Future climate of Brussels and Paris for the 2050s under the A1B scenario

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ACCEPTED is a research program that aims to improve our understanding of future exposure situations in cities and their impact on health, from an interdisciplinary approach. This will be achieved by using various state-of-the-art atmospheric models and measurements describing effects on exposure together with epidemiological studies and reviews.

Started in December 2012 and finished in 2015. ACCEPTED involves 11 different partners and is funded by the European network ERA-ENVHEALTH.
RMI task in WP1
Interaction between global climate change and the urban environment

~ 200 km

< 1 km
At the RMI, ALARO-0, is a version of the ARPEGE-ALADIN operational LAM with a revised and modular structure of the physical parametrizations (Gerard et al. 2009).

A specific approach is adopted, with an integrated sequential treatment of resolved condensation, deep convection, and microphysics together with the use of prognostic variables. This new version allows for the production of consistent and realistic results at resolutions ranging from 10 km down to less than 4 km.

A version at ~4km resolution has been in use operationally since 2009.
One important feature of the externalized surface: each grid cell is divided into 4 elementary units called tiles according to the fraction of covers in the grid cell.

Masson et al., 2013, GMD
Faroux et al., 2013, GMD
INLINE MODE

Surfex output as surface boundary conditions for atmospheric radiation and turbulent scheme.

**ALARO model**

- Albedo
- Emissivity
- Radiative temperature
- Momentum flux
- Sensible heat flux
- Latent heat flux

Atmospheric forcing
- Sun position
- Downward radiative flux

Hamdi et al., 2014, GMD
OFFLINE MODE

Atmospheric forcing
Sun position
Downward radiative flux

albedo
emissivity
radiative temperature
momentum flux
sensible heat flux
latent heat flux

Mean Flux

Hamdi et al., 2009, JAMC
Hamdi et al., 2012, IJC
Regional climate simulations using ALARO+SURFEX+TEB

GLOBAL

20 km

4 km
Urban climate simulations using SURFEX+TEB+SBL

ALARO+SURFEX INLINE 4km

SURFEX OFFLINE 1 km, Brussels, 30x30

SURFEX OFFLINE 1 km, Paris, 55x55
Town Energy balance

TEB, Masson 2000

TEB-SBL Hamdi and Masson 2008

Basel-Sperrstrasse

Rocks
Two simulations are done with and without TEB where the city is considered just as rock.

This is to mimic what is done in the state-of-the-art regional climate model.

<table>
<thead>
<tr>
<th></th>
<th>Regional Climate simulation</th>
<th>Urban climate simulation</th>
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<tbody>
<tr>
<td></td>
<td>Rock</td>
<td>TEB</td>
</tr>
<tr>
<td>ERA-40</td>
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<td>yes</td>
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<td>yes</td>
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<tr>
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<tr>
<td>A1B_IN</td>
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</tbody>
</table>
DYNAMICAL DOWNSCALING Simulations set-up

Hamdi et al., 2014, IJC

Summer 1961-1990

ARP_RF, UHI[T_MIN] = 1.71 °C
ERA_RF, UHI[T_MIN] = 1.46 °C

ARP_OF, UHI[T_MIN] = 1.97 °C
ERA_OF, UHI[T_MIN] = 1.86 °C

ARP_IN, UHI[T_MIN] = 2.56 °C
ERA_IN, UHI[T_MIN] = 2.54 °C

Hamdi et al., 2014, IJC
Table 2
The seasonal and annual mean temperature increase (FUT_1-HIS_1, in °C) for the 2050s horizon under the A1B emission scenario for the city center of Brussels, the rural (Brussegem) station, the city center of Paris and the rural (Melun) station.

<table>
<thead>
<tr>
<th></th>
<th>Urban center (°C)</th>
<th>Rural (°C)</th>
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<tbody>
<tr>
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<td>Summer</td>
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<tr>
<td>Fall</td>
<td>1.8</td>
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<tr>
<td>Annual</td>
<td>1.6</td>
<td>1.8</td>
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</table>

Table 3
The seasonal variation of the 10-year average nocturnal and daytime UHI (in °C) at the city center of Brussels and Paris calculated from: (i) ERA_1, (ii) HIS_1, and (iii) FUT_1 minus HIS_1. Significant results of the Student’s t-test at the 95% confidence level are shown with *. Bold values present the largest and statistically significant changes.

<table>
<thead>
<tr>
<th></th>
<th>UHI_N (°C)</th>
<th>UHI_D (°C)</th>
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<tbody>
<tr>
<td></td>
<td>ERA_1</td>
<td>HIS_1</td>
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<tr>
<td>Paris city center</td>
<td></td>
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<tr>
<td>Spring</td>
<td>2.8</td>
<td>2.8</td>
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<tr>
<td>Summer</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Fall</td>
<td>2.7</td>
<td>2.9*</td>
</tr>
<tr>
<td>Winter</td>
<td>2.2</td>
<td>2.2</td>
</tr>
</tbody>
</table>

| Brussels city center | | | |
| Spring               | 1.8    | 1.8    | 0.15*    | 0.4    | 0.8*   | 0.07*     |
| Summer               | 1.8    | 1.8    | -0.10    | 0.6    | 0.2*   | -0.11*    |
| Fall                 | 1.7    | 1.9*   | 0.12      | 0.6    | 0.5*   | -0.04     |
| Winter               | 1.2    | 1.2    | **0.22**  | 0.5    | 0.6*   | 0.07*     |
ERA-Interim 1981-2010

(a) UHI_N Observed

Hamdi et al. 2016, UC submitted

(b) UHI_N Simulated
We spend now on average 1.62 hours per day of HW at a dangerous level and that will rise to 2.25 hours.

Humidex = \( T + \frac{5}{9}(e - 10) \)

\( e = RH \times 6.11 \times e^{\left(\frac{17.67 \times T}{(243.5 + T)}\right)} \)

Comfortable (H < 27)
Some discomfort (27 ≤ H < 30)
Great discomfort (30 ≤ H < 40)
Dangerous (40 ≤ H < 55)
Very dangerous (H ≥ 55) (heatstroke upcoming).
1. The responses of urban and rural areas to climate change are NOT THE SAME.

2. The feedback between urban environment and climate change is very important for urban impact studies.

3. Compared to the warming due to climate change (an increase of few degrees), changes in the magnitude of the UHI remain very low.

4. Decrease in daytime UHI during summer is related to soil drying over rural areas.

5. Increase in nocturnal UHI during winter is due to projected decrease of wind speed.
6. Climate change will, on average, have a limited impact on the UHI intensity, however, large impacts can be expected from the combination of urban development and potentially more frequent occurrence of extreme climatic events such as heat waves.

7. Evidence of the occurrence of more stable meteorological conditions for the 2050s with an increase in PM10 concentrations.

8. The number of days in which ozone concentrations exceed the warning thresholds during HW will increase by a factor 2.5.
References:

