SPECIAL PROJECT FINAL REPORT

Reporting year 2025

Project Title: Continuation of the intensive test of ICON-LAM Model with urban parameterization scheme TERRA_URB

Computer Project Account: Spitmil2

Principal Investigator(s): Massimo Milelli (mcy)

Affiliation: CIMA Research Foundation

Name of ECMWF scientist(s) collaborating to the project

(if applicable)

Start date of the project: 2025

Expected end date: 2025

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

		Previous year (2024)		Current year (2025)	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			1900000	2344000
Data storage capacity	(Gbytes)			500	200

ESG vs GLC Model Comparison

Executive summary
This report summarises a hindcast comparison between the ICON GLC operational land-cover configuration and an ICON ESG branch configuration. The evaluation focuses on the May-June 2023 period over a 1 km resolution domain, using ICON-EU initial and boundary conditions. The comparison is intended to assess whether the ESG branch produces material changes in standard meteorological skill and urban heat island diagnostics when compared with observations.

- Overall differences between ESG and GLC are small in the available statistical diagnostics.
- The comparison should be interpreted with caution because the two model versions are not identical beyond the land-cover configuration.
- GLC remains the reference configuration and appears to be strongly tuned in the current modelling chain.
- A relevant follow-up is the development and testing of a new physical parameterisation pathway in COSMO, including BEM/BEP components for urban processes.

1. Project objective and scope

The project objective is to compare the behaviour of the ICON ESG configuration against the latest official ICON GLC release, with emphasis on near-surface temperature, relative humidity and urban-rural thermal contrasts. The analysis uses station-based diagnostics, Taylor diagrams and time-series comparisons against observations.

The scope of the current report is deliberately concise: it documents the experimental set-up, summarises the evidence shown in the presentation, and captures the key interpretation and recommended next steps for project follow-up.

2. Simulation set-up

Parameter	Configuration
Hindcast period	2023-05-01 00 UTC to 2023-07-01 00 UTC
Horizontal resolution	about 1,000 m
GLC configuration	ICON GLC, latest official release, October 2025
ESG configuration	ICON ESG, parallel test branch
Initial and boundary conditions	ICON-EU

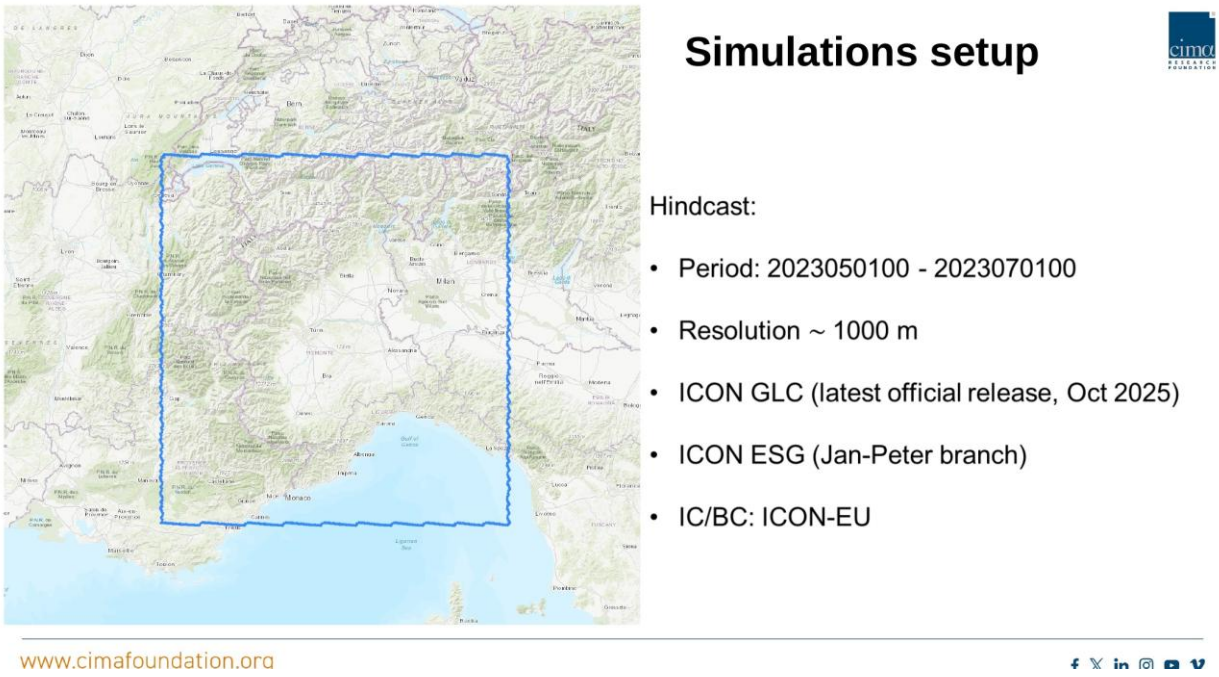

Figure 1. Simulation domain and modelling configuration used for the ESG vs GLC hindcast comparison.

3. Observational reference and station aggregation

The station-based comparison follows the urban-rural framework used for urban heat island analysis in Turin. The diagnostic plots aggregate the urban stations CON, RER and ALE, the rural southern stations BAU, SAN and CAR, and the rural northern station VEM considered individually.

The observational reference and station grouping are derived from the approach described by Bassani et al. (2022), which was designed to support urban-rural site selection for urban heat island analysis.

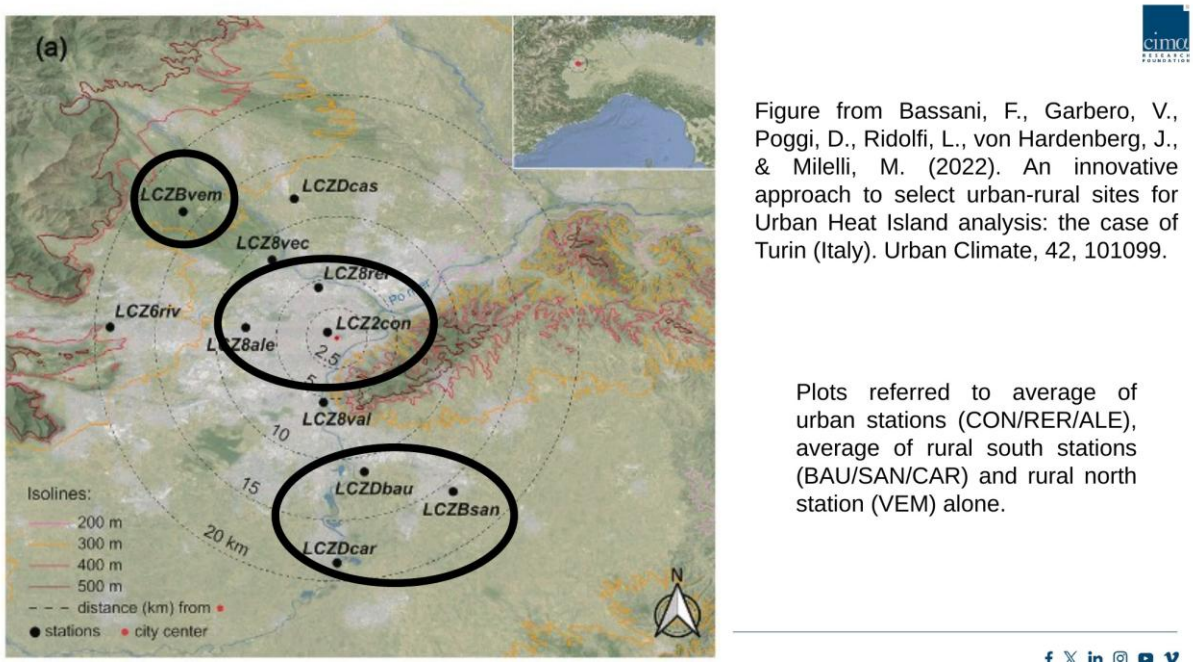

Figure 2. Urban and rural reference stations used to support the Turin-focused urban heat island diagnostics.

4. Statistical model performance

Taylor diagrams are used to compare model performance against observations by combining correlation, centred root-mean-square difference and standard deviation. The presentation includes diagnostics for relative humidity at 2 m and temperature at 2 m. In both cases, the ESG and GLC points are generally close to each other, indicating limited separation in skill over the selected period and station groups.

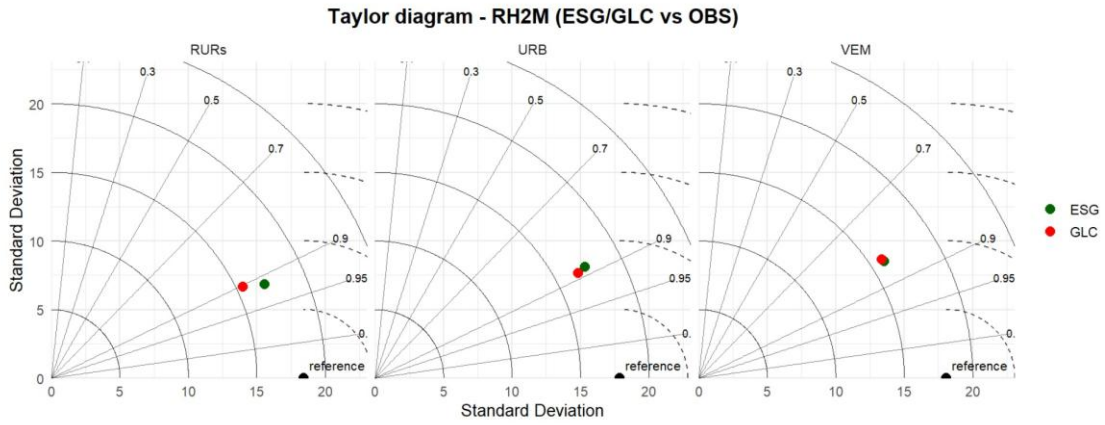

Figure 3. Taylor diagram for 2 m relative humidity, comparing ESG and GLC against observations.

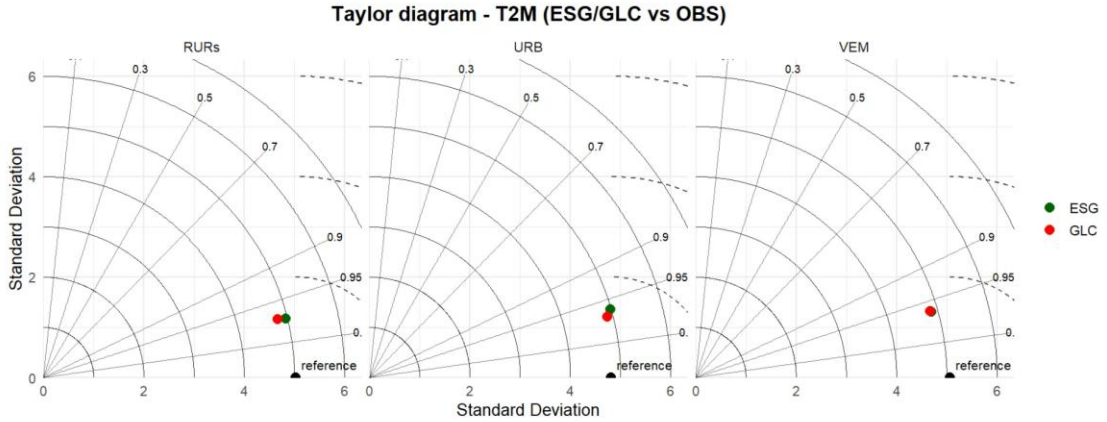

Figure 4. Taylor diagram for 2 m temperature, comparing ESG and GLC against observations.

5. Urban heat island diagnostics

The urban heat island diagnostics compare the urban-station aggregate with the rural references. The time-series plots show that ESG and GLC broadly reproduce similar temporal structures, with differences that are visible but not large enough to dominate the overall interpretation. The lower panels in the diagnostics summarise the ESG-GLC spread in relation to the observational reference.

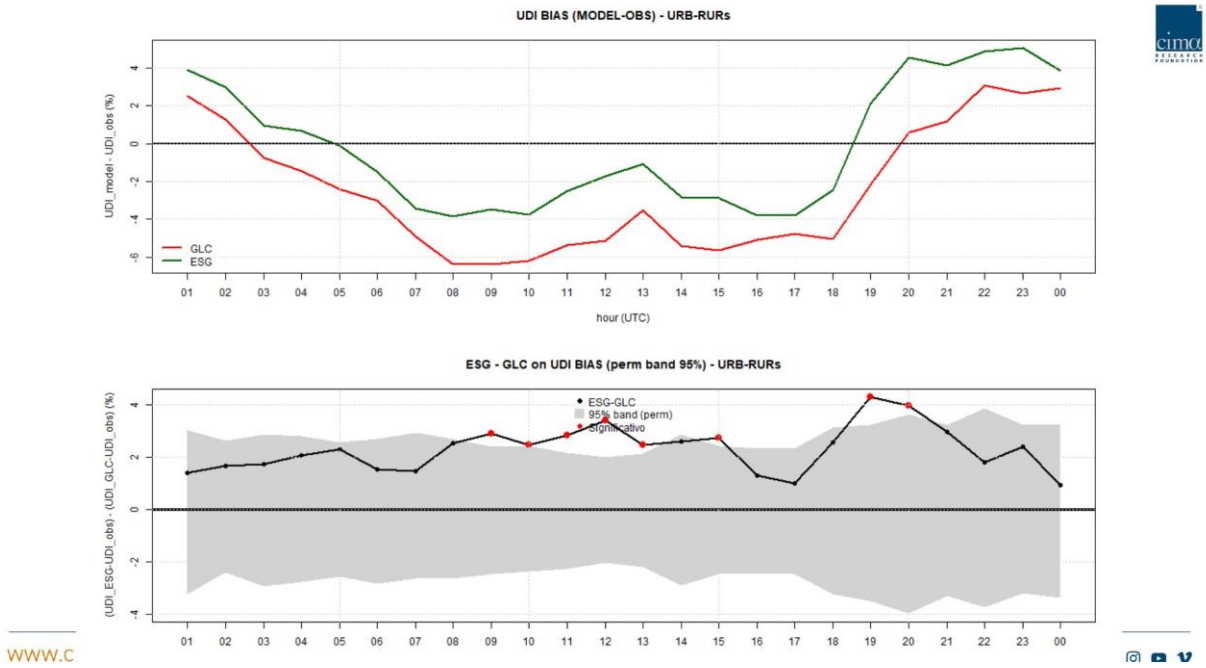

Figure 5. Urban heat island diagnostic using the rural northern reference station VEM.

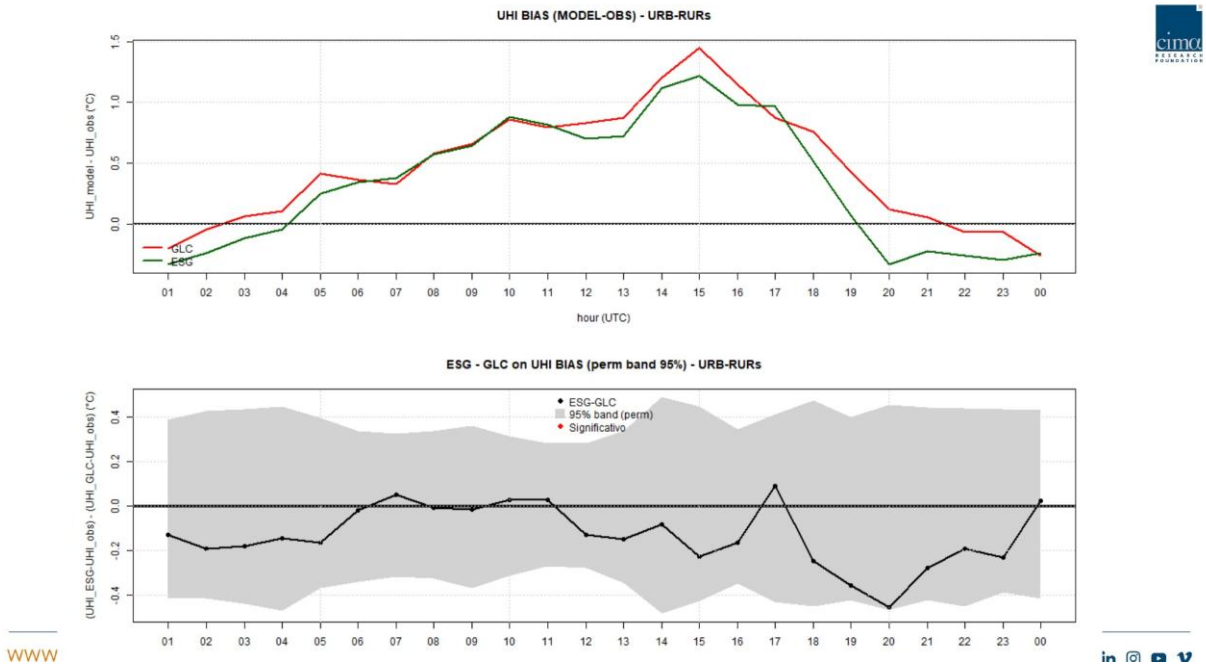

Figure 6. Urban heat island diagnostic using the rural southern station aggregate.

6. Interpretation and limitations

- The model-to-model differences are small in the statistical indicators.
- The comparison is not fully controlled, because the two simulations use different model versions and therefore cannot be attributed only to the land-cover treatment.
- The current GLC configuration appears to be well calibrated within the existing modelling system, which may reduce the apparent benefit of the ESG branch in this preliminary comparison.
- The hindcast covers two months. This is useful for a targeted test, but longer and seasonally diverse evaluation periods would strengthen the robustness of the conclusions.

7. Conclusions and recommended next steps

The current ESG vs GLC comparison does not show large statistical differences in the available diagnostics. The evidence suggests that the ESG branch can be considered comparable to GLC for this hindcast, but not demonstrably superior based on the present work.

The recommended next step is to move towards a more controlled experiment and to test new physical parameterisation developments in COSMO, with particular attention to Building Energy Model and Building Effect Parameterisation components for urban applications.

Final note: the SBU required for this work are more than the allocated amount because there were technical problems with the simulations and there were a lot of trials before getting to a final and correct configurations.

Reference

Bassani, F., Garbero, V., Poggi, D., Ridolfi, L., von Hardenberg, J., and Milelli, M. (2022). An innovative approach to select urban-rural sites for Urban Heat Island analysis: the case of Turin (Italy). Urban Climate, 42, 101099.