Continuous Atmospheric Radon-222 Concentration Observation in East Asia

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Abstract. Continuous observation of atmospheric radon-222 (^{222}Rn) concentration has been operated for years in China, Korea and Japan, including remote islands isolated in the ocean. The sites were allocated along main wind directions of monsoon from the continent to the ocean in winter and yellow dust storm in spring. Higher levels of ^{222}Rn concentrations with typical diurnal variation with early morning maxima were observed on the continent, while lower levels with no diurnal variation at remote islands. Seasonal variations with summer minima and winter maxima commonly obtained, and they suggested contribution of ^{222}Rn originated from the continent to atmospheric ^{222}Rn over the remote islands. A backward trajectory analysis showed clear relationship between variation in wind field and in ^{222}Rn concentration at Hachijo Is., Japan, and proved availability of the observation for analysis of atmospheric transport in East Asia.

Keywords: radon-222, Rn-222, atmospheric transport, long range transport, environmental monitoring, monsoon
PACS: 92.60.hg, 92.60.Sz ,93.30.Db, 93.85.Np

INTRODUCTION

Atmospheric radon-222 (^{222}Rn, radon) is one of naturally occurring radionuclides. It is originated from the ground surface with relatively uniform exhalation rate (flux density) and rarely from the sea surface. Since ^{222}Rn is an inert and chemically stable gas, its transport in the atmosphere is just caused by the motion of air, and its removal from the atmosphere is attributed to only its radioactive decay with a half-life of 3.82d, compared with a time scale of long-range air transport over several thousands km. Therefore, ^{222}Rn is expected to have less complicated behavior than other atmospheric chemical species and be a useful natural tracer for regional transport of air and airborne substances between continents and oceans [1-2]. Simpler behavior of ^{222}Rn in the atmosphere is also suitable for validation of numerical models relating to atmospheric transport phenomena [3-4]. We have established an observation network of continuous measurement of atmospheric ^{222}Rn concentration in East Asia, where is considered one of the important areas in terms of emission and atmospheric transport of aerosols, yellow dust storms and sorts of air pollutants, relating to regional health problems, environmental damages and global radiation forcing, *i.e.*, the global warming [5]. The observation at more than ten locations has continued for several years to a decade.

CP1034, *The Natural Radiation Environment—8th International Symposium,* edited by A. S. Paschoa

METHODS

Hourly concentrations of atmospheric ^{222}Rn at each site have been continuously observed with an Electrostatic Radon Monitors (ERM) [6], which counts alpha emissions by ^{222}Rn decay products produced newly in it and collected on a negatively charged electrode. The lower detection limit of the ERM was estimated c.a. 0.3 Bq m^{-3}, and precision of an hourly ^{222}Rn concentration value was c.a. 1 Bq m^{-3} for typical air over massive lands and c.a. 0.5 Bq m^{-3} for typical air at remote islands in terms of 1σ.

The locations of observatories have ranged from Asian Continent to isolated islands in East Asia region as shown in Figure 1, *i.e.*, Beijing and Qingdao, China, Seoul, Donghae and Jeju Is., Korea and Cape Ochiishi, Hegura Is., Kawazawa, Nagoya, Omaezaki, Hachijo Is. and Hateruma Is., Japan. The sites were allocated along main wind directions of monsoon from the continent to the ocean in winter and dust storm in spring. The continent is important source area of atmospheric ^{222}Rn, while atmospheric ^{222}Rn over remote isolated small islands are expected to represent long-range transported air mass mixed well with large volume of air and be less affected from locally emitted ^{222}Rn.

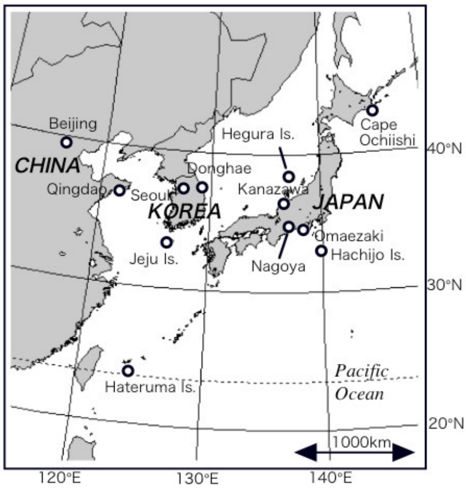

FIGURE 1. Locations of atmospheric radon-222 concentration measurements in East Asia.

RESULTS AND DISCUSSIONS

Clear difference of levels of the concentrations was obtained between continental sites, Beijing and Seoul, with higher concentrations of 5 to 20 Bq m^{-3} and the remote sites, Hachijo Is. and Hateruma Is., with low concentrations of less than 3 Bq m^{-3}. The ranges of seasonal variations at the continental sites and the remote sites also showed large difference, *i.e.*, ranges of 7 Bq m^{-3} and more at Beijing and Seoul, while those of 2 Bq m^{-3} at Hachijo Is. and Hateruma Is. However, phases of their seasonal variations in monthly mean concentrations with maxima in winter and minima in summer was similar for all five sites.

Monthly mean diurnal variations in ^{222}Rn concentrations are illustrated in Figure 2. In Beijing and Seoul, diurnal variations with periodic oscillation with maxima during nighttime to early morning and minima in afternoon were observed. These were typical variation on the land and well explained by the variation in atmospheric stability caused by daytime mixing due to solar radiation and nighttime accumulation of ^{222}Rn released locally around the sites in bottom air [7]. Thus, existence of this typical periodic diurnal variation gives an evidence of contribution of locally released ^{222}Rn to atmospheric concentration. While, at two remote island sites, Hachijo Is. and Hateruma Is., no apparent diurnal variation was observed through a year as shown in Fig. 2. As expected, the observed concentration at these two sites would be not affected by ^{222}Rn emitted in the islands.

The common seasonal variation in East Asia region and no diurnal variation due to little contribution of local ^{222}Rn at Hachijo Is. and Hateruma Is. suggest ^{222}Rn released at the land distant from these remote sites would be transported and control atmospheric ^{222}Rn concentration there.

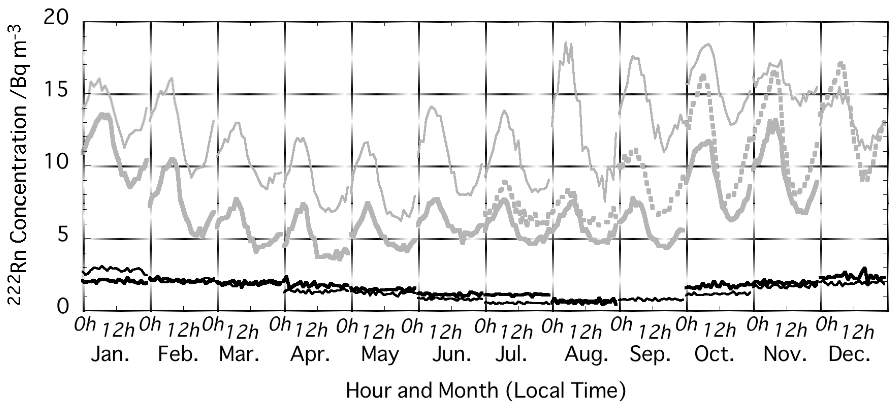

FIGURE 2. Monthly mean diurnal variations in atmospheric ^{222}Rn concentrations at two continental sites of Beijing in 2003 (shown with gray solid line), Seoul in 2000 (gray bold) and in 2005 (gray bold dotted) and two remote island sites of Hachijo Is. in 2005 (bold) and Hateruma Is. in 2005 (solid).

A backward trajectory analysis by HYSPLIT model with FNL meteorological database [8-9] was adopted for the observations at Hachijo Is., and its results showed good correspondence between the observations with higher concentrations and northwesterly wind field from Asian Continent to Pacific Ocean, especially in winter, and that between lower concentrations and arrivals of maritime air masses, particularly in summer.

CONCLUSIONS

The result of the continuous atmospheric ^{222}Rn concentration observation in East Asia showed its availability for analysis of atmospheric transport, which relate to many environmental issues such as air pollutions and the global warming.

ACKNOWLEDGMENTS

We would like to thank for Prof. M. Uematsu of Univ. of Tokyo, Dr. N. Kaneyasu of AIST, Japan Coast Guard, Prof. G. Inoue of Nagoya Univ., Mr. N. Oda and Mr. F. Shimano of The Global Environmental Forum, Prof. K. Komura of Kanazawa Univ., Wajima City, Dr. T. Yamasaki of Chubu Electric Power Co., Ltd., Dr. K. Yoshioka of Shimane Pref., Japan, and Dr. S.-C. Hong of Inje Univ., Prof. E.-S. Jang of Donghae Univ. and Prof. C.-H. Kang of Cheju National Univ., Korea, for their kindly cooperation for the observation at each site shown in Fig. 1. The authors gratefully acknowledge the NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport and dispersion model and READY website (http://www.arl.noaa.gov/ready.html) used in this publication. This study was supported by KAKENHI (B) 10044148, 13480165 and 16310039, and The 21st Century COE Program "Isotopes for the prosperous future" of MEXT, Japan.

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