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Valuing scarce observation of rainfall variability with flexible semi-distributed hydrological modelling – Mountainous Mediterranean context

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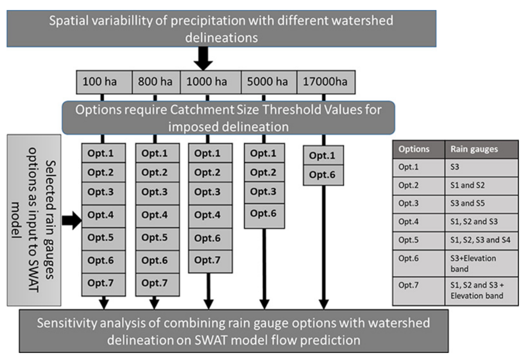
HIGHLIGHTS

- Variability in the number of HRUs influences little SWAT's prediction of streamflow.
- More rain gauges do not necessarily improve predictions in the Joumine catchment.
- Must identify best combination of rainfall gauges and HRUs before model calibration.

GRAPHICAL ABSTRACT



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ABSTRACT

To represent spatial and temporal variability in rainfall adequately, rainfall-runoff models must compromise among modelling objectives, data availability, conceptualization options, and the actual variability in rainfall. This is of utmost importance for challenges of integrated water management in the rapidly changing Mediterranean context. We evaluated the sensitivity of the SWAT model to combinations of spatial rainfall variability and catchment subdivision in a data-scarce mesoscale mountainous Mediterranean context. The case study focused on the Joumine catchment, in northern Tunisia, which is emblematic of agro-hydro-chemical changes and challenges. The double-mass curve method was used to verify the consistency of rainfall time series from 1991 to 2003, indicating proportionality between annual rainfall at the reference gauge and that of the nearest gauge. The rainfall lapse rate at the Joumine catchment was 69.9 mm per 100 m of altitude. Seven sets of rain gauges and five subdivision configurations of the catchment were simulated. Differences between measured and predicted streamflow at the outlet were assessed using three indices of model fit. Predicted streamflow was extremely sensitive to spatial rainfall variability but relatively insensitive to catchment subdivision. Daily predictions were most accurate for the wettest year (2002—2003) and least accurate for the driest year (1993–1994).

1. Introduction

The Mediterranean region faces huge challenges to its water security (Benabdallah, 2003; Cudennec et al., 2007; Young et al., 2015; Ludwig

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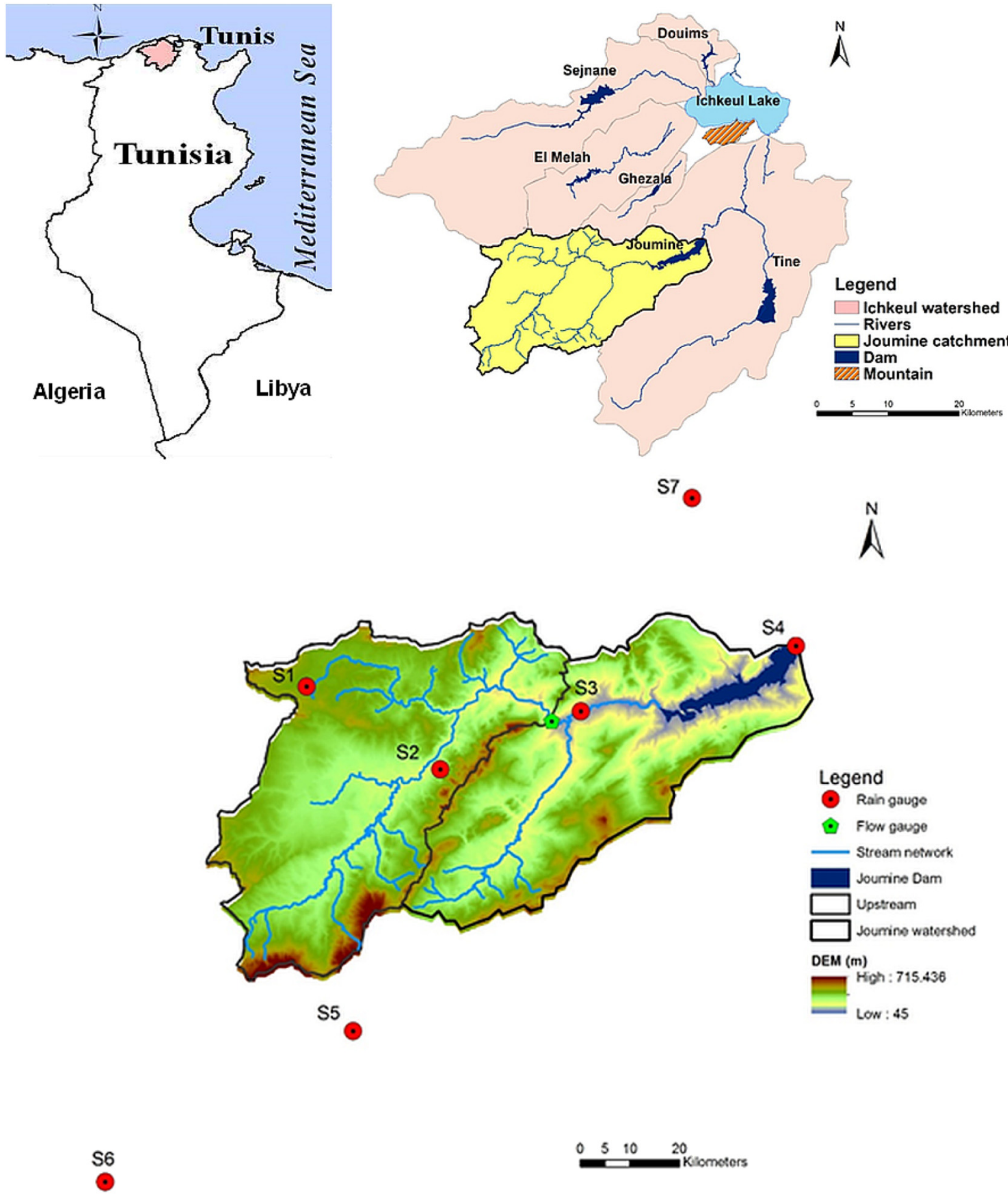

Fig. 1. Study area location, digital elevation model and gauge distribution in and around the Joumine catchment.

and Roson, 2016), essentially because of high temporal and spatial variability in hydrological processes, resources and hazards. This variability is co-evolving with societal changes and subsequent intertwined drivers (Sivapalan et al., 2014; Bai et al., 2016; Baouab and Cherif, 2017; Santos Pereira, 2017; Leduc et al., 2017). Improved hydrological understanding and assessment, including modelling approaches are needed for resilient design and management of catchments, infrastructure and demands (Garrote et al., 2016; Mereu et al., 2016). They must assimilate and make the best use of the knowledge and data available, even if the latter remain uncertain and too scarce, by using flexible and robust approaches (Blöschl et al., 2013; Hrachowitz et al., 2013; Meyer et al., 2016; Sellami et al., 2016).

Rainfall-runoff modelling has high uncertainty due to rainfall variability and its corresponding observation data (Bardossy and Das, 2008; Zhang et al., 2009; Leonardo and Augusto, 2014; Galván et al., 2014; Dalkhlaoui et al., 2017) and to corresponding conceptualizations of catchment spatial and geomorphological organization and functioning (Romanowicz et al., 2005; Cudennec, 2007; Kannan et al., 2008;

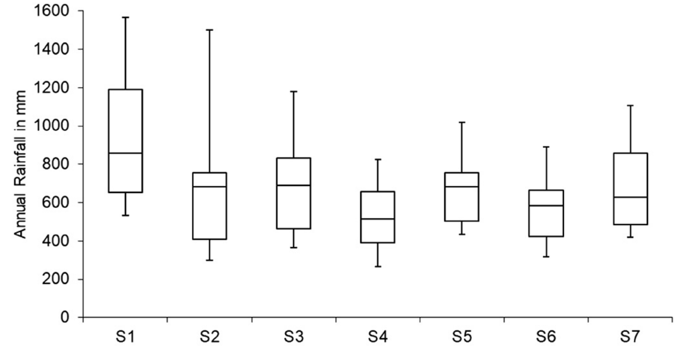

Fig. 2. Boxplots of annual rainfall from 1991 to 2003 for the seven rain gauges studied in and around the Joumine catchment.