Climate Digital Twin (DE340)

DESTINATION EARTH

Heat waves in urban environments
A DestinE use case in the ClimateDT

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INTRODUCTION

By 2020, approximately **56 % of the world's population lived in urban environments**, numbering 4.36 billion people in total. The share of urban population is expected to keep growing, reaching **70 % by 2050**, according to UN projections [1].

Climate projections point towards a **severe increase in the intensity, duration, frequency and geographical extension of heat extremes** under current climate change conditions (Fig. 2). Certain regions of the planet present a higher vulnerability to these high-temperature extreme events, though the overall observed change affects almost the entire planet [2][3].

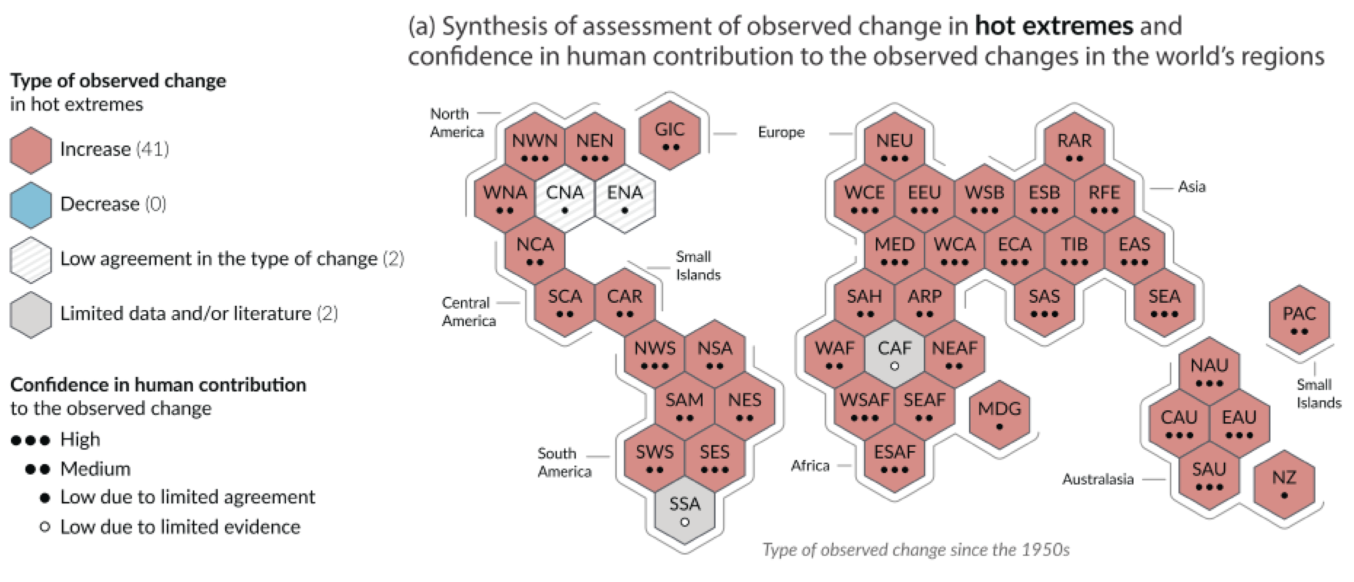

Figure 1: Observed change in hot extremes. AR6 Climate Change 2021: The physical science basis (SPM), IPCC

Urban environments are particularly susceptible to the impacts of heat waves due to the **urban heat island (UHI) effect**, which magnifies the severity of heat waves inside cities and significantly increases the health-related risks associated with heat stress [4][5].

The goal of the Urban use case is to analyse the **spatiotemporal variability of heat waves** in urban environments through an extensive set of climate indicators related to **heat extremes** and human **thermal comfort**.

USERS & STAKEHOLDERS

Current key user:

- **CoLAB +ATLANTIC**

The urban key user representing +ATLANTIC is Dr. Ana Oliveira. She is a geospatial data analyst who has developed an Urban ML downscaling model, currently operational for the city of Lisbon. She has extensive expertise in temperature extremes and heat waves, publishing peer-reviewed papers on the impact of climate and land cover on urban climates.

Potential key users

Stakeholders working in urban and health-related fields can benefit from the information produced in the Urban use case. For instance, city councils and policymakers could improve civil protection and health services. At the same time, this information could help urban planners design more resilient cities, better adapted to the impacts of extreme temperatures and heat waves.

How can the initiative help to improve the state of the art methods in this sector?

For this we can identify the user needs and requirements that the ClimateDT will be able to address:

Needs	Requirements
Gain an improved understanding of how climate change will impact urban areas by investigating indicators of extreme heat and consequent health risks.	Analyze the spatial and temporal variability of heatwaves in urban environments by modelling temperature extremes at high-resolution and with updated land use/cover data.
Quantify UHI intensity and extent by comparing it to future scenarios based on climate projections to support urban planning regulation enforcement.	Access to at least 30 years of observational data from ground stations to support the downscaling model and account for the fine-scale physical processes of the UHI effect.

TECHNICAL DESIGN

The Urban application is being developed as a Python library (current version: 0.3.0), with two main scripts containing an extensive set of indicators and supporting scripts containing auxiliary functions for data pre- and post-processing [6][7].

Feature	State-of-the-art	ClimateDT
Land cover	Urban ground not present in land cover schemes of GCMs	**Urban ground present** in land cover schemes of GCMs
Temporal resolution	3 to 6 hourly	**1 hourly** to sub-hourly
Spatial resolution	100 km (CMIP) 12.5 - 50 km (CORDEX)	**2.5 - 5 km**
Location	RCMs / downscaling required for regional climate information	**Regional climate information available globally**

Table 1: Summary of novel features introduced by the ClimateDT in GCMs.

The application will be capable of producing a set of indicators in a streaming configuration, using ClimateDT data as input, including:

- Temperature extremes (TR20, SU25, TX90p, TN90p, TXx, TNx, etc.)
- Heat waves (EHF, etc.)
- Thermal comfort (HI, WBT, AT, NET, etc.)

The data used by the application, simulated by the IFS-NEMO/FESOM and ICON models and then standardized into a Generic State Vector (GSV), consists of several climate fields, including but not limited to:

- 2m temperature
- 10m u/v wind components
- 2m dewpoint temperature / relative humidity

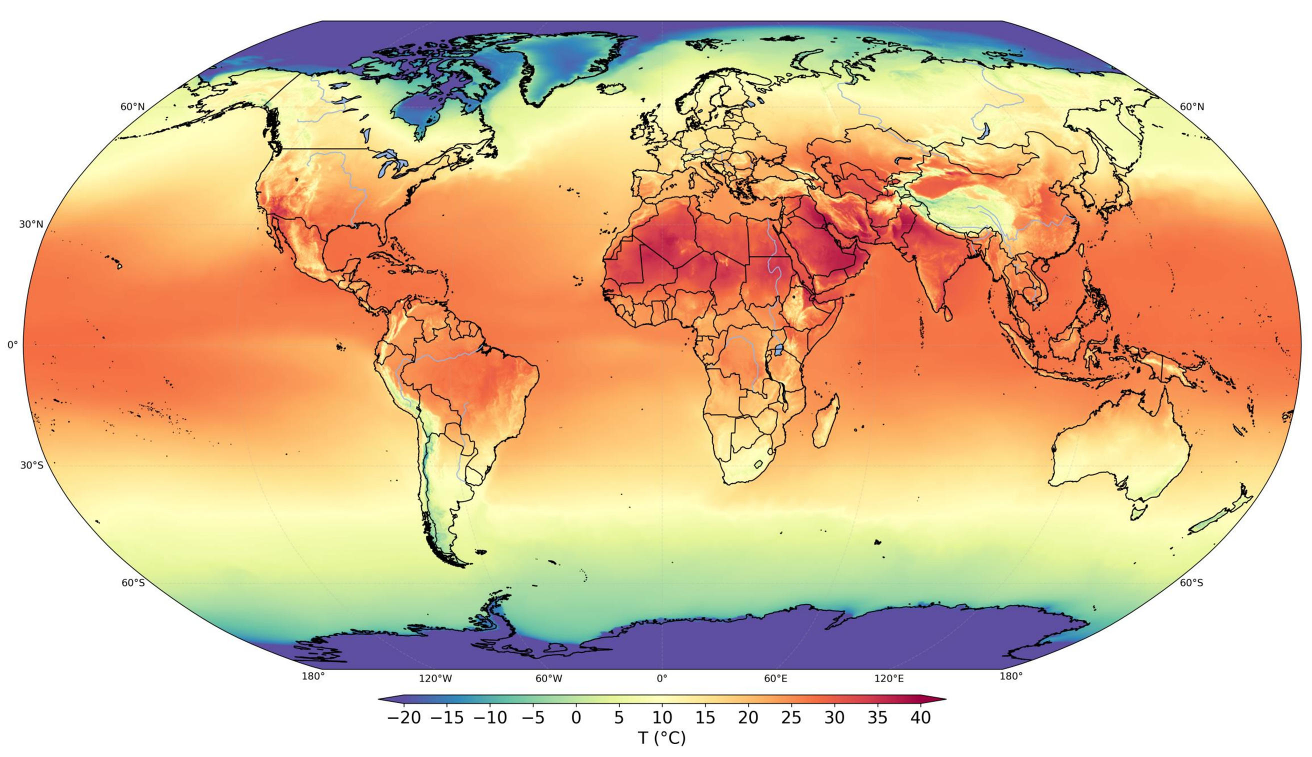

Figure 2: Temperature at 2m averaged over JJA for 1950 from 1-hourly temperature. Data was obtained from the ClimateDT IFS-NEMO control simulation.

IMPLEMENTATION IN THE WORKFLOW

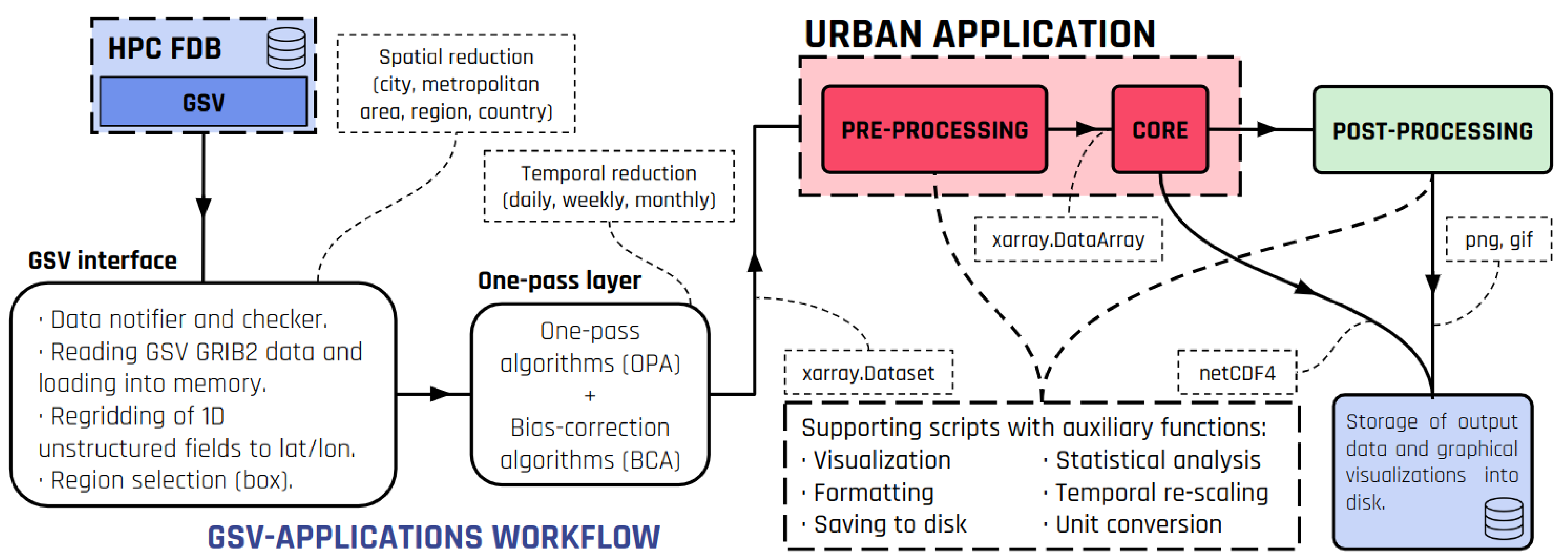

Figure 3: Architecture of the Urban application and its implementation in the DestinE workflow.

RESULTS

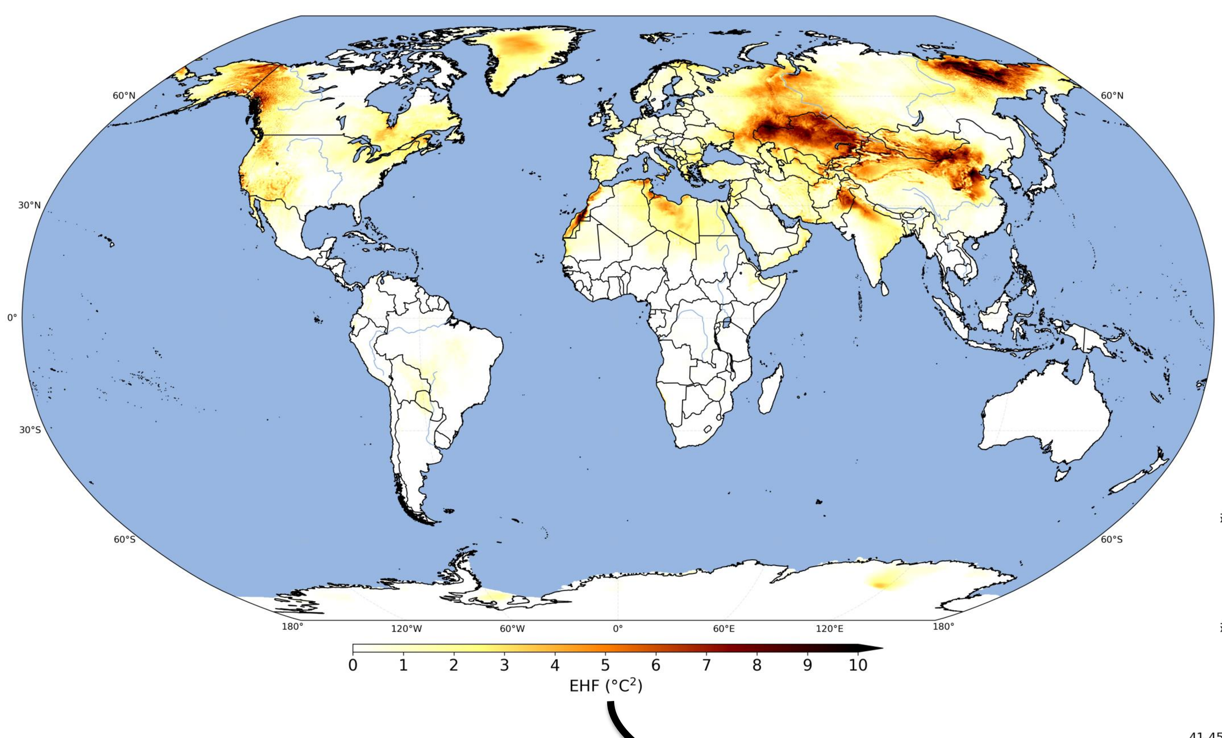

Figure 4: Excess Heat Factor (EHF) averaged over JJA for 1950. Data was obtained from the ClimateDT IFS-NEMO control simulation. The 30-year reference period for the climatology was obtained from ERA5-Land data regridded to 5km through conservative interpolation.

Climate information from global to urban scale.

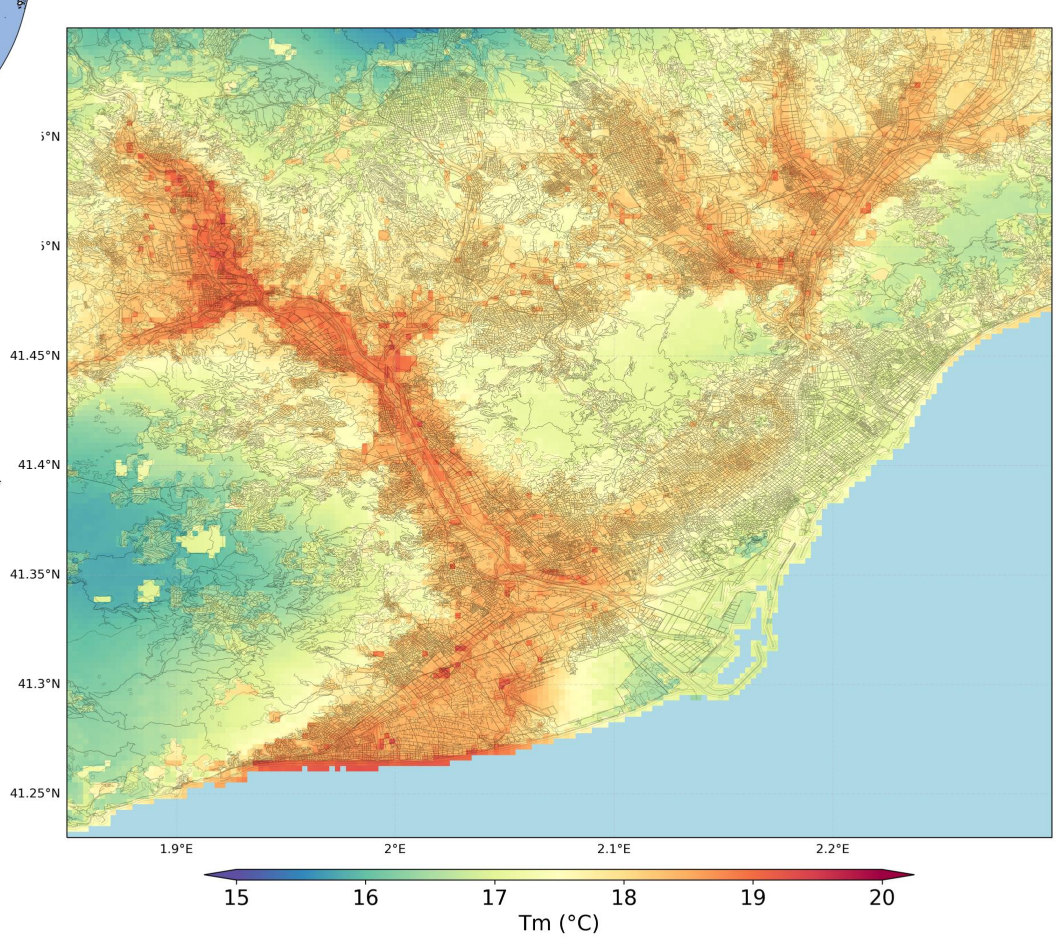

Figure 5: Preliminary results of mean temperature at 2m over one day in June 2021 for Barcelona and its metropolitan area at a 200m resolution. Data was produced by +ATLANTIC through their Urban ML downscaling model.

References

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