# SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

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|---|---|
| **Reporting year** | 2025 |
| **Project Title:** | *Integrated Physical Numerical Modelling for Assessing Urban Climate Projections over Southwestern European and Brazilian cities* |
| **Computer Project Account:** | spptsoar |
| **Principal Investigator(s):** | Pedro MM Soares |
| **Affiliation:** | Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lisboa |
| **Name of ECMWF scientist(s) collaborating to the project** (if applicable) | - |
| **Start date of the project:** | 01/01/2025 |
| **Expected end date:** | 31/12/2027 |

## Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

| | | Previous year | | Current year | |
|---|---|---|---|---|---|
| | | Allocated | Used | Allocated | Used |
| **High Performance Computing Facility** | (units) | - | - | 100 M SBU | 0 SBU |
| **Data storage capacity** | (Gbytes) | - | - | 120 000 GB | 0 GB |

## Summary of project objectives (10 lines max)

This project aims to advance urban climate projections for Southwestern European cities and the Brazilian megacities São Paulo and Rio de Janeiro. It addresses the misrepresentation of urban processes in climate models by performing high-resolution (3 km) WRF simulations using advanced urban parameterizations (e.g. BEP-BEM) and detailed land cover datasets. The simulations contribute to the CORDEX Flagship Pilot Study on Urban Environments and Regional Climate Change (URB-RCC). The work covers present, historical, and future periods under different emission scenarios, providing key information on urban climate variables, land-atmosphere interactions, and extremes. The ultimate goal is to support effective climate adaptation and mitigation strategies. The project also seeks to evaluate model sensitivity to urban morphological characteristics, such as building heights and urban fractions. Results will help quantify the urban climate change signal and its implications for public health and infrastructure. Collaboration across modelling teams ensures harmonised protocols and inter-comparability of results.

## Summary of problems encountered (10 lines max)

During this first reporting period, we faced several challenges that delayed the consumption of SBU resources and the start of production simulations. Critical bugs were identified in the WRF model, notably within the BEP-BEM urban scheme and Noah-MP land surface model, which required extensive debugging and code corrections. Resolving these issues involved close collaboration with FPS-URB-RCC teams and multiple model testing phases. Considerable effort was also dedicated to the harmonisation of simulation protocols for Paris and São Paulo, ensuring consistency across modelling groups. The complexity of agreeing on domain settings, land cover datasets, and urban parameter tables added to the delay. Additionally, we opted to pre-process boundary conditions locally in Lisbon to improve data integrity and minimise transfer time. Although time-consuming, these steps were vital to ensure robust, high-quality simulations in the next phase.

## Summary of plans for the continuation of the project (10 lines max)

We will proceed with STAGE-1 simulations at 3 km resolution following CORDEX FPS-URB-RCC protocols, focusing on Paris (core city) and São Paulo (our selected satellite city). The present-day period (2000–2009, with 1999 spin-up) will be simulated first, forced by ERA5, followed by historical (2005–2014) and future (2046–2055, 2091–2100) runs driven by MPI-ESM1-2-HR under SSP2-4.5 and SSP3-7.0. All simulations will use WRF v4.5.1.7 with BEP-BEM urban canopy scheme, a common namelist.input, and harmonised URBPARM_LCZ.TBL parameters. Pre-processed boundary conditions will optimise transfer and runtime. Domains and vertical resolution match STAGE-1 specs, with sensitivity runs exploring building heights, urban fractions, and A/C effects. Outputs will include 2D urban diagnostics and selected 3D variables, contributing to coordinated FPS-URB-RCC ensembles and intercomparisons.

## List of publications/reports from the project with complete references

For this special project there are not yet publications.

## Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

During this reporting period, substantial preparatory work was accomplished as part of the FPS-URB-RCC coordinated effort. Our team contributed to the definition and validation of the STAGE-1 simulation protocols, focusing on Paris as the core city and São Paulo as our selected satellite city. We actively participated in defining common domain configurations, vertical resolution, and the standard namelist.input settings, ensuring consistency across modelling groups. Decisions included

the adoption of WRF v4.5.1.7, applying the BEP-BEM urban canopy scheme, and harmonised use of URBPARM_LCZ.TBL parameters for morphological data. These steps were critical to establish a robust framework for the production runs.

A major focus was addressing technical challenges in the WRF model identified during coordination meetings, including bugs in the BEP-BEM scheme affecting output file sizes, and issues in Noah-MP diagnostic outputs (e.g. T2 and U10 over urban points). Our group contributed to testing fixes, adjusting hard-coded parameters (e.g. nbui_max, dz_u), and validating outputs from the modified model. These actions were crucial for reducing restart file sizes and ensuring model stability for long-term urban climate simulations, while keeping sensitivity impacts within acceptable thresholds (typically <0.5°C).

We also engaged in extensive planning for pre-processing and managing input data. This included preparing boundary conditions locally in Lisbon to improve control over data integrity and reduce transfer times to ECMWF. Our work aligned with FPS-URB-RCC decisions on using LANDMATE_PFT data for European domains and determining suitable alternatives for São Paulo. Considerable time was dedicated to refining urban parameter tables and ensuring that urban morphological and land cover data would be appropriate for the selected cities.

Finally, our team contributed to the design of coordinated sensitivity experiments, targeting the influence of urban morphology (e.g. building heights, street width), air conditioning use, and urban fractions on model outputs. Although no SBUs were consumed during this initial phase due to the focus on coordination and technical preparation, these efforts lay the foundation for robust, harmonised simulations that will feed into the FPS-URB-RCC ensemble for urban climate assessment and resilience studies.