The 10th International Workshop on the Geological Aspects of Radon Risk Mapping

Some difficulties in soil radon monitoring for predicting earthquakes

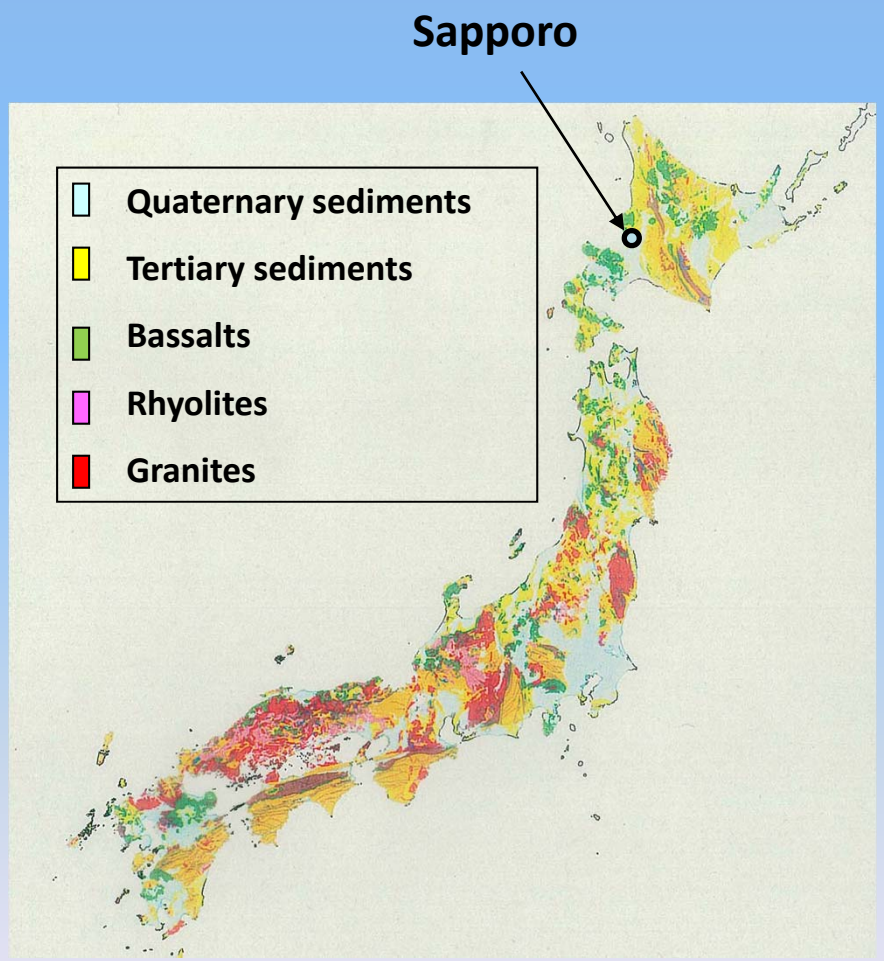
Ryoko FUJIYOSHI[1], Kazumasa OKAMOTO[1], Takashi SUMIYOSHI[1],
Ivan KOBAL[2], Janja VAUPOTIČ[2]

[1] Faculty of Engineering, Hokkaido University, Kita 13, Nishi 8, Sapporo, Hokkaido, Japan
[2] Radon Center, Jožef Stefan Institute, 1000 Ljubljana, Slovenia

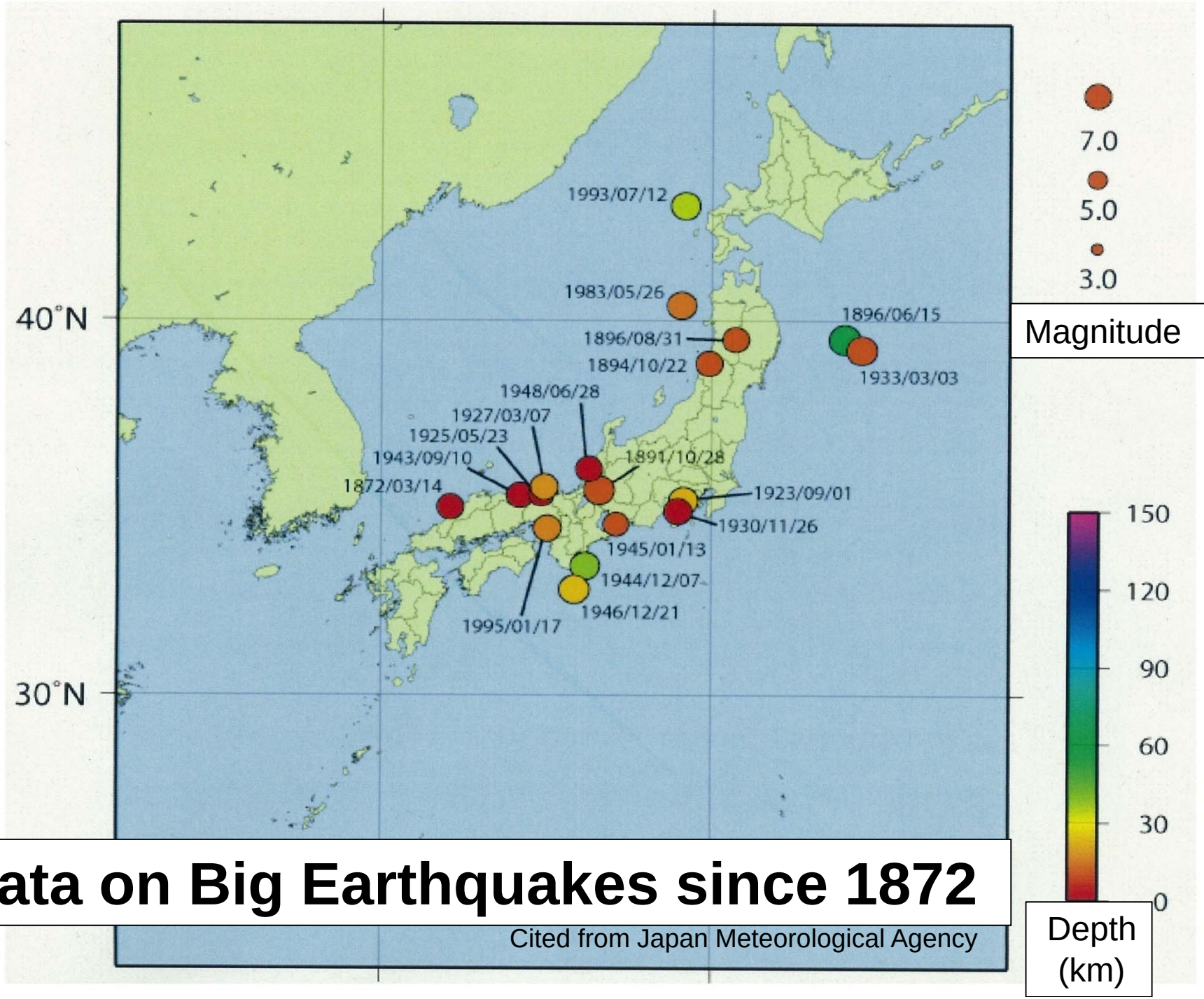
Where I'm from?? You may know now…

Sapporo City in Japan

Location: N43, E141
Altitude: 1.8-1,488 m a.s.l.
Mean temperature: 8.5 ℃
Mean precipitation: 1,100 mm
Population: 2 million



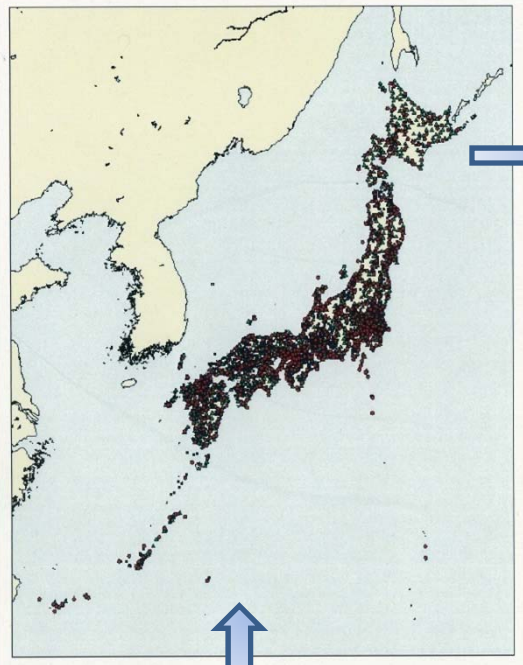
Surface Geologic map of the Japanese Islands



Data on Big Earthquakes since 1872

Cited from Japan Meteorological Agency

Earthquake observatories in Hokkaido Island



There are many seismological observatories in Japan
(cited from Japan Meteorological Agency)

Cited from Institute of Seismology & Volcanology, Hokkaido University

Sapporo

Mitsuishi

JMA & JAMSTIC
Hokkaido University
Hi-net

42°N
41°N
139°E
140°E
141°E
142°E
143°E
144°E
145°E
100 km

Geological and topographical view of Mitsuishi site

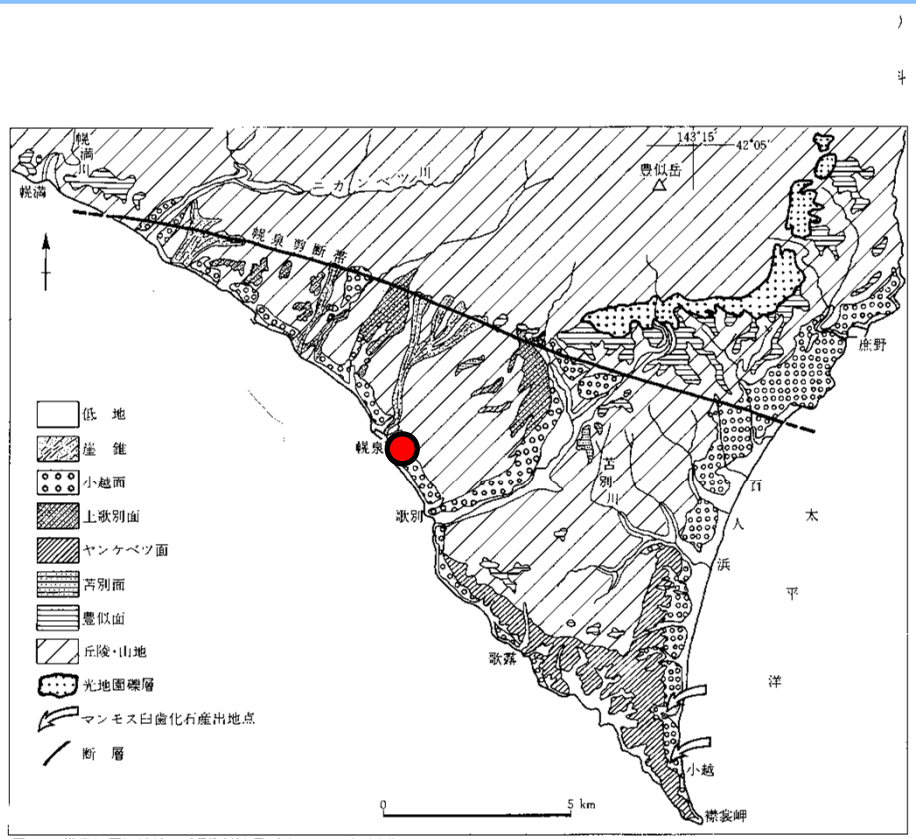
Regional Geology of Hokkaido, Part 1 Hokkaido, ed. M. Kato et al., (1990)

Location: Mitsuishi, Shinhidaka-cho in Hokkaido
(42.14’ N, 142.33’ E)

Length of the coastline: 58 km

Topography: Hilly site lower than
400 m in altitude
(Sea and river terraces)

Geology: Congromerates formed
during the last glacial period



Topographic map of Hidaka district

Methods

1. Measurement of ^{222}Rn activity concentration in soil air and in a drilled hole on the bedrock with a radon probe(**Barasol, Algade, France**). The probe has a battery powered solid state silicon detector, and also monitors temperature and barometric pressure every one hour with a data logger. Sensitivity: 0.02 pulses/h for 1 Bq/m^3.

2. Measurement of ^{222}Rn activity concentration in soil air with a Lucas cell and an alpha scintillation counter (**AB-5, Pylon, Canada**).

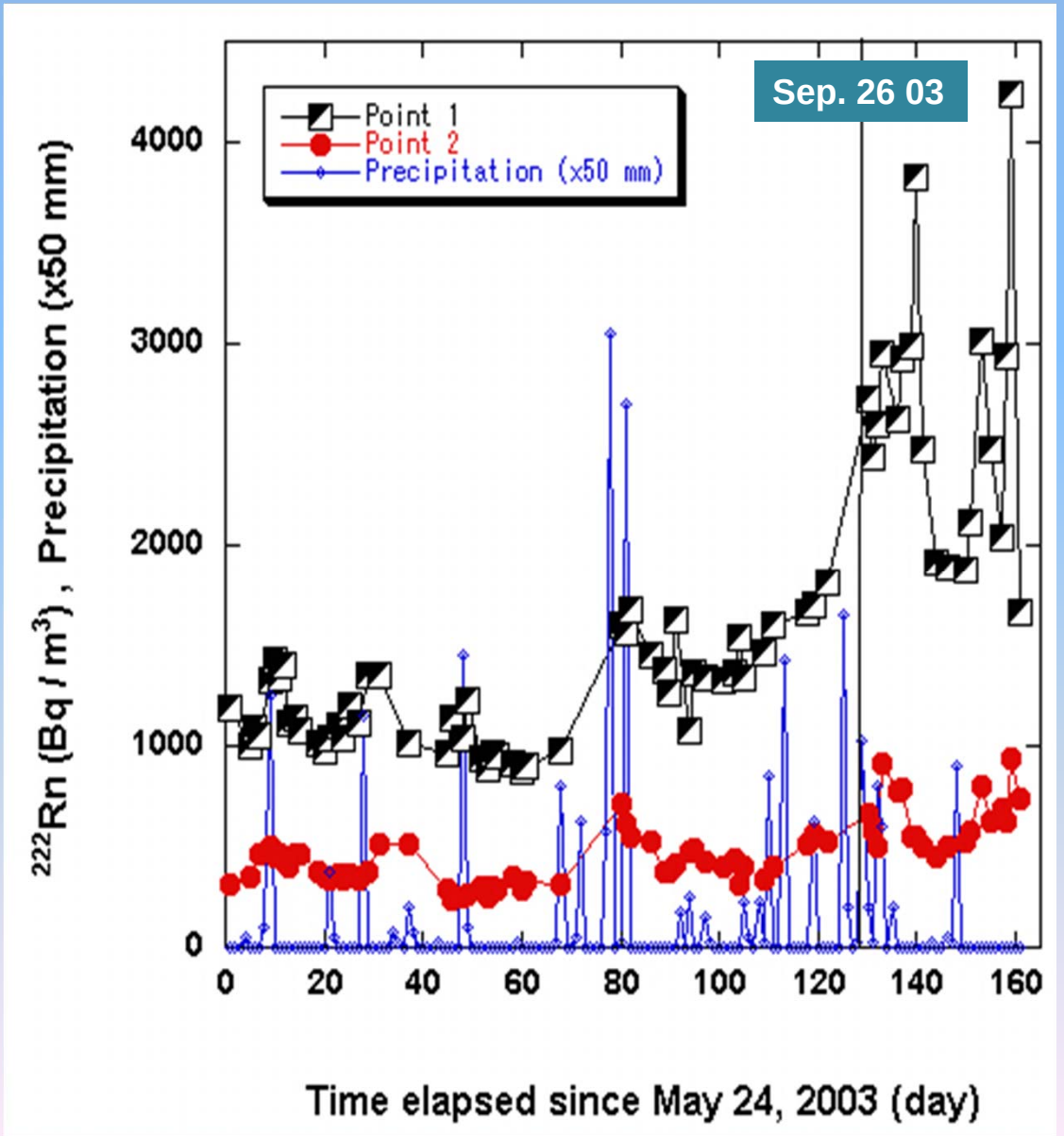
3. Monitoring barometric pressure just above the ground surface (**KADEC-U21, Kona System, Japan**).

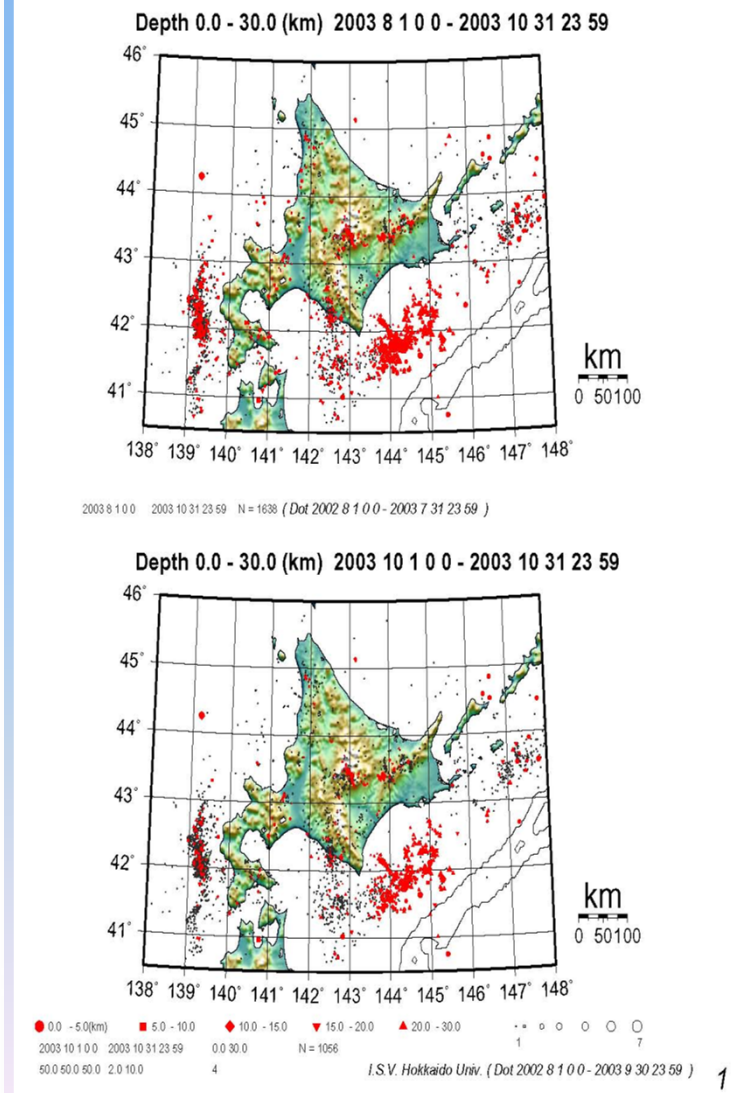
4. Monitoring soil humidity (**Profile Probe, Delta-T Devices, UK**).

5. Monitoring barometric pressure differences between underground and ground surface (**Kadec-U21, North One Co. Ltd., Japan**).

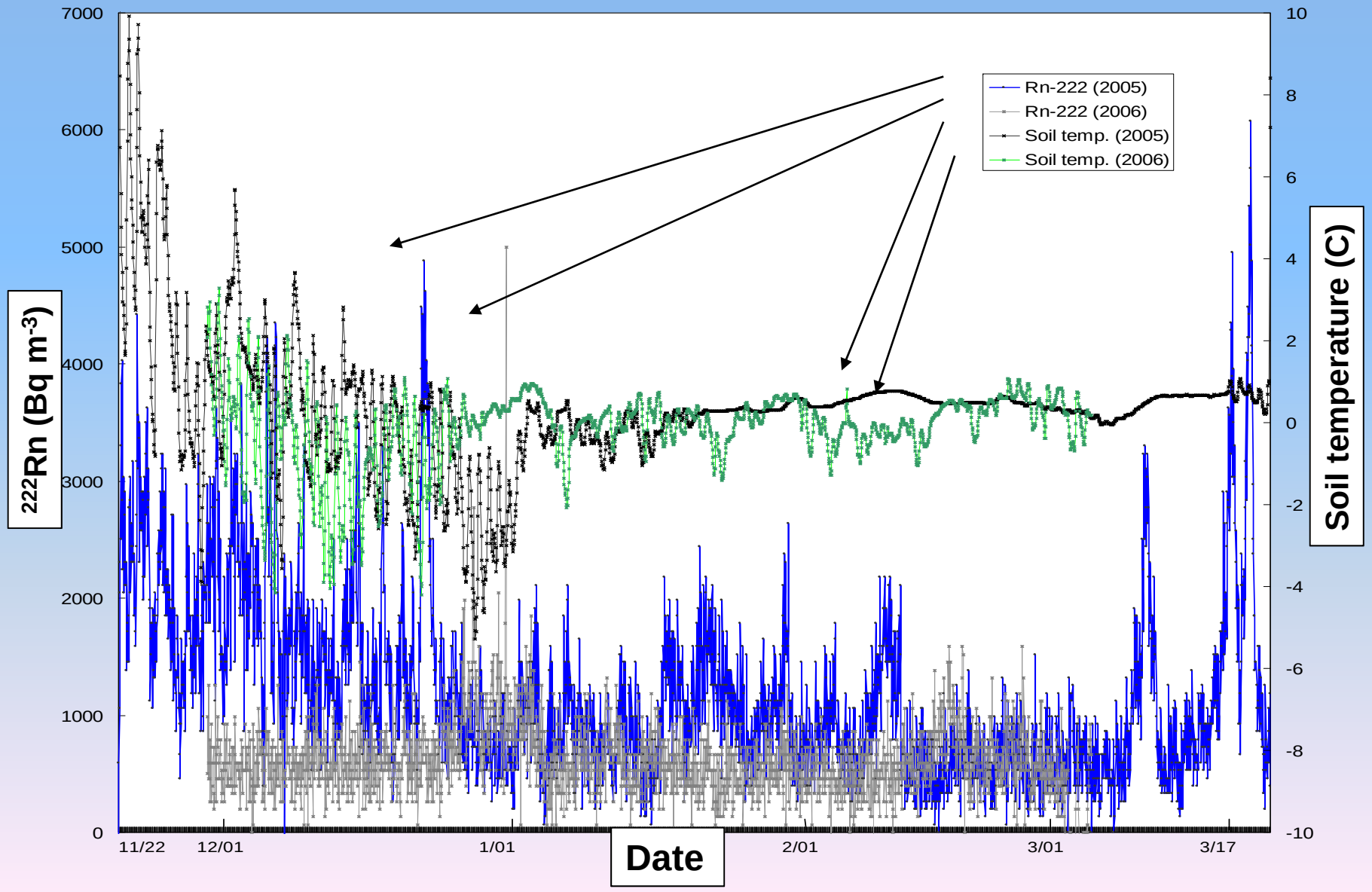
6. Periodical soil sampling for checking soil properties and measuring activity of several environmental radionuclides including ^{226}Ra.

Previous results obtained on the campus of Hokkaido University using a Lucas cell technique

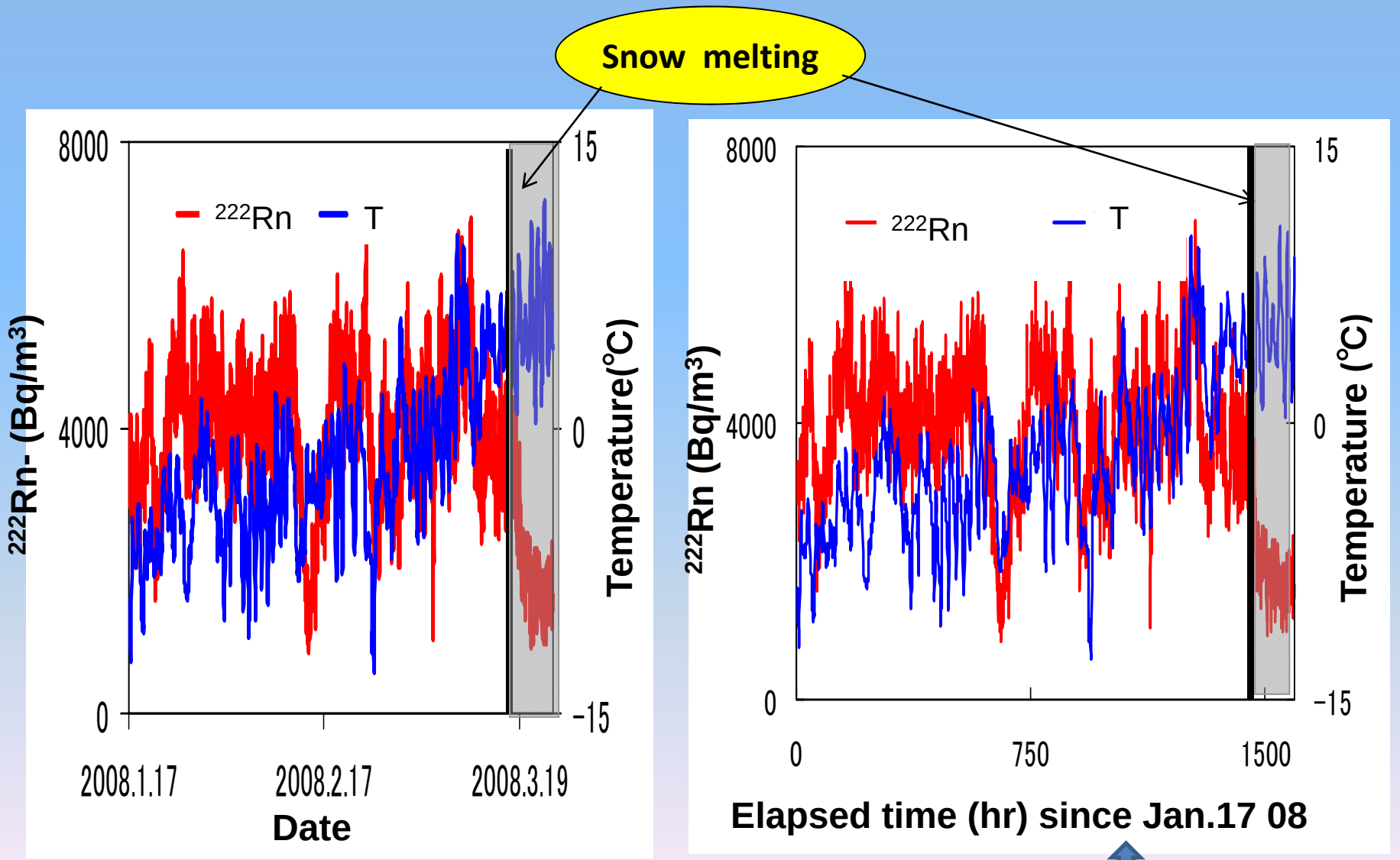




Previous result: Time-series plots of soil radon concentration and temperature at a depth of 10 and 30 cm during winter months in 2004-2005 and 2005-2006, respectively

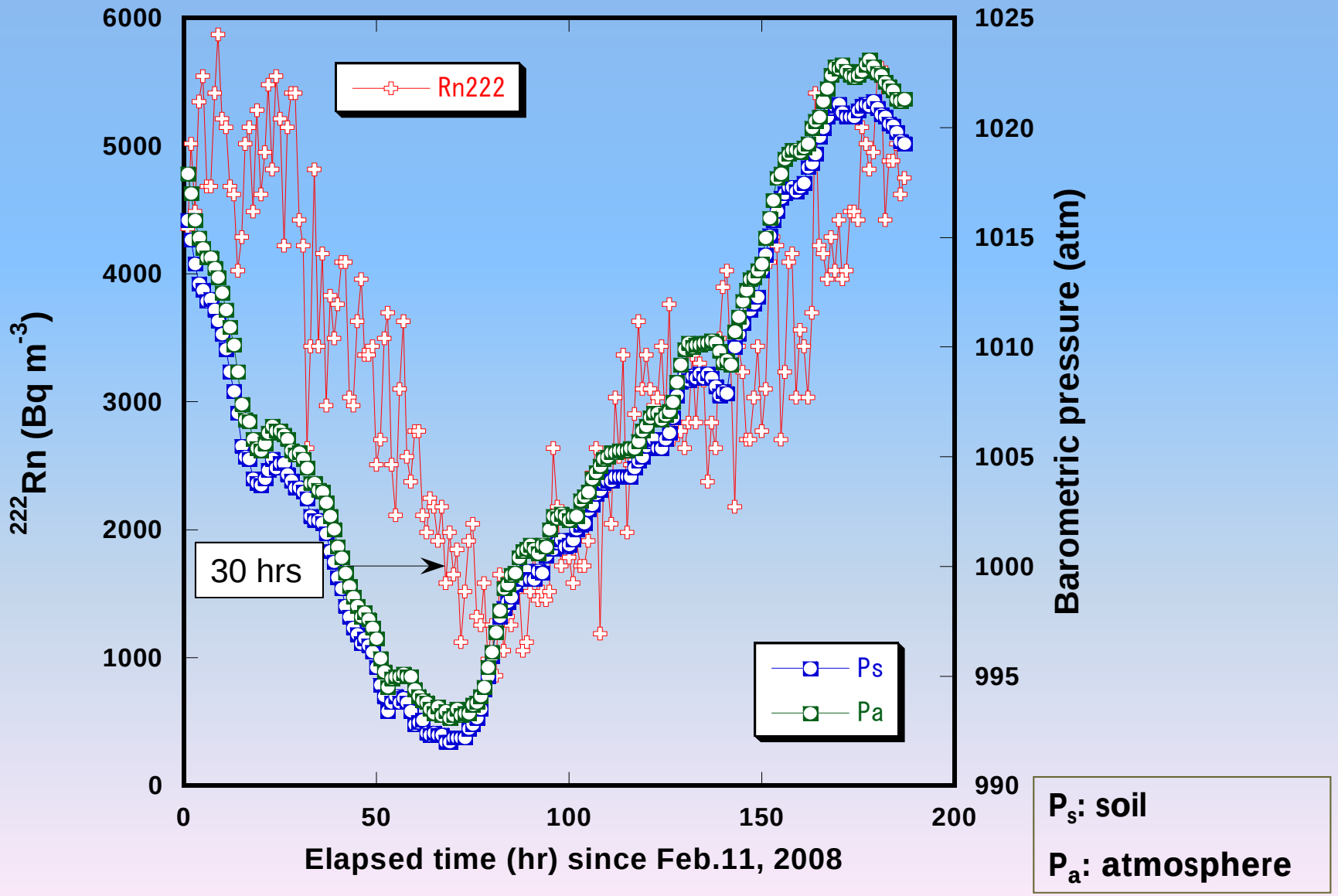


Time series plots of ^{222}Rn in soil air and atmospheric temperature in winter (Jan.17 – Mar.24 08)



Time lag of ^{222} Rn behind atmospheric temperature

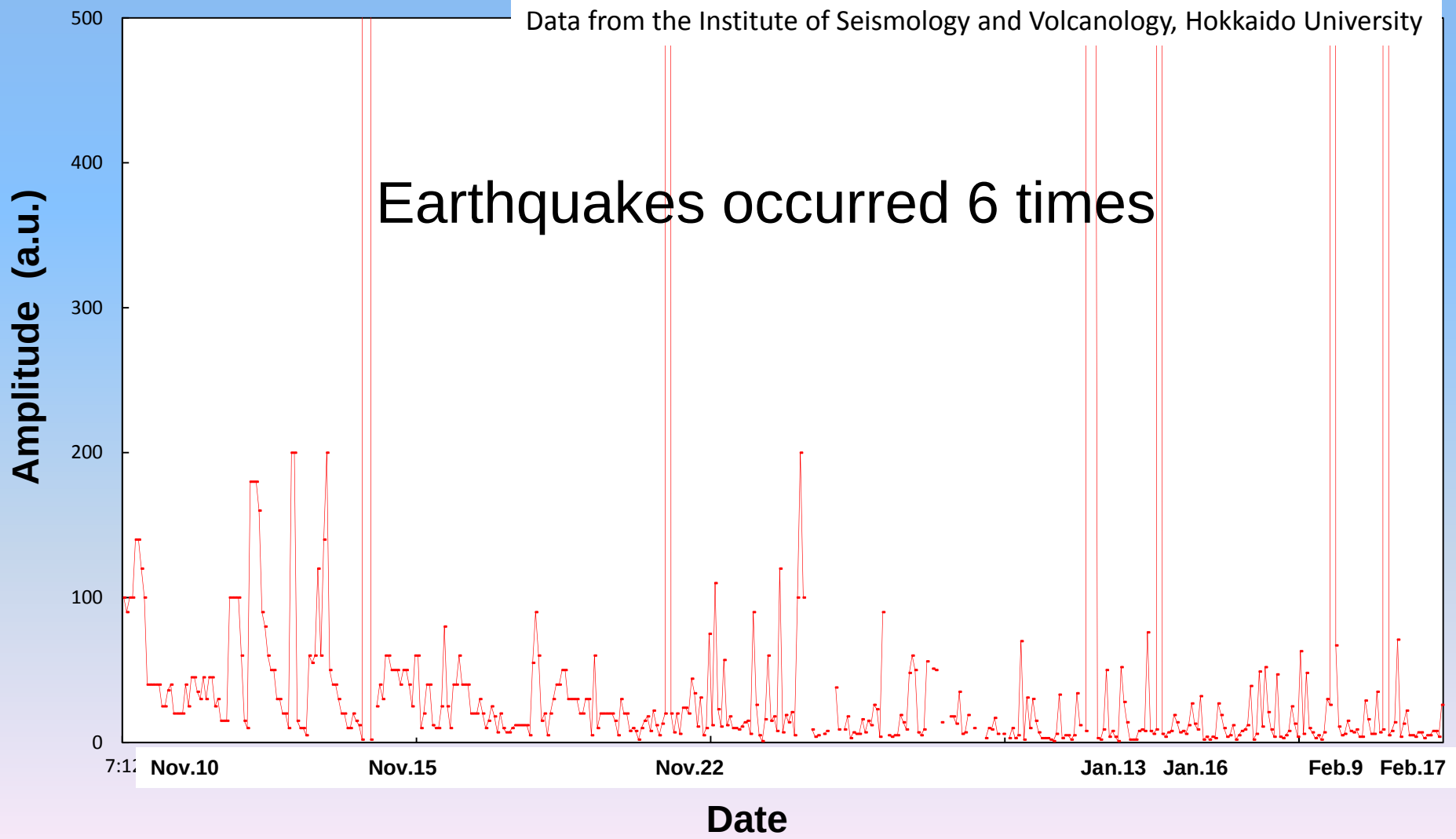
Change in ^{222}Rn activity concentration with barometric pressure in the atmosphere and in soil at a depth of 80 cm



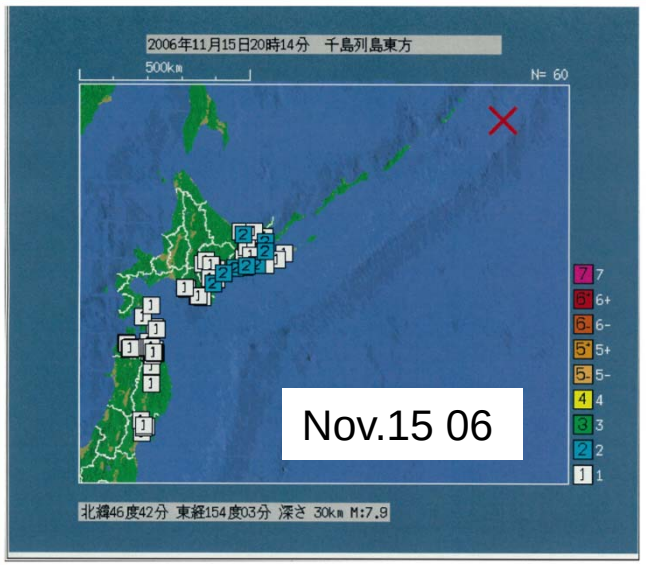
P_s: soil

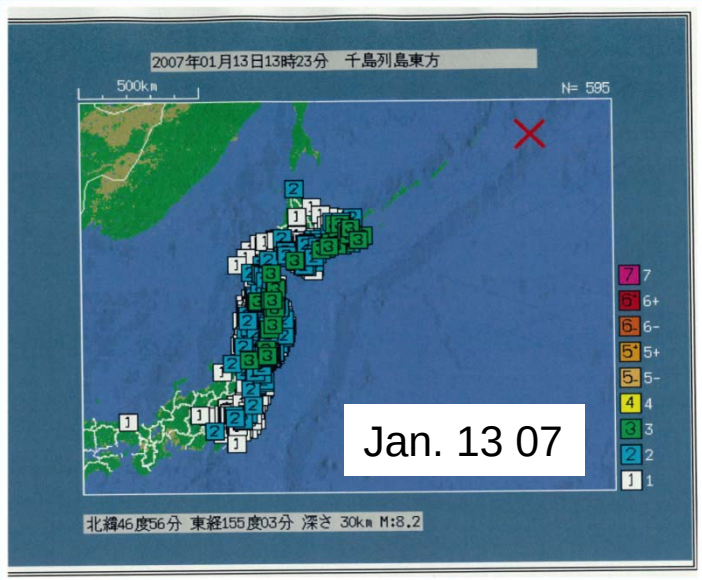
P_a: atmosphere

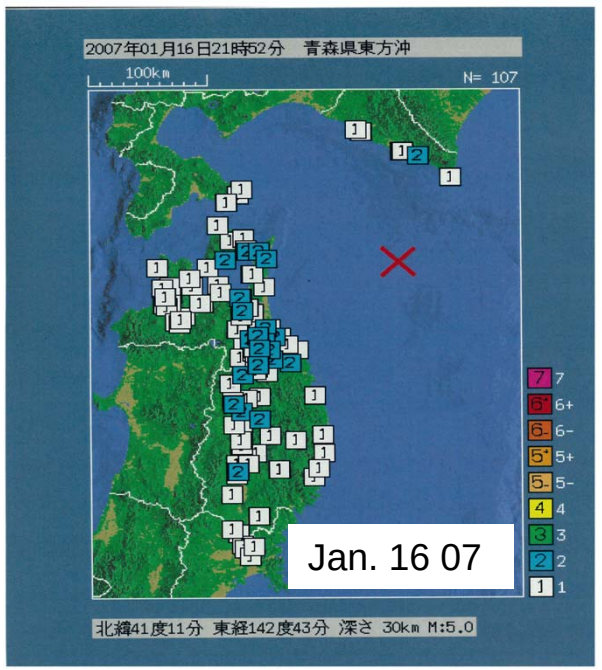
Time-series plots of wave amplitude detected by a seismometer installed at Mitsuishi Observatory (Nov. 2006 – Feb. 2007)

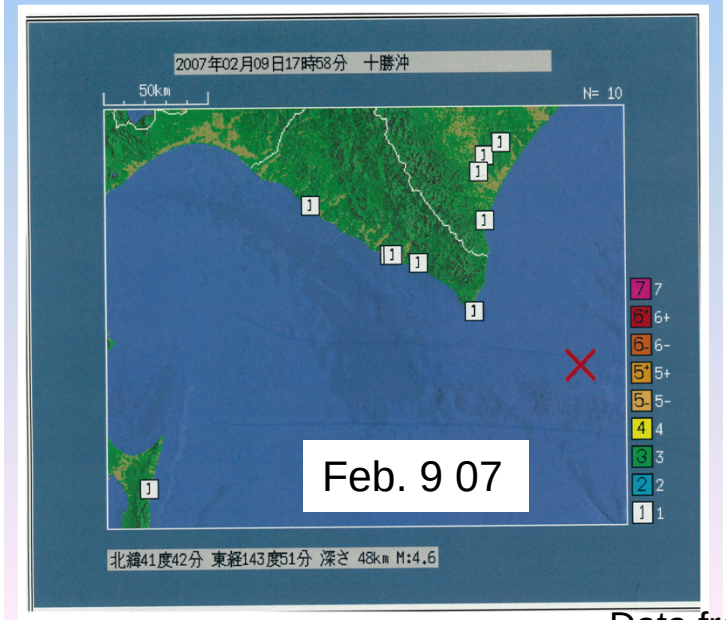


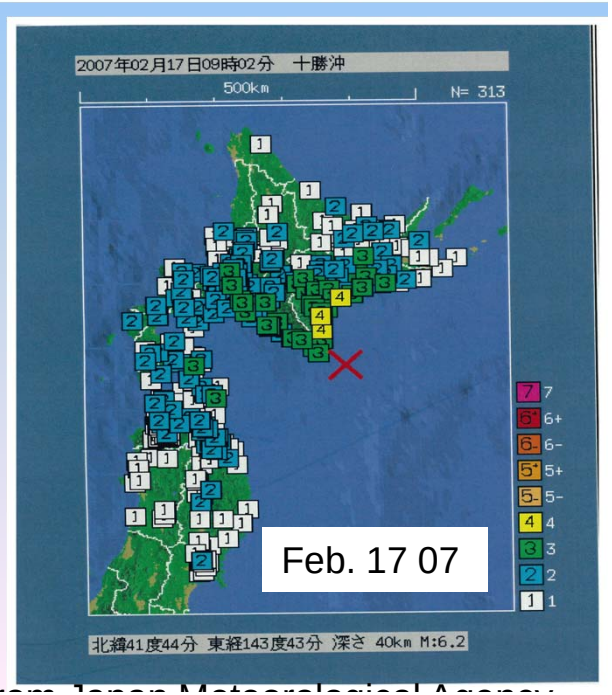
Epicenter and JMA seismic intensity scale of the earthquakes occurred in the observation period (Nov. 2006 – Feb. 2007)





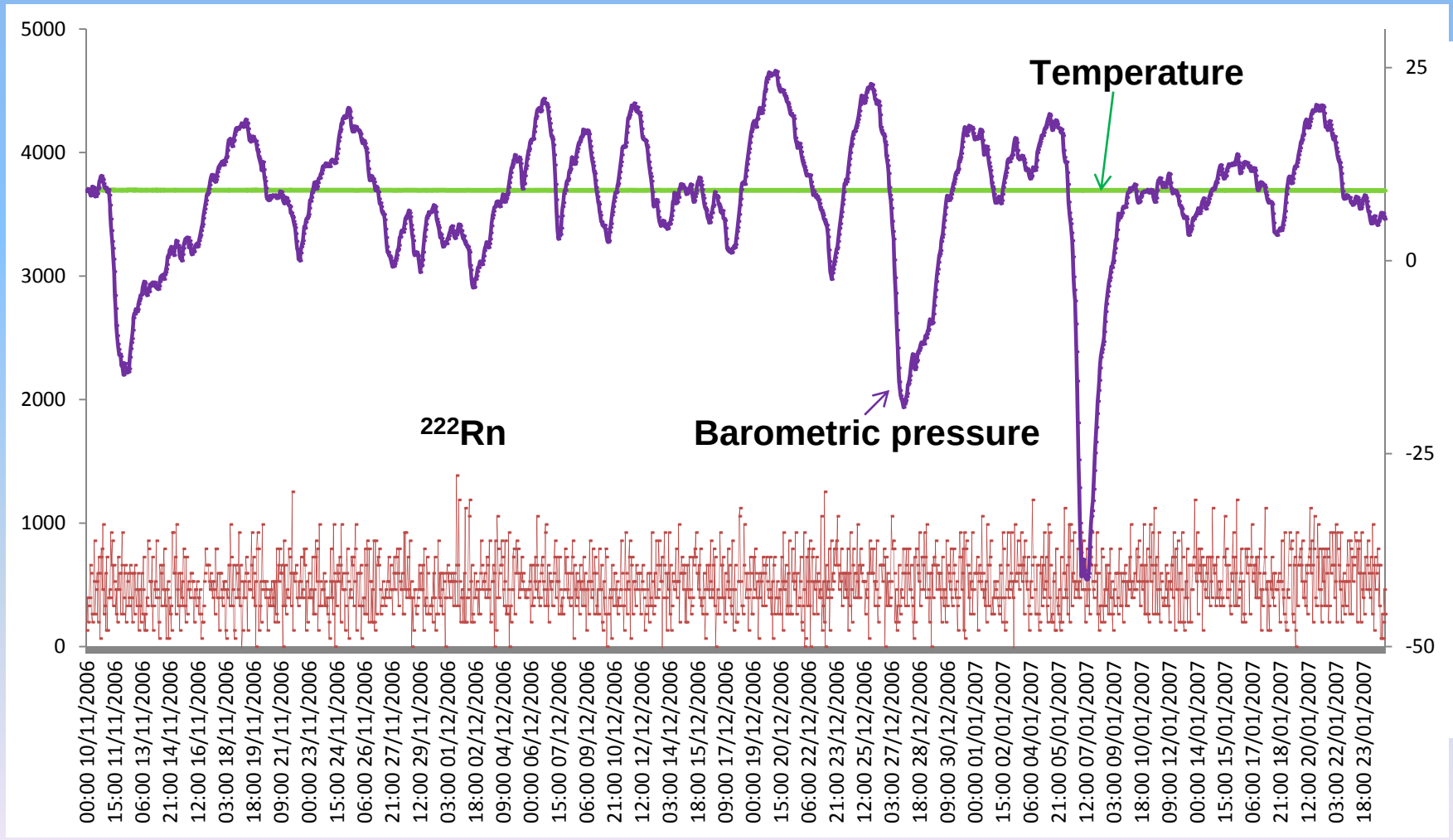






Data from Japan Meteorological Agency

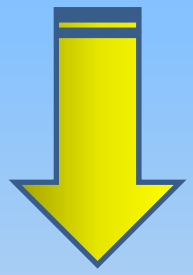
Time series plots of ^{222}Rn activity concentration, temperature and difference in barometric pressure in a hole of the wall of Mitsuishi observatory



Time and Date **(Nov 06 – Jan 07)**

Results at Mitsuishi observatory

High seismic activity with frequent ground motion ↔ Low ^{222}Rn concentration with little variability



Stable geologic environment?
(No cracks and fissures in the rock)

How ^{222}Rn is transported to a hole in the rock?
(Diffusion or advection)

Estimating diffusion-controlled distance of ^{222}Rn migration from the source

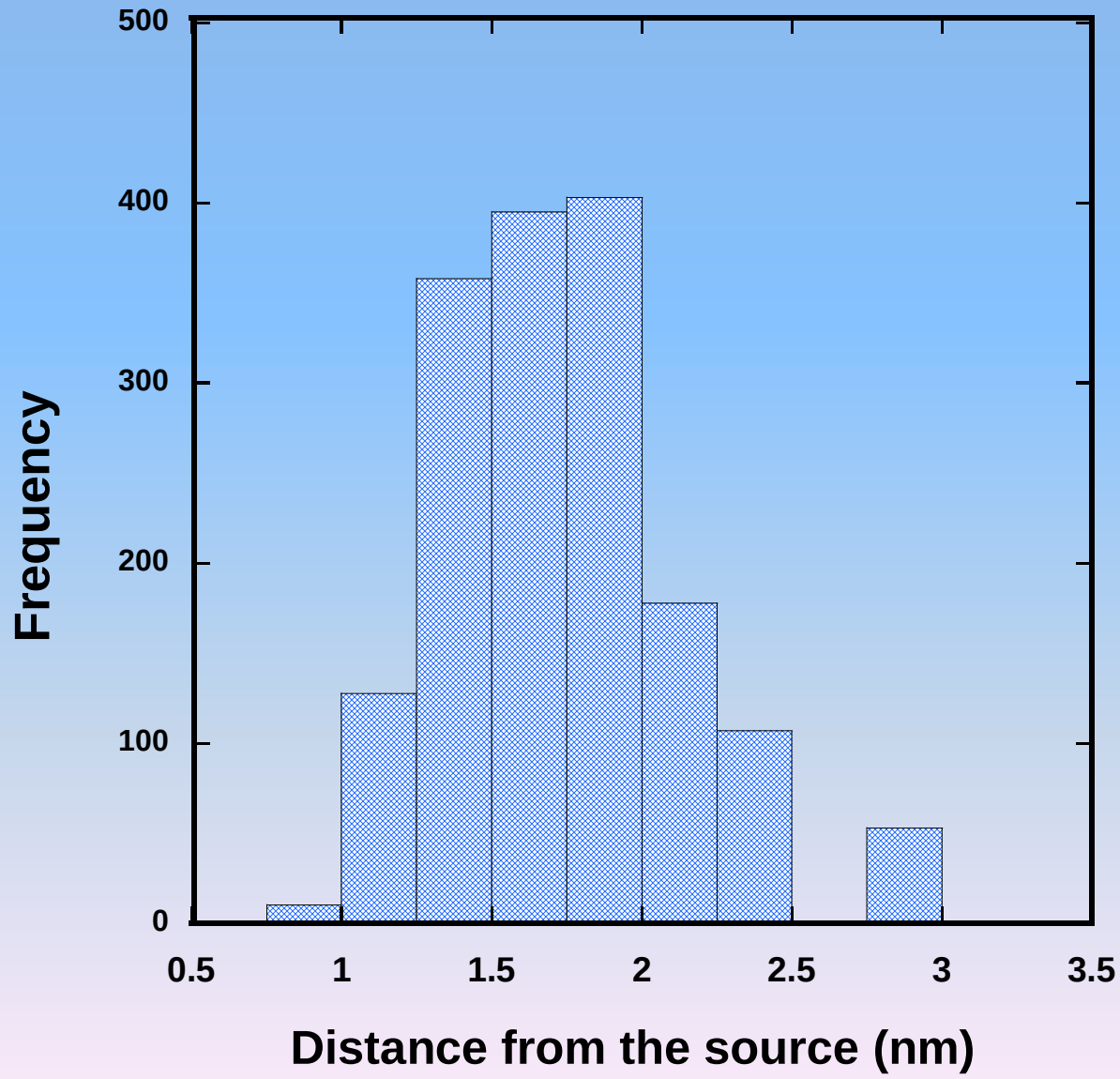
Postulates:

1. Variation of ^{222}Rn level is solely due to different distance for radon migrating form the source

2. Diffusion length of ^{222}Rn: 7.0×10^{-10} m

3. Initial ^{222}Rn activity concentration is estimated from emanation factor, mean activity concentration of ^{226}Ra and density of the rock.

Data: Mar- June 2007



Estimating distance by advective transport of ^{222}Rn from the source

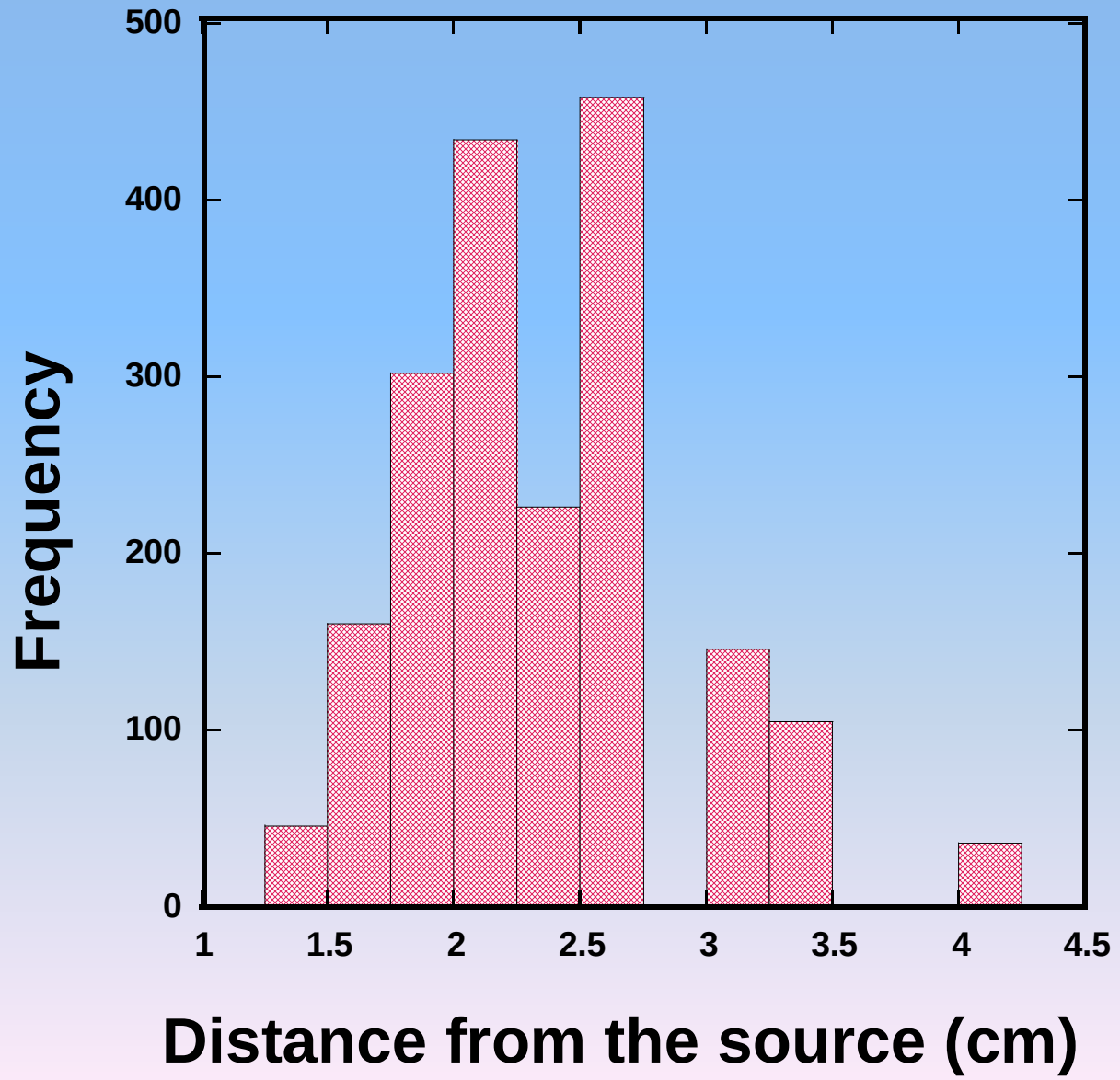
Postulates:

1. Variation of ^{222}Rn level is solely due to different distance for radon transported advectively by a gas carrier form the source

2. Velocity (v) of the carrier gas: 10^{-2} m s^{-1}

3. Initial ^{222}Rn activity concentration is estimated from emanation factor, mean activity concentration of ^{226}Ra and density of the rock.

Data: Mar-June 2007



Possibility of radon transport by carrier gas

- Pressure-driven continuous gas-phase flow through dry fractures

- Pressure-driven continuous gas-phase displacing water in saturated fractures

- Buoyancy of gas bubbles in aquifers and water-filled fractures

Difference in barometric pressure between both ends of the hole

Other gases including CO_2 as a carrier of radon

Summary

Monitoring of ^{222}Rn with multiple detectors at certain places for a long time may provide information on precursory phenomena of earthquakes.

Carrier gas dynamic analyses are inevitable to elucidate behavior of trace gas radon used as a tracer for earthquake prediction.


Thank you for sharing your time with me.
Ryoko Fujiyoshi
Mt. Yotei in Hokkaido, also called “Ezo Fuji “ covered with funny cloud