Radio Mobile

Training materials for wireless trainers

The Abdus Salam
International Centre
for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

This 60 minute talk gives an introduction on Radio Mobile, a free software for Windows that provide a detailed simulation tool for wireless networks using freely available Digital Elevation Maps.

Version 1.2, @2010-03-12
Version 2.2, @2013-03-5

Goals

- To learn how to use Radio Mobile, a free software that provides a detailed propagation model for radio. It allows to simulate a radio link and perform "what if?" scenarios, by changing the link parameters. It can also show the area coverage from a given site.
- There are two versions of the program: an on-line application and a downloadable version that runs on Windows.
- We will also describe the use of Google Earth for building elevation profiles.

Software for radio link simulation

There are many programs that can be used to simulate radio links and base station coverage, some of which cost thousands of dollars.

By using a link simulator, you can save considerable time during link planning and analysis. For example, if a link is proven to be impossible in simulation, there is little need to perform a site survey, and other options have to be considered (such as the use of repeater sites).

Radio Mobile is a free program developed for radio amateurs by Roger Coudè that is based on the well known Longley-Rice Irregular Terrain Model and predicts radio propagation from 20 MHz to 20 GHz, making use of several sets of freely available Digital Elevation Maps.

This program has been used for a number of years by radio hams and WiFi engineers with good results, provided that sound judgment is employed, since every model has limitations and in particular the free digital maps do not include buildings and other structures.

Windows Vs Web Radio Mobile:

On-line version (web)

Pros: runs on any machine (Linux, Mac, Tablet); does not require big downloads; saves sessions; user friendly, will fetch the elevation data automatically

Cons: requires connectivity; only certain frequencies

Windows version

Pros: runs offline; can use the GPS

Cons: runs on Windows only; requires big downloads; user must select digital elevation maps; hard to learn

It is advisable to start using the on-line version to get acquainted with the capabilities of the software and then move to the downloadable version for extra features.

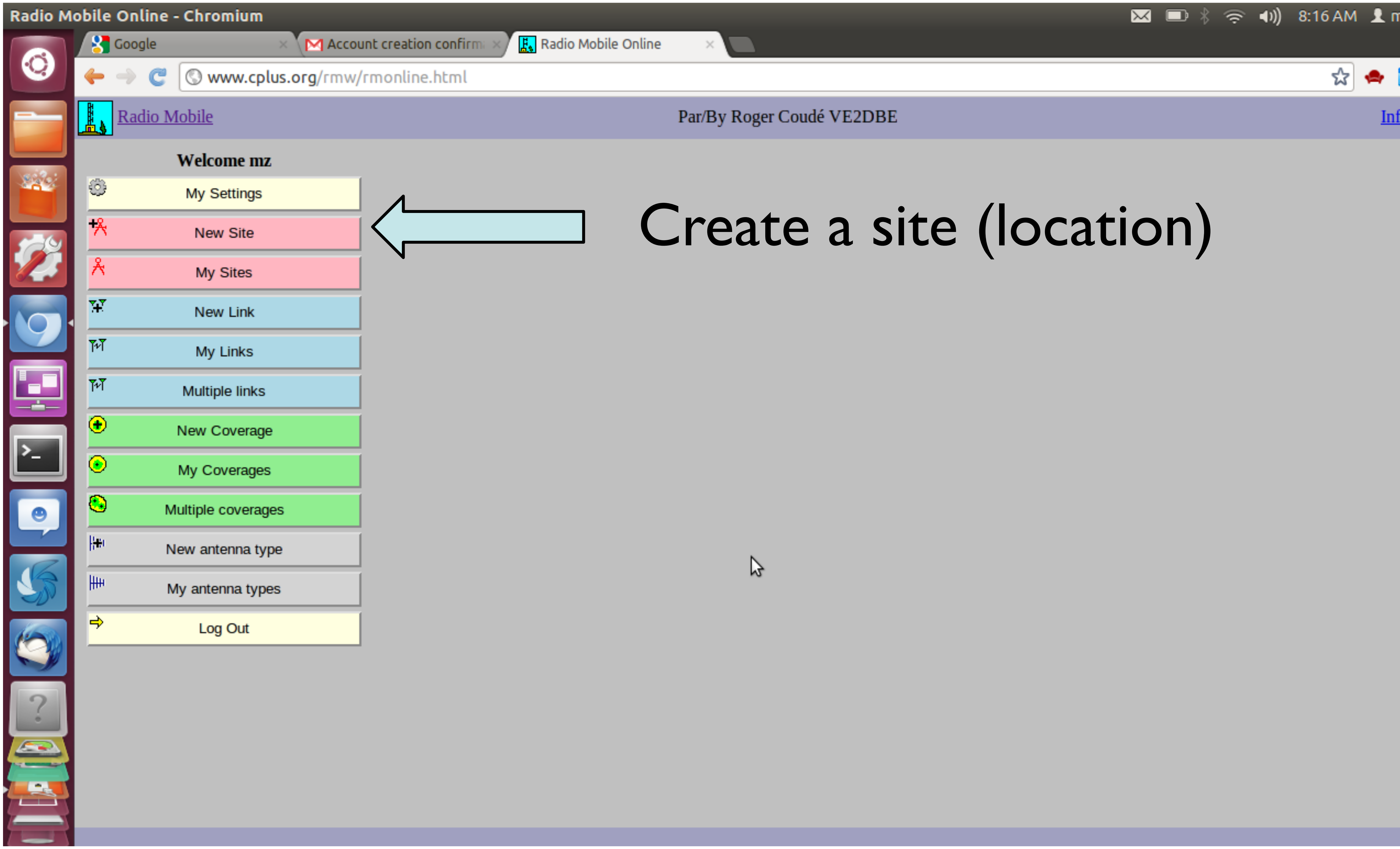
Radio Mobile On-Line

- Point your web browser to

http://www.cplus.org/rmw/rmonline.html

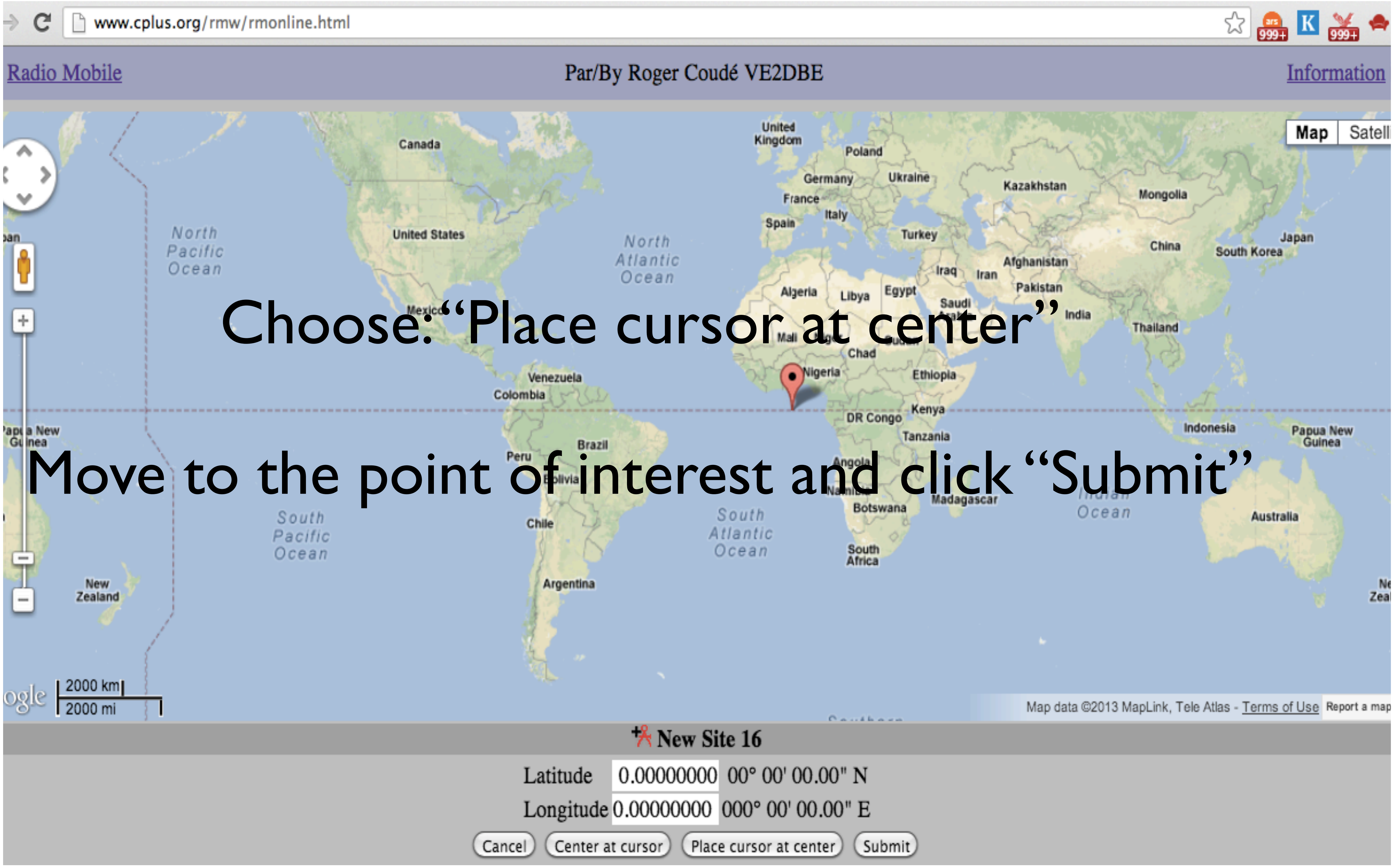
- Register in the site (no cost) and create your account, you will receive your password in your e-mail account.
- You can then start using the program.

Radio Mobile On-Line



Create a site (location)

Radio Mobile On-Line



Choose: “Place cursor at center”

Move to the point of interest and click “Submit”

Radio Mobile On-Line

If you happen to know the coordinates, you can modify the values on the screen.
Check that the elevation provided by the program is reasonable.
Assign a name to the site and click "Add to my sites"
Repeat the procedure for the second site.

A word on power

Electrical power in watts is $P = v^2/R$

Telecommunication antennas have normally R = 50 ohm

In that case, $P = v^2/50$, $v = SQRT(50P)$

The received power level RP is frequently expressed in dBm:

$RP = 10Log_{10} (P/10^{-3})$, therefore $P = 10^{-3}10^{RP/10}$

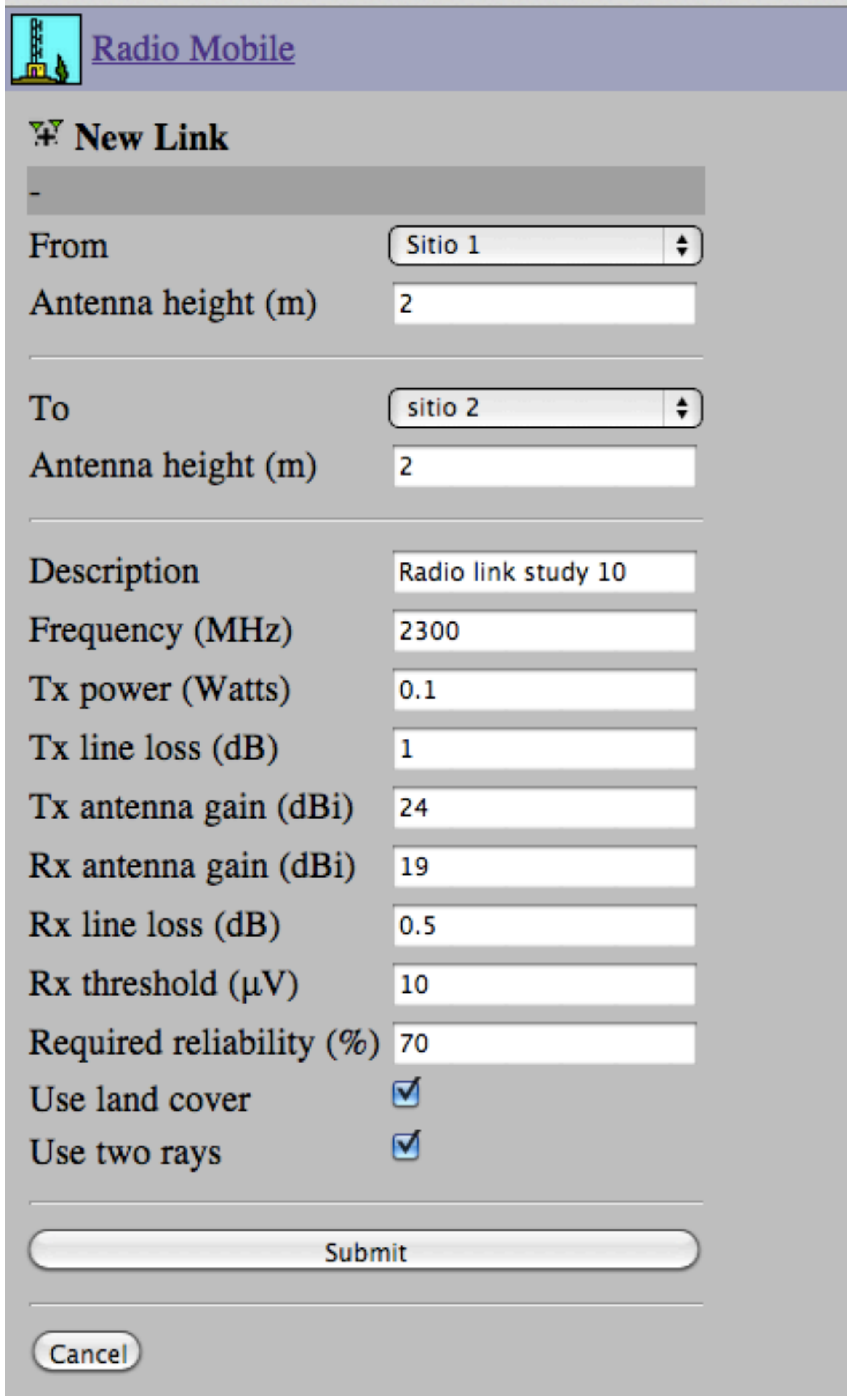
So, the received voltage corresponding to RP dBm is:

$v = SQRT(0.05x10^{RP/10})$

Example: for RP -90 dBm, $v = SQRT(0.05x10^{-9}) = 0.00000707$

That is v = 7.07 microvolts, this the RF voltage one would measure at the antenna terminals

Radio Mobile On-Line



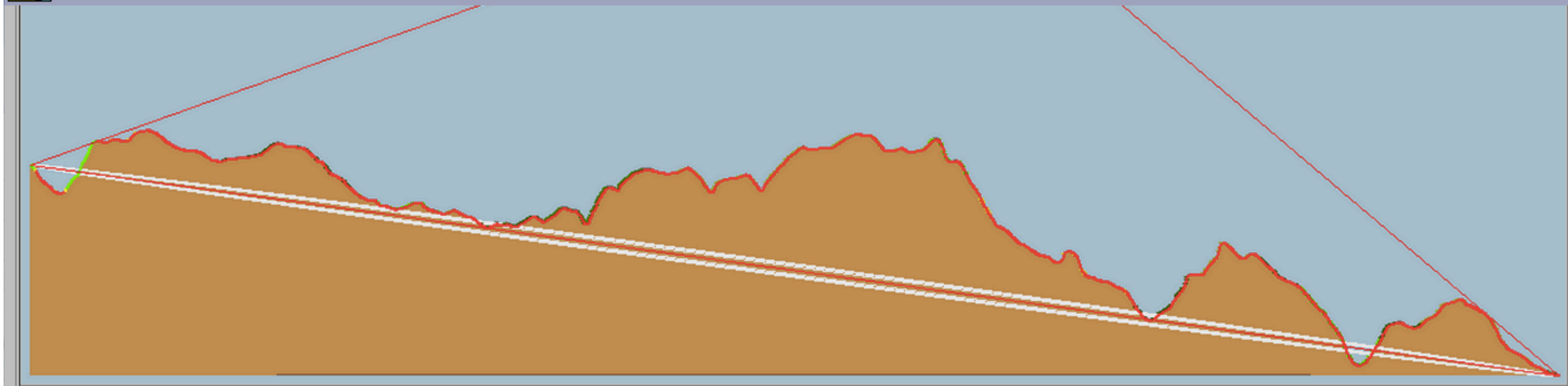
Input 2300 MHz as frequency when working at 2.4 GHz and 5825 MHz when working at 5 GHz, since in the on-line version they are the closest allowed frequencies. This will affect the propagation loss by a small amount.

"Rx Threshold" is the minimum received signal in microvolts, also called "Receiver sensitivity"

Click "Submit".

Radio Mobile On-Line

Radio Mobile — Par/By Roger Coudé VE2DBE — Information



Radio link study 10

Sitio 1 (1)		(2) sitio 2	
Latitude	4.535356 °	Latitude	4.653080 °
Longitude	-73.666077 °	Longitude	-73.355713 °
Ground elevation	2927.1 m	Ground elevation	1082.5 m
Antenna height	2.0 m	Antenna height	2.0 m
Azimuth	69.15 °	Azimuth	249.18 °
Tilt	-3.03 °	Tilt	2.70 °

Radio system		Propagation	
TX power	20.00 dBm	Free space loss	130.96 dB
TX line loss	1.00 dB	Obstuction loss	117.51 dB

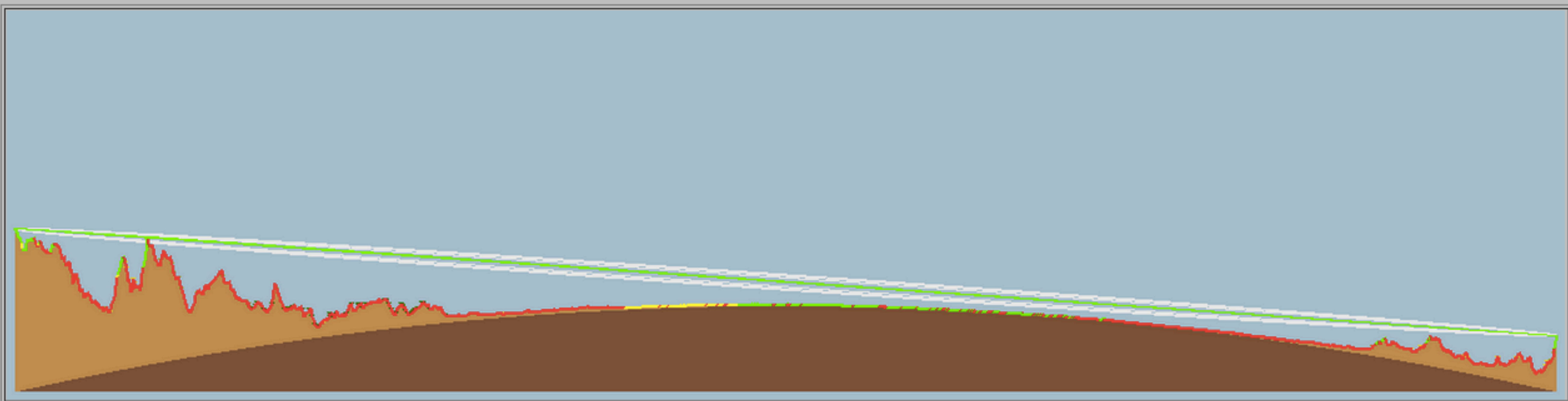
This link is not feasible because of the blocked line of sight

Radio Mobile On-Line

Let's see another link:

Radio Mobile | Par/By Roger Coudé VE2DBE | Information

Return to my links | Return to main menu



Aguila-Platillon

Aguila2012 (1)		(2) Platillon	
Latitude	8.829425 °	Latitude	9.859167 °
Longitude	-70.834667 °	Longitude	-67.521770 °
Ground elevation	4165.4 m	Ground elevation	1519.7 m
Antenna height	2.0 m	Antenna height	2.0 m
Azimuth	72.25 °	Azimuth	252.79 °
Tilt	-2.11 °	Tilt	-1.32 °

This link has a clear line-of-sight and a free Fresnel zone, shown as the white curved line surrounding the straight green line. Notice that the antenna tilt is negative at both ends, despite the fact that one end is much higher. This is because the radio beam is curved due to the refraction introduced by the atmosphere.

Radio Mobile On-Line

Radio Mobile — Par/By Roger Coudé VE2DBE — Information

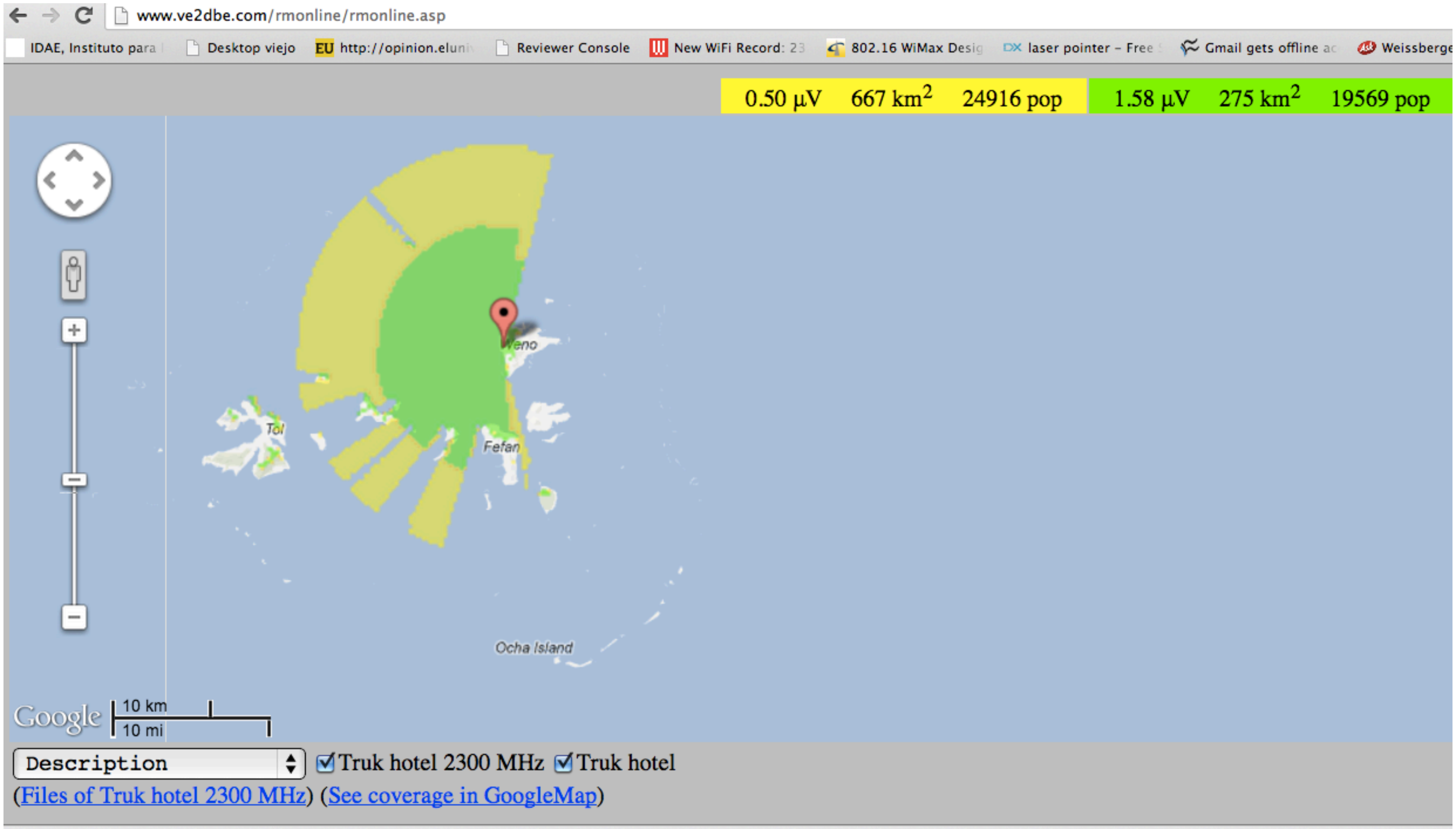
Radio system		Propagation	
TX power	20.00 dBm	Free space loss	151.26 dB
TX line loss	0.00 dB	Obstuction loss	16.58 dB
TX antenna gain	34.00 dBi	Forest loss	1.00 dB
RX antenna gain	34.00 dBi	Urban loss	0.00 dB
RX line loss	0.00 dB	Statistical loss	2.83 dB
RX sensitivity	-97.46 dBm	Total path loss	171.67 dB

Performance		
Distance	**381.091**	**km**
Precision	190.6	m
Frequency	2300.000	MHz
Equivalent Isotropically Radiated Power	251.189	W
System gain	185.46	dB
Required reliability	70.000	%
Received Signal	-83.67	dBm
Received Signal	14.68	µV
Fade Margin	**13.79**	**dB**

Radio Mobile On-Line

Radio Mobile On-Line

Example of area coverage from another site



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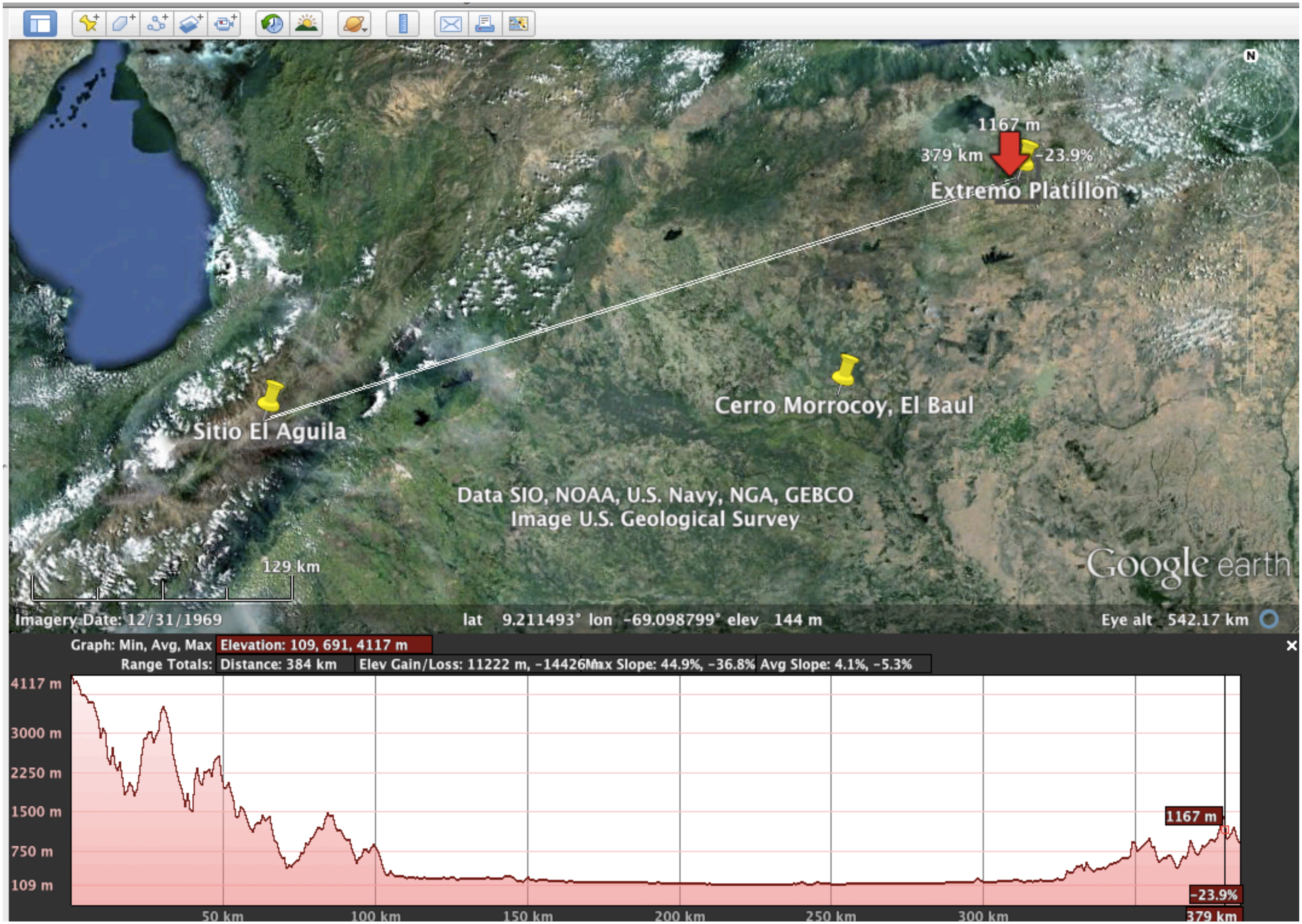
In this area coverage, from a 12 m antenna in a Pacific island, one can see in green the area where the received signal strength is at least 1.58 microvolt and in yellow the area with at least 0.5 microvolt, covering a total of 667 square kilometers.

Elevation profiles with Google Earth

1) In the upper menu, click "Add path"
2) Click to establish the first point and then the second
3) Assign a name to the link (for instance "Longest”) and click OK in the pop-up window
4) The link will show up in the menu on the left.
5) Right click in the link name ("Longest” in our example)
6) Select "Show elevation profile"
7) The elevation profile will be shown on the bottom of the screen
8) Moving along the profile, a red arrow will show the position on the map.



You can see that the earth curvature is not apparent in this graph, so this program is not very useful for long distances, but it can give valuable information for short distance links where the earth curvature is irrelevant.

Why use downloadble Radio Mobile?

Radio Mobile runs in Windows but it can be used in Linux or Mac OS by means of emulators.

It provides all sort of details for point to point links, including expected signal level at any point along the path, including diffraction losses due to obstacles.

Radio Mobile automatically builds a profile between two points on the digital map, showing Fresnel zone and earth curvature clearance, as well as required antenna heights. It is a wonderful tool for exploring "what if?" scenarios.

Download Radio Mobile

Download Radio Mobile here:

http://www.cplus.org/rmw/english1.html

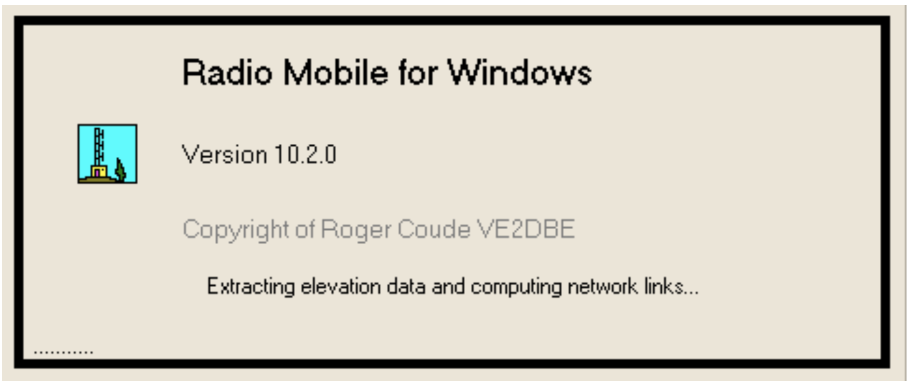
Instructions are provided for how to download the digital elevations maps for your area of interest.

Digital elevation maps come in one degree longitude, X degree latitude tiles so you might need to download a few tiles for your application. Resolution of 30 and 3 arc seconds (or better!) are available for all regions of the world.

Once you have downloaded the maps, you no longer need Internet access (unlike using Google Earth).

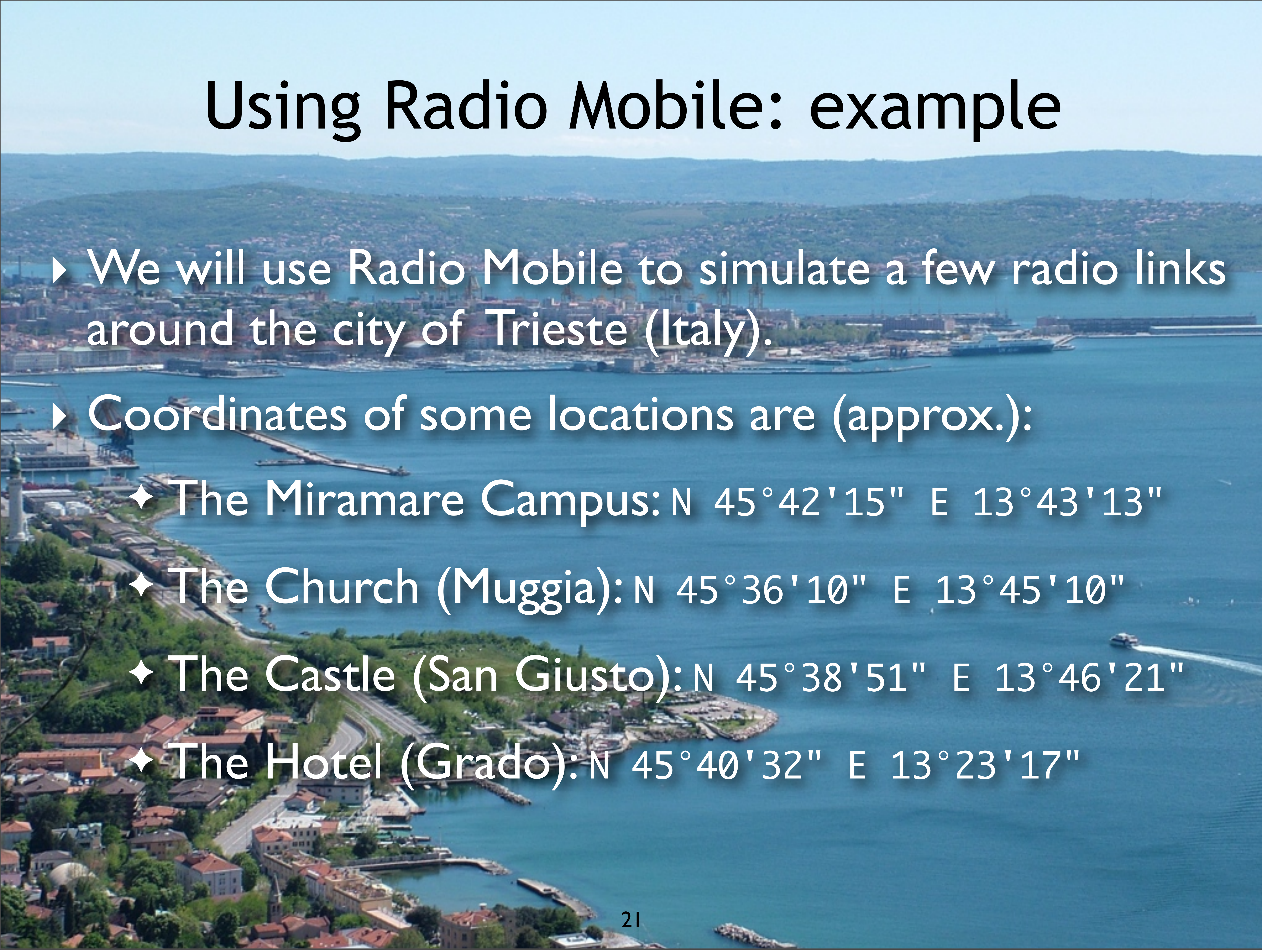
Using Radio Mobile

- Let's assume Radio Mobile is already correctly installed on your computer (installation instructions are provided in the download page).
- We will now review the procedure to simulate a simple wireless network composed of a few nodes
- We will then use Radio Mobile to perform some simple link budget calculations, coverage analysis and "what if?" simulations



Radio Mobile does not come with an installer. The procedure for the installation is quite simple and doesn't require more than a few steps, and a minimum knowledge of Windows OS.

The software comes in two parts, one zip file is common for all languages and it should be decompressed and moved to its final destination on the hard disk (you may choose any reasonable location). A second zip file is localized for different languages. You should select the languages you want to use, download the proper zip file, decompress it and move the resulting executable file into the same folder chosen before. Then double click on this last file to start the program.



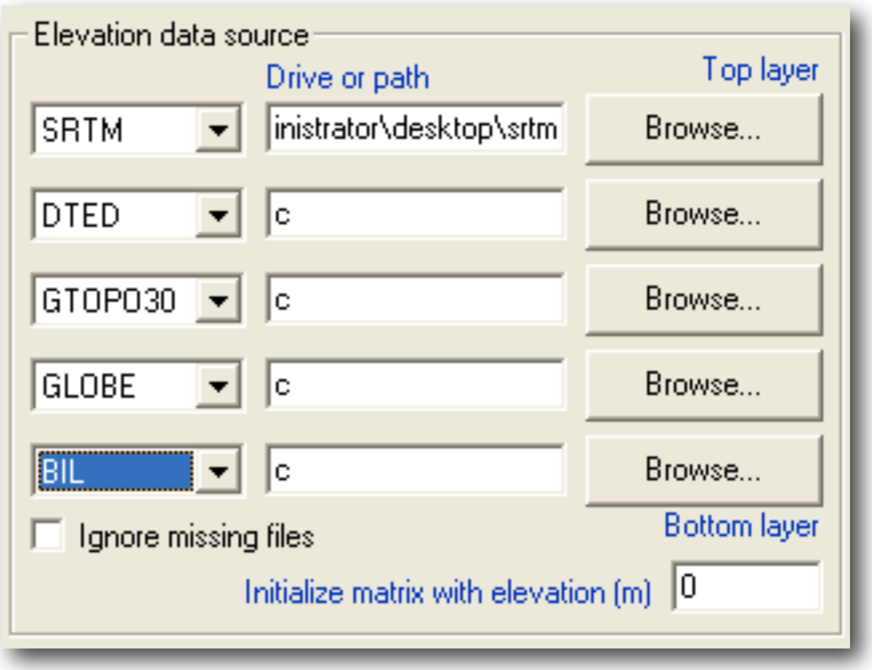
Using Radio Mobile: example

- We will use Radio Mobile to simulate a few radio links around the city of Trieste (Italy).
- Coordinates of some locations are (approx.):
  - The Miramare Campus: N 45°42'15" E 13°43'13"
  - The Church (Muggia): N 45°36'10" E 13°45'10"
  - The Castle (San Giusto): N 45°38'51" E 13°46'21"
  - The Hotel (Grado): N 45°40'32" E 13°23'17"

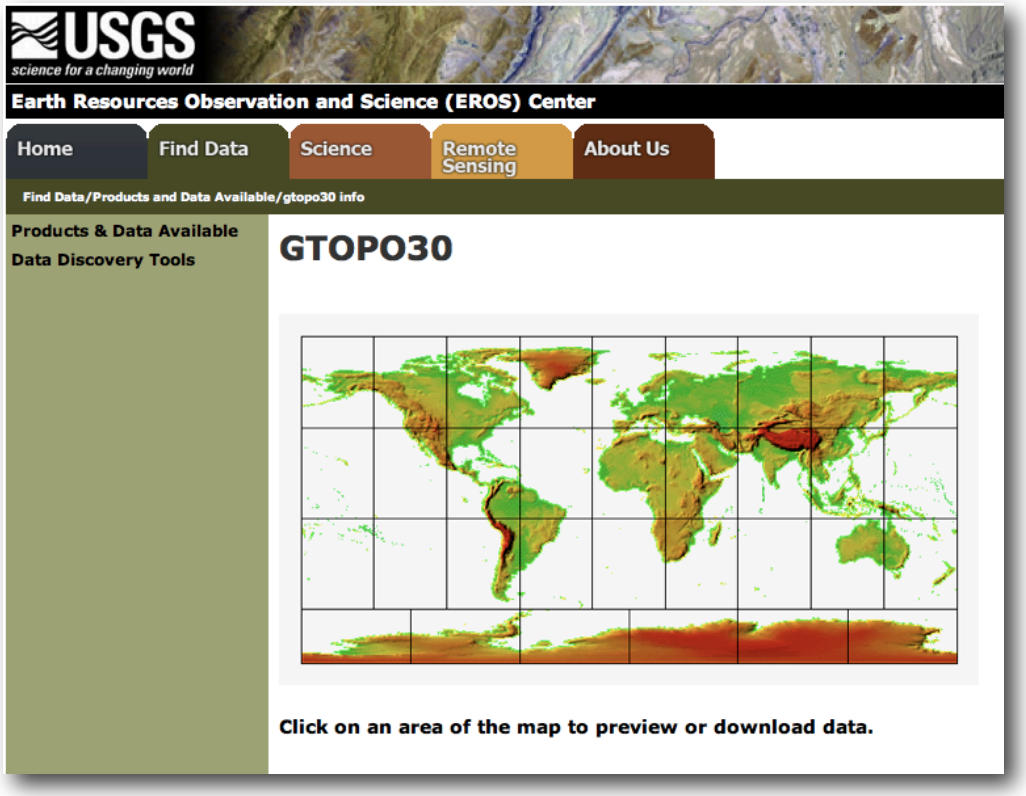
Trieste is a city and seaport in north eastern Italy. It is situated towards the end of a narrow strip of land lying between the Adriatic Sea and Italy's border with Slovenia, which lies almost immediately south, east and north of the city. Trieste is located at the head of the Gulf of Trieste. In 2009 it had a population of about 205,000 and it is the capital of the autonomous region Friuli-Venezia Giulia and Trieste province.
[from Wikipedia]

Using Radio Mobile: DEMs

- Before you start working with Radio Mobile, you may want to download the Digital Elevation Maps of your area of interest. Radio Mobile can use a number of formats including SRTM.



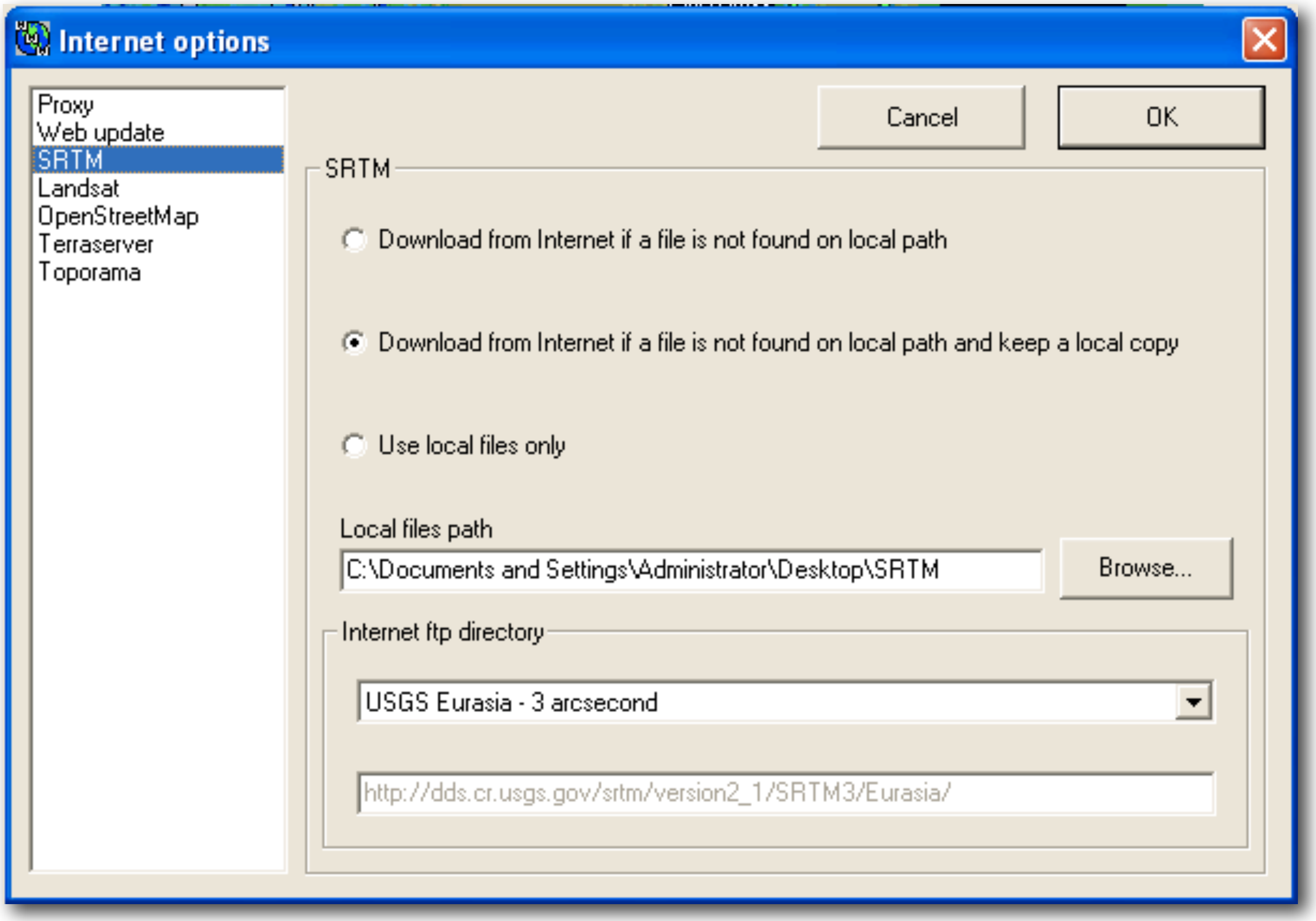
Radio Mobile screenshot



http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30_info

Using Radio Mobile: DEMs

- The simplest way to get elevation data is to let Radio Mobile download it automatically when needed. It will also store the data locally for future use.



Radio Mobile screenshot

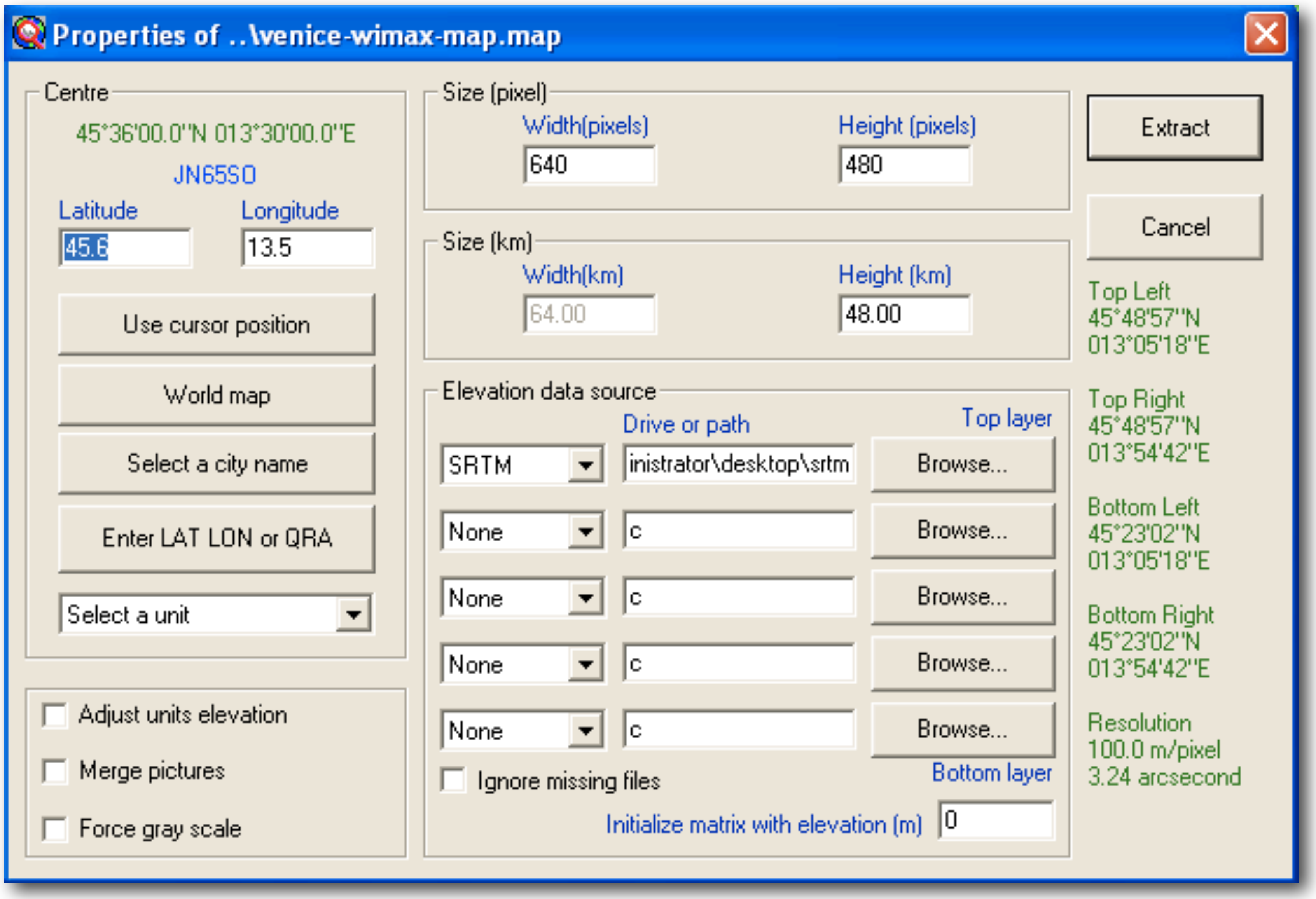
To be sure that the software keeps a local copy of the DEMs and only download what is really needed, you should select the option "Download from Internet if a file is not found on local path and keep a local copy" in the menu “Options”, submenu "Internet", for all different formats.

Using Radio Mobile: create map

- Menu “File”, select item “Map properties”
- Insert coordinates (center of map) and dimensions of the map
- We use:

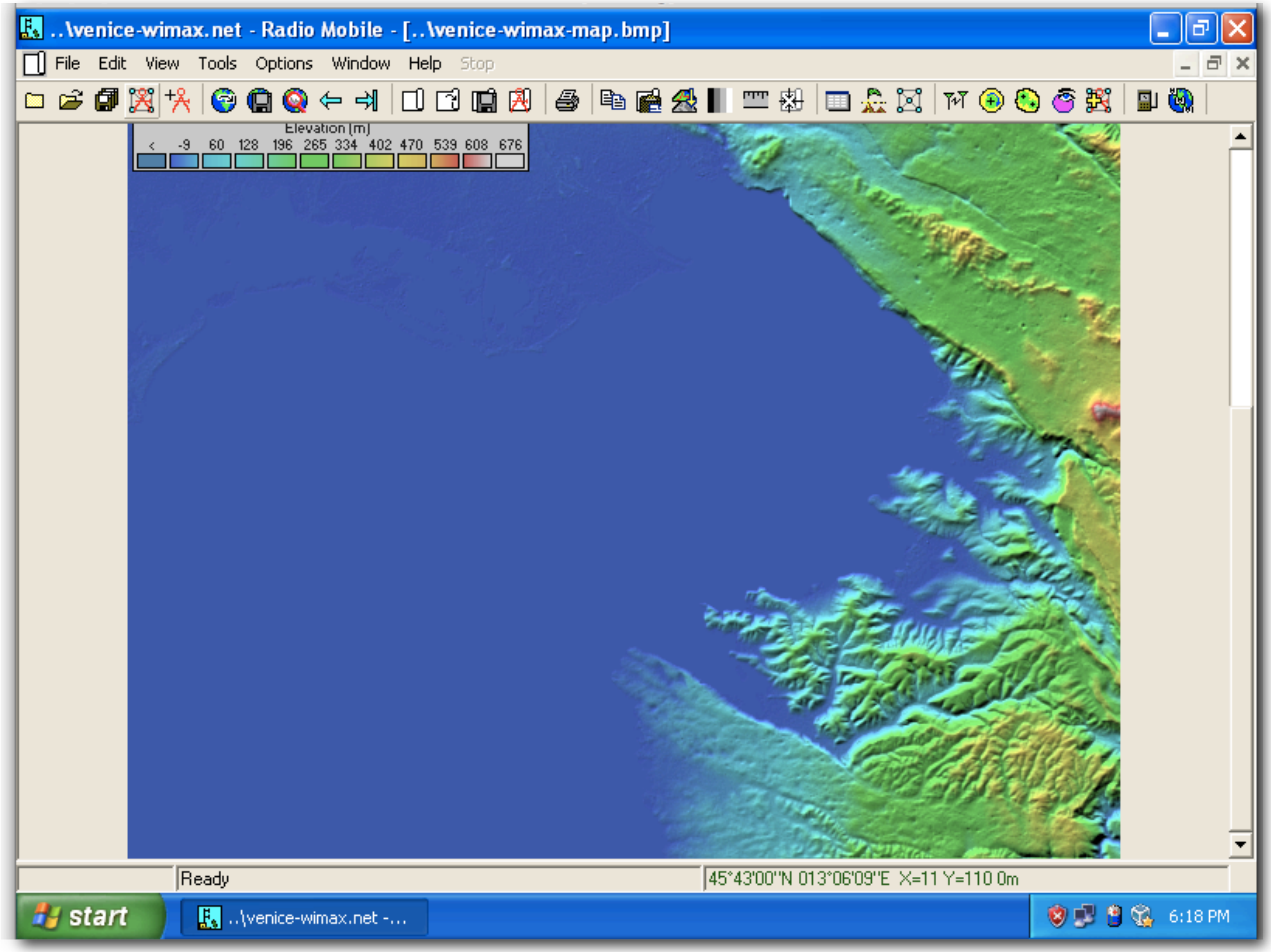
N 45.6 - E 13.5
640x480 pixels
64x48 km

- “Extract”



Radio Mobile screenshot

Using Radio Mobile: the map



The upper left corner looks like flat blue (that means sea level, see the legend with "Elevation" gauge, with different colors showing different ranges of values in meters). But if we look more closely, there are some fine details barely visible: in fact there is a lot of low-elevation terrain there (it's a lagoon area).
Sometimes Radio Mobile does not make it very easy to recognize cities and other geographic features (roads, etc.). You can add (superimpose) a topographic map with roads and other indications to make this task easier, though these maps may not be available everywhere.

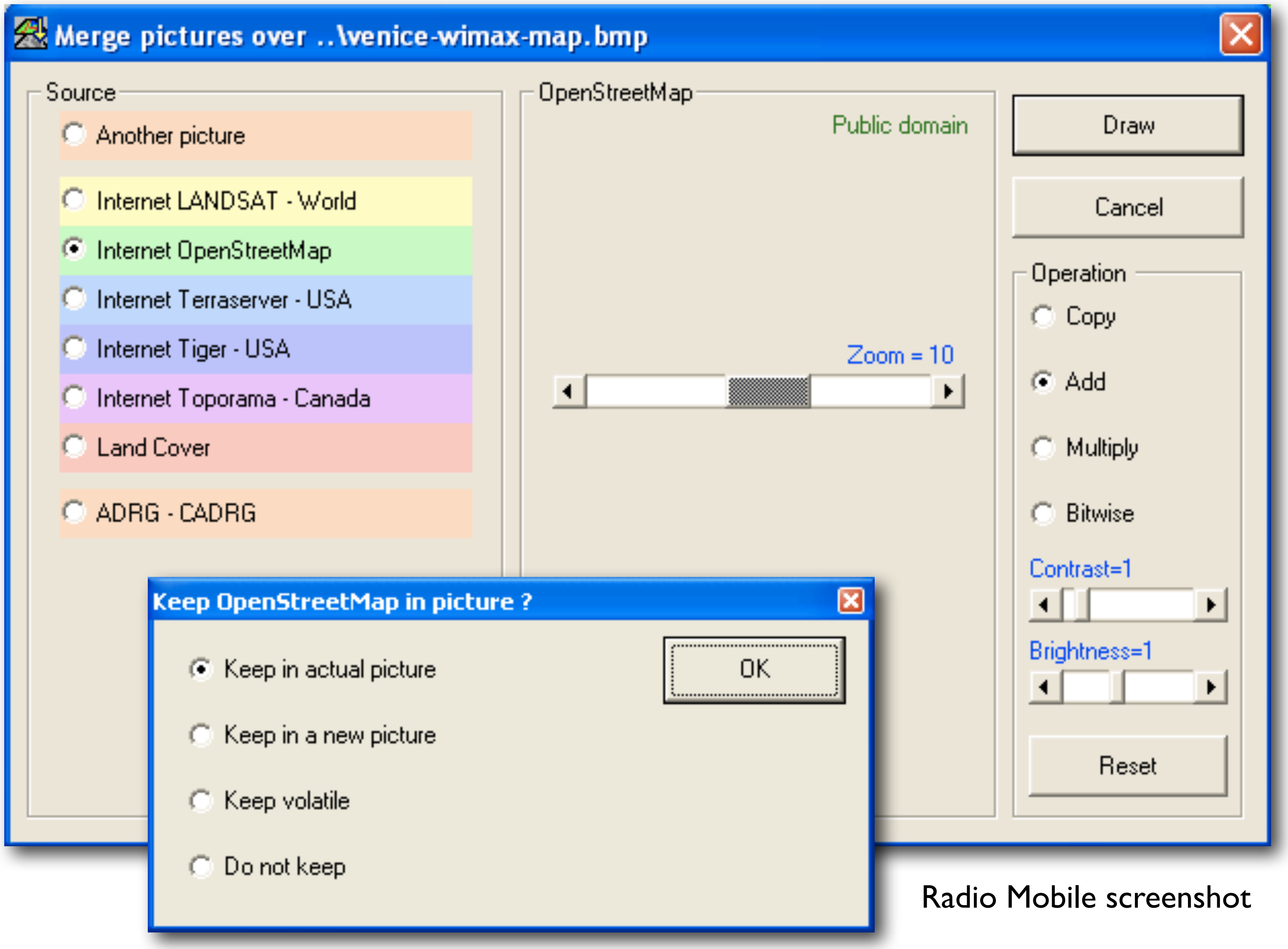
Using Radio Mobile: add map

- We can add road details using this procedure: menu “Edit” select item “Merge pictures...”
- Then select

  OpenStreetMap

  with Zoom=10

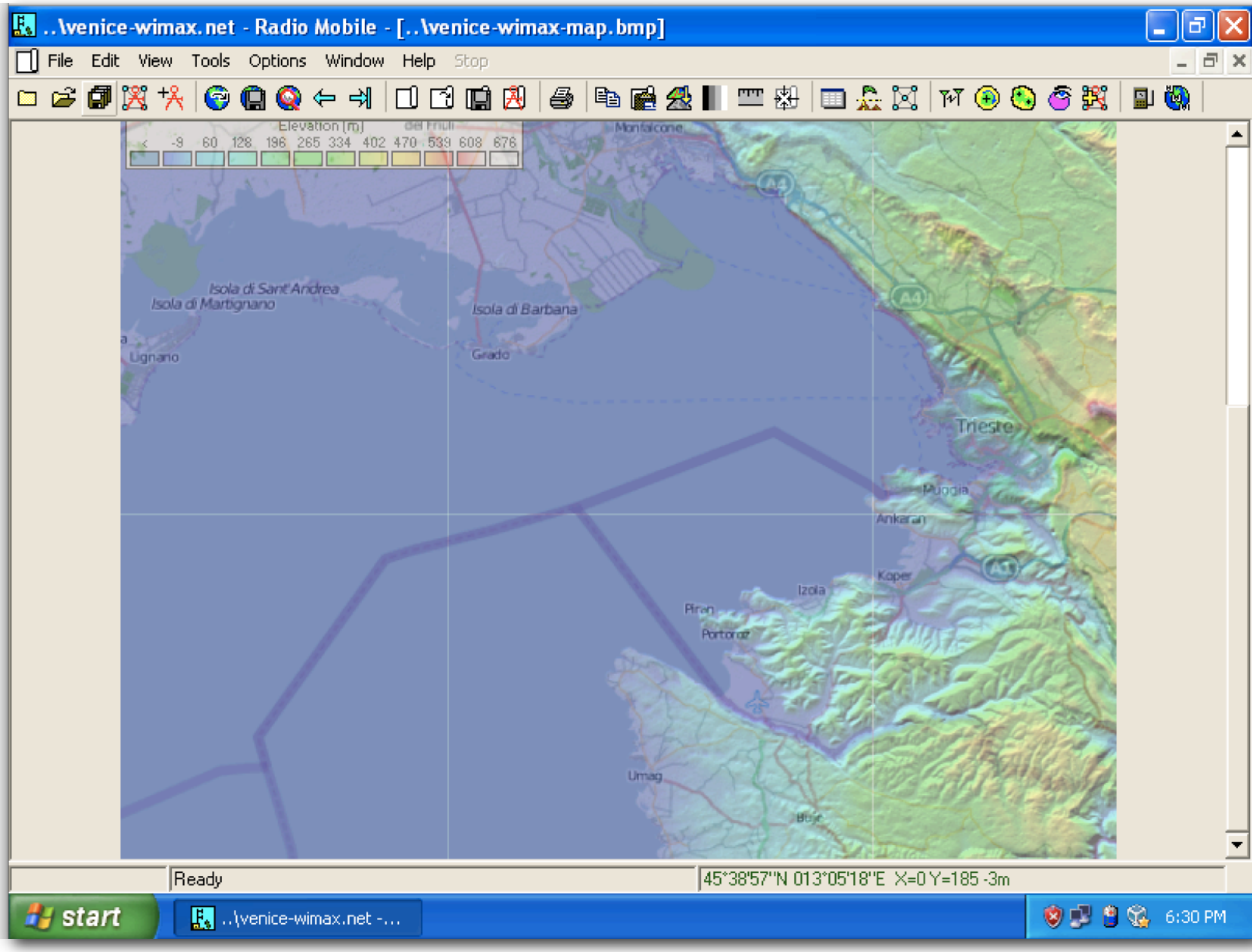
  Operation: Add
- click on “Draw”
- “Keep in picture”



Radio Mobile screenshot

OpenStreetMap creates and provides free geographic data such as street maps to anyone who wants them. The project was started because most maps you think of as free actually have legal or technical restrictions on their use, holding back people from using them in creative, productive, or unexpected ways.
[from OpenStreetMap website www.openstreetmap.org]

Using Radio Mobile: new map



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The result is the superimposition of two maps, the first one showing the digital elevation and the second one with details of roads, cities, borders, etc...
Now the lagoon area in the upper left corner is clearly visible (including the town of Grado)

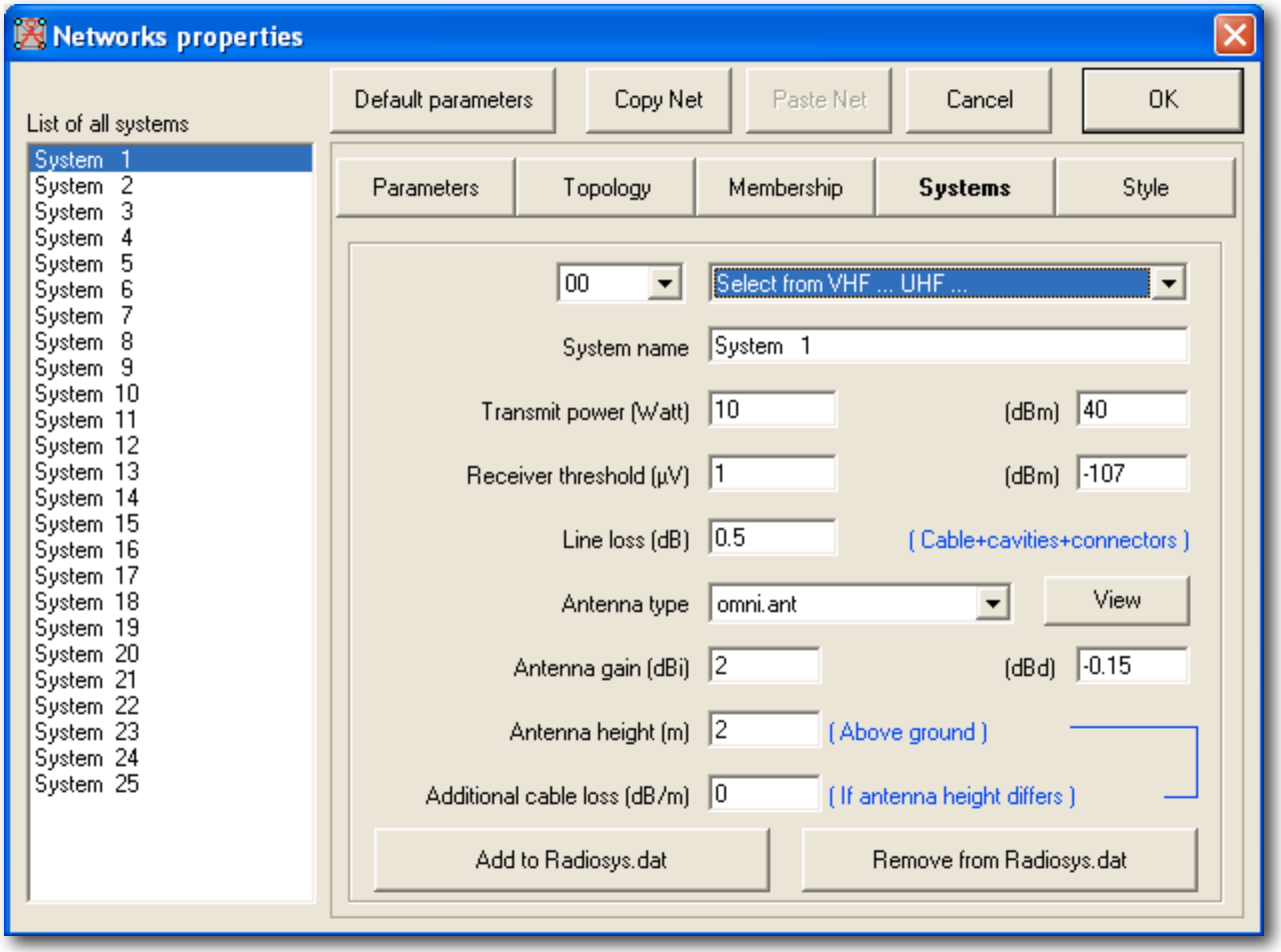
Using Radio Mobile: terminology

- Radio Mobile has its own special terminology. In order to create radio links we need to learn a few new terms:
  - a **system**: a particular choice of radio and antenna (TX power, gain, radiation pattern, ...)
  - a **unit**: a system installed in a particular location (coordinates, height of antenna, ...)
  - a **network**: a set of units, part of the same radio network (all at the same frequency)

These terms are listed in the order in which we need to create them:
We will make a network composed of 4 units. They will be created using two different systems (radio+antenna).

Using Radio Mobile: systems

- Let's create two different systems (WiFi@2.4GHz):
- SmallRadio: P_{TX}=16dBm S_{RX}=-90dBm omni 8dBi
- BigRadio: P_{TX}=20dBm S_{RX}=-96dBm dish 24dBi
- other: default



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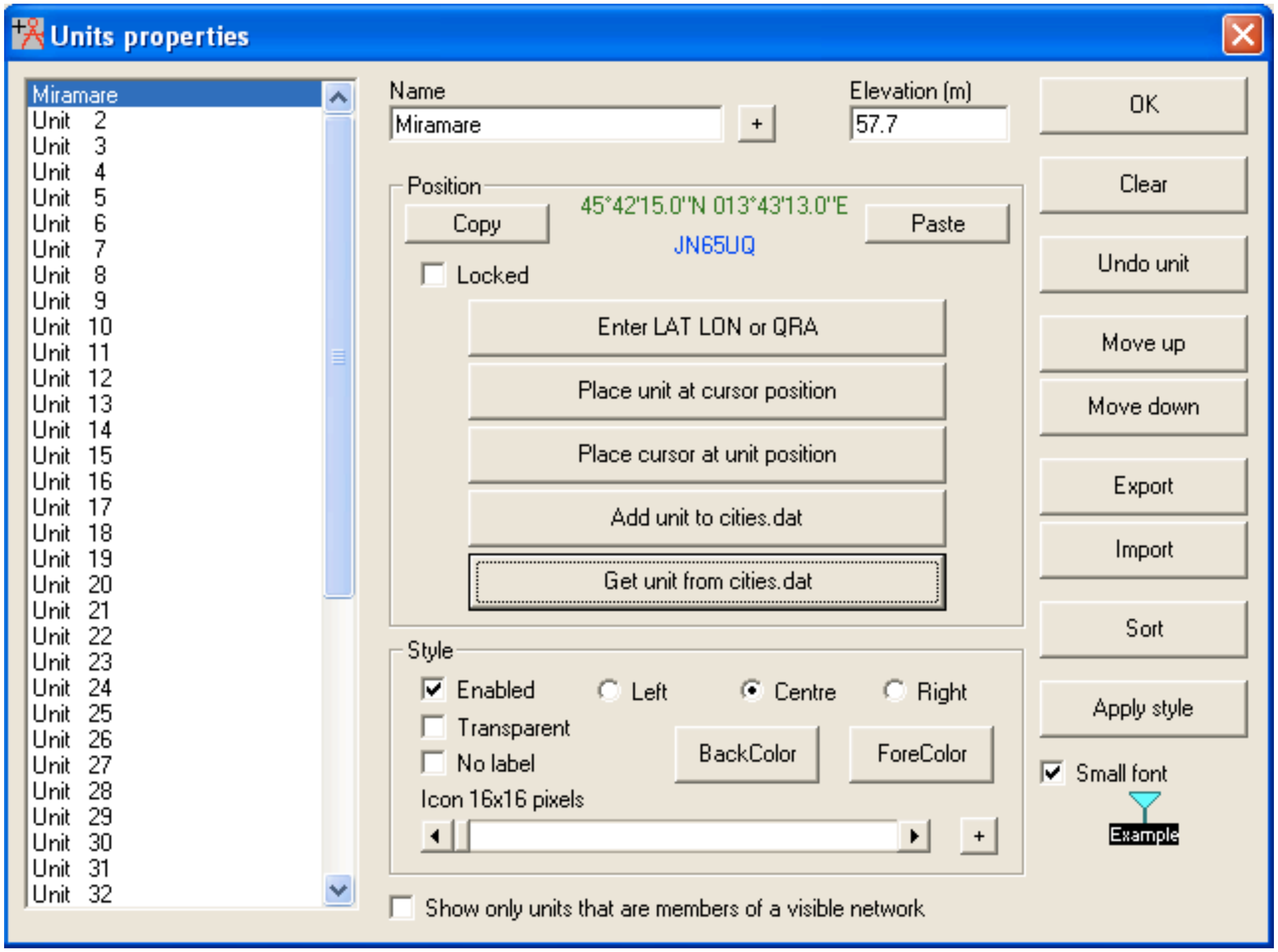
Select item "Network properties" from the menu "File", and go to the tab called "Systems".
Trick: to make things simpler at the beginning, for the system "BigRadio" you can just select an antenna of type "omni" and change the gain to 24dBi. This will be equivalent to a dish of 24dBi, working in all directions.

Using Radio Mobile: units

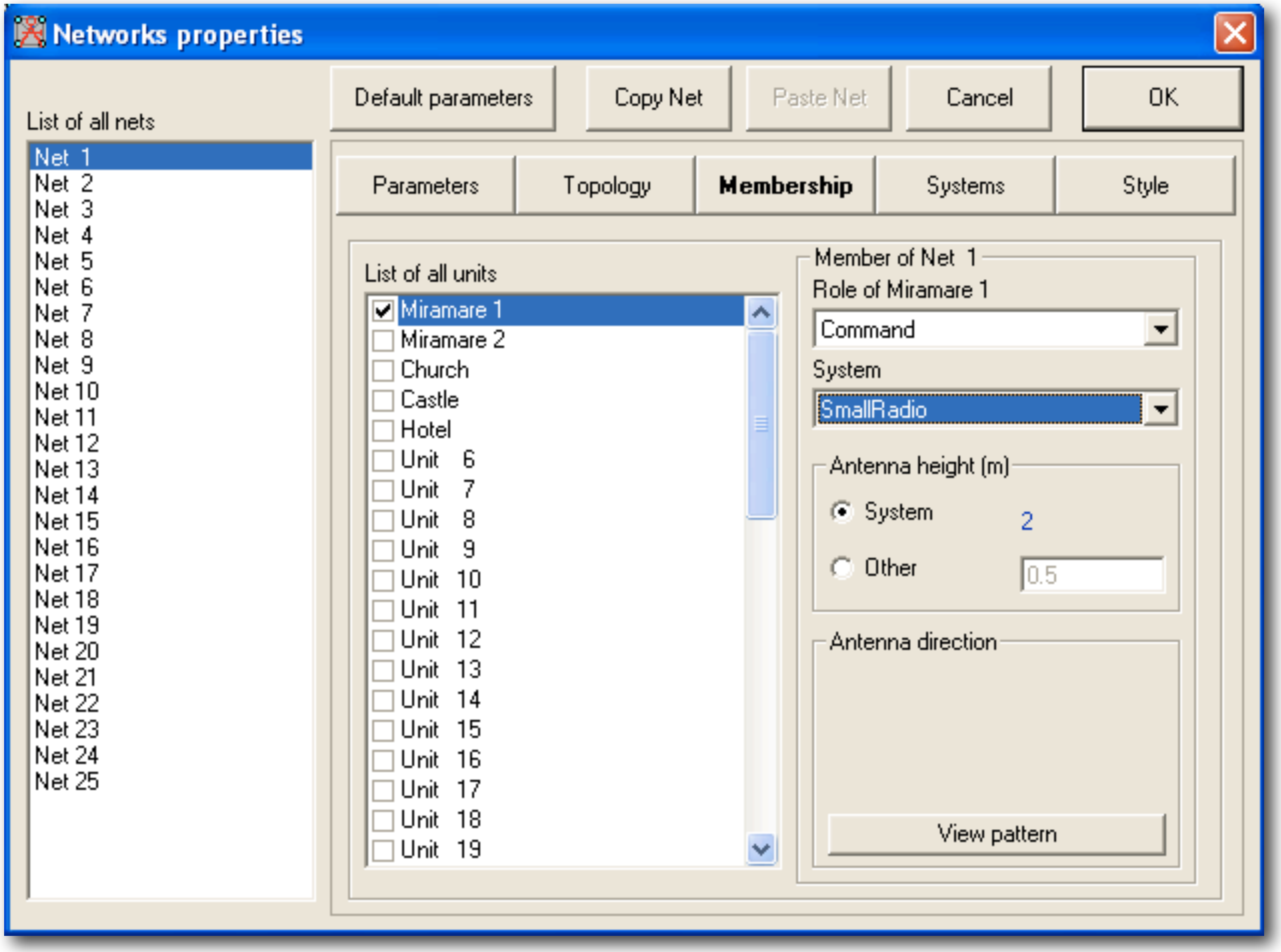
- Let's create 5 new units, located in the 4 sites:
  - *Miramare 1*
  - *Miramare 2*
  - *Church*
  - *Castle*
  - *Hotel*



Select item "Units properties" from the menu "File".
Then you can enter the Name and the coordinates. The elevation of the point will be automatically retrieved from the DEM.

Using Radio Mobile: units

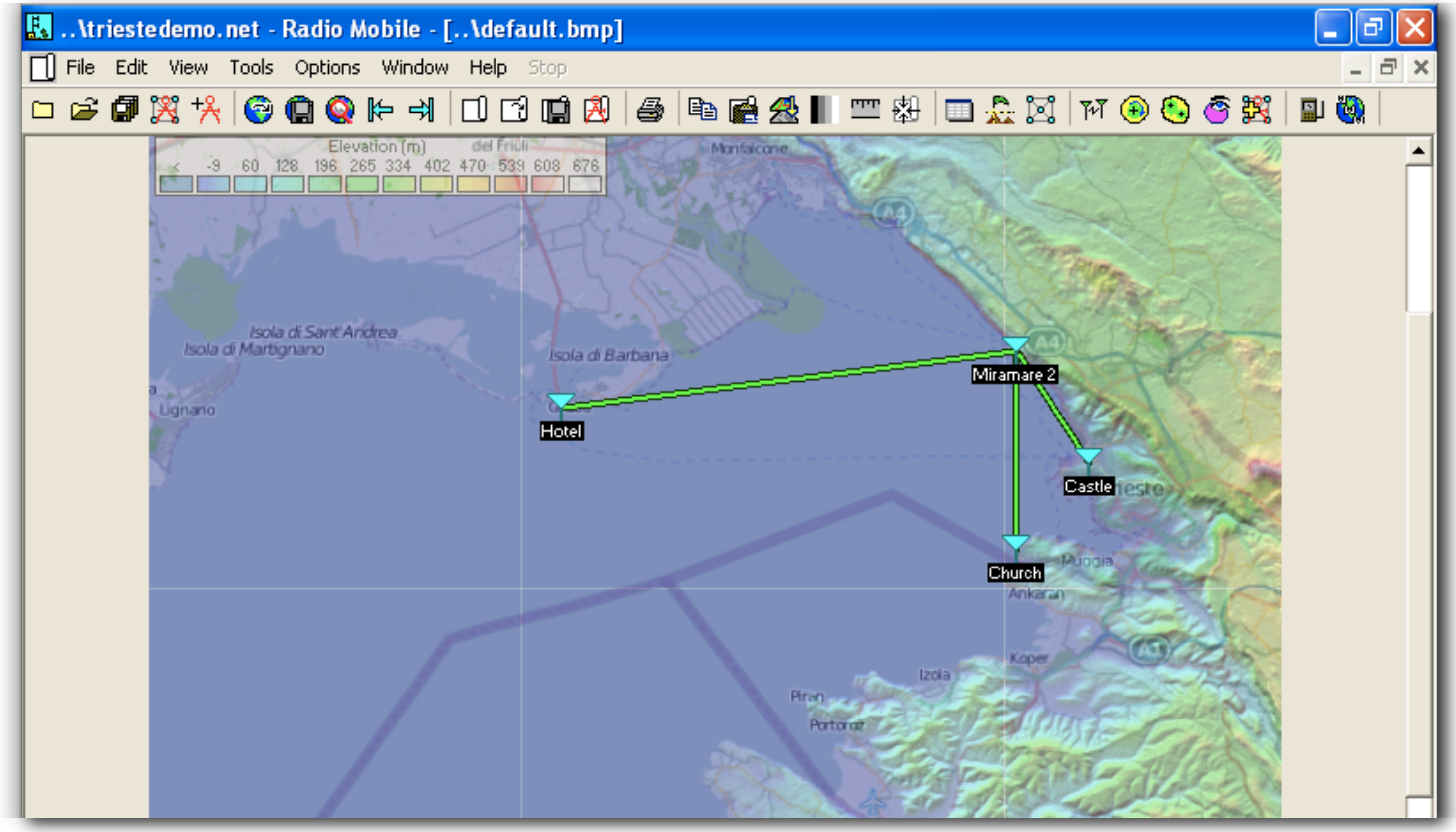
- After creation, you should assign the proper system to each unit:
- *Miramare 1*
- *Church*
- *Castle* are all "SmallRadio"
- *Miramare 2*
- *Hotel* are both "BigRadio"



Select item "Networks properties" from the menu "File".
Then go to the tab "Membership" and there you will be allowed to edit the system and role for each unit.
Use the role of "Command" for Miramare 1 and Miramare 2, and the role of "Subordinate" for all other units.
Before to make any change, you have to enable the unit in the list (by clicking on the small box in front of its name in the list).

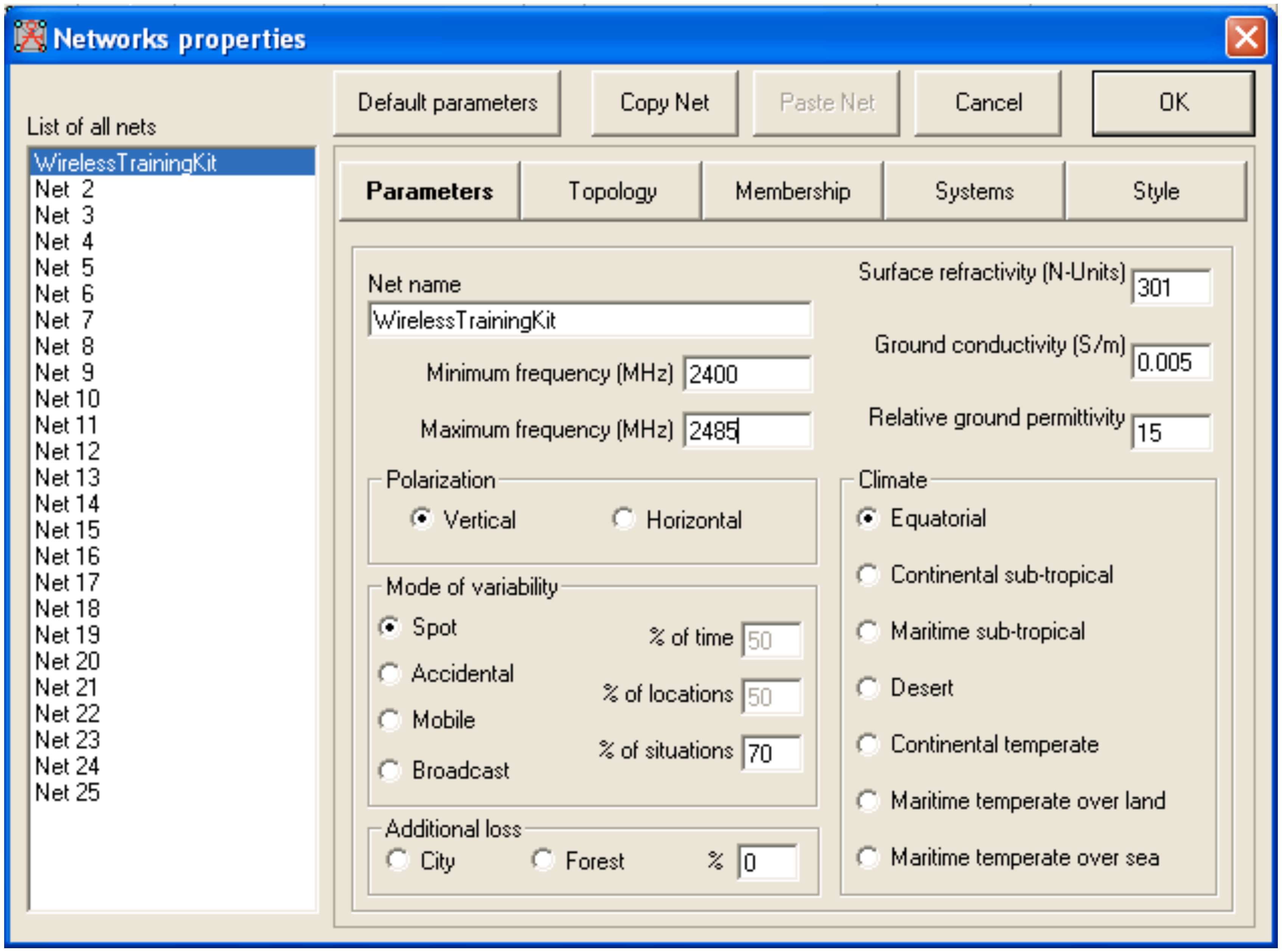
Using Radio Mobile: network

- To view your network on the map, just select "View" →"Show networks"→"All"



Using Radio Mobile: network

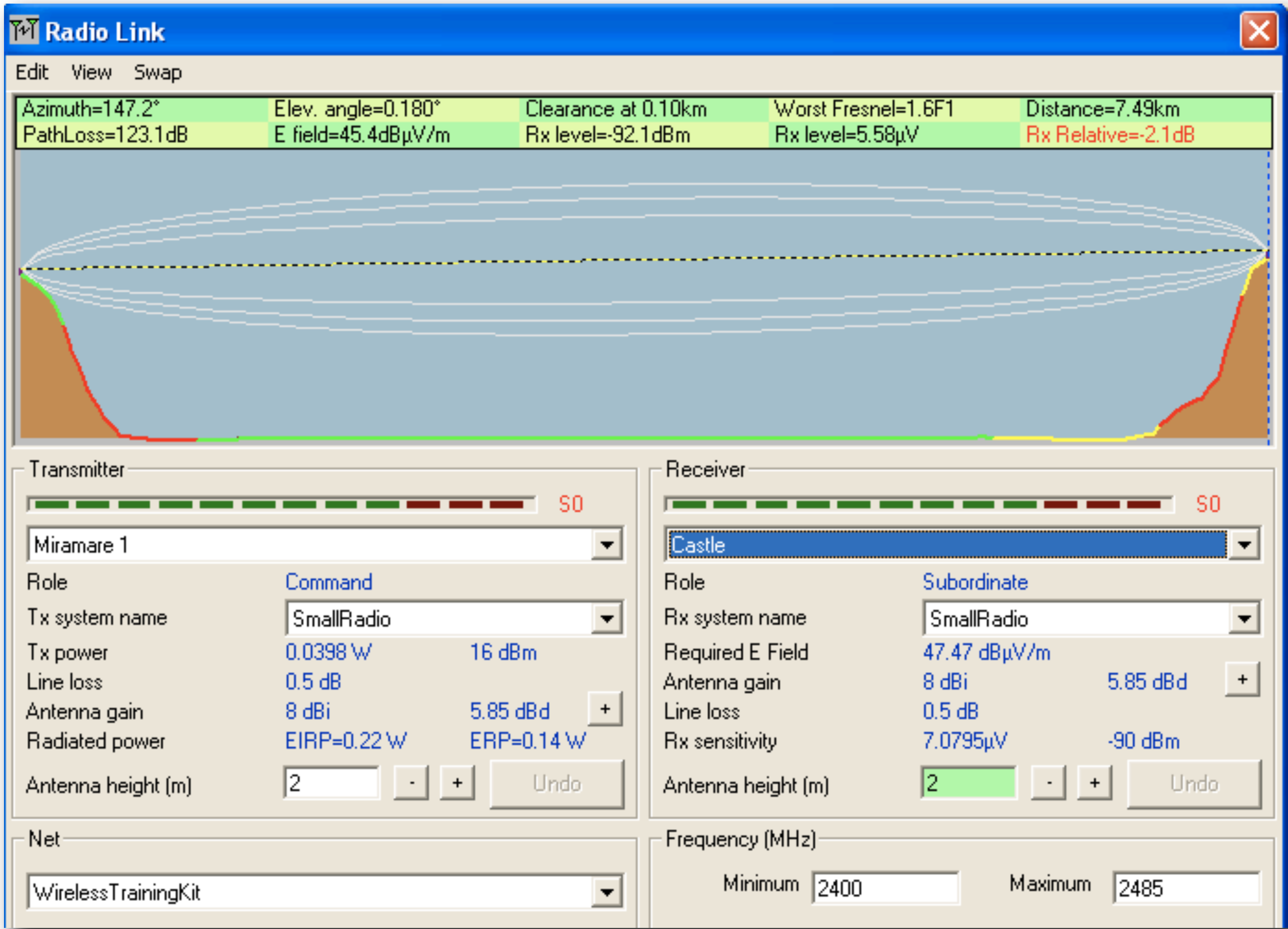
- To be able to correctly calculate the loss due to propagation, you should set the correct frequency.
- We are using the 2.4GHz band, so let's set the range 2400-2485.



We can leave the polarization vertical and anything else with a default value for now (but there is a lot of room for "playing" with all parameters later and seeing the results).

Using Radio Mobile: results

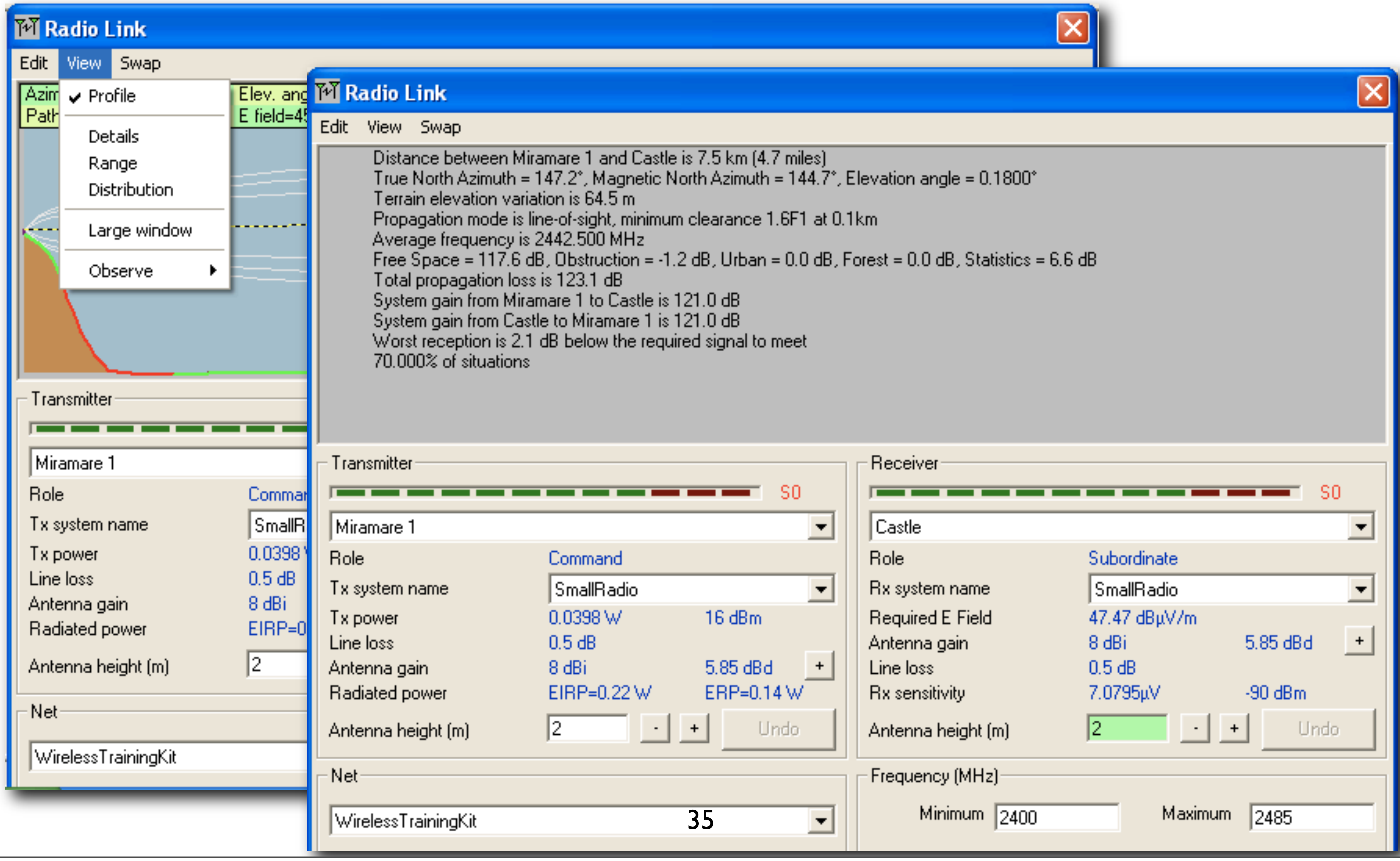
- Now that we have set our scenario, let's calculate the link budget for our links: "Tools" → "Radio link"



The software will now output a graph of the link profile and also the result of the calculation.

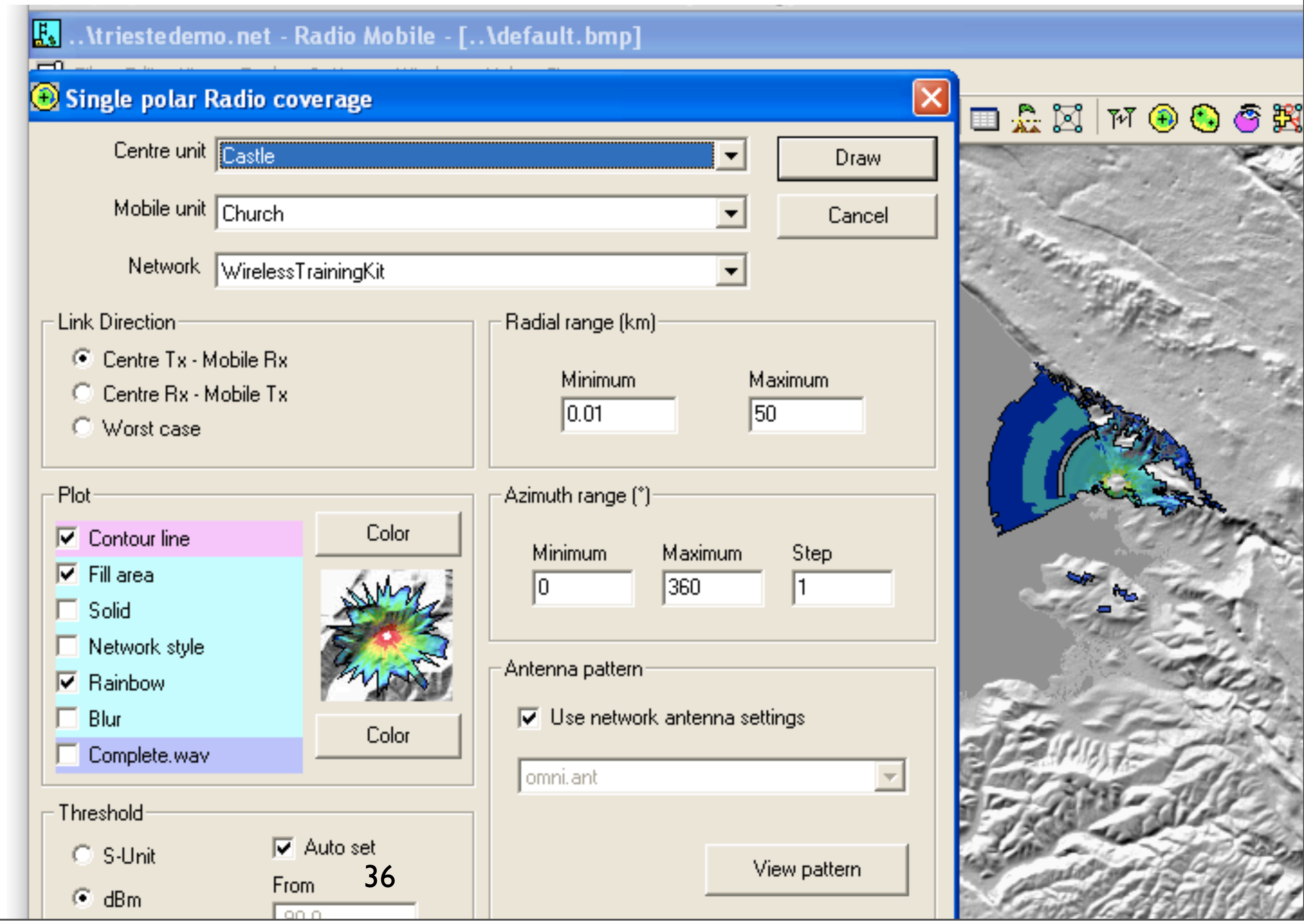
Using Radio Mobile: results

- You can switch to the detailed view, that gives you a textual description of the output of the simulation



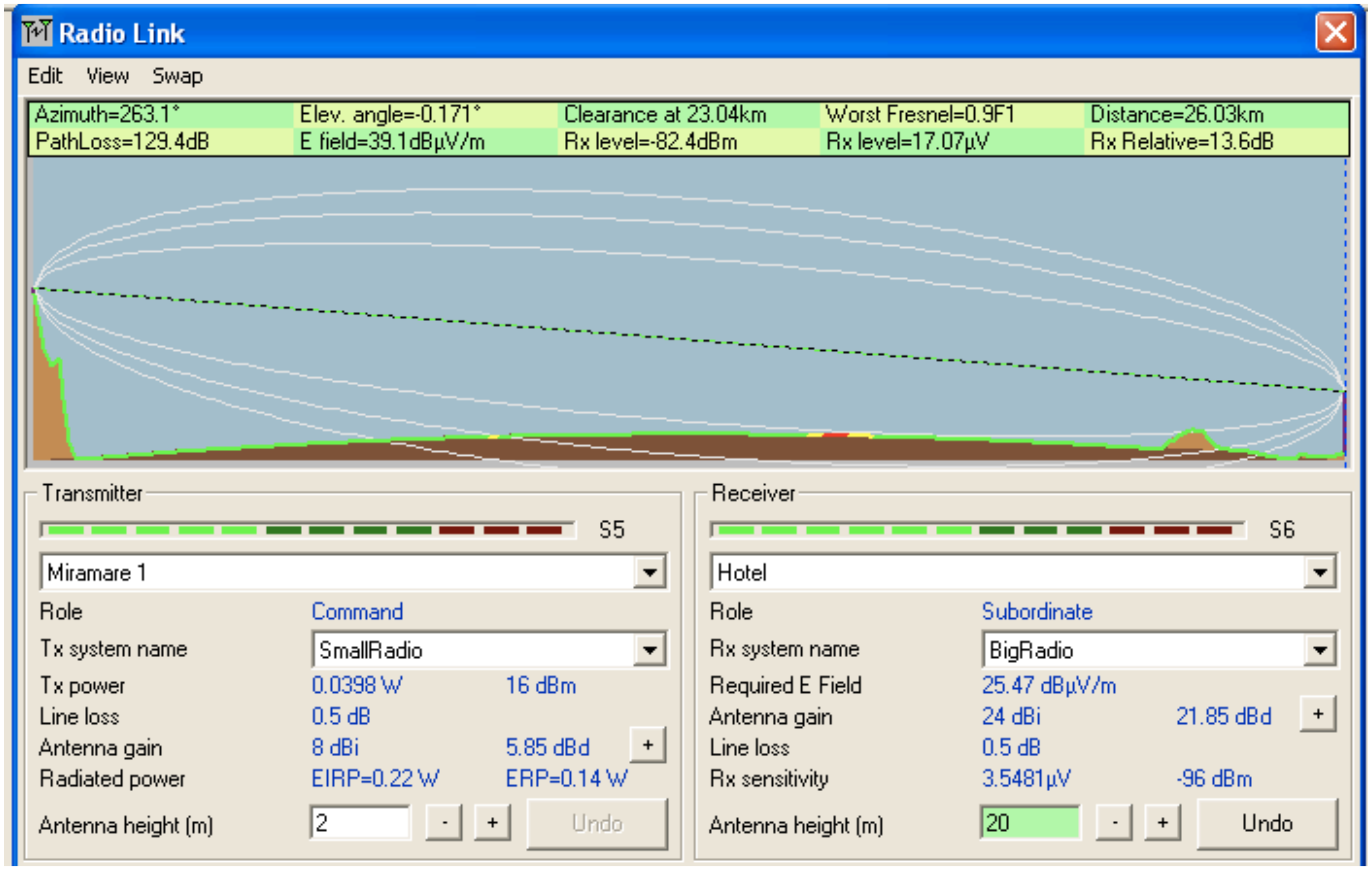
Using Radio Mobile: coverage

- “Tools” → “Radio coverage” → “Single polar”
- This will start the calculation of the coverage area of a selected station in your net.

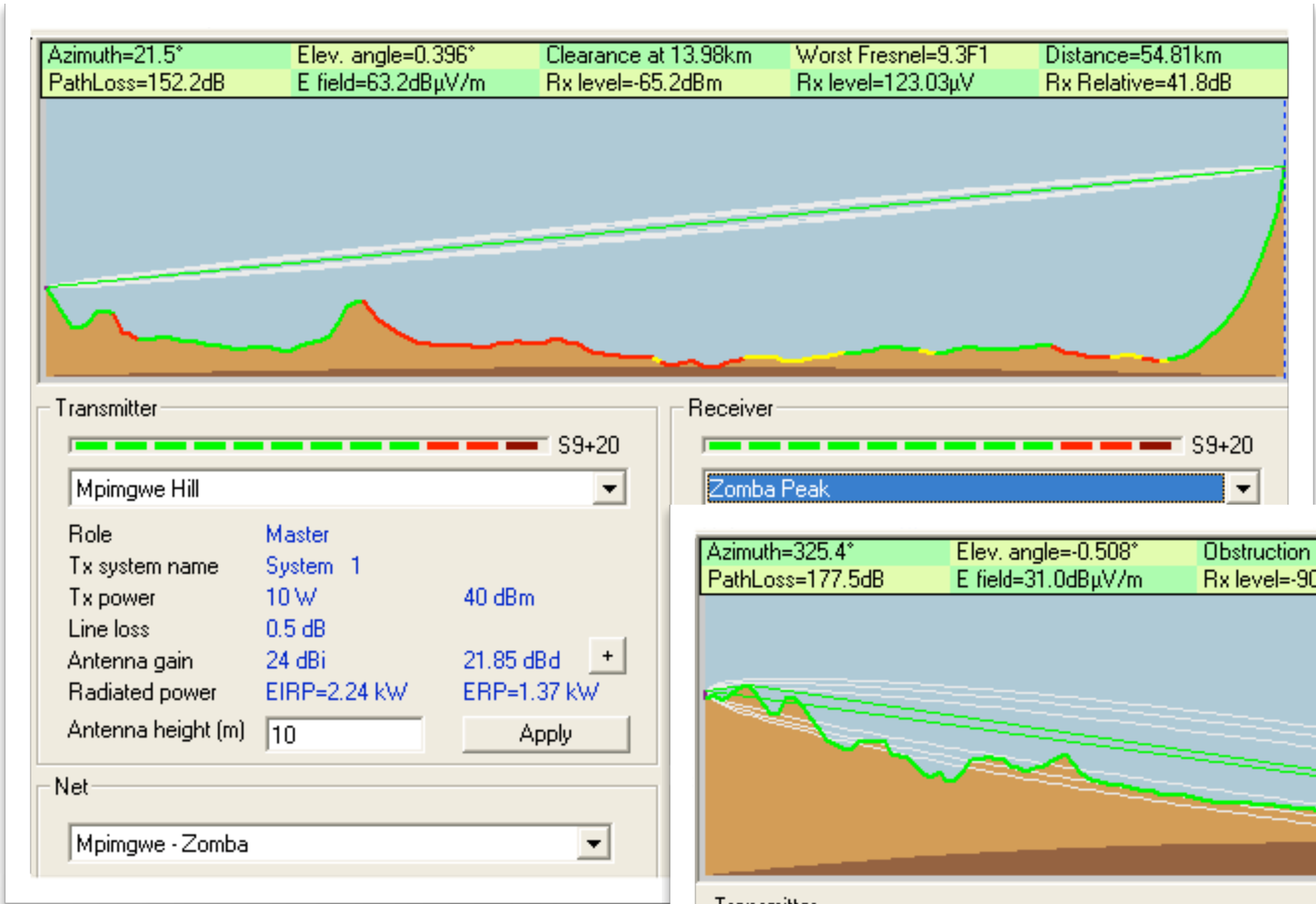


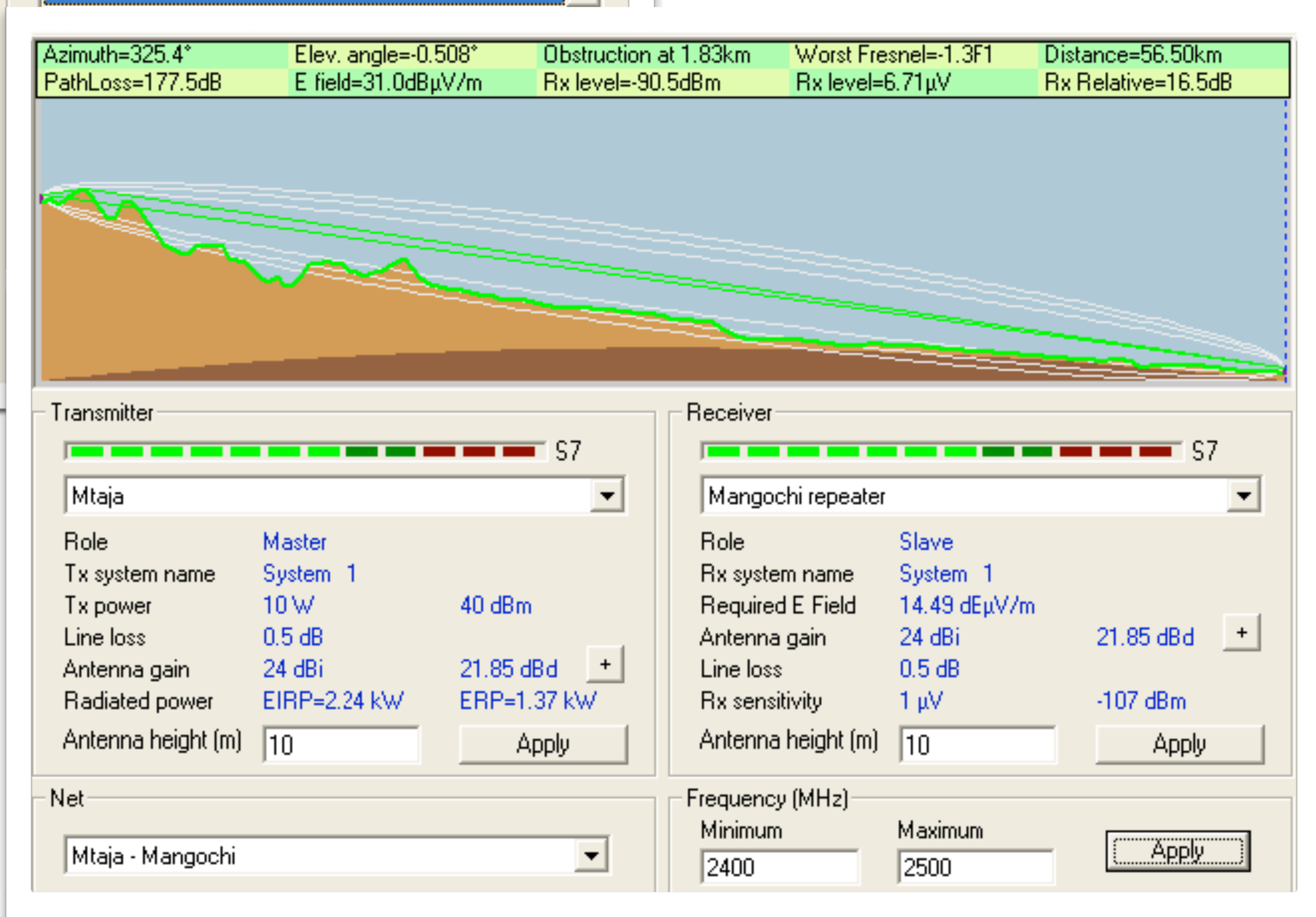
Using Radio Mobile: "what if?"

- With the help of Radio Mobile is very easy to simulate different scenarios, or just different values of the antenna height and/or gain, TX power, etc...



Other examples (Malawi)



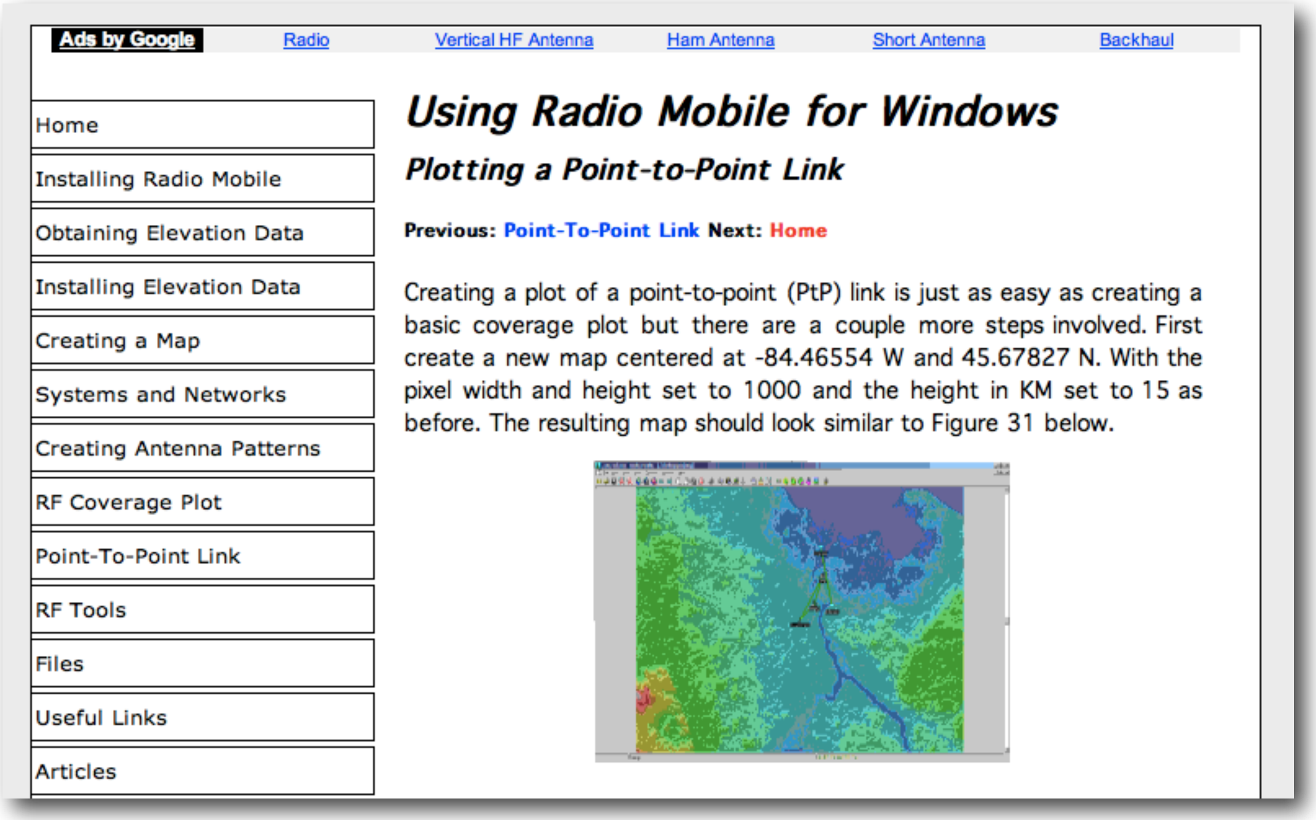


Radio Mobile showing line-of-sight terrain profiles for good and poor links. Note the curvature of the earth in the 56 km example on the right.

Fresnel Zones are shown as white curved (ellipses) lines. The worst first Fresnel zone is reported.

Links

http://radiomobile.pe1mew.nl/?About_Radio_Mobile



http://www.pizon.org/radio-mobile-tutorial/point-to-point-link.html

These links provide some good tutorials on how to use Radio Mobile.

Conclusions

- Radio Mobile makes it possible to simulate one or more radio links and perform "what if?" simulations, changing various link parameters
- While it cannot prove that a link is 100% possible, Radio Mobile can prove that a link is not possible (or would be very difficult).
- By combining DEM data and free overlay maps, it is possible to make very informative reports about coverage, link quality, and other radio parameters.

Thank you for your attention

For more details about the topics presented in this lecture, please see the book ***Wireless Networking in the Developing World***, available as free download in many languages at:

http://wndw.net/