Application and validation of SWAT model to an alpine catchment in the Central Spanish Pyrenees

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2011 SWAT

Soil & Water Assessment Tool SWAT

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Introduction

Characteristics of the Spanish Pyrenees → reservoirs

Rugged topography
Regime of the rivers
Changes in land use

soil erosion

siltation
reservoir management problems
(Valero-Garcés et al. 1999; Navas et al. 2009).

Continuous direct measurements + spatial coverage ≠ Mountain ecosystems

A robust computational hydrologic model

↓

An effective means of studying land-surface dynamics

Snow-dominated mountain catchment → spatially distributed modeling

- highly heterogeneous climate drivers
- complex topography
- environmental gradients

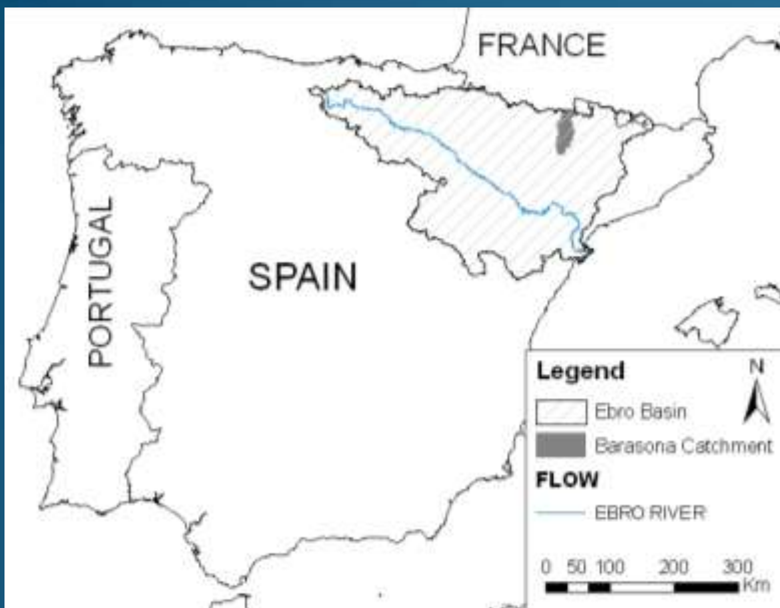
Precipitation and temperature lapse rates computed → restrict the ability of the model

This study → calibration and validation of a mountainous catchment + limit climatic data, important snowmelt streamflow, main dammed river

Materials and Methods

Study Area

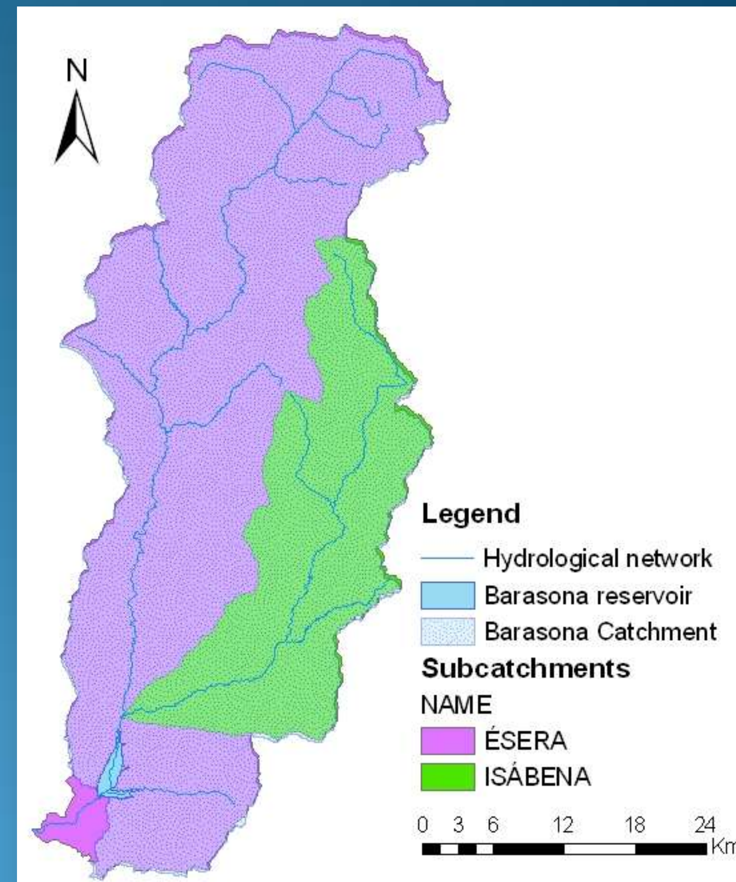
- The drainage basin of the Barasona reservoir
- Central Spanish Pyrenees



The Barasona reservoir limits

An agroforestry catchment

1,509 km^2



Barasona reservoir	Year	Capacity (hm^3)
Build	1932	71
Increased	1972	92
Today	2011	85

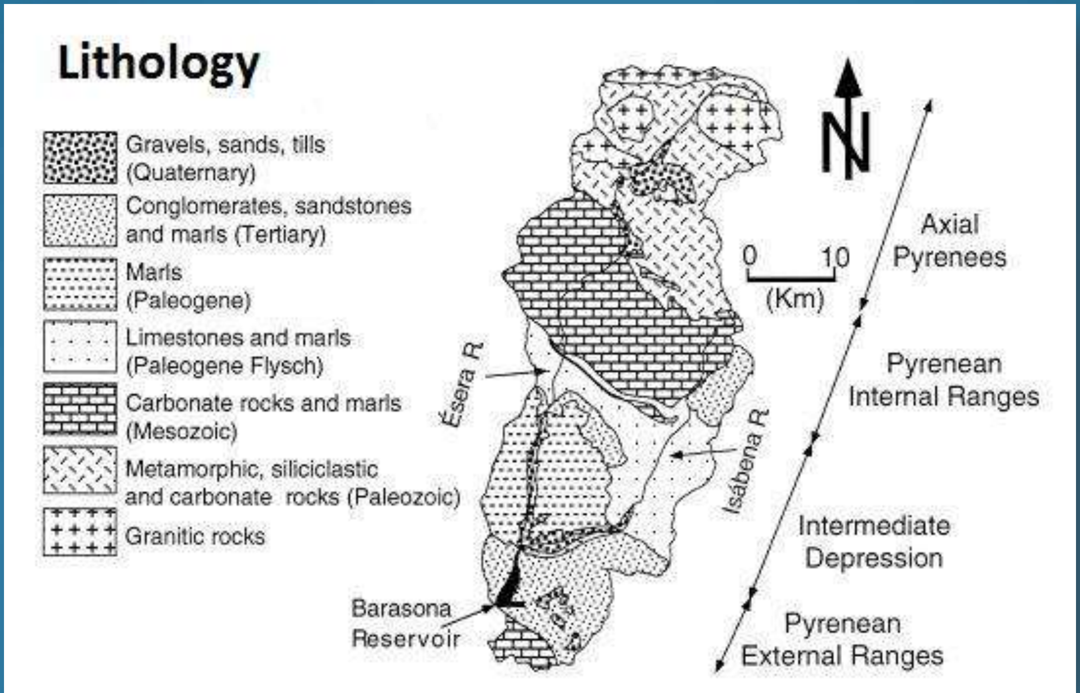
The Aragón and Cataluña canal → 105,000 ha

Materials and Methods

Geology

Heterogeneous topography and lithology → 4 Pyrenees Structural Units (WNW–ESE trending)

- Axial Pyrenees → Paleozoic rocks and granodiorites with peaks above 3000 m.a.s.l.
- Internal Ranges → Cretaceous and Paleogene sediments with Internal Depressions (Eocene marls)
- Intermediate Depression → Miocene continental sediment
- External Ranges → Tertiary materials



(Valero-Garcés et al. 1999)

Materials and Methods

Topography

Rugged topography

Altitudinal range of 3000 m:

424 m.a.s.l. → 3404 m.a.s.l. (Aneto Peak)

Mean elevation of 1313 m

Average catchment slope is 39 %

DEM

Aragón Territorial Information System (SITAR, 2010)

Spatial resolution = 20 m

Catchment configuration

DEM + gauge stations

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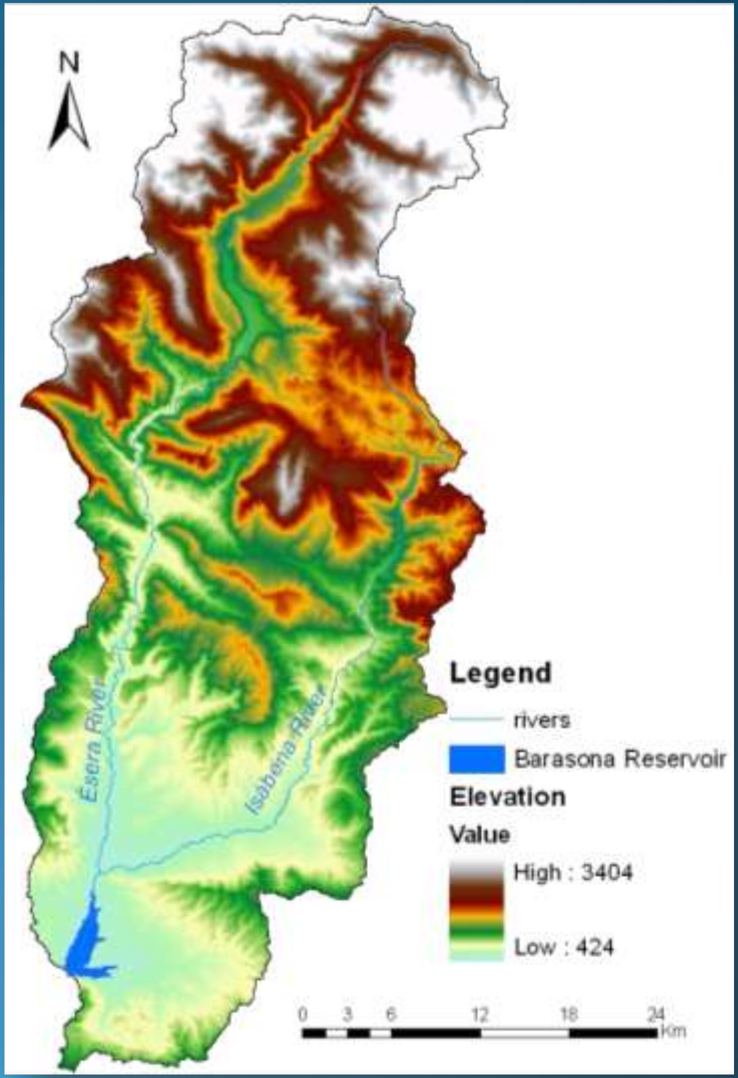
4 sub-basins and 290 HRUs



Materials and Methods

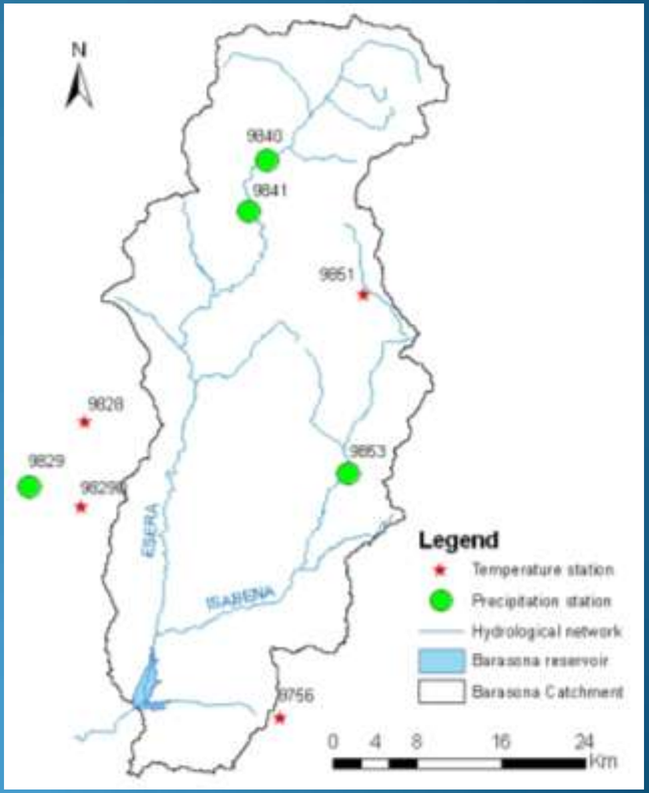
Climate

This is defined as mountain type, wet and cold

Temperature and precipitation gradients

- 500 mm and 12^{o}C at the reservoir
- > 2000 mm and < than 4^{o}C above 2000 m.a.s.l.

0 ^{o}C isotherm → around 1650 m.a.s.l.



Climate input

- daily max and min temperature
- daily rainfall

Rainfall stations	Elevation (m)	Temperature station	Elevation (m)
(9829) Mediano	483	(9829D) Trillo	597
(9853) Serraduy	905	(9828) Tierrantona	635
(9841) Sesue	943	(9756) Benabarre	734
(9840) Eriste	1078	(9851) Las Paules	1402

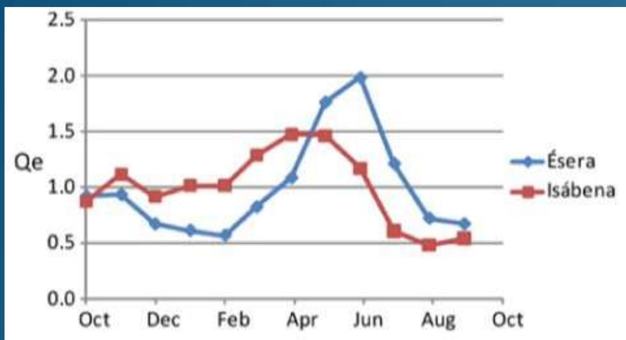
Governmental Meteorological Agency (AEMET Agencia Estatal de Meteorología)

Materials and Methods

Hydrology

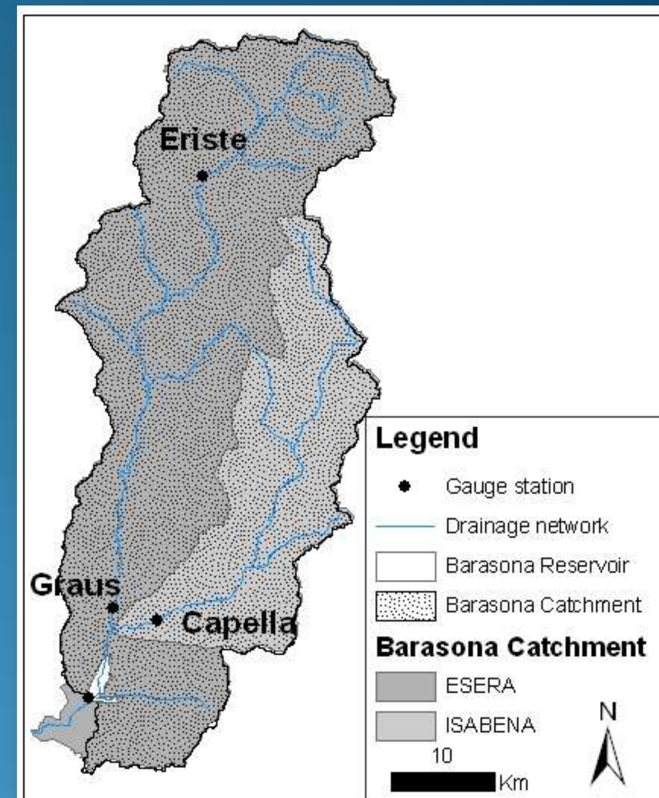
Drainage network:
- Ésera River
- Isábena River

They have different hydrological characteristics



The hydrologic regime is transitional pluvial–nival

Floods:
- late spring–early summer snow melt and heavy rains
- summer thunderstorms
- late autumn heavy rains



Hydrological data

3 gauge station

Linsoles Reservoir → was configured in the model

Ebro River Hydrographic Administration (CHE)

Materials and Methods

Soil

Characteristics:

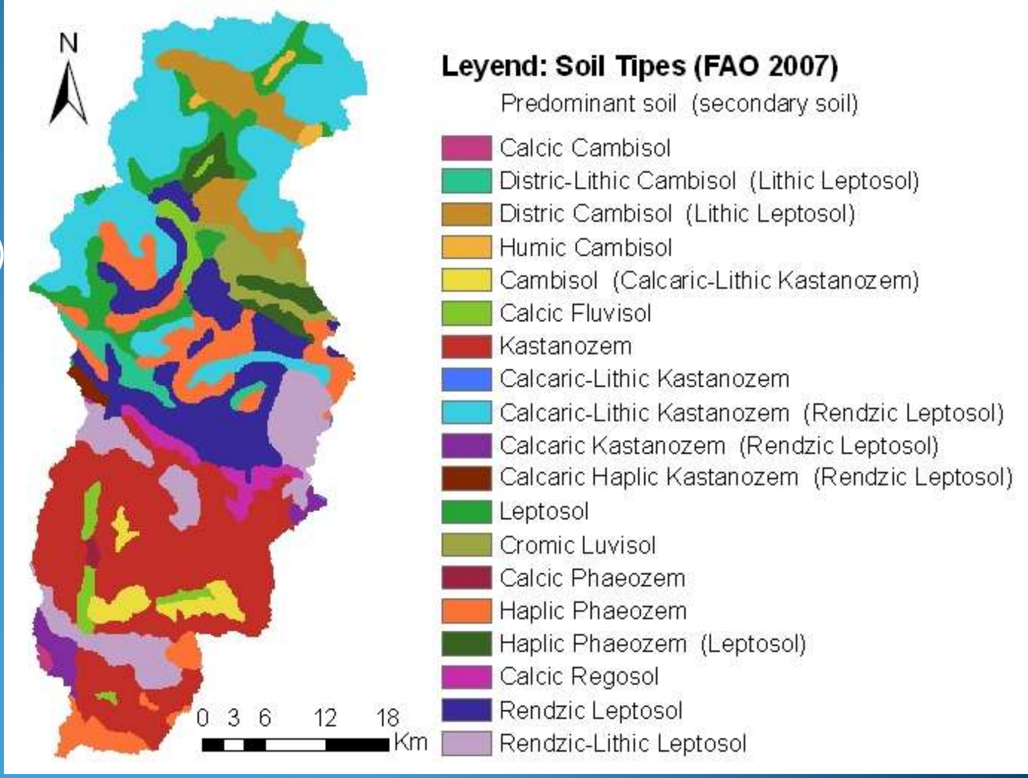
- stony and alkaline
- overlying fractured bedrock
- textures from loam to sandy loam
- shallow (< 1 m)
- low organic matter contents (< 3-4 %)
- well drained soils
- limited average water contain
- moderate to low structural stability.

Soil input data

Soil Map of Aragón (Machín J., awaiting publication)

19 types of soil: FAO (2007)

Harmonized World Soil Database (HWSD, 2008)

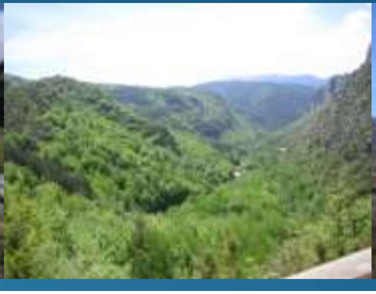


Materials and Methods

Land use

Distribution of land uses

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


Land use input

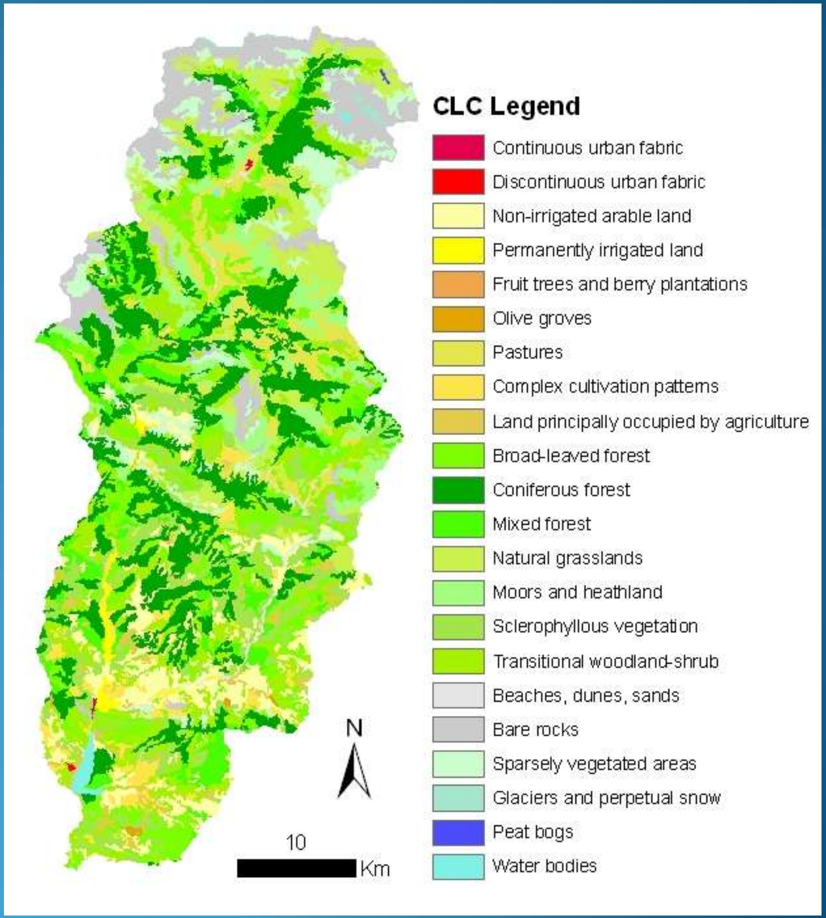
European Project Corine Land Cover (1990)

Resolution = 100 m

22 classifications

> 50% Forest

Land cover Type	Area (%)
Urban	0.1
Water	0.5
Range, grass	7.9
Bare rock, perennial ice and snow	8.5
Range, brush	11.2
Forest, deciduous	13.3
Forest, transitional and mixed	13.3
Agricultural Land	16.5
Forest, evergreen	28.6



Materials and Methods

SWAT model

SWAT2009 + ArcMAP (9.3)

Model Parameterization

10 elevations bands

Precipitation lapse rates = 1000 mm/km

Temperature lapse rates = -5 ^{o} C/km

Snow-snowmelt final Parameterization

Parameter	Value
Snow fall temperature, SFTMP (ºC)	2
Snowmelt temperature, SMTMP (ºC)	1.5
Maximum melt rate of snow during a year, SMFMX (mm⁄ ºC⁄ day)	3.5
Minimum melt rate of snow during a year, SMFMN (mm⁄ ºC⁄ day)	0.1
Snow pack temperature lag factor (TIMP)	0.1
Minimum snow water content at 100% snow cover, SNOCOVMX (mm)	200
Snow water equivalent at 50% snow cover, SNO50COV	0.1

Model Calibration and Validation

Model Evaluation

Two gauge stations → Graus and Capella

Nash–Suttcliffe coefficient (ENS, Nash and Suttcliffe, 1970)
Deviation in total volume (Dv, ASCE, 1993)

} The ability of the model to replicate temporal monthly trends

Model Calibration and Validation

SWAT-CUP + SUFI-2 + Nash-Sutcliffe efficiency (ENS)

Capella gauge station

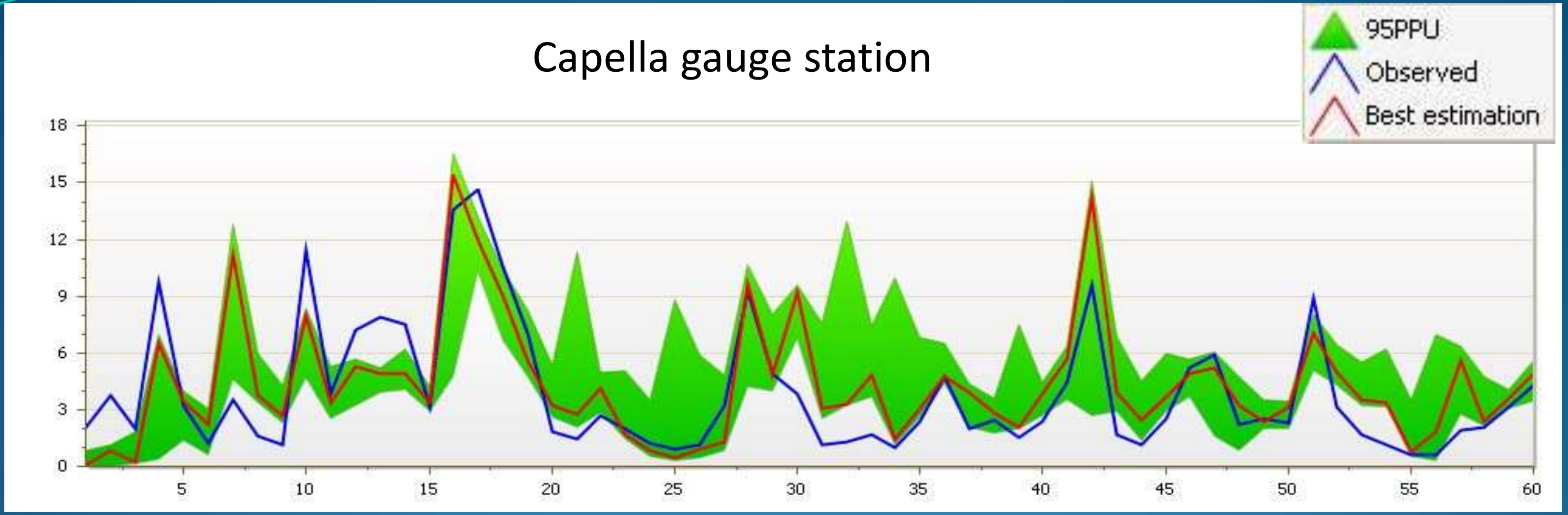
Periods

Calibration 1987-1991

Validation 1992-1996

Parameter	Fitted Value
r__CN2.mgt	0.08075
v__ALPHA_BF.gw	0.0215
v__GW_DELAY.gw	25.32625
v__CH_N2.rte	0.00885
v__CH_K2.rte	2.61225
v__ALPHA_BNK.rte	0.60485
v__SFTMP.bsn	1.33603
v__SMTMP.bsn	4.3
v__SMFMX.bsn	1.375
V__SMFMN.bsn	0.375
V__TIMP.bsn	0.09775
V__SNOCOVMX.bsn	462.5
v__SNO50COV.bsn	0.25475

Results and Discussion



- The error in the high flows → uncertainties of the precipitation → local thunderstorms
- Limited climatic data in altitude + inferred snow routine → The rest of the error

	NS		Dv (%)	
	Graus	Capella	Graus	Capella
Initial	0.51	0.64	-0.68	-3.91
Calibration	0.40	0.65	0.11	0.41
Validation	-0.12	0.46	0.08	0.30

Conclusions

Rugged topography
\+
Lack of meteorological data → They are limitations for SWAT mountain simulation

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Generation of snow, snowmelt and streamflow present some inconsistencies

It is necessary → an improved definition of the climatic data for the catchment

The dammed characteristics of the Ésera River → affects the simulation results

Detailed adjust of inflow-outflow in the Linsoles reservoir

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It improved the calibration of the Ésera subcatchment


Thank you very much