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Impact of urban heat island on inorganic aerosol in the lower free troposphere: a case study in Hangzhou, China

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Urban heat island (UHI) and urban air pollution are two major environmental problems faced by many metropolises. The UHI affects air pollution by changing the local circulation and the chemical reaction environment, e.g., air temperature and relative humidity. In this study, the WRF-CMAQ model was deployed to investigated the impact of UHI on the vertical distribution of aerosols, especially secondary inorganic aerosols (SIA), in a strong UHI case in Hangzhou. Results show that due to the UHI effect, $PM_{2.5}$ concentrations over Hangzhou decreased by about 26% in the boundary layer (BL) but increased by about 21% in lower free troposphere (LFT). This is mostly attributed to the UHI circulation (~90%) rather than the changed air temperature (~5%) and humidity (~4%). The UHI circulation not only directly transports aerosols from ground level to LFT, but also redistributes aerosol precursors. In the LFT, the directly transported aerosol accounted for 80% of the UHI circulation effect and the secondary formed aerosol due to the transport of aerosol precursors accounted for 20%. The secondary formation of inorganic aerosols, especially nitrate and ammonium aerosols, contributed 91% of the secondary formed aerosol in the LFT over the urban area. The UHI circulation transported ammonia and nitric acid, the precursors of ammonium nitrate aerosol, from the lower BL to the LFT, where ammonium nitrate aerosol is formed. The ammonium nitrate is dissociated at the higher temperature in the lower part of the BL and in the LFT the lower temperature results in a shift of the equilibrium between the gases and ammonium nitrate aerosols toward the aerosol phase. The UHI circulation changed the vertical distribution of SIA, which may have potential implications on radiation budget, cloud formation, and precipitation in the urban and surrounding areas.