Castor-ELEC

Version 5.0 – Electromagnetic pollution

Electrosmog · Mobile phone towers · Software

MANUAL

Castor

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ξ Printed on recycled paper.

IMPORTANT. READ ATTENTIVELY

CASTOR SOFTWARE CASTOR-ELEC FOR WINDOWS 95

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FOREWORD

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

The software admits meteorological data to establish the form of the electromagnetic pollution. The software calculates the emission that is produced by each one of the sources and it considers the estates of the sources and the state of the atmosphere.

The system of simulation of processes of dispersion that CASTOR-ELEC has, offers to the beginner and the expert programmer, a quick and practical system to evaluate the electromagnetic 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-ELEC is one of the best tools, to carry out numeric simulations of electromagnetic 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-ELEC 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 electromagnetic 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 electromagnetic 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 electromagnetic 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.

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1. Introduction

Software for analysis of electromagnetic pollution in environment: environmental modeling, environmental impact assessment, environmental engineering, environmental consultancy service and environment simulation.

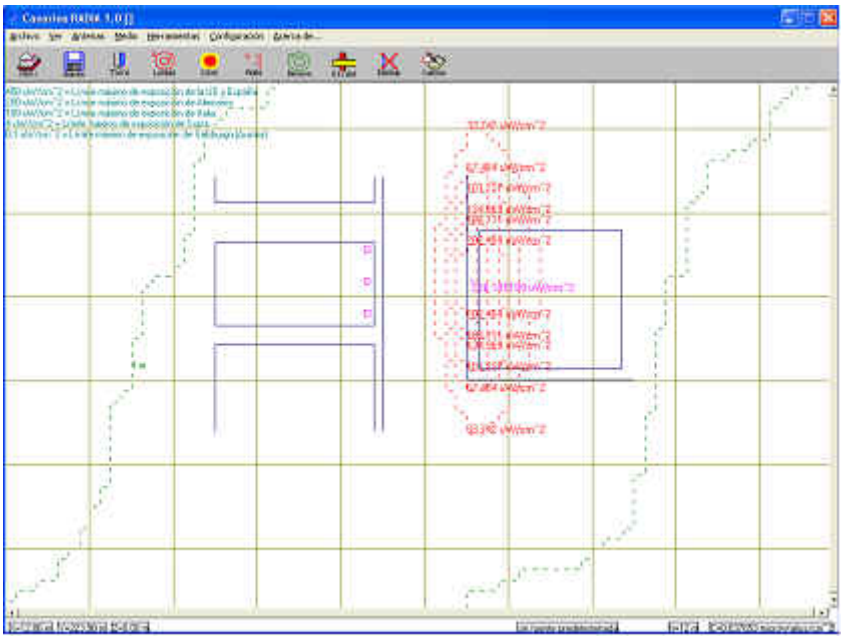
CASTOR-ELEC is a electromagnetic pollution modeling software. The program calculates the elecromagnetic pollution in each point of the air considering each one of the antennas in mobile phone towers. The system of simulation of processes of pollution that CASTOR-ELEC has, offers to the beginner and the expert programmer, a quick and practical system to evaluate the pollution in the air. The program is based on the operating system Microsoft WINDOWS where one works intensively with the mouse and the graphic windows. We can say, with a certain security that the software CASTOR-ELEC is one of the best tools, to carry out numeric simulations of electromagnetic pollution processes.

CASTOR-ELEC SOFTWARE Solutions:

It is ideal for environmental impact assessments, environmental consultancy services and environmental engineering.

With this application you will be able to import images and pictures (previously saved BMP files) and Google maps. These images will be background pictures and images for your program window. 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.
This software can also be used for risk studies and safety in cities.

At the present time, numerous universities and study centers use this program for teaching and education.

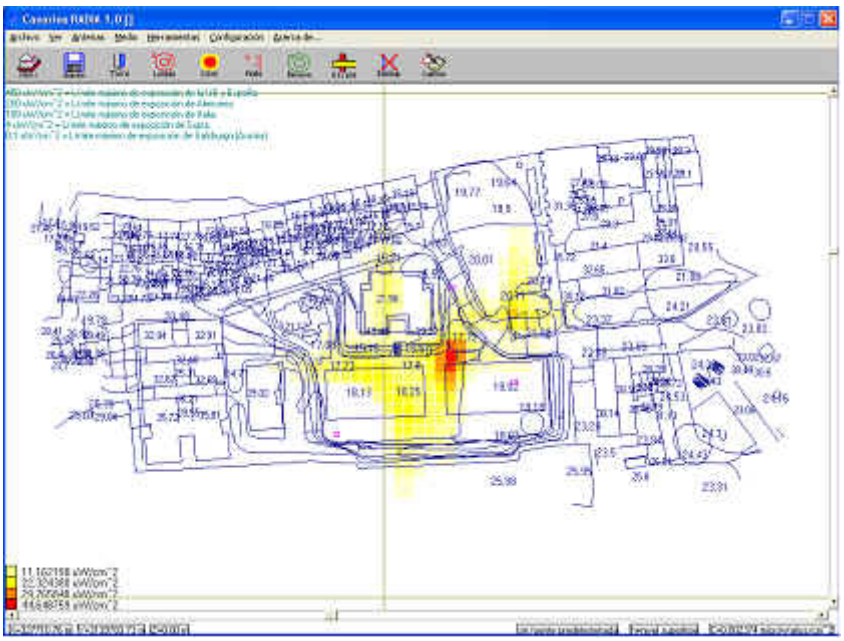


CASTOR-ELEC Software: electromagnetic pollution map with three different antennas in three different mobile phone towers.

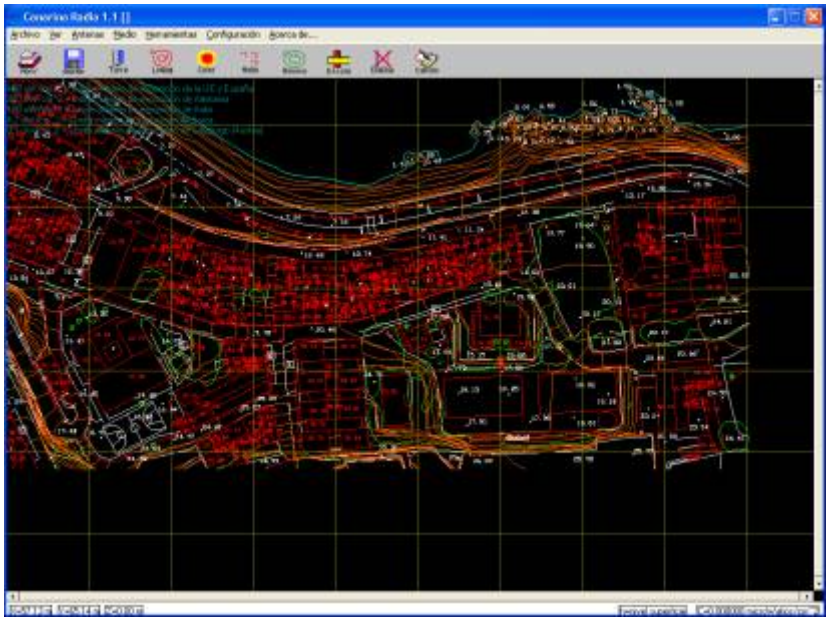
CASTOR-ELEC SOFTWARE Advantages:

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.
With this application you will be able to export your simulation results (BMP files). These images will contain the background picture (map) and your simulation results. Many programs and computer applications (AutoCad, 3d Studio, ArcView, MS Power Point, MS Word,...) can import your saved BMP files.

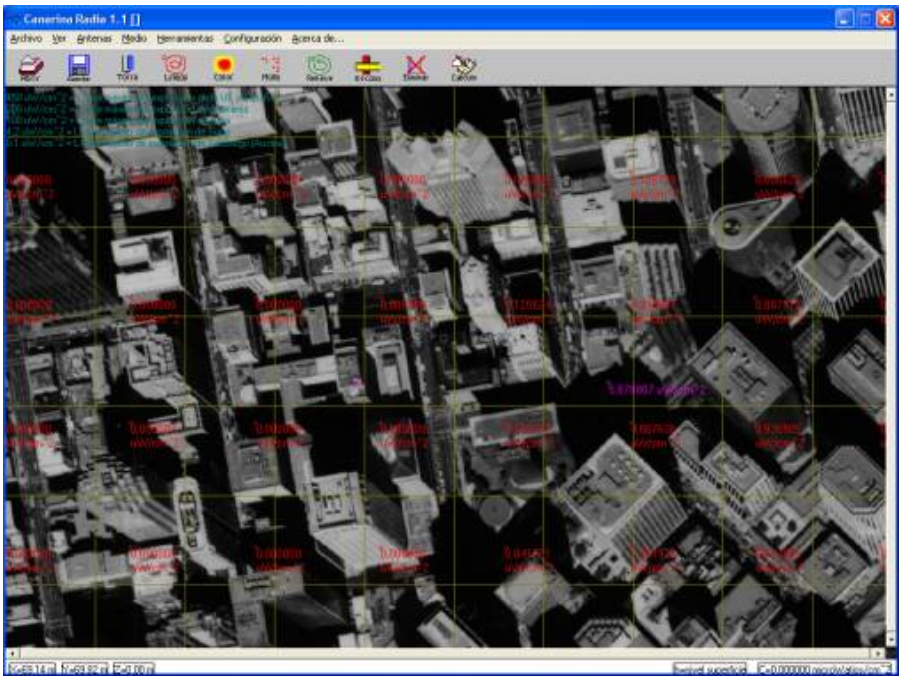
It works in cartesian and geographical coordinates and the results can be exported in Microsoft EXCEL csv files. It is possible to import the CUSTIC generated data in GIS systems, as ArcMap or ArcView.
It is possible to obtain XY and XZ electromagnetic pollution maps.



CASTOR-ELEC Software: electromagnetic pollution map with different antennas with a background image.



CASTOR-ELEC Software: electromagnetic pollution map with different antennas with an AutoCAD map.



CASTOR-ELEC Software: electromagnetic pollution map with different antennas with a background image.

Software characteristics

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

1.1 Mobile phone towers

A **cell site** is a term used primarily in North America for a site where antennas and electronic communications equipment are placed to create a cell in a mobile phone network (cellular network). A cell site is composed of a tower or other elevated structure for mounting antennas, and one or more sets of transmitter/receivers transceivers, digital signal processors, control electronics, a GPS receiver for

timing (for CDMA2000 or IS-95 systems), regular and backup electrical power sources, and sheltering.

A synonym for "cell site" is "cell tower", although many cell site antennas are mounted on buildings rather than as towers. In GSM networks, the technically correct term is Base Transceiver Station (BTS), and colloquial British English synonyms are "mobile phone mast" or "base station". The term "base station site" might better reflect the increasing co-location of multiple mobile operators, and therefore multiple base stations, at a single site. Depending on an operator's technology, even a site hosting just a single mobile operator may house multiple base stations, each to serve a different air interface technology (CDMA or GSM, for example). Preserved treescapes can often hide cell towers inside an artificial tree or preserved tree. These installations are generally referred to as concealed cell sites or stealth cell sites.

Place in the wireless network

Cell sites are connected via copper facilities, optical fiber, or microwave. Copper facilities deliver either T1s or E1s, while microwave and optical fiber can offer T3s or Ethernet in addition to T1s or E1s. Copper facilities and optical fiber are usually provided as part of a service from the incumbent telephone company, but microwave is generally self-built by the mobile telephone company. Whatever the connection, the next elements in the mobile telephone network are Base Station Controllers (BSCs) and Radio Network Controllers (RNCs) at the mobile telephone switching office (MTSO). The base station controller is connected to a telephone switch, which is connected to the public switched telephone network (PSTN), while the Radio Network Controller handles 3G service, and is connected to Serving GPRS Support Node (SGSN), which is in turn connected to a data network, a telephone switch, or both.

Cell site range

The working range of a cell site - the range within which mobile devices can connect to it reliably is not a fixed figure. It will depend on a number of factors, including

- The type of signal in use (i.e. the underlying technology), similar to the fact that AM radio waves reach further than FM radio waves.
- The transmitter's rated power.

- The transmitter's size.
- The array setup of panels may cause the transmitter to be directional or omni-directional.
- It may also be limited by local geographical or regulatory factors and weather conditions.

Generally, in areas where there are enough cell sites to cover a wide area, the range of each one will be set to:

- Ensure there is enough overlap for "handover" to/from other sites (moving the signal for a mobile device from one cell site to another, for those technologies that can handle it - e.g. making a GSM phone call while in a car or train).
- Ensure that the overlap area is not too large, to minimize interference problems with other sites.

In practice, cell sites are grouped in areas of high population density, with the most potential users. Cell phone traffic through a single cell mast is limited by the mast's capacity; there is a finite number of calls that a mast can handle at once. This limitation is another factor affecting the spacing of cell mast sites. In suburban areas, masts are commonly spaced 1-2 miles apart and in dense urban areas, masts may be as close as ¼-½ mile apart. Cell masts always reserve part of their available bandwidth for emergency calls.

The *maximum* range of a mast (where it is not limited by interference with other masts nearby) depends on the same circumstances. Some technologies, such as GSM, have a fixed maximum range of 40km (25 miles), which is imposed by technical limitations. CDMA and iDEN have no built-in limit, but the limiting factor is really the ability of a low-powered personal cell phone to transmit back to the mast. As a rough guide, based on a tall mast and flat terrain, it is possible to get between 50 to 70 km (30-45 miles). When the terrain is hilly, the maximum distance can vary from as little as 5 kilometres (3.1 mi) to 8 kilometres (5.0 mi). The concept of "maximum" range is misleading, however, in a cellular network. Cellular networks are designed to create a mass communication solution from a limited amount of channels (slices of radio frequency spectrum necessary to make one conversation) that are licensed to an operator of a cellular service. To overcome this limitation, it is necessary to repeat and reuse the same channels. Just as a station on a car radio changes to a completely different local station when you travel to another

city, the same radio channel gets reused on a cell mast only a few miles away. To do this, the signal of a cell mast is intentionally kept at low power and many cases tilting downward to limit its area. The area sometimes needs to be limited when a large number of people live, drive or work near a particular mast; the range of this mast has to limited so that it covers an area small enough not to have to support more conversations than the available channels can carry.

A cellphone may not work at times, because it is too far from a mast, but it may also not work because the phone is in a location where there is interference to the cell phone signal from thick building walls, hills or other structures. The signals do not need a clear line of sight but the more interference will degrade or eliminate reception. Too many people may be trying to use the cell mast at the same time, e.g. a traffic jam or a sports event, then there will be a signal on the phone display but it is blocked from starting a new connection. The other limiting factor for cell phones is the ability of the cell phone to send a signal from its low powered battery to the mast. Some cellphones perform better than others under low power or low battery, typically due to the ability to send a good signal from the phone to the mast.

The base station controller (a central computer that specializes in making phone connections) and the intelligence of the cellphone keeps track of and allows the phone to switch from one mast to the next during conversation. As the user moves towards a mast it picks the strongest signal and releases the mast from which the signal has become weaker; that channel on that mast becomes available to another user.

Temporary cell sites

Cell-on-wheels, or COW

Although cell antennas are normally attached to permanent structures, cell providers maintain a fleet of temporary cell sites. When mounted on a trailer, they are called a COW or Cell On Wheels. These usually include a base station controller and a telescoping tower with antennas attached. A generator may be included when electrical power isn't

available, and an additional backhaul antenna may be mounted to link the temporary tower into the network.

COWs are often used at the site of a permanent cell site. Floods, fires, terrorism, and other disasters may destroy permanent antennas or base stations controllers, and fast dispatch of COWs can maintain vital communications during an emergency. They are also used in planned outages, such as when an antenna site is unavailable due to construction or maintenance. Finally, they are often used to augment capacity when large number of additional cell phone users are expected.

BTS *raw land* type.

Antenna BTS

Frequency= 900 MHz. (system BTS)

Frequency=1800 MHz y 1900 MHz (system DCS).

1 microwatts/cm^2= 1 uW/cm^2 = 0,001 mW/cm^2= 0,000001 W/cm^2.

Limits:

Country	*Frequency (MHz)*	*Power density (uW/cm^2)*
United Status (USA) – United Kingdom	*900 -1.800*	*570 – 1.000*
European Union (1999)	*900 -1.800*	*450 – 900*
Spain	*900 -1.800*	*450 – 900*
Germany	*900 -1.800*	*200 – 900*
Italy	*3 -3.000*	*100*
China	*900 -1.800*	*6*
Russia	*900 -1.800*	*5*
Switzerland	*900 -1.800*	*4,2*
Salzburgo (Austria)	*900 -1.800*	*0,1*

2. Commands CASTOR-ELEC

2.1 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.

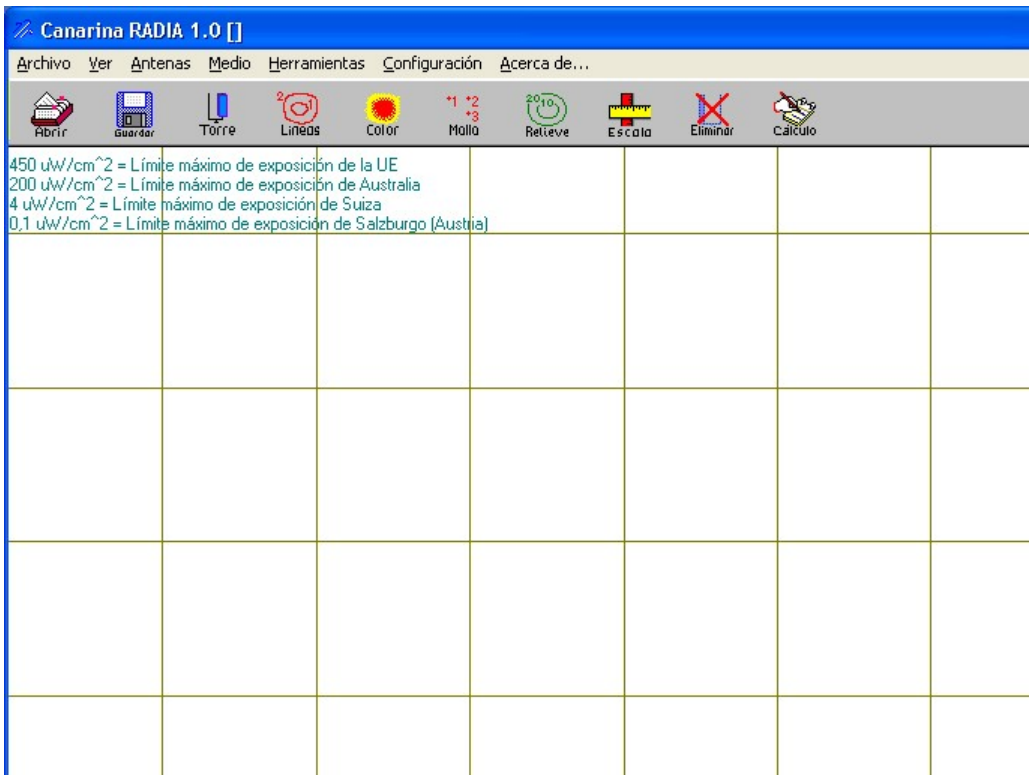
Many programs, computer applications and word processors (AutoCad, 3d Studio, ArcView, MS Word,...) import BMP files. You will be able to load images generated by CUSTIC.

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).

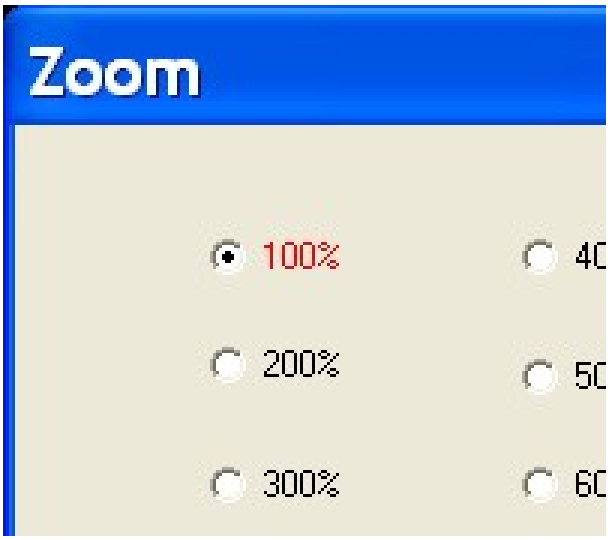
Exit.- The **Exit** command allows you to exit directly from the application.



2.2 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.

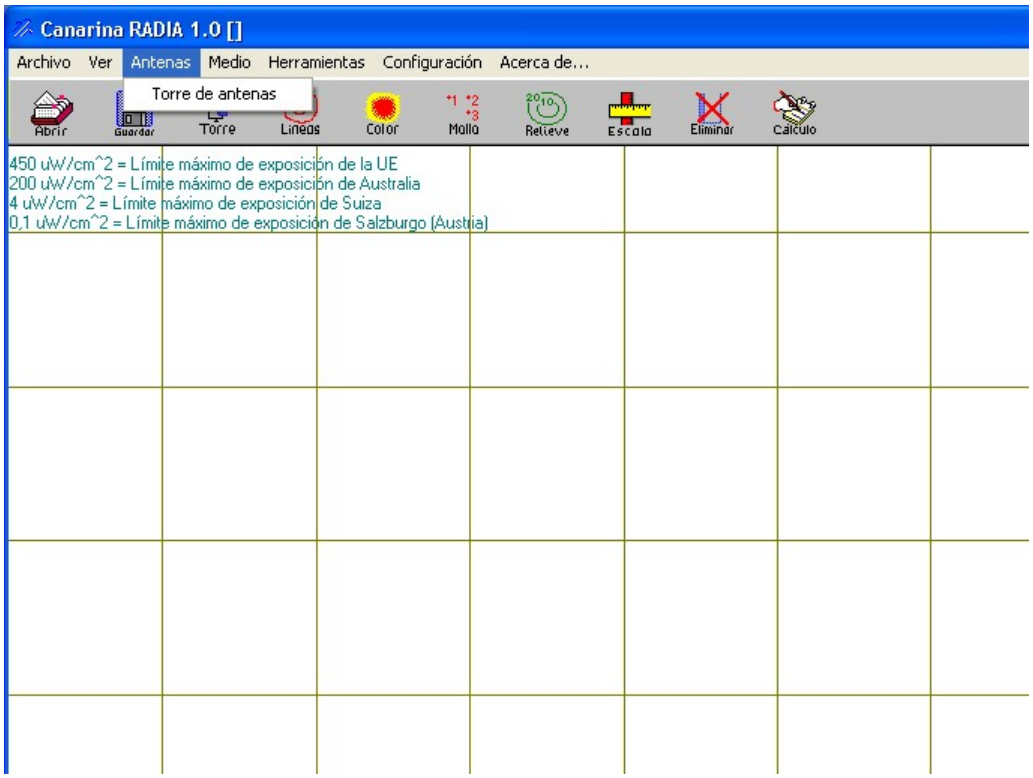
Draw grid lines.- If you select **Draw grid lines** command, the grid appears.

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.

2.3 Antenna



Mobile phone tower.- It is for a pollutant source fixed in the space and small if we compare with the area where the calculation is done.

where we can introduce all the antennas from the mobile phone tower that we want simulate.

Antenna type: BTS (panel) o DTS (stick and old mobile phone system).

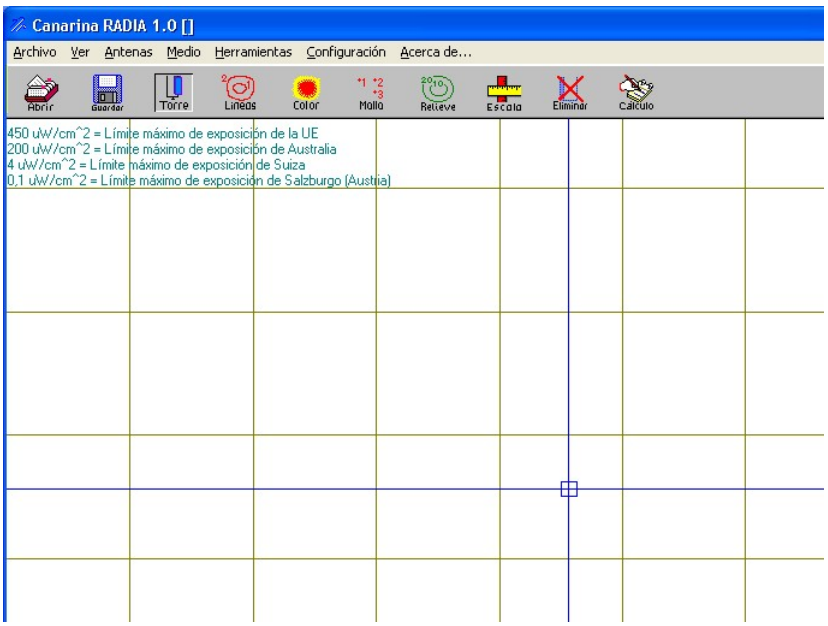
Height of the antenna from the ground (m): It is the height of the antenna from the ground level (antenna base) and is in meters or number of floors (3 meters each floor).

Angle of fall (grads): Only for BTS (panel antenna). This type of antenna use to point a place that is located at 50m or 200m from the antenna base. A typical value can be 5 or 20 grads.

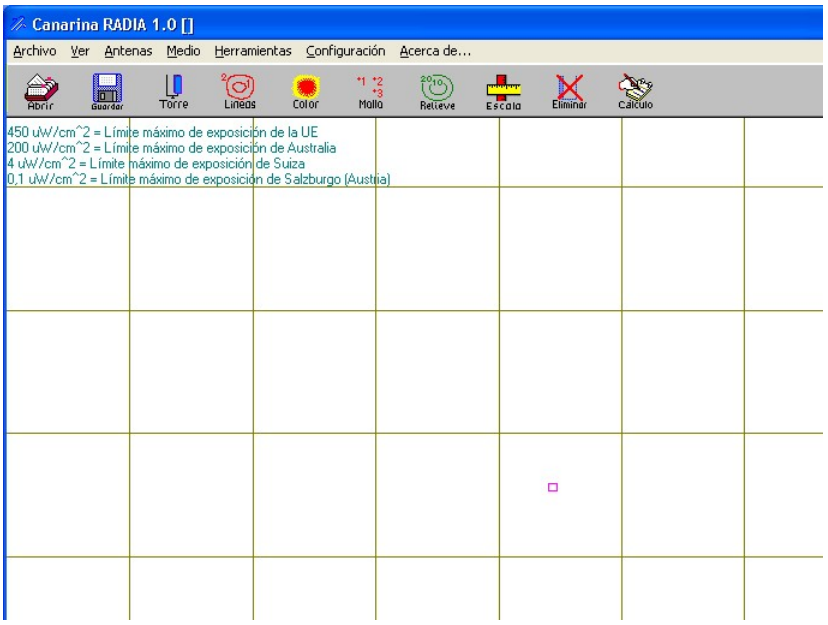
Power (Watts ERP): It is the power when the antenna works.

Antenna direction: Only for BTS (panel type). This type of antenna uses to point a direction. It can be expressed in grads or North (N), East (E), South (S) and West (W) directions.

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

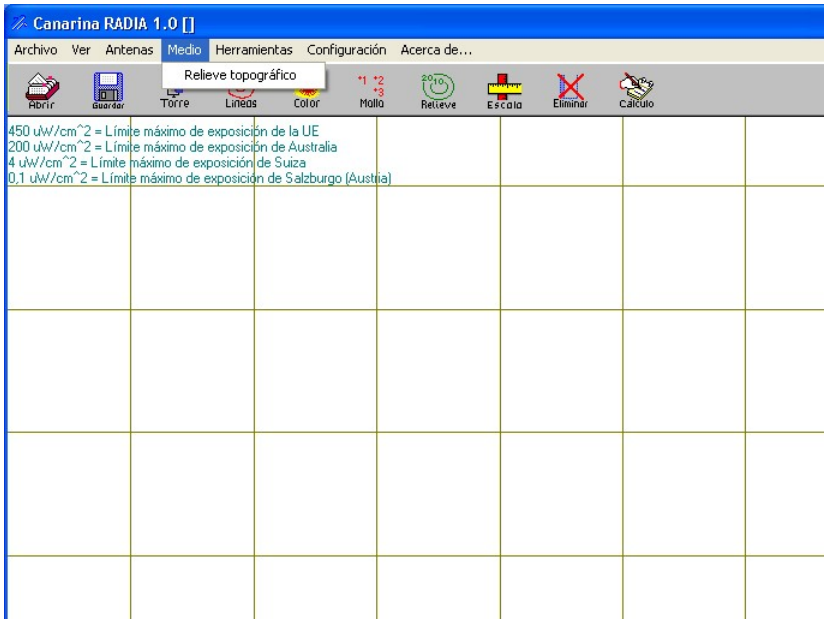


Two blue axis points the place where we can fix the source position. After clicking the program window, you draw the point source.

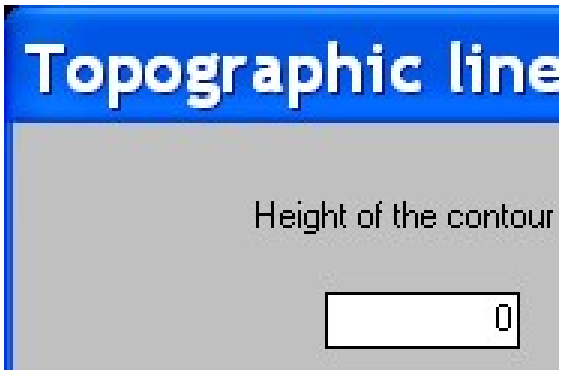


The small fuchsia square shows the source location. We can draw all the noise sources that we want (up to 1,000). To change the point source data, we can click the source location in the program window. Then, the point source dialogbox is again displayed. We are not able to put two noise sources in the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

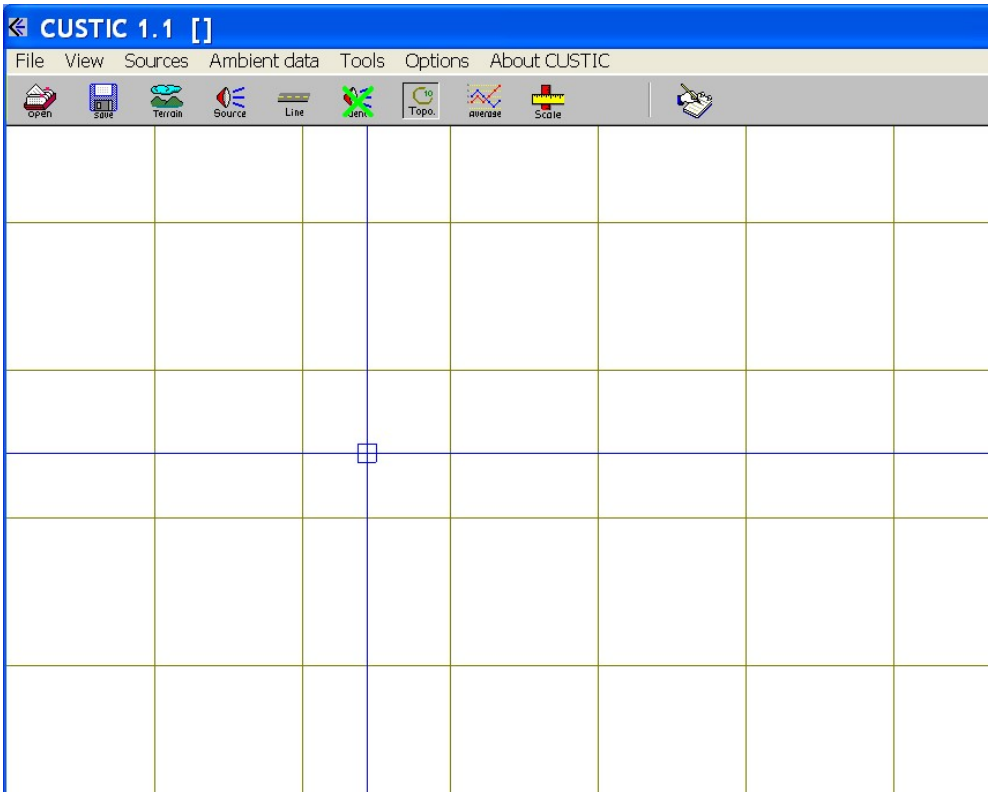
2.4 Environment



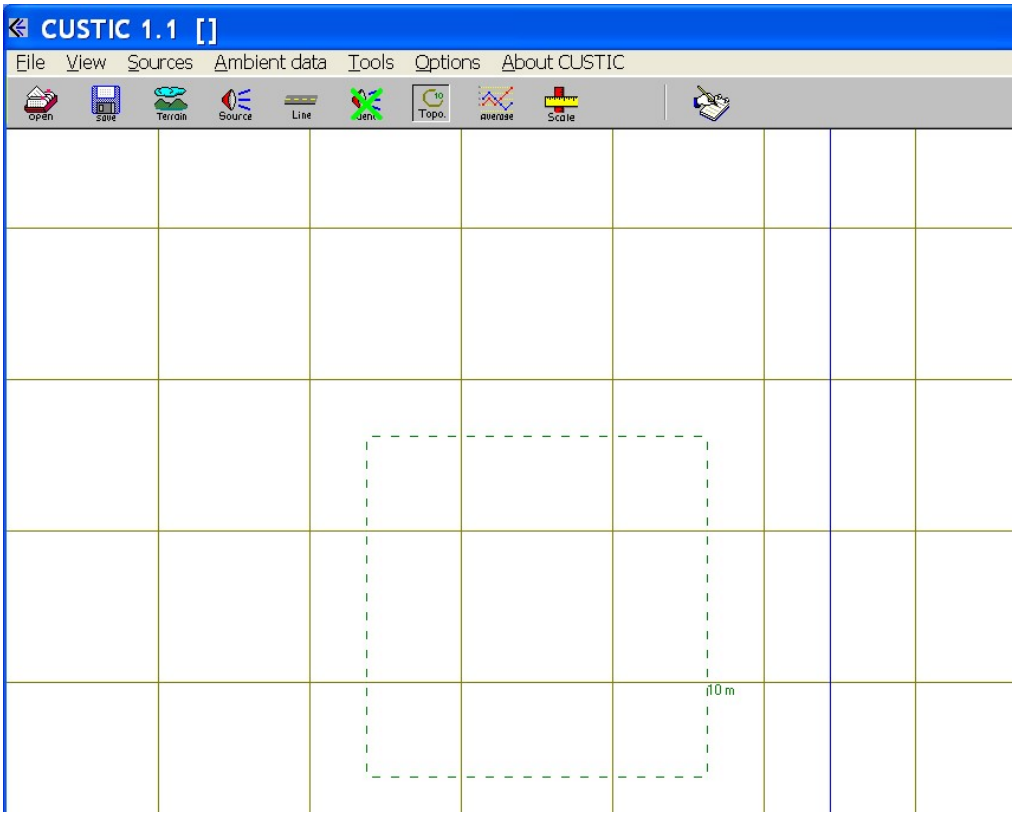
Topographic lines.- This command is to draw topographical lines. If you click this command, the next dialog box is shown:



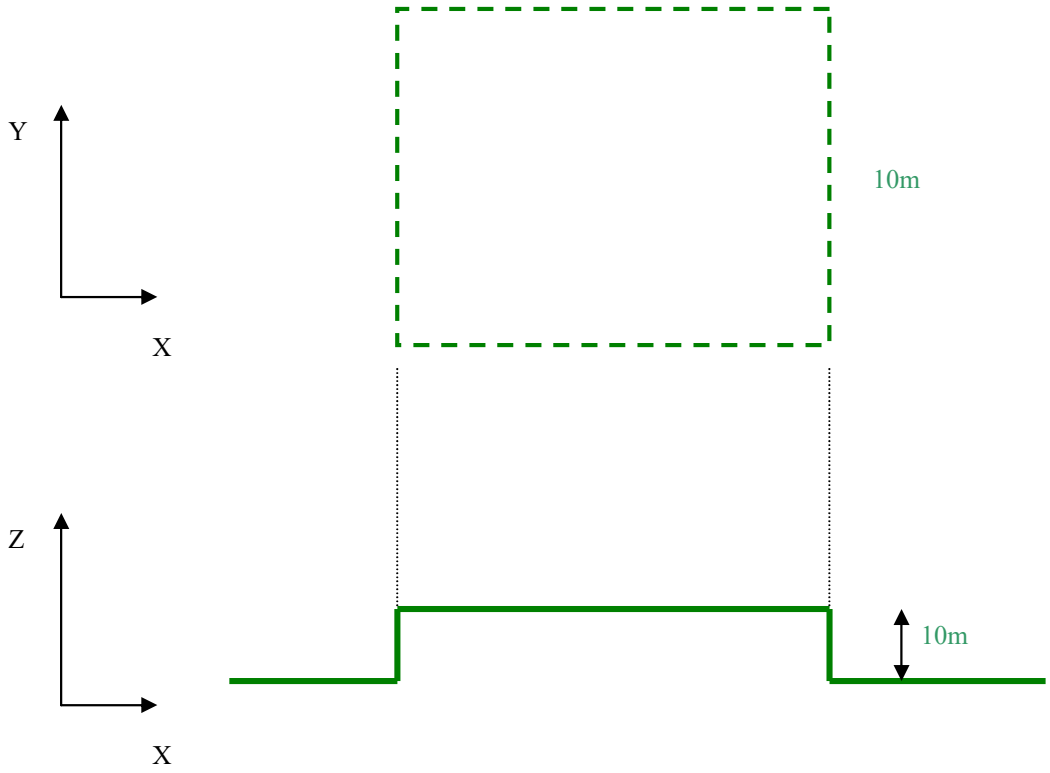
The height of the contour line can be written in the textbox. If you click the Accept button, the next computer screen is shown:



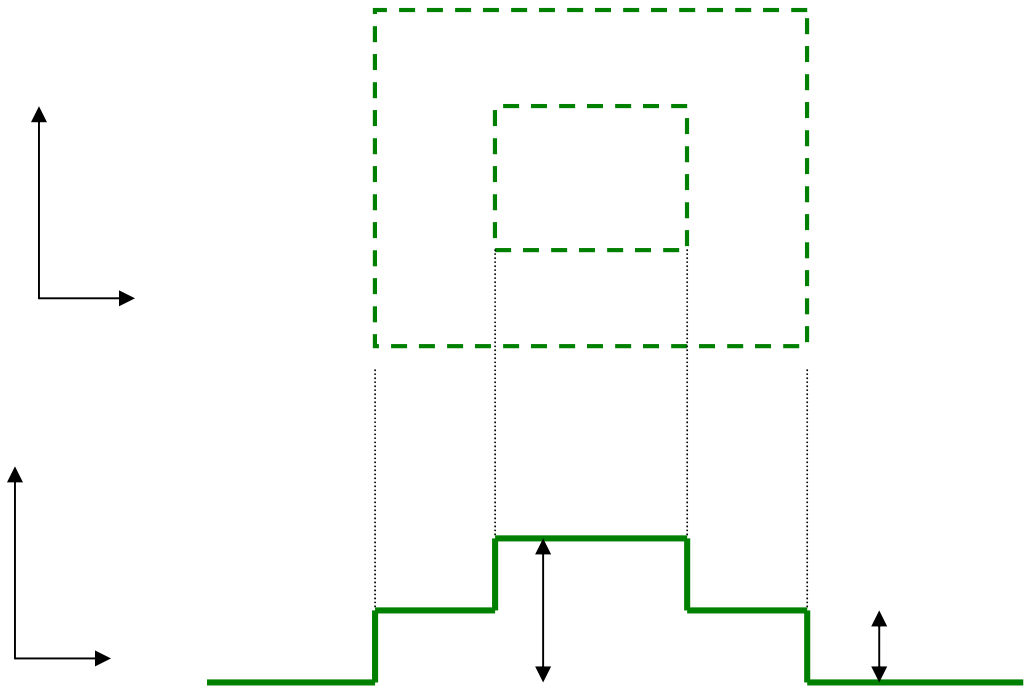
Then, and if you click the computer screen and move the mouse (mouse down), a square is shown and when you mouse up (the height of the contour line is different to zero):



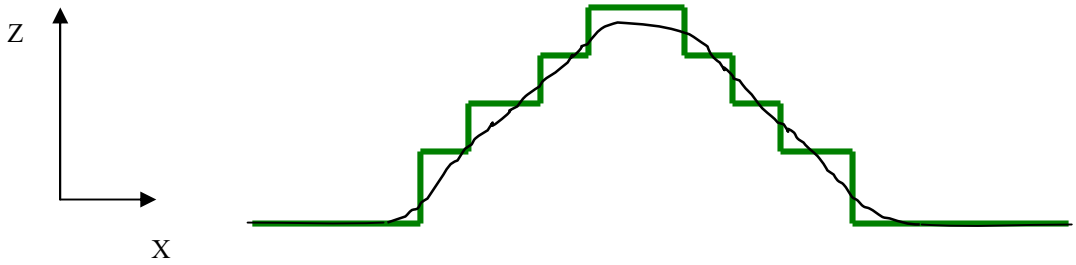
The area inside this contour has a 10m height. A rectangle elevation could be represented by the program in the next way:



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

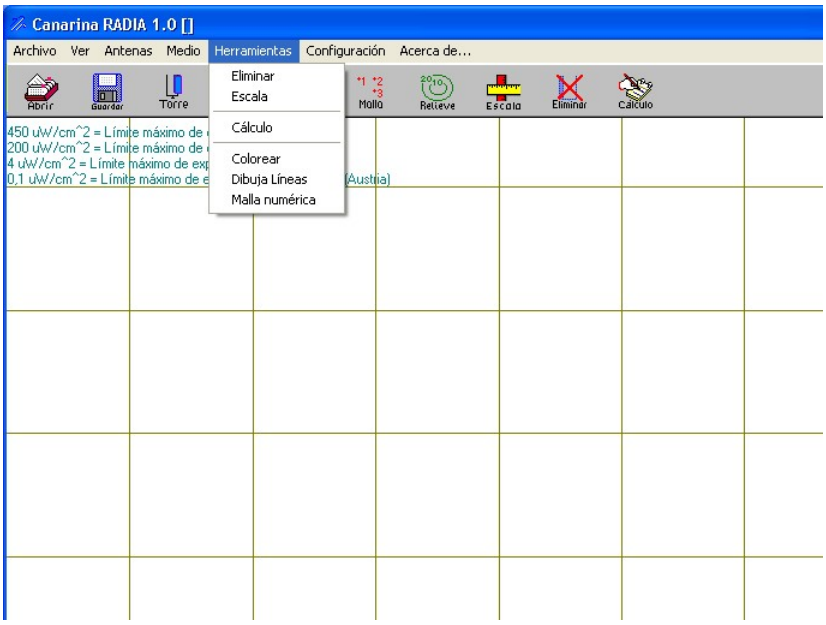


A mountain could be represented by the program in the next way:

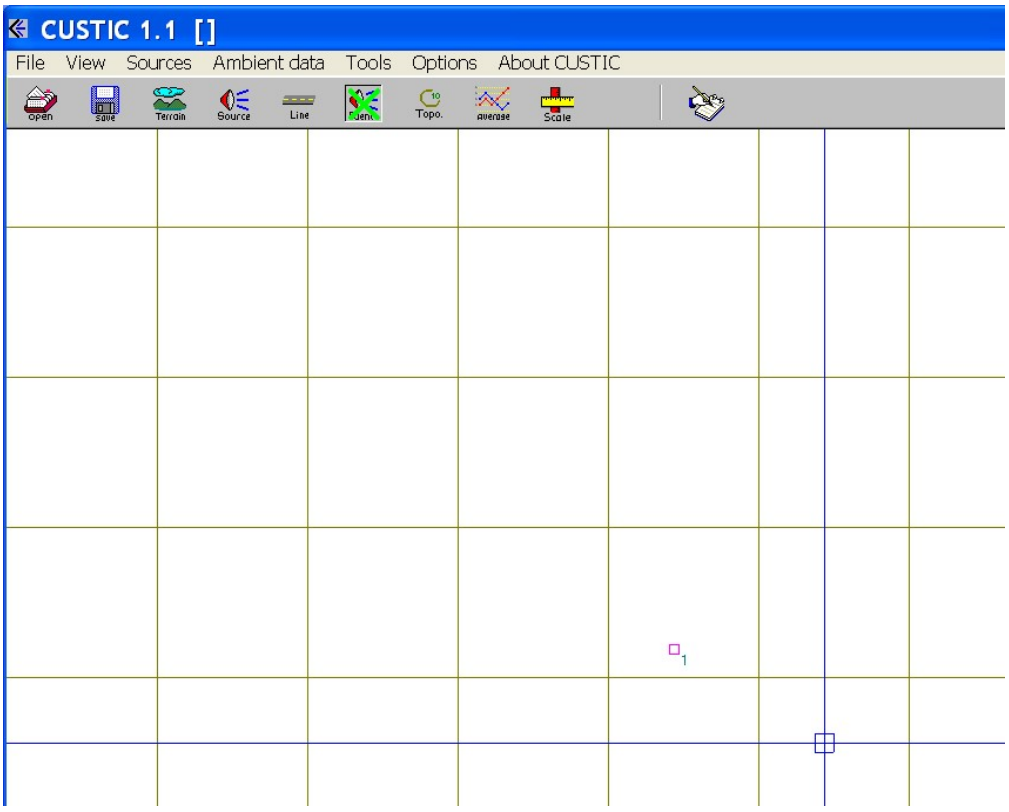


2.5 Tools

The Tools Menu contains the tools you use to process your data. The File Menu lists: **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:

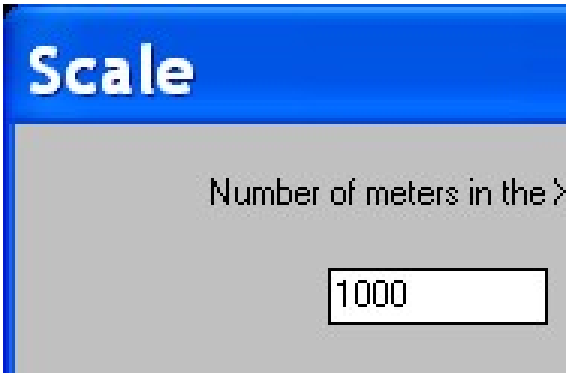


Delete.- This command is used to delete pollutant sources that we don't want in the simulation. If you click the **Delete** button, the next program window is shown:



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

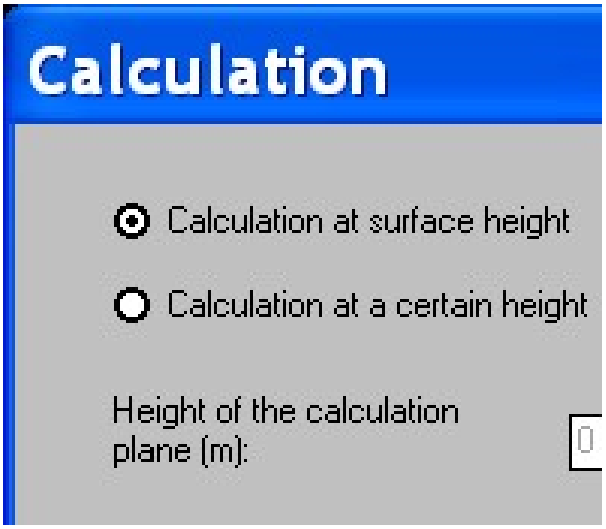
Scale.- With this command, we will decide the work area size in the simulation process. It is an important tool because with their good use we will be able to interpret and to extract interesting data of the numeric simulation. The scale is defined according to the width in meters that we want to associate to the X-Axis of our program window. If you click the **Scale** button, the next program window is shown:



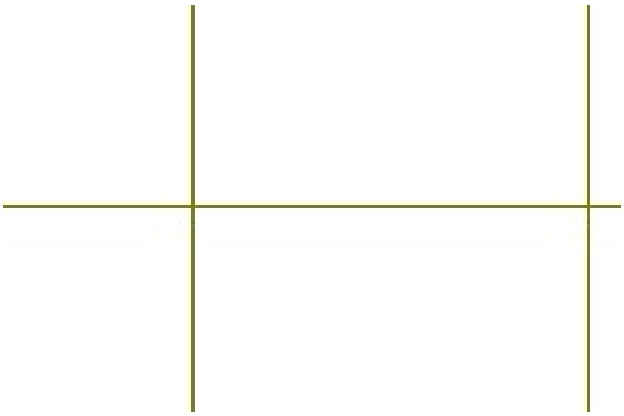
In this window we will be able to choose the number of meters that we want to have in the X-Axis. When we have the value written in the textbox, we will make click with the mouse on Accept button and this value will be modified and the previous window will disappear. If we click the Cancel button it 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.

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:



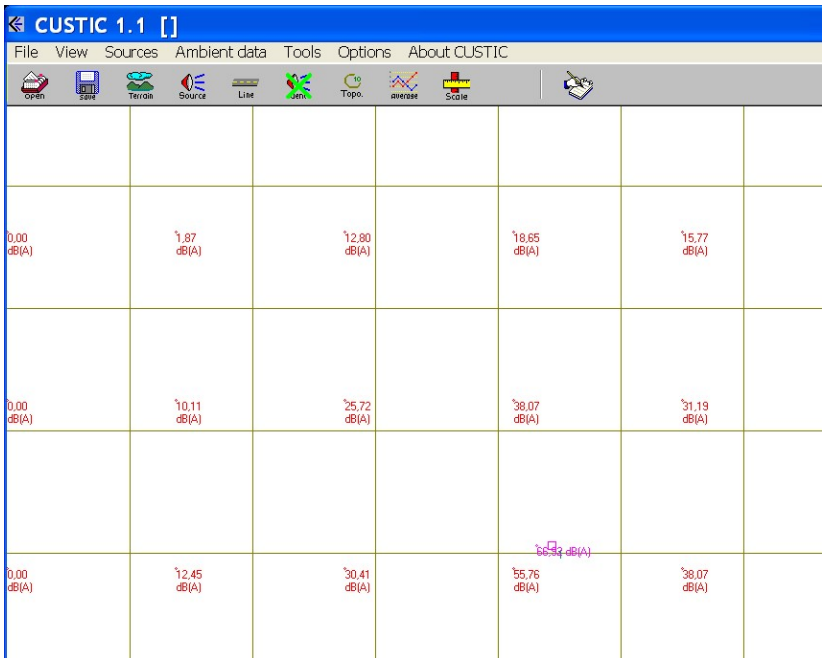
The program works in the following way: while it calculates, the machine centers all the capacity of the CPU in the calculation, stopping the other tasks of Windows. If we want to stop a tedious calculation, we will be able to make it making use of the keys CTRL+ALT+DEL.

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.

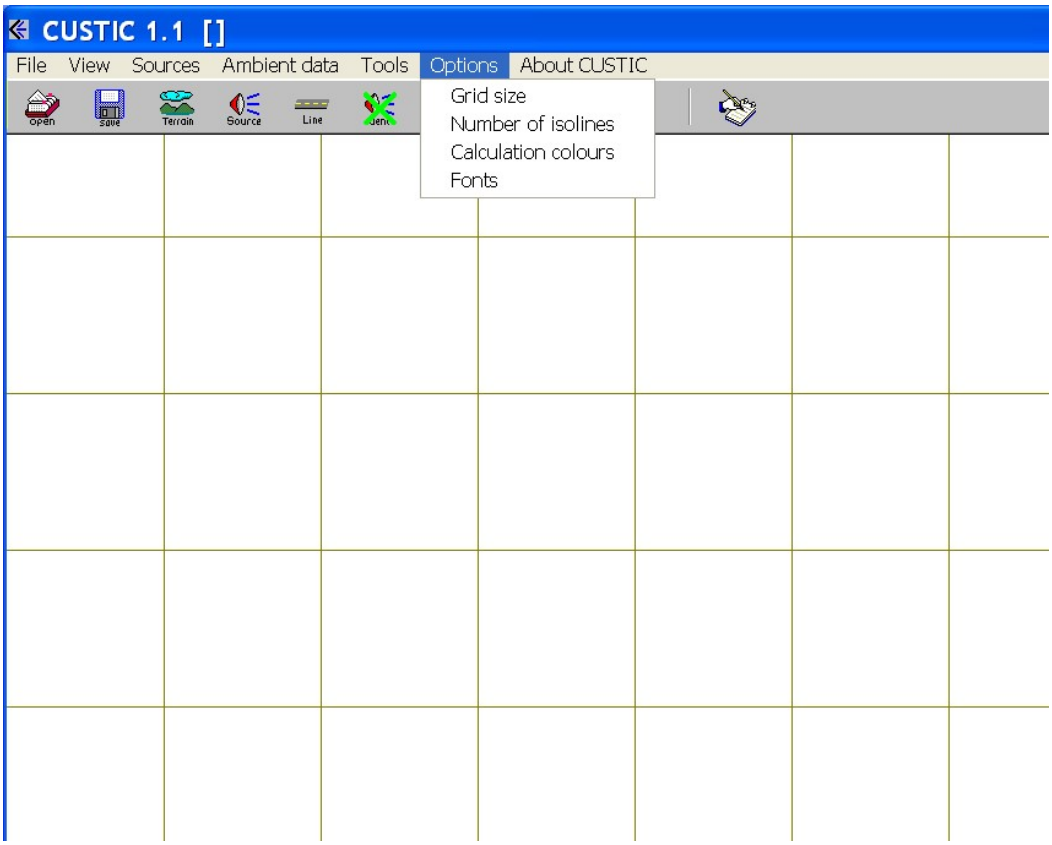
If you click the **Numerical grid** button, the next program window is shown:



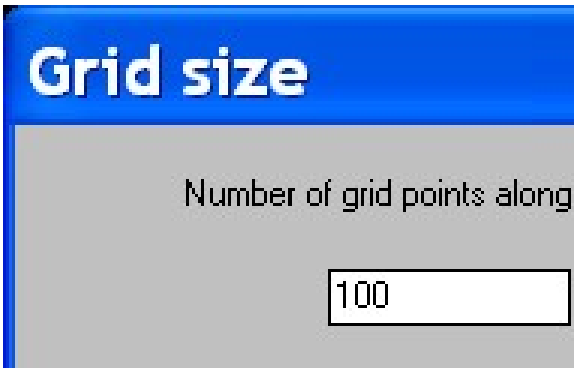
Calculation parameters.- This command will show us the parameters that we have assigned before carrying out the calculation. It is convenient their use with the purpose of verifying that we have written the parameters correctly.

2.6 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:



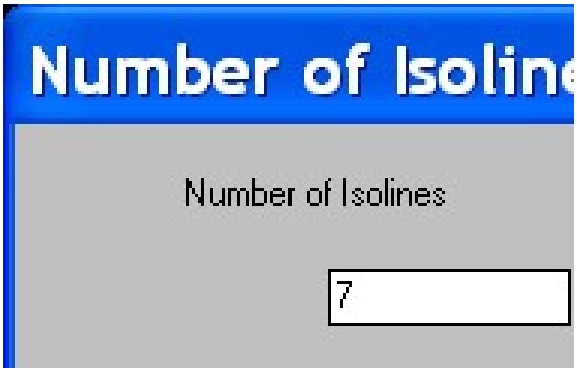
Grid size.- The grid size is an important parameter in the configuration of the system. We will decide the number of calculation points in the grid that we will take to make the simulation. As we increase the number of points, the computer will take much more time in carrying out the calculation but 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.

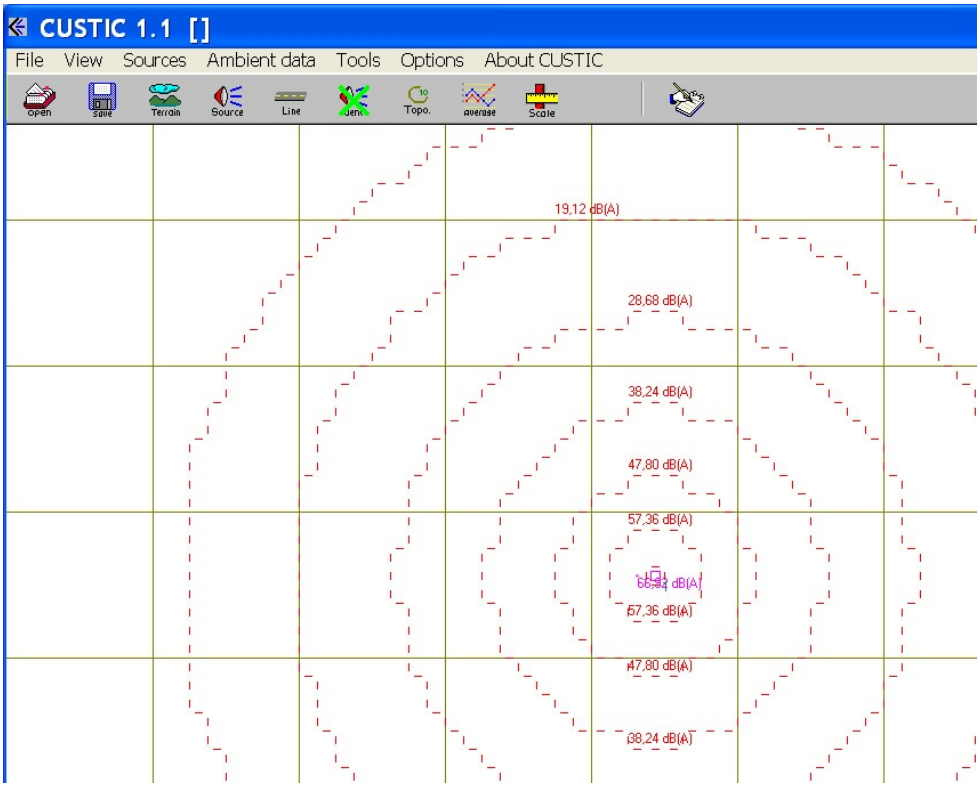
To increase the number of grid points produces that the program needs much more RAM-memory. If we take such a high number of grid points that it overcomes the available memory of the PC, the computer will be blocked.

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:

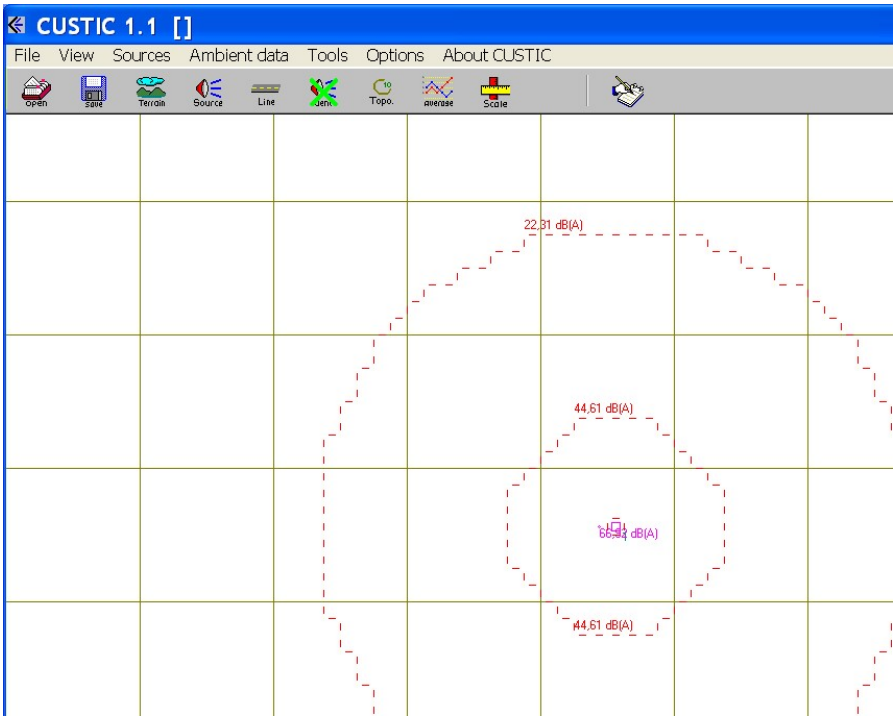


In this window we will be able to choose the number of isolines that we want to have in our computer screen. To calculate the lines, the program also considers the maximum point as a line.

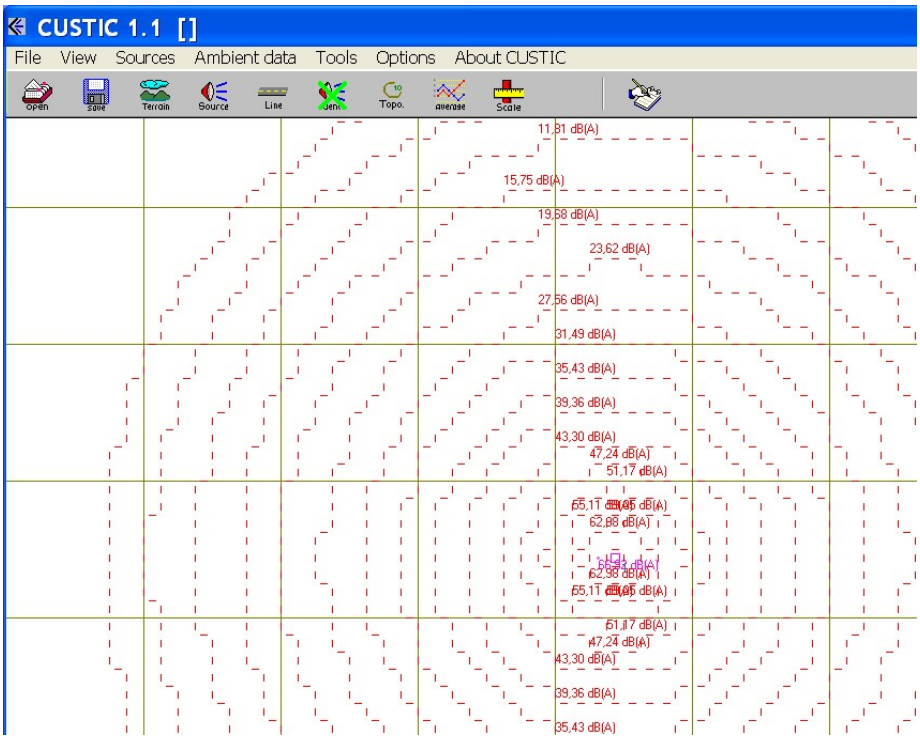
To illustrate the use of this command, we will carry out the same simulation varying the number of isolines. We will use three different number of isolines. Here, the number of isolines is 7.



Here, the number of isolines is 3.



Here, the number of isolines is 17.



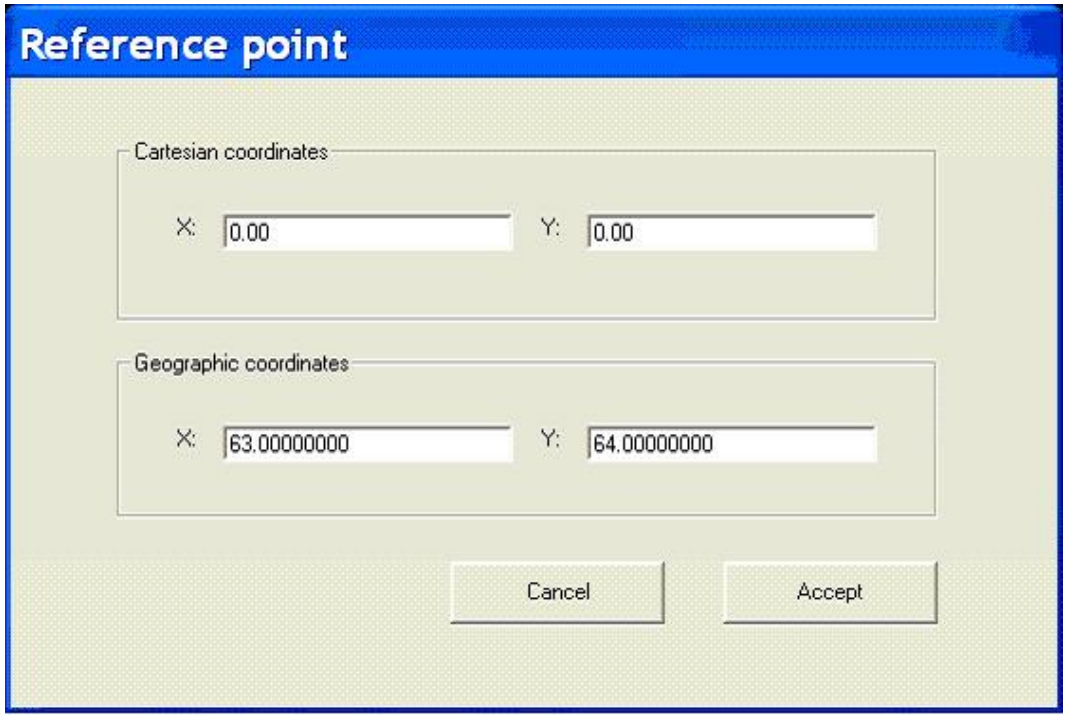
Calculation colours.- By means of this command, we will be able to change the colors of the isolines, of the maximum point and of the point sources.

2.7 GIS

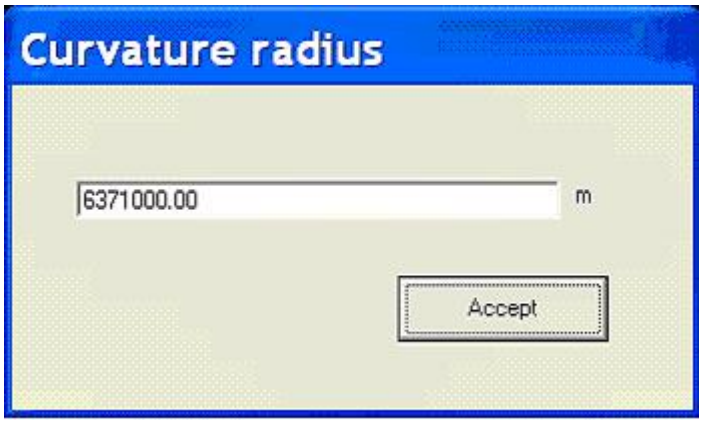
In this option it can be found all necessary to work with geographical information system.

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.

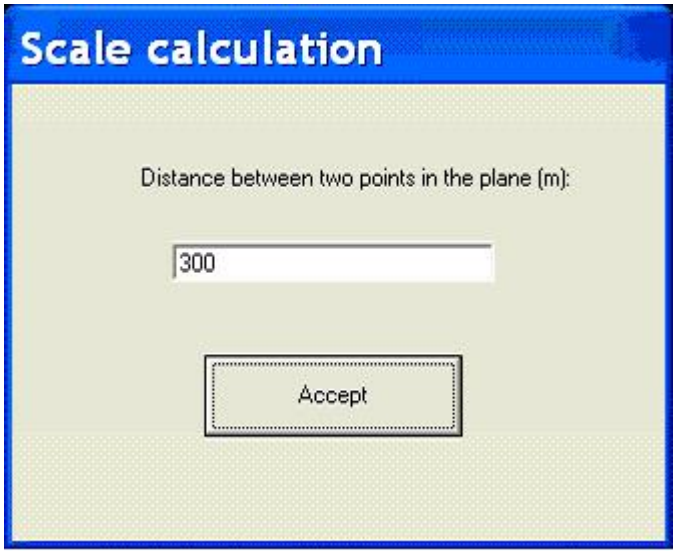
Reference points.- With this command we can decide the coordinate values of a point, that we previously know, in the map in order to have a referenced system. It is possible to work with geographical and Cartesian coordinates. Once you have introduced the desired coordinates, you make 'click' in the 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.



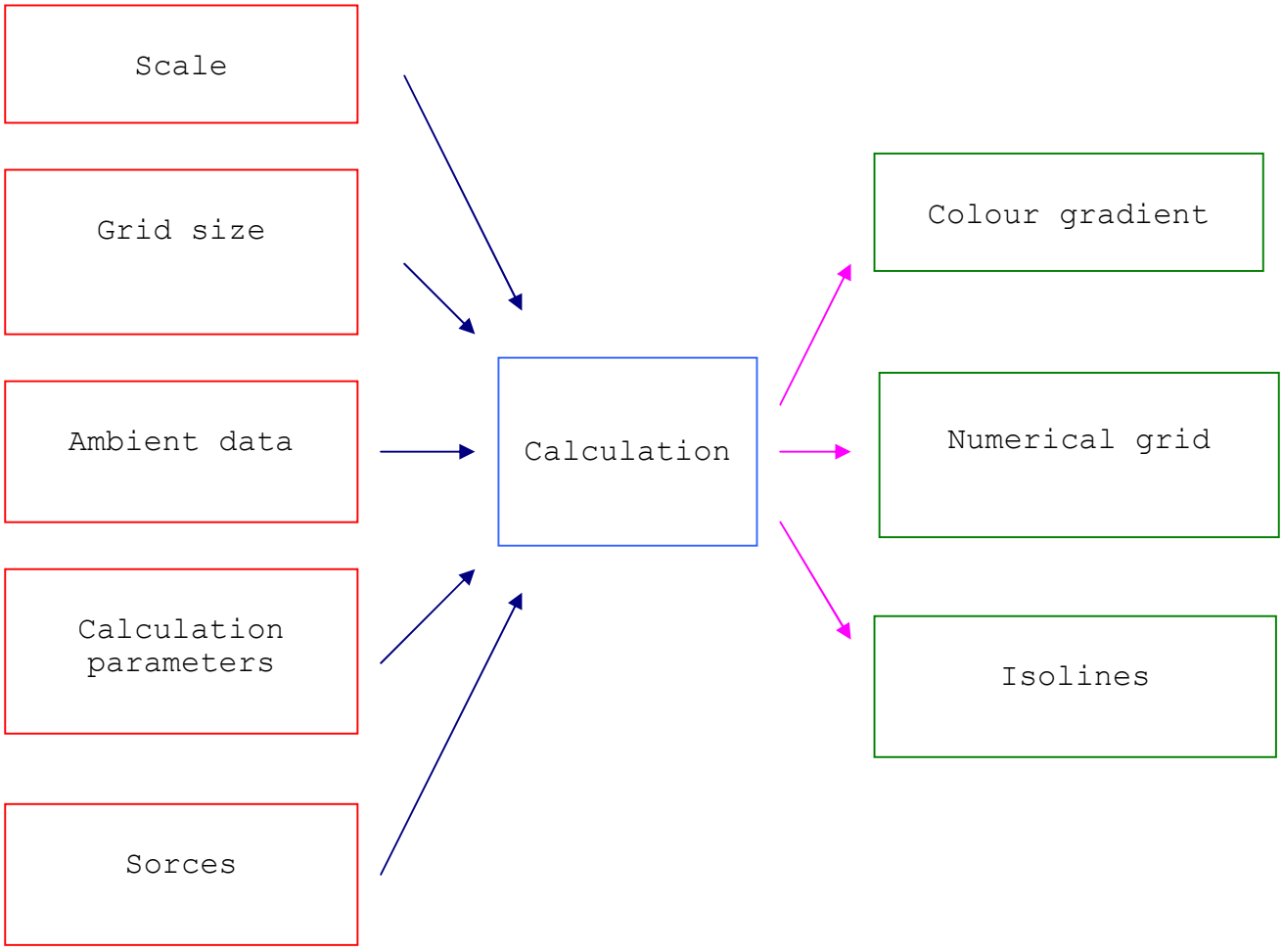
Export maximum, concentrations,….- These are to export the different elements of the programs (isolines, source positions,…) to Microsoft EXCEL csv file. To import without problems with Arcview we have used the english format system for the numbers. For example, one euro and 30 cents is 1.30 euros (NOT 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.

3. 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.

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