

IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Impact of changing the wet deposition schemes in IdX on ^{137}Cs atmospheric deposits after the Fukushima accident

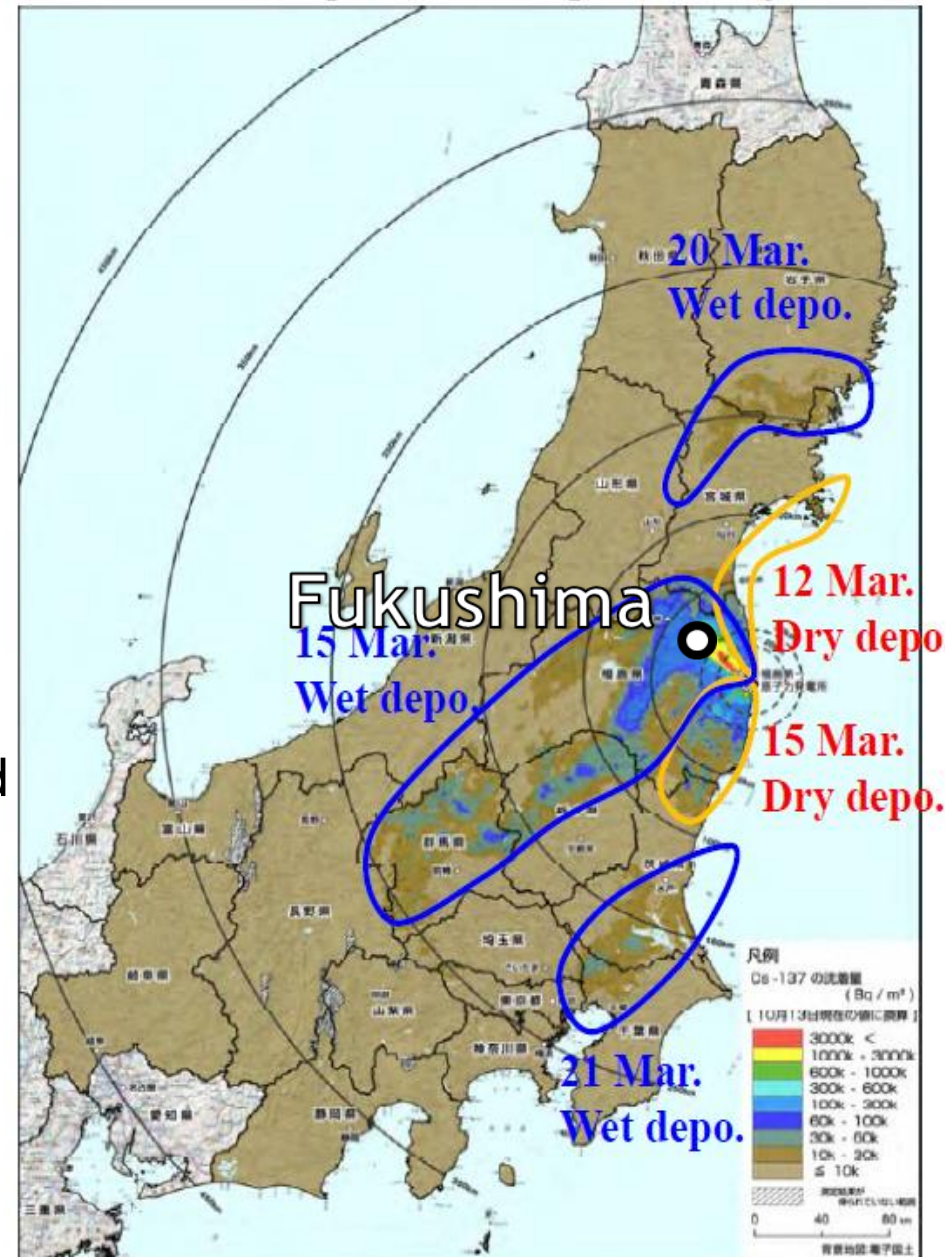
Arnaud Quérel, **Denis Quélo**, Yelva Roustan, Anne Mathieu, Mizuo Kajino, Thomas Sekiyama, Kouji Adachi, Damien Didier, Yasuhito Igarashi and Takashi Maki

SAKURA project framework

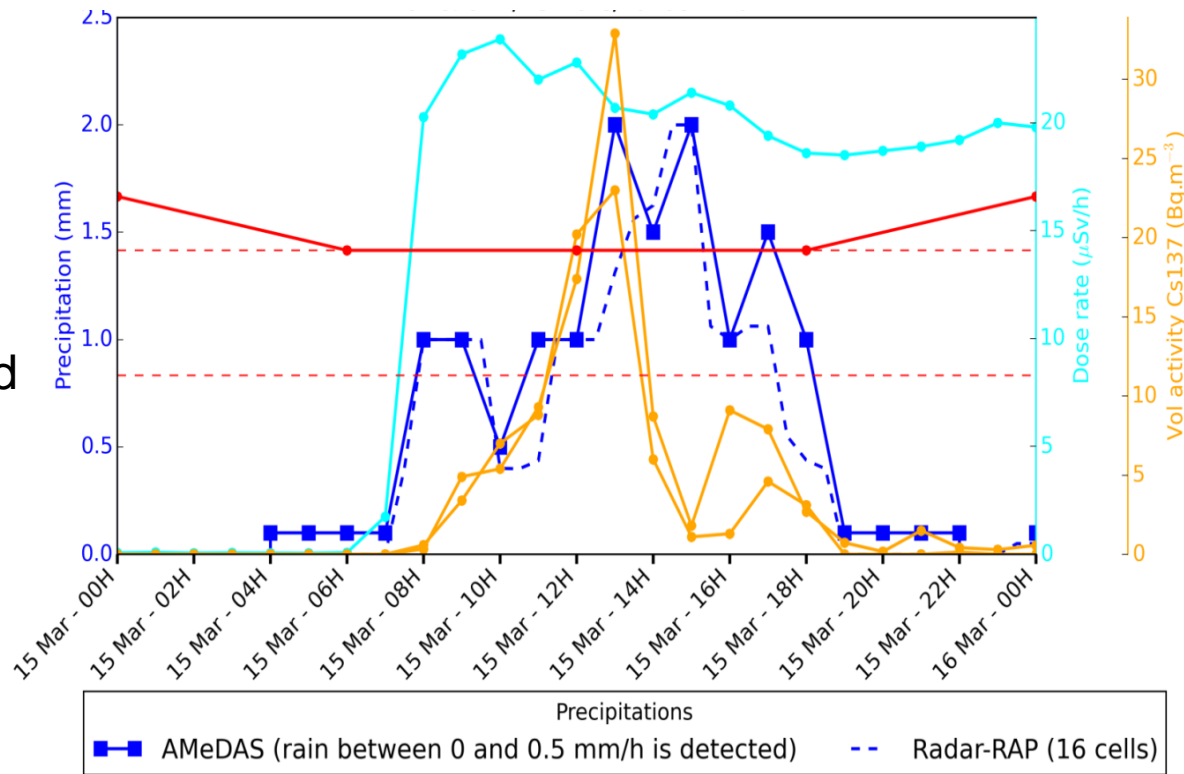


DavyRamirez.com

- Observation map of cesium established several months after the accident.
- Several releases leading to a large scale deposit: contaminated areas further than 150 km.
- The main process of deposition was wet scavenging of the plume.
- Precipitation involved: **rain**, snow and fog.
- This accident provided an opportunity to study the atmospheric dispersion modelling of radionuclides.



- Measurements of **radioactivity** and **precipitation** are available almost at the same location.
- Plume was passing at ground between 08h and 22h (low levels).
- Rain started at 07h and was detected few hours before (0.5 mm/h detection limit)



- The dose rate indicates an increase between 07h and 08h before the arrival of the plume at ground, then almost a stay at the same level.
- This massive deposit happened fast in the presence of rain.

➤ Scavenging of a plume in altitude.

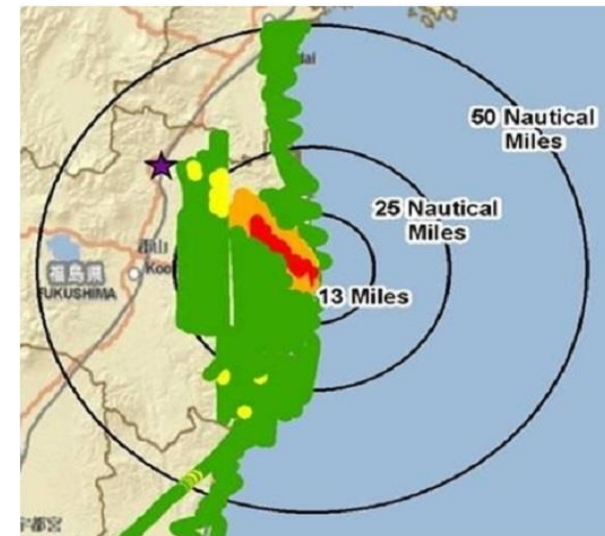
Advise on emergency actions to protect people:

- Sheltering-in-place, iodine tablet distribution (emergency phase).
 - Food restrictions (ingestion of contaminated products).
- > transfer to the food chain of the deposit
- How to live in contaminated areas in the long term?
- > ground shine of the deposit

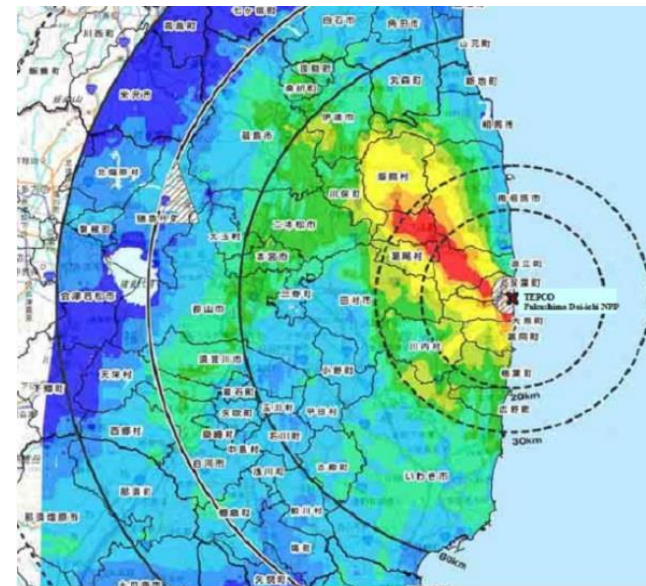
Modelling of deposit is a key point in nuclear emergency response

Motivation:

- Do advances in the modelling of wet deposition to be integrated in IRSN operational atmospheric models



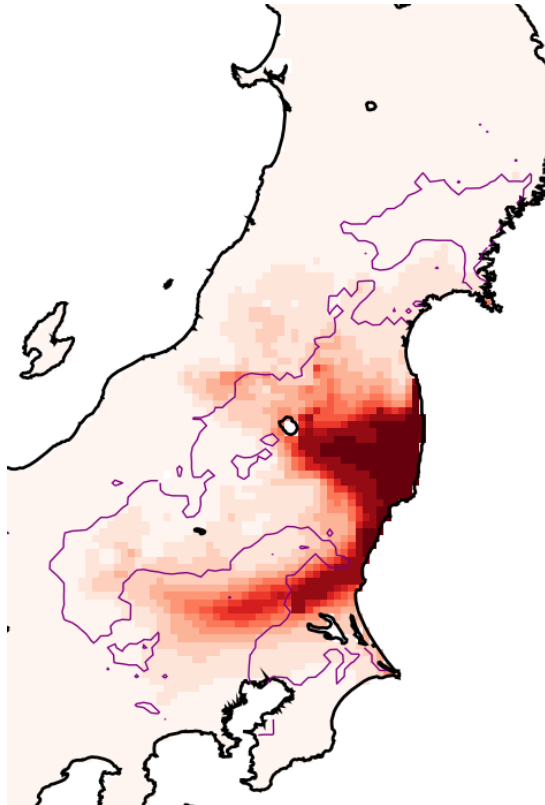
Available on 22nd, March 2011



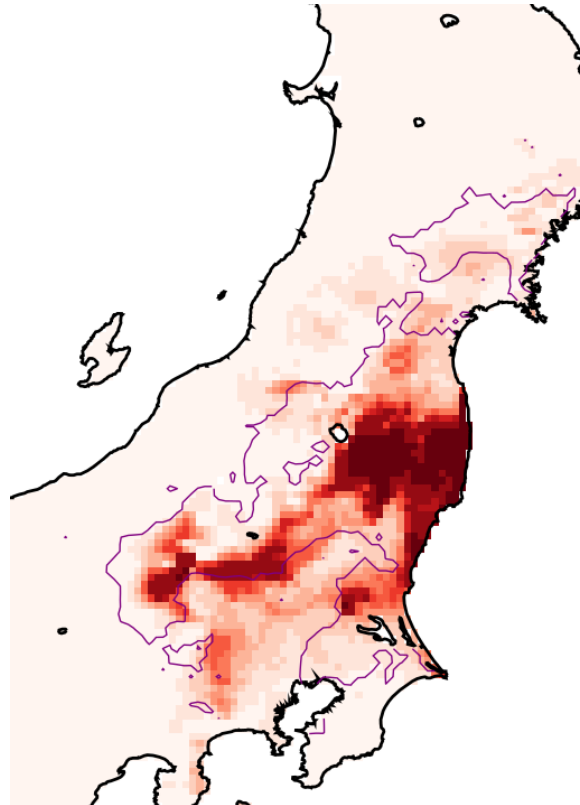
Available on 26th, May 2011

➤ A diversity of wet deposition schemes available in the literature

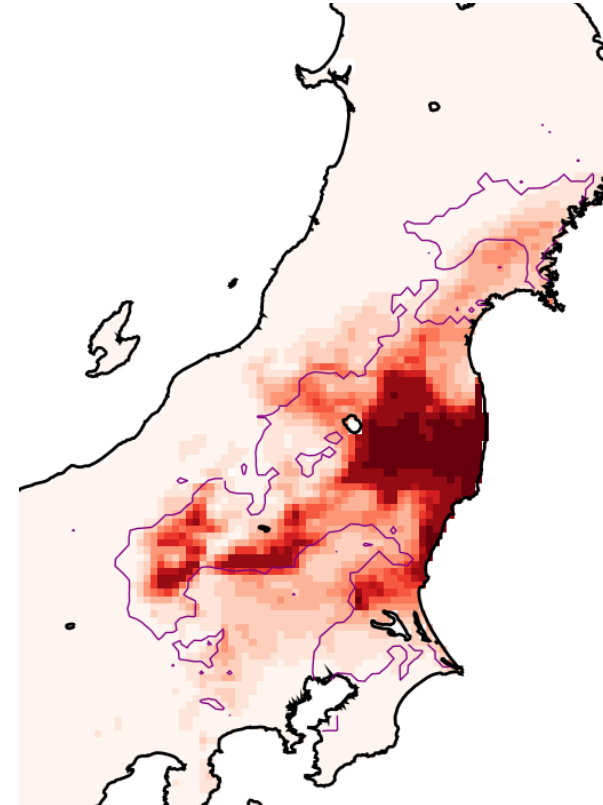
Below- and in-cloud scavenging based on **relative humidity** (Pudykiewicz)



In-cloud scavenging based on **liquid water content** (Roselle & Binkovski)



In-cloud scavenging based on **rain intensity** (Scott)



■ Criteria of a “good” wet deposition scheme

- Better to know where the material is deposited than to evaluate precisely the deposit levels. **assessment of risk zones**
- Important to not reconsider any estimation upward (communication issues). **no underestimation, “reasonably conservative results”**

-> favorite metrics: **FMS**, FAC2, correlation,...

■ Emergency response context: information vary in time

- more and more available: several estimates (of the release quantity)
- more and more reliable , but not perfect: deal with **uncertainties**

-> use an ensemble-type framework combining several meteorology data, source terms, wet deposition schemes (both in- and below- clouds)

➤ Looking for a swiss army knife?

Previous step: a sensitivity analysis (4600 simulations)

- Hints to discriminate the choice of wet deposition models applied to an accidental radioactive release. Quérel, A., Roustan, Y., Quélo, D., Benoit, J.-P., 2016. (HARMO 16th)

Main lessons

- Complex wet deposition schemes (describing rain drop size, aerosol size) do not lead to an overall improvement in comparison to simple parameterizations
- a “best” wet deposition scheme (suitable for any criteria) could not be highlighted

➤ Better to have several schemes at our disposal

Give a chance to schemes operated in similar operational atmospheric dispersion models: WMO Task Team investigating the dispersion of radioactive material from Fukushima-Daiichi Nuclear Power Plant (Draxler et al., 2012)

-> useful to have this modelling for comparison in case of another event

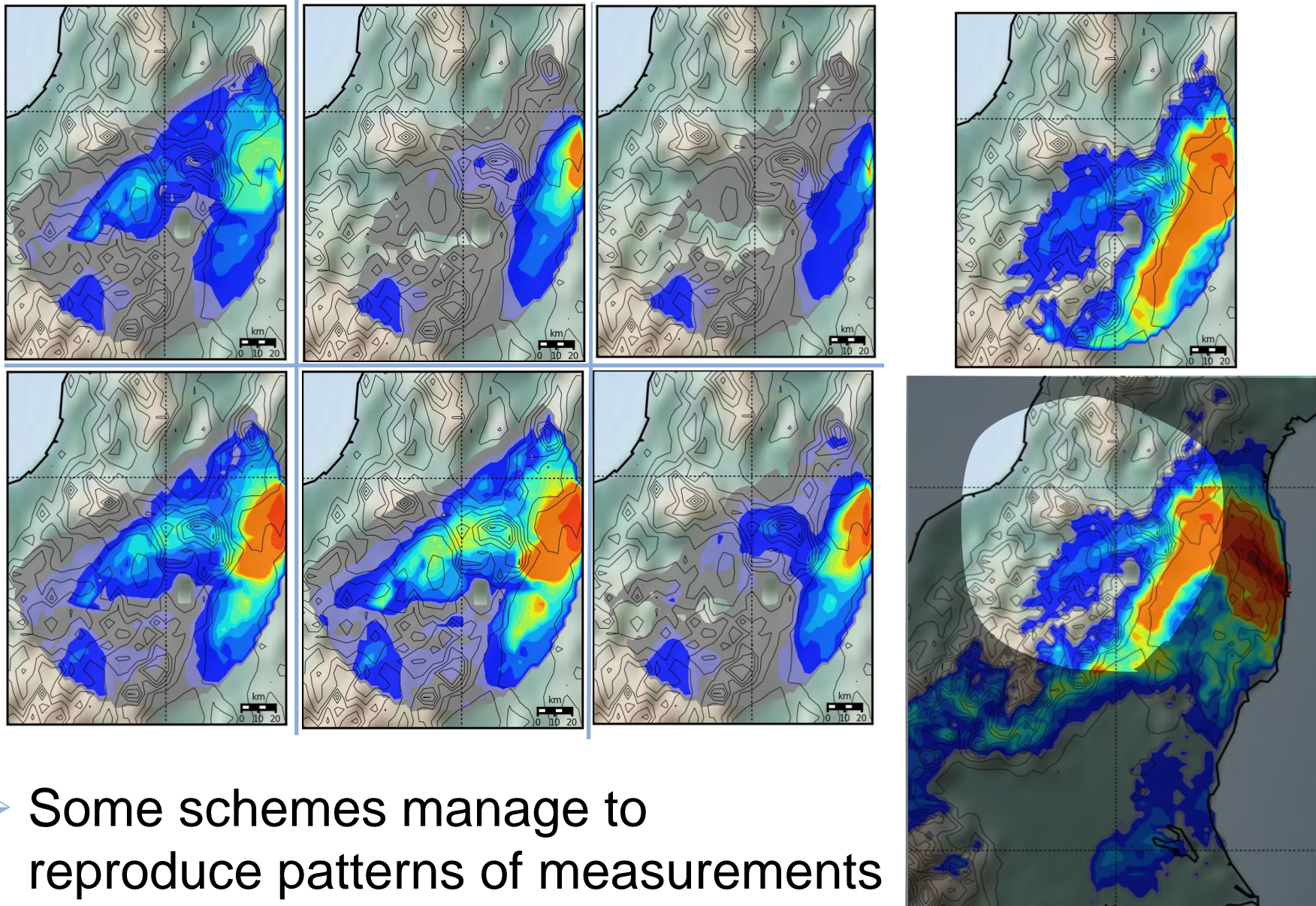
Wet deposition schemes

Atmospheric transport modelling	Below-cloud scheme	In-cloud scheme
CMC-MLDP0	$\Lambda = 0$	$\Lambda = 3 \times 10^{-5}$
FLEXPART	$\Lambda = 10^{-5} I^{0.8}$	Hertel et al. (1995)
HYSPLIT	$\Lambda = 10^{-6}$	Hertel et al. (1995) with $S = 4 \times 10^4$
IRSN	$\Lambda = 5 \times 10^{-5} I$	$\Lambda = 5 \times 10^{-5} I$
NAME	$\Lambda = 8.4 \times 10^{-5} I^{0.79}$	$A = 3.36 \times 10^{-4} I^{0.79}$
RATM	$\Lambda = 2.78 \times 10^{-5} I^{0.75}$	Hertel et al. (1995) with LWC model

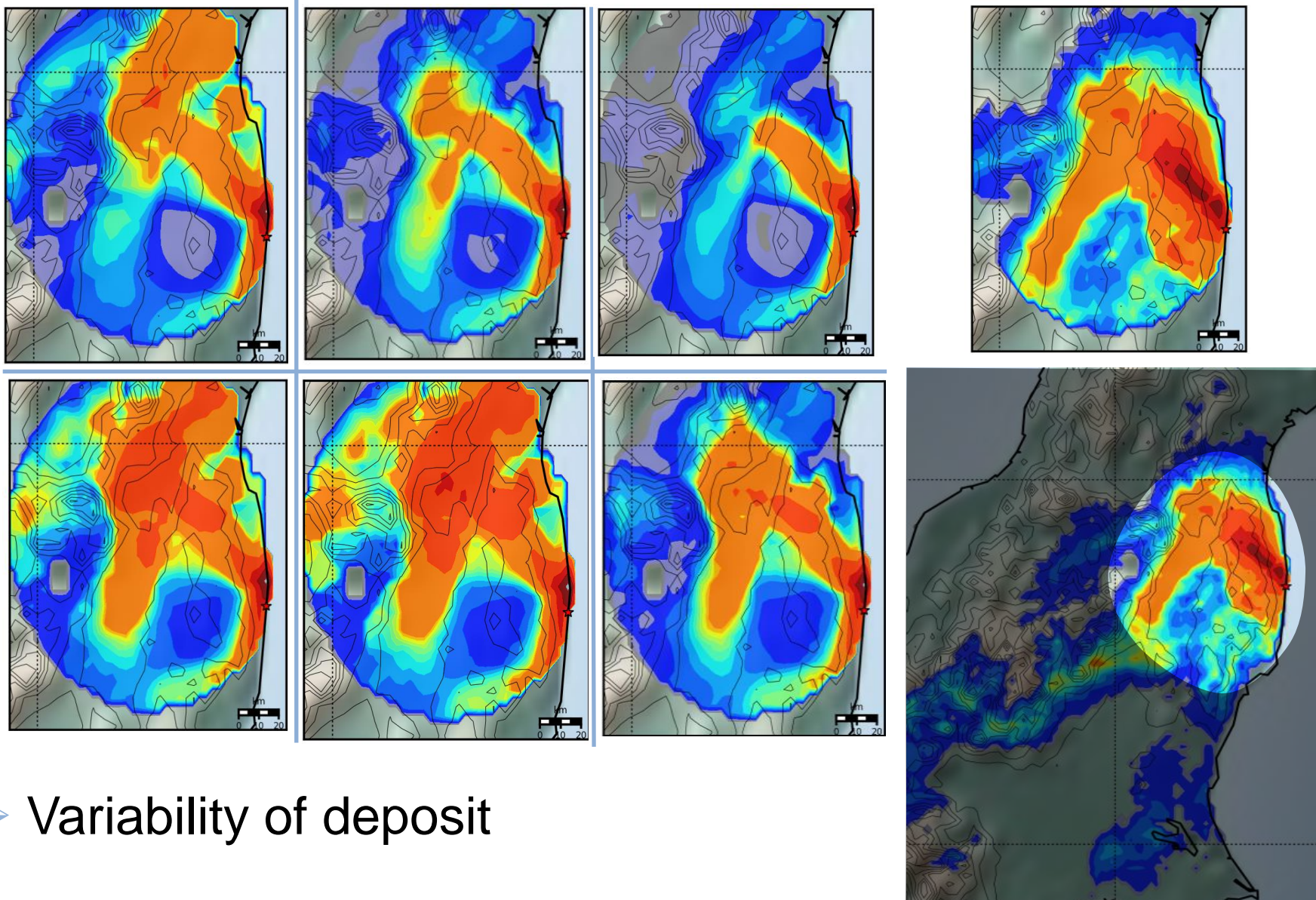
- Below-cloud: null, constant, rain intensity dependant
- In-cloud: constant, function of rain intensity, function of liquid water content

Input data of the ensemble-type

- Source terms: Katata (2015), Terada (2012), **Saunier** (2013)
- Meteorological fields: Sekiyama et al. (2013, members #1 and #8)
- Precipitations: produced by the meteorological model or derived from radar/rain gauges-analyzed precipitation.



- Some schemes manage to reproduce patterns of measurements



➤ Variability of deposit

■ The 6 options of wet deposition modelling perform differently according to:

- area
- input data (meteorology, source term)
- criteria

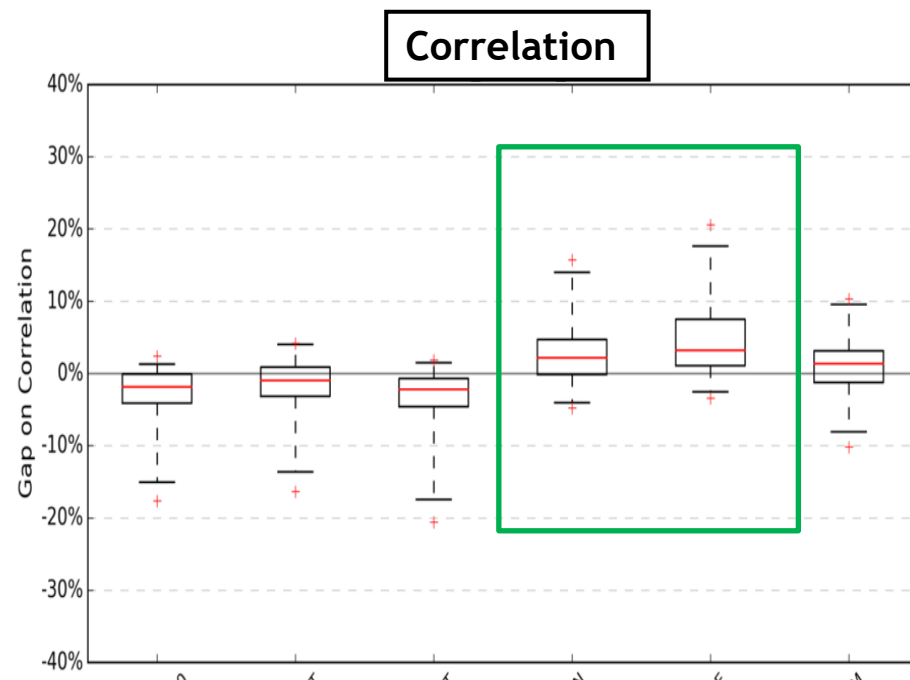
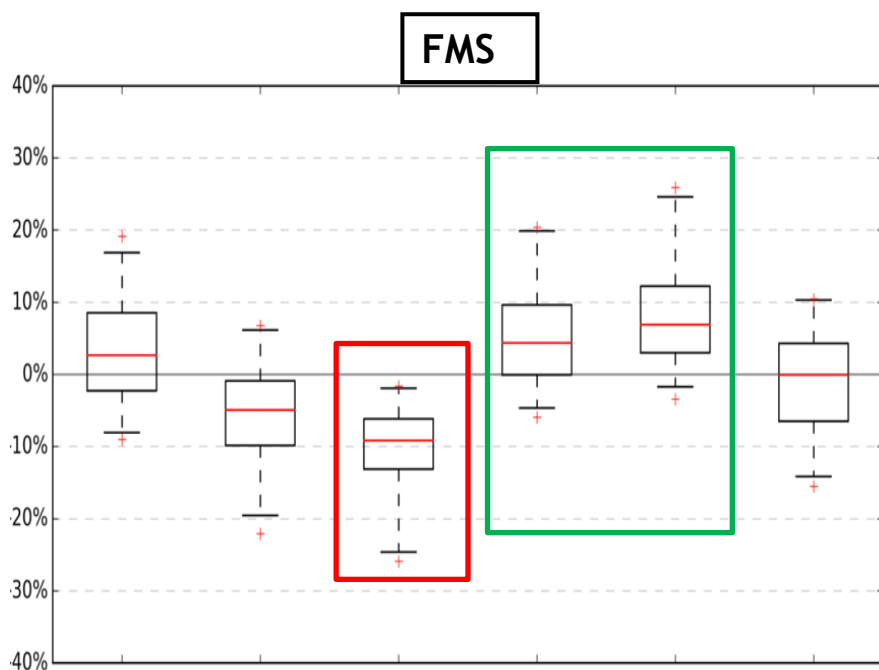
➤ Which one as a first choice?

■ Evaluate the robustness of one specific scheme:

- focus on one wet deposition scheme and compare its results to those derived from other choices in the same configurations in the ensemble of simulations
 - How many simulations are improved ?
 - Is this improvement meaningful?

Impact of one choice rather than others

- Whisker boxes represent distributions of discrepancies on a statistical indicator for each choice of wet deposition scheme in a simulation sharing the same configuration.



- One scheme never gives better FMS than others
- Two schemes perform better in many situations

Summary

- Our long-range transport model IdX includes now several wet deposition modelling able to reproduce different patterns of the Fukushima deposit map
- Two of them appear to be more robust and could be the standard in our operational configuration

Future works

- Consolidate these preliminary results (increase the size of the ensemble)
- Work on parameters which influence the repartition between in- and below-cloud scavenging
 - clouds modelling (base and top) as a constituent of the wet deposition modelling (for now, same configuration is used)
 - Vertical position of the plume