(T1.3-P3)

Atmospheric Transport Modelling for the Radionuclides Detection of Northeast Asia in 2010

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CTBT: SCIENCE AND TECHNOLOGY 2017 CONFERENCE
26 TO 30 JUNE
HOFBURG PALACE
VIENNA, AUSTRIA

Introduction

In May 2010, xenon and xenon daughter radionuclides were detected at four radionuclide measurements stations in South Korea, Japan, and the Russian Federation. Some scientists estimated that the detected radionuclides originated from mountain Mantop where underground nuclear tests have been performed, or the Yongbyon site in North Korea, where a small nuclear reactor is operated.

In this study, the source regions are estimated using an atmospheric dispersion model LADAS (Lagrangian Atmospheric Doses Assessment System)[1], which has been developed in South Korea. Simulations were first carried out to estimate the source area using the backward trajectory and atmospheric dispersion models based on four radionuclide measurements stations. From the simulations, the possible source regions are estimated in north east areas of North Korea.

Radionuclide Measurement in 2010 Event

Between 13 and 23 May 2010, four atmospheric radionuclide surveillance stations, in South Korea, Japan, and the Russian Federation, detected xenon and xenon daughter radionuclides in concentrations up to 10 and 0.1 mBq/m3 respectively[2].

Table 1. Xenon and barium isotopes detected at Geojin, Takasaki, Okinawa and Ussuriysk in May 2010[2]

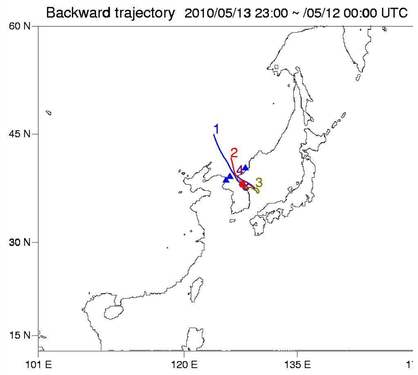
Station	Collection start UTC	Collection stop UTC	^{131m}Xe mBq/m^3	^{133m}Xe mBq/m^3	^{133}Xe mBq/m^3	^{135}Xe mBq/m^3	^{140}Ba μBq/m^3
Geojin	13 May *11:00*	13 May *23:00*	*<0.2*	*<0.2*	*2.45 ± 0.2*	*10.01 ± 0.6*	
Takasaki	15 May 06:46	15 May 18:46	<0.02	<0.06	<0.10	<0.61	
Takasaki	15 May 18:46	16 May 06:46	0.04 ± 0.03	<0.09	0.16 ± 0.07	<0.57	
Takasaki	16 May 06:46	16 May 18:46	0.05 ± 0.03	<0.08	0.23 ± 0.06	<0.47	
Takasaki	16 May 18:46	17 May 06:46	0.16 ± 0.07	<0.09	1.49 ± 0.11	<0.20	
Takasaki	17 May 06:46	17 May 18:46	<0.04	<0.05	0.52 ± 0.07	<0.06	
Takasaki	17 May 18:46	18 May 06:46	<0.11	0.10 ± 0.06	0.79 ± 0.09	<0.58	
Takasaki	18 May 06:46	18 May 18:46	0.06 ± 0.03	<0.02	<0.10	0.42 ± 0.23	
Takasaki	18 May 18:46	19 May 06:46	<0.07	<0.05	0.18 ± 0.06	<0.52	
Okinawa	15 May 00:23	16 May 00:23					81.9 ± 3.6
Okinawa	16 May 00:23	17 May 00:23					22.7 ± 2.2
Okinawa	17 May 00:23	18 May 00:23					27.5 ± 2.2
Okinawa	18 May 00:23	19 May 00:23					28.1 ± 2.3
Okinawa	19 May 00:23	20 May 00:23					50.8 ± 2.9
Okinawa	20 May 00:23	21 May 00:23					43.8 ± 2.8
Okinawa	21 May 00:23	22 May 00:23					5.2 ± 1.6
Okinawa	22 May 00:23	23 May 00:23					5.0 ± 1.5
Ussuriysk	15 May 01:44	16 May 01:44					4.1 ± 1.4
Ussuriysk	16 May 01:44	17 May 01:40					<15
Ussuriysk	17 May 01:40	18 May 01:40					12.2 ± 2.3
Ussuriysk	18 May 03:44	19 May 01:49					5.3 ± 1.6

Simulation of Backward Trajectory and Dispersion

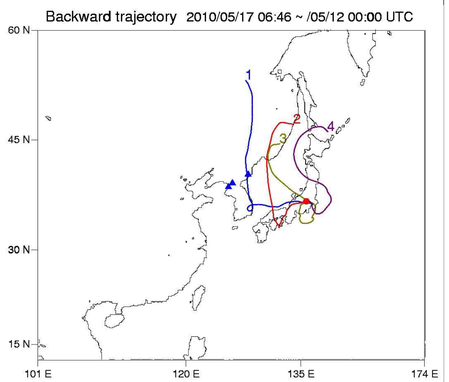
By using the backward trajectory and dispersion models[1,3], we estimated the possible source regions based on measurements at Geojin, Takasaki, Ussuriysk and Okinawa in May 2010. Backward trajectories started from Geojin and Ussuriysk and Okinawa were toward northwest such as Yongbyon and Hagab in North Korea, however some trajectories started from Takasaki were toward a Mantop where underground nuclear tests have been performed.

There are some uncertainties and errors when the trajectory model is employed alone to estimate the release point or area using the measured radionuclides data at monitoring stations. A backward atmospheric dispersion model was applied to improve the accuracy of the detective technology to find the emission area of radionuclides.

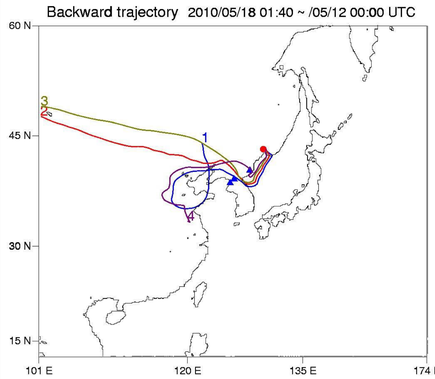
Calculated Backward Trajectories



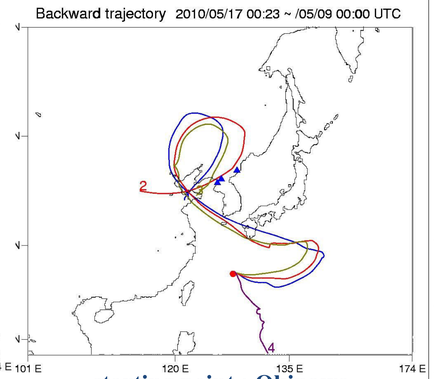
starting point : Geojin



starting point : Takasaki



starting point : Ussuriysk



starting point : Okinawa

Fig 1. Calculated backward trajectories started from Geojin, Takasaki, Ussuriysk and Okinawa in May 2010.

Calculated Backward Dispersions

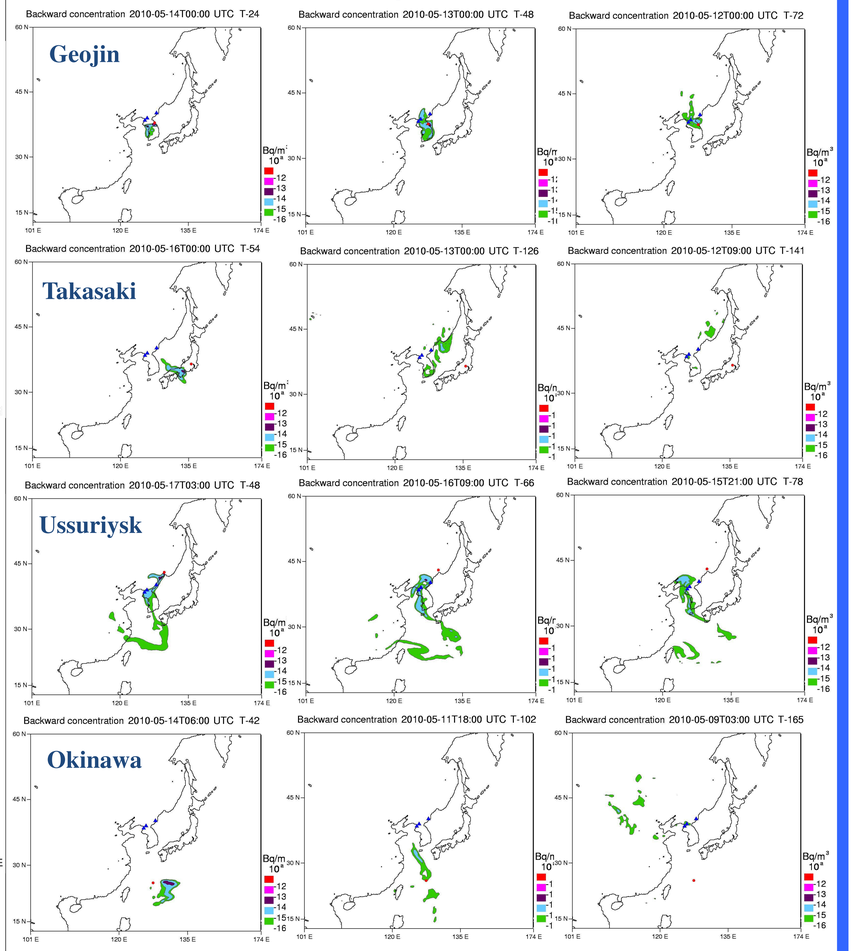


Fig 2. Calculated backward atmospheric dispersion patterns started from Geojin, Takasaki, Ussuriysk and Okinawa in May 2010.

Concluding Remarks

A three-dimensional trajectory and atmospheric dispersion models were applied to estimate a possible source region in 2010 event. Calculated backward trajectories have some uncertainties according to the starting time and release height. An atmospheric dispersion model was applied to reduce the uncertainties of the trajectory model and to improve the detective technology for estimating the radioisotopes emission area.

From 2010 event, the possible source region of radio xenon was inferred at Yongbyon or Hagab in North Korea. That event was inferred with a small laboratory experiment, not nuclear test. Because it didn't detect any seismic signal and the total release amount of xenon was a little small.

Even though there are some uncertainties in estimating unknown source areas owing to the lack of measurement stations, forward and backward atmopheric transport models can be a good tool to detect possible release regions from the covert nuclear activities near Northeast Asia.

References

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Acknowledgement

This research was supported by the National Research Foundation of Korea (NRF) and Nuclear Safety Research Program through the Korea Foundation of Nuclear Safety (KOFONS) Grant funded by the Korea government (MSIP: NRF-2012M2A8A4025912, NRF-2015M2A2B2034282). Also, this research was supported by a Grant [MPSS-NH-2015-81] through the Disaster and Safety Management Institute funded by Ministry of Public Safety and Security of Korean government.