The WUDAPT Project and Initial Workshop

This document provides an overview of the WUDAPT (World Urban Database and Access Portal Tools) project, a summary of the first WUDAPT workshop (held 7-9 July 2014 in Dublin), and the next steps in the WUDAPT project.

1 Overview of the WUDAPT Project

The world's population of over 7 billion is highly concentrated; over 50% live currently in urbanized landscapes that make up less than 3% of the land area of the world. Urbanization also replaces the natural cover with impermeable materials and buildings and concentrates activities, which generate wastes into the surrounding air, soil and water. Collectively, cities are one of the main drivers of global environmental change and are also uniquely vulnerable to the consequences of change (such as rising sea levels, increased air temperatures, etc.). At an individual city level, the urban environment is readily distinguishable from the background climate where the city is located; generally it is warmer and more polluted. Global urbanization will continue, especially in Asia and Africa so that within 50 years, the urban environment will be the norm for most of humanity.

The impacts of these cities on the climate at urban, regional and global scales is a topic of considerable debate but their comparatively small size poses a conundrum for researchers; how do we acquire and accommodate the relevant information into global science research? Much research has focused on mapping these urban centres using demographic and administrative information, often supplemented by remote sensing. However, these data provide no information on the internal make-up of cities, which is important for understanding their impact (and their vulnerability) yet we know very little about this. Although urban population censuses are regularly collected, there are no censuses of the built form of cities. Where some detailed information is available it is often gathered in an inconsistent manner that limits discussion or transferability between cities. The value of a database that uses consistent descriptors and gathers information at a suitable scale would be considerable. In particular it would aid the following:

- Knowledge Transfer: This would inform discussions about the character of cities and assess the potential for knowledge transfer between cities. It would also allow the comparison of city-based policies that are aimed at mitigating and/or adapting to environmental change.

- Models: A standard way of describing cities would provide us with the ability to extract useful parameters to run models at different scales. These models will allow scientists to assess climate impacts of urbanization and to examine future scenarios such as the intensity and character of urbanization changes. Many models, which are for mid-latitude, wealthy cities, will be able to be applied elsewhere, and globally.

- Risk and vulnerability: WUDAPT will provide the opportunity to evaluate the impact of global environmental change on cities. Many cities are located in topographic environments that are inherently at risk from climate-related events (such as sea-level rise). However, to assess vulnerability we need to know something of the spatial character of the city, both its infrastructure and population. This database would provide a basis for comparing risk and vulnerability in cities.

The WUDAPT project will develop and test an urban classification scheme using a combination of remote sensing, locally-based urban experts and crowdsourcing (using Geo-Wiki and other crowdsourcing tools). The project has two main components:

1. Gather basic information on a number of global cities using the Local Climate Zone (LCZ) classification scheme (Stewart and Oke, 2012), which describes the character of the urban landscape at a scale of about a sq. km. This part would be done using remote sensing in collaboration with an urban expert with local knowledge.

2. Acquire more detailed information of relevance to weather, climate and other models (material composition, street layout, building types, and various urban morphological descriptors) on these cities using web (and mobile phone) based technology and crowdsourcing. This information can be acquired from online sources but also requires 'on-the-ground' data collection, and by completing the first part, the information gathered here can be placed in context.

Such a proposed multi-purpose urban database could be employed in a number of contexts, including studies of weather and climate effects at different scales, the impact of climate change on cities and to assess the potential for modifying urban form to adapt/mitigate to these changes. Such a database will also be applicable to a wide range of other applications, e.g. energy and greenhouse gas assessment, air pollution modelling, etc.

2 Workshop to Initiate the WUDAPT Project (7 to 9 July 2014)

The objectives of the first WUDAPT workshop were:

- To develop a protocol for a global city database through discussions with experts in remote sensing, urban climate modelling, numerical weather prediction, energy balance modelling, planning, architectural design and the built environment, IT, GIS, land cover / land use and crowdsourcing
- To train local urban experts in developing the database for their city, which is then used to run a simple energy balance model
- To test the first draft of the training materials, which will be circulated more widely in Sep 2014
- To discuss the way forward in terms of future workshops, conferences and funding opportunities.

In addition to the organizers (Jason Ching, Gerald Mills, Linda See) and three local staff who helped with the training (Paul Alexander, Michael Foley and Martin O'Connor), there were 27 people who attended the workshop from 19 countries around the world. Appendix I provides a list of attendees, where funding was provided by several sources including the COST Action TD1202 Mapping and the Citizen Sensor, Argonne National Laboratory, University College Dublin, the German funded REDD-PAC project and the European funded CrowdLand project. The agenda of the workshop is provided in Appendix II.

Workshop Outcome 1: Developing a protocol for a global city database

Although WUDAPT has many potential uses and applications, the workshop focussed on the needs of the climate modelling community, particularly regional and urban-scale models. Global models have

horizontal resolutions of around 50 km and the urban footprint may just occupy a portion of one tile. Regional modelers and urban-scale researchers are interested in urban structure at a more detailed level. Regional models would have a resolution of about ½ km and therefore require more detailed information on heights of buildings, vegetation, etc. for urban canopy parameterizations. Urban-scale researchers are interested in even more detailed processes, where much of this community studies phenomena (e.g. the Urban Heat Island effect) that involve observations at micro-scales.

The protocol for the global city database has been divided into three levels of acquisition:

1. **Level 0** data is a basic geographic description of cities using the LCZ categorization scheme (Stewart and Oke, 2012). This divides the city landscape into similar neighbourhood types. These LCZs have associated generic ranges of urban canopy parameter (UCP) values. A workflow was devised by Benjamin Betchel and the local urban experts were trained in creating LCZ maps for their cities (see Outcome 2).

2. **Level 1** data is a more detailed examination of the urban landscape using the LCZ for a city as a sampling frame. Randomly selected areas within each LCZ are used to derive urban canopy parameters. The Cities Geo-Wiki branch was set up to collect one set of UCPs for Dublin, i.e. fractional land cover at a resolution of 100 m^2 to match the resolution of the LCZs. The local urban experts were provided with a brief training on this application (see Outcome 2).

3. **Level 2** data consists of the entire suite of desired UCPs parameters gathered wall-to-wall across the urban landscape.

Much of the subsequent workshop discussion concentrated on how to standardize the collection process, it identified the key UCPs needed and we discussed how best to store and disseminate the data acquired. Level 0 was agreed upon at the outset but Levels 1 and 2 required considerable discussion. A key issue was scale. Initially it was decided to focus on a minimum grid size for data collection, e.g. 100 m^2 using Geo-Wiki. However, it soon became clear that this would impose constraints on the subsequent use of the data. For this reason it was decided to move away from a sampling unit that consists of a minimum grid size and instead focus on sampling at points. The eventual WUDAPT portal would then allow modelers to aggregate the data to the grid size corresponding to their own models and their own modelling needs.

Appendix III contains the basic variables out of which the UCPs can be derived and how they could be obtained (depending on data availability). The initial focus will be on gathering land cover data using Geo-Wiki and the development of protocols for taking photographs on the ground.

Workshop Outcome 2: Initial development of WUDAPT for cities around the world

This workshop was a first attempt to gather information for a number of selected cities, focusing on Level 0 data. Local urban experts were trained in the methodology to create LCZ maps for their cities using data from Landsat and the open source SAGA software, which contains functions for image classification. Prior to the workshop, participants identified distinctive LCZs in their cities for use as training data (using a video on how to use Google Earth to capture representative areas and how to store the data as a Google kmz file). The LCZ classification process was iterative and the local urban experts were shown how to

implement the process and then how to improve their maps. The end result was initial LCZ maps for the following cities (in addition to Dublin, Hamburg and Houston, which were developed in the past): Beijing; Coimbra; Colombo; Como / Milan; Lahore; Khartoum; Kolkata; Medellin; Nantes; Sao Paulo; Vienna; Viktoria; and Wageningen, with one of the Brazilian participants agreeing to do Bel Horizonte in the future. At this stage, the LCZ can be linked to the range of canopy values provided by Stewart and Oke (2012).

On the afternoon of day 2, the experts were led through a simple exercise using Geo-Wiki to acquire UCPs, in particular fractional land cover in 100m grid cells sampled randomly across different LCZs, and how to collect an independent dataset to validate their LCZ maps. Due to the way Geo-Wiki is currently set up, it was not possible to load the completed LCZ maps from Day 1 of the workshop onto the system and create samples for data collection and validation. Therefore Dublin was used as an example so that the participants could understand how the data could be collected in the future. More time was then available for working on the development of their LCZ maps.

On the morning of day 3, the experts were shown how to run a simple energy budget model called LUMPS (Local-Scale Urban Model Parameterization Scheme) using a few different cities as an example.

Workshop Outcome 3: Ways forward

On day 3 we discussed a number of issues related to how to take the WUDAPT project forward. These can be summarized as follows:

1. Next WUDAPT workshop: This will be held in conjunction with the IAUC (International Association of Urban Climate) meeting in Toulouse in the summer of 2015. The idea would be to have a set of WUDAPT papers presented at the workshop and to have a training session on preparing LCZ maps, with an emphasis on African participation.
2. Marina Neophytou mentioned a summer school that she is organizing in 2015 where the materials could be used as part of this training event. Other opportunities will be investigated regarding where the materials could be incorporated into other summer schools and training workshops.
3. Funding opportunities: A short presentation was given on different potential funding opportunities for WUDAPT. A summary is provided below including where funding has now been applied for.
    - Horizon 2020: needs to be looked at carefully for 2015 calls
    - COST network funding: postponed until 2015 but could be a good way of building a European network for WUDAPT
    - Central Europe 2020: Linda See, Grega Milcinski and Tamas Gal agreed to look into the workplan for this funding source and develop a proposal under the smart cities theme
    - SESYNC funding for a PhD student project: A proposal has been drafted to advance the WUDAPT concept with a focus on anthropogenic heating to be submitted by four PhD students who attended the workshop in addition to the PhD student of Prof Maria Brovelli (deadline 30 Jul)
    - Prof Chandana Mitra submitted an NSF proposal for implementing WUDAPT across 40 Indian cities (deadline 21 July)
    - NASA Roses / ESA IAP funding / NSF GSS funding / GEF / World Bank / other national sources of funding / Asia Pacific funding / various foundations / commercial / Google Faculty Research Awards: sources need to be kept in mind and pursued

4. WUDAPT website, portal and training materials: A WUDAPT website will be set up by September where the training materials will be available. A presentation was made by Grega Milcinski of his online GIS tool (Geopedia/Hercules). It was agreed that this would provide a free visualization tool for hosting the WUDAPT data.
5. Moving forward on Level 1 and 2 data collection: It was agreed that Geo-Wiki would be modified to collect land cover at points distributed at 30m intervals across Dublin as a test case for calculating areal fractions of varying grid sizes. If successful, this will be rolled out to the other cities for which LCZ maps have been created. We will then move forward on other variables listed in Appendix III, including the development of a mobile app for data collection on the ground and classification of photos from Google Streetview, Flickr and Panoramio.

References

Stewart, I. D., & Oke, T. R. (2012). Local climate zones for urban temperature studies. Bulletin of the American Meteorological Society, 93(12), 1879-1900

Appendix I: WUDAPT Workshop Participants

Participant	Affiliation
WUDAPT Developers, Modelers, Architects, IT Specialists	
Paul Alexander (PA)	National University of Ireland Maynooth, Ireland
Benjamin Bechtel (BB)	University of Hamburg, Germany
Jason Ching (JC)	University of North Carolina, USA
Beth Drewniak	Argonne National Laboratory, USA
Rowan Fealy	National University of Ireland Maynooth, Ireland
Johan Feddema (JF)	University of Kansas, USA
Michael Foley (MF)	University College Dublin, Ireland
Tamas Gal (TG)	University of Szeged, Hungary
Adel Hanna (AH)	University of North Carolina, USA
Valery Masson (VM)	Meteo France, France
Grega Milcinski (GMilc)	Sinergise, Slovenia
Gerald Mills (GM)	University College Dublin, Ireland
Chandana Mitra	Auburn University, USA
Marina Neophytou (MN)	University of Cyprus, Cyprus
Martin O'Connor (MO'C)	University College Dublin, Ireland
Linda See (LS)	IIASA, Austria
Gert-Jan Steeneveld (GJS)	Wageningen University, The Netherlands
Ian Stewart (IS)	University of Toronto, Canada
Xuemei Wang	Sun Yat-Sen University, China
Urban Experts	
Taciana Albuquerque	Federal University of Minas Gerais, Brazil
Maria de Fatima Andrade	University of Sao Paulo, Brazil
Maria Brovelli	Politecnico de Milano, Italy
Debashish Das	Jadavpur University, India
Cidalia Costa Fonte	University of Coimbra, Portugal
Gwendall Petit	Institute for Research on Urban Sciences and Techniques, France
Uzma Hanif	Government College University Lahore, Pakistan
Jose Jimenez	National University of Colombia, Colombia
Stefan Lackner	University of Vienna, Austria
Weibo Liu	University of Kansas, USA
Narein Perera	University of Moratuwa, Sri Lanka
Nur Aulia Rosni	International Islamic University Malaysia, Malaysia
Nathalie Theeuwes	Wageningen University, The Netherlands

Appendix II: WUDAPT WORKSHOP AGENDA

The workshop was divided into plenary sessions/discussions in the morning and parallel sessions in the afternoon where the local urban experts undertook a series of practical exercises on creating an LCZ map for their city, using Geo-Wiki to extract information on UCPs and running LUMPS, a simple energy budget model. The plenary/discussions were focused on how WUDAPT will operate, the best way of acquiring urban data in a consistent manner, the types of data and the best means of gathering it and how to store, manage and access the database.

Day 1	**Topic**			**Leader(s)**
0900	Welcome and Overview of Project			JC,GM,LS
0930	Overview background of LCZ: gathering Level 0 urban data			IS
1000	Remote sensing and automating of LCZ			BB
1030	Coffee			
1100	Workshop Outcomes / Applicability of LCZs			All
1230	Lunch			
1400	Scope of WUDAPT	JC, JF, VM	**Creating LCZs**	BB
1500	Data management	JC, AH		MF, MO'C
1600	Archiving and accessing			
1700	Review			All

Day 2	**Topic**			**Leader(s)**
0900	Climate models			JC, JF, VM
0930	Urban parameterization			
1000	GeoWiki			LS
1030	Coffee			
1100	Model requirements, issues of scale, experiences from Hungary			JGS, MN, TG
1145	Panel: Acquiring urban parameters and LCZ			All
1230	Lunch			
1400	Open discussion on Level 1+ urban data	JC, JF, VM	**Geo-Wiki + Creating LCZs (continuation)**	LS
1500	Developing tools	JC, AH		MF, MO'C
1600	Modeling/Methodological applications			
1700	Review			All

Day 3	Topic	Leaders	Practical	
0900	Results of LCZ practice	JC, JF, VM	**LUMPS model**	PA
1000	Results of GeoWiki	JC, AH, GrM		MF, MO'C
1100	Establishing a protocol			
1230	Lunch			
1400	GeoPedia and Hercules: Potential solutions for the WUDAPT Portal / Visualization			GMilc
1415	Developing WUDAPT: Funding sources, expanding database, ICUC9			JC,GM,LS
1530	Disseminating information, follow-up work and papers			All
1700	Close			

Appendix III: Collection of Urban Form Variables

This table summarizes the variables that need to be collected and which will then be used to derive the model parameters within the portal. The first implementation will be the land cover collection via Geo-Wiki. Johan Fedema and Ian Stewart are currently working on a protocol for how photos should be taken using a mobile app.

Urban Form	Variable	Choices	Method of Collection	Priority
Cover	Land cover	Building Deciduous trees Coniferous trees Grassland Bare soil Impervious surface (roads, parking)	The centroids of a 30m grid (Landsat-based) will be used to collect land cover data, which can then be turned into areal fractions in the WUDAPT portal. This will be implemented using Geo-Wiki.	High
	Vegetation type	More detailed plant functional types	1. Photos from Google StreetView, Flickr, Panoramio 2. Data collection using mobile apps	Medium
	Vegetation organization	Street tree Garden Agriculture Others TBD	1. Photos from Google StreetView, Flickr, Panoramio 2. Data collection using mobile apps Agriculture can be determined from land cover above	Medium
Geometry	Building height	Number of floors or height in m	1. Photos from Google StreetView, Flickr, Panoramio 2. Data collection using mobile apps	High
	Width of streets	Measurement in m	Manual measurement from satellite imagery, aerial photos, OpenStreetMap implemented in either Geo-Wiki or GeoPedia sampled across different LCZs	Medium
	Contiguous or isolated buildings	Contiguous Isolated	1. This could be implemented as part of the land cover collection in Geo-Wiki 2. If building footprints or OSM building data exist, this could be calculated automatically	Medium
	Roof geometry	Flat Sloping OR Angle in degrees	1. Photos from Google StreetView, Flickr, Panoramio 2. Data collection using mobile apps	Low
	Wall type	TBD	1. Photos from Google StreetView, Flickr, Panoramio 2. Data collection using mobile apps	High
	Roof type	TBD		High

Urban Form	Variable	Choices	Method of Collection	Priority
Material	Window type	TBD		Medium
	Road materials	TBD		Low
	Window fraction on the wall	Number of windows or estimate of percentage of area		Medium
	Color/Albedo	TBD		Medium
Function	Building use	Residential Commercial Industrial Mixed TBD	1. Building stock database (if available) or information in OSM? 2. Estimates from photos 3. Data collection using mobile apps	High
	Irrigation	Yes / no	Data collection using mobile apps	Medium
	Road type	Need to find more universal road type nomenclature		Low
	Temperature setting	Tmin and Tmax	Data collection using mobile apps, e.g. survey tool	High
	Occupancy	Number living in the house	1. Detailed census data (if available) 2. Estimates from photos	Low
	Air conditioning	Yes / no	Data collection using mobile apps	High
	Shutters/shading	Types TBD	Data collection using mobile apps	Medium
	Window opening	Yes/no	1. Photos from Google StreetView, Flickr, Panoramio 2. Data collection using mobile apps	Low
	Building age	Date	1. Building stock database (if available) 2. Estimates from photos 3. Survey of local knowledge	Medium
	Building renovation post 1990	Yes/no	Survey, to be discussed further	Medium