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Development of emergency response tools for accidental radiological contamination of French coastal areas

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ABSTRACT

The Fukushima nuclear accident resulted in the largest ever accidental release of artificial radionuclides in coastal waters. This accident has shown the importance of marine assessment capabilities for emergency response and the need to develop tools for adequately predicting the evolution and potential impact of radioactive releases to the marine environment.

The French Institute for Radiological Protection and Nuclear Safety (IRSN) equips its emergency response centre with operational tools to assist experts and decision makers in the event of accidental atmospheric releases and contamination of the terrestrial environment. The on-going project aims to develop tools for the management of marine contamination events in French coastal areas. This should allow us to evaluate and anticipate post-accident conditions, including potential contamination sites, contamination levels and potential consequences.

In order to achieve this goal, two complementary tools are developed: site-specific marine data sheets and a dedicated simulation tool (STERNE, Simulation du Transport et du transfert d'Eléments Radioactifs dans l'environNEment marin).

Marine data sheets are used to summarize the marine environment characteristics of the various sites considered, and to identify vulnerable areas requiring implementation of population protection measures, such as aquaculture areas, beaches or industrial water intakes, as well as areas of major ecological interest. Local climatological data (dominant sea currents as a function of meteorological or tidal conditions) serving as the basis for an initial environmental sampling strategy is provided whenever possible, along with a list of possible local contacts for operational management purposes.

The STERNE simulation tool is designed to predict radionuclide dispersion and contamination in seawater and marine species by incorporating spatio-temporal data. 3D hydrodynamic forecasts are used as input data. Direct discharge points or atmospheric deposition source terms can be taken into account. STERNE calculates Eulerian radionuclide dispersion using advection and diffusion equations established offline from hydrodynamic calculations. A radioecological model based on dynamic transfer equations is implemented to evaluate activity concentrations in aquatic organisms. Essential radioecological parameters (concentration factors and single or multicomponent biological half-lives) have been compiled for main radionuclides and generic marine species (fish, molluscs, crustaceans and algae). Dispersion and transfer calculations are performed simultaneously on a 3D grid. Results can be plotted on maps, with possible tracking of spatio-temporal evolution. Post-processing and visualization can then be performed.

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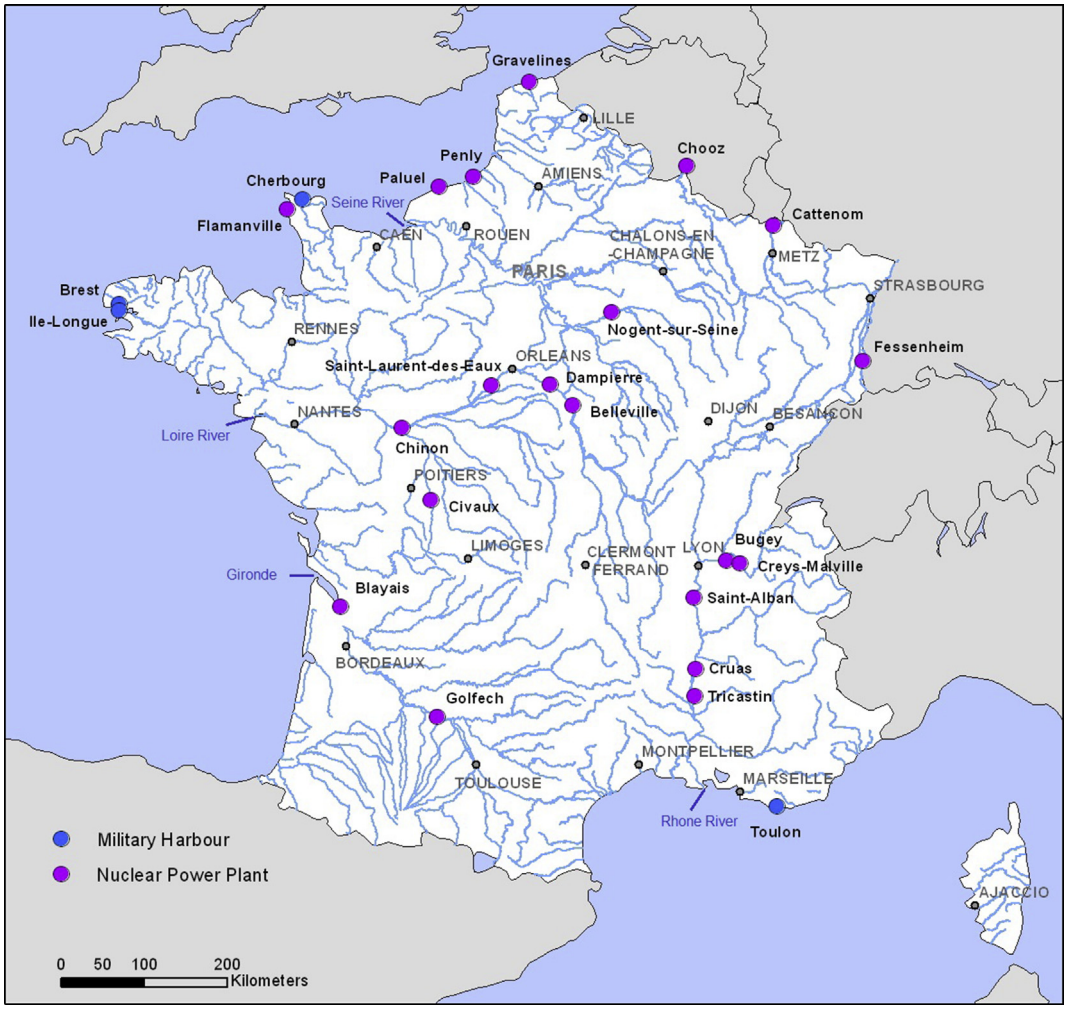

Fig. 1. French nuclear installations and coastal areas to be considered.

1. Introduction

Before 2011, some marine accidents involving radioactive material discharges have occurred in Europe (sinking of Mont Louis, Dover Strait, 1984; Carla, The Azores, 1997; Ece, English Channel, 2006), but their consequences were very limited. The nuclear accident at Fukushima in 2011 resulted in the largest ever accidental release of artificial radionuclides to coastal waters (UNSCEAR, 2014; Povinec et al., 2013, Science Council of Japan, 2014). The environmental and economic impact on Fukushima coastal area is enormous, particularly for fisheries (Okuda and Ohashi, 2012). It triggered an awareness of the need to set up operational tools for the management of a "marine crisis" and of possible lacks in the capability of many countries to efficiently manage such a radiological crisis.

About 130 nuclear reactors are operated in the European countries, 58 in France. Serious accidents on most of them would impact marine ecosystems, either through direct liquid release or aerosol fallout, or through transport of contaminated water masses by rivers. In addition, Atlantic and Mediterranean seas are the location of an intense maritime traffic including military nuclear powered ship traffic.

Although many research have been conducted in these areas to study behaviour of radioactivity in marine environment, the main knowledge concerns routine discharge of radionuclides. There is limited expertise to provide information for decision makers to use in the event of accidental inputs of radionuclides into the sea.

Henceforth, it appears essential to take this risk of accidental contamination of coastal areas into account. This concerns particularly areas most potentially exposed to accidental releases from land-based nuclear installations. To ensure optimal preparedness in the event of a nuclear emergency affecting the marine environment, it is necessary to develop and implement specific tools to assess the evolution and impact of radioactive marine contamination events. This information will be used to facilitate decision-making during an emergency and could serve as a basis for post-accident sampling strategies leading to realistic environmental impact assessment.

The French Institute for Radiological Protection and Nuclear Safety (IRSN) has for many years now equipped its emergency response centre with operational tools to assist experts in the assessment of potential risks to local populations and terrestrial environments in the event of accidental release of radionuclides to the atmosphere. These tools were used in particular in the case of the Fukushima accident, among other things to simulate the short and long-range atmospheric dispersion of released radionuclides (Mathieu et al., 2011; Korsakissok et al., 2013; Saunier et al., 2013). Atmospheric dispersion computer codes are combined with computational modules designed to predict exposure

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