Next Generation City Climate Services using Advanced Weather Models and Emerging Data Sources

CityCLIM Public Concept

D1.3 – Public CityCLIM Concept

This document shows the public version of the concept for the CityCLIM project

JULY 2022

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Foreword

Welcome to our CityCLIM Public Innovation Concept. 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 is funding the project "Next Generation City Climate Services Using Advanced Weather Models and Emerging Data Sources", or CityCLIM for short, as part of its Horizon 2020 programme. The aim of the project is to develop a cloud-based platform that 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 aims to develop a weather forecast model tailored to the needs of large cities. Unlike conventional forecast models, whose resolution is usually in the range of several kilometres, the new model will have a resolution of one hundred by one hundred meters. In addition, the model will combine data from weather satellites with measurements from the air and information collected on the ground. Data sources to be integrated include existing services of the European earth observation programme Copernicus [2] and information provided by the population itself.

Weather and climate services for the general public

The calculations made with the improved model will be made available to the general public in the form of various weather and climate services. Further services are also planned specifically for city councils and other authorities. These should make it possible, among other things, to examine the effect of urban planning measures in response to climate change. In this context, for example, the analysis of the impact of green spaces and water bodies on the urban climate is considered.

Implementation by a European consortium

Several European companies are involved in implementing the project, including four from the OHB Group: OHB System is acting as the project coordinator and is responsible for processing and providing the space-based earth observation data. OHB Digital Connect will use an airborne system to validate the calculated model predictions with thermal infrared measurement data. OHB Digital Services is responsible for the development of the cloud-based data platform in which all input data will be consolidated and subsequently made available as City Climate Services (CCS). The implementation of service demonstrations in the four selected pilot cities is being organised by OHB Digital Solutions from Austria.

Other industrial and academic partners include the Institut für angewandte Systemtechnik Bremen GmbH (ATB), which is responsible for the technical coordination of the project together with OHB and is also supporting the development of the cloud-based data platform. Meteologix AG, a subsidiary of Kachelmann GmbH, is responsible for developing the high-resolution weather model and providing the precise weather forecasts. Another scientific partner is the Global Change Unit of the University of Valencia, which will contribute novel data processing methods. Last but not least, the Helmholtz Centre for Environmental Research from Leipzig will develop methods to incorporate data collected by the population in the scope of citizen sciences.

Four European pilot cities as partners

In order to make the envisaged weather and climate services as application-oriented as possible, the CityCLIM project will be 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 are 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.

Starting from those motivations and general project objectives, we have conceptualised the CityCLIM System Concept as a technical basis for combating some of the negative effects of climate change in cities. All along, we have followed the maxim to think about the needs of Pilot Cities and Service Users, but also to win software developers (e.g. service providers) to develop and integrate into CityCLIM new services, engines or data processors, by designing a convincing trustworthy Ecosystem. Recently we have finalized the CityCLIM system concept and have started its detailed specification and development by our software and RTD development partners.

In this report you will find some more details about the CityCLIM system concept as a whole. You will find a description of the overall CityCLIM Ecosystem and Workflow representing a high-level structure and big picture of the CityCLIM solution as a blue-print for the system development, including a definition for each CityCLIM platform component and their mutual interaction. This overview is suitable basis for having a deeper look into the City Climate Service Concept and the Generic City Climate Platform Concept describing each service and component including their objectives, purposes, key functionalities, value and benefits. The document ends with the presentation of first laboratory prototypes that show a proof of concept of critical components and the engineering environment including an early validation by the industrial partners.

If you got curious about how all that is made possible, just continue on the following pages, enjoy the reading, and please contact us with your feedback or questions!

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1 CityCLIM Ecosystem and Workflow

The CityCLIM concept has a number of specific goals for the project:

1. to model the generic information flow through the whole GCCP for all envisaged pilot services (top level data exchange between platform components),
2. to verify if all components and data sources required to realise the services are covered by the architecture,
3. to identify which Generic City Climate Platform (GCCP) components and data sources are needed by which City Climate Services (CCS) and
4. to accomplish a ground basis for the detailed specification of services and GCCP components (including boundaries of what will be developed in the CityCLIM project).

The CityCLIM Ecosystem and Workflow description in this chapter shows the big picture of CCS and the GCCP components with a clear focus on pilots ecological, societal and business needs and technological challenges that can be solved by the CityCLIM solution.

Afterwards, subsequent chapters give detailed information about the City Climate Services Concept (see chapter 2) and the GCCP Concept (see chapter 3).

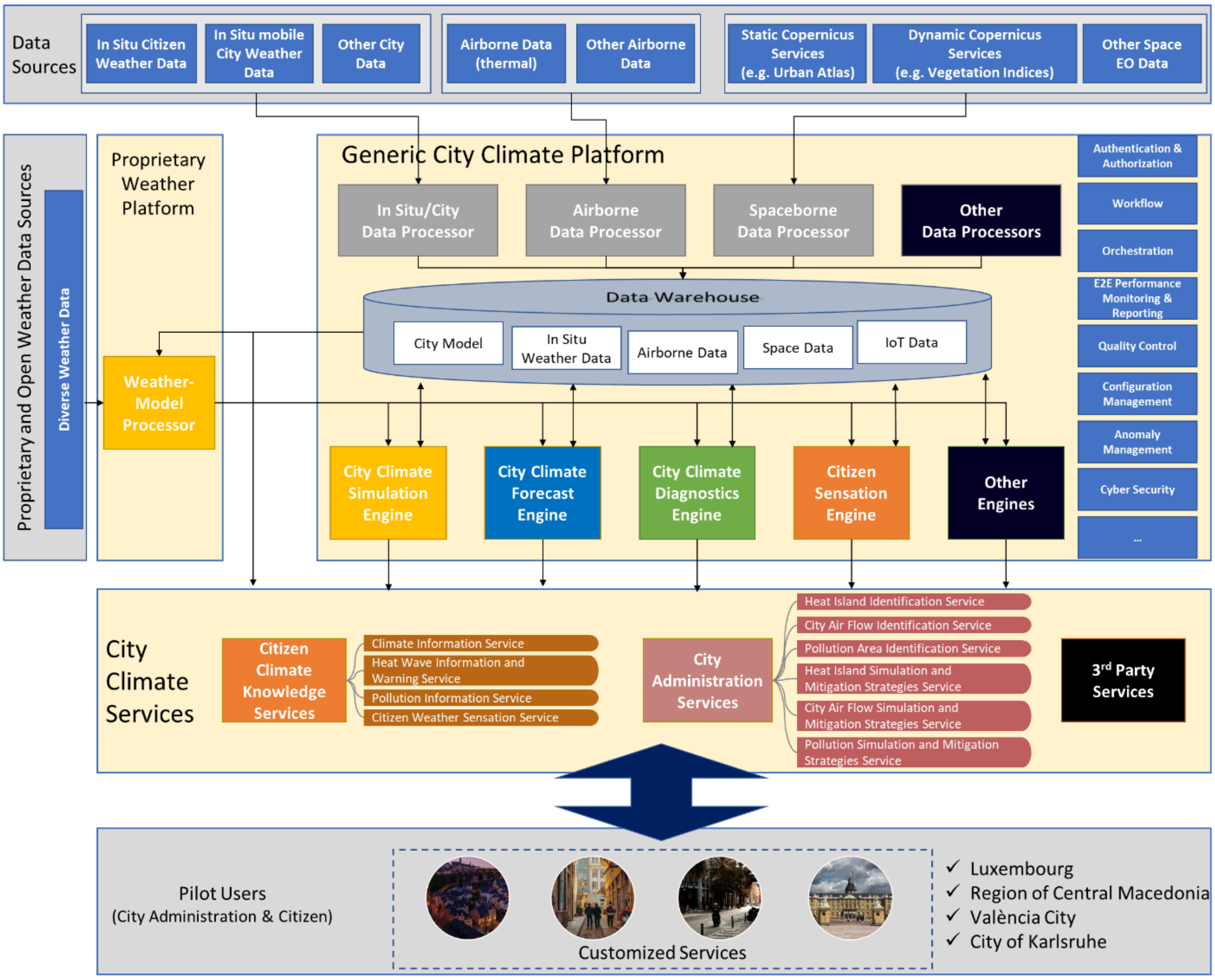


Figure 1-1: Overall CityCLIM Architecture

Figure 1-1 shows the overall CityCLIM Architecture which is a composition of four major modules (i.e., Data Sources, GCCP, Proprietary Weather Platform and CCS). The GUI or API based CityCLIM frontend is represented by the CCS used by pilot users who can (optionally) further customise these services. Starting from there, the architecture is described top-down from the pilots to the data sources in the following paragraphs.

Pilot Users in CityCLIM are different cities (i.e., Luxembourg City in Luxembourg, Valencia in Spain, Karlsruhe in Germany, Thessaloniki in the Region of Central Macedonia of Greece). All cities have different motivations and ambitions in the project which leads to the usage and later validation of different CCS provided by CityCLIM.

City Climate Services (CCS) (described in detail in chapter 2) represent the GUI or API based front end of the overall CityCLIM solution. They are grouped in two categories: "Citizen Climate Knowledge Services" are services targeting citizens and "City Administration Services" are services intended for city administration authorities. Based on results of the requirements analysis, a breakdown of the major CCS, i.e. of Citizen Climate Knowledge Services and City Administration Services, into a series of sub-services was made (see City Climate Services in Figure 1-1). Table 1-1 shows an overview of these identified sub-services.

Table 1-1: Identified sub-services of City Climate Services

Service Name	Brief Description
Citizen Climate Knowledge Services	
Heat Wave Information and Warning Service	Delivers live and forecast information about heat waves in cities. It uses the information also to send configured heat wave warnings if desired (described in detail in section 2.1.1).
Climate Information Service	Delivers a variety of city climate information (described in detail in section 2.1.2).
Pollution Information Service	Delivers live and forecast information about the degree of pollution in specific areas (described in detail in section 2.1.3).
Citizen Weather Sensation Service	Delivers subjective impressions of how citizens experience the weather. Provides the opportunity to "calibrate" the objective weather output to the own sensation to create individual temperature maps (described in detail in section 2.1.4).
City Administration Services	
Heat Island Identification Service	Provides statistical data preparation methods and graphical result display tools to statistically process aggregated existing operational UltraHD forecasts in order to identify UHII (described in detail in section 2.2.1).
City Air Flow Identification Service	Provides statistical data preparation methods and graphical result display tools to statistically process aggregated existing operational UltraHD forecasts in order to identify City Air Flow patterns (described in detail in section 2.2.2).
Pollution Area Identification Service	Provides statistical data preparation methods and graphical result display tools to statistically process aggregated existing operational UltraHD forecasts in order to identify typical pollution burden (described in detail in section 2.2.3).
Heat Island Simulation and Mitigation Strategies Service	Provides tools to manipulate the city model to run simulations to calculate heat island occurrence impacts and suggests mitigation measures (described in detail in section 2.2.4).

Service Name	Brief Description
City Air Flow Simulation and Mitigation Strategies Service	Provides tools to manipulate the city model to run simulations to calculate city air flows impacts and suggests mitigation measures (described in detail in section 2.2.5).
Pollution Simulation and Mitigation Strategies Service	Provides tools to manipulate the city model to run simulations to calculate pollution impacts and suggests mitigation measures (described in detail in section 2.2.6).

These identified CCS, introduced in Table 1-1 and described in detail in chapter 2, are using the GCCP to operate.

The **Generic City Climate Platform (GCCP)** (described in detail in chapter 3) represents the core of the CityCLIM solution. It is an extendable platform that provides several technical features, to ease service maintenance and usage like administration tools, anomaly and health management, configuration management, state of the art authorization & authentication means, and performance and business reporting. The platform is divided into the three major groups "Engines", "Data Processors" and "Other Components". An overview of each group and their components is given in Table 1-2.

A general distinction between engines and processors can be made based on the overall CityCLIM Architecture: Processors provide the functional link between Warehouse and Data Sources and implement processing steps such as quality and completeness checks, format conversions for standardization and pre-processing that should be applied to data prior to storage in the Warehouse. Data processors may also implement higher-level data analysis steps in preparation for user requests. Similarly, Engines represent the interaction of CCSs with the Warehouse and collect on-demand, service-focused data processing steps that are triggered upon or in preparation for user requests.

Table 1-2: Generic City Climate Platform groups and their components

Component Name	Brief Description
Engines	
City Climate Simulation Engine	Handles simulation calculations using a modified city model for heat island occurrences, city air flow and pollution areas (described in detail in section 3.1.2).
City Climate Forecast Engine	Near-future forecast calculations for heat island occurrences, city air flow and pollution areas (described in detail in section 3.1.3).
City Climate Diagnostics Engine	Handles calculations to analyse and interpret the results of the Forecast and Simulation Engines (described in detail in section 3.1.4).
Citizen Sensation Engine	Performs statistical calculations to prepare the subjective impressions of how other citizens experience the weather (described in detail in section 3.2.2).
Other Engines	The CityCLIM platform is open for further engines which might be developed in the future.

Component Name	Brief Description
Data Processors	
In Situ/City Data Processor	Receives in situ/city data from related Data Sources and transforms them into a unified format used by the CityCLIM engines (described in detail in section 3.3.1).
Airborne Data Processor	Receives and pre-processes airborne data from related Data Sources and transforms them into a unified format used by the CityCLIM engines (described in detail in section 3.3.2).
Spaceborne Data Processor	Receives and pre-processes spaceborne data from related Data Sources and transforms them into a unified format used by CityCLIM engines (described in detail in section 3.3.3).
Other Data Processors	To be developed on demand in the future to integrate other Data Sources into the CityCLIM platform.
Other components	
Data Warehouse	Stores pre-processed data provided by the data sources (e.g., In-Situ, Airborne and EO data), engine calculation results, weather model results and user related data (described in detail in section 3.4).
Cross-Layer Components	Provide features that are working across all layers to realise Authentication & Authorization, Workflow, Orchestration, E2E Performance Monitoring & Reporting, Quality Control, Configuration Management, Anomaly Management and Cyber Security.

Linked to the GCCP is also a Proprietary Weather Platform.

The **Proprietary Weather Platform** (described in detail in chapter 3.1.1) deploys a Weather Model Processor which is further linked to Proprietary and Open Weather Data Sources. The Weather Model Processor also represents an Advanced UltraHD model (an urban small-scale high resolution (100 m) full physics weather model), which processes data from mentioned data sources as well as from the GCCP to provide weather forecast information to engines located in the GCCP for further processing.

Data Sources provide data to the GCCP and are divided into three main groups (i.e., in situ/city data, airborne data and spaceborne data). These groups are linked with the Data Processors described in Table 1-2. Each group and its data sources are described in detail in Table 1-3.

Table 1-3: Data Sources providing data to the GCCP

Data Source Name	Brief Description
In Situ/City Data	
In Situ Citizen Weather Data	Data generated by citizens operating stationary sensor devices or historical data collected by citizens.

Data Source Name	Brief Description
In Situ mobile City Weather Data	Data generated by citizens operating mobile sensor devices.
Other City Data	Indicates that other urban data sources (such as a city model) may be integrated in the future.
Airborne Data	
Airborne Data (thermal)	Thermal data measured by planes equipped with special sensor devices.
Other Airborne Data	Indicates that other airborne data sources can be integrated in the future.
Spaceborne Data	
Static Copernicus Services	Static Data provided by satellites of the Copernicus earth observation program (e.g., Urban Atlas).
Dynamic Copernicus Services	Dynamic Data provided by satellites of the Copernicus earth observation program (e.g., Vegetation Status)
Other Space EO Data	Indicates that other Space EO data sources can be integrated in the future.

The overall **CityCLIM Ecosystem Workflow** from an architectural point of view starts with pilot cities interested in using City Climate Services of the CityCLIM solutions for their citizens or their city administration. Cities that are willing to use these services will be integrated in CityCLIM (by adding and configuring city-specific data sources required for city-specific CCS commissioning) and are free to further customize offered CCS if needed.

The CCS are representing an API or GUI based endpoint/front-end of the CityCLIM architecture and are realising several specific services offered to citizens or to city administrations. CCS are communicating and using for their purposes a multitude of connected engines that function as computationally intensive processing machines for simulations, forecasting's, diagnostics or sensation tasks. The engines are fed with multiple data needed for their internal processing coming from

- Data Processors that provide pre-processed (cleaned, constructed, integrated, formatted and enriched) In Situ/City, Airborne or Spaceborne data,
- a Weather Model Processor which provides results from a fully compressible large eddy simulation model (LES) with a two-moment warm and cold microphysics and optional basic atmospheric chemistry equation,
- a data warehouse which stores data coming from various CityCLIM components,
- and other engines if an orchestration of simulation, forecasting, diagnostic or sensation models is necessary.

In Situ/City, Airborne or Spaceborne data processors get their data for pre-processing from the multiple related connected data sources. The same data sources are available for the Weather Model Processor which has also access to a variety of other proprietary and open weather data sources.

The CCS and the overall GCCP components are described in more detail in chapters 2 and 3.

2 City Climate Services Concept

This chapter describes each of the identified CCS. Based on the results of the requirements analysis, a breakdown of the major CCS, i.e., of Citizen Climate Knowledge Services and City Administration Services, into a series of sub-services was made as shown in Figure 2-1.

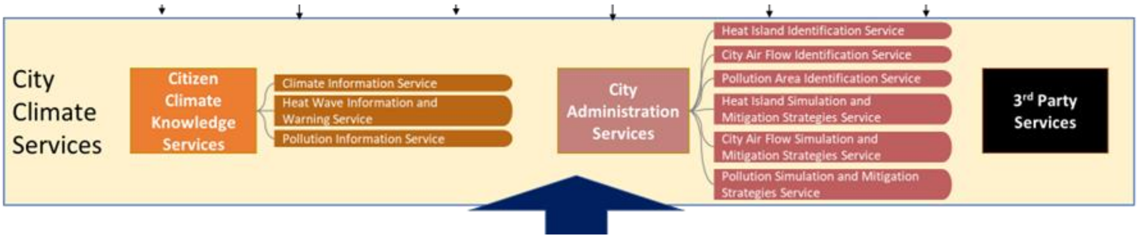


Figure 2-1: Focus of this section: City Climate Services

The CCS consist of two main content blocks: **1) The Citizen Climate Knowledge Service** that comprise a broad range of activities targeted at the citizen in each Pilot city (especially the Citizen Science and Warning Services) as well as the general public for the City Climate web portal that is available and of potential valuable information for all citizen, especially in Europe as the historical data density currently is the highest there. **2) The City Administration Service** that is aimed at supporting governmental entities in the information gathering and potential formation of subsequent mitigation strategies of the heat resilience of their city by identifying heat island effects and “hot-spots” through statistical evaluation of operational UltraHD runs over the course of weeks/months.

Both services categories aim to provide direct and easy access to relevant historical weather information as well as ongoing conditions, detection of change and the basis of mitigation strategies by pointing towards potential adjusting screws.

2.1 Citizen Climate Knowledge Services

The Citizen Climate Knowledge Services are publicly accessible services designed for interested citizens in and outside the pilot cities. The aim is to raise awareness for and gain insight into weather and climate related processes in the (urban) environment. They, again shown in Figure 2-2, were already introduced in Table 1-1 of chapter 1, and are described in detail in the following sub-sections.

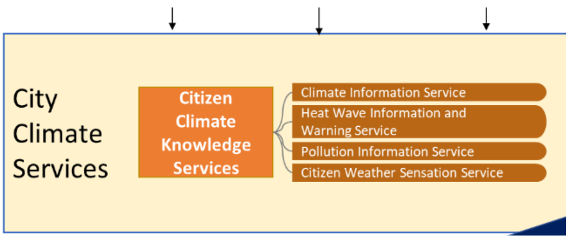


Figure 2-2: Focus of this section: Citizen Climate Knowledge Services

It is important to note that not all services will be provided for all participating Pilot cities as this is beyond the scope and budget of the current project. Warning services require an operationally running UltraHD nest throughout and will be run operationally in two of the Pilot cities (i.e. City of Valencia and City of Karlsruhe) and two cities will be run for limited time periods to provide the basis for some statistical analyses for the City Administration Services (identification of heat islands / “hot spots”, etc.).

2.1.1 Heat Wave Information and Warning Service

The objective of this Heat Wave Information and Warning Service (HWIaWS) is to provide information shortly before and during a heat wave. The target audience are interested citizens in some of the pilot regions. The service is mainly based on SuperHD and UltraHD model forecasts and in situ measurements, however for the Pilot in RCM we will also test a heat warning service using a MOS-based (model output statistics based) approach. It consists of two main products: 1) The analysis, which is produced using previous model runs and latest in situ measurements, represents the current state and provides information on the heat and moisture distribution within the city. 2) The other main product is a forecast for the upcoming days for parameters like 2m-Temperature, relative humidity and thermal comfort indices. The output is communicated using two-dimensional maps and diagrams.

The warning service provides the possibility to define thresholds for heat wave correlated parameters and an area of interest within the pilot domain. If the thresholds are reached, the user is informed using some sort of push service.

The use cases visualised in Figure 2-3 and described in Table 2-1 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

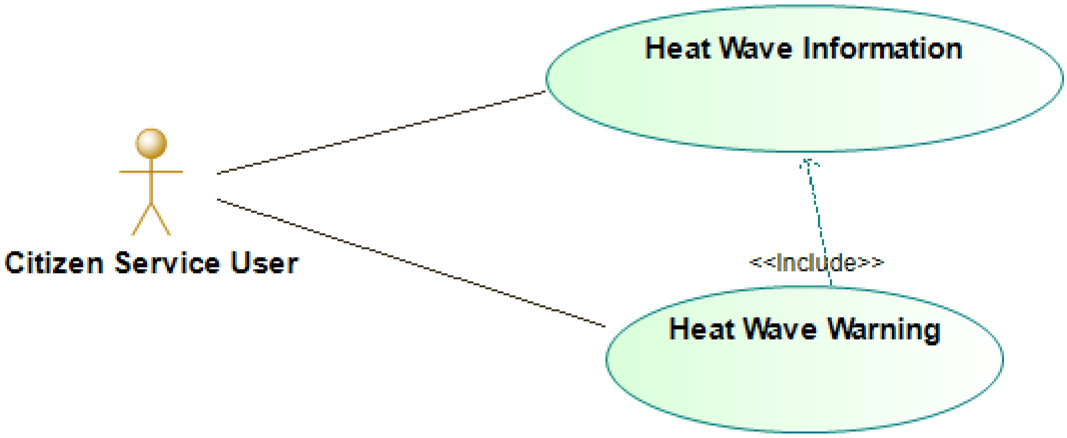


Figure 2-3: Heat Wave Information and Warning Service Use Case diagram

Table 2-1: Use case description for Heat Wave Information and Warning Service

Use case	Description
Heat Wave Information	This Service Use Case delivers live and forecast information about heat waves in cities. It delivers statistical information as well as live information and can be used for any planning of Citizen Service Users.
Heat Wave Warning	This Service Use Case enables to trigger warnings based on configurations by individual Citizen Service Users. To do so, it requires the Use Case “Heat Wave Information” to enable this functionality.

2.1.2 Climate Information Service

Climate Information Service

The Climate Information service will be part of the Meteologix Webportal (www.meteologix.com). It provides the possibility for citizens to get information on a wide range of climate related parameters, including monthly and yearly diagrams for temperature, humidity, precipitation and their anomalies. The main goal of this service is thus, to trigger user engagement by making vast climate information easily accessible by the utilization of an intuitive modern interface and data exploration tool.

This service will be implemented into MTL's proprietary weather platform meteologix.com to ensure an immediate exposure to an interested and broad audience. One of the project goals is to enrich the already available data pool, by using historical measurements and data sources not yet included.

Proprietary sources only accessible to the participating Pilot cities as well as open-data sources are collected and added to the historical climate database. They are then pre-processed and cleaned as well as homogenized to be displayed on the Climate Information Service web portal. This service will also allow for the possibility to compare different measurement series from different stations and perform simple statistics e.g., trend analysis.

The following Table 2-2 shows the currently envisioned inputs and functionalities in this web-based service:

Table 2-2: Envisioned functionalities of the Climate Information Service web portal.

Time horizon	Climate evaluation	Access & Functionality
Daily, monthly	Daily meteogram	Visual display: • bar charts, • box plots and range depiction • warming stripes • line graphs, • heat maps • tables (where applicable) Functionality: • Interactive graph: hovering shows data and additional information • Performing simple statistical significance tests (t-test, mean comparisons) • Free-zoomable maps to "graphically" explore data
	Monthly meteogram	
Time series 1+ year	Course of temperature (and climate means)	
	Precipitation (yearly and monthly)	
	Solar Radiation (and climate means)	
	Snow depths (and climate means)	
	Yearly evaluation of "hot days"/summer days (records)	
	Annual assessments (regional trends, global trends, heat and summer day, mean monthly temperature)	
	Grassland Temperature sums	
	Climographs	
	Area means	
	Phenology data	
Model reanalysis	ERA 5	Map layers over free-zoomable vector tiles
Other historical data (where applicable)	Satellite data	
	Lightening data	
	Precipitation radar data	
	Data collected by Citizen Science	Visual display of point data, data aggregation and visualization in charts or graphics (if applicable)

Citizen Science on historical Weather and Climate Data

Due to private interest, farming and school activities there is possibly still a lot of historical climate and weather data existent which are not yet accessible for large scale analysis. Examples are private records, records from school activities as well as local weather proverbs and information about former climate-based farm management practices. A suitable approach to collect these data and knowledge is citizen science. Within CityCLIM we will develop and test a web-based approach which will facilitate the provision of historical weather and climate data by citizens. Thereby, information about origin, location, time period and kind of data as well as the data itself will be collected and subsequent analysed.

From another perspective, it can be of importance to provide a platform, where private weather data can be collected and professionally processed and displayed to engage citizen in the interaction with weather and climate information and to motivate and spark interest in climate actions.

Thus, the Climate Information service web-portal could also provide a possibility to insert historical weather data – or live observations. The planning of a detailed pathway of how this can be accomplished, is currently conceptualized and discussed with the relevant partners at UFZ and MTL.

The use cases visualised in Figure 2-4 and described in Table 2-3 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

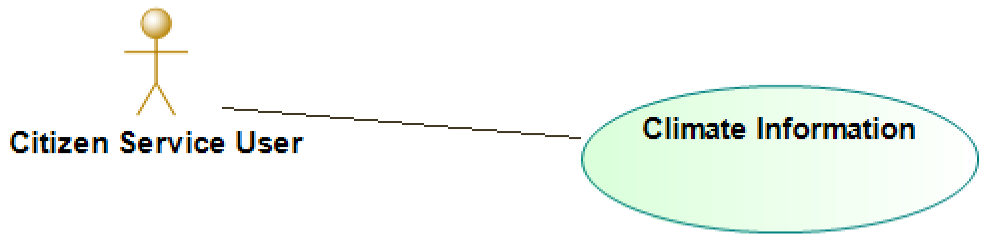


Figure 2-4: Climate Information Service Use Case diagram

Table 2-3: Use Case description for Climate Information Service

Use case	Description
Climate Information	This Service Use Case delivers a variety of city Climate Information to Citizen Service Users.

2.1.3 Pollution Information Service

Pollution Information Service

The pollution information service will be quite similar to the heat wave information service but with a different parameter focus and additional variables and equations in the UltraHD model. With the added equations the computational effort is significantly higher, therefore the service is planned to be implemented in one pilot region only (Valencia). The target parameters here will be pollution related. That includes aerosol compounds (PM10, PM2.5) and atmospheric trace gases (NOx, O3).

Like the heat wave information service, this is also based on SuperHD and UltraHD model forecasts and in situ measurements. It will provide the analysis, which is produced using previous model runs and latest in situ measurements and represents the current distribution of pollution within the city.

The other main product is a forecast for the upcoming days for the concentrations of pollutants. Because of the high computational demand, this forecast may be significantly shorter and it will strongly depend on the provided or analysed emission scenarios within the city.

The pilot region chosen for this service is Valencia, because an already operational measurement network exists within the smart city platform that can provide the necessary in situ parameters.

Beside the very detailed modelling of atmospheric transport and chemistry, another product of this service will be the “Urban Pollution Index” which is based on different meteorological variables like wind speed and stability and describes the affinity of the current and upcoming weather situation to accumulate pollutions within the lower layers of the atmosphere. This “Urban Pollution Index” is already part of the operational SuperHD model and will be included in the UltraHD as well. It will therefore be available in all pilots with operational UltraHD runs.

The use cases visualised in Figure 2-5 and described in Table 2-4 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

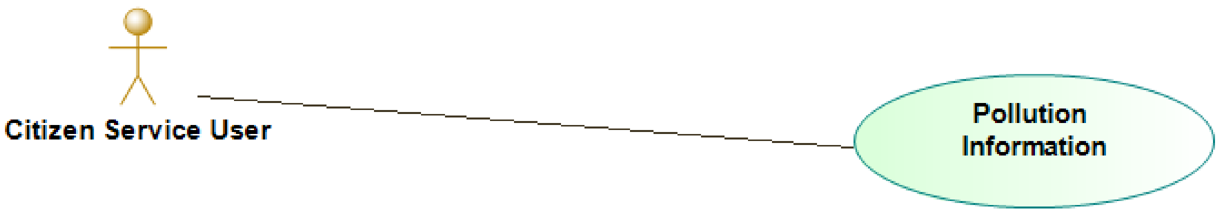


Figure 2-5: Pollution Information Service Use Case diagram

Table 2-4: Use case description for Pollution Information Service

Use case	Description
Pollution Information	This Service Use Case delivers Pollution Information to Citizen Service Users.

2.1.4 Citizen Weather Sensation Service

Citizen Weather Sensation Service

Weather and climate feeling depends strongly on the person and the context. Therefore, people would be interested for planning out-of-home activities such as walking out-door sports and shopping on easy-to-use maps of the current and forecasted weather in terms of their own preferences. We will address this wish with a “Citizen Weather Sensation Service” which provides easy to use maps with a traffic light legend. Areas on the maps indicated in green would be recommendable for the person, whereas red areas should be avoided.

The personal comfort ranges for air temperature, relative humidity and heat index can be set in the user interface. Based on these parameters, the “Citizen Weather Sensation Engine for Personalized Climate & Weather Feeling” creates the personalized map.

With the help of this map, the user can then plan his or her possible location and activities.

The use cases visualised in Figure 2-6 and described in Table 2-5 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

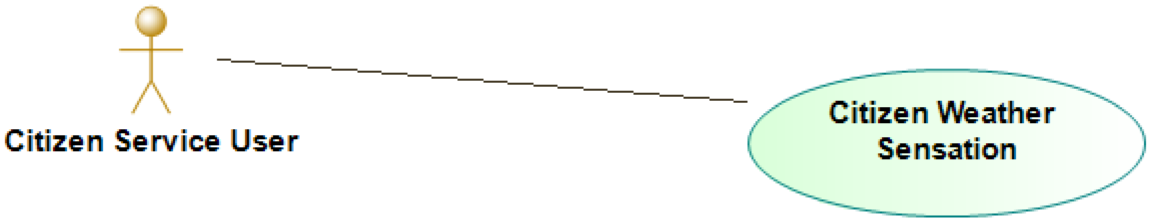


Figure 2-6: Citizen Weather Sensation Service Use Case diagram

Table 2-5: Use case description for Citizen Weather Sensation Service

Use case	Description
Citizen Weather Sensation	This Service Use Case delivers Citizen Weather Sensation Information to Citizen Service Users.

2.2 City Administration Services

The City Administration Services support users to identify different aspects of the city climate profile and allow to investigate effects of simulated changes to the urban areas. Identification, Simulation and Mitigation Services will be available by web-based graphical user interfaces (GUIs) for the themes heat island, pollution and city air flow.

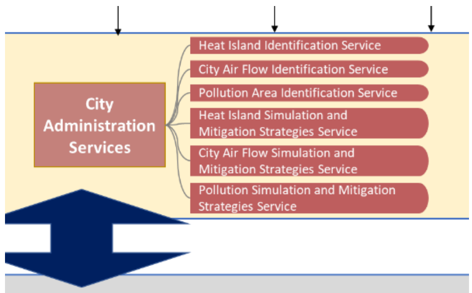


Figure 2-7: Focus of this section: City Administration Services

The **identification services** offer statistical maps that rely on aggregated results from past model runs, whereas, after the user has submitted simulated changes to urban areas, the **mitigation services** produce statistical difference maps comparing the model results from simulated changes to prototypical days (e.g. “HOT-SUMMER-DAY”) with respect to a predefined set of parameters.

In this way, (un)favourable air flows for cooling effects within cities as well as heat and pollution hazard zones can be identified and their mitigation strategies elaborated, so that the combination of all administrative services forms a decision support system for adaptation to current and upcoming climate change challenges in cities.

The City Administration Services, again shown in Figure 2-7, were already introduced in Table 1-1 of chapter 1, and are described in detail in the following sub-sections.

2.2.1 Heat Island Identification Service

The Heat Island Identification Service is a statistical analysis of a large number of operationally performed UltraHD runs and model analysis fields within one pilot region. It will help to identify hot and cool spots within the city by providing statistical means, minima and maxima for parameters like the urban heat island index (UHII), surface urban heat island index (SUHII), 2m temperature, land surface temperature and humidity. It may assist the city administration during city development and climate mitigation plans.

The use cases visualised in Figure 2-8 and described in Table 2-6 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

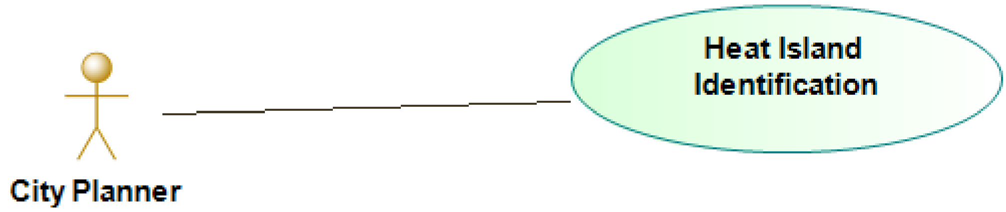


Figure 2-8: Heat Island Identification Service Use Case diagram

Table 2-6: Use case description for Heat Island Identification Service

Use case	Description
Heat Island Identification	The service includes the calculation of near-future heat island forecast, the sending of heat island warning notifications, statistical data preparation methods and graphical result display tools.

2.2.2 City Air Flow Identification Service

City Air Flow Identification Service

In analogy to the heat island identification service, the city air flow identification service will analyse a large number of operational UltraHD runs and model analysis fields with the focus on wind speed, direction and fresh air transport. It will provide insight in local weather flow patterns evolving within the city and its surroundings. It will help to identify sources for cooler air, show the way of the fresh air within the city and where emitted heat and moisture is transported.

It may assist the city administration during city development and climate mitigation plans.

The use cases visualised in Figure 2-9 and described in Table 2-7 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

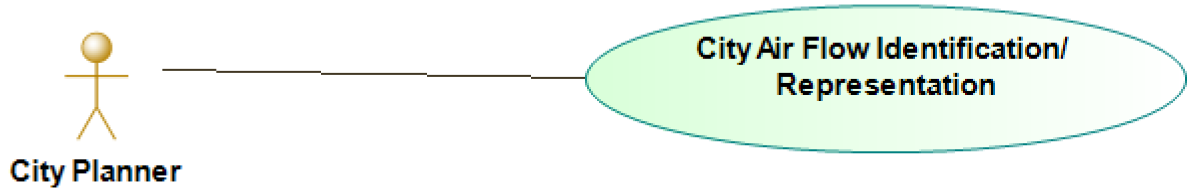


Figure 2-9: City Air Flow Identification Service Use Case diagram

Table 2-7: Use case description for City Air Flow Identification Service

Use case	Description
City Air Flow Identification/ Representation	The service includes the calculation of near-future air flow forecasts, the sending of air flow warning notifications, statistical data preparation methods and graphical result display tools.

2.2.3 Pollution Area Identification Service

Pollution Area Identification Service

In analogy to the previous two identification services, the pollution area identification service will analyse a large number of operational UltraHD runs and model analysis fields with the focus on atmospheric stability, wind speed, direction and pollution. It will provide insight in local weather flow patterns evolving within the city and its surroundings. It will help to identify regions that tend to accumulate pollution, sources for fresh air, the way of the fresh air within the city and where emitted pollution is transported.

This service is strongly dependent on provided emission scenarios and datasets.

It may assist the city administration during city development and climate mitigation plans.

The use cases visualised in Figure 2-10 and described in Table 2-8 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

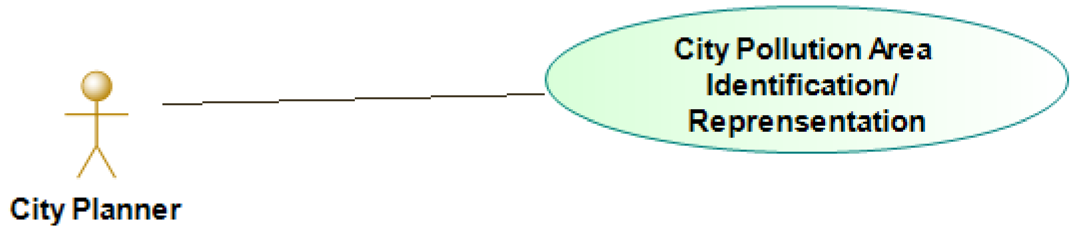


Figure 2-10: Pollution Area Identification Service Use Case diagram

Table 2-8: Use case description for Pollution Area Identification Service

Use case	Description
City Pollution Area Identification/Representation	The service includes the calculation of near-future pollution forecast, the sending of pollution warning notifications, statistical data preparation methods and graphical result display tools.

2.2.4 Heat Island Simulation and Mitigation Strategies Service

Heat Island Simulation and Mitigation Strategies Service

The Heat Island Simulation and Mitigation Strategies Service is the first of three simulation services within this project. It acts as an interface between the user, which in this case may be a city administration employee, and the UltraHD model. The aim is that the user can modify input fields for the UltraHD model using a web-based editor and reinitialize certain model runs via the interface. Therefore, this service depends on already processed UltraHD runs from which the necessary boundary conditions from the SuperHD model are stored in the generic data warehouse.

For this service the user should be enabled to change the land use characteristics of the underlying dataset (e.g. City Model). This modified land use data set is then uploaded to the data warehouse and a new model run with a selected previously saved scenario is requested. The proprietary weather model platform will then pull the new data set and the necessary boundary conditions from the data warehouse and rerun the UltraHD model. The results will be pushed back to the warehouse.

Within the service frontend the results of the so modified model run can be compared to the original model run by showing resulting maps side by side or building the difference. Focus lies on parameters like UHII, SUHII, 2m temperature, land surface temperature and humidity.

A second part of this service is built relying completely on spaceborne data sets. It is independent from the first part using the UltraHD weather model in terms of the processing chain but uses the same user interface. Also here, the user can modify urban characteristics (e.g. degree of imperviousness, land surface as built-up, urban green or urban water surface) and afterwards can explore the associated changes in LST and other heat-related variables and indices. For this, a relationship is used connecting LST on medium resolution (e.g. derived on 50m resolution from Landsat 9) with urban characteristics (from various Copernicus Service Layers, Urban Atlas, etc.) that was calibrated based on up-to-date (e.g. monthly) EO data. In the frontend the user can then compare the heat indices for the modified urban characteristics to the original heat indices and by that derive insights on which urban heat mitigation measure (e.g. extension of urban green spaces, water bodies, green roofs) is most effective. This purely EO data-based part complements the Simulation and Mitigation Service for project pilot cities where the UltraHD is not available for and enables for an extension for other European cities.

The use cases visualised in Figure 2-11 and described in Table 2-9 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

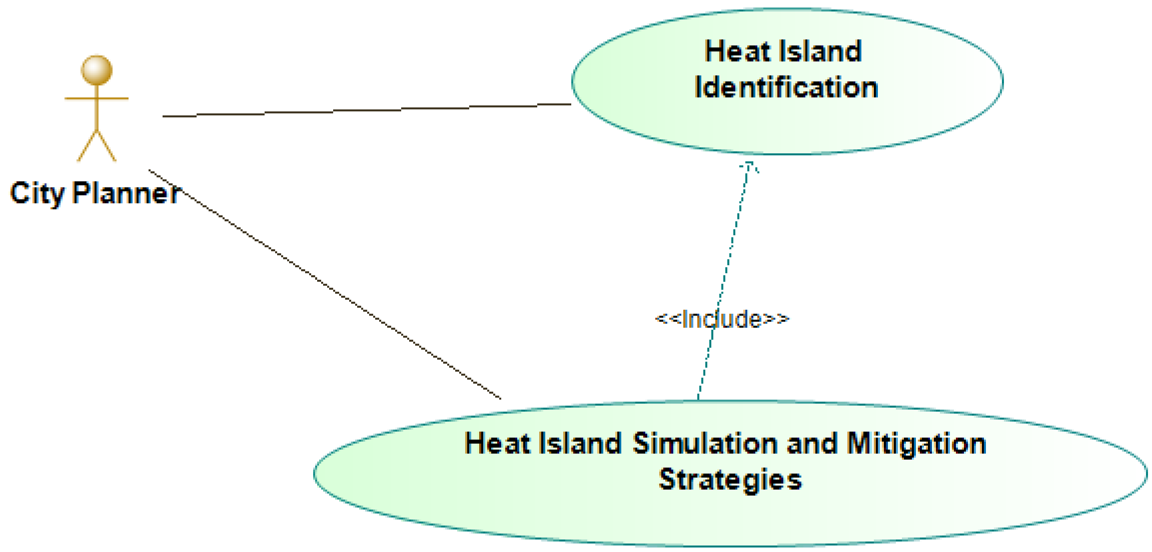


Figure 2-11: Heat Island Simulation and Mitigation Strategies Service Use Case diagram

Table 2-9: Use case description for Heat Island Simulation and Mitigation Strategies Service

Use case	Description
Heat Island Simulation and Mitigation Strategies	The service provides tools to manipulate the city model by removing, adding or changing city structure elements, and the subsequent simulation calculations to compute the impact of these measures on the occurrence of heat islands. Furthermore, suggestions for mitigation are provided.
Heat Island Identification	The service is the same as described in section 2.2.1, but in this case it is applied to the results of the City Heat Island Simulation and Mitigation Service for heat island detection and its graphical display.

2.2.5 City Air Flow Simulation and Mitigation Strategies Service

City Air Flow Simulation and Mitigation Strategies Service

The second Simulation and Mitigation Strategies Service focuses on city air flow parameters like wind speed, direction and fresh air flow. Like in the first simulation service the user will be able to change certain input fields, in this case land use and the digital elevation model, within a web-based editor.

The modified data sets are then uploaded to the data warehouse and a new model run with a selected previously saved scenario is requested. The proprietary weather model platform will pull the new data sets and the necessary boundary conditions from the data warehouse and rerun the UltraHD model. The results will be pushed back to the warehouse.

Within the service frontend the results of the so modified model run can be compared to the original model run by showing resulting maps side by side or building the difference.

The use cases visualised in Figure 2-12 and described in Table 2-10 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

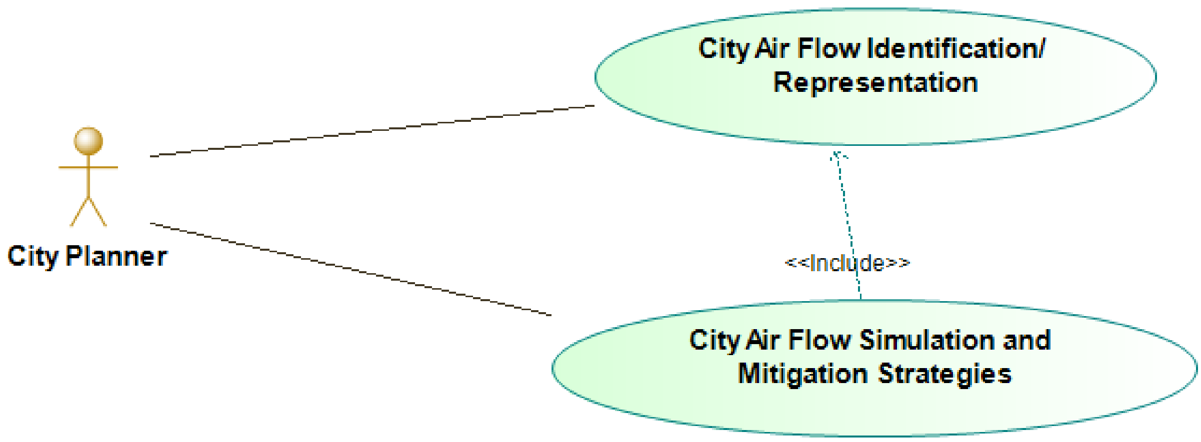


Figure 2-12: City Air Flow Simulation and Mitigation Strategies Service Use Case diagram

Table 2-10: Use case description for City Air Flow Simulation and Mitigation Strategies Service

Use case	Description
City Air Flow Simulation and Mitigation Strategies	The service provides tools to manipulate the city model by removing, adding or changing city structure elements, and the subsequent simulation calculations to compute the impact of these measures on the occurrence of city air flows. Furthermore, suggestions for mitigation are provided.
City Air Flow Identification/ Representation	The service is the same as described in 2.2.2, but in this case it is applied to the results of the City Air Flow Simulation and Mitigation Service for air flow detection and its graphical display.

2.2.6 Pollution Simulation and Mitigation Strategies Service

Pollution Simulation and Mitigation Strategies Service

The Pollution Simulation and Mitigation Strategies Service enhances the city air flow parameters like wind speed and direction with additional tracers for atmospheric gases and compounds like aerosols. Like in the first two simulation services the user will be able to change input fields, in this case land use, emission parameters and the digital elevation model, within a web-based editor.

The modified data sets are then uploaded to the data warehouse and a new model run with a selected previously saved scenario is requested. The proprietary weather model platform will pull the new data sets and the necessary boundary conditions from the data warehouse and rerun the UltraHD model. The results will be pushed back to the warehouse.

Within the service frontend the results of the so modified model run can be compared to the original model run by showing resulting maps side by side or building the difference. Within this service the main interest lies on the concentrations of the different atmospheric pollution compounds (PM2.5, PM10, NOx, O3) near the surface.

The use cases visualised in Figure 2-13 and described in Table 2-11 shortly show a set of actions (use cases) that a system (Service/GCCP Platform) should or can perform in collaboration with one or more external users of the system (actors). Each use case provides some observable and valuable result to the actors or other stakeholders of the system.

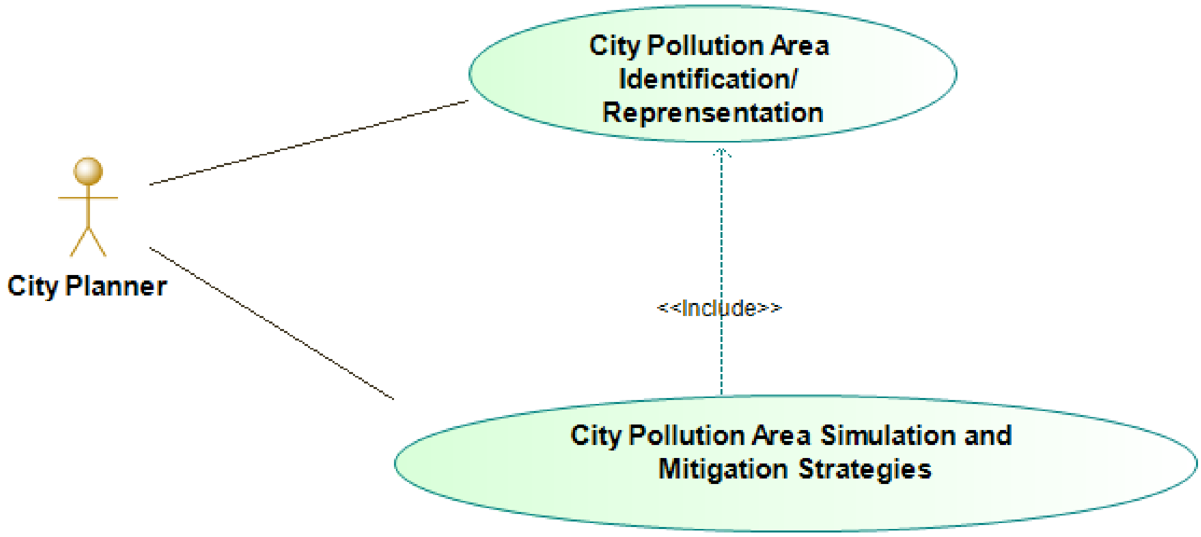


Figure 2-13: Pollution Simulation and Mitigation Strategies Service Use Case diagram

Table 2-11: Use case description for Pollution Simulation and Mitigation Strategies Service

Use case	Description
City Pollution Area Identification/Representation	The service provides tools to manipulate the city model by removing, adding or changing city structure elements, and the subsequent simulation calculations to compute the impact of these measures on the occurrence of city pollution areas. Furthermore, suggestions for mitigation are provided.
City Pollution Area Simulation and Mitigation Strategies	The service is the same as described in section 2.2.3, but in this case it is applied to the results of the City Pollution Area Simulation and Mitigation Service for air flow detection and its graphical display.

3 Generic City Climate Platform Concept

This section describes the individual components of the Generic City Climate Platform and linked (proprietary) components.

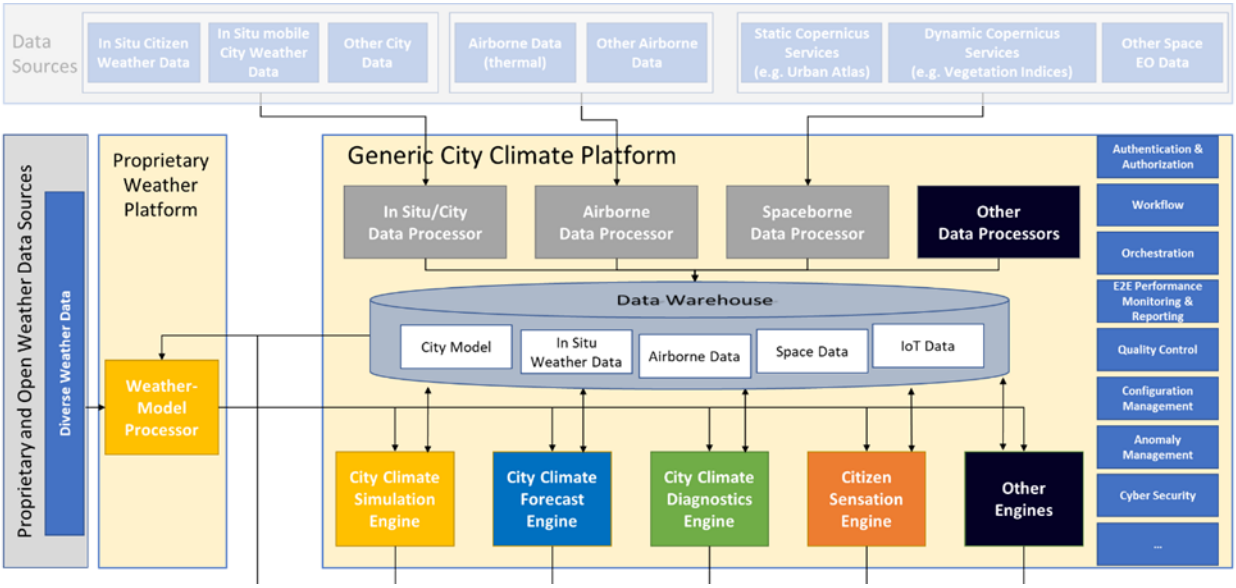


Figure 3-1: Generic City Climate Platform and linked proprietary weather platform

Figure 3-1 shows the GCCP and its (linked) components. It hosts as main components data and weather model processors, data management systems, and engines of different kinds, and moreover guarantees, among others, operational workflows between them, external data sources and attached services.

In the following, the processors, engines, and citizens science concepts for city climate monitoring are described that form the baseline for the CityCLIM services.

3.1 Advanced Urban Weather Model and City Climate Engines

This section describes components for Advanced Urban Weather Model and City Climate Engines.

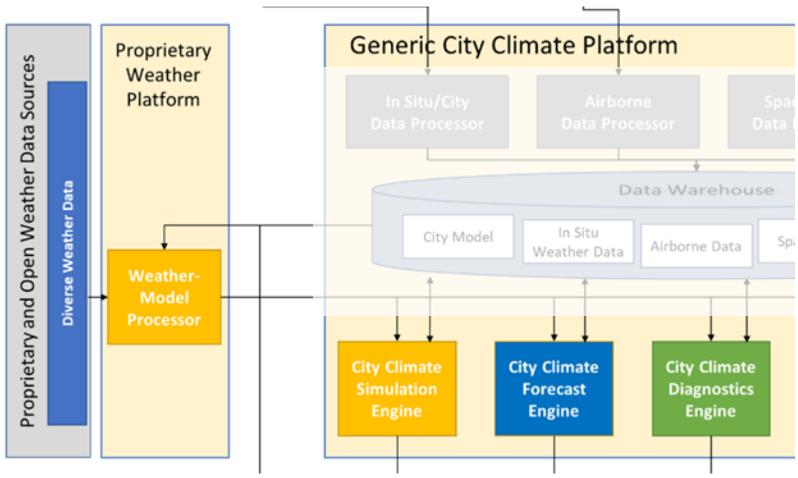


Figure 3-2: Components for Advanced Urban Weather Model and City Climate Engines

The different engines and the Weather Model Processor, again shown in Figure 3-2, were already introduced in Table 1-2 and the text of chapter 1, and are described in detail in the following subsections.

3.1.1 Weather Model Processor

Weather-Model Processor

The UltraHD Weather Model Processor is one of the key elements for the envisioned services. In short it is a fully compressible large eddy simulation model (LES) with a two-moment warm and cold microphysics and optional basic atmospheric chemistry equations. Since the model is implemented to run on graphics processing units (GPUs) it is possible to use the model in an operational forecast mode. It will feature a three-dimensional radiative transfer code and a soil and vegetation model at 100m resolution.

During this project the model will be used in two ways. The first mode is the operational forecast mode. That means the model runs every day, four times a day and will provide forecast fields for the necessary parameters up to three days in the future. Therefore, it is dependent on the operational SuperHD model by Meteologix which is already available for central Europe, covering Karlsruhe and Luxembourg and will be extended with additional nests for Valencia and Thessaloniki. The SuperHD model provides three-dimensional boundary conditions for the necessary prognostic variables like pressure, wind speed and direction, humidity and temperatures. The UltraHD will then perform a large eddy simulation with a resolution of 100m covering a domain with a side length of 50km. With that, it will be possible to study the interaction of the urban area with its surroundings and the atmosphere. The initial fields of the UltraHD model will be enhanced using in situ measurements providing regularly updated high-resolution model analysis fields.

The boundary condition fields from the SuperHD may be cropped and saved in the data warehouse for later use. With that the model can be used in the second mode. It can be initialized on-demand with changed input data sets but similar boundary conditions from the saved scenarios. With the comparison of such on-demand runs and the unmodified operational runs, it is possible to gain insight in the effects of city development and urban planning.

The results of the operational runs will be saved in the data warehouse and will be available for further analysis via the identification services.

3.1.2 City Climate Simulation Engine

City Climate Simulation Engine

The City Climate Simulation Engine is responsible for running the UltraHD Weather Model Processor on demand. It should organize SuperHD boundary conditions and other input data sets within the data warehouse into so-called scenarios. It should communicate with the Simulation and Mitigation Strategies Services to get modified input fields for land use, digital elevation models and emissions and save those to the data warehouse. Those scenarios can then be used by the Engine to request UltraHD model runs from the Weather Model Processor.

It should keep track of requested UltraHD simulations, report model status and simulation progress.

3.1.3 City Climate Forecast Engine

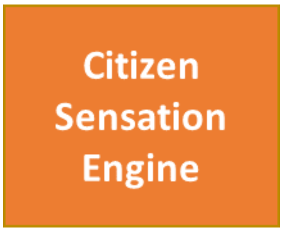
The City Climate Forecast Engine is responsible for the operational running mode of the UltraHD Weather Model Processor. It will provide actual in situ datasets and static boundary conditions to the Weather Model Processor on an operational basis and initialise the forecast runs. Another task is to keep track of the operational UltraHD simulations, report model status and simulation progress.

The resulting UltraHD data sets will be saved in the data warehouse for service access. The engine will provide map overlays and time series from the data warehouse for mapping and diagram visualisations.

3.1.4 City Climate Diagnostics Engine

The City Climate Diagnostics Engine will perform statistics over the operational UltraHD model run data saved in the data warehouse. That includes calculation of minima, maxima and mean values for different output parameters like land surface temperature, 2m temperature, humidity, urban heat island index (UHII), surface urban heat island index (SUHII). The results of the Engine will be used in the different Identification Services.

3.2 Citizens Science Concepts for City Climate Monitoring



Within the framework of the project, we want to develop **target-oriented** concepts on how suitable citizens from the most diverse **contexts** (private, employees of a company, members of an existing organization, etc.) can be approached and won over for a long-term commitment to research tasks and comprehensive environmental monitoring. In the case of the CityCLIM project, the **targets** as well as the selection of **appropriate context of citizens as research participants** will be specified in the course of the project based on site specific requirements of the pilot regions.

3.2.1 Citizen Science in Data Acquisition and Evaluation

Figure 3-3: Examples of data provided by citizens

Figure 3-3 shows identified data sources used for citizen science in Data Acquisition and Evaluation. The following targets for the involvement of citizen scientists can already be derived:

- stationary and mobile acquisition of weather data,
- collection of historical weather data,
- evaluation of the output of forecast and sensation engines developed in the CityCLIM project,
- evaluation of potential climate adaption measures of cities,
- development of a weather sensation engine for a personalized climate and weather feeling.

However, it is clear that not all of these goals will be addressed in every pilot region, and the intensity of work may vary from region to region.

With regard to the context, the following potential target groups can be distinguished for the recruitment of citizen scientists in the first phase of the CityCLIM project:

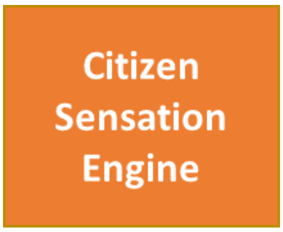
- individual persons,
- teacher and school classes,
- local associations,
- specialized supra-regional associations,
- employees of city administration,
- employees of municipal companies,
- employees of private companies.

The decision which group will be addressed in the project is based on a comparison of the objectives with the following questions for the potential groups:

- What can drive them in terms of the specific target?
- What can deter them in terms of the specific target?
- What is their communication structure/culture?
- How do we reach them?

What do we need to do to get and keep them activated (also for longer periods)?

3.2.2 Citizen Weather Sensation Engine for Personalized Climate & Weather Feeling



The sensations regarding a weather condition depend strongly on personal preconditions. For example, a certain air temperature and humidity together with the wind speed have an effect on a person's well-being. This feeling might not only depend on gender, but also on origin and state of health, for example.

The goal of the "Citizen Weather Sensation Engine for Personalized Climate & Weather Feeling" is to provide an individual map of the city with a traffic light system.

Here, not only air temperature and humidity are taken into account, but also the heat index. This is a combination of air temperature in the shade and relative humidity. This considers the fact that the human body cools itself primarily through perspiration. If the humidity is very high, the body can cool less effectively through evaporation.

Areas in which the temperature, humidity and heat index comfort zones are exceeded, will be marked in red. If only one of the ranges is exceeded, the area is yellow. If all values are within the ranges, the area is marked green. Here, users can select which weather data should be included in the calculation of the map and enter their preferred areas. The engine then displays the user's own position on the map coloured according to the traffic light system.

With the help of this map, the user can then plan his or her possible location and activities.

3.3 Data Processors for City Weather Model

This section describes the Data Processors for City Weather Model.

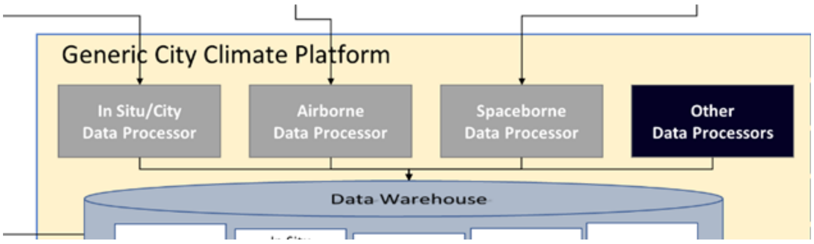


Figure 3-4: Data Processors for City Weather Model

The different Data Processors, again shown in Figure 3-4, were already introduced in Table 1-2 of chapter 1, and are described in detail in the following sub-sections.

3.3.1 In Situ/City Data Processor

The in situ/city data processor is the data hub and quality checking instance between terrestrial sensors and the data warehouse. This section describes this component through the description of key functionalities / objectives of the component. Figure 3-5 shows the key functionalities and the basic data flow from the sensor platforms to the GCCP.

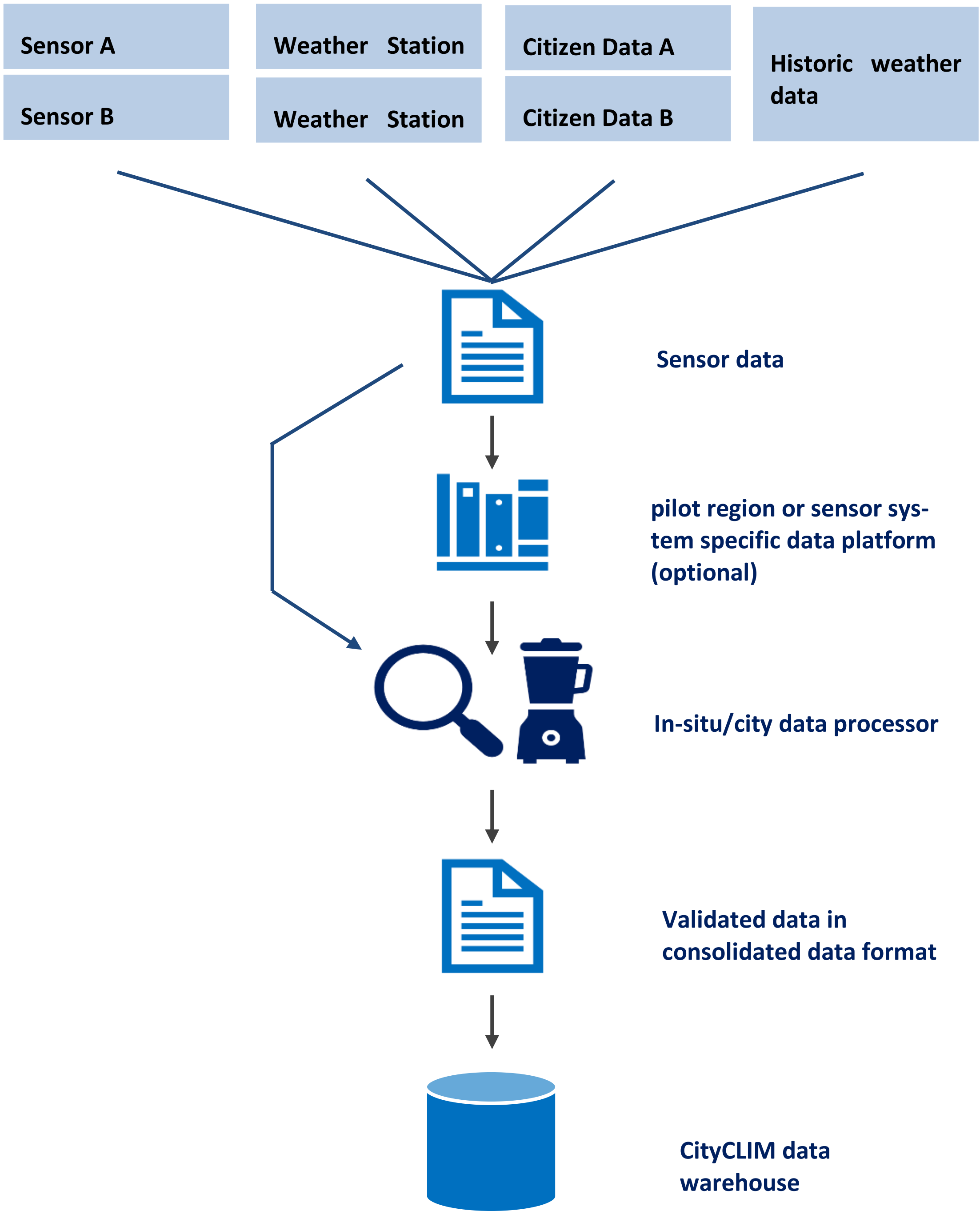


Figure 3-5: In situ/city data processor data flow

The in situ data processor is going to interface with a multitude of different measurement data-providing systems. The in situ data processor is either directly connected to data interfaces of sensor platforms or intermediate sensor platforms provided by third parties. The main functionalities of the in situ data processor are to perform quality checks on the incoming data and the parsing of measurement data frames to a consistent data format. As quality checking can already be part of previous data processing, this step will either consist of checking quality-related metadata or performing consistency and plausibility checks on the incoming data. These consistency checks may include unit checks, validation for unrealistic measurement values (range checks), jump detections, validation of the temporal and spatial metadata, etc. Additional to the quality checking, the in situ/city data processor is responsible to hand over the data to the data warehouse in a common data format, described by a to-be-defined data schematic. An optional step, depending on the measurement data type and the service requirements is the pre-processing of the input data. The pre-processing can either be a unit conversion, or the determination and elimination of systematic errors. Expected data products of the in situ/city data processor are listed in Table 3-1.

Table 3-1: In situ data processor data products

Level	Data products	Intended use	GCCP availability
L0	Geo- and time referenced raw sensor data (temperature, humidity, wind speed, wind direction, NO2, NOX, citizen science data, etc.)	Weather model validation	API
L1	Data schema and metadata for L0 raw sensor data		API

3.3.2 Airborne Data Processor

While spaceborne sensors are capable of providing data globally, their spatiotemporal resolutions are generally lacking for urban applications, and a trade-off between spatial and temporal resolutions needs to be considered. Missions with suitable resolutions are not expected to be operational before 2027, so methods need to be used during the CityCLIM timeframe that enable to bridge this gap. Besides thermal unmixing/downscaling methods that strive to interpolate missing timesteps or improve resolution computationally by exploring correlations with high-resolution data, airborne data acquisition is a useful on-demand approach for collecting high-resolution data at a selected point in time.

Within CityCLIM, airborne data is expected to serve multiple purposes. First, the very dynamic land surface temperature retrieved from longwave infrared sensing is unsuitable as a model input because of its singular availability and extended acquisition period, yet it may serve as a validation or calibration measure to assess the accuracy of model outputs or unmixing results, and it may serve as a high-resolution reference for the training of data-driven unmixing models. Second, land surface emissivities also collected via infrared sensing are much less dynamic and can serve as high-resolution model input maps for this parameter during CityCLIM in the regions where it has been acquired. Finally, data acquired at a suitable point in time, e.g., the prototypical hot summer day underlying different scenarios, may serve as a high-resolution visual reference for heat distribution on such a data, supplemented by gray-value or rgb data making association of, e.g., heat accumulations with urban structures much simpler.

This section details the processing steps required to produce useful airborne data products. The steps named here are planned for implementation within the GCCP, yet further required mission preparation or pre-processing steps need to be executed locally or even on-board during mission execution and therefore cannot use the platform. These steps will be elaborated in greater detail in the specification phase.

The airborne data processor aims at the GCCP-integration and cloud-based processing of airborne data collected during the CityCLIM airborne campaigns, and at making the final data products and useful intermediates for development available to the designated users.

During the airborne campaigns VIS and TIR data will be collected. To acquire LST data from this raw data a number of processing steps are needed. In addition, prior to data collection, regions of interest and places for vicarious calibration need to be defined and catalogued in terms of geolocation and desired observation time window, to then plan a flight track accordingly.

As established in the processing of earth observation data, the processing is dived into levels, where Level 0 (L0) is the raw data from the sensors, Level 1 (L1) is the georeferenced physical data at the surface and Level 2 (L2) contains the derived measurements like LST and LSE. A preliminary set of data products is shown in Table 3-2.

Table 3-2: Expected data products delivered by airborne data processor and available via the GCCP

Level	Data products	Intended use	GCCP availability
L0	Raw sensor data (VIS, TIR), metadata	L1 processing	-
L1	Geo-located VIS data		API, GUI
L1	Geo-located TIR surface radiances	Development, L2 processing	API
L2	LST, LSE		API, GUI

Accordingly, the Airborne Data Processor environment within the GCCP consists of a set of methods implementing the processing steps required to obtain the intended data products from raw airborne data supplied into the GCCP via API after campaign completion and ancillary data (e.g. DEMs of pilot cities, supplementary satellite data, atmospheric measurements, and laboratory calibration data).

In Figure 3-6 the rough architecture of the Airborne Data Processor is shown. The raw airborne data not only includes the raw pixel values, but also all necessary metadata like timestamps, location data, orientation data and calibration data. With that, first the geometric corrections mostly based on the camera parameters gathered during the geometric calibration are applied. This may include distortion corrections due to the wide-angle field of view of the cameras.

Secondly, radiometric corrections are applied. This includes calibration data collected during vicarious calibration and atmospheric profiles collected as part of the in situ campaign intended to accompany the airborne campaign.

Geometric processing is finalized by orthorectification, the process of projecting each pixel to the earth's three-dimensional surface, such that the scale is uniform and the coordinate system follows a given map projection. This may be accomplished using photogrammetry methods utilizing airborne VIS data, however for best accuracy GCCP access to DEMs of the pilot cities is required.

As the sensors will be of staring array type, their images will overlap. This overlapping can be used to create good orthomosaics via co-registration of overlapping image areas. These overlapping images can then be fused and blended to create views for larger areas. With this the level 1 processing is completed and the L1 data products, including TIR and VIS data, are made available for CCS and developers.

In the L2 processing the level 1 TIR data is processed utilizing the TES method to acquire LST and LSE data, which are also made available to the climate services.

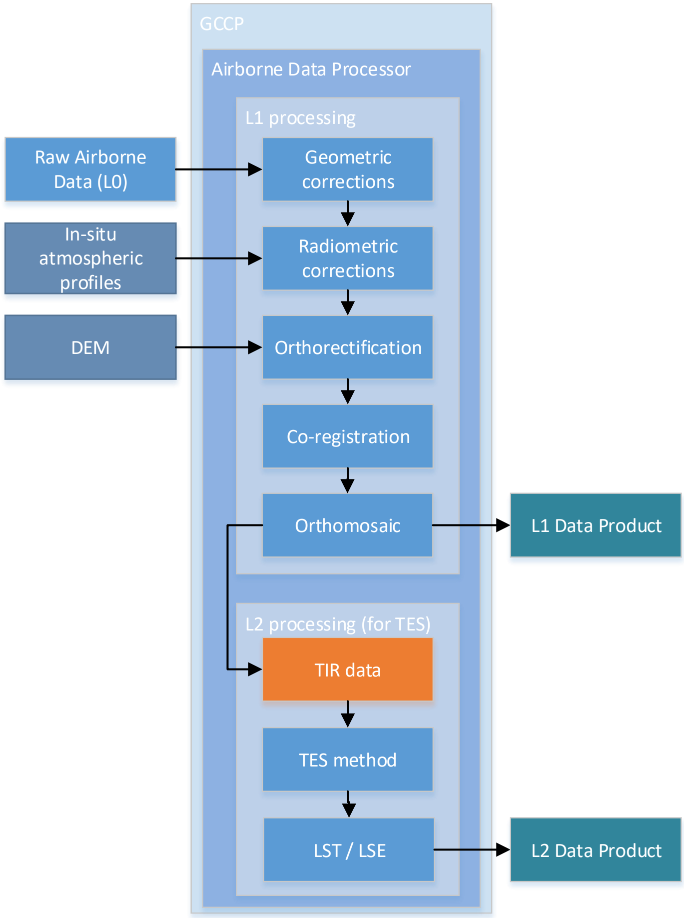


Figure 3-6: Architecture of the Airborne Data Processor

3.3.3 Spaceborne Data Processor

The spaceborne data processor is the instance processing EO data from Copernicus and other EO data sources before they are stored on the GCCP and used for the cloud-based processing in the diverse engines and services developed in CityCLIM. One aspect of the spaceborne data processor is to provide the EO data in a way that they can be assimilated by the UltraHD weather model (e.g. related to land use or vegetation status). To enable for this, a number of pre-processing steps have to be performed which are specific to each data source and the intended usage in the CityCLIM engines (see below). Besides these, the spaceborne data processor includes a processing chain related to the identification of urban heat as a number of metrics and indices (see below). As these are only calculated from spaceborne EO data and services, they are included here in the spaceborne data processor in contrary to the analyses of urban heat based on the outputs of the UltraHD weather model that are included in the Climate Diagnostics Engine. Both analyses of urban heat feed into CityCLIM's Heat Island Identification Service. Final data products and useful intermediates that can be used for development are made available by the spaceborne data processor the designated users.

The spaceborne data processor includes amongst others:

I. Pre-processing of diverse EO data, e.g. temporal aggregation (e.g. to monthly resolution), spatial selection (bounding boxes around the project cities) and reprojection.

II. Derivation of LST data from various satellite sensors with high accuracy (e.g. on 1km resolution from Sentinel-3A and 3B satellites, from MODIS on board TERRA and AQUA, from Landsat 9). For this, the Land Surface Emissivity (LSE) is characterized using high-spatial resolution land cover data and/or as an alternative, the NDVI threshold method, the TES algorithm or a supervised classified high spatial resolution image.
III. Land surface temperature (LST) maps from various satellites sensors will be obtained and thermal unmixing techniques will be applied to downscale LST to higher resolution (e, g. 30/50 m) using Sentinel 2
IV. From LST data the Surface Urban Heat Island Index (SUHII) is estimated as the difference between the LST obtained in the urban area and the LST of its surroundings
V. Provide maps of thermal comfort indices: Urban Thermal Variance Index (UFTVI), Discomfort Index (DI), SUHIImax and SUHIImin that assess the maximum and average SUHII of the urban area. Also here, unmixing techniques are applied.

The processing is dived into levels, where Level 0 (L0) is the raw data from the sensors, Level 1 (L1) is the georeferenced physical data at the surface and Level 2 (L2) contains the derived measurements like LST and LSE, and Level 3 (L3) contains the derived thermal comfort indices. Figure 3-7 shows the architecture of the spaceborne data processor (processing steps (blue) and data products (orange)) with examples of the key functionalities of Level 2 and 3 processing and the data flow to the data warehouse of the GCCP. A preliminary set of data products is shown in Table 3-3.

Table 3-3: Expected data products delivered by spaceborne data processor available via the GCCP

Level	Data products	Intended use	GCCP availability
L0	Raw sensor data (VIS, TIR), metadata	L1 processing	-
L1	Geo-located VIS data		API, GUI
L1	Geo-located TIR surface radiances	Development, L2 processing	API
L2	LST, LSE		API, GUI
L3	Thermal comfort maps (UFTVI, DI)		API, GUI
L3	Surface Urban Heat Island characterization (SUHIImax, SUHIImin)		API, GUI

A similar architecture to the one given in Figure 3-6 for the Airborne Data Processor will be used for the Spaceborne Data Processor with the only addition of L3 processing that uses the L2 data product (see Figure 3-7).

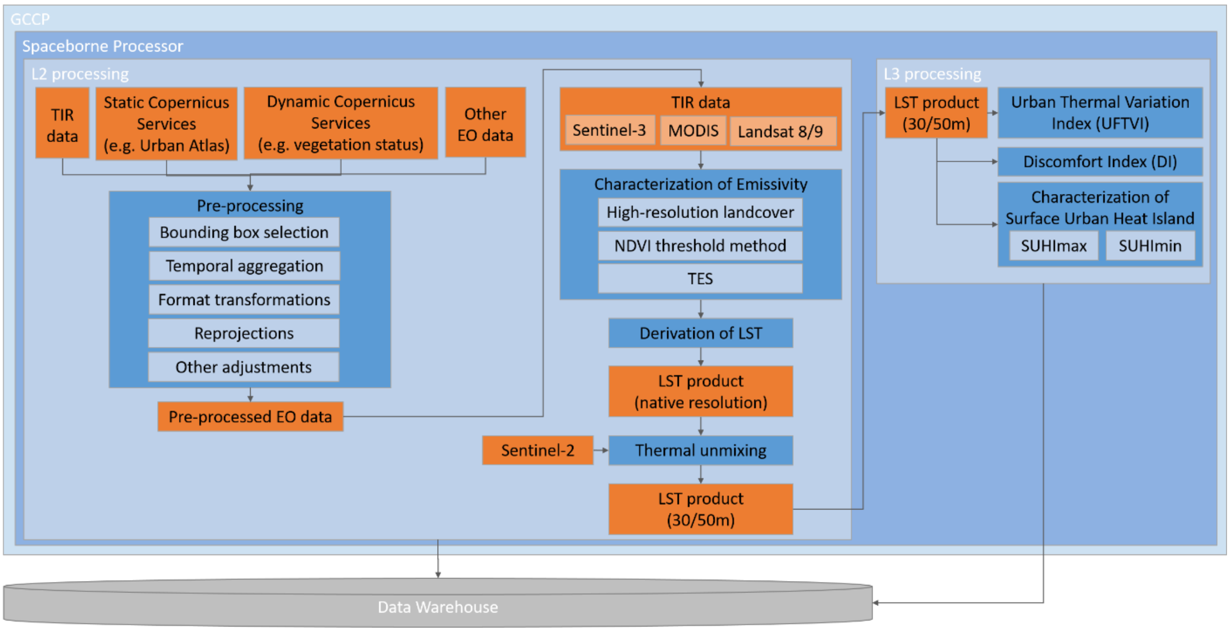


Figure 3-7: Architecture of the Spaceborne Processor

3.4 Data Warehouse

This section describes the CityCLIM GCCP Data Warehouse (see Figure 3-8).

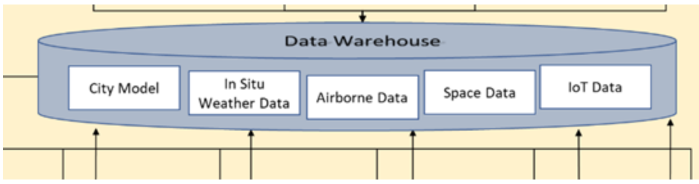


Figure 3-8: GCCP Data Warehouse

The Data Warehouse of the GCCP stores processed data from data sources (e.g., in-site, airborne and spaceborne), engine results, weather model results and user related data. Beyond that it has no further intelligence but is essential for the data exchange between components in the GCCP during their operation.

4 Laboratory prototypes

This section describes laboratory prototypes of CCS (see subsection 4.1) and GCCP (see sub-section 4.2).

The Laboratory prototypes can be seen as initial drafts of components that allow to analyse the service concepts and to address critical aspects (e.g., on data quality and acquisition rate) that then can be discussed with developers and end users. The provided feedback will be used to update related concepts. The laboratory prototypes are supported by (user) interface mock-ups, artificial data and, whenever available, real (historic) scenario data from pilots. They also serve as proof of the concept for critical parts and include an early validation by platform and service end user partners. The laboratory prototypes in an early stage of the project prevent misleading activities and support the elaboration of the CityCLIM concept.

Laboratory Prototypes are made for (1st) CCS, which are provided as mockups for the Climate Information Service (Web Portal), Administrative Services and the Citizen Weather Sensation Service (see section 4.1); and (2nd) for the GCCP, which are technical aspects of the Advanced Urban Weather Models including the interaction between the UltraHD and SuperHD model, and data quality challenges and the need for reward systems in the context of citizen science. Moreover, technical access to in situ data of the City of Valencia via the FIWARE platform is described, and required EO data for the calculation of different thermal comfort index maps are mentioned with an exemplarily presented visualization of the Level-2 LST product from the Sentinel-3A SLSTR spaceborne instrument. Finally, is also described an approach for identifying urban and surrounding references using Spaceborne data (see section 4.2).

4.1 City Climate Services Mockups

4.1.1 Climate Information Service (Web Portal)

The Climate Web Portal is supposed to present a graphical user interface to browse historical weather data with ease and without the need of prior knowledge. Thus, all components are planned to be easy to understand and accessible. To achieve this, we aim to keep the UI simple and not overly complicated, however, historical data sets are often extremely diverse and the UI needs to be able to handle the presence of missing data or special data types. The design of a universal navigation that accommodates all data types will be a major part of the development of the platform. Our first wireframes of the portal include to start the climate web portal with a freely zoomable historical map or a deviation map (anomaly map) like in Figure 4-1 (which shows a map with the difference between the model's forecast temperature and the climatologically expected temperature for a given time. Positive values indicate abnormally warm temperatures while negative values indicate abnormally cold temperatures.), enabling the user to see the deviation of the current temperature from the climatologically expected temperature of the day. This is meant to establish a direct connection from the now to the past for the user and aims to evoke interest in further exploring the data sets.

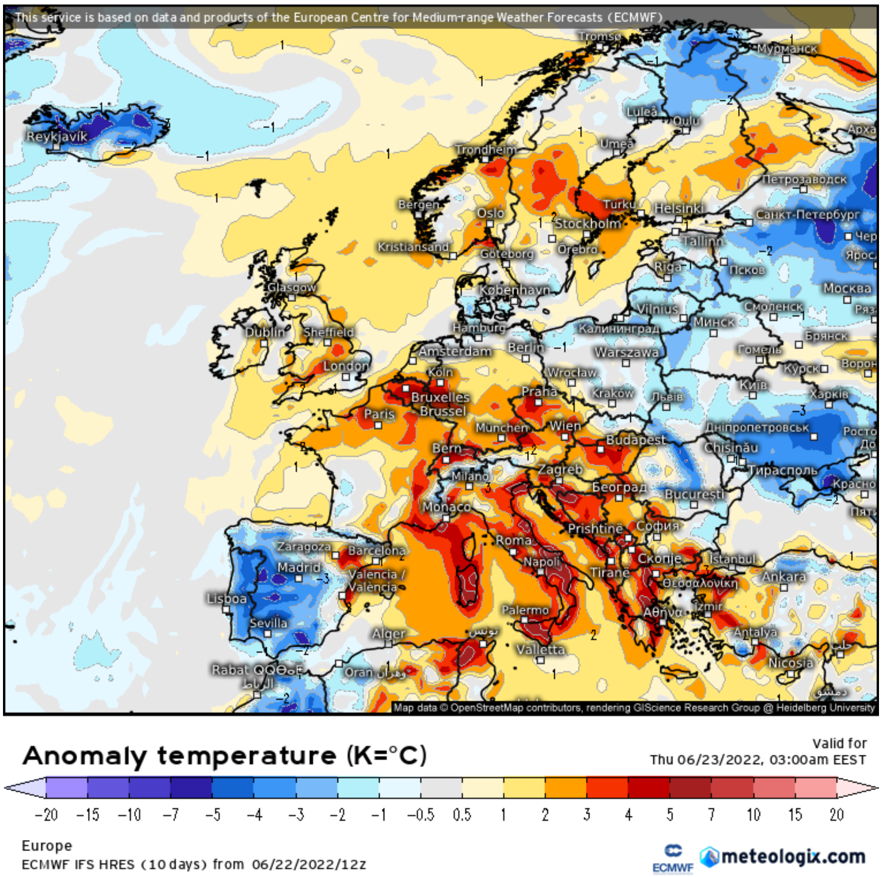


Figure 4-1: Model's forecast temperature vs. climatologically expected temperature for a given time

Changing date and range

The actual date (range) and displayed background maps as well as plotted observations customizable as far as the time series data will allow to provide as much flexibility for the user as possible. Reasonable defaults will be set. Figure 4-2 displays an early mockup view of the starting screen for the climate web portal. On the left-hand side is a navigational panel, where parameters, data range(s) and data sources can be selected that control the map and the station date range. Further elements for data selection can be found on the observation panels themselves. Other buttons to hide and show certain elements should be included to prevent overlapping elements. You can also see climate stripes as overview parameter for each station in the given time series. Climate stripes are an intuitive and already quite known visualization of vast data that can demonstrate impressively potential trends in temperature or precipitation.

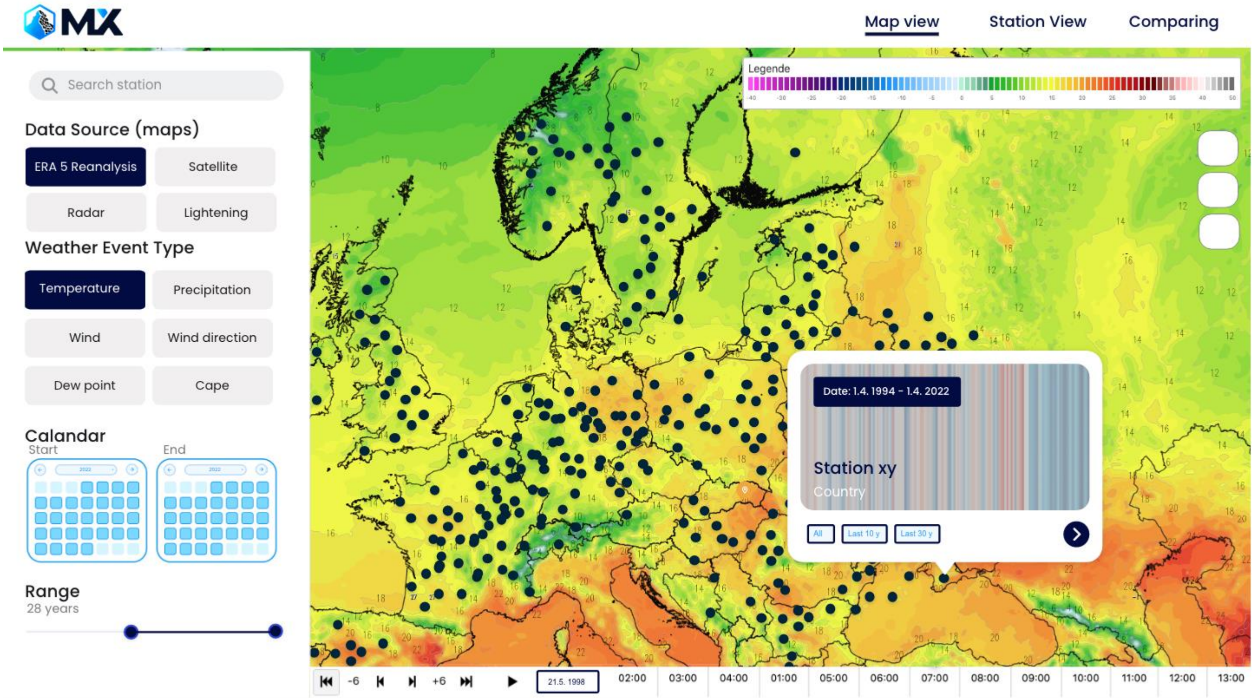


Figure 4-2: Early mockup view of the starting screen for the climate web portal.

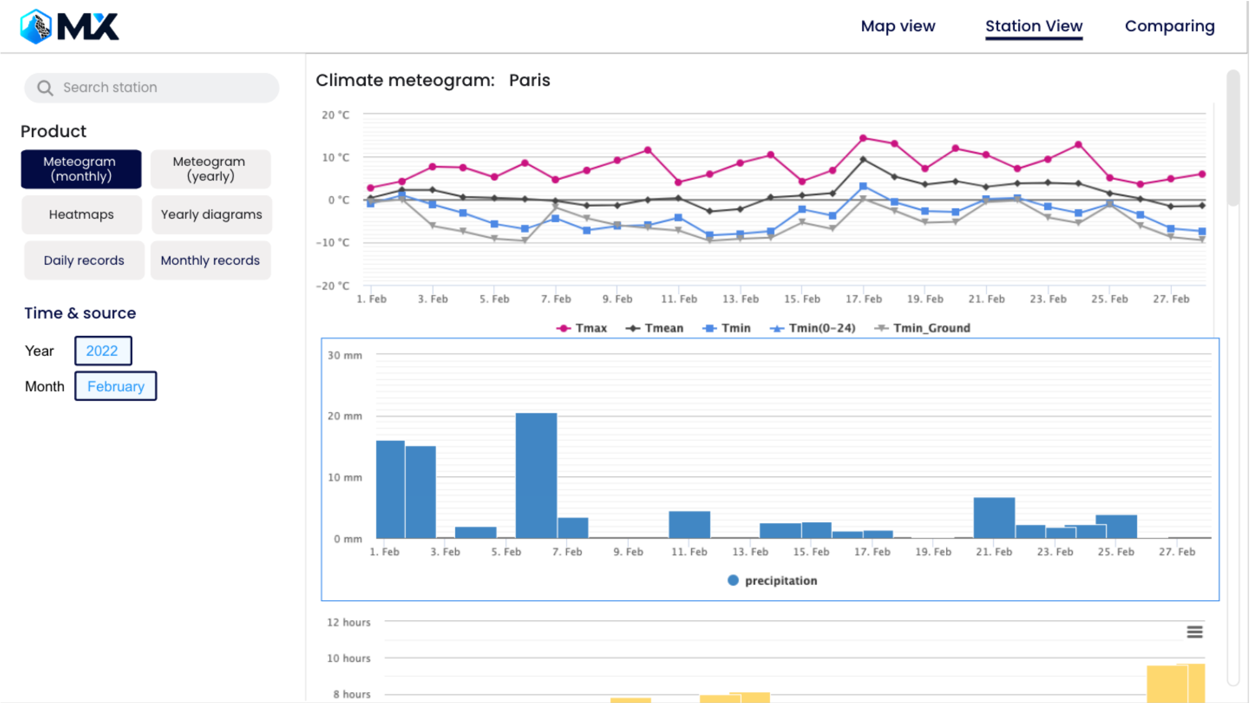


Figure 4-3: Station view of a selected weather station and its options (monthly view)

Station view:

Another view is the “station view” – this view is supposed to provide details on the time series data of each station. Stations can be searched via the search box. The user can then choose several aggregation and visualization options. Our laboratory prototype includes currently six: monthly and yearly meteograms, heatmaps, yearly diagrams, daily records and monthly records. Figure 4-3 shows the station view of a selected weather station and its options. Each station should provide a range of diagrams that the data range of existing historical data allows for.

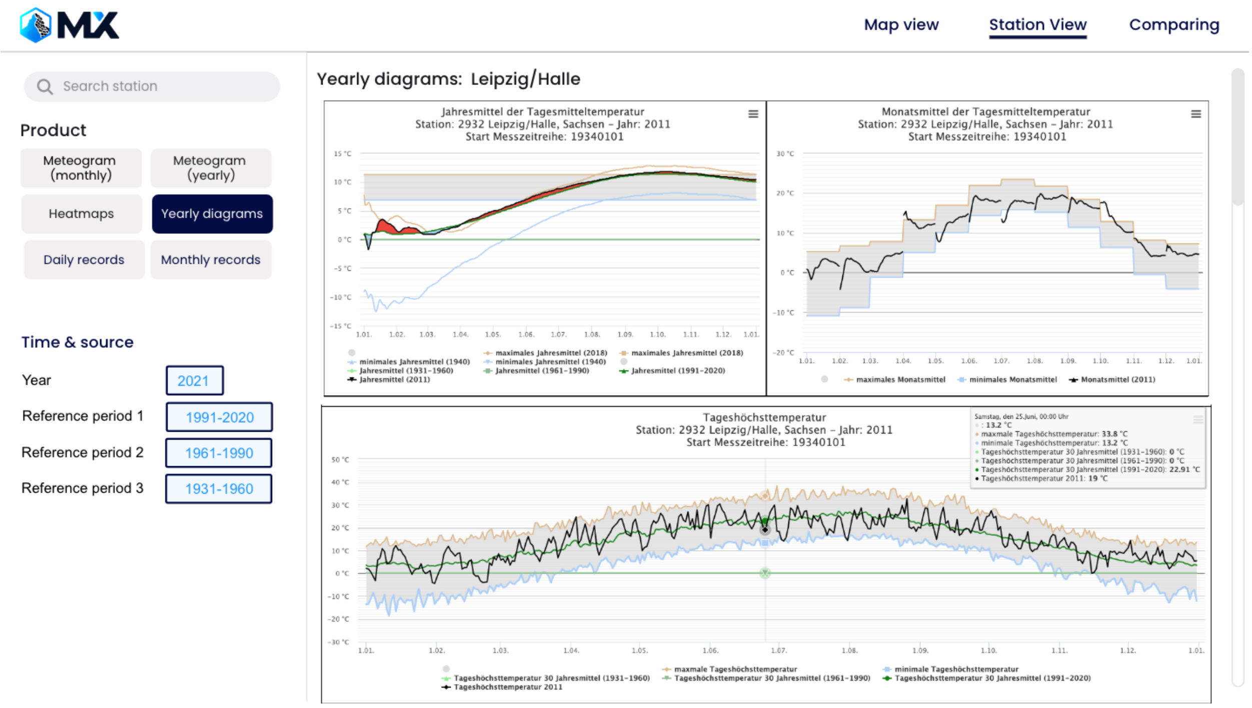


Figure 4-4: Station view: product yearly diagram.

Figure 4-4 shows the yearly diagram feature, which offers a display of the official reference periods and the deviation of the yearly mean from it. This visualization is especially suitable for showing changing maxima and ranges impressively.

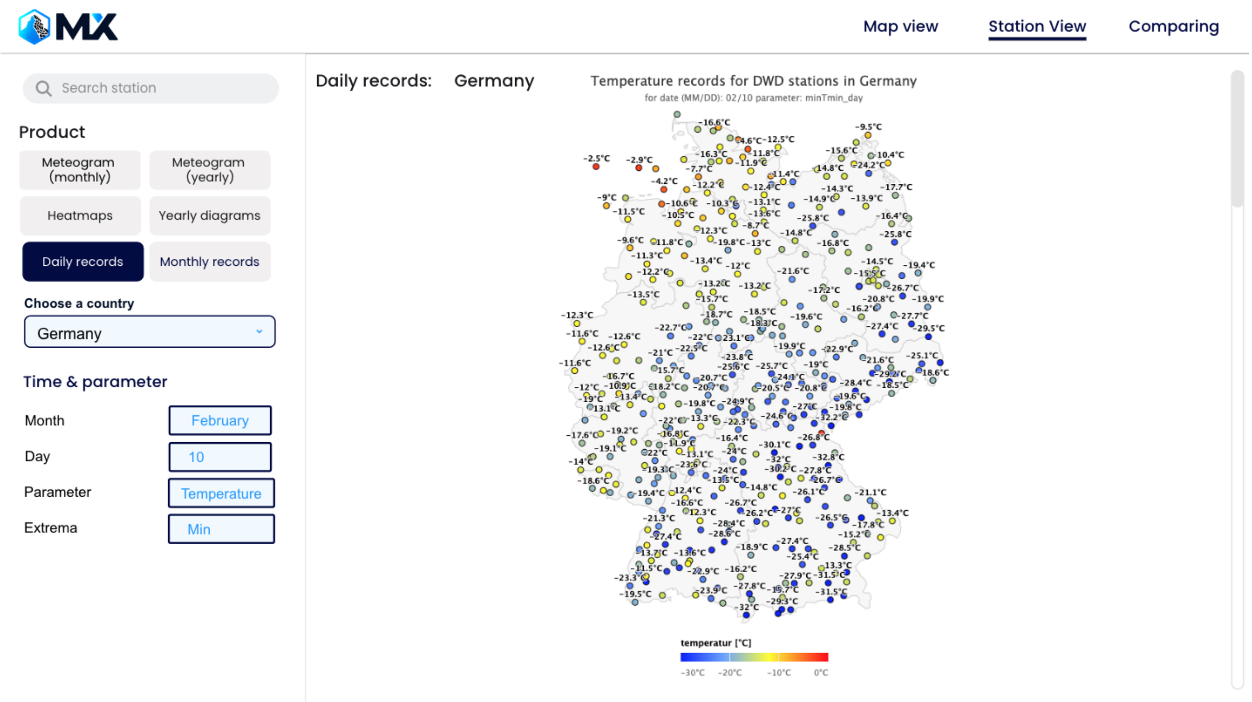


Figure 4-5: Record maps for a given country

The user can further explore daily records for a given country (if data sets are available). Records are an easy way to detect anomalies and even trends, and an intuitive format for all users. A map here would show all ever measured records for the chosen day for a certain region/country. This view is also extendable to other time aggregations like months.

Compare view:

This view will enable the user with means to compare selected data sets with other data sets of the same station or stations nearby. Another currently discussed functionality is the possibility to run simple statistical tests on the fly on the client-side. For example, one could compare the last 10 years to a similar period 20 years ago and run a simple t-test or similar tests for statistical significance.

Several other views and visualizations are currently under discussion for the Climate Information Service web-portal and ideas are collected from the participating Pilot Cities.

4.1.2 Administrative Services

This section provides first drafts of the simulation editor and heat island identification service as parts of the administration services. They are the results of discussions between technical partners and pilots and show basic functionality and user flows. Although not covering full functionality and design decisions, the initial versions help to analyse current service concepts and support further improvements and adjustments.

After logging in, the entry view of the administration services shows a map with fixed boundaries, that are attached to the logged-in user account. The user can choose between Identification and Mitigation Services and may also activate the “New Scenario” mode, which allows to integrate simulated changes to the urban area (within the registered map boundaries). The example below shows the pilot city Karlsruhe with its rural area.

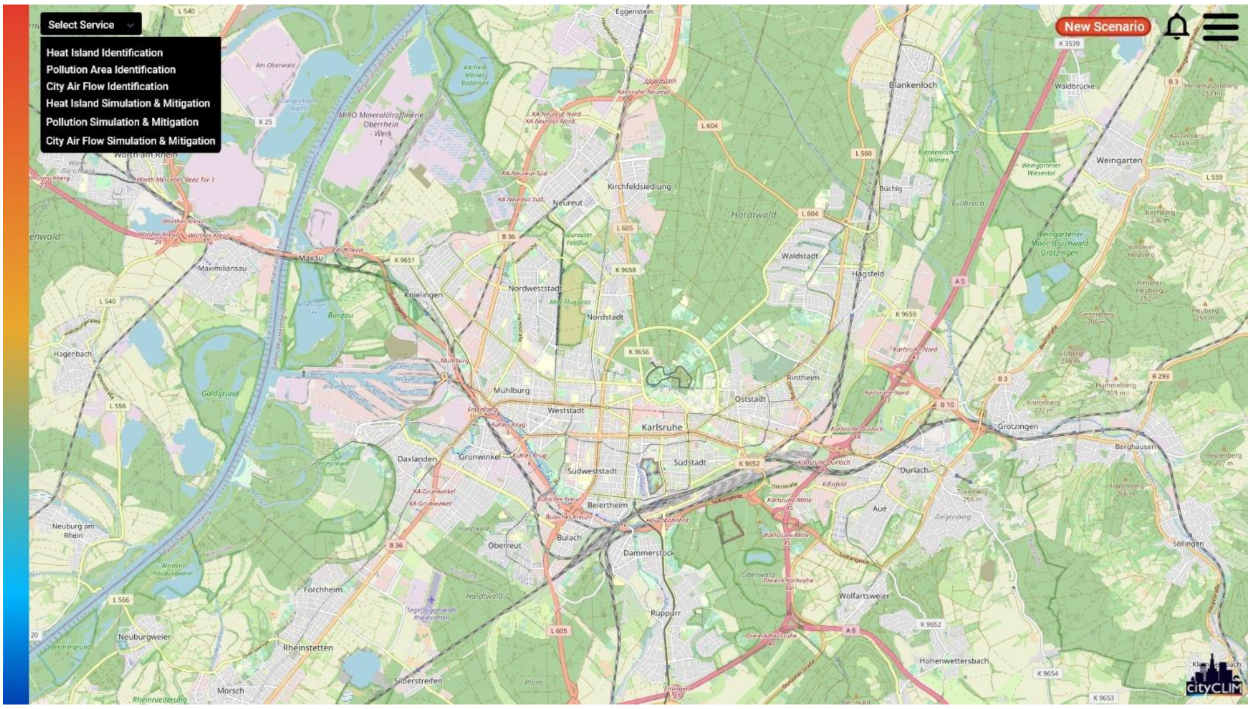


Figure 4-6: Init. view of the administration services showing a map of the pilot Karlsruhe with rural area

Entering the “New Scenario” mode, the user can navigate to an area of interest and choose to change landcover types or elevation of certain areas. Several landcover types as (e.g.) built-ups, tree cover, cropland, grassland, water bodies and bare vegetation will be available. In the example below the land cover mode is active with cover type “Built-ups” selected.

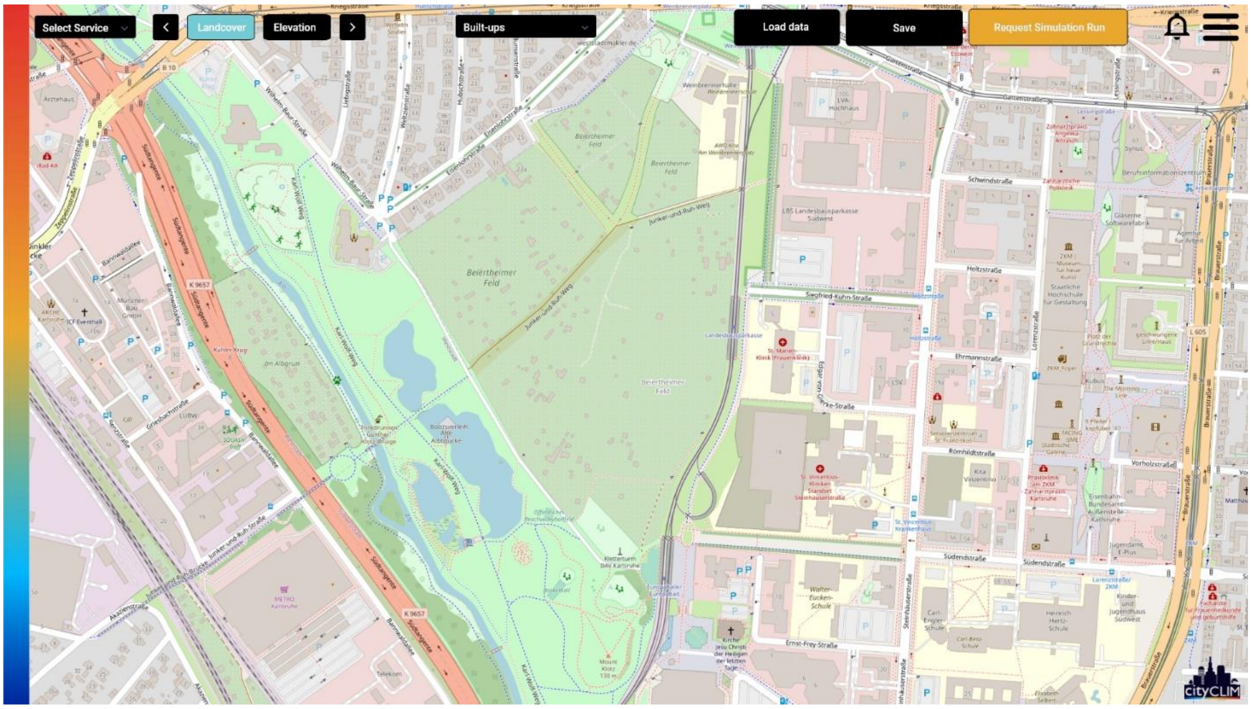


Figure 4-7: A park is selected to make new simulated changes to land cover.

Having selected a landcover type, the user can draw new simulated changes to the area of interest. The example below shows a scenario, where new built-ups and water bodies are planned. Moreover, the user can load previous maps with landcover changes and save newly integrated changes to a user-assigned storage.

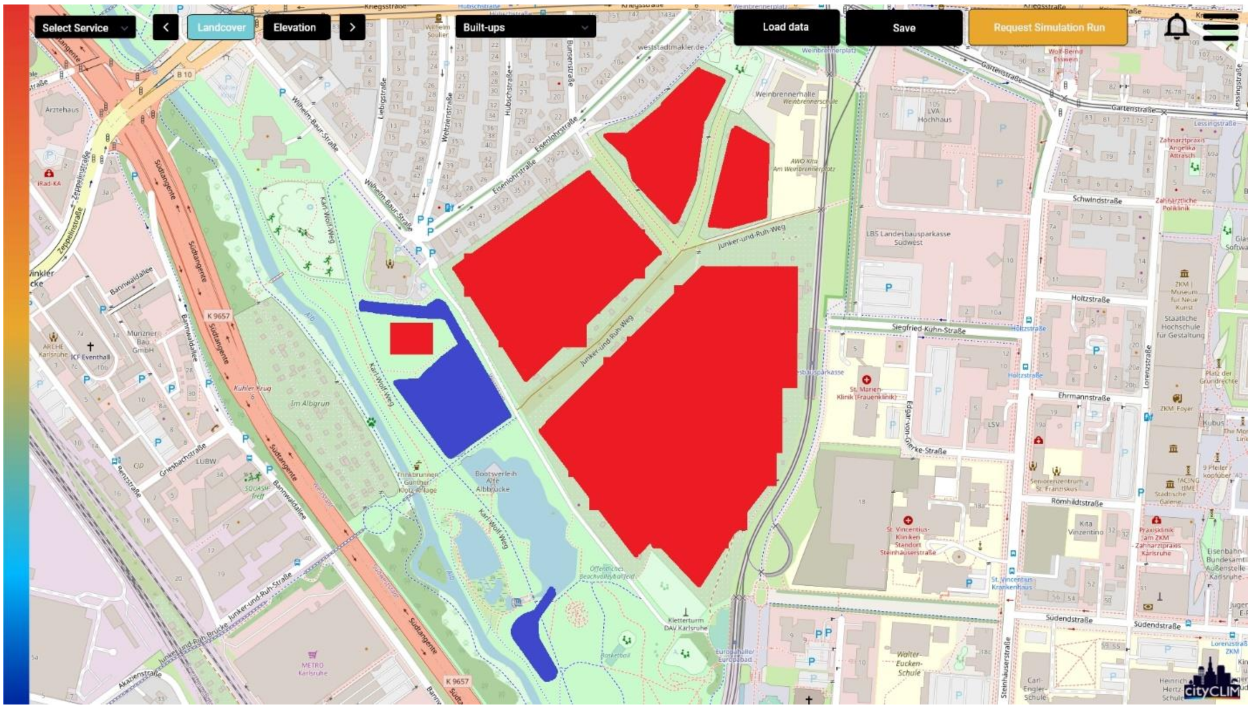


Figure 4-8: New simulated changes of type built-ups and water bodies have been integrated.

After the user finishes the integration of new simulated changes, switching to the elevation mode allows to adapt the elevation of current landcover types and newly simulated changes.

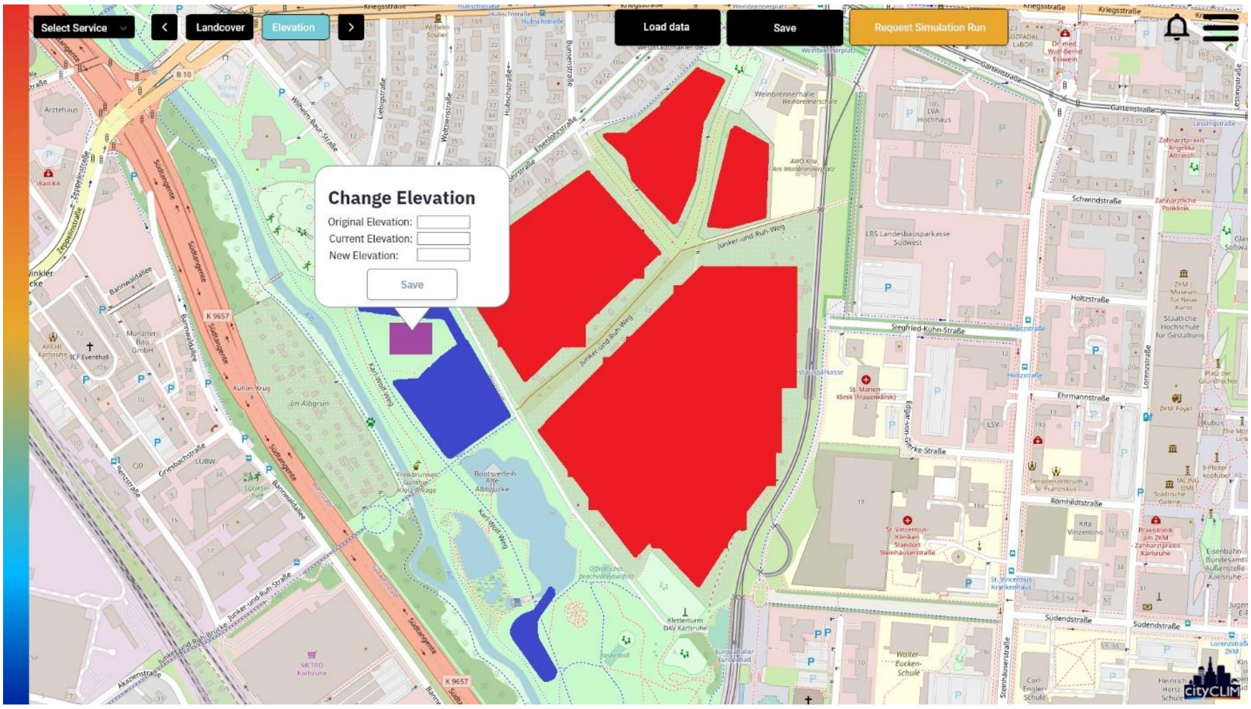


Figure 4-9: The elevation of newly integrated simulated changes are determined.

Once the scenario planning is completed, the user may request a simulation run, where the effects of the simulated changes are compared to local prototypical days as e.g., HOT-SUMMER-DAY as shown in Figure 4-10.

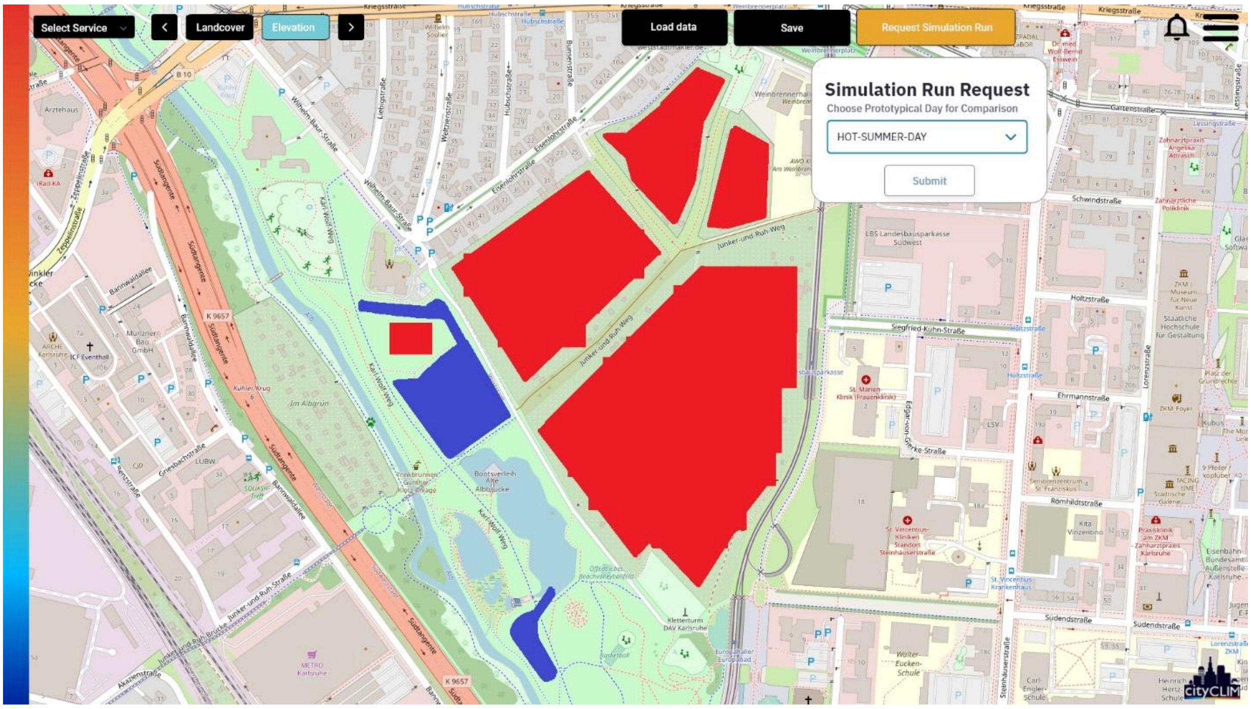


Figure 4-10: Request simulation run for a HOT-SUMMER-DAY

After having submitted the simulation run request, the user will be informed of the approximate time when the results are expected to be available. The results including statistical maps on the difference between submitted changes and prototypical days can then be seen within the mitigation services. The potential realisations of these statistical maps are still to be determined.

Feedback from technical partners and pilots shows that the design of the web interface should provide guidance on how to use all aspects of the administration services. Moreover, regarding the “New Scenario” mode a comprehensive “Drawing Menu” would be beneficial that allows to draw simulated changes to landcover using geometric shapes, and to change the landcover type of current units with ease. Additionally, the export of scenario data (and other administrative services related data) to established data formats would certainly increase the usability of the services.

Entering the Heat Island Identification Service, the user can choose between different parameter (e.g. land surface temperature). Depending on that choice moreover an aggregation parameter or central tendency can be selected (e.g., max 2m temperature, max land surface temperature or max dew point). The user then obtains a map that shows the heat distribution and hot spots based on all model runs that have been performed so far. The information how many model runs have produced the aggregated information is accessible by the web client. The potential different visualizations of statistical maps (with e.g., textual information on parameters on selected areas) are still to be determined. Figure 4-11 shows a first draft of a colourized map within the Heat Island Identification Service, which shows hot areas from aggregated model runs. The example with pilot city Valencia, where the parameter “Land Surface Temperature” with aggregation parameter “Max. 2 Meter Temperature” is selected, uses entirely artificial data.

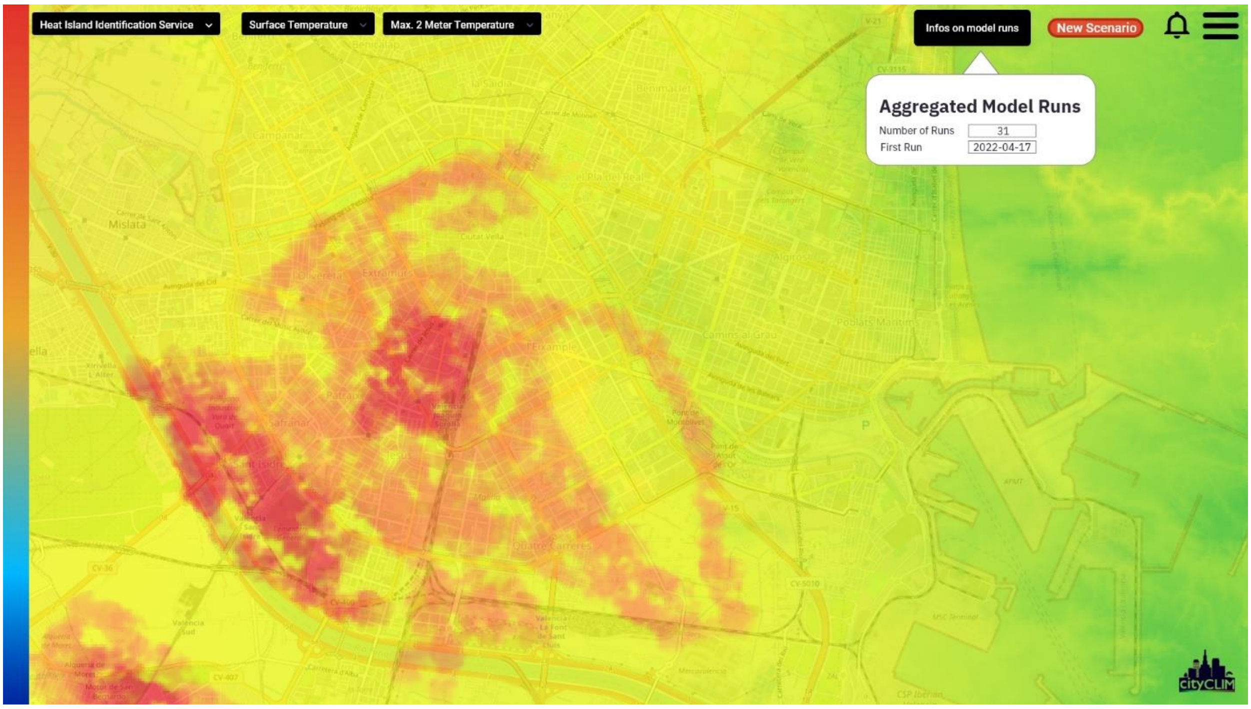


Figure 4-11: First draft of a colourized map within the Heat Island Identification Service

4.1.3 Citizen Weather Sensation Service

As introduced in section 2.1.4, weather and climate feeling depend strongly on the person and the context so that people would be interested in planning out-of-home activities such as walking, out-door sports or shopping on easy-to-use maps of the current and forecasted weather in terms of their own preferences.

Figure 4-12 shows such an easy-to use map with a traffic light legend. Areas on the map indicated in green would be recommendable for the person whereas red areas should be avoided. The basic scenario of the mockup-App will simulate, based on an area and time selection as input, the air temperature map and humidity map from a weather service and display it overlayed onto the street map. For the setting of the parameter of the personal well-being, sliders for temperature range, humidity range and maximal acceptable heat index will be provided. The map is then generated based on an evaluation of the input data according to the personal settings. An option in the mockup will allow to simulate the user decision regarding the sharing of own settings and feeling with different groups (no, public, limited group). This could help others to identify their own preferences as well as other entities (e.g. city administration) to evaluate the general situation.

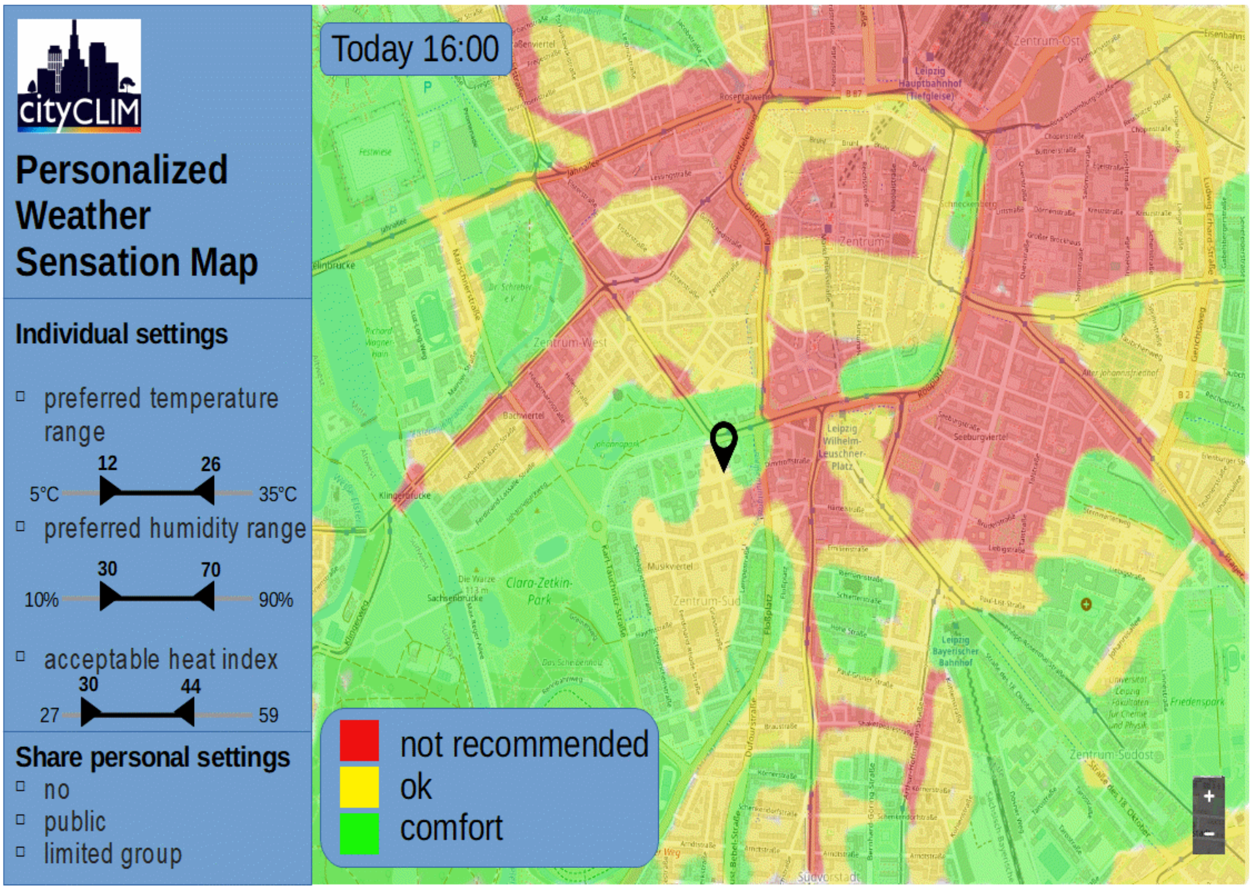


Figure 4-12: Mockup: “Citizen Weather Sensation Engine for Personalized Climate & Weather Feeling”

4.2 Generic City Climate Platform Lab-Prototypes

4.2.1 Advanced Urban Weather Models

The laboratory prototype of the UltraHD model uses operational boundary data from the existing SuperHD for central Europe. It can be run on an operational basis for one of the pilot cities (Karlsruhe). For the nest of Valencia, preliminary SuperHD boundary data was produced. With that, it was possible to provide first outputs for one hour model integration time for the region.

Output of the laboratory prototype consists of pre-rendered PNG images that may be used as map overlays and gridded surface fields in float format for diagrams and further processing. The output includes parameters like land surface temperature (LST), 2m temperature, 2m dewpoint, 10m wind speed and direction at 100m resolution. Since the implementation of the 100m soil model is part of ongoing development, soil parameters (LST, heat and moisture fluxes) are produced by downscaling from the SuperHD model soil and flux data.

In Figure 4-13 and Figure 4-14, preliminary output of the laboratory prototype for the pilot regions Karlsruhe and Valencia is presented. In panels a) a simulated RGB image of the domain is shown where different land use characteristics and clouds are visualized. The output of the simulation for Karlsruhe covers the whole day of the 27th of April in 2022 with a 5-minutes output timestep. The simulation starts at 00:00 UTC and the output presented is valid for 17:15 UTC. In panel b), which shows land surface temperature output, first signs of the urban heat island effects are already recognizable. Panel c) and d) present 2m values for temperature and dewpoint. Those are dominated by atmospheric boundary conditions but the surface effect is still noticeable. In the dewpoint map strong signals from smaller showers at the model boundary and from boundary layer mixing can be found. Wind speeds at that day were inconspicuous.

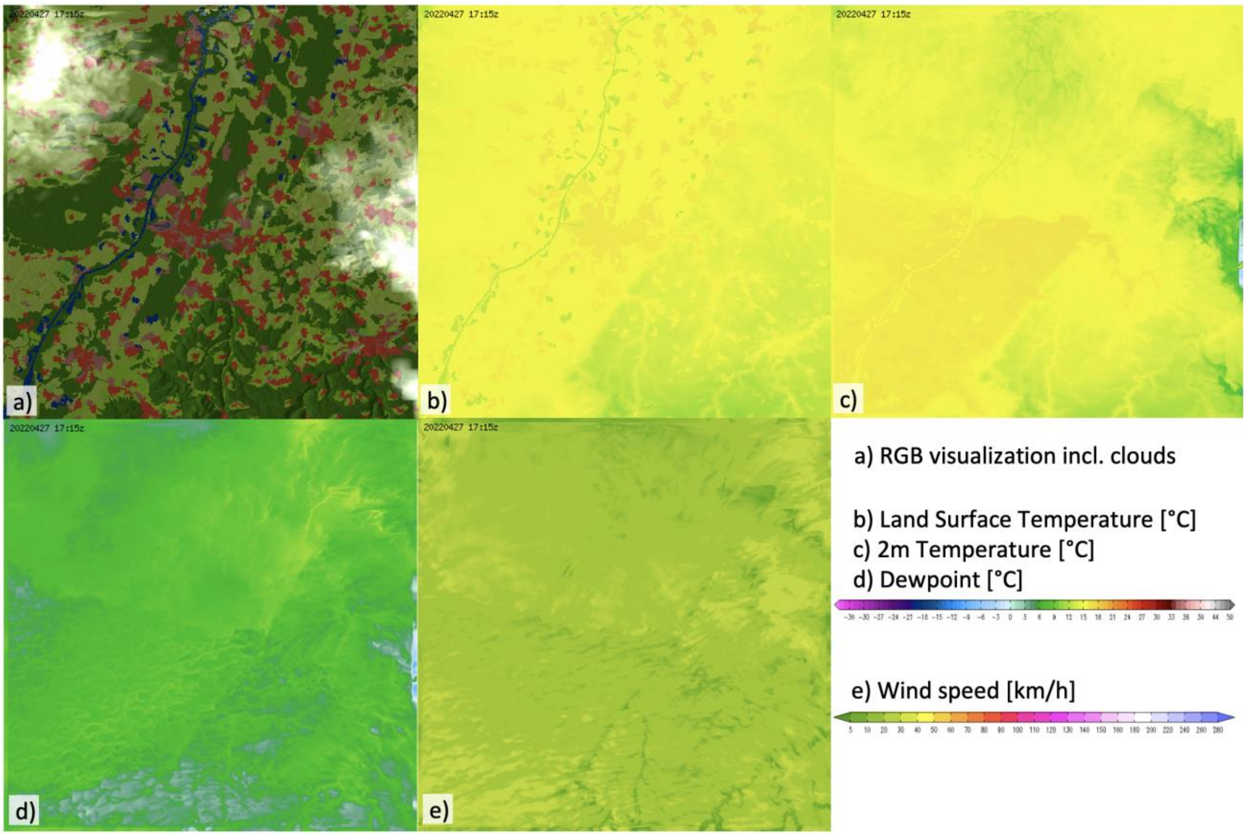


Figure 4-13: Preliminary output of the laboratory prototype for the pilot region of Karlsruhe

The second laboratory prototype test case covers the pilot region of Valencia. Since there is no operational SuperHD model available for that region yet, the SuperHD model was processed on demand to provide one hour of 3d boundary conditions data. The UltraHD model was run for that boundary data which covers the first hour of the 15th of March 2022. The model was integrated for one hour simulation time and output is presented in Figure 4-14. Since the model run covers one hour in the middle of the night with quite windy conditions no urban heat island effect could be identified for that time. Land surface temperatures and 2m temperatures differ slightly. Strong signals for that case could be found in the wind speed where boundary layer rolls behind the mountains north of Valencia developed and the sea breeze could be observed with higher wind speeds above the Mediterranean Sea.

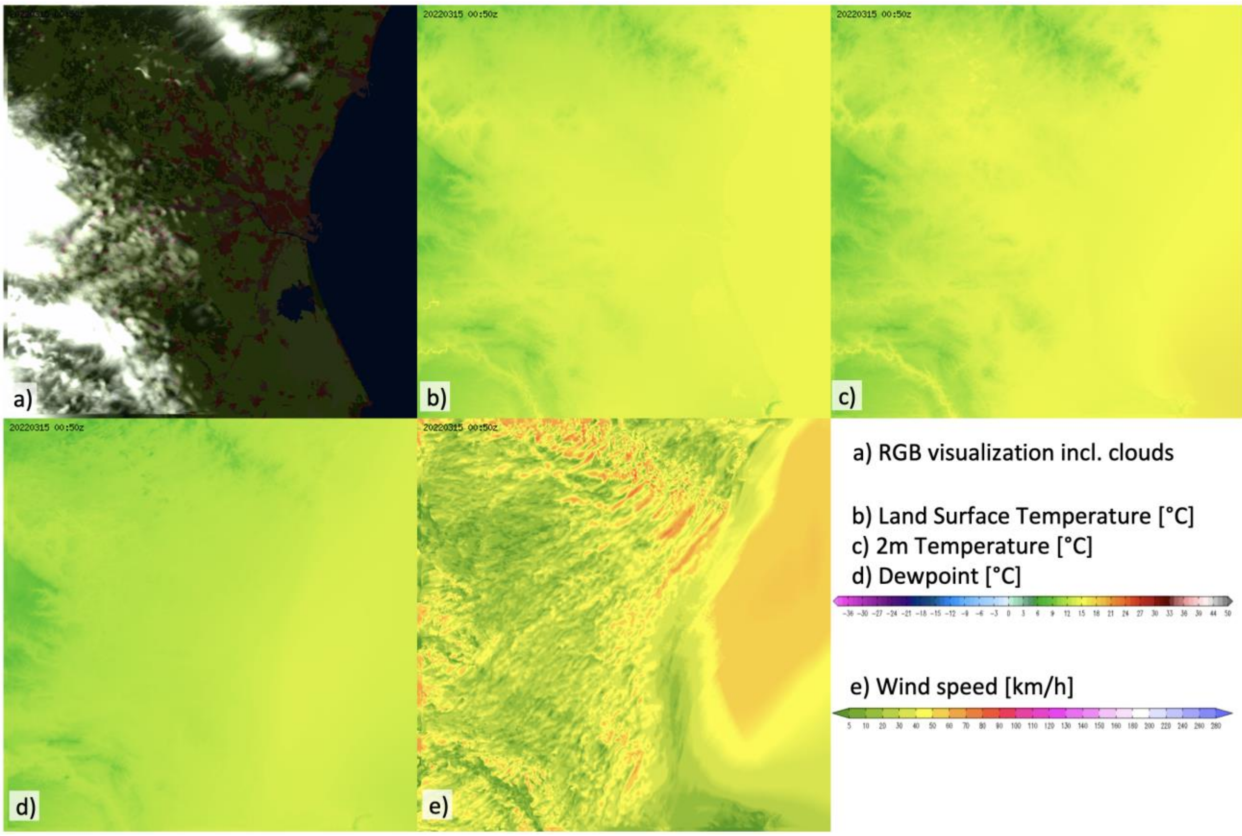


Figure 4-14: Preliminary output of the laboratory prototype for the pilot region of Valencia

4.2.2 Data Quality with Citizen Science Devices for In Situ Citizen Weather Data

Every weather model needs in situ data. These could be provided by citizen scientists. The question here is whether the data contain errors or deviations.

4.2.2.1 Data quality challenges with citizen science measurement systems

Various systems are available for the measurement of environmental parameters by citizen scientists, which differ in function, accuracy and operation. In order to gain an insight into the quality of the data, 3 systems were compared with each other on a measurement tour on 23.2.2022 in Leipzig. The measurement setup is shown in Figure 4-15.

Here, temperature, relative humidity, air pressure and GPS position were recorded. The example of the temperature measurement in Figure 4-16 shows clear differences. With the time offset of 2 minutes observed here, a difference in location of 300 metres can occur at typical bicycle speeds. This can make a considerable difference in densely built-up cities.

This makes it clear that the quality of the data must be assessed and documented. For example, the following information may be important:

- Sensor used and setup
- Calibrations carried out according to which standard
- Comparison tests carried out with sensor XY
- Location of the sensor including photo
- Age of the sensor

Figure 4-15: Setup for comparison test for mobile measurement systems

4.2.2.2 Reward system for data collectors and providers

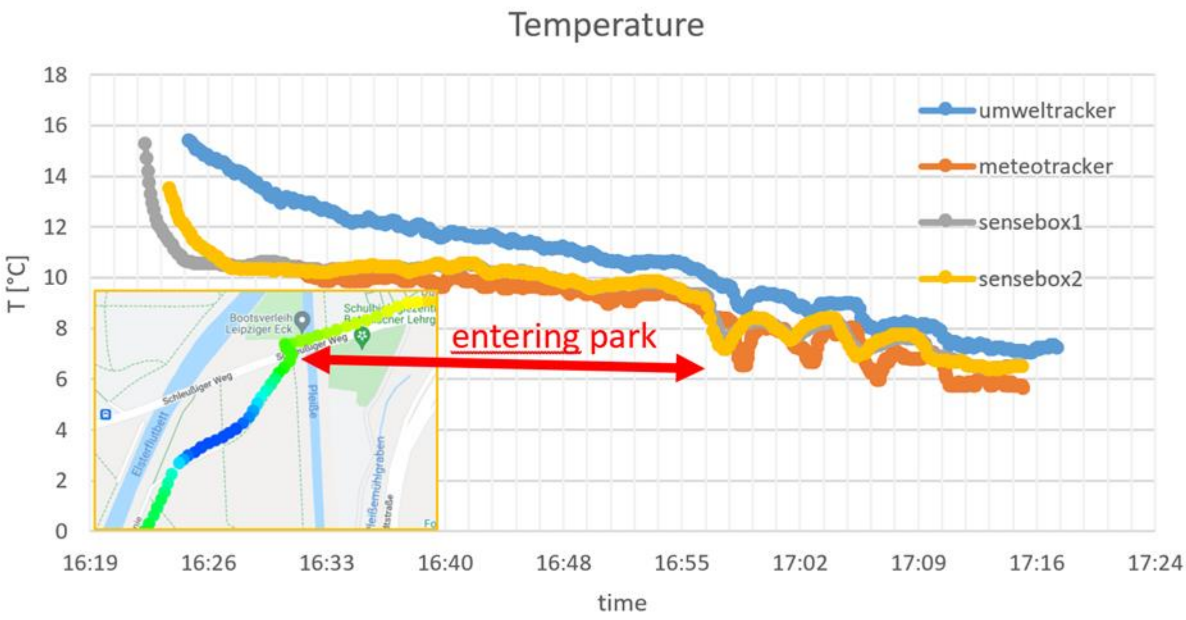


Figure 4-16: Results of comparison test of 4 mobile citizen science measurement systems

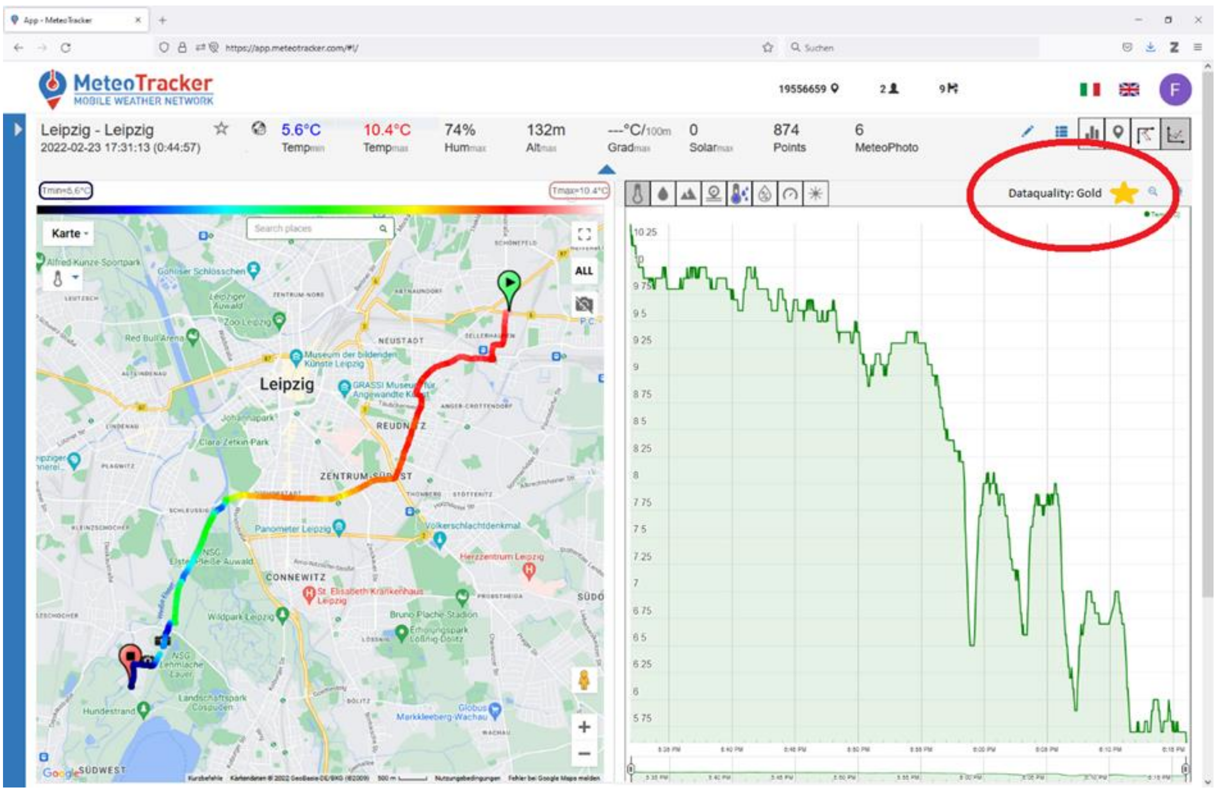


Figure 4-17: Meteotracker [1] dashboard of a mobile weather station with added quality indicator

In order to motivate the voluntary data providers to provide the above-mentioned data, a reward system could be used. In this system, a provider of data including complete meta-information should receive a kind of "gold standard" after a certain period of time. If the metadata is not provided or is incomplete, the provider remains at "Basic Standard". Thus, the quality of the data could simply be estimated. Figure 4-17 shows an example of the integration of the data quality rating indicator of the provider into the dashboard of the meteotacker (Source: meteotracker.com [1])

4.2.3 Data Processor for In Situ/City Data

The laboratory prototype of the in situ/city data processor uses the FIWARE data platform provided by the City of Valencia to perform a first assessment of the technical feasibility to interface with pilot area specific data platforms or terrestrial measurement systems. In addition to the feasibility analysis of the data interface the laboratory prototype analysed the data models provided by FIWARE to serve as a basis for the data models to be used by the CityCLIM generic data platform.

4.2.3.1 Data Access on the FIWARE platform

For the laboratory prototype of the in situ/city data processor, the first data access has been tested by the use of Postman. Postman is an API platform for developers to design, build, test and iterate their APIs. As FIWARE provides REST-based APIs, Postman is the optimal tool for first data request testing. Figure 4-18 shows an example weather observation request with Postman, returning weather observation data based on the WeatherObserved data model provided by Smart Data Models.

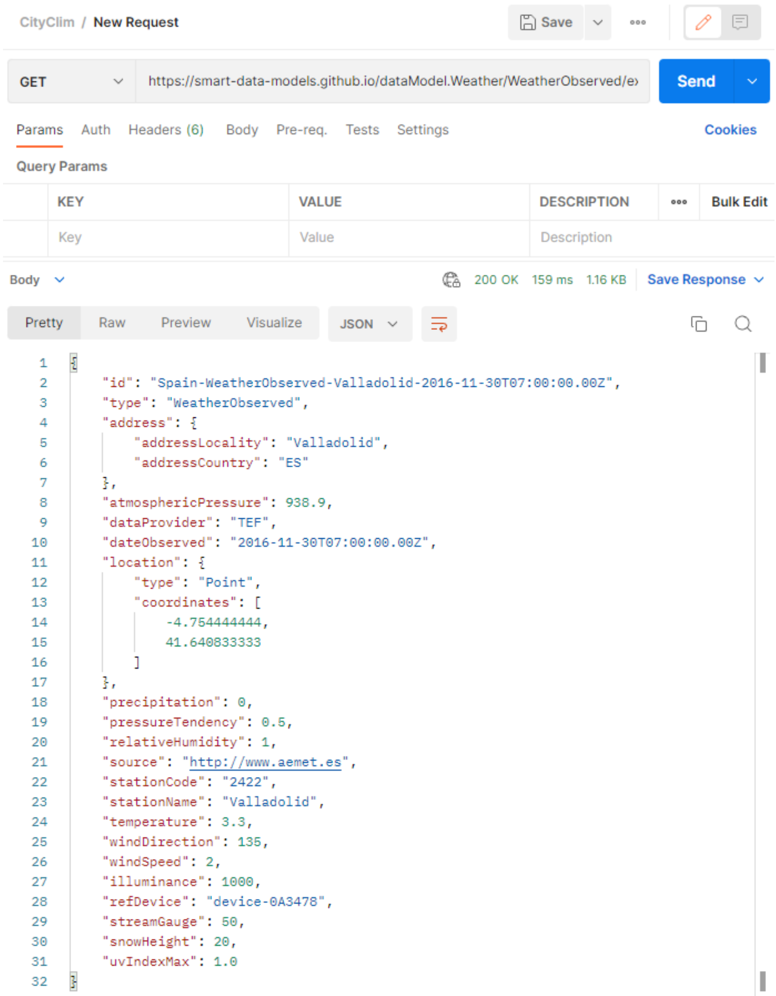


Figure 4-18: Example request of weather observations

The laboratory prototype of the in situ/city data processor proves the technical feasibility to interface with data sources such as the FIWARE platform. In addition to the data access the FIWARE ecosystem also provides data models further investigated and described in the section below.

4.2.3.2 Data models for weather observations

FIWARE is a curated framework of Open Source Platform components to accelerate the development of Smart Solutions. Together with its members and partners, FIWARE Foundation drives the definition – and the Open Source implementation – of key open standards that enable the development of portable and interoperable smart solutions in a faster, easier and affordable way, avoiding vendor lock-in scenarios, whilst also nurturing FIWARE as a sustainable and innovation-driven business ecosystem. As part of this ecosystem, smart data models are provided for a variety of different data types. A smart data model includes three elements: The schema, or technical representation of the model defining the technical data types and structure, the specification of a written document for human readers, and the examples of the payloads for NGSIv2 and NGSI-LD (Next Generation Service Interface-Linked Data) versions. All data models are public and of royalty-free nature. The licensing mode grants 3 rights to the users:

- Free use
- Free modification
- Free sharing of the modifications

One of the pre-defined smart data models is an excellent fit to serve as a basis for the CityCLIM project, describing geo-referenced weather observations. The "WeatherObserved" model is hosted in a Git repository to be accessed by GitHub[1]. The schema for this data model defines the following parameters listed in Table 4-1.

Table 4-1: WeatherObserved data schema

Property	Description	Mandatory
address	The mailing address	NO
airQualityIndex	Air quality index is a number used to report the quality of the air on any given day.	NO
airQualityIndexForecast	Forecasted overall Air Quality Index (AQI) over a certain duration in future.	NO
airTemperatureForecast	Forecasted value of air temperature over a certain duration in future.	NO
airTemperatureTSA	Object defining the temporal processing of a basic property during a period. It provides Maximum, minimum, instant value and average.	NO
alternateName	An alternative name for this item.	NO
aqiMajorPollutant	Major pollutant in the Air Quality Index (AQI).	NO
aqiMajorPollutantForecast	Forecasted major air pollutant in the Air Quality Index (AQI) over a certain duration in future.	NO
areaServed	The geographic area where a service or offered item is provided	NO
atmosphericPressure	The atmospheric pressure observed measured in Hecto Pascals	NO

[1] See https://github.com/smart-data-models/dataModel.Weather/tree/master/WeatherObserved

dataProvider	A sequence of characters identifying the provider of the harmonised data entity.	NO
dateCreated	Entity creation timestamp. This will usually be allocated by the storage platform.	NO
dateModified	Timestamp of the last modification of the entity. This will usually be allocated by the storage platform.	NO
dateObserved	Date of the observed entity defined by the user.	YES
description	A description of this item	NO
dewPoint	The dew point encoded as a number. Observed temperature to which air must be cooled to become saturated with water vapor	NO
feelLikesTemperature	Temperature appreciation of the item	NO
gustSpeed	A sudden burst of high-speed wind over the observed average wind speed lasting only for a few seconds.	NO
id	Unique identifier of the entity	YES
illuminance	Observed instantaneous ambient light intensity	NO
location	Geojson reference to the item. It can be Point, LineString, Polygon, MultiPoint, MultiLineString or MultiPolygon	YES
name	The name of this item.	NO
owner	A List containing a JSON encoded sequence of characters referencing the unique Ids of the owner(s)	NO
precipitation	Amount of water rain registered. Units: 'Litres per square meter'.	NO
precipitationForecast	Forecasted rainfall over a certain duration in future.	NO
pressureTendency	Enum: 'falling, raising, steady'. Is the pressure rising or falling? It can be expressed in quantitative terms or qualitative terms.	NO
refDevice	A reference to the device(s) which captured this observation.	NO
refPointOfInterest	Point of interest related to the item	NO
relativeHumidity	Humidity in the Air. Observed instantaneous relative humidity (water vapour in air)	NO
relativeHumidityForecast	Forecasted relative humidity (water vapour in air) over a certain duration in future	NO
seeAlso	list of uri pointing to additional resources about the item	NO
snowHeight	The snow height observed by generic snow depth measurement sensors, expressed in centimetres	NO

solarRadiation	The solar radiation observed measured in Watts per square	NO
source	A sequence of characters giving the original source of the entity data as a URL. Recommended to be the fully qualified domain name of the source provider, or the URL to the source object.	NO
streamGauge	The water level surface elevation observed by Hydrometric measurement sensors, namely a Stream Gauge expressed in centimetres	NO
temperature	Temperature of the item	NO
type	NGSI Entity type. It has to be WeatherObserved	YES
uVIndexMax	The maximum UV index for the period, based on the World Health Organization's UV Index measure. http://www.who.int/uv/intersunprogramme/activities/uv_index/en/ the values between 1 and 11 are the valid range for the index. The value 0 is for describing that no signal is detected so no value is stored.	NO
visibility	Categories of visibility	NO
weatherType	Text description of the weather	NO
windDirection	Direction of the wind bet	NO
windSpeed	Intensity of the wind	NO

The smart data models provided by the FIWARE ecosystem serve as an excellent basis for the data models to be defined for in situ measurements for the CityCLIM generic data platform. The validation of the incoming data against the data schemas will provide a first good measure of data quality monitoring.

4.2.4 Data Processor for Spaceborne Data

One of the main problems when quantifying urban heat phenomena is the difficulty in identifying urban and surrounding references. There is not clear definition in the literature of how to select these areas. To address this problem for the further work within CityCLIM, the following approach was developed and demonstrated in the laboratory prototype of the Spaceborne Data Processor.

Therefore, we use the Copernicus satellite products based on Sentinel 3 at 1 km resolution. Figure 4-19 shows the land surface temperature images (Sentinel-3A SLSTR Level-2 LST product) for the Valencia area for 2 August 2018 at 9:37 PM. The image covers the entire peri-urban area. The polygon is the urban area obtained from ESA CCI. From this product, the SUHII (Surface Urban Heat Island Index) and the urban comfort is estimated from heat index maps.

The urban reference was obtained from the classes “urban areas” in the global land cover map produced by the European Space Agency Climate Change Initiative[2]. As for the surrounding, three different reference areas were defined; the urban adjacent (SU), the future urban adjacent (Sf), and the peri-urban (SP). The width (WU, Wf, and WP) of the buffer for each surrounding is calculated from the urban area (Figure 4-20 shows the application to the Valencia city).

[2] See https://maps.elie.ucl.ac.be/CCI/viewer/

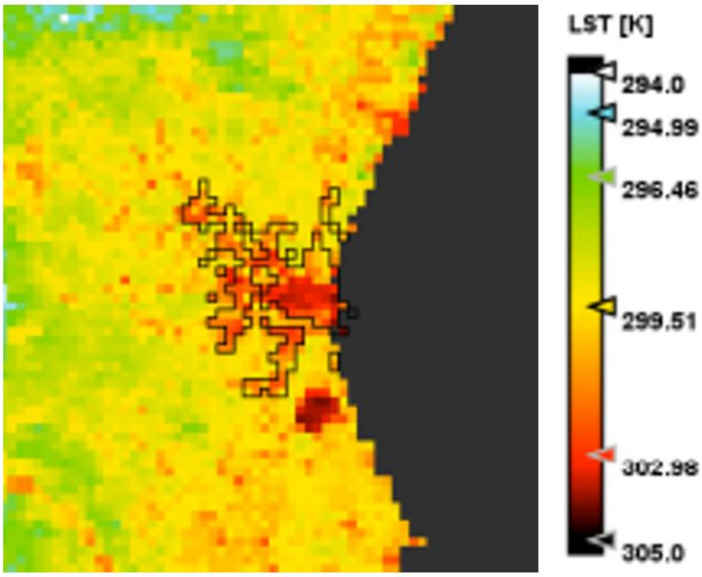


Figure 4-19: LST images for the Valencia area [02.08.2018 09:37PM]

Figure 4-20: Boundaries for Valencia area as used in the further work of the CityCLIM project.

To complement the analysis of SUHII in this laboratory prototype, two additional indices are considered: the Urban Thermal Field Variance Index (UTFVI) and the Discomfort Index (DI). The UTFVI is the most widely used index for the ecological evaluation of urban environment owing to its direct relation to LST and considers the thermal impact of the different sub-areas (district level) in the urban agglomeration area (A). UFTVI is used for evaluating the effect for each pixel located within the urban area with respect to the whole urban area. The Discomfort Index (DI) is a measure of the reaction of the human body to a combination of heat and humidity.

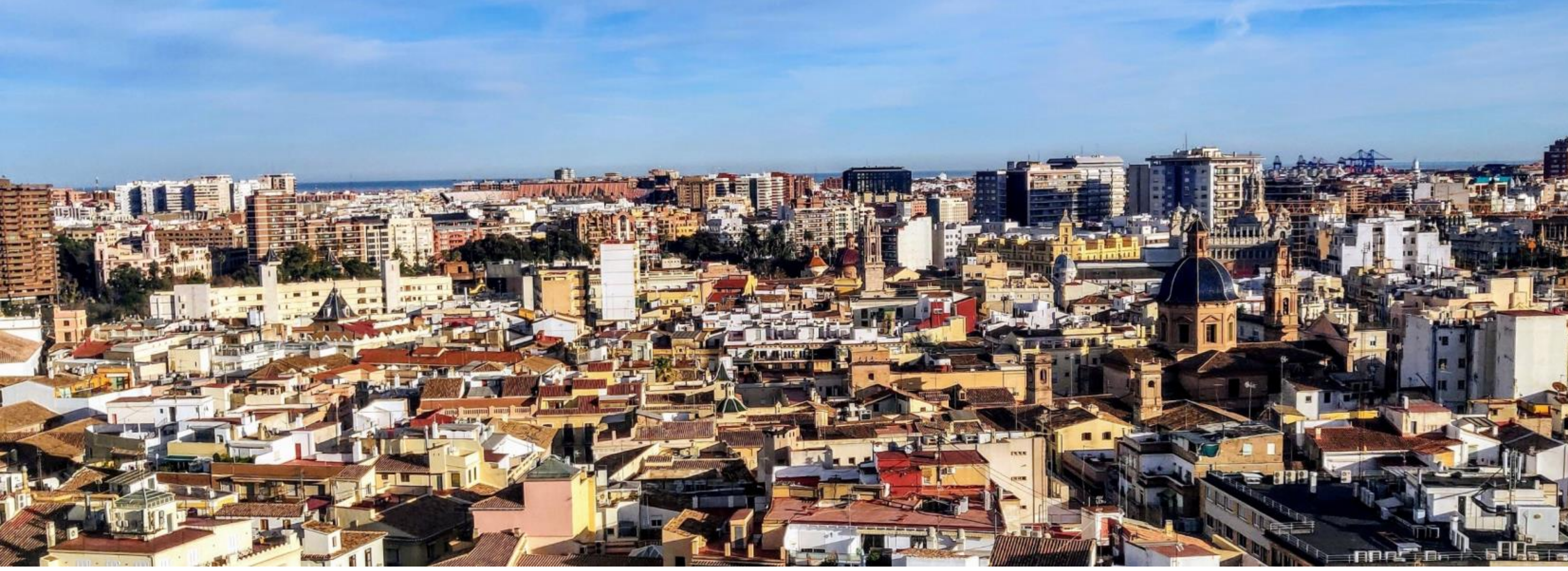
The results obtained this day for the city of Valencia show an average temperature in the urban area of 301.6 K, where 4.4 K, 4.8 K and 5.2 K are the values for the SUHIImax Su, Sf and Sp environments, and 1.8 K, 2.1 K and 2.5 K for SUHIImin, respectively. While 0.009 and 27.8 are the maximum values for the UTFVIMAX and DIMAX indices, respectively.

The work in the laboratory prototype of the Spaceborne Data Processor is a first implementation of the workflow of the Spaceborne Data Processor (see section 3.3.3) and demonstrates the capability of the proposed methods for the quantification of urban heat phenomena.

5 References

[1] Juri Iurato, Timoteo Galia, and R. Monni. (2022, 15.06.2022). *MeteoTracker - Mobile Weather Network*. Available: www.meteotracker.com

[2] European Commission. (2022, 21.06.2022). *Copernicus - European Union's Earth Observation Programme*. Available: www.copernicus.eu



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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