Emergency dispersion modelling at the Norwegian Meteorological Institute

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Background for operational modelling

- Chernobyl accident in 1986
- Contamination of Norwegian territory
- Threats from other potential sources (e.g. Kola)
- Nuclear accidents (explosions)
- Volcano eruptions
- Numerical Weather Prediction Models at met.no
- Cooperation with NRPA
- Cooperation with Nordic partners and EU
Main questions in case of nuclear accident (outside Norway):

• Will the radioactive cloud reach Norway?
• If yes, when will it arrive to Norway?
• What will be concentration and deposition?

Tools to answer:

• Norwegian, operational dispersion model SNAP
• MetNet (Scandinavian dispersion models)
• ENSEMBLE
• Results of measurements
Main questions in case of volcano eruption:

• Will the volcanic ash reach Norway?
• If yes, when will it arrive to Norway?
• What will be concentrations at different flight levels over Norway?

Tools to answer:

• Norwegian, operational dispersion model SNAP
• FLEXPART model at NILU
• MetNet (Scandinavian dispersion models)
• Satellite images and measurements
SNAP model - general

• Main ideas from UK NAME model
• Lagrangian particle model
• Gases, noble gases, particles of different size and density
• Advection and diffusion (Random Walk)
• Dry deposition (gravitational settling velocity for particles)
• Wet deposition (function of size and precipitation for particles)
• Meteorological input from HIRLAM 12 or 20 and from ECMWF
SNAP – operational model domain
Operational applications of SNAP

- Model runs performed by meteorologists on duty
  - nuclear accidents
  - volcano eruptions
- Model runs performed by scientists
  - nuclear accidents
  - nuclear explosions
  - volcano eruptions
- Remote model runs from NRPA in the ARGOS system
  - nuclear accidents
  - nuclear explosions (from OCT 2011)
On-line screen view for operational SNAP runs
Nuclear accident: MetNet exercise
Nuclear accident: MetNet exercise – time

integrated concentration of Cs-137
Nuclear accident: MetNet exercise - Ensemble

Agreement: Time Integrated Concentration – 16.10.2010 06UTC
Nuclear explosion – source term

Particle size classes and corresponding parameters used in the SNAP model calculations. Note: we have assumed an equal share of the activity to each size class.

<table>
<thead>
<tr>
<th>Class No.</th>
<th>Range of the particle radius (μm)</th>
<th>Activity share (%)</th>
<th>Gravitational settling velocity (cm/s)</th>
<th>Radius (μm) used for estimation of sedimentation velocity</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0 - 3</td>
<td>10</td>
<td>0.2</td>
<td>2.2</td>
</tr>
<tr>
<td>2</td>
<td>3 - 6.5</td>
<td>10</td>
<td>0.7</td>
<td>4.4</td>
</tr>
<tr>
<td>3</td>
<td>6.5 – 11.5</td>
<td>10</td>
<td>2.5</td>
<td>8.6</td>
</tr>
<tr>
<td>4</td>
<td>11.5 - 18.5</td>
<td>10</td>
<td>6.9</td>
<td>14.6</td>
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<tr>
<td>5</td>
<td>18.5 - 29</td>
<td>10</td>
<td>15.9</td>
<td>22.8</td>
</tr>
<tr>
<td>6</td>
<td>29 - 45</td>
<td>10</td>
<td>35.6</td>
<td>36.1</td>
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<td>7</td>
<td>45 - 71</td>
<td>10</td>
<td>71.2</td>
<td>56.5</td>
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<td>8</td>
<td>71 - 120</td>
<td>10</td>
<td>137.0</td>
<td>92.3</td>
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<td>9</td>
<td>120 - 250</td>
<td>10</td>
<td>277.3</td>
<td>173.2</td>
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<tr>
<td>10</td>
<td>≥ 250</td>
<td>10</td>
<td>direct deposition</td>
<td>-</td>
</tr>
</tbody>
</table>
Bomb version – source term

Initial shapes of the radioactive cloud shortly after explosion for 1, 10, 100 and 1000 ktonnes yield. Cylinder type on the left, mushroom on the right.
Simulation (1) – results

Class 1: Particle radius 2.2 \(\mu m\)
Class 2: Particle radius 4.4 \(\mu m\)
Class 3: Particle radius 8.6 \(\mu m\)
Class 4: Particle radius 14.6 \(\mu m\)
Class 5: Particle radius 22.8 \(\mu m\)
Class 6: Particle radius 36.1 \(\mu m\)
Class 7: Particle radius 56.5 \(\mu m\)
Class 8: Particle radius 92.3 \(\mu m\)
Class 9: Particle radius 173.2 \(\mu m\)

Accumulated total deposition for different classes particles, 60 hours after explosion.
Comparison of accumulated total deposition for cylinder and mushroom initial shapes for the radioactive cloud: 12, 24, 36, 48 and 60 hrs after the explosion. The location of explosion is Jan Mayen and the yield is 10 ktonnes.
Comparison of accumulated total deposition for cylinder and mushroom initial shapes for the radioactive cloud: 12, 24, 36, 48 and 60 hrs after the explosion. The location of explosion is Jan Mayen and the yield is 1000 ktonnes.
Simulation of Fukushima Accident
Source Term From NRPA

Release start: 12.03.2011 00UTC

Isotope: I-131

Release level: ground

Release rate: 1.0e+11 Bq/s (continues)
Volcex exercise – April 2011
CONCLUSIONS

• SNAP is fully operational at the Norwegian Meteorological Institute for applications in HIRLAM domain for nuclear accidents/explosions and volcano eruptions

• SNAP can be applied in the Hemispheric domain in case of nuclear accident or explosion

• Because of the requests from the Norwegian Authorities SNAP operational operational domain will be extended to the entire globe

• There were three major real emergency cases (E15, Fukushima, Grimsvotn) where SNAP was successfully used online for the dispersion simulations