Project: **1443**

Project title: **CoSynHealth - Conflicts and Synergies between carbon-neutral and healthy City Scenarios**

Principal investigator: **Peter Hoffmann**

Report period: **2025-05-01 to 2026-04-30**

Within the CoSynHealth project, PALM-4U simulations at different resolutions (2 m, 4 m, 8 m) were set up for Central Altona to estimate heat stress under heat wave conditions. The model was forced with constant profiles and soil conditions taken from multiple data sources (weather mast, CERRA reanalysis, and ERA5 reanalysis) for the 8. August, a heatwave day with high temperatures. Multiple test runs were conducted to evaluate the impact of the constant profiles by comparing it to observational data at three stations within the domain (Loprieno et al. 2026). The comparison shows that the diurnal cycle can be captured reasonably well, but the choice of the vertical profile determines the magnitude of the biases. Regardless of the forcing, the requirements for the large eddy simulations approach are fulfilled showing the general model set-up (e.g. spatial extent, choice of spatial and vertical grid) is suitable for the domain. However, especially for the simulations at 2 m resolution, the computational demand was higher than expected because of the requirements for the domain height and the vertical grid spacing. The original setup provided for a nested subdomain of 2 m resolution within a 4 m parent domain. However, the subdomain in question would have been too close to the boundaries of the parent domain to produce reliable physics between the parent and the child boundary. In addition, the scenario runs required a larger domain to investigate the non-local impacts of the planning scenarios. Single 2 m simulations ended up consuming a total of around 2000 node hours (NH) for 24h of simulation, against the 100 NHs estimated during the early stages of the project. Consequently, we were forced to run most of our simulations at a resolution of 4 m, even though a resolution of 2m visibly improves the representation of small-scale features such as trees.

Furthermore, the spatial distribution of heat stress was analyzed for different times of the day. Figure 1 shows the distribution of the Universal Thermal Climate Index (UTCI), a state-of-the-art index for human thermal comfort, and the wind velocity vectors at 4 pm local time. Low UTCI values can be seen in the shade of buildings and trees and in parks, while open spaces without vegetations or large sealed surfaces (e.g. wide streets) show high UTCI values. The temperature and UTCI maps based on these simulations are published by Loprieno et al. (2025a) via Zenodo. The 2 m simulation was used as a refences run for different planning scenarios, which were realized by adjusting the static driver (e.g. new buildings, trees and land use). These scenarios include the conversion of train tracks into a new city quarter (Loprieno et al. 2025b), which lead to a general reduction in heat stress. Lastly, the UTCI data was used as an input for an agent-based model (ABM), which simulates the exposure of the working population to heat stress as a function of individual activity and mode choices (Sirin et al. 2025).

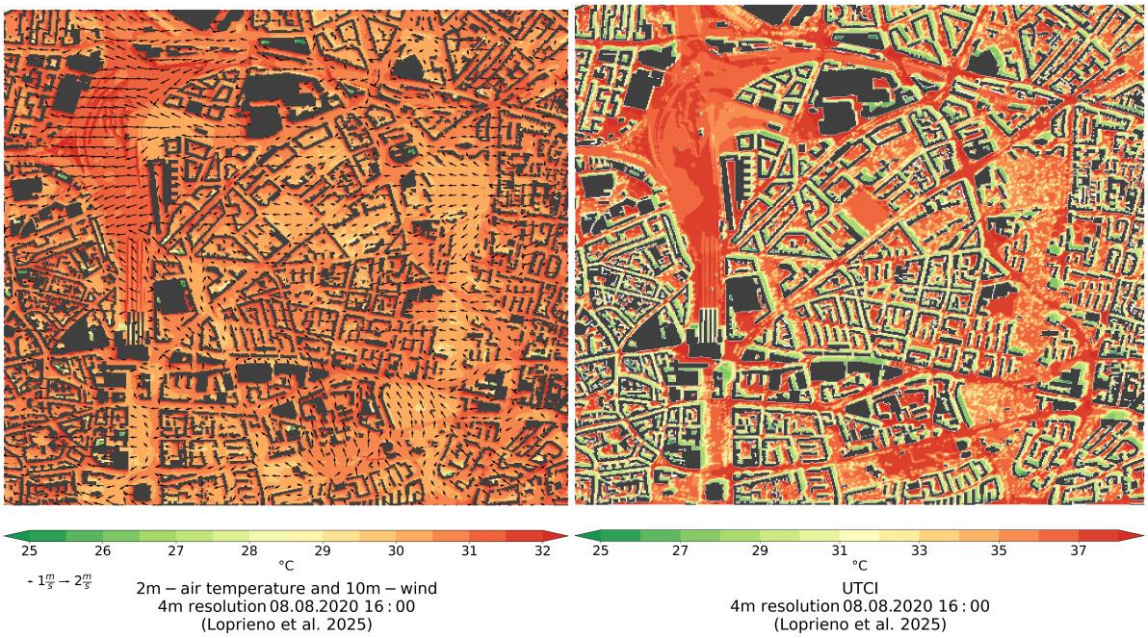

Figure 1: Simulated heat stress using the universal thermal comfort index (UTCI) (Loprieno et al. 2025a).

Publications

Loprieno L., Hoffmann P., Fritz S. (2025a). Heat stress and temperature in Hamburg-Altona simulated with PALM-4U (v1.0). Zenodo. https://doi.org/10.5281/zenodo.17294789

Loprieno L.L., Hoffmann P., Sillmann J. (2025b): Modeling the conversion of a train station with PALM-4U: the effects of urban greening on the microclimate of a Hamburg neighborhood, ICUC12 Rotterdam, https://doi.org/10.5194/icuc12-670

Loprieno, L. L., Hoffmann, P., Fritz, S., and Sillmann, J (2026): Can measurement and reanalysis data act as suitable forcing data for neighborhood-level PALM-4U simulations?, EGU General Assembly 2026, Vienna, Austria, 3–8 May 2026, EGU26-11487, https://doi.org/10.5194/egusphere-egu26-11487.

Sirin D., Hoffmann P., Scheffran J. (2025): Investigating the impact of carbon-neutral lifestyle changes on urban heat stress exposure: An Agent-Based Modeling approach. Social Simulation Conference (SSC) 2025, Delft