Metropolitan meteorology

Dr Valéry Masson discusses his project, which aims to model the effects of climate change on urban environments, predicting how our cities will adjust to shifting temperatures

Why does the ACCLIMAT project focus specifically on cities and urban areas?

Cities bring together 50 per cent of the world population, and this share exceeds 80 per cent in developed countries. Moreover, urban areas concentrate the vast majority of capital stocks, comprising housing, water delivery and transportation infrastructures. Clearly, such a population concentration gives rise to social, economic, and environmental concerns. Furthermore, cities modify their environment, increasing the local impact of some meteorological and climatic events, such as heat waves, floods and sea level rise. Such events are likely to occur in the future in the frame of climate change. This means that cities are particularly vulnerable to the effects of a changing climate, and our research aims to elucidate exactly the nature of this vulnerability.

What advantages are afforded by your model?

Our model is not a climate change model. The climate simulations are done beforehand by climate groups in the frame of the Intergovernmental Panel on Climate Change (IPCC), and are either global or continental. One could use any of them as climate warming input. Our coupled model contains on the one hand some models of the city itself, simulating how it could grow in the future depending on several scenarios, and on the other hand, an atmospheric model joined to an energy consumption model for buildings. The latter models allow for simulation of the interactions between the city and its microclimate. Cities can be warmer than the surrounding countryside by up to 10 °C centigrade at night, which has been poetically named the 'Urban Heat Island'. This can reduce the need for domestic heating in winter, but increase air conditioning in summer. We have shown that, for Paris, the use of air-conditioning can increase the air temperature by up to 2 °C centigrade, leading to greater energy demand for cooling. With a warming climate a distinct possibility, this trend could increase in the future.

How do you intend to apply this model to other European cities?

The models are based on general economic or physical laws, which are split across the different models we are using. Beyond this, they use some classical data including censuses and buildings databases. Some scenarios are world or Europe-wide, including energy cost and technology availability; some are across the country, including demographics and building regulations); and some are local specifically to the city, which covers everything from urban planning to local economic evolutions. The breadth of these inputs and their generic nature means that the models can be applied to other cities.

What challenges arise from targeting the issues of climate change in urbanised environments?

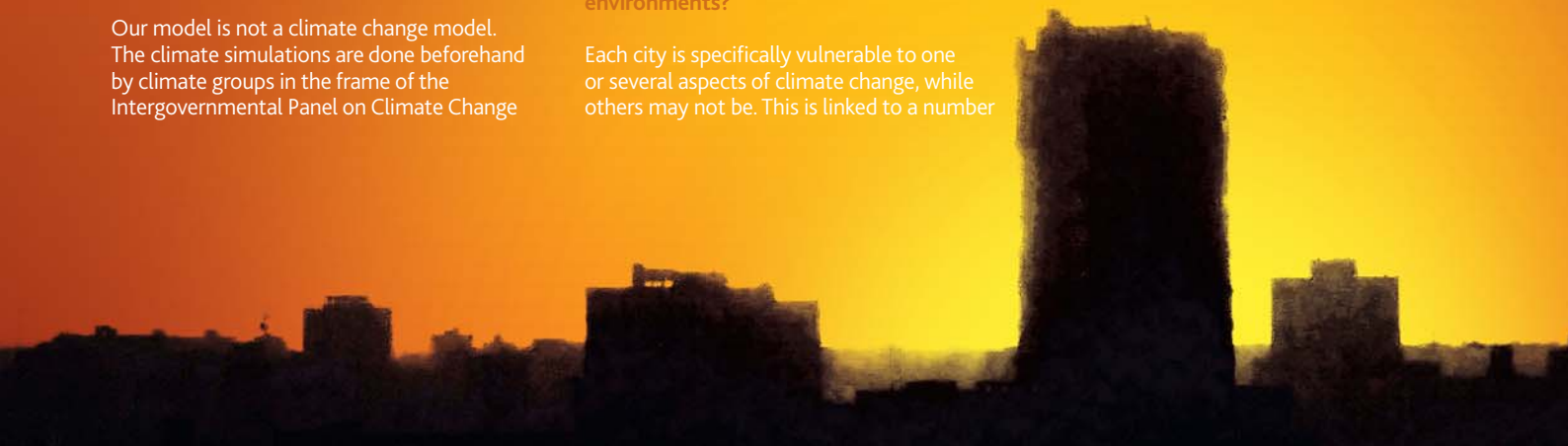
Each city is specifically vulnerable to one or several aspects of climate change, while others may not be. This is linked to a number of factors. The geographical position of the city is important, since a coastal city may be subject to sea level rise flooding, and local climate can have effects, such as if the city is subject to flash floods. Also important is the structure of the city, since old buildings may be badly insulated; the economic situation of the city; or social aspects like the age of the population, revenue of the people in relation with energy or transportation costs. Consequently, the number of aspects to take into account is very large and covers a wide panel of disciplines.

What have been some of the major considerations that have needed deliberating, in order to ensure the project is successful?

The most complex feature was the coupling between the economic model and the geographical model, in order for the models to profit from one another. A fine description of the spatial distribution of population and rents depending on socioeconomic factors on the one hand, and the ability to simulate at an even finer scale the geographic implementation of new urban areas depending on geographic and urban planning considerations on the other.

Are you using any methods to ensure your research has an impact and effective implementation on educational, societal and political disciplines?

We closely collaborate with territorial planning agencies in Toulouse and Paris. They are in our projects from the start, and dissemination of our research towards local policymakers will naturally transit through them. Our research is interdisciplinary, and we plan to present our methodology and results in a wide range of international conferences.



Climate century

An interdisciplinary team of economists, geographers, architects and meteorologists lead by the National Centre for Meteorological Research in France are nearing completion on their **ACCLIMAT** project, which addresses the challenges that metropolitan environments will face in the next 100 years

THE PLIGHT OF cities under climate change is one which is drawing increasing attention from the political forces of Europe and the world, and this is set to continue as shifts in weather patterns become more distinct. Cities are particularly specialised to the climate they experience, with everything from unusual levels of rain to unduly warm weather potentially upsetting the balance of living conditions and infrastructure. A team at France's National Centre for Meteorological Research, including other laboratories are pursuing the ACCLIMAT project, which is hoping to answer many of the important questions facing metropolises within Europe. Studying the interactions between urban development, urban microclimate and climate change, the team is producing interdisciplinary platforms in order to model changes which occur. Anticipating the course of urban expansion and the changes that this will have on the microclimate, the aim is to run different climate change scenarios, discovering the impact on metropolitan areas. Modelling the coming century, the team's work will build on the fourth Intergovernmental Panel on Climate Change (IPCC) report, which demonstrates that climate effects will be significant by 2070. Using international predications as a basis, the team is able to work towards producing models of the potential evolution of the climate, placing their numerical cityscapes within this.

The need for this arises from a number of interrelated factors. The climate change scale encompasses the next century or so, meaning that it is a problem which requires planning. Similarly, buildings are created to last for a century or more, and the designs of major cities are significantly older than some of the buildings which occupy them. A significant portion of the cities that will be facing the predicted challenge, through changes in their climate and other issues, are already built. Consequently, it is imperative for any new buildings to be able to deal with these shifts. On top of this, lifestyles will also evolve. When one considers the changes that have affected life in industrial cities in Western Europe over the last hundred years, the enormous difficulty of the team's challenge becomes apparent. However, through their modelling they are able to interrogate likely scenarios, relying upon broad brush patterns for the shifts in climate and worldwide economics. By narrowing their investigation to one city, the team are able to use interdisciplinary expertise to pick apart the adjustments which will have to be made, providing practical advice for the developments which are likely to be required.

Using international predications as a basis, the team is able to work towards producing models of the potential evolution of the climate, placing their numerical cityscapes within this

PLANNING FOR CHANGE

The project is hoping that its approach will be able to mitigate the hazards of climate change, preventing urban areas from being severely affected by the issues that the next century will bring. Dr Valéry Masson is leading the team in Toulouse, and has a clear aim for their work: "We want the ACCLIMAT software to help urban planners to adapt cities to climate change. Our objective is to show them what could be the impacts of various urban planning scenarios for their city". These scenarios are open to the numerous uncertainties which are a part of the modelling process, including differing long-term developments in climate change, economics or demographic evolution. In order to construct their models, the team began work initially for Toulouse and Paris. Having used these to set up the models, the researhers are able to contrast both of the cities, investigating the ways in which population density, energy consumption and human comfort may change in a number of events, and seeing how each will react to these shifts. These investigations play into the team's wider aims of broad applicability, since it is able to demonstrate the way in which the ACCLIMAT software can fit itself to the individual characteristics of the city it is working with, showing the different possible outcomes in the face of future scenarios.

INTERNATIONAL APPLICABILITY

A large part of the initial stages of the project was to construct a model for which the inputs are generic and data was reasonably available, resulting in a model with excellent potential to be transported between different cities. This generality and portability is an extremely important part of the work carried out, encouraging different Member States to implement the software. Masson is positive about the direction that the work is moving in: "Engaging and collaborating with numerous Member States on the challenges of climate change is certainly the next stage after the

first ACCLIMAT project". Moving beyond these broadly applicable numerical models, the team is developing indicators to city vulnerability. The aim is to show the ACCLIMAT platform in scientific conferences as well as to some territorial communities both within their native France, and across Europe. These developments mean that there is the chance that their model will become a significant factor as cities attempt to ready themselves for the challenges of the coming century, and ACCLIMAT hopes that its work will have a wide-ranging and positive impact.

SIMULATION REFINING

Producing the models has required a number of developments, which have been able to deal with the timeframe of the next hundred years. The coupling of the socio-economic model, which simulates city density and rent characteristics, with geographic modelling of urban planning strategies was the initial idea. This has then been matched to an architectural model which has moved the structural modelling to urban blocks, and these three core elements have together been able to simulate the city at block scale. This can then be used alongside a surface to atmosphere model that links this electronic city to the simulated atmospherics around it. Taking into account the trapping of heat within cities, as well as the energy demand on local energy production, this is set to provide a basis for the usability of the model. Having reached the final year of its development, ACCLIMAT is seeking to simulate a number of adaptation strategies under different climate scenarios, opening up the possibilities for the work of the project.

ONGOING PROGRESS

ACCLIMAT has enjoyed a number of successes in their work so far within the project, making significant inroads into the development of their model and test cities. Improving design as they move, the production of the simulation has not been as direct as originally planned, however, the architects of the software have now produced the urban block model. This has improved the quality of the information which has contributed to building energy computations over a metropolitan area as a whole. This completed, the team was then able to run the first models in their target cities, which included creating a simulation of Toulouse up to 2100 using a coupled socio-economic and geographic models. Furthermore, the project has been able to produce a coupled simulation between socioeconomic expansion and energy and atmospheric models, which have been applied to Paris, demonstrating the breadth of the utility of ACCLIMAT. These successes are paving the way for the wider demonstration and use of the software, opening up the possibility of moving the work to other cities and countries, working with urban planners and policy makers to improve the outlook of international metropolises.

INTELLIGENCE

ACCLIMAT

ADAPTATION TO CLIMATE CHANGE OF TOULOUSE URBAN AREA

OBJECTIVES

To study the interactions between urban development, urban micro-climate and climate change, in order to be able to assess several urban planning adaptation strategies.

A numerical modelling framework has been developed to couple physical models and economic, geographic, and architectural urban models, which will be driven by local climate change and socio-economic scenarios, including macro-economics, land-use, building materials, transportation and technological assumptions.

KEY COLLABORATORS

National Centre for Meteorological Research (CNRM) • **European Centre for Research in Scientific Computation** (CERFACS) • **International research Centre on Environment and Development** (CIRED) • **Laboratory of Research in Architecture** (LRA) • **Geography Laboratory** (GEODE) • **Urban Planning Agency of Toulouse** (AUAT) • **French Aerospace Laboratory**, (ONERA)

PARTNERS

French Scientific and Technical Center on Buildings (CSTB) • **Institute of Urban Planning of Île de France** • **Mayor of Toulouse** • **Regional Agency for Environment** • **Massachusetts Institute of Technology**

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VALERY MASSON is an Environmental Engineer and researcher at the French National Centre for Meteorological Research. His work activities include urban local climate and the adaptation of cities to climate change. He is also the coordinator of the interdisciplinary projects MUSCADE (Urban Modeling and Adaptation Strategies to Anticipate Energy Demand) and ACCLIMAT.

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