Review of model intercomparison projects (MIPs) of atmospheric dispersion model for ^{137}Cs emitted from Fukushima Daiichi Nuclear Power Plant (FDNPP)

~ MIPs with identical source term and meteorological data~

Yousuke Sato (Hokkaido University: yousuke.sato@sci.hokudai.ac.jp)

M. Takigawa, T. T. Sekiyama, M. Kajino, H. Terada, H. Nagai, M. Kadowaki, H. Kondo, J. Uchida, D. Goto, A. Quérel, D. Quélo, A. Mathieu, S. Fang, Y. Morino, P. von Schoenberg, H. Grahn, N. Brännström, S. Hirao, H. Tsuruta, T. Nakajima and H. Yamazawa

1, What we have done, and Purpose of MIPs

What we have done ?:

Conduct two model intercomparison projects (MIPs) targeting on ^{137}Cs emitted from FDNPP (Sato et al., 2018, 2020)

Purpose: Understand the variability of the results of the atmospheric dispersion models originated from internal element of the model (i.e., cloud physics, radionuclide physics, diffusion, and so on)

2, Strategy of MIPs, Participants and Experimental setup

Strategy: Use the same Meteorological data, Resolution, and Emission for excluding uncertainties originated from external data

Participants

Model name	Participate in Sato et al. (2020)	Participate in Sato et al. (2018)
AIST-MM	○	○
Pello	-	○
HIRAT	-	○
ldX	○	○
GEARN	○	○
WRF-Chem	○	○
NHM-Chem	○	○
WRF-CMAQ	-	○
SCALE	○	○
Polyphemus	-	○
WRF-Chem	○	○
NICAM-Chem	○	○

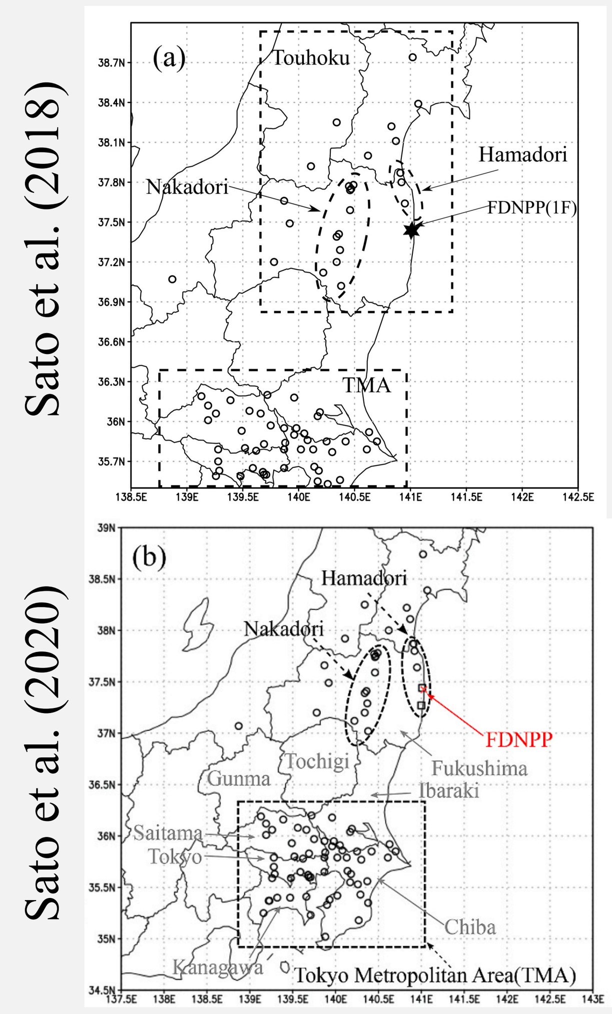
Experimental setup

	Sato et al. (2020)	Sato et al. (2018)
Domain size	Left figure (b)	Righgt figure (a)
Initial/Lateral condition	NHM-LETKF (*dx*=1km) (Sekiyama and Kajino 2020)	NHM-LETKF (*dx*=3km) (Sekiyama et al. 2015)
Emission	Katata et al. (2015)	
Calculation Period	2011, Mar. 11 ~ Mar. 31	2011, Mar. 11 ~ Mar. 23
Horizontal grid spacing	1 km	3 km

Observation data

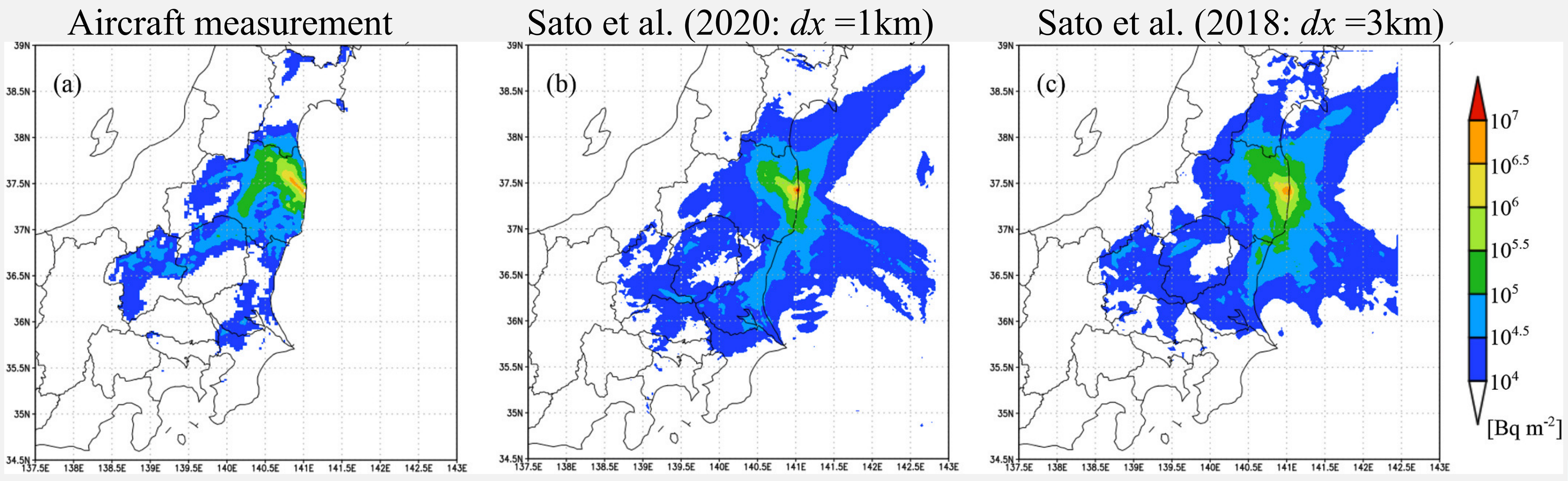
Atmospheric concentration of ^{137}Cs	SPM (Oura et al. 2011)
Cumulative deposition	Aircraft measurement (MEXT, 2011)

Calculation Domain

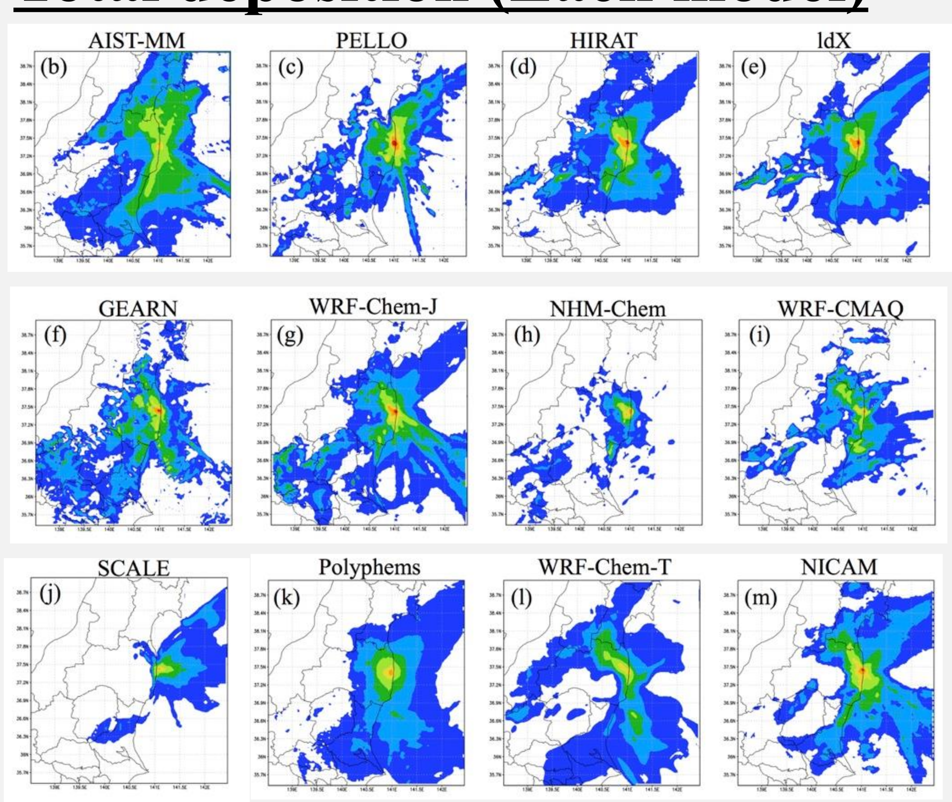


3, Results

Total deposition (Observation and multimodel ensemble)



Total deposition (Each model)



(Sato et al. 2018)

Dry deposition fraction

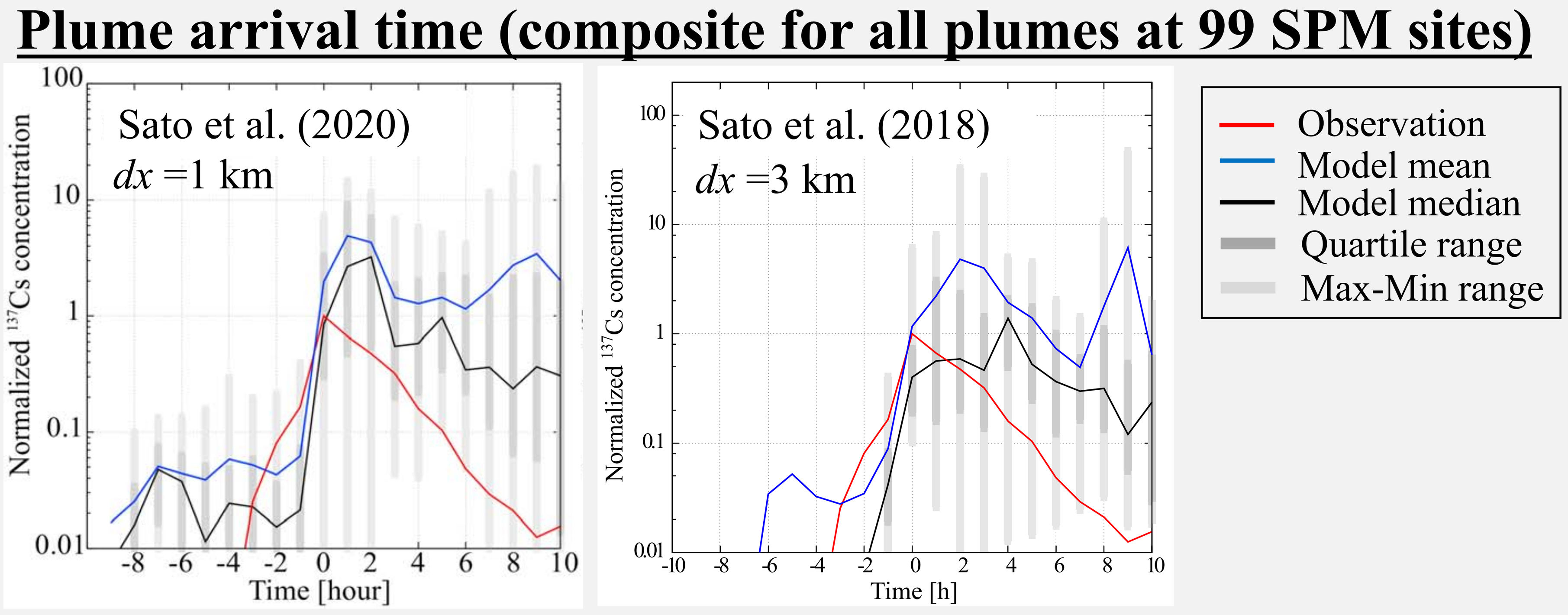
Cumulative ^{137}Cs Deposition Amount Over Land During March 2011 and Ratio of Dry Deposition to Total Deposition Over Land

Model (L/E)	Total deposition (PBq)	Area (km^2) where total deposition exceeding 10^4 Bq/m^2	Dry deposition fraction (%)
AIST-MM (E)	3.58	4.26×10^4	1.7
PELLO (L)	3.07	2.52×10^4	79.1
HIRAT-LPRM (L)	3.62	3.29×10^4	14.2
ldX (E)	3.08	2.57×10^4	24.4
GEARN (L)	4.03	4.09×10^4	23.4
WRF-Chem-J (E)	3.76	3.57×10^4	6.7
NHM-Chem (E)	1.45	1.69×10^4	18.5
WRF-CMAQ (E)	1.79	2.11×10^4	3.6
SCALE (E)	0.18	4.49×10^3	79.6
Polyphemus (E)	2.48	2.65×10^4	61.9
WRF-Chem-T (E)	2.04	3.84×10^4	6.6
NICAM (E)	3.17	2.57×10^4	9.0
Observation (MEXT, 2011)	2.65	3.28×10^4	—

(Sato et al. 2018)

Even though the same meteorological data and same emission, the deposition map and deposition fraction were different from model to model

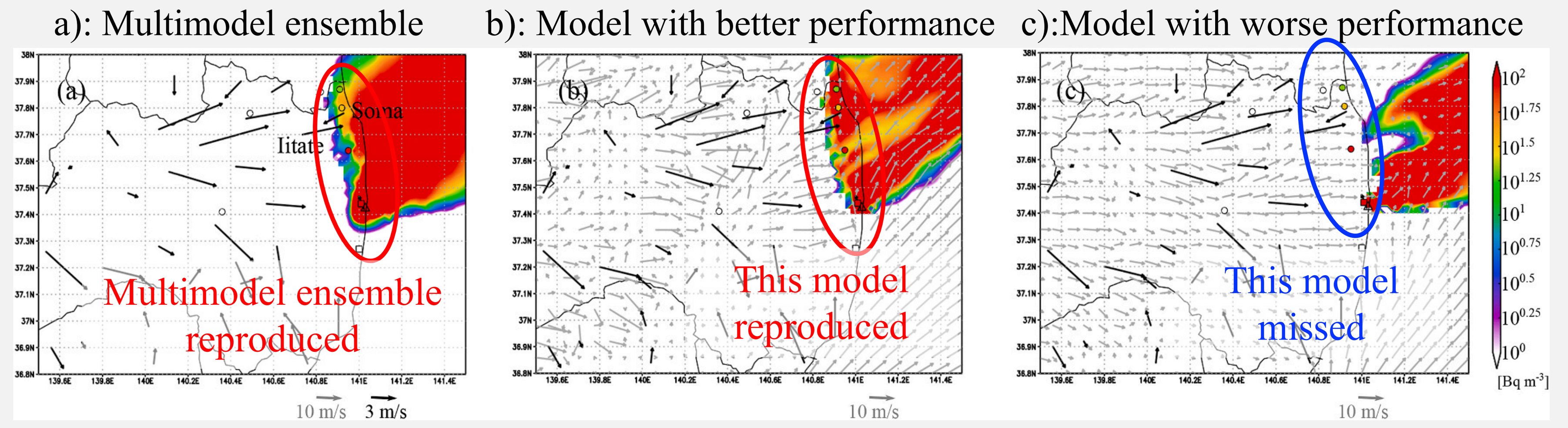
Plume arrival time (composite for all plumes at 99 SPM sites)



Most of the models well reproduced plumes arrival time with 2~3 hours delay from measured plumes at SPM sites during March. 2011

Advantage of multimodel ensemble (shade: model, circle: Obs.)

Geographical distribution of the concentration of atmospheric ^{137}Cs at 1st layer of the model



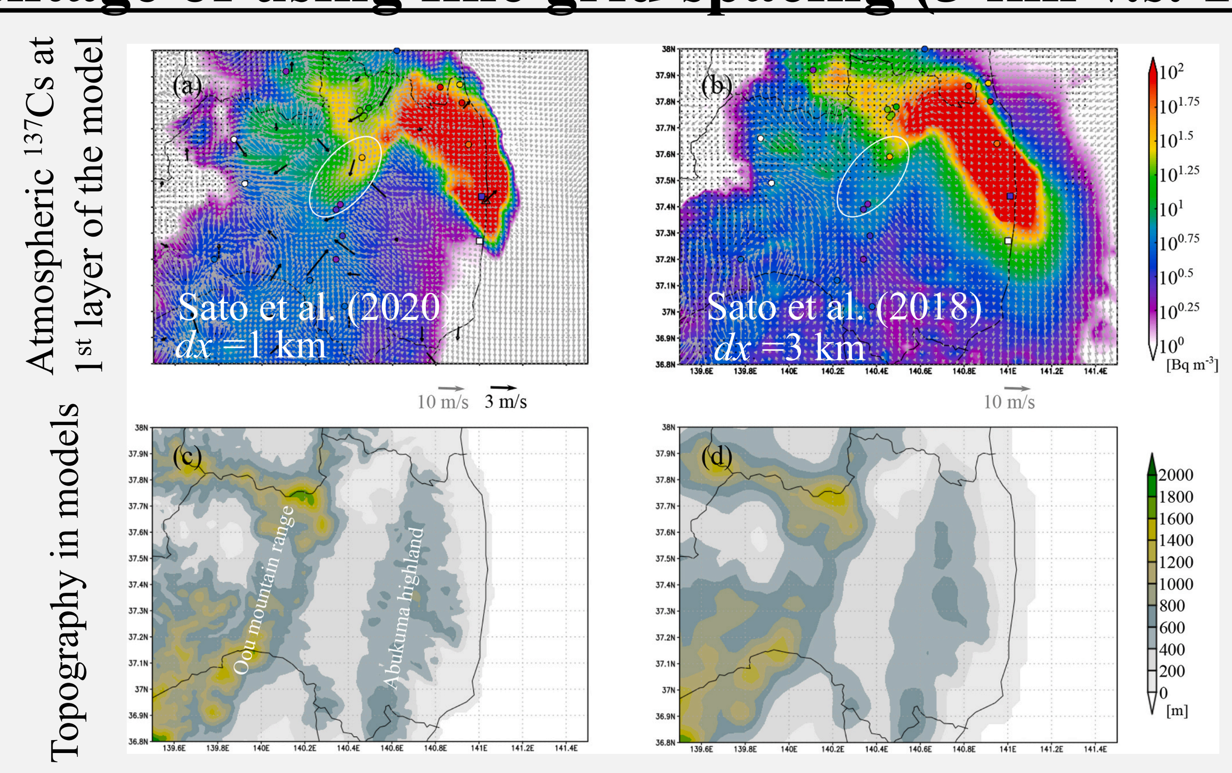
Good performance by some models cancelled bad performance of other models

Model name	RANK2 Sato et al. (2020)	RANK2 Sato et al. (2018)
AIST-MM	1.88	2.78
ldX	2.88	2.75
GEARN	2.65	2.86
WRF-Chem-J	2.93	2.98
NHM-Chem	1.64	1.90
WRF-CMAQ	1.92	2.38
SCALE	0.92	0.73
WRF-Chem-T	2.95	2.93
NICAM-Chem	2.50	2.57
Ensemble	2.72	3.21

RANK2 (Sato et al. 2018) :
An evaluation metric
High RANK⇨ Good performance

- Multimodel ensemble shows better performance than each model
- Fine resolution is not always improve the performance of the model

Advantage of using fine grid spacing (3 km v.s. 1 km)



The wind field affected by the topography was improved by using fine grid spacing, due to improvement of the topography in the model, and improve performance.

Acknowledgement: "Environment Research and Technology Development Fund (Grant number : JPMEERF20155001, JPMEERF20181002) of the Environmental Restoration and Conservation Agency of Japan" and "JSPS KAKENHI (Grant Number 17K00533, 18K11633, 19H01155)". Yousuke Sato is supported by "Research Field of Hokkaido Weather Forecast and Technology Development (endowed by Hokkaido Weather Technology Center Co. Ltd.)"