대기 방사선 피폭해석 시스템(LADAS) 연구 현황

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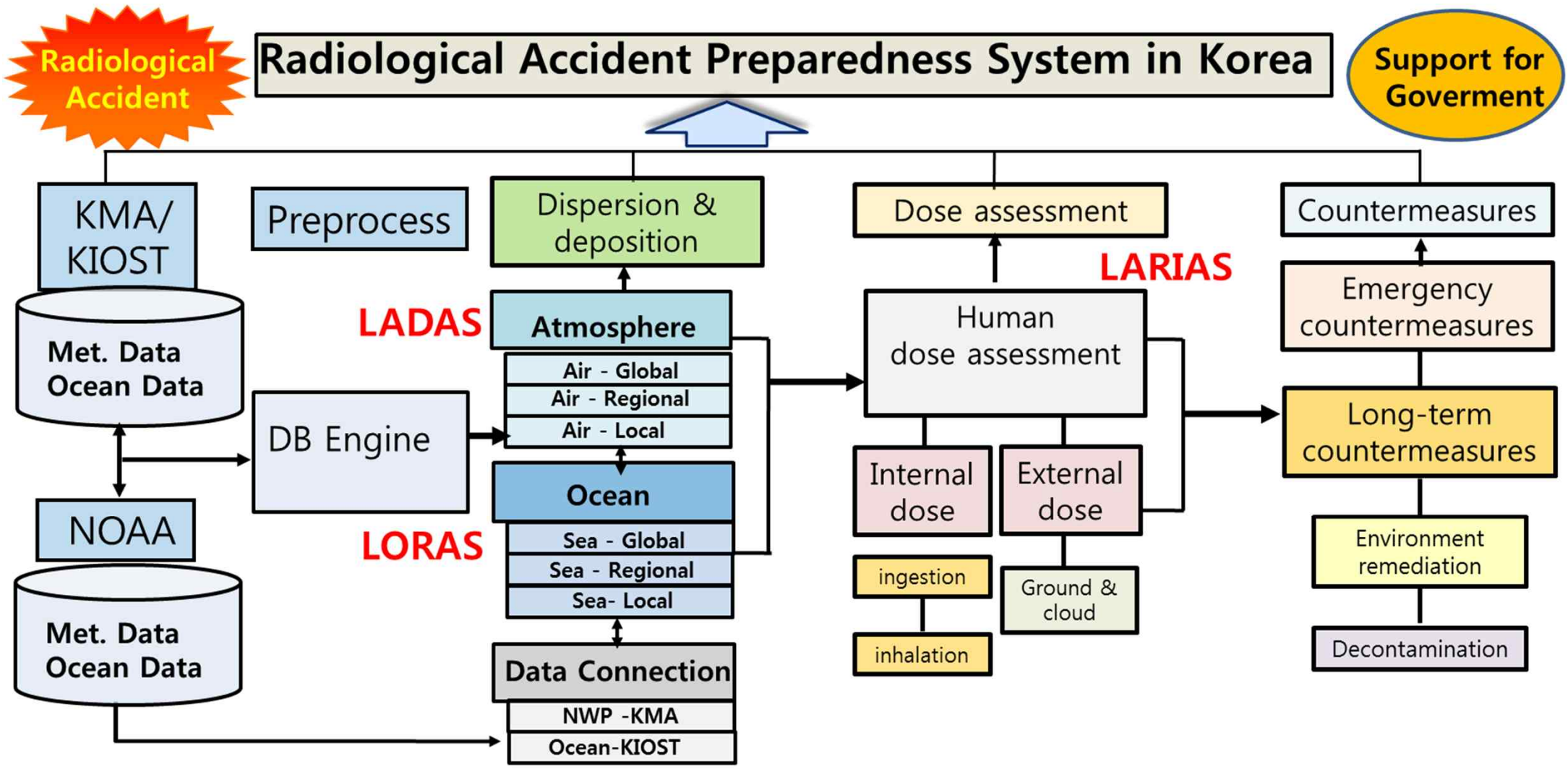
Introduction

- The environmental and health effects by the transport and diffusion of pollutants released into the atmosphere and ocean due to a nuclear accident must be evaluated rapidly and accurately for the safety of the surrounding population and ecosystem.
- It is necessary to develop atmospheric and marine dispersion models for a radiological emergency preparedness against a nuclear accident
- RAPS-K (Radiological Accident Preparedness System in Korea) has been developed to predict the atmospheric/marine dispersion of radionuclides and the following dose for a nuclear emergency
  - LADAS : atmospheric dispersion model
  - LORAS : marine dispersion model
  - LARIAS : dose assessment model
- This system is now operating on Web GUI based on Linux OS and to link with real-time weather and ocean data from KMA and KIOST
- Developed systems will be open about the end of October 2019.

General Description of RAPS-K



Overview of LADAS

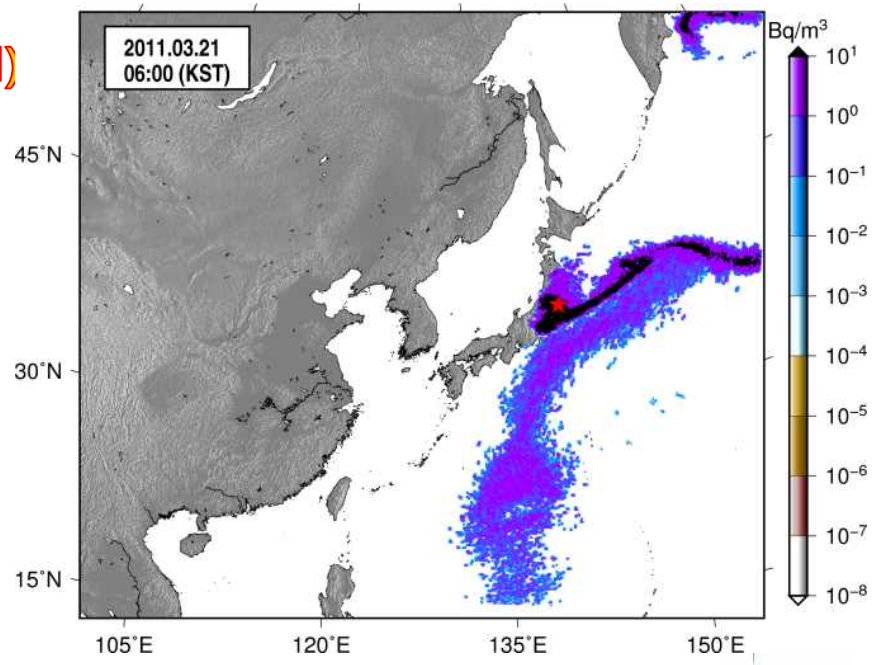
LADAS (Lagrangian Atmospheric Dose Assessment System)

Atmospheric dispersion evaluation system for nuclear accident

- Local, Northeast Asian region and Global in computational domain
- Three-dimensional Lagrangian particle tracking model
- Output : air, dry and wet deposited concentrations in time and space
- Output : external dose, internal dose due to inhalation,
  external dose due to groundshine on surface
- Preprocess module : connected to numerical weather forecast data from KMA

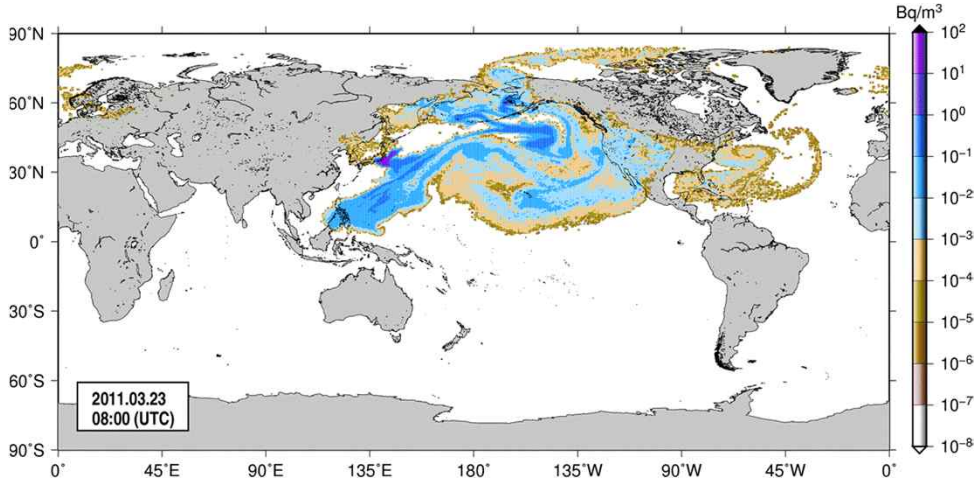
Completion of development and validation in 2006 (KAERI)

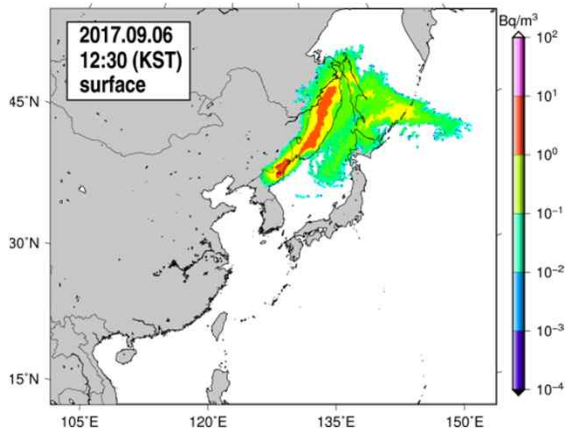
- Validation using ETEX data in Europe
- Validation using Chernobyl data
- Inter-comparison study of ATMES project
- Join and validation of ENSEMBLE project
- Join IAEA/MODARIA project

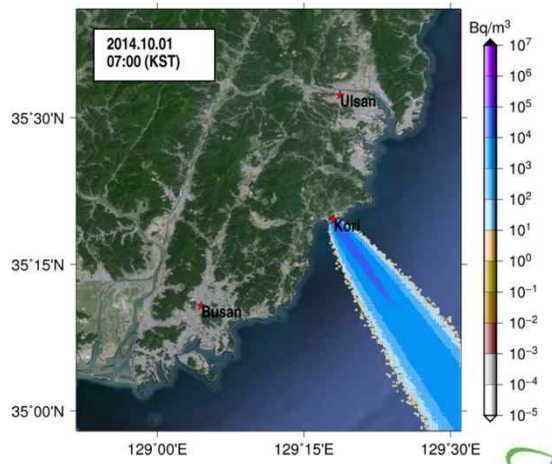


Computational Domain of LADAS

Domain	Area	Horizontal	Vertical	NWP data	Remark	Develop
Global	World	0 ~ 360 E 90 S ~ 90 N	~ 30 km	KMA, NOAA, ECMWF	Polar coord. Cyclic B.C.	2015
Regional	North-East	100 ~ 175 E 12 ~ 54 N	~ 20 km	KMA	Open B.C.	2006
Local	Korea	Radius 40 km	~ 1,2 km	KMA, KAERI model	PG stability	2015







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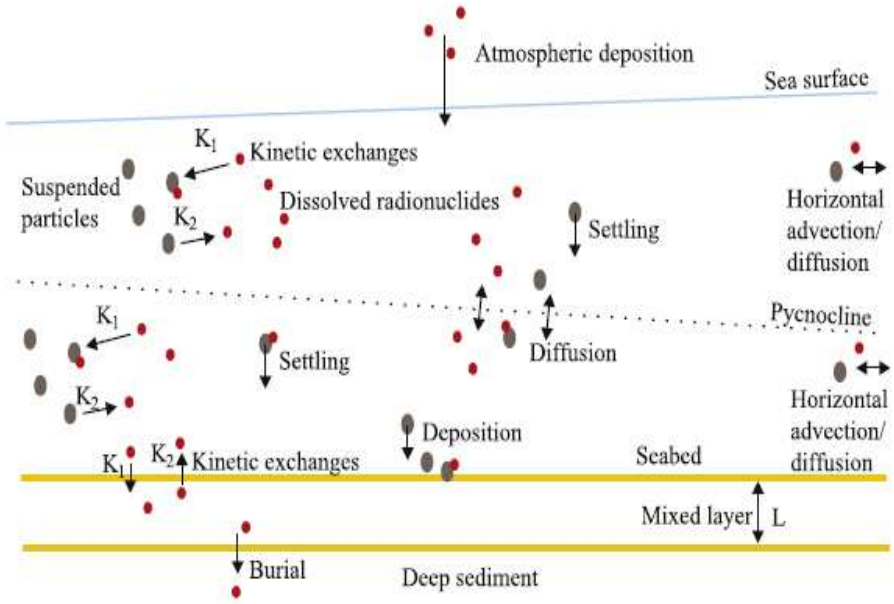
Overview of LORAS

LORAS (Lagrangian Oceanic Radiological Assessment System)

- Three-dimensional Lagrangian particle tracking model for non-conservative materials
- Local, regional and global regions
- Output : dissolved, suspended and bottom sediment concentrations in time and space
- Preprocess module to connect circulation data from KIOST, HYCOM, JCOPE2 and our own tidal data

Validation and Application

- Validation using World monitoring data for **Fukushima**
- Validation using Other models in IAEA/MODARIA
- Establishment of LORAS system including Yellow, South and East Sea near Korea
- Establishment of LORAS system with MPI for emergency preparedness



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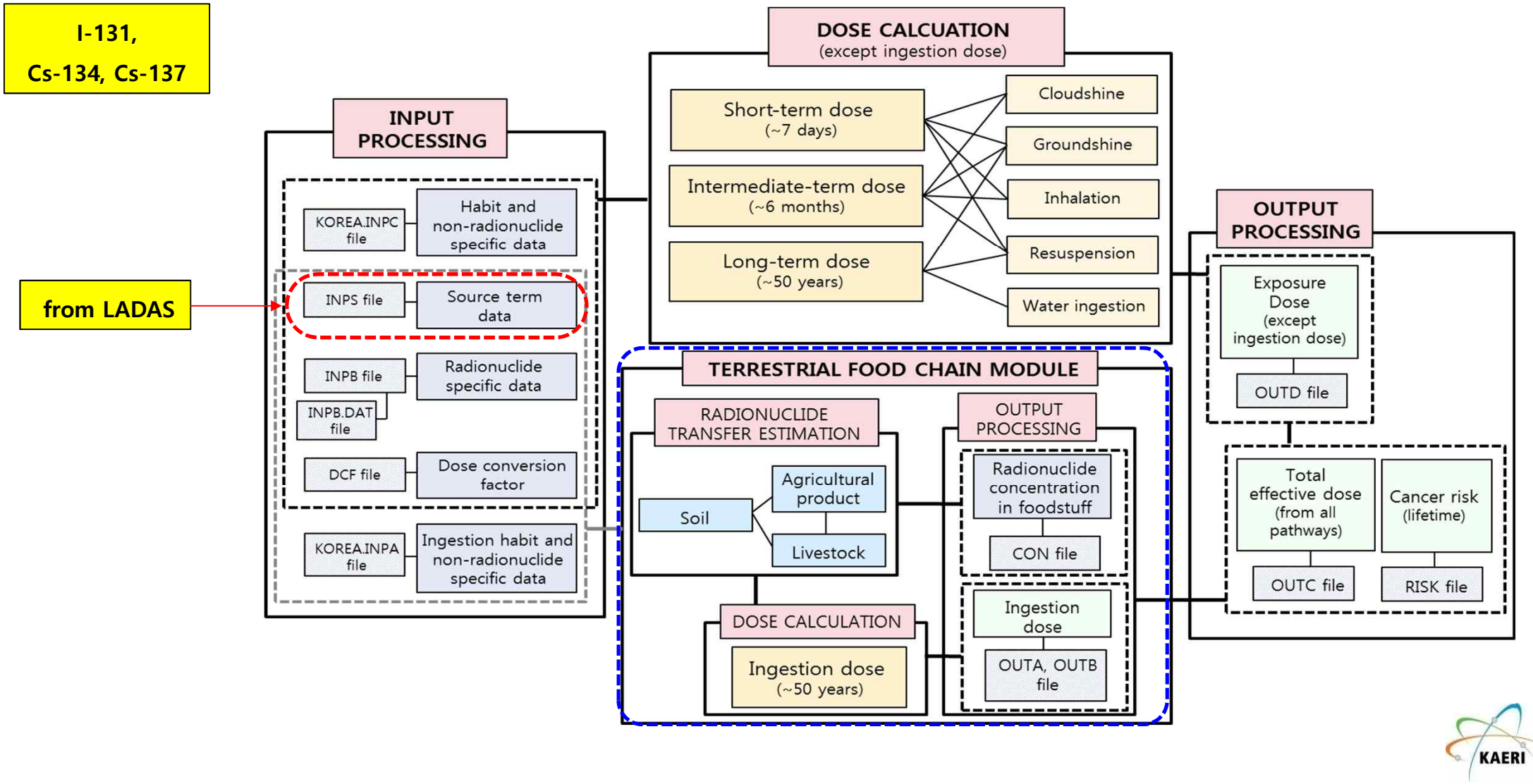
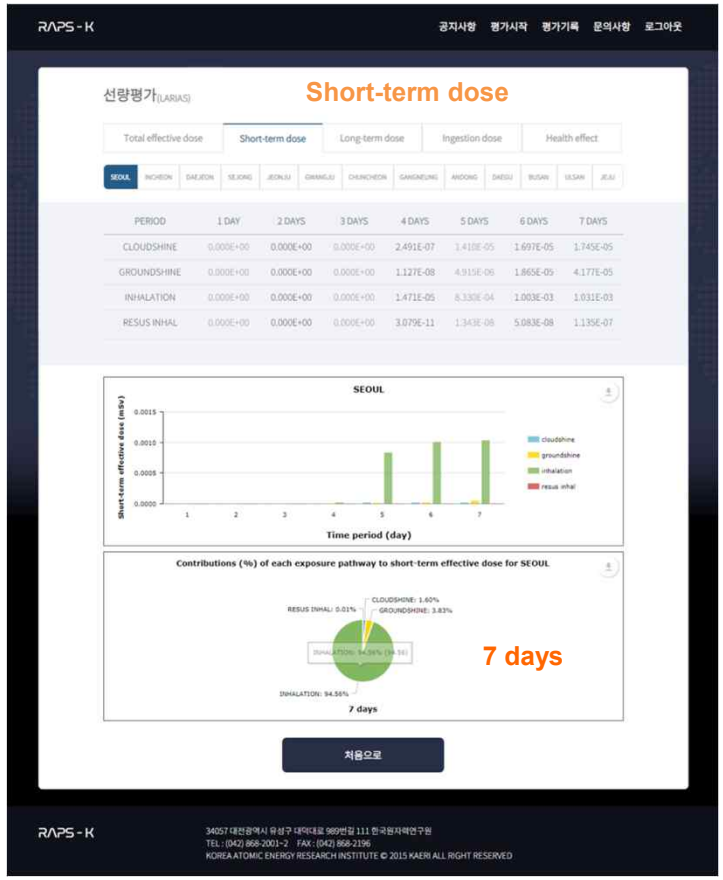
Overview of LARIAS

LARIAS (Land and Aquatic Radionuclide transport and Ingestion dose Assessment System)



Simulations of LARIAS

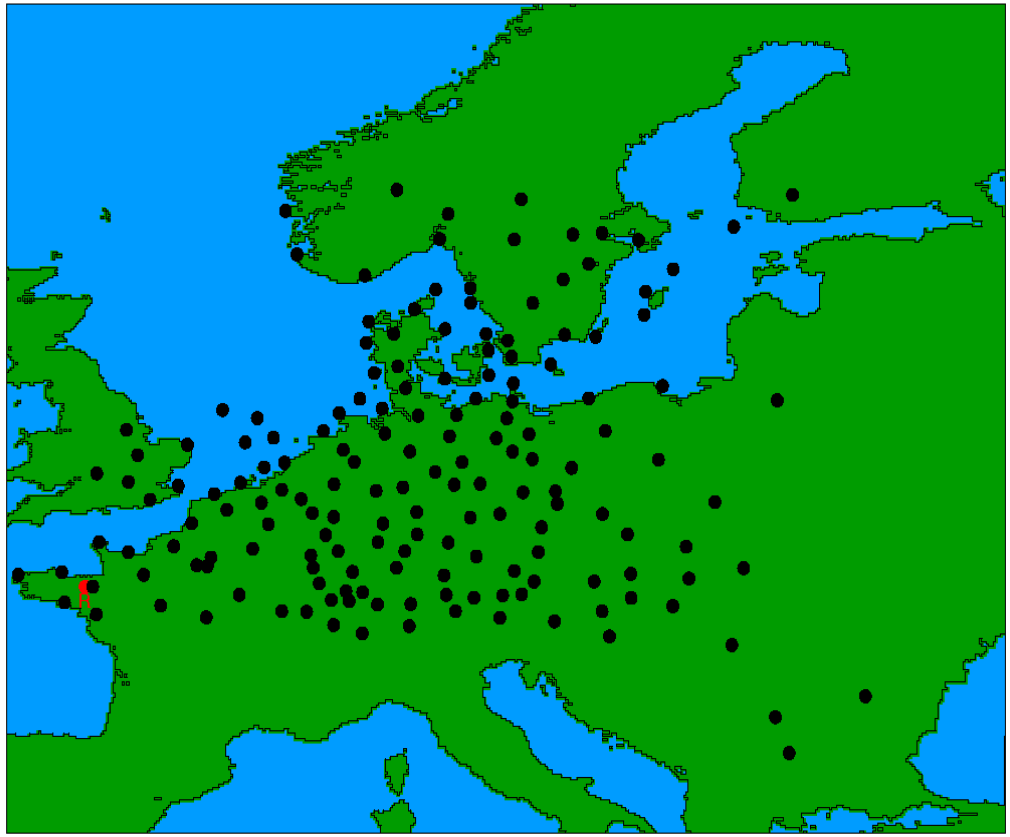


- ✓ **Based on LADAS/LORAS results (atmospheric/oceanic dispersion)**
- ✓ **Use Korea-specific input parameters**
- ✓ **Food chain model (terrestrial/aquatic)**

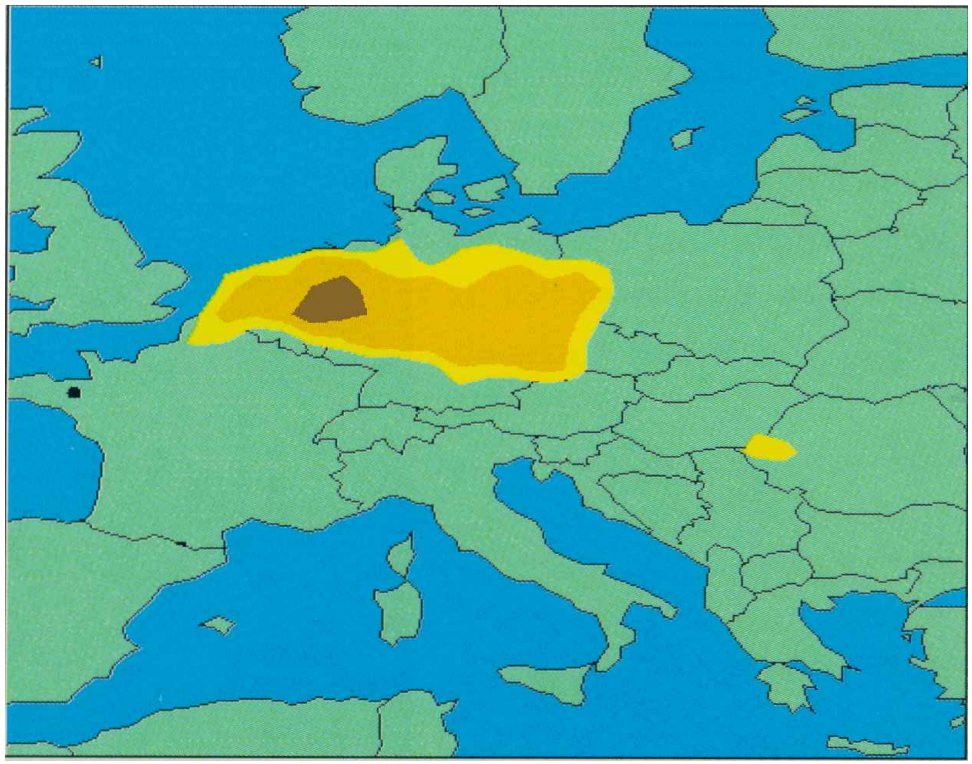
ETEX The First Experiment : 1994.10.23

- ♦ Release site : Monterfil (48.06° N, 2.0°W)
- ♦ Tracer : PMCH (perfluoromethylcyclohexane)
- ♦ Start of release : 23, Oct. 1600
- ♦ End of release : 24, Oct. 0350
- ♦ Quantity of PMCH : 340 kg
- ♦ Average flow rate of PMCH : 7.98 g/s
- ♦ Wind direction : Mainly west

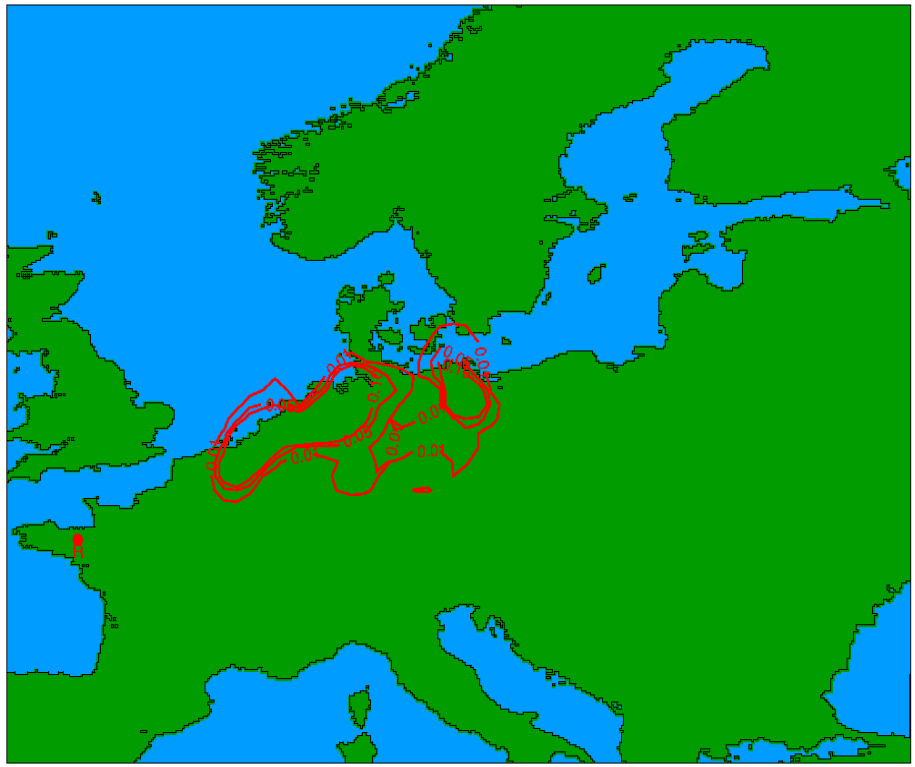
- ● 168 sampling stations in Western and Eastern Europe



ETEX : Comparison Results

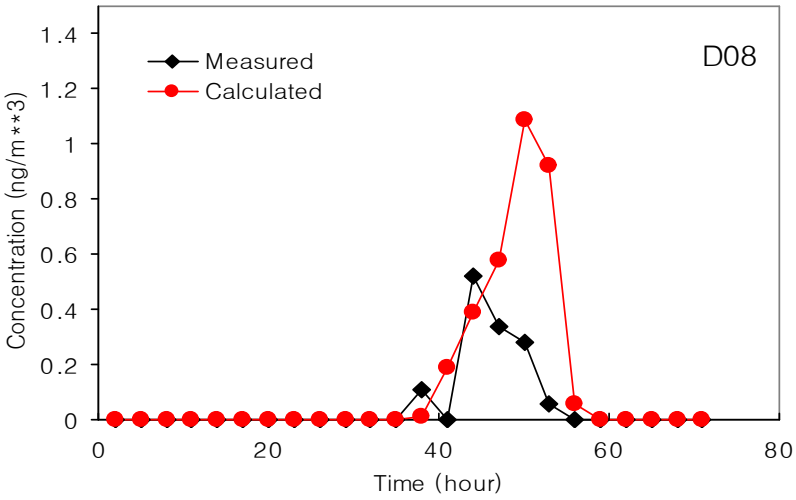


Concentration Profiles at T+36

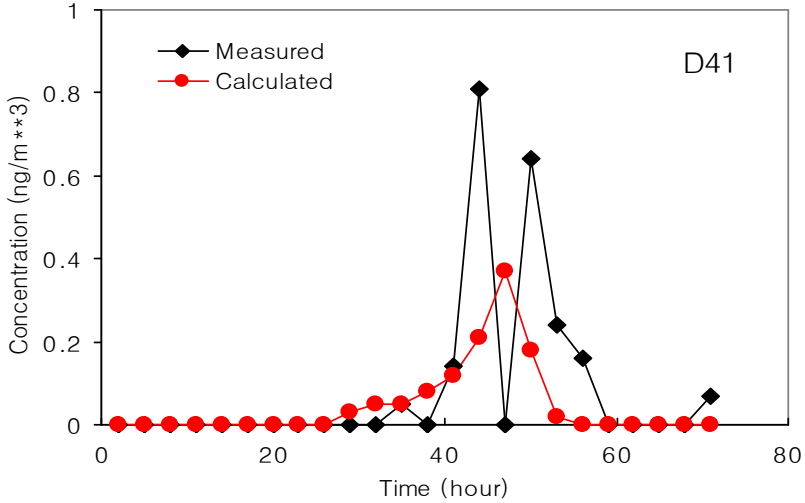


ETEX : Comparison Results

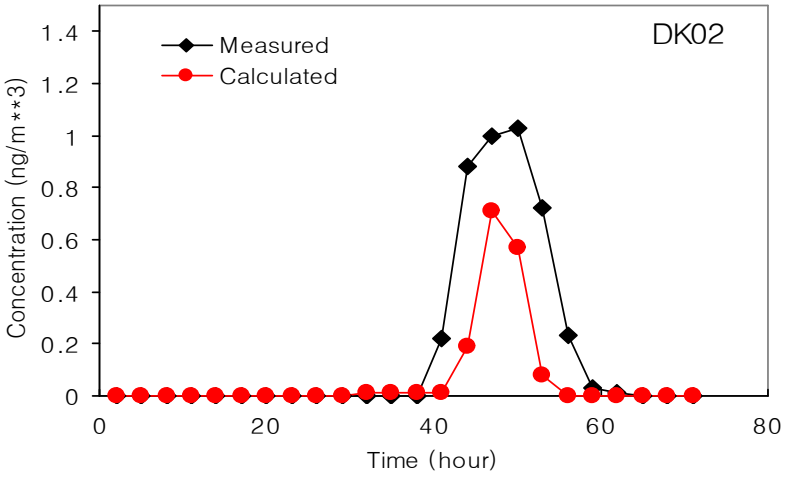
Cuxhaven (Germany)



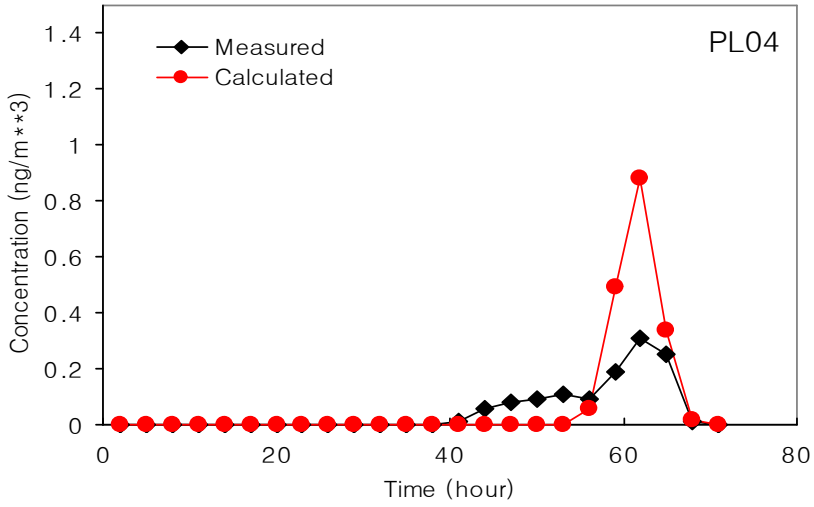
Schleswig (Germany)



Albuen (Denmark)



Koszalin (Polland)



General Description of ENSEMBLE

- New inter-comparison system of web-based model
- A system for the rapid exchange of results of the models
- Internet based server-side system
- A real-time inter-comparison by using graphical representation and statistical analysis

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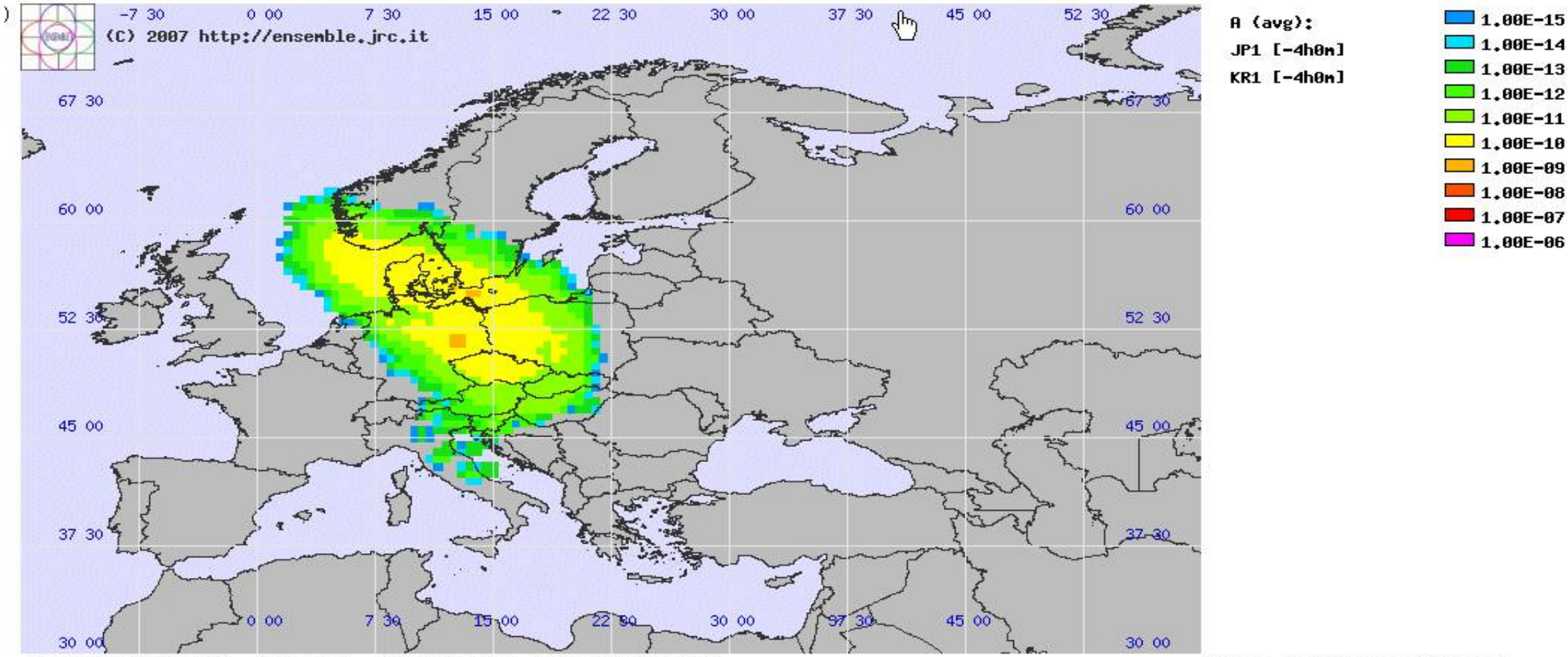
Grid plot of LADAS and WSPEEDI

Analysis - Grid plot (Concentration)



Case 901-001 (PMCH) - Grid plot - Concentration (0 m agl) in Bq/m3
Date and time: 1994-10-25 18:00 UTC (+50h0m after release start)
Data range: [1.89E-17,2.07E-09]

Created by user kssuh on 2007-02-23 05:04:51 UTC

Release from: Rennes (France)
Coordinates: 02:00 W 48:03 N
Start: 1994-10-23 16:00
Duration: 11.8333 h

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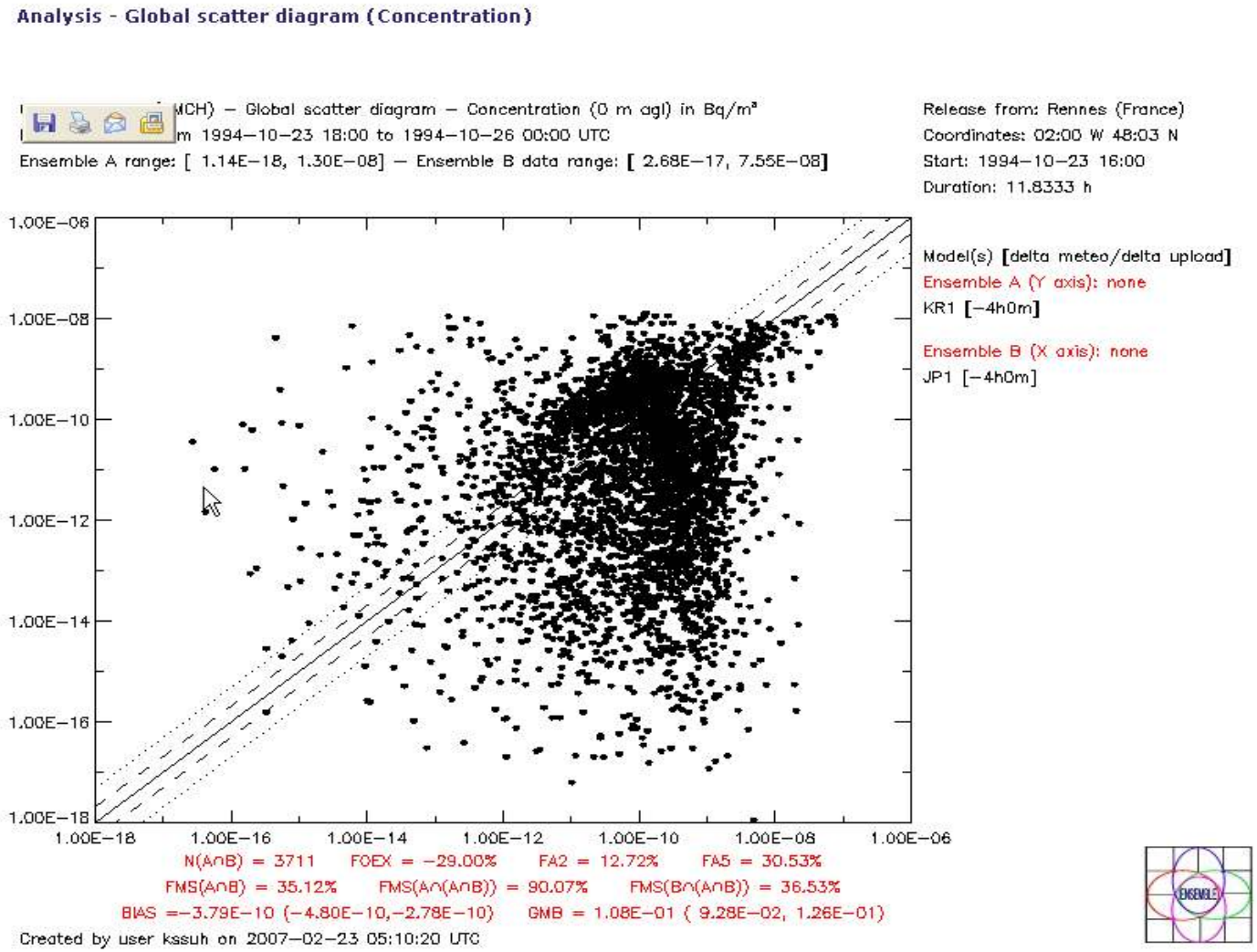
Scatter Diagram of LADAS and WSPEEDI



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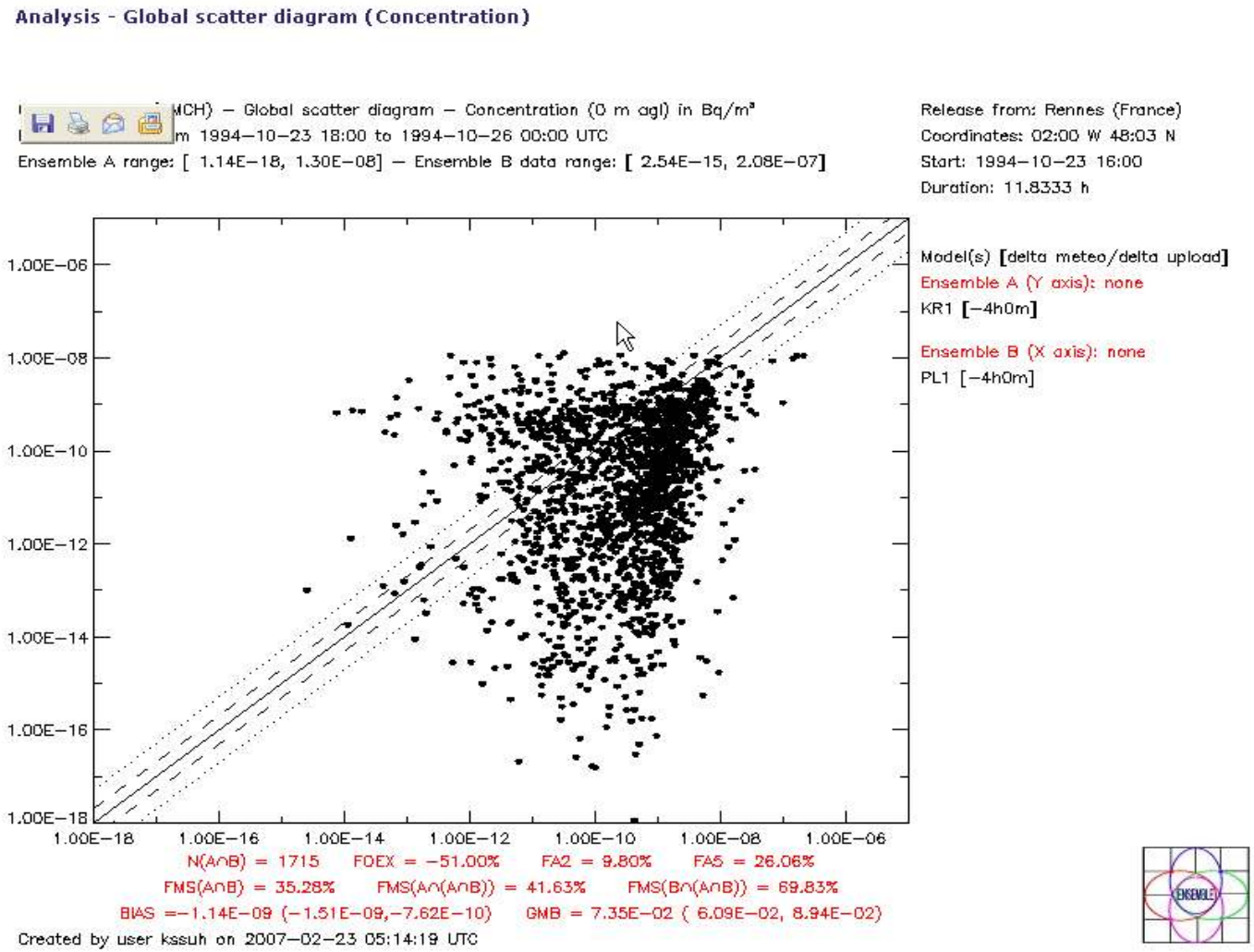
Scatter Diagram of LADAS and RODOS



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Application of LADAS for the Fukushima Accident

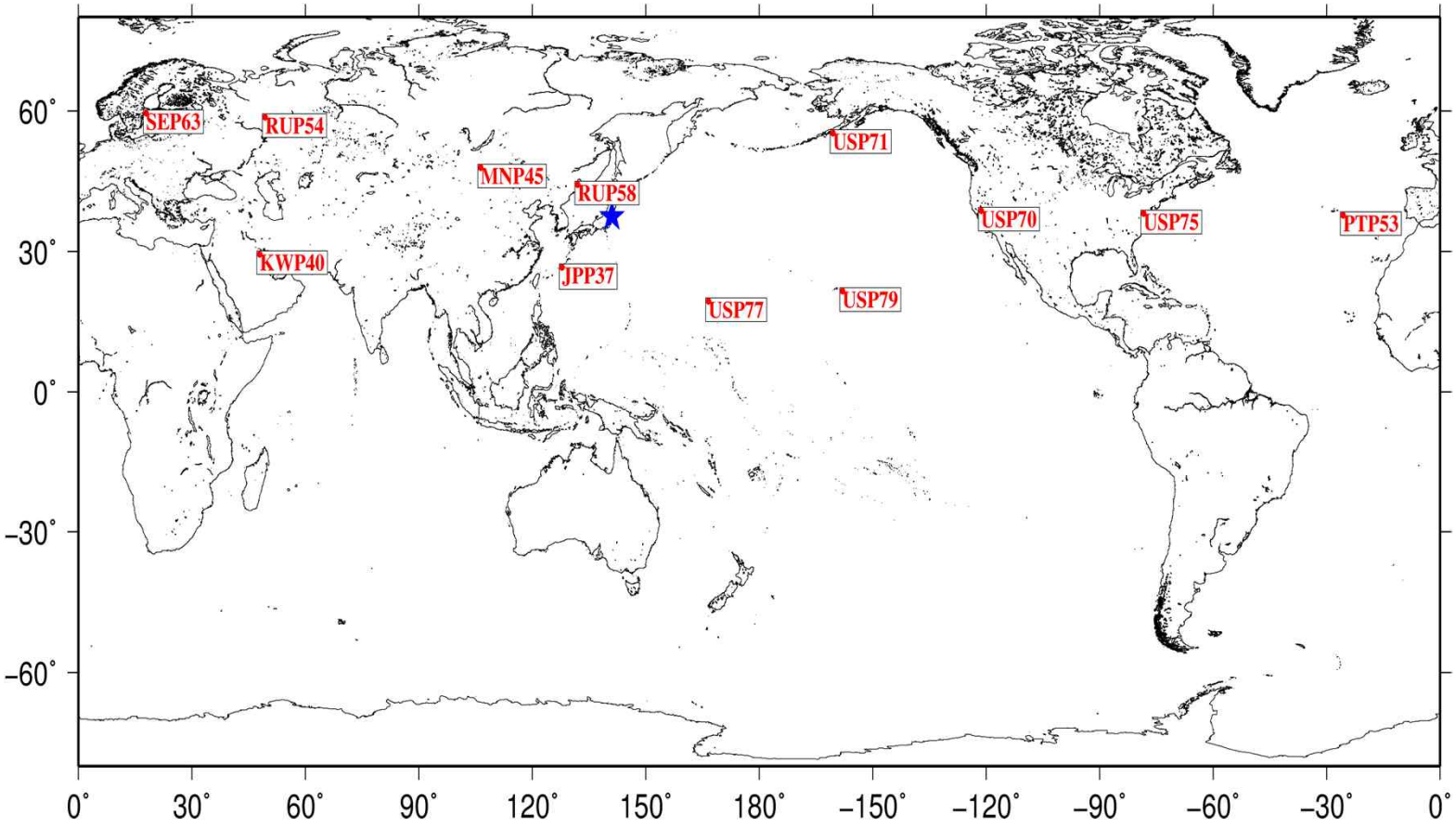
Radio-nuclide	Half life	Atmospheric release amount (1PBq=10^{15}Bq)			
		Fukushima	Fraction based on the Chernobyl	Chernobyl	Katata at JAEA (2015)
Xe-133	5 days	2,000 ~ 15,000	30 ~ 230 %	6,500	-
I-131	8 days	90 ~ 200	5 ~ 11 %	1,800	151
Cs-137	30 years	6 ~ 37	7 ~ 43 %	85	14.5

Organization	Atmospheric deposition on the sea surface			Direct release in the ocean		
	Period	I-131	Cs-137	Period	I-131	Cs-137
JAEA in Japan (Kobayashi, 2013)	2011.3.12~ 5.1	99	7.6	2011.3.26 ~ 6.30	11	3.5
KAERI in Korea (Kyung-Suk, 2013)	2011.3.12 ~ 4.30	88	6.9	2011.3.26 ~ 6.30	11	3.5

About 70 % of Cs-137 released into the air was deposited on the sea surface

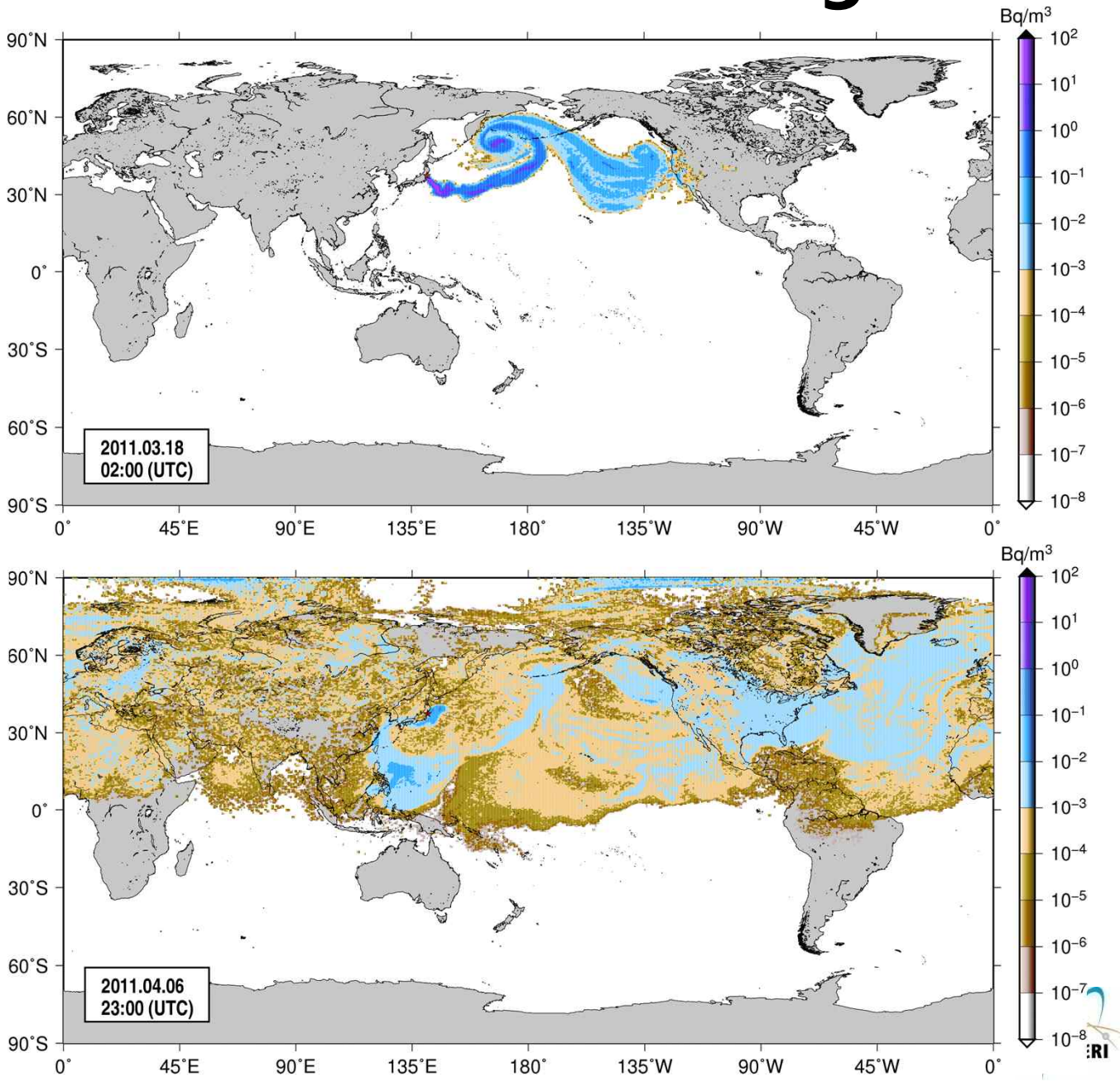
Measurements of radionuclides

- It was detected in North America during March 17-21, in European countries during March 23-24, and in Asia during March 24 to April 6, 2011. In particular, I-131 was measured from March 23 to April 22 in Korea. Global measurements were performed by CTBTO.



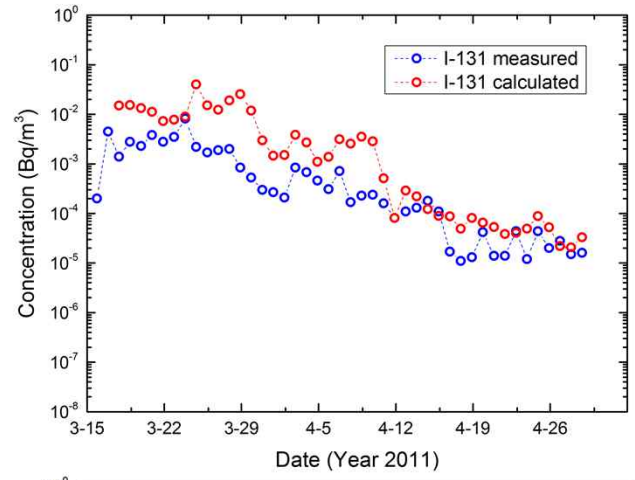
Dispersion profiles of I-131 in LADAS-global

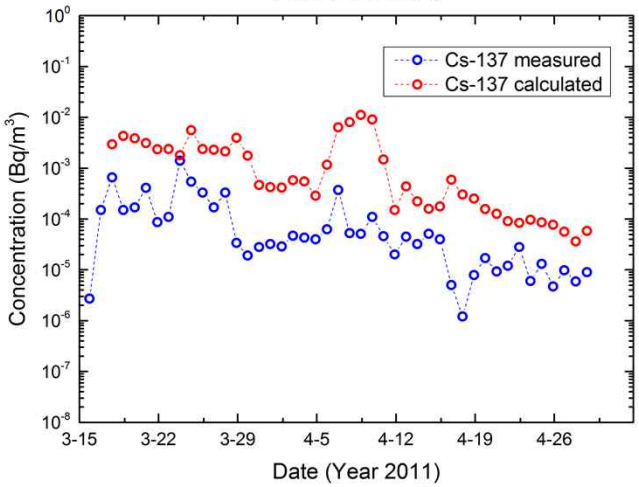
- Radionculides reached at 3/18 in the west of USA, 3/24 in Europe, 3/28 Mongolia, 4/5 in Taiwan
- Concentrations of I-131 and Cs-137 were measured from 3/31 in Korea
- Measured concentrations of I-131 and Cs-137 in Korea during April 1-10 were due to the combined effects of the westerly winds and direct tranpsort from Fukushima



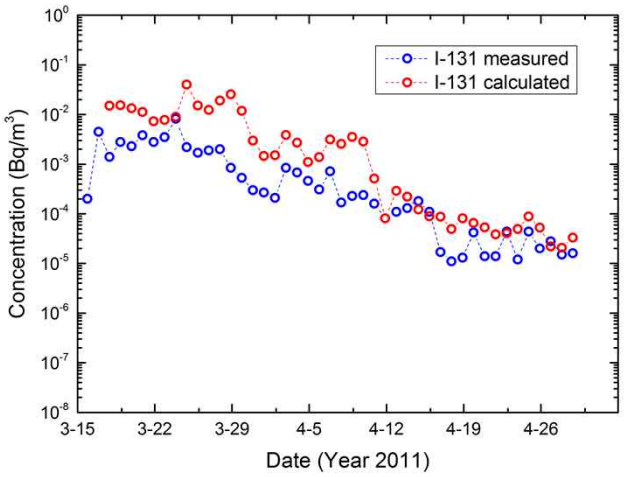
Comparison of calculated and measured concentrations in LADAS-global

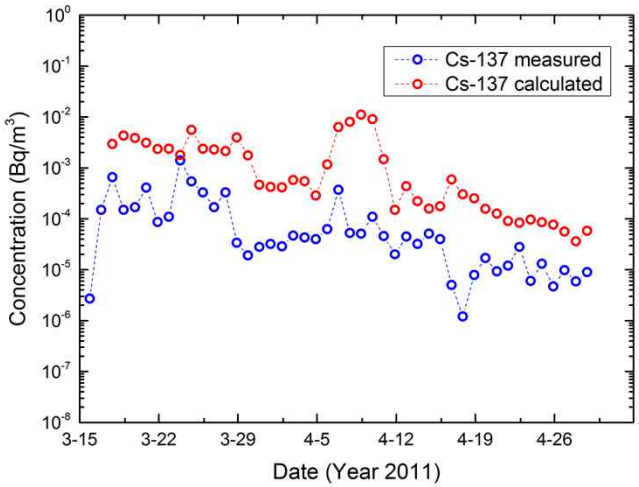
UPS70 (38.7° N, 121.4° W) : Sacramento



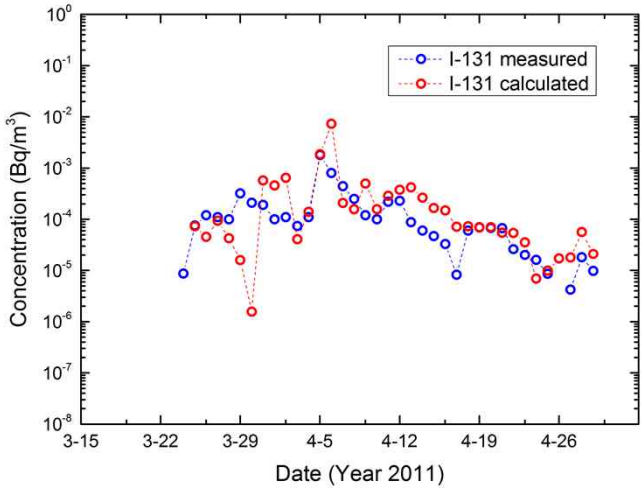


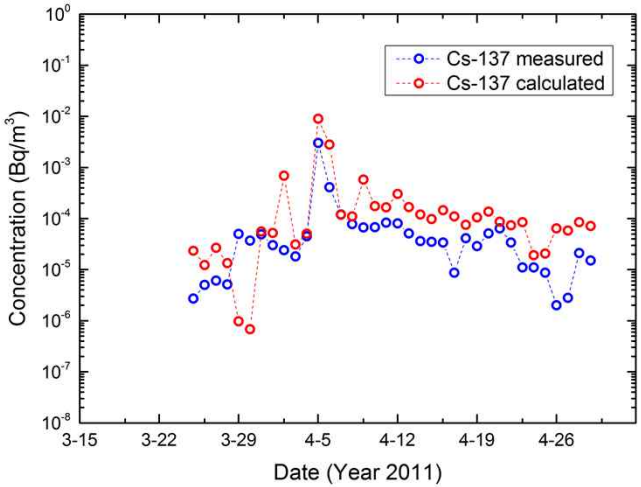
SEP63(59.4° N, 17.9° E) : Stockholm





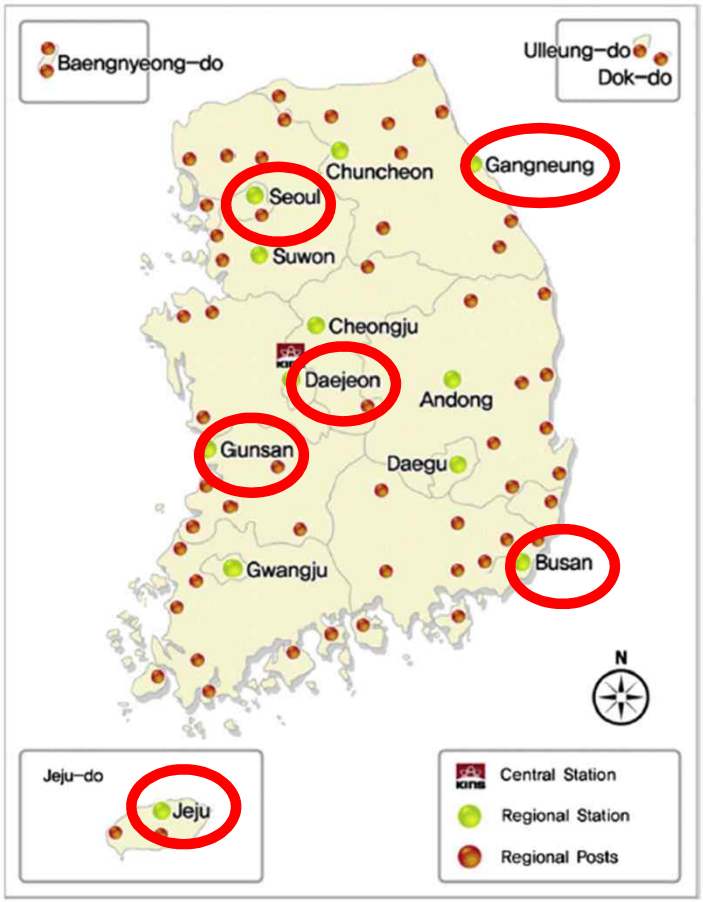
JPP37 : (26.5° N, 127.9° E) : Okinawa

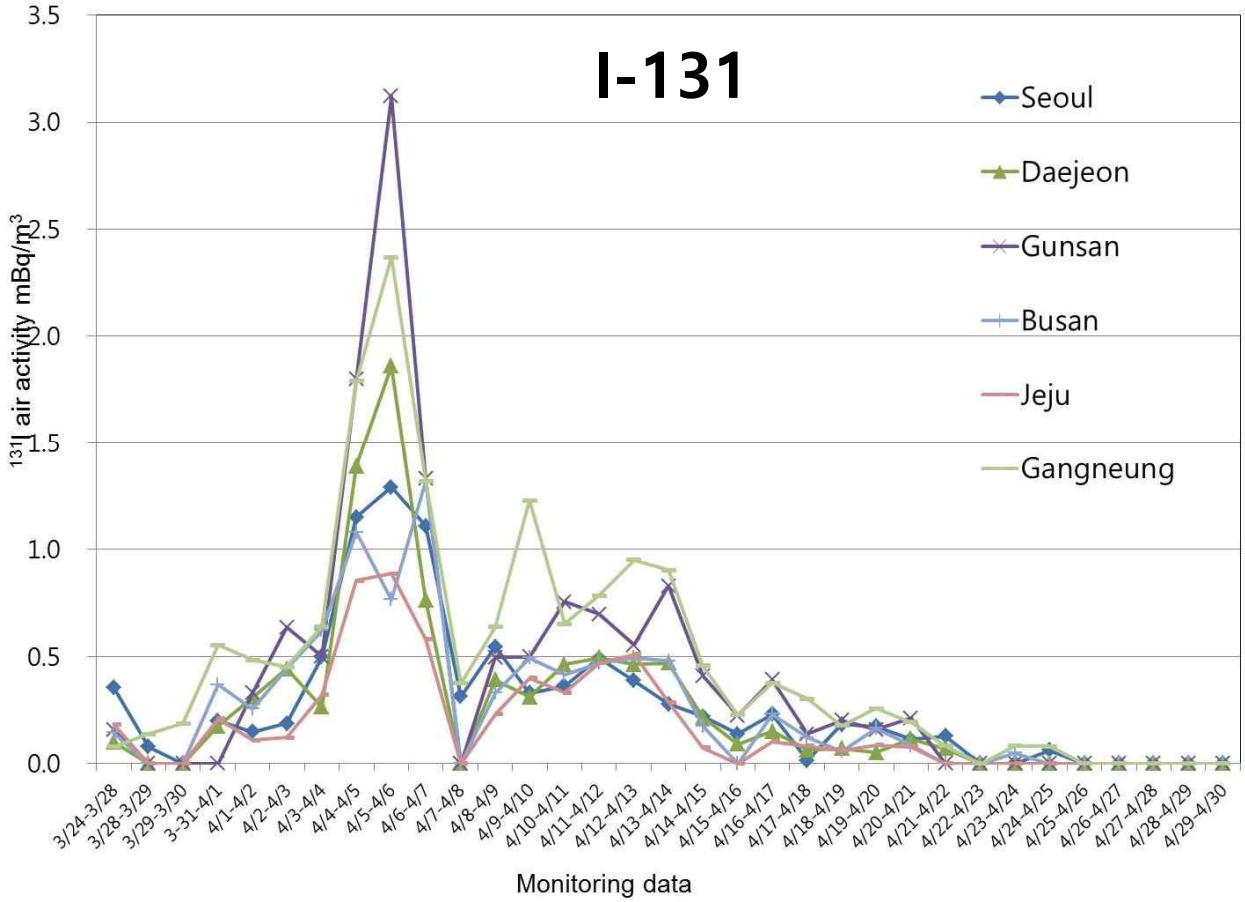




Evaluation of radionuclide pathway using measurements in Korea

- Relatively high concentrations of I-131 and Cs-137 were measured on 6 ~ 7 April at Gunsan and at Busan, respectively

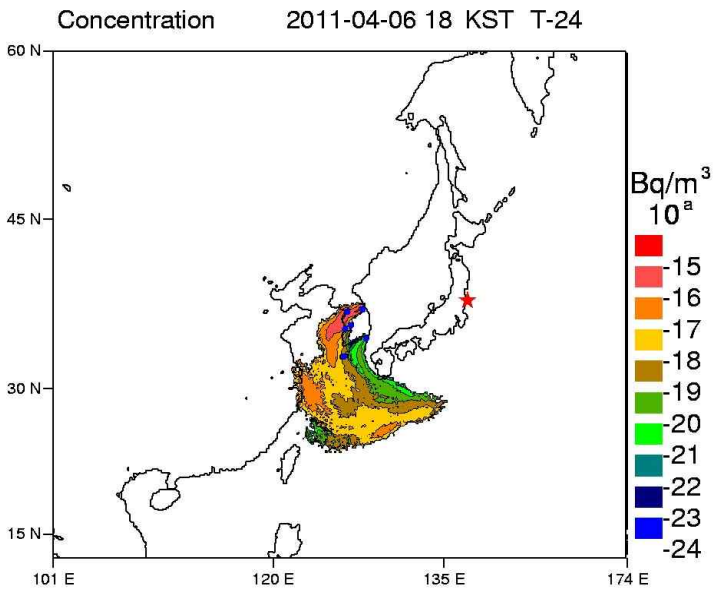


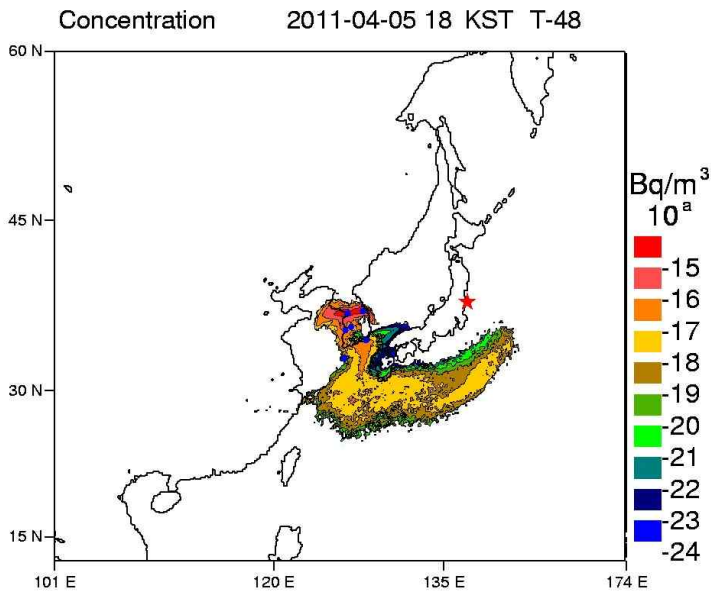


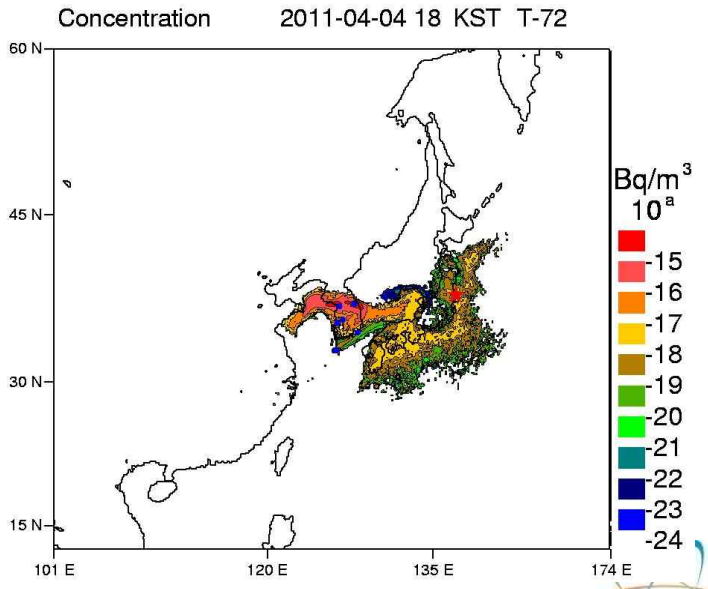
Evaluation of radionuclide pathway using measurements in Korea (LADAS-regional)

- 6 locations (Seoul, Dajeon, Gunsan, Busan, Jeju, Gangneung) were used to estimate pathway of radionuclide from the Fukushima in the early of April.
- From the simulations, radionuclides released into the air from the Fukushima were transported directly from 3 to 5 April.

Backward simulations







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Model Description of JAEA and KAERI (Atmospheric Dispersion Model for Simulation of Cs-137)

	JAEA	KAERI
Atmospheric dispersion model	**WSPEEDI-II** (Worldwide version of System for Prediction of Environmental Emergency Dose Information version II)	**LADAS** (Long-range Accident Dose Assessment System)
Meteorological data	**JMA (Japan Meteo. Agency)**	**KMA(Korea Meteo. Administration)**
Model domain to compare	27.57 ~ 47.82 N, 128.1 ~ 162.5 E	12.21~52.89 N, 101.57 ~ 173.82 E
Horizontal resolution	**6 km x 6 km (3 hour intervals)**	**12 km x 12 km (3 hour intervals)**
Simulation Period	2011.3.12.8h ~ 2011.5.31.02 h(JST)	2011.3.12.05h~ 2011.5.1.0h(KST)
Source term of Cs-137	**Terada et al., 2012**	**Terada et al., 2012**
Release height of Cs-137	20, 120 meters above ground and volume sources were used depend on the release condition(Terada et al., 2012)	20 meters above ground
Diffusion Coefficients (Kx, Kz)	Kx: Gifford (1982) Kz: Mellor-Yamada level 2.5	Kx = 2.5 x 10^4 m^2/sec, Kz = 1.0 m^2/sec
Dry deposition velocity	0.001 m/sec (0.005 m/sec on forest area)	0.001 m/sec
Wet deposition scheme	$S=(5.0e-5)I^{0.8}$ I=precipitation (mm/hr)	$S=(5.0e-5)I^{0.8}$ I=precipitation (mm/hr)
Output interval	3 hour	3 hour

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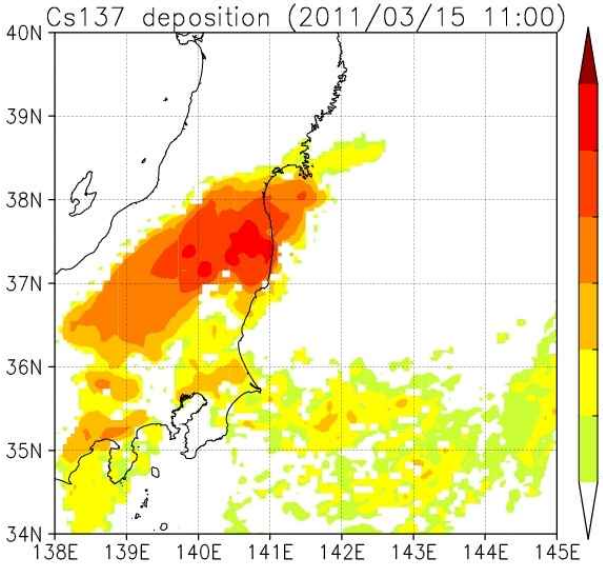
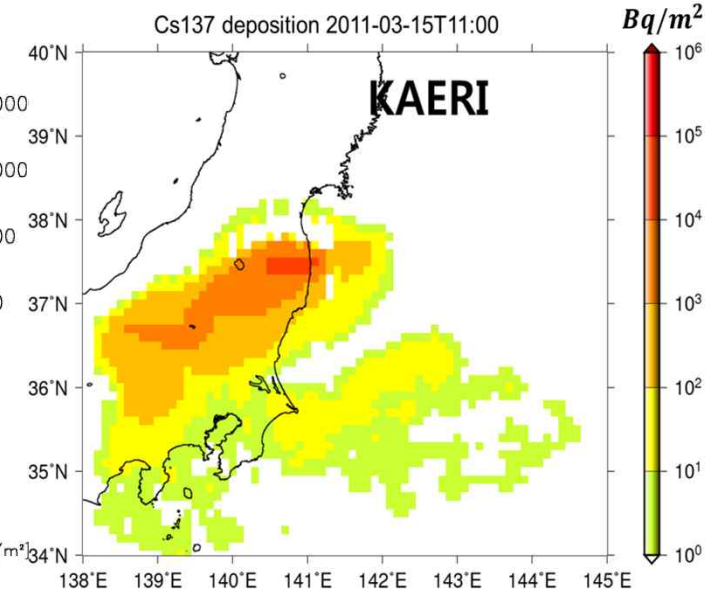
Contour maps of atmospheric depositions of Cs-137

- Atmospheric deposition results with 3 hour intervals showed as follows and the general patterns are similar from 3/12 ~ 6/30 between them. Therefore, ensemble average values of deposition from KAERI and JAEA are provided in participants for Fukushima run in **MODARIA WG10**.

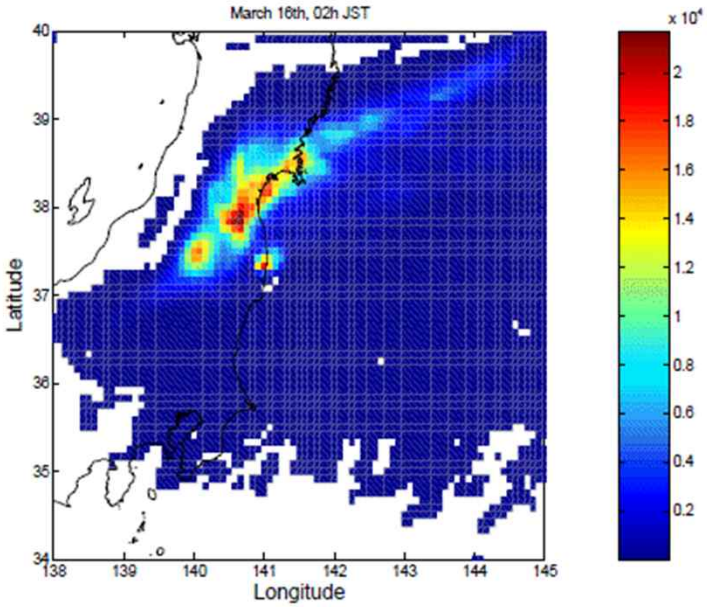
JAEA



KAERI

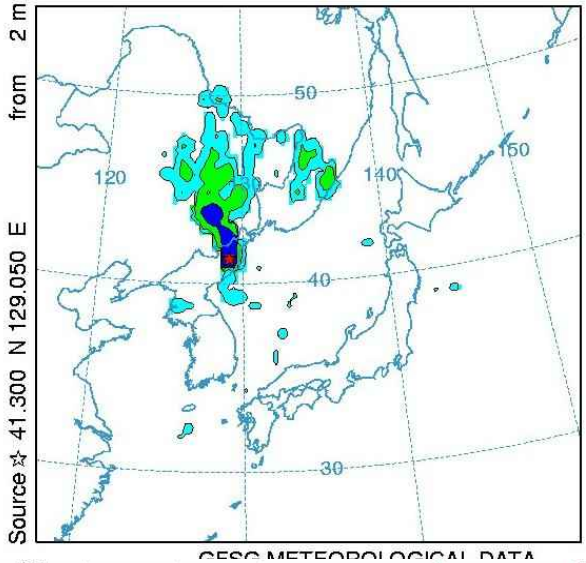


Averaged (Ensemble)

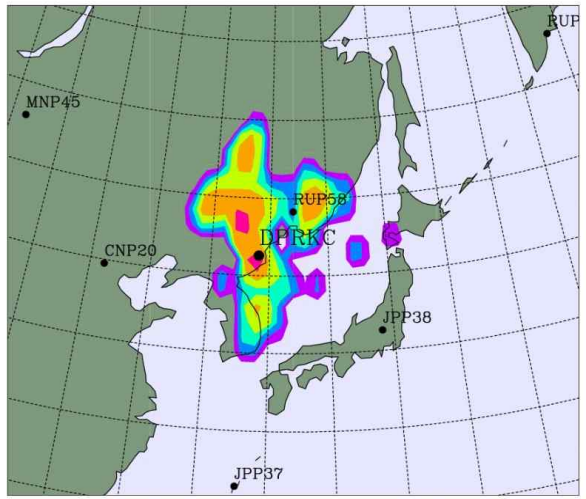


North Korea Nuclear Test

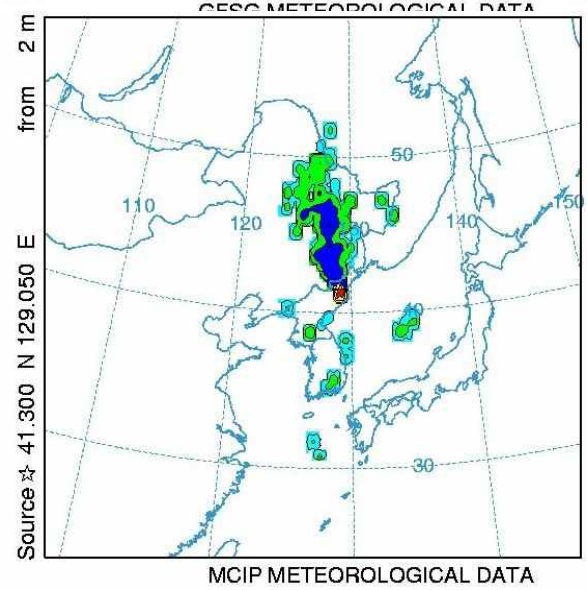
2016. 9.12 18:00 UST ~ 9.12. 21:00 UST (=2016. 9. 13. 6 KST)



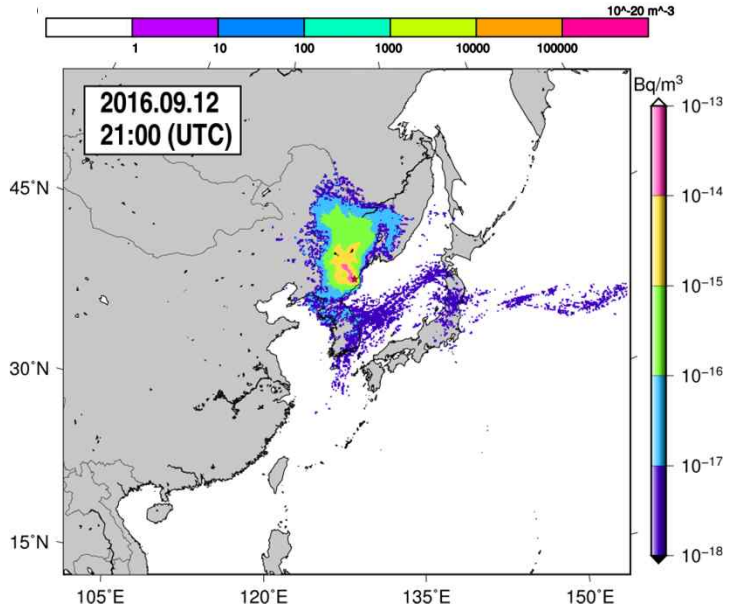
Hysplit :
0.5° NOAA



WebGrape :
0.5° ECMWF



Hysplit :
25 km KMA



LADAS :
12 km KMA

Summary

- Lagrangian models can be useful tool to evaluate the behavior of pollutants in environment, fast and real-time
- Most of emergency rapid-response models have been developed with Lagrangian types
- Wind and currents are one of the important factors to operate in dispersion models
- RAPS-K has been developed to evaluate the dispersion patterns of the radionuclides released into environment for a nuclear accident
- Especially, atmospheric and marine dispersion models have to link to investigate the effects of contamination due to the depositions in marine environment
- **Integrated radiological assessment system in Korea has been constructed to protect human and environment for a nuclear accident from neighboring countries or worldwide**

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