Title: D4.1 Visualisation Dashboard for co-designing Solutions/ Scenarios for Digital Twin

Work Package 4, Task 4.1 & subtask 4.1.1

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EXECUTIVE SUMMARY

This report is part of the D4.1 Visualisation Dashboard for co-designing Solutions/ Scenarios for Digital Twin deliverable and includes a demonstration video as the main component of the deliverable.

The report consists of a walk-through of the dashboard from the perspectives of case study 1 (CS1 Athens) and case study 8 (CS8 Torbay). The report is authored to work alongside the longer video walk-through: https://youtu.be/jpIJEZMfvTY .

The Athens case study is geared around the long-term planning and decision making of choosing appropriate nature-based solutions from a choice of cool roofs and cool streets, green roofs and urban greening and green roofs and urban trees.

The Torbay case study is geared around long-term flood resilience, though the use of CA flood as a flood simulation device and associated critical infrastructure failure and road risks. The flood resilience content is limited to authorised users. Short-term weather planning is realised through the collection and management of open-source sensor data from the Environment Agency and WeatherAPI. Weather planning is available to all users, however the dashboard also collects data from Torbay Council's sensor network, though this data is limited to authorised users.

The next steps of the dashboard / digital twin are geared around the delivery of D4.3 (Two Digital Twins) in M48 and is predicated around the development of the Black Sea digital twin (CS6) and associated dashboard along with on-going development of the Torbay (CS8) digital twin and dashboard components. It is expected that the CS6 development will benefit greatly from the existing and on-going digital twin and dashboard development from CS8 and CS1.

1 Introduction

This report is the 'visualisation dashboard for co-designing solutions/ scenarios for Digital Twin' and describes the operation of the dashboard for case studies 1 (Athens) and 8 (Torbay).

This deliverable builds on content presented in MS14 (Prototype Model of Digital Twin), as such that material has not been included in this deliverable.

The report consists of the following sections:

Section 2 – Operation of the dashboard
This section provides a walk-through of the dashboard for case study 1 (CS1 Athens) and case study 8 (CS8 Torbay).

Section 3 – Conclusions
This section lists conclusions from this initial iteration of the CS1 and CS8 dashboards.

Section 4 – Next steps
This section outlines steps for the next iteration of dashboard and associated digital twin development for D4.3 (Two Digital Twins).

2 Operation of the dashboard

This section of the report describes the screen-by-screen operation of the dashboard and is taken from the accompanying video (ARSINOE d41 video walkthrough.mp4). The walk-through describes case study 1 functionality and then the two modes (unregistered and registered users) of case study 8.

The dashboard is currently hosted at https://arsinoe.cafloodpro.com/, and entering that address into a browser will take the user to the front page of the application, Figure 1. Selecting either option will take the user to the appropriate case study. The modular approach of the dashboard allows case studies to be added as they are developed.

Please contact g.lewis2@exeter.ac.uk for a username and password for access to the authorised part of the Torbay case study.

Figure 1 - Dashboard Home Page

2.1 Athens Metropolitan Area Case Study (CS1)

The Athens case study has been developed to visualise the risk related to heatwaves and other compound hazards for the Athens Metropolitan area as well as the the impact of set of nature-based solution (NBS), including cool roofs and cool streets, green roofs and urban greening and green roofs and urban trees . It has been designed for ARSINOE CS1 living lab, but also the broader group of stakeholders for the CS to view the impact of several different NBS within the context of a set of city-based quantitative backdrops, Figure 2.

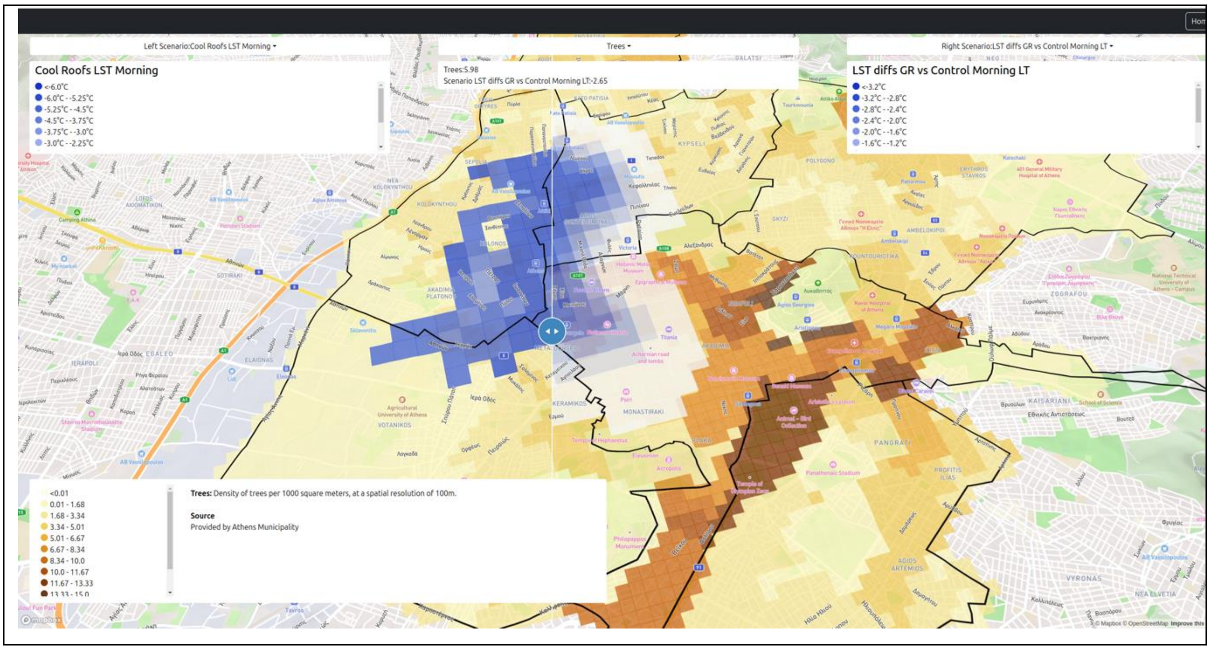


Figure 2 - Case Study 1 Dashboard

The dashboard comprises of a slip map view of Athens Metropolitan Area (provided through Mapbox), a series of quantitative layers (implemented as Mapbox GeoJSON layers), a set of NBS and other climate change adaptation interventions visualisation layers (implemented as Mapbox layers) and a set of UI components. The Mapbox visualisation takes advantage of Mapbox 'swipe' functionality (https://docs.mapbox.com/mapbox-gl-js/example/mapbox-gl-compare/) in order to provide the user with two synchronised maps containing different cool roof visualisations. The swipe interface allows users to A|B test pairs of NBS visualisations to determine their relative effectiveness.

2.1.1 The Endusers

CS1 dashboard does not involve information or data relevant to critical infrastructure or critical entities. For this reason it does not have any accessibility restrictions. It is of free access to any user that might want to be informed, test, compare, forecast or use any of the tools functionalities, related to the simulation of the heat waves risk or other involved attributes. The tool was designed assuming that the endusers are the stakeholders of the case study, the ones short listed for the Living Lab and/or even the ones for the long list. This means that the endusers belong to a wide range of expertise, sectors, and scientific fields (if any), which means that the tool should be popularised, not oo technical, appealing and not aimed to a necessalrily technologically shavy audience. Some examples of the dashboard's endusers are a) the Ministry of Tourism, b) Municipality of Athens, c) Region of Attica, d) the Water Utility of Athens, e) regional urban planning offices, f) the Antiquities Bureau, etc.

Staff from the Municipality of Athens were selected as an indicative enduser audience. The tool is co-created with staff from the municipality that are already partners in Arsinoe and will be validated and evaluated by other external staff of the munipality including the Heat Officer of Athens and the Athens Vice Mayor.

2.1.2 Athens Metropolitan Area Data

The visualised attributes for CS1 are supported by spatiotemporal data-series or spatial data series for static variables. The attributes are related to the different parameter clusters for the risk equation of heatwaves and compound hazards, i.e.a) hazard attributes (land surface temperature, air temperature, air quality, biodiversity clustering), b) vulnerability attributes (socio-economic vulnerabilities, such as the deprivation index, the percentage of elederly, the percentage of immigrants from low-income countries, etc), c) exposure (population density) and d) capacity (trees, accessibility to green areas, etc). The granularity for the layers is 100*100 meters or subzip code, depending on the available granularity of data.

Additionally to the aforementioned data, the estimated risk is also visualised in the form of risk hotspots maps that reveal the areas that are most vulnerable to the heatwaves and other compound hazards. Finally, sets of impact assessments for the recommended adaptation interventions are visualised to reveal adaptation potential comparison of the different solutions.

2.1.3 Athens Metropolitan Area Dashboard at a glance

The dashboard consists of three dropdowns at the top of the screen, the left and right dropdowns contain a list of adaptation intervention scenarios visualisations (cool roofs and cool streets, green roofs and urban greening and green roofs and urban trees). Selecting the morning or afternoon options for each scenario will display that scenario on the appropriate side of the Mapbox swipe, thus selecting different scenarios will enable uses to compare the impact of a given scenario.

The centre dropdown contains a list of urban risks (land surface temperature, heat, air quality, tree coverage, habitats for urban biodiversity, socio-economic heat vulnerability index, access to green spaces, risk and population). When selected, these layers are visualised on both sides of the Mapbox swipe to provide a common backdrop for the scenario A|B comparisons

2.2 Torbay Case Study (CS8)

The Torbay case study has been developed around flooding in the Torbay region and is covered in MS14. For this iteration of the dashboard, two types of users have been defined, a 'general' user that has access to all the open-source data (Environment Agency & WeatherAPI) and an 'authorised' user that additionally has access to the results of flood modelling, cascading failure processing and Torbay Council's private sensor network data.

2.2.1 General User

On selecting CS8 from the dashboard home page (Figure 1), the user is taken to the CS8 home page which presents the user with two options: 'Torbay at a Glance' and 'Torbay Data', Figure 3.

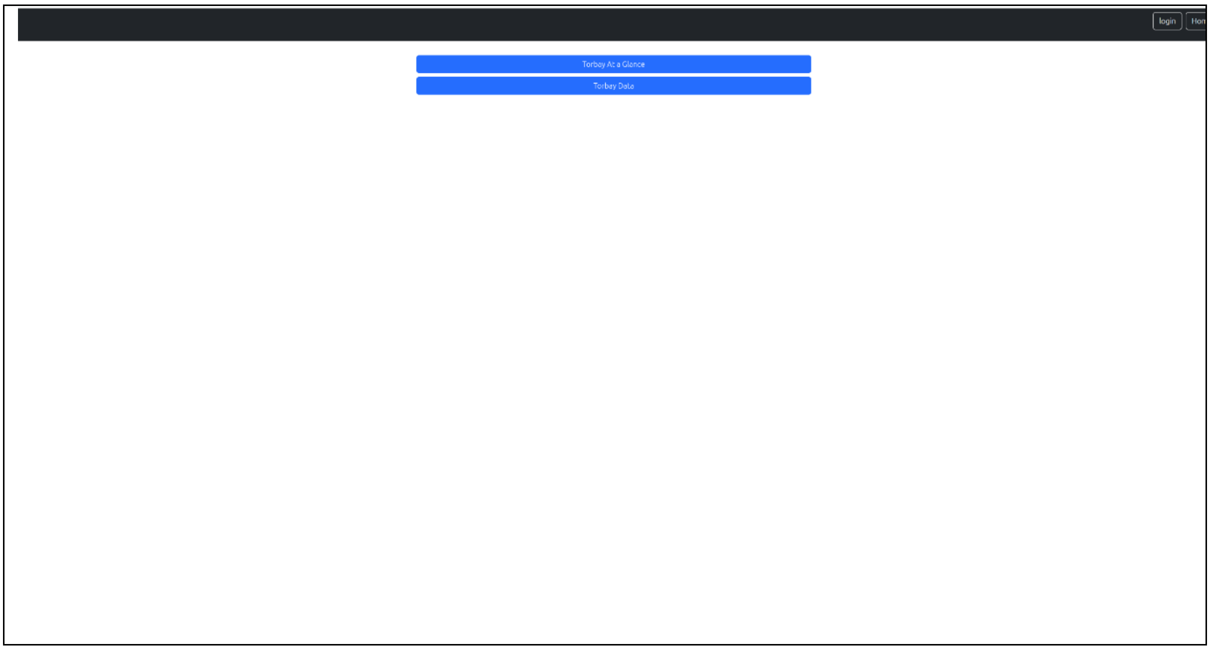
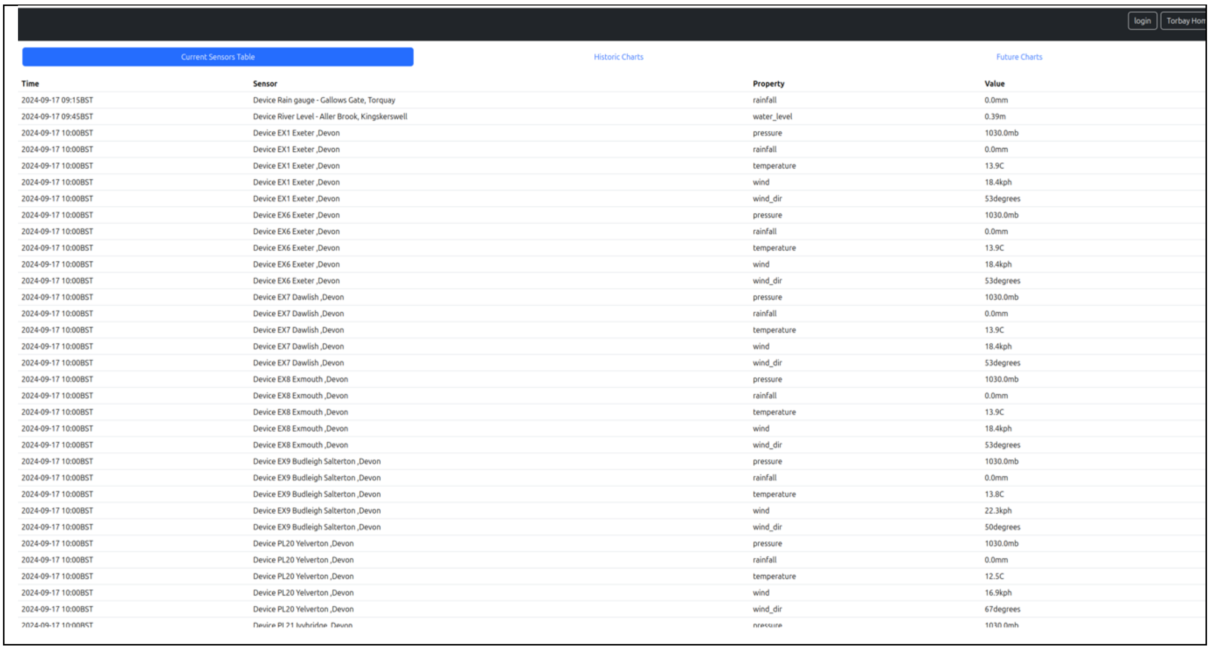


Figure 3 - CS8 Home Page

2.2.1.1 Torbay Data

Quantitative data for Torbay is collected from multiple sources (Environment Agency data portal, WeatherAPI Api and Torbay Council's weather sensor array) and normalised into a nsgi-ld/v1 context broker to store both current and historic data. Data is accessed through the nsgi-ld/v1 interface and transformed into dashboard-friendly formats.



Time	Sensor	Property	Value
2024-09-17 09:15BST	Device Rain gauge - Gallows Gate, Torquay	rainfall	0.0mm
2024-09-17 09:45BST	Device River Level - Aller Brook, Kingskerswell	water_level	0.39m
2024-09-17 10:00BST	Device EX1 Exeter ,Devon	pressure	1030.0mb
2024-09-17 10:00BST	Device EX1 Exeter ,Devon	rainfall	0.0mm
2024-09-17 10:00BST	Device EX1 Exeter ,Devon	temperature	13.9C
2024-09-17 10:00BST	Device EX1 Exeter ,Devon	wind	18.4kph
2024-09-17 10:00BST	Device EX1 Exeter ,Devon	wind_dir	53degrees
2024-09-17 10:00BST	Device EX6 Exeter ,Devon	pressure	1030.0mb
2024-09-17 10:00BST	Device EX6 Exeter ,Devon	rainfall	0.0mm
2024-09-17 10:00BST	Device EX6 Exeter ,Devon	temperature	13.9C
2024-09-17 10:00BST	Device EX6 Exeter ,Devon	wind	18.4kph
2024-09-17 10:00BST	Device EX6 Exeter ,Devon	wind_dir	53degrees
2024-09-17 10:00BST	Device EX7 Dawlish ,Devon	pressure	1030.0mb
2024-09-17 10:00BST	Device EX7 Dawlish ,Devon	rainfall	0.0mm
2024-09-17 10:00BST	Device EX7 Dawlish ,Devon	temperature	13.9C
2024-09-17 10:00BST	Device EX7 Dawlish ,Devon	wind	18.4kph
2024-09-17 10:00BST	Device EX7 Dawlish ,Devon	wind_dir	53degrees
2024-09-17 10:00BST	Device EX8 Exmouth ,Devon	pressure	1030.0mb
2024-09-17 10:00BST	Device EX8 Exmouth ,Devon	rainfall	0.0mm
2024-09-17 10:00BST	Device EX8 Exmouth ,Devon	temperature	13.9C
2024-09-17 10:00BST	Device EX8 Exmouth ,Devon	wind	18.4kph
2024-09-17 10:00BST	Device EX8 Exmouth ,Devon	wind_dir	53degrees
2024-09-17 10:00BST	Device EX9 Budleigh Salterton ,Devon	pressure	1030.0mb
2024-09-17 10:00BST	Device EX9 Budleigh Salterton ,Devon	rainfall	0.0mm
2024-09-17 10:00BST	Device EX9 Budleigh Salterton ,Devon	temperature	13.8C
2024-09-17 10:00BST	Device EX9 Budleigh Salterton ,Devon	wind	22.3kph
2024-09-17 10:00BST	Device EX9 Budleigh Salterton ,Devon	wind_dir	50degrees
2024-09-17 10:00BST	Device PL20 Yelverton ,Devon	pressure	1030.0mb
2024-09-17 10:00BST	Device PL20 Yelverton ,Devon	rainfall	0.0mm
2024-09-17 10:00BST	Device PL20 Yelverton ,Devon	temperature	12.5C
2024-09-17 10:00BST	Device PL20 Yelverton ,Devon	wind	16.9kph
2024-09-17 10:00BST	Device PL20 Yelverton ,Devon	wind_dir	67degrees
2024-09-17 10:00BST	Device PL21 Ivybridge ,Devon	pressure	1030.0mb

Figure 4 - CS8 Current Sensor Data

Figure 4 details current sensor data in a tabular form with sensors ordered by recency, i.e. the least recent data is displayed first. This provides users with current values for each sensor and a clear indication of data latency.

For general users, only open-source data is presented (Environment Agency and WeatherAPI). Torbay Council's sensor data is not present.

Figure 5 - CS8 Historic Sensor Charts

Figure 5 presents historic sensor data in a chart format, with data summarised over the last 7 days.

Figure 6 - CS8 Forecast Sensor Charts

Figure 6 presents weather forecast data from the WeatherAPI site. With our current free membership of the service, it is possible to collect 3-day forecasts that include rainfall and wind speed / direction (amongst other attributes).

For each these visualisations, data from the context broker is collected and processed periodically on the dashboard server and stored in client-friendly formats (HTML). This is primarily to reduce the latency in serving HTTP requests as client data is effectively cached rather than being processed on demand.

There are also split data paths for general and authorised users, such that 'restricted' data will not be processed on the client.

2.2.1.2 Torbay at a Glance

The Torbay at a Glance screen, Figure 7, looks to add value to the data stored in the context broker through curation and contextualisation. Sensor data is curated through only visualising sources that are deemed to be relevant and context is added by combining historic and forecast data. The philosophy behind this approach is that this dashboard component will enable general and authorised users to make informed short-term decisions.

Figure 7 - CS8 'Torbay at a Glance'

In the case of general users, the rainfall chart in the top left of the dashboard shows both historic and forecast rainfall, enabling users to plan according to likely rainfall. For authorised users, the tide height and wind speed and direction charts can provide insight into likely overtopping events for Torbay Road (the coast road that links Paignton and Torquay), section 2.2.2.5. However, for general users, these charts may also provide value beyond that of flood prediction. The tide height chart in the lower left has a great deal of value for sea users, in particular low and high tides. Also the wind speed and wind direction can be useful for beach goers to determine if it’s safe to swim with inflatables (inshore vs. offshore) such that they won’t get blown out to sea.

2.2.2 Authorised User

To enable the authorised user options, the user must log into the dashboard using the 'login' button to the top right of the dashboard screen to reveal the login dialogue, Figure 8.

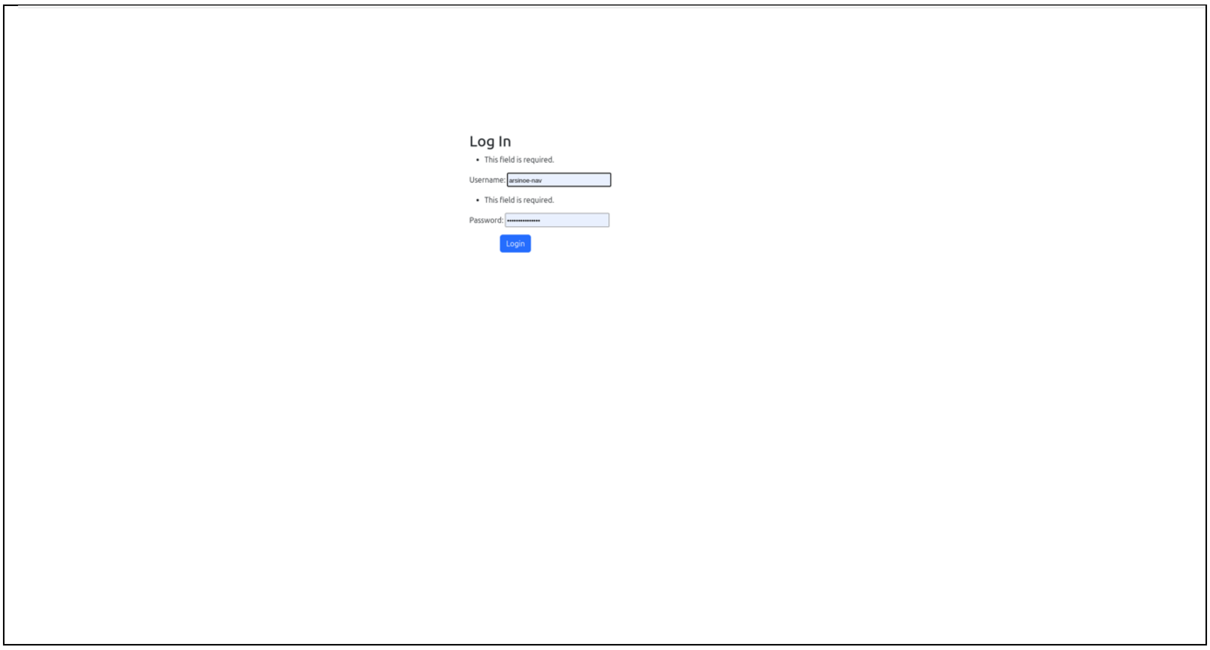


Figure 8 - Dashboard Login Screen

Upon successfully logging in, the user will be presented with an updated home screen that shows three additional options, Figure 9.

Figure 9 - CS8 Authorised User Screen

2.2.2.1 Cascading Failure

The cascading failure screen, Figure 10, contains the cascading failure testbed from D3.1. This screen allows users to explore the impact of four fluvial flood scenarios (1 in 1000 years, two 1 in 1000-year events, 1 in 10000 years and two 1 in 10000-year events). On selecting a scenario, the cascading failure process is performed live on the server with the results returned a short while later.

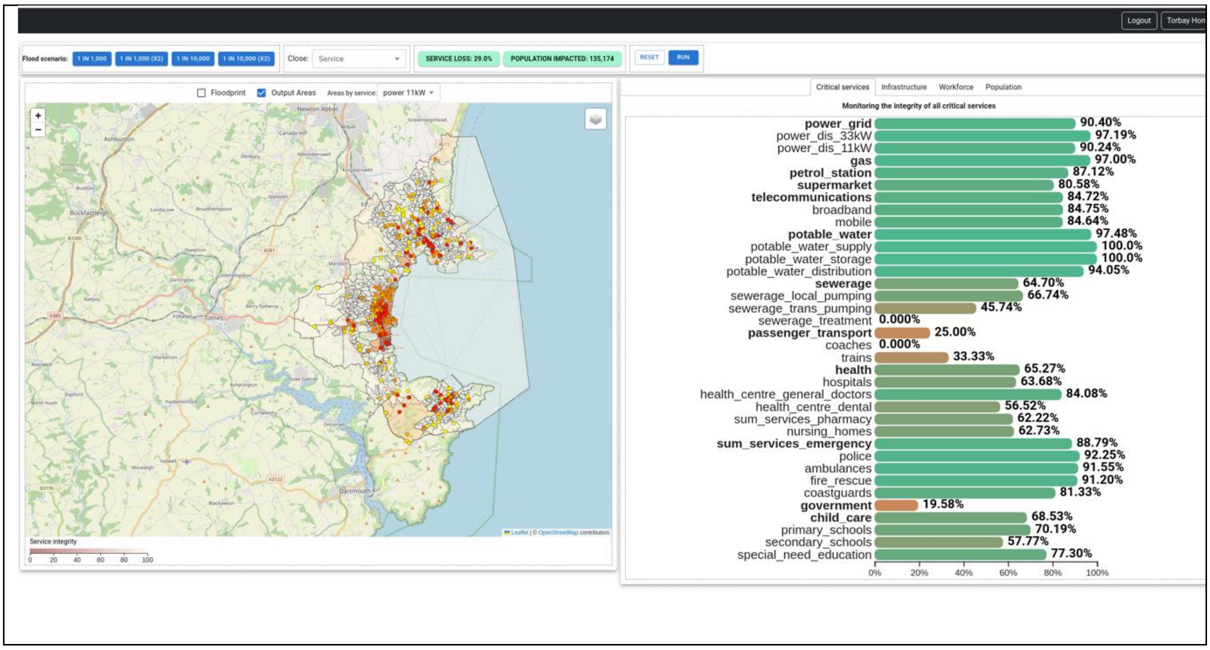


Figure 10 - CS8 Cascading Failure Screen

The results of the flood scenario are displayed on the screen, with the left-hand side showing impact geographically, and the right-side showing the quantitative impact on a per-service basis. The cascading failure screen operates as a sandbox, allowing users to protect and disable particular infrastructure nodes and types to explore the increased, or reduced, impact of given floods.

2.2.2.2 Flood Map

The flood map screen, Figure 11, builds on the functionality of the cascading failure sandbox to present the user with many historic flooding events, both fluvial flooding and coastal overtopping, that can be viewed, rather than interacted with.

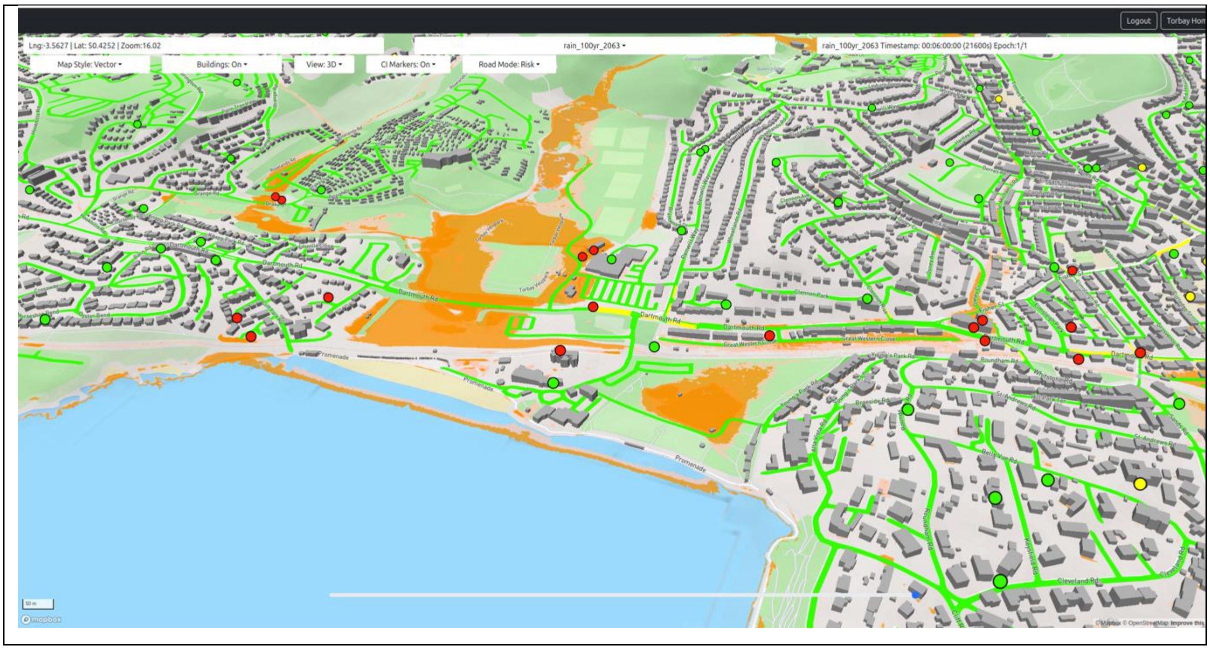


Figure 11 - CS8 Flood map screen

The flood map screen visualisation screen is realised through Mapbox, using a set of layers to visualise flood range and depth, state of critical infrastructure nodes and state of the road network, both in terms of risk and impact of flooding.

The dropdown at the top of the screen contains a set of historic and simulated flood events and once selected, the slider at the bottom of the screen allows uses to scroll through the timeline of the flood, which is summarised into a set of 6-hour epochs.

2.2.2.3 Side-by-Side

The Side-by-Side screen, Figure 12, builds on the functionality of the flood map, and the Mapbox swipe mode from CS1, to give users an environment where they can compare flooding events.

This screen doesn't use the same functionality as the CS1 dashboard, instead, it features two Mapbox maps, each of which is half the width of the screen and their scrolling is linked, such that when one map is moved, the other moves identically.

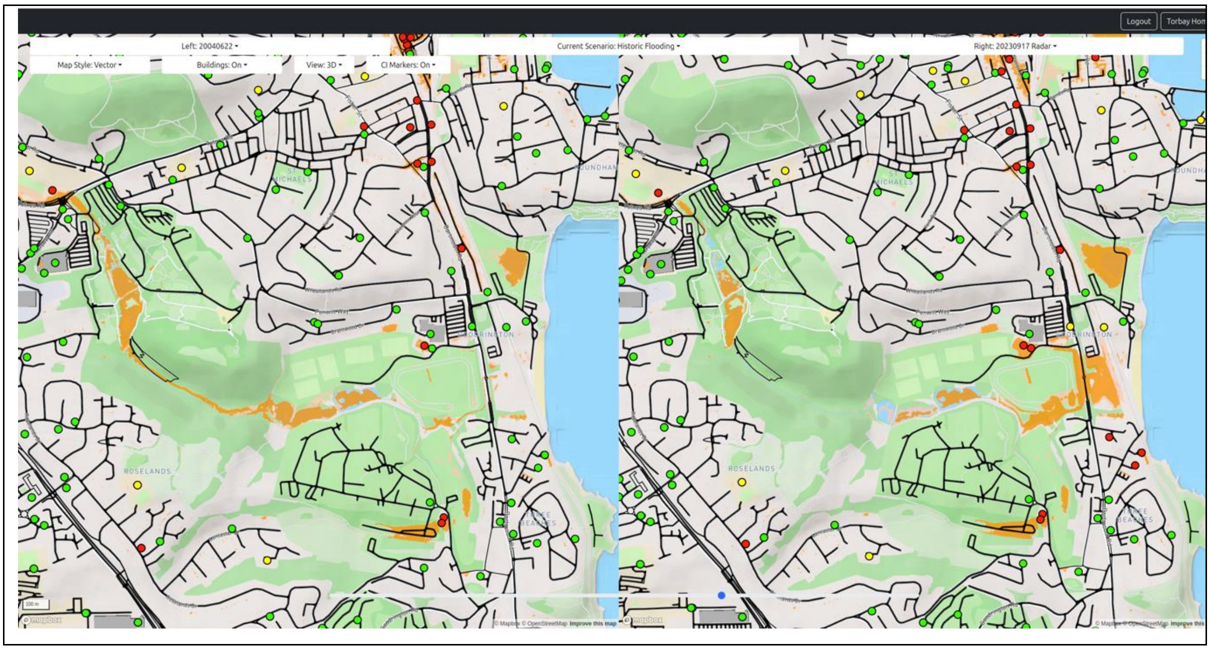


Figure 12 - CS8 Side-by-Side Screen

Like the CS1 dashboard, this screen contains three dropdowns; the centre dropdown contains a set of curated scenarios (overtopping events and rainfall events from the EU circle project, permeable pavement simulations and historic flooding events). On selecting one of these scenario types, the left and right dropdowns are populated with appropriate content. From there, different scenarios can be compared as A|B through the left and right views.

2.2.2.4 Torbay Data

The Torbay view for authorised users contains all the functionality from the general user view, however the authorised view also contains the restricted Torbay sensor data. This is shown as a side-by-side comparison, Figure 13, with the authorised view on the right containing extra data (HELE TANK, TEMPLER ROAD, GALLOWS GATE RES, COCKINGTON etc).

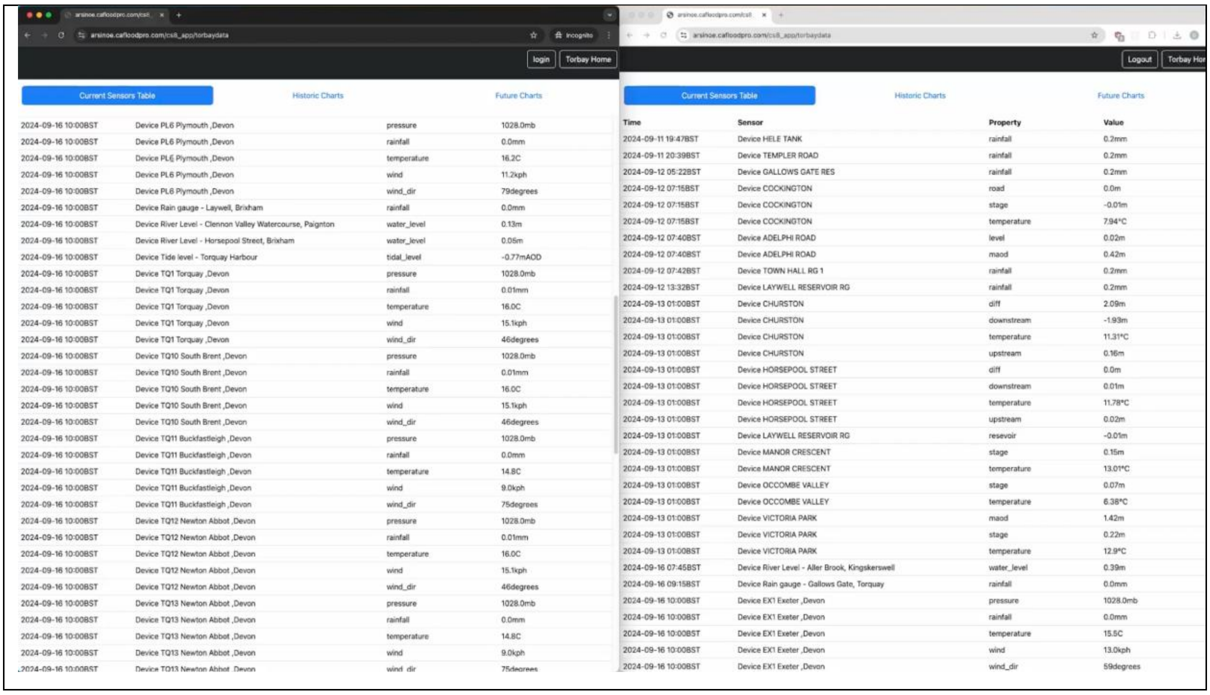


Figure 13 - CS8 Torbay Data, authorised view

2.2.2.5 Torbay at a glance

The authorised version of the ‘at a Glance’ screen is identical to the general user view. However, the inclusion of tide height and forecast wind speed and direction can be used by Torbay Council staff to estimate the likelihood of overtopping events that could lead to a closure of Torbay Road at Torre Abbey, Figure 14.

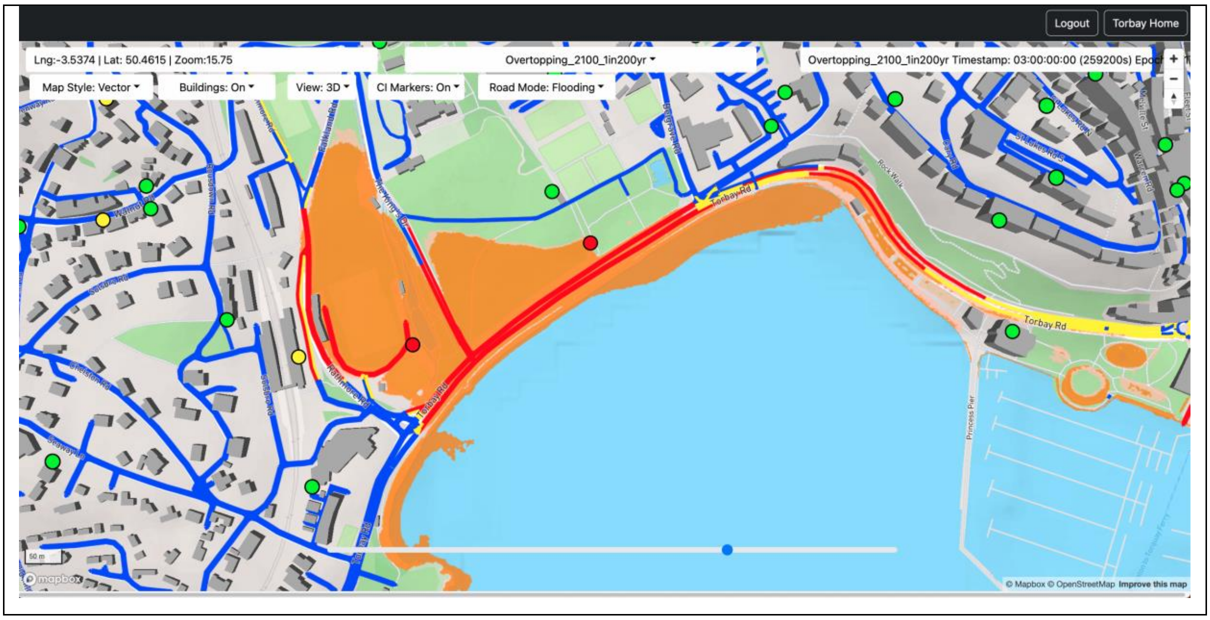


Figure 14 – Coastal overtopping showing the closure of Torbay Road at Torre Abbey.

3 Conclusions

This iteration of the dashboard had shown:

- Long-term decision making for CS1
  The CS1 dashboard demonstrates that it is possible to display complex visual information from multiple sources whilst also providing users with quantitative data. The interactive nature of the dashboard should support the decision makers at Athens municipality with their long-term decision making with respect their nature-based solution options.

- Short-term and long-term decision making for CS8
  The CS8 dashboard demonstrates that it is possible to bring data together from multiple sources (sensors and simulation) to provide multiple users with the ability to support both short and long-term decision making.

- Successful hosting of multiple pilots on a single Django environment
  Whilst Django was selected for dashboard development for arbitrary reasons, its support of multiple 'apps' has allowed the development of distinct pilot dashboards in a shared, but separated, environment. This bodes well for future dashboard work as new pilots can be added to the overall dashboard environment in a modular manner.

- Authorisation & Authentication with Django
  In addition, Django's integrated authorisation and authentication functionality has made it very straightforward to limit functionality and data available to specific types of users.

- Context broker suitability for sensor data management
  The use of a context broker for harmonising and storing data from a variety of sources has once again proved invaluable for our development work.

- Use of Mapbox to facilitate the geo-visualisation of data
  Mapbox has provided good levels of functionality for our visualisation work, particularly the 'swipe' functionality for CS1. We are now at a level of maturity with Mapbox where core Mapbox functionality has been wrapped into reusable components which we hope to re-use with the CS6 dashboard.

4 Next steps

- Scope to add short-term planning to CS1 with WeatherAPI data
  Currently, the CS1 dashboard is solely concerned with long-term planning through the visualisation and evaluation of nature-based solutions.
  However, our work with sensor data collection, management and visualisation in CS8 has shown that there is scope for short-term planning based on short-term weather forecasting. For CS1, there is scope to leverage the 3-day forecast, particularly in terms of temperature and air quality which may help citizens to make more informed decisions.

- Co-design user experience for CS8
  Much of the current visualisation functionality on CS8 was predicated on what was possible, rather than necessarily how users would want to interact with data. It would therefore make sense to organise several rounds of user-centred design to evaluate our current functionality and refine it to what both types of users will use.

- Automate CS8 digital twin as part of the D4.3 deliverable (Two digital twins)
  Currently, CS8 dashboard data is processed off-line to create the flood maps and associated critical infrastructure and road risk data and associated visualisation. Now that current and forecast weather data is being collected, it makes sense to 'close the loop' such that weather data can be fed into the digital twin flood simulator (CA flood) and its results rippled through the current offline processes.

- Embrace synthetic data generation
  As part of the 'automation of the CS8 digital twin', it would make a lot of sense to create synthetic data to create meaningful and varied test data for the overall digital twin process.

- Integrate CS6 (Black Sea) dashboard as part of the D4.3 deliverable
  Work is currently underway to develop the CS6 digital twin and associated dashboard. We are optimistic that we will be able to re-use our Mapbox visualisation components and charting for this and host it on the arsinoe.caflood.com service.

Systems Innovation Approach (SIA) addresses the growing complexity, interdependencies and interconnectedness of modern societies and economies, focusing on the functions of the cross-sectoral system as a whole and on the variety of actors. The Climate Innovation Window (CIW) is the EU reference innovations marketplace for climate adaptation technologies. ARSINOE shapes the pathways to resilience by bringing together SIA and CIW, to build an ecosystem for climate change adaptation solutions. Within the ARSINOE ecosystem, pathways to solutions are co-created and co-designed by stakeholders, who can then select either existing CIW technologies, or technologies by new providers (or a combination) to form an innovation package. This package may be designed for implementation to a specific region, but its building blocks are transferable and re-usable; they can be re-adapted and updated. In this way, the user (region) gets an innovation package consisting of validated technologies (expanding the market for CIW); new technologies implemented in the specific local innovation package get the opportunity to be validated and become CIW members, while the society (citizens, stakeholders) benefits as a whole. ARSINOE applies a three-tier, approach: (a) using SIA it integrates multi-faceted technological, digital, business, governance and environmental aspects with social innovation for the development of adaptation pathways to climate change for specific regions; (b) it links with CIW to form innovation packages by matching innovators with end-users/regions; (c) it fosters the ecosystem sustainability and growth with cross-fertilization and replication across regions and scales, at European level and beyond, using specific business models, exploitation and outreach actions. The ARSINOE approach is show-cased in nine widely varied demonstrators, as a proof-of-concept with regards to its applicability, replicability, potential and efficacy.

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