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Short communication

Contribution of Asian dust to atmospheric deposition of radioactive cesium (^{137}Cs)

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ABSTRACT

Both Asian dust (kosa) transported from the East Asian continent and locally suspended dust near monitoring sites contribute to the observed atmospheric deposition of ^{137}Cs in Japan. To estimate the relative contribution of these dust phenomena to the total ^{137}Cs deposition, we monitored weekly deposition of mineral particles and ^{137}Cs in spring. Deposition of ^{137}Cs from a single Asian dust event was 62.3 mBq m^{-2} and accounted for 67% of the total ^{137}Cs deposition during the entire monitoring period. Furthermore, we found high ^{137}Cs specific activity in the Asian dust deposition sample. Although local dust events contributed to ^{137}Cs deposition, their contribution was considerably smaller than that of Asian dust. We conclude that the primary source of atmospheric ^{137}Cs in Japan is dust transported from the East Asian continent.

1. Introduction

Since the cessation of atmospheric nuclear testing in 1980, there has been no known serious atmospheric contamination by ^{137}Cs apart from that from the Chernobyl nuclear reactor accident in 1986. There now remain only small amounts of anthropogenic radionuclides in the stratosphere that can be directly related to past testing (Igarashi et al., 1996). Thus, deposition of radionuclides such as ^{137}Cs from the stratosphere, which has been the primary pathway for global radioactive fallout, has diminished greatly. However, ^{137}Cs is still regularly found in atmospheric deposition samples in Japan. The recent deposition of ^{137}Cs appears to be the result of re-suspension by wind uplift of soil particles contaminated by past nuclear testing, followed by transport and re-deposition (Igarashi et al., 1996). Because of its long half-life, ^{137}Cs deposited on the ground during past testing has commonly remained in the soil, and re-suspension apparently occurs under windy conditions in areas where the dry surface soil is exposed.

Other studies have investigated the arid areas of East Asia as potential sources of radionuclide-bearing dust (Igarashi et al., 2003; Hirose et al., 2004). In Mongolia and China, a considerable amount of soil dust is lifted into the troposphere in spring by frequent strong winds and sand storms. Although dust events occurred in some regions around southern Mongolia, the Badain Jaran Desert, and the western Loess Plateau during the middle and late 1990s, the area of frequent dust events greatly expanded eastward, with frequent dust events also in the North China Plain, northeastern China, and the Korean Peninsula, from 2000 to 2002 (Kurosaki and Mikami, 2003). Kurosaki and Mikami (2003) suggested that frequent strong winds have been the primary cause of major dust events in recent years. Another possible

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explanation for the increase in the frequency of dust events is the reduction in vegetation cover in semiarid areas. Better vegetation cover in summer helps reduce the frequency of sand storms the following spring (Zou and Zhai, 2004). However, northeastern China experienced widespread droughts in 2001 and 2002 (Zou et al., 2005), and this may have led to a reduction in vegetation cover and a subsequent increase in the frequency of dust events. Soil dust originating in the East Asian continent can be transported over great distances by seasonal winds. High levels of ^{137}Cs deposition observed at Japanese monitoring sites in spring have been attributed to dust thus transported (Igarashi et al., 2003; Ueno et al., 2003). Furthermore, Akata et al. (2007) reported the deposition of considerable amounts of ^{137}Cs in association with a massive dust event in March 2002. They determined that southern Mongolia and northeastern China were the sources of the high levels of ^{137}Cs.

However, soil dust is also raised around the Japanese monitoring sites by the strong winds that are common in spring, and this local dust might also contribute to the deposition of ^{137}Cs. The relative contributions of Asian dust (kosa) and local dust to the atmospheric deposition of ^{137}Cs have been estimated previously, mostly on the basis of biweekly or monthly monitoring. Because dust events are short-term phenomena of a few days' duration (Iino et al., 2004), however, it has been difficult to determine the contributions of individual dust events by conventional monitoring. Therefore, to evaluate radionuclide deposition in Japan with more precision, it is essential to observe atmospheric deposition with a temporal resolution that is high enough to resolve the effects of Asian and local dust events. For this study, we undertook weekly observations of atmospheric dust and ^{137}Cs deposition in spring 2007.

2. Methods

2.1. Sampling

We collected deposition samples weekly for eight weeks from March to April 2007 at the National Institute for Agro-Environmental Sciences (NIAES) in Tsukuba, Japan (Fig. 1). Tsukuba, which is on the Pacific Ocean side of the Japanese Islands, is a typical Japanese suburb surrounded by rice paddies, cultivated fields, residential areas, and small woods and coppices. Six stainless-steel open-surface collectors with a total surface area of 1.18 m^2 were placed 1 m above ground level on the observation field. The collectors were filled with distilled water to prevent re-suspension of deposits. The samples, which resulted from both wet and dry deposition, were transported to the laboratory at NIAES and evaporated to dryness in evaporation dishes placed on hot plates.

2.2. Analysis of the deposition samples

After being dried in an oven at 110 °C, the deposition samples were weighed. Their radioactivities were determined by using gamma spectrometry with a well-type high-purity germanium detector (CANBERRA GCW) with an efficiency of 26% and a multi-channel analyzer. The gamma emission peaks for ^{137}Cs at 661 keV were used for these measurements. The count time was typically about 160 ks. The detection limit was defined as 3σ of the counted value (Cooper, 1971). The ^{137}Cs activities were corrected for decay that took place between the date of sample collection and the sample analysis. Total deposition of

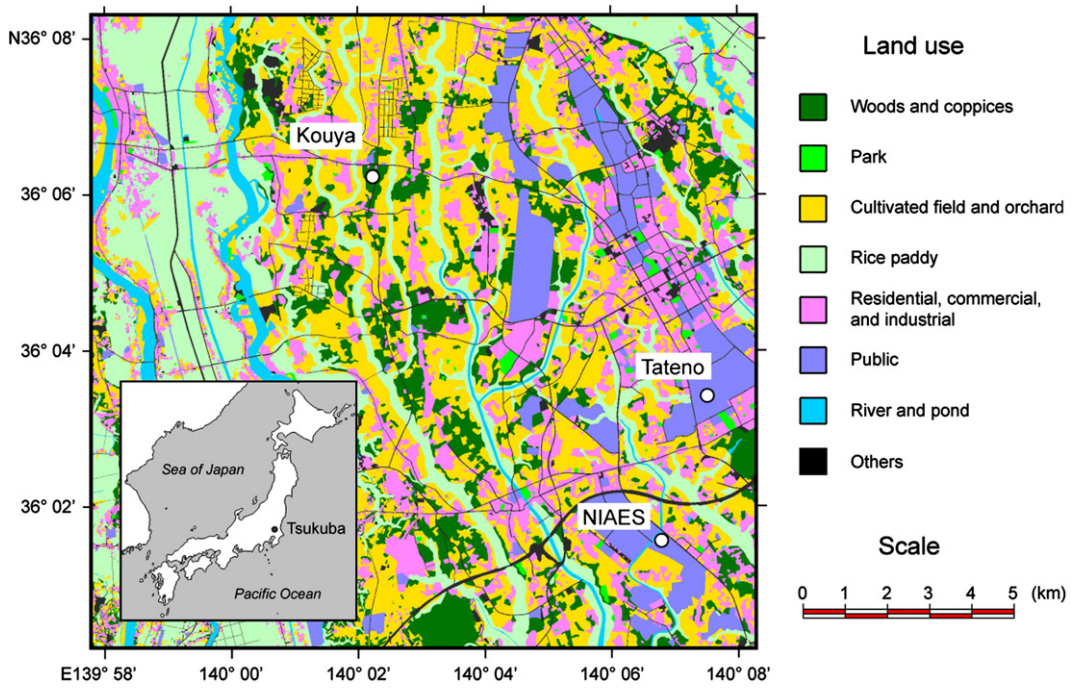

Fig. 1 – Locations of the sampling site for atmospheric deposition at NIAES, the monitoring station for SPM concentration at Tsukuba–Kouya, and the meteorological station at Tsukuba–Tateno. These sites are on the Pacific Ocean side of the Japanese Islands. Colors represent land-use types and are derived from Detailed Digital Land Use Information (Geographical Survey Institute, 1998).