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Impacts of Global Change on hydrologic and sedimentologic dynamics in the Northern Ebro River Basin (Spain)

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European Geosciences Union

Vienna, Austria & Online | 27 April–2 May 2025

Session: HS2.1.2

QR to abstract

INTRODUCTION

The shift from rural to urban living has resulted in natural revegetation of abandoned rural areas located in mountainous regions. These land-use changes, combined with recent temperature and precipitation trends, affect water resources and sediment yields. Consequently, surface runoff, water infiltration, and sediment production/transport are impacted (Juez et al., 2023). This study examines the changes in both water and sediment fluxes in the northern draining region of the Ebro River Basin.

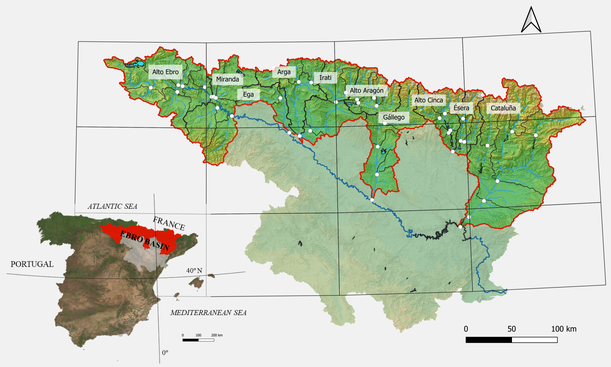
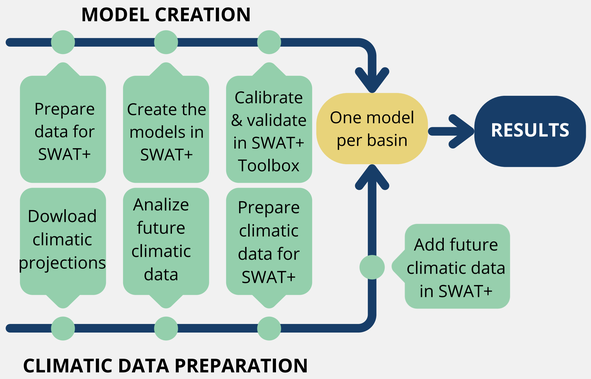


Fig 1. Ubication of the Ebro basin in Spain. The red line delimits the studied area. The white points mark the considered gauging stations. The mesh indicates the areas in which the basin was divided for the climatic studies.

METHODOLOGY

For each subbasin a hydrologic model was created using SWAT+. SWAT+ is a semi-distributed, deterministic, continuous basin model that operates on a daily time step.

Parallely, climatic data from CMIP6 (Copernicus Climate Change Service, Climate Data Store, 2021) was dowloaded and homogenized. This data was introduced in the created models for each basin.



RESULTS AND DISCUSSION

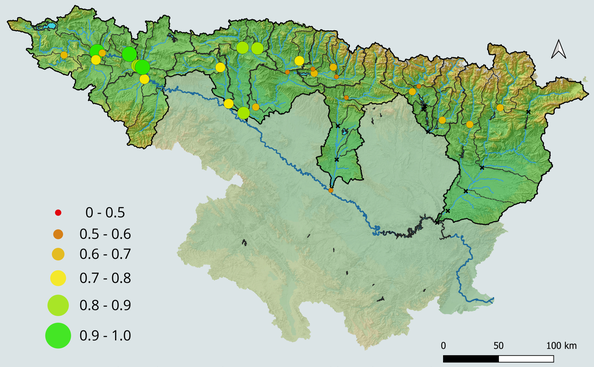


Fig 2. The NSE values represented by colours and sizes.

Hydrological calibration and validation were performed at gauging stations assesing it with the Nash-Sutcliffe Efficiency (NSE). Sediment calibration was based on reservoir bathymetry or sediment yield estimates from literature.

NSE values ranged from 0.53 to 0.95, with a mean of 0.75 for the entire basin, indicating the development of a well-calibrated hydrologic and sedimentologic model.

Future climate scenarios account for both radiative forcing (RCP) and socio-economic pathways (SSP), reflecting not only climate change but also societal mitigation and adaptation efforts (O'Neill et al., 2016). Five scenarios (SSP1-1.9 to SSP5-8.5) are used to represent a range of possible futures. Figure 3 illustrates projected changes in precipitation and maximum and minimum temperatures under the SSP5-8.5 scenario across the mesh cells shown in Figure 1.

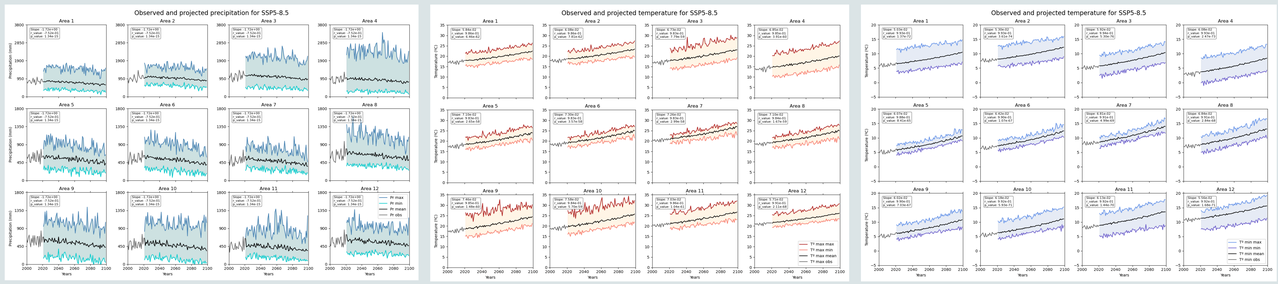


Fig 3. From left to right: the precipitation trends, the maximum temperature tendencies, the minumum temperature tendencies. In each of the graps, the gray line represents the observed data until 2020. The coloured area represents the different values that different models predict. The black line is the mean value of all the models.

In most of the cases the tendency is a decrease in precipitation

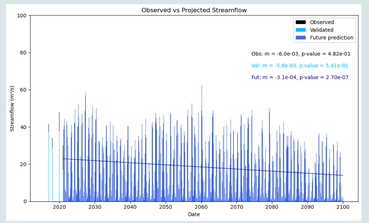
In all scenarios the tendency is a increase in maximum T°

In all scenarios the tendency is a increase in minimum T°

The response of the Arga basin to the SSP1-1.9 scenario is shown in Figure 4. The initial five years (2015-2020) were used for the validation while the subsequent years (2020-2100) represent the projected streamflow and the sediment yield at the sub-basin outlet.

The model predicts qualitatively streamflow and sediment yield trends at the outlet of the basin. A general tendency of decreasing of the streamflow is observed which is statistically supported by the p-value.

A critical challenge in these projections lies in the methodology for obtaining local-scale scenarios derived from General Circulation Models (GCMs). To address this, we are actively investigating various bias correction techniques and regression-based statistical downscaling strategies.



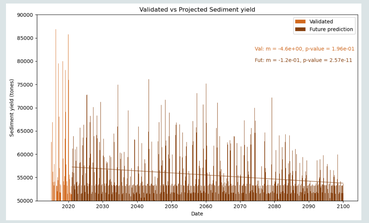


Fig 4. At the top: observed vs predicted streamflow in the outlet of the Arga River basin. The black line represents the observed data, the light blue the validated data from SWAT+ and the dark blue the predictions made for the years 2020-2100. at the bottom: validated and predicted sediment yield. The light brown is the validated data from SWAT+ and the dark brown the projected data.

CONCLUSIONS

- This study highlights how recent climate trends alter water and sediment fluxes in the northern Ebro Basin.
- The used methodology was able to replicate with various models the current performance of the basin with confidence.
- The analized future trends for the basin show a very small decrease in precipitation but an increase in the temperatures.
- The small decreasing trend in the Arga basin suggest that the streamflow will be reduced by 2100, but the land use changes are needed to be analized.

FUTURE WORK

1. Interpret the streamflow change of all scenarios an basins
2. Homogenize the land use change maps to the Ebro basin
3. Apply the land use change in the models
4. Work with high flow events and droughts

ACKNOWLEDGEMENT

This work is funded by the European Research Council (ERC) through the Horizon Europe 2021 Starting Grant program under REA grant agreement number 101039181 - SEDAHEAD.

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