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Creation of 3D model of the Tihany peninsula

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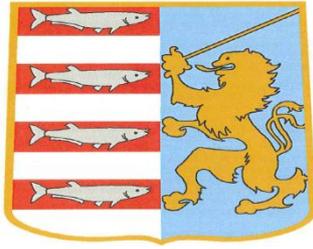
I. Introductory data about the autor

Ana Martínez García, Surveying Engineering student at the School of Building Construction of Barcelona and member of the institution, Polytechnic University of Catalunya.

This thesis is the result of an Erasmus exchange program between the Polytechnic University of Catalunya and the Eötvös University. It was developed in the Department of Cartography and Geoinformatics of the Faculty of Informatics in Budapest.

The work was carried out under the supervision of Prof. José Jesús Reyes Nuñez, associate professor at the Department of Cartography and Geoinformatics.

II. Introduction : Tihany



Tihany is a village located in the north of Balaton Lake on the Tihany peninsula, in the county of Veszprém, in Hungary. The Tihany peninsula divided Lake Balaton into two parts: the larger southern and the smaller northern (Figure 1).

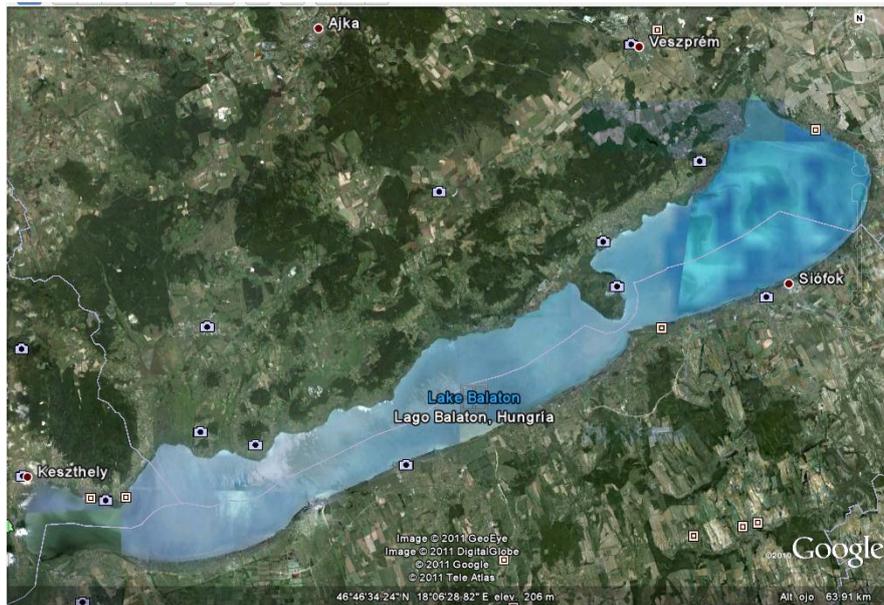


Figure 1 Balaton Lake

Within the peninsula is the town of Tihany, a small town in which reside about 1500 people. Tihany is the place where the Abbey was founded by King Andrew I of Hungary in 1055. Due to wars and subsequent restorations its style is baroque. King Andrew I of Hungary is buried in the crypt of the abbey and this is the place where is stored the manuscript of the founding of the abbey, which contains the first words written in Hungarian language. It is also famous because of echo phenomena recorded there since the XVIII century.

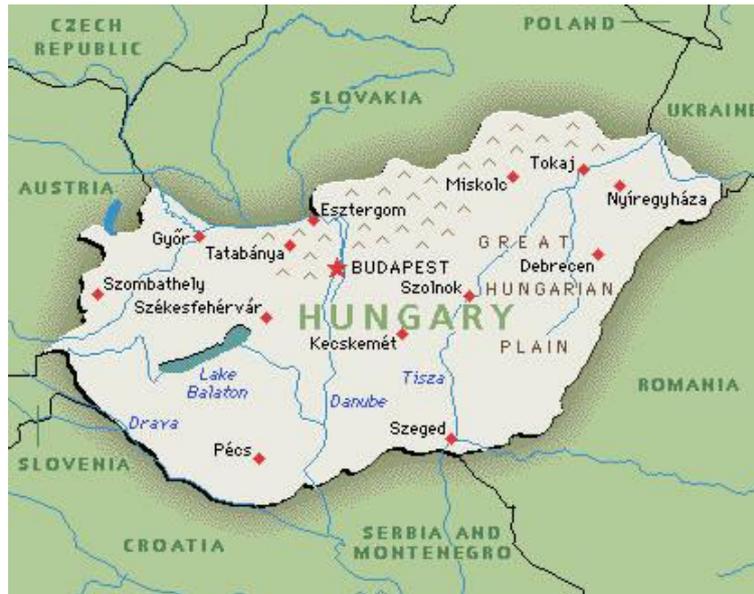


Figure 2 The Balaton Lake inside Hungary

Balaton lake is located in West Hungary (Figure 2). It's one of the most important lakes in Central Europe. It is located at the south west direction from Budapest, the capital, around 100 kilometers. It's the largest and more important lake in the country.

The area of Tihany peninsula is 12 square kilometres; most of them are intended to vegetation (Figure 3). During the summer you can enjoy Balaton Lake like the main and largest beach of Hungary, and in winter the water of the Balaton Lake can frozen.

Today it's one of the most attractive touristic places in the country, because its' historical, cultural and artistic importance.

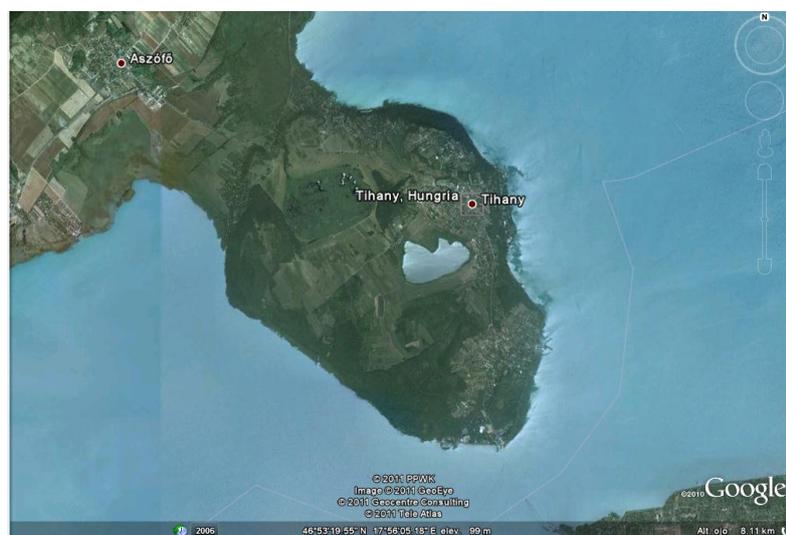


Figure 3 Tihany peninsula

To try to know better and view the actual Tihany peninsula, I decided to make a little trip to visit this area. I organized a one day excursion to visit the Tihany peninsula, Veszprém and Siófok.

I took some pictures of the different places in Tihany peninsula, in a future these pictures could be used in a possible geographic information system about tourism in Tihany, completing the maps with photos and other multimedia data.

I chose a selection of the pictures and there are presented in the Annex I of this thesis.

III. Project workflow

The works done during the first part of the process were the analysis of the XYZ files, in interest of identifying its' structure. This file was a text file, so to use it in ArcGis software I needed to convert it into dBASE format.

1. Getting ground data

I received the original files from János Mészáros, PhD student in the Department of Cartography and Geoinformatics of the Faculty of Informatics in Budapest. The data was extracted using the software Global Mapper.

The size of data file wasn't large, it's size was 1,07 Megabytes, so I could work without major difficulties in my laptop.

2. Processing ground data

The first step of the conversion process to dBASE was to change the dots by commas and the tabs by spaces.

For this process I used Microsoft Access software. I could use Microsoft Excel for this change, but finally I decided to choice Microsoft Access, because in my opinion the works within this software would be faster and more professional by the kind of data to transform.

To use Microsoft Access I needed a TXT file without tabs and dots. I had all the information (X,Y,Z coordinates) stored in only one file . Then I opened this file and exported and saved all the data to DBASE format. This step is presented in the Figure 4.

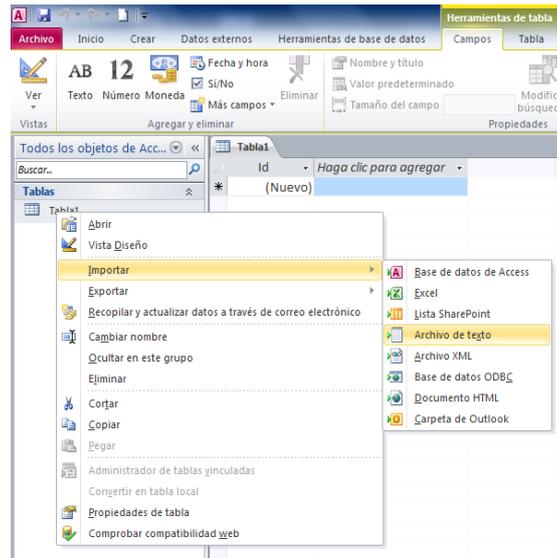


Figure 4 Import TXT to dBASE

I used the *Import Assistant*, choosing *Advanced Options* and later the options *Fixed width* and *Double format*. This step can be seen in Figure 5. Figure 6 shows the process to Import from Txt to dBASE.

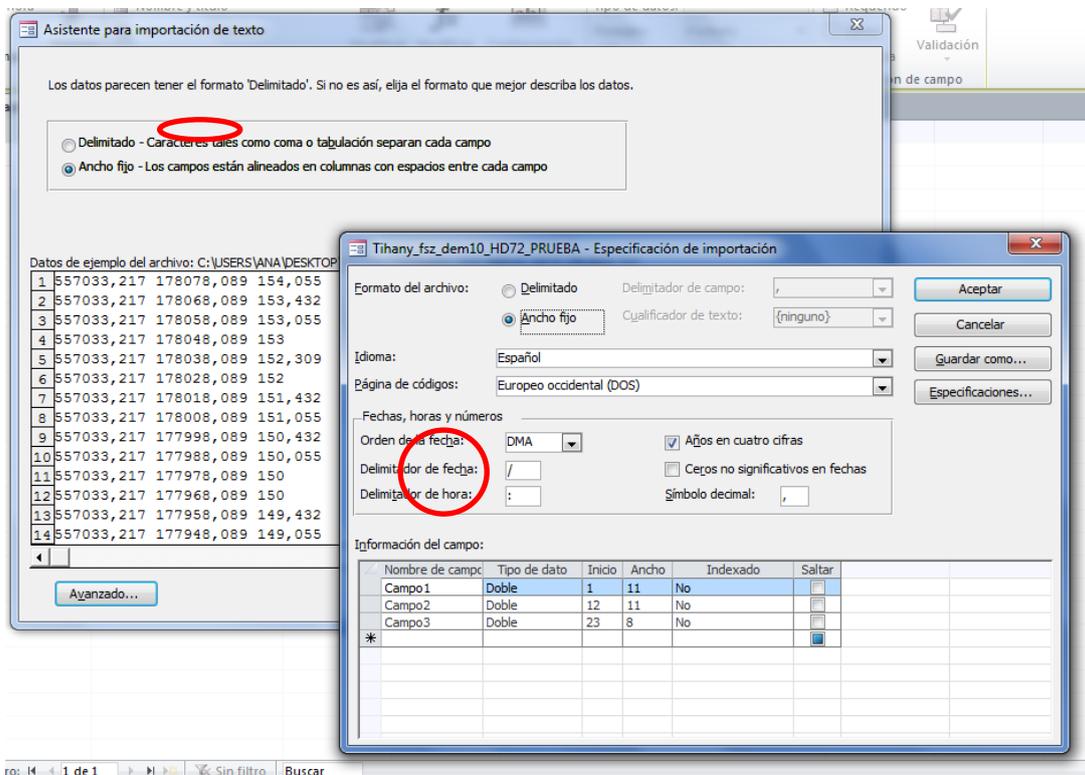


Figure 5 Choosing *Advanced Options* and later the options *Fixed width* and *Double format*

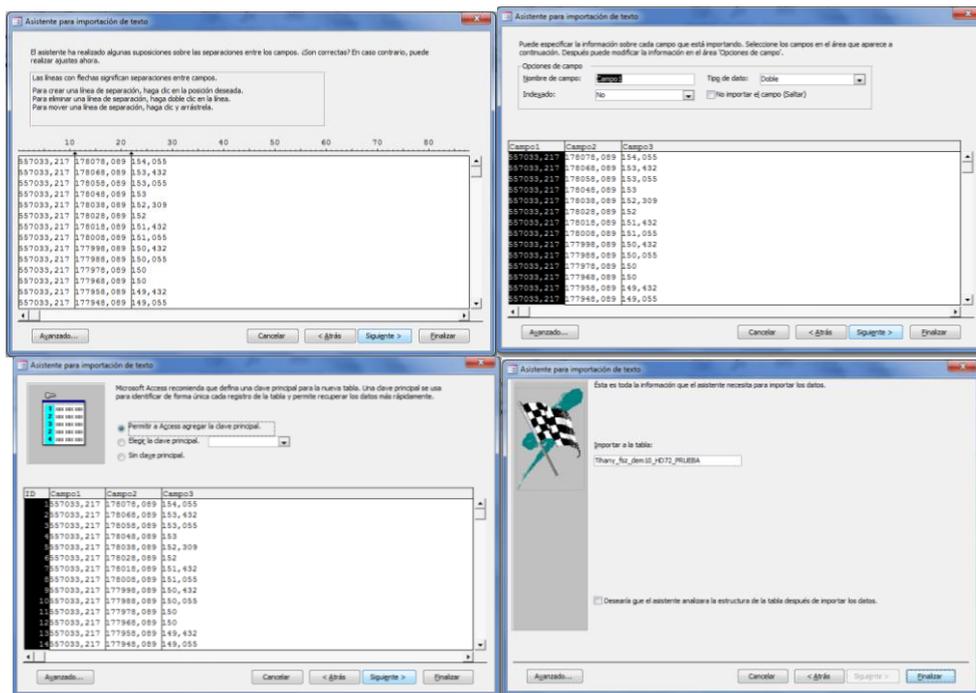


Figure 6 Creating and saving the table

Once the selected *Import field* command created a new table to be exported to dBASE format. After it I wrote the name of the table created and I saved it (Figure 7).

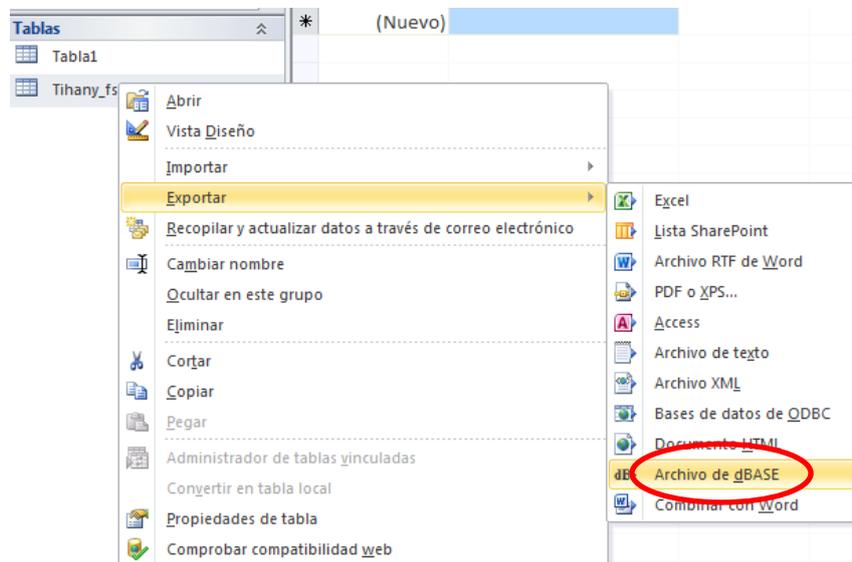


Figure 7 Exporting from TXT to dBASE

3. Processing ground data in ArcGis

The next step was to import all the data into ArcGis software. I done it just to have represented the information graphically, to test the created table and the most important step: to choose the correct coordinate system.

3.1 Coordinate system

At this point, I should pause the explanation about editing works to explain how I chose a coordinate system for my 3D model.

It's very important to know which projection is used in Hungarian maps. After a short search I knew that the official projection used in Hungary for all the geodesic points, maps and other ground data is the EOV (Egységes Országos Vetület, Uniform National Projection).

Some data about the Hungarian EOV projection (from <http://lazarus.elte.hu/gb/geodez/geod2.htm>):

Name:

EOV Egységes Országos Vetületi rendszer
(Uniform National Projection system).

Description:

The EOV is a plane projection system used uniformly for the Hungarian civilian base maps and, in general, for spatial informatics. (Base maps: 1:1000, 1:2000, 1:4000 large scale maps for cadastre and 1:10.000, 1:25.000, 1:100.000 topographic maps.)

Geometric classification:

Conformal cylindrical projection in transversal position.

Date of introduction:

1972-1975

Parameters:

Reference surface:

The IUGG GRS 1967 reference ellipsoid (Geodetic Reference System of International Union of Geodesy and Geophysics, 1967):

$a = 6\,378\,160.000\text{ m}$

$b = 6\,356\,774.516\text{ m}$

Ellipsoidal geographic coordinates: ,

Projecting sphere:

A Gauss-sphere fitted to reference ellipsoid at the normal parallel.

It is used for Gauss-sphere:

its radius: $R = 6\,379\,743.001$ m

and its spherical geographic coordinates: ,

Normal parallel:

Defined as average of latitudes for Hungary, with ellipsoidal and spherical latitudes below

= $47^{\circ}10'00.0000''$

= $47^{\circ}07'20.0578''$

Origin of geographic coordinates:

The Equator and the Greenwich meridian

Origin of projection:

A point on the meridian of site "Gellért-hegy":

= $47^{\circ}06'00''$

= $0^{\circ}0'0''$

the plane coordinates as

$x_0 = 0.0$ m

$y_0 = 0.0$ m

and by computing the ellipsoidal geographic coordinates:

= $47^{\circ}08'39.8174''$

= $19^{\circ}02'54.8584''$

Origin of EOVS plane coordinates:

Origin of the EOVS plane coordinates is moved to South-West with respect to origin of projection such that all possible EOVS coordinates be positive for Hungary:

$X_{EOVS} = x + 200\,000.000$ m

$Y_{EOVS} = y + 650\,000.000$ m

Projection zones:

A single cylindrical zone covers the area of Hungary in East-West direction.

Scale factor: $m_0 = 0.999993$

Linear distortion:

Along the y axis: -7 cm/km

North of Hungary: $+26$ cm/km

South of Hungary: $+23$ cm/km

Area distortion:

Along the y axis: -1.4 m²/ha

North of Hungary: +4.5 m²/ha

South of Hungary: +4.5 m²/ha

Formulas for computations (detailed see in Annex):

1. First case: From IUGG GRS 1967 ellipsoid to EOVS

- * (,) - (,) and (,) - (XEOV , YEOV)
- * From ellipsoid to the best fitting Gauss-sphere
- * From the best fitting Gauss-sphere to EOVS plane

2. Second case: From EOVS to IUGG GRS 1967 ellipsoid

- * From EOVS to the best fitting Gauss-sphere
- * From best fitting Gauss-sphere to the ellipsoid

3.2 EOVS in ArcGis

The selection of the Hungarian coordinate system in ArcGis was easy, because it is included in the software. I only needed to search the correct projection in the software.

In the figure 8 are represented the steps that I followed. I had to import the XYZ data and to choose the table that I wanted to import.

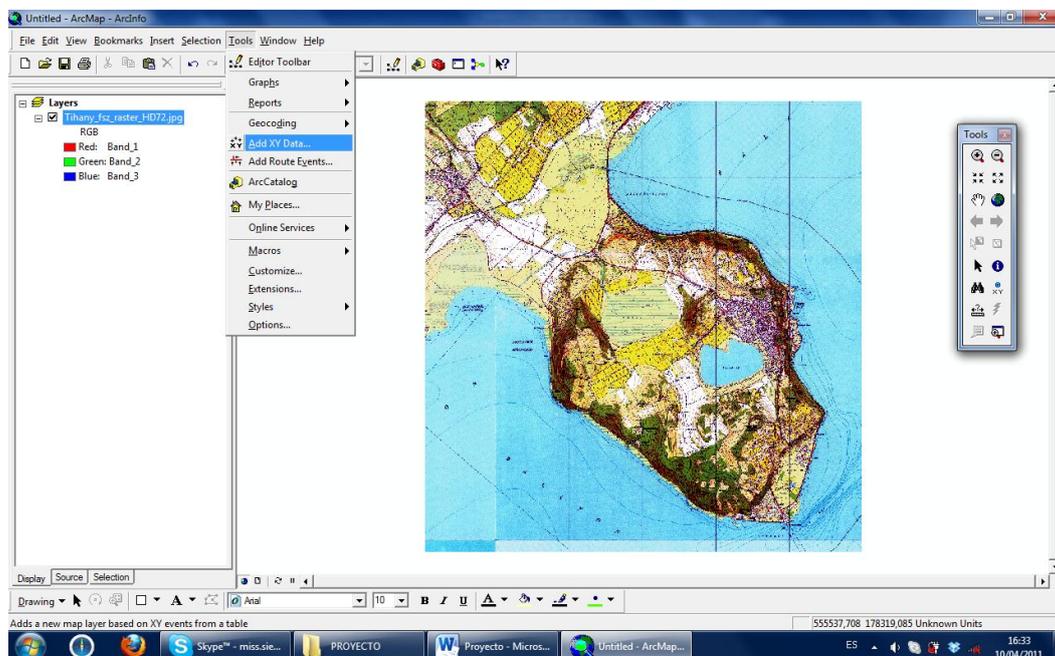


Figure 8 Add XY data

Once I had open the table, I chose the fields that stored the X and Y data (Figure 9).

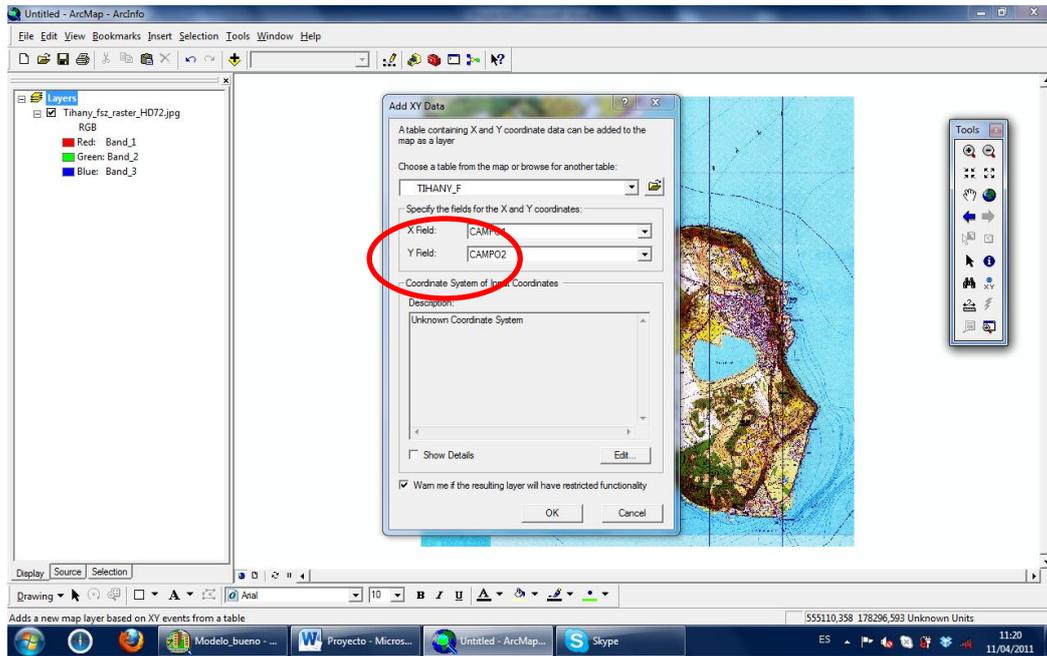


Figure 9 Chosing the fields X and Y data

After that I changed the coordinate system, I chose *Edit -> Select*, and the needed projection was included in the software.

In the figures 10 and 11 can be seen how I choose the coordinate system. During the first part of this task I worked with ArcGis-ArcMap.

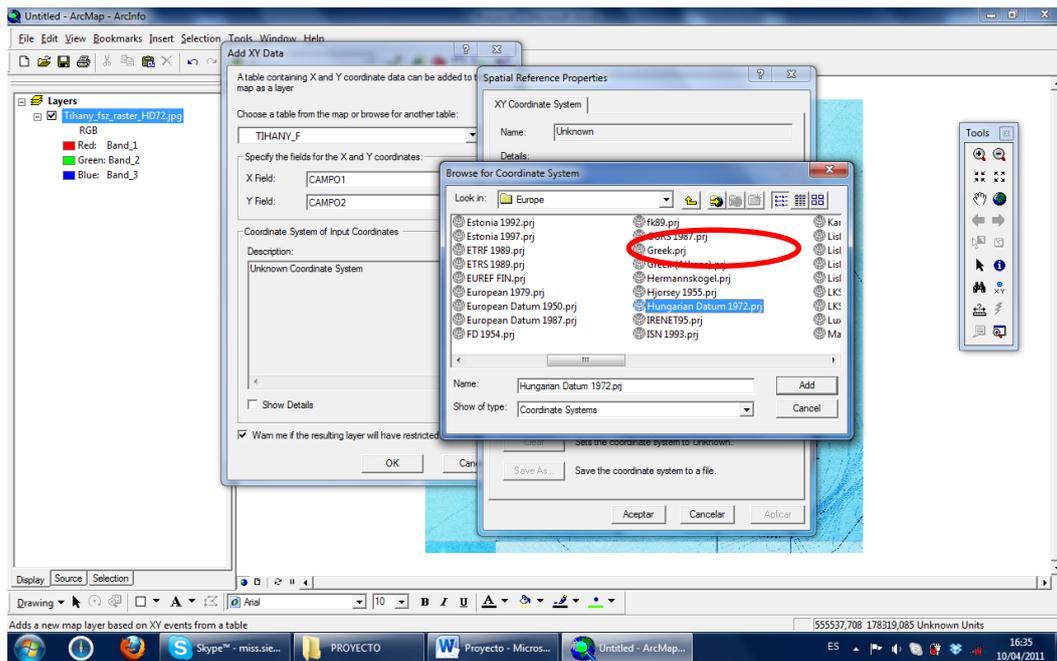


Figure 10 Chosing the coordinate system

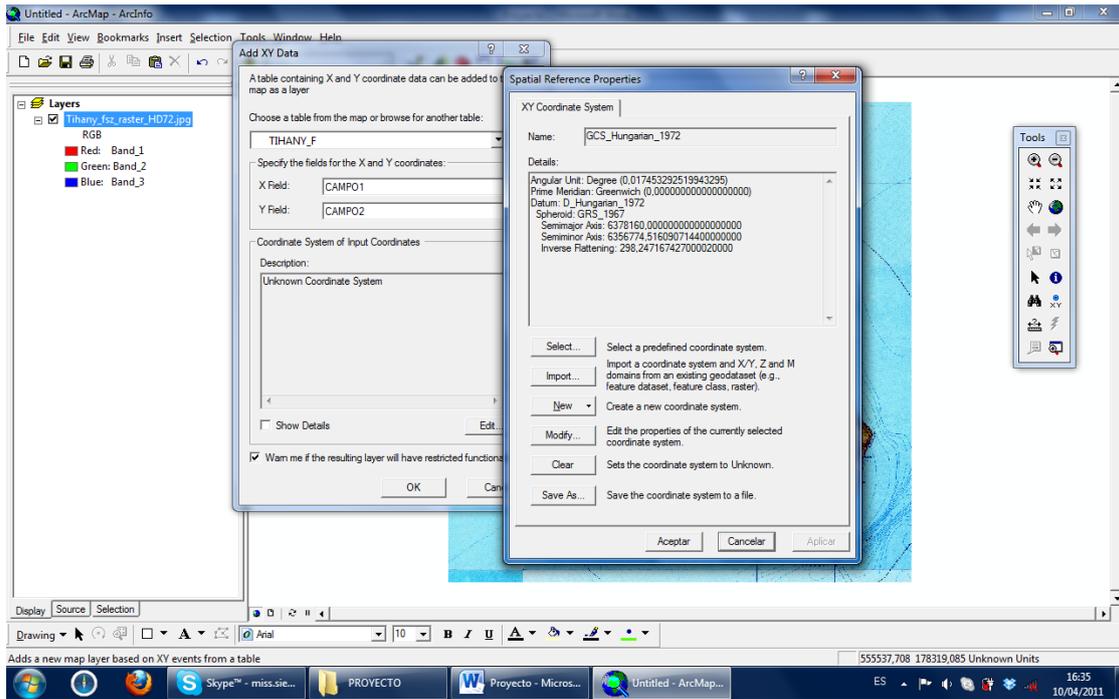


Figure 11 Details of Hungarian EOJ projection

Finally I had represented X and Y coordinates and I could see, zooming in the display, the cloud of points (Figure 12).

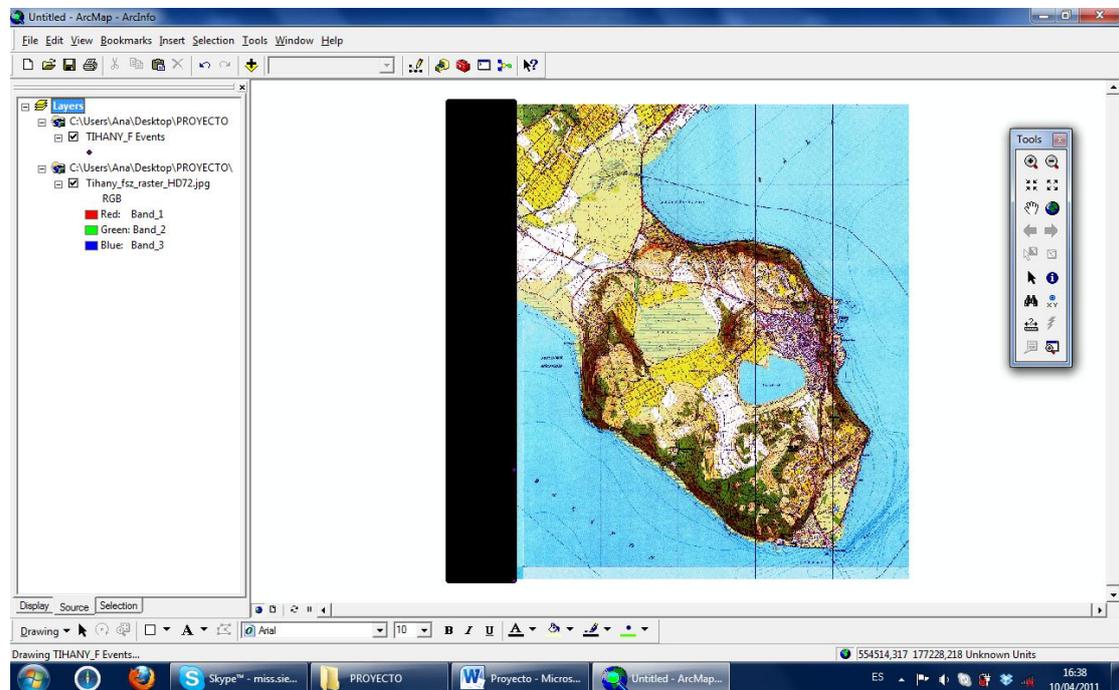


Figure 12 Representing coordinates

4. How to create a shape file

Beginning this thesis I asked myself what I need to create 3D model. I knew that I had to create a new shape file folder that includes all the XYZ coordinates contained in the dBASE file. The shape file is very important to create a new file abbreviated as TIN, to be used in my 3D model.

TIN is a 3D model, the surface can be represented by a mess of points and the TIN model consists of a set of triangles adjacent non-overlapping, which are obtained from a set of points with a irregular spacing. This model is used for uneven ground, to see the differences in slope, aspect and terrain shadows.

5. Creation of the shape file

From ArcCatalog I created the new file with the shape file extension. To do it I positioned to the layer containing the XYZ table .dbf extension, using the **Create Feature Class -> From XY Table** option (Figure 13).

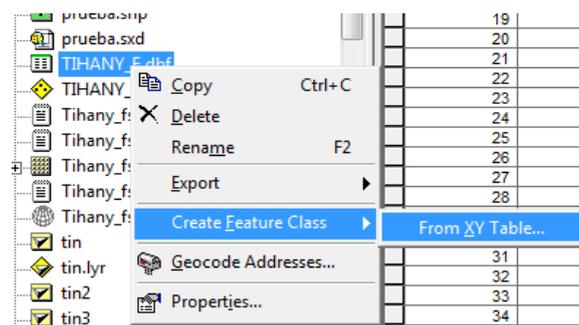


Figure 13 Creation of shape file

A new dialog box appeared on the screen, in which I had to select some fields to create the new file (Figure 14). In the appropriate fields scored the columns whose data coincided respectively with counterparts in the XYZ table, and the choice of the coordinate system in which I wanted to create the new shape. This step was needed for later works within ArcScene.

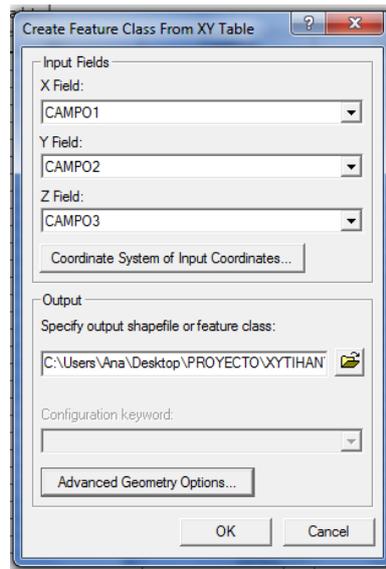


Figure 14 Saving the shape file

6. How to create a 3D model

The Tihany area presented no steep slopes or high altitude. The highest peaks in the peninsula are: the Csúcshegy (235 m), the Óvár (214 m) and the Hármashegy (212 m), with an elevation of only 120 to 130 meter above the water level.

Professor José Jesús Reyes Nunez suggested me that I could use *ArcScene* because all the process is fast and easier to do. I accepted his suggestion and I began to study this software.

To make the 3D model I followed the next steps:

- Using *ArcScene* in the bottom of the *3D Analyst* extension -> *Create/Modify TIN* -> *Create TIN from features* (Figure 15).

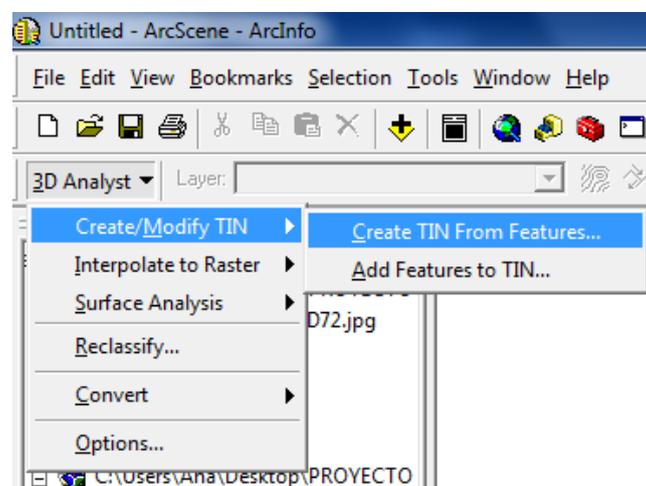


Figure 15 Creation of a TIN model

In the window that appeared I selected the type of file that must be created using txt file (shape file) (Figure 16).

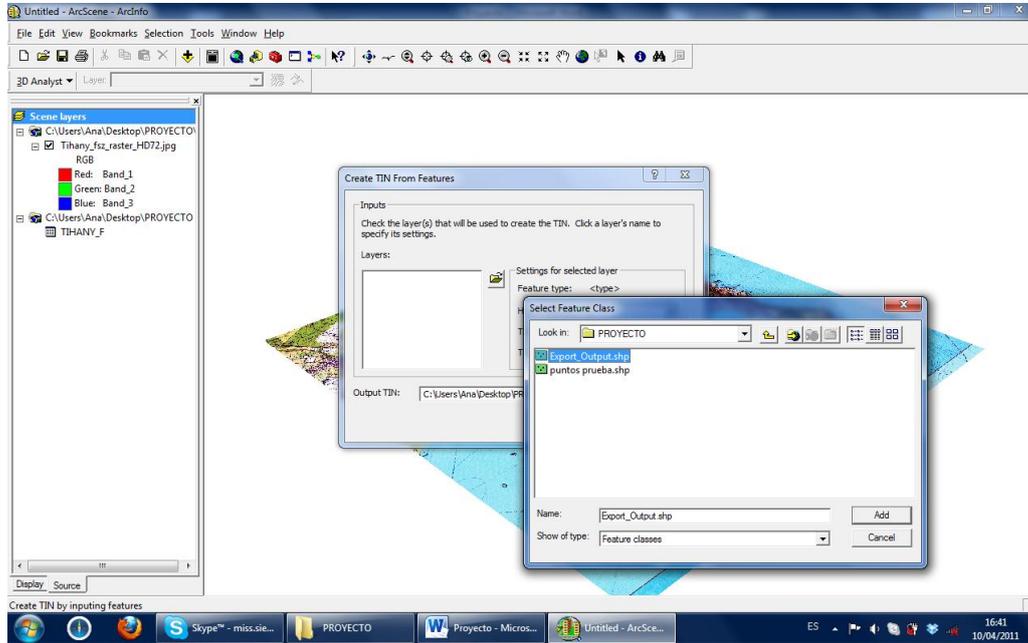


Figure 16 Select Feature Class

It was important to know the coordinates indicating the height of the points. In the field *Height source* I had to select the appropriated field, adding the coordinates corresponding to **Z** (Figure 17).

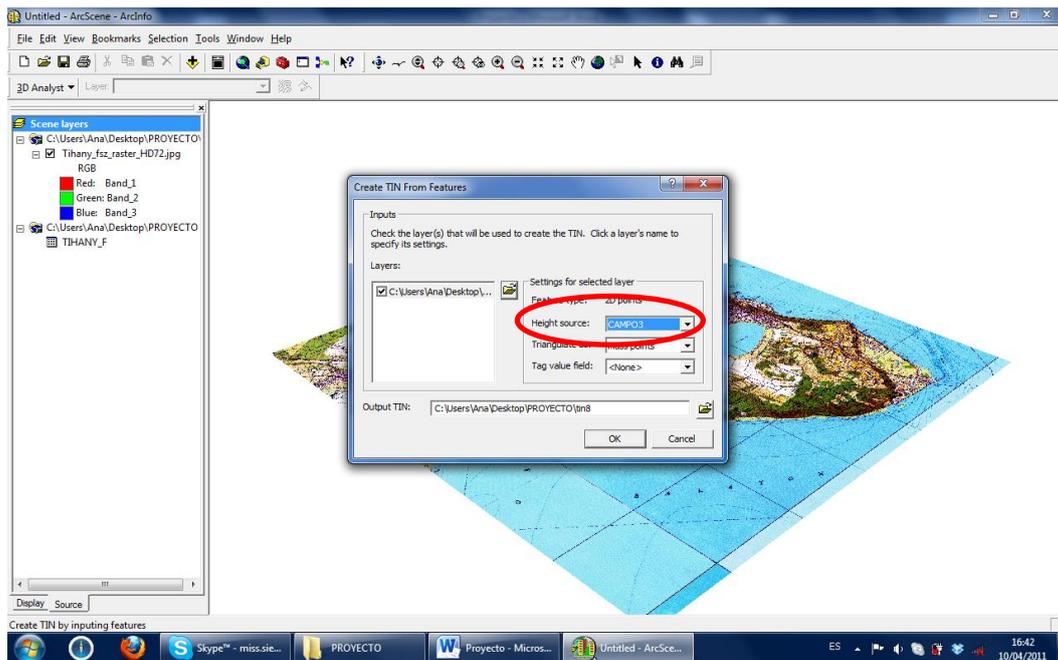


Figure 17 Chosing the Z field

Finally I obtained the resulting TIN. In this case the differences between heights could not be appreciated clearly, because the Tihany peninsula has no steep slopes. This is the reason because I decided to exaggerate the vertical scale to see the different slopes and the interior shape of the peninsula.

IV. Processing the ground 3D model

Following the works in *ArcScene*, my next step was to introduce data to the *Scene layer*. The final result was a 3D model in only one color (Figure 18).

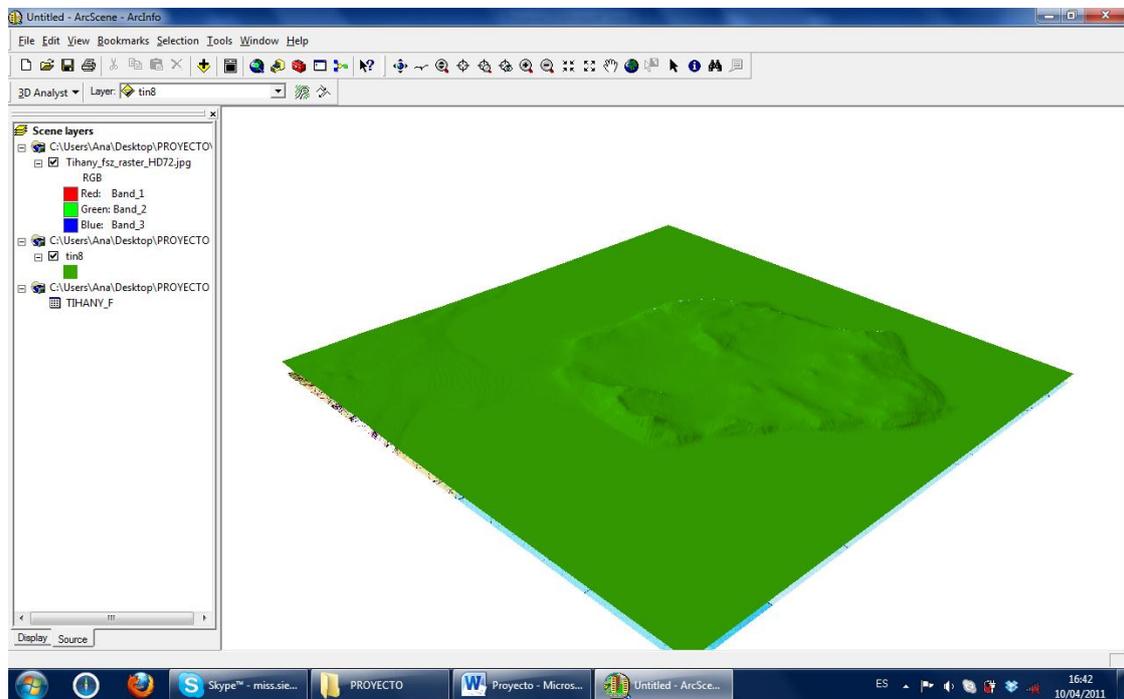


Figure 18 3D model in one color

The process to modify (exaggerate) the vertical scale is summarized in the following steps:

- Add the 2D map and create a three dimensional model through the *3D Analyst extension* -> *Create / Modify TIN* -> *Create TIN from Features* (Figure 19).

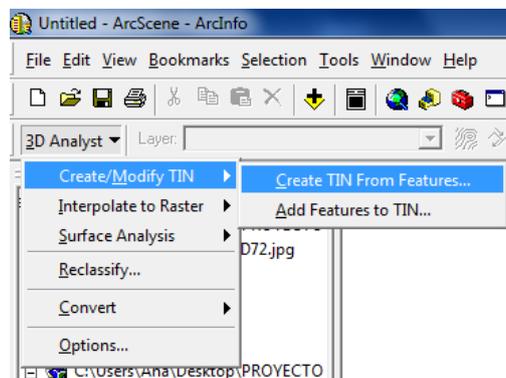


Figure 19 Create three dimensional model

1. Working with high-resolution map sheets

When I arrived to this phase of my thesis Professor José Jesús Reyes Nunez suggested me to work with original topographic maps scanned with high-resolution to try to obtain a more rigorous result (Figure 20). I considered it a very interesting proposal, trying to work with different maps and other applications.

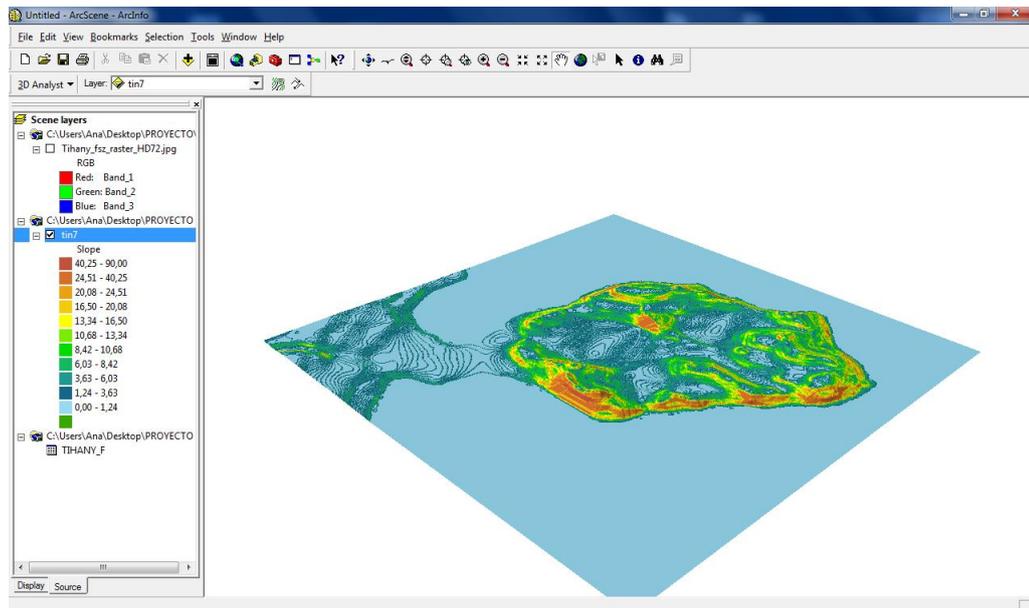


Figure 20 Tin model without exaggerated high scale

Once created the TIN model, the properties of this layer should be modified using the **Base Heights** tab and later to change the vertical scale in the section **Z conversion unit** (Figure 21).

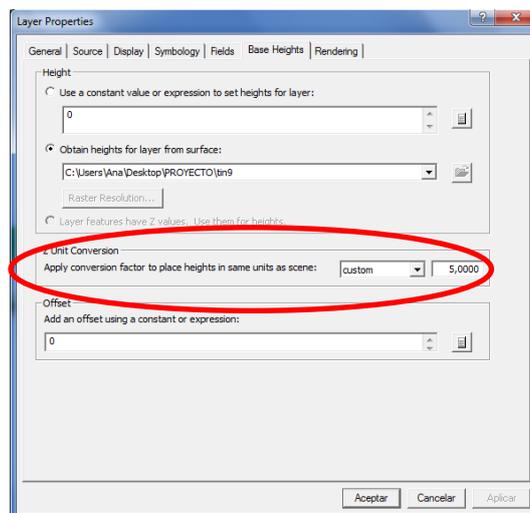


Figure 21 Exaggerating the vertical scale

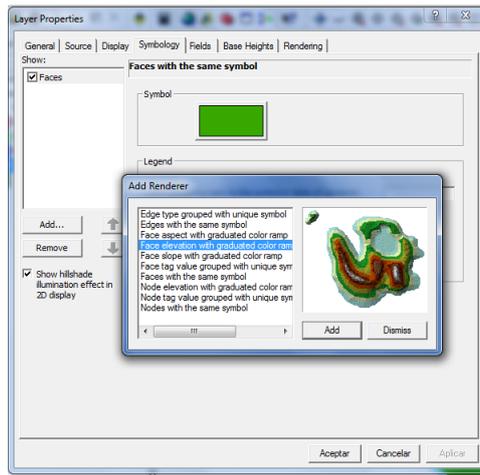


Figure 22 Chosing graduated color ramp

To create a model of heights I had to change the format of the new TIN layer. To do this, I choice the properties and selected the TIN model with *Face Graduated color ramp* elevation. Selecting this option (Figure 22) I got through the terrain slopes to create a TIN model with a chromatic scale to differentiate new elevations. After that I exaggerated the scale (Figure 23).

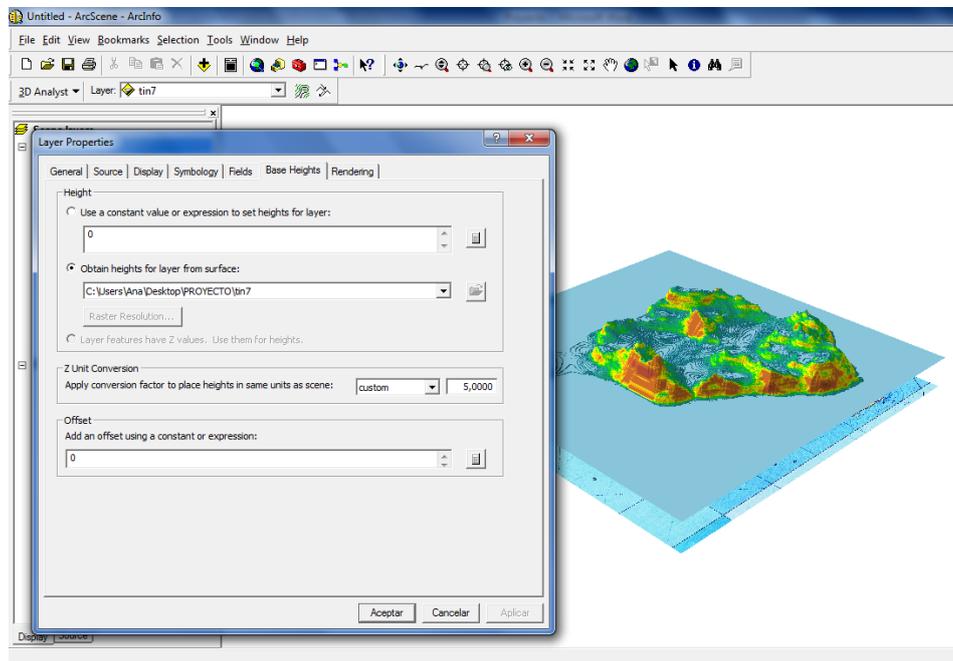


Figure 23 Creation of an exaggerated high scale

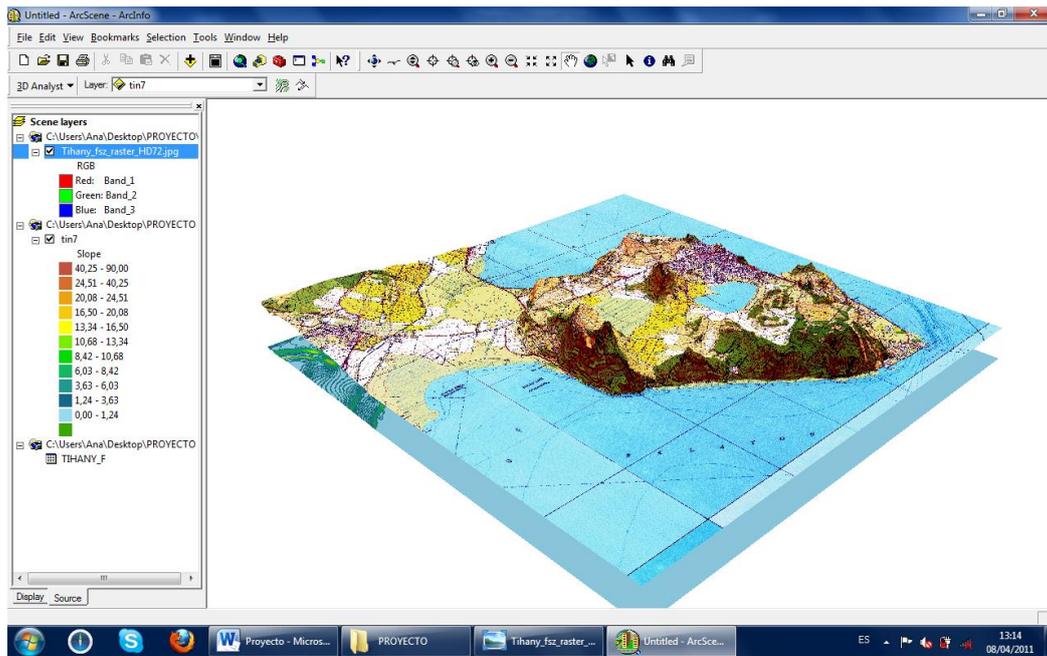


Figure 24 Final modell with map sheets

The final step is unselecting the TIN model, having the final map sheets modelled with exaggerate high scale (Figure 24).

Finally I did the opposite step. I opened the TIN model and the initial map that I had but this time without the exaggerated high scale.(Figure 25).

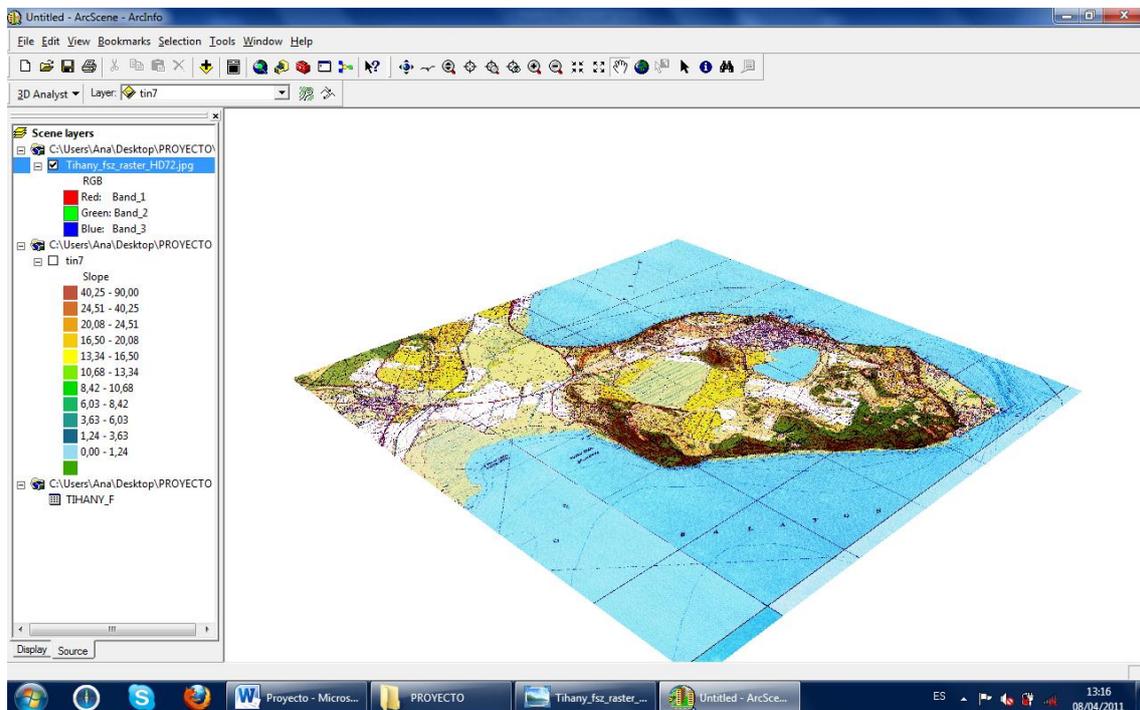


Figure 25 TIN model having the final map sheets modelled without exaggerate high scale

V. Future plans

The final result of this work I obtained two different three-dimensional models based on a point cloud of the peninsula of Tihany.

When I started this work I thought about possible applications. This type of three-dimensional model may have different uses, e.g.:

- Geographical research and natural sciences, developing some thematic databases.
- Maps connected to databases to present the region to fill touristic aims. In this case, I created an example of a map with the pictures that I took in Tihany and it is presented in the Annex II, having the opportunity to combine the presentation of this map with the 3D model and other multimedia based information.

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VII. Annex I









VIII. Annex II

An example of using pictures taken in my trip to Tihany on a map containing touristic information in ArcGis.

