HORIZON 2020

The EU Framework Programme for Research and Innovation

H2020-EO-1-2014

Users Feedback Report

Deliverable D2.3

URBANFLUXES

URBAN ANTHROPOGENIC HEAT FLUX FROM EARTH OBSERVATION SATELLITES

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DATE

21 January 2018

ISSUE

1.0

GRANT AGREEMENT

no 637519

DISSEMINATION LEVEL

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1 INTRODUCTION

1.1 Purpose of the document and document structure

This document summarizes the feedback from users of the URBANFLUXES (URBan ANthropogenic heat FLUX from Earth observation Satellites) Project.

1.2 Who are the users?

The URBANFLUXES researchers see other scientists as an important group of users. They also think their work is relevant for practitioners within local and regional governments, NGO's and the private sector. Relevant domains are urban planning and construction, energy, environment and health.

Scientists	Practitioners
• Remote sensing community • Micrometeorology, urban climatology • Regional and global climate scientists	• Urban planners (green cities) • City strategists (adaptation and mitigation) • Health departments / organizations • Energy departments / organizations • Smart cities / data departments • Environmental departments • Politicians (energy / CO_2) • London Climate Change Partnership • Urban engineers • Architects (depending on scale) • Regions: Basel cross-border, Crete • State agencies health & climate change • Swiss Tropical and Public Health Institute • EU and EEA

1.3 What are the products of URBANFLUXES?

URBANFLUXES potentially leads to a long list of usable products (see table). They can be divided in three categories (see figure):

- Input data: maps with data that URBANFLUXES collects from other sources such as the municipalities, their own previous work, global data sets and so on. Sometimes these datasets can be used; for example the elevation map of Heraklion was used to position telecom antennas in the optimal locations.
- Intermediate products: Several terms of the energy budget formula are calculated in URBANFLUXES to arrive at the Q_F term for anthropogenic heat. These intermediate data products can be used for other purposes as well, for example, to see the effect of vegetation cover on urban climate.
- Formally, the end product of URBANFLUXES is Q_F, an estimate of the anthropogenic heat factor across time and space. Daily, weekly and yearly patterns of heat production will be made visible on maps with a 100x100m grid. This can inform cities where energy can be saved. Monitoring this factor in the future can also indicate which measures of local governments lead to improved performance i.e. less Q_F.

Input data	Intermediate products	End products
• 3D maps, morphological structure of a city • Real-time data on wind, temperature, humidity • Land use maps • Buildings distribution • Urban vegetation characteristics • Sentinel data • Very high resolution satellite imagery	• Latent and sensible heat flux maps • Heat storage flux maps • Net all wave radiation maps • Surface temperature maps • Surface cover maps: bare soil, green (coniferous, deciduous), soil, etc. • Albedo maps • Emissivity maps • Algorithms for estimating fluxes • Sky view factor, morphology and roughness indicators	• Q_F – estimate of anthropogenic heat in maps for three cities • Gridded maps and zones • Time series of UEB fluxes • Automated process and tools to create UEB time-series • Methodologies and tools to calculate Q_F: manual and model package • URBANFLUXES App

1.4 Potential uses of URBANFLUXES products

The URBANFLUXES researchers list both intended and unintended potential uses of URBANFLUXES products. Intended uses comprise several uses of the formal end product Q_F as well as the intermediate products of the urban energy terms:

- Q_F - high energy consumption areas
  - Bad insulation
  - High air conditioning
  - Transport
- Urban Energy Budget – all energy fluxes
  - Albedo of surfaces causing low or high reflection of incoming radiation;
  - Materials causing low or high energy storage in buildings and urban surfaces;
  - Trees causing evaporation (latent heat flux);
  - Pervious surfaces allowing for water infiltration;
  - Urban structures leading to or blocking ventilation.

Maps of heat storage, sensible heat and latent heat fluxes for extended time periods provide the means to identify the areas of the cities that absorb a lot of energy during day and dissipate it during night. The heat absorption intensifies the UHI phenomenon. The maps also enable detection of the hottest neighbourhoods of each city where thermal comfort is reduced during hot days and the maps quantify the effect of the vegetation cooling in the UEB. Moreover, these map products can be used by the users to analyse which are the land cover, land use and structural parameters of the cities that have negative effects on the thermal behaviour and help them build rules of thumb for the percentage of open and green areas that are needed to balance the negative thermal phenomena in the cities. Users can also detect the time-periods and climatic properties that intensify the negative effects in the various neighbourhoods of the cities.

Next to these intended uses there are unintended (and sometimes surprising) uses of URBANFLUXES products:

- Buildings distribution: illegal building activities (for local law enforcement)
- 3D map: for deciding on optimal locations of telecom antennas
- In situ measurements: areas where thermal stress is reduced compared to surroundings, e.g. in parks
- In situ measurements: measurement of air pollution can easily be added on URBANFLUXES meteorological stations across the cities because the energy supply and software are already there.

1.5 Definitions and acronyms

3D	Three Dimensional
CoP	Community of Practice
EEA	European Environment Agency
EU	European Union
FORTH	Foundation for Research & Technology – Hellas, Heraklion, Crete
GIS	Geographical Information System, software for making maps
GLA	Greater London Authority
H2020	Horizon 2020 Research programme of the European Union (2014 to 2020)
Landsat	The Landsat Program is a series of Earth-observing satellites from the United States, providing Earth images since 1972
LCCP	London Climate Change Partnership
LIDAR	LIght Detection And Ranging of Laser Imaging Detection And Ranging, a surveying method that measures distance to a target by illuminating that target with a pulsed laser light, and measuring the reflected pulses with a sensor
LUCY	Large scale Urban Consumption of energY (LUCY). A model that calculates anthropogenic heat fluxes for cities around the world
NDVI	Normalized Difference Vegetation Index, a graphical indicator that can be used to analyze remote sensing measurements, and assess whether the target being observed contains live green vegetation or not.
NGO	Non- Governmental Organization
PDF	Portable Document Format
Q^*	net all-wave radiation flux
ΔQ_A	net advected flux ($\Delta Q_A = Q_{in} - Q_{out}$)
Q_E	turbulent latent heat flux
Q_F	anthropogenic heat flux
Q_H	turbulent sensible heat flux
ΔQ_S	net change in heat storage within the volume (including the flux into the ground)
S	all the other sources and sinks
SMS	short message service, a service to receive short messages via GSM
UEB	Urban Energy Budget
UHI	Urban Heat Island
UK	United Kingdom
UniBas	University of Basel

UoG	University of Gothenburg
UoR	University of Reading
URBANFLUXES	URBan ANthropogenic heat FLUX from Earth observation Satellites
W/m_2	Watts per square metre; a unit of energy
WP	Work Package
WUR	Wageningen University and Research

2 USER DEMANDS REGARDING URBANFLUXES

The questions and comments of CoP participants were noted during the CoP sessions (see Deliverable 2.2). These questions and comments were used to analyse the user demand in relation to URBANFLUXES results. The data were categorized according to what kind of urban problems the users were interested in, what type of data or results they would need, and other aspects of user demand. The table below shows the categorization and also includes a column from which city the demand came. In the next chapter these results will be interpreted and compared to the actual URBANFLUXES products.

2.1 User requirements regarding content

The first table shows the user demands what the result should be about in three categories of content: energy reduction /climate change mitigation; urban heat and climate change adaptation; and other.

Table: User demands regarding the content of URBANFLUXES outcomes in different cities

Content: reduce energy demand, energy loss, climate change mitigation	*Content: Urban heat, climate change adaptation*	*Content: other environmental issues*
CoP1 London		
Need to reduce energy demand under hot conditions. Options include retrofitting buildings, new building design, stop the adoption of air conditioning. Improve spatial information on temperature and energy use.	The relation between urban heat and health. To identify hotspots. Importance of green infrastructure for resilience.	Relation with flooding
CoP1 Basel		
A tool to evaluate the implementation of climate mitigation technologies.	A map of extreme temperature for the town of Basel; where are the hotspots, where should we change something? Why is it hot there; because of activities, or because of materials? What will the effects of changing certain areas be: to build a higher building or to make grassland. To measure in very green areas and in newly developed areas. How to plan the (green) infrastructure in a city. To have cool spots like a park, where there is shadow, or a river within walking distance. How to use certain materials; wood or concrete have different heat storage capacities.	

Content: reduce energy demand, energy loss, climate change mitigation	*Content: Urban heat, climate change adaptation*	*Content: other environmental issues*
CoP1 Heraklion		
Energy efficiency and climate mitigation. Planning guidelines for the energy agency of the region of Crete.	Southern cities suffer from climate change. To learn the hot spots of their city. Forests and vegetation are cooler, but the region needs more detailed information for city planning projects. There is a new airport planned for Heraklion which may become a hotspot, can URBANFLUXES propose solutions or actions for the airport plan? Confirmation that cool materials, or green roofs and other nature based solutions are needed in the city. How to adapt to climate change and integrate this into the city planning. How can we deal with current heat waves in order to protect the civilians? Changes in larger areas, like parks and squares can be analyzed.	Sensors for particulate matter can be included to monitor the air quality of the city.
CoP2 London		
You can track heat loss in buildings so if we retrofit we want to see how that is scaling up in different places. You do modelling of buildings, can you also look at effects between air conditioning and passive cooling?	Can you show changes in tree canopy cover? Could you apply the models to green areas as well? Do you try to relate heat loss to urban temperature? Can you see where it heats up city? There are opportunity areas for housing, can you do work specifically related to those areas; e.g. how densification affects climate? There are risks of under-heating in winter and overheating in summer. Can you infer from data what the risk areas are? What are design principles to minimize fluxes and reduce urban temperature? The London City Corporation made an adaptation plan in 2007; we are interested to see how it has developed and what more we need to do.	

Content: reduce energy demand, energy loss, climate change mitigation	*Content: Urban heat, climate change adaptation*	*Content: other environmental issues*
CoP2 Basel		
Investigate the effect of strict energy use laws by comparing the heat production from buildings of Basel-Stadt with the region. Especially for the summer to see if the cooling prohibition has an effect. In Basel all energy is already renewable? Traffic still uses fossil fuel; And all the old buildings still produce the heat. Energy also can be saved with better insulation.	To reduce the urban heat effect. Human use of energy is not the only factor that heats up the city, the sun is most important and different building materials and urban green can make a difference.	
CoP2 Heraklion		
Sustainable urban development strategies. A guide for future expansion plans and to improve the energy efficiency of public buildings. Climate change mitigation planning for the city of Heraklion. methods for the reduction of greenhouse gases and traffic regulations.	The urban heat affects the microclimate and people's lives. It is necessary to implement changes in Heraklion to reduce the urban heat phenomenon. Cities and regions need strategies for adapting to climate change. The priorities in the planning strategies should be three, i.e. an increase of green areas, the use of cool materials in construction and adaptation to climate change.	Another factor is urban pollution. Urban environmental management, To support urban planning, urban governance and civil protection in the broader area of Heraklion.

2.2 User requirements regarding the form of the output

The table shows the user demands regarding the form of URBANFLUXES results in four categories: level of detail, geographical scale, time aspects, and other issues.

Table: User demands regarding the form of URBANFLUXES outcomes in different cities

Form: resolution, level of detail	*Form: geographical scale, overview*	*Form: time aspects, past, present, future*	*Form: other issues*
CoP1 London			
		An airtext system has been introduced for vulnerable people. To test if interventions have a positive effect.	
CoP1 Basel			
A lot of details are needed so cities can really analyse the situation.	Not only the town but the whole agglomeration including	We need scenarios for planning; if you change something, what will happen?	A guideline for urban planning is needed. The municipality of Basel has not integrated heat-

Form: resolution, level of detail	*Form: geographical scale, overview*	*Form: time aspects, past, present, future*	*Form: other issues*
Will there be enough data for sufficient detail? Preferably information on buildings. For Basel it seems better to have a very detailed map that can be used in plans for 10 years.	Germany and the airport. Local authorities have nearly all the data in GIS format, but only up to the national border, so not into France or Germany, and even in this limited corner of Europe the data is already in different formats in each country. The differences between cities are interesting.	Because the measurements will now be available more often, a city can actually monitor the effect of its measures. There is already a lot of data available of a high frequency, there is already a monitoring system in place. The plans as a whole are changed every 10 years, but some small parts are changed every 2 years. So a 5-10 years frequency will be fine.	related factors at the moment in building plans, but they will be integrated in the near future. It is not part of the building regulations.
CoP1 Heraklion			
		Heraklion is a "smart city" that focuses on open data available through the internet. The data are available to the public. FORTH will give access to the municipality of Heraklion. The main goal of civil protection is prevention rather than facing the existing issues.	Guidelines for city planning are needed as outcome of the URBANFLUXES project. Help Heraklion to be reformed, become more green, more cool and more livable for the citizens. The local organizations also need to know what to do with those results in the end. How do they make the city more comfortable in terms of heat for the citizens? Knowledge on the thermal behavior of cities. Indicators like green area per person.
CoP2 London			
Can we get heat loss data for each separate building? We want to see how that is scaling up in different places. Do you also have data on characteristics of buildings?	A satellite sees the whole city of London, while in situ measurements only see a small part of the city.	Can you do time series over the past 15 years? Could you show environmental change over time? For example, you could make one estimate per year. Can you infer from data what the risk areas are of under-heating in winter and overheating in	Do you have messages to designers what to do? What are design principles to minimize fluxes and reduce urban temperature?

Form: resolution, level of detail	*Form: geographical scale, overview*	*Form: time aspects, past, present, future*	*Form: other issues*
		summer? A kind of alarm system? We would have to know what sets off the alarm, including socio-economic data to identify target areas. There are opportunity areas for housing, can you also model forward how this densification affects climate?	
CoP2 Basel			
	Cities maybe can learn from each other. For example the effect of less insulation and less strict rules.	Do you have a system to regularly update your data?	Are the data free? everything we produce is freely available;
CoP2 Heraklion			
		Heraklion still lacks efficient environmental planning and tools for environmental monitoring.	The project cooperates with the authorities to manage the measurement infrastructure and the authorities use the data and information generated by the project.

3 Conclusions on user requirements for Urban Energy Budget knowledge

3.1 Conclusions on content requirements

All three cities are interested both in reducing energy demand (spatial knowledge on Q_F), and in reducing urban heat in general (other heat fluxes). In London the focus is more on reducing energy demand and energy losses. Urban heat is also seen as a problem, but mostly to control potential raises in energy demand for cooling purposes.

In Basel and Heraklion the focus is more on reducing urban heat problems for the citizens through urban planning and regulation. In Basel much energy is already from sustainable sources and regulations on energy use of buildings are quite strict. However, the burden of heat waves is experienced as a growing problem for the city centre. Heraklion suffers from very high temperatures in the summer and lacks green infrastructure. Scientific results are a motivation to involve the citizens and private sector of Heraklion into improvement plans.

All three cities are interested both where the hot spots are and where the cool spots are. They also want to know how to influence the urban temperature with urban design, green infrastructure and building materials.

3.2 Conclusions on form requirements

Regarding the form of URBANFLUXES output, Basel and London are keen on highly detailed maps. London prefers information at building scale. Heraklion does not comment on the level of detail because so far all new data is welcome.

Regarding the geographical scale, both London and Basel benefit from the fact that a satellite can provide data of a large part of the earth in one picture. London is a big agglomeration and it is difficult to gather detailed data with other methods. Basel lies in the corner of Switzerland while the agglomeration stretches across the border into France and Germany. Due to different data standards it has been hard to combine data from three different jurisdictions (or more when the Swiss cantons are included). A satellite provides data on the whole area in one and the same format.

Similarly, satellites can provide comparable datasets for different cities, which Basel would be interested in, order to learn from other cities.

Regarding the temporal aspect, the cities are not only interested in data on the present but also on the past and the future. The ESA Sentinels have as a main attraction that they monitor the present developments. However, this can be put in context by also involving data from older satellites. London is interested in looking back in that way. Basel is not so dynamic in its spatial developments and for this city highly detailed data in the spatial sense once every ten years could be sufficient.

Regarding the present, both London and Heraklion are interested in informing their citizens almost real-time about health-related problems. London has an airtext system for warning vulnerable people about air pollution and Heraklion makes data available to the public via the Internet within the frame of a 'Smart City'.

The future is the most interesting for the planners: all three cities would like to see scenarios that show the climatic effects of planned spatial developments through data and modelling. They want to use this for more sustainable urban planning.

Finally, the concreteness of the research outputs are an issue. All three cities hope that the outcomes of URBANFLUXES will be translated into specific guidelines for better urban planning and building design. The guidelines should inform cities how they can make their city more comfortable for the citizens. It might even result in adapted building regulations or in an indicator for the amount of urban green per person.


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