



# Earth observation for urban climate

Urbanised regions tend to be much warmer than their rural counterparts, threatening the comfort and health of susceptible city dwellers and contributing to climate change. **Dr Nektarios Chrysoulakis** presents a means of monitoring, and dissecting the causes of, the 'urban heat island' effect from space

## What inspired you to launch the concept of 'Urban anthropogenic heat flux from Earth observation satellites' (URBANFLUXES)?

Although methods exist for monitoring land-use changes using Earth observation (EO) data, a clear link between urban land-use patterns and energy consumption at local scale is missing. Moreover, EO-based methods for determining energy fluxes in urban areas are still under development. Therefore, estimating the spatial patterns of urban energy budget by current EO systems is a challenge. The greatest test, however, is the exploitation of the Copernicus

Sentinel satellites' synergistic observations to estimate the spatiotemporal patterns of anthropogenic heat flux. URBANFLUXES was launched to meet this challenge.

## Having been chosen for the first Horizon 2020 Space Call, how does your project fit within the remit of 'New ideas for Earth-relevant space applications'?

URBANFLUXES introduces novel ideas on anthropogenic heat flux observation

from space. It will exploit the Copernicus Sentinels' observations, which provide improved data quality, coverage and revisit times. These observations will generate novel scientific insights into the spatial distribution of the urban energy budget fluxes in cities, thereby generating new EO opportunities of benefit to climate change mitigation/adaptation and civil protection.



## Taking Europe's temperature

A European consortium of researchers, led by the **Foundation for Research and Technology Hellas**, Greece, seeks to quantify and disentangle the parameters of the urban energy budget. Through the use of newly launched satellites, the URBANFLUXES project will advance understanding of urban climate dynamics

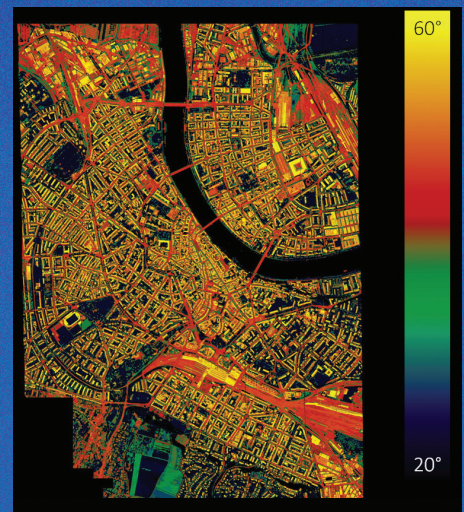
**THE CONCRETE JUNGLE** harbours a great deal more solar and thermal energy than the soil and vegetation of the countryside, a phenomenon dubbed the 'urban heat island' (UHI) effect. As the mercury level of the global thermometer rises, our UHIs will only grow hotter. While there remains little doubt that humankind is responsible for climate change, we know little of how our activities influence urban climate.

Dr Nektarios Chrysoulakis is spearheading 'Urban anthropogenic heat fluxes from Earth observation satellites' (URBANFLUXES), a Horizon 2020 project launched earlier this year involving the use of Copernicus Sentinel satellites. The project focuses on three European cities: Basel, Switzerland; Heraklion, Greece; and London, UK. By combining observations from different satellites, the urban energy budget may be quantified at local scale.

### THE RATIONALE

As the rate of warming in urban areas exceeds the global average, warming data must be obtained from individual cities in order to quantify the contribution of the UHI effect to climate change. Unfortunately, taking multiple heat flux measurements *in situ* is practically impossible. The only viable alternative to taking such measurements on Earth's surface is remote detection via satellites.

Anthropogenic heat emission data obtained by multiple Sentinel satellite missions is supported by conventional meteorological measurements. Combining these datasets permits the calculation of heat flux patterns diurnally, and over the course of each week, month and year. The resultant temporal trends will serve to inform the city planning and scientific sectors, while also permitting a more accurate estimation of the urban energy budget.



Surface temperature in Basel derived from very-high resolution thermal infrared imagery analysis



## Why is it important that we advance our understanding of the urban energy budget's influence on urban heat islands (UHIs)?

The UHI effect tends to exacerbate global warming. A positive feedback cycle occurs in many urban areas, where higher temperatures result in more energy being used for cooling, which in turn adds to heat emissions and further increases temperatures during periods of high heat wave risk. It is expected that, without mitigation measures, energy demand will continue to increase during the warmest months. URBANFLUXES advances current knowledge of the impacts of urban energy budget fluxes on UHIs, and consequently on energy consumption in cities. The project will therefore lead to the development of tools and strategies to mitigate these effects, improving thermal comfort and energy efficiency.

## How close are you to providing anthropogenic heat emission benchmark data for practical applications?

The spatiotemporal distributions of anthropogenic heat flux will be generated

## FACTORS OF INFLUENCE

A number of factors are at play behind the scenes of the UHI effect, including vehicular emissions; the heating and cooling of buildings; and even the human metabolism. These examples represent the anthropogenic facet of UHIs, with which URBANFLUXES is concerned.

By virtue of their compounded datasets, and some impressive mathematical operations, Chrysoulakis and the URBANFLUXES consortium are able to infer the key culprits responsible for the urban warming. Satellite data will first be analysed to map urban surface morphology and cover, before local climate zones are derived and imposed upon these urban maps. "Using the local climate zones as a framework, advanced Earth observation-based methods will be used to estimate urban energy budget fluxes," explains Chrysoulakis.

Over the next two years, Chrysoulakis and his collaborators will disentangle the influence of urban structures, air conditioning systems, green spaces and transport on urban heat. In so doing, URBANFLUXES will inform countermeasures against the metropolitan malady of UHIs. However, the project is principally a proof of concept; a bedrock upon which further Earth observation technologies may be cultivated. In this

way, the URBANFLUXES project serves to demonstrate the repurposing potential of Earth-observing satellites, as Chrysoulakis explains: "Although Sentinel satellites are not designed for monitoring the urban energy budget, their spatial and temporal characteristics are suitable for addressing challenges associated with anthropogenic interference in the Earth's system".

for our project's case studies across three European cities. These products will be evaluated by comparison with alternative methodologies at specific locations, whereas uncertainties will be specified and analysed. Therefore, they are considered as benchmark datasets for the above cities, and can be used for practical applications. URBANFLUXES is committed to exploring new ideas for space applications; as such, its main outcome is not anthropogenic heat maps for all cities, but rather an innovative method to exploit Copernicus Sentinels' observations for estimating urban energy budget fluxes.

## What obstacles in your field do you hope to overcome?

Understanding the relationship between urban form, energy use and carbon emissions. The key characteristics governing energy exchange between urban surface and atmosphere must be identified if adequate action is to be taken towards climate change mitigation at the local scale. Space research is expected to support meeting these challenges.

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## URBAN ENERGY BUDGET

Imagine a city and place it in a theoretical box, just big enough to accommodate the envisioned metropolis. The urban energy budget is the amount of energy added to this box (chiefly by the Sun's rays) versus that which escapes it. A number of parameters (ie. heat storage in buildings and turbulent heat exchanges between the surface and the atmosphere) define the influx and efflux of energy into the urban system, and human activities can offset the balance by adding yet more heat to the environment.

## URBANFLUXES

### OBJECTIVES

- To investigate the role of anthropogenic heat flux on the development of 'urban heat island'
- To develop a satellite-based approach to estimating the urban energy budget

### PARTNERS

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**Centre d'Etude Spatiale de la Biosphère**, Paul Sabatier University, France

**University of Reading**, UK

**Universitaet Basel**, Switzerland

**Goeteborgs Universitet**, Sweden

**GEO-K srl**, Italy

**ALTERRA**, Netherlands

For more information about the URBANFLUXES partners, visit: <http://urbanfluxes.eu/about>

### FUNDING

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**NEKTARIOS CHRYSOULAKIS** has considerable experience in the fields of Earth observation and urban climate, holding a Master's degree in Environmental Physics and PhD in Remote Sensing. In addition to his responsibilities as Director of Research at FORTH, he is Coordinator of both the Horizon 2020 project URBANFLUXES, and the ERA.Net Rus Plus project, SEN4RUS. Chrysoulakis also participates in the Horizon 2020 project ECOPOTENTIAL and the LIFE+ project FLIRE.



**URBANFLUXES**