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Nocturnal evolution of atmospheric radon concentration under near-surface meteorological conditions

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Accumulation and dispersion processes in the atmosphere have been studied vigorously for regulation purposes to prevent the public from health hazards of air pollutant materials. The transient variations and the strength of the processes follow vertical profiles of meteorological conditions. These can also be well traced by radon suitable for atmospheric study because of its chemical inertia. From previous radon studies, effective mixing height, which is calculated from radon variation in unit time and radon flux at earth surface, is a proxy for the strength in turbulent diffusion. However, it has not been established yet how effective mixing height quantitatively relates to meteorological conditions. In this study we construct an equation of its relation based on heat exchange process of the atmosphere. The result shows that effective mixing height can be determined from near-surface parameters of heat flux and a rate of change in potential temperature from sunset. In addition, the constructed equation suggests that effective mixing height is proportional to inversion layer height with a slope which depends on a vertical profile of potential temperature. In order to validate the equations, we calculate nocturnal evolution of atmospheric radon concentration from the Day 33-34 data of Wangara experiment and compare it with a simulation by other modeler using the same meteorological data. The trend of the simulated nocturnal evolution is similar to that by other modeler with their differences of about 1 Bq m^{-3} (within 10%). The validity is also evident from the previous radon studies by Italian researchers that effective mixing height is proportional to nocturnal mixing depth, i.e., inversion layer height with a slope of about 0.5, of which value is consistent with that in case of linear increase in potential temperature in the inversion layer in the constructed equation. This result proposes that the nocturnal evolution of atmospheric radon concentration can be estimated from radon flux and near-surface meteorological data, and conversely, radon flux can also be determined from the other parameters.