

# Some topics on soil radon ( $^{222}\text{Rn}$ ) monitoring at forest sites in northern Japan

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# Topics

1. A case study of  $^{222}\text{Rn}$  monitoring at a seismically active site in Hokkaido
2. Soil  $^{222}\text{Rn}$  variability in winter under different environmental conditions in Hokkaido
3. Dynamics of soil  $^{222}\text{Rn}$  and moisture in a temperate deciduous forest site in Fukushima

Knowledge of applicability and limit of  $^{222}\text{Rn}$  monitoring for tracing natural phenomena in forest soil environment

# Locations of interest



## Sapporo

Location: 43.03N, 141.21E  
Geology: alluvial sediment  
Altitude: 1.8-1,488 m a.s.l.  
Mean temperature: 8.5 °C  
Mean precipitation: 1100 mm

## Tomakomai

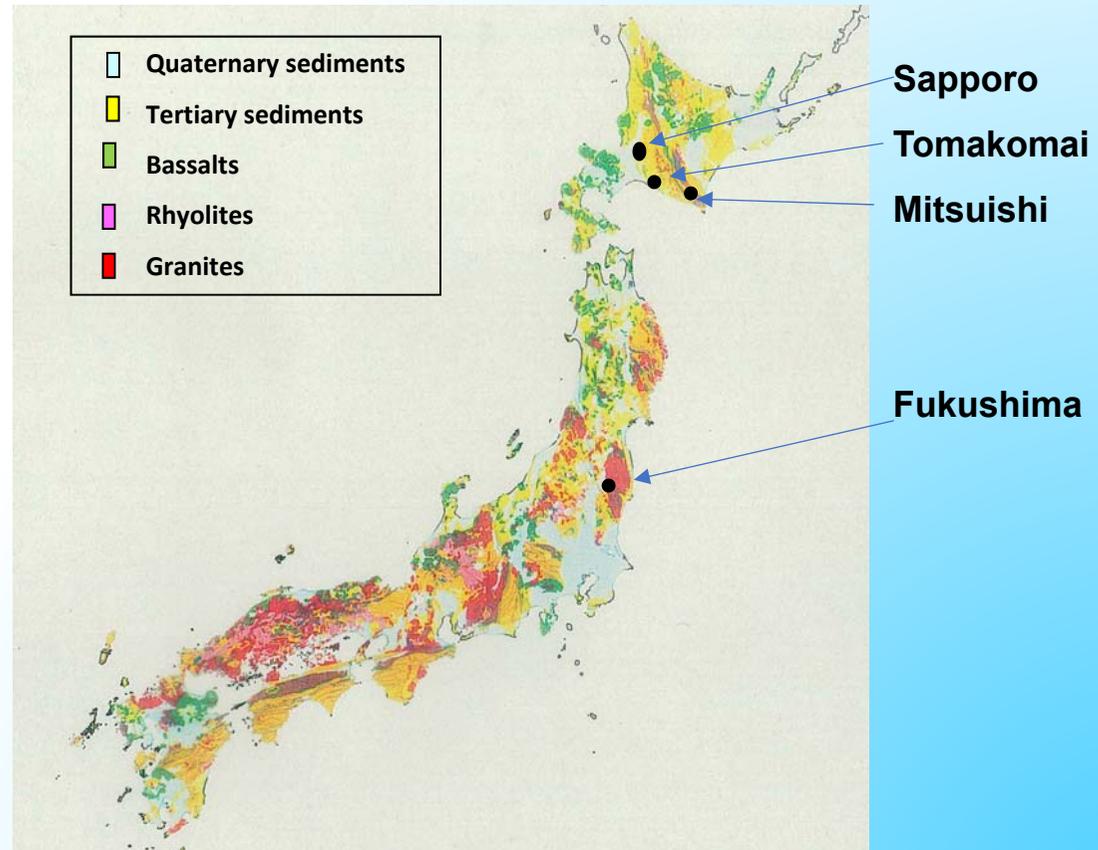
Location: 42.40N, 141.36E  
Geology : volcanic ash  
Altitude: 20~90 m a.s.l.  
Mean temperature : 6.4 °C  
Mean precipitation : 1200 mm

## Mitsuishi

Location: 42.14N, 142.33E  
Geology: conglomerates  
Altitude: < 400 m a.s.l.  
Mean temperature: 7.5 °C  
Mean precipitation: 1093 mm

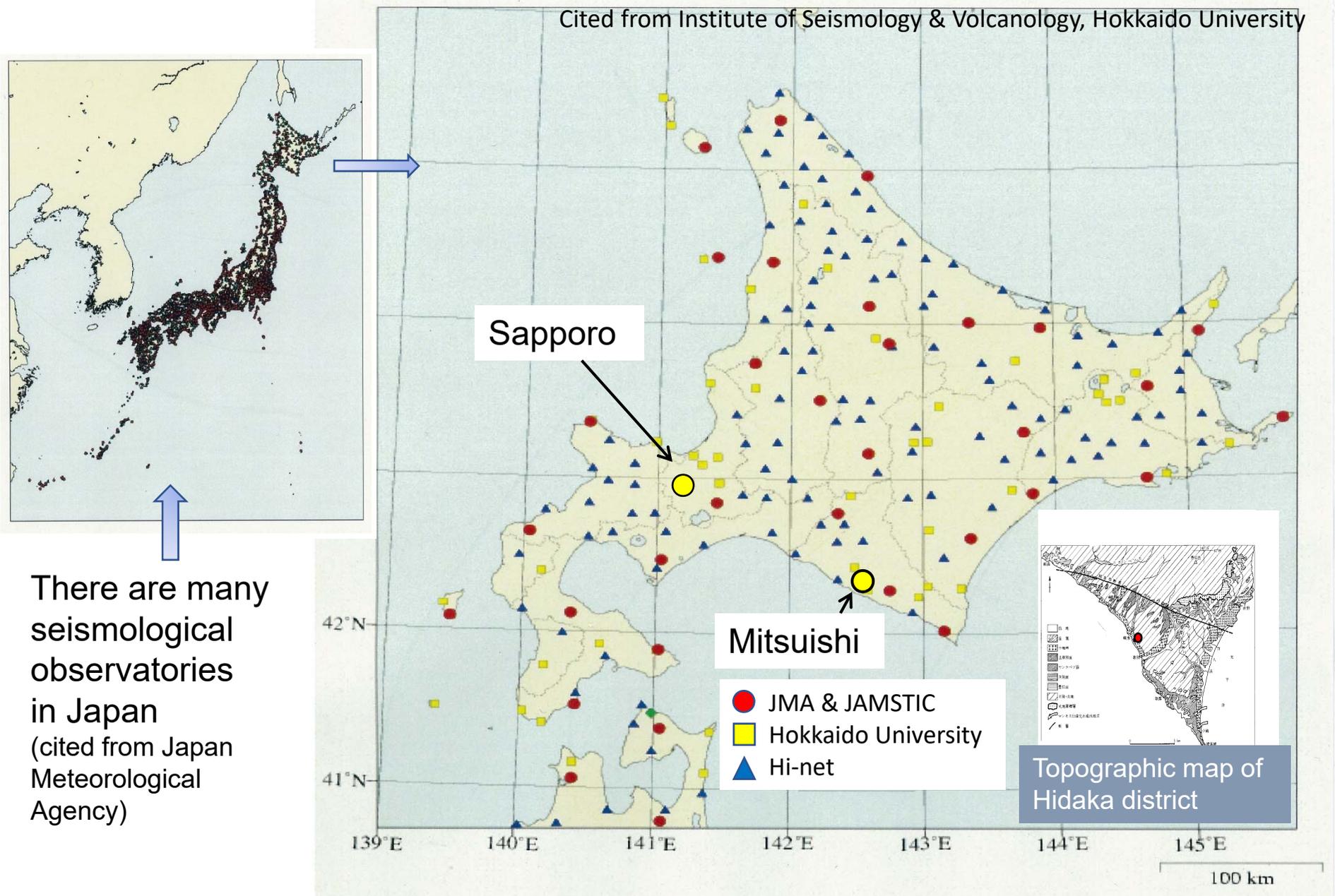
## Fukushima

Location: 37.68N, 140.45E  
Geology: loam  
Altitude: 206 m  
Mean temperature : 12.8 °C  
Mean precipitation : 1105 mm  
Mean snow depth : 8 cm



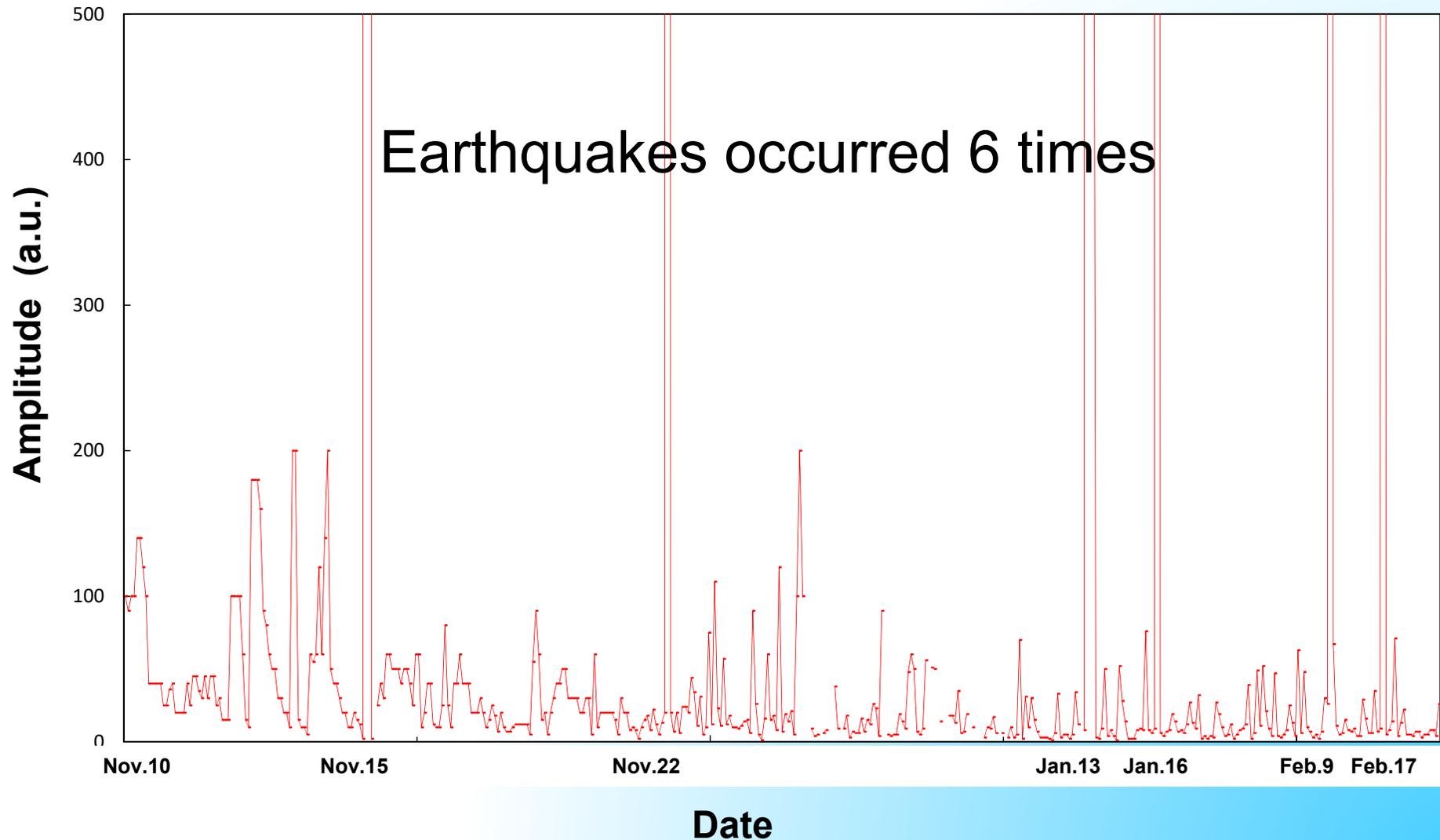
Surface geology of the Japan Islands

# 1. A case study of $^{222}\text{Rn}$ monitoring at a seismically active site in Hokkaido

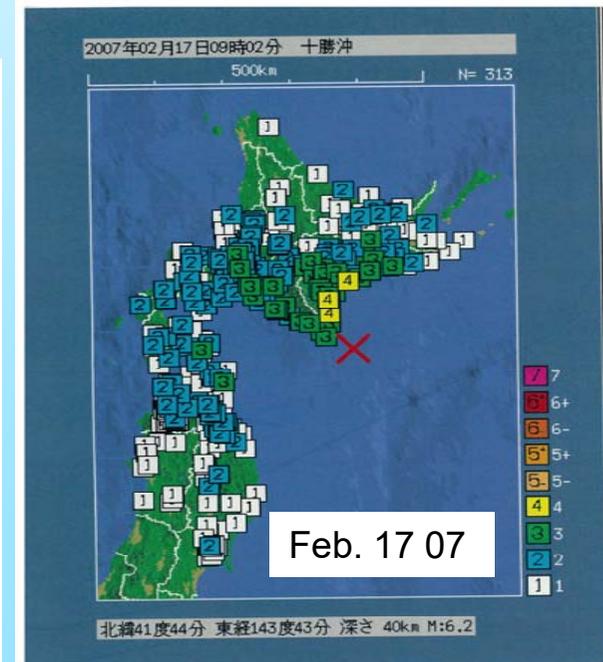
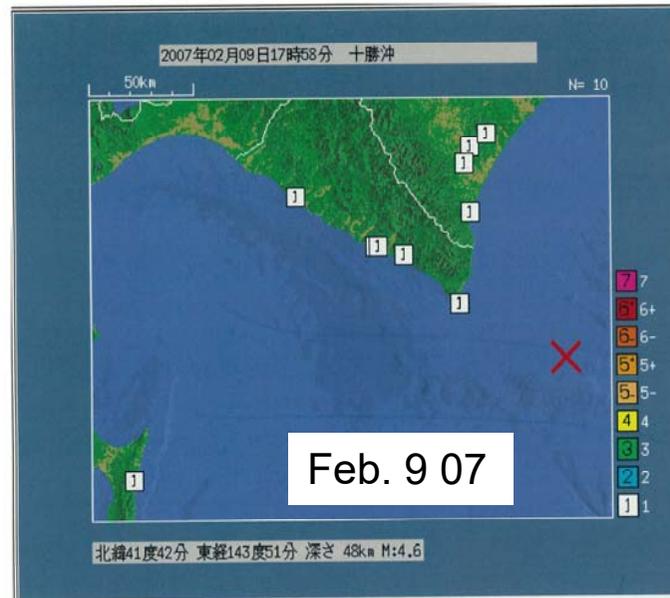
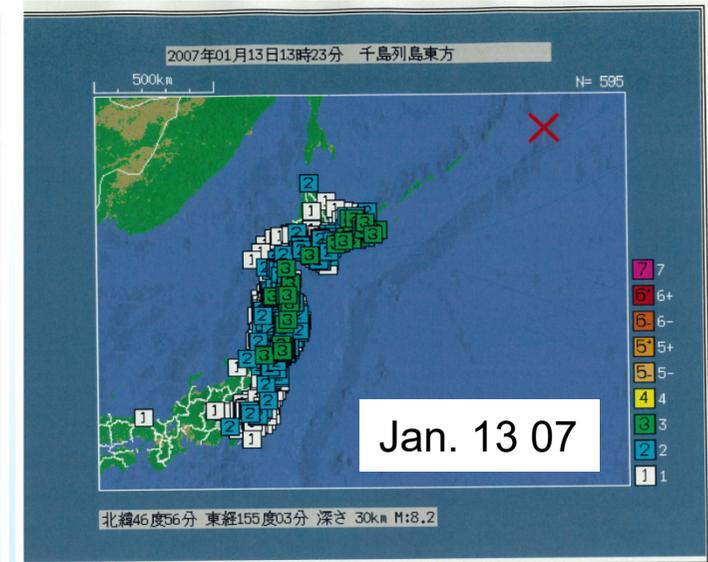
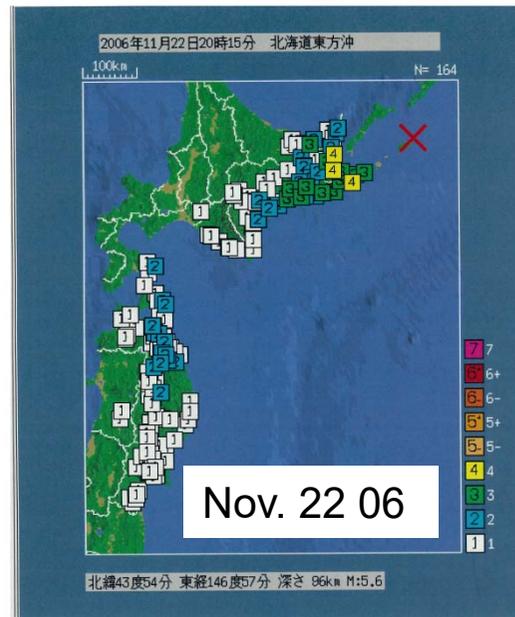
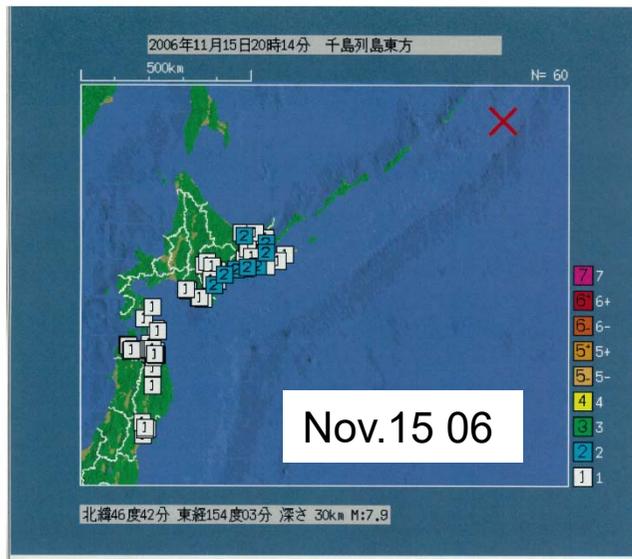


# Time-series plots of wave amplitude detected by a seismometer installed at Mitsubishi Observatory

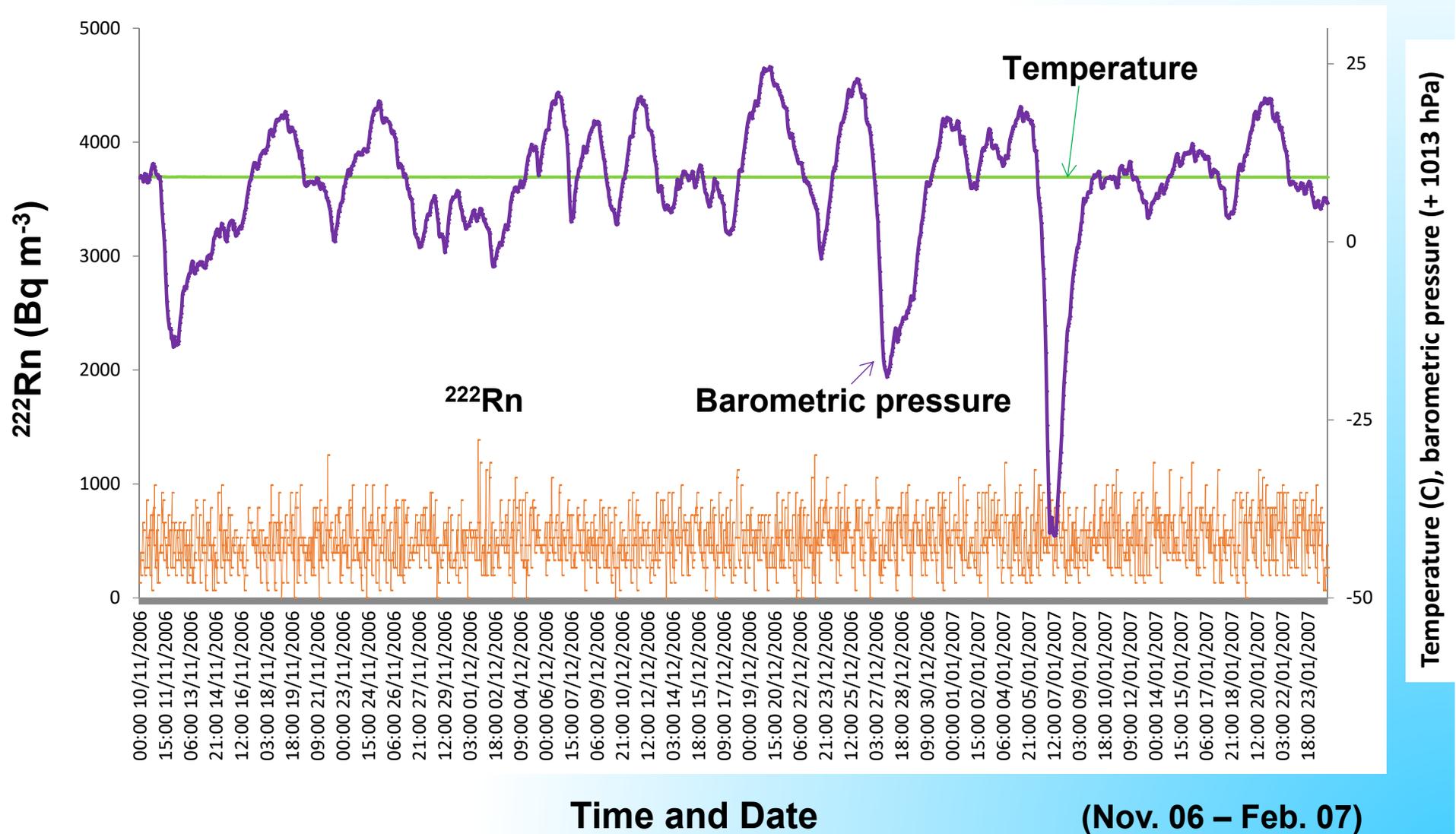
(November 2006 – February 2007)



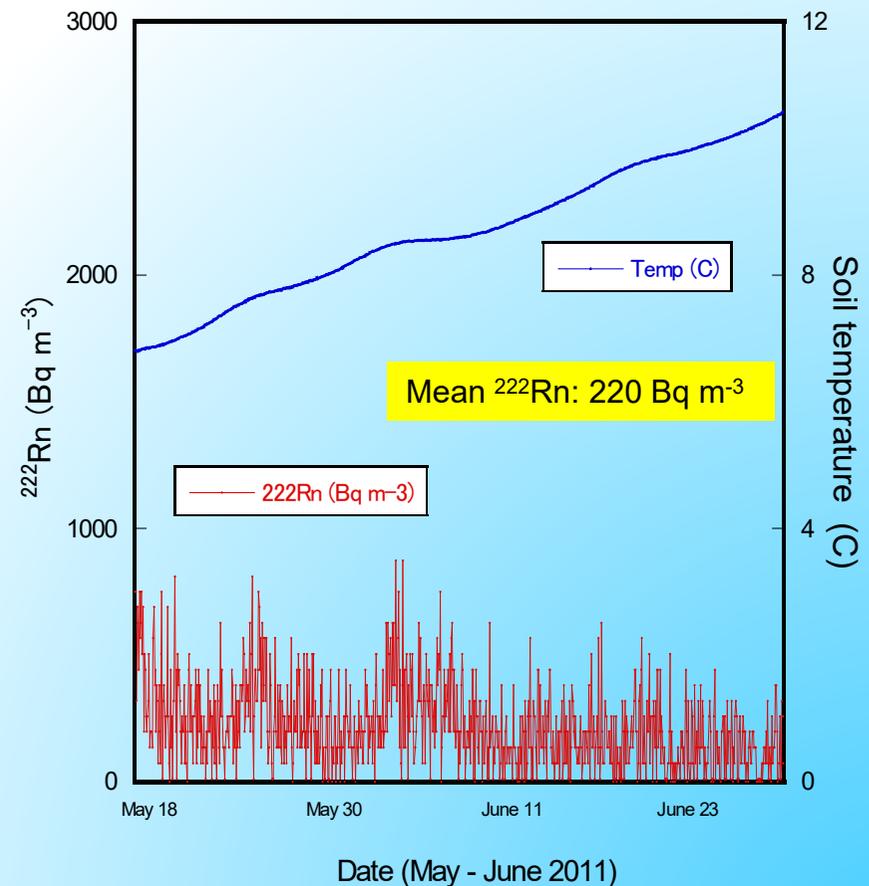
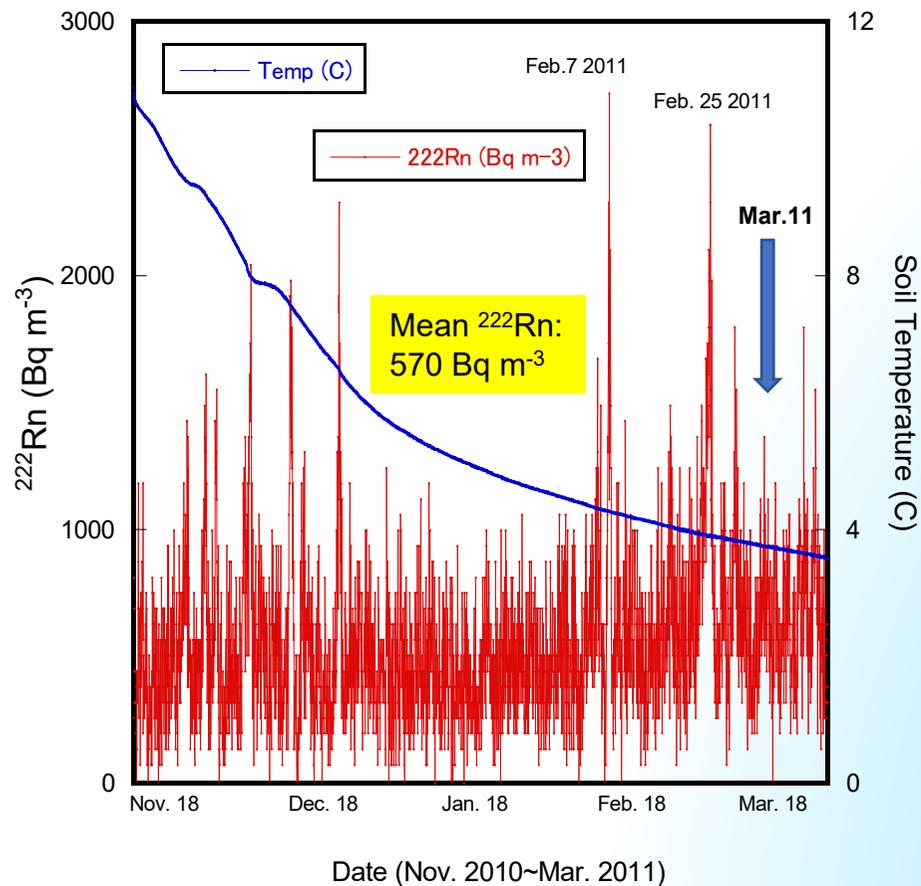
# Epicenter and JMA seismic intensity scale of the earthquakes occurred in the observation period



# Time series plots of $^{222}\text{Rn}$ activity concentration, temperature and difference in barometric pressure at the Mitsubishi observatory



# Time series plots of $^{222}\text{Rn}$ concentration and soil temperature at a depth of 1.0 m under cool temperate deciduous stand (Tomakomai, Hokkaido) before and after the **Great East Japan Earthquake** (Mar. 11 2011)



# Update of 2018 Hokkaido Eastern Iburi Earthquake

Time: 3:08am

Date: Sep.6 2018

Depth: 33.4 km

Epicenter: Iburi

Magnitude: 6.7

Max Intensity: 7

Type: Intraplate

Aftereffects:

Land slides

Soil liquefaction

No electricity all

over Hokkaido

Island for one day

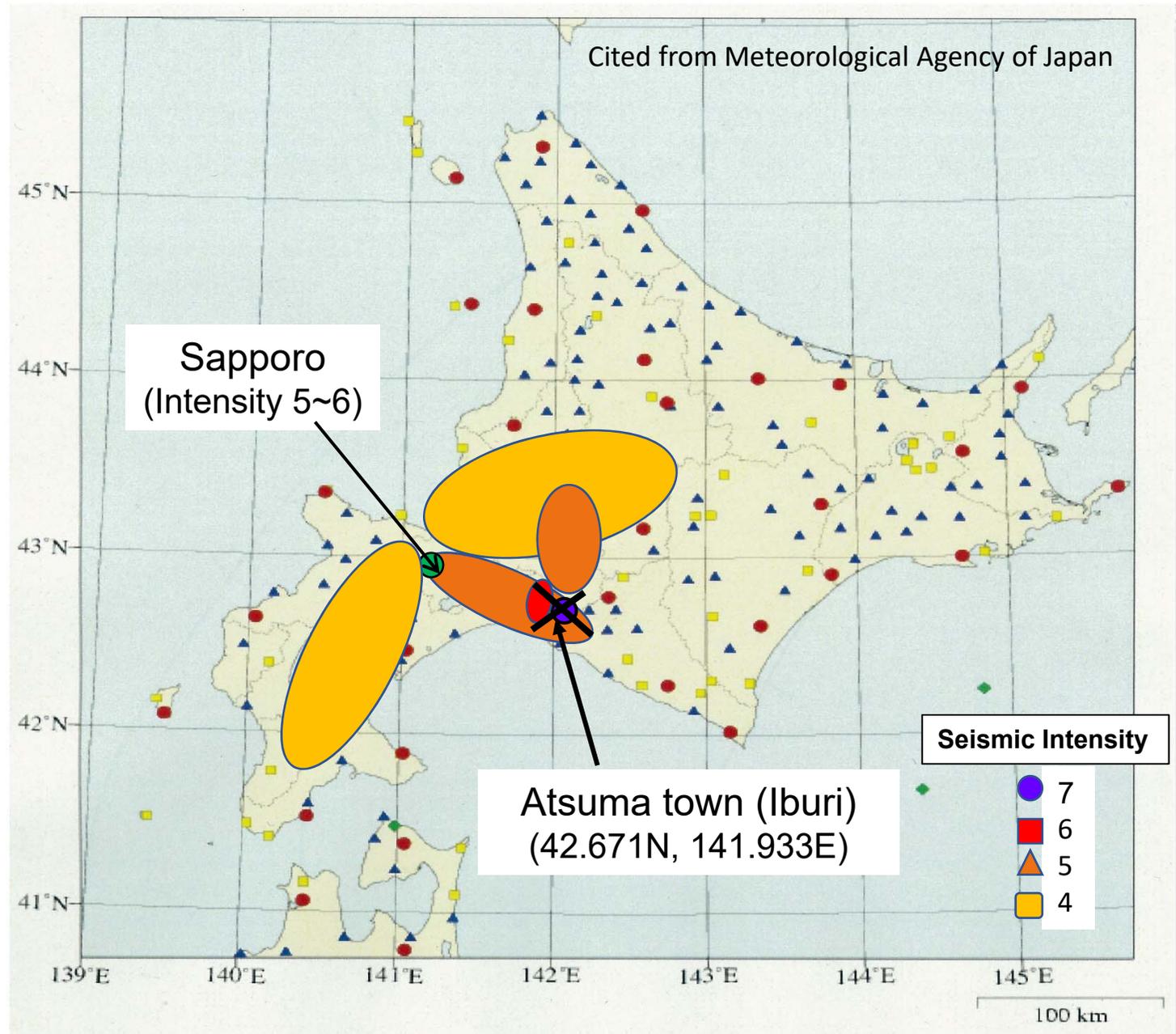
No water supply

in some places

Death: 41

Missing: 0

Injured: 681

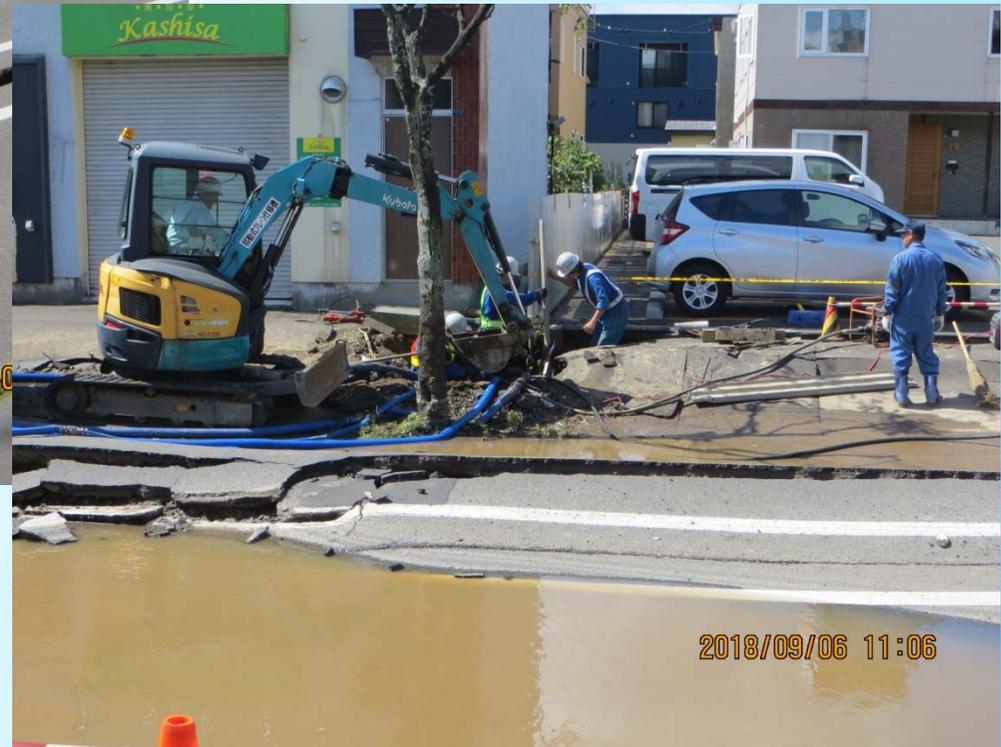


# 2018 Hokkaido Eastern Iburi Earthquake

Many people have been evacuated to live in quite severe situation.



Cracked and lifted road in Sapporo



## 2. Soil $^{222}\text{Rn}$ variability in winter under different environmental conditions

Factors affecting  $^{222}\text{Rn}$  in soil

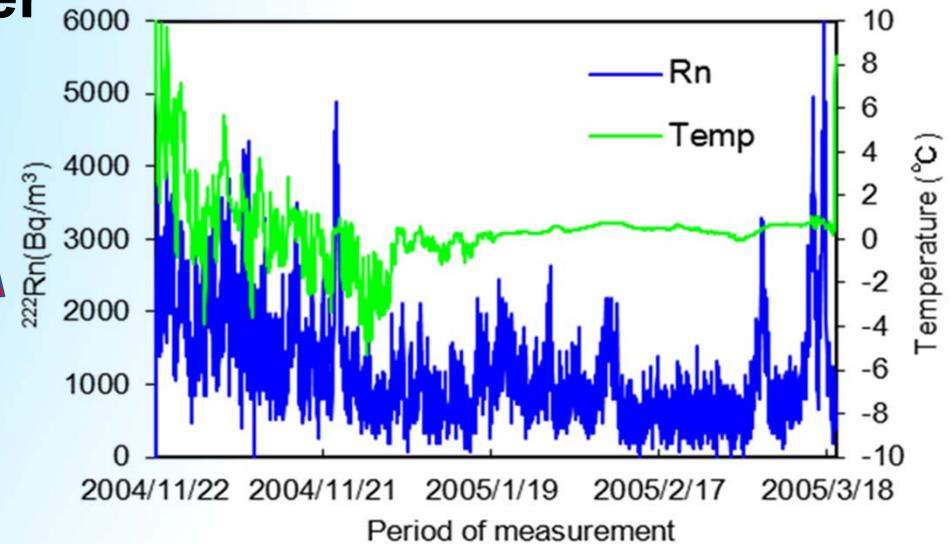
**Summer**  
Diurnal trend  
Temperature  
(soil, air)  
Precipitation

**Winter**  
(0.3 m in depth)  
Soil Temp:  $0^{\circ}\text{C}$   
**Lower Rn level**  
Low variability

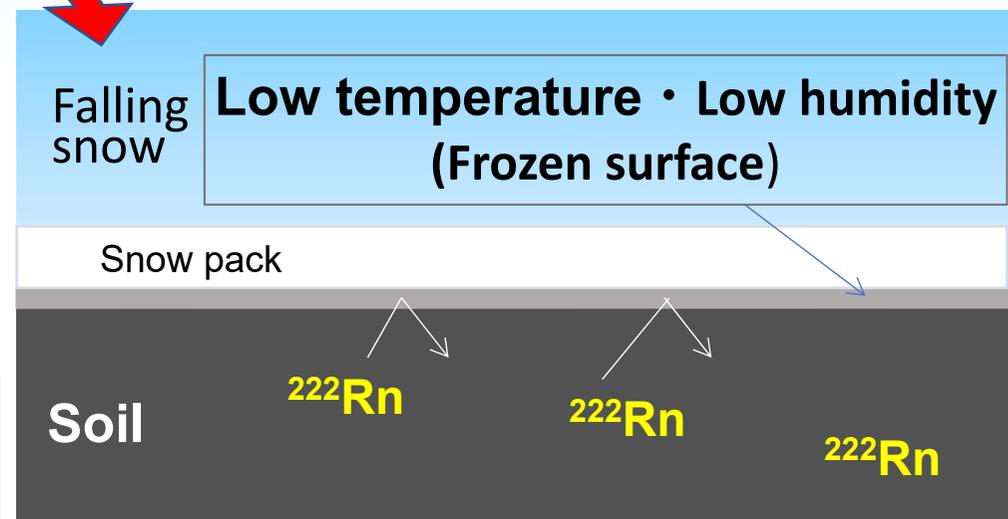
As in the case of Tomakomai,

**Higher soil radon level in winter**  
Winkler et al. Sci. Total Environ., 272,  
273-282, (2002)

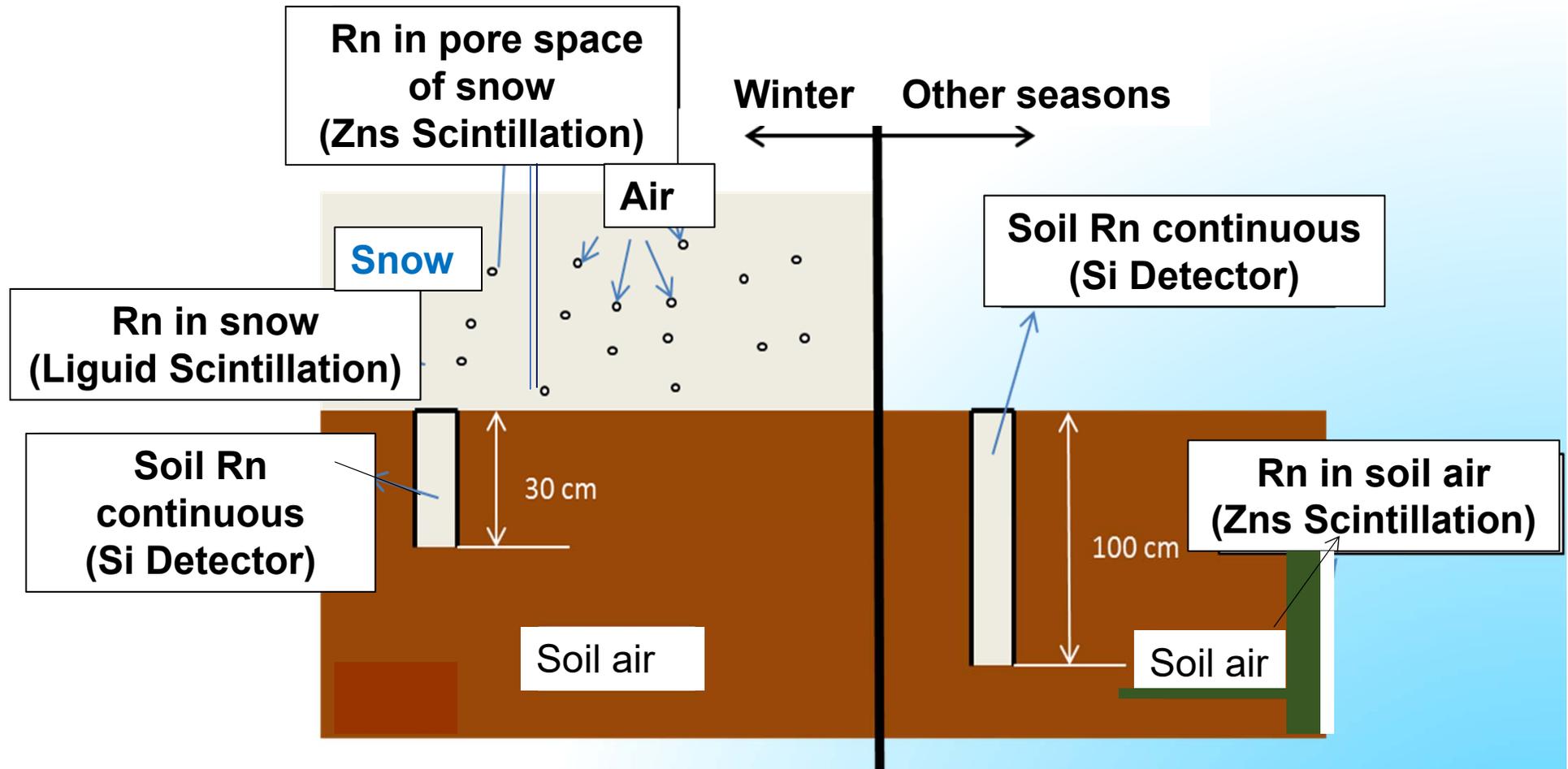
**What's going on soil  $^{222}\text{Rn}$   
in winter in Sapporo?**



Time series of  $^{222}\text{Rn}$  and temperature in soil air in Sapporo, Hokkaido (Nov. 22 2004~Mar. 20 2005)



# Procedures



1. Time series data on soil radon ( $^{222}\text{Rn}$ )
2. Radon in pore space of snow just above the ground surface
3. Radon in snow

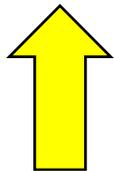
# Radon in soil and snow in winter in Sapporo

## Atmosphere

$^{222}\text{Rn}$  in pore space of snow

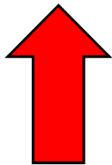


$^{222}\text{Rn}$  in snow



$0.4 \text{ mBq m}^{-2} \text{ s}^{-1}$

$^{222}\text{Rn}$  in soil



$^{226}\text{Ra}$  in soil  
( $13\text{-}15 \text{ Bq kg}^{-1}$ )



Meteorological parameter

$^{222}\text{Rn}$  in snow  
( $9\text{-}540 \text{ Bq m}^{-3}$ )

Snow air  $^{222}\text{Rn}$   
( $40\text{-}250 \text{ Bq m}^{-3}$ )

Snow

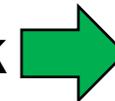


Soil

Soil  $^{222}\text{Rn}$  ( $1400\text{-}4500 \text{ Bq m}^{-3}$ )



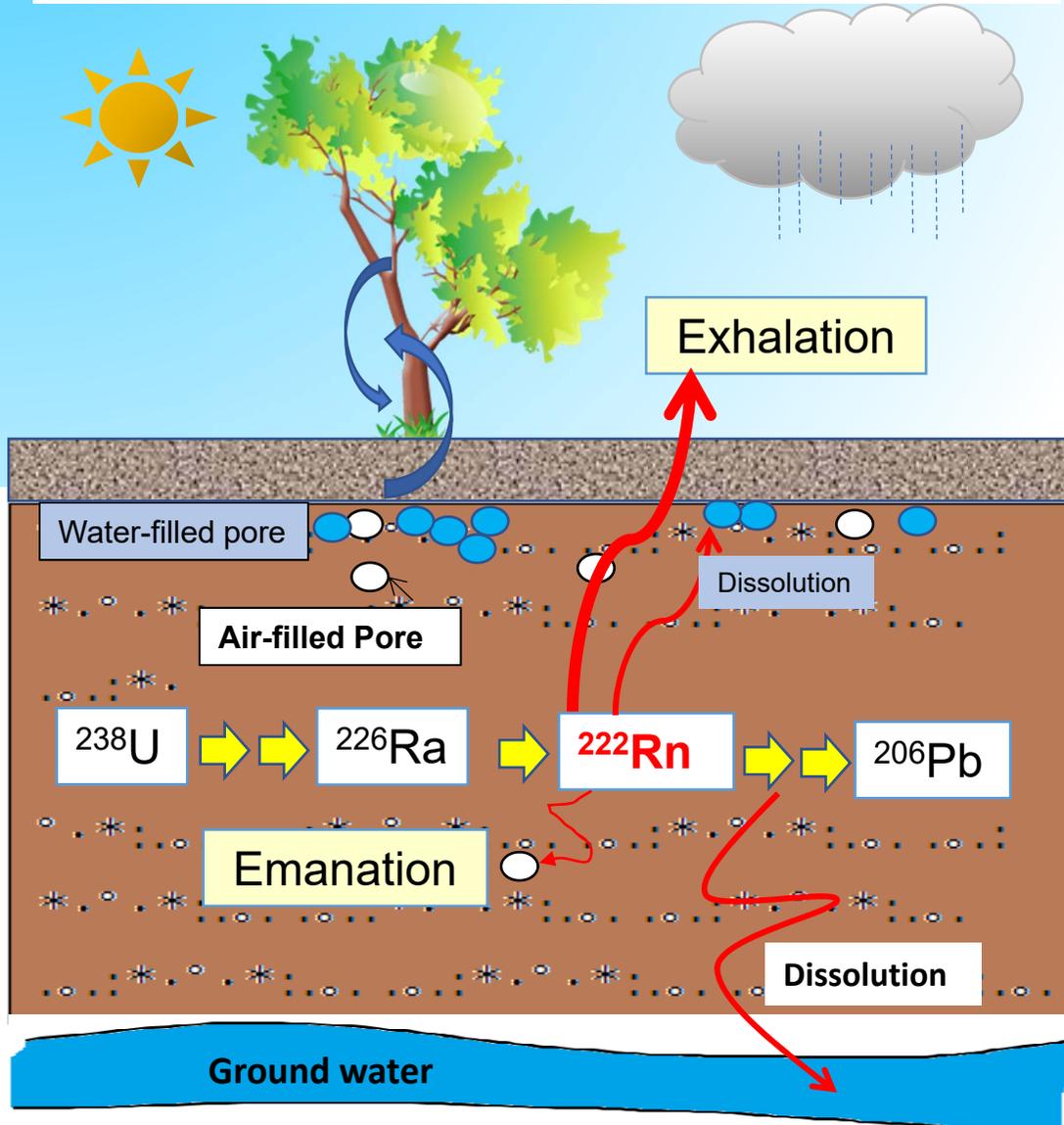
Radon is released  
into snow pack



Lower  $^{222}\text{Rn}$  level  
In soil in winter

### 3. Dynamics of soil $^{222}\text{Rn}$ and moisture under a temperate deciduous stand in Fukushima, Japan

Radon as a useful tracer in soil



Properties of radon isotopes

	$^{219}\text{Rn}$	$^{220}\text{Rn}$	$^{222}\text{Rn}$
Half life	3.96 s	55.6 s	3.82 d
Decay series	$^{235}\text{U}$	$^{232}\text{Th}$	$^{238}\text{U}$
Alpha energy (MeV)	6.946	6.404	5.490

Continuous soil  $^{222}\text{Rn}$  and moisture monitoring at three different depths



$^{222}\text{Rn}$  & moisture level, their variability  
soil & meteorological parameters



Soil air (water) movement in soil

# Comparative plotting of time series $^{222}\text{Rn}$ , moisture and meteorological parameters (snow depth, hourly precipitation)

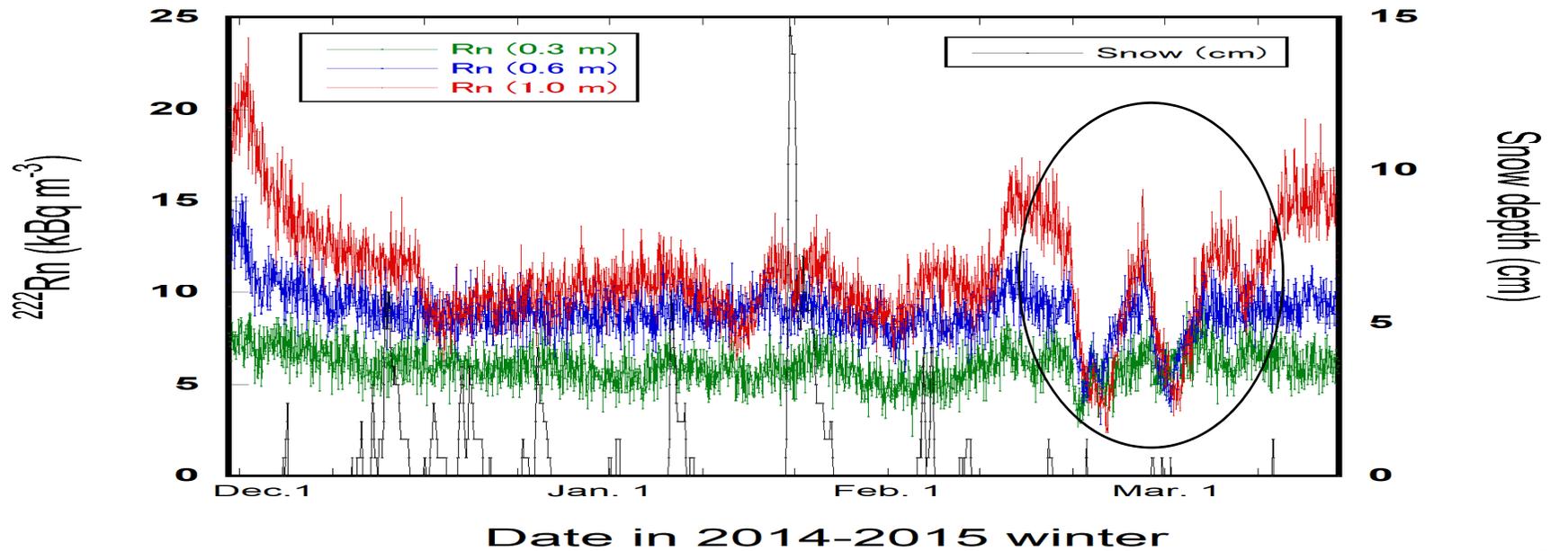
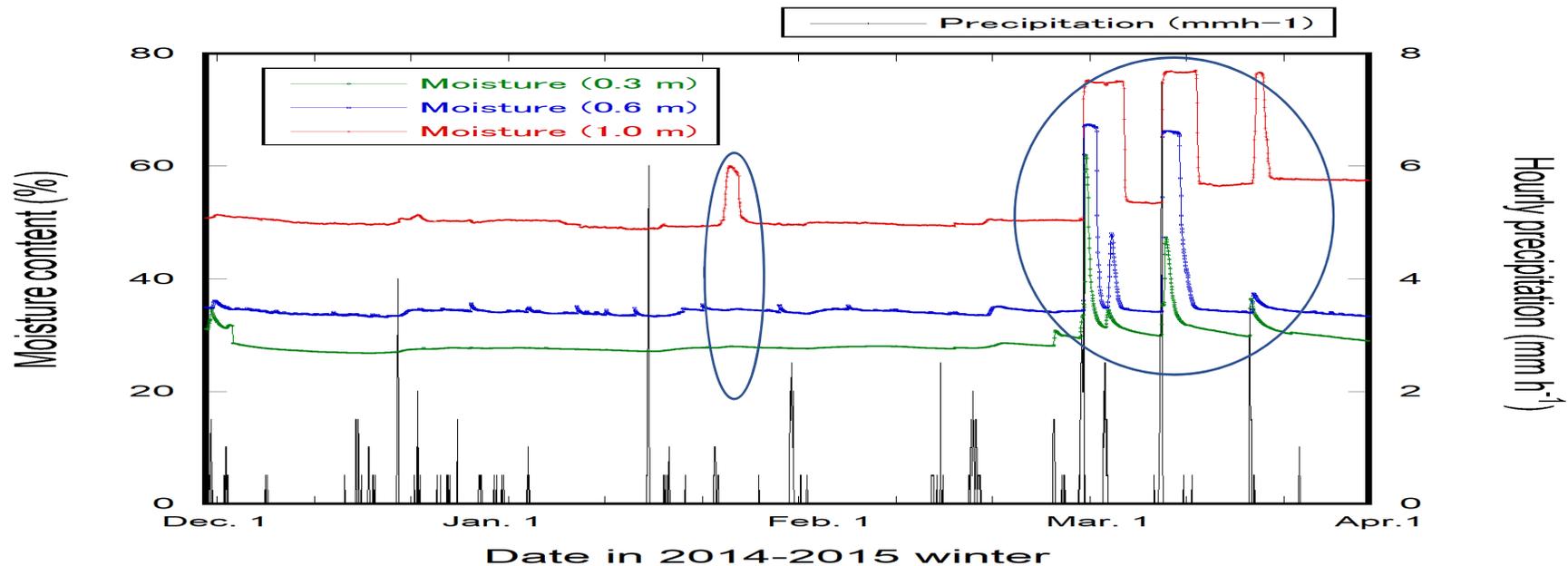
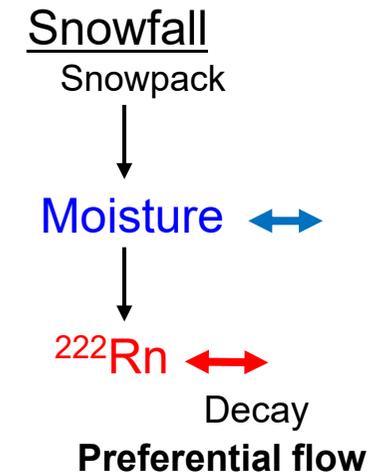
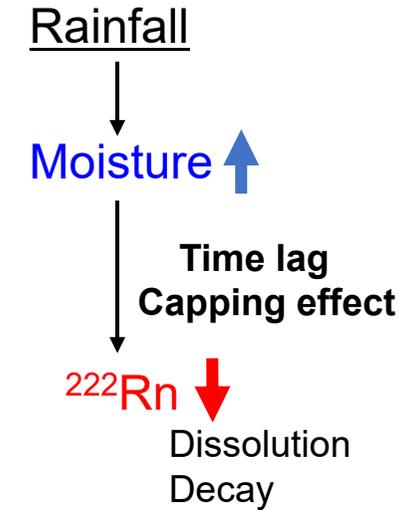
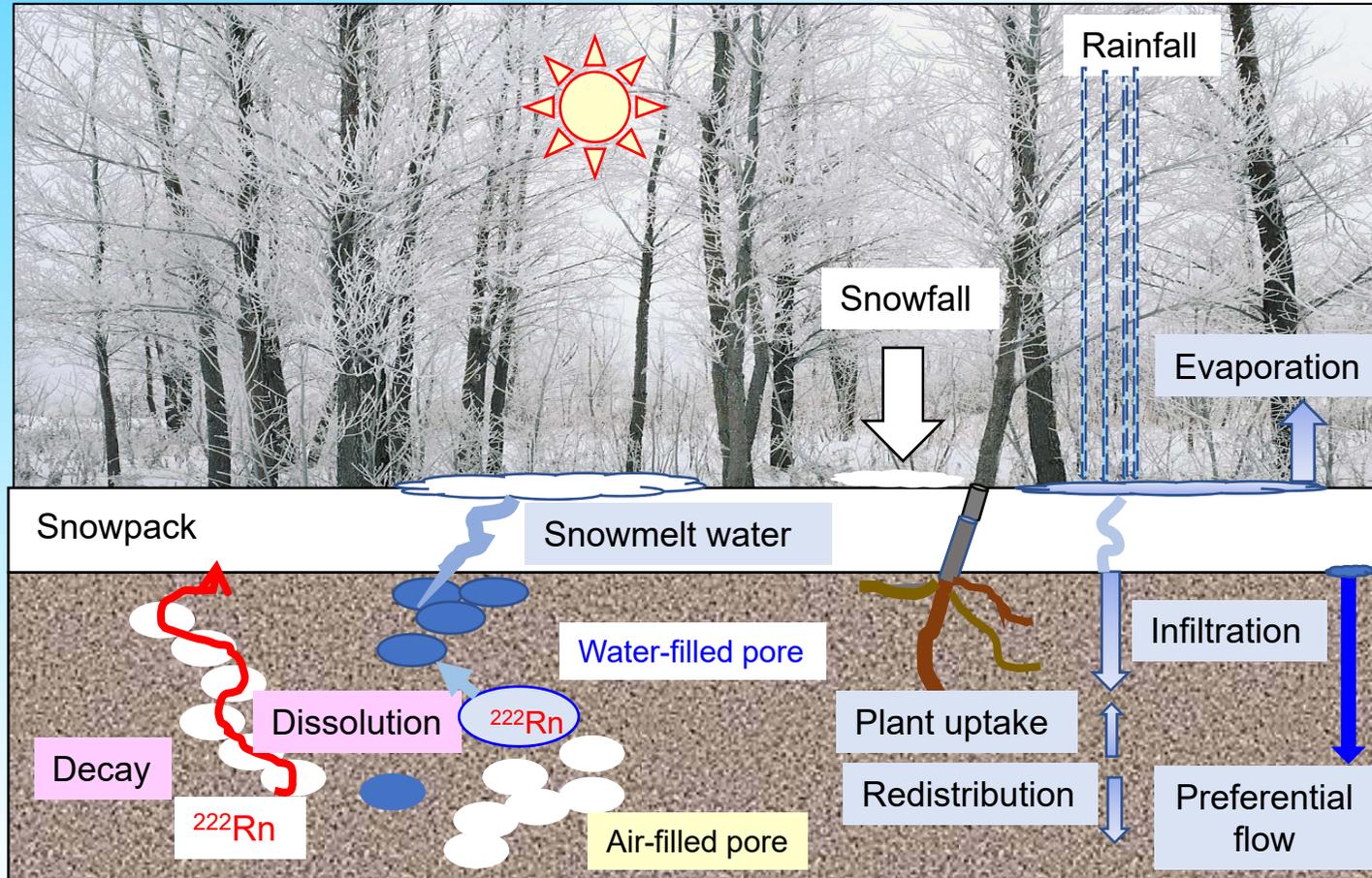


Fig. 1



# Dynamics of $^{222}\text{Rn}$ and moisture in soil in winter

Simultaneous monitoring of both  $^{222}\text{Rn}$  and moisture in soil at different depths provides information on their dynamic properties



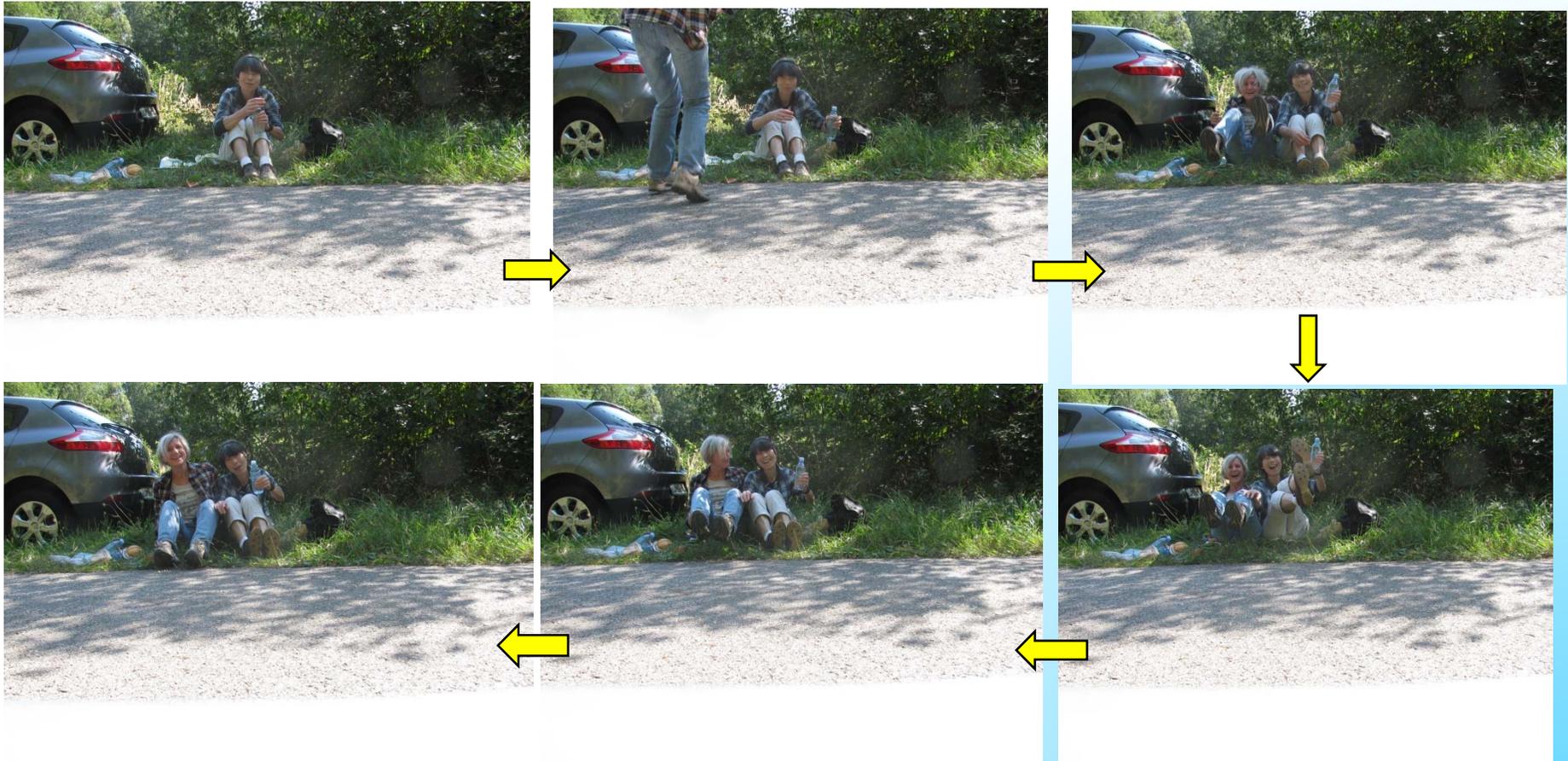
- Diffusivity, dissolution rate, lag time evaluation of  $^{222}\text{Rn}$
- Infiltration and evaporation rates of water in soil

## Concluding remarks

### Findings from soil $^{222}\text{Rn}$ investigation in northern part of Japan

- Diurnal and variability depending on meteorological parameters (temperature)
- Seasonal variability, i.e. lower level in winter (Sapporo, Fukushima), or higher level in winter (Tomakomai, many European countries)
- affected by precipitation over a critical level in intensity like typhoon events in Japan
- Importance of selecting reliable observation site (active faults) for investigating earthquake prediction, but still difficult at present
- Applicable of  $^{222}\text{Rn}$  as a tracer of transportation of gaseous components in soil with various environmental parameters including moisture
- Stable and radioisotopes, such as  $\text{CO}_2$  and its carbon isotopes are also useful for elucidating dynamics of soil

Great fun at lunch in the field (A forest site in Slovenia)



Thank you for your attention!

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