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Impact of climate change on floods in Pamplona (Spain) by using climate change projections and a distributed hydrological model

Marco Lompi[1,2], Luis Mediero[2], and Enrica Caporali[1]
[1]University of Florence, Department of Civil and Environmental Engineering, Firenze, Italy
[2]Universidad Politécnica de Madrid, Department of Civil Engineering: Hydraulic, Energy and Environment, Madrid,Spain

Understanding how floods are expected to change is essential for decision making and flood risk management, as flood risks are expected to increase in the future. Several studies have analysed the impact of climate change on flood risks with rainfall-runoff models and climate projections as input data. Nevertheless, most of these studies involve large-scale river basins instead of focusing on smaller river basins or points of interest like urban areas. This study quantifies the expected changes in flood quantiles at the River Arga in the city of Pamplona (Spain) within the SAFERDAMS project (PID2019-107027RB-I00) funded by the Spanish Ministry of Science and Innovation. It uses climate change projections from 12 climate models of the EURO-CORDEX programme for two Representative Concentration Pathways - RCPs as input data of the RIBS distributed hydrological model (Garrote and Bras 1995 ab, JoH). The analysis considers seven return periods (2, 5, 10, 50, 100, 500 and 1000 years), two greenhouse gas emission scenarios (RCP4.5 and RCP8.5) and three time windows (2011-2040, 2041-2070 and 2070-2100).

First, the RIBS model has been calibrated with a set of objective functions to minimise the bias between simulations and observations recorded at a streamflow-gauging station located in the Arga River in Pamplona. The seven greatest flood events occurred in Pamplona in the last decade are considered. A long set of random combinations of model parameter values are used. The combination of parameter values that led to the smallest errors were selected.

Second, 24-h design rainfall storms with a time step of 1 h in the current scenario at a set of rainfall gauge stations in the Arga River catchment are obtained by using an extreme frequency analysis. Expected changes in daily rainfall quantiles in the Arga River catchment obtained by processing climate change projections are used (Garijo and Mediero 2019, Water). Current and future design rainfall storms were obtained for the seven return periods, two RCPs and three time windows. The input data in the RIBS model are provided in a raster format. Hence, design rainfall storms were transformed into spatial distributions of precipitation with the Thiessen polygons technique.

The findings show a decrease in design peak discharges for return periods smaller than 10 years and an increase for the 500- and 1000-year floods for both RCPs in the three time windows. However, 50- and 100-year return period flood quantiles are expected to increase especially in the 2041-2070 and 2071-2100 time windows only in the emission scenario RCP8.5. The emission

scenario RCP8.5 always provides greater increases in flood quantiles than RCP4.5, except for the more frequent floods (2, 5 and 10 years) in the time window 2011-2040. The increases of design discharges are 10-30% higher in RCP8.5 than in RCP4.5 for the greatest return periods. Therefore, flood magnitude changes for the most extreme events seem to be related to the evolution of greenhouse gasses emissions, following the same behaviour of the RCPs: the greatest expected changes are in the 2040 for the RCP4.5 and in the 2100 for the RCP8.5.