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Can measurement and reanalysis data act as suitable forcing data for neighborhood-level PALM-4U simulations?

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In light of increasingly intense heat waves threatening various regions around the globe, densely built urban environments are vulnerable to elevated heat stress values. Large-eddy simulations like the obstacle-resolving model PALM-4U act as suitable tools to quantify urban heat stress on the neighborhood- to street-level due to their ability to resolve small-scale variability of atmospheric variables. PALM-4U simulations must be forced with vertical profiles, either as initial profiles or as dynamic profiles adapted from mesoscale models. However, the use of the latter can potentially introduce some model biases into the urban climate model, affecting the representation of the boundary layer. Furthermore, mesoscale model simulations might not always be available at a certain location at a specific time. This favors the use of observation-informed data products as driving data. This study presents the performance of a set of PALM-4U simulations forced with various initial vertical atmospheric and soil profiles in simulating 2m-air temperature at different grid spacings for a densely populated city quarter within the Hamburg-Altona district in northern Germany. Furthermore, the ability to simulate the variability of heat stress indices and other thermal comfort-related measures is investigated. Three different atmospheric forcing profiles are employed: (i) an observation-based profile constructed by merging data from the Hamburg Weathermast with CERRA and ERA5 reanalysis data, (ii) a reanalysis-based profile constructed by merging data from CERRA and ERA5 reanalysis, and (iii) a profile based on ERA5 reanalysis data only. Soil parameters were taken from CERRA-Land reanalysis. Simulations were conducted at horizontal grid spacings of 8m, 4m, and 2m for a heatwave day that stands out against other summer days regarding the near-surface air temperature. The evaluation was performed against measurements of three weather stations, which had been set up during a field campaign in the months June-August 2020 in Hamburg, Germany, and are located within the modelling domain. This study answers the question whether reanalysis data provide a suitable base for forcing PALM-4U simulations. This would allow realistic forcing profiles to be constructed over domains with little observational or mesoscale model data availability.