TerraDT

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IMPACT WORKSHOP

# Urban Impact Models for Climate Adaptation

23 February 2026 | Barcelona [ES]

Funded by the European Union

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WELCOME AND INTRODUCTION

# Isra Mohamed Hussein

*CSC - IT Center for Science*

23 February 2026 | Barcelona [ES]

Funded by the European Union

# Event Agenda

| |
|---|
| 14:00 - 14:05 \| Welcome and introduction |
| 14:05 - 14:25 \| Overview of TerraDT & the Urban Impact Model |
| 14:25 - 14:40 \| UrbanAIR presentation |
| 14:40 - 15:10 \| Use Case Showcase & Demonstration |
| 15:10 - 15:40 \| Coffee break & Networking |
| 15:40 - 16: 40 \| Expert panel: User perspectives |
| 16:40 - 17:45 \| (In person only) Interactive Session: collecting user needs and requirements |
| 17:45 - 18:00 \| Wrap-up and closing |
| 18:00 - 19:00 \| Networking cocktail |

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Brief introduction to the TerraDT project

# Devaraju Narayanappa

*(CSC - IT Centre for Science)*

23 February 2026 | Barcelona [ES]

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Digital Twin of Earth system for Cryosphere, Land surface and related interactions

# New Digital Twin for Destination Earth: TerraDT

Devaraju Naraynappa* and whole TerraDT team
*CSC-IT Center for Science, Espoo, Finland.
Email: devaraju.narayanappa@csc.fi

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**Workshop: Urban Impact Models for Climate Adaptation**
**23 February 2026, Barcelona, Spain.**

# TerraDT project key details

- **Call:** HORIZON-INFRA-2024-TECH-01
- **Project name:** Digital Twin of Earth system for Cryosphere, Land Surface and related Interactions (TerraDT)
- **Duration:** 1.1.2025-31.12.2028 (4 years)
- **Co-ordinator:** CSC – IT Center for Science, Finland
- **Website:** www.terradt.eu

TerraDT website

# Consortium- 18 partners across Europe (10 countries)

# Context – Why new DT for DestinE is needed?

- Destination Earth **builds Digital Twins of Earth to support decision making**
  - Climate DT for high-resolution global climate projections & impact assesments
- However, there are some limitations in DestinE Climate DT
  - Km-scale climate models have shortcomings for some key components of Earth system - cryosphere, land surface etc.
  - Adding new components to core models is challenging as the models are not built in modular manner
  - Information relevant for some impact sectors are limited

TerraDT responds to these needs by developing **new Digital Twin components (DTCs), impact models** and **modular software infrastructure**

 **Enhanced DestinE infrastructure** providing more reliable and relevant information for climate adaptation and mitigation!

# Why new LandSurface DTC?

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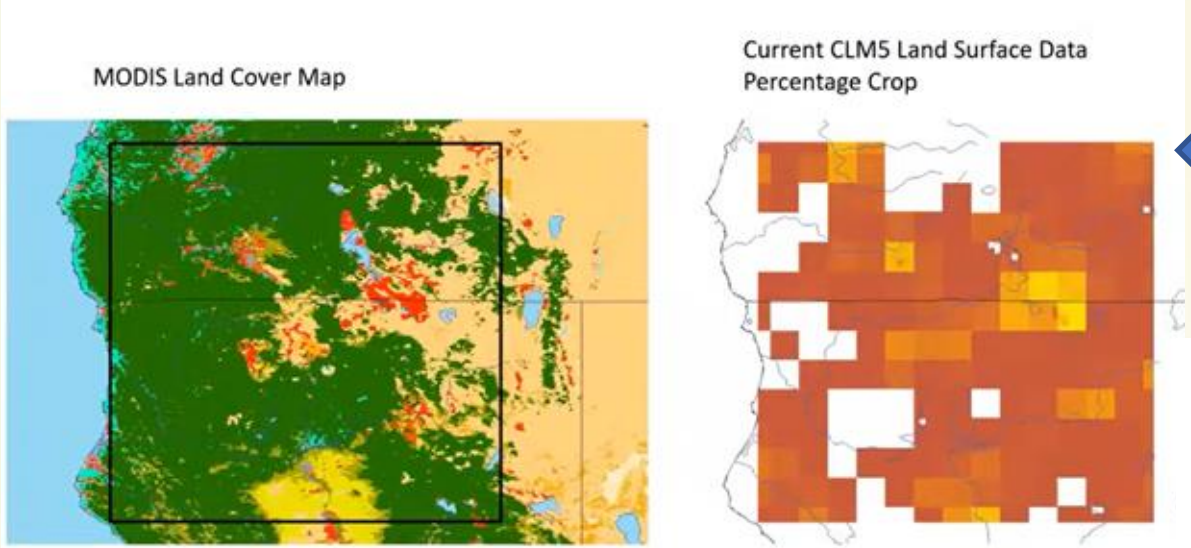
**Relevant to Urban IM workshop !**

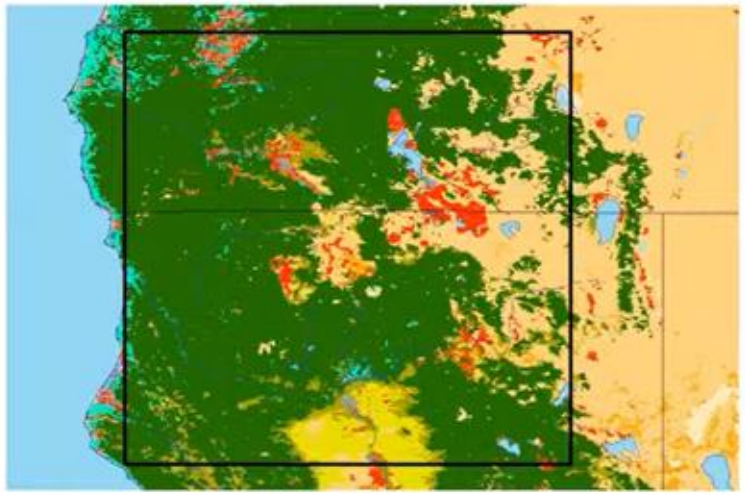
## CMIP Climate Models Land types representation

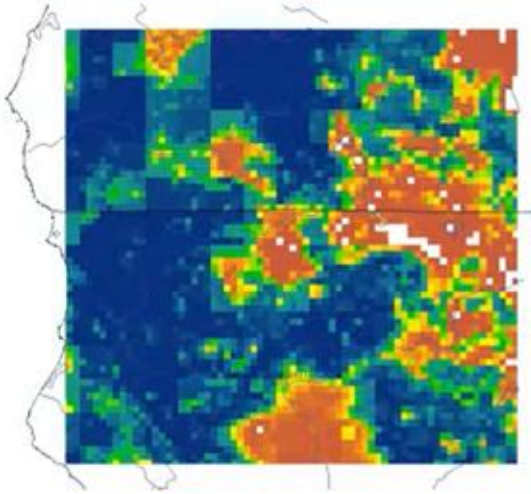



**Coarser resolution**

**Fine resolution**

## Integrating Land Data To Represent Land Use in CLM5



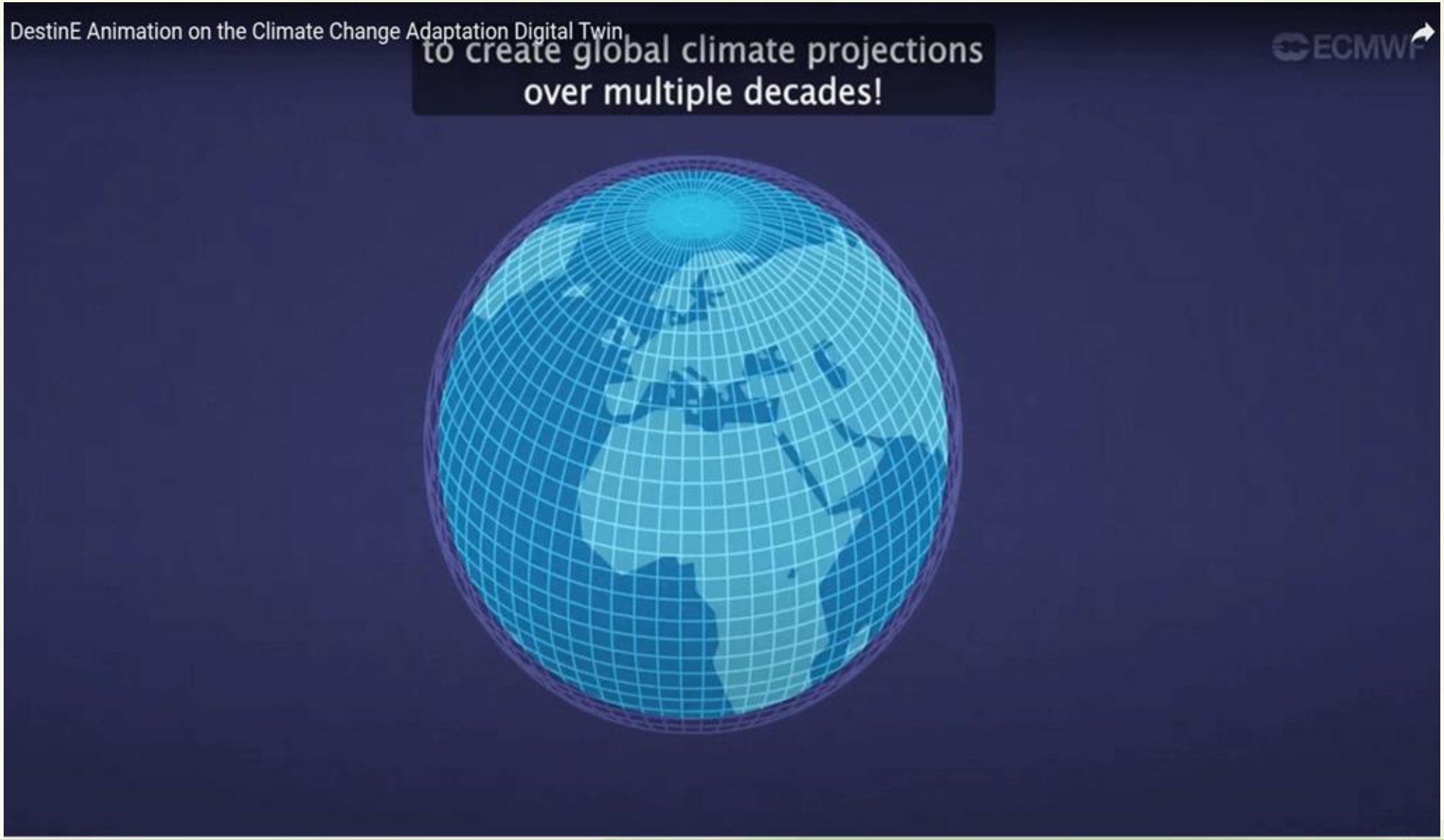




*Lawrence et al LMWG presentation (2022)*

# DestinE Climate DT implemented by ECMWF

**Reliable, high-resolution information on regional and local climate impacts**

**is crucial for effective climate change adaptation and mitigation strategies**

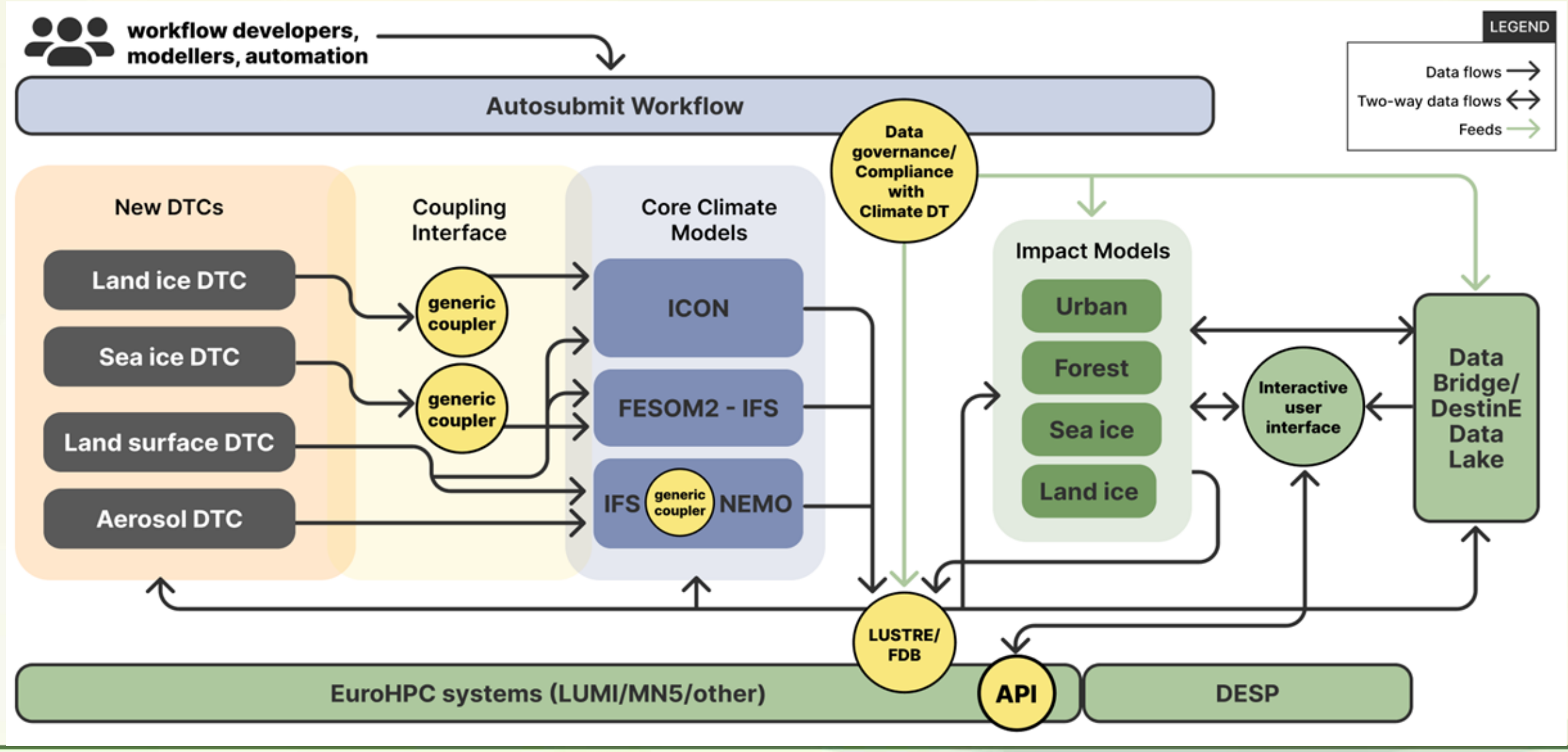


# Primary Objectives of TerraDT

- **Modular & Interoperable Platform –** we're extending ClimateDT using portable, plug-and-play Digital Twin Components (DTCs)
- **Improve Climate Projections & Impact Assessments**
  Enhance representation of cryosphere and land-surface processes and integrate AI/ML-based models for more accurate and actionable climate insights.
- **Strengthen User Engagement & Accessibility**
  Interactive interfaces and impact models to deliver user-oriented information and foster adoption by scientific, public, and private stakeholders.
- **Ultimately, Advance the DestinE's Vision**
  Expand the interoperable and interactive DestinE (ClimateDT) ecosystem to support more effective climate adaptation and mitigation strategies.


*AI generated image (copilot)*

# TerraDT Software Architecture



# DTCs Enhances Capabilities of DestinE core climate models

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Land Ice DTC - ICON

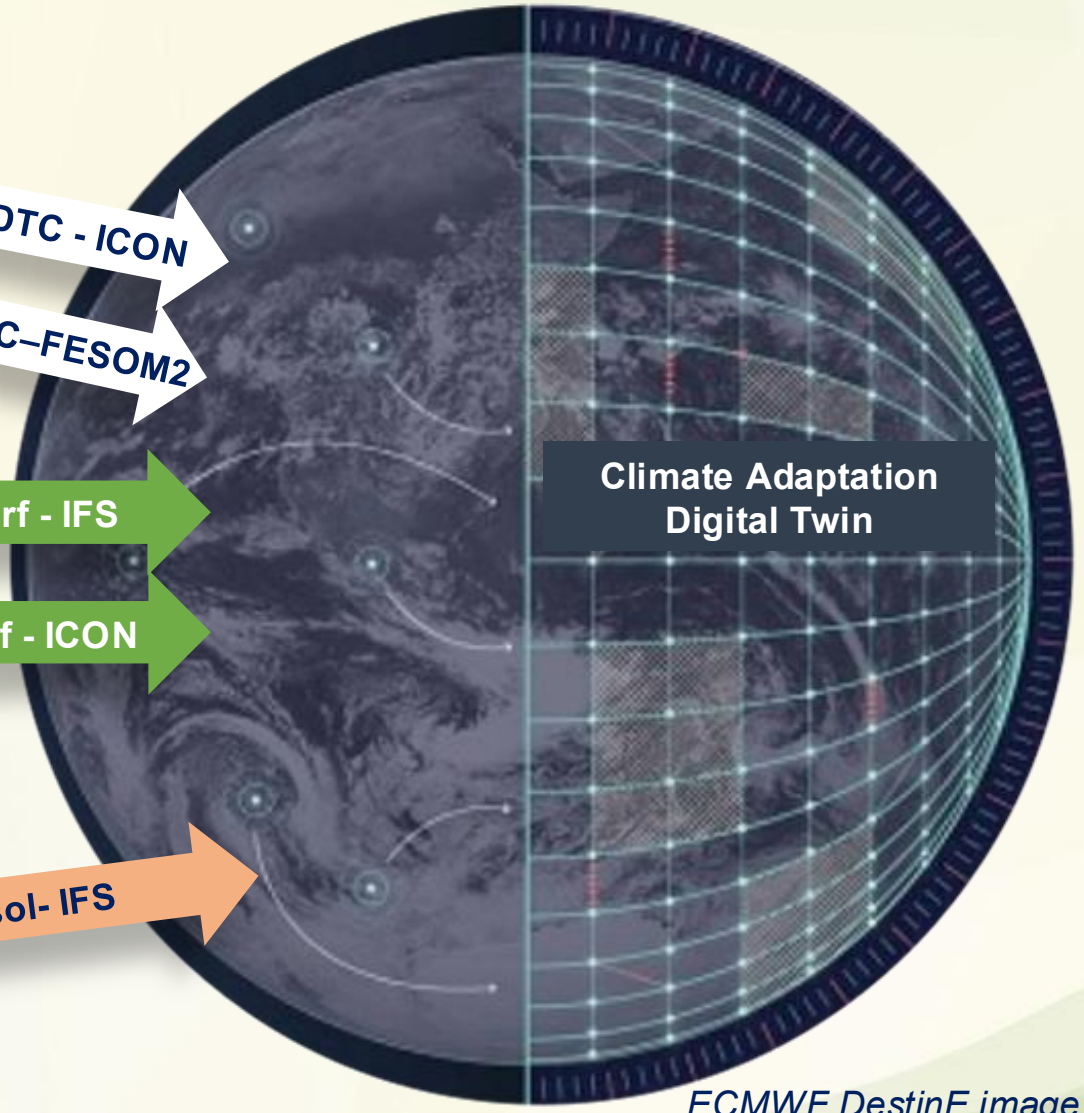
Sea Ice DTC–FESOM2

LandSurf - IFS

LandSurf - ICON

*AI generated Earth images*

Aerosol- IFS



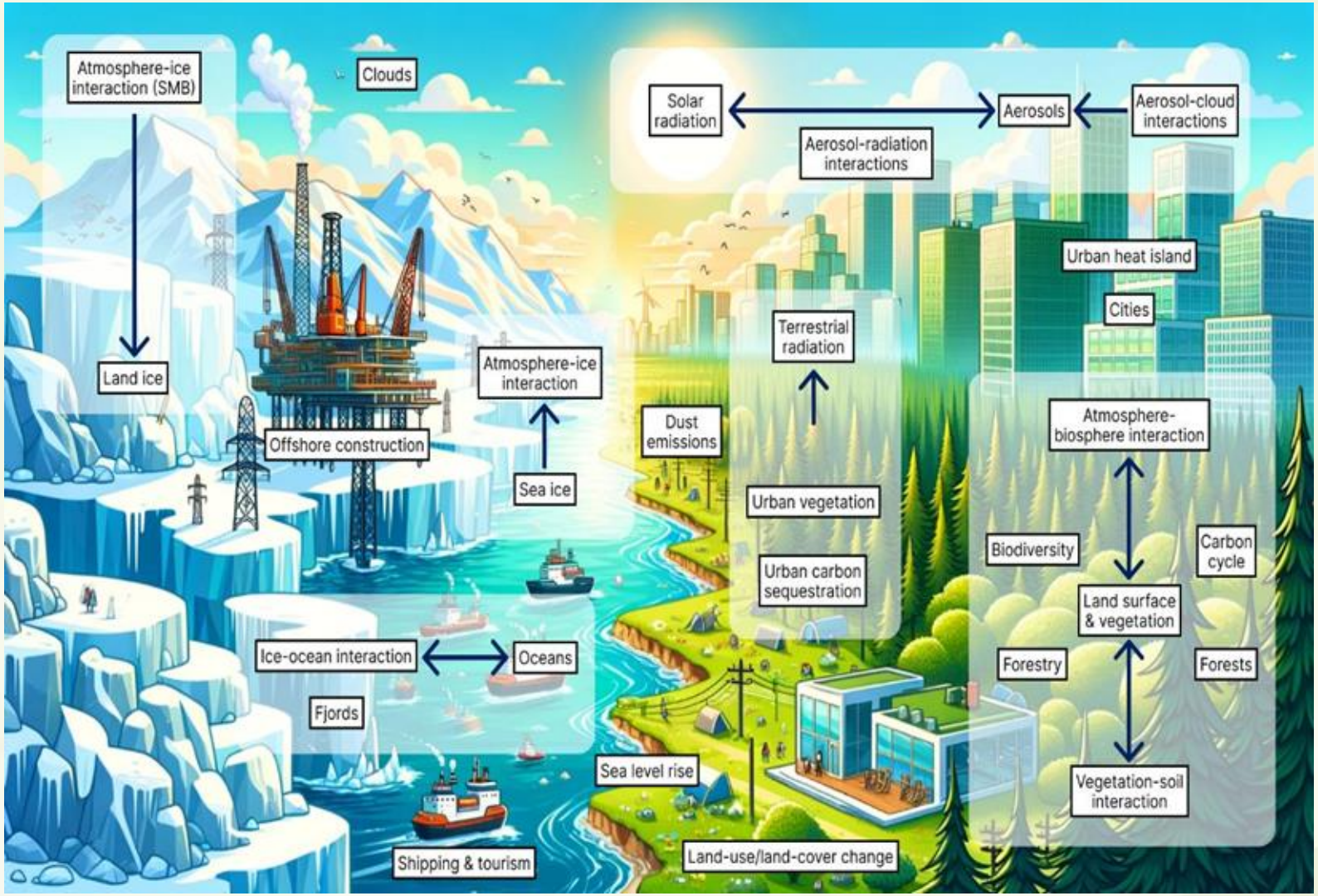

*ECMWF DestinE image*

**Improved feedbacks between land-ice and atmosphere**

**Improved land-atmosphere feedbacks**

**Improved or efficient computation of aerosol-cloud interactions**

# Expanding DestinE Capabilities to Explore new Impact sectors




Sea-level rise from tidewater glaciers

Informed decisions in marine infra, and maritime navigation etc.

Urban planning, Forest managment

# DestinE-Compliant Software Infrastructure

- DestinE core Climate Models software

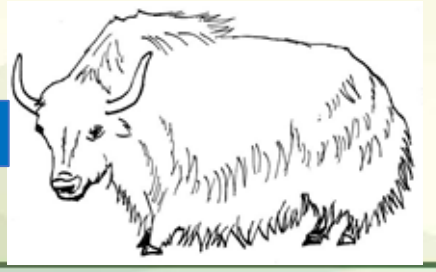
ICON IFS-NEMO IFS-FESOM

- Workflow infrastructure compatible: *seamless integration with existing systems*

- Computing infra- EuroHPC machines

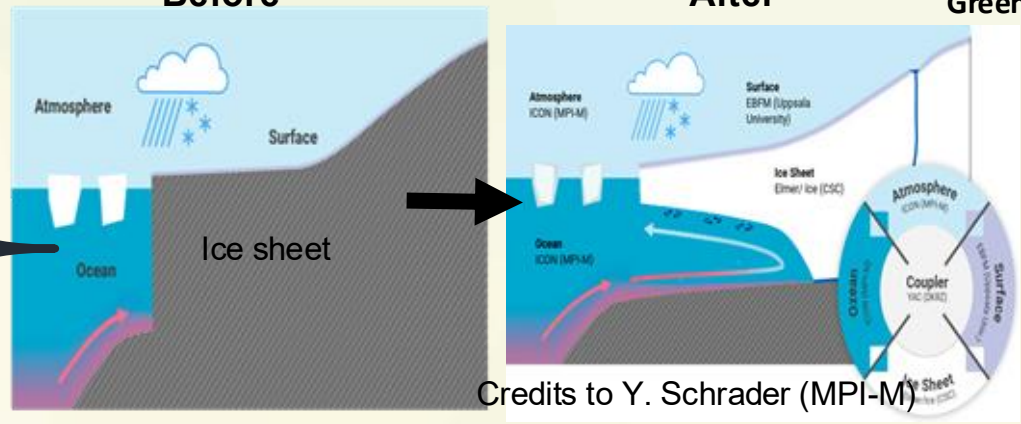

- Generic coupling Interface*: scalable, interoparable and portable solution for expanding DestinE DTs*

YAC

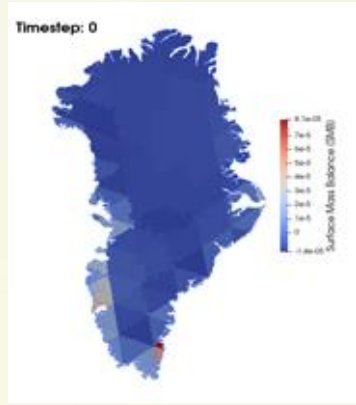


# One Year ON – Progress highlights

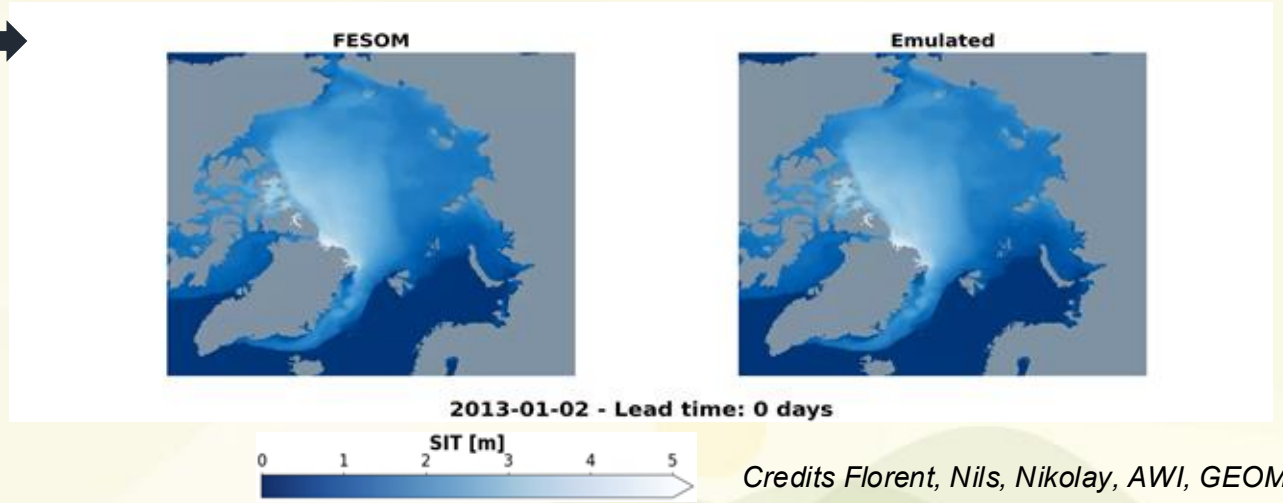
- **Generic coupling interface:** Strengthened modularity and interoperability by maturing YAC-based coupling interface
- **LandIce DTC:** Prototype coupling established between Elmer/Ice and ICON via YAC coupler.




Credits to Y. Schrader (MPI-M)



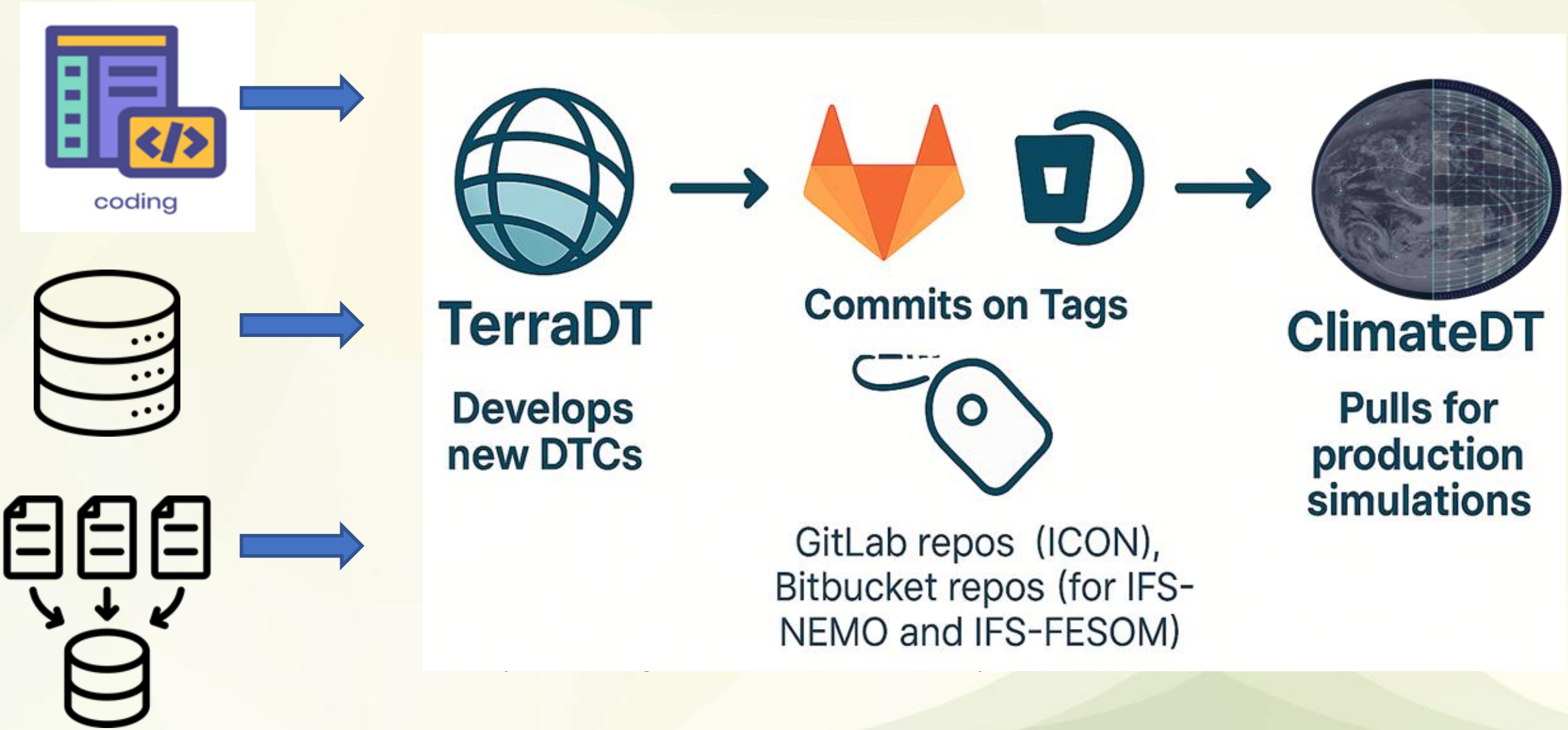

- **Sea-Ice DTC:** Decoupling sea-ice from FESOM and AI based sea ice emulator tested for 7yr rollout.




*Credits Florent, Nils, Nikolay, AWI, GEOMAR*

- **Aerosol DTC:** A simplified aerosol model (HAM-LITE) tested and integrated into (open) IFS model.
- **LandSurface DTC:** ML based Dynamic vegetation model work is underway
- Progress has also been made in advancing **impact modelling** capabilities and **User Interface**. **Forest, Urban, Sea Ice and Land Ice**

# Envisioned integration with the DestinE infrastructure



# Climate models and coupler integration

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**Developments in TerraDT** → **Operational ClimateDT**

Land Ice DTC

Generic coupling Interface (YAC)

Land surface DTC

ICON

IFS

Sea Ice DTC

Generic coupling Interface (YAC)

FESOM

AI Sea Ice emulator

Land surface DTC

Aerosol DTC

NEMO

Generic coupling Interface (YAC)

EuroHPC

*climate models*

GSV

FDB

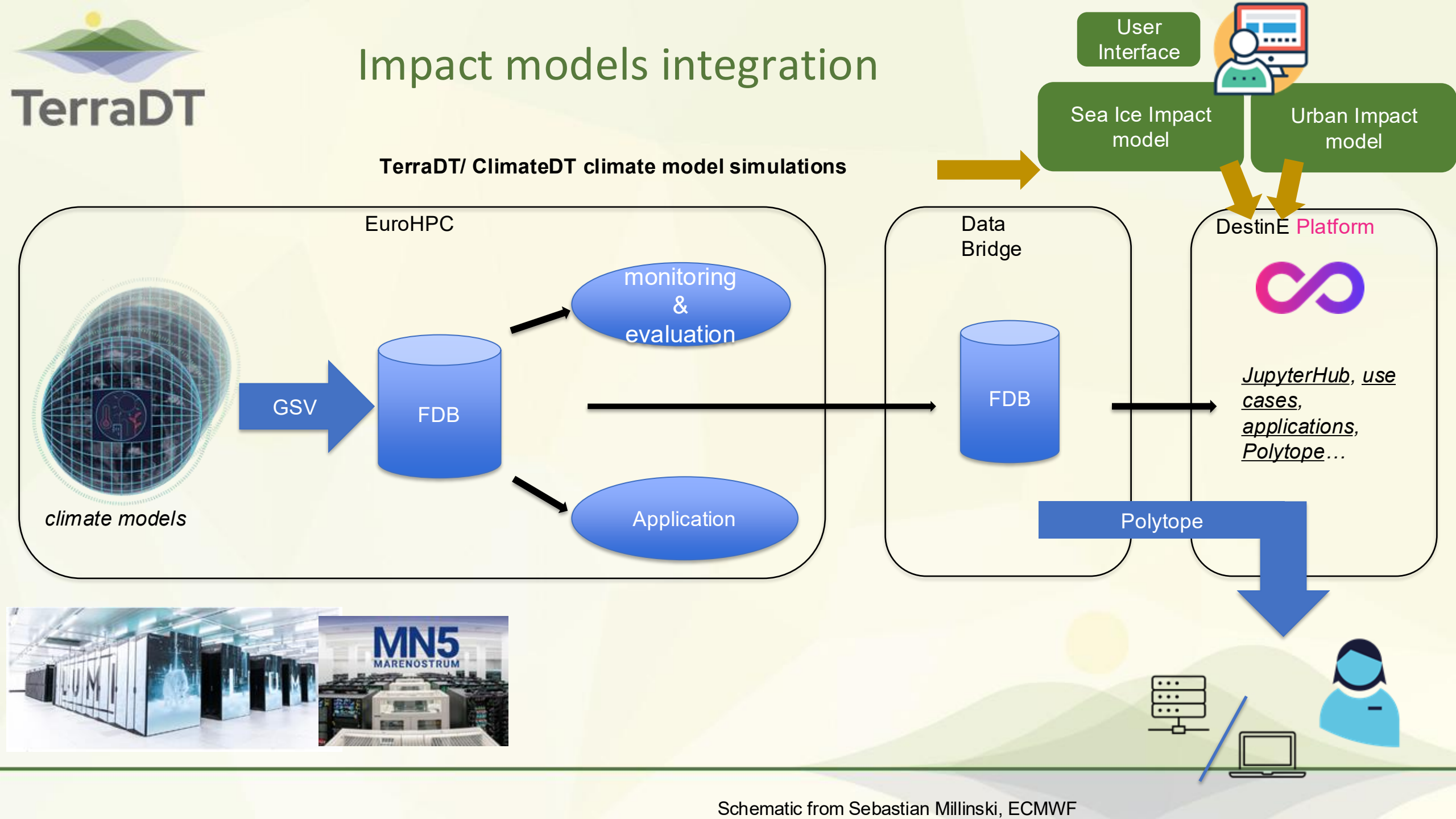
Common format & data governance

Database for grib2 output

monitoring & evaluation

Schematic from Sebastian Millinski, ECMWF

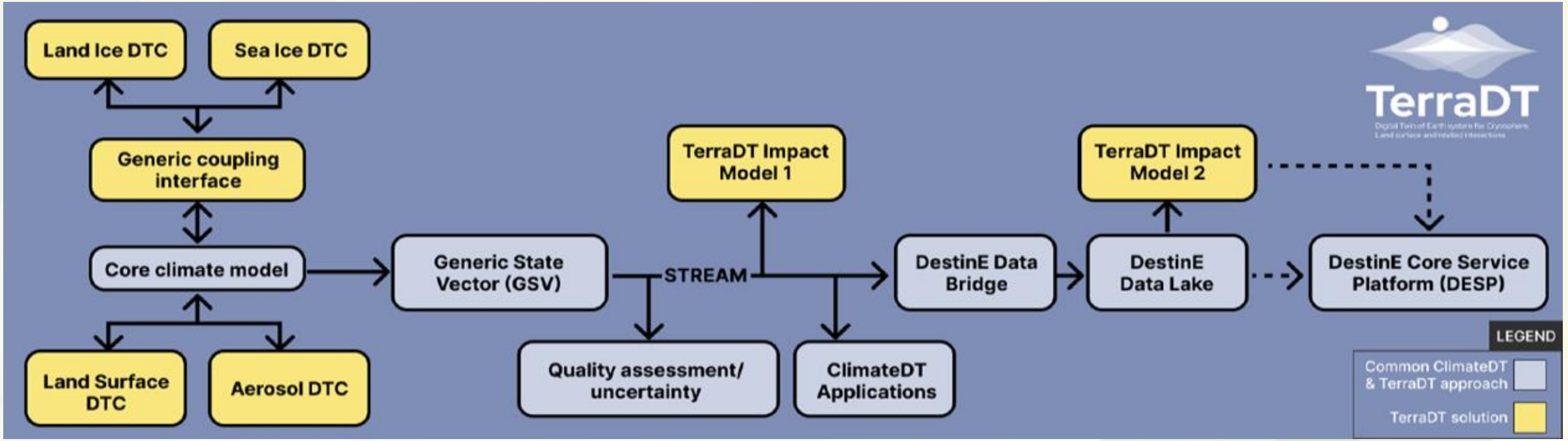
# Impact models integration




Schematic from Sebastian Millinski, ECMWF

# Integration of TerraDT components to DestinE

- TerraDT builds on DestinE Climate DT approach and adds new technical and scientific capabilities.



# Looking Ahead – TerraDT outcomes

- Full coupled climate models including new DTCs - enhanced version of Climate DT
- Multi-decadal coupled simulations with the new DTCs
- New Impact sector models linked to land ice, sea ice, forests and urban
- Generic coupling interface developed
- Model performance improvements and data governance & workflow solutions compatible with DestinE
- Strengthens partnerships and expands DestinE capabilities to new impact sectors (e.g. Agriculture, sea level rise and maritime navigation etc.).

# Take away message

TerraDT will mark a significant leap forward for DestinE by enhancing the DestinE infrastructure with new scientific and technological capabilities

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Digital Twin of Earth system for Cryosphere, Land surface and related interactions

# THANK YOU


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State-of-the-art capabilities of the Urban Impact Model

# Liisa Kulmala

*(Finnish Meteorological Institute)*

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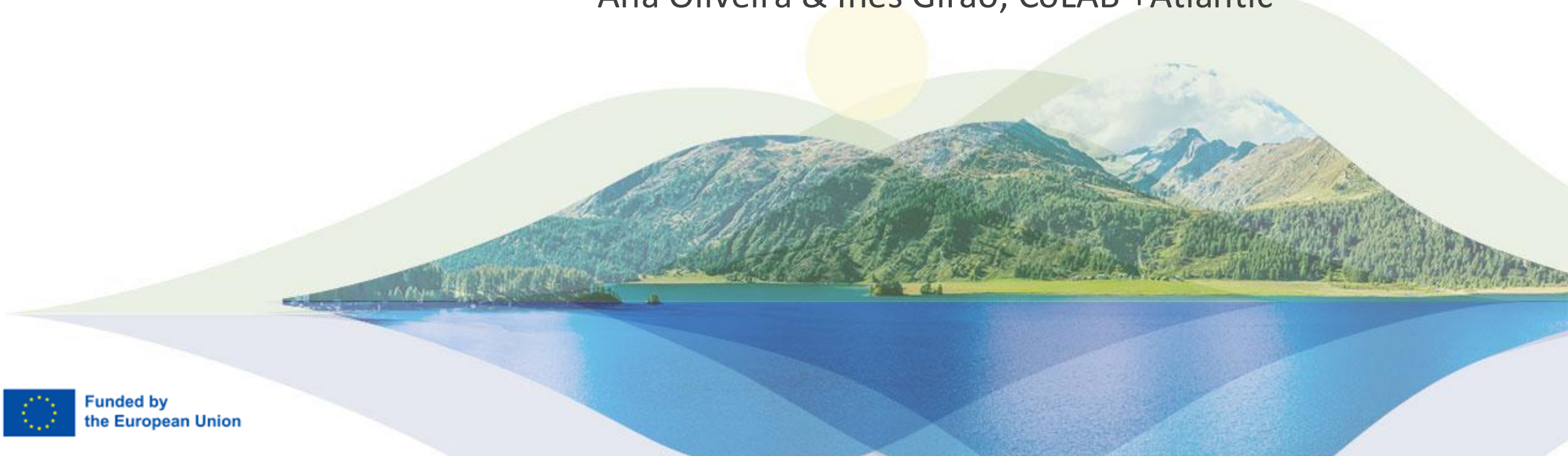
Digital Twin of Earth system for Cryosphere, Land surface and related interactions

# Context and State-of-the-Art for Urban Impact Modelling

Liisa Kulmala, Finnish Meteorological Institute

Ana Oliveira & Inês Girão, CoLAB +Atlantic



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# What do cities, planners and residents expect from urban nature?

**Residents**

- Cooler, greener, healthier neighbourhoods
- Access to nature & recreation
- Access to shade

**Cities**

- Climate resilience: heat, drought & extreme weather
- Cooling (Health + lower energy demand)
- Progress toward carbon neutrality
- Cost-effective climate solutions

**Planners**

- Reliable, scalable data & models
- Tools for carbon & cooling scenarios
- Evidence for different choices (species/soil)
- Integrating NBS into zoning & design

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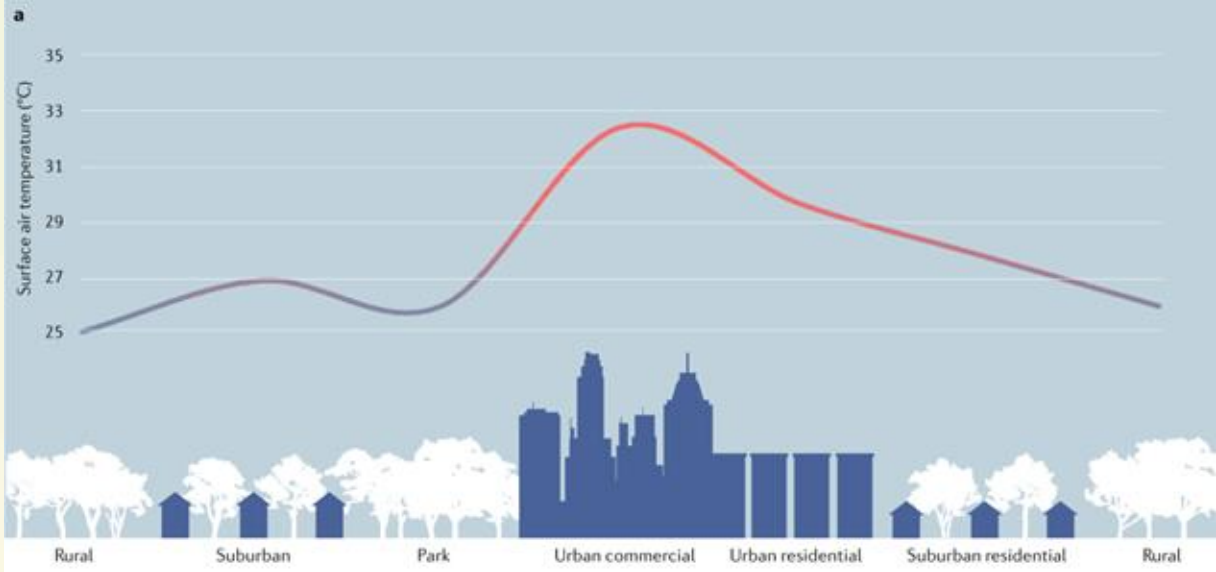
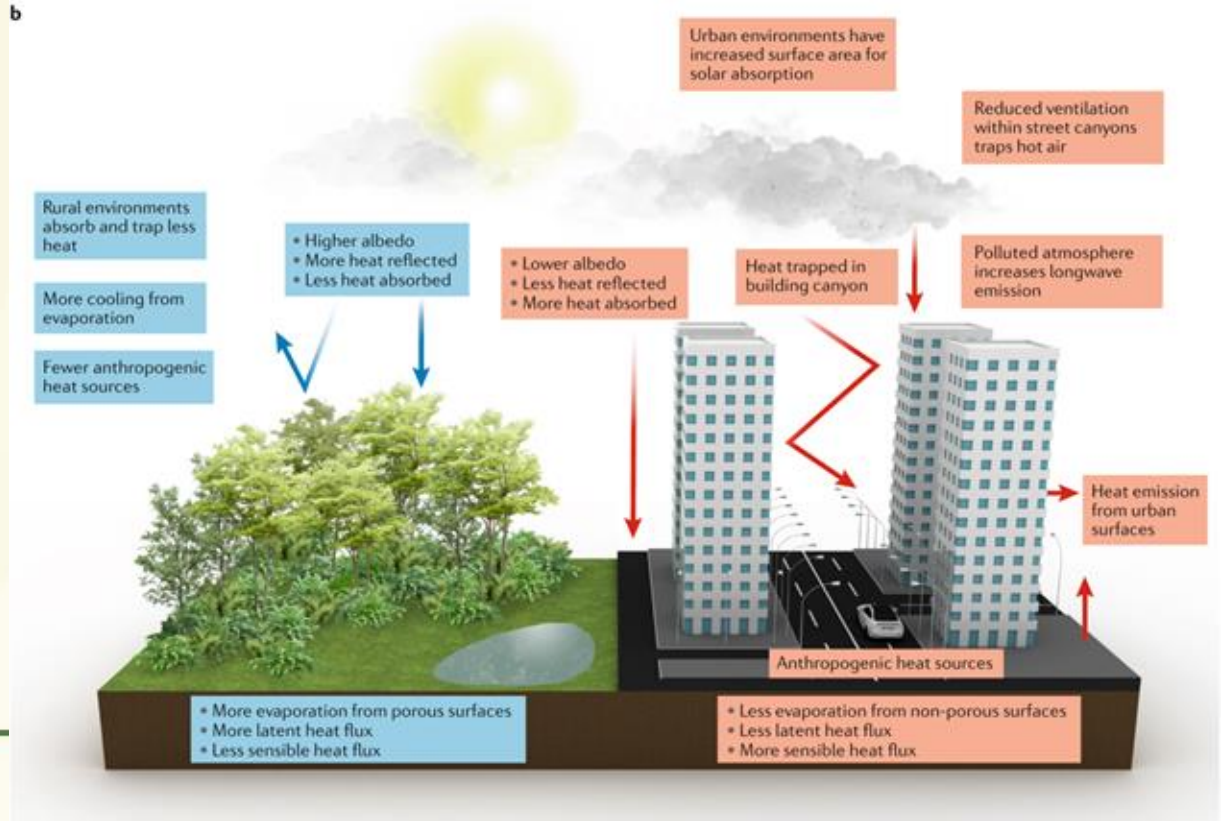
# Urban characteristics affect urban heat

Climate and Environmental Hazards are LOCAL
Their monitoring and forecast IS NOT

Currently, weather, climate and environmental monitoring lacks spatial detail

✓ **OK** regarding **WHEN**
! **NOK** regarding **DETAIL**



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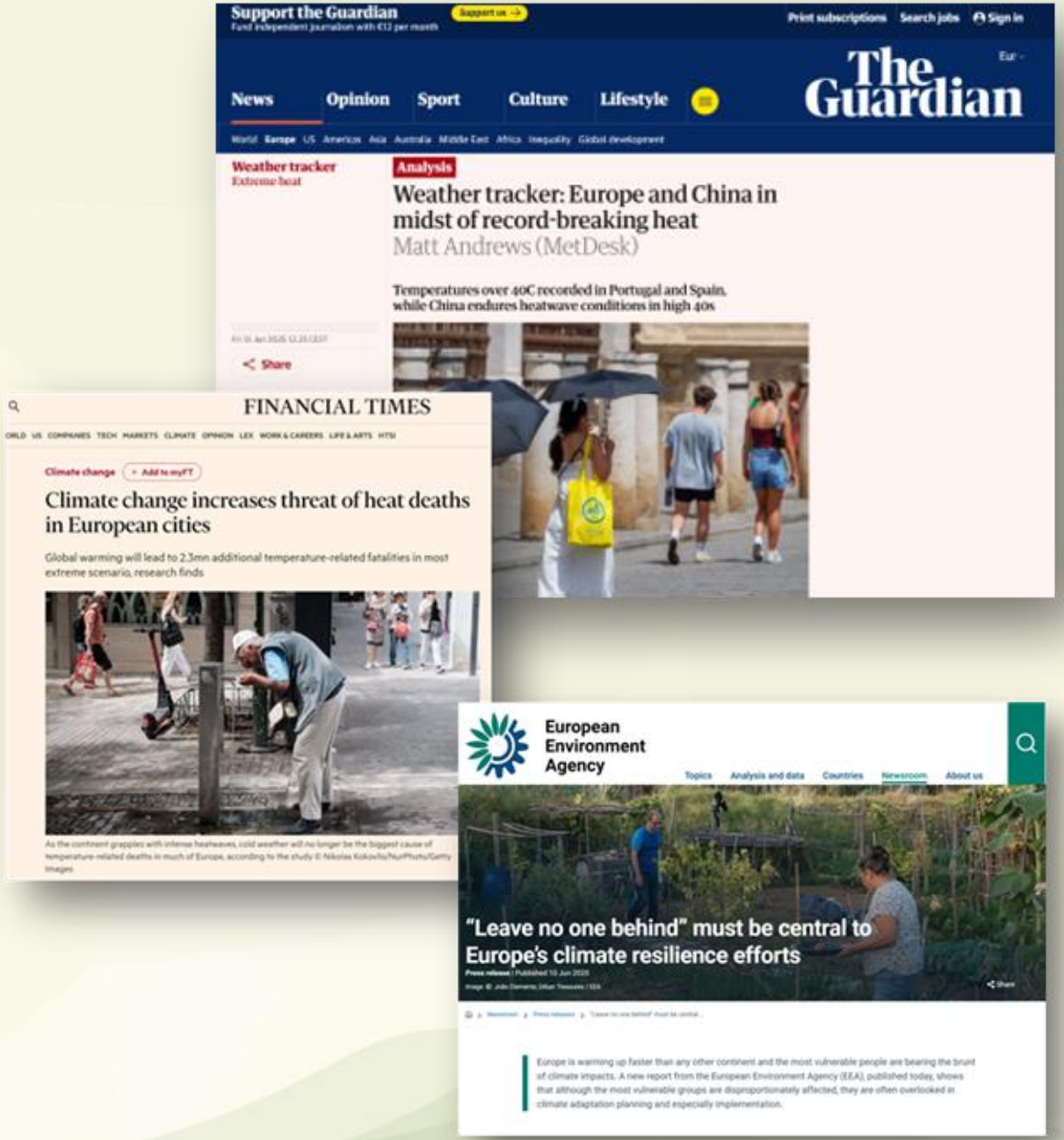


✓ **OK** regarding **WHEN**
! **NOK** regarding **DETAIL**

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# State of the art in science and in practice: ML for Urban Climate Prediction

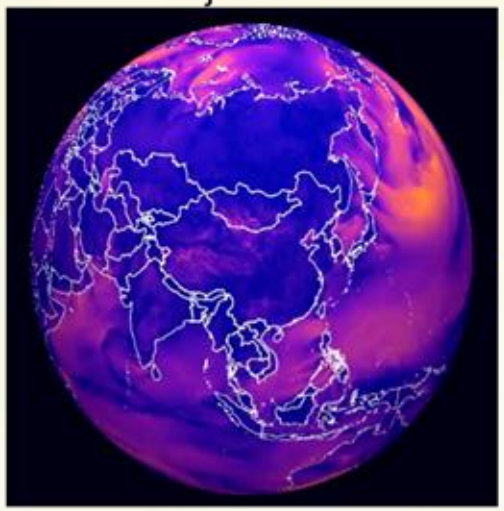
**Observations**

Sensors, IoT, Crowdsourcing

=

**Synoptic (Background) Weather**

Reanalysis, Forecast and Climate Projections



+

**Local (Time-Fixed) Predictors**

Landscape and Urban Features

**Topography**

Terrain, Topographic Wind Exposure

**Green Features**

Vegetation Density and Type, Phenology

+

**Urban Features**

Urban Density, Imperviousness, Sky View Factor

**Blue Features**

Proximity to the Coast or Large Water Bodies

+

**Machine Learning**

Domain-Informed Data-driven Downscaling

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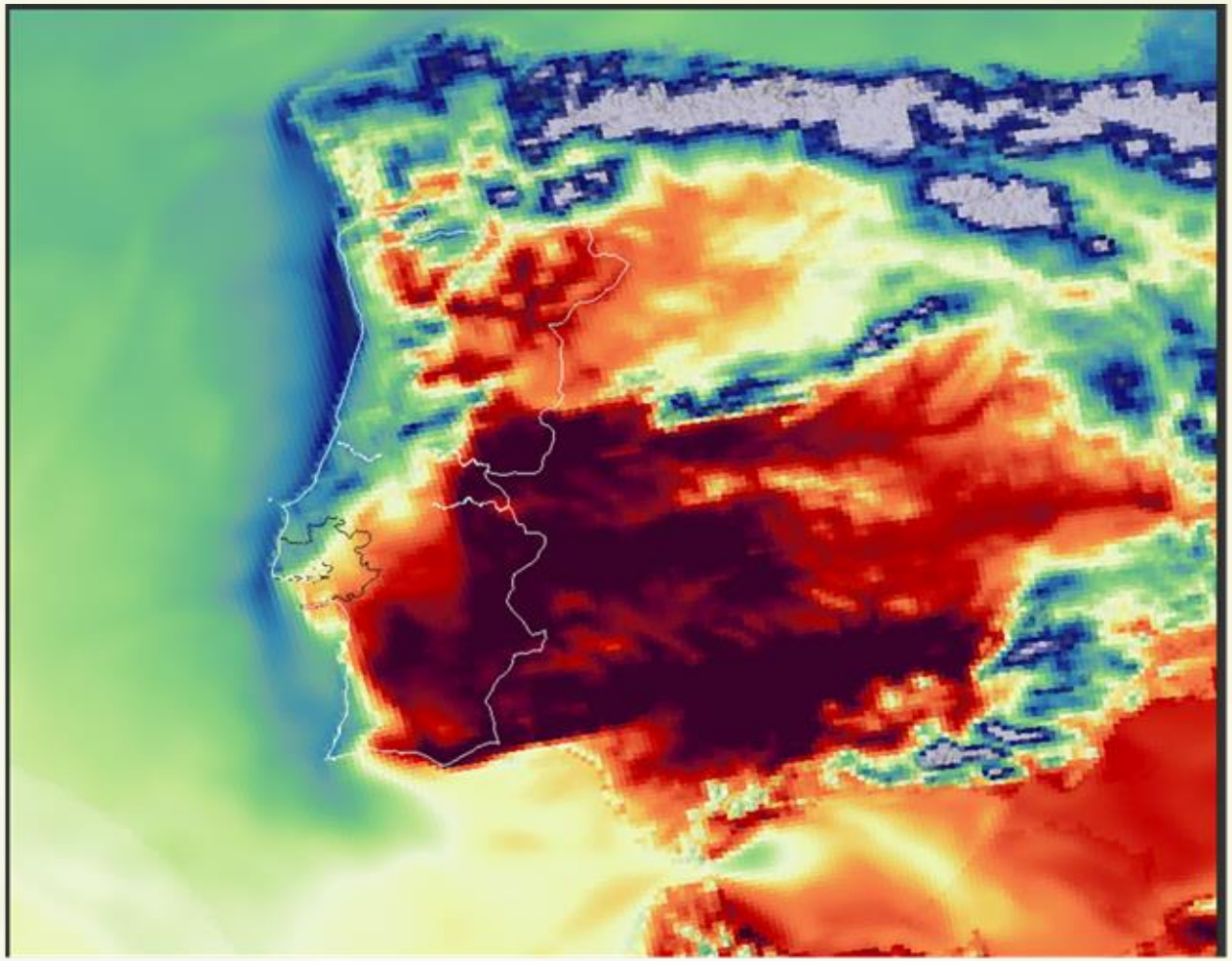
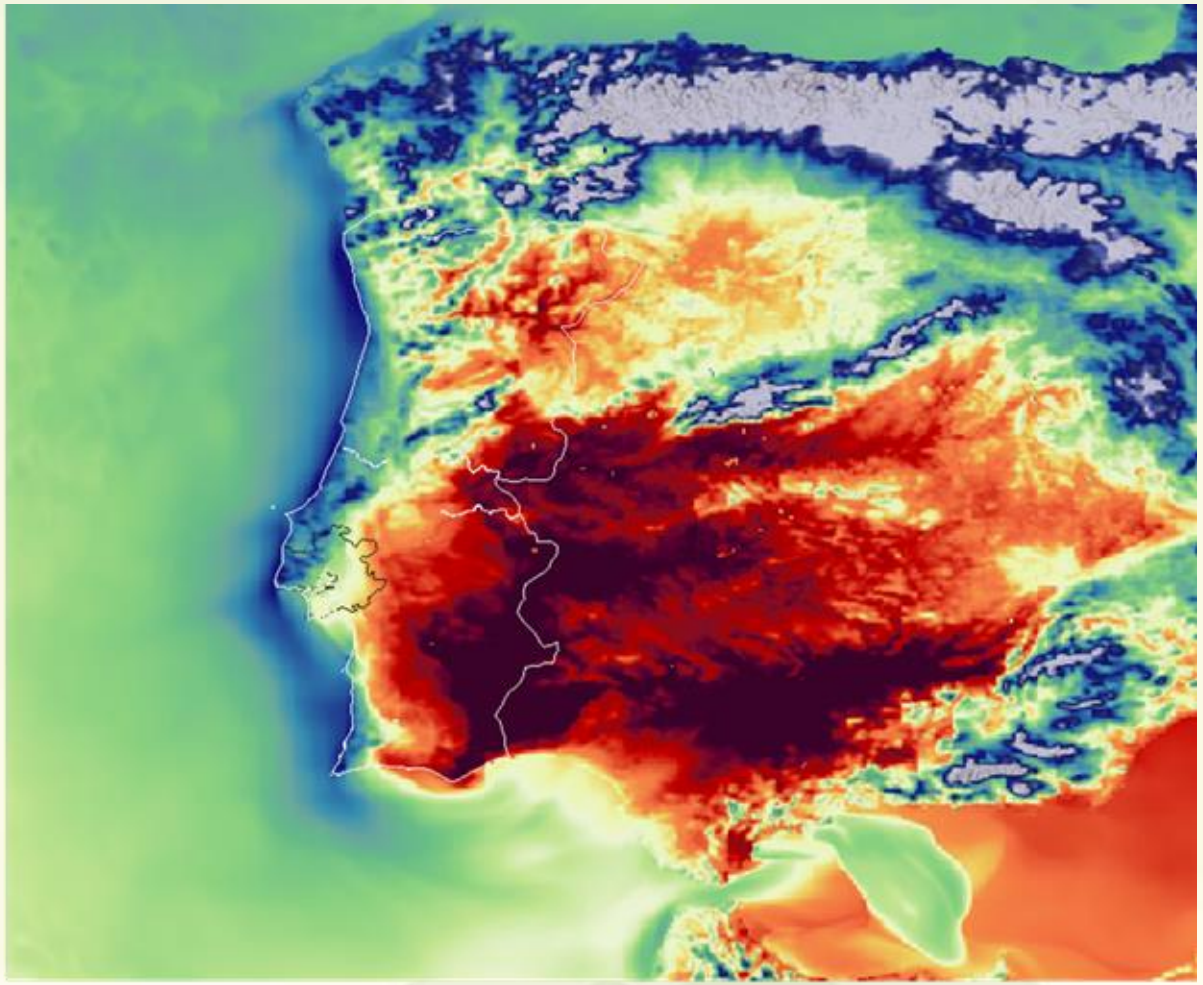
# State of the art in science and in practice: ML for Urban Climate Prediction



CERRA (0.05x0.05º)



AROME - IBI (0.025x0.025º)

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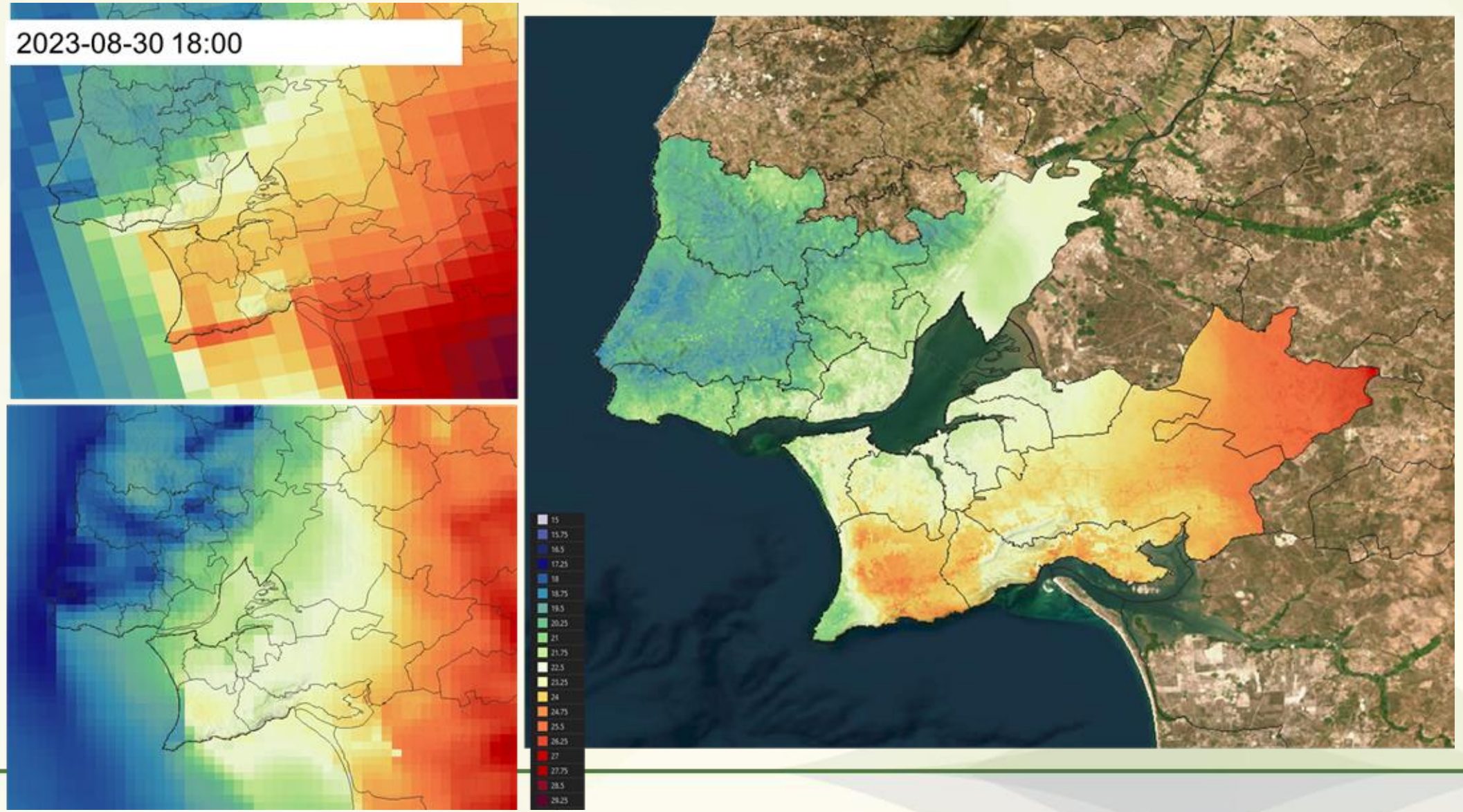
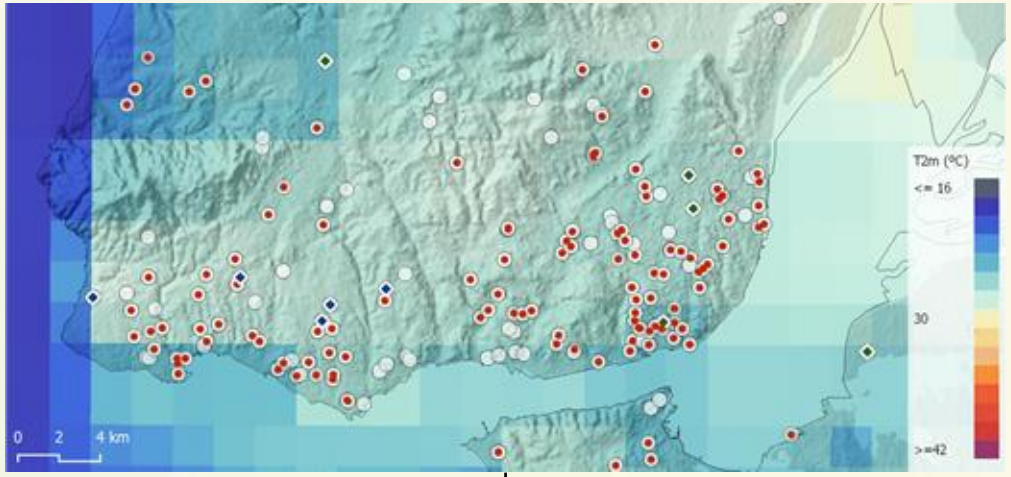
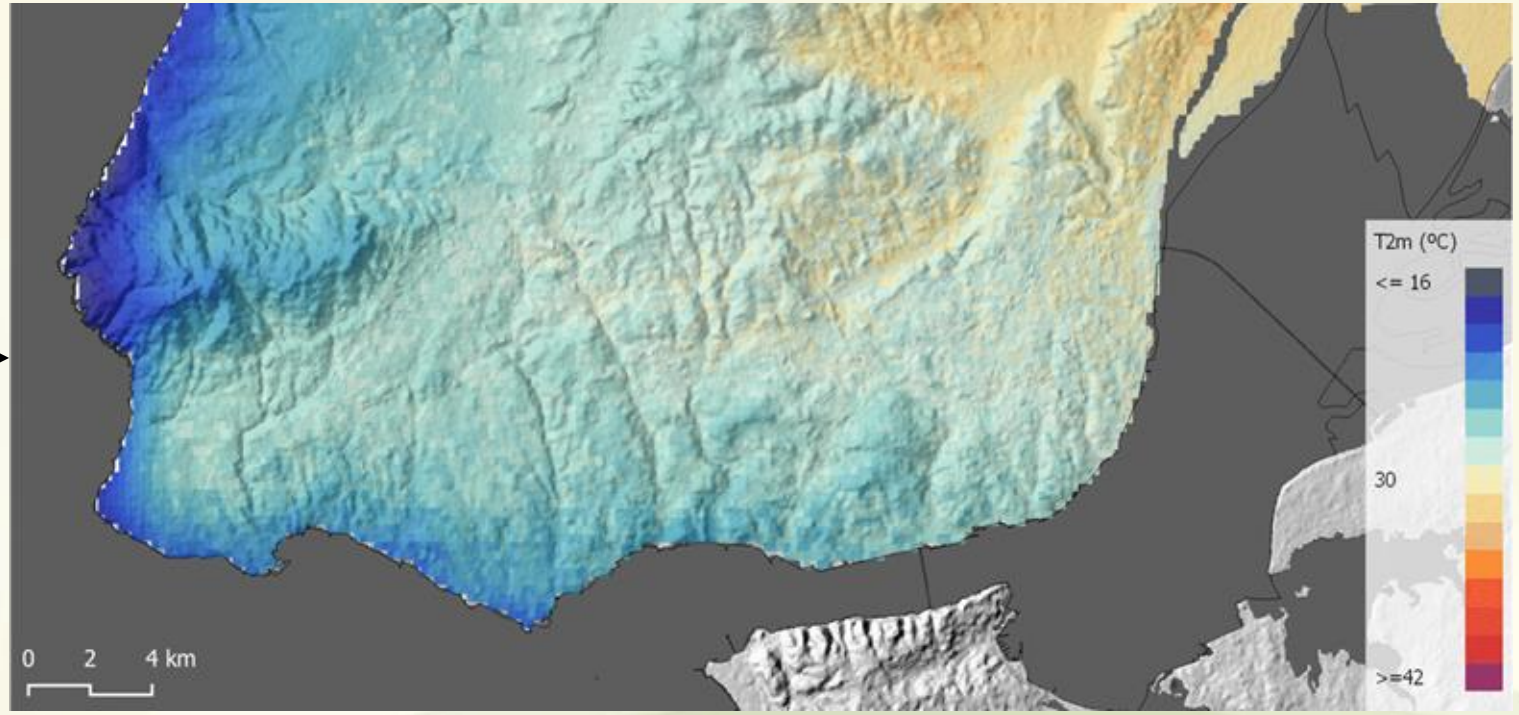
# State of the art in science and in practice: ML for Urban Climate Prediction

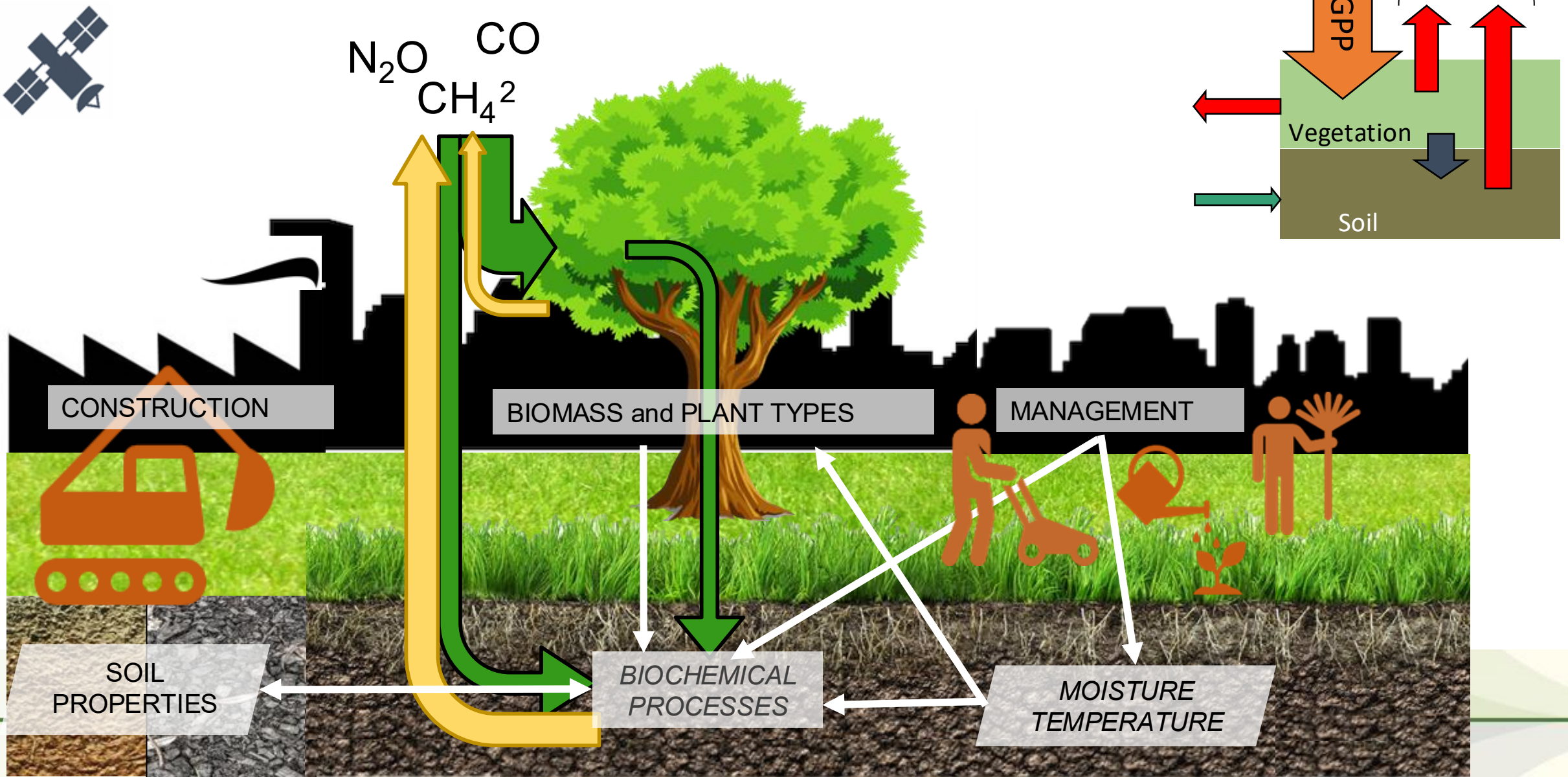


# State of the art in science and in practice: ML for Urban Climate Prediction



# Urban nature & Carbon cycle



# Measurement campaigns in Helsinki, Zurich, Munich and Paris

## Otaniemi

Lawn (EC)

## Viikki

Meadow

Lawn

## Kumpula

Orchard

Park

Forest

Street trees

Meadow

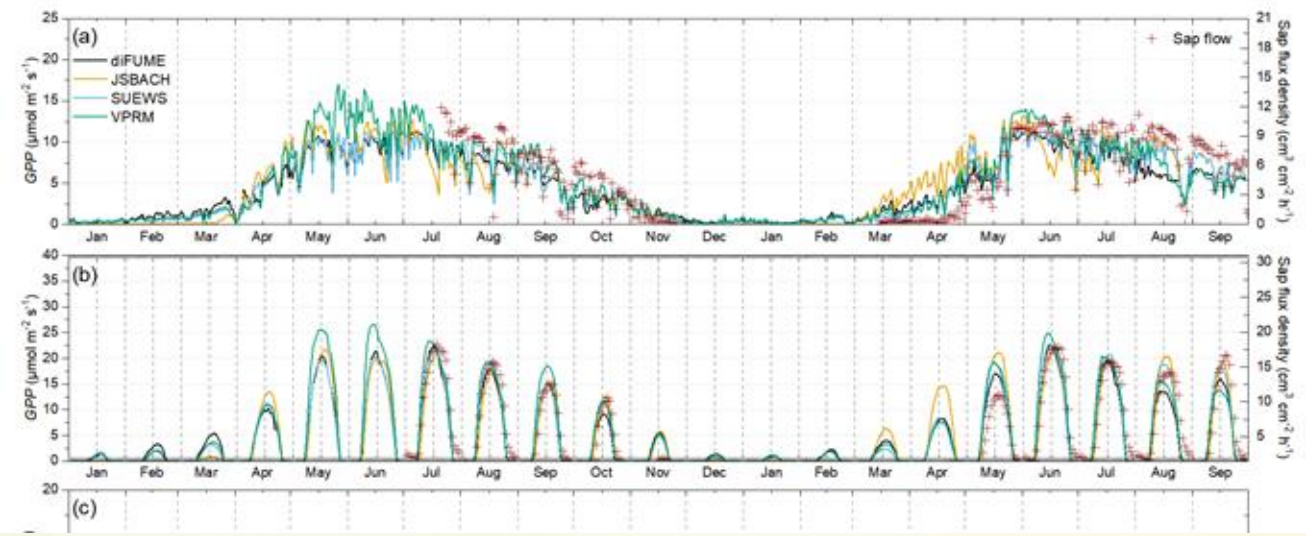
Aerial photo: National Land Survey of Finland (2023)

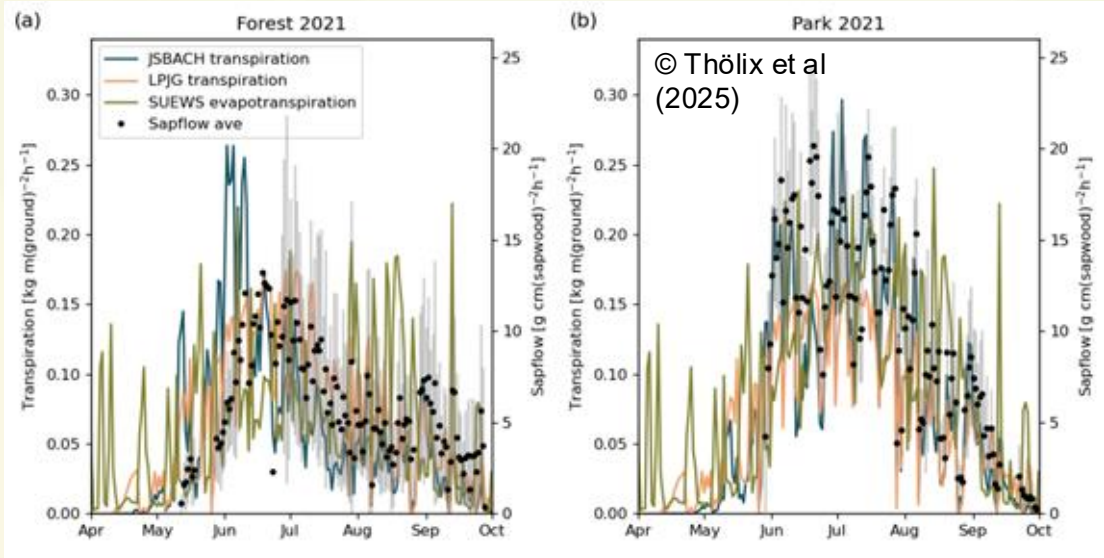
Photos: Esko Karvinen, Yasmin Frühauf, Jesse Soininen

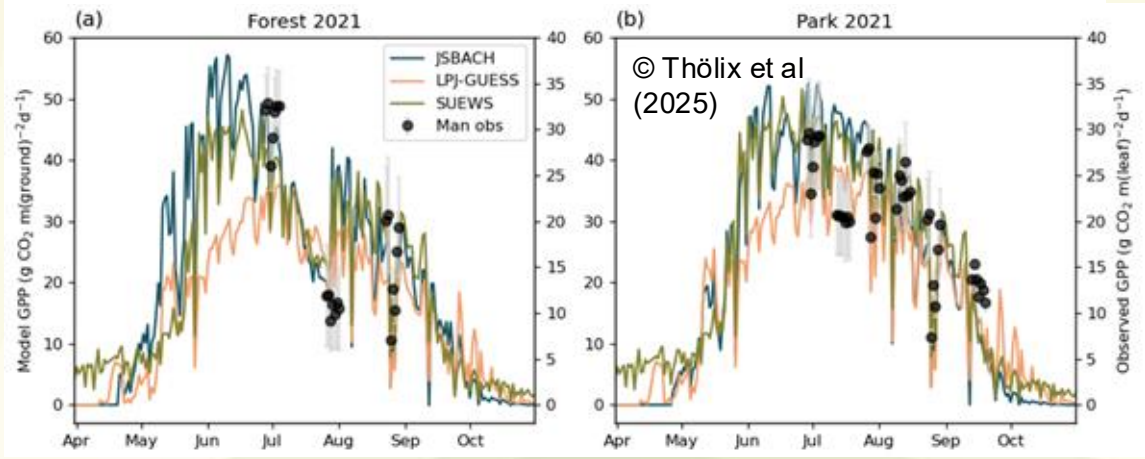
Photos: Esko Karvinen
Yasmin Frühauf

- C storage
- $CO_2$ exchange
  - Components
  - EC
- Chl. fluorescence
- Transpiration
- Growth dynamics
- Roots longevity
- Meteorology + soil
- Satellites: LAI + SIF

# Model testing and development with the observations





Stagakis S et al. (2025): Intercomparison of biogenic CO2 flux models in four urban parks in the city of Zurich, Biogeosciences, 22, 2133–2161, https://doi.org/10.5194/bg-22-2133-2025

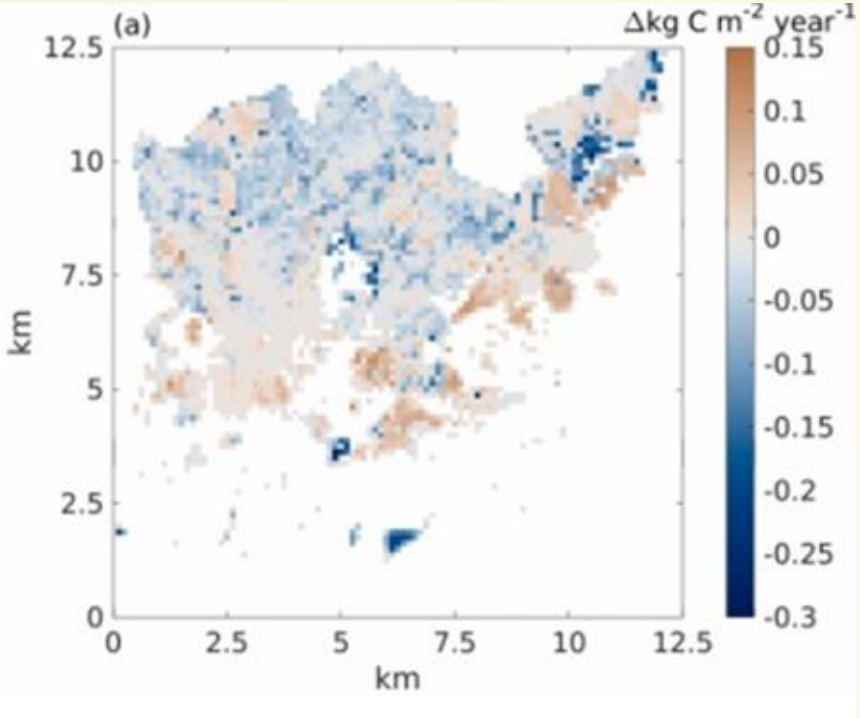
Thölix L et al. (2025): Carbon sequestration in different urban vegetation types in Southern Finland, Biogeosciences 22, 725–749, https://doi.org/10.5194/bg-22-725-2025

Karvinen E et al. (2024) Soil respiration across a variety of tree-covered urban green spaces in Helsinki, Finland. Soil, 10, 381–406 https://doi.org/10.5194/soil-10-381-2024

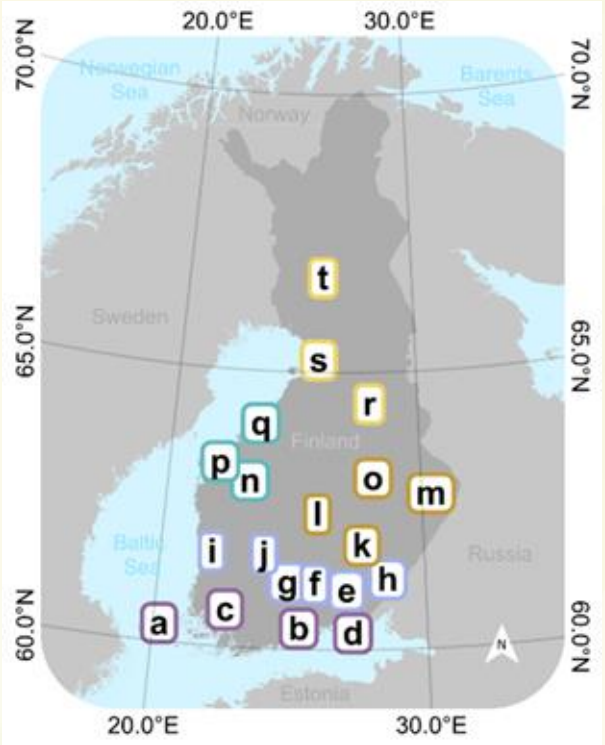
Havu M et al. (2024) CO2 uptake of urban vegetation in a warming Nordic city. Urban Forestry & Urban Greening. Article ID 128261. https://doi.org/10.1016/j.ufug.2024.128261

Trémeau J et al. (2024) Lawns and meadows in urban green space – a comparison from perspectives of greenhouse gases, drought resilience and plant functional types, Biogeosciences, 21, 949–972, https://doi.org/10.5194/bg-21-949-2024

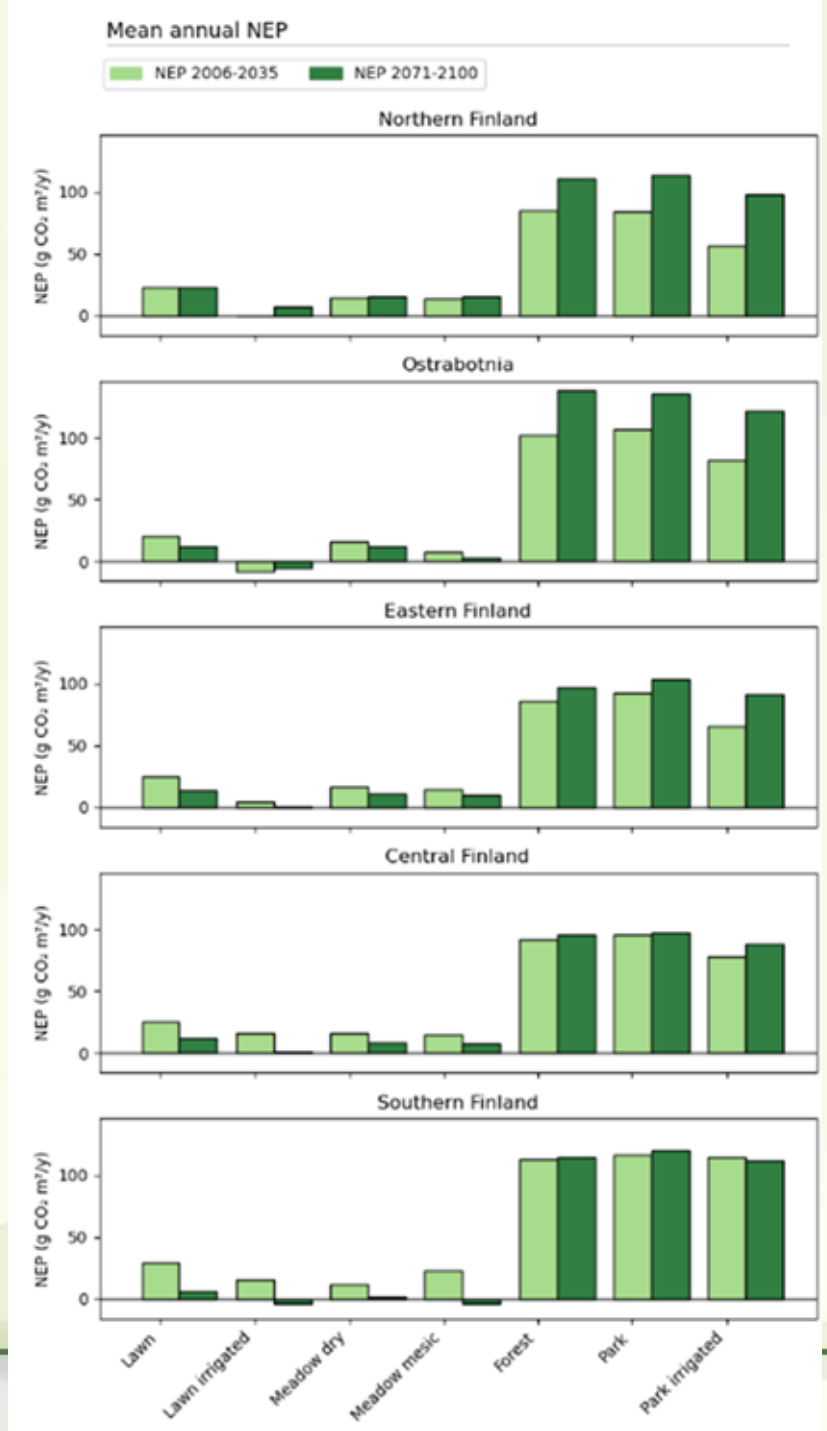
# Scaling in space and time




Havu M, Kulmala L, Lee HS, Saranko O, Soininen J, Ahongshangbam J, Järvi L (2024) CO2 uptake of urban vegetation in a warming Nordic city. Urban Forestry & Urban Greening. Article ID 128261. https://doi.org/10.1016/j.ufug.2024.128261




Koiso-Kanttila, A., Backman, L., Karvinen, E., Järvi, L. & Kulmala, L. (2026). Future Climate Impacts on Carbon Sequestration Dynamics Across Urban Ecosystem Types in Finnish Cities. Urban Ecosystems (under review).



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Digital Twin of Earth system for Cryosphere, Land surface and related interactions

# THANK YOU

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Overview of the UrbanAIR project

# Jan Mateu

*(Barcelona Supercomputing Centre)*

23 February 2026 | Barcelona [ES]

Funded by the European Union

UrbanAIR

urbanair-project.eu

# Towards a digital twin of the urban atmosphere for decision support

Jan Mateu Armengol

on behalf of
Femke C. Vossepoel, Maarten van Reeuwijk,
Natalie Theewes, Nele Veldeman,
Florence Gignac, Sam Pickard

Funded by the European Union

Funded by the European Union under Grant Agreement number 101188131. Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.

# URBAN simulation for AIr quality and heat Resilience strategies

**Climate adaptation**

- Urban heat and other extremes
- Wind comfort

**Urban planning and design**

- High- versus low-rise
- Green spaces
- Mobility choices

**Hazard response/ Health**

- Evacuation toxic gases
- Crowd control
- Air quality

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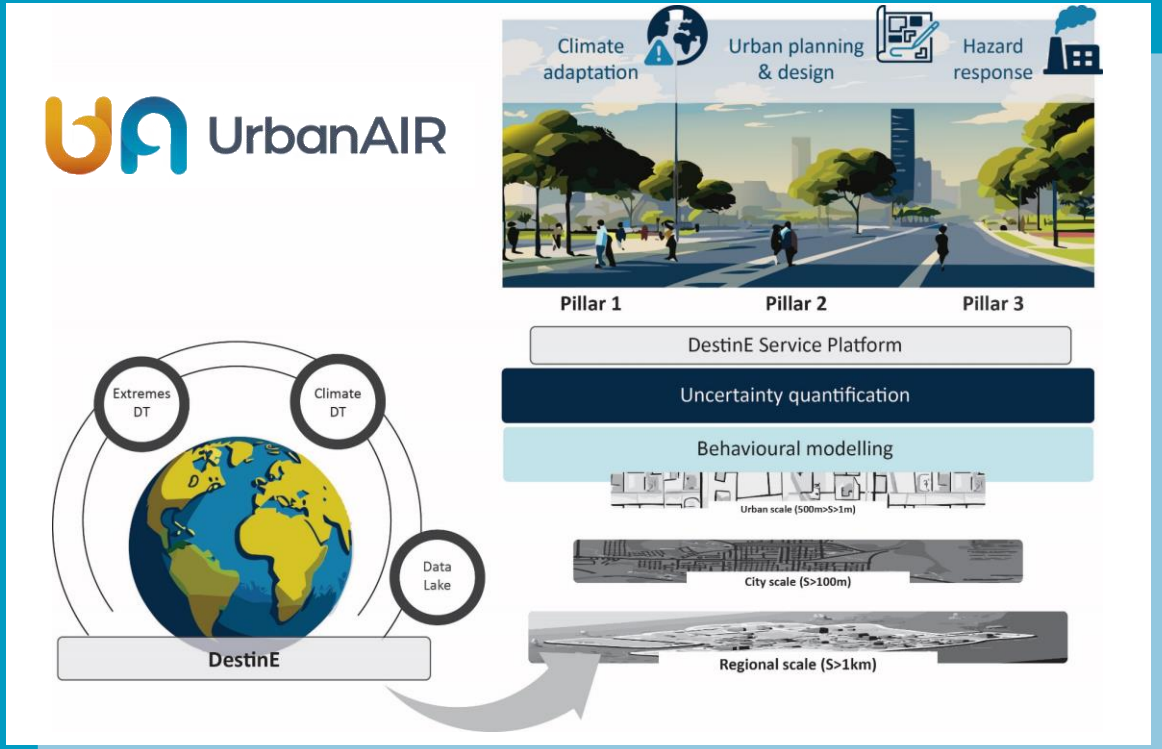


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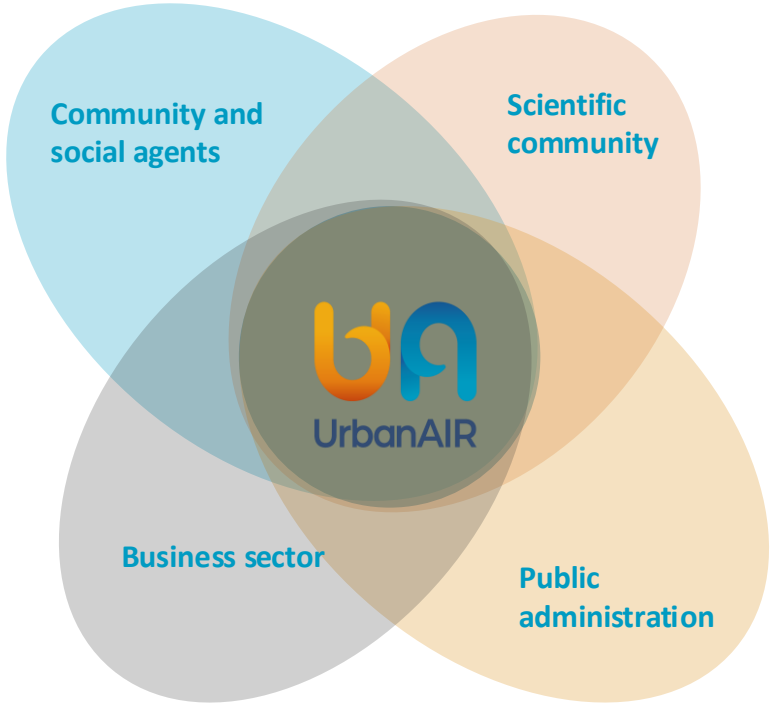
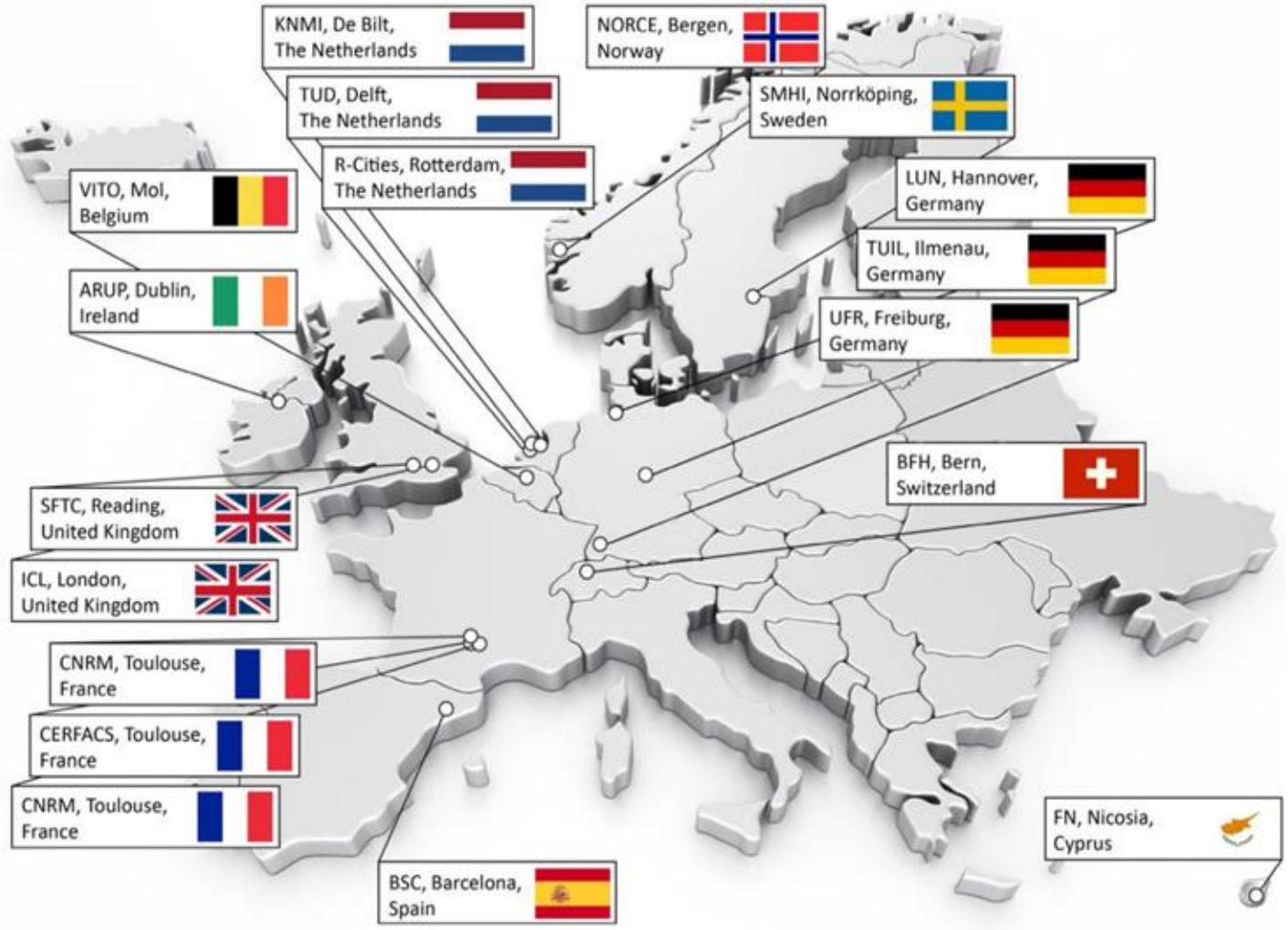
# UrbanAIR collaboration




Funded by the European Union

# UrbanAIR collaboration

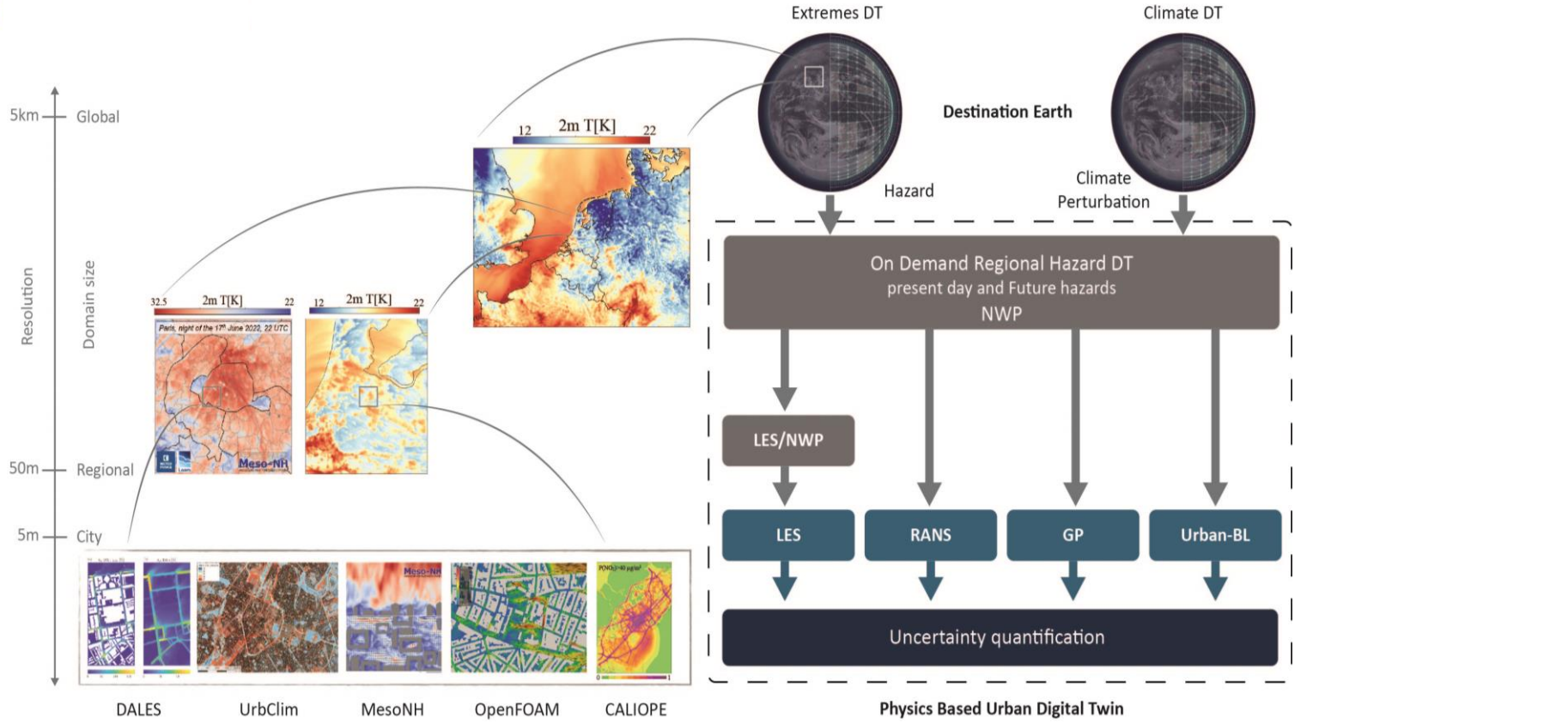
- Interdisciplinary:
  environmental modellers, social scientists, stakeholders, mathematicians, software developers, computer scientists , communication specialists

- Building on existing tools and technologies

- Connecting to Destination Earth infrastructure

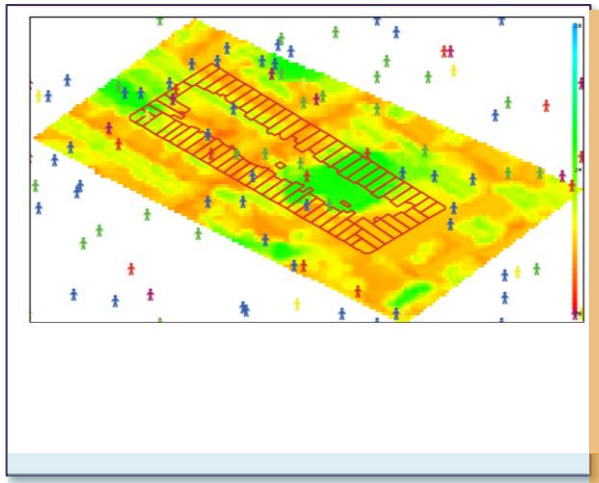
Funded by the European Union

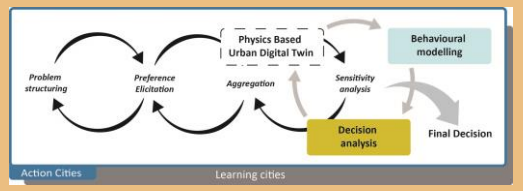
# Cascading resolutions in atmospheric models




Funded by
the European Union

# Behavioural and decision-making aspects



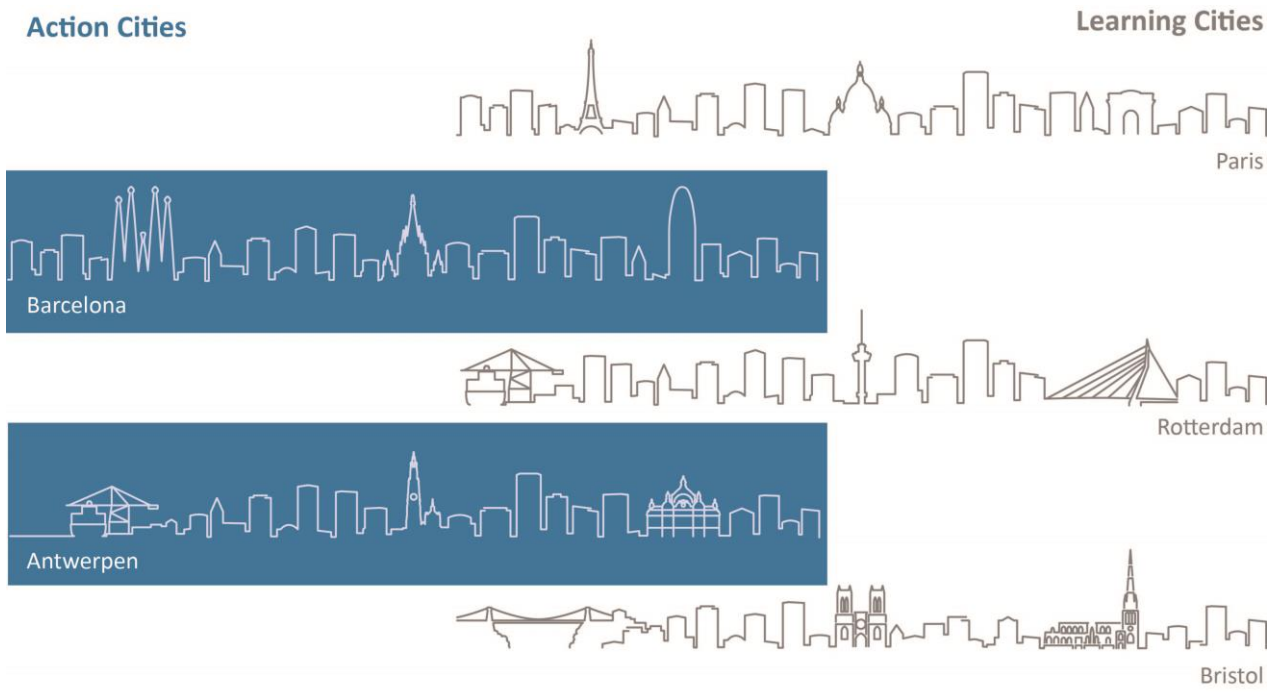



**Agent-based models to incorporate human behaviour**

**Decision analysis to evaluate decision criteria**

Funded by the European Union

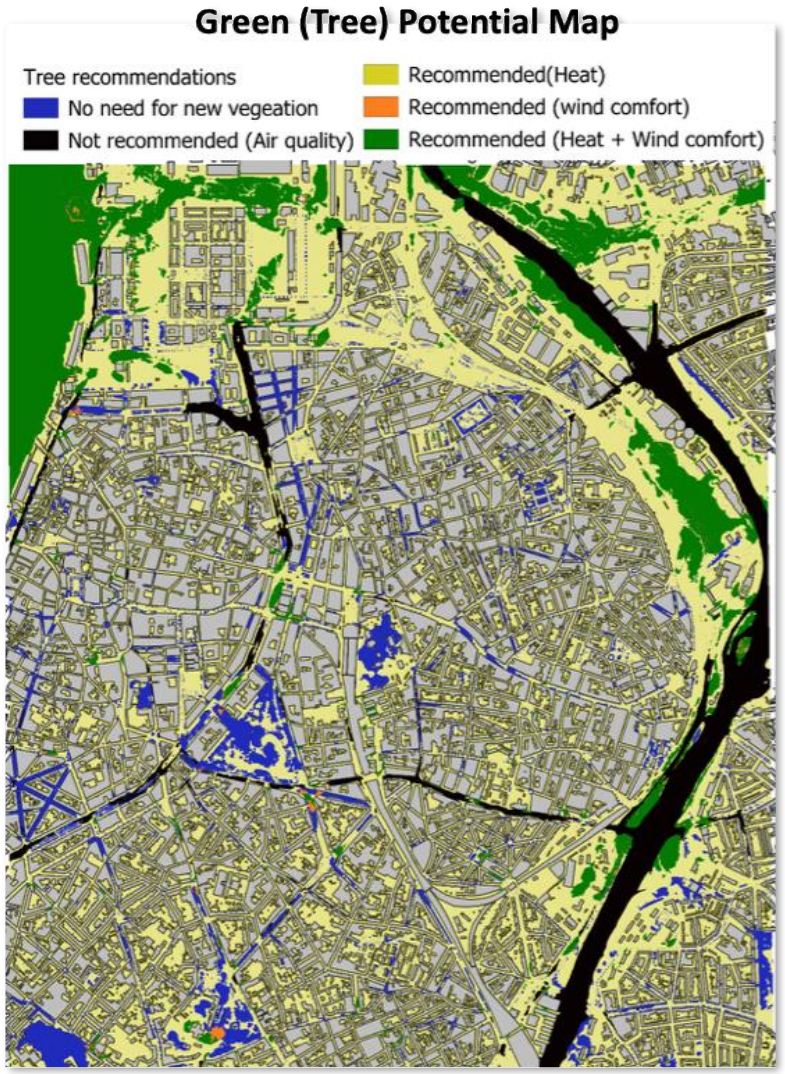
# Involving action cities and learning cities




Funded by the European Union

# Three User Journeys

- Green potential maps
  - Where and how can we cool the cities?
  - Need to know air quality, heat, and wind
  - Focus on Antwerp



# Three User Journeys

- Green potential maps
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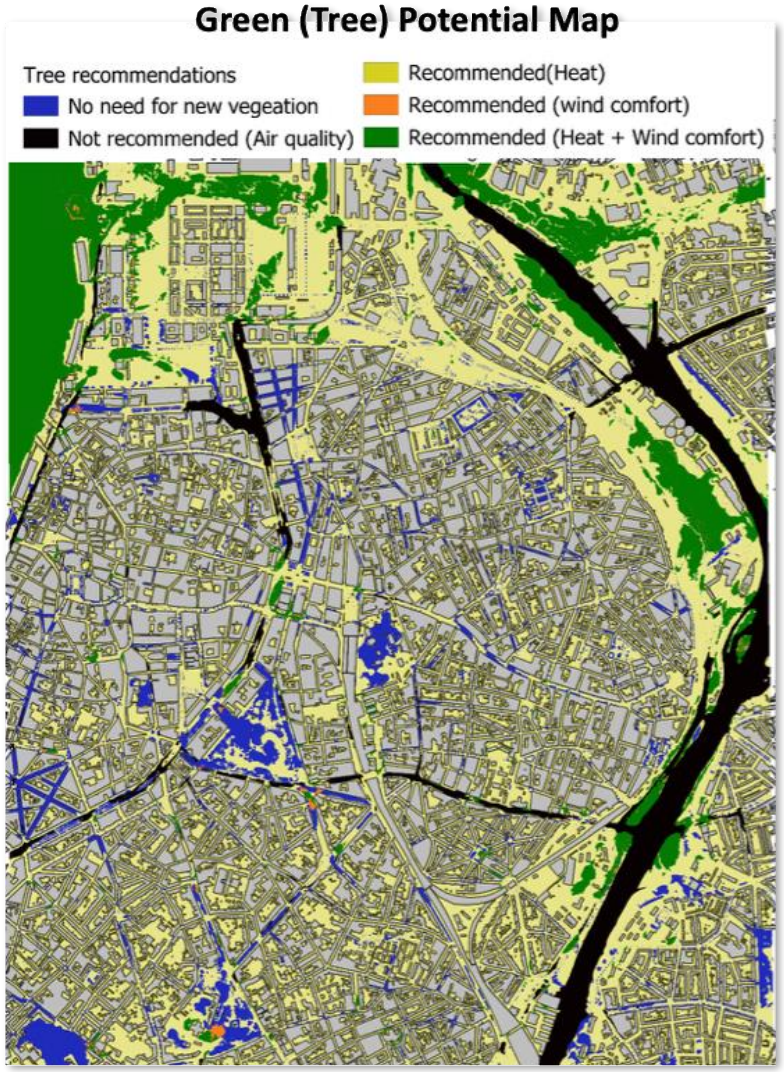
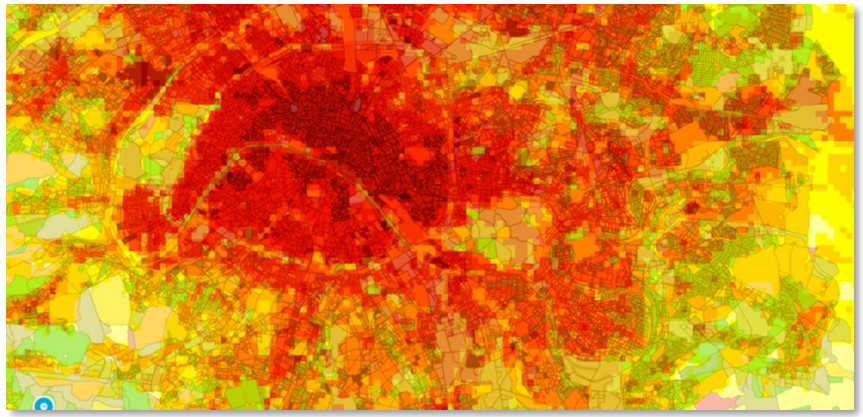
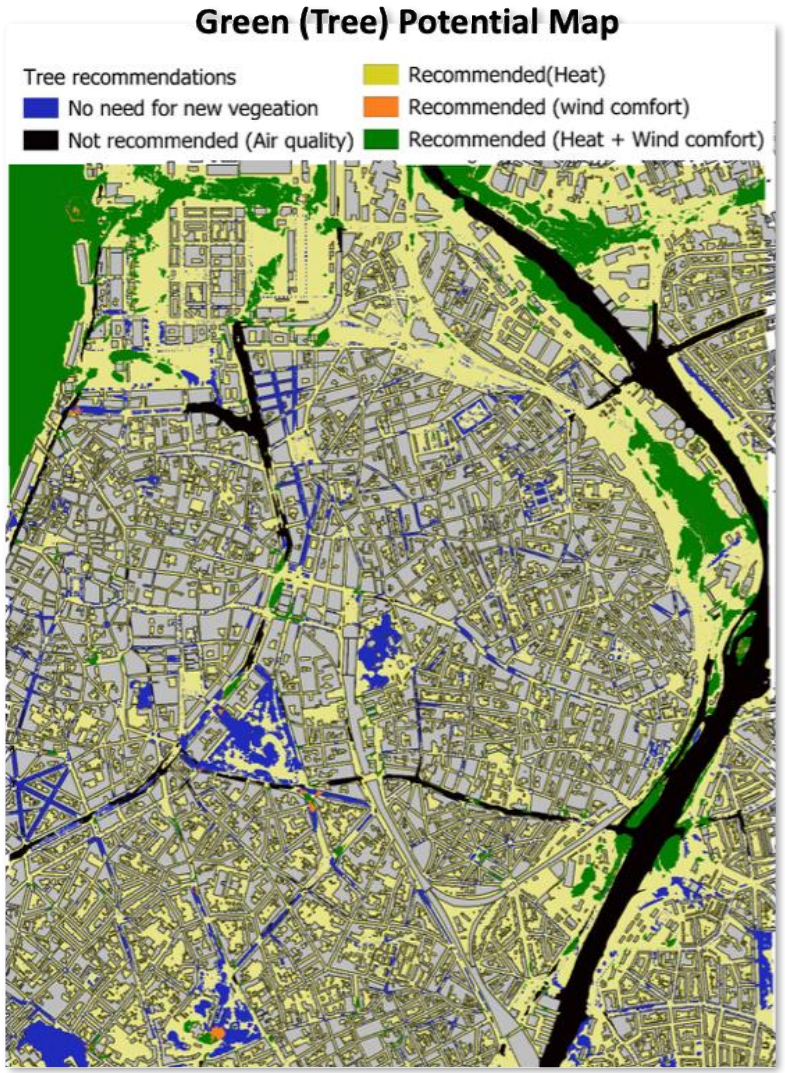
- Climate extremes and hazards
  - Example of Paris, summer 2023

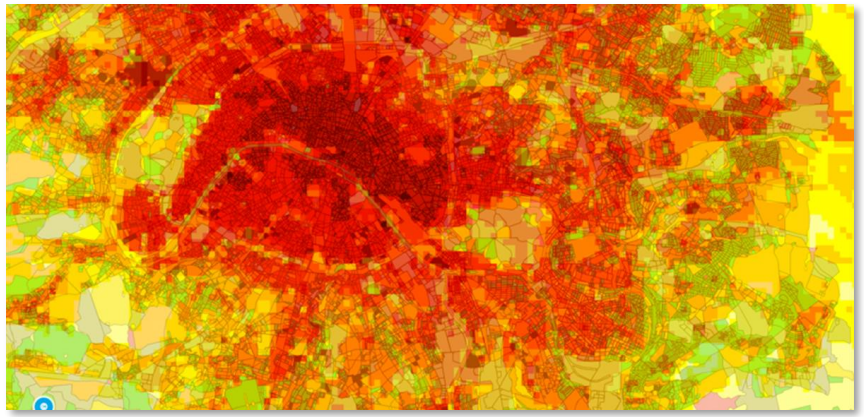


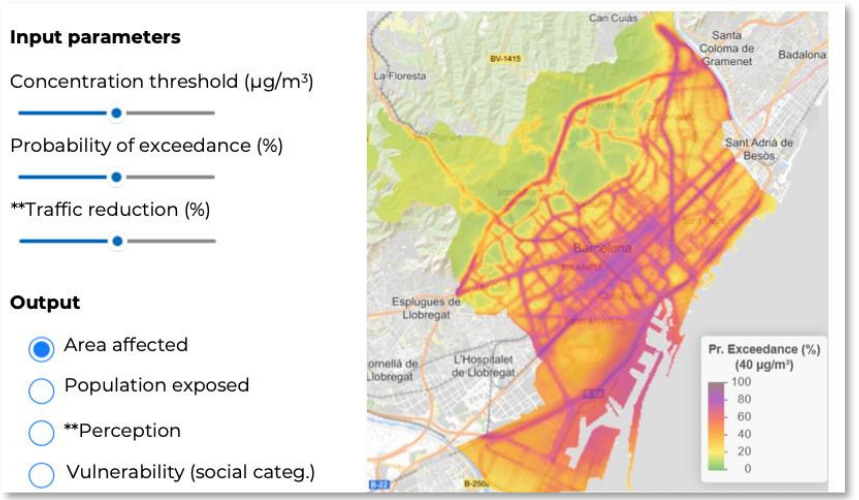



# Three User Journeys

- Green potential maps
  - Where and how can we cool the cities?
  - Need to know air quality, heat, and wind
  - Focus on Antwerp
- Climate extremes and hazards
  - Example of Paris, summer 2023
- Air quality directive
  - Exceedance maps
  - Focus on Barcelona



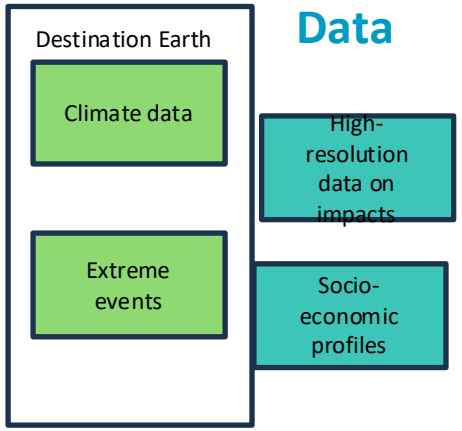





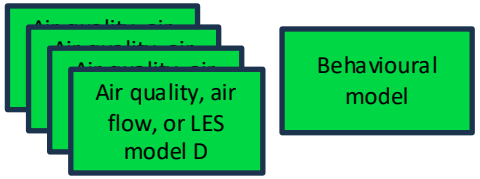
# Building blocks



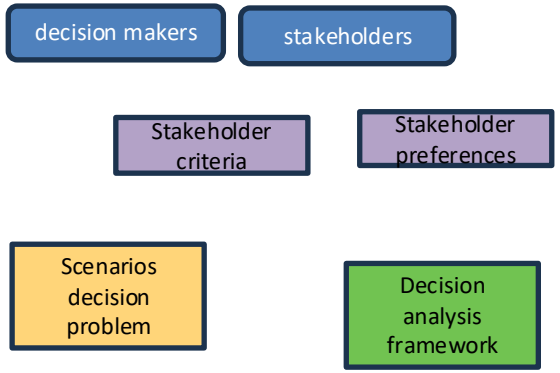
## Data



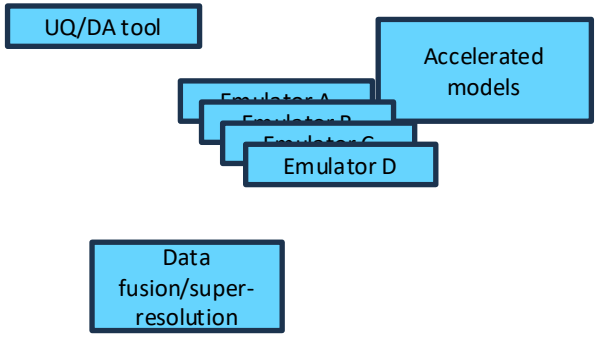

## Models



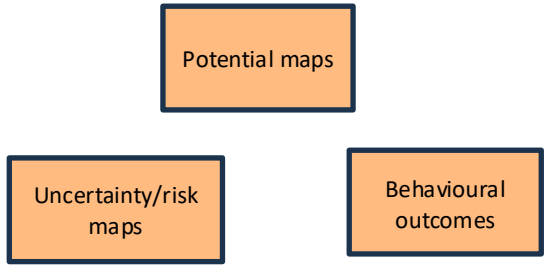

## Users and user input




## UQ/DA




## Desired outcomes

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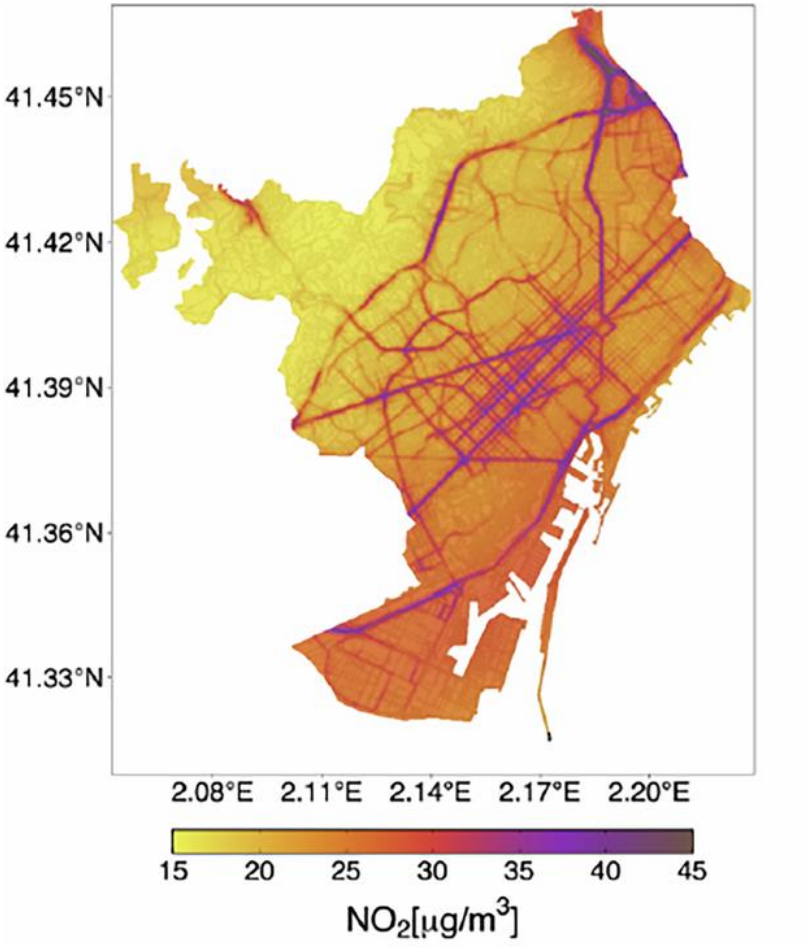
# Use case: Clean Air Directive, Barcelona

# Use case: Clean Air Directive, Barcelona

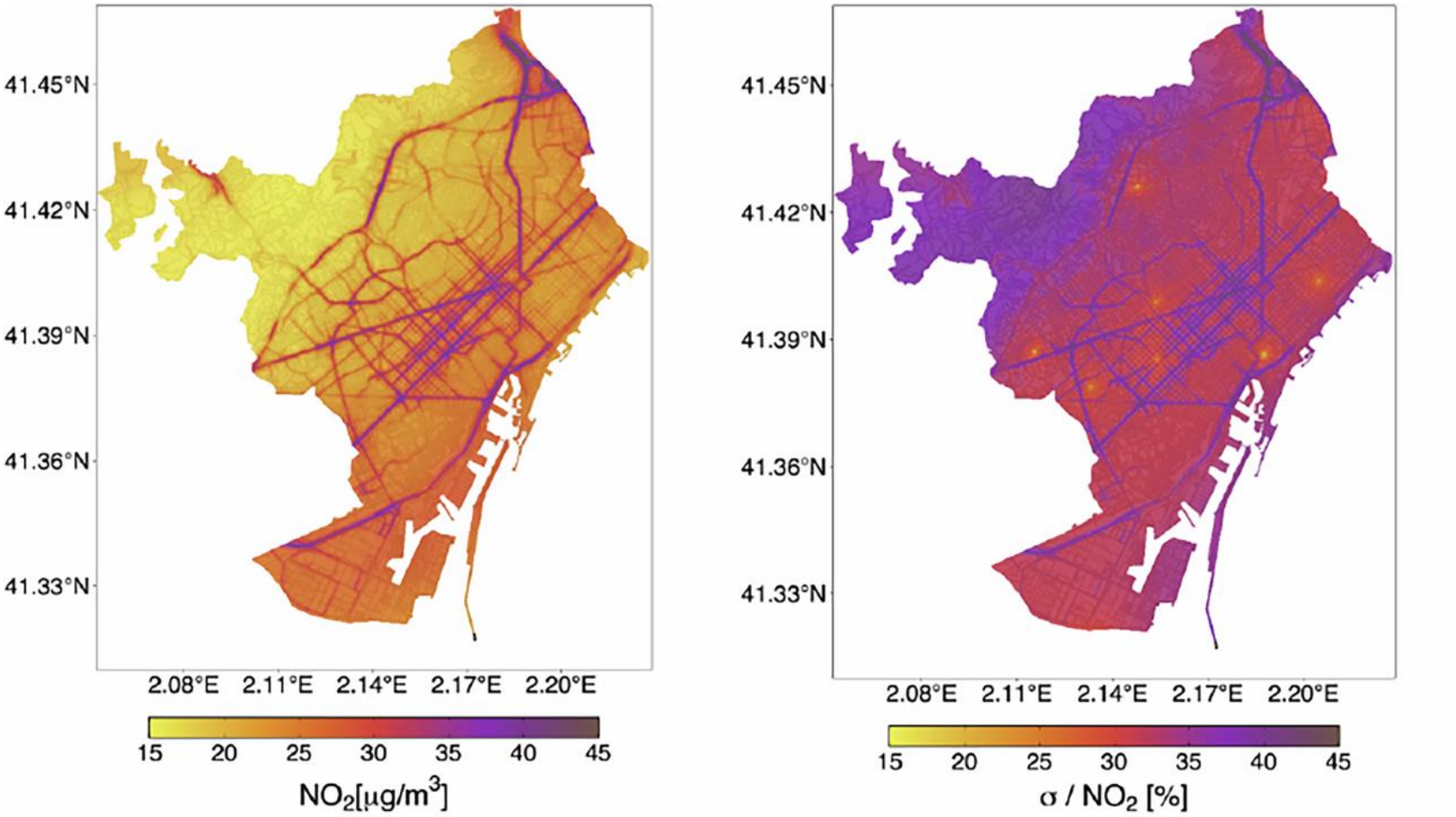





CRIADO, A., et al. Street-and census-level NO2 data for Barcelona with uncertainty and exceedance probability mapping. *Scientific Data*, 2026.

# Use case: Clean Air Directive, Barcelona






CRIADO, A., et al. Street-and census-level NO2 data for Barcelona with uncertainty and exceedance probability mapping. *Scientific Data*, 2026.

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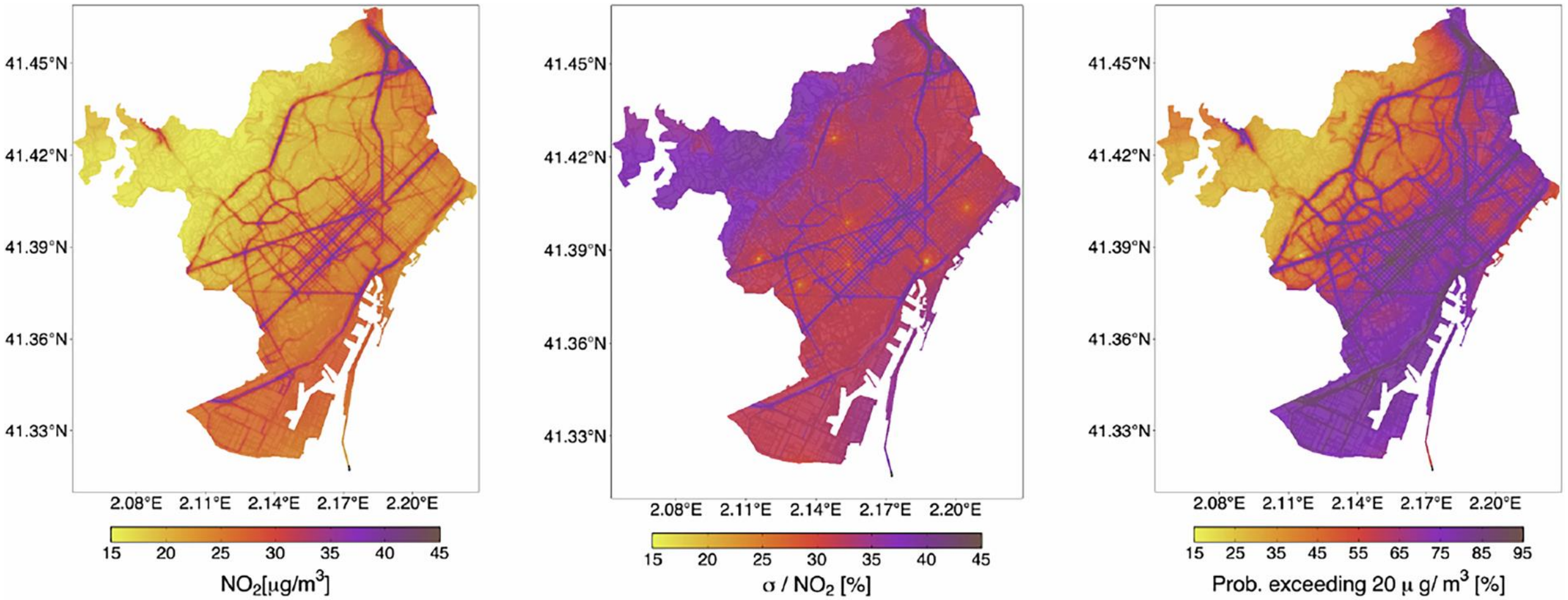



CRIADO, A., et al. Street-and census-level NO2 data for Barcelona with uncertainty and exceedance probability mapping. *Scientific Data*, 2026.

# Use case: Clean Air Directive, Barcelona



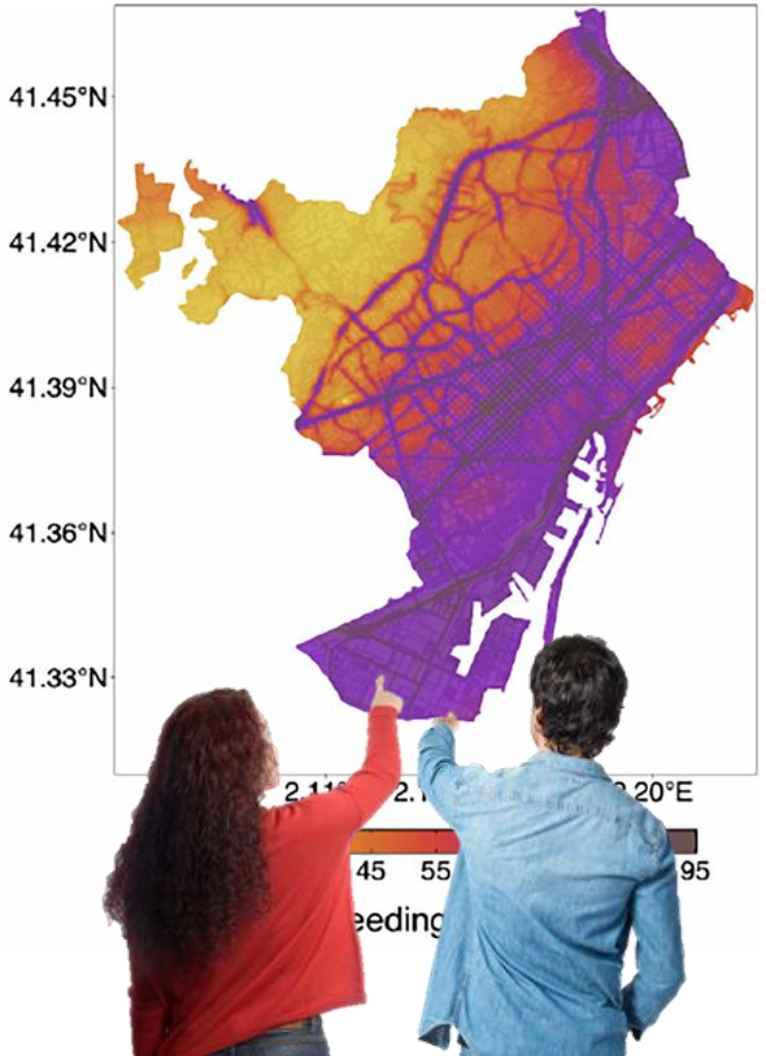
**Input parameters**

Concentration threshold (µg/m³)

Probability of exceedance (%)

**Output**

- (●) Area affected
- ( ) Population exposed



# Use case: Clean Air Directive, Barcelona



**Input parameters**

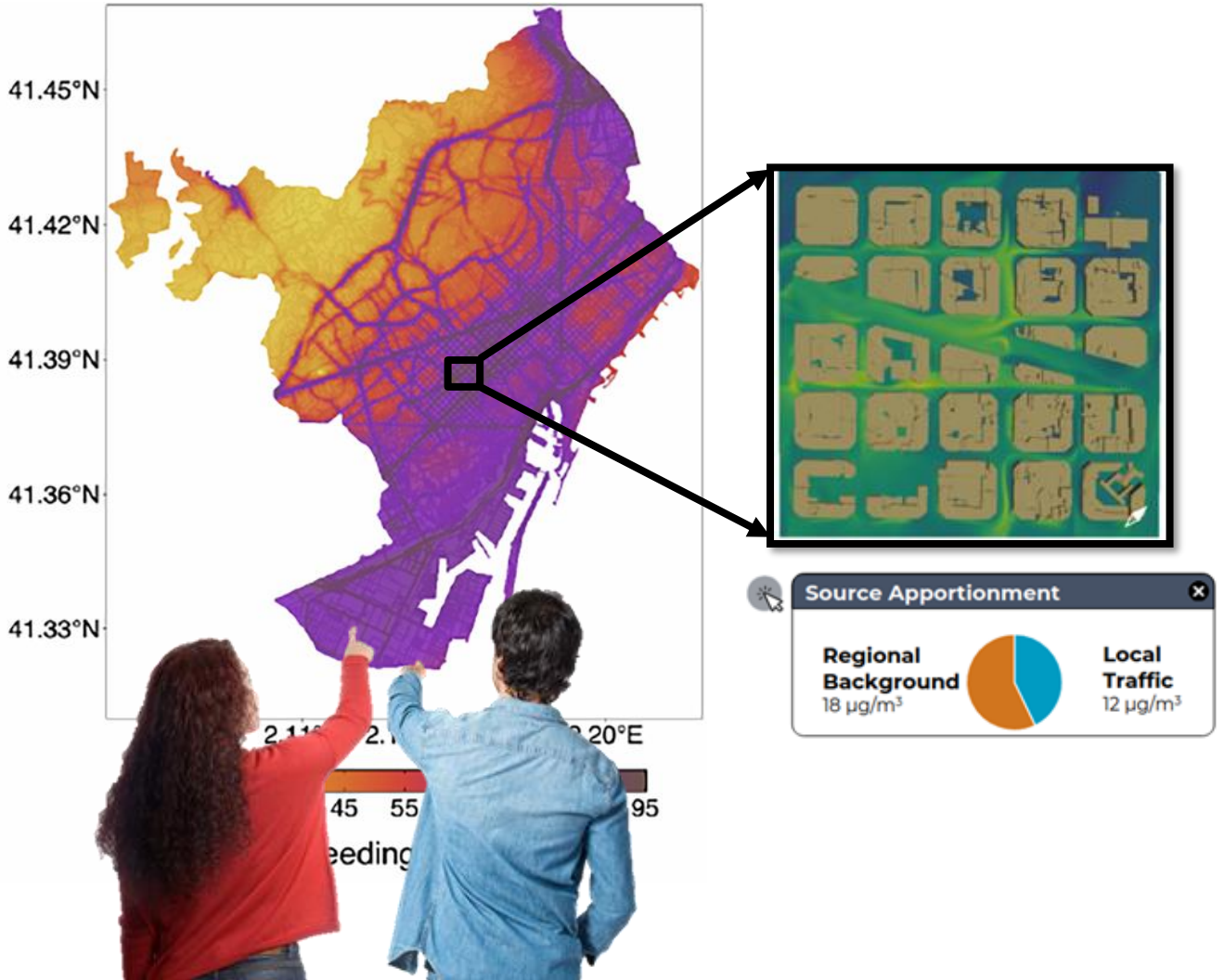
Concentration threshold (µg/m³)

Probability of exceedance (%)

**Traffic reduction (%)

**Output**

- (●) Area affected
- ( ) Population exposed



# Use case: Clean Air Directive, Barcelona



**Input parameters**

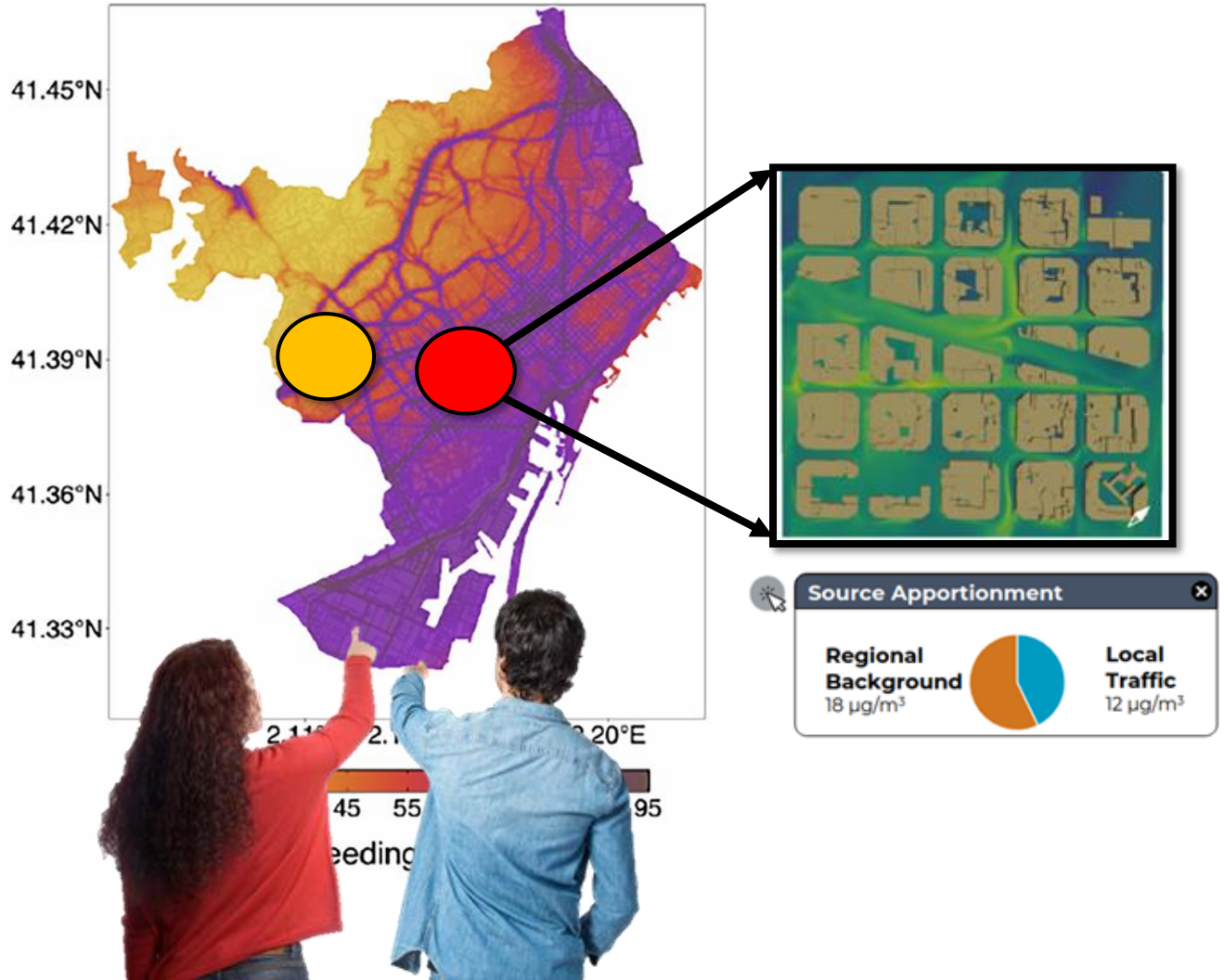
Concentration threshold (µg/m³)

Probability of exceedance (%)

**Traffic reduction (%)

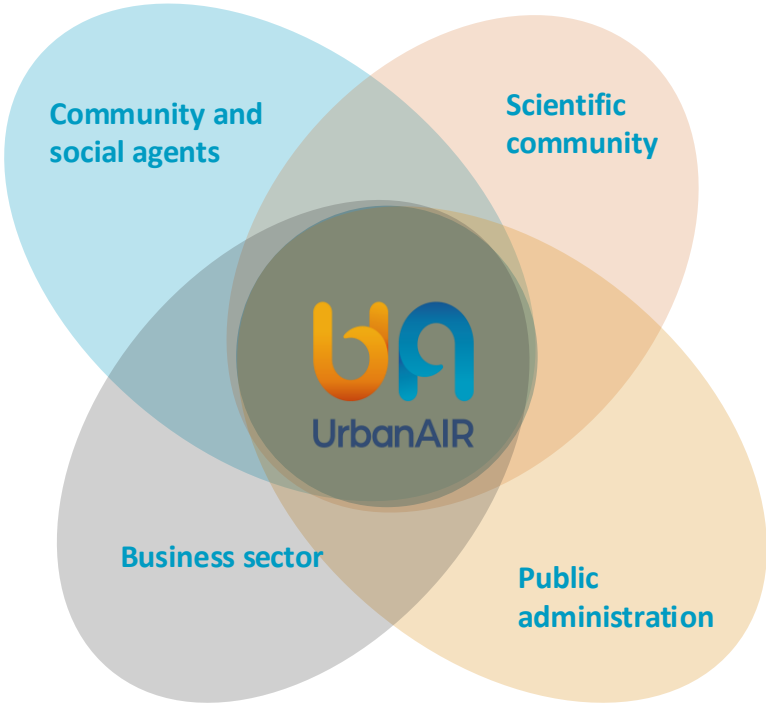
**Output**

- (●) Area affected
- ( ) Population exposed
- ( ) Perception
- ( ) Vulnerability (social categ.)



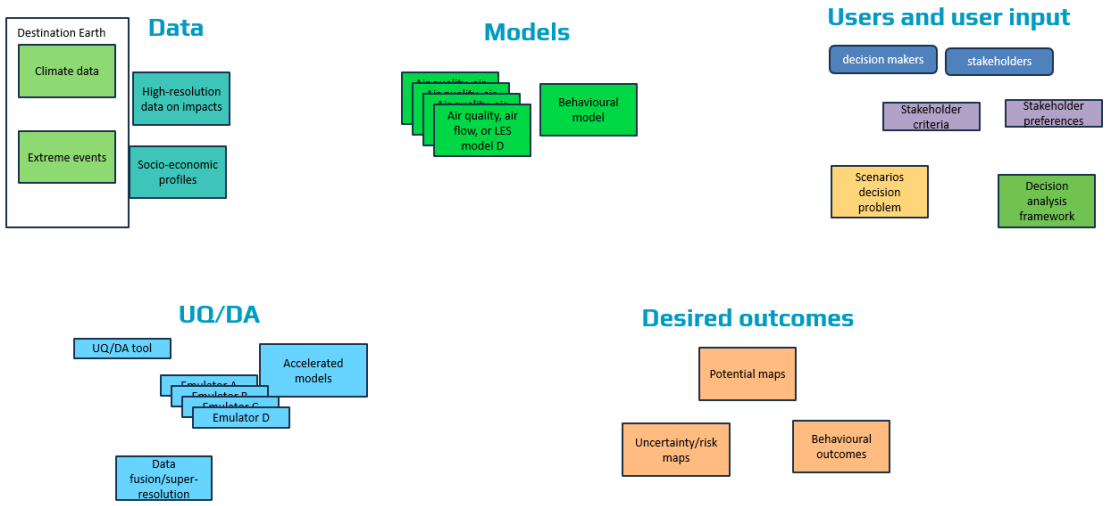
# In summary, the UrbanAIR DT will…

- **Be case-specific, designed together with the end user**



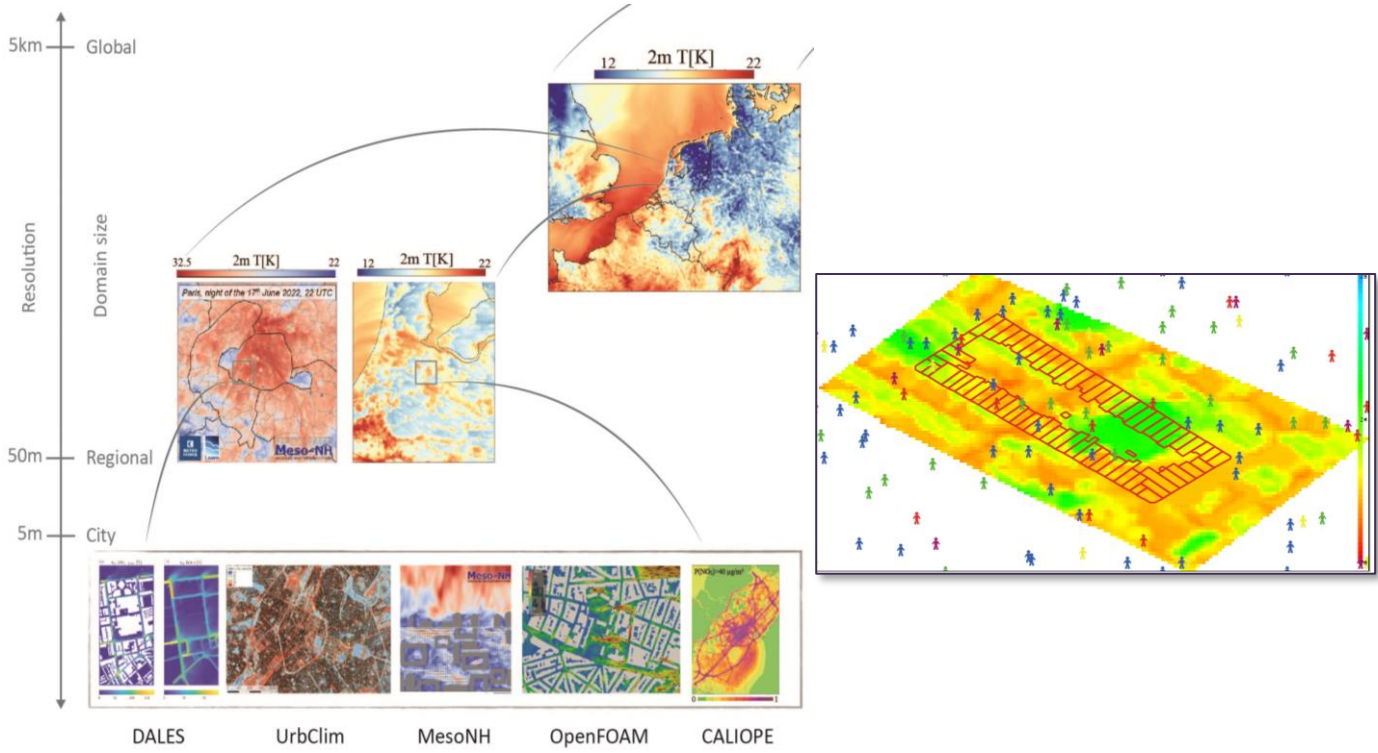
# In summary, the UrbanAIR DT will…

- **Be case-specific, designed together with the end user**
- **Consist of modules linking to the DestinE components**



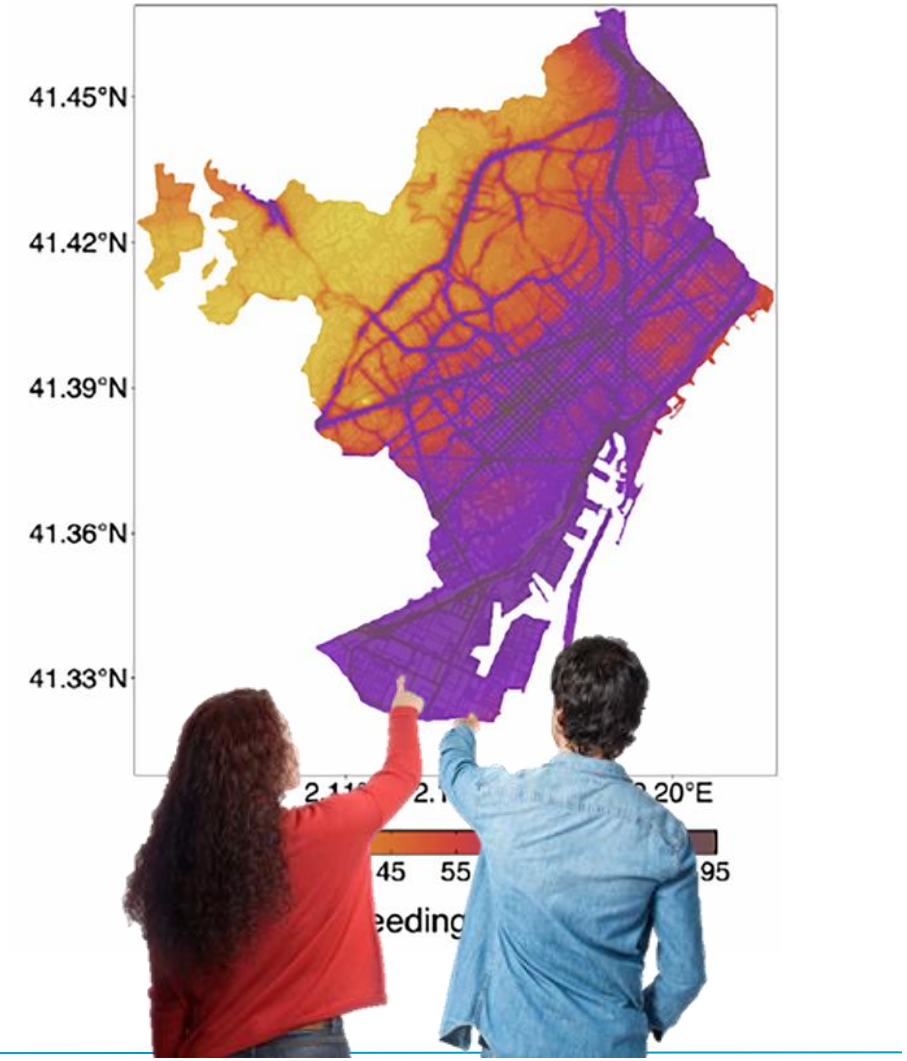
# In summary, the UrbanAIR DT will…

- **Be case-specific, designed together with the end user**
- **Consist of modules linking to the DestinE components**
- **Integrate atmospheric models with behavioural models in a decision-analysis framework**



# In summary, the UrbanAIR DT will…

- Be case-specific, designed together with the end user
- Consist of modules linking to the DestinE components
- Integrate atmospheric models with behavioural models in a decision-analysis framework
- Provide uncertainty assessment, integrating data and models and making use of AI tools for enhanced resolution and reduced computing time



# Thank you!

urbanair-project.eu

Funded by
the European Union

TerraDT

UrbanAIR

Mapping of heat-exposure extremes in cities

# Inês Girão

*(+ATLANTIC CoLab)*

23 February 2026 | Barcelona [ES]

Funded by the European Union

TerraDT

Digital Twin of Earth system for Cryosphere, Land surface and related interactions

CoLAB +ATLANTIC

# MAPPING OF HEAT- EXTREME EXPOSURE IN CITIES

**Inês Girão**

**+ATLANTIC CoLAB**

Funded by the European Union

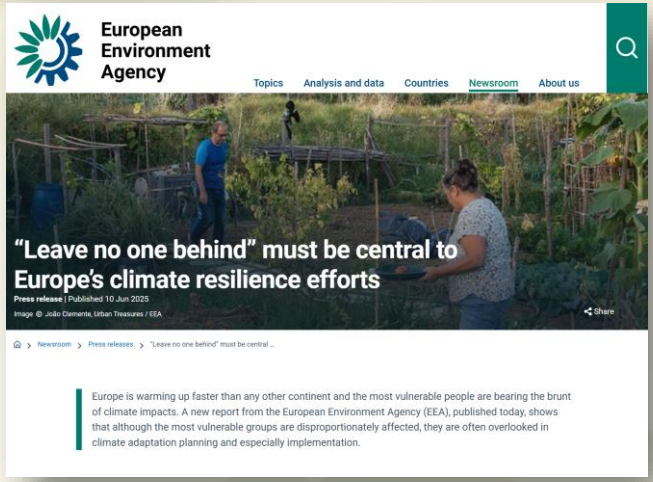
TerraDT

# THE PROBLEM

Climate and Environmental Hazards are LOCAL
Their monitoring and forecast IS NOT

Currently, weather, climate and environmental monitoring lacks spatial detail



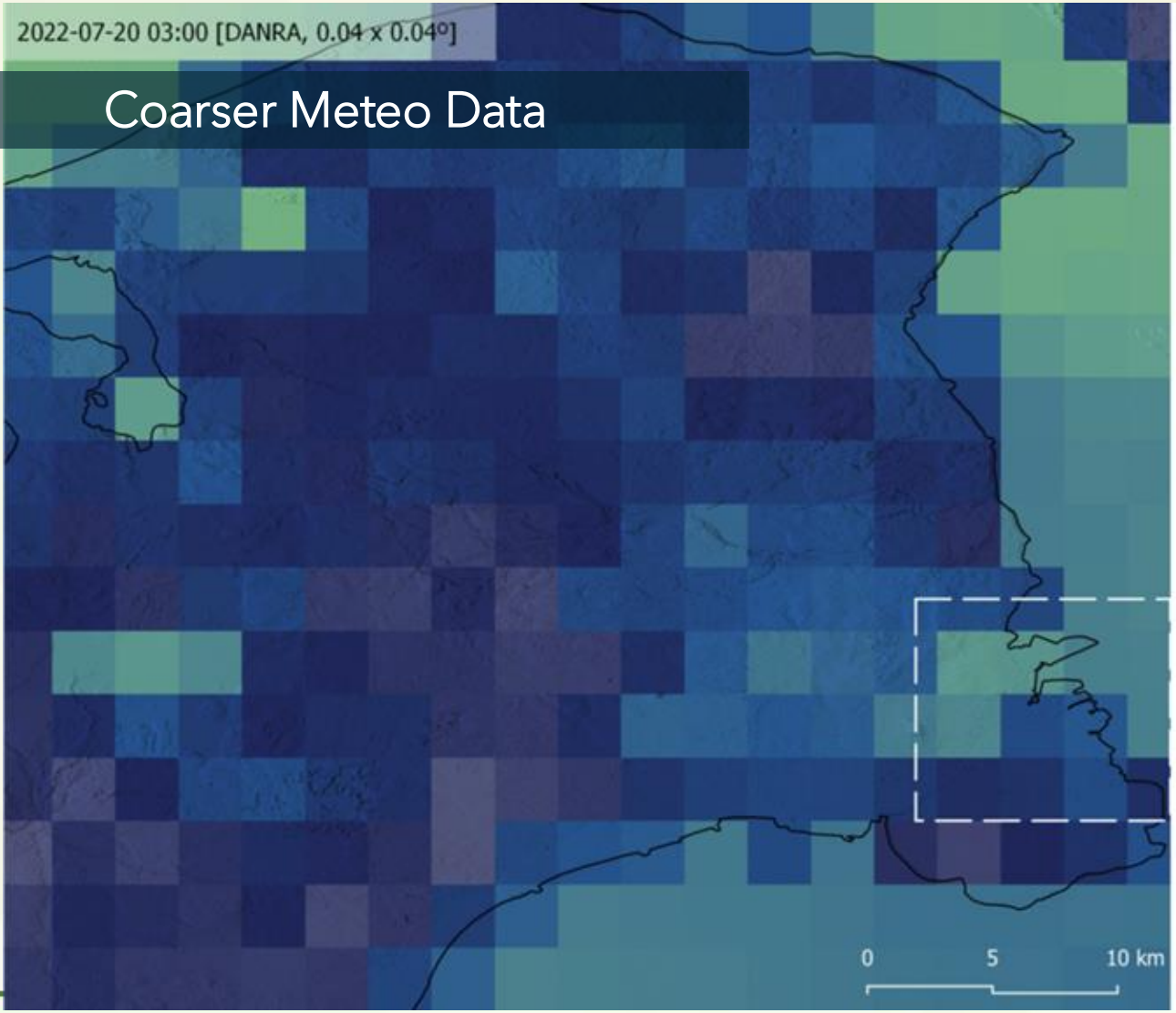


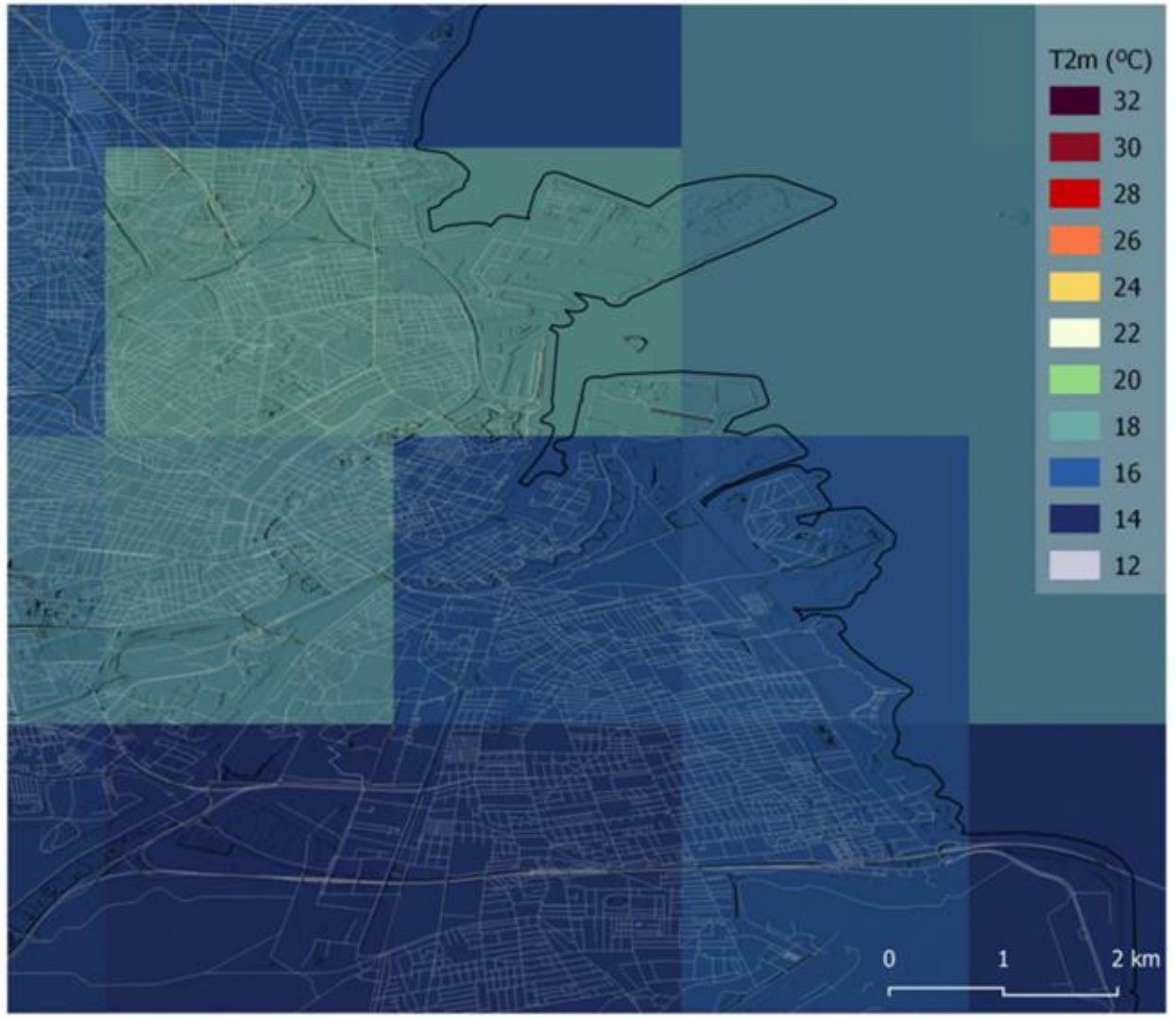

✓ **OK** regarding **WHEN**
! **NOK** regarding **DETAIL**

TerraDT

# THE SOLUTION

CLIM4 CITIES

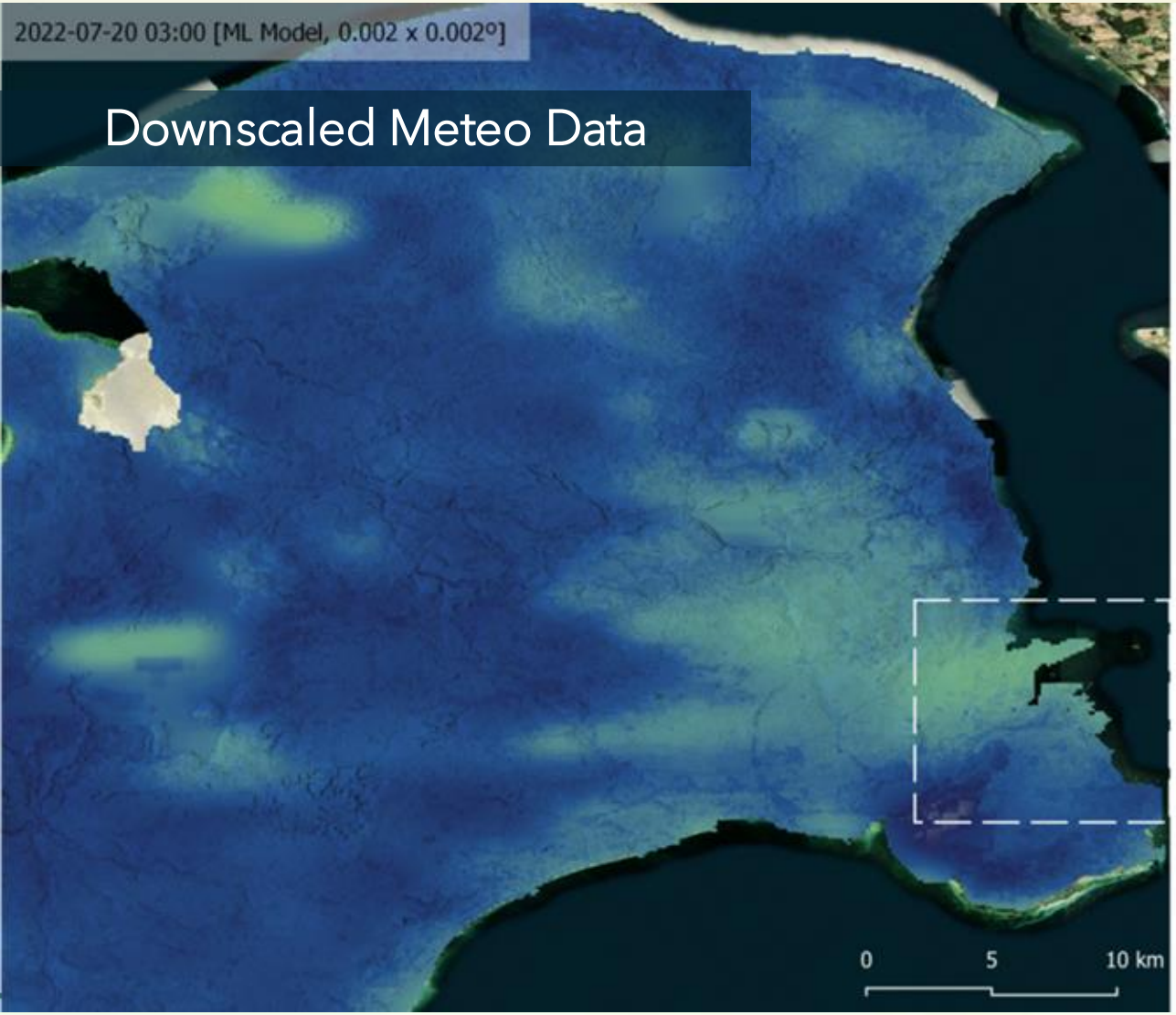


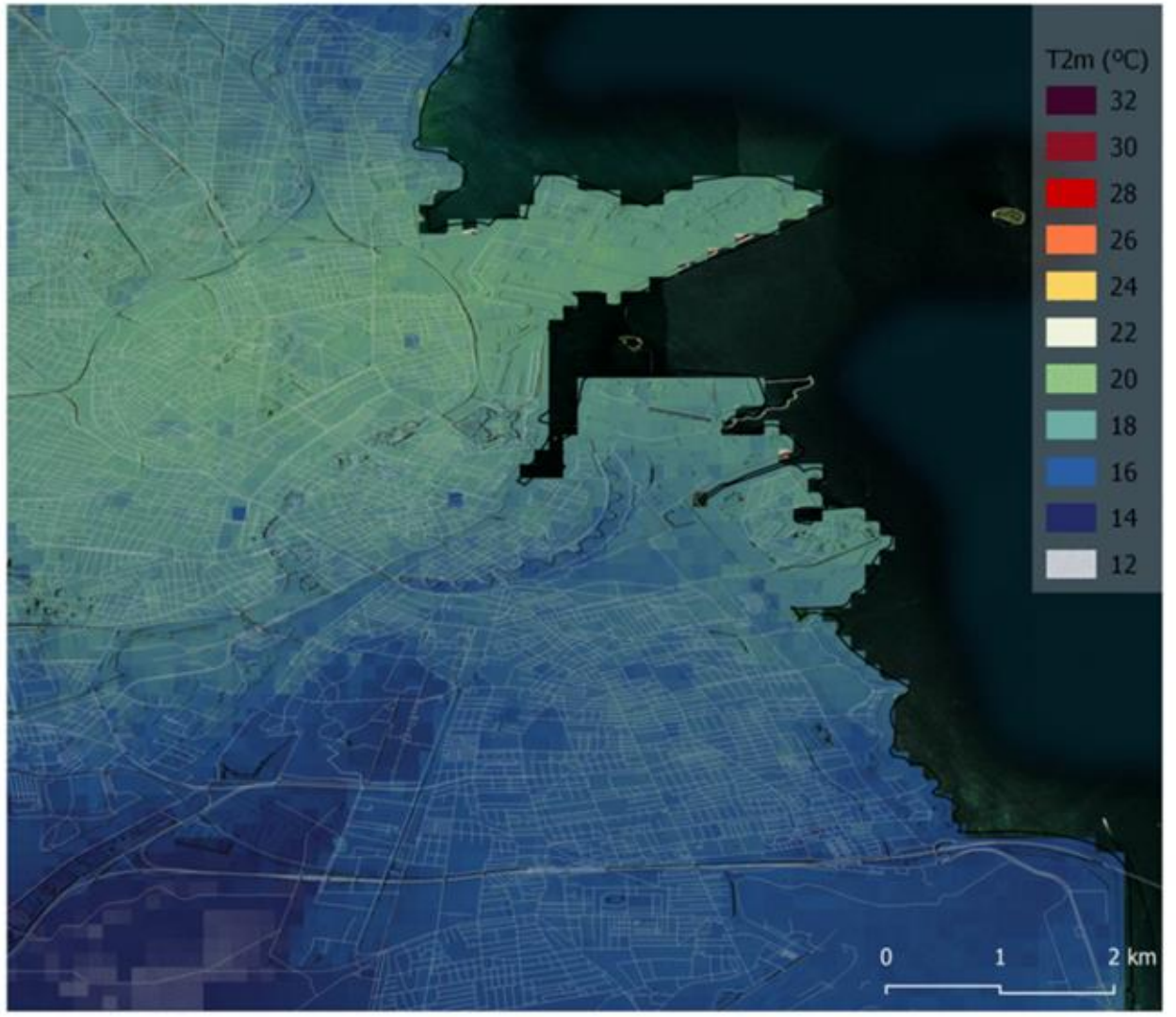



TerraDT

# THE SOLUTION

CLIM4 CITIES



TerraDT

# THE SOLUTION

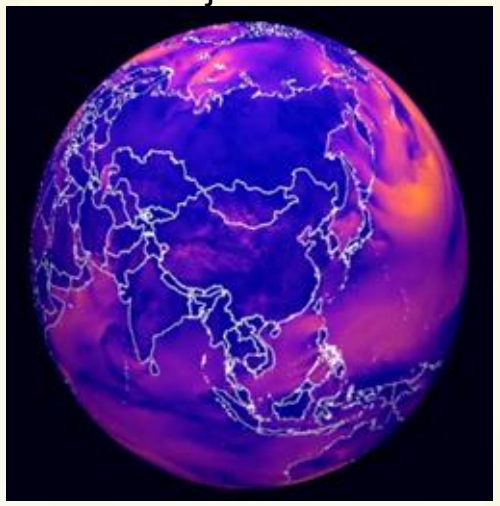
**Observations**

Sensors, IoT, Crowdsourcing

=

**Synoptic (Background) Weather**

Reanalysis, Forecast and Climate Projections



+

**Local (Time-Fixed) Predictors**

Landscape and Urban Features

**Topography**

Terrain, Topographic Wind Exposure

**Green Features**

Vegetation Density and Type, Phenology

+

**Urban Features**

Urban Density, Imperviousness, Sky View Factor

**Blue Features**

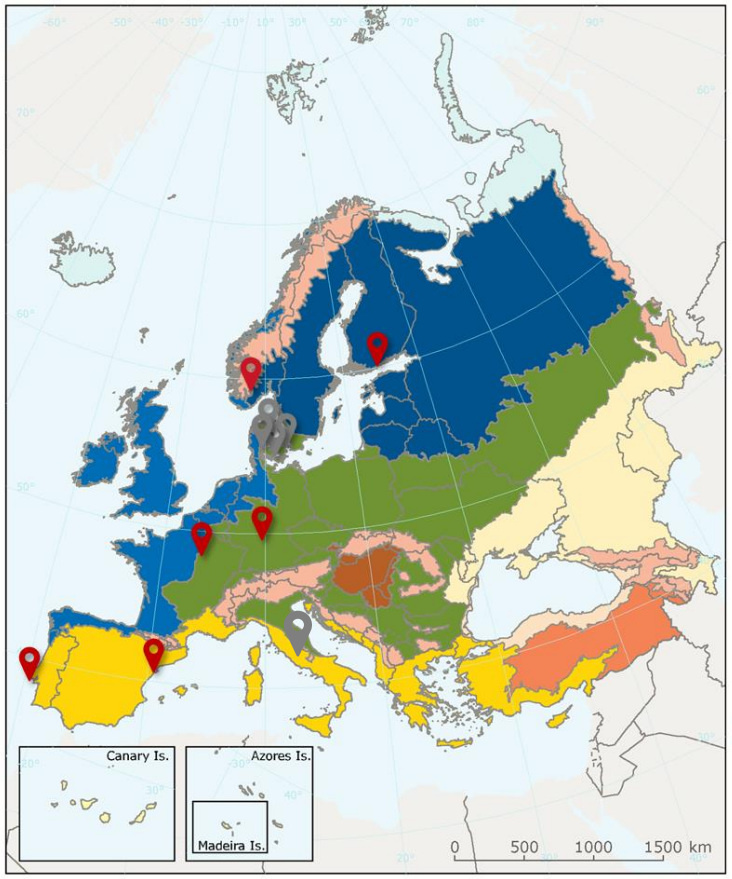
Proximity to the Coast or Large Water Bodies

+

**Machine Learning**

Domain-Informed Data-driven Downscaling

# THE SOLUTION

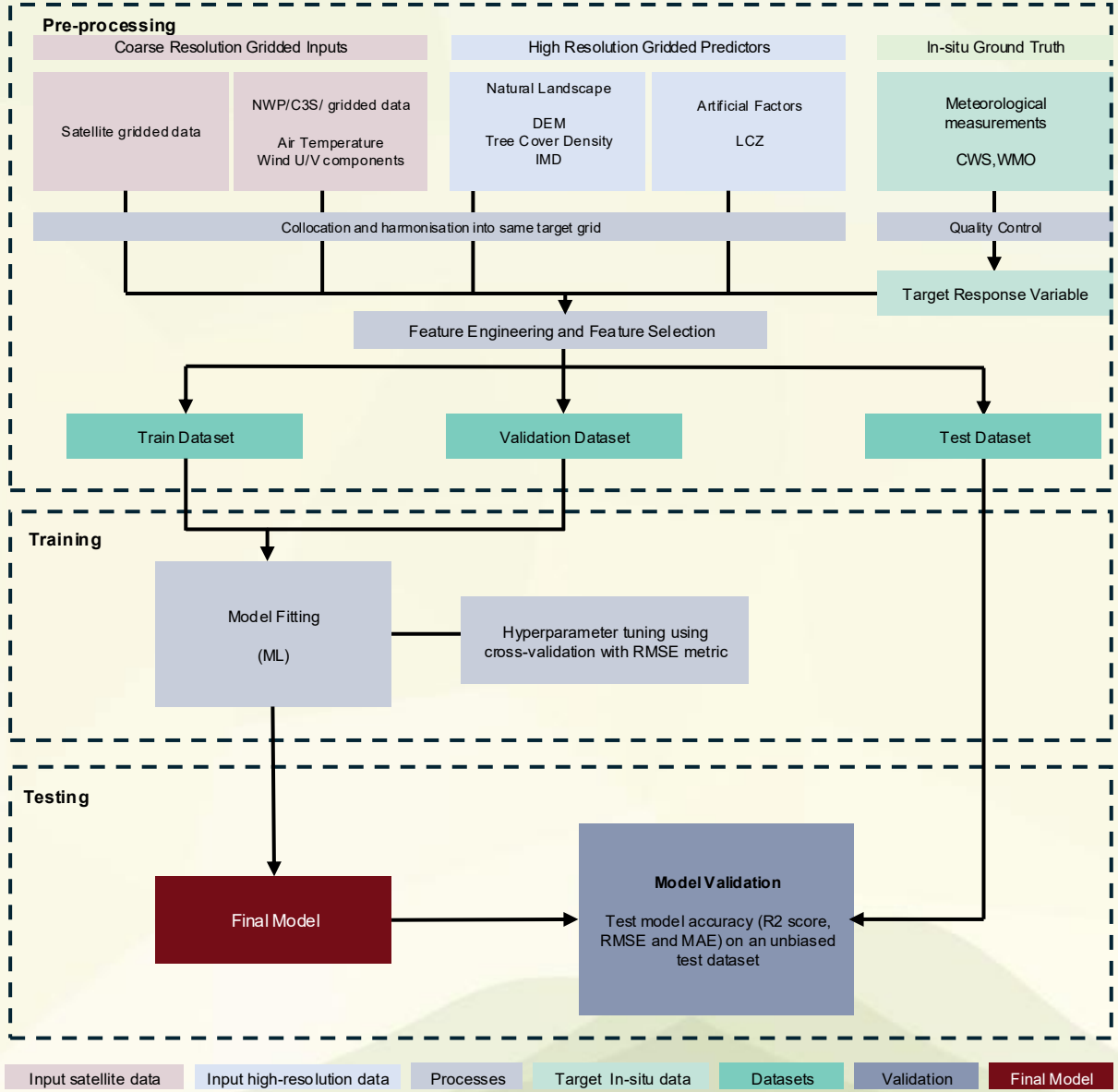



**Biogeographical regions in Europe, 2016**

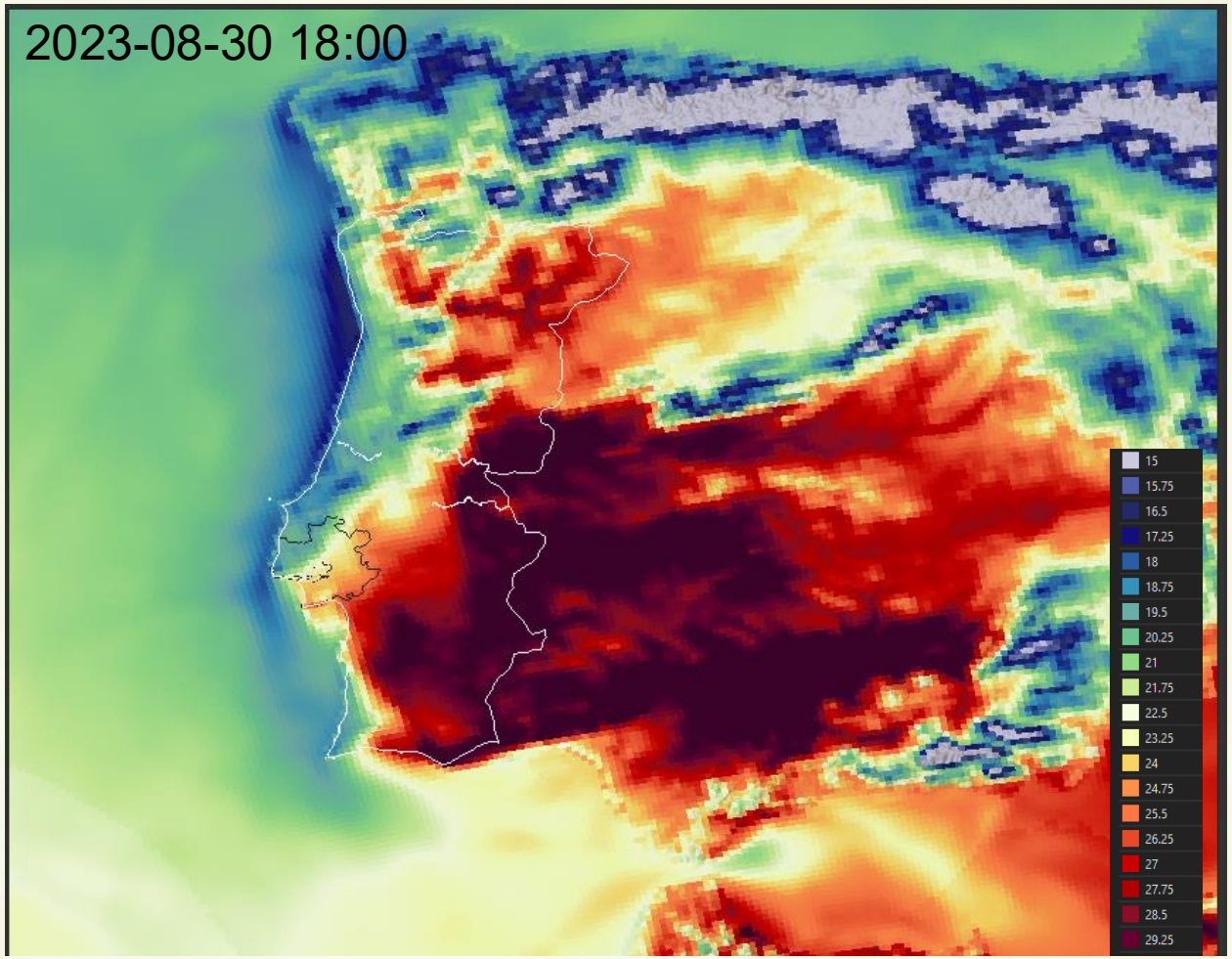
- Alpine
- Anatolian
- Arctic
- Atlantic
- Black Sea
- Boreal
- Continental
- Macaronesia
- Mediterranean
- Pannonian
- Steppic
- Outside data coverage

**Project Acronym [Expected ML availability]:**
Country: Functional Urban Area

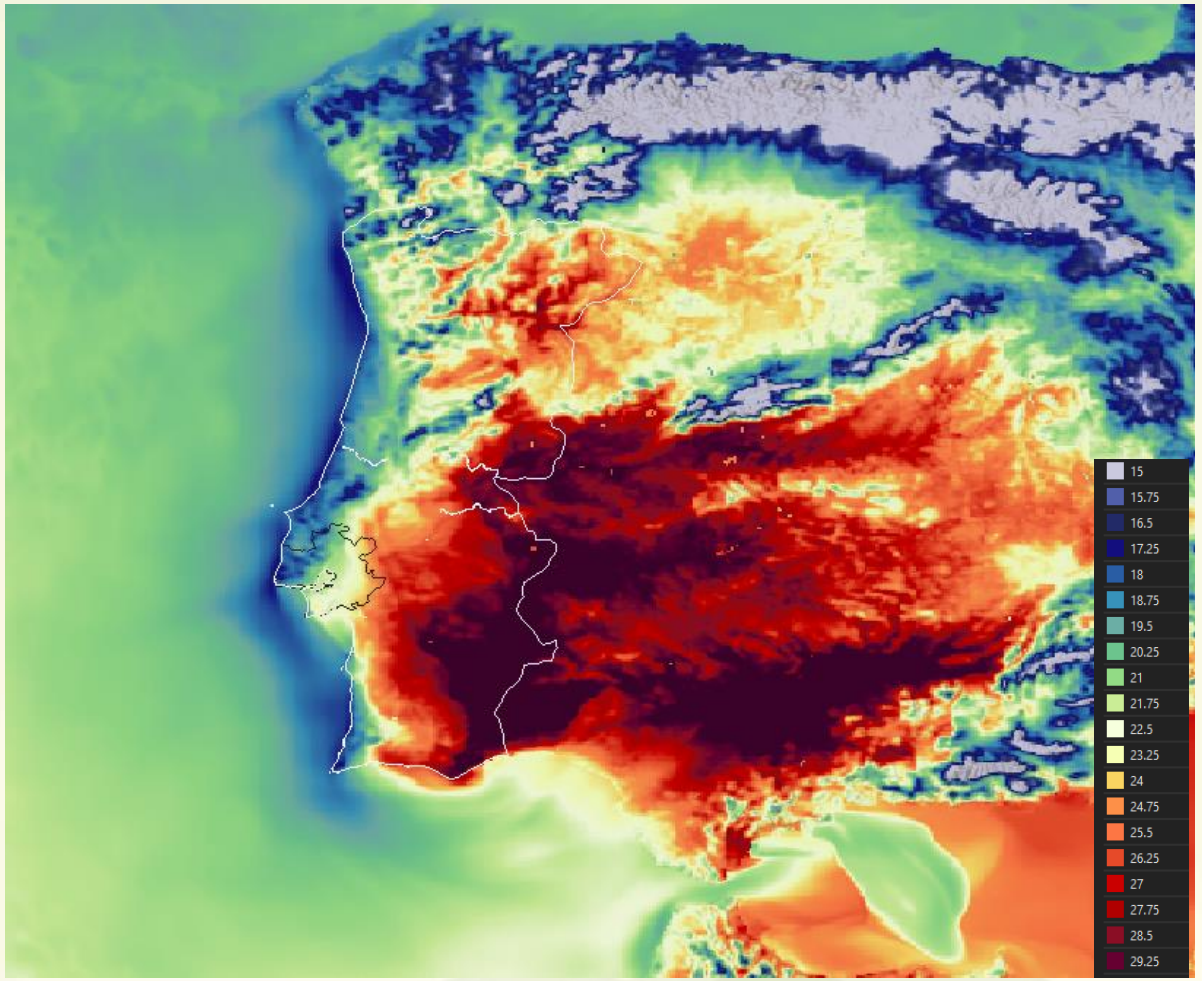
**HORIZON EU Terra DT [Mar 2026]:**
ES: Barcelona
PT: Lisbon
FI: Helsinki
DE: Munich
FR: Paris



TerraDT

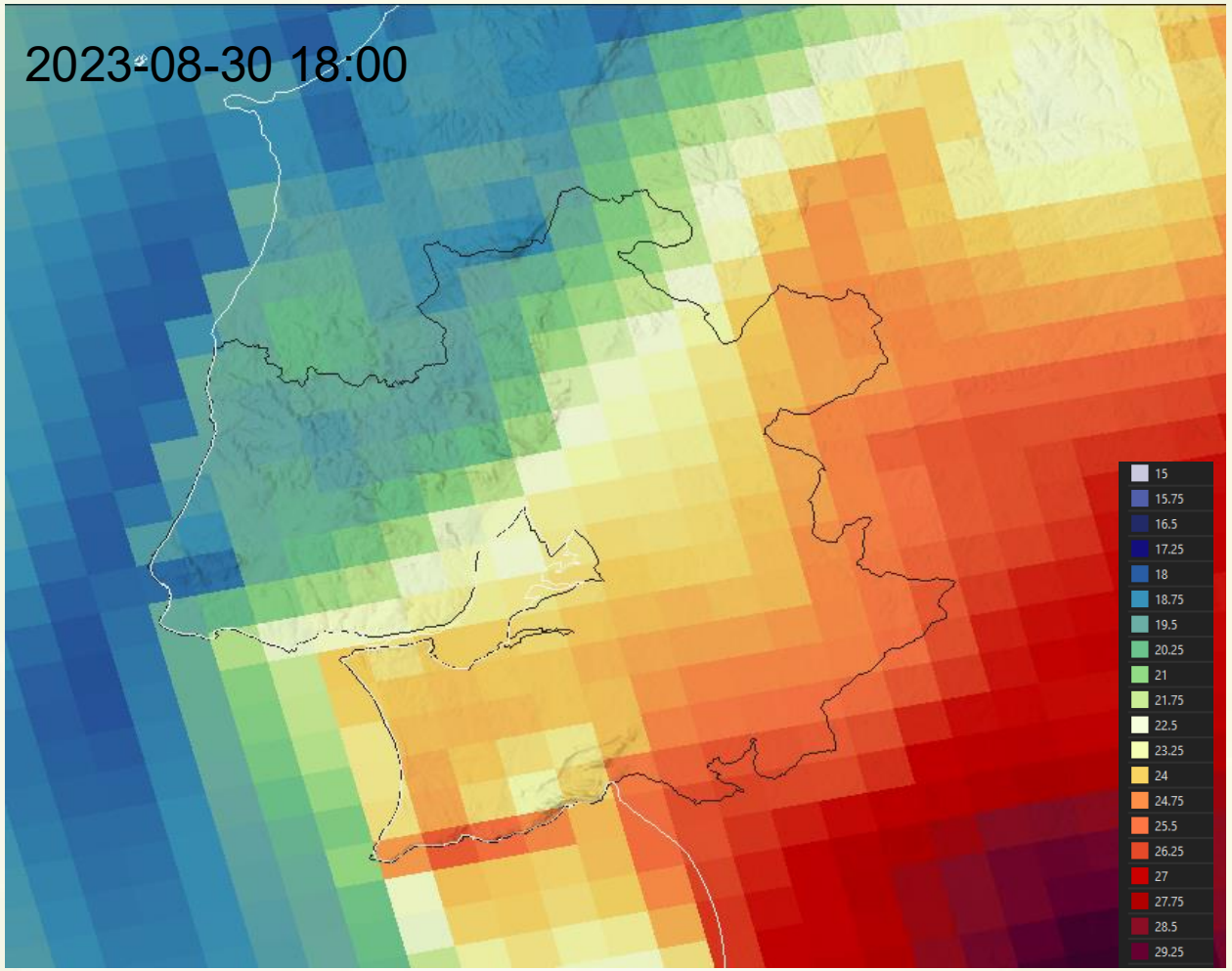



CERRA (0.05x0.05º)

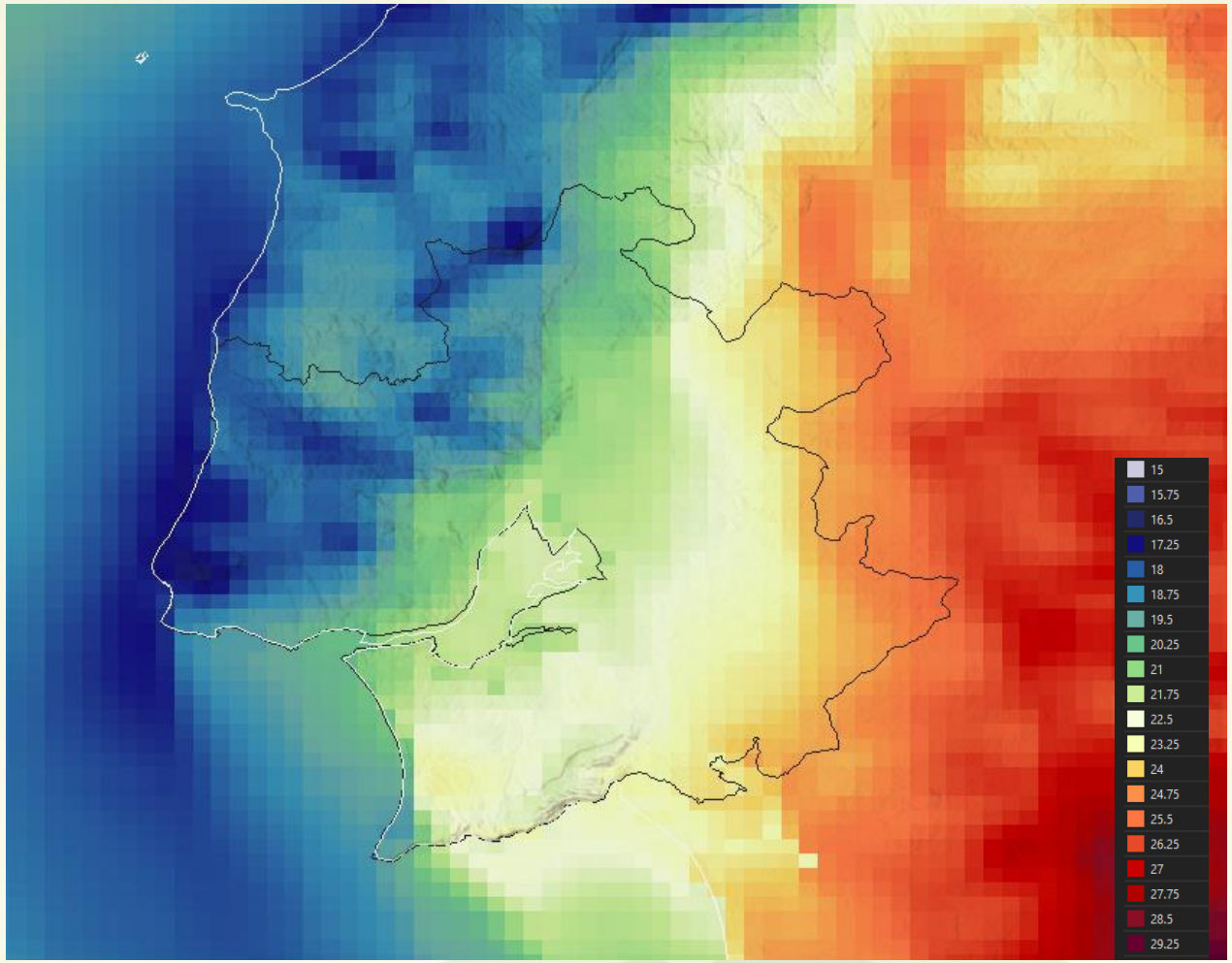



AROME - IBI (0.025x0.025º)

TerraDT

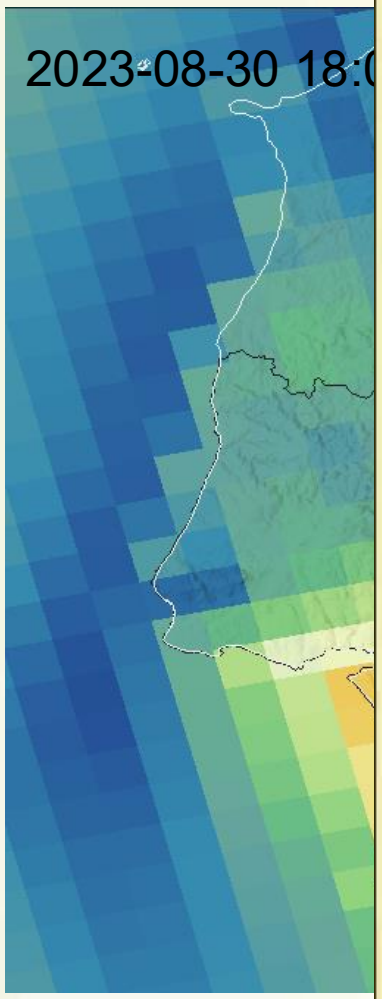



CERRA (0.05x0.05º)

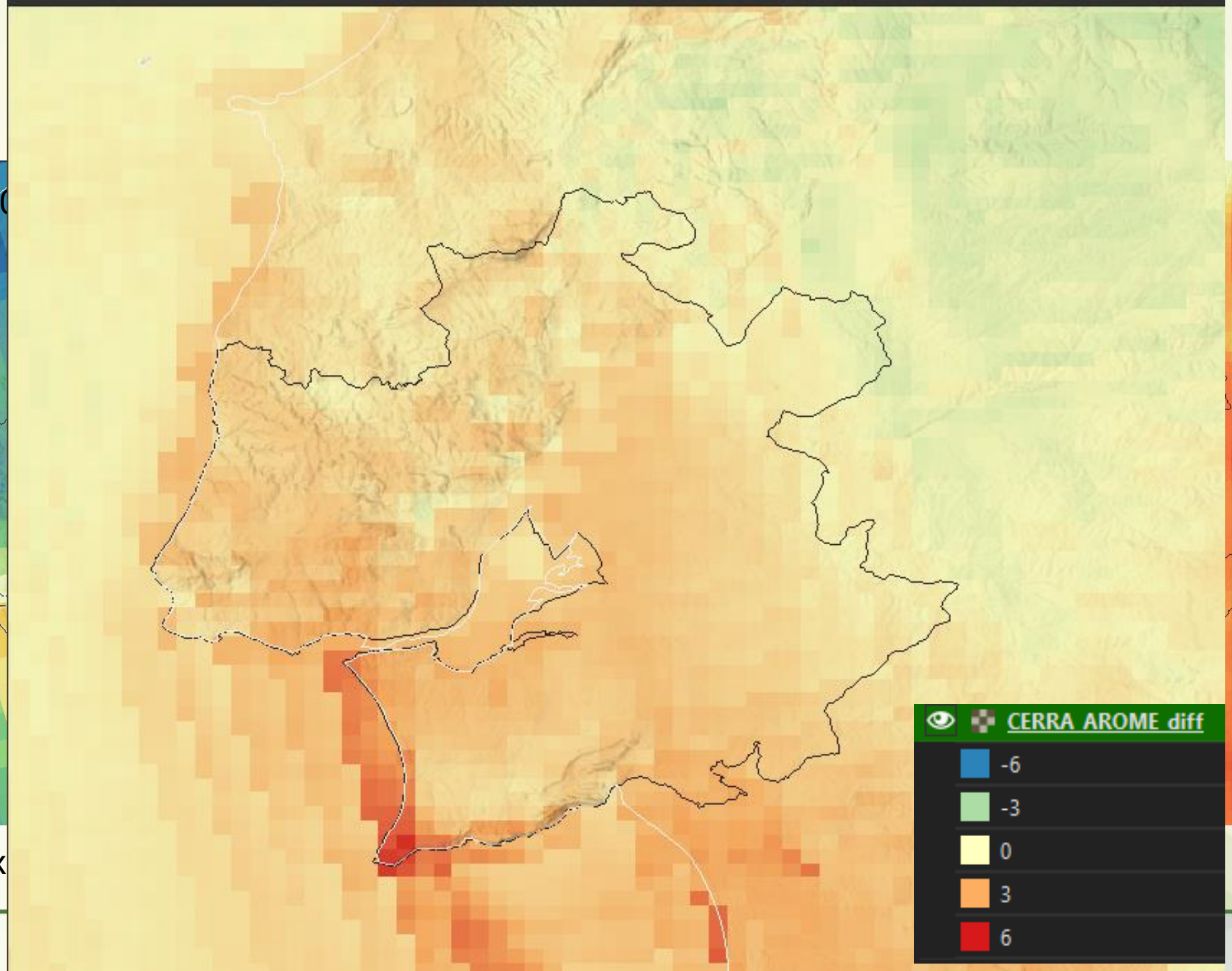


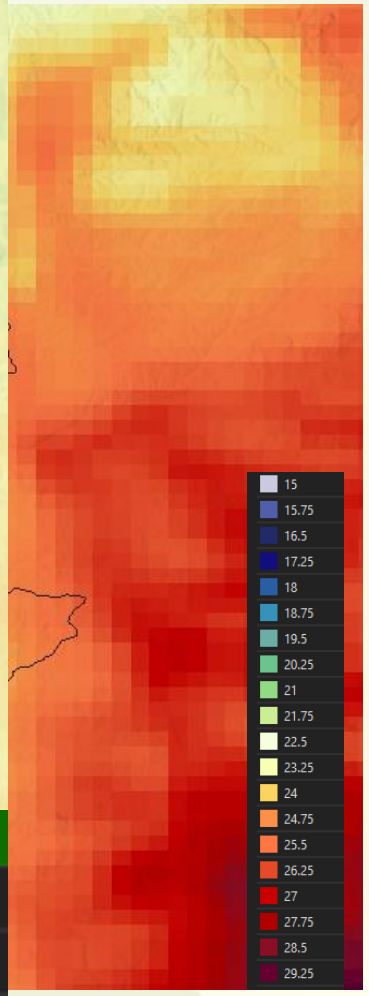

AROME - IBI (0.025x0.025º)

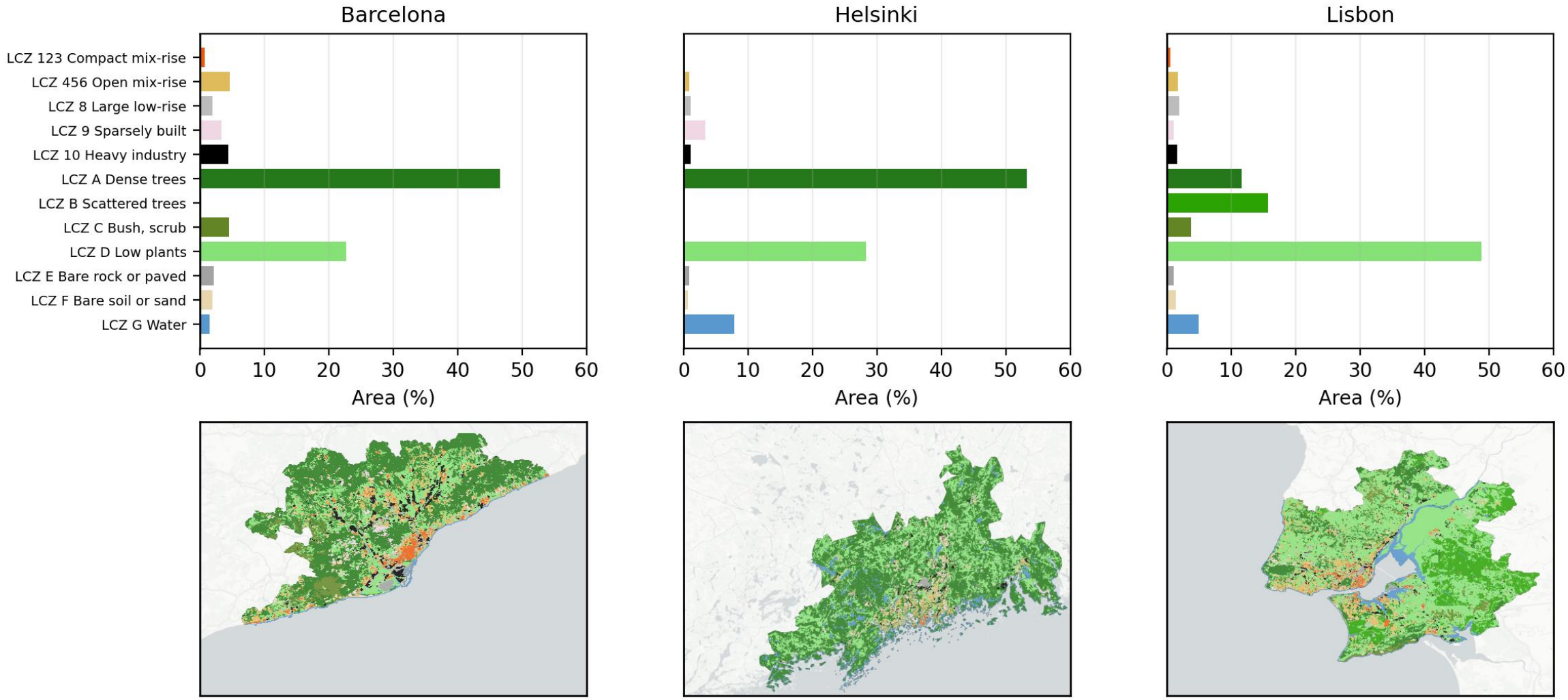
TerraDT



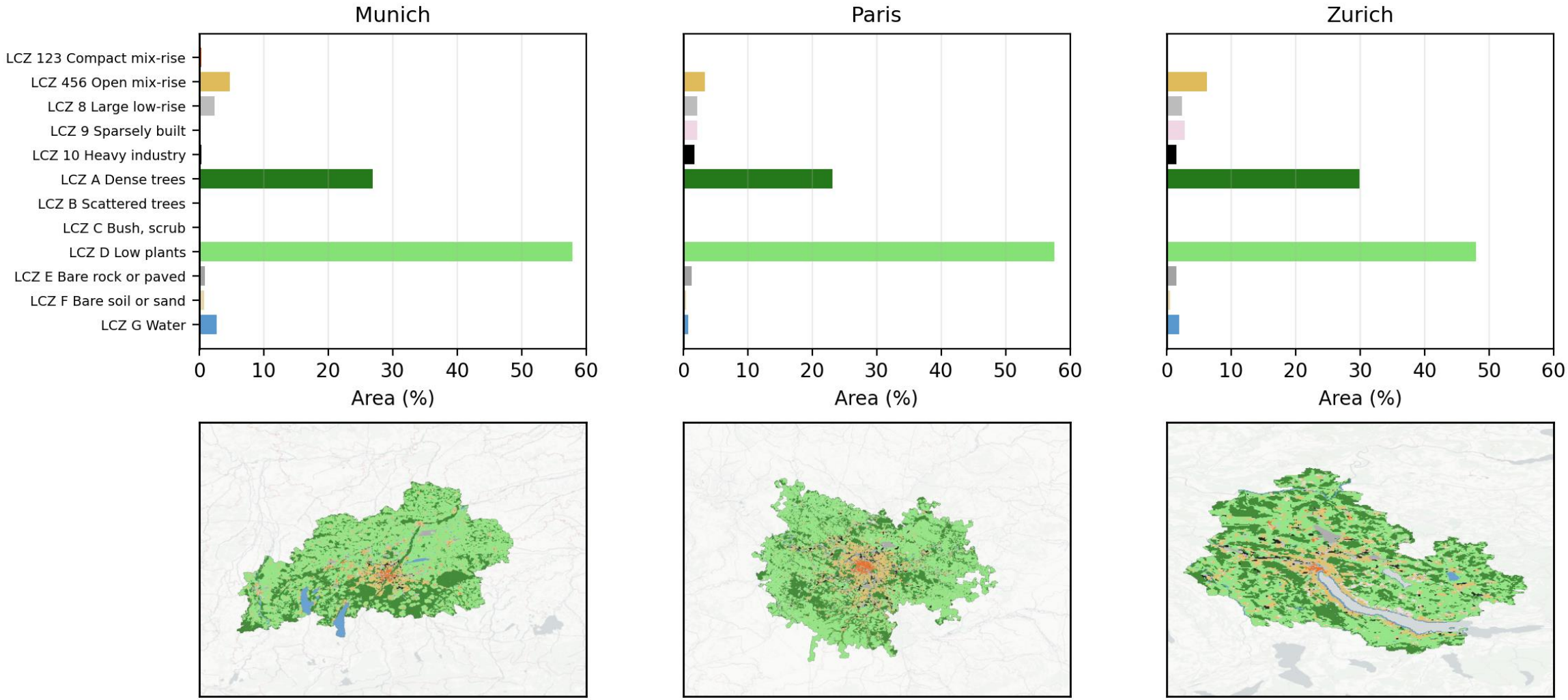

CERRA (0.05x



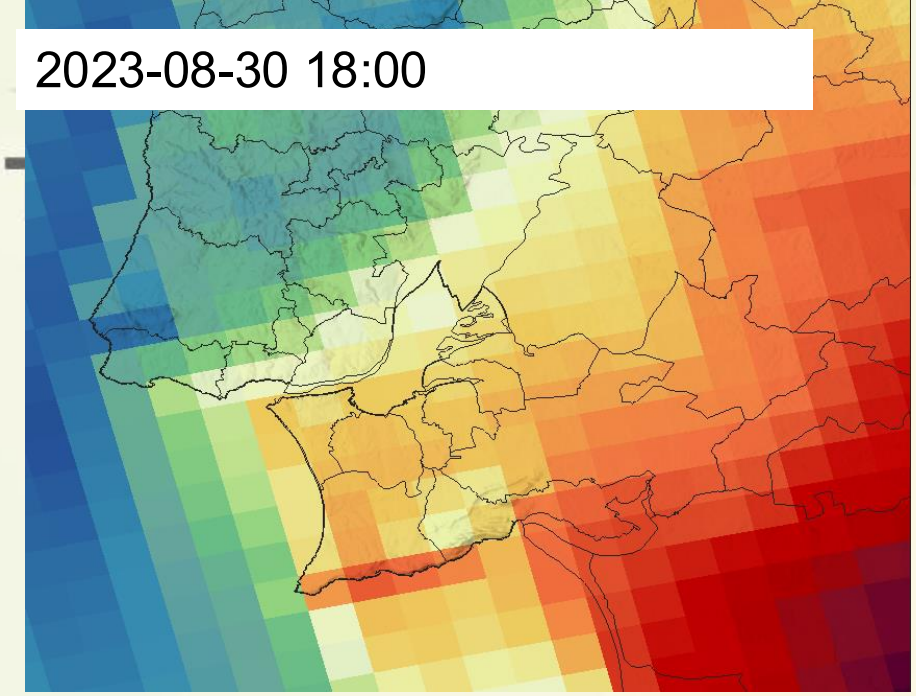


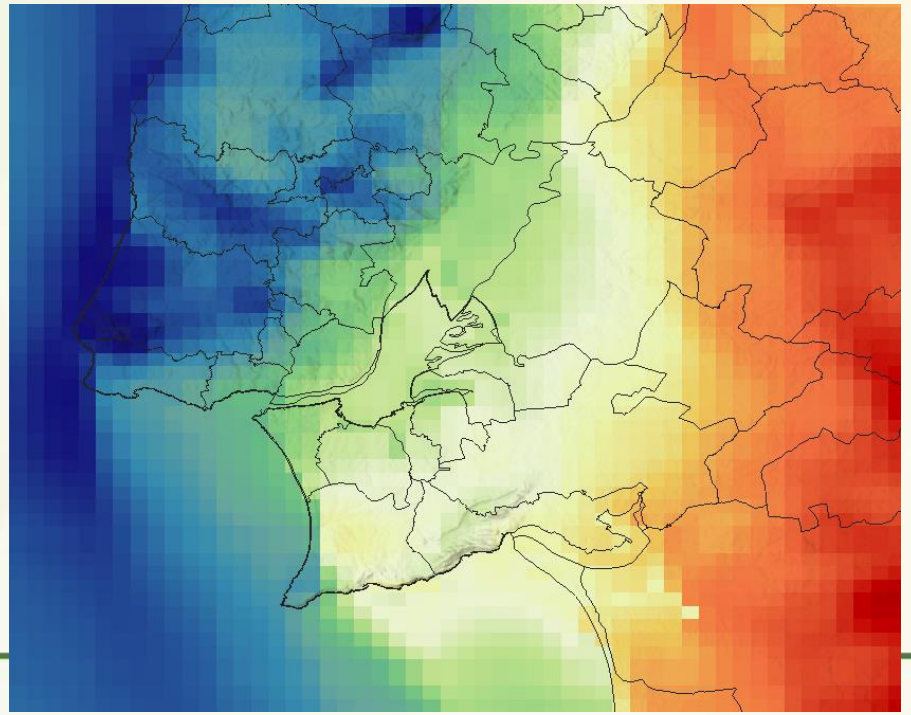

Oliveira et al., 2020

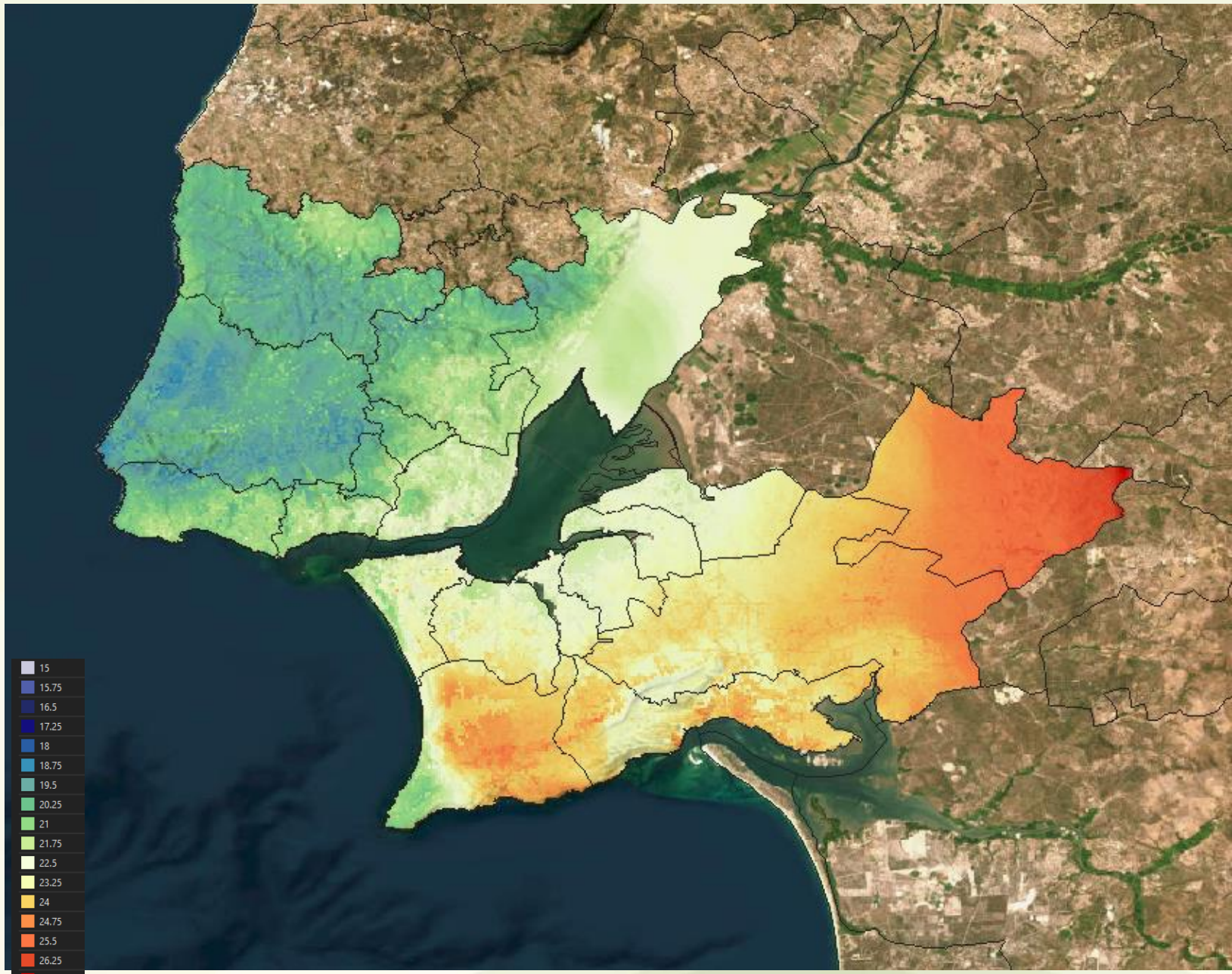



Oliveira et al., 2020

2023-08-30 18:00







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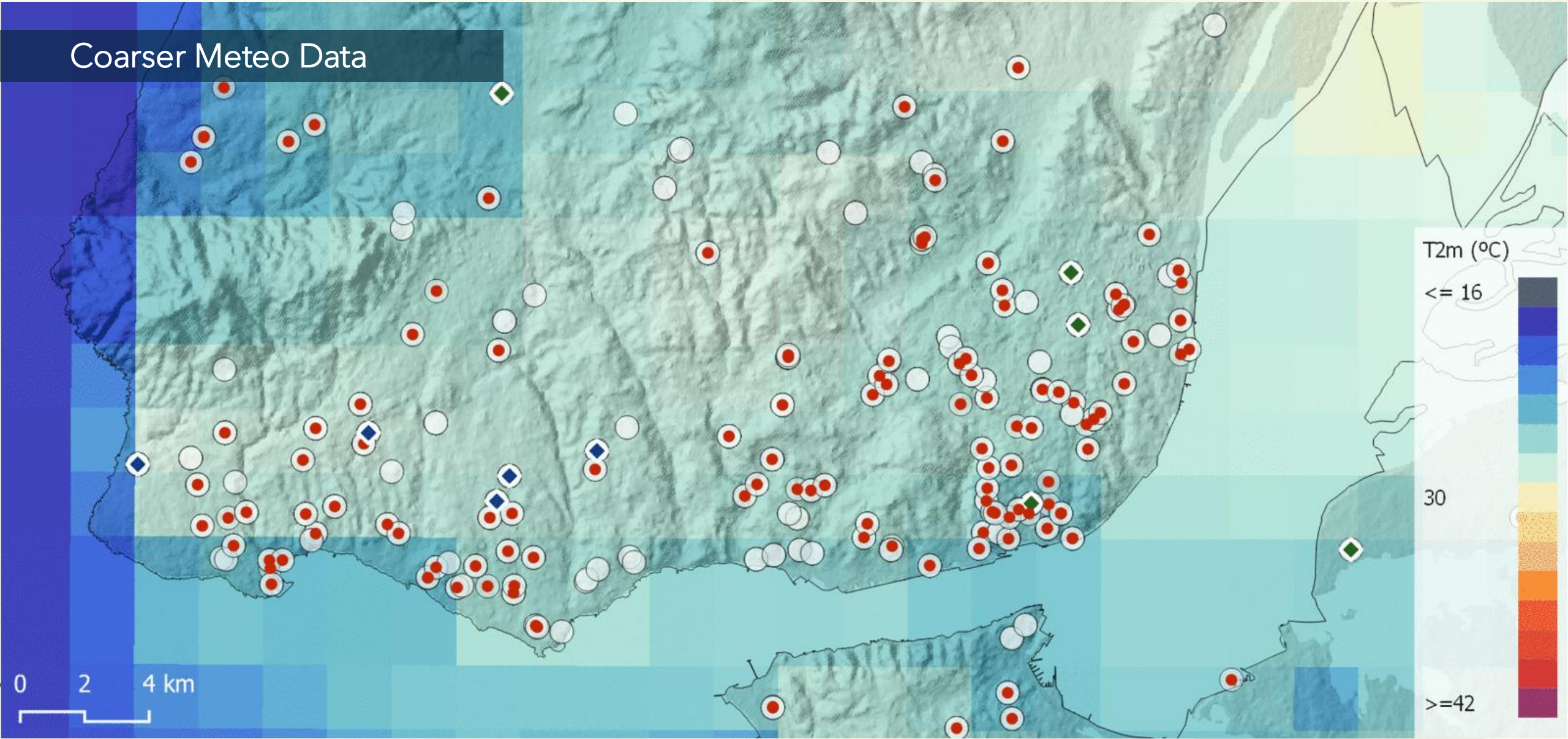
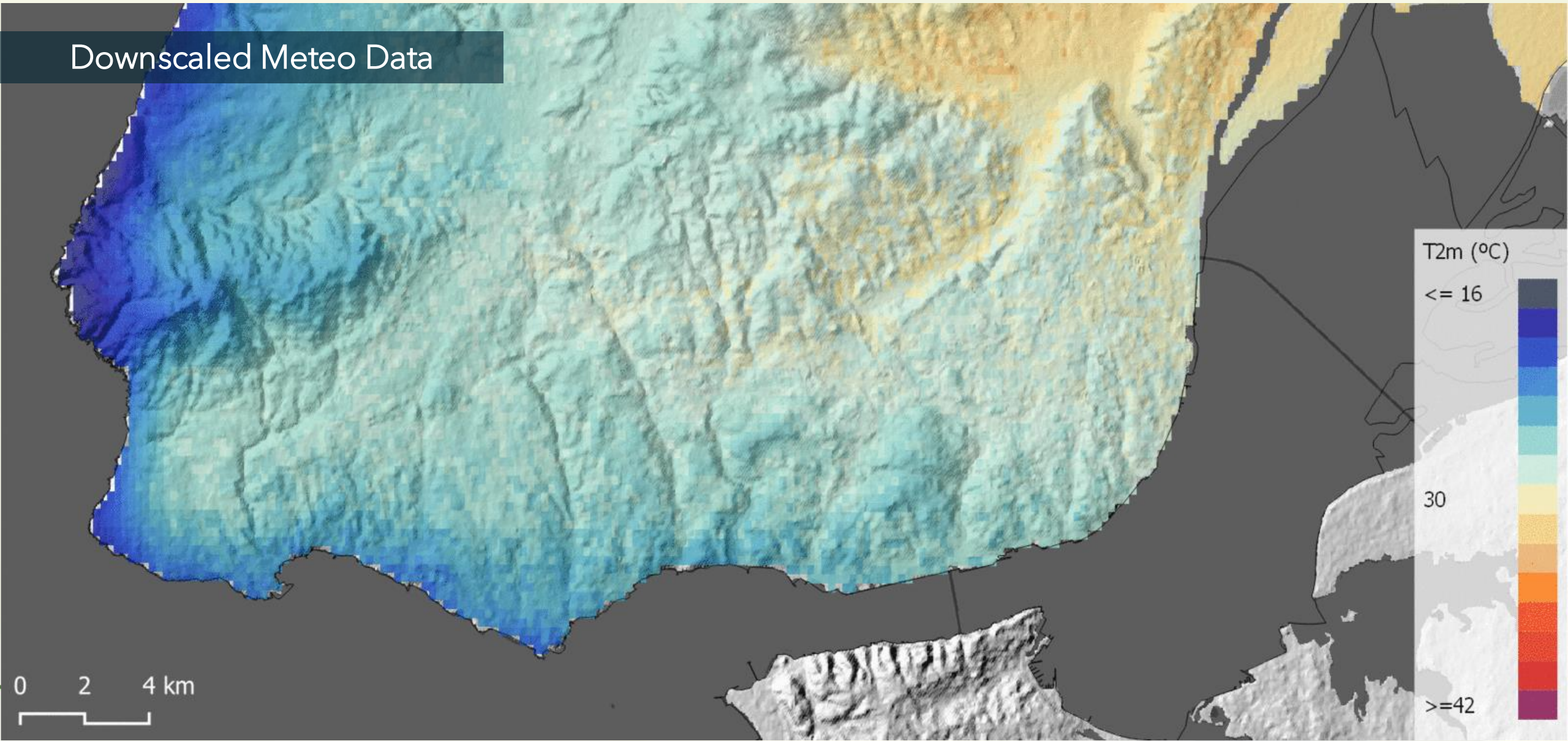
# Coarser Meteo Data

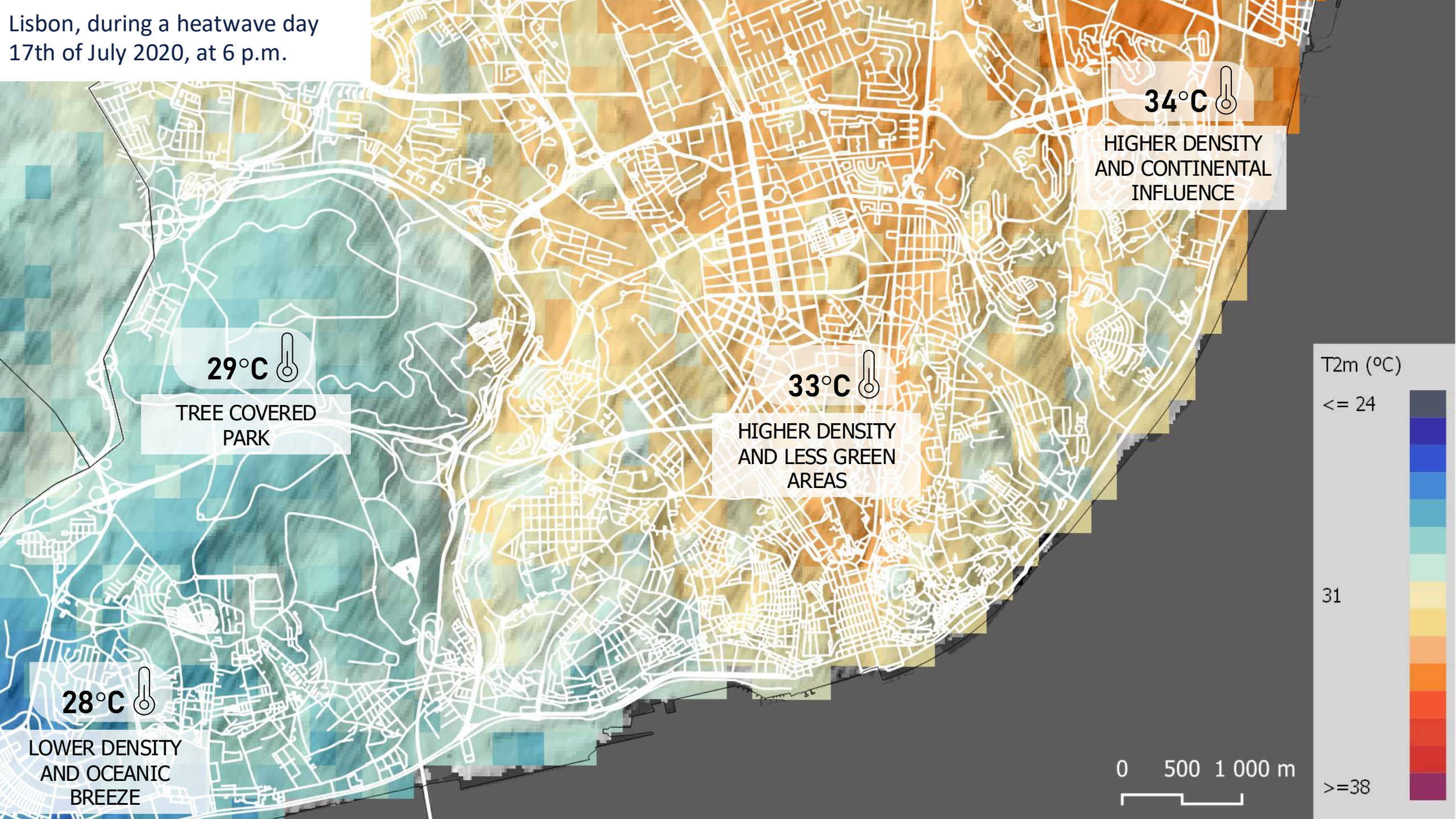


Lisbon, during a heatwave day
17th of July 2020, at 6 p.m.

TerraDT

# Downscaled Meteo Data




Lisbon, during a heatwave day
17th of July 2020, at 6 p.m.
34°C
HIGHER DENSITY AND CONTINENTAL INFLUENCE
29°C
TREE COVERED PARK
33°C
HIGHER DENSITY AND LESS GREEN AREAS
28°C
LOWER DENSITY AND OCEANIC BREEZE
T2m (°C)
<= 24
31
>=38
0 500 1 000 m

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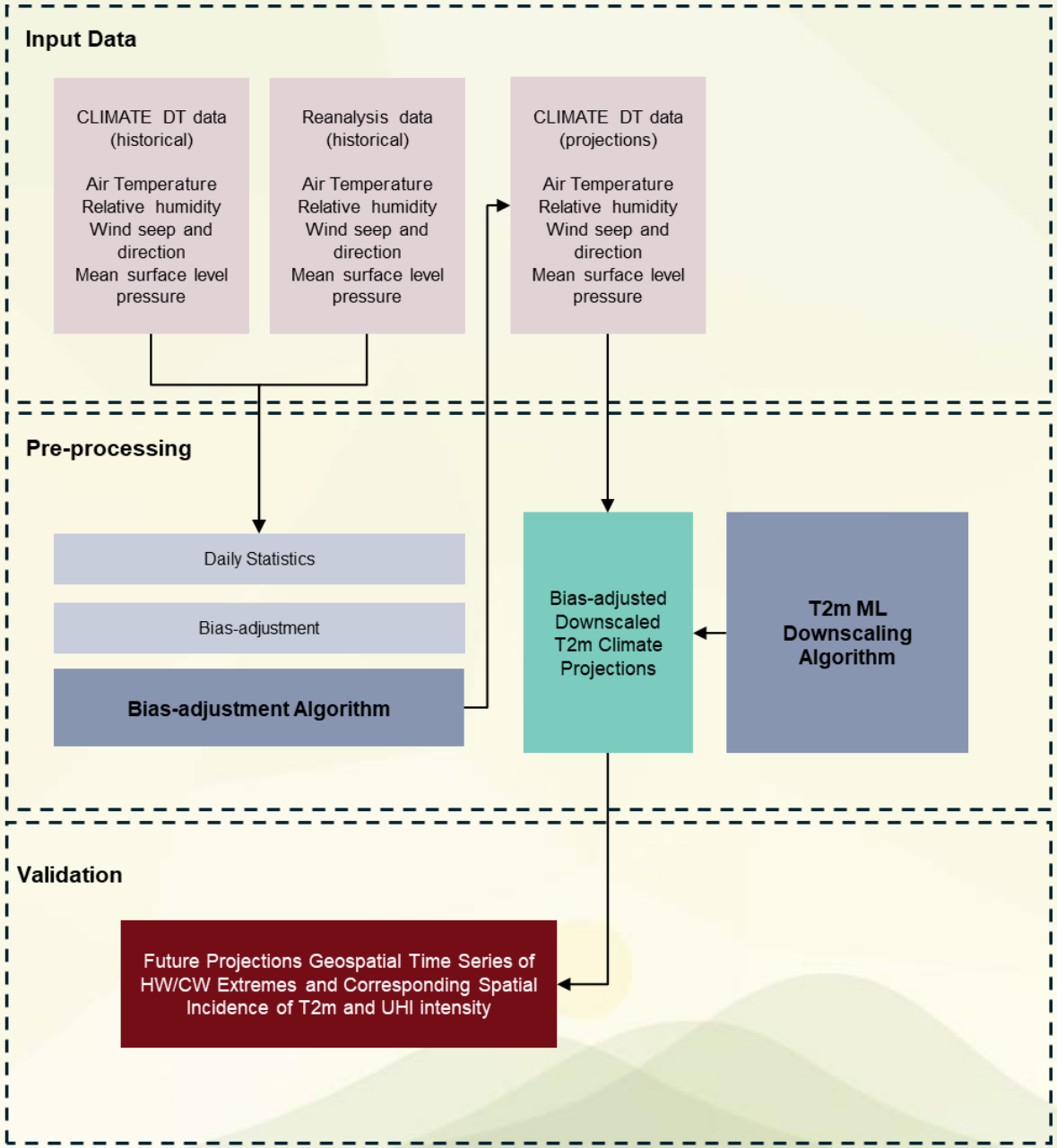
# What about the future?



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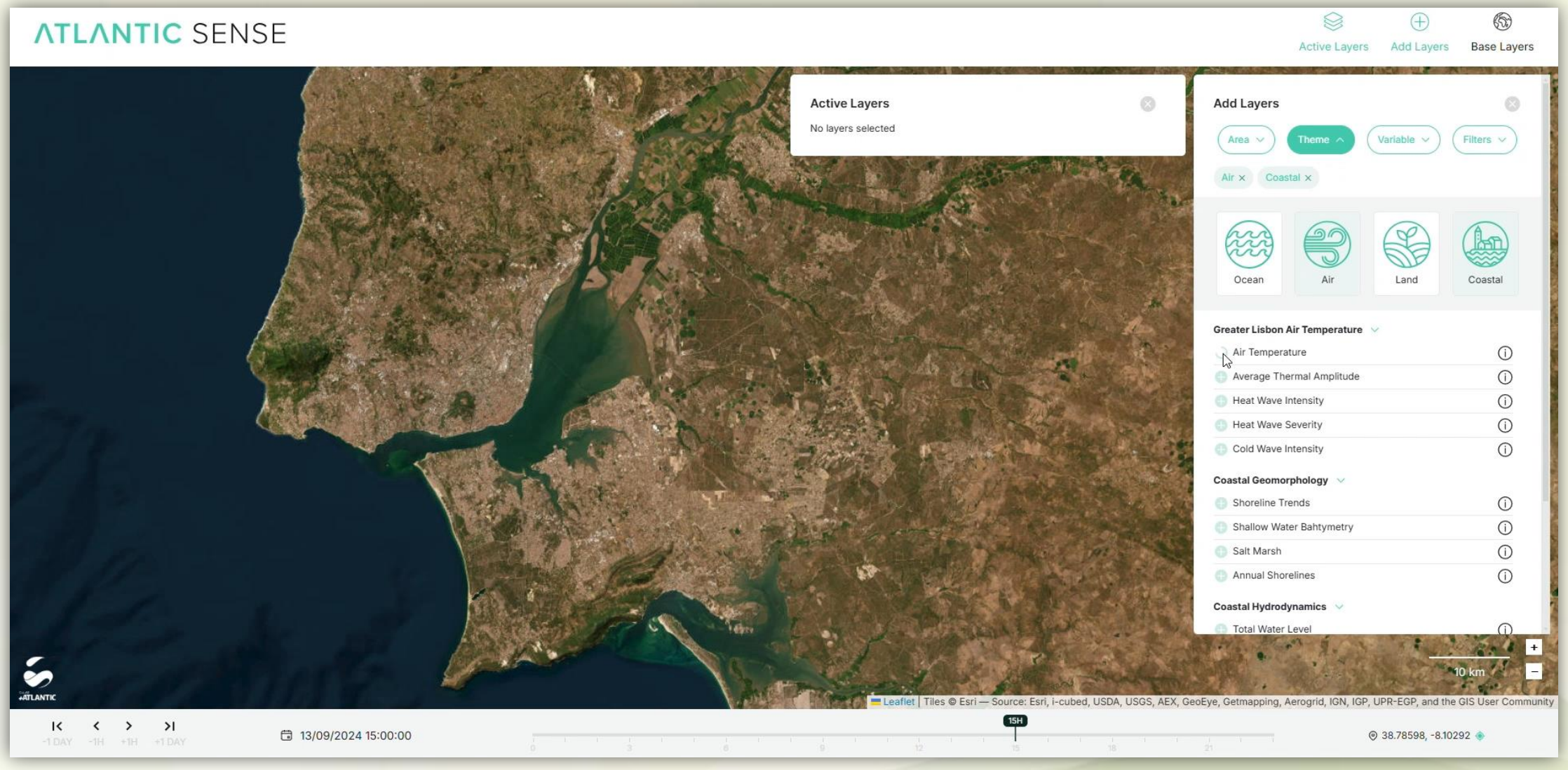
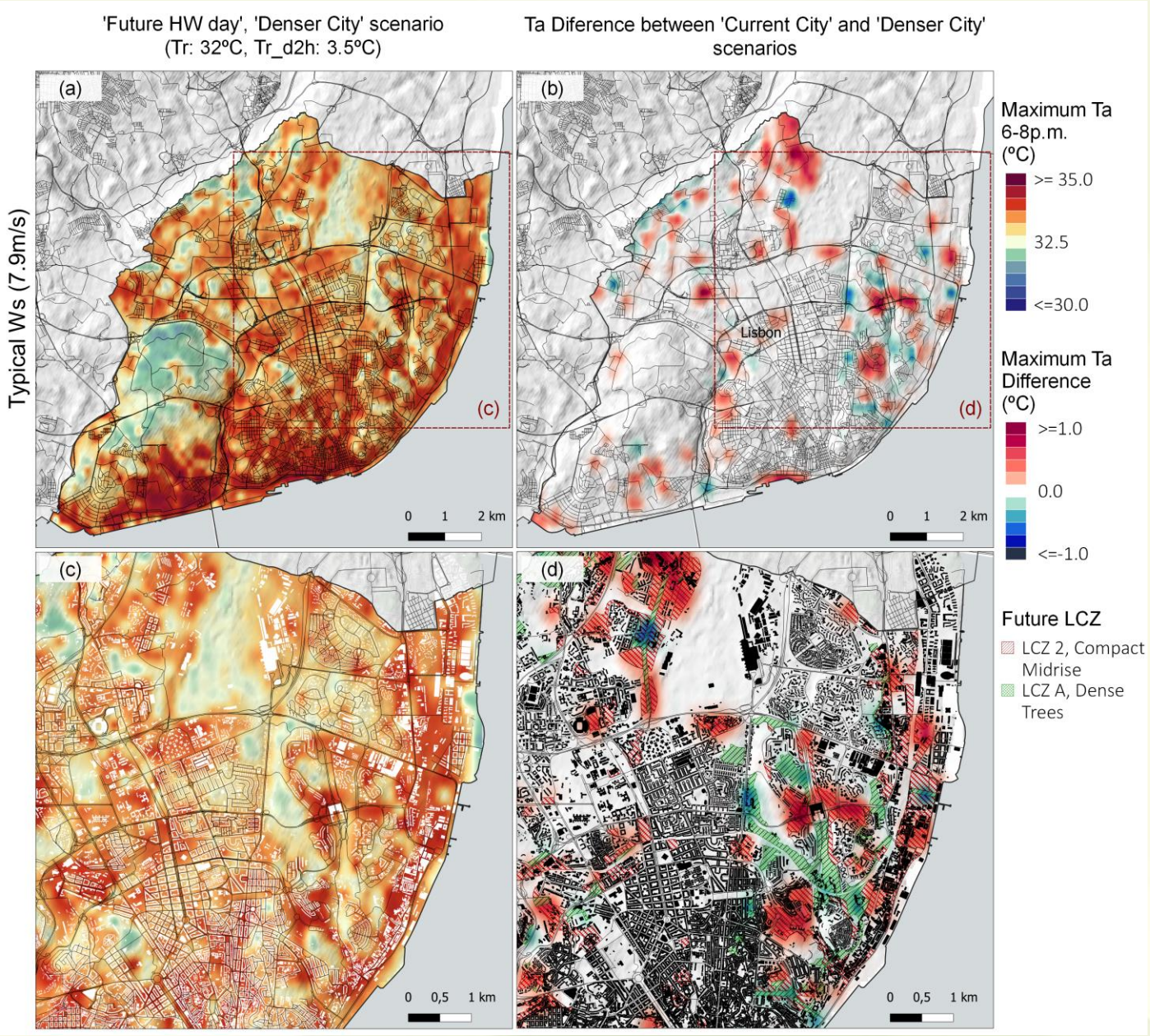

ATLANTIC SENSE
Active Layers
Add Layers
Base Layers
Active Layers
No layers selected
Add Layers
Area
Theme
Variable
Filters
Air ×
Coastal ×
Ocean
Air
Land
Coastal
Greater Lisbon Air Temperature
Air Temperature
Average Thermal Amplitude
Heat Wave Intensity
Heat Wave Severity
Cold Wave Intensity
Coastal Geomorphology
Shoreline Trends
Shallow Water Bahtymetry
Salt Marsh
Annual Shorelines
Coastal Hydrodynamics
Total Water Level
10 km
Leaflet | Tiles © Esri — Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community
-1 DAY
-1H
+1H
+1 DAY
13/09/2024 15:00:00
15H
38.78598, -8.10292

TerraDT

- How much cooler/warmer a neighbourhood is, compared to the long-term average climate?
- How extreme is the heat (cold) in a given neighbourhood, compared to the local temperature range?
- Which are the cooling (heating) acclimatization needs, in each neighbourhood?



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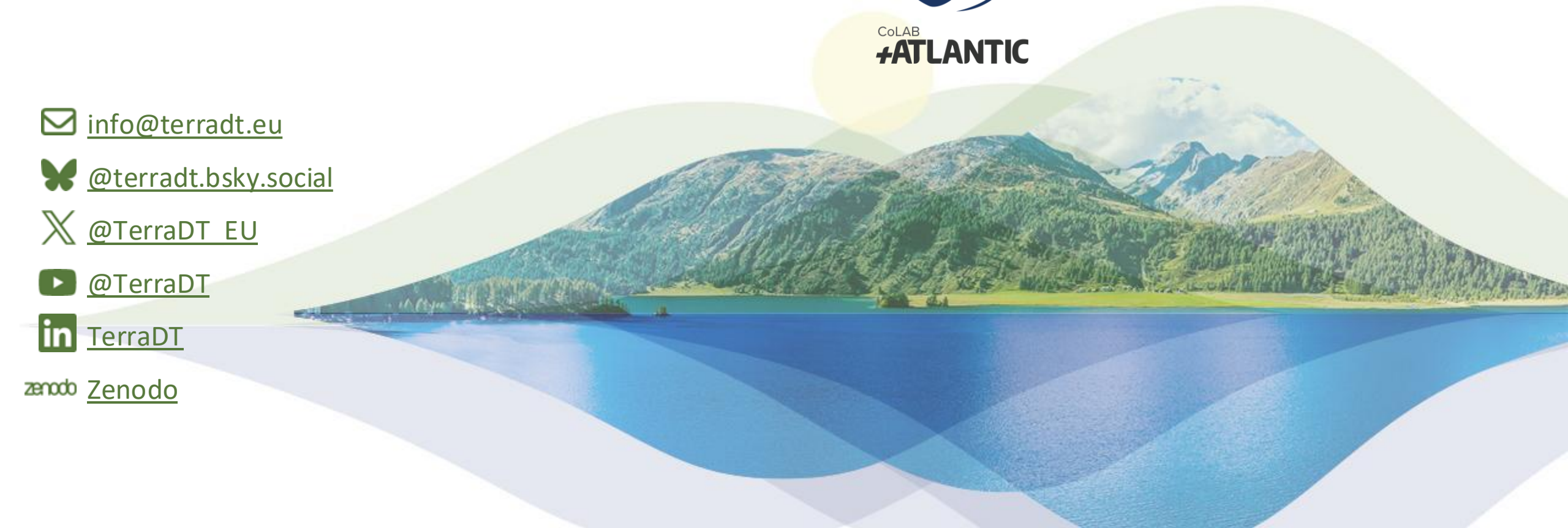
Digital Twin of Earth system for Cryosphere, Land surface and related interactions

# THANK YOU

CoLAB +ATLANTIC

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Zenodo

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Mapping High-Resolution Carbon Fluxes from Urban Green Spaces

# Leif Backman

*(Finnish Meteorological Institute)*

23 February 2026 | Barcelona [ES]

Funded by the European Union

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FINNISH METEOROLOGICAL INSTITUTE

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Digital Twin of Earth system for Cryosphere, Land surface and related interactions

# Mapping High-Resolution Carbon Fluxes from Urban Green Spaces

Urban Impact Models for Climate Adaptation

Barcelona, February 23, 2026.

**Leif Backman, Veera Vasenkari, Juha Leskinen, Liisa Kulmala et al.**

Photo: Esko Karvinen

# Urban Green Spaces


Photo: Tuija Vuorinen

## Urban vegetation provides

- Heat mitigation (UHI)
- Biodiversity & well-being
- Carbon uptake

## Climate change threatens these services

## Planning decisions today shape long-term carbon balance

# How Can We Estimate Current and Future Carbon Fluxes in Urban Ecosystems?

## Land Surface Models

Physically based, mechanistic

Simulate photosynthesis, soil carbon, hydrology, etc

## But ...

Difficult to run interactively

Computationally expensive at high spatial resolution + long time horizons

Not suitable for real-time planning tools

# Emulators Instead of a Complex Model

- Machine-learning model trained on:
  - Predictors derived from meteorology (Reanalysis data, Climate model data)
  - Carbon fluxes from ecosystem model simulations
- Learns relationships
- Runs in seconds/minutes instead of hours
- Enables:
  - Interactive exploration
  - Scenario testing

- Demonstration cities
  - Barcelona, Lisbon, Munich, Paris, Zürich and **Helsinki**
- Meteorological forcing
  - TerraDT climate simulations
    - high-resolution temperature data

# Helsinki Demonstration Case

## Emulator for carbon fluxes from urban green spaces

- **Gross Primary Production (GPP)**
  → Carbon taken up by vegetation through photosynthesis
- **Net Ecosystem Exchange (NEE)**
  → Net carbon exchange between the ecosystem and the atmosphere
- Helsinki municipality area
  - 50 m resolution
  - Deciduous and Coniferous trees, Lawns, Crops based on landcover data
- Emulator training data for multiple ecosystem types from ecosystem model (JSBACH) simulations
- Observation based meteorology
  - for driving ecosystem model
  - as predictors for the Emulator
- Vasenkari et al., (2026) Estimation of Carbon Fluxes in Urban Vegetation Using Machine Learning Emulators of the Land Surface Model JSBACH, Manuscript.

# JSBACH vs. Observations

Thölix, L., *et al.* (**2025**): Carbon sequestration in different urban vegetation types in Southern Finland, https://doi.org/10.5194/bg-22-725-2025

Karvinen E., *et al.* (**2024**): Soil respiration across a variety of tree-covered urban green spaces in Helsinki, Finland, https://doi.org/10.5194/soil-10-381-2024

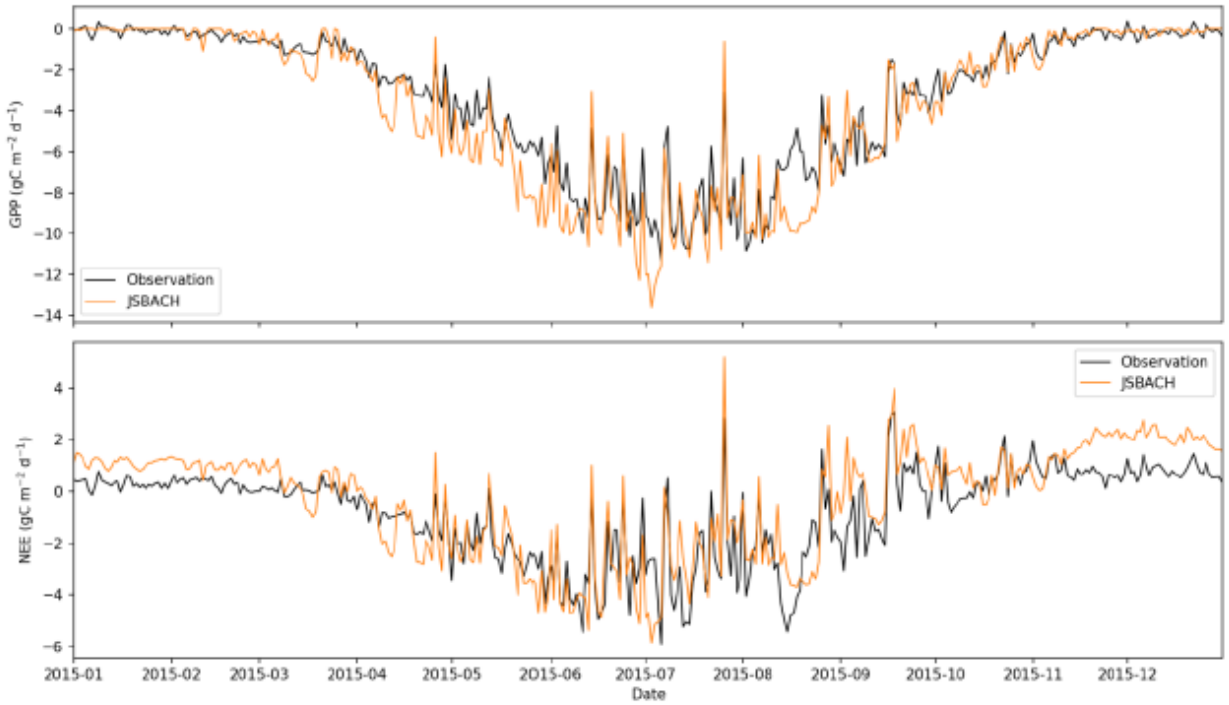
Trémeau J., *et al.* (**2024**): Lawns and meadows in urban green space – a comparison from perspectives of greenhouse gases, drought resilience and plant functional types, https://doi.org/10.5194/bg-21-949-2024

Stagakis S., *et al* (**2025**): Intercomparison of biogenic CO2 flux models in four urban parks in the city of Zurich, https://doi.org/10.5194/egusphere-2024-2475

- A process-based land surface model that simulates the exchange of carbon, water, and energy between ecosystems and the atmosphere
- Represents plant physiology, soil processes, and hydrology to estimate fluxes such as GPP and NEE
- Validated against observations and compared with other models for urban green areas
  - Soil temperature and moisture
  - Soil respiration
  - Sap flux
  - Leaf Area Index
  - EC flux data (NEE)
  - GPP

# JSBACH vs. Observations

**Coniferous trees**




EC data, SMEARII, Hyytiälä

- A process-based land surface model that simulates the exchange of carbon, water, and energy between ecosystems and the atmosphere
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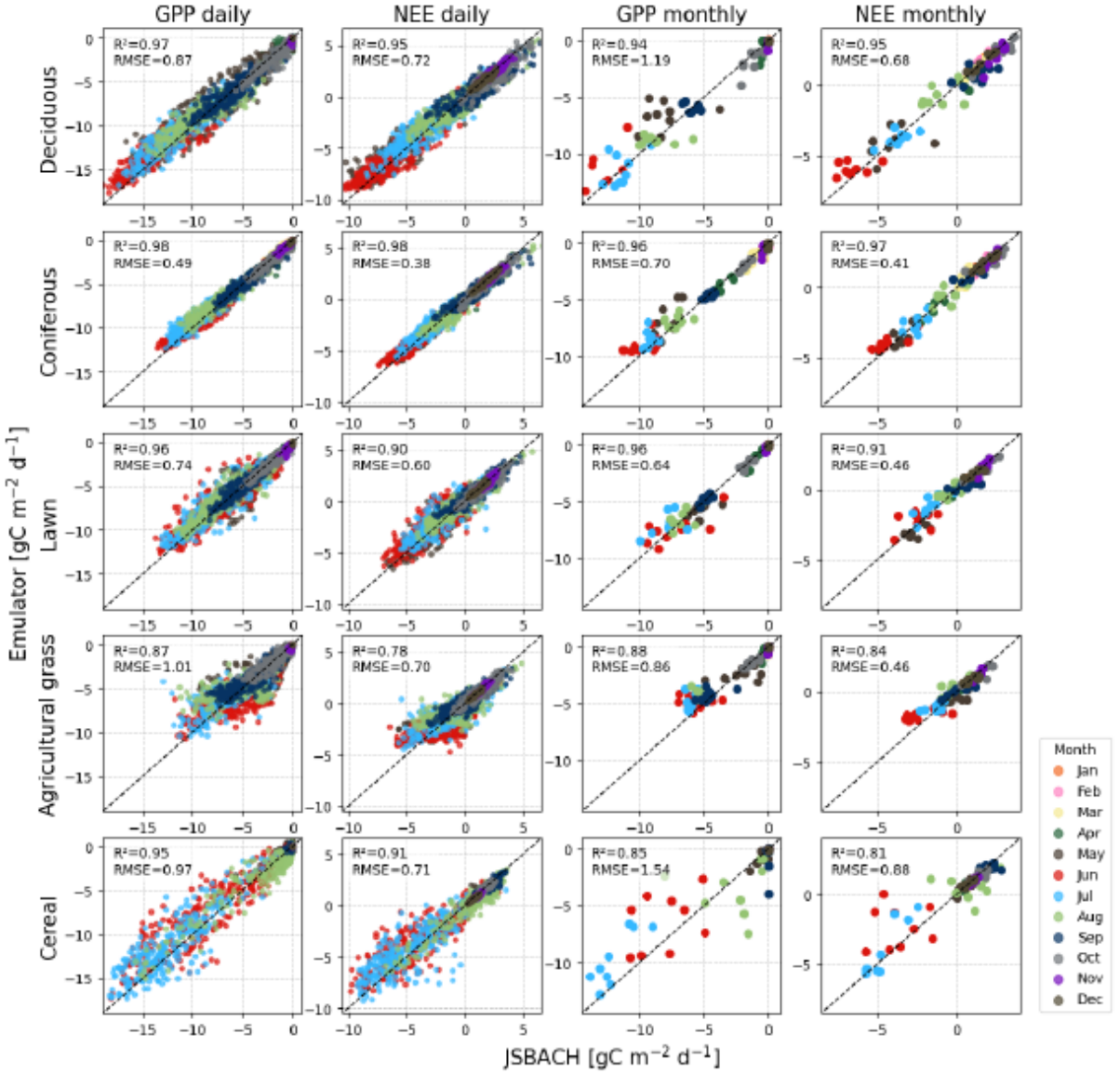
  - Leaf Area Index
  - EC flux data (NEE)
  - GPP

# Emulator vs. JSBACH

- Emulators for both daily and monthly fluxes for representative ecosystem types based on land cover
  - Gradient boosting models
- Predictors derived from
  - 2m temperature
  - Precipitation
  - Shortwave radiation

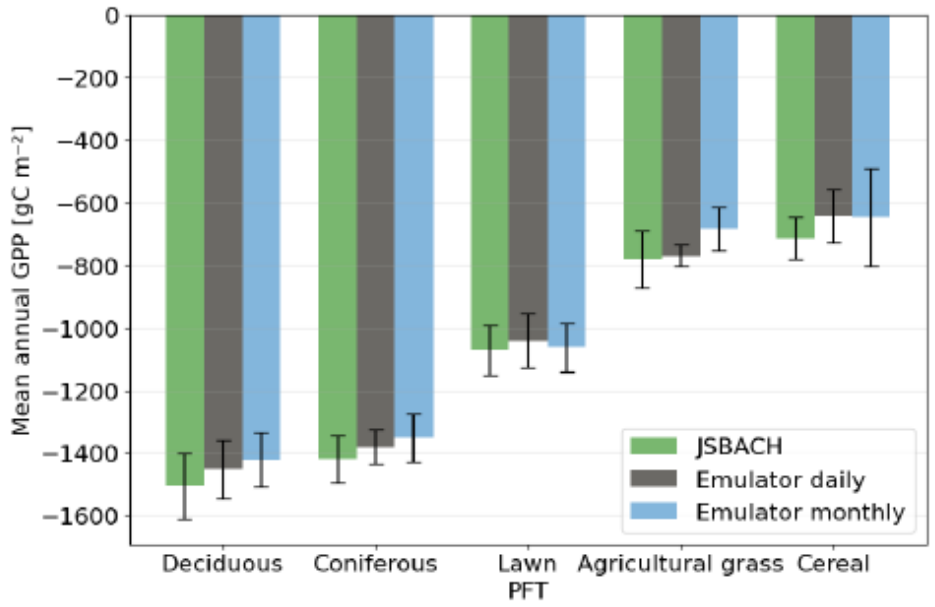



© Veera Vasenkari

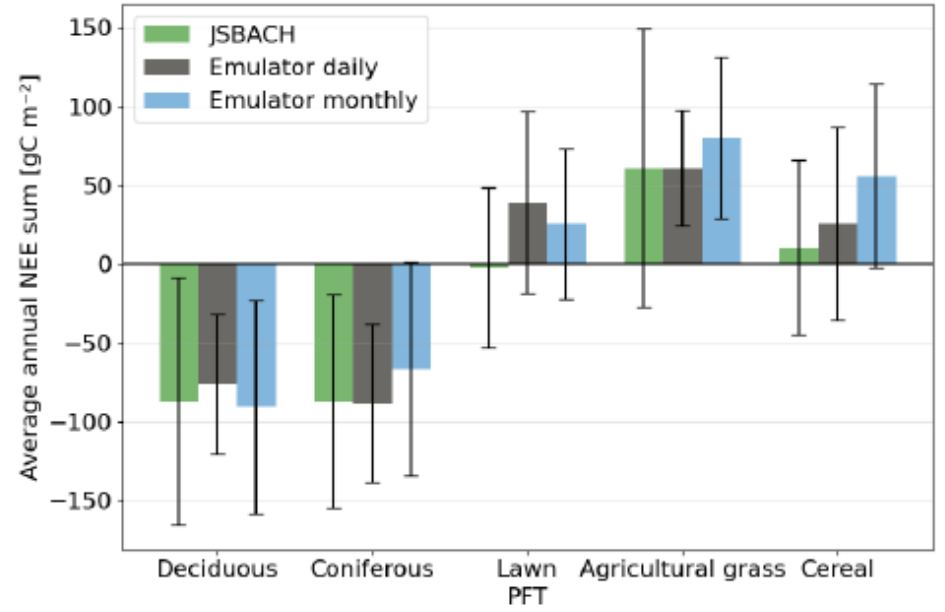
# Emulator - Mean Annual Fluxes

- Emulators for both daily and monthly fluxes for representative ecosystem types based on land cover
  - Gradient boosting models
- Predictors derived from
  - 2m temperature
  - Precipitation
  - Shortwave radiation
- Fluxes presented as multi-annual means

GPP




NEE



# From Land Cover to Flux Maps

- Fractional coverage of each ecosystem type on every 50 by 50 m grid cell
- Coniferous and Deciduous tree fractions from Copernicus High Resolution Layer Dominant Tree Cover data
- Predictors derived from air temperature, precipitation and shortwave radiation
- Emulators trained for each ecosystem type
- Land cover maps will be based on high-resolution satellite products

Helsinki metropolitan area land cover dataset

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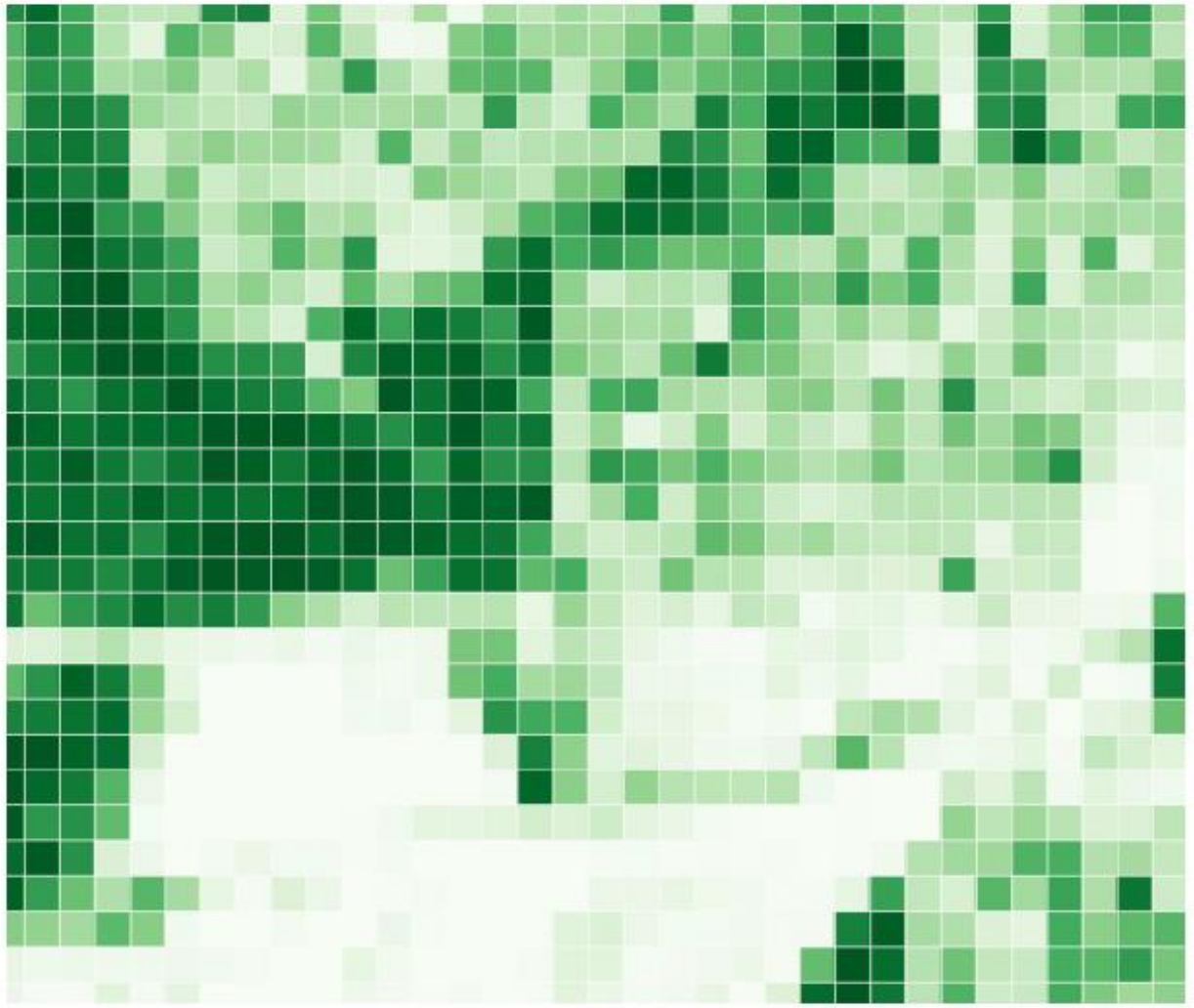
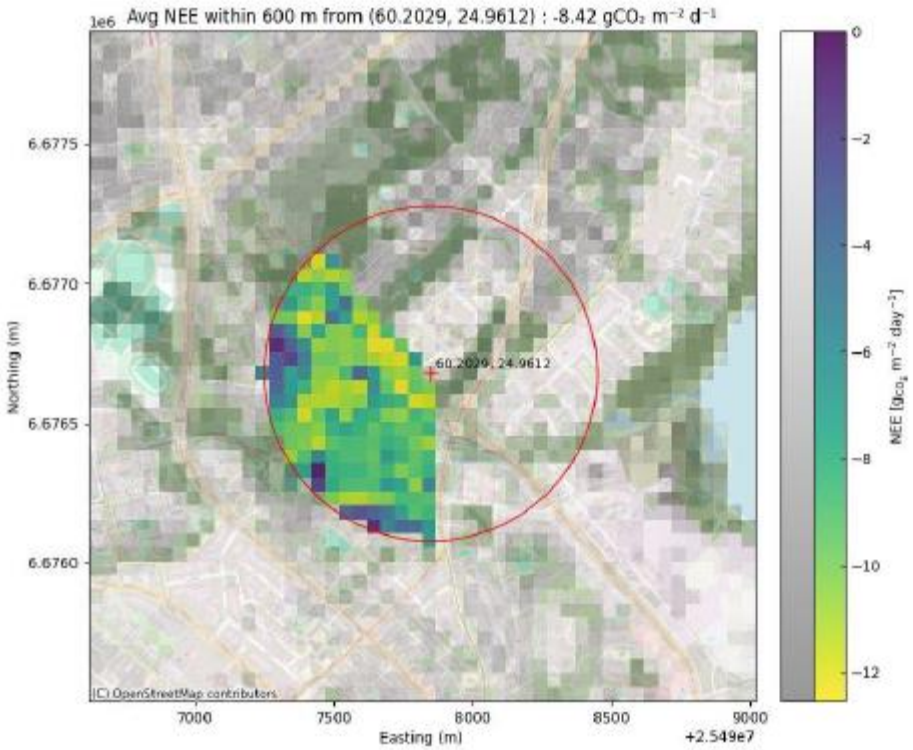
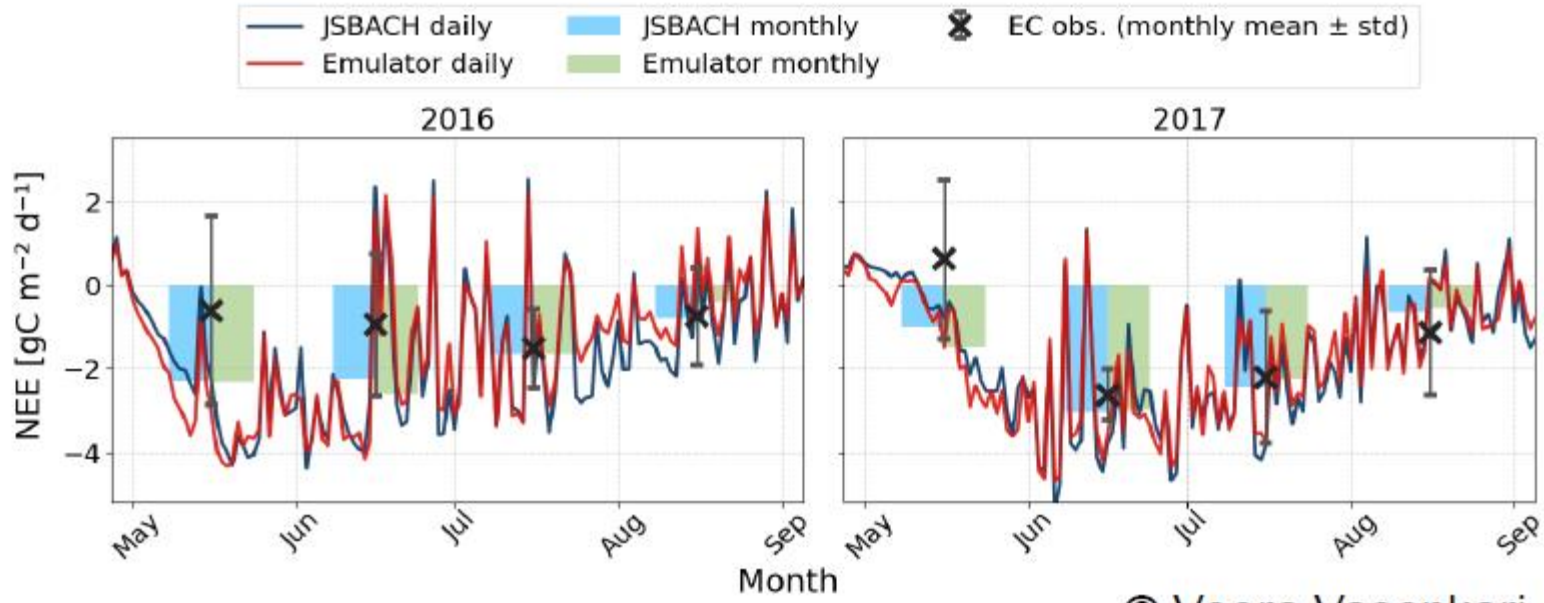


# Emulator – Validation EC Flux Data

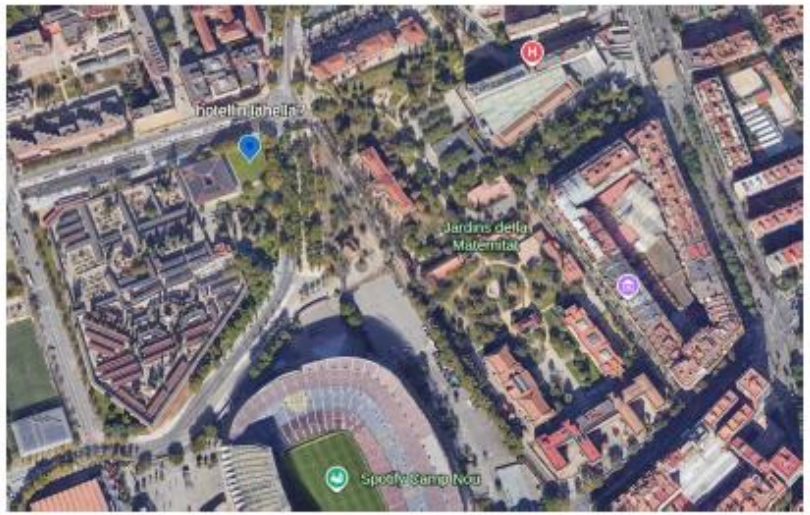


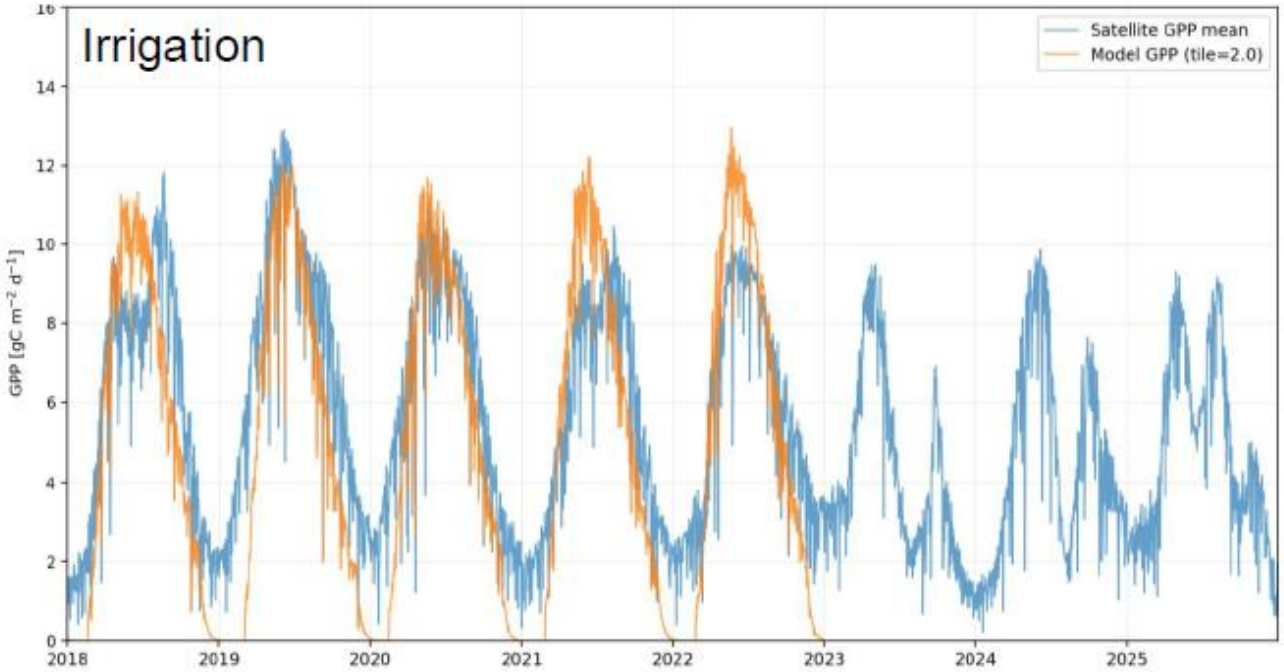

© Veera Vasenkari

EC data, SMEAR III
Urban measurement station

# Lawns Under Mediterranean Climate – Barcelona




- GPP simulated by JSBACH
- Satellite (Sentinel 2) derived GPP
- ~20 lawn/meadow type locations




Vira, J., et al. (2025). Improving agricultural carbon monitoring with Sentinel-2 and eddy-covariance-based plant productivity estimates. *Carbon Management*, *16*(1).

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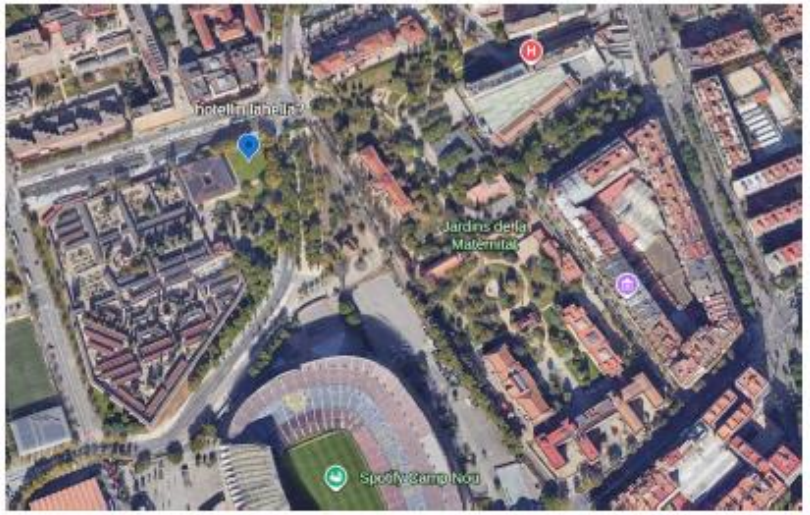


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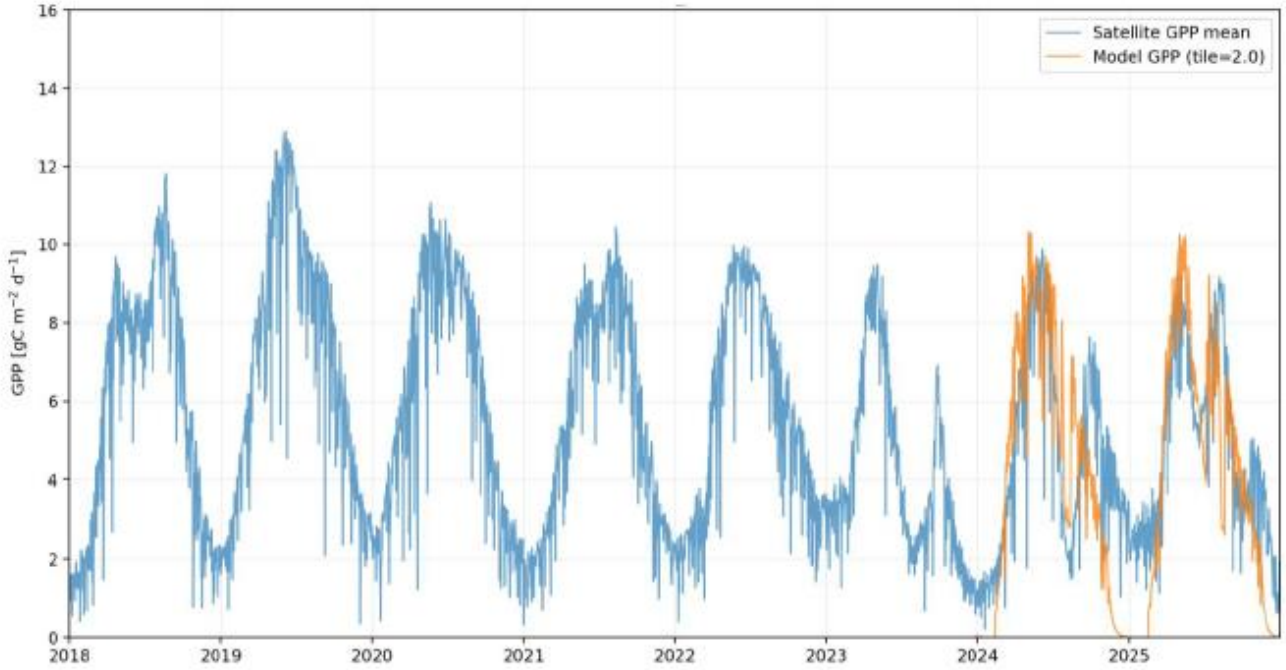


Vira, J., et al. (2025). Improving agricultural carbon monitoring with Sentinel-2 and eddy-covariance-based plant productivity estimates. *Carbon Management*, *16*(1).

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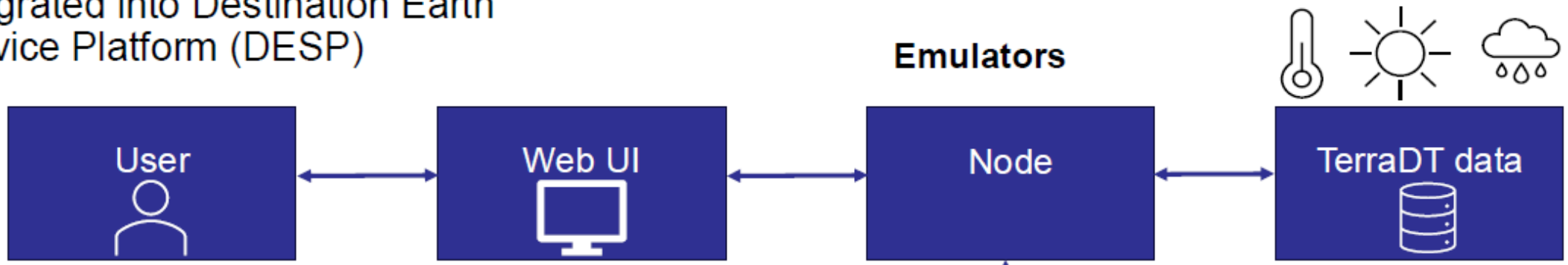
# From climate data to interactive carbon maps – TerraDT

Integrated into Destination Earth Service Platform (DESP)




User can:

- Select city
- Modify land cover (e.g., add parks)
- Choose climate scenario
- Run emulator

View:

- Maps (50-200 m resolution)
- Graphs
- Summary statistics

# What can this enable?

- Next steps
  - Integration with high-resolution temperature fields
  - Coupled carbon + temperature impacts (UHI)
- Compare green-space design options
- Assess climate scenario sensitivity
- Support
  - Urban planning
  - Climate mitigation strategies
  - Nature-based solutions

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# Thank you!

22.2.2026

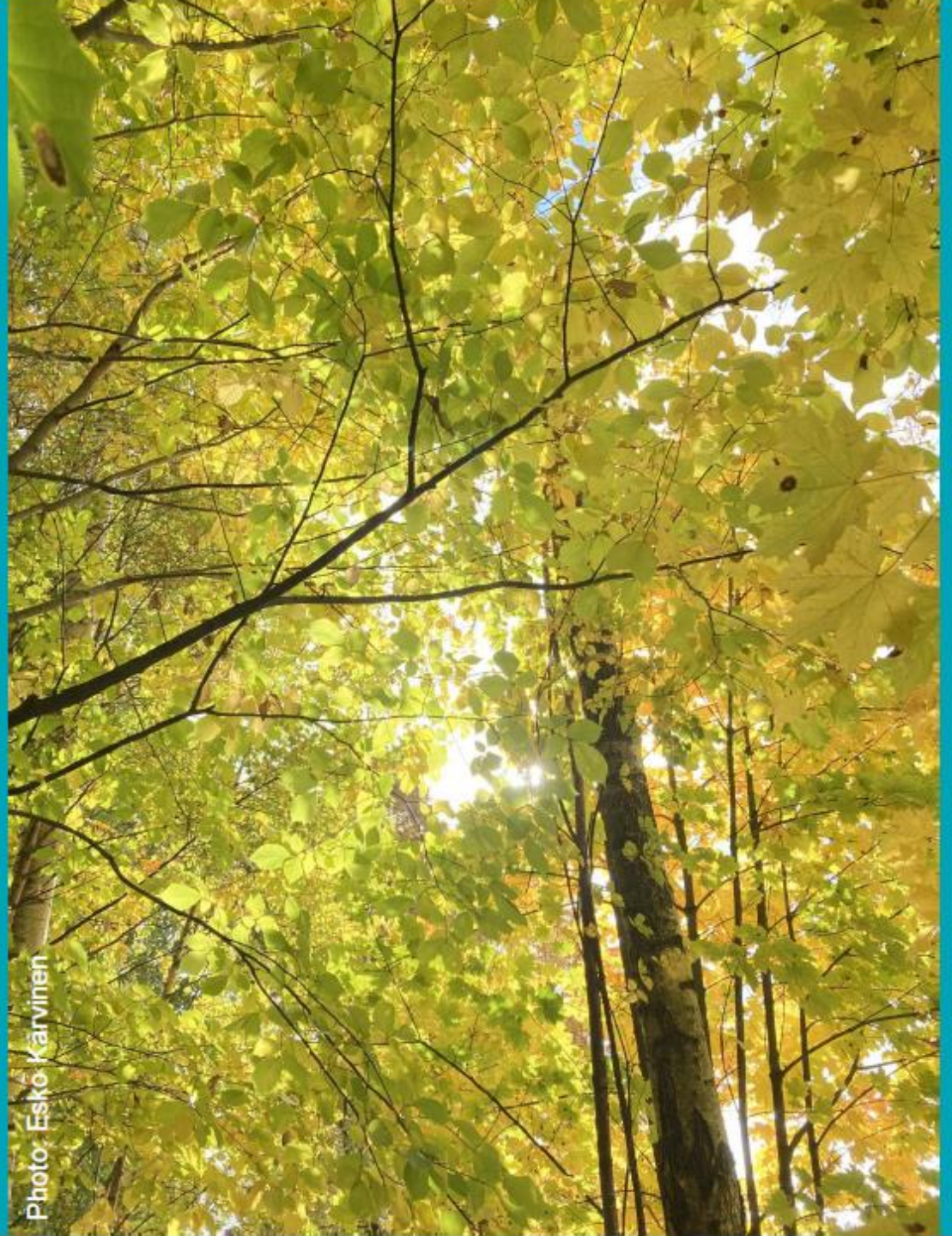
Photo: Esko Kärvinen

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WELCOME AND INTRODUCTION

# Isra Mohamed Hussein

*CSC - IT Center for Science*

23 February 2026 | Barcelona [ES]

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IMPACT WORKSHOP

# Coffee break

## 15:10 - 15:40

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**Impact Workshop**
Urban Impact Models for Climate Adaptation

## EXPERT PANEL: USER PERSPECTIVES

### Tero Aalto
*(Moderator)*
*CSC - IT Center for Science*

### Jaana Bäck
*University of Helsinki*
*(TerraDT UAG)*

### Anu Riikonen
*Sitowise*
*(TerraDT UAG)*

### Dragana Bojović
*BSC (Impetus4Change)*

### Pablo Martinez
*300.000 Km/s*

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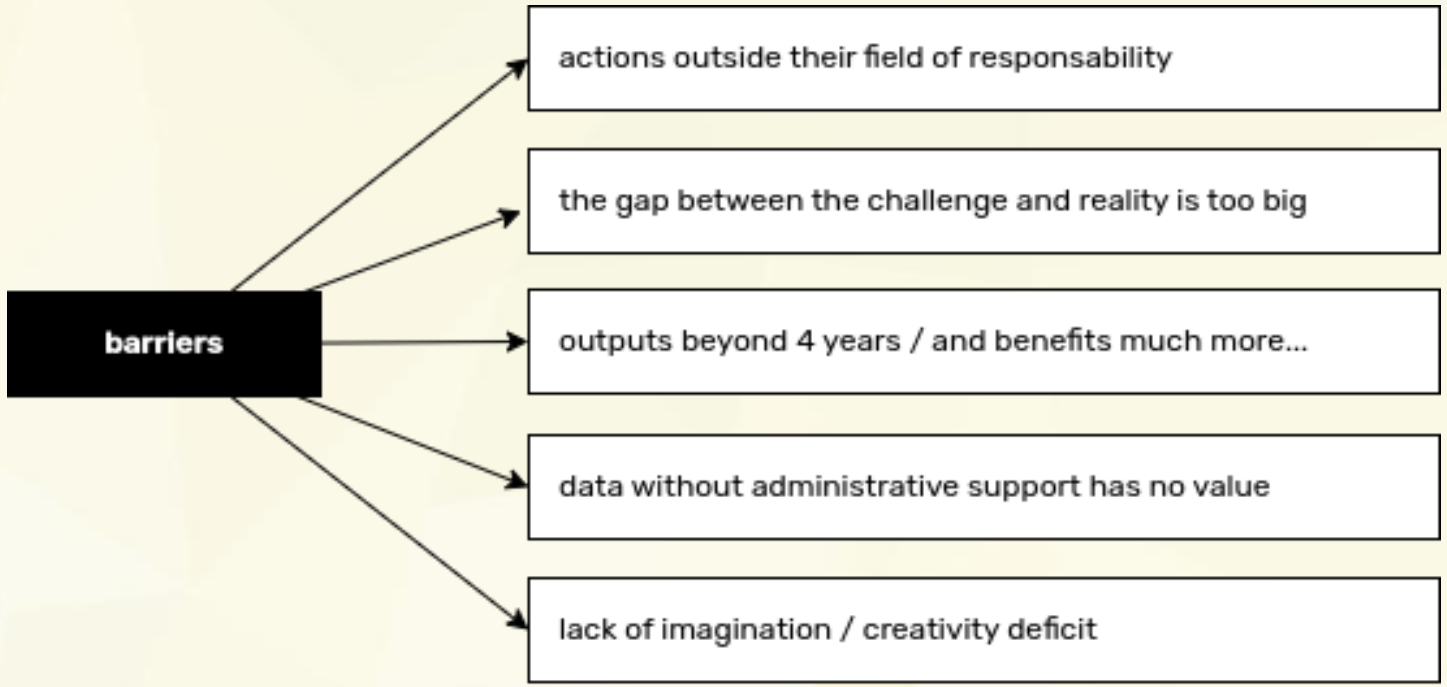
**the barriers**

it’s not only about data access, data formats, interoperability or quality...



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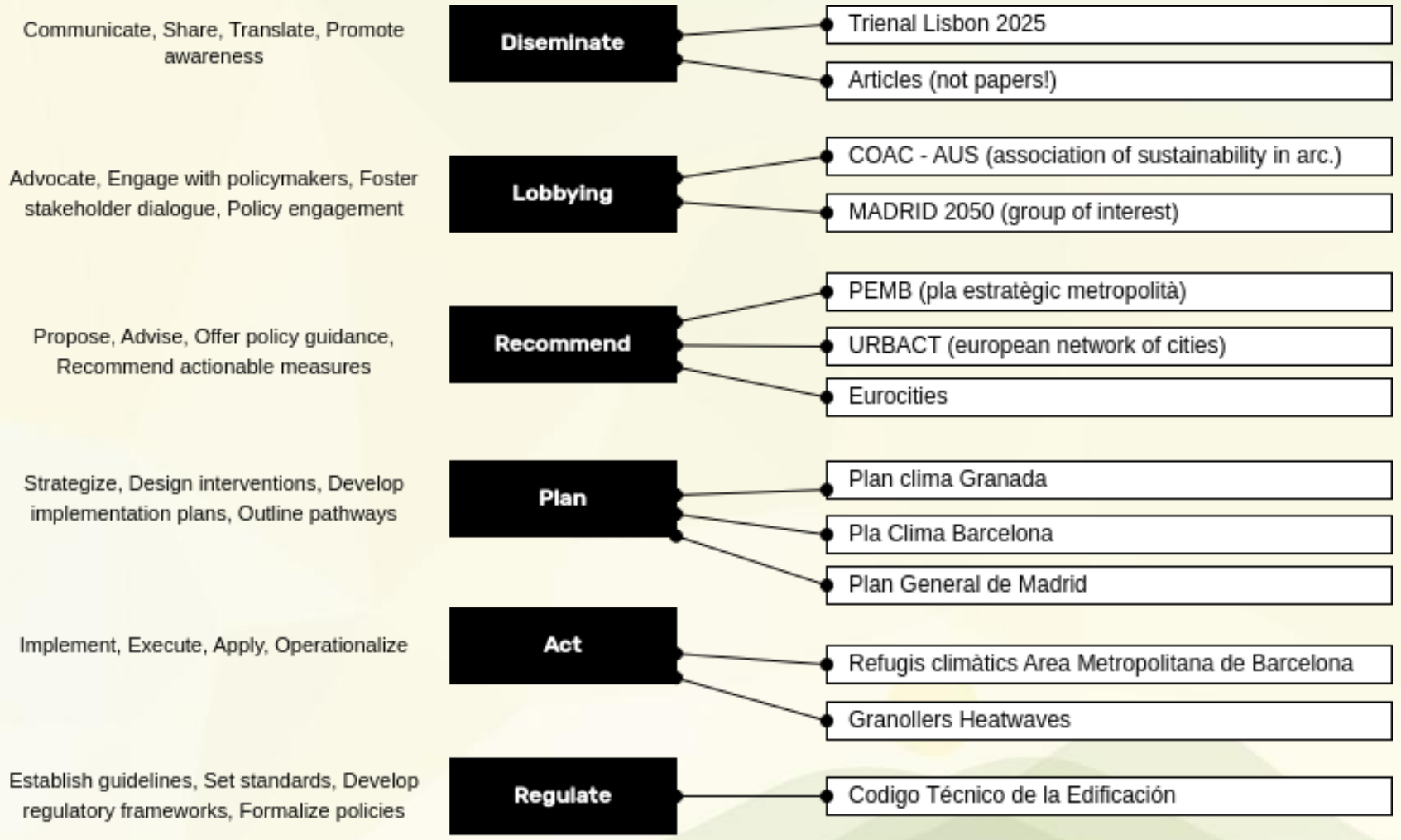
**from science to policy**
**from data to decisions**



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IMPETUS 4CHANGE

# IMPETUS4CHANGE: **Improving near-term climate predictions for societal transformation**

*AKA: Where urban practitioners, social scientists and modellers co-create novel climate knowledge*

# Coproduction of climate services in I4C demonstrators

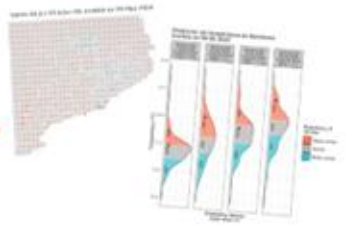
**Co-production framework; Step 2**

Involvement. Co-design

ADAPTALABS

**Co-production framework; Step 3**

Empowerment. Co-development





**Co-production framework; Step 1**

Engagement. Co-exploration

*Who to involve?*


*What to focus on?*


**Co-production framework**

Co-evaluation

*Throughout*

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**Impact Workshop**
Urban Impact Models for Climate Adaptation

INTERACTIVE SESSION

# Collecting user needs and requirements


## Diana Urquiza
*Barcelona Supercomputing Center*



## Antonia Frangeskou
*Barcelona Supercomputing Center*


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# Networking cocktail

## 18:00 - 19:00

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# THANK YOU


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