Flood simulation with the RiverCure approach: The open dataset of the Águeda 2016 flood event

Ana M. Ricardo[1], Rui M.L. Ferreira[3], Alberto Rodrigues da Silva[2], Jacinto Estima[2, 4], Jorge Marques[2], Ivo Gamito[2], Alexandre Serra[2]

[1]CERIS - Civil Engineering Research and Innovation for Sustainability, 1049-001 Lisbon, Portugal
[2]INESC-ID, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal
[3]CERIS, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal
[4]CISUC, Departamento de Engenharia Informática, Universidade de Coimbra, 3030-790 Coimbra, Portugal

Correspondence to: Ana M. Ricardo (ana.ricardo@tecnico.ulisboa.pt)

Abstract. Floods are among the most common natural disasters responsible for severe damages and human losses. Combining numerical modelling with user-friendly tools for geographically referenced data has been adopted to increase preparedness and reduce vulnerabilities. This paper describes the numerical dataset of hydrometric variables that characterize a flood event occurred in February 2016 in the Portuguese Águeda river, shortly defined as Agueda.2016Flood. The dataset was numerically produced and managed through the RiverCure Portal, a collaborative web platform connected to a validated shallow-water model featuring modelled dynamic bed geometries and sediment transport. The dataset Agueda.2016Flood can be used as a starting point to design other experiments and tools, and to learn and apply the proposed approach by directly using the RiverCure Portal. This dataset includes modelled hydrodynamic data (output data) and the topographic, geometrical, land-use and hydrologic data (input data) necessary to carry out the numerical simulation of the flood event.

1 Introduction

Floods cause widespread damages and human losses. For instance, according to the Centre for Research on the Epidemiology of Disasters, floods were the most frequent type of natural disasters between 1998 and 2017 (Wallemacq et al, 2018). There have been changes in the frequency and magnitude of floods (Amponsah et al, 2018), including an increase in their severity in central and north Europe (Blöschl et al, 2019; Hall et al, 2015). Recently, severe floods were observed in Germany and Belgium in the summer of 2021 (Fekete and Sandholz, 2021).

Therefore, accurate forecasting tools and early warning systems have been proposed to increase preparedness and reduce vulnerabilities (Yuan et al, 2022). While planning for flood resilience differs from nowcasting (Yuan et al, 2022), both activities rely on analysing available hydrological data and hydraulic modelling, even at different time scales. Crucially, both require decision support systems that channel available input data, conduct hydraulic modelling, possibly combined with the assimilation of input data, and collect and organize results into datasets ready to be interpreted by decision-makers.

30 The RiverCure Portal (http://rivercure.inesc-id.pt/) is a web platform developed to integrate hydrodynamic and morphodynamic modelling tools and input data. The RiverCure Portal was designed to allow flexibility in the upload of input data. These data can be composed by measurements from physical instruments, curated outputs of sensing devices or virtual entities that conjoin lower level modelling results or other information not directly acquired by a physical device.

This paper describes the dataset of hydrometric variables that spatially and temporally characterize a flood occurred in the
35 Portuguese Águeda river in February 2016, as well as the main tasks to produce and use those data through the RiverCure Portal. The Águeda river crosses the small city of Águeda, that has registered many flood occurrences causing significant damages. As a prone to flood area, Águeda municipality had made considerable investments in flood protection. Namely, in 2015, it invested around two million euros in constructing a secondary river channel to divert the river flow. However, those efforts were not enough to prevent a severe flood event in February 2016, which was considered the most significant flood of
40 the previous 15 years (https://www.jn.pt/local/noticias/aveiro/agueda/agueda-com-maiores-cheias-dos-ultimos-anos-5027652.html). That flood event was the result of heavy precipitation associated to strong instabilities in the North Atlantic, causing significant disturbances in the city of Águeda, affecting mobility, public services, and infrastructures. That flood revealed weaknesses in the flood defence infrastructure of the municipality.

This paper presents the key input geometric and hydrologic data, the pre-processing steps and the rationale for establishing the
45 parameters of the hydrodynamic modelling tools that ultimately produce the hydrometric datasets of the aforementioned February 2016 flood event. It also serves as a reference database of similar flood simulation efforts and as a training example for more general usage of the RiverCure Portal. The community can use this dataset as a starting point to design independent experiments and tools. Moreover, the dataset can also be employed to learn and apply the proposed approach by directly using the RiverCure Portal.

50 **2 Methods**

The simulation of Águeda 2016 involved a geographical extent corresponding to an area of 560 ha crossed by a 9.8 km long stretch of the Águeda river, including the riverfront part of Águeda city. This section briefly describes the key steps to use the RiverCure Portal and the main features of the numerical model. The methodology to prepare the input data (topographic, geometrical, land-use and hydrologic data) is detailed, and a description of the generated output data is provided.

55 **2.1 Supported software tools**

The software tools used in the scope of this research are the RiverCure Portal and the HiSTAV numerical model, which run in an integrated way, as sketched in Fig. 1.
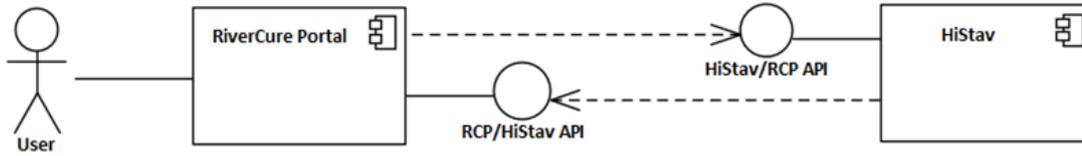
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Figure 1: Sketch of the integrated software tools used in the scope of this work.

2.1.1 The RiverCure Portal

The RiverCure Portal (RCP) is a collaborative web application, publicly available at http://rivercure.inesc-id.pt/, that allows different organizations to setup and manage their geographic contexts, sensors and events in a controlled way. RCP has been developed with Web and GIS technologies, such as Django, GeoDjango, PostgreSQL and PostGIS. RCP conveys geographical and hydrological data to a numerical model, as a processing service to provide simulation results. The numerical model is HiSTAV however it could use other existing simulation tools.

The structure of RCP consists of two main top-level concepts: Contexts and Sensors (Fig. 2). The Context allows defining the geometry of the area and managing the events to be modelled and simulated. The geometrical details consist of the set of georeferenced features included in the above input data list that are visualized and edited over a basemap from OpenStreetMaps (Haklay and Weber, 2008) through the Leaflet (https://leafletjs.com/) library (Peterson, 2014 and Edler and Vetter, 2019). The polygons and polylines can be either uploaded (i.e., when they are developed offline) or directly defined in the RCP. The raster files containing the altimetry and the roughness coefficients should be uploaded. The geographic features of the Context include the mesh generation process, as the mesh is a required feature of the numerical modelling. The mesh is generated from the geometrical and raster input data and employs the open-source 3-D finite element grid generator Gmsh (Geuzaine and Remacle, 2009). The connection between the RCP and the numerical model HiSTAV is established by defining an event to be modelled. The Event features allow the user to define the results writing rates and the simulation's starting and ending time.
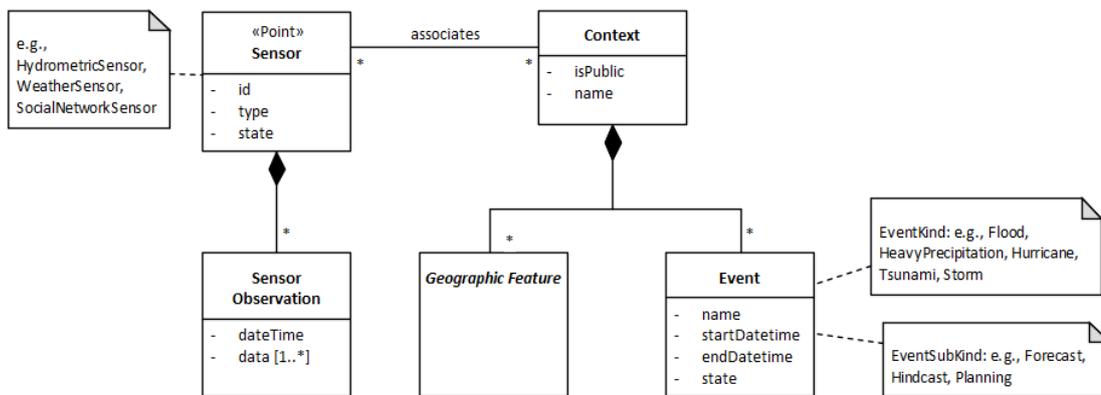

Figure 2: The RiverCure Portal management structure model: top-level view (UML).

The Sensors represent cyber-physical devices that load and store the environmental data in the RCP. Generically, a Sensor reads and collects data in a given location, usually a geographical point, with a given frequency. The Sensor Observations
80   (data values) are automatically obtained or manually introduced in the RCP, by users, either on a value-by-value basis or in sets of values by a given spreadsheet (such as the input data file *Agueda_hydrometric_Ribeiro.xlsx).* The mapping between a Sensor and a Context is defined by associating a Sensor with a boundary point or an entire boundary of a Context.

2.1.2 HiSTAV

HiSTAV is an in-house shallow-water model featuring dynamic bed geometries and sediment transport modelled via the
85   difference between capacity bedload discharge and local solid discharge (Ferreira et al, 2009; Canelas et al, 2013; Conde, D. 2020). The model comprises the total mass conservation equation, the momentum conservation equation and the sediment mass conservation equation. The conservation equations system is hyperbolic and discretized with a finite-volume method employing a flux-splitting technique and a reviewed Roe–Riemann solver with appropriate source-term formulations to ensure full conservativeness (Conde et al, 2020). The sediment mass conservation expresses the interaction between the bed and the
90   flow in the bed.

In HiSTAV, the closed conservation equations are discretized by a Finite Volume approach and solved explicitly, obeying a CFL condition. The implementation is entirely cross-compatible between CPUs and GPUs, through an intuitive object-oriented approach (Conde et al, 2020). It thus supports distributed and heterogeneous computing of significant problems at very high resolutions. Therefore, there are no special requirements for the machines that may run HiSTAV; it can spread its load through
95   available GPUs or CPUs. The current simulations were run on a multi-CPU/GPU computational server with two nodes, each with two Xeon(R) E5-2650 Octa-core CPUs and 4 NVIDIA GPUs, with 128GB ECC RAM installed and a 1TB de 10Krpm hard disk TYAN FT77A-B7059 2013.

The data produced by HiSTAV is stored in *.vtk* files created by the Visualization Toolkit (VTK), state-of-the-art open-source software for manipulating and displaying scientific data (https://vtk.org/).

100   ## 2.2 Input data

The ASTER Global Digital Elevation Model (GDEM) Version 3 (ASTGTM), publicly provided by NASA (https://search.earthdata.nasa.gov/) was the base for the topographic characterization of the modelled area. The ASTER platform has three subsystems: a visible and near-infrared radiometer, a shortwave-infrared radiometer, and a thermal-infrared radiometer (Yamaguchi et al, 1998; Fujisada et al, 2018). Version 3 counts with a technical methodology for improving the
105   initial tile-based waterbody data (Fujisada et al, 2018). The geographic coverage of the ASTER GDEM extends from 83° North to 83° South, divided into 22912 tiles with a spatial resolution of 1 arc second (approximately 30-meter horizontal posting at the equator). Each tile is distributed in GeoTIFF format and projected on the 1984 World Geodetic System (WGS84)/1996 Earth Gravitational Model (EGM96) geoid. The tile ASTGTMV003_N40W009, which includes the littoral centre and North of Portugal, was downloaded, and the interest region was cropped. Then, the main channel was superimposed

110 with its width defined through Google Earth and considering about 5 m of depth. The resulting raster file is used as the digital terrain model (DTM) required as model input.

The spatial distribution of the roughness coefficient over the modelled area is also a required model input. It was obtained from the COS2018, a spatial dataset produced by the Portuguese Governmental office for territorial development, DGT (Direção Geral do Território - https://www.dgterritorio.gov.pt/dados-abertos), representing the thematic map of land use and

115 land cover for mainland Portugal for the year 2018. COS2018, made available as Linked Open Data (LOD) in RDF format, is a map of polygons with a defined minimum cartographic unit (1 ha) with a distance between lines equal to or greater than 20 m. It is based on photo interpretation and has a terminology with more than 80 classes. Manning's coefficient values (n) used for specific land cover are based on the well-established values presented in Chow (1959) and van der Sande et al. (2003). The model employed requires the Manning-Strickler friction coefficient, $K_s = 1/n$ [m$^{1/3}$s^{-1}].

120 Concerning the geometrical input data, the numerical model requires a polygon delimitating the modelled area (domain) and polylines coincident with the domain, to identify the inlet and outlet boundaries. The boundaries are characterized by the type of boundary condition (input, known output, critical or transmissive) and, when applicable, the type of data to be given as input to the model (depth, discharge, velocity or elevation). Those features can be set or updated through the user-friendly interface of the Portal. Moreover, the user may also define a polyline defining the main channel alignment and/or polygons to

125 select parts of the domain to have mesh refinements.

A feature named 'CL', storing an indicative value for the length of the largest cell size in meters must be an attribute of the polygons defining the domain and the desired mesh refinement zones as well as of the polyline defining the main channel alignment. To fulfil the mesh generator requirements, the geometries cannot intersect, i.e., any larger polygon must completely contain a given polygon or polyline.

130 **2.3 Output data**

The combination of RCP with HiSTAV allows the production of a mesh and additional data stored in *.vtk* files.

The mesh consists of a set of unstructured triangular cells containing the following data: cell ID (named Address, [-]), bed level ([m]), roughness coefficient ([m$^{1/3}$s^{-1}]), and physical tag to identify the cells corresponding to boundary cells ([-]) and the length of the largest cell size ([m]).

135 The results' datasets include maps of bed level ([m]), water level([m]) and flow velocity ([m/s]) for a given time instant. These state variable files are written with a periodicity defined by the user. At the end of the simulation, a file containing the maxima values of the flow variables is generated. The variables included are: flow depth, water level, flow velocity, hazard index (defined as $h \times (v + 0.5)$ where h is the flow depth, and v is the flow velocity), the time to reach the maxima hazard index of each cell and the time to reach the wet state of each cell. The maxima values are updated during the simulation at a rate

140 specified by the user.

3 Data Records

The dataset Agueda.2016Flood (Ricardo et al, 2022) is publicly available on the repository HydroShare. The specification of the employed data entities uses the controlled natural language RSL, as discussed in Rodrigues da Silva and Savić (2021) (see

145   Appendix A for details on the main concepts and properties related the Context definition). The present data record includes the input dataset and the generated output flood simulation data.

3.1 Input data

Concerning the input data, the dataset includes:

1)   A set of lines and polygons is defined using a supported geographic information system (in GeoJSON format), namely:

150   - *domain.geojson*: polygon delimitating the modelled area;

    - *refinements.geojson*: polygons delimitating areas where specific mesh refinements are desired;

    - *alignments.geojson*, a polyline identifying the river centreline;

    - *boundaries.geojson*: polylines aligned with domain limits defining the inlets and the outlet of the domain.

155   2)   Raster files in Tiff format:

    - *Agueda_DTM.tif*: the digital terrain model ([m]);

    - *Agueda_FrictionCoef.tif:* the special distribution of the Manning-Stricker friction coefficient ($[m^{1/3}s^{-1}]$).

    3)   Udometric data in .xlsx format consisting in hourly measurements of precipitation registered between 09/02/2016 and

160   16/02/2016 for nearest rain gauges included in the public meteorological database of the Portuguese Environmental Agency (APA, https://snirh.apambiente.pt/). A synthetic and constant time series, with 20 hours of length and precipitation equal to the value registered at 09/02/2016 00:00, was added before the measured series to ensure the model warm up. The udometric data is stored in the following files:

    - *Agueda_hydrometric_PonteRedonda.xlsx:* for the rain gauge Ponte Redonda located at latitude 40.563 and longitude -

165   8.401 (ETRS89 / Portugal TM06 coordinate system);

    - *Agueda_hydrometric_Ribeiro.xlsx:* for the rain gauge Ribeiro is located at latitude 40.566 and longitude -8.396 (ETRS89 / Portugal TM06 coordinate system).

3.2 Output data

The output data of this dataset includes the following files:

170   1)   *Agueda_maxima.vtk* stores the maximum value of the flow variables computed for each cell. During this simulation, the maxima values are updated every second.

2) *hydro-*.vtk* with the instantaneous results. The numbers in the file name are related to the simulation time step. In the present case study, this instantaneous results files were written hourly but sampled every three hours as a compromise between a detailed time characterization and storage management. The hourly dataset will be shared upon request directly to the authors.

4 Data validation

The validation tests grant the quality of the output data shown by the HiSTAV tool. The HiSTAV model has been compared with theoretical solutions and experimental data for both resistance and solid transport (Canelas et al, 2013) and was tested in a benchmark text of 2D bam-break flows over a sand bed (Soares-Frazão et al, 2012). HiSTAV has also been employed to model a tsunami in the Tagus estuary (Lisbon), demonstrating a good performance on the Monai Valley benchmark and in comparison with historical data (Conde et al, 2015).

The Águeda 2016 flood event was reported mainly on the Portuguese media allowing them to know reasonably well the limits of the flooded areas. Figure 3 illustrates the geometric input data uploaded on the RiverCure Portal to allow the numerical simulation of the Águeda 2016 flood event. Although the numerical model has been run with coarse topographical data (DTM with 30m of resolution), the extent of the flooded areas was in good agreement with the observed flood. Figure 4 presents a 2D distribution of the maximum water depth values on the modelled domain overlapped on the terrain model.
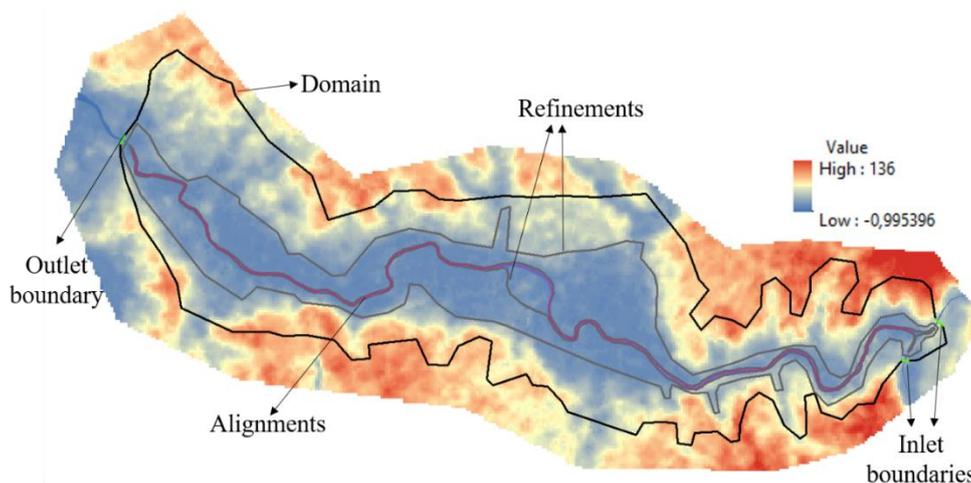
Figure 3 Geometric features and the DTM employed in the simulations for the output dataset production. The black polygon line defines the domain limit, the grey polygon lines represent the specified areas for mesh refinement, the pink polyline identifies the main course (alignment), and the green lines indicate the input and output boundaries.
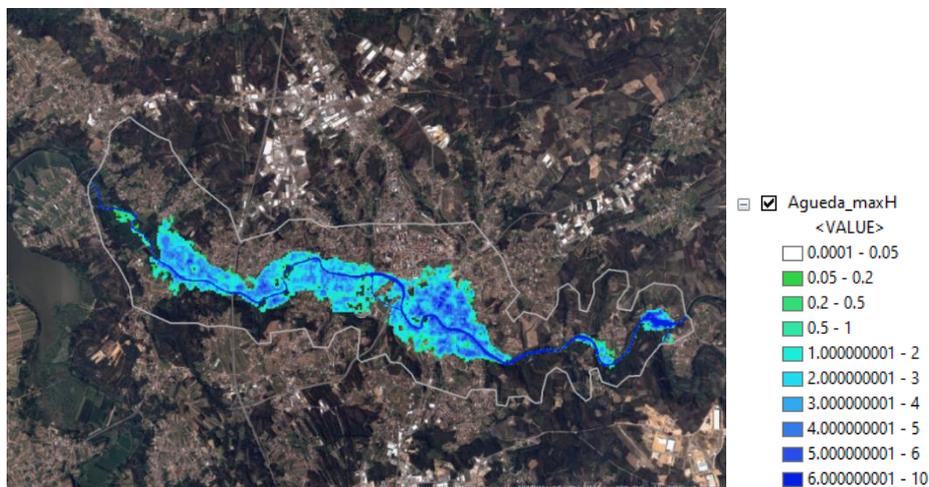
Figure 4 Maxima water depth overlapped on the terrain map. The colour scale is in meters (m). The aerial view is a basemap of ArcMap™ software by ESRI.

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Another way to verify the reliability of the produced dataset is to compare the input hydrological data with hydrographs sampled on an upstream and a downstream section within the modelled domain, as shown in Fig. 5. The "upstream" hydrograph was sampled approximately 400 m downstream of the domain limit at the intersection of the two inlet channels. The discharge computed in that section coincides with the summation of the two input hydrographs. The "downstream" hydrograph was

200 sampled at the domain outlet boundary. The comparison of the two computed hydrographs shows the expected delay and damping of the flood from the entrance to the outlet of the domain.
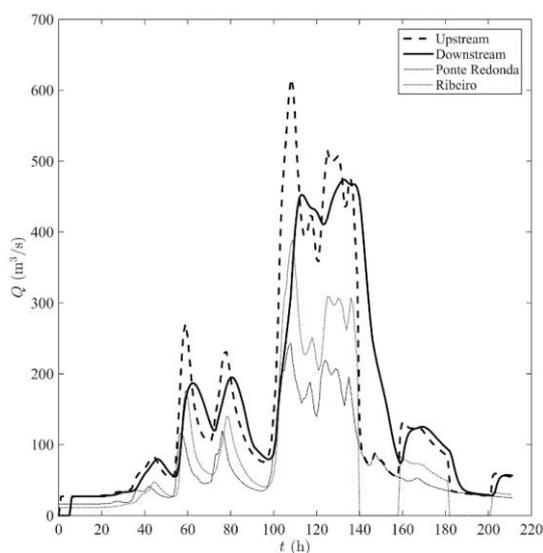

Figure 5 Tine series of flow discharge at the inlet boundaries (Ponte Redonda and Ribeiro), at the confluence of the two inlet streams (Upstream) and downstream boundary. Rain gages provided the values at Ponte Redonda and Ribeiro boundaries. The 'Upstream' and 'Downstream' hydrographs were computed from the numerically produced database.

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5 Data and code availability

All data is store on the Agueda.2016Flood data (http://www.hydroshare.org/resource/937927473a3a4e66a07a2e2fdd9d581e, Ricardo et al, 2022), that is publicly available on HydroShare repository. HydroShare is an open source web-based system developed, mainly, for water related professionals to easily share, collaborate and publish all types of scientific data.

210 HydroShare adheres to the FAIR archival standard and provides a Representational State Transfer (REST) Application Program Interface (API) that allows third-party applications to interact with HydroShare resources.

The RiverCure Portal is publicly available at http://rivercure.inesc-id.pt/ and can be used to run the presented case study or any other case upon a free registration. The numerical model HiSTAV can be explored through the RiverCure Portal. Conde et al (2020) provides further model details.

6 Conclusions

This work describes the dataset Agueda.2016Flood which stores the data related to the hindcasting of the flood event occurred in February 2016 in the Portuguese Águeda river. This dataset includes modelled hydrodynamic data (output data) and the topographic, geometrical, land-use and hydrologic data (input data) necessary to carry out the numerical simulation of the flood event. The dataset was numerically produced and managed through the RiverCure Portal, a collaborative web platform

220 connected to HiSTAV, a validated shallow-water model featuring modelled dynamic bed geometries and sediment transport. Agueda.2016Flood is a complete flood event dataset that can be used as a starting point to design other experiments and tools, and to explore the RiverCure Portal.

Appendix A

Below it is illustrated the data model supported by the RiverCure Portal that shows its main concepts and properties related

225 the Context definition. This specification is defined according to the ITLingo RSL language (Rodrigues da Silva and Savić, 2021).

```
// Contexts
DataEntity e_Context "Context": Master [
    attribute id "Id": Integer [constraints (PrimaryKey)]
    attribute code "Code": String [constraints (NotNull Unique)]
    attribute Name "Name": String [constraints (NotNull Unique)]
    attribute organization "Organization": Integer [constraints (ForeignKey(e_Organization))]
    attribute creator "Creator": Integer [constraints (ForeignKey(e_User))]
    attribute createDate "Create Date": Datetime
    attribute isPublic "Is public" : Boolean [defaultValue "False"]
    attribute hydrofeature "Hydro Feature": Integer [constraints(NotNull ForeignKey(e_HydroFeature))]
    attribute geomExternalBoundary "Geometry External Boundary": GeoPolyline  // domain ?
    attribute CLExternalBoundary "CL External Boundary": Decimal
    attribute hasMesh "Has mesh" : Boolean [defaultValue "False"]
    attribute taskId "Task id": String
    attribute requester "Requester": Integer [constraints (ForeignKey(e_User))] ]
```

```
// Context's Geo Features
DataEntity e_ContextDTM "Context DTM": Parameter [
    attribute id "Id": Integer [constraints (PrimaryKey)]
245    attribute context "Context": Integer [constraints(NotNull ForeignKey(e_Context))]
    attribute rasterFile "Raster File": FilePath
    attribute raster "Raster": GeoRaster   ]


DataEntity e_ContextFrictionCoeff "Context Friction Coefficient": Parameter [
250    attribute id "Id": Integer [constraints (PrimaryKey)]
    attribute context "Context": Integer [constraints(NotNull ForeignKey(e_Context))]
    attribute geometry "Geometry": GeoPoint [constraints (multiplicity "*")]  // LineString
    attribute fileName "Geometry File Name": FilePath  ]


255 DataEntity e_ContextRefinement "Context Refinement": Parameter [
    attribute id "Id": Integer [constraints (PrimaryKey)]
    attribute context "Context": Integer [constraints(NotNull ForeignKey(e_Context))]
    attribute geometry "Geometry": GeoPolygon
    attribute fileName "Geometry File Name": FilePath
260    attribute cl "CL": Decimal ]


DataEntity e_ContextAlignment "Context Alignment": Parameter [
    attribute id "Id": Integer [constraints (PrimaryKey)]
    attribute context "Context": Integer [constraints(NotNull ForeignKey(e_Context))]
265    attribute geometry "Geometry": GeoPolyline [constraints (multiplicity "*")]  // LineString
    attribute fileName "Geometry File Name": FilePath
    attribute cl "CL": Decimal ]


DataEntity e_ContextBoundaryLine "Context Boundary Line": Parameter [
270    attribute id "Id": Integer [constraints (PrimaryKey)]
    attribute context "Context": Integer [constraints(NotNull ForeignKey(e_Context))]
    attribute geometry "Geometry": GeoPolyline //GeoPoint [constraints (multiplicity "*")] //FileField
    attribute fileName "Geometry File Name": FilePath
    attribute type "Type": DataEnumeration ContextBoundaryChoices [constraints (NotNull)]
275    attribute dataType "Data type": DataEnumeration ContextBoundaryLineDataKindChoices [constraints (NotNull)] ]


DataEntity e_ContextBoundaryPoint "Context Boundary Point": Parameter [
    attribute id "Id": Integer [constraints (PrimaryKey)]
    attribute contextBoundaryLine "Context Boundary Line": Integer [constraints(ForeignKey(e_Context))]
280    attribute geometry "Geometry": GeoPoint
    attribute fileName "Geometry File Name": FilePath   ]


// Context's Sensors
DataEntity e_ContextSensor "Context Sensor": Master [
285    attribute id "Id": Integer [constraints (PrimaryKey)]
    attribute boundaryPoint "Boundary Point": Integer [constraints(ForeignKey(e_ContextBoundaryPoint))]
    attribute sensor "Sensor": Integer [constraints(ForeignKey(e_Sensor))]
    attribute Description "Description": String [constraints (NotNull)]
    attribute associateDateTime "Associate Date Time": Datetime ]
290
// Context's Events
DataEntity e_ContextEvent "Context Event": Document:Regular [
    attribute id "Id": Integer [constraints (PrimaryKey)]
    attribute context "Context": Integer [constraints(NotNull ForeignKey(e_Context))]
295    attribute Name "Name": String [constraints (NotNull Unique)]
    attribute type "Type": DataEnumeration ContextEventTypeChoices [constraints (NotNull)]
    attribute subType "Subtype": DataEnumeration ContextEventSubTypeChoices [constraints (NotNull)]
    attribute State "State": DataEnumeration ContextEventStateChoices [constraints (NotNull)]
    attribute startDateTime "Start Datetime": Datetime [constraints (NotNull)]
300    attribute endDateTime "End Datetime": Datetime [constraints (NotNull)]
```

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```
        attribute Description "Description": String
        attribute returnPeriod "Return Period": Integer [defaultValue "1 "]
        attribute warmUp "Warm Up": Boolean [defaultValue "False"]
        attribute writingPeriodicity "Writing Periodicity": Decimal [defaultValue "1.0"]
305     attribute writingPeriodicityUnit "Writing Periodicity Unit": String
        attribute updateMaximumValue "Update Maximum Value": Decimal [defaultValue "1.0"]
        attribute updateMaximumValueUnit "Update Maximum Value Unit": String
        attribute hasSimulation "Has Simulation": Boolean [defaultValue "False"]
        attribute taskId "Task id": String
310     attribute requester "Requester": Integer [constraints (ForeignKey(e_User))] ]

    DataEntity e_ContextEventResult "Context Event Result": Document:Weak [
        attribute id "Id": Integer [constraints (PrimaryKey)]
        attribute contextEvent "Context Event": Integer [constraints(ForeignKey(e_ContextEvent))]
315     attribute maxDepth "Maximum Depth": GeoRaster
        attribute maxLevel "Maximum Level": GeoRaster
        attribute maxQ "Maximum Q": GeoRaster
        attribute maxVel "Maximum Velocity": GeoRaster
        attribute time "Time": Datetime [constraints(NotNull)] ]
```

320 Appendix B

The RiverCure portal requires a (free) user registration. The registration form is available on the RCP homepage through the 'Register' link. The simulation of the flood event presented in the described dataset can be reproduced employing the RCP by following the next sequence of tasks (see Fig. B1 for suggestive screenshots):

T1. Create and Setup Context. Use the functionality 'Add Context' in the Management section. After creating the Context, the
325 user should upload the files with the geographic data ('Geo Edit') and check and update the attributes of each feature ('Upload & Define manually').

T2. Associate Sensors to Context. The Sensors are already defined, and the observations are loaded; nevertheless, the user may create new sensors for practice purposes. The association of the corresponding sensor to an input boundary is carried on through the 'Define manually' functionality of the 'Geo Edit' by selecting a boundary point, selecting the Sensor from a list including
330 all the sensors located with a user-defined distance and associating it to all the boundary points.

T3. Generate Mesh. The button 'Generate (or Regenerate) Mesh' sends a request, to the background server, for mesh generation. While the process is running, the temporary button 'Progress' allows the user to follow the progress and identify possible problems preventing a successful mesh generation.

T4. Create Simulation Event. On the main page of the defined Context, the user should define the event to be modelled (name
335 and properties, start and end time, periodicity for results, time resolution and maxima updates).

T5. Run Simulation Event. On the defined event page, the user may edit the event or launch the simulation ('Run'). While the simulation is running in the background, the temporary button 'Progress' allows the user to follow the progress and identify possible problems stopping the simulation before the end. In this case study, the simulation of 212 h of real-time was carried out in about 62h.
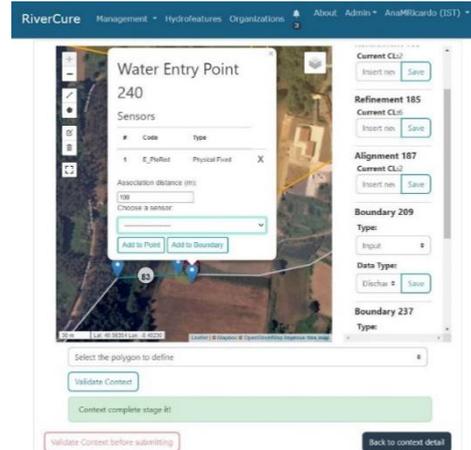
340   T6. Download and visualize the output data. After the simulation ends, the user shall download the output files on the event page and visualize them using web-based tools or dedicated software, like Paraview, a popular open-source VTK viewer.
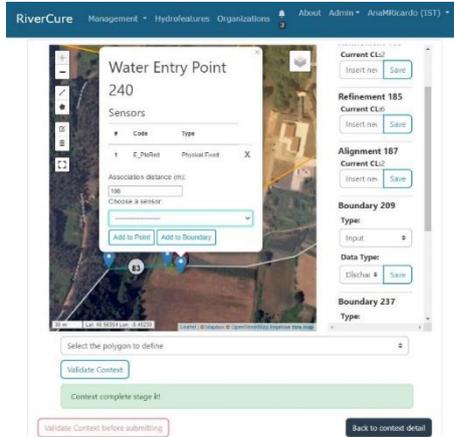
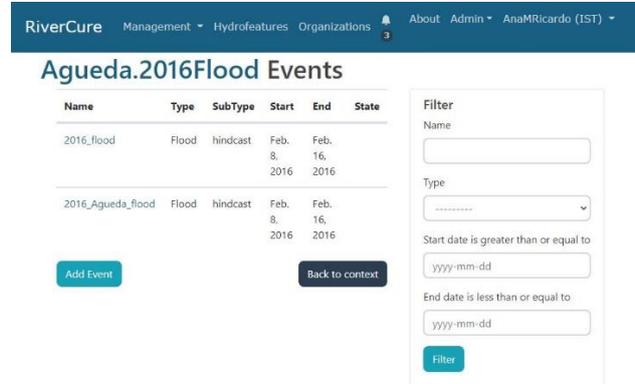T1. Setup context: Geo Edit: Upload files
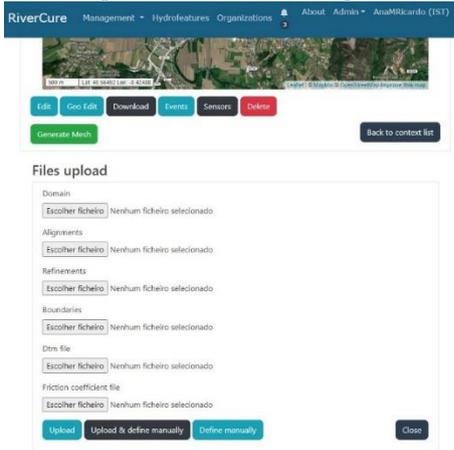
T2. Associate Sensors to Context

T3. Generate Mesh

T4. Create Simulation Event

T5. Run Simulation Event

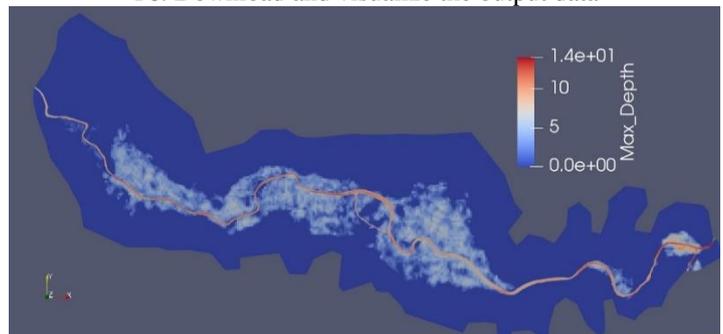T6. Download and visualize the output data

Figure B1 Screenshots of the RiverCure Portal main tasks. The aerial views are from ©OpenStreetMaps empoying Leaflet and ©Mapbox.

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Author contributions

345

All authors contributed to the article conception and design. The RiverCure Portal was designed by ARS, RF, JE and developed by AS, JM and IG. AMR performed material preparation and data collection. The manuscript was written by AMR, ARS and RF. All authors read and approved the final manuscript.

Competing interests

350   The authors declare that they have no conflict of interest.

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