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Detection of cloud droplets or fog by a polarization optical counting sensor: Circumstantial evidence for cloudwater deposition of radionuclides in mountainous areas of Japan during the Fukushima nuclear accident

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Introduction

Radionuclides emitted from the accident of Fukushima Dai-ichi Nuclear Power Plant contaminated extensive region in eastern Japan, including mountainous areas. Hososhima and Kaneyasu (2015) observed that the Nikko mountain area, located north of the Kanto Plain, was characteristically contaminated across an altitude range of 700–1400 m above sea level and they suggested that the altitude-dependent contamination was the result of cloudwater deposition (fog deposition, or occult deposition) of radionuclides included in the cloud droplets.

Methods

To establish the validity of this mechanism of contamination the author utilized data derived from pollen sensors, deployed on radio towers by a mobile phone company (NTT Docomo Ltd). The principle of operation of the pollen sensor is that it distinguishes particle shape using a depolarization of scattered light by the article. Therefore, if the sensor can distinguish spherical water droplets with a geometric diameter greater than several micrometers from Cedar pollen and local soil dust particles, then the deployed sensors can detect the presence of cloud droplets.

The pollen sensor PS2 (Shinei Technology, Japan) was first tested on the balcony of the National Institute of Advanced Industrial Science and Technology building in Tsukuba, Japan, during early spring, when Cedar pollen and local soil dust particles were present in the atmosphere. The sensor was also tested in a water spraying chamber in the Meteorological Research Institute, Japan.

Results

A depolarization ratio was calculated from the output of the sensor, as defined by:

$D = S/\ P$

where S denotes photodiode voltage (V) generated as a result of light being scattered by a particle, with a polarization filter *in situ*, and P denotes the voltage generated by scattered light without using a polarization filter. The depolarization ratio$D$ was less than 0.25 when the sensor was placed in the water spraying chamber, and was generally greater than 0.17 during periods when there was extensive Cedar pollen in the atmosphere or local dust storm events. From these measurements, we concluded that a particle detected by the sensor was a water droplet when D was less than 0.17.

Sensor data deployed in Fukushima, Tochigi, Gunma, and Ibaraki prefectures were analyzed for the period of 1200–2400 JST, March 15, 2011, when the radioactive plume arrived at the mountainous area of northern Kanto and southern Tohoku areas, Japan. The analysis showed that 24 out of 73 sites exceeded the tentative criterion (100 counts) for D $<$0.17, which we regarded as reflecting the presence of cloud droplets or fog at that time. The location of these sites generally coincided with that of the radio-contaminated area, although some differences were apparent, which should be attributed to other surface contamination mechanisms.