



score

## D3.7: Package of short-term hazard modelling

DATE OF DELIVERY - 22/12/2023

AUTHORS(S) - Carlo Brandini, Alberto Ortolani, Michele Bondoni (LAMMA); Neslihan Beden, Vahdettin Demir, Bahtiyar Efe, Nazire Goksu Soydan Oksal, Sema Ariman (SAMU)







## DOCUMENT TRACKS DETAILS

Project acronym	SCORE
Project title	Smart Control of the Climate Resilience in European Coastal Cities
Starting date	01.07.2021
Duration	48 months
Call identifier	H2020-LC-CLA-2020-2
Grant Agreement No	101003534

Deliverable Information	
Deliverable number	D3.7
Work package number	WP3
Deliverable title	Package of short-term hazard modelling
Lead beneficiary	LAMMA & SAMSUN
Author(s)	Carlo Brandini, Alberto Ortolani, Michele Bendoni (LAMMA); Neslihan Beden, Vahdettin Demir, Bahtiyar Efe, Nazire Goksu Soydan Oksal, Sema Ariman (SAMU)
Due date	31/12/2023
Actual submission date	22/12/2023
Type of deliverable	Demonstrator
Dissemination level	Public

## VERSION MANAGEMENT

Revision table			
Version	Name	Date	Description
V 0.1	Carlo Brandini, Alberto Ortolani, Michele Bendoni (LAMMA); Neslihan Beden, Vahdettin Demir, Bahtiyar Efe, Nazire Goksu Soydan Oksal, Sema Ariman (SAMU)	12/12/2023	First draft
V 0.2	Iulia Anton, Fredrick Otieno (ATU)	18/12/2023	Document review
V1.0	Iulia Anton (ATU), Salem Gharbia (ATU)	22/12/2023	Final version





All information in this document only reflects the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

## LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Meaning / Full text
CCLL	Coastal City Living Lab
DEM	Digital Elevation Model
EBA	Ecosystem-Based Approaches
EU	European Union
HEC-RAS	Hydrologic Engineering Center's River Analysis System
RPO	Research Performing Organisation
SME	Small and Medium Sized Enterprise
SSH	Secure Shell
SW	Software
WP	Work Package
XS	Cross-section





## BACKGROUND: ABOUT THE SCORE PROJECT

The intensification of extreme weather events, coastal erosion and sea-level rise are significant challenges to be urgently addressed by European coastal cities. The science behind these disruptive phenomena is complex, and advancing climate resilience requires progress in data acquisition, forecasting, and understanding the potential risks and impacts of real-scenario interventions. The Ecosystem-Based Approach (EBA) supported by smart technologies has potential to increase climate resilience of European coastal cities; however, it is not yet adequately understood and coordinated at European level.

SCORE is a four-year EU-funded project aiming to increase climate resilience in European coastal cities. SCORE outlines a co-creation strategy, developed via a network of 10 coastal city 'living labs' (CCLs), to rapidly, equitably and sustainably enhance coastal city climate resilience through EBAs and sophisticated digital technologies.

The 10 coastal city living labs involved in the project are: Sligo and Dublin, Ireland; Barcelona/Vilanova i la Geltrú, Benidorm and Basque Country, Spain; Oeiras, Portugal; Massa, Italy; Piran, Slovenia; Gdansk, Poland; Samsun, Turkey.

SCORE will establish an integrated coastal zone management framework for strengthening EBA and smart coastal city policies, creating European leadership in coastal city climate change adaptation in line with The Paris Agreement. It will provide innovative platforms to empower stakeholders' deployment of EBAs to increase climate resilience, business opportunities and financial sustainability of coastal cities.

The SCORE interdisciplinary team consists of 28 world-leading organisations from academia, local authorities, RPOs, and SMEs encompassing a wide range of skills including environmental science and policy, climate modelling, citizen and social science, data management, coastal management and engineering, security and technological aspects of smart sensing research.

## EXECUTIVE SUMMARY

This document is a deliverable of the SCORE project, funded under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003534.

The D3.7, related to Task 3.4 and entitled " Package of short-term hazard modelling ", is the seventh WP3 report. This report simply aims to provide a series of links concerning the models and procedures that have been adopted to install/compile and run the urban scale flood model. A more scientific/technical discussion describing the urban scale, short-term hazard modelling, including the obtained hazard maps, is provided by D3.8.





## TABLE OF CONTENT

1. Introduction .....	6
1.1 Scope of the deliverable.....	6
1.2 Structure and content of the deliverable .....	6
2. HEC-RAS model.....	6
3. XBeach model.....	7
4. Coupling the models.....	9
4.1. Step-by-step procedure to run the coupled models .....	9
5. Conclusions and recommendation .....	10
6. References.....	10





# 1. INTRODUCTION

## 1.1 Scope of the deliverable

Package of modeling tools and local datasets produced in Task 3.4 regarding local hazards, specifically flooding, and their occurrence probabilities. The present deliverable aims to address numerical models, software (SW) scripts, and data files with which the urban scale flooding simulation is performed, as technically described in D3.8. In this deliverable, WP1 results are used for the local assessment of hazards. It consists of a complete hydrological-hydraulic model set up to simulate urban flooding scenarios for main hazard situations with different occurrence probabilities as determined from the clustering tools of D3.5. Data and tools from D3.1 and D3.3 are also inputs of this deliverable and additional local observations from the WP4 activities relevant to the specific objective.

Part of the numerical models, SW scripts and data files are already available online and the links are provided as part of this deliverable. However, the other tools have been developed for the project and available in the specific script folder associated to the present document. The whole D3.7 deliverable is available in the next link:

### [Model](#)

Part of these procedures cannot be considered plug-and-play ones, as they need at least some expert support to verify rightness and meaningfulness of the results or some cases specific modifications, e.g. of input data interfaces to process specific dataset formats not included in the development phase.

## 1.2 Structure and content of the deliverable

The deliverable is organised in two sections related to the two model jointly employed to simulate the flooding and a section for the coupling. Each section provides a short introductory description of the content and a table listing and addressing the different SW tools (models, scripts, data files, etc.).

Procedures for the coupling are written in various languages, including R, Python, and Matlab. Some of these scripts are also documented within the “Model” file.

# 2. HEC-RAS MODEL

The main hydrodynamic model employed to simulate the flood propagation over an urban area is the HEC-RAS model, an open license tool freely downloadable (Brunner, G. W., 2016). HEC-RAS is used to both simulate the flood due to a large river discharge and to simulate the effect of storm surge from the sea, by applying specific boundary condition at the coast. The boundary condition at the coast can be provided in two ways: i) manipulating the output from the XBeach model (Section 3); ii) imposing a time series of sea level accounting for the secure shell (SSH) and the effect of wave runup (simplified approach). The scripts to manipulate the XBeach output and transform it into a HEC-RAS input file are reported in Section 4. A detailed description of the two procedures will be reported in the D3.8 at M36.





The information about how to download and install HEC-RAS and how to practice with it are reported in Table 1. Table 2 contains the data you need to elaborate in order to create the input files to run the model, whereas Table 3 contains the needed input files to launch a simulation.

Table 1 Links to webpages relate to the HEC-RAS model.

Aim	Link	What is
To download the model	<a href="https://www.hec.usace.army.mil/software/hecras/download.aspx">https://www.hec.usace.army.mil/software/hecras/download.aspx</a>	HEC-RAS 6.4.1
To download the manual	<a href="https://www.hec.usace.army.mil/software/hecras/documentation.aspx">https://www.hec.usace.army.mil/software/hecras/documentation.aspx</a>	Several documents fully detailed
To find tutorials	<a href="https://www.hec.usace.army.mil/software/hecras/training.aspx">https://www.hec.usace.army.mil/software/hecras/training.aspx</a>	Examples to practice with the model

Table 2 Raw data needed to create the geometry and input files.

	What	Description
Needed data to run the model	DEM	Digital elevation model of the geographical domain, containing information about the buildings
	River data	Dataset containing river path coordinates and cross sections
	Hydraulic structures	data related to the presence of hydraulic structures within the river bed or at the coast
	Bathymetry	Elevation of the underwater coastal area
	Discharge	Time series of discharge to be imposed to the upstream boundary
	Water level	Time series of water level to be imposed at coast, close to the shoreline

Table 3 Input files to launch a simulation.

	Name	Description
Needed files to run the model	modelname.prj	Project file
	modelname.pXX	File associated to a specific plan
	modelname.gYY	File associated to a specific geometry
	modelname.uZZ	File associated to specific boundary conditions

### 3. XBEACH MODEL

The model we propose to simulate the effect of storm surge and strong wave forcing to the coast is the XBeach model. This is an open-source hydrodynamic model to simulate extreme wave condition and associated morphodynamics, which can be run in a fully phase resolving or phase-averaging approach, in both 2D and 1D (cross section) domains (Roelvink et al. 2009).

A more detailed description of the different modelling approach will be thoroughly described in D3.8.





The information about how to download and install HEC-RAS and how to practice with it are reported in Table 4. Table 5 contains the data you need to elaborate in order to create the input files to run the model, whereas Table 6 contains the needed input files to launch a simulation.

Table 4 Links to webpages related to the XBeach model.

Aim	Link	What is
To download the model	<a href="https://oss.deltares.nl/web/xbeach/release-and-source">https://oss.deltares.nl/web/xbeach/release-and-source</a> <a href="https://svn.oss.deltares.nl/repos/xbeach/trunk/">https://svn.oss.deltares.nl/repos/xbeach/trunk/</a>	XBeach
To download a Matlab Toolbox	<a href="https://oss.deltares.nl/web/xbeach/tools">https://oss.deltares.nl/web/xbeach/tools</a>	Several scripts to support the pre- and post-processing
To download the manuals	<a href="https://svn.oss.deltares.nl/repos/xbeach/trunk/doc/manual/XBeach_manual_master.pdf">https://svn.oss.deltares.nl/repos/xbeach/trunk/doc/manual/XBeach_manual_master.pdf</a> <a href="https://svn.oss.deltares.nl/repos/xbeach/trunk/doc/manual/XBeach_manual_kingsday.pdf">https://svn.oss.deltares.nl/repos/xbeach/trunk/doc/manual/XBeach_manual_kingsday.pdf</a>	User manual and technical documentation

Table 5 Raw data needed to create the geometry and input files.

	What	Description
Needed data to run the model	Bathymetry	Elevation of the underwater area up to 1-2 km offshore or till the water depth is around 10-20 m
	Hydraulic structures	data related to the presence of hydraulic structures
	Granulometry	Size distribution of the sediment (in case a morphodynamic simulation is run)
	Wave climate	Data of the wave climate close to the coast (wave spectrum or synthetic data)
	Water level	Time series of the water level offshore

Table 6 Input files to launch a simulation. Additional details on the typology of input files based on the employed approach are reported in the manual.

	Name	Description
Needed files to run the model	params.txt	Parameters input file
	modelname.dep	Bathymetry file
	modelname.grd	Grid file
	zs0file	Offshore water level
	bcfile	Offshore wave climate file

To balance computational resources and reliability, we choose to simulate a coastline as a sequence of 1D cross sections orthogonal to the coast, each 200 m apart (based on the complexity of the shoreline). In case several cross sections are needed to cover the whole are, we provide a shell script to launch them in parallel on a computational cluster (for “parallel” we mean we launch several 1D simulations simultaneously):







launch\_multiple\_xbeach.sh

The procedure to run multiple XBeach simulation, in relation to the linking to HEC-RAS, is described in the next section.

## 4. COUPLING THE MODELS

The XBeach model gives several outputs. It is possible to extract the time series of water level at a specific location toward the coast. Such a water level is then used as a coastal boundary condition for the HEC-RAS model. In order to do it, we use several scripts reported in Table 7.

Table 7 Scripts to run multiple XBeach simulation and link the output to the HEC-RAS model.

	Name	Description
Link XBeach to HEC-RAS	copy_input_files_transects.sh	Copy input files to run simulations on other transects with the same boundary conditions
	launch_multiple_xbeach.sh	Script to run several XBeach simulation, each on a different cpu
	update_wl_sea_xs.sh	Script to update HEC-RAS input file with XBeach output
	filter_xbeach_wl.py	low pass filtering of the water level
	column_to_hecras	Script to manipulate the structure of the HEC-RAS input file (compiled Matlab script)

It is important to underline that the linking is performed offline and that the XBeach model does not receive feedbacks from the HEC-RAS model.

### 4.1. Step-by-step procedure to run the coupled models

The Step-by-step procedure to run a HEC-RAS model forced by water levels from XBeach simulations is reported in the following.

- 1) Run XBeach simulations
- 2) Manipulate XBeach output and update HEC-RAS bc file
- 3) Copy HEC-RAS bc file into the project folder and run

1<sup>st</sup> Step: It is necessary to run as many simulations as there are cross-sections (XS) on the HEC-RAS model. Each XS corresponds to a water-level boundary object and is identified as IDXXX.

Also, it is necessary to run the simulation for the ID001 XS in order to create the XBeach bc wave climate data to be used for the other IDs. Go into the ID001 folder, modify the params.txt file, and add to the folder the jons\_XXX.txt1 and level\_XXX.txt files (wave climate and water levels, respectively).

```
$ cd /home/pathToYourRunFolder/ID001
```

```
$ ./xbeach
```

<sup>1</sup> Columns in the XBeach spectra file <Hm0> <Tp> <mainang> <gamma> <duration> <dbtc>. Remember that in case of 1D simulation if we assign  $d\theta = \theta_{max} - \theta_{min}$  the waves are always perpendicular to the coast





Once the simulation is completed is now necessary to run the simulations for the other XS (other IDs) using the same offshore wave climate data (it is necessary to update the name of the water level time series in the `copy_input_files_transects.sh` script).

```
$ cd /home/pathToYourScriptsFolder/scripts
$ ./copy_input_files_transects.sh
```

Now it is necessary to run in parallel several XBeach models (means more than 1 run simultaneously). If necessary, modify the `launch_multiple_xbeach.sh` script.

```
$ screen (or screen -r) (this is optional)
$ ./launch_multiple_xbeach.sh
$ ctrl+a d (to exit the screen) (if you used screen)
```

once the runs are finished it is necessary to handle the XBeach outputs.

2<sup>nd</sup> Step: The `update_wl_sea_xs.sh` script takes each XBeach output (water level time series at a certain position), filter it through a low-pass filter and sample the filtered time series at a specific sample rate (`filter_xbeach_wl.py`). Then, the one column array is modified into a HEC-RAS readable format (`column_to_hecras`). Finally, the HEC-RAS bc file is updated. It is necessary to update the `update_wl_sea_xs.sh` script concerning the name of the HEC-RAS bc file and the low-pass frequency and output frequency values.

```
$ ./update_wl_sea_xs.sh
```

3<sup>rd</sup> Step: Copy the update HEC-RAS bc file into the HEC-RAS project folder and run the model.

## 5. CONCLUSIONS AND RECOMMENDATION

The present document is aimed to allow to access all the model, data, tools etc. necessary for the urban-scale short-term flood modelling. A folder is associated to this document, containing data, example of input files, and SW scripts. The deliverable is organised in specific sections related to the models employed to simulate the urban flood due to both storm surge and high river discharge.

All the work is not meant to provide plug-and-play tools, being an expert supervision necessary for the initial set up and use of the developed downscaling procedures.

## 6. REFERENCES

Brunner, G. W. (2016). HEC-RAS River Analysis System: Hydraulic Reference Manual, Version 5.0. US Army Corps of Engineers–Hydrologic Engineering Center, 547.

Roelvink, D.; Reniers, A.; van Dongeren, A.; de Vries, J.V.T.; McCall, R.; Lescinski, J. Modeling storm impacts on beaches, dunes and barrier islands. *Coast. Eng.* 2009, 56, 1133–1152.

