CHANGING THE EUROPEAN DEBATE DAHRENDORF SYMPOSIUM

FOCUS ON CLIMATE CHANGE | 2013

Tiziana Susca and Felix Creutzig

EUROPEAN CITIES CAN CONTRIBUTE TO CLIMATE CHANGE MITIGATION BY CHANGING URBAN ALBEDO

Dahrendorf Symposium Paper Series

Summary

LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE
Stiftung Mercator
Hertie School of Governance

About the authors

Dr. Tiziana Susca is a postdoctoral fellow in the working group on Land Use, Infrastructures and Transport. Tiziana Suscas research interests include climate change, environmental assessment, urban studies, assessment of urban ecosystem services with a specific interest in broadening Life Cycle Assessment (LCA) application to the evaluation of the environmental and urban policies. In 2012 she was research fellow at the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) in Bologna, Italy. Tiziana Susca earned a Ph.D. in Engineering at Polytechnic University of Bari (Italy) on March 2011 with an inter disciplinary thesis on LCA focused on the implementation of the LCA methodology to include the effect of variation in urban albedo on climate. During her Ph.D. Tiziana Susca was visiting scholar at Columbia University's Center for Climate and Systems Research, NASA-Goddard Institute for Space Studies in New York City a world-leading institution in climate research. In 2008 Tiziana Susca participated in the course on urban climate at Polytechnic University of Milan. She holds a Master in building engineering from Polytechnic University of Bari, Italy.

Dr. Felix Creutzig is principal investigator of the Land Use, Infrastructures, and Transport group at the Berlin-based Mercator Research Institute on Global Commons and Climate Change. His research focuses on low-carbon urban infrastructures, land rent and the challenges of comprehensively assessing large-scale bioenergy. He studied various aspects of climate change mitigation as a postdoctoral researcher in Beijing, Berkeley and Princeton, holds a Ph.D. in computational neuroscience from Humboldt-Universität zu Berlin and graduated with a Master of Advanced Studies from the University of Cambridge. His most recent book, *Sustainable Low Carbon Transport*, complements his contribution to the IPCC as lead author of the upcoming assessment report.

This paper was developed for the 2013 Dahrendorf Symposium, a joint initiative of the Hertie School of Governance, London School of Economics and Political Science (LSE) and Stiftung Mercator.

Tiziana Susca and Felix Creutzig

Abstract

EUROPEAN CITIES CAN CONTRIBUTE TO CLIMATE CHANGE MITIGATION BY CHANGING URBAN ALBEDO

The IPCC Working Group I Fourth Assessment Report found that since pre-industrial times until 2005, Land Use and Land Cover Change (LULCC) led to an increase in Earth´s albedo mainly due to the deforestation and the modification of land for agricultural use. However, urban LULCC is also an important driver for global and local climate warming, driven by ongoing rapid urbanisation. Here we investigate how much cities in different geographic regions across Europe can contribute to climate change mitigation by increasing urban albedo.

Earth is currently in transition from a mostly rural to a mostly urban planet, with more than half of the world population now living in cities. In the 19th century a substantial increase in urbanisation started in Europe (Antrop 2004) reaching about 82% in 2010 (United Nations 2013). With urbanisation the massive human built-up environment becomes a significant factor influencing both local and global climate (Landsberg 1981; Kalnay and Cai 2003). The substitution of natural materials with artificial ones alters some optical and thermal characteristics of the natural environment. In particular, in urban environments, albedo, the ratio of reflected radiation from a surface to incoming solar radiation reaching the same surface, is lower than in a rural landscape (Brest 1987). The decrease in the natural albedo due to urbanisation causes a further energy imbalance on Earth´s energy budget, contributing to an increase in radiative forcing as well as to an urban-induced warming at different scales. In contrast, the increase in urban albedo surfaces, such as pavements and rooftops, can contribute to counteract the increase in regional and local temperature (Menon et al. 2010). Urban albedo increase has already been encouraged in various cities, for instance in New York (USA) where local laws (2011) mandate the increase in rooftop albedo to reduce the urban heat island effect and hence, for example, reduce stress from summer heat waves. On a regional scale, the European Commission supports urban albedo modifications with the Cool Roofs project that aims to diffuse bright roofs instead of the traditional dark ones (Cool Roofs 2013). However, the project's aim does not provide any geographical distinction for the wide increase in urban albedo. To enable decision makers to prioritise interventions and development of science-based policies, we evaluate the mitigation potential of albedo increase across a sample of the most populous European cities. Through the peculiar climatological and morphological characteristics of each city we obtained a geographically explicit consideration of the increase in albedo. To quantify the potential decrease in instantaneous radiative forcing by albedo increases, climatological data, such as clearness index and incoming solar radiation at the top of the atmosphere, were retrieved from satellite sources (NASA 2013). The data about the urban morphology – such as the amount of urban surface for transport, for residential uses and for commercial activities – were retrieved from Eurostat (2013). Both marginal and total mitigation potential by albedo modifications were calculated for each city.

First, we investigated the local instantaneous potential decrease in radiative forcing of 145 European cities – i.e., their responsiveness. The increase in albedo is potentially two times more effective in southern European cities than in other regions. This is as a result of two factors: low cloudiness (clearness index) and high solar radiation in Southern Europe. The clearness index is on average higher in Scandinavian cities than in northern-central European ones, while the incoming solar radiation is lower in Scandinavian cities. Surprisingly then the mean increase in unitary albedo is slightly more effective in the sample of Scandinavian cities we considered than in the central-northern European ones. The responsiveness in Scandinavian cities is about 46 W m^{-2}, and 45 W m^{-2} in northern-central European cities.

Second, we included urban morphological characteristics into our analysis, investigating 55 of the 145 cities. Understanding the urban morphology of each city, we were able to calculate the total potential increase in urban average albedo. In accordance with published literature (e.g., Akbari et al. 2009), a feasible increase in albedo is assumed: 0.15 for pavements and 0.25 for rooftops. The effects of the so-called 'non-initial radiative forcing' derived by the increase in urban albedo – for instance evapotranspiration – were excluded in our calculation.

A fine-grained look at the data reveals that a restricted number of metropolitan areas have six times higher albedo-related mitigation potential than most other cities: Athens, Lisbon, and Ruhr. These three metropolitan areas are in different geographical regions. The potential of Athens in decreasing radiative forcing is mainly due to the high incoming solar radiation while the urban morphology reveals limited potential for modifications. Lisbon is also characterised by a high incoming solar radiation and a high potential in the increase in the average urban albedo, even though by the smallest surface. In Ruhr, high total surface and the urban morphology allows a high increase in the average urban albedo.

The effect on local climate, i.e., the mitigation of the urban heat island, is mainly dependent on the potential increase in the average urban albedo, significantly interacting with local urban morphology characteristics.

The analysis conducted shows that, depending on one of the other characteristics (geographical, climatological or morphological), the increase in albedo in several cities characterised by different structures can actively contribute to mitigate the urban-induced warming at local and global scales. The local effect mitigating urban heat stress, having an order of magnitude between 0.3-0.9 degrees Kelvin, is more relevant and could spur local action.

The increase in urban albedo is a viable contribution to mitigation and adaptation strategies. It can be easily integrated in urban and building maintenance plans, the results being economically feasible since it would not require any additional public investment. In addition, the time necessary for the transition to higher albedo cities would be reasonable compared to other mitigation strategies. The main findings of this study provide information for policymakers and planners for the future transformation of the urban and natural landscape. The findings can be useful for shaping science-based policies as well as for the prioritisation of urban actions in European cities. Since the effect of the albedo modification can involve different scales, the results of this study point to a debate about the role of the harmonisation of local actions with national and regional ones.

References:

- Akbari, H. et. al. Global cooling: increasing world-wide urban albedos to offset CO2. Climatic Change, 94 (36), 275–286 (2009)
- Antrop, M. Landscape change and the urbanization process in Europe. Landscape and urban planning, 67, 9–26 (2004)
- Brest, C.L. Seasonal albedo of an urban/rural landscape from satellite observations. American Metereological Society, September, 1169–1187 (1987)
- Cool Roofs (2013). Retrieved on September 2013 from: http://www.coolroofs-eu.eu/
- Eurostat (2013). Statistics. Retrieved on February 2013 from: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Kalnay, E., Cai, M. Impact of urbanization and land-use change on climate. Nature 423 (2003)

- Landsberg, H. E. The Urban Climate (Vol. 28). New York: International Geophysics Series (1981)
- Local laws of the City of New York (2011). Retrieved on June 2013 from: http://www.nyc.gov/html/dob/downloads/pdf/local_law_99_05.pdf
- Menon, S. et al. Radiative forcing and temperature response to changes in urban albedos and associated CO2 offsets. Environmental Research Letters 5, 1–12 (2010)
- NASA (2013). NASA Surface meteorology and Solar Energy - Available Tables Retrieved on February 2013 from: http://power.larc.nasa.gov/cgi-bin/cgiwrap/solar/grid.cgi?&p=grid_id&p=swvdwncook&p=avg_kt&p=daylight&p=day_cld&p=toa_dwn&p=srf_alb&num=197132&lat=41&veg=17&hgt=100&submit=Submit&email=grid@larc.nasa.gov&lon=16&step=2&sitelev=
- United Nations (2013). Retrieved on September 2013 from: http://esa.un.org/unup/unup/index.html