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Investigating the influence of distributed anthropogenic heating to simulated ozone formation

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Surface ozone levels are strongly influenced by temperature, with elevated concentrations commonly observed during summer. However, the ozone-temperature relationship requires further investigation due to the non-linear mechanisms governing ozone formation. In urban areas, anthropogenic heat emissions (AHE) contribute to local temperature increases, yet their effect on ozone levels remains uncertain and has not been fully quantified.
This study pioneers the coupling of distributed urban parameters in WRF's Single-Layer Urban Canopy Model (SLUCM) with atmospheric chemistry in WRF-Chem version 4.6. This version enables the representation of AHE and spatially varying urban morphological parameters (roughness length for momentum, displacement height, and sky-view factors).
The Model for Ozone and Related Chemical Tracers (MOZART) coupled with the Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) was used for gas-phase chemistry and aerosol representation. Chemical concentrations were initialized using output from the Whole Atmosphere Community Climate Model (WACCM), while biogenic emissions were derived from the Model of Emissions of Gases and Aerosols from Nature (MEGAN). Anthropogenic emissions were incorporated from the EDGAR HTAP_v3 inventory. Using this configuration, we examine the role of urban effects in driving surface ozone formation over the Kanto region of Japan for one week in August 2021, with a finest domain resolution of 1.5km.
Comparing simulations with and without AHE, we confirm that AHE significantly influences ozone transformation. In urban areas, AHE generally leads to an increase in ozone concentration. Notably, the increase in temperature (☐T) and ozone (☐ozone) reach their maximum in the evening, but their peaks do not coincide. The peak in ☐T occurs first, followed by the peak in ☐ozone after a lag of several hours. This temporal offset suggests complex interactions between AHE, meteorology, and atmospheric chemistry, which this study aims to determine by analyzing the mechanisms driving these interactions and their implications for urban air quality.