

Workshop on
“Selected Problems in Environmental Risk Management and Emerging Threats”

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ON THE INTEROPERABILITY OF SOFTWARE TOOLS FOR RISK ANALYSIS

This short note is provided to supplement the information given in the set of slides concerning the interoperability of software for risk analysis and in particular the software demonstration. The software developed deals with the following problems:

- 1) Interpolation of results of consequence assessment models on a 2D grid;
- 2) Interface of different software for risk analysis; and
- 3) Comparison of the results of accident scenarios given by different software.

All data exchange files were described using XML.

1. Interpolation of the results of consequence assessment models on a 2D grid

Interpolation is necessary when:

- Models do not use the same grid dimensions;
- Models represent the results in different ways (1D, 2D contours, 2D grid);
- The file dimension of the 2D grid consequence results is too large to be exported (export sampled data / contours).

A special test has been designed to examine the effectiveness and appropriateness of the interpolation methods on a selected number of practical cases. In general, the physical effects produced by the accident consequence models are normally represented by their values on a downwind centreline (1D-model), as effect contour lines or as a grid points (2D-model). The first case can always be regarded as a 2D-model with concentric contours. For this reason all type of models can be treated in the same way. As an example Figure 1 illustrates the general process at the basis of the test applied to the grid generation and interpolation of accident consequence results. This test was performed using a Gaussian dispersion model.

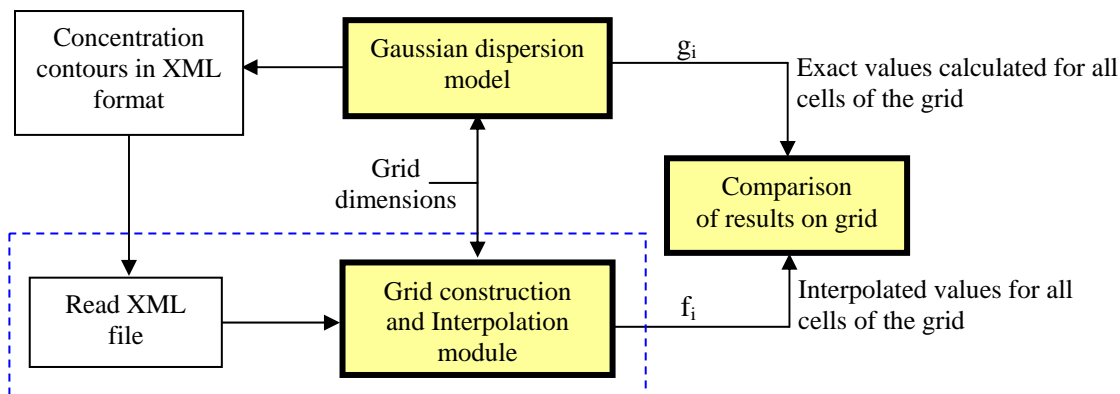


Figure 1. Diagram showing the experimental phases to verify the suitability of the selected interpolation methods

In order to check the accuracy of the interpolation method applied, the following coefficients are calculated:

$$D^+ = \sum_{i=1}^N \frac{f_i - g_i}{g_i} 100 \quad (\text{if } f_i > g_i) \quad (1)$$

$$D^- = \sum_{i=1}^N \frac{g_i - f_i}{g_i} 100 \quad (\text{if } f_i < g_i) \quad (2)$$

$$D = D^+ + D^- \quad (3)$$

where f_i is the interpolated value in the i -th cell, g_i is the exact value obtained analytically and N is the total number of cells of the grid. Eq. (3) is equivalent to take the absolute values of the difference between f_i and g_i .

Table 1 provides the results obtained for the Gaussian dispersion model. Different simulations have been considered by changing the number of contours and the distance between points on each contour. The best method is the Constrained Cubic Spline (CCS) for which the maximum (conservative) error is about 10% when 5 contours were considered in which the distance between points was 100 meters.

Table 1. D-parameters from the interpolation of Gaussian dispersion results described in different ways.
Interpolation method: Constrained Cubic Spline.

Contours(n)-Data Points Distance (m)					
9-4	9-20	5-4	5-20	5-40	5-100
$D^+ = 0.59\%$;	$D^+ = 1.28\%$;	$D^+ = 1.57\%$;	$D^+ = 2.13\%$;	$D^+ = 3.59\%$;	$D^+ = 10.14\%$;
$D^- = 0.11\%$;	$D^- = 0.23\%$;	$D^- = 0.34\%$;	$D^- = 0.28\%$;	$D^- = 0.34\%$;	$D^- = 0.66\%$;
$D = 0.70\%$	$D = 1.52\%$	$D = 1.91\%$	$D = 2.42\%$	$D = 3.93\%$	$D = 10.79\%$

This test was performed also using other models. All results were very good.

2. Interfacing different software for risk analysis

The first test concerned the interoperability between two different pool fire models. The availability of the source codes allowed us to perform a complete test, i.e. a two-way data exchange test by implementing the import-export modules in XML. The two selected models, characterised by a different degree of complexity, were of type 1D and 2D. Figure 3 shows that one model can run by using the input data exported by the other model and vice versa. Differences in input data must be addressed by the user. In Figure 3 these types of data are represented as “extra data”.

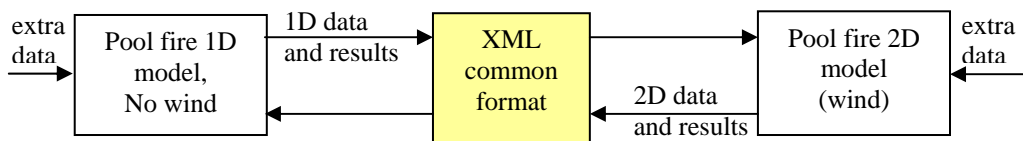


Figure 3: Diagram showing the exchange of data between 1D and 2D pool fire models

The software developed to implement this trial was linked to a specific database on substances. This was done in order to perform an automatic uploading of substance data requested by the model. By selecting the substance, some associated data are extracted from the database and displayed in the model interface. Other data (e.g. CAS number, molecular weight), are also extracted from the database and stored in the XML input file without being displayed in the model interface. This is a typical example of the problem associated with the decision of which input parameters have to be exported and which not.

Moreover, the problem of unit measures was considered. The file UM_Conversion.xml was prepared containing the conversion factors from two different systems. The conversion is performed in two phases:

- Conversion from unit A to the International Standard System;
- Conversion (if any) from the International Standard System to unit B.

Other tests have been carried out using some well known software e.g. PHAST, EFFECTS and ALOHA; however, due to the unavailability of their source codes it was not possible to carry out the two-way tests. Thus, the experiments consisted in performing a one-way transfer of data (through the XML format) from the above consequence assessment tools to ARIPAR, a GIS based tool for area risk analysis and control. Figure 4 shows the diagram of the experiment carried out to perform an area risk analysis using result from different tools, applied to different accident scenarios, integrated with the data needed to characterise the geographical area of interest (GAUSS and STARS are two software for consequence assessment developed in the past by the JRC). The CCS interpolation method was applied to represent the results of accident consequences on 2D grids.

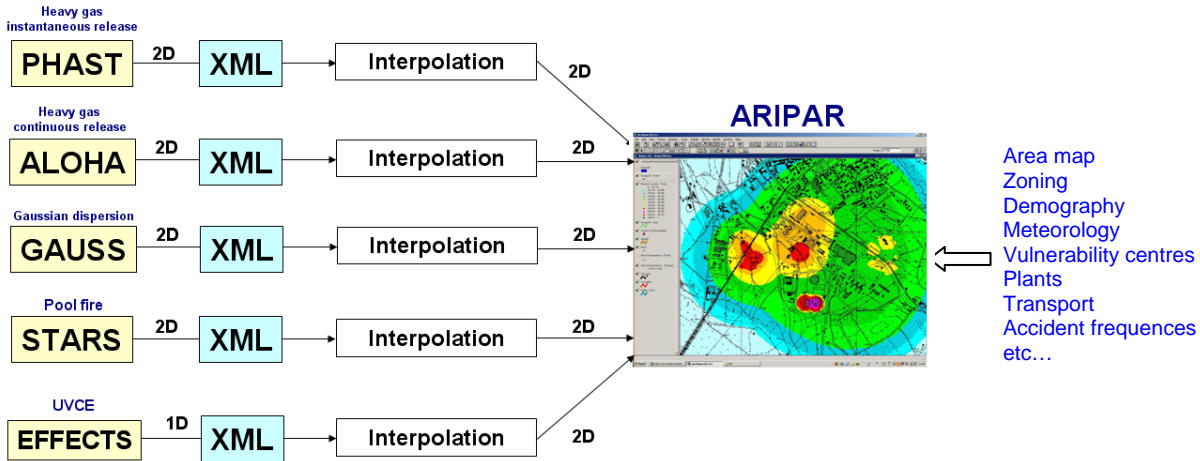


Figure 4: Diagram showing the interface of different consequence assessment tools with an area risk analysis tool.

3. Comparison of the results of an accident scenario analysed by means of different software tools

It is particularly interesting the case of the comparison of different consequence models for the same accident scenario. This situation is rather typical when the competent authority has to evaluate the risk assessment results produced by the plant operator using different models in the review process; or when new software (model) needs to be tested (validated).

The following cases were addressed in the study:

- comparison of results of 1D models;
- comparison of results of a 1D model with a 2D model;
- comparison of results of two 2D models.

In order to perform the comparison of two different consequence effect maps, and in turn, the outcome of two different consequence models/tools, the CEM (Comparison Effects Models) specific software has been developed containing the interpolation methods and the map viewer.

Other uses of CEM can be envisaged, e.g. comparison of the results of different interpolation methods applied to a given accident consequence model; performing the sensitivity analysis on the input data of a given accident consequence model; and so on.

An example of application of CEM is provided in Figure 5 where the data of the two pool fire models (XML files) are imported and represented together with the map resulting from their comparison.

The overall difference between the two models' outcome is also measured in terms of the D-parameters.

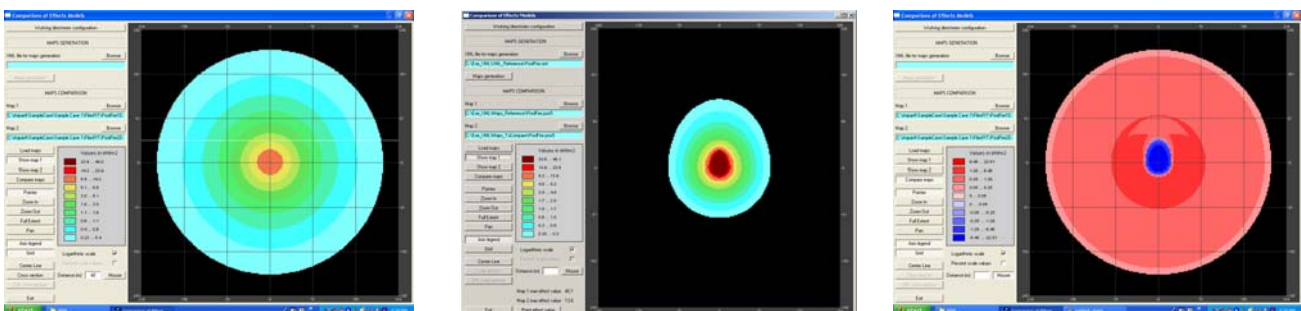


Figure 5: Interpolated grid of 1D and 2D pool fire models and results of their difference

In order to get a more precise idea about the differences in results, effects' profiles for the third displayed map can be obtained as shown in Figure 6.

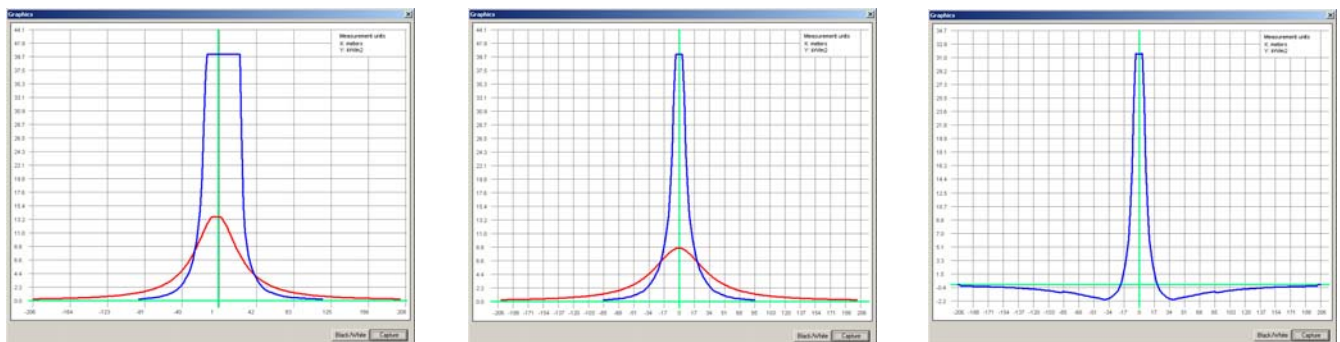


Figure 6: Differences between effect profiles for the 2D (blue) and 1D (red) pool fire models. Profiles have been taken respectively at (a) Centreline and (b) at 25 meters from the centre of the pool. In (c) the difference is given.

Another possible way that can be envisaged is to compare the two maps determining the differences between two contours, starting from the innermost and representing the results on a histogram. More precisely, each bar of the histogram would represent the total difference of the effects between the two considered contours.