Impacts of land-surface forcing on local meteorology and ozone concentrations in a heavily industrialized coastal urban area

ABSTRACT

In this study, the Weather Research and Forecasting/Community Multiscale Air Quality (WRF-CMAQ) model was used to investigate the interaction of urban land-surface forcing with local circulations and the impact on boundary layer ozone concentrations in southern Taiwan at an urban-scale resolution. Two simulations were performed with the same emissions but different land cover designations. URBAN was the baseline simulation representing the current urbanized condition, while NO-URBAN replaced all urban grid cells with cropland. The interaction of the sea-breeze with the urban-heat-island (UHI) convergent flow during the daytime in URBAN transports near-surface O_3 precursors to the upper planetary boundary layer (PBL). When the UHI convergent flow stalls over the city center, a circulation flow is formed and traps the pollutants at an elevated height, increasing the reaction rate of hydroxyl radical with volatile organic compounds by 2.0–4.0 ppbv h−1 at 1000–1500 m. At nighttime, the deeper boundary layer of URBAN diluted the NOx mixing ratio by ~17 ppbv and weakened the titration effect, contributing to higher O_3 by +15 ppbv in the urban area. However, once the daytime vertical mixing diminished, the O_3 aloft also diffused downward to the surface level and further degraded the nighttime air quality.