The decadal projection of the Belgian urban heat island under changing climate and land use

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1. MOTIVATION

In the framework of the project MASC 'Modelling and Assessing Surface Change Impacts on Belgian and Western European climate', future decadal climate projections will be made based on the coupling of an Agent-Based Model, a vegetation Model and a Regional Climate Model (RCM). Regional and local climate is simulated by dynamically downscaling lateral boundary conditions (LBCs) from the Global Climate Model (GCM) ARPEGE.

The ALARO-0 RCM used by the RMI (described in De Troch et al. 2014) uses an old surface scheme called ISBA. This model has been validated for long climate runs (Giot et al., in preparation) and is now being used to contribute to the CORDEX project.

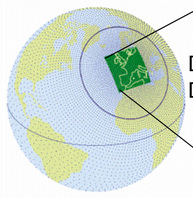
Meanwhile the newer scheme SURFEX (Masson et al. 2013) has been implemented in this RMI ALARO-0 version, and this setup has shown improvements in NWP applications (Hamdi et al. 2014). This setup was used for the forcing of SURFEX in offline mode, which has projected a significant increase of the Urban Heat Island (UHI) during winter for Brussels and Paris (Hamdi et al. 2015).

The aim here is to (a) test the potential of the ALARO-0 RCM with implemented SURFEX as forcing for high resolution SURFEX offline and (b) to exploit possibilities to use these results for Urban Climate studies.

2. EXPERIMENTAL SETUP

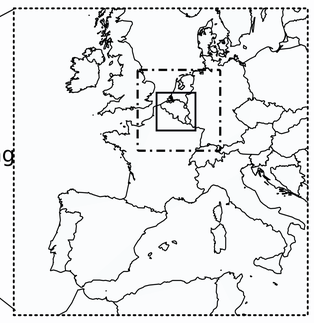
ALARO-0=ALADIN+new physics parameterisations centered around improved convection and cloud scheme

ARPEGE-IFS GLOBAL CLIMATE MODEL (GCM) / GLOBAL REANALYSIS



Dynamical Downscaling

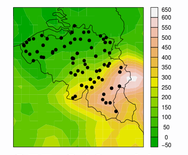
DRIVING LIMTED AREA MODEL (LAM) ALARO-0 20km



One-way nesting

HIGH-RESOLUTION LAM ALARO-0 4km

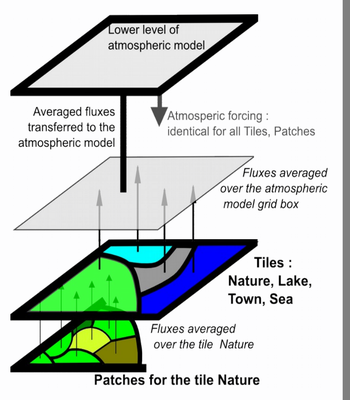
URBAN/ BELGIUM SURFEX OFFLINE 1km



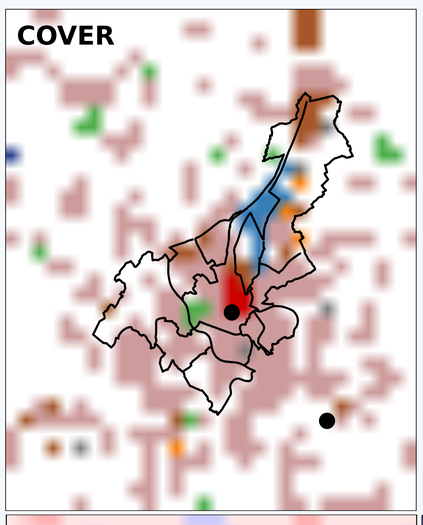
277x240 grid

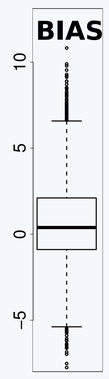
- 20 years 1991-2010, ERA-interim forcing
- Hourly output
- Cover from ECOCLIMAP II database
- Observations from RMI climatological network
- Formula UHI: $UHI\_N_i = T_{min,i} - \overline{T}_{min,rur}$ (nocturnal)
  $UHI\_D_i = T_{max,i} - \overline{T}_{max,rur}$ (daytime)
  where $T_{min(max),i}$ = 2 m min(max) temperature at each grid point i
  $\overline{T}_{min(max),rur}$ = 2 m min(max) temperature averaged over the rural (non-urban) grid points

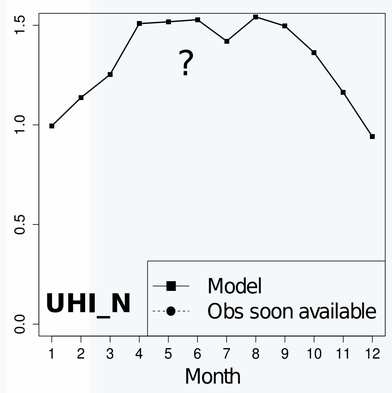
SURFEX



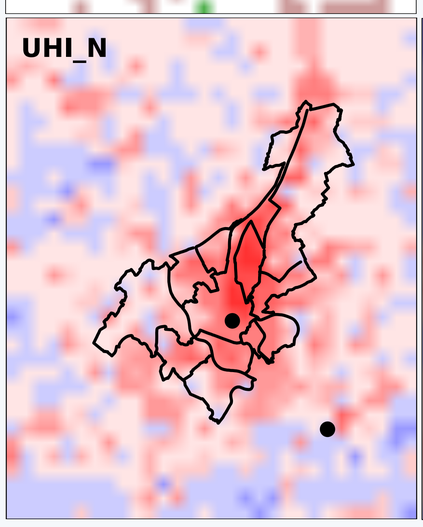
3A. RESULTS GHENT

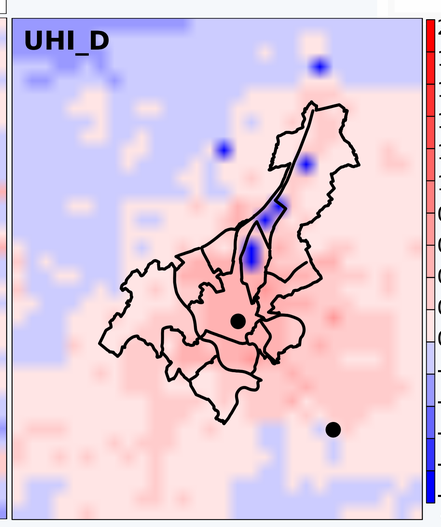


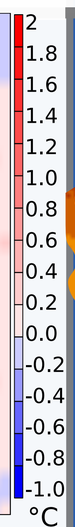




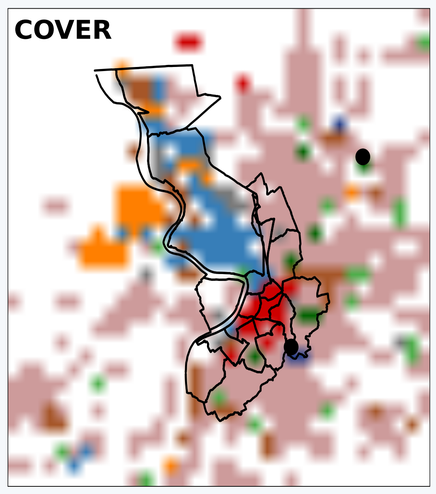
● Rural and Urban station

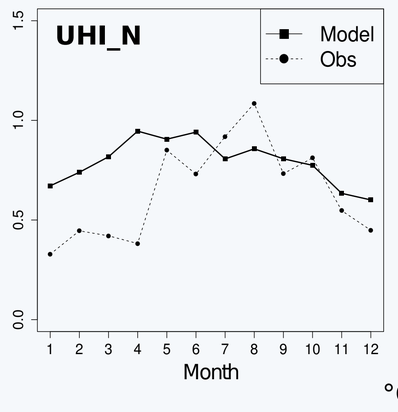


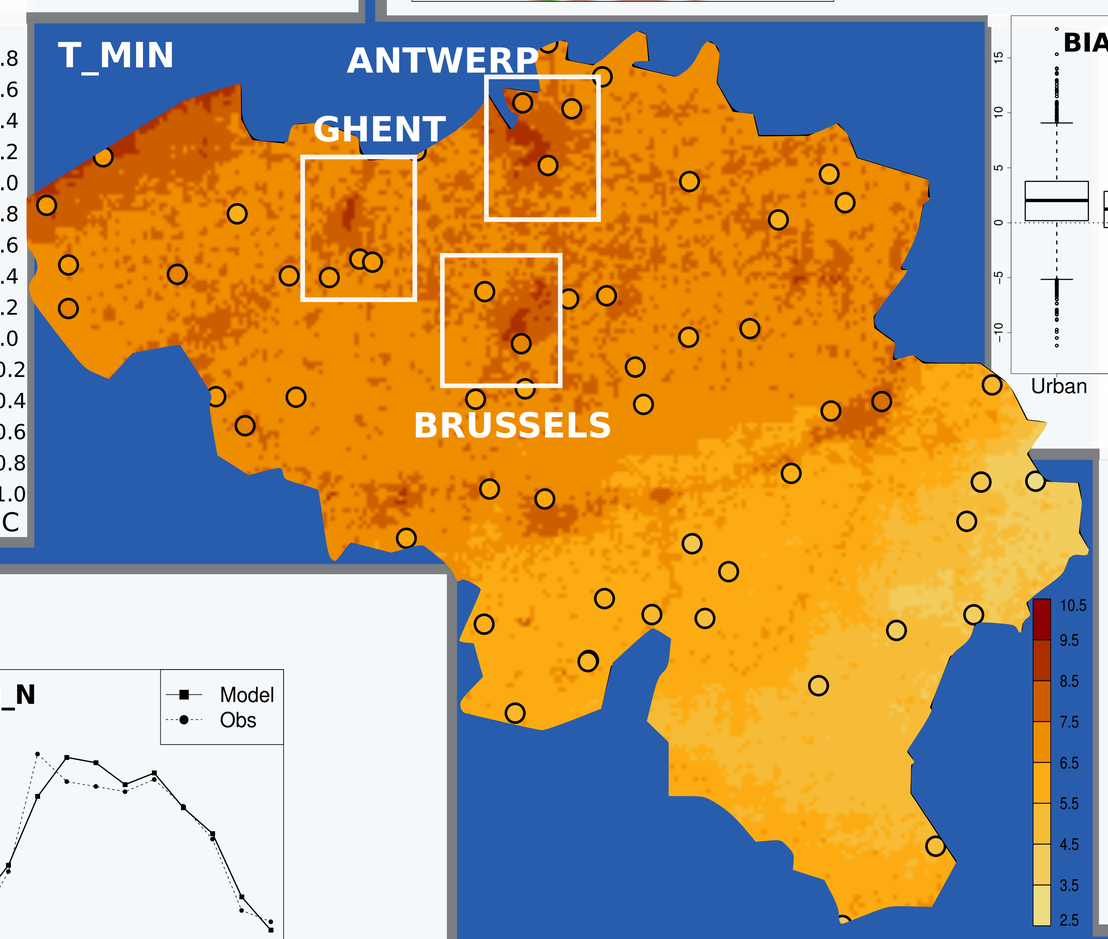


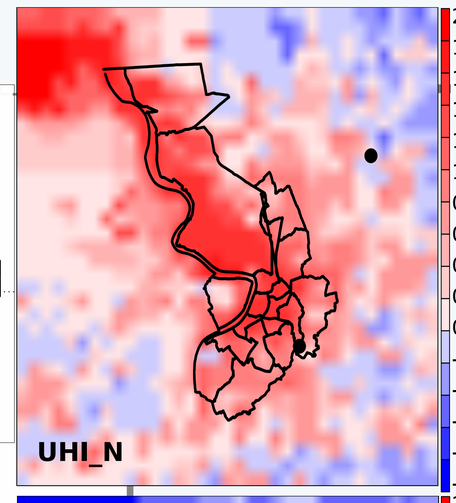


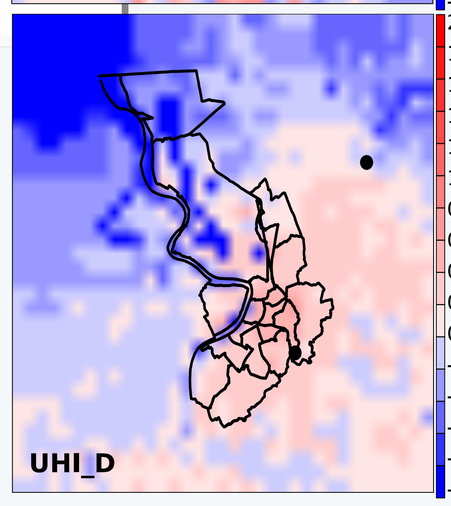
3B.RESULTS ANTWERP



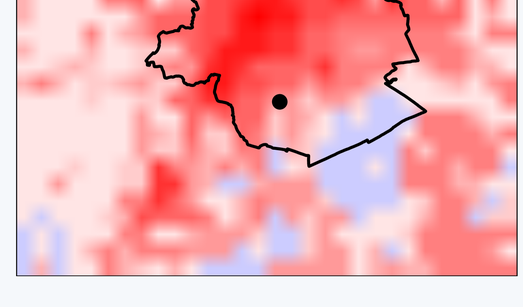




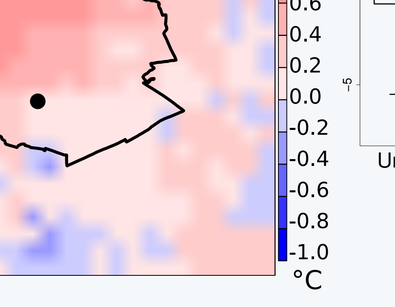




3C.RESULTS BRUSSELS



DENSE URBAN
TEMPERATE SUB–URBAN
INDUSTRIES AND COMMERCIAL AREAS
ROAD AND RAIL NETWORKS
AIRPORT
MINERAL EXTRACTION CONSTRUCTION SITES
URBAN PARKS
SPORT FACILITIES
NON–URBAN



● Rural and Urban station

5.DISCUSSION

The minimum temperature (T_MIN) in the 1km SURFEX simulations is well represented, compared to the observations, and shows the orographic cooling in the southeastern part of Belgium.
For all stations, the UHI_N is much higher than the UHI_D, indicating that the UHI is most visible in the T_MIN.
The highest values occur in the city center during night, extending along the port in Ghent and Antwerp. and decreasing values towards the outer boundaries of the city.
During daytime, the pattern of UHI follows the dominating wind direction, which can be seen by highest values in the southeast of Ghent and Antwerp, while northeast in Brussels.
In the context of the project MASC, the validated 1km offline SURFEX simulations will be run with revised land use and land cover under future scenarios RCP4.5 and RCP8.5.

De Troch et al. (2014), Multiscale Performance of the ALARO-0 Model for Simulating Extreme Summer Precipitation Climatology in Belgium, Journal of Climate, 26, 8895-8915
Hamdi et al. (2014), Evaluating the performance of SURFEXv5 as a new land surfacescheme for the ALADINcy36 and ALARO-0 models, Geosci. Model Dev., 7, 23-39
Hamdi et al. (2015), Future climate of Brussels and Paris for the 2050s under the A1B scenario, Urban Climate, 12, 160-182
Masson et al. (2013), The SURFEX v7.2 land and ocean surface platform for coupled or offline simulation of earth surface variables and fluxes, Geosci. Model. Dev., 6, 929-960