Optimized Citizen Climate Services

Deliverable 6.3 – Optimized Prototype of the Citizen Climate Services

This deliverable outlines the key services targeted at citizens developed within the CityCLIM project.

September 2024

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Change History of D6.3

Include Parameters for the Pollution Information Service	A new section (4.2.) has been added with the list of available parameters and the requirements of adding potential other parameters into the service.	23.01.2025
Provide Updates on the Pollution Information Service for Valencia	Added in the “main achievements” section 4.5	23.01.2025
Include Access Links to Services	Links to all services have been added to the document and additionally made more prominent on the project’s website cityclim.eu.	23.01.2025

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 provide 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 user-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.

Citizen Climate Services

This deliverable summarizes the main achievements within the WP6 of the CityCLIM project in regards to the Citizen Climate Services – that is, those climate services that are directly targeted to the public. It presents each service shortly and summarizes the main features and aims of the service. Every service is described and outlined as well as a short methodology

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1 Introduction

Within the overall CityCLIM ecosystem (see Figure 1-1), WP6 covers the specification, implementation and optimisation of Citizen Climate Service developed within the project as based on the City Weather Model, the GCCP as well as other data processers developed within the CityCLIM framework. Those are based on building of a reference dataset of in-situ measurements, the acquisition of high-resolution weather forecast modelling as well as the acquisition and post-processing of vast data sets of in-situ observations.

WP6 aimed at the development and provision of impactful climate change information and mitigation services for both urban and local areas, as well as large-scale country level. The services addressed all stakeholders, but each service focusses on a specific group: The City Climate City Administration service assessed and addressed the needs of each pilot city and provide meaningful and actionable insight on the current city inherent climatic conditions of each city, as well as its vulnerabilities and possible mitigation scenarios based on case studies. These have been documented in the public deliverable D6.6. The Citizen Climate services have focused on the dissemination of knowledge to all citizen about both local and regional present and historic weather conditions by providing easy-to-use web tools that make exploring easy and interesting. The work inside all WP6 tasks was structured according a development lifecycle, covering specification, development of early (TRL4-5) and implementation of full prototype (TRL6-7) solutions, and went through an ongoing refinement of developments based on T7.3 verification and validation feedback, which were reflected in the corresponding deliverables D6.1-6. This public deliverable D6.3 at the final M36 of the CityCLIM project documents the Optimized Full Prototypes (OP) of the Citizen Climate Services as a summary of the achievements of the final developments within all tasks of WP6.

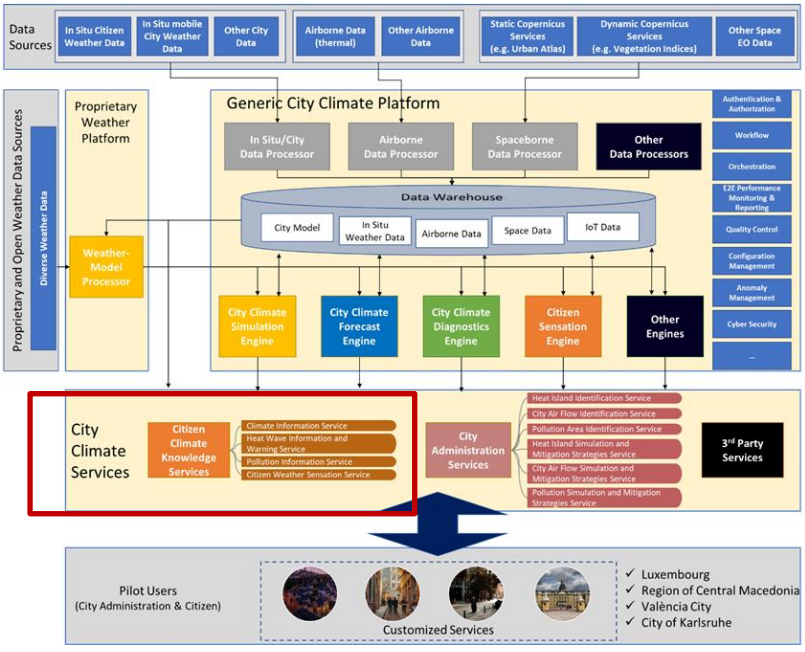

Figure 1-1. The components of WP6 “Citizen Climate Services” (red box) within the CityCLIM architecture.

2 Optimized Prototypes of Weather Sensation Service

The Weather Sensation Service is a customized technical independent prevention tool that shows its users a high-resolution weather forecast map for heat, translated into the heat index, which takes humidity and temperature into consideration. Based on this heat index, users can indicate their comfort zones of acceptable temperature and receive a tailored heat forecast map based on their indications. As such, this service provides a prevention tool that supports the avoidance of excessive heat stress for its users.

2.1 Key features

- …the Weather Sensation Service provides the user with a heat sensation map that allows for a personalized weather forecast.
- …as such it allows the user to indicate certain temperature ranges that describe comfortable, acceptable and unacceptable temperature ranges that are translated into colours.
- …these colours correspond to the temperature forecasts of the UltraHD city weather model and colorize the resulting forecast map indicating, which areas are at which time point acceptable or to be avoided by the user.
- …the heat sensation map is a prevention aid aimed at citizen to adapt their behaviour to the upcoming potentially hazardous heat conditions.
- …it engages citizen to take preventive actions and understand their local city climate.

Figure 2-1: Heat sensation map as integrated into the RTL Luxembourg weather website.

2.2 Methodology

The Weather Sensation Service utilizes two main components: The UltraHD city weather model forecast as well as a web widget solution that translates the forecast output data into a two-dimensional weather layer projected on a terrain map and a graphical user interface. The graphical

user interface allows the user of this service to indicate their own temperature ranges of comfort and is transformed by the web widget into the traffic light colouring system, resulting in a colorized temperature map that mirrors the user's comfort zones within the forecast.

2.3 Application potential

- This service is a prevention aid for citizens to increasing heat stress, especially in urban areas, where heat tends to accumulate and get trapped in so-called Urban Heat Islands.
- Cities can provide this service to their citizen to aid them identify appropriate time frames or locations of when or where to go during a heat wave.
- This service indicates when heat waves are to be expected as it provides a 48h weather forecast for the forecasted area.
- This service is designed as an easy plug-and-play service if the UltraHD model nest is in place. It can be easily integrated in any existing web-framework as the web widget solution is an independent component that does not require sophisticated web engineering to be inserted.

2.4 Main achievements

The establishment of a work flow that enables the production of high-resolution weather forecast layers into an independent web widget that includes all necessary functionality to be inserted in any web framework. As such this prevention service can be used by any interested city to inform their citizens about upcoming heat waves and where and when these phenomena might impact their daily lives. The service has been implemented on the RTL website for the city of Luxembourg and is available for usage here: https://today.rtl.lu/info/weather

3 Optimized Prototypes of Heat Wave Information Service

The Heat Wave Information and Warning Service provides weather forecasts and warnings with respect to extreme heat events using beyond state-of-the-art full physical weather models. This service is accessible by a web interface and, additionally, dedicated variants allow it to embed weather forecast information to existing websites.

3.1 Key features

A graphical user interfaces that provides …

- … weather forecast as video overlay on a map.
- … the possibility to compare specific locations with respect to their exposure to heat by line-charts.
- … export functionality for time series data.
- … an integrated user guides explaining the functionality and workflows.
- … multi-language support.
- … the additional heat index that indicates colorized temperature maps according to a traf-fic-light system colorizing areas with excessive heat in the forecast

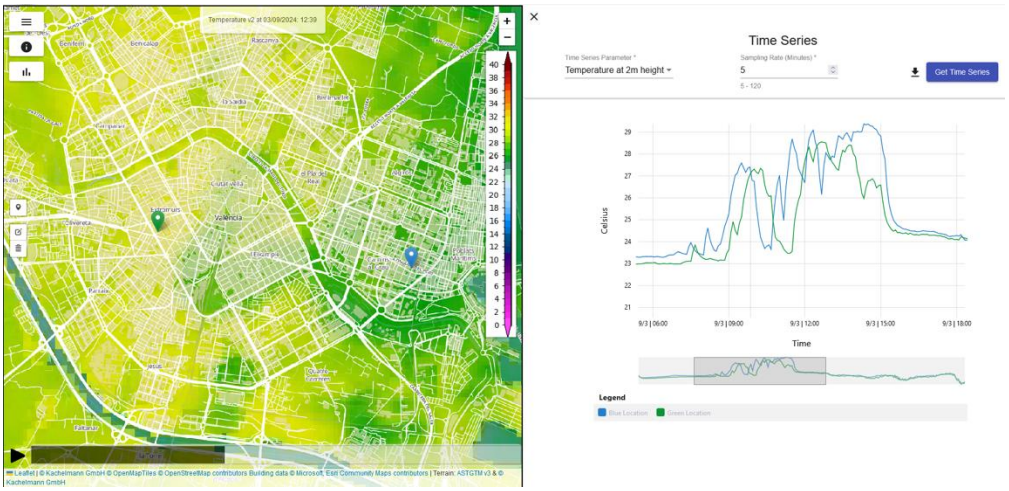

Figure 3-1: View on the Heat Wave Information Service graphical user interfaces with opened line charts showing temperature development of two locations during the next two days.

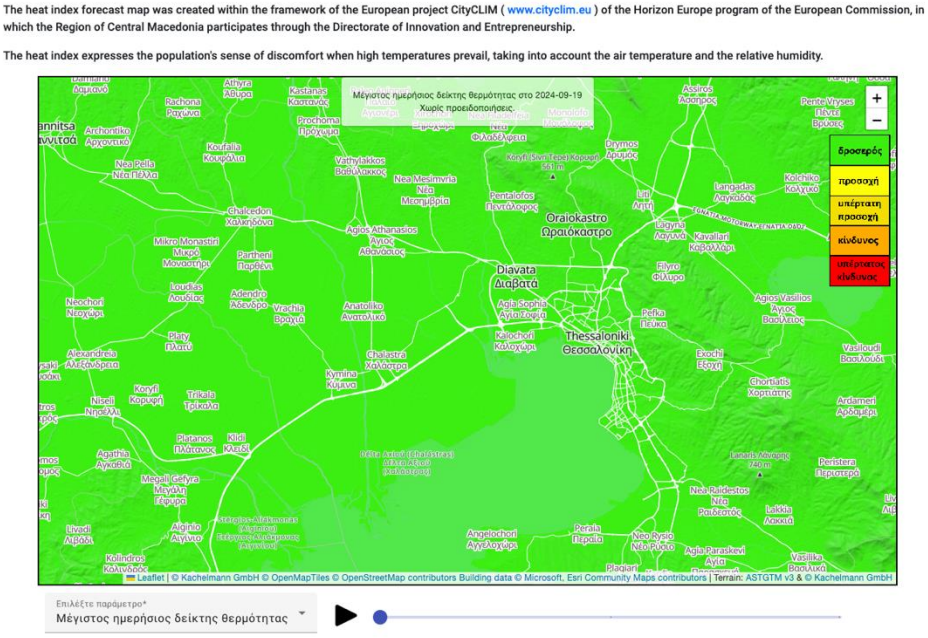

Figure 3-2: Heat information warning service as implemented for the Pilot Region of Central Macedonia (Thessaloniki) including warning colorization for different heat related parameters.

3.2 Methodology

The integrated weather models provide heat related information (e.g., surface temperature, temperature at 2m height, dewpoint, …) at 100m spatial resolution in 5 minutes steps. The weather forecast covers 2-3 days. The service moreover supports a coarser light-weighted weather model with 4km spatial resolution and hourly time steps that requires less computational resources.

3.3 Application potential

- Identify heat stress distribution within the urban area for an upcoming heat wave.
- Release warnings to citizens for single districts in view of an approaching extreme heat event.
- Compare heat exposure and development of individual locations for an upcoming heat wave.

3.4 Main achievements

Establishment of workflows from the model applications, forecast processing to the presentation of understandable information on a web interface within an operational cloud environment. The service is available on the City of Karlsruhe's website: https://www.karlsruhe.de/umwelt-klima/klimaschutz-klimaanpassung/hitze-in-karlsruhe/stadtplan-fuer-heisse-tage-map and on the website of the administration of Thessaloniki: https://www.pkm.gov.gr/cityclim/

4 Optimized Prototypes of Pollution Information Service

The Pollution Information Services provides weather forecasts with respect to pollution distribution within urban areas using beyond-state-of-the-art full physical weather models.

4.1 Key features

A Graphical user interfaces that provides …

- … pollution forecast as video overlay on a map.
- … the possibility to compare specific locations with respect to their exposure to pollution by line-charts.
- … export functionality for time series data.
- … an integrated user guides explaining the functionality and workflows.
- … multi-language support.

4.2 Parameters

The following basic parameters have been implemented:

- HNO3 - Nitric Acid,
- NO2 - Nitrogen dioxide,
- O3 - Ozone,
- PM10 - Particulate Matter
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This list of parameters can be extended to other relevant chemicals or indices (statistical or compound parameters of air quality) depending on the availability of respective in-situ measurements.

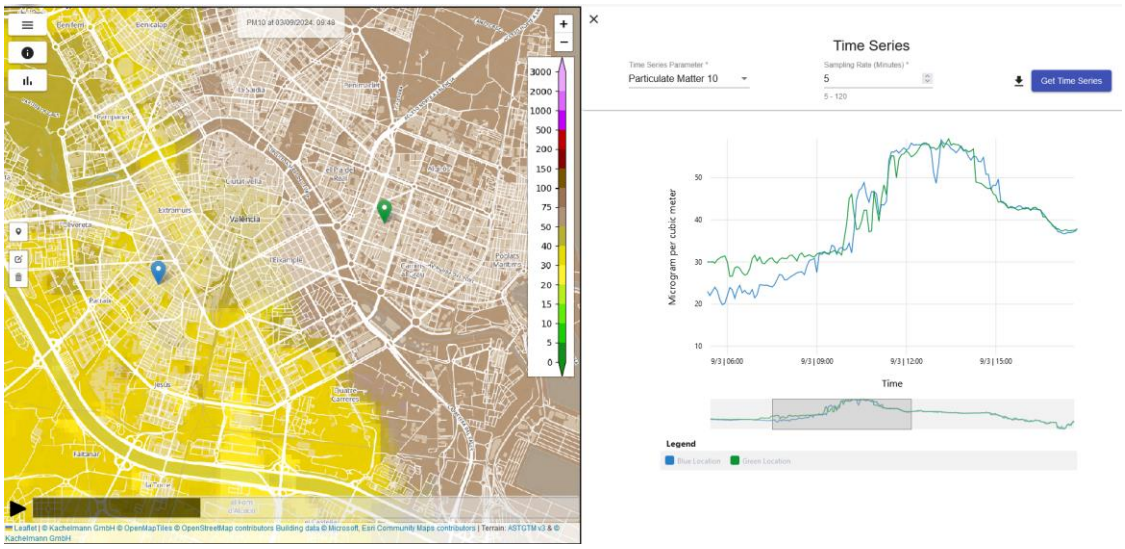

Figure 4-1: View on Pollution Information Service with opened line charts showing pollution development of two locations regarding particulate matter during the next two days.

4.3 Methodology

The integrated weather models provide pollution related information (e.g., ozone, nitrogen dioxide, nitric acid, particulate matter, …) at 100m spatial resolution in 5 minutes steps. The pollution forecast supports coverage for 2-3 days.

4.4 Application potential

- Identify pollution distribution within the urban area for the upcoming days.
- Release warnings to citizens for single districts, whenever pollution induced threats are expected.
- Compare pollution exposure and development of individual locations for the upcoming days.

4.5 Main achievements

Establishment of workflows from the model applications, forecast processing to the presentation of understandable information on a web interface within an operational cloud environment. The pollution information service has been prototypical implemented for the Pilot city of Valenica. It is available on their administration's website for citizen: https://www.valencia.es/valenciaalminut/val/projecte-city-clim.

5 Optimized Prototypes of Climate Information Portal

The Climate Information Portal provides a various number of different climate observations all over the world. The information comprised stational climate data, country/area values, and climate projections for users to investigate the changing climate conditions at various places in the world. This service is continuously extended to include more stationary data and updates daily/weekly to include latest observational data. As such, it is a key feature in the CityCLIM project to transfer complex climate data in an accessible way to citizens quick and easy. The service address people with different previous knowledge on climate - it is not necessary to have a background in data science or any technical knowledge to retrieve vast observational data sets. It provides easy-to-use graphical interfaces and functionalities allowing anyone to access terabytes of data in a matter of seconds and a few clicks.

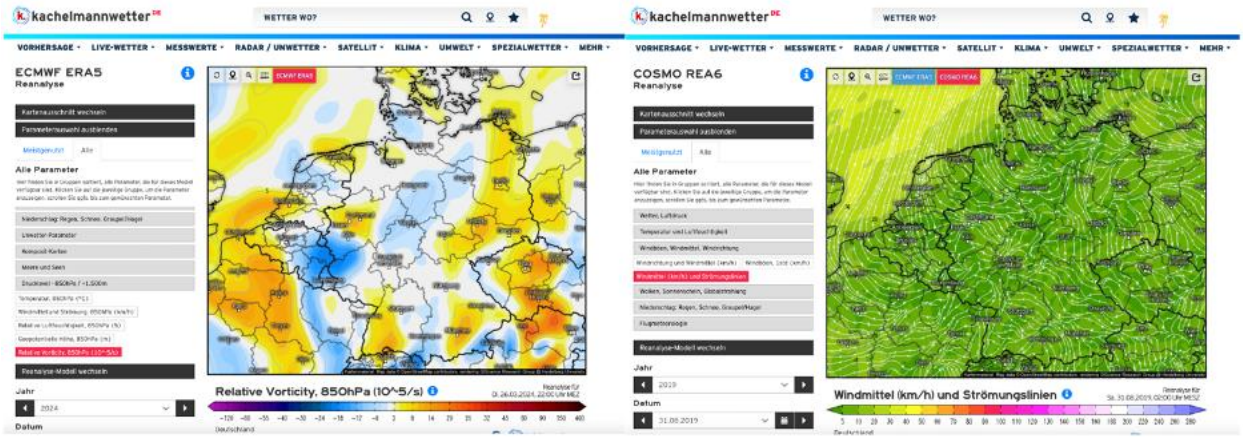

Figure 5-1: Some examples of different pages for this service. To the left: ERA5 reanalysis data displayed on a map. The 62 parameters also include special severe weather parameters like relative vorticity at various pressure levels. To the right: COSMO REA6 analysis displaying wind and wind direction

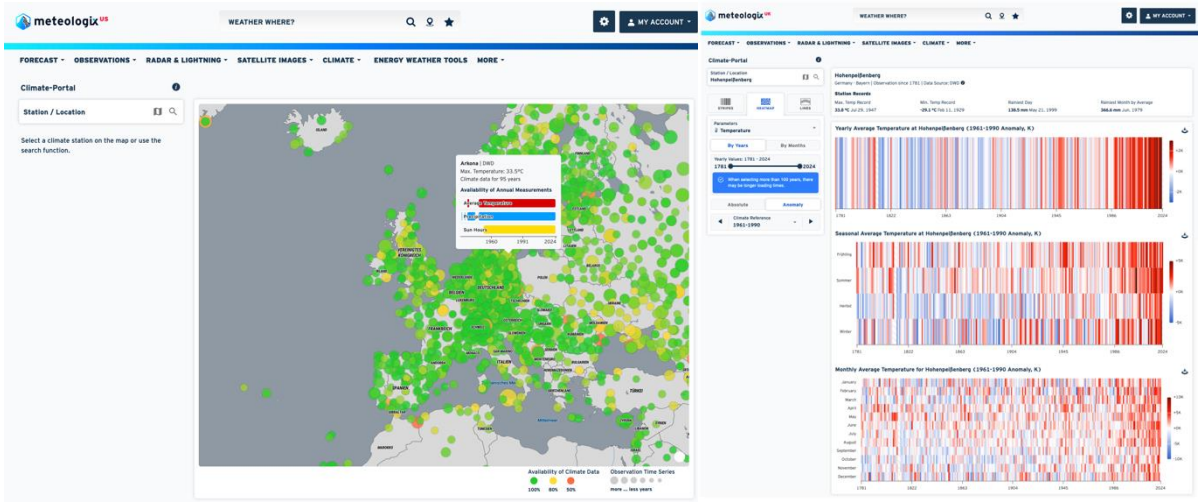

Figure 5-2: Some examples of different pages for this service. To the Left: interactive map of available stations with first hand meta information in optical view. To the Right: Yearly/seasonal/monthly mean anomaly temperature over past 250 years of station Hohenpeißenberg.

5.1 Key features

- Merge and combine complex climate data in a state-of-the-art data base (timescale).
- Conceptual storage in different timescale-tables for a fast response to request from frontend to build climate views.

- Transfer climate information in an understandable way to citizens.
- Every costumer of this service should be able to choose the climate information they want to receive information in an easy understandable way of nicely coloured graphs, more detailed content with various number of different parameters and time periods through tables, lists, diagrams or other views.
- Gaining citizens interest for climate while using the service through easy linked climate views and interacting map.

5.2 Methodology

This service includes all parts from searching for climate data, store climate data in an appropriate way and visualize this data in different forms. Especially find ways, to transfer climate information to the citizens.

Climate data were gattered through different sources (global – NOAA, national – DWD, DMI, ...) and combined a huge data base (TimescaleDB). The complexity of climate data from different source appears in temporal resolution (daily, monthly, yearly values), definition of meteorological parameters and update routines. To overcome this complexity a various number of routines were developed in the backend and operate on TimescaleDB server. Throughout this, it is possible to make several requests from the frontend to generate many different climate views.

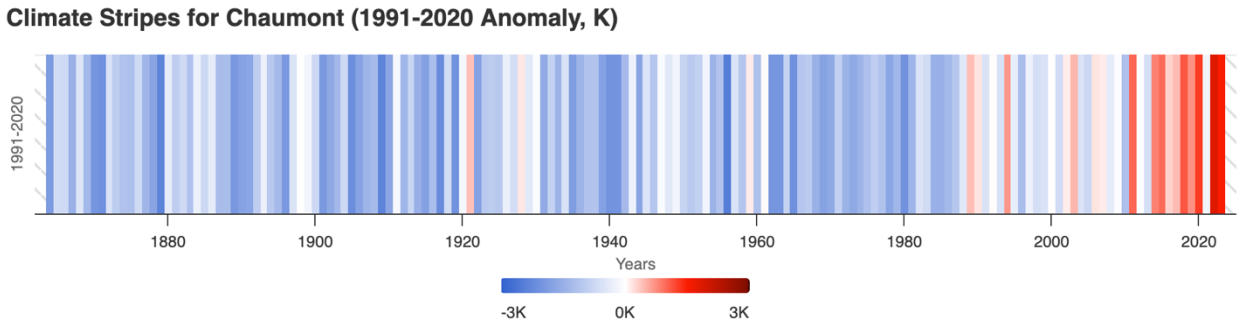

Figure 5-3: Climate stripes of the station Chaumont (CH). Climate stripes are yearly mean temperatures normalized by a 30-year climate reference value.

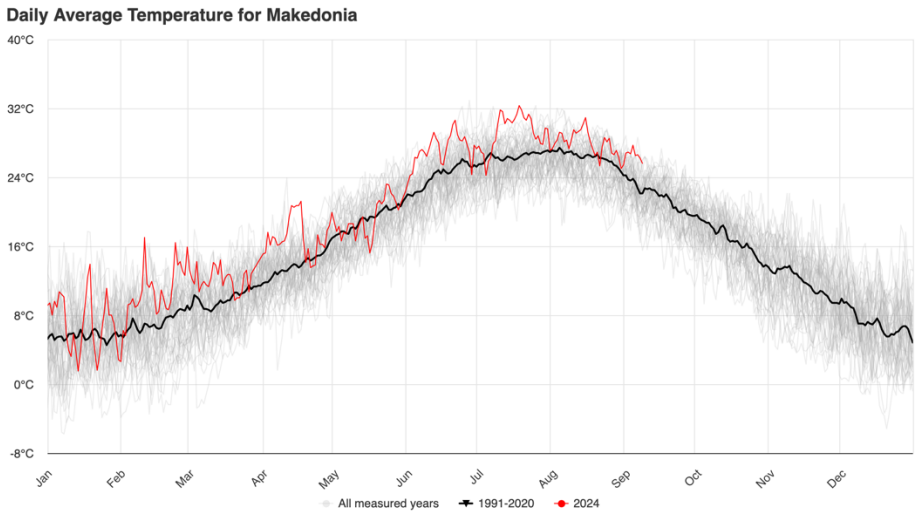

Figure 5-4: Annual cycle of daily mean temperatures. A selectable year can be compared with all past years and a 30-year climate reference on a diurnal scale.

5.3 Application potential

- …this service was built for citizens who want to have a fast response to the question on “How was the climate at my location in the past years compared to now?”. With this starting questing the service informs the user with different climate views that enable the investigation of vast data sets within seconds.
- …the service is modular and allows for the integration of various parameters, climate periods, areas, aggregation forms and more.
- …the service allows for a quick and easy identification of normal ranges, outliers and trends in climate data.
- …as it has been setup as a modular framework further interactive visualizations can be easily amended and implemented.

5.4 Main achievements

The Climate Information Portal presents extensive climate details, such as temperature, humidity, and rainfall records of the past decades for hundreds of locations and areas around the world. The user-centric platform promotes the active engagement of its users by presenting this historical weather and climate data in an accessible and easy understandable manner that requires no pre-existing knowledge. The service has descriptions and explanations of the data used, its aggregation procedures and how-to-use guides and aims to further awareness of climate change and local climate data. The service is available on all country version of Meteologix.com: https://meteologix.com/be/climate/stations

6 Conclusions

The development and dissemination of the Citizen Climate services envisioned in WP6 has been successfully completed. The work in WP6 has produced several stand-alone services to be included and provided to interested public entities such as cities or organizations based on the UltraHD city model or as in the case of the Climate Information Portal on the Meteologix.com website. For these services, several developmental steps had to be taken:

- Setup of additional sensors in the Pilot regions.
- Collection and post-processing of vast observational data sets for the Climate Information Portal, aggregation, visualization and transformation options.
- Development of the UltraHD city weather model:
    - Integration of chemistry for modelling of air quality,
    - Integration of soil model for modelling of more complex relationships of radiation, evaporation and heat accumulation,
    - Integration of complex radiation modelling, and more …
- Collection of earth observation data to inform UltraHD weather model.
- Collection of in-situ data from Pilot regions.
- Development of indices (heat index, air quality index, etc.) to translate meteorological data into more user-friendly data fields.
- The development of several stand-alone components that combine these technical achievements in ready-to-use services that can be easily integrated in foreign web frameworks (like e.g., city websites).
- Development of graphical user interfaces, user-testing and complex functionalities to manipulate and view data.

Overall, the results of the CityCLIM WP6 have provided a collection of ready-to-use tools and data-driven solutions to cities and other interested entities to face challenges like Urban Heat Islands and other climate-change related hazards. These services provide the prevention potential as well as information sources to create awareness for climate change related weather phenomena. They encourage citizens to engage with the provided data and enable them to make self-informed data-based informed decisions.

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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