Optimized Full Prototype of Citizens Science Concepts for Urban Climate Monitoring

Deliverable 4.4

This document describes the optimized full prototypes of the Urban Climate Monitoring which is represented by T4.1 (Citizen Science in Data Acquisition and Evaluation), T4.2 (Citizen Weather Sensation Engine for Personalized Climate & Weather Feeling) and T4.3 (Citizen Science on historical weather and climate data). It also includes a prototype regarding Standard Operation Procedures for citizen data collection campaigns.

September 2024

Foreword

Welcome to the CityCLIM project. Europe's metropolitan areas are increasingly suffering from the effects of climate change. Prolonged heat waves pose a threat to the health of the population. To counter this threat, it is important to understand its causes and identify suitable countermeasures in good time. For this reason, the EU funded the project "Next Generation City Climate Services Using Advanced Weather Models and Emerging Data Sources", or CityCLIM for short (2021-2024), as part of its Horizon 2020 programme. The aim of the project was to develop a cloud-based platform which provides various weather and climate services specifically for metropolitan areas based on data from weather models, Earth observation and ground measurements.

Heat waves are a major problem for densely populated areas

As a result of climate change, heat waves are occurring with increasing frequency. Especially densely populated areas are strongly affected by high temperatures, as the heat usually lasts longer and temperatures hardly drop even at night. For this reason, the health burden caused by heat is significantly higher in cities than in surrounding areas. This is why the CityCLIM project aimed to develop a weather forecast model tailored to the needs of large cities. Unlike conventional forecast models, which resolution are usually in the range of several kilometres, the new weather model has a resolution of one hundred by one hundred meters. In addition, the model combines data from satellites with measurements from in-situ sensors and information provided by the population itself.

Weather and climate services for citizens and city administrations

The improved weather model and Earth observation data are the basis for deriving a suite of City Climate Services for combating some of the negative effects of climate change in cities, namely:

- Climate Information Services: Heat Wave Information and Warning, Pollution Information, historical Climate Information Service
- Citizen Weather Sensation Service
- Identification Services: Heat Island, City Air Flow and Pollution Area
- Simulation and Mitigation Strategies Services: Heat-Island, City Air flow and Pollution

These services are made available to the general public, specifically addressing citizens, city councils and other authorities. The services make it possible, among other things, to examine the effects of urban planning measures on urban heat or air flow.

Implementation by a European consortium

Several European companies were involved in implementing the CityCLIM project. OHB System AG was acting as the project coordinator and was responsible for processing and providing the satellite Earth observation data and services. OHB Digital Connect developed an airborne system to validate the calculated model predictions with thermal infrared measurement data. OHB Digital Services developed the cloud-based platform storing and processing the data and hosting the City Climate Services (CCS). OHB Digital Solutions from Austria was responsible for the integration of in-situ data from the pilot cities and the exchange with the pilot cities. Other industrial partners include the Institut für angewandte Systemtechnik Bremen GmbH (ATB), which was responsible for the technical coordination of the project together with OHB and was also supporting the development of the cloud-based data platform. At Meteologix AG, a subsidiary of Kachelmann GmbH, the high-resolution weather model providing the precise weather forecasts was developed. Scientific partners were the Global Change Unit of the University of Valencia, which contributed novel processing methods for thermal spaceborne data for the examination of urban heat islands. Finally, the Helmholtz Centre for Environmental Research from Leipzig developed methods to incorporate data collected by the population in the scope of citizen science.

Four European pilot cities as partners

In order to develop the City Climate Services as application-oriented as possible, the CityCLIM project was carried out in close cooperation with four pilot cities which are spaced out across

Europe to represent its climatic diversity. These are Karlsruhe in Germany, the city of Luxembourg, Valencia in Spain and Thessaloniki in Greece. The cities were contributing to the project by defining their specific needs towards the City Climate Services and the data platform, by supporting the provision of data and by enabling the project results to be validated in a real environment.

Prototype of Citizens Science Concepts for Urban Climate Monitoring

In this report you will find information to the prototypes of Citizens Science Concepts for Urban Climate Monitoring. This deliverable describes the overall workflow approach of citizen science approaches to urban climate monitoring, which is particularly reliable for the planning, coordination and implementation of such a project. This approach considers, among other things, the targeted identification of stakeholders and tools for participation, as well as data quality and ethical aspects. The deliverable will also include optimized prototype explorations and outcomes related to T4.1 (Citizen Science in Data Acquisition and Evaluation), T4.2 (Citizen Weather Sensation Engine for Personalised Climate & Weather Feeling) and T4.3 (Citizen Science on Historical Weather and Climate Data).

Based on WP4 objectives, this includes:

- Development of the prototypes of mobile and stationary sensor packages towards an easy and robust use by citizens
- Further development of the citizen science framework (SOP) for implementation and evaluation of city climate data products and services
- Further development of the citizen science data quality framework for enabling citizen scientists to easily inspect and evaluate their own data, giving them also the opportunities to provide context information (e.g., specific information about the environment in the surrounding of the measuring station) allowing a reliable assessment of data quality and data information content

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1 Introduction

Citizen science (CS) has become increasingly popular in recent years as a way of involving communities in scientific research and data collection. CS describes an approach where scientific knowledge is generated by individuals not professionally involved in the scientific field, with or without support from professional researchers (Bonney et al., 2009). Citizen science represents a collaborative scientific research effort that involves the public in the scientific process (Bonney et al., 2009). The level of involvement can range from short-term data collection to the intensive use of leisure time to explore a research topic with scientists and/or other volunteers. Although, it is not a prerequisite for participation in research projects, many volunteer scientists are educated to degree level. The objectives of CS can therefore be anything from simple data collection to more complex research studies requiring the use of specialist skills or equipment. Typical of many projects is the collection and analysis of data, often in collaboration with professional scientists.

Within the overall CityCLIM ecosystem, WP4 covers the city climate services related to CS and its collected data. The optimised full prototypes of the Citizen Science Concepts in Data Collection and Evaluation, Citizen Weather Sensation Engine for Personalised Climate & Weather Feeling, Citizen Science on Historical Weather and Climate Data optimised full prototype approach also include an online guide to Standard Operating Procedures (SOPs) for Citizen Data Collection Campaigns, covering 12 different steps from defining the project goal to post-project activities.

In this context, deliverables D4.4 & D4.3 cover the results of the full prototype of the envisaged Citizens Science Concepts for Urban Climate Monitoring. D4.3 builds on the results of D4.1 Specification of Citizens Science Concepts for Urban Climate Monitoring and D4.2 Early Prototype of Citizens Science Concepts for Urban Climate Monitoring. D4.4 is an optimised version of D4.3. The CityCLIM system architecture described in D4.1 highlights the platform, its components and their interaction, which includes the main functionalities of the CityCLIM concept. D4.4 covers the optimised full prototype of the Citizen Science concepts work of T4.1 (Citizen Science in Data Acquisition and Evaluation), T4.2 (Citizen Weather Sensation Engine for Personalised Climate & Weather Feeling) and T4.3 (Citizen Science on Historical Weather and Climate Data).

There are many benefits to citizen science projects, including learning opportunities, personal enjoyment, social benefits, publication of research findings, contribution to scientific evidence that can influence policy at many levels (local, national and international), and connecting the wider community to science (NSW, 2024). The benefits to citizens are opportunities to engage with science and contribute to important research efforts. For professional scientists, citizen science projects can help collect data that would otherwise be difficult or impossible to collect. They can also help raise public awareness of science and its importance.

For the best results from citizen science projects, careful planning is vital. Setting clear goals and objectives is important for any citizen science project, as it helps to guide the project's activities and assess its impact. In particular, when collecting environmental monitoring data for a CS project, the aim should be to obtain meaningful, useful data to advance scientific understanding (Sachs et al., 2007), so the planner should know what kind of available technology is appropriate and what its strengths and limitations are. In addition, citizen scientists can be involved in different stages of the scientific process by participating in developing research questions, designing methods, collecting and analysing data, and communicating results. Therefore, proper planning and coordination is essential to achieve the best possible results and to save citizens' time (NSW, 2024). It should be mentioned that planners and coordinators should take into account legal and ethical considerations, and that citizen scientists should be appropriately acknowledged in all forms of communication. These considerations include copyright, intellectual property, data sharing agreements, confidentiality, attribution, the safety and well-being of participants, consultation with traditional owners, and the environmental impact of any activities (NSW, 2024).

2 Optimized Prototypes of Citizens Science Concepts for Urban Climate Monitoring

The CityCLIM project involves citizens in the collection of in-situ data using stationary weather stations and mobile devices. This is one of the value propositions of CityCLIM since no other project has explored urban climate using an operational weather model enriched with in-situ and EO data while integrating citizen science (D1.1 State of the art Update, Requirements and Pilots Specifications [1]).

Another important context is the urban environment in which CityCLIM citizen science activities will take place. Cities, with their dense population and infrastructure, are more vulnerable to climate change than less populated regions. However, there is also more potential for climate adaptation solutions, as cities have more resources and power, and citizens themselves can act as catalysts for societal change. The citizen science data collected through CityCLIM activities and services in the pilot cities will provide opportunities for co-design methodologies for urban climate adaptation. An advantage of co-design is that the participatory role of citizens is more likely to result in policies and adaptation measures that are more relevant to the communities they serve. Participation in citizen science activities alone will raise social awareness of urban climate change and engage citizens in climate action.

In the CityCLIM project, there are various targets for involvement of citizen scientists:

- Stationary/mobile acquisition of weather data
- Collection of historical weather data
- Development of weather sensation engine for personalized climate/weather feeling
- Evaluation of output of forecast/sensation engines, and
- Evaluation of potential climate adaption measures of cities (D1.3 CityCLIM Public Concept [2]).

The aim of these targets is to make citizens aware that climate change is already visible and detectable in their local community, with a focus on providing climate knowledge needed for citizens' lives. The targets will be achieved through CityCLIM tasks and services: Citizen Science in data collection and analysis, Citizen Weather Sensation Engine for personalised climate and weather sensations, and Citizen Science on historical weather and climate data. Citizens will gain awareness and insight into weather and climate-related processes in the (urban) environment by collecting local and historical data and visualising it in a way that is accessible to non-scientific audiences (e.g. removing access barriers such as the need to download data). The citizen weather sensation map will be another way for citizens to engage with their local urban climate conditions at an individual level. The following section presents the targeted approach to understanding the participants of the CityCLIM citizen science services using a stakeholder analysis methodology.

In addition, an optimised full prototype including the planning workflow of citizen science projects, in particular the Standard Operating Procedures (SOPs) for citizen data collection campaigns, covering 12 different steps from defining the project goal to post-project activities, is established and available.

2.1 Standard Operation Procedures for citizen data collection campaigns

There are many benefits for science, society and the participants from CS projects. Citizen science projects produce data to answer scientific questions and solve real-world problems, providing learning opportunities, social benefits, and contributing to scientific evidence. Such projects can raise public awareness and contribute to important research efforts. Low-cost sensors are crucial for citizen scientists to collect data on environmental factors like air and water quality, providing valuable insights for policy decisions and public health initiatives, but are not a replacement for traditional scientific methods. Key performance indicators are important to evaluate e.g. scientific outputs, data quality, participant experience, and stakeholder dialogue.

To achieve optimal results from citizen science projects, clear goals, appropriate techniques, and active participation from citizen scientists are crucial. Legal and ethical considerations, including copyright, intellectual property, confidentiality, and environmental impact, should be taken into account. The objectives and goals of the research activities need to be defined as clearly as possible to ensure a productive citizen science data collection campaign. The implementation process of a citizen science campaign includes setting precise goals, specifying the research question, defining the outcomes, and establishing success criteria. It also involves managing the flow of data, choosing appropriate sensor equipment, selecting suitable participants and setting up an implementation plan. Participants are recruited and trained, and measurements are taken for testing and comparison. Data quality issues are addressed and measurement campaigns are set up. Press releases and events are prepared, and citizens' efforts are recognised and rewarded. Analysing, evaluating, processing, visualising, trending and storing data according to FAIR principles are all steps in the process. The results will then be shared with the public through events, publications in scientific journals and the media. The workflow also includes evaluating post-project activities, assessing long-term impact, exploring funding opportunities, forming new collaborations, and disseminating project results and lessons learned.

The CityCLIM Citizen Science Standard operating protocol (CityCLIM SOP) focused on streamlining a citizen science project's workflow, recruiting and deploying citizens for data collection campaigns (using in-situ sensors and historical climate data), completing recruitment materials for these campaigns, implementing web application forms, and developing questionnaires that were given to participants in pilot cities to inquire about their expectations for communication, visualization, and rewards as well as their motivations and obstacles. The following 12 stages were identified and are included in the CityCLIM SOP (Figure 1).

URL link: https://www.ufz.de/index.php?en=51534

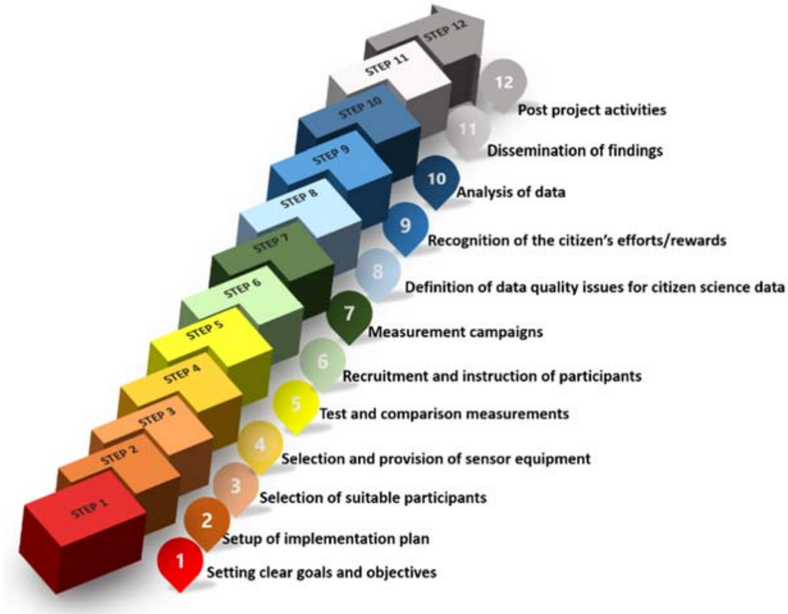

Figure 1: Overview of the CityCLIM Citizen Science SOP.

Key features:

- Cover all aspects of the planning, execution and finishing of a CS project
- Definition of Standard Operating Procedures (SOPs) for citizen data collection campaigns
- Definition of questions for each step within the SOPs
- Online guideline is available

Methodology

This prototype describes the planning workflow of citizen science projects, in particular the Standard Operating Procedures (SOPs) for citizen data collection campaigns, which cover 12 different steps from defining the project goal to post-project activities. The SOP for citizen data collection campaigns has been developed in collaboration with e.g. pilot cities for the CityCLIM project, focusing on clear objectives, activities, expected data and stakeholder characterisation. In the online tool, each step is explained in more detail and questions are defined. These questions will help people planning CS projects to consider all aspects of such projects and integrate them into their plans. The results of a questionnaire answered by participants in the pilot cities confirms some key points of the workflow.

Application potential

- These SOP provide valuable guidance and best practices for researchers and project managers who want to actively involve citizens in their research. They cover various aspects of project planning, from conception to implementation and follow-up.
- Also, this tool enables administration and project funders to understand the process of planning and executing a citizen science project and establish the requirements for CS activities accordingly.
- This tool also enables participants to understand the entire process of CS projects and the means and methods used, which can increase their motivation to take part in such a complex project.

Main achievements

Online tools such as Zooniverse, CitSci.org, Maptionnaire, iNaturalist and KomMonitor offer a wide range of features to efficiently plan, implement and manage citizen science projects. These features include project planning, participant management, data collection, data analysis, communication platforms, surveys, reporting, geospatial management and visualisation of environmental data.

However, there are a number of requirements that need to be taken into account when planning citizen science projects in order to ensure the success of the project and to achieve both scientific and societal goals. Only through careful planning and coordination of all the necessary elements or steps can a project be successfully implemented and achieve both scientifically valuable and socially relevant results. Furthermore, coordinating citizen science projects is a challenging task that requires careful planning and implementation to enable successful collaboration between scientists and citizens. Successful coordination of citizen science projects requires a balance between clear communication, participant support, quality management, motivation, technological infrastructure and resource management. Closing a citizen science project is also a carefully planned process that includes recognising participants, evaluating results, ensuring sustainability and clear communication.

There are a number of guides that have been developed specifically to support the planning and implementation of citizen science projects (e.g. European Citizen Science Association (ECSA) Ten Principles of Citizen Science, Green Paper on Citizen Science, Citizen Science Toolkit from SciStarter, Citizen Science Guide from CitSci.org). The comprehensive tool described here takes all steps into account and therefore provides valuable support for the successful planning and implementation of citizen science projects.

2.2 Citizen Weather Sensation Engine

The Heat Sensation Engine is a personalised weather tool or map that allows users to select their thermal comfort zone.

The perception of weather and climate is subjective and highly individual. For example, people from cold regions perceive temperate regions as warm, while people from hot regions perceive the same temperate region as cold. This is known as 'acclimatisation' and means that people from certain climates have become accustomed to the temperatures there, which affects their sensitivity to other climates. It is also important to understand the differences in comfort temperatures between men and women. Studies consistently show that women prefer warmer temperatures. Age also plays a role: older people tend to have a lower tolerance to heat than younger people, i.e. their perception of heat may be the same, but their tolerance to extreme temperatures is lower. Other factors such as seasonality, number of layers of clothing worn, activity level, health status and social factors (our desire to fit in with others, our knowledge/attitude) can also influence thermal comfort and risk. When you check the weather on the news or on your favourite weather website, you will usually see the air temperature. However, in addition to air temperature, there are many other environmental variables that can affect how warm you feel. Examples include humidity, wind speed, shade and surrounding vegetation. The heat index is one way to get a more accurate idea of "how hot it really is". In addition to air temperature, relative humidity is also included in the calculation.

The idea behind this is the interaction of the body with the ambient temperature through perspiration, which is dependent on humidity. Sweat evaporation is a cooling process for the human body, so if sweat cannot evaporate effectively (e.g. if the humidity is already high), the body would feel warmer than the actual air temperature. There is a direct correlation between air temperature and relative humidity and the heat index: the higher the air temperature and relative humidity, the higher the heat index and vice versa. For example, if you read in the newspaper that tomorrow's temperature will be 29°C, you might think that it will be a nice summer day to be outside. However, you may not realise that the humidity will also be very high (e.g. 90%). This means that you will feel as if the temperature is 39°C. With this information, you may want to stay indoors where it is cooler to avoid health risks such as heat stroke.

Key features:

RTL Luxembourg worked with Meteologix and the Helmholtz Centre for Environmental Research - (UFZ) in Leipzig to create a special feature on the RTL app and website that allows citizens to view their personal weather map. Users can enter their subjective temperature preferences and the map uses a 'traffic light' system to show which areas are likely to be at optimal thermal comfort and which areas should be avoided at certain times, for example during certain heat waves.

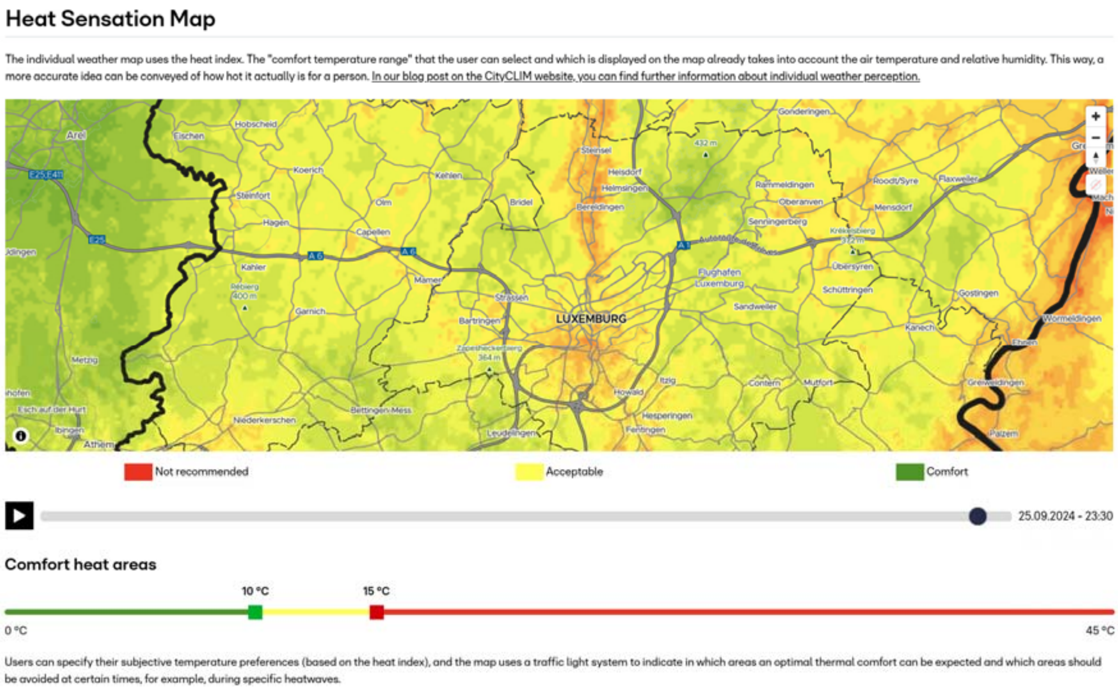

Figure 2: Heat Sensation Map at RTL Luxembourg

Methodology

The individual weather map uses the heat index. The Heat Index is an index that shows how humidity affects the feels like temperature in hot weather. The higher the humidity, the higher the perceived temperature appears than the actual temperature. The Heat Index is always higher than the actual air temperature. The 'comfort temperature range', which can be selected by the user and displayed on the map, already considers air temperature and relative humidity, giving a more accurate idea of how hot it actually is for a person. RTL Luxembourg app is hosting the Citizen Weather Sensation map (https://www.rtl.lu/meteo or the Englisch page https://today.rtl.lu/info/weather) which is based on the heat index and testing were done on the existing userbase.

Application potential

- Enhance personal and localised weather insights
- Provides detailed, specific information tailored to a particular location.
- Helps individuals plan daily activities and make informed decisions.
- Helps prepare for extreme weather events, especially for the elderly.
- Optimises personal and professional activities, including outdoor events and sports.
- Helps improve energy management and conservation by enabling informed decisions about heating and cooling.
- Aids in health and safety considerations, helping to manage symptoms and prevent weather-related health conditions.
- Reduces risks associated with outdoor activities, such as avoiding excessive exposure to the sun or ensuring safe exercise conditions.

Main achievements

Thermal comfort is difficult to measure and numerous indices have been proposed over time. It does not depend solely on environmental parameters, and physiological/personal variables can also influence subjective perception. For example, clothing insulation, activity level/metabolic rate

(Fanger, 1982), subjective factors (age, health status, chronic illness) (Beckmann et al., 2021) and social factors (our desire to fit in with others, our knowledge/attitude (Diffey, 2018) can all influence thermal comfort and risk.
RTL Luxembourg, in collaboration with MTL and UFZ, has enhanced the RTL app to allow users to express their subjective temperature perception. The aim is to raise awareness of local weather conditions and how objective measurements translate into subjective thermal perception.

The City Weather Sensation Map is a tailored weather map that incorporates the Heat Index (HI) and allows users to select their 'comfort temperature range', taking into account both air temperature and humidity. This provides a clearer understanding of the perceived temperature for an individual. The map is designed to help plan activities, with colours indicating comfort levels: green is ideal and red suggests avoidance. Users can adjust their comfort preferences and the map, part of the Citizen Weather Sensation Service, is generated based on these settings, helping users to decide on their activities and locations accordingly.

2.3 Historical Climate Data Engine

The Historical Climate Data Engine draws on a variety of sources, not just citizen-collected data. The goal is to inform citizens that climate change is already visible and detectable in their community by collecting local and historical data. D6.1 provides technological explorations of the Historical Climate Data Engine's software, module, and interface, including component/sequence diagrams and data flow.

Here the description focuses on how historical data can be collected from citizens especially the dedicated citizen science landing page hosted on meteologix.com and the digital web form provided.

The citizen historical climate data collection task requires also to provide the opportunity for data input in a digital web form format for privacy or other reasons. This web form format includes predefined fields, free form entry, and drop-down menus. Such web-based forms are generally more accessible to a wider audience and very user-friendly. Participants can easily access the questionnaire via a link on a website, social media, or email, without needing to download or install additional software. Such a web form also allows participants to remain anonymous or to provide only certain information, which in some cases is important. This encourages broader participation, especially from people with limited technical expertise. The web form includes a file upload option in several file formats (txt,xls,csv,doc,png,jpg).

Key features

- Easy to understand data upload in two common formats (csv, txt) via a landing page hosted by meteologix.com
- Second option a digital web form for data upload
- Collection of metadata and contact data in agreement with privacy and ethical issues
- Easy-to-use webpage hosted on meteologix.com that enables citizens to easily explore climate information and display data as plots, maps, and climate stripes

Methodology

MTL has built a dedicated citizen science landing page hosted on meteologix.com that allows manual data upload (csv, txt) by citizen scientists along with a set of metadata and personal data.

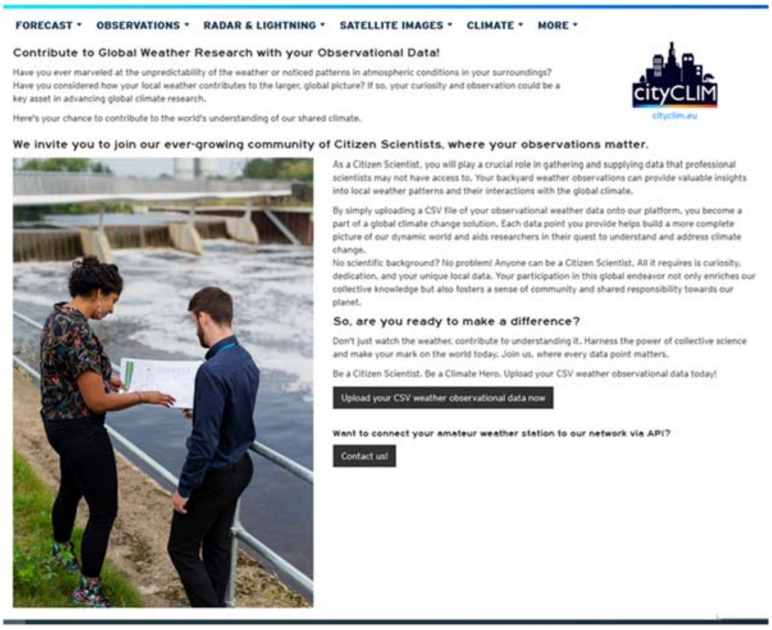

Figure 3: Website to upload historical data

It implements live column matching of uploaded documents to MTL database columns to ensure fast processing and display of data on the website. Interested citizens can also register their weather station with us via API and send us the data, which would then appear here: https://kachelmannwetter.com/de/amateurstationen/deutschland/temperatur/20230904-0600z.html

Following metadata of the historical data are needed:

- Latitude, longitude,
- elevation,
- what name should be on the map
- and what type of air pressure is the station reporting
- Station Type
- Optional: picture of the station (how it is setup)
- consent that the data can be displayed on the website

A direct upload is possible at:

- https://meteologix.com/ng/info/citizenscience
- https://kachelmannwetter.com/de/info/citizenscience

The format expected by the tool is Comma Separated Values (CSV). To submit data, the user can either drag and drop their files or browse the files on their device and locate the file to upload. Once the file is selected and placed in the upload field, the program automatically processes the CSV and automatically detects columns and values. The user then has the option of specifying each column and what values are captured. Depending on the values specified, different additional value drop down menus will appear. For example, if a column is specified as 'Date', a further dropdown will appear asking for the date format used, or if a column is specified as 'Temperature', the unit and time interval will be asked for. After the user has provided information for each column, additional meta information is requested that is required to display the station data in the correct location and to sort the station data to the correct location and time. Contact information and a station name are also required. Finally, a captcha must be filled in to prevent malicious bots and programs from uploading data. After the user submits the data, it is stored in the database of Meteologix's and processed. Meteologix's perform certain plausibility checks and finally upload the data to our website within the "Amateur Station" network: https://meteologix.com/fr/weather-reporter/france/weather-observation/20240507-0400z.html.

However, the citizen historical climate data collection task requires also to provide the opportunity for data input in a digital web form format for privacy or other reasons. This web form format includes pre-defined fields, free form entry, and drop-down menus. Such web-based forms are generally more accessible to a wider audience and very user-friendly. Participants can easily access the questionnaire via a link on a website, social media, or email, without needing to download or install additional software. Such a web form also allows participants to remain anonymous or to provide only certain information, which in some cases is important. This encourages broader participation, especially from people with limited technical expertise. The web form includes a file upload option in several file formats (txt,xls,csv,doc,png,jpg).

Based on the early exploration of voluntary weather data entry forms explained in D4.2, a data entry form using LimeSurvey (https://survey.hifis.dkfz.de/544485?lang=en) has been created.

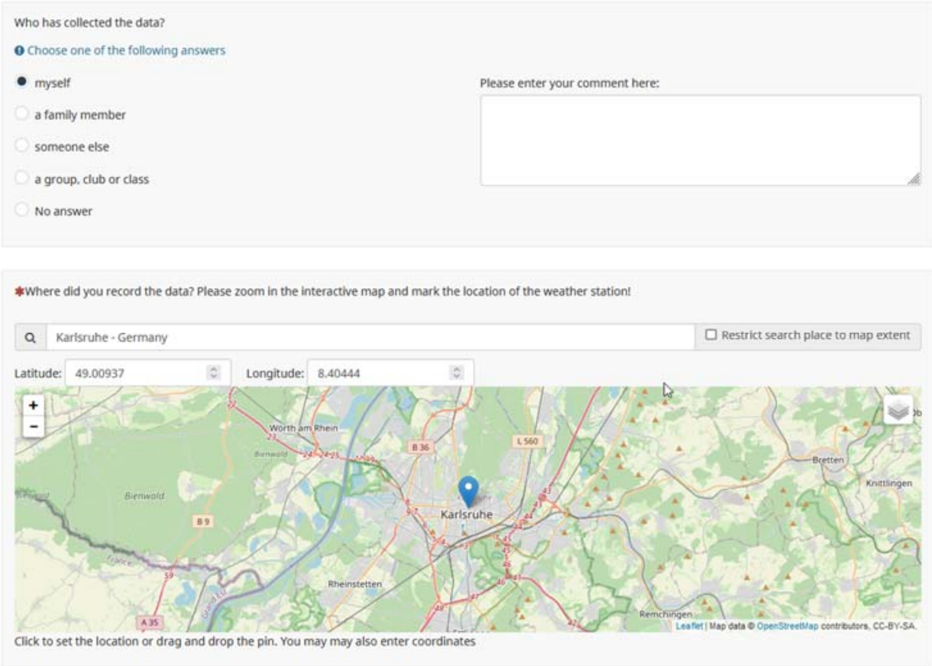

Figure 4: Questionnaire regarding upload historical data

In this web form following questions are asked:

- Are you interested in data evaluation and data analysis (e.g. comparing your data with a city temperature map or remote sensing data)?
- In your opinion, who would be interested in the results of this historical data collection?
- Would you be willing to share your historical weather data with us?
- If you were to share your historical weather data with us, what level of control would you prefer to have over what data is shared with whom (select one)?
- Are you authorised to share this historical weather data with us?
- For what purpose did you record this weather data?
- Which measuring device do you use?
- Who has collected the data?
- Where did you record the data? Please zoom in the interactive map and mark the location of the weather station!
- For which period can you provide us with the data? State the starting time of the measurements!
- For which period can you provide us with the data? Name the end point of the measurements!
- Describe the location of the device?
- Please select the parameters that have been measured! Please indicate the units of the measured parameters in the comment line!
- In what format is your historical weather data available?
- Do you have other data to upload from the same location?
- Do you have any comments or remarks you would like to share with us?

The uploaded data is QA/QC checked and then made available to the Historical Climate Data Engine for visualisation and further analysis.

A webpage in German to collect citizen observations was created on the UFZ website: https://www.ufz.de/index.php?de=51436.

Application potential

Historical weather data is critical for analysing long-term climate trends, studying extreme weather events, developing climate models, assessing environmental impacts, disaster preparedness, agricultural planning, energy forecasting, urban planning, health and safety assessments, and providing context for historical events and societal changes. It helps predict future weather patterns, assess the impact on ecosystems and plan for disasters. It also helps to predict energy needs, design infrastructure for extreme weather conditions, and study health-related issues. Overall, historical weather data provides valuable insights into human history.

Main achievements

The Historical Climate Information Service on Meteologix is based on historical weather observations that include citizen observed data. For example, the oldest data observations are digitized from hand written meteorological observations. Currently, as mentioned above, interested citizens are able to register their amateur weather stations or submit weather information digitally. The Historical Climate Information Service takes this complex and vast amount of climate data and translates the information into an easy and understandable format to citizens, in order to enable them to explore local climate information on their own and without the help of experts. The user interface is easy to use, data is quickly retrieved, and information is displayed in visually appealing Climate Stripes, Heat Maps, and Time Series plots. These plots are easily downloadable and shareable, which empowers citizens to obtain knowledge about their own local environments and to educate others about changing climate. This service is planned to be extended not only over the rest of the project's timeline but also beyond the project, adding more and more data sources to it (including citizen science sources) in order to enrich this service and make it a better source for conclusive local climate information. Through this service, citizens with amateur weather stations and those interested in accessing climate data will continue to be engaged.

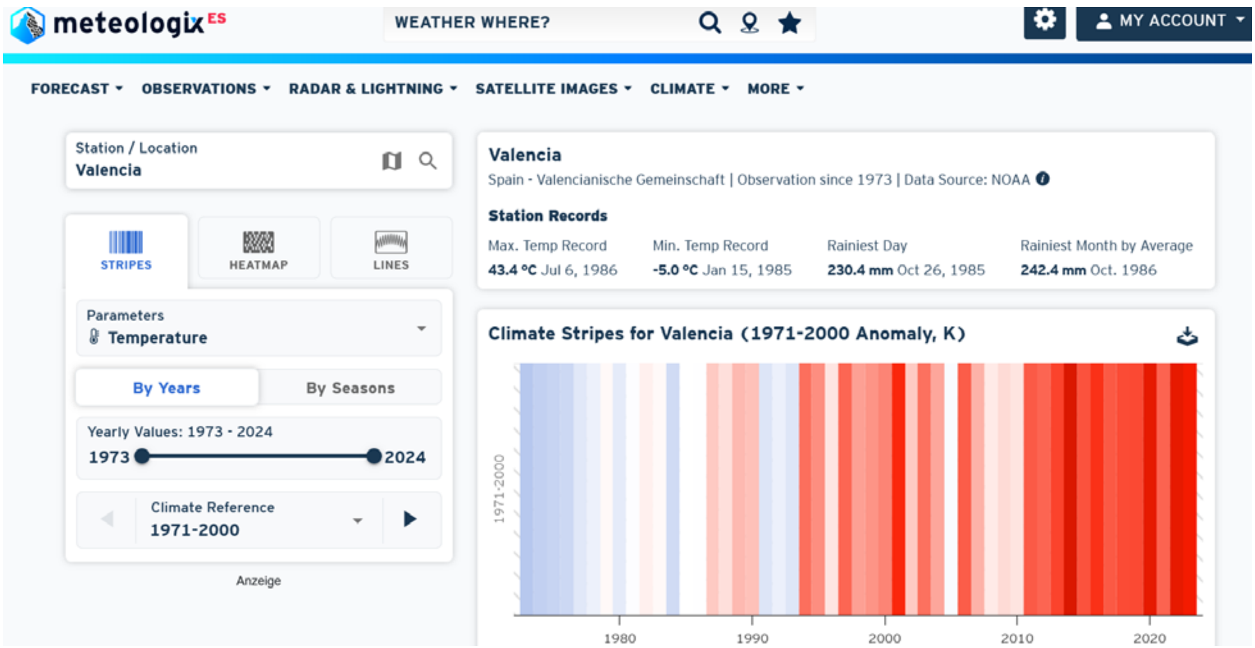

Figure 5: Front end of the Historical Climate Information Service on Meteologix, which sources historical weather observations from professional and amateur meteorological data

3 Conclusions

Citizen science (CS) involves communities in scientific research and data collection, generating knowledge from individuals without professional support. CS can range from short-term data collection to complex studies requiring specialist skills. There are many benefits for science, society and the participants.

The need to communicate effectively with the public is common to all citizen science projects. This is to recruit and retain citizen scientists, but also to keep them informed, train them and thank them in the right way at the end of the project. The CityCLIM project has developed a Standard Operation Procedure (SOP) for citizen science activities to address this need. Twelve basic steps for planning, designing and implementing a citizen science project are outlined in this SOP. The steps are presented online in a sequence, but each step also stands on its own. Each provides resources to help you answer your specific questions. If you are in the process of setting up a project and want to involve volunteer citizen scientists, our online tool will guide you through the steps. The purpose of these SOPs is to provide academic researchers, their institutions and funding bodies with principles and guidelines on how to carry out citizen science projects in an academic setting. They provide answers to pertinent questions, thereby helping to make Citizen Science projects more attractive to researchers and helping to recognise and legitimise them. The standards address specific issues of citizen science and offer ways to address them.

All eyes are on the temperature as the summer heat heats up. But often, experts say, it's the heat index that should be of greater concern. The heat index measures how hot it really feels outside when humidity and other factors are considered alongside temperature. This has important implications for the comfort level of the human body. When the body gets too hot, it will start to sweat or perspire in order to cool itself down. If the sweat is not able to evaporate, the body will have no control over its temperature. Evaporation is a process that cools you down. The body temperature is effectively lowered when perspiration evaporates from the body. However, when the air humidity is high, the rate of evaporation from the body is reduced. In other words, the human body feels warmer in humid conditions. Some agencies, such as the US National Weather Service, use heat index values to know when to issue heat advisories, watches and warnings, which urge people in an area to stay indoors during the hottest parts of the day. For example, on a day when the temperature outside is around 33°C and the humidity is 70%, the heat index is 44°C. When the heat index reaches this level, it's dangerous and can cause sunstroke, muscle cramps and heat exhaustion. Heat stroke is also a risk for those who are physically active or who are outdoors long enough in these conditions. With the help of the Citizen Weather Sensation map, comfort zones can be defined, and the user can identify areas that are no-go areas or preferred areas. Employees in old people's homes or kindergartens can also use this map to plan outdoor activities and help to gauge the maximum amount of time that should be spent outside.

CityCLIM developed user-friendly platforms (landing page on meteologix.com and online tool for data upload) that allow citizens to easily share their historical weather observations. Historical climate data is a valuable resource for understanding and addressing environmental challenges. It helps scientists identify long-term trends and variations in temperature, precipitation and other climate variables, and provides a baseline against which to assess current climate change. It also plays a critical role in studying extreme weather events such as hurricanes, droughts, floods and heat waves to better understand their frequency, intensity and impact. Accurate climate models rely on historical data to simulate past conditions and predict future scenarios, helping policymakers assess potential impacts on sectors such as water resources, agriculture and public health. Historical climate data is also essential for understanding ecological change, as shifts in temperature and precipitation can affect the distribution of plant and animal species, migration patterns and overall biodiversity. It also provides insights into past human societies, offering lessons for contemporary climate adaptation efforts. Overall, historical climate data is a valuable resource for predicting future climate change and preparing for its impacts. Therefore, such data are important for many different stakeholders. Citizen contributions can provide valuable localized data, especially in areas where official weather stations are sparse or historical records are incomplete.

It is anticipated that citizen science initiatives will have had a significant impact by raising public awareness of urban climate change and igniting public interest in climate action. Citizens involved in the data collection campaign using mobile and stationary weather sensors reached over a thousand people, which included volunteers riding bicycles with MeteoTrackers, citizens that maintained weather stations on their balconies or backyards, and teachers with school children that installed weather stations in their schools. Citizen science data gathered from CityCLIM services create opportunities for co-design approaches for city climate adaptation, resulting in a greater commitment from cities to involve the public in decision-making and to motivate citizens to participate more actively in political processes.

4 References

Beckmann, S.; Hiete M., Beck, C. (2021). Threshold temperatures for subjective heat stress in urban," Climate Risk Management, vol. 32, p. 100286, 2021

Bonney, R., Cooper,C., Ballard, H. (2016). The Theory and Practice of Citizen Science: Launching a New Journal. Citizen Science: Theory and Practice, 1(1): 1, pp. 1–4, Doi:10.5334/cstp.65

Diffey, B. (2018). Time and Place as Modifiers of Personal UV Exposure," International Journal of Environmental Research and Public Health, vol. 15, no. 6, p. 1112, 2018.

Fanger, P.O. (1982) Thermal comfort. Analysis and applications in environmental engineering, Thermal comfort, Malabar : Robert E. Krieger Publishing, 1982.

NSW Government (2024). SEED Citizen Science Hub: Connecting people, projects and data, Fact Sheet, Available online at https://www.seed.nsw.gov.au/sites/default/files/2020-11/DOC20%20575512%20%201654_SEED_Citizen-Science-Hub_Fact-sheet.pdf, latest access on 12 April 2024

Sachs, S., Super, P.E., Prysby, M. (2007). Citizen Science: A Best Practices Manual and How it Can be Applied, Proceedings of the 2007 George Wright Society Conference, 280-284, Available online at http://www.georgewright.org/0753sachs.pdf on 12 April 2024, latest access on 12 April 2024

About CityCLIM

The strategic objective of CityCLIM is to significantly contribute to delivering the next-generation of City Climate Services based on advanced weather forecast models enhanced with data both from existing, but insufficiently used, sources and emerging data sources, such as satellite data (e.g., Copernicus data) or data generated by Citizens Science approaches for Urban Climate Monitoring etc. For City Climate Services, data products of interest related to land surface properties, atmospheric properties (e.g., aerosol optical thickness), geometry etc. For all of those, information of interest concerns e.g., Copernicus data products and services that are already existing (e.g., based on Sentinel-3/OLCI, PROBA-V, SPOT, Sentinel-1, MetopASCAT data), will exist in the near future (based on already flying satellites such as Sentinel-2), or will exist in the mid-term (based on satellites currently under development) and long-term (based on satellites soon starting concept phase) future. The project will establish; (i) an open platform allowing for efficient building of services based on access to diverse data; (ii) enhanced weather models based on data from diverse existing and emerging sources; (iii) a set of City Climate Services customizable to specific needs of users in cities; and (iv) a generic Framework for building next generation of Urban Climate Services. CityCLIM will be driven by 4 Pilots addressing diverse climate regions in Europe (Luxembourg, Thessaloniki, Valencia, Karlsruhe) which will define requirements upon the tools to be developed, support specification and testing of the services and serve as demonstrators of the selected approaches and the developed technologies. The consortium will elaborate business plan to assure sustainability of the platform and services.

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