From regional scale to city scale

through calibration of dynamical downscaling simulations

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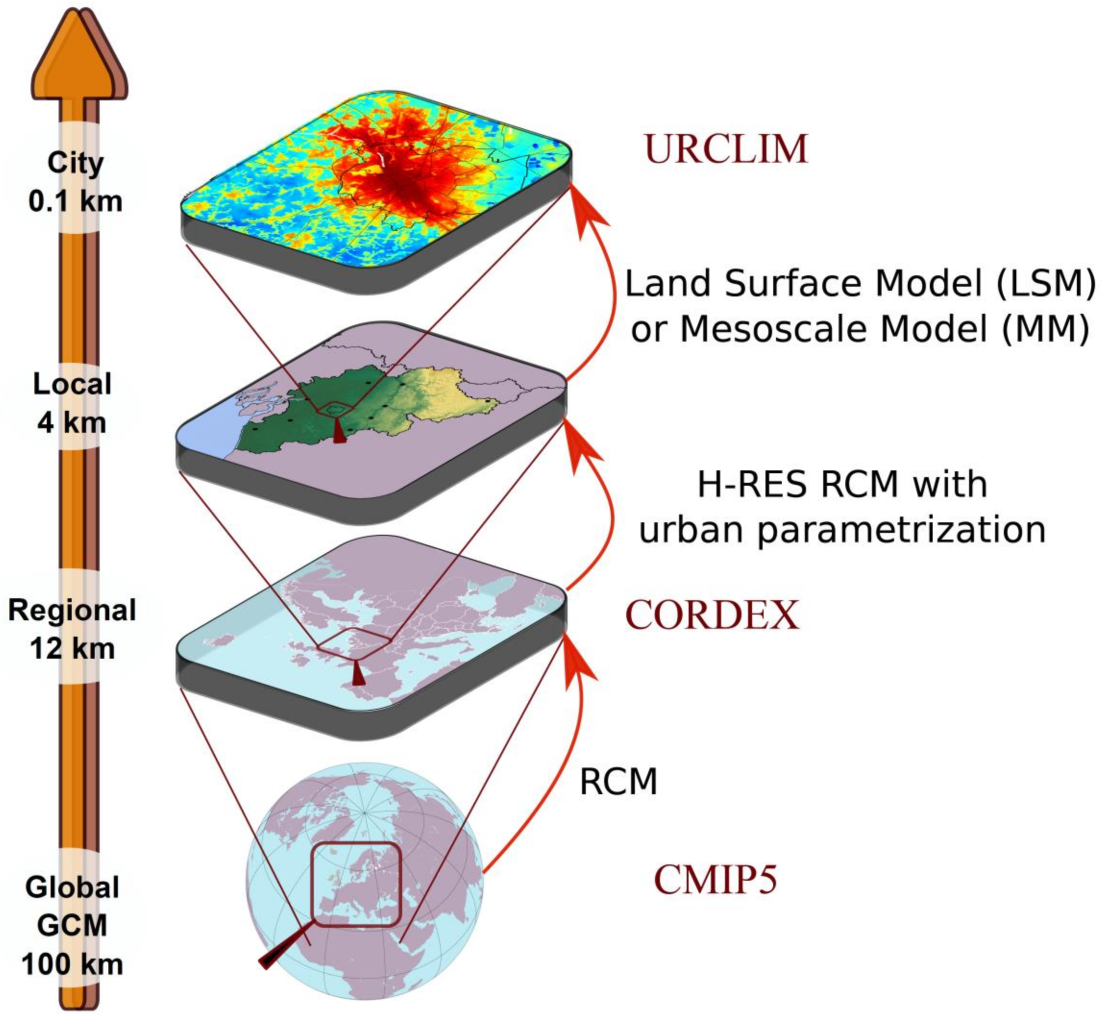
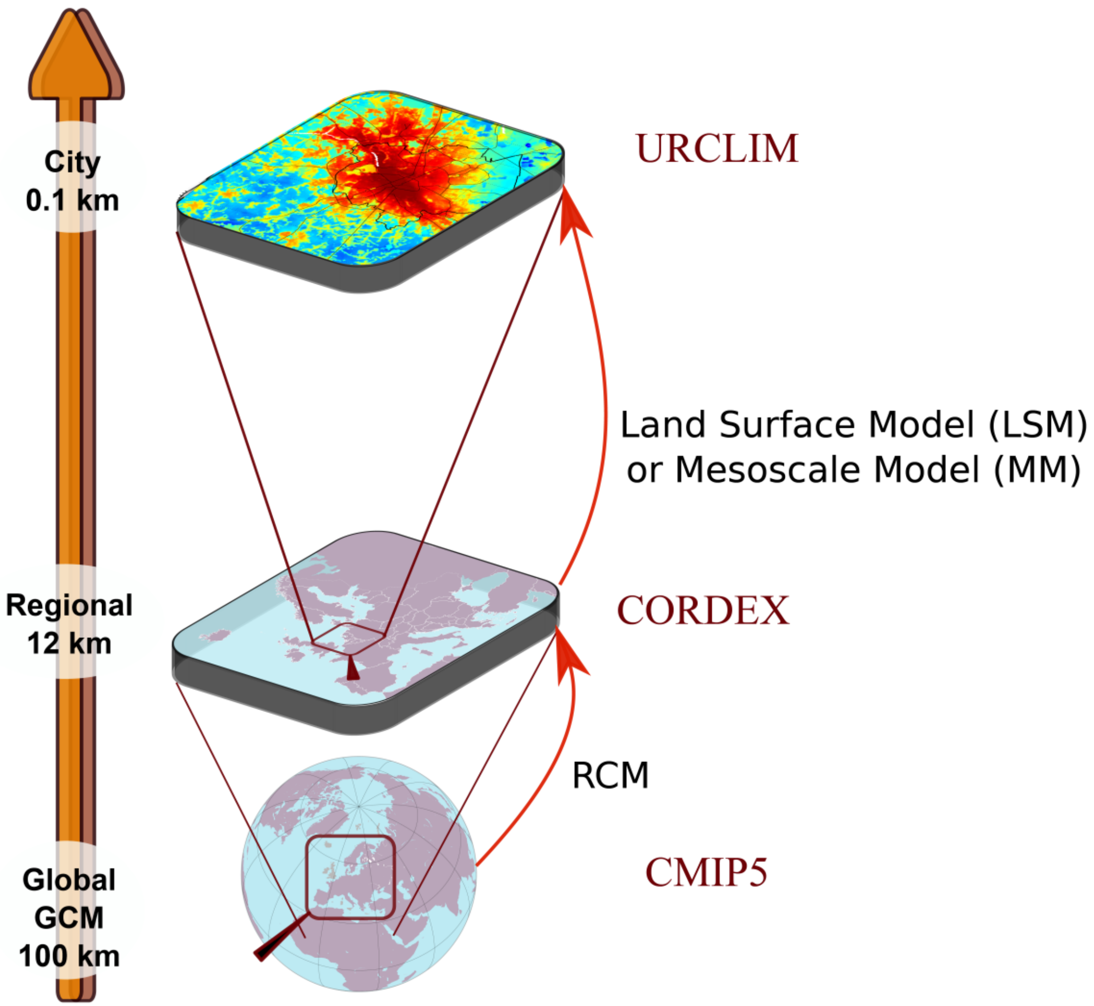
Project URCLIM is part of ERA4CS, an ERA-NET initiated by JPI Climate with co-funding of the European Union (Grant n° 690462)

Downscaling approach



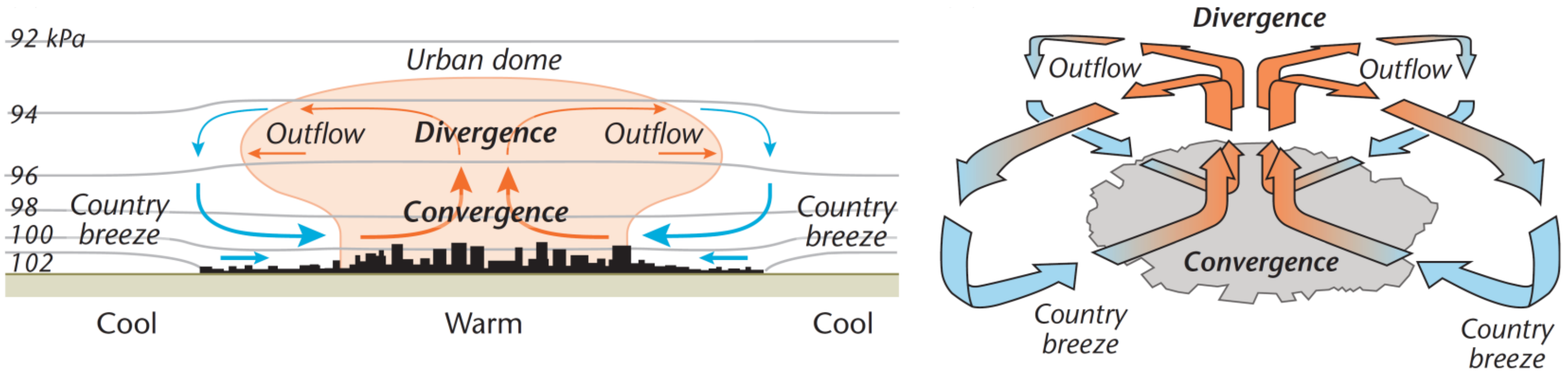
Full dynamical approach
RCM → H-RES UP → LSM/MM

Downscaling alternative: skip H-RES step

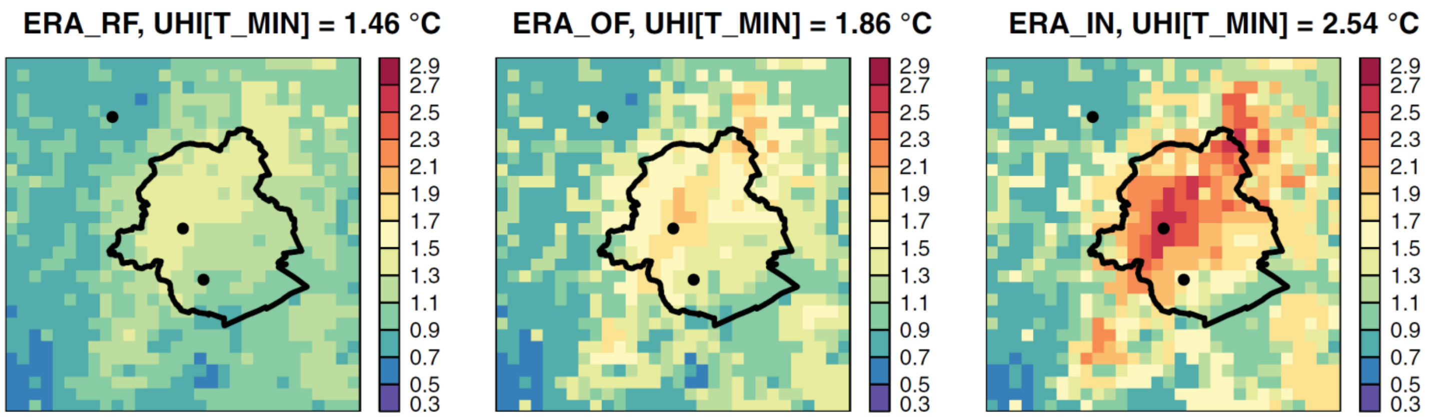


RCM → LSM/MM

City-atmosphere interaction



Oke et al. 2017



Hamdi et al. 2014

RCM → H-RES NO-UP → LSM NO-UP

RCM → H-RES NO-UP → LSM UP

RCM → H-RES UP → LSM UP

Downscaling pros and cons

Criteria that we want downscaling to satisfy:

1. Does it incorporate adequate city-atmosphere interactions?

2. Is output physically & spatio-temporally consistent.

   In other words: are the correlations among variables, trough time and space physically realistic?

3. Computationally manageable

   In other words: Can it integrate climate-long time series with multiple models & scenarios?

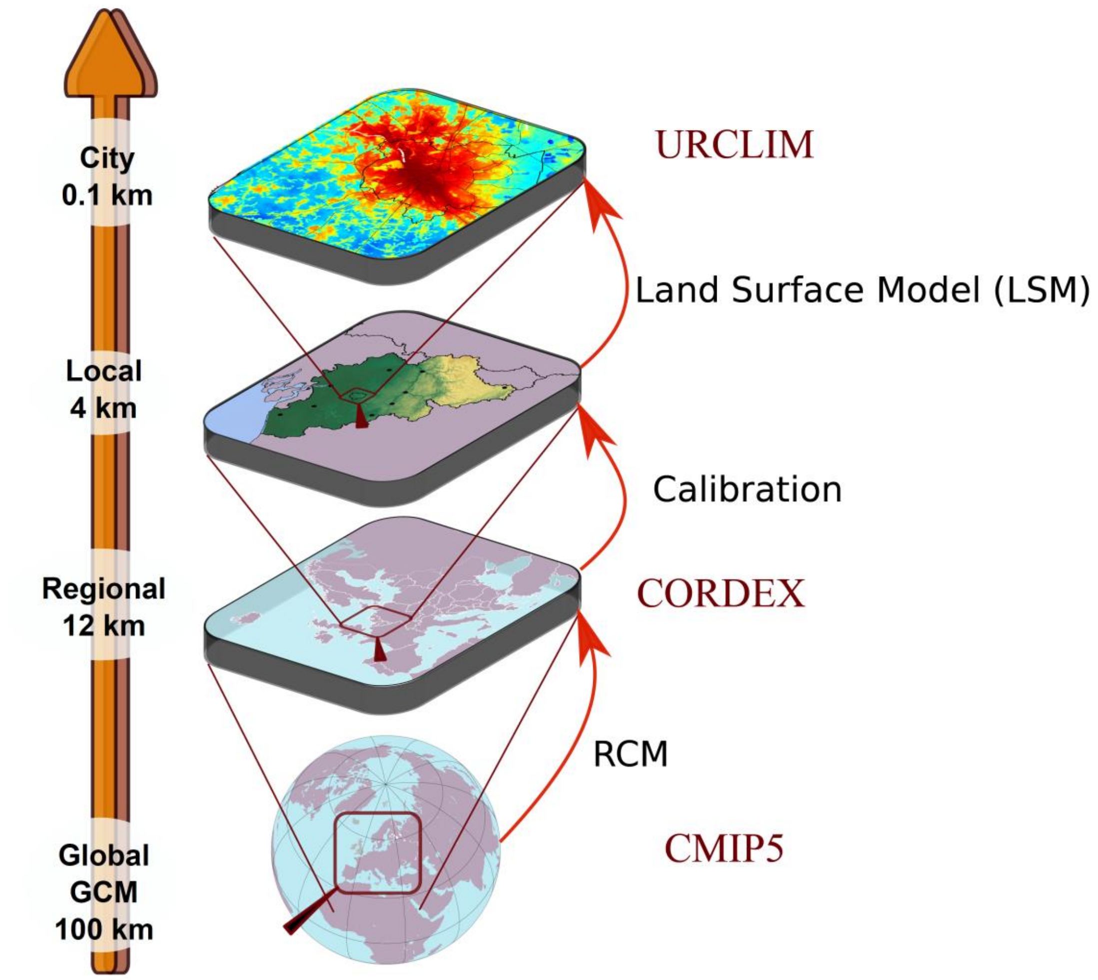
Summary state of the art

	Dynamical		
	RCM → H-RES UP → LSM	RCM → H-RES NO-UP → LSM	RCM → LSM
Adequate city-atmosphere interactions	✓	✗	✗
Output physically & spatio-temporally consistent	✓	✓	✓
Computationally manageable	✗	✗	✓

Summary state of the art

	Dynamical					
	RCM → H-RES UP → LSM	RCM → H-RES NO-UP → LSM	RCM → LSM	Statistical Downscaling	Dynamical-statistical Downscaling (SDD)	New SDD RCM → calibration → LSM
Adequate city-atmosphere interactions	✓	✗	✗	✗	✓	✓
Output physically & spatio-temporally consistent	✓	✓	✓	✗	✗	✓
Computationally manageable	✗	✗	✓	✓	✓	✓

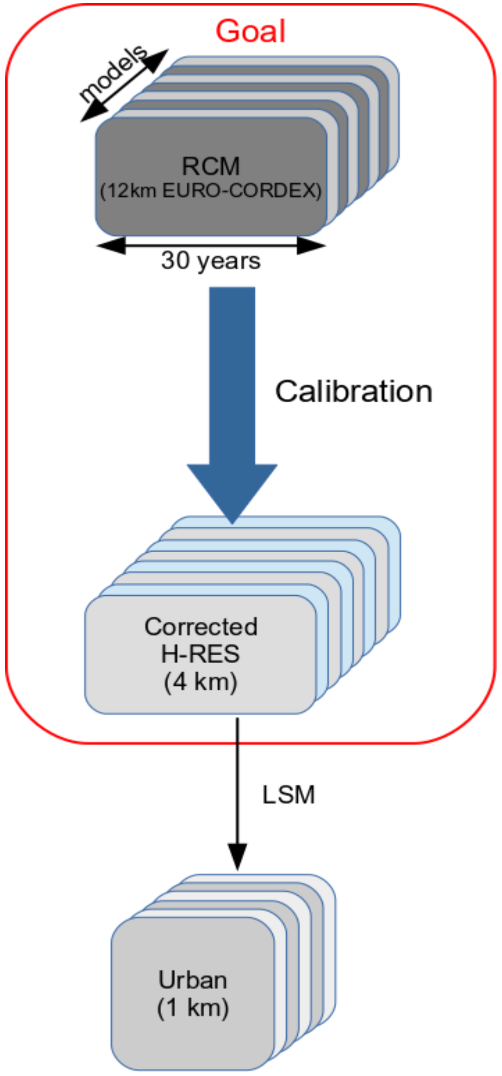
New dynamical-statistical approach



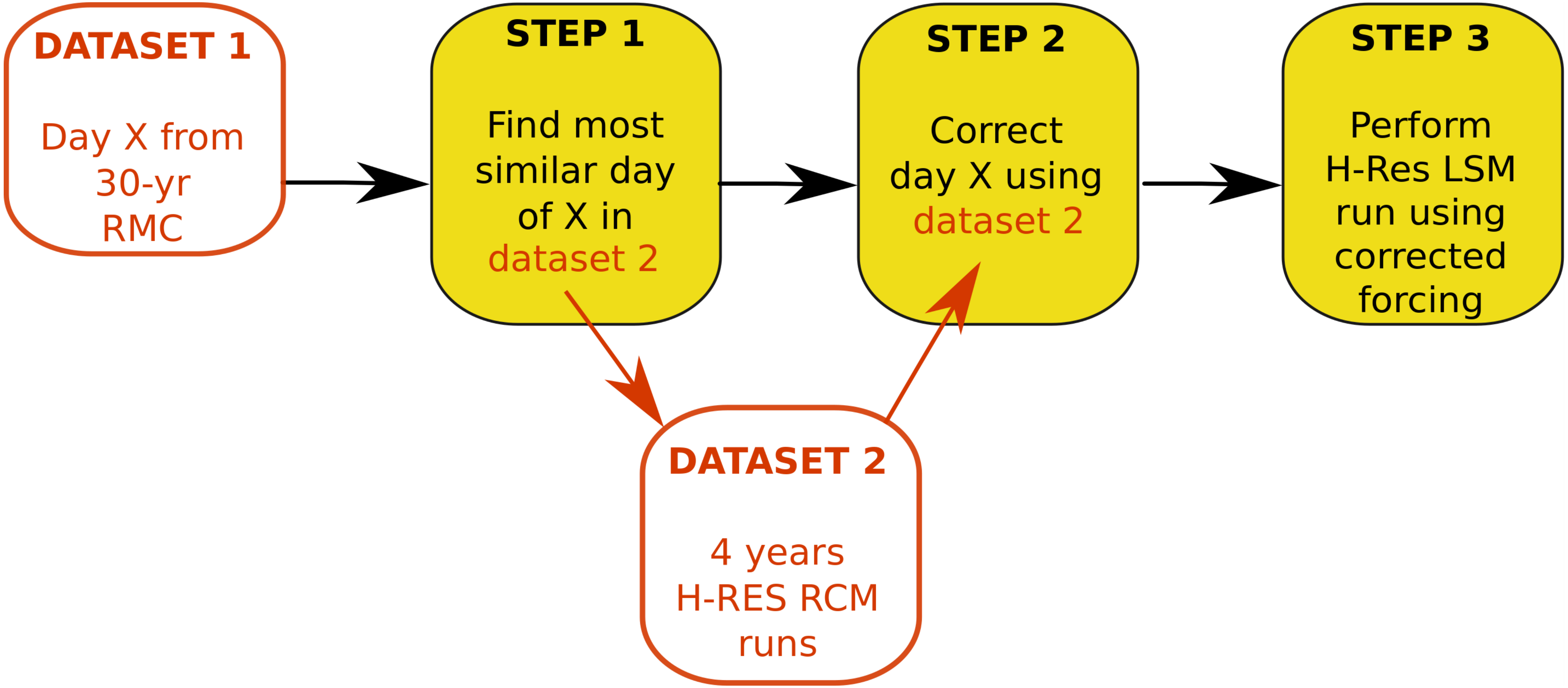
RCM → calibration → LSM

Goal & method

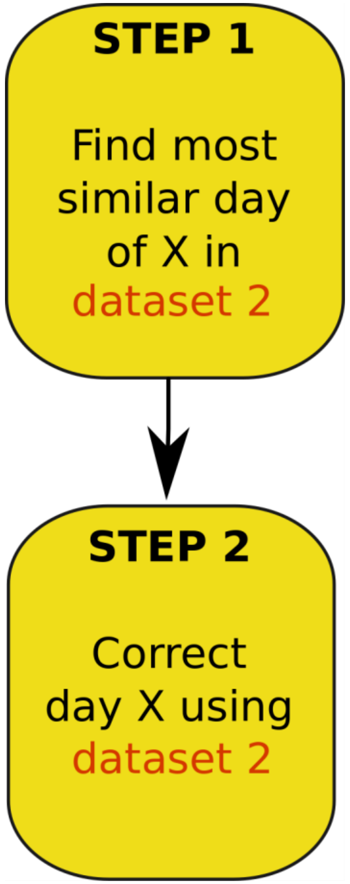
- Developing statistical method to calibrate the RCM data before use as LSM forcing data
- Should reproduce results of the “full dynamical approach”.
- Calibration such that city-atmosphere interaction is included (so taken from H-RES UP runs)
- Output is physically & spatio-temporally consistent after run of LSM

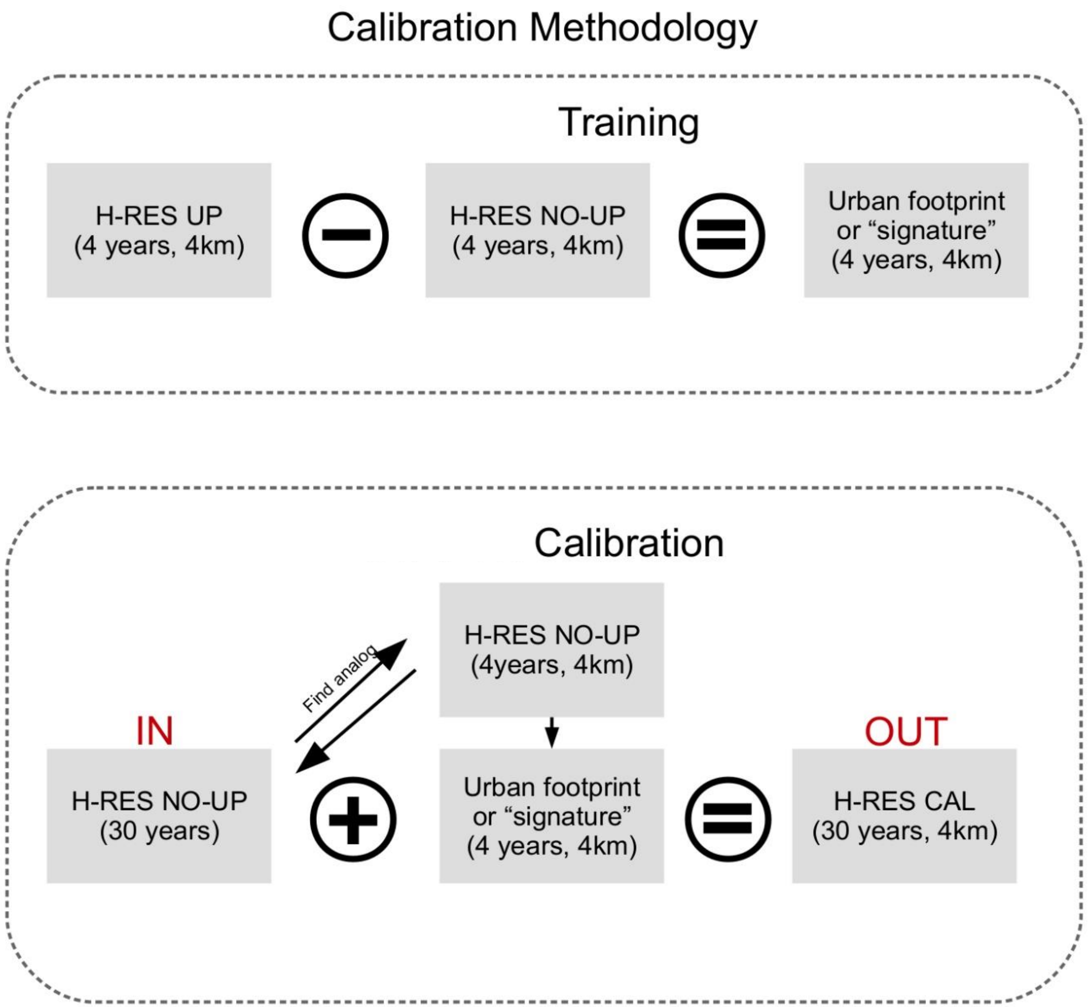


Calibration of uncoupled run



Step 1 of correction method

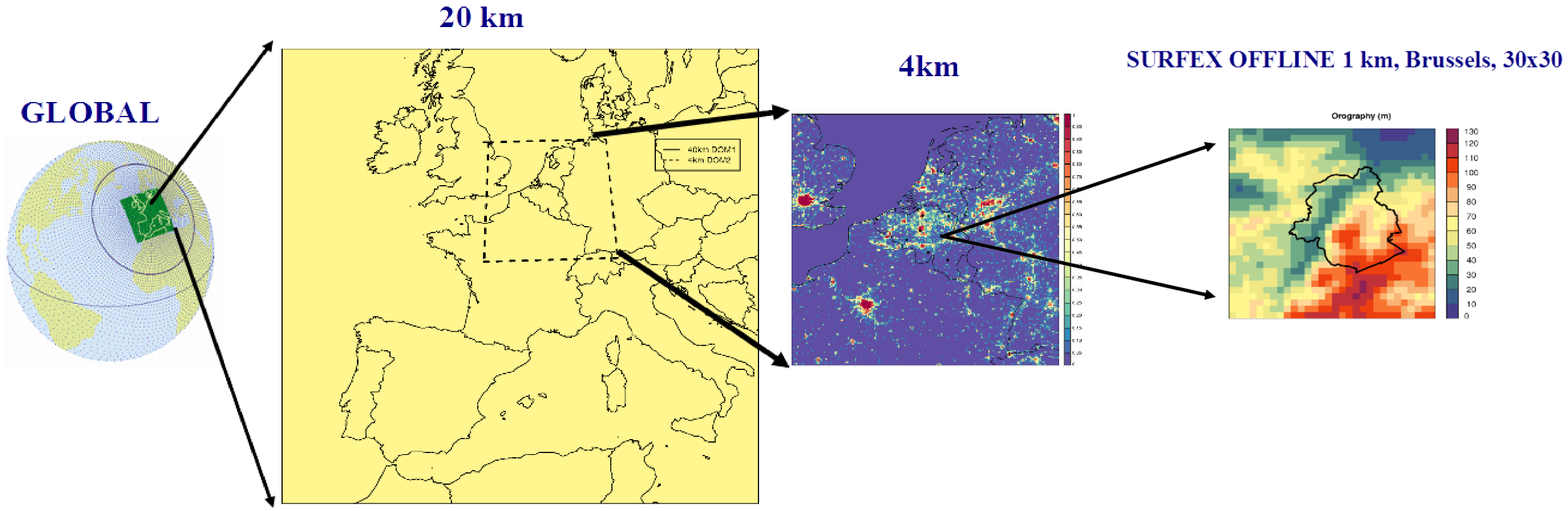




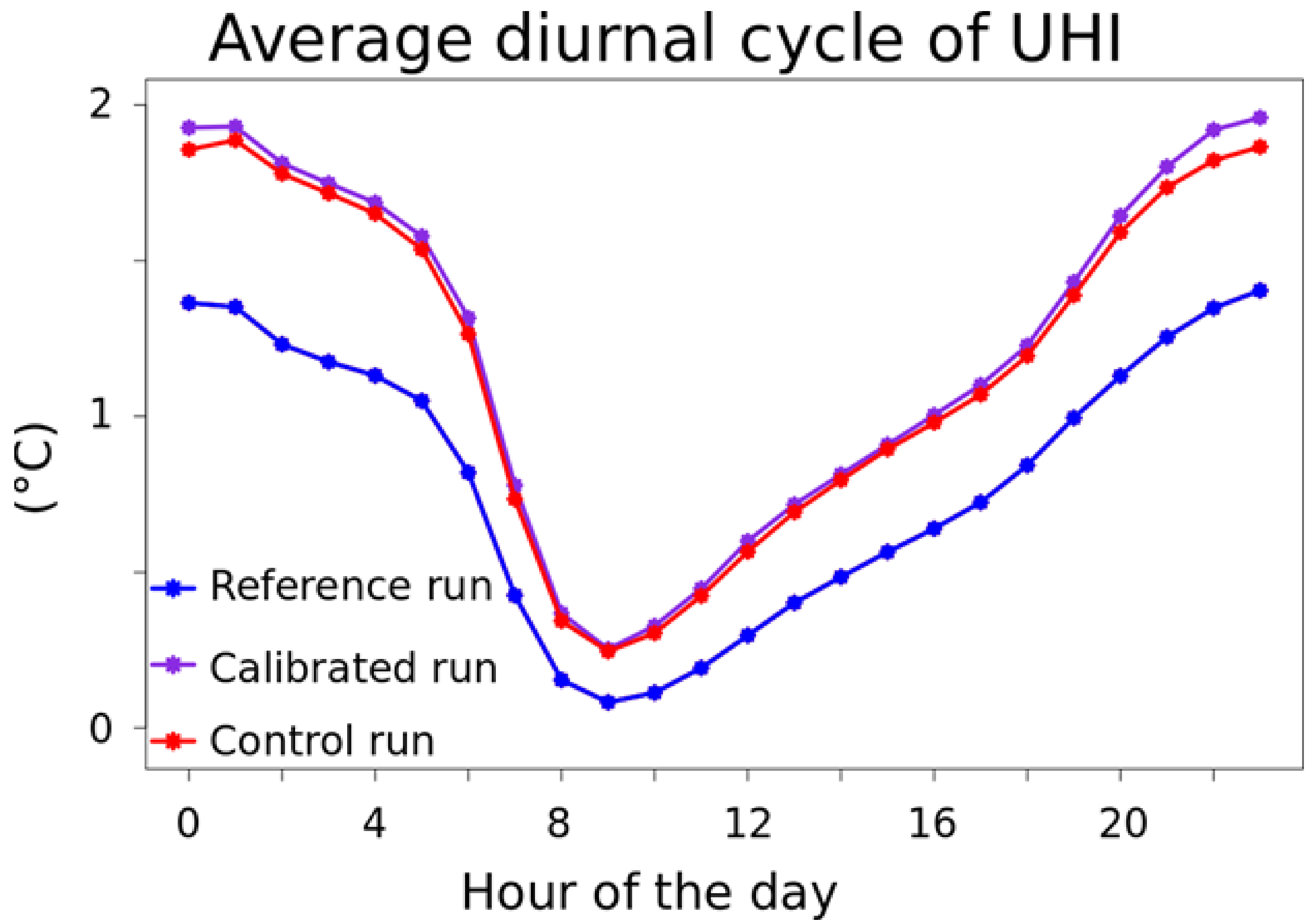
Downscaling Setup for Brussels

- Set-up for Brussels: 30-yr runs, ERA-driven with and without Town Energy Balance (TEB). RCM: ALADINcy36, LSM: SURFEXv6 (Hamdi et al, 2012, Masson, 2000)

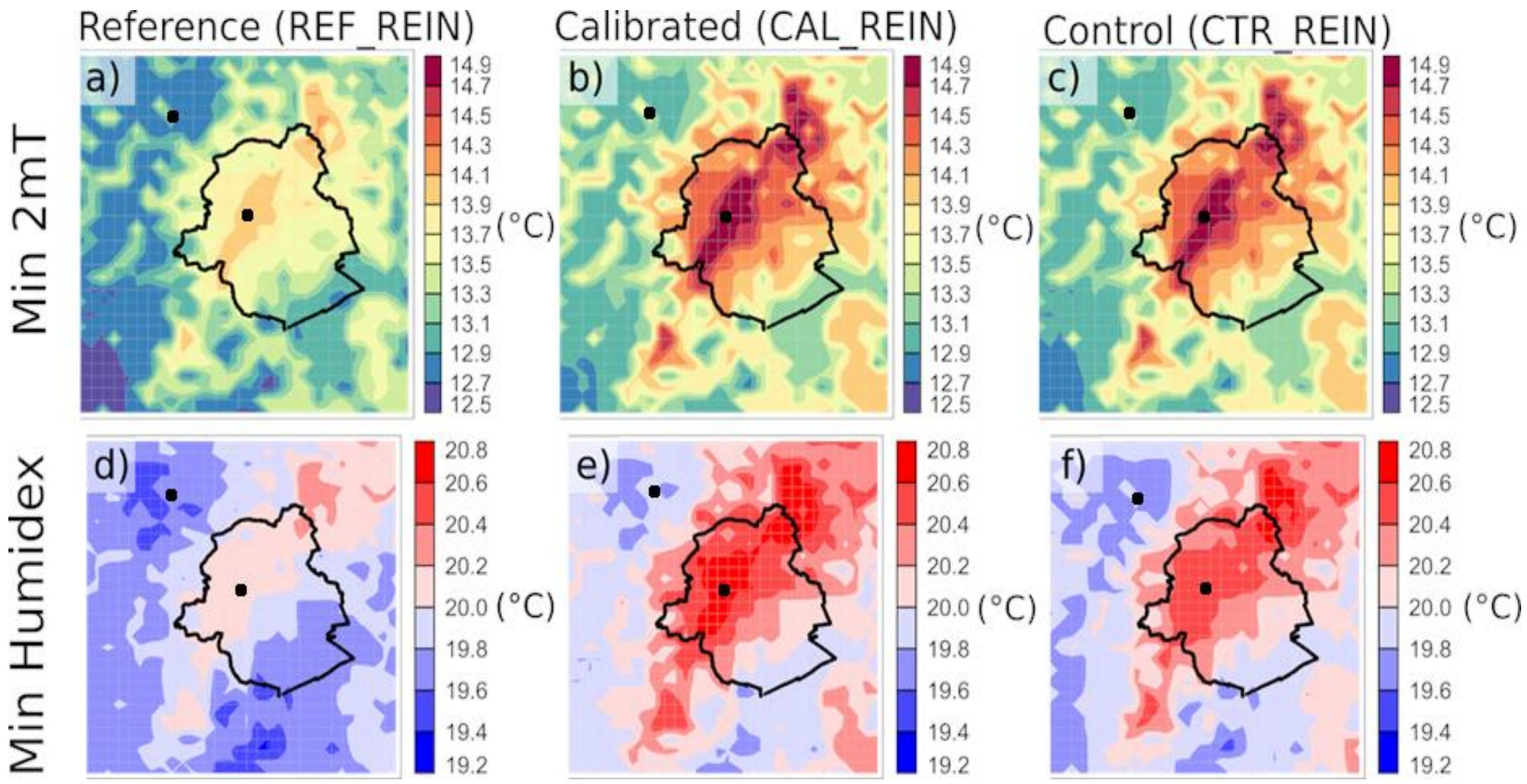
Regional climate simulations using ALARO+SURFEX+TEB



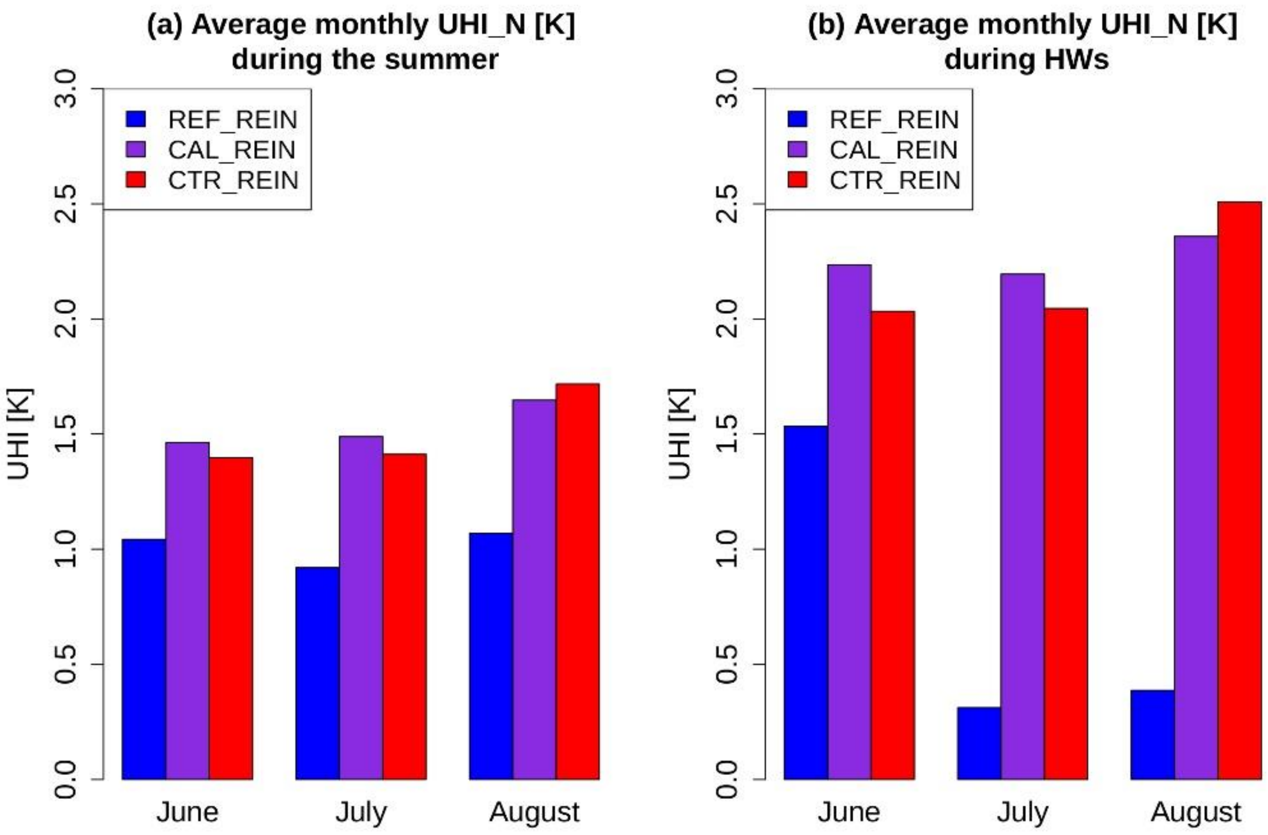
Results: diurnal cycle correction



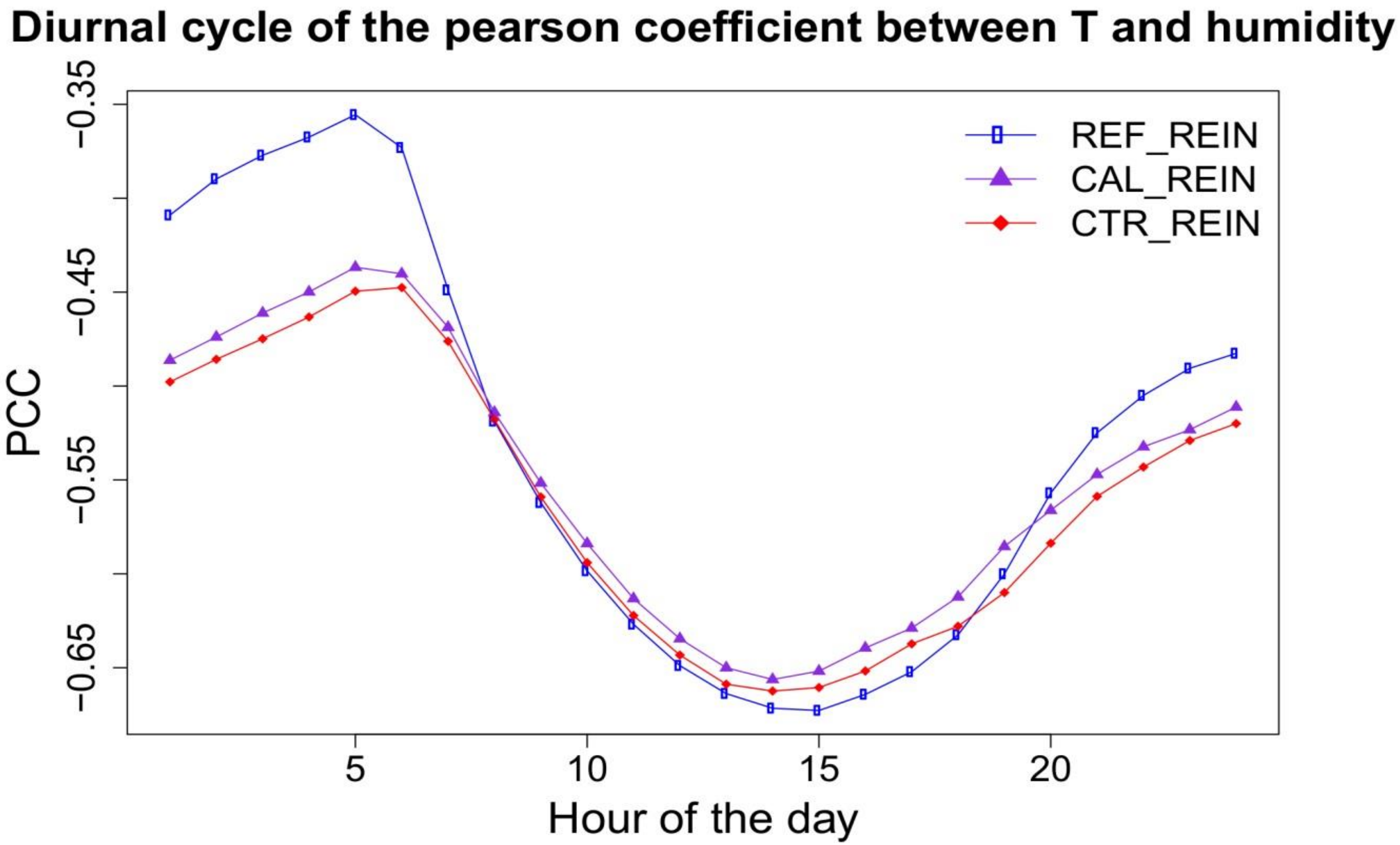
Results: diurnal cycle calibration



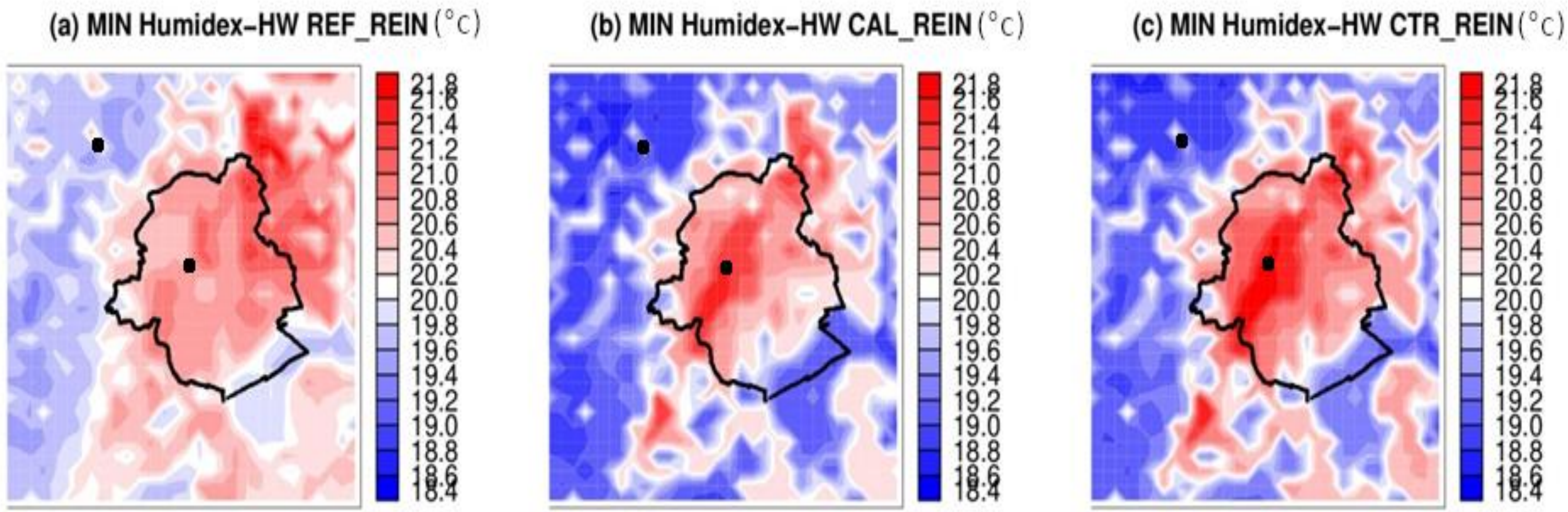
Calibration of heat waves



Calibration of temperature-humidity correlation



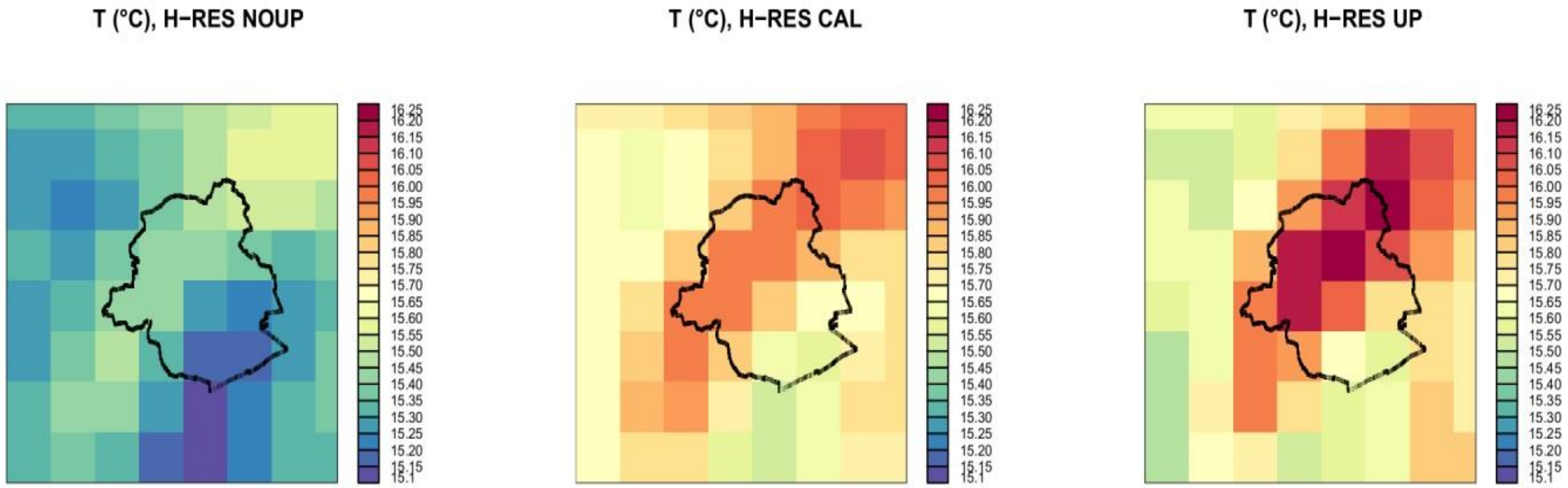
Humidex


(a) MIN Humidex-HW REF_REIN (°C)
(b) MIN Humidex-HW CAL_REIN (°C)
(c) MIN Humidex-HW CTR_REIN (°C)
21.8
21.6
21.4
21.2
21.0
20.8
20.6
20.4
20.2
20.0
19.8
19.6
19.4
19.2
19.0
18.8
18.6
18.4

Conclusions

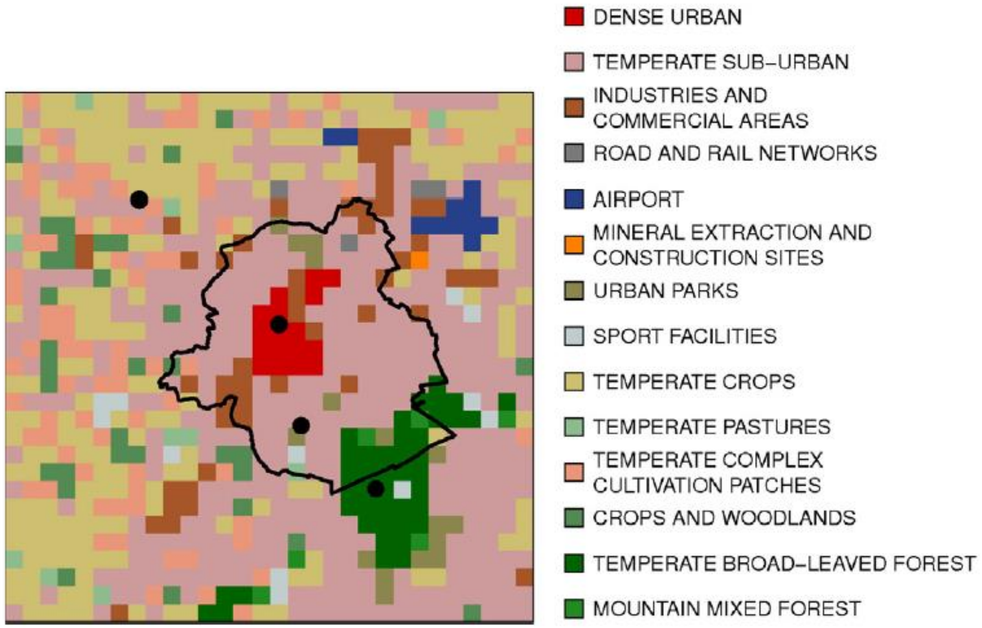
- New statistical-dynamical downscaling approach that
  - Is computationally cheap
  - Incorporates the mesoscale urban-atmosphere feedback on the mesoscale climate
  - Can be applied using RCM models with the aim of sampling uncertainty at city scale
- Future investigations:
  - Apply on EURO-CORDEX projections

Urban signature



Land use over Brussels

- ECOCLIMAP, dominant urban classes over Brussels



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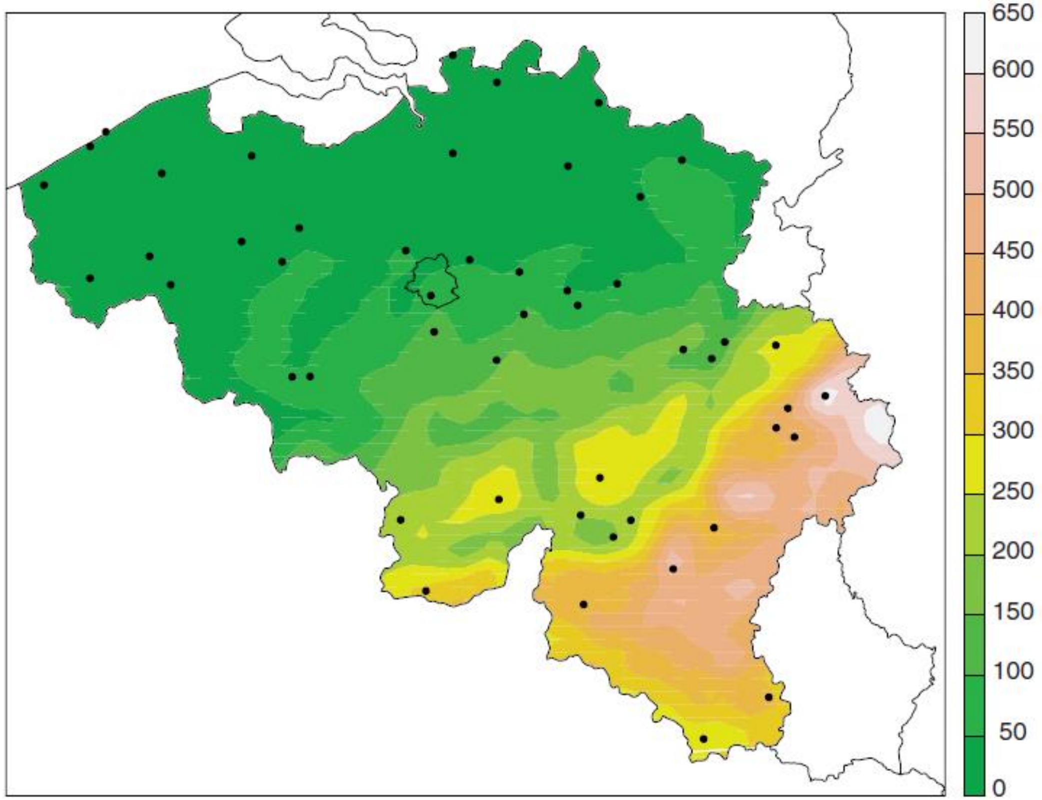
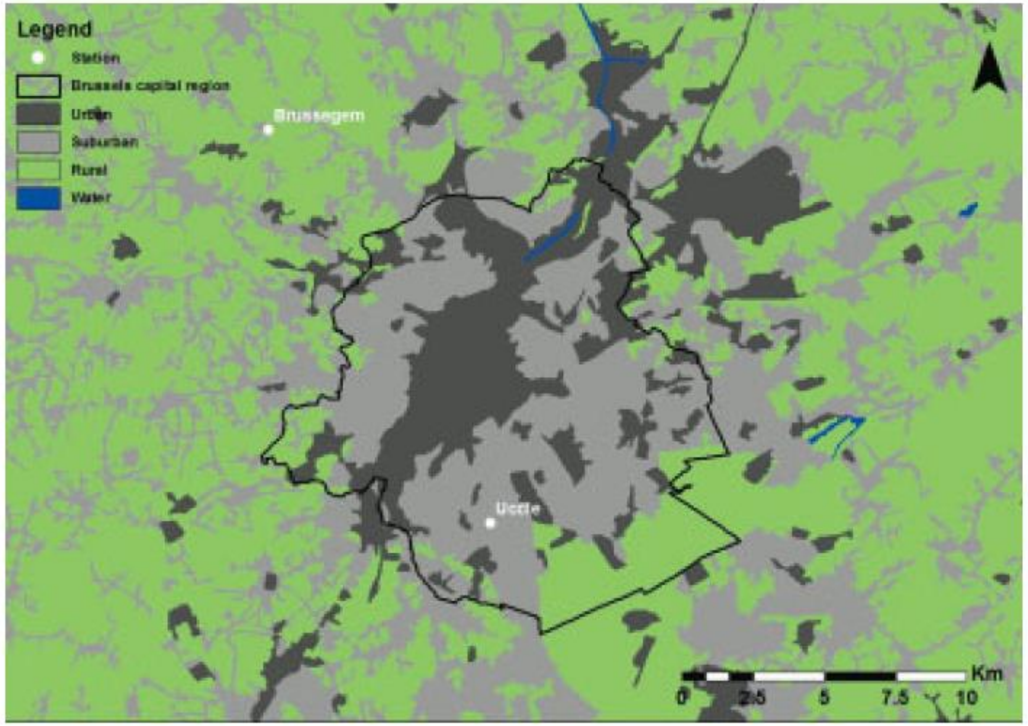
Orography and land use over Brussels





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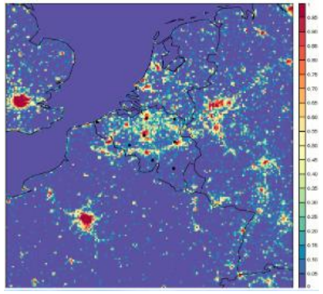
WP3: Downscaling methods & uncertainties

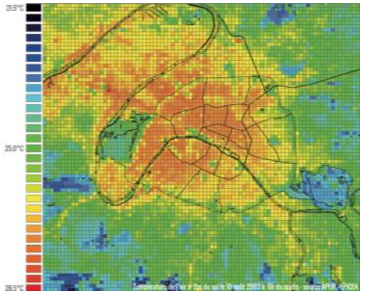
2) Downscaling methods from regional climate models to urban scales & uncertainties

20km



?

4km

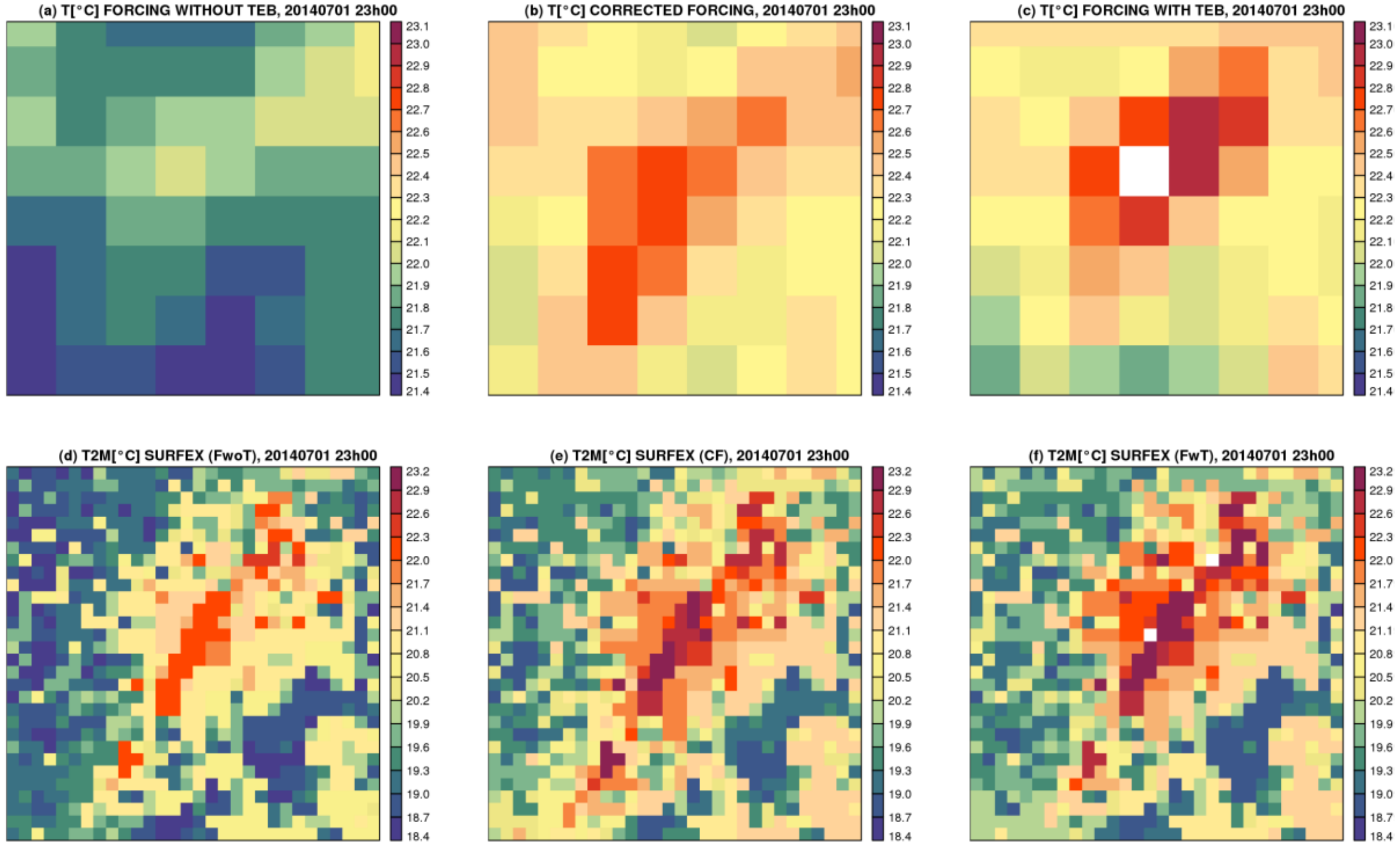


1km

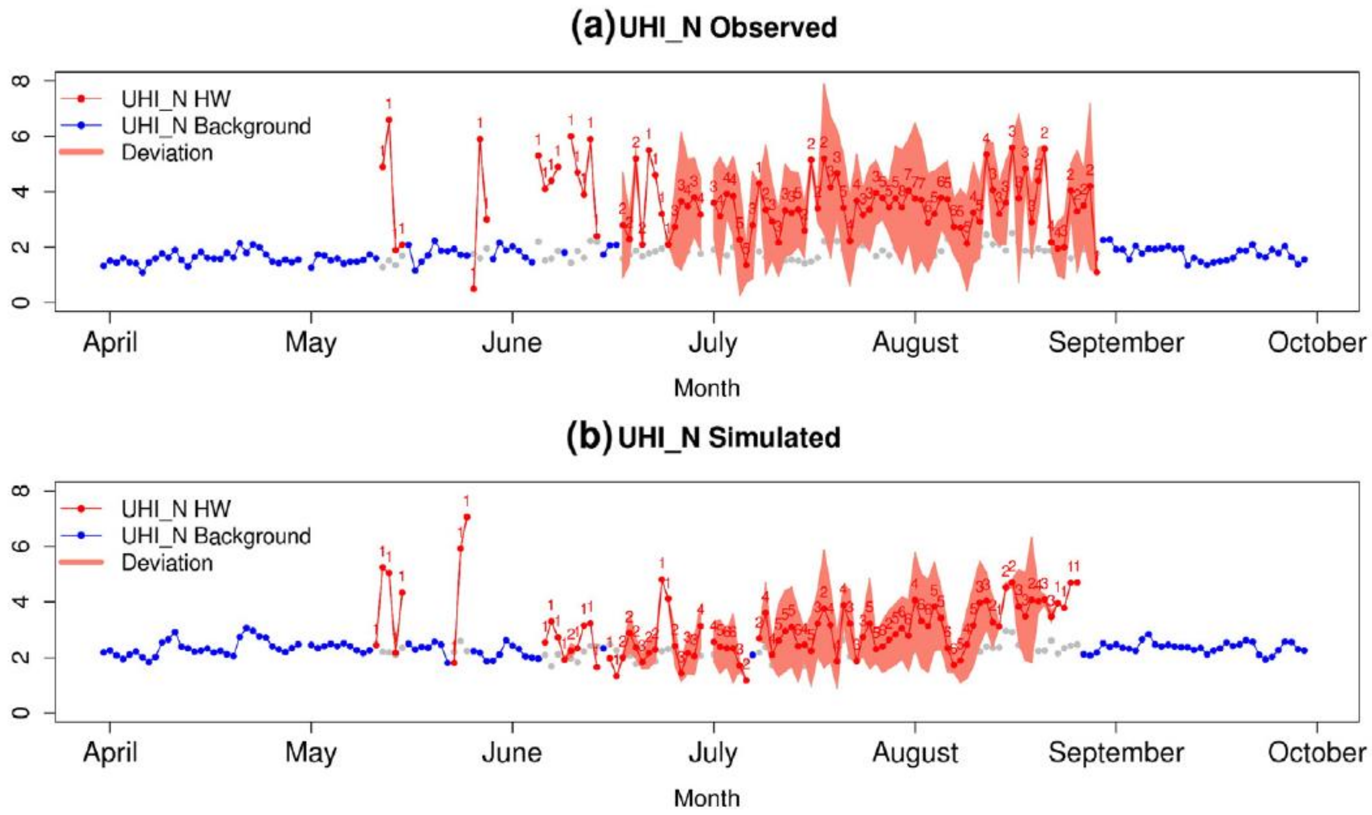
?

- Urban Heat Island
- Precipitations extremes
- Snow and ice for road
- Air Quality
- Economic impacts

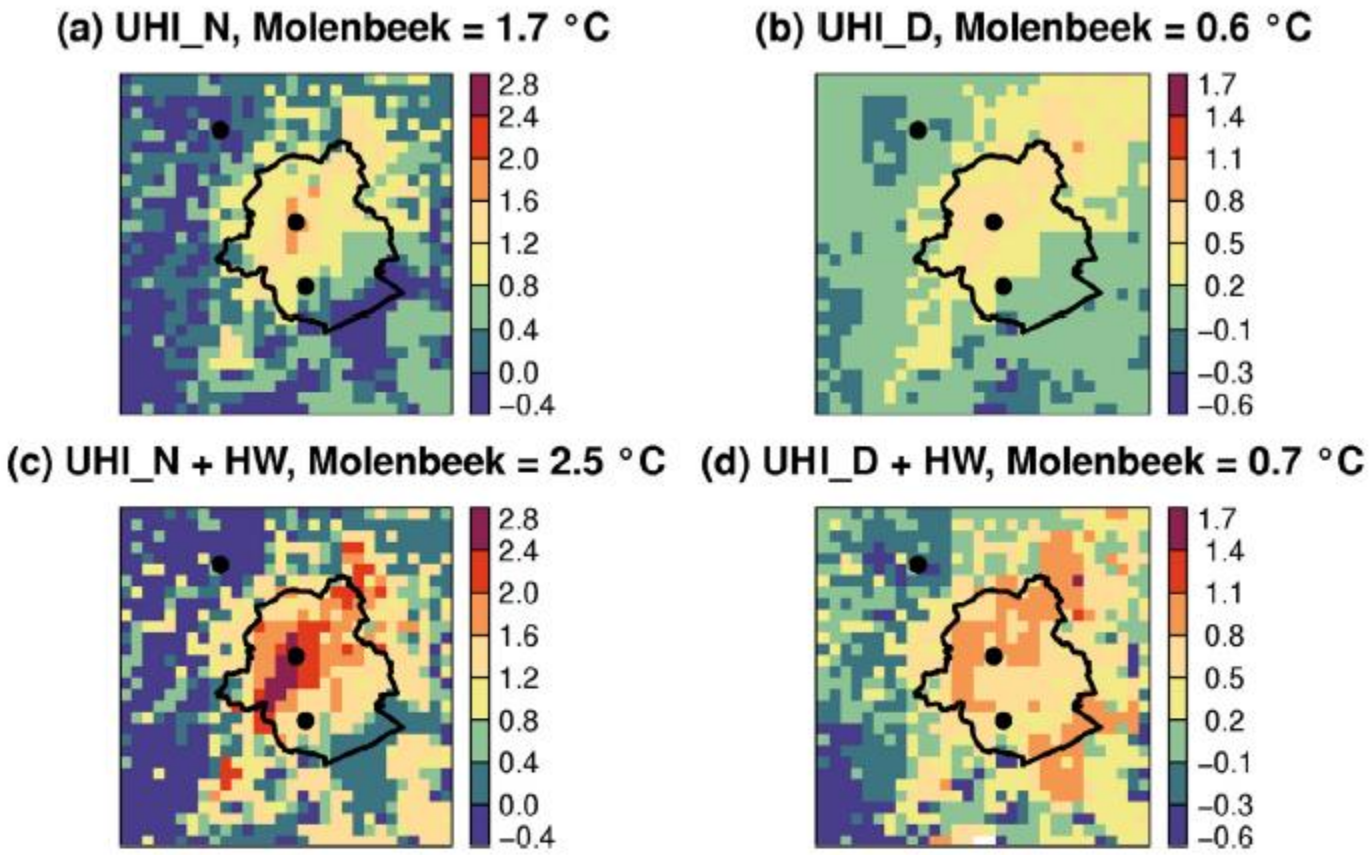
Example of correction



Validation of Model runs over Brussels



UHI over Brussels



Hamdi et al (2016)

Objectives of the URCLIM project

- The realization of integrated Urban climate Services (UCS)
  - For urban planners and related stakeholders
  - Using open urban data and regional climate data

- European project with 7 partners
  - 5 Meteorological institutes of HIRLAM-ALADIn consortia (MF,RMI,KNMI, Met-Ro,FMI)
  - 1 national mapping agency (IGN)
  - 1 research laboratory in geomatics (Lab-STICC)
- Sept 2017 – sept 2020

- More info: www.urclim.eu

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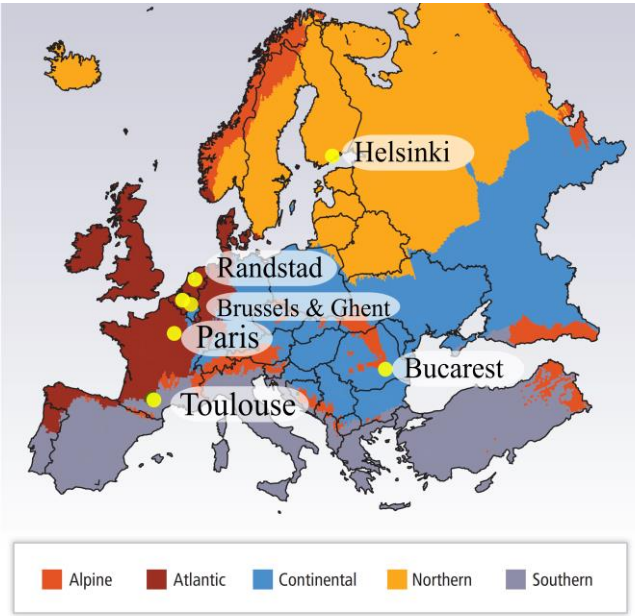
5 European case study cities



Ghent & Brussels

The Randstad

Helsinki

Bucharest

Toulouse & Paris

- Case study cities in different climate zones
- At least one case study in each country
  - Contact with local stakeholders
  - Meteorological data, city observations & expertise

Methodology

- 1) High resolution urban maps for climat

Example of open urban data:
www.openstreetmap.org

- 2) Methods to go from regional climate models to city scale & uncertainties

- 3) multi-criteria impacts and evaluation of adaptation strategies
  (Urban Heat Island & heat waves, precipitation, snow cover, economy,…)

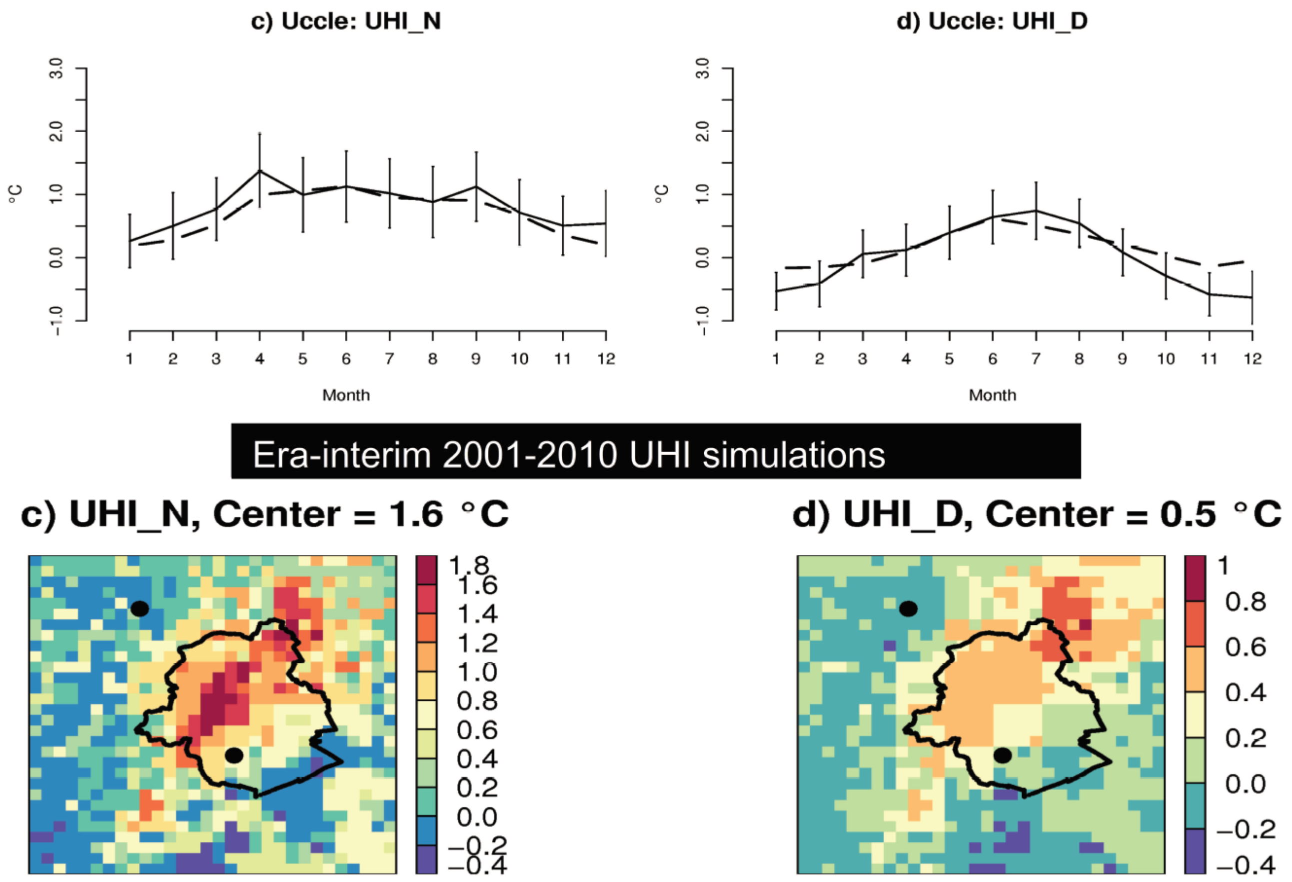
- 4) Urban Climate with stakeholders) & co-visualization of ur a

Example of visualization of
flood in Paris, source: IGN

Task 3.1: UHI and uncertainty

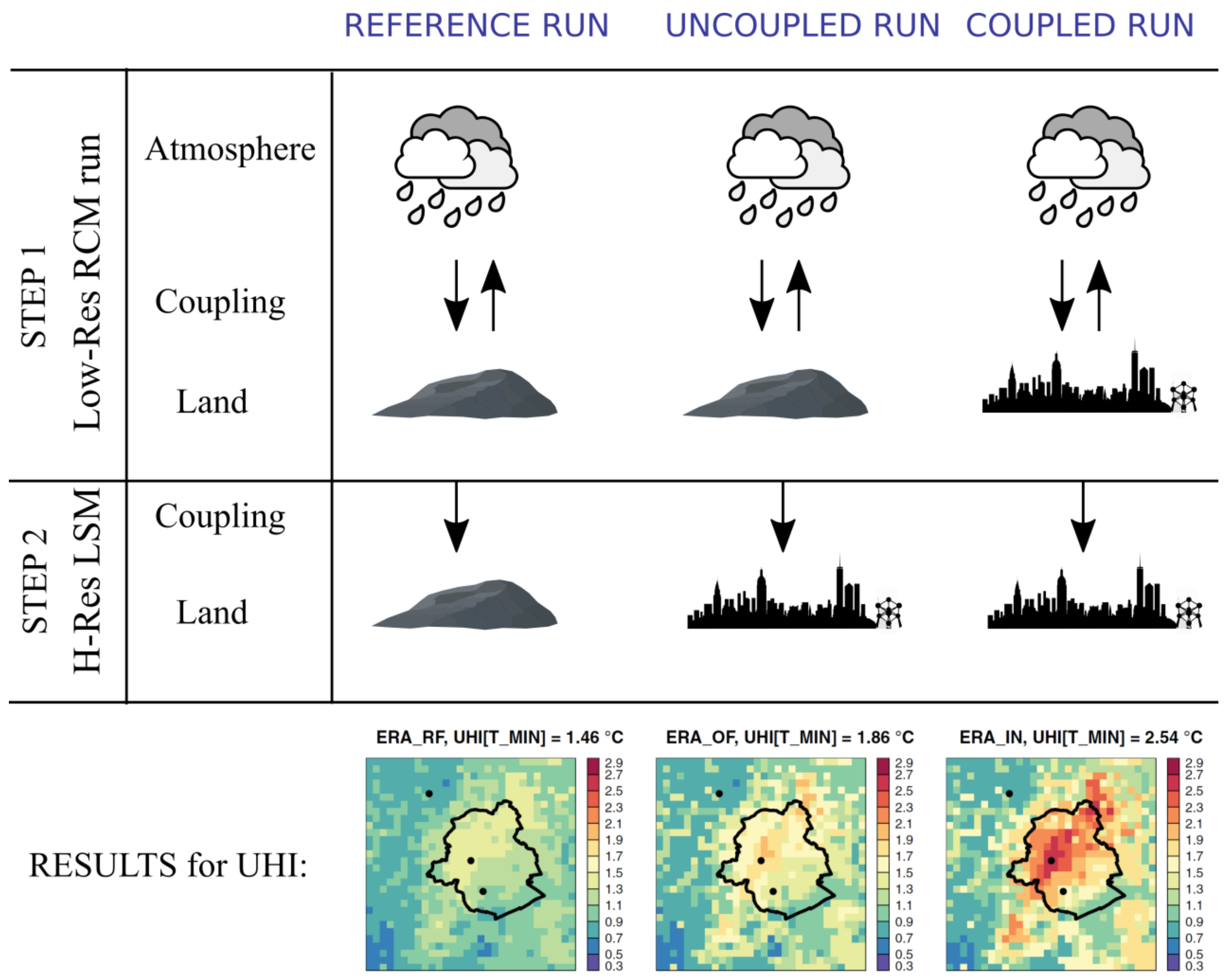
- Proof of concept:
  - Validation results over following cities:
    - Brussels (yrs: 1980-2013)
    - Toulouse (yr: 2004-2005)
    - Bucharest (runs done, yr 2015)
    - Helsinki (runs with ECOCLIMAP I and II done, 2012)
  - Next step:
    - Ghent (runs ongoing, yr 2017)
    - Amsterdam/Rotterdam (yr 2016-2017 (?))

Validation of UHI over Brussels



Hamdi et al (2016)

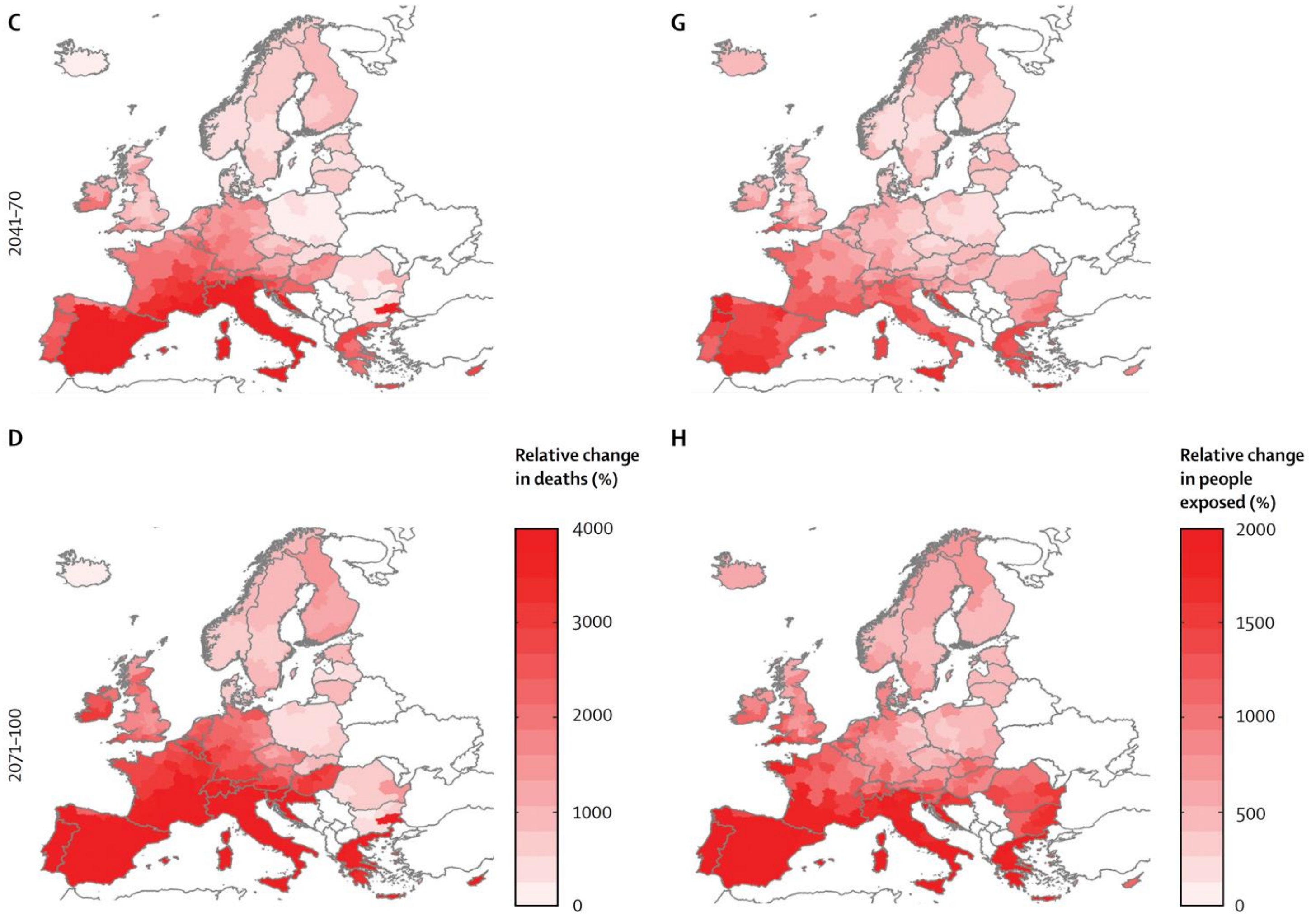
Coupled vs Uncoupled results



Hamdi et al. 2013

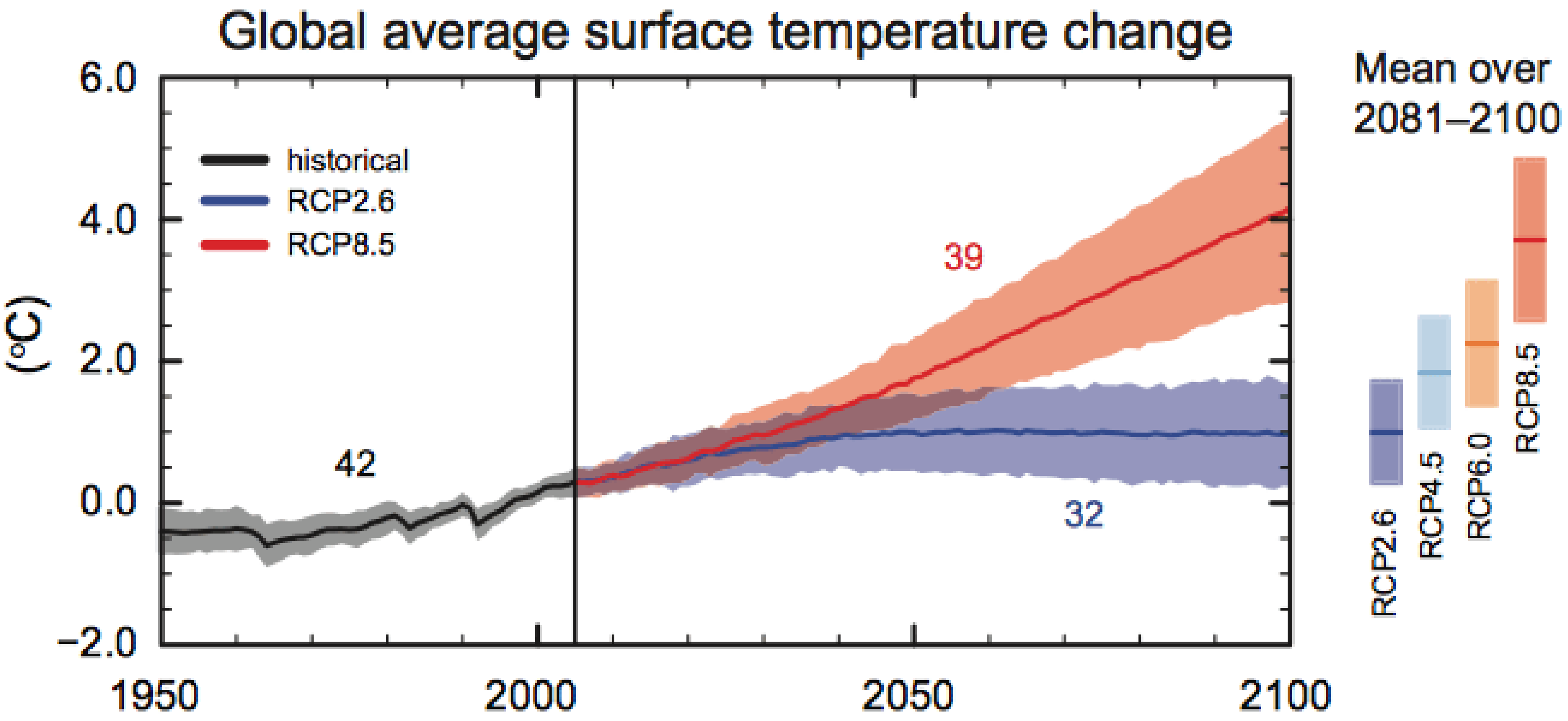
Increasing risk over time of weather-related hazards

- Weather-related disasters could affect 2/3 of European population annually by 2100 (351 million people) compared with 5% now (25 million).
- About 50 times the number of fatalities occurring annually (152 000 deaths).
- Risks increasing towards southern Europe with premature mortality rate due to weather extremes will be greatest risk factor.
- The projected changes are dominated by global warming (more than 90%) & mainly due to heatwaves (about 2700 heat-related fatalities per year vs 151 now).



Forziori et al., 2017, The Lancet

IPCC projections of global temperature



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