

Research Highlight

'Urban Heat Island in the Eastern Mediterranean and Middle East: Multi-City Approach in Regional Climate Modelling'

Summary

This study evaluates the Weather Research and Forecasting (WRF) model's ability to simulate summer urban heat island (UHI) effects across the Eastern Mediterranean and Middle East (EMME) using a simple bulk urban parameterization. WRF downscale ERA-Interim reanalysis data at 16 km and nested 4 km resolutions for 2000–2002. Model biases show overestimation of maximum air temperatures (+1–2°C) and underestimation of minimums (−1–2°C) against ERA5-Land, with larger land surface biases, though 16 km performs better than 4 km when validated against station and satellite observations (possibly due to the lack of model physics optimization in the highest resolution). Detailed analysis for Cairo reveals nighttime air/surface UHIs of 3–5°C and daytime surface cool islands of 5–10°C, driven by urban-rural contrasts in albedo, soil moisture, and heat storage. Averaged across 11 EMME cities, results indicate stronger nighttime surface UHIs (5–6°C) than air UHIs (3–4°C), with pronounced daytime surface cool islands (−12.5°C) and minor canopy heat islands (1–1.5°C). The results indicate the suitability of the simple urban model treatment for multi-city regional climate change assessments in the EMME region.

Impact

The study advances EMME urban climate modeling as the first multi-city quantification of diurnal UHI and cool island contrasts in arid Eastern Mediterranean and Middle East (EMME) cities using the WRF model, revealing surface-canopy discrepancies—such as a 2°C stronger surface UHI—tied to albedo differences (urban 0.15 vs. rural 0.3–0.4) and heat fluxes, which is key for interpreting satellite versus in-situ data. Importantly, this work represents one of the first attempts to bridge regional to local scales by assessing urban-aware regional climate projections in the region, paving the way from broad climate model outputs to city-scale climate services. It provides insight into the

Authors' bios



Dr. Katiana Constantinidou is an Associate Research Scientist, member of the Climate System Processes (CliSP) research group at the Environmental Predictions Department (EPD) of the Climate and Atmosphere Research Center (CARE-C). Her work focuses on regional/local climate modeling and the effect of urban and land surface parametrizations on climate.



Dr Panos Hadjinicolaou is an Associate Professor at the

resolution-physics trade-off by demonstrating that higher spatial resolution alone does not improve model performance without targeted physics optimisation, consistent with MENA-CORDEX setups, thereby guiding "grey-zone" modeling strategies and emphasizing the need for bias correction in threshold-based applications. The work offers practical value for climate services by validating simple bulk urban schemes for long-term regional simulations, bridging to future Shared Socioeconomic Pathways (SSP) projections and downscaling, while supporting urban adaptation in data-sparse MENA regions through plausible UHI estimates without computationally intensive multi-layer schemes. Finally, it fills a regional knowledge gap by highlighting unique arid UHI signatures, like daytime cool islands from high rural albedo, to inform bias metrics and urban parameterization refinements amid climate change.

Reference

Constantinidou, K., P. Hadjinicolaou, A. Tzyrkalli, G. Zittis, and J. Lelieveld. 2026. "Urban Heat Island in the Eastern Mediterranean and Middle East: Multi-City Approach in Regional Climate Modelling." *International Journal of Climatology* e70255. <https://doi.org/10.1002/joc.70255>.

Climate and Atmosphere Research Center (CARE-C) of the Cyprus Institute, where he leads the Climate System Processes Research Group. He is the contact point of the MENA hub of CORDEX.



Anna Tzyrkalli is a PhD student at the Environmental Predictions Department of the Cyprus Institute's Climate and Atmosphere Research Center (CARE-C) with a background in Environmental Physics. Her research focuses on the impact of climate change in human health in the Middle East and North Africa region.

Contact details

Dr. Katiana Constantinidou – k.constantinidou@cyi.ac.cy



Dr George Zittis is a Research Scientist at the Climate and Atmosphere Research Center (CARE-C) of the Cyprus Institute, where he leads the Climate Change Downscaling & Extremes Research Group. Since 2025 he is the Chair of the MedCLIVAR scientific network. He contributes to MedECC and other international initiatives and research projects about climate change and its impacts on the broader Mediterranean and Middle East region.



Prof Jos Lelieveld is an Emeritus Director at the Max Planck Institute for Chemistry in Mainz, and a Professor at the Cyprus Institute where he leads the Environmental Prediction Department of CARE-C.