Institution: University of Birmingham

Unit of Assessment: UOA 7 – Earth Systems and Environmental Sciences

Title: Adapting to the impact of climate change on Birmingham's urban heat island

1. Summary of the impact

Extreme heat events are likely to occur more frequently in a warmer future climate. Cities worldwide are concerned that the urban heat island effect will exacerbate the impact of climate change on urban populations and infrastructure. The UK government expects local councils to play a vital role in making sure the country is prepared for climate change. Birmingham City Council, the largest local authority in the UK, has worked in partnership with the University of Birmingham (UoB) in the BUCCANEER project (*Birmingham Urban Climate Change Adaptation with Neighbourhood Estimates of Environmental Risk*). The city has drawn extensively on BUCCANEER to design climate resilience into their city systems. The project has had public policy impact by informing the City's influential Green Commission and by being included in the City Council's new development Guidance — **urban temperature change has become a mandatory factor to be considered for every new development** requiring permission in the city. The guidance explicitly points developers towards BUCCANEER as the tool with which to consider this factor. A second public policy impact derives from the value of the tool for health planning: a significant proportion of the inner-city population is particularly vulnerable to extreme temperatures through age or ill-health and live where the heat island effect is shown to be largest. This aspect is now being increasingly employed by Public Health analysts and managers in the city. As a result of the city/university partnership, Birmingham has been recognised by the European Union as a Peer City and source of best practice for urban climate resilience.

2. Underpinning research

The Urban Heat Island (UHI) is a direct consequence of urban built form and anthropogenic influences on our local climate. A reliable prediction tool must be underpinned by a comprehensive understanding of the land-use characteristics relevant to the UHI and of key land-atmosphere energy exchange processes. The Meteorology and Climate Group (part of the Environmental Health Sciences theme) at the University of Birmingham (UoB) have carried out extensive research on this issue since around 2003. The research has embraced two areas: urban meteorological/climate modelling and urban climate observation.

Urban meteorological/climate modelling: Insight into the land-surface processes over a conurbation was gained initially through 3D meteorological modelling of the West Midlands led by Dr. Cai (Senior Lecturer) as part of a NERC-funded consortium project, PUMA, led by Prof. Harrison (references 3a, 3b and 3c). Further development of a state-of-the-art 3D urban meteorological model allowed careful investigation into the major characteristics of London's UHI and its impact on London's regional climate (3d). Contributing researchers were J. Salmond (Lecturer, 2002 – 2006), H. Thompson (doctoral student 2004 - 2008) and D. Grawe (National Centre for Atmospheric Science Fellow 2004-09). The work described in the case study is, therefore, derived from generalised results from different cities and can be applied to cities other than Birmingham with the appropriate data input.

These studies have underpinned the BUCCANEER project, which employed a local-equilibrium energy balance model and a statistical model. The energy balance model used was the national-capability JULES model, which is the land-surface scheme for UK global climate modelling. The BUCCANEER project has led to a NERC-funded CASE studentship focusing on developing a generic methodology of correcting the UHI pattern from a local-equilibrium model by incorporating the wind advection effect derived from a 3D meteorological model.

Urban climate observation: The on-going NERC-funded HiTemp project (High Density Temperature Measurements in the Urban Environment: NE/I006915/1) has enabled the establishment of the Birmingham Urban Climate Laboratory (BUCL). The project is transforming the city into a unique, world-class climate facility consisting of an array of over 250 wi-fi air temperature sensors nested within a coarser array of 30 weather stations (uniqueness established in critical review 3f). The fundamental issue of establishing a standardised protocol for urban meteorological networks (3e) underpins BUCL and, hence, BUCCANEER. The observations provide particularly challenging datasets for model evaluation and are now being used directly to

evaluate the impact of current and future climate on the people and infrastructure of Birmingham. For example, AMEY (holder of a 25 year PFI contract with BCC) are already incorporating BUCL data in a winter maintenance forecasting project funded by the Technology Strategy Board.

The BUCCANEER project also drew on research conducted within Geography by Cai's colleagues at Birmingham on the in the areas of remote sensing, GIS mapping, and environmental risk assessment. They are: Thornes (Professor, 2006-2011), Chapman (Lecturer (L) 2009-2010, Senior Lecturer (SL) 2010-2013, Reader (R) 2013-), McGregor (L/SL/R 1993-2005), Bouzarovski (SL 2010-2012), Young (PDRA, 2011-2013), and Muller (PDRA, 2011-).

3. References to the research

University of Birmingham staff are underlined. The outputs that best demonstrate the quality of the research are given in **boldface**.

a) Cai, X.-M., Y. Zheng and G.R. McGregor, 2002, Modelling of meteorological conditions at an urban scale for the PUMA winter campaign, Physics and Chemistry of the Earth, 27, 1479-1485.

b) Baggott, S., X.-M. Cai, G.R. McGregor, and R.M. Harrison, 2006: Model simulation of meteorology and air quality during the summer PUMA intensive measurement campaign in the UK West Midlands conurbation, Science of the Total Environment, 360, 26-42.

c) Cai, X.-M., G.R. McGregor, R.M. Harrison and D. Ryall, 2007: Modelling of Meteorological Conditions at an Urban Scale for the PUMA Campaigns. Meteorological Application, 14, 311-326.

d) Grawe, D., H.L. Thompson, J. Salmond, X.-M. Cai, K.H. Schluenzen, 2013: Modelling the impact of urbanisation on regional climate in the Greater London Area, *Int. J. Climatology*, 33, 2388-2401. DOI: 10.1002/joc.3589

e) Muller, C., L. Chapman, D. Young, C.S.B. Grimmond and X.-M. Cai, 2013: Towards a standardised protocol for urban meteorological networks, Bull. Amer. Meteor. Soc., DOI: 10.1175/BAMS-D-12-00096

f) Muller, C., L. Chapman, C.S.B. Grimmond, D. Young and X.-M. Cai, 2013, Sensors & The City: A Review of Urban Meteorological Networks, Int. J. Climatology, first published online, DOI: 10.1002/joc.3678

4. Details of the impact

The UK government Department for Communities and Local Government have stated that *"local councils play a vital role in making sure the UK is prepared for the impacts of climate change at a local level. They provide many services that will be affected by climate change. This will present different challenges to each area, and local councils are free to decide how best to address these challenges and take advantage of any opportunities."* [source 1]

Birmingham City Council, the largest local authority in the UK, have worked in partnership with UoB researchers in the BUCCANEER project and drawn extensively on their research to inform the City's approach to adapting to the increasing risk of extreme temperatures posed by the combination of urban heat and climate change. The adoption of the BUCCANEER tool is clearly demonstrated in the City's Climate Change Adaptation Action Plan, in its planning framework and in its emerging approach to identifying the effect of extreme temperatures on its most vulnerable residents (such as the elderly and people in poor health). The work has achieved impact on public policy through helping the City underpin its strategic direction on this crucial issue and providing a novel operational tool for use in spatial planning; there are further health benefits from its adoption by public health analysts in the City.

The partnership work between the Council and the UoB research team is continuing with the HiTemp project which is viewed by the Council, along with the ongoing NERC CASE studentship, as the means for informing the next stages of their work on climate change adaptation.

BUCCANEER – a university / city council partnership

This partnership between the City Council and UoB was fostered through Birmingham's Climate Change Adaptation Partnership which was established in 2008. The Partnership planned to understand the risks to people and places from the UHI and climate change but a lack of research meant that only a blanket approach to understanding heat distribution across Birmingham could be

used. In order to understand the local risks, a new tool was required [sources 2 and 3].

UoB research delivered a tool that now enables the City Council to conduct spatial risk assessments. The BUCCANEER project established a new web-based planning tool based on the modelled UHI maps, and was first made available to the Council in 2011. The tool is available at http://www.birminghamclimate.com/ for free public use by arrangement with the UoB team.

The tool enables mapping of Birmingham's UHI up to 2100, together with transport, health, air quality, housing, population and life expectancy, in order to help identify vulnerability and risks for people and places. It also contains a green infrastructure assessment function and the ability to export layers into Google Earth for 3D mapping as a communications tool. The BUCCANEER tool has been demonstrated to a wide range of council services and external organisations, including the Environment Agency, the NHS, Public Health England and Natural England, and has been widely welcomed.

The partnership work on this issue has won two major awards: (a) the Local Authority Research and Intelligence Association (LARIA) award in 2010 for ground-breaking GIS risk mapping research, and (b) a Lord Stafford Award for Innovation for Environmental Sustainability in 2012.

BUCCANEER's contribution to Birmingham's Green Vision for an adapted city

The overarching approach to mitigating and responding to climate change in Birmingham has formed a crucial aspect of the work its Green Commission [source 4] and its subsequent Green Living Spaces Plan (publication consultation draft issues December 2012; adopted by City Council September 2013) [source 5]. The novelty of the city's green vision is stated explicitly: *"No other UK city has undertaken such a comprehensive combined evaluation and mapping exercise. This has produced a totally new map series of the city …[which are the] new evidence bases that the city must work with, in the near future with all its stakeholders, public, private and citizens to collectively address these leading green city challenges."* Councillor James MacKay, in [source 5]

The Green Living Spaces Plan links the issues of climate change, public health and spatial planning as a key ingredient of the city's future planning framework, and informs other detailed policies. Principle 1 in the plan is *"an adapted city"*; the case study used in the Plan for this principle is BUCCANEER. The Plan says the use of BUCCANEER means that "*for the first time decisions can be taken with consideration of the varying heat stress across the City caused by the urban heat island and the likely impacts of climate change up to 2100… Thanks to BUCCANEER and the follow-on studies Birmingham has become recognised by the EU as a Peer City; and the city is building an international reputation for its climate modelling*" (p.13).

City Council planning policy and guidance

The use of the BUCCANEER tool was identified in the City Council's public consultation on its Core Strategy for sustainable growth [source 6], where its proposal on adapting to climate change said that their Development Management process would be used to ensure that all new developments requiring permission would include measures to reduce the impact of extreme heat. The document highlights the role of BUCCANEER as the principal means to implement this approach; the tool enables the identification of areas most vulnerable to extreme heat and demonstrates the impact of adaptation measures, as well as having the potential to inform future planning decisions (paras 5.38-5.40).

Subsequently, the Council issued its public consultation version of its Detailed Supplementary Planning Policy Guidance [source 7]; this is the guidance which all developers need to consider when submitting planning applications anywhere in the city. Section 3 of this guidance focuses on Green Infrastructure and Climate Change Adaptation, and sets out the requirements on developers to show, with evidence, that they have taken account of the Council's policy on climate change adaptation. It states: *"Birmingham's approach has been to use Geographic Information System (GIS) mapping (BUCCANEER Project) to understand the varying degree of climate change impact across the city on two key areas:*

- *Temperature and UHI*
- *Flood risk*

Developers need to take into account this mapping to assess how extreme weather and climate

impacts will vary depending on their site location."

The Council expects **all new developments** in the city to minimise overheating and reduce the reliance on air conditioning. Site layout and building design can help to reduce the UHI effect making developments more resilient to increased temperatures as a result of climate change. This Guidance was formally adopted by the City Council in September 2013. [source 8]

BUCCANEER and planning for public health

As well as the spatial planning measures, Birmingham's Climate Change Adaptation Partnership has also been concerned with the public health implications of higher temperatures in the city. BUCCANEER is being used as one of the tools to identify which communities are likely to need the most help to adapt to the effects of climate change. Often in cities, much of the most-deprived population lives in densely-populated areas subject to UHI effects, with consequent implications for public health planning. The development of the tool helped demonstrate the significance of this issue to senior public health officials in the City (Public Health Lead | Policy & Regulation). The practical value of data on temperature extremes is now being considered when analysing issues like the pattern of hospital admissions for lung conditions and asthma and COPD (Chronic Obstructive Pulmonary Disease) in Birmingham. As well as assessing the clinical aspects, they are also looking to include the wider determinants and risk factors such as air quality/pollution and climate/temperature as provided by the BUCCANEER tool.

Wider use of BUCCANEER

There is also evidence that other organisations are using the BUCCANEER tool. For instance, the major energy company E.ON have confirmed that they used the BUCCANEER tool when assessing the potential for investing in a combined heat and power solution for the new New Street Station, and said that *"the tool clarified the primary long term need for cooling as opposed to heat and helped us better understand future demand profiles"*. [source 9]

Birmingham Airport's Climate Change Adaptation Report (May 2011) says that the Airport Company have agreed to share information with the City Council to use BUCCANEER, and notes the potential advantage of having a far greater resolution (500m) than the 25km of the national tool, known as UKCP09 [source 10, p.14].

5. Sources to corroborate the impact

Source 1 - https://www.gov.uk/climate-change-adaptation-information-for-local-authorities,
source 2 - Birmingham Climate Change Adaptation Action Plan 2012+:
http://www.bebirmingham.org.uk/uploads/BCCAAP_final.pdf
source 3 - Buccaneer_Lord_Stafford_application_submitted_2012
Source 4 - Birmingham's Green Commission: http://www.birmingham.gov.uk/greencommission
Source 5- Green Living Spaces Plan http://www.birmingham.gov.uk/greeninfrastructure
Source 6 - Birmingham Core Strategy 2026: a plan for sustainable growth
http://www.birmingham.gov.uk/corestrategy - , issued December 2010
Source 7 - Places for the Future - Detailed Supplementary Planning Document (SPD) Guidance - Draft for Public Consultation (February 2012): http://www.birmingham.gov.uk/placesforthefuture
Source 8 – Birmingham City Council, Cabinet meeting decision, 16th September 2013
Source 9 - Birmingham - climate change and vulnerable communities
http://www.local.gov.uk/web/guest/health/-/journal_content/56/10171/3510483/ARTICLE-TEMPLATE
Source 10 -Birmingham Airport, Climate Change Adaptation Plan, May 2011