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Analysing Hydrological Regime of a River Network in a Mediterranean Basin Using Multivariate Analysis

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Abstract

This paper presents a study aimed at analysing the hydrological regime of a number of stream reaches using Hydrological Indexes (HI), which describe magnitude, frequency, duration, timing and rate of change of hydrologic conditions. The Indicator of Hydrological Alteration Indexes software (IHAs) was used to calculate 33 HIs in 9 gauging stations of the Candelaro river basin (S-E Puglia). Daily streamflow data recorded over a long time period were used to calculate the HIs, which depend on some basin characteristics: climate, topography, land use, management, soil type, and other factors. The Principal Component Analysis was applied to these 33 Indexes to identify subsets of HIs that describe the major aspects of regime while minimizing redundancy. The authors report that streams draining small watershed are mainly described by duration, variability and predictability indices. These HIs can adequately represent the major aspects of Mediterranean streams flow regime.

Introduction

River flow regimes show regional patterns that are determined largely by watershed size and shape, climate, geology, soil type, topography, and land cover. The spatial and temporal distribution of flow and its quantity provides the geomorphic forces necessary to create and maintain stream river habitats [1]. Streamflow influences not only an ecosystem process, but it also affects numerous other processes, including sediment regime, channel formation, floodplain and flood processes, groundwater and surface water interactions, nutrient delivery, and water quality. The knowledge about streamflow quality and quantity is essential for watershed management.

A multitude of different way exists in which streamflow can be characterized. Thus, a large number of hydrological indices (HIs) have been developed to describe hydrological regimes and their degree of alteration [2]. All of these indices can be grouped into five classes based respectively on focusing in the description of magnitude, frequency, duration, timing and rate of change of hydrologic conditions [3]. These characteristics, that can be used to describe the entire range of flow regimes and specific hydrological phenomena, such as floods or low flows. Stream ecologists have to face the difficult task of choosing from a plethora of available hydrologic indexes a minimum subset of HIs which adequately describe the main aspects of the flow regime.

This paper presents a study carried out to analyse hydrological regime in a Mediterranean basin. It developed 33 HIs using a long-term flow records from 9 gauging stations in the Candelaro river basin, which represent flow characteristics. Among these indexes we identified a set of non-redundant indexes which describe the main critical characteristics of regime in the study area.

Materials & Methods

The study area (2186 km^2) is the Candelaro river basin (Puglia, Southern Italy). The main river course has a length of about 70 km and drains into the Adriatic Sea. Celone, Salsola and Triolo streams are its most important tributaries. The basin has a mean elevation of 300m a.s.l., with a maximum altitude of 1142m a.s.l.. It has typical Mediterranean semi-arid features, characterized by flash floods and drought period.

Using daily flow records (1965-1996) from 9 gauging stations in the Candelaro river basin (Fig. 1), 33 HIs were examined. The IHA software [4] was used for calculate all these indices, using parametric statistics. Before compare results a normalization procedure was performed because some parameters depend on the subbasin area.

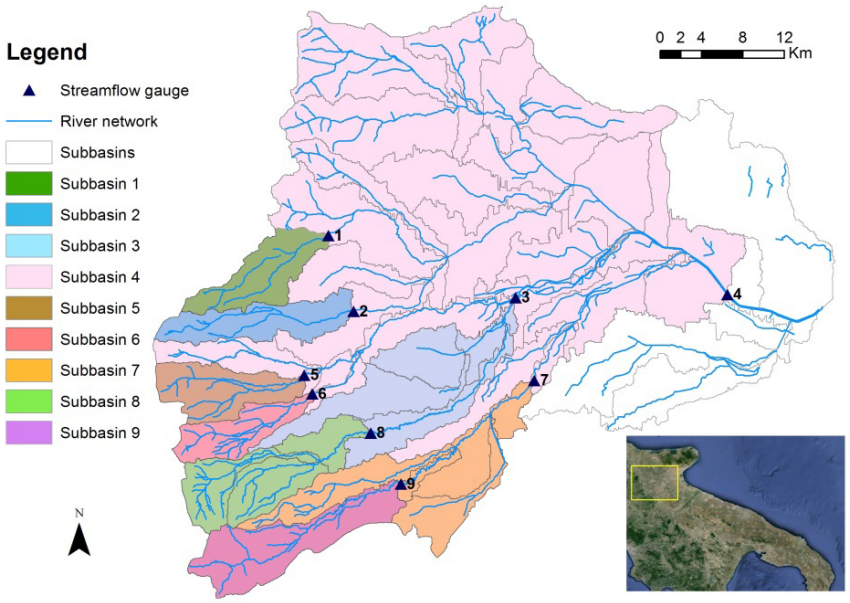

Fig. 1; Candelaro river basin (Puglia, Italy)

The Principal Component Analysis (PCA) was used to choose among the 33 calculated HIs those which represent the main aspects of flow regime and that are uncorrelated. The analysis was performed using R software. The correlation matrix of the HIs was used; a hydrological variable was considered significantly correlated with a PC when the correlation with this component was at least 0.60 [5]. Only the factors that have eigenvalues greater than one was retained for interpretation [6].

Results

The Candelaro river basin drains a mean annual flow (1965-1996) of about 99400 $m^3/(year*km^2)$. At the outlet of the basin, the 1-day minimum flow (DL1) and 1-day maximum flow (DH1) are $0{,}26*10^{-4}$ $m^3/(s*km^2)$ and 0,12 $m^3/(s*km^2)$, respectively. The date of minimum flow (TL1) is recorded between spring and summer seasons; the date of maximum flow (TL1) is registered during winter. The number of reversals (RA3) is between 16 (Subbasin 5) and 91 (Subbasin 3). The number of Zero-Days ranges from 33 (Subbasin 3) to 168 (Subbasin 1). After removing HIs showing no variance, five principal component were extracted from the retained variables. The first principal component is mainly associated with magnitude and duration of high flow event, the second associated with the duration of low flow event, timing and rate of change characteristics.

Conclusions

The minimum subset of HIs that adequately describe the main aspects of the Candelaro and its tributaries flow regime is linked to variability, predictability and duration. Using these parameters it's possible to derive generalizations and information which are useful for river basin management.

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