IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Operational model and response

International Workshop on Dispersion and Deposition Modeling for Nuclear Accident Releases

-Transfer of science from academic to operational models-

March 2 2015, Fukushima University

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Environmental transfers modelling section
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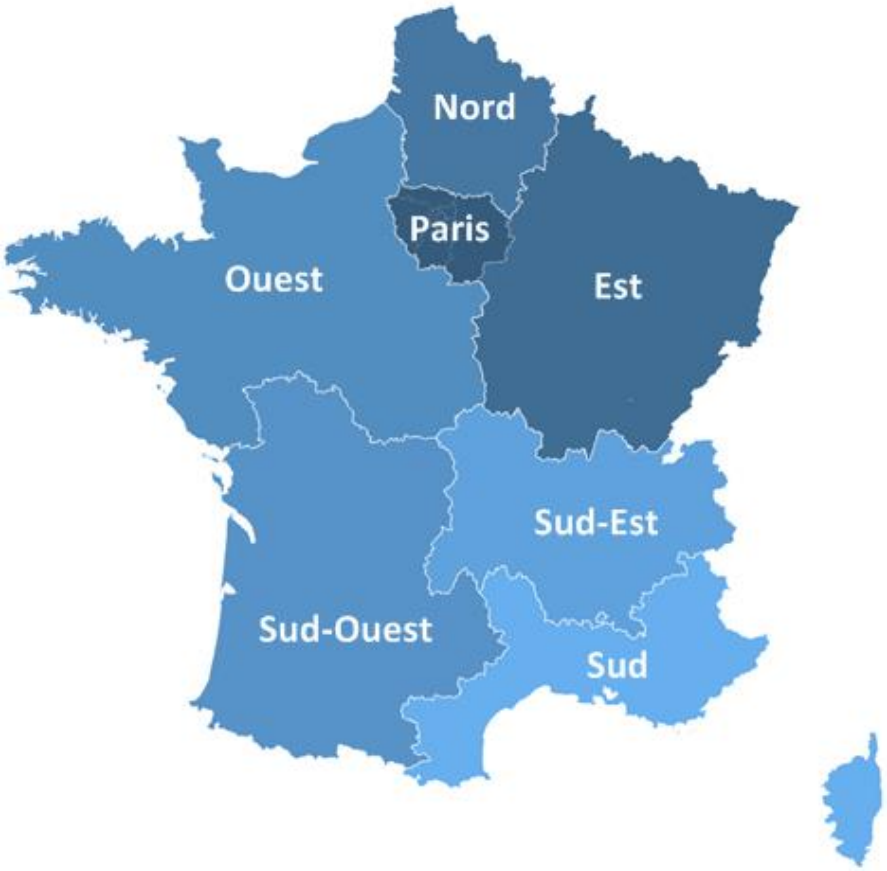
Evacuation decision process

- Organizational structure, responsibilities and authorities

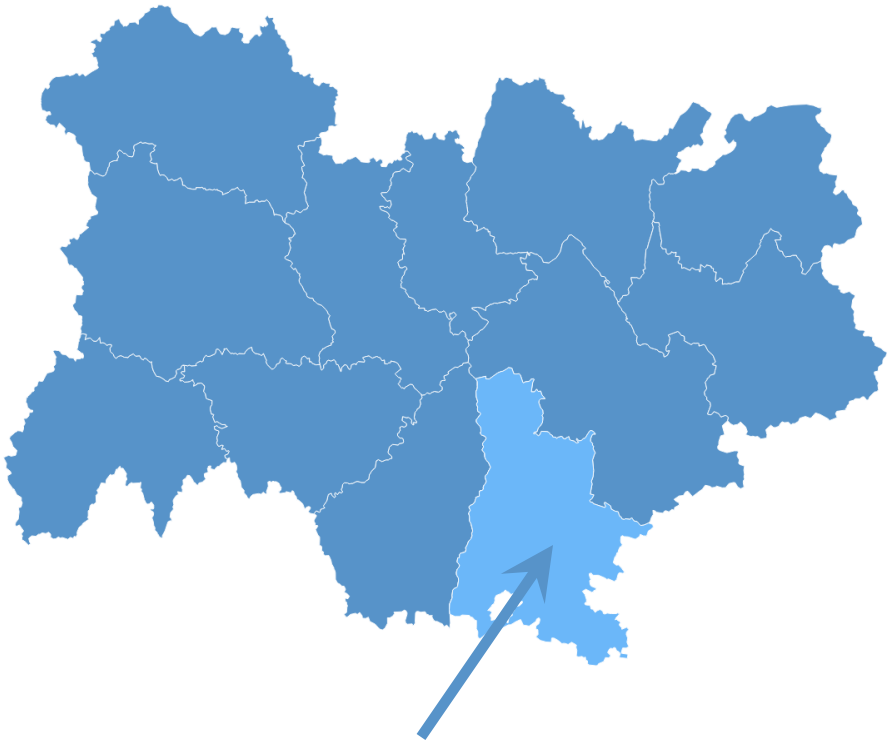


7 defense and security zones
96 metropolitan departments + 5 overseas

National

- **Government**: CIC
  - Centralize all information
  - Analyze / Anticipate
  - **Prepare strategic & policy decisions**
  - Prepare communication
- **ASN / ASND**: Safety – Radioprotection authority - Government adviser
- **IRSN**: **Technical adviser to ASN, ASND & public authorities**
  → provide tech. expertise and support
- **CEA**: Special duties
- **Operator**: by invitation

At the zonal level



Impacted Department

Regional/Local

- Departmental Prefect : COD
  - Centralize all information
  - Directs the local emergency response
  - Public safety and civil protection
  - Inform the public & local officials
- Zonal Prefect: COZ
  - Coordinates between Dept. prefects
  - Gives assistance to Dept.
  - Coordinates with zones & neighbors
- **IRSN: Mobile team**
  - **Coordinates monitoring strategies**
  - **Contributes to the monitoring actions**
  - **Does the population controls**
- Other operators:
  - Environmental monitoring means

LEVEL 3

Crisis Director (IRSN DG)

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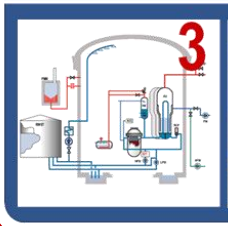
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE
Enhancing nuclear safety

Post-Fukushima

LEVEL 2

Communication Unit


Technical Emergency Centre



Remote Monitoring

Mobile Unit


Advisers to Public Authorities

ASND
CIC Gouvernement
asn
IRSN

Environmental Monitoring Unit

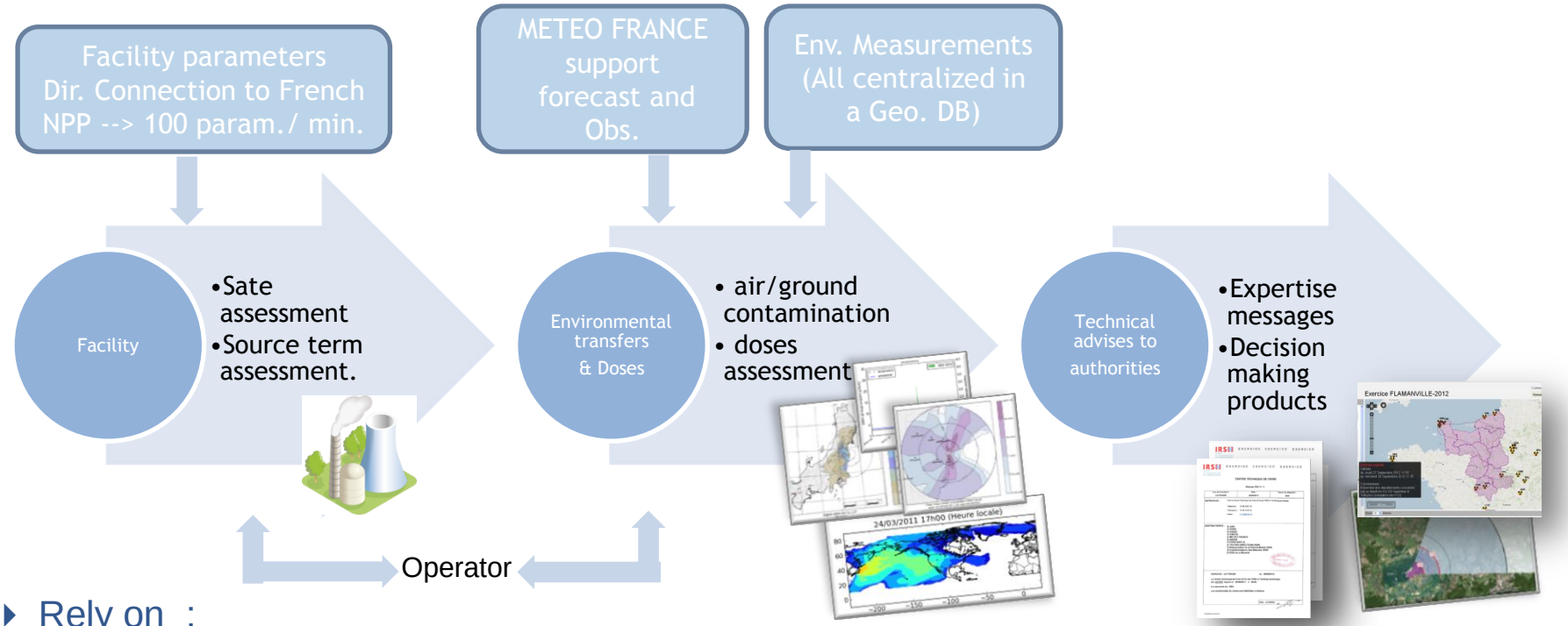

Post-Fukushima

International Unit

Post-Fukushima

Health Unit


THE TECHNICAL EMERGENCY CENTER OF IRSN



- Rely on :
  - Trained experts - up to 15 national exercises per year
  - Methods
  - Tools - a dozen of specific software's
- Activation
  - In less than 1 hour
  - with ~30 people

Evacuation decision process

- Organizational structure, responsibilities and authorities
- **Basis for evacuation decision (predicted or measured releases)**
  - ***and others protective actions***
- **Model output applicable to the decision process**

↗ 2 main modes to decide protective actions

Reflex mode, based on safety criteria

- Sheltering are applied on predetermined zones (planning phase)

Based on consequences assessment

- **Release threat phase**
  - Proposal of protective actions based on the **prognosis of the consequences**

    (predicted release assess by facility experts, met. forecast)
    - What could be the consequences is nothing is done ?
      - » Impacted zones, how quickly, etc.
- **Release phase**
  - Confirmation of earlier set up countermeasures OR proposal of extension, based on **the diagnosis of the consequences** (diagnostic release and env. Measurements, met. Obs. if possible).
  - Same as release threat phase to manage the ongoing release (**prognosis of the consequences).**

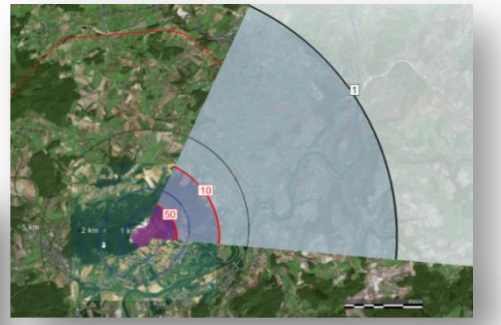
↗ Protective actions should be applied before the actual exposure of the population → need to forecast

↗ All these phases need the use of ATM → Env. measurements alone can't be sufficient

- Decision makers ask for reliable and safe assessment on what protective actions should be taken

→*Different than a best estimate*

- Evaluation of the reasonable upper bound of consequences (time & space)
  - Hypothesis and output products should take into account the risks induced by met., release and dispersion uncertainties
  - Decision products are customizable by experts to deal with these uncertainties and particularities.



Typical kind of emergency map
Derived from the Gaussian puff model pX

- These evaluations are limited by ST & Met durations and their uncertainties which increased over time
  - Usually, protective actions products are limited to the next 24h - 48h.

Model output applicable to the decision process

- In France, guide levels are based on projected doses :

Protective action	Guide levels
Evacuation	Effective dose > 50 mSv
Sheltering and listening	Effective dose > 10 mSv
Stable iodine ingestion	Thyroid dose > 50mSv

Include plume inhalation, plume shine, ground shine exposure pathways
Most conservative population category

- Model outputs used are effective dose and thyroid dose over time
  - Directly computed with air concentrations and deposits ATM outputs.
  - Population is supposed outdoor

Activities during the early phases of the Fukushima Accident

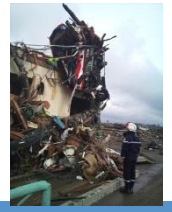
Activation

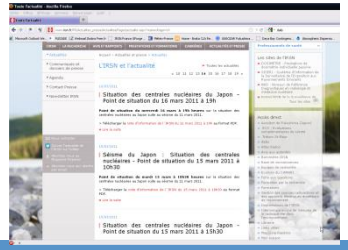
- Activation March 11 @ 10 UTC, De-activation April 29 @ 10 UTC
- 24/7 mode during 4 weeks
  - 30+ experts during day time (inc. spokesmen)
  - 20+ experts during night time
  - Organisation with a « action/anticipation » team @ CTC, and a development team in back office

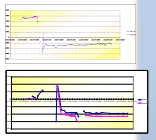
Role

- Support French authorities, specially French Embassy in Japan.
- Provide relevant technical information to the media (more than 1K requests)
- Support of the French rescue team (search for survivors in the rubble)

↗ **Existing organization, methods and tools were used and adapted**





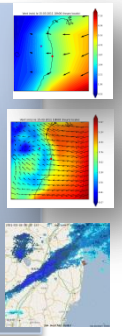


- Expertise on each reactor & spent fuel pool from TEPCO parameters
- ~40 ST assessed
- 12 ST led to an external communication
- Use of env. measurements to set the diagnostic STs

Source Term

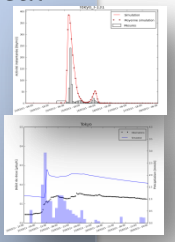
Met.

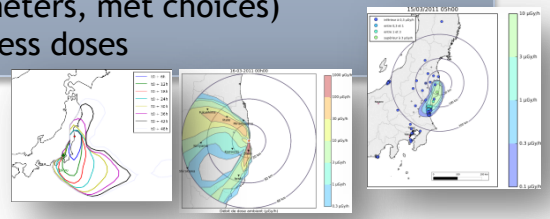
- Meteo France Forecast (ARPEGE 0,5°)
- ECMWF 0,125° (mid-april)
- Exchange with MF who did 11 specific runs
- TEPCO met. observation
- Radar rain from JMA website animations (early april)



Rad. Conseq. ASSESSMENT

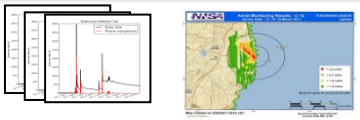
- ~165 consequences assessments (ATM, local to global scale, smoke plume, diagnosis, prognosis)
- 122 internal messages
- Calculated - Measurements comparisons (scores)
- Use of measurements (diagnosis)
  - To improve simulations (ST, dispersion parameters, met choices)
  - To assess doses





Env. measurements

- Download of public measurements from Japanese web sites (scripts dev.)



Decision support products - communications

- Reply to 90 referrals (ASN, Ministry, Embassy, Industrials)
- Release of 82 reports

→ Facility and consequences expertise

- Publication on the IRSN web site of the status of the Fukushima site and reactors on a daily basis (at least)
- Publication on the IRSN web site of the plume behavior from March 19 on a regular basis
- Publication of the first evaluation of the source term from March 22

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22 mars 2011

L'IRSN publie une évaluation de la radioactivité rejetée par la centrale de Fukushima Daiichi (Fukushima I) jusqu'au 22 mars 2011

Annexe

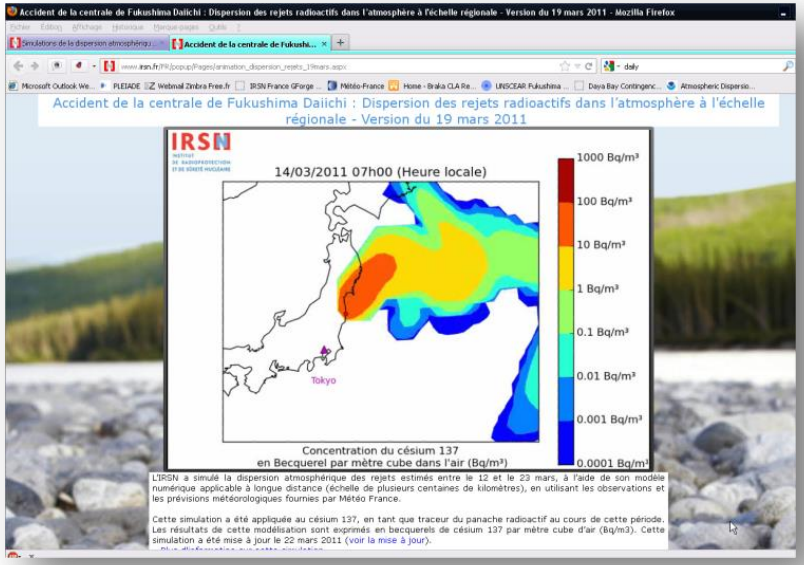
Composition détaillée du rejet utilisé pour estimer les niveaux de contamination de l'air

Isotope	Cumul (Bq)
Kr-85	2 E+16
Kr-85m	1 E+14
Kr-87	7 E+11
Kr-88	5 E+13
Xe-133	2 E+18
Xe-133m	2 E+16
Xe-135	2 E+16
Xe-138	9 E+01
Kr-83m	1 E+13
Xe-131m	2 E+16
Xe-135m	6 E+14

Isotope	Cumul (Bq)
I-131	9 E+16
I-132	7 E+16
I-133	2 E+16
I-134	4 E+11
I-135	2 E+15
I-129	2 E+09
I-132m	2 E+10
I-128	4 E+04
I-130	5 E+13

Isotope	Cumul (Bq)
Cs-134	1 E+16
Cs-136	6 E+15
Cs-137	1 E+16
Cs-138	3 E+09
Cs-134m	1 E+12

Isotope	Cumul (Bq)
Rb-88	5 E+13
Rb-89	3 E+02
Te-133m	4 E+10
Te-134	6 E+09
Sb-130	1 E-15
Sb-125	6 E+14
Sb-127	4 E+15
Sb-128	1 E+10
Te-127	5 E+15
Sb-128m	1 E+13
Sb-129	4 E+13
Te-129m	7 E+15
Sb-131	8 E+05
Te-125m	1 E+14
Te-132	6 E+16
Te-127m	1 E+15
Te-131	5 E+14
Te-131m	2 E+15
Te-133	7 E+09
Br-83	2 E+12
Br-84	7 E+07



↗ Main technical issues about consequences assessment

- Gathering reliable information such as env. measurements took so much time
  - Spread sources, hard to browse…
- Lack of tools and methods to efficiently use the env. measurements
  - Validate, store, use.
- Huge difficulties to deal with uncertainties
  - Source term and met. data., measurements.
  - Difficulties to consolidate the diagnosis and the prognosis

Model improvements since Fukushima

- Most of the improvements has been concentrated on our operational platform C3X (GUI, workflow, features)

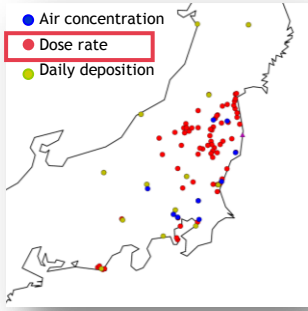
- BUT All our research activities are now connected to the Fukushima case

Following Fukushima, an inverse method based on dose rate has been developed (Saunier & al, 2013)

➔Performs better than our best expert's ST without any strong assumptions or first guess

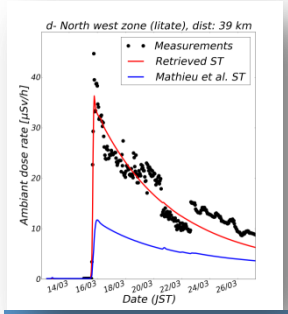
➔Its use in operational framework is in progress

➔Only for diagnosis and post accidental purposes



Current activities

- Simultaneous reconstruction of release events detected close to the source location as well as those detected far away.
- Improve the reconstruction of the isotopic composition by using all together air concentration, deposition and dose rate observations.



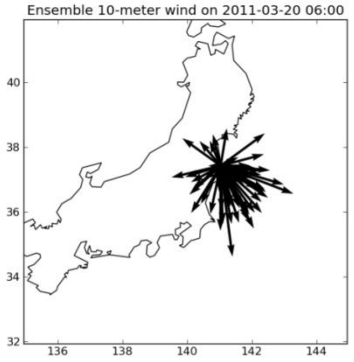
$$J(\sigma) = \|\mu - H\sigma\|^2 + \lambda^2 \|\sigma - \sigma_b\|^2 + \sum_{i=1}^{n_{isotope}-1} r_i^2$$

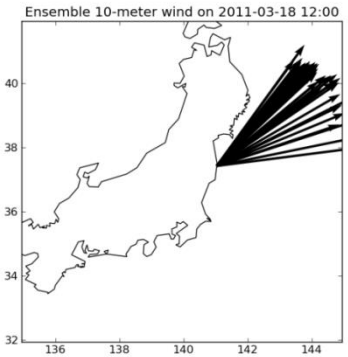
Scores (dose rate)	Inverse ST	Mathieu et al. ST
Fac2 (%)	79.8	60.0
Bias	0.42	0.59

Scores (Air conc.)	Inverse ST Fac5 (%)	Mathieu ST Fac5 (%)
^{136}Cs	52,3	35,4
^{137}Cs	58,2	47,0
^{131}I	57,1	31,4
^{132}Te	53,7	40,1

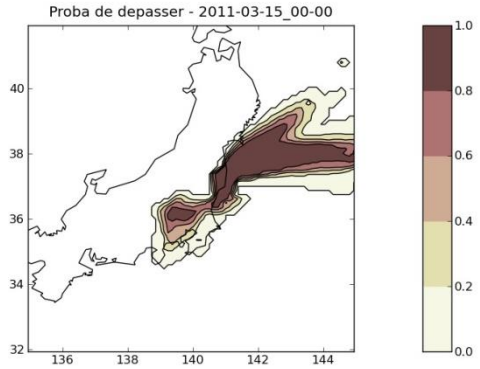
Uncertainties modelling

- Need to improve our basic and weak approach used to propose protective actions
- Research works in progress (Girard et al., 2014)
- Goals :
  - Taking into account uncertainties (ST, Met, models) in forecast
    →More safe, more reliable advices (or at least be aware when we just don't know!)
  - Use error modelling for model to measurements comparisons and inversion





ECMWF ensemble forecast

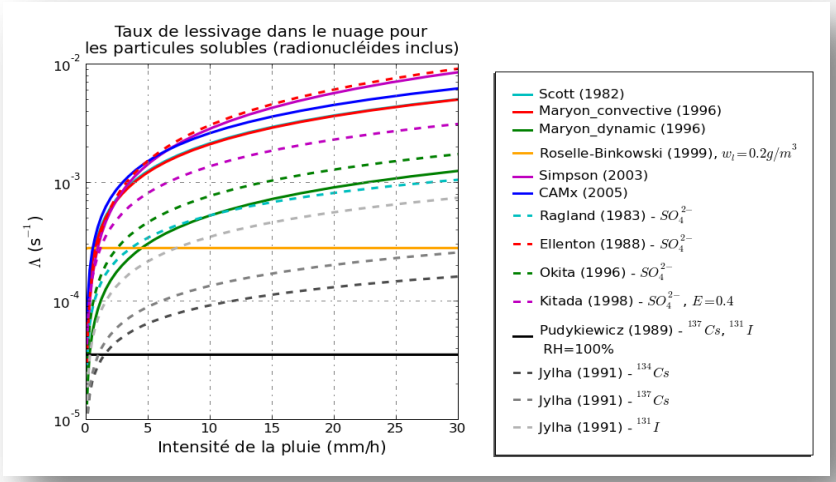


exceedence probabilities

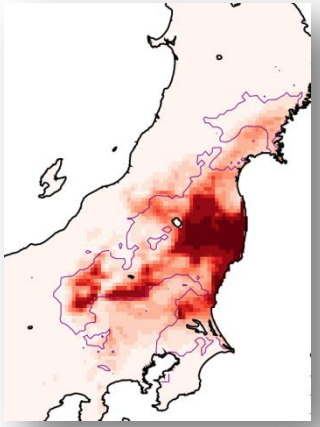
Deposit modeling (wet/dry)

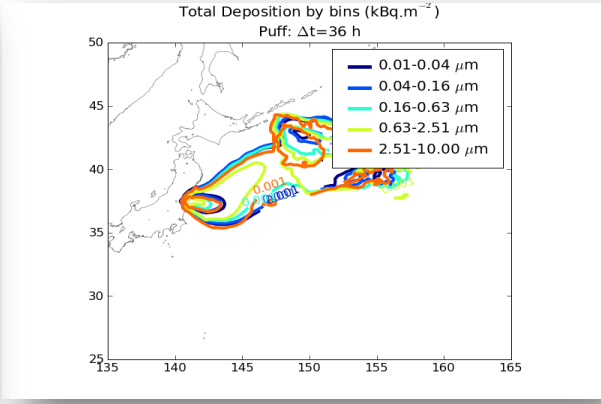
- Goals : improving models accuracy
  - Sensitivity studies based on different models, on Fukushima/Chernobyl cases.
    - » In cloud/below cloud scavenging ratio, modelling
    - » kz effects, Aerosols size distributions, mono/poly dispersed droplet…

→ *See A. Mathieu presentation, the 2nd of March.*



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





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Inversion

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Operational platform

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Thank you for your attention