Impact of temporal resolution of rainfall inputs on the performance of the SWAT model in Peninsular Spain

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Scientifical Context:

- Rainfall is one critical factor affecting the hydrological processes of river basins.
- Temporal resolution of rainfall plays an important role in determining the hydrological response of river basins.
- Rainfall temporal variability can be considered one of the most critical elements on the predictive performance of rainfall–runoff models.

Objectives:

- Assessment of SWAT model in different climatic watersheds in Peninsular Spain.
- Analysis of performance of daily and hourly resolution in rainfall to simulate the streamflow in oceanic and semiarid climates.

Study Site and Data:

- Two basins were selected for this study due to their location in two contrasting climatic regions of Peninsular Spain (Fig. 1). To ensure the validity of the results, the selected catchments are in natural regime.
- The **Ibaizábal** river basin (Table 1), located in the Basque Country, is a clear example of oceanic climate. Land uses are mainly agricultural and forest, especially pine forests.
- The **Segura** river basin (Table 1) has a predominant semiarid climate and it is located in the southeastern part of Peninsular Spain. More than 50% of the basin is occupied by perennial tree forested areas. In the rest of the basin shrubs (30%) and agricultural areas (10%) alternates.

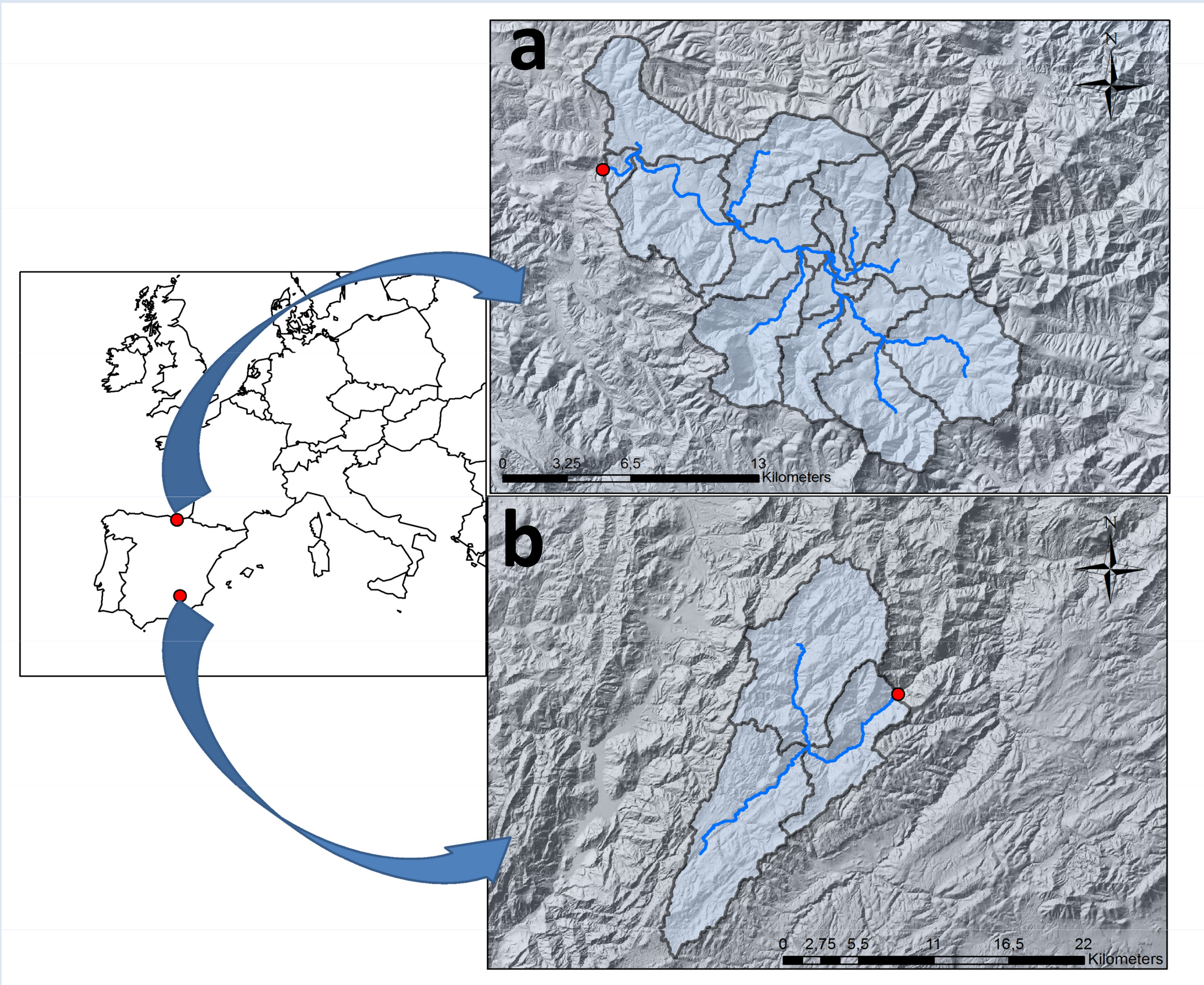

Figure 1: Localization of the study catchments (a-Ibaizábal river basin, b-Segura river basin).

Basin	Surface (km^2)	Average Altitude (m.a.s.l.)	Average yearly precipitation (mm)	Average discharge (m^3/s)
Ibaizábal	252.39	341.56	1224	8.53
Segura	235.78	1422.58	634	1.39

Table 1: Summary of catchments characteristics.

Data type	Source and description
DEM	Spanish National Geographic Institute with a resolution ratio of 25 m
Land use map	CORINE Land Cover 1:100,000 vector map
Soil map	Harmonized World Soil Database with a resolution of 1 km
Weather data	Rainfall from Euskalmet and from CHS. Temperature from Spain02 (Herrera et al., 2012)
Stream discharge	CEDEX site nº 1163 at Lemona and nº 7001 at Anchuricas Reservoir

Table 2: Source of input data.

Methodology:

SWAT Modelling approach (Arnold et al., 1998, Williams et al., 2008):

- The study period is 5 years: 2010–2014 in the Ibaizábal river basin and 2003-2007 in the Segura river basin. The data series was divided into two sets. The first 3 years were used for calibration and the remaining 2 years were used in model verification.
- Both daily and hourly rainfall observations were used as inputs to SWAT for monthly streamflow simulation in the Ibaizábal and Segura river basins.
- Infiltration methods used have been the curve number method (SCS, 1972) Eq. 1 and Eq. 2) in daily rainfall inputs and the Green-Ampt (Green and Ampt, 1911) (Eq. 3) in hourly simulations.

$$Q_{Surf} = \frac{(R_{day} - I_a)^2}{(R_{day} - I_a + S)}$$

Eq. 1

$$S = 25.4\left(\frac{100}{CN} - 10\right)$$

Eq. 2

$$f_{(t)} = K_e\left(1 + \frac{\psi \Delta\theta}{F_{(t)}}\right)$$

Eq. 3

Q_{surf} acumulated runoff (mm)
S, retention parameter (mm)
R_{day} Rainfall depth for the day (mm)
I_a, Initial abstractions (mm)
CN, Curve Number of the day

f(t) Infiltration rate for time t (mm/hour)
K_e effective hydrulic conductivity
Ψ Wetting front matric potential (mm)
Δθ Variation of moisture content
F(t) Cumulative infiltration (mm)

Results and Discussion:

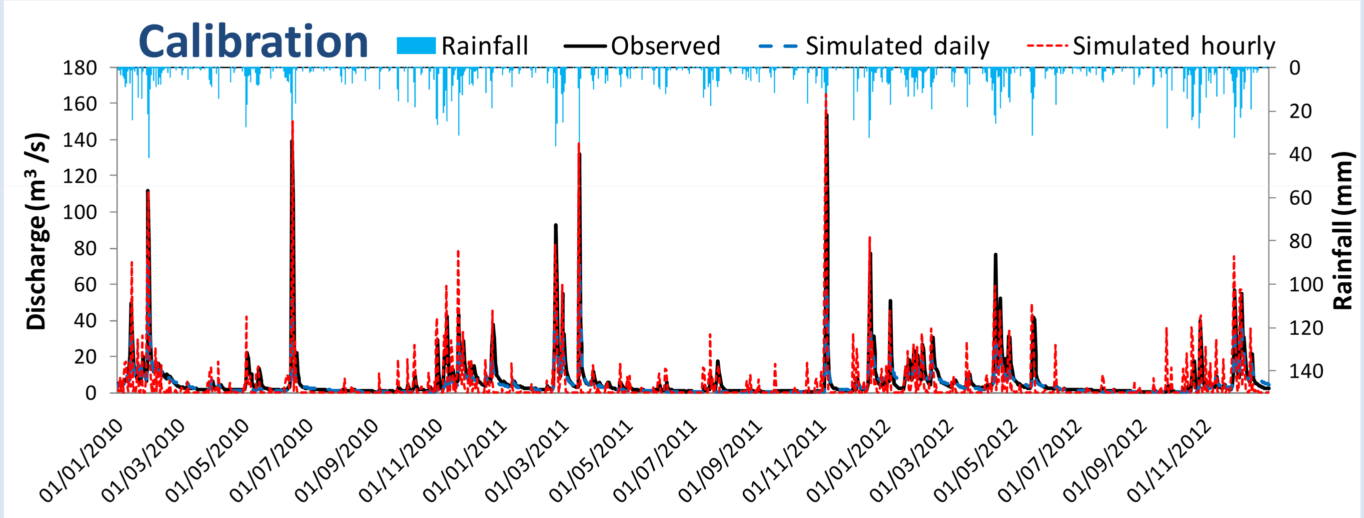

Figure 2: Observed and simulated runoff discharge in Ibaizábal river basin for calibration period (2010-2012)

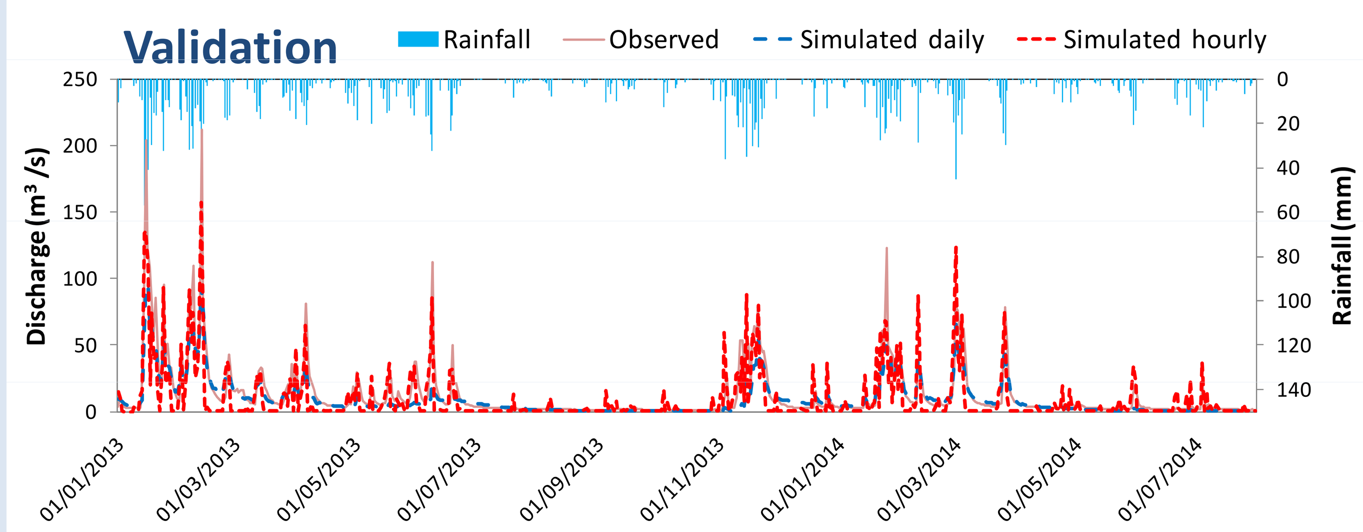

Figure 3: Observed and simulated runoff discharge in Ibaizábal river basin for validation period (2013-2014)

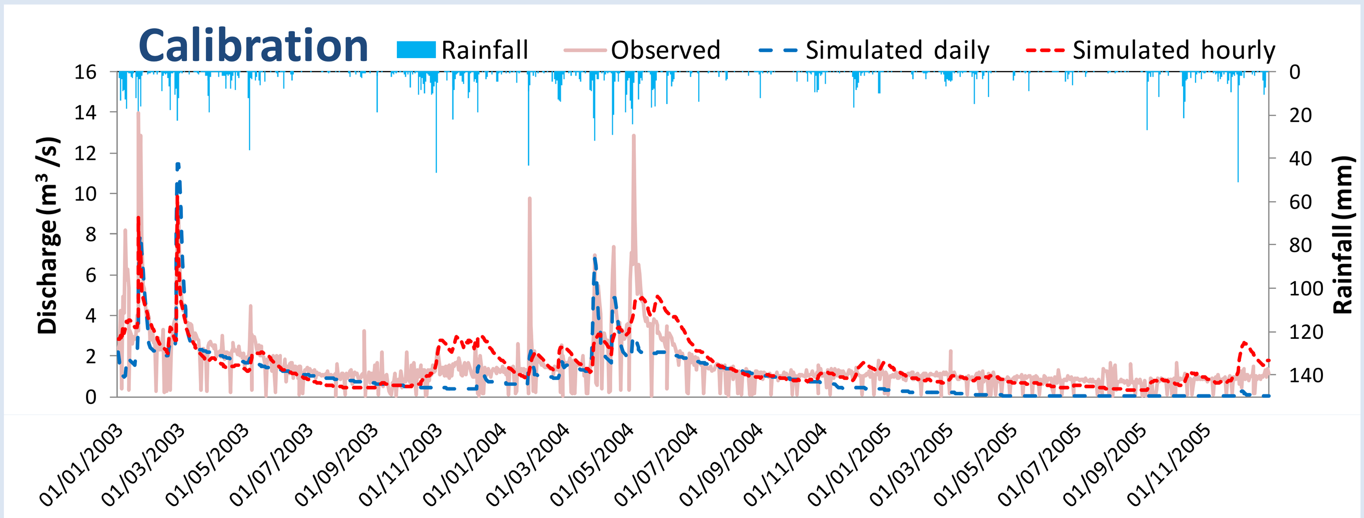

Figure 4: Observed and simulated runoff discharge in Segura river basin for calibration period (2003-2005)

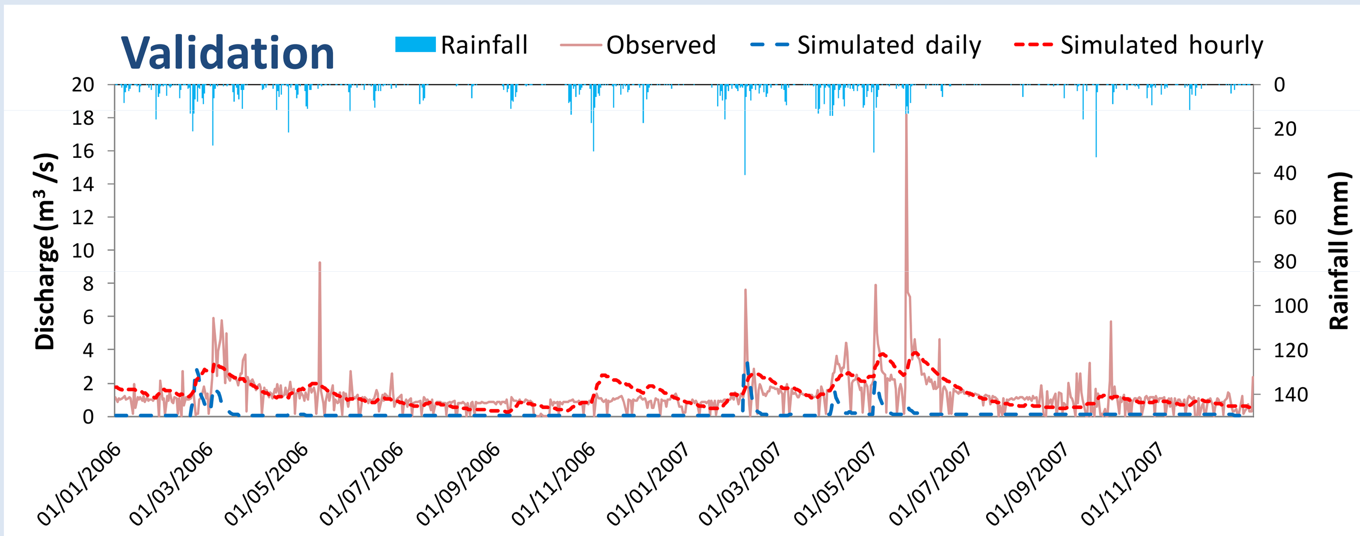

Figure 5: Observed and simulated runoff discharge in Segura river basin for validation period (2003-2005)

	Ibaizábal river basin				Segura river basin			
	Calibration		Validation		Calibration		Validation	
	Daily	Hourly	Daily	Hourly	Daily	Hourly	Daily	Hourly
NSE	0.67	0.68	0.78	0.79	0.47	0.74	0.11	0.75
PBIAS	31.88	25.54	27.63	28.89	33.76	-3.47	86.93	-6.95
RSR	0.57	0.57	0.47	0.46	0.73	0.51	1.75	0.50

Table 3: Monthly evaluation of the results.

Model Performance Indicators (MPI): As shown in Table 3 to compare the results of the models, NSE, PBIAS and RSR values were calculated. The Ibaizábal river basin (example of humid peninsular region) shows similar results with both daily and hourly precipitation data. Nevertheless, in semiarid regions, as the Segura river basin, the hourly rainfall inputs performance better than daily inputs both in calibration and validation, obtaining satisfactory results in all the goodness-of-fit tests used.

Conclusions:

From the results obtained in this study, hourly precipitation record for SWAT sub-daily with the Green–Ampt infiltration method was proven to be efficient for streamflow simulation, especially for Mediterranean basins, where rainfall regime is characterized by a high variability and irregularity. In the Segura river basin, model performance obtained using hourly precipitation and applying the Green-Ampt infiltration method has demonstrated to perform better than the model obtained using daily rainfall inputs and applying the curve number method, primarily due to its better capability of simulating peak flows (Figs. 4 and 5). In the Ibaizábal river basin, model performance (Figs. 2 and 3) is very similar in both cases, but a more realistic value for the most sensitive parameters has been obtained using daily rainfall inputs and applying the curve number method.

References:

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