A Climate Adaption Concept for the Urban Heat Island

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Introduction

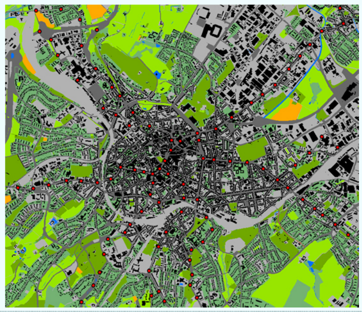
- A new German Federal Building Code since 2011 requires adequate measures of climate protection and climate adaption in connection with urban planning and construction
- The City of Aachen presently sets up a new preparatory land-use plan, climate adaption measures based on a climate adaption concept are going to be implemented
- The climate adaption concept has a focus on the situation of the urban heat island (UHI) and is based on data from an experimental study of RWTH Aachen University
- Results from the study were used to locate present hot spots of thermal load and to establish a geostatistical model which is used to simulate potential future zones of heat load
- Patterns of distribution of population and especially of children or vulnerable persons were analyzed additionally
- Private urban planning consultancy BKR Castro & Hinzen (now BKR Aachen) coordinates all aspects of urban planning incl. implemantation into the preparatory land-use plan

Area of Investigation

- The City of Aachen has about 250 000 Inhabitants and is situated in a wide valley between 140 m und 360 m a.s.l. near the Eifel low mountain area in Northrine-Westfalia, Germany
- The densely built-up city centre is situated in the central part of the valley and the urban developement mainly took place radially along the watersheds between small side valleys
- According to the general situation, inversions are frequent and local cold air drainage flow is very important for urban ventilation

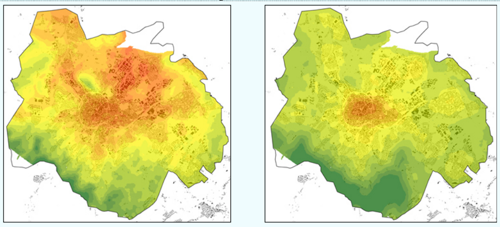
Data and Data Availability

- Mobile measurements were performed during an experimental study of RWTH Aachen University in Aachen using local public busses as a carrier system for temperature and GPS sensors
- Buses along four lines were equipped with the sensor system and data were collected over a 1 ½ year long period during different weather situations (Buttstädt et al., 2014a)
- Data were collected for 256 predefined points along the bus routes for which land use data of the german cadastral map system ALKIS were used
- The results were transformed into differences to a reference station not far from the city centre
- Data for local cold air drainage flow were generated by the DWD cold air model KLAM_21 (Sachsen et al., 2013)
- Climate projections for 2030 were used to estimate future warming trends (Buttstädt et al., 2014b)
- In another case study, in the City of Münster, Germany, data from mobile measurements of a short period (one day) with 463 predefined points were combined with a here available ten year time series of an urban-rural pair of weather stations to form the basis of geostatistical analysis



Land use model based on ALKIS data

Geostatistical Analysis



Geostatistical temperature model – afternoon situation (left) evening situation (right)

- Measured data were transformed into temperatures relative to a reference station
- A multiple linear regression model was set up to characterize the effect of those green and building structures which can be modified by urban planning
- Land use characteristics influencing air temperature with high R^2 are the proportion of forest area, green area, building area, sealed area and altitude
- For the afternoon and the evening situation best and significant R^2-combinations are partly different
- Geostatistical model:

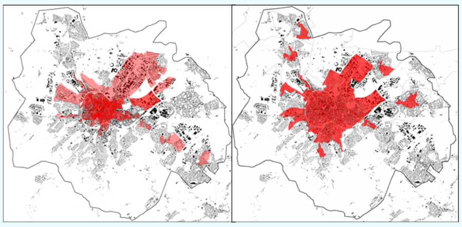
  Afternoon situation (left figure): T = 2.29393 - 4.3349e-5*F500 - 8.0176e-5*G500 + 4.18342e-4*S90250 - 0.0123915*A

  Evening situation (right figure): T = 2.7625 - 1.17895e-4*F500 - 0.00447877*A + 3.67743e-4*B500

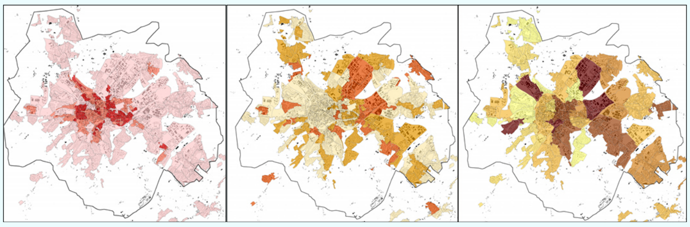
  (T [air temperature], F500 [forest raster points 15x15m in r = 500m], G500 [green area points r = 500m], B500 [built-up area points r=500m], A [altitude a.s.l.], S90250 [90% sealed area r = 250m]; Multiple R^2 = 0.85 [afternoon] / 0.80 [evening], $p < 0.05$; Buttstädt et al., 2014a)
- Compared to Aachen, the Münster results show significant (warming) effects of sealed and building areas rather than cooling by green areas and no significant effect of altitude (the city is located in the lowlands)

Overlay of climate effects and population data

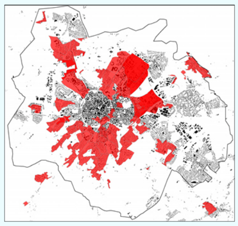
- Beside UHI characteristics, air quality situation and cooling by cold air drainage flow are used to characterize the spatial structure of the entire ambient air exposure (Sachsen et al., 2014)
- Expected effects of climate change were implemented into the geostatistical model as a linear offset according to a study for Aachen (Buttstädt et al., 2014b) showing that the number of urban districts affected by one or more thermal and air pollution expusure features at supernormal level probably will increase (see figure below left)
- Urban population data are used to outline the spatial distribution of sensivity factors in the city like population density, proportion of children and of people with cardi-vascular deseases (see figure below center) with an overlay pattern of urban districts with one or more of these sensitivity factors at supernormal level (below reight)
- While areas of higher exposure and sensitivity level (below left and right) presently appear to be seperated, increasing load in areas with more sensitive population is to be expected



Districts affected by high thermal and pollution exposure – 2010 (left) and 2030



Districts with higher population density (left), proportion of children (center) and number people with cardio-vascular deseases

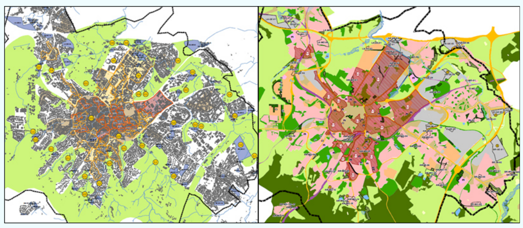


Districts with one or more sensitivity factors

Planning Implementation

- Areas with expected future superposition of exposure to thermal and air pollution load are located
- Measures for migitation are described and allocated to areas with need for planning activities
- These are general measures with climatic effects (G) and measures with effects on air flow pathways (L)
- The developed measures (plan of measures; left) is then assigned to possible planning regulations
- These planning regulations are presented in a map of suggestions for the preparatory land-use plan which gives an overview on the location of main regulations (right)
- The preparatory land-use plan transforms climatological findings into planning regulations according to national or regional planning laws or guidelines
- One tool can be assignment of special areas of urban climate restructuring similar to areas of urban renewal („KA“)
- The City of Münster intends to use the results rather for strategical development than for a new preparatory land-use plan

Plan of measures (left) and suggestions for new preparatory land-use plan (right)



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