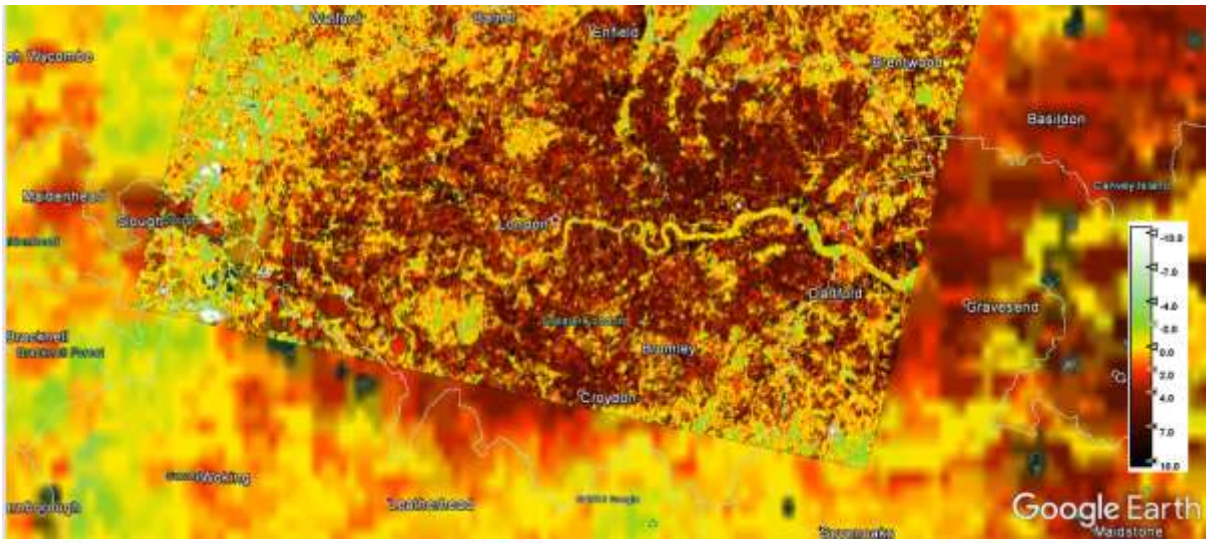
Heat data and vulnerability

EVENT REPORT

29 November 2019 10:00 – 13:00
Room 304, Nobel House, Smith Square SW1P 3JR and online



National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

UNIVERSITY OF LEICESTER

UKRI Natural Environment Research Council

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EXECUTIVE SUMMARY

The Heat data and vulnerability event brought 33 professionals from across the research, industry and policy communities. to start a conversation about the potential to obtain and use data to create a heat vulnerability index for cities, or a similar information product to support implementation, measuring progress, and monitoring risk across a range of different needs and sectors. This report summarises the key discussion points that emerged during the workshop.

The workshop took place on the 29th November and was chaired by Kristen Guida, manager of the London Climate Change Partnership. The structure included a series of talks and presentations, providing insight into the heat data challenges faced by, and requirements of, a range of professionals including those from city decision making, environmental health, and the Committee on Climate Change. Discussion also included activities to develop vulnerability datasets and new heat datasets available from the Earth Observation science community.

In light of the talks, delegates were asked to consider and discuss:

- What is needed by people trying to implement and monitor adaptation in relation to heat
- What are the data challenges and next steps – ensuring that data is relevant

Key messages and issues raised by workshop participants:

- There is potential to link urban heat and impacts for the use and effectiveness of green infrastructure – and to understand the limits of GI interventions
- Opportunities exist to influence and set priorities for future earth observation missions – a few user requirements were identified, for example, the ability to see the impact of smaller areas of vegetation.
- Heat and other with other socioeconomic and asset level information can be combined to meet a range of user needs in understanding and promoting resilience
- We still need to understand the viability of the adaptation messages we're recommending, and linked to this, consider why people are vulnerable. For example, specific health problems v. limits on mobility that lead to lots of time spent indoors.
- Still links to be made with other agendas – including air pollution and contaminated land.

A number of positive steps forward were suggested by the workshop participants:

- A further technical workshop to scope the possibility of a heat vulnerability index with uses for multiple cities and sectors/users
- The Committee on Climate Change to follow up with researchers to consider thresholds and how to use a baseline of socioeconomic vulnerability data.

The organisers

SPACE4CLIMATE

Space4Climate, a member of the London Climate Change Partnership, works to raise the profile of, and support, the UK's world-leading climate community in delivering, sustaining and making use of trusted climate information from space. Space4Climate is hosted by group member the National Centre for Earth Observation (NCEO), a distributed NERC centre of over 100 scientists from UK universities and research organisations, providing national capability in Earth observation science – monitoring the health of our planet through satellite instruments and more – with world-class capability in interpreting these data. S4C brings this capability to LCCP, and is constantly looking for ways in which, where appropriate, climate satellite data can help inform:

- climate emissions detection and monitoring
- action to identify, better cope with, and prevent detrimental impacts of climate change in London on people, assets, infrastructure and business operations.

LONDON CLIMATE CHANGE PARTNERSHIP

The London Climate Change Partnership (LCCP) is the centre for expertise on climate change adaptation and resilience to extreme weather in London. LCCP is comprised of public, private and community sector organisations that have a role to play in preparing London for extreme weather today and climate change in the future.

Through its network, LCCP coordinates activities among different partners, from all different sectors and organisations, with the intention of protecting London against the impacts of climate change. This means helping to work out what climate change will mean for London's services, communities, and sectors, and how we can work in partnership to devise robust and viable solutions.

The workshop

Potential participants were identified through their existing national heat/vulnerability related activities and work presented previously to, or resulting from, the LCCP Heat Risk sub group. The Space4Climate group also made several additional attendee recommendations given the potential additional use of the satellite heat data for national indicators, contaminated land risk analysis and monitoring and vegetation health, stress and extent monitoring.

SPEAKERS

Brendan Freeman
Lead Analyst, Committee on Climate Change

Dr. Darren Ghent
Senior Research Scientist. National Centre for Earth Observation (NCEO). University of Leicester

Gemma Holmes
Senior Analyst, Committee on Climate Change

Kristen Guida

Manager, London Climate Change Partnership, Greater London Authority

Matt Ellis
Climate Resilience Officer, Greater Manchester Combined Authority and Environment Agency

Tamara Sandoul
Policy Manager, Chartered Institute of Environmental Health

Professor Sarah Lindley
Professor of Geography, University of Manchester

Session 1 – background and purpose

New, validated, open access, longitudinal satellite heat datasets have been developed. The Space4Climate group felt knowledge of this data could be helpful to LCCP partners in their work to understand, mitigate and adapt to heat related impacts on buildings, infrastructure and vegetation, in light of climate change. In discussion with Kristen Guida, manager of LCCP, it was felt that knowledge of this data and the discussions it would no doubt provoke around vulnerability, risk and intervention monitoring were a discussion many other cities and national bodies would wish to be part of.

LCCP's Heat Risk in London sub group has a long history of providing a platform for researchers and practitioners from the built environment, public health, research, and policy sectors to come together to share challenges and evidence for robust approaches to monitoring both heat risk and efforts to reduce detrimental impacts of heat posed by climate change.

The workshop was designed to bring together perspectives from different cities across the UK, and from national bodies to help understand heat related adaptation progress, but also different user needs when it comes to data and user information. The structure provided the opportunity for different sectors and organisations to share achievements and challenges to date and for all to think about the interdependencies between health, built environment, natural environment, policy and practice in terms of environmental (natural and human) health. The workshop provided an opportunity to take stock of types of data and indexes we already have and to discuss whether existing and new data is usable for evidence informed decision making in policy and practice, particularly for cities.

The workshop also had the objective of facilitating consideration of the potential to develop a heat vulnerability index for cities, usable across different user needs and cities across the UK. At the heart of the workshop was a chance for delegates to discuss what we could aspire to, with regard to heat data and vulnerability indexes, rather than making do with what's currently known and available.

Session 2 – City challenges – data and implementation challenges

London: Kristen said that there is an early effort to monitor how well London is doing to adapt to climate change. The challenges have related to finding data to illustrate the different aspects of risk, and especially vulnerability. There has been more of a focus on indicators of adaptation – for example amounts of green space installed or numbers of homes retrofitted. However, there is a question about targets – how much adaptation is enough? In relation to social vulnerability, the Climate Just framework has been useful in terms of understanding and promoting understanding of who is vulnerable and why. However, there has been less progress in making sure that this

understanding is being used for monitoring or informing real decision-making so that things are done differently. The GLA is currently scoping a project to look into this in greater detail and understand barriers to action.

Manchester: Matt Ellis told the group about the IGNITION project, an EU funded project seeking innovative approaches to financing green infrastructure retrofit. IGNITION is not about new approaches to adaptation. it is about working out how to bring well known nature based (Suds, street trees) projects into pipelines and understand the value flows and business models they provide (e.g., health costs avoided). Then at scale, build business cases to engage with investors and, assuming projects and funding match, develop the procurement, governance and delivery processes needed to deliver the programs on the ground at the scale needed.

Better understanding of heat hazard events, the exposed populations, and the likely impacts (particularly health) can help build a business model. Can the data show us how many events vulnerable exposed populations would experience and can evidence of the costs of that exposure then be transposed in to costs avoided? Could the data be examined to show the mitigating effect of adaptive—ideally nature-based—actions, and the costs of implementing these then considered against the negative costs avoided, thereby building a conceptual business model to engage around with investors and decision makers?

Session 3 – Monitoring adaptation in the UK: indicator categories and assessment limitations

The Committee on Climate Change representatives provided a brief overview of their indicator framework which enables the Committee to assess trends in risk factors: hazard, vulnerability and exposure. They also collect indicators to assess trends in adaptation action and impacts. In the most recent 2019 Progress Report to Parliament, the Committee set out their wish list of priority indicators for assessing progress in adaptation in Appendix B. Within those none were specific to urban areas, but are the types of indicators that could make use of satellite data.

For their work on the built environment, in the latest progress report, the Committee looked at overheating in homes (often small scale studies that are now a few years old) and assessed demand for air conditioning units (but don't have actual sales data). The NHS and SDU have started to collect overheating data in hospitals. The Committee also looks at net gain/loss of urban green space using OS map (only for England). The wish list included more data collected by government on vulnerability in health care facilities, particularly overheating in care homes, to better understand the issue; currently a lot of the evidence is anecdotal. There are gaps in knowledge of current overheating risk in existing housing and in guidance on how to target cooling strategies. The Committee has requested an impact indicator to monitor overheating and indoor air quality in existing and new build, including the number of incidences of overheating exceedances, and number of homes currently adapted to overheating. The government has set up research to better understand the magnitude of overheating in existing homes in England.

The Committee is interested in linking urban heat to impact on natural green infrastructure within the urban environment and wants to disentangle climate drivers from other socio-economic drivers. They have also requested information on number of SUDS installations, would like to have a better understanding of green infrastructure benefits—whole-life cost benefit information that will allow comparison of green vs grey solutions at a site level in order to determine effectiveness and benefits of GI projects.

The Committee also have a range of commissioned research projects to feed into the third UK Climate Change Risk Assessment (CCRA3) which includes looking at thresholds, including those in human as well as natural habitats – one area is heat, to understand impacts of urban cooling and how that will impact on work and productivity. There's also a project to map risk interactions within and between built environment, infrastructure and natural environment sectors and set out a priority set of risks for government and for the CCRA3, to enable understanding of magnitude of risks that might be impacted by built environment. Projects are due to complete by March.

Key issues with finding appropriate data for heat related indicators were related to determining the effectiveness of adaptation actions and disentangling impacts attributed to climate change from those attributable to other socio-economic changes, e.g., flooding and heat risk amplification from the manner in which buildings are built out and the land they are built on.

Q&A/Discussion

Cost effectiveness of GI -GI does more than just tackle heat: there has been a disjointed approach to GI; it had initially been driven more by flooding and not health before the climate change discussion. We need to join up the dots and this meeting is helping to do that.

Is the CCC taking account of population health trends? The increasing susceptibility of population was mentioned in relation to current and expected increases in cardiovascular illnesses and obesity and lifestyle related diseases -whilst the link isn't made statistically to these illnesses being triggered/attributed to heat episodes resulting from climate change, they alter the susceptibility of the population and should be considered alongside anticipated changes in climate and other socioeconomic factors. The Committee said they lacked evidence for attribution although they have in the past raised and continue to raise the linkages. A public health colleague mentioned that at local level they are interrogating data to look at impact of heat, or combination of heat and air quality, on mortality. It was also flagged that every time we experience a heatwave, we need to look in vulnerability terms, not just at the state of people's health, but also ability to take adaptive action, e.g., ability to purchase fans/cooling mechanisms and ability to open windows. We need to consider the feasibility of the adaptation options we recommend.

During this discussion the PHE Public health outcomes framework was mentioned in the context of a discussion of aging population and complex care needs.

The recently published report by the City of Melbourne on Quantifying the benefits of Green Infrastructure in Melbourne was also mentioned.

Session 4 – Earth Observation data capability for monitoring heat

Darren Ghent presented work he and his colleague, Mike Perry, also present, had done to illustrate the potential for using land surface temperature satellite data records for urban heat monitoring, and to demonstrate what is possible. He asked those present whether they felt the data would be useful, what the potential gaps might be, how they could improve the data, and if there are datasets owned by others that would complement or combine with this data for analysis.

Understanding the urban thermal environment is important to the health and sustainability of a population within a city. This can be done with air temperature, but unless you have multiple air temperature sensors in a city, it doesn't capture the spatial heterogeneity (e.g. the different materials, heights, densities of buildings, edge effects of green and blue infrastructure, etc.). Heat

vulnerability within a city is dependent on the spatial and structural aspects of the built environment, and that is where the satellite data can have a real impact on understanding and monitoring.

SATELLITE DATA

The land surface temperature enables review of different aspects of urban environment in a consistent way. When trying to understand changing and complex urban thermal environments, it's important to have access to consistent collection of datasets and to be able to explore trends in variation during the day and at night as well as over seasons and years, in relation to the spatial heterogeneity. Scientists interpreting satellite data can now provide this data in a robust and consistent manner with data records from 1995 to present day. There is a European Space Agency (ESA) project led by Darren and the team at the university of Leicester dedicated to developing and making available these global datasets.

There are multiple satellites in orbit that can provide land surface temperature data for cities but there's a trade off between the temporal resolution and the spatial resolution. The satellites that revisit on a daily basis (day time and night time overpass) provide data at the km scale (with records going back over 25 years) whereas other satellites can provide data at higher spatial resolution—less than 100m (some 30m when re-sampled)—so can see at block level but might have a revisit time of 16 days. For understanding dynamics of heat in cities, both are needed.

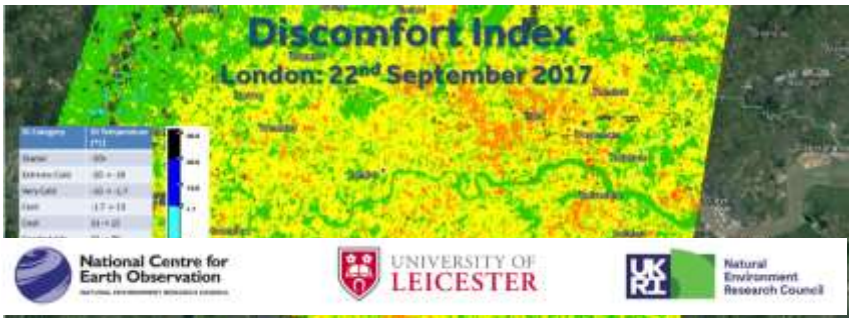
Darren then presented examples of the MODIS data (the low spatial resolution -1km) showing day and night temperatures during the 2003 heatwave against the average temperatures for the period 2002-2014. The MODIS data can provide the timeseries, a constant source of progression of temperature in a city, which helps identify when a heatwave occurs.

The higher resolution satellite data reveals that artificial materials such as asphalt and concrete, as well as green and blue space, can substantially alter the emissivity and thermal retention of the surfaces, it can also identify the stress of heat on vegetation in urban green space.

INDEXES – URBAN HEAT, THERMAL DISCOMFORT AND VEGETATION HEALTH & COOLING SERVICES

The land surface temperature (LST) data can be converted into indexes to help further understand urban thermal dynamics. One of these is the Urban Heat Island, where the non-built up area is compared to the urban, which reveals the urban environment over London is warmer than the background environment—by up to 10 degrees in the image presented. It also reveals the impact of urban structures in creating street canyons resulting in obstruction and shadowing, and also that individual building climate control mechanisms can change the urban heat dynamics in their surroundings.

Darren then presented a basic thermal discomfort index (DI), showing urban temperature relative to humidity. This is known as the Thom Index, using the methodology of Troy et al (2007). The image of London used is for a warm day in September 2017, not a heatwave, yet still showing a few 'torrid' areas of extreme discomfort.



Some of these areas were not identified as high heat in the land surface temperature data.

LST data can also be used to examine the effect of vegetation and water on the thermal environment. The example shown from Manhattan revealed the 'edge effects' from Central Park, which had a cooling effect of a few degrees up to 100m away from the edge of the green space/water. This analysis can be done for London or other UK cities quite easily.

In summary, we can use satellite data to:

- help put a heatwave event in context with historical occurrences (particularly over period satellite data is available for)
- develop vulnerability indices with addition of socio-economic/flora/fauna data to identify areas of cities where human/vegetation/fauna population is most at risk and use it for a range of other environmental and natural health applications. For example, the potential for pest/disease vector spread, or threshold breaching for GI managers to see that vegetation is under heat stress before it visually presents.
- use near real-time data to provide a current snapshot, not just in context of past heatwaves. Processing time period for the satellite data is a lag time of just hours, which could potentially be speeded up.

Potential applications for urban planning, health sector risk analysis, green infrastructure strategies and monitoring.

This is what is currently possible, future satellite missions could obtain higher spatial resolution data -see this CIBSE article for what's proposed. If there are specific data user requirements from cities/national bodies, these can be fed into mission design. Whilst the data might be 5-10 years off, it will help to address a number of data issues we currently have. These next-generation thermal imaging satellites are being designed to map land temperature and evapotranspiration from low Earth orbit.

Q&A/Discussion

Different vulnerability and risk analysis requirements -while we can work towards a consistent national index for all UK cities, different asset owners, service providers might wish to combine the heat data with their own asset level/socio-economic data.

Role of topography in urban heat -the higher the buildings/land mass the greater the area of shadow, so from the satellite you see what's in view of the satellite.

Research has found that dryness hinders the cooling functionality of green space, and that there's a point at which shading for cooling building becomes more important. As the vegetation dries out, as it stops transpiring, its temperature shoots up.

If we identify the threshold at which the vegetation ceases to have maximum cooling effect, we can use the thermal satellite data. As the plants become stressed, they stop transpiring a lot earlier than can be seen from the change in colour. They will still appear green whilst heating up. This can be seen with thermal data up to two weeks in advance of the vegetation turning brown. It could provide an early warning indicator that the vegetation is becoming stressed.

Is there a correlation between radial positive cooling effect of vegetation/waterbody and size of surface area? Not everyone will live within 100m of a park or water feature. Is there a way to widen the radial cooling effect? This has been investigated by scientists from a water perspective, and it has been found that the size of the water body does impact the cooling effect. This has not been studied from the vegetation perspective, to the knowledge of the researchers present. The cooling effect of the albedo in healthy vegetation is less than the cooling effect of the evaporation and transpiration of plants. Darren reported that it depends on the material properties, not reflectance, example given of ExCEL Centre in London. The combination of the material and its usage means that it stands out as a hot spot (the aluminium roof has profound effect on thermal urban environment).

Mike Perry reported that despite the known thermal properties of materials, and what reflectance can be seen in the visual spectrum, the satellite thermal data can reveal radically different thermal responses are often occurring in reality.

Next steps with use of this data

- **PHE – datasets for London,** particularly for new project to set up cool spots and make better use of green and blue infrastructure to help manage exposure to heatwaves.
- **Natural England - Green Infrastructure/Nature Based Solutions index –** how to link with a vulnerability index for people but also a vulnerability index and monitoring for green infrastructure in urban environments. Currently there is not much in the way of thresholds for when habitats or species are impacted for when flora/fauna become stressed/irreversibly impacted by climate change. This could be a way to start to identify some. They would need ARC GIS format.
- **Natural England -** keen to know if it is possible to gauge the impacts of street trees, other small pockets of green infrastructure like green walls and roofs. Even at 100m resolution (average of all the thermal signatures in that 100m), if there are a lot of trees on the street Darren reported you do see that in the data, it is that sensitive.
- **For higher spatial resolution data requirements for future missions,** helpful to know that one of the user requirements will be to monitor effectiveness of and help detect impact of small pockets of vegetation in urban environments.
- **University of Manchester -** Wiesam Essa drew people's attention to ECOSTRESS , which is looking at, among other things, how the biosphere is responding to changes in water availability. Using thermal downscaling methodology.

- **Use of thermal data -**to look at different responses from surfaces. Libraries of materials in the lab enable more differentiation than permeable/impermeable surfaces. Thermal data can show impact of changes in materials in urban environment, for example before and after installation of a runway. Development of multi-channel instruments is enabling better distinction between different materials. Potential use for Environmental Impact Assessment monitoring if one of the elements that matters is changing heat or microclimate?
- **Local public health -day and night temperatures really helpful** Marie-Noelle said that these differences are critical for public health decisions and interventions for helping local populations cope with heat. Keen to layer on the map of the borough the various indicators, already using flooding, and heat island and other heat data would be helpful for looking at impact of heat and to analyse that in relation to resident's ability to carry out adaptation measures.

Session 5 – Overheating in dwellings and the role of environmental health practitioners

CIEH represents the environmental health profession, which looks after the health and wellbeing of the environment and people. Members work across many areas, increasingly on climate change plans with the climate emergency declarations by local authorities. Members also regulate health and safety at work, including care homes.

At the moment most of their members tend to encounter overheating within private housing. Members use the Housing Health and Safety Rating System to enforce, the system is currently being updated by the Ministry of Housing.

Although the private rented sector is an important part of housing provision it also tends to have some of the worst conditions and increasingly is housing the most vulnerable groups due to the shortages of social housing. Often housing is not well insulated, nor adapted for heat.

BRE guidance on overheating can be used as a predictive measure and includes consideration of various factors, including willingness of residents to open windows at night. Other issues members have identified as common problems include top floors without adequate insulation causing excess heat and cold. Security concerns sometimes inhibit occupants from opening windows.

A CIEH expert panel for housing report that new dwellings are often the worst for overheating because they are often so well insulated and don't have adequate ventilation systems. They can also be single aspect, thus preventing cross-ventilation. And sometimes the windows are designed not to open to prevent noise, for example with windows facing railway lines.

Existing dwellings can present risks as subdivision can create single aspect or roof apartments increasingly likely to overheat.

With vulnerable groups, it is worth considering why they are vulnerable. For example, those spending more time in the home are more exposed than those moving about who are able to benefit from air conditioning elsewhere.

There's a Future Homes Standard consultation open until 7 February. Research indicates that the ventilation aspects of building regulations haven't been adhered to in most new buildings which is worrying. This contributes to poor indoor air quality as well as overheating risk.

Session 6 – Social vulnerability and Climate Change

Sarah Lindley presented about Climate Just, a web resource based on mapped indicators of social vulnerability to heat and flooding at LSOA scale across England. The website contains the mapping plus information about how decision-makers might use it to do particular tasks or in particular job roles.

Factors underpinning social vulnerability to heat were set out well in Eric Klinenberg's book about the disastrous 1995 heatwave in Chicago. Sarah talked about some of the elements of vulnerability that were included in the mapping and how these can be considered to tailor interventions to protect vulnerable populations.

The Climate Just resource is not updated regularly – the flood data was updated in Spring 2018 but the majority of the socioeconomic data is based on the 2011 census.

It would be good to lay over the high resolution Met Office projections and the social vulnerability data to the satellite heat data presented earlier

There is potential to crowd source validation of the socio-economic variables.

Discussion

- An urban heat index should account for temporal characteristics of urban life, including when areas are occupied e.g., in industrial areas risk may be present during the day but not at night.
- What is the combination of wind velocity and heat data, is it an area of stagnant hot air or is wind reducing heat build up? And how to innovate and create wind via building facades/urban form. Could we deliberately put high thermal emitting roof surfaces alongside rivers in cities to help spread the cooling effect? This higher evapotranspiration could have other consequences for the natural environment and atmospheric chemistry.
- If we improve our heat data and indices, we could ask citizens to share their sleep data so that we can better understand heat-sleep impacts.
- There are implications if we find contaminant dust is mobilised and/or issues with air tightness in homes for insulation and exposure to gases like radon.
- Concerns raised over use of EO data for landcover mapping due to accuracy and attribution of landscape and land-use type particularly for priority habitat inventory - ground based records showing errors in some EO mapping.
- On GI, can we use data to design and choose interventions more effectively?
- Need to consider co-benefits but also risks from interventions, e.g., insulation that causes overheating
- Need to consider cascading impacts, and need to map interdependencies between heatwave and air quality in London boroughs
- Do we need transition spaces, for example shading in hot cities and air quality protection between indoors and outdoors? Question also about who provides the research on heat emissions from surfaces in urban environments and potential to form pollutants/secondary pollutants and health impacts.
- Microclimatic effects of air conditioning units and roof materials
- Characterising neighbourhoods to reveal what do people personally have access to e.g. balconies, green spaces

- We need research on perception of value of vulnerable habitats; understanding this would impact on the way heat vulnerability metrics are applied.
- Discussion about role of social cohesion in responses to urban heat
- Links with contaminated land community
    - Better understanding of air tightness in relation to levels of radon/other gases if changes in ground water mobilise contaminants and there's an impermeable cover
    - in soil moisture and wind data, particularly for understanding dust and movement.
- Soil moisture data was also a variable that PHE would like to have more detailed datasets for.

Workshop key messages – chair's summary

Kristen thanked participants for a productive and interesting discussion. There were some key points to follow up on and important messages:

- Potential to link urban heat and impacts for the use and effectiveness of green infrastructure – and to understand the limits of GI interventions
- Opportunities to influence and set priorities for future earth observation missions – a few user requirements were identified, for example, the ability to see the impact of smaller areas of vegetation.
- The possibility to combine heat with other socioeconomic and asset level information to meet a range of user needs in understanding and promoting resilience
- We still need to understand the viability of the adaptation messages we're recommending, and linked to this, consider why people are vulnerable. Not just about solely personal characteristics, but also things like their time spent indoors due to limits on mobility.
- Still links to be made with other agendas – including air pollution and contaminated land.

AGREED NEXT STEPS

- LCCP and S4C to run a scoping workshop early in the new year dedicated to exploring heat vulnerability index capable of being run for multiple cities across the UK
- UoL team to liaise with the CCC over use of heat data to inform work underway on thresholds -in addition to the heat data, the CCC are interested in the Manhattan example especially if possible for different vegetation types.
- Sarah Lindley to liaise with Brendan Freeman as baseline socio-economic data would be helpful
- Kristen to circulate event report including links to resources and the London Resilience partners' interdependencies framework

Annex 1: Workshop attendees

Name	Organisation
Ed Barsley	Director, The Environmental Design Studio
Marc Beveridge	Regional Lead EPRR and Sustainability, Public Health England
April Cole	Regulatory Policy Officer, Care Quality Commission
Mariella DeSoissons	Defra
Claire Dickinson	CIRIA
Matthew Ellis	Environment Agency/Greater Manchester Combined Authority
Wiesam Essa	CARA and SRF Fellow, University of Manchester
Rachel Flint	BEIS
Brendan Freeman	Lead Analyst, Committee on Climate Change
Darren Ghent	University of Leicester
Camilla Ghiasee	Public Health England
Keith Gori	Earth Observation Strategy Manager, UK Space Agency
Kristen Guida	Manager, London Climate Change Partnership
Eli Hatleskog	Researcher, University of Reading
Gemma Holmes	Senior Analyst, Committee on Climate Change
Jane Houghton	Project Manager, Green Infrastructure Standards Project
Candice Howarth	PCAN Policy Fellow, LSE
Professor Sarah Lindley	Professor of Geography, University of Manchester
Helen Macintyre	Senior Environmental and Public Health Scientist, Public Health England
Doug McNab	Environment and Planning Team Leader, Defra
Anastasia Mylona	Head of Research, CIBSE
Mike Perry	Researcher, Land Surface Temperature, UHI, and Urban Energy Balance, University of Leicester
Gianluca Pescaroli	Lecturer in Business Continuity and Organisational Resilience, UCL
Frances Pimenta	Defra
Victoria Ramsey	Met Office, Climate Services
John Remedios	Director, National Centre for Earth Observation
Sarah Richards	Lambeth Council
Tamara Sandoul	Policy Manager, Chartered Institute of Environmental Health
Sarah Taylor	Senior Specialist, Climate Change Adaptation, Natural England
Ross Thompson	Environmental Public Health Scientist, Public Health England
Briony Turner	Climate Services Development Manager, Space4Climate
Regina Vetter	Cool Cities Network Manager, C40 Cities
Marie-Noelle Vieu	Public Health Consultant, Health Protection, Older People, and Disability, Lambeth Council
Clare Warburton	Principal Advisor, Green Infrastructure, Natural England

Annex 2: Workshop programme

Time	Item
09:45	**Coffee and networking**
10:00	**Welcome and introductions**
10:20	**Background and purpose of the meeting** Kristen Guida, LCCP
10:25	**City challenges – data and implementation challenges** **Scene setting from cities: Glasgow, Manchester, London** Matt Ellis, EA/GMCA Kit England, Climate Ready Clyde Kristen, London
10:40	**Monitoring adaptation in the UK: indicator categories and assessment limitations** Brendan Freeman and Gemma Holmes, Committee on Climate Change
10:50	**Earth Observation data capability for monitoring heat** Darren Ghent, Dept of Physics and Astronomy, University of Leicester
11:20	**Overheating in dwellings and the role of environmental health practitioners** Tamara Sandoul, Policy Manager, Chartered Institute of Environmental Health
11:30	**Social vulnerability and Climate Change** Sarah Lindley, University of Manchester
11:45	**Perspectives from different sectors / user requirements** • What is needed by people trying to implement and monitor adaptation in relation to heat • What are the data challenges and next steps – ensuring that data is relevant
12:30	**Lunch**