Ensemble Simulation of Atmospheric Dispersion of Radionuclides During the Fukushima Nuclear Accident

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Contents

- JMA Ensemble Data Assimilation System (NHM-LETKF)
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- Ensemble Simulation of Fukushima Nuclear Accident
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- Summary and Future Plan

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JMA NHM-LETKF

Non-Hydrostatic Model (JMANHM) operationally used for JMA weather forecasts

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Local Ensemble Transform Kalman Filter (LETKF) developed by Univ. of Maryland (e.g. Miyoshi et al. 2006, 2012)

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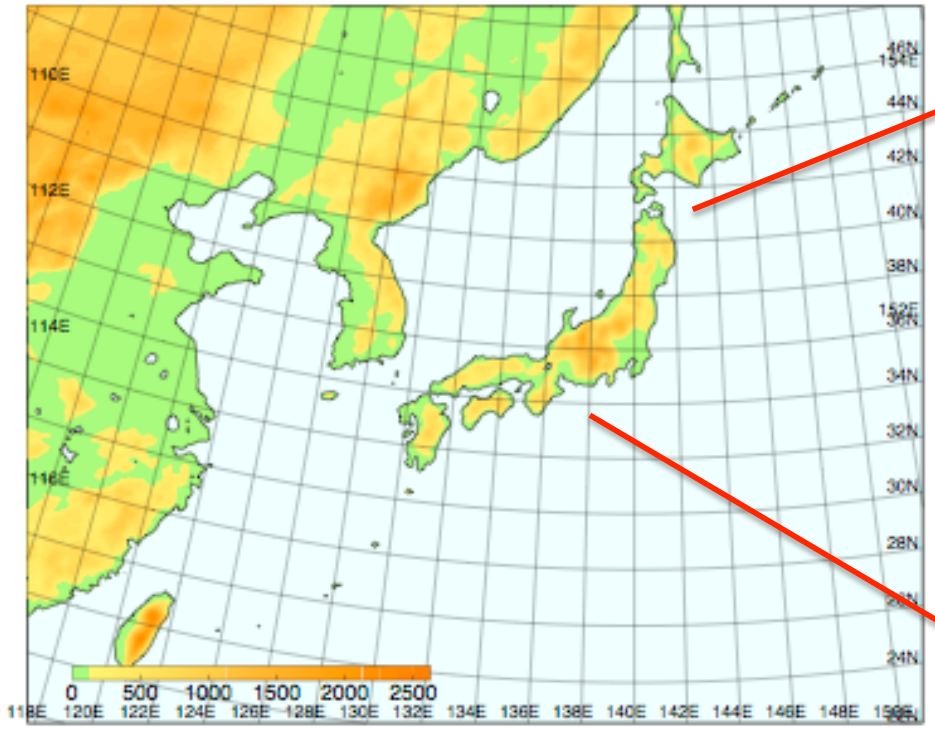
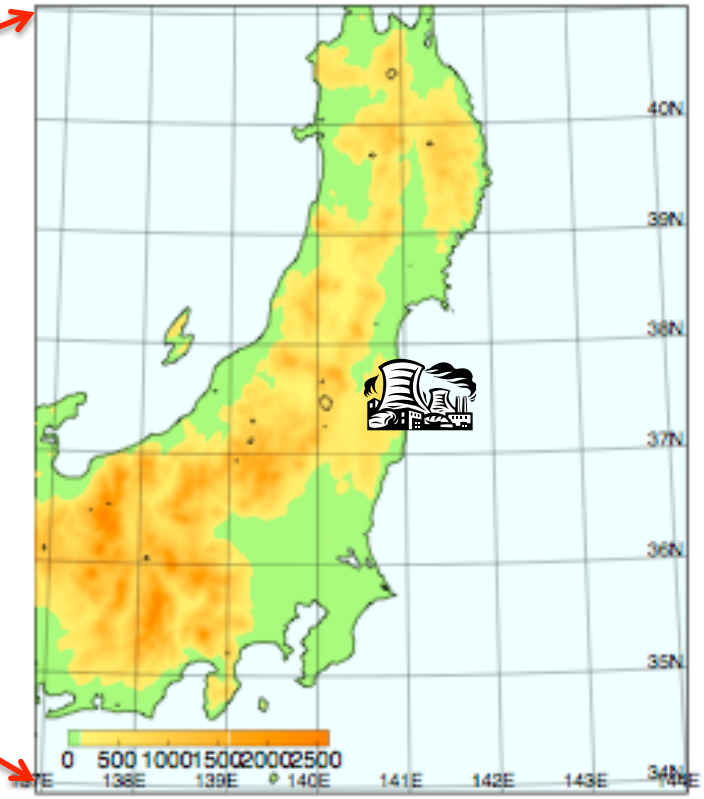
Observation Data used for JNoVa (JMA operational weather forecasts); except for satellite and radar data

NHM-LETKF Domains



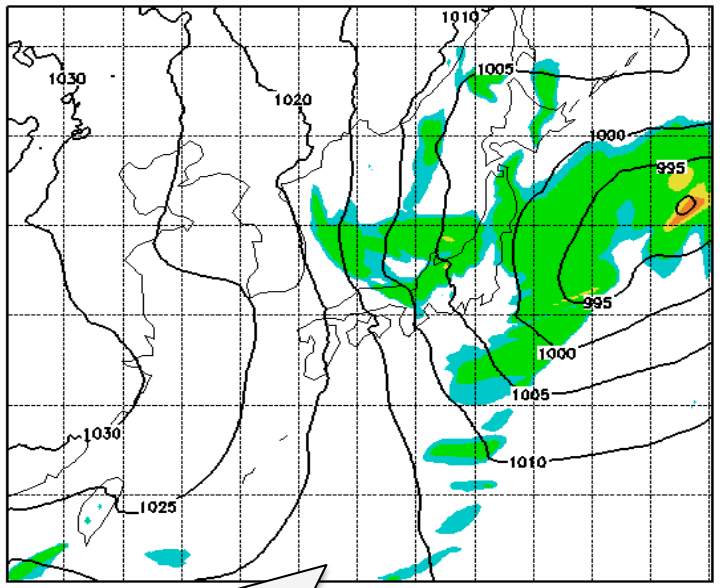
Resolution: 15x15km L50
Boundary condition: JMA global 20km analysis data



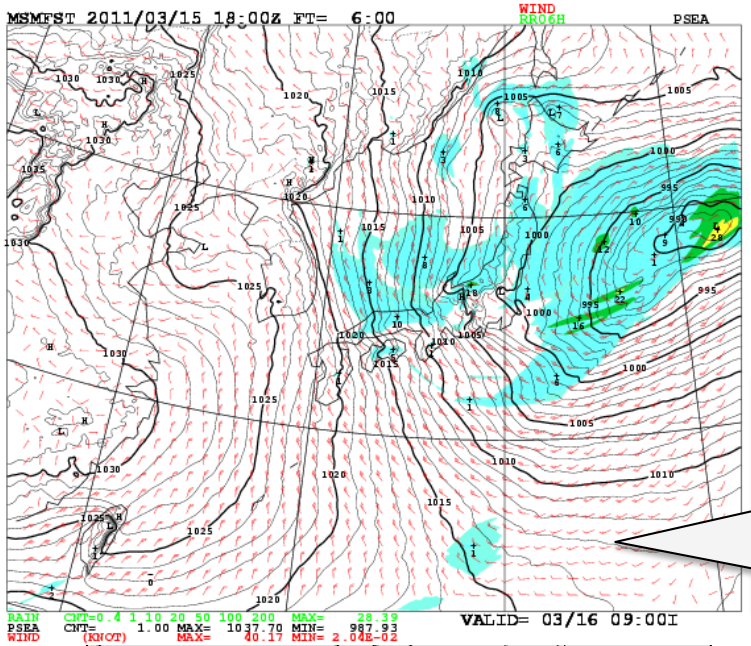
Resolution: 3x3km L60
Boundary condition: the 15x15km ensemble members

Data Assimilation Results

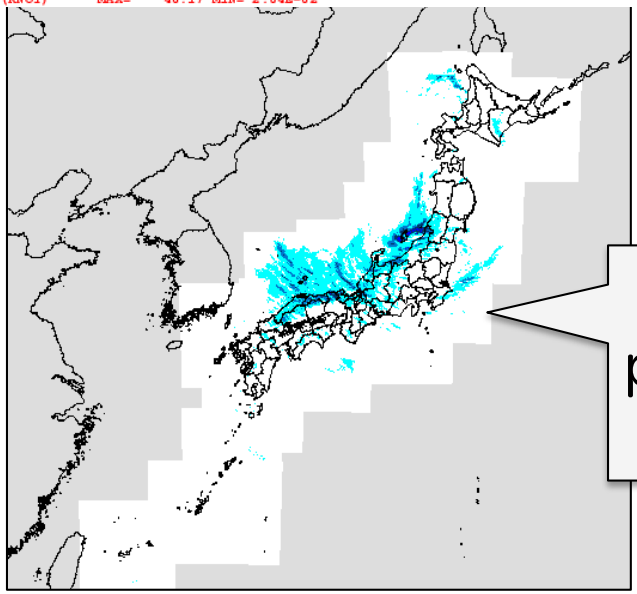
00:00UTC 16Mar2011
Precipitation and Psea



NHM-LETKF:
20-member ensemble mean



JMA mesoscale analysis



JMA radar precipitation estimates

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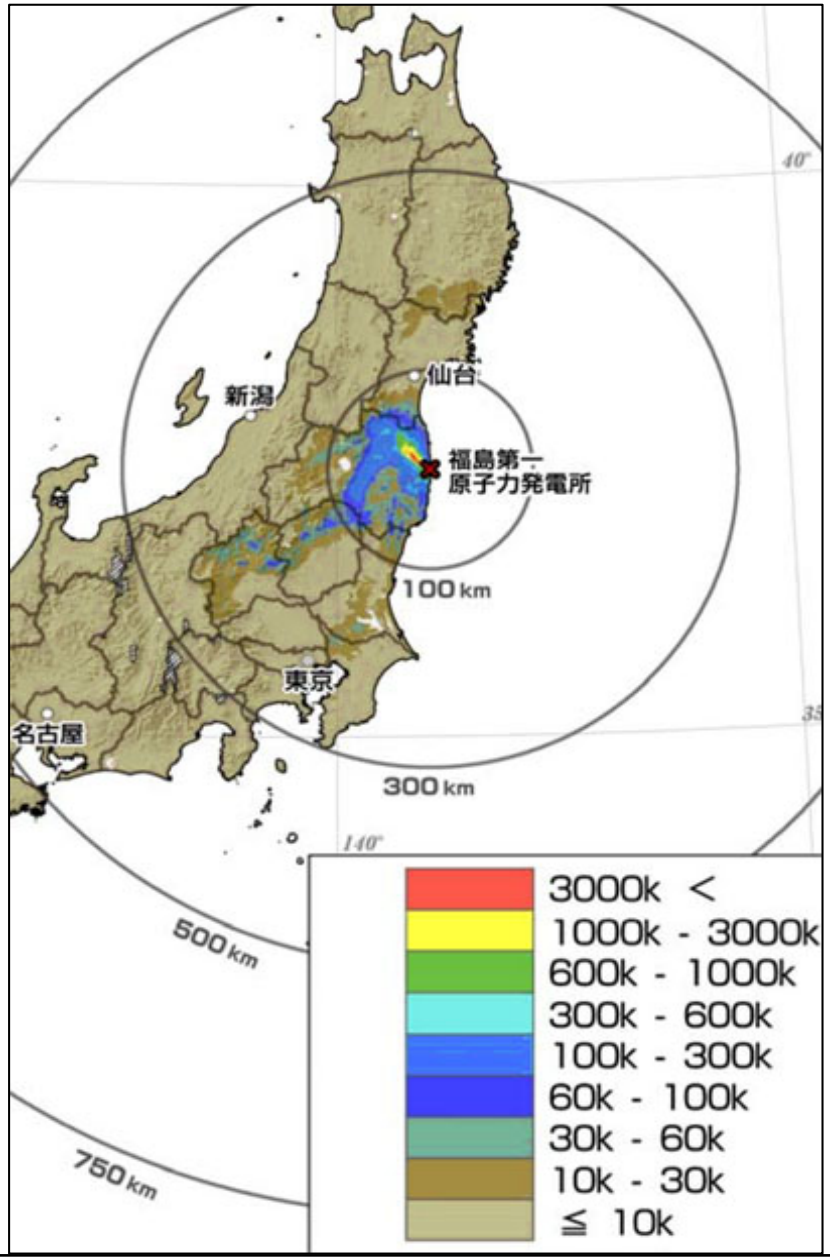
JMA NHM-Chem

- Eulerian chemistry transport model coupled with JMANHM

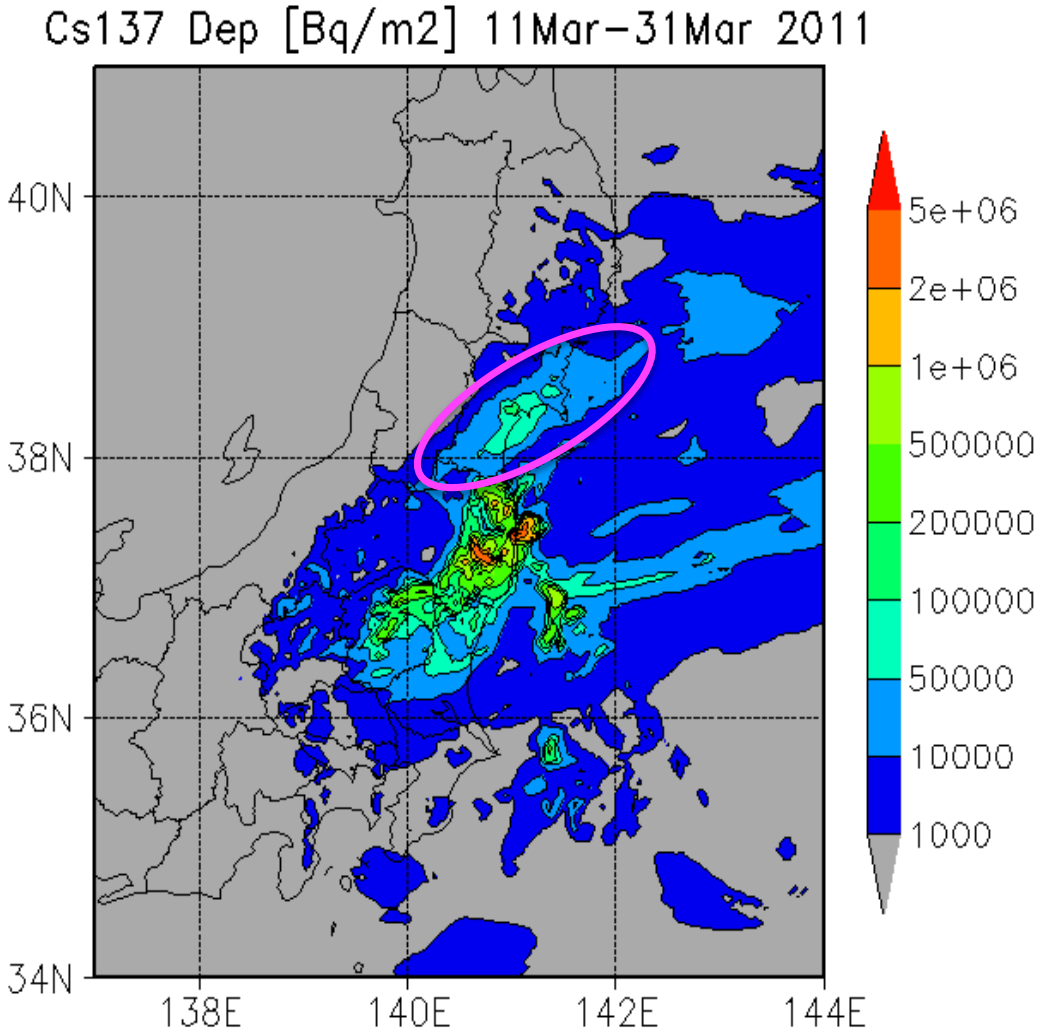
Cs-137&134	Assumed 100% mixed in sulfate aerosol particles (lognormal dist.: d=500nm, s=1.6)	Dry deposition	Considered
		Wet deposition	Rain-out: assumed cloud nucleation and its precipitation
			Wash-out: assumed coagulation due to gravitational settling
I-131	Assumed 80% in gas (I_2) and 20% in sulfate aerosol with Cs-137/134	Dry deposition	Considered
		Wet deposition	Assumed gas dissolution equilibrium in raindrops (constant water pH = 5)
Xe-133	No dry deposition No wet deposition		

Deterministic Simulation

Japan government aircraft observation Cs137

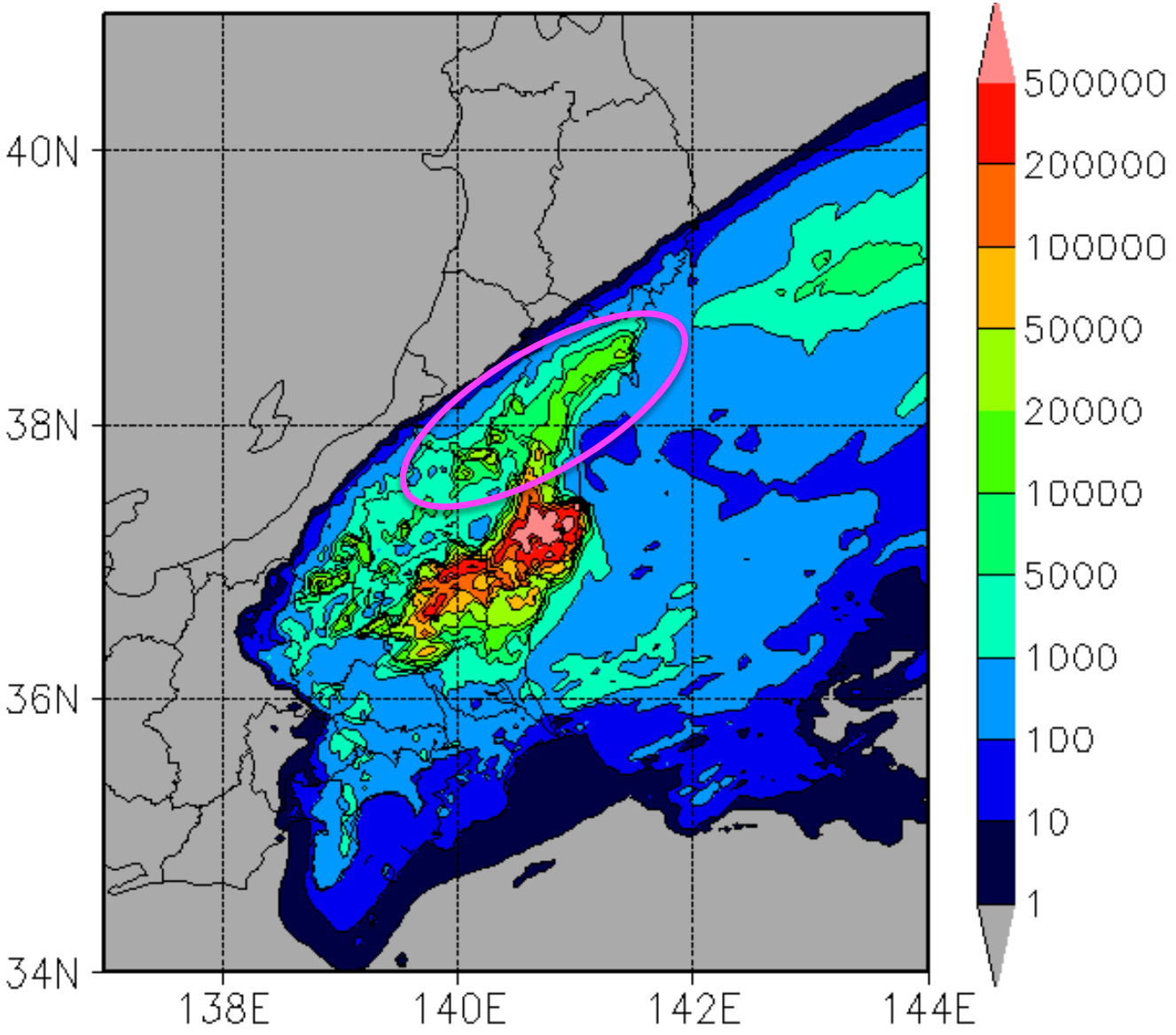


3-week deposition of Cs137
simulated by NHM-Chem



What happened on 15 March 2011?

1-day deposition of Cs137 on 15 March 2011 [Bq/m^2]



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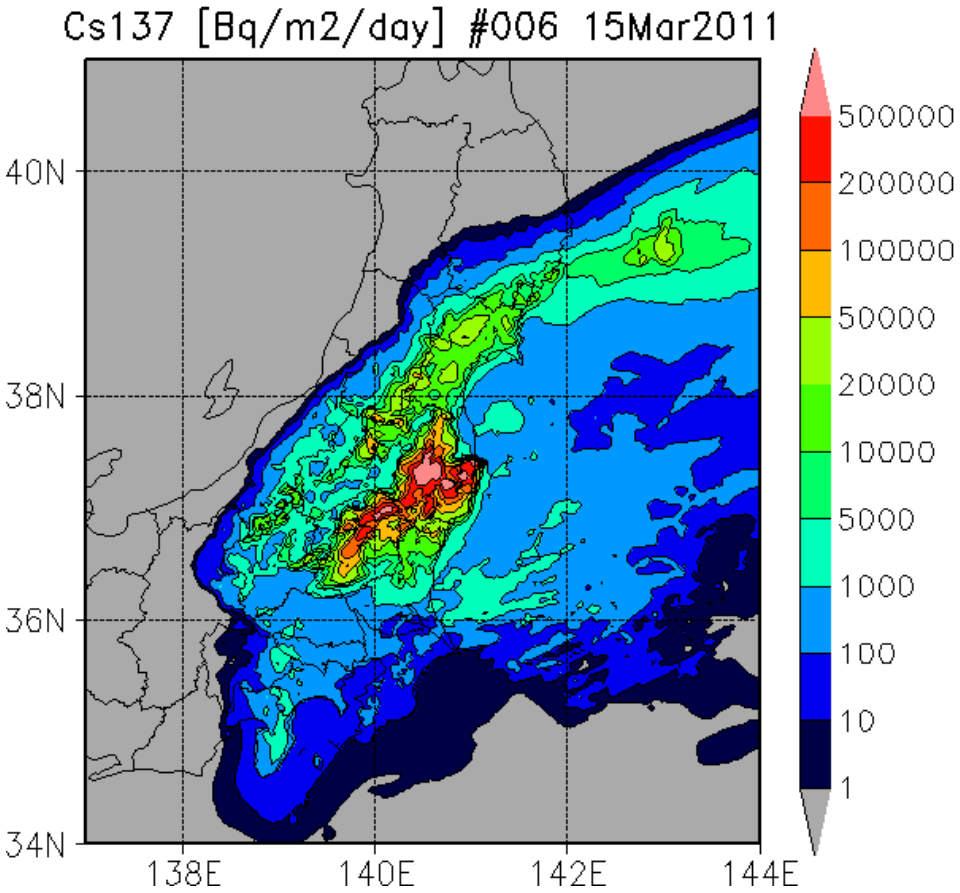
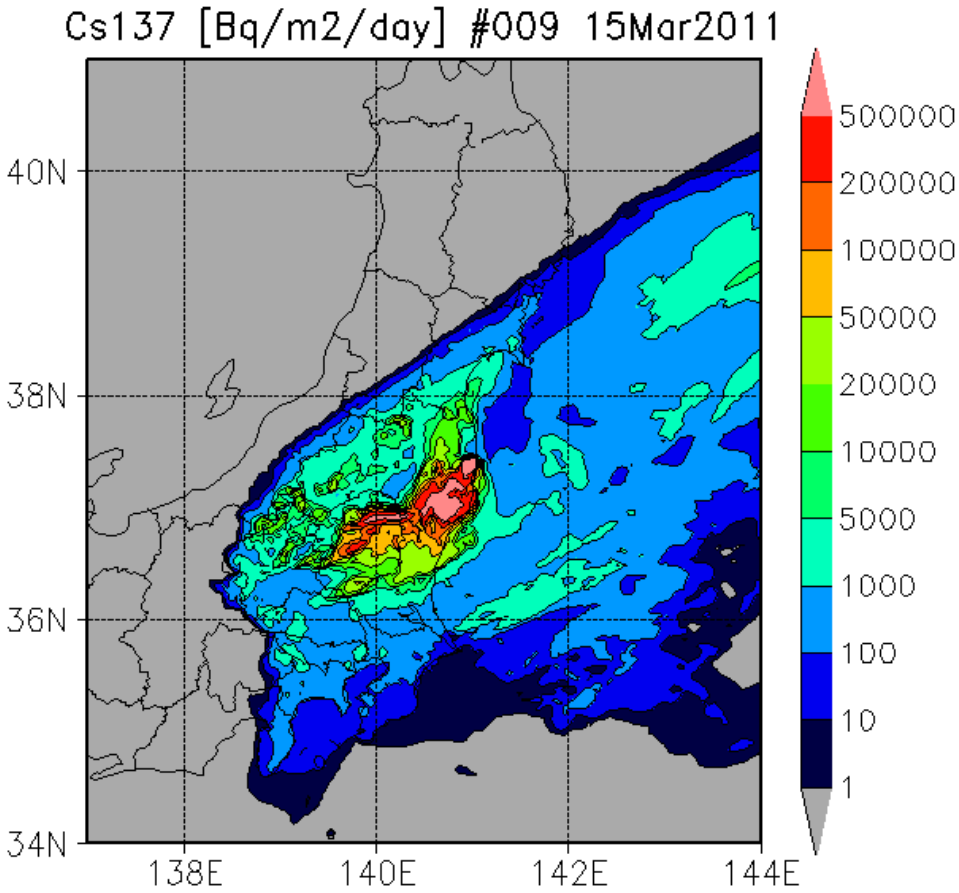
Ensemble Simulation

1-day deposition of Cs137 on 15 March 2011



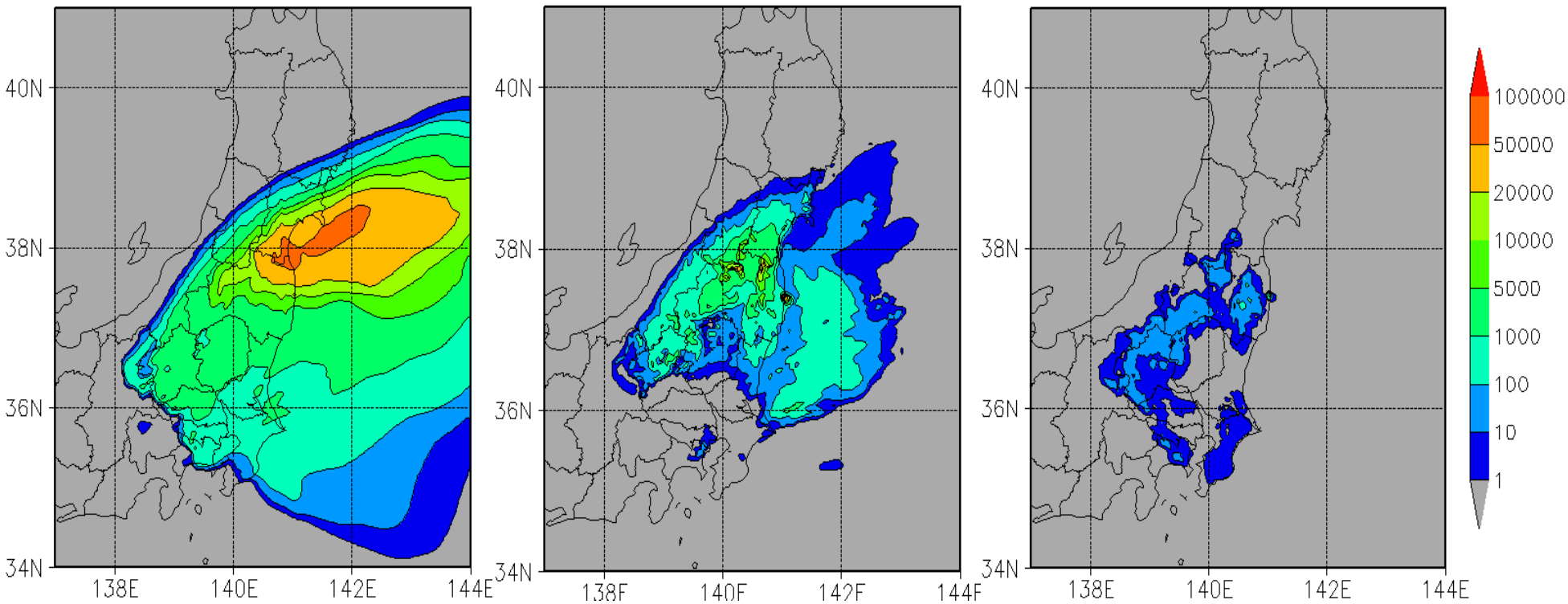
Ensemble member #6



Ensemble member #9

14:00UTC on 15 March 2011

20-member ensemble mean of the NHM-LETKF-Chem simulation



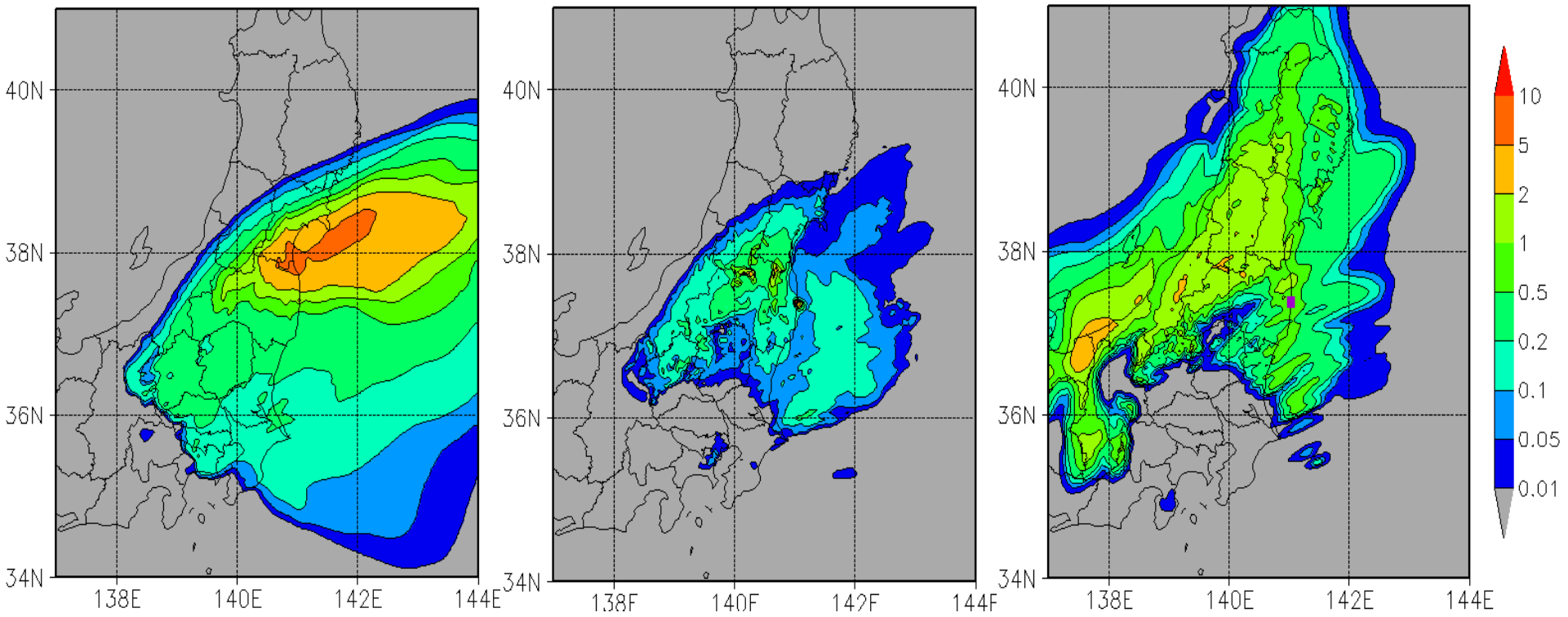
Column Cs137 [Bq/m²]

Wet deposition Cs137 [Bq/m²]

Dry deposition Cs137 [Bq/m²]

14:00UTC on 15 March 2011

20-member ensemble mean of the NHM-LETKF-Chem simulation



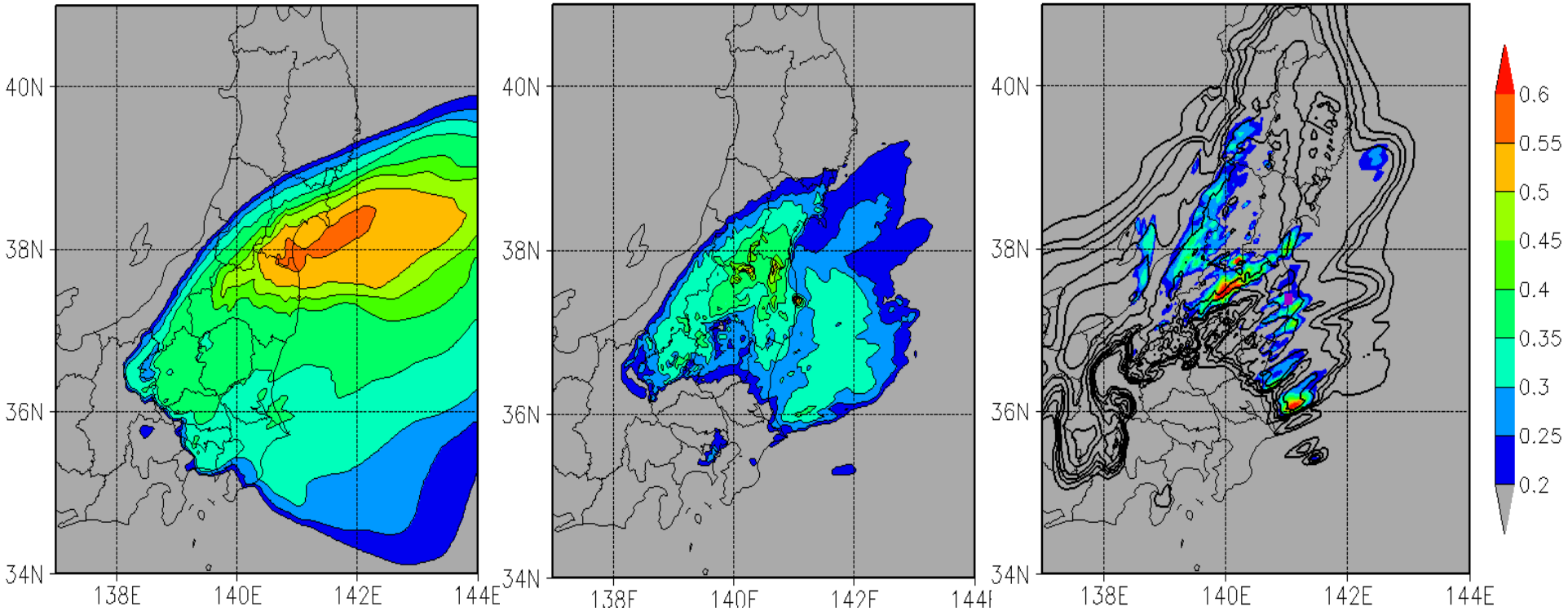
Column Cs137 [Bq/m^2]

Wet deposition Cs137 [Bq/m^2]

Precipitation (rain+snow) [mm/hr]

Ensemble Spread

20-member ensemble deviation of the NHM-LETKF-Chem simulation (14:00UTC 15Mar2011)



Column Cs137 [Bq/m^2]

Wet deposition Cs137 [Bq/m^2]

Precipitation (rain+snow) [mm/hr]

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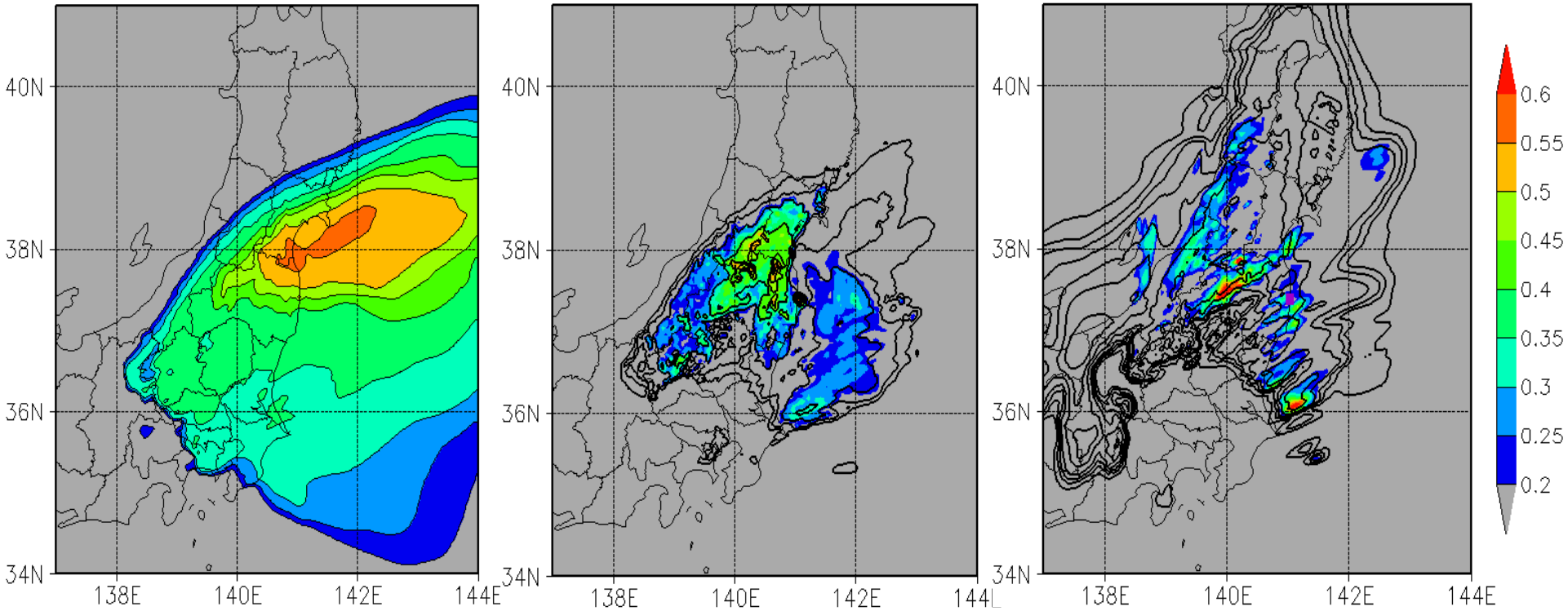
20-member ensemble deviation of the NHM-LETKF-Chem simulation (14:00UTC 15Mar2011)



Column Cs137 [Bq/m^2]

Wet deposition Cs137 [Bq/m^2]

Precipitation (rain+snow) [mm/hr]

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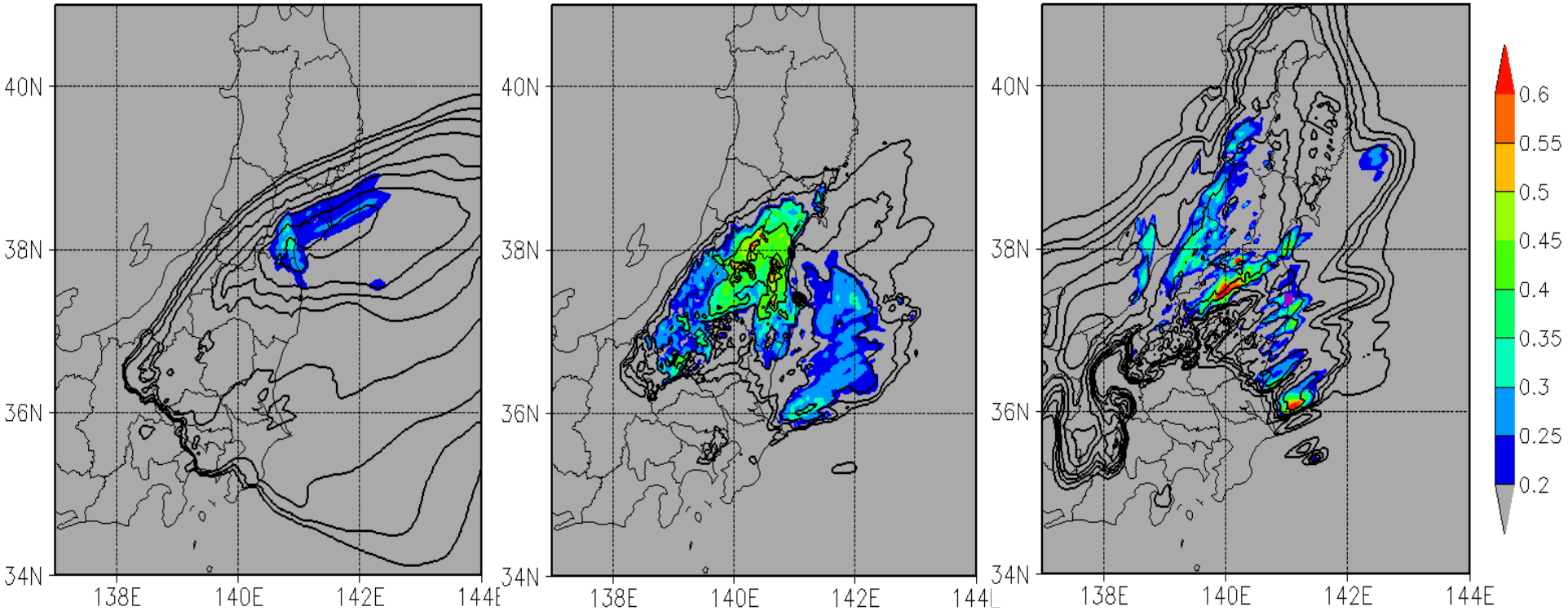


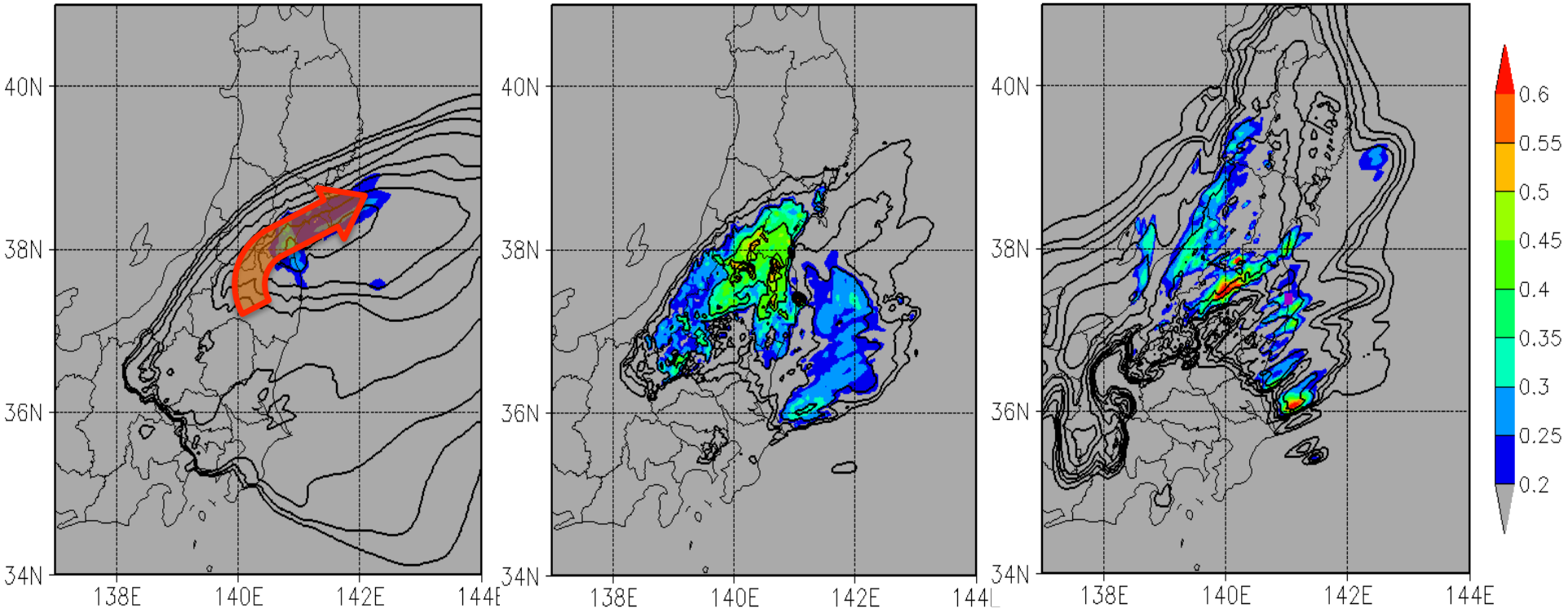
Column Cs137 [Bq/m^2]

Wet deposition Cs137 [Bq/m^2]

Precipitation (rain+snow) [mm/hr]

Signal Propagation

Large ensemble deviation = “poorly known”
The “poorly known” signal is propagated downwind.



Column Cs137 [Bq/m²]

Wet deposition Cs137 [Bq/m²]

Precipitation (rain+snow) [mm/hr]

Red arrow: wind direction

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Summary

- JMA NHM-LETKF-Chem was developed
- Probabilistic simulation based on the ensemble Kalman filter was performed
- Simulations have uncertainty
- Ensemble simulation provides statistical information
  - Statistical signal is propagated downwind

Future Plan

- Ensemble hindcasting
- Adding new met observations to NHM-LETKF
  - Weather monitoring posts around the nuclear plant
  - Doppler radar of Fukushima Univ
- Data assimilation of radionuclides
  - Concentration measurements
  - Deposition measurements

Prometheus