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Very-high resolution WRF mesoscale urban-modeling for a coastal complex terrain metropolitan area

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Urban-weather forecasts are necessary for well-known applications such as air pollution and urban comfort predictions. In the past few years additional uses arose such as urban air traffic by drones and helicopters. All of these applications require high-resolution numerical weather-forecasts that need to include the effect of the urban canopy. While CFD and LES methods are necessary to provide detailed information about the flow at the street level, mesoscale forecasts are needed to provide their initial and boundary conditions.

This work presents very-high resolution (500-m grid size) WRF simulations over a coastal complex terrain metropolitan area, Haifa, Israel, which is prone to high pollution events.

The simulations include three approaches to simulate the impact of the city on the simulated urban weather:

- Bulk parameterization; which corresponds to the default MODIS landuse categories of the WRF modeling system.
- Detailed local urban-canopy information for the Haifa metropolitan area derived with the help of a GIS tools was used with the two following urban canopy modules:
- The single-layer urban canopy (SLUCM) parametrization.
- The multi-level layer urban- canopy parameterization, specifically the building-effect parameterization with building energy model (BEP-BEM).

We focused on a wide variety of synoptic-scale weather conditions that, among others, can lead to or worsen high pollution events. The simulations used ERA5 reanalyses for initial and boundary conditions. We explored the sensitivity of the simulated urban flow and heat island effect to the planetary boundary layer parameterizations (YSU and Boulac), and the urban canopy modeling. Due to the lack of specific anthropogenic-heat information for the Haifa area, we used crude estimations of the timing and desired temperatures for air-conditioning usage in the BEP-BEM parameterization, and a typical diurnal cycle of anthropogenic heat for the SLUCM parameterization (with estimation of the maximal heat loads following literature for cities in similar climate zones and with similar population).

The simulations were compared to near surface observations of wind, temperature and relative humidity within and outside the urban area, and to vertical soundings at the only launching location in Israel, Beit-Dagan. Objective verification scores as well as visual verification of 2D maps of the aforementioned variables demonstrate that the simulations reproduce the different mesoscale dynamics under very different synoptic conditions. The impact of the detailed urban modeling (BEP-BEM and SLUCM) without specific information on the anthropogenic-heat, is limited in this case.