Hydrology and sediment yield calibration for the Barasona reservoir catchment (Spain) using SWAT

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Validation and uncertainty in soil erosion modelling: achievements and challenges

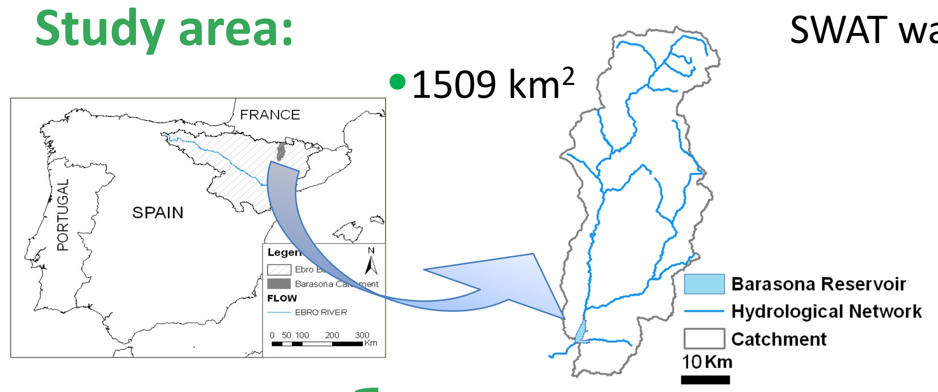
Introduction

Hydrological and soil erosion models, as Soil and Water Assessment Tool (SWAT), have become very useful tools and increasingly serve as essential components of integrated environmental assessments that provide information outside of direct field experiments and causal observation.

Purpose: improve the calibration of SWAT model to use it in an alpine catchment as a simulator of processes related to water quality and soil erosion.

Material and Methods

Study area:



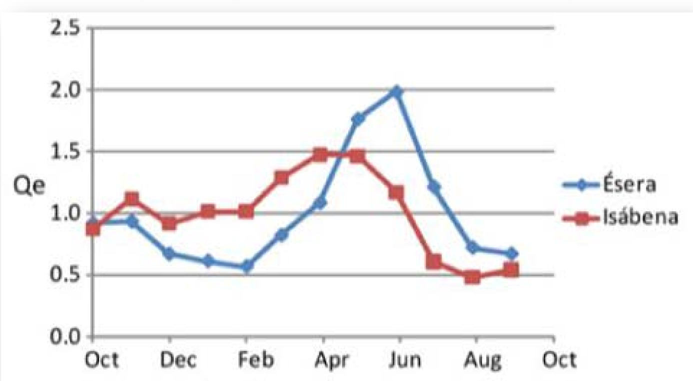
SWAT was applied to the Barasona reservoir catchment → Central Spanish Pyrenees.
→ Siltation problems (Valero-Garcés et al. 1999; Navas et al. 2009)

Climate: mountain type, wet and cold.
Precipitation and temperature gradients
- from 500 mm and 12ºC at the reservoir
- to > 2000 mm and < 4ºC above 2000 m a.s.l.
  0 ºC isotherm → around 1650 m a.s.l. (García-Ruiz et al. 2001)

Rugged topography
- Altitudinal range of 3000 m
- Mean elevation of 1313 m
- Average catchment slope: 39 %

Drainage network:
- Ésera River → dammed
- Isábena River

The hydrologic regime is transitional pluvial–nival



- Northern areas → grassland
- Central areas → forest
- Southern areas → cultivated land

Soil characteristics:
- stony and alkaline
- shallow (< 1 m)
- textures: loam - sandy loam
- well drained soils
- limited average water contain
- moderate - low structural stability

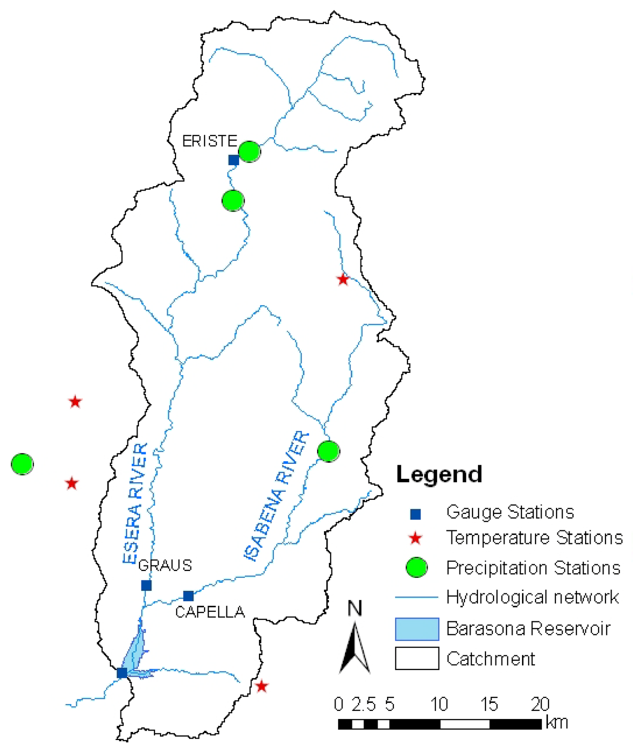
SWAT
- spatially semi-distributed, agro-hydrological model that operates on a daily time step (as a minimum) at basin scale.
- designed to predict the impact of management on water, sediment and agricultural chemical yields in ungaged catchments.
- provides physically based algorithms as an option to define many of the important components of the hydrologic cycle.

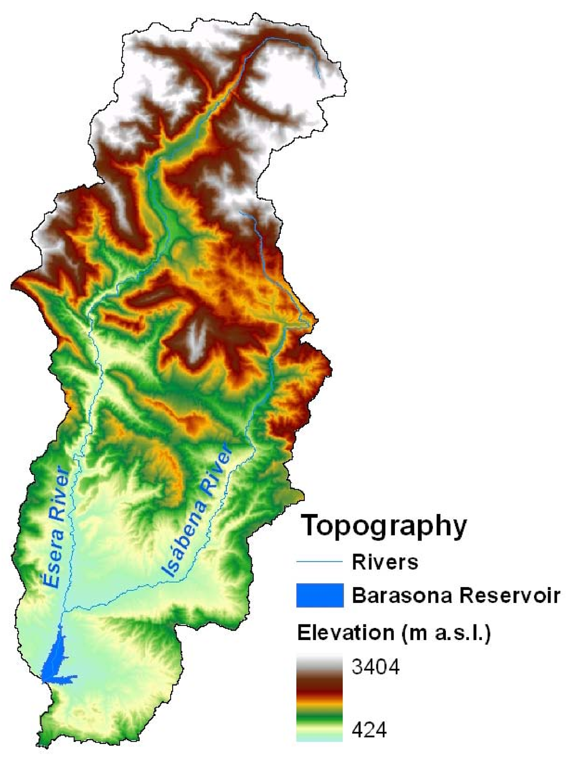
(Arnold et al. 1998)

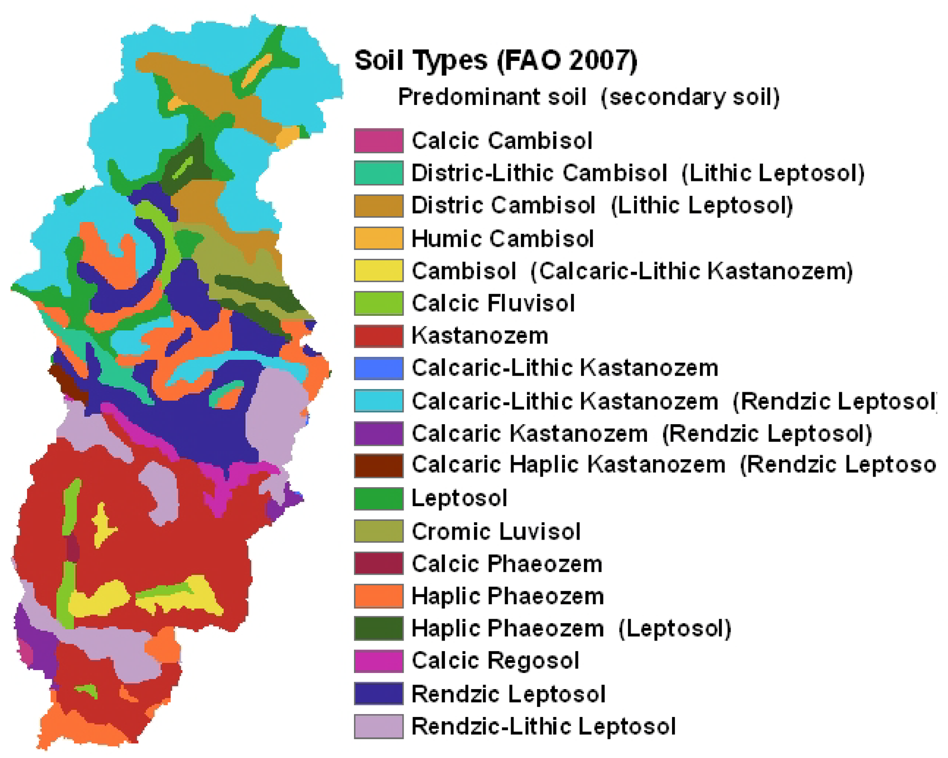
Model setup and calibration:

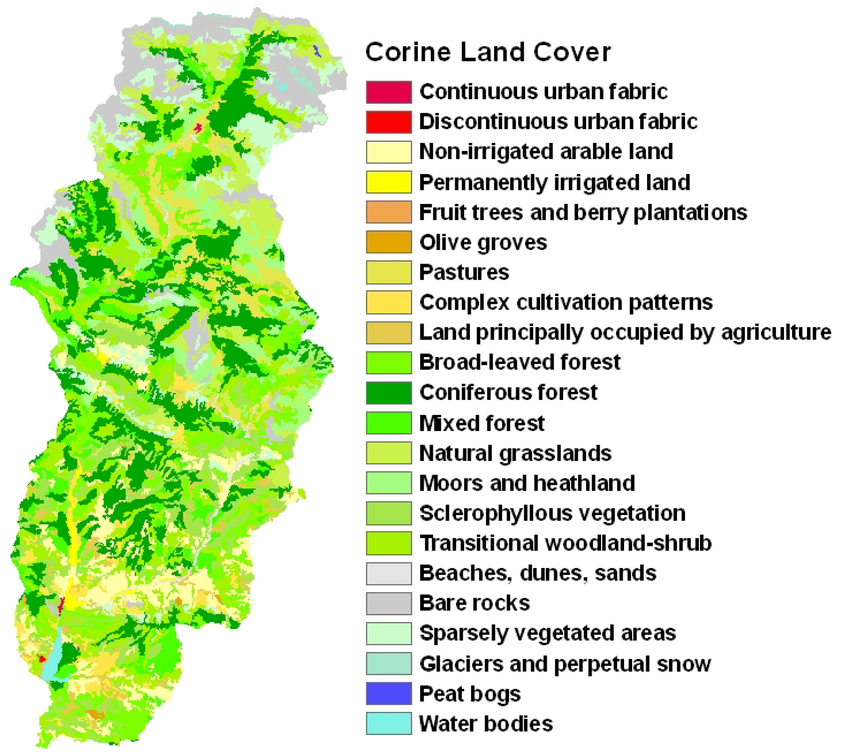
Input requirements: data about climate, topography, soil properties, vegetation, and land management practices.

Due to the inexistence or scarcity of tabulated data → Compilation required considerable investigation, documentation and adaptation of the available information









Simulation period: 2003-2005

The mountainous characteristics of the catchment, in addition to the scarcity of climate data in the region, require specific calibration for some processes.

Snowfall and snowmelt:
- significant processes in the hydrologic regime of the area calibrated in a previous work

Model performance
Evaluated using several statistical parameters:
- Nash– Sutcliffe efficiency coefficient (NSE)
- Average runoff volume deviation (Dv)

Hydrology
using continuous measured streamflow data from two gauge stations, Graus and Capella (CHE: Ebro Hydrological Confederation).

Sediment yield
based in specific sediment yield calculated from bathymetric surveys in the Barasona reservoir (period 1932-1996: **350** t/km^{2}year; Sanz-Montero et al. 1996).

Challenges → improvement the previous calibration for better hydrology and sediment simulation.

Two reservoirs:


Linsoles reservoir

Reservoirs	Drainage area (km^2)	Capacity (hm^3)	Annual inflow (hm^3)	Trap efficiency (%)
Paso Nuevo	118	3	101	60
Linsoles	284	3	180	45

Jueu karst system:

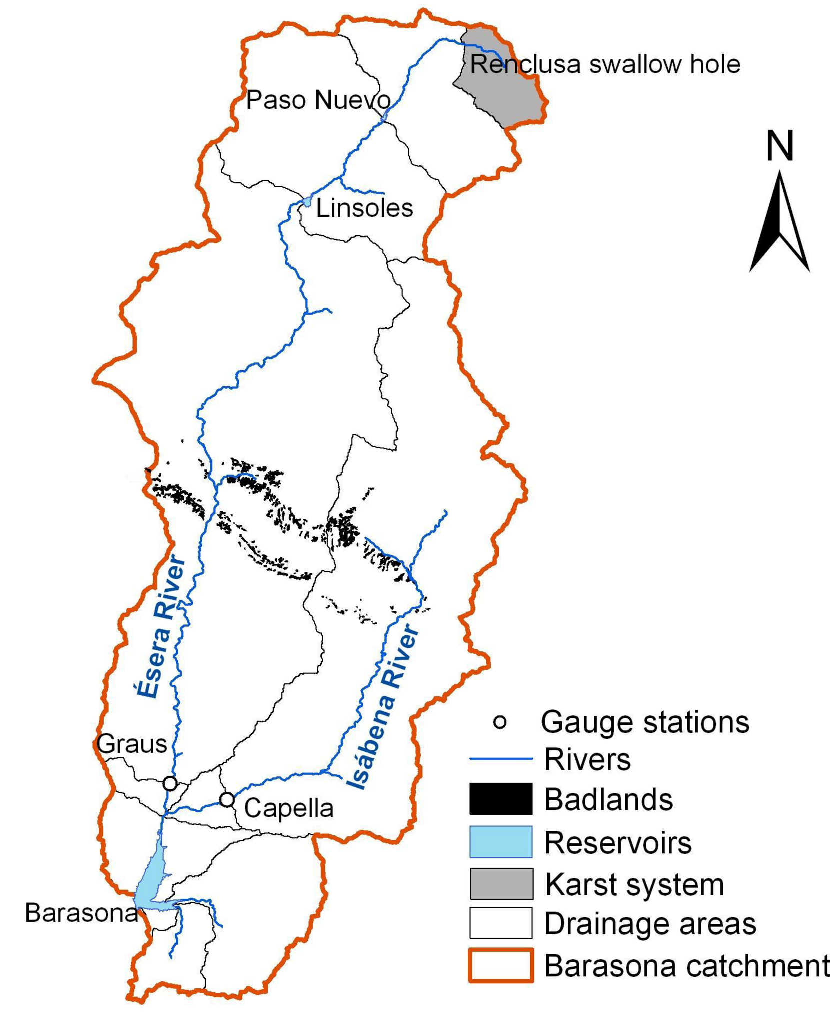

Forau de Aiguallut

- well developed → Renclusa, Aiguallluts and Toro de Barrancs swallow holes
- deviate the discharge of the upper part of the Ésera River
- parameterized to drain all of the discharge and sediment out of the catchment

Tracer tests observed a spring discharge of 0.02-11.5 m^3/s

Calculated comparing specific discharges (1963-1994) between the Ésera River headwater and other similar Pyrenean rivers → 25-30 % of the discharge was drained to the Garonne River

Badland area
- < 1 % of the catchment
- Eocene marls
- Manually defined → Added to the soil and CLC maps



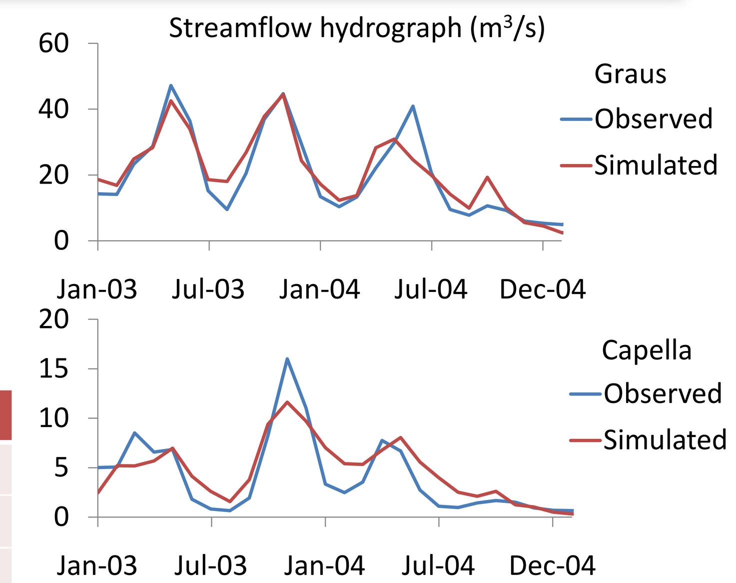
Results

Hydrologic performance

	Graus		Capella	
	NS	Dv	NS	Dv
Default SWAT	0.12	-1.21	0.57	-31.36
Previous calibration	0.75	-8.00	0.74	-14
Improved calibration	0.82	-6.13	0.74	-14

NS and Dv without simulated Jueu karst system for Graus gauge station: 0.8 and -12, respectively.

NO hydrological improvements for Capella gauge station.



Sediment calibration

	2003-2005	2003	2004	2005
Simulated precipitation (mm)	1046	1381	882	874
SSY default SWAT	147	260	99	82
SSY Improved calibration	534	926	381	294

SSY: Specific sediment yield (t/km^{2}year)

Simulated reservoirs sediment retention:
Paso Nuevo → **31905** t
Linsoles → **54944** t

Simulated sediment lost by Jueu karst system:
5439 t
Average discharge of **1.1** m^3/s

Badland area production
Average SSY **519** t/km^{2}year
78 % of the catchment

Conclusions

The introduction of these improvements in the model performed better results than previous simulations enhancing the calibration of SWAT for the Barasona catchment.

The final calibration of the model allows modeling water and sediment production closer to reality and therefore the study of the catchment processes would be more reliable.

The present study reveals the potential of the SWAT model for its use as simulator of processes of a Pyrenean catchment and identification of sediment sources and productions.

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