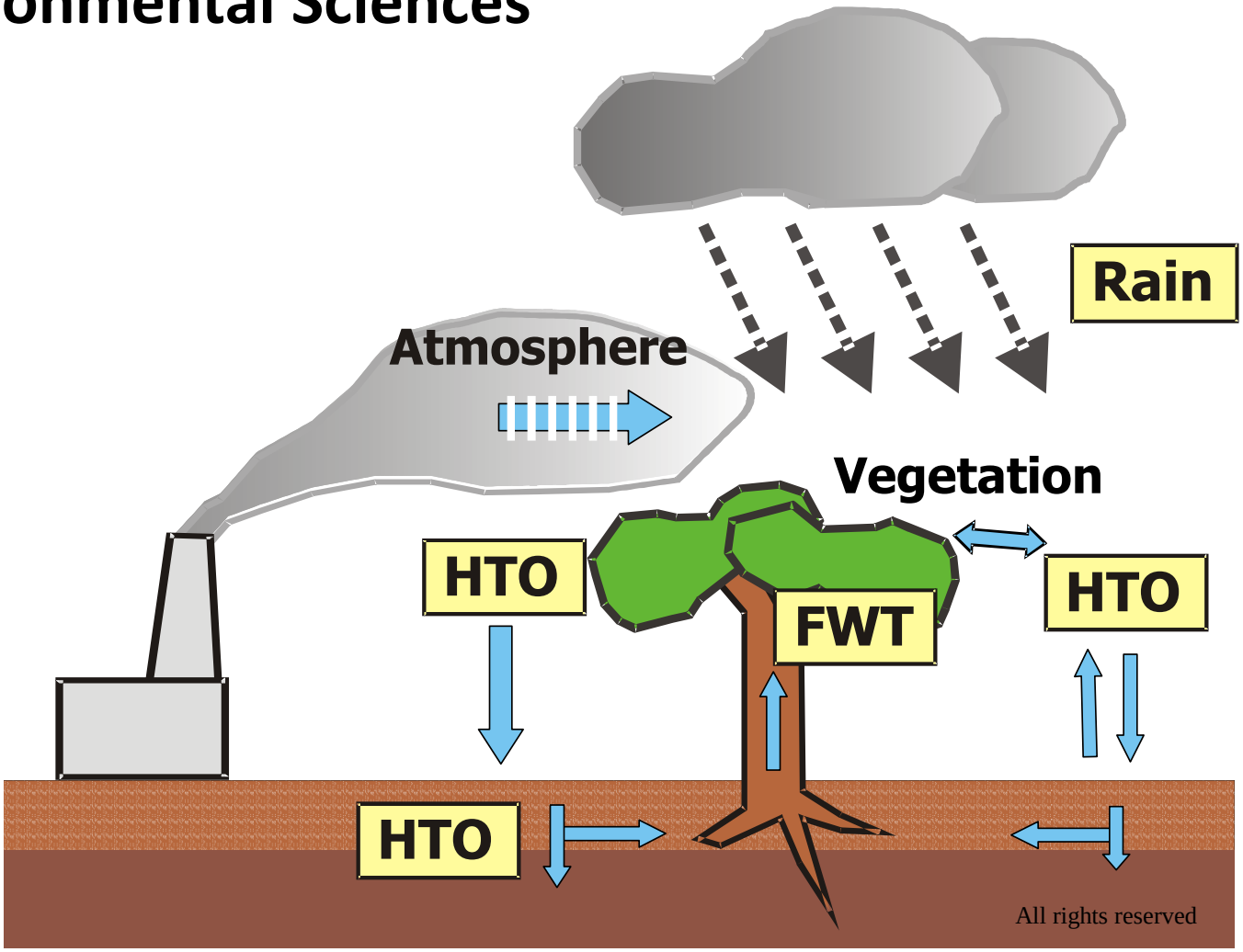
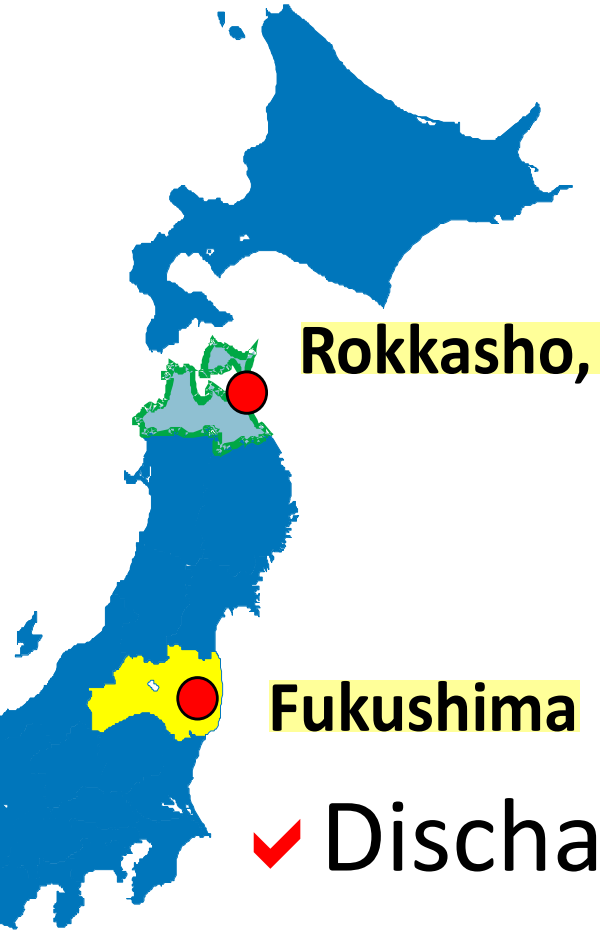
Concentration of ^{3}H in Vegetations around Fukushima Dai-ichi Nuclear Power Station

Hideki KAKIUCHI

Institute for Environmental Sciences

February 25, 2013





Our institute is located Rokkasho, Aomori. We study behavior of radionuclide in the environment. After the accident, we start investigation in Fukushima following topics.

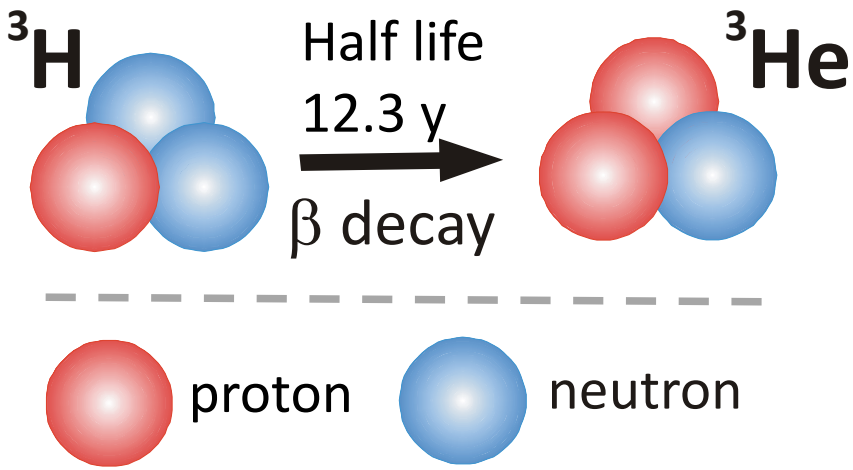
- Discharges of Cs from contaminated watersheds
- Distribution of Cs in air
- Distribution of tritium in the terrestrial environment.

A large amount of radionuclides was released from the **Fukushima Dai-ichi Nuclear Power Station** (**FDNPS**) following the damage caused by the tsunami due to the Great East Japan Earthquake on 11 March 2011.

We present here the first survey results of **^{3}H** concentrations **in vegetation** samples collected around the FDNPS in 2011 from shortly after the accident.

Tritium Basics

Tritium (^{3}H or T) is a radioactive **isotope of Hydrogen**.



Emits low energy **beta** particle (average energy of 5.7 keV)

Transforms into stable helium.

Most common chemical form is **water**.

I. Natural tritium

Cosmogenic Tritium

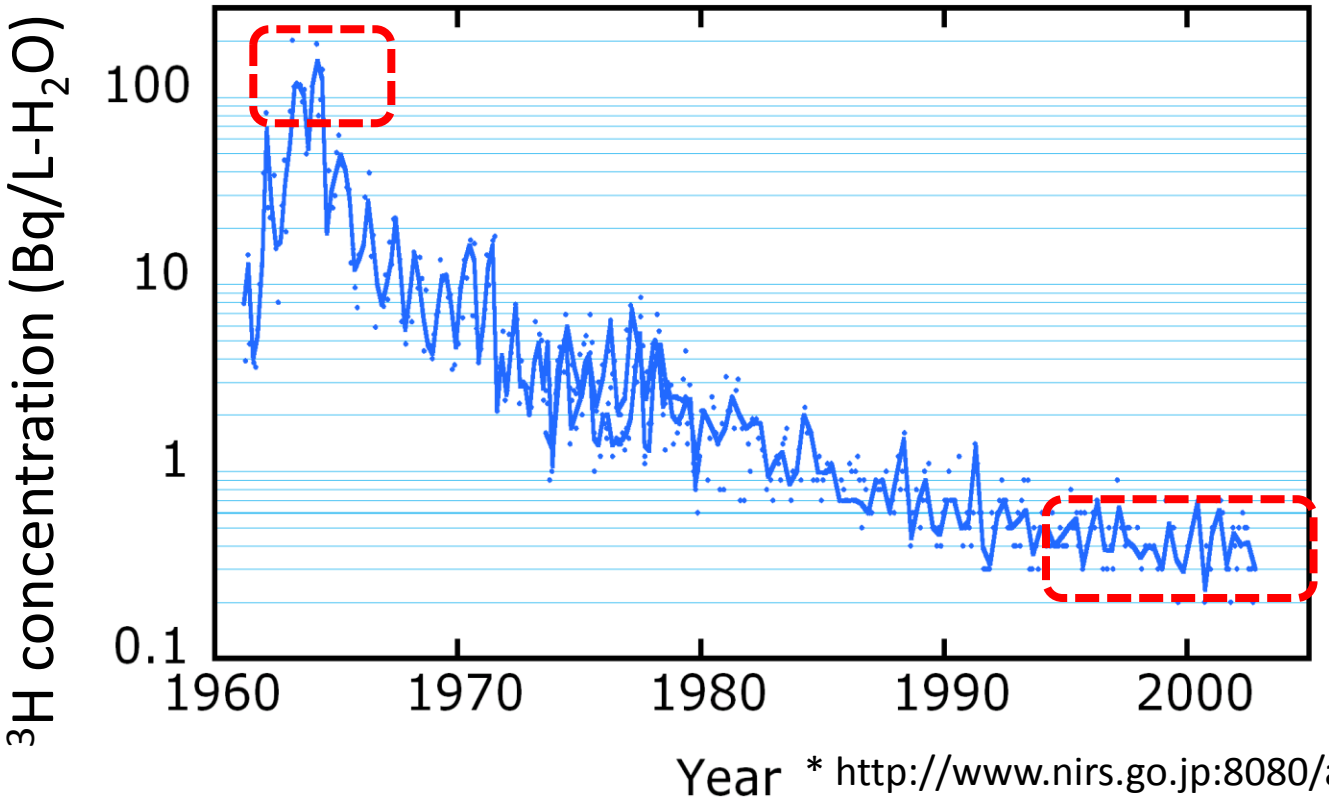
Naturally produced tritium due to spallation is primordial – its always been here at a relatively constant level

II-a. Artificial tritium

Weapons Testing Tritium

Nuclear weapons testing injected a large amount of ^{3}H to atmosphere

^{3}H concentration in rain at Tokyo and Chiba, Japan*



* http://www.nirs.go.jp:8080/anzendb/PHP/HTO_rain.php

Atmospheric tritium levels peaked in early 1960s (over 100 Bq/L in rain).

Accounts for 0.1 to 0.6 Bq/L “baseline” in recent rain.

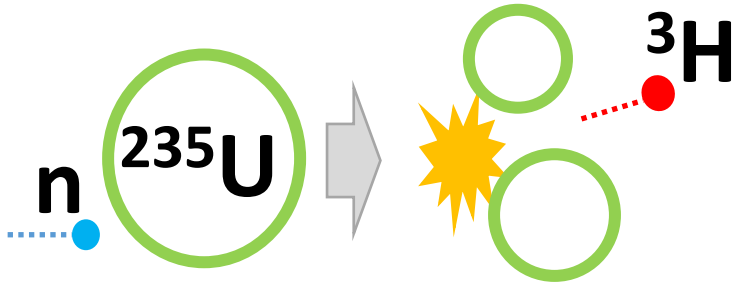
II-b. Artificial tritium

Tritium in Nuclear Power Plants (BWR)

FDNPS is a Boiling Water Reactor (**BWR**) complex.

Neutrons react with boron (**B**) in the control rods of BWRs to produce ^{3}H. $^{10}B\ (n,2\alpha)\ ^{3}H$

^{3}H is produced as a result of both **ternary fission** and **neutron activation of deuterium** (^{2}H).

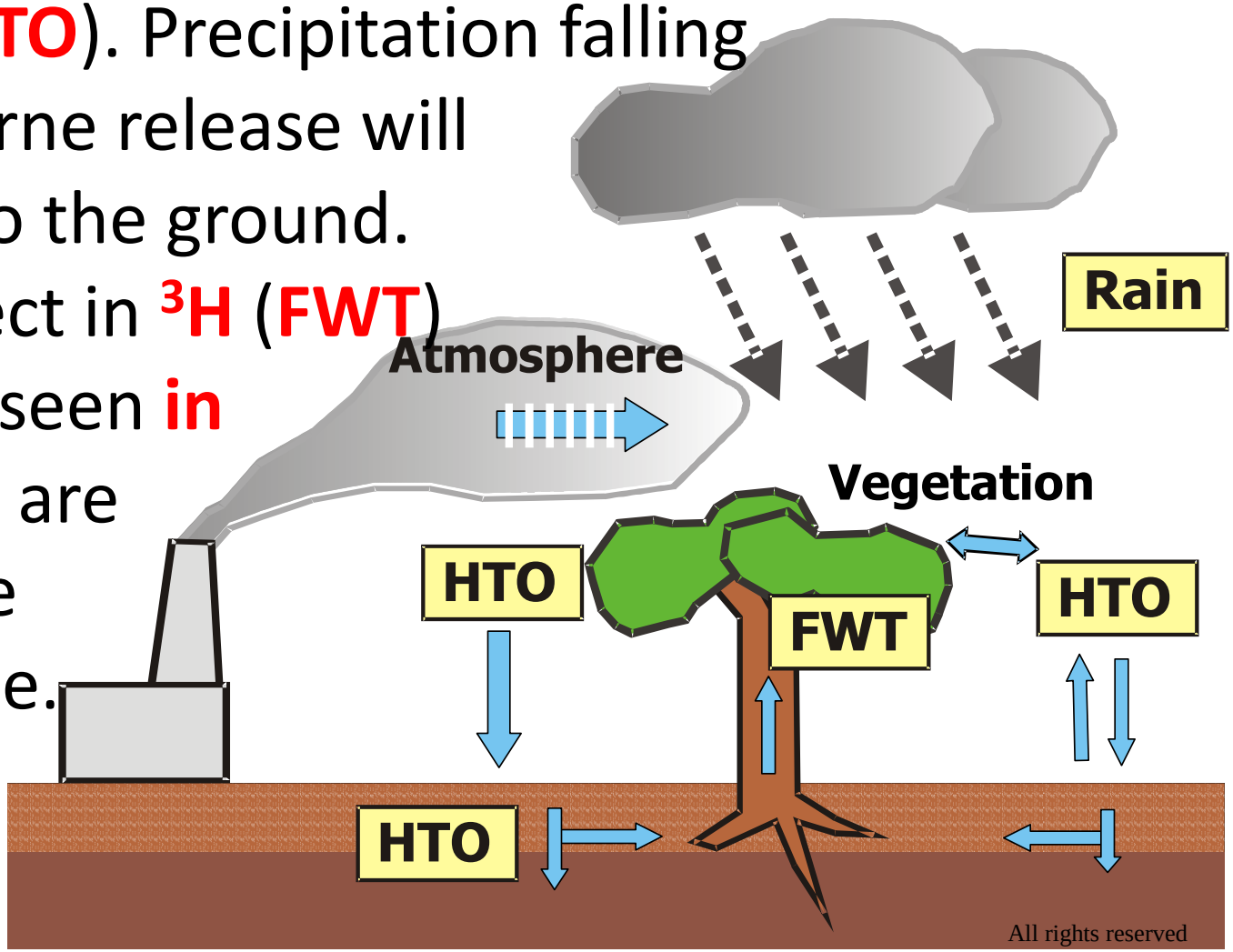


$^{2}H\ (n,\gamma)\ ^{3}H$

Accidental release (Environmental Tritium Processes)

Precipitation Washout

Most airborne ^{3}H is released from NPP as **atmospheric water vapor** (**HTO**). Precipitation falling during an airborne release will "washout" ^{3}H to the ground. This could reflect in **^{3}H** (**FWT**) concentrations seen **in vegetation** that are the result of the airborne Release.



FWT
(Free water tritium)

If the contaminated vegetation was detected near the affected nuclear vegetation, HTO in air as the resultant dose to an individual would be estimated at the accident by following relation.

$$C_L = (1/\gamma) \times \{RH \times C_a + (1\text{-}RH) \times C_s\} \quad (1)$$

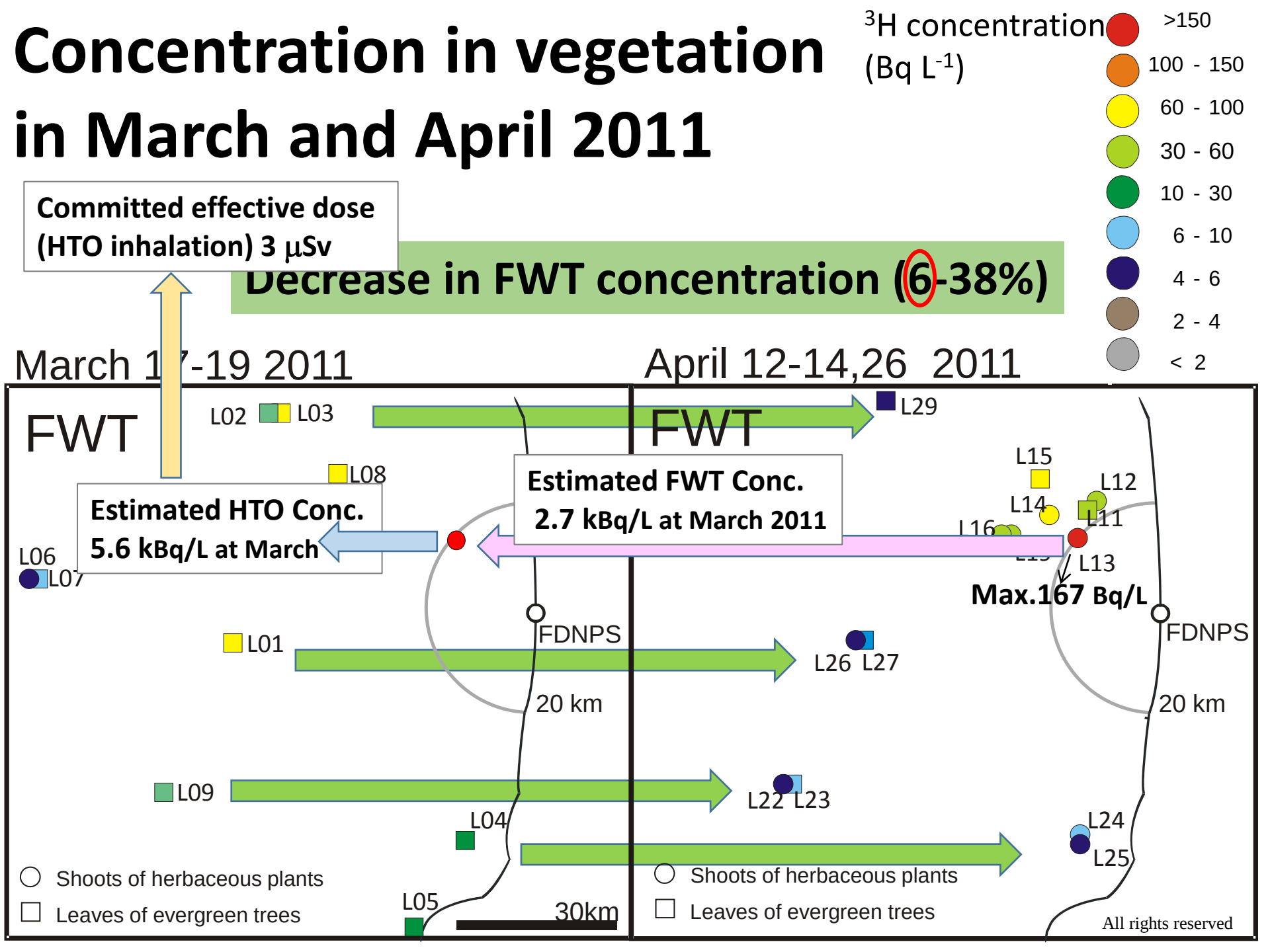
C_L : FWT in vegetation
C_a : HTO in air moisture
C_s : HTO in soil moisture
RH : Relative humidity
γ : The ratio of vapor pressures between HTO and H_2O **(= 1.1)**

In March 2011, HTO deposited on soil surface assumed not to be reached the zone rooting of plants. **Cs →0**

Estimation of C_a from C_L

$$C_a = \gamma C_L / RH \quad (2)$$

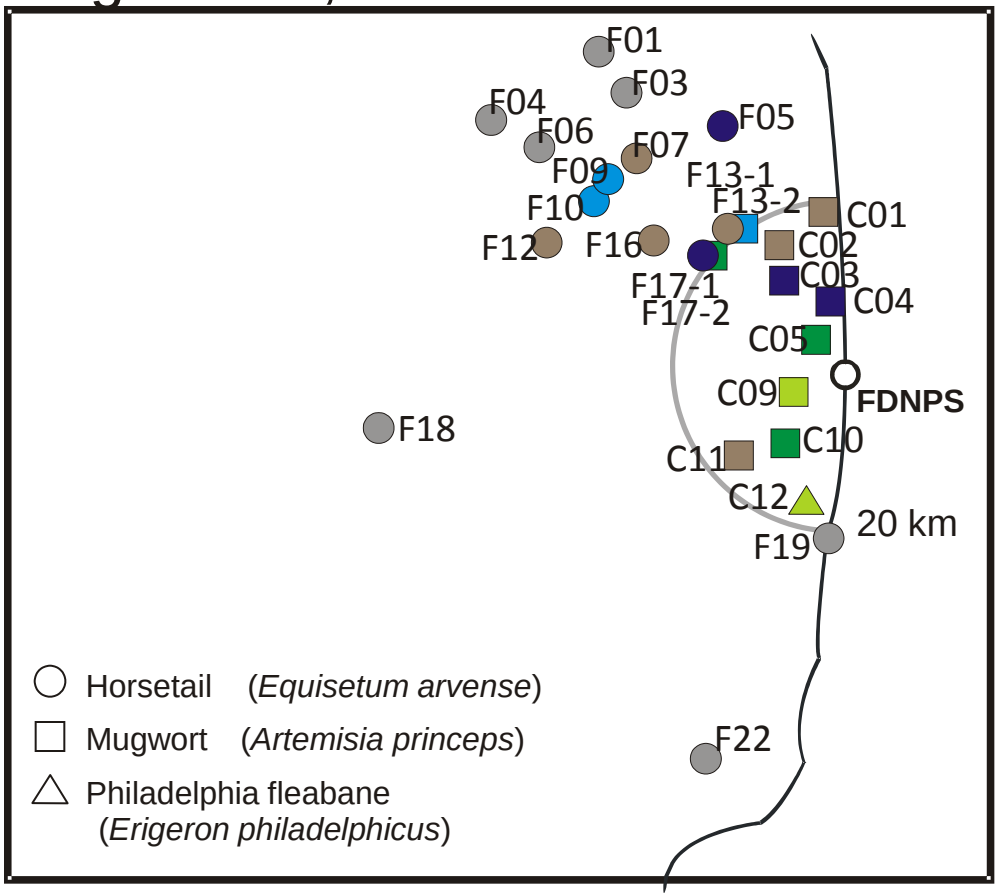
Concentration in vegetation in March and April 2011

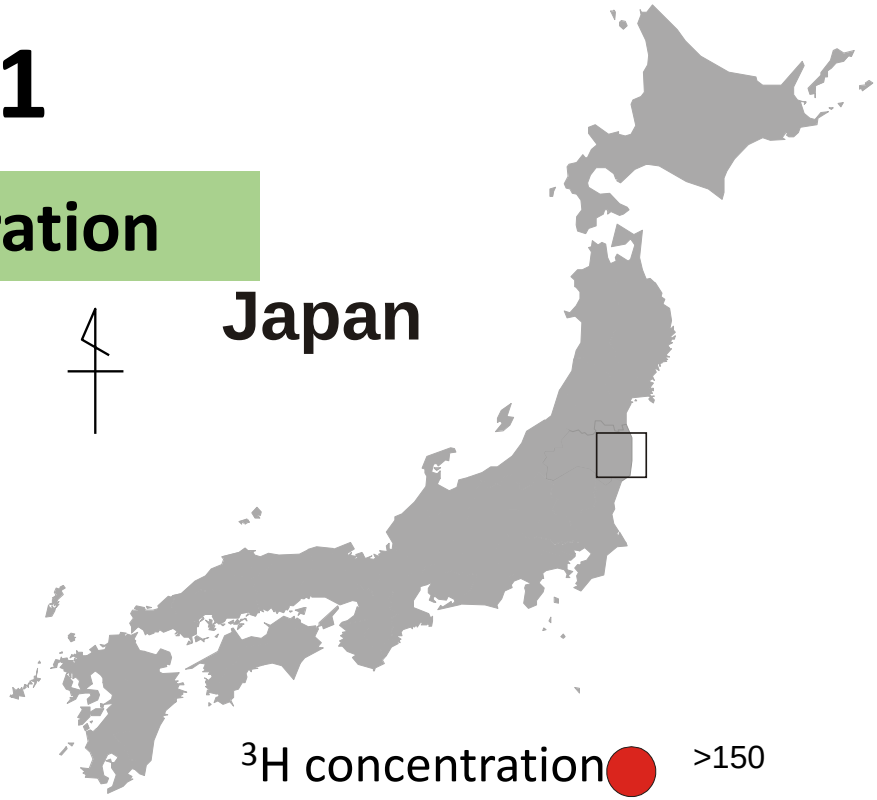


Concentration in vegetation in July and August 2011

More decrease in FWT concentration

July 21, 28-29,
August 1-5, 9-11 2011





Summary

Gaseous effluents from FDNPS were washed out by rain and show up in surface and vegetation samples.

The FWT concentrations in vegetation were considerably higher than the background concentration, and diminished with distance from the FDNPS.

Summary (continued)

Although reconstruction of atmospheric HTO after the accident is difficult, a rough estimate of the radiation dose due to HTO inhalation about 20 km from the FDNPS is on the order of a few microsieverts (μSv).

Thank you for your attention.

Special thanks:
(Hirosaki University) S. Tokonami, M. Yamada, M. Hosoda, A. Sorimachi, H. Tazoe, K. Noda, and the members of Fukushima Agricultural Technology Centre, Japan

This work was performed under contract with the government of Aomori Prefecture, Japan.