HYDROEUROPE PROJECT: EVALUATING UNCERTAINTIES IN ADVANCED HYDROLOGICAL AND HYDRAULIC MODELLING, CLIMATE CHANGE IMPACTS ON FLASH FLOODS, AND ACCIDENTAL WATER POLLUTION ACROSS SIX EUROPEAN CATCHMENTS. THE CRITICAL ROLE OF HIGHER EDUCATION PROGRAMS

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EXTENDED ABSTRACT

In recent decades, education has been a central concern in Europe, playing a crucial role in fostering better and healthier societies. The financing of educational programs and projects has been an essential tool for addressing a wide range of challenges affecting the continent. In this context, educational institutions play a vital role through traditional academic programs, master's courses, and research initiatives. Given the international nature of universities and research centers, collaboration has been key to enhancing local programs and expanding educational opportunities beyond institutional and national borders.

Each year, numerous initiatives emerge to improve education and to train young students and future professionals with the skills necessary to contribute meaningfully to society and integrate into the European job market. Since many societal challenges stem from natural phenomena, particularly those related to climate, various initiatives have been launched to study these issues in depth. With the climate crisis already impacting the daily lives of millions, it is essential to allocate significant resources and foster collaboration between the public and private sectors to study these challenges and develop effective measures to mitigate their negative effects.

The HydroEurope project was born out of the need to study flash floods, climate change, and water pollution from a Pan-European perspective. Climate projections indicate that the primary concern related to climate change in Europe is the increasing frequency of extreme weather events. These can be catastrophic and can affect/disrupt daily life of millions of people. These problems can create important issues related to water management and the water cycle, and due to the importance of this, it cannot be ignored. Understanding these problems is essential for improving knowledge and developing tools to address water-related challenges effectively.

Through a collaborative structure and organization, the HydroEurope project is structured to produce highly advanced teaching materials that train students and young professionals in water-related issues. By selecting six different case studies across Europe (six catchments), the project aims to analyze and understand a diverse range of situations affecting the water cycle from a European perspective. The figure 1 shows a flowchart on how the project is structured.

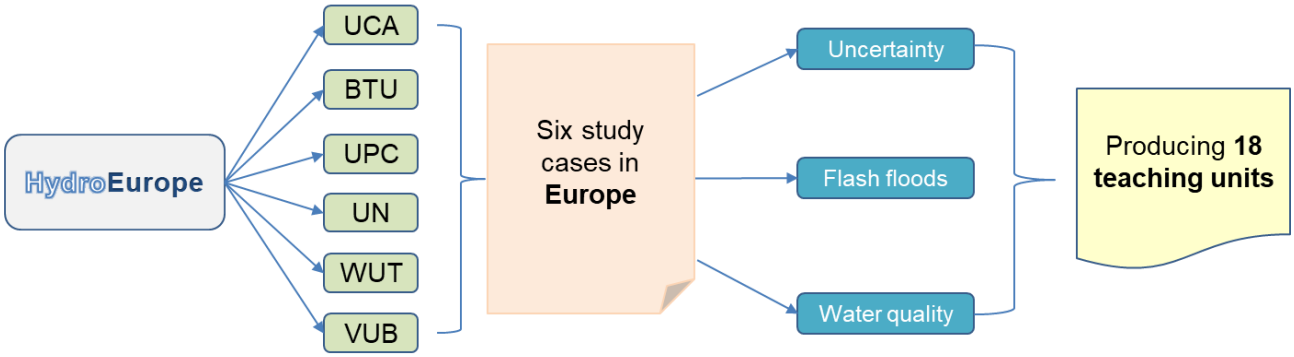

Figure 1: flowchart for the structure of HydroEurope project.

As shown in the figure 1, HydroEurope is structured around the collaboration of six universities across Europe: Université Côte d'Azur (UCA), Brandenburg University of Technology Cottbus-Senftenberg (BTU), Universitat Politècnica de Catalunya (UPC), Newcastle University (UN), Warsaw University of Technology (WUT), and Vrije Universiteit Brussel (VUB). These universities develop advanced teaching units on topics such as uncertainty in hydrological modeling, the impact of climate change on flash floods, and accidental water pollution, using local case studies (catchments). Figure 2 presents the selected catchments.

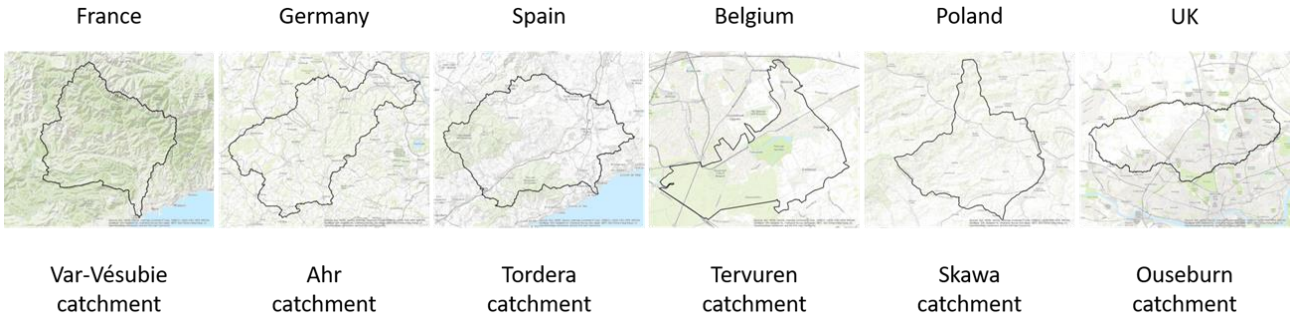

Figure 2: catchments selected as cases of study (at country level) by each university.

The catchments selected in the project reflect a wide range of different situations that represent the diversity of water related issues that can affect Europe. At the same time, selecting different topics of analysis increases the amount of information that can be produced and can describe a wide range of phenomena. For example, catchments located in the Mediterranean basin, as *Var-Vésubie* and *La Tordera* are affected by hydrometeorological events different to the ones affecting catchments like *Skawa*, *Ahr*, *Ouseburn* and *Tervuren*. Mediterranean catchments are mostly subjected to flash flood and high intensity rainfall events and are frequently affected by droughts. On the other hand, inland catchments might be affected by floods than can be temporally distributed in more time and can be less intense. At the same time, the land conditions (land use) are different so the impact of floods and pollution can have different implications. Both, *Tervuren* and *Ouseburn* are catchments with a higher urban occupation so they are affected more by urban floods that tend to cause problems in the city. On the other side, catchments like *La Tordera* or *Var-Vesubié* are mostly covered by forest and the main problems can occur in the last part of the catchment that drains into the sea (river mouth).

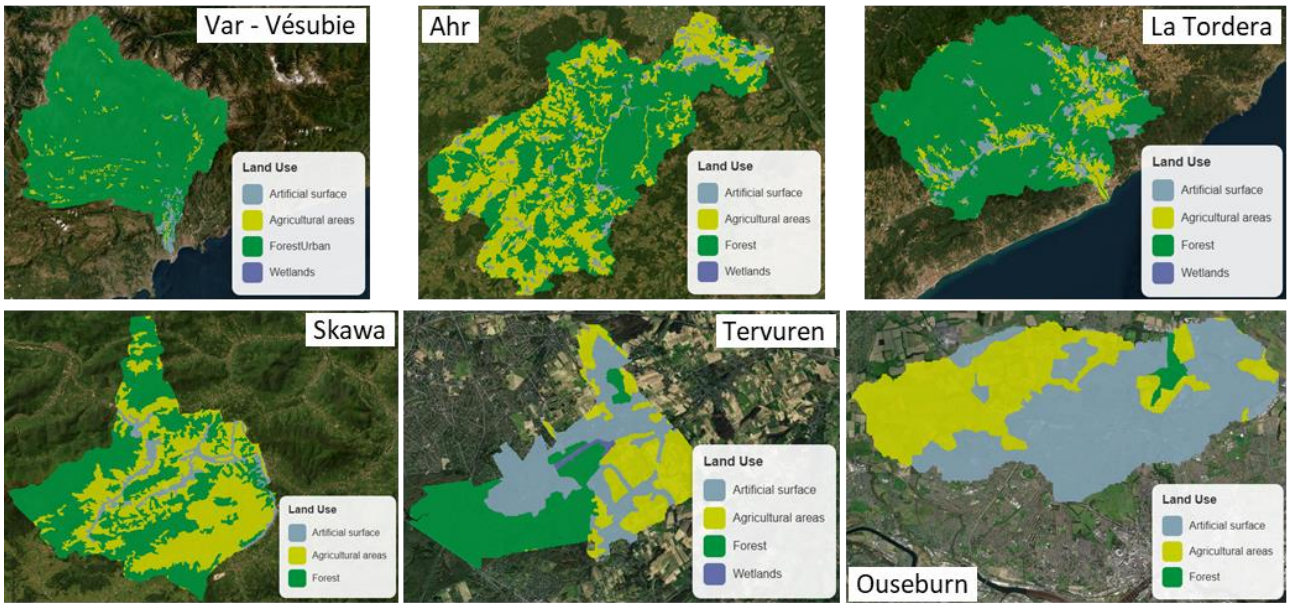

Figure 3: main land uses in the six catchments studied.

As a key outcome of the project, 18 advanced teaching units were developed over the three years of the program. These units covered topics related to flash floods, climate change, and water pollution for each case study, providing educational material designed for an in-depth analysis of the selected catchments. The teaching units enabled students to understand key challenges such as uncertainty in hydrological modeling, the occurrence of flash floods, the frequency of high-intensity rainfall events, the effects of climate change on local meteorological phenomena, the impact of water pollution on water bodies, and how these issues affect urban settlements. To support these analyses, tutorials and guides were created, featuring real case studies, exercises, and training manuals explaining the use of various hydroinformatics tools. These tools covered a range of fields, including hydrological modeling, 1D and 2D hydraulic modeling, frequency analysis, weather generation processes, GIS processes, water quality modeling, and groundwater modeling.

Some of the most commonly used tools included TELEMAC 2D, Iber, HEC-RAS, MIKE11, SWAT, HEC-HMS, SHETRAN, CityCAT, RWEG, MODFLOW, MT3DMS, ArcGIS, QGIS, among others. Additionally, input data such as Digital Terrain Models (DTMs), land use maps, soil maps, hydrometeorological data, and climate change projections facilitated a detailed analysis of each case study within the project. Furthermore, to validate and test the material developed during the project, the program brought together a significant number of students from consortium universities in two locations, Nice and Barcelona over the three years of the program. This was complemented by an online phase preceding the face to face activities. From October to February, students participated in online sessions led by tutors and professors from the partner institutions, covering the topics outlined in the project. They engaged in exercises and training tasks to deepen their understanding of key concepts and hydroinformatics tools. During the two-week face to face phase in Nice and Barcelona, students continued working on the project topics and presented the results of their case study analyses. To facilitate collaboration and knowledge sharing, a dedicated website was created for students and tutors to interact (https://sites.google.com/view/hydroeurope2025/).

Since the main objective of the program is to create advanced teaching materials on the concepts discussed in this document, a second website has been developed to share the teaching units and all the materials produced during the project (https://hydroeurope.upc.edu/). These units are designed to enhance the current knowledge concerning the topics of the project and be available to be used, if decided, in different educational programs around Europe and the world.

An additional outcome of the project is the social benefits it provides by bringing together students from diverse technical, educational, and cultural backgrounds. Beyond the technical challenges involved in analyzing complex case studies, participants also face the challenge of working in a multicultural environment.

This experience offers significant advantages for students and young professionals who will enter the water industry or research institutions. The program fosters training, raises awareness of current water-related issues, and enhances essential skills such as collaboration and teamwork. These competencies are crucial for the development of the next generation of professionals in the field. Figure 4 presents images from the event held at Universitat Politècnica de Catalunya (UPC) in Barcelona in February 2025 during the two-week face to face sessions.

Figure 4: students gathering at UPC in February 2025 during the two weeks face to face sessions.