Optimised City Administration Services

Deliverable 6.6

Key features and achievements of the Administration Climate Services as part of the CityCLIM ecosystem.

September 2024

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No *101036814*

Foreword

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

Heat waves are a major problem for densely populated areas

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

Weather and climate services for citizens and city administrations

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

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

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

Implementation by a European consortium

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

Four European pilot cities as partners

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

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

Optimised Administration Climate Services

The City Administration Services support users to identify various aspects of the city climate profile and allow them to investigate effects of simulated changes to the urban areas.

Indeed, the City Administration Services consist of so-called Identification, Simulation and Mitigation Services, that are available by web-based graphical user interfaces (GUIs) for the themes heat island, pollution, and city air flow.

Most services are based on an advanced full-physics weather forecast model processor. Note that the weather model processor is specialized for weather forecasts, i.e., short-term forecasting, and not for longer term climate projections. Hence the Simulation services do not aim to analyse mitigation measures strategies in regard of the long-term consequences of the climate change, i.e., effects of mitigation actions for climate conditions expected in 10, 20, 30 years. Rather the simulation services allow to analyse mitigation actions with respect to current local climate conditions (which already is strongly influenced by climate change related effects).

For the analysis of urban heat, additional variants of the Identification and Simulation Services is available that relies purely on Earth observation data. These complement the weather model-based services.

The operation of the City Administration Services is based on workflows that involve many components of the CityCLIM ecosystem, e.g., data processors, engines, remote sensing, and in-situ data. Hence in that sense the Identification and Simulation Services demonstrate a substantial part of the implemented workflows within the CityCLIM project.

Table of Contents

1 Introduction

Within the overall CityCLIM ecosystem (see Figure 1), a dedicated work package covers the specification, implementation and optimisation of Citizen Climate Services and City Administration services, which, among others, requires workflows that includes the building of a reference dataset of in-situ measurements, the acquisition of high-resolution imagery from airborne sensors and the development of data processor for satellite data on urban agglomerations. The work inside all related tasks is structured according to a development lifecycle with a gradual refinement of developments from specification, the development of the early prototype (EP, TRL4-5) to the implementation of the full prototype (FP, TRL6-7). Each step is documented in a dedicated project-internal deliverable (D6.4-D6.5). Finally, the full prototype implementations are optimized according to the feedback from the performed validation and field testing with end users (D7.7). This public deliverable D6.6 at the final M36 of the CityCLIM project documents the Optimized Full Prototypes (OP) of the City Administration Services as a summary of the achievements of the final developments within all tasks with respect to the City Administration Services.

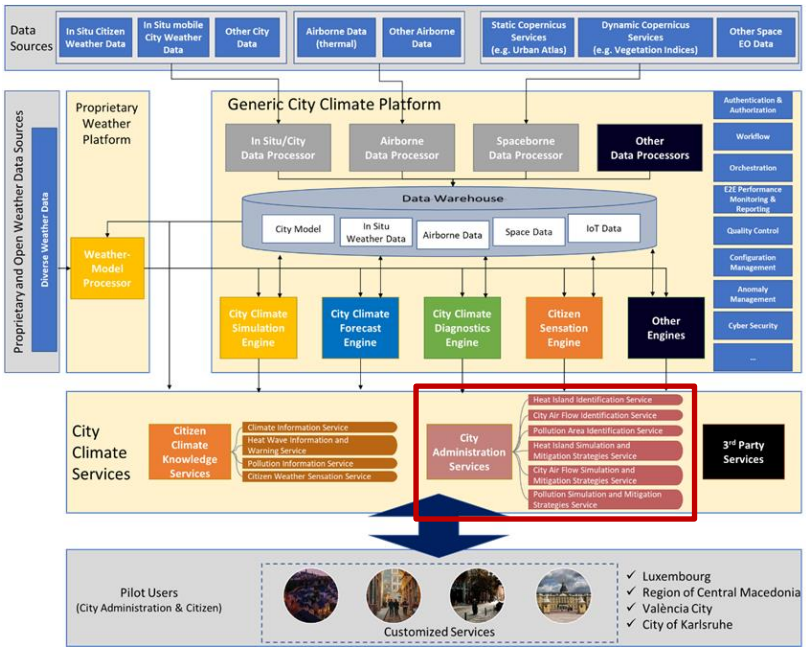

Figure 1: The components of the City Administration Services from WP6 “City Climate Services” (red box) within the CityCLIM architecture.

The City Administration Services are not public services, and potential user groups are given as follows:

- Agencies (e.g., environmental, health, planning, …),
- Building Authorities,
- Insurance companies,
- Real estate.

2 Optimized Prototypes of the UltraHD-based Identification Services

The UltraHD-based Identification services offer statistical analysis using different configuration capabilities related to the themes heat, pollution and city airflow, that rely on aggregated results from past UltraHD weather forecasting model runs.

Key features:

A graphical user interface (see Figure 2) that provides

- on-demand requests to analyse local urban climate for time periods (e.g., for the last 7 days) that returns an image overlay as a result for the entire urban area,
- the possibility to compare specific local urban areas with respect to their exposure to heat, pollution and airflow related aspects by line-charts,
- export functionality for time series data,
- access to already calculated results that prevents re-calculation and allows to share results.
- an integrated user guide that explains the functionality and workflows
- multi-language support

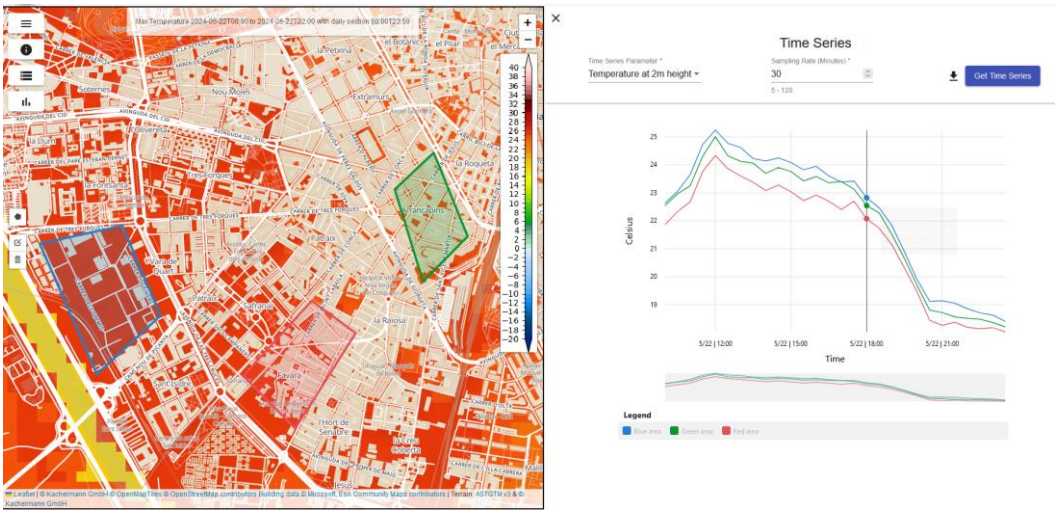

Figure 2: View of the UltraHD-based Identification Services showing analysis results for the entire region and specified local areas via a map and line-charts.

Methodology

The involved statistical operations are performed by an aggregation of UltraHD model runs contained in the considered analysis period, where the calculation is executed on-demand. All relevant data is received from the GCCP Data Warehouse.

Application potential

The UltraHD-based Identification Services allows to identify …

- … local urban areas that are heavily exposed to the urban heat effect, and so indicates need for mitigations.
- … sources of cooler air and the way of fresh air within the city and where emitted heat and moisture is transported.
- … regions that tend to accumulate pollution-related parameters, including sources for fresh air.

Main achievements

Performing analysis for local urban areas in view of their local climate conditions based on beyond state-of-the-art datasets for larger periods (e.g., performing monthly analysis).

3 Optimized Prototypes of the Simulation and Mitigation Services

The Simulation and Mitigation Services allow to analyse the effect of mitigation activities (e.g., planting trees, or building constructions) with respect to heat, pollution and city airflow related aspects of urban local climate. The manipulation of urban structure can be performed by using a 2D map editor, where another web interface provides information of their induced effects.

Key features:

Graphical user interfaces (see Figure 3) that provide

- visual interpretation of the difference between the original UHD model run and the UHD model run with user-manipulated input data by single image overlay for each timestamp and by video overlays showing the entire model loop.
- capabilities to compare the differences between the manipulated and original model run for user-defined locations by time series presented as line-charts.
- export functionality for time series data and access to already performed analysis.
- multi-language support and user guides explaining the functionality and workflows.
- a 2D-Editor which allows to simulate manipulated changes to urban structures (e.g., adding more trees or remove buildings).
- an overview of registered, ongoing and completed simulations.

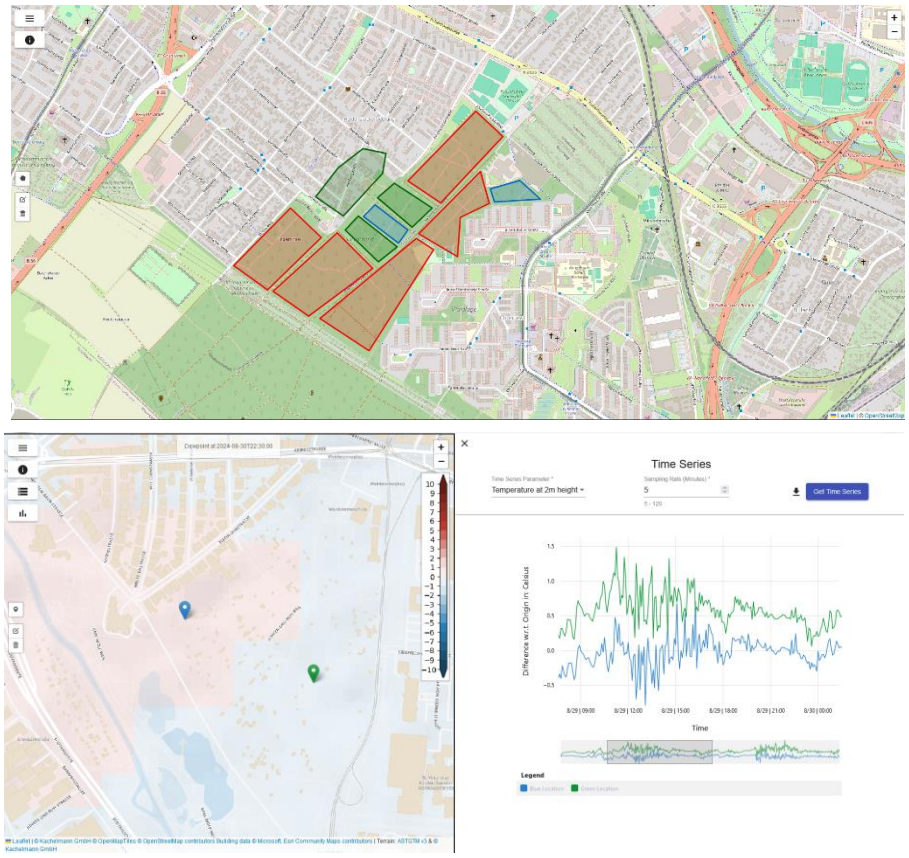

Figure 3: View of the Simulation Services showing the analysis outcome of the comparison of an original model run and a run with modified urban structure by the user.

Methodology

Based on the user-provided inputs from the Simulation Editor Earth observation data is manipulated (e.g., land cover datasets). Subsequently, the UHD model runs again with this manipulated data, where the outputs are then compared with the original model run.

Application potential

The Simulation Services facilitates decision-making processes by allowing the …

- … measurement of the impact of planned mitigation activities (e.g., planting trees, building constructions) before actual execution of the work.
- … comparison of several mitigation options regarding the effect to the local climate.

Main achievements

The Simulation and Mitigation Service is a novel application that allows to manipulate local urban areas and measure its impact to the local climate based on beyond state-of-the-art datasets.

4 Optimized Prototypes of the EO-based Heat Island Simulation and Mitigation Service

The EO-based Heat Island Simulation and Mitigation Strategies Service follows the same purpose as the other simulation services but only focusses on heat and in comparison to the other Simulation Services applies solely Earth observation (EO) data instead of a process-based model. The urban structure can be manipulated by using a 2D map editor and subsequently the effects of the user-made changes on the urban heat distribution can be explored in a GUI. The service is available for average and extreme summer days of 2021-2024.

Key features:

The key features of the prototype are provided and organised in a graphical user interface (see Figure 4) in three steps:

- **Step 1 "Info":** Allows to explore the heat distribution of the four CityCLIM pilot cities with LST measured from satellite as indicator.
- **Step 2 "Editor":** Allows to simulate user made changes to urban structures (e.g., adding tree vegetation or remove buildings) using the 2D map editor
- **Step 3 "Result":** Allows a visual interpretation of the difference between the original heat distribution and the one predicted for the user-made changes. The effect of the user-made changes is visible and multiple mitigation options (i.e., scenarios) can be compared.

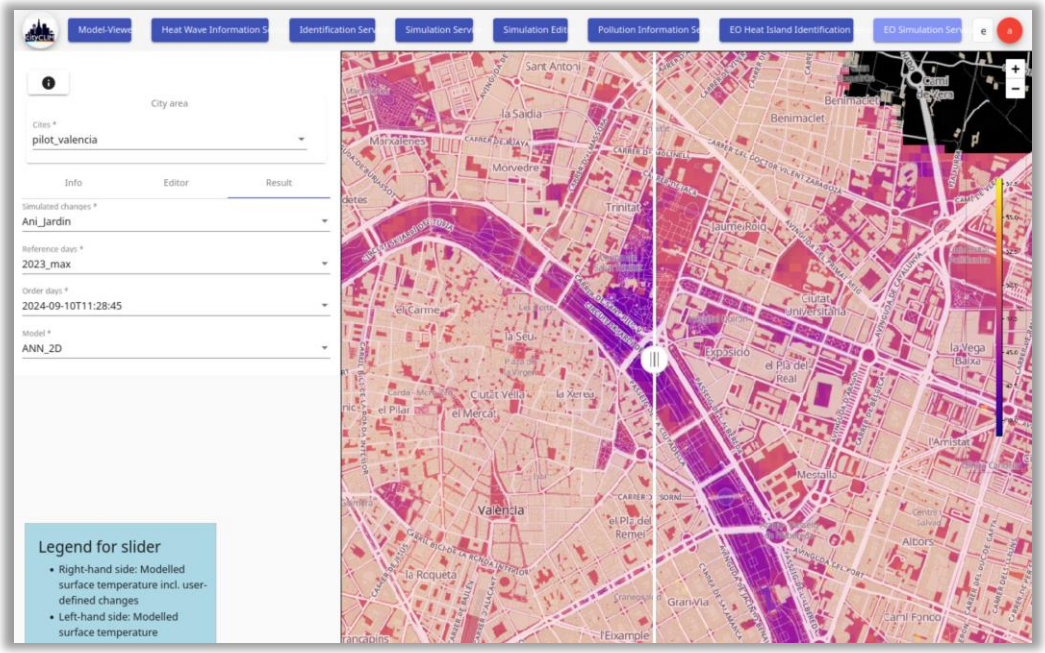

Figure 4: The graphical user interface of the EO-based Heat Island Simulation and Mitigation Strategies Service where the effects of user-made changes in the urban configuration on urban heat can be explored with a slider.

Methodology

Technically, the EO-based tool underlies a machine learning model linking LST measurements from Landsat 8/9 to several layers characterizing the urban land surface which are derived from multispectral Sentinel-2 data (vegetation and built-up indices, distances to vegetation and water) and the 3D structure of a city (derived from city DEMs). The calibrated machine learning model is used to predict LST upon user-defined changes in the urban structure. The engine underlying this service is described from a scientific perspective in D5.4 at https://www.cityclim.eu/info-material.

Application potential

- The engine and service were developed to support practitioners, i.e. city administrations, in assessing and implementing urban heat mitigation options (e.g., planting trees, building constructions).
- The tool can also be valuable for the interested public as information and to enhance the understanding of urban heat patterns and the immediate effects of changes in the urban landscape on the urban heat distribution.

Main achievements

A service supporting practitioners in evaluating options for urban heat mitigation which is solely based on EO data has been successfully created.

The EO data-based Simulation Service is an easy-to-use tool answering requests within seconds to minutes. It uses standard EO data, its requirements for data storage and processing are low and it can easily be transferred to new cities. Therefore, the tool qualifies as first-access point for cities also with little efforts and budget.

5 Conclusions

The Identification and Simulation Services represent innovative tools that enables on the one hand to identify urban areas that are exposed to extreme climate conditions, and on the other hand allows to assess the impact of simulated mitigation measures on the local climate, utilizing advanced beyond-state-of-the-art datasets. Hence, together both services form adequate software solutions to face current and upcoming challenges to urban life induced by climate change.

Moreover, the City Administration Services operate through workflows that integrate various components of the CityCLIM ecosystem, including data processors, engines, remote sensing, and in-situ data. In that sense, the Identification and Simulation Services play a critical role in demonstrating a significant portion of the workflows implemented within the CityCLIM project.

A detailed user guide for using the City Administration Services is provided in Manuel 3 at https://www.cityclim.eu/info-material.

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.

Funded by the Horizon 2020 Framework Programme of the European Union