



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.

Overview

✓ THE DISTRIBUTED MODEL

- Input data
- Theory

✓ SWAT MODEL

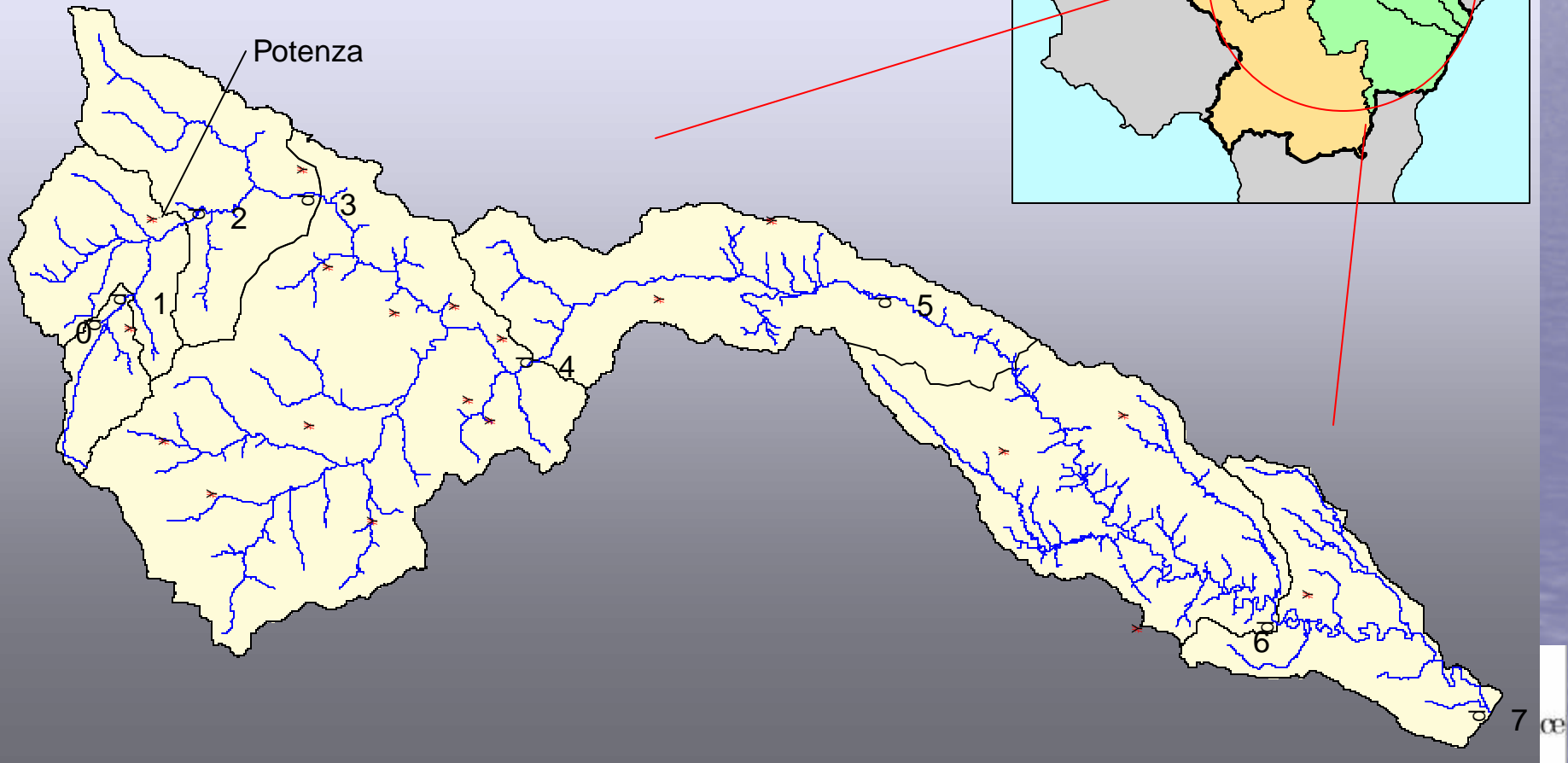
- Input data

✓ RESULTS AND DISCUSSION

- Comparison among SWAT, distributed model and observed daily discharge for 4 years of simulation

Distributed model

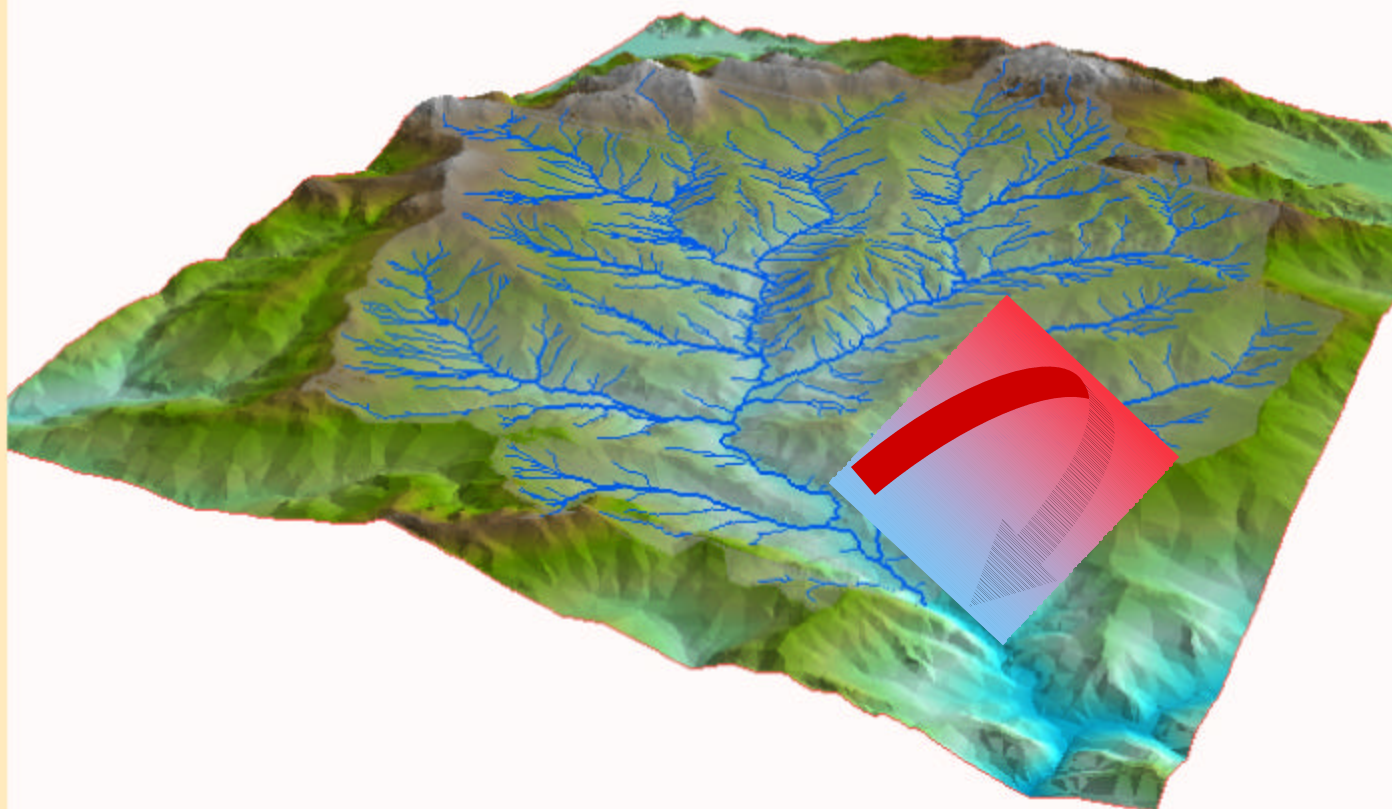
BASENTO RIVER



**Bacino idrografico del
torrente Camastra**



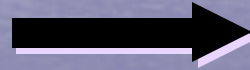
**Modello tridimensionale
e reticolo idrografico**



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

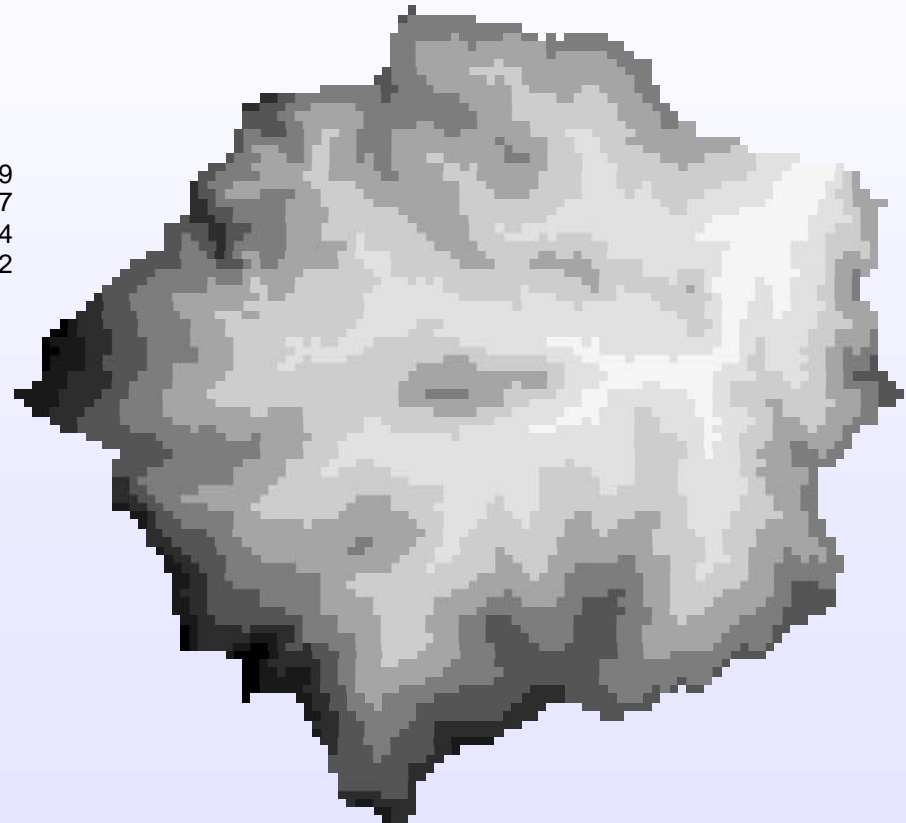
- ✓ Basin Area: 350 km²
- ✓ 94 rows
- ✓ 102 columns
- ✓ 240 m grid

Camastra river basin

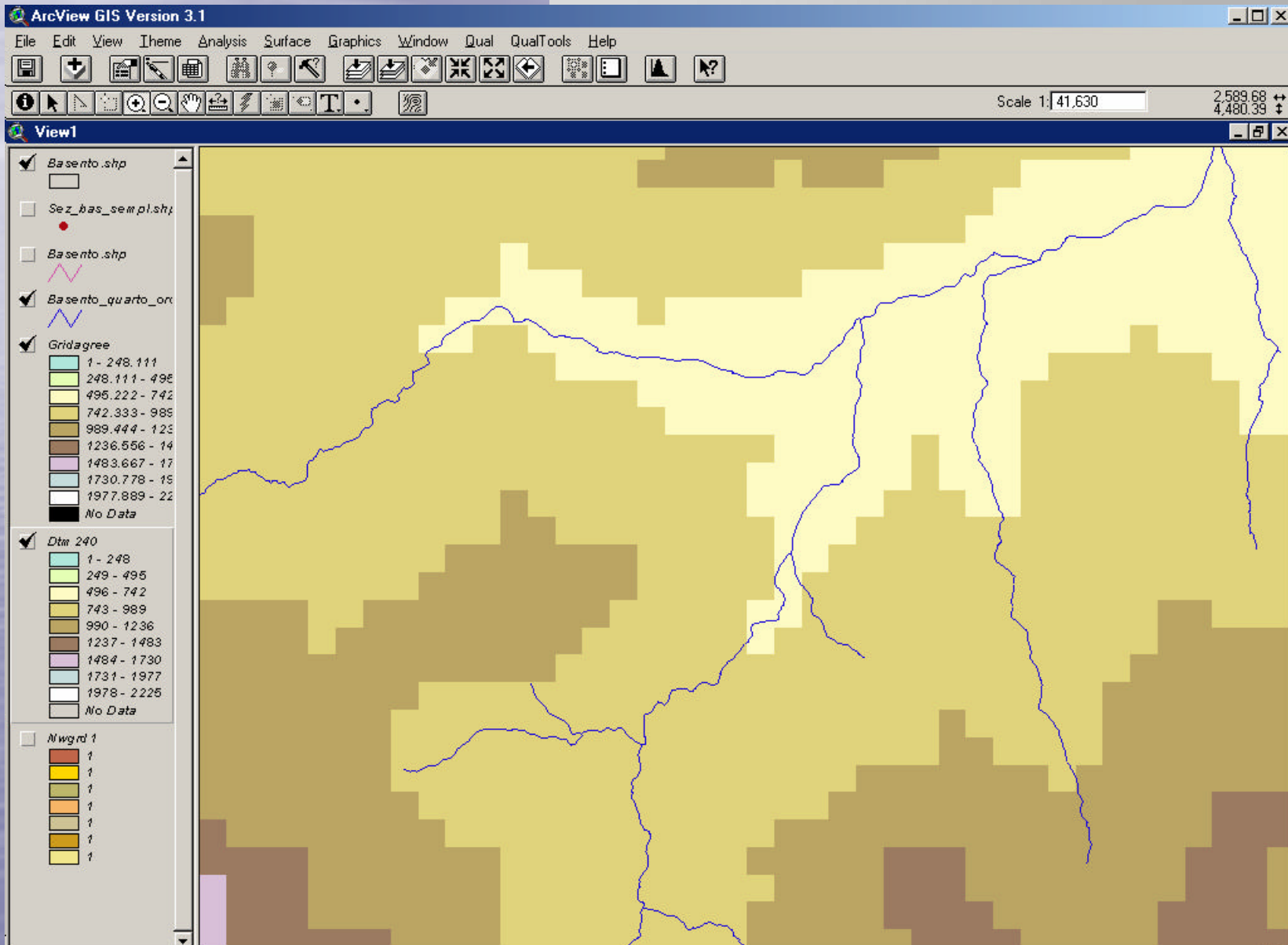
DEM 240 x 240 m

Elevation (m)

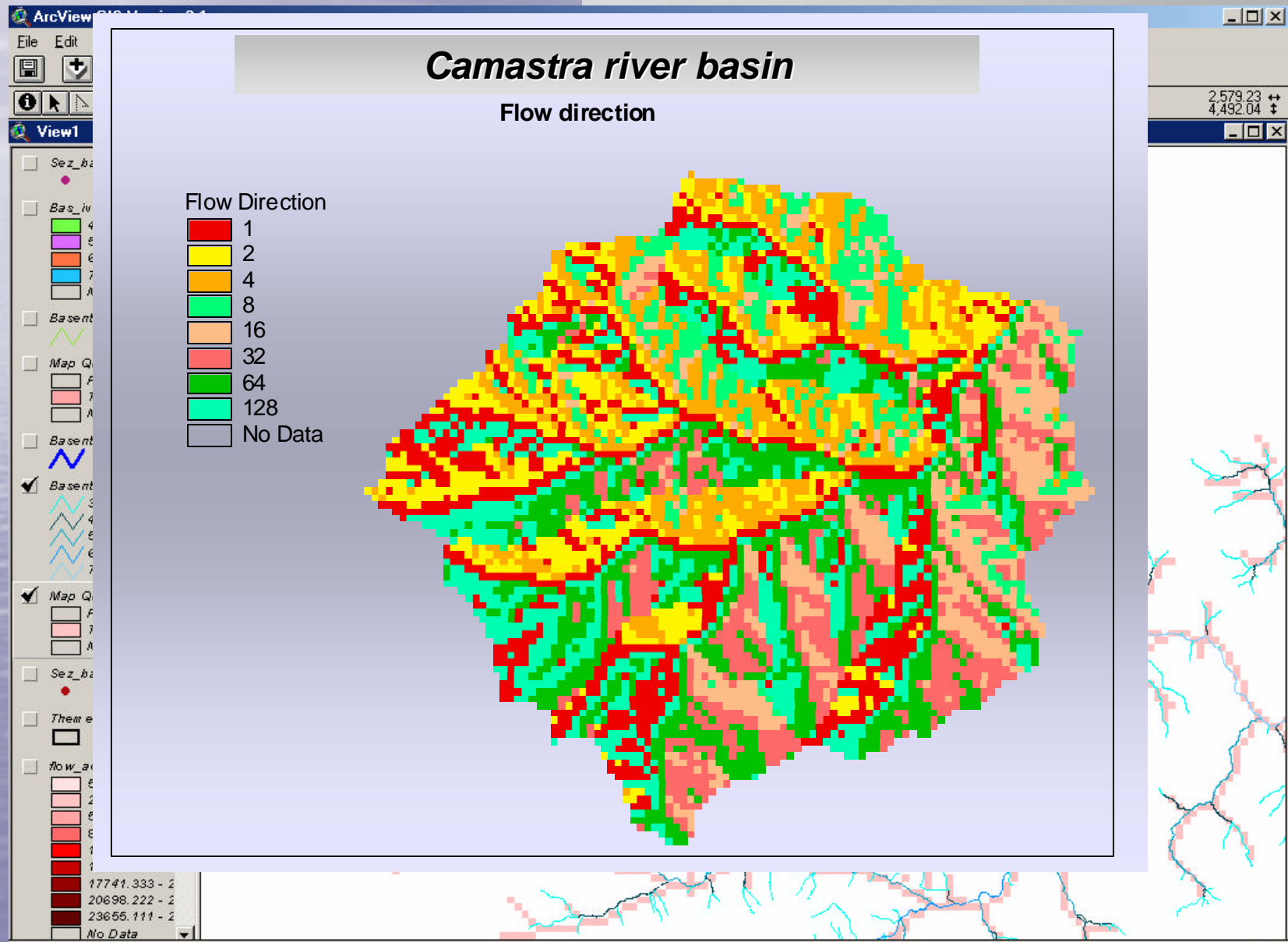
489 - 632.778
632.778 - 776.556
776.556 - 920.333
920.333 - 1064.111
1064.111 - 1207.889
1207.889 - 1351.667
1351.667 - 1495.444
1495.444 - 1639.222
1639.222 - 1783
No Data



Dem recoditioning












Stream network extraction and basin delineation

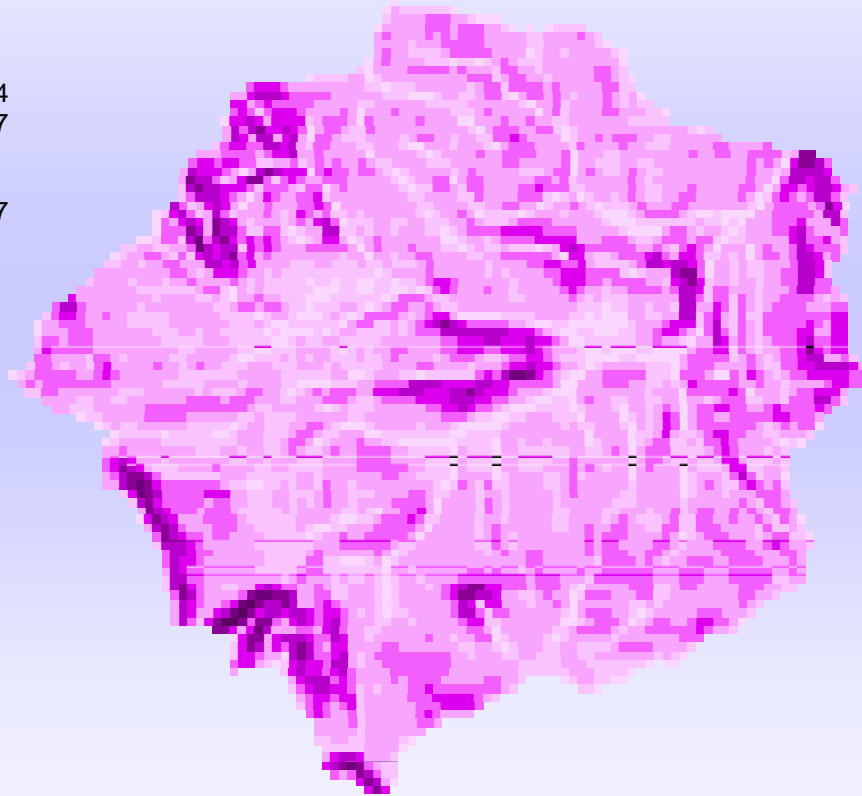


Slope

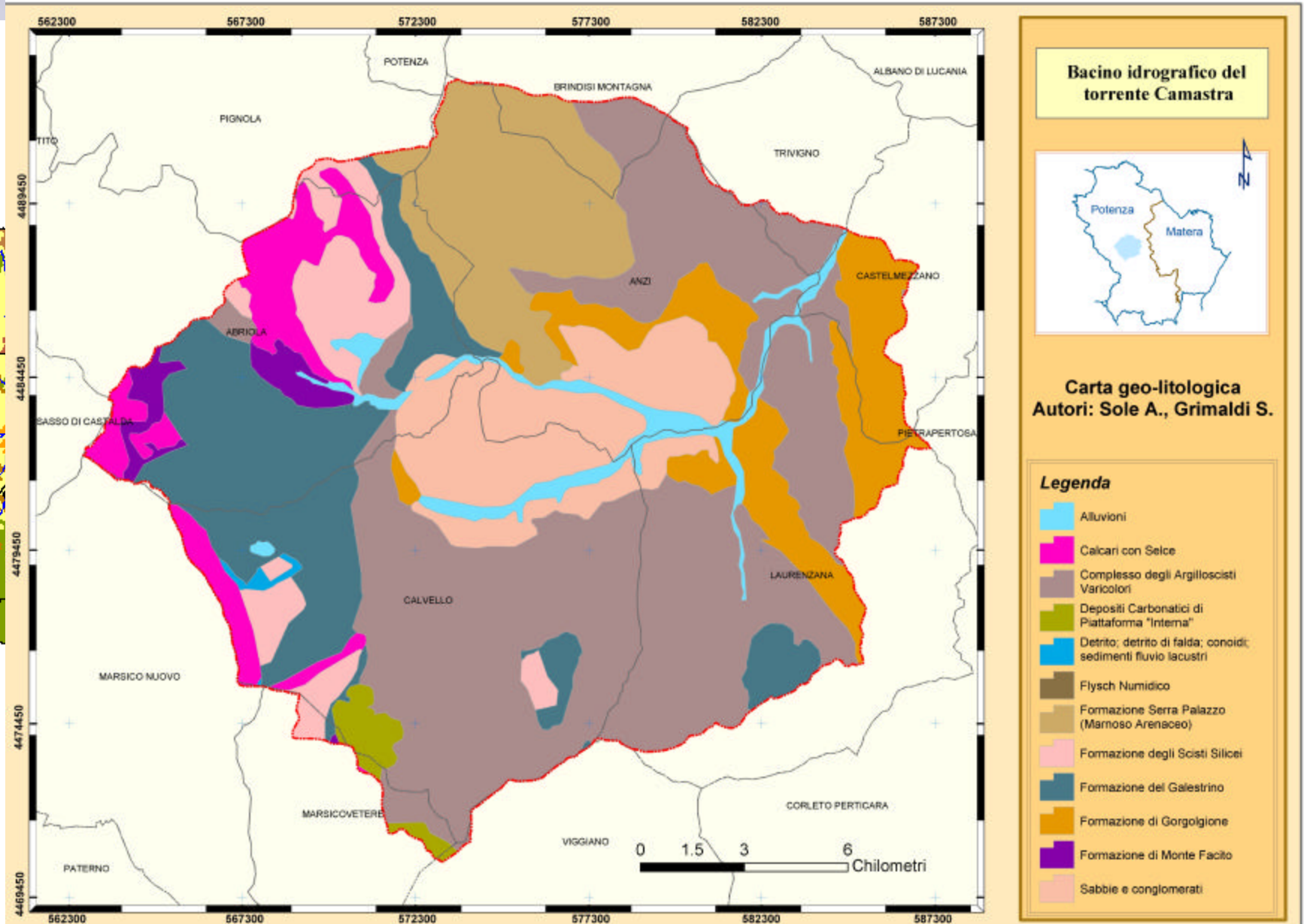
Camastra river basin Slope map

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

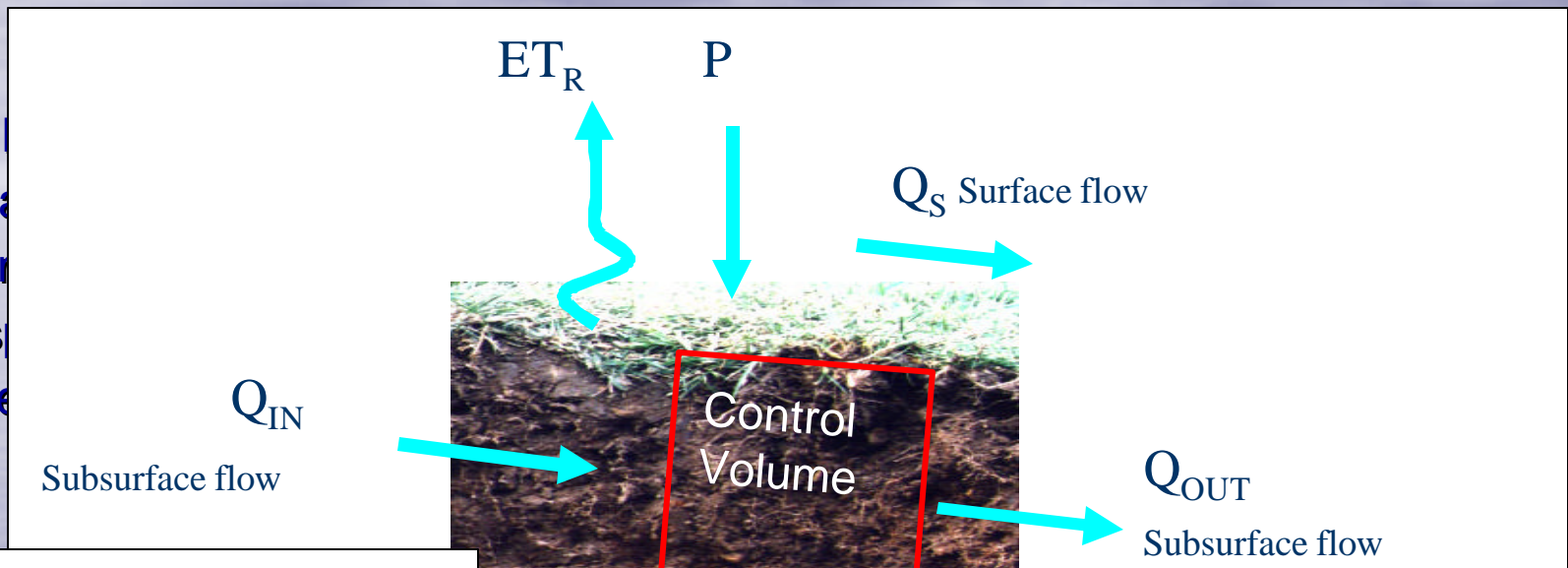


crops

wit

Distributed model

The
spatial
schem
trans
single



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)

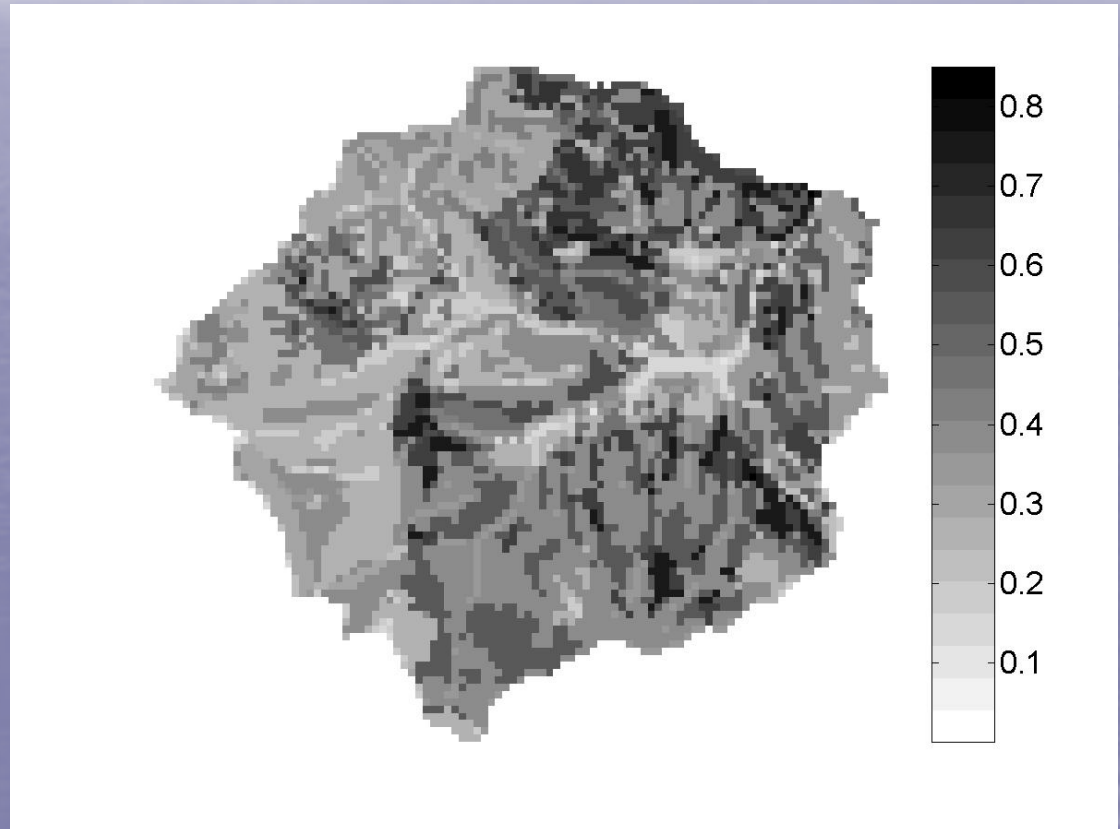
Distributed model

Runoff coefficient, C

Runoff

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

De Smedt (2000)

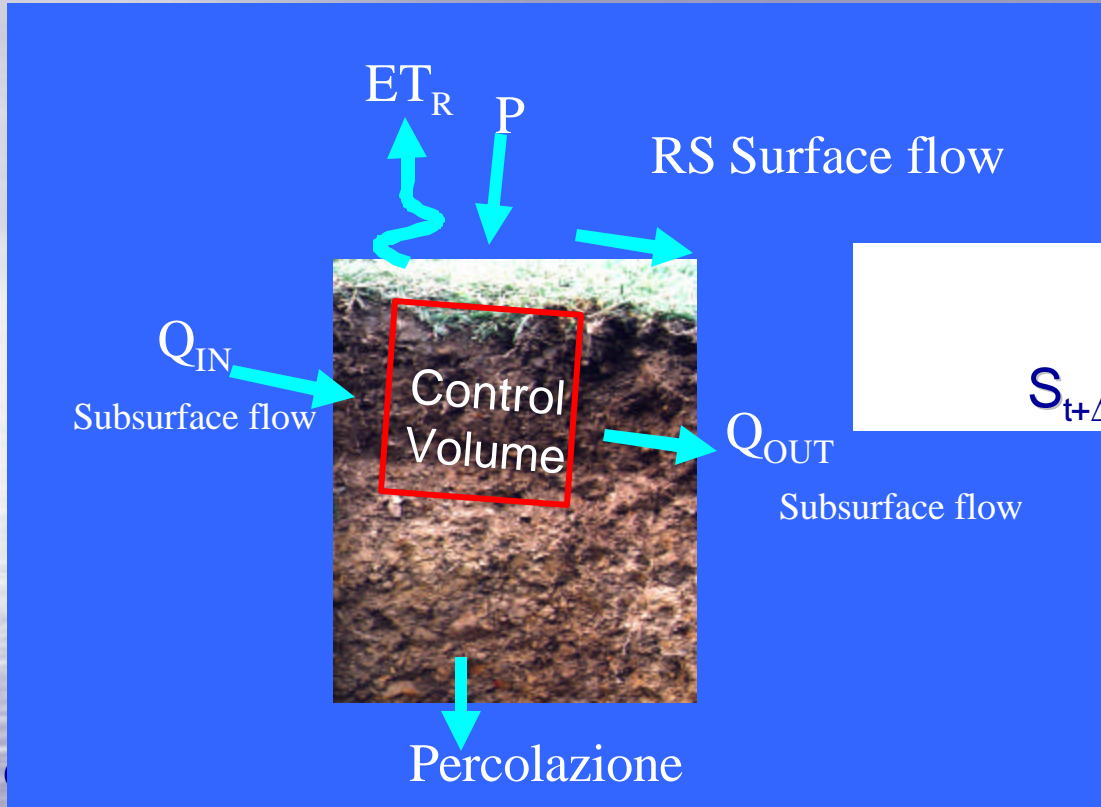


Distributed model

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 $t + Dt$ (mm),
- ✓ S_t = total soil water content at time t (mm),
- ✓ F_t = infiltration amount into the soil during the time t ($Q_{in} + P - RS$)
- ✓ 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

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

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:

$$RG = K \text{ grad}(h)$$

where

- ✓ RG = groundwater recharge (mm/h),
- ✓ K = hydraulic conductivity (mm/h),
- ✓ $\text{grad}(h)$ = hydraulic gradient

Distributed model

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

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

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

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

where:

(Blaney-Criddle equation)

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

Actual evapotranspiration

$$ET_t = (1 - e^{-b(q_t - q_0)/(q_C - q_0)}) ET_0$$

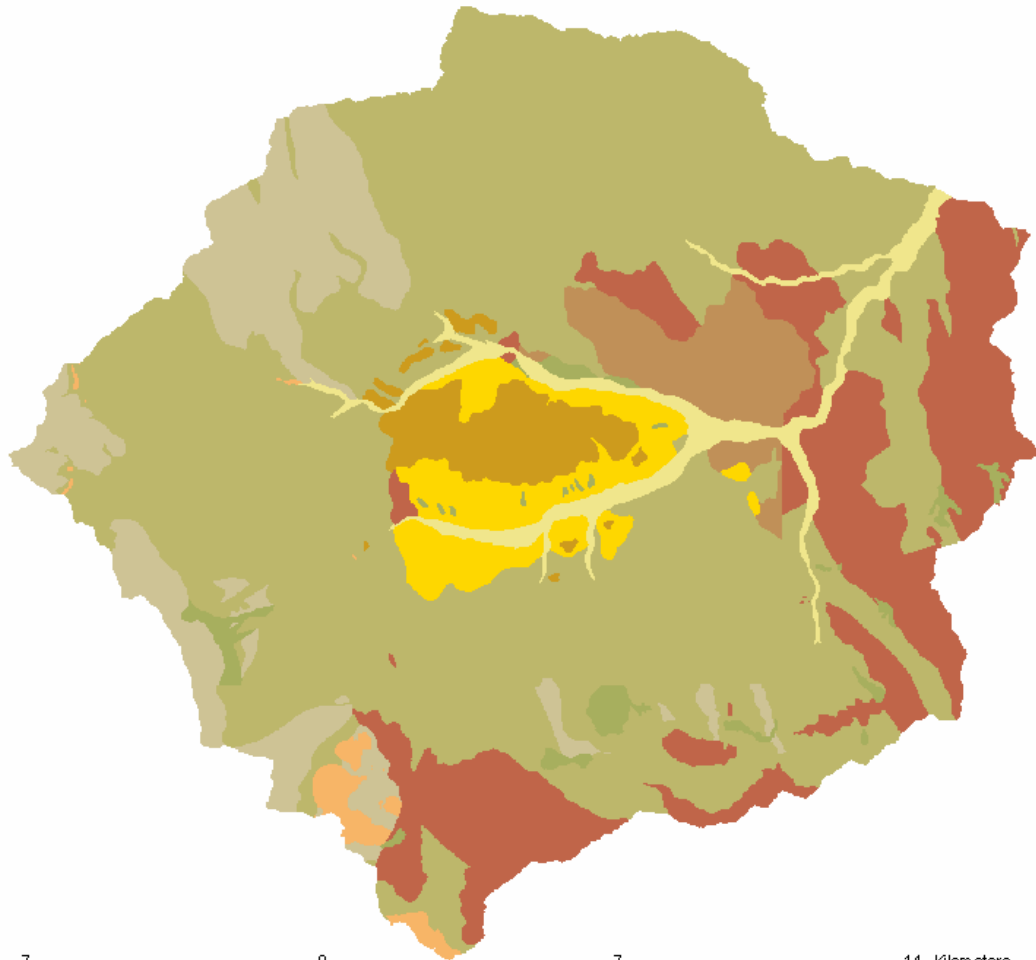
(Davies ed Allen, 1973)

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

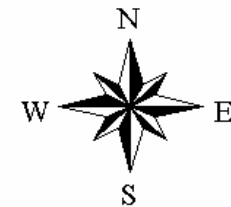
Soils



7 0 7 14 Kilometers

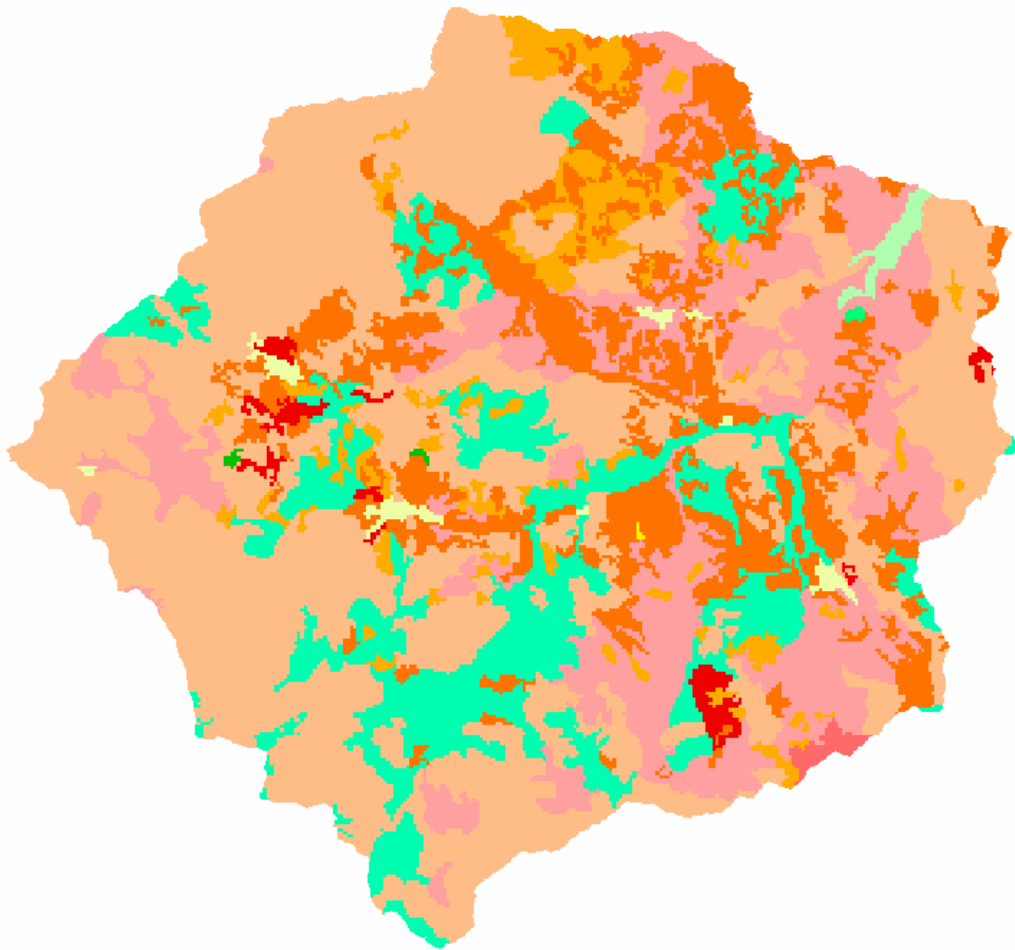
SoilClass

	arecon
	argill
	argmar
	calcar
	calsil
	conglo
	dalluv
	detrit
	sabbio















SWAT data: land use layer

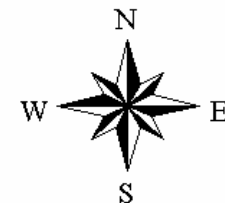
Land use



7 0 7 14 Kilometers

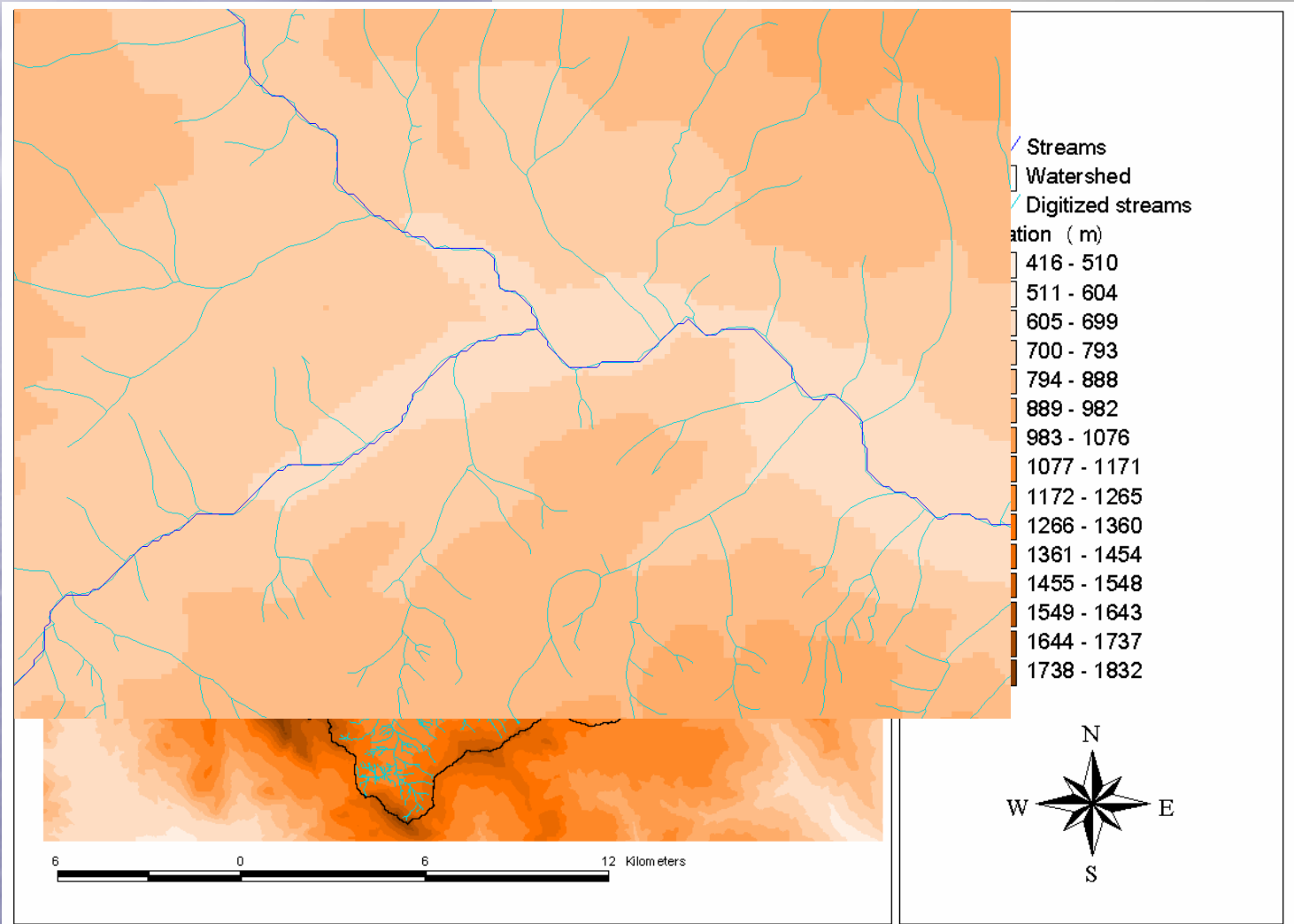
SwatLandUseClass

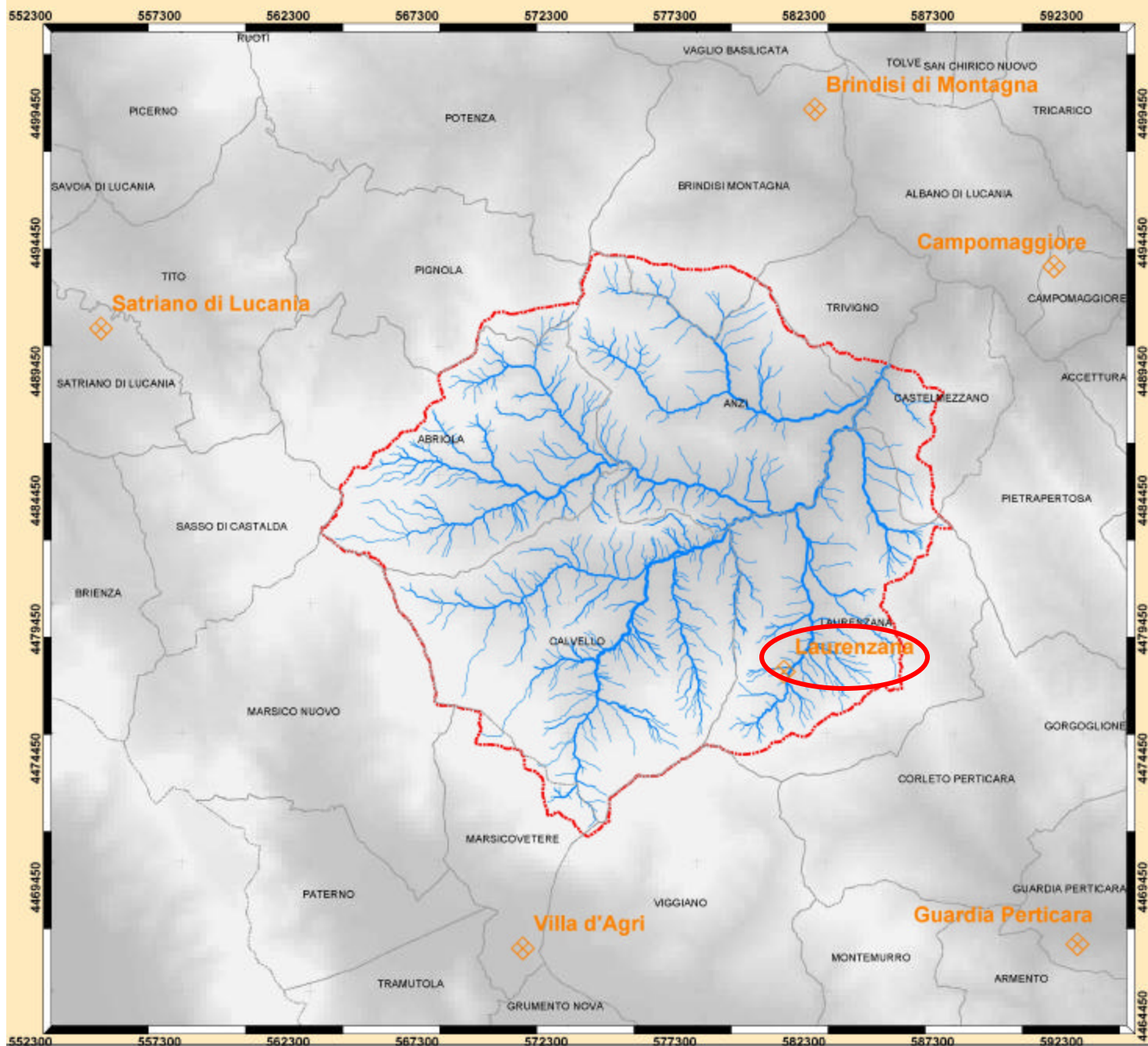
	AGRL
	AGRR
	BROM
	CORN
	FRSD
	FRSE
	ORCD
	PAST
	URMD
	WATR
	WETF
	WWHT



SWAT data: DEM

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





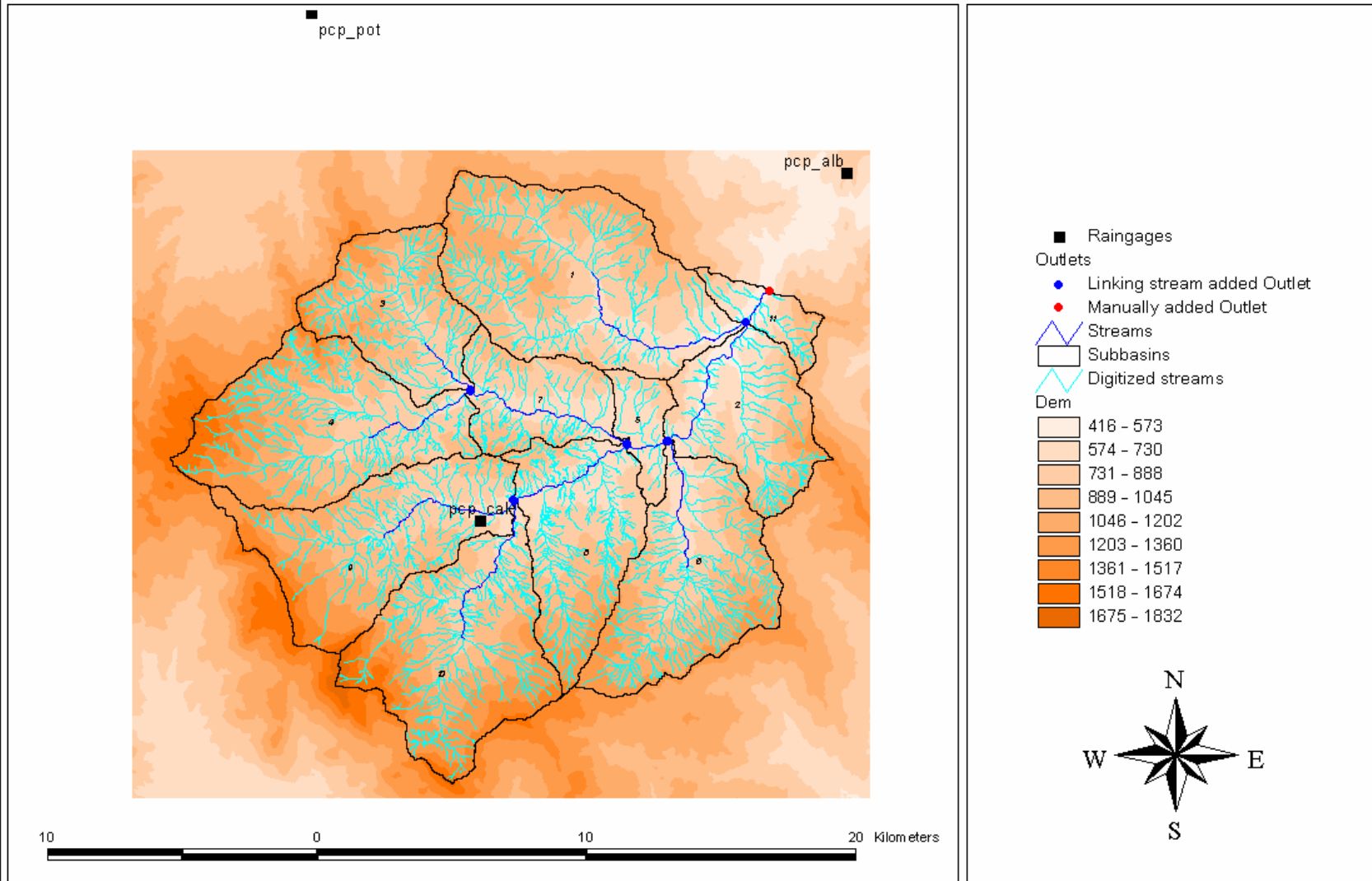
Gage location



Ubicazione delle stazioni
Agrometeorologiche
ALSIA

SWAT: meteorological data

Precipitation gage location



SWAT databases

SWAT - ArcView interface

Edit SWAT databases

For editing double click on the

- User Soils
- User Weather Stations
- Land Cover/Plant Growth
- Fertilizer
- Pesticide
- Tillage
- Urban

Fertilizer database

15-15-15	Fertilizer Name	26-00-00
16-20-20	FERTNM	26-00-00 [8 characters]
18-04-00	FMINN	0.260 [kg min N/kg fertilizer]
18-46-00	FMINP	0.000 [kg min P/kg fertilizer]
20-20-00	FORGN	0.000 [kg org N/kg fertilizer]
22-14-00	FORGP	0.000 [kg org P/kg fertilizer]
24-06-00	FNH3N	0.000 [kg NH3 N/kg min N]
25-03-00	BACTPDB [OPTIONAL]	0.000 [#bacteria/kg manure]
25-05-00	BACTLPDB [OPTIONAL]	0.000 [#bacteria/kg manure]
26-00-00	BACTKddb [OPTIONAL]	0.000 [fraction]
26-13-00	Is Manure	<input type="checkbox"/>
28-03-00		
28-10-10		

Delete Add New [Modify] Add New Help Exit

Environmental variables
Return to Current Project
camastra.swat

SWAT: management input data

camastra.swat - AVSWAT2000 - Blackland Research Center - Ver. 1.0

File Edit View Theme Input Edit Input Simulation Reports Window Help

Scale 1: 580,826.17
4,477,543.40

SWAT View

Watershed
 Digitized streams
 Reticolo.shp
 Mask
 Mask.shp
 Dem

Mgt: 5_FRSD_subcog

Management Data:

Load Scenario Save Scenario

NCRP
No Crop Curently Growing

BIO_MIN 0.00 CN2 83.00
BIOMIX 0.20 USLE_P 1.00

Curve

Schedule by Date Schedule by Heat Units

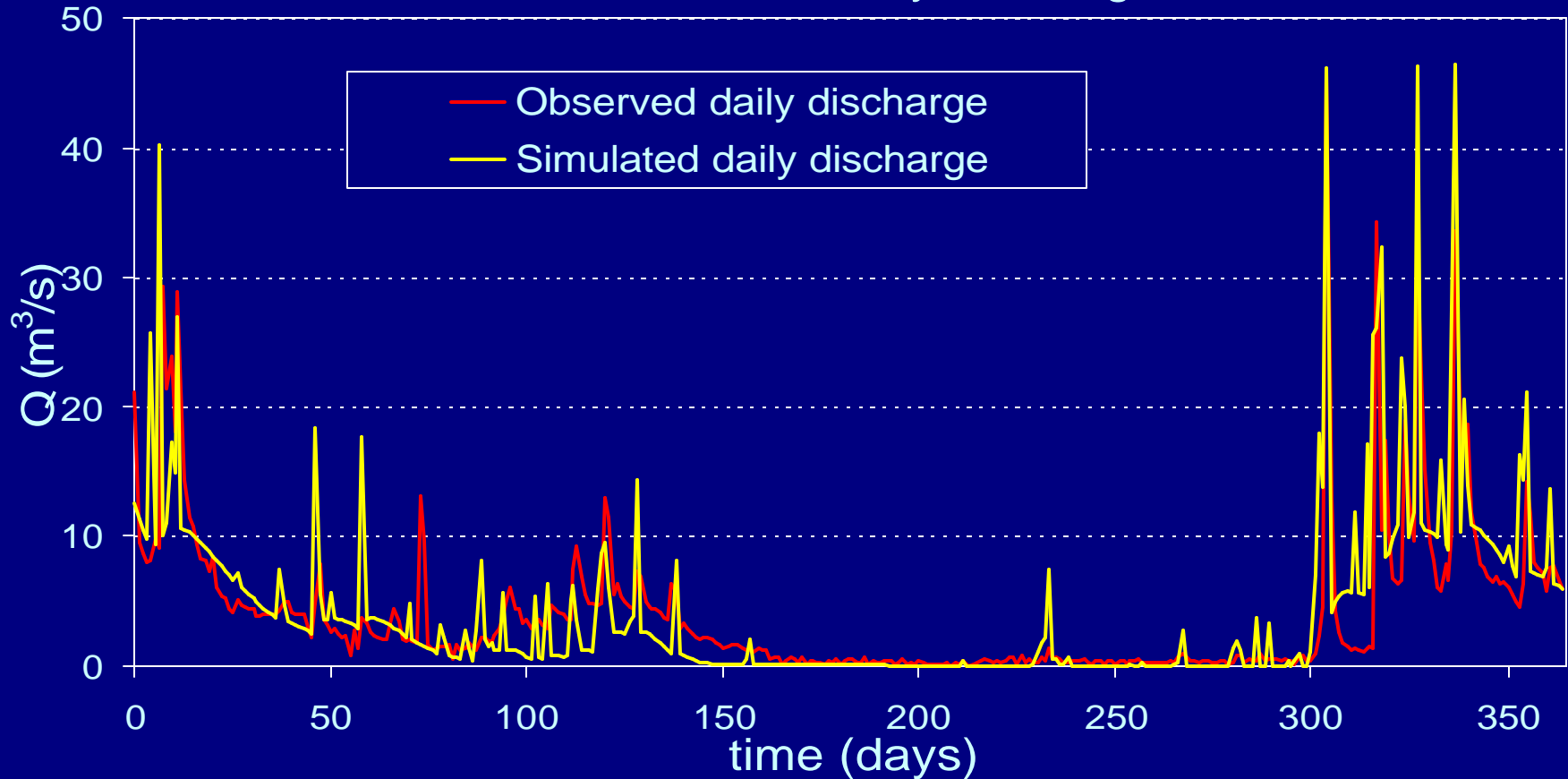
Year	Operation	Crop	Heat Units
1	Plant/begin. growing season	FRSD	0.150
1	Harvest and kill operation	FRSD	1.200

Add Year
Delete Year
Add Operation
Delete Operation
Edit Operation

Help Cancel OK

Distributed model results

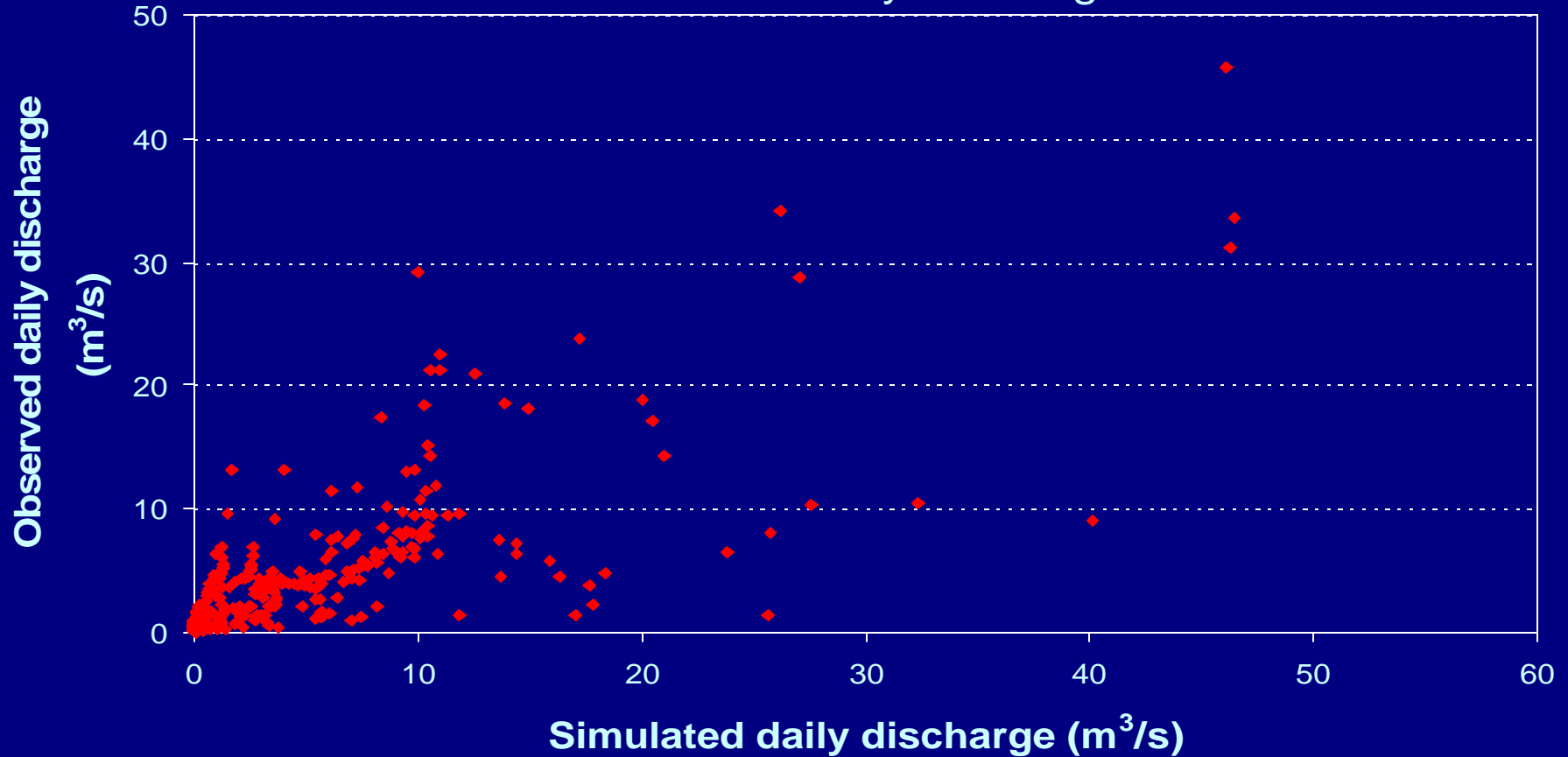
Observed and simulated daily discharge - 1997



Correlation coefficient 0,77
Mean square error 2,91

Distributed model results

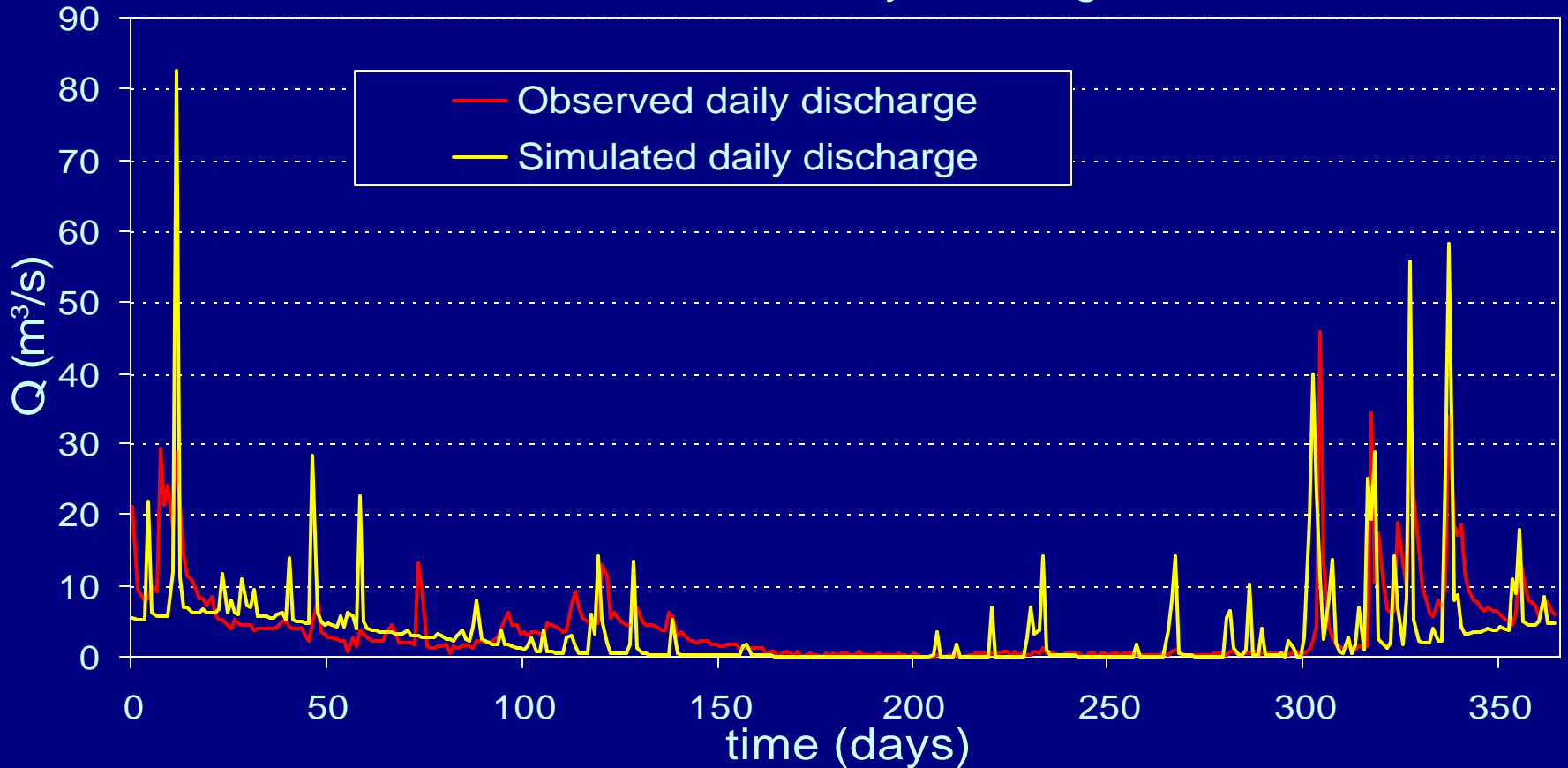
Observed and simulated daily discharge - 1997



Correlation coefficient 0,77
Mean square error 2,91

SWAT model results

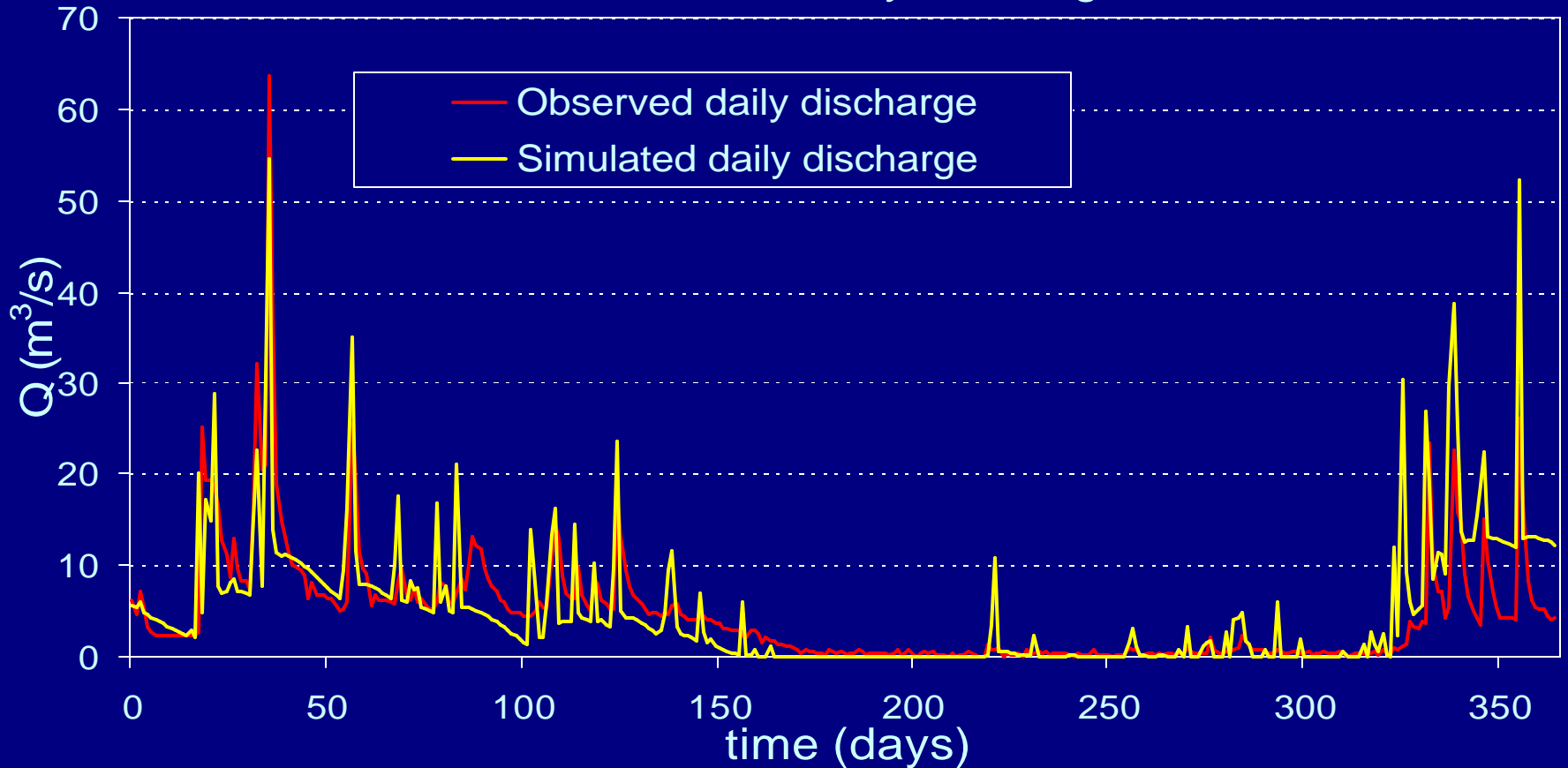
Observed and simulated daily discharge - 1997



Correlation coefficient 0,53
Mean square error 13,00

Distributed model results

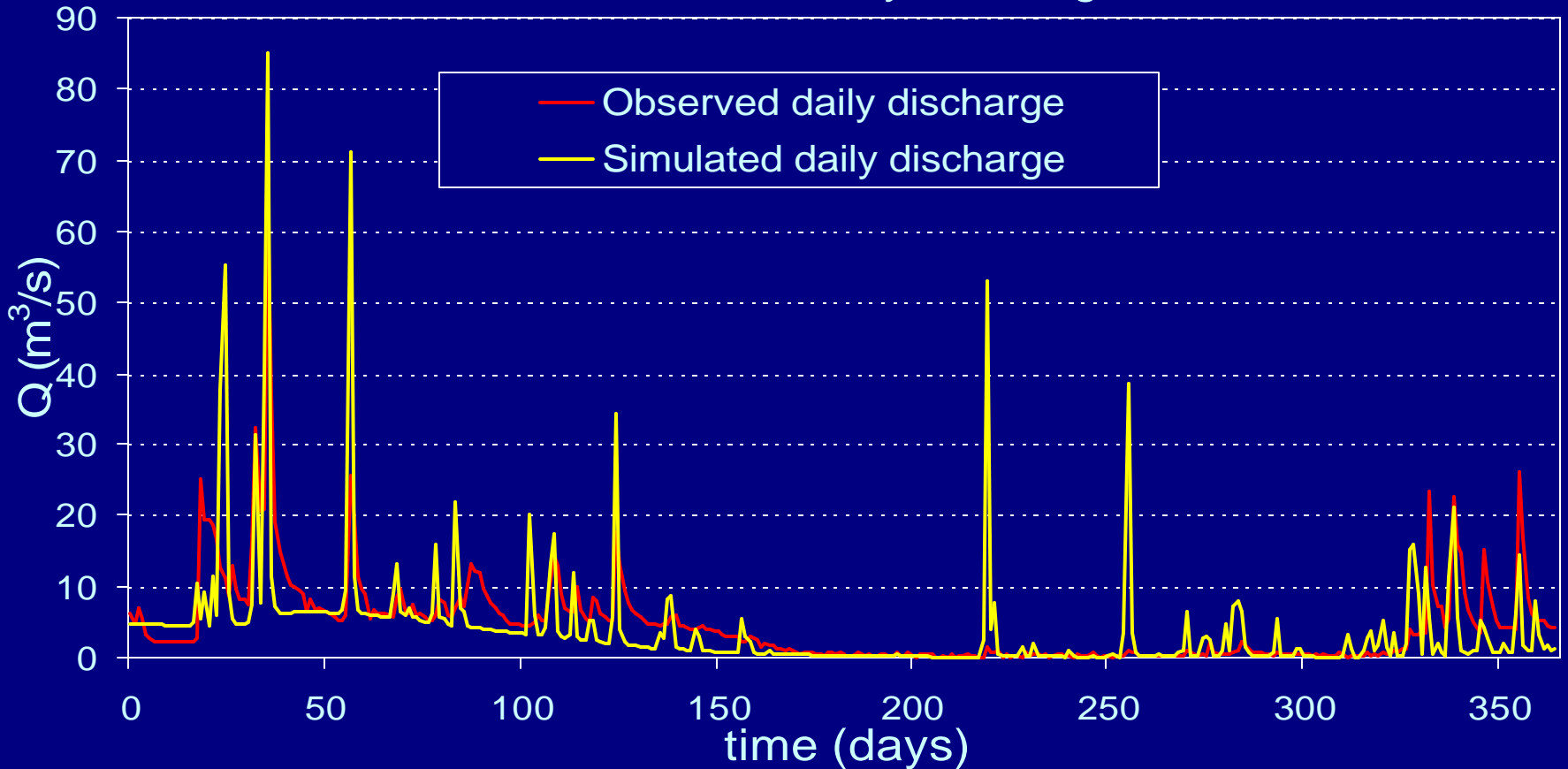
Observed and simulated daily discharge - 1998



Correlation coefficient 0,75
Mean square error 4,72

SWAT model results

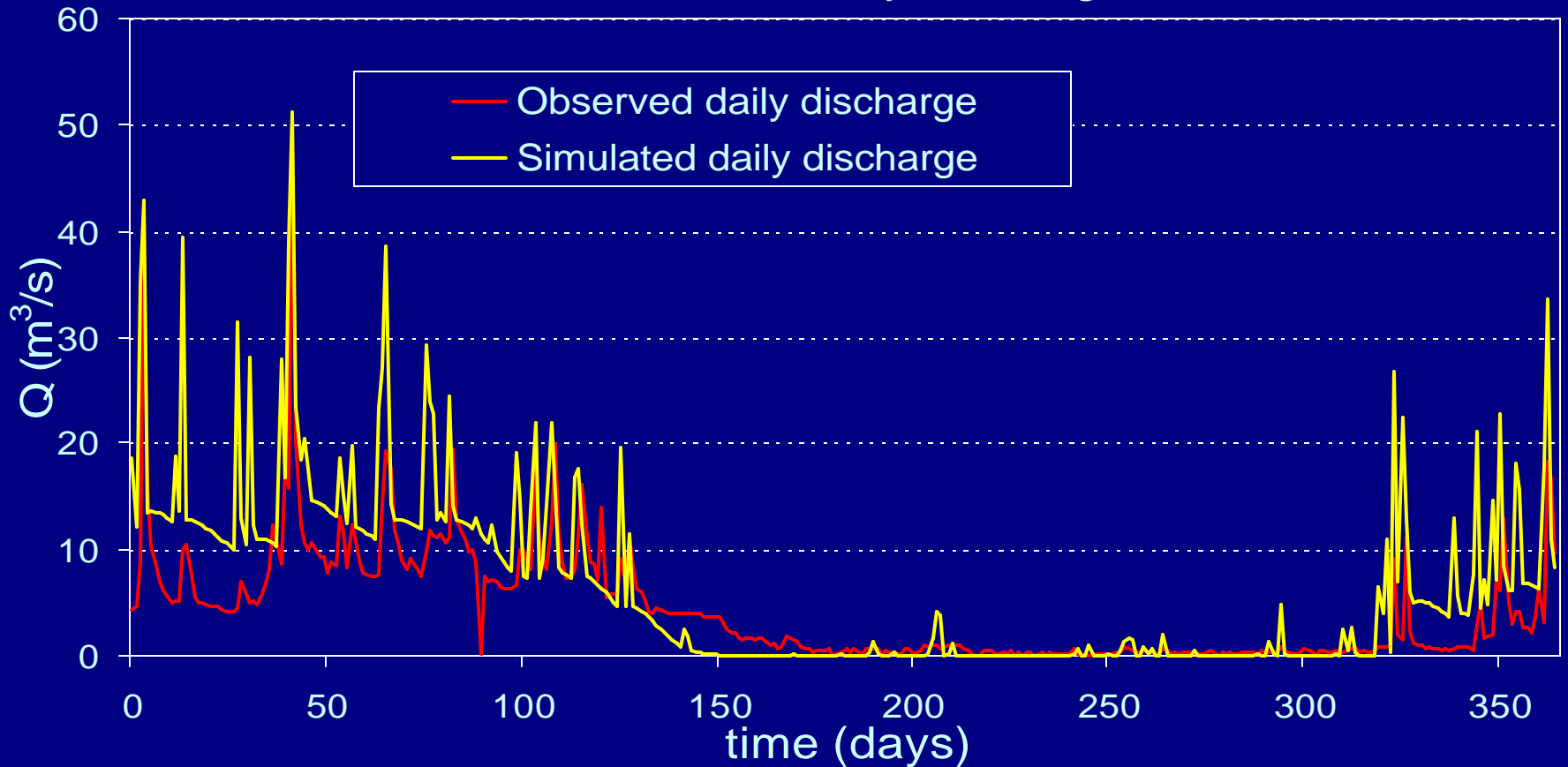
Observed and simulated daily discharge - 1998



Correlation coefficient 0,62
Mean square error 39,04

Distributed model results

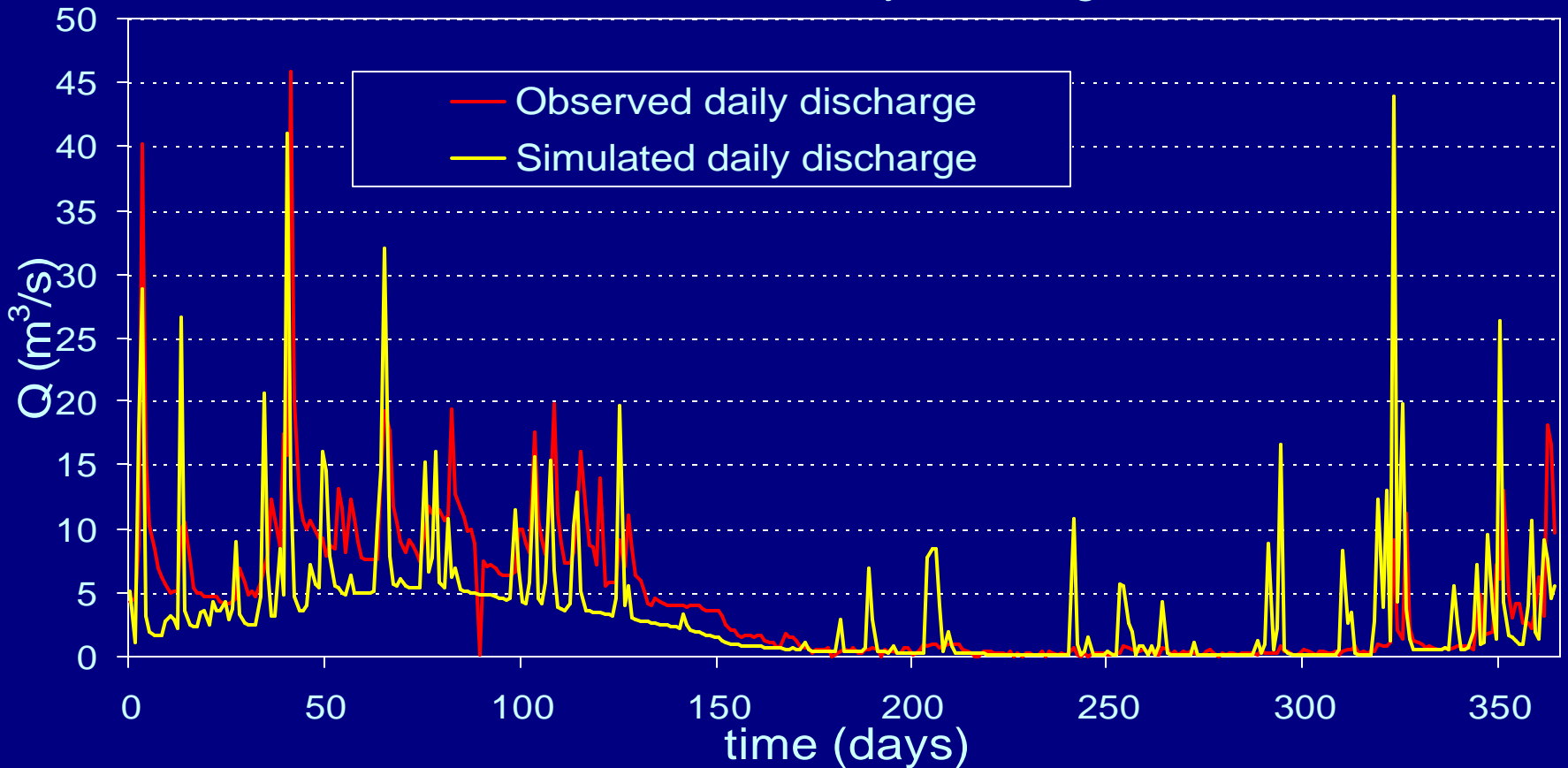
Observed and simulated daily discharge - 1999



Correlation coefficient 0,80
Mean square error 20,78

SWAT model results

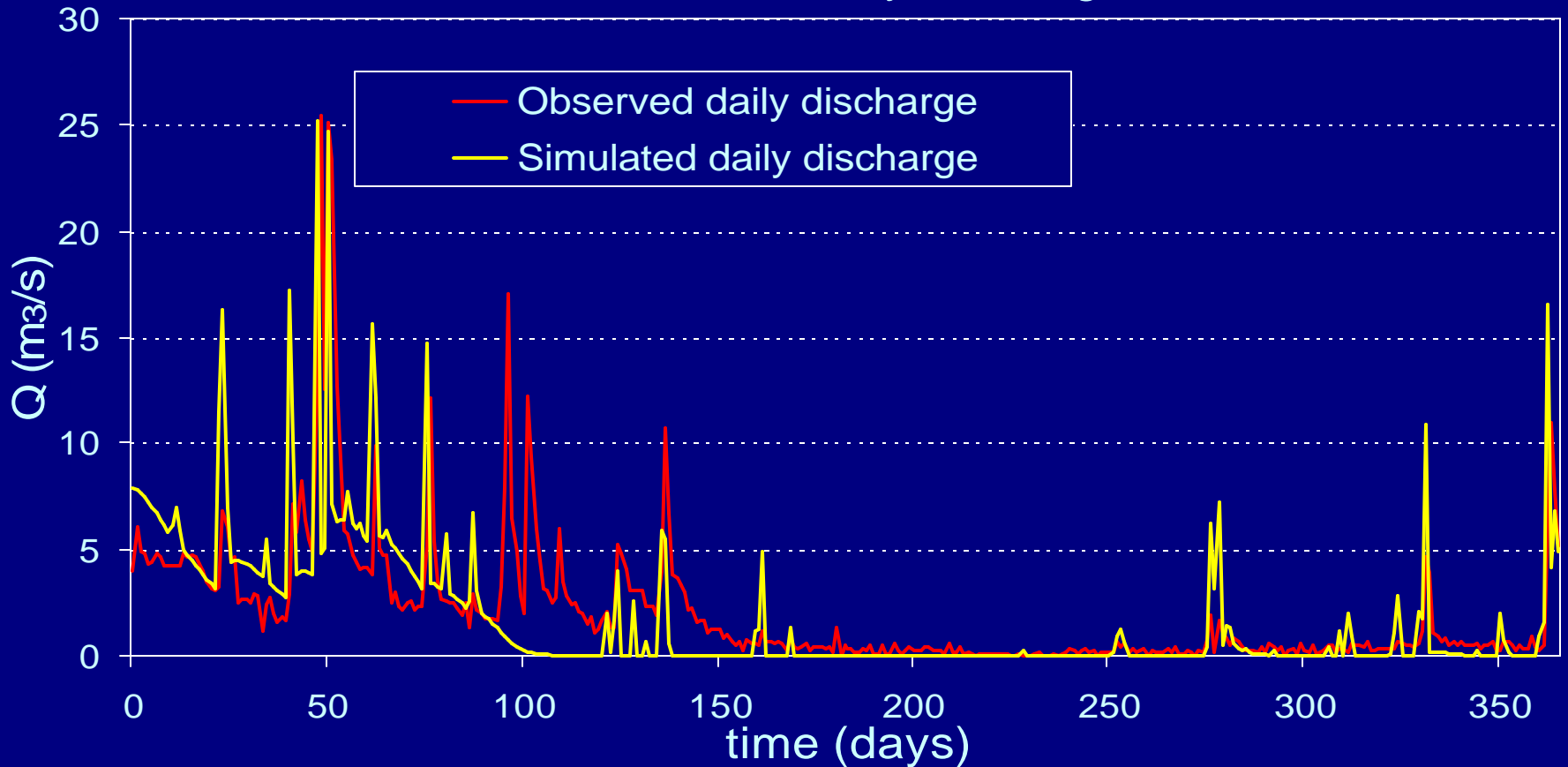
Observed and simulated daily discharge - 1999



Correlation coefficient 0,55
Mean square error 15,50

Distributed model results

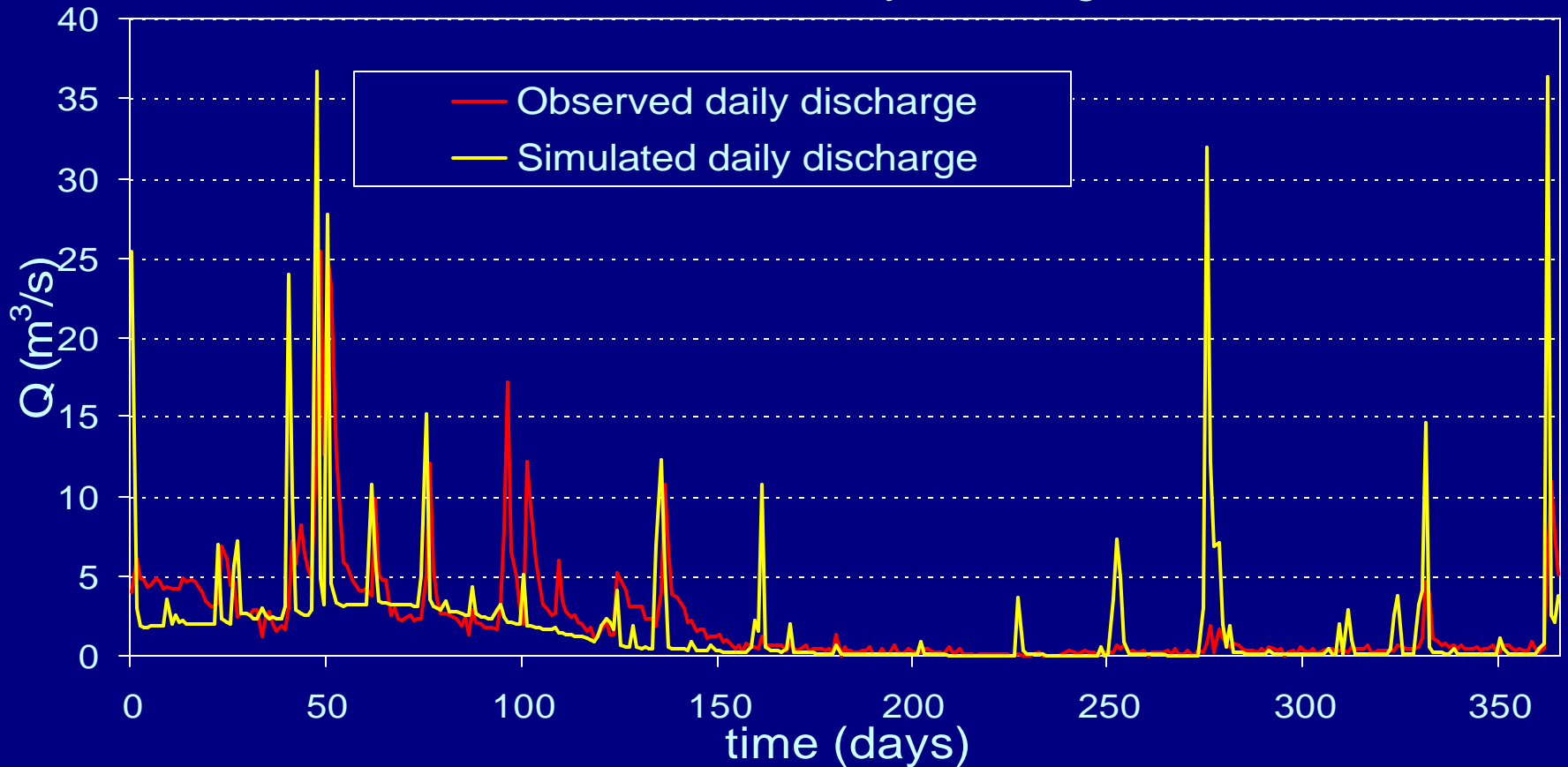
Observed and simulated daily discharge - 2000



Correlation coefficient 0,60
Mean square error 2,53

SWAT model results

Observed and simulated daily discharge - 2000



Correlation coefficient 0,42
Mean square error 22,12

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.



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

Aurelia Sole
Donatella Caniani
Ignazio Mancini

Simulation results

Confronto tra i valori di concentrazione calcolati e i risultati ottenuti attraverso l'applicazione del modello proposto

