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Dependence of nocturnal increase in atmospheric radon concentration on a heat-related parameter

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Radon is a useful tracer for studying accumulation and dispersion processes of materials in atmospheric boundary layer since it is radioactive gas with a suitable half-life (3.8 days) and chemical inertia. Atmospheric radon concentration varies with strength in atmospheric stability, and it increases in nighttime when turbulent diffusion lowers. In addition, the dispersion property in the atmospheric boundary layer partially accords to heat budget which causes the formation of thermally stratified structure of the atmosphere in nighttime. Thus, the evolution of radon concentration is qualitatively related to the heat exchange. However, its quantification has not been established yet, and required vertical meteorological data in previous studies. In this presentation, we compare nocturnal increase in radon concentration with heat-related parameters, i.e., heat flux and air temperature near the ground.

We conducted the measurements of atmospheric radon concentration, heat flux, and air temperature on the Oshika Peninsula, Miyagi Prefecture. The detectors are a diffusion-type ionization chamber for radon concentration, thermopile-type (copper-constantan) net radiometer for heat flux, and Pt100 temperature sensor for air temperature. They are mounted on the roof top of monitoring station at 4 m above the ground. The measurements are performed every an hour for radon concentration and every ten minutes for heat flux and air temperature, the latter two are transformed one-hour average values for analysis. The data on radon concentration are taken from July 2005 to October 2007 and those on heat flux and air temperature are from April 2 005 to October 2007.

The data are analyzed based on daily variation of radon concentration averaged in each month and during nighttime defined as a period of negative heat flux. As a result, the clear correlations of radon increases with heat flux (except around sunset) and air temperature difference are found, but its trends are quite different. The positive and negative correlations are determined in heat flux and air temperature difference, respectively. When dT(t) presents history of heat budget in the atmosphere and H(t) instantaneous heat flow under a specific diffusion condition at time t, for the two trends being approved together, we introduce a parameter expressed by air temperature difference divided by heat flux (dT(t)/H(t)). As plotted the radon increase based on dT(t)/H(t), positive linear trends are found with high correlation coefficient ($r > 0.95$) in each month. The variation of dT(t)/H(t) depends on thermally stratified structure of the atmosphere. These results indicate that dT(t)/H(t) is a useful parameter for describing strength in atmospheric stability and, as a consequence, evaluating radon increase during the thermal stratification stage.

Keywords: radon, atmospheric boundary layer, air temperature, net radiation, inversion layer, night