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A new insight into the deposition mechanism of airborne radionuclides from the Fukushima accident

KANEYASU, Naoki[1*] ; HOSOSHIMA, Mutsuo[2]

[1]National Institute of Advance Industrial Science and Technology, [2]Mibu High School

Introduction

On the radiocesium emitted from Fukushima Daiichi Power Plant (FDNPP) and transported to Eastern Japan, airborne (MEXT, 2012) and car-borne (Tanigaki, 2014) surveys have been conducted to map the horizontal distribution of contaminated area.

In the mapped ^{134,137}Cs distribution by the airborne surveys, the contamination in the Nikko Mountain area, located 120 km north of Tokyo, is prominent. From the previously reported results of transport/dispersion/deposition modeling studies, this radioactive contamination appeared to have occurred in the transport event in March 15, 2011.

We thus analyzed the formation mechanism in this area by the on-hoot measurements of ambient gamma dose rate (GDR) in air at multiple mountains conducted from 2012 to 2014.

Instrumentation and Measurements

Altitudinal distributions of GDR in air were measured in the Nikko Mountainous area at the northern rim of the Kanto Plain, Japan, using a portable CsI (TI) scintillation gamma-ray detector (Gamma RAE II R, RAE Systems) carried along the mountain trails. The horizontal position of the observer was pinpointed by a global positioning system.

Results and Discussion

In the Nikko Mountain area, the altitudinal distribution of ambient GDR exhibited maxima at about 900-2,000 m above sea level (ASL).

Meteorological sounding data indicated that the corresponding altitudes were within the cloud layer. A visual-range monitor deployed in an unmanned weather station at 1,292 m ASL also recorded low visibility on the afternoon of March 15. In the gridded data products of Japan Meteorological Agency Meso-scale Model, cloud over (%) of low struts started to cover over the Nikko area at about 1500 JST, as seen in Figure 1. Radar-AMeDAS (Automated Meteorological Data Acquisition System) analysis shows this area was not affected by precipitation until 2300 Japan Standard Time on March 15, 2011. The mechanism anticipated to have caused the concentrated deposition in a particular altitudinal range was cloud deposition (or fog/occult deposition). Atmospheric aerosol particles often act as cloud condensation nuclei (CCN) so that cloud (fog) droplets form on them. With cloud/fog deposition, these droplets, and with them the original aerosol particles are intercepted by vegetation and deposited on the ground.

Airborne radiocesium, one of the major gamma-ray emitting radionuclides deposited onto the land and marine environments after the FDNPP accident, exists in the aerosol phase. Kaneyasu et al.(2012) reported that sulfate aerosols are a potential carrier of airborne radiocesium. Sulfate aerosol is one of the representative species acting as CCN. Therefore, cloud or fog droplets activated from CCN, including radiocesium and other gamma-ray emitting radionuclides, have greater deposition velocities than that of sulfate aerosol itself. This leads to the transfer of radionuclides from the atmosphere to the forest and ground surface being far more effective. Recently, Katata et al.(2014) incorporated a simple fog deposition scheme into their transport/disposition model and reproduced the deposition pattern in the mountain area qualitatively.

Conclusion

The proposed mechanism of the altitude-dependent radioactive contamination in Nikko Mountain area was the cloud (fog/occult) deposition process of the radionuclides contained in aerosols acting as cloud condensation nuclei.

Acknowledgement

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References

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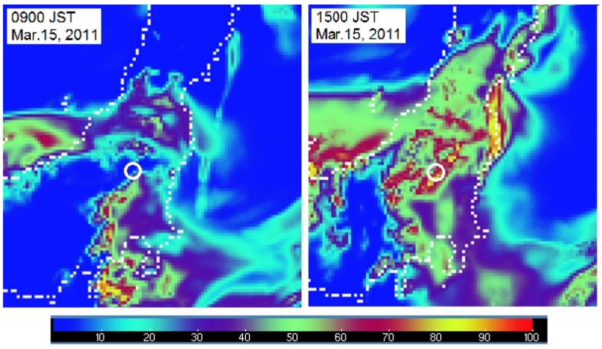

Figure 1 Cloud cover of low stratus in the gridded data products of Japan Meteorological Agency Meso-scale Model (MSM) on March 15, 2011. White circles indicate the location of Nikko Mountain area.