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Training event “Climate change and air quality: challenges and objectives for the atmospheric research.”

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 “Education and Research” - Component 2: “From research to business” - Investment 3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani

Climate change and cities

Dr. Gaby S. Langendijk

INTRODUCTION

Bachelor: Earth System Science (Uva)
Master: Climate Studies (WUR / ETH)

- **UN WMO / WCRP Science officer** *(2015 – 2017)*
  - Cross-cutting group urban
  - CORDEX / CMIP & regional climate information

- **PhD at Climate Service Center Germany (GERICS) – Helmholtz** *(2017 – 2021)*
  - Climate information for cities, regional climate models

- **Post Doc at Climate Service Center Germany (GERICS) Helmholtz** *(2021 - 2023)*
  - EU Horizon Project: Impetus4Change
  - 10 New Insights in Climate Science (FutureEarth, WCRP, Earth League) (Limits to Adaptation)
  - CORDEX Flagship Pilot Study URB-RCC
  - Managing editor Climate Services Journal

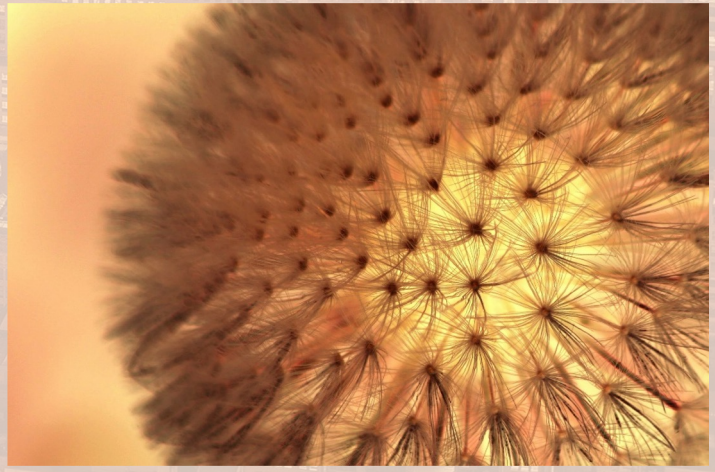
- **Post Doc Deltares** *(2023 - 2025)*
  - EU Horizon project: REACHOUT

  - CORDEX Flagship Pilot Study URB-RCC *(cont.)*
  - Scientific Steering Group member of WCRP Lighthouse Activity “My climate risk” *(cont.)*

Currently, ~55% of the world's population lives in cities
~70% of the population projected to live in cities by 2050

Around 40% of world population live within 100km of the coast

By 2050 at least 570 cities and ~800 million people will be exposed to rising seas and storm surges under 2.0°C warming




Science-based, high-quality climate information
tailored to city needs are required to *enhance resilience* in urban areas to on-going and projected *climate change*
© Climate Service Center

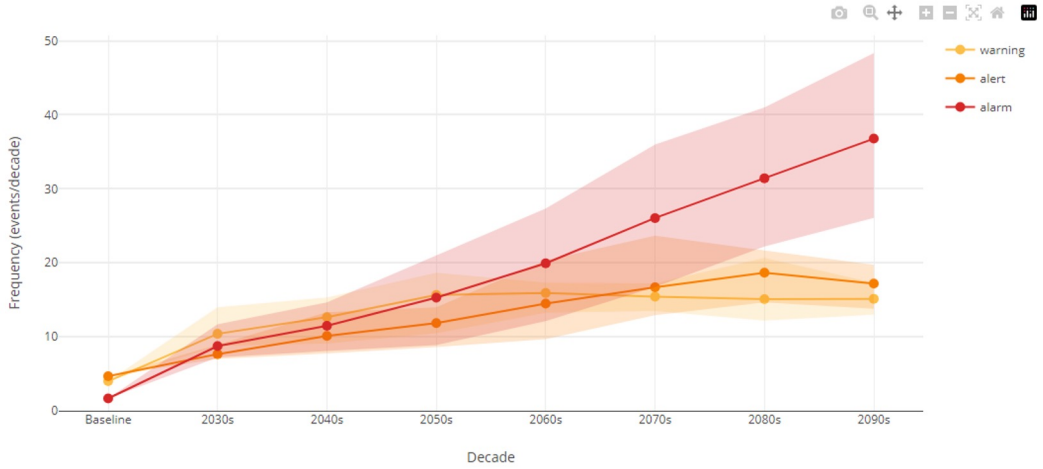
Thermal Assessment Tool (Tecnalia)

IT_015146: Milano

Historical | Intermediate emissions | **Very high emissions**

This scenario represents the future regional climate conditions, assuming a very high greenhouse gases and aerosols emissions scenario (i.e. RCP8.5), according to the EURO-CORDEX dataset of the Copernicus Climate Data Store.

Frequency of heatwaves per decade (+)

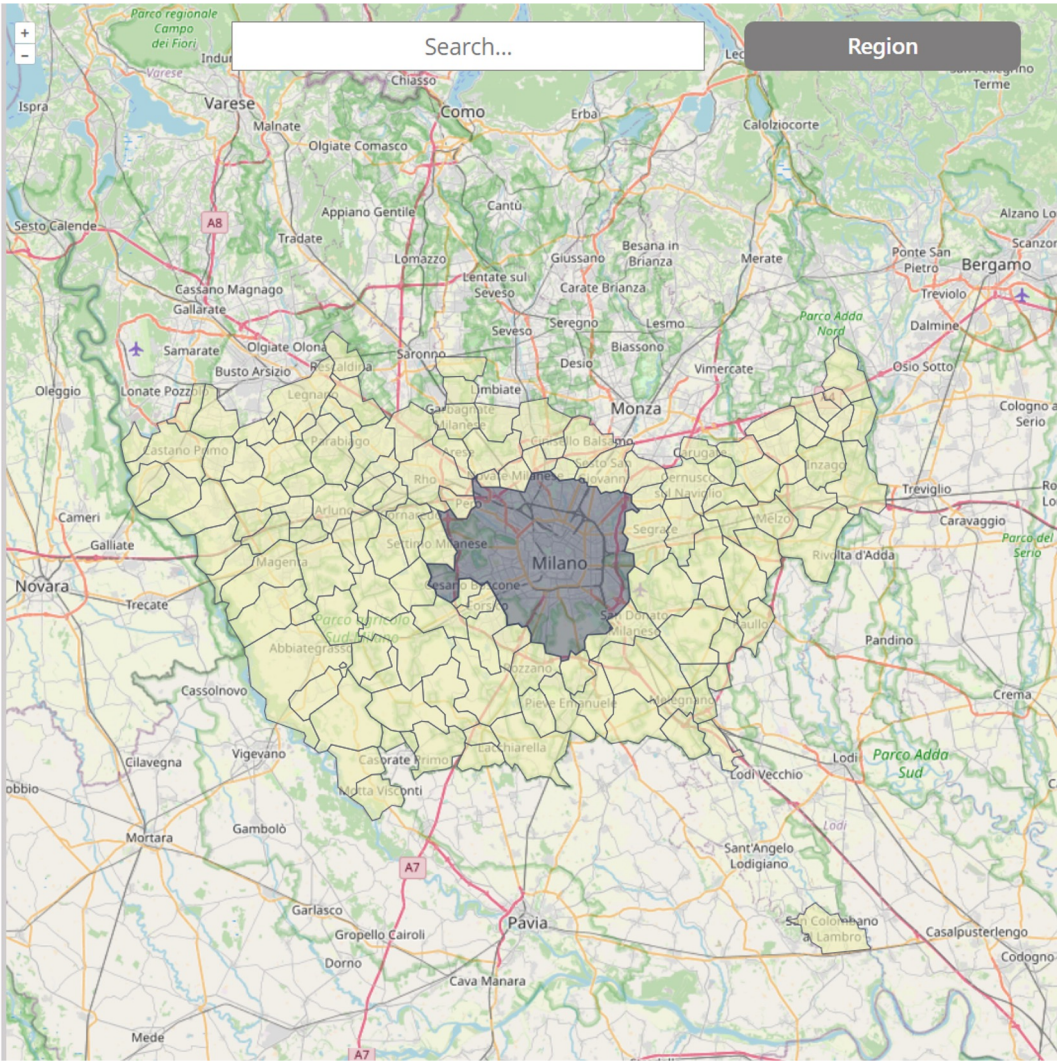


In Milano **12 warning** events, **14 alert** events and **5 alarm** events took place **during the baseline period (1981-2010)** (note that the above plot provides decadal statistics).

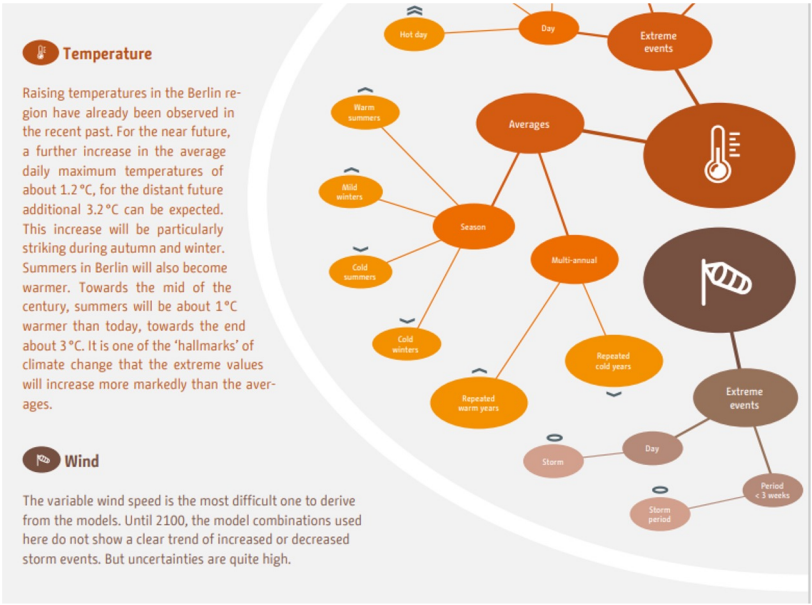
Regarding future projections, the above plot visualizes that:

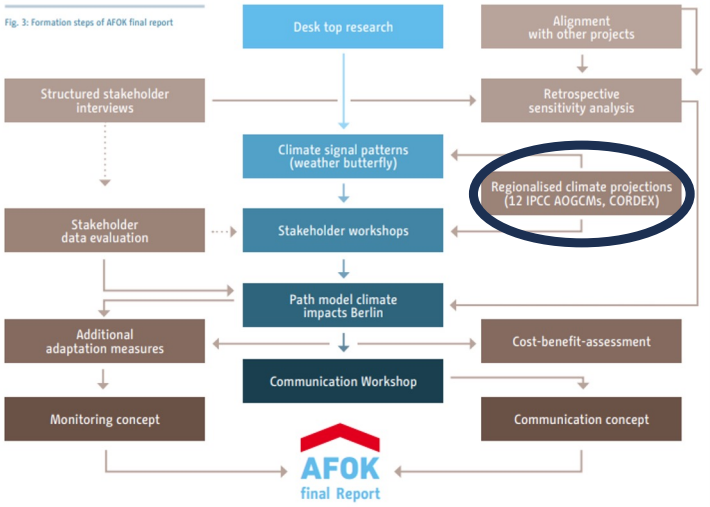
in the **middle of the century** (2050s) **4 times more warning** events, **3 times more alert** events and **9 times more alarm** events are expected.

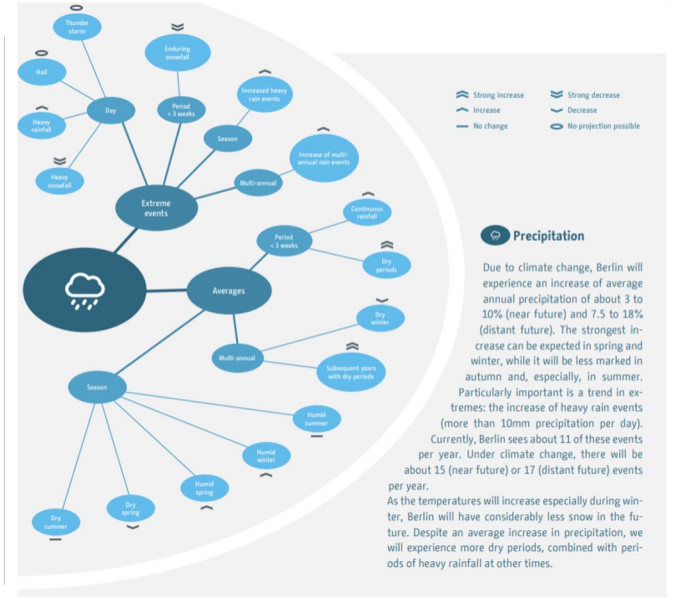
in the **end of the century** (2090s) **4 times more warning** events, **4 times more alert** events and **22 times more alarm** events are expected.



Berlin Climate Adaptation Plan



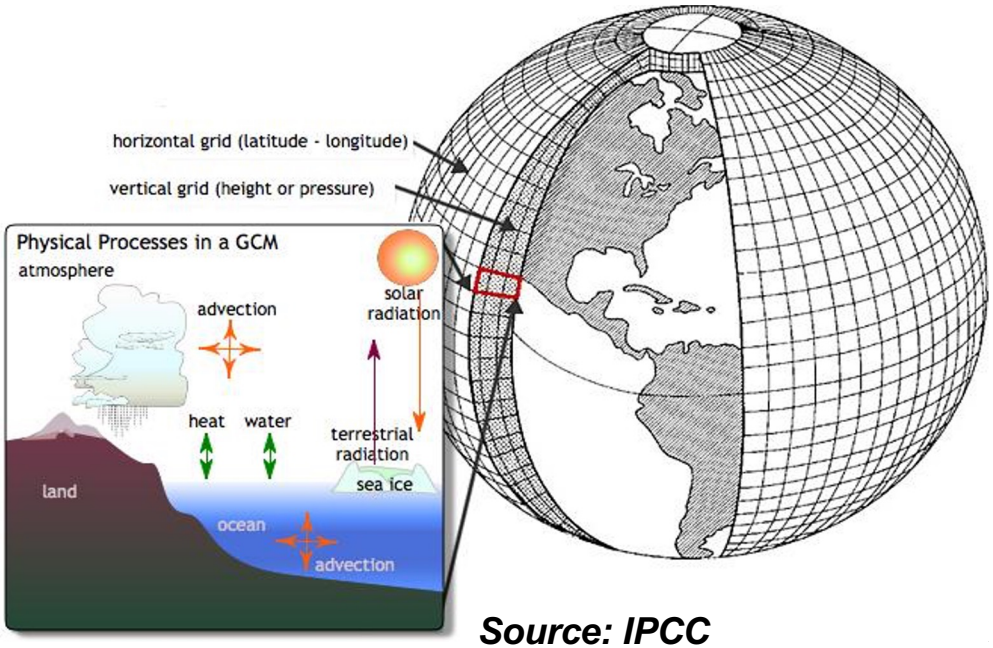


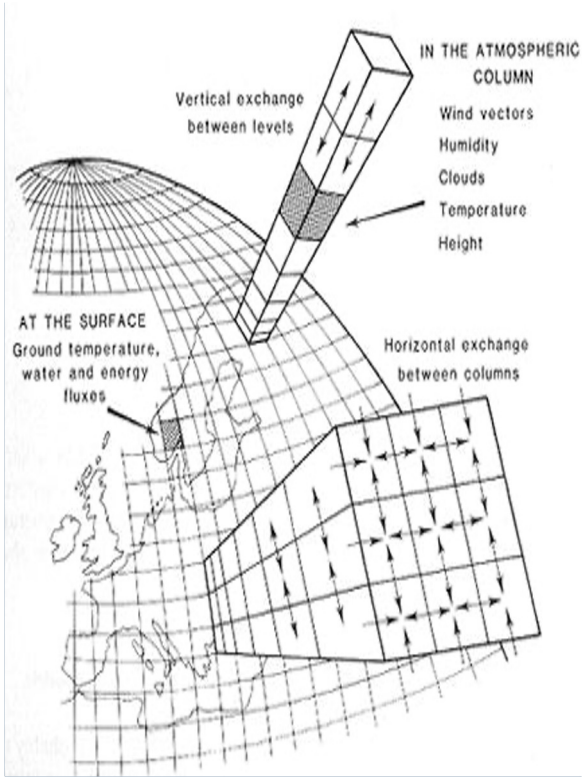


How do (regional) climate models work?
Regional climate projections for cities & impacts

HOW DO CLIMATE MODELS WORK AND WHAT CAN THEY TELL US?

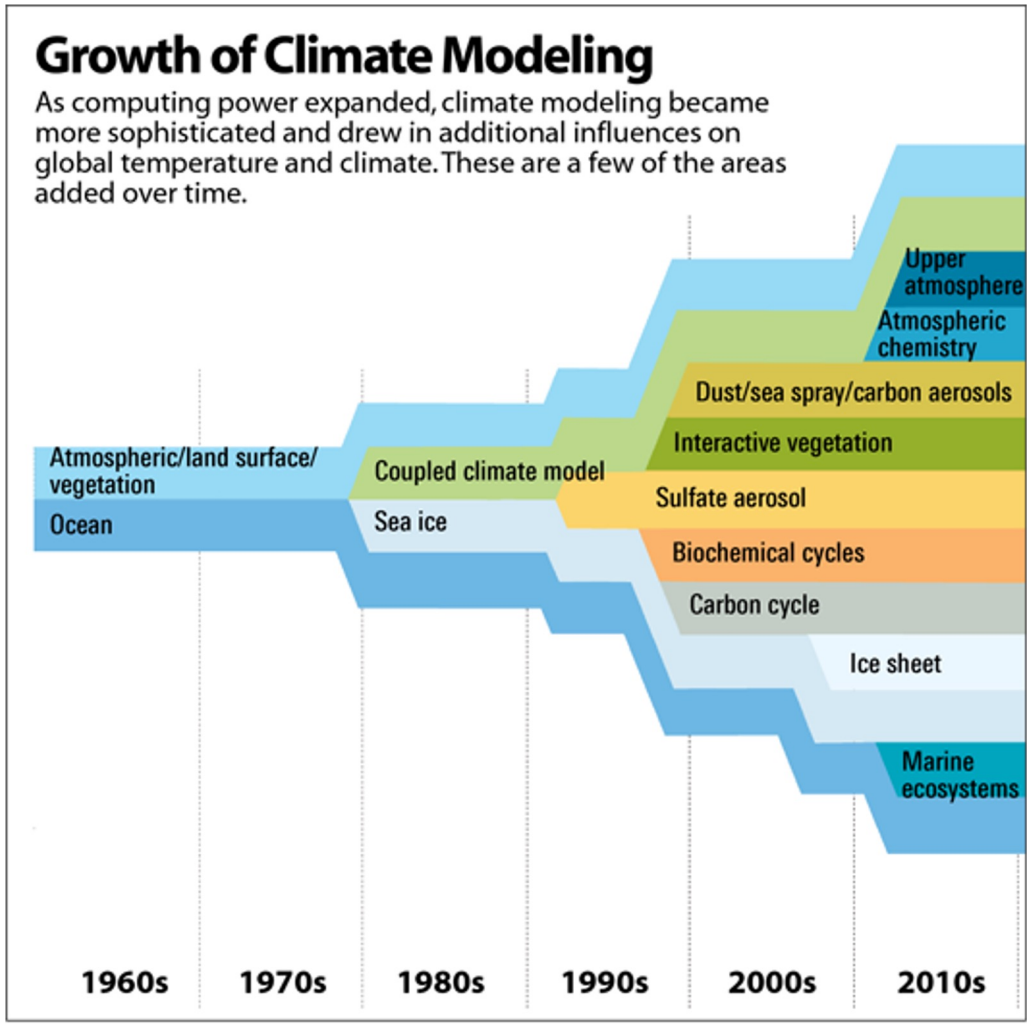
GLOBAL CLIMATE MODELS (GCM)





Source: IPCC 2007

Differential equations describing dynamics and physics in the climate system:
discretized on a 3-D grid, time dependent numerical solutions and physical parameterisations for subscale processes

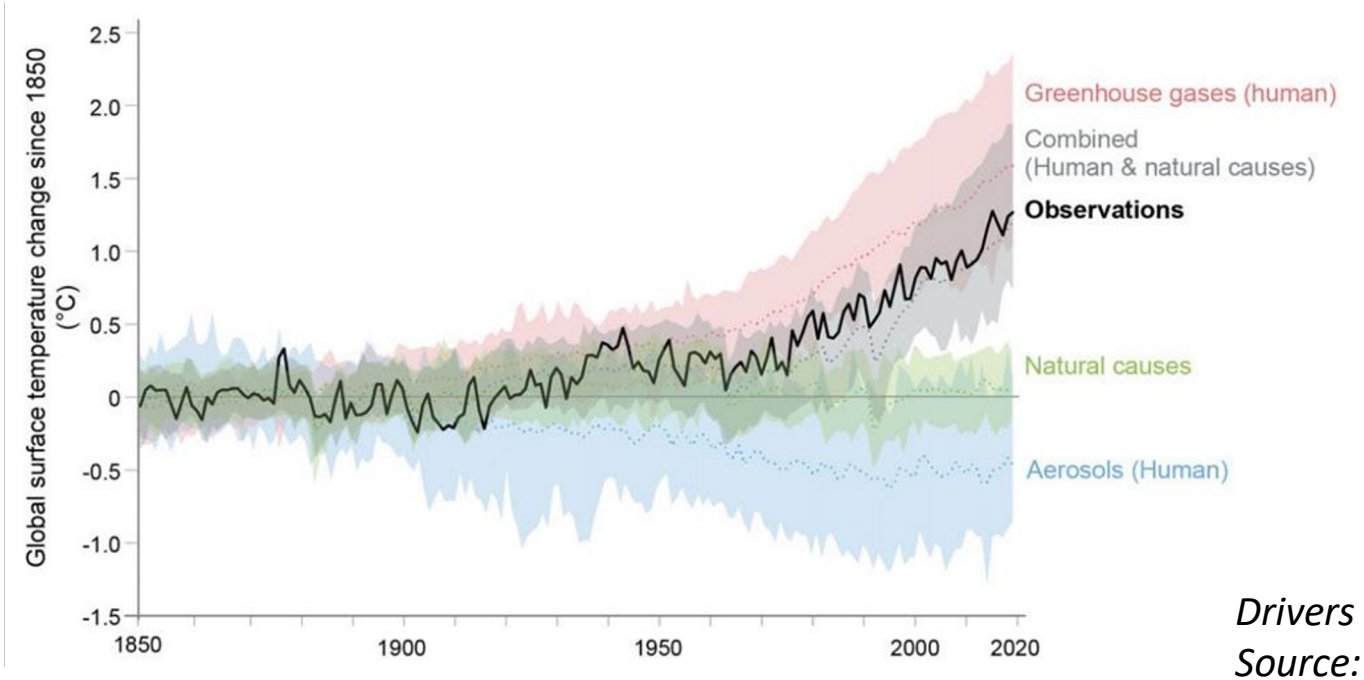


Evolution of Global Climate Models (GCM)

- >30 research groups worldwide with their own GCM
- Computer models with thousands rows of computer code
- Simulations on super computers
- Petabytes of model output data
- Worldwide coordination & comparison of results

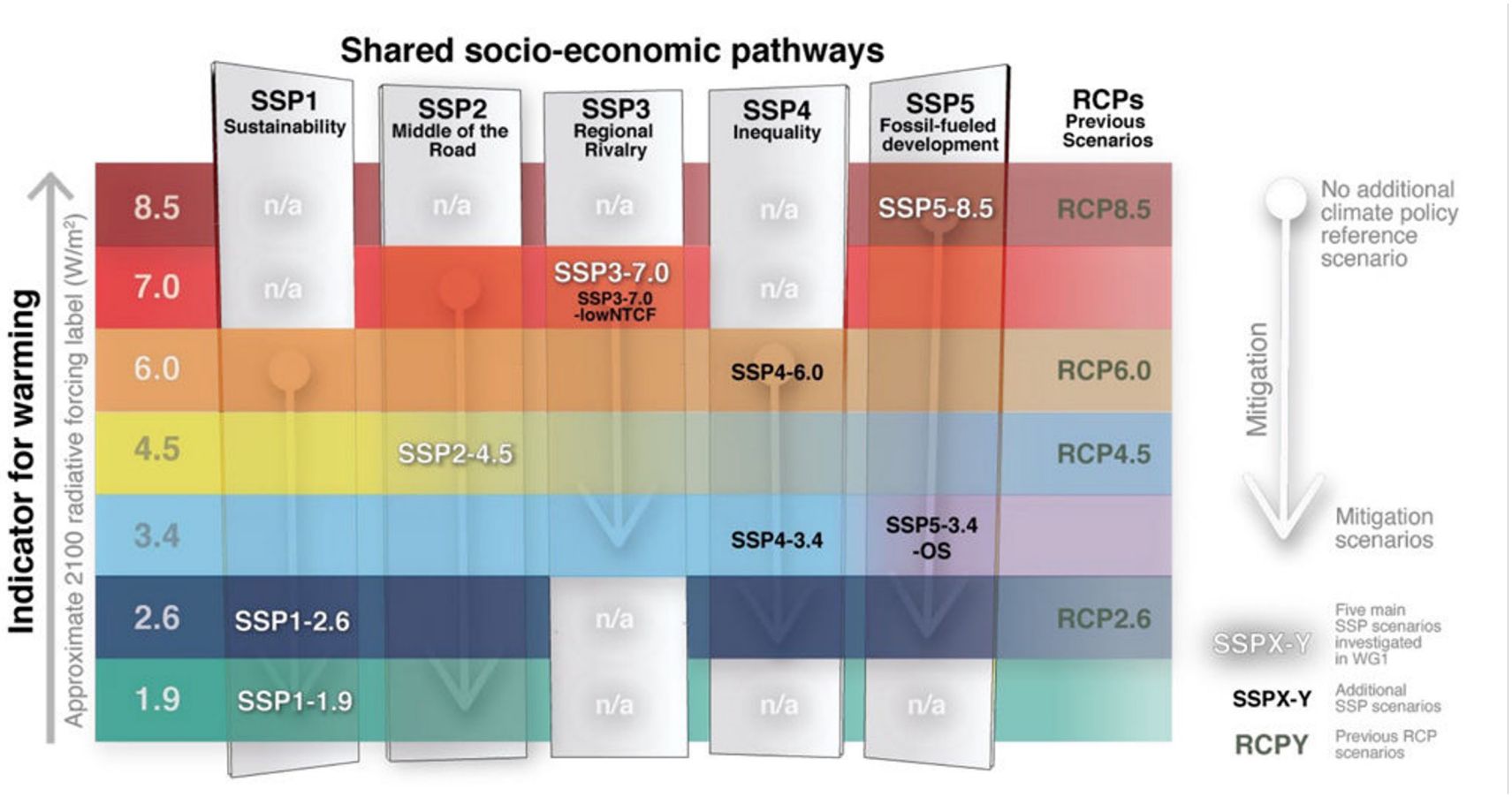
How do we know humans are causing climate change?

Climate models can only reproduce the observed spatial and temporal patterns of warming when they include natural AND anthropogenic forcings:

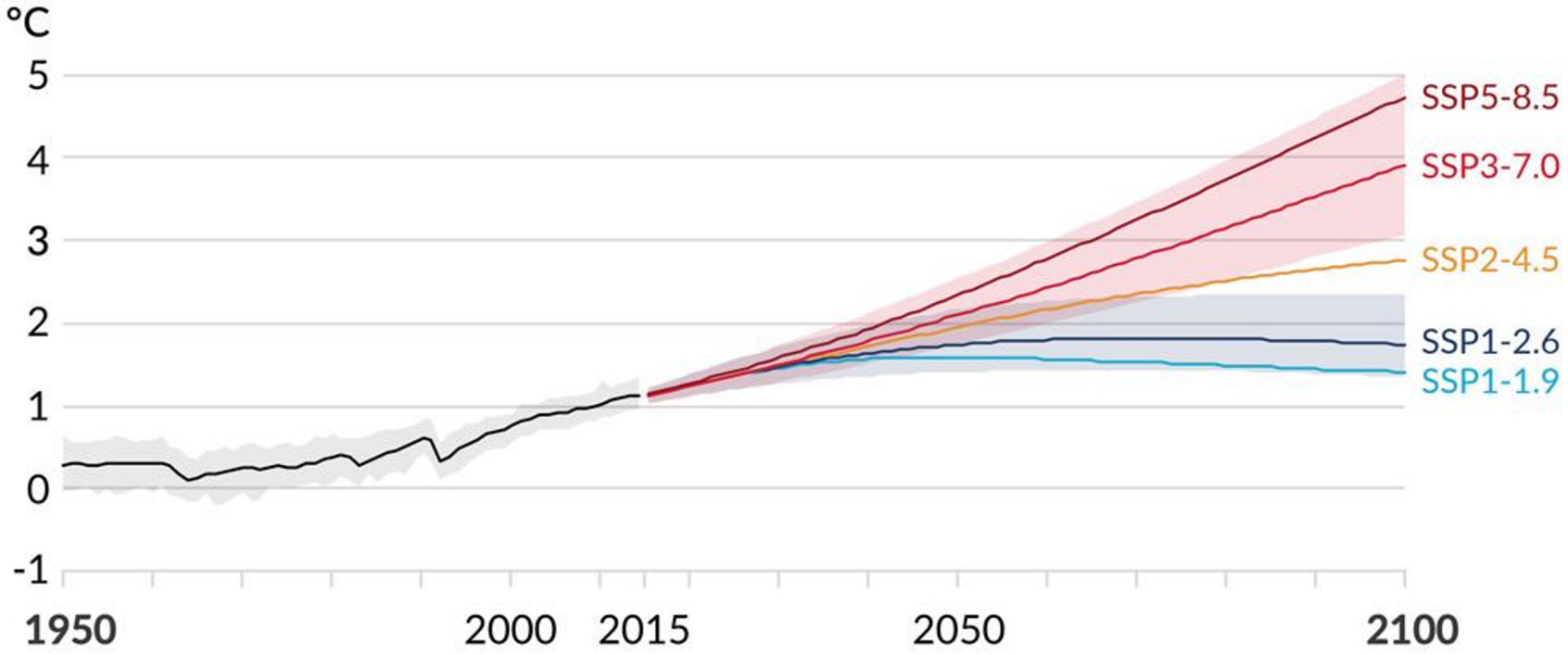


Drivers of observed warming over 1850-2020.
Source: IPCC (2021) FAQ 3.1, Figure 1.

CLIMATE SCENARIOS (SSPs):



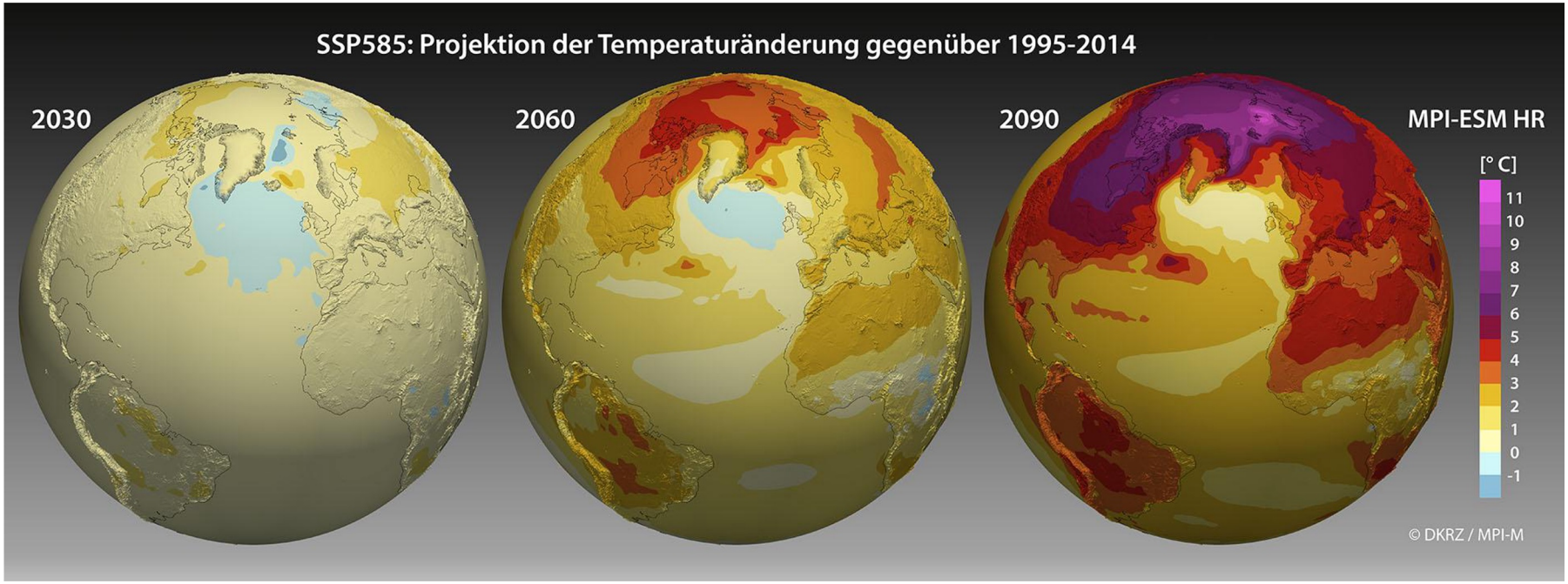
CLIMATE SCENARIOS (SSPs):



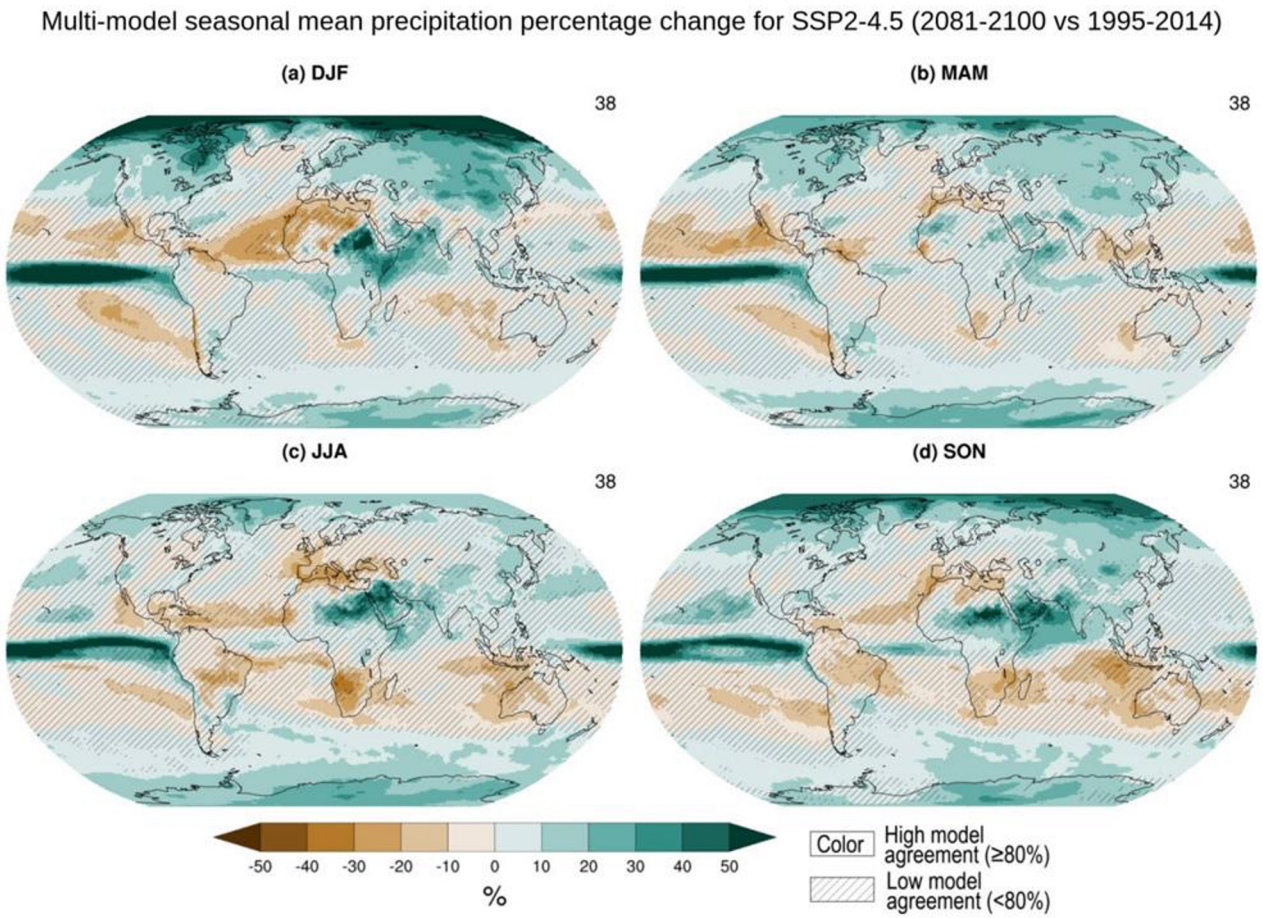
Global surface temperature changes relative to 1850-1900, degrees C, under the five core emissions scenarios used in AR6. Source: IPCC (2021) Figure SPM.8a.

Temperature change projections

Relative to 1995-2014



Projections of seasonal precipitation change




HOW CAN WE UNDERSTAND AND MODEL THE URBAN CLIMATE IN A REGIONAL CONTEXT?
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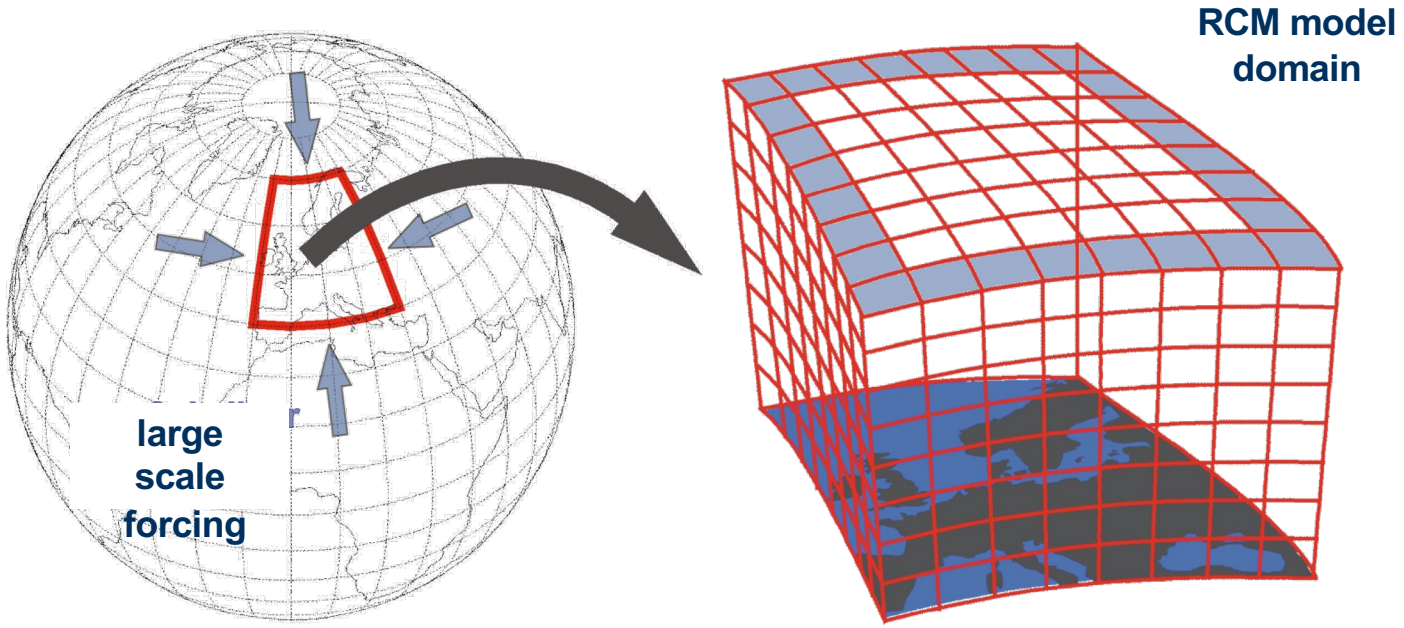
REGIONAL CLIMATE MODELS (RCM)



Global climate models (GCM)

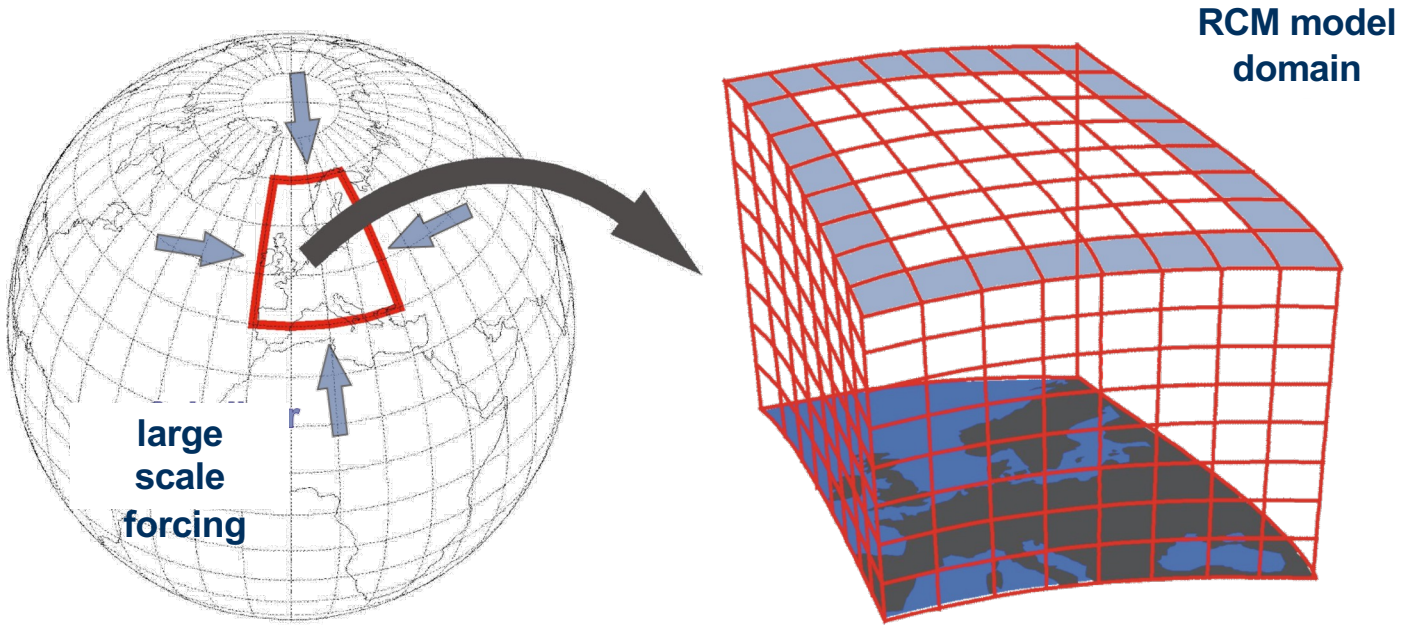
Regional climate models (RCM)

POLL:

Knowing that Global Climate Models reach spatial scales of 400x400 km to max. ~50kmx50km, what max. spatial resolution do you expect for a regular regional climate model?

a. Also up to 50x50km
b. 20x20 km
c. 3x3 km
d. 100mx100m

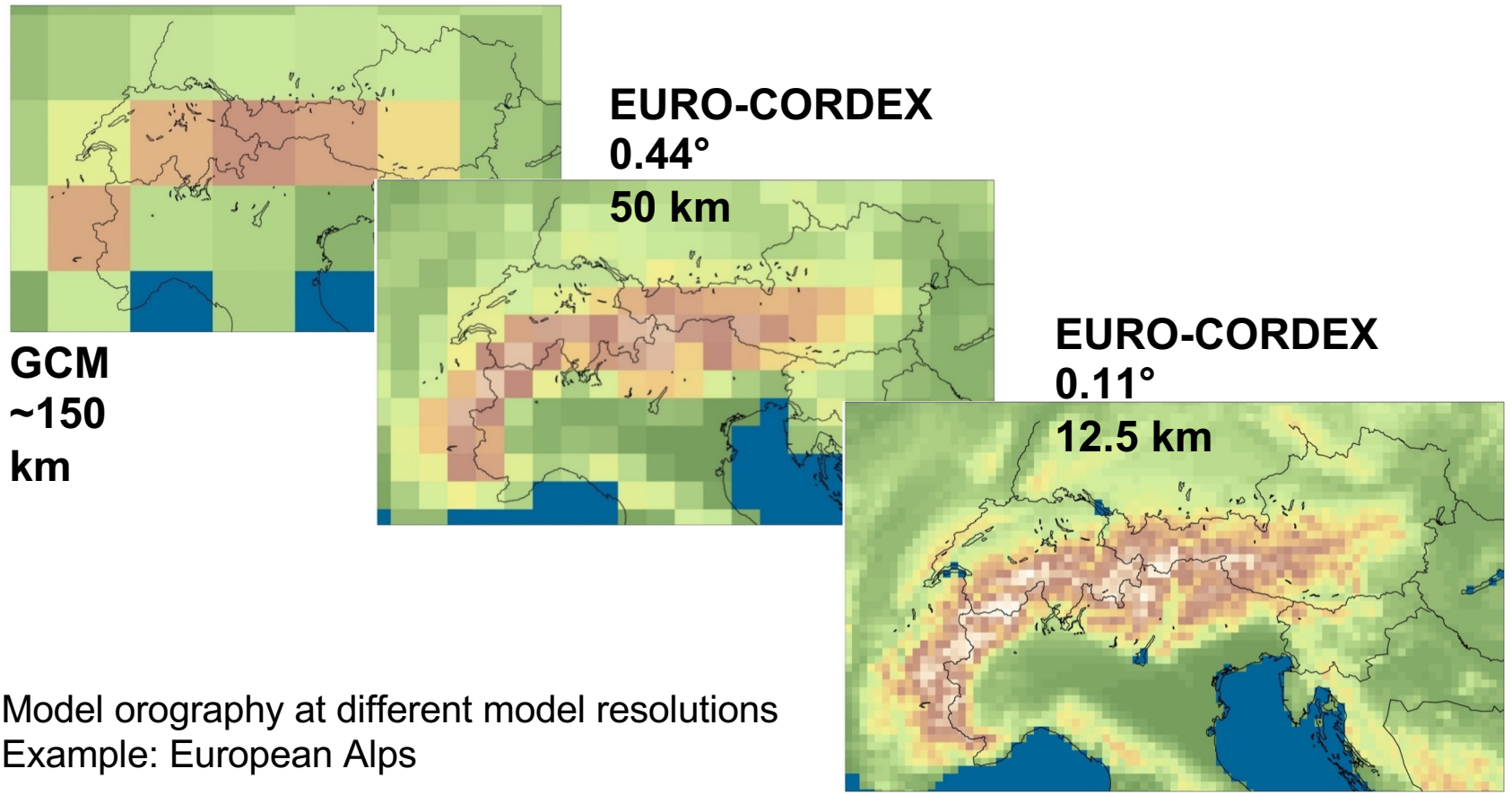
REGIONAL CLIMATE MODELS (RCM)



Global climate models (GCM)
400 km to 50 km

Regional climate models (RCM)
50 km to 2.5 km

Model resolutions from GCM to RCM

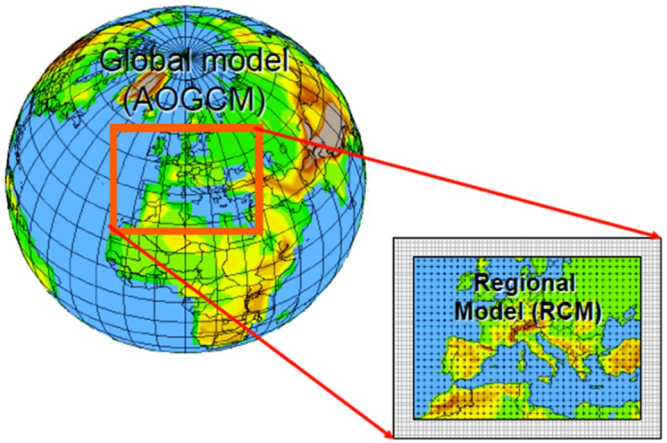


Model orography at different model resolutions
Example: European Alps

What is CORDEX?

Cordex= “Coordinated Regional Climate Downscaling Experiment”

Main aim: To better understand relevant regional/local climate phenomena, their variability and changes, through downscaling and coordinating the science and application of regional climate model (RCM) downscaling through global partnerships.

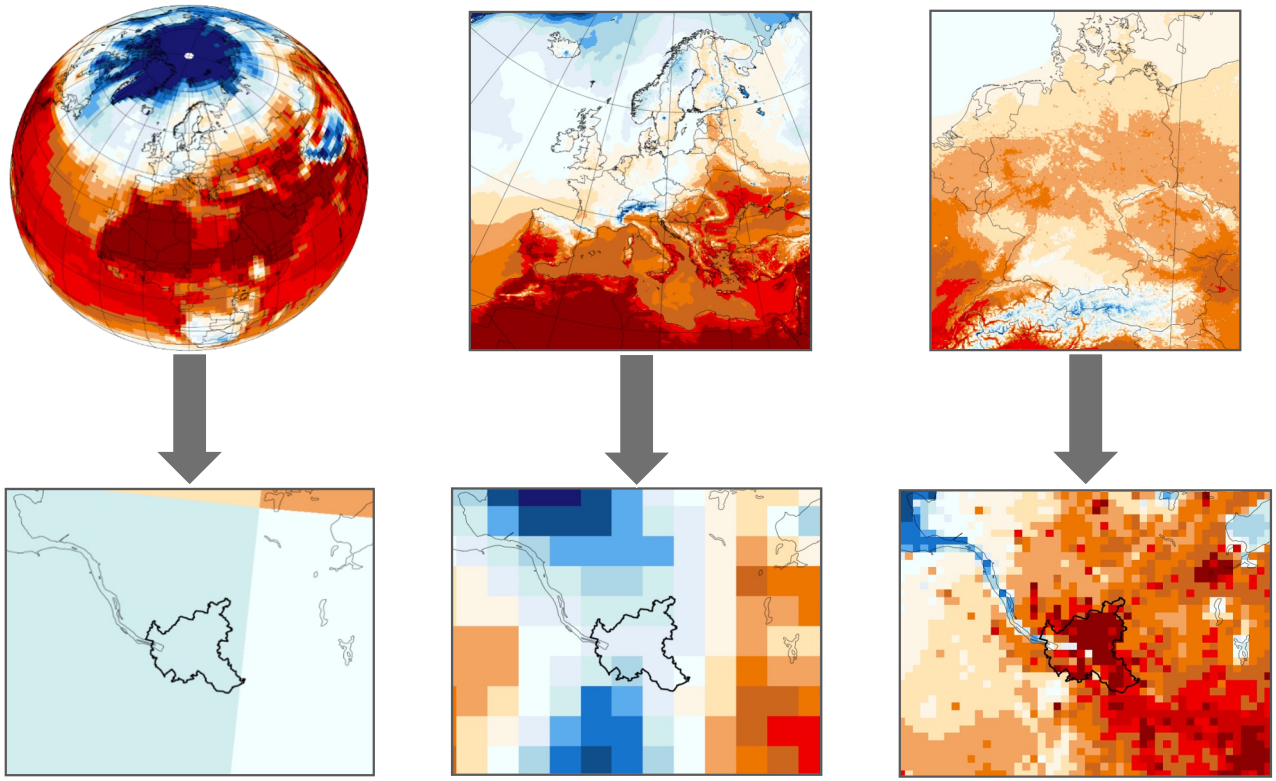


WCRP
World Climate Research Programme

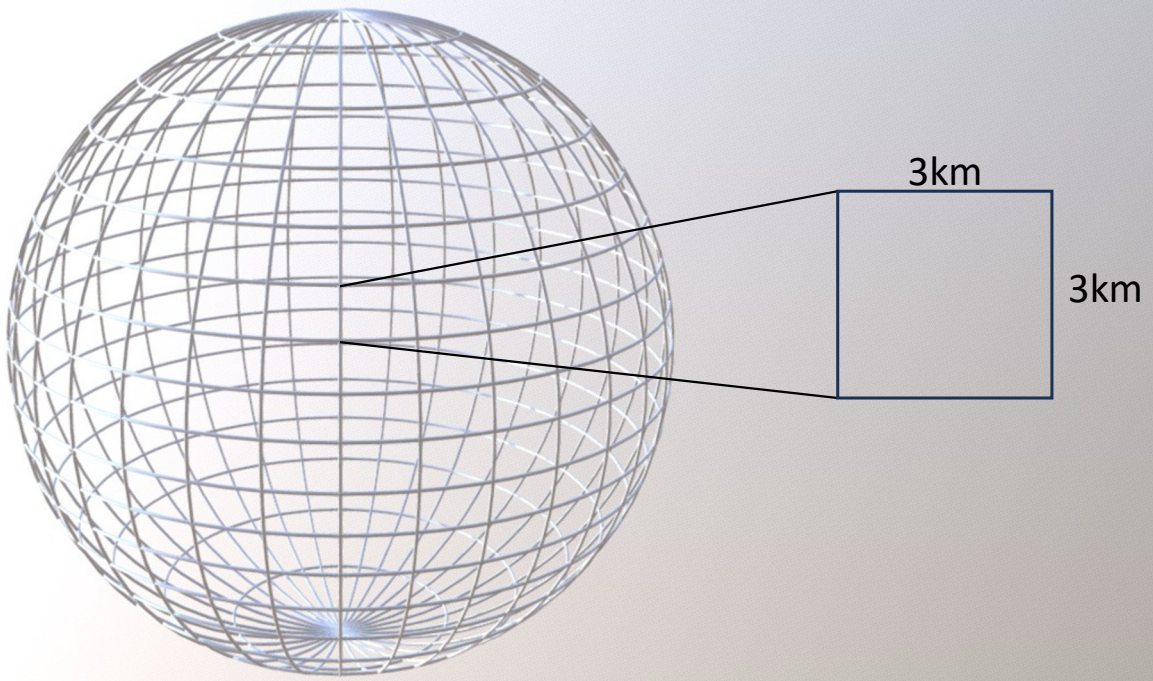
WORLD METEOROLOGICAL ORGANIZATION
unesco
International Science Council

- CORDEX is an activity under the World Climate Research Programme
- Approx. >30 modelling groups worldwide
- Simulate land areas across the world

Model Resolutions: City of Hamburg

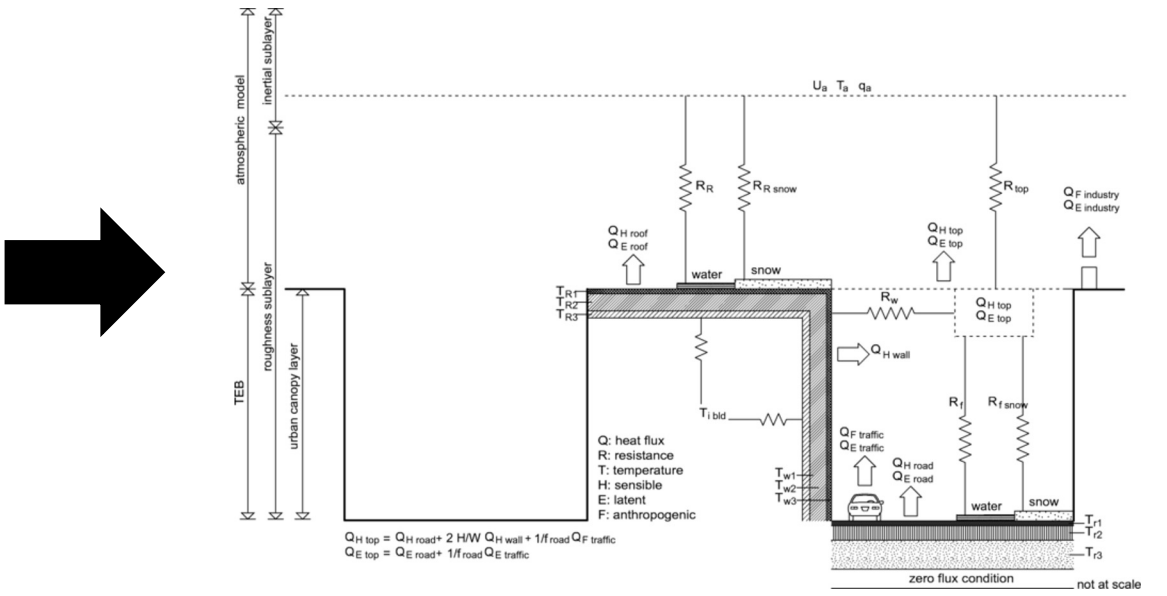


~150 km ~12.5 km ~3 km


3km
3km

Cities are represented in the CORDEX regional climate models as:

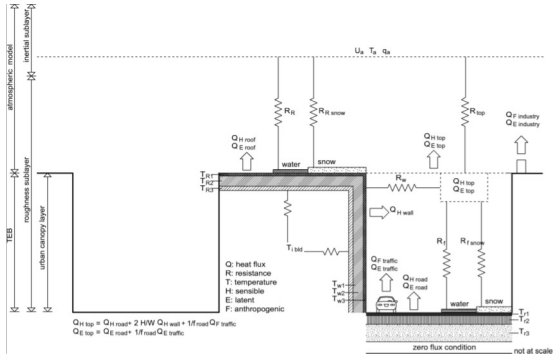
More and more models are working on complex representations of urban areas to improve simulations of cities and regional climate change

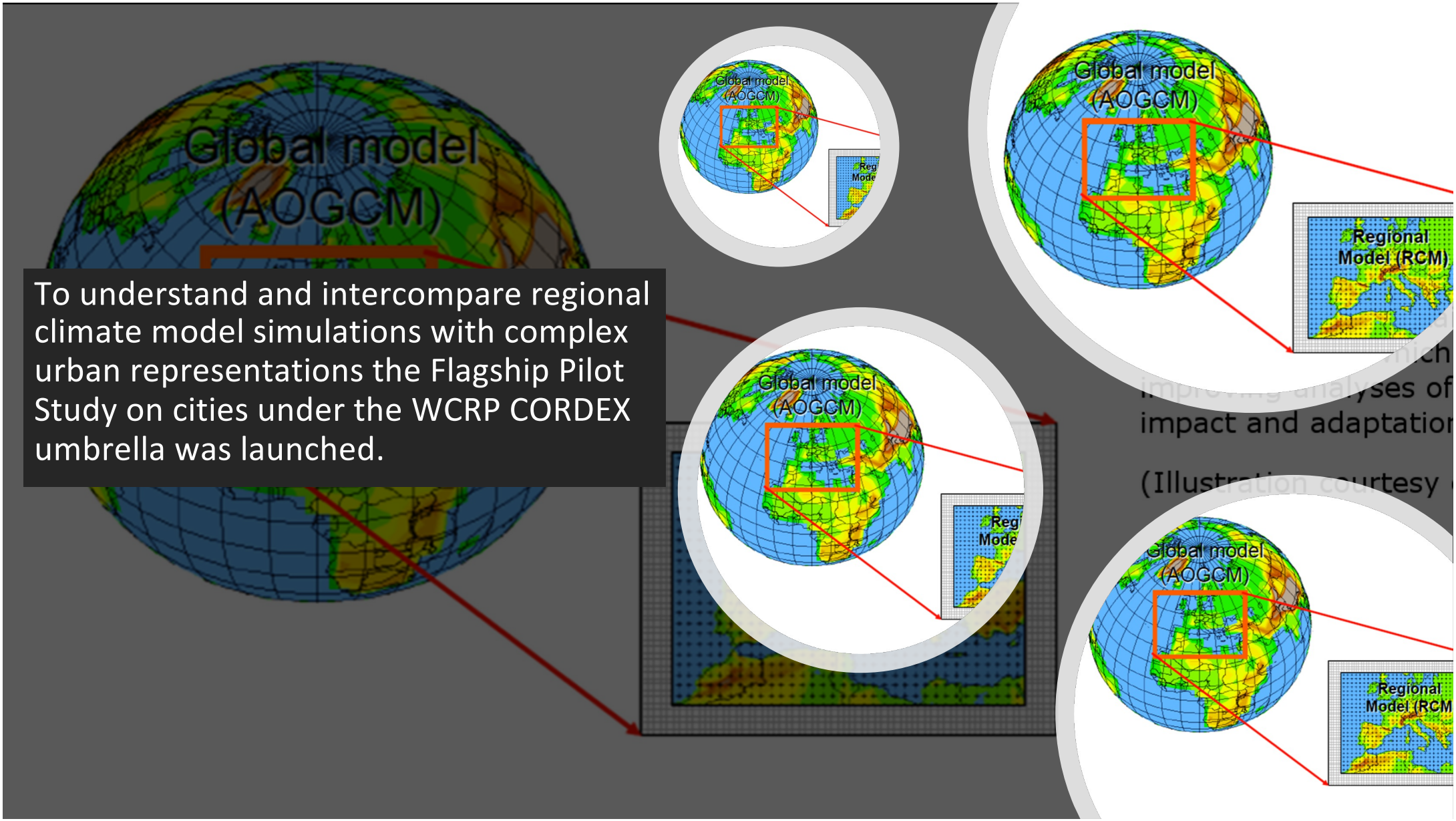


Masson, 2000

(Potential) added value

- Better representation of urban heat island effect, esp. at night
- Understanding urban-rural interactions under climate change
- Understanding changes in precipitation over and alongside cities under climate change
- Changes in wind over cities under climate change
- Analysing effectiveness and lifetime of adaptation and mitigation measures in cities under regional climate change




Global model
(AOGCM)
Regional
Model (RCM)
To understand and intercompare regional climate model simulations with complex urban representations the Flagship Pilot Study on cities under the WCRP CORDEX umbrella was launched.

Main objectives of the CORDEX Flagship Pilot Study on cities (FPS URB-RCC)

- Investigating the ***interactions of urban environments with local/regional climate change*** based on a coordinated ensemble using urbanized RCMs under a common experiment protocol.
- Intercomparing ***urban parameterization schemes*** and identifying key processes and parameterizations for further use within CORDEX.
- Providing the science to ***underpin climate services*** for cities.

FPS URB-RCC

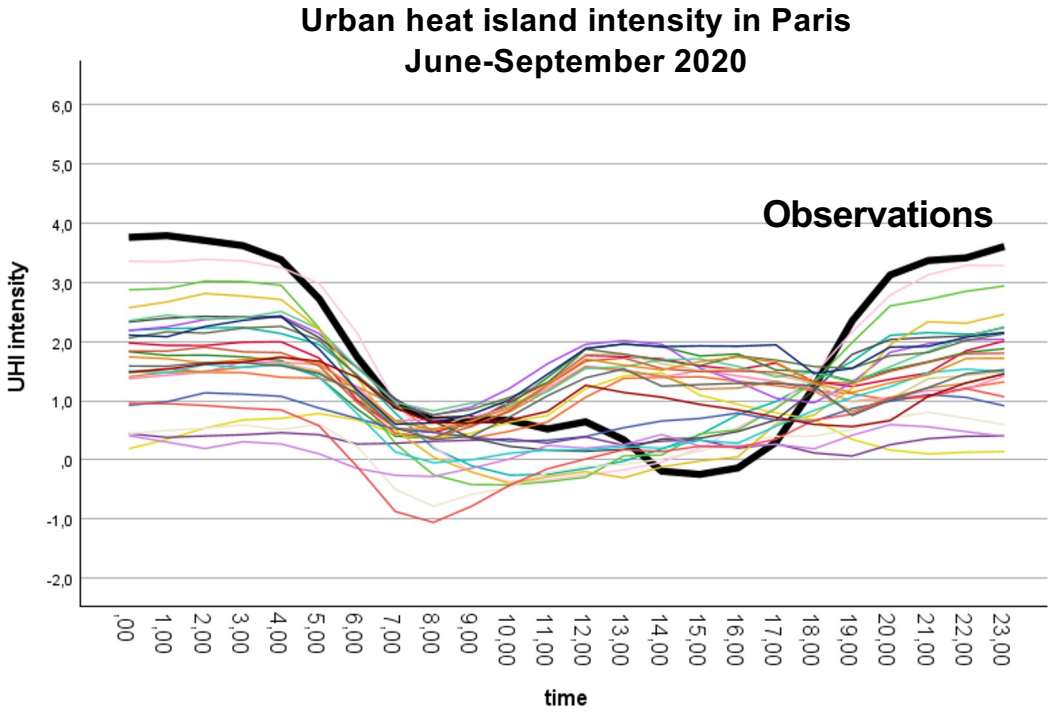
CORDEX

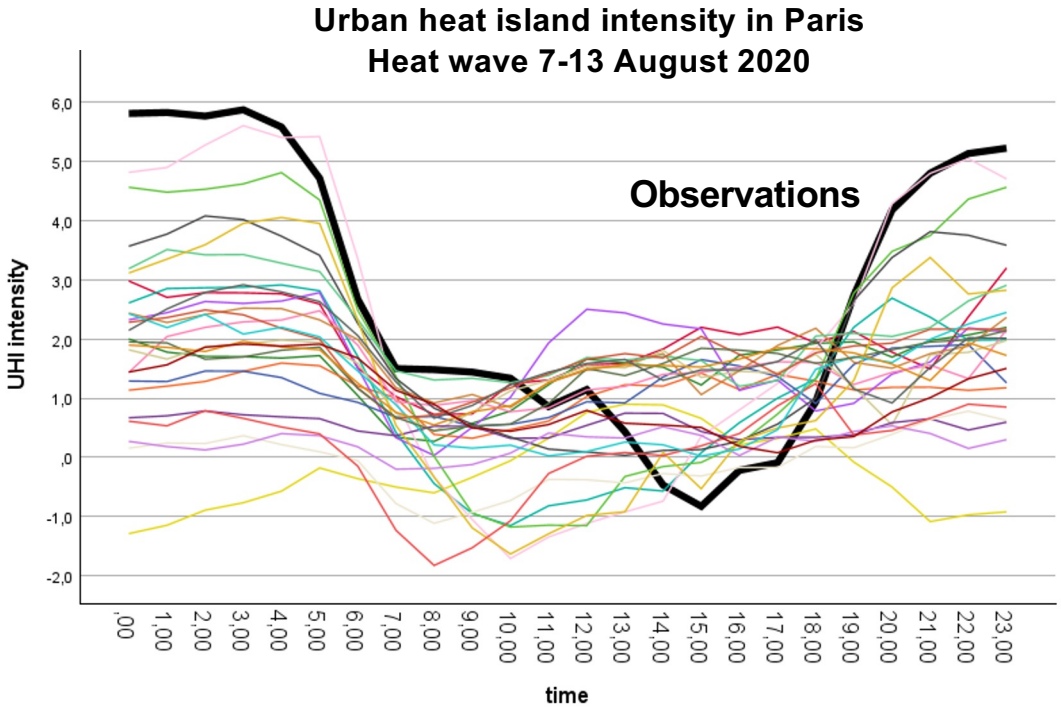
2021

2025

Regional climate model simulations

Daily cycle urban heat island

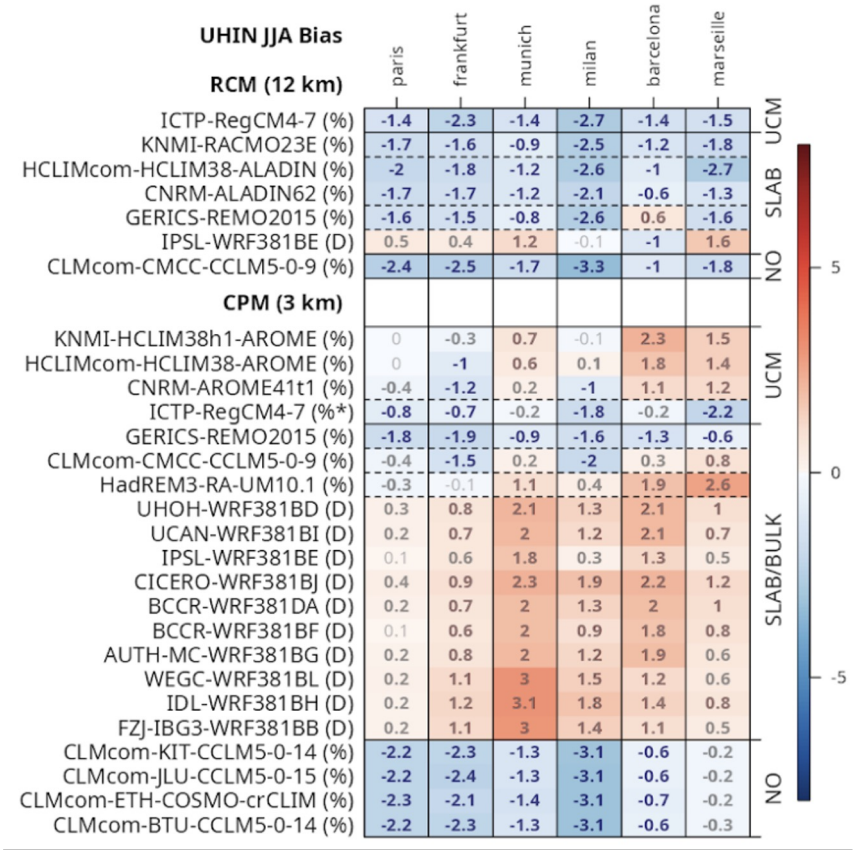




FPS URB-RCC

CORDEX

Existing regional climate model datasets analysis



Regional climate models using Urban Canopy Models tend to represent nocturnal UHI intensities in continental cities better than those using simpler approaches,

but this is not necessarily the case for coastal cities.

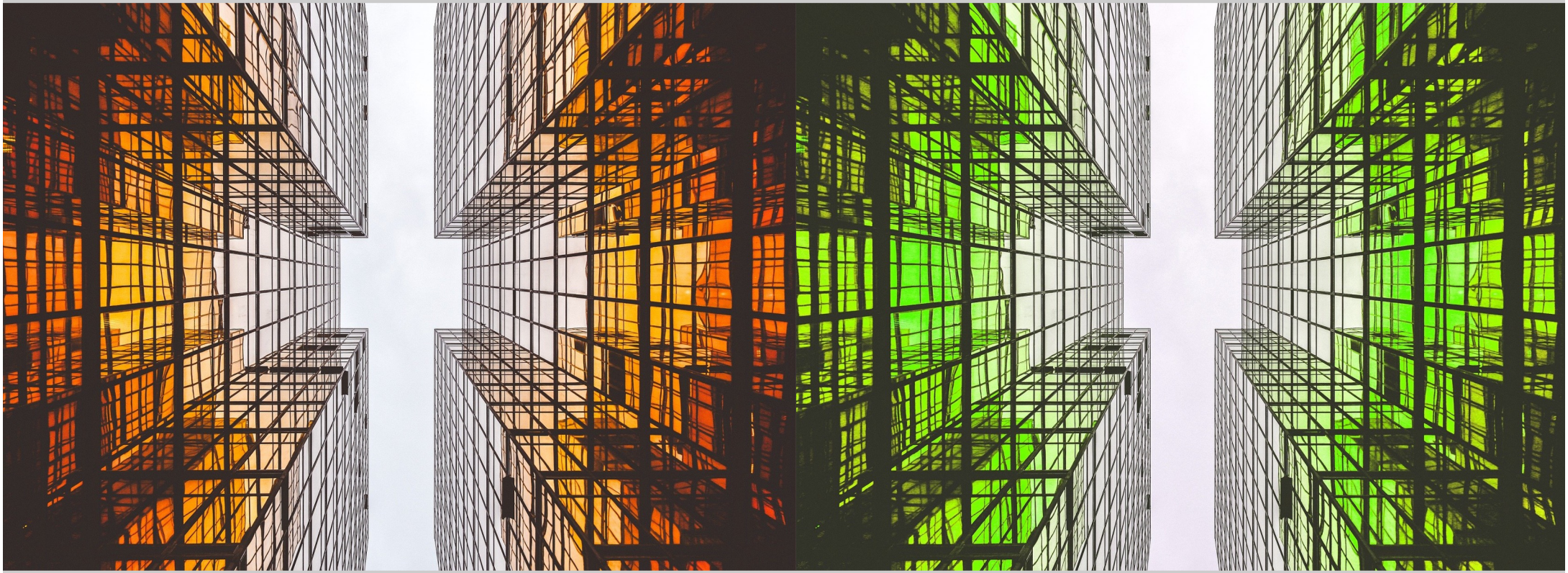
Average nighttime UHI biases (TN 2000-2009 JJA [based on observations]) simulated by different CPMs and some of their driving RCMs. (NO means no urban parametrization; SLAB/BULK refers to more simpler approaches; UCM stands for Urban Canopy Model; % means the model uses a fractional approach to differentiate multiple covers inside a point; D means the model uses a dominant cover approach). (Le Roy et al., in preparation)

PRACTICAL IMPLICATIONS

HEALTH

CULTURAL HERITAGE & BUILDING STRUCTURE

BIODIVERSITY



QUESTIONS?

Gaby S. Langendijk • Email: langendijk.gs@gmail.com

CORDEX Flagship Pilot Study:
URBan environments and Regional Climate Change (URB-RCC)

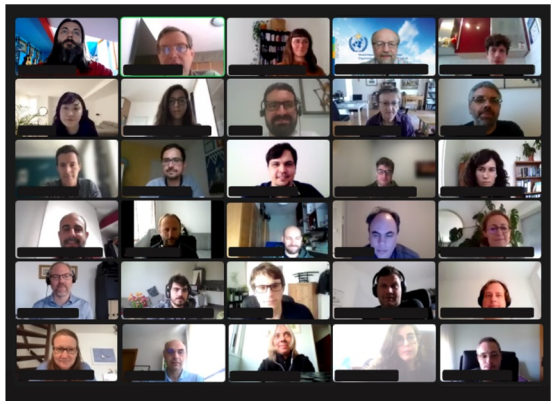
Main aim:
Understanding the effect of urban areas on the regional climate, and the impact of regional climate change on cities, with the help of coordinated regional climate model experiments.

Selected city for coordinated experiments: Paris

~30 partners globally

2021-2027

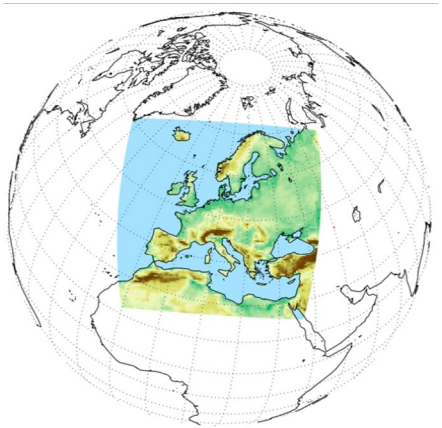
FPS URB-RCC
WCRP CORDEX



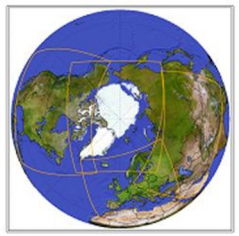
REGIONAL CLIMATE MODEL PROJECTIONS

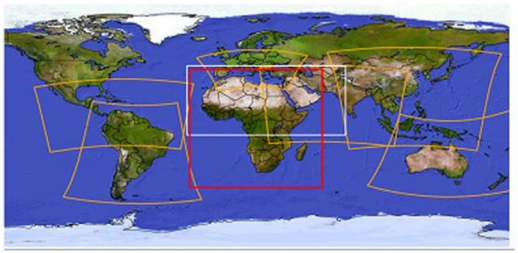
CORDEX:

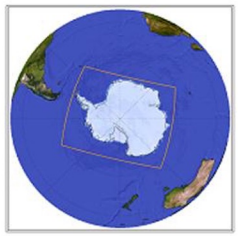
- Coordinated experiments and projections, based on global climate models
- ~30 model groups in Europe (EURO-CORDEX)
- Open access data



WCRP CORDEX : COordinated Downscaling EXperiment







CORDEX

http://www.cordex.org

http://www.euro-cordex.net

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THANKS!

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