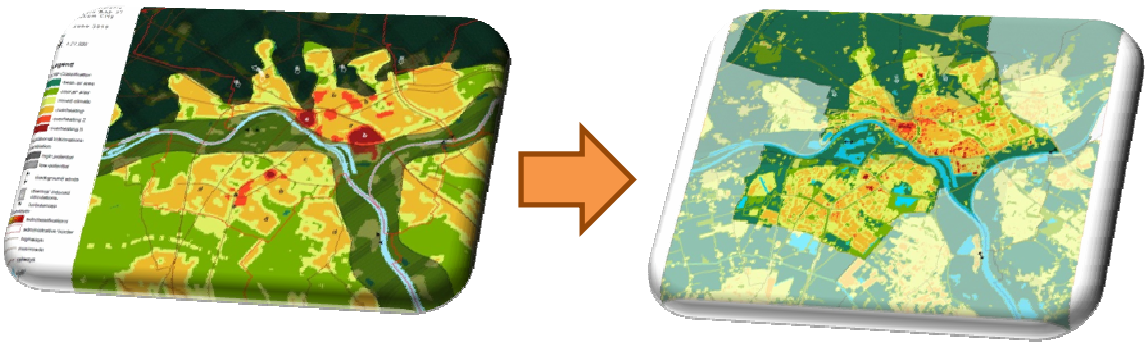
Update report of the Urban Climate Map of Arnhem



Using new input data and methods

Kassel, 07.01.2013

Editor
Dipl.-Ing. René Burghardt

Scientific administration
Prof. Dr. Lutz Katzschner

umet
Department of Environmental Meteorology

Institute for Architecture, Urban Planning and Landscape Design

UNIKASSEL VERSITÄT
Henschelstraße2
34127 Kassel, Germany

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
nwe
INTERREG IVB

Future Cities
urban networks to face climate change

Content

1. Background The Urban Climate map of Arnhem was first developed in 2010. Therefore, we used different input data, described in the original report, to create the imprint of the thermal and climatic situation of the city of Arnhem. Depended of the input and the method the grid size was limit to 50m x 50m.

In consequence of the availability of new building and surface information, new land use information and further method development the UCM is now recalculated to a 25m x 25m grid. The method now includes the capture of greenery out of open source satellite images like "Google" or "Microsoft Virtual Earth", the building volume, and the frontal area ratio depending on the ventilation situation.

The improvement is closing with the possibility of a grouping analysis of the UC vector grid. This method provides to create categories, which are similar to each other in their attributes. Out of this, it is possible to analyse the circumstances of the UC classification. (This step is not included yet, but will be tested next)

2. Input Data The following two tables shows the used input dataset and the further used layers for the recalculation of the UCM. To get a slightly overview about the input changed the content of the first UCM is added too.

UCM of Arnhem 2010		**UCM of Arnhem 2012**	
Data	***Year / Description***	***Data***	***Year / Description***
land use data	year 2000 - 2003	land use data (GMES) EEA Urban atlas open source	year 2011; pan-european comparable land use data for areas with more than 100.000 inhabitants.
elevation data 5m / 25m	year 1996-2003	elevation data 0,5m	year 2010 (northern part of the municipality) and 2011 (southern part of the municipality)[1]; New elevation laser scan data first selection (raw dataset)
building footprints	footprints year 2010	building footprints	New building footprints; year 2012; without building height; get height value from elevation data
wind distribution	Annual wind roses; year 1979 - 2009	wind distribution	Annual wind roses; year 1979 - 2009
		greenery	Collection of greenery out of satellite images

[1] Nothern part is the part of the municipality situated north of the river 'Nederrijn'. Southern part is the part of the municipality south of the river 'Nederrijn'.

UCM of Arnhem 2010		**UCM of Arnhem 2012**	
Calculation layer		***Calculation layer***	
thermal potential land use		thermal potential land use	
dynamic potential slope		dynamic potential slope	
--		dynamic potential frontal area ratio	
ventilation cooling		ventilation cooling	
sealing rate		sealing rate	
--		building volume	
--		greenery effect	

3. Layer For the calculation of the UCM the input data is used to create different layers. These layers describe different effects on the thermal and dynamic aspect of the research area. All layers have a resolution of 0,5m (0,36m greenery), but carried information are always meso-scale information, so the reference value is set to 25m. The high detailed resolution is necessary to collect data which have effect on the meso climate, like trees etc.

Thermal potential land use layer In the European land use dataset 19 categories are defined. For the calculation layer three main categories with corresponding subclasses were created. The classification set mainly describes the thermal potential as low, neutral or high.

Thermal class (calculation value)			Item
Main classification	Effect	Sub classification	
1	+	1	Agricultural & semi-natural areas & wetlands
1		1,2	Forests
1		1,2	Green urban areas
2	0	2	Land without current use
2		2,2	Sports & leisure facilities
2		2,5	Water bodies
2		2,6	Railways & associated land
2		2,6	Fast transit roads & associated land
2		2,8	Mineral extraction & dump sites
3	-	3	Other roads & associated land
3		3,2	Isolated structures
3		3,2	Discontinuous very low density urban fabric
3		3,4	Discontinuous low density urban fabric
3		3,4	Construction sites
3		3,6	Discontinuous medium density urban fabric
3		3,8	Discontinuous dense urban fabric
3		3,8	Port areas
3		4	Continuous urban fabric
3		4	Industrial, commercial, public, military and private units

Dynamic potential slope The slope detection layer collects areas which have high potential for nocturnal cooling. The classification only differs in “yes” or “no”.

Slope classification (positive/negative)	Effect	Calculation value	Slope in degree
yes	+	0,5	>= 2°
no	0	0	< 2°

Dynamic potential frontal area ratio The frontal area ratio describes the potential wind blocking area of a thiessen polygon depending on a special direction. The directions are defined by the underlying wind rose information. The thiessen or voronoi polygons are created by aggregating buildings to blocks, if they are closer than 1m to each other. The so called plot area guaranteed every point inside is closer to buildings inside as to any other building.

Frontal area ratio	Effect	Calculation value
0,1	+++	0,1
0,2	++	0,2
0,3	+	0,3
0,4	0	0,4
0,6	-	0,6
0,8	--	0,8
1	---	1

Ventilation cooling Based on the actual wind roses, the main wind directions are located coming from the west and southwest in the summer.

Ventilation direction	Effect	Calculation value
north (nocturnal flow)	+	-0,4
west (river side / catchment)	+++	-0,8
southwest	++	-0,6

Building volume Elaboration of the building-related thermal stress caused by the heat storage capacity and reflection, based on the building mapping derivation of the physical behavior (both total and urban micro-climate).

Building volume (25m x 25m x 50m)	Effect	Calculation value
0%	++	0
0%-25%	+	0,25
25%-50%	0	0,5
50%-75%	-	0,75
75%-100%	--	1

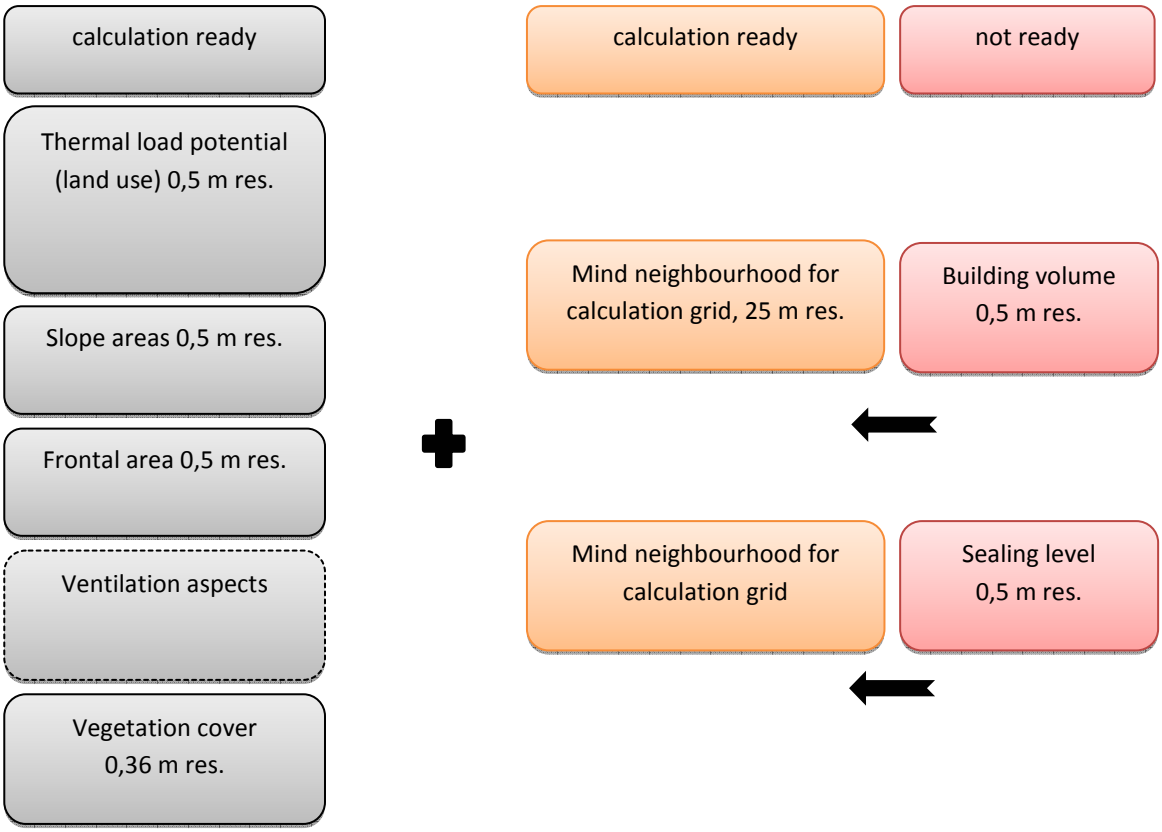
Sealing rate Elaboration of the sealed areas and generalization of certain types of areas. Two-dimensional view based on the real-use mapping, mapping of buildings and land use data (traffic areas) as material for the thermal analysis.

Sealing rate (25m x 25m)	Effect	Calculation value
0%	++	0
0%-25%	+	0,25
25%-50%	0	0,5
50%-75%	-	0,75
75%-100%	--	1

Greenery effect To collect the greenery in and around Arnhem, satellite images of Google earth were used. Even if they are not 4-band infrared, by using special Gis technics it is possible to extract the existing greenery. To avoid collecting errors, building footprints and vegetation land use classifications were substrate. Unlike to use only the official land use classification or tree field book, this method provides the possibility to collect nearly all vegetation, even private green in the re-search area

Green availability	Effect	Calculation value
yes	+	-1
no	0	0

4. Calculation matrix



Interim calculation result 0,5 m / 10 m / 25 m res.

- neighbourhood circle catchment 1,5 m on 0,5 m source
- aggregation from 0,5 m to 10 m
- neighbourhood circle catchment 30 m on 10 m source
- aggregation from 10 m to 25 m

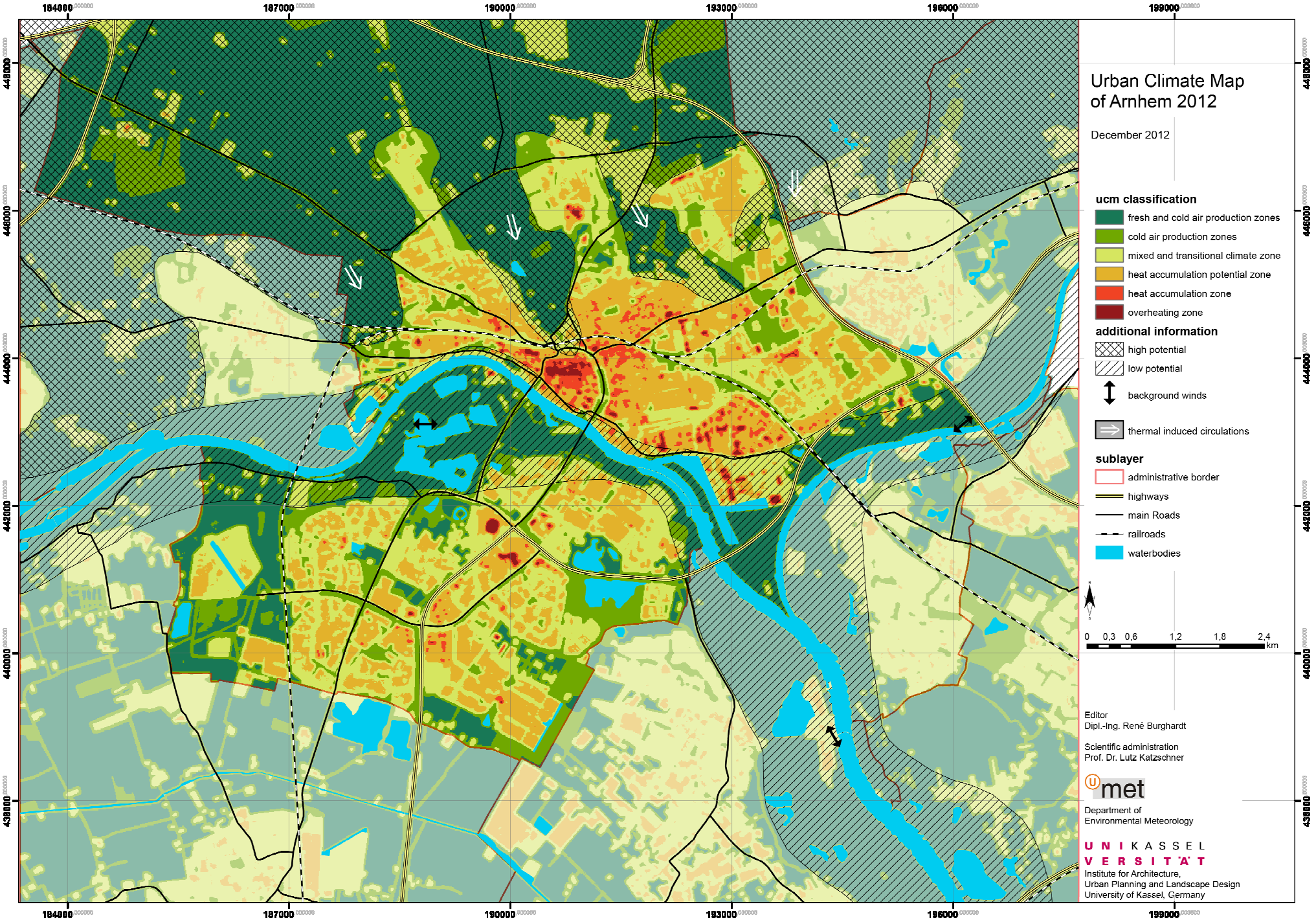
Final calculation result for 25 m res. map

Unique classification as follow:

climatope 1:	0,545 – 1,134
climatope 2:	1,134 – 2,145
climatope 3:	-2,145 – 3,700
climatope 4:	3,700 – 4,455
climatope 5:	4,455 – 5,014
climatope 6:	5,014 – 6

5. Urban Climate Map and classification

Category	Climatope	Description	Evaluation / Planning Zones
1	Fresh & cool air production zones	Open areas with significant climatic activity, cool and fresh air production; Climatically active open sites in direct relation to housing area; Very high nocturnal heat degradation	*Areas to preserve carefully:* High sensitivity with respect to intervention which changes in land use. Do not allow to increase the surface roughness (e.g. no further constructions or buildings). Keep open of cold/ fresh air stream; Minimize the existing barrier on the air streams. The air movement connections must be fully analysed and understood including the source of the air stream channels, which may be far away from the concerning area.
2	Cool air production zone	Open areas with less significant climatic activity; Cool & fresh air with effects to neighborhoods; Areas without any emissions; High nocturnal heat degradation	*Areas to preserve:* The increasing surface roughness (e.g. further constructions or buildings) can only be allowed if they respect slope winds and thermal induced circulation pattern; furthermore, redevelopments should only be allowed in exception case, which is supported by detailed investigation and analysis on climatic function aspect.
3	Mixed & transitional climate zone	Strong daily variation through income radiation, but good cooling effect; Areas with high percentage of vegetation; Low & discontinuous emissions; Buffer zones between different climatope; Moderate / good nocturnal heat degradation	*Areas with possible development:* Important linkage areas, foresee the orientation and density of buildings, surface roughness should not be in-creased due to reduction in ventilation with effect on neighborhoods
4	Heat accumulation potential zone	Some heat storage but mainly buffered through greeneries and wind; Dominated construction areas with lots of vegetation in the open spaces; Low nocturnal heat degradation	*Development allowed:* No appreciable sensitivity in terms of climate with respect to intensification of use and building agglomeration. Generally redevelopment is possible if they take care about ventilation and if the ratio between built up area versus green area is maintained/respected.
5	Heat accumulation zone	Heat storage remarkable but still some wind effects and cooling potentials; Density development with little vegetation in open spaces; Very low nocturnal heat degradation	*Areas for improvement and plan actions are necessary:* Risk of future heat stress with some ventilation. So generally the areas should be maintained or improved, and not worsen. Development can only be allowed with compensation for climate effects. The existing air circulation should be analysed before any proposed change so that the urban climate is respected
6	Overheating zone	Heat storage high; Low cooling potentials and low ventilation; Heavily compressed and sealed inner city areas; No / very low nocturnal heat degradation	*Areas for improvement and plan actions are necessary:* In need of renewal from the point of view of urban climate. Greenery for facades and surfaces are needed. Increasing of existing heat stress, due to the accumulated problems on thermal load in the high dense built-up area, the climatic condition of this zone should be improved. Development in this zone is allowed only if enough compensation is done. Improving air exchange is one major recommendation together with shadow providing design.


184000
187000
190000
193000
196000
199000
448000
446000
444000
442000
440000
438000
Urban Climate Map
of Arnhem 2012
December 2012
ucm classification
fresh and cold air production zones
cold air production zones
mixed and transitional climate zone
heat accumulation potential zone
heat accumulation zone
overheating zone
additional information
high potential
low potential
background winds
thermal induced circulations
sublayer
administrative border
highways
main Roads
railroads
waterbodies
0 0,3 0,6 1,2 1,8 2,4 km
Editor
Dipl.-Ing. René Burghardt
Scientific administration
Prof. Dr. Lutz Katzschner
umet
Department of
Environmental Meteorology
UNIKASSEL
VERSITÄT
Institute for Architecture,
Urban Planning and Landscape Design
University of Kassel, Germany