

## Investigation on distribution of radioactive substances in Fukushima

### (9) Analysis of temporal changes in ambient dose equivalent rates in forests over 6 years following the FDNPP accident

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#### Abstract

We analyzed changes in ambient dose equivalent rates ( $\dot{H}^*(10)$ ) between 2011 and 2017 in forests in Fukushima Prefecture. PHITS was used to calculate the effect of re-distribution of  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  over time within forests on  $\dot{H}^*(10)$ . Transfer of radiocesium from the crowns of evergreen coniferous trees to the forest floor appeared to cause slower declines in  $\dot{H}^*(10)$  at 1 m height initially after March 2011 than expected by the rate of radiocesium decay.

**Keywords:** forest, environment, ambient dose equivalent, radiocesium,  $^{134}\text{Cs}$ ,  $^{137}\text{Cs}$ , FDNPP accident, PHITS, Monte Carlo, simulation

#### 1. Introduction

Ambient dose equivalent rates ( $\dot{H}^*(10)$ ) have been observed to decrease more slowly in forests than in other areas since the 2011 Fukushima Daiichi Nuclear Power Plant (FDNPP) accident [1]. Moreover, between 2011 and 2013,  $\dot{H}^*(10)$  at 1 m above the ground in some forests decreased slower than the rate of radioactive decay of the radiocesium fallout [2]. The reasons for this behavior were examined by using radiation transport simulations.

#### 2. Methods

Forests in Fukushima Prefecture monitored by FFPRI [3] were modelled with the PHITS code [4]. We calculated the contributions to  $\dot{H}^*(10)$  at 1 m above the ground from  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  in the canopy, trunks, organic layer, and soil layers separately. The results were compared to  $\dot{H}^*(10)$  measurements from hand-held survey meters.

#### 3. Results

Yearly fluctuations in the measured  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  inventories in forests meant the inventories had to be normalized to a common baseline to understand the effects of re-distribution of  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  within forests on  $\dot{H}^*(10)$ . The results show that changes in the distribution of  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  on the centimeter scale within the organic layer and soil affect the temporal trends of  $\dot{H}^*(10)$  in forests.

#### 4. Conclusions

The slower decreases in  $\dot{H}^*(10)$  in forests compared to other land uses was a consequence of the high retention of  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  by forests, and the tendency of  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  to remain near the top surface of forest soil. Radiocesium transfer from the crowns of evergreen coniferous trees to the forest floor explained a slower rate of decline in  $\dot{H}^*(10)$  between 2011 and 2013 than expected by the rate of radioactive decay.

#### References

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