

Modelling urban climate in Bilbao (Spain) for planning purpose

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Introduction

From the social, economical and meteorological point of view, the urban areas are complex systems in which multidisciplinary agents should work together. Cities modify the regional climate and develop a particular urban climate. Climate variables are modified due to an alteration in surface energy balance and air flow dynamic.

It is of special interest to provide climate information to urban planners and decision-makers in a suitable way so that they can use it for planning purposes. The Urban Climate Map (UC-Map) aims to solve the existing gap between urban climatologist and urban planners. It is considered an important tool that integrates both disciplines and is essential for urban development strategies, specially in a climate change context. The concept of UC-Map was first developed in Germany on the 1970s (Matzarakis, 2005). Actually, more than 15 countries are processing their own UC-Map, applying climate measures and guidelines to urban planning (Ren et al, 2010).

Bilbao municipality is a medium city (355,048 inhabitants in year 2009) located in the northern part of the Iberian Peninsula. The urban area is located in an estuary, 16 km. from the sea. The urban area is oriented in a NW-SE direction following two mountain ranges (300-700 m. a.s.l.).

Local climatology in the region is significantly influenced by complex topography and the proximity to the sea. Surface air flow is channelled through the valleys. Additionally, sea/land and mountain/valley breezes occur frequently, especially with stable atmosphere situation. Anabatic/katabatic winds are conditioned by mountain slopes and their orientation. Consequently, the interaction of all these meteorological phenomena influence ventilation properties and, consequently thermal comfort in the urban area.

Recently the first UC-Map for Bilbao has been concluded. In this sense, the integration of urban climate in an urban planning tool (UC-Map) is a new perspective in Spain that should be extensive applied during the following years.

Methodology

The method to develop an UC-Map (Analysis Map + Recommendation Map) for Bilbao (Spain) is based on GIS calculations, specific climate measurements and urban climate expert knowledge.

Two parallel analyses are undertaken: **surface thermal load** based on land use characteristics, and **dynamic potential** associated to ventilation patterns (Figure 1). Data used are: general land-use description (forest, farmland, urban...); building characteristics (location, surface covered, and height); urban vegetation (calculated from satellite NDVI index); air flow characteristics (regional winds and thermal induced circulations); and topography (elevation and slopes).

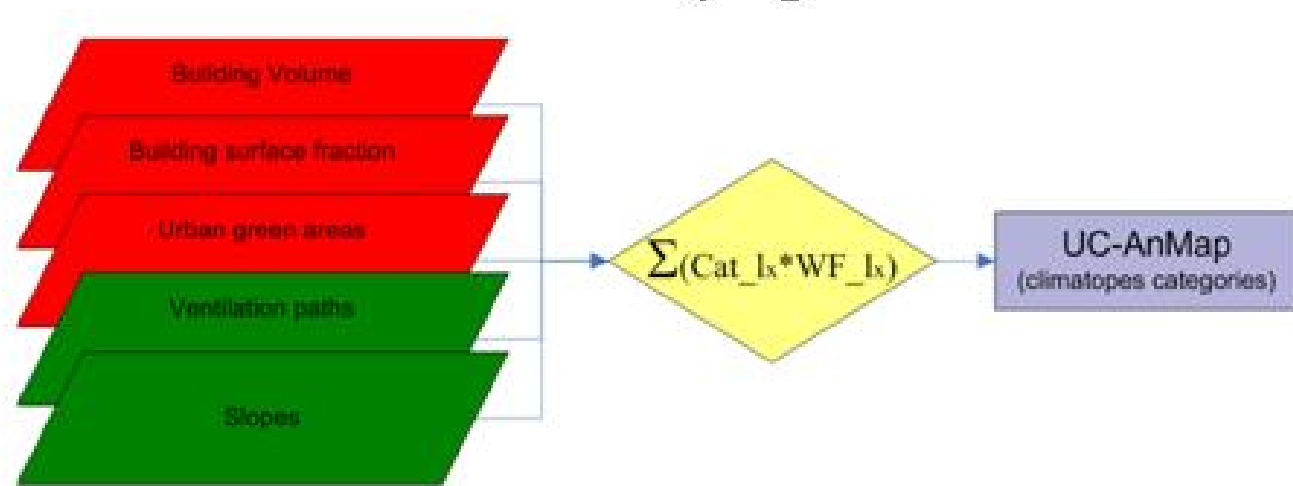


Figure 2. GIS calculations to derive UC-AnMap

To describe climatopos (i.e. areas with homogeneous climate variables in terms of thermal comfort) in an UC-AnMap all the necessary information is grouped in **5 GIS layers**: building volume, building surface fraction, urban green areas, ventilation paths and slopes (Figure 2). Also topography/height and incoming solar radiation are evaluated but the results show a negligible influence in Bilbao compared with the rest of the layers described. A 100 meter grid resolution is used.

Urban climate knowledge is essential to evaluate ventilation patterns in the area deeply influenced by sea breezes and cold air drainage flow. Additionally, three **climate measurement campaigns** are carried out combining stationary and mobile devices (Figure 3). Climate variables (T_a , W_S , T_{mrt} and RH) are used to adjust the weighting factors (WF) that combine the GIS layers (k_x), and thus validate the UC-Map.



Figure 3. Mobile and stationary measuring systems

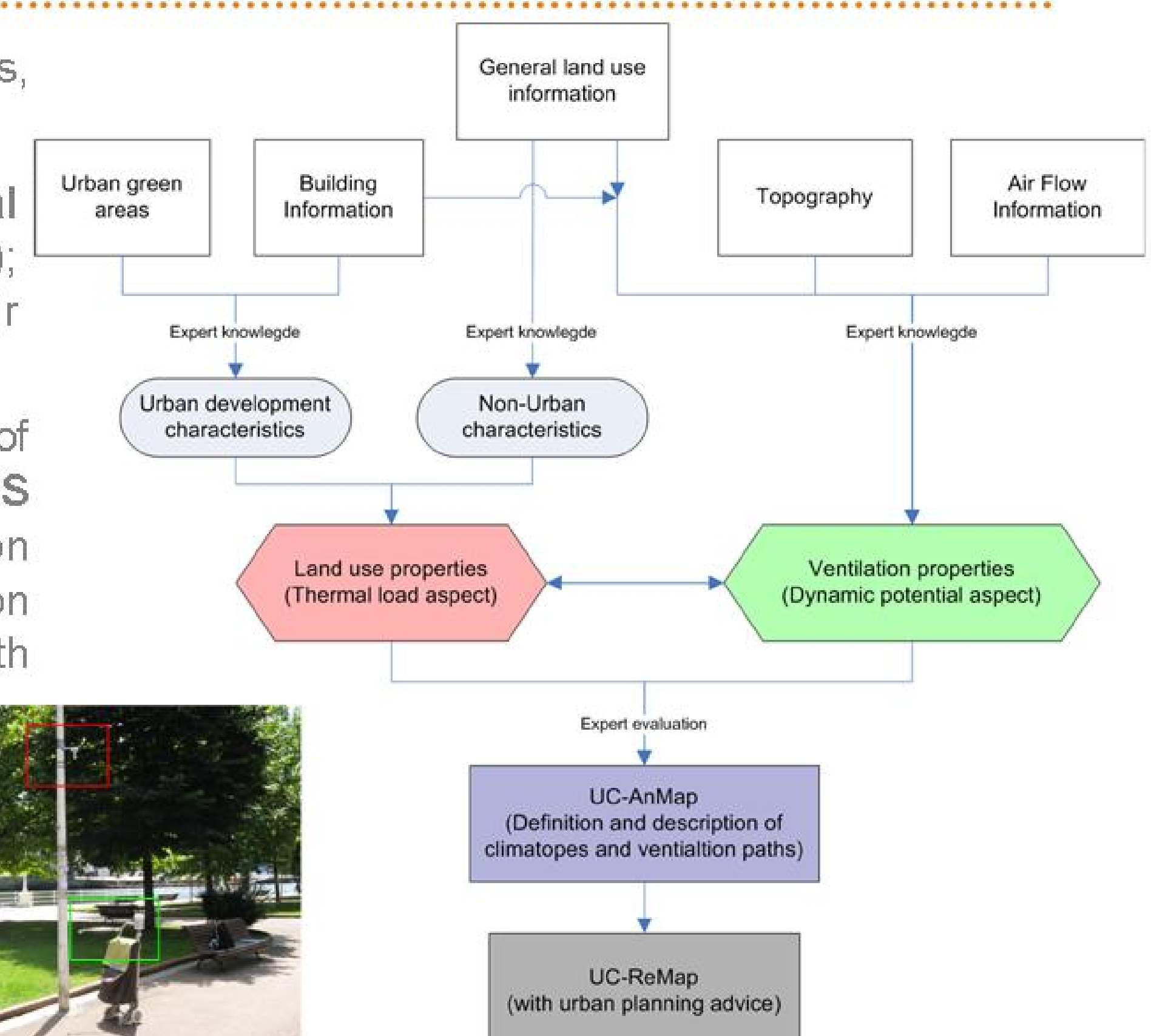
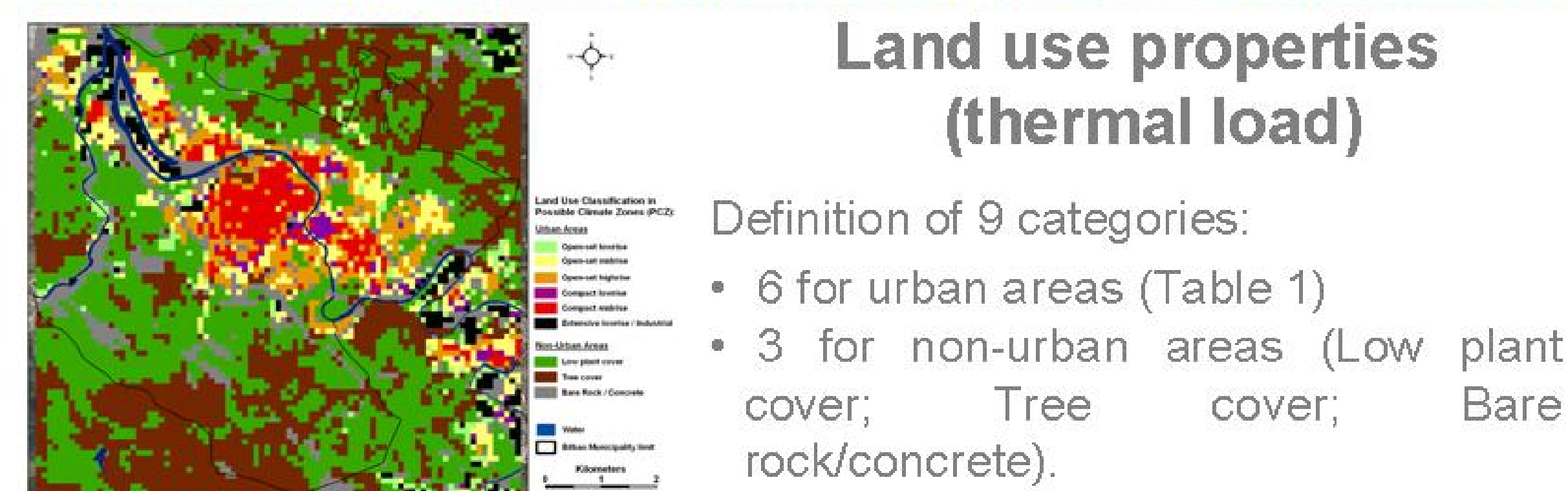


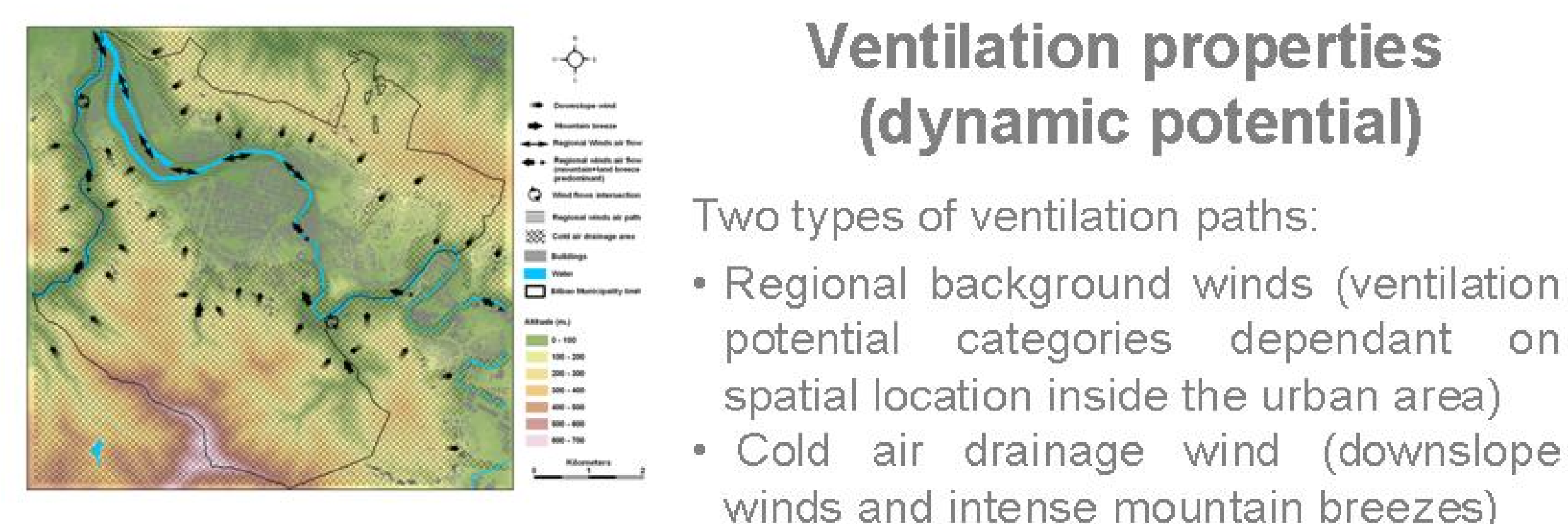
Figure 1. Concepts and methodology for UC-Map

Results



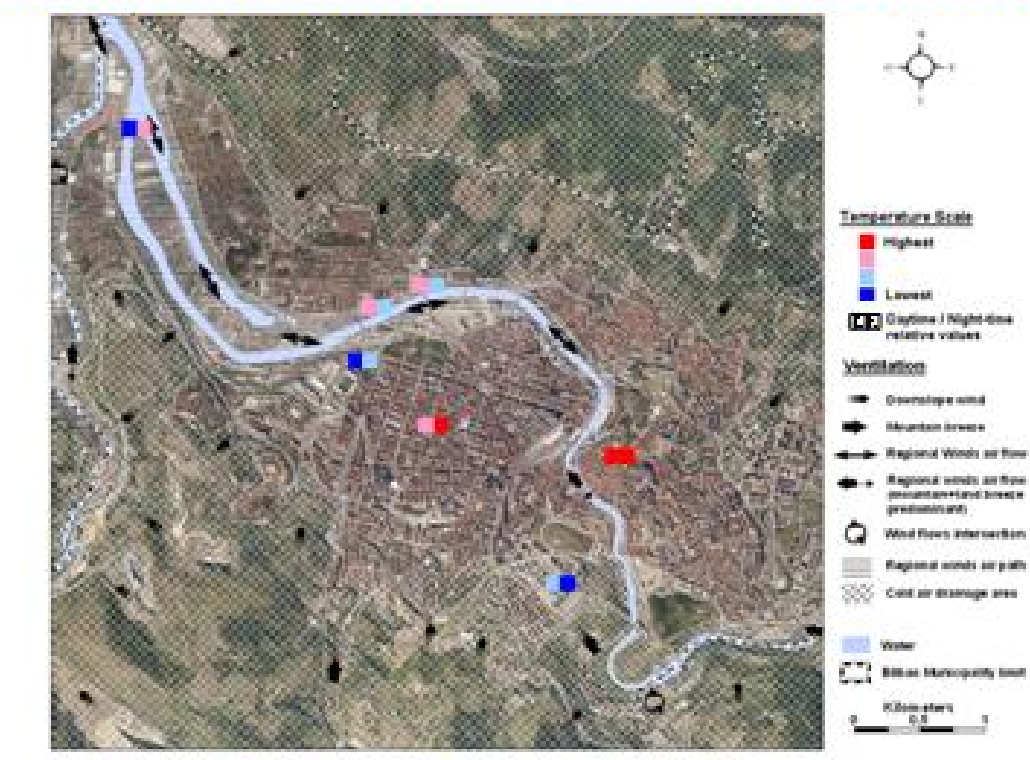
	Building surface fraction (%)	Building reference height (m.)	Presence of vegetation	Presence of occurrence (%)
Open-set high rise	10-40	≥ 20	None-Low	23.8
Open-set midrise	10-40	10 - 20	None-Low	25.1
Open-set lowrise	10-40	< 10	Low-Medium	12.3
Compact midrise	≥ 40	20 - 30	None	17.1
Compact lowrise	≥ 40	10 - 20	None	4.8
Extensive lowrise	≥ 10	< 10	None-Low	12.5

Table 1. Description of urban land use characteristics for climate purpose in Bilbao



Measurement campaigns

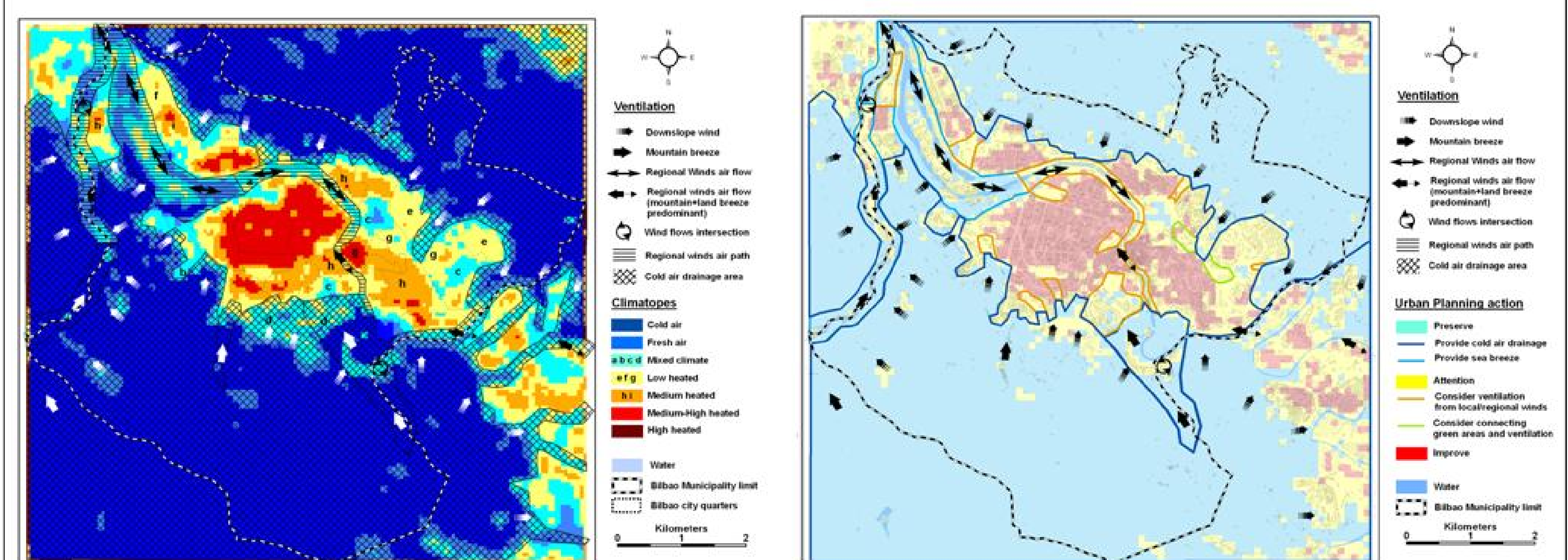
UHI ~ 1-2°C with differences between urban zones (conditioned to exposure to mountain/slope and sea breeze that vary spatially and along the day)



Final UC-Map (UC-AnMap + UC-ReMap)

GIS calculation plus validation with measurements result in an **UC-AnMap** with 7 categories of climatopos.

Adequate recommendations are derived for urban planning in the **UC-ReMap**



Conclusions

- Calculations with GIS layers plus climate measurements and urban climate knowledge can be used to derive an UC-Map with planning purpose.
- The method simplifies input data (5 information layers) and is easy to update.
- Urban climate expert knowledge is essential to evaluate ventilation paths and their impact on urban climate, specially in areas with complex meteorological phenomena.
- UC-Map is presented as a tool (clear and easy to understand) for urban planners.

References

- Matzarakis, A. (2005). Country Report: Urban Climate Research in Germany. IAUC Newsletter 11.
- Ren, C., Ng, E., Katschner, L. (2010). Urban climatic map studies: a review. International journal of Climatology DOI: 10.1002/joc.2237.