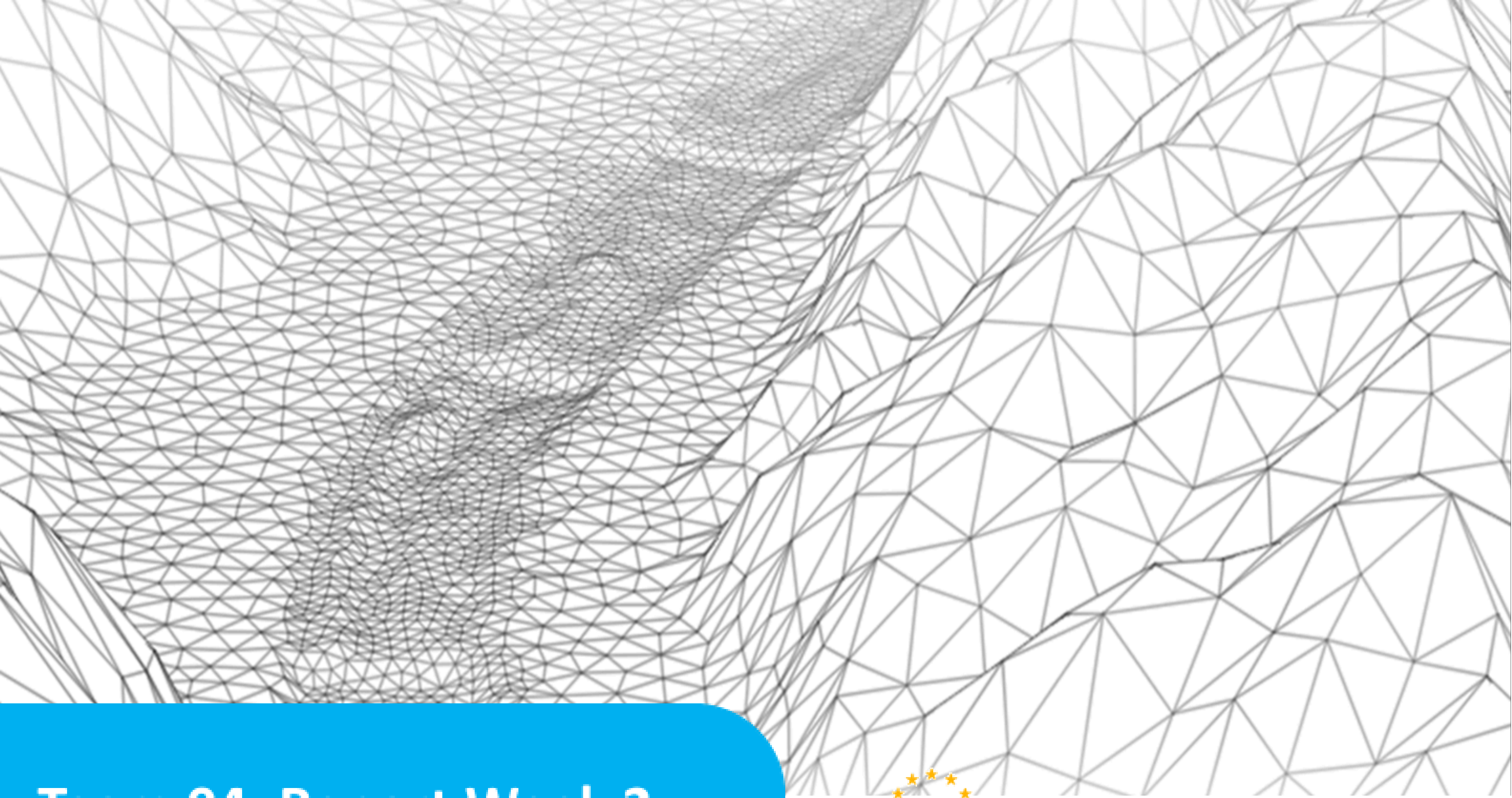

Team 04: Report Week 2

HYDROEUROPE

Erasmus+ Programme Cooperation Partnerships
2022-1-FR01-KA220-HED-000089658
HydroEurope

WP2: Uncertainty in Advanced Hydrological and Hydraulic Modelling
WP3: Climate Change Impacts on Flash Floods
La Tordera Catchment (Spain)

Team 4 - Report Week 2:
Climate change impact on hydraulics

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Version 3.1 - 1 Mar 2024

1. Introduction

River Floods, natural phenomena with widespread environmental, social, and economic impacts (Merz et al., 2010; Group et al., 2011; Priest et al., 2016), can be intensified by human activities such as urban expansion into floodplains and change in land use. climate-induced intensified rainfall events, suggest an escalating flood risk, particularly in regions like the Mediterranean basin (Giorgi, 2006; Parmesan et al., 2022) resulting in flash floods, which are defined as sudden floods in small catchment areas typically less than 1000 km2, occur within 6 hours or less of the initiating event, such as heavy rain, dam breaks, or rapid snowmelt. They often commence within 2 hours of intense rainfall onset. Flash floods may result from localized heavy rainfall or be part of a larger flood event. They pose significant risks, especially in coastal regions with high urban development and population density, where extreme events, predominantly convective in origin, exhibit strong seasonality. The Mediterranean basin is particularly susceptible to these extreme events (Marchi et al., 2010; Sala, 2003; Gaumeet al., 2009)

Flash floods are prevalent in the Mediterranean region, especially in north-west region (Jansa et al., 2014), which is characterized by littoral and pre-littoral mountain chains, the conditions are conducive to intense, concentrated rainfall in small catchments. This, coupled with short concentration times and very high runoff rates, can lead to the rapid development of catastrophic flash floods. In the Mediterranean, convective thunderstorms and showers typically occur in summer and early autumn due to low-level instability and high temperatures. Summer events tend to be localised and brief, while autumn sees an increase in catastrophic flash floods due to warmer sea surface temperatures and the prevalence of cyclones and organised disturbances (Jansa et al., 2001, 2014). In Catalonia, flash floods predominantly occur from August to October, aligning with the pattern of convective precipitation distribution (Llasat et al., 2014; Llasat, 2001)

Climate change has raised concerns regarding the rise in river floods due to the increased moisture-retaining capacity of a warmer atmosphere (Field, 2012). These concerns are underscored by the large evidence of increasing economic damages linked to flooding across various regions worldwide, Europe being among them (Hov et al., 2013). Any alterations in river flood patterns would carry enduring implications for devising flood protection strategies and flood risk zones (Hall et al., 2014).

River flood study over la tordera catchment. low amount of data with 24h hours precipitation and temperature. In 2013, the combined population of the two cities located at the mouth of the river was recorded at 58,089 inhabitants. Municipal data indicates a seasonal increase of approximately 18% in population during the summer months, attributed to the region's significance in tourism.

The region faces recurrent flooding from the Tordera river, with historical records from the ACA (2002; 2011) documenting a minimum of 38 instances of river flooding over the past seven decades.

The river ecosystem underwent significant alterations, transitioning from a natural system to a heavily influenced one, primarily due to human activities and infrastructure development. Sediment extraction exacerbates the situation, contributing to the system's degradation.

2. Study area

Detailed characteristics (landuse, soil, climate -temp and precipitation-, DEM, slope, geological)

La Tordera is an emblematic river in Catalonia, Spain, flowing through the picturesque town of Tordera. Stretching over a distance of 55 kilometres , this river originates in the Montseny massif before majestically joining the waters of the Mediterranean Sea. With an average flow of 5.01 cubic metres per second, the Tordera draws its vitality from major tributaries such as the Riera de Gualba, the Riera de Arbúcies, the Riera de Santa Coloma and the Riera de Valmanya.

The Tordera's ecosystem is further enhanced by its passage through crucially important protected areas, including the Parc Natural del Montseny and the Parc Natural del Montnegre i el Corredor. In harmony with these preserved environments, the river becomes a natural testimony to Catalonia's ecological wealth, captivating those who travel its banks and explore its watershed.

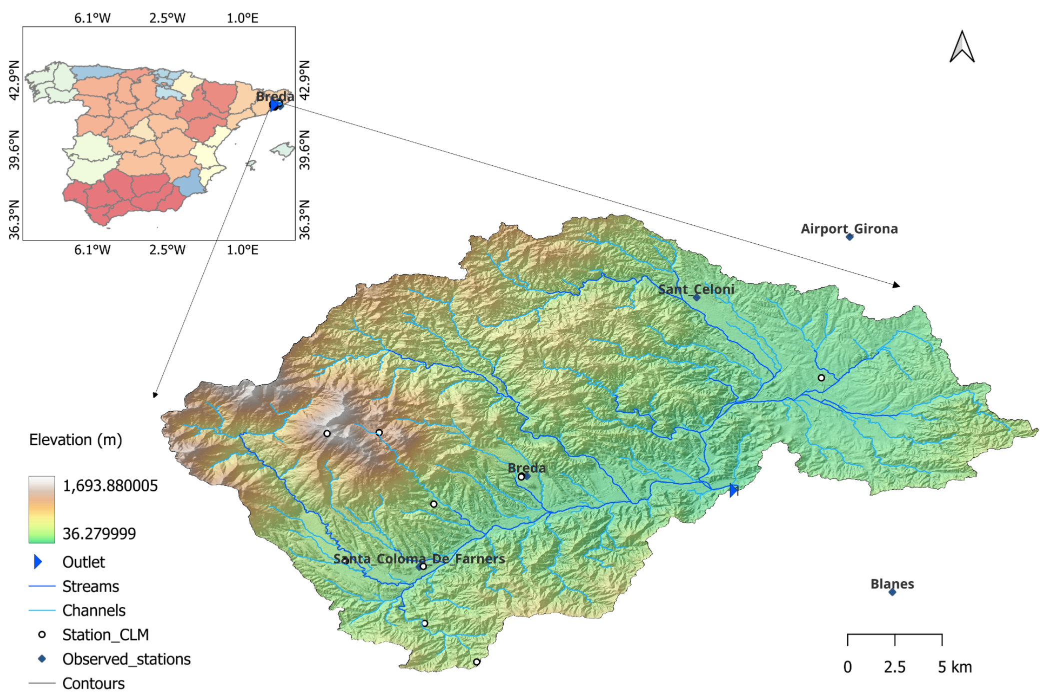

Figure 1.

The river La Tordera in Spain is characterised by a Mediterranean climate. The Mediterranean climate is characterised by hot, dry summers and mild weather. Rainfall is generally concentrated in the autumn and spring months, while summers are often dry. Winters can be rainy, but temperatures are generally mild shown in fig: 2.a

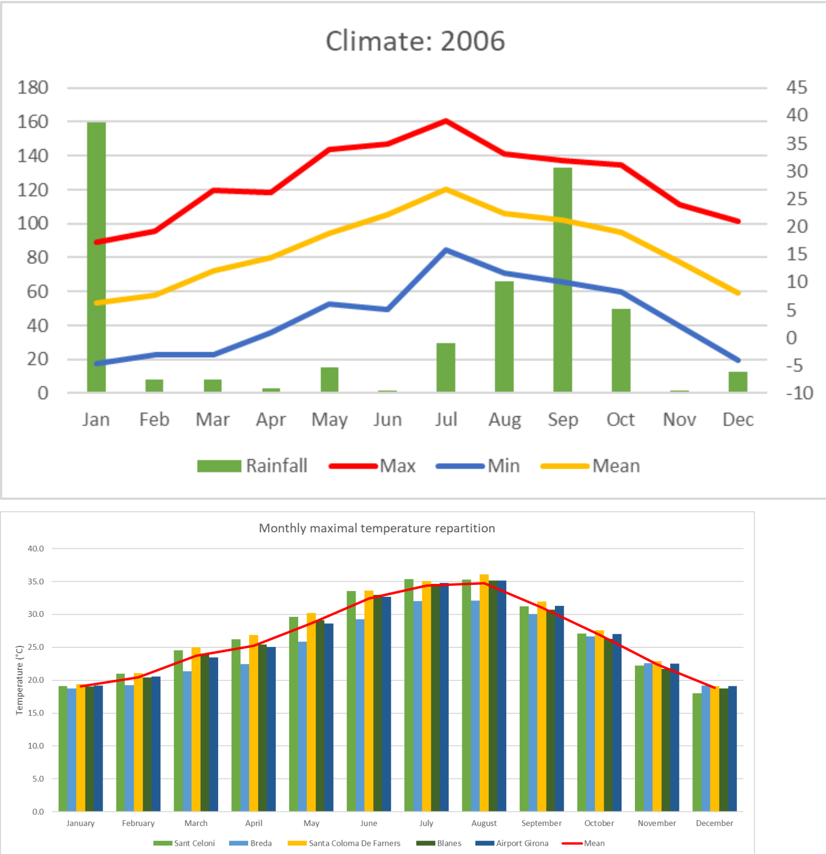

Figure 2. a. Climate for year 2006, b. Monthly maximum temperature

Summer temperatures in the La Tordera region are generally high, with daytime averages that can exceed 30°C in the hottest months. Winters in this region are mild, with daytime temperatures varying between 10°C and 15°C. Nights can be cool but rarely freezing, with minimum temperatures around 5°C to 10°C.

Rainfall in the La Tordera region is mainly concentrated in autumn (September-November) and spring (April-May). Summer precipitation is relatively rare, but there can be occasional thunderstorms, often accompanied by heavy rain.

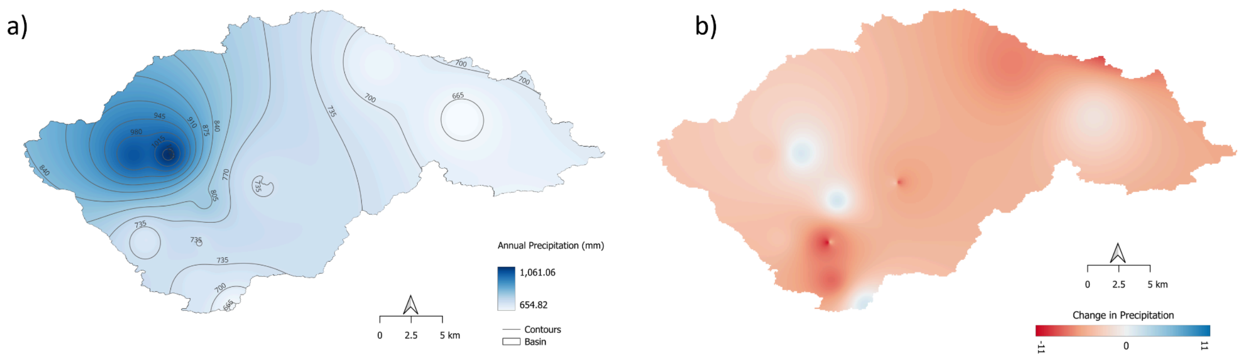

Figure 3. a) Interpolated distribution of precipitation b) Change in precipitation

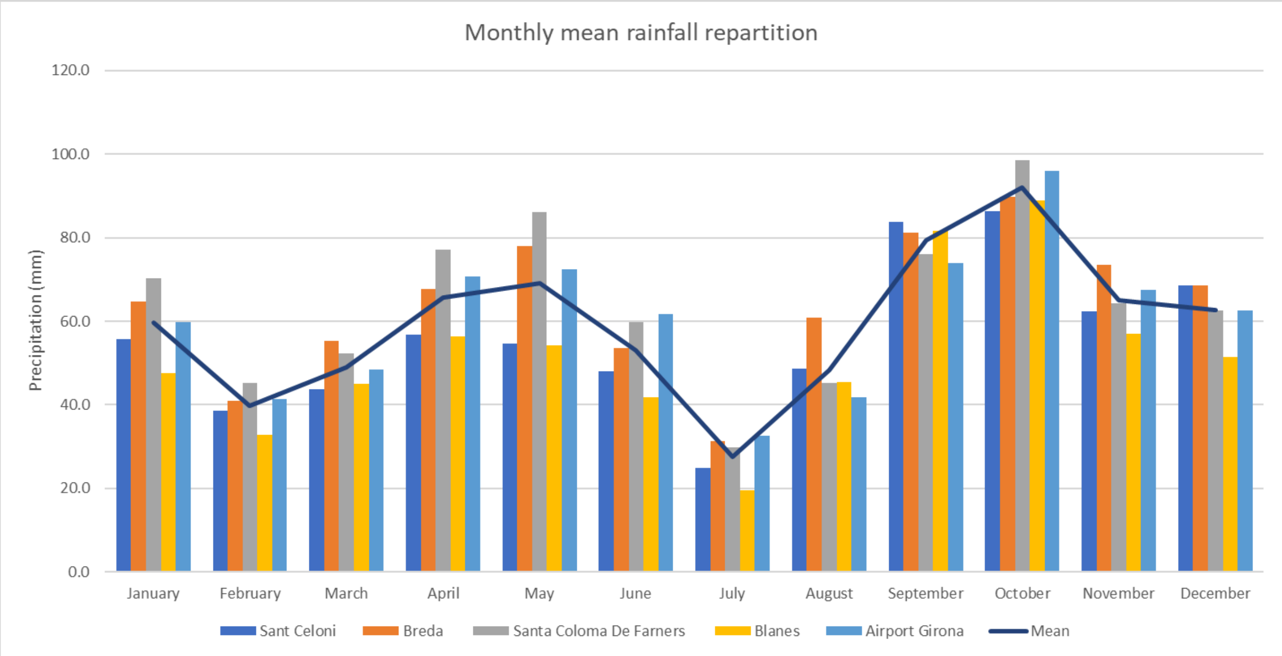

Figure 4. Monthly distribution of the rainfall

The Tordera watershed features a diversity of land uses that reflects the region's natural and human characteristics. This watershed, dotted with natural parks, agricultural areas and urbanised spaces, is a complex ecosystem where the coexistence of nature, agriculture and urbanisation is closely intertwined.

Firstly, a large part of the watershed is characterised by abundant vegetation, mainly due to the presence of natural parks and protected areas. These natural areas provide a crucial habitat for a variety of native flora and fauna, contributing to regional biodiversity. The region's natural parks are environmental gems that attract nature lovers, hikers and tourists alike, while preserving fragile and unique ecosystems.

In addition, the Tordera watershed also includes agricultural areas where various farming activities are practised, such as fruit and vegetable growing, as well as livestock farming. These agricultural areas play an essential role in the local economy. However, it is important to manage this agricultural land wisely to preserve soil quality and avoid environmental degradation.

Finally, there are also urbanised areas in the Tordera watershed, including towns and residential areas. Urbanisation brings its own set of challenges in terms of natural resource management, environmental preservation and sustainable development.

Land use in the Tordera watershed is varied and complex, encompassing areas of lush vegetation, productive agricultural land and ever-expanding urbanised areas. Balanced and sustainable management of this land is essential to ensure the preservation of the natural environment, the support of local agriculture and the quality of life of the region's inhabitants.

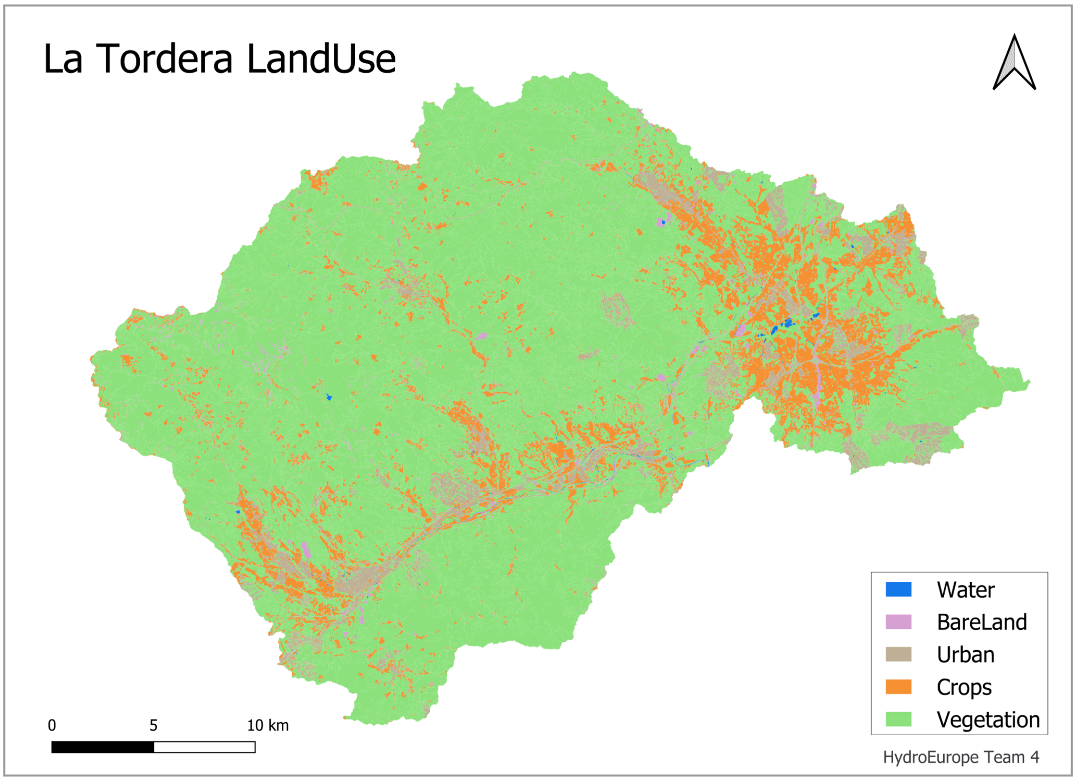

Figure 5. Landuse of the Tordera Catchment

The study on river flooding across the La Tordera catchment area is hindered by limited data availability, particularly concerning 24-hour precipitation and temperature records.

Temperature data were particularly crucial, enabling us to calculate the area's evapotranspiration. This parameter is essential for understanding water flows in the riparian ecosystem and for assessing the water requirements of the various crops and natural habitats.

Precipitation data were used to develop intensity and frequency curves, a fundamental step in determining Montana's coefficient and peak discharge. This information is essential for flood risk management and hydraulic infrastructure planning in the region.

Land use has also played a crucial role in our hydrological models. By understanding the distribution and characteristics of different soil types along the watershed, we were able to refine our simulations with models such as TELEMAC and HEC-HMC. This integration of soil data greatly improved the accuracy of our predictions concerning water flows and interactions with the natural environment.

3. Methods

a. HEC-HMS

HEC-HMS stands for Hydrologic Engineering Center's Hydrologic Modeling System. It is a widely-used software developed by the U.S. Army Corps of Engineers for modelling hydrologic processes.

HEC-HMS is designed to simulate rainfall-runoff processes and predict the flow of water through different components of a watershed or river basin. It helps in understanding and analysing the response of watersheds to various hydrological inputs, such as rainfall, snowmelt, and land use changes. HEC-HMS is used in various engineering and environmental applications, including flood forecasting, reservoir operation planning, and watershed management. It is employed by hydrologists, water resources engineers, and environmental consultants for decision-making and water resource planning.

HEC-HMS offers a range of tools for hydrologic analysis, including precipitation data processing, runoff modelling, and flow routing. It allows users to define the watershed characteristics, such as land use, soil types, and drainage properties, to create a comprehensive hydrologic model.

One of the fundamental equations used in HEC-HMS is the "S curve Unit Hydrograph" equation, which describes the transformation of rainfall into runoff over time.

$$Q(t) \ = Q_p \times (1 - e^{-\frac{t}{t_c}})^{1/p}$$

Where:

$Q(t)$ = Runoff at time \(t \)

Q_p = Peak discharge

t_c = Time to peak

p = Recession limb parameter

b. SWAT

SWAT stands for Soil and Water Assessment Tool. It is a comprehensive hydrological model developed by the United States Department of Agriculture (USDA) Agricultural Research Service (ARS) for simulating water, sediment, and agricultural chemical yields in large, complex watersheds.

SWAT is designed to assess the impact of land management practices, climate change, and land use changes on water resources, soil erosion, and water quality. It facilitates integrated watershed management and supports decision-making processes related to land and water resources. WAT is used in various fields, including agriculture, water resources management, environmental impact assessment, and land use planning. It is employed by researchers, watershed managers, government agencies, and policymakers for analysing the effects of different land management scenarios on water quantity and quality.

SWAT integrates various hydrological and agricultural processes, including surface runoff, groundwater flow, evapotranspiration, soil erosion, nutrient cycling, and crop growth. It allows users to define watershed characteristics, land use, soil types, management practices, and climate data to create a comprehensive model of the study area. One of the fundamental equations used in SWAT is the Curve Number (CN) method, which estimates direct runoff from precipitation events based on land cover, soil type, and antecedent soil moisture conditions.

$$Q \ = \frac{P - I_a}{1 + \frac{P - I_a}{I_a}}$$

Where:

Q = Direct runoff

P = Precipitation

Ia = Initial abstraction (a function of Curve Number, antecedent moisture conditions, and potential maximum retention)

c. TELEMAC

i. Presentation

TELEMAC-MASCARET is a suite of numerical modelling software developed by the Laboratoire National d'Hydraulique et Environnement (LNHE) in France. It is primarily used for simulating hydrodynamics, sediment transport, and water quality in rivers, estuaries, and coastal areas. It is designed to provide accurate predictions of flow patterns, sediment transport, and water quality parameters in complex hydraulic systems. It supports a wide range of applications, including flood forecasting, river engineering, coastal management, and environmental impact assessment.

TELEMAC-MASCARET offers advanced numerical models for solving the shallow water equations, sediment transport equations, and water quality equations. It includes modules for turbulence modelling, morphodynamic processes, and ecological modelling, allowing for comprehensive simulations of hydraulic and environmental processes. It is widely used in hydraulic engineering, coastal engineering, and environmental modelling studies. It is utilised by government agencies, consulting firms, research institutions, and academia for various applications, including flood risk assessment, sediment management, and ecosystem restoration.

One of the primary equations used in TELEMAC-MASCARET is the Saint-Venant equations, which describe the conservation of mass and momentum in open-channel flow.

$$\frac{\delta A}{\delta t} + \frac{\delta (AU)}{\delta x} = 0$$

Where:

A = Cross-sectional area of flow

U = Velocity of flow

x = Spatial coordinate

t = Time

ii. Overview of DTM data used

In the initial phase of creating a digital model, it is imperative to precisely delineate the study area, encompassing the minor bed, the major bed and the flood risk zone. This crucial step requires the pre-processing of GIS data, including the exploitation of data from a digital terrain model (DTM) obtained from a 1-metre resolution airborne Lidar survey (second coverage: 2016-2017) for the study area. This data is essential for generating bathymetry points and contours related to the study area. Given the large volume of the Tordera digital terrain model, we have delimited a study area corresponding to a fragment of the topography centred on the section under study. To this end, we create a Shapefile for the area, then extract the raster using our area mask. Before generating the bathymetry and the various contours of the area, we checked that the DTM contains only one class, which is the natural terrain; hence the absence of structures and obstacles in the riverbed.

iii. GIS data pre-processing

The preliminary processing of topographic data involves several stages, each of which is of fundamental importance in guaranteeing the quality of the data used and, consequently, optimising modelling accuracy. It is imperative to ensure the reliability of each step in the process, from the initial collection of topographic data to its integration into the model:

. Delimitation of the study area, including :

. Minor river bed.

. Major river bed.

. Areas likely to be flooded.

To ensure accurate delimitation, we used the map of flood-prone areas available on the website SNCZI-Inventario de Presas y Embalses (mapama.gob.es). We then georeferenced it on ArcGIS.

. Importing the DTM into ArcGIS: We then used a 1-metre digital terrain model, made up of several tiles. However, we had to specifically select and filter the tiles required in our study area and bring them together to obtain a single digital terrain model.

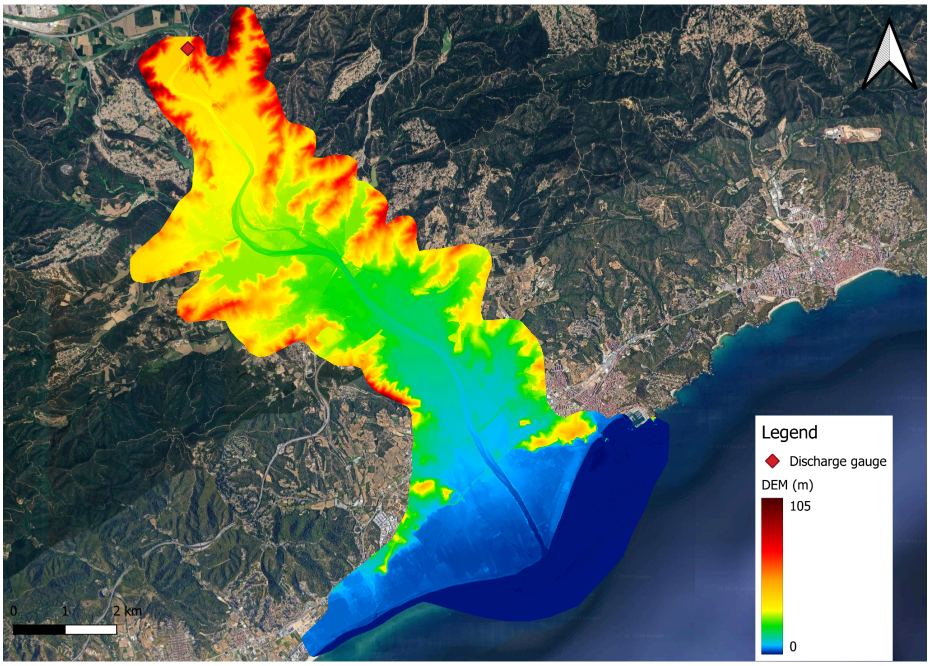

Figure 6. Digital terrain model of the study area (Lidar 1-metre)

. Generation of a point cloud based on the centre of each DTM mesh: Initially, we will generate the corresponding shapefiles of the minor and major bed, as well as the previously defined flood zone.

. Generating the land cover of the study area: In order to get closer to reality, it is necessary to run the model with spatialized Strickler coefficients. A land-use map was produced with 5 different classes. For each class, the corresponding Manning value was inserted in the attribute table. The resulting shapefile will be used in Bluekenue to interpolate to the final bathymetry.

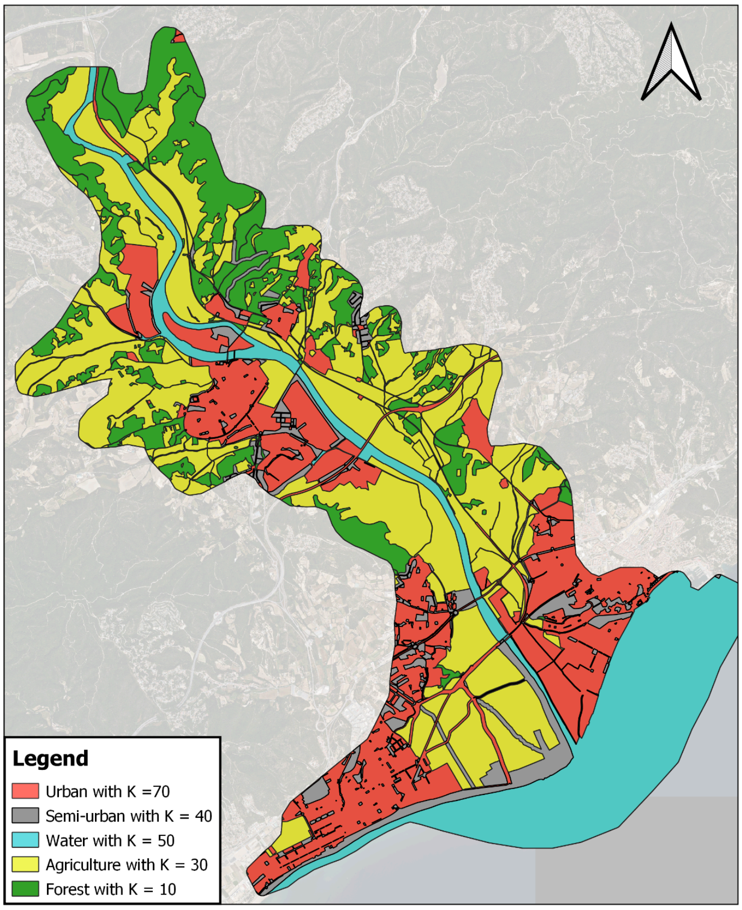

Figure 7. Land Use: spatial distribution of Strickler coefficients

. Recovering XYZ coordinates and converting them into a txt file: Next, we'll extract the raster values of specific points (x,y) located in the study area. For the extent of the sea, we've generated a point cloud by imposing a bathymetry of 0 metre. After obtaining the bathymetric data (X, Y, Z), we export them in .txt format, then save them in xyz (bathymetry) to create the mesh on BlueKenue.

iv. Mesh generation and interpolation (Bathymetry and land use)

Using BlueKenue, the graphical interface essential for creating the files required for TELEMAC, we imported and visualised the shapefiles describing the contours of the minor and major river beds and the spatial distribution of Strickler's coefficients, saving them as files.i2s, along with the bathymetric data for our study area. We then generated the mesh covering the entire right-of-way.

To optimally meet the project's requirements, we adopted a differentiated mesh approach in three distinct levels:

. A fine mesh with a resolution of 10 metres along the minor bed, offering a detailed representation of this crucial portion of the watercourse.

. An intermediate mesh with a resolution of 30 metres on the major bed, adapted to the greater extent of this section of the river.

. A coarser mesh with a resolution of 50 metres over the rest of the area, providing a more global view while maintaining computational efficiency.

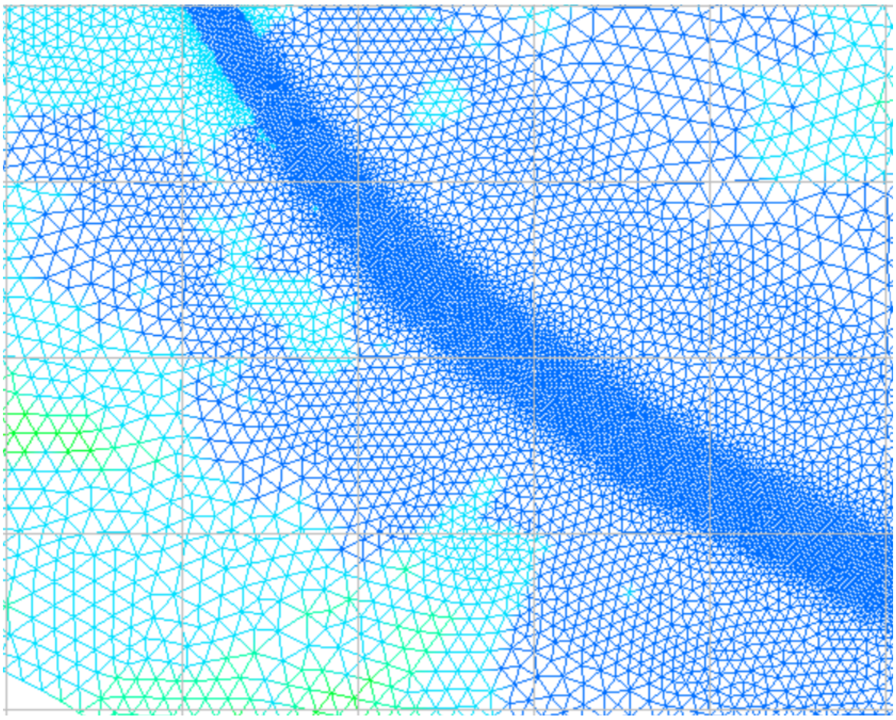

Figure 8. The Presentation of the different mesh sizes in the study area

Once the mesh has been created, the depth must be integrated into it, using the bathy.xyz file to interpolate bathymetric data onto the mesh files, enabling depth information to be integrated into these files. This creates a digital terrain model (DTM) representing the topography of the seabed.

A second interpolation was performed using the spatial distribution of Manning's coefficients. The result of the two different interpolations is a digital terrain model (DTM) representing the topography of the water bottom, incorporating Manning's coefficients (Bottom friction).

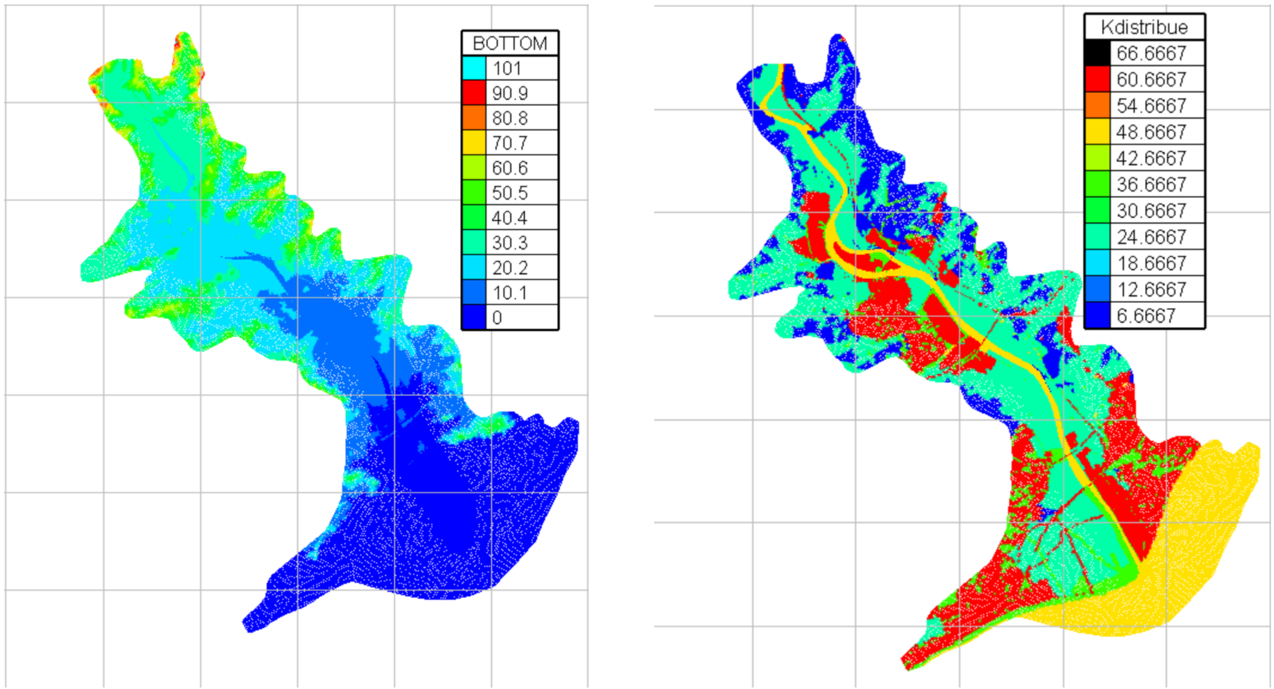

Figure 9. Presentation of bathymetry interpolation and spatialized strickler coefficient over the entire study area

v. Geometry files

BlueKenue generates a geometry file in Selafin (.slf) format, based on the attributes created during interpolation. These files contain essential information about the area's topography, which is required for hydrodynamic simulation.

It is crucial to include in the files.slf the names of relevant variables, such as BOTTOM for the bottom and BOTTOM FRICTION for the spatial repartition of Manning's coefficients, so that TELEMAC correctly recognizes them as bathymetric data.

vi. Boundary conditions

After meshing and obtaining the geometry file, it is important to define the upstream and downstream boundary conditions, using the "Boundary conditions" function and adding the upstream and downstream boundary segments. At this stage, upstream, the flow rate must be prescribed as the boundary code ''Open boundary with prescribed Q'', while downstream, the height must be notified as the boundary code ''Open boundary with prescribed H''. Each type of condition has its own boundary code. The resulting file is saved with the extension ''fichier.cli'' and will be inserted into the .cas file for simulation purposes.

In addition to boundary conditions (Input-Output), it is also necessary to define wall conditions. In fact, all segments for which no boundary conditions have been defined are not considered to be walls TELEMAC2D-Bluekenue

4. Performance evaluation

5. Climate change

The climate change data are composed of 11 projections from different agencies on 10 stations over and around the catchment. Only 2 stations are on an observation station, we used them to get a comparison of the data.

Some stations are unstable and present missing data, we only compare 9 of them. To compare it, we used PBIAS, RMSE and correlation. PBIAS stands for Percent Bias and RMSE stands for Root Mean Square Error. They are statistical measures used to assess the accuracy of a model's predictions or estimates compared to observed values. PBIAS quantifies the average tendency of the model to either overestimate or underestimate the true values. RMSE provides a measure of the typical deviation of the model's predictions from the actual observed values. Correlation describes the degree to which two variables are related or move together in a systematic way; it quantifies the strength and direction of the linear relationship between two variables.

No.	Climate Change Projection
1	BCC-CSM2-MR
2	EC-EARTH3
3	CNRM-ESM2-1
4	MRI-ESM2-0
5	MPI-ESM1-2-HR
6	ACCESS-CM2
7	CMCC-ESM2
8	CanESM5
9	NorESM2-MM

Figure 10. Climate change projections

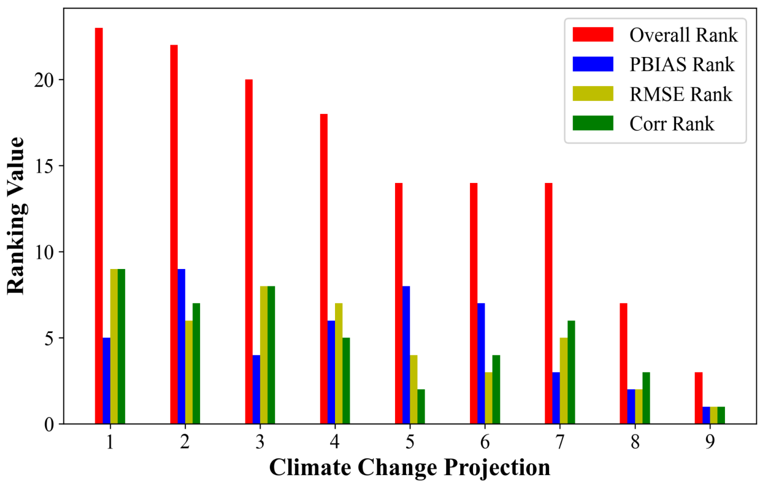

Figure 11. Ranking of the climate change projections

With those tools, we have been able to sort the climate change projection and we decided to use 4 best projections. We used BCC-CSM2-MR, EC-EARTH3, CNRM ESM2-1, and MRI-ESM2-0 based on their ranking.

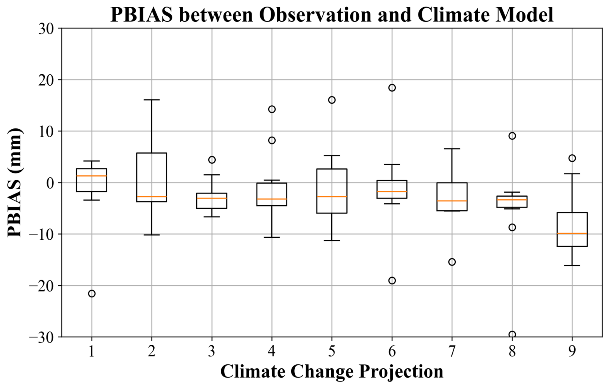

Figure 12. PBIAS of the projection with the observed values

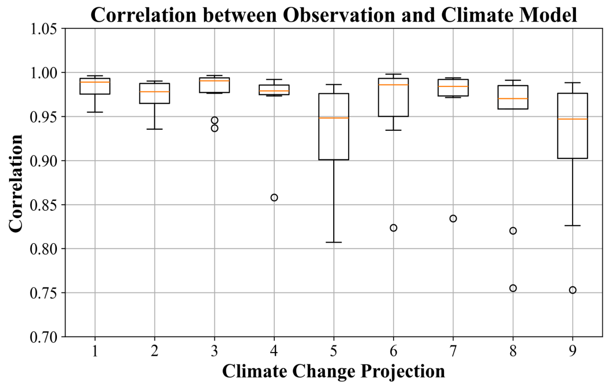

Figure 13. Correlation of the projections with the observed values

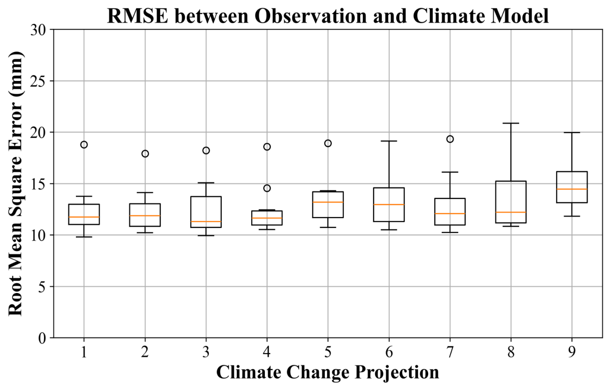

Figure 14. RMSE of the projections with the observed values

Based on those projections we calculated the return period for each climate change scenario available (SSP126, SSP245, SSP370 and SSP585). SSP means "Shared Socioeconomic Pathways," which are a set of scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) to explore different potential futures of socioeconomic development and their implications for greenhouse gas emissions and climate change. The SSPs are used in climate modelling to assess the potential impacts of different socioeconomic pathways on climate and to inform policy decisions.

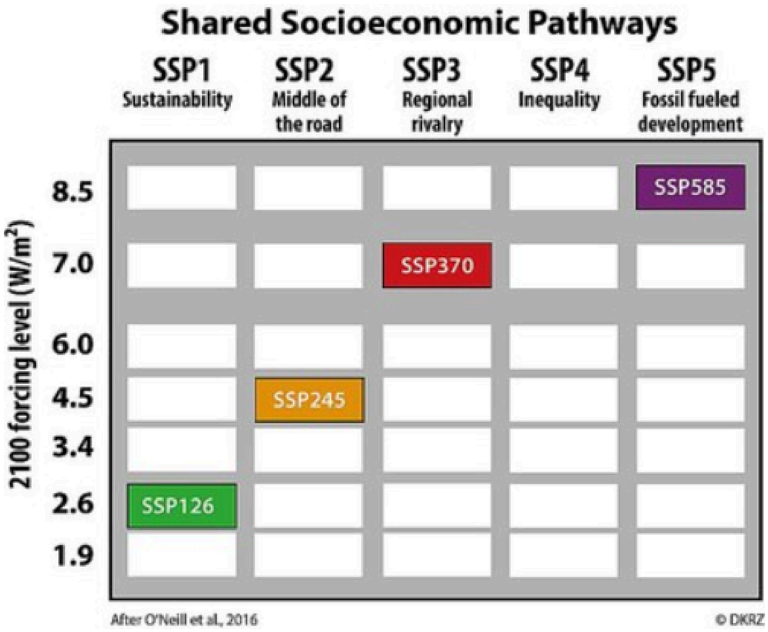

Figure 15. Shared Socioeconomic Pathways meaning

In the case of SSP126:"SSP'' refers to Shared Socioeconomic Pathways, "1" indicates a pathway characterised by a low baseline scenario for future socio economic development. Finally "26" indicates a radiative forcing level in the year 2100, expressed in watts per square metre (W/m²). In this case, SSP126 represents a pathway with a low radiative forcing level in 2100 compared to other SSPs, suggesting lower greenhouse gas emissions and less severe climate change impacts.

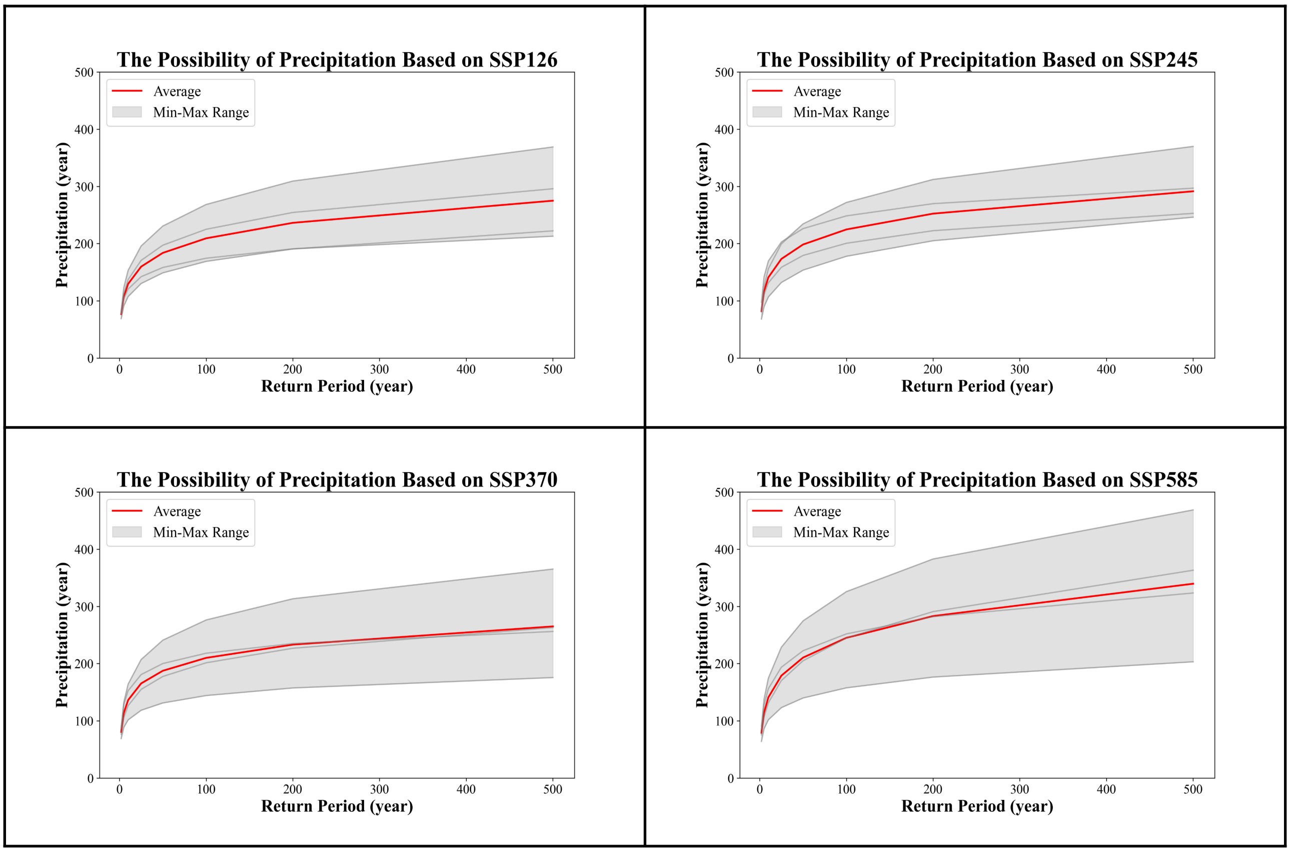

Figure 16. Return period spectrum for the different climate change scenario

Based on the return period of each projection we plotted the possibility of precipitation with the impact of climate change. The range of value is very wide and uncertain. It starts from 200mm per year to nearly 500mm per year.

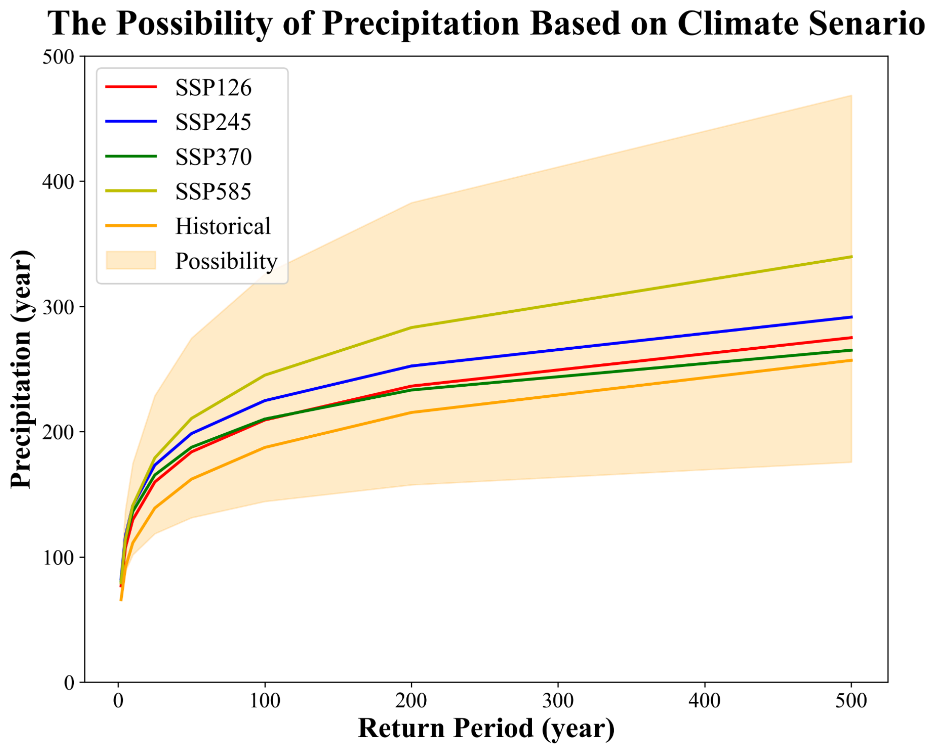

Figure 17. Uncertainty spectrum of the return period

6. Results

a. Hydrology

The objective of the hydrologic part is to obtain discharge value at the discharge gauge station to be able to simulate climate change impact on the flooded area. To get the discharge we need to use a calibrated HEC-HMS model. HEC-HMS needs data of solar radiation, precipitation, evapotranspiration to work. Once the model is calibrated we use data from climate change for the simulation.

Part on how do we get discharge from le HMS model with climate change data

The Spanish ministry of the environmental transition provides data of floodings for different return periods. For a return period of 500 years the linked discharge is 2815 m3/s in La Tordera. We calculated this same discharge for the observed value and got 2 759 m3/s.

To calculate the discharge for observed data and climate change, we used the rational method. First, we used the Desbordes formula to determine the concentration time of the catchment. Regarding the runoff coefficient, we used the previously established land use, we find Cr = 0.25.

$$Tc = \frac{5.3}{0.8} \times S^{0.3} \times P^{-0.38} \times C^{-0.45}$$

With :

S : Surface (ha) = 77 600 ha

P : Average slope (%) = 3.28 %

C : Runoff coefficient = 0.25

$$Tc = \frac{5.3}{0.8} \times 77\,600^{0.3} \times 3.28^{-0.38} \times 0.25^{-0.45} = 255\ min = 4.25\ h$$

With Tc, we can determine the rainfall intensity for a rainfall of duration using the Montana formula:

$$i(t) = a \times t^{-b}$$

The Montana coefficients a and b are determined using IDF curves from historical data.

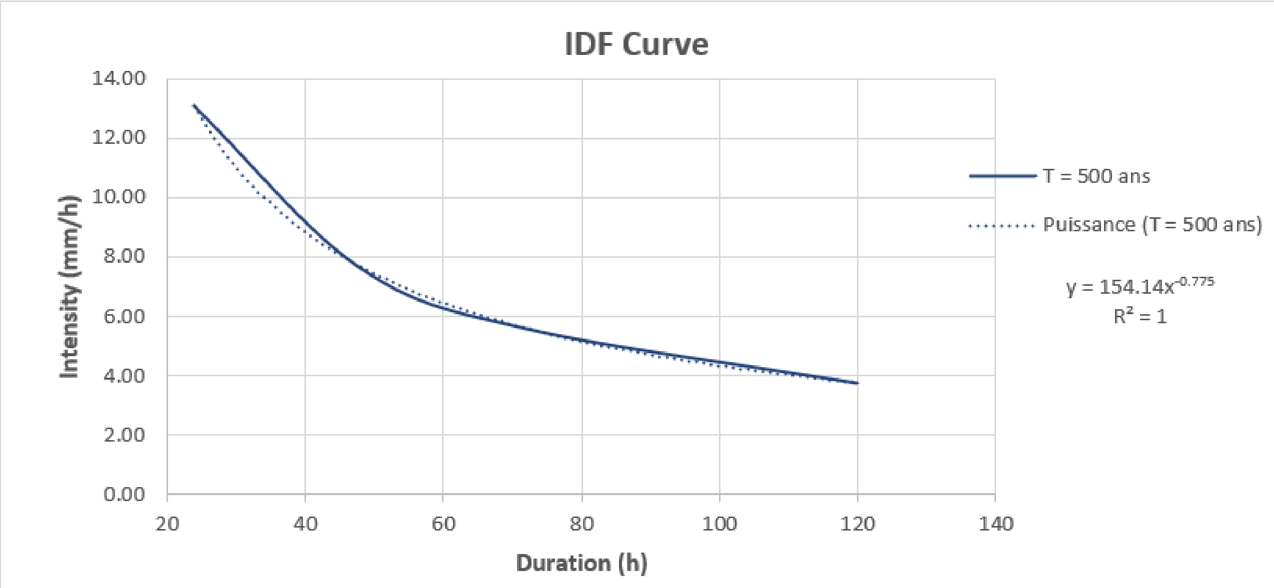

Figure 18.

We obtain the following result :

$$i(Tc) = 154.14 * 4.25^{-0.775} = 50.2\ mm/h$$

We now use the rational method to estimate the peak discharge at the outlet of the watershed, for a rainfall duration of Tc.

$$Q = \frac{C_r \times I \times A}{3600}$$

With :

Q = Flow rate (l/s)

Cr = Runoff coefficient = 0.25

A = Watershed area (m²)

Thus, we obtain:

$$Q = \frac{0.25 \times 50.2 \times 776\,000\,000}{3600} = 2\,759\,011\ l.s^{-1} = 2\,759\ m^3.s^{-1}$$

However, this result should be taken with caution because the average slope of the watershed varies greatly depending on the area, as well as the intensity given the extent of our watershed.

We now use the same method with the climate change data from the ssp126 and ssp585 stations. We then obtain different Montana coefficients as well as a different intensity for a rainfall of duration Tc.

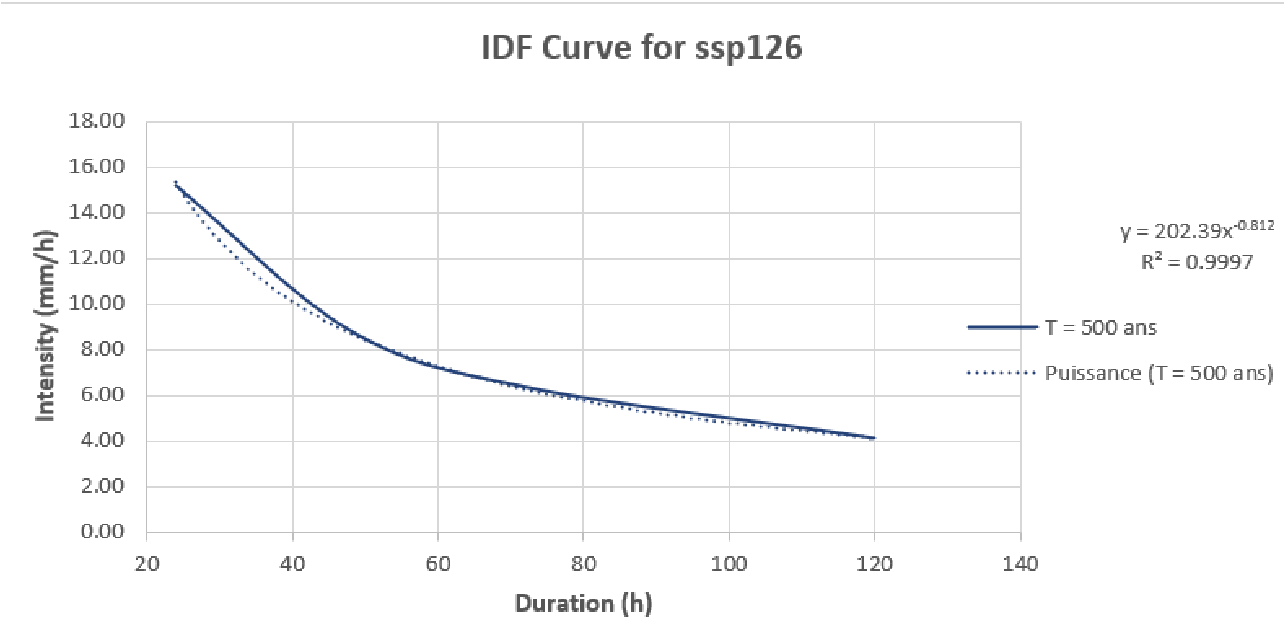

Figure 19.

For the ssp126 station, we find Montana coefficients of a = 202.39 and b = 0.812.

We then obtain the following intensity :

$$i(Tc) = 202.39 * 4.25^{-0.812} = 60.5\ mm/h$$

So, we obtain a flow rate of :

$$Q = \frac{0.25 \times 62.5 \times 776\,000\,000}{3600} = 3\,433\,782\; l.s^{-1} = 3\,433\; m^3.s^{-1}.$$

For station ssp585 :

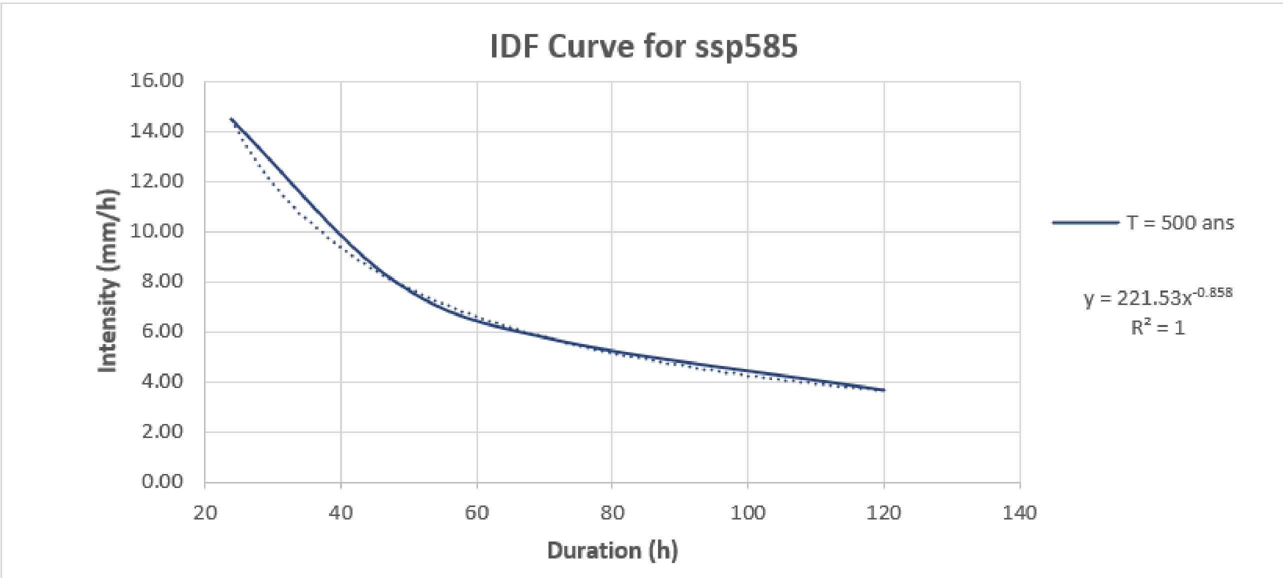

Figure 20.

We find Montana coefficients of a = 221.53 and b = 0.858.

We then obtain the following intensity :

$$i(Tc) = 221.53 * 4.25^{-0.815} = 68.1\; mm/h$$

So, we obtain a flow rate of :

$$Q = \frac{0.25 \times 68.1 \times 776\,000\,000}{3600} = 3\,742\,232\; l.s^{-1} = 3\,742\; m^3.s^{-1}.$$

Discharge for T =500 years (m3/s)	Average	Change from observed data
Observed_calculated	2759	0%
SSP126_calculated	3433	+18%
SSP585_calculated	3742	+24%

With HEC-HMS we tried different solutions to obtain the discharge for climate change projection. We preferred PEARSON III to calculate the return period compared to GEV or any other distribution because In some cases, PEARSON Type III distribution might provide a better fit for certain types of data compared to the GEV distribution, particularly when dealing with bounded or skewed datasets. Pearson Type III distribution can model a wider range of tail behaviours compared to the GEV distribution. This flexibility allows for better fitting of data with non-standard tail behaviors.We firstly tried to average the rainfall data of the 4 best projections, but the return period was nonsense and was around 200m3/s. We then tried another solution, running the model individually for each projection and then studying them. We calculated the mean, minimum and maximum for each scenario.

Discharge for T =500 years (m3/s)	Average	Minimum	Maximum
Observed	2815*		
SSP126_HMS	1900	1410	2940
SSP585_HMS			

** discharge value from the Spanish ministry*

Figure 21. Table of the discharge used for TELEMAC

b. Hydraulics

The goal of the hydraulic study is to understand the change in the flooded area of the catchment with climate change. To do this we used a hydrologic model as input for the hydraulic model.

i. Model initialization and launch

As with any model, TELEMAC2D's initialization phase is of particular importance. It involves initialising the model by defining initial conditions, based on previous studies and bibliographic research carried out in the study area, before validating it using specific scenarios.

In the case of our model, it is essential to create a .cas file grouping together the various data and files required for the simulation, including the geometry file, the boundary conditions file and the results file.

- **Boundary conditions**

At this stage, in steady state, as boundary conditions, we have set a flow upstream of 2815 m^3/s, corresponding to the flow obtained from the Spanish government site with a return period of 500 years. In the downstream section, we have maintained a head h=0 m, corresponding to the sea level.

- **Initial conditions**

As an initial condition, a water level of 1 cm is imposed over the entire study area for model impoundment.

ii. Launching the steady-state model with the flow rate and calculated flows (SSP 126 and SSP585)

- **1st scenario to calibrate the model**

To initiate and calibrate the model, we ran a simulation using the flow rate (2815 m^3/s) observed on the government site, with a return period of 500 years. The results obtained enabled us to produce a flood map with water heights for comparison with the map available on the government site.

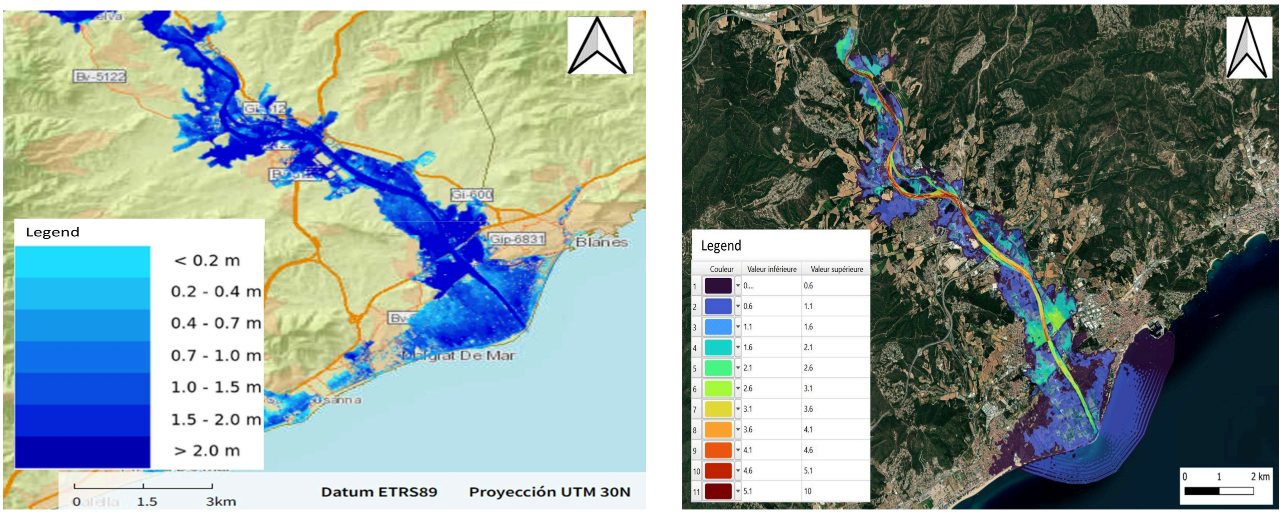

Figure 22. Flooded area for T = 500 years by the Spanish ministry of the ecological transition

7. Ressources

https://coastal-management.eu/node/216.html#:~:text=Historical%20flood%20events,during%20the%20last%207%20decades.

https://sig.mapama.gob.es/WebServices/clientews/snczi/Default.aspx?nombre=ZI_LAMINAS_Q500&claves=ID_ZONA&valores=HF050_201906_T500_0001_FID_64&origen=8

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9. Appendix