Methodology for environmental radiological assessment applied to the decommissioning of the Italian Nuclear Power Plants

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Abstract.

The present study is the second part of a program of characterization of the sites surrounding the Italian Nuclear Power Plants (NPPs) which are currently involved in decommissioning activities. In the first phase of the project an analysis of the Garigliano NPP was carried out and the reference groups of the population were established on the basis of a socio-economical survey of the site. A field campaign was carried out aiming to assess the "zero level" due to the natural and past anthropogenic radioactivity [1, 2].

In the second part the study was extended to the other three Italian NPPs, namely Latina, Trino and Caorso. The radiological doses due to the planned and accidental releases during the decommissioning phases were calculated on the basis of environmental parameters related to the area of interest. These parameters include climatological, hydrological, geomorphological data. The implementation of transport and diffusion specific models of radionuclides in the environment was another step for the dose calculation using specific evaluation software. The current software (VADOSCA) specially built and used in the past for Italian NPPs has been replaced by the framework FRAMES-GenII 2.0 which is a calculation code updated in the transport model and in the reference laws, and running under new computer operating systems. This code has been used to design the possible scenarios for each site by using conceptual calculation models which contain local input data and adequate dispersion models. The input data consist of (i) way and amount of radionuclide release in planned and accidental cases, (ii) reference groups of population and their food habits, (iii) climatic data of the area under study. The dispersion models are implemented by considering releases in water (canal, river, sea) and in atmosphere.

In order to allow a simplified, efficient and friendly utilisation of the Frames-GenII code, it has been enriched with a routine, DSA-Reader, which simplifies the browsing and the analysis of outputs in terms of specific activity and doses. The generation of a report containing sizeable amount of information on the site is planned.

Introduction.

In the present contribution we show the results of the second two-years collaboration between Environmental Sciences Department (DSA) of the Second University of Naples and Sogin, the public firm in charge of the decommissioning.

The work has been carried out following three main points:

- Critical study of the dispersion models and of the calculation codes. A general study of the alternative models of dispersions of radionuclides in the environment was carried out. After that, the framework Frames-GenII has been chosen as the modelling code.

- Collection of the data for the sites and creation of the conceptual models of the sites. The goal is the estimation of the environmental impact and of the doses to the reference groups of population following the decommissioning procedures of each NPP. In the present paper we show the procedure followed to model the sites of Caorso and Latina.

- Creation of documentation and supporting tools to simplify the research work.

Critical study of the dispersion models and of the calculations codes.

The features requested for the modelling of the dispersion from decommissioning of the italian NPPs were:

- Planned chronic and accidental acute releases of radionuclides;

- Atmospheric dispersion models: gaussian plume and lagrangian puff;

- Aquatic (river and sea) dispersion models;

- Transport models for all main exposure pathways: soil, air, water, ingestion, inhalation;

- Assessment of the doses, in agreement with ICRP dosimetry and FGR13 risk factors.

Until now the routinely used code was Vadosca; however, it experienced "ageing" both because of the old user interface and for the reference rules and dispersion models. From the studies of several available codes, the Frames-GenII framework appeared to be the most suitable [3-7].

Thus, the last version of Frames-GenII 2.0 has been chosen for the upgrade. It shows up as a graphical framework in which the modules can be chosen and connected to model the specific site features.

The Fig. 1 depicts the conceptual model of the Frames-GenII code: the modules are collected in groups. They represent the path of the radionuclides from the sources up to the health effects.

Collection of the data for the sites and creation of the conceptual site models.

This is the most important step from the practical point of view. As a preliminary phase it is necessary the creation of a scenario for every site after the acquisition of data related to it. A scenario is a conceptual model of the site that describes patterns of human activity, events, and processes that result in radiation exposure of people. The collected data include:
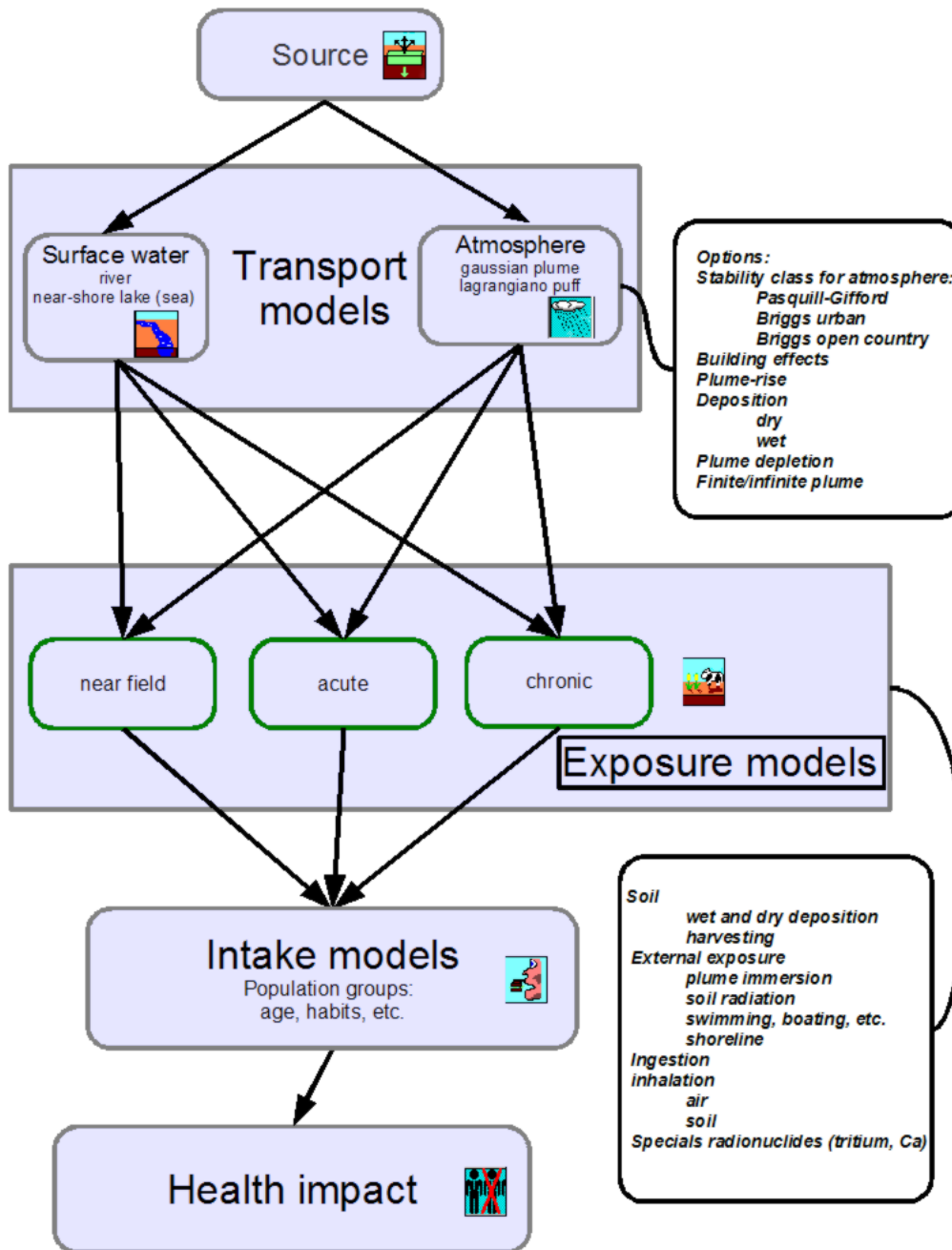
Fig.1 – Schematic model of the Frames-GenII code

- Way and amount of releases of radionuclides. They include both the planned amount for normal decommissioning activities or amount for possible incidental events.

- Reference group of population. They are classified by living (and feeding) habits and age category.

- Food and life habits for each population group.

- Information regarding the animals and vegetables of the area of interest (food, yield, etc.).

- Climatological data for the area and for the period under study.

- Hydrological and building data (river/sea data, chimney height and area, etc.).

The next step is the development of a conceptual model for the site. The Figure 2 shows in a
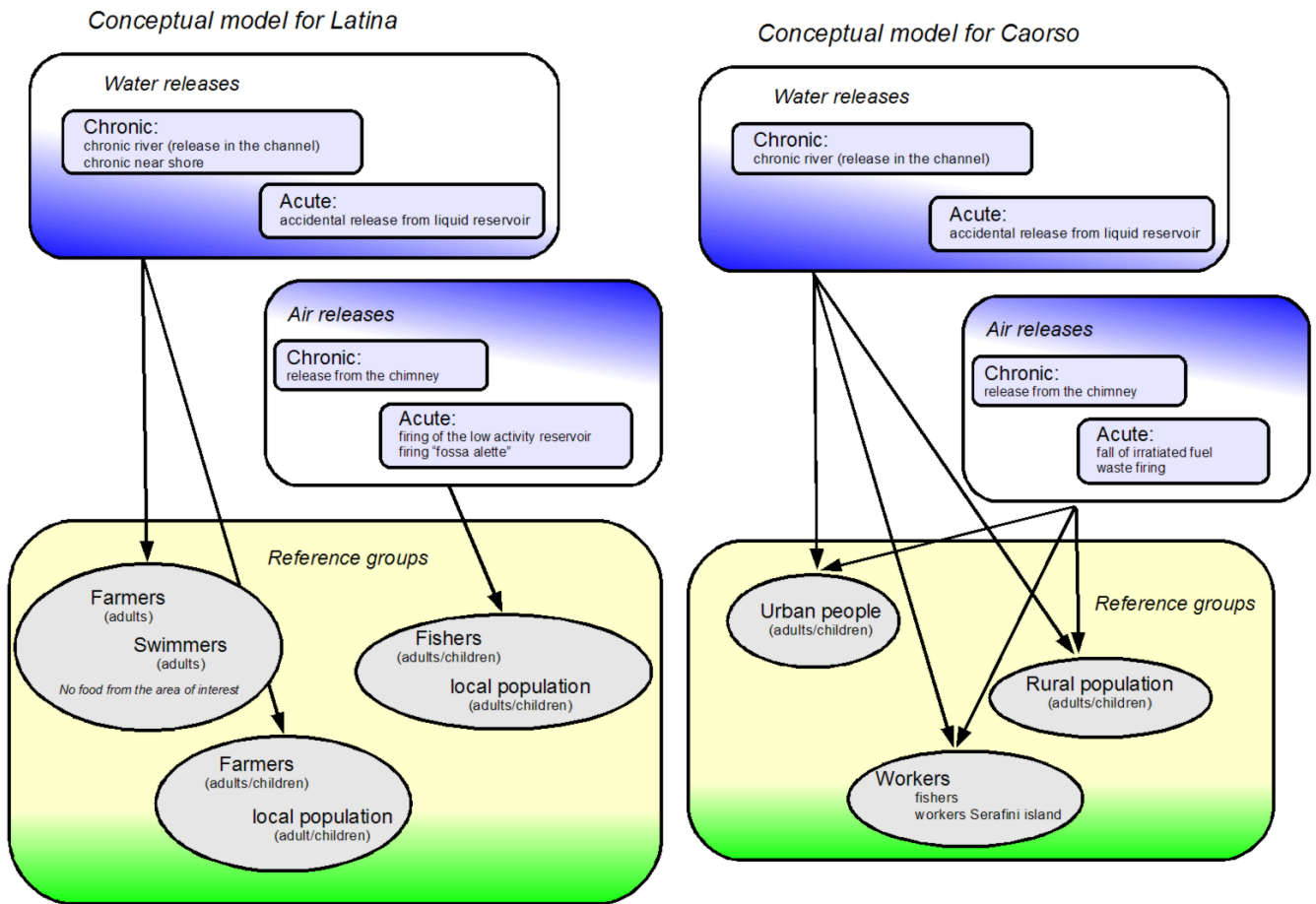

Fig.2 - conceptual models for the sites of Latina and Caorso

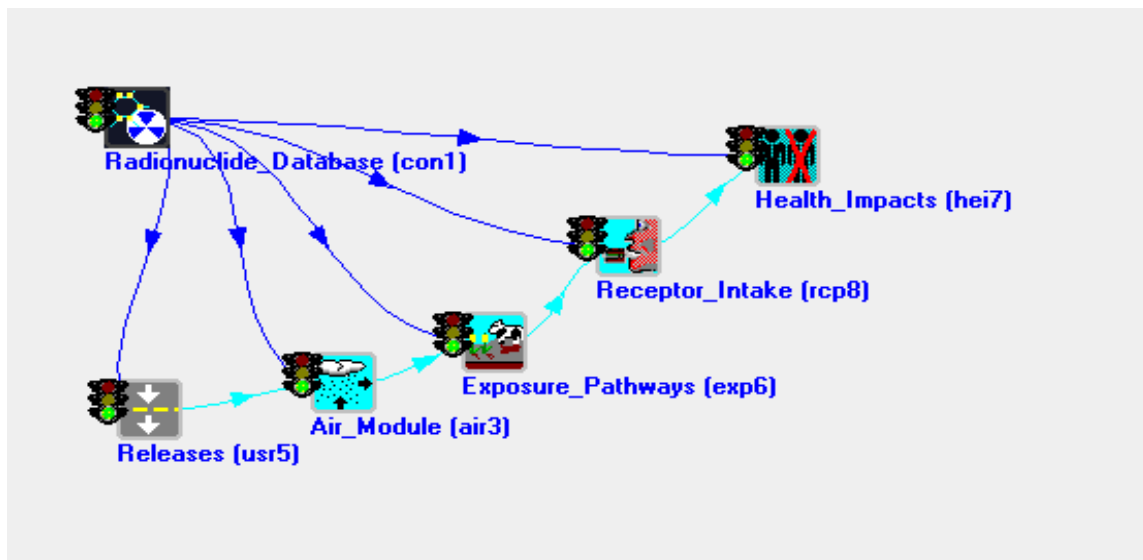schematic way the conceptual models for the sites of Latina and Caorso.

Fig.3 – A simple scenario in Frames-GenII

The releases in atmosphere have been studied using a sector-average gaussian plume with Briggs open country dispersion coefficient. Water releases in river use simple dilution models.

Figure 3 displays a simple scenario such as shown in the Frames-GenII interface: the radionuclide database is connected with each module icon (gliph); the radionuclide path from the release to the health impact calculations is shown. A file is created for each reference group and release type. All the files have been created by the end of 2005 and delivered to Sogin for dose assessment. Table 1 shows chronic food and habits parameters for Latina (referred to one year).

	Swimmers	Farmers	Fishers	local population	Fishers (children)	Loc. pop. (children)
Swimming / boating (hours)	100	100	1000 (200+800)		300	
Water immersion (hours)	200					
Shoreline (hours)	300	200	1000		800	
Shoreline (sediments, hours)					200	
salt water fishes (g)			8.03E+4	4.00E+3	4.16E+4	2.60E+3
molluscs (g)			3.35E+4	4.00E+3	1.20E+4	2.60E+3
crustacea (g)			3.21E+4	2.00E+3	1.35E+4	2.00E+3
Water ingestion (cc)	7.35E+5	7.35E+5	7.35E+5	7.35E+5	5.10E+5	5.10E+5
Water ingestion while swimming (cc)	1.00E+3	1.00E+3	1.00E+3	1.00E+3	1.00E+3	1.01E+3

Tab.1 - Chronic food and habits parameters for Latina site

Other parameters, related to releases in atmosphere, are reported in Table 2.

Air model: Chronic Gaussian Plume (plume rise enhanced dispersion)							
Particle size: 7,5 micron; 1,5 g/cm3							
Sigma model	Exit area of the chimney (m²)	Exit height of the chimney (m)	Adjacent structures (m)	Exit air velocity (m/s)	Exit temp. (C)	Ambient temp. (C)	Angular sectors
Briggs Open Country	3,14	45	0	10	20	20	16

Tab.2 - Parameters related to releases in atmosphere for Latina site

The complete list of parameters and discussion of the criteria for their choices are reported in [1, 8].

Creation of documentation and supporting tools.

For a correct use, Frames-GenII needs a system using the "dot" (".") as a decimal separator. This is a common problem for US scientific programs used on non-US systems. To overcome this problem, DSA created a "small" software tool "*change_settings*" allowing to switch on the fly from the Italian setting to the US one and vice-versa.

An important issue of Frames, common to other radiological modeling codes, is the difficulty to browse and analyze the health impact data and the concentration in the environment. In particular it is quite tiresome to evaluate differences in the doses/concentrations when parameters change.

To overcome these problems, the DSA created *"DSA-Reader",* a program helping in the graphical-tabular representation of the output data. It is also useful for the publication of the results: it is often necessary to broadcast the data to non-technical people and the tabular or, better, graphical representation allows a simpler scrutiny of each contribution.

The main features of DSA-Reader are:

- It can read and represent in tabular form the Health Impact Files (HIF), created by the Health Impact Modules and containing the risks and radiation doses to the population.

- It can read and represent in tabular form the Air Transport Output (ATO), created by the Air Modules and containing the air related parameters (concentrations, depositions, direct doses) due to atmospheric releases.

- The data in tables can be grouped and sorted in different ways; partial sums can be shown. Selected views can be printed for further studies.

- Imported data are automatically saved for easy reading in external spreadsheets or number crunching software;

- It can import Global Input Data files (GID), containing the overall parameters of a site (at the time of writing, Febraury 2006, it is still in beta-version);

- HIF data can be graphically analyzed in a powerful ad-hoc environment. Graphs can show doses or risks relative to each organ, radionuclide, position in space, pathway, year of releases etc. Almost all parameter of the graph can be selected or changed for a clear presentation.

DSA-Reader can be run in *stand-alone* mode, i.e. when it is called directly from the icon that the installer puts on the desktop. The file under study should be opened by choosing the extension in the *File* menu.

DSA-Reader can also be run in *embedded* mode, i.e. directly as a frame viewer: it can be accessed
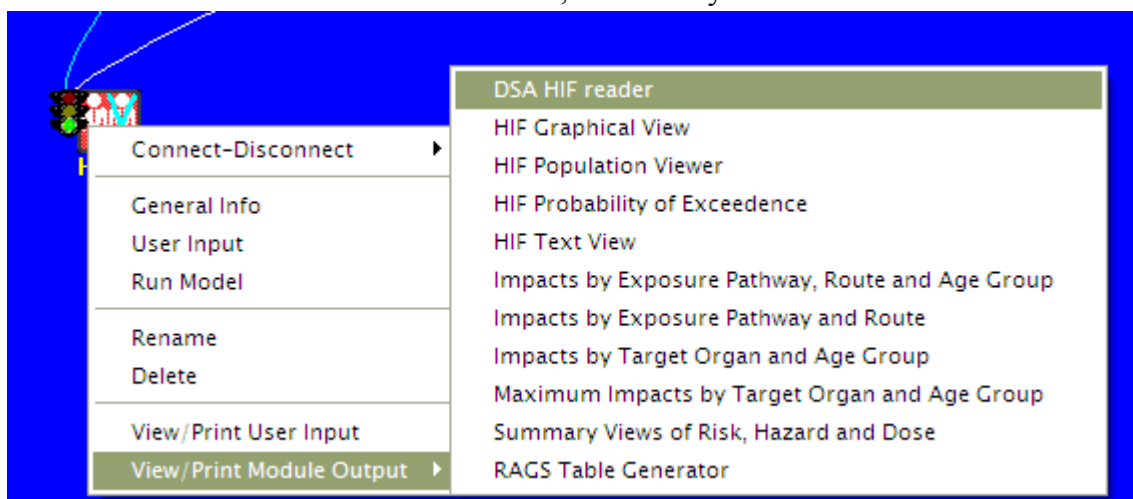

Fig.4 – How to call DSA-Reader from Frames

by clicking the right mouse button on the H*ealth Impact* or *Atmospheric Transport* gliphs as shown in Fig. 4.

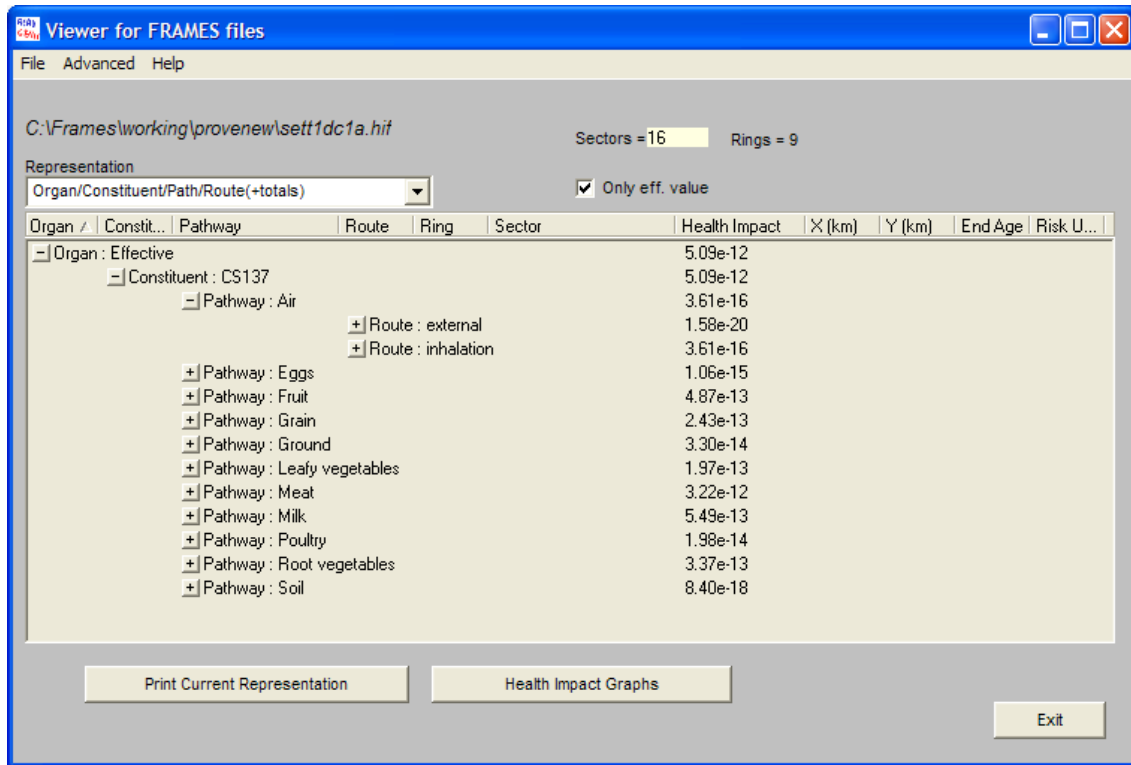in this case the file is automatically opened and the File menu is deactivated.

Fig.5 – DSA-Reader: tabular representation of doses
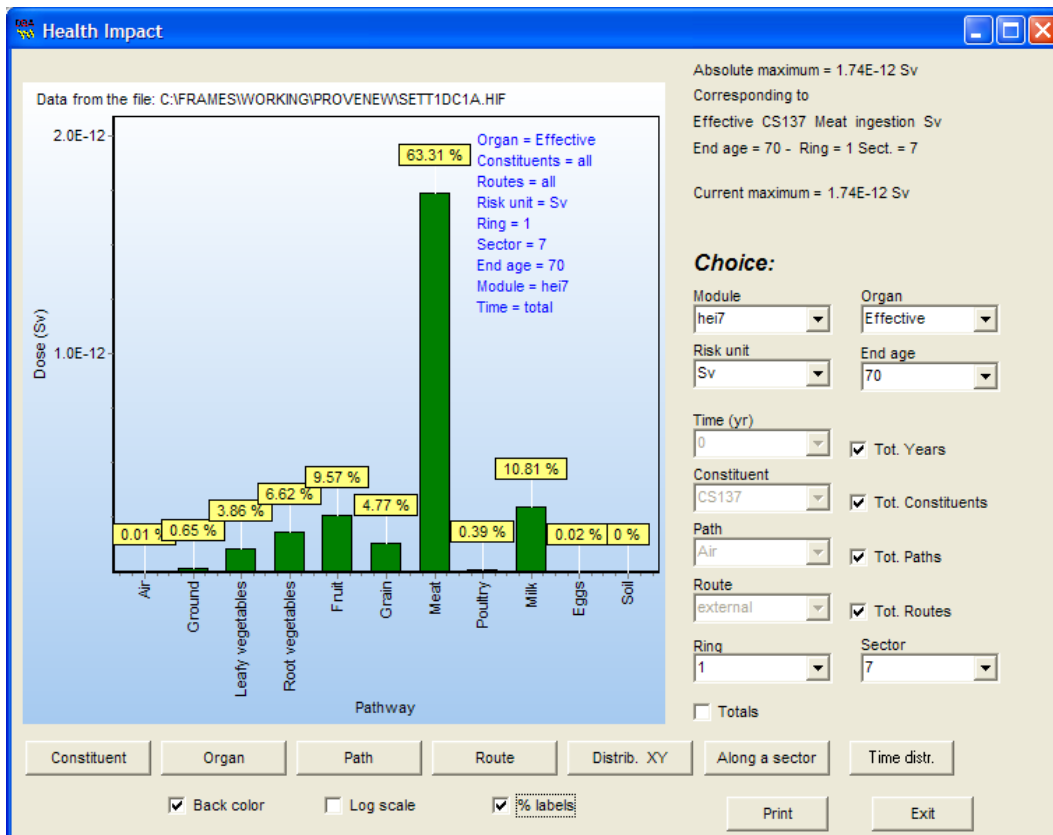

Fig.6 - DSA-Reader: graphical representation of output data

Fig. 5 shows a tabular representation of doses in which data are grouped by

organ/constituent/pathway/route. In the column "Health Impact" are reported the sums of the doses for each group. The elements of a groups are shown by clicking on the "+" sign. Other collecting trees (representations) are possible. Ascending and descending sorting can be achieved by clicking in the small rectangle at the top of the columns.
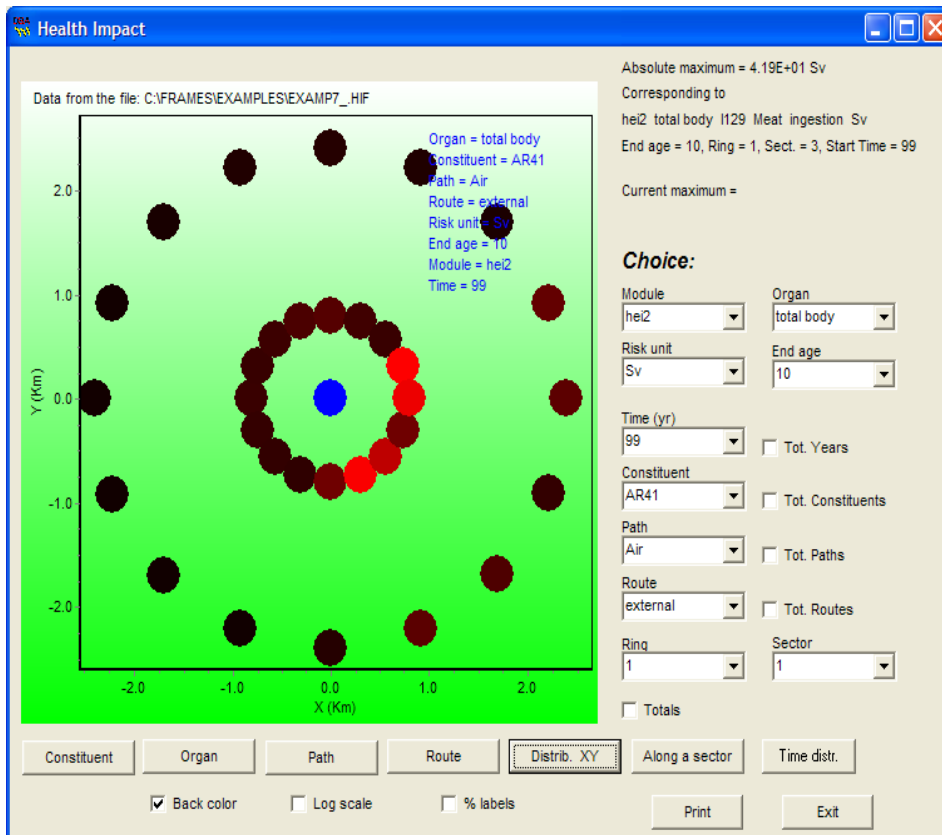

Fig.7 - DSA-Reader: space distribution of health impacts factors

An example of graphical representation is reported in Fig. 6: the contribution to the effective dose of each pathway are graphed. Other representations (by constituent, organ, etc) are chosen by clicking the buttons in the bottom of the graph. More details and options are reported in the help.

The space distribution of health impacts factors for air releases can be also shown by clicking the button "Distr. XY". A typical results is shown in Fig. 7. Doses are indicated in false colors (from black to red). The blue dot represents the release point.

DSA-Reader is an on-going project. Future releases will extend its features. In particular it is planned a button to generate a report containing sizeable amount of information of the site.

Both *change settings* and *DSA-reader* are freely available on request from the authors.

Conclusions.

In this work we summarized the activity performed by DSA for the radiological calculations concerning Italian NPPs.

The preliminary work addressed a suitable code for assessment of radiological releases in the environment: the choice was Frames-GenII v.2.0, an user friendly program updated for regulatory rules.

After that, a conceptual model was created for the sites of Latina and Caorso. This work resulted in the creation of the scenario files for both sites. They will be used for radiological impact calculation in the future.

The work generated some aid tools for the user. In particular the freely available program *DSA-Reader* is a very useful helping tool for researchers.

References

[1] DSA. A*ttività svolta dal Dipartimento di Scienze Ambientali nell'ambito della convenzione DSA-Sogin stipulata il 12/06/2002*. Relazioni semestrali 1-4. 2002.

[2] A.M. Esposito, C. Sabbarese, C. Sirignano, L. Visciano, D'Onofrio, C. Lubritto, F. Terrasi, S. Alfieri, G. Migliore. *Preliminary study of the environmental radiological assessment for the Garigliano Nuclear Power Plant decommissioning*. Proceedings of the European IRPA Congress 2002, Firenze 8-11 October 2002.

[3] Napier . *GenII Version 2, User guide*. US-EPA 1999.

[4] Napier, Strenge, Ramsdell, Eslinger, Fosmire. *GenII Version 2, Software Design Document*. US-EPA 1999.

[5] S. J. Maheras, P. D. Ritter, P. R. Leonard, R. Moore. *Benchmarking of the CAP-88 and GenII computer codes using 1990 and 1991 monitored atmospheric releases from the Idaho National Engineering Laboratory*. Health Phys. 1994 Nov; 67(5).

[6] E. R. Faillace, J. J. Cheng, C, Yu. *RESRAD Benchmarking against six radiation exposure pahways models*. Argonne National Laboratory, ANL/EAD/TM24. 1994.

[7] *GenII Version 2. Environmental radiation dosimetry system: an SAB advisory*. Report EPA-SAB-RAC-ADV-01-002. 2001.

[8] DSA. *Attività svolta dal Dipartimento di Scienze Ambientali nell'ambito della convenzione DSA-Sogin stipulata il 28/11/2003*. Relazioni semestrali 1-4. 2004-2005.