

Environmental Radiation Monitoring System in Korea

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International Cooperation

1. Radiations in Environment

- There are two classes of radiation

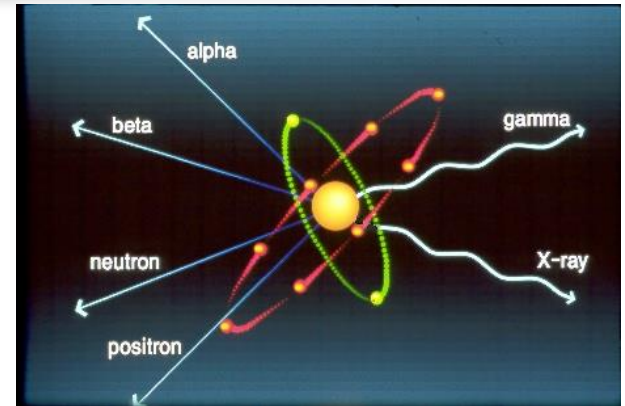
- Non-ionizing radiation
- Ionizing radiation

- The origin of the radiation

- Natural radiation
- Artificial (man-made) radiation: weapon testing, nuclear reactor, accelerator

- Radiation and radioactivity

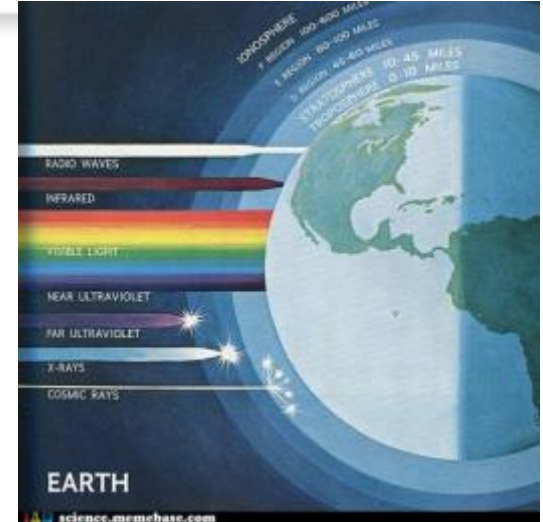
- Radiation: energy that comes from a source and travels through some material or through space
- Types of Radiation
 - Particle emission (α , β^- , β^+)
 - Photon emission (γ , X-ray)
- Radioactivity: activity defines the number of nuclear processes (disintegrations) per second
 - ✓ SI unit: Bq (Becquerel), $1 \text{ Bq} = 1 \text{ disintegrations s}^{-1}$
 - ✓ Former unit: Ci (Curie), $1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$, $1 \text{ Ci} \sim \text{Activity of 1g Radium}$



Natural Radiation

Radiation is a fact of life - all around us, all the time

- Origin from cosmogenic radiation
 - Cosmic radiation, solar radiation
 - Be-7, H-3, C-14
- Origin from terrestrial (from earth)
 - Rn-222 and its daughter (Po-210, Bi-214)
 - Rock, soil, building materials
 - By the burning of fossil fuel
- In the human body
 - ^{40}K : 1461 keV (0.012 % in K, 0.889 dpm/mg of KCl)
 - Radiation exposure from human to human
- Food stuff
 - ^{40}K , U-Th series, ^{87}Rb
 - Food chain from fertilizer to plants
- Etc.
 - NORM, TENORM



Man-made Radiation

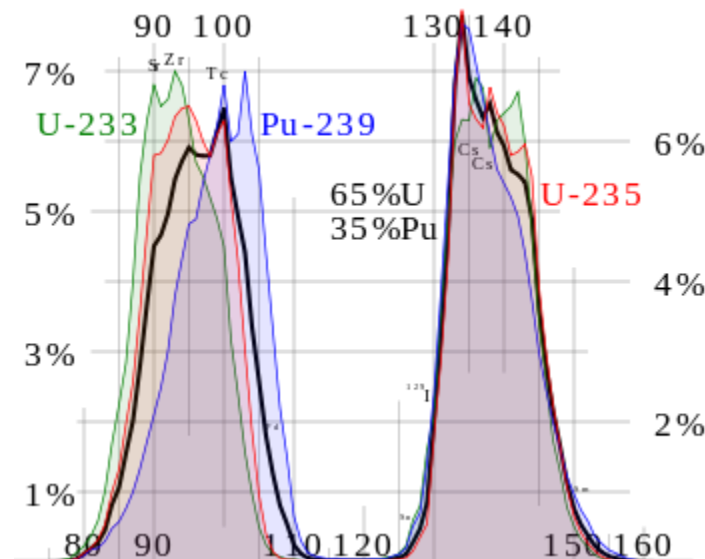
- Nuclear weapon testing, nuclear reactor, reprocessing of nuclear spent fuel
- Long half-lived actinides (Pu, Np, Am, Cm)
- Fission products (Sr-90, Cs-137) and neutron activation radionuclides (H-3, C-14, Co-60)
- From accelerator or medical uses by researcher reactor (I-131, Tc-99)

	Source	Radionuclide	Radiation	Half-life
Nuclear sector	Nuclear industries	Technetium-99 (^{99}Tc)	β -activity,	213 000 yr
		Caesium-137 (^{137}Cs)	β -activity, γ -activity	30.17 yr
		Plutonium-239 (^{239}Pu) ¹	α -activity	24 100 yr
		Plutonium-240 (^{240}Pu) ¹	α -activity	6560 yr
		Tritium (^3H) ²	β -activity	12.3 yr
Non-nuclear sector	Offshore oil and gas industry	Lead-210 (^{210}Pb)	β -activity	22.3 yr
		Radium-226 (^{226}Ra)	α -activity, γ -activity	1600 yr
		Radium-228 (^{228}Ra)	β -activity	5.76 yr
		Thorium-228 (^{228}Th) ³	α -activity	1.9 yr
	Medical uses	Technetium-99 (^{99}Tc) ⁴ Iodine-131 (^{131}I)	β -activity β -activity, γ -activity	213 000 yr 8 d

¹ ^{239}Pu and ^{240}Pu are measured together ($^{239,240}\text{Pu}$). ² Tritium discharges are reported, but no evaluation of these data has been carried out due to the lack of practicable abatement options. This will be kept under review. ³ Insufficient data reported for assessment. ⁴ Due to the short half-life (6 hours) of $^{99\text{m}}\text{Tc}$, ^{99}Tc has been identified as the indicator radionuclide for the medical use of $^{99\text{m}}\text{Tc}$.

Man-made Radiation

- Mainly from commercial and research nuclear reactor and from nuclear fuel reprocessing
- Long half lived and high fission yield radionuclides (Sr-90, Cs-137, Cs-134, Pu) are main target radionuclides in environmental monitoring



Fission product yields by mass for thermal neutron fission of U-235, Pu-239, a combination of the two typical of current nuclear power reactors, and U-233 used in the thorium cycle.

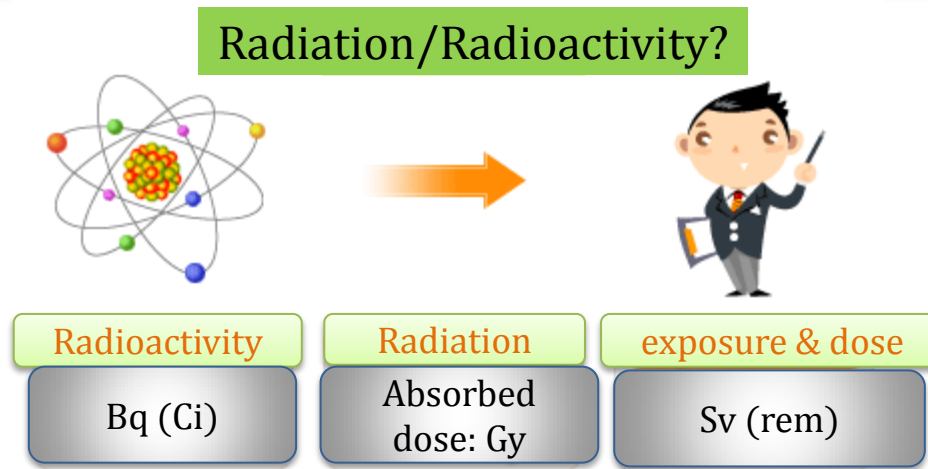
“the most toxic substance known to man”?

Substance	LD50 in mg/kg
Ethanol	10,000 injection
Morphine	900 injection
Nicotine	1 injection
Pu-239	1 injection
	2 inhalation
Tetradotoxin	0.1 injection
Dioxin	0.001 injection
Botulinustoxin	0.00001 injection

Plutonium and radiotoxicity

- 3 -5 t due to > 400 above-ground nuclear tests
- Most dangerous aerosols, e.g. PuO_2
- Transfer into body fluid depends on physical-chemical properties of the compound
- In body fluid: 50% go to skeleton, 30% to liver, rest excreted
(bio half life is 50 years in bones, 20 years in liver)
- Biochemical toxicity only observed at about $\text{LD}_{50} = 1\text{ mg Pu-239/kg}$ in blood (intravenous)
- Lethal dose for human: 50 mg Pu-239 (100 MBq) inhalation
- Alphas cause lung cancer and leukemia

Radiation and Effective Dose

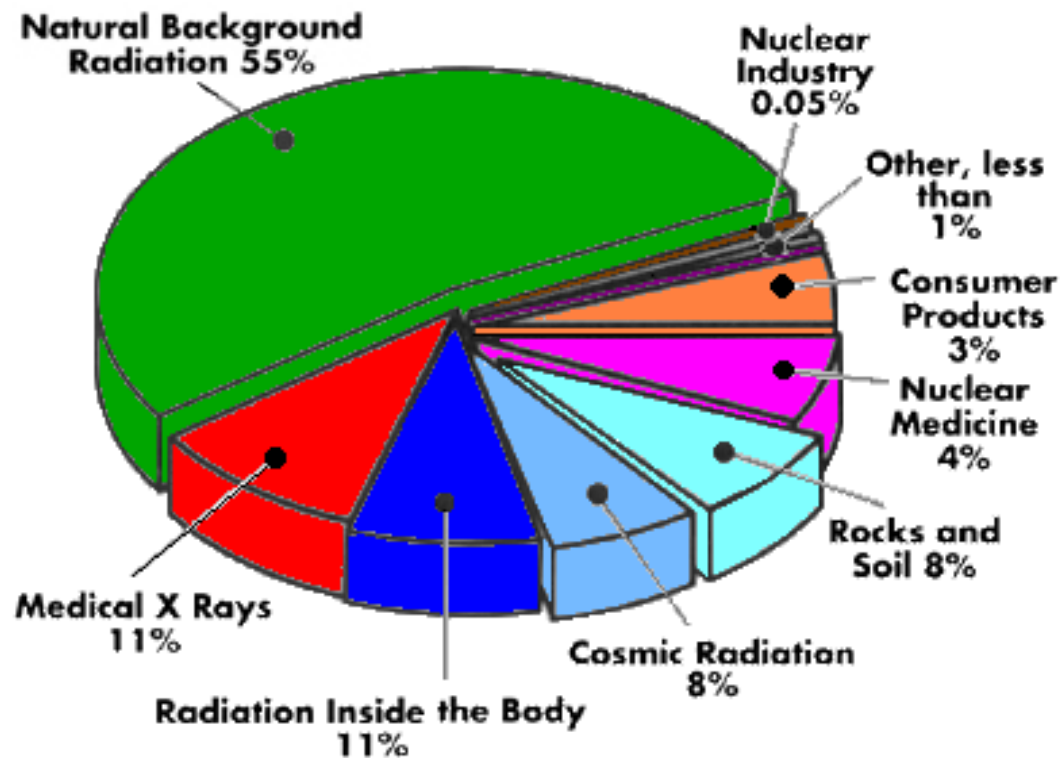


- Effective dose (Sv = 100 rem):

$$E = \sum_T w_T \cdot H_T$$

- w_T : tissue weighting factor for tissue T.
 - H_T : equivalent dose
- International recommendation (ICRP)
 - 1 mSv/y : public, 20 mSv/y : occupationally exposed worker
 - 1 μ R/hr $\Rightarrow$ 8.77 nGy/hr for air $\Rightarrow$ 9.73 nGy/hr for tissue $\Rightarrow$ 9.73 nSv/hr
- Symptom depend on effective dose (mSv)
 - 0 ~ 250 mSv: no symptom, 250 ~ 1,000 (500 mSv) : Leukemia
- Airborne dose rate in Korea: 10~20 μ R/hr (97.3 ~ 195 nSv/hr)

Radiation Sources and Distribution of Average Radiation Exposure to the Population

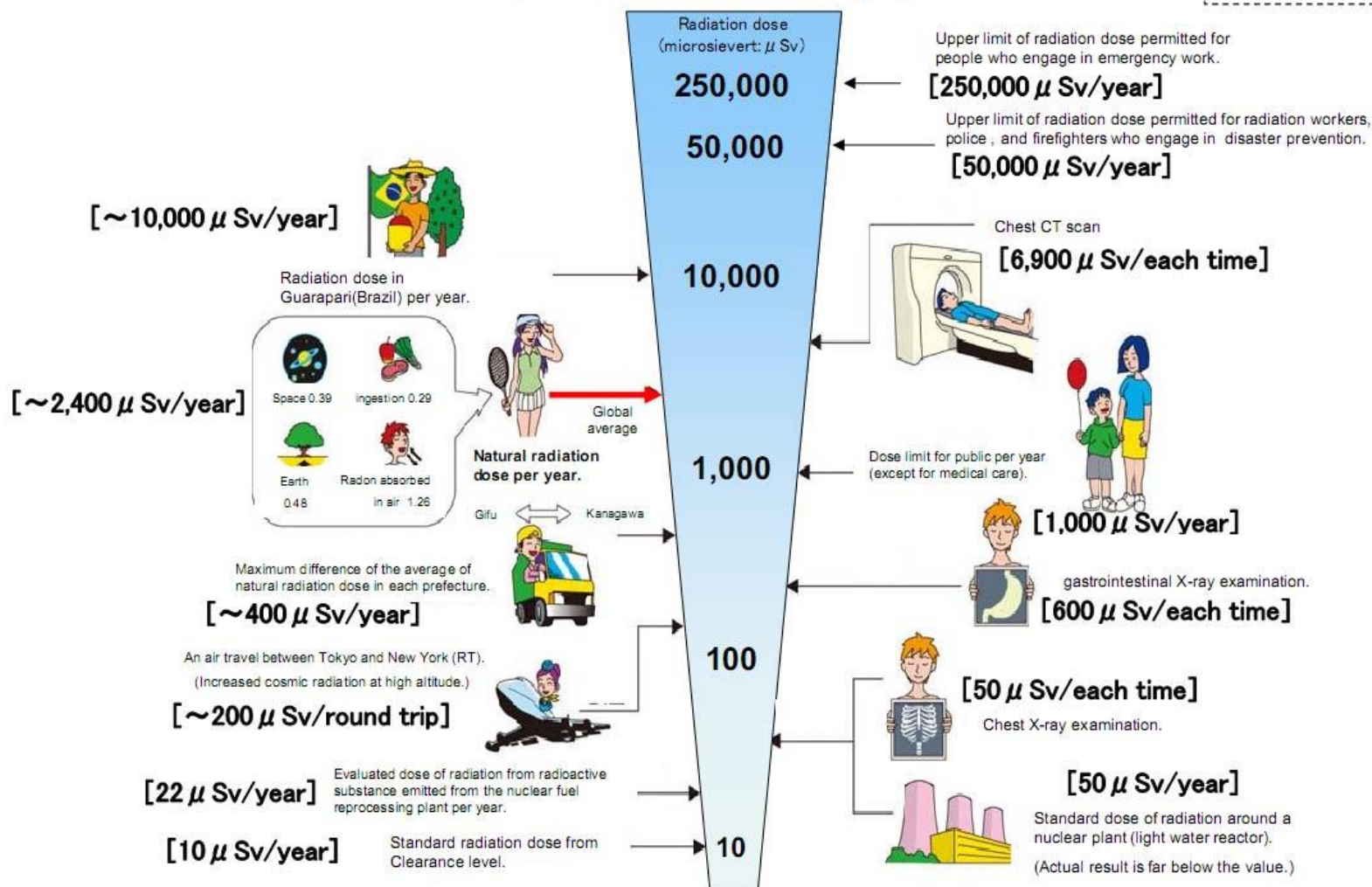


Source: National Council on Radiation Protection and Measurements, NRCP report 93.

Dose rate by Natural and Artificial Radiation

Radiation in Daily-life

※Unit : μSv



2. Radioactivity Contamination around the World

Environment was contaminated at global or local scale by the following nuclear power plant or radiation sources accidents

- Nuclear weapon testing by nuclear weapon country
- Commercial NPP disasters
 - Chernobyl in Ukraine in 1986 : INES level 7
 - Fukushima Daiichi in Japan in 2011- partial meltdowns in multiple reactors: INES level 7
 - Three Mile Island, Pennsylvania, United States : INES level 5
- Ocean disposal of radioactive waste by most of NPP possessing countries
- Pu-238 contamination by falling of nuclear fueled satellite (Systems for Nuclear Auxiliary Power (SNAP)-9A)
- Local contamination by wrong doing of civilian radiation sources in many countries
 - Goiânia, Brazil (1987)- cesium-137 source stolen, ruptured, wide exposure to radioactivity

Nuclear Weapon Test

- Weapon test was started since 1945
- In particular, testing was peaked during in later 1950 and early 1960s
- Most ground was stopped in 1964 after partial test ban treaty open in signature
- In total, about more than 2000 times carried out in the world



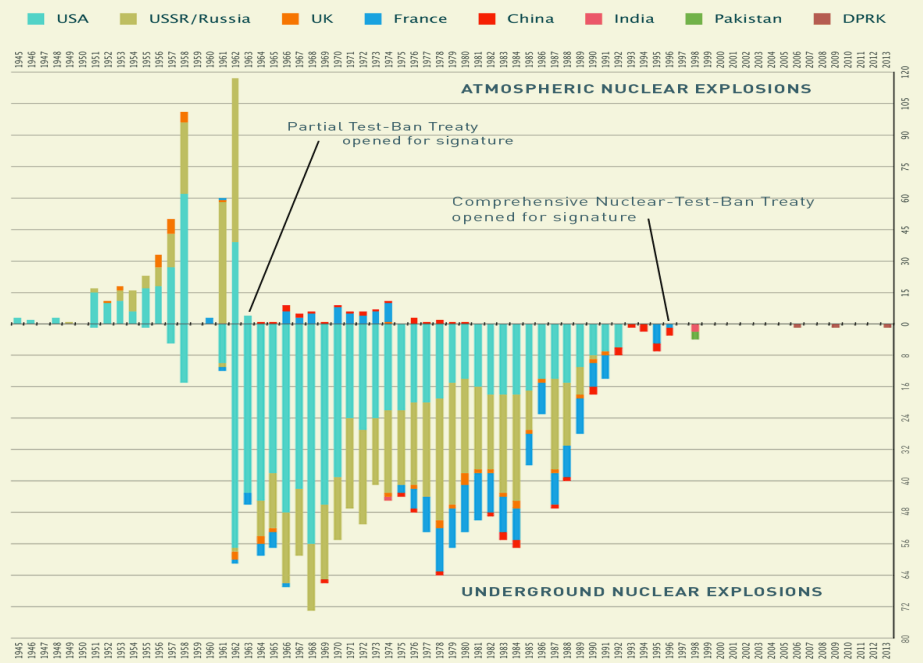
NUCLEAR TESTING AS OF MAY 2009

COUNTRY	TOTAL TESTS	FIRST TESTED	LAST TESTED	(CTBT STA
UNITED STATES	1,032	16 July 1945	23 September 1992	Signed: 2 Not ratifi
SOVIET UNION/RUSSIA	715	29 August 1949	24 October 1990	Signed: 2 Ratified:
UNITED KINGDOM	45	3 October 1952	26 November 1991	Signed: 2 Ratified:
FRANCE	210	13 February 1960	17 January 1996	Signed: 2 Ratified:
CHINA	45	16 October 1964	29 July 1996	Signed: 2 Not ratifi
INDIA	3	18 May 1974	13 May 1998	Neither si nor ratifi
PAKISTAN	2	28 May 1998	30 May 1998	Neither si nor ratifi
DPRK	2	9 October 2006	25 May 2009	Neither si nor ratifi

2,054

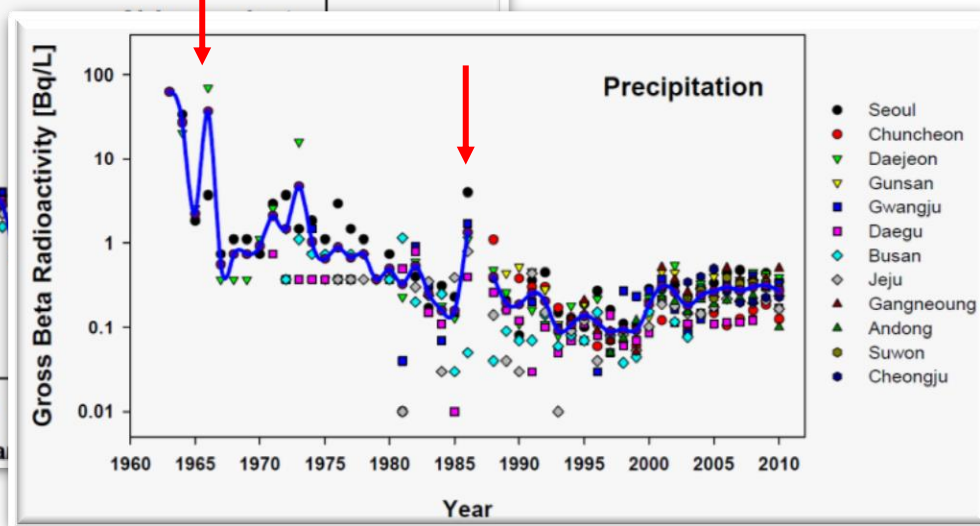
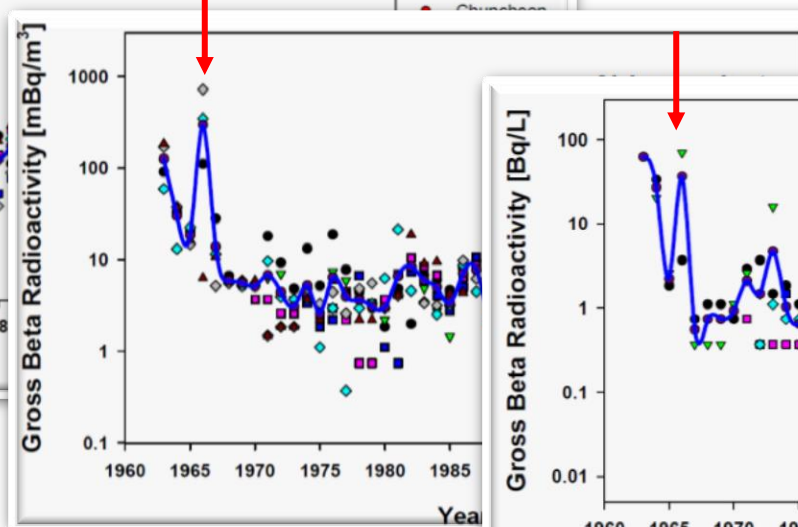
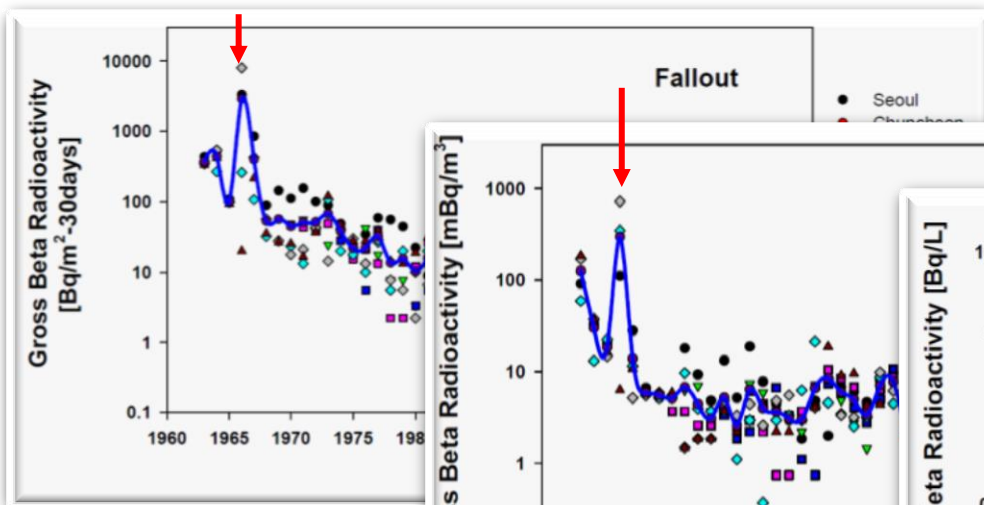
5 Signed,
3 Non-si

WORLDWIDE NUCLEAR TESTING: ATMOSPHERIC AND UNDERGROUND 1945-2013



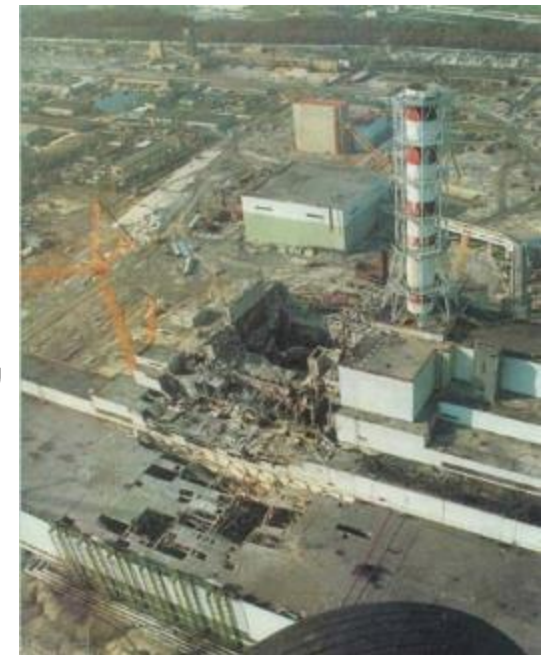
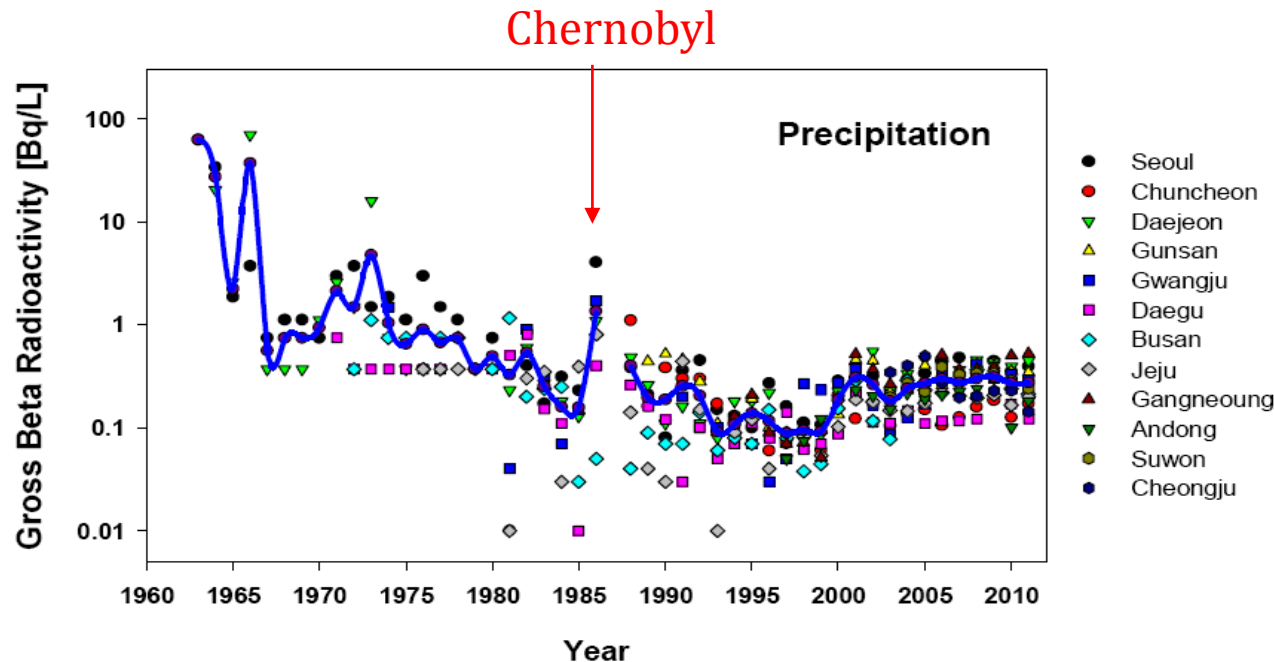
Radioactive Contamination by China Weapon Test

- Maximum gross beta after 1st test (1964.10.16) in Seoul
 - 354.2 mCi/km².day (13.1 MBq/m².day) in fallout
 - 37.8 pCi/m³ (1.4 Bq/m³) in airborne particle
 - Maximum gross beta after 5th test (1966.12.28)
 - 6032 mCi/km².day (223) in fallout
 - 235 pCi/m³ (8.7) in airborne particle
- Most severe contamination in the Korean peninsula



Radioactive Contamination by Chernobyl Disaster

- Disaster released 1/100 to 1/1000 of the total amount of radioactivity released by nuclear weapons testing during the 1950s and 1960s.
- Approximately 100,000 km² of land was significantly contaminated with fallout, with the worst hit regions being in Belarus, Ukraine and Russia. Slighter levels of contamination were detected over all of Europe except for the Iberian Peninsula.



Variation by year on radioactivity of gross beta in precipitation in Korea

26.04.1986

Radioactive Contamination by Fukushima Disaster

RADIOACTIVE PLUME

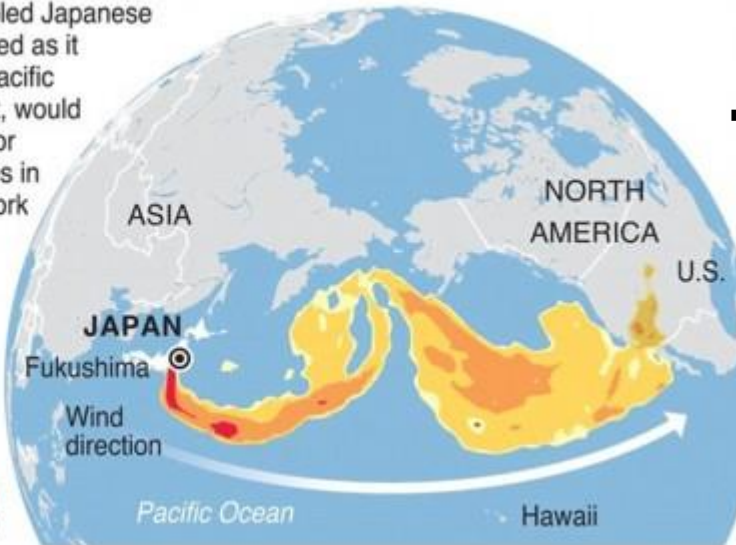
Radiation from crippled Japanese reactors will be diluted as it travels across the Pacific Ocean and, at worst, would have extremely minor health consequences in the U.S., the New York Times reported on Thursday

Forecast for Friday 0600 GMT

Relative levels of radiation (in arbitrary units)

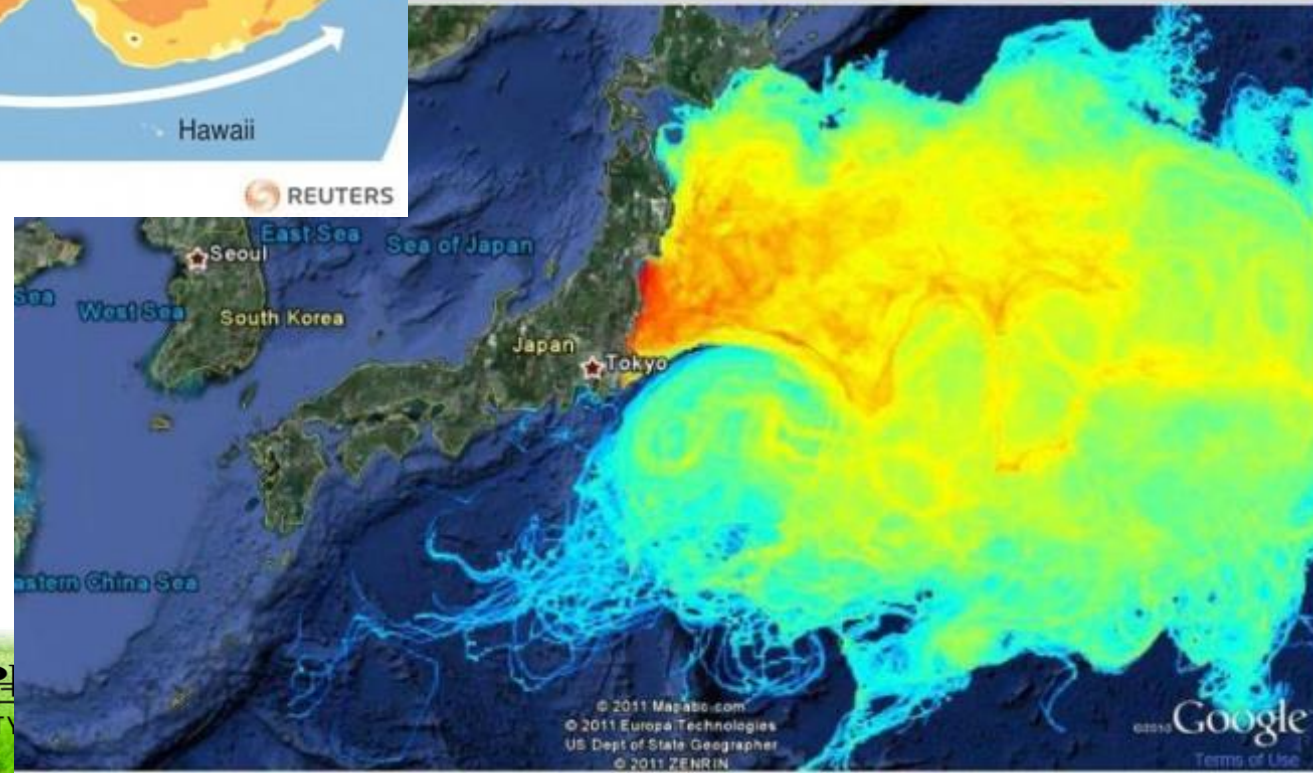


Source: The New York Times



- Maximum level of radiation detected:
 - ✓ Fuku: 72,900 mSv/h (Inside Reactor 2)
 - ✓ Chen: 300,000 mSv/h shortly after explosion in vicinity of the reactor core
- Radiation released
 - ✓ Fuku: 900 PBq "into the atmosphere in March last year [2011] alone
 - ✓ Chen: 5,200 PBq

seawater Impact Map (update: 10.08.11)



Ocean Disposal of Radioactive Waste



Country total at the major site. SU: Soviet Union (39,243TBq) and Russia (2.8TBq), GB: UK (35,088TBq), CH: Switzerland (4,419TBq), BE: Belgium (2,120TBq). US: United States of America (3,496TBq), JP: Japan (15TBq), KR: South Korea (?TBq), NZ: New Zealand (1+TBq). France (354TBq), Germany (0.2TBq), Italy (0.2TBq), the Netherland (336TBq), Sweden (3.2TBq) are within GB marker.

- From 1946 through 1993, thirteen countries (fourteen) used ocean disposal or ocean dumping as a method to dispose of nuclear/radioactive waste
- Total prohibition of disposal at sea came into force on 20th Feb. 1994
- 1st ~2nd joint expedition to the radioactive waste dumping area in East Sea in 1995~1996
- Assessment of Sr-90, Cs-137 and Pu in seawater, sediment and fish in this area



3. Environmental Radiation Monitoring System in Korea

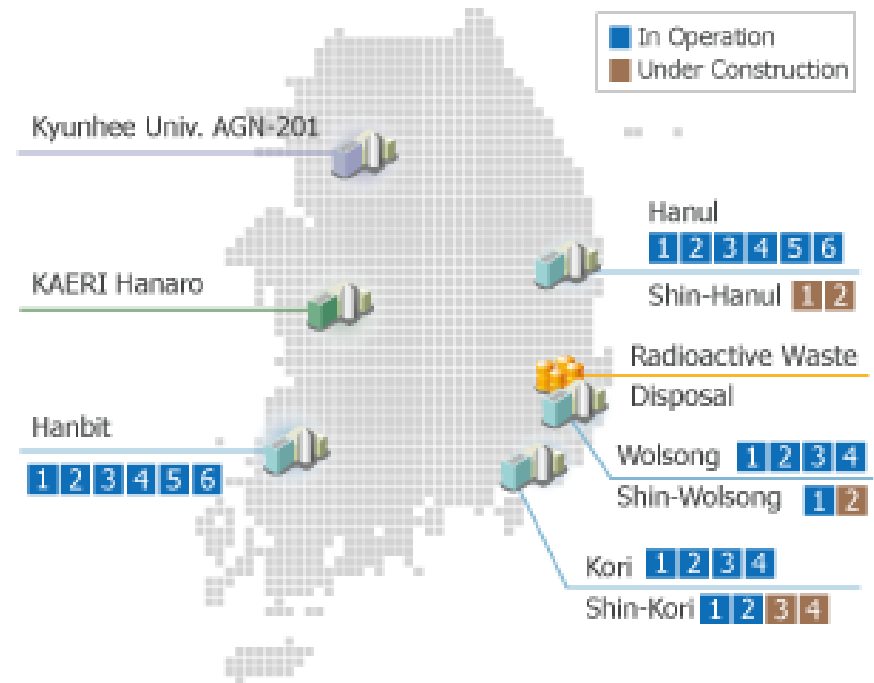
- History of environmental radiation monitoring in Korea
 - Start the radiation monitoring of gross beta analysis with 7 metrological posts (1963)
 - Inauguration of Nuclear Safety Center in 1987
 - Inauguration of the Korea Institute of Nuclear Safety (KINS) in 1990
- Major survey channel and monitoring systems in Korea
 - Continuous airborne ambient dose rate monitoring system at 128 radiation monitoring systems & operation of IERNet system
 - ✓ Central Radiation Monitoring System (CRMS, KINS)
 - ✓ Regional Radiation Monitoring System (RRMS, 14 universities)
 - ✓ Unmanned Monitoring Posts (UMP, 113)
 - Nationwide environment monitoring survey for territory (mainland, ocean)
 - Radiological surveillance around nuclear facilities

Nuclear Facilities in Korea

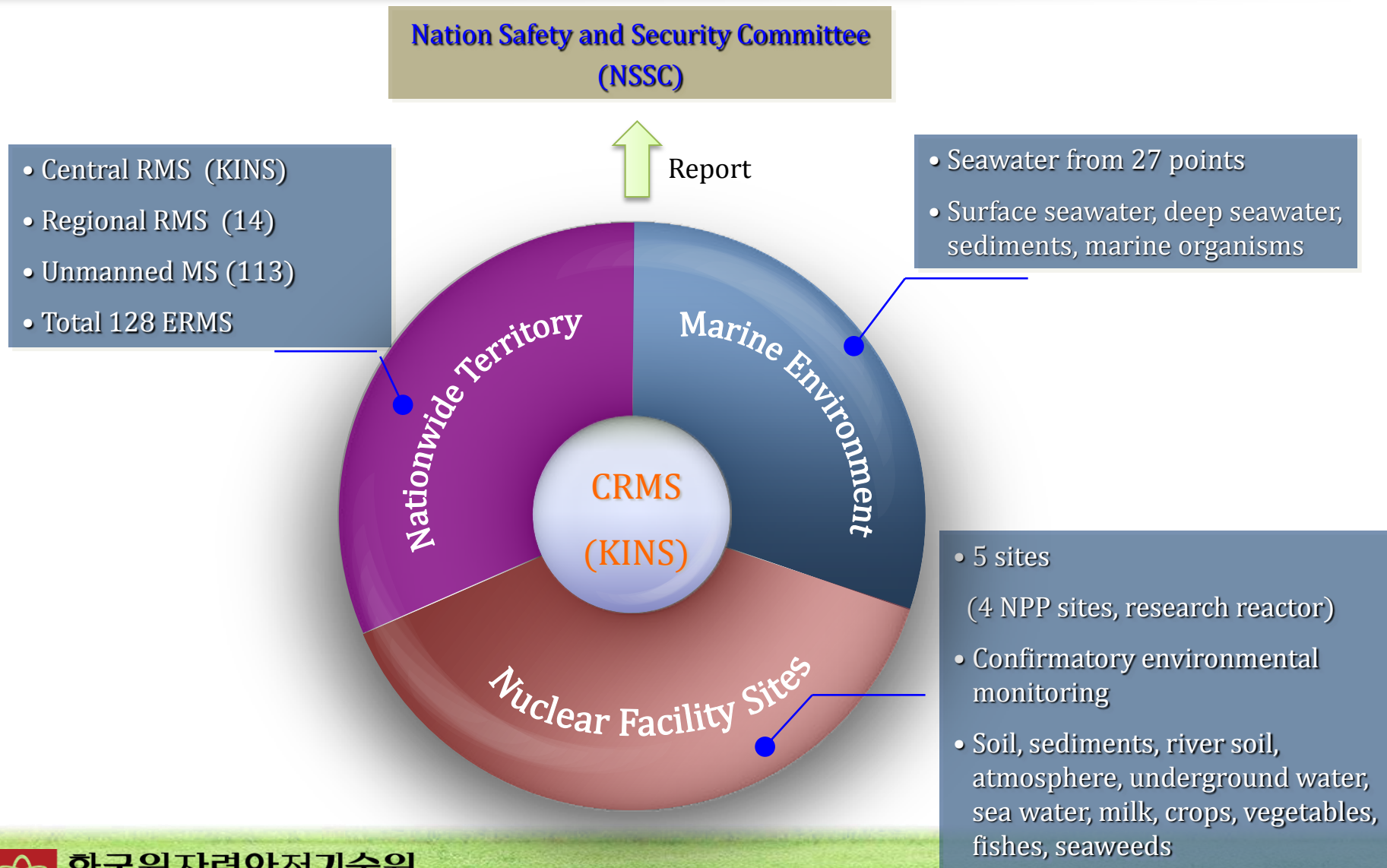
- The first commercial plant began in 1978, currently 23 NPPs in operation
- Research reactor : HANARO, TRIGA General Atomics Mark II (TRIGA-Mark II)
- KSTAR Reactor: test fusion reactor
- Nuclear fuel fabrication: KNFC(Korea Nuclear Fuel Co., Ltd.) was established in 1982 as Korea's first and sole nuclear fuel company.
- Nuclear waste disposal site



[HANARO]



Major Radiation Monitoring Framework in Korea



IERNet

Integrated Environmental Radiation Monitoring Networks (IERNet)

- Purpose: a national network of monitoring stations that regularly collect environmental radiation levels
- Functions
 - Real time on-line monitoring of nationwide environmental radiation
 - Real time publication of radiation levels via the internet
 - Early warning system with rapid notification of radiation emergencies via a short message service (SMS)
 - Functions
- Objectives
 - Normal monitoring conditions: Early detection of abnormal environmental radiation, Provides data on ambient levels of radiation in the environment
 - Radiation emergencies: Provides data for radiation emergency response assessments, Informs the general public and public officials

IERNet - Timeline

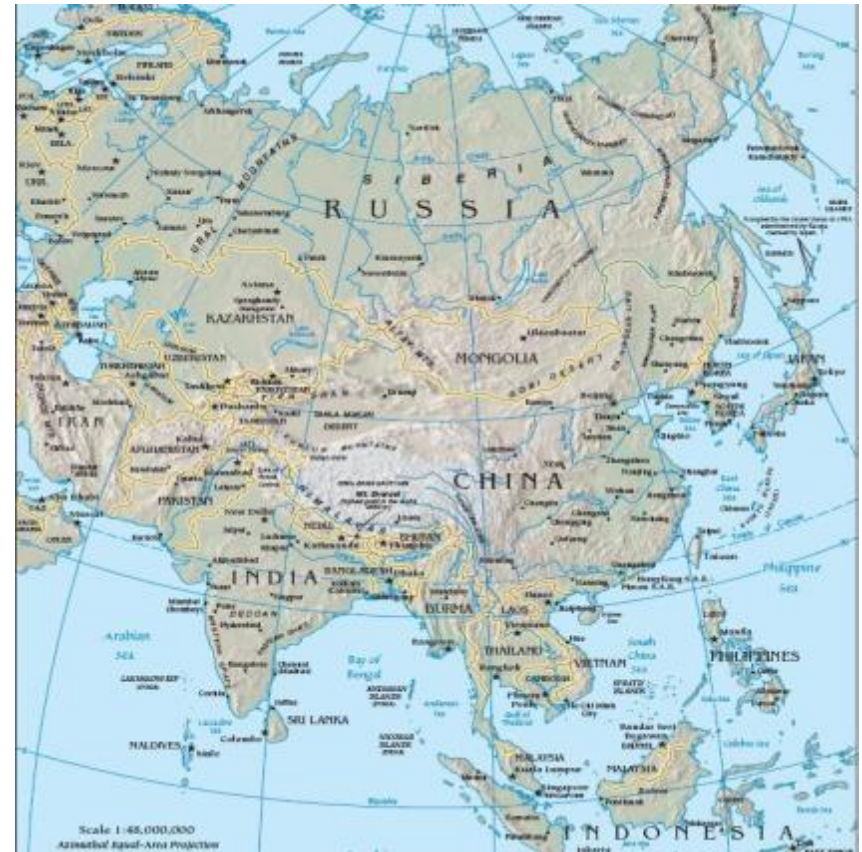
- 1967: Environmental radioactivity monitoring began with 6 stations (gross beta)
- 1983: Environmental radiation continuous monitoring (RCM) began with 2 stations
- 1990 (Chernobyl disaster) : RCM - 7↑
- 1994 : RCM - 15↑ (Radioactivity waste dumping in East sea by soviet)
- 1996 : Started to develop an automatic monitoring network
- 1997 : IERNet was completely built with 17 RCM
- 2002 : Increasing nationwide radiation monitoring stations - 37↑

Korea-Japan world cup held (preparedness for radioactivity terror)

- 2008 : Increasing nationwide radiation monitoring stations (RMS) to 70
- 2014 : RMS -128 ↑

(continuous radionuclides monitoring system for particulate airborne sample)

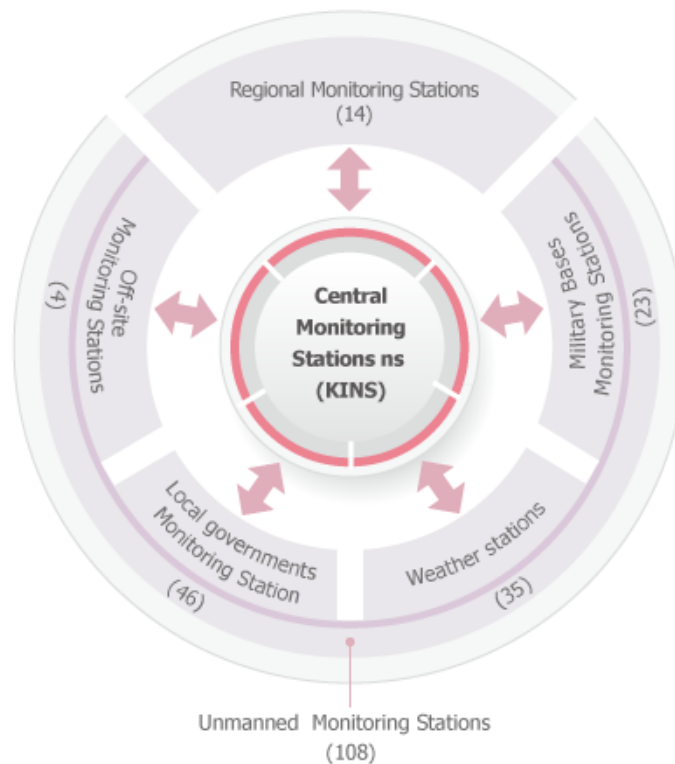
IERNet - Radiation Monitoring Stations



IERNet - Radiation Monitoring Stations

- Total 128 ERMS are running by KINS as of May 2014

Radiation Monitor Installed at	Number of position
Weather station	35
Regional monitoring station	14+1
Local government	46
Military base	23



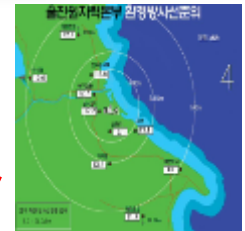
Nuclear Facilities Operators' On-line RM Networks

Sites	Facilities	ERM stations
Kori	Power Plants	11
Wolsong	Power Plants	10
Ulchin	Power Plants	10
Yonggwang	Power Plants	10
Daeduk	Research reactor	6

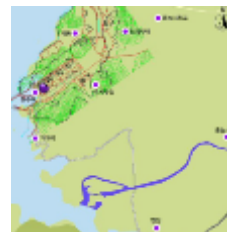
Daeduk



Ulchin

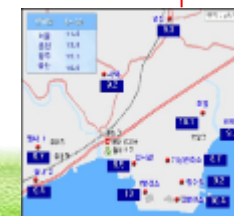


Yonggwang



Wolsong

Kori



Environmental Radiation Monitoring Stations (ERMS)



Environmental Radiation Monitor (ERM)



- High Pressure Ion Chamber (HPIC)
 - Detection Level : 0 to 100 mR/h
 - Frequency of data collection: 1sec
 - Data recording interval : up to 999999 sec
 - Data recording buffer size : up to 20000
- Preset times for monitoring radiation
 - Frequency of recording data in normal : 900 sec
 - Frequency of recording data in emergency : 60 sec
- Housing for communication unit and power supplier
- Radiation level display

Advanced ERM

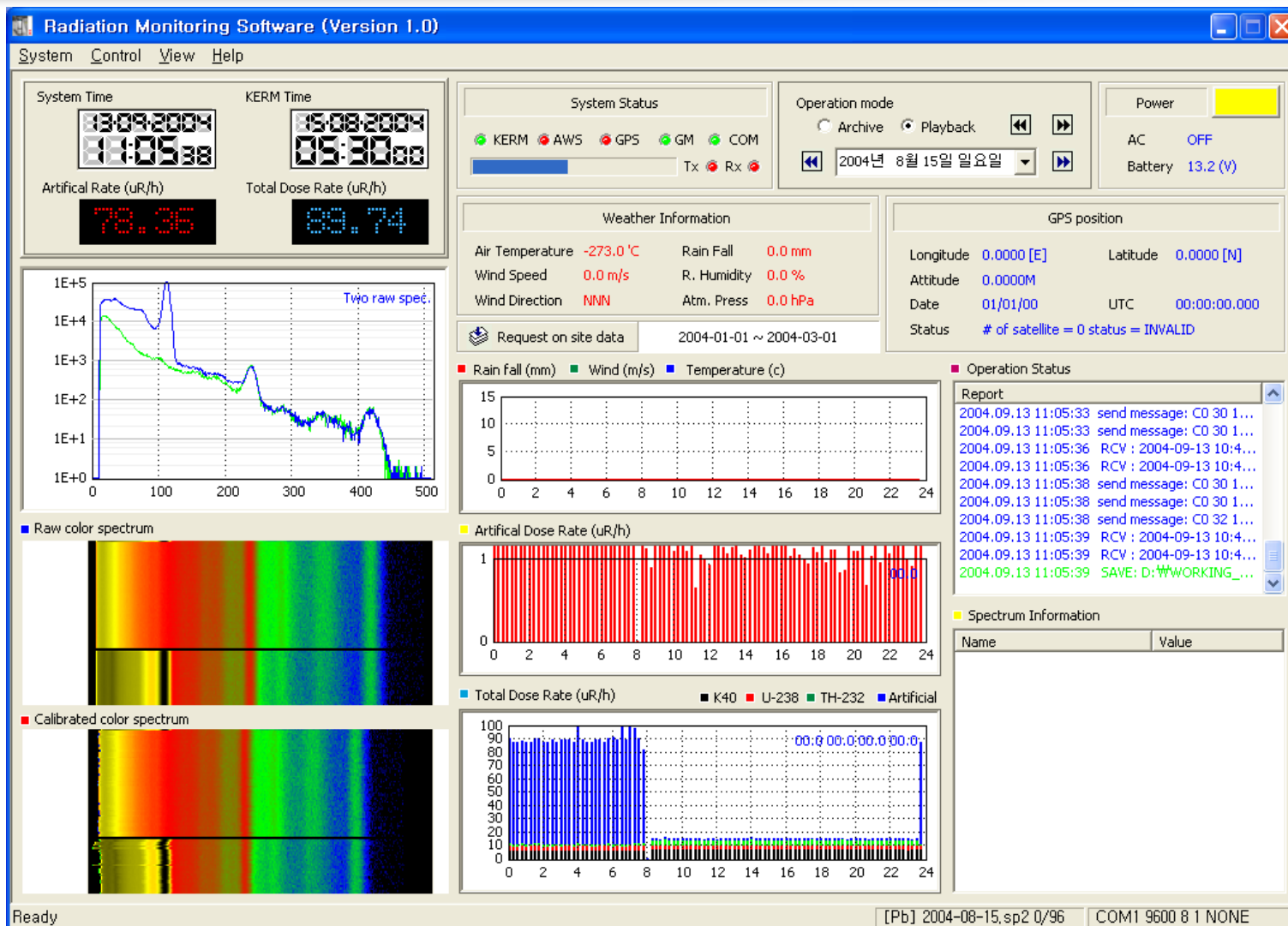
- “Channel Shift Compensation” and “Dose Rate Evaluation” for NaI Detector
- Discrimination of natural & artificial radionuclides using “Energy Band Method”
- Built-in GPS system and meteorological measurement system
- Installed around at 4 nuclear power plants



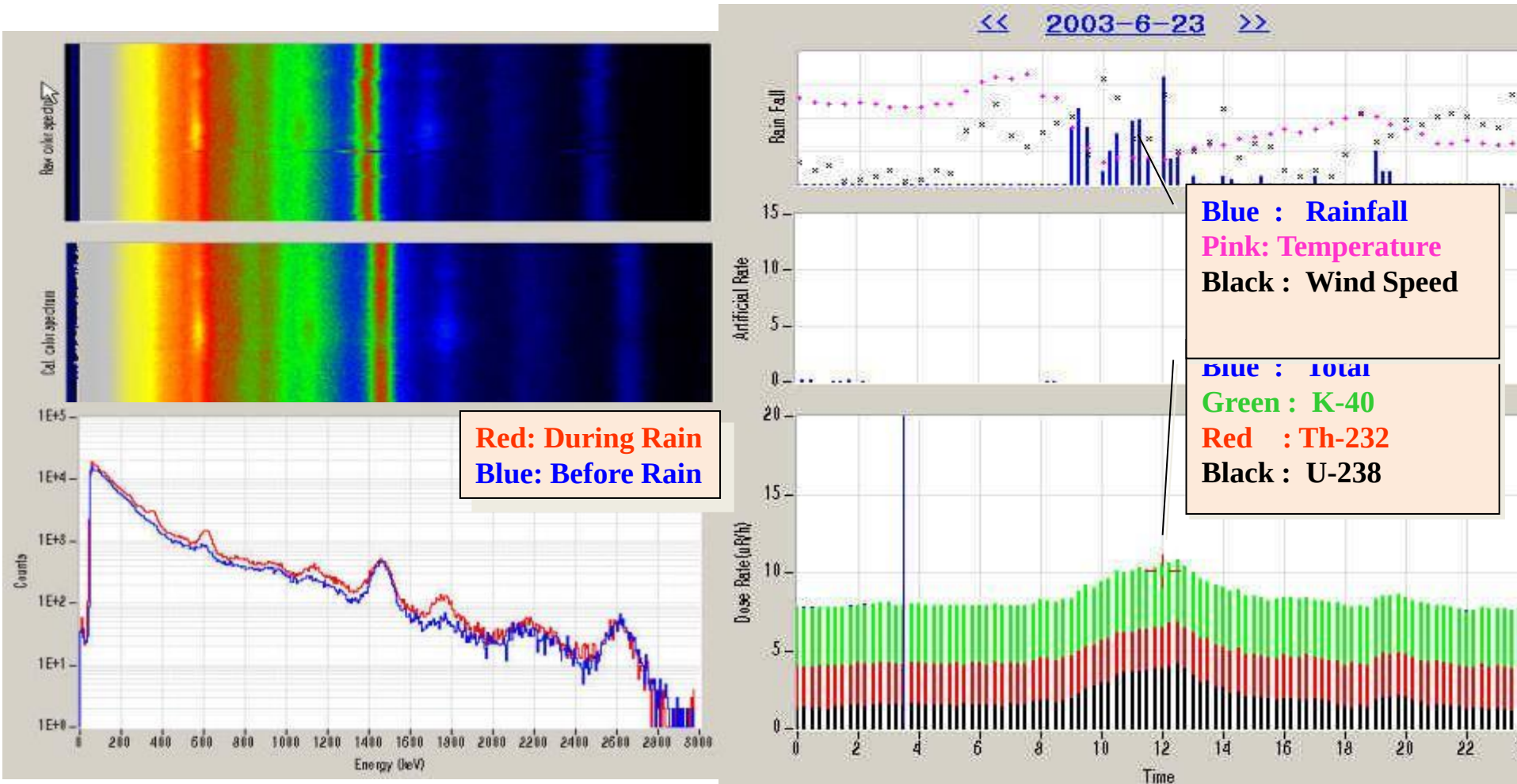
Sensors

- NaI (Tl) Detector: up to 5 mR/h
- Meteorological sensors: rainfall, temp.
- GPS: time & location

Advanced ERM Program-1



Advanced ERM Program-2



IERNet - Monitoring of Real Time Dose Rates

- Dose rates on the map
- Statistics of dose rates
- Status of radiation level
- Charts



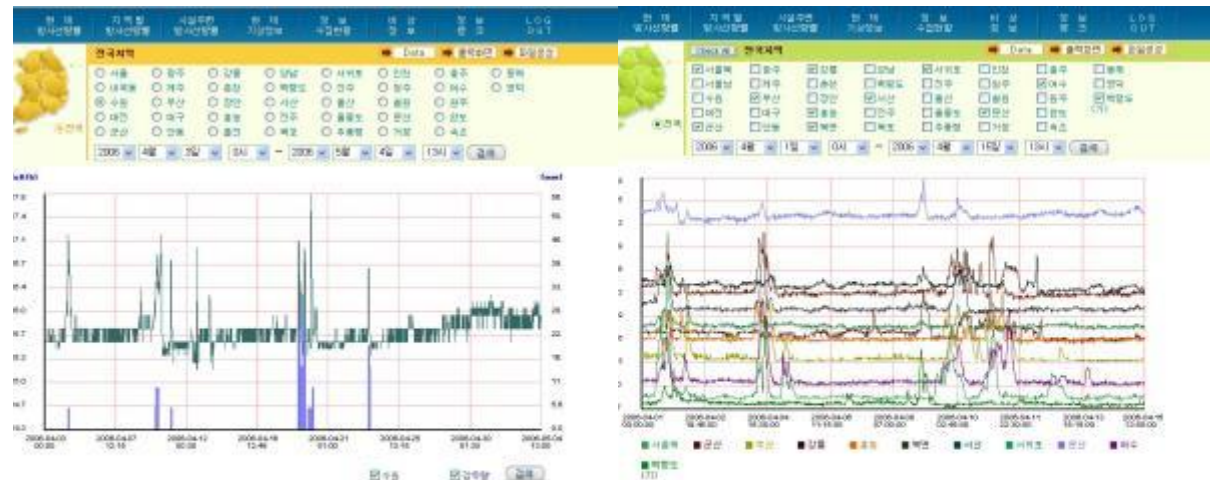
IERNet - Evaluation of Radiation Data

- Central monitoring station's IERNet server calls ERM in monitoring stations and records radiation data automatically.
- IERNet collects weather information automatically (every 10 minutes).
- Operator verifies radiation data in IERNet : compare with weather condition, advanced ERM, other stations etc.

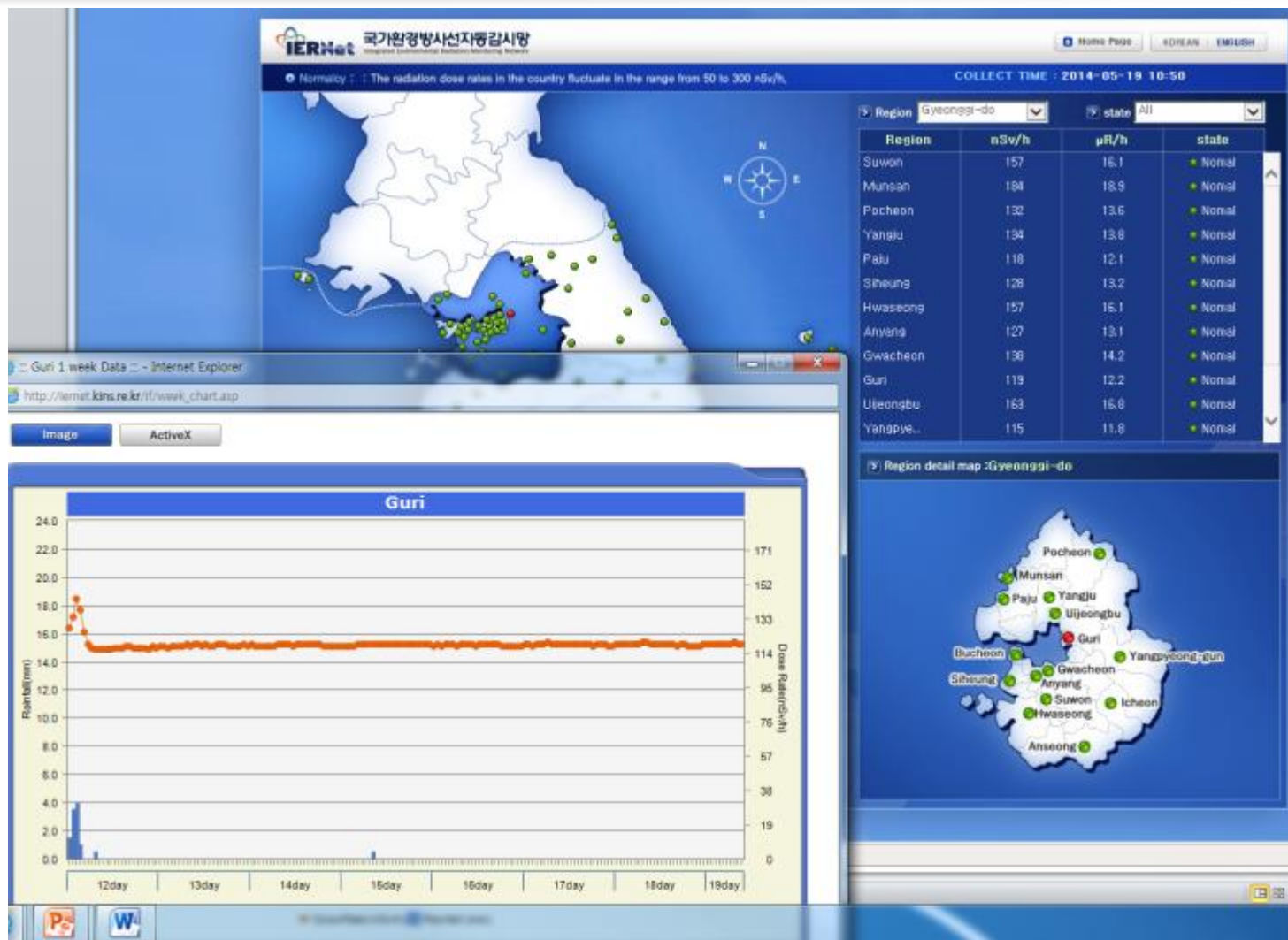
※ 실시간 전국 기상정보



수도권지역	충청	충북	충남	전북	전남	전라
속초	-999	-999	0	-999	-	-
철강	2562	15	0	0	-	-
강산	45.6	2.8	0	0	-	-
충남	3048	10	0	0	14.4	-
영남	1227	56	0	0	-	-
전남	2117	24	0	0	-	-
전북	3001	10	0	0	-	-
충청	1089	20	0	0	-	-
수원	1156	3	0	0	15.8	-
충주	41.7	2	0	0	-	-
서산	1906	30	0	0	-	-
강주	2676	20	0	0	12.8	-
대전	-999	-999	0	-999	13.2	-
숙주	2456	23	0	0	-	-
전남	2010	16	0	0	11.1	-
대전	1891	41	0	0	14.3	-
대구	3048	20	0	0	11.4	-
전주	609	7	0	0	-	-
충남	2209	13	0	0	-	-
강주	2677	19	0	0	12.3	-
목포	-999	-999	0	-999	-	-
여수	2065	5	0	0	-	-
강도	1150	23	0	0	-	-
제주	-999	-999	0	-999	8.5	-
서귀포	3011	1	0	0	-	-
진주	2306	11	0	0	-	-
영덕	2657	30	0	0	-	-
거북	3015	5	0	0	-	-
서해	1557	14	0	0	12.3	-
강릉	1159	30	0	0	11.7	-
백령도	1933	53	0	0	3.4	-
내곡동	1951	10	0	0	14.4	-
종로	1014	13	0	0	11.7	-

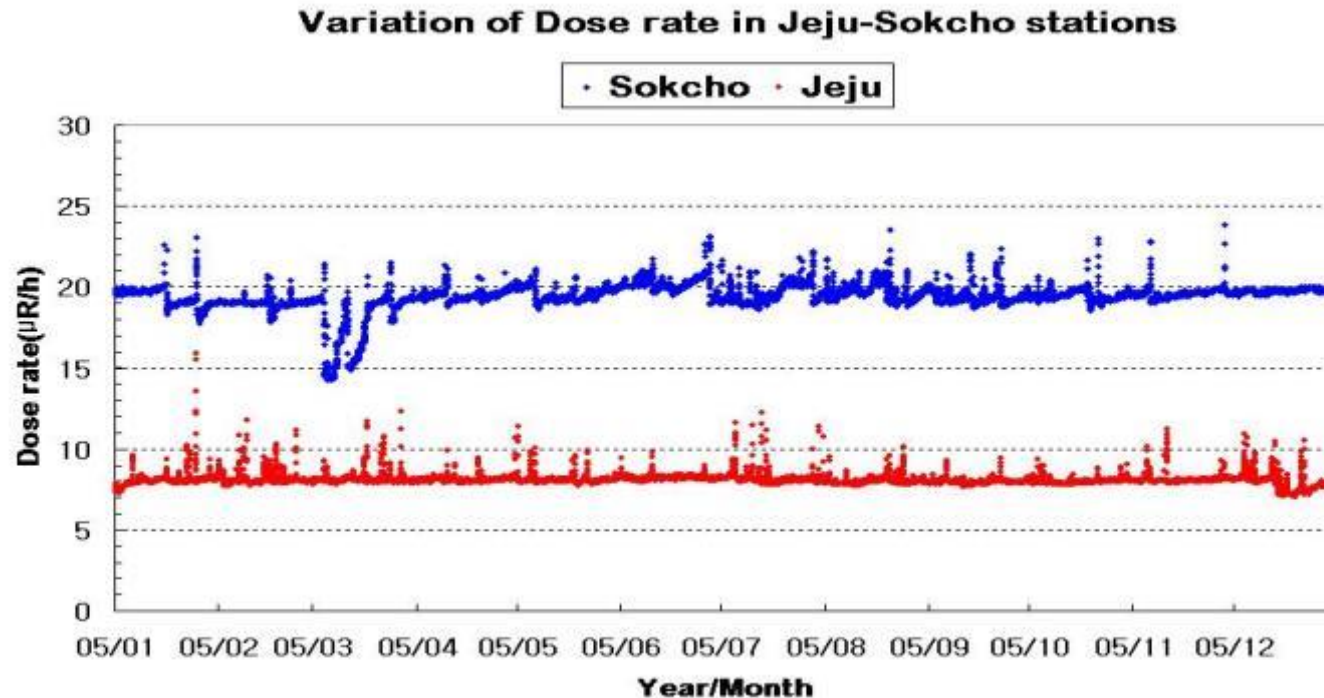


IERNet –Homepage (Eng. Version)



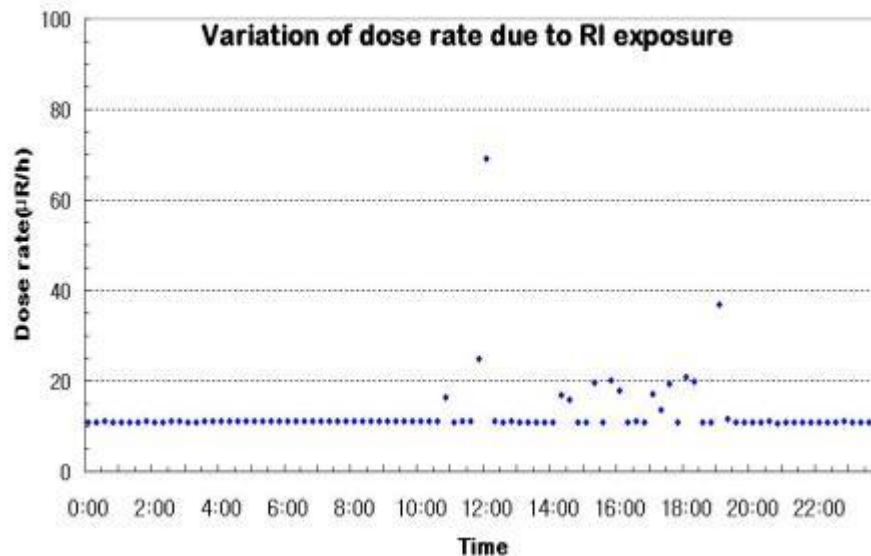
Different Dose Rate with Location

- Radiation levels difference with composition in the ground
 - Sokcho station : granite (very old rocks)
 - Jeju station : Igneous rocks (eruptive rocks)
- Other factors: weather (rain, snow, wind etc.)



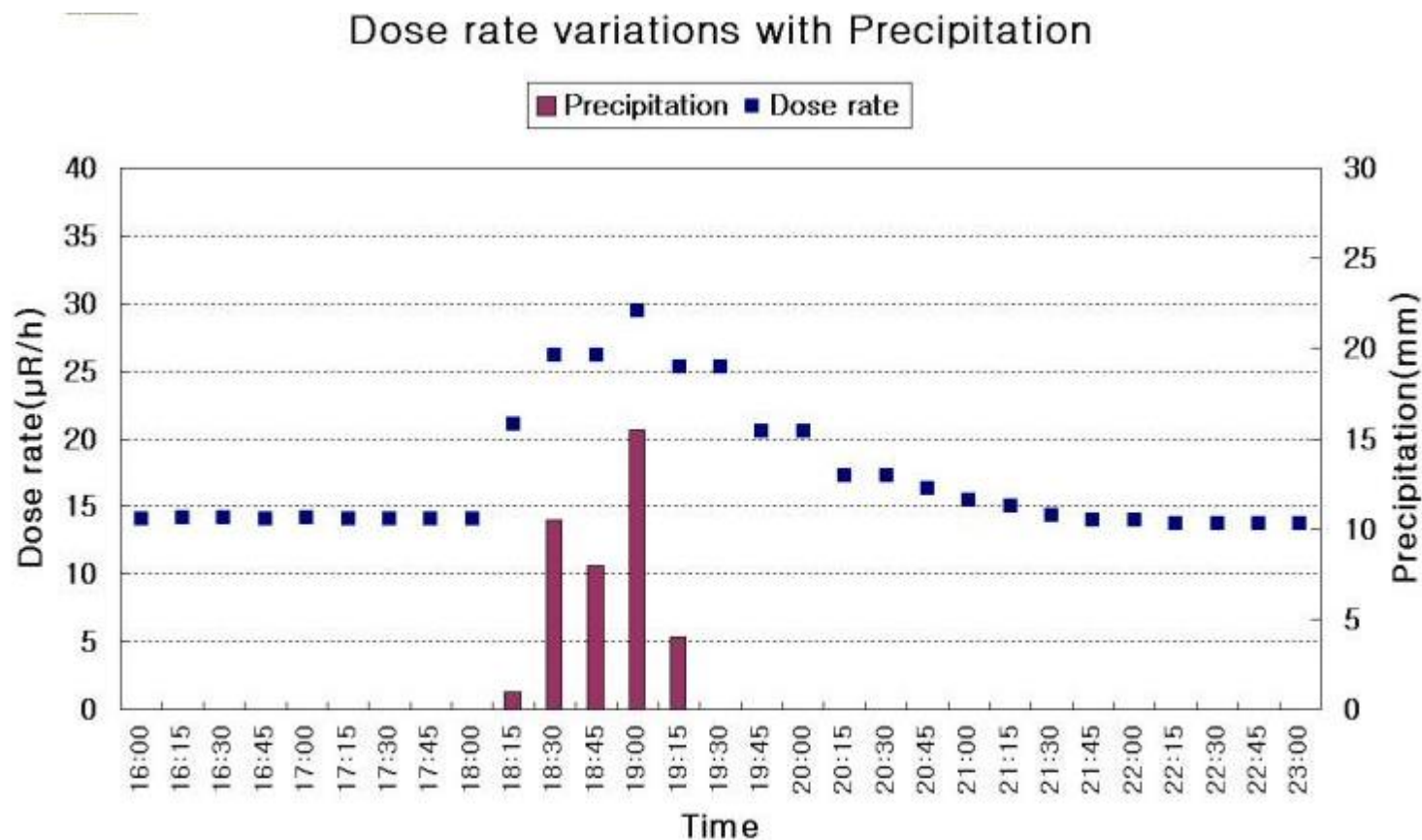
Variation of Dose Rate

- Comparison between natural and artificial radiation
 - Due to radioactive isotope : increasing and decreasing rapidly
 - Due to rain : slow change increasing and decreasing slowly

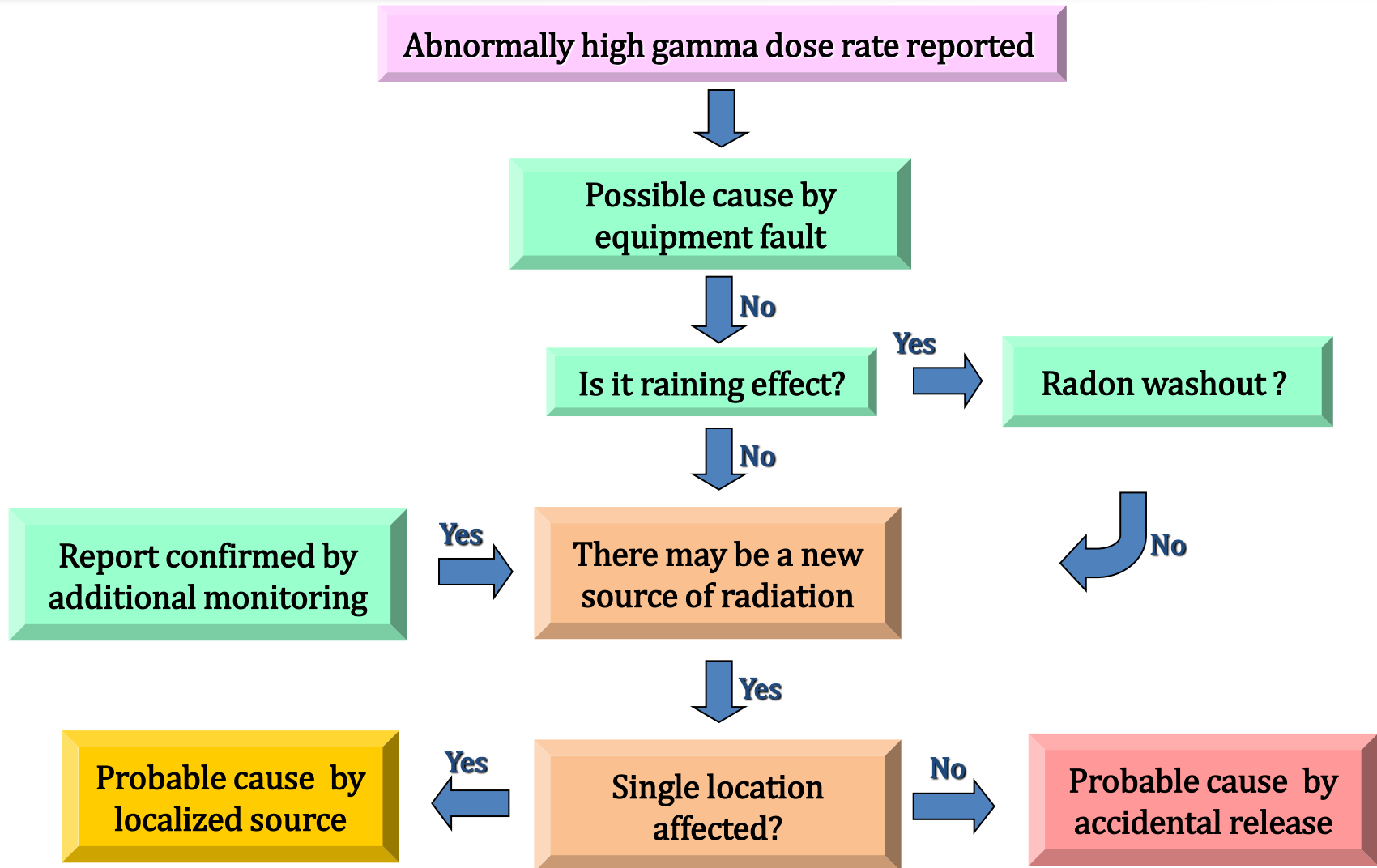


Comparison between Natural and Artificial Radiation

- Due to unknown radioactive isotope : rapid change
- Due to rain : slow change in rate



Investigation Protocol of Abnormal Radiation Level



IERNet - Management Program

- Local system maintenance
 - Automatically check the conditions of system units at monitoring stations
- Early warning system with SMS-mail
 - Radiation high : higher than (average + 10 uR/h)
 - System fail : CPU, A/D, Battery, data memory
 - Communication fail

The image displays three screenshots of the IERNet web management program interface, accessed via Microsoft Internet Explorer.

Left Screenshot: System Status Overview
 The main menu includes: 현재 IERNet, 정보 수집 현황, 환경방사선량 검색, 기상정보, 관리지, 정보링크, 사용자정보, 관리정보 Link, IERNet 홈페이지, and SYSTEM MAP.
 The '현재 IERNet' section shows a table of system units with columns for location, time, and various status indicators (CPU, A/D, Alarm, etc.).

Middle Screenshot: Maintenance Log
 The '정보수집(확선)정보' section displays a table of system maintenance records, including columns for location, time, and status.

Right Screenshot: SMS Alert Log
 The '알림통보' section shows a table of SMS alerts, including columns for key, time, location, and status.

Publication of the IERNet Data

- Nation Safety and Security Committee (NSSC) in Government : on the graphic situation monitoring panel in NSSC
- Public : via internet (<http://iernet.kins.re.kr>)



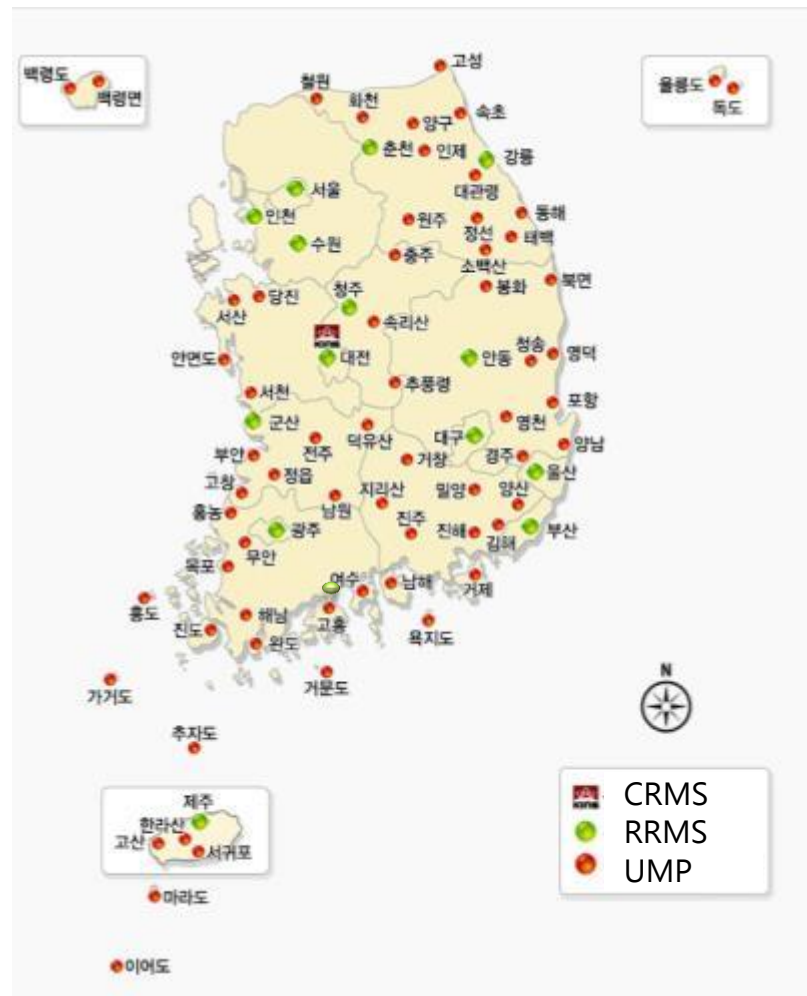
지 역	현재 방사선량 (μR/h)	지 역	현재 방사선량 (μR/h)	지 역	현재 방사선량 (μR/h)
서울특별시	12.2	강원	10.4	안산	10.6
수원	15.6	충북	12.0	철원	13.0
대전	12.5	대전	15.8	서산	13.2
광주	12.6	안남	10.4	간성	12.2
부산	10.6	북양도	7.4	북포	12.0
인천	11.2	양성	10.5	사리동	8.2
충남	13.4	동대	10.0	간성	10.9
광명	11.5	사수	19.7	충남	11.2
대구	11.0	안동	11.1	충북	11.0
청주	12.6	충주	12.9	충북	10.0
제주	7.9	대주	9.2	인천	10.4
군산	13.9	충주	14.1		
서포남	15.1	거창	10.9		

※ 일반적으로 공기 또는 기압이 높고 맑은 날 방사선량 측정치가 낮아짐. 이는 환경보시의 정확(2000년) 자체로 일 700~800에 강수로 인한 Washout효과(강수) 현상과 기상현상(대기) 때문이며 대개 700에 강수 현상으로 500~600의 강수 현상과 강수로 인한 방사선량이 증가하는 경우가 많음. 기상현상(대기) 현상과 방사선량 측정치 변동은 대개 5에서 30 μR/h 정도까지 낮아지고 있다.

대한방사선 측정기구 구성품 '방사선' 대한 방사선 측정기 사양서 114호 한국원자력안전기술원 (TEL042-888-0033 FAX042-888-0056 Copyright 2000~2002 by KINS. All rights reserved. Mail to Webmaster)

Role of CRMS and RRMS

- **Central Radiation Monitoring System (CRMS, KINS)**
 - Sample: Airborne particle, fallout, washout deposit, precipitation, milk, seawater, marine organism, sediment, etc.
 - Analysis items: H-3, C-14, Sr-90, gamma radionuclides, accumulated gamma dose by thermoluminescent dosimeters (TLDs), Pu, U, Tc-99, I-129
- **Regional Radiation Monitoring System (RRMS, 14 universities)**
 - Airborne particle, fallout, washout deposit, precipitation, soil, agricultural stuff, indicator plants
 - External gamma radiation dose rate, gross beta, gamma radionuclides



Infrastructure at CRMs for Radioactivity Measurement

■ Labs

- Sample receipt & drying and ashing room
- Seawater pretreatment lab.
- Gamma spectrometry analysis room
- Low alpha beta counting room
- Sample screening room
- Alpha analysis lab.
- Sr-90 lab.

■ Measurement & sampling system

- Radiometric system: HPGe detector (15), LSC (4), alpha beta counter (3) alpha spectrometry (3 set), Rn counting system, TLD reader
- Mass spectrometry: ICPMS (multi collector, sector, quadrupole)
- Noble gas detector: Xe monitoring system
- In-situ gamma spectrometry
- Environmental samplers

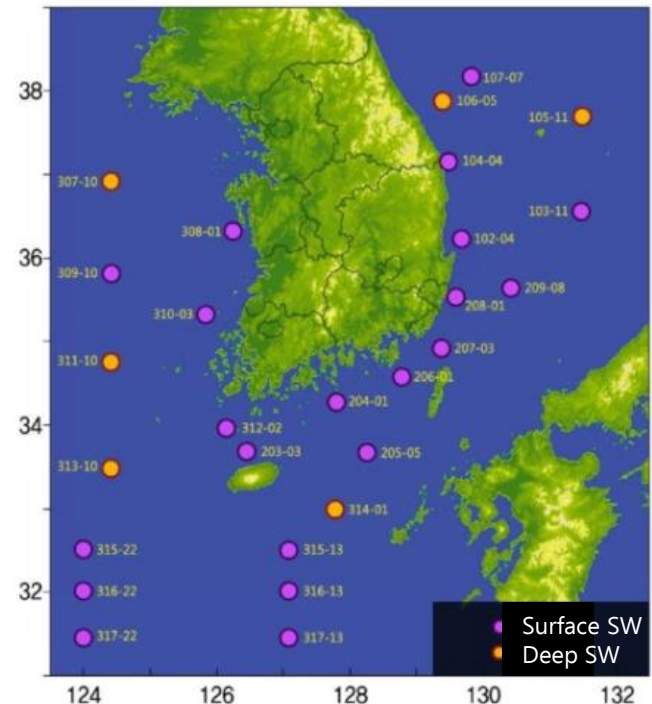
Marine Environmental Surveillance

- Purpose: evaluate the distribution and the fluctuation of environmental radioactivity level (base on the Korea Atomic Safety Law 105)
- Mainly to protection of public health as well as preservation of environment from the radioactivity events in Korea and other country
- It was enforced in 2013 to examine the marine contamination initiated by the leak of radioactive storage water at Fukushima in Japan
- Sample: Surface seawater, deep seawater, sediments, marine organisms
- Analysis items: H-3, Sr-90, Cs-137, Pu-239+240, Pu-240/Pu-239 atomic ratio

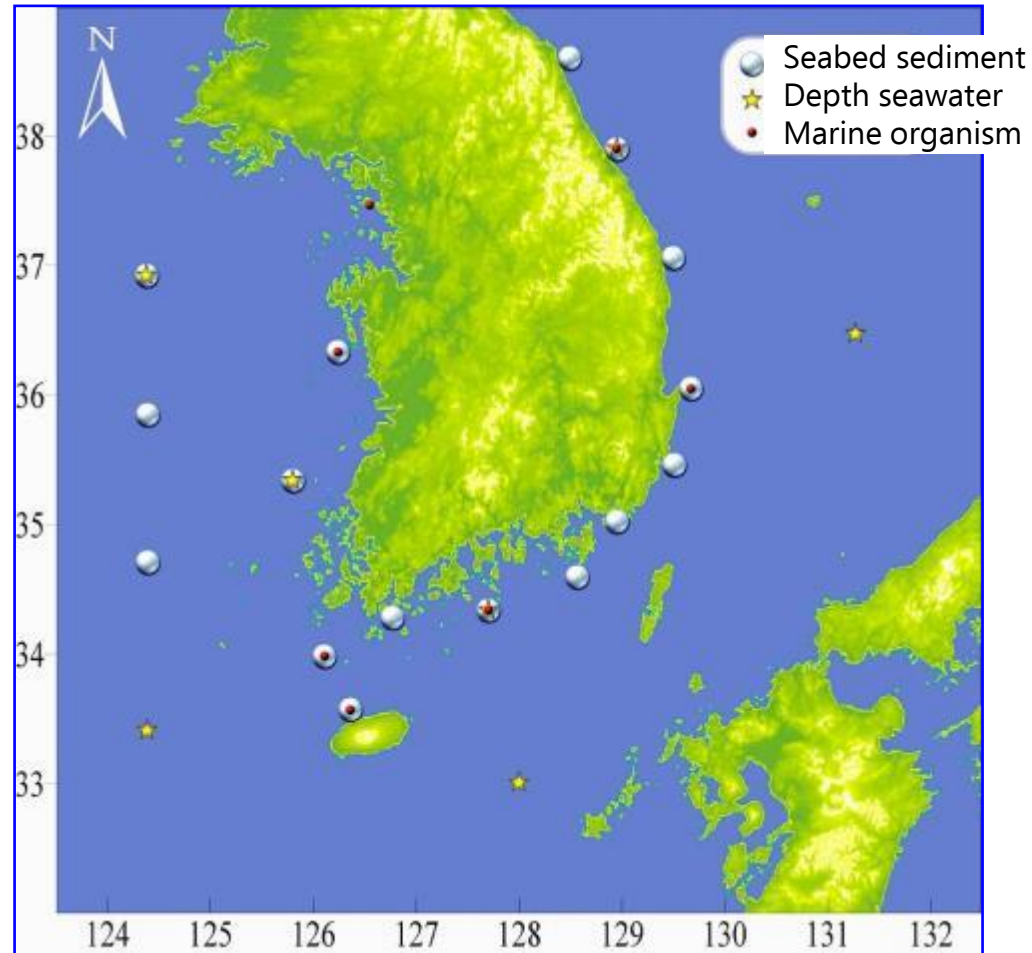
Marine Environmental Surveillance Program

Enforced surveillance program after Fukushima disaster

Sampling		Before Accident	'2011 (accident)	'1212~1213
Seawater	Sampling points	21 points	10-44 points	27-33 points
	Collection Frequency	2/year	Monthly	4/year
Marine organism	Sampling points	7 points (14 fishes)	87points (87 fishes)	87 points
	Collection Frequency	2/year	During year	During year



Sampling Points in Marine Samples



Marine Surveillance Result in 2013

- Cs-137 concentration in seawater in 2013: <DL ~ 2.35 mBq/L

'2013	Sample no.	^{134}Cs (mBq/L)	^{137}Cs (mBq/L)
1/4 quarter	27	< MDA	< MDA ~ 1.87
2/4 quarter	47 (with depth)	< MDA	< MDA ~ 2.35
Since Sept.	22 (East china se, Ulrunng island)	< MDA	< MDA ~ 2.66

※ Conc. range for 5 years before Fukushima: ^{134}Cs : <MDA, ^{137}Cs : <MDA ~ 4.04 mBq/L

- Cs-137 concentration in fish

Year	Sample no.	^{134}Cs (Bq/kg)	^{137}Cs (Bq/kg)	^{40}K (Bq/kg)
2013	62	< MDA	< MDA - 0.174	18 - 118

※ Conc. range for 5 years before Fukushima: ^{134}Cs : <MDA, ^{137}Cs : <MDA ~ 0.184 Bq/kg

4. Radicochemical Analysis of Environmental Samples

- **Gamma radionuclides**
 - Drying and ashing for biological sample
 - Co-precipitation with AMP or MnO_2 for seawater or ground water
 - Packing in measuring sample vessel (specifically designed plastic sample holder)
- **Beta radionuclides in routine analysis**
 - Sr-90
 - ✓ Chemical separation
 - ✓ Measurement by LSC using Cherenkov light
 - H-3, C-14
 - ✓ From air, biological, water sample
 - ✓ Extraction, Conversion to carbonate form
 - ✓ Measurement by LSC
 - Cs-137, Tc-99, I-129
 - ✓ Chemical separation
 - ✓ Gas proportional alpha beta counter for Cs-137, Tc-99 and LSC for I-129
- **Alpha radionuclides in routine analysis**
 - Total Pu-239+240, Pu atomic ratio
 - U isotopes (U-234, 235, 238)
 - Am-241 or Np-239
 - ✓ Chemical separation
 - ✓ Mass spectrometry or alpha spectrometry

Environmental Sampler at CRMS



Automatic wet & dry
Deposition collector



Precipitation collector



High volume air sampler



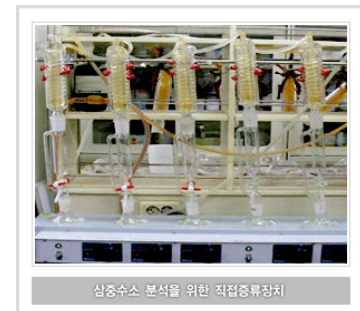
Low volume air sampler

Non-radiometric Measurement System

- **Non radiometric system – mass spectrometry**
 - Fast measurement and low detection limit
 - Detection of ions counts instead of radiation
 - Radionuclide with long half live but close radiation energy can be detectable
 - Strong advantage in measurement of isotopic ratio (Pu-240/Pu-239, Pu-241/Pu-242, U-235/U-238)
 - Pu detection is feasible even in the 20L of seawater
 - Expensive instrument and run by experienced operator
 - Installed in the clean room



Sample Pretreatment and Chemical Separation



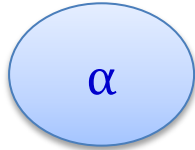
■ Purpose of pretreatment

- Concentration of target radionuclides
- Simplify sample matrix
- Procedures: ashing, evaporation, filtration, co-precipitation, electrolysis

■ Chemical separation and purification

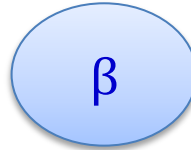
- Separation of interference material
- Avoid the self attenuation
- Shaping of final measuring sample for detector geometry
- Procedures: distillation, conversion of chemical form, coprecipitation, column separation, solvent extraction, electro-deposition, dissolution, milking

Measurement



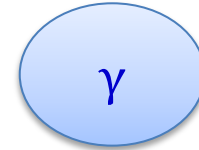
**Pu, U, Th,
Ra, Rn**

Alpha-spectrometer
MC-ICP-MS



**H-3, C-14,
Sr-90**

LSC
Alpha/beta counter



Cs-137, Cs-134

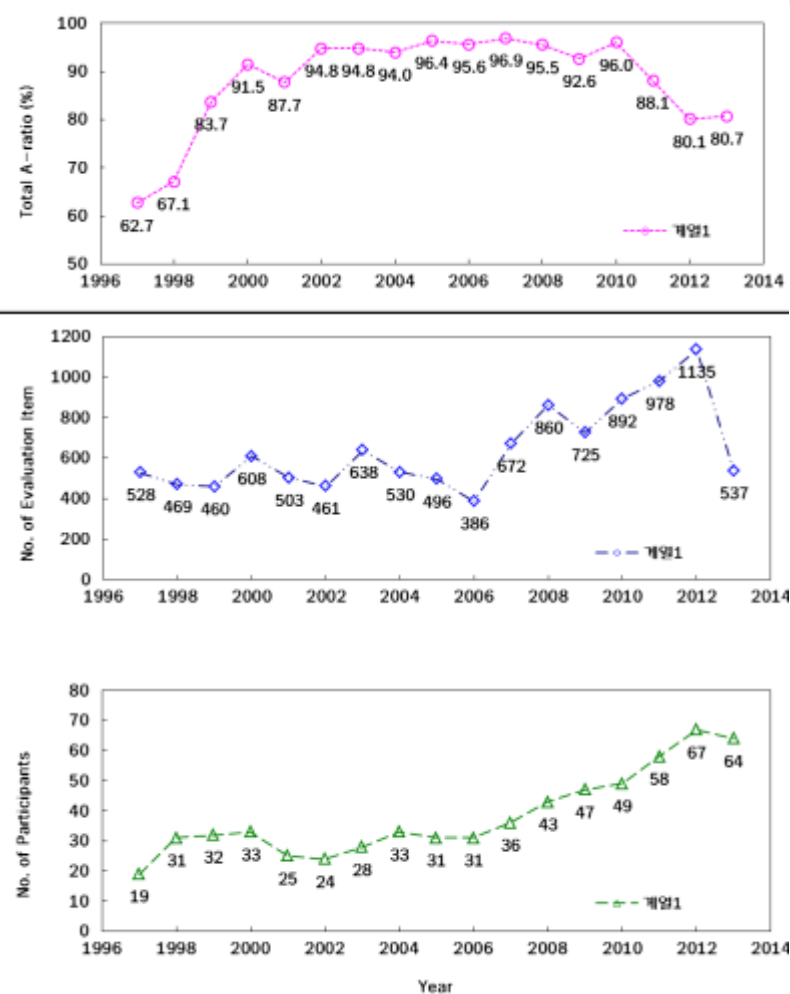
Gamma-spectrometer



Quality Control Activity of CRMS (KINS)

- Role of domestic quality control tower in radiation monitoring lab.
 - It was started in 1997 for QC of RRMS
 - Radionuclides: gross beta, gamma radionuclides, Sr-90, H-3, Pu, U for spiked solution and environmental samples
 - Participation of total 64 lab. in 2013
 - * Exercise for in-situ gamma spectrometry measurement was started in 2013
- QC activities in abroad
 - Intercomparison with Japan (Japan Chemical Analysis Center: JCAC) since 1991
 - Regularly participation in the proficiency test organized by IAEA
 - Participation in intercomparison exercise organized by environmental measurement lab (EML) for 7 times
 - 4 times intercomparison with China (Radiation Monitoring Technical Center, RMTC)
- Cooperation with IAEA
 - Assigned as a Asia Pacific “Collaborating Center” for enhancing the reliability and comparability of measurement results obtained by nuclear analytical techniques in member state lab. by IAEA

Domestic Quality Control Results



“A” ratio (top) and items number (middle) in evaluation, and exercise participation labs (bottom) since 1997

Intercomparison Program between KINS and JCAC in 2012~2014

Samples	Cumulative dose	γ -ray nuclides	^{137}Cs	^{226}Ra (LSC)	^{239}Pu ^{240}Pu	$^{240}\text{Pu}/^{239}\text{Pu}$ Atomic ratio	^{237}Np
Soil		●			●	●	●
Phosphogypsum		●		●	●		
Seawater			●				
TLD	●						
Measurement using in-situ Ge detector at JCAC and in Jeju island in Korea, if possible.							