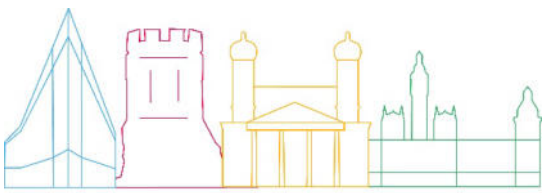
ARCH

ARCH D4.3

Threats and Hazard Information System



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Executive Summary

This deliverable has been prepared for the European Commission-funded research project ARCH: Advancing Resilience of historic areas against Climate-related and other Hazards. It is the key output of Task 4.3 “Information Management about Environmental Hazards” within work package 4 “Hazard & Object Information Management System”. The aim of Task 4.3 was the development of systems, tools and data-processing to provide measurable indicators, which characterise threats and hazards potentially affecting the historic areas.

The match-making online meetings and co-creation processes (led by ICLEI) involving cities, stakeholders and technical partners, allowed to identify the main environmental threats and hazards, as well as to select measurable indicators for their characterisation. However, considering that the historic areas in ARCH are exposed to different threats, specific analyses and tools were required for each case study, and only some datasets were collected in the same way for all cities. To this end, ad-hoc services and database were developed to manage historical datasets, real-time measures from monitoring systems and projections for the future. The indicators obtained from the data-processing are provided to support the subsequent risk analysis and impact scenarios, as well as to inform cities and their stakeholders.

The work described in this deliverable focused on:

- the implementation of an earthquake monitoring service to notify as soon as a new earthquake occurs in the European area, by querying the official catalogues, and to process the recordings coming from the Real-Time Urban Seismic Network deployed in (and around) the historic centre of Camerino (Italy);
- the development of the database to structure: (1) environmental measurements from crowd-sensing and official monitoring system, in order to inform about the climatic conditions and air quality in near real-time, and (2) available time-series relating to different categories of indicators, which were calculated on the base of local measures, to characterise the weather and climate extremes in the past;
- the development of a sub-system for mapping environmental contaminations considering their potential spatial and temporal evolution;
- the development of ad-hoc climate services, by processing of datasets available from existing services, to elaborate specific projections of the most relevant indicators characterising the threats and the potential effects related to the climate-change.

Finally, the main information are made accessible through the GIS dashboards of the Threats and Hazard Information System (THIS), which together with the tools of the Historic Area Information System (HArIS), are implemented in the web-platform of the ARCH information systems reachable through the ARCH-Hub.

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List of abbreviations

Abbreviation	Meaning
CAMS	Copernicus Atmosphere Monitoring Service
CAV10	Standard Cumulative Absolute Velocity
CDS	Climate Data Store
CH	Cultural Heritage
CORDEX	Coordinated Regional Climate Downscaling Experiment
CSV	Comma-separated values
DB	Database
DSS	Decision Support System
Dx.y	Deliverable of the ARCH project related to the WPx and numbered y
ECA&D	European Climate Assessment & Dataset
EEA	European Environment Agency
FTP	File Transfer Protocol
FTPS	File Transfer Protocol Secure
GCM	Global Climate Models
GeoJSON	Geographical JavaScript Object Notation
GHG	Greenhouse gas
GIS	Geographical Information System
HArIS	Historic Areas Information System
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
InSAR	Interferometric Synthetic Aperture Radar
JSON	JavaScript Object Notation
KML	Keyhole Markup Language
KMZ	Keyhole Markup Language Zipped
MARS	Copernicus Emergency Management Service
MME	Multi-model ensemble
NetCDF	Network Common Data Form
RCM	Regional Climate Model
RCP	Representative Concentration Pathways

Abbreviation	Meaning
RUSN	Real-Time Urban Seismic Network
SAR	Synthetic Aperture Radar
THIS	Threats and Hazard Information System
WP	Work package
WSDI	Warm Spell Duration Index

List of indicators

Abbreviation	Meaning
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3	Isothermality (BIO2/BIO7) (×100)
BIO4	Temperature Seasonality (standard deviation ×100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter
CDD	Maximum number of consecutive dry days (RR<1mm)
CFD	Maximum number of consecutive frost days (TN<0°C)
CSU	Consecutive Summer Days

Abbreviation	Meaning
CWD	Consecutive Wet Days
FD	Frost Days
HNO_3	Nitric acid
O_3	Ozone
NO_2	Nitrogen Dioxide
$PM_{2.5}$	Particulate matter with a diameter of 2.5 μm or less
PM_{10}	Particulate matter with a diameter of 10 μm or less
PGA	Peak Ground Acceleration
PSA	Pseudo-Spectral Acceleration
RR	Precipitation sum
RR1	Number of wet days, with precipitation higher than 1mm
RR2	Number of wet days, with precipitation higher than 2mm
RR10	Number of wet days, with precipitation higher than 10mm
RR20	Number of wet days, with precipitation higher than 20mm
RX1DAY	Maximum amount of precipitation in 1 day
RX2DAY	Maximum amount of precipitation in 2 days
RX5DAY	Maximum amount of precipitation in 5 days
R75p	Days with precipitation>75^{th} percentile of daily amounts
R75pTOT	Precipitation fraction due to R75p
R95p	Days with precipitation>95^{th} percentile of daily amounts
R95pTOT	Precipitation fraction due to R95p
R99p	Days with precipitation>99^{th} percentile of daily amounts
R99pTOT	Precipitation fraction due to R99p
SPI3	3-months Standardised Precipitation index
SPI6	6-months Standardised Precipitation index
SPEI	Standardised Precipitation-Evapotranspiration Index
SO_2	Sulphur dioxide
SU	Summer Days
TG	Mean of daily mean temperature
TGx	Maximum value of daily mean temperature
TG10p	Days with TG<10^{th} percentile of daily mean temperature

Abbreviation	Meaning
TG90p	Days with TG>90th percentile of daily mean temperature
TN	Mean of daily minimum temperature
TNx	Maximum value of daily minimum temperature
TN10p	Days with TN<10th percentile of daily mean temperature
TN90p	Days with TN>90th percentile of daily mean temperature
TR	Tropical Nights
TX	Mean of daily maximum temperature
TXx	Maximum value of daily maximum temperature
TG10p	Days with TN<10th percentile of daily mean temperature
TX90p	Days with TX>90th percentile of daily mean temperature
WSDI	Warm Spell Duration Index

7. Web-dashboards and operational guide in THIS

To make the data and information accessible to the user, specific web-tools were designed by INGV. In particular, as already described in previous ARCH deliverables (e.g. D4.2 [3] and D7.5 [4]) and graphically reported in Figure 2, three tools have been developed:

- **GIS Dashboards** enable users to obtain information by location-based analytics, using intuitive and interactive data and maps to be viewed on a single screen.
- **Building/Object Sheets** to query and visualise structured data included in the databases, for example providing information about assets and objects in the historic areas; these web-sheets will be used also for editing and data entry performed by authorised users.
- **3D model viewer** to visualise the three-dimensional models of assets and objects, also enabling users to extract a subset of three-dimensional data.

The web tools are integrated into the same platform to show data in both HArIS and THIS. In particular, GIS dashboards have been developed to access the main datasets described in this document, and others included in the ARCH database and repository (eg satellite products) and already described in D4.1 [2].

The overall design of the dashboards for THIS followed the criteria, already introduced in D4.2 [1] for HArIS, i.e. easy-to-use by non-expert users (and users not familiar with GIS applications) and easy understanding of the data representation, also providing links for further information where necessary.

7.1. How to access information systems

In this section, the dashboards developed for THIS (version v1.2021) are presented and a quick user manual is illustrated. Currently, the landing page of the information systems (Figure 59) can be reached at the web link http://www.cs.ingv.it/ARCHPortal/.

The access way to the web-platform, as reported in this document, is the same as that already described in D4.2 [3].

After clicking on the button at the top right in the landing page, the user can login (Figure 60), if registered, otherwise she\he can request the registration of a new account (Figure 61), that will be managed by INGV before granting it. This control process is necessary as the authorised user has access to all functionalities; with the possibility also of modifying information concerning the assets of her\his own historic area. However, the unregistered user can have access in consultation mode to all public information contained in the systems.

Currently, all information in THIS is available without registration.

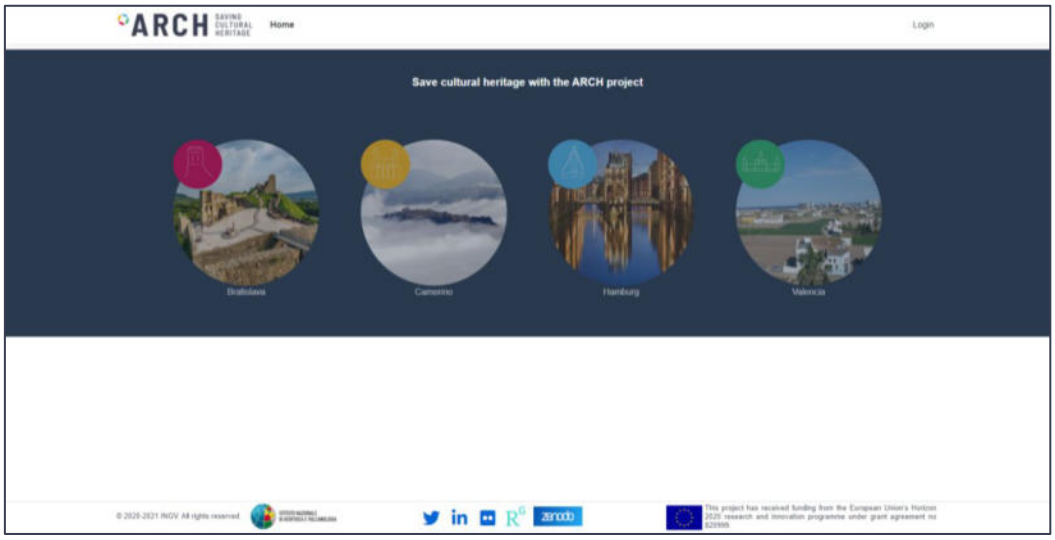


Figure 59. Landing page of the Information System platform

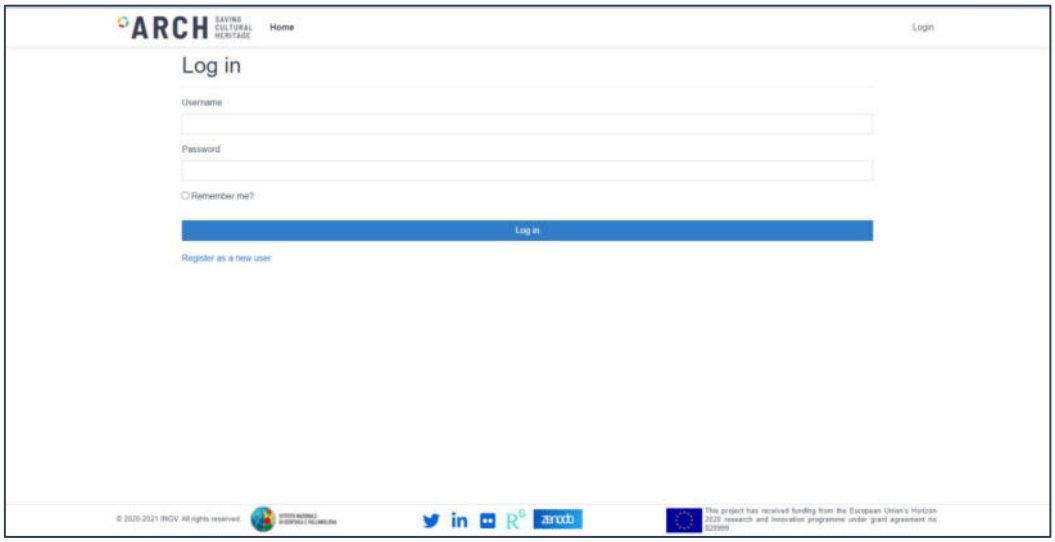


Figure 60. Login to the information systems

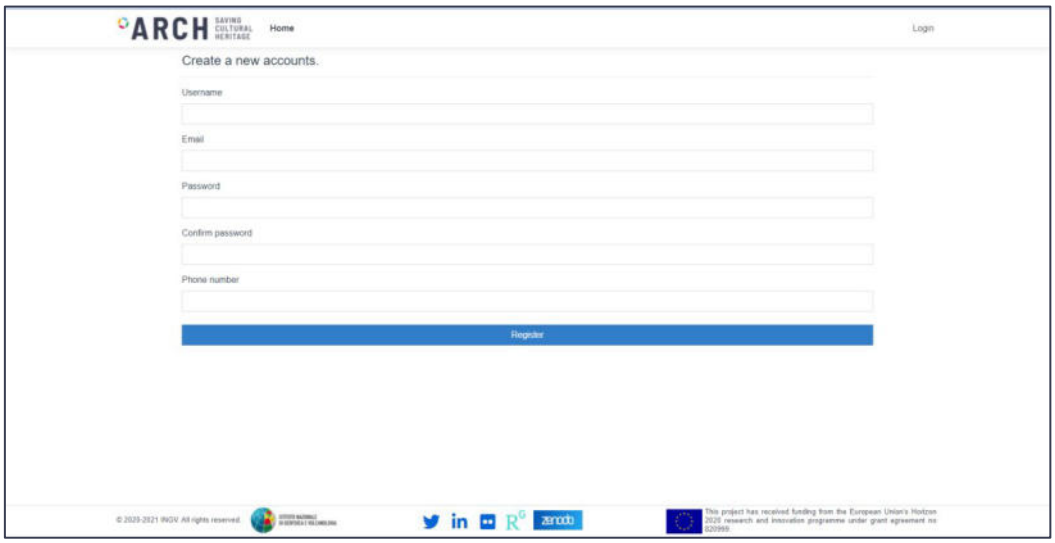


Figure 61. Registration of new account

In the landing page, the image of the city lights up when the mouse pointer is positioned over it and, at this point, the corresponding GIS dashboard (Figure 62) is loaded with a simple click. Once this new page has been loaded, a menu in the header (1 in Figure 62) allows accessing to the tools of the information platform, always remaining available so that the user can easily change her\his choice. This menu reports the follow link:

- "Home" to return to the landing page and choose another city;
- "GIS dashboard" to obtain the tool to query the cartographic layers both in HArIS (cf. section 4.2 in D4.2 [1]) and THIS (cf. Sections 7.2 - 7.7 below);
- "Construction\Object Sheet" to consult the information on the assets (cf. section 4.3 in D4.2 [1]);
- "Geocatalog" to browse and search metadata and link related to GIS web-services and datasets in HArIS and THIS. This functionality is being developing in Task 4.4 and will be described in D4.4 "Knowledge information management system for decision support", including how services and data can be reached by other systems.

Figure 62. GIS dashboard of HArIS (example for the case of Hamburg) by D4.2 that appears when the city is selected by the landing page. From this page the THIS dashboards can be reached by clicking on Threats and Hazard Information System in menu 2

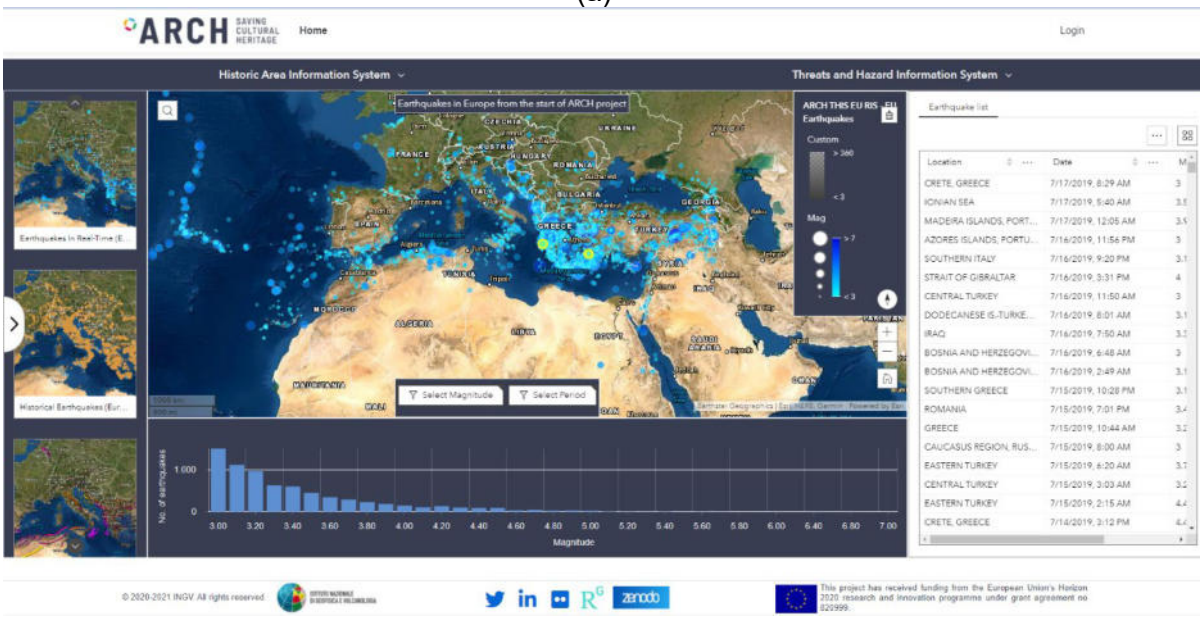
The two drop-down menus (2 in Figure 62) can be used to choose the different products related to HArIS and THIS. In particular, by clicking on Threats and Hazard Information System some links are available (depending on the selected city) to reach the following dashboards:

- **Earthquake monitoring service** (only for Camerino)
- **Air quality**
- **Historical climate**
- **Environmental parameters**
- **Climate services** (for Bratislava, Valencia and Hamburg)
  Satellite products - SAR (for Hamburg and Valencia) and thermal maps (for Bratislava and Valencia)

7.2. Earthquake monitoring service

Figure 63 shows the dashboard related to the earthquake monitoring service that can be used to query the information related to the earthquake monitoring (cf. Section 3.1).

(a)



(b)

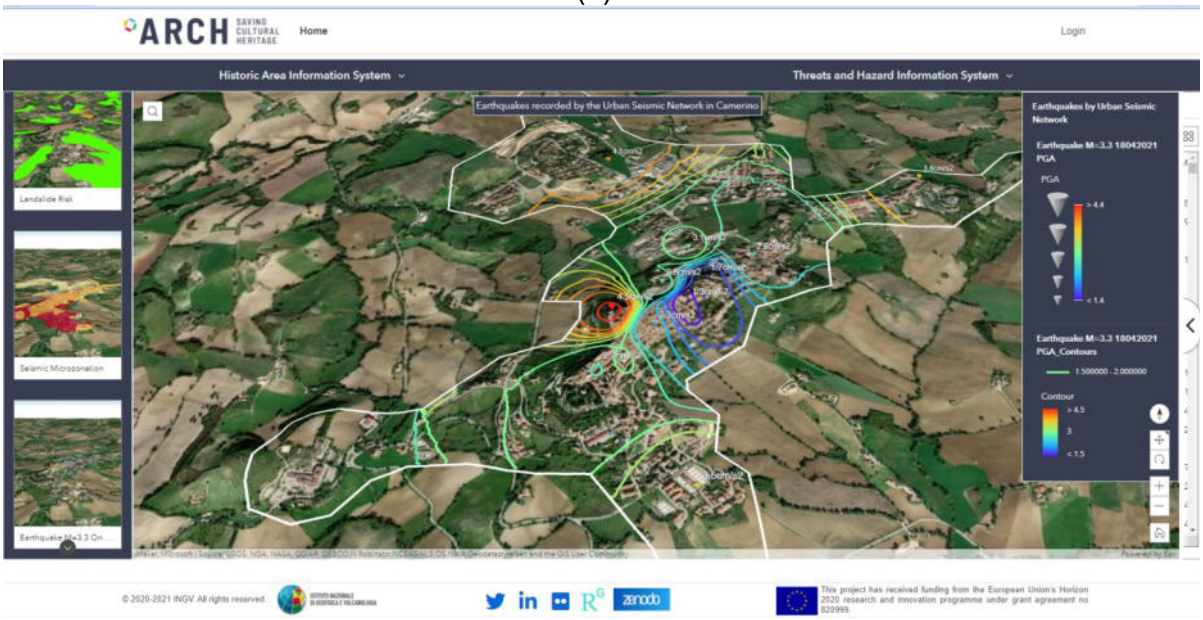


Figure 63. Seismic service dashboard: earthquakes occurred in near real-time, historical earthquakes and seismogenic sources (a); ground motion parameters related to the earthquakes that occurred near Camerino (b).

In the main page of the dashboard (Figure 63.a) the current situation in Europe is available by means of:

- a map where epicentres are plotted, and clicking on a specific earthquake details and external link can be obtained through the pop-up;

- a chart below that summarizes the number of earthquakes on the map grouped by magnitude;
- a table on the right side with the list of the earthquakes for a specific selection, with a menu that allows to show/clear selection, show/hide columns, export the selected element directly in CSV, JSON or GeoJSON format and highlight the selected earthquakes on the map.

In addition, two buttons in the map allow defining a specific period and a magnitude range to filter the entire dataset. Instead, the information about historical earthquakes, seismogenic sources and seismic hazard can be plotted using the scrolling menu on the left side of the dashboard.

The information provided by the recordings of the RUSN (cf. Section 3.1) and local information on the Camerino historic area can be obtained through the arrow button on the left side. The new map frame allows to display:

- the location of the RUSN stations;
- the local geological setting (modified by [52]);
- the landslide risk[30];
- the seismic microzonation [52];
- the recorded parameters of the ground motion (cf. Section 3.1).

All the local information can be easily viewed using the scrolling menu on the left side. In particular, Figure 63.b shows the PGA values and the contours obtained by processing the time-histories recorded during the low-energy earthquake, that occurred near Camerino on 18th April 2021 (cf. Section 3.2) about two months after the installation of the RUSN.

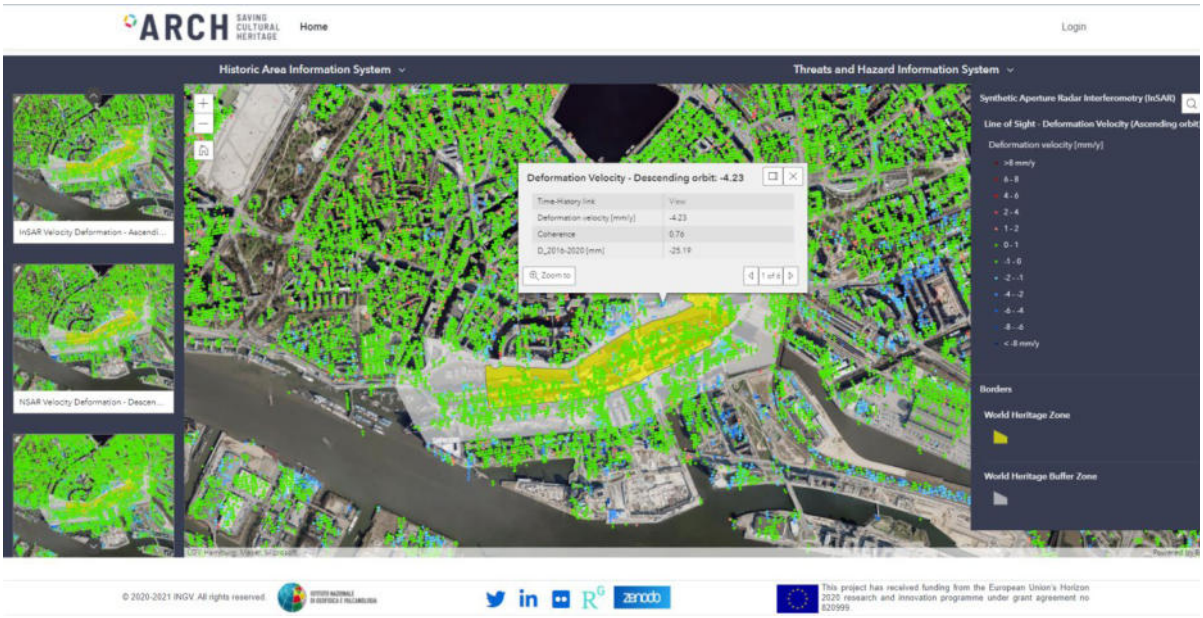
7.3. Satellite products

Figure 64 shows the dashboard related to the satellite products that were obtained by the processing of the satellite datasets as described in the Section 5.1 and 5.2 of the D4.1[2]. In particular, deformation velocities obtained by InSAR technique and temperatures from thermal images, as well as the potential UHIs, are made available to the users.

The scrolling menu on the left allows selecting the available results for the city: deformation velocity (Figure 64.a) and/or thermal map (Figure 64.b). On the right, the legend explains the information relating to the layers drawn in the map. Furthermore, clicking on a measurement point in the InSAR map the pop-up opens with the summary values and the Time-History link. The latter allows to reach the time-history of the relative displacement between the satellite sensor and the measurement point along the Line Of Sight (LOS), in fact the chart opens in a new window (Figure 65).

(a)

[30] Available at: https://www.regione.marche.it/Regione-Utile/Paesaggio-Territorio-Urbanistica-Genio-Civile/Piano-assetto-idrogeologico



(b)

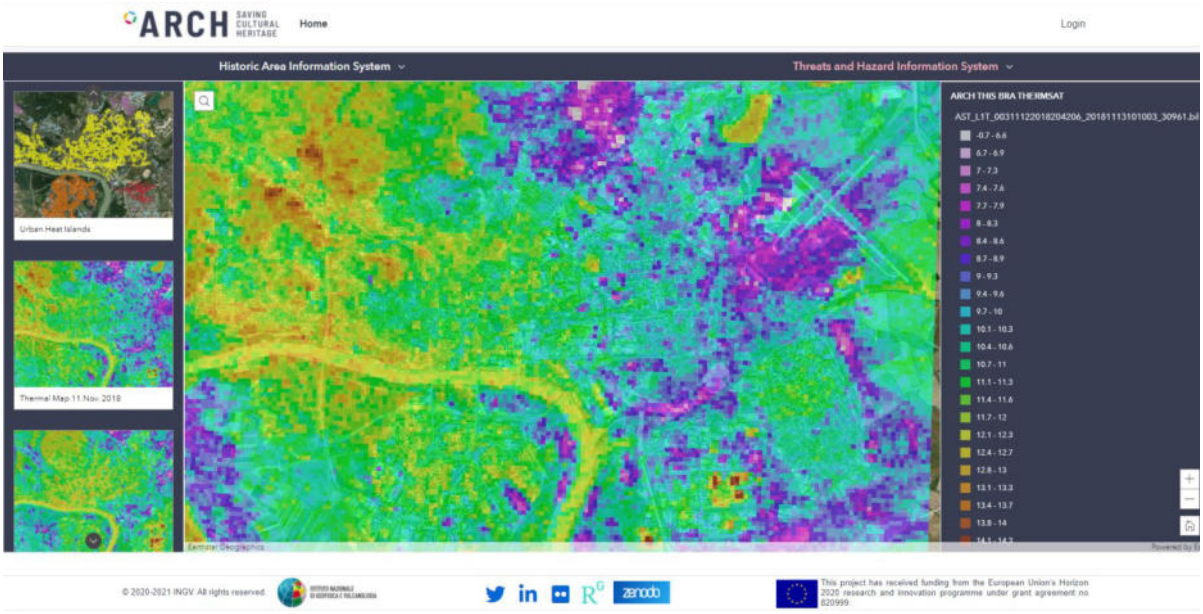


Figure 64. Satellite products dashboard to show the InSAR deformation velocity map (a) and thermal map (a), as provided by processing described in D4.1 [10].

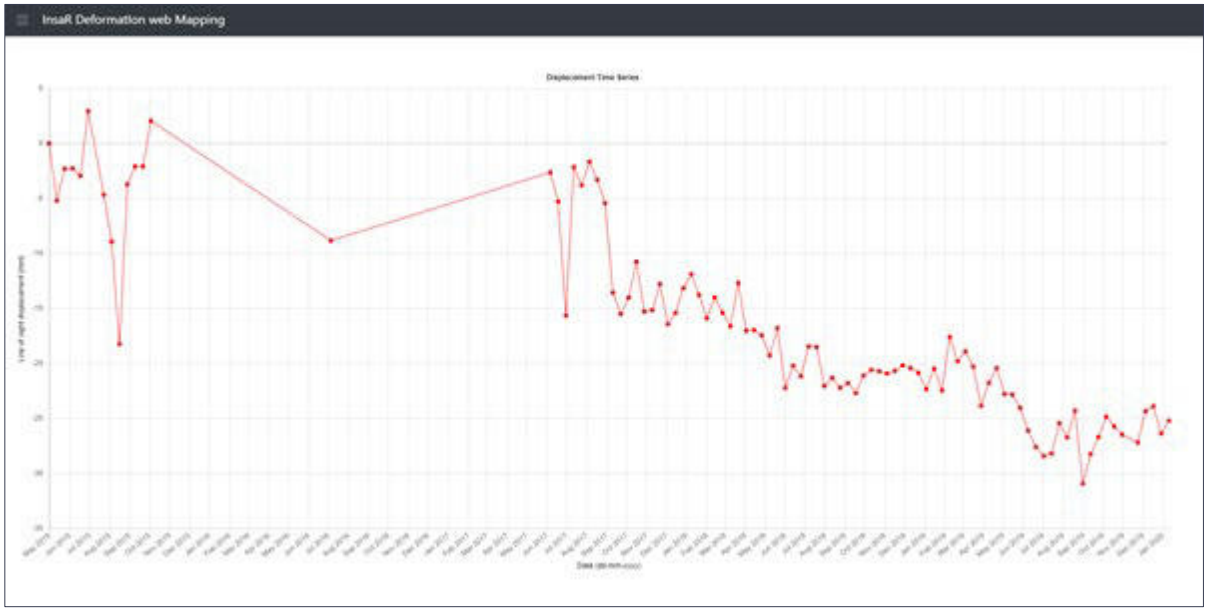


Figure 65. Displacement time-history by InSAR technique calculated along the LOS.

7.4. Air quality

Figure 66 shows the dashboard designed in the information system GIS platform in order to provide information in near-real time on the air quality in or close the HAs. Information on the data structure, ARCH services and data providers can be found in Section 4.1 of this document and in Section 2.3 of D4.1 [2].

Figure 66. Air quality dashboard to show the measures related to the pollutants in (and around) the historic areas, with values updated during the day and the trend of the last few days.

The information displayed on the dashboard can be managed by means of the drop-down menu on the left side, where the user can select:

- One or more recording station(s) shown on the map
- The pollutant measured by EEA local monitoring, that will be shown in the chart “EEA ground sensors” on the bottom side
- The pollutant measured by CAMS satellite monitoring, that will be shown in the chart “CAMS satellite sensors” on the bottom side
- The links to reach the official site of the data providers

A quick guide is also provided directly in the dashboard to inform the user.

The choices made through the previous menu have the effects on:

- the central map, with a zoom on the positions of the selected stations;
- the chart below, in fact trend(s) in the last days is displayed both for “Trend by EEA ground sensors” and “CAMS satellite sensors”;
- the indicators on the right, which indicate the maximum values of PM_{10}, NO_2, O_3 and SO_2 on the last 24-hours

Finally, on the map panel the user can choice:

- the map with the location of the official recording stations and the measurement points provided by the open platforms based on the crowd-sensing (cf. Section 2.3 of D4.1 [2]);
- the map with the current situation on the European zone provided by CAMS services, in this case the pollutant can be selected directly from layer tool on the map.

The user can enlarge the time scale simply by interacting with the bar on the chart.
Moreover, each panel in the dashboard can be resized or open in full screen directly by the user.

7.5. Real-Time Environment parameters

Figure 67 shows the environmental parameters dashboard that allows visualising the parameters on the last hour available in ARCH database: temperature, relative humidity, pressure, rain, wind and gust. The measures can be plotted on the map through the scrolling menu on the left side. Instead, on the right side the measures on the last 7 days are available in a table, with the possibility to filter dataset for a specific period range and a rectangular area by defining longitude and latitude ranges. In the same table, the menu allows to show/clear selection, show/hide columns and export the selected element directly in CSV, JSON or GeoJSON format.

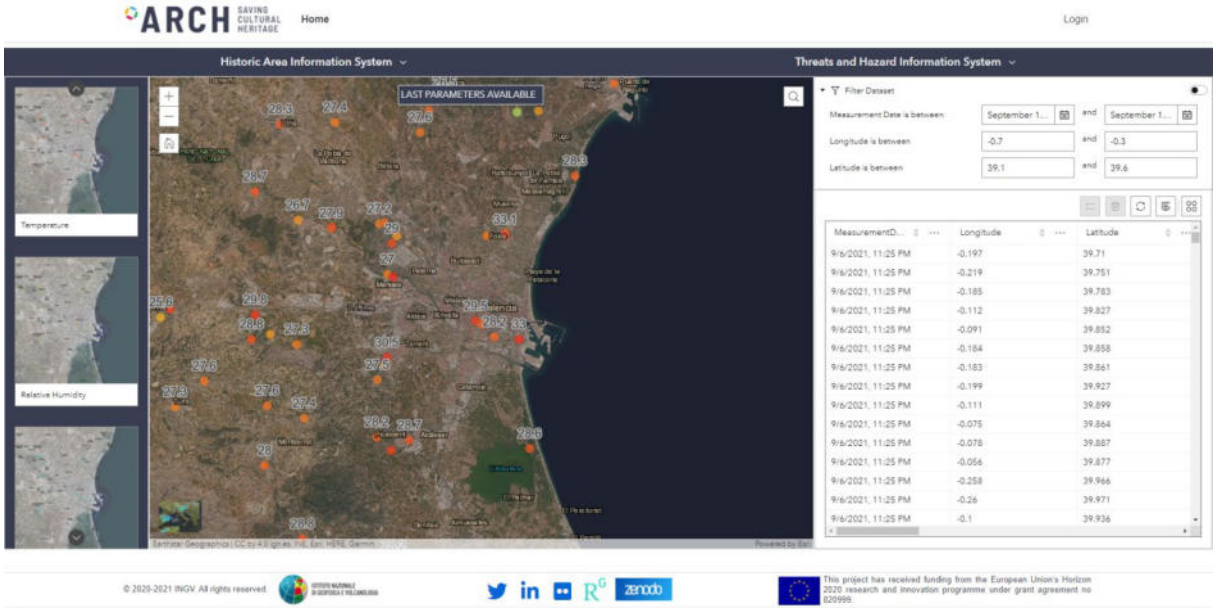


Figure 67. Dashboard for the environmental parameters: the last parameters plotted on the map (on the left side) and table to view and download data on the last 7 days (on the right side).

7.6. Historical climate

Figure 68 shows the dashboard to query the indicators of the historical climate. Information on the data structure, ARCH services and data providers can be found in Section 5.

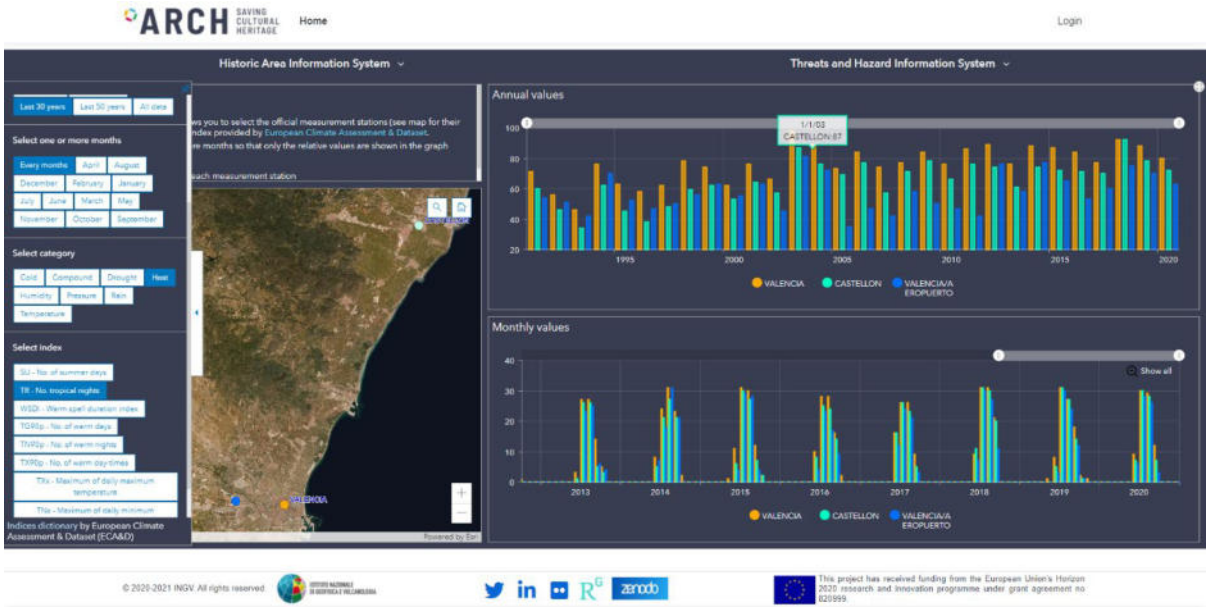


Figure 68. Historic climate dashboard to show indices related to the climate change, as provided by ECA&D [27]. Both annual and monthly values are displayed following the request of the user.

The information displayed on the dashboard can be managed by means of the drop-down menu on the left side, where the user can select:

- One or more recording station(s) showed on the map

- The period on that the indicators are graphed
- The months to be displayed in the monthly chart
- The category and, then, one of the related indices

A quick guide is also provided directly in the dashboard to inform the user.

The choices made through the previous menu have the effects on:

- the central map with a zoom on the positions of the selected stations;
- the annual values of the index are showed on the chart above;
- the monthly values of the index are showed on the chart above for the chosen months and over the observation period;

The user can enlarge the time scale simply interacting with the bars on the charts. Moreover, each panel in the dashboard can be resized or open in full screen directly by the user.

7.7. Climate Services

Figure 69 shows the climate services dashboards that are developed to structure and display the main results obtained by the data processing described in the previous Section 6. In particular, the datasets of the indicators have been gridded by starting from the NetCDF files to be included in the THIS GIS platform.

The dashboard is composed by two maps, in order to display the main indicators:

- on the left map panel can be displayed the historic (1981-2010) and near future (2011-2040) datasets;
- on the right map panel, the mid-term (2041-2070) and far future (2071-2100) datasets.

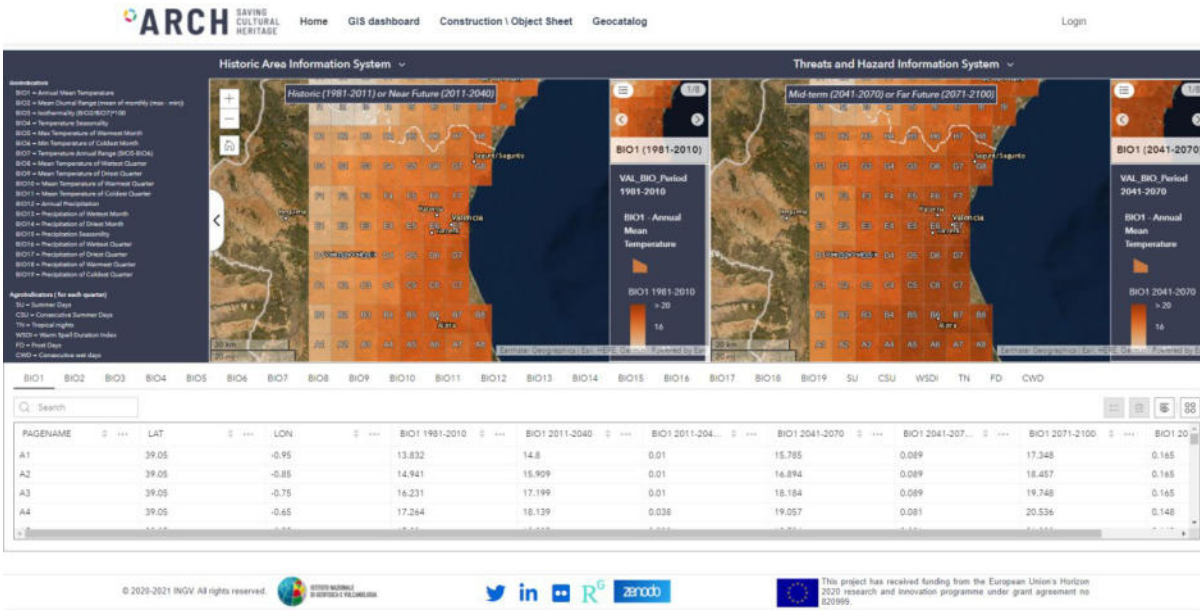
The indicator map can be selected by means of the menu-box on at the top right of the panel. Instead, on the right bottom the legend is displayed with reference to the choice.

Furthermore, on the left side of the dashboard, an arrow button allows you to open the list of indicators in which the abbreviations are explained (Figure 69.a).

The lower part of the dashboard houses the table that provides the values on the different reference periods, as well as the standard deviations, when a specific indicator is selected (see the list in the upper part of the table). In the same table are also available:

- on the left, a search box to select a specific cell of the grid on the map;
- on the right, a menu that allows to show/clear selection, show/hide columns and export the selected element directly in CSV, JSON or GeoJSON format (Figure 69.b).

(a)



(b)

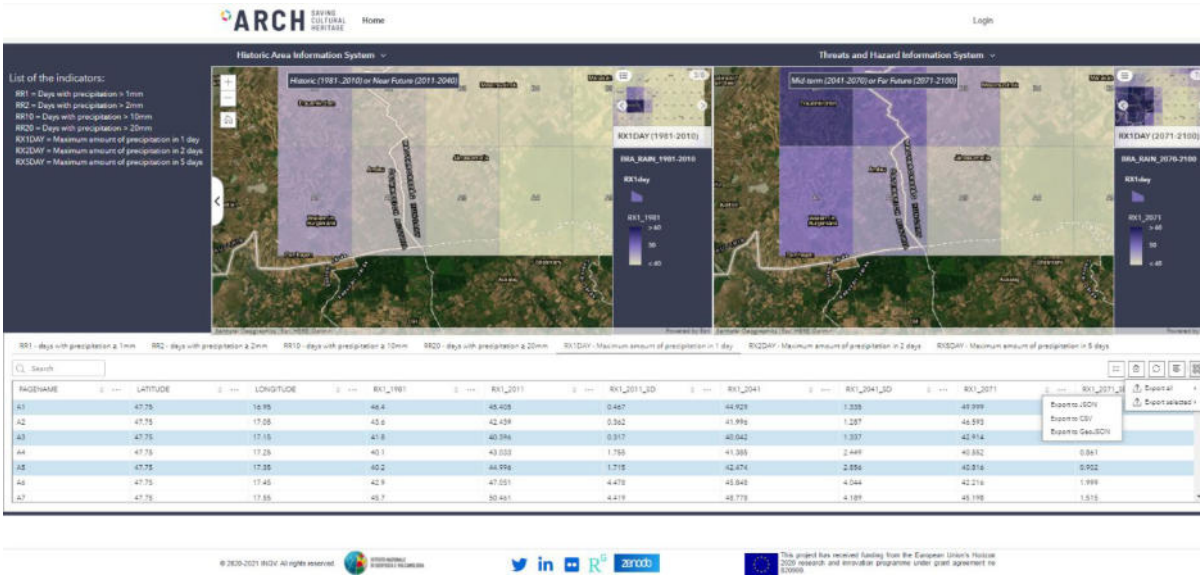


Figure 69. Climate services dashboards: datasets for Valencia (a) and Bratislava (b)