March 19, 2011

Simulation of atmospheric dispersion of the radioactive plume formed by releases from the Fukushima Daiichi nuclear power plant since 12 March

1 - What is known about the radioactive releases emitted since 12 March 2011?

IRSN does not have any direct information regarding the composition and scale of the radioactive releases. From the interpretation of dose rates measured at the site and probable degradation scenarios for the 3 reactors since 12 March, together with the assumption that these releases will continue until 20 March, we draw the conclusion that the radioactive elements released during the various release episodes are noble gases in combination with volatile elements.

The noble gases are radioactive elements with a very low chemical reactivity, and they remain in the air without being posed on the ground. The volatile elements consist of mainly radioactive iodine, including iodine-131 which has a radioactive half-life of 8 days, and radioactive caesium, including caesium-137 with a half- life of 30 years. These volatile elements constitute aerosols, which due to their weight will end up falling on the ground.

The proportions of these different radioactive elements are estimated on the basis of the general know-how and experience feedback in relation with nuclear reactors.

2 - Dispersion of radioactive releases in the air

IRSN has simulated the atmospheric dispersion of estimated releases emitted between 12 and 20 March using its long-range numerical model (a scale of several hundred kilometres), and based on the meteorological forecasts supplied by Météo France.

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This simulation was applied to caesium-137, used as a tracer in the radioactive plume during this period. From the first day on (12 March) this simulation has been continuously carried out every other hour and the results of this simulation are given in becquerels of caesium-137 per cubic metre of air (Bq/m^3). In addition the results are compared to the values measured in the vicinity of the Chernobyl plant, just after the accident that occurred on 26 April 1986. The values exceeded 100,000 Bq/m and they were around 100 to 1000 Bq/m3 in countries seriously affected by the radioactive plume (Ukraine and Belarus) in France, the values measured in the east were around 1 to 10 Bq/m3 (on 1 May 1986). A very low level of radioactive caesium-137 still remains in the air, around 0.000001 Bq/m3.

The same model applied in the case of Japan shows that the plume travelled in various directions over the course of time: first, up to the northeast until 14 March, then down to the south and southwest, towards Tokyo, on 15 March, and then to the east and towards the Pacific Ocean.

IRSN compared the results of the simulation with the results of air contamination measurements taken in Tokyo. For iodine-131 and caesium-137I the results are of the same order of magnitude as the values measured in Tokyo, shown in the graphs below.

In view of this comparison, it is possible to consider that the atmospheric dispersion modelling carried out by IRSN provides satisfactory results for the agglomeration of Tokyo and that the doses calculated by IRSN based on this model are representative of the doses likely to have been received by the population exposed to the radioactive plume.

3 - Estimating the doses likely to have been received by people exposed to the radioactive plume

IRSN has estimated the doses likely to have been received by a person exposed to the radioactive plume, assuming that this person remained in the same place and with no protection (i.e. outside) throughout the entire release period (from 12 to 20 March). For these dose calculations, IRSN studied the case of a one-year old infant, the most sensitive to iodine-131 (dose to the thyroid). In other words, these are the most cautious hypotheses.

The simulations below show how the doses evolve over time, throughout the simulation period. If there are further releases in the future, these doses may increase further if the most exposed people are unprotected.

- Whole body doses likely to be received by a one-year old infant with no protection during the releases

In the event of an accident, the recommended minimum dose values used to launch protective actions are 10 mSv for taking shelter and 50 mSv for evacuation. Below 10 mSv, the health risk is deemed to be sufficiently low and therefore such protective actions are considered unnecessary. To compare, the average annual dose received in France due to natural radioactivity and medical exposure is 3.7 mSv.

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- Doses to the thyroid likely to be received by a one-year old infant with no protection during the releases

In the event of an accident, the recommended minimum dose values for prescribing the ingestion of stable iodine are 100 mSv in Japan.

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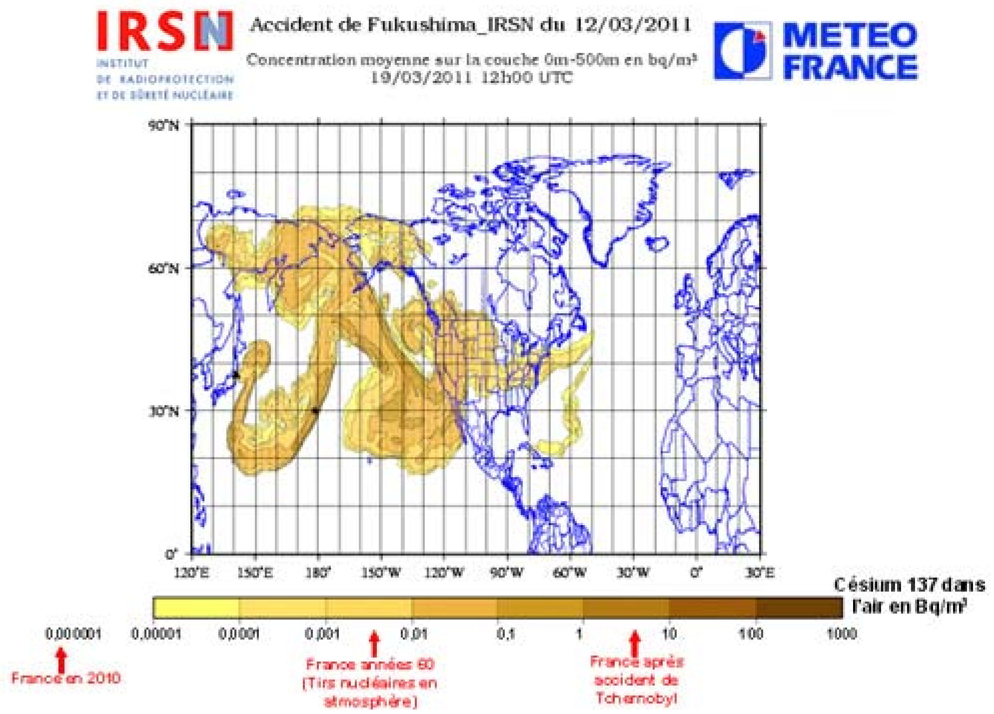
4- Modelling the dispersion of radioactive releases into the atmosphere on a global scale

Using the release values estimated by IRSN, Météo France simulated the dispersion of radioactive releases over a very great distance, with forecasts up to 26 March.



> View the simulation

According to this simulation, the radioactive plume will now have reached north-eastern Siberia, the United States and the western Atlantic. It should reach France from 23 or 24 March on.

According to this simulation, the concentrations that can eventually be expected may be around 0.001 Bq/m3 in the mainland of France and in the French Overseas Territories in the northern hemisphere. As expected, the southern hemisphere is not significantly affected by this large-scale dispersion.