

Sustainability and the Megalopolis Seminar Series

Climate Change and the Megalopolis

21st January 2009

bridging the gaps
Supported by: Sustainable Urban Spaces

Speakers

Prof. Mark Maslin (UCL Department of Geography)
'Large Scale Climate Changes and Effects on Large Urban Areas'

Prof. Sir Alan Wilson (Centre for Advanced Spatial Analysis)
'Megalopolis: Analysis through Modeling'

Prof. Michael Batty (Centre for Advanced Spatial Analysis)
'Climate Change and Cities'

Prof. Michael Davies (Bartlett School of Graduate Studies)
'London's Urban Heat Island'

Summary

In an era of urbanisation but also of increasing urban scale, not only are cities getting bigger, but they are increasingly best seen as forming parts of urban regions with complex internal inter-connections. A variety of terms have been used to capture this emerging urban reality but **megalopolis** is particularly useful, suggesting the importance of scale and of governance across a complex urban area.

In the first of a series of six seminars, an assembled group of speakers drawn from UCL's Geography department, the Centre for Advanced Spatial Analysis (CASA) and the Bartlett School of Graduate Studies sought to address what the effects of climate change on the megalopolis might be and how we might plot and predict them. In the introduction to his presentation on 'Large Scale Climate Changes and Effects on Large Urban Areas', Mark **Maslin** stated that the real challenge facing urban environments was not the predicted average temperature rises brought about by climate change, but how cities would cope with the increase in short term extreme events. Urban climates have a minimum and maximum coping range for temperatures and rainfall; however, coping ranges change slowly unlike the changes in climate.

By 2040 average summer temperatures in Europe are set to be those experienced in the heat-wave of 2003 in which between 30,000 and 35,000 people died in Northern

Europe, while heat-waves in 2040 will be twice as hot as those we experience now. Winters, meanwhile, will be increasingly wet and warm with floods like those of 2000 becoming standard. The Thames Barrier's ability to protect London against a one in five hundred year storm will steadily decrease so that by 2080 London will be at risk of flooding. The effects of extreme events such as flooding on a megalopolis would not just be disastrous on an infrastructural level but would be catastrophic to the global economy. If London were flooded, the 24 hour global trading network would be irreparably disrupted, causing economic catastrophe that would be felt world-wide.

Alan Wilson, Michael Davies, and Michael Batty probed how modeling urban development was an invaluable tool when trying to combat the challenges of climate change. Alan Wilson in his presentation 'Megalopolis: Analysis through Modeling' detailed how mathematics and computer science could be used as tools to model the functioning and evolution of large city regions as complex systems, and could thus be utilised when analysing the effects of climate change on the megalopolis.

The megalopolitan system, **Wilson** explained, is comprised of population, economy, employment, products and services (and their uses), and their interactions in transport and communications. These factors go towards creating what Wilson calls an urban physiology or 'DNA' that characterises the structure of the city, and determines its development. The principle sectors within a modeling framework or megalopolitan system are population, housing, economy, public services, retail services, economic capacity and government. The spatial interactions of these sectors lie in journeys between homes, work, businesses and public services for instance, which lead to definitions of algebraic key variables and interaction variables. The analysis challenge lies in breaking down these variables to create viable models that can in turn be used to plot and project the dynamics or 'DNA' of the megalopolis, and thus the impact of climate change upon it.

These computer models could therefore be used to identify phase transitions—the shift from slow to fast dynamics of the city. Slow dynamics are the slow changes of infrastructure in the city, while fast dynamics are quicker reactions to contingent situations. They can radically alter patterns within a short period of time. Comprehensive megalopolitan models could thus identify and project what the possible phase transitions caused by climate change might be. The analysis of phase transitions also has to take account of path dependence, since outcomes are heavily constrained by a set of initial conditions—the megalopolitan DNA. These models would therefore allow us to consider what the effects of adjusting the DNA of the megalopolis might be. The research challenge lies in learning how to represent climate change, sustainability and extreme events as possible changes in the model's variables, thus enabling us to explore and identify the changes in the fast and slow dynamics of the megalopolis.

Michael **Davies** described how just such modeling techniques were being used to analyse London's urban heat island as part of UCL's Lucid Project. In his presentation, Davies explained how temperatures across London varied with central areas being on average significantly hotter than suburban areas. Models, informed by data such as air temperatures taken from vehicles moving across London, surface temperatures measured by satellite remote sensing, land-use information, and building heat emissions, can estimate the possible energy, health and comfort benefits and disbenefits of London's heat island (fig.1).

**Anthropogenic heat emissions
(buildings, transport and metabolic)**



fig.1.

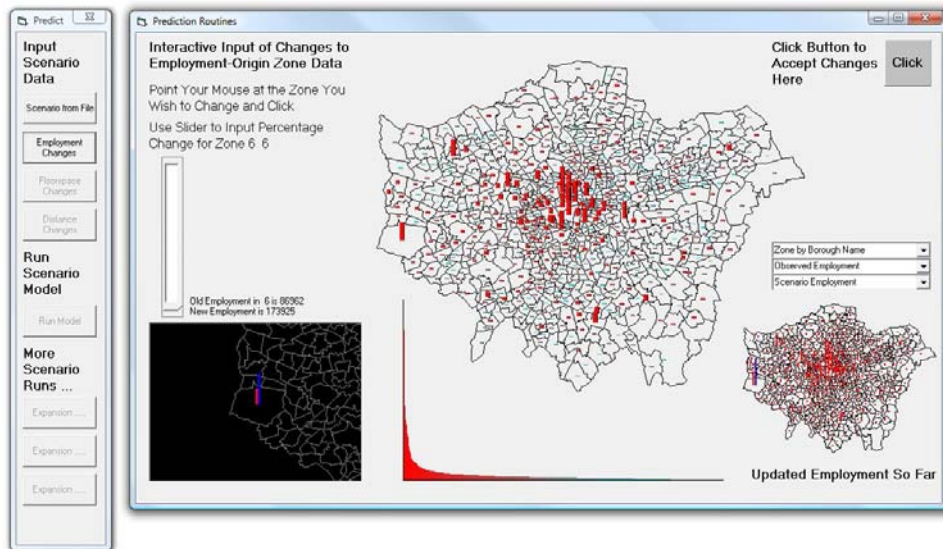
Davies described how bespoke weather files could therefore try and project future summer temperatures to include both contributions from the urban heat island and future climate change. This information could then be used when calculating, for instance, compliance with building regulations with regards to overheating.

Using a process called morphing, weather files can capture the general shape of predictions for future scenarios. Feeding in different future scenarios it would be possible to calculate their differing effects across specific locations in London. Scale models could look at the thermal impacts of planned developments, or calculate the expected level of mortality in a heat-wave at specific locations. At the moment the GLA intends to create an 'Urban Heat Island Action Area', in which future developments would have to demonstrate that they have taken account of their impact on the urban heat island; however, ways in which this can actually be made to work have yet to be finalised.

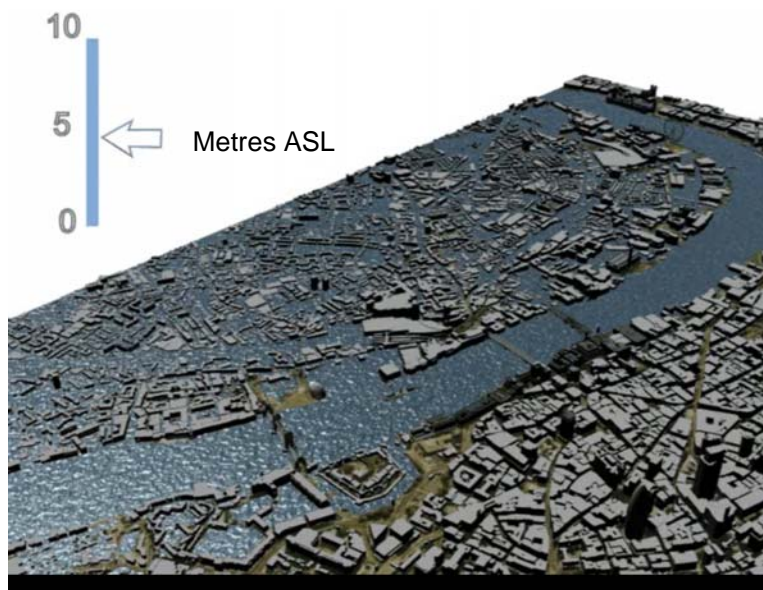
Michael **Batty** went on to describe the tools and theories developed at CASA that have been put to such effective use in the urban heat island project. In his presentation on 'Climate Change and Cities', Batty detailed how research at CASA was committed to setting aside anecdotal and impressionistic theory in favour of robust measurable theories and models that could be used to make predictions about the possible impact of continued urban expansion and climate change.

Research conducted as part of the cities theme at the Tyndall's Centre brings together models and data collected by CASA, Newcastle University, Leeds University and Cambridge Econometrics among others. Emissions models, global climate models, GIS models, flood models, population site models and others are stitched together, and using a land-use and transportation model built for Greater London and the Thames Gateway, the Tyndall Centre assesses the impact of climate change on small areas in the metropolitan region, looking in particular at rising sea levels and pollution in the next 50-100 years. Visualisations are then produced by these models and can, for instance, show visually how employment changes can affect the population density of different areas of London (fig.1), or what rises in water levels would do to London's urban landscape

(fig.2). These models and visualizations can thus be used to explore and predict the effects of climate change on the city, and so be utilised when calculating how changes in urban infrastructure could meet the demands of extreme events such as flooding.



(fig.3)



(fig.4)

Three key issues emerged from the presentations and following discussion:

1. Data and Knowledge

Models of London have a wealth of data to draw on that can be used to predict possible futures; however, the amount of available data in developing cities such as Lagos or Jakarta can be easily overestimated. How much data is sufficient in order to create viable models that can plot and predict the effects of climate change, and can generic models be derived from models created for London?

Caution is necessary when using generic models. Conceptually a model applicable to a western European city is not necessarily applicable to a developing city. Several different models need to be created for every situation in order to account for fundamental cultural differences that might make generic models problematic. There is, however, a difference in the amount of data required for modeling for peer review and that needed to drive policy. Viable generic models already exist that need a fraction of the data available and are often sufficient to drive policy.

In order to create statistically reliable models, however, large sets data are needed. Satellite remote sensing data has rich data sets relating to traffic, congestion and movement from across the developing world that could be used in order to create models for developing cities. Relatively little data is needed from the ground in order to create and calibrate these models. Generic heat island models can be generated using just this kind of remote sensing data. Ground level data can, however, be collected, and involving local communities in the collection of data can, in fact, be instrumental in changing behaviour.

2. Phase Transitions

The importance of collecting data and creating computer models lies in being able to plot and predict phase transitions. Phase transitions are difficult to forecast. The private sector already actively uses the kinds of models described by Alan Wilson to optimize networks and maximize profits; however, the public sector, still overly reliant on short term predictive models, often overlooks the potentialities of modelling to show how small changes in Government policy and cultural behaviour can bring about quick phase transitions. Drilling populations for the possibility of natural disasters, early warning systems, the introduction of the congestion zone in London, are all examples of quick phase transitions. British government policy's inability to properly and consistently model the use of public transport, for instance, has affected its ability to create effective public policy that encourages suburban populations to use public transport.

If we were to generalize retail models into more complex models of cities, we ought to be able to identify possible phase transitions, especially those brought about by exogenous changes such as climate change. These models would allow us to plot how quickly or slowly populations and/or city infrastructures adapted to different environmental conditions, as well as calculate our ability to shape phase transitions

Infrastructural phase transitions are habitually slow; however, it is the ability of the megalopolitan infrastructure to respond to the effects of climate change that will determine urban resilience in the face of the extreme events brought about by climate change. Questions need to be asked to determine whether protracted phase transitions can be accelerated, and whether government policies and building regulations are encouraging or stifling the phase transitions necessary to make the megalopolis sustainable.

3. Interactions of infrastructure, climate change, culture and behaviour.

Two thirds of cities are located in coastal areas making them inherently vulnerable to the disruption of our climate. How can we integrate infrastructure, climate change, culture and behaviour to make our cities more sustainable and resilient to the effects of climate change?

The ever increasing density of population in megalopolises makes the urban infrastructure less resilient, as the rapidity of change caused by the increase in population

far outstrips the speed of infrastructural phase transition. Infrastructural change is needed to deal with the extreme events of climate change. Renewable energies can be embraced, defenses can be built, building practices can be improved using passive and active engineering , renewable energies, and creative management, populations can be encouraged to abandon the car in favour of walking, cycling and public transport. These are all infrastructural and cultural solutions that will make our existing cities and urban populations more resilient, but should more extreme solutions be found? Should we, as Maslin suggested, abandon our unsustainable and vulnerable cities in favour of sustainable ones?

The ability of our urban infrastructures to respond to climatic disasters determines the megalopolis's ability to survive the effects of climate change. The next seminar in the series will consider exactly this, tackling the problems and solutions for 'Transport, energy and water infrastructure, sustainability and the megalopolis'.

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We would appreciate your comments, please email karolina.kendall-bush@ucl.ac.uk with any comments or corrections you may have.