IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Impact of changing the wet deposition schemes in ldX on 137-Cs atmospheric deposits after the Fukushima accident

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SAKURA project framework

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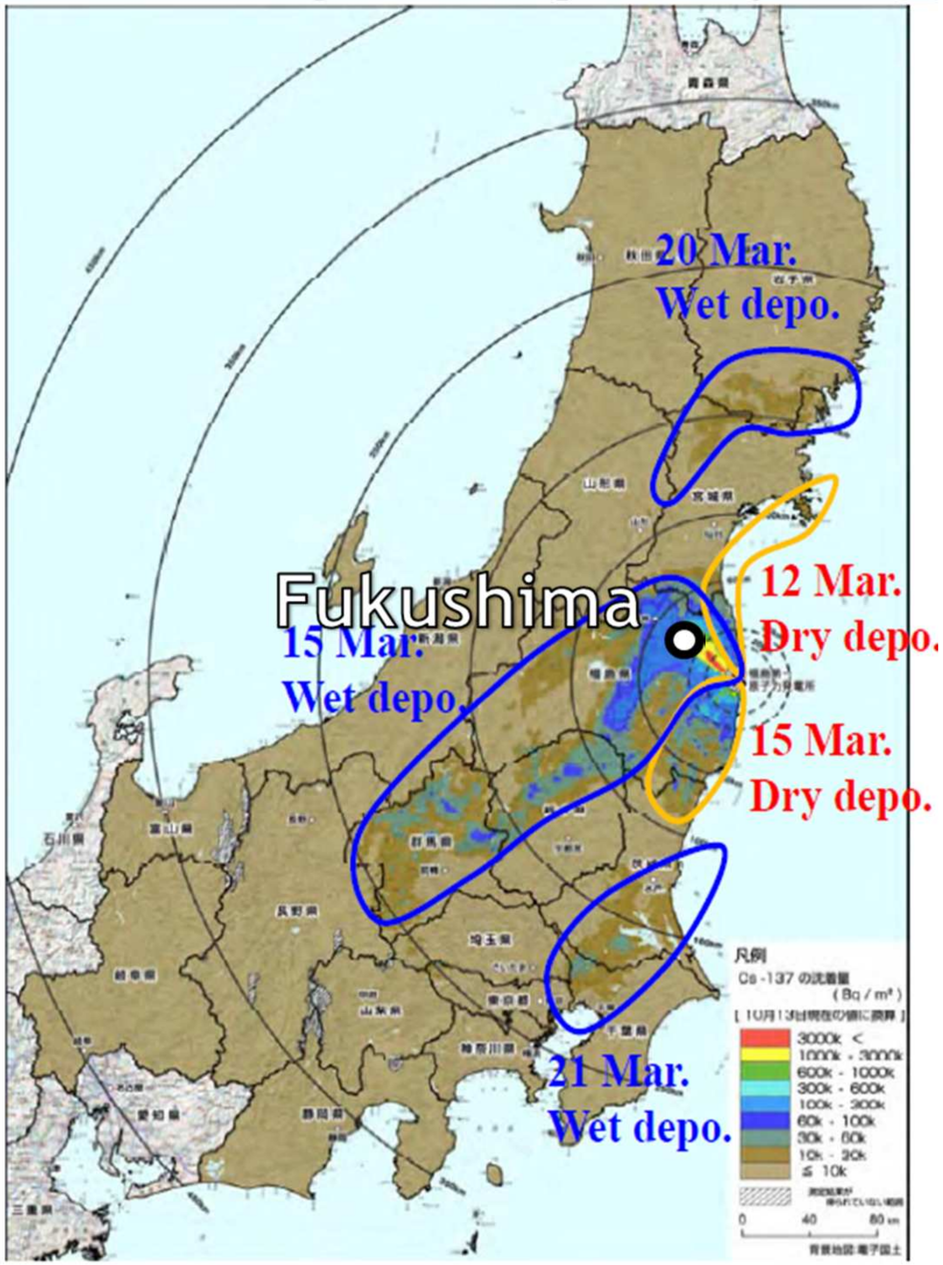
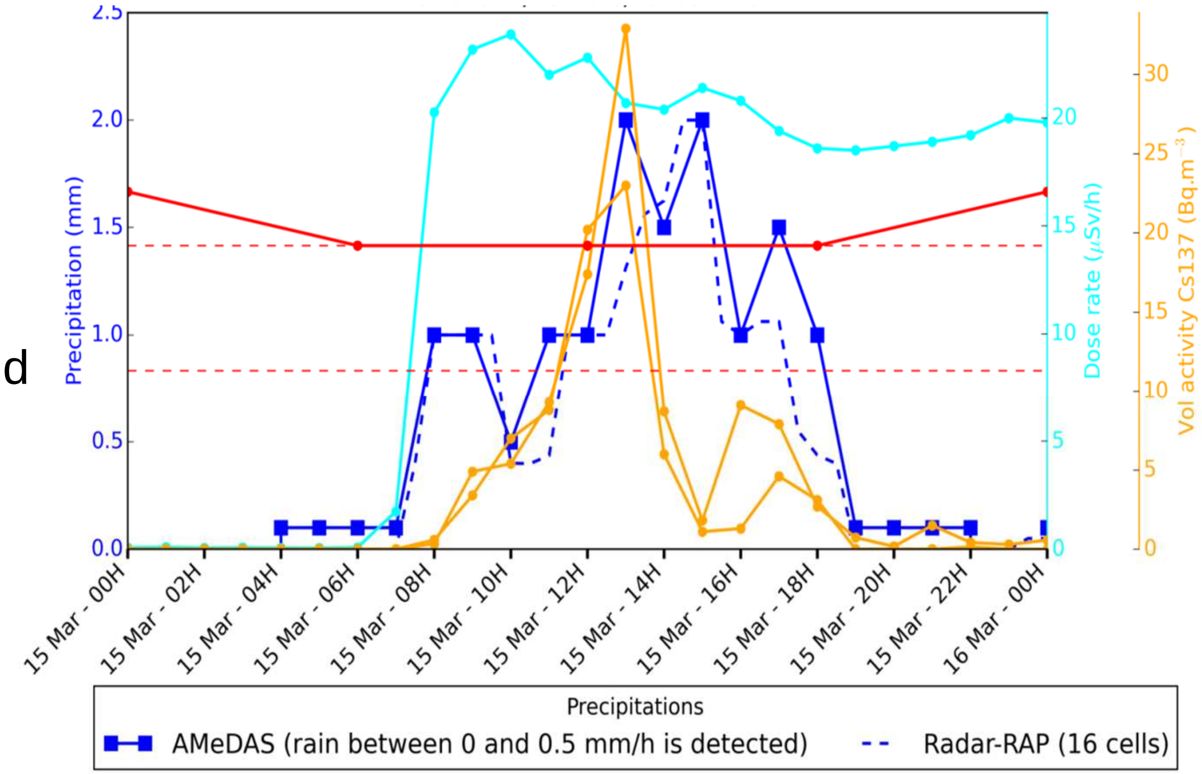
- Observation map of cesium established several months after the accident.
- Several releases leading to a large scale deposit: contaminated areas further than 150 km.
- The main process of deposition was wet scavenging of the plume.
- Precipitation involved: **rain**, snow and fog.

➢ 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.

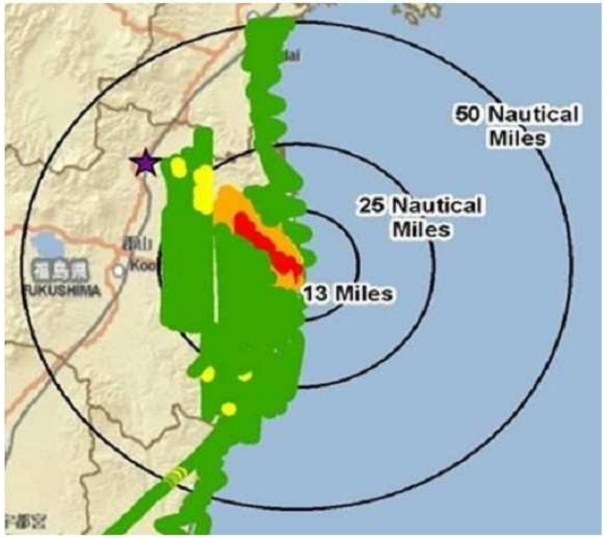
Advise on emergency actions to protect people:

- 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



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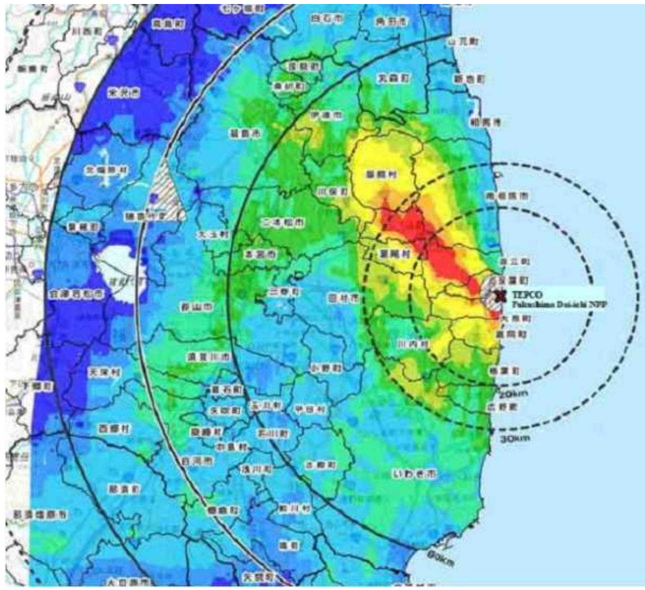


Available on 26th, May 2011

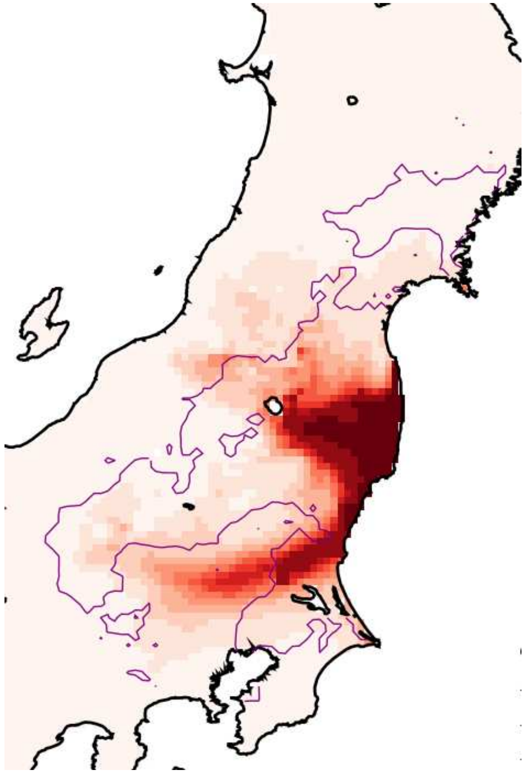
Modelling of deposit is a key point in nuclear emergency response

Motivation:

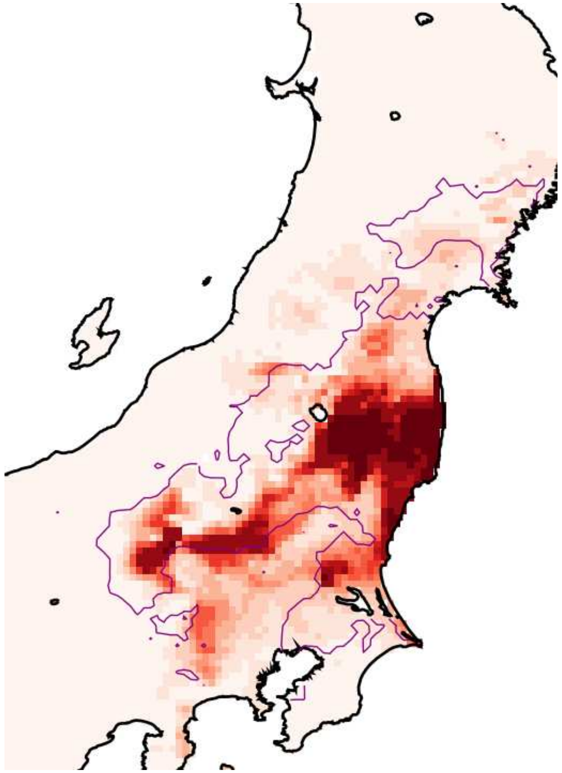
➢ Do advances in the modelling of wet deposition to be integrated in IRSN operational atmospheric models

A diversity of wet deposition schemes available in the literature

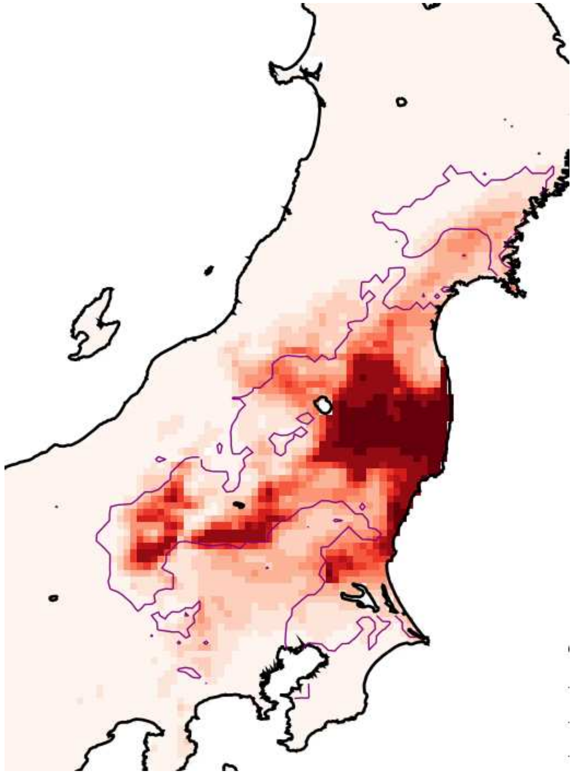
Below- and in-cloud scavenging based on relative humidity (Pudykiewicz)



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



In-cloud scavenging based on rain intensity (Scott)



- Which wet deposition schemes to choose?

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

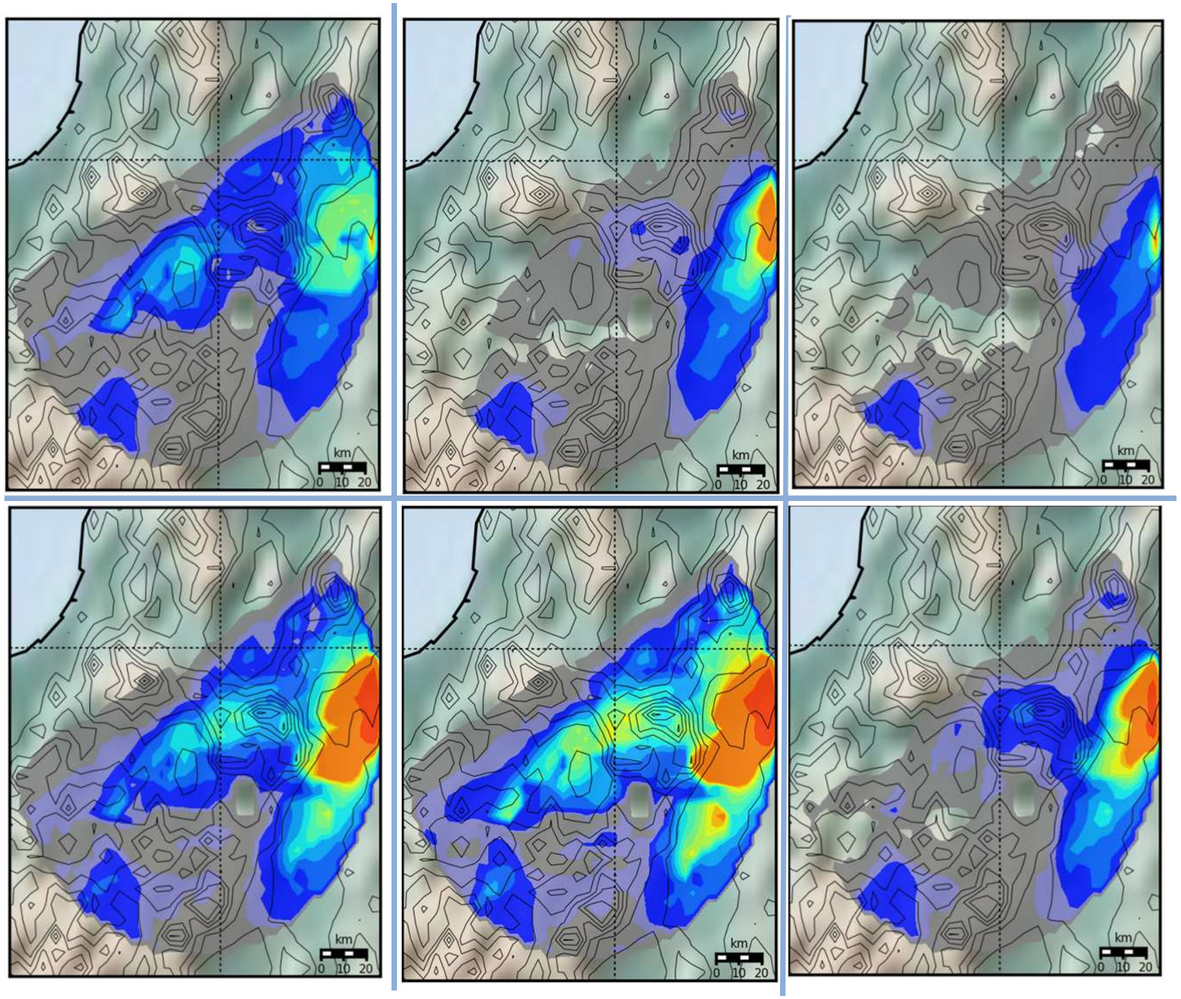
Wet deposition schemes

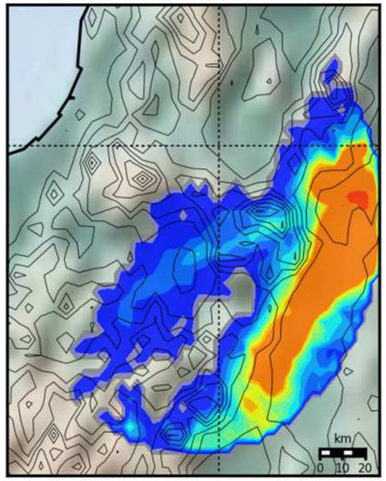
Atmospheric transport modelling	Below-cloud scheme	In-cloud scheme
CMC-MLDP0	$\Lambda = 0$	$\Lambda = 3\times 10^{-5}$
FLEXPART	$\Lambda = 10^{-5} I^{0.8}$	Hertel et al. (1995)
HYSPLIT	$\Lambda = 10^{-6}$	Hertel et al. (1995) with $S = 4\times 10^{4}$
IRSN	$\Lambda = 5\times 10^{-5} I$	$\Lambda = 5\times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

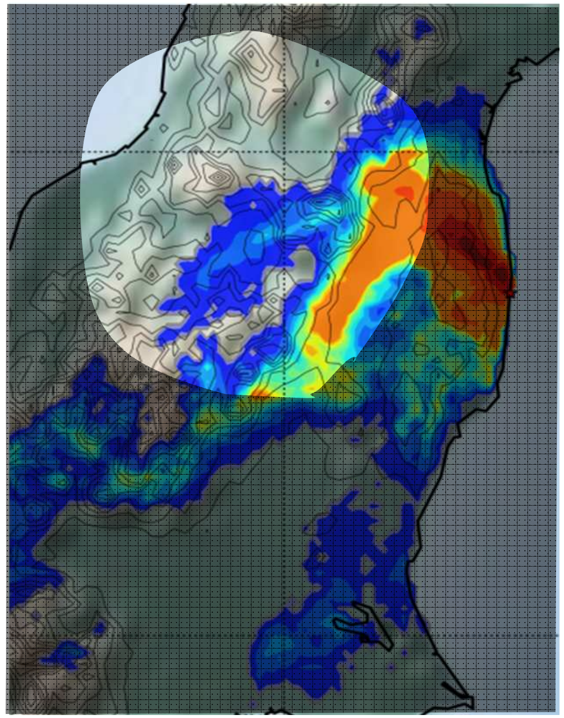
- Below-cloud: null, constant, rain intensity dependant
- In-cloud: constant, function of rain intensity, function of liquid water content

Input data of the ensemble-type

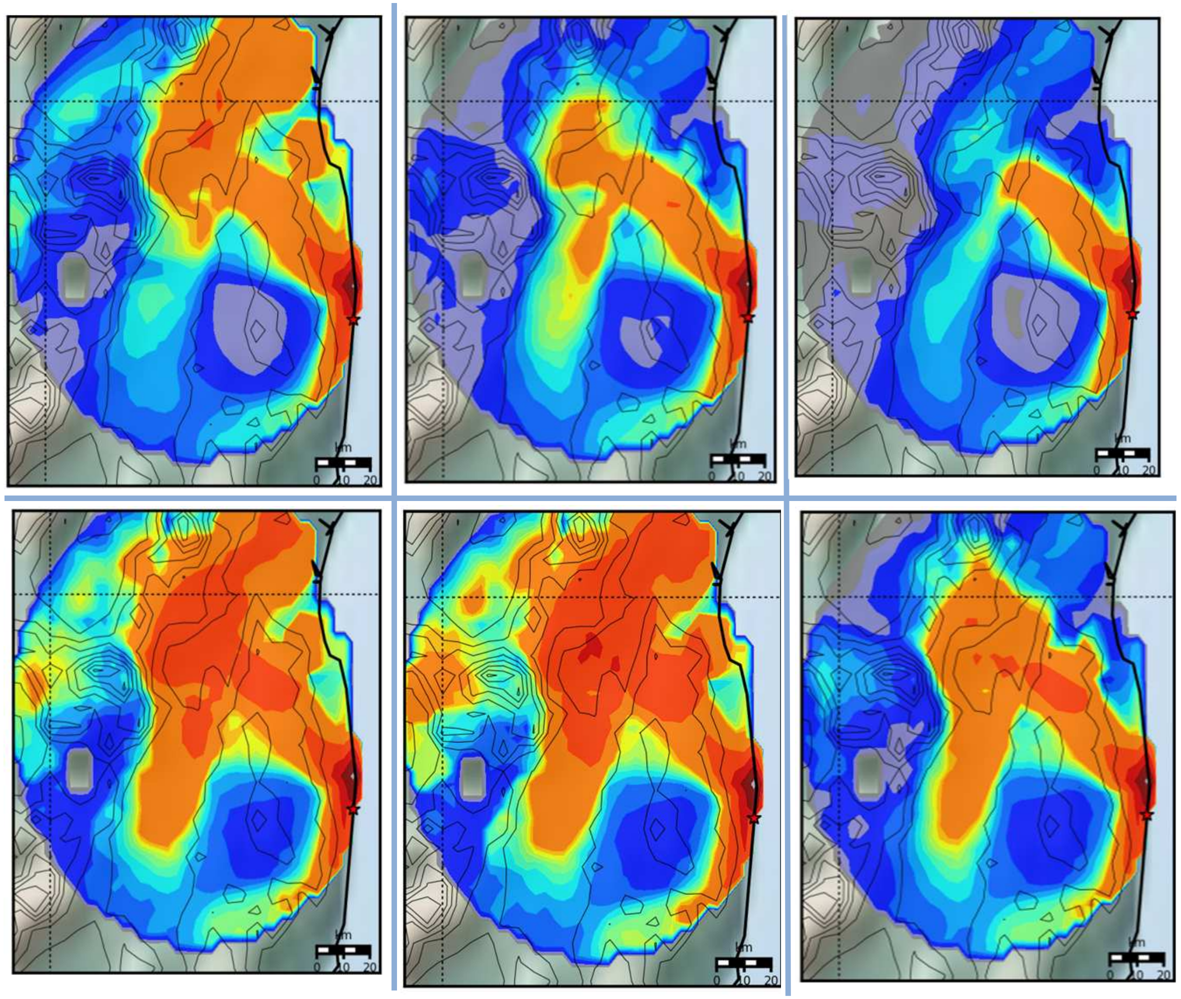
- Source terms: Katata (2015), Terada (2012), **Saunier** (2013)
- Meteorological fields: Sekiyama et al. (2013, members #1 and #8)
- Precipitations: produced by the meteorological model or derived from radar/rain gauges-analyzed precipitation.

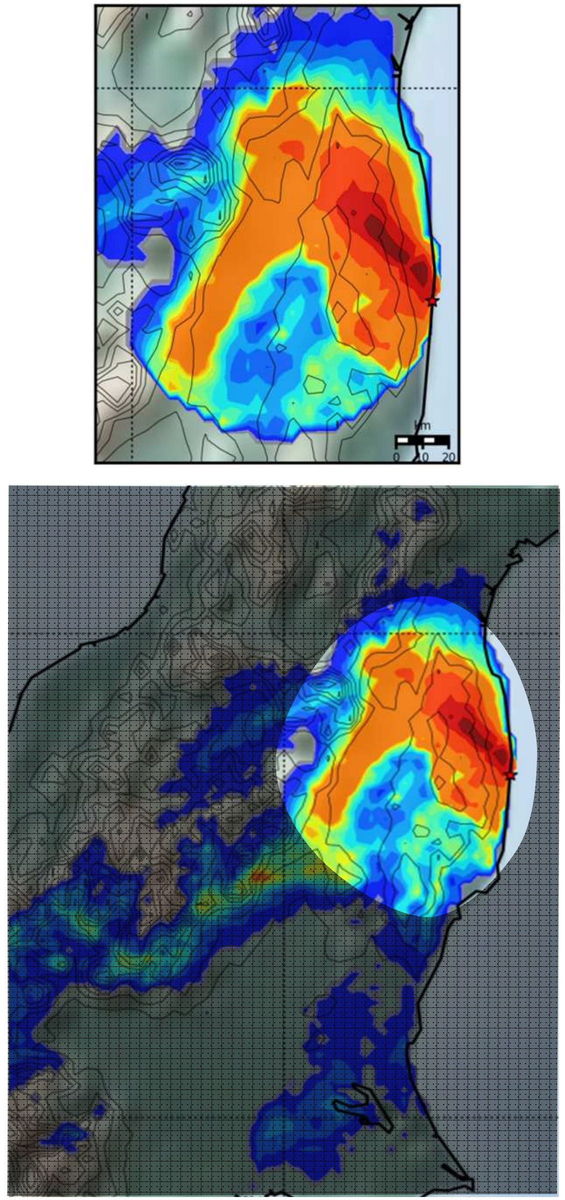






- Some schemes manage to reproduce patterns of measurements





- Variability of deposit

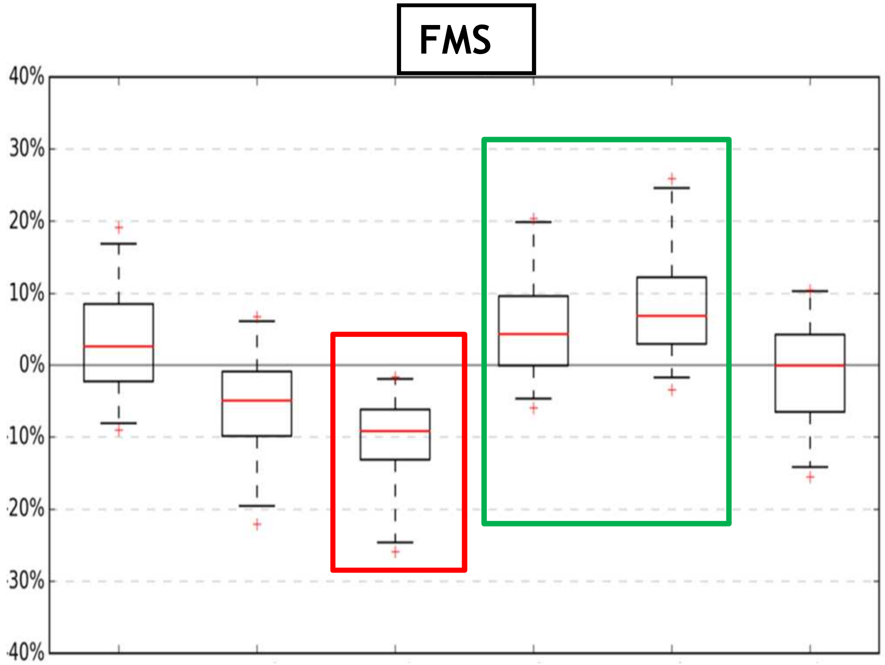
- The 6 options of wet deposition modelling perform differently according to:
  - area
  - input data (meteorology, source term)
  - criteria

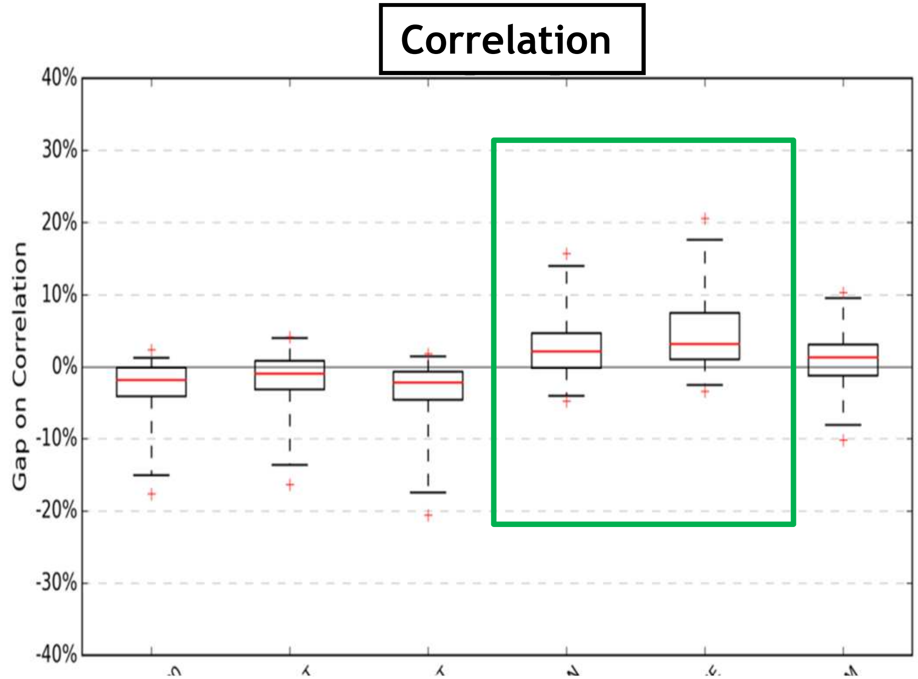
➢ Which one as a first choice?

- 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 ldX 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