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Effects of aerosol-radiation feedback and topography during an air pollution event over the North China Plain during December 2017

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The online coupled Weather Research and Forecasting–Chemistry (WRF-Chem) model was used to investigate a regional haze event, which occurred over the North China Plain (NCP) from 27 to 30 December 2017. Modeling scenarios with and without aerosol-radiation feedback within the planetary boundary layer (PBL) were investigated. By adding aerosol-radiation feedback to the model, we captured the spatial and temporal characteristics of the observed temperature and relative humidity (RH), as well as surface PM2.5, SO_2, and NO_2 concentrations during this event. The primary meteorological driver of this event was stable meteorological conditions, namely, a low PBL, strong temperature inversion, high RH, and a weak wind field. Aerosol-radiation feedback mechanisms affected these meteorological fields, causing reductions in maximum surface solar radiation, the surface energy budget, PBL height, surface 2-m temperature and middle atmosphere RH, while increasing surface 2-m RH, middle atmosphere temperature, and atmospheric stability. Changes in meteorological variables in turn affected air pollutant distributions and concentrations, with PM2.5 increasing by more than 20 μg/m3 over the NCP during this event. Another sensitivity experiment was carried out over the Taihang and Yanshan mountain areas, in which topography was flattened to a 30-m height to explore the impacts of topography on air pollution in the NCP region. Modeling revealed various topographic effects on meteorological variables related to these two mountains, including a lowered PBL height, reduced wind speed, blocked uniform surface winds, and more intense temperature inversion. Consequently, surface air pollutant concentrations increased unevenly over the NCP in this experiment. Implementation of more detailed PBL processes, as well as radiosonde and satellite data products into the WRF-Chem model would improve simulations of haze formation over the NCP.