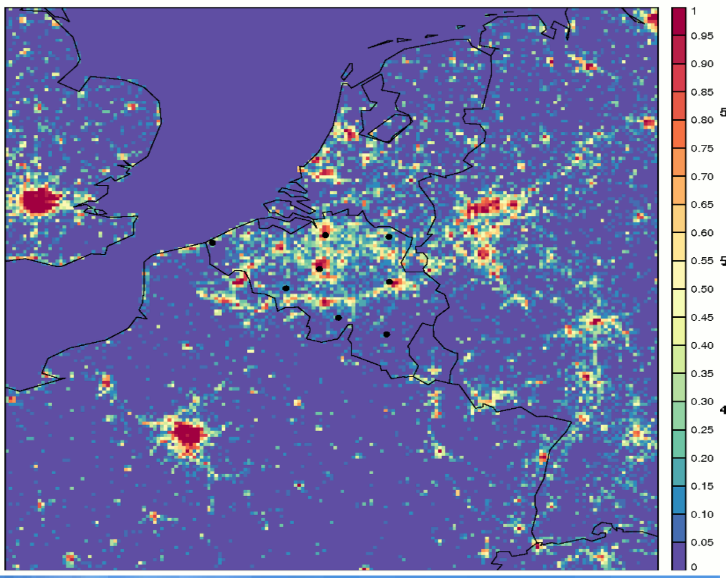
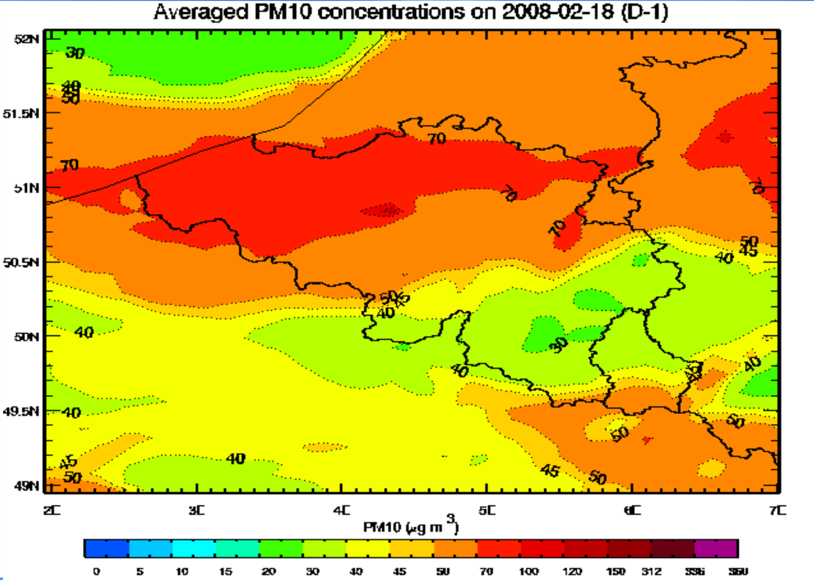
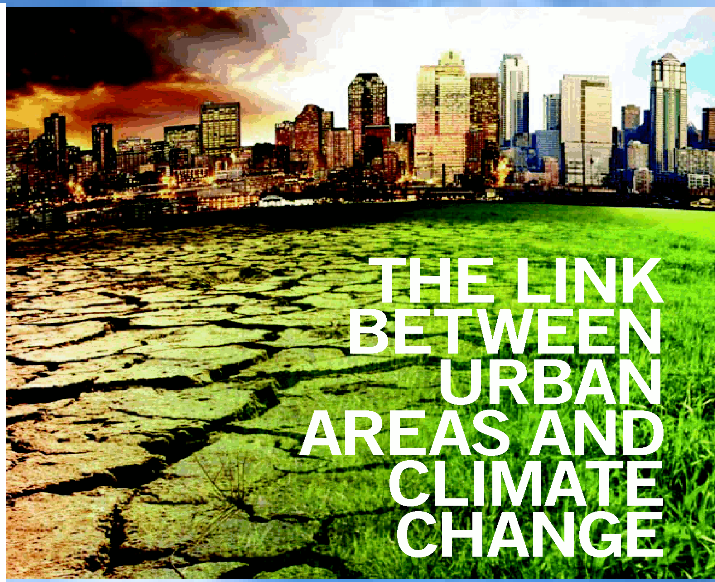
Future climate of Brussels and Paris for the 2050s under the A1B scenario of the global climate model ARPEGE-Climat

Rafiq Hamdi

Royal Meteorological Institute, Brussels, Belgium.







ACCEPTED

Assessment of Changing Conditions, Environmental Policies, Time-activities, Exposure and Disease.

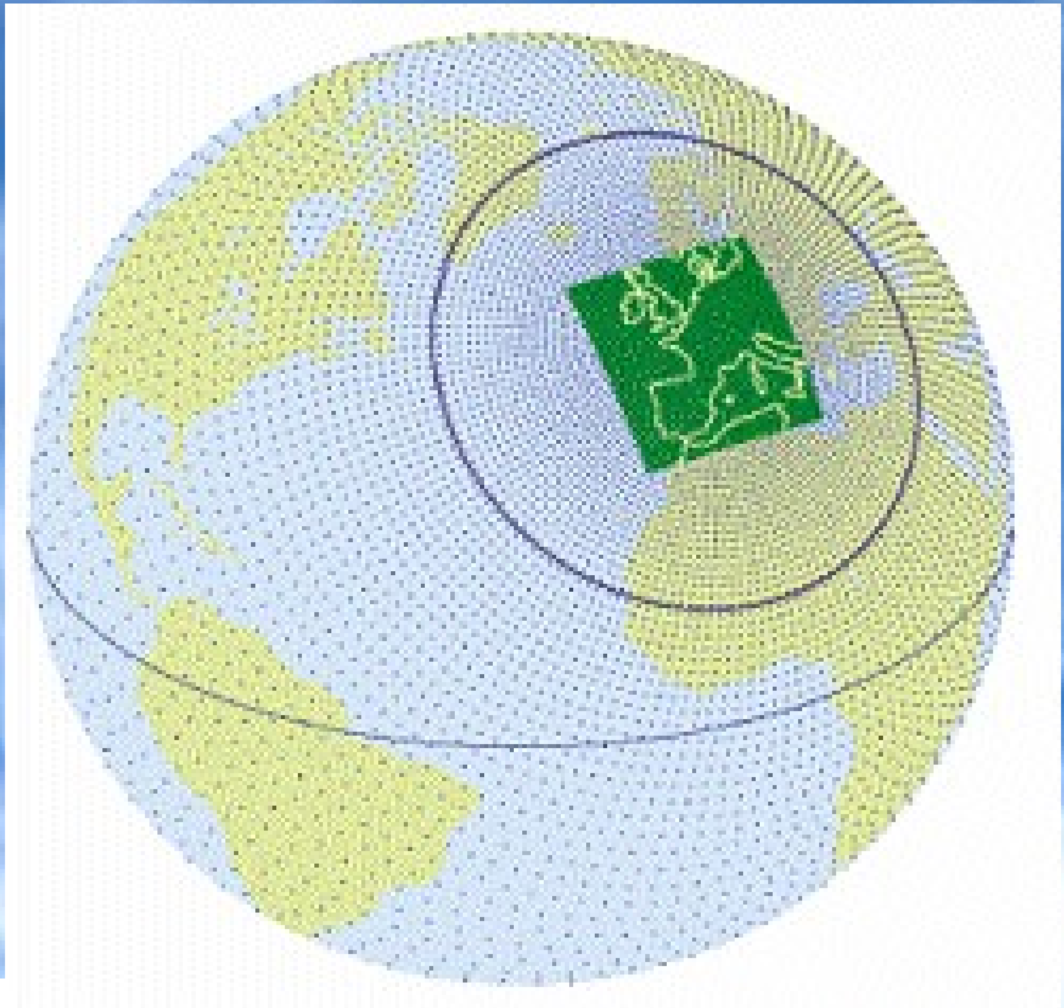
ACCEPTED is a research program that aims to improve our understanding of future exposure situations in cities and their impact on health, from an interdisciplinary approach. This will be achieved by using various state-of-the-art atmospheric models and measurements describing effects on exposure together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

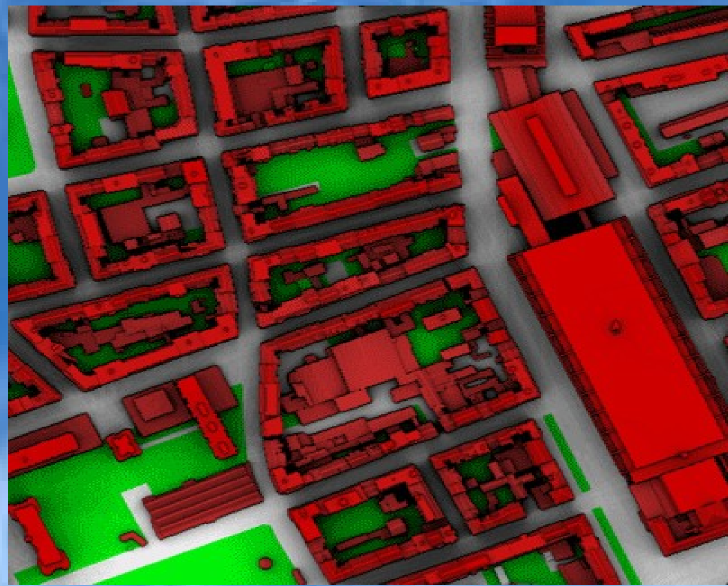
Interaction between global climate change and the urban environment

~ 200 km



?

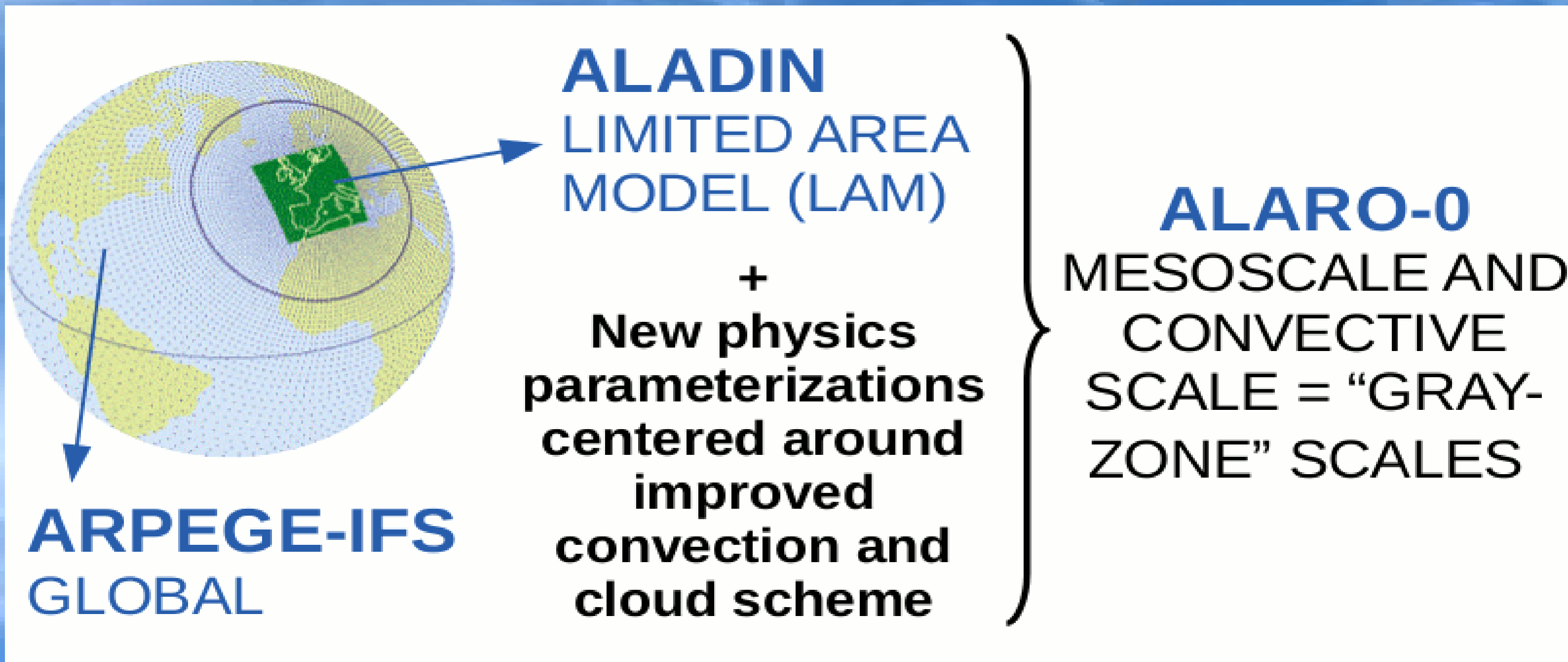
< 1 km



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).

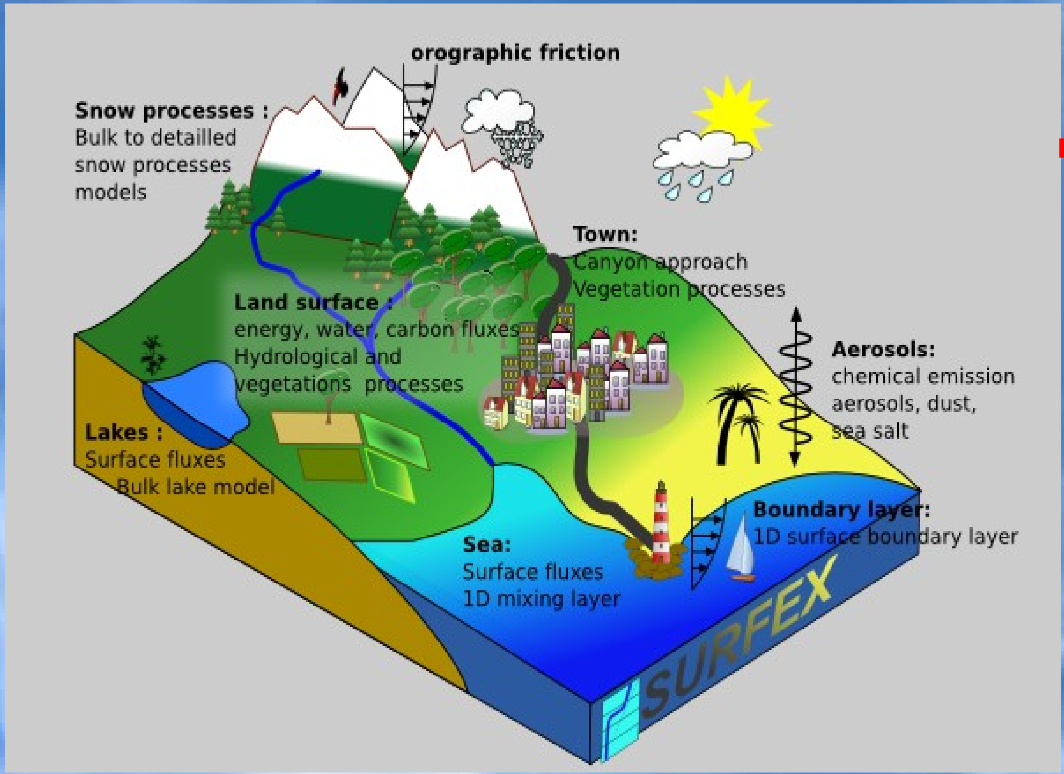
A specific approach is adopted, with an integrated sequential treatment of resolved condensation, deep convection, and microphysics together with the use of prognostic variables. This new version allows for the production of consistent and realistic results at resolutions ranging from 10 km down to less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

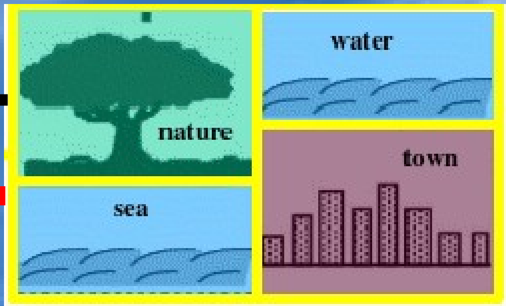
A version at ~4km resolution has been in use operationally since 2009.



Tiling

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





1: bare ground
2: rocks
3: permanent snow
4: deciduous forest
5: conifer forest
6: evergreen broadleaf trees
7: C3 crops
8: C4 crops
9: irrigated crops
10: grassland
11: tropical grassland
12: garden and parks

ECOCLIMAP database

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

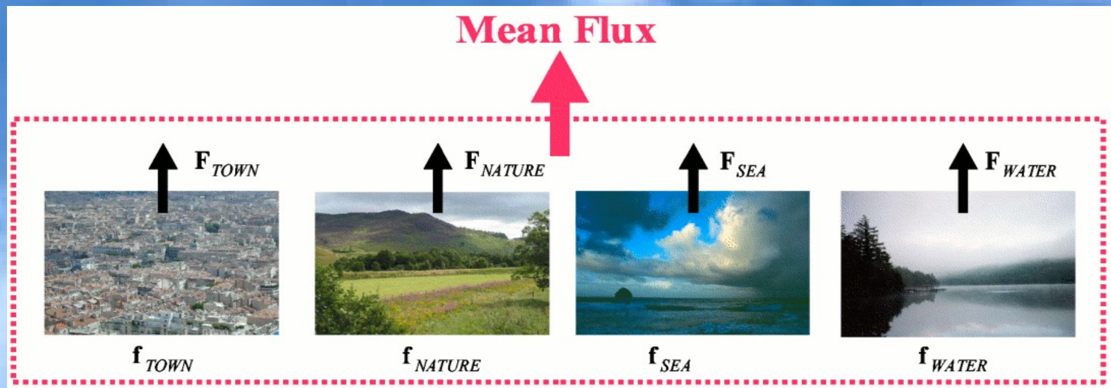
INLINE MODE

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

- albedo
- emissivity
- radiative temperature
- momentum flux
- sensible heat flux
- latent heat flux
- CO_2 flux
- chemical flux

ALARO model

- Atmospheric forcing
- Sun position
- Downward radiative flux

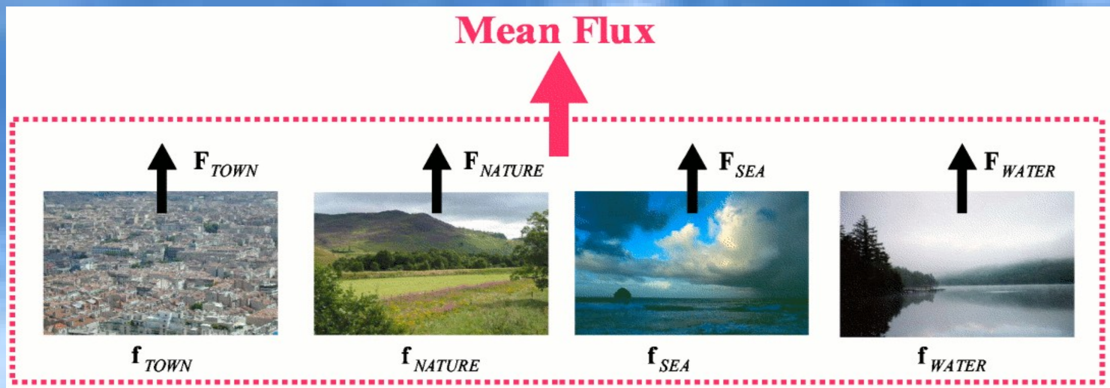


Hamdi et al., 2014, GMD

OFFLINE MODE

- albedo
- emissivity
- radiative temperature
- momentum flux
- sensible heat flux
- latent heat flux
- CO_2 flux
- chemical flux

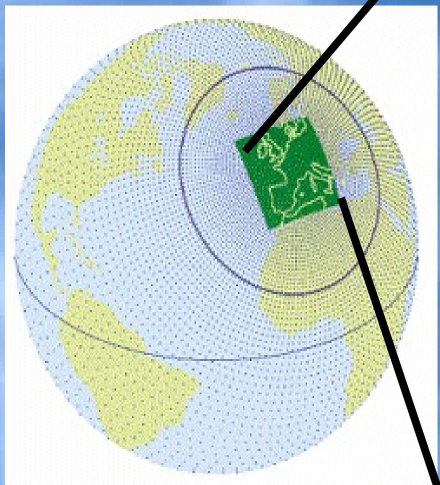
Atmospheric forcing
Sun position
Downward radiative flux



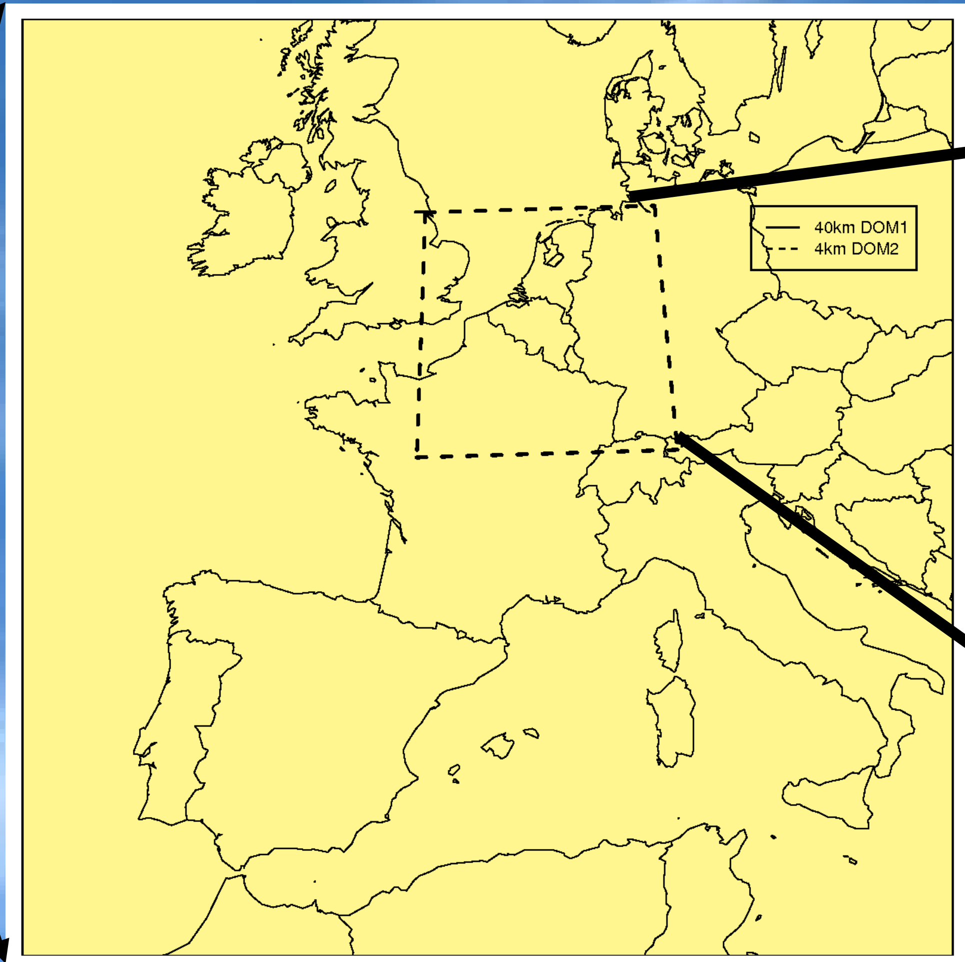
Hamdi et al., 2009, JAMC
Hamdi et al., 2012, IJC

Regional climate simulations using ALARO+SURFEX+TEB

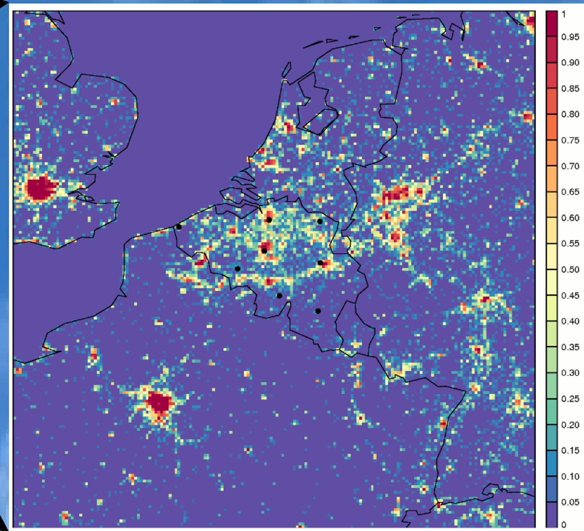
GLOBAL



20 km

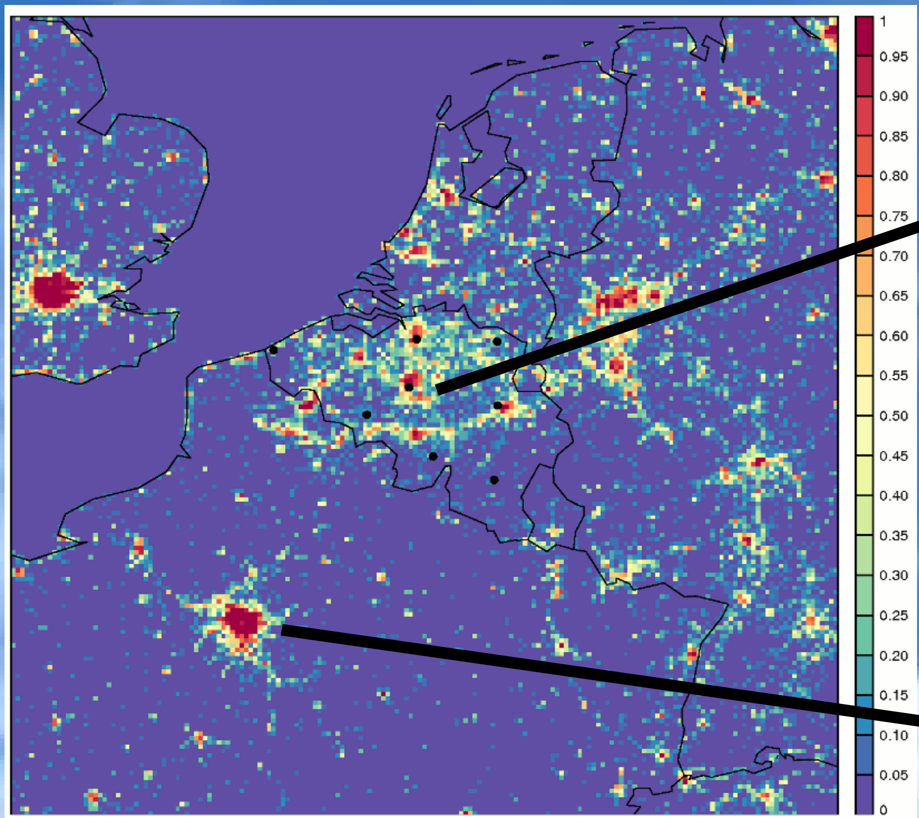


4km

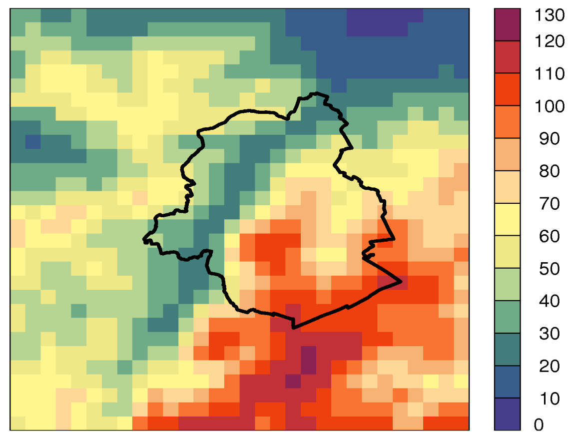


Urban climate simulations using SURFEX+TEB+SBL

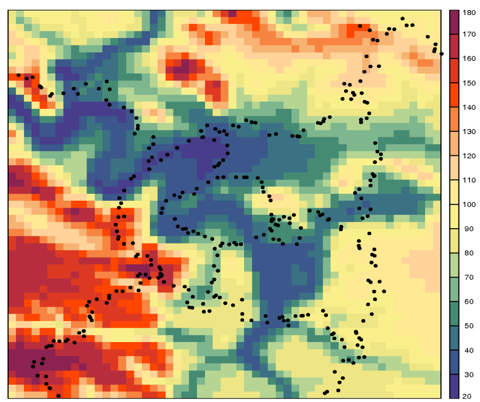
ALARO+SURFEX INLINE 4km



SURFEX OFFLINE 1 km, Brussels, 30x30

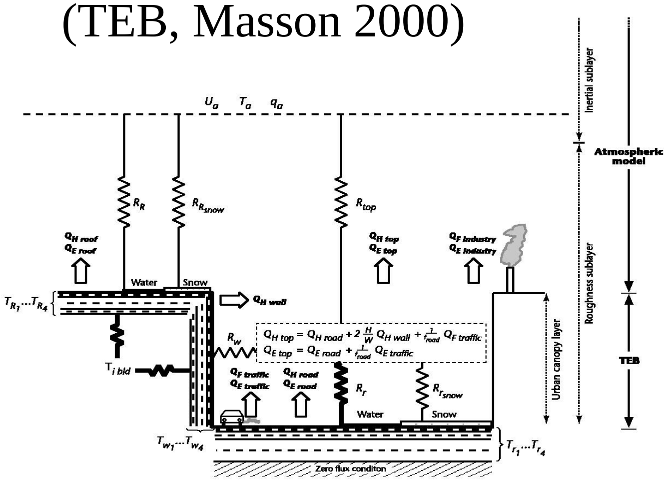


SURFEX OFFLINE 1 km, Paris, 55x55



Town Energy balance

(TEB, Masson 2000)



Rocks

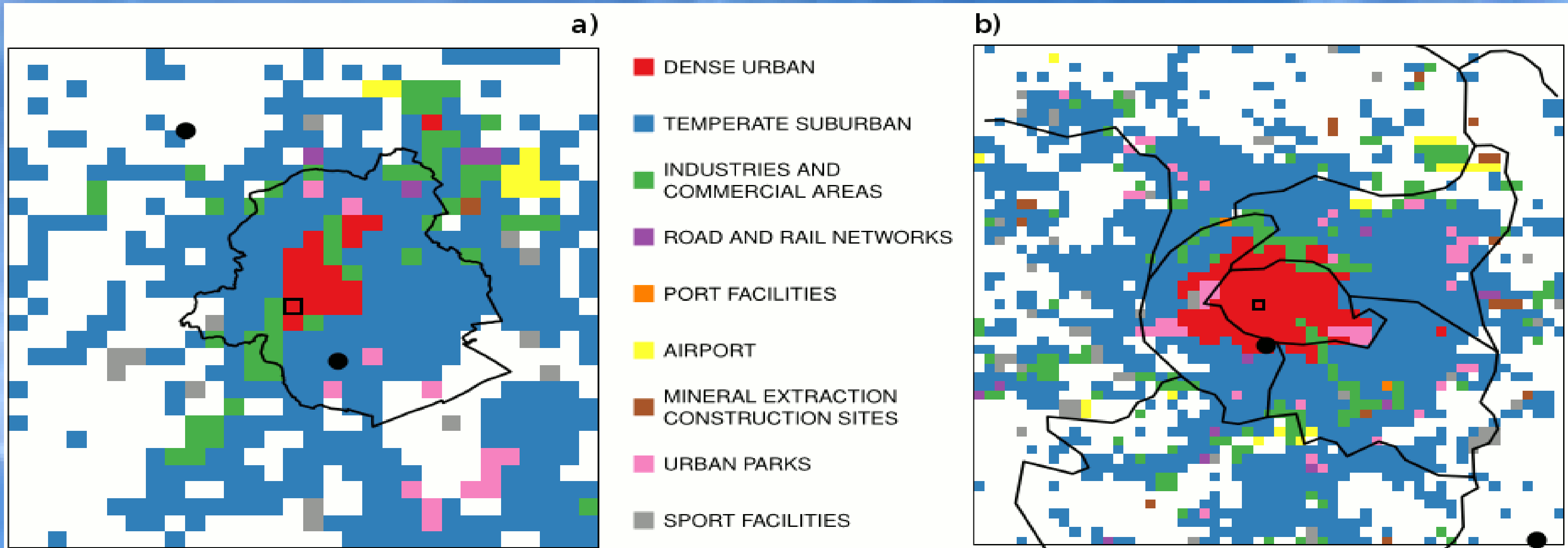
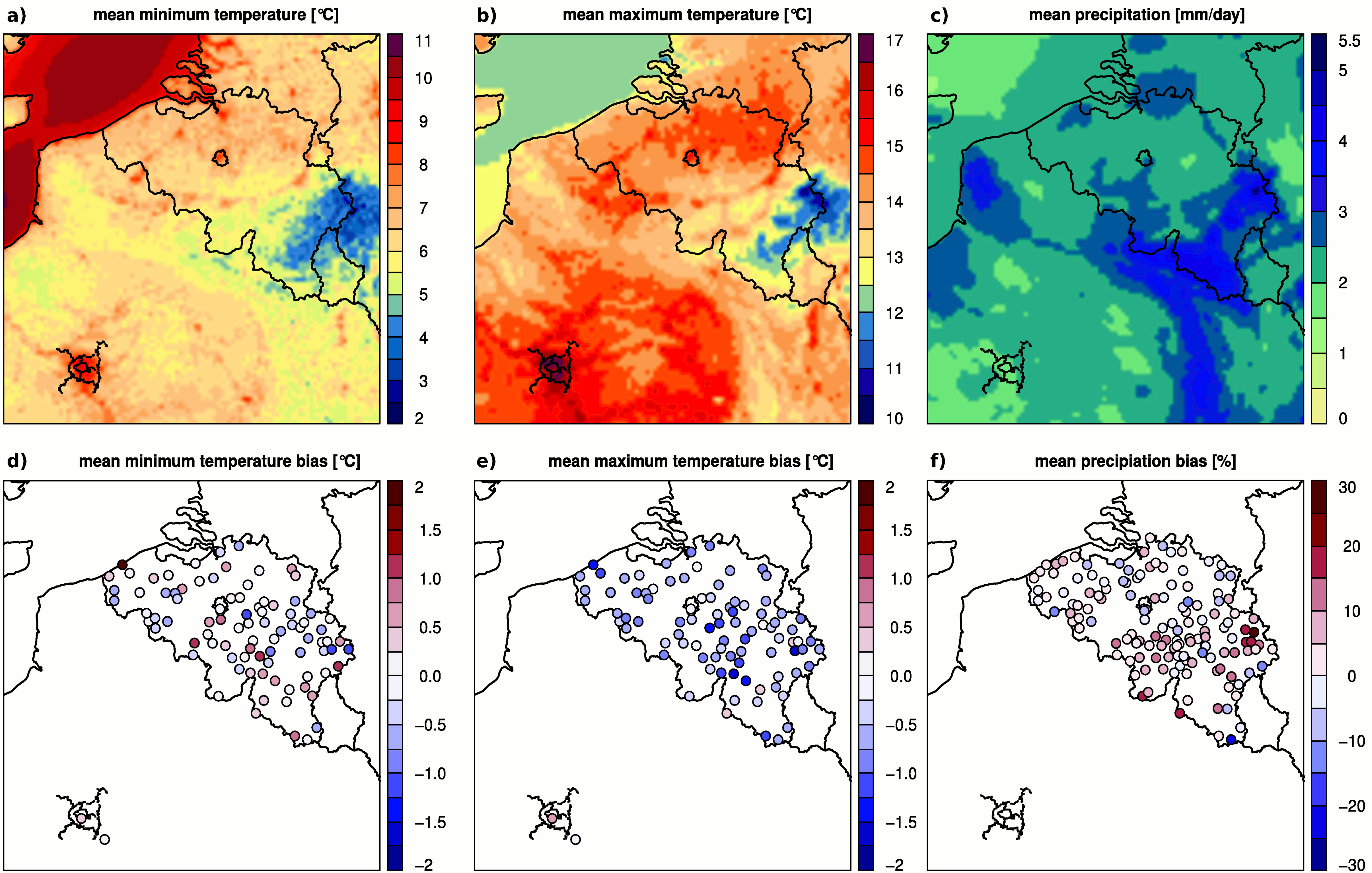


Table 1
Description of the numerical experiments.

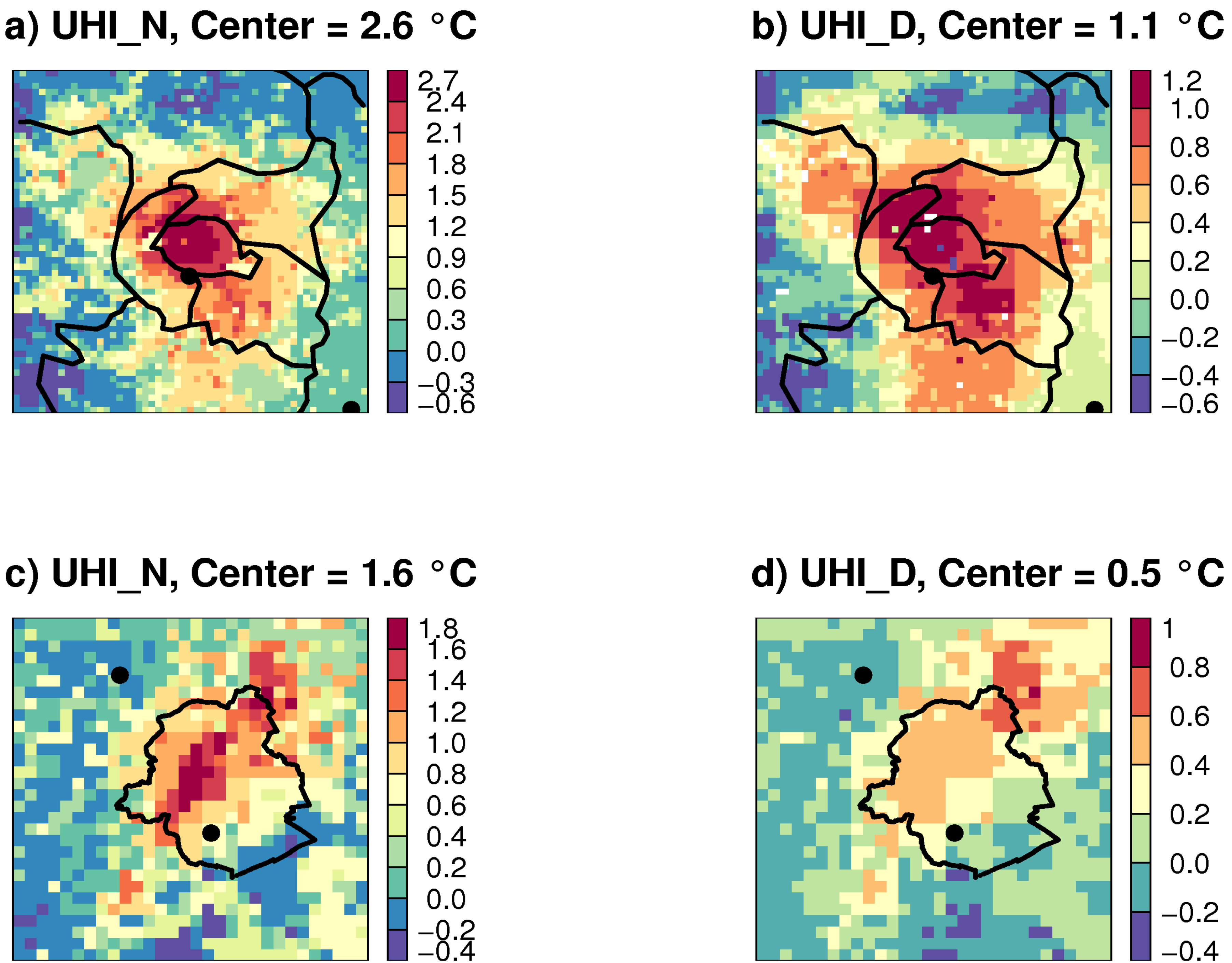
Acronym in the text	Coupling	Simulation period	Resolution (km)
Regional climate simulations			
ERA_4	ERA-INTERIM re-analysis	2001–2010	4
HIS_4	ARPEGE-Climate, hereafter CNRM-CM3	1990–1999	
FUT_4	ARPEGE-Climate, hereafter CNRM-CM3	2046–2055	
Urban climate simulations			
ERA_1	ERA_4	2001–2010	1
HIS_1	HIS_4	1990–1999	
FUT_1	FUT_4	2046–2055	

PRESENT CLIMATE

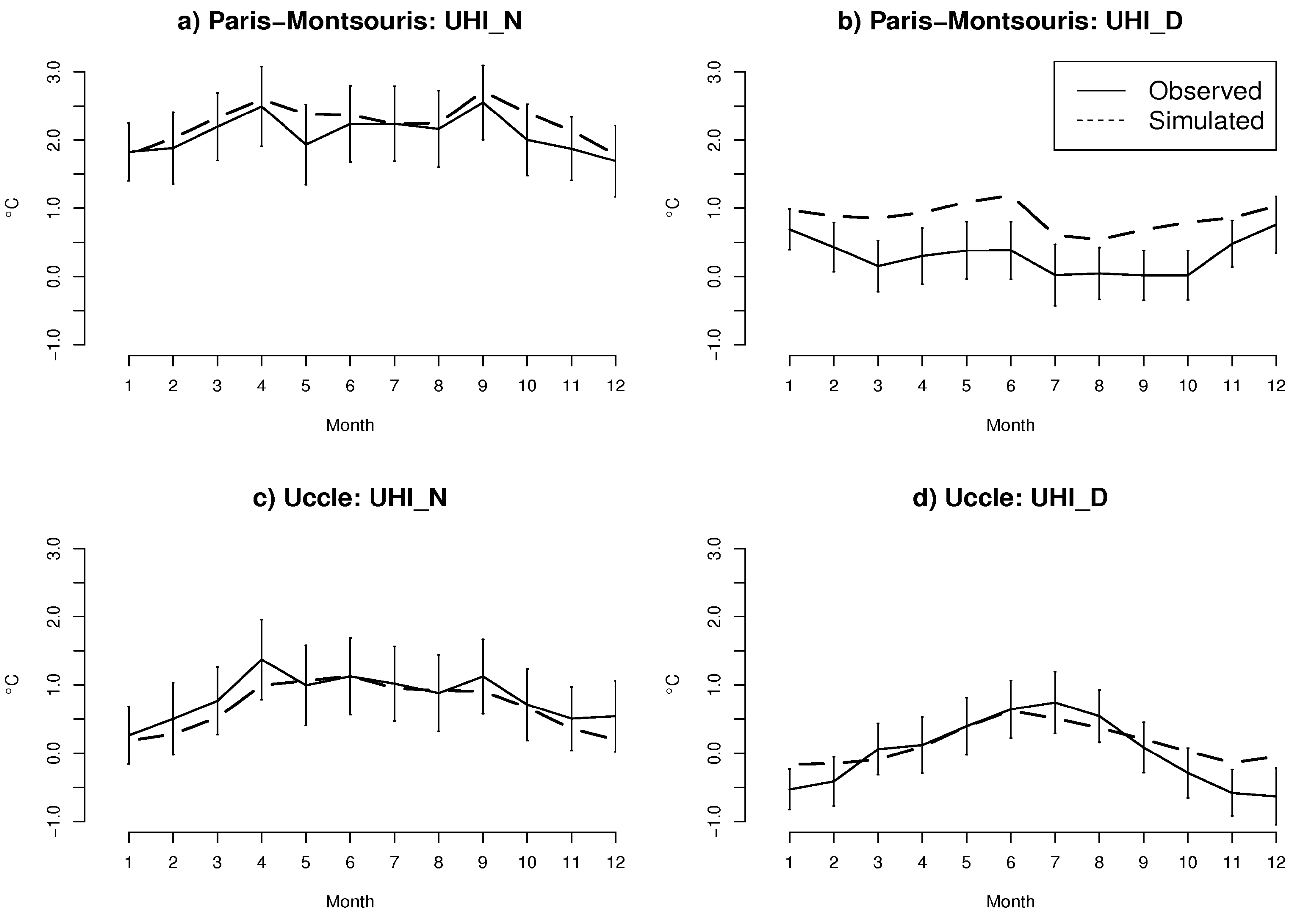
Era-interim 2001-2010 driven simulations



Era-interim 2001-2010 UHI simulations



Era-interim 2001-2010 UHI simulations



precipitation and cloud cover

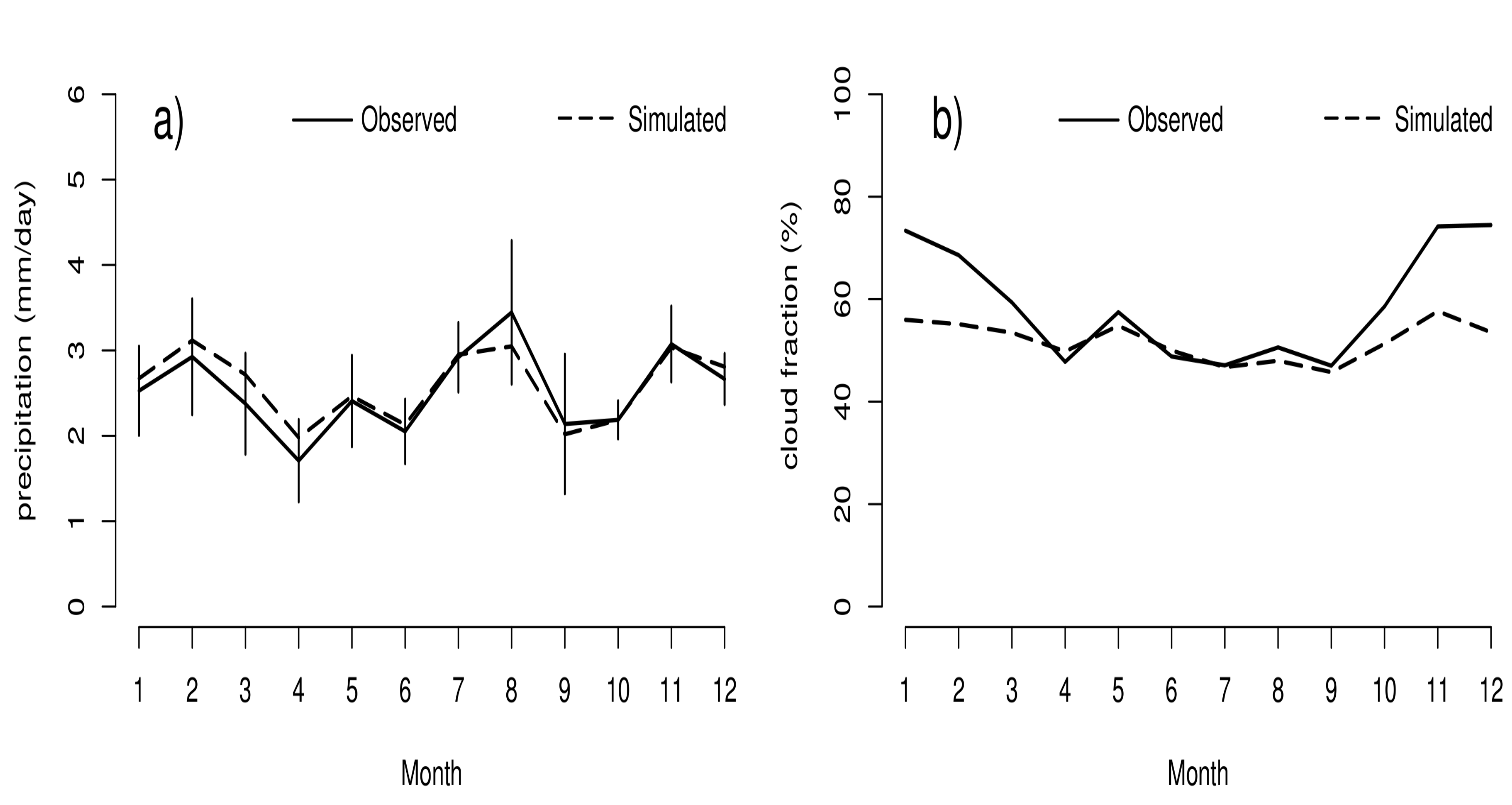


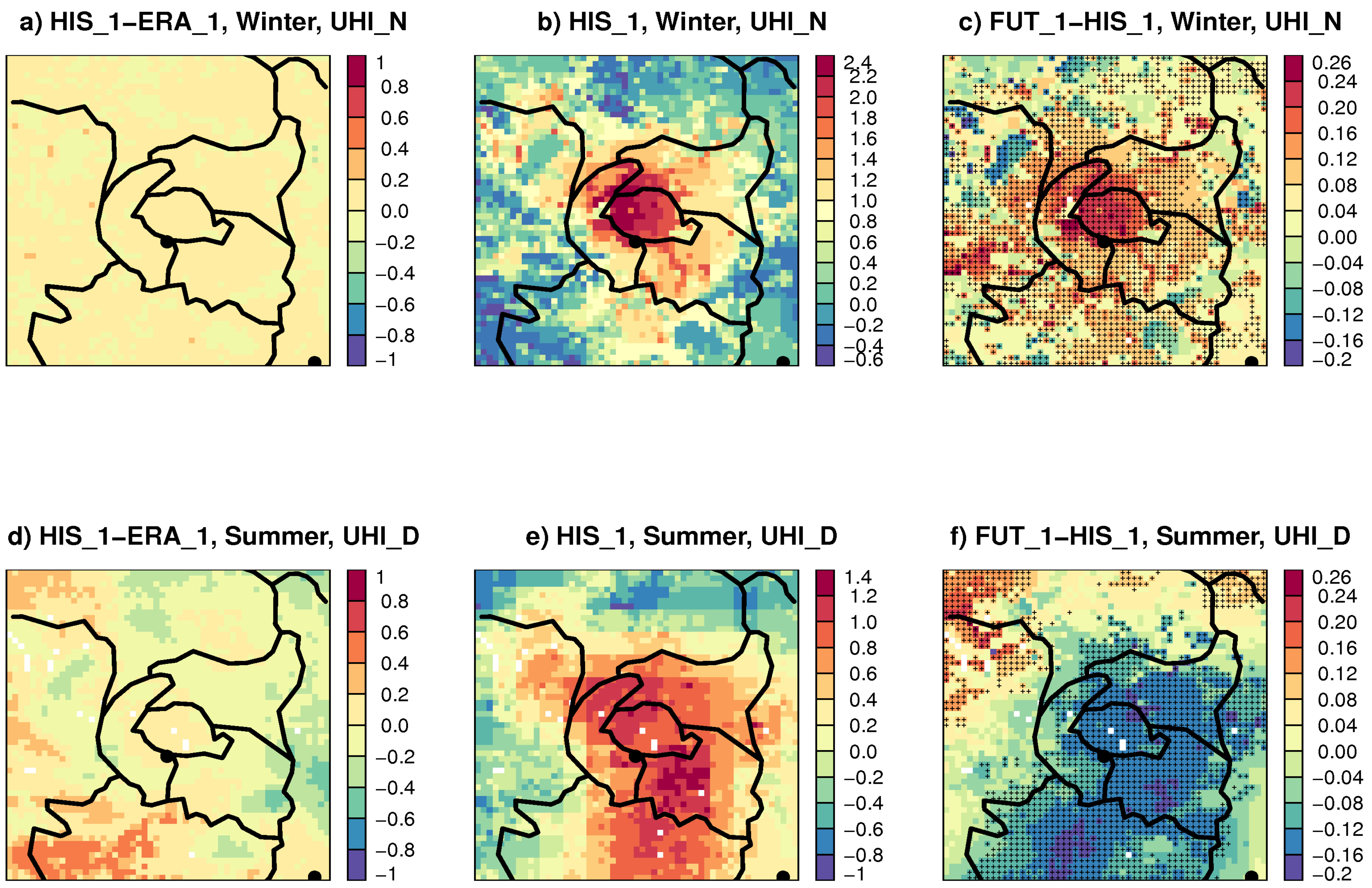
Table 2
The seasonal and annual mean temperature increase (FUT_1-HIS_1, in °C) for the 2050s horizon under the A1B emission scenario for the city center of Brussels, the rural (Brussegem) station, the city center of Paris and the rural (Melun) station.

	Urban center (°C)		Rural (°C)	
	BCR	GPR	BCR	GPR
Spring	1.8	2.0	1.7	1.9
Summer	1.6	2.0	1.6	2.2
Fall	1.8	1.9	1.8	1.9
Winter	1.1	1.2	0.9	1.1
Annual	1.6	1.8	1.5	1.8

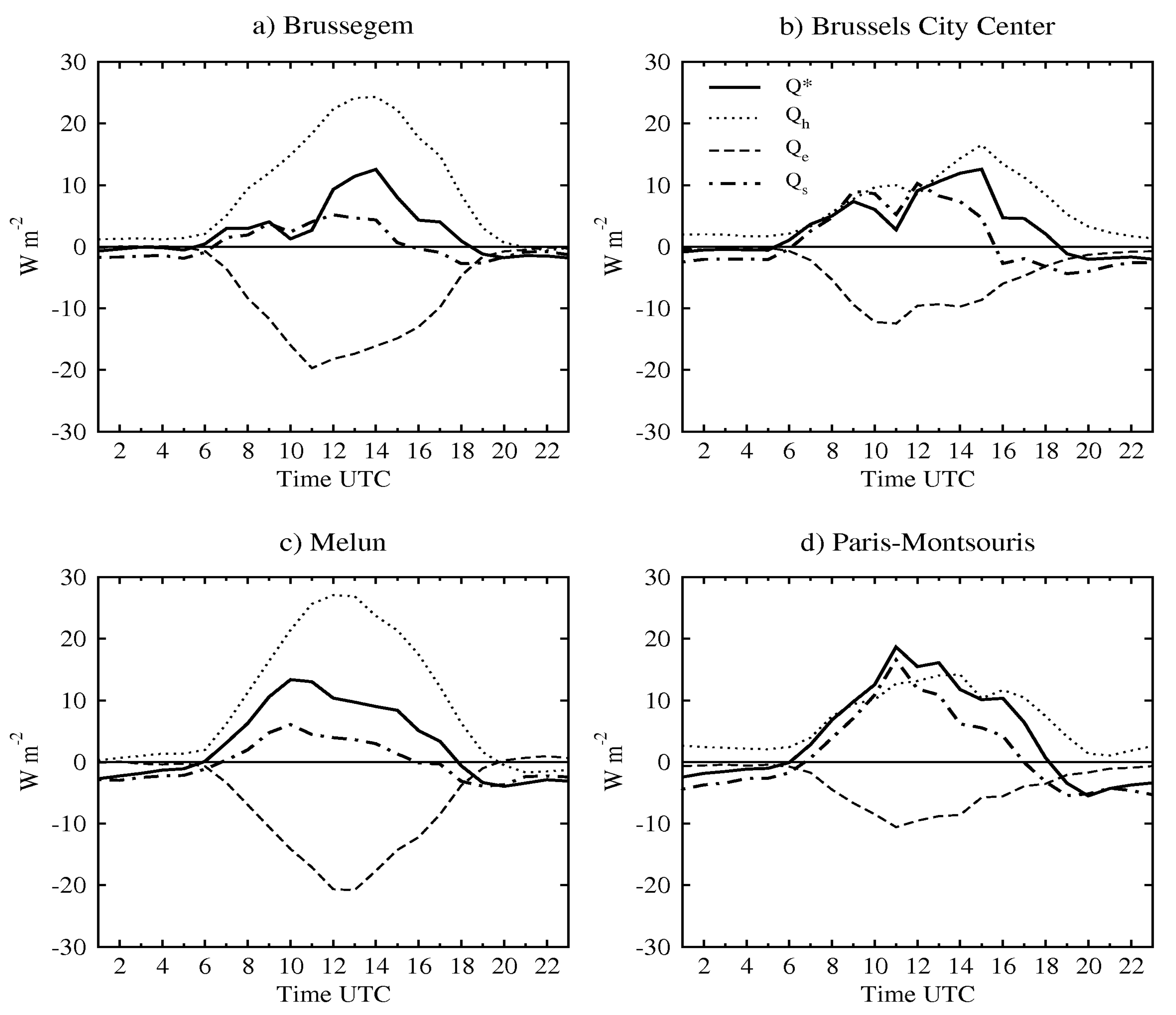
Table 3
The seasonal variation of the 10-year average nocturnal and daytime UHI (in °C) at the city center of Brussels and Paris calculated from: (i) ERA_1, (ii) HIS_1, and (iii) FUT_1 minus HIS_1. Significant results of the Student's *t*-test at the 95% confidence level are shown with *. Bold values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

	UHI_N (°C)			UHI_D (°C)		
	ERA_1	HIS_1	FUT_1-HIS_1	ERA_1	HIS_1	FUT_1-HIS_1
Paris city center						
Spring	2.8	2.8	0.13	1.2	1.6*	0.10*
Summer	2.7	2.7	–0.17*	1.1	1.1	–**0.14***
Fall	2.7	2.9*	0.12	1.2	1.2	–0.08*
Winter	2.2	2.2	**0.23***	1.2	1.4*	0.06*
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*

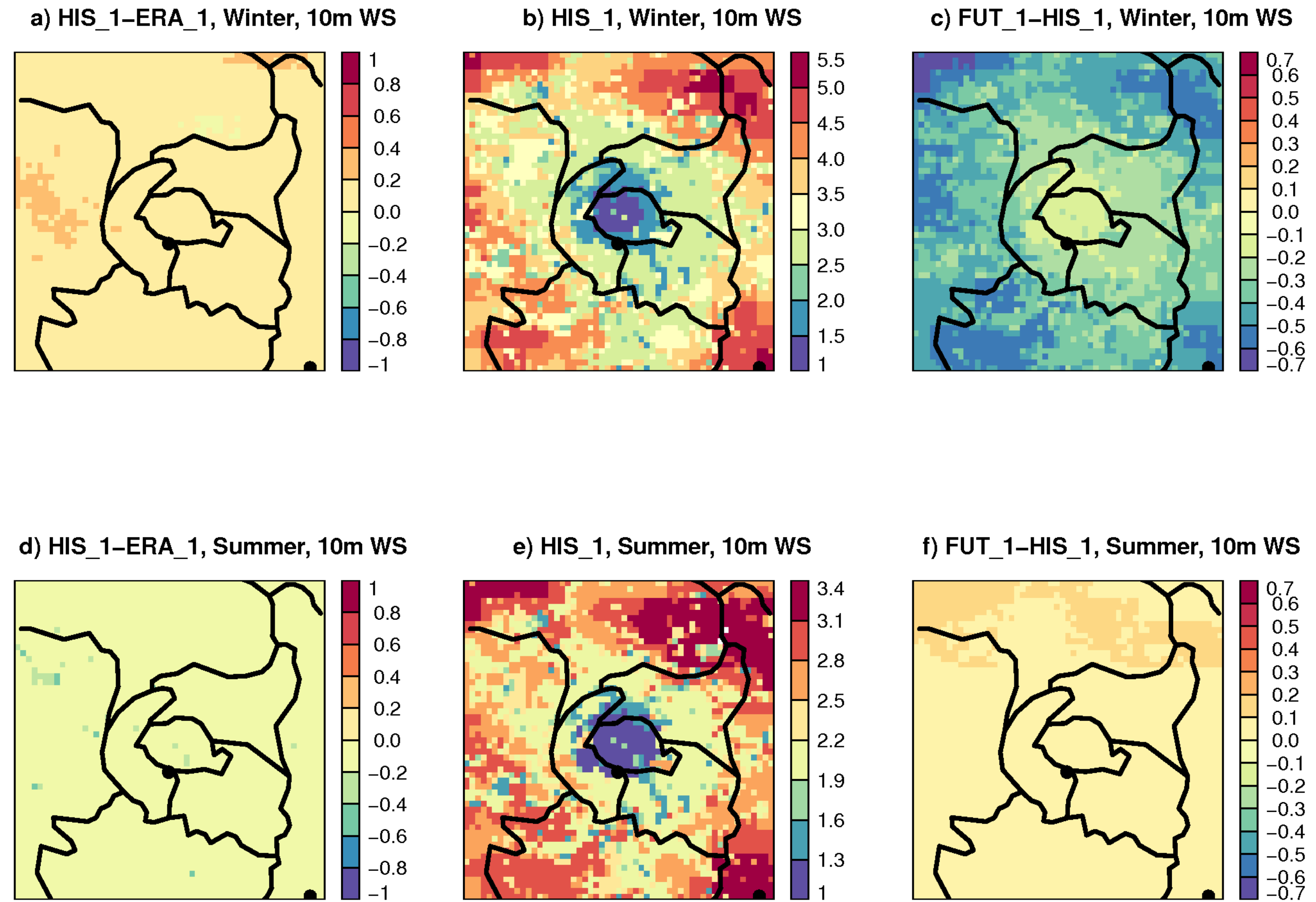
Evolution of the UHI of Paris



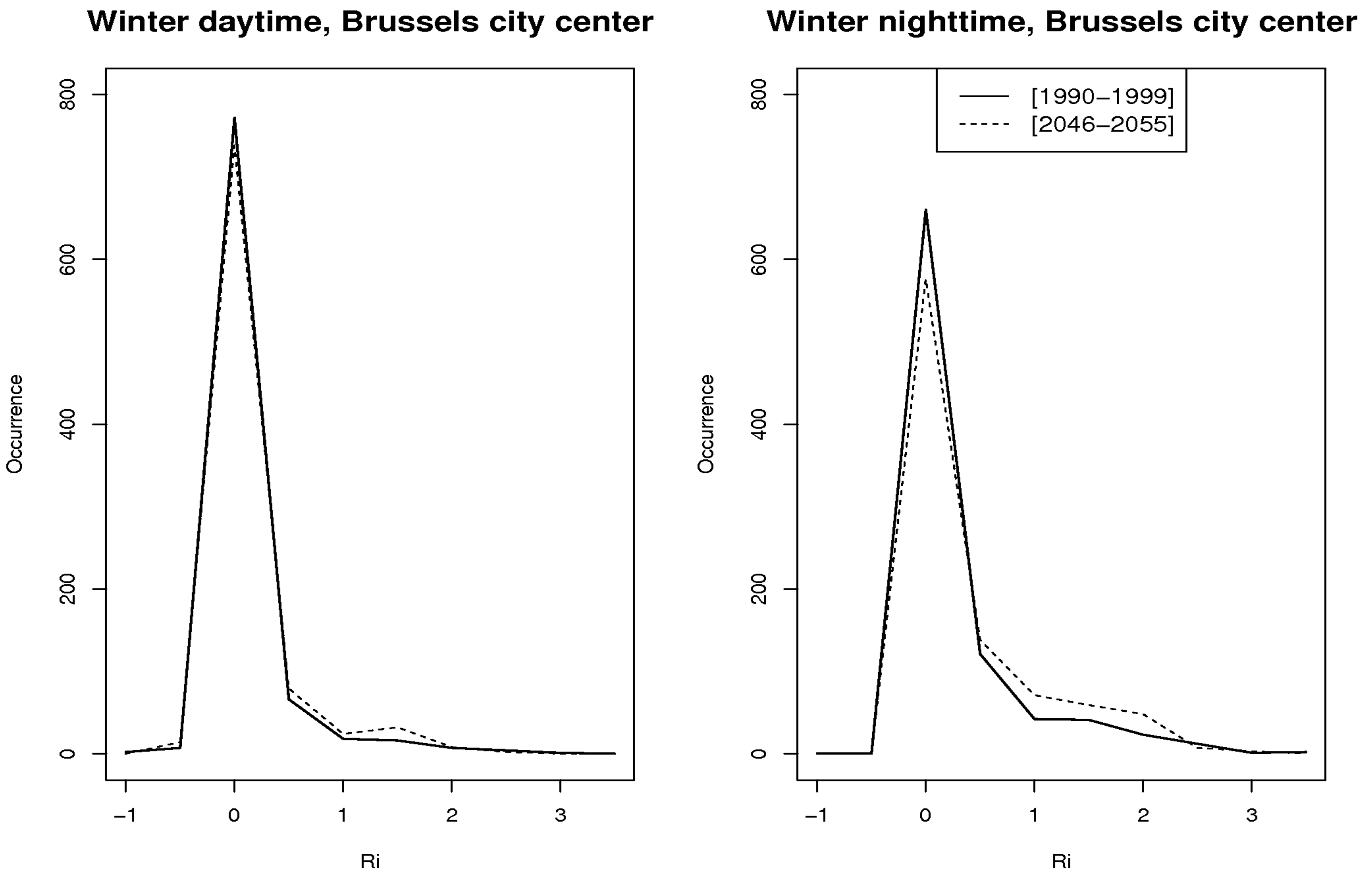
Evolution of the surface fluxes



Evolution of wind speed



Evolution of winter stable situations



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 (a decrease of of a few tens of degrees in the city center)

1. Significant changes of nocturnal (daytime) UHI are noted during winter (summer).

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

3. Increase in nocturnal UHI during winter is due to projected decrease of wind speed.

4. 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.

1. Future results for A1B scenario elucidates an increase in PM10 concentrations.

2. Evidence of the occurrence of more stable meteorological conditions during 2046-2055 scenario

FUTURE WORKS

1. Study the heat stress in Brussels during future heat wave period.

2. Study the effect of some mitigation options: vegetation, white roofs, green roofs, compact city or sprawl city.

3. Use scenario for the future urbanization of Brussels together with climate change.

4. Use of the latest scenarios from IPCC: RCPs

5. Different time periods: 2030s, 2050s, 2071-2100.

References:

1. Rafiq Hamdi, H. Van de Vyver, R. De Troch, P. Termonia. Assessment of three dynamical urban climate downscaling methods: Brussels's future urban heat island under an A1B emission scenario. *International journal of climatology*, Volume 34, Issue 4, March 2014, Pages: 978–999, DOI: 10.1002/joc.3734, 2014.

2. Rafiq Hamdi et al., 2015: Future climate of Brussels and Paris for the 2050s under the A1B scenario. Urban Climate, 12, 160–182. http://dx.doi.org/10.1016/j.uclim.2015.03.003