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Adapting cities to climate change: A systemic modelling approach

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ABSTRACT

Societies have to both reduce their greenhouse gas emissions and undertake adaptation measures to limit the negative impacts of global warming on the population, the economy and the environment. Examining how best to adapt cities is especially challenging as urban areas will evolve as the climate changes. Thus, examining adaptation strategies for cities requires a strong interdisciplinary approach involving urban planners, architects, meteorologists, building engineers, economists, and social scientists. Here we introduce a systemic modelling approach to the problem.

Our four-step methodology consists of: first, defining interdisciplinary scenarios; second, simulating the long-term evolution of

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[1] The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

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cities on the basis of socio-economic and land-use models; third, calculating impacts with physical models (such as TEB), and; finally, calculating the indicators that quantify the effect of different adaptation policies. In the examples presented here, urban planning strategies are shown to have unexpected influence on city expansion in the long term. Moreover, the Urban Heat Island should be taken into account in operational estimations of building energy demands. Citizens' practices seem to be an efficient lever for reducing energy consumption in buildings.

Interdisciplinary systemic modelling appears well suited to the evaluation of several adaptation strategies for a very broad range of topics.

1. Introduction

Climate projections have foreseen both global warming, sea level rise and an increase in the frequency and intensity of extreme events (IPCC, 2013; Solomon et al., 2007), such as heavy rain and storm events (hurricanes, monsoons, and floods), heat waves, desertification, and giant forest fires. The IPCC assessment reports (IPCC, 2013, 2007b) confirm that greenhouse gas emissions have to be drastically reduced to limit on-going global warming and the pace of the resulting climate change. These reports also acknowledge that adaptation of societies to a new climate context is of prime importance.

These issues have particular relevance to urban areas where valuable assets are concentrated and more than half the world's population resides. Moreover, in some instances the projected global-scale changes can be exacerbated by city-scale phenomena, such as the formation of heat islands (UHI), which during heat wave events, may result in many deaths (Gabriel and Endlicher, 2011; Johnson and Wilson, 2009).

Each of these project climate changes will have an impact on cities that will probably necessitate different adaptation strategies, depending on their specific features (and the interactions between them), the city characteristics and location, the local governance and the level of social and economic development.

At the international scale, the assessment of urban vulnerability to an altered climate is an emerging research topic as shown by projects such as *Engineering Cities: how can cities grow while reducing vulnerability and emissions*?[2] (Tyndal Centre, UK), *Urban lifestyles, sustainability and integrated environmental assessment*"[3] (Postdam Institute for Climate, Germany) and the *New-York Climate and Health Project*.[4]

These works tackle different aspects of environmental risk in cities: flood risks (De Roo et al., 2007) and water system management (Rosenzweig et al., 2007); epidemiological impact of ozone and fine particle pollution (Bell et al., 2007); and heat-related mortality (Dessai, 2003; Knowlton et al., 2007) or discomfort (Kusaka et al., 2012). Environmental risks and vulnerability are often quantified using empirical and statistical approaches (Bell et al., 2007; Dessai, 2003; Knowlton et al., 2007) instead of physically-based models (Kusaka et al., 2012; Masson et al., 2013). Most of them, however, are not based on a interdisciplinary (systemic) approach that accounts for the social, economic and physical processes that interact together at the city-scale; instead they are often limited to one or a few closely related scientific fields.

[2] See: http://www.tyndall.ac.uk/publications/other-tyndall-publications/engineering-cities

[3] See: http://www.pik-potsdam.de/research/past/1994-2000/europa/euro9.html.

[4] See: http://www.mailman.columbia.edu/academic-departments/environmental-health/climate-health-program/new-york-climate-and-health-project.

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