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Radon-based atmospheric mixing layer height and its influence on major air pollutant concentrations in Bratislava, Slovakia

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The aim of this work is to determine the mixing layer height (MLH) based on outdoor radon concentration and study its influence on the concentration of major air pollutants (i.e., PM10, PM2.5 and O3). MLH is a key parameter for characterization and interpretation of green-house gases and air pollution. It is the lower part of atmospheric boundary layer (ABL) which ranges from few meters to hundreds of meters. Radon activity concentration (RAC) and the air pollutants concentration were monitored simultaneously in the urban area of Bratislava during the whole year 2020. Continuous measurement of RAC shows a diurnal cycle with a maximum in the early morning and a minimum in the late afternoon. Mean annual concentrations are: 8.21 Bqm-3 for radon, 11.91 µg.m-3 for PM2.5 , 18.27 µg.m-3 for PM10 and 59.82 µg.m-3 for O3 respectively.
An improved box model based on radon was used to obtain the mixing layer height and investigate its influence on the concentration of air pollutants. The MLH exhibits nearly a diurnal cycle with a minimum in the early morning (i.e., when the ABL is shallowest and most stable), and a maximum in the late afternoon (i.e., when the ABL is well mixed and unstable). The data were grouped based on the Sturges method in order to reduce the influence of other factors (e.g., emission rate, wind speed, and chemical reaction) on the air pollutant concentration. Using grouped MLH data, strong correlations were observed between MLH and air pollutant concentration, with the following correlation coefficients:-0.71 for PM2.5, -0.75 for PM10 and 0.75 for O3. These result reveal that MLH is strongly correlated with ozone and strongly anticorrelated with particulate matter. The strong correlation between MLH and O3 is due to the fact that both MLH and ozone concentrations increase after sunrise. The rise in ozone concentration is caused by photochemical production after sunrise, when the MLH grows due to radiative heating of the ground and increased convection. The significant anticorrelation in the case of particulate matter can be explained by vertical diffusion, whereby higher MLH permits greater particulate matter diffusion from the surface to high levels and lower MLH causes the pollutants to accumulate in the area close to the ground. As a result, significant influence of MLH on air pollutant concentration was observed.

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