

A projekt az Európai Unió támogatásával és az Európai Szociális Alap társfinanszírozásával valósul meg (támogatási szerződés száma TÁMOP 4.2.1/B-09/1/KMR-2010-0003)

# 3D modelling of the Danube River and the floods during March and April of 2006 in Nagymaros and Szob

Author: Ramiro Marco Figuera Professor. José Jesús Reyes Nunez

2010

Eötvös Loránd Tudományegyetem – Universitat Politécnica de Catalunya

I. Introductory data about the autor	3
II. Introduction	4
III.Project workflow	7
1. Getting ground data	7
2. Processing ground data	7
3. How to create the 3D model	18
4. Processing the ground 3D model	20
5. Getting water data	23
6. Processing the water data	25
7. Processing the water 3D model	28
IV.Conclusions	28
V. Working with high-resolution map sheets	29
VI. Alternative workflow, working with remote sensing methods	32
VII. Bibliography	33
VIII. Annexes Hiba! A könyvjelző nem létezi	ik.

## I. Introductory data about the autor

Ramiro Marco Figuera, student of Geomatic and Topography Enginnering at the Polytechnic Building School of Barcelona, an institution member of the Polytechnic University of Catalonia.

This thesis is a research made on the scope of the ERASMUS program between the Polytechnic University of Catalonia and the Eötvos Loránd University. It was developed in the Department of Cartography and Geoinformatics, Faculty of Informatics.

The thesis was implemented under the supervision of Associated Prof. José Jesus Reyes Nuñez, in the Department of Cartography and Geoinformatics.

## **II. Introduction**

Every year the Danube (Duna) River uses to flood in the spring. In March and April 2006 the Duna floods up to a really high level in the Nagymaros and Szob villages. The flood goes up to 6 meters from its regular level. Water covered like a half of the villages provoking lots of problems in their inhabitants' normal life.

The main task of this research is the planning and making of a 3D model of the Duna River region called "Dunakanyar" in Hungarian language, including the above mentioned villages, and presenting what happened and how those floods affected the population living there. I also tried to make an analysis of this situation and find some options or alternatives due to the security systems and the emergency service.

#### The Duna River:

The river originates in the Black Forest in Germany as the much smaller Brigach and Breg rivers, which join at the German town of Donaueschingen and being known as the Duna River from here, flooding southeastward for a distance of more or less 2850 km (1771 miles), passing through four Central and Eastern European capitals, before emptying into the Black Sea via the Danube Delta in Romania and Ukraine.

The river floods through or acts as part of the borders of ten countries: Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Moldova, Ukraine and Romania (Figure 1).



Figure 1 The Danube River

Nagymaros:



Nagymaros is a little town situated in the border of the Danube River just in front of the town of Visegrád. It's connected with this town by ferry. It is situated in the kilometer XXXX. The population in 2001 was 4469 inhabitants and it has an area of 34,39Km<sup>2</sup>. In this town there's a hydrographic station from where I took some water flood data.



Figure 2 Nagymaros

Szob:



Szob is a little town situated in the border of the Danube River. It's also situated in the boundary between Hungary and Slovakia. The population in 2008 was 2971 habitants and it has an area of 20.07  $\text{Km}^2$ . In this town there's a hydrographic station from where I took some water flood data.



Figure 3 Szob

#### **III.** Project workflow

In this project I needed to study the use of some new software as ArcScene from ESRI and Microsoft Access from. I can resume the whole process in 7 main parts:

#### 1. Getting ground data:

It was the easiest part of the project. I obtained the ready information from János Mészáros, PhD student in the Department of Cartography and Geoinformatics. The data was extracted using the software Global Mapper and it belonged to the DTA-50 database (digitized topographic maps at scale 1:10000), made by the Institute of Military Cartography of Hungary. The data was stored in a unique 300Mb file in XYZ format.

#### 2. Processing ground data:

My task during the first part of the process was on the analysis of the XYZ file, to know in detail its' structure and other characteristics .

The first step to work with this data is to change it to a TXT format. Because of the large size of the original file, I had to divide it into 300 files of 1Mb each. Once I had those 300 files I opened them one by one and changed points per comas. This step was needed to avoid any difficulty using the regional configuration of my computer. Once I had this done, I started the more difficult and complex part of the project.

I had to put this data into the ArcGIS software, but before this step I transformed all the files to a DBF format, because ArcGIS doesn't recognise the TXT format, offering the options to import data in XLS or DBF format. I chose DBF format because is the database format used by ArcGIS software.

Next I used Microsoft Access software to change the format from TXT to DBF. Obviously I knew that I could do the same using Excel software, but I preferred to use a more professional (database oriented) software from the same Microsoft product family. • The process in Microsoft Access was really easy to do, comparing to the process in Excel. I didn't need to open tables one by one to change the format. The process was making a database and importing all the tables to that database. Then I chose the format that I would to save those tables. If you choose DBF format the tables are save to this format automatically. I created a new database and imported a table chosen TXT format

Abrir 🛝 Diseña	wgevo × ≝ <u>a</u>	0+ 0+	8:8: III		A	Cydone				
Objetos   Tablas   Consultas   Formula   Informes   Páginas   Ancos	Crear una tabla i Crear una tabla i Crear una tabla i	en vis utilizai ntrod	ta Diseño ndo el asistente uciendo datos <u>Ver</u> Organizar (conos	<b>&gt;</b>	Mis documentos recientes Escritorio Mis documentos Mi PC	Ingusta Mis archivos rec Mis archivos rec Mis imágenes Mis imágenes OpenOffice.org Updater5 UrbusDJ Øbd1.mdb Øbd2.mdb	bidos 3.0 (es) Installation Files			
Módulos		X	Importar			Nombre de archivo:			~	Importar
Grupos			Vincular tablac		Mis sitios de red	<u>Tipo de archivo:</u>	Microsoft Office Access (*.mdl	o;*.adp;*.mda;*.mde;*.ade)	~	Cancelar
Favoritos		1	Pegar Relaciones				Outlook() Paradox (*.db) Archivos de texto (*.txt;*.csv Windows SharePoint Services   XML (*.xmi;*.xsd) Basec de debos OPEC ()	;".tab;".asc) )	( ) ( )	
		6	_ Editor de Visual Basi	ic						

Figure 4 Importing TXT format

• Using the Import assistant I chose Advanced Options and there I chose A LONG format

a Asistente para importación de texto						
Los datos parecen tener el formato 'Delinitado'. Si no es así, elija el formato que mejor describa los datos.	100	Prueb_a - Especific	ación de impo	ortación		L
		ormato del archivo: 🧿	Delimitado	Delimitador de campo	t (: 💌	Aceptar
💿 Delmitado - Caracteres tales como coma o tabulación separan cada campo		C	Ancho filjo	Cyalificador de texto:	(ninguno)	Cancelar
Ancho fijo - Los campos están alineados en columnas con espacios entre cada campo	le le	ŝoma: E	spañol	12.2.2	×	Curreday come
	<u>P</u>	ágina de codigos: E	uropeo occidental	(DO5)	× 1	guardar como
1 824005;287995;171.000 2 624005;287995;171.000 3 624005;287975;170.000		Delmitador de hora:		≦imbolo decimal: ,		
4 624005;287965;170.000		Nombre de campo T	po de dato	Indexado Salta	8	
5 624005;287955;169.000		Campol Ent	ero largo No ero largo No		_	
6 624005;2 7945;169.000	-	Campo3 Dol	le No			
x D		*)			- H	
	_					

Figure 5 Choosing LONG format

• Then selected Import a new table and I changed the names of the fields to x,y,z. After it I put a main key and wrote the name of the table to save it.

Alternative parts in	spector bio de texts	100	The growing he	ca anglattachée de terre		
rite de alternation sector las cas alternation de las de	de los campos? Selectore el defentados personallo o composito en In-mile vidita primie que ajumine alegio.	-	Partie exercite an en el less que ser	a enformación estimo codo ramas recor abase. Templalis puede nos	que édit reportands, failectaire los co Binar la información de al àrea Optione	10 AN
the of deletative and	requestion company.		Contractory of			
O Jahanne (S)	Patrone IO the O faet O pre-		The second second	-		725
-		100	Bears or the		The search of the search of the	- 21
- generation		-	- Postan	<u> </u>	. Tomatous a bida towar	
and barrent b		100	Courses, Course	of Research		1
14005 237985	111.000		124001 2172	85 171.000		
13 4008 287975 3	170.000	10	COLUMN TWO	16 110.000		1
CADER DRIVES	49,000		STATE INTO	AS \$40,000		
124005 287945 2	149.000	145	211115 CATH	45 349.000		
*1.11		32	101			
Augusta Barris	Canan   Lower Theater   Inc	1	Transmission in the	Province 1	and the second se	
And in the other designed of the other desig	International Academic Street		des annual de la companya de la comp	CLASSING -	C dates	
			Tatalante pe	an hergeirtischies die techn		1
			This is a second	ra languertus kin da landa		1
7 Kilotuuto para 1	Negerlaide de lexite	-	Tattion p	na konportación de fecto fata es subi la inferes supertar las datas	an an i amin'n wataan	1
Thirton part	Regentiel de Bellevie Neuerland des services aussender des définie des des des des		Z Antonio po	ta bagarin kin di kulu Anton ta bahan	alle an el annelle revolucion	1
Thirten part	Regential das Belleche Personit Access reconnection das definis das ders produ- lar ders radio jute das de la cessiones ders produc- lar ders radio complete de la date i panden emigen et Arte est de la definieren	er <b>1</b>	1	at lageria dia di kole fitta e takia di kolen mente ka dita.	alle an el annette recontaciones	1
Tation part	Reported das Bertente Research Aussis versionen de stat deltra inter den dertifie Research Aussis (des Dertifiet de seus des dertifiet Research aussis (deltra de seus de seus de seus Research de seus traditionen de seus de seus de seus Aussis de seus de seus traditionen de seus de seus de seus Aussis de seus de seus traditionen de seus de seus de seus Aussis de seus de seus traditionen de seus d	er <b>1</b>	1	at lagerin lin & hole	alle an el annelle recelacion	_1
Astrony part	Reported das Bellevile Research Access research and data at an area dering Research Access reals regards & bit data operation for a set reals regards & bit data operation Area est reals regards Area est reals regards	E		A begarin in in in ante	alto an el amerito recontaciones	1
Autom part	Negerital da la factor Negerital da se tente la seria da la seconomida da difera des des destru- la seria da la seconomida de difera de destru- des este del activita de la seconomida de de destructuras de la seconomida de la seconomida de la seconomida de destructuras de la seconomida de la seconomida	ET 10		A tempertection de teches fata en mais de teches mantre tes datas paratre e als tables antes a se tables	alto an el amorte recolacion	
	Negerital da Bolante Result Access resonantes da deta disa da parte la sera da la secona de la compañía da esta persona la sera completente da esta comp	27 27		A tempertection de teche faise en table la statem manifar les dates proviner et la table arrest	alte an el amerite recontacione	
	Negerifiel de la factor Negerifiel de la factor la cherrist de secondario de de dése de la comparis la cherristica des productions de la comparise dere este optimiseron de factor est optimiseron de factor est optimiseron O factor de comparise De la cherristica O factor de comparise De la cherristica De la comparise De la comparise			A tempertection de teche faise en table la statem manifar les dates paperter et la table anne	alte an el amerite recontacione	
	Negerital da Bolante Result Access resonantes da detai da des las proje- lo ser de la como constato da detai da de proje- lo ser de la como contra de la como de la como Aria e de defenerario De de la como constato de la da como de la como Aria e de defenerario De de la como como de la da como Aria e de defenerario De de la como de la da como De de la como De de de la como De de de la como De de de de la como De de de de de la como De de			A tempertection de teche finance entrés la vision marrier les dats. Descriter a la table	alte an el amerite recontacione	
	Negerifación de la factor Negerifación de seu encomplete de deltas des derá proje- baseros tallo, de la deserración de la del a conservación de la conservación aprese de la del a conservación de la deservación de la del a conservación de la deservación de la deservación d			Construction de ferete Construction de ferete Construction de la colonia Secondo a la tables	an de anno a matagere	
	Negential Mar Be Jacobs Negential Marcon recommission dat define Anno Anno Anno Anno redo registra data data data data data Anno redo registra data data data data data data Anno redo registra Anno redo registra Anno redo registra Anno redo data data data data data data data Anno redo data data data data data data data Anno redo data data data data data data data Anno redo data data data data data data data da	87		An importantion de ferrie	edo que el semento reconducares	
	Negential da la factori Negential da con museriale da della de	E		Construction die Versche Construction die Versche Construction die Auforma Amportung die Auforma Amportung die Tables Amportung die Tables	do au el activito recubicario	1
	Negenthal Mar Be Textur Nerseaff Access recommisks par define and particle between statis, the theory program Artise extra operations Defines a function groups to most arrival Defines a function of the function of the function of the function Defines a function of the function of the function of the function Defines a function of the function of the function of the function Defines a function of the function of the function of the function Defines a function of the function of the function of the function Defines a function of the function of the function of the function of the function Defines a function of the fun	E		Construction die Verscher Construction die Verscher Construction die Verscher Propertier alle Tables Table Ta	ccio que el quillerito recondicipari	
	Negenthal Mar Be Textur Negenthal Marcon recommission data define attack participation international definition of the state of the state of the state international definition of the state of the state of the state international definition of the state of the state of the state international definition of the state of the state of the state international definition of the state of the state of the state international definition of the state of the state of the state of the state of the state international definition of the state of the s			Construction die Verscher Construction die Verscher Construction die Verscher Propertier alle Tables Theorem in Ausscher Construction die Ausscher Con	ccio que el quillerito recondiciones registo de que el quittorio funcio funda	-

Figure 6 Creating and saving the table



• The final step was to export the table as a DBF (IV) database

Figure 7 Exporting to DBF (IV)

Before importing all the data to the ArcGIS I had to know which projection is used in Hungarian official maps. The projection used for all the geodetic points, maps and other ground data in Hungary is the EOV (Egységes Országos Vetület, Uniform National Projection). Here I add some information from the projection extracted from the Internet (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 m

**b** = 6 356 774.516 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:  $\mathbf{R} = 6\ 379\ 743.001\ m$ 

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°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  $\mathbf{x}_{o} = 0.0 \text{ m}$   $\mathbf{y}_{o} = 0.0 \text{ m}$ and by computing the ellipsoidal geographic coordinates: =  $47^{\circ}08'39.8174"$ =  $19^{\circ}02'54.8584"$ 

#### **Origin of EOV plane coordinates:**

Origin of the EOV plane coordinates is moved to South-West with respect to origin of projection such that all possible EOV coordinates be positive for Hungary:  $X_{EOV} = x + 200\ 000.000\ \mathrm{m}$  $Y_{EOV} = y + 650\ 000.000\ m$ **Projection zones:** A single cylindrical zone covers the area of Hungary in East-West direction. **Scale factor:**  $m_0 = 0.99993$ Linear distortion: Along the **y** axis: -7 cm/km North of Hungary:-/ cm/kmSouth of Hungary:+26 cm/km+23 cm/km Area distortion: North of Hungary: South of Hungary:  $-1.4 \text{ m}^2/\text{ha}$  $+4.5 \text{ m}^2/\text{ha}$  $+4.5 \text{ m}^2/\text{ha}$ 

Then I imported all the data into ArcGIS software, this time one by one using the XY data. In this step I also chose the reference system to work. Choosing the Hungarian EOV system was really easy, because it is included in the ArcGIS software. I repeated this process with each table. • The first step is to import the XY data and choose the table that we want to import.



Figure 8 Importing XY data

• Then I chose the fields where the X and Y data is stored. I had to choose the reference system too. In this case I found it in the projected coordinated system and in the national grids. Its name in ArcGIS is "HD 1972 Egyseges Orszagos Vetulet.prj"



Figure 9 Choosing the reference system

• Finally we have represented the XY data in the software.



Figure 10 Final result of one table

Once I had this data in the software, the next step was to delete all the data that I don't need. I did that because from the beginnings I was working with ground date of all the country and I only needed a small part of it.

To know what part of the whole data I need, I put 21 georeferenced map sheets into the software. With these maps and the ground data in the software, the next step was to select the points placed within the map sheets.



Figure 11 Map sheets

Next I saved all those ground data points into a unique DBF table. I did it first selecting those points, and later going to the Data Management Tools, to choose the Merge Action. I introduced one by one all the tables following the same process, and the final result was only one table.



Figure 12 Merge table result

This step was necessary because working with one table is always more practical, easier and faster than working with 91 tables as I was working. Finishing this part of the process the data was ready for the next, more complex step.

## 3. How to create the 3D model

The first question to answer is how I do that?, that is what software and technology can be the more appropriated to make my 3D model. To answer this question I was doing some groundwork through Internet, visiting some geoforums. I found two possible solutions:

- a. The first one and directly discarded was working with AutoCad Civil software. I discarded it because going on that way includes changing totally my work mentality, using non-cartographic software and being the hardest way to reach my objective.
- b. The second, chosen way was working first with 3D Analyst in ArcGIS and after it exporting all this information to the ArcScene software.

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

 Using the 3D Analyst extension → Create/Modify TIN → Create TIN from features (Figure 13)



Figure 13 Creating TIN

 Choose the layer → Height source : Z → Triangulate as: mass point → Tag value field: none → Choose the output route:

Check the layer(s) that will be used to its settings.	create the TIN. Clic	k a layer's name to specify
Layers:	- Settings for selec	ted layer
	Feature type:	2D points
	Height source:	z
	Triangulate as:	mass points 💌
	Tag value field:	<none></none>
Dutput TIN: a de Trabajo/ZONA B	JENA DE TRABAJO	0\dbf_per_exportar\tin

Figure 14 Saving TIN

• Finally, the resulting TIN model is displayed



Figure 15 Final TIN

## 4. Processing the ground 3D model

To manage the 3D model was used the ArcScene software developed by ESRI. With this software we can manage the TIN format and see it in XYZ axes. This software is really easy to use. I can resume the process in the next steps:

The first step is adding data to the Scene layers as we used to do in ArcGIS. I obtained a 3D model in only one colour.



Figure 16 TIN displayed in ArcScene

The next step was to introduce some georeferenced maps sheets into the model. These map sheets obtained the height information from the TIN to model them. The process is resumed in the next steps:

• I added one by one the four map sheets before adding data



Figure 17 Adding map sheets

• I clicked on the Layer command and then on Properties. After it I clicked on the Base Heights flap and selected "Obtain heights for layers from heights". Then we had to choose where our TIN was stored. On the Z UNIT section I chose Custom and a conversion factor of 1,000.



• Then I pressed Acept and the modeled map sheet was made.



Figure 19 Obtaining the modelled map sheets

• The final step is unselecting the TIN having the final map sheets modelled.



Figure 20 Final modelled map sheets

## 5. Getting water data

To get the water information my professor, Jesus Reyes told that there's a web site (www.vizadat.hu), which collects all the water height data. This web site is written in Hungarian language and I needed some help to translate and navigate through the site.

• Once in the site, we should go to Felszíni vízállás idősorok (Time series of surface water) section.



Figure 21 Main page from www.vizadat.hu

• In this section I chose the hydrographical station situated in Nagymaros and gave the lapse of time of the data.

Főoldal >> Felszíni vízállás idősorok					
	Felszíni vízállás idősorok				
Állomás:	Duna - 1694,6 Fkm - Nagymaros	Választ			
Kezdő időpont: Záró időpont:	2006.3.1 2006.5.1	Választ			
Jelenítse meg az első	1000 🗘 adatot				
	Eredmények listázása				

## Figure 22 Choosing the options

• Then clicking on Eredmények listázása we get the information in graphic and table format



10		CONTRACTOR OF		
Allomás:		Duna - 1694,6	Fkm - Neg	ymaro
Kezdő időpont		2006.3.1		
Záró kóőpont		2006.5.1		
Találatok száma:	8	1000		
	-			
	Ssz	klöpont	Vizállás	
	1,	2006.03.01 07:01	90	
	2	2006.03.01 19:01	82	
	3.	2006.03.02 07:01	74	
	4.	2006.03.02 19:01	67	
	5.	2006.03.03 07:01	62	
	6.	2006.03.03 19:01	61	
	7.	2006.03.04 07:01	61	
	8.	2006.03.04 19:01	62	
	9.	2006.03.05 07:01	50	
	10.	2006.03.05 19:01	60	
	11.	2906.03.06 07:00	55	
	12	2005.03.05 19:00	55	
	13.	2005.03.07 07:00	60	
	14.	2006.03.07 19:01	65	
	15.	2006.03.08 07:01	69	
	16.	2006.03.08 19:01	67	
	17.	2006.03.09 07:10	63	
	18.	2005.03.09 19:01	61	
	19.	2006.03 10 07:01	60	
	20.	2006.03.10 19:01	64	
		-		

Figure 23 Data presentation in graphic and table format

## 6. Processing the water data

Similar to the ground data, I needed to process the water data before using it. The selected data was measured between 25<sup>th</sup> March and 26<sup>th</sup> April 2006. The first step was putting the data into an Excel sheet to make some calculus. In a normal day 3 or 4 measurements were made, but in the days with big floods their number was increased to 20 measurements. Because of this, the first step was to make some average calculus to have one average measurement per day. I made it for the Nagymaros station and for the Szob station, having all the data in centimetres.

_					
0	A	В	С	D	
-		2006.03.25			_
30	50.	07:01	225	226	
		2006.03.25			
31	51.	19:01	227		
		2006.03.26			
32	52.	07:01	223	224	_
	60	2006.03.26	225		
33	55.	19:01	220		
34	54	07:01	245	272	
34	54.	2006 03 27	240		_
35	55.	19:01	299		
		2006.03.28			
36	56.	07:01	362	389	
		2006.03.28			
37	57.	10:31	376		
		2006.03.28			
38	58.	12:01	382		
-	50	2006.03.28	205		
39	59.	15:01	395		
40	60	18-01	405		
40	00.	2006 03 28	400		
41	61.	19:00	405		
		2006.03.28			
42	62.	21:01	415		
		2006.03.29			
43	63.	00:01	424	447	
		2006.03.29			
44	64.	03:01	432		
	05	2006.03.29	100		
45	65.	06:01	438		
46	66	2006.03.29	445		
40	00.	2006.03.29	445		
47	67.	07:36	445		
		2006.03.29			
48	68.	09:01	449		
		2006.03.29			
49	69.	12:01	455		
	70	2006.03.29			
50	70.	15:01	467		
51	71	2006.03.29	175		
21	71.	2006.03.20	4/5		
52	72	19:00	475		
		2006.03.29	415		
53	73.	21:01	482		
		2006.03.30			
54	74.	00:01	488	515	
		2006.03.30			
55	75.	03:01	496		
		2006.03.30			

Figure 24 Data calculus

In figure 24 in red colour can be seen the average calculus per day. I used the average data to create the water floods shapes.

The next step was to decide how to put this data to the GIS software and how to make the 3D shapes. Before realizing this step I found some problems to solve. The first one was to decide which points I can use to make the TIN shape. After doing some attempts finally I decided first to make one table per day containing the data from the hydrographical station, and second to complete the shape, including the XYZ coordinates from the points, which were in the four corners of the map sheet of the zones of Nagymaros and Szob. Once finished this task, I saved all those tables in XLS format.

Х		у		Z	
	636913		274578		111,27
	642926		270311		110,39
	648215		267045		110,39
	648225		277085		110,39
	635255		277115		111,27
	635255		267095		111,27

The new XLS table was imported in to the GIS software, following the same steps described in the ground data section. I used the "Import XY data" and then I created the TIN shapes. I did the same for each table because I needed one TIN shape per day, obtaining a total of 30 shapes.



Figure 25 Water TIN shape

## 7. Processing the water 3D model

The process of water data was the same than with the ground data. I imported the TIN model into the ArcScene software and then I chose a colour for the shape. Selecting and running in an animation the different TIN shapes we can have an idea about the magnitude of the floods and what areas of the zone where more affected.



Figure 26 Final result

## **IV.** Conclusions

The final results of this research are two 3D models, one based only on ground data and 30 shapes made using water data to present the Danube flood in this region in March, April and May 2006. Combining it, on those zones of study can be obtained a total of thirty 3D models of the floods. Those models can be used to make some studies about how the water floods affect those towns and their habitants. It also can be used to make some studies about what the Hungarian government could do to fix this annual situation or to, at least, reduce the impact on the population in these towns. In my opinion I can say that the floods in this part of the country are very regular and due to the proximity of those towns to the Duna River it's very difficult to fix it.

## V. Working with high-resolution map sheets

In interest of obtaining a more rigorous result, I asked my tutor if I could work with high-resolution map sheets. I obtained two high-resolution Nagymaros map sheets from János Mészáros to begin this work. The reason of this request was that using the actual scanned map sheets when you zoomed in the resolution was really low, presenting a very pixeled image on the display.

I considered that if somebody wants to make a study about the impact of the floods in the Nagymaros zone, high-resolution map sheets should be used to see really as far as the water level can cover the riversides within the town.

The first step was importing both images to the ArcGIS software and georeference the sheets.

• With the maps in the software I selected the Georeferencing module.



Figure 27 Georeferencing module

• Then I deactivate the Auto adjust mode and I began to georeference the map. If we know the coordinates of the square we can click on the map, adding a control point and typing the coordinates into the equivalence table. Other possible solution is that we can click into the square of the map adding a control point and go to the low-resolution map sheets, which have the same scale, and click on the same square. I chose the second one, because it was faster than the first one.



Figure 28 Georeferencing

• Once we have this map sheet referenced we go to the Georeferencing module and choose Rectify. We should save it in JPG format.

Save As		? 🗙
Cell Size:	0,424470	
Resample Type:	Nearest Neighbor (for discrete data)	•
Output Location:	C:\Documents and Settings\Ramiro\Esci	2
Name: Kismaros_75_144	4: Format: JPG	•
Compression Type: JPEG	Compression Quality 75 (1-100):	
	Save Ca	ncel

Figure 29 Saving the output image

The next step was to import those map sheets into the ArcScene. The process was similar to the followed steps working with the TIN: clicking Add Data and selecting the maps sheets, and. repeating the process to model the map sheets to the TIN as we did before.

After finishing this process, I hoped to zoom in the Nagymaros zone and to have a more real and detailed vision of the magnitude of the problem. That was that I expected, but the real result was pixels again (figure 29).



Figure 29 Pixels in the high-resolution images

I have two theories about the negative result obtained with the high-resolution images:

- One of the reasons could be the image pyramid process, because probably the software is working with the less resolution shape of the image.
- The software can't handle those high-resolution images. Probably this software was created to work with 3D data but not with shapes with high-resolution images.

## VI. Alternative workflow, working with remote sensing methods

From the first time I was thinking about to use some remote sensing methods because this is my speciality on the Geomatics engineering degree. Working on that way is faster and easier. The only negative point is that the satellite images are very expensive and the result depends on the quality of the images.

In this case I recommend working with multispectral images with three bands or radar images.

- If we work with multispectral images we have at least three bands (blue, red and green bands). Then we can see this image in a false colour construction combining the bands. Those images use to have a very high resolution, depending on the satellite used to take the images. If we work with the Thematic Mapper Sensor carried on the Landsat 5 satellite we will have a resolution of 30m. Otherwise working with the Geo-Eye 1 we will have a resolution of 1.65m working with the multispectral sensor. The negative aspect is that always the result depends on the weather conditions because if when the picture is taken the sky is cloudy, then we can't work with this image.
- Using radar images we have only one panchromatic (B&W) band. With the SAR antenna carried on the TerraSar-X satellite we can obtain a 1m resolution, working with the SpotLight mode. The SpotLight mode can only work with a 10km x 10 km image. The positive aspect of working with radar images is that we don't depend of the weather conditions or if it's night or day. This kind of satellites can work always.

I tried to work with some images from the Landsat 5 satellite, but on March an April of 2006 the cloud cover in the image was circa 75-80%, being totally impossible to work with it. I chose the Landsat 5 satellite because we can obtain free images from the United States Geological Survey (USGS) web site. The other satellites are always really expensive.

The main aim of the use of the images is not to obtain a 3D model, but to finish faster the study about how the floods affect the zone.

The workflow is very easy. I can resume the process with 3-band images in this flow diagram: First we should analyze the bit level of an image. It usually goes from 0 to 265. Analyzing the bit levels for the water areas we can make a bounding for those levels and assign it for the water areas.

Second, we assign the value 1 to the bits for the water and the value 0 for the rest. We repeat the same process for the image with normal water level and for the image with a high water level.

After the first two steps we have two images with two bit levels. Then we superimpose the images and make some easy bit calculus, writing a little algorithm in Query language to make a comparison: if the bit value from the  $X_n$  pixel from the image A is the same that the bit value from the  $Y_n$  pixel from the image B, then paint those pixel in red colour. Then if the bit value from the  $X_n$  pixel from the image A is not the same that the bit value from the  $Y_n$  pixel from the image A is not the

The blue painted area is the area of the flood. If we selected this area and save it as a shape, we can superimpose it in a high-resolution image to see how the floods affected those towns.

As we can see, the process is shorter and easier. To make an study about floods – only about the floods! – it is better to use remote sensing, but if we want to do a 3D model the only method to follow is to work with the initial process developed in this thesis.

## VII. Bibliography

GeoEye, 2010. *GeoEye fact sheet*. [online] Avaliable at: <http://launch.geoeye.com/LaunchSite/about/fact\_sheet.aspx>

Infoterra, 2009. *Basic product specification*.[online] TerraSar-X Ground Segment. Avaliable at:<http://www.infoterra.de/asset/cms/file/tx-gs-dd-3302\_basic-product-specification-document\_1.6\_signed\_small.pdf>

Infoterra, 2009. *Servicios TerraSar-X*.[online] Potsdam: Infoterra GmbH. Avaliable at:<http://www.terrasar.de/asset/cms/file/es\_servicios-terrasar-x\_i4\_200809.pdf>

U.S. Geological Survey, 2010. *United States Geological Service*.[online]. Avaliable at: <a href="http://www.usgs.gov/>">http://www.usgs.gov/></a>

NASA, 2010. *The Landsat program – Technical Details*. [online] Avaliable at:<http://landsat.gsfc.nasa.gov/about/tm.html>

Vituki Rtk., 2010. *VíZÜGYI ADATBANK*. [online]. Avaliable at: <a href="http://www.vizadat.hu/">http://www.vizadat.hu/</a>

Department of Cartography and Geoinformatics Eötvos Loránd University, 2009. *Description Directory for EOV Projection System*. [online]Budapest: ELTE. Avaliable at: <a href="http://lazarus.elte.hu/gb/geodez/geod2.htm">http://lazarus.elte.hu/gb/geodez/geod2.htm</a>

Gabriel Barrientos M., 2009. *3D Analyst Arctoolbox:Guía Rápida de herramientas*.[online] Gabriel Barrientos M. Avaliable at: <a href="http://www.gabrielortiz.com/descargas/3D\_Analyst\_9\_2.pdf">http://www.gabrielortiz.com/descargas/3D\_Analyst\_9\_2.pdf</a>>

Jaime Díaz. 2008. Convertir un archivo XYZ a Raster en ArcGIS 9.2. *El blog del geografo*.[blog] 13 january. Avaliable at: <a href="http://jaimegeografo.blogspot.com/2008/01/convertir-un-archivo-xyz-raster-en.html">http://jaimegeografo.blogspot.com/2008/01/convertir-un-archivo-xyz-raster-en.html</a>

Cartesia. 2006. Acoplar imagen a TIN. *Foro Cartesia*.[blog] 28 November. Avaliable at: <a href="http://www.cartesia.org/foro/viewtopic.php?t=8119">http://www.cartesia.org/foro/viewtopic.php?t=8119</a>

Wikipedia, 2010. *Danubio*.[online] (Updated 11 november 2010). Avaliable at: <a href="http://es.wikipedia.org/wiki/Danubio">http://es.wikipedia.org/wiki/Danubio</a>

Wikipedia, 2010. *Nagymaros*.[online] (Updated 30 september 2010). Avaliable at: <a href="http://en.wikipedia.org/wiki/Nagymaros">http://en.wikipedia.org/wiki/Nagymaros</a>

Wikipedia, 2010. *Nagymaros*.[online] (Updated 1 november 2010). Avaliable at: <a href="http://hu.wikipedia.org/wiki/Nagymaros">http://hu.wikipedia.org/wiki/Nagymaros</a>

Wikipedia, 2010. *Nagymaros Dams*.[online] (Updated 30 november 2010). Avaliable at: <a href="http://en.wikipedia.org/wiki/Gabč%C3%ADkovo\_-\_Nagymaros\_Dams>">http://en.wikipedia.org/wiki/Gabč%C3%ADkovo\_-\_Nagymaros\_Dams></a>

Wikipedia, 2010. Szob.[online] (Updated 19 june 2010). Avaliable at:

<http://en.wikipedia.org/wiki/Szob>

Wikipedia, 2010. *Levee*.[online] (Updated 25 november 2010). Avaliable at: <a href="http://en.wikipedia.org/wiki/Levee">http://en.wikipedia.org/wiki/Levee</a>

Wikipedia, 2010. *Weir*.[online] (Updated 30 november 2010). Avaliable at: <a href="http://en.wikipedia.org/wiki/Weir">http://en.wikipedia.org/wiki/Weir</a>

GoogleMaps, 2010. Szob. [online] Avaliable at:

<http://maps.google.es/maps?f=q&source=s\_q&hl=es&geocode=&q=Szob,+Hungr%C 3%ADa&sll=40.396764,-

3.713379&sspn=9.535213,19.753418&ie=UTF8&hq=&hnear=Szob,+Hungr%C3%AD a&t=h&z=13>

GoogleMaps, 2010. Nagymaros. [online] Avaliable at:

<http://maps.google.es/maps?f=q&source=s\_q&hl=es&geocode=&q=nagymaros&sll=4 0.396764,-

3.713379&sspn=9.167412,19.753418&ie=UTF8&hq=&hnear=Nagymaros,+Hungr%C 3%ADa&t=h&z=13>