Assessment of atmospheric dispersion and radiological consequences for the Fukushima Dai-ichi Nuclear Power Plant accident

IRPA 13 - Fukushima session

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Operational response to the Fukushima crisis

Role of IRSN in case of a Radiological Emergency

- Assess risk induced by accidental situation
- Provide technical expertise to public Authorities

The Fukushima crisis

- Activation of the Emergency Response Centre for 6 weeks
- To provide advice to the French embassy - Local response: Projection of a technical adviser at the French Embassy
- To keep informed the French authorities of the situation and risks induced by the accident

Task

- Evaluation of the reactors state, releases to the atmosphere (diagnostic/prognosis)
- Evaluation of the radiological consequences (doses et depositions)
- Analysis of the measures over the world

Providing a relevant technical information to the media and French people in Japan became a major objective
Outline

Atmospheric dispersion and input data

Event analysis and doses assessment

Conclusions and Perspectives
Atmospheric dispersion models

Operational models from C3X platform

Local scale

Gaussian puff model

Input Data
Met. data: ECMWF (0.125°); Daiichi Obs.; Rain Radar
Source term

Parameterizations
Dry deposition: \( \nu_{\text{dep}} = 2 \times 10^{-3} \, \text{cm/s} \)
Wet deposition: \( \Lambda_s = a p_0^b \), with \( a = 5 \times 10^{-5} \) and \( b = 1 \)
Radioactive decay
73 radioisotopes

Regional to continental scale

Eulerian model

Input Data
Met. data: ARPEGE (0.5°); ECMWF (0.125°)
Source term
Assessment of the release (quantities, kinetic and spectrum)

Diagnostic approach based on
- Chronology of events (explosion, smokes, venting, etc.)
- Monitoring of reactor parameters (pressure, tank level, etc.)
- Measurements (dose rate, concentration, deposit)

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<tr>
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<th>IRSN</th>
<th>NISA</th>
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<tbody>
<tr>
<td>Xe 133 (Bq)</td>
<td>5.9 e+18</td>
<td>1.1 e+19</td>
</tr>
<tr>
<td>Iodine 131 (Bq)</td>
<td>2.0 e+17</td>
<td>1.6 e+17</td>
</tr>
<tr>
<td>Cesium 137 (Bq)</td>
<td>2.1 e+16</td>
<td>1.5 e+16</td>
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- Assessment consistent between the different institutions except a factor 2 for Xe-133

- Still highly uncertain
**Period 1:** R 1 explosion  
(March 12, 15h36 JST)

- Very few or no observations
- Source term: the timing is correct but the quantity is uncertain

**Period 2:** R 3 venting + explosion  
(March 13, 8h - March 14, 11h JST)
**Period 3:** R 2 venting + depressurization (March 15, 0h - 6h JST)

- Main contamination of Japan land due to wet scavenging
- Particularly difficult meteorological situation to forecast (wind direction, precipitation)

**Best simulation:**
- Rain radar observations
- Wind observed in Daiichi

*From US-DOE/NNSA (AMS) measures and MEXT*
- **Venting R2**: S direction
- **Depressurization R2**: W direction then NW direction and Pacific Ocean and Tokyo directions
- **NW contamination**: done mainly by wet deposition between 3/15 at 21h and 3/16 at 03h
Model to data comparisons

- Ambient dose rate (μGy/h)
  30/03/2011 00h00 JST

- Good agreement between measurements and model
- Model deposit is slightly too North from Iitate compared to measurements
**Assessment of the timing and quantities of the releases**
- too much uncertainties on the power plant state
- based on observations analysis only

**Contamination in Ibaraki - Tokyo**
Reconstruction of the plume and deposition due to Fukushima events

Actual understanding
- 4 main periods of release
- Agreement between model and observations:
  - Gamma dose rate over Japan land: in a factor of 5-10 during the plume passage
  - in a factor of 2 for the dose due to deposition
- Dose assessment: component due to the plume exposition difficult to estimate

Many uncertainties on
- The source term (kinetic, spectrum, quantities)
- The meteorological conditions

To improve the contamination assessment
- Inverse modeling for the reconstruction of the source term (Winiarek et al 2011; Saunier et al)
- Taking uncertainties into account: Ensemble approach (Mallet et al 2011)
- Comparisons with other analysis of the Fukushima accident
Lessons from the Fukushima accident

New tools for crisis management to reconstruct the source term based on measurements: inverse modeling and data assimilation techniques

Inversion of gamma dose rate measurements

改善 of the source term assessment.
Large part of the contamination was carried toward the Pacific ocean
March 16-18 radionuclide detected in Canada - US
March 22-23 radionuclide detected in Europe
Goal: assess radiological consequences on populations

Dose for the whole body for a 1 year child without any protection during the release period

Dose received in the thyroid by a 1 year child without any protection during the release period
Conclusions and perspectives

Lessons from the Fukushima accident

New tools for crisis management to better assess environmental risks: model uncertainties with ensemble approach