4.1. Monitoring water quality in the rivers of Sierra Nevada

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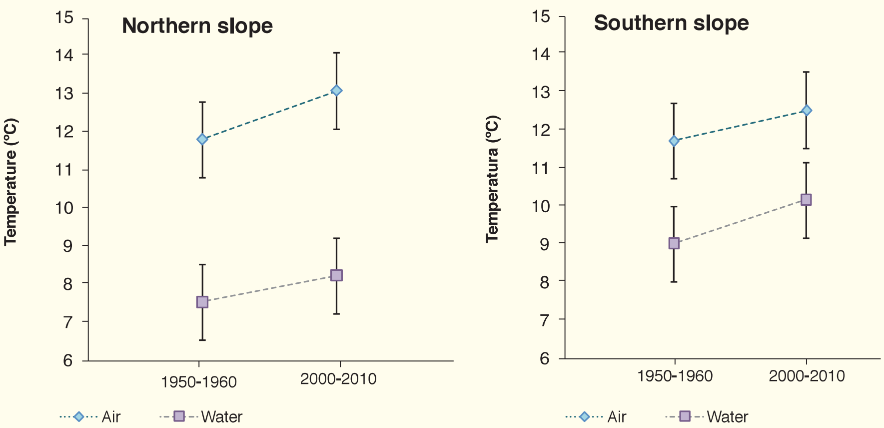
Abstract

Aquatic ecosystems are completely dependent on the environmental conditions surrounding them and global change alters the heat and water cycles, endangering the delicate equilibrium of these systems and of the organisms that inhabit them. Therefore, a retrospective analysis has been made of the environmental changes that are expected to have the strongest repercussions on aquatic environments, in order to suggest new measures for their future conservation.

Aims and methodology

For the ecological and chemical monitoring of rivers, several physico-chemical parameters (pH, electrical conductivity, dissolved oxygen, and temperature) have been locally measured in each of the sampling seasons (spring, summer, and autumn) at 23 sites distributed in 8 rivers. In addition, data loggers for continuous temperature records were located in 10 sampling sites in 2009, measuring data until 2014. Similarly, in 2009 water temperature data loggers were installed in 4 high-mountain lakes (La Caldera, Laguna Larga, Río Seco, and Aguas Verdes), and variations in the water level were measured using hydrostatic pressure in three of them (La Caldera, Laguna Larga, and Río Seco). Water flow was locally measured during samplings and, in addition, data published by the Centre for Hydrographic Studies of CEDEX of the Environment Ministry (http://hercules.cedex.es/ general/default.htm) on the gauging station belonging to the Guadalquivir Hydrographic Confederation (Confederacion Hidrografica del Guadalquivir) were used. Air-temperature data were provided by the Environmental Information Network of Andalusia.

Figure 1



Air and water temperature (mean and 95% confidence intervals) of the Alhorí (northern slope) (left) and Trevelez rivers (southern slope) (right).

Results

The comparison of the mean air temperature over two rivers situated on both slopes of the Sierra Nevada between the two decades 50 years apart (1950-1960, 2000-2010) revealed a rise of 1.5°C (Figure 1), which must have had a strong repercussion on the mean temperature of the water of the rivers and streams.

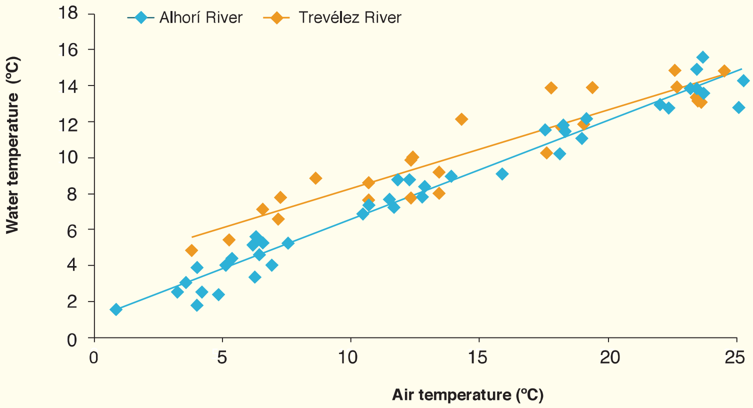
The air temperature was positive and significantly correlated with that of the water at these two sampling sites (Figure 2). It was estimated an increase of 0.5 °C of the mean water temperature between aforementioned decades and the current one. In addition, the water temperature was compared in two study periods 20 years apart (1984-1987, 2008-2009) at 19 sites all over the Sierra Nevada, indicating a mean temperature increase of 1.63 °C (Figure 3). The stronger effect was detected on the rivers situated on the southern slope.

An important factor to take into account with respect to the thermal oscillations of the water over the day is the presence of riparian vegetation [1], as seen when comparing two sites of the Andarax river with and without riparian vegetation due to elevation. The thermal fluctuations were softened up to 4 °C in the summer season in the site with riparian vegetation (the lowest in altitude).

Analyses of the flow data (annual averages) have shown a slightly decrease trend in three of the four studied rivers (Alhori, Dilar, Genil, and Monachil) in recent years (Figure 4).

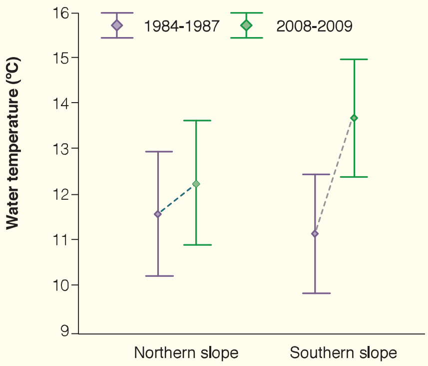
In the case of the high-mountain lakes, for Laguna Larga, a thermal inversion was detected during the winter period, when the surface of the lake was ice covered. Thermal inversion dissapeared in spring due to heating of lake surface. Thawing water provoked an abruptly descence of water column temperature. In summer, the sunlight increased the temperature of the water surface, being somewhat colder deeper without reaching a situation of marked thermal stratification, as it forms a layer more or less homogeneous by wind influence on the surface [2].

Figure 2



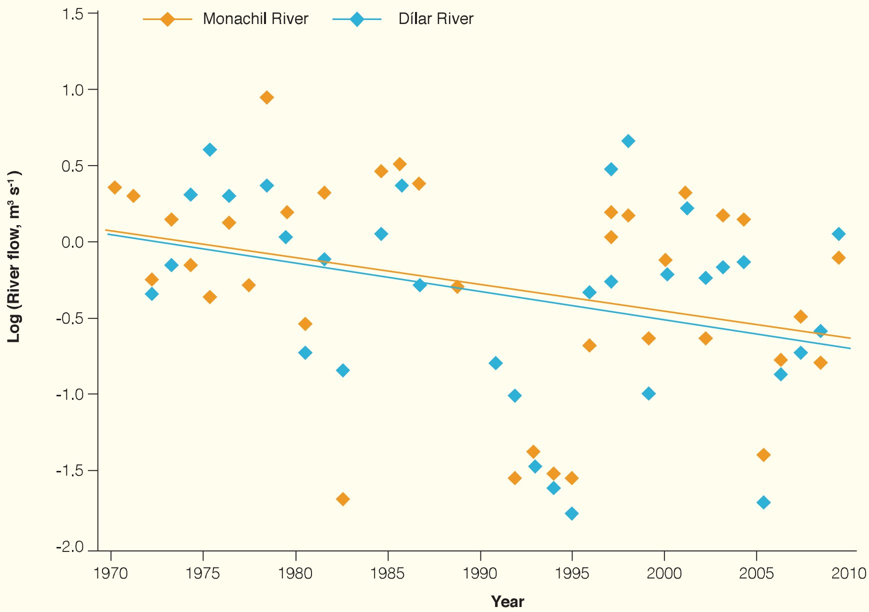
Linear regression between mean monthly air and water temperatures for the rivers Alhorí (northern slope) and Trevélez (southern slope) (Alhorí R^2= 0.966, Trevélez R^2= 0.898).

Figure 3



Mean water temperature (± 95% CI) at the northern and southern slope of the Sierra Nevada streams and rivers in the two studied periods, 1984–1987 and 2008–2009.

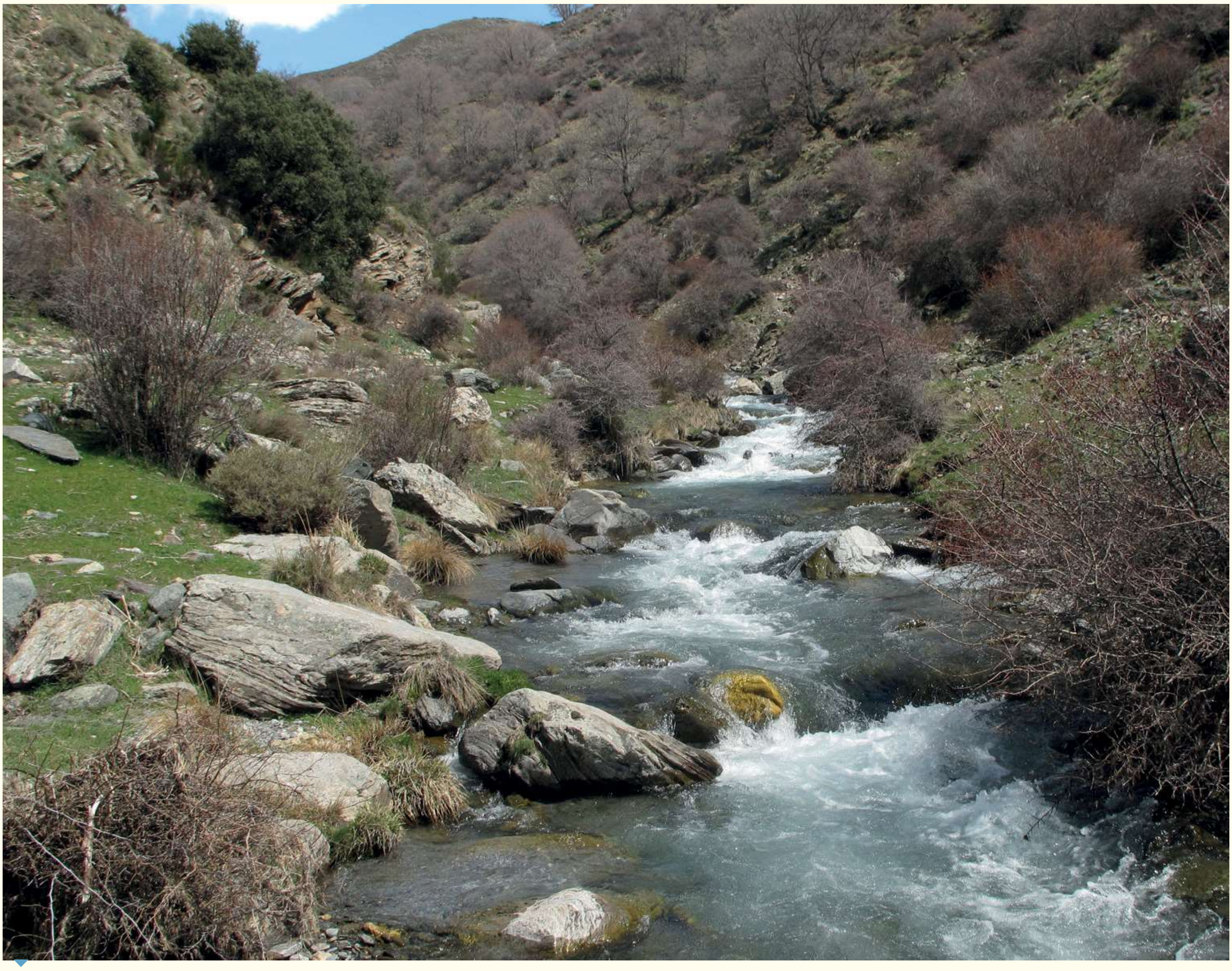
Figure 4



Trends in mean annual flow (in logarithms) for Dílar and Monachil Rivers in recent years.

Discussion and conclusions

The future of aquatic ecosystems from the Sierra Nevada is uncertain due to the potential effects of global change. On the one hand, the riparian vegetation has diminished due to human activity. On the other, air temperature, directly related to water temperature, has increased; being stronger the effect with a low river flow [3]. Also, the gradual decline in river flow in recent decades is giving rise to changes in the thermal regime of the rivers and streams of the Sierra Nevada. All these factors in turn influence the physico-chemical processes of the water as well as as the biological communities inhabiting the rivers. Therefore, it is of particular interest to intensify control and regulation of water resources in order to minimize the negative effects of global change in these ecosystems.



High course of Dílar River.