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URBANFLUXES

URBAN ANTHROPOGENIC HEAT FLUX FROM EARTH OBSERVATION SATELLITES

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CONTENTS

1 Introduction 4
1.1 Purpose of the document and document structure 4
1.2 Definitions and acronyms 4
1.3 Document references 6
2 Project Overview 8
3 First interview round: Early expectations of URBANFLUXES results 10
3.1 Main problems to solve within the project 10
3.2 Benefits from Earth Observation data 11
3.3 Differences between the cities 11
3.4 Available useful knowledge 12
3.5 Expected outcomes 12
3.6 Certain and uncertain outcomes 13
3.7 Knowledge exchange with partners 13
3.8 Message for first short video 14
3.9 Local authorities expertise of potential interest 15
3.10 Conclusions first round of interviews 15
4 Community of Practice in London 21 January 2015 16
4.1 URBANFLUXES idea and methods 16
4.2 Likely benefits of URBANFLUXES for London 16
4.3 London urban heat knowledge and related policies 17
4.4 Foreseen interaction between URBANFLUXES and Greater London Authority 18
4.5 Conclusions CoP 1 London 18
5 Community of Practice in Basel 23 June 2015 19
5.1 Program and participants 19
5.2 Welcome and explanation of program 20
5.3 Poster session 22
5.3.1 Poster: Novel approach for anthropogenic heat flux estimation from space 22
5.3.2 Poster: Urban heat island of Basel seen from different perspectives 26

5.3.3 Poster: Exploiting Earth Observation data for mapping Local Climate Zones 28
5.3.4 Poster: Influence of urban development on the local urban climate in Basel 31
5.4 Explanation of flux tower 33
5.5 Presentations on urban heat and health effects 33
5.5.1 Climate risk and vulnerability assessment in Basel (Mario Betschart) 33
5.5.2 Heat waves and health (Martina Ragetli) 35
5.6 Discussion with all participants 36
5.7 Conclusions CoP 1 Basel 38
6 Community of Practice Heraklion 17 December 2015 39
6.1 Program and participants 39
6.2 Welcome and explanation of program 41
6.3 Presentations 42
6.3.1 Earth Observation for Urban Climate (Eberhard Parlow) 42
6.3.2 Anthropogenic heat flux estimation from space (Nektarios Chrysoulakis) 44
6.3.3 Exploiting Earth Observation data for mapping Local Climate Zones (Zina Mitraka) ... 46
6.3.4 New Heraklion Meteo Stations Network (Nektarios Spyridakis) 47
6.4 Discussion with all participants 48
6.5 Conclusions CoP 1 Heraklion 53
7 Second interview round: Messages to URBANFLUXES users 54
7.1 Introduction 54
7.2 Who are the users? 54
7.3 What do users want? 55
7.4 What are the products of URBANFLUXES? 56
7.5 Potential uses of URBANFLUXES products 57
7.6 Worries and solutions 59
7.7 Ideas for second CoP round 60
7.8 Ideas for the second video 60
7.9 Conclusions second interview round 60
8 Second CoP meeting Basel 18 January 2017 62
8.1 Aim and programme 62

8.2 Overview of the URBANFLUXES project (Eberhard Parlow) 63
8.3 First results from Basel and London (Christian Feigenwinter) 64
8.4 GeoRhena for data across borders (Boris Stern) 65
8.5 Discussion with all participants 66
8.6 Conclusions CoP 2 Basel 68
9 Second CoP meeting London 14 February 2017 70
9.1 Aim and programme 70
9.2 Overview of the URBANFLUXES project (Nektarios Chrysoulakis) 71
9.3 Copernicus satellites (Zina Mitraka) 73
9.4 URBANFLUXES London results (Sue Grimmond) 74
9.5 Anthropogenic heat fluxes (Andrew Gabey) 75
9.6 Discussion with all participants 76
9.7 Conclusions CoP 2 London 78
10 Second CoP meeting Heraklion 14 July 2017 81
10.1 Aim and programme 81
10.2 Introducing Local Authorities & Stakeholders 83
10.3 Overview of URBANFLUXES (Nektarios Chrysoulakis) 84
10.4 Heraklion as a Smart City: The environmental component (Kostas Mohianakis) 85
10.5 Environmental Projects in Crete (Eleni Hatziyanni) 85
10.6 Urban surface cover and morphology from satellites (Dimitris Poursanidis) 85
10.7 The URBANFLUXES Wireless Sensors Network in Heraklion (Nektarios Spyridakis) 86
10.8 Heat storage in buildings of Heraklion (Zina Mitraka) 86
10.9 Turbulent heat and CO_2 fluxes in Heraklion (Stavros Stagakis) 87
10.10 Discussion with all participants 88
10.11 Conclusions CoP 2 Heraklion 89
11 Conclusions on user requirements for URBANFLUXES 91

1 INTRODUCTION

1.1 Purpose of the document and document structure

This document summarizes the results from the stakeholder involvement activities of the URBANFLUXES (URBan ANthropogenic heat FLUX from Earth observation Satellites) Project. The report aims to provide ideas on the potential use of URBANFLUXES end products and intermediate products in practice. These ideas are based on the Communities of Practices in the cities of London, Basel and Heraklion.

After a general introduction of the URBANFLUXES project, the results of the first and second round of Community of Practice (CoP) meetings are described. Each round is followed by intermediate conclusions. Furthermore, the results of two interview rounds among the URBANFLUXES scientists are reported. The report ends with general conclusions on the outcomes of the CoP's and the interview rounds.

1.2 Definitions and acronyms

3D	Three Dimensional
ARUP	Arup Group Limited, a multinational professional services firm headquartered in London
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer, a device on board the Terra satellite
BRIDGE	sustainaBle uRban plannIng Decision support accountinG for urban mEtabolism, an EU FP7 project (2008-2011)
CESBIO	Centre d'Etudes Spatiales de la BIOsphère/ Center for the Study of the Biosphere from Space, located in Toulouse, France
CoP	Community of Practice
DART	Discrete Anisotropic Radiative Transfer, a model run by Cesbio that simulates measurements of passive and active satellite/plane sensors, as well as the radiative budget, for urban and natural landscapes
DEM	Digital Elevation Model
DLR	Deutsches Zentrum für Luft- und Raumfahrt/ German Aerospace Center
DSM	Digital Surface Model
DSS	Decision Support System
EC	Eddy Covariance
EEA	European Environment Agency
EO	Earth Observation

ESA	European Space Agency
ESTM	Element Surface Temperature Method, a model to calculate the storage heat flux
EU	European Union
FORTH	Foundation for Research & Technology – Hellas, Heraklion, Crete
FP7	Seventh Framework Programme, research programme of the European Union (2007-2013)
GEO-K	A spin-off company of the Tor Vergata University of Rome to make the know-how developed by the University's Earth Observation Laboratory available in the form of user-oriented applications.
GIS	Geographical Information System, software for making maps
GLA	Greater London Authority
GPRS	General Packet Radio Service, a mobile data service on the 2G and 3G cellular communication system's global system for mobile communications (GSM).
H2020	Horizon 2020 Research programme of the European Union (2014 to 2020)
INFRAS AG	Swiss research organization situated in Zurich and Berne
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
LCZ	Local Climate Zones
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
LU/LC	Land Use/Land Cover
MCR Lab	Meteorologie, Klimatologie und Fernerkundung, micrometeorological research unit of the University of Basel
MODIS	Moderate-resolution Imaging Spectroradiometer, a device on board the Terra and Aqua satellites from NASA
MoH	Municipality of Heraklion
NDVI	Normalized Difference Vegetation Index, a graphical indicator that can be used to analyse remote sensing measurements, and assess whether the target being observed contains live green vegetation or not.

NGO	Non- Governmental Organization
PDF	Portable Document Format
PMV	Predicted Mean Vote, a way to measure subjective heat stress
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)
RoC	Region of Crete
S	all the other sources and sinks
SMS	short message service, a service to receive short messages via GSM
SUEWS	Surface Urban Energy and Water Balance Scheme, a model to simulate the urban radiation, energy and water balances using meteorological variables and information about the surface cover
TPH	Tropical and Health Institute
UBL	Urban Boundary Layer
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

1.3 Document references

Groot, Annemarie, Judith Klostermann, Eddy Moors (2009). D.2.3 Protocol for Developing Communities of Practice in the context of BRIDGE. BRIDGE Project (sustainaBle uRban planning Decision support accountinG for urban mEtabolism) EU FP7 Contract no.211345

Klostermann, J.E.M., A. Groot, A. Gonzalez (2014). The use of Communities of Practice to involve stakeholders in the decision support system design. In: Nektarios Chrysoulakis, Eduardo

Anselmo De Castro, Eddy J Moors (eds) Understanding Urban Metabolism. A Tool for Urban Planning. Routledge, New York. pp 131-140

URBANFLUXES Grant Agreement, n. 637519, 05/11/2014

URBANFLUXES Consortium Agreement, 31/10/2014

2 PROJECT OVERVIEW

The anthropogenic heat flux (Q_F) is the heat flux resulting from vehicular emissions, space heating and cooling of buildings, industrial processing and the metabolic heat release by people. Both urban planning and Earth system science communities need spatially disaggregated Q_F data, at local (neighbourhood, or 100 m x 100 m) and city scales. Such information is practically impossible to derive by point *in-situ* fluxes measurements, while satellite remote sensing potentially is a valuable tool for estimating the Urban Energy Budget (UEB) parameters exploiting Earth Observation (EO) data. The estimation of Q_F spatial patterns by current EO systems is therefore a challenge; however, the major challenge for the EO community is the innovative exploitation of the Copernicus Sentinels synergistic observations to estimate the spatiotemporal patterns of Q_F and all other UEB fluxes.

The main goal of URBANFLUXES (URBan ANthropogenic heat FLUX from Earth observation Satellites) is to investigate the potential of EO to retrieve Q_F, supported by simple meteorological measurements. The main research question addresses whether EO is able to provide reliable estimates of Q_F for the time of the satellite acquisition. URBANFLUXES will answer this question by investigating the potential of EO to retrieve Q_F spatial patterns, by developing a method capable of deriving Q_F from current and future EO systems. This method can be used operationally to derive spatiotemporal patterns of Q_F in the near future, when observations with adequate temporal resolution become available. Methods to estimate UEB related products from EO will be developed and by combining these products the Q_F spatial patterns will be derived. URBANFLUXES therefore aims to develop an EO-based methodology easily transferable to any urban area and capable of providing Q_F benchmark data for different applications, including UEB models to assess the implication of Q_F on the urban climate; building energy models to characterize buildings-to-atmosphere/soil/water heat exchange pathways; Decision Support Systems (DSS) for urban sustainable planning and mapping of pollutant emissions related to energy consumption in urban areas. URBANFLUXES is expected to increase the value of EO data for scientific analyses and future emerging applications (such as urban planning and local/regional level climate change mitigation/adaptation), by exploiting the improved data quality, coverage and revisit times of the Copernicus Sentinels data. The ultimate aim is to support sustainable urban planning strategies relevant to climate change mitigation and adaptation in cities, by taking into account the contribution of the anthropogenic heat.

$$Q^* + Q_F = Q_H + Q_E + \Delta Q_S + \Delta Q_A + S \quad (\text{W m}^{-2}) \qquad (1)$$

The energy balance residual approach (Offerle et al. 2005, Pigeon et al. 2007) will be used in URBANFLUXES. Although a rather straightforward method when the rest UEB components are known, its primary drawback is the accumulation of estimation errors of each energy budget flux in Q_F, in Equation (1), and the error of having neglected any unmeasured terms. Errors in the estimated flux terms include those stemming from normal observation inaccuracies plus the real spatial variability of the surface energy budget. In the framework of URBANFLUXES this spatial variability will be derived from satellite observations. Therefore, given small or unbiased ΔQ_A (net advected flux ($\Delta Q_A = Q_{in} - Q_{out}$)and S (all the other sources and sinks) in Equation (1) and determining Q* (net all-wave radiation flux), Q_H (turbulent sensible heat flux), Q_E (turbulent latent heat flux) and ΔQ_S (net change in heat storage within the volume) directly from EO data, with the support of standard meteorological observations, the expected value of the residual term would be a reliable estimate of Q_F, since, from a measurement perspective, it is impossible to remove anthropogenic contributions from the other terms in Equation (1). The Q_F considered here captures only the effects of energy released within the system, which is not necessarily equivalent to energy consumption, as for example for the case of buildings, due to the heat transfer resistance between buildings and atmosphere and the thermal inertia of buildings. Q_F is estimated by regressing ($Q_H + Q_E$) versus ($Q^* - \Delta Q_S$), defined for every pixel. Given that UEB closure is achieved, the regression will result in Q_F, estimating also the respective uncertainty.

Three different urban areas are selected in URBANFLUXES as case studies (Figure 6): a highly urbanized mega city (London), where high values of Q_F are expected in all seasons; a typical central European medium size city, that requires a substantial amount of energy for heating (Basel metropolitan area); and a smaller, low latitude Mediterranean city with dynamic urbanization process that requires a substantial amount of energy for cooling (Heraklion). In both Basel and Heraklion lower Q_F values are expected; however the two latter cases are considered as representative test-beds to investigate possible limitations of the URBANFLUXES methodology. In all cities local scale and city scale Q_F estimations will be performed.

In order to develop a method that will be welcomed by potential users, it is important to involve them in the project from the beginning. The project will use a Community of Practice (CoP) approach (Klostermann et al. 2014), which means that in the case studies, local stakeholders and scientists of the URBANFLUXES project will meet on a regular basis in order to learn from each other. The CoP will make clear what aspects are important for the future users of the URBANFLUXES products. The scientists, in turn, will explain what the possibilities and limitations of the methods and models are. The interactions will be informal and open in order to lead to an increased understanding of the system under study for both the future users and the scientists. It also provides network contacts for collecting spatial and non-spatial datasets for each case study. This approach will also be used to create an "umbrella" CoP across the participating cities, as well as with the broader scientific community, to exchange ideas and experience of the URBANFLUXES products on a European level.

3 First interview round: Early expectations of URBANFLUXES results

The following chapter presents an analysis of interviews conducted with the scientists within URBANFLUXES in a very early stage, between February 5 and March, 16, 2015, before the first round of CoP's. The purpose of the interviews was to gain more information of the aims and the expectations of the scientists responsible for the different Work Packages. The respondents explain what knowledge was available at the start and what potential extra information they expected to be established within the course of the study.

The method that was used to retrieve these results were semi-structured interviews, conducted by two scientists of Alterra. For this purpose a questionnaire was developed, consisting of nine questions. The interview analysis was conducted in two stages: firstly, in order to systematically order the interview data, coding software - "Atlas-ti" was used. The second stage consisted of an interview analysis based on the questions asked within the interviews. The analysis aimed to derive information about the points of view of the different parties involved in the project and about the expertise they can offer for the planned CoPs in the different cities.

The analysis that will be presented in this chapter is based on the following codes: Main problems to solve within the project; Benefits from EO data; Types of sensors used in the project; Technical innovations for climate change; Differences between the cities; Expected outcomes; Certain and uncertain outcomes; Available useful knowledge; Knowledge exchange with partners; Short film message and Local authorities expertise of potential interest.

3.1 Main problems to solve within the project

According to the researchers the main problems that will be solved within the project are in the first place to reduce the energy consumption in the cities by investigating the UEB with a focus on anthropogenic heat. They expect also to:

- Establish what measures can be taken on local level to reduce urban heat;
- Mitigate the anthropogenic heat within the cities;
- Make an estimation of the released heat which affects the energy consumption, and;
- Gain understanding how to enhance energy use in the cities.

"The main thing is energy consumption; to make citizens aware of energy use and variations within a city."

3.2 Benefits from Earth Observation data

Researchers see two main benefits of Earth Observation data for cities, related to space and time:

- Better spatial data; detailed maps with data over large areas.
- More frequent measurements

These data become available for less money than by measurements on the ground or air plane measurements.

Time-related data can create patters for day and night; weekdays and weekend; and for the seasons. Such patterns show how people use energy. The data can also be used for the longer term: monitoring of the effect of adaptive measures; and land use changes.

Spatial information can show where the urban heat island effect occurs, and it can be used for microclimate modelling.

Earth Observation data also have two important limitations:

- The resolution may be too low for urban planners;
- EO data still need processing by a qualified scientist before they can be used by a city.

The scientists claim that at the moment the main satellite data sources are Landsat, MODIS, ASTER, but their aim is to use also the information derived from Sentinels 1, 2 and 3.

"...a synergetic use of the data from Sentinels 2 and 3. Sentinel 2 is a high spatial resolution optical system, whereas Sentinel 3 is a low resolution optical system with a high frequency of acquisition."

According to some scientists mainly from Basel and Heraklion there is still no information about any technical adaptation measures to tackle urban heat. For Heraklion:

"There are no green roofs at all within the city. There are solar panels, to collect energy, but not for heat mitigation"

3.3 Differences between the cities

Researchers classify the differences within the three studied cities in two general groups, namely physical differences and socio-economic differences. The physical differences include:

- The size of the city and the latitude where it is situated;
- The main layout of the urban area;
- Climatic differences related to a location, e.g. near a sea or near mountains;
- Difference in the seasonal UEB and the expected UHI peak occurrence.

On the other hand, the socio-economic differences include factors as:

- The way cities use the information that the project will deliver and where the local authorities put the focus of their other urban research.
- The urban problems that the cities face in terms of urban heat and their consequences, such as UEB and seasonal energy consumption.

"Social behaviour and economic activities have a big impact on the models"

3.4 Available useful knowledge

The researchers mention the following kinds of knowledge that they already have now, which can be useful for the case study cities:

- Knowledge on the urban energy balance; where heat /energy is lost from the cities.
- Knowledge on the anthropogenic heat flux: how energy is used by humans (heating of buildings, traffic).
- Urban microclimate, urban heat island, local climate zones.
- Maps of imperviousness
- Soil moisture / drought index.

When asked what knowledge can be useful, the researchers often mention things that they can do, but they do not know if this is useful. For example:

"We are able to deal with EO data and generate added value from the sensor data."

Furthermore, researchers mention that a lot of information is still lacking to make their knowledge useful. For example:

"For Heraklion there is almost no knowledge at all."

3.5 Expected outcomes

The researchers see the deliverables of the project as products that would be achieved gradually within the duration of the project and end products that would be delivered after the official end of the study, after all the data have been gathered and analysed. The products that are expected during the course of the project are:

- To learn what the spatial distribution of anthropogenic heat looks like in a city;
- To achieve an active knowledge exchange between the partners in terms of micrometeorological approaches;
- To learn how Earth Observation (EO) technology can be used for microclimate studies and urban planning;

- To create more precise products which are adapted to the needs to the end users and;
- To learn what the actual needs of the end users are.
- The second group of products that the researchers are hoping to deliver are the actual end products of the project, namely:
- A wide range of high resolution maps of urban fluxes and UEB fluxes on a local scale which are in a useful format for the urban planners;
- A methodology to build UEB models and knowledge from the interaction between the partners, the CoPs and with the local society.

Furthermore, the researchers claim that they will be able to define the zones and the areas with more dynamic energy consumption and to monitor and predict the process in a high resolution. They would also be able to measure the impact of vegetation on UEB in the cities.

3.6 Certain and uncertain outcomes

According to the researchers few promises can be made at this stage of the project. In this initial stage there are many more uncertainties than certain outcomes. Namely:

- The outcome highly depends on data that will be acquired in the course of the research and all the restrictions that brings.
- A concrete and universal solution cannot and should not be promised at this stage.
- The images that would be acquired depend on the satellites and on the climatic conditions, such as cloud coverage.

The only promise that could be given with some certainty according to the researchers, is that they will develop EO based method to map energy budget parameters, as well as the end product of this methodology, namely the maps that show the Q_F distribution and intensity within the city.

"We do not have to make particular promises about the accuracies characterizing the results that will be reached."

"The URBANFLUXES products will be urban energy budget maps for the cities, with detailed, specific distribution of energy fluxes in each location of the city."

3.7 Knowledge exchange with partners

The researchers estimate that the main benefit of the project to themselves is the exchange of expertise that each partner can offer, for example, the knowledge about the different methods that will be used within the research. The knowledge they can provide to each other can be divided into two main groups.

Remote sensing expertise:

- DLR, CESBIO, FORTH and UniBas have expertise on satellite image processing- they could provide climate related dataset for the cities;

Urban climate expertise:

- UniBas - micrometeorology and urban climate expertise on the local level. Moreover, expertise on UEB, in situ series of Eddy Covariance;
- CESBIO - radiative transfer model for local scale albedo and radiation balance;
- UoR and UoG - expertise on urban climate.

Furthermore, GEO-K contributes expertise on the automatization of the methodology. This partner will contribute to the project by developing an app to disseminate the products.

"For Heraklion the knowledge of [Reading] and [Basel] about modelling and measuring techniques"

3.8 Message for first short video

Depending on their background, the scientists see the potential message of a short promotion video in two main directions. Some of them consider that the message of the film should be more focused on the urban climate and how it is affected by urban heat. The message should consist of:

- A general description of the energy balance to give an explanation of urban heat;
- Explanation of the importance of the urban fluxes within a city;
- The importance of including the local society, because they could have a contribution in reducing UHI.

The second group of scientists considers that the message of the first film should focus more on satellites:

- Since URBANFLUXES aims to develop EO data derived from ESA satellites it will create satellite-based indicators that would help urban planners;
- To show how satellites can have a positive impact on people`s lives through helping to tackle climate change

In general the video should be a strong and very visual message that would attract local authorities to participate in the project.

"The film should encourage people to come to the project to work with us and to do something together."

3.9 Local authorities expertise of potential interest

Lastly, in terms of expertise of potential interest from the local authorities, according to the researchers there are three levels of inclusion. First, national level authorities might be interested in the results of URBANFLUXES. Second is the city level, including the following departments which would be potentially interested in the project:

- Energy use;
- City traffic;
- Environment and climate mitigation;
- Construction departments and architects;
- Departments of city planning;
- Landscape and urban green departments.

On a societal level potentially interested parties could be educational organizations and also the civil society of the studied cities.

3.10 Conclusions first round of interviews

In the first interview round at the start of the project the researchers see two main problems in cities that are addressed in the project: the reduction of urban heat and the reduction of energy use in cities. They want to contribute by generating Earth Observation maps with higher detail, higher frequency and for larger areas than before. With higher frequency data patterns over day and night, weekend and week days, and over the seasons can reveal how people use energy. ESA Sentinels are new satellites whose data will have to be combined because some datasets are with high spatial resolution and others with high temporal resolution, and URBANFLUXES aims to provide both.

Although anthropogenic heat is the main aim of the project, intermediate results are expected to be of use as well. Examples of such useful knowledge: where heat is lost in cities; how energy is used (buildings, traffic); urban microclimate and urban heat island; maps of imperviousness.

Final outcomes that are expected are a knowledge exchange on methods between the partners; how earth observation data can be used for microclimate studies; local-scale maps of different urban energy fluxes; the effect of vegetation on the urban energy balance; and the spatial distribution of anthropogenic heat.

The researchers acknowledge that there are many uncertainties in the project and they cannot promise achievement of all of the goals of the project.

4 COMMUNITY OF PRACTICE IN LONDON 21 JANUARY 2015

Place: City Hall, Greater London Authority

Participants

Sue Grimmond	University of Reading / URBANFLUXES
Alex Nickson	Greater London Authority (GLA)
Nathalie Bellanger	London Climate Change Partnership (LCCP)
Robert Hall	London First - Security and Resilience

4.1 URBANFLUXES idea and methods

A city like London is warmer than its surroundings. Urban structures absorb and trap more solar and thermal radiation than soils or short vegetation which helps to cause an increase in the air temperature. Human activities add heat to the urban system. The heating and the cooling of buildings, the traffic, various industrial activities and our own human metabolism release energy in the form of heat. The combined sources are called anthropogenic heat. Because of these effects, cities are warmer than their surroundings, a phenomenon known as the Urban Heat Island (UHI). The UHI combined with a heat wave can enhance energy consumption, decrease human comfort and enhance human mortality.

The H2020 URBANFLUXES project investigates the urban energy budget fluxes including the anthropogenic heat flux. For this research satellite observations are combined with surface based meteorological measurements. The satellite-based approach provides wide spatial coverage which has the potential for transfer of methods across a city and to other cities. With this knowledge, measures to reduce urban energy use can be monitored and tested.

Connection to the FP7 BRIDGE project: both projects look at London as a case study. The consortium is partly the same. URBANFLUXES is more focused in the Urban Energy Balance rather than urban metabolism with many other components such as the water balance and air quality. At the same time, URBANFLUXES is more open in terms of product outputs. Instead of aiming for a DSS, URBANFLUXES aims at different potential products that can be made based on Earth Observation data.

4.2 Likely benefits of URBANFLUXES for London

The presence of the urban heat island effect in London is a well-known phenomenon. If, as expected, heat waves occur more frequently and with greater severity due to climate change, it is likely that more companies and individual households in London will begin to use air conditioning. This will leading to additional energy use in the summer. The energy system of London is not resilient to heat waves and peak energy demand; it is just on the edge of brown-outs due to over-demand of power under hot conditions. It works less well under hot conditions and the infrastructure is old. There have been a few examples recently when key areas, for example, Oxford Street lost power. Some cities choose who is going to get the remaining power. For example, cities like Shanghai and Beijing are building in a predefined decision in their planning in terms of who is to get the power when something fails and who is going to lose it. This is not a strategy as yet adopted by London. But it is an issue the city wants to avoid.

London has an energy system that does not work well under hot conditions. Anything that can be done to reduce energy demand and to reduce the proximity to a threshold helps to improve resilience. Options include reducing energy use, retrofitting buildings, new building design, and other measures that will stop the adoption of air conditioning.

The potential benefits of URBANFLUXES for London are:

- To improve spatial information on temperature and energy use,
- To identify hotspots,
- To test if interventions have a positive effect.

4.3 London urban heat knowledge and related policies

The present status of knowledge on urban heat in London is good. Estimates of anthropogenic heat for all of London already exist. London has been considering heat-related issues for the last 10 - 15 years and wants to improve the resilience to heat waves.

It is a government requirement for all companies and other organizations to have a Risk Register. This involves assessing the resilience of an organization and to identify what it is that may cause failure.

Green infrastructure is now included in the Risk Register for London. Green infrastructure is important for resilience; it has a benefit in its own right. Because parks and trees are part of the Risk Register, the implications of cutting them down/reducing them have to be considered. An assessment has to be made of how things are linked, for example, green infrastructure may be flooded and then its benefits are lost.

GLA, LCCP and the UK Climate Change Partnership make recommendations for London rather than policies. URBANFLUXES has the potential to inform these recommendations.

Health is always of concern in London. When energy fails it has health implications. There is also a relation between urban heat and health. An airtext system has been introduced for vulnerable people.

The authorities immediately see the benefit of a project like URBANFLUXES.

4.4 Foreseen interaction between URBANFLUXES and Greater London Authority

Relevant partners and organizations for follow up:

- GLA (including energy experts)
- London climate change partnership
- Industry

There will be another meeting, when URBANFLUXES is able to show some results. This will provide the opportunity for URBANFLUXES to say: we have these data, how would you like us to map it in a different way? It has to be a work session, not just for information. The London stakeholders can give feedback on how they would interact with potential data and tools to inform how the project should move forward. There should not be too many meetings, and the project should provide actual results, something London could use.

4.5 Conclusions CoP 1 London

The presence of the urban heat island effect in London is a well-known phenomenon. If, as expected, heat waves occur more frequently and with greater severity due to climate change, it is likely that more companies and individual households in London will begin to use air conditioning. The energy system of London is not resilient to heat waves and peak energy demand. Anything that can be done to reduce energy demand and to reduce the proximity to a threshold helps to improve resilience. Options include reducing energy use, retrofitting buildings, and new building design. Green infrastructure is also important for resilience.

The potential benefits of URBANFLUXES for London are that it can help to identify hotspots, and it can test if interventions have a positive effect. The project should provide actual results, something London could use.

5 Community of Practice in Basel 23 June 2015

5.1 Program and participants

The first Community of Practice meeting of the URBANFLUXES project for the case study in Basel took place in the morning of Tuesday, the 23rd of June, 2015. The venue was at Basel University, Klingelbergstrasse 27, 4056 Basel. The meeting lasted from 9:00 to 13:00 and included a buffet lunch. The program is shown in Table 1. The list of participants is shown in Table 2.

Table 1: Program of the CoP meeting of 23 June 2015

09:00	Welcome and short film	UNIBAS – Eberhard Parlow
09:10	Introduction of the CoP	WUR-Alterra – Judith Klostermann
09:30	Poster session introducing URBANFLUXES	FORTH – Nektarios Chrysoulakis UNIBAS – Christian Feigenwinter FORTH – Zina Mitraka UNIBAS – Andreas Wicki
10:15	Explanation flux tower	UNIBAS – Christian Feigenwinter
10:30	Coffee Break	
10:45	Climate risk analysis Basel	Mario Betschart – INFRAS AG Zurich
11:05	Heat waves and health	Dr. Martina Ragettli - Swiss TPH Basel
11:25	Questions and discussion	WUR-Alterra – Judith Klostermann
11:45	Summary and follow up	WUR-Alterra – Judith Klostermann
12:00	Buffet Lunch	

Table 2: Participants of the CoP Basel

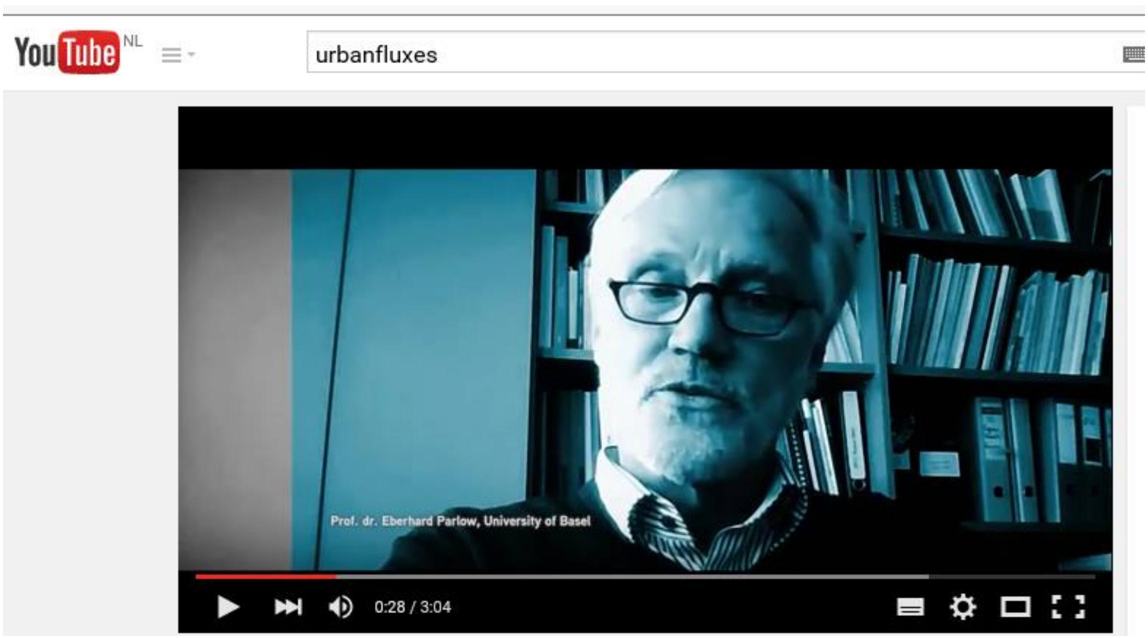
Channah Betgen	Wageningen UR, Alterra	Wageningen	Netherlands
Mario Betschart	INFRAS AG Zurich	Zurich	Switzerland
John Carmichael	SensorScope Sàrl	Basel	Switzerland
Nektarios Chrysoulakis	FORTH (Greece)	Heraklion	Greece
Christian Feigenwinter	University of Basel, MCR Lab	Basel	Switzerland
Fabio del Frate	GEO-K; Tor Vergata University	Rome	Italy
Jean-Philippe Gastellu-Etchegorry	CESBIO	Toulouse	France
Judith Klostermann	Wageningen UR, Alterra	Wageningen	Netherlands
Björn Lietzke	Statistisches Amt Basel-Stadt	Basel	Switzerland
Frederik Lindberg	University of Gothenburg	Gothenburg	Sweden
Zina Mitraka	FORTH (Greece)	Heraklion	Greece
Hans-Rudolf Moser	Lufthygieneamt (department for air quality management)	Basel	Switzerland
Eberhard Parlow	University of Basel, MCR Lab	Basel	Switzerland
Stephan Parlow	Umwelt und Klimaschutz, Stadt Lörrach	Lörrach	Germany
Martina Ragettli	Swiss TPH	Basel	Switzerland
Bettina Rahuel	Planungsamt (Construction and planning department, Planning office)	Basel	Switzerland
Franziska Siegrist	FRASUK Environment and Communication Agency	Basel	Switzerland
Roland Vogt	University of Basel, MCR Lab	Basel	Switzerland
Andreas Wicki	University of Basel, MCR Lab	Basel	Switzerland

5.2 Welcome and explanation of program

Eberhard Parlow welcomes all participants to the session and briefly introduces the project. URBANFLUXES (urbanfluxes.eu) addresses the problem of urban heat. Cities are generally warmer than their rural surroundings. During a heat wave, this can cause problems for human health and working conditions. To address these problems, knowledge is needed on how urban structures and human activities influence the urban microclimate. URBANFLUXES is an EU H2020 project that started in January 2015 and will run for three years.


The project is further introduced with a short video that can be found on YouTube:

https://www.youtube.com/watch?v=hxS6FqwrvIA



Judith Klostermann briefly introduces the aims of the meeting and the program. A Community of Practice is a group of people who share a concern or a passion for something they do and who learn how to do it better as they interact regularly. So, the most important aim of this CoP is to learn from each other. Communities of Practice develop around things that matter to people. For this CoP the topic is urban heat and urban sustainability. The members of a community deepen their knowledge and expertise in a particular area by interacting on an ongoing basis. The members are both scientists from the URBANFLUXES project and representatives from organizations in Basel that might benefit from the project.

5.3 Poster session

5.3.1 Poster: Novel approach for anthropogenic heat flux estimation from space

An overview poster of the URBANFLUXES project is presented by Nektarios Chrysoulakis. The main objective of the project is to study the components of the urban energy budget. For URBANFLUXES, the most important component is the anthropogenic heat flux Q_F, which will be estimated by calculating the other fluxes. Two main users are envisioned for the outcomes: the planning community and the scientific (climate) community. There are two main sources of data: satellite data and in-situ measurements (point measurements in cities with meteorological measurement stations). The key aim of the project is to investigate the synergy between the two types of data. Two sentinels are launched in 2015 from which data will be collected; one Sentinel satellite provides high resolution data (100x 100 m) and the other Sentinel satellite will provide high frequency data (four times per day). The results of the project will be guidelines for the urban planning community and input parameters for climate modellers. Since it is a satellite based methodology, it can be transferred to any city. ESA says the Sentinel data will be operational for the next 20 years.

Nektarios Chrysoulakis presenting the poster on URBAN FLUXES

A novel approach for anthropogenic heat flux estimation from space

URBANFLUXES

N. Chrysoulakis[a], T. Esch[b], J.P. Gastellu-Etchegorry[c], C.S.B. Grimmond[d], E. Parlow[e], F. Lindberg[f], F. Del Frate[g], J. Klostermann[h], Z. Mitraka[a]

[a]Foundation for Research and Technology Hellas (FORTH), Greece, [b]German Aerospace Center (DLR), Germany, [c]Centre d'Etude Spatiale de la Biosphère (CESBIO), France, [d]University of Reading, UK, [e]University of Basel, Switzerland, [f]University of Goeteborgs, Sweden, [g]GEO-K s.r.l., Italy, [h]Alterra, Netherlands

Abstract

The recently launched Horizon 2020 project URBANFLUXES investigates the potential of EO to retrieve **urban energy budget** components, focusing on the anthropogenic heat flux. The main challenge of this project is the innovative exploitation of the **Copernicus Sentinels synergistic observations** to estimate **local scale** spatiotemporal patterns of the anthropogenic heat emission in cities. These EO-based **spatially disaggregated** estimations contain valuable information for both the **urban planning** and the **Earth System Science** community.

The URBANFLUXES approach

Anthropogenic Heat Flux (Q_F)

Energy balance residual approach

Urban Surface Energy Budget

$$Q^* + Q_F = Q_H + Q_E + \Delta Q_S + \Delta Q_A + S$$

where $\Delta Q_A = Q_{in} - Q_{out}$ and S represents all other sources and sinks

Sensible Heat Flux (Q_H) – Latent Heat Flux (Q_E)

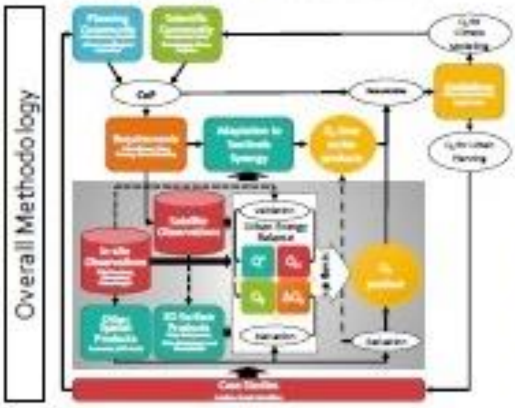
Adjusted Aerodynamic Resistance Method for EO data

Net all-wave Radiation Flux (Q^*)

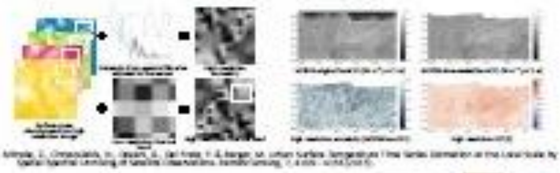
Discrete Anisotropic Radiative Transfer (DART) approach

Heat Storage Flux (ΔQ_S)

Element Surface Temperature Method



Adaptation to Sentinels Synergy



The Vision

URBANFLUXES develops an automated **EO-based method** for estimating urban energy budget components, enabling its integration into operational services. Therefore, it prepares the ground for innovative exploitation of space data in **scientific activities** (i.e. Earth system modelling) and **future and emerging applications** (i.e. sustainable urban planning). Its products is expected to support both sustainable planning strategies to **improve the quality of life in cities**, as well as Earth System scientists to provide more robust climate simulations.

The Consortium

FORTH, DLR, CESBIO, University of Reading, University of Basel, GEO-K

Question: When will the project be finished?

By the end of 2017.

Question: Will the result by a heat/energy map for the town of Basel or will there also be a map of extreme temperature?

The result will be maps of every part of the urban energy budget component, amongst these will also be temperature maps at high resolution. A city probably wants to know the hot spots in a city, and URBANFLUXES will provide this information.

Question: Can you give an example of this guideline for urban planning?

Guidelines on how to plan the (green) infrastructure in a city, or on how to use certain materials or a tool to evaluate the implementation of these types of climate change mitigation technologies can be made. Because the measurements will now be available more often, a city can actually monitor the effect of its measures.

Question: will it have a lot of details so I can really analyse the situation? For example, where is it really hot in the city and why is it hot there?

It would be interesting to know not only where the hotspots are, but also what the effect of changing certain areas will be: to build a higher building for instance or to make grassland. Such an instrument would be very useful for the planners. When the land use is adjusted the fluxes will change. URBANFLUXES can quantitatively inform a city what changes in the fluxes occur when interventions are made. How detailed the instrument will be is not clear yet. One should also keep in mind that climate change/climate warming should lead to planners reducing all the heat fluxes that increase the air temperature. It is not enough to exchange one heat flux for another heat flux.

Question: What is the swath width of the satellite images?

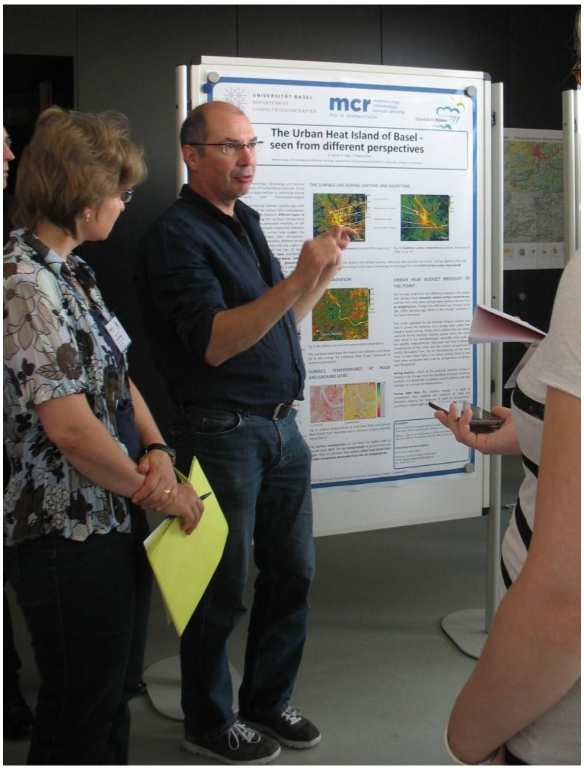
250 km, so it covers quite a large area. The point measurements that are available from the ground are not suitable for interpolation. This can be done by combining it with spatial information from satellites and run models. The resolution of satellite data is even higher, the data is aggregated to 100x100 m.

Question: what area of Basel will be mapped? Only the town or the agglomeration?

It will include the agglomeration valleys, but also Germany and the airport. The University already has a large number of in-situ measurement stations and will expand the number, we also want the measurements of the institutes in Basel.

5.3.2 Poster: Urban heat island of Basel seen from different perspectives

Christian Feigenwinter explains: We want to evaluate the local climate zones in this project within the different cities. And we try to capture those with the in-situ measurements. In Basel we have two towers to validate the satellite data, at Klingelbergstrasse two stations that already capture different environments and the MeteoSwiss data. Airport data is in hands of MeteoFrance. The rest of the stations will be placed on several places within Basel, like on the bridge (high evaporation, well ventilated) according to the local climate zones.



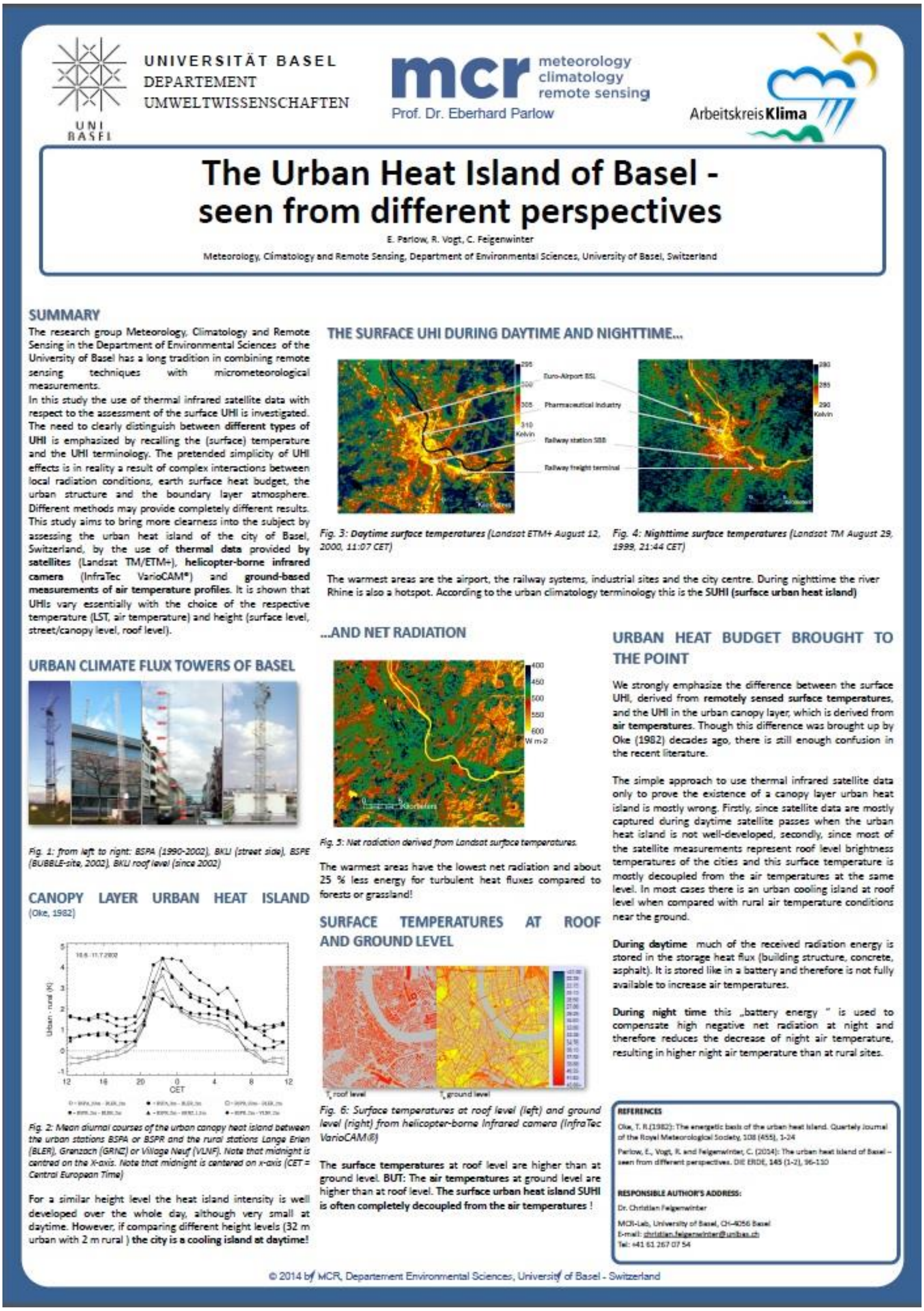
Question: What will you be measuring?

We measure temperature, humidity and surface temperature (via infrared). A different system also measures wind, precipitation and air pressure. Stations are independent, their power comes from solar radiation and data are sent via mobile phone network.

Question to the participants: are there any places where you would like them to measure?

One example is Kannenfeldpark which is a very green area in Basel. It is closed at night, so that is a good measure against vandalism. It also depends on who the owner is, you need permission for the measurements.

A new area in Basel that is being developed could be interesting Dreispitz It is a very dynamic area.



UNIVERSITÄT BASEL
DEPARTEMENT
UMWELTWISSENSCHAFTEN

mcr meteorology climatology remote sensing
Prof. Dr. Eberhard Parlow

ArbeitskreisKlima

The Urban Heat Island of Basel - seen from different perspectives

E. Parlow, R. Vogt, C. Feigenwinter
Meteorology, Climatology and Remote Sensing, Department of Environmental Sciences, University of Basel, Switzerland

SUMMARY

The research group Meteorology, Climatology and Remote Sensing in the Department of Environmental Sciences of the University of Basel has a long tradition in combining remote sensing techniques with micrometeorological measurements.
In this study the use of thermal infrared satellite data with respect to the assessment of the surface UHI is investigated. The need to clearly distinguish between **different types of UHI** is emphasized by recalling the (surface) temperature and the UHI terminology. The pretended simplicity of UHI effects is in reality a result of complex interactions between local radiation conditions, earth surface heat budget, the urban structure and the boundary layer atmosphere. Different methods may provide completely different results. This study aims to bring more clearness into the subject by assessing the urban heat island of the city of Basel, Switzerland, by the use of **thermal data provided by satellites** (Landsat TM/ETM+), **helicopter-borne infrared camera** (InfraTec VarioCAM®) and **ground-based measurements of air temperature profiles**. It is shown that UHIs vary essentially with the choice of the respective temperature (LST, air temperature) and height (surface level, street/canopy level, roof level).

URBAN CLIMATE FLUX TOWERS OF BASEL

Fig. 1: from left to right: BSPA (1990-2002), BKLI (street side), BSPE (BUBBLE-site, 2002), BKLI roof level (since 2002)

CANOPY LAYER URBAN HEAT ISLAND

(Oke, 1982)

Fig. 2: Mean diurnal courses of the urban canopy heat island between the urban stations BSPA or BSPR and the rural stations Lange Erlen (BLER), Grenzach (GRNZ) or Village Neuf (VLNF). Note that midnight is centred on the X-axis. Note that midnight is centered on x-axis (CET = Central European Time)

For a similar height level the heat island intensity is well developed over the whole day, although very small at daytime. However, if comparing different height levels (32 m urban with 2 m rural) **the city is a cooling island at daytime!**

THE SURFACE UHI DURING DAYTIME AND NIGHTTIME...

Euro-Airport BSL
Pharmaceutical industry
Railway station SBB
Railway freight terminal

Fig. 3: Daytime surface temperatures (Landsat ETM+ August 12, 2000, 11:07 CET)

Fig. 4: Nighttime surface temperatures (Landsat TM August 29, 1999, 21:44 CET)

The warmest areas are the airport, the railway systems, industrial sites and the city centre. During nighttime the river Rhine is also a hotspot. According to the urban climatology terminology this is the **SUHI (surface urban heat island)**

...AND NET RADIATION

Fig. 5: Net radiation derived from Landsat surface temperatures.

The warmest areas have the lowest net radiation and about 25 % less energy for turbulent heat fluxes compared to forests or grassland!

SURFACE TEMPERATURES AT ROOF AND GROUND LEVEL

T_s roof level
T_s ground level

Fig. 6: Surface temperatures at roof level (left) and ground level (right) from helicopter-borne Infrared camera (InfraTec VarioCAM®)

The **surface temperatures** at roof level are higher than at ground level. **BUT:** The **air temperatures** at ground level are higher than at roof level. **The surface urban heat island SUHI is often completely decoupled from the air temperatures** !

URBAN HEAT BUDGET BROUGHT TO THE POINT

We strongly emphasize the difference between the surface UHI, derived from **remotely sensed surface temperatures**, and the UHI in the urban canopy layer, which is derived from **air temperatures**. Though this difference was brought up by Oke (1982) decades ago, there is still enough confusion in the recent literature.

The simple approach to use thermal infrared satellite data only to prove the existence of a canopy layer urban heat island is mostly wrong. Firstly, since satellite data are mostly captured during daytime satellite passes when the urban heat island is not well-developed, secondly, since most of the satellite measurements represent roof level brightness temperatures of the cities and this surface temperature is mostly decoupled from the air temperatures at the same level. In most cases there is an urban cooling island at roof level when compared with rural air temperature conditions near the ground.

During daytime much of the received radiation energy is stored in the storage heat flux (building structure, concrete, asphalt). It is stored like in a battery and therefore is not fully available to increase air temperatures.

During night time this „battery energy " is used to compensate high negative net radiation at night and therefore reduces the decrease of night air temperature, resulting in higher night air temperature than at rural sites.

REFERENCES

Oke, T. R.(1982): The energetic basis of the urban heat island. Quartely Journal of the Royal Meteorological Society, 108 (455), 1-24
Parlow, E., Vogt, R. and Feigenwinter, C. (2014): The urban heat island of Basel – seen from different perspectives. DIE ERDE, 145 (1-2), 96-110

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Question: how are local climate zones defined?

They are defined from the geometry, like a surface model of the buildings. It concerns regions or neighbourhood which are the same by definition in climate, for example, air temperature, and also have similar characteristics in building height, density, geometry of the buildings, open spaces, amount of sealed surface and green fraction.

Question: is the aim to put a measuring station in each climate zone?

Yes, but there is a maximum of 20 stations, they are quite expensive, so the places should be carefully chosen. We try to get all the data from private and public measurements that are available.

Question: we are very interested, but we never heard of anything like this before. The municipalities are end users, and they are not involved in the research of the project itself.

URBANFLUXES is the first Horizon 2020 project in Switzerland. Its funding comes from the Swiss national government and the European Union. URBANFLUXES also has a travelling budget for municipalities to travel to meetings. Municipalities were not involved in the proposal, but are invited via these meetings to participate in the project. In a previous research project (FP7 project BRIDGE) municipalities were involved in a similar way and London is now involved in this project as well. Such continuity we also want to accomplish in Basel.

5.3.3 Poster: Exploiting Earth Observation data for mapping Local Climate Zones

Zina Mitraka explains: 'Local climate zone' is a new term, but it is basically a land use classification. A classification scheme was developed for all the cities, to discriminate between different climate zones in air temperature. 10 parameters were selected that influence air temperature which can be related to a climate zone.

The parameters can be derived from satellites. This is already done in Heraklion. The City of Heraklion is very homogenous; there are no high buildings, so it can essentially be put into two classes: high angle compact low rise and open low rise.

Question: What are the differences between the case study cities Basel, Heraklion and London?

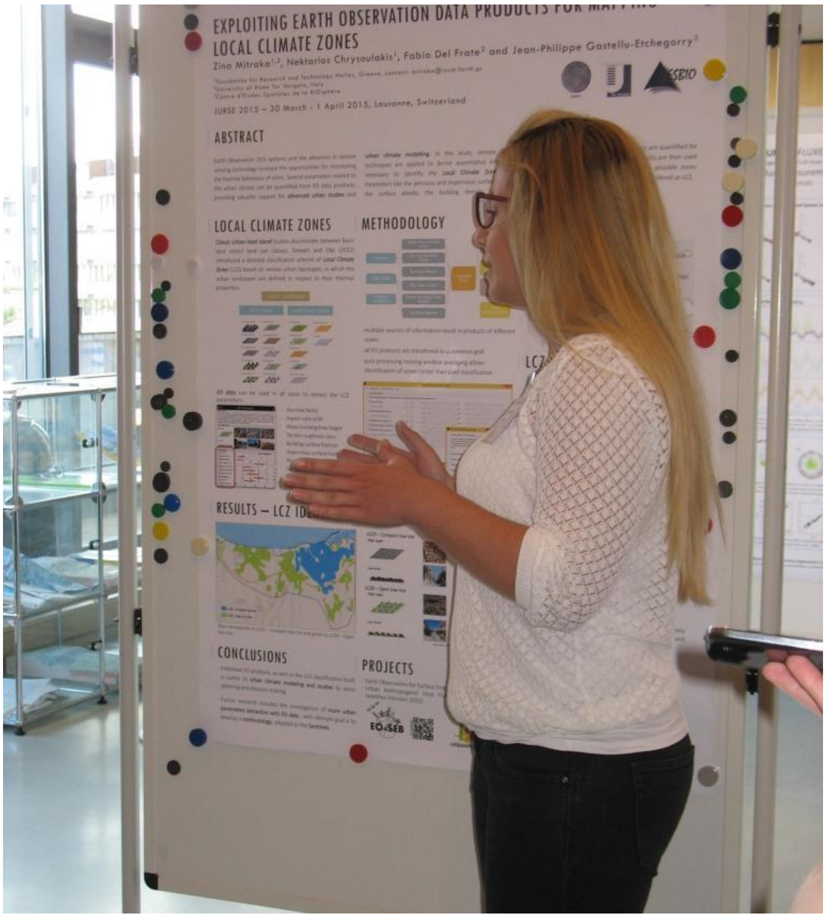
The local climate zones will be different in each city. The structures of each city are build up in different times, structure of the streets are different. There are two different things; there are common materials and structures. Materials are very important for the storage, wood or concrete have different storage capacities. The shape or geometry is also very important for the fluxes. Central part of London for example is constantly changing which leads to constant changes in the fluxes. Tallest building in Switzerland is built as well.

Question: will there be enough data for sufficient detail?

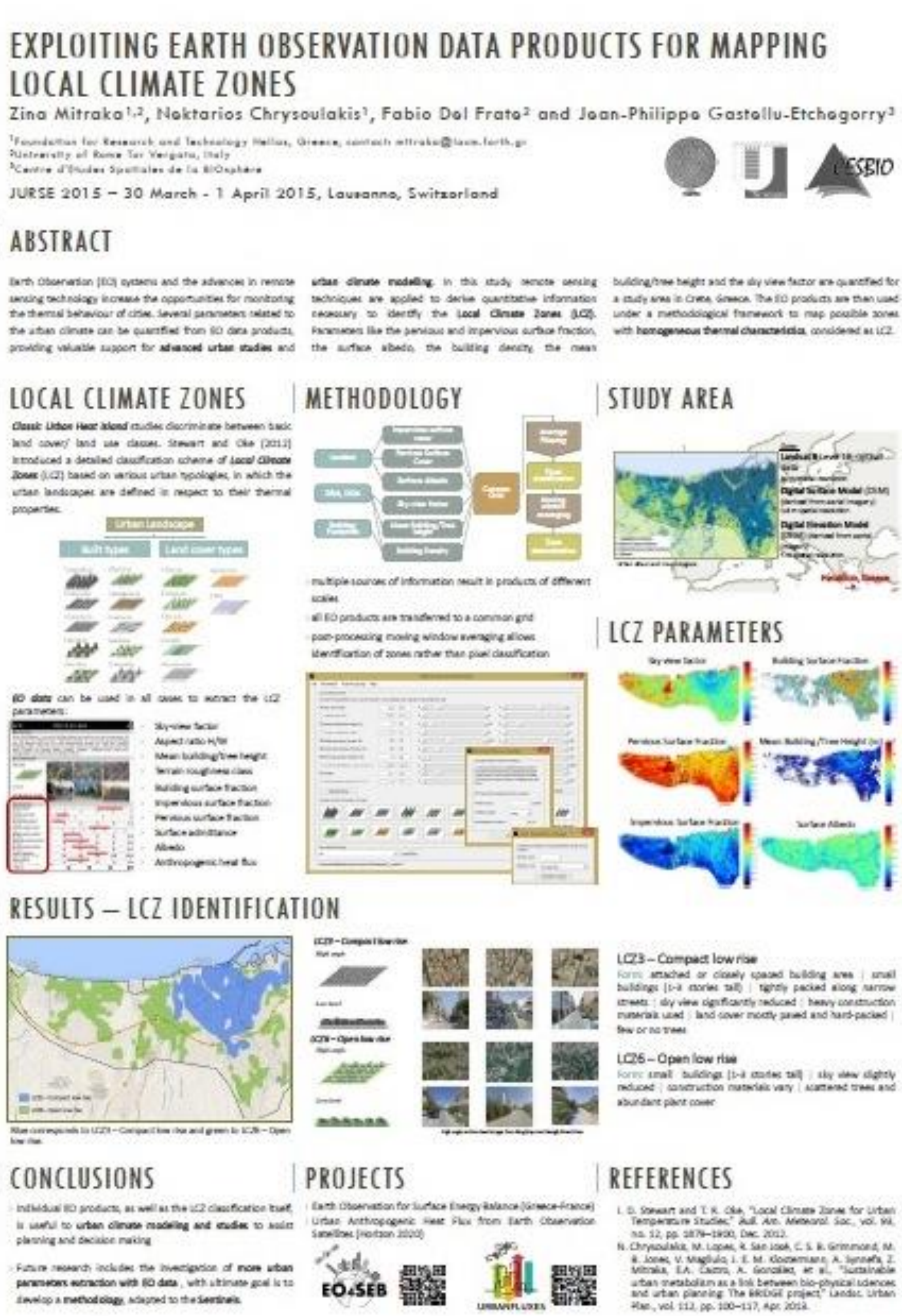
A previous project involved partners from local authorities; the conclusion was that they have nearly all the data in GIS format, but only up to the national border, so not into France or Germany, but that information is needed too because of advection from these countries.

There was a big project called Dreiland, they need to have data from all countries surrounding Basel. But even in this limited corner of Europe the data is already in different formats in each country. Even the daily mean temperature is calculated differently and can differ 2 degrees. It is the same for the geographic data for the planners, but it gets better.

For Basel we have the information on buildings. If the data does not exist, we can get information about buildings from satellite data that go into the surface models on a 50x50 m resolution for all areas.



Zina Mitraka presenting the poster on Climate Zones


EXPLOITING EARTH OBSERVATION DATA PRODUCTS FOR MAPPING LOCAL CLIMATE ZONES
Zina Mitraka1,2, Nektarios Chrysoulakis1, Fabio Del Frate2 and Jean-Philippe Gastellu-Etchegorry3
JURSE 2015 – 30 March - 1 April 2015, Lausanne, Switzerland
ABSTRACT
Earth Observation (EO) systems and the advances in remote sensing technology increase the opportunities for monitoring the thermal behaviour of cities. Several parameters related to the urban climate can be quantified from EO data products, providing valuable support for advanced urban studies and urban climate modelling. In this study, remote sensing techniques are applied to derive quantitative information necessary to identify the Local Climate Zones (LCZ). Parameters like the pervious and impervious surface fraction, the surface albedo, the building density, the mean building/tree height and the sky view factor are quantified for a study area in Crete, Greece. The EO products are then used under a methodological framework to map possible zones with homogeneous thermal characteristics, considered as LCZ.
LOCAL CLIMATE ZONES
METHODOLOGY
STUDY AREA
LCZ PARAMETERS
RESULTS – LCZ IDENTIFICATION
LCZ3 – Compact low rise
LCZ6 – Open low rise
CONCLUSIONS
Individual EO products, as well as the LCZ classification itself, is useful to urban climate modeling and studies to assist planning and decision making
Future research includes the investigation of more urban parameters extraction with EO data, with ultimate goal is to develop a methodology adapted to the Sentinels.
PROJECTS
Earth Observation for Surface Energy Balance (Greece-France)
Urban Anthropogenic Heat Flux from Earth Observation Satellites (Horizon 2020)
EO4SEB
URBANFLUXES
REFERENCES
I. D. Stewart and T. R. Oke, "Local Climate Zones for Urban Temperature Studies," Bull. Am. Meteorol. Soc., vol. 93, no. 12, pp. 1879–1900, Dec. 2012.
N. Chrysoulakis, M. Lopes, R. San José, C. S. B. Grimmond, M. B. Jones, V. Magliulo, J. E. M. Klostermann, A. Synnefa, Z. Mitraka, E.A. Castro, A. González, et al., "Sustainable urban metabolism as a link between bio-physical sciences and urban planning: The BRIDGE project," Landsc. Urban Plan., vol. 112, pp. 100–117, Apr. 2013.

5.3.4 Poster: Influence of urban development on the local urban climate in Basel

Andreas Wicki explains: We did a modelling study on how a new building (70 m) would change the local climate. As a measure for this PMV was used as a value for heat stress and another scenario was chosen with a park, and thirdly the former situation where a prison (with lots of concrete) was situated on the same location. The old situation of the prison showed the highest heat stress, the park showed only a slightly reduced level of heat stress. In this example the park is very small, so the effect is also quite small.

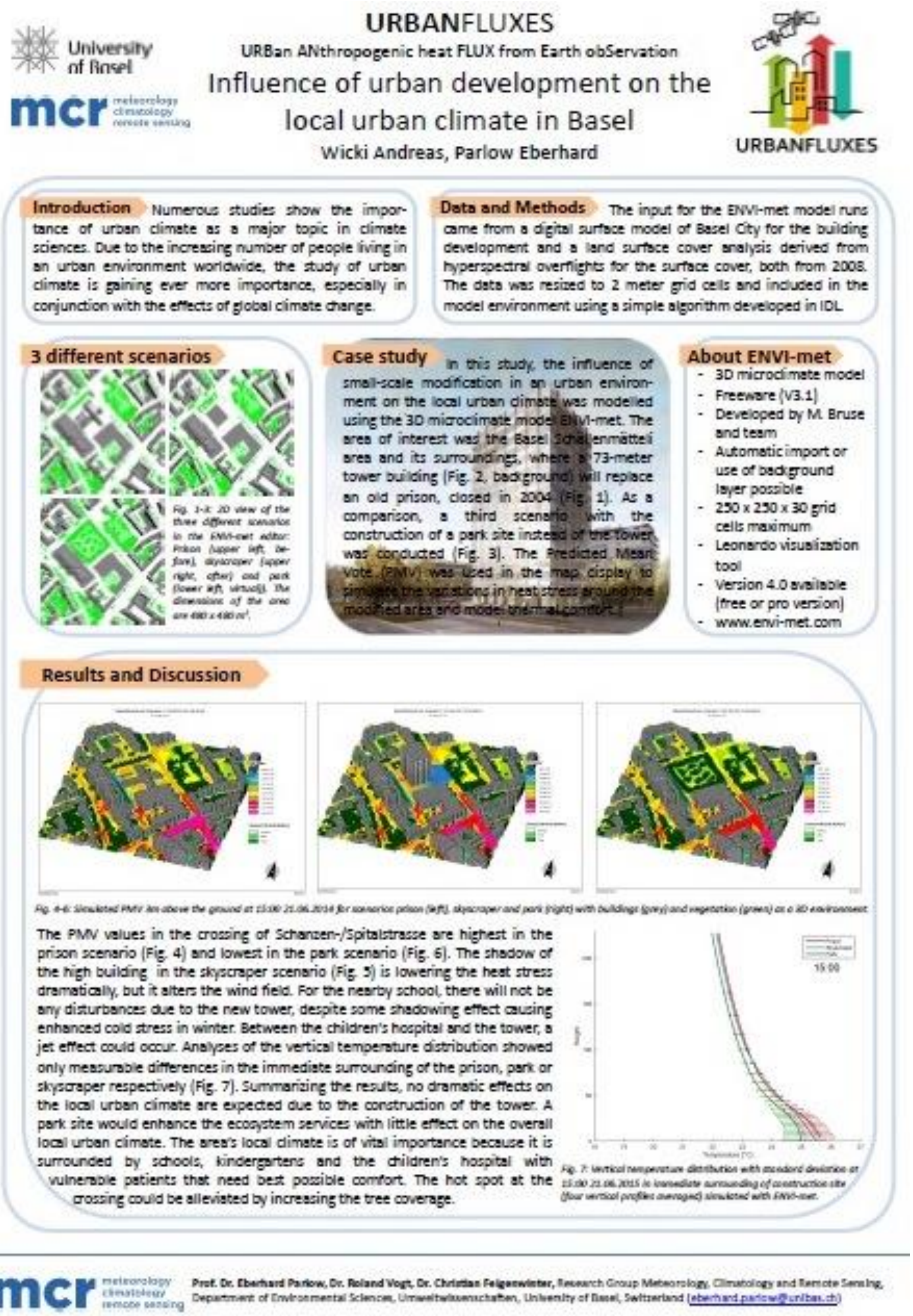
Question: Yesterday it was very warm, and at least a park provides a cool spot to go to, wouldn't that also be useful?

If people can go to a park this increases the comfort in a city, but that is not directly measureable. A single park site would not have a lot of influence on the heat stress of the surrounding study area. But a good urban climate is where you have a cool spot like a park, where there is shadow, or a river within walking distance. And if you build a tall building you need a small park for the people that work in that tall building.

Question: would the work of URBANFLUXES make such a modelling study easier?

In URBANFLUXES no scenarios are calculated, it could be a follow up, or parallel. And it can be comparable. By comparing local climate zones you can have expectations of areas that are similar in climate characteristics. That is something we want to learn in URBANFLUXES, and we will see if we can make some easy planning rules out of the results.

Andreas Wicki presenting the poster on local climate in Basel



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URBANFLUXES

URBan ANthropogenic heat FLUX from Earth obServation

Influence of urban development on the local urban climate in Basel

Wicki Andreas, Parlow Eberhard

URBANFLUXES

Introduction

Numerous studies show the importance of urban climate as a major topic in climate sciences. Due to the increasing number of people living in an urban environment worldwide, the study of urban climate is gaining ever more importance, especially in conjunction with the effects of global climate change.

Data and Methods

The input for the ENVI-met model runs came from a digital surface model of Basel City for the building development and a land surface cover analysis derived from hyperspectral overflights for the surface cover, both from 2008. The data was resized to 2 meter grid cells and included in the model environment using a simple algorithm developed in IDL.

3 different scenarios

Fig. 1-3: 2D view of the three different scenarios in the ENVI-met editor: Prison (upper left, before), skyscraper (upper right, after) and park (lower left, virtual). The dimensions of the area are 480 x 480 m².

Case study

In this study, the influence of small-scale modification in an urban environment on the local urban climate was modelled using the 3D microclimate model ENVI-met. The area of interest was the Basel Schällenmätteli area and its surroundings, where a 73-meter tower building (Fig. 2, background) will replace an old prison, closed in 2004 (Fig. 1). As a comparison, a third scenario with the construction of a park site instead of the tower was conducted (Fig. 3). The Predicted Mean Vote (PMV) was used in the map display to simulate the variations in heat stress around the modified area and model thermal comfort.

About ENVI-met

- 3D microclimate model
- Freeware (V3.1)
- Developed by M. Bruse and team
- Automatic import or use of background layer possible
- 250 x 250 x 30 grid cells maximum
- Leonardo visualization tool
- Version 4.0 available (free or pro version)
- www.envi-met.com

Results and Discussion

Fig. 4-6: Simulated PMV 1m above the ground at 15:00 21.06.2014 for scenarios prison (left), skyscraper and park (right) with buildings (grey) and vegetation (green) as a 3D environment.

The PMV values in the crossing of Schanzen-/Spitalstrasse are highest in the prison scenario (Fig. 4) and lowest in the park scenario (Fig. 6). The shadow of the high building in the skyscraper scenario (Fig. 5) is lowering the heat stress dramatically, but it alters the wind field. For the nearby school, there will not be any disturbances due to the new tower, despite some shadowing effect causing enhanced cold stress in winter. Between the children's hospital and the tower, a jet effect could occur. Analyses of the vertical temperature distribution showed only measurable differences in the immediate surrounding of the prison, park or skyscraper respectively (Fig. 7). Summarizing the results, no dramatic effects on the local urban climate are expected due to the construction of the tower. A park site would enhance the ecosystem services with little effect on the overall local urban climate. The area's local climate is of vital importance because it is surrounded by schools, kindergartens and the children's hospital with vulnerable patients that need best possible comfort. The hot spot at the crossing could be alleviated by increasing the tree coverage.

Fig. 7: Vertical temperature distribution with standard deviation at 15:00 21.06.2015 in immediate surrounding of construction site (four vertical profiles averaged) simulated with ENVI-met.

mcr meteorology climatology remote sensing
Prof. Dr. Eberhard Parlow, Dr. Roland Vogt, Dr. Christian Feigenwinter, Research Group Meteorology, Climatology and Remote Sensing, Department of Environmental Sciences, Umweltwissenschaften, University of Basel, Switzerland (eberhard.parlow@unibas.ch)

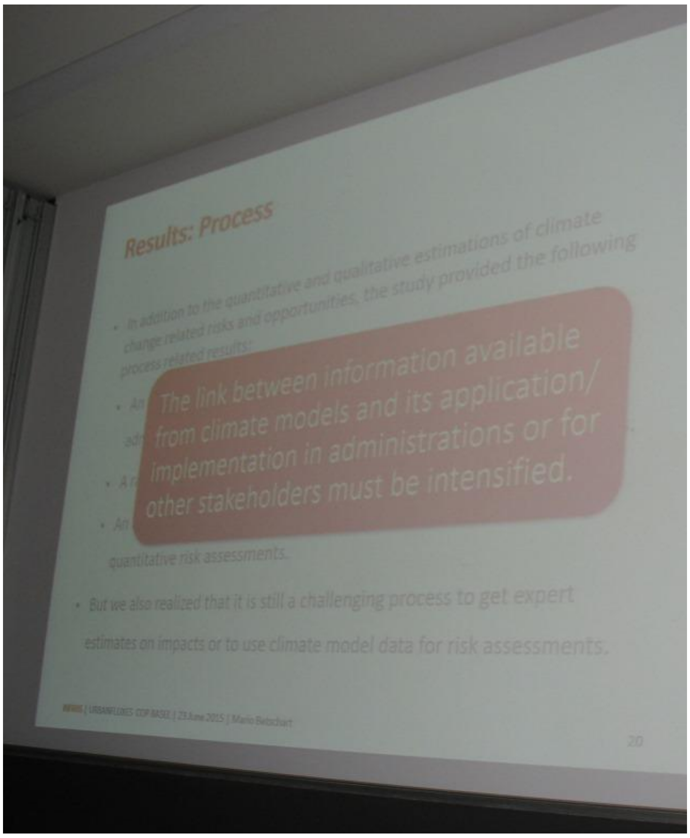
5.4 Explanation of flux tower

The participants are invited to visit the roof of the university building where a flux tower has been installed for urban climate measurements. The long-term flux tower at Basel Klingelbergstrasse collects data in the city centre of Basel since 2003. The vertical profile measurements provide a dataset for investigating the spatio-temporal distribution of CO_2 in an urban environment. A second measurement tower was installed at Basel Aeschenplatz in 2009, enabling a comparison of two close-by flux sites only 1.6 km apart from each other. Residential areas are bordered by business areas and major roads, which leads to a fundamental dependence of carbon dioxide fluxes on wind direction. Besides, the diurnal course of the fluxes is explainable with traffic emissions while its annual course follows heating-related combustion emissions. A more detailed insight into micro scale CO_2 transport processes within the urban boundary layer (UBL) was gained through concentration and flux measurements inside the street canyon next to the long term site at the Klingelbergstrasse.

5.5 Presentations on urban heat and health effects

5.5.1 Climate risk and vulnerability assessment in Basel (Mario Betschart)

Mario Betschart from INFRAS AG Zurich presents a case study on Basel. Basel is one of the case studies in the Swiss climate change adaptation strategy. That study will be input for the Swiss municipalities. Six different case studies were included, of which two were urban case studies. Two time steps were taken: 2010 and 2060. Two different climate change scenarios were applied: weak and strong climate change. The researchers did assessments for annual events and severe events with return periods of 100 years. The focus was on quantitative analysis (if a lot of data was available) and otherwise qualitative data were used (if less data were available). Socio-economic and demographic changes until 2060 were taken into account. A lot of information became available on temperature and on precipitation changes for the future in Switzerland (for different scenarios).



In Basel five 5 specific sectors were assessed: health, energy, infrastructure and buildings, water, and biodiversity. Results were summarized into a relevance matrix. Over the entire year, the urban heat effect showed only 1 K degree difference between urban and rural areas, but tropical nights are expected to increase from 3 to 29 days in 2060. And in the city alone from 1 to 17 (under the strong climate change scenario). Health and biodiversity results indicate high risks and costs. The energy sector actually benefits from higher temperatures in wintertime. Total risk will increase with 60-200 % in costs. The main driver for the costs is the health sector. It could even cost 1,5 billion Swiss francs.

The link between the information from climate models and its application/implementation should still be improved. In the final report the level of uncertainty is valued between 'very low' and 'strong'. The report is used as an advice document to the Swiss government.

Discussion:

The climate models used have a spatial resolution of 1x1 km; the models are from MeteoSwiss.

Health costs come from the mortality rate and decreasing work effort. Mortality is also related to air pollution.

The Federal office of environment decided on the city of Basel as a case study.

5.5.2 Heat waves and health (Martina Ragetli)

Martina Ragettli works at the Swiss Tropical and Health Institute in the Unit Environmental Exposures and Health. A lot of research is done on air pollution but now also on heat. For the presentation see the annex.

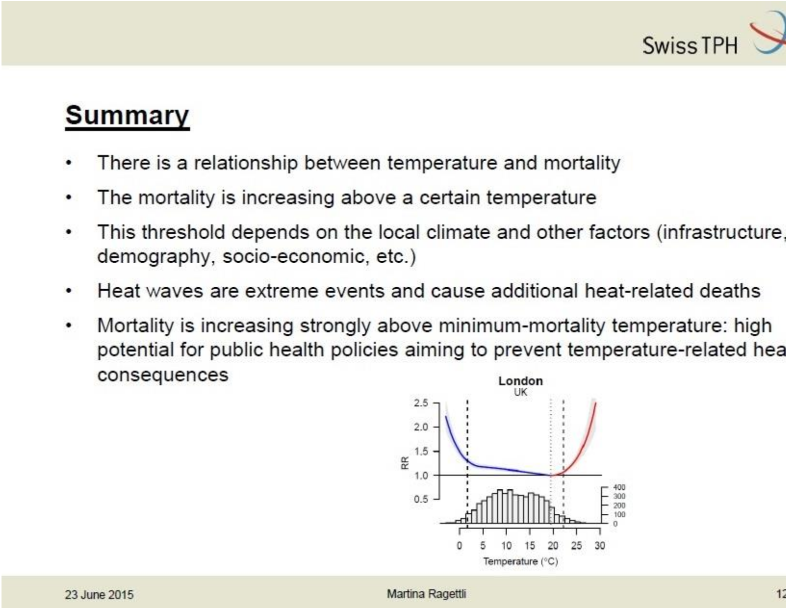
Why is heat a health risk? At normal temperatures the body has normal thermoregulation, while increasing temperatures lead to disturbed thermoregulation. The amount of heat stress depends on:

- Heat exposure;
- How sensitive the population is to heat (socio-economic factors, population density, quality of infrastructure);
- Access to treatment;
- Adaptation strategies and information for population.

There is a natural relation between heat and mortality. The threshold of minimum mortality rate differs per city, and the slope of mortality increase (percentage per degree) is also different. This shows how a population in southern Europe is more used to hot conditions.

Heat waves cause additional deaths. There can be an up to 3 times greater mortality rate if a heat wave lasts long and has a high intensity. The timing of the heat wave also influences the mortality rate: the first one of the year results in more mortality.

Public health measures can already have a big effect on the decrease in mortality. It is not clear how fast people can adapt to higher temperatures. Parameters are not always clear in different research efforts (for example, which temperature is used, minimum, apparent, or maximum). After the heat wave of 2003 Switzerland created heat plans, but it is not yet known if it helps.



The project Martina is working on is part of the adaptation to climate change plan (2014-2016). Statistical data is available on mortalities, hospitalizations, influenza data, air quality, and the meteo data are from MeteoSwiss. Results will be presented at the Swiss Public health conference (www.swisstph.ch).

Discussion:

Most studies look at temperature, and not at factors like humidity (or only in combination with temperature). Accidents (at work) do occur more often under hot conditions, but these data are not used in the research yet. In Sweden solar radiation is also used in studies on mortality.

The Italian and French parts of Switzerland have more heat plans in action than the German part.

The municipality of Basel has not integrated heat-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. The information on climate is dispersed. It needs be obligatory for people to take it into account. It is important to involve the politicians in meetings such as this URBANFLUXES meeting.

5.6 Discussion with all participants

What municipal departments and other people need in this project:

- Is the health department included into plans of climate change? It is currently not included. Health costs are clearly important to consider.

- The planning department can make the change, not the building department, they do not have the overview. We should invite the actual spatial planners, not the persons who make the guidelines. Modern places are still not adapted to climate change. In Basel the planners are actually in the department, they are not outsourced, so they should come to these meetings.
- The energy department has a climate change expert
- We should invite people from cantons, but maybe also civilians.

What kind of results do we need for planning:

- Where are the hotspots, where should we change something? Where can we reduce the heat island effect?
- You want to know where it is hot, but also why; is it because of activities, or because of materials?
- And what should we change? We need scenarios; if you change something, what will happen?
- To have data after the project would be good. We have 15-20 year old data on climate in Switzerland, now it is going to be updated, with better spatial resolution, and measurements will be included.

What will this guideline look like? We are not sure yet. URBANFLUXES' main contribution is to show where it is hot, but also why it is hot there. A main output of the project will be local scale maps of the distribution of heat, and which energy component is responsible for this. A publically accessible form of the maps will be put on the website.

The Municipality can use this project to formulate arguments for changes in policy. People do not understand why a warmer climate is a problem. The political parties don't see it either.

What kind of information channels should we use?

- Meetings like this, where we invite spatial planners.
- Involving people in workshops. Where some real work is done.
- We should give talks around the city.

What temporal/ spatial resolution is needed? If URBANFLUXES produces land cover maps, would Basel require maps on a regular basis (like several times per year), or more specific, spatially detailed maps, but just once every several years, because it takes a lot of computing time? For Basel it seems better to have a very detailed map that can be used in plans for 10 years. 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.

5.7 Conclusions CoP 1 Basel

The most successful part of the CoP meeting was the poster session in which the participants actively engaged. The questions of the participants gave a lot of input to think about and discuss within the URBANFLUXES project team.

The two presentations on the subject of health and heat strengthened the problem of urban heat and gave food for thought for the participants. Participants indicated:

- For city planning activities it is important to receive results from the URBANFLUXES project on where the hotspots in the city are, why they are there and what can be done to address the hotspots.
- In building regulations nothing is obligatory on reduction of heat stress. Municipal employees are not given time to work on this unless it is obligatory.
- Local participants seem to be more familiar with in-situ measurements, remote sensing data was more difficult to grasp.
- It is important to know how comfortable planners are with working with EO data, we don't know now. As long as it's high resolution data, people are happy (especially engineers). We have to connect the users more to the data.

We have a tendency to use words/definitions that are not understandable, so language should be simplified. People are unfamiliar with scientific presentations, so maybe a combination between presentations and workshop will work well.

6 COMMUNITY OF PRACTICE HERAKLION 17 DECEMBER 2015

6.1 Program and participants

The first Community of Practice meeting of the URBANFLUXES project for the case study in Heraklion took place in the morning of Thursday, the 17th of December, 2015. The venue was at the Hall of the Regional Council of Crete on Eleftherias Square in Heraklion. The meeting lasted from 9:00 to 14:00 and included a buffet lunch. The program is shown in Table 3. The list of participants is shown in Table 4.

Table 3: Program of the CoP meeting of 17 December 2015

09:00	Welcome	S. Arnaoutakis, Regional Governor of Crete
09:10	Welcome and short film	FORTH - N. Chrysoulakis
09:20	Introduction participants and expectations of the CoP	ALTERRA - J. Klostermann
09:35	Earth Observation for Urban Climate	UNIBAS - E. Parlow
09:55	URBANFLUXES Overview	FORTH - N. Chrysoulakis
10:10	Heraklion Morphology, Structure and Local Climate Zones	FORTH - Z. Mitraka
10:20	The URBANFLUXES Wireless Sensors Network in Heraklion	FORTH - N. Spyridakis
10:35	Questions to the URBANFLUXES Consortium	
10:45	Coffee break – Wireless Sensors Installation	
11:15	Panel discussion on the potential of URBANFLUXES to support urban planning, urban environmental management, energy efficiency, urban governance and civil protection in the broader area of Heraklion.	Moderator FORTH - N. Chrysoulakis

	Panellists: • G. Alexakis, Regional Councillor of Crete • E. Hatziyianni, Region of Crete, Director of Environment and Spatial Planning • E. Manousaki, Urban Planning Office, Municipality of Heraklion • C. Mochianakis, Head of Information & Communications, Municipality of Heraklion • M. Pattakos, Vice-Mayor, Head of Civil Protection, Municipality of Heraklion • G. Tzanokostakis, Head of the Civil Protection of Crete • N. Zografakis, Director of the Regional Energy Agency of Crete	
12:30	Discussion	FORTH - Z. Mitraka
12:45	Summary: data and knowledge needs	ALTERRA - J. Klostermann
13:00	Buffet Lunch	

Table 4: Participants of the CoP Heraklion

Nektarios Chrysoulakis	FORTH	Heraklion	Greece
Zina Mitraka	FORTH	Heraklion	Greece
Eberhard Parlow	UNIBAS	Basel	Swiss
Judith Klostermann	Alterra – Wageningen UR	Wageningen	The Netherlands
Nektarios Spyridakis	FORTH	Heraklion	Greece
Dimitris Poursanidis	FORTH	Heraklion	Greece
George Alexakis	Region of Crete	Heraklion	Greece
Eleni Hatziyianni	Region of Crete	Heraklion	Greece
Eleni Manousaki	Municipality of Heraklion	Heraklion	Greece

Kostas Mochianakis	Municipality of Heraklion	Heraklion	Greece
Marinos Pattakos	Municipality of Heraklion	Heraklion	Greece
Eleni Papadaki	Region of Crete	Heraklion	Greece
Nikos Zografakis	Region of Crete	Heraklion	Greece
Eleni Kalemaki	Municipality of Heraklion	Heraklion	Greece
Giannis Tzanokostakis	Region of Crete	Heraklion	Greece
Stavros Stagakis	FORTH	Heraklion	Greece
Giannis Latzanakis	FORTH	Heraklion	Greece
Nikos Manioudakis	FORTH	Heraklion	Greece
Maria Kondiloyiannaki	Region of Crete	Heraklion	Greece

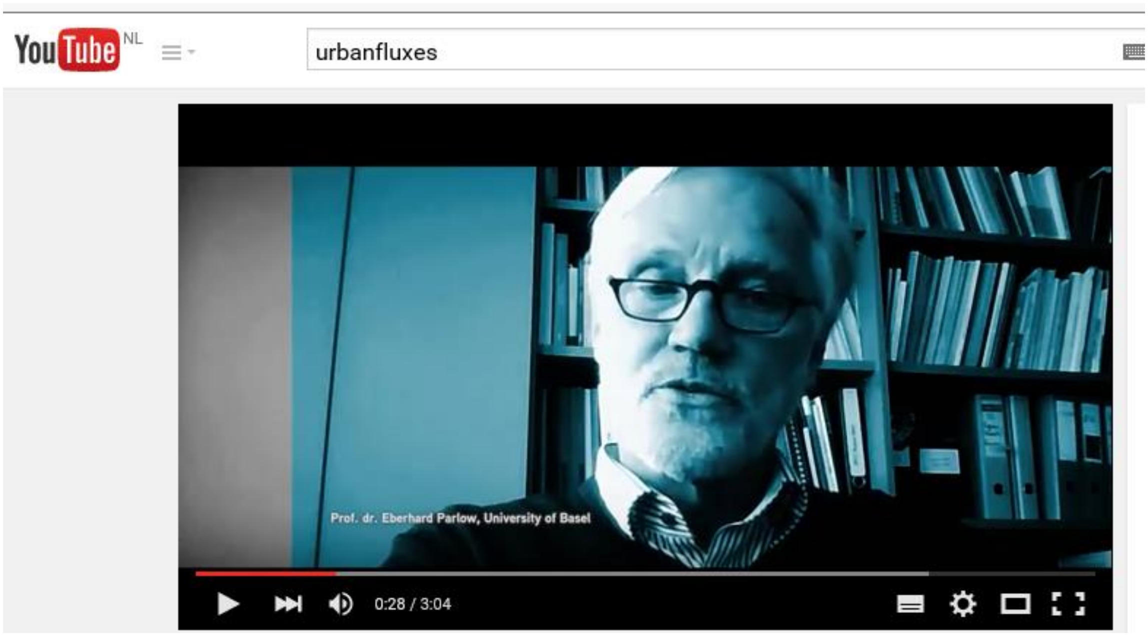
6.2 Welcome and explanation of program

George Alexakis welcomes all participants to the CoP and expresses the interest of the Region of Crete and the municipality of Heraklion in the URBANFLUXES project. Nektarios Chrysoulakis continues with the introduction and gives an explanation of the agenda. He asks the participants to stay involved in the project and he presents the benefits Heraklion could have from joining URBANFLUXES. Nektarios also explains that the participants are very welcome to present their point of view on things.

URBANFLUXES (urbanfluxes.eu) addresses the problem of urban heat. Cities are generally warmer than their rural surroundings. During a heat wave, this can cause problems for human health and working conditions. To address these problems, knowledge is needed on how urban structures and human activities influence the urban microclimate. URBANFLUXES is an EU H2020 project that started in January 2015 and will run for three years.

The project is further introduced with a short video that can be found on YouTube:

https://www.youtube.com/watch?v=hxS6FqwrvIA



Judith Klostermann outlines the Community of Practice framework, the aims of the meeting and the program. A CoP is a group of people who share a concern or a passion for something they do and who learn how to do it better as they interact regularly. So, the most important aim of this CoP is to learn from each other. Communities of Practice develop around things that matter to people. For this CoP the topic is urban heat and urban sustainability. The members of a community deepen their knowledge and expertise in a particular area by interacting on an ongoing basis. The members are both scientists from the URBANFLUXES project and representatives from organizations in Heraklion that might benefit from the project. Judith Klostermann explains that Heraklion is one of three case studies and the CoPs from the three cities will all meet in one event to share their ideas.

6.3 Presentations

6.3.1 Earth Observation for Urban Climate (Eberhard Parlow)

An explanation on 'Earth Observation' and 'Remote Sensing' is presented by Eberhard Parlow from the University of Basel. He explains that remote sensing is the science to retrieve information about objects by contact-free measurements. In the URBANFLUXES case we observe objects and processes at the Earth surface from space (and sometimes from aerial platforms like airplanes or helicopters). The term 'Remote Sensing' was introduced in the late 1950s by Evelyn Pruitt, a scientist at the US Office of Naval Research. Remote sensing technology uses electro-magnetic radiation, which is emitted or reflected from an object and sometimes can penetrate clouds. Different spatial scales are available: from 1x1 km to 15 meter grid size or even 60cm; but higher resolution is not always better, it depends on the purpose.

Advantages of Earth Observation are that the information:

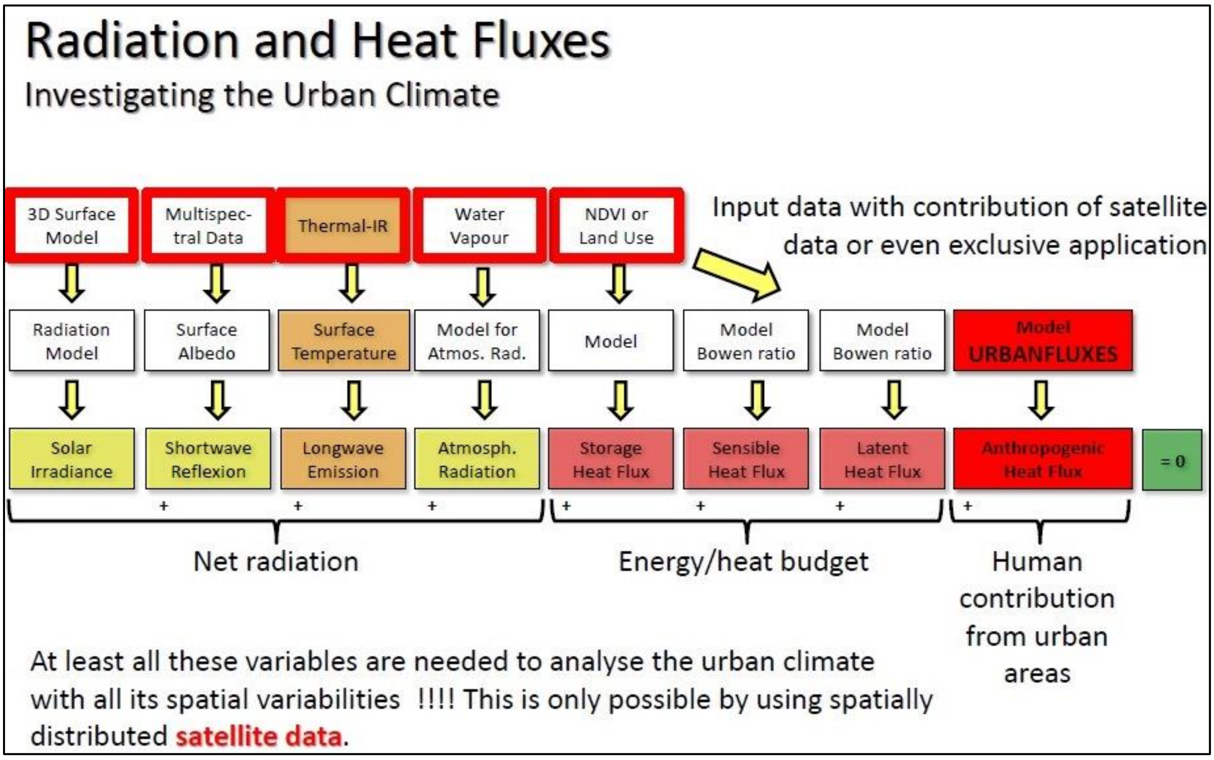
- Is spatially distributed compared to point measurements;
- Is repeated on a certain time frequency depending on satellite technology to make spatio-temporal dynamics detectable;
- Is an important tool for regions which are located in remote areas (like polar regions or deserts) or difficult to access (as is the case in most urban areas);
- Day- and night-time thermal infrared information is available.

Basel also has local measurements on the ground: flux towers that have been measuring continuously for many years, some since 1990 and others since 2002. These measurements give very precise information for that location:

- Vertical profiles of air temperature & humidity (ventilated psychrometers), wind speed, turbulence (Eddy Covariance) and CO_2-fluxes;
- All radiation fluxes and net radiation at 2 m;
- Wind direction at 10 m;
- Precipitation;
- Soil heat flux at various depths;
- Soil temperatures at various depths;
- Soil humidity by TDR (time-domain reflectometry) sensor.

The disadvantage of measurement towers is that you only know it for that specific location. The measurements are used to validate and calibrate the outcomes of the remote sensing measurements. This has shown that there is only a 3-5% difference between the measurements on the ground and the remote sensing measurements. It is hard to say which of the two methods is best because measurements on the ground can also have errors in them; so a combination of the two is the best option. Therefore, further locations for the SensorScope wireless sensor network stations are planned in Basel (air temperature, humidity, surface temperature, wind speed & direction, air pressure). This will lead to a higher density of the existing network. This is similar to the network that is now under construction in Heraklion.

In urban areas thermal infrared satellite data always show high surface temperatures during daytime and nighttime. A mistake that is often made in the literature on the Urban Heat Island is that authors only use the surface temperature. There are many other variables that are important (see next figure), and the data also need to be spatially distributed. This can only be achieved with satellite data. The last factor in the picture is what the URBANFLUXES project focuses on: the anthropogenic factor. This is the heat that is added to a city by human activities such as heating and cooling of buildings, traffic and industrial processes.

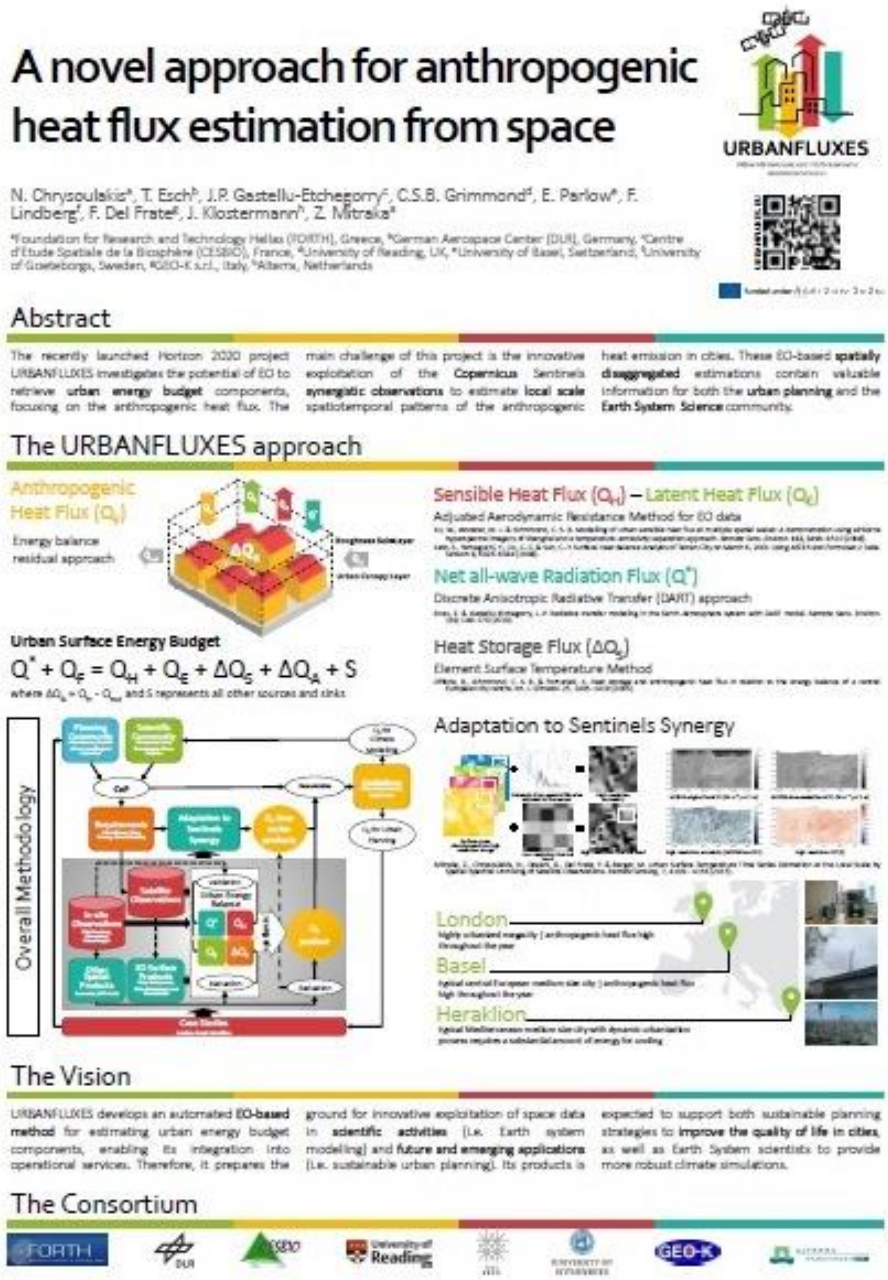


Finally, to understand the UHI effect, one needs to look at the causes. Since land use & land cover (LU/LC) strongly influence heat fluxes it is important to have a detailed database of how the whole urban area is partitioned into climatologically relevant urban local climate zones (LCZ). Important classes of land use are: dense urban, urban, suburban, roads/rails/concrete, industry, agriculture, vineyard/shrub, forest/plantation, and water. Additional data from non-satellite sources are also useful. Since urban trees have an important influence on urban climate (exposure to human heat stress, air pollution etc.) it is very interesting to include a digital urban tree database in the project. For the city of Basel there is such a database with information on tree height, type of tree, age of tree etc. It was made available by the local authorities.

6.3.2 Anthropogenic heat flux estimation from space (Nektarios Chrysoulakis)

An overview of the URBANFLUXES project is presented by Nektarios Chrysoulakis. The main objective of the project is to study the components of the urban energy budget. For URBANFLUXES, the most important component is the anthropogenic heat flux Q_F, which will be estimated by calculating the other fluxes. Two main users are envisioned for the outcomes: the planning community and the scientific (climate) community. There are two main sources of data: satellite data and in-situ measurements (point measurements in cities with meteorological measurement stations). The key aim of the project is to investigate the synergy between the two types of data. Two satellites (Sentinel I and II) have been launched in 2015 from which data will be collected; one Sentinel satellite provides high resolution data (100 x

100 m) and the other Sentinel satellite will provide high frequency data (four times per day). The results of the project will be guidelines for the urban planning community and input parameters for climate modellers. Since it is a satellite based methodology, it can be transferred to any city. The ESA says the sentinel data will be operational for the next 20 years.

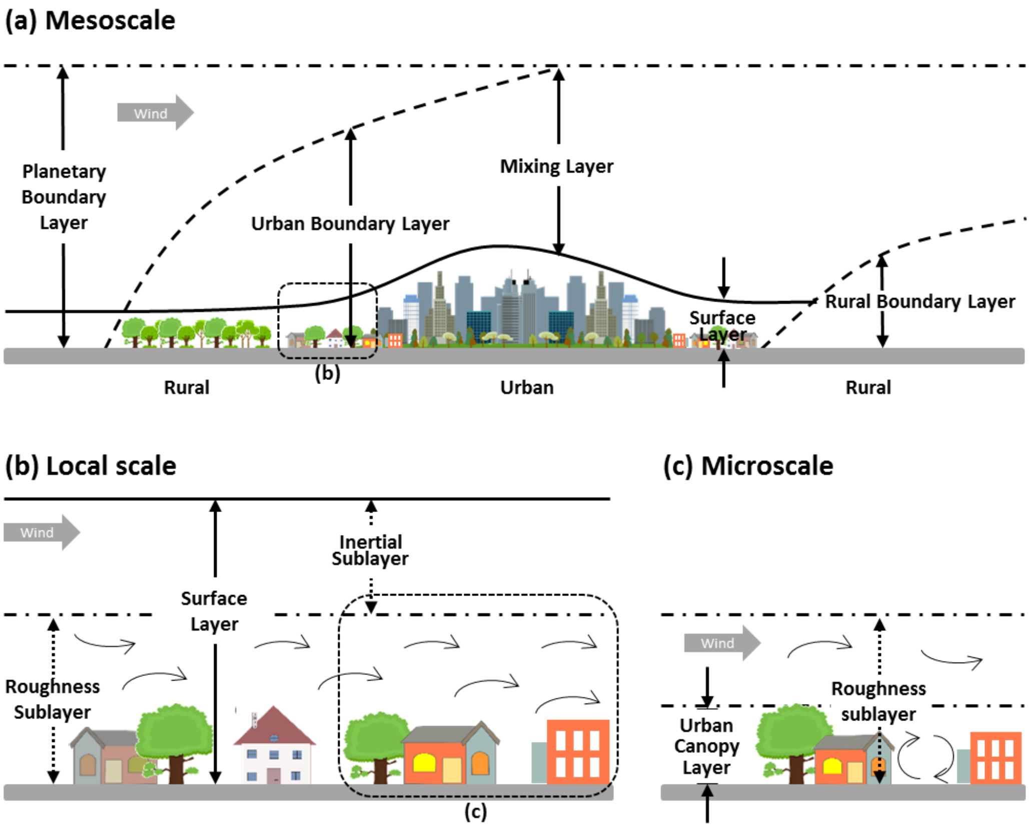


6.3.3 Exploiting Earth Observation data for mapping Local Climate Zones (Zina Mitraka)

Zina Mitraka explains: 'Local climate zone' is a new term, but it is basically a land use classification. A classification scheme was developed for all the cities, to discriminate between different climate zones in air temperature. 10 parameters were selected that influence air temperature which can be related to a climate zone.

The parameters can be derived from satellites. This is already done in Heraklion, and is put into the Urban Atlas. The City of Heraklion is very homogenous; there are no high buildings, so it can essentially be put into two classes: high angle compact low rise and open low rise.

The local climate zones will be different in each case study city. The structures of each city were built up in different periods, and the structure of the streets is different. Two aspects are important; the common materials and the structures. Materials are very important for the heat storage; for example, wood and concrete have different storage capacities. The shape or geometry is also very important for the fluxes. The central part of London, for example, is constantly changing which leads to constant changes in the fluxes.

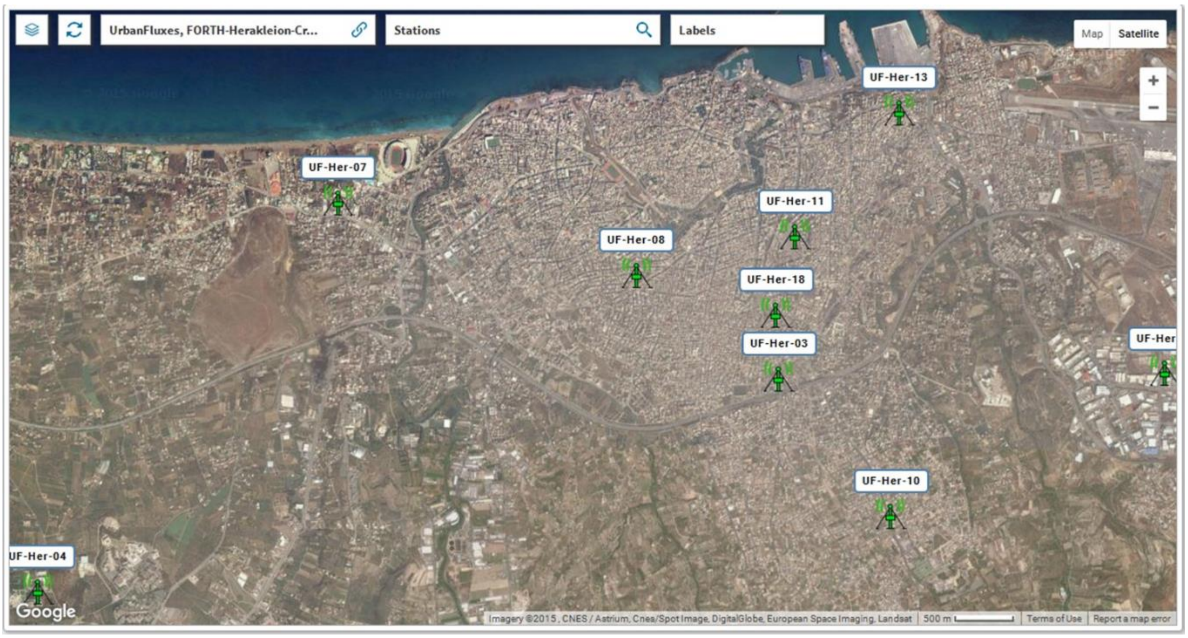


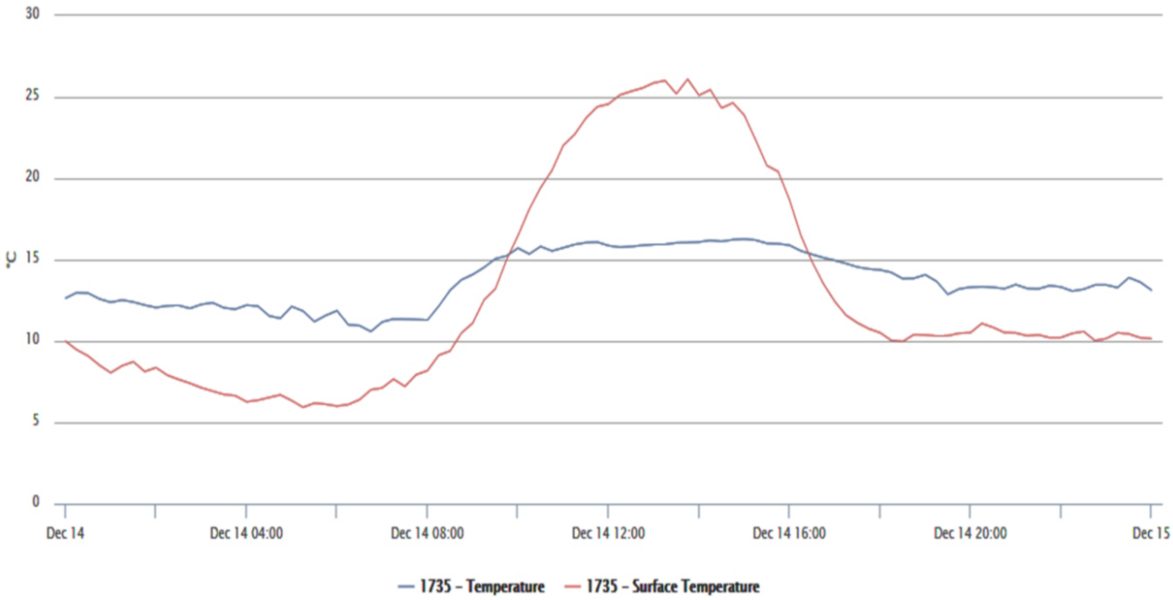
6.3.4 New Heraklion Meteo Stations Network (Nektarios Spyridakis)

Within the framework of the URBANFLUXES project 20 measurement stations will be installed to monitor the urban climate of Heraklion. At this point 9 of them are already active. Location selection was done by taking into account a preliminary analysis of local climatic zones, uniform distribution / uniform land cover, topography, building density, and accessibility. The measurement stations are connected by GPRS and SMS. Very frequent measurements are possible: one measurement per sensor per minute. Data (pack) transmission occurs once per 15 minutes. The stations have instruments to measure:

- Air Temperature
- Relative Humidity
- Wind Speed - Direction
- Solar Radiation
- Surface Temperature

The picture below shows the presence of the first nine stations. The measurements are accessible real-time on the internet. The second picture shows an example of one day of measurements.





6.4 Discussion with all participants

After the coffee break a panel discussion was set up around the potential of URBANFLUXES to support urban planning, urban environmental management, energy efficiency, urban governance and civil protection in the broader area of Heraklion. Questions that were already asked by the participants include:

- *How we can exploit the results from your research project and in general research projects into our urban planning projects?*
- *How accurate are the measurements of the ground stations, for example, the ones installed on traffic lights, and are the sensors protected from external influences in some way?* Nektarios ensured that only extreme weather events will cause problems and security issues for the ground stations.

A participant explains that Heraklion is a "smart city" on an international level, fulfilling all the requirements for being labeled as a smart city. He focuses on open data available through the internet and he mentions an agreement with another part of FORTH and the University of Crete that data is collected for the city of Heraklion. Two systems will be built; a system for data collection and a system that will make the data available to the public. They aim at a smart system for managing the data relating to the city. The main goal of the system will be to make better daily decisions for the city. He mentions an example of this system for traffic accidents. After an accident, the traffic lights are adjusted in other areas to avoid traffic jams. Data from the URBANFLUXES project would be most helpful to add to the database of this decision system.

Nektarios makes clear that the data from the URBANFLUXES project are available to the municipality of Heraklion, but he has to make sure that this is OK with the project consortium. For technical issues, he mentions that the data can be collected from the FORTH infrastructure. The intention of FORTH is not to operate the sensors up to the end of the project, but afterwards as well, like the sensors in Basel. Moreover, the sensors are only complementary for our products in FORTH, because we also use a large variety of satellite data.

Question: Are there other data available, rather than the sensor's measurements? Nektarios explains that FORTH has a lot of products available for the municipality to use, but Nektarios also believes the municipality has useful data for FORTH.

Question: Will there be guidelines at the end of the project, and some sort of conclusions? That is one of the reasons of this CoP meeting. The URBANFLUXES team needs the feedback from participants as to what kind of results they expect from the project. The project is oriented to "space data exploitation", so the research will be around the use of satellite data for urban climate. We have a lot of research going on and in the end of the project lots of products related to the project will be produced that can be useful to city planning.

Question: How can the municipality and the region access the data of URBANFLUXES? The in-situ sensor data will be available for registered users. FORTH will give access to the municipality of Heraklion. The satellite products will also be available to the scientific community and the three municipalities. The main advantage of this project is that we will combine the satellite data with the in-situ measurements.

Question: What is the timetable of the project and who reviews the project? The project has been running for one year now. There was a delay with the in-situ sensors because of the capital controls. We ordered the sensors from Switzerland. We are now in progress of ordering the tower and the Eddy Covariance system. The project is reviewed by members assigned by the EU, once every year.

A person from the Region of Crete mentions the importance of this project. The urban climate is very important for cities like Heraklion, because southern cities suffer a lot more from climate change than northern European cities. He mentions a project about measuring the temperature of a single building that he was recently following. The reason for this study was to assess the costs of the buildings and their energy efficiency. That is why he was very interested in the temperature variations Nektarios presented for the urban canyon. He mentions that the project team should use this kind of information to advance the "value" and brand name of the city.

He asks about the land use; we know that forests and vegetation are cooler than the cities, but the region needs more detailed information for city planning projects and they hope to gain that information from URBANFLUXES. There is a new airport planned for Heraklion, he noticed that airports are much hotter in the given presentations. Can URBANFLUXES propose solutions or actions for the airport plan?

The participants expect to learn the hot spots of their city. They need to know how to deal with the hotspots after the project. The results of the project can be published, resulting in having the results publicly available, but the local organizations also need to know what to do with those results in the end. How can the participants use this information for the city planning? How do they make the city more comfortable in terms of heat for the citizens? How do they associate the project data with the planning projects? The city planning office does not have this knowledge. The participants expect from the researchers not to produce products only, but also to share their knowledge on the thermal behavior of cities.

The main goal of civil protection is prevention rather than facing the existing issues. How can we deal with current heat waves in order to protect the civilians?

There is a river passing by Heraklion and it has been transformed into a waste disposal. The participants want to share the information with the city planners of the other cities (Basel and London) to know how they are dealing with these kinds of issues. They expect that the project results will help Heraklion to be reformed, become more green, more cool and more livable for the citizens.

One participant focuses on the use of satellite data and sees possibilities to exploit this data for Heraklion. The collaboration with Basel and London is seen as very valuable, not only in terms of marketing, but also in scientific terms, since the three cities have different climatic conditions. It is important to gather all the data from different organizations studying Heraklion and Crete. The University of Crete also has data available and we should all share our products for better city planning in the end.

The region of Crete is currently making plans for energy efficiency and runs a study for energy exploitation on the island. The URBANFLUXES project can contribute to these plans for energy use in the city. According to the participants, this can also lead to a boost in the industry, if we identify that cool materials, or green roofs are needed in the city.

The results of the project can be further exploited for a meta-study for practical projects with specific guidelines for city planning. Heraklion needs to investigate not only how to avoid climate change by using less fossil fuel, but also how to adapt to climate change and integrate this into the city planning in the coming years.

A useful result from the project will be planning guidelines for the energy agency of the region of Crete. At an urban level, Crete does not have much information on energy for cities.

Offer of URBANFLUXES team

Nektarios mentions that the URBANFLUXES project aims to get "inside" the city and not just refer to one value for energy in the city, but access the intra-urban variations of energy in the city. The project's focus is on the cities because we live in them. Larger scale studies of the natural landscape are also important, but focused studies on cities are very important. A very interesting point was the one about the cool materials and other nature based solutions. The URBANFLUXES team also believes that the local authorities can help in boosting the local industry into this direction and scientists can then assess the effect of those interventions in the city climate.

The team can install a station in Kasteli area, after the suggestions of the participants, and in later times, sensors for particulate matter can be included to monitor the air quality of the city. URBANFLUXES can also estimate indicators like green area per person if there is a need for this, but there is not so much green urban area, so that isn't really useful.

Question: Which parts of Heraklion were judged as environmentally OK according to the smart city project?
For environmental issues, the whole city was judged negatively and we expect that the URBANFLUXES project will help on changing that.

Nektarios continues with an explanation on how the urban climate is studied; why URBANFLUXES needs the satellites; and what the advantage of using satellites is. He mentions the BRIDGE project (EU FP7 project) and how the impact of planning alternatives for other cities was assessed.

Nektarios explains the difference between urban planning in northern Europe and the non-guided planning in Greece. Judith Klostermann emphasizes that in such a planning process the private sector can be involved so that, for example, project developers can exploit the data from the project. The Region of Crete indicates that engineers can find the data useful. In terms of real estate, "better" areas in terms of climate can be identified and plans can be made for these areas. Changes in larger areas, like parks and squares can be analysed as well. The greatest help will be in suggesting and monitoring adaptation technologies.

Report by the Region of Crete after the CoP Public services, as it is required and indicated by the new model of European Governance and Administrative Systems, should be able, to uptake the new scientific information and utilize it. In respect to that, and in terms of its responsibilities, the Directorate of Environment and Spatial Planning of the Region of Crete could be benefit by the implementation of URBANFLUXES Project towards two critical points:

1. By understanding the transition and the differences between "Climatic Variations" and "Climatic Change"
2. By reclaiming the role of a Regional Environmental Authority in respect to the regional planning for climate change

Public services so far use to take the scientific raw data by collecting and keeping them for future possible use, checking outliers, stating risk situations and imposing restrictions. To exploit the results of URBANFLUXES, an environmental agency should be able to understand how changes in meteorological parameters and climate parameters- data coming from URBANFLUXES:
a. could possibly be combined with relevant information outside the urban areas with different cover / land use and how different land uses are affecting the energy balance because of the different energy flows;
b. could lead together with prior information in understanding the climate change, and thus the public sector and the community in general will be able to face it.
The latter is of great importance because of the key role of a regional environmental authority in regional planning for the adaptation to climate change. Regions are invited by the law to develop a regional strategy to address climate change. Such regional strategies should follow timely the national strategy to combat climate change. At the Region of Crete, this is directly connected with the implementation of relevant projects / actions within the Regional Operational Programme 2014-2020.
The draft Greek National Strategy on Climate Change has been given recently to public consultation and has been completed a few days ago. Even though the final document has not been approved yet, in any case and in respect of the urban environment, the Greek National Strategy is moving around specific actions and individual prevention measures: e.g. "Developing climate services (integrated climatic services) at national and regional level, to provide easy access to meteorological observations and to design effective adaptation measures". When appropriate, a regional planning should be developed.
Here a regional environmental authority has an important role, to influence how they will utilize the results and the outputs of research work such as the URBANFLUXES project.
The two points mentioned above are crucial in terms of URBANFLUXES' supportive capacity to the regional stakeholders. But indeed, both ultimately are linked and depend on:
1. how much the public body, which is a key stakeholder in research European funded programmes, is able to
i) assimilate and utilize the resulting scientific information, and
ii) find and successfully exploit the associated link among all the relevant programmes implemented (for instance, Region of Crete is currently implementing a new LIFE funded project "Adaptation of three Mediterranean islands to Climate Change-ADAPT2CLIMA)
2. the way that the new Research Funding Framework 2014-2020 should aim at substantial engagement in substantive and long-term added value of the end-users - such as the public regional authorities.
Dr Eleni Hatziyanni

Director of Environment and Spatial Planning Region of Crete, Greece

6.5 Conclusions CoP 1 Heraklion

There was a good participation from several relevant organizations: the Region of Crete, the municipality and the Energy department.

The method in the CoP was more classical compared to the previous meeting in Basel: first presentations and then discussion. There was an abundance of time in the program for an open debate which was used actively by the invited participants. A demonstration of the new measurement instruments was included in the meeting and accessibility of the data through a mobile app was demonstrated.

The participants see the great potential of the URBANFLUXES for Heraklion and believe they can learn from the other case study cities of Basel and London. Participants have a great need for guidelines for city planning in order to adapt to climate change and to make citizens more comfortable and safe, but also for ways to allow Heraklion to be more energy efficient. They are very keen to have access to data out of the project. The fact that Heraklion is a member of the 'Smart cities' program is one of the reasons for this interest. The question is, therefore, how we can also make URBANFLUXES relevant for the citizens of Heraklion?

Participants of the CoP also see a great potential of the URBANFLUXES project becoming a boost for the local industries for materials to reduce heat in the city. The participants expect to gain knowledge on the hotspots of their city and they hope that the researchers not only produce data products, but also to share their knowledge on the thermal behavior of cities and how to improve on it.

7 SECOND INTERVIEW ROUND: MESSAGES TO URBANFLUXES USERS

7.1 Introduction

The second round of interviews was held between February 16, 2016 and August 11, 2016. Topics of the second interview round were:

- Who are the users?
- What do users want?
- What are the products of UF?
- Potential uses of URBANFLUXES products
- Worries and solutions
- Ideas for 2nd CoP round
- Ideas for second video

7.2 Who are the users?

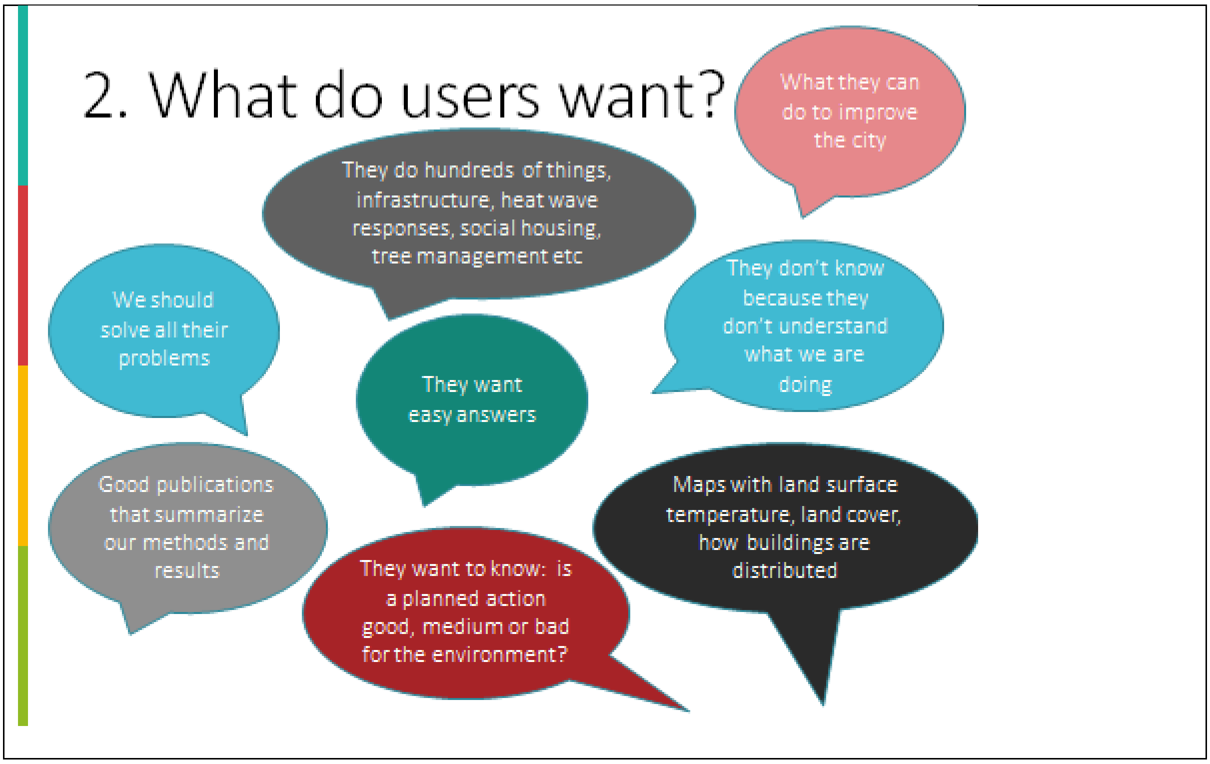
The URBANFLUXES researchers see other scientists as an important group of users. They also think their work is relevant for practitioners within local and regional governments, NGO's and the private sector. Relevant domains are urban planning and construction, energy, environment and health.

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

7.3 What do users want?

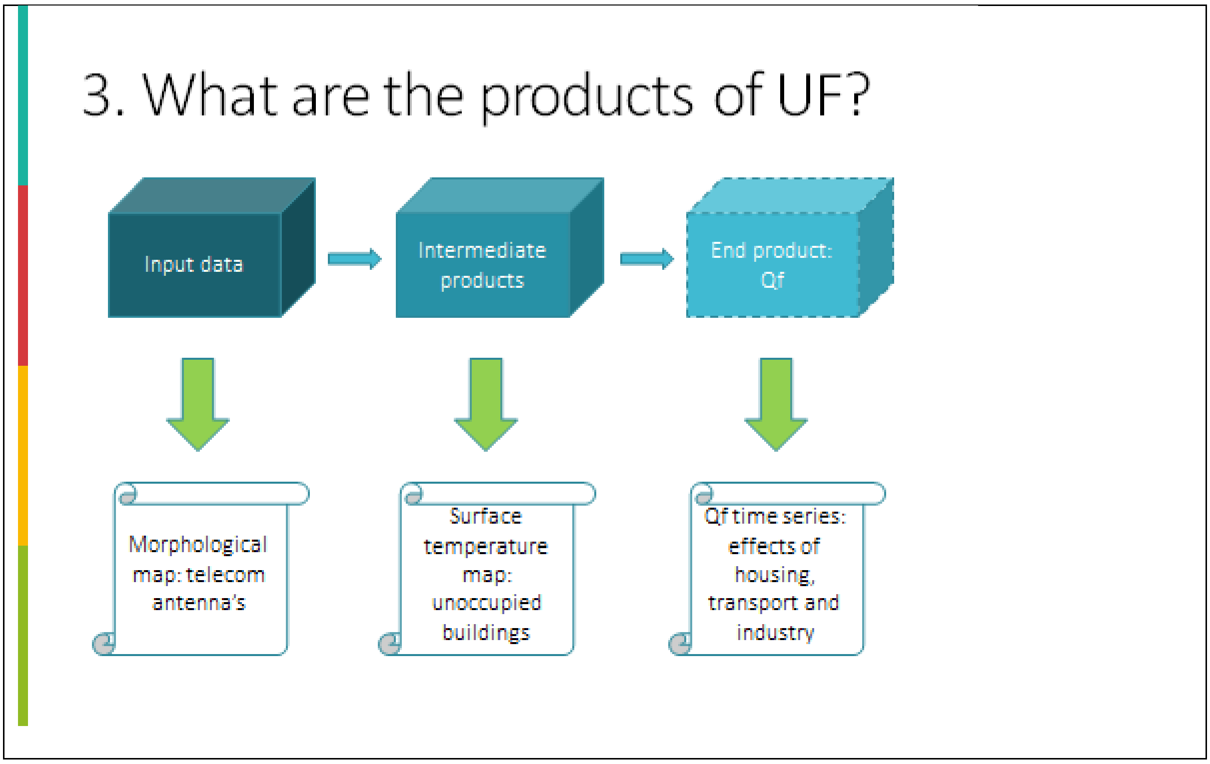
URBANFLUXES researchers have mixed feelings about what the users want from them (see figure for some examples). Some potential users expect too little and some too much. The estimate of the user understanding differs among the respondents; some think the project is hard for users to understand what the project does, others think they will be able to use the detailed maps that URBANFLUXES will produce.



7.4 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 product: Q_F
• 3D maps, morphological structure of a city: where to place antennas • Real-time data on wind, temperature, humidity: where to plant trees or create ventilation? • Land use maps • Buildings distribution • Surface temperature maps • Sky view factor, roughness • New sentinel data	• Latent and sensible heat flux maps • Heat storage flux maps • Net all wave radiation maps • Time series for these fluxes • Surface cover maps: bare soil, green (coniferous, deciduous), soil sealing... • Albedo maps • Thermal properties of building materials • Algorithms for estimating fluxes • Algorithms to produce land cover maps	• Q_F – estimate of anthropogenic heat in maps for three cities • Gridded maps and zones • Different moments of the day, aggregated for a year etc • Time series and time profiles for full days, animations? • Automated process to use sentinel data • Overall methodology to calculate Q_F: manual and model package • App

7.5 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:

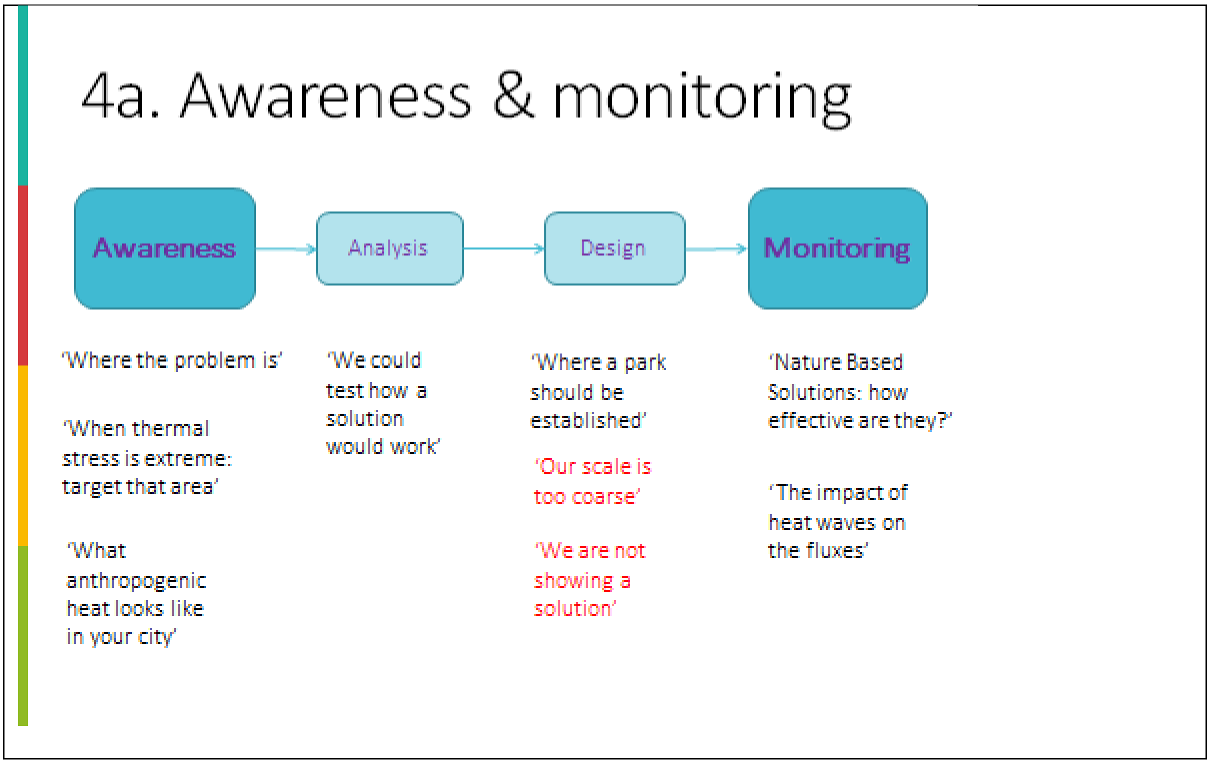
- Q_F - high energy consumption areas
    - Bad insulation
    - High air conditioning
    - Transport
- Urban Energy Budget – all energy fluxes
    - Albedo of surfaces causing low or high reflection of incoming radiation;
    - Materials causing low or high energy storage in buildings and urban surfaces;

- Trees causing evaporation (latent heat flux);
- Pervious surfaces allowing for water infiltration;
- Urban structures leading to or blocking ventilation.

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

- Surface temperature: detection of unused buildings (can be used by squatters)
- 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: to the devices measuring meteorological parameters measurement of air pollution can easily be added because the energy supply and software are already there.

The respondents were asked in which phases of urban development URBANFLUXES products would be most helpful: awareness, analysis, design or monitoring? They expected them to be most helpful in the awareness phase and the monitoring phase (see figure).



URBANFLUXES end products are maps that show energetic terms as they appear to a satellite; without an explanation of why this is the case. This means that they can be used for **awareness** raising; as a starting point for a discussion in a city what the causes for these sources and sinks of urban heat are, and what could be done to reduce urban heat. For **analysis** URBANFLUXES products are only a starting point: other data sources are needed as well such as local databases on energy use, vegetation type, types of activity in buildings and urban spaces, and so on. URBANFLUXES products aim at a 100x100m grid which is a scale that is often too coarse for urban **design** projects. Only a relatively large scale operation such as planning a large park could be done based on URBANFLUXES maps; but large parks are not planned so often in the lifetime of a city. URBANFLUXES products are based on satellite data that will be produced in a higher frequency than before. Therefore, URBANFLUXES products are expected to be helpful for **monitoring** the energetic performance of a city after measures have been taken.

7.6 Worries and solutions

URBANFLUXES is an ambitious project. It aims for practical results, but many uncertainties remain and the validity of the outputs is one of them. The table shows the main worries of the researchers half way into the project lifetime. For some of their worries they also have solutions in mind.

Worries	Solutions
• Accuracy of resulting Q_F estimate	• Work on accuracy of input data, intermediate products, and models • Estimate uncertainties so that it is clear if an output has any significance
• Internal communication and understanding	• Cooperate well; monitor progress
• How to translate to users?	• Discuss with users how to communicate results: colours, detail, maps?
• Results still need interpretation of causes • Is 100x100 enough detail? • Delay of sentinel data	

7.7 Ideas for second CoP round

Respondents were asked what their ideas were for the second round of CoP's. They came up with the following ideas:

- Show what URBANFLUXES products are mainly about: improving human health and reducing energy use.
- Show the effect of green roofs, small and big parks, albedo, and geometry of a city on urban climate.
- Show cities how to use data from ground measurements as well as satellite sources.
- Ask users' requirements for the URBANFLUXES products: what parameters, and what accuracy do they need?
- Ask how we should communicate results: what color schemes, what level of detail; ask what they see in the maps we produced so far.

7.8 Ideas for the second video

Finally the respondents were asked what ideas they had for the contents of the second video.

The first idea is to present URBANFLUXES as a part of an ongoing research process: before, Q_F was neglected in the calculations of the Urban Energy Budget. In this project the variation of Q_F in time and space is investigated. After URBANFLUXES the search for causes and solutions to reduce Q_F can begin.

The second idea is to show what was done in URBANFLUXES in more detail:

- Measured data, models, Sentinel data
- Maps of UEB components for one case study city
- Time series; e.g. an animation showing that stone and vegetation have a different pattern in storage heat fluxes

The third idea is to explain why URBANFLUXES is useful; for example, an old man could be shown, looking for a cool spot with his smartphone. An urban planner could tell the audience how he/she has used URBANFLUXES. It is important to make clear that urban heat problems are not solved when a city is carbon-neutral. Albedo and other energy fluxes matter more for the urban climate than Q_F.

7.9 Conclusions second interview round

The URBANFLUXES researchers 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. They also see other scientists as an important group of users. URBANFLUXES researchers have mixed feelings about what the users want from them (see figure for some examples). Some potential users expect too little and some too much.

The URBANFLUXES project leads to a long list of usable products (see table).

Category	Products	Uses
Input data	Maps with data that URBANFLUXES collects from other sources	• 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
Intermediate products	Data for several terms of the urban energy budget	• 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.

The end product Q_F	The anthropogenic heat factor across time and space. Daily, weekly and yearly patterns of heat production on 100x100m grid maps.	• Where energy can be saved; high energy consumption areas
		  ○ Bad insulation
		  ○ High air conditioning
		  ○ Transport
		• Which measures of local governments lead to improved performance i.e. less Q_F

Although the researchers see many potential uses of their products, they fear that the use will be limited by the accuracy of the resulting Q_F estimate. They also worry if a 100x100 grid offers enough detail. Furthermore, a delay of Sentinel data would lead to limited maturity of the developed methods.

8 SECOND COP MEETING BASEL 18 JANUARY 2017

8.1 Aim and programme

The second CoP in Basel was held on January the 18th 2017 in the Universität Basel, Department Umweltwissenschaften, Meteorologie, Klimatologie und Fernerkundung, Klingelbergstrasse 27, CH-4056 Basel. The URBANFLUXES CoP is a mixture with scientists and practitioners from municipalities and other organizations. The aim is to learn from each other on a certain topic namely urban heat problems.

Programme:

09:00	Welcome	Franziska Siegrist
09:10	Overview URBANFLUXES Project	UNIBAS – Eberhard Parlow
09:25	Anthropogenic Heat Flux in LONDON and BASEL – first Results from the URBANFLUXES Project	UNIBAS – Christian Feigenwinter
09:45	Data sources and data acquisition for the URBANFLUXES Project in the Basel triangle (population, energy, traffic, digital maps)	UNIBAS – Christian Feigenwinter
10:05	Coffee break	
10:30	The GEORHENA Project: A Geoportal for the three-country area (www.georhena.eu)	GEO-RHENA – Boris Stern
11:00	Discussion / Workshop	Moderation: Franziska Siegrist
12:00	Buffet Lunch	

Participants:

Name	Organization
Roland Vogt	Unibas, UF
Andreas Wicki	Unibas, UF
Christian Feigenwinter	Unibas, UF
Eberhard Parlow	Unibas, UF
Judith Klostermann	WUR, UF
Franziska Siegrist	Frasuk
Boris Stern	GeoRhena, GIS Dépt du Ht-Rhin
Pascale Schmidiger	Conseil Dép du Ht-Rhin
Julian Pfefferle	Basel Amt für Mobilität

Franziska Schwager	Basel Amt für Umwelt und Energie
Samuel Diethelm	Mobilität
Hansruedi Moser	Basel Lufthygieneamt
Martina Ragettli	Swiss Public Health Institute
Bjorn Lietzke	Statistisches Amt
Rafael Alù	Statistics Dep. Kanton Basel

8.2 Overview of the URBANFLUXES project (Eberhard Parlow)

The aim of URBANFLUXES is to use Satellite data to estimate human energy use, for example, from heating and cooling of buildings, traffic, and industry. Human metabolism is also a term but it is only small. Basel is one of the case studies.

Heat in cities is problematic because of the heat island effect. In a Nature article from 2015 'beat the heat' it is stated that urban heat cannot be solved with green roofs. Green roofs often have dryland plants that do not contribute to evaporation. 'They are not going to move the needle.' Something else is needed. On a clear summer day net radiation is around 500-600 W/m_2 influx from the sun. 30% of this energy goes into in heat storage in cities (200-250 W/m_2), in a forest this is only 10% and this is the largest difference between cities and forests.

URBANFLUXES calculates the whole energy budget from different components. The overall budget is positive during daytime and negative during night-time. Terms are sensible heat, latent heat, heat storage and anthropogenic heat. Anthropogenic heat (Q_F) is always positive. With models, satellite data, etc., all terms can be measured and calculated and hopefully the remaining term is Q_F.

The aim of URBANFLUXES is also to produce spatial maps. The tower on the roof of UniBas is an example of a point measurement. ESA has launched new satellites that collect data on a daily basis and with a resolution of 10m. They cover all of Europe and the data are free. So we will have European data instead of the US Landsat data.

The case studies are London, Basel, and Heraklion. London is a megacity, Basel is a middle-European medium size city with an old city centre, and Heraklion is a southern European city. In situ observations in London and Basel have already been collected for decades and in Heraklion are they now incorporated for the URBANFLUXES project. The stations measure complex things variables like the turbulent heat and CO_2 fluxes but also simple standard measurements like temperature, humidity and wind velocity/direction. We also use maps of surface morphology from each city.

The advantages of satellites are that they cross borders; they collect data every day. A series of satellite images can show the vegetation's dynamic It has an infrared sensor that sees the amount of chlorophyll in leaves. So the data are spatially and temporally specific.

8.3 First results from Basel and London (Christian Feigenwinter)

While natural energy fluxes are generally positive in the daytime and negative during the night (building up of energy vs losing energy) the anthropogenic heat flux (Q_F) is always positive; day and night. Sources of anthropogenic heat are heating and cooling of buildings, transport and human metabolism. Waste water also is an energy component but we do not consider it in the project.

The IPCC calculated an average Q_F of 65 W/m^2 for urban environments; seasonal and spatial differences.

Different methods exist for estimating anthropogenic heat: top-down inventories, models for simulation, energy balance closure, direct measurement, remote sensing, and as a derivative of air quality.

Calculating the residual of the urban energy balance is the method of URBANFLUXES, and URBANFLUXES compares this calculated Q_F to data from the remote sensing inventory method.

In London a data inventory is used with high spatial specificity; the LUCY model calculates energy consumption and produces spatially divided numbers. It is based on population density, the spatial effect of work and private (day /night and week/ weekend pattern), transport data with vehicle speed, energy use data, etc.

For London pictures are available from overpasses in different seasons at 11:00. They are in a logarithmic scale so not much differences can be seen. There is a small difference between seasons, but when Q_F is distinguished in components/ sources differences can be seen. Heating of buildings is the same year round, but transport is different between day and night. Human metabolism is not an important term. Q_F of London seems to be between 200-300Wm$_2$ at 11:00 hours.

In Basel 6 different offices administrations have to be involved for acquiring the data (energy use, mobility, population, etc.) for an inventory study; 3 kantons in Switzerland, across the French border there is St Louis, and there is the German part. Eventually only for the Swiss parts of Basel data from all parts of the URBANFLUXES Basel grid, including the French and the German part, were sent to Reading. Data from the measurement tower were sent for comparison. A simulation with LUCY followed; Q_F was calculated by Reading and is presented as maps, also in logarithmic scale; the industry region is clearly visible though. Also seasonal pictures were made showing that in winter more anthropogenic heat is produced than in August. Anthropogenic heat is mainly produced by buildings. Human metabolism is a very small term. In Basel at the peak 80W/m_2 is produced in March. Radiation balance was 500W/m_2 so Q_F of Basel is low compared to London.

The problems of data acquisition: for Basel city the best data are available, but for the larger area 4 kantons are involved who all use different age groups. In France statistics institute Insee (https://www.insee.fr/en/accueil) is the central data source in Paris, and in Germany the Kreis of municipalities has the data. URBANFLUXES needs population data, work related data, data on energy use, building heights and vegetation maps. Different governments use different classes and they have different places for keeping the data (local, regional, national). It takes a lot of time to acquire the data, but when they are found they are quite good. Some data are not open, these are political decisions. Sometimes data are not digitally available (PDF) and sometimes they come in a shapefile. Sometimes you have to pay and sometimes there is a free website but this does not always function well. In France everything is centralized. In Germany less detailed traffic data are collected than in Switzerland. For Basel-Stadt these data are very good, for Basel land they are less good. In Germany we have to pay 5000 euro for DEM data, in France it's just very difficult. The big question also is: who to call for the data? It takes a lot of time to find out.

8.4 GeoRhena for data across borders (Boris Stern)

The aim of GeoRhena is to produce maps for the border-crossing region of the upper Rhine basin. It is a European office with a network of 500 experts. It is connected to the tri-national cooperation 'Oberrhein konferenz' that aims to improve cooperation in the upper Rhine between France, Germany and Switzerland. Data from the three countries become available through GeoRhena in the form of GIS maps. The French Departement du Haut-Rhin is host, EU pays 50% for a period and 11 partners pay the rest.

The plan is to also install a competence centre for making cross-border geodata available in a geoportal online.

A similar organization exists for the lower Rhine basin. There also is cooperation with an organization that developed the software for border-crossing geodata projects.

How does GeoRhena operate: we connect experts with the people who need data; everyone who wants data is welcome. For example there was a request on protected nature areas; all governments send us data, we produce the maps, and these are checked and validated by other experts. GeoRhena does not have all the expertise, but we cooperate with other organizations to produce sufficient quality. We always cooperate with statistical offices at national, regional and local level.

It can take between 6 months and two years to produce the requested maps. When we collect the data from different sources we often find out that the definitions are different, so we have to go back to the data producers, etc. It can be a long procedure. And even then you need 20 pages how to read the maps. Measurement units are also different. Population census takes place every year in Switzerland and Germany but only once every 5 years in France. So there are lots of differences that require careful use of the combined data.

Data property is also an issue. After adapting the data for cross-border use, have they become ours? Who owns them? Sometimes data are protected (e.g. risk data in France and Germany). Sometimes we can give the maps but not the data.

In short: it will remain very difficult to create and use data across borders.

Q: Are the data free?

A: Yes, everything we produce is freely available; except when other parties ask money for their data. And do not expect us to have everything ready for you; we only produce datasets on request.

Q: On your website you offer remote sensing data from 2000 which is very old. Also we see many discontinuities in time and space in your data. Do you have a system to regularly update your data? Or would it be an idea to ask the Oberrhein konferenz to produce certain updates on a regular basis?

A: I know this is a problem. However, we only produce data on request, because our funding is limited. When no-one asks for data, they normally will not be updated. Regular updating will mean a lot of work. When certain data are requested often we do update them. We have a yearly rotating presidency and this person also decides on priorities.

In our first year we said: we will collect all the data and make maps, but after one year we decided it is impossible. There are too many differences in the data and it is too much work to acquire and adapt them. So we decided to become a network and to work on request only. We connect the experts: who has the data, how can we connect them.

We are working on a geoportal. The kick off will be in January 2017 and we plan to have it active in April 2017. Then it will become simpler to get the data. Our website already exists and the portal will be accessible from there. www.georhena.eu.

8.5 Discussion with all participants

Q: What is the plan for the URBANFLUXES project?

A: All work packages were shifted forward a few months because of data problems as all work packages are interdependent. Most maps from data inventories and measured data are now available; only for Heraklion they will be a bit later still. Already available on the website: the heat fluxes for Basel of WP6. Andreas is working on a radiation balance with satellite data, models and inventory data from Basel University. With the maps of the components, the energy balance maps now have to be made in WP7. This is done by Reading and not by Basel. These maps will become available on the URBANFLUXES website as soon as they are approved by the Commission. Mid-February there is a review meeting with the EU officer and soon after that the material will be available.

The aim of URBANFLUXES is to produce 4 maps per day for all case studies. This is based on the new ESA Sentinels I, II and III that will pass over more often and will produce maps with more detail (10m instead of 30m). However, these satellites were launched during the URBANFLUXES project; and once they are launched they need 3-6 months of testing their equipment. So in URBANFLUXES so far mostly measured data and data from old satellites have been used to develop the method: US Landsat8 passes over Basel since 2013 but because of cloud cover this means only 10-12 good scenes per year (and one scene is already a few gigabytes). So for the last 3 years there now are good maps of seasonal changes, based on the older satellites. The more interesting steps are WP7 in which all maps will be combined until we know the complete urban energy balance; and WP8 that makes the method operational for the data from the new satellites. The Sentinels will cover the whole region of the upper Rhine basin

Q: what can URBANFLUXES contribute to Basel when all energy is already renewable? And the law for Basel-Stadt is that active cooling is not allowed for buildings (only small scale air conditioning for one household); and heating of buildings with electricity is also not allowed since 10 years. Of course Basel-region is less strict and so are Germany and France.

A: Traffic still uses fossil fuel; and it does not matter if energy was produced in a sustainable way, the heat produced is still the same. And all the old buildings still produce the heat. It would be interesting to investigate the effect of these strict 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. During the day there is little difference between Basel city and the rural area (0,3°C) but during the night it is larger (3-4°) because the stored heat is released.

Then another use of the project is 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. There is a whole industry around cool roofs, for example in France; with special paint 80-90% of infrared can be reflected back into space. However, most people don't want a snow white roof. There will be a conference in Venice soon.

And it is not only important to select energy sources well; energy also can be saved with better insulation. This reduces anthropogenic heat significantly. The difference now provisionally calculated between Basel and London is 80W/m_2 for Basel and 200-300W/m_2 for London and this may be due to less insulation and less strict rules. London also has more old homes. The number is for the city centre of London of course with very dense urban structures. Cities maybe can learn from each other.

Q: When Christian puts in a request for data GeoRhena will produce a map one year later. So it cannot be used in URBANFLUXES. Are the data of URBANFLUXES useful for GeoRhena?

A: URBANFLUXES has another scale than GeoRhena; it is a small part of the upper basin. But also for smaller border-crossing projects cooperation is possible. With a clear request everything is possible.

Q: When you look with a satellite, you cannot see a border between Basel-Stadt and Basel-Region. But when you use the data from the two offices, the border becomes visible. Can this be solved?

A: This is because of different underlying assumptions in the models. It is not so easy to change because then ongoing data collections become discontinued. However it should be possible to standardize between municipalities. Now with Lidar flights everyone organizes their own plane, and the plane even crosses the other areas.

It is clear that because of these differences, people sometimes think they talk about the same things but they mean different things. It can only be solved with a lot of cooperation. With satellites some of these problems are solved.

8.6 Conclusions CoP 2 Basel

The aim of URBANFLUXES is to use satellite data to estimate human energy use, for example, from heating and cooling of buildings, traffic, and industry. Human metabolism is also a term but it is only small. The aim of URBANFLUXES is also to produce spatial maps. Different methods exist for estimating anthropogenic heat: top-down inventories, models for simulation, energy balance closure, direct measurement, remote sensing, and as a derivative of air quality. Calculating the residual of the urban energy balance is the method of URBANFLUXES. For London heating of buildings is the same year round, and transport is different between day and night. Q_F of London seems to be between 200-300 W m^{-2} at 11:00 hours.

In Basel 6 different offices administrations have to be involved for acquiring the data. It takes a lot of time to acquire the data, but when they are found they are quite good. Q_F was calculated by Reading and is presented as maps; the industry region is clearly visible. Also seasonal pictures were made showing that in winter more anthropogenic heat is produced than in August. Anthropogenic heat is mainly produced by buildings. In Basel at the peak in March 80 W m^{-2} is produced. The radiation balance was 500 W m^{-2} so Q_F of Basel is low compared to London.

The aim of GeoRhena is to improve cooperation in the upper Rhine between France, Germany and Switzerland. Data from the three countries become available through GeoRhena in the form of GIS maps. GeoRhena connects experts with the people who need data. It can take between 6 months and two years to produce the requested maps. When data are collected from different sources the definitions often are different, so GeoRhena has to go back to the data producers. It can be a long procedure. Data property is also an issue. There are too many differences in the data and it is too much work to acquire and adapt all of them. Therefore, GeoRhena decided to become a network and to work on request only.

In Basel all energy is already renewable. And the law for Basel-Stadt is that active cooling is not allowed for buildings (only small scale air conditioning for one household); and heating of buildings with electricity is also not allowed since 10 years. Of course Basel-region is less strict and so are Germany and France. What can URBANFLUXES contribute? Traffic still uses fossil fuel; and it does not matter if energy was produced in a sustainable way, the heat produced is still the same. All the old buildings still produce the heat. It would be interesting to investigate the effect of these strict laws by comparing the heat production from buildings of Basel-Stadt with the region.

Another use of the project is to reduce the urban heat effect. The 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. There is a whole industry around cool roofs, for example in France; with special paint 80-90% of infrared can be reflected back into space. Energy also can be saved with better insulation.

URBANFLUXES is not yet finished and will inform the participants of further progress.

9 SECOND COP MEETING LONDON 14 FEBRUARY 2017

9.1 Aim and programme

The meeting on variability of heat emissions in London was held in Committee Room 4, City Hall, The Queen's Walk, London, SE1 2AA

As part of the H2020 URBANFLUXES project the spatial variability of heat fluxes within cities is being explored. Specific Focus of this event is to provide an overview of the London URBANFLUXES work, the results so far and to identify areas of potential applications that would be interested in having the "real" time data and/or higher spatial resolution. The meeting should benefit the partnership between the research community and policy makers, and we aimed to discuss how measurements of urban heat fluxes can be made useful for policy making.

Photo: GLA office

Meeting Agenda:

15:00	Welcome and brief introduction of all attendees	All
15:10	Overview of the URBANFLUXES project	Nektarios Chrysoulakis (FORTH)
15:25	The Copernicus Sentinels to support city planning	Zina Mitraka (FORTH)
15:30	Questions	All
15:40	London work and results so far › Characteristics of the anthropogenic heat emissions in London › Uncertainty of the fluxes determined Planned next directions	Sue Grimmond (UoR)
16:00	Discussion – Round Table	All
16:45	Evaluation round and follow up plans	All

Participants:

Name	Organization
Kristen Guida	GLA
Judith Klostermann	URBANFLUXES, WUR-Alterra
Nektarios Chrysoulakis	URBANFLUXES, FORTH
Zina Mitraka	URBANFLUXES, FORTH
Sue Grimmond	University of Reading
Andy Gabey	University of Reading
Katherine Drayson	GLA
Helen Macintyre	Public Health England
Ross Thompson	Public Health England
Anna Sexton	Public Health England
Mathew Frith	London Wildlife Trust
Lewis Bassett-Butt	London Wildlife Trust
Janet Laban	City of London Corporation
Jessica Lewis	London Environment Directors Network / London Councils
Simon Wyke	GLA / Celsius project
Rajat Gupta	Professor sustainable architecture and climate change, Brookes University, Oxford
Jake Hacker	ARUP
Matthew Clifton	GLA

9.2 Overview of the URBANFLUXES project (Nektarios Chrysoulakis)

URBANFLUXES (UF) is working to calculate all the terms of the urban energy budget. Climate change causes higher temperatures and for cities the effects will be more severe because of the urban heat island effect. Cities can be up to ten degrees Celsius warmer than the surrounding rural areas. The number and severity of heat waves will increase; in Athens it is a heat wave when temperature rises over 37 degrees for more than 3 days. In London this is defined at a lower temperature; in any case it will cause an increase in energy use for cooling buildings. This will further heat up the city.

In the project we aim to map the energy fluxes in a city with help of data from satellites. It is not possible to get city-wide maps with in situ measurements. We use Copernicus satellites to measure heat patterns over time and space. A year ago a Nature publication stated: 'green roofs will not move the needle'; indicating that more large scale measures are needed to mitigate the urban heat island effect. Nature based solutions in smart cities is an important new research topic for Brussels. Manchester participates in one of these projects. We need to develop robust monitoring, so that we can evaluate how implementation of nature based solutions works out in practice.

The Urban Energy Budget (UEB): long and short wave radiation is stored in buildings; after storage it is released into space again and this release at night is related to human comfort in cities. Heat is also used to evaporate water; and there is a horizontal flux. Additionally the Q_F is part of the UEB: human-made heat from transport, heating and cooling of buildings, and industry. Satellites cannot differentiate this Q_F from the total energy amount so it has to be calculated. In URBANFLUXES we combine spatial data, space data, and in situ measurements to calculate Q_F. Then we use Sentinel data to produce time series.

We use in situ measurements for the sensible heat flux; Eddy Covariance measurements for CO_2 and energy fluxes; surface morphology to calculate the roughness (elevation of buildings, sky view factor etc.). We use data on surface cover (buildings, impervious soil, bare soil, water, vegetation etc.). We make a comparison of ground data and inventory data with satellite data. We combine data from two satellites: one with good spatial resolution but passing over only every two weeks; another passes over one every day but has data with lower spatial resolution. In a map of the latent heat flux you can see it is near zero in the commercial centre of London, because there is no evaporation. Heat storage needs to be calculated from satellite data with models. The scale of out output is 100x100 metres.

We organize these meetings to keep information flowing between scientists and cities. The impact the URBANFLUXES project is to reduce energy consumption, to improve human comfort, to help with implementation of nature based solutions, and to inform policy making about urban heat issues.

Questions

You do the downscaling with the DART model?

We use DART to get the 3D effect, to calibrate with real observation data. The DART model combines data on city structure with satellite data. In London we look from all angles so we know what we see in 3D, but a satellite sees only a small portion of a city, mainly rooftops and streets, and we have to know how to relate to the 3D reality of a city. On other hand a satellite sees the whole city of London, while in situ measurements only see a small part of the city. We need to be able to downscale satellite images from 1x1km to 100x100 metres.

You measure different temperatures: air, buildings etc. How do you know the internal temperature?

Indeed we need to know the temperature gradients and the heat storage; we measure the air temperature, and on the temperature inside buildings we use assumptions from the building community; it is calculated with models. We use a typology of buildings, taking insulation into account; with GIS data on the distribution of buildings.

Could you apply the models to green areas as well?

Yes, our work also includes green spaces. We calculate it as the fraction of vegetation per pixel; and we use three classes of vegetation: deciduous trees, evergreen trees and low vegetation.

We know where every tree is so out input data are at a fine scale and the output is on the grid of 100x100 metres. We want to know what nature based solutions can do for the urban climate, so we need a system to monitor the interventions.

9.3 Copernicus satellites (Zina Mitraka)

The URBANFLUXES project aims to make use of the potential of Copernicus Sentinels. In the Copernicus program Sentinels are launched for environmental security; it is a family of satellites to monitor environmental aspects.

- Sentinel 1 has a 10m resolution, and does data acquisition on demand. London is well covered, a radar captures images independent of cloud cover.
- Sentinel 2 is similar to Landsat, it collects optical images with a spectral resolution in 13 bands. It has a frequent revisit time.
- Sentinel 3 has optical instruments with a spatial resolution of 30m but with a very good revisit time; 4 acquisitions per day, and if we combine this with MODIS data we have a total of 6 acquisitions per day, but the spatial resolution is 1 km. We downscale it to the 100 m grid.

Examples of applications:

- Monitoring of urban changes, time series: you can monitor the building process, for example the construction of the Olympic stadium (Envisat image).
- Surface cover changes in Rome: changes in vegetation, how phenology is changing over the year.
- Landsat vs Sentinel 2: we monitor changes on 10m resolution and upscale this to 100 m; for example to monitor vegetation; we will have more cloud free acquisitions.
- Particular matter from Sentinel 3: for London, mean concentrations of the past 15 years.
- Land surface temperature
- Heraklion: downscaling to a high resolution emissivity map.

Questions

So you can do time series over the past 15 years? With what kind of data? Could you show environmental change over time? How do you get comparable data? Can you show changes in tree canopy cover?

You mean to go back and see how it develops over time? Yes that is possible, not with Sentinel data but with Landsat; Landsat goes back to the seventies. For example, you could make one estimate per year; we did not think about going back in time so far but yes it would be useful.

We have LIDAR data for London available. Data like NDVI are also accessible. We have an archive of spatial data at different spatial resolutions, for last 8 years for London. High resolution data is not free, but not expensive either. New data will be free, and for the future there will be more data.

You can track heat loss in buildings, so if we retrofit and want to see how that is scaling up in different places; can we get data for each separate building?

Not building by building heat loss, but we can work with fractions. So far we were looking ahead with future data acquisitions from sentinels and we did not think about looking back. You also need data of the past. Sentinel 1 collects data at 10x10m. We scale up to 100 m but some data are more detailed like 1m for the sky view fraction. This is something we could potentially do. We can check our datasets and see what answers we can provide. Looking at past data may also be a way to see if our algorithms are working.

What water aspects can you measure: water quality, flooding? Not flood events I suppose?

Water quality is not investigated in this project, but you can use the spectral signature of water, which is related to water quality. There are studies in Crete and Cyprus; Sentinel 2 produces spectral band high resolution data, it has a high potential. Sentinel 1 uses radar and may see a flood event. In a LIFE project we are combining data for London on floods.

There are risks of under-heating in winter and overheating in summer. Can you infer from data what the risk areas are?

You mean a kind of alarm system? I'm not sure. In other projects, with tracking and modelling, we would have that capability. We would have to know what sets off the alarm, including socio-economic data to identify target areas. Satellite imagery gives a ground truth and if this is combined with sensors it might be possible. So we would also need to measure on the ground and model the effects over a larger area. Satellite images from summer and winter could show the hottest and coldest periods and spots.

9.4 URBANFLUXES London results (Sue Grimmond)

The London results of the URBANFLUXES project are based on data from direct measurements on the ground and modelling which are combined with satellite data. An alternative method with inventory data (population, energy use, transport data etc.) is also used because cloud cover limits the use of satellite data for London and we can already learn about the uncertainties with the alternative method.

With direct observations regular meteorological data are collected like temperature, wind speed, humidity; and also more advanced data like boundary layer height, long and short wave radiation, Eddy Covariance - latent heat fluxes, sensible heat fluxes and CO_2 fluxes. We have a triangle of instruments looking across London and we use scintillometry for the calculations. We have 7 years of data on the nature of the climatic variability in London. We can go to very high temporal resolution like every minute heat fluxes. So we have a lot of measurements.

To use the satellite data the measured data are indispensable. For the surface energy balance we use the well-known URBANFLUXES heat fluxes equation to calculate Q_F. Does it make a difference for the urban climate what people are doing in London? If not, the weekday and weekend should look the same. But in winter and summer there is a difference between weekdays and weekend; so there is a significant effect from heating of buildings but also from transport. Larger building volumes cause more heat.

We can also look at the surface and how it affects the data: more vegetation allows for more evaporation and when there are more buildings more anthropogenic energy goes into the atmosphere. After a rainy period we can see more energy goes into evaporation until the surface dries out. The colder the weather, the more heating we need, the higher the anthropogenic energy flux from buildings.

On 2 October 2015 there was a clear day with a satellite acquisition of data at 11:00. This day is used for a lot of testing. For the tallest buildings, the temperature seen by the satellite is cooler: what satellite sees is only the top of the buildings and it cannot see all the way down. This shows we cannot just look at roof temperatures; models are needed to calculate to the 3D version of a city. By combining all the data we can validate the data of other models and measurements, and differentiate between all the terms. With URBANFLUXES measurements and modelling we know how much heat is produced and what is the effect of vegetation on urban temperature.

9.5 Anthropogenic heat fluxes (Andrew Gabey)

Anthropogenic heat (Q_F) is the energy released through human activities. We cannot observe it directly but have to infer it from models and calculations. Sources are transport, buildings and human metabolism. Inventory data can help with partitioning of heat fluxes: heating of buildings, waste water, human metabolism, etc.

In the Urban Energy Balance method the residual factor is calculated with SUEWS and this is compared with the inventory based model LUCY. LUCY uses an emissions model, these are spatially disaggregated with a population model, over time and an emissions model, so it produces a highly localized output. We distinguish the home population from the working population; and also use transport models with traffic flows. The metabolic heat from human bodies is based on the number of people.

We compared two areas in London: Barbican and Kings College London. Using a lot of data from London we created time series for the two areas. We want to know how much of the heat that gets out is human-made. There is variability between days, influenced by the outside temperature: on colder days, more heat is produced. We expect a separate private and industrial cycle but the Barbican is classified as an industrial site. We can see transport and heating of buildings are the main factors. Buildings dominate overall; and roads dominate where there are no buildings. On 2 Oct 2015 200 Watts/m_2 came in from the sun so that amount of energy is competitive with the man-made energy. Human metabolism does not contribute much.

Comparing the cities: The data for London is perfect but for Basel and Heraklion we still need to get there. There also are differences in the population data. The satellite does not pass over every city at same time, and we use different overpass days, so it is difficult to analyse everything correctly and find explanations for the differences that we see.

Total Q_F: London not only has the highest Q_F but it is also more widespread; Basel has the same amount of Q_F per capita but it is less spread; Heraklion has less per capita. In London the highest Q_F is caused by heating, in Heraklion by cooling. Buildings are most important in both cases. What is the prevalence of air conditioning in London? It is calculated as a proportion. There is a big effect of residential vs commercial areas, everyone is going to the centre in the daytime. Remaining questions are: do we include the tube? And how to allocate the heat? What if everyone changes to another energy source? If we had a base of observations we could calculate a lot of other things like air quality.

So we have lots of data, tools have to be developed further and Sentinels are only just up there and need start-up time. The results we will have are relevant for energy use and health and vegetation planning. Urbanclimate.net is our website and there you can look at our work.

9.6 Discussion with all participants

You do modelling of buildings, can you also look at effects between air conditioning and passive cooling?

We can do that with modelling, an agent based type of modelling, with all energy uses in a building. We can measure air temperature and model an anthropogenic heat flux; however we think the model is constrained by real data, and we can look at it historically, and assume how buildings behave. We have to know that what we calculate is correct. We use a top down method based on energy use. It is also a matter of scale: If techniques are implemented on a large scale we can measure it.

Do you also have data on characteristics of buildings?

We look across the whole of London. The EU urban atlas has detailed data; someone has looked at each city and looked at building materials, and so for our 100m grid we include 4 types of buildings; the height of buildings, the height of trees; wall temperature on all walls separately. We do not distinguish every building but use 4 classes of buildings and their characteristics.

You use sensors?

Yes; we have internal building measurement and cameras outside.

If you measure air temperature in a city, do you see an elevated temperature in the winter?

No, we just figure out how much heat escapes the building and not how it heats the city.

Do you try to relate heat loss to urban temperature? Or can you see where it heats up city? Is Q_F artificially heating up the city? Can you show: Here the city is hotter because of elevated temperature?

We cannot do direct observation of what is going into heating the atmosphere. The heating of buildings is driven by the inside-outside temperature differences. We can see a difference between weekdays and weekend, and between types of buildings. In the morning the boundary layer goes up (the part that can get polluted). From 400 m to a higher level. The amount of energy is thus mixed into a larger part of air and in winter time the boundary layer is lower. So it is complicated but you can do the calculations. In any case it is a lot of energy that is lost. In Heraklion energy use is lower; but this is in January; and in summer the city uses more energy, also for tourists, so we expect more energy use in august, and then we have the extra heat from cooling.

One application would be to go back in time; what else might you be interested in?

There are opportunity areas for housing, can you do work specifically related to those areas; let's say it going to be the densest part of London, can you also model forward how this densification affects climate?

Yes, with modelling we can look forward, like with the LUCY model, if we know what the areas are, we can use LUCY for scenario building. We can also provide the baseline now, and you can set your targets.

We want to put in an H2020 bid, and this knowledge would be very useful, I will put you in touch with colleagues, they are planners working on that, it is the land use they are looking at.

For what topic is the bid? Nature based, or environmental? The nature based calls say: develop monitoring.

Topic III probably, URBANFLUXES can be linked.

Do you have messages to designers what to do?

Not explicitly, to find out what is important we can do the scenario modelling, but I don't know if we can model it correctly, if we use the model in extreme conditions; we are not sure how well it works under those conditions. But we can show, for example, what building density or vegetation cover do, we have tools to show what that does. What is OK for the air temperature: that is only a small signal.

You do flux measurements rather than temperature measurements?

Flux measurements improving to better scale.

How can you help spatial planning? What are design principles to minimize fluxes and reduce urban temperature?

Our models need to be improved but the type of energy is important. Houses needing less gas heating are good, and improving latent heat flux with vegetation may be good.

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

9.7 Conclusions CoP 2 London

The London results of the URBANFLUXES project are based on data from direct measurements on the ground and modelling which are combined with satellite data. An alternative method with inventory data (population, energy use, transport data etc.) is also used because cloud cover limits the use of satellite data for London. The satellite does not pass over every city at same time, and we use different overpass days, so it is difficult to analyse everything correctly and find explanations for the differences that we see.

Does it make a difference for the urban climate what people are doing in London? If not, the weekday and weekend should look the same. But in winter and summer there is a difference between weekdays and weekend; so there is a significant effect from heating of buildings but also from transport. Larger building volumes cause more heat. More vegetation allows for more evaporation and when there are more buildings more anthropogenic energy goes into the atmosphere. After a rainy period we can see more energy goes into evaporation until the surface dries out. The colder the weather, the higher the anthropogenic energy flux from buildings. For the tallest buildings the temperature seen by the satellite is cooler: what satellite sees is only the top of the buildings and is affected by shadowing.

The inventory based model LUCY uses an emissions model. We distinguish the home population from the working population; and also use transport models with traffic flows. We compared two areas in London: Barbican and Kings College London. We can see transport and heating of buildings are the main factors. Buildings dominate overall; and roads dominate where there are no buildings. London not only has the highest Q_F but it is also more widespread; Basel has the same amount of Q_F per capita but it is less spread; Heraklion has less per capita. In London the highest Q_F is caused by heating, in Heraklion by cooling. Buildings are most important in both cases. There is a big effect of residential vs commercial areas, everyone is going to the centre in the daytime.

The table below shows questions asked during the CoP in London about potential use of URBANFLUXES data and models and answers. Many questions lie within the scope of URBANFLUXES, even though the project is not designed to answer precisely these questions. A few questions are outside the scope just because of the spatial resolution (100x100m vs building scale) and the forward-looking nature of the project (instead of backward).

Question	*Answer*	*Inside or outside URBANFLUXES scope*
There are risks of under-heating in winter and overheating in summer. Can you infer from data what the risk areas are?	We would have to know what sets off the alarm, including socio-economic data to identify target areas. Satellite imagery gives an estimate and if this is combined with sensors it might be possible. Satellite images from summer and winter could show the hottest and coldest periods and spots.	Inside
There are opportunity areas for housing, let's say it going to be the densest part of London, can you also model forward how this densification affects climate?	Yes, with modelling we can look forward, we can use LUCY for scenario building. We can also provide the baseline now, and you can set your targets.	Inside
What are design principles to minimize fluxes and reduce urban temperature?	Our models need to be improved but the type of energy is important. Houses needing less gas heating are good, and improving latent heat flux with vegetation may be good.	Inside
Could you apply the models to green areas as well?	Yes, our work also includes green spaces. We calculate it as the fraction of vegetation per pixel; and we use three classes of vegetation: deciduous trees, evergreen trees and low vegetation. We want to know what nature based	Inside

	solutions can do for the urban climate, so we need a system to monitor the interventions.	
Can you also look at effects between air conditioning and passive cooling?	We can do that with modelling, an agent based type of modelling, with all energy uses in a building.	Outside
Do you also have data on characteristics of buildings?	The EU urban atlas has detailed data on buildings in cities. We do not distinguish every building but use 4 classes of buildings and their characteristics.	Outside
Can we get data on heat loss for each separate building?	Not building by building heat loss, but we can work with fractions.	Outside
Can you do time series over the past 15 years?	Yes that is possible, not with Sentinel data but with Landsat; Landsat goes back to the seventies. For example, you could make one estimate per year; we did not think about going back in time so far but yes it would be useful.	Outside
What water aspects can you measure: water quality, flooding?	Water quality is not investigated in this project, but you can use the spectral signature of water, which is related to water quality. Sentinel 2 produces spectral band high resolution data, it has a high potential. Sentinel 1 uses radar and may see a flood event.	Outside

10 Second CoP meeting Heraklion 14 July 2017

10.1 Aim and programme

On July 14, 2017, the second Community of Practice meeting for the URBANFLUXES project was organized in Heraklion. The event took place in the facilities of the Municipality of Heraklion. Participants of the meeting included, besides the URBANFLUXES scientists, representatives of the Municipality of Heraklion, the Region of Crete and the Decentralized Administration of Crete.

After the short welcomes by G. Alexakis, Regional Councillor of Crete and G. Anastasakis, vice Mayor of Heraklion, N. Chrysoulakis, coordinator of URBANFLUXES, made an introduction on the methods and the scopes of URBANFLUXES project. Then, K. Mochianakis, Programming Director in the Heraklion Municipality, gave a thorough presentation of the actions, projects and goals of Heraklion as a smart city and E. Hatziyanni, Directorate of Environment and Spatial Planning in the Region of Crete, gave an overview presentation of the environmental projects and infrastructure in Crete.

In the second part of the meeting, URBANFLUXES scientists made a series of presentations regarding the main project outcomes and data that can be potentially valuable for the sustainable urban planning in Heraklion. After this demonstration, a panel discussion took place with contributions from all participants.

Detailed Agenda:

09:00	Introducing Local Authorities & Stakeholders	All
09:30	URBANFLUXES Overview	FORTH - N. Chrysoulakis
09:50	Heraklion as a Smart City: The environmental component	MoH - K. Mochianakis
10:10	Environmental Projects in Crete	RoC - E. Hatziyanni
10:30	Coffee break	
11:00	Urban surface cover and morphology from satellites	FORTH - D. Poursanidis
11:20	The URBANFLUXES Wireless Sensors Network in Heraklion	FORTH - N. Spyridakis
11:40	Heat storage in buildings of Heraklion	FORTH - Z. Mitraka
12:00	Turbulent heat and CO_2 fluxes in Heraklion	FORTH - S. Stagakis
12:20	Discussion on the potential role of URBANFLUXES to support urban planning and governance in the broader area of Heraklion.	All
13:20	Wrap up & Follow up	ALTERRA - J. Klostermann
13:30	Buffet lunch	

Figure: The 2nd Community of Practice meeting in Heraklion was held in the facilities of the Municipality of Heraklion

Participants

Name	Organization
Petros Iniotakis	Deputy Mayor of Heraklion
Ioannis Anastasakis	Deputy Mayor of Heraklion
Ioannis Rasoulis	Deputy Mayor of Heraklion
Marinos Pattakos	Deputy Mayor of Heraklion
Kostas Mohianakis	Heraklion Programming Director
Georgios Fournarakis	Heraklion Director of Urban Planning
Nikos Michaelakis	Heraklion Director of Technical Works
Renia Drosou	Heraklion Programming Department
Irini Manousaki	Heraklion Department of Urban Planning
Eleni Kalimaki	Heraklion Department of Urban Planning
Stylianos Mikrakis	Heraklion Counsellor of the Mayor
Giorgos Alexakis	Deputy Regional Governor of Crete
Nikos Kalogeris	Deputy Regional Governor of Crete
Eleni Hatziyanni	Region of Crete Director of the Environment
Giannis Tzanakostakis	Region of Crete Director of Civil Protection
Nikos Zografakakis	Region of Crete Head of Energy Centre of Crete
Maria Koziraki	Decentralized Management - Regional Governor
Nektarios Chrysoulakis	URBANFLUXES, FORTH

Zina Mitraka	URBANFLUXES, FORTH
Stavros Stagakis	URBANFLUXES, FORTH
Dimitris Poursanidis	FORTH
Nektarios Spyridakis	FORTH
Dimitra Tzelidi	FORTH
Judith Klostermann	URBANFLUXES, WUR-Alterra

10.2 Introducing Local Authorities & Stakeholders

Welcome by Deputy Mayor of Heraklion, Ioannis Anastasakis

The deputy mayor stated that the municipality has a steady cooperation with FORTH. The outcomes of Horizon 2020 projects are useful to the municipality and are taken into account in sustainable urban development strategies. Ioannis Anastasakis and his colleagues are looking forward to see the URBANFLUXES project outcomes.

Welcome by Deputy Regional Governor of Crete, Nikos Kalogeris

Climate change influences will become even more obvious in the next years, especially to people that live in big cities. The urban heat affects the microclimate and people's lives. It is important for the scientists to understand climate change and find ways of dealing with this problem. The URBANFLUXES project combines accurate satellite information with land measurements. This is important and the results of this work could be a guide for future expansion plans. The Region of Crete (RoC) already has strategies for adapting to climate change. Scientific researchers have shown that Crete will be influenced by climate change in the coming years. This is a challenge for the RoC. Through European cooperation the RoC aims to improve the energy efficiency of public buildings. Another factor that RoC is interested in is urban pollution. RoC representatives expect that the URBANFLUXES outputs will be very useful to them.

Welcome by Deputy Mayor of Heraklion, Ioannis Rasoulis

The deputy mayor expresses his gratitude for the high level scientific work. The municipality has the obligation to incorporate information from research like URBANFLUXES in their studies and proposals. The political beliefs should change. The municipality people and scientists should be in constant cooperation from now on. The deputy mayor expects that the project's outputs will be useful.

Welcome by Deputy Regional Governor of Crete, George Alexakis

The deputy regional governor states that the URBANFLUXES newsletter deserves to be read from the beginning to the end and each of the governors should wonder what it can contribute to reduce the effects of climate change. The scientific studies are important, but not enough. The municipality people should cooperate with the scientists. Changes should be made based on scientific evidence in order to avoided mistakes in the future. For this reason, the contribution of the URBANFLUXES project is important.

Welcome by Deputy Mayor of Heraklion, Petros Iniotakis

The deputy mayor agrees with the previous speakers. It is necessary to implement changes in Heraklion to reduce the urban heat phenomenon. The priorities in the planning strategies should be three, i.e. an increase of green areas, the use of cool materials in construction and traffic regulations. In general, the people of Greece are strongly interested in applying methods for the reduction of greenhouse gases and adaptation to climate change. An example is that some municipalities already have used cool materials. The results are really promising.

10.3 Overview of URBANFLUXES (Nektarios Chrysoulakis)

The percentage of built-up areas is growing. This explains the changes in urban metabolism and air quality. The importance of URBANFLUXES is the combination of satellite and land measurements. The Eddy Covariance system that counts CO_2 emissions will be presented in detail in the next session.

Photo: Nektarios Chrysoulakis giving an overview presentation of URBANFLUXES project

10.4 Heraklion as a Smart City: The environmental component (Kostas Mohianakis)

Cities are influenced by the issue of climate change as well as the global economic crisis. Since 2012 Heraklion is one of the 240 smart cities of the world. It is a smart city because of instruments used in governance, civil society, and finance. However, smart tools are still lacking in environmental, urban mobility and quality of life information. A list of obligations that the municipality needs to fulfil to reach the goal of smart city is presented. A graph shows the interaction between different stakeholders. The city will build an app for civilians to be able to contact the municipality and report issues in the city. The city is also building a platform with all the data of the municipality.

10.5 Environmental Projects in Crete (Eleni Hatziyanni)

A list is shown of the different projects with a focus on the environment which the Region of Crete is running at the moment. "Environment" means for the city: water, air quality, energy, mobility. "Sustainability" includes these same issues but links them with the economy and the social aspects. A map of Crete was presented which showed the areas of interest to the RoC. Images show the deformation in the sea and flood in the mainland, air quality and Heraklion coping with Sahara dust. Projects that the RoC runs encompass environmental management, cruise tourism, and waste disposal. There is a strategy for dealing with climate change which is connected with the national government strategy. The national government at first wouldn't agree with the regional strategy of Crete. It took time to convince them. The RoC participates in a European working group for the maritime regions of Europe. The impact of climate change in the agricultural areas of three islands (Crete, Cyprus and Sicilia) is measured. Crete is moving to a circular economy in line with the trend in Europe. The RoC is collaborating with other regions with similar interests. The region is particularly interested in nature based solutions for the coastal area and the sea in Crete.

10.6 Urban surface cover and morphology from satellites (Dimitris Poursanidis)

The 3D form of the urban landscape was explained, as well as the available tools and methods for the production of it in the form of Digital Surface Model (DSM). The project used commercial high resolution Earth Observation products and the indices that are necessary for the study of heat storage. Cadastral data that have been prepared during the project and the management of the geospatial data of the project were demonstrated. Introduction and demonstration to the used morphometrics (Plan Area Index, Frontal Area Index, Building Frontal Area Index, Canyon Aspect Ratio, Sky View Factor) has been done. An example on the use of Pleiades 1A/B constellation and the use of the unique tri-stereo image acquisitions for the extraction of a high resolution DSM were shown. High Resolution Land Cover by using WorldView II image has been demonstrated as well. The participants were interested in the Pleiades constellation, as with a relevant low price, cities can have an updated DSM for use in urban planning. The urban morphometrics attract participants from the Heraklion planning office, as these can be used for future urban interventions, indicating where to create green/open spaces for efficient ventilation and air flow. The dataset on urban morphometrics for the Heraklion city has been produced for the first time for the city. The participants asked questions and discussed potential shared use of them.

10.7 The URBANFLUXES Wireless Sensors Network in Heraklion (Nektarios Spyridakis)

The Meteorological Network in the city of Heraklion was demonstrated. Information was supplied for the parameters being measured, the data accuracy, quality and sampling and transmission frequency. The dedicated URBANFLUXES site was presented, describing all the necessary steps to retrieve meteorological data, starting from the team site (rslab.gr). Examples of single and combined meteorological parameters were presented, as well as examples of one parameter from combined stations, in order to explain the necessities the urbanfluxes.eu site is covering. Diversification in the meteorological parameters was presented, based on the specific features of different stations (area characteristics, building density and structural material), by combined presentation of the collected data. A short reference was made to the Eddy Covariance system, which is part of the field instrumentation of the project. The need of close collaboration with the city authorities for the maintenance of the network was mentioned. The availability of the network meteorological data to the public, in real time, as a tool for any and every application was also mentioned.

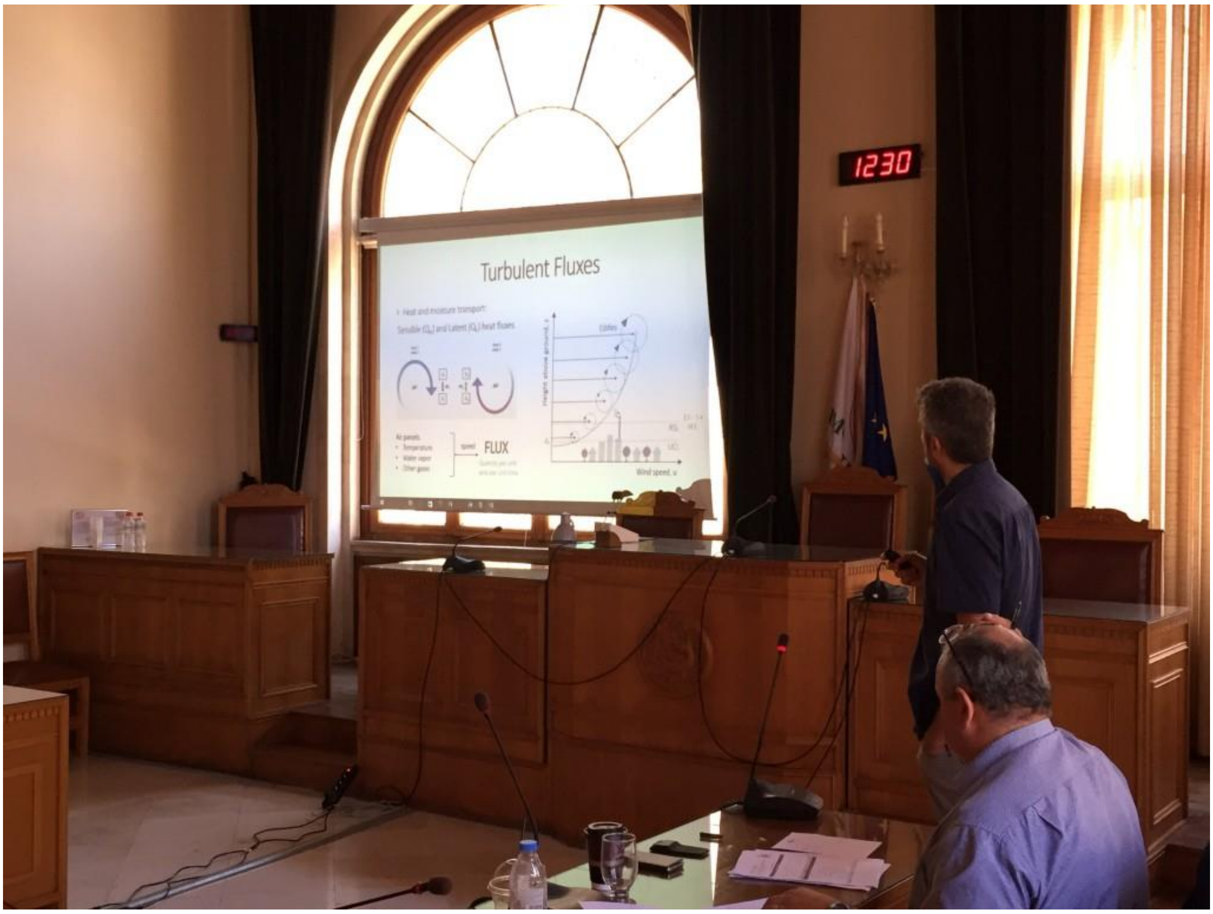
10.8 Heat storage in buildings of Heraklion (Zina Mitraka)

The approach followed in URBANFLUXES to estimate the heat storage in the city of Heraklion was explained. A short introduction on what we mean by "heat storage flux" in a city was given and how it is modelled in URBANFLUXES using the Element Surface Temperature Method (ESTM). The contribution of the satellite data was emphasized, along with the large, diverse and detailed information necessary to make estimates of heat storage in a city. The application of the ESTM method for the city of Heraklion was demonstrated along with initial results. The participants were interested to see the areas in the city with different heat storage fluxes. The need for a detailed spectral library for the city of Heraklion was stressed, presenting as an example the London spectral library of urban materials. Participants from the Heraklion planning office were particularly interested in the construction material properties and their thermal behaviour, and discussed potential use of the information that URBANFLUXES is producing for the first time for Heraklion.

Zina Mitraka explaining the model for Heat Storage Flux estimation

10.9 Turbulent heat and CO_2 fluxes in Heraklion (Stavros Stagakis)

The URBANFLUXES methodologies for in-situ measurement and EO-based estimation of turbulent heat fluxes (Q_H, Q_E) were presented, along with the main outcomes of the project that can be potentially valuable for the sustainable urban planning in Heraklion. In this framework, the Eddy Covariance (EC) that has been recently installed in the centre of Heraklion was highlighted during the presentation, focusing on the first EC results regarding the measured turbulent heat and CO_2 fluxes for Heraklion centre. The concept of the EC source area was introduced and the modelling applications and results were presented for Heraklion EC. The evaluation of the URBANFLUXES EO-based estimation of Q_H and Q_E in Basel and London using the EC measurements in these cases studies was also presented. The participants were interested in the EO-based turbulent heat fluxes maps of Heraklion, giving particular attention to the effects of green areas on these fluxes. The positive effects of urban greenery on urban heat fluxes were noted and the absence of considerable green spaces in Heraklion was emphasized. Moreover, participants were particularly interested on the CO_2 fluxes in Heraklion, measured by the installed EC system. The effects of the traffic patterns on the CO_2 emissions were discussed with respect to the sustainable energy action plan of Heraklion municipality and the overall CO_2 emission reduction target.



Stavros Stagakis presenting the methods of in-situ measurement and satellite estimation of turbulent heat fluxes

10.10 Discussion with all participants

The discussion focused on how URBANFLUXES data can support climate change mitigation planning for the city of Heraklion. Furthermore, there was a round of questions to the URBANFLUXES Consortium on the potential of URBANFLUXES to support urban planning, urban environmental management, energy efficiency, urban governance and civil protection in the broader area of Heraklion.

The local stakeholders gave positive feedback on the usefulness of URBANFLUXES data in their efforts for sustainable planning in Heraklion. It was made clear by all participants that Heraklion still lacks efficient environmental planning and tools for environmental monitoring. Thus, the

URBANFLUXES project makes a significant contribution by upgrading the available environmental infrastructure with the most up-to-date and innovative tools.

The second CoP made clear that contacts between the URBANFLUXES team and the municipality as well as the Region of Crete have increased and have led to mutual learning. The project cooperates with the authorities to manage the measurement infrastructure and the authorities use tha data and information generated by the project.

Judith Klostermann summarizing the conclusions of the 2nd Community of Practice meeting in Heraklion

The press release of the event was extensively covered by the local press (e.g. cretalive.gr, candianews.gr, rethnea.gr).

10.11 Conclusions CoP 2 Heraklion

The municipality of Heraklion has a steady cooperation with FORTH. The outcomes of Horizon 2020 projects are useful to the municipality people and are taken into account in sustainable urban development strategies. Since 2012 Heraklion is one of the 240 smart cities of the world. It is a smart city because of instruments used in governance, civil society, and finance. However, smart tools are still lacking in environmental, urban mobility and quality of life issues. The municipality has the obligation to incorporate information from research like URBANFLUXES in their studies and proposals. It is necessary to implement changes in Heraklion to reduce the urban heat phenomenon. The priorities in the planning strategies should be an increase of green areas, the use of cool materials in construction and traffic regulations.

The Region of Crete (RoC) already has strategies for adapting to climate change. Research has shown that Crete will be influenced by climate change in the coming years. RoC representatives expect that the URBANFLUXES outputs will be very useful to them. The RoC is particularly interested in nature based solutions for the coastal area and the sea in Crete.

The urban morphometrics developed in URBANFLUXES attract participants from the Heraklion planning office, as these can be used for future urban interventions, indicating where to create green/open spaces for efficient ventilation and air flow.

The Meteorological Network in the city of Heraklion was demonstrated. The dedicated URBANFLUXES site offers meteorological data to the public in real time. For the maintenance of the network close collaboration with the city authorities is necessary.

The approach followed in URBANFLUXES to estimate the heat storage in the city of Heraklion was explained. The participants were interested to see the areas in the city with different heat storage fluxes. Participants from the Heraklion planning office were particularly interested in the construction material properties and their thermal behaviour.

The Eddy Covariance (EC) that has been recently installed in the centre of Heraklion was highlighted, focusing on the first results regarding the measured turbulent heat and CO_2 fluxes for the centre of Heraklion. The participants were interested in the EO-based turbulent heat fluxes maps of Heraklion, giving particular attention to the effects of green areas on these fluxes. The positive effects of urban greenery on urban heat fluxes were noted and the absence of considerable green spaces in Heraklion was emphasized. The effects of the traffic patterns on the CO_2 emissions were discussed with respect to the sustainable energy action plan of Heraklion municipality and the overall CO_2 emission reduction target.

The discussion focused on how URBANFLUXES data can support climate change mitigation planning for the city of Heraklion. The local stakeholders gave positive feedback on the usefulness of URBANFLUXES data in their efforts for sustainable planning in Heraklion. It was made clear by all participants that Heraklion still lacks efficient environmental planning and tools for environmental monitoring.

11 CONCLUSIONS ON USER REQUIREMENTS FOR URBANFLUXES

This report aimed to provide ideas on the potential use of URBANFLUXES end products and intermediate products in practice. The URBANFLUXES project uses satellite data to estimate spatial maps of urban energy balance fluxes related to the urban land cover characteristics, structure and human activities. These human activities comprise e.g. energy use for heating and cooling of buildings, traffic, and industrial activities.

The first interview round in the beginning of 2015 revealed that researchers see two main challenges in cities that can be addressed within the project: the reduction of urban heat and the reduction of energy use in cities. Final project outcomes that were expected are a knowledge exchange on methods between the partners; methods on how earth observation data can be used for urban climate studies; local scale maps of different urban energy fluxes; the effect of vegetation on the urban energy balance; and the spatial distribution of anthropogenic heat. The researchers acknowledged from the beginning that some of the project scientific goals are very ambitious, associated with a high level of uncertainty.

In the first round of CoPs (2015) the participants stated their knowledge needs:

- The energy system of **London** is not resilient to heat waves and peak energy demand. Anything that can be done to reduce energy demand and to reduce the proximity to a threshold helps to improve resilience. The potential benefits of URBANFLUXES for London are that it can help to identify hotspots, and it can test if interventions have a positive effect.
- For city planning activities in **Basel** it is important to receive results from the URBANFLUXES project on where the hotspots in the city are, the causes generating these hotspots and what can be done to address the hotspots. Participants are most interested in high resolution data.
- Participants in **Heraklion** have a great need for guidelines for city planning in order to adapt to climate change and to make citizens more comfortable and safe, but also for ways to make Heraklion more energy efficient. The URBANFLUXES project could help recognizing the effects of the building materials in urban heat and improving the knowledge on the hotspots of their city.

In the second interview round in 2016 the URBANFLUXES researchers 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. They also see other scientists as an important group of users. The URBANFLUXES project leads to a long list of usable products (see table). Although the researchers see many potential uses of their products, they fear that the use of some products may be limited due to their medium spatial resolution and increased uncertainty. Furthermore, there is a concern that the delay of Sentinel data would lead to limited maturity of the developed methods within the project lifetime.

Category	Products	Uses
Input data	Data that URBANFLUXES collects from various sources	• 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
Intermediate products	Data for several terms of the urban energy budget	• 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.

The end product Q_F	The anthropogenic heat factor across time and space. Daily, weekly and yearly patterns of heat production on 100x100m grid maps.	• Where energy can be saved; high energy consumption areas
		  o Bad insulation
		  o High air conditioning
		  o Transport
		• Which measures of local governments lead to improved performance i.e. less Q_F

After the second round of CoP meetings (first semester of 2017), considering the evolution of the project, we see that both the researchers and the participants of the CoP's have a clear view on what the project offers and what the cities need. The main offer of URBANFLUXES is information on Q_F, but also other interesting intermediate products to help cities with reducing urban heat and energy losses. 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. On the other hand, the participants find it difficult to work with the 100 x 100 m grid, and prefer some data to be on building scale. The project did bring specific advice for each city, namely:

- that the Q_F of **London** is very high, and that is important for this city to increase energy saving measures both for winter and summertime;
- that energy saving already seems the practice in **Basel**, but this does not solve the urban heat island effect; this city needs to do more in reducing heat storage in built-up areas and increasing evaporation and shadowing by trees;
- that **Heraklion** consumes less energy than the other two cities, but has a big urban heat problem in the summer and needs to do more in reducing heat storage, increasing ventilation, decreasing traffic in the city centre and adding green infrastructure.

The project seemed the most interesting to urban planners and city administrative CoP participants of Heraklion because they received additional measurement infrastructure that is accessible for the public in real-time. Moreover, the urban morphometrics developed in URBANFLUXES attract participants from the Heraklion planning office, as these can be used for future urban interventions, indicating where to create green/open spaces for efficient ventilation and air flow. Participants from the Heraklion planning office were also particularly interested in the construction material properties and their thermal behaviour.

Further assistance of cities in using URBANFLUXES knowledge is possible with some additional effort from the researchers, such as looking back in time with the same methods. Hopefully contacts between the research groups and municipalities will remain after the project ends so that cities can profit from the knowledge acquired in URBANFLUXES.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