Regional Hydrological Signs for Climate Change in the Basque Country

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Introduction

Results presented here were obtained in the **K-Egokitzen** project. The main objective of this project is to analyze climate change evidences and the most effective adaptation measures to confront the potential impacts on water resources, infrastructures, urban environments, coasts and natural or agricultural ecosystems.

Changes in discharge (average and extreme) expected for the near future depend, on trends observed in discharge during the last decades. Considering the time horizon established for the now ongoing Programs of Measures included on the River Basin Management Plans (2027, WFD) near future is very important. Historical observations are an important tool for obtaining a clearer understanding of what the near future will hold. Analogues of past variability are useful in identifying climate related risks of failing to meet specific objectives.

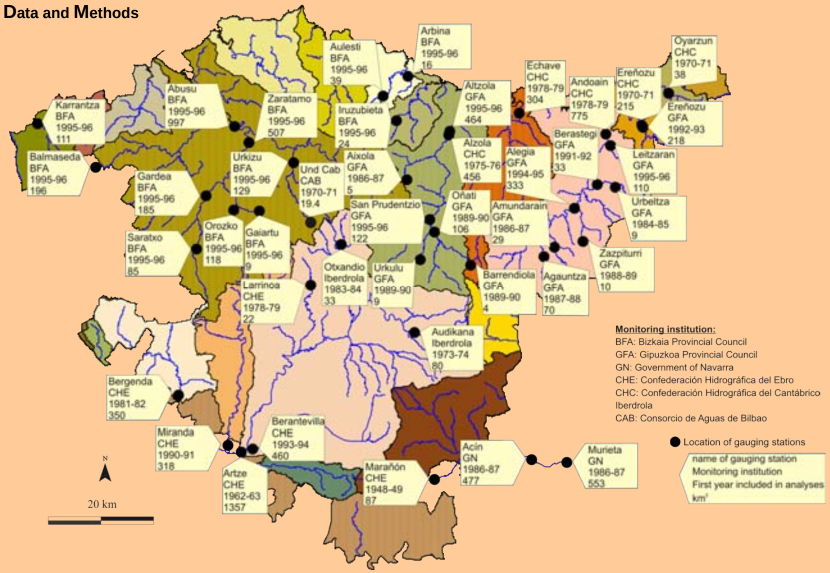
As discharge integrates the influence of changes on climatic parameters is more appealing for detecting regional trends than point measurements of precipitation. But, little attention is given to extreme discharges, especially droughts. Extremes are especially prone to man-made environmental changes and also more vulnerable to measurement errors. In any case, for the projection of impacts on freshwater ecosystems knowledge on the temporal evolution in the lower part of the hydrograph is essential.

Not only variability of the hydrologic response but also its amplitude has to be considered. The catchment-scale studies show that reporting hydrological change in terms of mean river discharge, can mask greater changes in low and high flows which are of fundamental importance to water management.

Objective

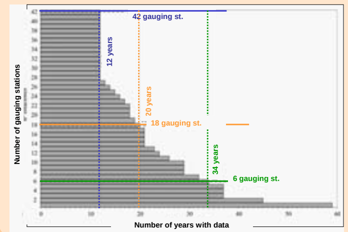
The aim of this study is to fill the gap of knowledge existing in the Basque Country about the hydrological signs, particularly in extremes, for climate change in a regional scale. This is done by examining the trends in average, high, and specially, low flows from 42 gauging stations and data series that go from 12 to more than 34 years.

Data and Methods



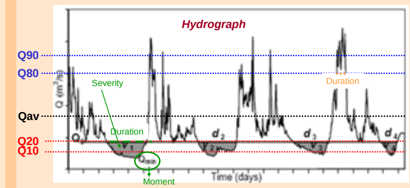
Data Series

Various time periods, each of them with a different number of gauging stations to be analyzed, were selected.



Parameters

Parameters related to average, low and high flows were annually and seasonally calculated. All calculated in a daily basis.



- **Qav**: average annual and seasonal discharge
- Low Flows: **Duration** of the period below Q20 or Q10; **Severity**: annual volume below Q20 or Q10; **Moment** for the minimum discharge considering a 7-day moving average series of daily discharge.
- High Flows: **Duration** of the period above Q80 or Q90.

Statistical aproach

Mann-Kendall trend test was used in order to detect a trend or the lack of it in the calculated parameter series:

$$S = \sum_{k=1}^{N-1} \sum_{j=k+1}^{N} sign(x_j - x_k) \quad \text{where} \quad sign(x_j - x_k) = \begin{cases} 1 & x_j > x_k, \\ 0 & x_j = x_k, \\ -1 & x_j < x_k. \end{cases}$$

For n larger than 10, the test statistic can be normalized as:

$$Z = (S-1)/\sigma_S \quad \text{when } S>0$$
$$Z = (S+1)/\sigma_S \quad \text{when } S<0, \text{ or}$$
$$Z = 0 \quad \text{when } S=0$$

IPCC guidelines where followed to consider the likelihood of occurrence of trends detected using Mann-Kendall trend test (IPCC, 2005)

Terminology	Likelihood of ocurrence
Virtually certain	> 99% probability of occurrence
Extremely likely	> 95% probability
Very likely	> 90% probability
Likely	> 66% probability
About as likely as not	33 to 66% probability
Unlikely	< 33% probability

Results

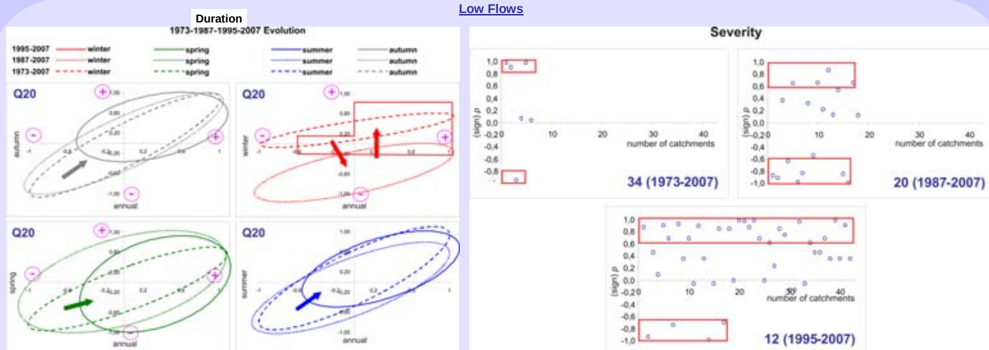
Average discharge

	1973	1987	1995	2007
Annual	*decreasing*	no trend	no trend	Cantabrian
Autumn	decreasing	*no trend*	*no trend*	
Winter	*decreasing*	*increasing*	*increasing*	
Spring	*decreasing*	*decreasing*	increasing	
Summer	*no trend*	no trend	*decreasing*	
Annual	*decreasing*	increasing	*increasing*	Mediterranean
Autumn	no trend	increasing	no trend	
Winter	no trend	*increasing*	*increasing*	
Spring	*decreasing*	decreasing	*increasing*	
Summer	decreasing	no trend	no trend	

When the name of the trend is colored or bold, it means that this is statistically significant (likely, very likely, extremely likely or virtually certain) and it can be observed in most of the stations analyzed. In plain text trends that being majority are not generalized were written.

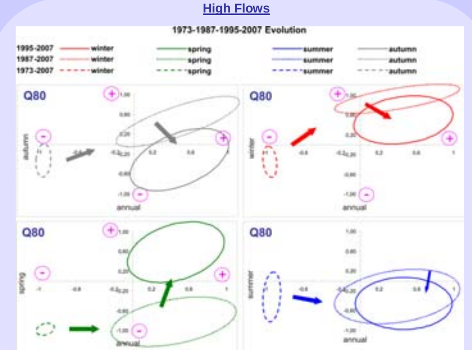
Decreasing trend in data series of annual average discharge of the last 34 years was observed. In the last 20 years the observed trend is increasing in the Mediterranean basin, very evident in the last 12 years. No trend is observed in the Cantabrian basin.
In winter a clear decreasing trend is observed in the Cantabrian basin in the longest data series and also in spring in both basins. This trends are clearly increasing, especially in winter, in the shortest data series in both basins.
No significant trend was observed in autumn. Something similar occurs in summer, even if in the Cantabrian basin, during the shortest period a decreasing trend was detected.

Low Flows



Comparing the shortest time period with longer ones, in the first one (12 years) an evident homogenization is observed with most of the catchments showing an increasing trend in the low flow period **duration**. It should be highlighted the regional homogenization in the increasing trend on the duration of the annual low flow period, conditioned by the significant increasing trends during autumn and summer.
It seems that there is an evolution towards the increase of **severity** that comes along with the increase of the duration of the low flow period. The fact that some of the catchments show a different trend does not have a spatial logic, so local conditions should be analyzed in those cases. There is no significant trend in any sense for the **moment** of the minimum discharge.

High Flows



A marked temporal evolution is observed in the **duration** of the high flow period, being for the period between 1995 and 2007 for the one that the regional response of the catchments has been more homogeneous, for all the seasons, with a clear increase of the high flow period from autumn-winter towards winter-spring, being really evident the increase during spring and the decrease during autumn.

Conclusions

•Considering the observations made in the extreme domains of the hydrological response can be concluded that response of the catchments go towards a regional homogeneity in the Basque Country, which can reflect the prevalence of the regional climate (maybe also becoming more homogeneous) over local conditions.

• An increasing trend of the low flow periods in summer and autumn and of the high flow period in winter and spring is observed. This involves a longer time for extreme discharges to remain into the annual hydrograph, which can be understood as a reinforcement of the amplitude of the hydrograph (discharge variability).

• At the same time the extreme discharge periods are seasonally moving ahead. This movement of periods is much more evident for high flows moving ahead towards spring.

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