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Impacts of the emission sources of volatile organic compounds on air quality and human health in South Korea

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In this study, we investigated the contributions of the emission sources of volatile organic compounds (VOCs) to air quality (O_3 and $PM_{2.5}$) and the subsequent health effects in the megacity of Seoul, South Korea, during a photochemically active period (June 9-18, 2015). This analysis was performed using a three-dimensional chemical transport model, Community Multiscale Air Quality (CMAQ) with brute-force method (BFM), and the Environmental Benefits Mapping and Analysis Program (BenMAP). The simulation experiments of four VOC sources (solvent use, on-road mobile, electric generating utility (EGU) combustion, and biogenic emissions) were conducted using the simplest source sensitivity approach (CMAQ-BFM) to quantify the source contributions to the concentrations of O_3 and $PM_{2.5}$. The solvent use and on-road mobile emissions were the dominant sources of the ambient VOC concentration in the study area. The contribution of solvent use (3.4% with a daily mean 2.6%) to O_3 production during the day was the most dominant followed by biogenic (0.9% with 0.6%), on-road mobile sources (0.8% with 0.6%), and EGU combustion (0.3% with 0.3%). The maximum impact (+11 ppb) of solvent use on the daytime O_3 concentrations increased by 13% around the downtown areas that suggested VOC-limited conditions for O_3 production in the study area (Seoul megacity). Meanwhile, the impact of VOCs on $PM_{2.5}$ was different from that on O_3, and depended on the location and/or emission sources. The biogenic emission source (5.6% with a daily mean of 2.4%) in the study area during the day contributed considerably to the $PM_{2.5}$ production compared to the other three emission sources (≤0.4% with ≤0.3%). The maximum increase in $PM_{2.5}$ concentrations for biogenic emissions was approximately 7 μg m^{-3}, indicating the increased rate of 28% from 25 to 32 μg m^{-3}. O_3 production from solvent use and $PM_{2.5}$ production from biogenic emission via the oxidation of VOCs in the study area can contribute to an increase in the number of premature deaths (i.e., approximately 15% and 4% of total death due to respiratory diseases in Seoul, respectively).