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# Evaluation of water resources of the Pyrenees in a context of climate change and adaptation strategies



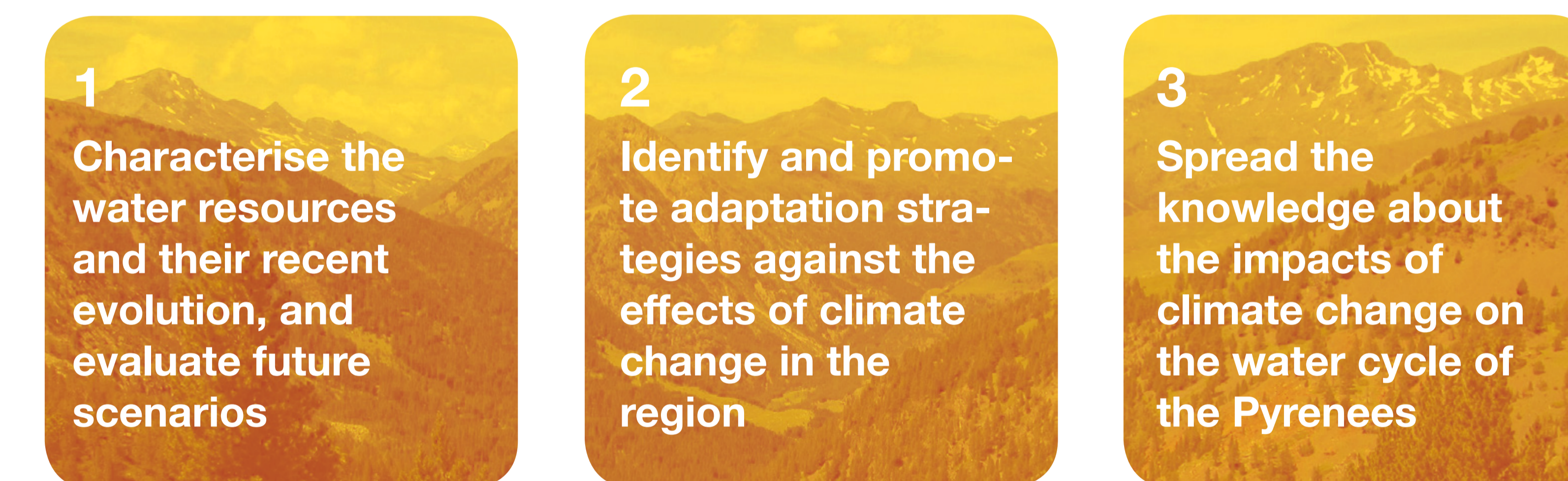
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## Objectives

The PIRAGUA project, funded by the Interreg POCTEFA Programme of the EU, addresses the **assessment of the hydrological cycle of the Pyrenees in the context of climate change**. The time span of the project is 2018-2020.

The goals of the project are to unify and homogenise the existing information, prospect future scenarios, develop indicators of change, and propose adaptation strategies with impact on the territory, with the ultimate goal of supporting investments made for climate change adaptation in relation to water resources in the region. Thus, the project evaluates the components of the hydrological cycle and the water resources of the Pyrenees range in the recent past and in future scenarios. In addition, the project develops seven case studies about adaptation strategies at the local and regional scales, focusing on different socio-economic sectors including hydropower production; sensitive head-water ecosystems; water and forests; irrigation agriculture; extreme events; tourism and areas of high ecological value; and multi-sector analysis, including the water-energy connection.

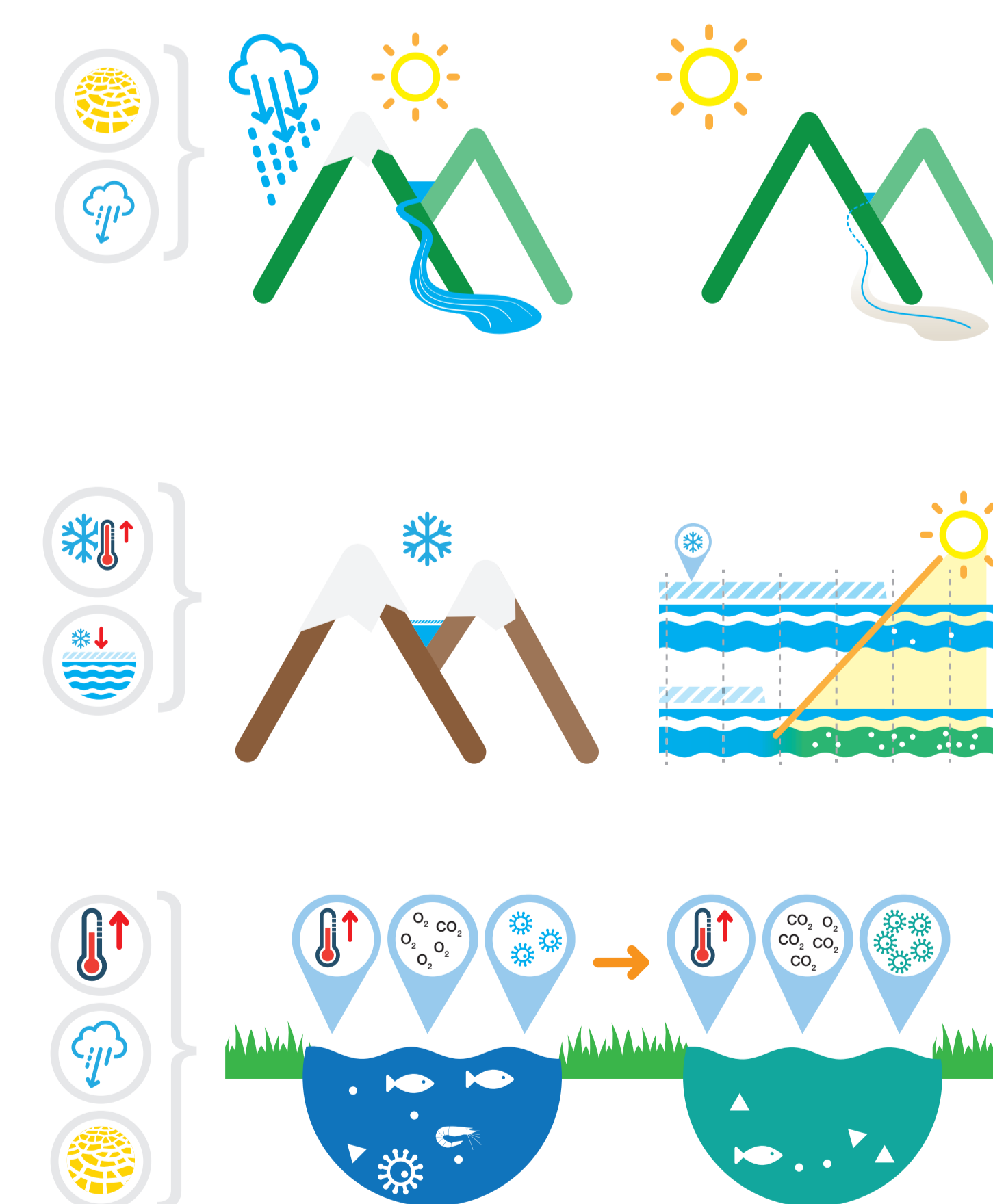


## Climate change

The average annual discharge of many Pyrenean rivers has decreased over recent decades. This is attributed both to climatic causes and to changes in land use and plant cover, making it difficult to quantify the influence of each factor separately.

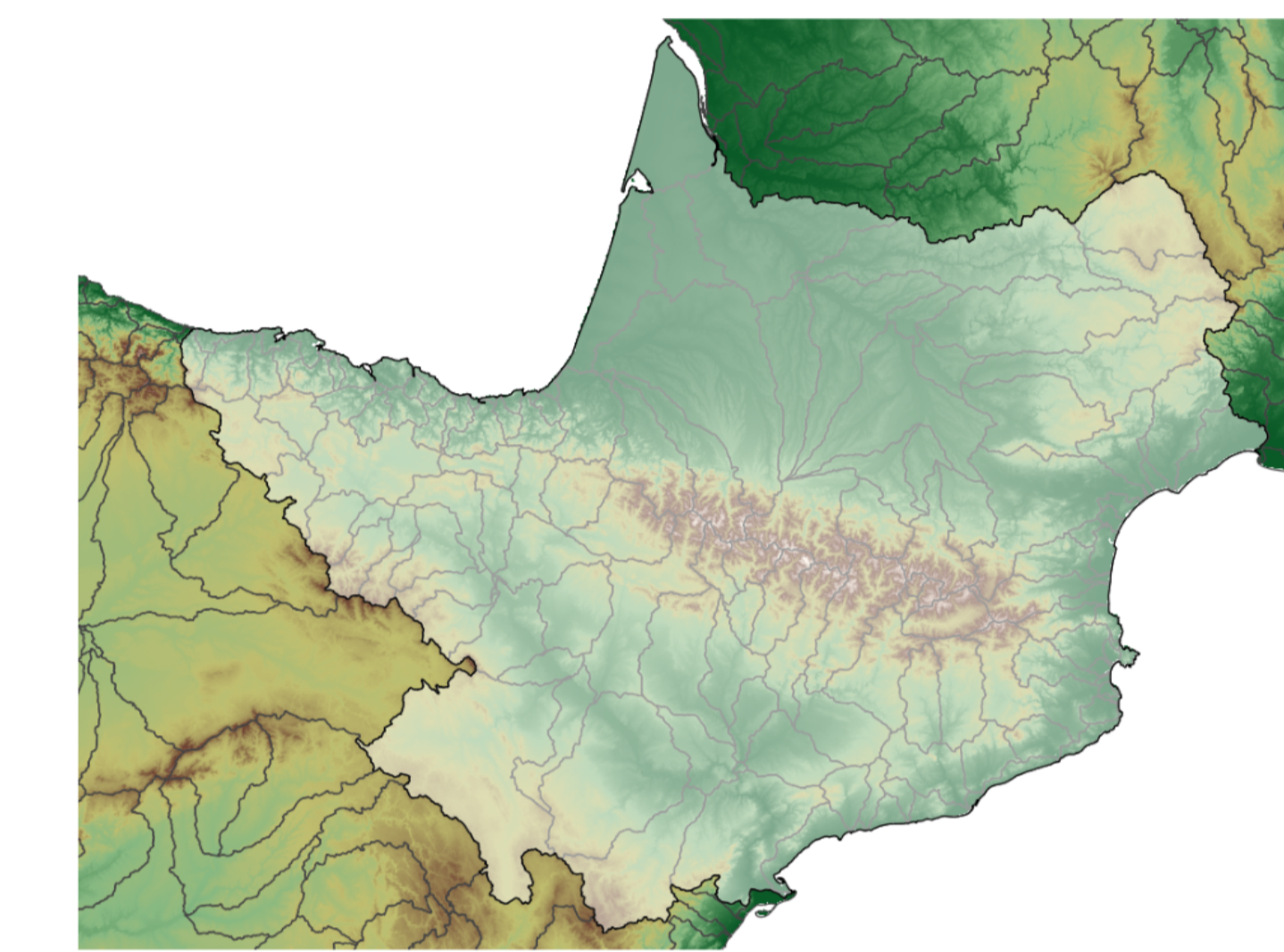
The decrease in snow accumulation each winter due to higher temperatures and less frequent solid precipitation is causing higher winter discharge. In contrast, lower discharge is registered in summer and autumn.

Rising temperature and changes in the water cycle caused by climate change can alter the physical and chemical characteristics of water affecting its quality, and may also have serious effects on their biological composition.



## Study area

The Pyrenees mountain range is a transboundary region shared by Spain, France and Andorre. As many mountain regions, it generates a surplus of water resources that are used in a much larger area that includes important urban concentrations and productive rural areas. This territory is particularly vulnerable to the consequences of climate change.



## Analysis of the hydrological cycle in the Pyrenees

PIRAGUA is evaluating the hydrological cycle and the generation of water resources in the Pyrenees in the recent past (1980-2015), and will evaluate future scenarios (2030-2050).

A coherent hydrological database is being constructed with reference gauging and groundwater level data collected by the different water authorities. Using this observational dataset the following indicators will be computed at each location for each year in the series:

- Mean daily streamflow, and quartiles (25%, 50%, 75%).
- Number of days below / above each quartile.
- Low-flow and high-flow events based on pre-defined thresholds (e.g., 10th and 90th daily quantiles). For each event, computation of length, starting and ending times, and volume.
- Frequency analysis of high / low flow events.

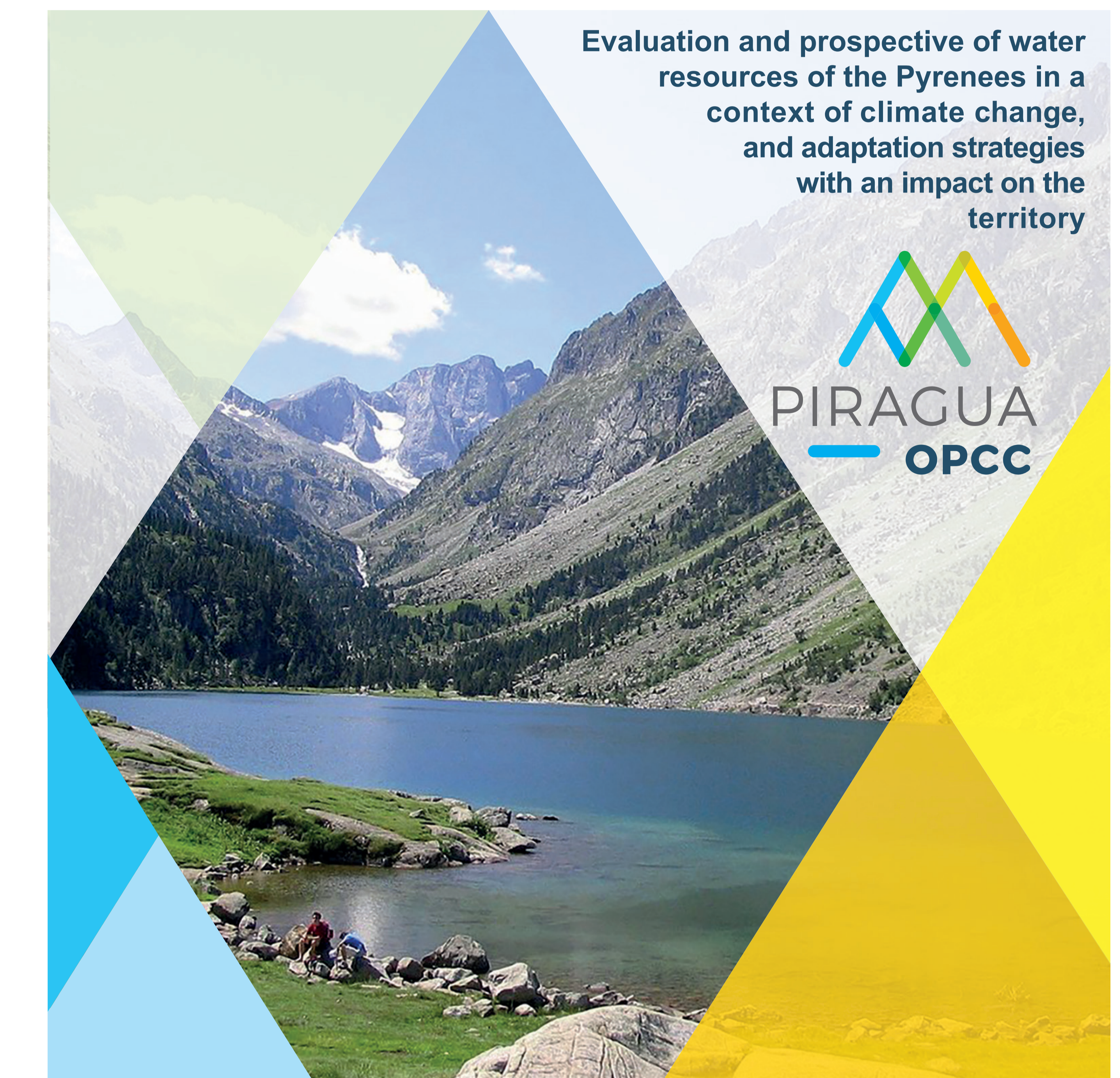
Time series of the indicators will be the basis for the evaluation of changes in the observational record.

Additionally, a gridded dataset is being developed for the forcing of hydrological simulation models. The SAFRAN meteorological analysis system is being used to produce an estimation of daily values of the following meteorological variables: temperature, precipitation, wind speed, and air humidity. Due to problems with cloud cover data in Spain, solar radiation data from the ERA-5 analysis will be used. At least three different codes will be used for producing a spatially-explicit evaluation of the components of the hydrological balance in the whole territory: SWAT, GIS-BALAN and SURFEX. Time series of the different components (evapotranspiration, surface discharge and groundwater recharge) will be computed and compared between codes and with the observational records.

Future climate change scenarios of daily temperature and precipitation provided by the Interreg POCTEFA CLIMPY project will be used as a basis for developing a set of forcing datasets for future climate. A statistical analogs method will be used in combination with the SAFRAN data for estimating the remaining variables required for hydrological simulation. The calibrated simulation models will then be applied to produce a portfolio of future hydrological scenarios. All these results will be summarised and distributed in the project's geodatabase.

## Sectoral case studies

- Water and forests:** Añarbe-Bidasoa basin (Basque Country - Navarre). Main water uses: environmental (forests, fluvial ecosystems), supply to San Sebastián agglomeration. Objective: Incorporate water resources management criteria to forestry activities, including public policies. Tasks: monitoring, modeling, socioeconomic analysis, collaborative work with end users.
- Water and agriculture:** Gállego and Ésera-Cinca river basins (Aragón). Main water uses: irrigation, hydroelectricity, supply, environment. Objective: Incorporate water resources management criteria into land management in headwater areas, promote water use efficiency in irrigation agriculture. Tasks: monitoring, modeling, collaborative work with end users.
- Sensitive headwater ecosystems:** Haut Vicdessos headwater (Midi-Pyrénées). Main water uses: environmental (forests, fluvial ecos.), hydroelectricity, supply. Objective: interaction between forest management, water quality and environmental preservation of high altitude peat bogs. Tasks: controlled felling experiment, monitoring, modeling, collaborative work with end users.
- Tourism and natural areas:** Ordesa (Spain) and Pyrenees (France) national parks. Main water uses: environmental. Objective: Evaluate the impact of tourism on the quality of water and aquatic ecosystems, assess tensions in a context of climate change and promote adaptation actions. Tasks: monitoring, modeling, collaborative work with end users (park authorities).
- Extreme events:** Whole Pyrenees. Multisectoral analysis of all water uses. Objective: Evaluate the impact of extreme events on the management of water resources, including energy production, reservoir management and supply. Tasks: multidisciplinary analysis of past events, futurization of events based on scenarios, work with end users.
- Hydropower production:** Lake-reservoir of Oule (Aure valley, Hautes-Pyrénées). Main water use: hydroelectric production. Objective: Assess the impacts of climate change on the hydrology of high mountain lakes and on the management of reservoirs, and their impacts on other downstream uses. Tasks: monitoring, modeling, collaborative work with actors (SHEM / CNR, SNCF).
- Multi-sector analysis:** Andorre. Main water uses: supply, hydropower, tourism (snow production). Objective: Evaluate the competition between water uses and the incidence of different policies. Tasks: monitoring, socio-economic analysis, management and policy scenarios, collaborative work with actors (water and territorial management agencies).



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