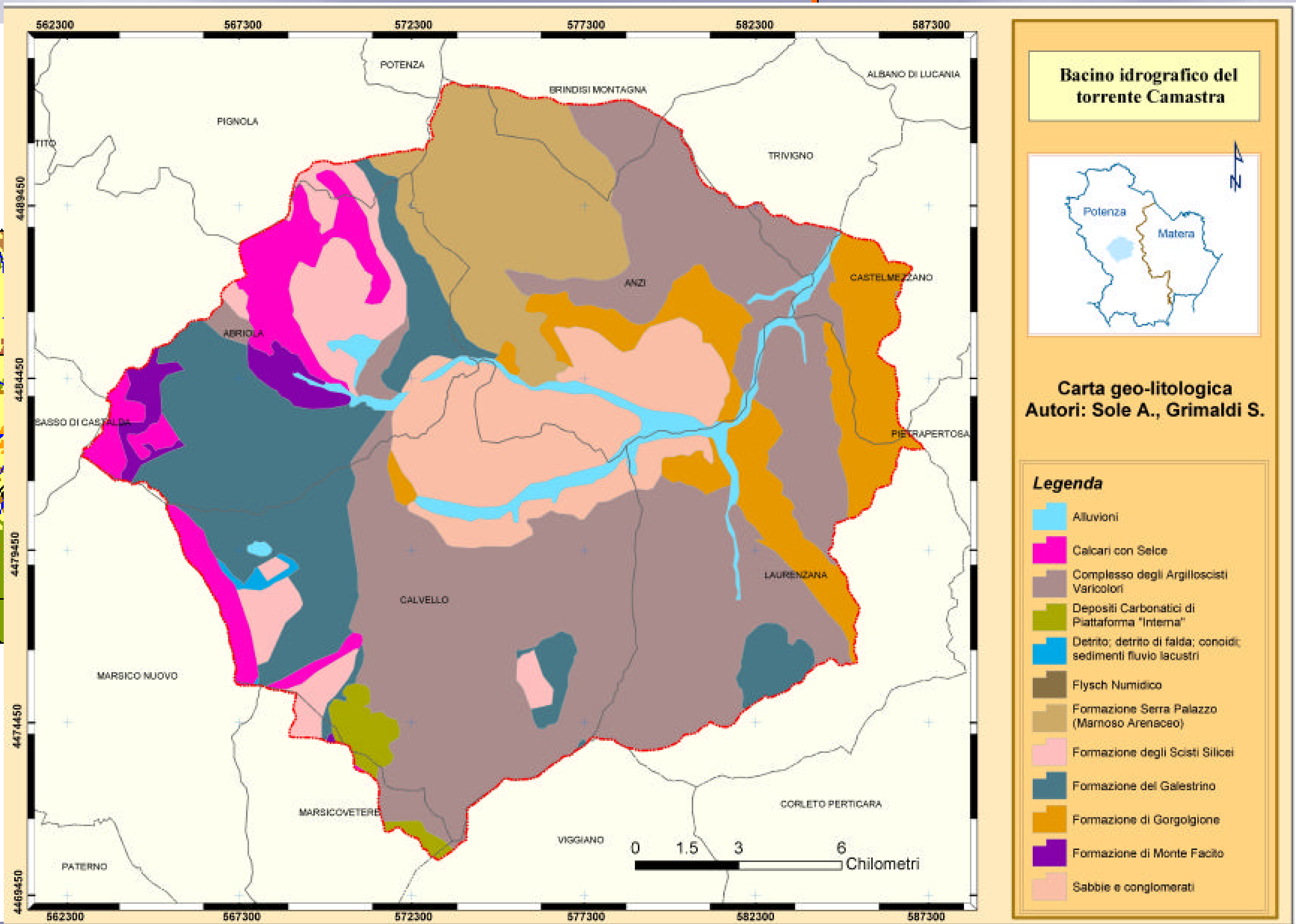
Slope



Camastra river basin
Slope map
Pendenze
0.211 - 3.764
3.764 - 7.318
7.318 - 10.871
10.871 - 14.424
14.424 - 17.977
17.977 - 21.53
21.53 - 25.084
25.084 - 28.637
28.637 - 32.19

Land use and soils maps





crops

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Distributed model

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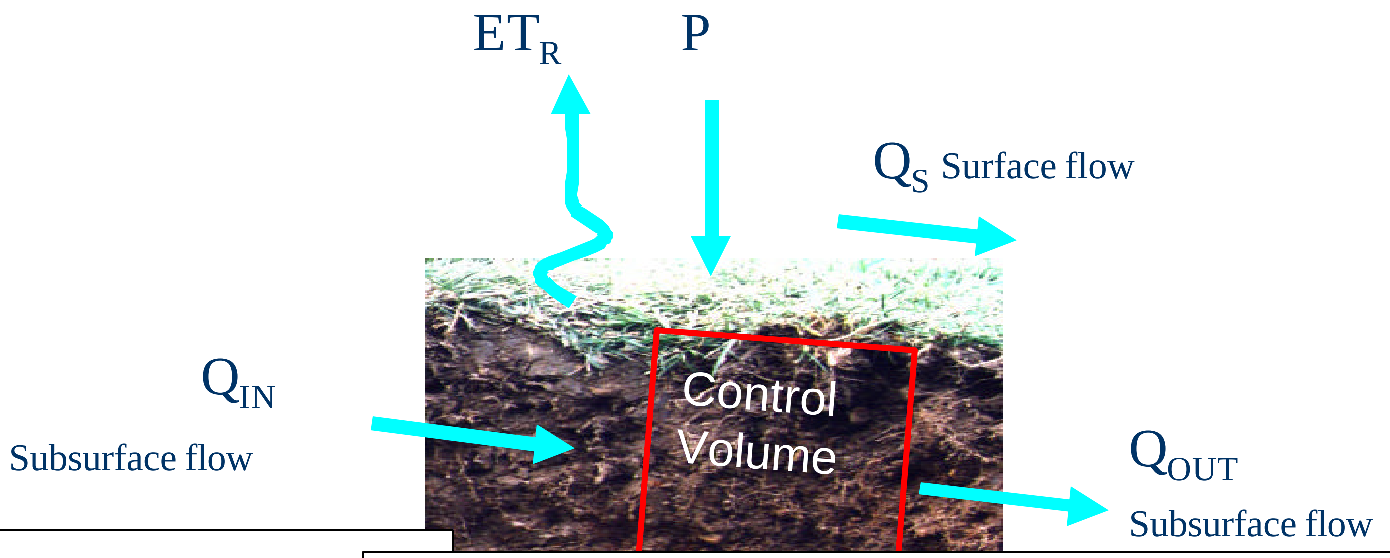


Runoff

$$Q_S = CP \frac{(q_t - q_0)}{(q_s - q_0)}$$

De Smedt (2000)

- ✓ *C* runoff coefficient
- ✓ P net precipitation (*mm*)
- ✓ q_t soil moisture content *at time t (mm)*
- ✓ q_S saturated soil moisture content *(mm)*
- ✓ q_0 residual soil moisture (*mm*)

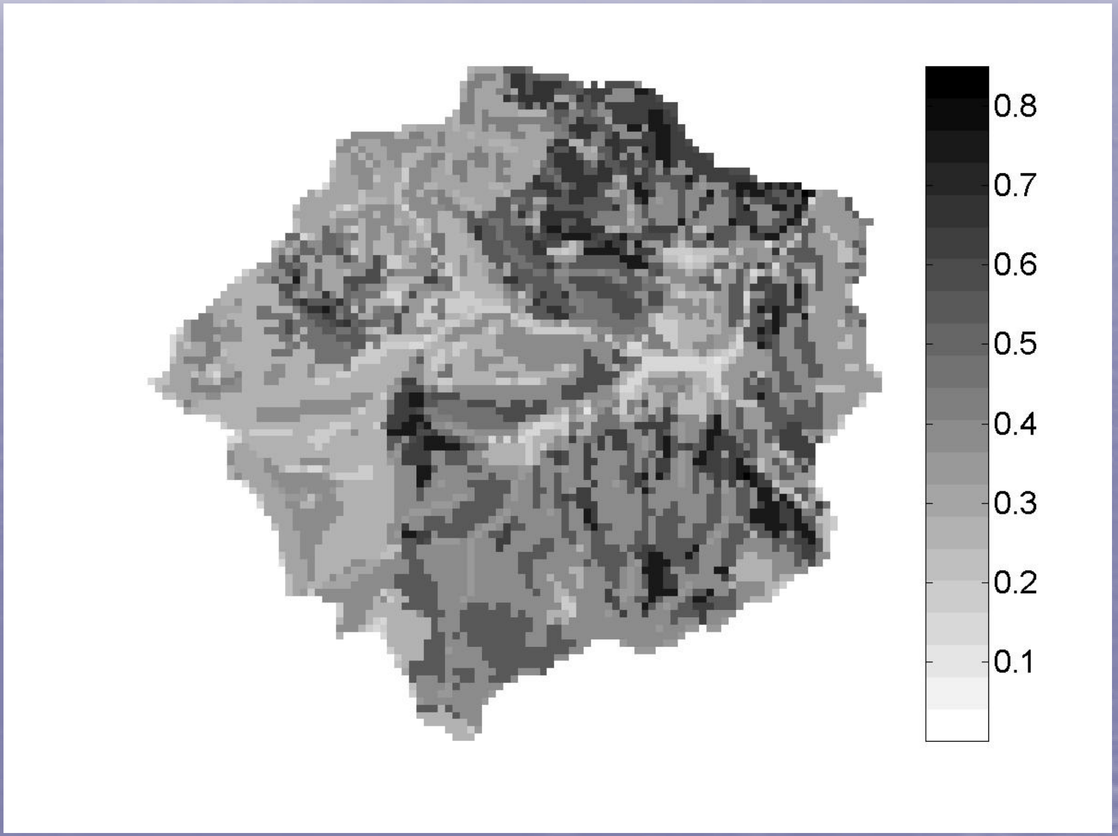
Distributed model

Runoff

$$Q_S = CP\frac{(q_t - q_0)}{(q_s - q_0)}$$

De Smedt (2000)

Runoff coefficient, C

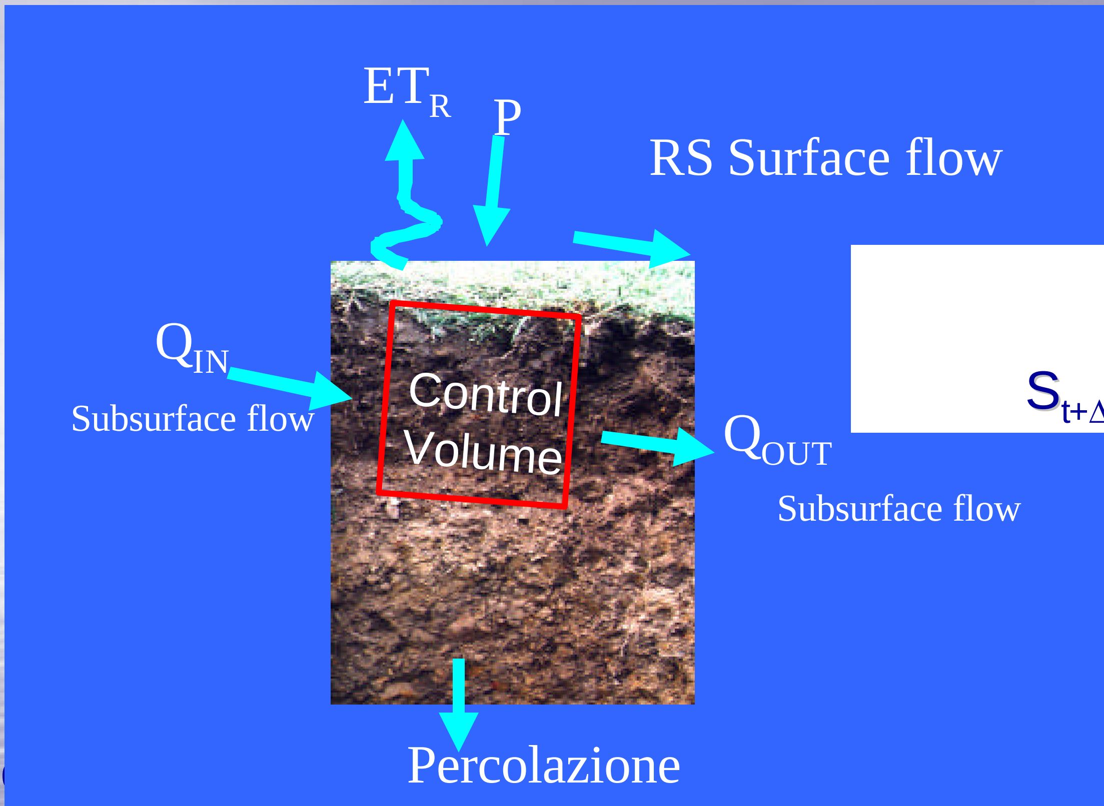


Distributed model

Default runoff coefficient Mallant e Feyen (1990)

Land Use	Slope (%)	Sand	Loamy sand	Sandy Loam	Silty Loam	Silt	Loam	Sandy Clay Loam	Silty Clay Loam	Clay Loam	Sandy Clay	Silty Clay	Clay
Forest	<0.5	0,03	0,07	0,10	0,13	0,17	0,20	0,23	0,27	0,30	0,33	0,37	0,40
	0.5-5	0,12	0,13	0,15	0,17	0,19	0,22	0,25	0,28	0,32	0,36	0,40	0,45
	5-10	0,17	0,19	0,21	0,23	0,25	0,27	0,29	0,32	0,35	0,39	0,44	0,50
	>10	0,23	0,27	0,30	0,33	0,37	0,40	0,43	0,47	0,50	0,53	0,57	0,60
Grass	<0.5	0,03	0,07	0,10	0,13	0,17	0,20	0,23	0,27	0,30	0,33	0,37	0,40
	0.5-5	0,07	0,09	0,12	0,15	0,18	0,21	0,24	0,28	0,32	0,36	0,40	0,45
	5-10	0,15	0,15	0,16	0,18	0,20	0,23	0,27	0,31	0,36	0,42	0,48	0,55
	>10	0,20	0,21	0,22	0,24	0,26	0,29	0,33	0,37	0,42	0,47	0,53	0,60
Crop	<0.5	0,23	0,27	0,30	0,33	0,37	0,40	0,43	0,47	0,50	0,53	0,57	0,60
	0.5-5	0,27	0,31	0,34	0,37	0,41	0,44	0,47	0,51	0,54	0,57	0,61	0,64
	5-10	0,33	0,37	0,40	0,43	0,47	0,50	0,53	0,57	0,60	0,63	0,67	0,70
	>10	0,45	0,49	0,52	0,55	0,59	0,62	0,65	0,69	0,72	0,75	0,79	0,82
Bare Soil	<0.5	0,33	0,37	0,40	0,43	0,47	0,50	0,53	0,57	0,60	0,63	0,67	0,70
	0.5-5	0,37	0,41	0,44	0,47	0,51	0,54	0,57	0,61	0,64	0,67	0,71	0,74
	5-10	0,43	0,47	0,50	0,53	0,57	0,60	0,63	0,67	0,70	0,73	0,77	0,80
	>10	0,55	0,59	0,62	0,65	0,69	0,72	0,75	0,79	0,82	0,85	0,89	0,92
Impervius Area	<0.5	0,32	0,35	0,37	0,39	0,42	0,44	0,46	0,49	0,51	0,53	0,56	0,58
	0.5-5	0,35	0,37	0,38	0,40	0,42	0,45	0,47	0,50	0,52	0,55	0,58	0,62
	5-10	0,40	0,41	0,41	0,42	0,44	0,46	0,49	0,52	0,55	0,59	0,64	0,69
	>10	0,44	0,44	0,45	0,47	0,48	0,51	0,53	0,56	0,59	0,63	0,67	0,72

Distributed model



Soil moisture storage

$$S_{t+\Delta t} = S_t + F_t - E_t - RI_t - RG_t$$

- ✓ S_{t+D} = water content in the soil profile at time t+ *D*t (mm),
- ✓ S_t = total soil water content at time t (mm),
- ✓ F_t = infiltration amount into the soil during the time t (Qin+P-RS)
- ✓ E_t = actual evapotranspiration from the soil during the time t (mm),
- ✓ RI_t = lateral in and out subsurface flow of the soil during time t (mm)
- ✓ RG_t = groundwater recharge during time t (mm).

Distributed model

The subsurface flow starts when the soil water content exceeds the field capacity.

Subsurface lateral flow

$$Rl_t = \max\left(0\ ,\ c_i\,(S_t - S_C)\right)$$

where

- ✓ R_{lt} = subsurface flow during time t (mm),
- ✓ S_t = total soil water content at t time (mm),
- ✓ S_c = soil water content at field capacity at t time (mm),
- ✓ c_i = “subsurface flow coefficient”.

The percentage of water that comes into the saturated zone can be derived by the use of the Darcy law:

$$RG = K\ grad(h)$$

where

- ✓ RG= groundwater recharge (mm/h),
- ✓ K= hydraulic conductivity (mm/h),
- ✓ *grad(h)*= hydraulic gradient

Distributed model

The Irmay equation has been used in this study to calculate the groundwater recharge flow of the single cell:

$$RG_t = K_t \Delta t = K_s \left(\frac{q_t - q_0}{n - q_0} \right)^a \Delta t = K_s \left(\frac{S_t}{S_S} \right)^a \Delta t$$

where:

- ✓ RG_t = groundwater recharge at time t (mm),
- ✓ K_t = hydraulic soil conductivity at t time (mm/h),
- ✓ K_s = saturated hydraulic conductivity (mm/h),
- ✓ n = porosity
- ✓ α = index characterizing dimension and distribution of soil porosity
- ✓ q_t soil moisture content at time t (mm)
- ✓ q_0 residual soil moisture (mm)

Distributed model

Potential evapotranspiration

$$ET_0 = k_c\, p(0.46T + 8)$$

(Blaney-Criddle equation)

where:

- ✓ k_C = crop coefficient,
- ✓ T = average temperature of the last 10 days

Actual evapotranspiration

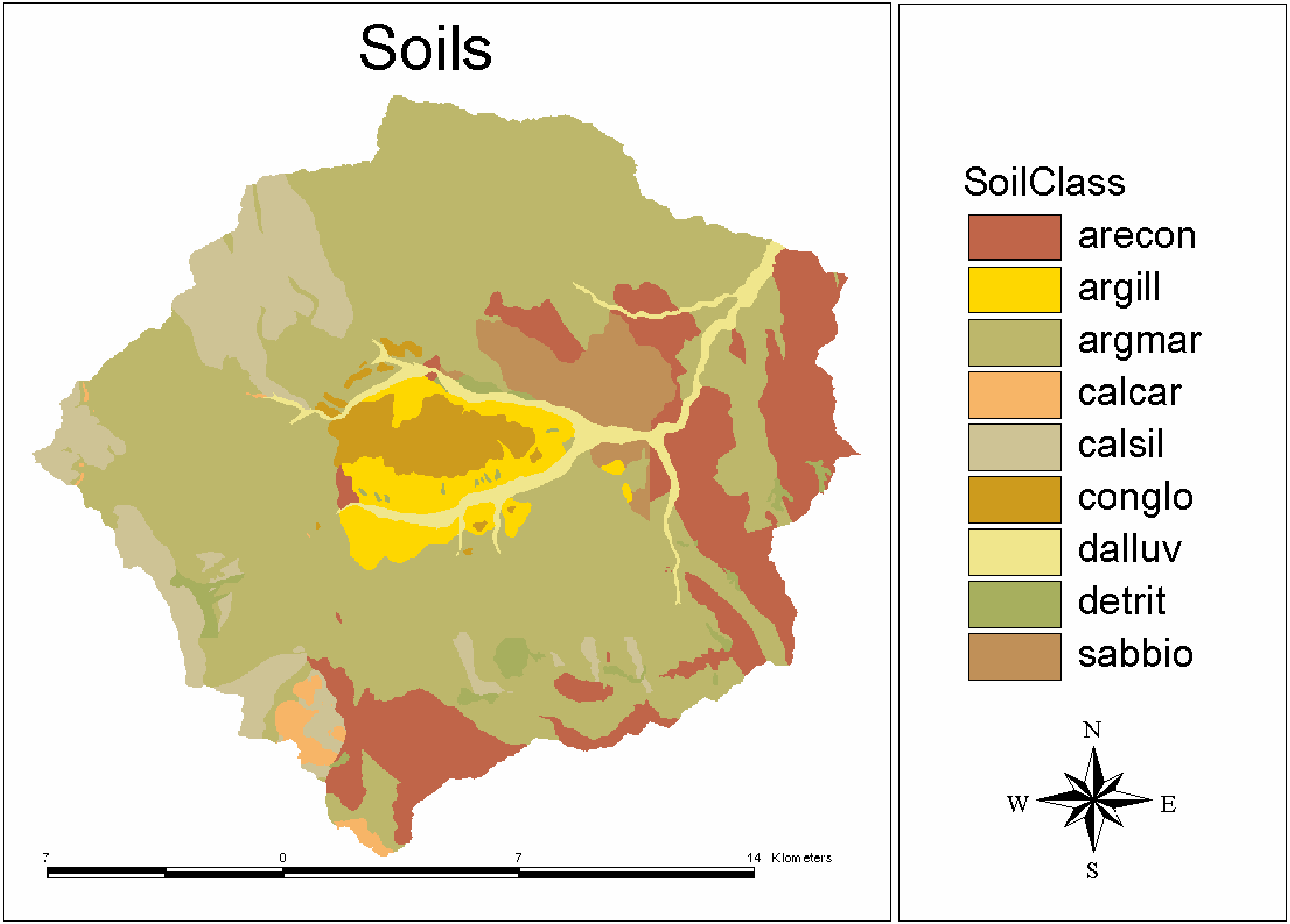
$$ET_t = (1 - e^{-b\,(qt-qo)/(qc-qo)})\, ET_0$$

(Davies ed Allen, 1973)

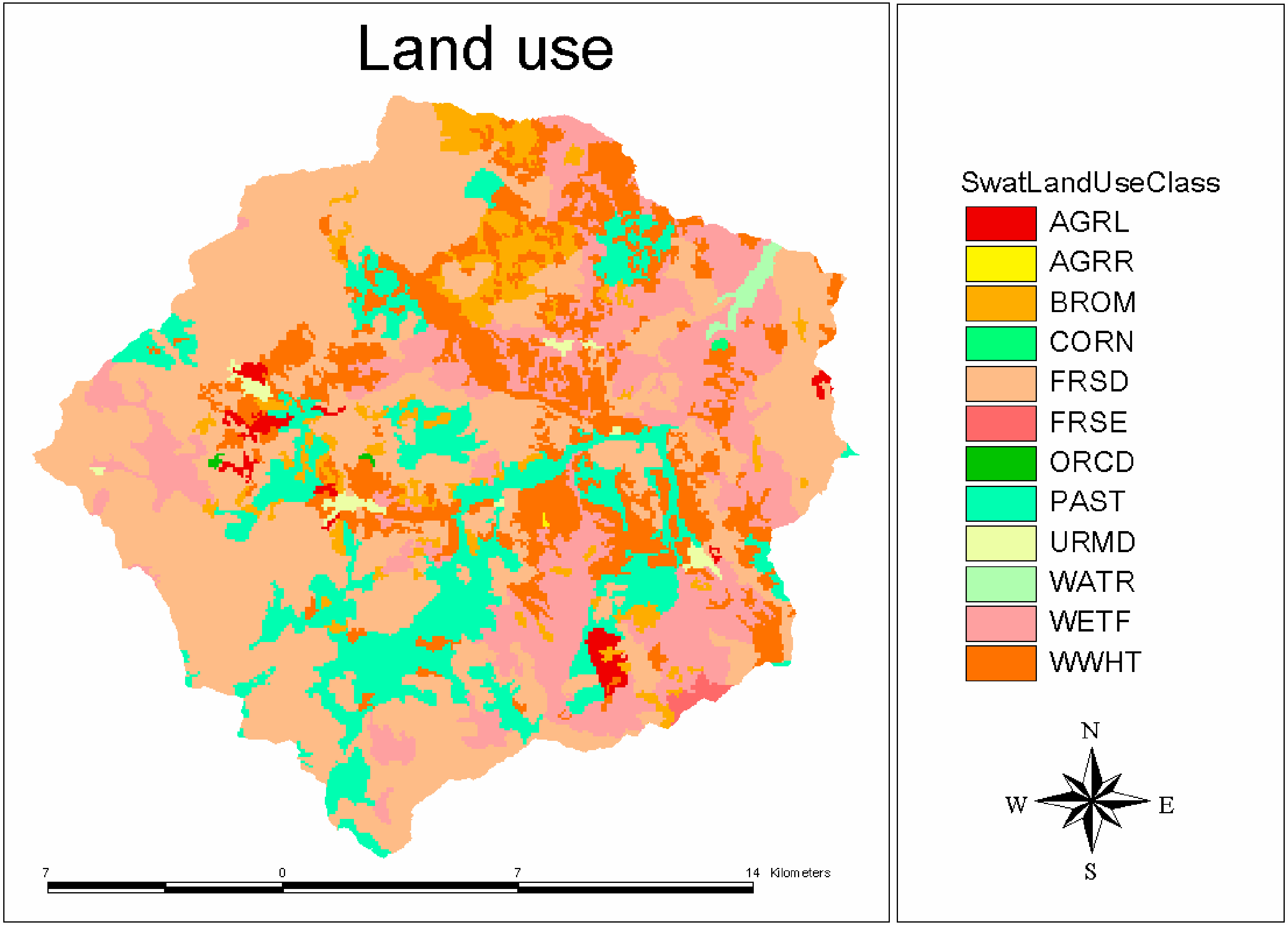
where:

- ✓ ET_t = actual evapotranspiration (mm),
- ✓ ET_0 = potential evapotranspiration at time t (mm),
- ✓ *b* = 10.56 empiric value,
- ✓ q_t = soil moisture content at time t (mm),
- ✓ q_0 = residual soil moisture (mm),
- ✓ q_C = soil moisture content at field capacity (mm).

SWAT data: soils layer

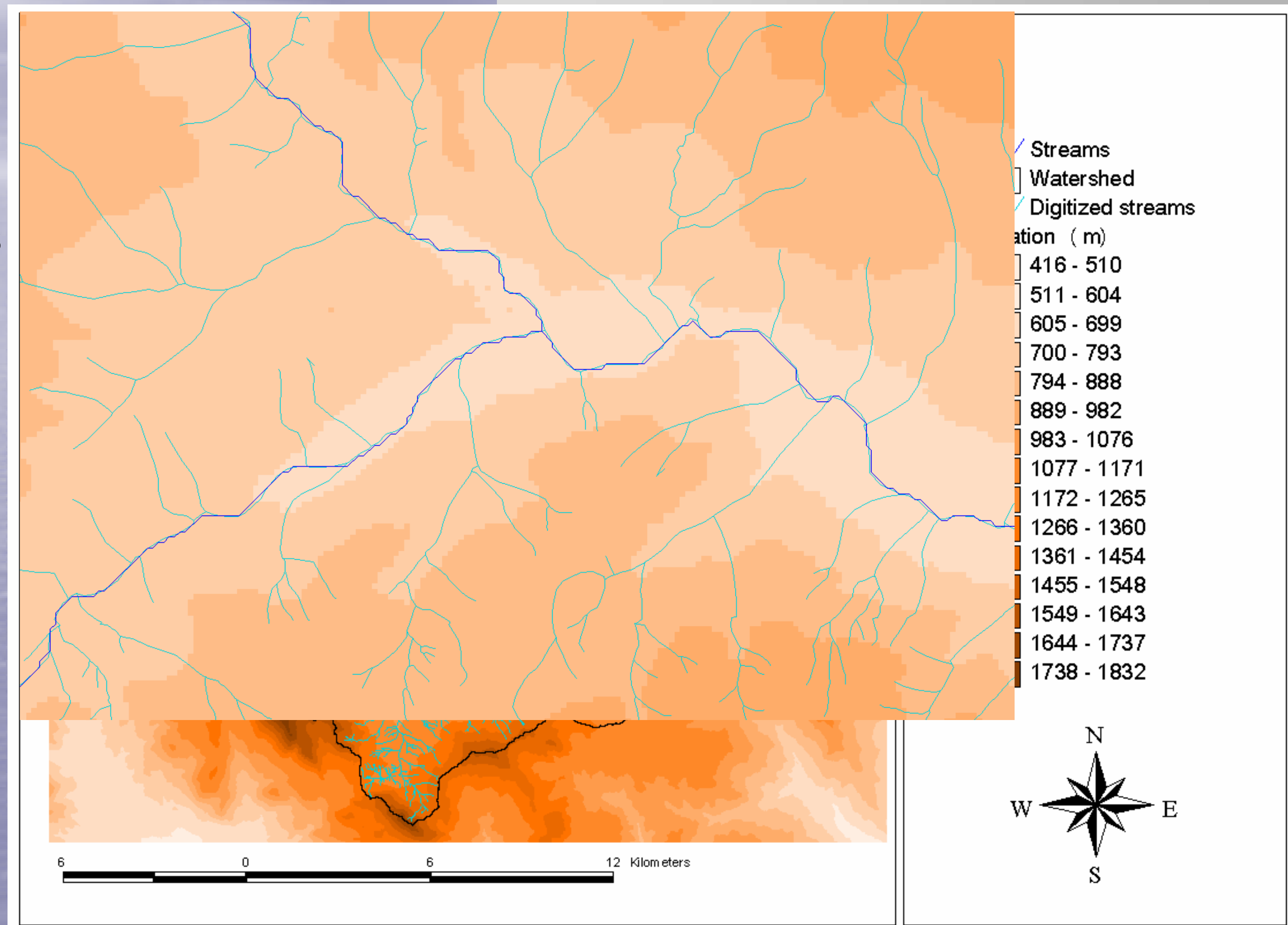


SWAT data: land use layer



SWAT data: DEM

- ✓ 1160 rows
- ✓ 1297 columns
- ✓ 20 m grid



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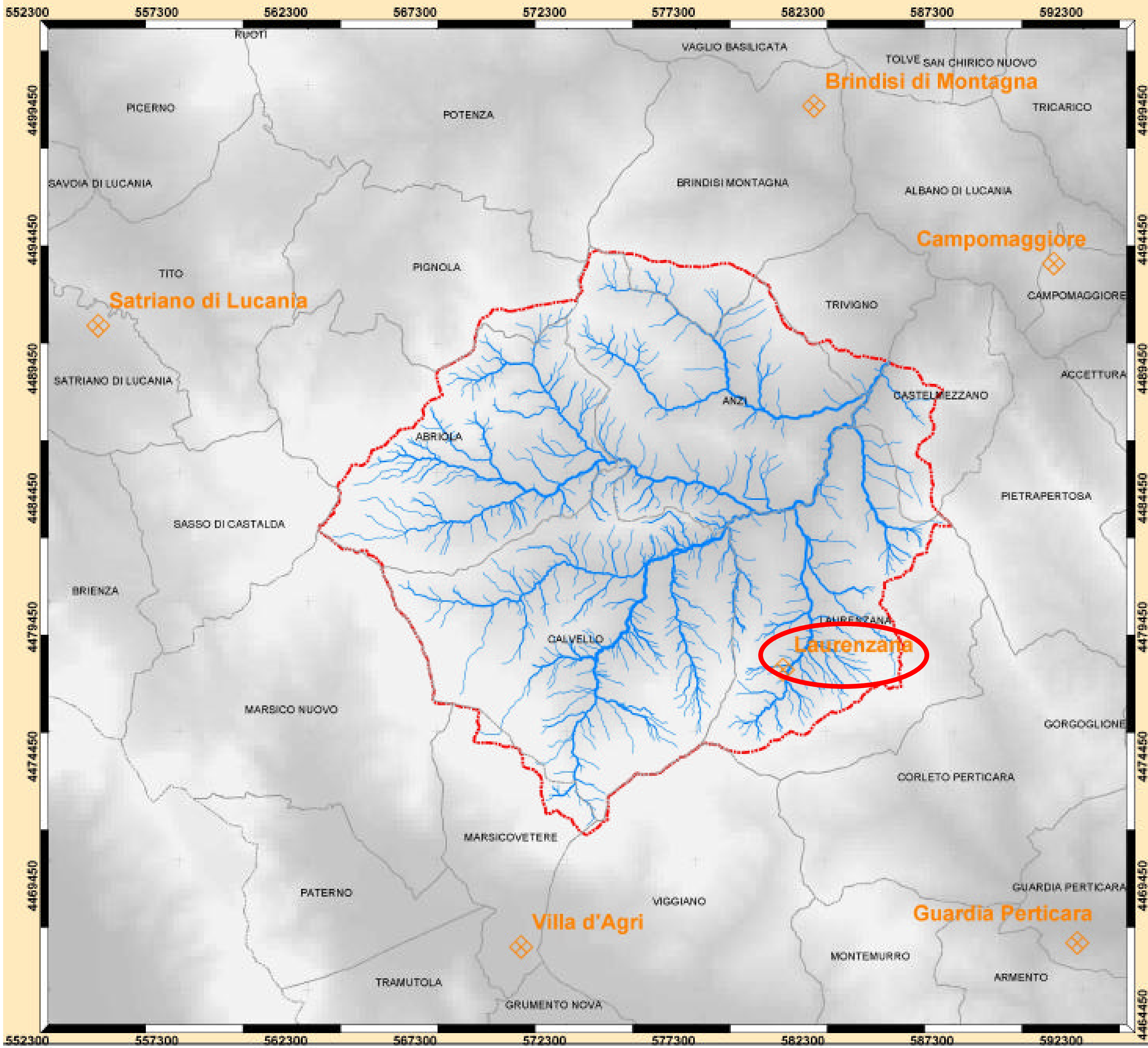
SWAT:

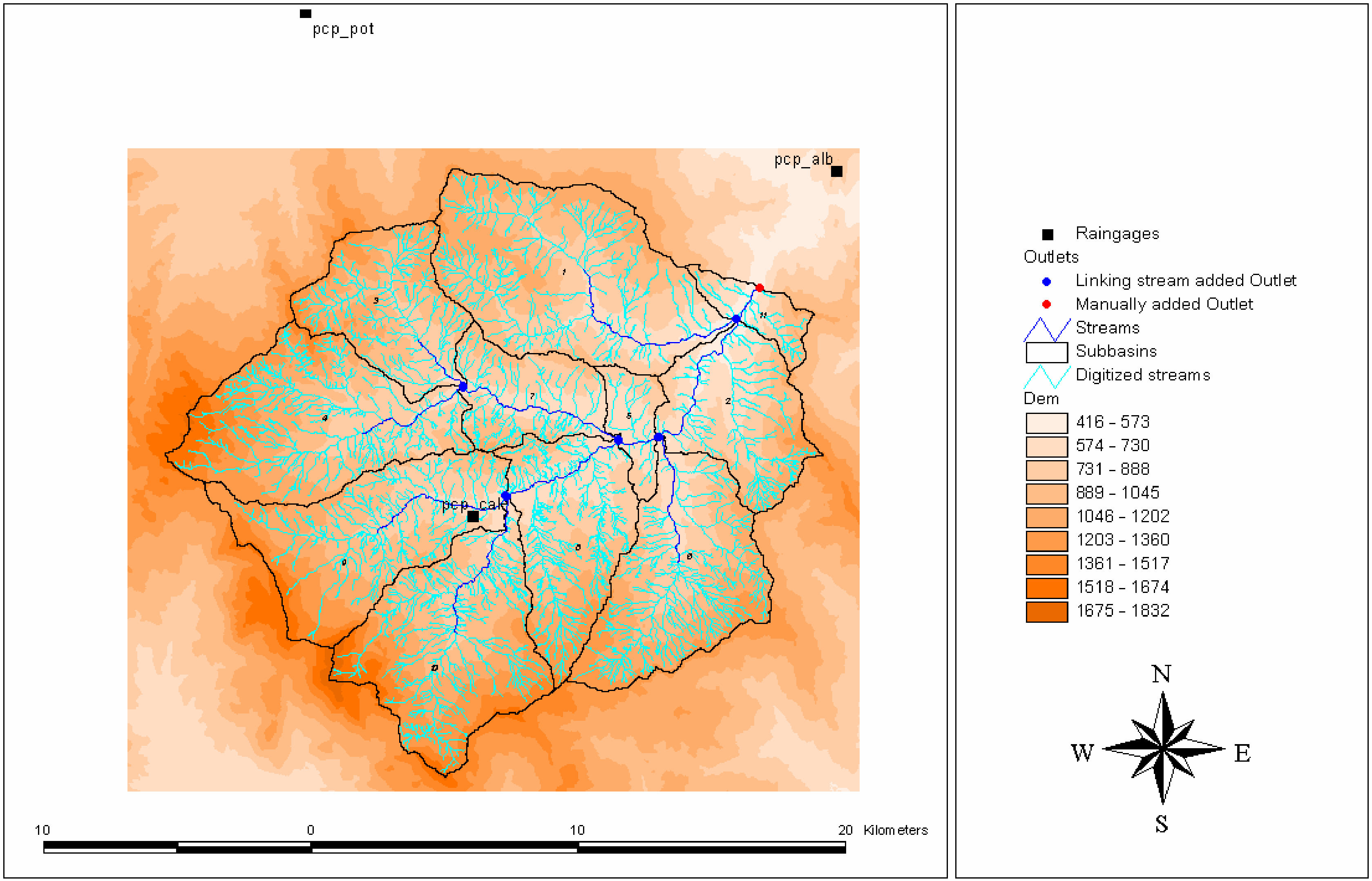


Gage location

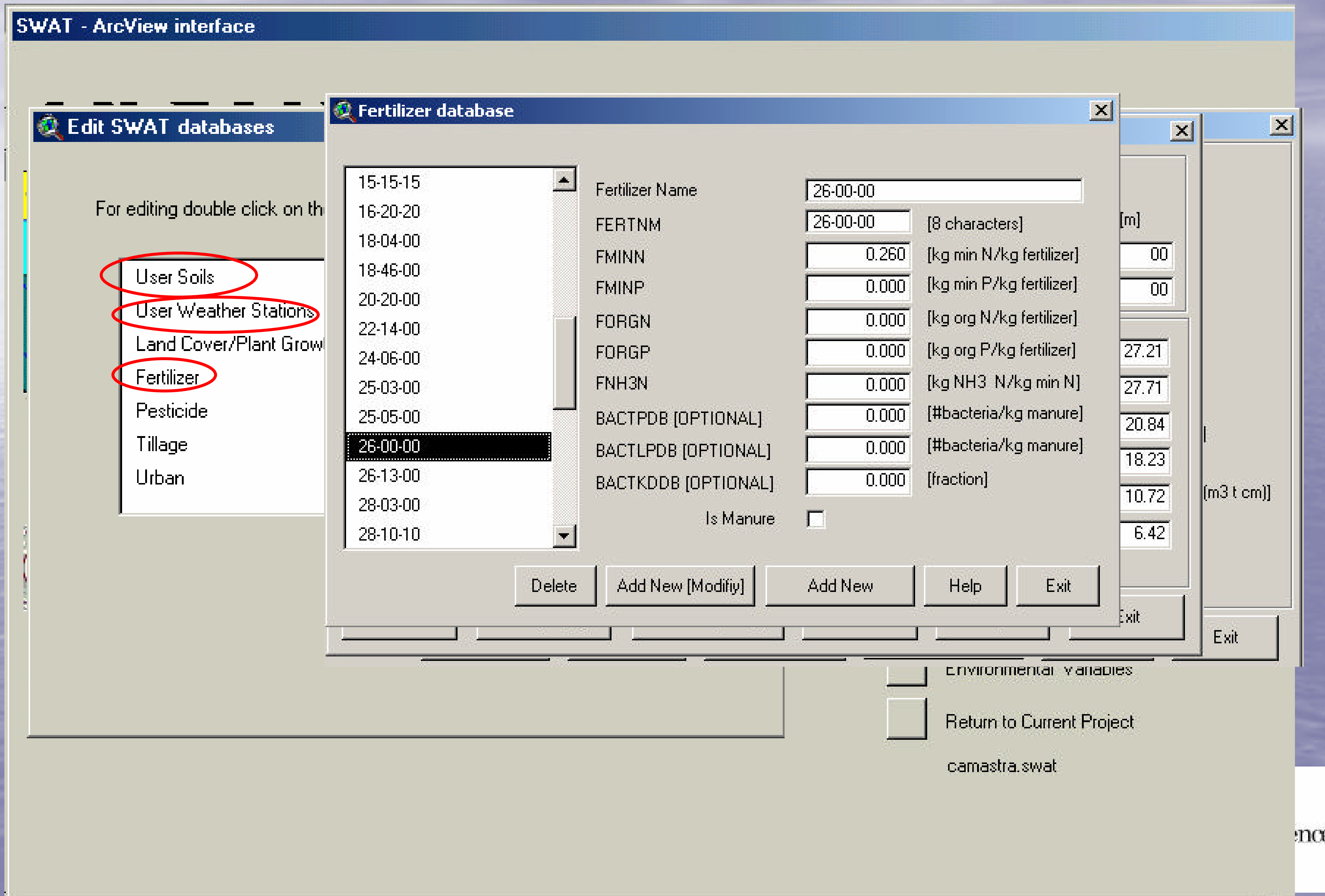
Ubicazione delle stazioni Agrometereologiche ALSIA

SWAT: meteorological data

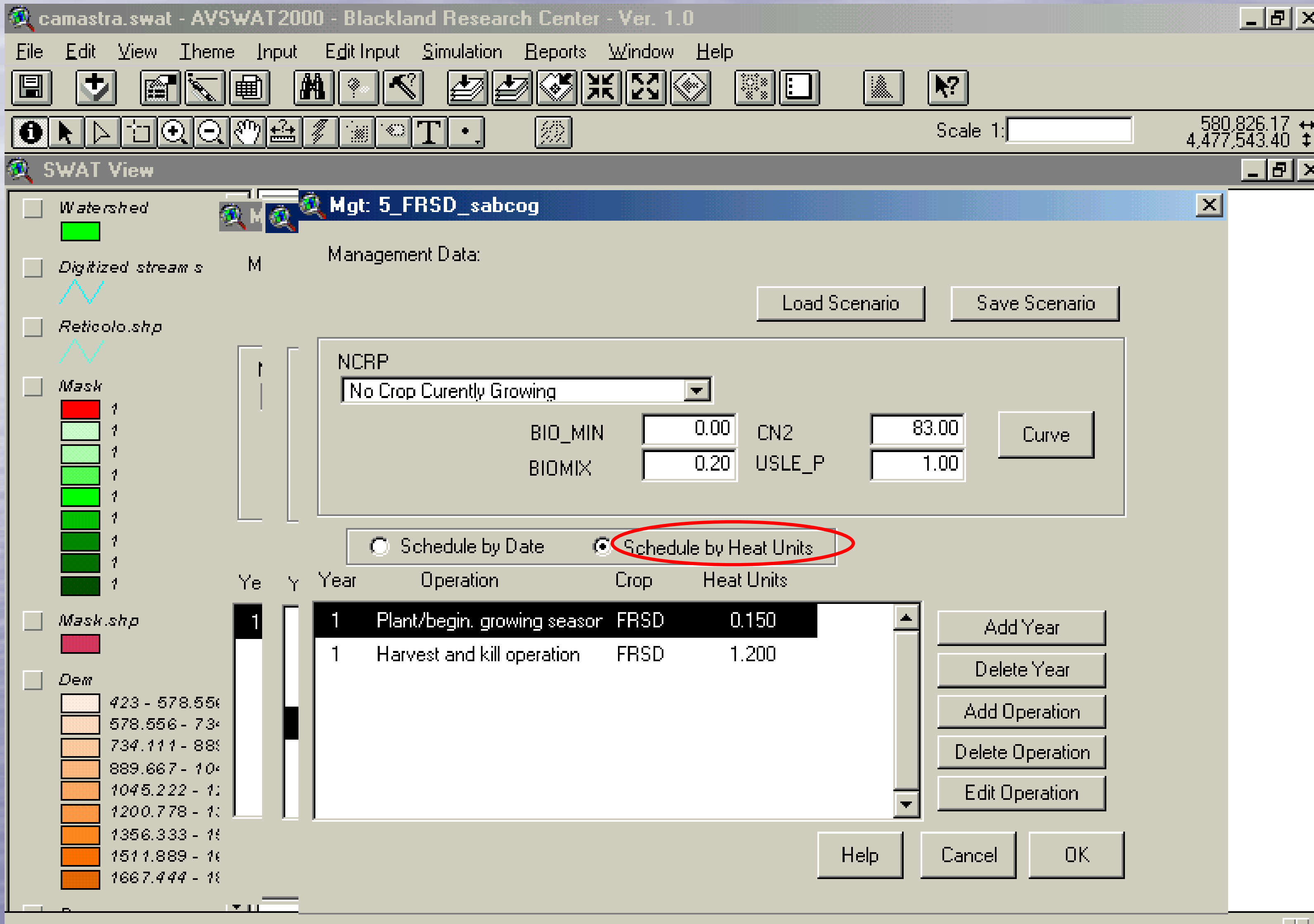
Precipitation gage location



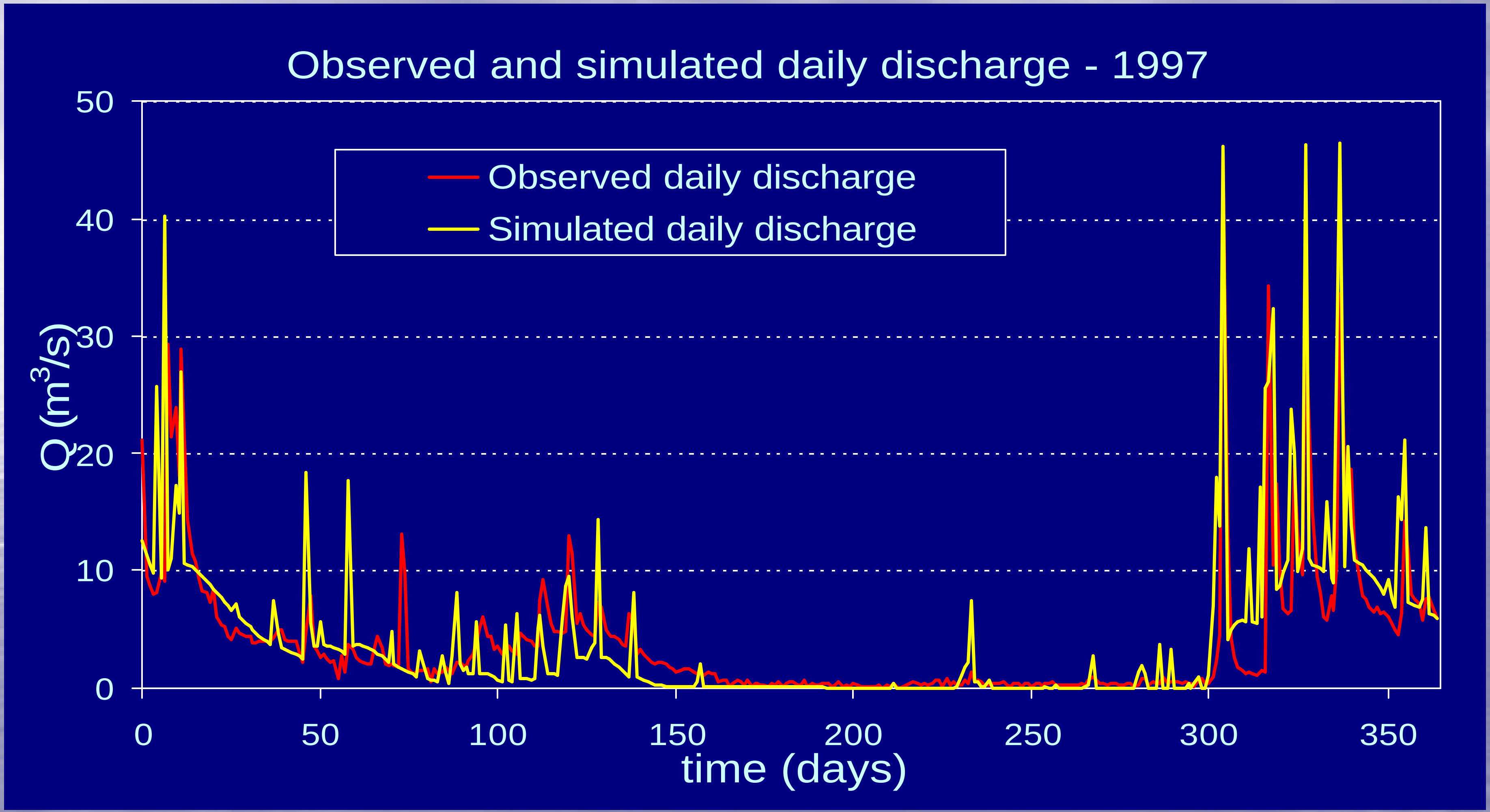
SWAT databases



SWAT: management input data



Distributed model results



Correlation coefficient 0,77

Mean square error 2,91

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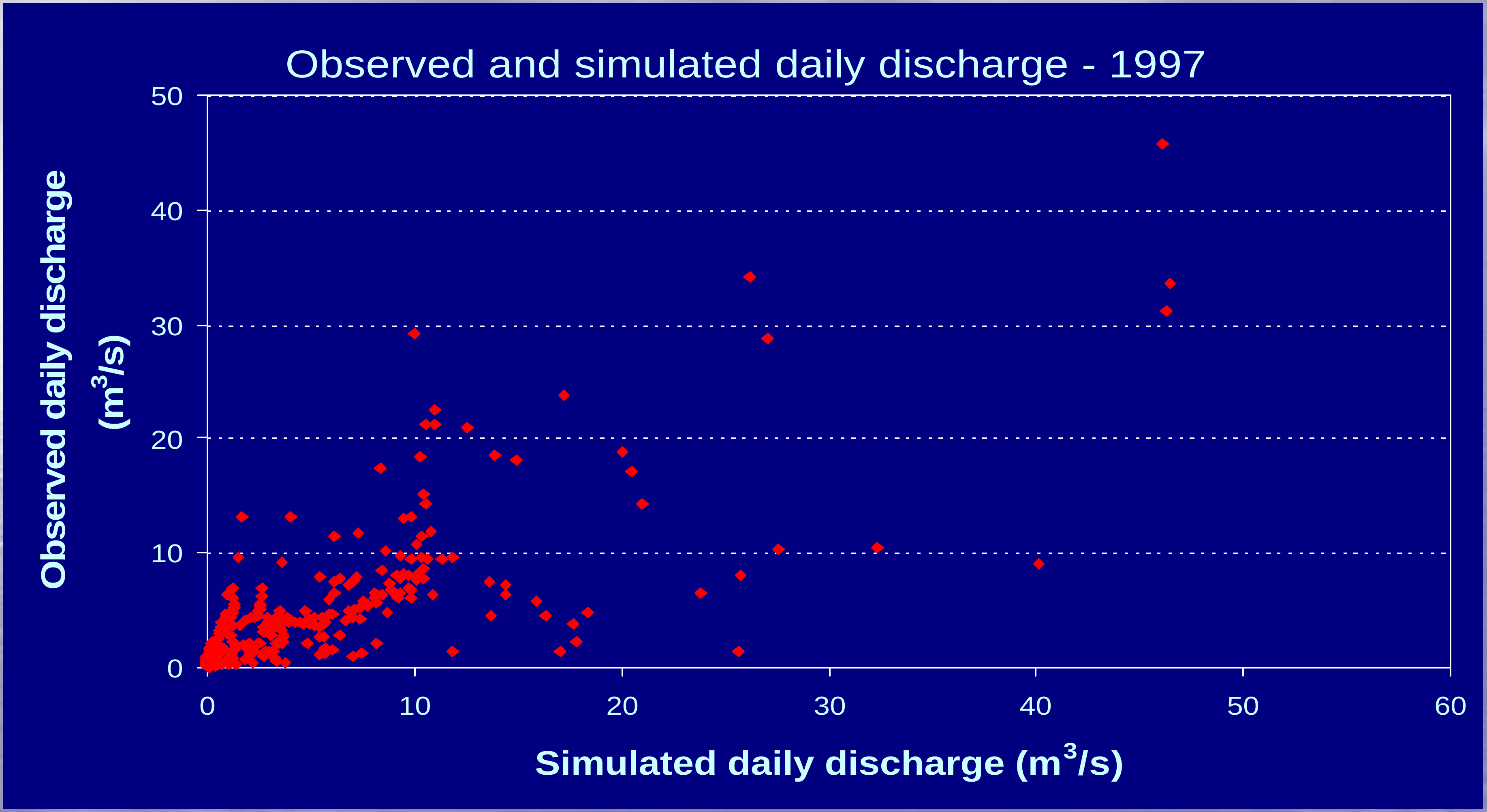
Distributed model results



Correlation coefficient 0,77

Mean square error 2,91

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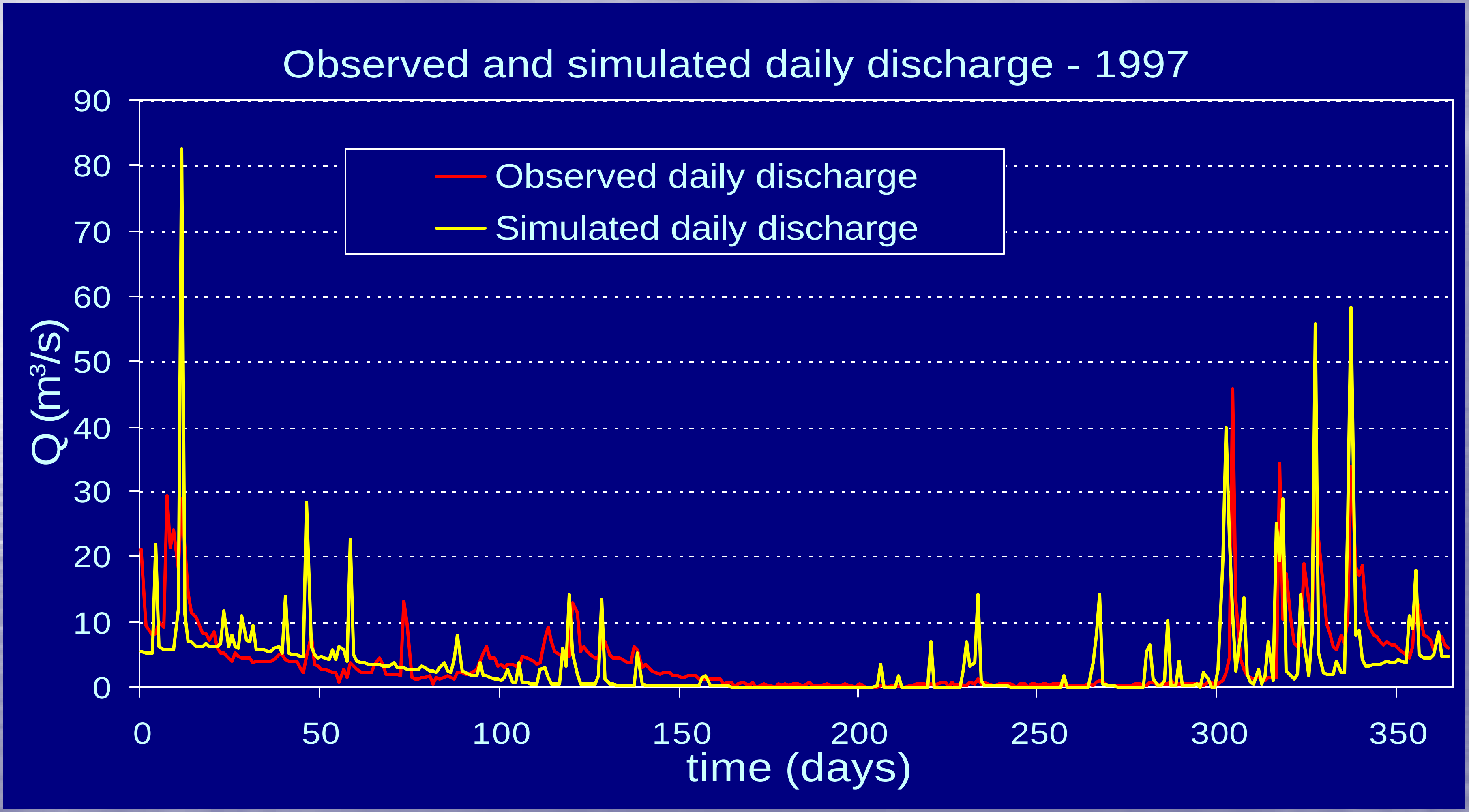
SWAT model results



Correlation coefficient 0,53

Mean square error 13,00

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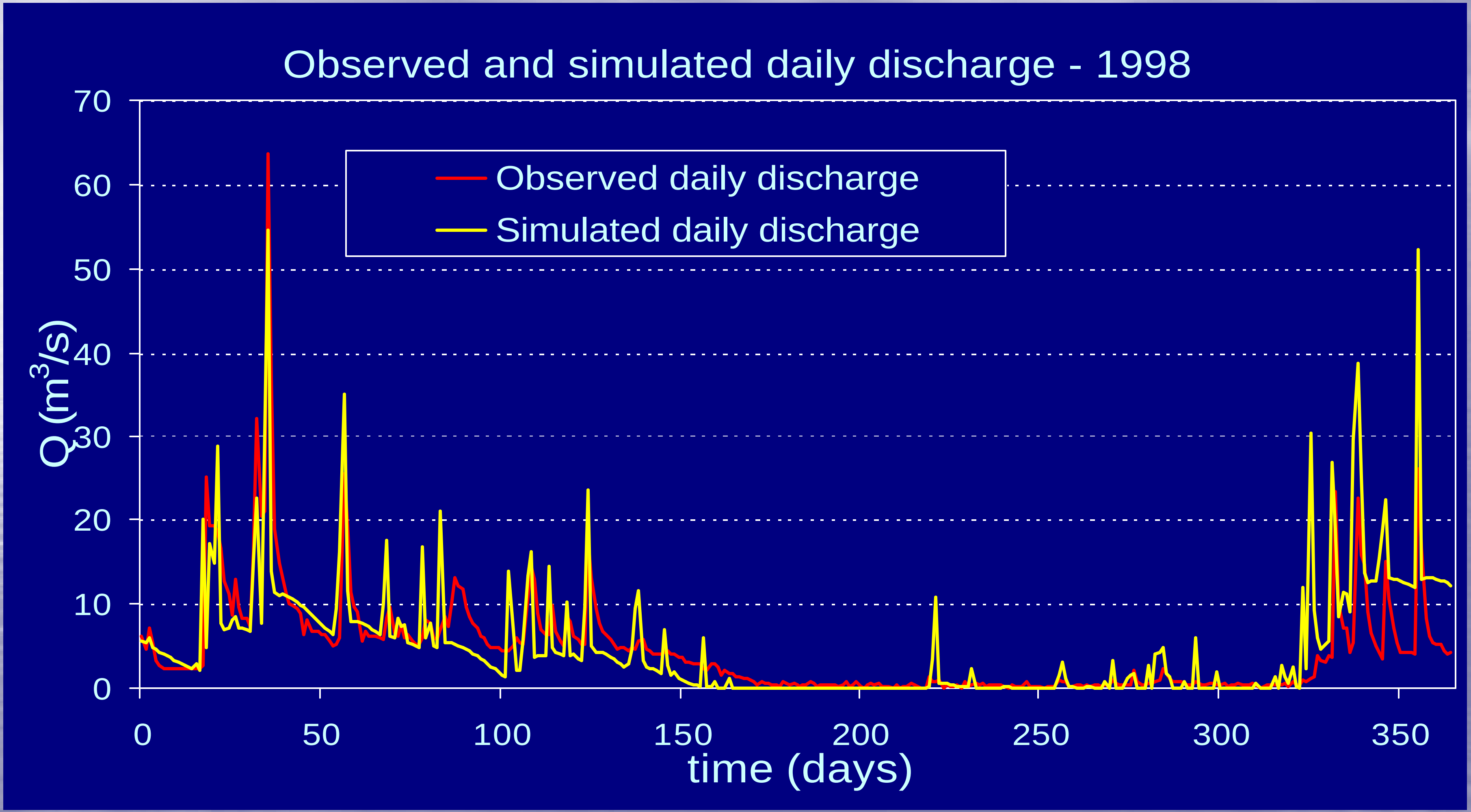
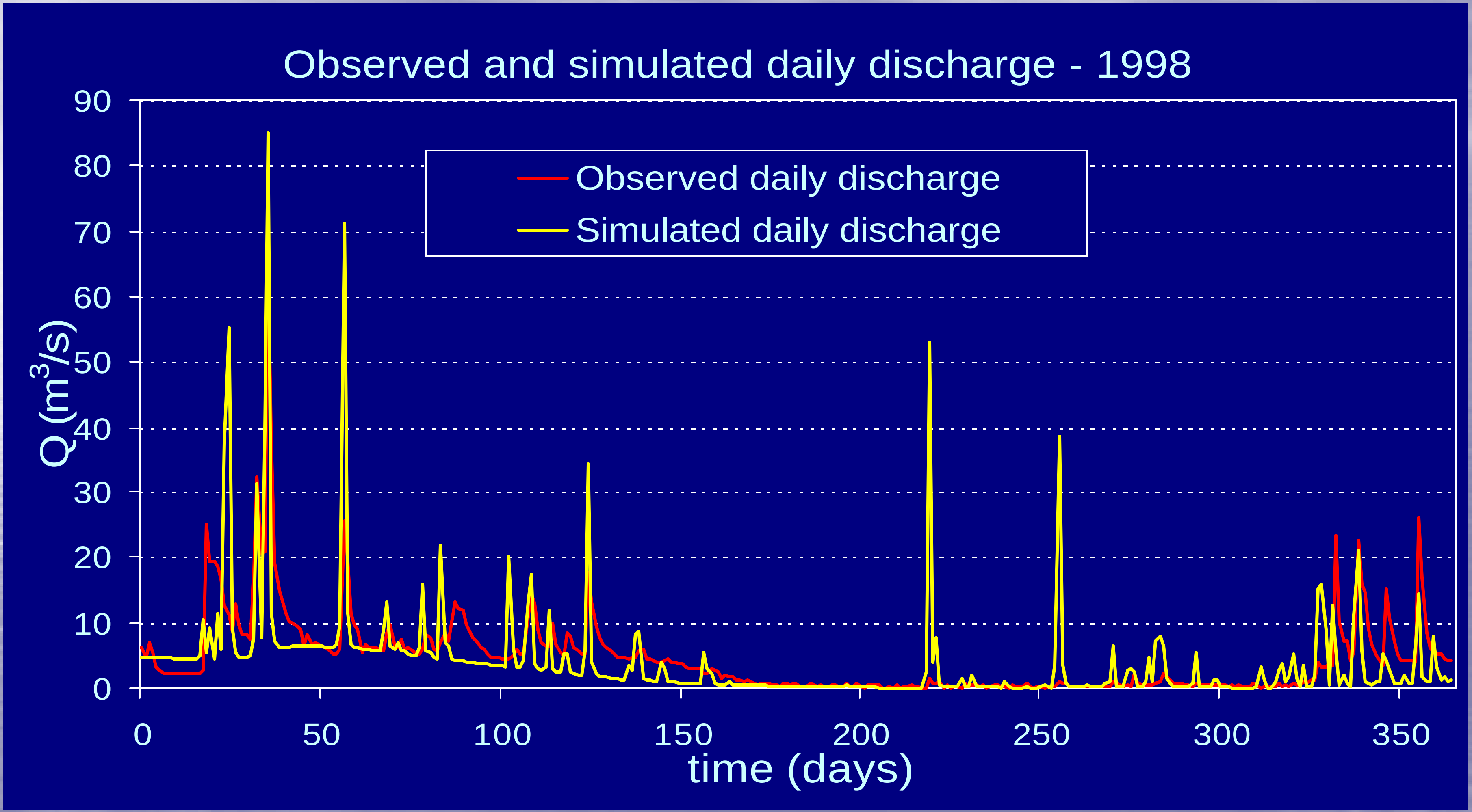
Distributed model results



Correlation coefficient 0,75

Mean square error 4,72

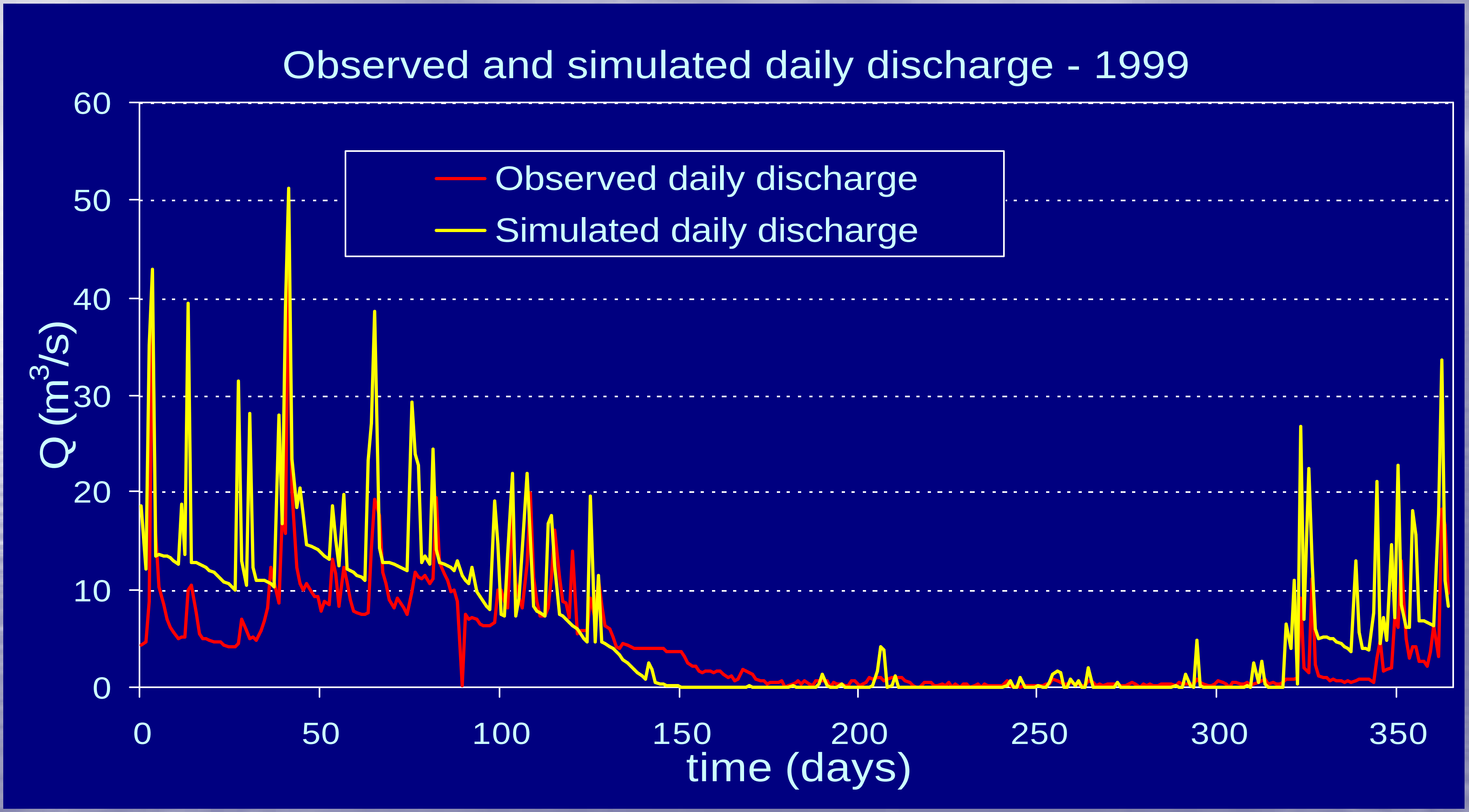
SWAT model results



Correlation coefficient 0,62

Mean square error 39,04

Distributed model results



Correlation coefficient 0,80

Mean square error 20,78

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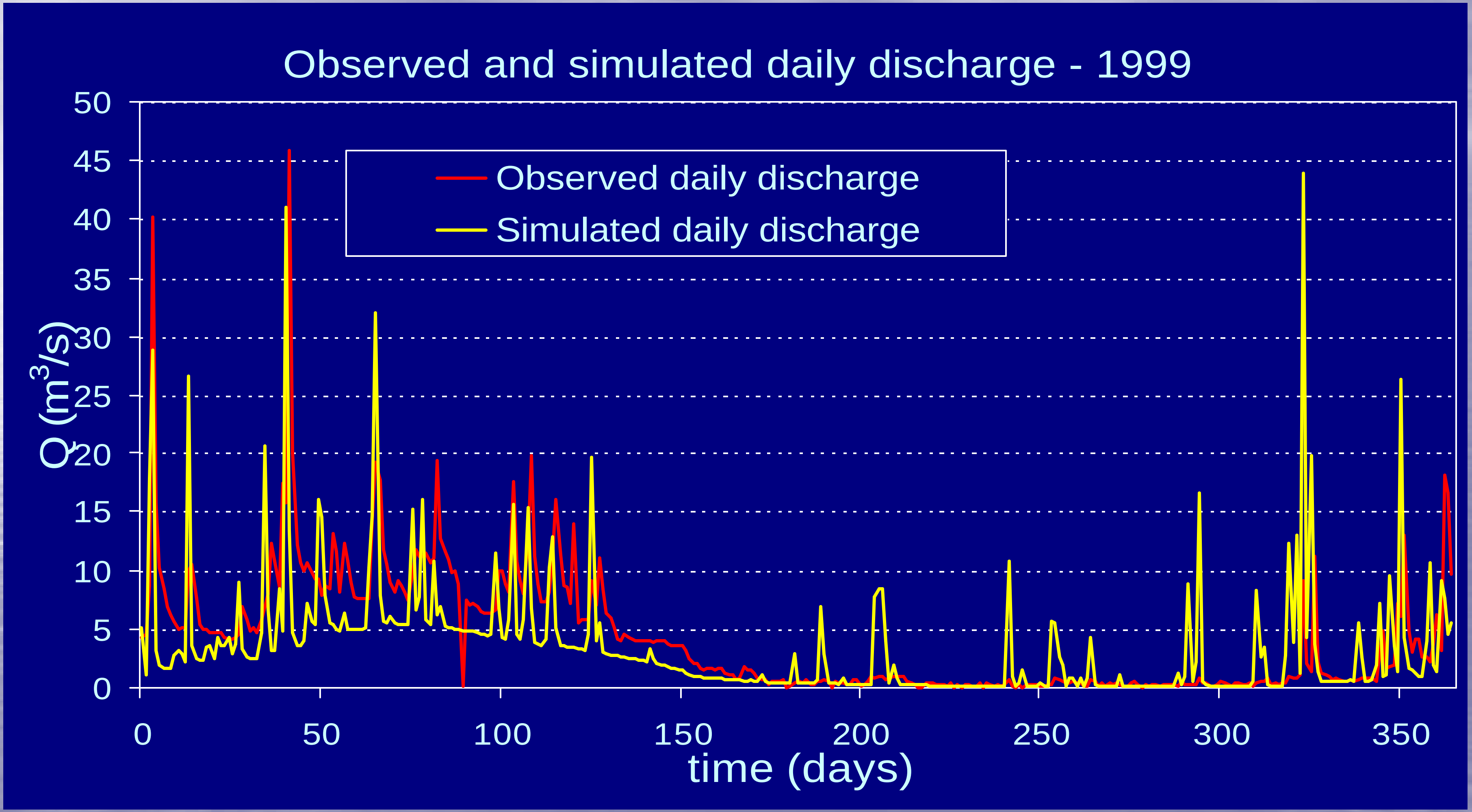
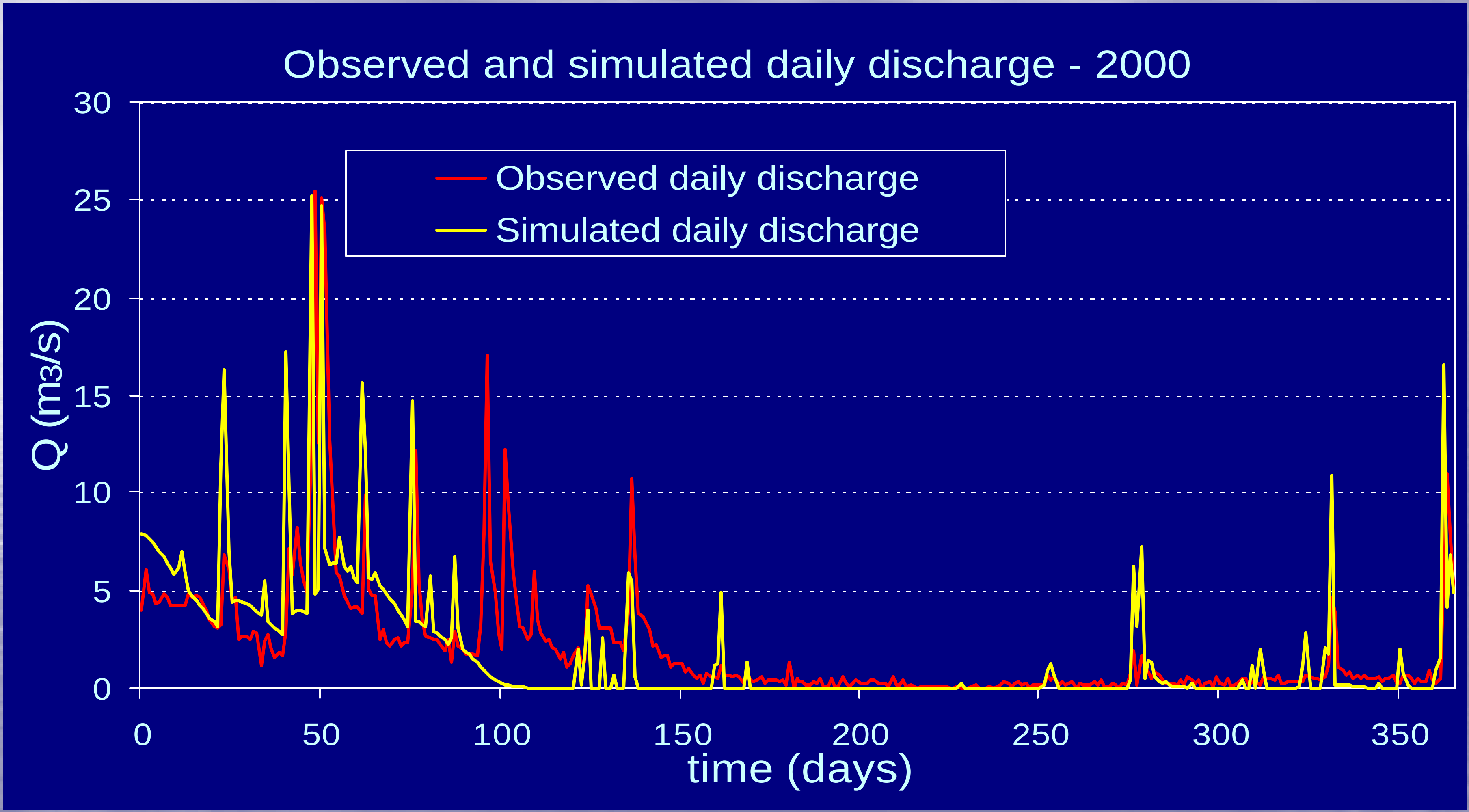
SWAT model results



Correlation coefficient 0,55

Mean square error 15,50

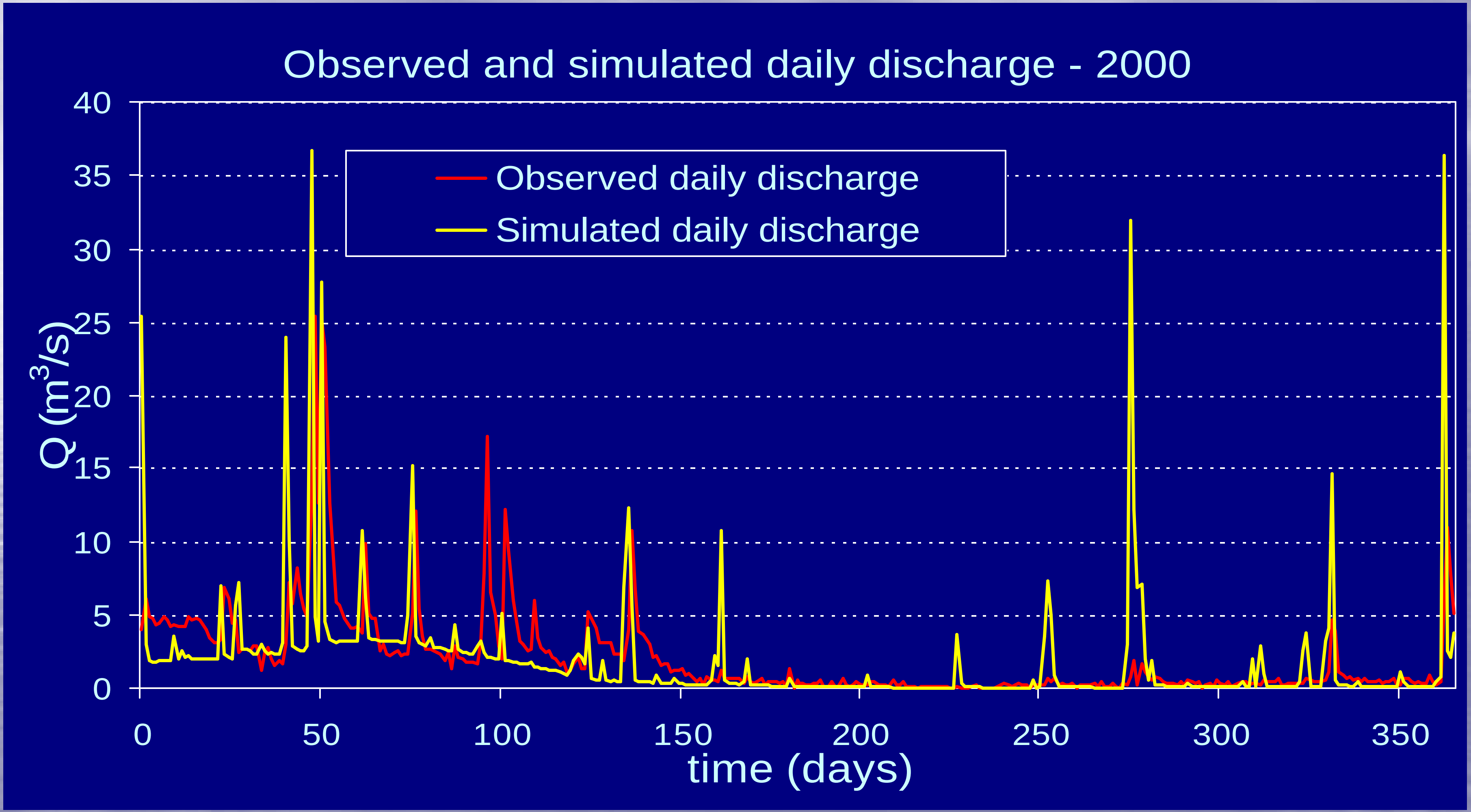
Distributed model results



Correlation coefficient 0,60

Mean square error 2,53

SWAT model results



Correlation coefficient 0,42

Mean square error 22,12

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Conclusions and Discussion

- ✓ Results provide daily simulations of streamflow over the entire watershed, obtained with both models.
- ✓ Better results by using the distributed model even by using less accurate input data
- ✓ Difficulties: data availability and calibration of SWAT model
- ✓ Lack of soils parameters, potential evapotranspiration, solar radiation wind speed and relative humidity data.

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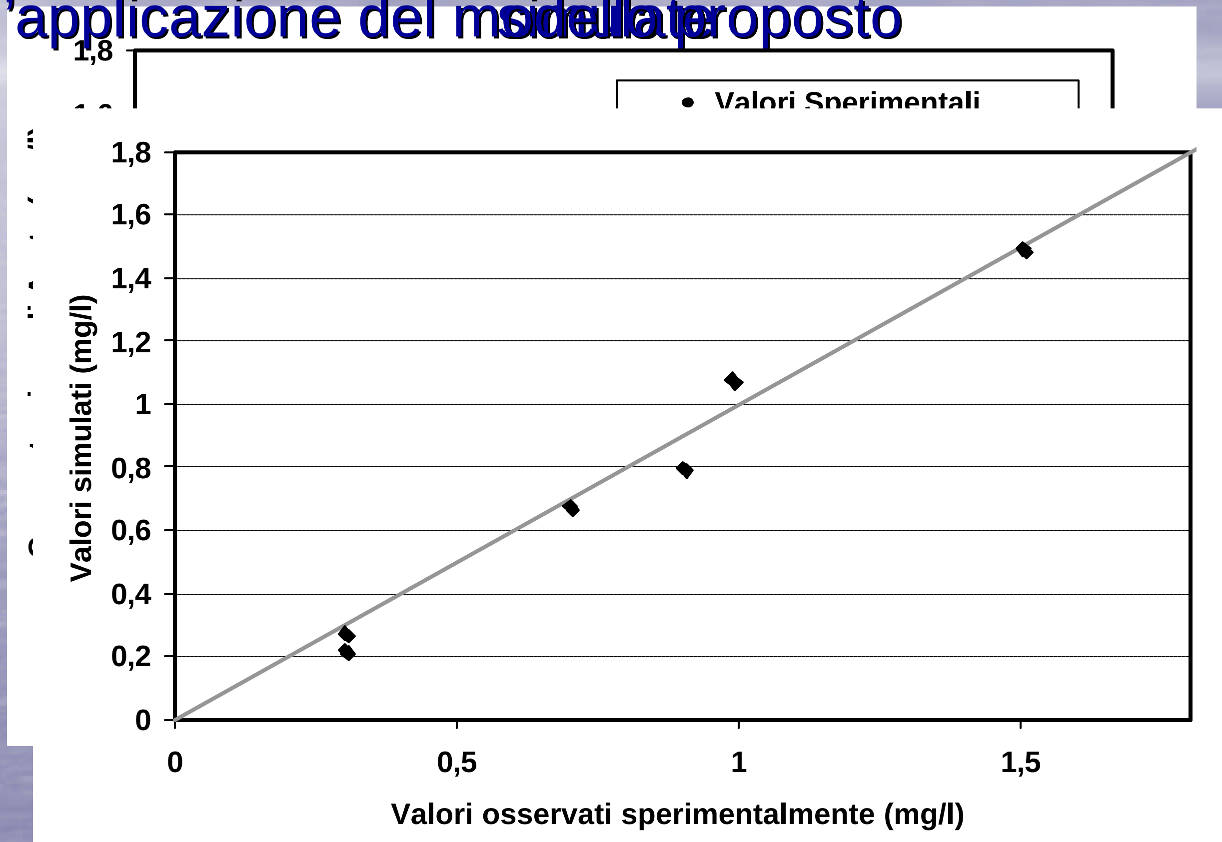
Simulation results

Confronto tra i valori di concentrazione di azoto registrati e simulati attraverso l'applicazione del modello proposto

Grafico di correlazione tra i valori misurati e simulati



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