On the Use of the Climate Twins Approach to Pose the Challenges of Urban Adaptation

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Rationale

Despite growing climatic threats and scientific consensus, 72% of the 200 main European cities do not have implemented a climate adaptation plan yet[1].

→ **This paucity of political investment can be associated with a lack of understanding from both civil society and decision-makers, because typical scientific statements are usually out of reach and inapplicable for most of the non-specialists.**

→ **Therefore, there is a need to develop innovative tools which provide intuitively understandable climate information.**

⇒ **The Climate Twins approach[2], by matching the future climate of a city A with the current climate of a city B, addresses this need[3].**

1) How to efficiently match current and future European cities' climates together?
2) How and to which extent this approach can be used as a raise-awareness tool and climate adaptation tool in urban areas?
3) What are the uncertainties associated with this concept?

Methodology

Climate Data and Statistics

- **Two periods of 30 years, daily data:**
  - **Current climate → 1961-1990**
  - **Future climate → 2071-2100**
- **Outputs from ten 50-km resolution RCMs simulations under the A2 scenario, from the PRUDENCE Project[4].**
- **Calculation based on these statistics:**
  - **Monthly mean temperature (°C)**
  - **Monthly mean max summer temperature (°C)**
  - **Monthly mean min winter temperature (°C)**
  - **Monthly temperature standard deviation (°C)**
  - **Monthly mean precipitation (mm/day)**
  - **Annual mean precipitation (mm/year)**
  - **Annual mean snowfall (mm(w.e)/year)**
  - **Monthly mean 10-m wind (ms^{-1})**

Climatic Twinning

The following method is used to determine all the climate analogues of a city (called « City of Interest » - COI):

- **For all the climate statistics:**
  - **Calculation of the Euclidean distances between the future climate of the COI and the current climate of all other grid points.**
  - **Establishment of distances thresholds under which the grid points are considered analogous, for each climate statistics.**
- **If a grid point has all its associated Euclidean distances under the thresholds for all the climate statistics → Climate analogue**
- **If the climate analogue is located near (<50km) a main European city → City Climate Twin**
- **Use of different RCMs / scenarios to assess the uncertainty.**

Results

- **The Climate Twins approach has been conducted over 100 European cities → 70 cities were found to have at least one climate analogue and 39 were found to have a climate twin city (Fig. 1 and Fig. 2 provide several examples).**
- **There is a great climatic proximity between the COI's future climate and its city climate twin's current climate for the variables of temperatures and a low climatic proximity for precipitation variables (Fig. 3).**

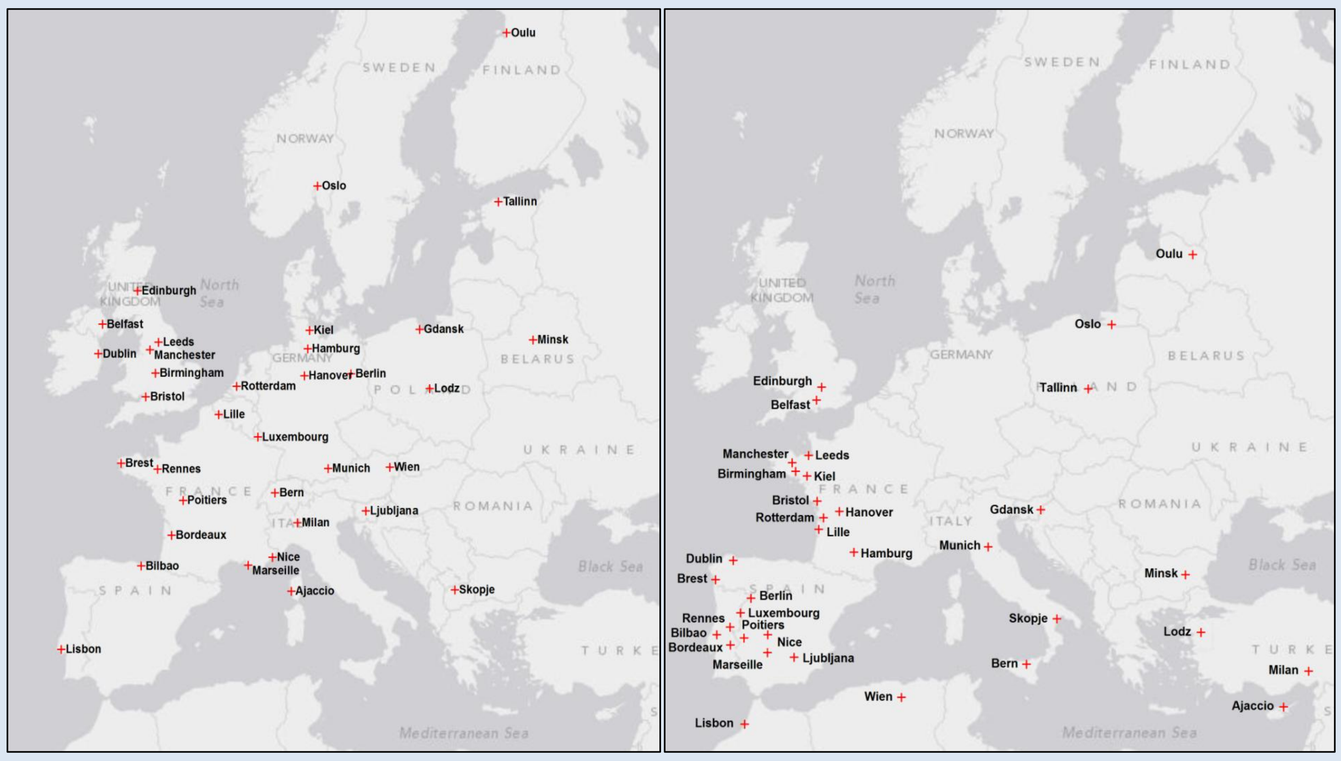

Fig. 1 – Current location of 36 main European cities (left) and location of these cities' best climate analogue (right), representing the current location of their future (2071-2100) climate

Future climate of…	=	*Current climate of…*
Amsterdam		Nantes
Berlin		Saragossa
Brussels		Bordeaux
Edinburgh		London
Hamburg		Toulouse
Leeds		Lille
Liverpool		Plymouth
Ljubljana		Athens
Luxembourg		Saragossa
Milan		Adana
Moscow		Kiev
Nice		Naples
Nuremberg		Marseille
Oslo		Kaliningrad
Prague		Bologna
Rotterdam		Bordeaux
St-Petersburg		Warsaw
Stockholm		Berlin
Stuttgart		Valladolid
Tallinn		Wroclaw
Warsaw		Balikesir
Zagreb		Cordoba

Fig. 2 – List of 22 City Climate Twins

Climatic proximity of the climate twins: case-study with the couple Hamburg - Toulouse

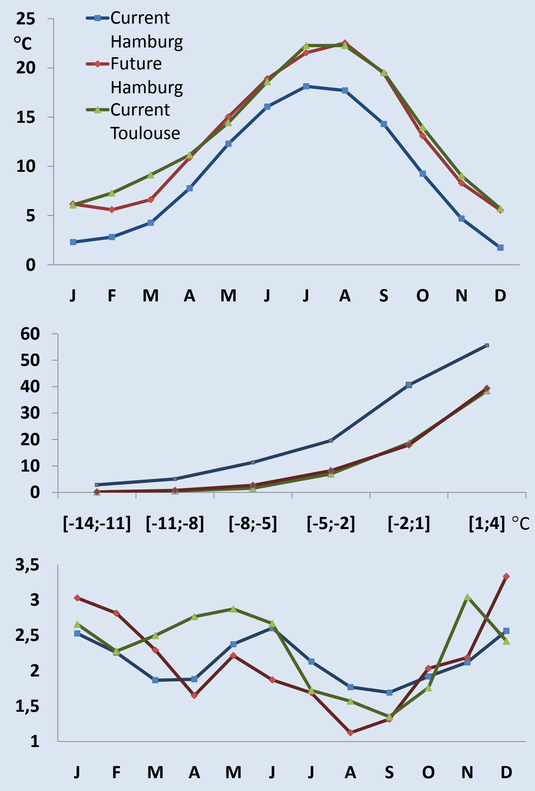

Fig. 3 – Monthly mean temperatures (top); number of days/year according to the daily min temperatures (middle); monthly mean precipitation (mm/day) (bottom), averaged over 30-years periods.

Applications

Urban Adaptation Tool

- **Because of the great climatic proximity, for temperatures variables, between the COI's future climate and its city climate twin's current climate, this approach could be used as a urban adaptation tool for heat waves management in urban areas.**
- **Stakeholders from the COI can identify the infrastructures, policies and best practices that are currently implemented in the city climate twin to face its climate and its extreme temperatures events.**

→ **They can then intuitively and immediately envision the changes, in terms of policies and infrastructures, that are required in their own city to better face future impacts of climate change and heat waves.**

Raise-Awareness Tool

- **The most obvious use of the Climate Twins approach is to raise awareness of the general public about the impacts of a changing climate on the cities they live in.**
- **Through an accessible and user-friendly tool (Fig. 4) users can immediately visualize the current location of any European city's future climate (represented by its climate analogues).**
- **Through this interface, users can intuitively envision the main changes – in terms of climate – that their city will have to face in the 21st century .**

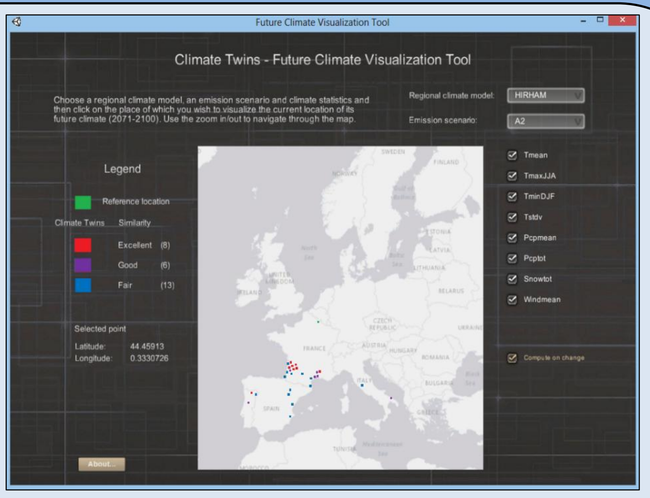

Fig. 4 – User-interface of the Climate Twins Tool

Uncertainties

The number and the location of climate analogues greatly differ depending on:

- **The RCMs that are used: Fig. 5 shows the results' differences for Hamburg's climate analogues, with two different RCMs: HIRHAM (left) and ARPEGE (right).**
- **The emissions scenarios that are used: climate analogues are located more southwards with A2 scenario than with B2 scenario.**
- **The thresholds that are chosen for each climate statistics: the climatic proximity between two climate twins strongly relies on these thresholds.**

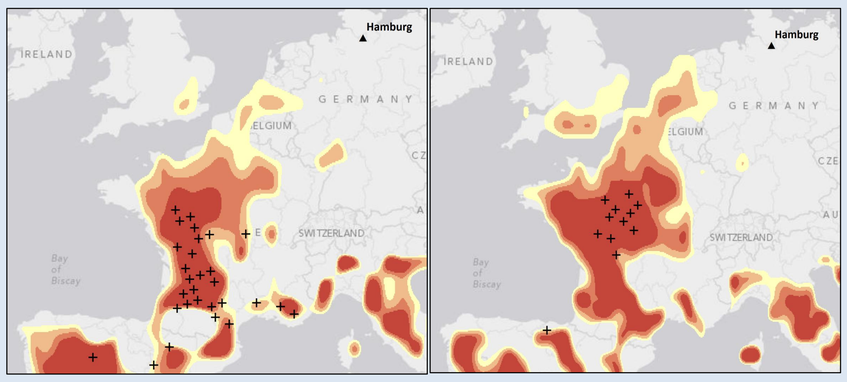

Fig. 5 – Hamburg's climate analogues location, for two different RCMs

Conclusions and Outlook

- **Despite some limitations, principally due to the uncertainties in climate projections, the use of climate twins appears to be efficient to raise-awareness about the forthcoming impacts of climate change and to readily and intuitively identify the policies, infrastructures and best practices that must be implemented in a city to be well-adapted to climate change.**
- **The main advantage of this approach and this tool is that they can be easily used and understood by urban stakeholders and decision-makers.**

→ **The Climate Twins approach, by its innovativeness, its ease of use and its scientific legitimacy, is a useful and promising tool to address the challenges of urban adaptation in a climate change context.**

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[1] Reckien, D. et al., 2014. Climate change response in Europe, what's the reality? Analysis of adaptation and mitigation plan from 200 urban areas in 11 countries. *Climatic Change* , 122 (2), pp.331-340.
[2] Ungar, J., Peters-Anders, J. and Loibl, W., 2011. Climate Twins – An attempt to quantify climatological similarities. *Environmental Software Systems - Frameworks of Environment*, 359 (1), pp. 428-436.
[3] Beniston, M., 2013. European isotherms move northwards by up to 15 km/year: using climate analogues for awareness-raising. *International Journal of Climatology*, DOI: 10.1002/joc.3804.
[4] The PRUDENCE Project, www.prudence.dmi.dk.