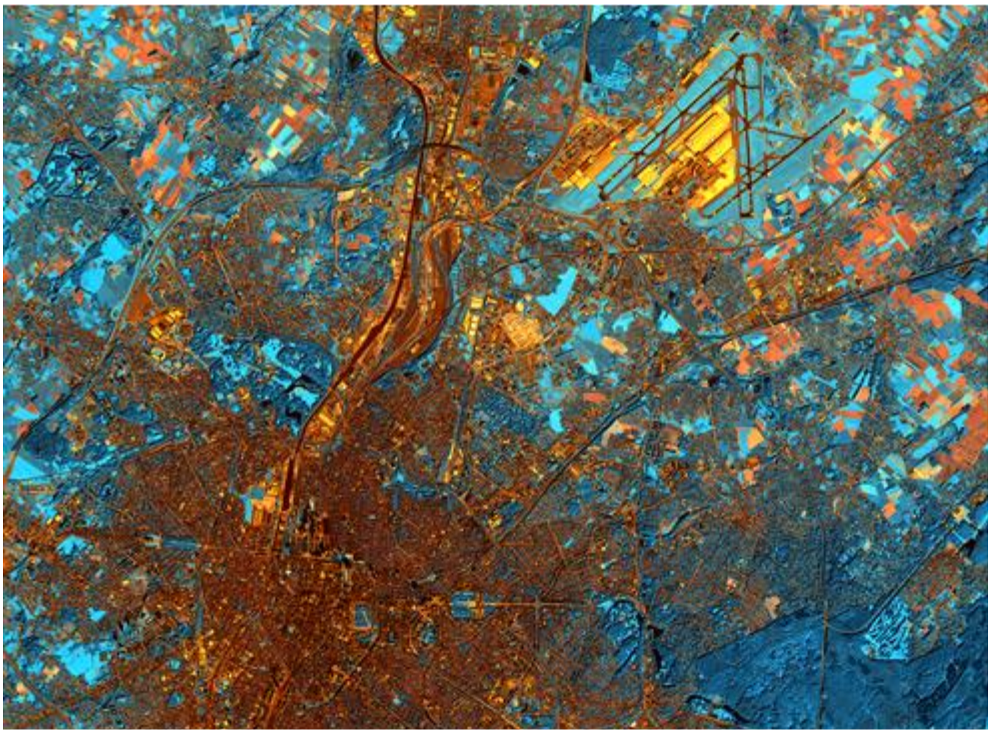

January 2022

COPERNICUS FOR URBAN RESILIENCE IN EUROPE

Editorial

by Nektarios Chrysoulakis

CURE (Copernicus for Urban Resilience in Europe) is one of the three projects that were funded from the Horizon 2020 Space call on Copernicus evolution (LC-SPACE-04-EO-2019-2020). It is a joint effort of 10 partners that synergistically exploit Copernicus Core Services to develop an umbrella application for urban resilience (CURE System) based on DIAS (Data and Information Access Services). This System consists of 11 Cross-cutting Applications, evaluated at several European cities, for climate change adaptation/mitigation, energy and economy, as well as healthy cities and social environments.

The CURE project attempts to innovatively deploy information from Copernicus Core Services concerning atmosphere, land, climate change and emergency; in order to address the multidimensionality of urban resilience. In parallel, it exploits spatially disaggregated environmental Earth Observation (EO) data and products, which are not directly available from the Copernicus Core Services, such as data from contemporary satellite missions and in-situ observations. All the above are combined with third-party EO modelling towards coping with the required local scale.

The main project's milestones for the second half of 2021 concerned the 1st Demonstration Workshop, the completion of the CURE Cross-cutting Applications and the development of the CURE System. The Workshop was fulfilled with the participation of CURE Applications users, who provided feedback about them. Taking into consideration this feedback, the Applications and its methods were finalized, providing a publicly available sample dataset. In parallel, the development of the CURE System platform was completed; i.e. its main components were installed, the connection to the Copernicus Core Services Interface was established and its functionality was validated. Moreover, the 3rd Progress Meeting was held aiming at coordinating research and innovation activities of the project partners for the fourth semester of the project.

The 4th issue of the CURE Newsletter introduces three more CURE Cross-cutting Applications: a) Urban Flood Risk Application (AP05), b) Urban Air Quality Application (AP07) and c) Urban Thermal Comfort Application (AP08). Also, the main CURE project activities during this period are described in this issue.

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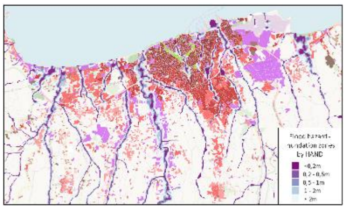

Urban Flood Risk Application

This Application informs about localization, extent and magnitude of exposure to flood hazard due to flash or other types of flood.

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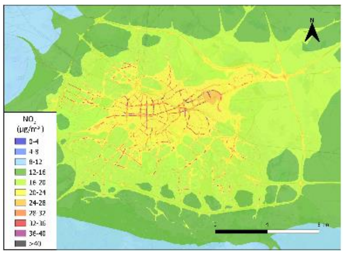

Urban Air Quality Application

This Application provides air quality maps with a spatial resolution of 10m x 10m describing the yearly mean pollution in the cities.

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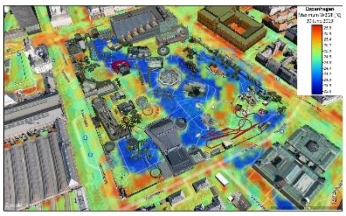

Urban Thermal Comfort Application

This Application supports heat stress factors understanding, identifying hot spots in a city, and assessing the effectiveness of adaptation measures.

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Urban Flood Risk Application

by Katerina Jupova, Tomas Soukup, Miroslav Kopecky and Erika Orlitova

The CURE AP05 aims to support cities with enriched information about flood hazard to urban assets and related dangers. Specifically, it can provide city authorities with both synoptic and detailed knowledge about localization, extent and magnitude of exposure to flood hazard due to flash or other types of flood.

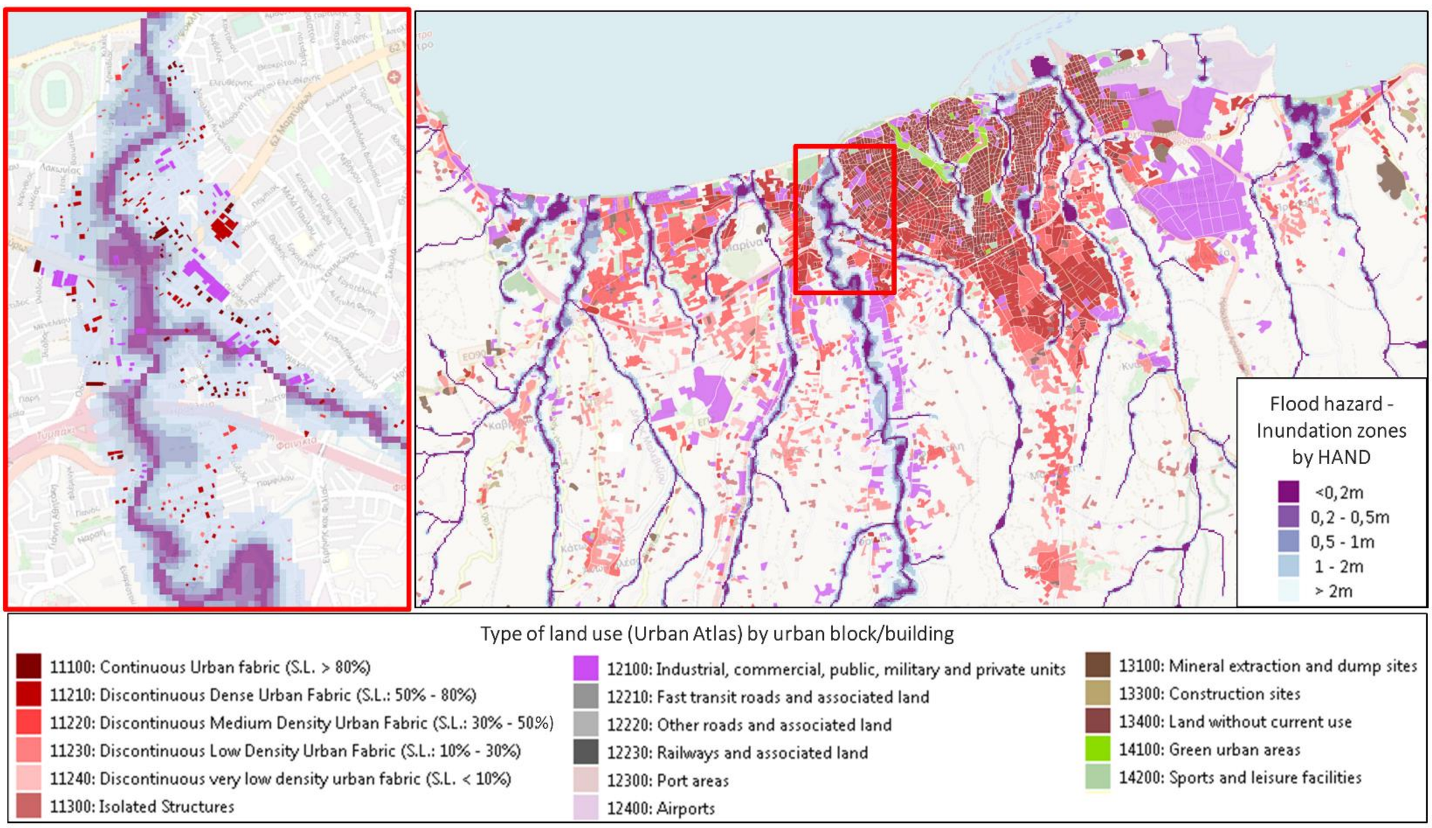
This Application is based on combination of information related to flood risk; concerning local terrain and its hydrological characteristics as well as spatial pattern, internal structure and temporal evolution of urban areas. It adopts a scenario modelling approach, i.e. scenarios representing different intensities of flood events as well as (potential) damage on urban assets and population caused by these events can be modelled and compared. This modelling is based on input data such as Digital Elevation Model (DEM) and river network, reference information about flood events in the past, and simulations of estimated intensities of expected floods in the future considering different potential climate change scenarios.

Combining Copernicus Core Services data with local datasets

The main type of input data for this Application is represented by the Copernicus Core Services data. This data type secures high replicability potential of the Application, allowing to cover any city-region in Europe. The modelling method is using the Copernicus DEM and Hydro River Network databases as the main data inputs. Additionally, other Copernicus datasets from Copernicus Climate Change Service (C3S) or Emergency Management Service (EMS) can be used to improve estimation of flood event intensity as well as of expected frequency of such events in the future. Moreover, these main input datasets are supplemented by the Copernicus Urban Atlas and the World Settlement Footprint Evolution (WSF-E) layers to obtain information about the structure and development of urban land, which is needed to be able to assess the flood hazard to urban assets. These datasets can be integrated with local city information, or replaced by more precise local data, where available and requested by the user. This may include Digital Terrain Model (DTM) or Digital Surface Model (DSM), and local meteorological/hydrological data (river network, runoff, discharge data, sea level, etc.). Instead of, or as a supplement to the Copernicus Urban Atlas database, the local city plans or urban planning maps can be used, giving more detailed information about the city structure. In particular, location of buildings, infrastructure elements, flood-vulnerable units, etc. are appropriate to be incorporated into this Application. As reference information, the local data on previous flood events are used to evaluate the quality of modelling results or to calibrate them.

Modelling flood extent for different flooding scenarios

In the first step of this analysis, the distribution of flood hazard zones is



Estimation of flood hazard for functional urban blocks and buildings by type of land use (from Copernicus Urban Atlas).

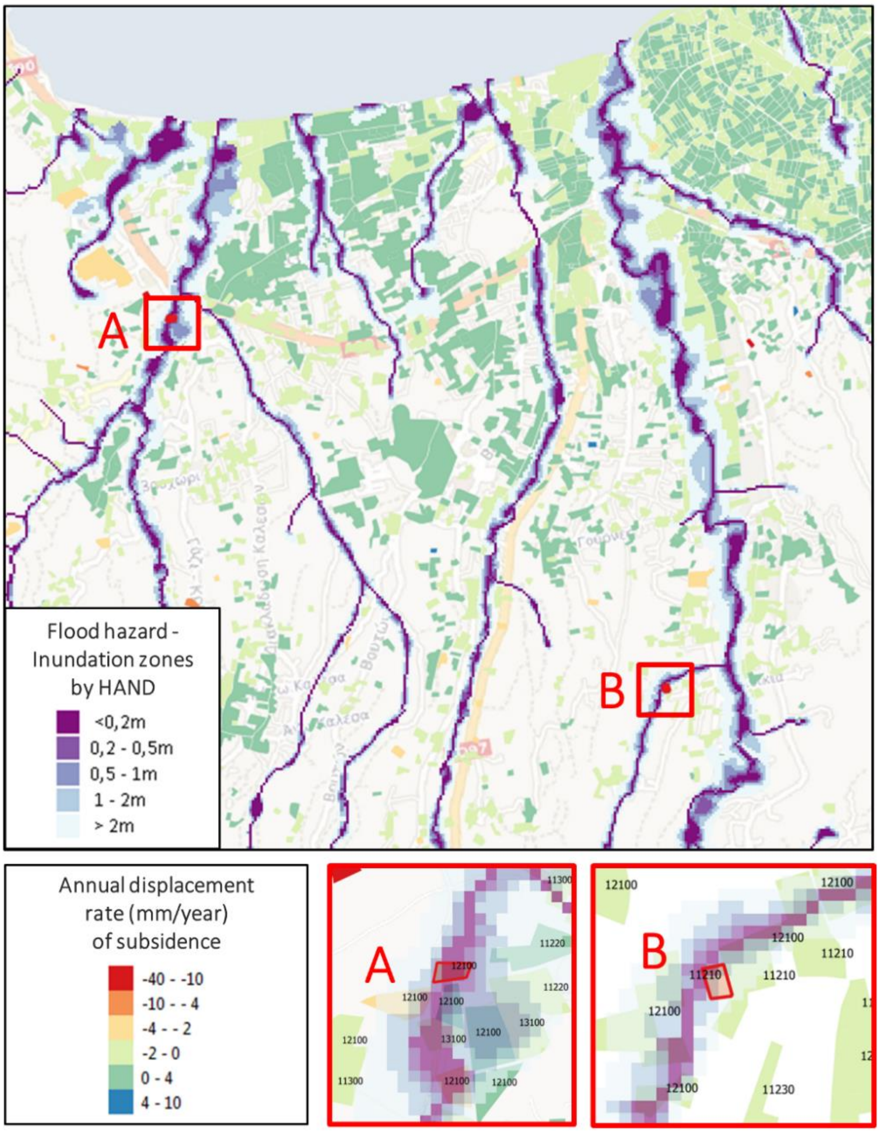
estimated and flood hazard maps are prepared. For this purpose, a modelling approach is applied dealing with local terrain characteristics as well as distribution and categorization of water streams in the area of interest. By default, Copernicus datasets are used as the data inputs for the Application to secure its replicability in any European city-region. However, to achieve high-quality results in each particular area, local specificities have to be taken into consideration.

A modelling approach, based on Height Above Nearest Drainage (HAND) index method that estimates the geographical extent of flood hazard prone zones for different flood heights above nearest drainage, is applied. The modelling works in an automated manner and allows for user-driven parametrization. Thus, flood hazard zones for different scenarios of flood event intensity can be modelled and compared.

Estimation of flood-related hazard to urban assets

The second step of the process consists of integration of information about the flood hazard with information about urban land structure and its evolution in time. From this integration, meaningful intelligence and understanding of the flood hazard-related situation in the city and surrounding areas are derived. To estimate the level of flood hazard for particular urban assets, the flood hazard map is overlaid by Copernicus Urban Atlas delineation. Zonal statistics are applied in order to obtain information about the level of potential flood for each particular urban block in the city. Thus, information about flood hazard is automatically combined with the land use type of each block; which allows for identification of residential, commercial, industrial, or potential development areas endangered by flood hazard.

This analysis is also performed for urban blocks with building footprints obtained from local Geographic Information System (GIS) database or Open Street Map (OSM). Exploiting such datasets, approximate level of flood hazard for each urban block, building, or any other type of urban unit of interest can be estimated and combined with other relevant properties of this unit (type of urban block; age, type, construction material, and condition of building; number of inhabitants; etc.). Such information allows to assess the level of flood hazard in the city-region as well as to predict and evaluate expected impact of flood events in the future. This estimation can support the effective prevention of potential issues related to increased susceptibility to flood, and thus the adaptation to potential future flood events.



Combining information about flood and subsidence hazard – identification of urban blocks endangered by both flood and subsidence hazards.

Combining information about flood and subsidence risk in urban areas

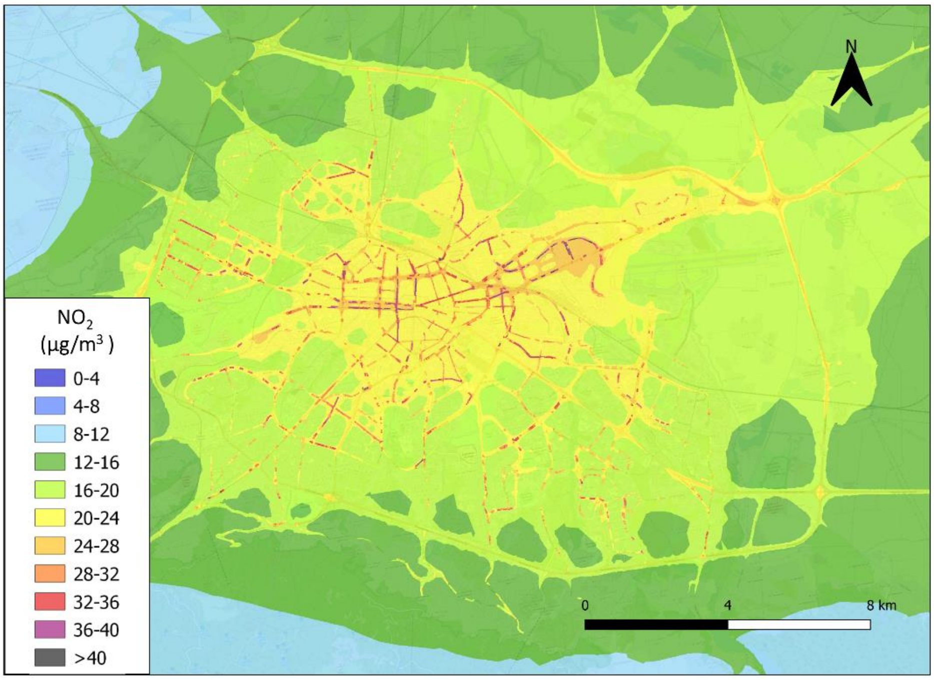
For effective urban planning, the integrated approach is crucial. Therefore, also for the CURE project, it is important to meaningfully combine information acquired by means of different Applications. Focusing on the CURE AP05 and Urban Subsidence, Movements and Deformation Risk Application (AP06), there can be a specific direct link between these two types of natural hazards. The urban (or sub-urban) land subsidence can occur or intensify as a consequence of previous flood events. On the other hand, the flood risk to a particular urban area can increase in time, in case a land subsidence process is present at that area. Thus, information acquired from the CURE AP05 and AP06 can be combined to enable the end-users to prevent potential interrelations between floods and terrain subsidence. An example of this approach is provided in the left figure, where the urban blocks in the Heraklion city endangered by both types of hazard are identified warning end-users to focus on these urban units.

Urban Air Quality Application

by Hans Hooyberghs

Urban air pollution and its health impact

Ambient air pollution is one of the key environmental problems in Europe. In 2021, the World Health Organization (WHO) published new air quality guidelines following a systematic review of the latest scientific evidence on how air pollution damages human health. The European Commission estimates that currently almost the entire urban European population is exposed to air pollution levels exceeding the upper limit values of these new guidelines. Focusing on Particulate Matter with diameter smaller than 2.5 µm ($PM_{2.5}$) and Nitrogen Dioxide (NO_2), the 97% and the 94% of the population, respectively, is living at locations, where the new upper limit values are exceeded. According to the WHO, exposure to these high levels of air pollution is associated with acute health impacts caused by short-term exposure, as well as chronic diseases following long-term exposure. The increased morbidity also leads to a significant attributable mortality. The European Environmental Agency (EEA) estimates that in 2019 more than 350.000 deaths in the European Union (EU) are related to exposure to air pollution. Because of the severe health impacts, air pollution also has considerable economic impacts, increasing medical costs and reducing productivity through lost working days across various economic sectors.



Annual mean NO_2 concentrations in 2019 in Sofia.

Exposure to outdoor air pollution is therewith one of the key environmental stressors in European cities. To limit the health impacts and reduce the pollution levels, a profound understanding of the hot spots for pollution and the sectors related to the pollution is of great importance. The CURE AP07 contributes to this understanding combining data from the Copernicus Core Services and an integrated air quality model chain.

Methodology

Urban air quality is a multi-scale problem. Pollutant concentrations on a street-level scale are influenced by regional background concentrations; urban increments due to local industrial, traffic and residential heating sources; and recirculation in narrow streets with high rise buildings adjacent to them (the so-called street-canyons). Only when the contribution of all these three scales is taken into account, the urban air quality exposure can be correctly determined. Also, monitoring the compliance with limit values requires the combination of the three scales, as otherwise local exceedances could be overlooked.

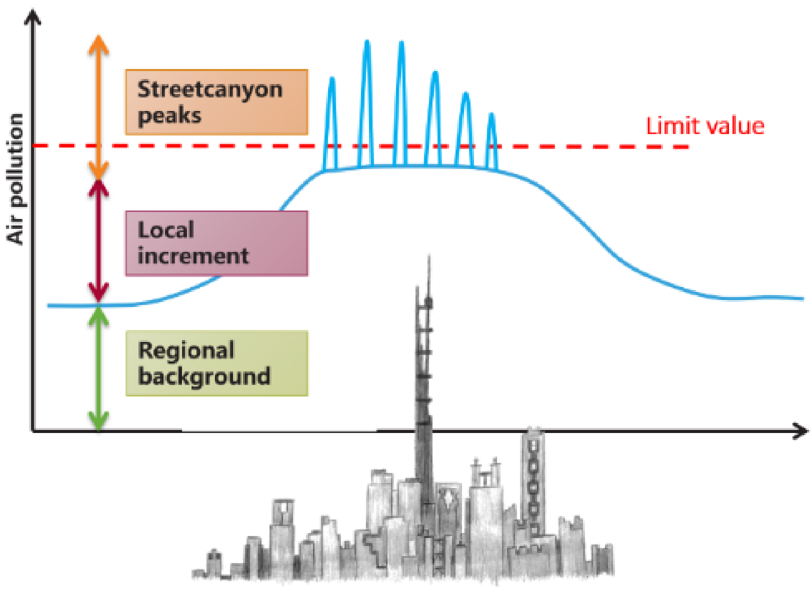
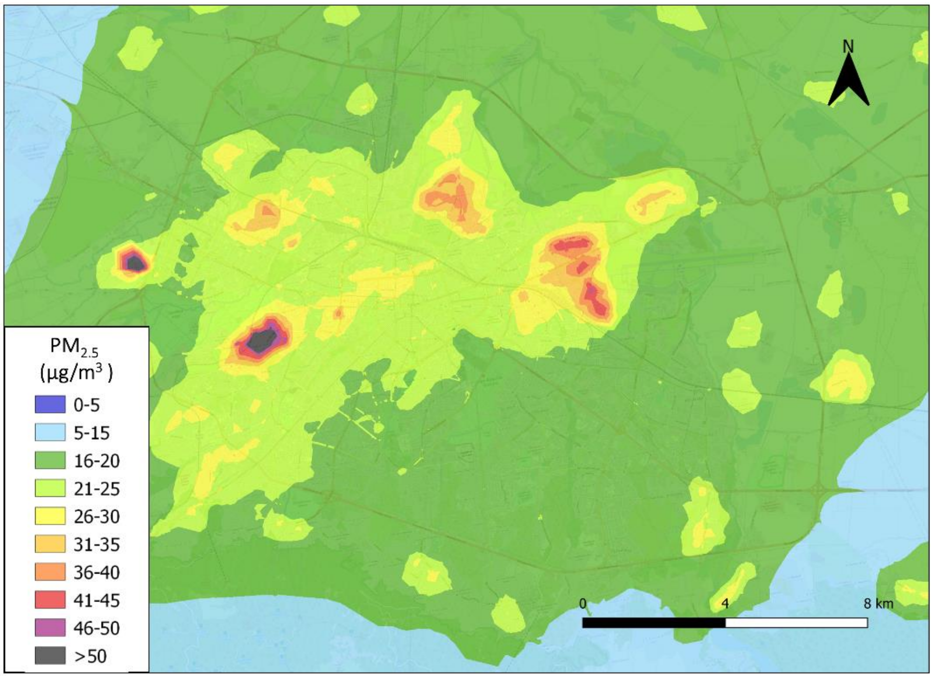


Illustration of the different scales involved in urban air quality assessment.

The CURE AP07 assesses the urban air quality using the integrated ATMO-Street Application, which is an extensively validated model chain designed to correctly assess and combine the different scales of urban air quality. Input data for the model chain is provided by the Copernicus Core Services: background concentrations and coarse-scale emission input from



Annual mean $PM_{2.5}$ concentrations in 2019 in Sofia.

the Copernicus Atmosphere Monitoring Service (CAMS), as well as meteorological data from C3S and building data from the Copernicus Land Monitoring Service (CLMS). The input data is further downscaled to the required resolution using pan-European open-source proxy data (e.g. OSM), supplemented with local datasets (e.g. locations of coal/wood burning heaters).

In the context of this Application, NO_2 and PM pollutants, playing a key role in urban air pollution in Europe, are considered for the most recent year, when all the relevant Copernicus data is available (i.e. 2018). NO_2 is a gaseous air pollutant strongly linked to road traffic emissions in an urban context. PM is the sum of all solid and liquid particles suspended in air ($PM_{2.5}$ is considered for this Application). The dominating source of PM pollution varies across Europe: atmospheric processes that lead to the formation of particles as a result of traffic, domestic heating and agriculture emissions are the most considerable in the Western Europe; while domestic fuel burning is the main source of PM in the Eastern Europe.

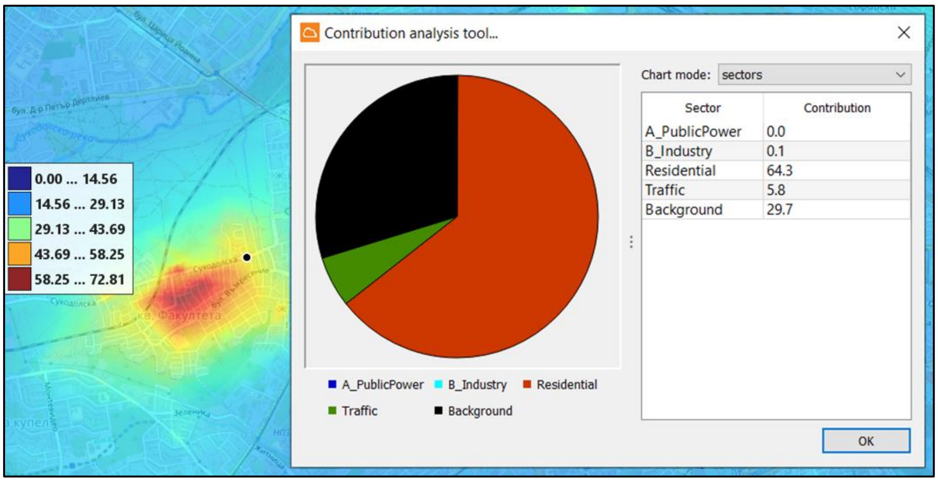
Detection of hot spots

The primary outcome of the CURE AP07 are air quality maps with a spatial resolution of 10m x 10m describing the yearly mean pollution in the cities. The above maps visualize how the air quality in the Sofia city varies strongly over short distances. For NO_2, the highest concentrations are observed near the most important roads, i.e. busy street-canyons in the city centre. For $PM_{2.5}$, the highest concentrations are observed in the neighbourhoods with an abundance of coal and wood burning heaters.

The maps allow stakeholders to identify the neighbourhoods and districts with the worst air quality, and to decide in an informed manner the prioritization of areas for taking action. Moreover, the maps can be used for checking the compliance with the limit values. The EU Ambient Air Quality Directive sets thresholds of 40 µg/m^3 and 20 µg/m^3 for the yearly mean NO_2 and $PM_{2.5}$ concentrations, respectively. Focusing on the above maps, a breach of these standards for NO_2 is observed in the busiest street-canyons, while the standards for $PM_{2.5}$ are breached at most locations in the city centre (all locations are not shown in the relevant map). The more stringent WHO guidelines are exceeded at all locations for both NO_2 and $PM_{2.5}$, indicating that significant health effects are observed everywhere in the metropolitan area of the Sofia city.

Sector contribution

A second output of the CURE AP07 concerns the sector contribution on a 10m x 10m spatial resolution. For each of the emission sectors that are explicitly considered in the integrated model chain (road traffic, industry, power plants, and residential heating), the approximative pollution due to the emissions of the specific sector in the urban area is computed too. In addition, a background contribution indicates the share of the pollution originating from either outside the domain or sectors that are not explicitly considered (e.g. rail transport). Using these results, stakeholders can identify key sectors, for which measures should be taken. For instance, the sample results for the Sofia city (shown in the below figure) highlight the importance of the urban residential emissions at this specific area. Also, the urban traffic emissions contribute significantly to the total concentrations, whereas the urban power plant and industrial emissions are responsible for only a minor fraction of the total pollution.



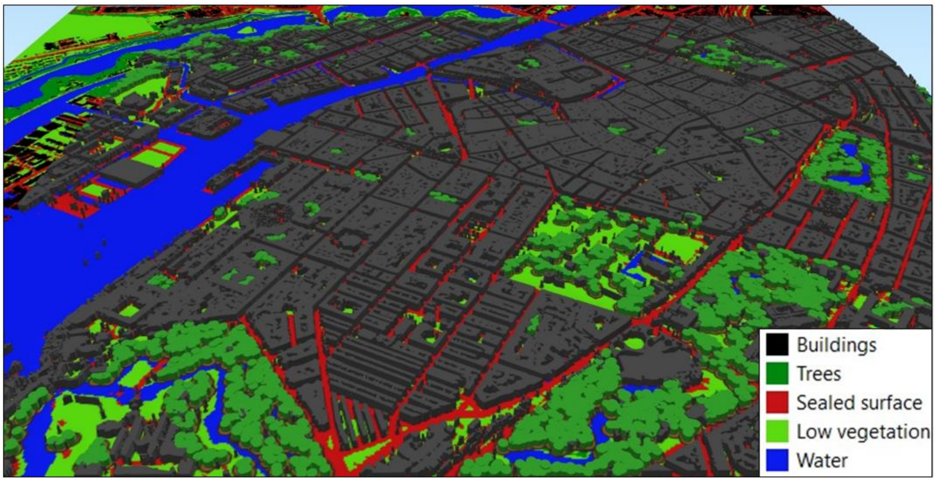
Sector contribution in the Sofia city for $PM_{2.5}$. The pie plot and the table show the relative contribution of the different emission sectors to the total concentration at the location of the black dot on the map. The following sectors are considered: road traffic (green), public power (blue), industry (light blue), residential (red), and the background concentration

Urban Thermal Comfort Application

by Dirk Lauwaet

Heat stress and health in cities

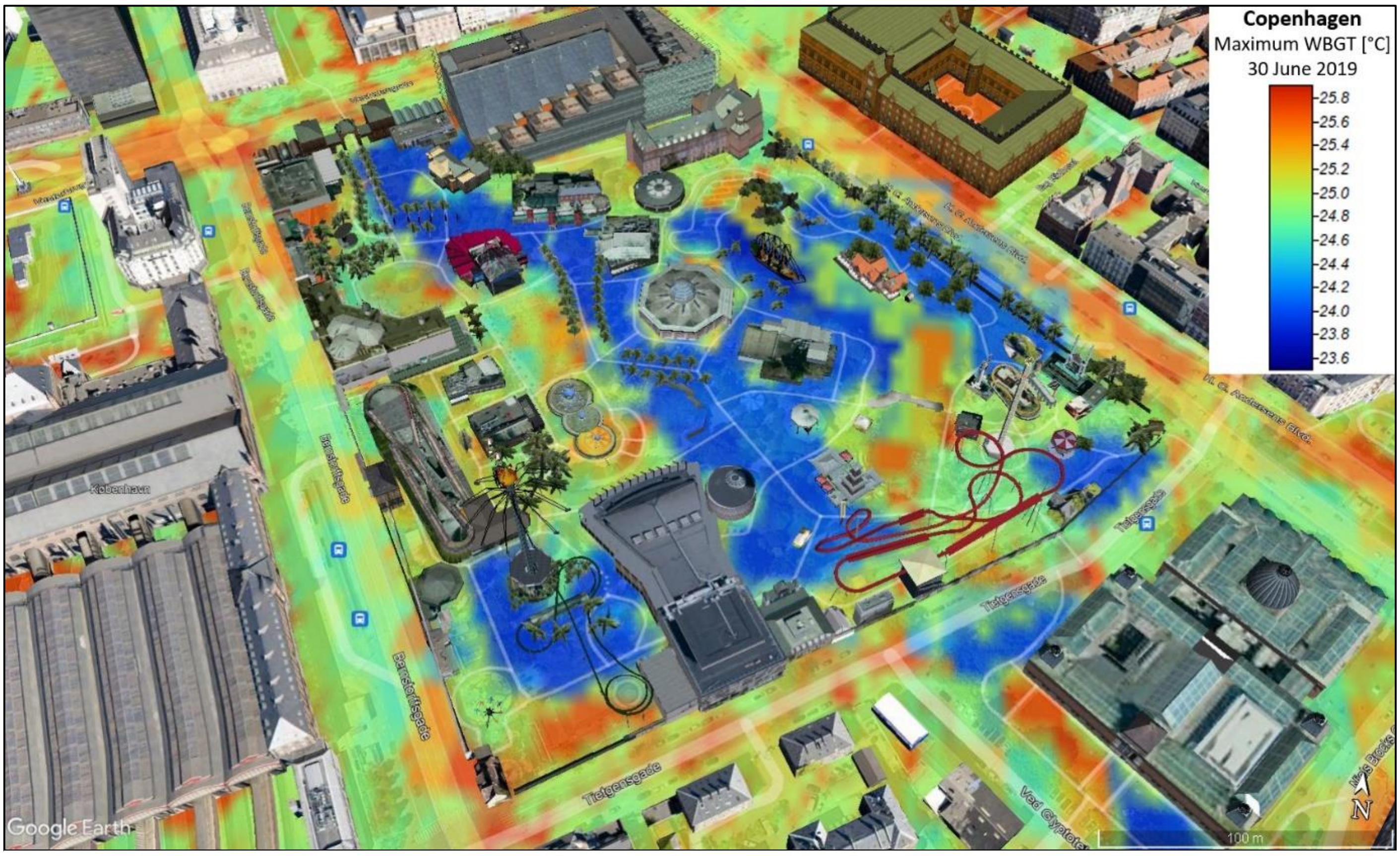
Heat stress is an increasing problem in many European cities due to the ongoing climate change. Citizens experience higher levels of heat stress than people living in rural areas due to higher surface and air temperatures (as proved by other CURE Applications), lower wind speeds, and higher levels of solar and thermal radiation coming from building materials. Heat stress has a negative impact on sleep, productivity, morbidity and mortality of urban residents. Especially, elderly, infants and children are vulnerable population groups at risk of heat-related illness and death. The EEA reports that 2% of deaths across 15 European cities in the 1990s were attributable to heat; and due to climate change, annual fatalities from extreme heat could rise tenfold by 2050. It is therefore essential to have a good understanding of the factors contributing to heat stress, identifying hot spots in a city, and assessing the effectiveness of adaptation measures. This is the focus of the CURE AP08.



Detailed land cover input map for the city of Copenhagen. Buildings are assumed to have a height of 20m, and trees have a height of 15m.

Wet Bulb Globe Temperature

To map the heat stress in a city with a high level of spatial detail, it is important to take all the important contributing factors into account: air temperature, humidity, wind speed and radiation load (both shortwave and longwave). The international standard heat stress indicator is the Wet Bulb Globe Temperature (WBGT), which combines the air temperature, the wet bulb temperature and the black globe temperature. It is the International Organization for Standardization (ISO) standard for quantifying thermal comfort and has clear thresholds based on a large number of observations. The WBGT can be measured easily with rather cheap equipment, making it an



Daily maximum WBGT in the Tivoli Gardens in Copenhagen on 30 June 2019.

ideal indicator for model validation and citizen science campaigns raising awareness about heat stress issues.

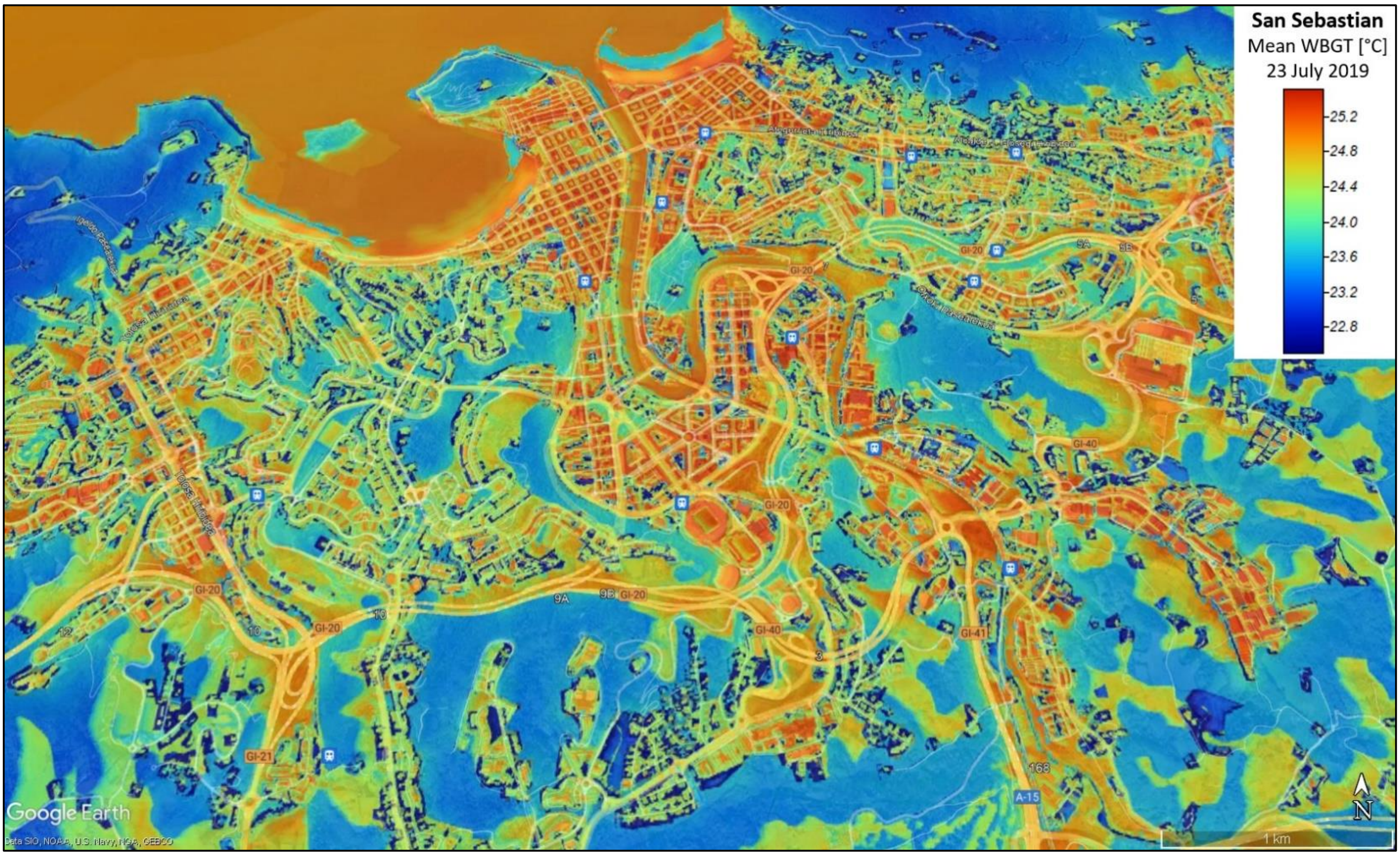
In the CURE AP08, the WBGT is simulated with a spatial resolution of 2m x 2m, based on a very detailed land use map that is calculated from Copernicus Data Warehouse layers. The location of the trees in the cities is added from the Urban Atlas Street Tree layers. The thermal comfort model downscales meteorological conditions from the atmospheric reanalysis of the global climate (ERA5) of the European Centre for Medium-range Weather Forecasts to the city centre, and combines these with detailed radiation maps, in which the shading effect of buildings and trees is taken into account. The resulting maps depict real live conditions and can be validated against EO measurements.

Products

For assessing the produced WBGT maps, the focus is on typical hot summer days, when people suffer from heat stress issues. The CURE AP08 delivers heat stress maps for a typical hot summer day for 4 European cities: Copenhagen, Ostrava, San Sebastian and Sofia. Both daily maximum and daily mean WBGT maps are calculated from the hourly model output. The daily maximum WBGT maps focus on the hottest hours of the day, when shading is crucial to lower the local heat stress. The daily mean WBGT maps show a time-average of the heat stress situation and also consider the night-time, when the Urban Heat Island (UHI) is at its peak. When assessing the WBGT values, it is good to keep in mind that the values are typically a few degrees lower than regular air temperature values, and a difference of a few degrees can have a strong effect on human thermal comfort.

From the example maps shown here, it is clear that forested areas are the coolest locations in cities, as the trees provide shade and cool the air through evapotranspiration. On the other hand, open sealed areas without shade from trees or buildings are the hottest locations. Water areas can provide some cooling during the hottest hours of the day, but they often keep a high temperature during the night, aggravating the UHI problem. Planting trees is therefore considered as the most efficient adaptation measure to tackle heat stress problems in a city.

The WBGT maps of this Application allow stakeholders (e.g. urban planners and city administrations) to identify hot spots, and give them insight into the local variation of heat stress with a high level of spatial detail. From these maps, overview statistics can be calculated (e.g. city district averages, area above/below defined threshold values). Furthermore, the Application allows users to modify the input land cover map and upload different land use scenarios, from which new WBGT maps can be calculated instantly. As a result, the users can assess the effectiveness of e.g. green-blue adaptation measures and justify urban adaptation strategies, providing evidence about the impact of these strategies and the related measures on the local urban climate. Also, they can assess the impact of specific intentions of developers on the local urban thermal comfort conditions, supporting them to identify the intentions that should be realized or avoided from an environmental point of view.



Daily mean WBGT in San Sebastian on 23 July 2019.

Project activities

1st Demonstration Workshop

The CURE 1st Demonstration Workshop was held on-line on 15 October 2021 and based on the initial specification of the CURE Cross-cutting Applications and their products. The aim of this Workshop was to get user feedback and assess operational feasibility, usability and effectiveness of the CURE Applications, primarily for front runner cities. This Workshop provided a highly effective platform for engagement with a broad range of high-level CURE stakeholders (i.e. city planners, developers, scientific communities) on the usability of the CURE Applications in addressing urban resilience challenges. During the Workshop, several sessions took place including presentations, video demonstrations, question and answer sessions, stakeholder dialogues and an interactive exercise. As to participants, CURE partners attended supporting discussion with stakeholders and clarifying technical aspects, as well as 26 stakeholders were engaged generating a rich and diverse range of views.

CURE
1st Demonstration Workshop

In particular, the views concerned the themes of climate change mitigation, climate change adaptation and healthy cities; and provided deep insights into the challenges facing cities in pursuing these policy objectives, and the various ways, in which CURE Applications can most effectively contribute to the delivery of integrated policy strategy solutions.

3rd Progress Meeting

The 3rd Progress Meeting of the CURE project was held virtually on 2 July 2021 with the participation of the CURE Consortium partners. During the Meeting, the CURE progress during the first semester of 2021 and the CURE planning for the next six months were outlined through presentations and discussion.

CURE presentation in international scientific meetings

The CURE project was presented in the following meetings:

- Data Research, Access and Governance Network (DRAGoN) Launch Event, 1 July 2021
- IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 12-16 July 2021
- SPIE Remote Sensing Digital Forum, 13-17 September 2021
- EuroGEO Workshop, 20-23 September 2021

All activities of the CURE project are available through the project's web-site: http://cure-copernicus.eu/news.html.

CURE

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CURE H2020 Project

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