University of Birmingham

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Research Fellow
(Guest Lecturer)

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About

Dr Catherine Muller is currently working on the NERC-funded 'HiTemp' project examining Birmingham's urban heat island using a dense network of air temperature sensors which forms part of the **Birmingham Urban Climate Laboratory (BUCL)** (http://www.bucl.org.uk) along with a number of TSB-funded projects utilising the data from this network as well as crowdsourcing side-projects. During her doctoral research, Catherine examined the impact of urban areas on clouds and precipitation using a range of remote sensing, in situ and laboratory techniques. In addition, she is involved with educational outreach, teaching, public engagement and knowledge transfer activities.

Qualifications

- BSc (Hons) Environmental Science (1st class) – University of Birmingham (2001-2004)
- MSc (Hons) Applied Meteorology and Climatology (Distinction) – University of Birmingham (2004-2005)
- PhD in Atmospheric Science / Meteorology – University of Birmingham (2005-2008). Thesis: "A Microscale Study of Clouds and Precipitation over Birmingham, UK"

Biography

After completing her BSc in Environmental Sciences, Catherine went on to achieve an MSc in Applied Meteorology and Climatology. She the completed a PhD examing rainwater dissolved organic carbon (DOC) using fluorescence techniques and urban influences on clouds and precipitation using a variety of approaches, including satellite and ground-based remote sensing, in situ monitoring and chemical analyses. After completing the PhD within 3 years, she accepted a position with the Earth Observation Science group in the Spac Research Centre at the University of Leicester, where she worked as a PDRA in the field of Satellite remote sensing, and as educational outreach scientist on the **Space Academy** (http://nationalspaceacademy.org/) project which used Space technology and Climate Change themes to teach a range of STEM-subjects for Key Stage 1 to 5. She was also successful in obtaining a number of funding awards for additional public engagement and outreach activities.

She has now returned to University of Birmingham where she is working as Research Fellow on the NERC-funded HiTemp project (**High Density Temperature Measurements within the Urban Environment** (http://www.birmingham.ac.uk/schools/gees/centres/bucl/hitemp/index.aspx)). The HiTemp project will see the implementation of the Birmingham Urban Climate Laboratory (BUCL): a network of 250 temperature sensors and 25 weather stations installed in the Birmingham conurbation. 131 of these will be located on schools, approximately 100 on lampposts in the CBD, whilst the weather stations will be sited in primary sub-stations and schools. The project will see Birmingham having the densest urban air temperature-sensor network in th world and will allow the research team to identify, model and promote adaptation to the impacts of urban heat and climate change on the people and infrastructure of major conurbations.

Catherine is also part of two TSB-funded consortiums (Smart Streets and DISTANCE) where she will apply data from BUCL for a number of 'Internet of Things' applications over the next 12 months, as well as a NERC-funded project (SUMNs) to explore the sustainability ar applicability of BUCL and a number of side projects involving crowdsourcing data.

www.bucl.org.uk (http://www.bucl.org.uk/)

Teaching

Catherine has led, redeveloped and taught a post-graduate module, in addition to undergraduate modules, including remote sensing. She has also conducted seminar classes, conducted open-air tutorials and supervised urban climatology projects on undergraduate field trips. Catherine is also involved in educational and pedagogic research and innovative approaches to teaching and learning, including the use of sensors and technology.

Applied Meteorology and Climatology Masters course: M3 Atmospheric Data Processing & Statistics (M3b Programming component)

Related Publication:

Muller, C.L. and Kidd, C. (2014) Debugging Geographers: Teaching Programming to Non-Computer Scientists, *Journal of Geography in Higher Education*, in press

Postgraduate supervision

Doctoral Research supervision:

Doctoral Researcher: Juliana Antunes de Azevedo
Topic: High-resolution meteorological data and geoprocessing for the analysis of Urban Heat Island and Electric Household energy consumption.
This doctoral research will analyse the temporal and spatial variability of Birmingham's UHI and its relationship with household energy consumption using high-resolution meteorological data from BUCL, MODIS and Landsat ETM+ data and Energy Consumption data.

Supervisor: Dr. Lee Chapman

Co-supervisor: Dr. Catherine L. Muller

MSc dissertation supervision (various topics including urban climatology and rainwater chemistry)

Research

Catherine's research interests are focused on the impacts of urban areas on weather and climate, and in turn the effect these modifications have within the built environment; the main focus of this research centres on clouds, precipitation and temperature. Specifically, this includes: Urban meteorology and climatology (from urban heat islands to weather modifications over urban environments); aerosols, clouds and precipitation interactions; field measurements (in situ, sensor networks, remote sensing, satellite observations and novel sensin techniques); crowdsourcing for a range of climate, environmental and societal applications; laboratory analyses (e.g. stable isotope analyses, fluorescence spectrophotometry) of rainwater, cloudwater and aerosols; geography pedagogy and innovative approaches to teaching and learning.

Current Projects

HiTemp project (High Density Temperature Measurements within the Urban Environment) [NERC-funded]

www.bucl.org.uk (http://www.bucl.org.uk/)

The long-term aim of the HiTemp project research team is to identify, model and promote adaptation to the impacts of urban heat and climate change on the people and infrastructure of major conurbations. Urban heat is amongst the most pressing priorities of impacts of climate change. The Urban Heat Island (UHI) is a direct consequence of anthropogenic influences on our local climate - although the UHI phenomenon is well documented, the basic measurement of temperatures across urban areas remains very limited. Climate change scenarios suggest increases in mean temperatures exacerbate heat waves - most noticeable in urban areas. Impacts include:

- Human health (e.g. heat stress, deaths) - the 2003 heat wave was considered to be responsible for 14802 and 2045 excess deaths in France and the UK, respectively - most of these deaths were in urban areas. Heat waves such as this may be typical by 2040
- Society (e.g. law and order)
- Infrastructure of the urban areas themselves, such as transportation (e.g. roads melting, rail buckling) and power supplies (e.g. transformer overloading due to increased heat and the need for air conditioning)

The HiTemp project will see the installation of the Birmingham Urban Climate Laboratory (BUCL) containing 250 temperature sensors and 33 weather stations: 131 of these will be located on schools, approximately 100 on lampposts in the CBD, whilst the weather station will be sited in primary sub-stations. The project will see Birmingham having the densest temperature-sensor network in the world and will lead to a number of research projects examining Birmingham's urban heat island (UHI) in more detail than ever-before possible.

Sustainable Urban Meteorological Networks: Managing the Legacy of the Birmingham Urban Climate Laboratory (SUMNs) [NERC-funded; Co-I]

SUMNs will investigate ways in which the legacy of the Birmingham Urban Climate Laboratory will be managed. The study will identify prospective end-users and applications (businesses, industrial, service sector, scientific, public, educational) of the new Urban Meteorological Network (UMN) in Birmingham (funded by the NERC Network of Sensors). The information will then be assimilated to characterise a sustainable UMN in terms of size (i.e. number of sites), data quality / assurance and associated ongoing costs. Ultimately, this project will identify the way forward for financially sustaining an UMN long term and, in particular, what business cases can be made. The study effectively acts as a means to build a consortium for the forthcoming New Business Solutions from Environmental Data NERC/TSB call.

DISTANCE (Demonstrating the Internet of School Things – A National Collaborative Experience) [TSB-funded; PI]

www.iotschool.org/ (http://www.iotschool.org/)

This project will offer every school in the UK the ability to measure and share data by creating an information hub in the cloud using an open-source and infinitely scalable application platform. The UoB role in this project is to make BUCL data available (in an interoperable form) and assist with its integration into teaching and learning themes such as transport, energy, weather and health. (Partners include Intel, Xively, the OU, CASA UCL, the geography collective and ScienceScope)

Smart Streets consortium [TSB-funded; Co-I]

www.smartstreetshub.com/ (http://www.smartstreetshub.com/)

The aim of the Smart Streets project is to develop an integrated, connected infrastructure that encompasses notions of intelligent transport and smart street furniture, acting as an integration point for a variety of sensor-based smart systems (a system of systems) and providing a key component of the future smart city or smart region. Application 1: Environmental reactivity to handle flash flooding; Application 2: Intelligent infrastructure for better highway maintenance Application; 3: Smart sensing for transportation efficiencies. (In Touch Limited is the project lead)

Previous Projects

ADVANSE (ADVANced retrieval system for greenhouse gases from Sciamachy on Envisat) project [ESA funded]

Production of a global, daily, speciated satellite-derived aerosol database for improving CO_2 retrievals from SCIAMACHY.

(A)ATSR Exploitation Plan [DEFRA-funded]

Development of a tool for (A)ATSR end users to provide transparency on the full (A)ATSR exploitation life cycle and to encourage the synergetic use of resources by determining the strategic science issues, identifying how (A)ATSRR could contribute and making recommendations for the future.

Doctoral Research: Microscale study of Clouds and Precipitation [University of Birmingham funded]

Catherine's PhD explored modifications of microphysical processes in clouds and precipitation using a novel combination of satellite observations from SEVIRI on Meteosat-9, a sparse network of ground-based vertically-pointing remote sensing devices and in situ rain gauges. As part of this research, Catherine also conducted laboratory analyses of rainwater and aerosol samples using a novel fluorescence technique for identifying low concentrations of dissolved organic carbon compounds, the results of which have been frequently cite in a number of subsequent studies. Many of the techniques Catherine used were innovative, such as utilising vertically-pointing micro rain radars (MRRs) for detailed assessment of precipitation and personally designing and building a scaled-down automatic rainwater collector which allowed small-scale, intra-event chemical variations to be assessed, providing provided an indication of the state of the atmosphere.

Other activities

Knowledge Transfer

Catherine is keen to see her research activities incorporated operationally for the benefit of society. In order to achieve this she works with the TSB Knowledge Transfer Network and numerous industrial partners, including Birmingham City Council, AMEY, Western Power, Severn Trent and Space industries, as well as a number of SMEs and other academic institutes. She has also developed Earth Observation and Remote Sensing training materials for SMEs as part of the **G-STEP project (http://www.g-step.co.uk/)** at University of Leicest and is currently involved in three KT-related projects.

Related Funding:

- PI: TSB 'Internet of Things' Competition demonstrator funding - *Demonstrating the Internet of School Things – A National Collaborative Experience (DISTANCE)* consortium (UoB: £68,863, 02/2013). Partners include Intel, Cosm, the OU, the geography collective and ScienceScope
- Co-I: TSB 'Internet of Things' Competition demonstrator funding - *Smart Streets* consortium (UoB: £68,863, 02/2013). In Touch Limited is the project lead. UoB will provide the real-time weather data and expertise
- Co-I: NERC 'Environmatal Data Call' - *Sustainable Urban Meteorological Networks: Managing the Legacy of the Birmingham Urban Climate Laboratory (SUMNs)* (£13k, 06/2013).

Educational Outreach and Public Engagement

Catherine carries out a number of educational outreach (key stages 1-5) and public engagements activities, including:

- Her involvement with the **Space Academy (http://nationalspaceacademy.org/)** at University of Leicester and the National Space Centre
- STEM workshops and masterclasses for KS 1-5 (Earth Observations; Climate Change; Weather and Climate; Remote sensing; GIS; Urban meteorology)
- Websites/e-learning/computer-based practicals
- Social Media (@BUCL_HiTemp, **BUCL facebook page (http://www.facebook.com/pages/Birmingham-Urban-Climate-Laboratory-BUCL/240027709353703)**)
- Press releases
- Career events / talks / outreach events
- Mentoring, tutoring and work experience
- Teacher CPD workshops
- Podcasts: **http://planetearth.nerc.ac.uk/multimedia/story.aspx?id=1252 (http://planetearth.nerc.ac.uk/multimedia/story.aspx?id=1252)**

Public Engagement Funding:

- PI: UK Space Agency 'Space for All' Sponsorship Scheme 2012/13 (£2,040.00, SFA2011-024): *'Hot Cities: Monitoring the Health of our Cities from Space!'* Hands-on workshops for KS 1-3 and teachers to introduce urban climatology and thermal remote sensing of cities.
- PI: UK Space Agency 'Space for All' Sponsorship Scheme 2010/11 (£3,386.52): ***'The Blue Marble: Monitoring Earth from Space (https://sites.google.com/site/earthbluemarble/)'*** Inter-disciplinary, hands-on materclasses for KS 1 & 2 to introduce Earth Observations, Global Navigation and applications.
- PI: RCUK National Science and Engineering Week Awards 2010 (£1,692.08): *'Observing Planet Earth: You can be a scientist!'* An inter-disciplinary, hands-on introduction to Earth Observation Science (EOS) and applications for Key Stage 4 physics, chemistry and biology students, incorporating demonstrations and activities.

Related Publications and Proceedings:

Muller, C.L., Roberts, S., Remedios, J.J., Henderson, J., Wilkinson, J., Wilkinson, M., Illingworth, S., Greaves, R. (2013) The Blue Marble: A Model for Primary School STEM Outreach, Physics Education, vol. 48, p. 176

Roberts, S.J., **Muller, C.L.,** Knight, P.T. & Ojha, A. (2010) SpaceAcademy: Developing Geospatial Capability in UK Schools – The Role of Open Source GIS, Google Earth, Google Forms and the Global Positioning System, Open Source GIS Conference 2010,University Nottingham, 21st-22nd June 2010

Muller, C.L., S. Roberts, A.Wells, A. Ojha, C. Bishop, J.J. Remedios, T.Moore, A. Edwards,(2010) East Midlands, UK: Communication, Education and Training Activities, NEREUS CET workshop, Toulouse Space Show 2010, 8th-11th June 2010

Muller, C.L. (2010) Geospatial Data and Technology in the Classroom: Multispectral remote Sensing workshop, Space Conference for Science Teachers,Leicester, 24th-16th April 2010

Ojha, A., Williamson, R., **Muller, C.L.,** Hill, S. (2010) Space Academy Workshop, Space Exploration Education Conference, NASA Houston, February 2010

Roberts, S. and **Muller, C.L.** (2010) Using the Global Positioning System in the Science Classroom, Association for Science Education Annual Conference 2010,Nottingham, 6-9 January 2010

Muller, C.L., Ojha, A., Hill, S., Remedios, J.J., Moore, T., Wells, A.,Barstow, M., Jarvis, T., Brown, C., Allen, S., Green, J., Althorpe, S., Williamson, R., Carr, C., Knight, P. (2009) SPACE ACADEMY: Using Earth Observations in Science Teaching, RSPSoc conference 2009, Leicester, 7th - 11th Sept 2009

Professional Memberships

- Royal Meteorological Society Associate Member
- American Meteorological Society

Publications

Kidd, C., Kirschbaum, D. B., Huffman, G.J., Jackson, G. S., Joe, P., **Muller, C.L**. So, how much of the Earth is covered by rain gauges?, *Bulletin of the American Meteorological Society*, in prep

Chapman, L., **Muller, C.L.,** Young, D.T., Warren, E.L., Grimmond C.S.B., Cai, X.-M., Ferranti, J.S. The Birmingham Urban Climate Laboratory: An open meteorological testbed and challenges of the smart city, *Bulletin of the American Meteorological Society*, under review

Muller, C.L., Chapman, L., Johnston, S., Kidd, C., Illingworth, S., Foody, G., Overeem, A., Graves, R. Crowdsourcing for Climate and Atmospheric Sciences: Current status and future potential, *International Journal of Climatology*, under review

Azevedo, J.A., Chapman, L., **Muller, C.L.** A critique of the degree day methodology to enable long term energy consumption assessments: a case study in Birmingham, UK. *Climatic Change*, under review

Muller, C.L., Fairchild, I.J., Boomer, I., Baker, A., Kidd, C. Intra-event trends in stable isotopes: Exploring mid-latitude precipitation using a vertically-pointing micro rain radar, *Journal of Hydrometeorology*, revisions submitted

Illingworth, S.M., **Muller, C.L,** Graves, R., Chapman, L. (2014) UK Citizen Rainfall Network: A pilot study, *Weather*, in press

Muller, C.L. and Kidd, C. (2014) **Debugging Geographers: Teaching Programming to Non-Computer Scientists (http://www.tandfonline.com/eprint/ntuGSXqWRFXJi4HVKND2/full)**. *Journal of Geography in Higher Education*, doi:10.1080/03098265.2014.908275

Young, D.T, Chapman, L., **Muller, C.L.**, Grimmond, C.S.B., Cai, X.-M. (2014) **A low-cost wireless temperature sensor: evaluation for use in environmental applications (http://journals.ametsoc.org/doi/abs/10.1175/JTECH-D-13-00217.1?af=R)**. *Journal of Oceanic an Atmospheric Technology*, doi: http://dx.doi.org/10.1175/JTECH-D-13-00217.1

Muller, C.L. (2013) **Mapping snow depth across the West Midlands using social media-generated data (http://onlinelibrary.wiley.com/doi/10.1002/wea.2103/abstract)**. *Weather*, vol. 68(3), p.82

Muller, C.L., Chapman, L. Young, D.T., Grimmond, C.S.B., Cai, X.-M. (2013) **Towards a Standardised Metadata Protocol for Urban Meteorologcial Networks (http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-12-00096.1)**. *Bulletin of the American Meteorological Society*, vol. 94, p.1161–1185.

Muller, C.L., Chapman, L.. Grimmond, C.S.B., Young, D.T., Cai, X.-M. (2013) **Sensors & The City: A Review of Urban Meteorological Networks (http://onlinelibrary.wiley.com/doi/10.1002/joc.3678/abstract)**. *International Journal of Climatology*, vol. 33(7), p. 1585–160

Muller, C.L., Roberts, S., Remedios, J.J., Henderson, J., Wilkinson, J., Wilkinson, M., Illingworth, S., Greaves, R. (2013) **The Blue Marble: A Model for Primary School STEM Outreach (http://iopscience.iop.org/0031-9120/48/2/176)**. *Physics Education*, vol. 48, p. 176

Muller, C.L., Kidd, C., Fairchild, I. J., Baker, A., (2010) **Investigation into clouds and precipitation over an urban area using micro rain radars, satellite remote sensing and fluorescence spectrophotometry (http://www.sciencedirect.com/science/article/pii/S0169809509002348)**. *Atmospheric Research*, vol. 96, Issues 2-3, p. 241-255

Kidd, C. and **Muller, C.L**. (2009) **The Combined Passive Microwave-Infrared (PMIR) Algorithm (http://books.google.co.uk/books?id=_fQxL1ayZzcC&pg=PA68&lpg=PA68&dq=The+Combined+Passive+Microwave-Infrared+(PMIR)+Algorithm,+In:+Satellite+Rainfall+Applications+for+Surface+Hydrology&source=bl&ots=C4dFoILDau&sig=6893Am0Favc_mj4857QMDIf19rE&hl=en&sa=X&ei=exQJUdSVEsiK0AWdhIDgBA&ved=0CDwQ6AEwAQ#v=onepage&q=The%20Combined%20Passive%20Microwav Infrared%20(PMIR)%20Algorithm%2C%20In%3A%20Satellite%20Rainfall%20Applications%20for%20Surface%20Hydrology&f=false)**. In: *Satellite Rainfall Applications for Surface Hydrology*, Gebremichael, M. and Hossain, F. (Eds.), Publ. Springer

Muller, C.L., Baker, A., Hutchinson, R., Fairchild, I.J., Kidd, C. (2008). **Analysis of Rainwater Dissolved Organic Carbon Compounds using Fluorescence Spectrophotometry (http://www.sciencedirect.com/science/article/pii/S1352231008006055)**. *Atmospheric Environment*, vol. 42, p. 8036-8045

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