



Birmingham Urban Climate Laboratory (BUCL): Experiences, Challenges and Applications of an Urban Temperature Network



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(1) Background & Overview



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What is HiTemp?

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- Aim: to provide a <u>high resolution</u> <u>demonstration sensor</u> <u>network (BUCL) initially designed</u> <u>to measure air temperature</u> across the morphologically heterogeneous Birmingham conurbation
- Air temp will be mapped at a scale not previously possible (previously 1 'urban' station, 1 'sub-urban' and 1 'rural' station).
- Motivated by the need to test models such as the MO JULES model developed for Birmingham by BUCCANEER project



(1) Coarse Array Automatic Weather Station Network

- 25 full weather stations (Vaisala WXT520) [precipitation, wind, RH, pressure, solar radiation]
- Urban equipment will be located in secure primary electricity substations (Western Power/E.ON) and schools
 - Avoid vandalism
 - Provide data to project partner E-ON
- WXTs also sited in surrounding rural areas to record background conditions
- Average spacing: 3km (or 1 per 25km²)
- Data transmitted via GPRS (BT sims)
- Solar-powered

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(2) Wide Area Array Air Temperature Network

- 131 air temperature sensors located in schools (plus a few in 'rural' schools /parks/farms outside conurbation)
- Average spacing: 1.5km

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- Bespoke wireless air temperature sensors (thermistor) and radiation shield are a bespoke design from Aginova, USA.
- Small and inexpensive (approx. £87 each)
- Data relayed via existing Wi-Fi networks
- Battery powered life is estimated at 3 years(?)



(3) Fine Scale Array: CBD Air Temperature Network



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- 100+ air temperature sensors will be located on lighting columns across the CBD (50/km²)
- Local Council (via AMEY) are currently replacing around 41,000 street lighting columns so that the Council can monitor and manage energy used more effectively
 - → utilising AMEY's city-wide wireless comms network to transmit data

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• Will provide detailed, fine-scale measurements of local temperature differences across the CBD

Public Website: www.bucl.org.uk

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HiTemp_ID: S023 MSOA04CD : E02001849 Station_Name : Abbey RC Primary School Visit Date : 21/11/2011

Who : CLM & DTY

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 Online data access and real-time display

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 Development of near-real time interpolation plots, website widgets, popup graphs/data etc

Our University: a community where students, partners, alumni, staff and our research create international impact

Home / Schools and Departments / School of Geography, Earth and Environmental Sciences / BUCL



The Birmingham Urban Climate Lab (BUCL) was established in the School of Geography, Earth and Environmental Sciences in May 2011. The research lab will focus on all aspects of urban climate over the coming years.

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21% 34%	Rainfall*
	All data is pr

University of Birmingham		
13/02/2012 - 12:30		
Temperature	15.5 °C	
Humidity	88.3 %	
Wind Speed	4.5 m/s	
Wind Direction	SW	
Wind Gust	7.8 m/s	
Solar Radiation	150 W/m ²	
Pressure	1000.3 hPa	
Rainfall*	0.2 mm	
All data is provisional	. *Since midnight	

Current Weather

Text Info Make Home ©BUCL 2012

(2) Challenges & Experiences

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...Towards the development of a standardised protocol

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Calibration and Field Testing of low-cost sensor: UK Met Office

- In-house and at UK Met Office calibration/inter-comparisons – all results will be published (paper in prep):
- Two tests undertaken in Met Office instrument testing lab.

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- Water bath 3 sensors and liquidin-glass thermometer tested between -20 and 40 °C.
- 2) Chamber 3 sensors tested at -25,
 0, 20, 30 & 40 °C.
- Sensors performed well (≤ ± 0.10 °C) over the range -20 to 30 °C relative to the standard (≤ ± 0.3 °C @ 40 °C).





Calibration and Field Testing of low-cost sensor: UK Met Office

- Calibration against a standard for observation traceability.
- Water bath calibration against liquid-in-glass thermometer.
- (Continual) field performance tested against screen Met Office thermometer (to identify sensor drift).
- Regular calibration/replacement of sensors at all sites.





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QA/QC



• Quality Control - Procedures include range testing, step change & persistence.

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- Data Flagging 10 flag system employed so end user can make decision on data use.
- Quality Assurance Provided by extensive + regularly updated metadata, sensor calibration against traceable standard & field testing
- Quality Management Ensures that all QA/QC procedures are applied correctly and clearly documented

→ All data + metadata stored in netCDF format



Siting & representativeness in urban environments

- Placing sensors over grass not representative of the local-scale urban environment.... No 'perfect' urban location!
- Microclimate impacts?
 → Metadata is key!
- Source areas /footprints under different meteorological conditions & temporal scales → dynamic! → what defines a local area?





...Metadata Protocol

- BAMS paper (in press) on a proposal for a standardised urban meteorological network (UMN) metadata protocol for:
 - Improving data quality and urban network consistency;
 - Ensure the end-user has access to all the supplementary information they would require for conducting valid analyses;
 - encouraging the adequate recording and documentation of any changes to in-situ urban networks over time.

Bulletin of the American Meteorological Society 2013 ; e-View doi: http://dx.doi.org/10.1175/BAMS-D-12-00096

Towards a standardised metadata protocol for urban meteorological networks

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Capsule

A metadata protocol for Urban Meteorological Networks (UMN) that combines urban climate stations and existing networks best practice.

(3) Applications & The Future...

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...(in)finite possibilities!



Future Plans (1)

Numerous potential uses for BUCL....

- Detailed spatiotemporal analysis of UHI.
- Development of satellite algorithms for deriving air temperatures using surface heat measurements (surface v. canopy heat islands) → apply technique to other cities worldwide using just remote sensing.
- A testbed for urban climatology models.
- Assimilation of BUCL data into weather forecasting models.



• Validating crowd-source (public) weather data using BUCL

[+ Met Office interested in marketing air temp sensors for public use (link into WOW site)]





Future Plans (2)

- Apply data for range of applications: Health, Energy, ICT, Education, Healthcare, Transport (roads, rail), Utilities (low water flows & reduction in water quality), Communications
-Currently part of 2 TSB 'Internet of Things' consortiums:
- 1. Smart Streets

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2. Demonstrating an Internet of School Things – A National Collaborative Experience ('DISTANCE')







Future Plans (3)

- Capacity at weather stations for additional sensors:
 - Air pollution sensors;
 - Surface / IR sensors;
 - Rain gauges for improved rainfall monitoring
 - → This will allow for impacts other than urban heat to be investigated (e.g. Pluvial flooding)

....BUT must sustain funding!

- Aim is for a 30 year climatology...
- ...but in a tough funding environment so co-operation of academia, government, industry and users.



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Thank you – any questions?

Website: www.bucl.org.uk

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