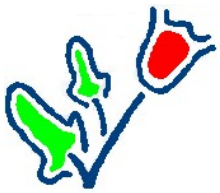
Castor-NOISE

Version 5.0

Noise pollution modeling software



Castor

Environmental Software, C.P.

28034 Madrid, Spain

www.environmental-impact.eu

IMPORTANT. READ ATTENTIVELY

Castor-NOISE 5.0 FOR WINDOWS 95

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Castor Environmental Software

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The CASTOR-NOISE 5.0 software estimates the dispersion of noise in the air. These types of numeric simulations are a method to estimate the contamination in an approximate way. Castor Environmental Software doesn't guarantee that the results obtained by this program coincide with the real concentrations that we can find in the air. The software, the used algorithms and the manual have been conscientiously examined of the possible existence of errors or omissions. Although we have checked the operation of CASTOR-NOISE 5.0 keeping in mind the results that we can find in the existent scientific literature on the area, Castor Environmental Software is not responsible for errors or omissions that we can find in the software, in the used calculation algorithms and in this manual. Castor Environmental Software is not responsible for losses or damages caused by the use of this software or of the user's manual. This software has been conscientiously examined of the possible existence of computer virus before its distribution.

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FOREWORD

The numeric algorithms that CASTOR-NOISE 5.0 uses gives us the possibility to study the noise pollution that we find in our environment. The numerical method uses a equation that estimates the dispersion of the noise in the air.

The software admits meteorological data to establish the form of the noise pollution. The software calculates the sound emission that is produced by each one of the sources and it considers the estates of the sources and the state of the atmosphere. CASTOR-NOISE 5.0 carries out temporary averages (daily, monthly or annual) so that you can calculate the pollution average in each point of the affected area.

The system of simulation of processes of dispersion that CASTOR-NOISE 5.0 has, offers to the beginner and the expert programmer, a quick and practical system to evaluate the noise pollution. The program is based on the operating system Microsoft WINDOWS where one works intensively with the mouse and the graphic windows. The bars of icons facilitate the realization of the different tasks of the program. We can say, with a certain security that the software CASTOR-NOISE 5.0 is one of the best tools, to carry out numeric simulations of noise pollution processes. Without considering the experience that the user possesses in programming languages or in the use of simulation tools, in few minutes he will be able to have the first results.

This manual will describe the use and the possibilities of CASTOR-NOISE 5.0 that we will show with the use of examples. It is not strictly necessary possessing knowledge on the handling of the operating system of Microsoft WINDOWS although it is advisable. Along the user's manual we will simulate some noise pollution processes whose development will illustrate the use of the program in the case of complex systems. We will describe the necessary steps for the study of a noise pollution process with the software.

Finally, we will say that they exist in the scientific literature a great quantity of models to evaluate the dispersion of noise in the air. In this way, we will obtain numeric differences among the results of the program and the results of other numeric models. This is not strange since there are numeric differences among the different models of the scientific literature. The problem is that the dispersion is a complex physical phenomenon (that involves turbulences, non-linear dynamics and thermodynamic of the irreversible processes) and we want to simplify it with a simple equation.

Contents

1. Introduction

Our planet is fragile and limited as for its potential of generating the resources that the humanity requests and its capacity to absorb the residuals that we emit. The precariousness of the ecological and environmental resistance of the earth can end up threatening the humanity's development. IUICN, PNUMA, WWF and Agenda 21 plead insistently to reach the sustainable development. This admits a growth and an evolution of the carrying capacity of the ecosystems, without committing the necessities of the future generations, by means of the environmental administration of the different places of the Planet.

2. Administration and Environmental Impact

The environmental administration is based on two fundamental tools: the planning and the evaluation of the environmental impact. These two instruments are fundamental to coordinate the human activity and to maintain the quality of the environmental resources. The process of environmental planning combines the characteristics of each place with the possibilities of economic development. We will define administration objectives that will achieve the optimization of the use of the resources minimizing the impact generated on the environment. We will define the environmental impact that suffers a certain region as the difference among the future environmental situation of the place, after the realization of a project, and the environmental state of the area if this project had never taken place. The correct diagnosis of the impact demands to know all the elements implied in the environmental process. A study of environmental impact will also include a planning of the environmental surveillance of the project.

One of the fundamental physical systems for the study of the environmental quality of a region is the atmosphere. The atmosphere play a fundamental paper in the development of the life. In this software, we will center ourselves in the study and in the administration of the noise pollution.

3. Noise pollution

The word "noise" comes the Latin word "nausea" meaning Sea sickness. Noise is among the most pervasive pollutants today. Noise pollution can be caused by many sources including highways, vehicles, factories, engines, machine, aircraft, helicopters, industrial development and construction work. Noise negatively affects human health and well-being. Problems related to noise include stress, sleep loss, distraction, and a general reduction in the quality of life. Noise pollution can be also harmful to animals. High enough levels of noise pollution may interfere with the natural cycles of animals.

Noises are irregular and disordered vibrations including all possible frequencies. The intensity of a sound **I** can be expressed in decibels with the standard equation:

$$L=10 \log(I/I_0)$$

where $\mathbf{I_0}$ is the quietest sound most people can hear, the threshold of hearing $10^{-12}Wm^{-2}$. When the ratio is between two field strength (so that the power being transmitted is proportional to the square of the pressure, the formula is:

$$L_{dB}=10 \log[p^2/(p_0)^2]$$

The decibel unit is often used in acoustics to quantify sound levels relative to some 0 dB reference. The reference may be defined as a sound pressure level (SPL), commonly 20 micropascals. The reference sound pressure (corresponding to a sound pressure level of 0 dB) can also be defined as the sound pressure at the threshold of human hearing, which is conventionally taken to be 20 micropascals. It can therefore be seen that a ratio expressed in decibels. A-weighted decibels are abbreviated dB(A) . When acoustic measurements are being referred to, then the units used will be dB SPL (sound pressure level) referenced to 20 micropascals = 0 dB SPL.

The frequency range of sound audible to humans is approximately between 20 and 20,000 Hz. The amplitude range of

sound for humans has a lower limit of 0dB, called the threshold of hearing. Sound is technically at its upper limit at 194.09 dB. Sounds begin to do damage to ears at 85 dB and sounds above approximately 130 dB.

dB	Source
250	Inside of tornado
180	Rocket engine at 30 m
120	Jet aircraft taking off at 100 m
100	Pneumatic hammer at 2 m
90	heavy truck at 1 m
70	Busy traffic at 5 m
60	Office inside
40	Residential area
10	Human breathing
0	Threshold of hearing (human with good ears)

The intensity of two sounds L_1 and L_2 can be added in decibels with the standard equation:

$$L_{dB}=10\ \log[(p_1/p_0)^2+[(p_2/p_0)^2]$$

and then,

$$L_{dB}=10\ \log[10^{L_1/10}+\ 10^{L_2/10}]$$

In this way, decibels from two different sources can be added. CASTOR-NOISE 5.0 Software will consider this method of calculation.

3. Before you begin

Welcome to CASTOR-NOISE 5.0 - software for noise pollution modeling. The CASTOR-NOISE 5.0 Software allows you to create robust and useful numeric simulations that fully make use of the graphical user interface. This chapter show you how to sep up CASTOR-NOISE 5.0 on your computer.

We can say, with a certain security that the software CASTOR-NOISE 5.0 are one of the best tools, if not the best and simpler, to carry out numeric simulations of noise pollution. It takes just a few minutes to build your first numerical simulation.

Due to the features of the software that allows to simulate the process of noise pollution immediately, the numeric simulation is carried out with a remarkable speed.

You create the graphical interface for your pollutant sources by drawing point sources in a graphical way. You create the simulation process by drawing point sources on the CASTOR-NOISE 5.0 window. Next, you set properties for the point sources and ambient data to specify such values as temperature, noise power,… Finally, the numeric simulation is carrier out.

3.1 CASTOR-NOISE 5.0 Software

Before you attempt to install and use the program, make sure your personal computer meets the hardware and software requirements shown in the following table.

- System requirements: Windows 95, 98, 2000 and XP
- CD-ROM drive
- RAM Memory: 16MB or higher

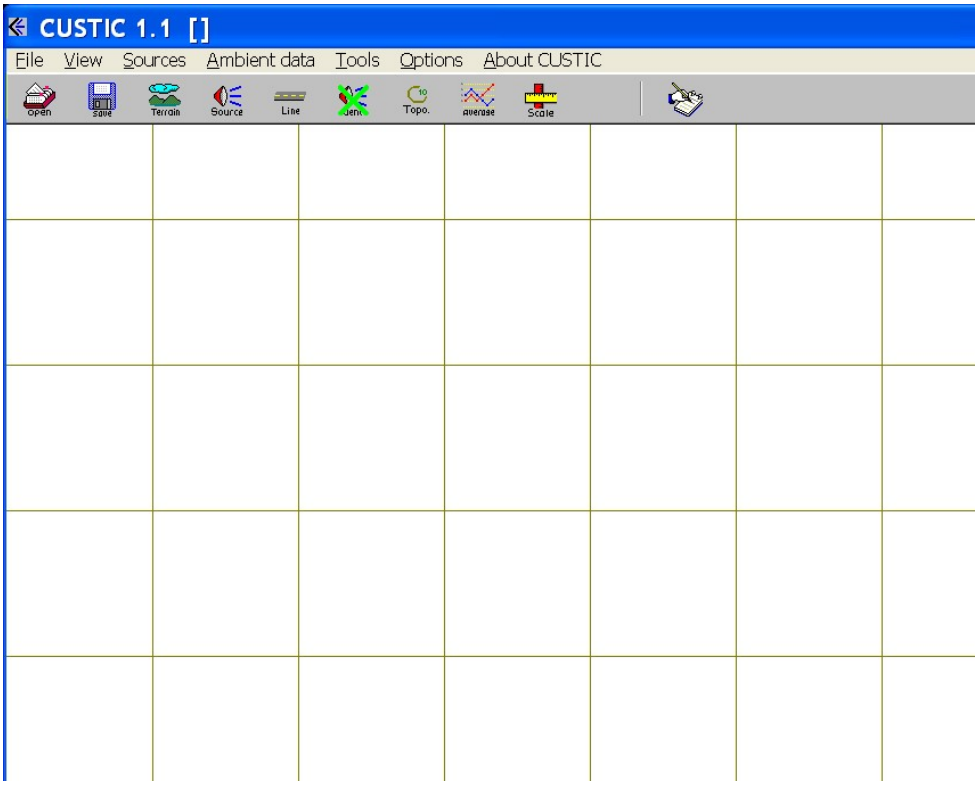
3.2 Installation

- Insert the CD. The CASTOR-NOISE 5.0 CD window appears on your screen.
- Click the button labeled **SETUP** and follow the instructions on the screen.

If the CASTOR-NOISE 5.0 CD window does not appear, the CD autorun feature might be disabled on your computer. To install CASTOR-NOISE 5.0, open the CD-ROM drive icon, open the PC directory, and double-click the Installer icon.

3.3 Starting CASTOR-NOISE 5.0

Click Start, go to Programs, and choose CASTOR-NOISE 5.0 . Here is the program window after startup.



The window has a Menu bar at the top, a Status bar at the bottom and a basic tool bar in the window. The program commands are available through the menus and toolbar buttons. Some commands have associated dialog boxes which you can choose additional options.

4. Understanding the Workplace

The MS Windows bar doesn't appear. In this way, you have more space to draw. However, and if you want, you can modify the properties of the MS Windows bar in the Microsoft Windows system. The program window size is fixed and it cannot modify. The menu bar lists the menus shown above. When you choose one of the menus, the program displays a pull-down list of available commands. The menu bar lists: **File**, **View**, **Sources**, **Ambient data**, **Tools**, **Options** and **About CASTOR-NOISE 5.0**. The program window has a basic tool bar at the top.

In the center of the program window, we will draw and we will calculate the different polluting processes. We draw using a plane that is parallel to the land surface (XY). There is a grid in the XY-plane. The coordinate origin is on the left bottom corner (X=0, Y=0).

The program window is a XY-plane (parallel to the land surface). A noise source is represented by a small square.

In the Status bar at the bottom, we have X and Y coordinate values in meters and data on our environmental system. Point the mouse where you want in the program window and the X and Y values will be shown in the status bar at the bottom.

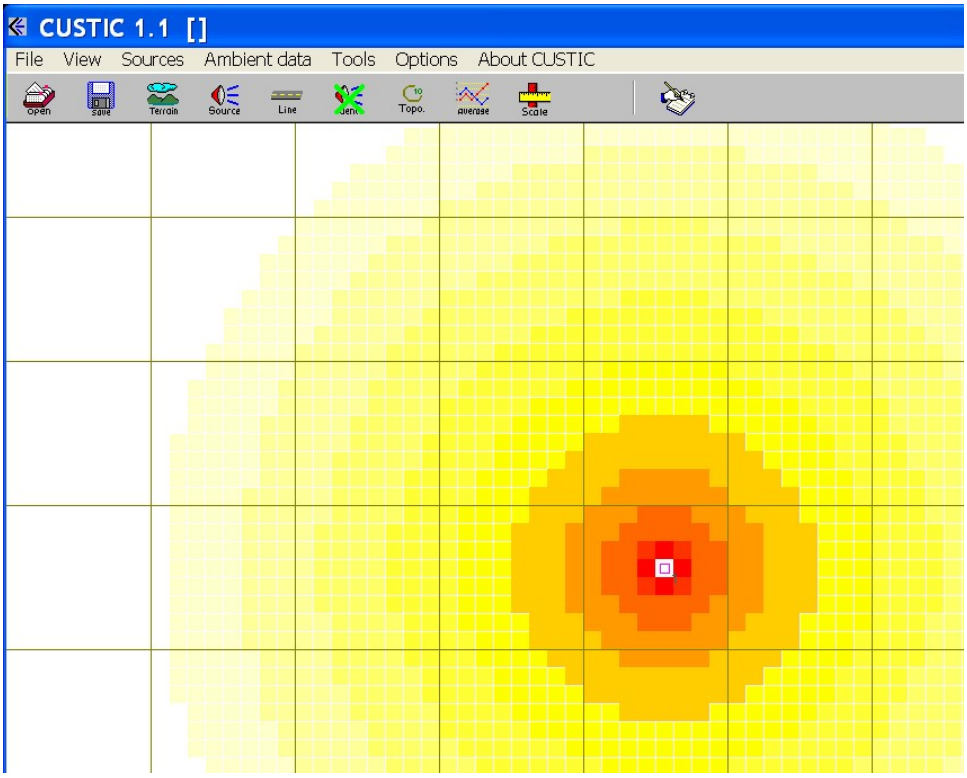
On the left bottom corner, two different text boxes appear: The position of the XY-coordinates and the noise value in decibels, dB(A). Point the mouse where you want in the program window and the noise value will be shown in the text box.

The noise levels will be calculated in a parallel plane to the land surface (XY-Plane). The plane height will be determined by the user (z_r).

All the points of the XY-plane will be to a z_r height. The z_r value is chosen by the user before the calculation. We will be able to make many calculations considering different plane heights. The different plane heights will be determined by the

user (z_r values). In this way, the physical form of the noise power can be studied.

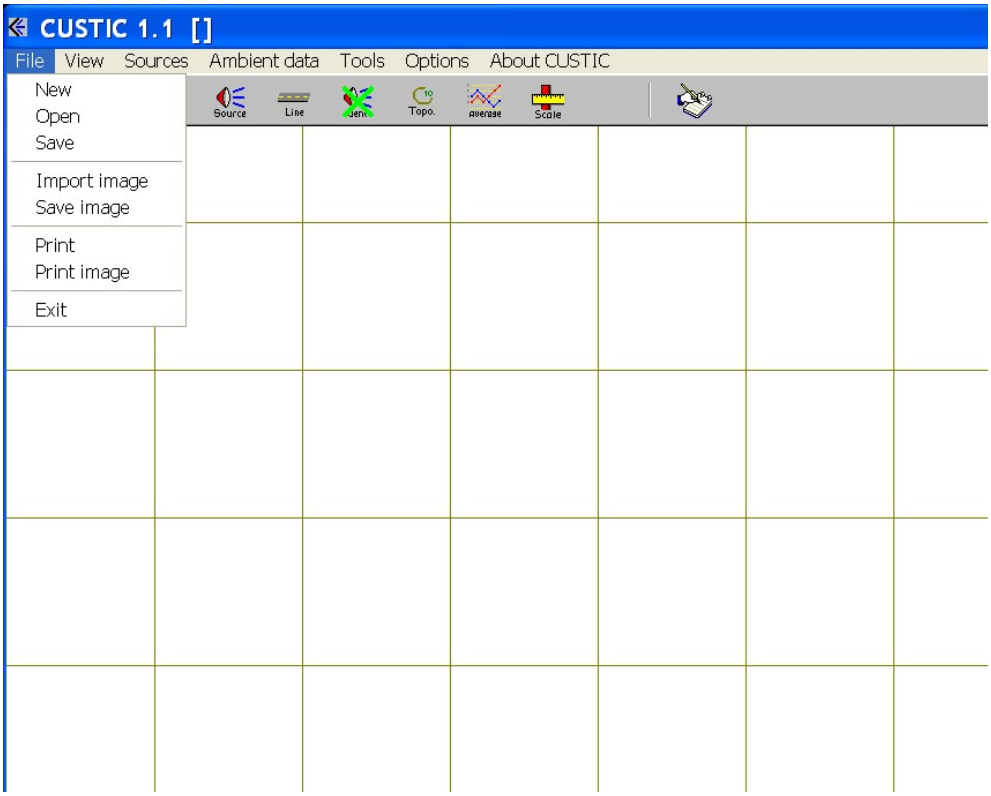
Example: Calculation in the XY-plane, zr=0 (height of the land surface). The red square represents a point source. The red colour represents high noise levels.



4.1 Menu Bar

Display the commands you use to build your simulation. When you choose one of the menus, the program displays a pull-down list of available commands. The program window has a basic tool bar under the Menu bar. The tool bar provides quick access to commonly used commands in the program. You click a button on the toolbar once to carry out the action represented by that button.

For example, when you choose **File** in the Menu bar, the program displays:



4.1.1 File

The File Menu contains the tools you use to open, close and save new and existing files, and import and export graphics. The File Menu lists: **New**, **Open**, **Save**, **Import Picture**, **Export Picture**, **Print**, **Print Picture** and **Exit**.

New.- This command is to begin a new simulation, deleting all that has been made previously.

> ***Save the work with the Save command before clicking the New command. The program doesn't allow to open two files at the same time. This way, we can optimize the available memory and the calculation speed.***

Open.- This command is to open an existing file. The program files exist as separate files with **.cus** filename extension.

Save the current work with the Save command before clicking the Open command. The program doesn't allow to open two files at the same time.

Save.- This command is to save an existing result.

The process of saving a file is carried out proportionally to the size in which the elements are drawn in the screen. Then, the saved file will depend on the screen format that we are using (for example, 1280x1024,...). If we try to read a file, saved in another different computer, we will have problems to open it.

Import Picture.- With this command you will be able to import images and pictures (previously saved BMP files). These images will be background pictures and images for your program window. You can display an image by double-clicking the filename of a bitmap (BMP).

Many programs and computer applications (AutoCad, 3d Studio, ArcView,...) export BMP files. You will be able to load pictures and images generated by these programs.

The displayed image size will depend on the size that had when it was saved. If it is necessary, modify the picture size before loading the image (for example, you can use windows Paint, Adobe Photoshop,…). You will be able to load BMP maps generated by AutoCad.

Bitmaps and scanned maps must be loaded into memory and then adapted to the program scale (we will make use of the **Scale** command). The X-Axis width (meters) in the program window can be easily changed to be able to compare both images (simulation results and background maps). Then, the X-Axis width (in meters) of the imported map and the X-Axis width (in meters) of the program window match together. The imported images are not stored physically in the simulation process. Terrain elevations (represented on the imported map) don't interact in the simulation process (sound reflections). We

haven't the possibility to zoom an imported map with the **Zoom** command. This command only acts in the calculation process. If it is necessary, zoom the map before loading the image.

Export Picture.- With this command you will be able to export images and pictures (BMP files). These images will contain the background picture and the simulation results.

Many programs, computer applications and word processors (AutoCad, 3d Studio, ArcView, MS Word,...) import BMP files. You will be able to load images generated by CASTOR-NOISE 5.0.

Print.- The users' printer drivers and printers impact print quality. With this command you can send graphics and text (of the simulation results) to a printer. This command provides the best printing quality across a variety of printers because Windows translate text and graphics from the device-independent drawing space to the Printer object to best match the resolution and abilities of the printer. However, the background pictures cannot be printed.

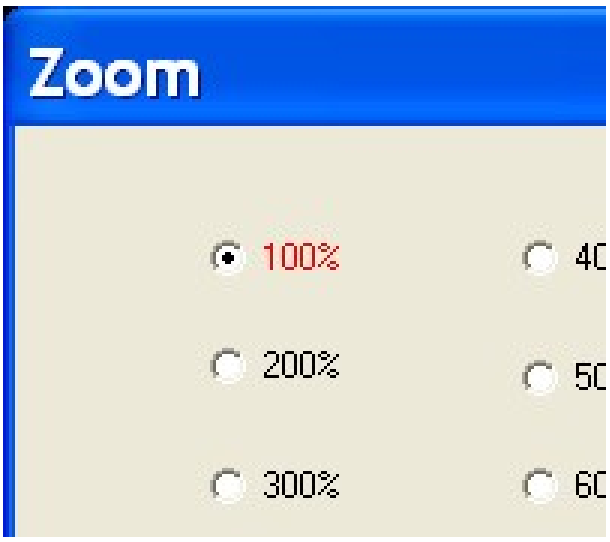
Print image.- This command send a pixel-by-pixel image of the program window to the printer. To print with **Print image** command, you must first display that information on the program window and then print with this command. This command is by far the easiest way to print from your application. Because it may send information to the printer at the resolution of the user's screen (typically 96 dots per inch), results can be disappointing on printers with much higher resolutions (typically 300 dots per inch for laser printers).

Exit.- The **Exit** command allows you to exit directly from the application.

4.1.2 View

The View Menu contains the tools you use to view your computer screen. The File Menu lists: **Zoom**, **Black background**, **White background**, **Draw grid lines**, **Eliminate grid lines**, **Draw picture**, **Eliminate picture** and **XY and XZ view**.

Zoom.- We have the possibility to zoom a part of the program window with the **Zoom** command. However, we won't be able to enlarge background pictures with this command. If it is necessary, zoom the map before loading the background image. This command only acts in the calculation process. This way, we can place a point source in a side of the computer screen and we can calculate the concentrations in another different detailed region.



To activate the **Zoom** command, eliminate the background picture first.

Black background.- The Black background command allows you to have a black background colour in your screen.

White background.- The White background command allows you to have a white background colour in your screen.

Draw grid lines.- If you select **Draw grid lines** command, the grid appears.

Eliminate grid lines.- If you select **Eliminate grid lines** command, the grid disappears.

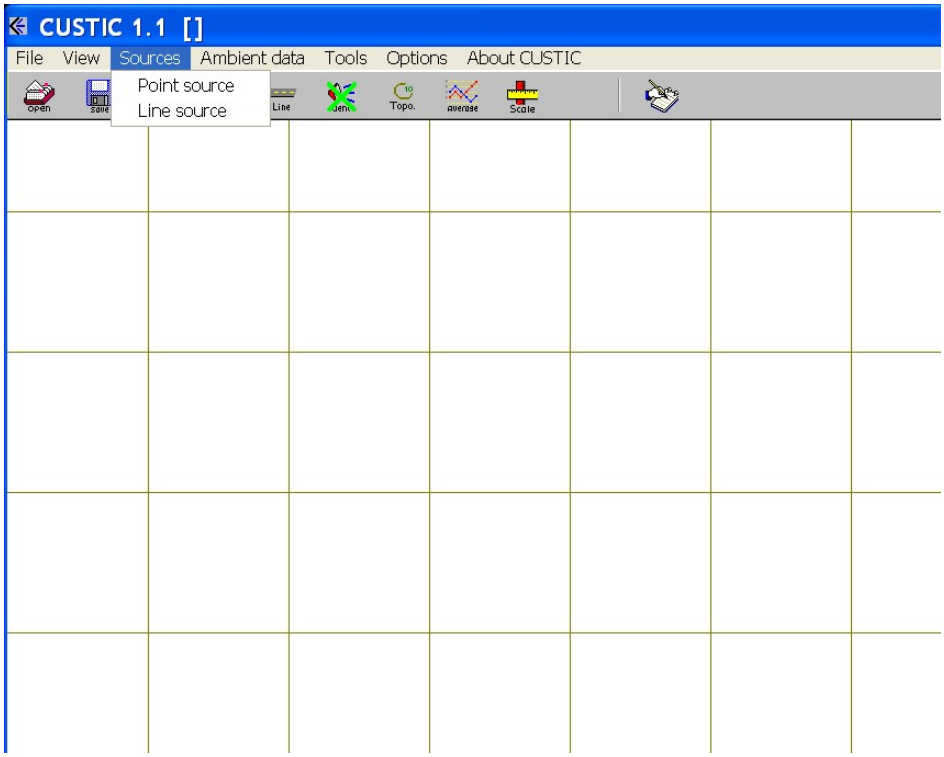
Draw picture.- With this command you will be able to see background images and pictures (previously loaded BMP files).

Eliminate picture.- With this command you will eliminate background images and pictures (previously loaded BMP files).

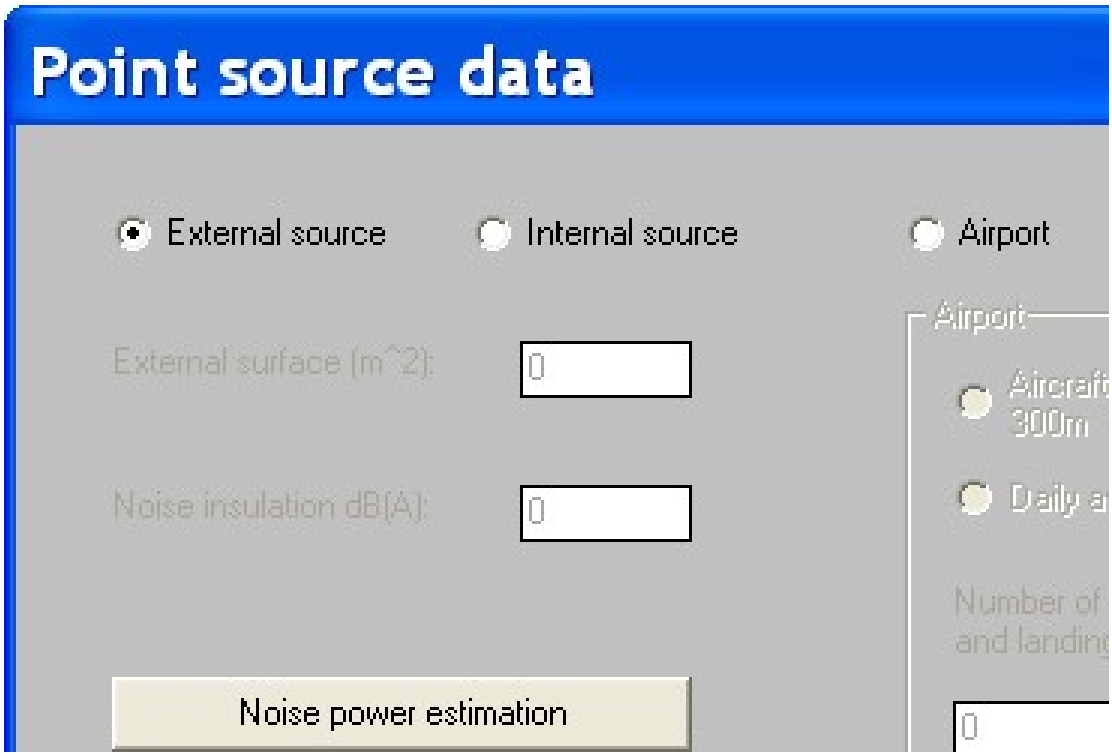
XY and XZ view.- These command are to get views of the XY and XZ planes.

4.1.3 Source

The **Sources** Menu lists the possible noise sources: the point source and the line source.



Point source.- This is a point source. The source size is small if we compare it with the size of the area in which we are simulating (point source). If you click this button, the next dialog box is shown:



The necessary data is:

External source/internal source/airport options: This is the External/internal/airport option. External means a noise source placed out of a building (for example, a vehicle engine).

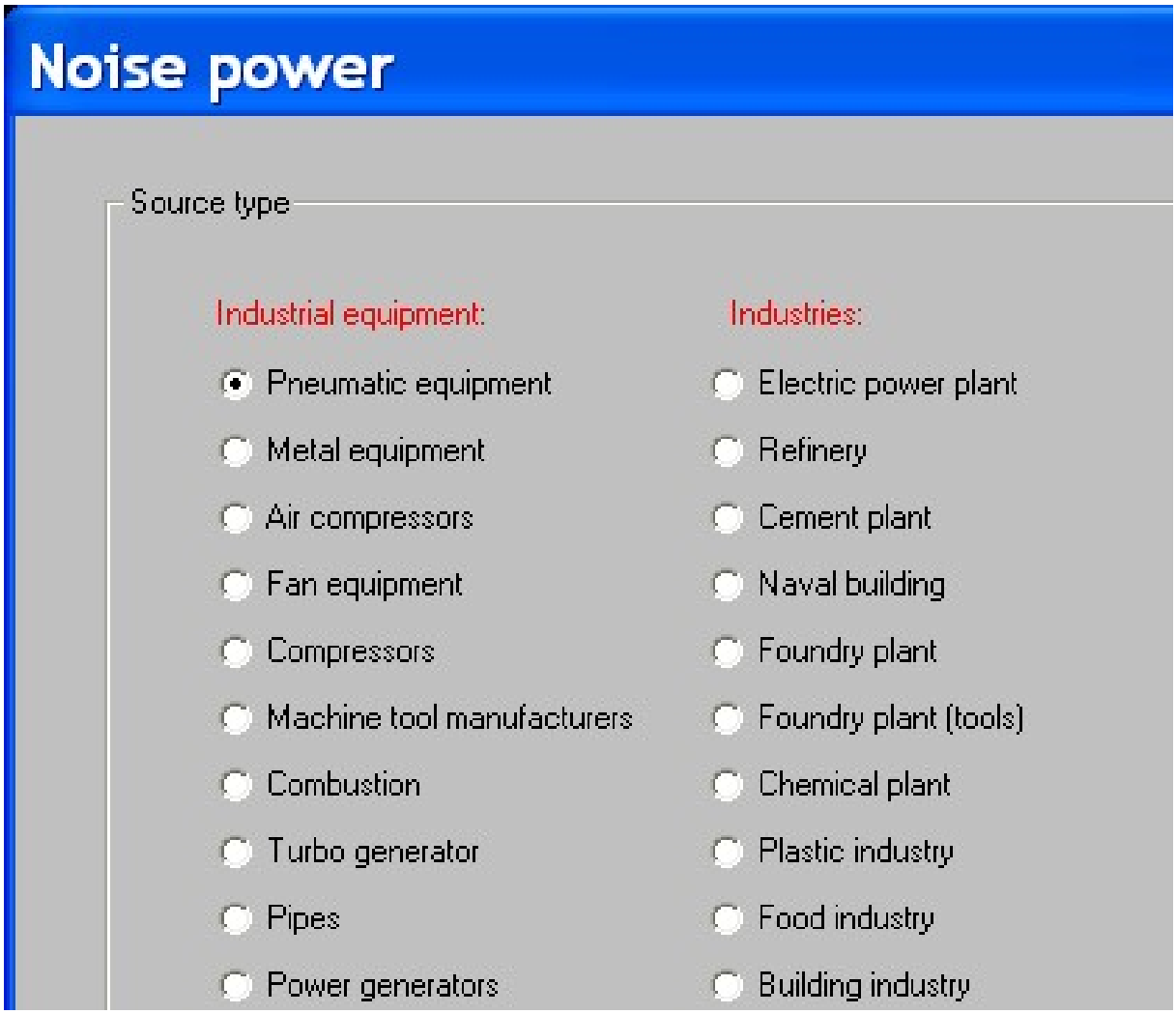
External surface (m^2): In the internal source option, this is the external area of the building.

Noise insulation (dB): In the internal source option, this is the noise insulation value.

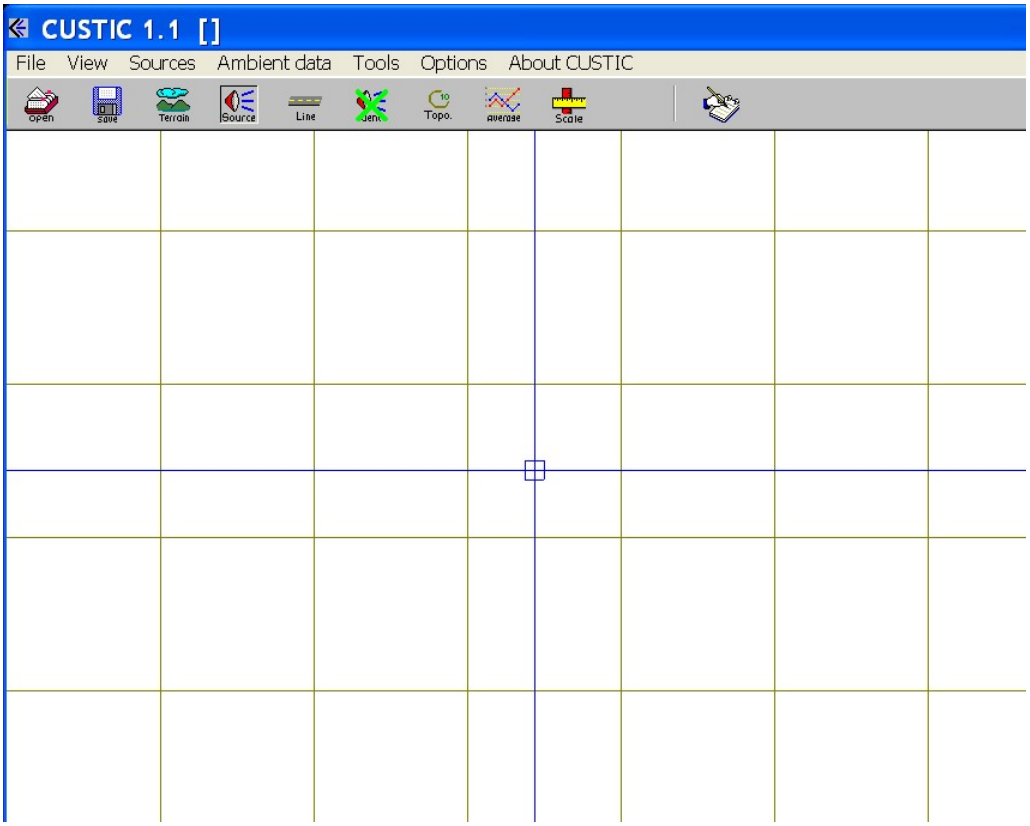
Noise power (dB): This is the noise power at source position in decibels.

Airport options: We have two options: An aircraft landing/taking off at 300m or Daily average (number of airport operations in a day).

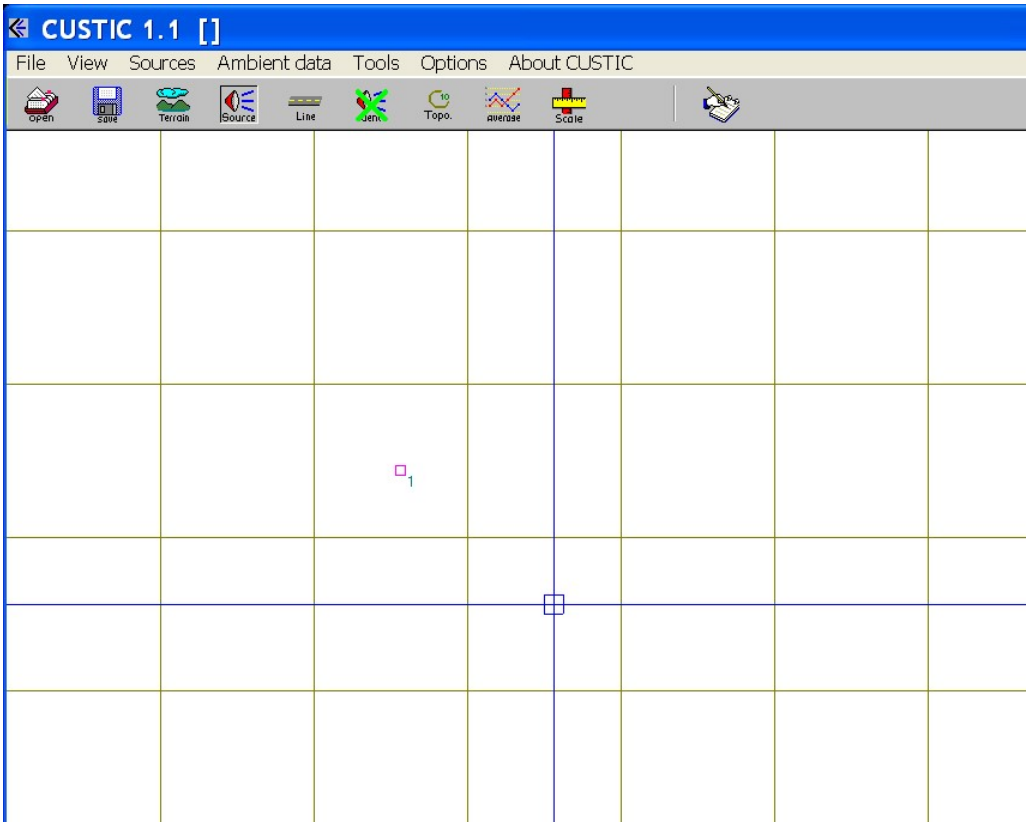
Noise power estimation: With this button, you can estimate the noise level if it is unknown. If you know the power, you don't need to use this command. You can write it directly in the noise power textbox. If you click this button, the next dialog box is shown:



If you click the OK button, the next program window is shown

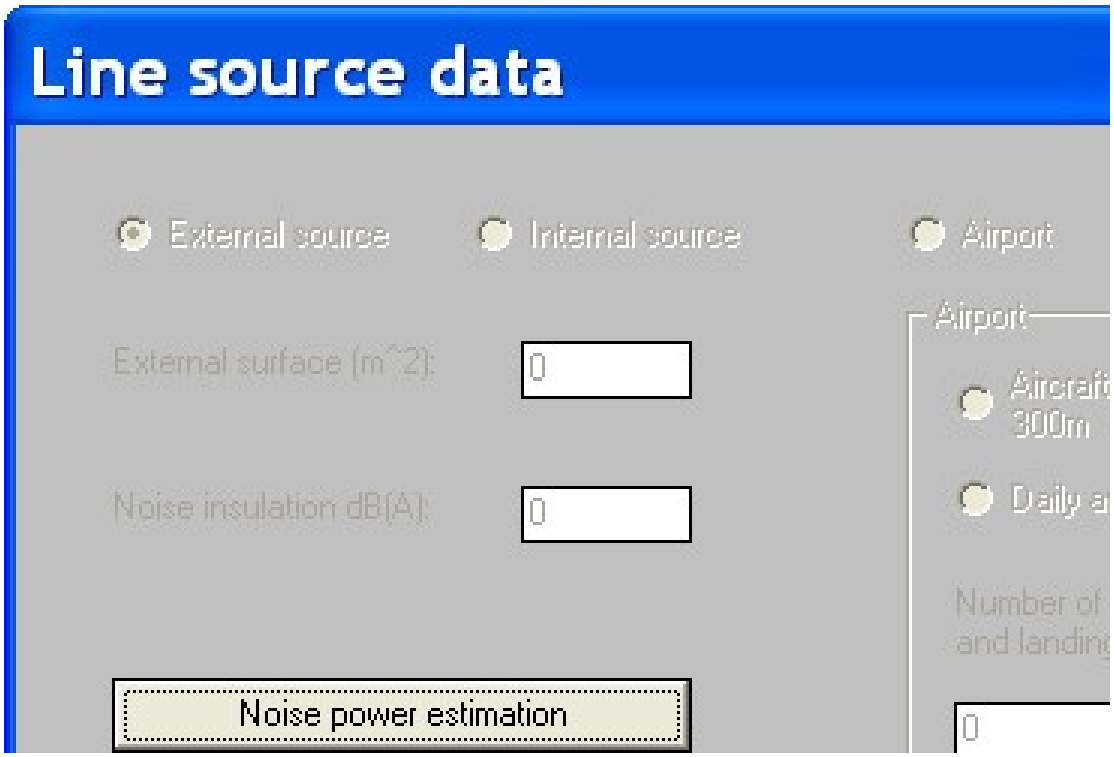


Two blue axis points the place where we can fix the source position. After clicking the program window, you draw the point source.



The small fuchsia square shows the source location. We can draw all the noise sources that we want (up to 1,000). To change the point source data, we can click the source location in the program window. Then, the point source dialogbox is again displayed. We are not able to put two noise sources in the same location. The older one is eliminated automatically.

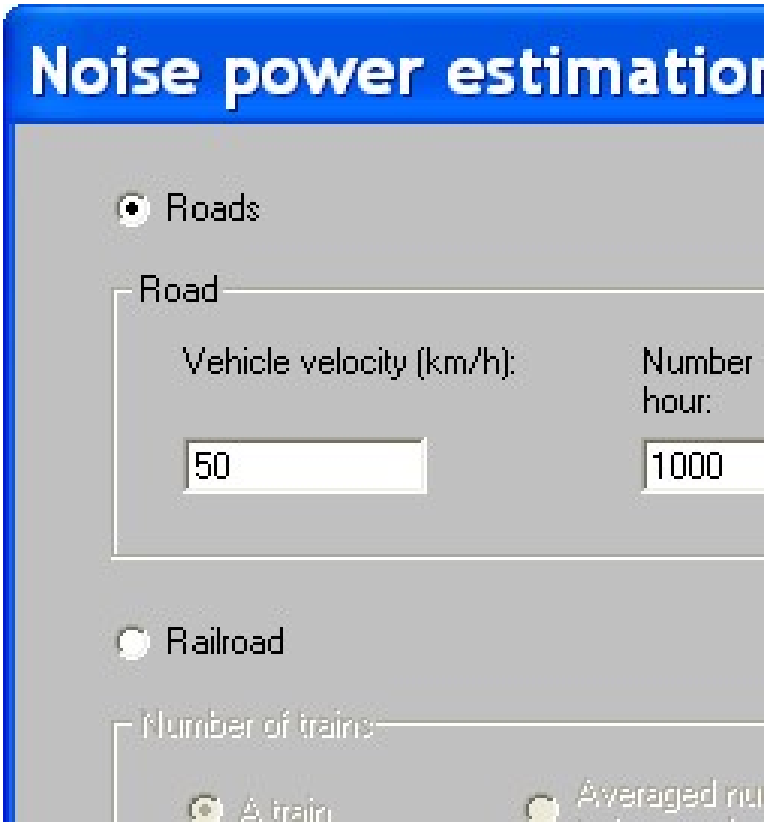
Line source.- This is a line source of noise. The line width is small if we compare it with the size of the area in which we are simulating (line source). If you click this button, the next dialog box is shown:



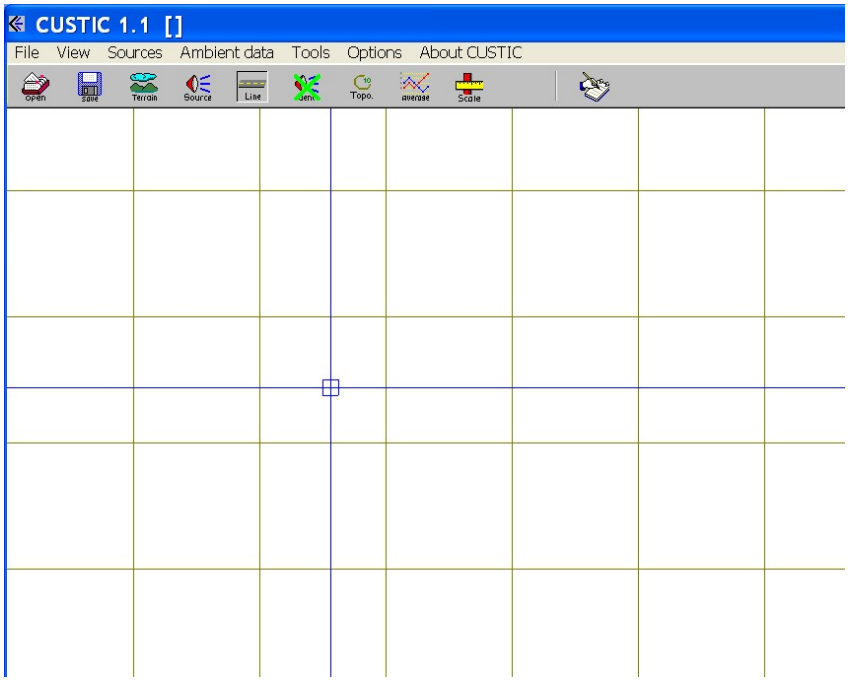
Here, only some data can be modified. The necessary data is:

Noise level (dB): This is the noise power at source position in decibels.

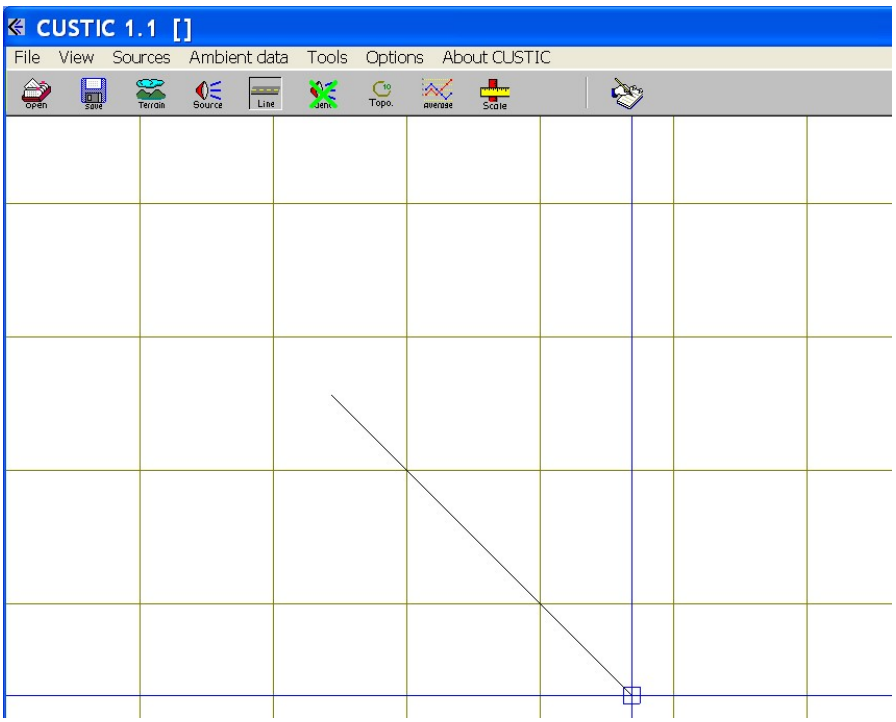
Noise power estimation: With this button, you can estimate the noise level if it is unknown. If you know the power, you don't need to use this command. You can write it directly in the noise power textbox. If you click this button, the next dialog box is shown:



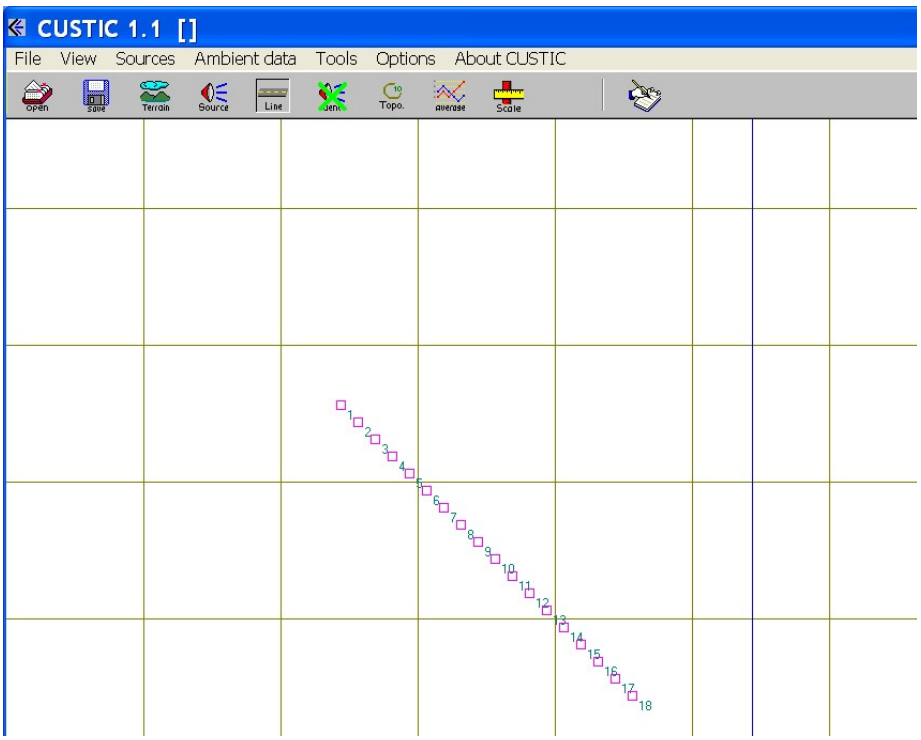
If you click the OK button in the Line source data window, the next program window is shown



If you click the computer screen and move the mouse, a straight line is shown

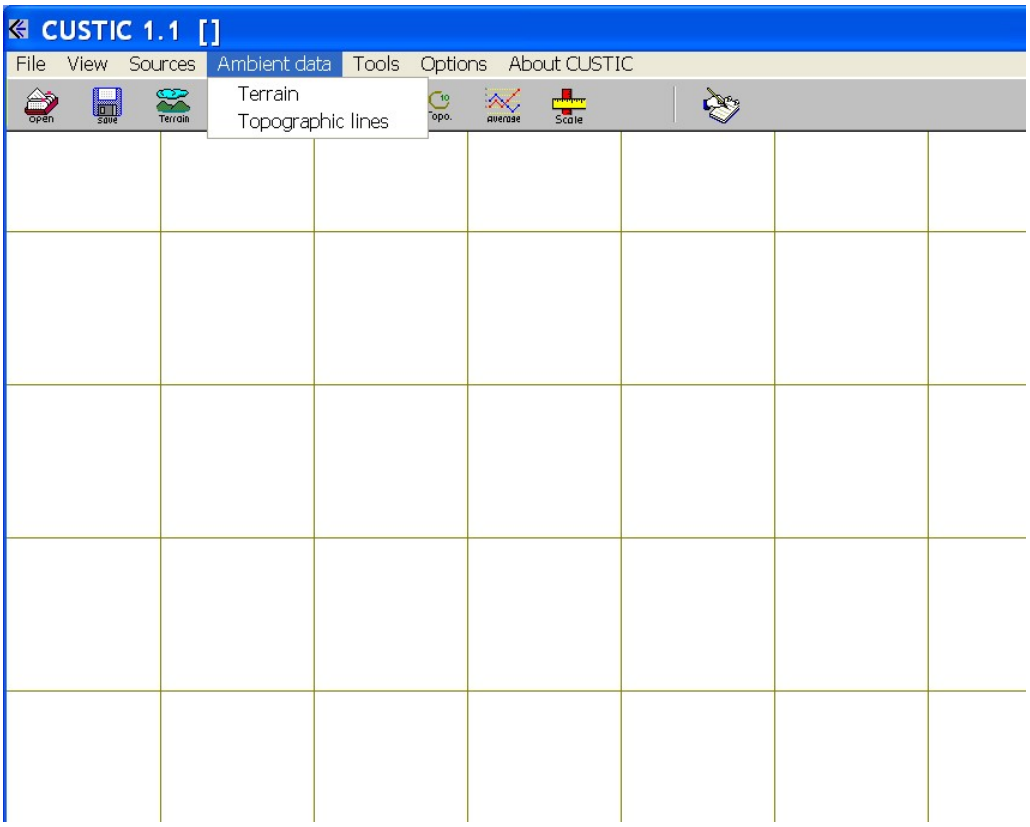


If you click again on the computer screen, a line source is drawn

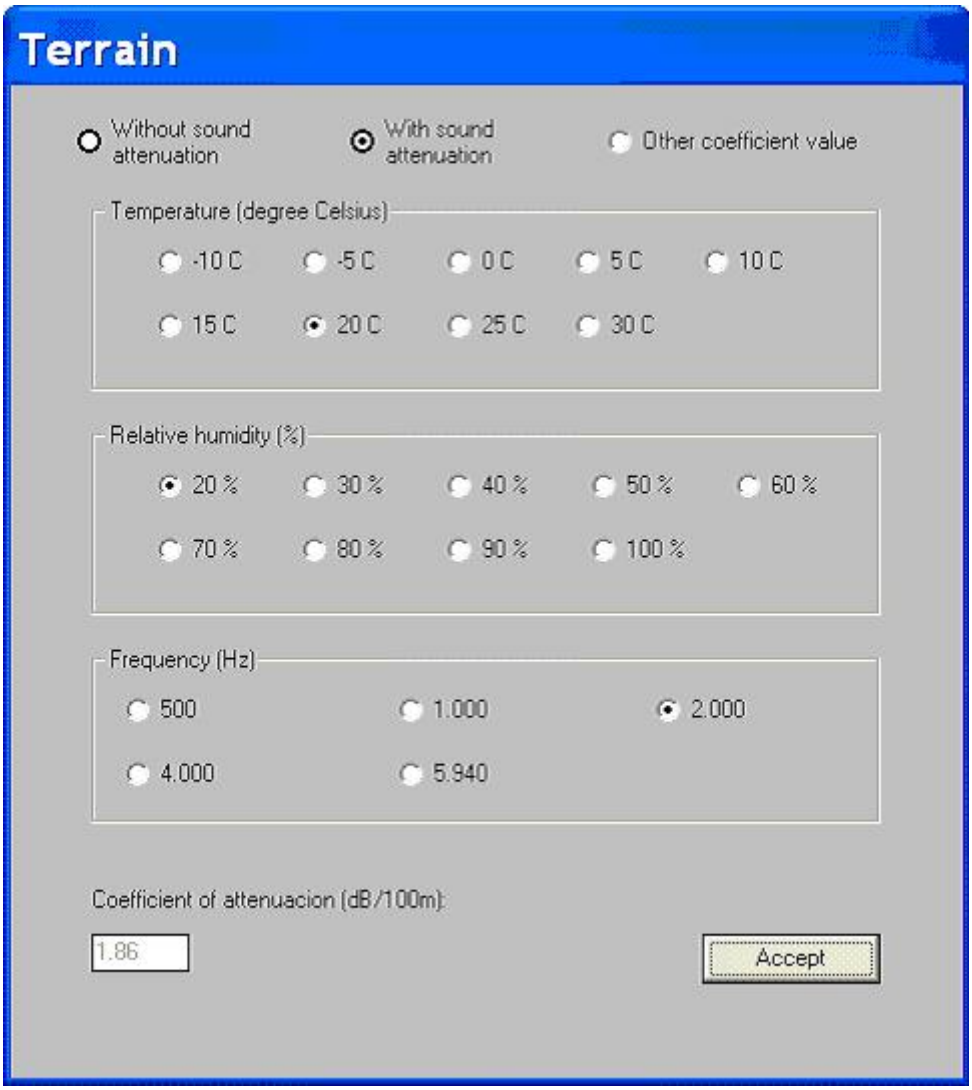


4.1.4 Ambient data

Ambient conditions are defined by the land and atmospheric conditions in the vicinity of the pollutant emission. The **Ambient data** Menu lists: terrain, topographic lines and barriers.

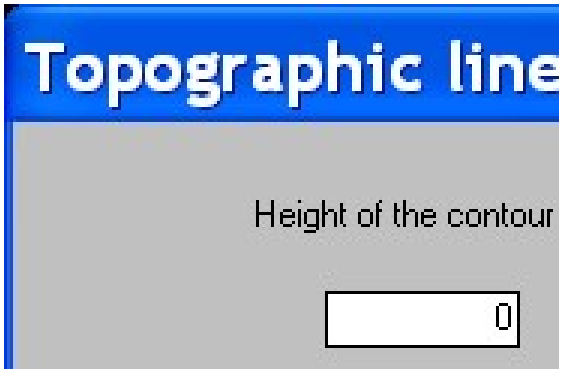


Terrain.- This command is to draw topographical lines. If you click this command, the next dialog box is shown:

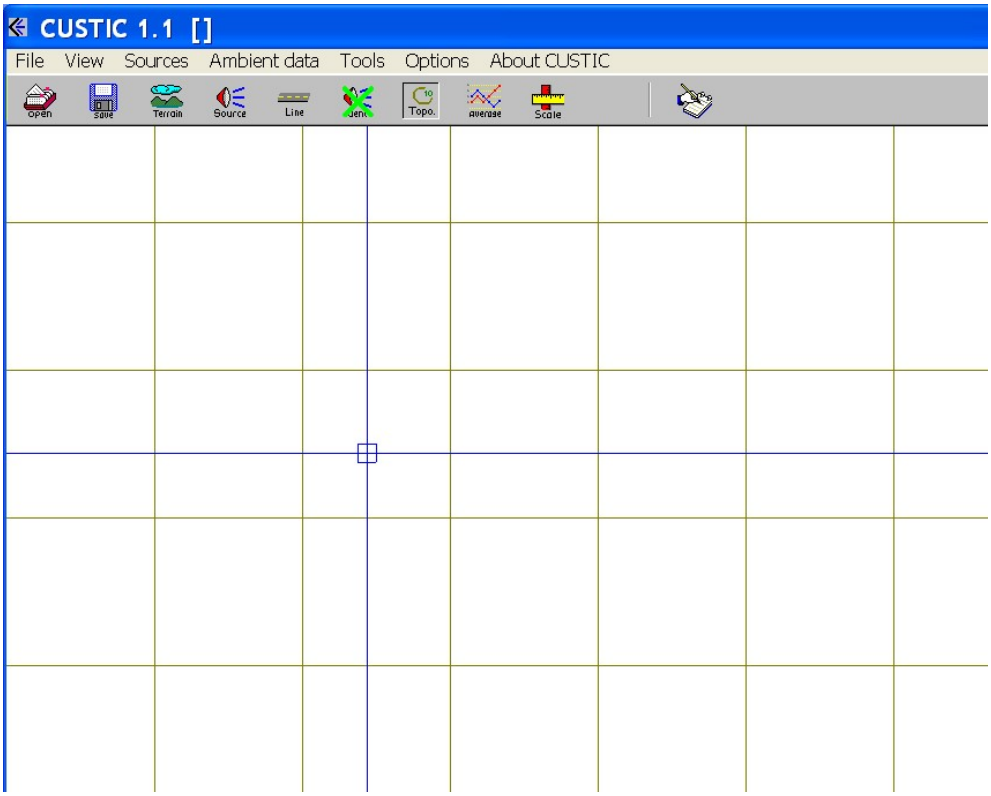


This window is to determine the reduction of sound with distance. It is often used to describe the change in sound level as one move toward or away from a sound source. Attenuation coefficient can describe the reduction of sound per unit distance. It depends on temperature and relative humidity. If you don't want to work with frequencies, you can use an average frequency for the simulation, 2000 Hz.

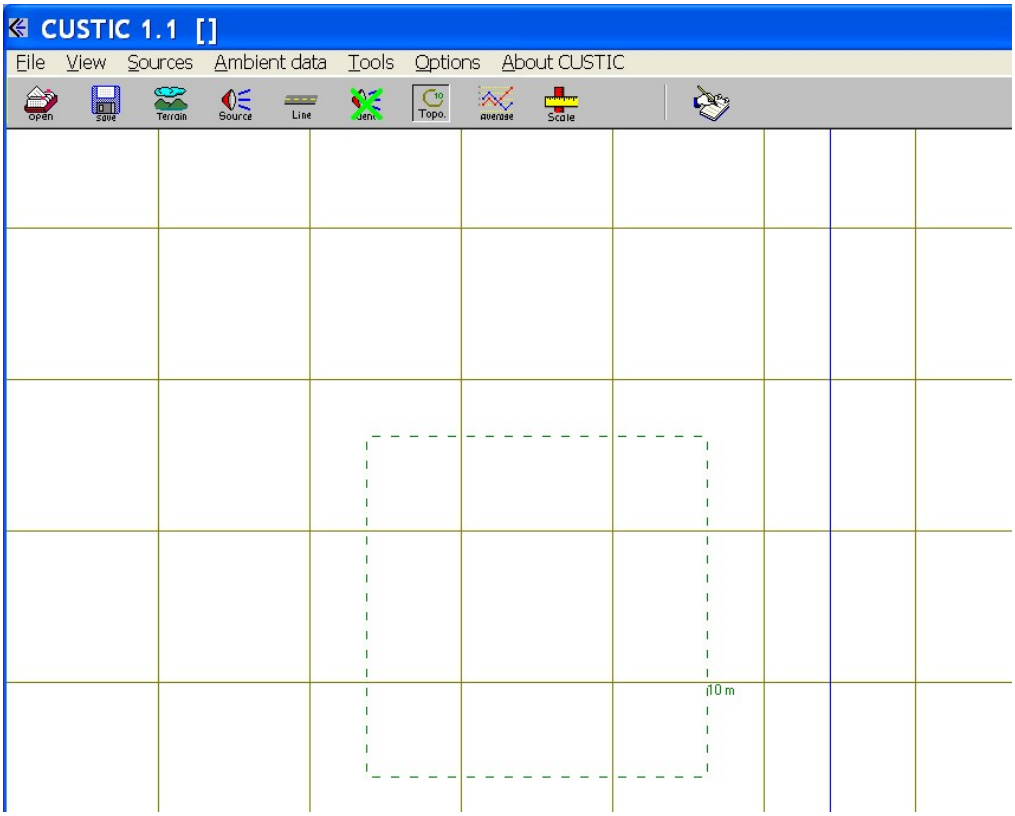
Topographic lines.- This command is to draw topographical lines. If you click this command, the next dialog box is shown:



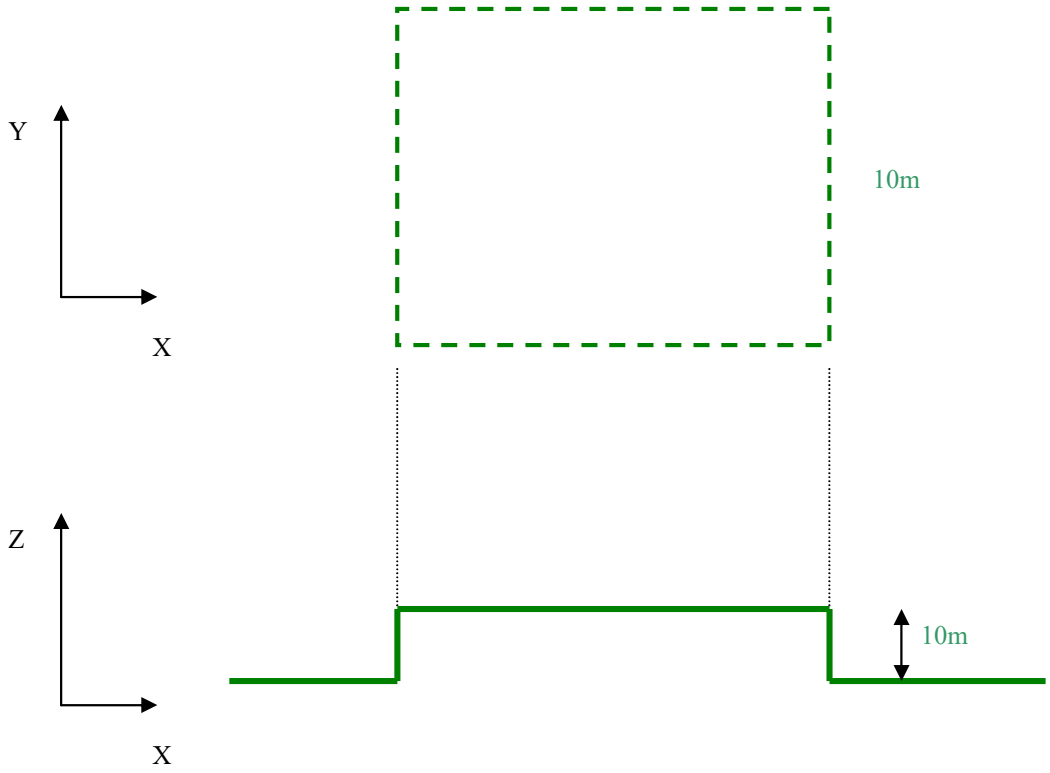
The height of the contour line can be written in the textbox. If you click the Accept button, the next computer screen is shown:



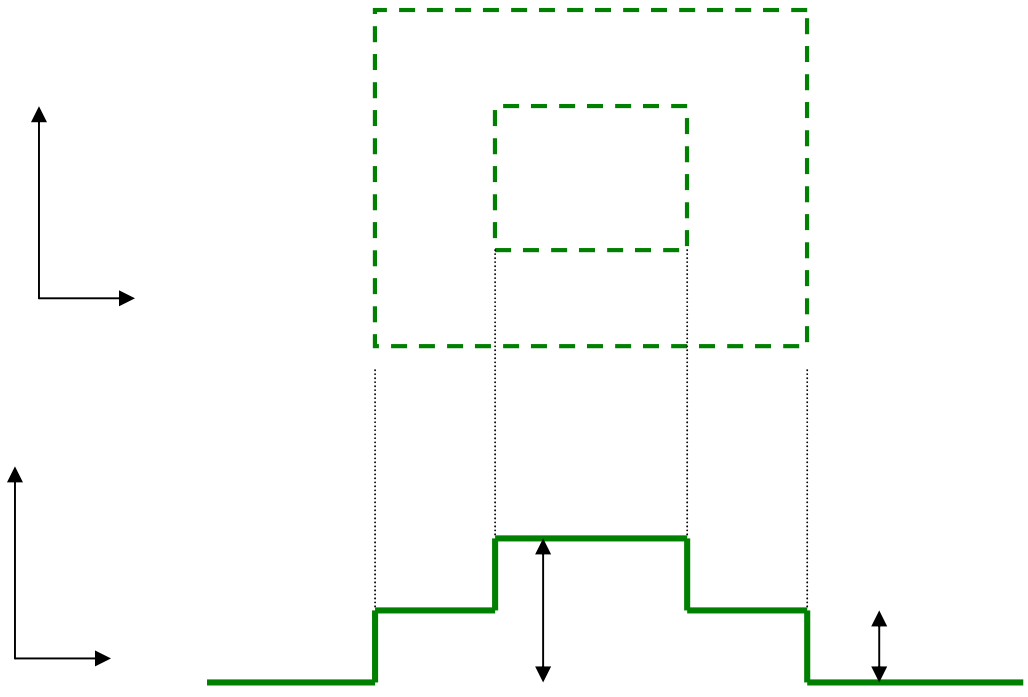
Then, and if you click the computer screen and move the mouse (mouse down), a square is shown and when you mouse up (the height of the contour line is different to zero):



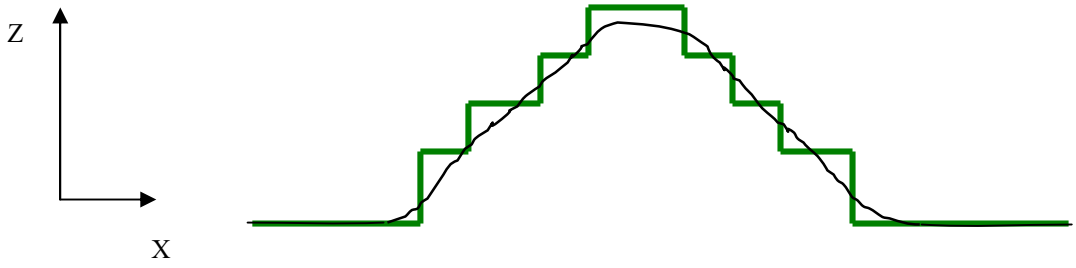
The area inside this contour has a 10m height. A rectangle elevation could be represented by the program in the next way:



To draw a small mountain, we can use a lot of small rectangles.

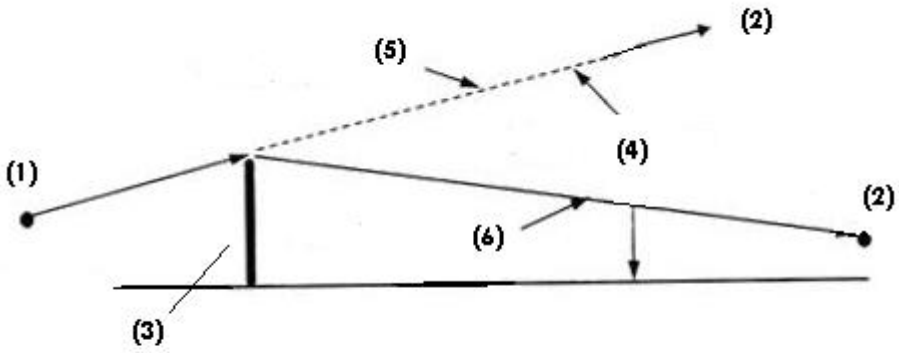


A mountain could be represented by the program in the next way:



Barriers.- With this command, you can draw barriers on the computer screen. The barrier can be eliminated through the ELIMINATE command (used also to eliminate sources).

The software calculates the shadow regions and it applies attenuations values in that places. The buildings can be also considered as sound barriers.



(1) Source
(2) top - receptor (without transmission loss) e down - receptor (with transmission loss)
(3) Barrier

(4) Shadow region
(5) Direct
(6) Difraction

Transmission loss:

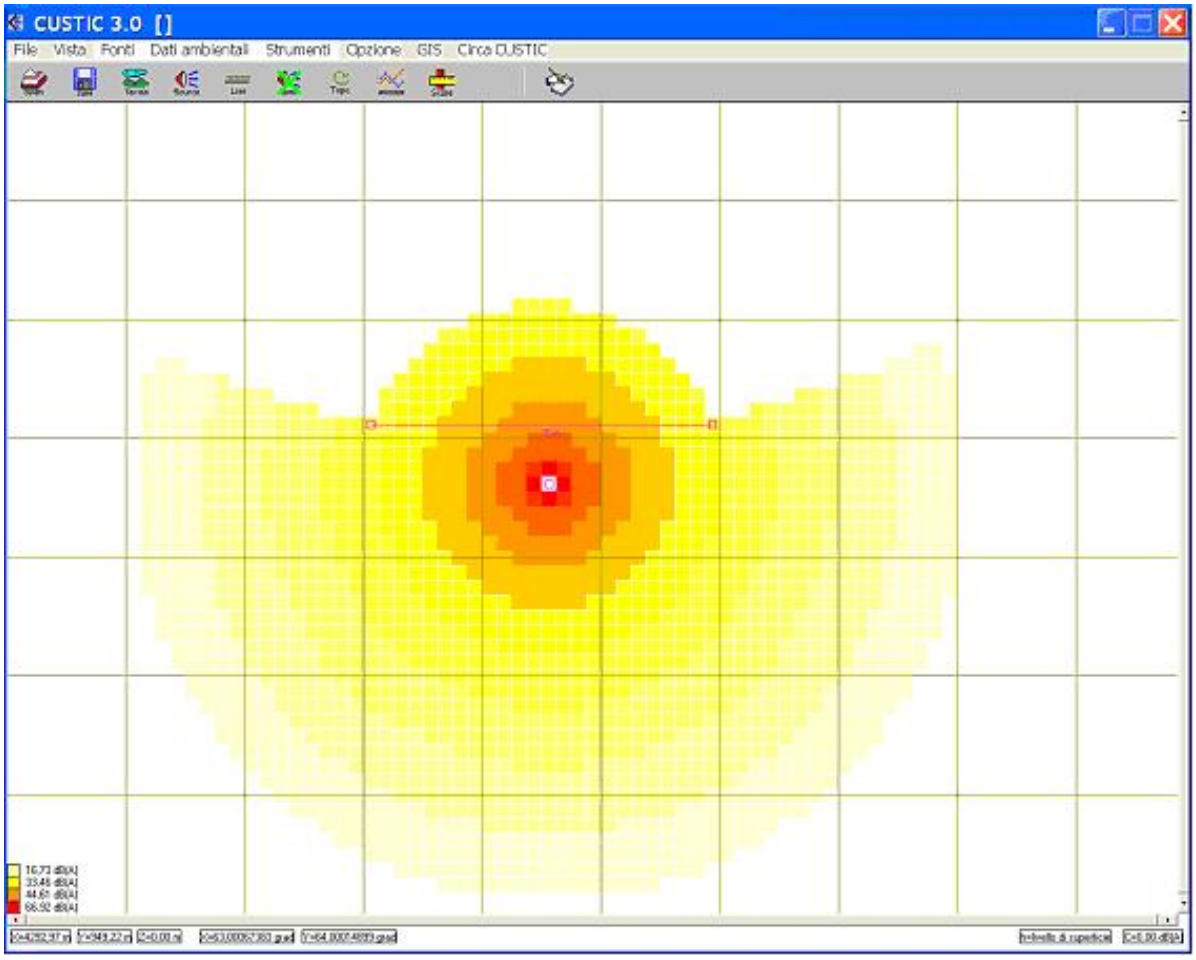
Material	Thickness mm	Surface Density kg/m^2	Transmission Loss, dB (A)
(Polycarbonate)	8-12	10-14	30-33
(Acrylic -Poly-Methyl-Meta-Acrylate (PMMA)-)	15	18	32
(Concrete Block 200x200x400 light weight)	200	151	34
(Dense concrete)	100	244	40
(Light concrete)	150	244	39
(Light concrete)	100	161	36
(Brick)	150	288	40
(Steel), 18 ga	1.27	9.8	25
(Steel), 20 ga	0.95	7.3	22
(Steel), 22 ga	0.79	6.1	20
(Steel), 24 ga	0.64	4.9	18
(Aluminium Sheet)	1.59	4.4	23
(Aluminium Sheet)	3.18	8.8	25
(Aluminium Sheet)	6.35	17.1	27
(Wood)	25	18	21

(Plywood)	13	8.3	20
(Plywood)	25	16.1	23
(Absorptive panels with polyester film backed by metal sheet)	50-125	20-30	30-47

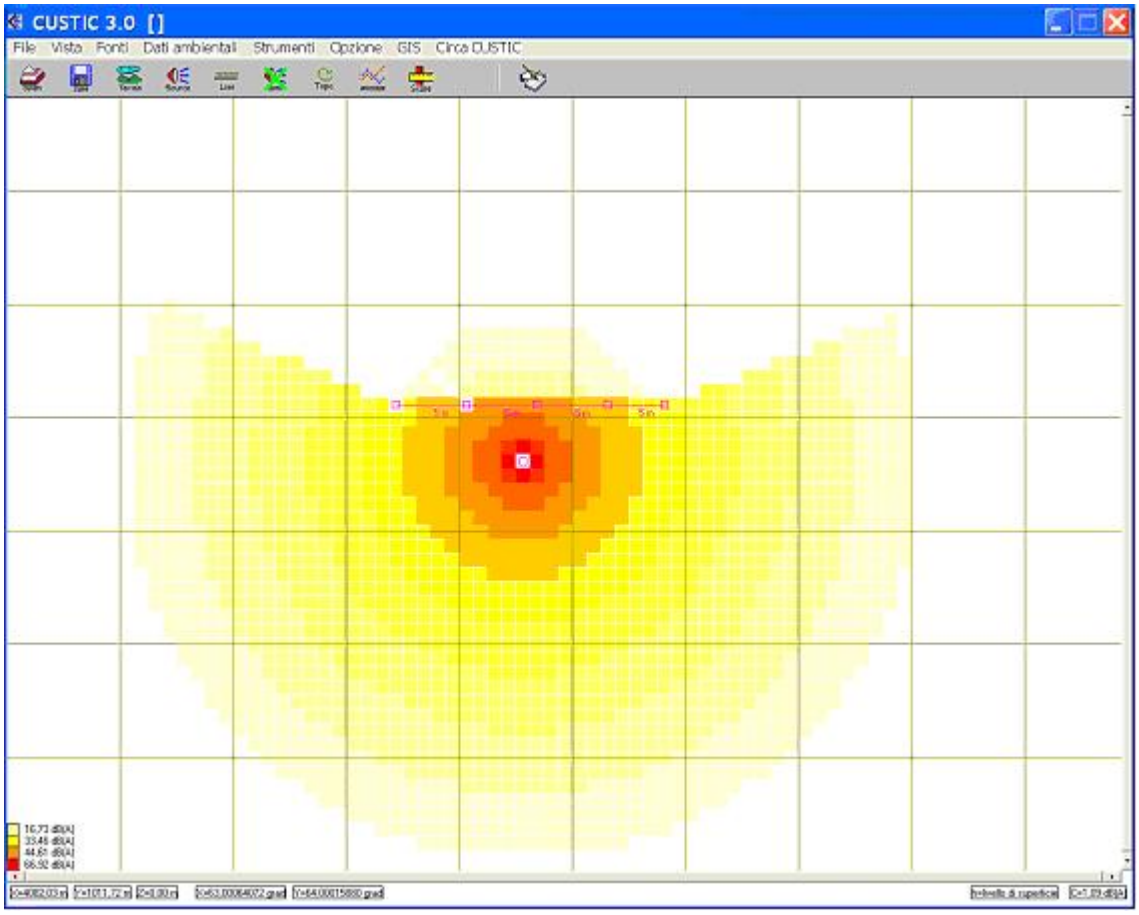
(* Values assuming no openings or gaps in the barriers)

The calculation result is better if you introduce more than one barrier. Example:

One barrier:



Several barriers:

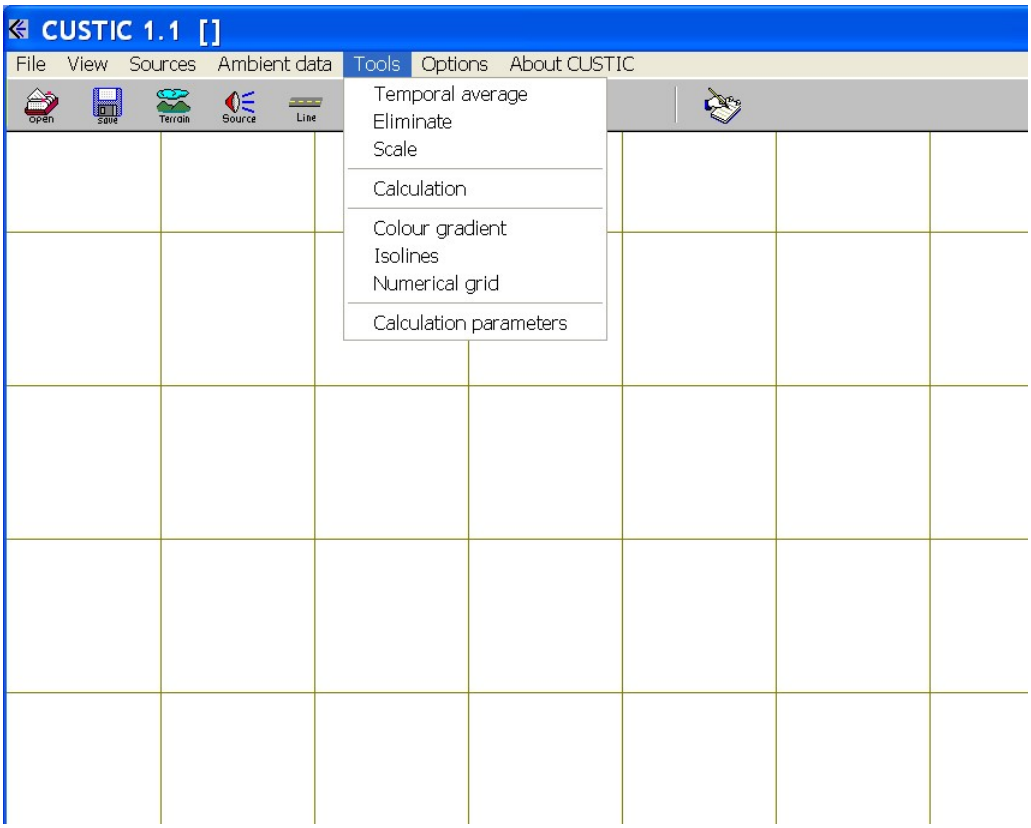


For more than 4 barriers, the calculation converges. We use the same model as London and Hong Kong.

An important point is that the topographic line command doen't consider sound reflections. You need to pay attention if you use both commands (topographic lines and barriers) at the same time.

4.1.5 Tools

The Tools Menu contains the tools you use to process your data. The File Menu lists: **Temporal average**, **Delete**, **Axis scale**, **XY and XZ Calculation**, **Colour gradient**, **Isolines**, **Numerical grid** and **Calculation parameters**. When you choose **Tools** in the Menu bar, the program displays:

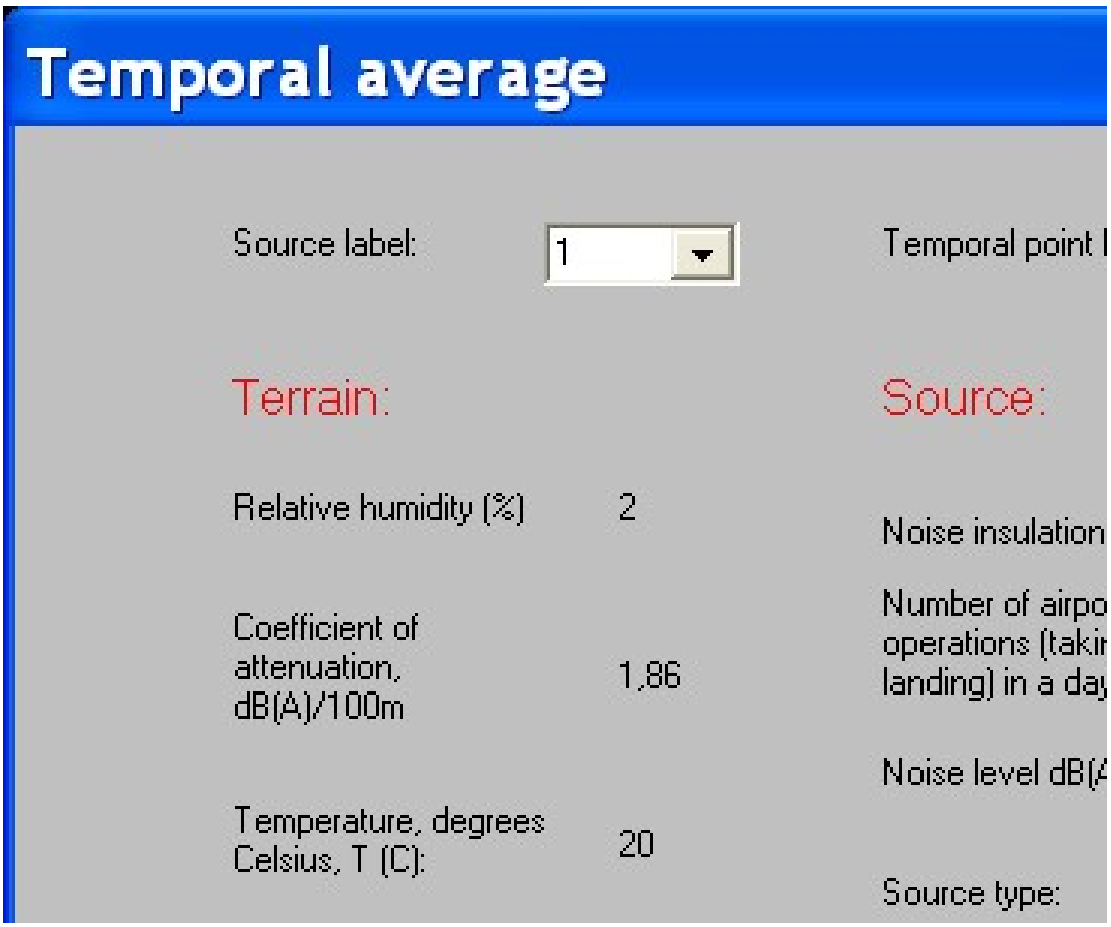


Temporal average.- Some discharge data can vary with time (air temperature, noise power,...). Taking this into account, the program can do temporal averages in the calculation. In the CASTOR-NOISE 5.0 Software, these data are allowed to vary with time. If you click this command, the next dialog box is shown:

We can write in the text box the number of temporal points per average. To be able to make an average, we will take more than a temporal point.

The temporary points are elements of an average and we will be able to relate them with any temporary instant. That is to say, if we have data of air temperature for every hour of one day (a total of 24) and we want to make an average of the noise pollution in one day, we will be able to make a temporal average with 24 temporal points to calculate the daily average.

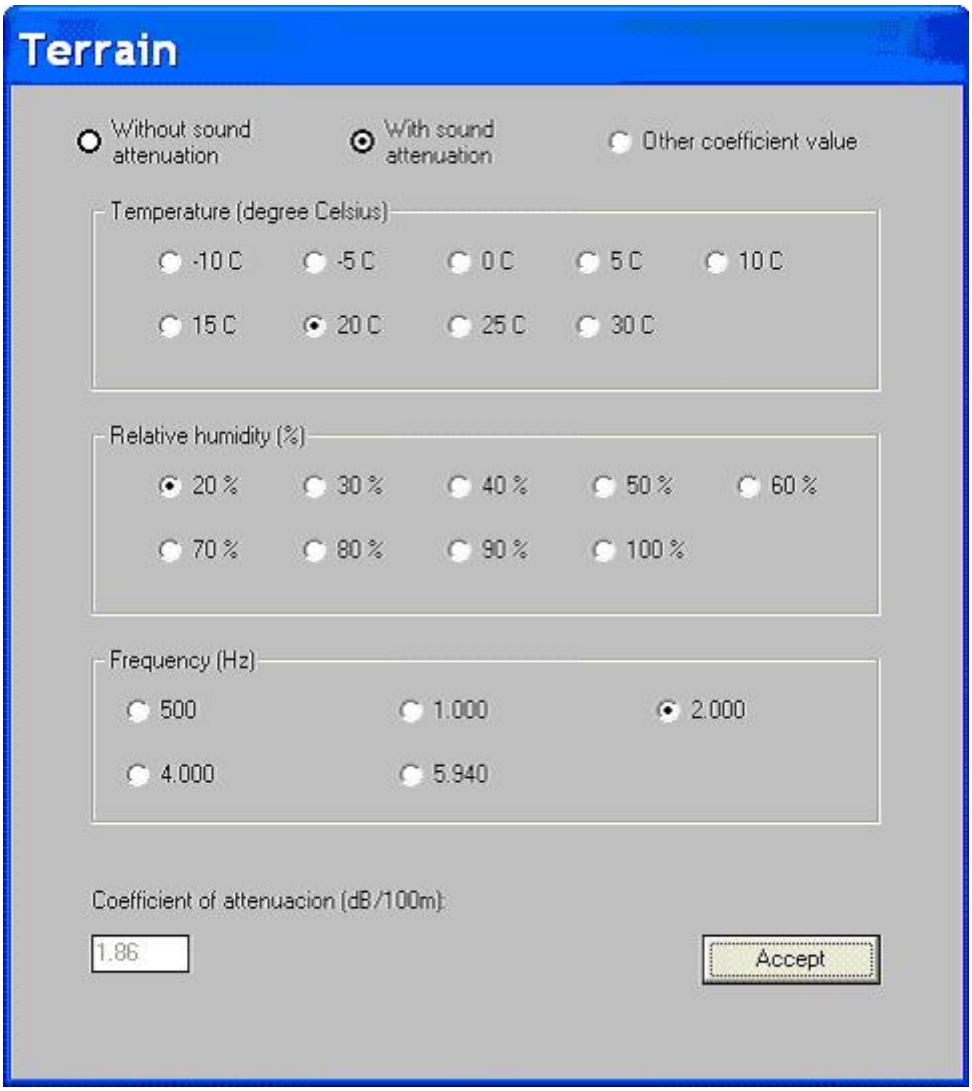
Each temporary point that we average represents the data in a hour of time. If we have monthly data, and we want to make an annual average, we will be able to average with 12 temporary points (the twelve months). Then, and if you click the OK button, the next dialog box is shown:



The window allows to visualize the data to make the average. It also allows to modify the data or to change them. We have two groups of data that can vary in time: Terrain and Source data.

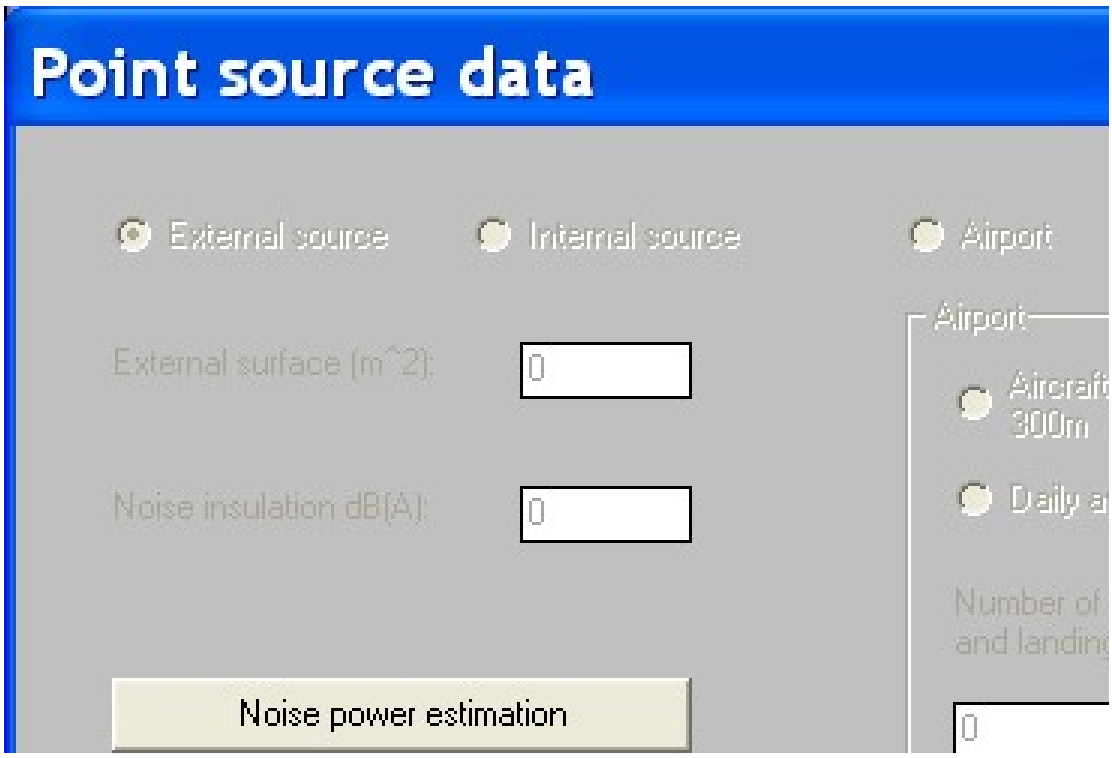
At the top of the dialog box, two different text boxes appear: source label and temporal point label. We can click both arrows to change these values and to visualize the data.

Every time that you enable a new average, the software allocates to all temporal points the same quantities. These quantities coincide with the values that we had in the **Terrain** and **Source** dialogboxes before enabling an average. To modify the ambient and emission data in the temporal average, we can click **Terrain** and **Source** buttons in the dialogbox. Then, and if you click the **Terrain** button, the next dialog box is shown:



Some data of the dialog box cannot be modified: the attenuation options can not be modified. There is not interest in varying these data in time. To modify these data, we will have before to disable the temporal average and to open the source and Terrain dialogboxes in the **source Menu** and in the **Ambient data Menu**, respectively. To disable the temporary average, we will have to click the **Temporal average** command and to write **1** in the textbox of the **Number of temporal points**.

If you click the **source** button in the **Temporal average** dialogbox, the next dialog box is shown:



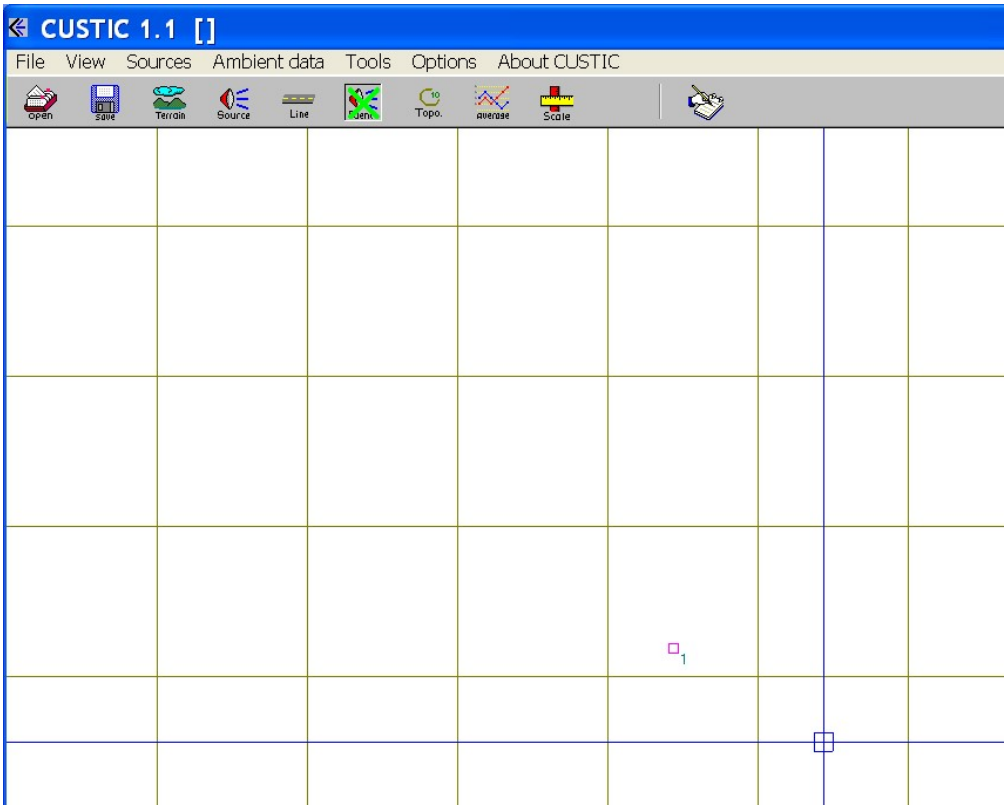
Some data of the dialog box cannot be modified: the external surface,... There is not interest in varying this data in time To modify these data, we will have before to disable the temporal average and to open the source and terrain dialogboxes in the **Source Menu** and in the **Ambient data Menu**, respectively. To disable the temporary average, we will have to click the **Temporal average** command and to write **1** in the textbox of the **Number of temporal points**.

Before running the calculation it is convenient to check the data that we have in the average.

If we enable an average with more than a temporal point, and if later we increase the number of temporal points, it is necessary to be careful since there are data that can have null value. The ideal procedure is to define well, and from the beginning, the number of temporal points before writing the values for the average. If we want to modify an activated

average it can be more comfortable to delete the activated average and then to define a new one. To delete a temporal average, we will have to click the **Temporal average** command and to write **1** in the textbox of the **Number of temporal points**.

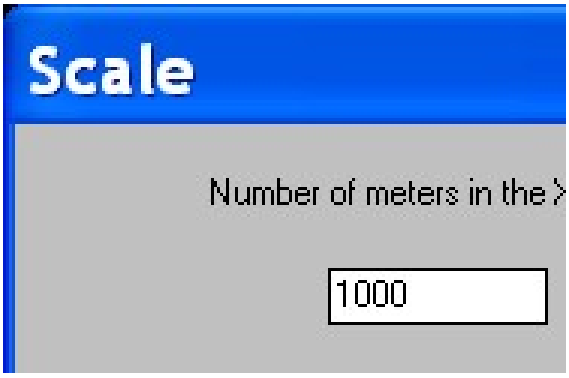
Delete.- This command is used to delete pollutant sources that we don't want in the simulation. If you click the **Delete** button, the next program window is shown:



Clicking on these points we will delete them from the screen and from the calculation.

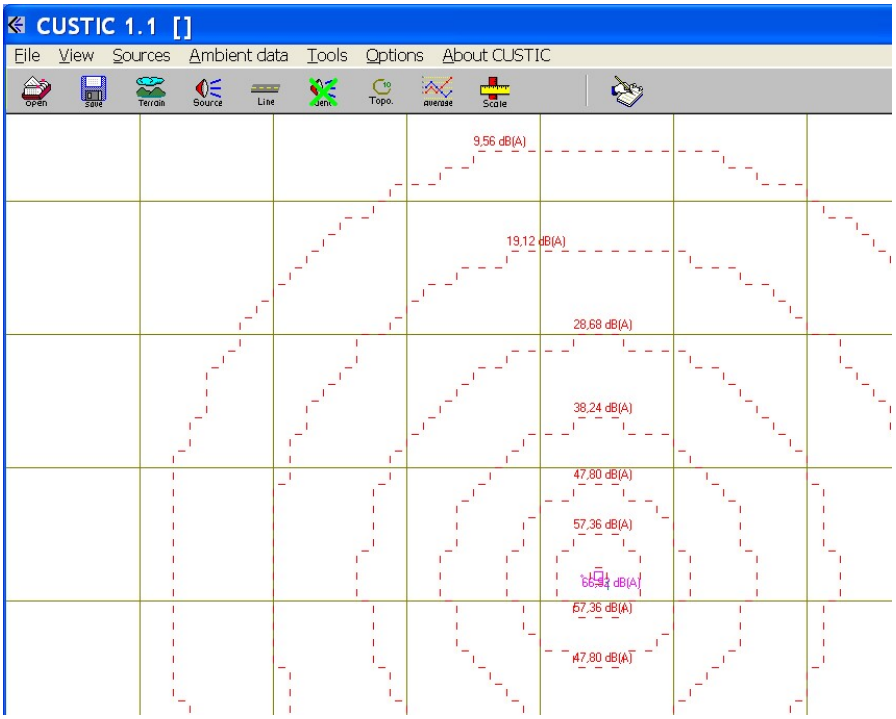
Scale.- With this command, we will decide the work area size in the simulation process. It is an important tool because

with their good use we will be able to interpret and to extract interesting data of the numeric simulation. The scale is defined according to the width in meters that we want to associate to the X-Axis of our program window. If you click the **Scale** button, the next program window is shown:

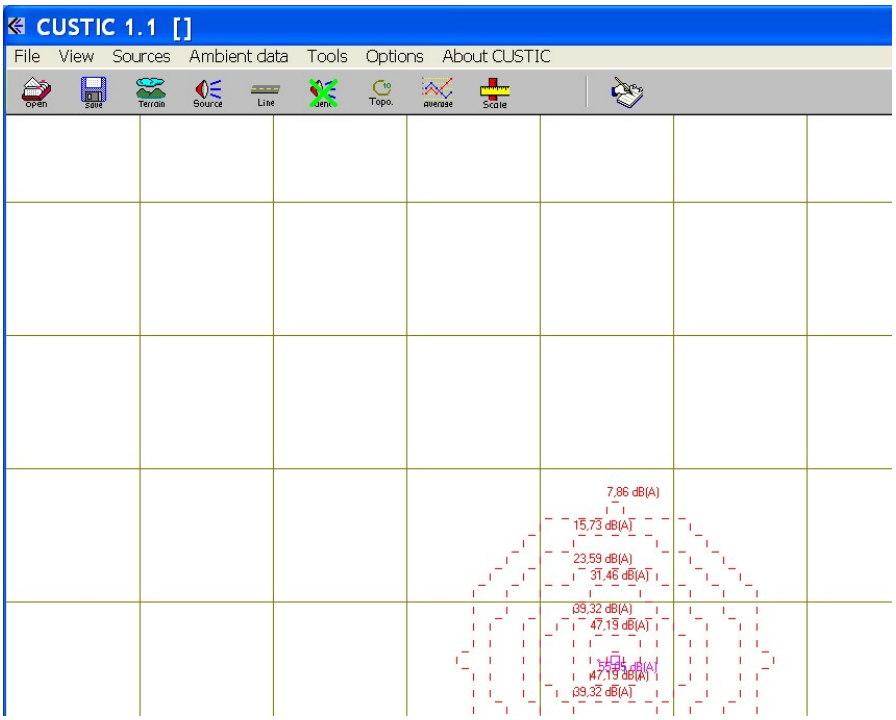


In this window we will be able to choose the number of meters that we want to have in the X-Axis. When we have the value written in the textbox, we will make click with the mouse on Accept button and this value will be modified and the previous window will disappear. If we click the Cancel button it closes the window without modifying the value. This command will be used before using the calculation command, since this parameter should be perfectly defined before making the simulation. When we use this program command, we clean the whole screen of the computer and we lose all the elements of the simulation placed previously. If we don't want to lose the information obtained until the moment we will use the Save command before executing the Scale command.

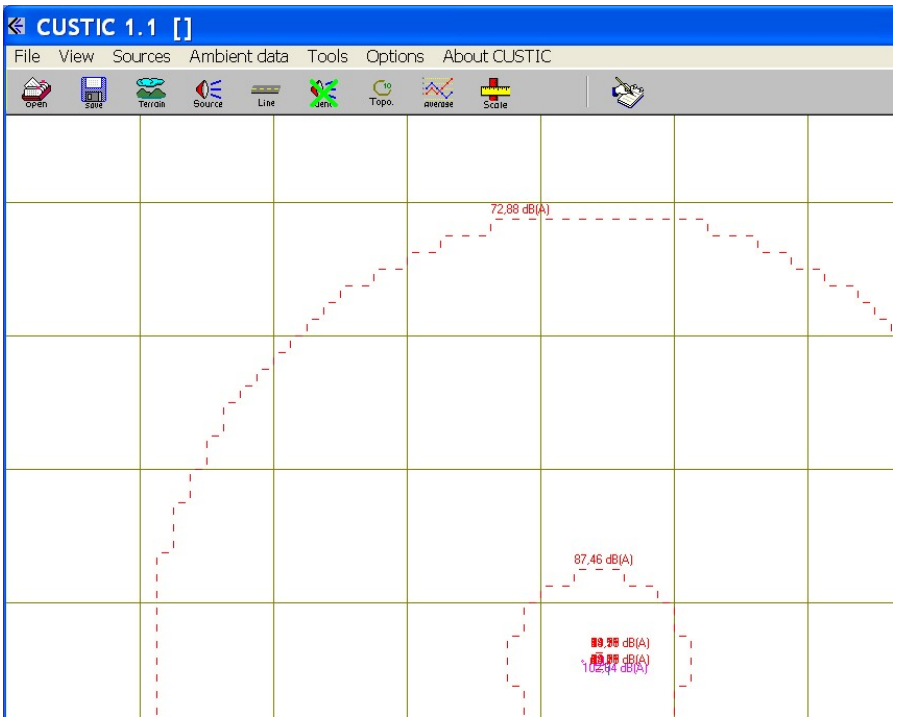
In certain situations, it can be interesting to have a high number of meters in the X-Axis for a better visualization. To illustrate the use of this command, we will carry out the same simulation varying the scale. We will use three different scales. Here, the width of the X-Axis is 5,000 m.



Here, the width of the X-Axis is 15,000 m.

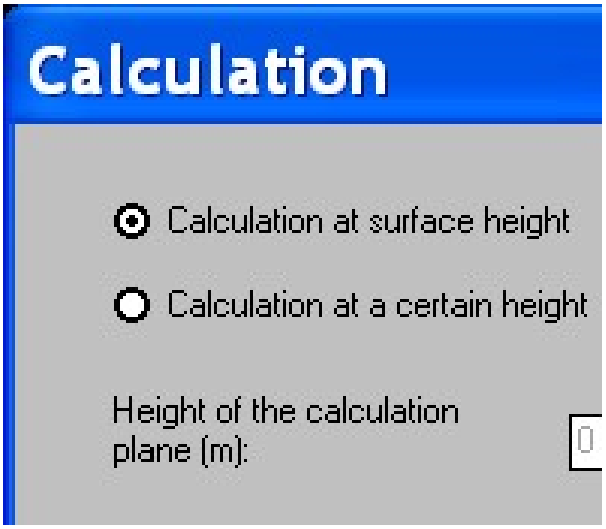


Here, the width of the X-Axis is 100 m.

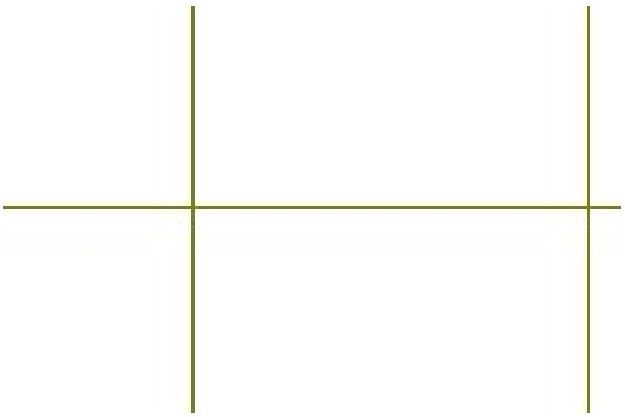


As we can see, when the X-Axis is 5,000 m, it is when we have a clearer representation, where it is shown the value of the maximum point and the concentration lines clearly.

Calculation (XY and XZ plane).- The calculation commands run the necessary algorithm to carry out the numeric simulation. We will run the command after having fixed the necessary data for the simulation, that is to say, the sources, the ambient data, the scale,... If we change any initial data (as the position of the source,...), we will need to run the command again so that this is reflected in the result. If we make click on **XY-Calculation** command, we open the following window :



In this window we will be able to choose if we want to carry out the calculation in the land surface or to a certain height (two options). In the first option, the calculation of the noise pollution will be carried out at surface height. If we choose the option for the calculation to a certain height, we will write in the textbox the plane height in which we will obtain the results (0m for the surface of the sea). If we make click on **XZ-Calculation** command, we open the following window:

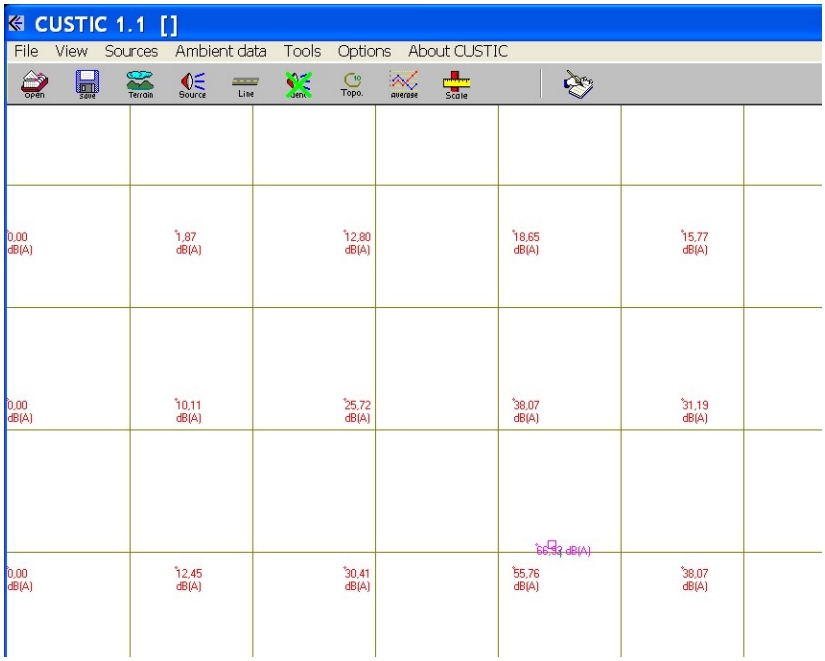


The program works in the following way: while it calculates, the machine centers all the capacity of the CPU in the calculation, stopping the other tasks of Windows. If we want to stop a tedious calculation, we will be able to make it making use of the keys CTRL+ALT+DEL.

Colour gradient.- This command is to draw maps of noise pollution making use of a colour gradient. It is specially useful when the variation of the noise levels is very strong in a very short distance. The program takes the maximum value of the noise and it assigns to the maximum the red colour. Then, the program assigns the different colours to the grade of noise pollution in a qualitative way. We will be able to obtain the exact values locating the arrow of the mouse on any point and looking at the inferior right textbox of the program.

Isolines.- This command induces an opposite effect. We will use this command with the purpose of obtaining the isolines again. This way we will be able to change representation easily making use of these last two commands.

Numerical grid.- This command allows us another alternative representation of the calculated noise levels. It establishes a numerical grid throughout the calculation screen. It is specially useful if we load topographical planes, because with the other representations there are many images in the screen. If you click the **Numerical grid** button, the next program window is shown:

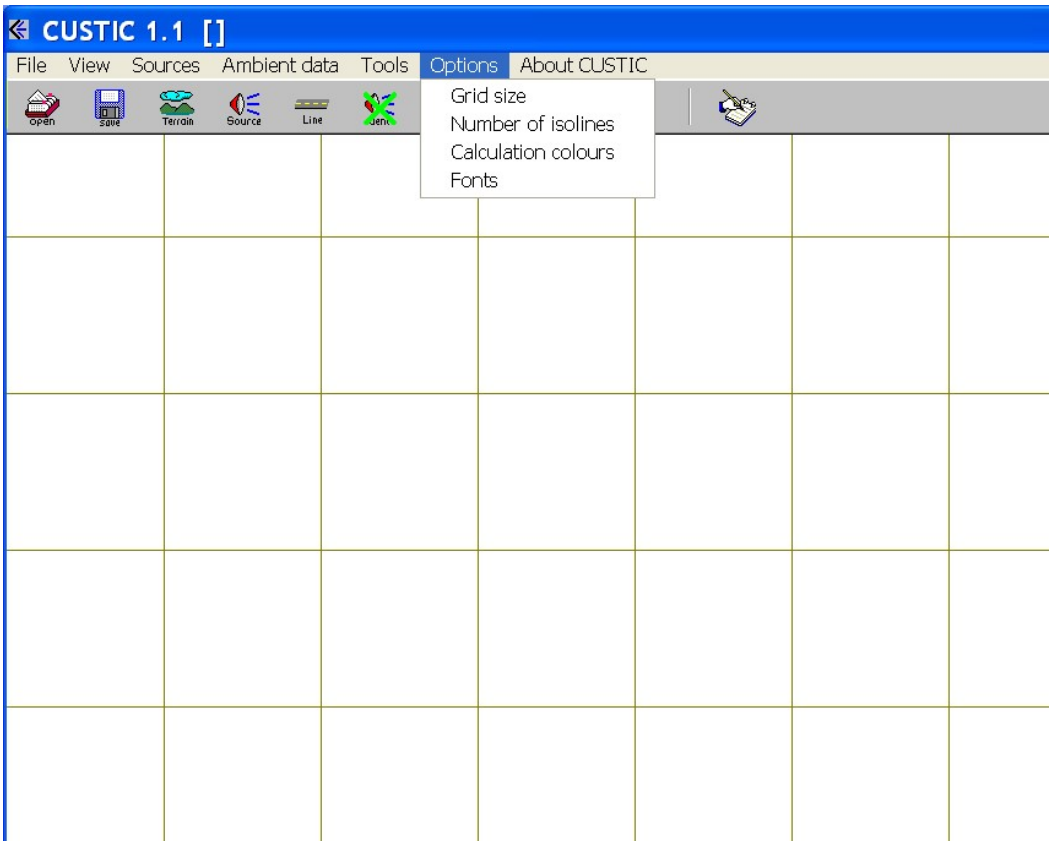


Calculation parameters.- This command will show us the parameters that we have assigned before carrying out the calculation. It is convenient their use with the purpose of verifying that we have written the parameters correctly. Once finish the calculation, the command shows us, also, the value of the maximum noise level and its position.

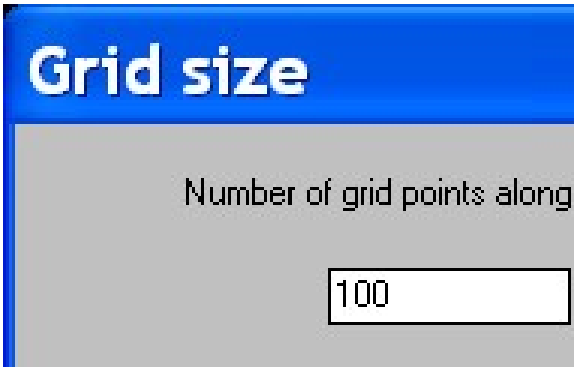
4.1.6 Options

The Options Menu includes all the elements for the numeric configuration of the simulations. We will use these commands before using the calculation command because these parameters should be perfectly defined before running the simulation. The Options Menu lists: **Grid size**, **Number of Isolines**, **Calculation colours**, **Fonts** and **Calculation models**.

When you choose **Options** in the Menu bar, the program displays:



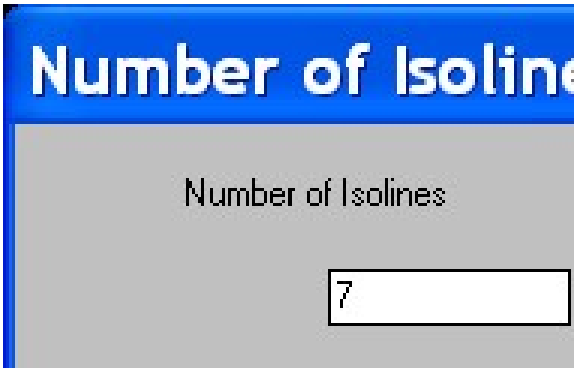
Grid size.- The grid size is an important parameter in the configuration of the system. We will decide the number of calculation points in the grid that we will take to make the simulation. As we increase the number of points, the computer will take much more time in carrying out the calculation but the result will be much more exact. If you click the **Grid size** command, the next program window is shown:



In this window we will be able to choose the number of grid points (calculation points) that we want to have in the X-Axis. The number of points to calculate will increase quadratically with the number of grid points along the X-Axis N, that is to say, it will increase as N^2.

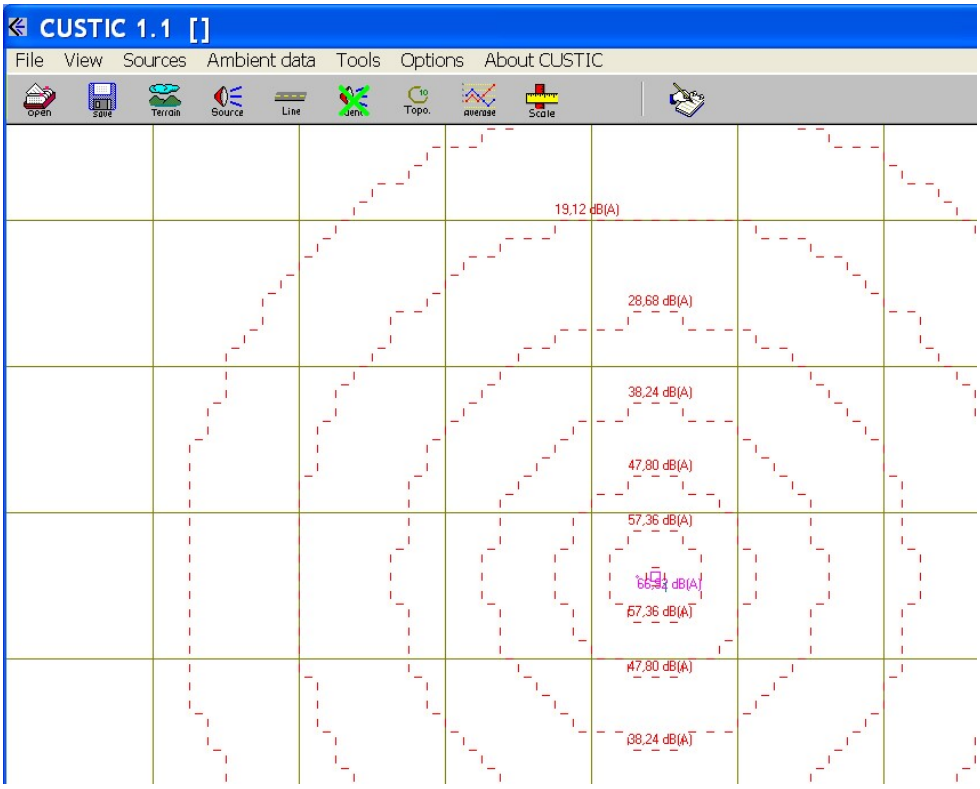
To increase the number of grid points produces that the program needs much more RAM-memory. If we take such a high number of grid points that it overcomes the available memory of the PC, the computer will be blocked.

Number of isolines.- This command is an auxiliary tool for making the maps of noise pollution. We will decide the number of isolines in the screen that we will take to make the representation. In certain situations, it can be interesting to have a high number of isolines for a better visualization. We will use this command before using the calculation command because this parameter should be perfectly defined before running the simulation. If you click the **Number of isolines** button, the next program window is shown:

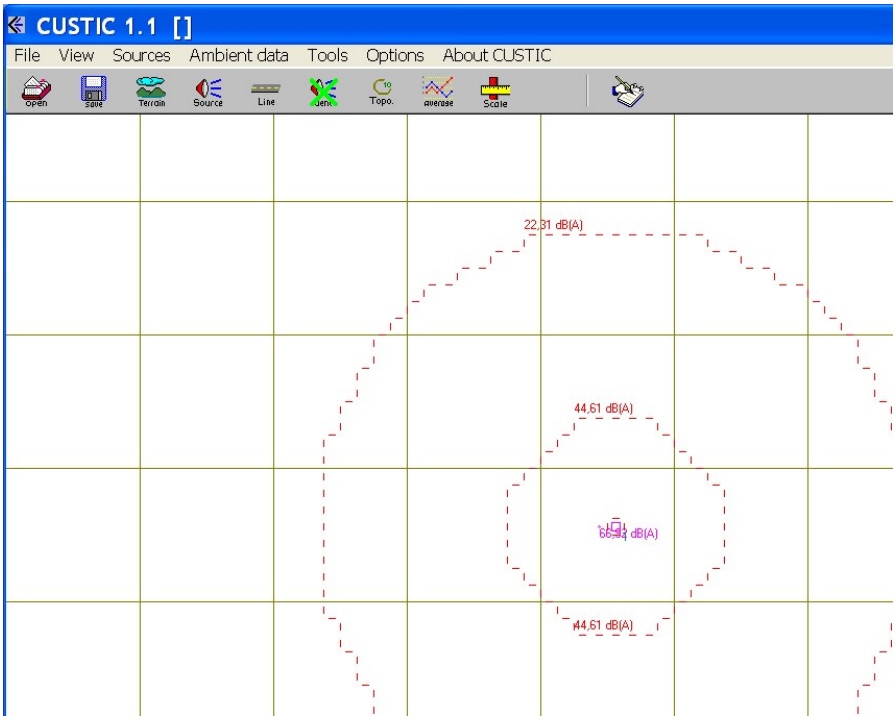


In this window we will be able to choose the number of isolines that we want to have in our computer screen. To calculate the lines, the program also considers the maximum point as a line.

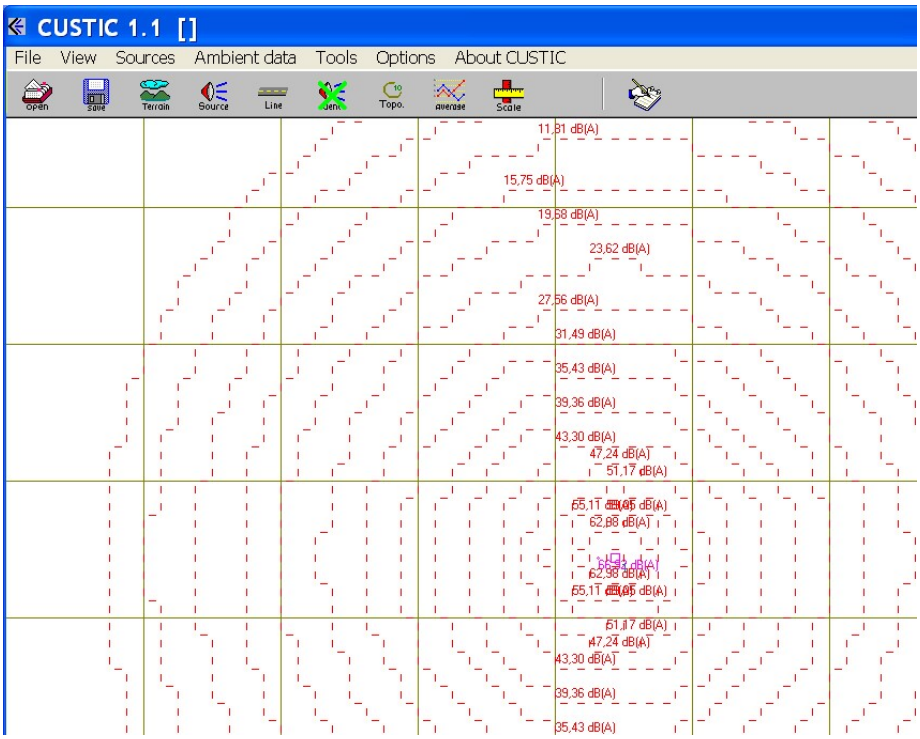
To illustrate the use of this command, we will carry out the same simulation varying the number of isolines. We will use three different number of isolines. Here, the number of isolines is 7.



Here, the number of isolines is 3.

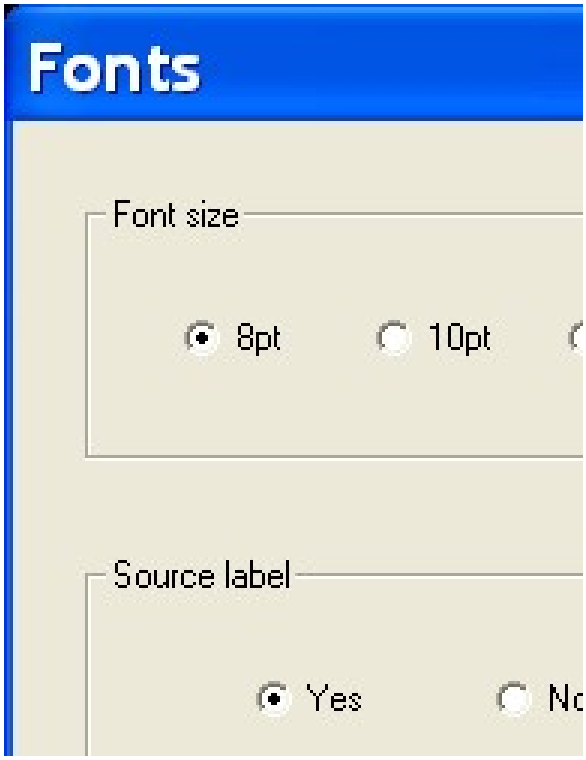


Here, the number of isolines is 17.

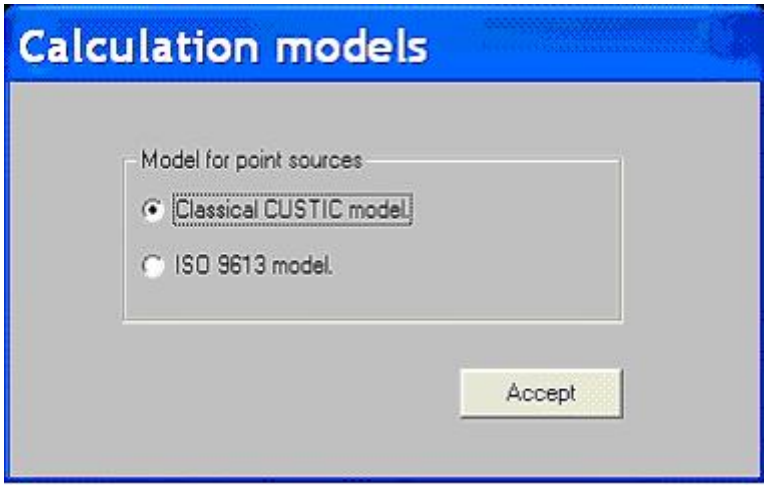


Calculation colours.- By means of this command, we will be able to change the colors of the isolines, of the maximum point and of the point sources.

Fonts.- This command is an auxiliary tool for making the maps of noise pollution. In this command we have two different options. We can choose: font size and source label (Yes/No).



Calculation models.- This option is to decide the mathematical model that will be used in the calculation. We can choose between two different models: Classical CASTOR-NOISE 5.0 model and ISO-9613. The ISO method of calculation can be used for punctual sources considering humidity, temperature and the solid angle for the source. In the case of roads, only angle solid effects will be considered when the ISO option is activated.



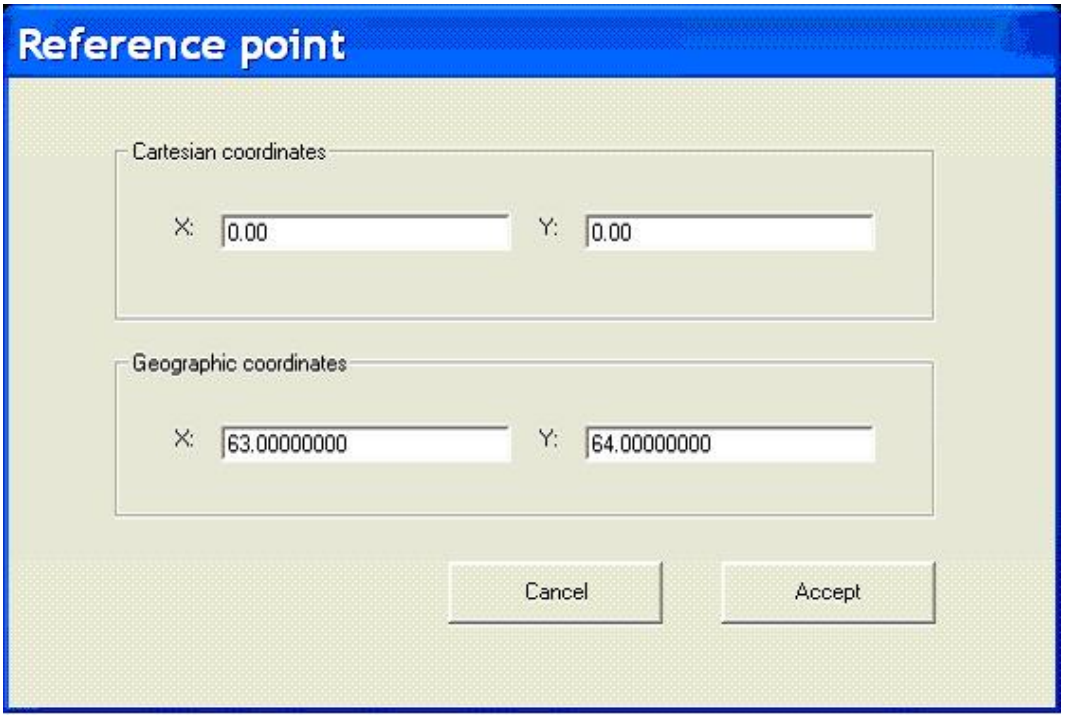
4.1.7 GIS

In this option it can be found all necessary to work with geographical information system.

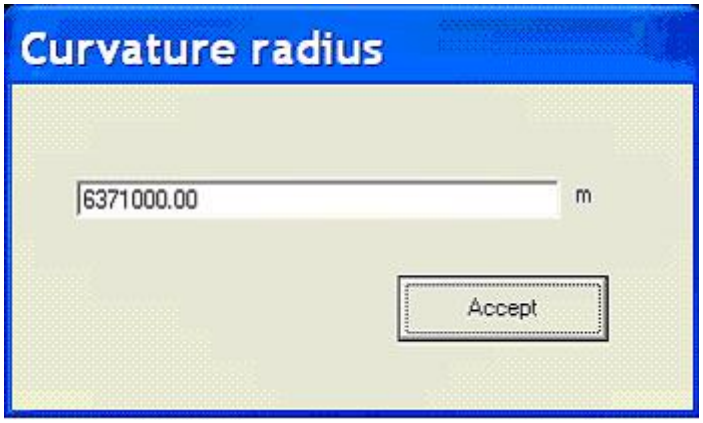
Coordinates of the origin.- With this command we can choose the value for the origin of coordinates. It is initially in the left bottom corner of the program window. It is possible to work with geographic and Cartesian coordinates (X = Longitude and Y = Latitude).

Reference points.- With this command we can decide the coordinate values of a point, that we previously know, in the map in order to have a referenced system. It is possible to work with geographical and Cartesian coordinates. Once you have introduced the desired coordinates, you make 'click' in the point of the screen where you want to situate the reference. In this point will appear red marker. After that, it will be possible to export the results to a GIS system.

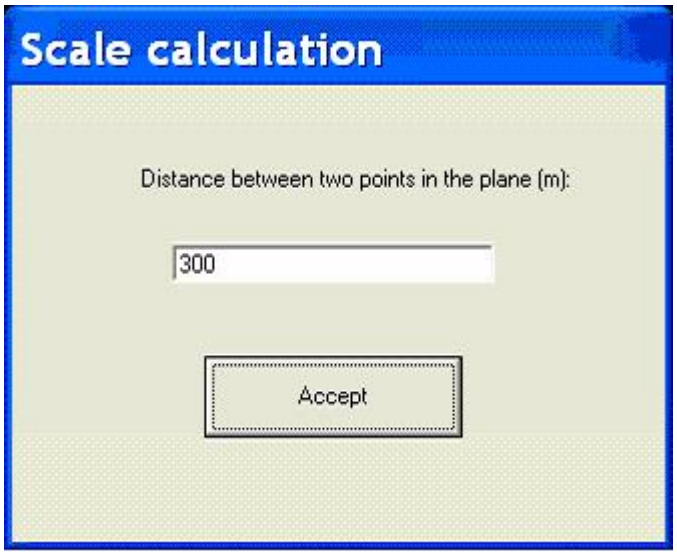
Radius of curvature.- By means of this command, you can choose a



value for the Earth radius. This radius can be slightly modified to adjust the reference system with the available data. The program considers the Earth as a perfect sphere with an exact radius. We know that this is not exactly true. This option is to correct this kind of effects.



Scale calculation.- With this command it is possible to estimate the map scale that corresponds to a background image, that has trees previously imported by the user. It is necessary to know the distance between to different points in the map. After introducing the distance data, you can click consecutively both points, and the scale will be automatically calculated.



Export maximum, concentrations,….- These are to export the different elements of the programs (isolines, source positions,…) to Microsoft EXCEL csv file. To import without problems with Arcview we have used the english format system for the numbers. For example, one euro and 30 cents is 1.30 euros (NOT 1,30!) in the english format.
If you are using the spanish format, when you open the exported file with EXCEL you obtain "al numbers in the same box". In such a case, the best way is to change your number format in your computer. It is very easy. Just go to WINDOWS >> START >> CONTROL PANEL >> REGIONAL CONFIGURATION and look for english format before opening with your EXCEL program.

4.1.8 3D

The 3D commands are for a qualitative representation, not quantitative. The system generates random points to help you to obtain a 3D view of the pollution process. The pollution concentration value that appears in the screen is an orientative value. In the 3D options you can modify the number of random points and other parameters. The TEMPORAL AVERAGE command doesn't work in 3D and the barriers haven't effect on the calculations.

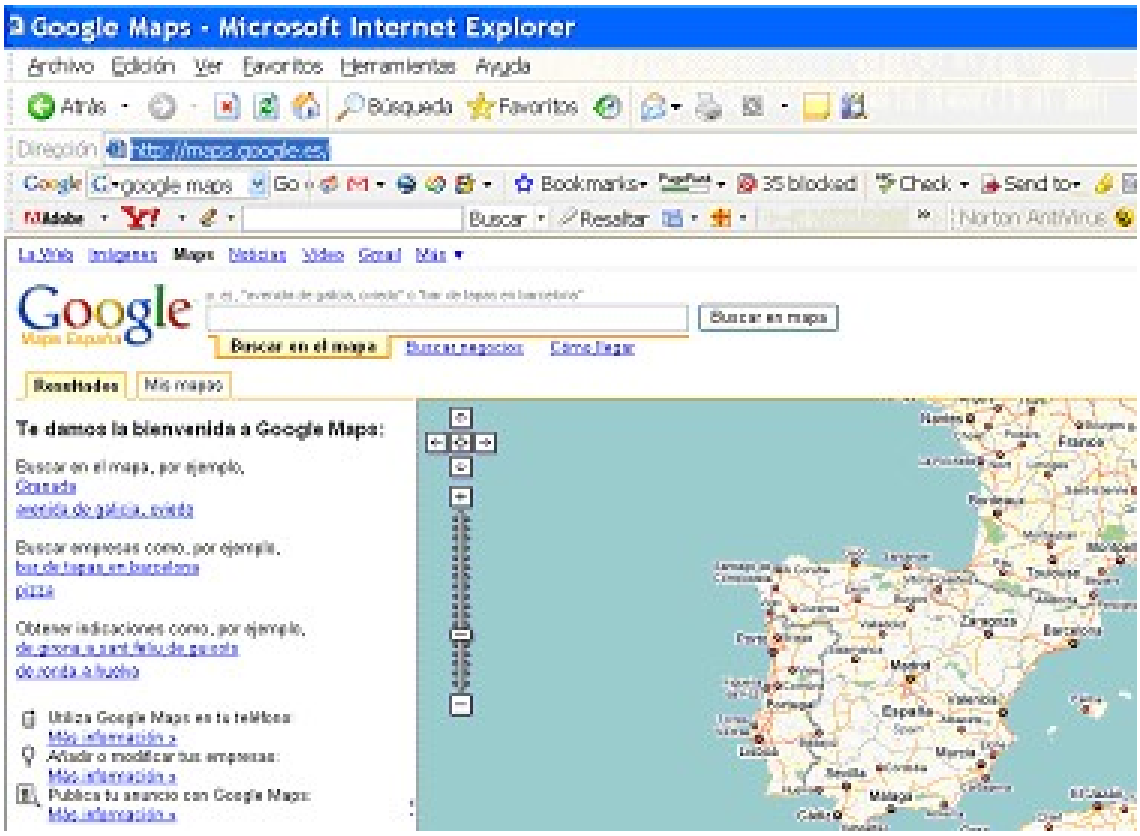
The 3D window is an extension of the 2D XY window. The X coordinate, Y coordinate and concentration value that appear on the bottom of the screen correspond to the XY plane view. The calculated XY data will be deleted after a 3D calculation. The PRINT command only prints the XY view. To print in 3D, you need to use the PRINT IMAGE command. Or you can save a BMP file and print such a file with an another standard program (windows PAINT, ...).

4.2 Icon bar

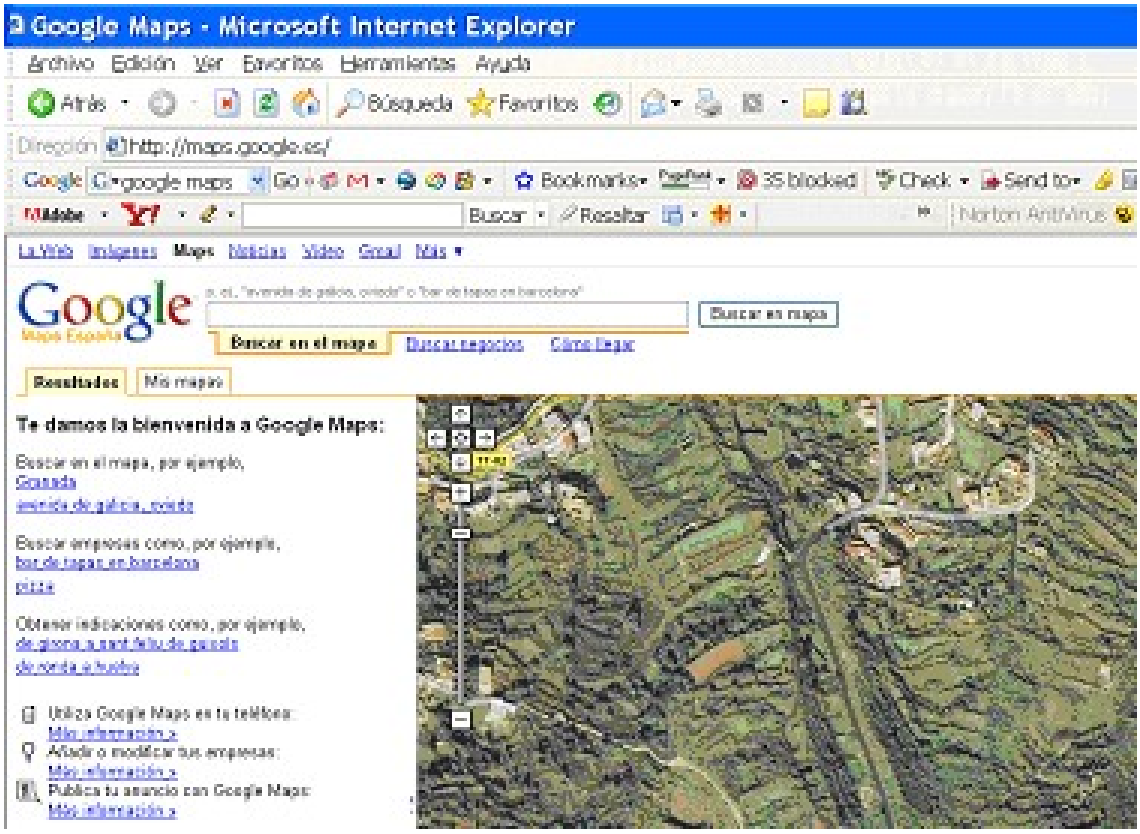
The menu bar display the commands you use to build your simulation. When you choose one of the menus, the program displays a pull-down list of available commands. The program window has a basic icon bar under the Menu bar. The icon bar provides quick access to commonly used commands in the program. You click a button on the icon bar once to carry out the action represented by that button.

5. Working with Google maps

1. Firstly you can can navigate to Google maps web. http://maps.google.com/

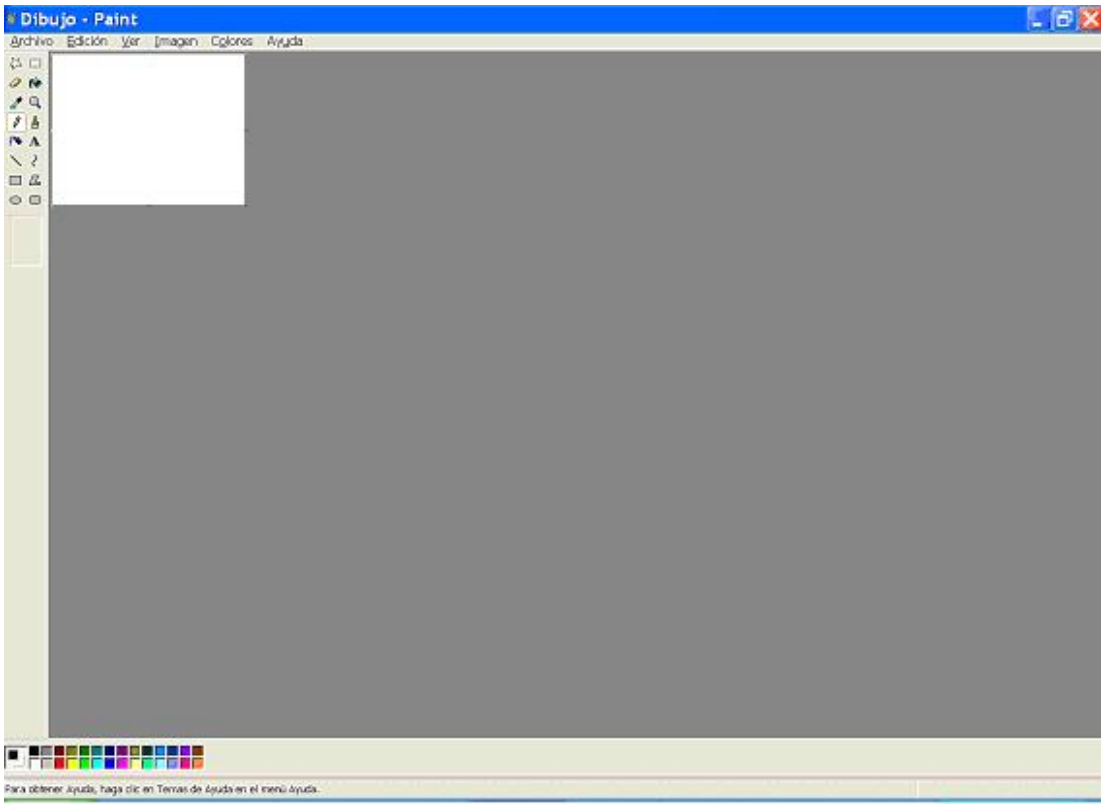


2. Using the screen arrows move to the map area that you want to watch. For example, we can watch *Garachico* in *Tenerife* North.

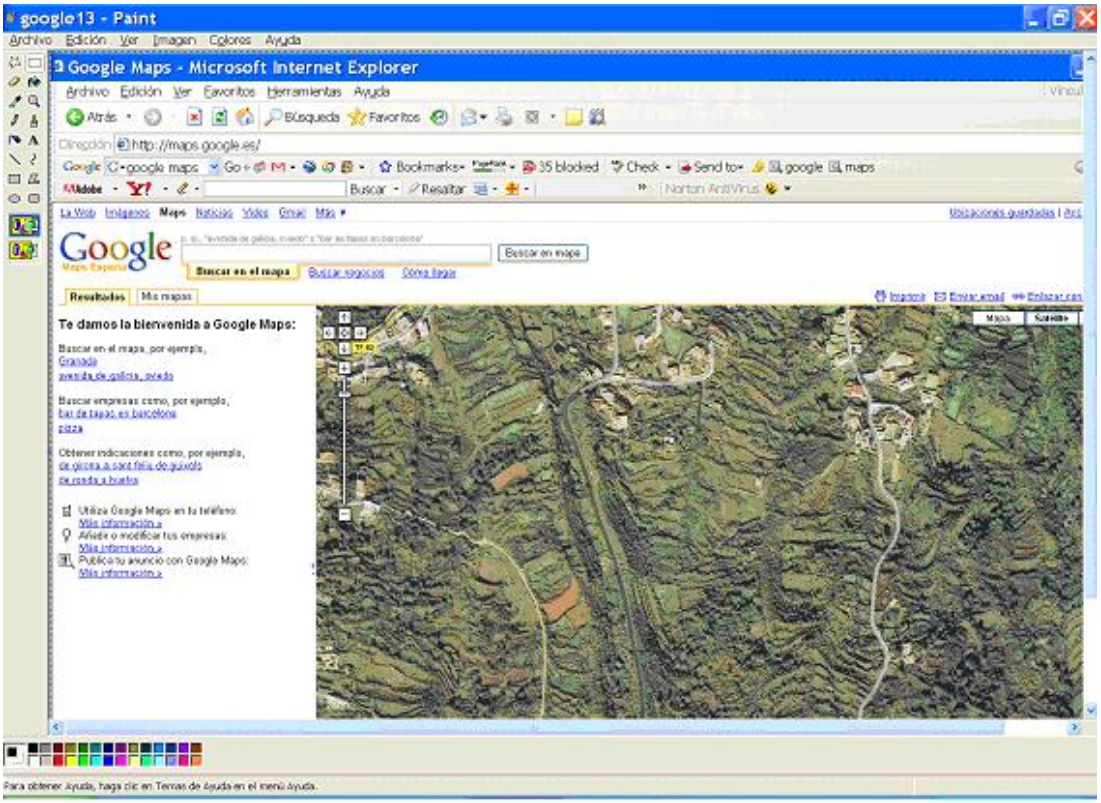


3. For the image capture, it is possible to use in the keyboard *Ctrl+Alt+PrtSc)*. In the keyboard you can push at the same time (*Ctrl+Alt+PrtSc*). In that way, the screen image is copied by the computer memory.

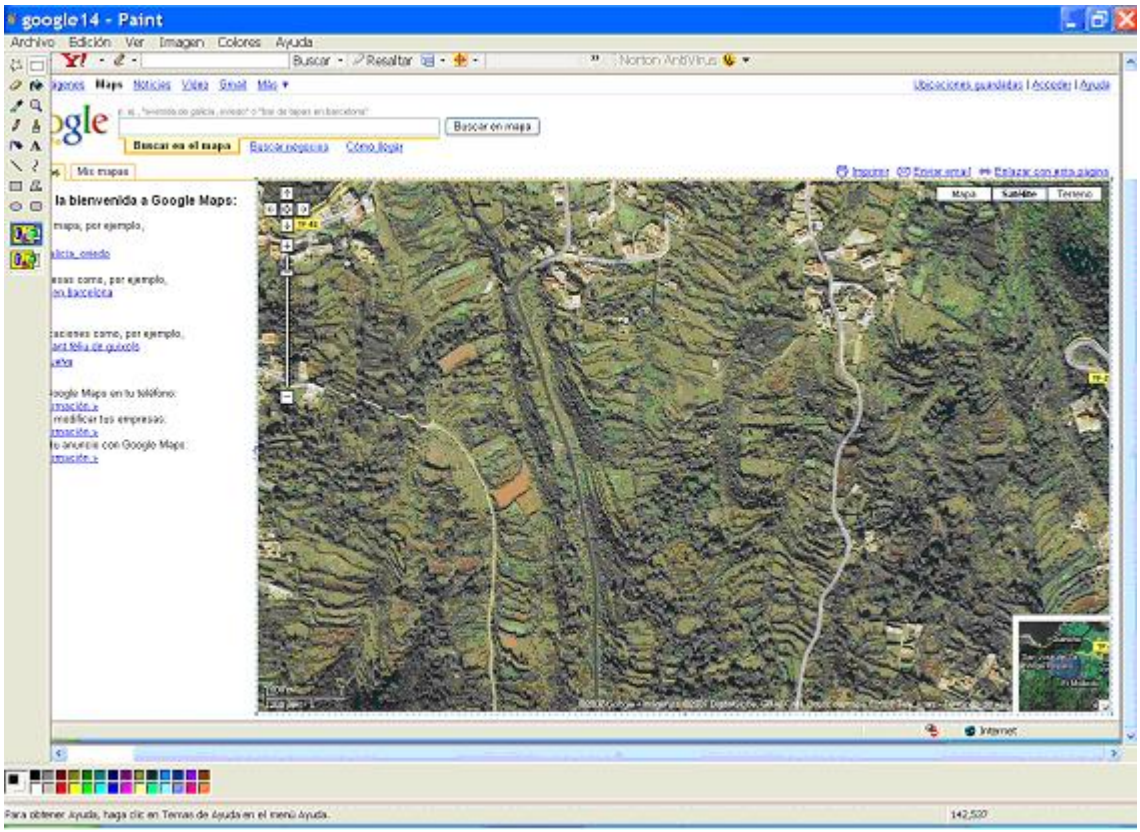
4. Open the windows PAINT program (*Windows >> Start>> Programs>> Accessories >> PAINT*).



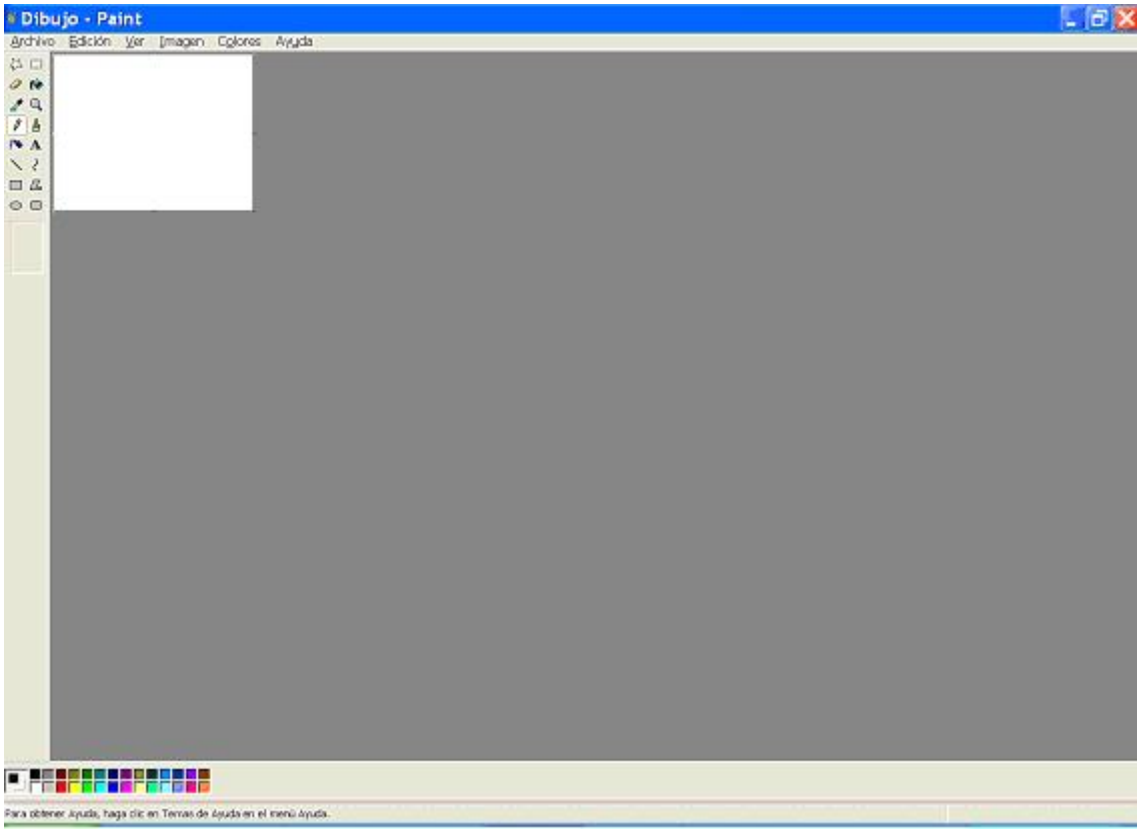
5. To paste the image that has been previously copied in the computer memory, you can use the commands (*Edit >> Paste* in the *PAINT program*) or (*Ctrl+V*). You can watch now the copied image from the Google maps web page.



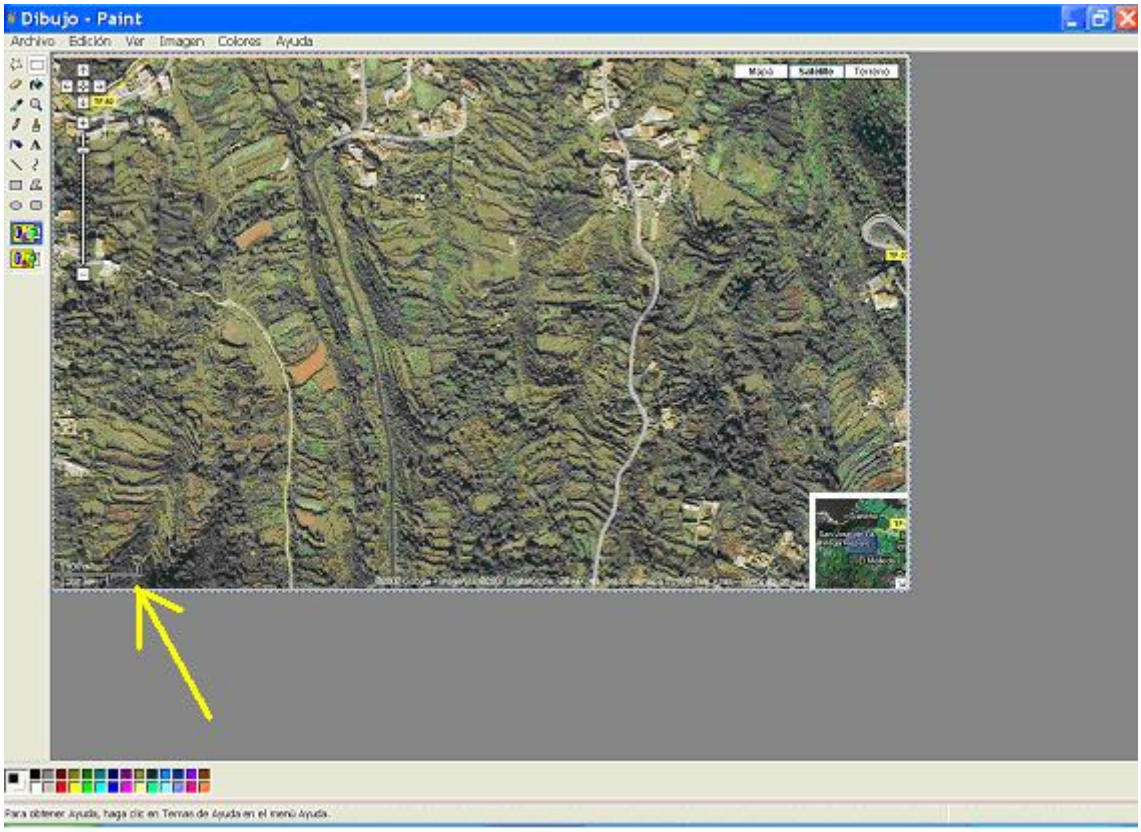
6. It is obvious that you don't want to watch the navigator bars that appears in the screen. Use the arrows of the PAINT program to center the image, that you are interested for, in your computer screen. In the toolbar of PAINT, you can use the icon SELECT (it is on top of the toolbar and at the right in the last picture). Drag the mouse arrow selecting the screen area that you are interested for. For our case, it is the rectangle where the picture of the terrain appears.



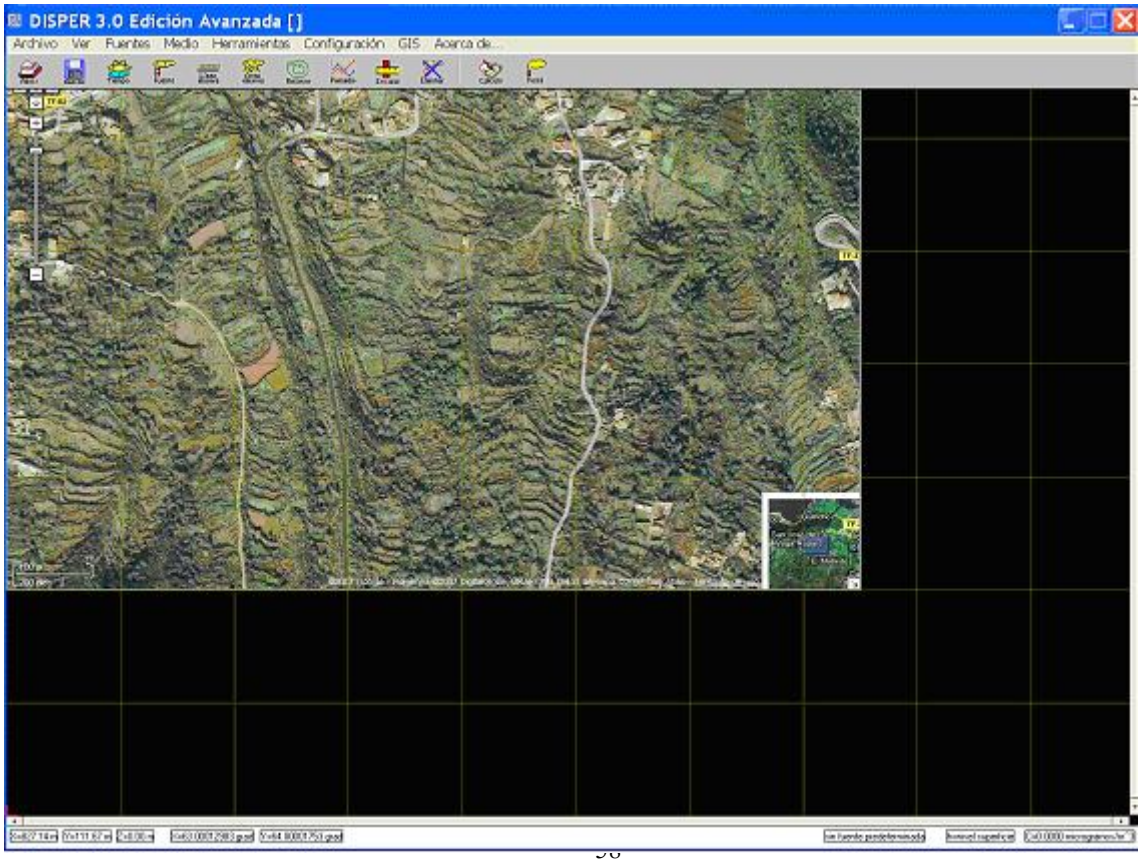
7. Copy now the selected area by the rectangle in the last image using (*Ctrl+C*) or the command (*PAINT Edit>>Copy*) in the PAINT program. Then, you can use the command (*File>>New*) in the PAINT to have a new and clear screen



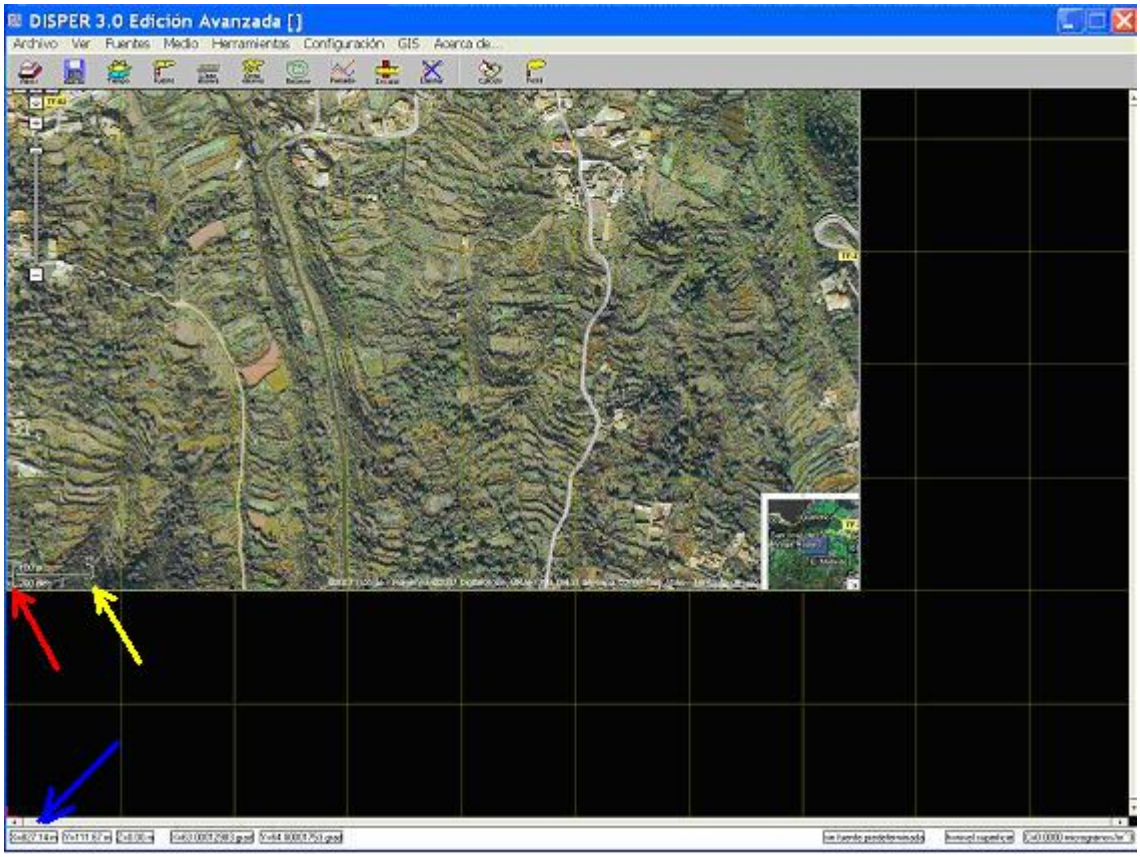
8. Use (*Ctlr+V*) command in the keyboard, or (*Edit>>Copy*) in the PAINT program to paste the selected retangle. The copy of the image appears now in the PAINT screen. The scale of the map imported from Google maps appears now in our screen (marked by a yellow arrow). This will be of great interest in a near future. It is important to have this scale in the image that you have selected.



9. Save the file using BMP format using the commands of the PAINT program (*File>> Save as. . .*). Then, you can open the previously saved BMP file using the program.



10. To work in the correct scale, we need to check the scale bar width in the Google map. The Google scale bar is between the red and yellow arrows (in the next picture). The Google bar width is in meters. When we put the mouse pointer in the point of the red arrow we can see the X-Coordinate value in the box marked by a blue arrow. If we put now the mouse pointer in the point of the yellow arrow, we will obtain a new value for the X-coordinate. The difference between both values in meters must be the same that the original Google bar width in meters to be in the correct scale.



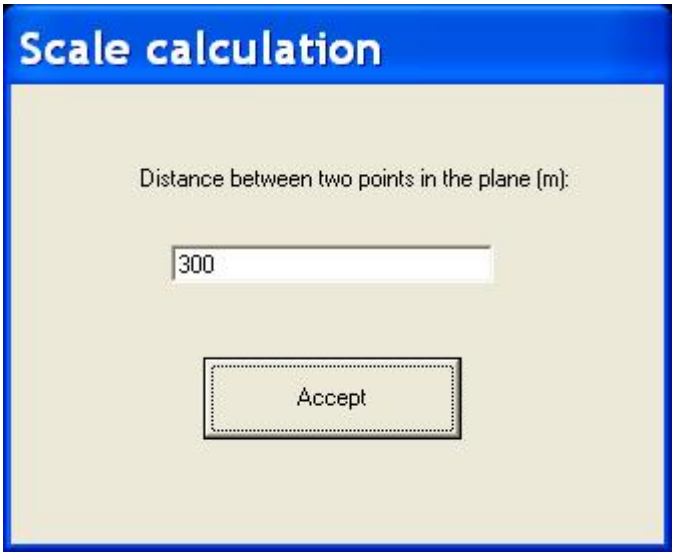
When we put the mouse pointer in the point of red arrow, it is found 7 m in the X-Coordinate box (marked with a blue arrow). If we do the same with the yellow arrow, we obtain 75 m in the box marked with a blue arrow. Then, and in our actual scale, the bar width have 75 m -7m = 68m. However, the correct value in the original Google scale is 100 m. The correcting ratio is

P = 100/68 = (real value)/ (our value).

P=100/68=1.47

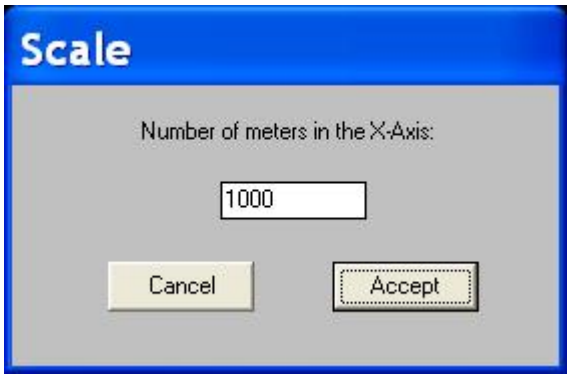
11. To work in the correct scale, we have two methods:

METHOD A:
We go now to *program>> GIS >> Scale calculation* in the program and we get



We replace the 300m value that appears in the last picture by 100m (the original Google bar width in meters) and 'click' *ACCEPT*. Then we click firstly in the left extreme of the original Google scale bar and secondly, we click again in the right extreme of the original Google scale bar (both points in the screen were market with red and yellow arrows in the last step 10). The imported Google map is now in the correct sale and we can check it. When we put the mouse pointer in the red arrow, we get an X-Coordinate value equal to 10 m (in the box market with a blue arrow). We can also get 110 m for the position market with the point of the yellow arrow. The difference is now 110 in -10m = 100 m. Such a value coincides with the original value of the Google map bar. So, the program scale is correct now.

METHOD B:
We go now to *program>> Tools >> Scale* in the program and we get



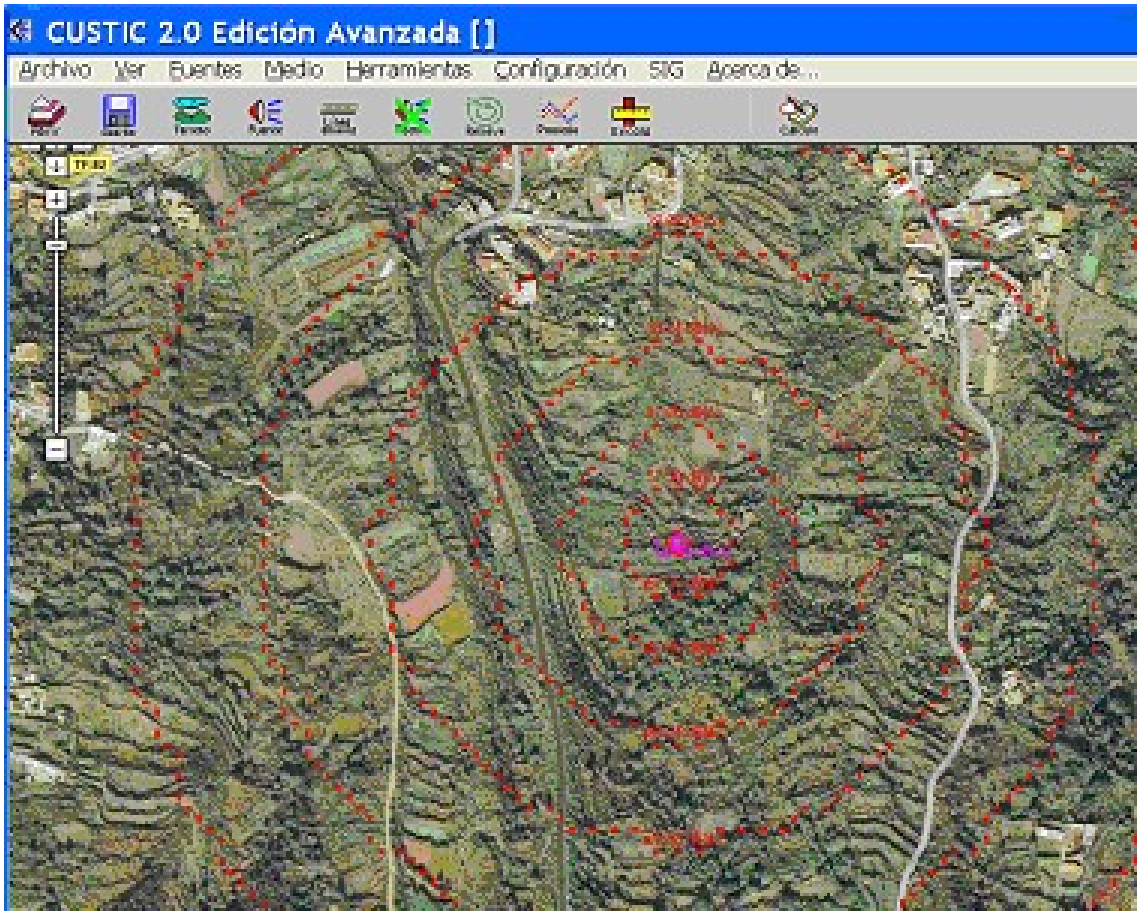
Now we multiply (our actual X-Axis width) by P to get the correct X-axis width,

(correct X-Axis width)=Px(X-Axis width)

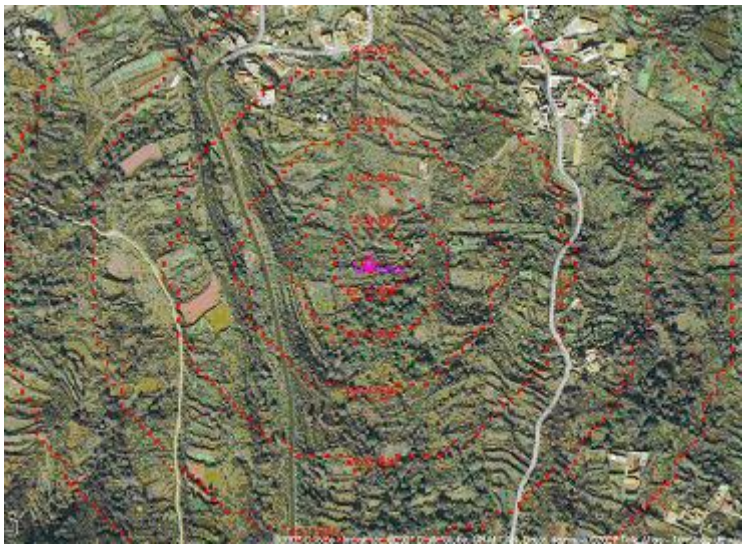
(correct X-Axis width)=1.47x1000=1470m

And we introduce the new X-Axis width and click *ACCEPT* in the last window. The imported Google map is now in the correct scale and we can check it. When we put the mouse pointer in the red arrow, we get an X-Coordinate value equal to 10 m (in the box market with a blue arrow). We can also get 110 m for the position market with the point of the yellow arrow. The difference is now 110 in -10m = 100 m. Such a value coincides with the original value of the Google map bar. So, the program scale is correct now.

12. Now we introduce a pollutant source and we make the simulation. The result can be exported to a BMP file using the software.



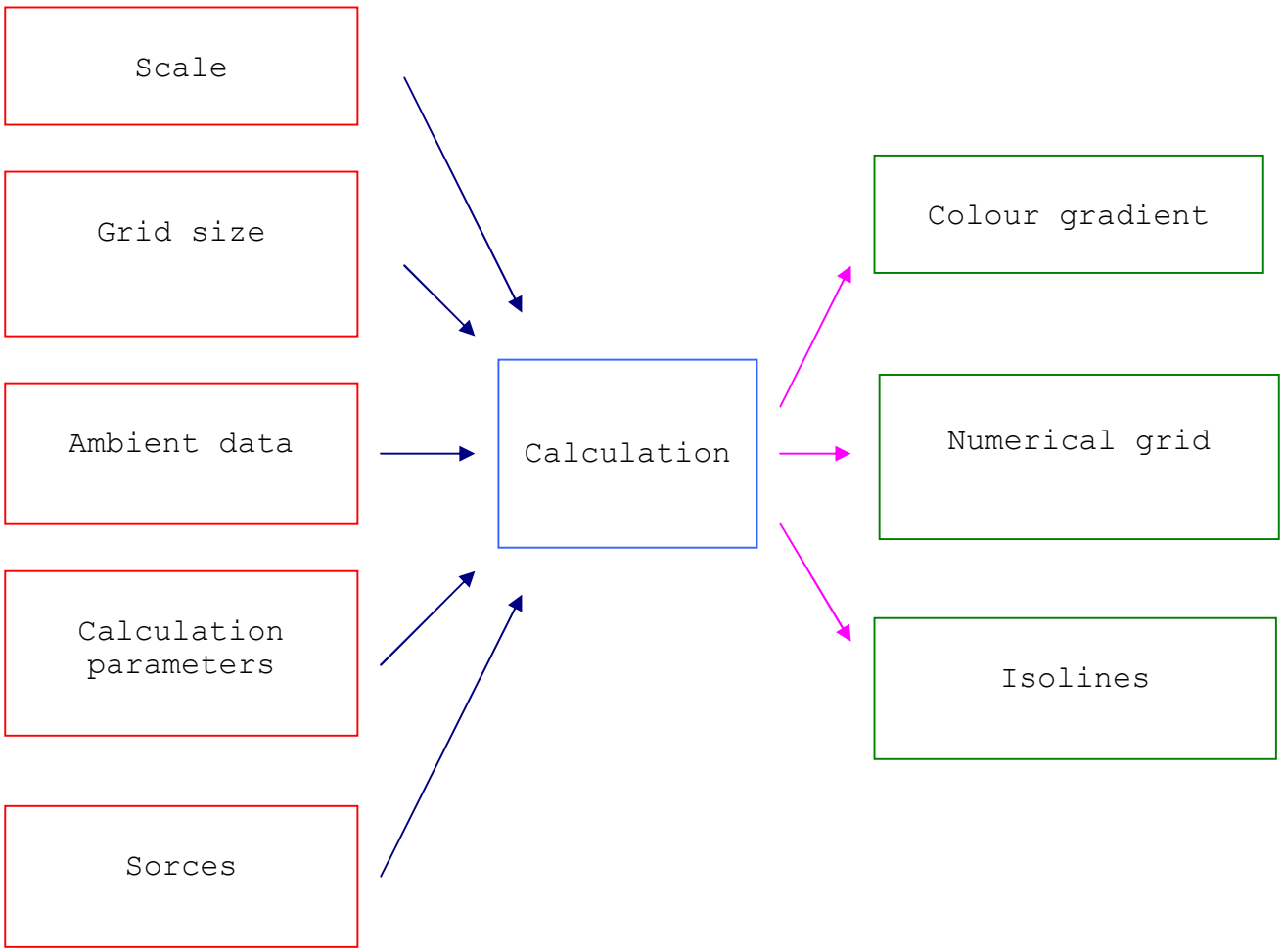
13. We can repeat the 6-7-8 steps 'in order to eliminate not necessary parts in the picture. At the end we have a clean image with both the Google map and the simulation process results.



6. Application structure

In this section, the general structure of the application will be shown. The Options Menu includes all the elements for the numeric configuration of the simulations. We will use these commands before using the calculation command because these parameters should be perfectly defined before running the simulation.

If we change any initial data (as the position of the source, air temperature,...), we will need to run the command again so that this is reflected in the result. We will be able to choose Calculation command to obtain different pollution maps.



Colour gradient, Isolines and Numerical grid commands should be applied after running the calculation.

7. Mathematical algorithms

The mathematical model that the software uses provides options to model noise emissions from a wide range of sources that might be present at industrial areas and urban areas.

The basis of the model is the linear sound propagation equation, which is used to model simple point source emissions from vehicles, industries, aircrafts,… Emission sources are categorized into two basic types of sources: point sources and line sources. The algorithms used to model each of these source types are described in detail in the following sections.

The CASTOR-NOISE 5.0 software accepts meteorological data records to define the conditions for sound propagation. The model estimates the noise level for each source and receptor combination and calculates user-selected averages.

For an external source, the noise level equation is

Leq=LW-20Log(r)-11dB(A)

where r is the distance and LW the source power. However, for an industrial complex, the next equation will be used:

Leq=Li+10Log(S)-20Log(r)-14dB(A)

where S is the external surface and Li is the internal noise power.

In a road case, we shall consider several points. We shall consider a minimum number of 1000 vehicles per hour N with a 50km/h minimum velocity (100km/h is the maximum velocity). Then we have a 68 dB(A) noise level at 10m from a lineal road (infinity length). The noise level will be,

Leq=68dB(A)+30Log(v/50)+10Log(N/1000)-10Log(r/10)

in the lineal (infinite) road case.

In the curved road case, the program considers a finite element method of calculation. Each small size of road contributes to the total noise level. Each contribution will be given by

Li=-10Log(a/180)

being a the angle of the small road size(degrees).

To obtain the total noise level, we add the different L_i values following the equation

$$L_{eq} = 10.\mathrm{Log}[\Sigma_i 10^{(L_i/10)}]$$

In the railway case, we shall calculate the noise level in a similar way. For airports, we shall use the next equation

Leq=Leq(300m)-20Log(r/300)

where Leq(300m) is the noise level at 300m from the airport.

This model performs satisfactorily for simple sound propagations with no ground interaction or attachment. The application will not consider sound reflections in the ground surface.

8. References

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