Estimating available water resources of the Sardinian island using the SWAT model

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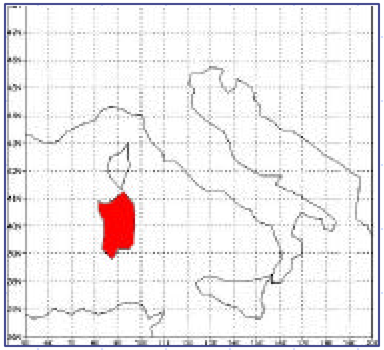


Centro di Ricerca Sviluppo e Studi Superiori in Sardegna

Topics

study the water cycle on a regional scale using a physically based model and estimate the total available water resources of the Sardinian island

produce a parameterisation database for the land use and soil at regional scale

how to deal with inadequate daily climatic data

Former approaches (black box models)

Previous studies (in Sardinia) have:

worked to improve empirical models to represent the hydrological peculiarities of the island

The most important experience in Sardinia is the "SISS" the study on the superficial water resources of the Sardinian Island

They use a stochastic model (the Box & Jenkins approach) to reconstruct missing records and to develop scenarios.

Data availability

CORINE land cover map (1:100000), low resolution but good quality

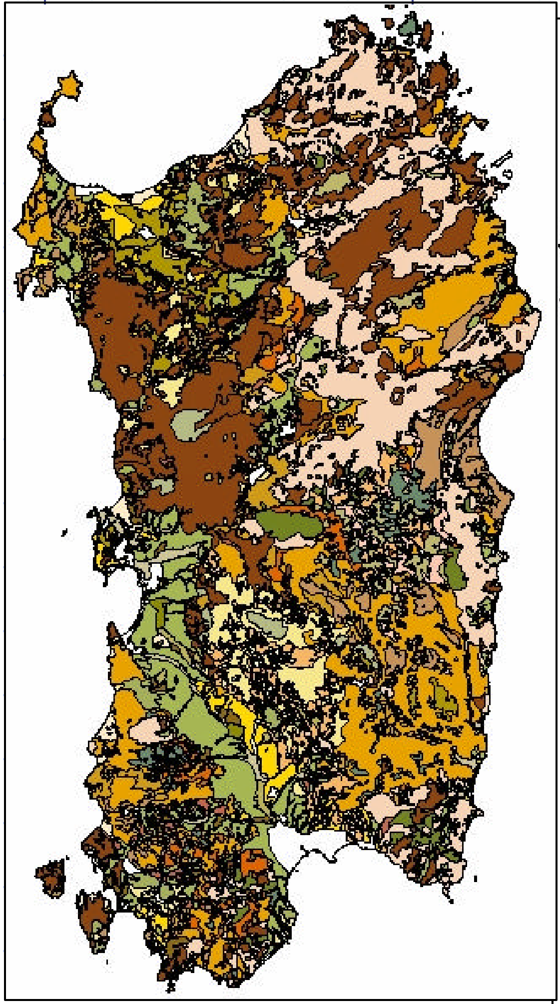
geo-pedologic map (1:250000); low resolution and poor quality

monthly rainfall and averaged thermometric data; gages well scattered on the island (not complete daily data in tabular form)

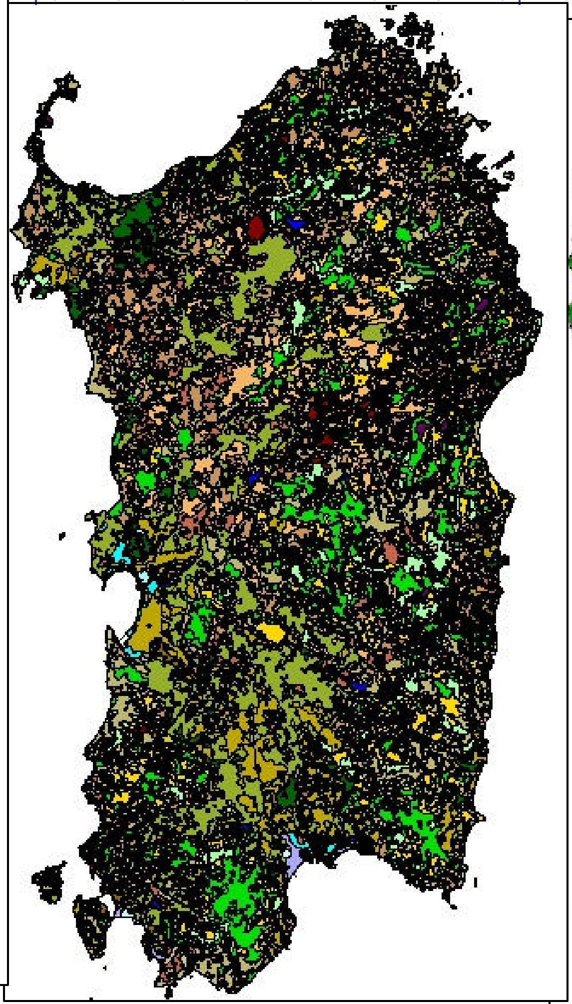
17 streamflow monitoring stations within the main Sardinian basins

Soil, Land Use and DEM

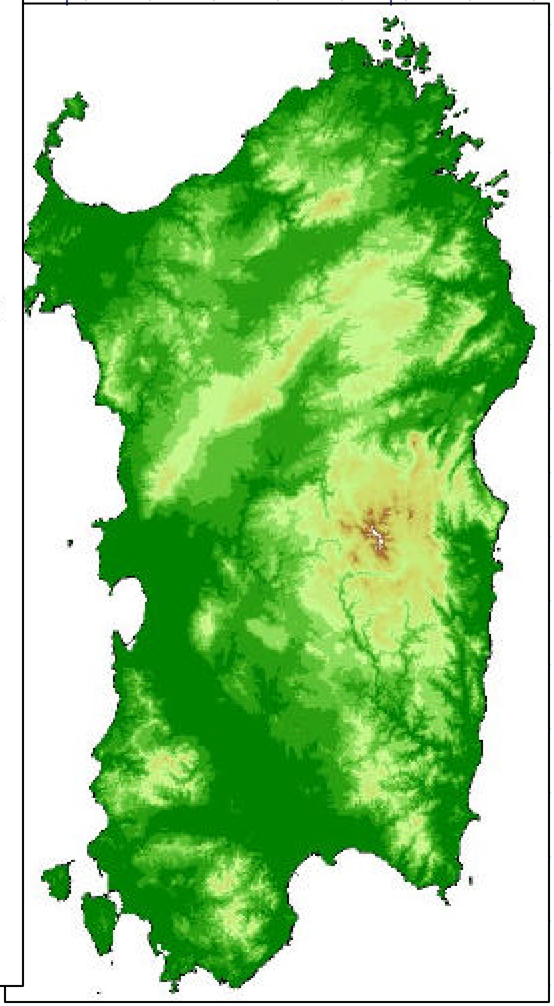
Soil (1:250000)



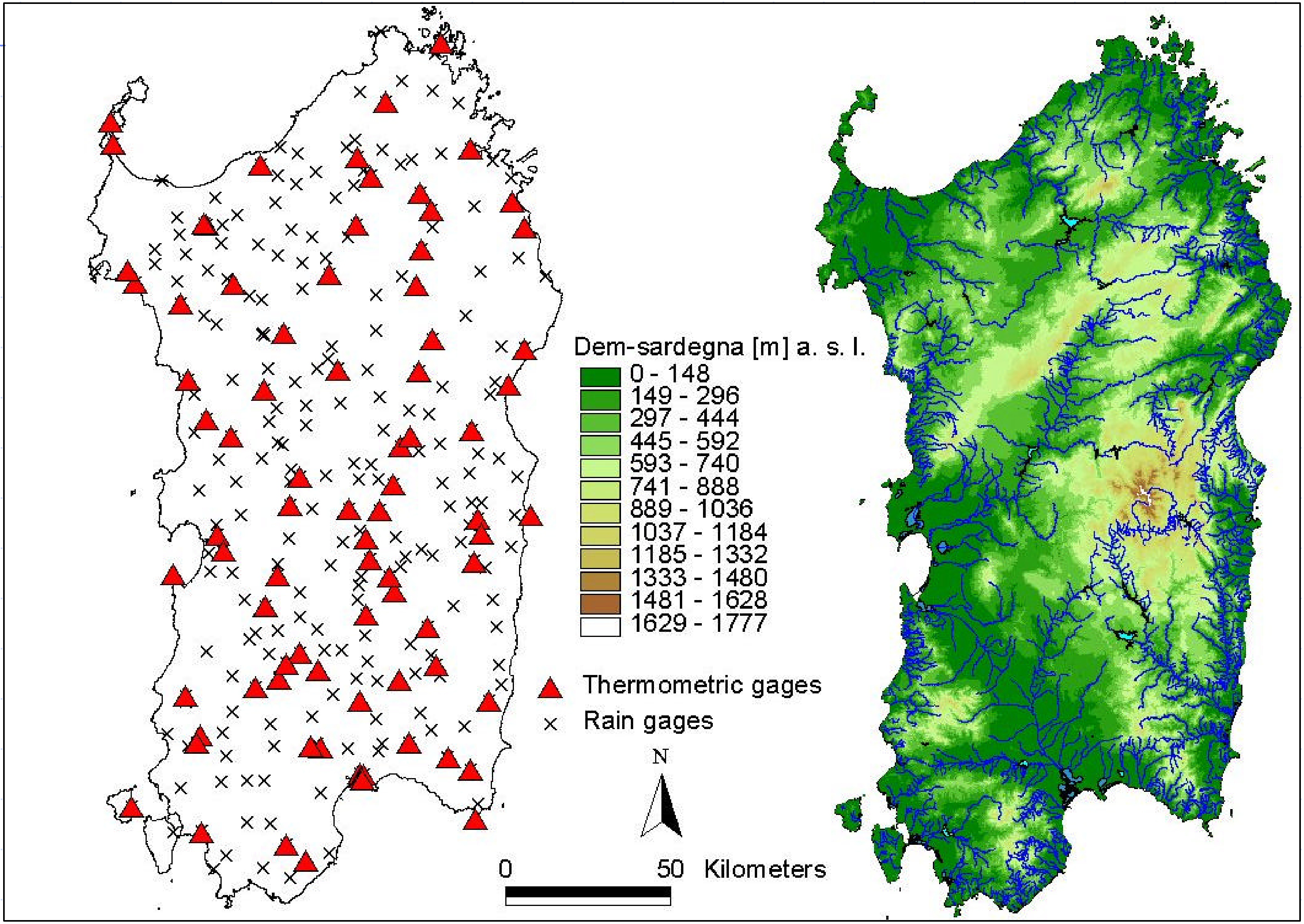
Land use (1:100000)



DEM (400 m)



Climatic gages and hydrography



Parameterisation

Soil:

a) each cartographic unit of the vector map was associated with one or two delineations corresponding to subgroups of USDA soil taxonomy.

b) about 40 representative soil profiles are described and classified according to the USDA and FAO guidelines, in tabular form.

c) Classical pedotransfer functions are used to calculate dependent variables (field capacity, permanent wilting point, AWC, saturated hydraulic conductivity) from independent variables: sand, silt and clay content

Land Use:

a) Conversion of the CORINE land cover classification codes to the SWAT land cover/plant codes.

Climatic characterization

Rainfall characterization
Options:

a) reconstruct daily missing records (linear regression) on a limited number of raingages

b) downscale the monthly rainfall data (stochastic approach) on a well scattered number of raingages

Temperature characterization

Simulate the temperature with the SWAT generator

Rainfall synthetic series

Sardinian rain gages and basins have been grouped in two different homogeneous classes, (East and West rain gages) using a clusterization technique based on the spatial distribution of standard deviation and skew of daily rainfall data

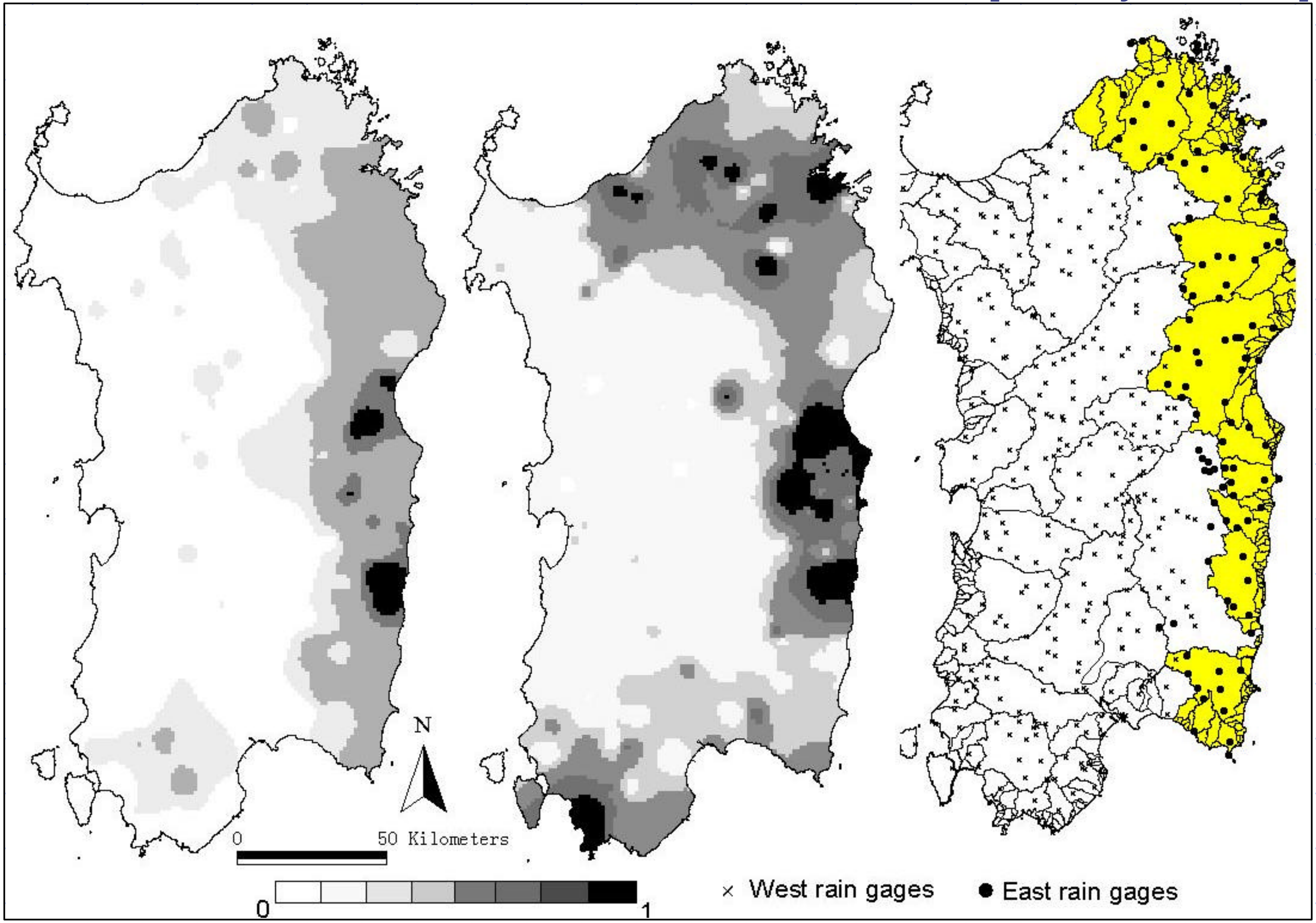
a Markov chain-skewed generator [Nicks, 1974] is used to:

- determine if the day is wet or dry for the East and West raingages
- then use the skewed distribution to generate the precipitation amount

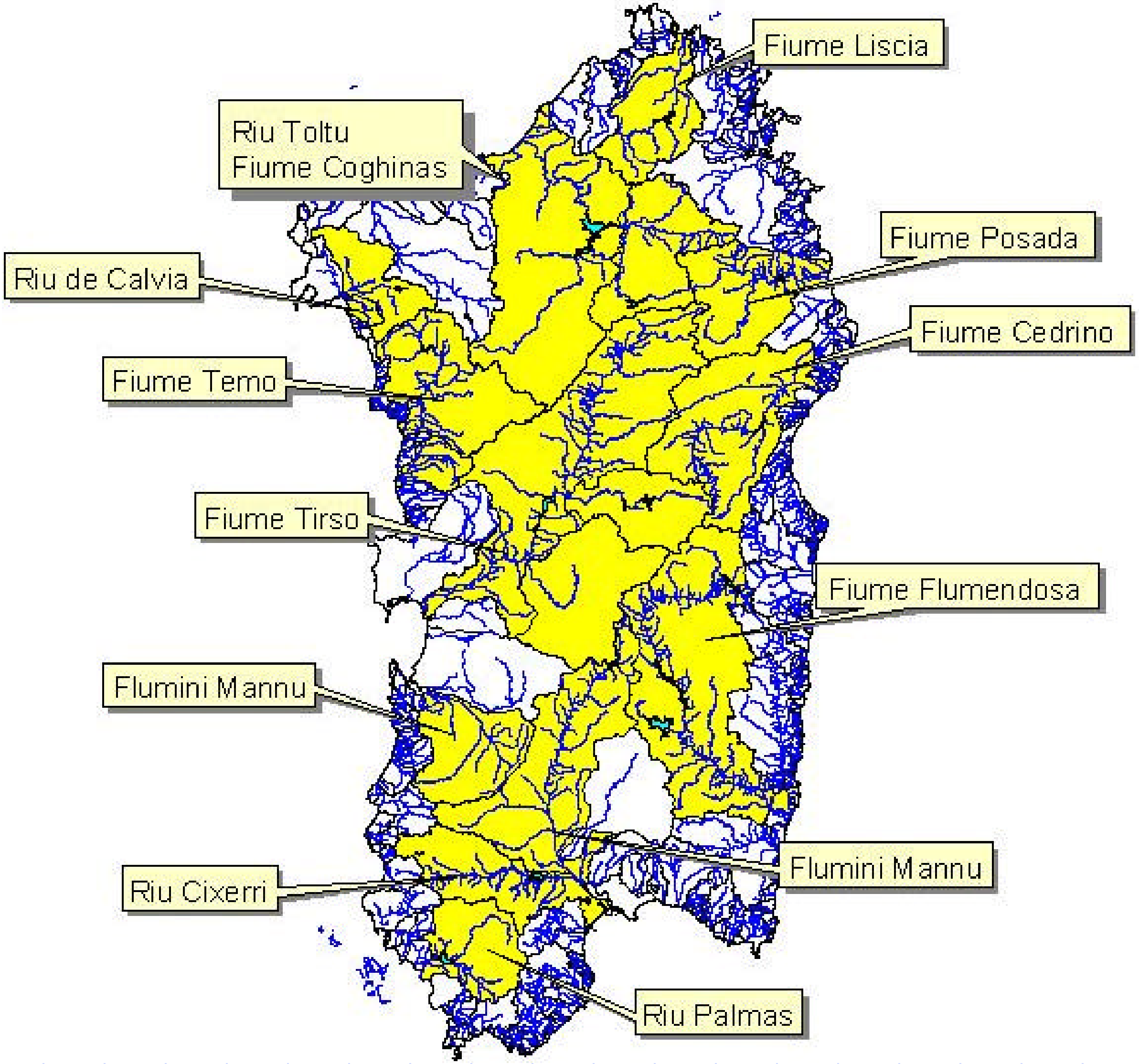
Finally, the sum of the daily precipitation of each month of each year is scaled to match the monthly registered rainfall for each station.

Sardinian raingages clusterization

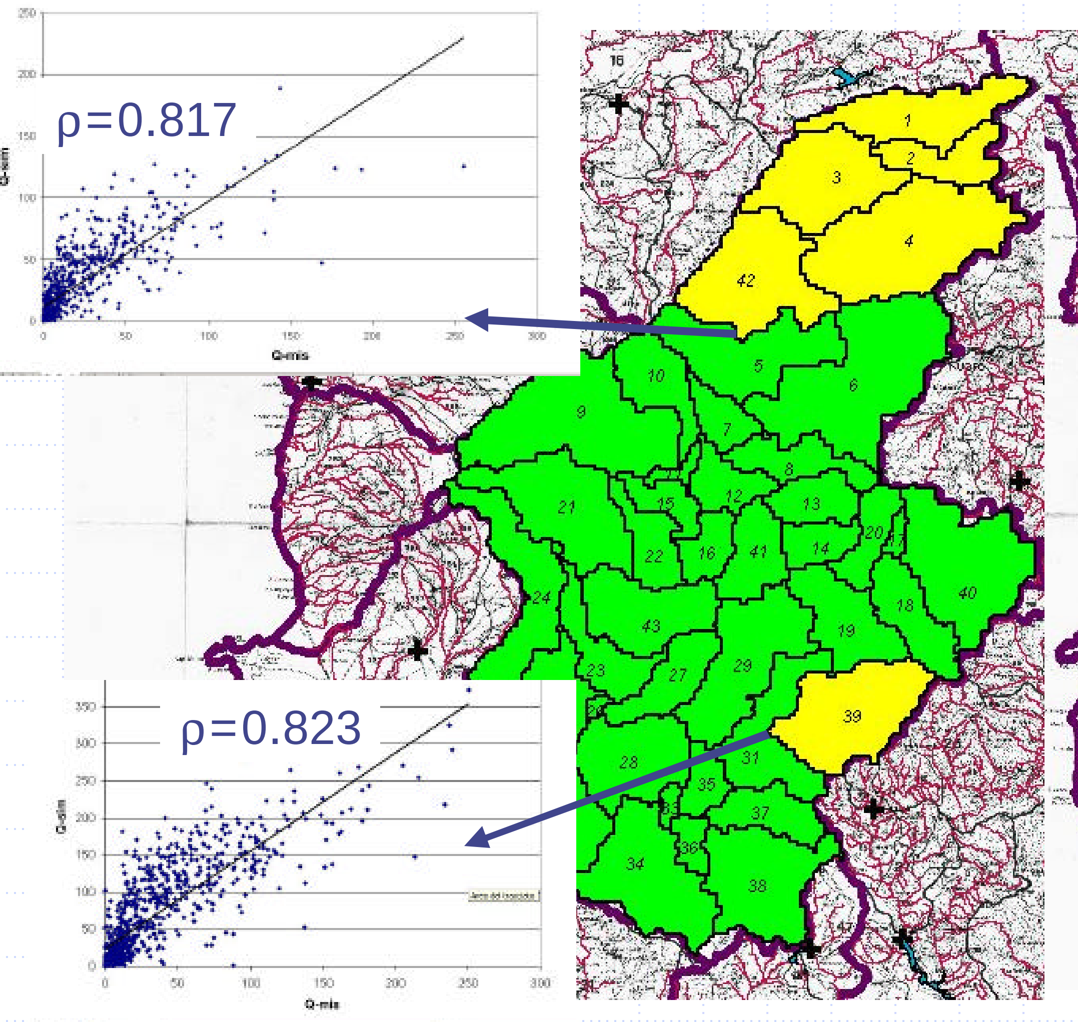
Normalized standard deviation (left) and skew (middle) maps for the daily precipitation records [February 1952-1992]

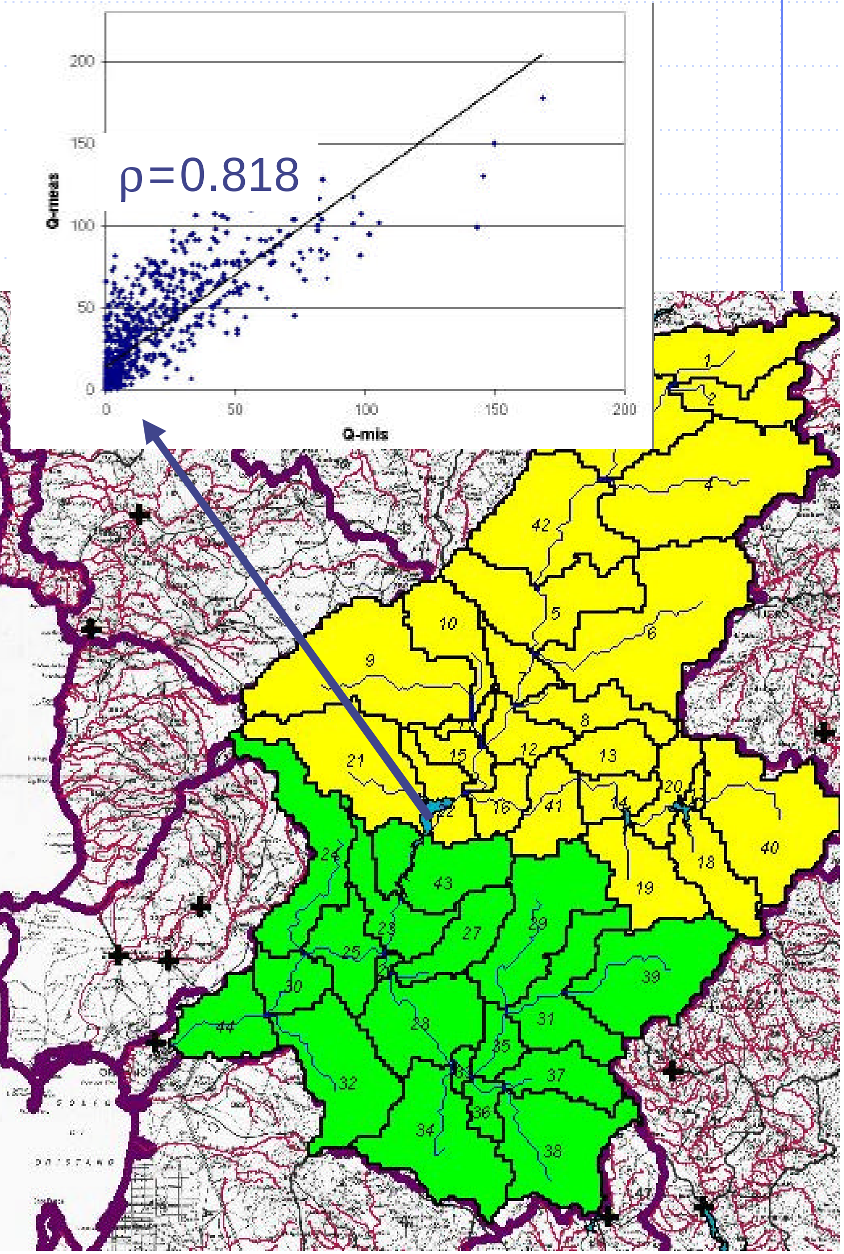


Basins under investigation

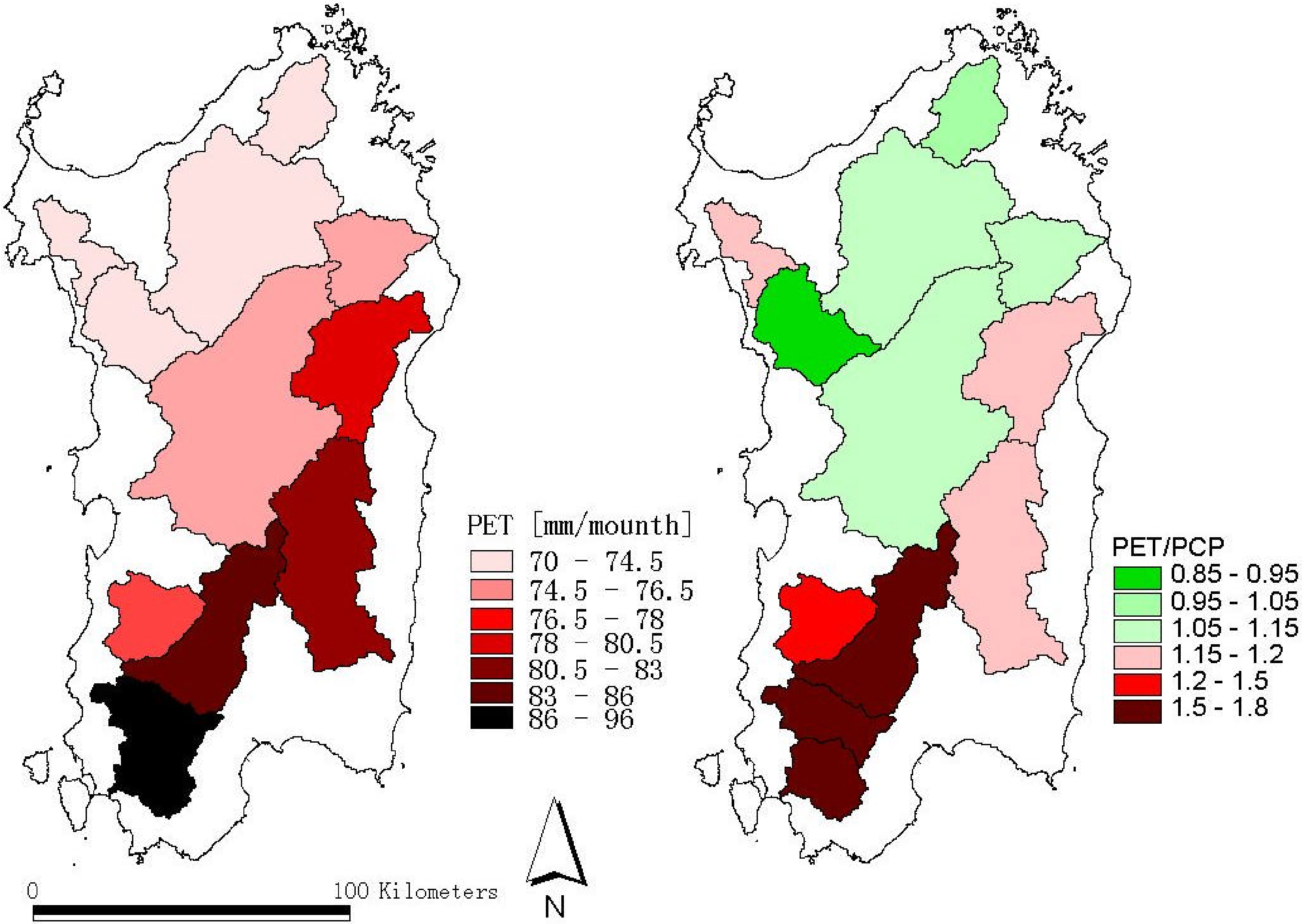


Monitoring gages

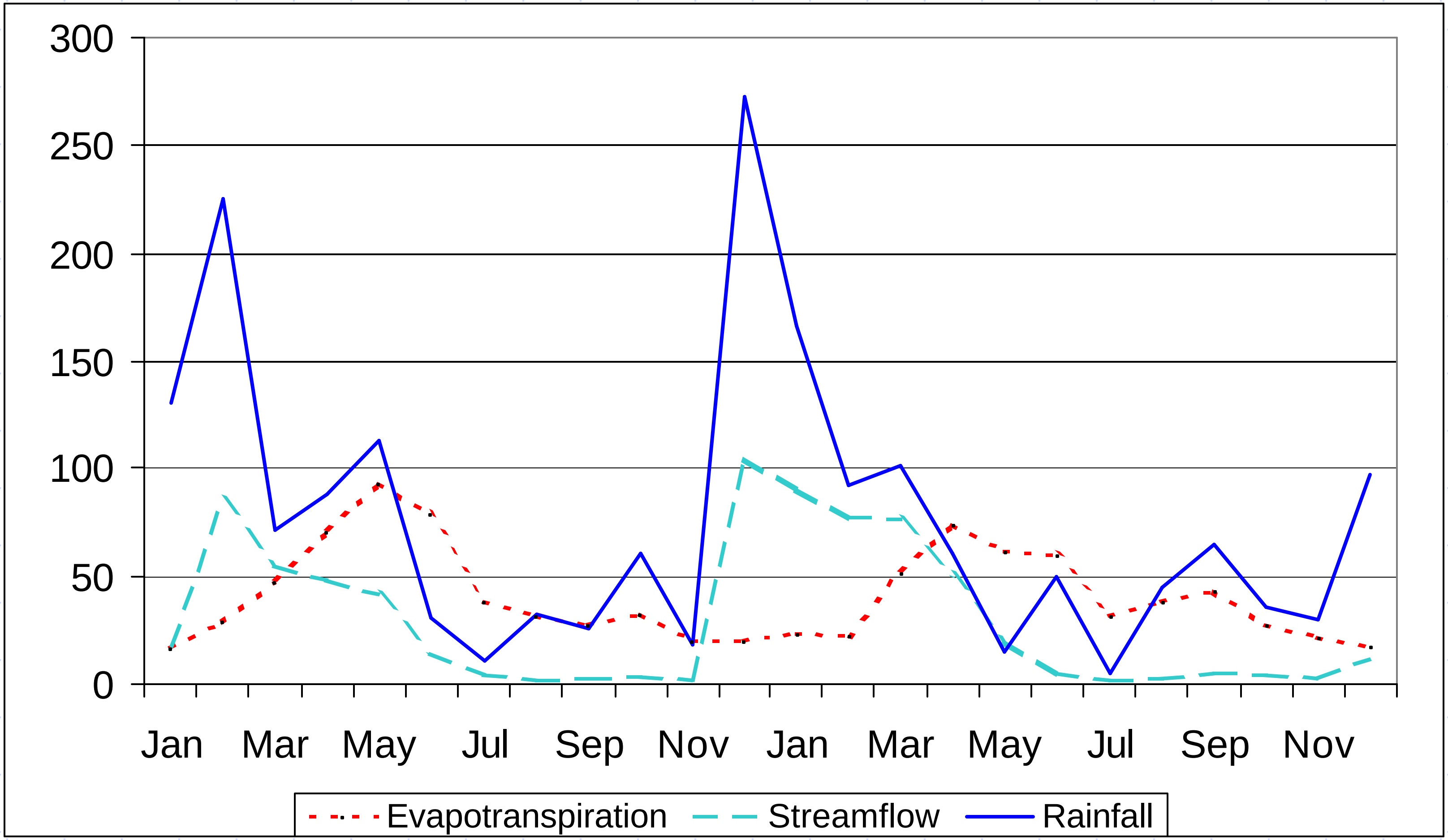




PET and PET%

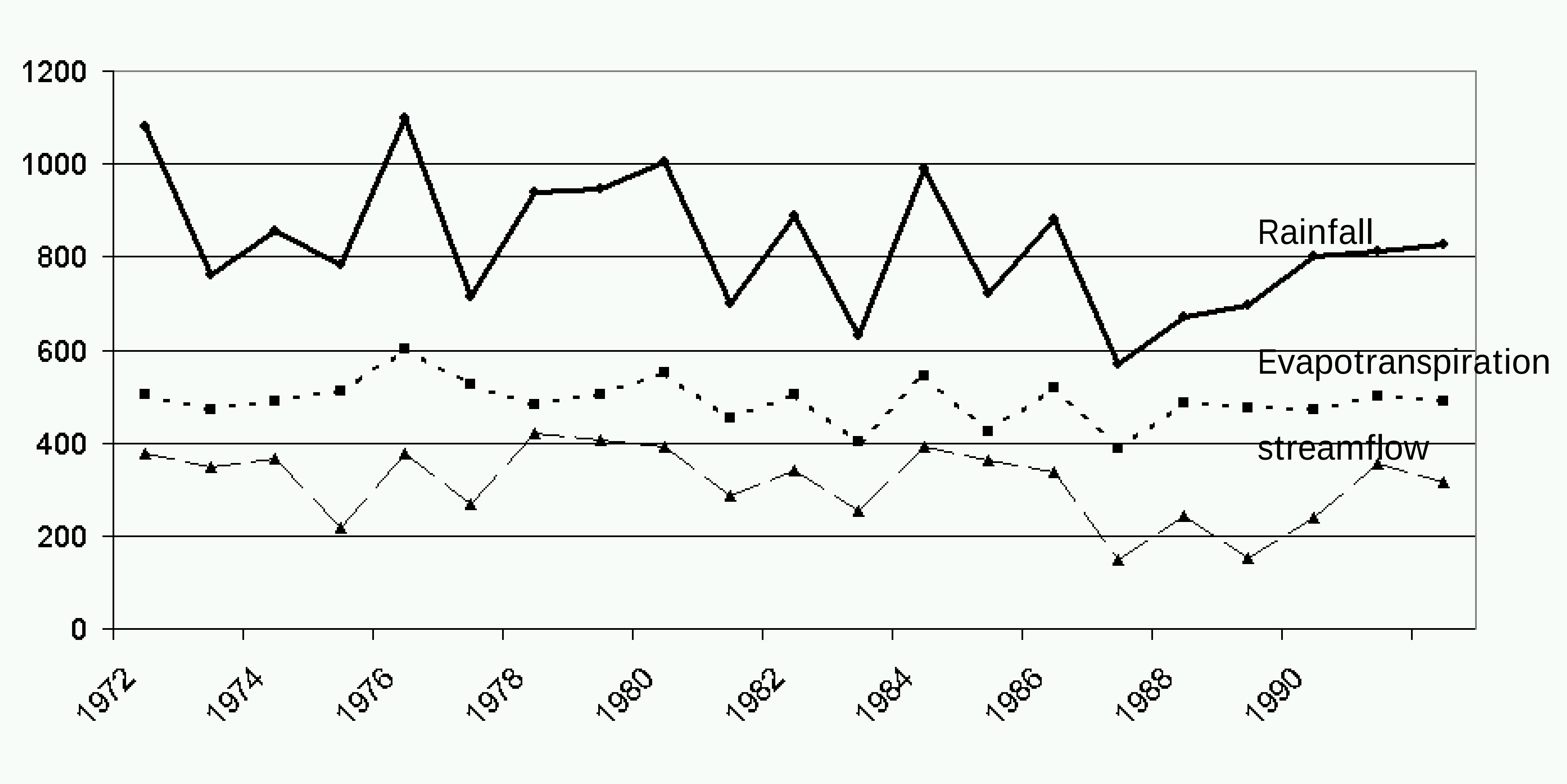

PET [mm/mounth]
70 - 74.5
74.5 - 76.5
76.5 - 78
78 - 80.5
80.5 - 83
83 - 86
86 - 96
0
100 Kilometers
N
PET/PCP
0.85 - 0.95
0.95 - 1.05
1.05 - 1.15
1.15 - 1.2
1.2 - 1.5
1.5 - 1.8

Water budget calculations



Water budget for the time period 1971-1972, for the draining basins

Water budget calculations



Yearly rainfall, evapotranspiration and streamflow on the draining basins [mm/year]. The potential water avalaibility is about 2325 million m^3

Conclusions

An extensive quality assessment of the available climatic, soil, & land use data has been carried out on a regional scale. GIS initializations has been drastically reduced by simply relying on these regional framework databases

A conceptual approach (via a stochastic methodology) has been used to downscale monthly rainfall data.

Still, the spatial scalability of the system is limited by the poor quality of the soil vector map. A better information is required for smaller scale studies.

Post-processing tools have been designed to derive regional indicators from the basin framework calculations.

The rainfall generator

is a Markov chain-skewed generator [Nicks, 1974]:

a) determines if the day is wet or dry
b) a skewed distribution is used to generate the precipitation amount

The skewed distribution reads as follows:

$$R_{day} = \mu_{mon}+2\sigma_{mon}\cdot\{[(SND_{day}-g_{mon}/6)\cdot(g_{mon}/6)+1]^3-1\}/g_{mon}$$

where R_{day} is the amount (mm) of daily rainfall on a given day

μ_{mon} is the mean daily rainfall (mm) for the month

σ_{mon} is the standard deviation of daily rainfall (mm)),

SND_{day} is the normal deviate calculated for the day

g_{mon} is the skew coefficient for daily precipitation in the month.