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EM.Terrano Tutorial Lessons



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EM.Terrano Tutorial Lesson 16

Performing Link Margin Analysis above a Sea Surface Model

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16.1 What You Will Learn

In this tutorial lesson, you will use a wizard to create a sea surface profile. You will run margin analysis on an aerial link in the presence of the sea.

 **EM.Terrano Manual:**

<http://www.emagtech.com/wiki/index.php/EM.Terrano>

 **EM.Terrano Tutorial Gateway:**

http://www.emagtech.com/wiki/index.php/EM.Cube#EM.Terrano_Documentation

 **Download projects related to this tutorial lesson:**

http://www.emagtech.com/downloads/ProjectRepo/EMTerrano_Lesson16.zip


16.2 Getting Started

Start a new project with the following parameters.

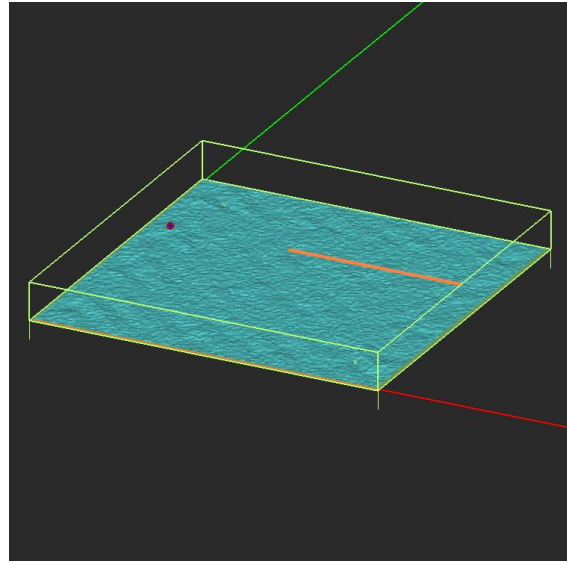
Starting Parameters	
Name	EMTerrano_Lesson16
Length Units	Meters
Frequency Units	GHz
Center Frequency	5GHz
Bandwidth	1GHz

16.3 Creating a Sea Surface Model in Terrain Surface Group

For this tutorial lesson, you will use a wizard to create a large sea surface profile in the project workspace.

Click on the **Sea Surface Wizard**  button of the **Wizard Toolbar** (Figure 1) or select the menu item **Tools** → **Propagation Wizards** → **Sea Surface Wizard**.

Tutorial Project: Performing Link Margin Analysis above a Sea Surface Model



Objective: To learn how to create a sea surface profile and simulate an aerial communication link above sea level.

Concepts/Features:

- Sea Surface Model
- Aerial Link

Minimum Version Required: All versions



Figure 1. EM.Terrano's wizard toolbar.

A dialog opens up and asks for the total area extents and the surface (Figure 2). Select **Rough Periodic** option for the **Select surface type** section of the dialog and then click the **OK** button.

Sea Surface Wizard - Quick Settings

Geometry

Lower Left World Coord. : X: 0 Y: 0

Area Size: 1000 1000

Select surface type:

Smooth Periodic **Rough Periodic** Random Rough

Sea State or Swell Specification

Select scale type:

Douglas Scale - Sea State 5 - Rough

Douglas Scale - Swell 6 - Rough

Beaufort Scale - Sea State 7 - High Wind or Moderate Gale or Near Gale

Wind Speed: N/A knots N/A km/h

Wave Height Range: 2.50 - 4.00 m

Wavelength Range: N/A m

Wave Parameters

Sig. Wave Height: 3.25 m Wavelength: 100 m

Wave RMS Height: 1 m Cell Density per Wavelength: 10

OK Cancel

Figure 2. EM.Terrano's default Terrain dialog.

A large sea surface object appears with a random rough surface as shown in Figure 3.

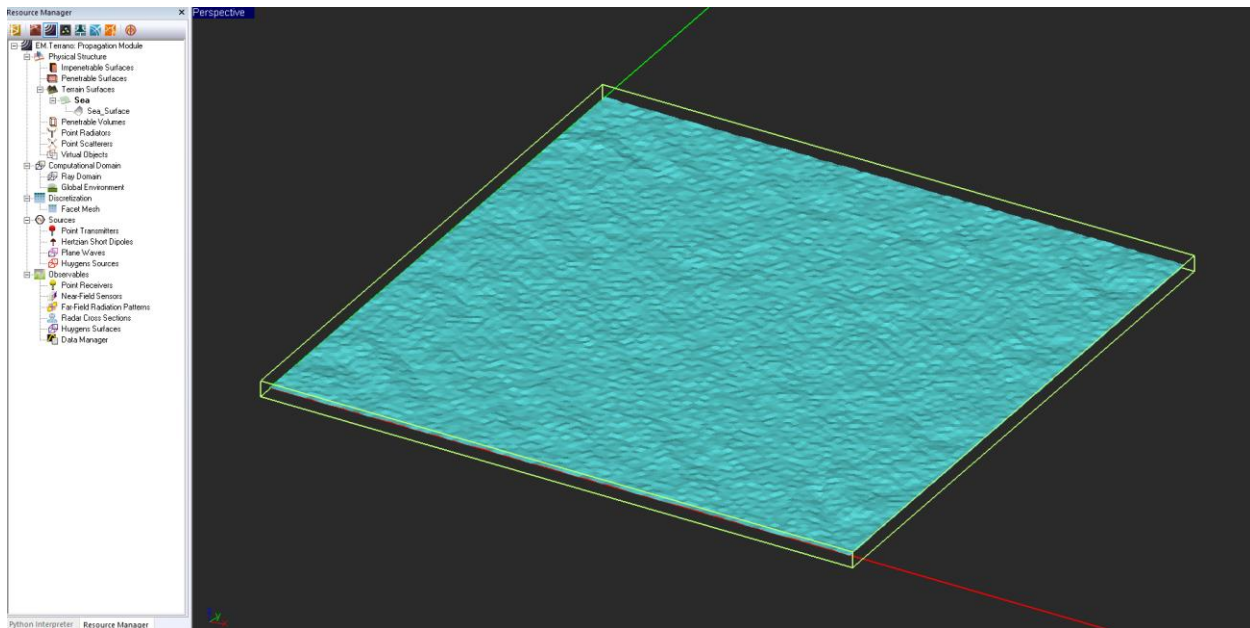
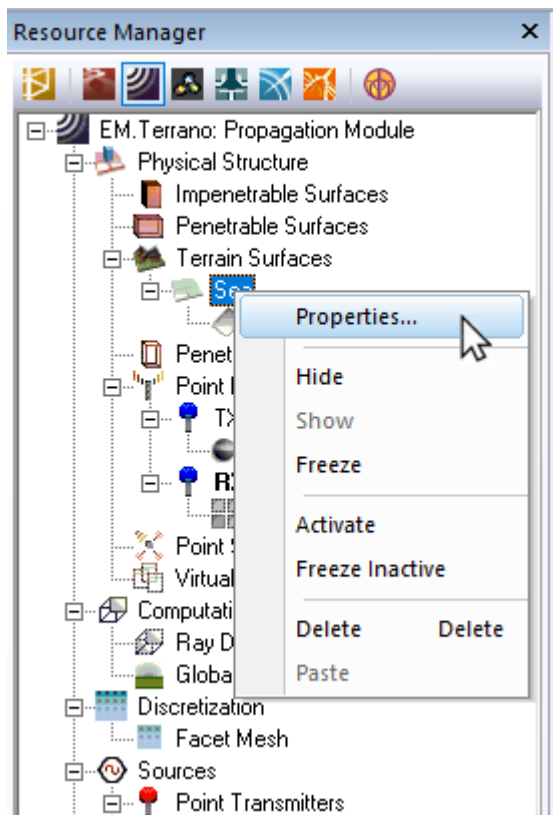


Figure 3. The geometry of the default sea surface created by the wizard.



An object called "Sea" is created by the wizard under the **Terrain Surface** section of the navigation tree. Open its property dialog by right-clicking on its name in the navigation tree and selecting **Properties...** from the contextual menu (Figure 4). As shown in Figure 5, the relative permittivity of the sea water is $\epsilon_r = 81$ and $\sigma = 4S/m$.

Figure 4. Opening the property dialog of an object from the navigation tree.

Next, select and highlight “Water_sea” item in the table and click the **Add/Edit** button of the dialog. A new Edit Layer dialog opens up, showing the material properties of sea water (Figure 6). Click the **Material** button to open up EM.Cube's Materials Dialog (Figure 7).

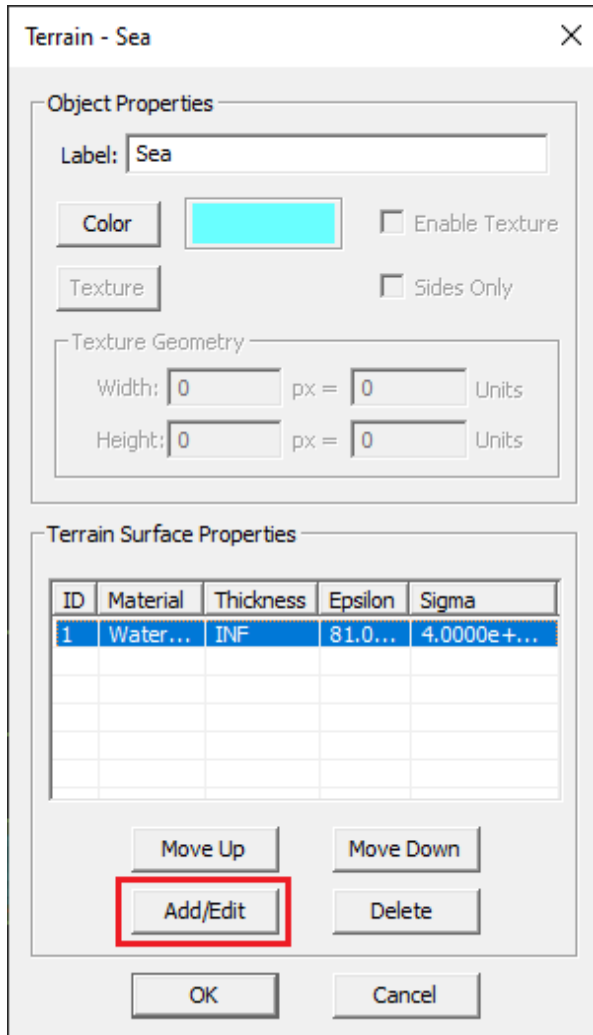


Figure 5. EM.Terrano's Terrain - Sea dialog.

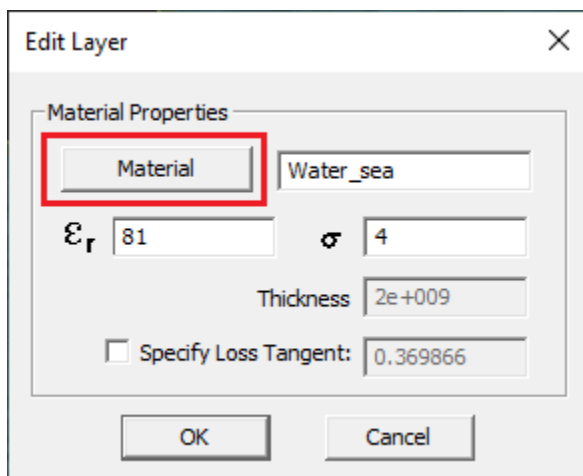


Figure 6. EM.Terrano's Add Layer dialog

Typing "w" on your keyboard will take you down the table where the material names start with the letter W.

Material	Epsilon	Mu	Sigma	Sigma_m	Rho (kg/m...	Cp (J/kg.K)	k (W/m.K)	
TACONIC TLY-5A	2.17	1	0	0				
TACONIC TSM-30	3	1	0	0				
Teflon (PTFE)	2.1	1	0	0				
Teflon (tm)	2.1	1	0	0				
Tin	1	1	8.67e+006	0	7310	227	67	
Titania	20	1	0	0				
Titanium	1	1	1.82e+006	0	4540	523	22	
Tungsten	1	1	1.82e+007	0	19300	134	174	
Vacuum	1	1	0	0	0	0	0	
Vaseline	2.16	1	0.0005	0				
Water_distilled	77	1	0.67	0	1000	4181.3	0.6	
Water_fresh	81	1	0.01	0	1000	4181.3	0.6	
Water_sea	81	1	4	0	1030	4181.3	0.6	
Wood - Birch	5.2	1	0.005	0	670	1900	0.14	
Wood - Chip Board	2.4	1	0.04	0	700	2500	0.15	
Wood - Maple	4.4	1	0.005	0	680	1600	0.16	
Wood - Oak	3.3	1	0.005	0	710	2400	0.17	
Yttrium Iron Garnet (...)	15.3	32	0.0001	0				
Zinc	1	1	1.67e+007	0	7000	387	116	

* Only user defined materials can be edited or deleted from the list.

New... Edit Delete OK Cancel

Figure 7. EM.Terrano's Materials list.

Next, open the Rough Object Properties dialog by going to the navigation tree and selecting **Sea_Surface** under Sea item as shown in Figure 8. Then, click the **Edit Primitive** button of the dialog to open the Surface Generator dialog. Change the values of the **Z** coordinate to 4m and then click the **OK** button (Figure 9).

Rough Object Properties

Label: Sea_Surface **Edit Primitive**

Tessellation Settings

Curved Edge Angle Tolerance: 30.000000

Surface Roughness Properties

RMS Height: 1.000000

Correlation Length: 10.000000

Height Distribution: Uniform

Allow editing and updating rough surface properties

OK Cancel

Figure 8. Rough Object Properties dialog.

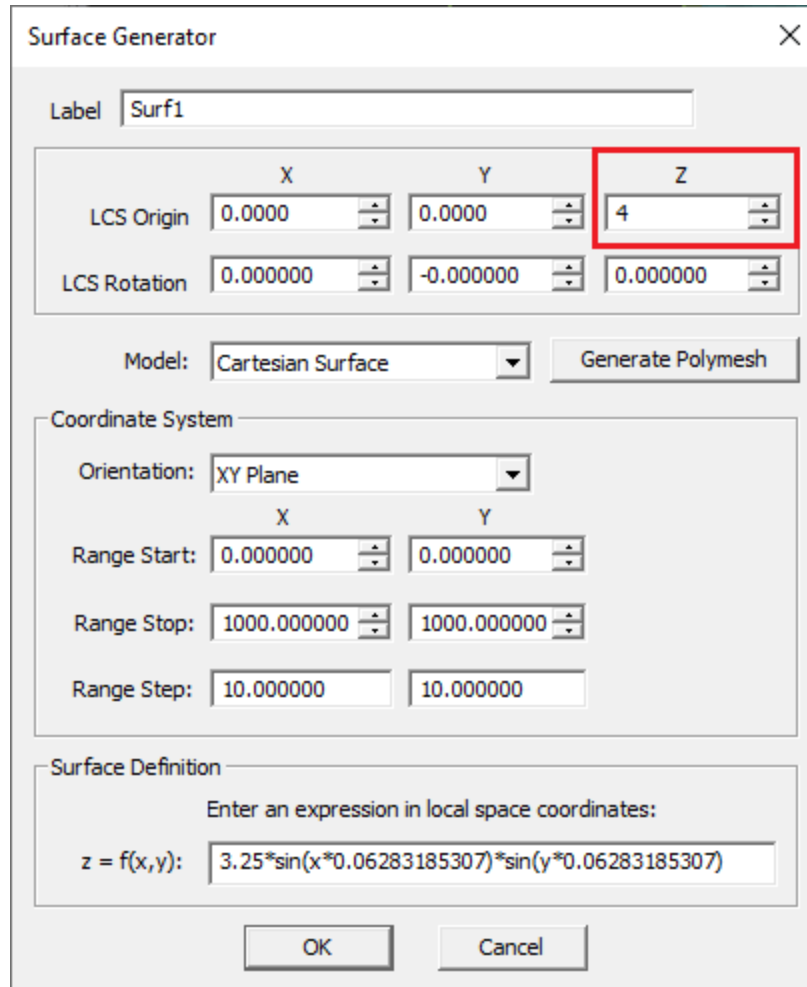


Figure 9. Surface Generator dialog.

Make sure the EM.Terrano's global ground is enabled. To access EM.Terrano's global ground settings dialog, right-click on the **Global Environment** item under **Computational Domain** in the navigation tree and select **Global Environment Settings...** from the contextual menu (Figure 10).

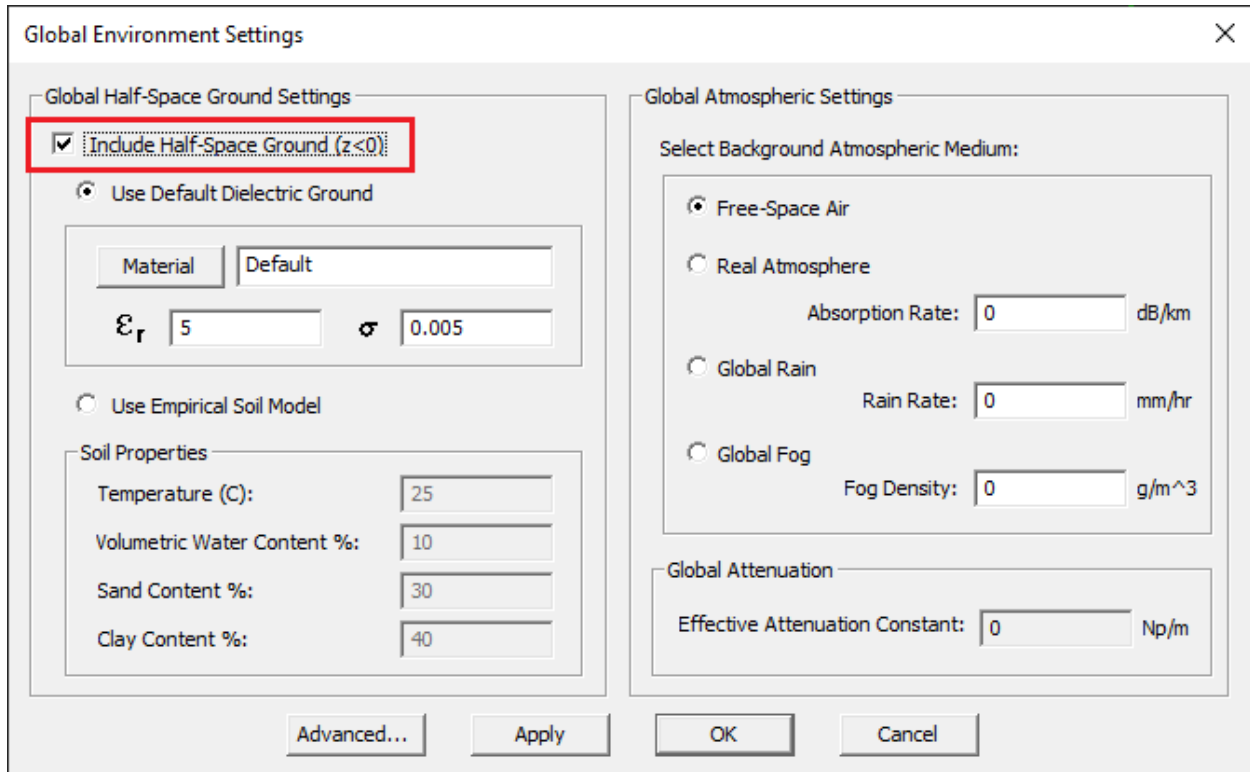


Figure 10. EM.Terrano's Global Environment Settings dialog.

16.4 Defining the Transmitter & Receivers

Create a vertically (Z) polarized dipole transmitter (TX_1) associated with the point radiator "TXB" and a grid of vertically (Z) polarized receivers (RX_1) associated with the point radiator "RXB". Your transmitter will be located at Point_1(500m, 3000m, 4000m)

Object	Geometry	Block Group	Physical Structure	Location Coordinates
Point_1	Point	TXB	Point Radiators	(150m, 500m, 100m)

To create the grid of receivers, draw a point at the location (500m, 500m, 100m)

Object	Geometry	Block Group	Physical Structure	Location Coordinates
Point_2	Point	RXB	Point Radiators	(500m, 500m, 100m)

and build an array of points as indicated in the table below:

Array Object	Parent Object	Element Count X	Element Count Y	Element Count Z	X Spacing	Y Spacing	Z Spacing
Point_2_Array_2	RXB	500	1	1	1m	0	0

Next, assign a transmitter set to the first radiator set and assign a receiver set to the second radiator set. Figure 11 shows the free-space propagation scene with the transmitter and receivers.

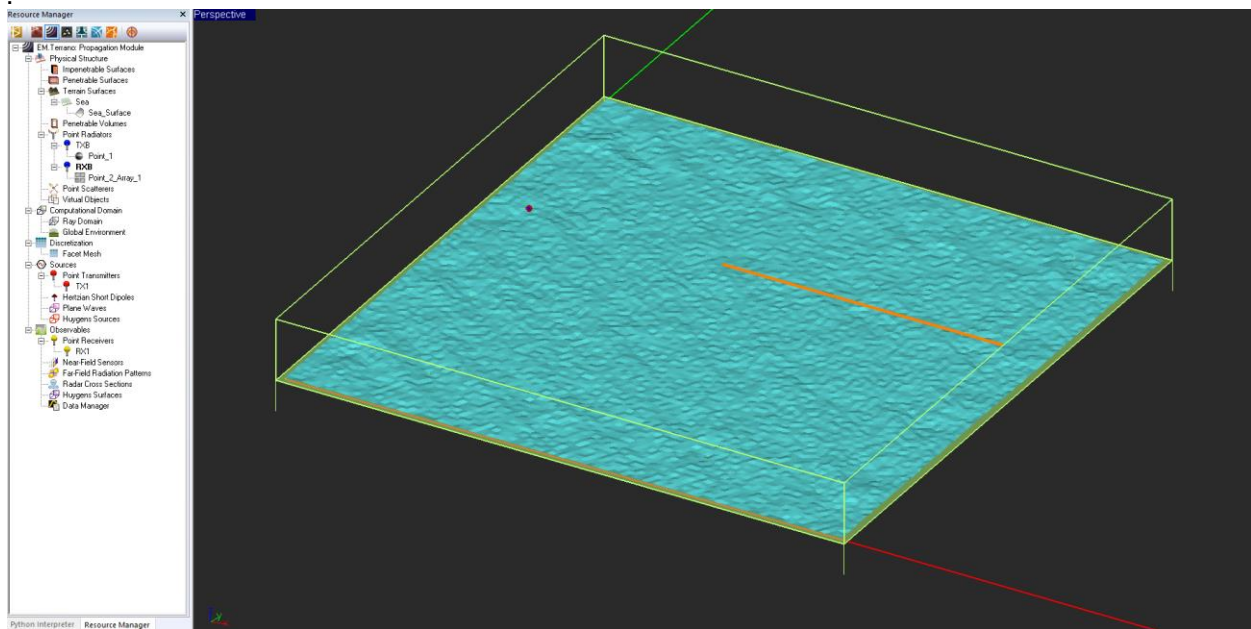


Figure 11. The transmitter and array of receivers in the project workspace.

16.5 Running the Simulation & Examining the Results

Run the **Long-Haul Channel Analyzer**. Next, select the **BPSK** option from the **Modulation Type dropdown list** in the property dialog of the receiver set and click the **Apply** button. You may get warning about the symbol rate as shown in Figure 12. Click the **OK** button and proceed.

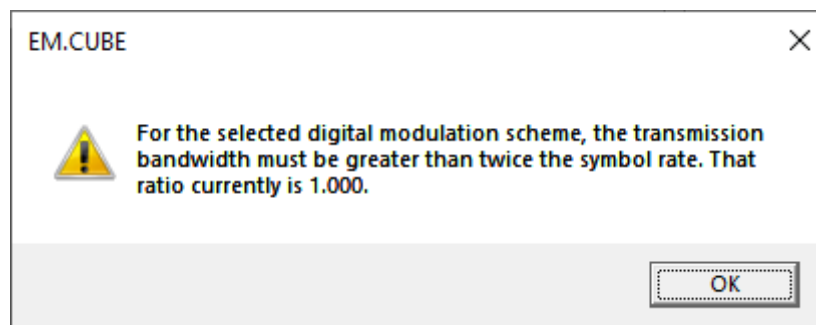


Figure 12. EM.Terrano's warning on the ratio of the transmission bandwidth and the symbol rate.

Run the **Communication Link Solver** and view the signal and noise power data in the property dialog of the receiver set. The table below summarizes the signal and noise power data at the first receiver:

Rx Index	Modulation	Received Power	Noise Power	SNR	Link Margin
1	None	-64.096 dBm	-94.472 dBm	20.376 dB	20.789 dB

Click the **Margin** button to plot the graph of link margin vs. range as shown in Figure 13.

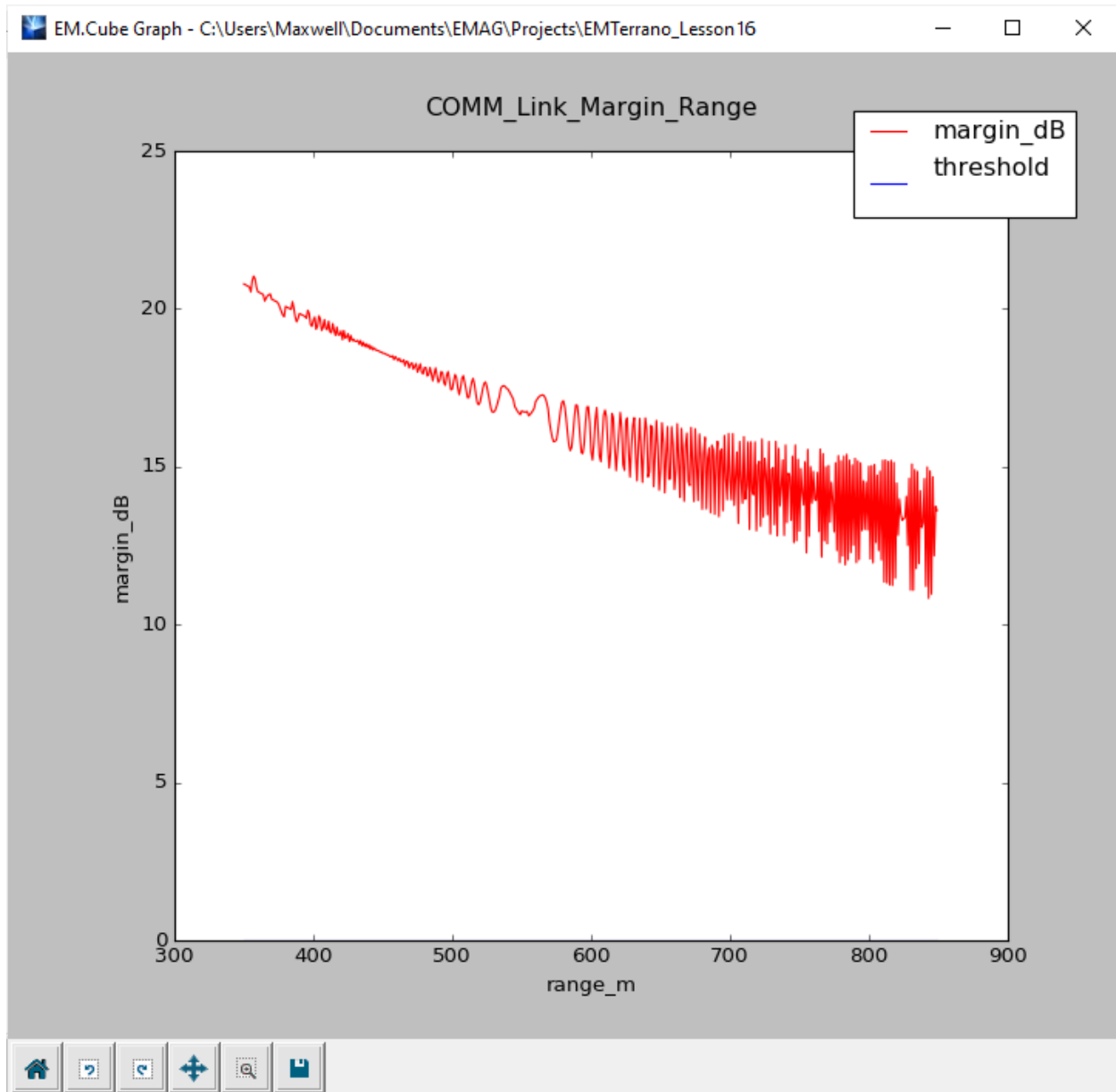


Figure 13. A plot of the computed link margin vs. range with BPSK modulation.

In the Data Manager, select the data file called “COMM_Link_Margin_Range.DAT” and rename it as “COMM_Link_Margin_Range_0.DAT”. Copy the renamed file in a different folder for future use.

16.6 Running the Simulation in a Rainy Weather Environment

In this section, you will run your simulation in a rainy weather environment. To do so, open EM.Terrano's global ground settings dialog. Select the **Global Rain** item under **Global Atmospheric Settings** section of the dialog and set **Rain Rate** to 200 mm/hr as shown in Figure 14. Click the **Apply** button and view the effective attenuation constant.

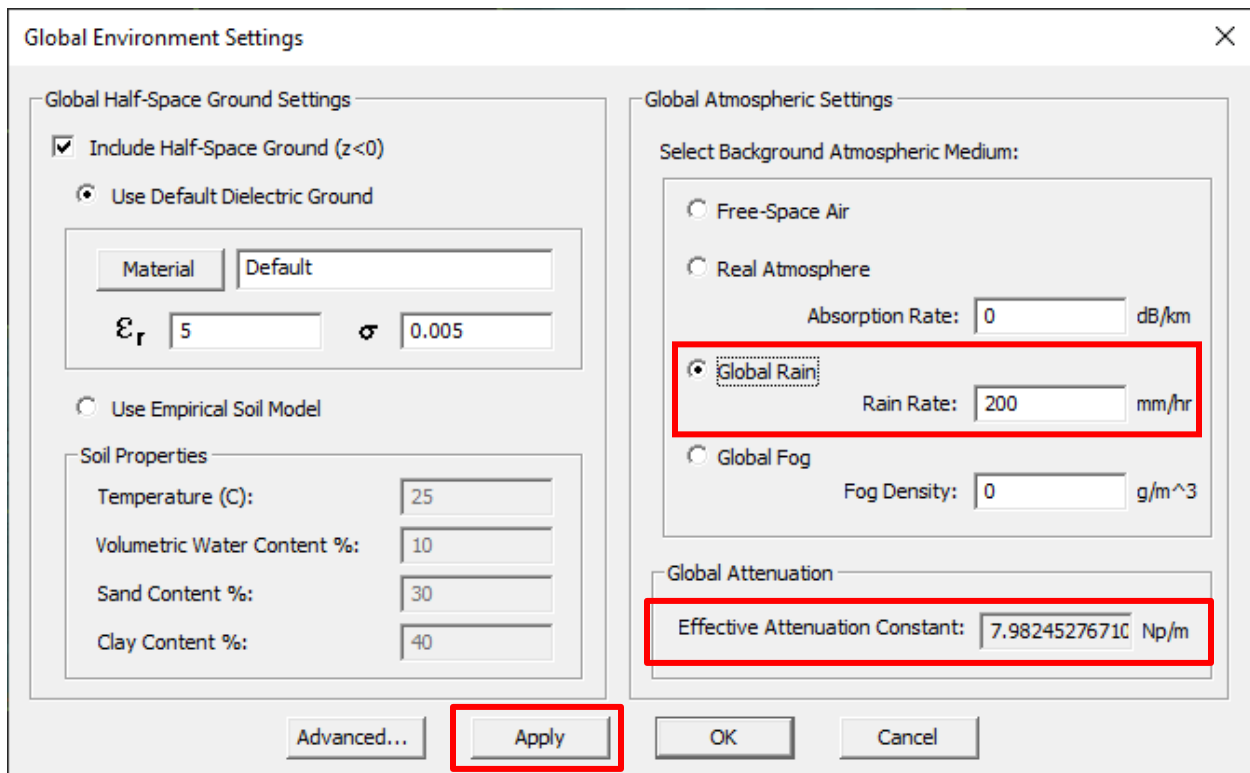


Figure 14. Setting Global Rain in EM.Terrano's Global Environment Settings dialog.

Run the **Long-Haul Channel Analyzer** first, and the **Communication Link Solver** next, and plot the graph of link margin vs. range as shown in Figure 15.

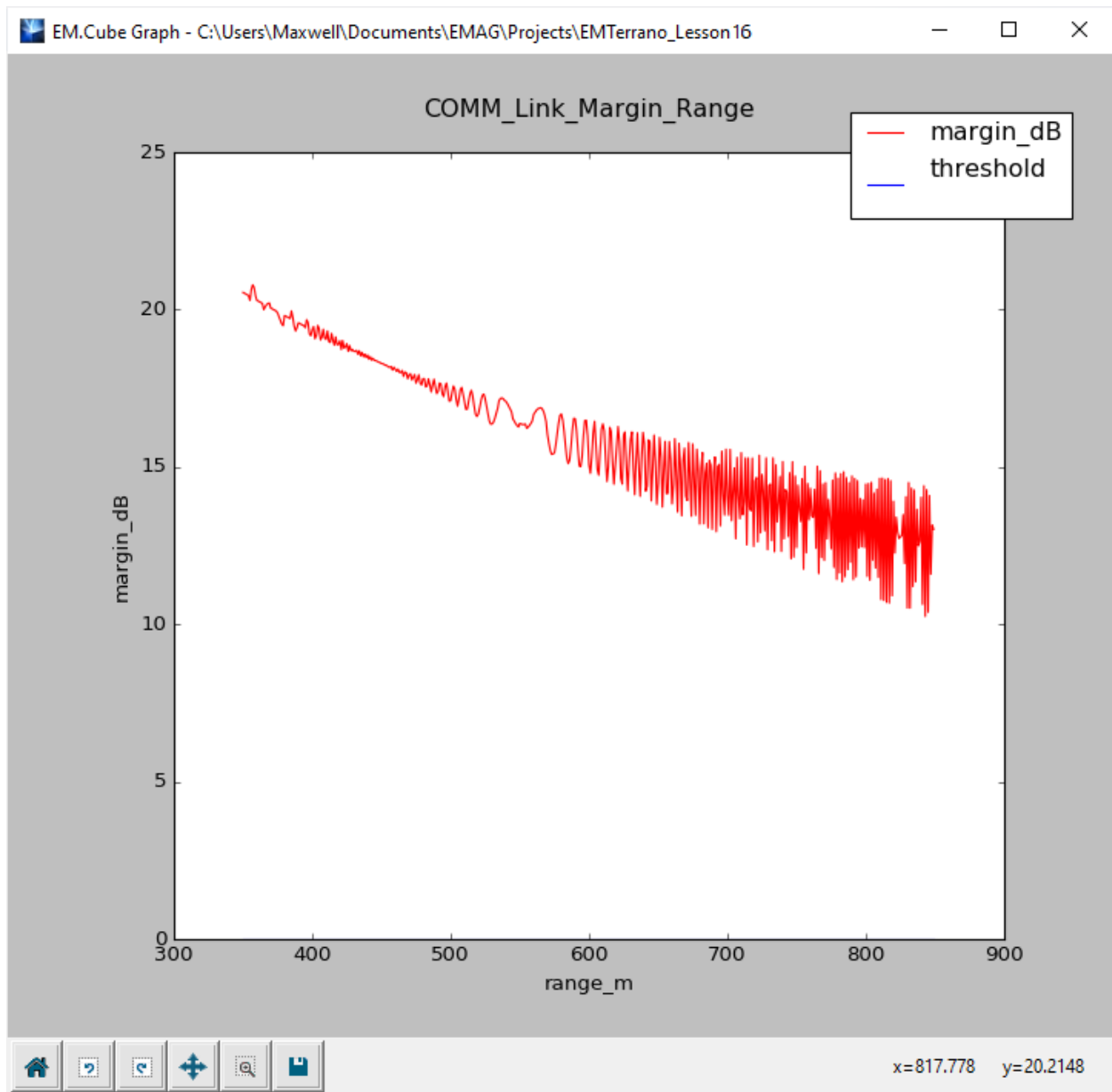


Figure 15. A plot of the computed link margin vs. range with BPSK modulation in a rainy environment with a rain rate of 200 mm/hr.

Finally, copy the data file “COMM_Link_Margin_Range_0.DAT” back into the current project folder. Open Data Manager and select the two files named “COMM_Link_Margin_Range.DAT” and “COMM_Link_Margin_Range0.DAT” together and plot them as shown in Figure 16.

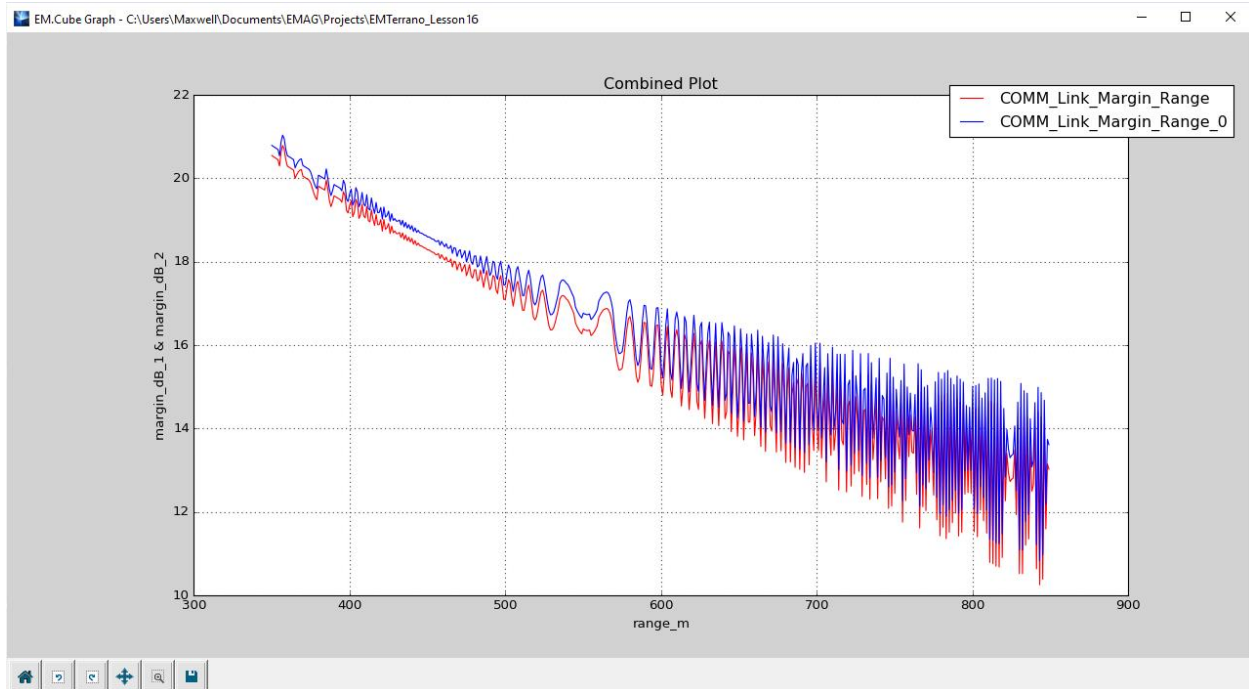


Figure 16. A plot comparing the computed link margin vs. range with BPSK modulation in dry air and a rainy environment with a rain rate of 200 mm/hr.