

Review of Urban Climatic Map Studies around the World

城市環境氣候圖國外研究概況



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20th May, 2008

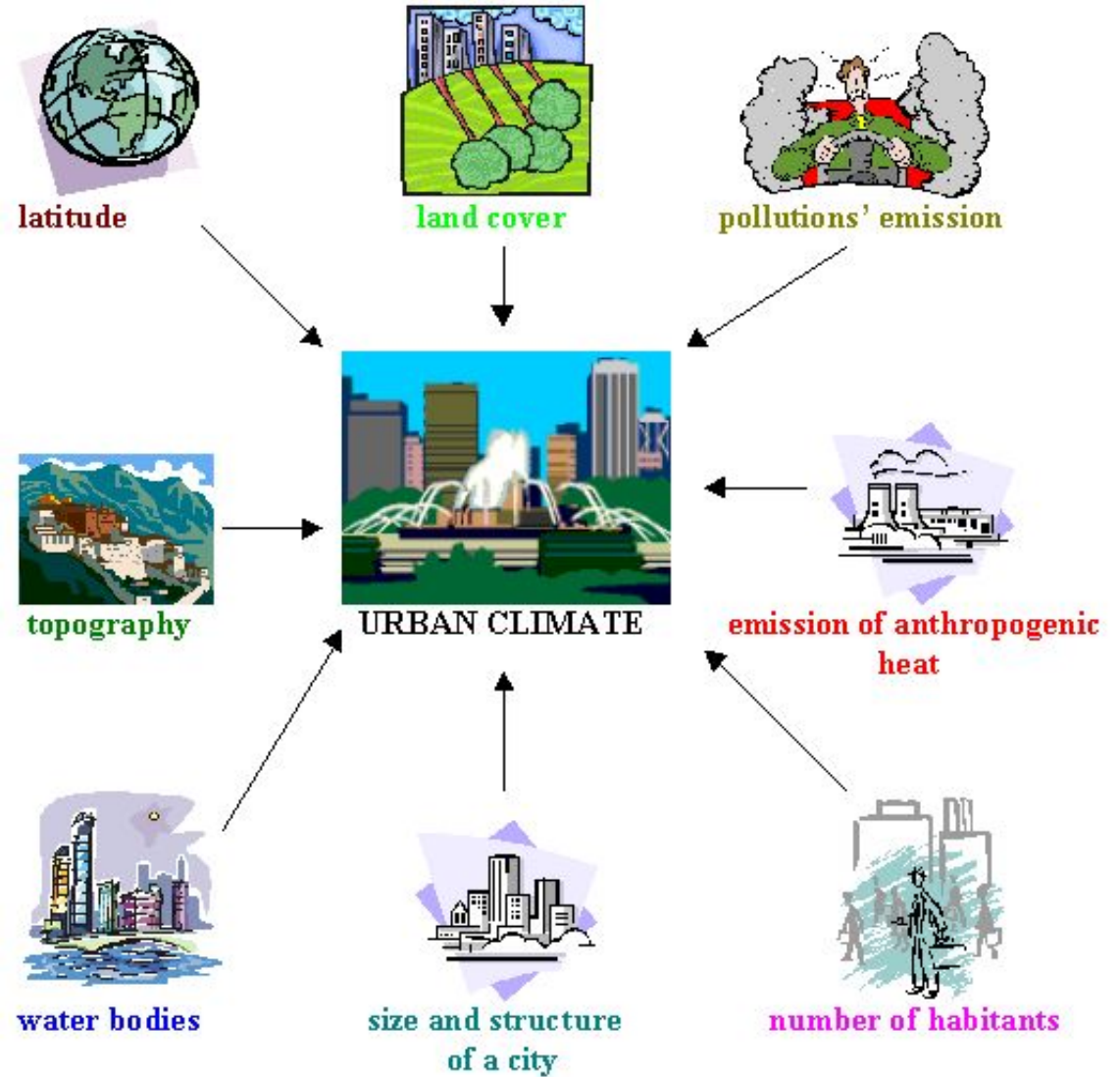
二〇〇八年五月二十日



Background 背景

Urban Climate 城市气候

在大城市的特殊下墊面和城市中人類活動的影響下形成的一種局地氣候。





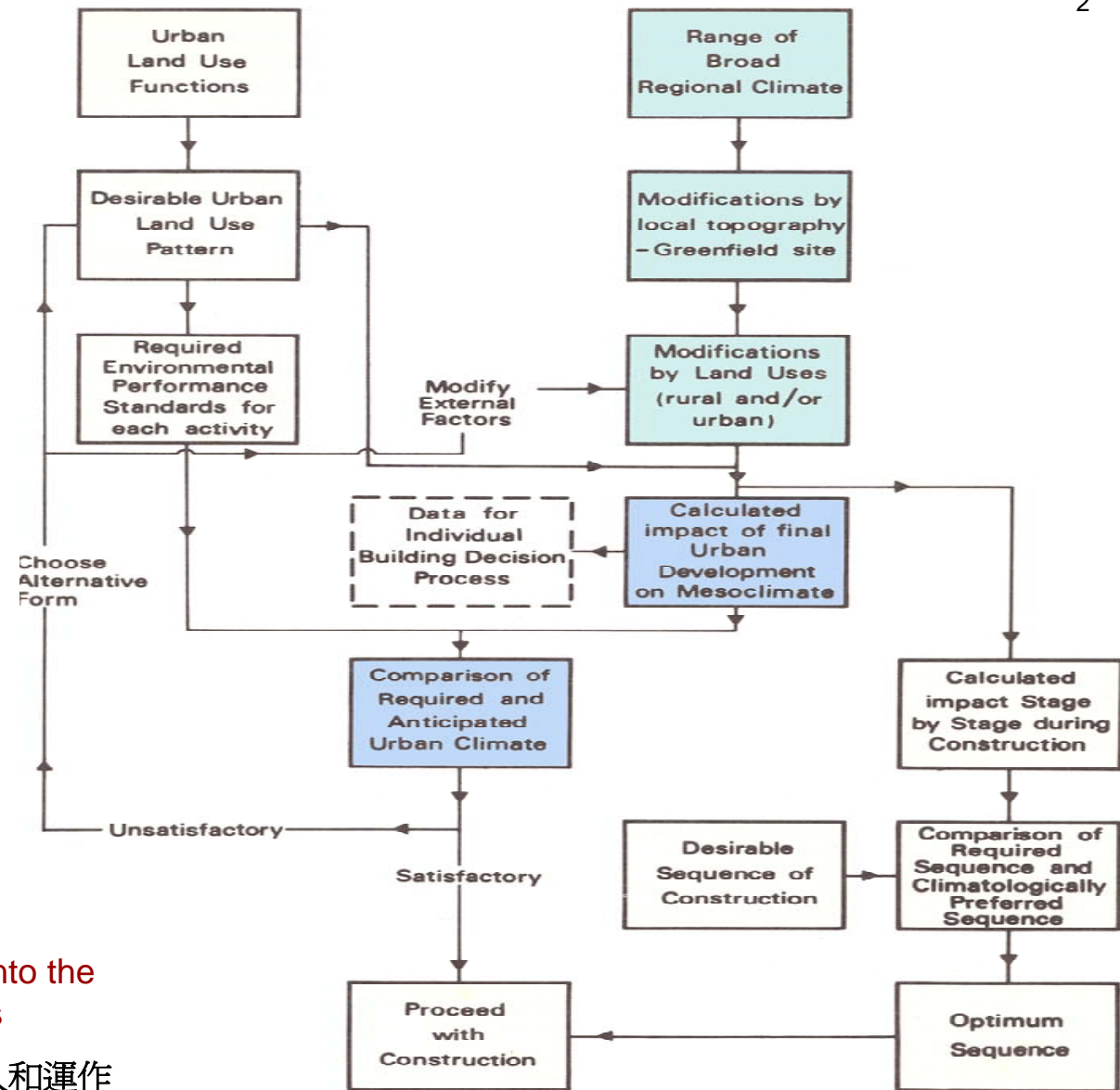
Background 背景

WMO Symposium on Meteorology as Related to Urban and Regional Land-use Planning in Nov.1975

1975年世界氣象組織召開涉及城市、區域土地規劃領域的應用氣象學研討會

Flow diagram for a climatological input into the urban planning decision-making process

圖解城市規劃決策過程中氣候因素的輸入和運作





Problem 存在的问题



I. Eliasson, (2004) The use of climate knowledge in urban planning, Landscape and Urban Planning, 48, 31-44



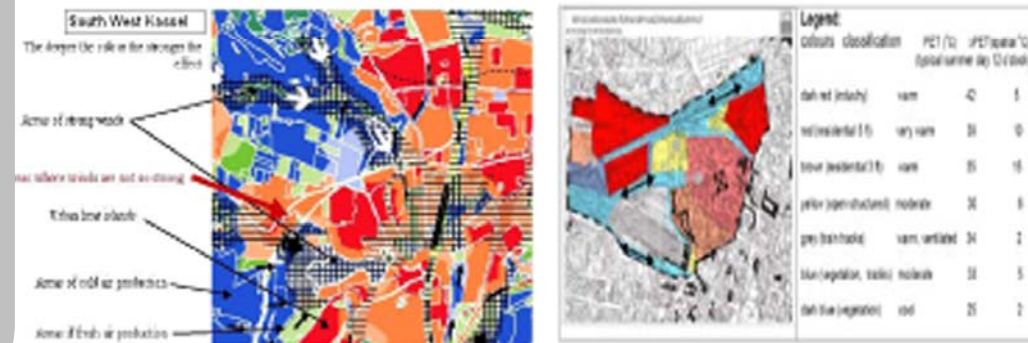
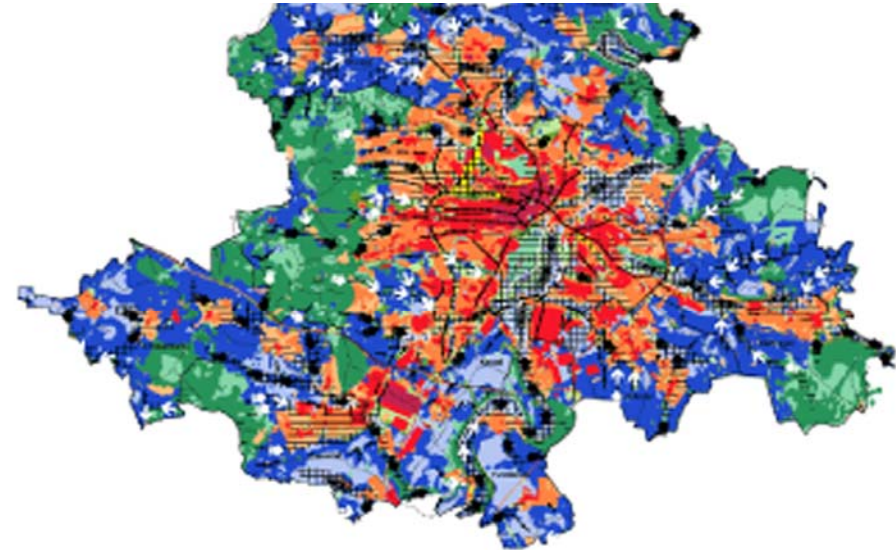
Urban Climatic Map 都市環境氣候圖

What is Urban Climatic Map?

甚麼是城市環境氣候圖

Urban climatic map makes use of **climatic parameters** like wind directions and speeds, solar radiation, air temperature and so on. They are superimposed onto our city topography, landscape, building bulks, street grids and so on. The map can tell **how the streets are ventilated**; where are the more comfortable spots, where the problem areas are, and **how the building are affecting the city wind**. With information like this, planners and designers have a better basis of decision making.

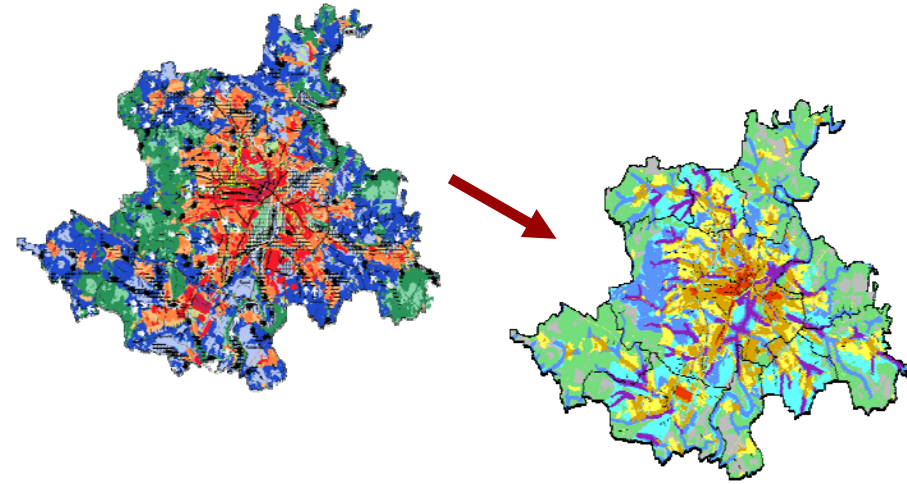
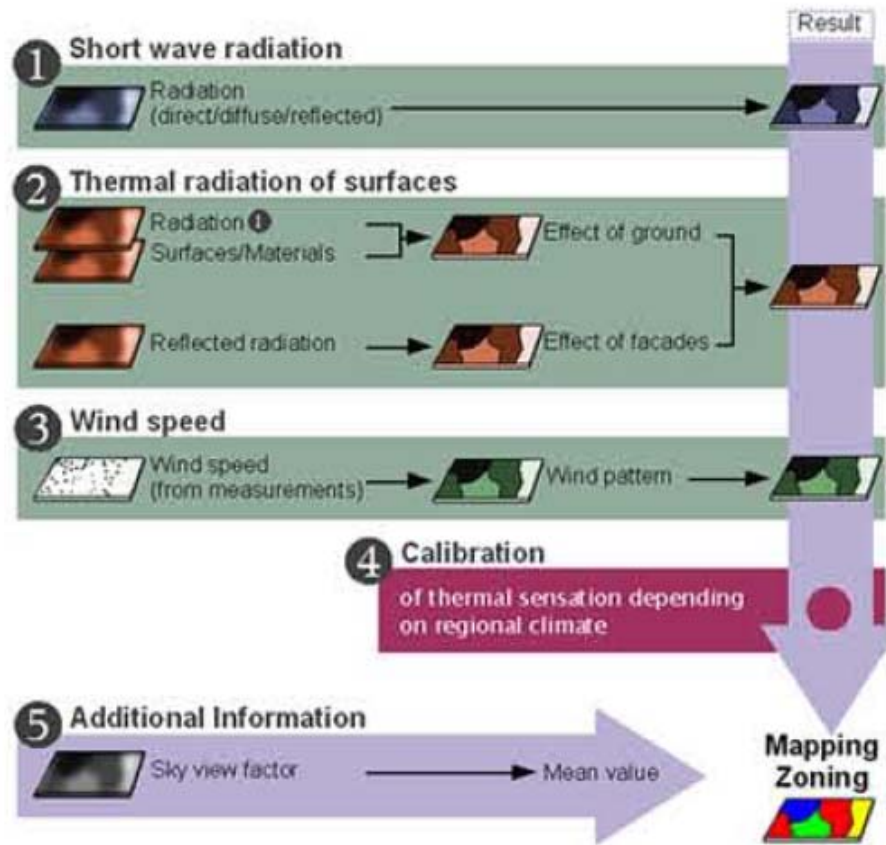
- 都市氣候圖把氣候參數，如風向、風速、太陽幅射、氣溫等資料融入至城市的地形、景觀、建築群、街道結構等當中。
- 都市氣候圖可以告訴我們街道通風的情況，並列出哪些地方較舒適、哪些地區出現氣候問題，以及指出建築物如何影響都市的風環境。城市規劃師及設計師可利用這些資料作為決策的準則。



The concept of UC-Map originated in Germany in the 1980s.



Urban Climatic Map 都市氣候環境圖



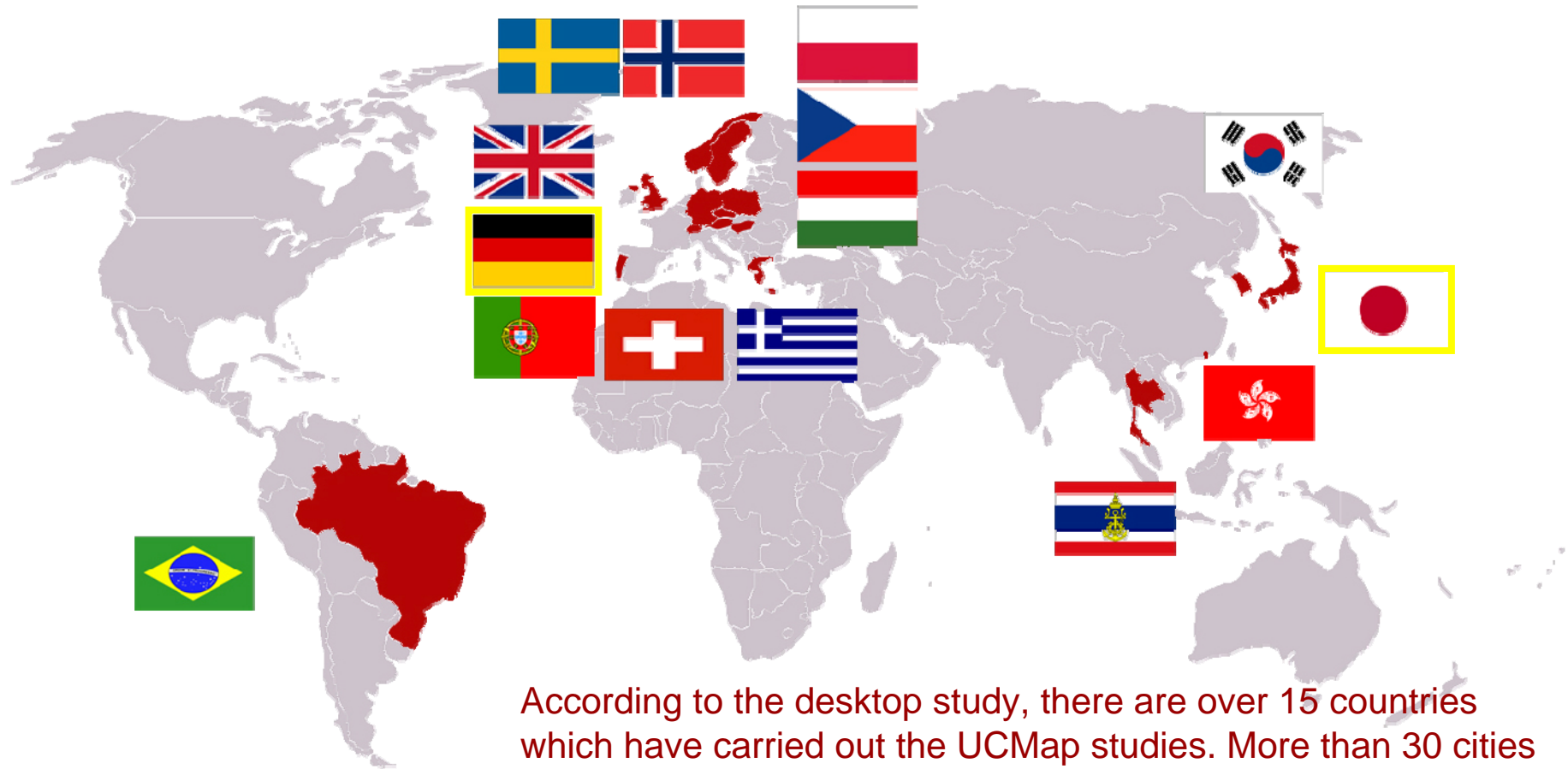
Evaluation is carried out through a GIS based calculation method, which calculates weighting factors for every grid with a result for **thermal load** and **dynamic potential** maps. Then, this is combined to the planning function map with an evaluation to the UCMAP for **planning use**.

城市環境氣候的評估主要是以GIS為軟體平臺，進行計算。同時在每個單位格內計算各個因素的權重，從而得到熱學分析和動態分析的圖紙。接下來，轉譯成城市氣候規劃功能圖，並對城市規劃的決策進行指導。



UCMap Studies Around the World

世界範圍內的城市氣候環境圖研究



According to the desktop study, there are over 15 countries which have carried out the UCMap studies. More than 30 cities have their own UCMap.

根據現階段收集到的資料，在世界範圍內超過15個國家都已先後開展了城市環境氣候圖的研究；超過30各城市擁有自己的城市環境氣候圖。



UCMap Studies in Germany

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德國城市氣候環境圖研究概況



German Federal Building Law
联邦德国建筑法律



Federal Emission Protection Law
联邦废气排放保护法律



Building Use Regulation
建筑使用条例

According to the BauGB, BImSchG and BauNVO in 1987

- The urban development planning has to be sustainable, integrating the social, economic and ecologic demands.
- Urban development plans have to contribute to an environment fit for human beings and to the protection and development of natural resources.
- They also have to develop the townscape and landscape in responsibility for future generations.

根據德國建築法律、聯邦廢氣排放保護法律以及建築使用條例的要求

- 城市規劃必須符合可持續發展，同時兼顧社會性，經濟性和合理性的需求。
- 城市發展規劃必須有助於建設適於人居，同時有助於保護和發展自然資源。
- 它們還必須為下一代考慮建設城鎮景觀和綠化景觀。



UCMap Studies in Germany

德國城市氣候環境圖研究概況

planners + meteorologists + governors

Cooperation

1. to synergize climatic, topographical and urban parameters
2. to draft urban climatic maps and urban parameters

in order to more objective guiding the planning decision process



H. Mayer & A. Matiarakis (1983)

Map of Bioclimatic Effects of Urban Air Paths in Munich at the early stage

早期慕尼黑城市風道氣候效應分析圖

因此德國規劃師、氣象學家和科學家合作開展城市環境氣候圖的研究，嘗試將氣象、地形及城市等要素綜合納入研究範疇，從而為科學的規劃決策提供依據。



UCMap Studies in Germany

Research Projects of Urban Climate Investigation

In the 1980s, in southern West Germany

STADTKLIMA BAYERN: research project of urban climate of the state of **Bavaria** (including Augsburg, München, Nürnberg, Fürth, Erlangen and Schwabach)

- In the 1990s, after re-unification of Germany

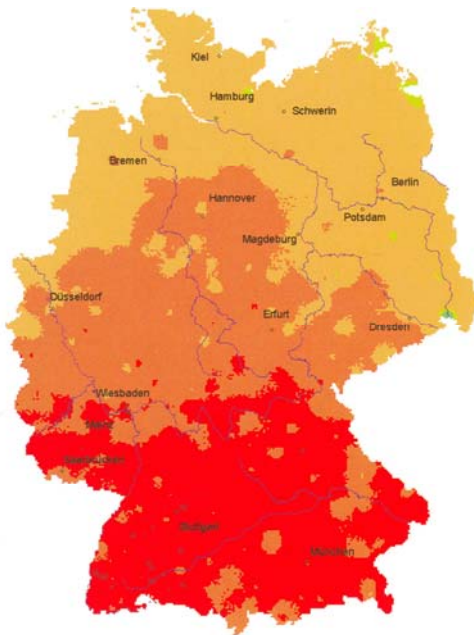
STUTTGART 21: to analysis the urban climate of **Stuttgart**

BERLIOZ: to study the air pollution of **Berlin** and its surrounding suburbs

Klimabewertungskarte Hessen: to analysis the urban climate of the state of Henssen (including Kassel, Wetzlar, Frankfurt, Mainz, Darmstadt and etc.)

- Recent,

KLIMES: to develop strategies for mitigating enhanced heat stress in urban quarters due to regional climate change in Central Europe



Heat Stress in Germany

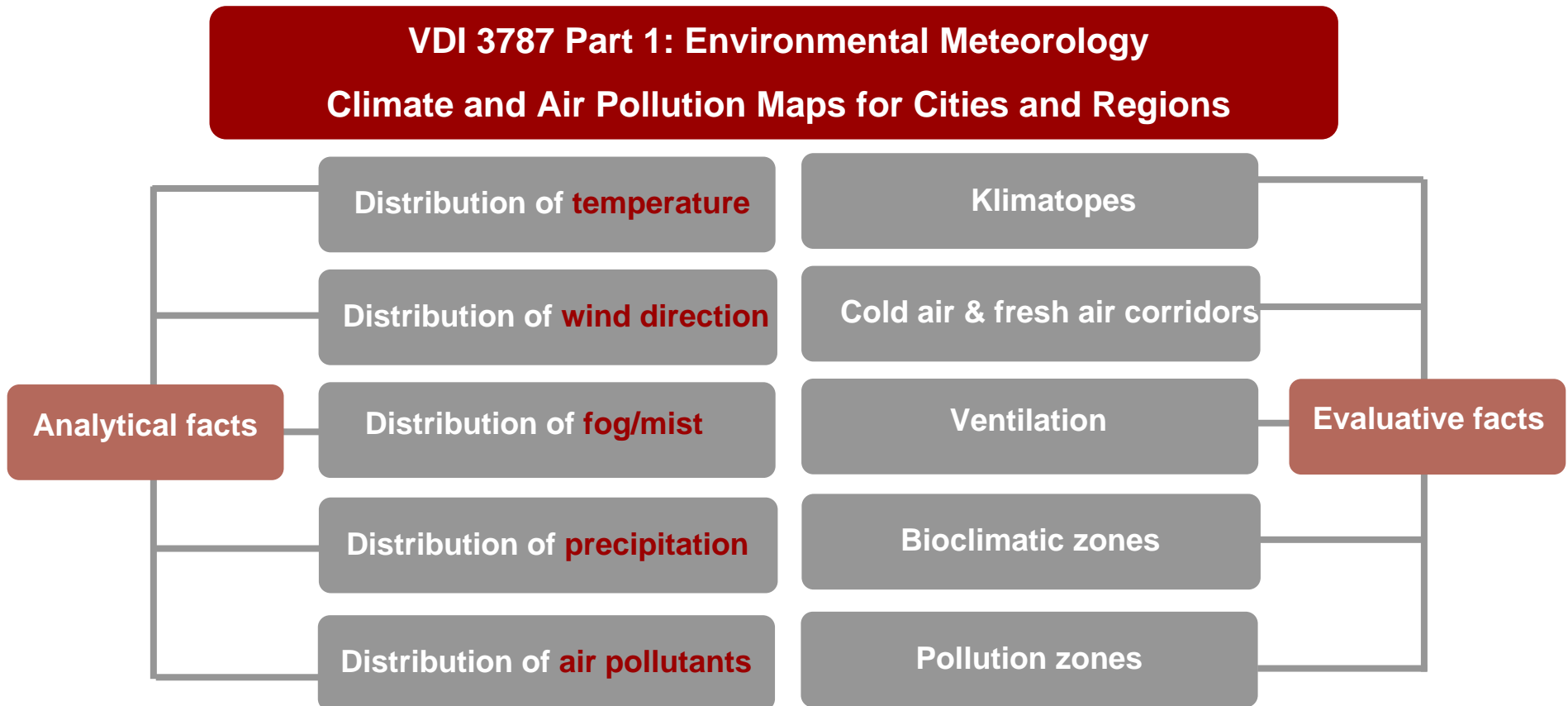


UCMap Studies in Germany

德國城市氣候環境圖研究概況

With the development of UCMap studies, in 1997 **the Guideline for drawing up climate and air pollution maps (VDI 3787 Part 1)** is published by the work group of Urban Climatic Map of committee of applied climatology.

It aims to **define** the symbols and representations used in UCMaps and **make a standard** for their application.



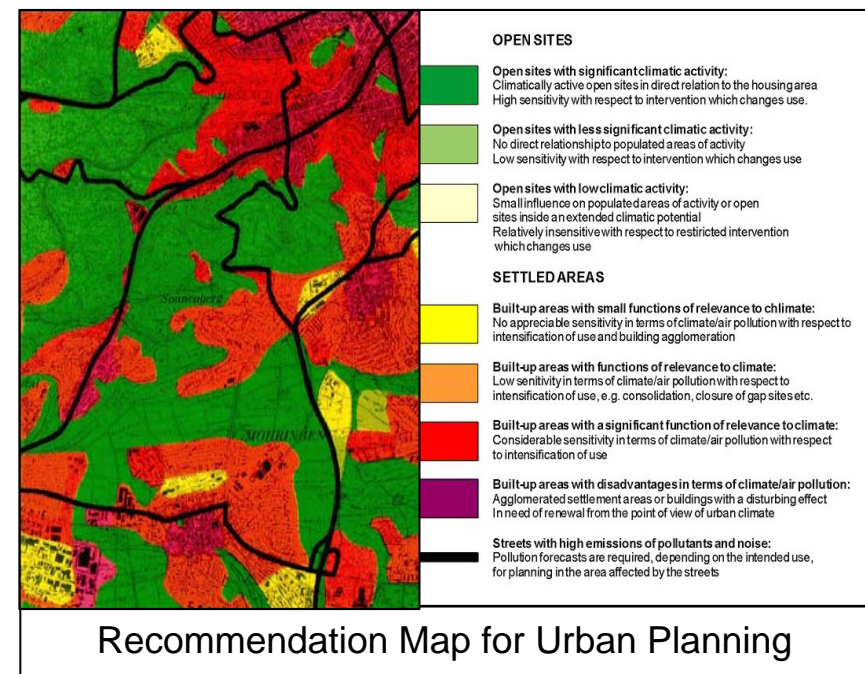
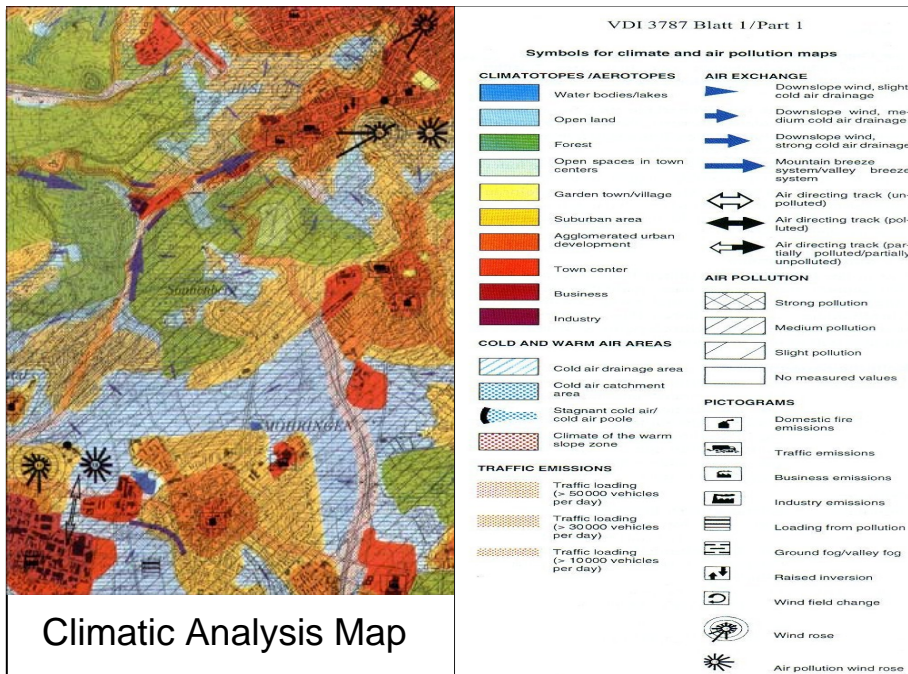


UCMap Studies in Germany

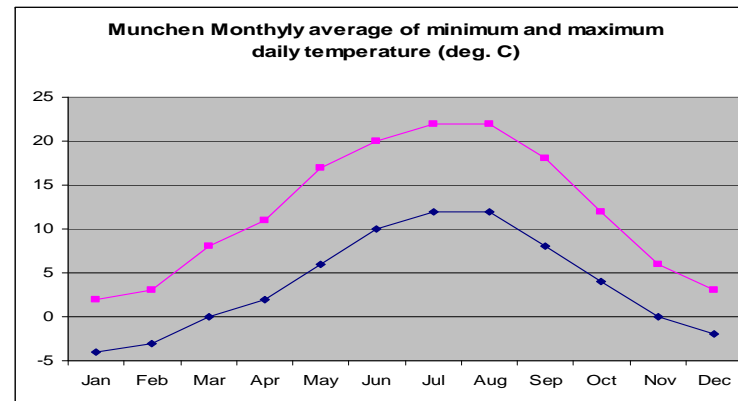
德國城市氣候環境圖研究概況

VDI 3787 Part 1: Environmental Meteorology Climate and Air Pollution Maps for Cities and Regions

Example map for Stuttgart city area



City Example – München, Germany

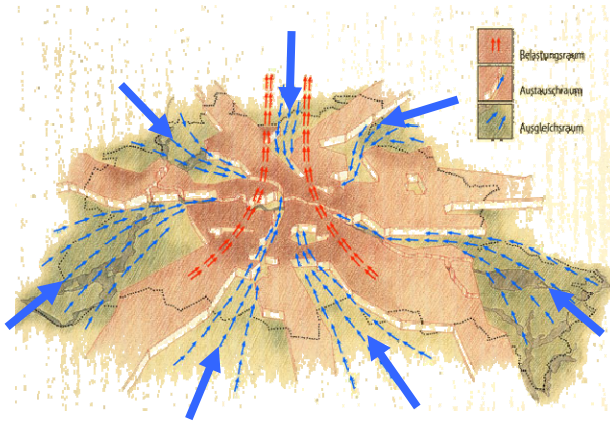


City Area: 310.43 sq.Km
 Population: 1.35 millions
 Average Density: 4,320 /sq.Km
 Location: Inland
 Topographical: in a Valley

Climate: Continental
 summer: warm
 winter: cold

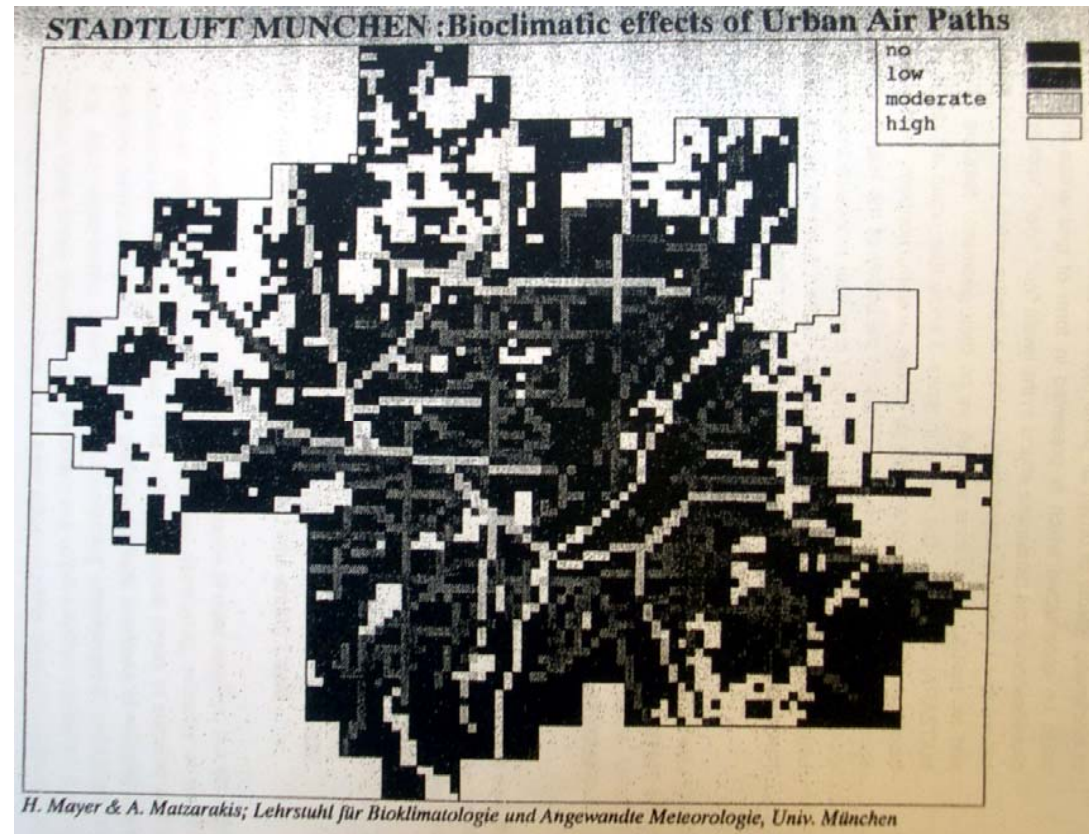
City Example – München, Germany

PROJECT of STADTLUFT MUNCHEN



Urban Air Paths

They are significant for the reduction of **thermal stress** and **air pollution** on residents of cities.



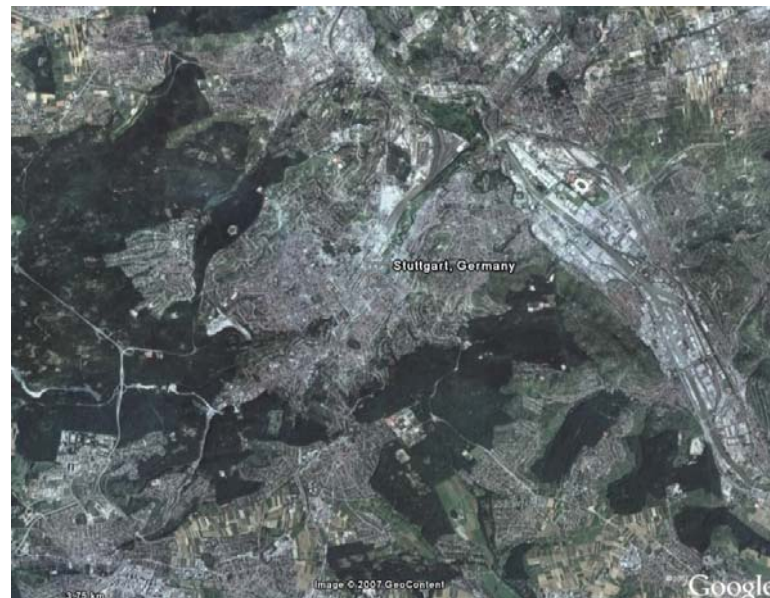
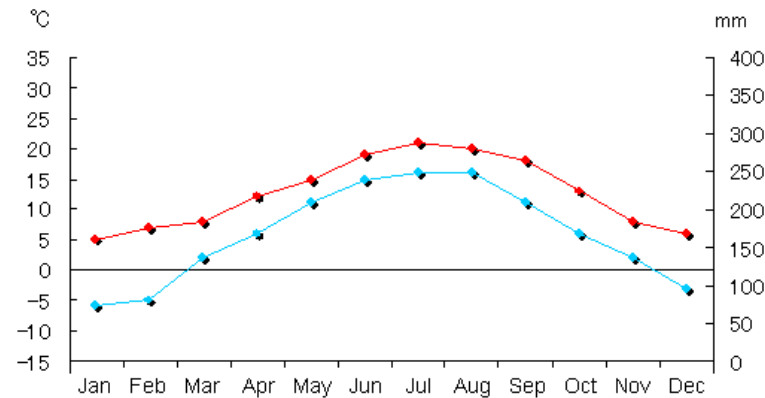
Bioclimatic effects of Urban Air Paths in München

- *Matzarakis, A. and Mayer, H. (1992). "Mapping of Urban Air Paths for Planning in Munich." Planning Applications of Urban and Building Climatology, Wiss. Ber. Inst. Meteor. Klimaforsch. Univ. Karlsruhe 16: 13-22.*
- <http://www.stadtentwicklung.berlin.de/umwelt/landschaftsplanung/lapro/en/plaene/karteluftaust.shtml>

City Example – Stuttgart, Germany



Stuttgart: Monthly average of the minimum and maximum daily temperatures (°C)



City Area: 207.36 sq.Km
 Population: 0.59 millions
 Location: Inland
 Topographical: in a Valley

Climate: Temperate
 summer: warm
 winter: mild

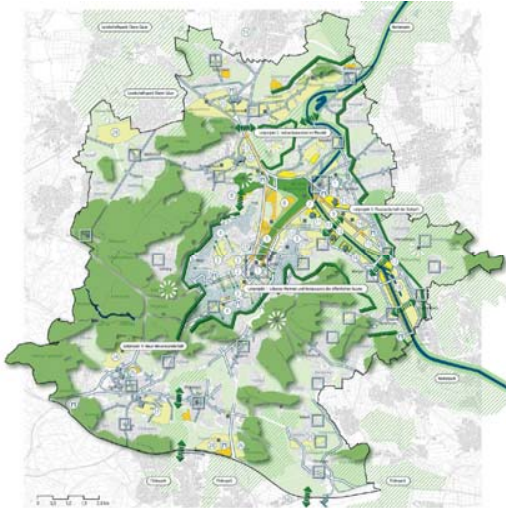
City Example – Stuttgart, Germany

Stuttgart Urban Climatology and Planning Strategies to Mitigate Heat Stress and Air Pollution Problems

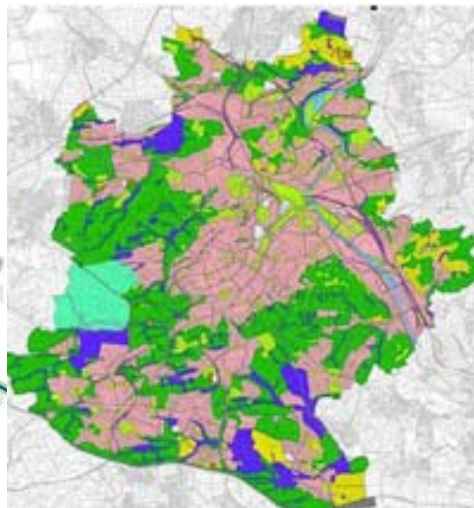


PROJECT of STUTT GART 21

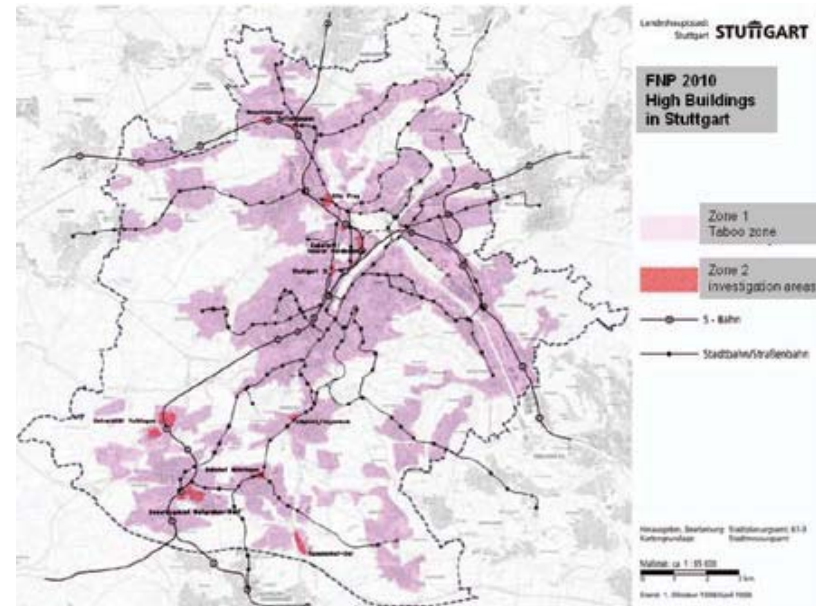
- Baumüller, J. (2006). Implementation of climatic aspects in urban development: the example Stuttgart. *Urban Climate+Urban Greenery*. Hong Kong, PGBC: 42-52.



Green Areas Map



Landscape Plan Map



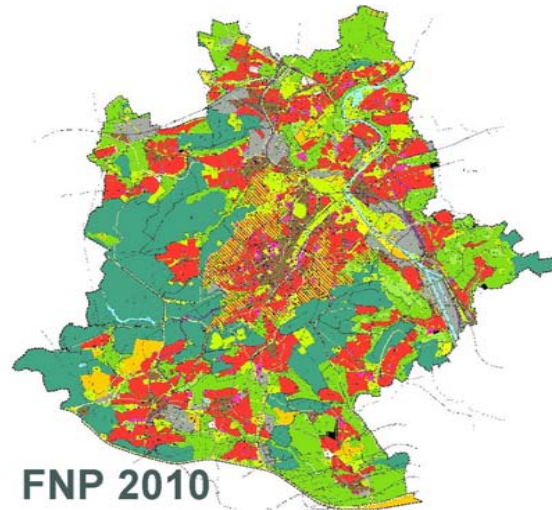
Forbidden zones for high-rise buildings



City Example – Stuttgart, Germany

Stuttgart Urban Climatology and Planning Strategies to Mitigate Heat Stress and Air Pollution Problems

They develop and improve the urban climatic map for application at the diverse scales



Land Use Plan Map 1:10 000



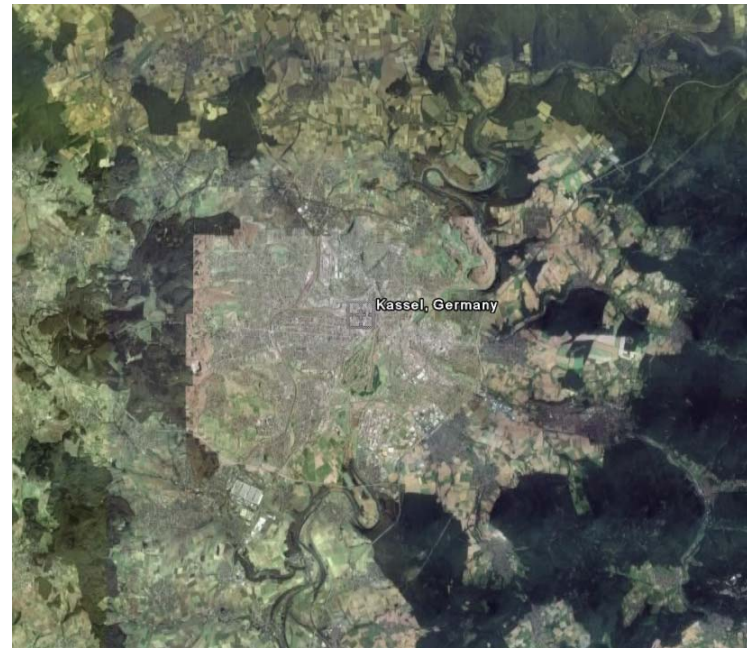
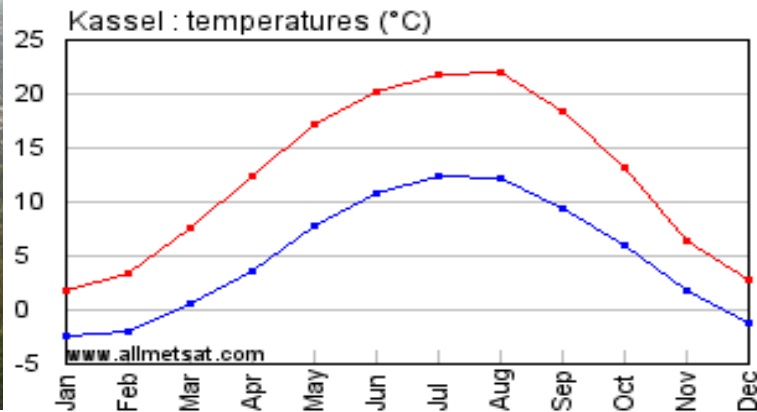
Masterplan Map 1: 2 500



Building plan Map 1:500

- Baumüller, J. (2006). *Implementation of climatic aspects in urban development: the example Stuttgart. Urban Climate+Urban Greenery. Hong Kong, PGBC: 42-52.*
- Source from: <http://www.stgt.com/stuttgart/stgt21e.htm>

City Example – Kassel, Germany



City Area: 106.77 sq.Km
 Population: 0.19 millions
 Location: Inland
 Topographical: Flat urban area, but city is in a Valley

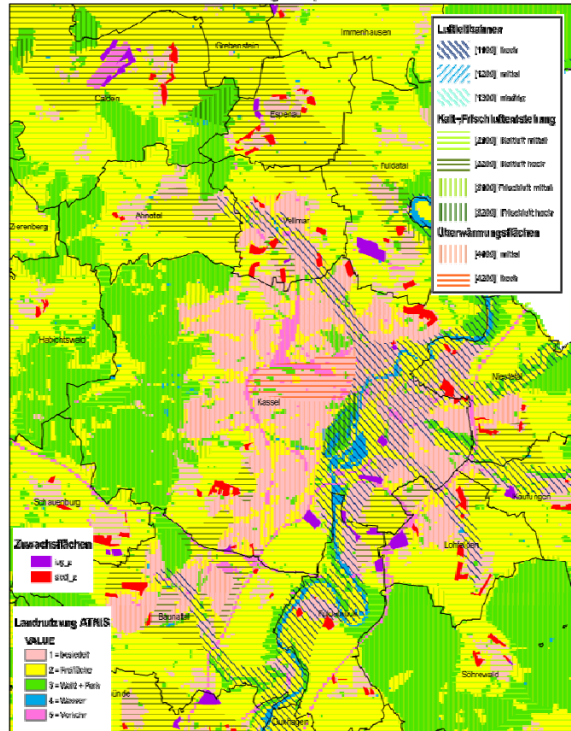
Climate: Temperate
 Summer: warm
 Winter: mild

City Example – Kassel, Germany

Urban Climatic Mapping System of Kassel

Fachgutachten Klimabewertung Hessen
Taraxacum e.V. / Universität Kassel
Mai 2003
Klimafunktionskarte 1997
sowie Zuwachsfächen nach dem Regionalplan

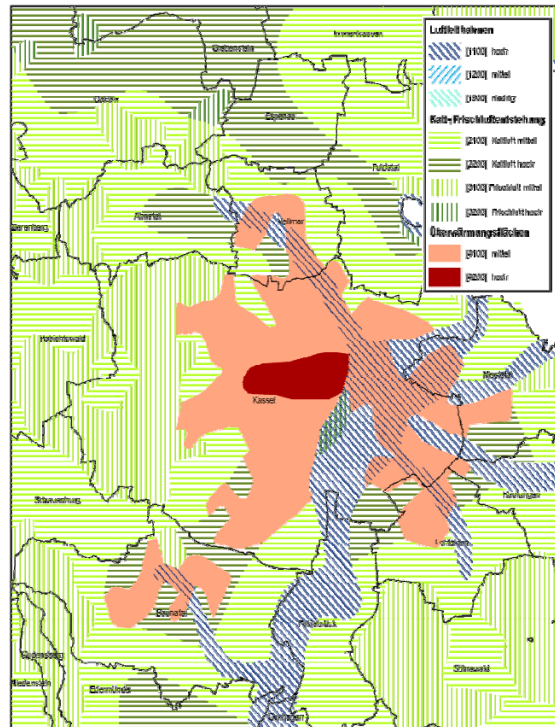
Raumbezug : Kassel
1:100.000



Land Use Map
土地利用圖

Fachgutachten Klimabewertung Hessen
Taraxacum e.V. / Universität Kassel
Mai 2003
Klimafunktionskarte 1997

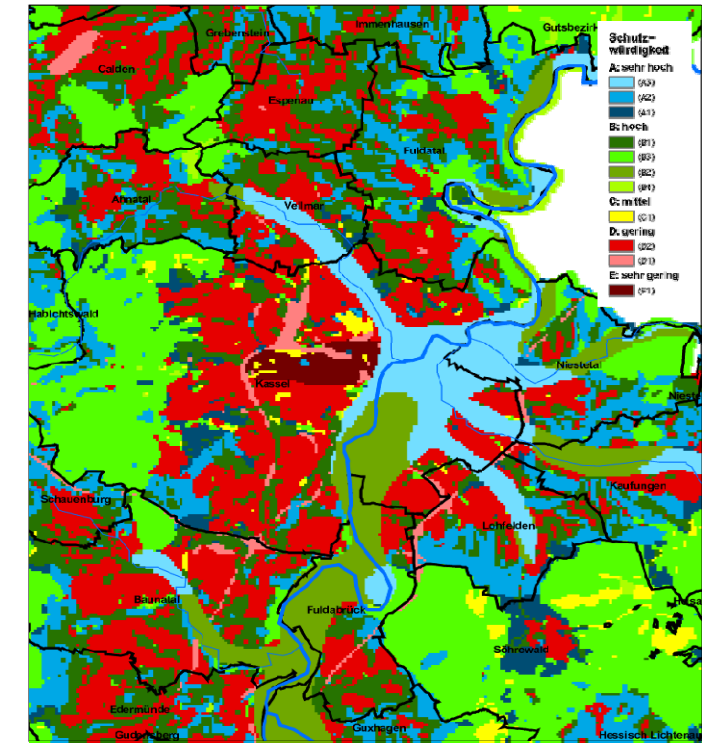
Raumbezug : Kassel
1:100.000



Thermal Condition Map
熱環境圖

Fachgutachten Klimabewertung Hessen
Taraxacum e.V. / Universität Kassel
Mai 2003
Klimabewertung gestuft in 11 Klassen (50x50 m Raster)

Raumbezug : Kassel
1:100.000

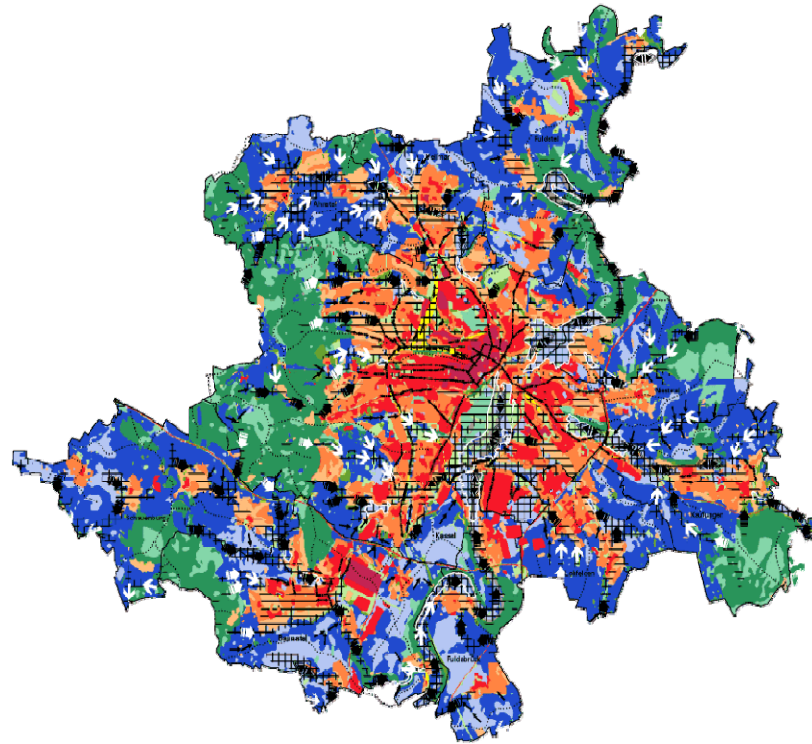


Climate Evaluation Map
氣候評價圖

Katzschner, L. (2006). Urban climatology and Urban Planning. An Expert Forum on UCMaP & CFD for Urban Wind Studies in Cities. Hong Kong, Department of Architecture, The Chinese University of Hong Kong & Professional Green Building Council, Hong Kong.

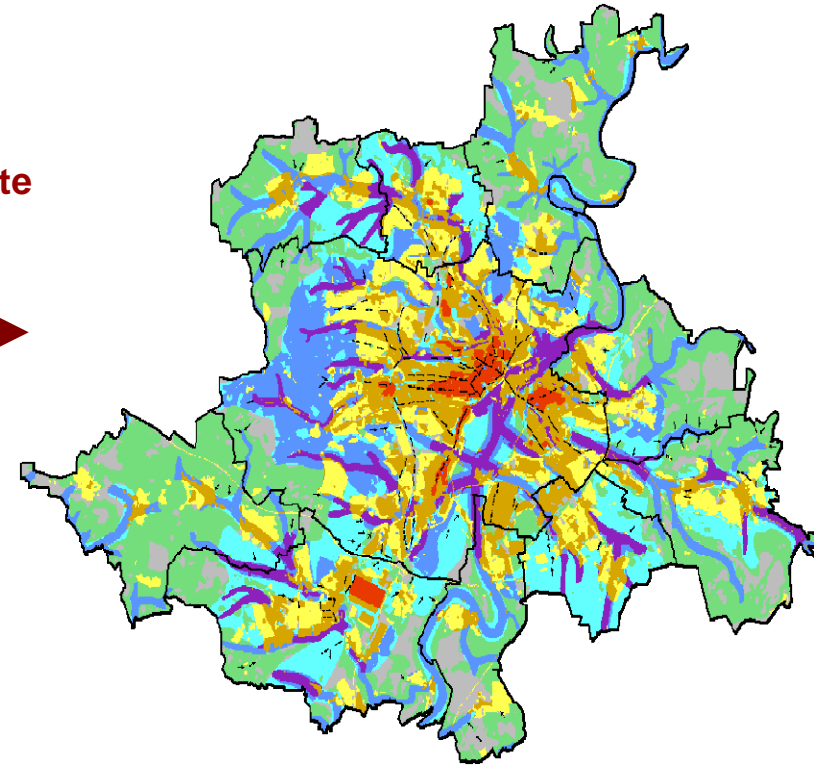
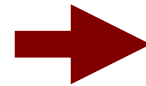
City Example – Kassel, Germany

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Urban Climatic Analysis Map
城市氣候環境分析圖

Translate
轉譯



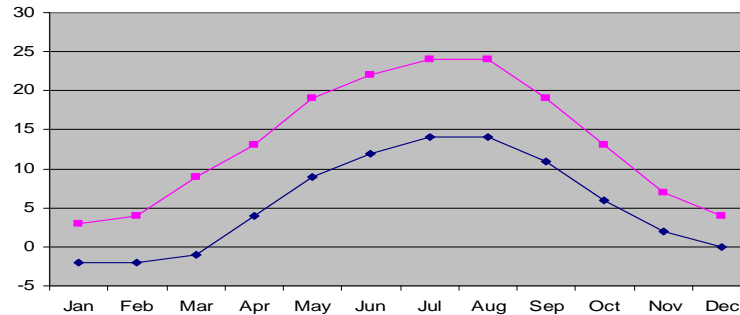
Urban Recommendation Map
基於氣候分析的城市規劃建議圖

Katzschner, L. (2006). Urban climatology and Urban Planning. An Expert Forum on UCMaP & CFD for Urban Wind Studies in Cities. Hong Kong, Department of Architecture, The Chinese University of Hong Kong & Professional Green Building Council, Hong Kong.

City Example – Berlin, Germany



Berlin Monthly average of minimum and maximum daily temperature (deg. C)



City Area: 889 sq.Km
 Population: 3.4 millions
 Location: Inland
 Topographical: Flat

Climate: Temperate
 Summer: warm
 Winter: mild

City Example – Berlin, Germany

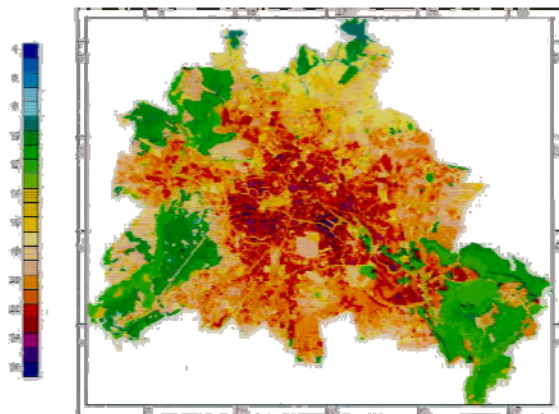


Natural and built environment

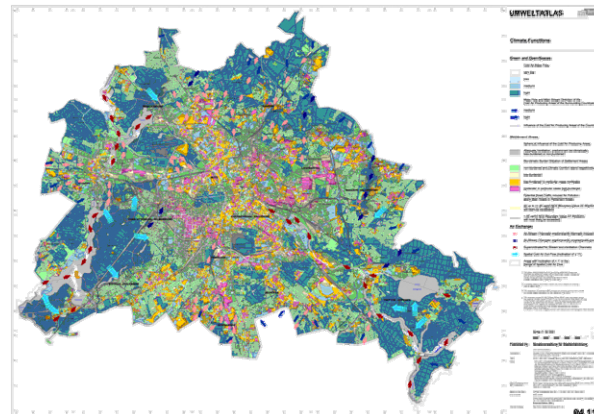
Berlin Digital Environmental Atlas (1985-2000)

The Environmental Atlas is including **eighty topics** such as soil, water, air, **climate**, land use, traffic, noise and energy. This system processes more than **400 maps** organized under the different topics.

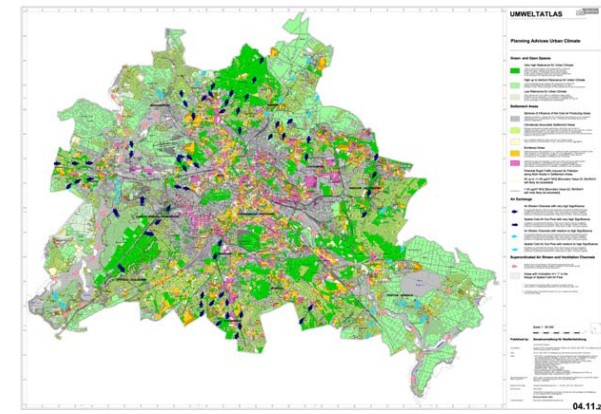
For understanding the urban climate, the investigation has been used various methods including **field measurements**, **long-range ascertainment methods**, **wind tunnel studies**, and the application of numerical **simulation models**.



Bioclimatic Map



Climate Functions Map

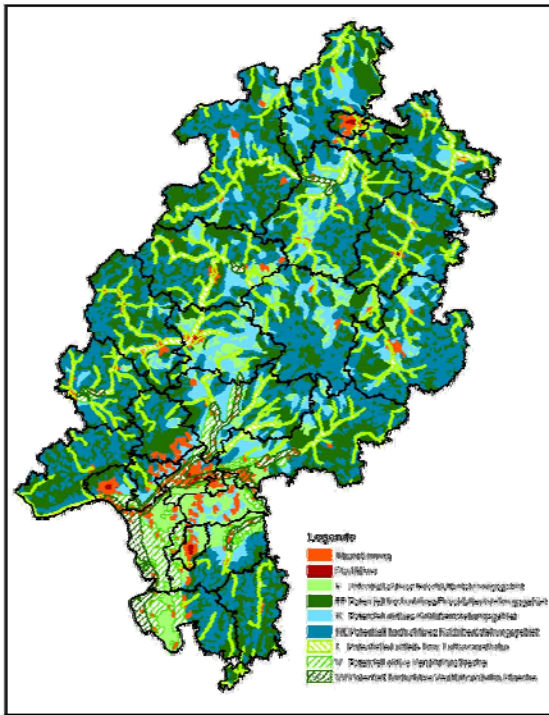


Planning Recommendation Map

Source from: http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/edinh_04.htm

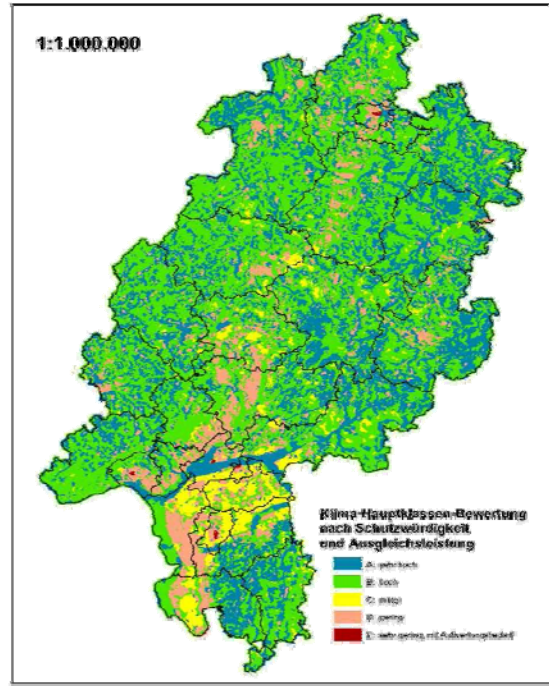
State Example – Hessen & Bayern, Germany

Klimafunktionskarte Hessen 1:1.000.000

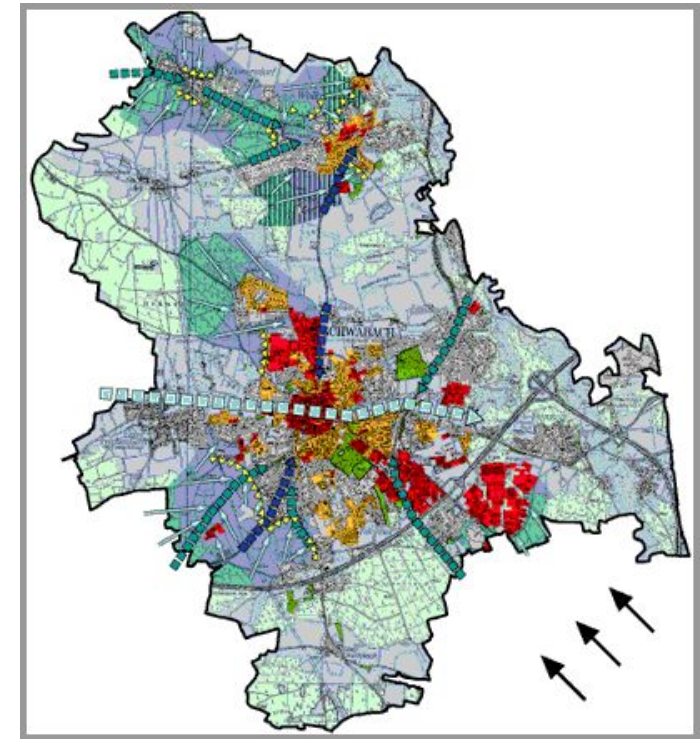


Climate Functions Map
The State of Hessen

Fachgeprüfte Klimafunktionskarte Hessen
Technische Universität München
März 2005
NRK 1: Klimafunktionskarte in 6 Hauptkategorien (Dokumentation)



Climatic Analysis Map

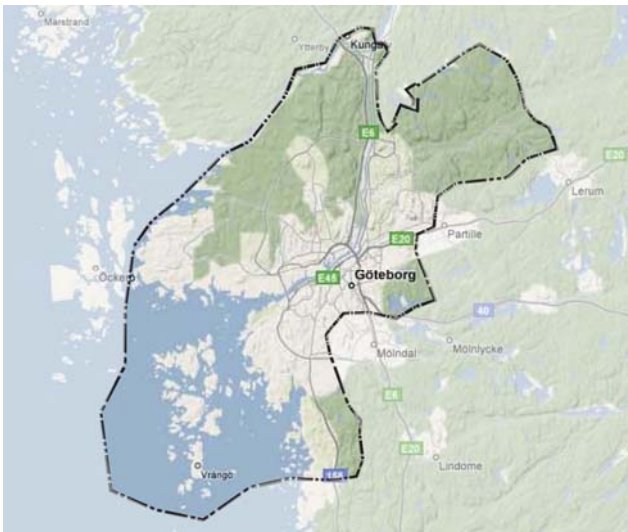
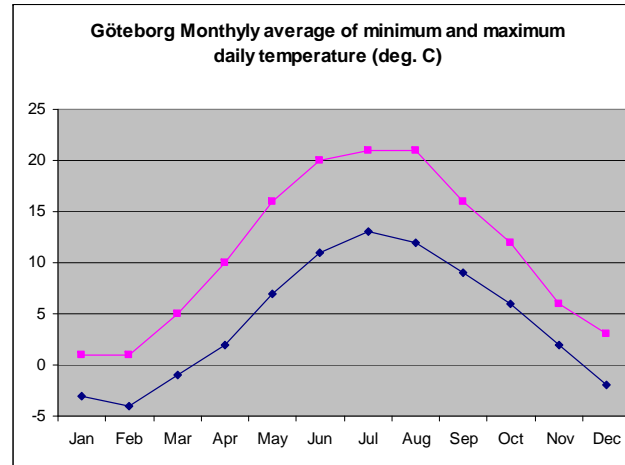


Climatic Analysis Map
The State of Bayern

- *Katzschner, L. (2007). Future Steps in Urban Climate and Climate Change. Neitherland.*
- http://www.lfu.bayern.de/natur/fachinformationen/absp_stadt/naturnahe_erholung/index.htm



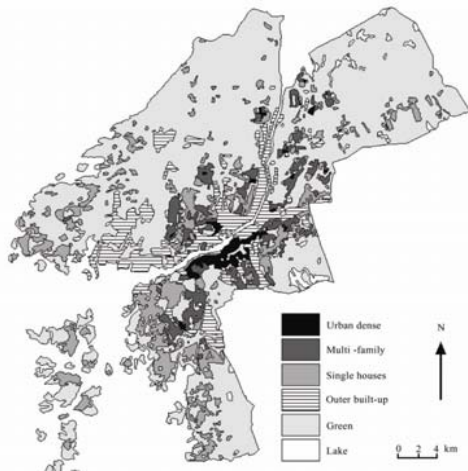
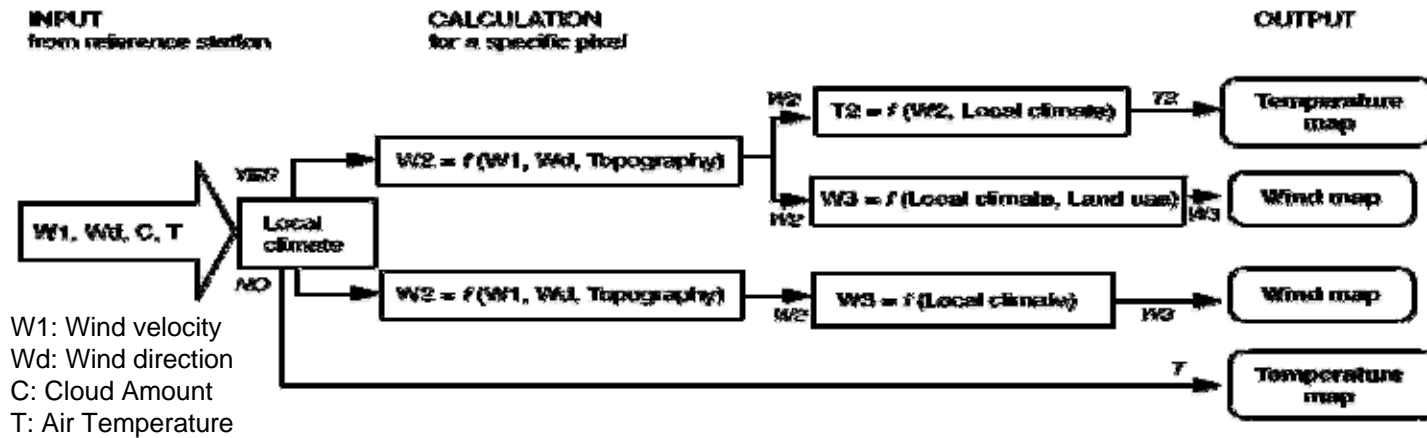
City Example – Gothenburg, Sweden



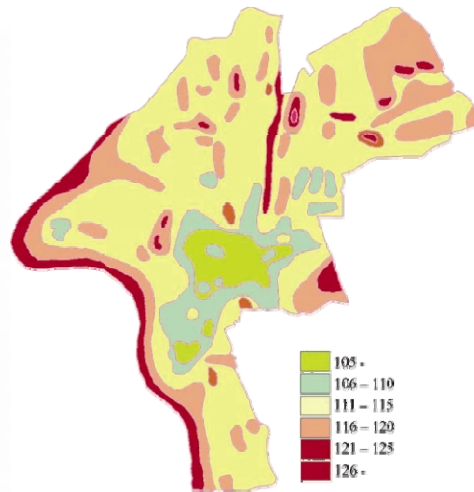
City Area: 449 sq.Km
 Population: 1.0 millions
 Location: Inland
 Topographical: Flat

Climate: Mild Coastal
 Summer: warm
 Winter: mild

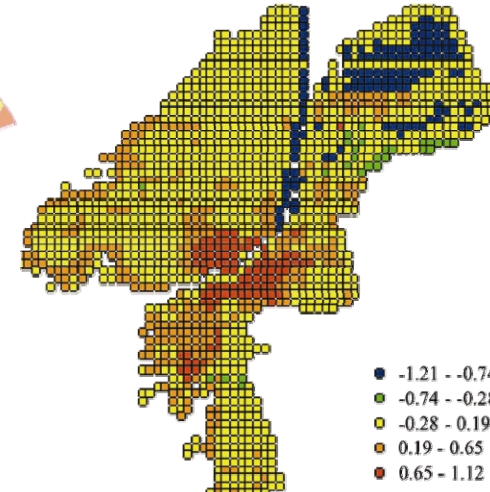
City Example – Gothenburg, Sweden



Land Use Map



Energy Index Map

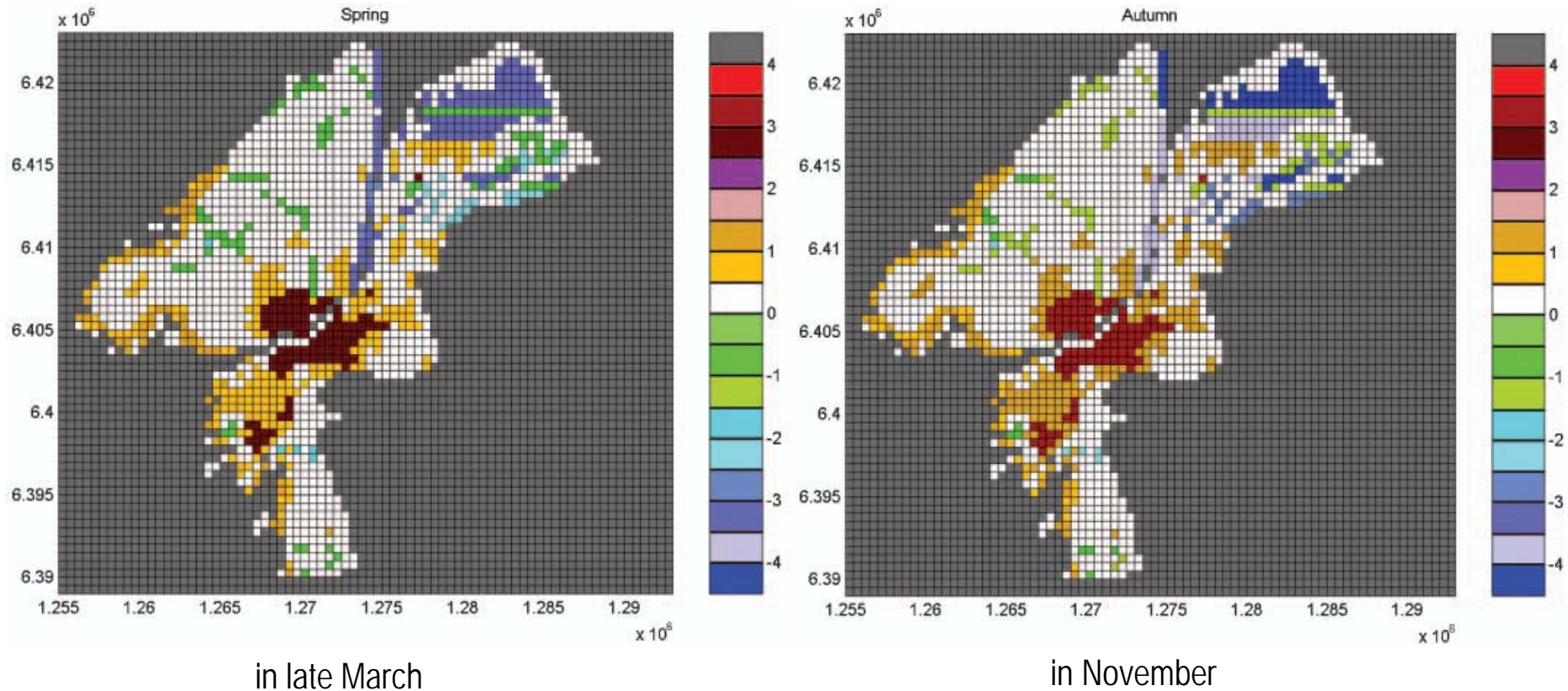


Air Temperature Map

Svensson, M. K., Eliasson, I. and Holmer, B. (2002). "A GIS based empirical model to simulate air temperature variations in the Goteborg urban area during the night." Climate Research 22: 215-226.

City Example – Gothenburg, Sweden

Simulation of Temperature Pattern, 3 h after sunset

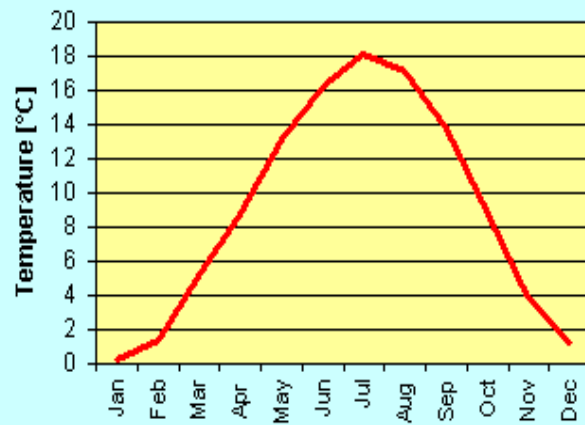


Svensson, M. K., Eliasson, I. and Holmer, B. (2002). "A GIS based empirical model to simulate air temperature variations in the Goteborg urban area during the night." Climate Research 22: 215-226.

City Example – Basel, Switzerland



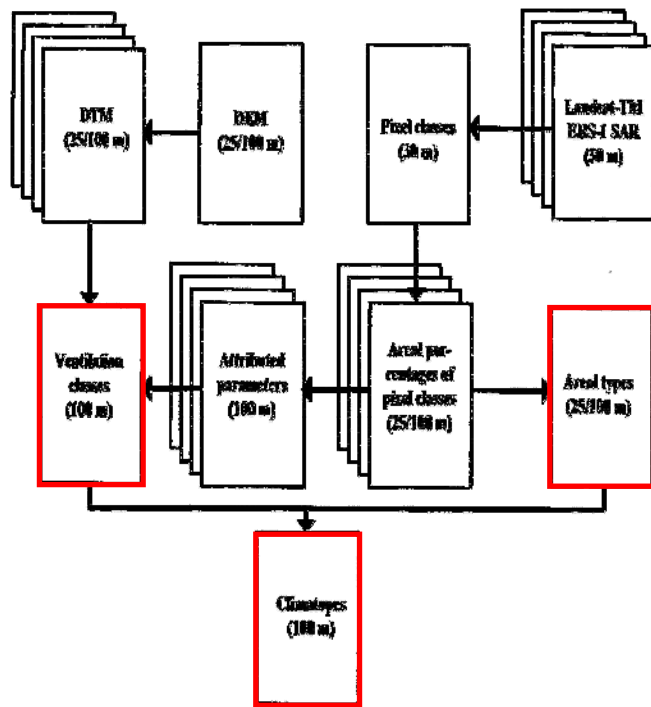
Average Temperature in Basel



City Area: 22.75 sq.Km
 Population: 0.16 millions
 Location: Inland
 Topographical: Flat

Climate: Mild
 Summer: warm
 Winter: mild

City Example – Basel, Switzerland

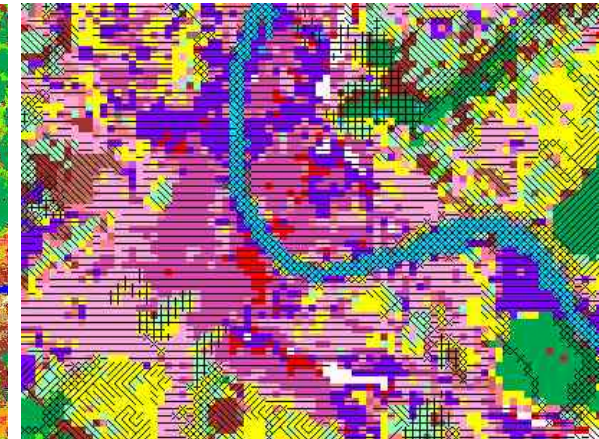


PROJECT of KABA

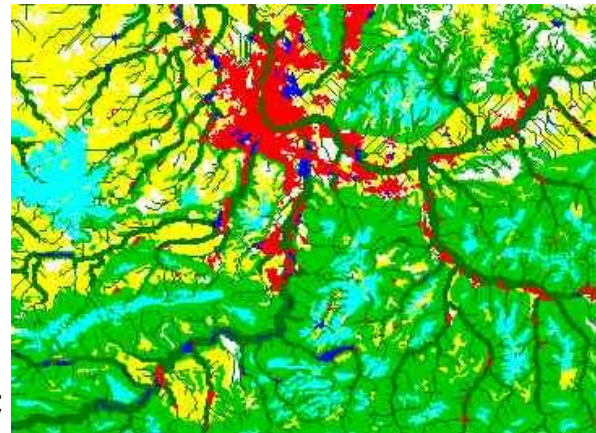
- To investigate the physic-and social-graphic settings for the regional climate of Basel;
- To control the air quality and urban planning;



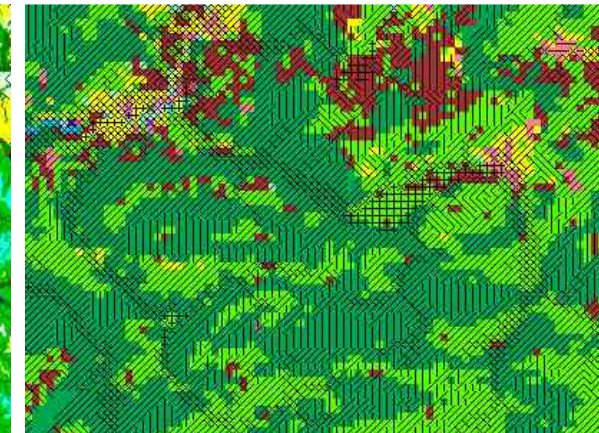
Satellite-based land-use pixel classes



Urban Frame of Climatopoes



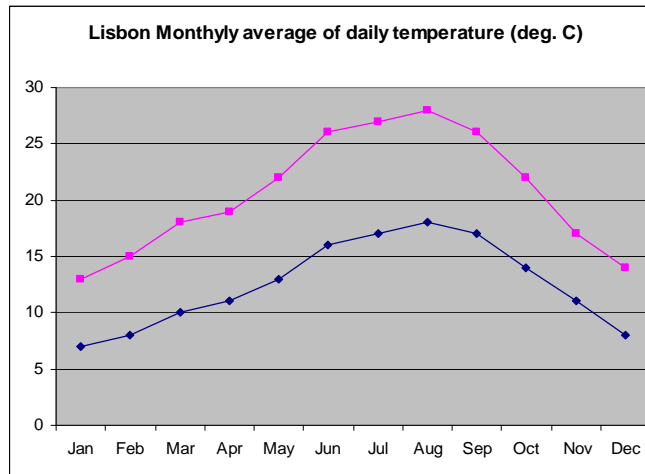
Ventilation Situation Map



Rural Frame of Climatopoes

- Scherer, D., et al. (1999). "Improved concepts and methods in analysis and evaluation of urban climate for optimizing urban planning process." *Atmospheric Environment* 33: 4185-4193.
- Parlow, E., et al. (1995). "Analysis of the Regional Climate of Basel/Switzerland", from http://pages.unibas.ch/geo/mcr/Projects/KABA/Klimatop/kt_map.en.htm.

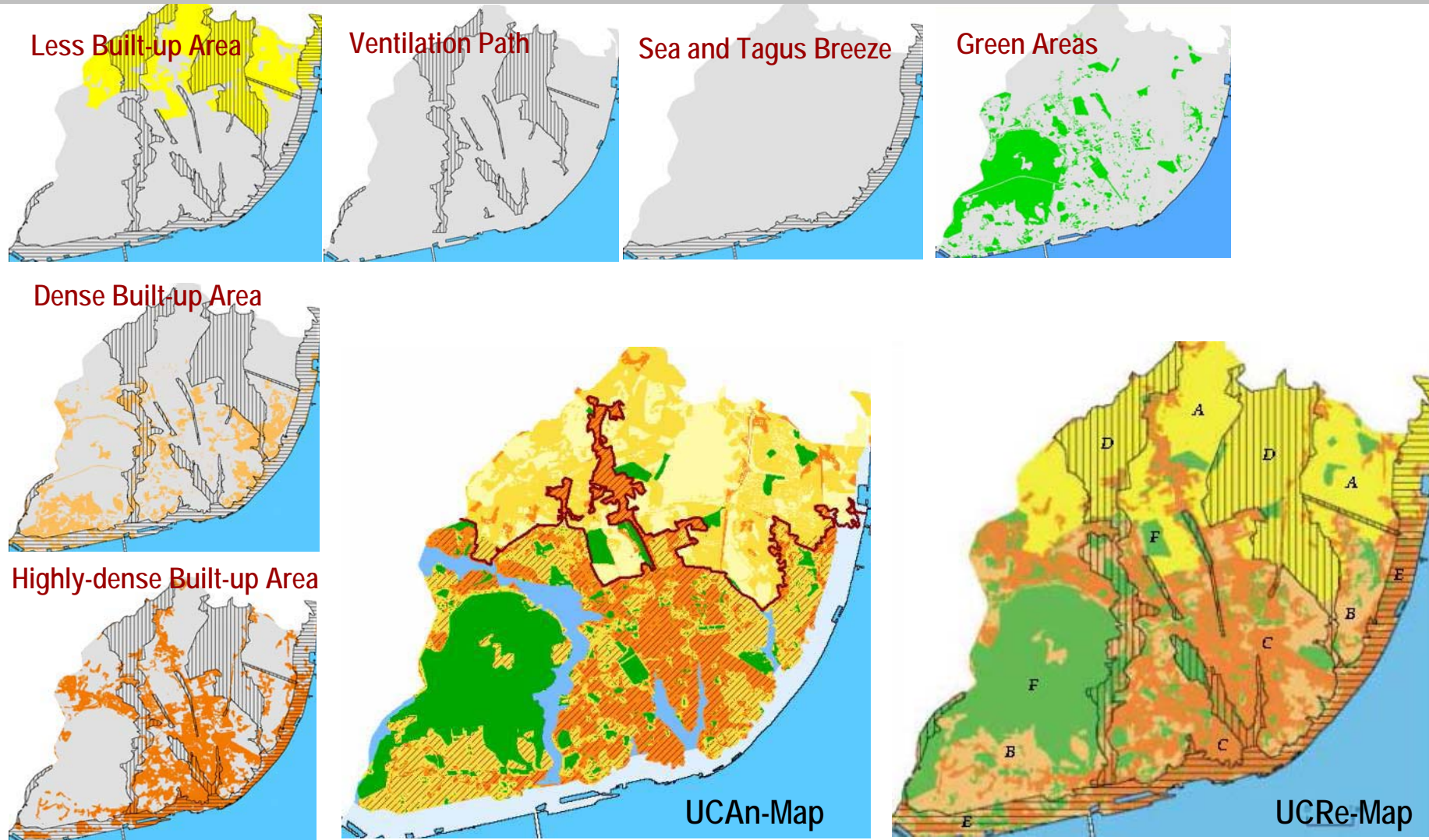
City Example – Lisbon, Portugal



City Area: 84.8 sq.Km
 Population: 2.0 millions
 Location: Coastal
 Topographical: Flat

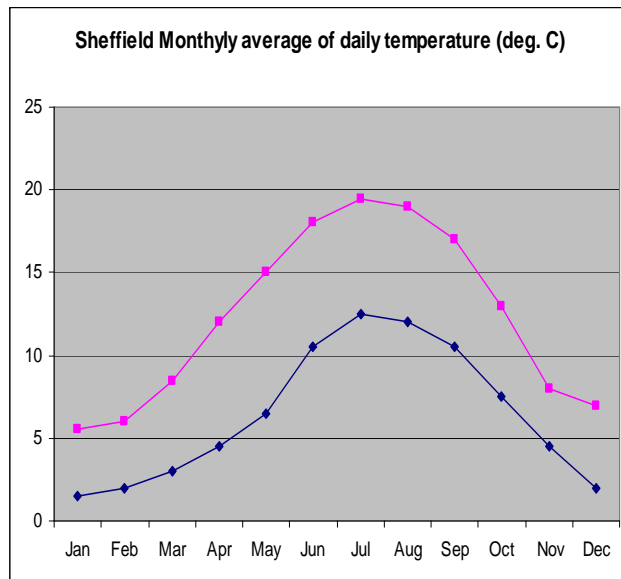
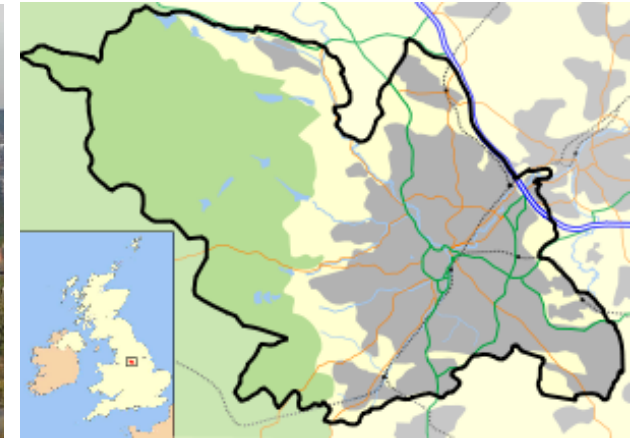
Climate: Warm Coastal
 Summer: warm
 Winter: mild

City Example – Lisbon, Portugal



Alcoforado, M. J., et al. (2006). *Climatic guidelines for urban planning in Lisbon. The 6th ICUC*. Gothenburg, Sweden.

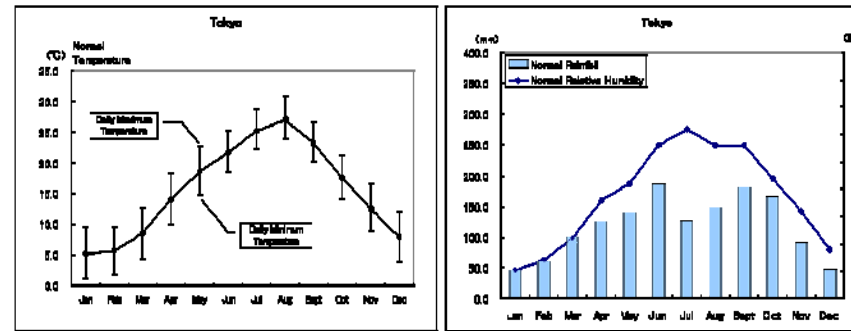
City Example – Sheffield, UK



City Area: 142.1 sq.Km
 Population: 0.53 millions
 Location: Inter land
 Topographical: in a Valley

Climate: Temperate
 Summer: warm
 Winter: mild

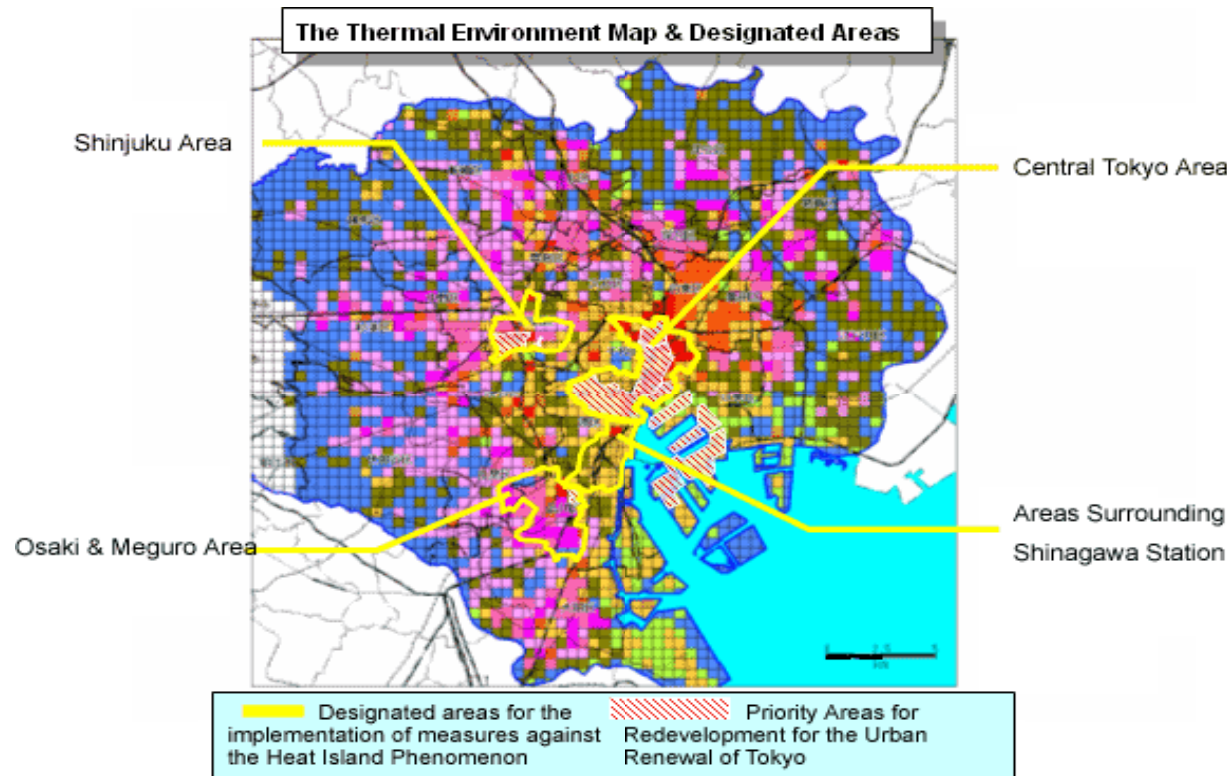
City Example– Tokyo, Japan



City Area: 2,187.08 sq.Km
 Population: 12.57 millions
 Location: Coastal
 Topographical: Flat

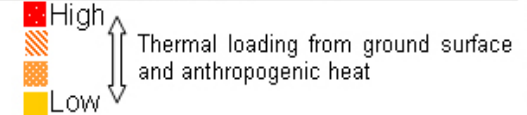
Climate: Temperate
 Summer: warm and humid
 Winter: cold

City Example– Tokyo, Japan



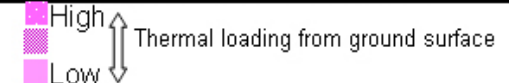
【Properties of Each Type】

Type I Business Cluster Area



Areas where there is a high proportion of office floor space and asphalt surfaces, and a high level of anthropogenic heat.

Type II High-Density Residential Areas



Areas where there is a high proportion of buildings and a low proportion of vegetation. Buildings are high-density, radiating a high level of heat.

Type III Areas where there is a relatively high proportion of bare land and greenery

Type IV Open areas

Type V Mixed areas

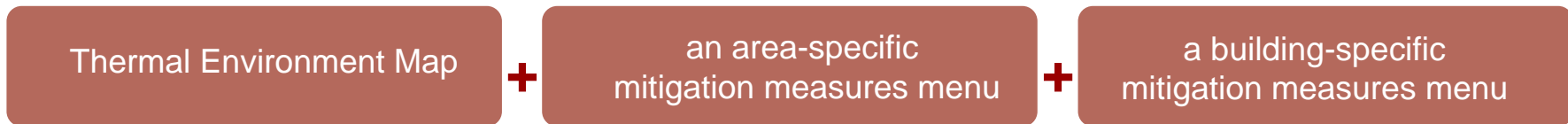
Names of Areas	Local Specificity	Area	Characteristics
Central Area	Countermeasures for business accumulation zones	About 1,600 ha	Because of the substantial heat load derived from artificially covered surfaces such as office buildings/asphalt paving and excessive exhaust heat from buildings, the temperature is high at all times of the day or night.
Shinjuku Area	Countermeasures for business accumulation zones	About 600 ha	Because of the substantial heat load derived from artificially covered surfaces such as office buildings, houses, and asphalt paving, the temperature is high at all times of the day or night.
Osaki/Meguro Area	Countermeasures for dense residential zones	About 1,100 ha	Substantial heat load derived from the ground surface makes it difficult for this dense residential zone to cool down at night. (Area characterized by many tropical nights.)
Area around Shinagawa Station	Introduction of countermeasures according to the development plan	About 600 ha	In this area, extensive development is expected in the future and urban development projects are to be introduced according to the plan with preliminary consideration given to heat island countermeasures.

According to The Thermal Environmental Map, Tokyo Metropolitan Government designated **four areas** as “areas for the implementation of urban heat island effect mitigation measures”

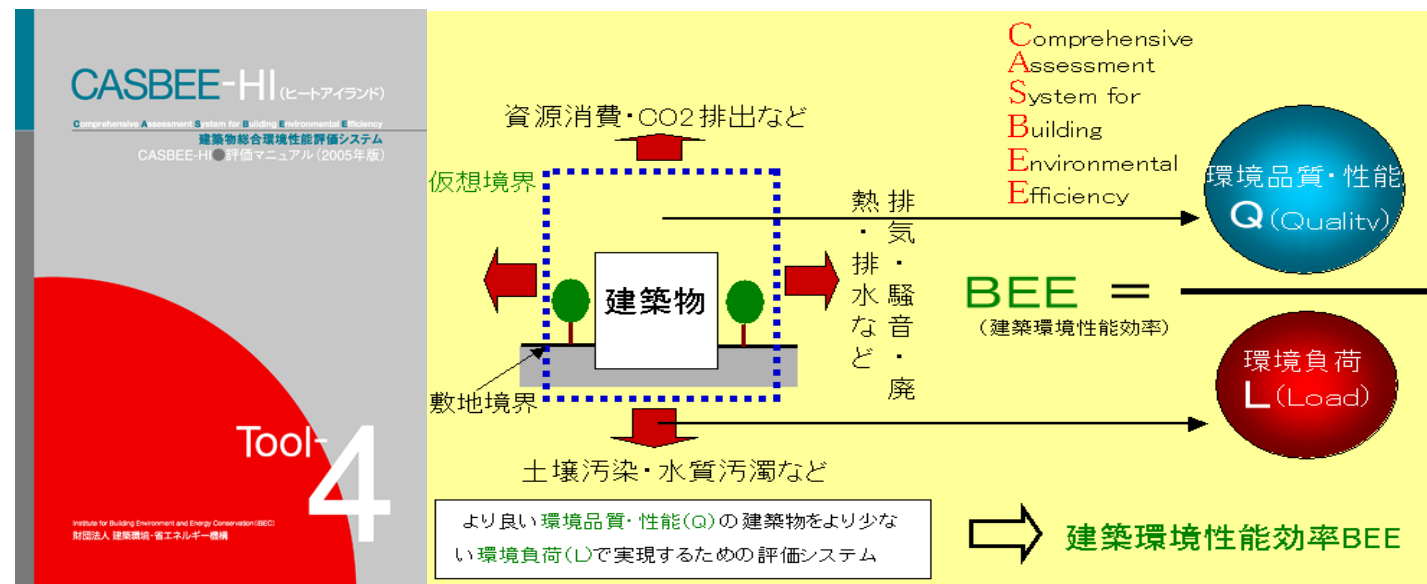
City Example– Tokyo, Japan

In July 2005, the Tokyo Metropolitan Government developed the “**Guidelines for Urban Heat Island Mitigation Measures**” to encourage the development of mitigation measures.

These guidelines comprise:

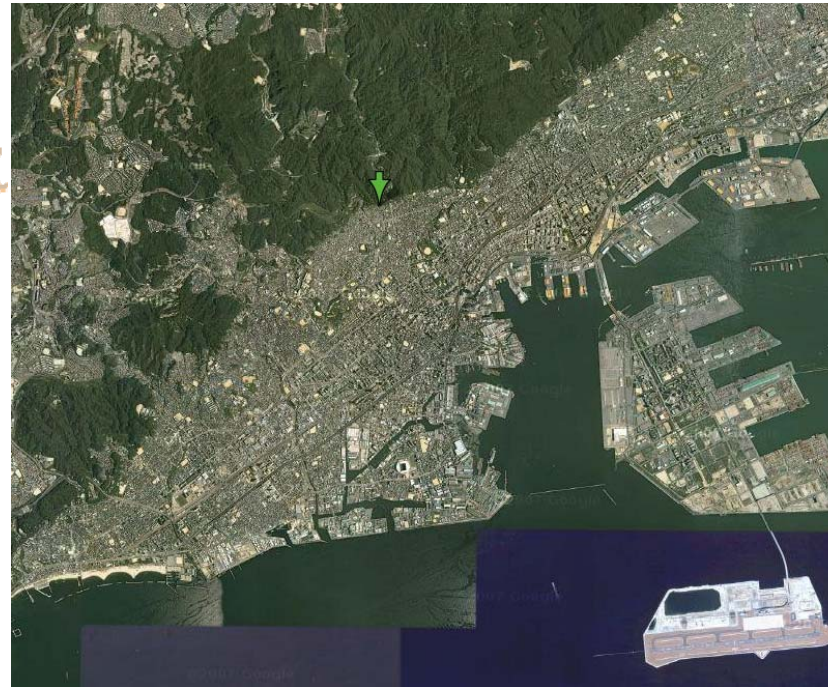
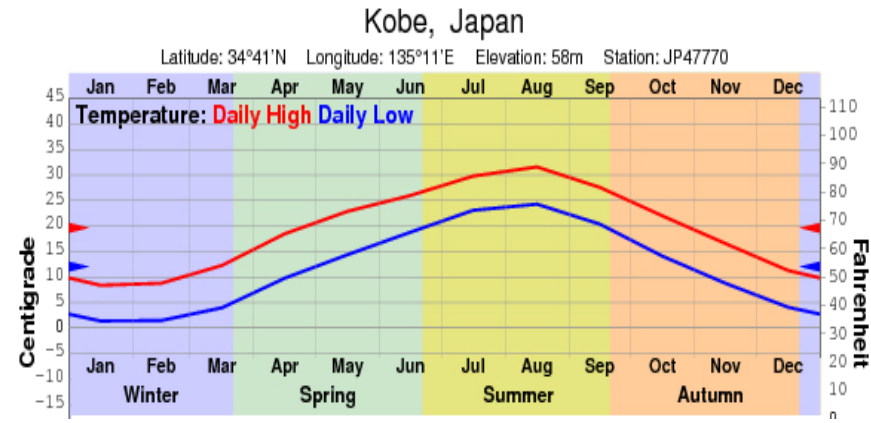


CASBEE-HI
 Comprehensive Assessment System for Building Environmental Efficiency - **Heat Island**



- The Tokyo Metropolitan Government: <http://www.metro.tokyo.jp/INET/OSHIRASE/2005/04/20f4b100.htm>
- CASBEE-HI, http://www.ibec.or.jp/CASBEE/cas_hi.htm

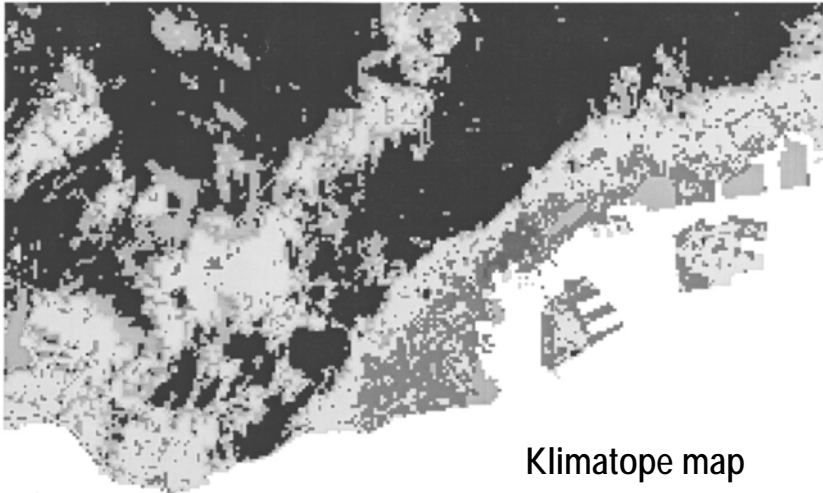
City Example– Kobe, Japan



City Area: 552.8 sq.Km
Population: 1.53 millions
Location: Coastal
Topographical: Flat

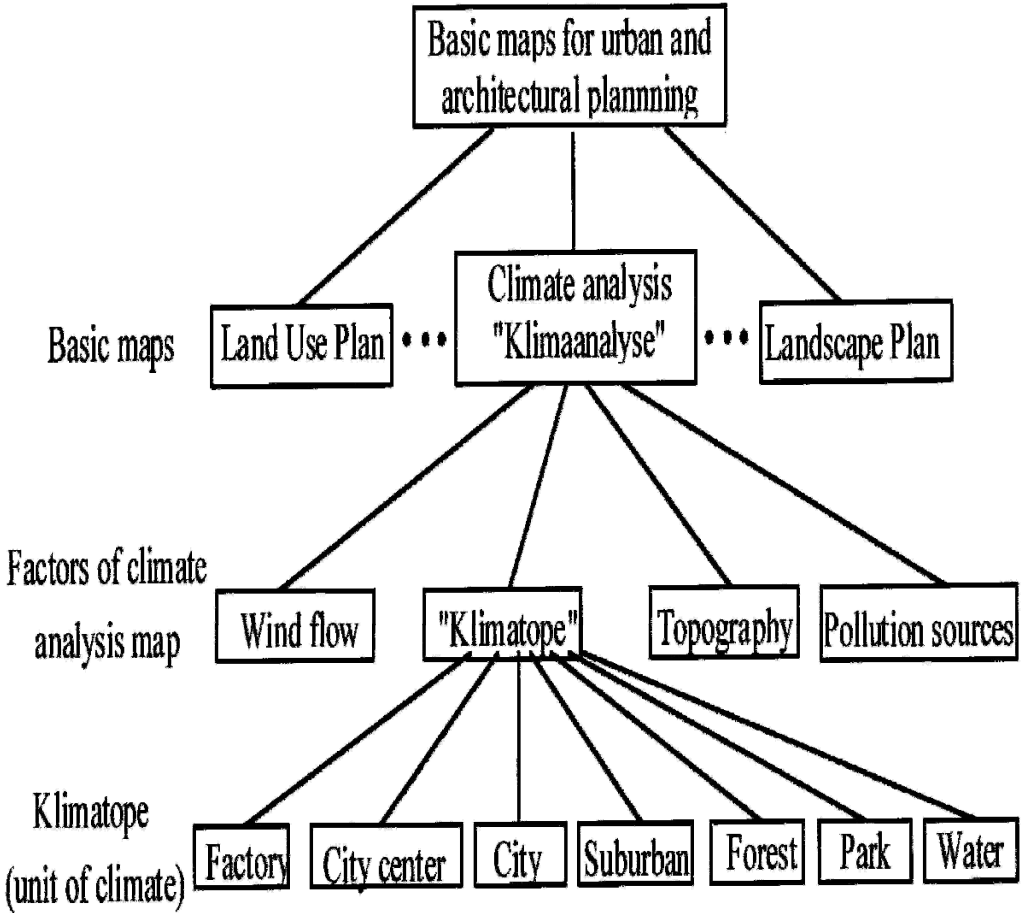
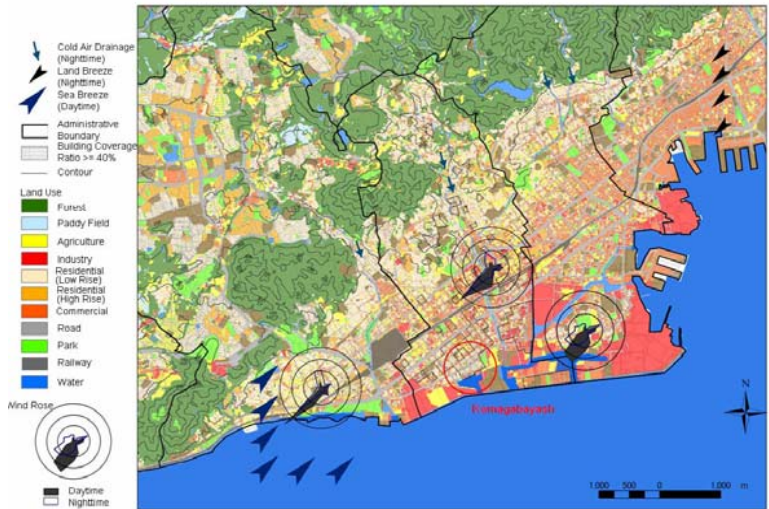
Climate: Temperate
Summer: hot and humid
Winter: cool

City Example – Kobe, Japan



Klimatope map

■ : Forest ■ : Park ■ : Suburban ■ : City ■ : City center ■ : Factory



The structure of Kobe UCMAP

Moriyama, M. and Takebayashi, H. (1999). "Making method of "Klimatope" map based on normalized vegetation index and one-dimensional heat budget model." *Journal of Wind Engineering and Industrial Aerodynamics* 81: 211-220.



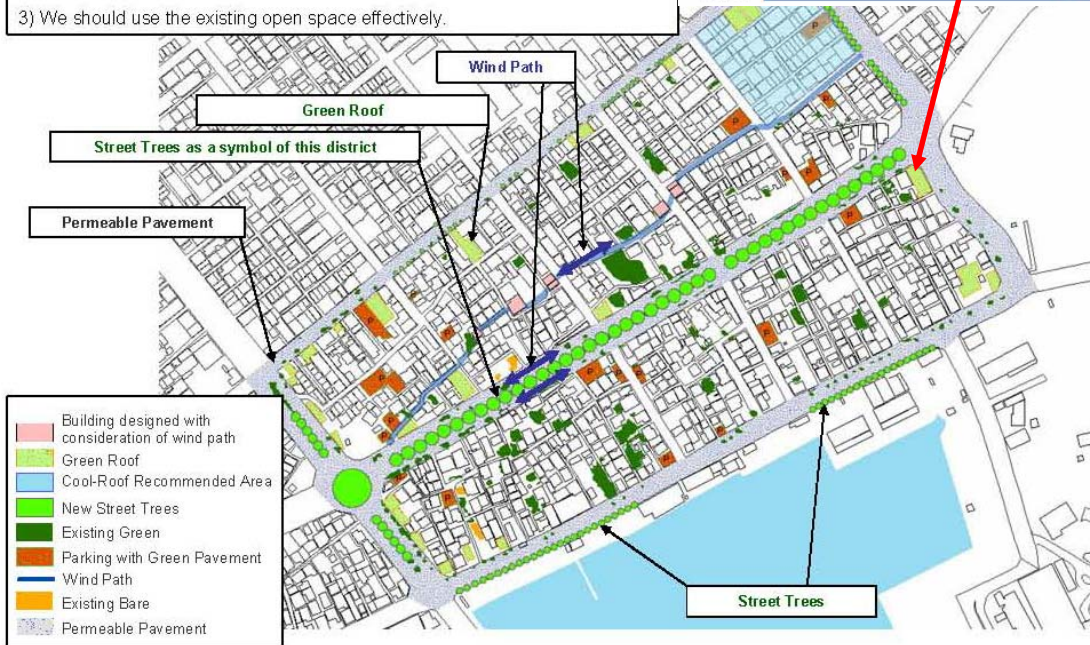
City Example – Kobe, Japan

<Policy for the Planning>

- 1) We should leave the existing landscape as much as possible (Good community is in the district because existing condition is good for the communications).
- 2) We should promote cool-roof but green roof in the district, for leaving the existing landscape
- 3) We should use the existing open space effectively.



Climatic Analysis Map



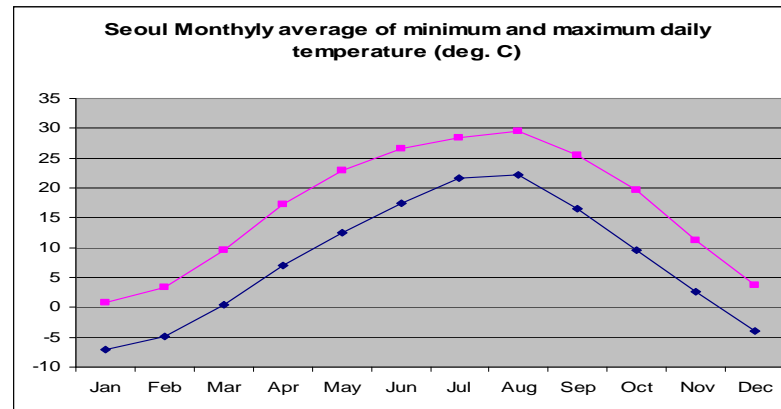
One Planning Proposal based on UCMAP



Planning Recommendation Map

Moriyama, M. and Takebayashi, H. (1999). "Making method of "Klimatope" map based on normalized vegetation index and one-dimensional heat budget model." Journal of Wind Engineering and Industrial Aerodynamics 81: 211-220.

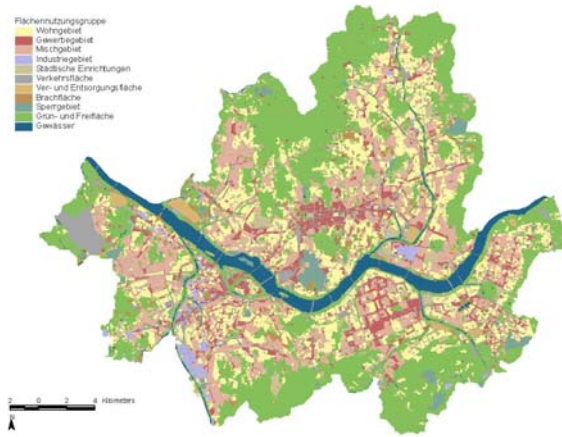
City Example- Seoul, South Korea



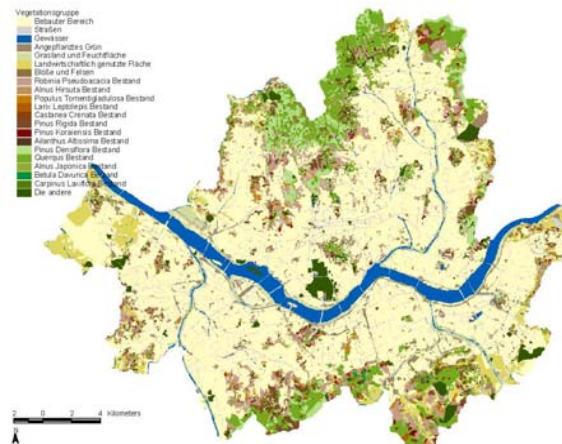
City Area: 605.3 sq.Km
Population: 10.3 millions
Location: Inner land
Topographical: in a Valley

Climate: Humid
continental
Summer: hot and humid
Winter: cold

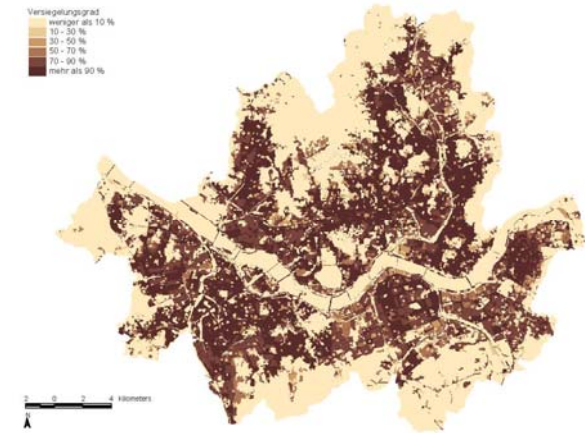
City Example – Seoul, South Korea



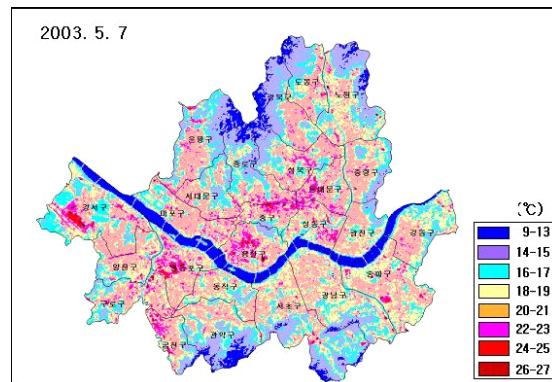
Land Use Map



Vegetation Map

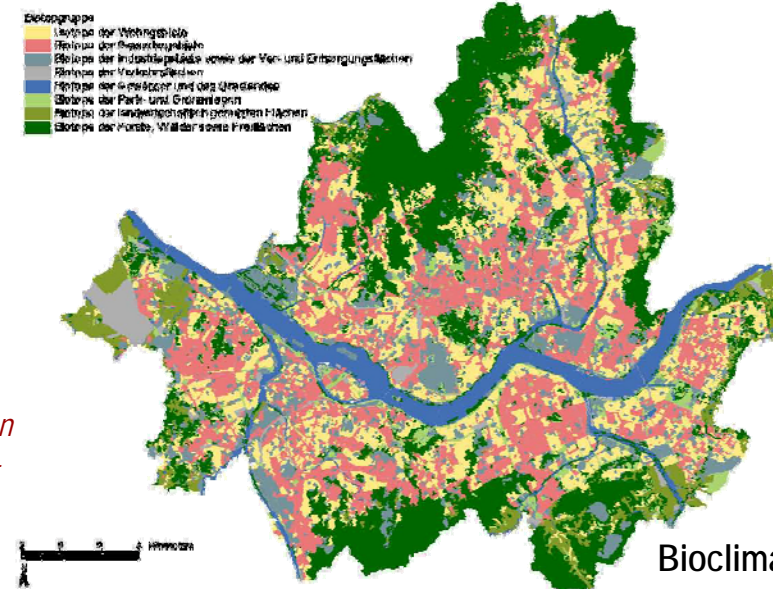


Coverage Density Map



The Distribution of Surface Temperature

Kim, H. O. (2007). *Beitrag sehr hochauflösender Satellitenfernerkundungsdaten zur Aktualisierung der Biotop- und Nutzungstypenkartierung in Stadtgebieten – Dargestellt am Beispiel von Seoul. Berlin, Germany, der Technischen Universität Berlin. Master of Science in Landscape Architecture.*

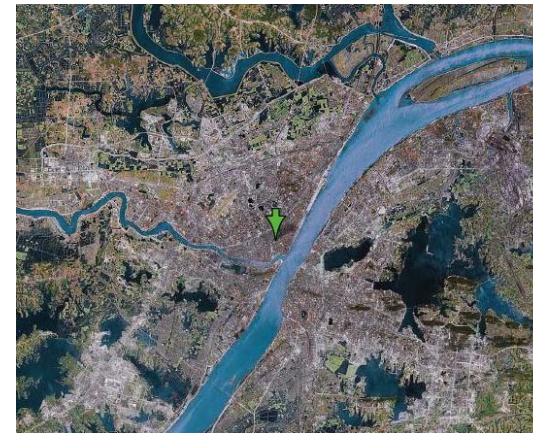


Bioclimatopoes Map

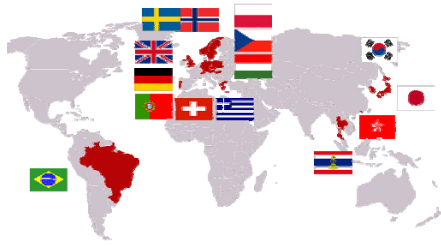
City Example – Wuhan, China



- To use Remote Sensing Technology and Analysis
- To conduct the CFD Simulation
- To create the Thermal Environmental Map

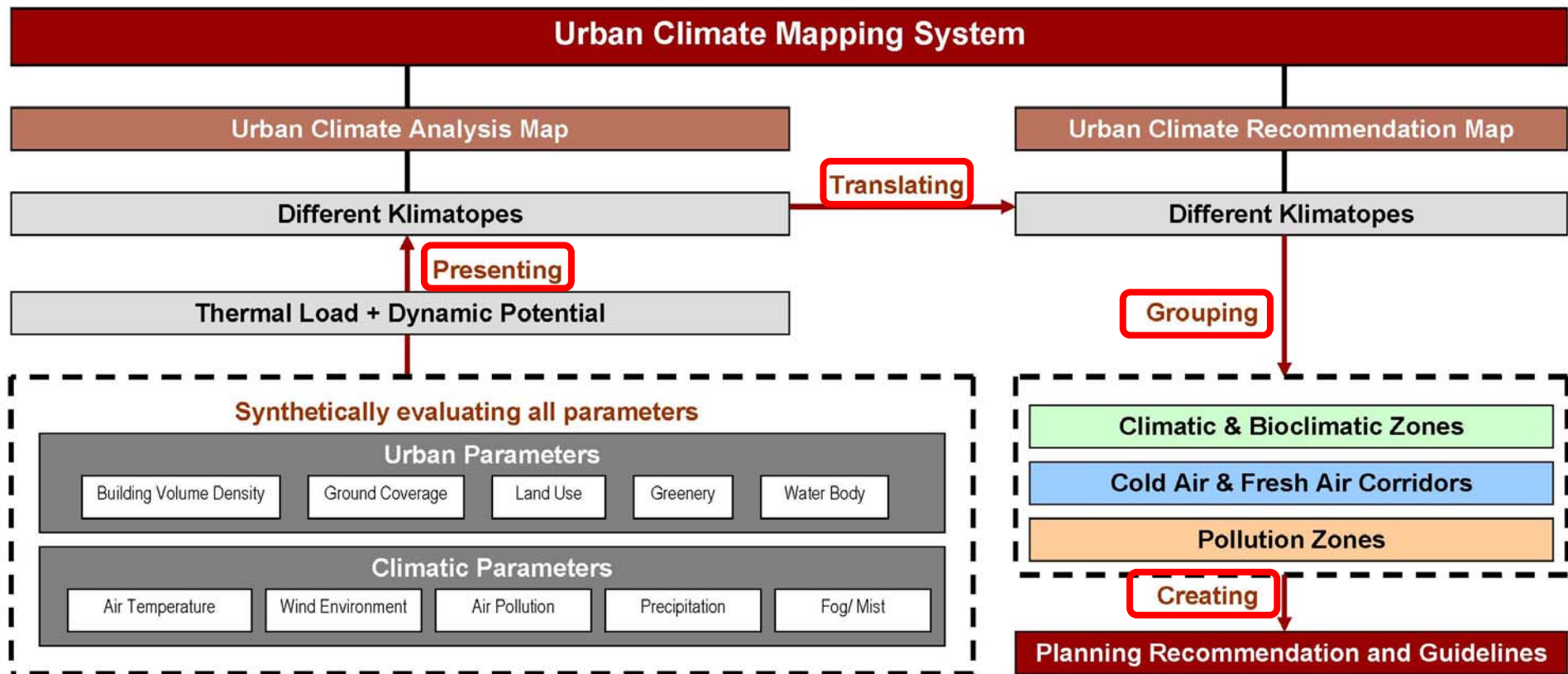


Class	Bldg Volume	Ground Coverage	Population Density	Greenery
1	<10%	<0.5	<200	Great
2	10%—20%	0.5—1.0	200—400	Good
3	20%—30%	1.0—1.5	400—600	Not Good
4	30%—40%	1.5—2.0	600—800	Bad
5	>40%	>2.0	>800	Very Bad



Lessons Learned from the World Experience

The analysis is based on **knowledge** and **expert evaluation**.



Lessons Learned from the World Experience





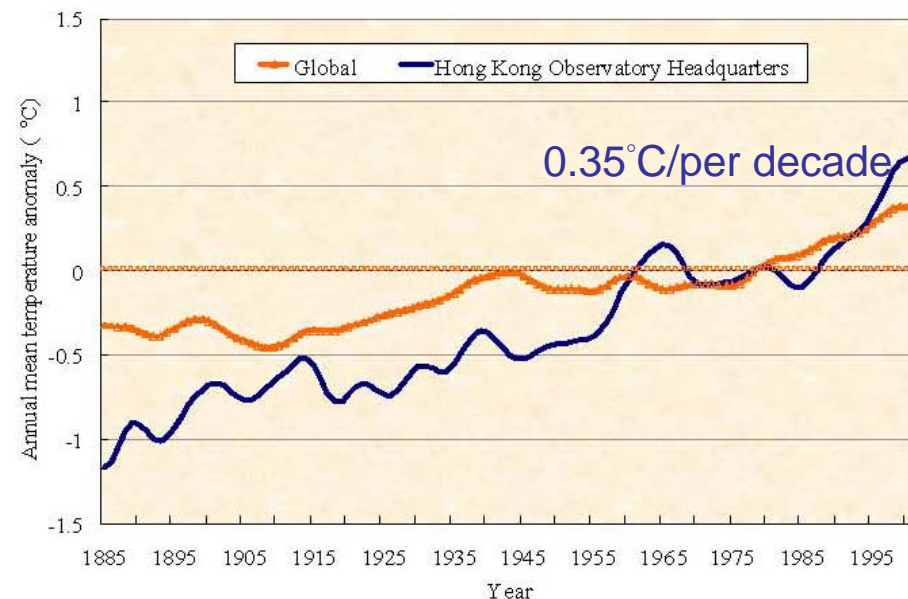
The Challenges 問題嚴峻...

Global Temperatures continually Increase 全球氣溫持續增長...

Based on finding of Intergovernmental Panel on Climate Change (IPCC), global warming and higher summer temperature is an inevitable future. Many governments around the world are planning to cope with the changes.



Fast urbanization since the 1950s



Annual mean temperature anomalies globally and at the Hong Kong Observatory Headquarters, (HKO report, No. 107)

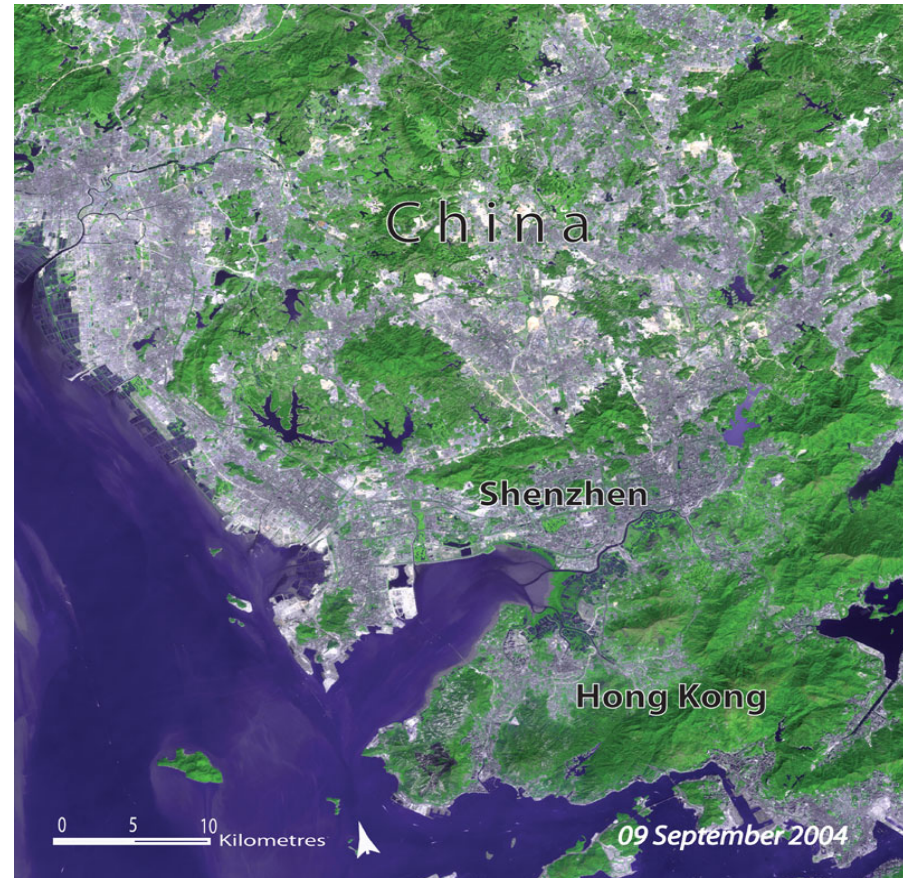
Leung, Y. K., et al. (2004). Climate Change in Hong Kong. Technical Note No. 107, Hong Kong Observatory, HK SAR GOV.

The Challenges 問題嚴峻...

Rapid Urbanization



1979

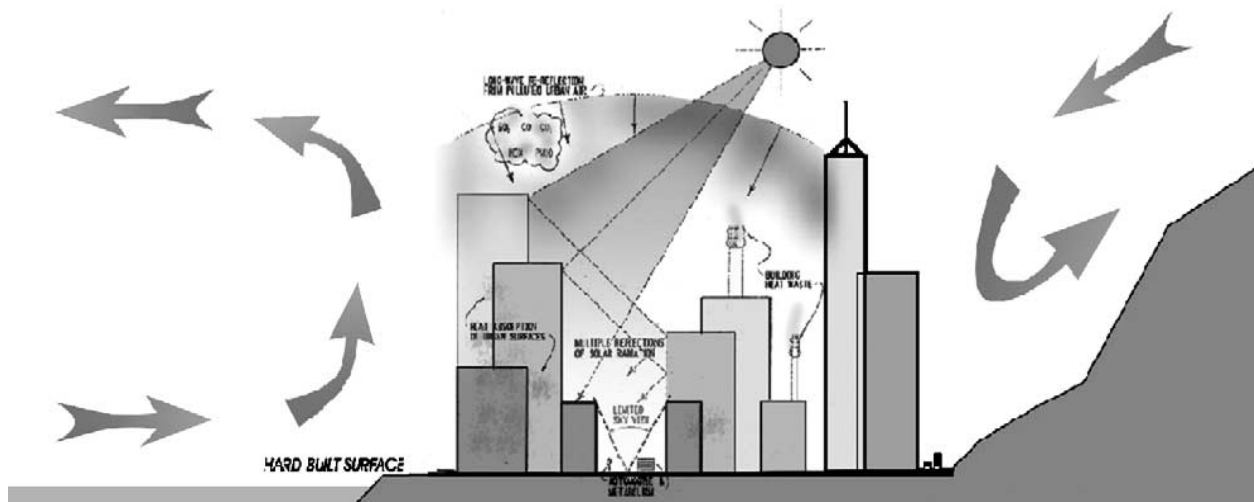


2004



To Carry out UCMap Studies for Hong Kong

Hong Kong has **high density urban context**. The typical buildings in Hong Kong are high rise and the H/W ratio is narrow. Some wind-blocking buildings at the seafront block the wind penetration and reduce wind speed. This special urban context deteriorates the urban living condition and intensifies the **Urban Heat Island**.



The conceptual character of Hong Kong urban geometry and heat generating process, Modified after Emmanuel, 1997 (Giridharan et al., 2005)

Giridharan, R., Ganesan, S. and Lau, S. S. Y. (2005). "Nocturnal heat island effect in urban residential developments of Hong Kong." *Energy and Buildings* 37: 964-971.



Thanks



For the future and the next generation

為了明天和下一代

email: renchao@cuhk.edu.hk