Radon as a tracer of atmospheric influences on traffic-related air pollution in a small inland city

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One year of radon, benzene and carbon monoxide (CO) concentrations were analysed to characterise the combined influences of variations in traffic density and meteorological conditions on urban air quality in Bern, Switzerland. A recently developed radon-based stability categorisation technique was adapted to account for seasonal changes in day length and reduction in the local radon flux due to snow/ice cover and high soil moisture. Diurnal pollutant cycles were shown to result from an interplay between variations in surface emissions (traffic density), the depth of the nocturnal atmospheric mixing layer (dilution) and local horizontal advection of cleaner air from outside the central urban/industrial area of this small compact inland city. Substantial seasonal differences in the timing and duration of peak pollutant concentrations in the diurnal cycle were attributable to changes in day length and the switching to/from daylight-savings time in relation to traffic patterns. In summer, average peak benzene concentrations (0.62 ppb) occurred in the morning and remained above 0.5 ppb for 2 hours, whereas in winter average peak concentrations (0.85 ppb) occurred in the evening and remained above 0.5 ppb for 9 hours. Under stable conditions in winter, average peak benzene concentrations (1.1 ppb) were 120% higher than for well-mixed conditions (0.5 ppb). By comparison, summertime peak benzene concentrations increased by 53% from well-mixed (0.45 ppb) to stable nocturnal conditions (0.7 ppb). An idealised box model incorporating a simple advection term was used to derive a nocturnal mixing length scale based on radon, and then inverted to simulate diurnal benzene and CO emission variations at the city centre. This method effectively removes the influences of local horizontal advection and stability-related vertical dilution from the emissions signal, enabling a direct comparison with hourly traffic density. With the advection term calibrated appropriately, excellent results were obtained, with high regression coefficients in spring and summer for both benzene (r2 0.90–0.96) and CO (r2 0.88–0.98) in the two highest stability categories. Weaker regressions in winter likely indicate additional contributions from combustion sources unrelated to vehicular emissions. Average vehicular emissions during daylight hours were estimated to be around 0.503 (542) kg km−2 h−1 for benzene (CO) in the Bern city centre.

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