RESEARCH COLLABORATION PROGRAM

'MODELLING ENVIRONMENTAL PROCESSES'

REPORT 2 (Phase 2)
PERIOD 2000-2001

RADIOECOLOGICAL SOFTWARE PACKAGE

Linking to Origin 6.0 and MapInfo Professional

ANPA

AGENZIA NAZIONALE PER LA PROTEZIONE DELL'AMBIENTE, ITALIA

UNIVERSIDAD NACIONAL DE SAN LUIS, ARGENTINA

UNSL

Edited by Hugo Velasco
2002

Contents

1. Preface

This documents reports the activities carried out during the second year of work in the framework of the scientific collaboration program: *Modelling Environmental Processes.* This program is developed in the frame of an agreement between the National Environmental Protection Agency, Italy (ANPA) and the National University of San Luis, Argentina (UNSL).

According to the programmed activities, in this second period (year 2001), the DAGES code, a general system based in a Monte Carlo algorithm, was applied to calculate the external photon exposure from γ-emitter on the ground for different source distributions.

On the other hand, the report includes a partial description of the Radioecological Software Package (RSP). This package constitutes one of the main objectives of the present scientific collaboration program. The RSP program includes three modules:

- Module 1: Radionuclides vertical transport in soil, using Rabes Model.
- Module 2: Radionuclides soil to plant transfer.
- Module 3: Dose Assessment, using DAGES Code.

The National Environmental Protection Agency (ANPA) has provided the data contained in the present summary and the National University of San Luis (UNSL) the used software.

2. Contributors

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3. Introduction

As it was explained in Report 1, a Monte Carlo algorithm (Dages Code) was developed to evaluate the external gamma irradiation from surface contamination on the ground. Every one of the possible interactions of a representative number of photons is simulated from the initial emission from the source up to the end of its trajectory. A procedure was developed to obtain the external dose in a detector situated 1 m over the contaminated ground. Two different types of source distribution were considered: a) profiles which are uniformly distributed with depth and, b) profiles which are exponentially distributed with depth.

Figure 1 shows the results obtained using DAGES Code for the dose rate in air due to a slab of finite thickness in soil with uniform ^{137}Cs concentration. The values obtained from the analytical procedure proposed by Kocher (1985) and the simulation carried out by Chen (1991) are comparatively shown.

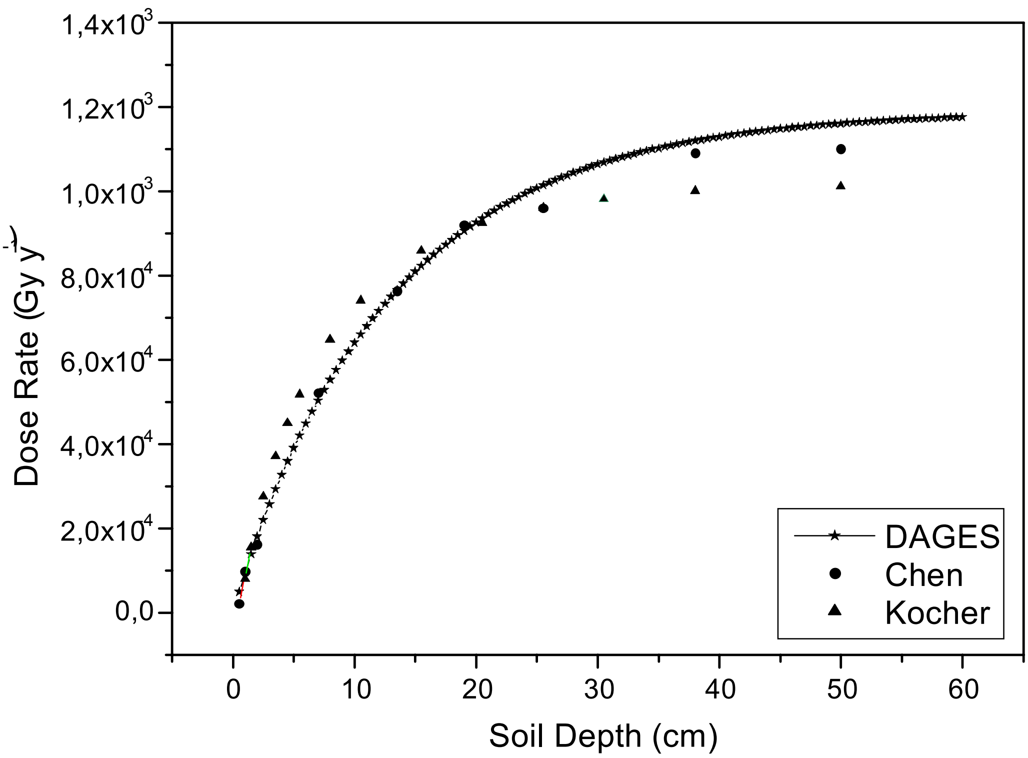


Figure 1. Dose rate in air due to a uniform distribution of the source in the ground.

Dages Model was applied to studying the dependence of DRF with:

- the analysed radius of soil below the detector,
- the radionuclides distribution in soil expressed in the relaxation depth value, and

The results obtained have been compared with those found by other authors.

In this period, our activities have also been focused on the development of a software package for the simulation of the radionuclides environmental circulation and evaluation of the external irradiation on the population. The architecture and general details of the Radioecological Software Package (RSP) are included in the present report.

4. Application of DAGES Model

The calibration of Dages Model was done in order to determine:

a) DRF values for different source distributions

b) The sensibility of the model to changes of some physical parameters.

The following topics have been investigated:

- Calculation of DRF due to ^{137}Cs deposited in soil (source energy: 0.661 MeV) with exponential decrease distribution. The distribution is characterized by its relaxation length and superficial concentration.
- Dependence of DRF with the radius of the circular surface of soil considered below the detector.
- Dependence of DRF with the source vertical distribution in soil.

Figure 2 shows the variations of DRF versus the relaxation length for 50 simulation runs. In all cases the total superficial activity considered is 1 Bq cm^{-2}, and the source energy is 0.661 MeV.

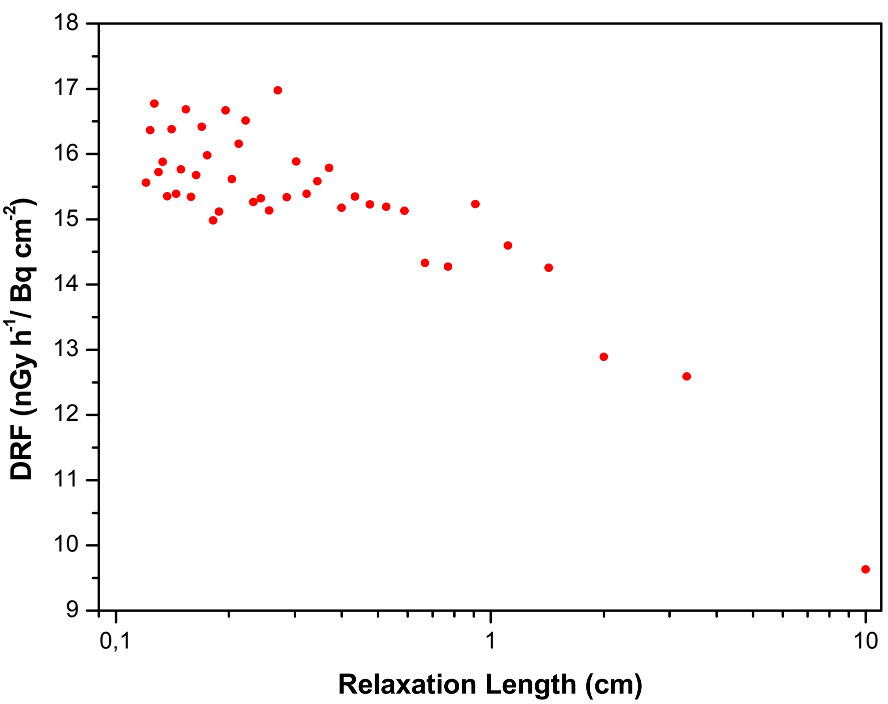


Figure 2. DAGES model. DRF vs relaxation length.

Table 1 gives the mean results of DRF for three typical relaxation lengths.

Table 1. DRF obtained using Dages Model for different relaxation lengths

Relaxation Length (cm)	DRF (nGy h^{-1} / Bq cm^{-2})
10	9.6
2	12.9
1	15.3

In order to determine the minimum portion of soil below the detector that is representative to carry out the simulation process, DRF values were calculated for different radii of a circular portion of soil with its centre situated vertically below the detector. Table 2 shows DRF values obtained using DAGES model for relaxation lengths of 1, 2 and 10 cm. In all cases, for a radius of 50 m, the equilibrium state was found.

Table 2. DRF values obtained from DAGES model for three different relaxation lengths considering different radii of a circular surface of soil below the detector. In all cases a ^{137}Cs superficial activity of 1 Bq cm^{-2} was considered.

Radius (cm)	Relaxation Length (cm)		
	10	2	1
	DRF (nGy h^{-1} / Bq cm^{-2})	DRF (nGy h^{-1} / Bq cm^{-2})	DRF (nGy h^{-1} / Bq cm^{-2})
1000	0.2	0.5	0.5
2000	1.3	2.1	2.4
3000	3.5	5.1	5.5
4000	5.4	8.9	9.0
5000	9.6	12.9	15.2

The same information in Table 2 is showed graphically in Figure 3.

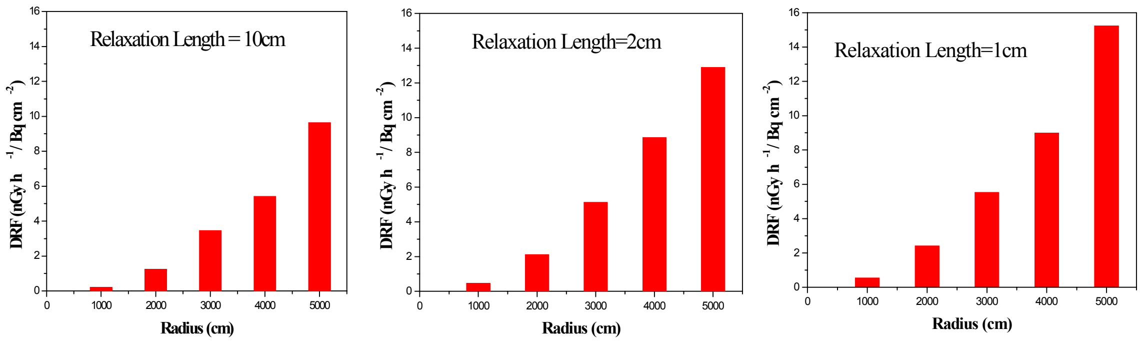


Figure 3. DRF vs. radius of the considered portion of soil for different relaxation lengths

Figure 4 shows the results obtained using DAGES Model, for different relaxation lengths.

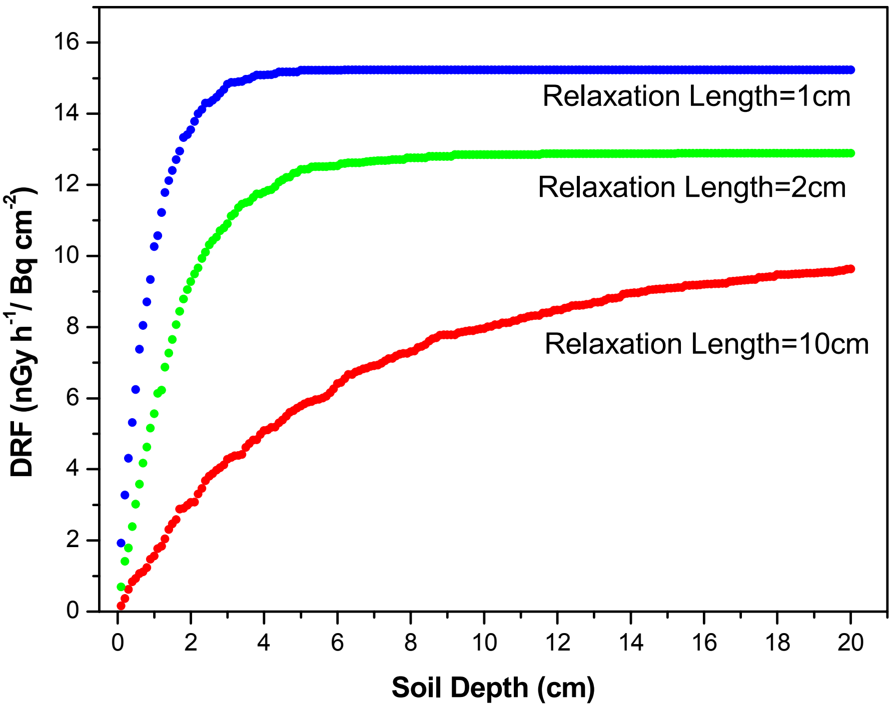


Figure 4. DRF vs. thickness of a contaminated soil layer with a superficial activity of 1 Bq cm^{-2} of ^{137}Cs. Different relaxation depths are considered.

5. RADIOECOLOGICAL SOFTWARE PACKAGE

RSP (Radioecological Software Package) is an interactive support software that simulates the behaviour of radionuclides in semi-natural environments and the consequences on the population, in terms of the external exposition.

RSP consists of three modules:

Module 1: Soil transport

This module permits to simulate the radionuclides vertical transport in soil. RABES model (Velasco et al. 1993, 1997) has been used to determine the temporal variation of the radionuclides vertical profile in soil and its mean concentration in each considered soil layer.

Module 2: Soil to Plant transfer

This module permits to determine the radionuclide soil-to-plant transfer using the soil concentration in the root zone (calculated according to Module 1) and values of soil-to-plant transfer factor reported in the literature. Generic TF values obtained from Frissel et al. (2002) will be incorporated to simulate the radiocesium transport from soil to plant. The procedure is mainly based on a reference TF value, which depends on soil properties such as nutrient status, exchangeable K-content, pH and moisture content. Different vegetation types can be considered.

Module 3. Dose assessment

Using this module, dose-rate factor in air at a height of 1 m above ground can be calculated for sources distributed in a slab o finite thickness and sources which are exponentially distributed with depth. The calculations are performed using DAGES Model, a Monte Carlo algorithm developed to simulate the photon transport for the soil/air configuration.

6. Linking to Origin and MapInfo

With the purpose to make possible a more advanced data processing of the results obtained from each module of **RSP**, two links with external softwares have been performed.

The first one (an internal link in this case) connects with Origin 6.0 (Microcal™, 1999). Origin is a general-purpose scientific graphics and analysis software for Windows. It enables to import and analyse data and create presentation quality graphs for print or graphic export. Origin transforms and analyses the data to:

- Built in tools for smoothing/filtering
- Peak analysis
- Math on datasets
- Linear and non-linear curve fitting
- Inter/extrapolate data
- Descriptive statistics (sample t-Test, 1 way ANOVA)

In the same way, **RSP** permits to arrange the processed data in Excel format to be processed with the Geographical Information Systems: MapInfo Professional (MapInfo Corporation, 1998). This software make possible:

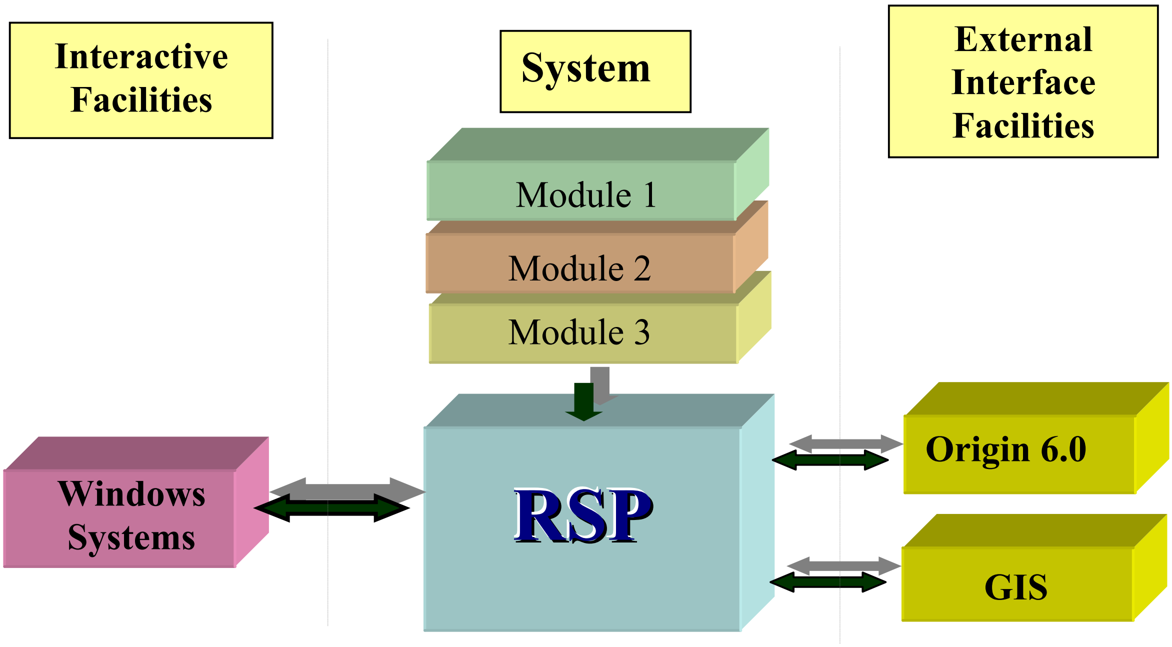
- Create highly detailed maps of the selected study area
- Reveal patterns and trends of stored data
- Create thematic maps (as deposition or dose maps of the selected area)
- Analyse environmental damage
- Analyse different countermeasures

7. References

1. Chen S. (1991): *′Calculation of effective dose-equivalent responses for external exposure from residual photon emitters in soil′*. Heath Phys. 60. N3, pp 411-426.
2. Kocher D. and Sjoreen A. *Dose-rate convertion factors for external exposure to photon emitters in soil.* Health Phys. V.48 N 2, pp 193-205, 1985.
3. Velasco, R.H., Belli, M., Sansone, U., Menegon, S. *′Vertical Transport of Radiocesium in Surface Soils: Model Implementation and Dose-Rate Computation′*. Health Physics, 64, 37-44.(1993).
4. Velasco R H., Toso J., Belli M. and Sansone U.: *′Radiocesium in Northeastern Part of Italy after the Chernobyl Accident: Vertical Soil Transport and Soil to Plant Transfer.′* J. Environ. Radioactivity. Vol 37/1. pp73-84. 1997.
5. J. P. Toso and R.H. Velasco: *Describing the observed vertical transport of radiocesium in specific soils with three time-dependent models*. J. of Environ. Radioactivity 53. (2001) 133-144.
6. Origin 6.0 . Microcal™ (1999).
7. MapInfo Professional (MapInfo Corporation), 1998.

ANNEX

I) PACKAGE ARCHITECTURE



II) *RSP* USER'S GUIDE MANUAL

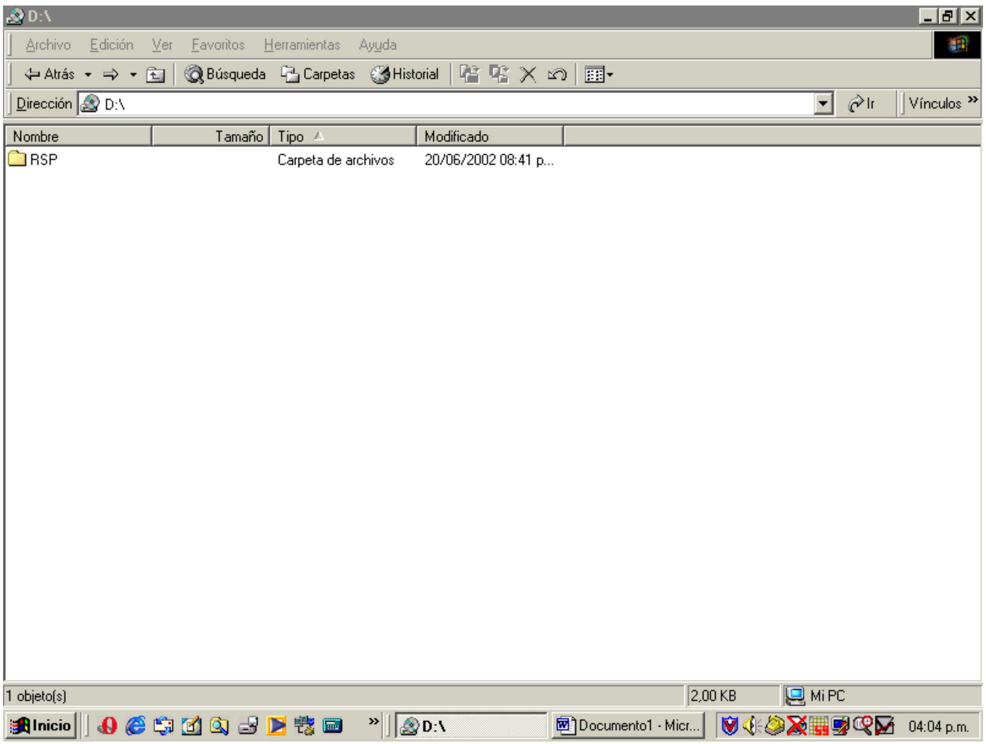
This manual is divided into two parts. First comes the installation process, second the instruction manual on how to use the program.

System requirements

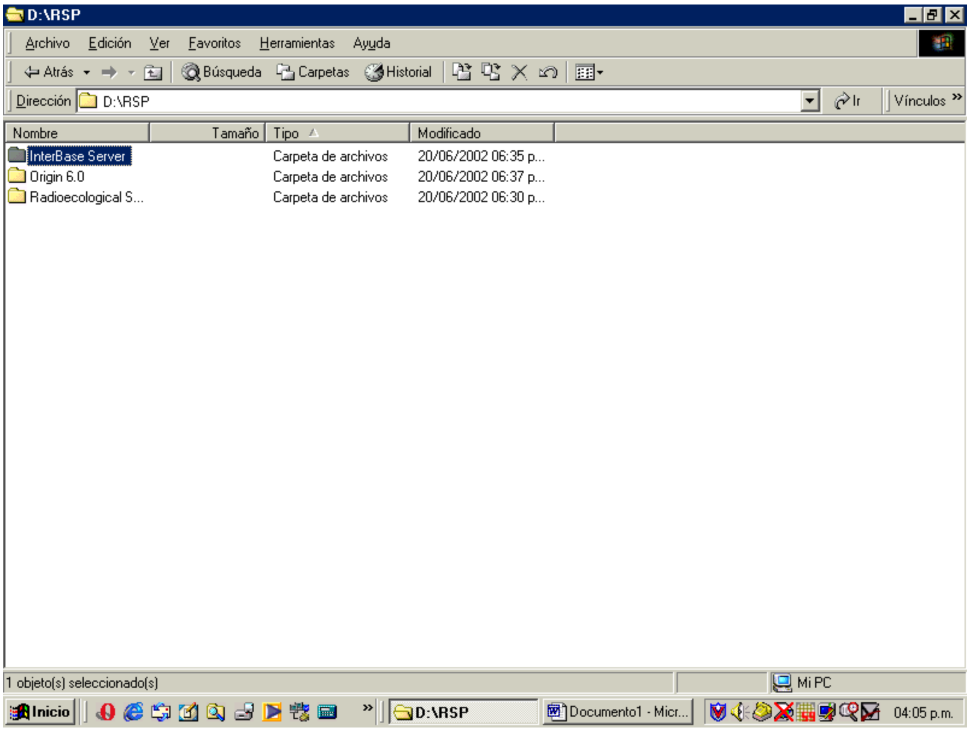
Hardware:	30 or more Mb of RAM memory.
	Free space in disk for 80 Mb.
	A Pentium II Processor.
Software:	Windows 98 O.S. or superior.
	Origin 6.0 (included in the RSP CD)
	InterBase data base administrator (included in CD)

A) Installation Process

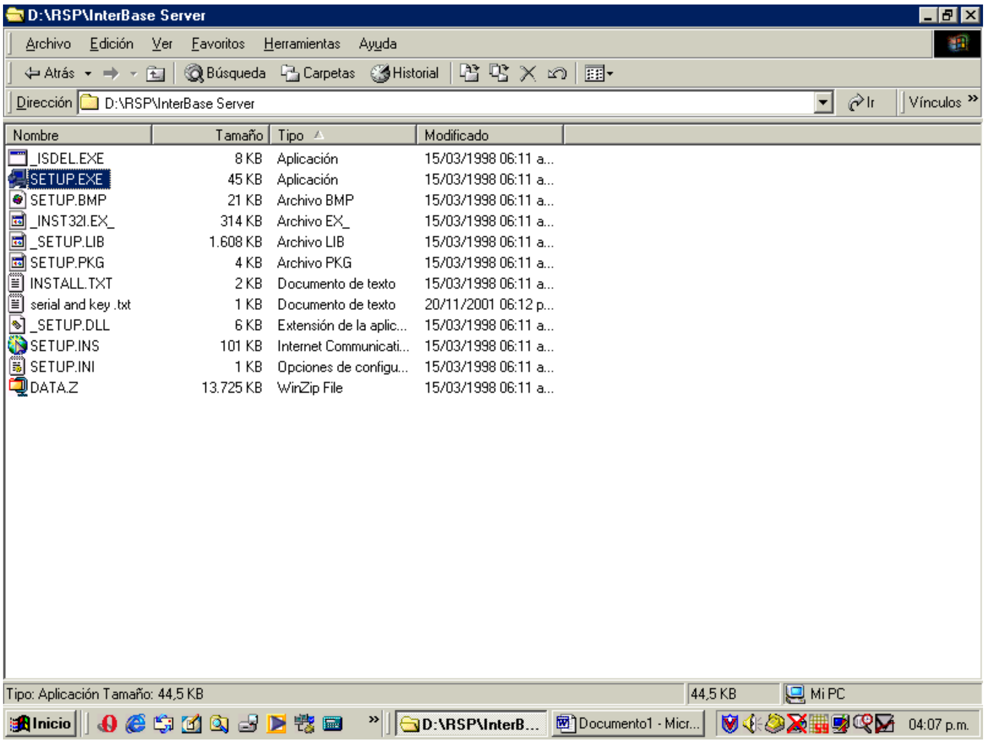
1.On your RSP CD, open the RSP folder.



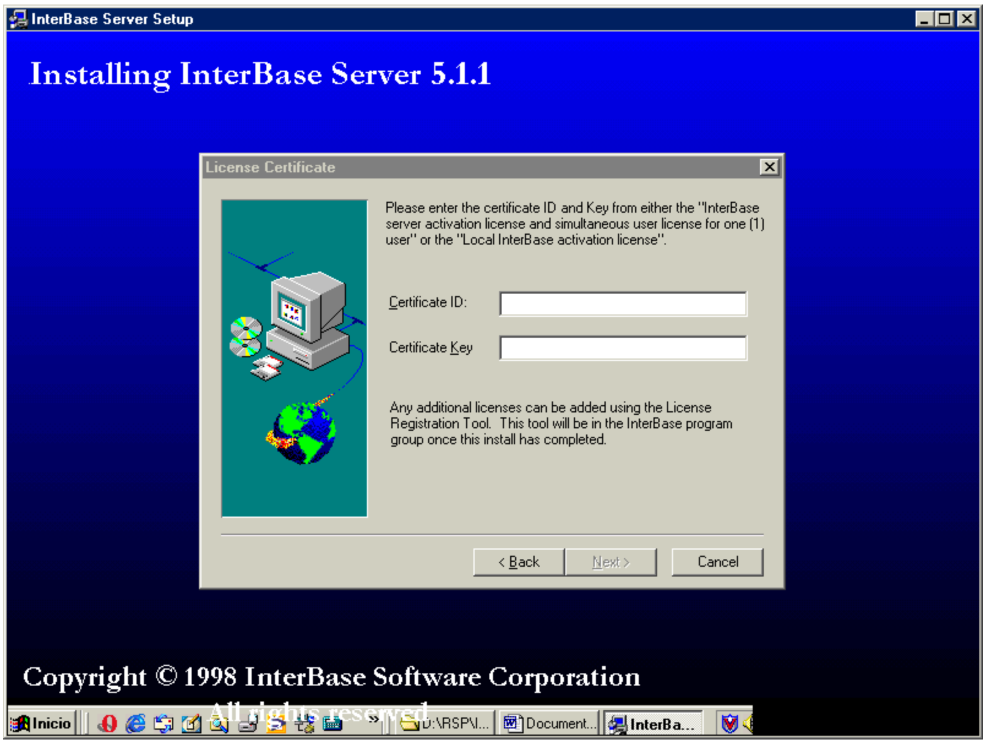
2. Open the InterBase Server folder.



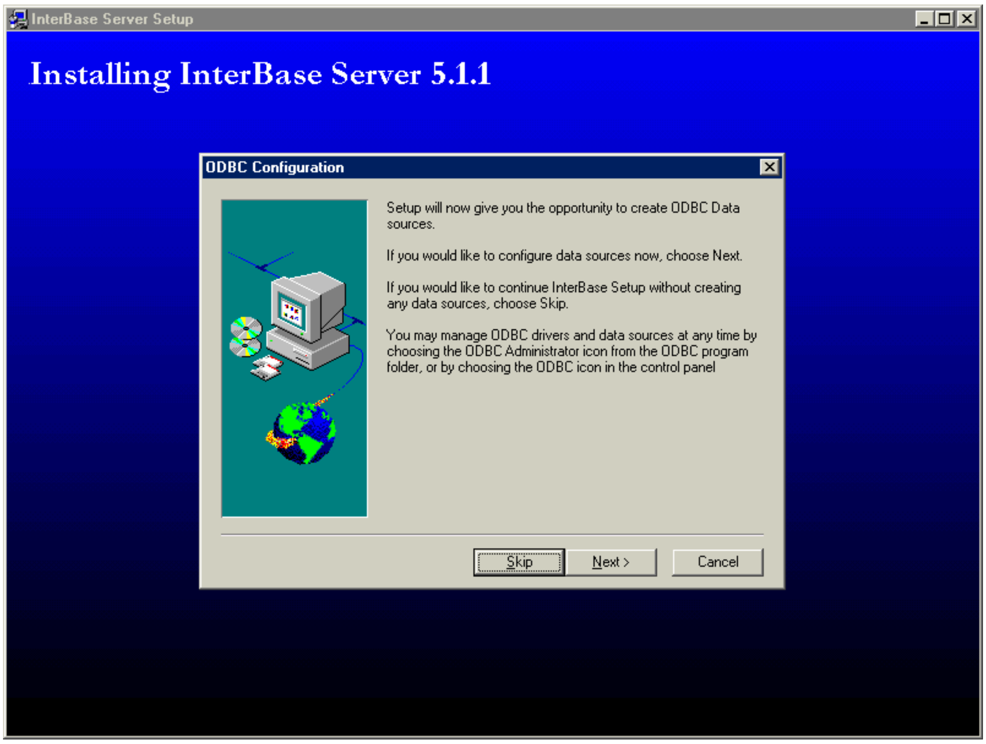
3. Double click SETUP.EXE and follow through the installation.



4. You can find your Certificate ID and Certificate Key on the InterBase folder under the name "serial and key.txt",



5. When asked if you want to create ODBC Data sources, click Skip.

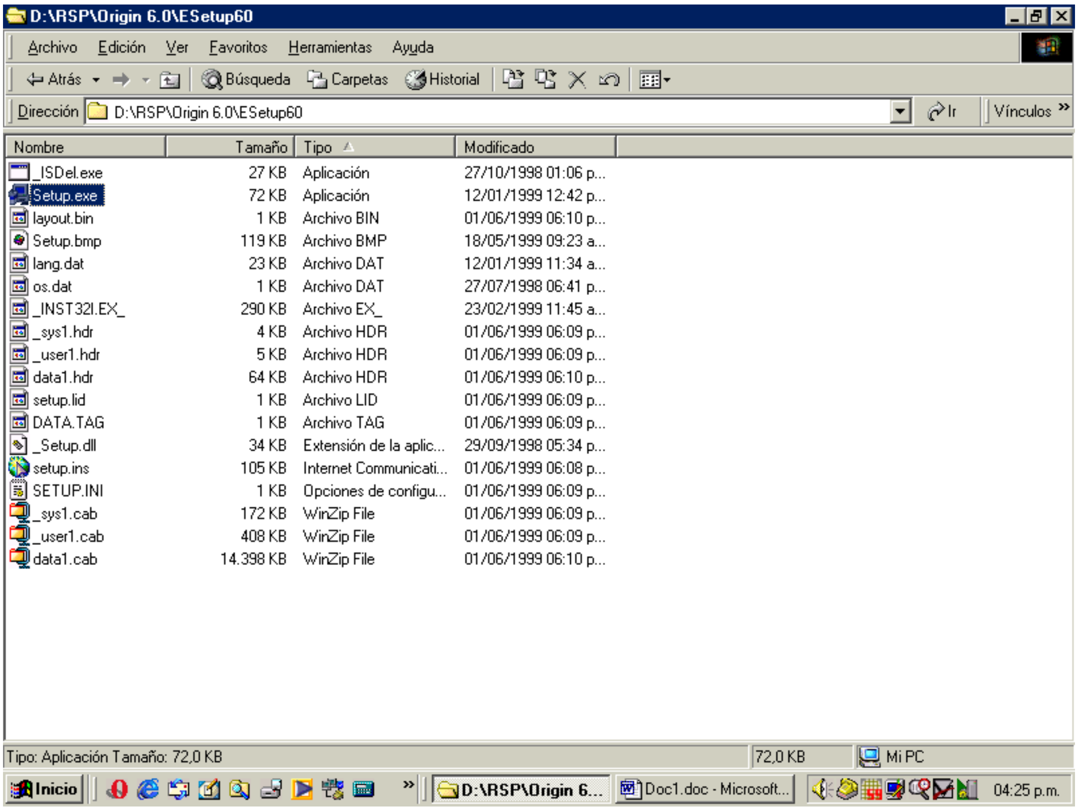


6. The Set Up is now complete.

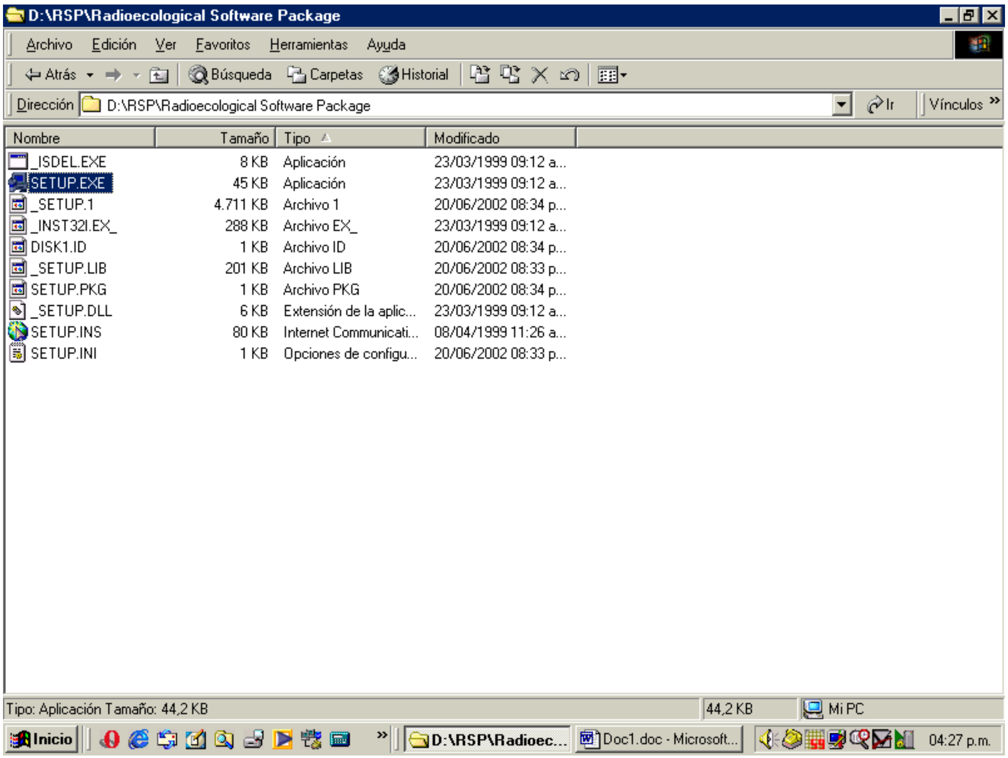
7. Next go to Start / Programs / InterBase 5.0 and click on InterBase Guardian. This will activate the data base server.

8. The InterBase icon should now be on the menu bar.

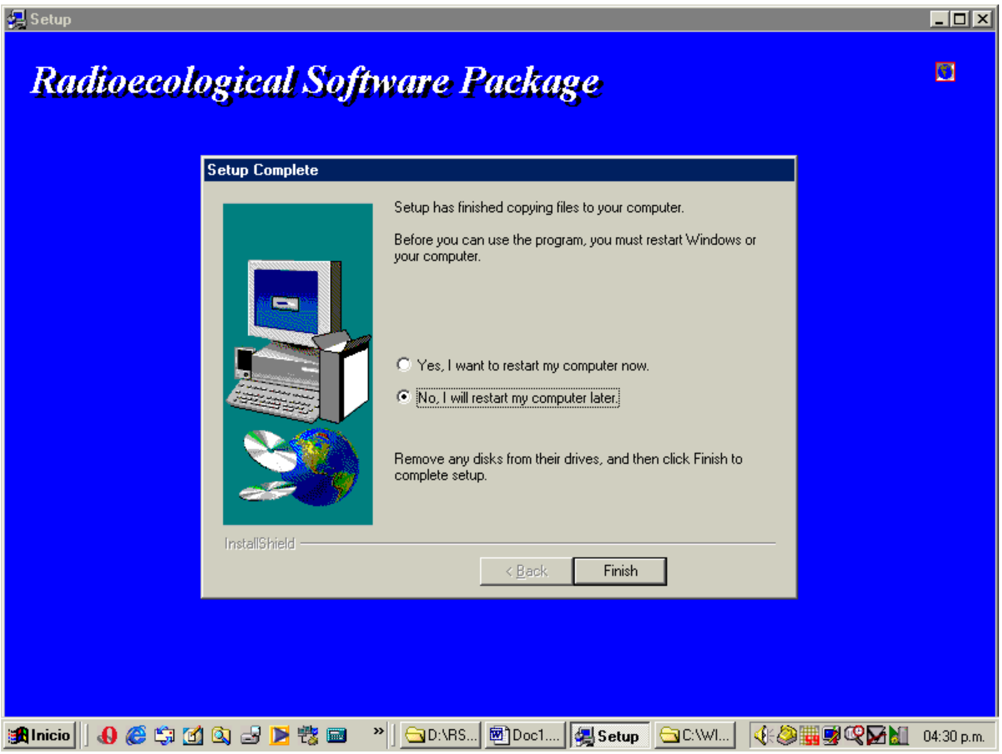
9. If you would like to view the output with Origin 6.0 and you haven´t installed it yet, you can find a copy of it on RSP\Origin 6.0\ESetup60. Just double click on Setup.exe and follow through the installation.



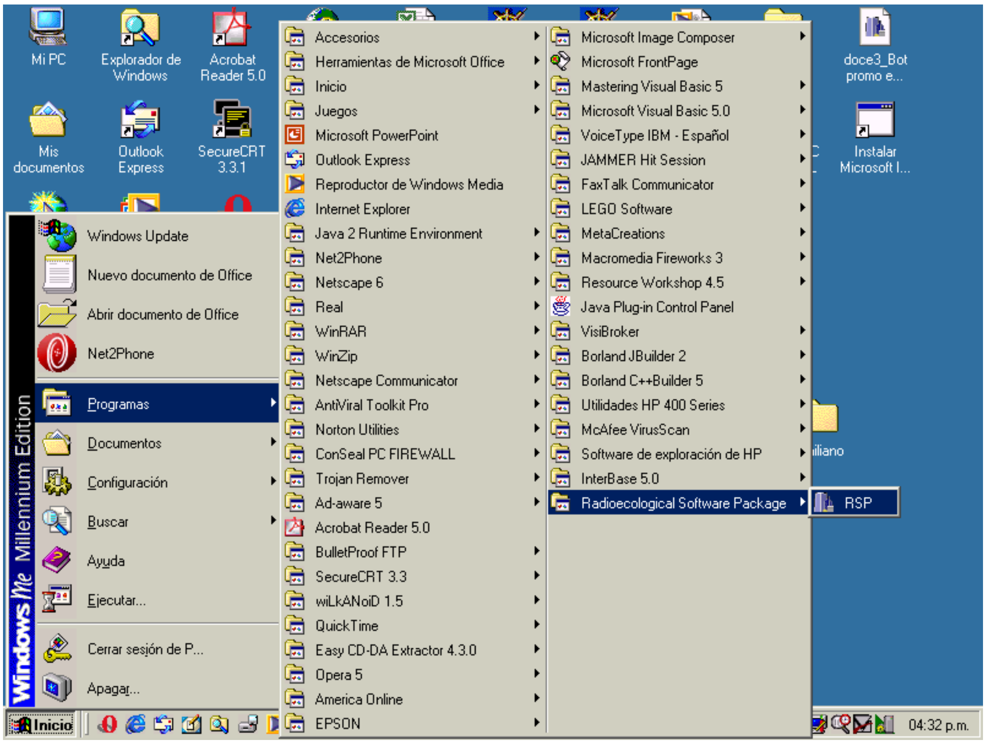
10. Now go back to the RSP folder and open the Radioecological Software Package folder. Double click on SETUP.EXE.



11. When asked if you want to restart your computer now CLICK NO, I WILL START MY COMPUTER LATER. This is very important. If you don´t, you will have to re-install Windows. Then click Finish.



12. The Set Up is now complete. You can run the Radioecological Software Package.



B) Using the Radioecological Software Package

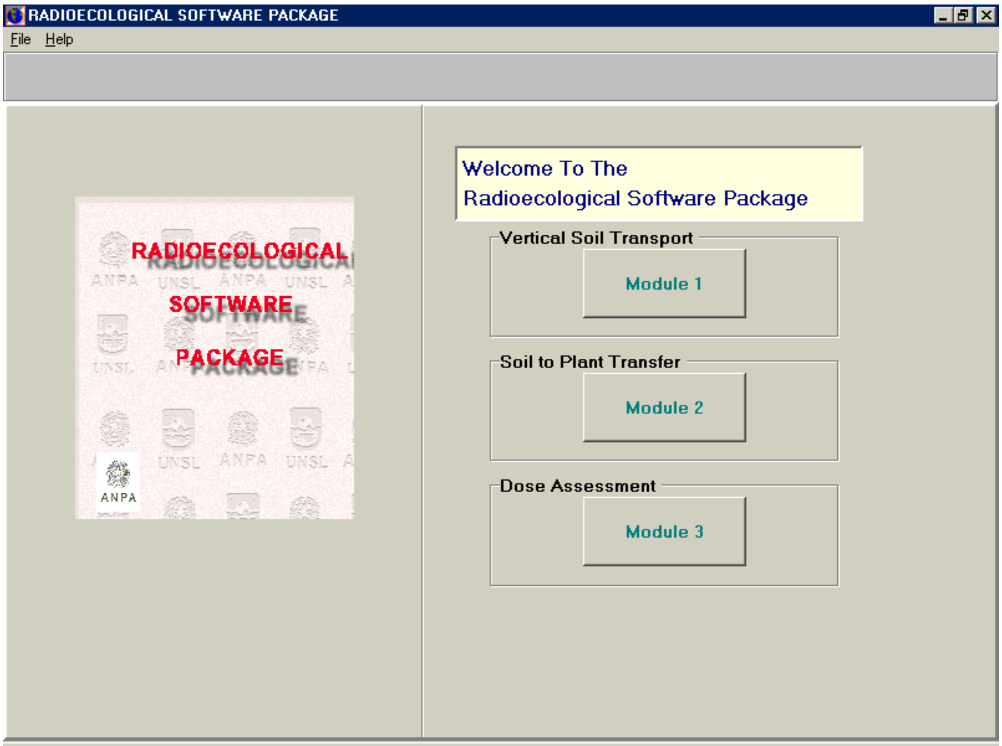
The program has the following structure:

It has three modules, each of which consist of:

1) a window for entering data and running the simulation .

2) a window for viewing the results as tables and/or graphics.

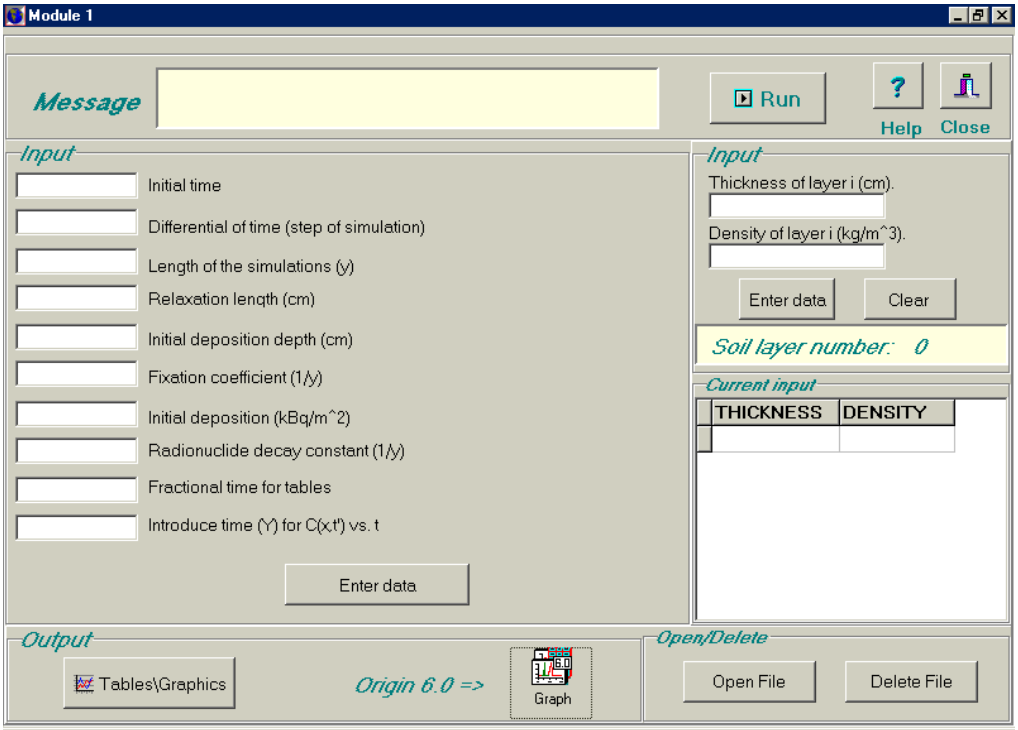
3) a window for opening and deleting files.



Module 1: Vertical Soil Transport.

In this module, RABES I (Toso & Velasco (2001)) has been used to describe the radionuclide vertical migration process in undisturbed soil. Temporal changes in the radionuclide vertical profile, intercompartment transfer rate vs time, and the relaxation length of the distribution vs. time can be obtained starting of the selected initial condition.

You can run Module 1 either by opening an existing file or by running the simulation from a new set of data.



To run a new a new simulation, enter the data on the blank fields. Then click the **Enter data** button.

If you want to clear all fields, click on **Clear**.

Where requested to enter thickness and density of layer i, you are allowed to enter data of up to 10 layers of soil.

After each layer, click the **enter data** button. You will be able to view your input on the lower part of your screen.

To view the results, click the **run** button.

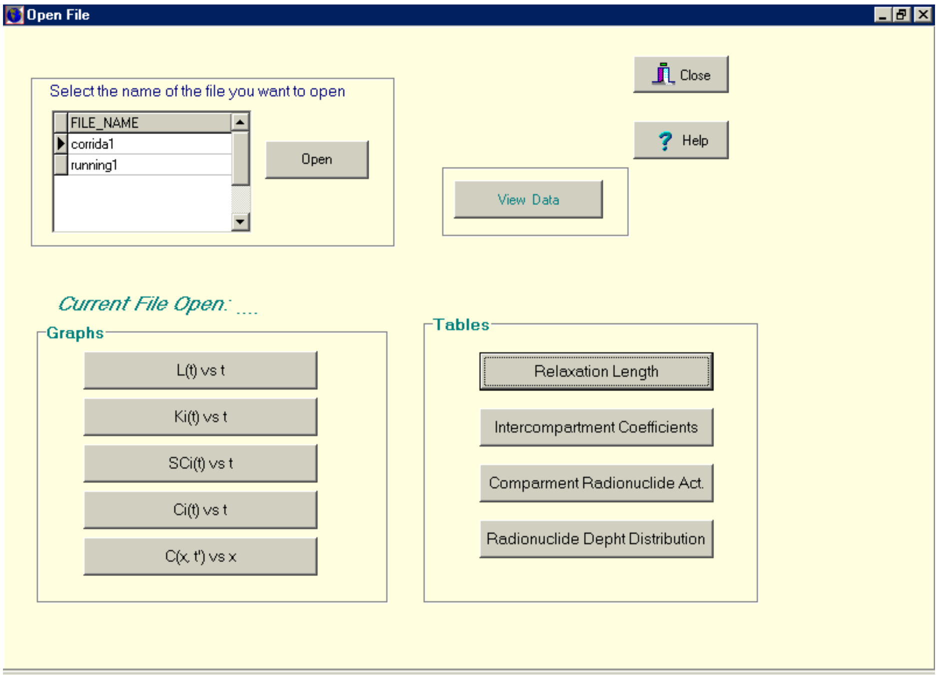
A window will pop up asking you to wait until the simulation has ended running.

You can view the results either by clicking the Tables and Graphics button or by running Origin 6.0.

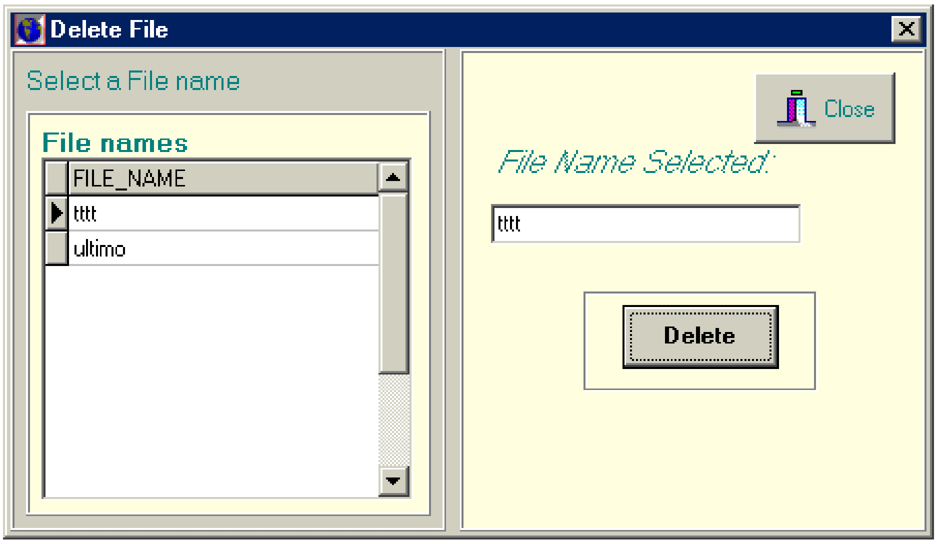
Opening and deleting files

To open an existing file, click the **Open file** button. Select the file from the list and click **open**. Then click on the table or graph you want to view as you would with a new simulation.

To view the data stored click **view input**.



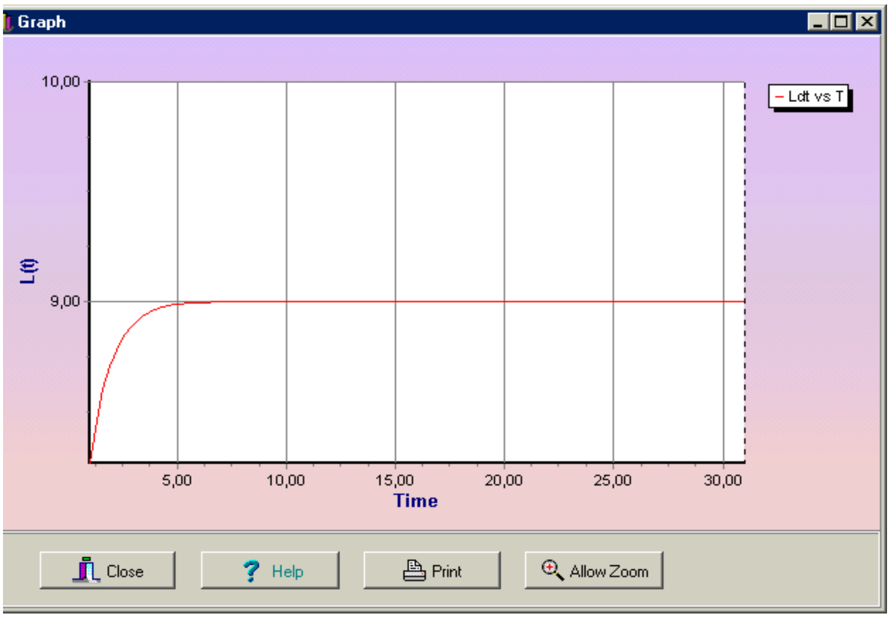
To delete a file, click on **Delete file** and pick the name of the file you wish to delete from the list on your screen. Then click **Delete**.

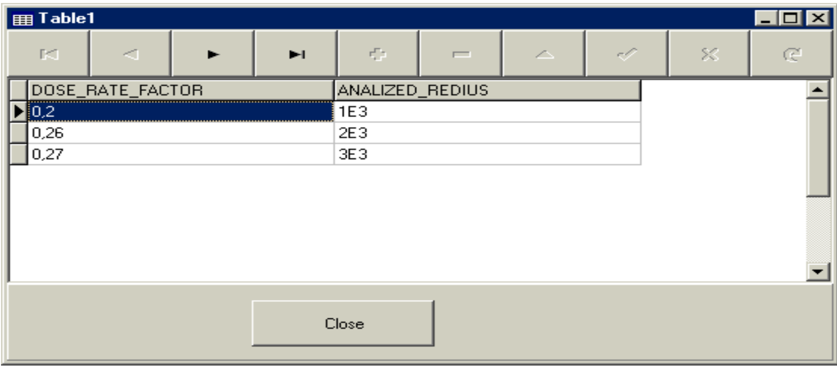


Viewing results

Viewing tables and graphics with the Tables/Graph option:

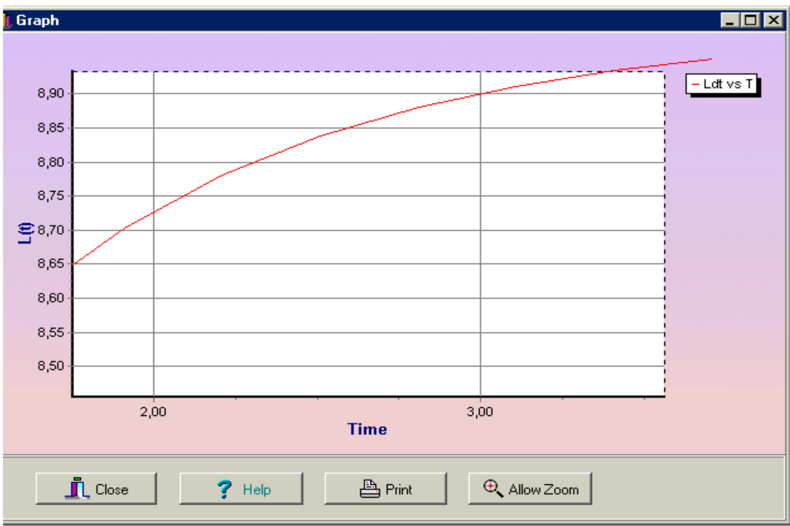
To view a table or a graph click on its button. Click **Close** to close or click on another table or graph and the former will be automatically replaced.





You can zoom a chart area by holding the left mouse button and dragging the mouse toward down/right. You'll see a rectangle around the selected area. Release the left mouse button to Zoom. You can continue zooming again and again.

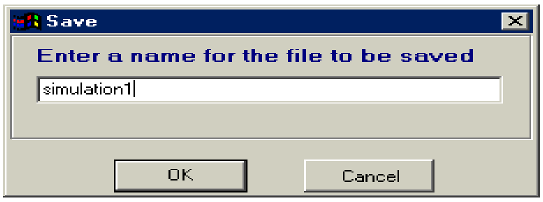
To RESTORE (or UNDO) the zoom, drag a rectangle in the opposite direction (up/left).To displace the graph, hold the right mouse button and move mouse.



Saving results.

To save the results click **Save**. A window will pop up asking you to name the file, then click **OK** (do not click Enter).

If you exit without saving, the results will be stored until you run a new simulation.



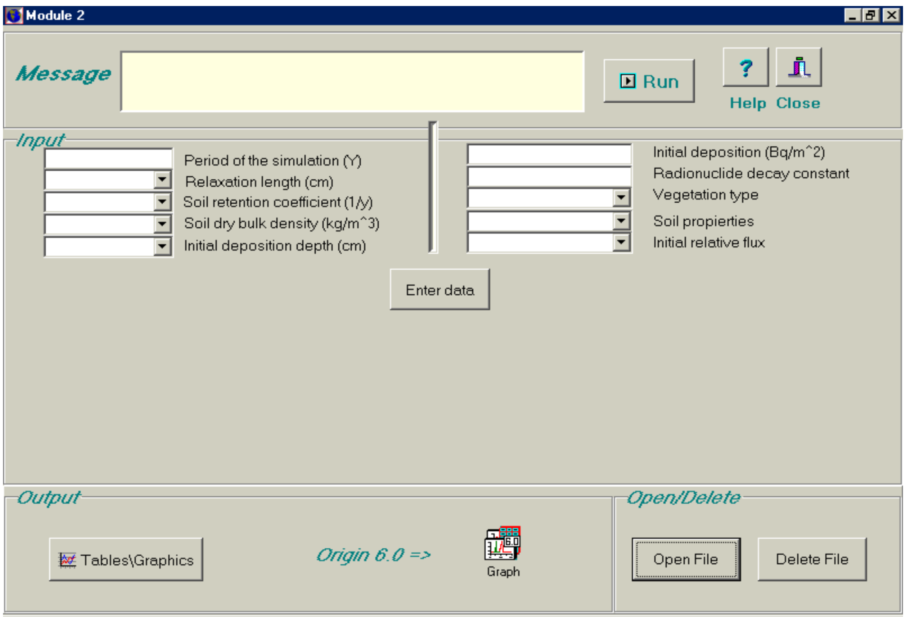
Viewing tables and graphics with origin 6.0

If you have chosen to view the output with Origin 6.0, double click on the **Origin 6.0** icon and retrieve files with ASCII format from the following address:

C:\RADIOECOLOGICAL SOFTWARE PACKAGE, select File|Import|ASCII form its main menu and then choose the file you want to open.

Module 2: Soil to plant transfer

This module permits to determine the radionuclides soil-to-plant transfer using the soil concentration in the root zone (calculated according to Module 1) and soil-to-plant transfer factor reported in the literature. Generic TF values obtained from Frissel et al. (2002) have been incorporated to simulate the radiocesium transport from soil to plant. The procedure is mainly based on a reference TF value, which depends on soil properties (nutrient status, exchangeable K-content, pH and moisture content). Different vegetation types can be selected.



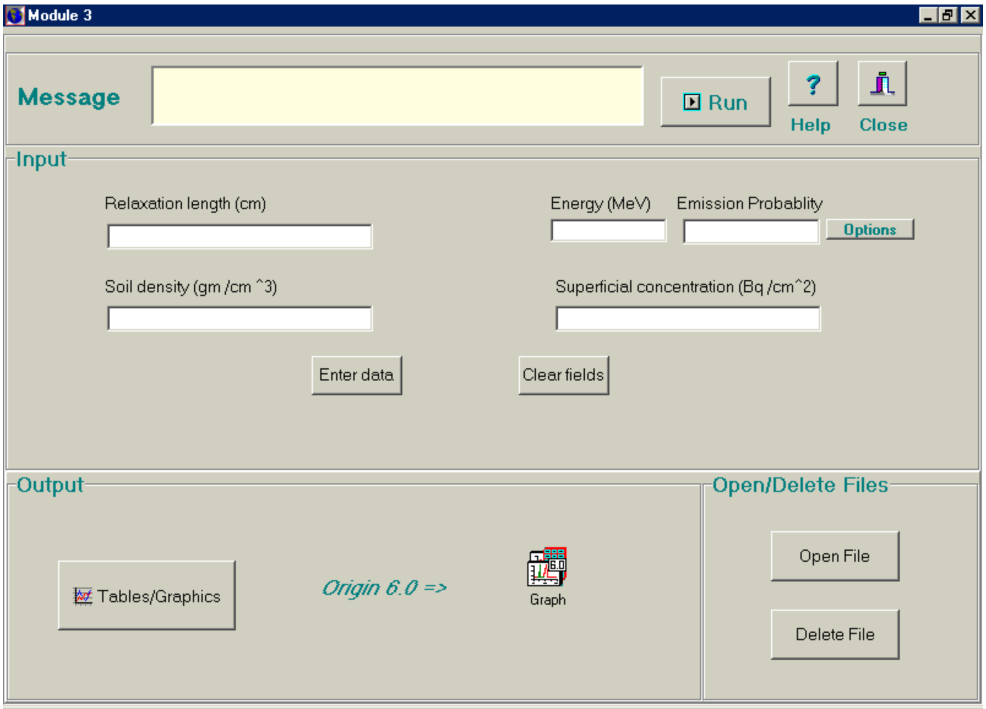
To run a new a new simulation, enter the data on the blank fields or pick a value from the menu. Then click the **enter data** button.

To enter a value different from the ones on the list, simply click on the filed and then type it. If it is a real value, separate the integer part from the decimal part by a colon (,) instead of by a period (.). If you don´t, a window will appear giving an error message.

To view tables and graphics or open or delete files, follow the same procedure as in Module1.

Module 3: Dose Assesment

Using this module, dose-rate factor in air at a height of 1 m above ground can be calculated for sources distributed in a slab o finite thickness and sources which are exponentially distributed with depth. The calculations are performed using DAGES Model, a Monte Carlo algorithm developed to simulate the photon transport for the soil/air configuration.



To run a new simulation, enter the data on the blank fields or pick a value from the menu.

On the Energy Emission probability field, to enter a value different from the ones on the list, click on other and then simply type the value on the field.

If it is a real value, separate the integer part from the decimal part by a colon (,) instead of by a period (.). If you don´t, a window will pop up giving an error message.

To view tables and graphics or to open or delete files, follow the same steps as in Module 1.