



The 2nd Meeting of the ASEAN Network on NPSR



Thailand, 15-17 March 2018

Dispersion of Radionuclides Released from Fukushima Daiichi Nuclear Accident

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- 1) *New Situation in Vietnam*
- 2) *Atmospheric Dispersion for Radionuclides from FDN Accident*
- 3) *Results of Simulations for Fangchenggang and NT1 NPPs*
- 4) *Concluding Remarks*

1. The New Situation in Vietnam

- 1) The NPP projects (Ninh Thuan 1 and Ninh Thuan 2 NPP projects) have been cancelled (November 2016)
- 2) New Chinese NPP units (8 units) operate close to Vietnamese border (about 300 km to Hanoi)
- 3) China has launched a new program related to Floating NPPs (FNPPs) which can be used for disputing islands
- 4) Renewable energy becomes a focus of Vietnamese Government (however, many difficulties have been arisen)
- 5) Thermal Power Plants (TPPs) are facing with big difficulties related to public acceptance

1. The New Situation in Vietnam



The Main Focus for Vietnam Currently:

- 1) Reactor physics (Neutron Kinetics – N/K), nuclear physics (relevant to the new Research Reactor – RR project) – the Center for Nuclear Energy Science and Technology – CNEST; **Relevant research around the new RR**
- 2) Thermal Hydraulics (T/H), safety analysis/ assessment
- 3) Radiation dispersion calculation and simulation (the Radiation Monitoring and Emergency Warning System – **RMEWS** project)
- 4) Non-Destructive Evaluation techniques; Seismic designs
- 5) Risk and Safety Study Center (RSSC/CNEST) etc.

1. The New Situation in Vietnam

Nuclear Power Plants in China



Source: World Nuclear Association

2. Atmospheric Dispersion for Radionuclides from FDN Accident



Parameter	Value
FLEXPART Version	FLEXPART v9.02, FLEXPART MPI
Operating system	RHEL Server 5.5, CentOS Server 6.5
Radionuclides	^{131}I and ^{137}Cs
Meteorological data	NCEP CFSv2, $0.5^\circ \times 0.5^\circ$
Time of simulation/ Time of release	15h00 11/3 - 00h00 20/4/2011 UTC
Latitude/ Longitude	37.4214, 141.0325
Total number of particles to be released	~10 million particles
Mixing height	0-500 m
Output layer height	0-1500 m (850 hPa)
Observed data	Vietnam, Japan and CTBTO stations

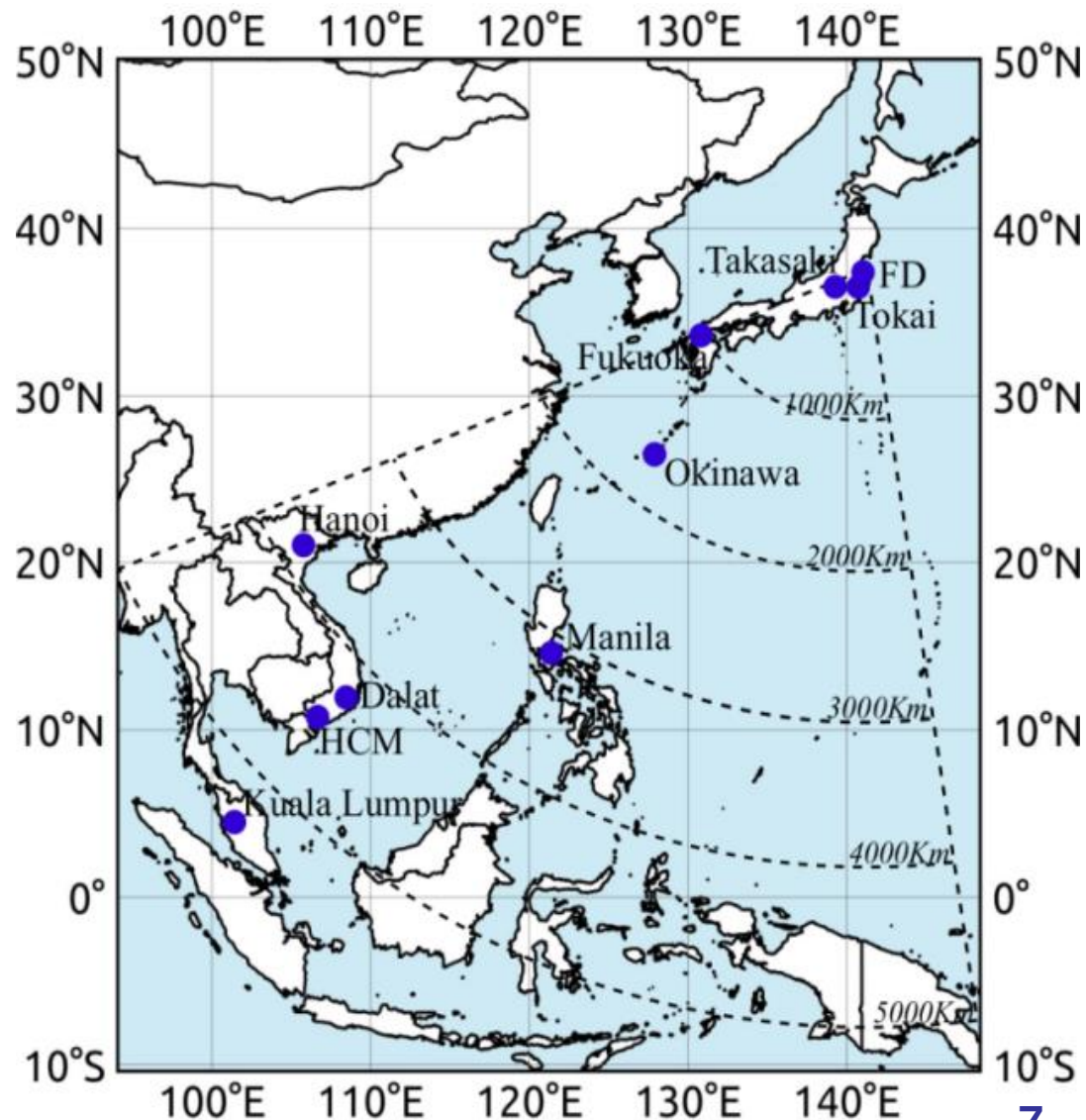
Map of monitoring stations of Vietnam, Japan and CTBTO

Vietnam: Hanoi, Dalat and HCM stations

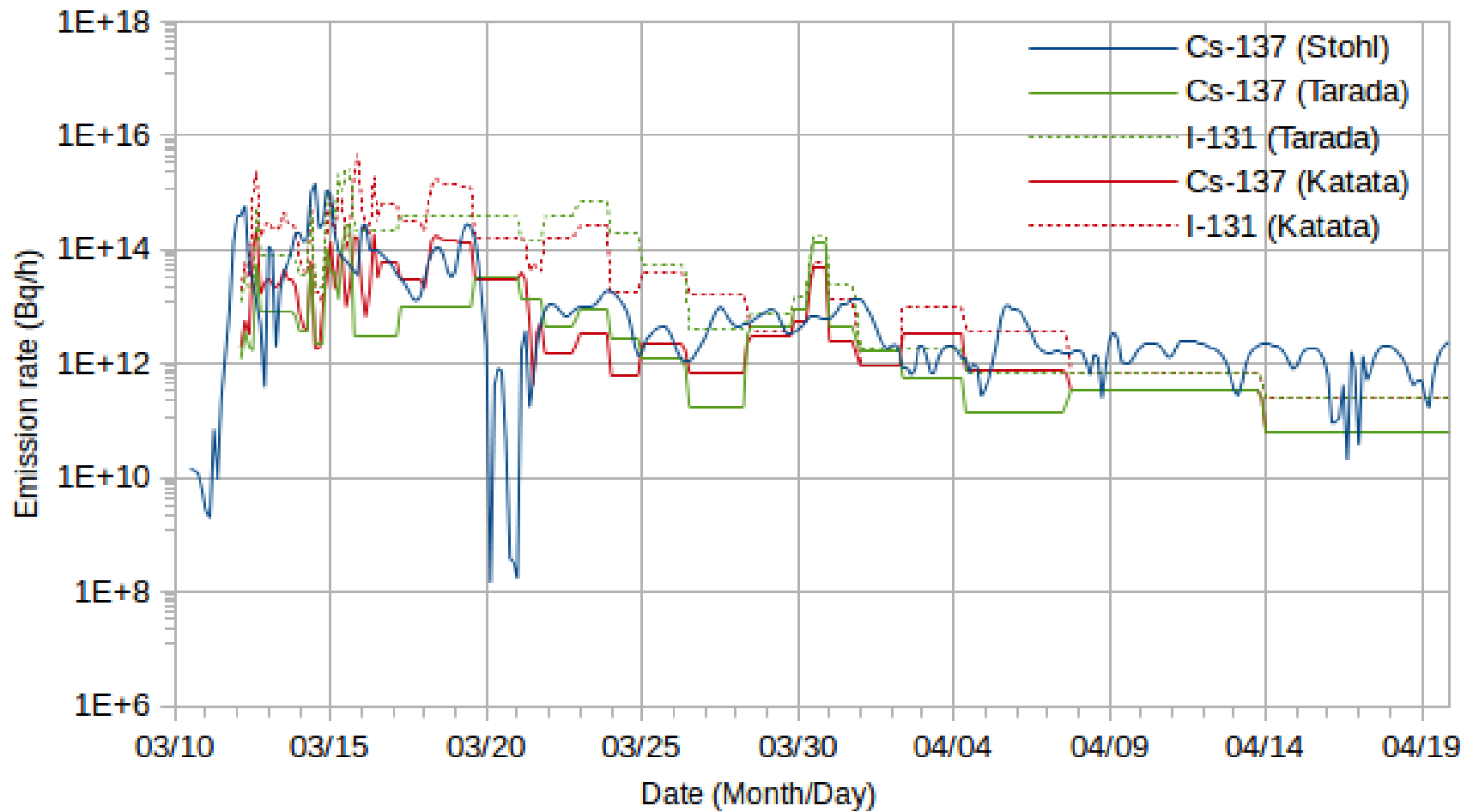
JAPAN: Tokai and Fukuoka stations

CTBTO: Takasaki, Okinawa, Manila, and
Kuala Lumpur stations

FD is the location of the Fukushima Daiichi
nuclear power plant



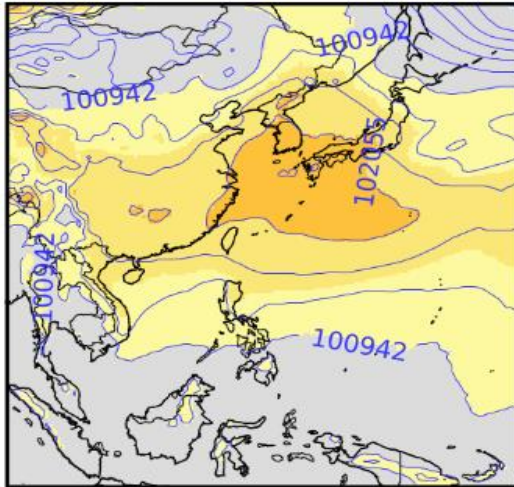
Emission Rate (Bq/h)



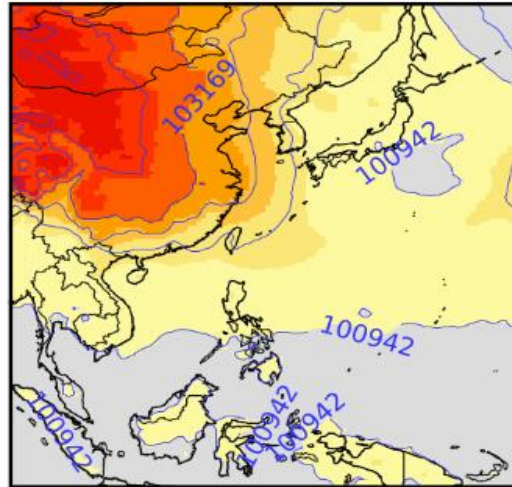
Atmospheric pressure during the Fukushima Daiichi nuclear accident

Pressure @ Mean sea level [Pa]

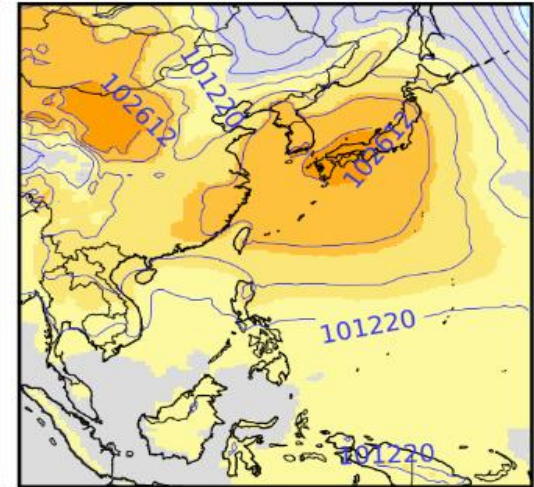
a) 2011/03/11 12:00 UTC



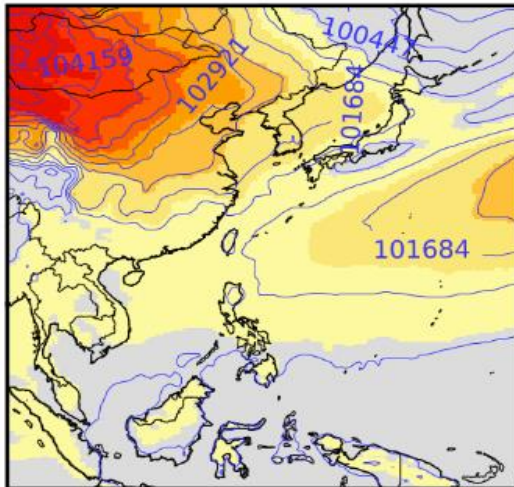
b) 2011/03/15 00:00 UTC



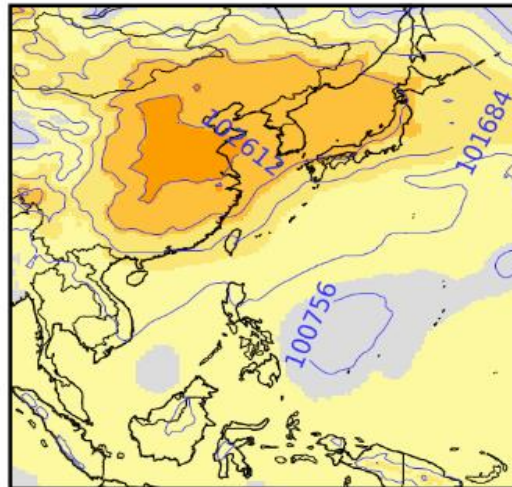
c) 2011/03/18 00:00 UTC



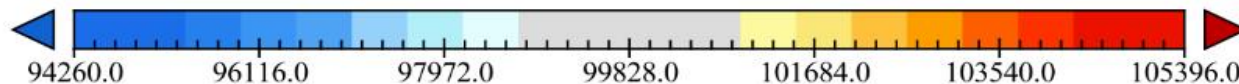
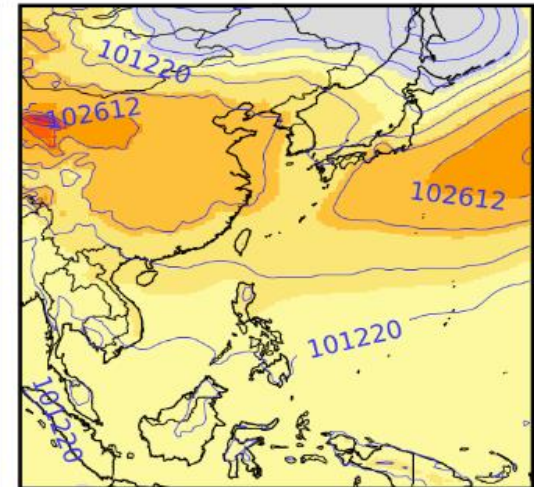
d) 2011/03/21 00:00 UTC



e) 2011/04/04 00:00 UTC



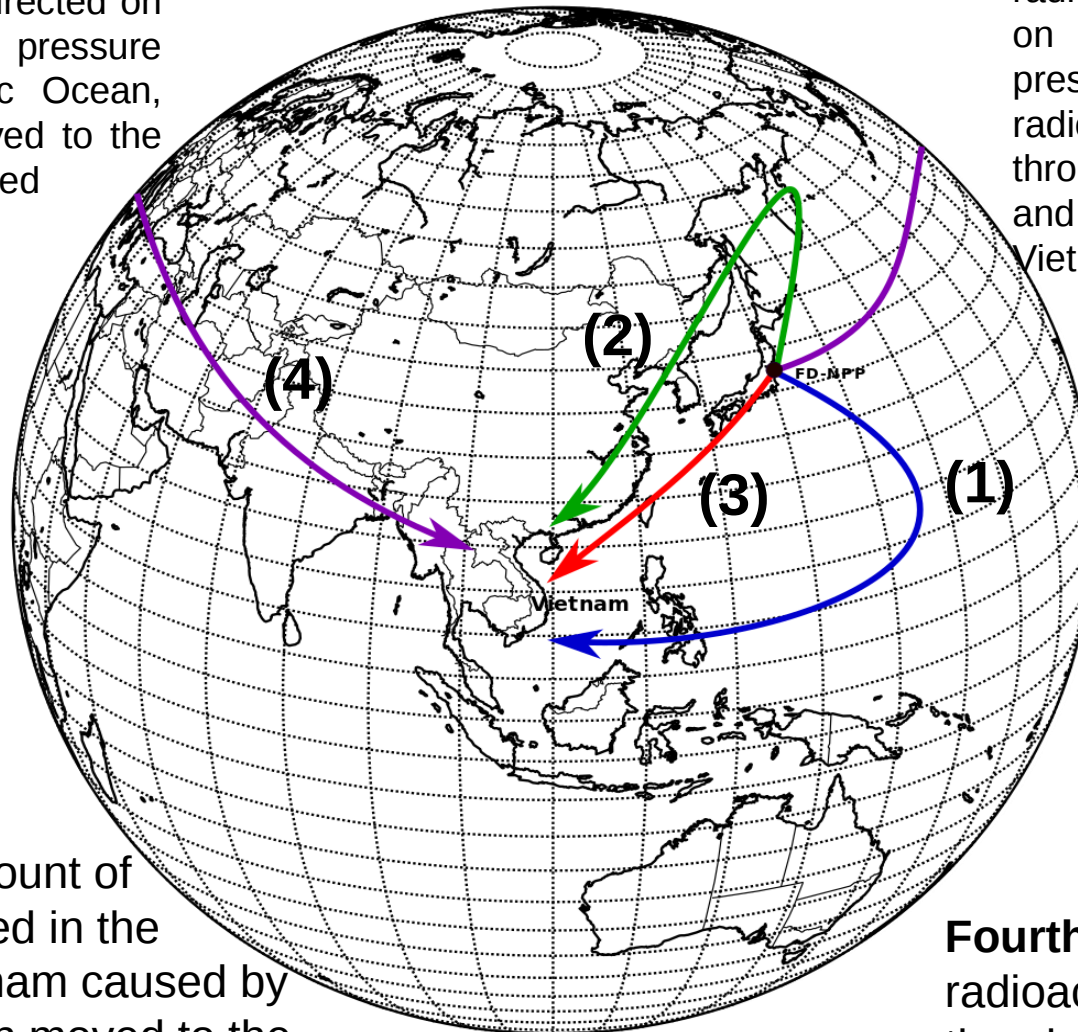
g) 2011/04/08 00:00 UTC



Four distinctive transport routes of radionuclides to Vietnam

Firstly, the amount of radioactive was redirected on March 18 by high pressure towards the Pacific Ocean, the radioactive moved to the southwest then moved to Vietnam through the East Sea.

Secondly, the amount of radioactive was redirected on March 21 by low pressure in the north, the radioactive material arrives through the Gulf of Tonkin and mainland China to Vietnam on March 22.



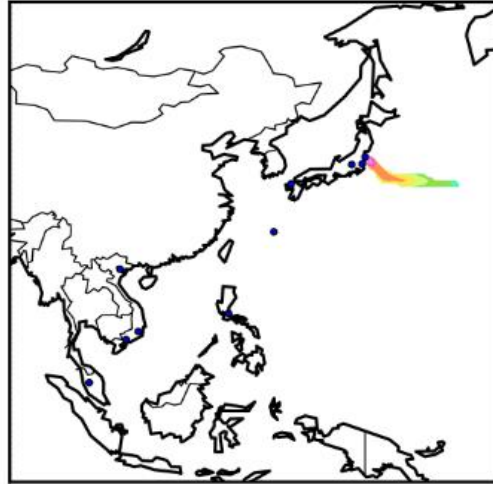
Thirdly, the amount of radioactive moved in the direction to Vietnam caused by the Siberian High moved to the coast of China and Japan on April 4.

Fourthly, the amount of radioactive spread around the globe to Vietnam. **10**

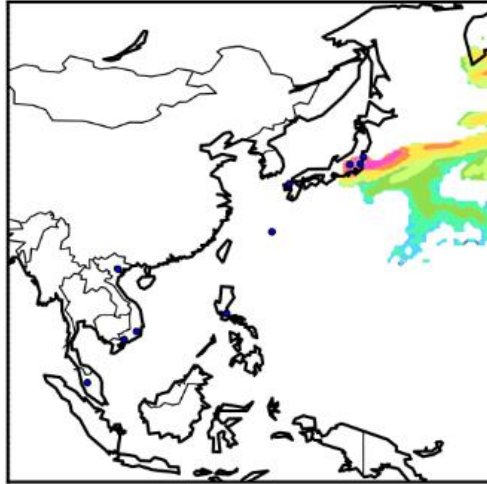
Simulated results of ^{137}Cs from Fukushima Daiichi nuclear power plant

Surface concentration of Cs-137 [Bq/m^3]

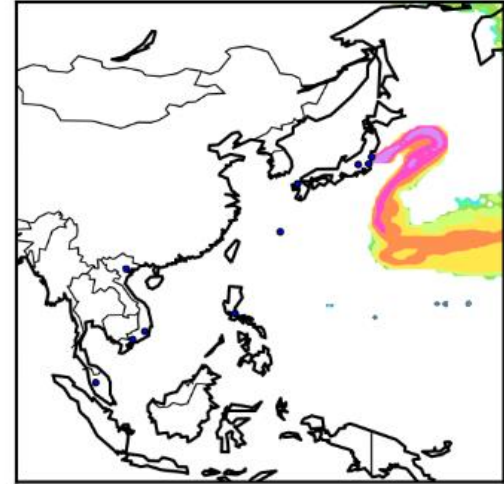
a) 2011/03/12 06:00 UTC



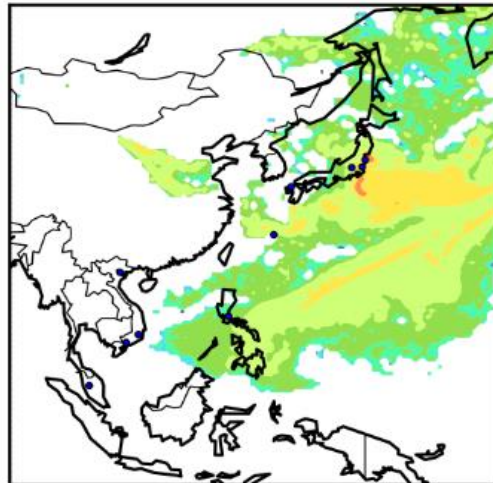
b) 2011/03/15 06:00 UTC



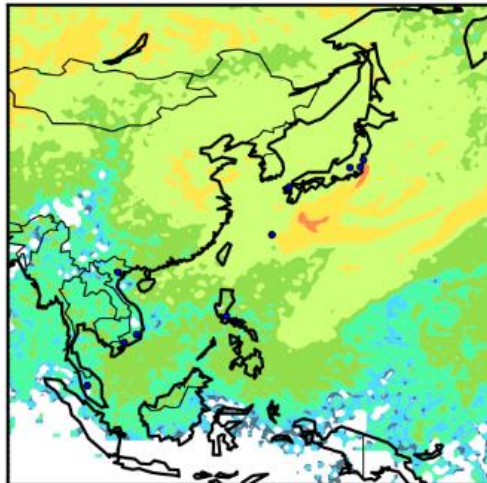
c) 2011/03/19 06:00 UTC



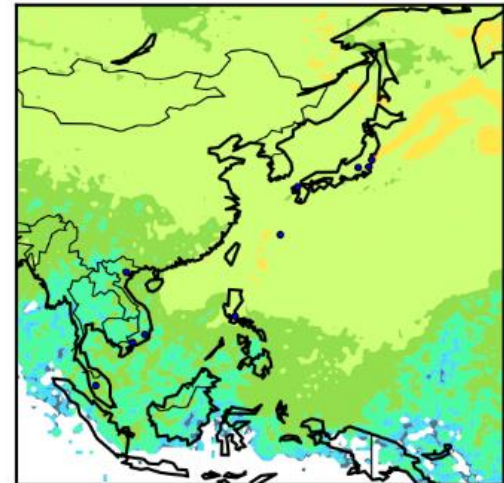
d) 2011/03/24 06:00 UTC



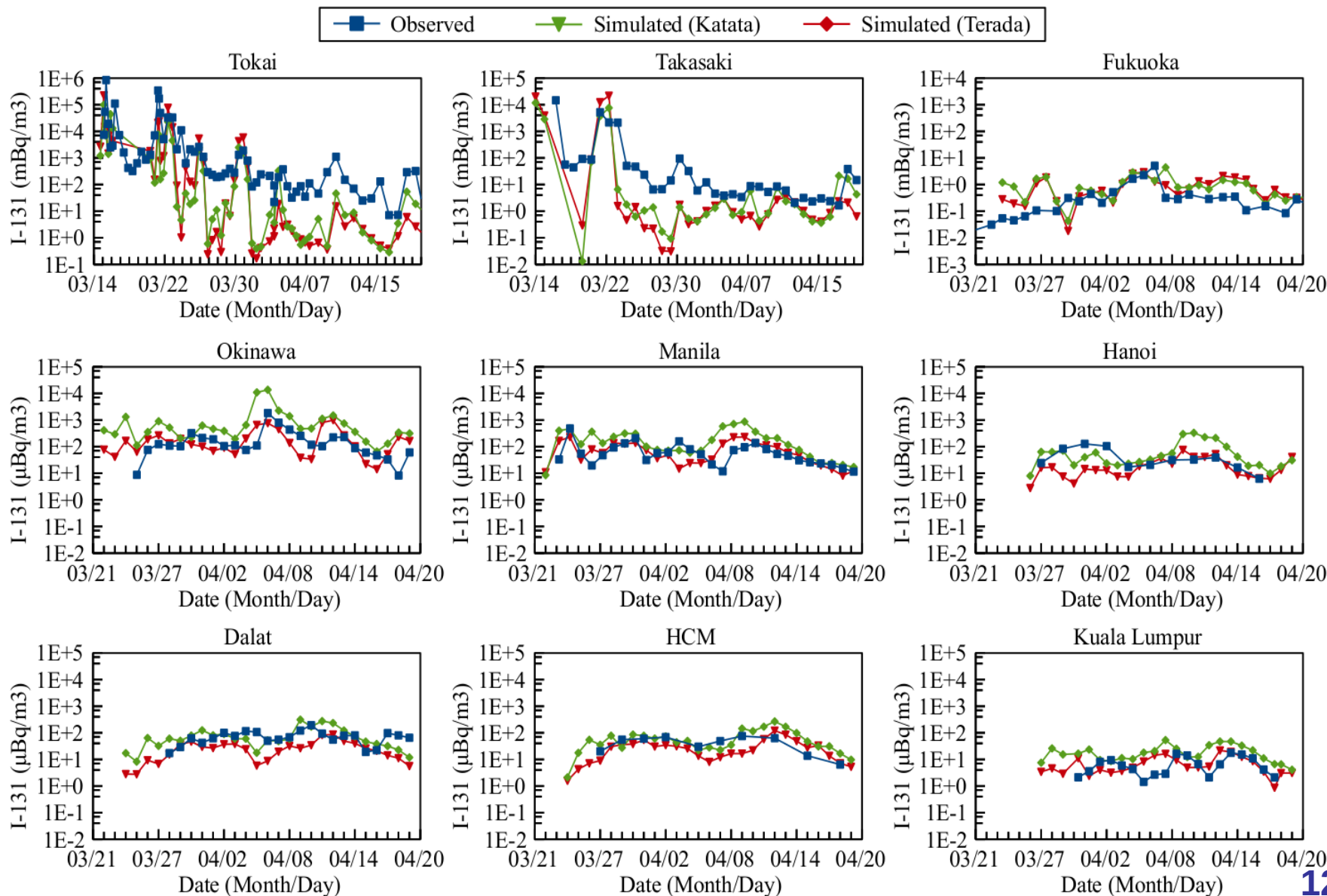
e) 2011/04/05 06:00 UTC



g) 2011/04/08 06:00 UTC

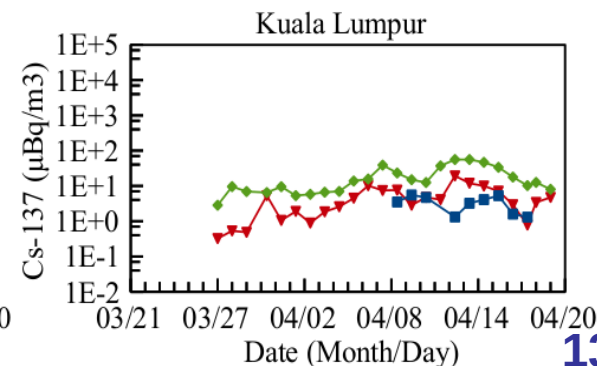
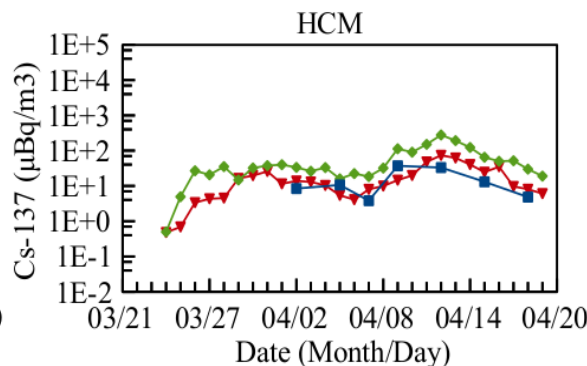
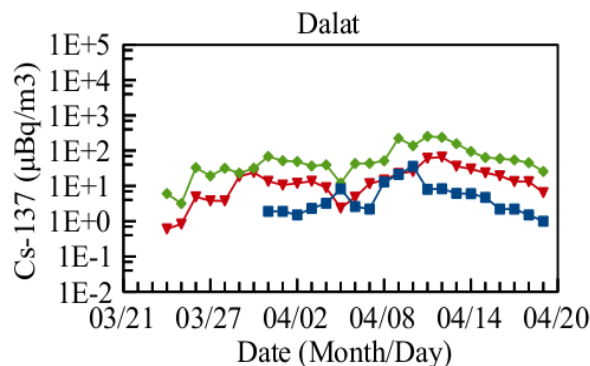
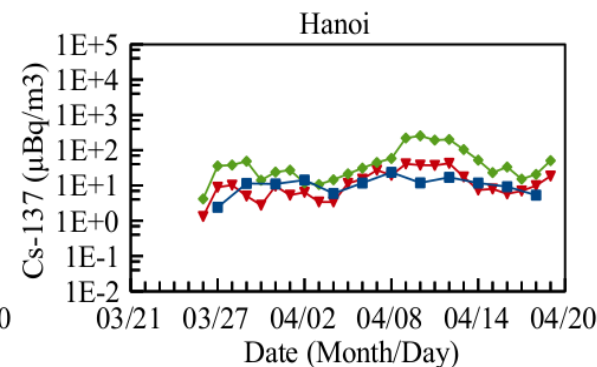
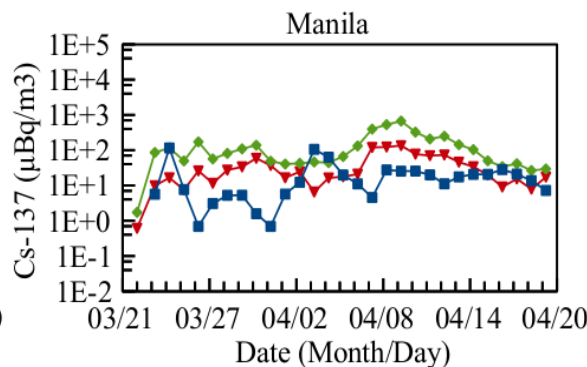
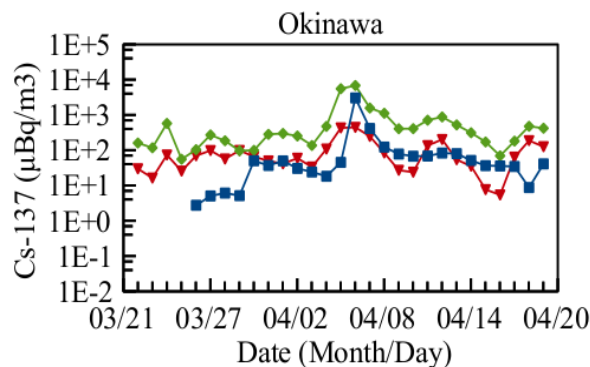
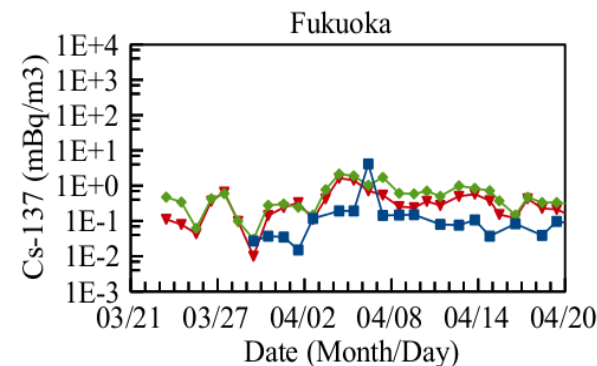
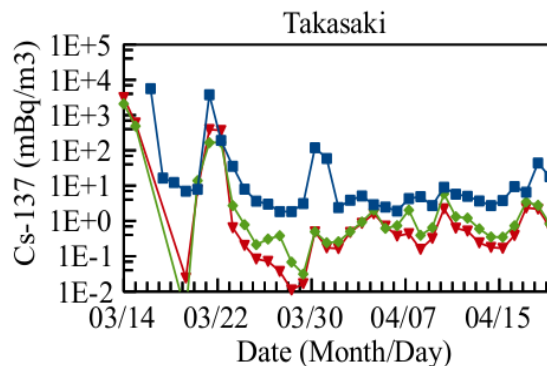
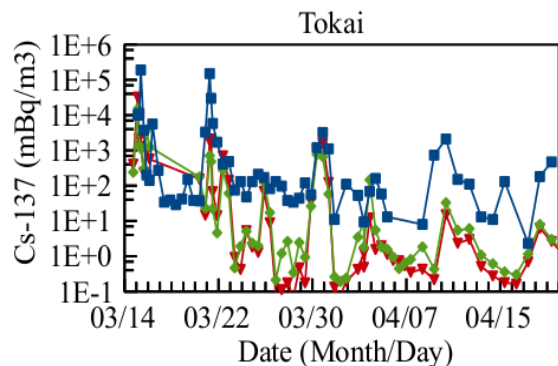


Comparison of simulations against observations in Southeast Asia (Iodine-131)



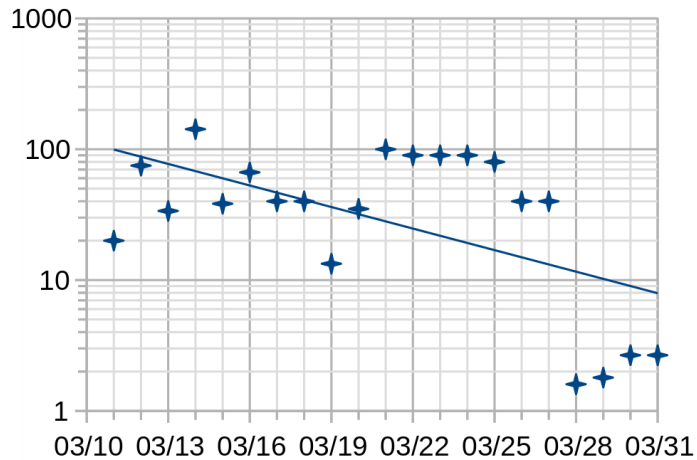
Comparison of simulations against observations in Southeast Asia (Cesium-137)

—■— Observed —▼— Simulated (Katata) —◆— Simulated (Terada)

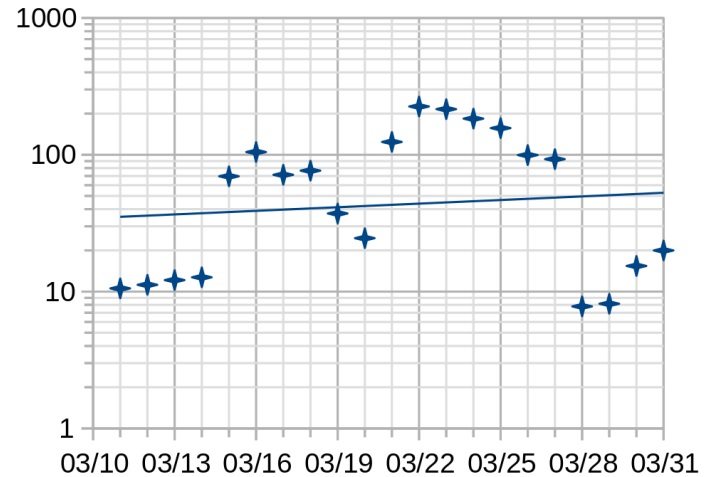


The $^{131}\text{I}/^{137}\text{Cs}$ ratio at the source (FD-NPP)

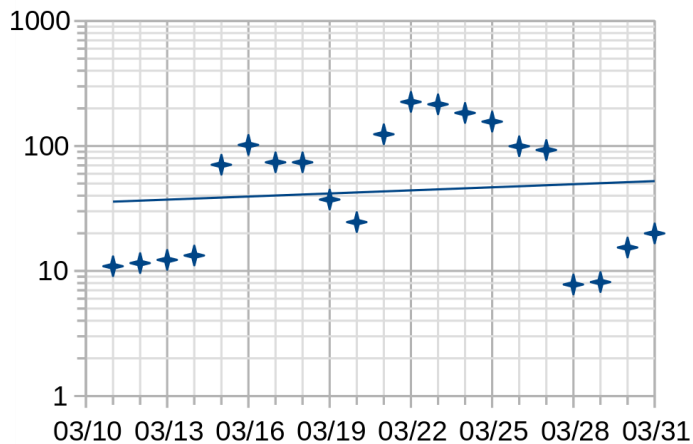
✦ I-131/Cs-137 (Chino)
— Exponential (I-131/Cs-137 (Chino))



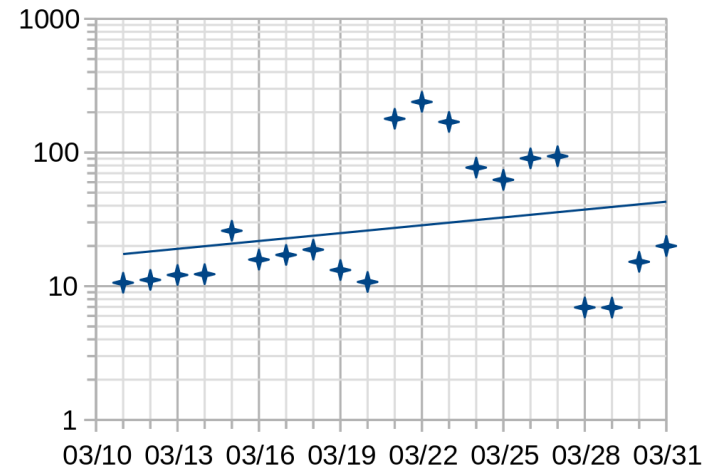
✦ I-131/Cs-137 (Kobayashi)
— Exponential (I-131/Cs-137 (Kobayashi))



✦ I-131/Cs-137 (Terada)
— Exponential (I-131/Cs-137 (Terada))

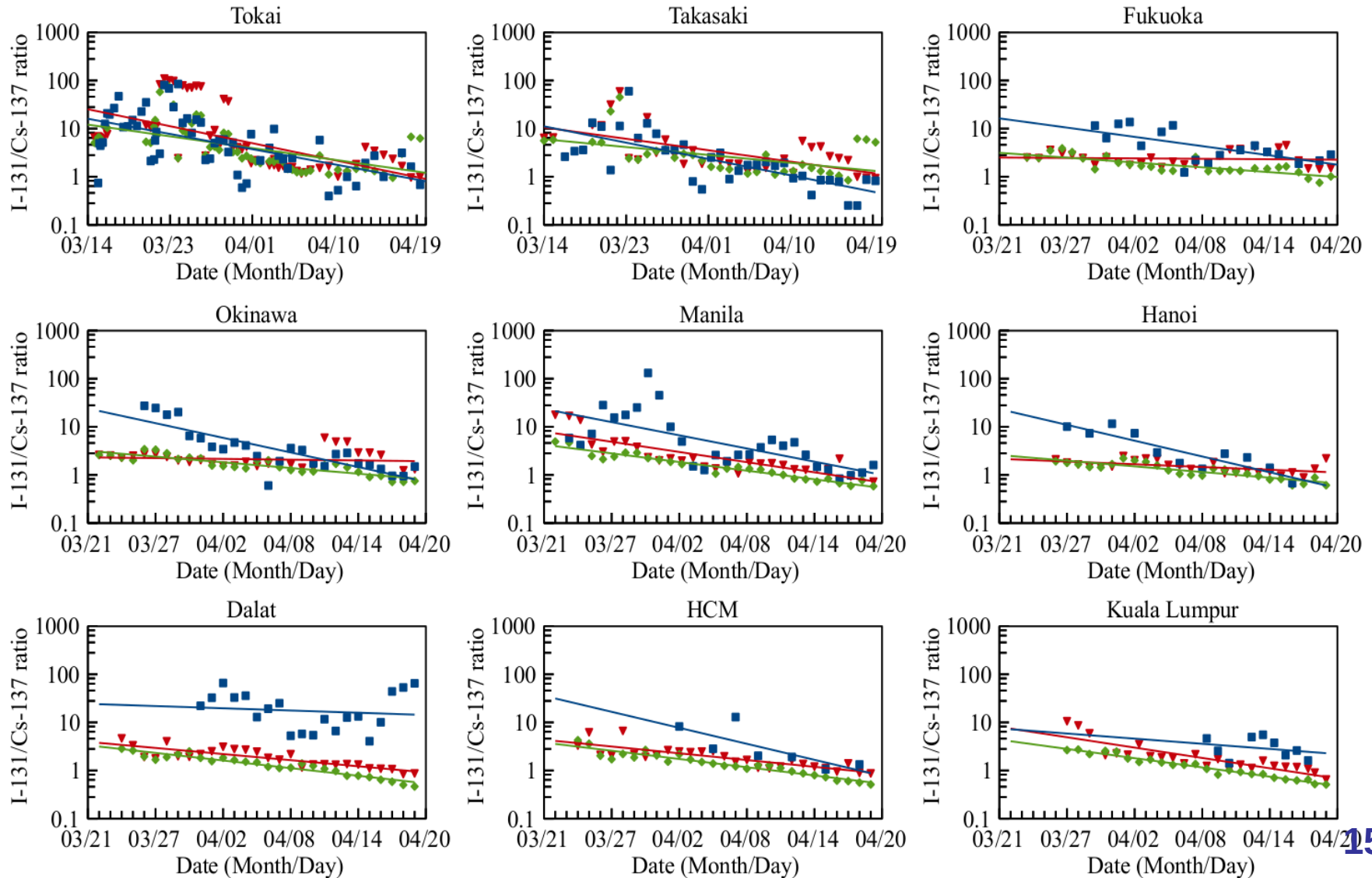


✦ I-131/Cs-137 (Katata)
— Exponential (I-131/Cs-137 (Katata))

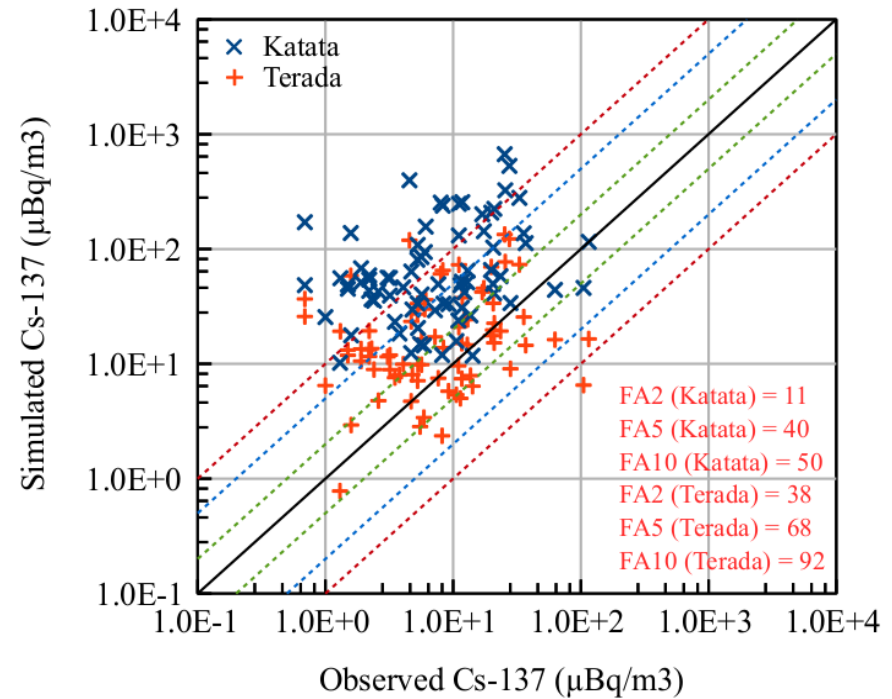
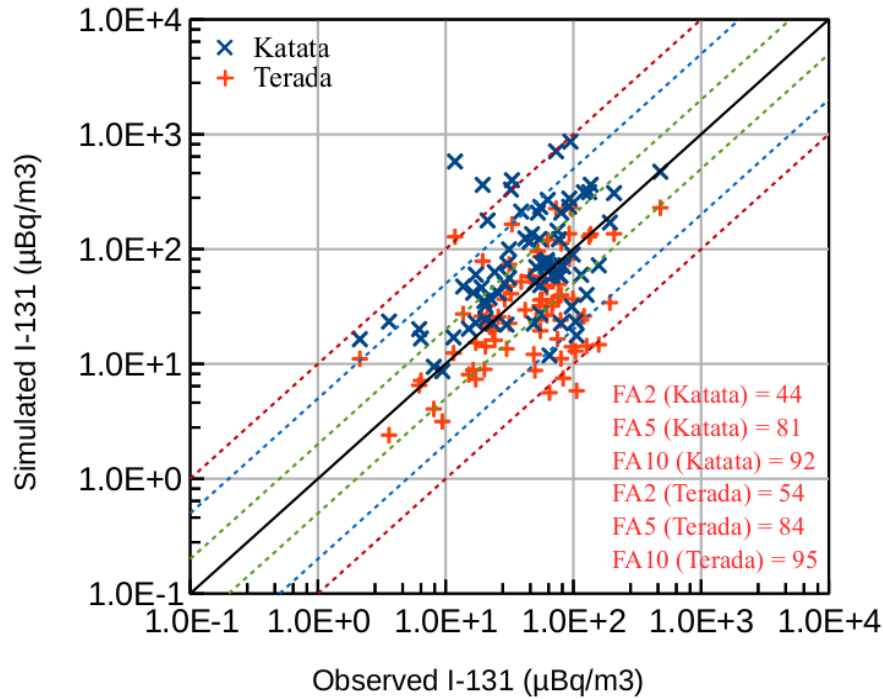


The $^{131}\text{I}/^{137}\text{Cs}$ ratios at nine stations

—■— Observed —▼— Simulated (Katata) —◆— Simulated (Terada)

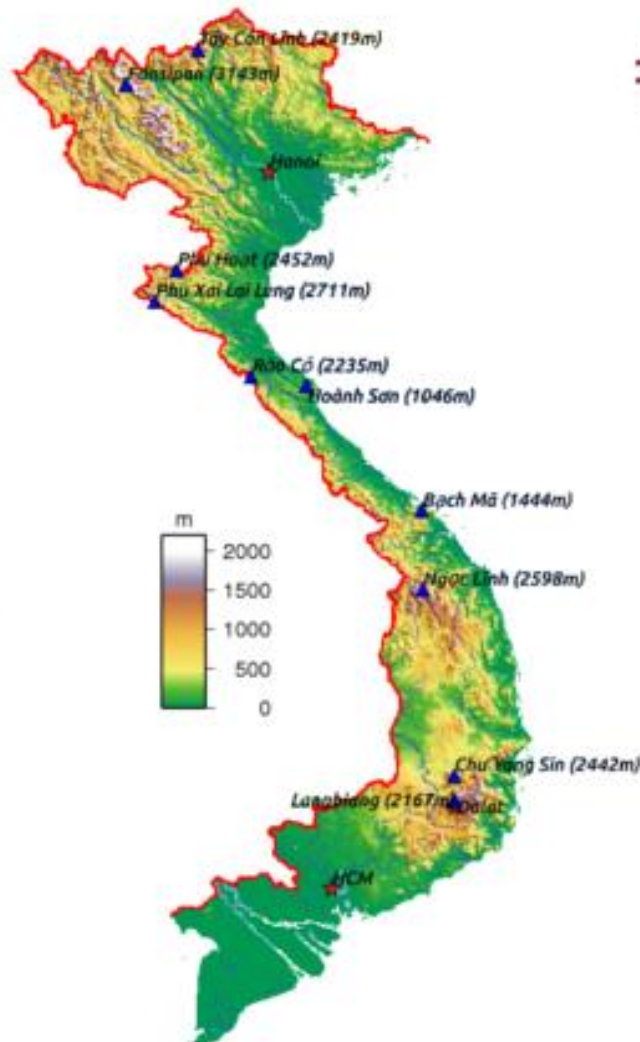


Scatter plots of observed and simulated concentrations for ^{131}I (left) and ^{137}Cs (right) at five monitoring stations in Southeast Asia (Manila, Hanoi, Dalat, HCM, Kuala Lumpur) between 3000 km and 5000 km from the FD-NPP

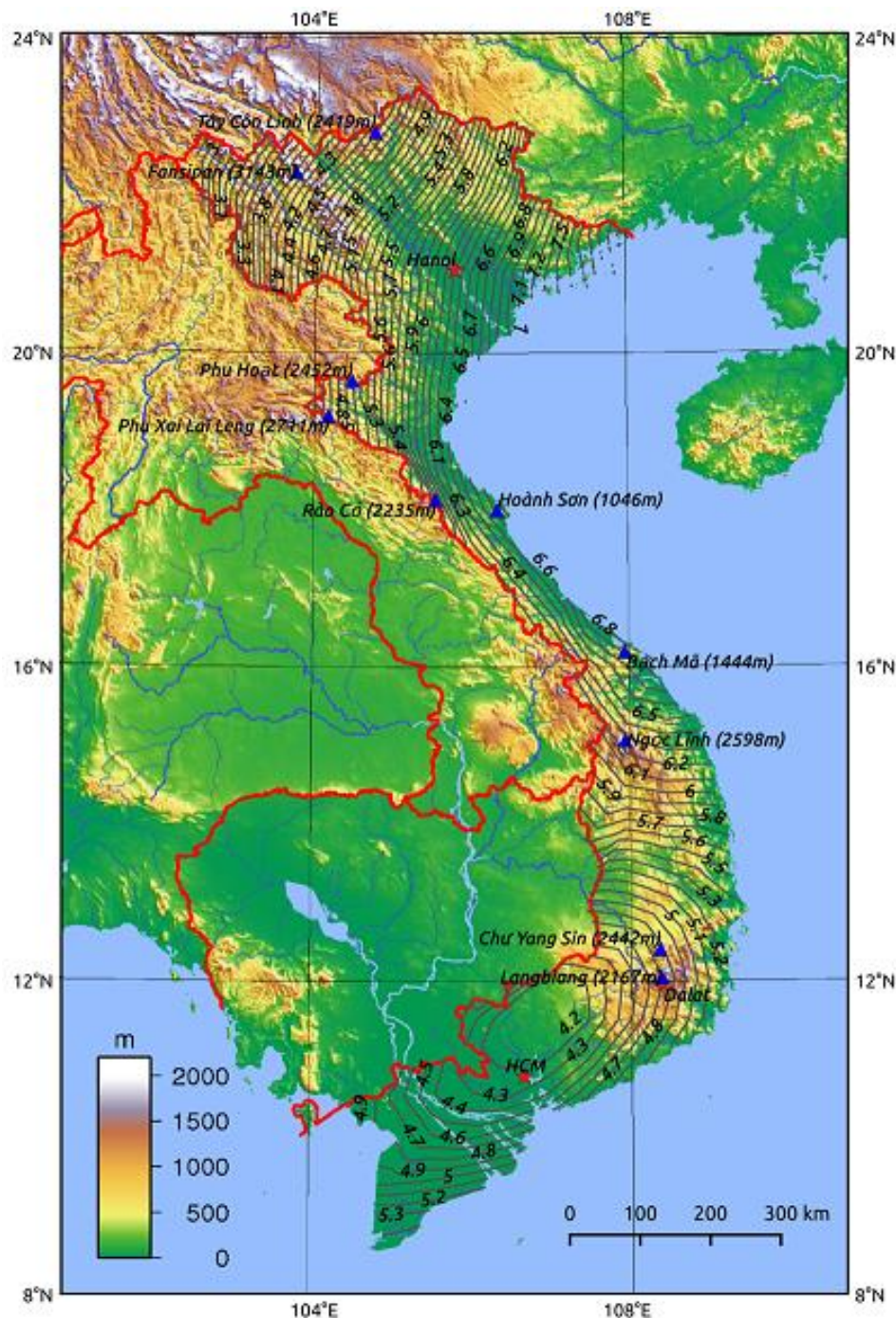


The black line in the middle is the 1:1 line and upper and lower dashed lines represent a factor of 2 (green), 5 (blue), and 10 (red) over- and underestimates.

Topography of Vietnam



Regions of Vietnam (left); topographic map of Vietnam (center); virtual monitoring stations (red points) according to the meteorological grid (right).



The contour lines of average concentration of ^{137}Cs ($\mu\text{Bq}/\text{m}^3$) combined with the topographic map of Vietnam

Northern Vietnam

- The radioactive moved mostly to Vietnam through the Gulf of Tonkin.
- High activity concentration of radionuclides in the coast and Red River Delta.
- The simulated concentration decreases when encountering the Hoang Lien Son range in the Northwest and high mountain in the Northeast

Central Vietnam

- The radioactive moved mostly from the east sea caused the simulated concentration in the coastal areas is higher and decreases when encountering the Truong Son range.
- We can see clearly the effect of topography when radioactive moved from the East Sea to Central Highlands of Vietnam.
- The amount of radioactive material passes through Chu Yang Sin and Langbiang peaks, at this point the radioactive is high up caused the results obtained at the virtual monitoring stations behind the mountains have lower values.

Southern Vietnam

- The radioactive moved similarly from the east sea caused the coastal provinces have higher concentration.
- Some provinces in the Southeast bordering the Central Highlands also have lower radioactive concentrations than the surrounding areas

3. Simulations for Fangchenggang and NT1 NPPs



The input parameters for simulations

	Fangchenggang NPP	Ninh Thuan 1 NPP
FLEXPART Version	FLEXPART v9.02	FLEXPART v9.02
Operating system	RHEL Server 5.5, CentOS 6.5	RHEL Server 5.5, CentOS 6.5
Radionuclide	Cs-137, I-131	Cs-137, I-131
Meteorological data	NCEP CFSv2 01/01/2015 – 31/12/16	NCEP CFSv2 01/01/2015 – 31/12/16
Time of simulation	1 month	1 month
Time of release	1 month	1 month
Latitude/ Longitude	21.666667, 108.566667	11.413333, 108.974722
Total number of particles to be released	1 million particles	1 million particles
Height of level	500m	500m
INES scale	Level 7	Level 7

3. Simulations for Fangchenggang and NT1 NPPs



Fangchenggang NPP

Unit	Type	Construction start	Operation start	
Phase I				
Fangchenggang 1	CPR-1000	30 July 2010	1 Jan 2016	
Fangchenggang 2	CPR-1000	23 Dec 2010	1 Oct 2016	
Phase II				
Fangchenggang 3	HPR1000	24 Dec 2015	2022	
Fangchenggang 4	HPR1000	23 Dec 2016		
Fangchenggang 5	HPR1000			
Fangchenggang 6	HPR1000			

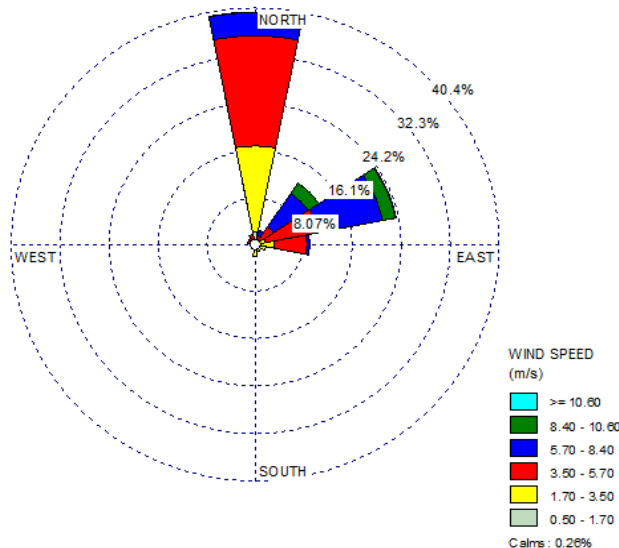
3. Simulations for Fangchenggang and NT1 NPPs

The input parameters for simulations

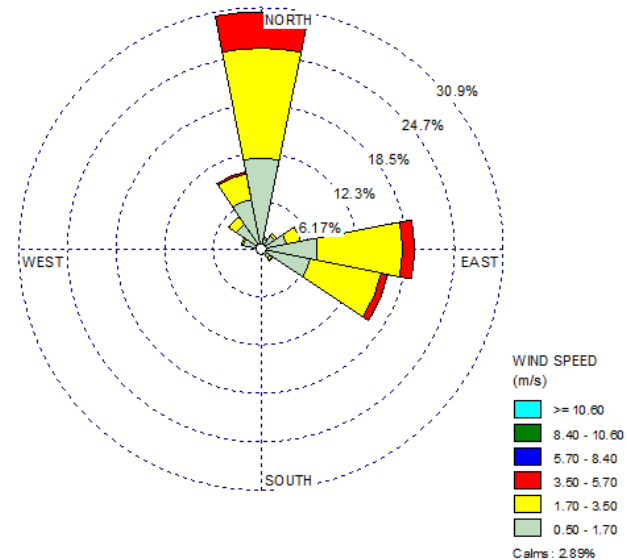
- Meteorological data**

- Hourly meteorological data for 1 year at Ninh Thuan and Fangchenggang, which are provided by Vinatom. The meteorological data includes: date; wind direction; wind speed; stability; rainfall

**Wind rose at the
Ninh Thuan site**

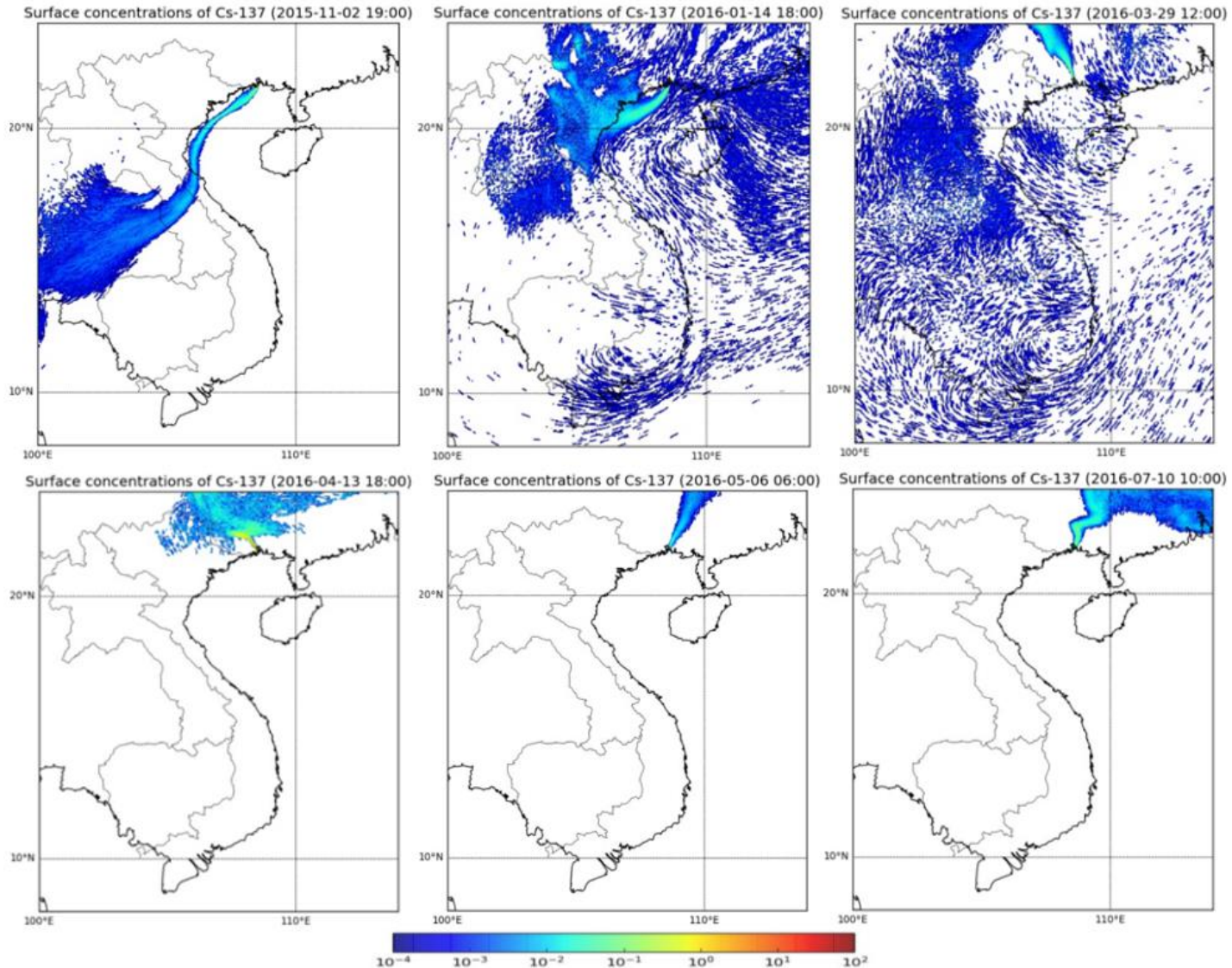


**Wind rose at the
Fangchenggang site**



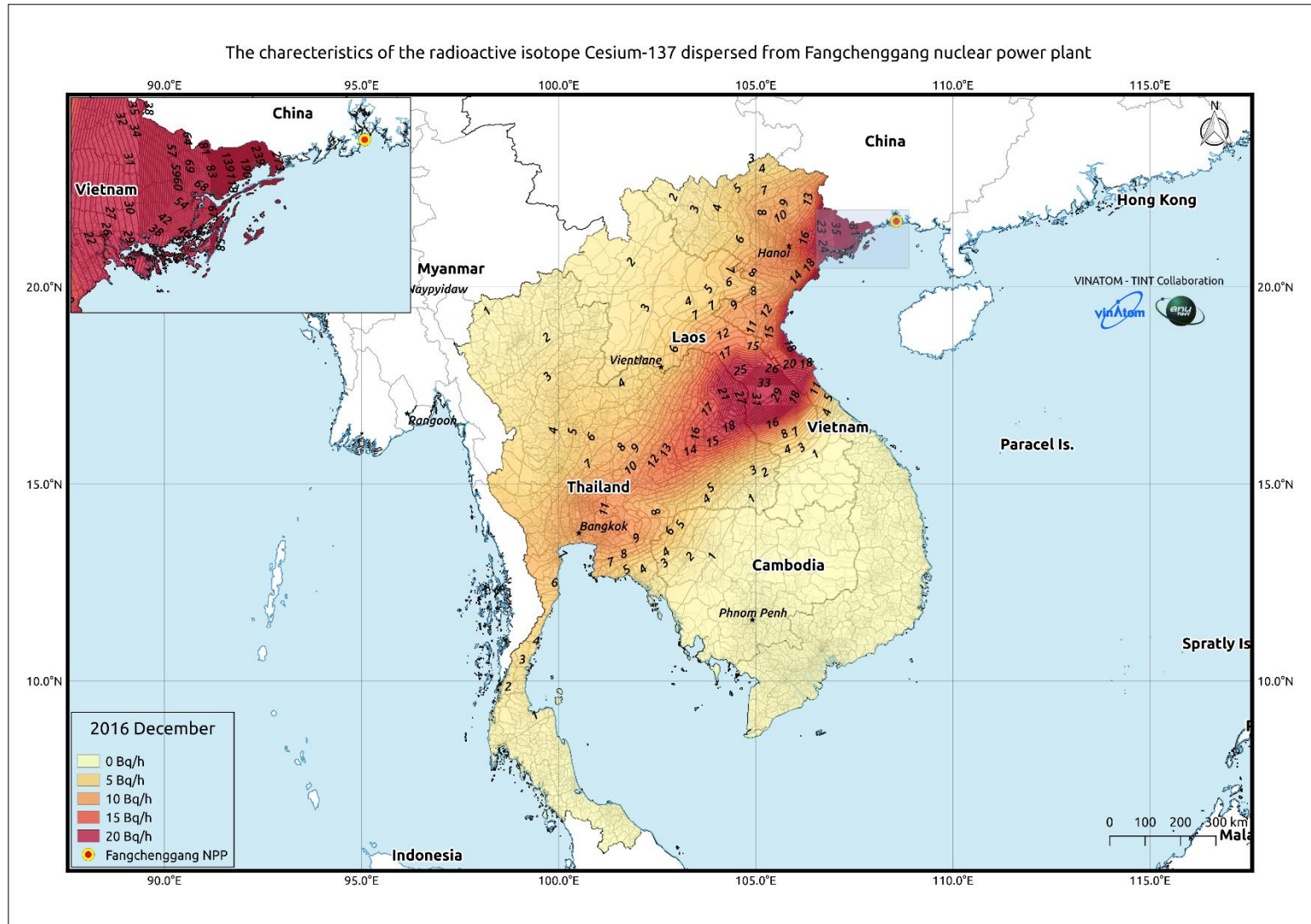
3. Simulations for Fangchenggang and NT1 NPPs

The Preliminary results from Fangchenggang NPP



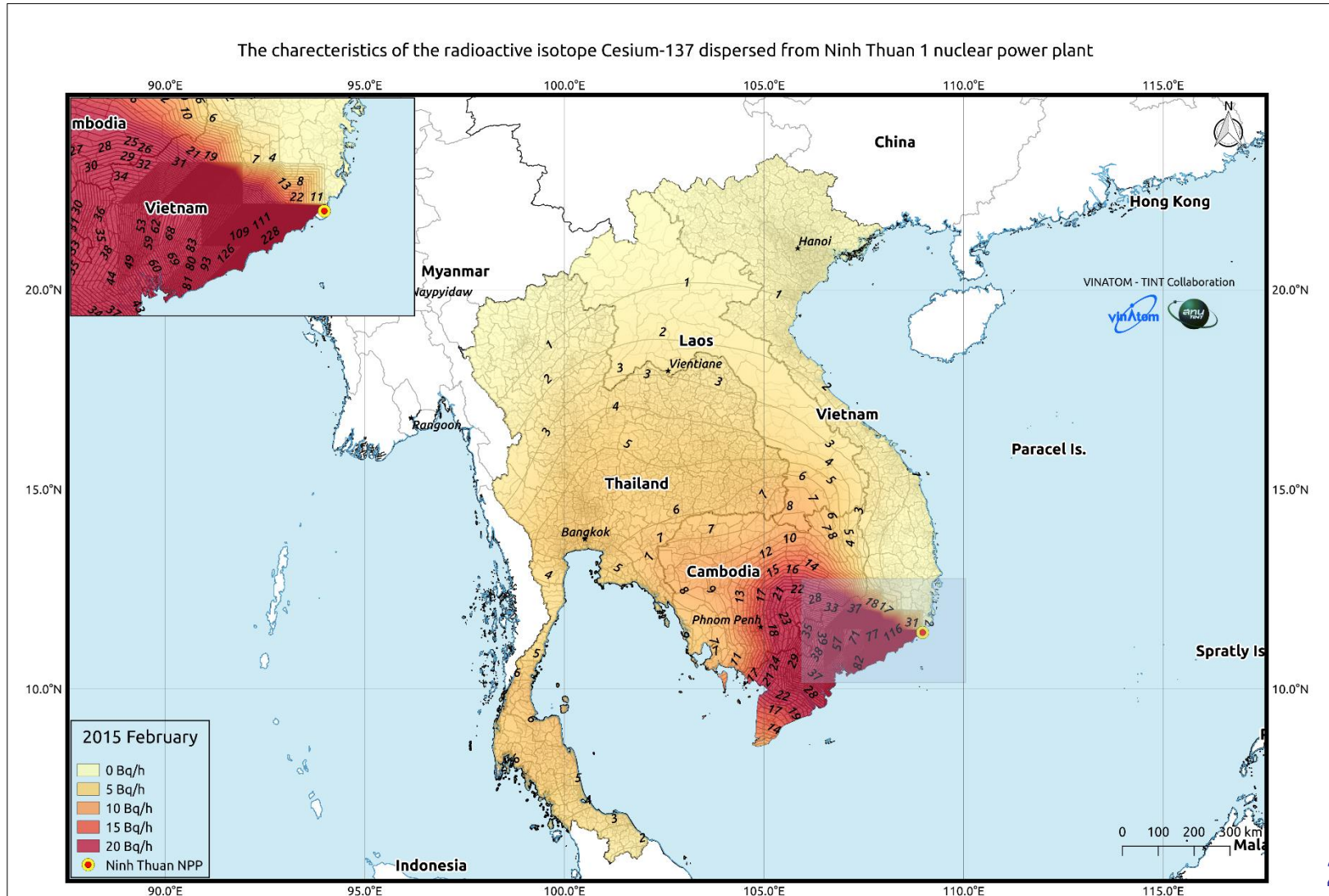
3. Simulations for Fangchenggang and NT1 NPPs

The Preliminary results from Fangchenggang NPP



3. Simulations for Fangchenggang and NT1 NPPs

The Preliminary results from Ninh Thuan 1 NPP



6. Concluding Remarks



1) Vietnam should be prepared to the emergency situation

2) Vietnam is building a national project of Radiation Monitoring and Emergency Warning System (RMEWS)

3) Capacity building in radiation dispersion simulation and prediction (a group in VINATOM)

➤ VINATOM is ready for cooperation in:

- ✓ Nuclear physics, reactor physics (including design, implementation and operation of the new research reactor)
- ✓ NPP designs and nuclear safety
- ✓ **Fission Product (FP) transport and environment monitoring**
- ✓ Marine Environmental Studies

6. Concluding Remarks



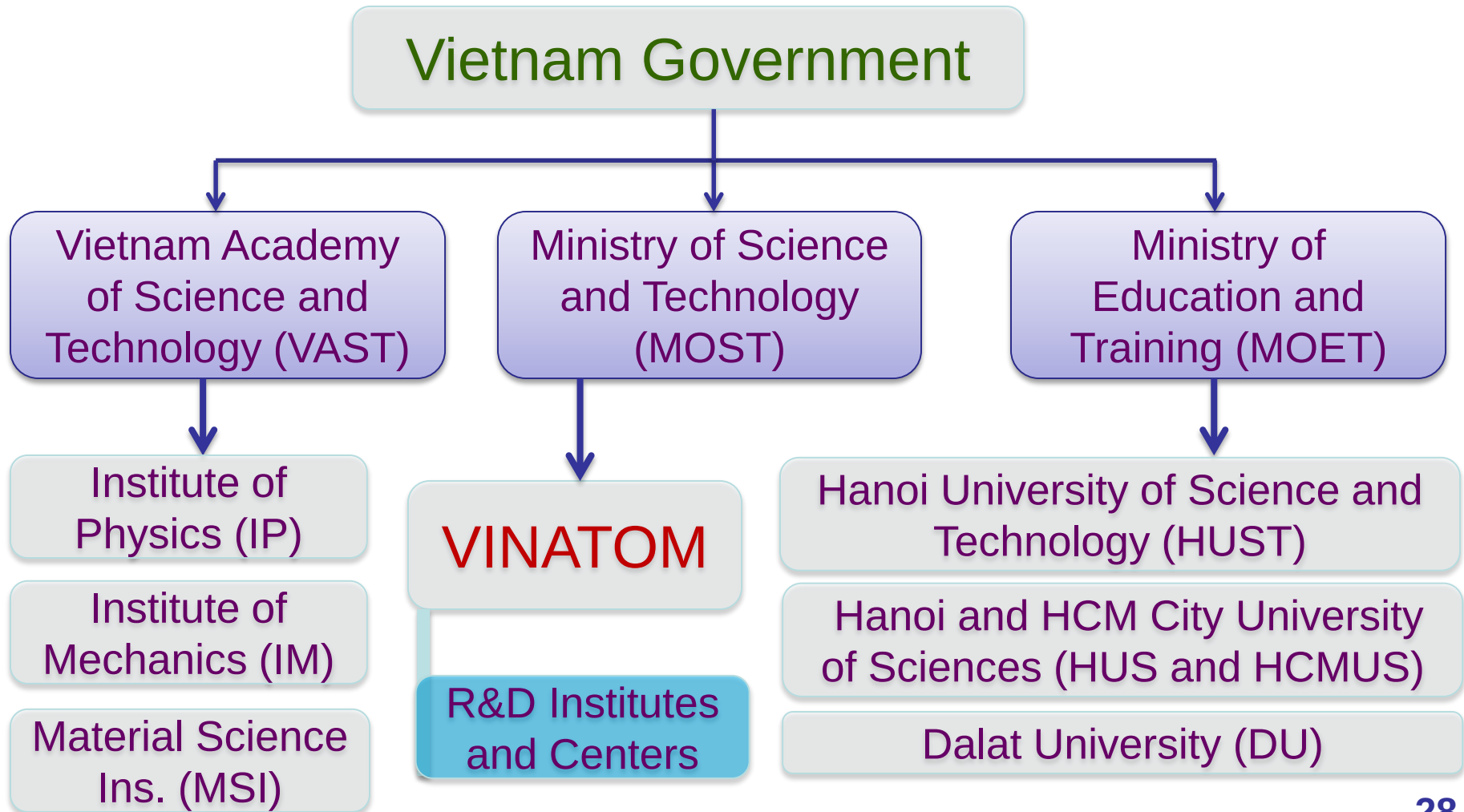
- In the present, we are performing the simulations on short-range (**FLEXPART-WRF code**) and long-range (**FLEXPART code**) dispersion of radioactive material from Fangchenggang and Changjiang NPPs (area of 300 km)

Thank you!

1. Safety Research Organizational Structure



Vietnam Nuclear R&D Organizational Structure



1. Safety Research Organizational Structure



Relevant Nuclear Safety Research Institutions

- Vietnam Atomic Energy Institute (VINATOM):
 - *Nuclear Physics Center (NPC), Nuclear Safety Center (NSC); Nuclear Energy Center (NEC)/INST*
 - *Nuclear Reactor Center (NRC)/Dalat Nuclear Research Institute (DNRI)*
 - *Nuclear Fuel Group (NFG)/Institute for Technology of Radioactive and Rare Elements (ITRRE)*
 - *Reactor Materials Group (RMG)/Non-Destructive Evaluation (NDE)*
- Hanoi University of Science and Technology (HUST):
 - *School of Nuclear Eng. and Environmental Physics (SNEEP)*
 - *Fluid Mechanics and CFD (FMC)*
 - *Int. Institute for Computational Science and Engineering (IICSE) + DASI (ANSYS Representative)*
- Vietnam Academy of Science and Technology (VAST):
 - *Mechanical Institute (MI); Institute of Physics (IP)*
 - *Institute of Geophysics (IGP)*
 - *Material Science Institute (MSI)*

1. Safety Research Organizational Structure



Relevant Universities

- Hanoi University of Science and Technology (HUST):
 - *School of Nuclear Eng. and Environmental Physics (SNEEP)*
 - *Fluid Mechanics and CFD (FMC)*
 - *Int. Institute for Computational Science and Engineering (IICSE) + DASI (ANSYS Representative)*
- Hanoi National University of Natural Sciences:
 - *Faculty of Nuclear Physics*
 - *Faculty of Radiochemistry*
- HCM City National University of Natural Sciences:
 - *Faculty of Nuclear Physics*
 - *Faculty of Material Sciences*
- Dalat University in Dalat (close to Nuclear Research Institute – NRI/ under VINATOM):
 - *Faculty of Nuclear Physics*
 - *Faculty of Nuclear Engineering*