C3X : A SOFTWARE PLATFORM FOR ASSESSING THE CONSEQUENCES OF AN ACCIDENTAL RELEASE OF RADIOACTIVITY INTO THE ATMOSPHERE

IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

Marilyne Tombette, Emmanuel Quentric, Denis Quélo, Jean-Pierre Benoit, Anne Mathieu, Irène Korsakissok and Damien Didier

Institut de Radioprotection et de Sûreté Nucléaire (IRSN), PRP-CRI, SESUC, BMTA, Fontenay-Aux-Roses, 92262, France

The C3X platform is a software developed by the French Institute for Radioprotection and Nuclear Safety (IRSN) for atmospheric dispersion and consequences (doses) assessment. C3X has been specifically designed for a use in IRSN's Technical Crisis Centre, and in particular for the emergency phase management.
This presentation shows the capabilities of the C3X platform. It is easy to use and is able to:
- **perform calculation from quite rough assessments to most sophisticated ones;**
- **to use observed and forecasted (1D / 4D) meteorological data;**
- **to cover the local scale (several hundred meters) up to regional scale;**
- **to represent calculated contamination and doses through maps, plots and statistics.**

C3X DESCRIPTION

As described in Figure 1, C3X is a platform that contains:
-krX, a software to define the run case through a Graphical User Interface (GUI) and to compute the atmospheric dispersion, the ground deposition and the subsequent radiological consequences (projected doses for emergency phase and measurements simulation);
-reportX, a tool for reporting the results computed by krX to be humanly readable. The advantage is that the information required for emergency management is quickly available;
-cartX, a Geographical Information System (GIS) which imports krX (or paZ) results, and provide specific post-processing method;
-valorX, a web app to prepare the appropriate standard or customized maps to illustrate the krX (or paZ) results.

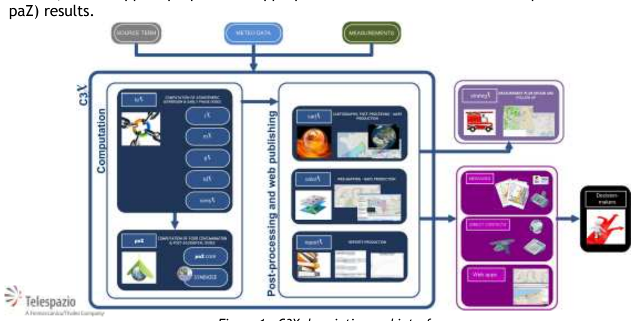

Figure 1 : C3X description and interfaces

krX itself contains a suite of several scientific modules which are necessary to perform the atmospheric dispersion simulation (see further sections).
C3X also includes the paZ software, which is dedicated to the assessment of people's exposure due to the radioactive deposition that may exist (ground shine, ingestion of contaminated food, inhalation of resuspended material). paZ is not described further in this paper.
The GUIs of C3X tools are developed by Telespazio France, whereas scientific modules (pX, ldX, mX, consX and Symbiose – Gonze et al., 2011) are developed by IRSN.
CartX render relies on an Open Scene Graph 3D engine. It proposes several raster map backgrounds, some provided by Web Map Servers (WMS) . Raster images and vector data in standard formats can be imported or exported. The geographic content window can also be connected to the IRSN's geodatabase containing geographical information relative to nuclear facilities. CartX can load any krX study and apply post-treatments on the krX outputs. Post-processes can be saved and then can be reused as a model for future results. Also, cartX can be connected to the measurement database CRITER (Leprieur et al., 2012) to be able to make model-measurement comparisons easier.

METEOROLOGICAL DATA

Two types of meteorological fields can be considered: 0DT (homogeneous in space but time-dependent) or 3DT (outputs of Meteo France weather forecast modelling).
Nuclear facilities have meteorological measurements means by obligation. In a diagnostic mode and at a local scale, this 0DT data can be used in krX by entering it manually.
In a prognosis mode, weather forecasts provided by Meteo France have to be used. IRSN forecasts from the ARPEGE model of Météo France at two resolutions over two domains: 0.5° (Europe) and 0.1° (France). Meteorological data downloads are performed four times per day and stored into C3X's related meteo server. These forecasts are then readily available, and the past networks can be used which is an advantage because each forecast is assimilated at the beginning time.

ATMOSPHERIC DISPERSION MODELS

At a local scale (from several hundred meters up to several ten kilometers), the Gaussian puff model pX is used (Soulhac and Didier, 2008; Korsakissok et al., 2013). pX has been developed for the specific needs of nuclear emergency management, speed being the most important requirement. The parameters of the Gaussian distributions depend on atmospheric stability and the parameterization used. These parameterizations are empirical and several exist in the pX model: Doury, Pasquill and Briggs. Similarity laws will be included in the short term.
At a regional scale, the eulerian model ldX is used. ldX is the adaptation for a nuclear context of Polair3D (Boutahar et al., 2004), which has been created to study air quality at a regional scale. Polair3D has been validated for accidental conditions on the ETEX, Chernobyl and Algeciras cases (Quélo et al., 2007). More recently runs performed during and after the Fukushima accident with pX and ldX have made IRSN even more confident in this modellings (Mathieu et al., 2011).

CONSEQUENCES CALCULATIONS

The assessment of projected doses (effective doses, committed equivalent doses to the thyroid, etc.) are computed by the consX module. It is based on air and ground activity concentrations of each considered radionuclide, which are outputs from the atmospheric dispersion models. For inhalation, the breathing rate depends on the population category and is based on (ICRP, 1994). For each radionuclide, the dose coefficients depend on the population category and on the organ of interest, and come from the IRSN ECRIN database (http://www-ecrin.irsn.org).
In addition, consX contains a library of in situ transportable contamination devices (detection surface, kind of particles detected, efficiencies as a function energy,…) so it can compute the corresponding expected count rates. Model-to-measurement comparisons are made easier.

C3X CAPABILITIES

1.Plume localization
The goal is to identify territorial concerns and to help the public emergency services to settle in the vicinity of the facility. At a local scale, the downwind area can be drawn using a sector shaped zone the parameters of which depend on meteorological conditions (see Figure 2). At a regional scale, the plume footprint is obviously preferred. With this product, there is no quantification of the consequences of any realistic release. This can be made at a local range as well.

Figure 2 : Post-treatment at small and regional scales used to represent the localization of the plume

2.First rough assessment
Once a source term estimator has been defined by the facility experts, the first assessment aims at providing quickly the distances up to which the protective action guide levels might be exceeded. For that purpose, krX can run simulations in an 'emergency mode', where the concentrations are calculated downwind considering a single reasonably pessimistic meteorological condition during the simulated time period. Then, reportX can automatically compute the distances of interest in a table (see Figure 3). Given the administrative information, cartX can also extract the city names concerned by countermeasures.

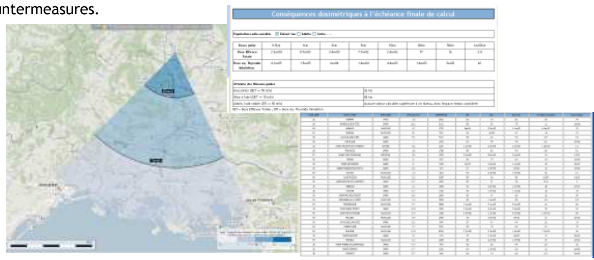

Figure 3 : Examples of post-treatments used in an emergency mode : sectors, table of distances for countermeasures and statistics (cities concerned by a countermeasure)

3.More accuracy
As the accident is going on, more accurate assessments are needed, especially for diagnosis assessments (reconstitution of the contamination scenario) and because measurements will have to be compared with a realistic simulation. At last, an evaluation in this advanced mode is better to prepare a monitoring plan (standalone probes to be deployed for instance). Advanced simulations (at local scale as well as at regional scale) can be done with krX with 3DT meteorological fields. Figure 4 and Figure 5 show different possible post-treatments with cartX.

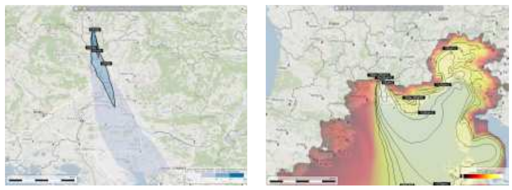

Figure 4 : Representation of efficient dose 100 km around the release point (left) and total deposit at regional scale (right)

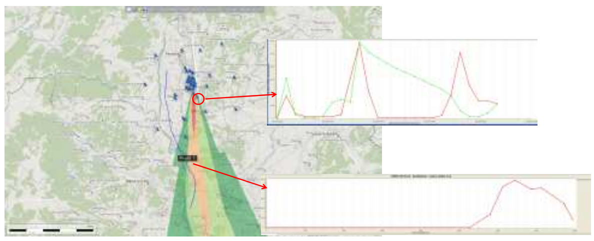

Figure 5 : Model-to-measurement comparison at a monitoring station (up) and dose rate along a route (down).

C3X is an intuitive and comprehensive tool specially developed for nuclear emergency responders, simulating the atmospheric dispersion of an accidental release and its consequences from local to regional scales (contamination fields, dose projected fields).
The future development are largely resulting from Fukushima's experience, among them:
• similarity theory for pX Gaussian puff standard deviation, model uncertainties, source term reconstruction based on available measurements (see Saunier et al., 2013);
• improving the calculation time : code parallelization, enhanced automation of assessment products, enlarge products availability through web interface.

References

Boutahar, J.,et al., 2004. International Journal of Environment and Pollution 22, 17-28.
Gonze, M.-A. et al, 2011. Proceedings of the International Conference on Radioecology and Environmental Radioactivity.
ICRP, 1994. ICRP Publication 66 Ann. ICRP 24 (1-3).
Korsakissok, I., et al.. Atmos. Environ., 70 (2013), pp. 267-279.
Leprieur, F., et al., IRPA 2012.
Mathieu, A., et al., 2011. Atmospheric dispersion of Radioactivity. Elements (2012), Fukushima special edition, DOI: 10.2113.
Quélo, D., et al. Atmospheric Environment 41, 5300-5315.
Saunier, O., et al., Atmos. Chem. Phys., 13, 11403-11421, 2013.
Soulhac, L., Didier, D., 2008. Technical note IRSN/DEI/SESUC/08-39. IRSN.