RiskCity

Application of GIS for multi-hazard risk assessment in an urban environment

Cees van Westen (ed)

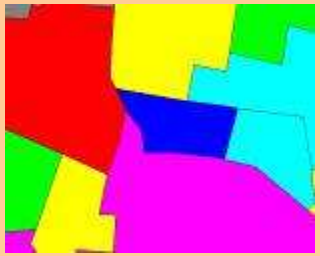
ITC

Associated Institution
UNITED NATIONS UNIVERSITY

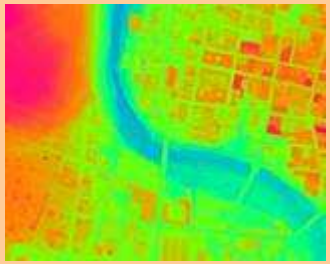
adpc 20 years of reducing disaster risks in Asia and the Pacific

High res image

Ward & census



DEM Lidar



Thematic layers:

- Flood discharges
- Seismic catalogs
- Soil and rock data
- Landslide information
- Technological information
- etc.

Elements at risk

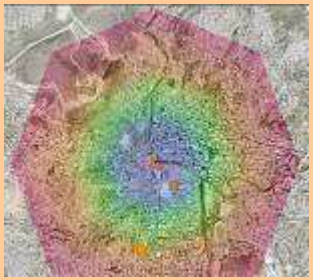
Building Attributes:

- Urban land use
- Nr of buildings
- Height of buildings
- Nr. people (daytime)
- Nr. people (nighttime)

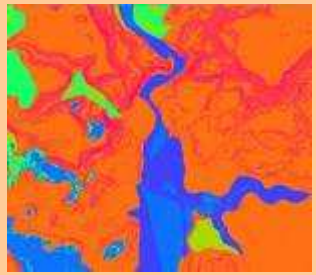
Hazard maps

Landslides

Flooding



Technological



Earthquake

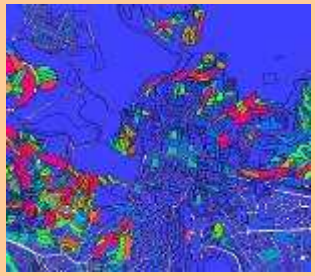
Risk = Hazard * Vulnerability * Amount

Risk maps

Landslides

Flooding

Technological



Earthquake

Risk curve

Objective of case study

- **The objective of this exercise is to demonstrate the concepts of the use of GIS for landslide susceptibility, hazard and risk assessment in an urban setting.**

- **Risk is defined *as the probability of harmful consequences, or expected loss (of lives, people injured, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human induced hazards and vulnerable/capable conditions*.**
- **Risk assessment with GIS can be done on the basis of the following basic equation:**

  Risk = Hazard * Vulnerability * Amount of elements at risk

ILWIS key features

- Import and export of widely used data formats
- On-screen and tablet digitizing
- Comprehensive set of image processing tools
- Orthophoto, image georeferencing, transformation and mosaicing
- Advanced modeling and spatial data analysis
- 3D visualization with interactive editing for optimal view findings
- Rich projection and coordinate system library
- Geo-statistical analyses, with Kriging for improved interpolation
- Production and visualization of stereo image pairs
- Spatial Multiple Criteria Evaluation

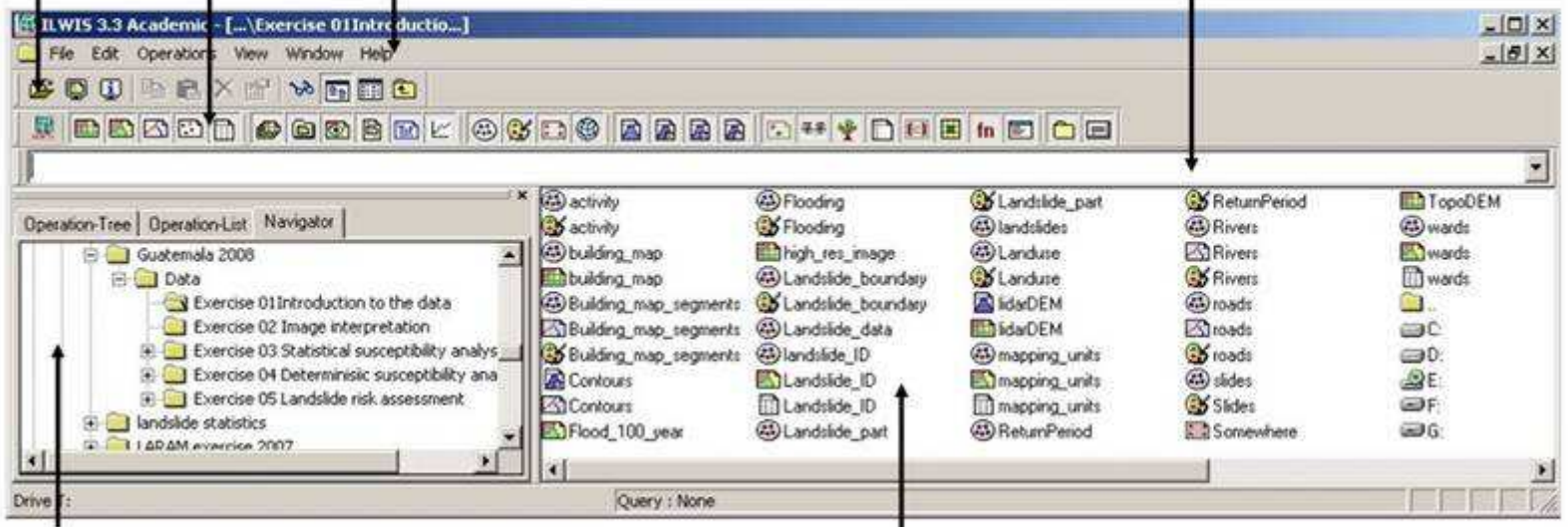
Main window

Object selection
Defines which objects are visible in data catalog

Toolbar

Menu bar
Used for executing most operations

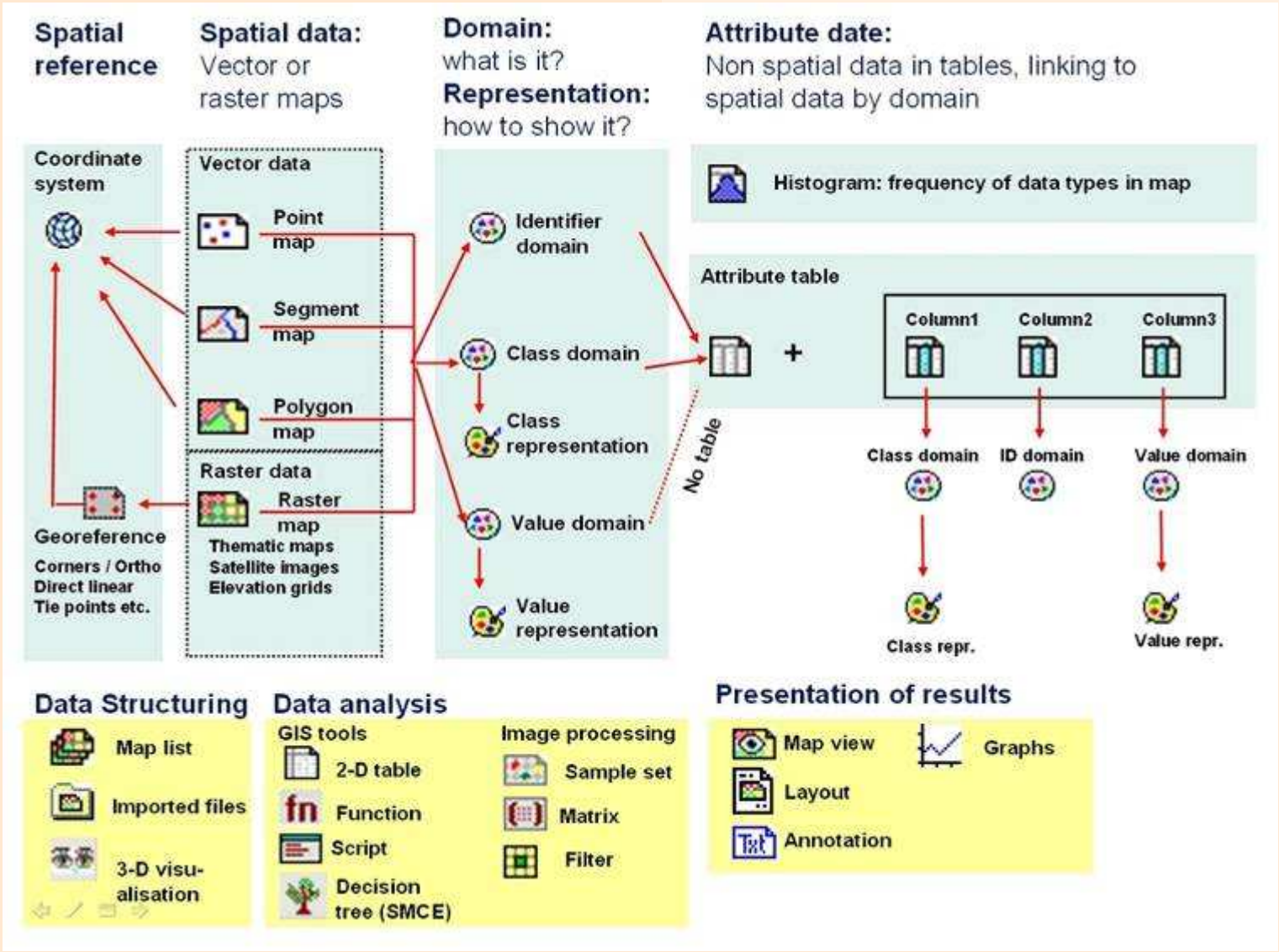
Command line:
Used for executing most of the calculations with maps



Navigation pane
You can also change it to operation-tree or operation list

Data catalog
with icons indicating different types of data.
Note: right-clicking on an icon gives the operations that are possible

Main structure



Installation

Installation instructions

The ILWIS binaries are very simple to install. Copy the folder in the downloaded zip file. In this folder there is an ILWIS30.EXE which is the main executable for ILWIS. Double click this file to start ILWIS.

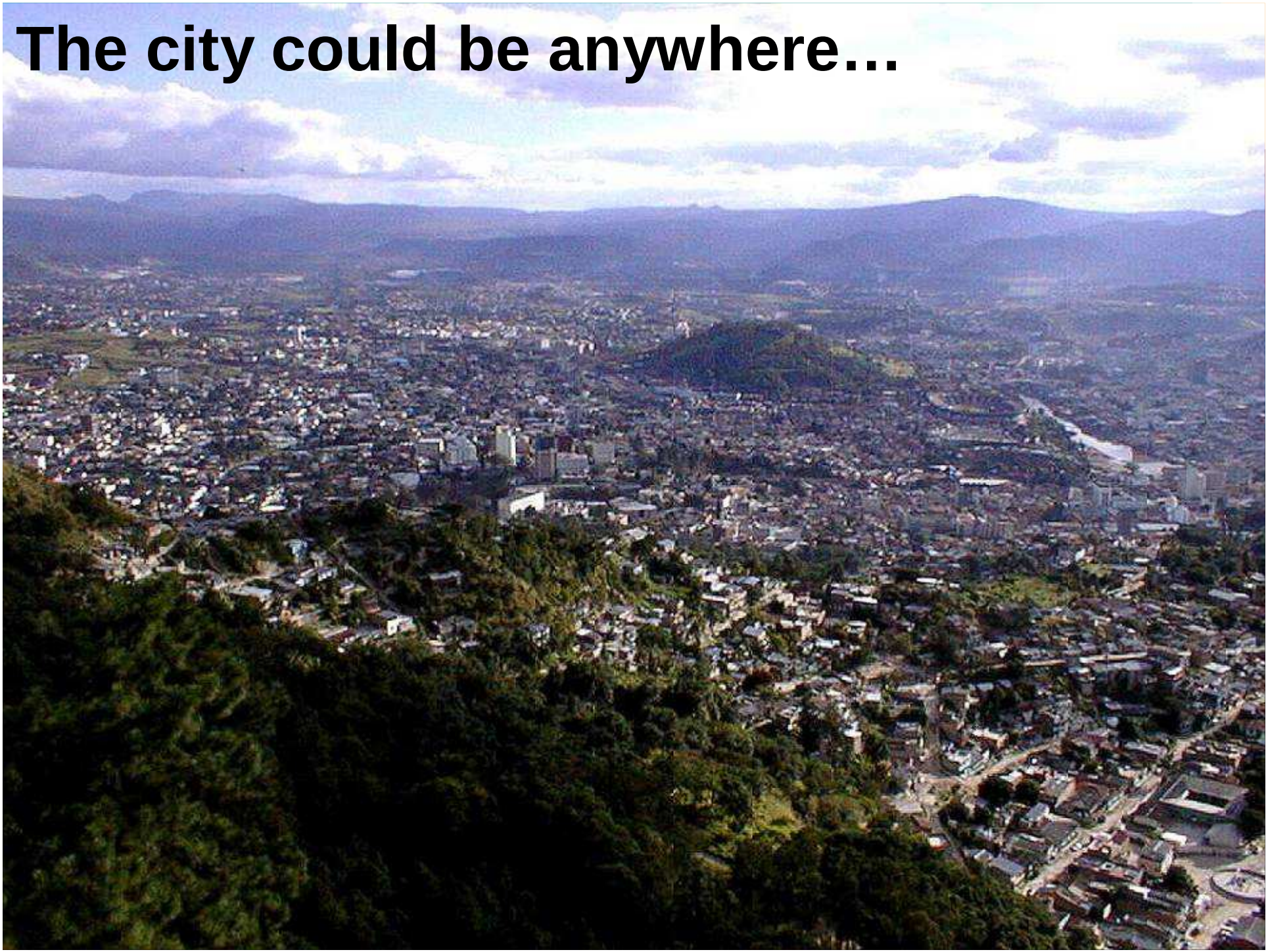
IF and ONLY IF the user wants to use the command line COM functionality of ILWIS (make the ILWIS command line available through the Windows COM functionality), the following steps must be taken. The COM registration needs two steps (assume the current directory is the directory with ILWIS30.EXE). These are started from the windows command line (via “Start|Run”, or from a “Command Prompt” window).

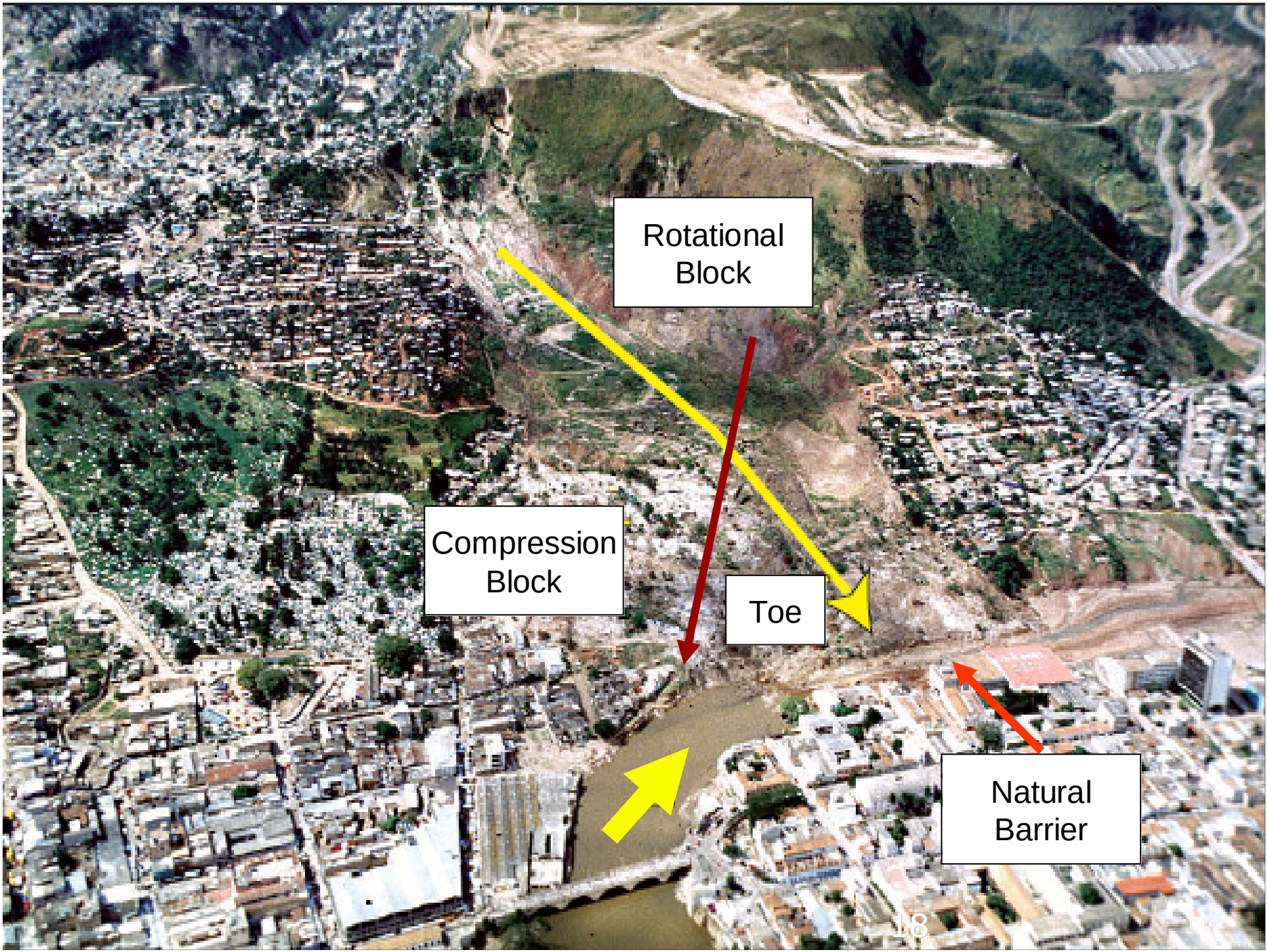
regsvr32.exe /s IlwisComProxy.dll

ilwis30.exe -RegServer

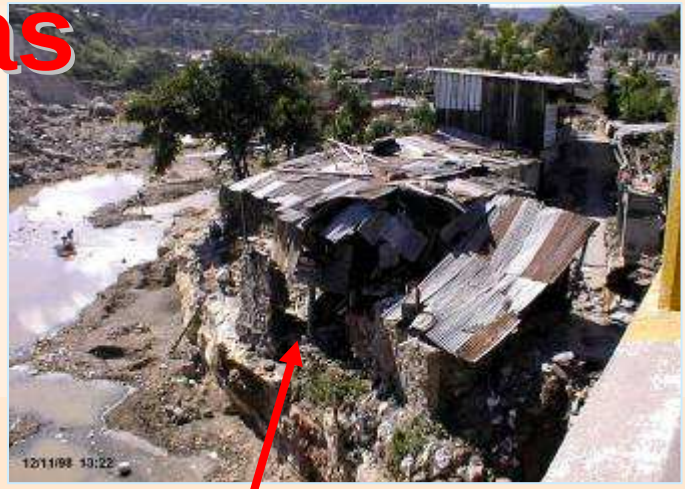
The option -RegServer needs to be typed exactly as written here. The order in which the commands are executed is not important

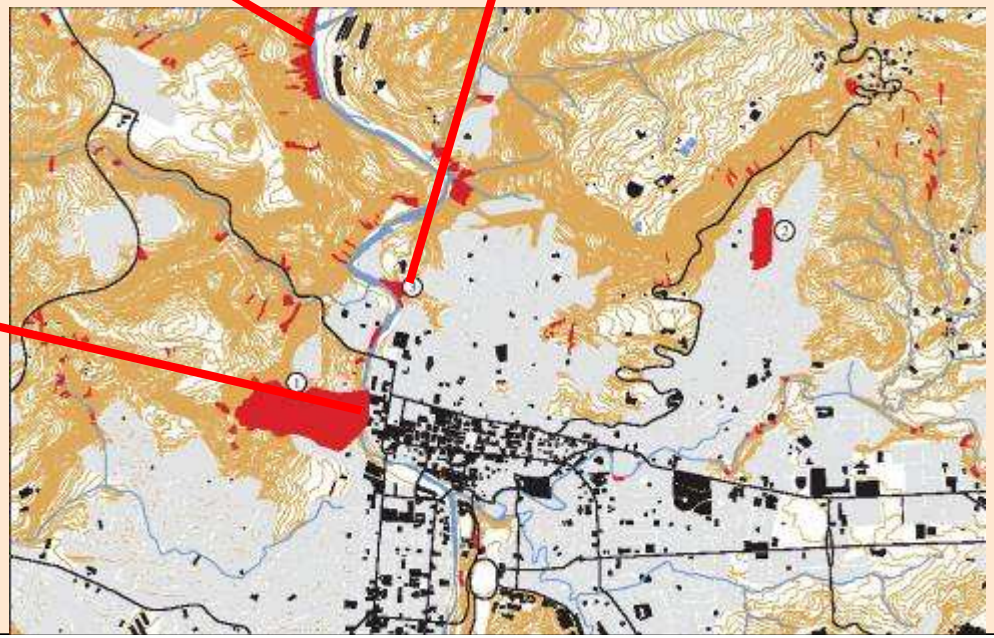
The city could be anywhere…



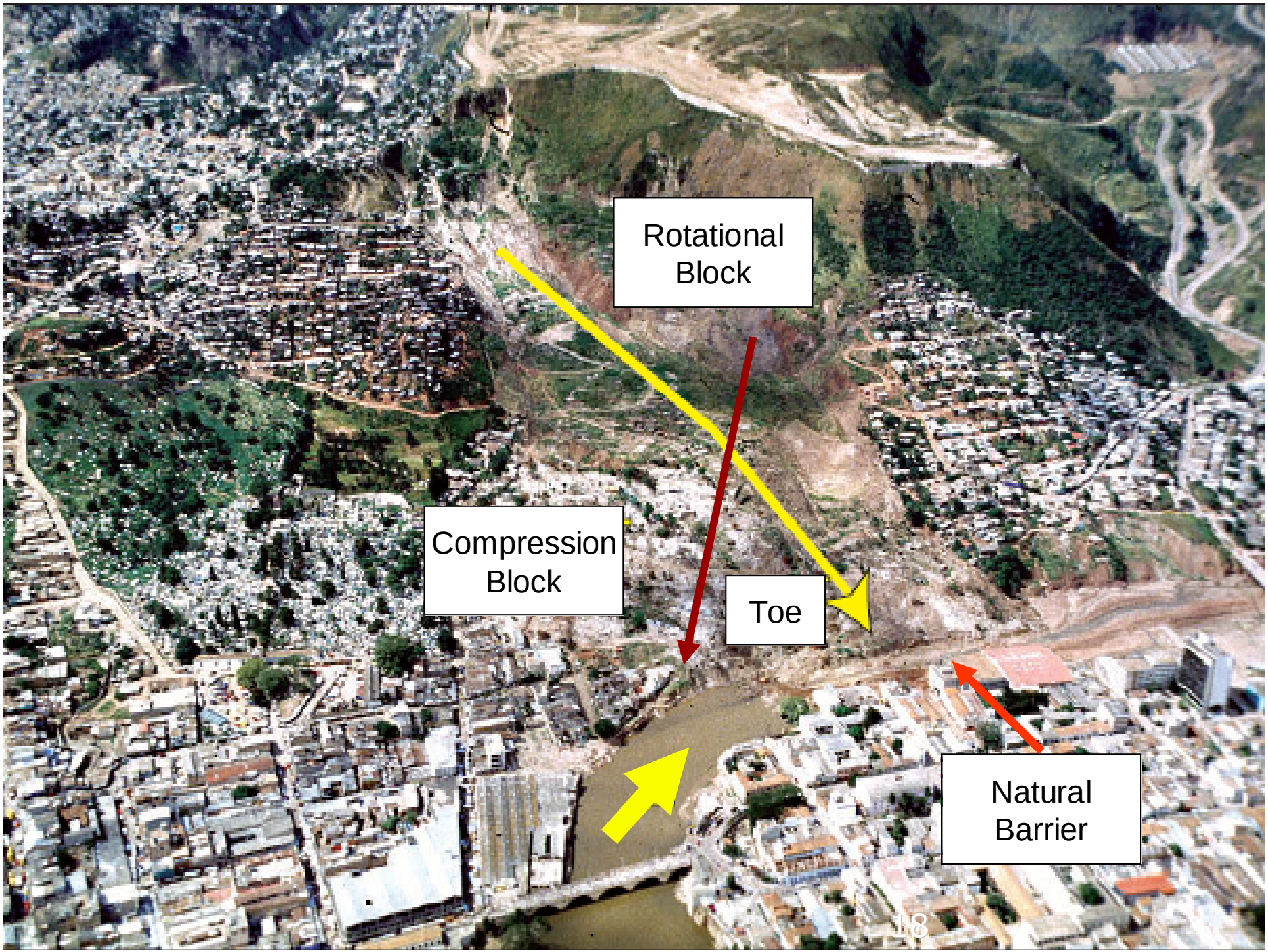

Rotational Block
Compression Block
Toe
Natural Barrier

Example: Tegucigalpa, Honduras





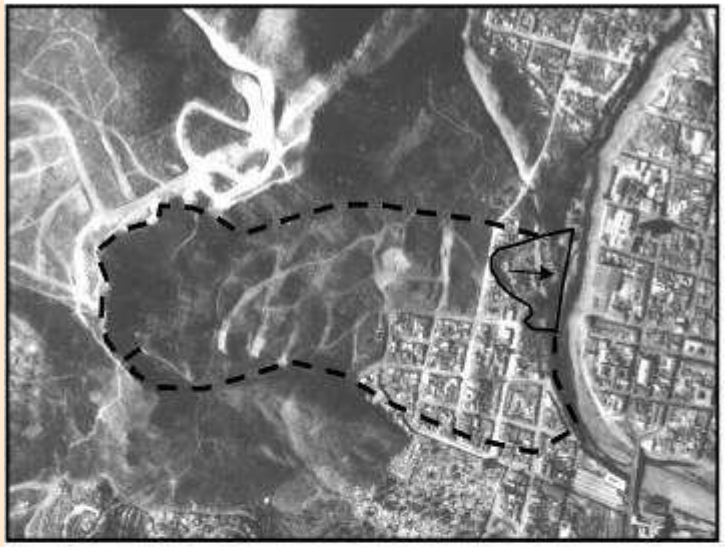

North
Landslide
Saturday, October 31
Ponded water


Rotational Block
Compression Block
Toe
Natural Barrier

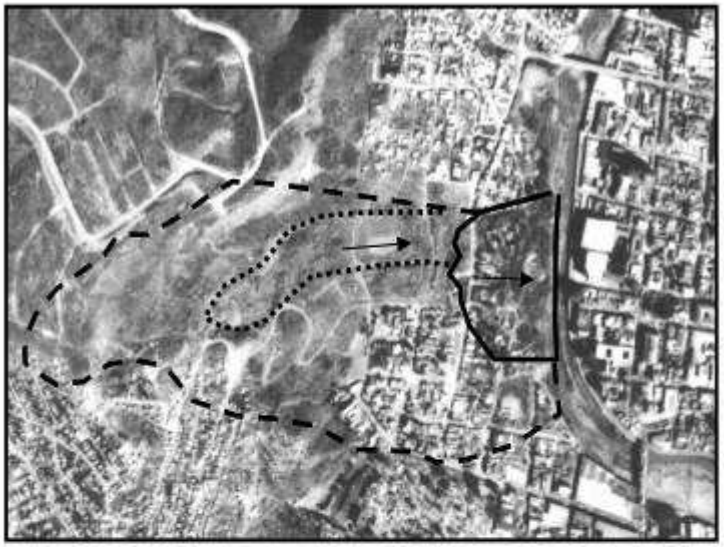
Flood and landslide

Example: Berrinche landslide

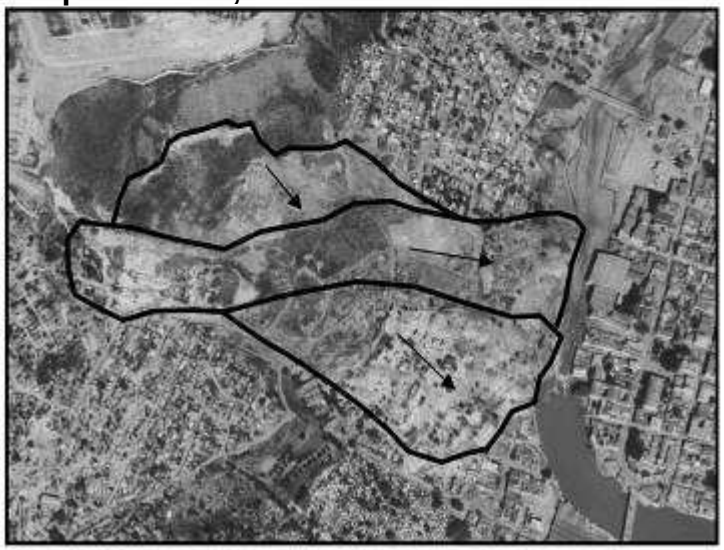
Airphoto 1:14,000 from 16-March-1975



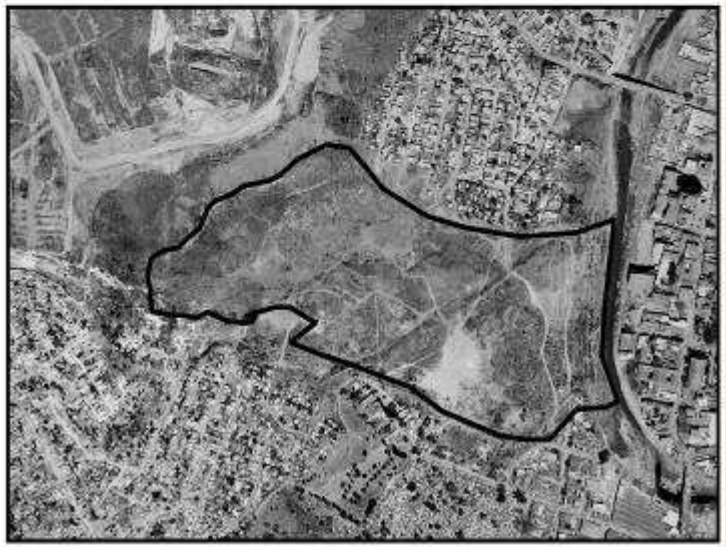
Airphoto 1:20,000 from 9-February-1990



Airphoto 1:25,000 from 1998

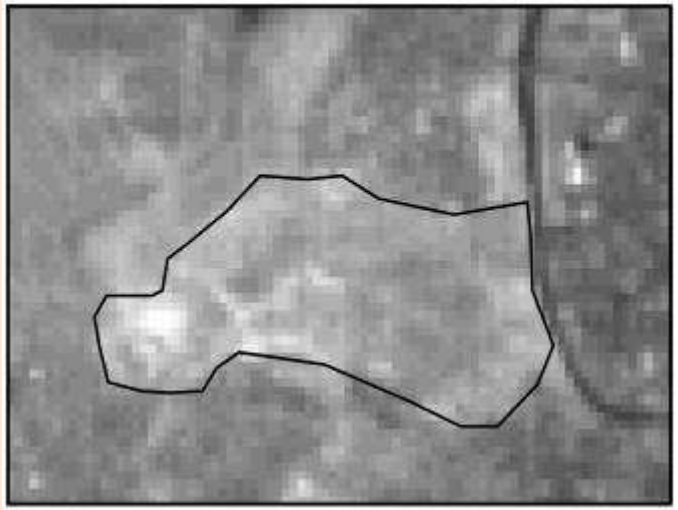


Airphoto 1:10,000 photos from May 2001

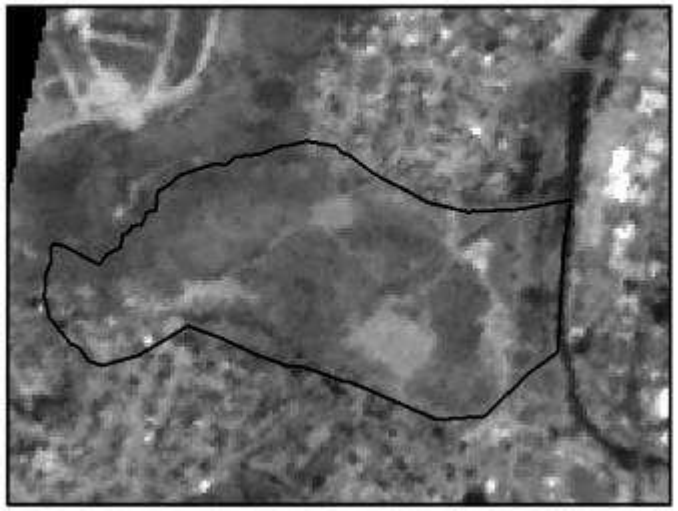


Example: Berrinche landslide

Aster image (15 m. spatial resolution) 2005

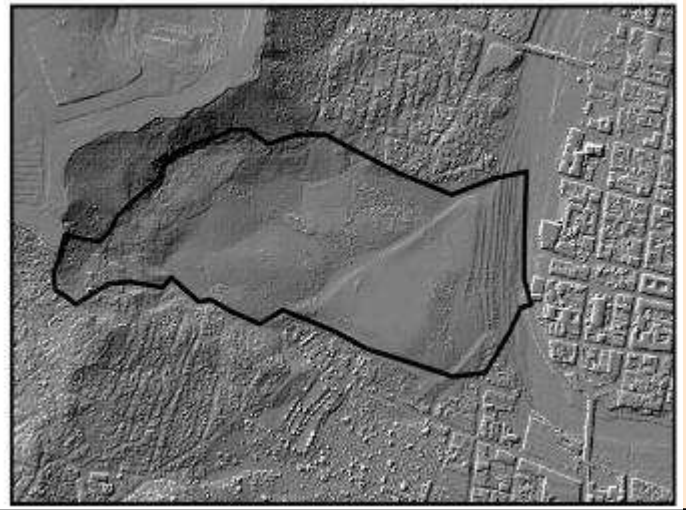


IRS-P6 (5.6 m. resolution) from 2006



Google Earth (Digital Globe image) 2007

Lidar hillshading image

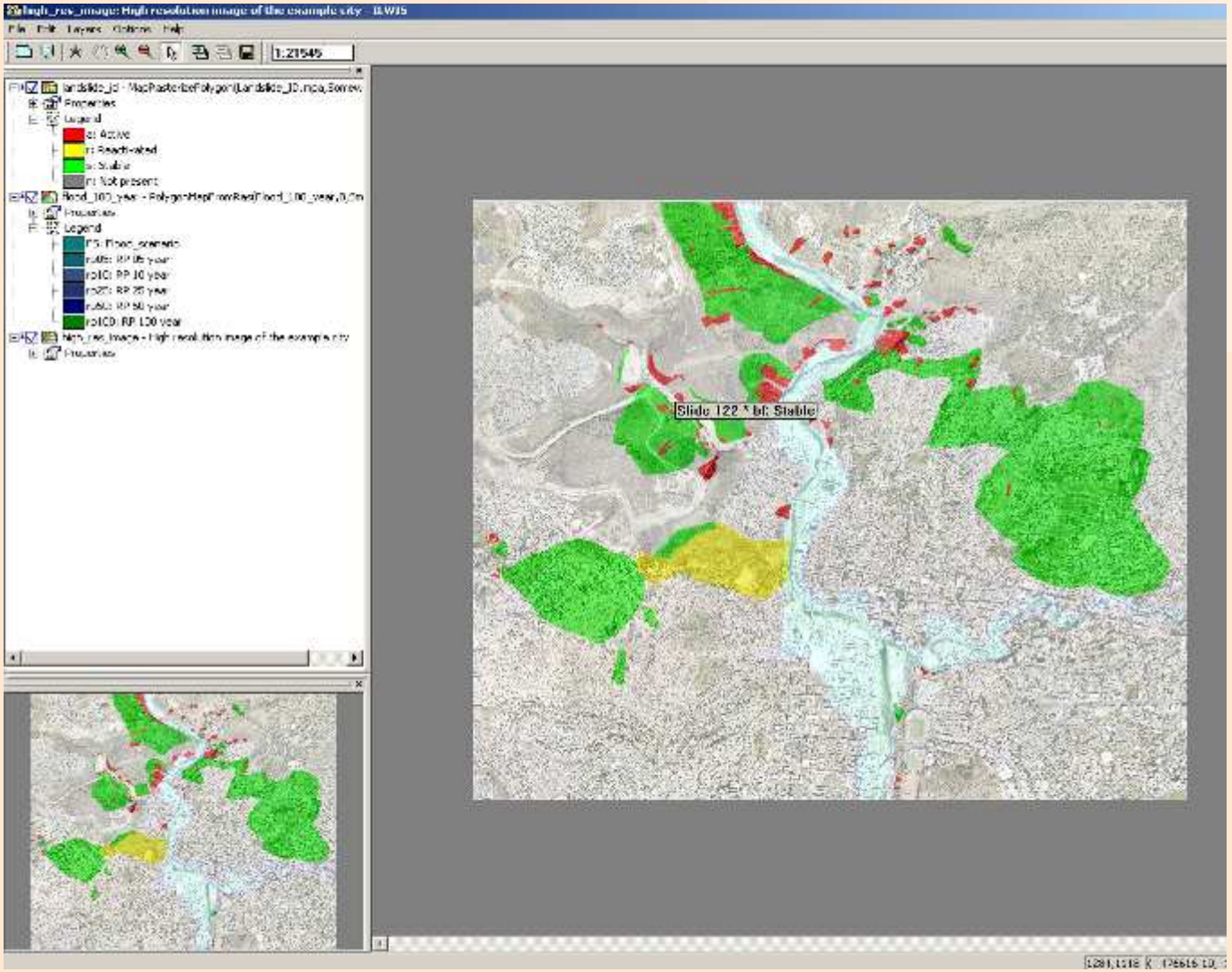


Input data

- **Image data**
- **Hazard data**
- **Elements at risk**
- **Height data**

Name	Type
Image data	
High_res_image	Raster image
Elevation data	
LidarDEM	Raster map
Contours	Segment map
TopoDEM	Raster map
Elements at risk	
Wards	Polygon map
Mapping_units	Polygon map and table
Building_map	Raster map
Roads	Segment map
Hazard data	
Landslide_ID	Raster map
Flood_100_year	Polygon map
Rivers	Segment map

HAZARD DATA



Landslides

Landslide inventory

Table "Landslide_ID" - Table linked to the landslide map - ILWIS

File Edit Columns Records View Help

	Landslide_part	Activity	Part	ReturnPeriod	Area	Landslide_nr	Depth	Act
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	274	Slide 1	3.40	Not
Slide	Body of fossil landslide	Stable	Body	1/300 years	14128	Slide 10	16.00	Sta
Slide	Scarp of fossil landslide	Stable	Scarp	1/300 years	70188	Slide 10	16.00	Sta
Slide	Body of fossil landslide	Stable	Body	1/200 years	9102	Slide 100	7.93	Sta
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	27206	Slide 101	40.00	Sta
Slide	Body of fossil landslide	Stable	Body	1/200 years	59058	Slide 102	34.00	Sta
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	13020	Slide 103	11.35	Sta
Slide	Body of recent landslide	Active	Body	1/100 years	9063	Slide 104	7.90	Not
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	7343	Slide 105	6.40	Not
Slide	Body of fossil landslide	Stable	Body	1/200 years	60845	Slide 107	24.00	Sta
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	23820	Slide 107	24.00	Sta
Slide	Body of reactivated landslide	Reactiva	Body	1/100 years	186126	Slide 109	45.00	Sta
Slide	Scarp of recent landslide	Active	Scarp	1/050 years	230	Slide 11	3.30	Not
Slide	Scarp of reactivated landslid	Reactiva	Scarp	1/200 years	28527	Slide 112	38.00	Sta
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	939	Slide 113	1.30	Not
Slide	Scarp of recent landslide	Active	Scarp	1/050 years	941	Slide 115	3.70	Not
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	477	Slide 116	1.30	Not
Slide	Body of fossil landslide	Stable	Body	1/200 years	23718	Slide 117	40.00	Sta
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	3504	Slide 117	40.00	Sta
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	1470	Slide 118	1.28	Not
Slide	Scarp of recent landslide	Active	Scarp	1/050 years	8585	Slide 119	7.48	Not
Slide	Scarp of recent landslide	Active	Scarp	1/050 years	319	Slide 12	1.80	Not
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	4746	Slide 120	4.14	Sta
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	903	Slide 121	1.20	Not
Slide	Body of fossil landslide	Stable	Body	1/300 years	67606	Slide 122	39.00	Sta
Slide	Scarp of fossil landslide	Stable	Scarp	1/300 years	32772	Slide 122	33.00	Sta
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	43640	Slide 124	55.00	Sta
Slide	Body of fossil landslide	Stable	Body	1/200 years	16859	Slide 125	14.69	Sta
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	2519	Slide 126	2.20	Not
Slide	Body of fossil landslide	Stable	Body	1/200 years	2821	Slide 127	2.46	Sta
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	611	Slide 128	1.40	Not
Min					110		1.02	
Max					374143		55.00	
Avg					14488		8.92	
StD					42137		13.33	
Sum					2636881		1624.11	

Statistics of Landslide area

Total landslide area

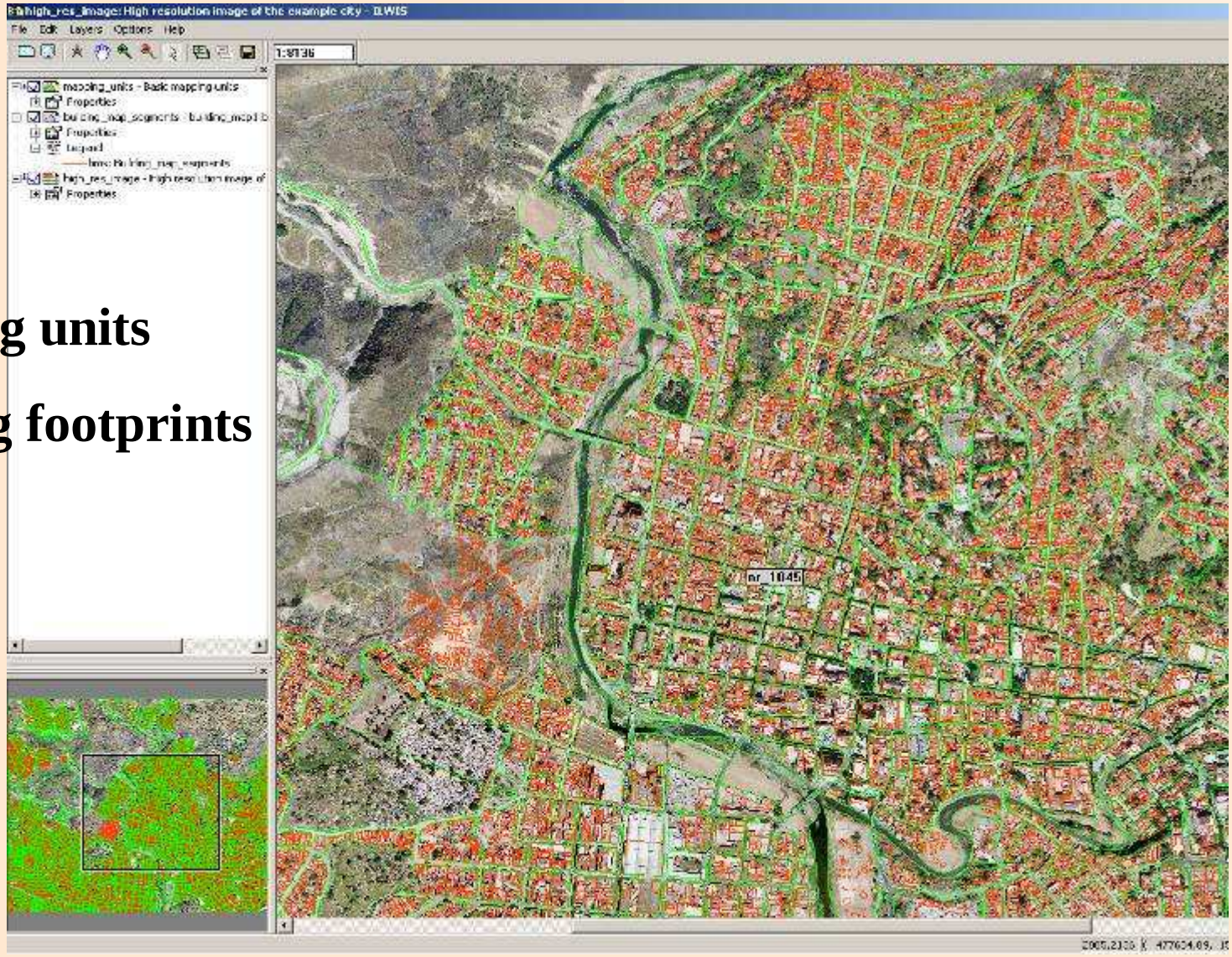
Element at risk data

wards

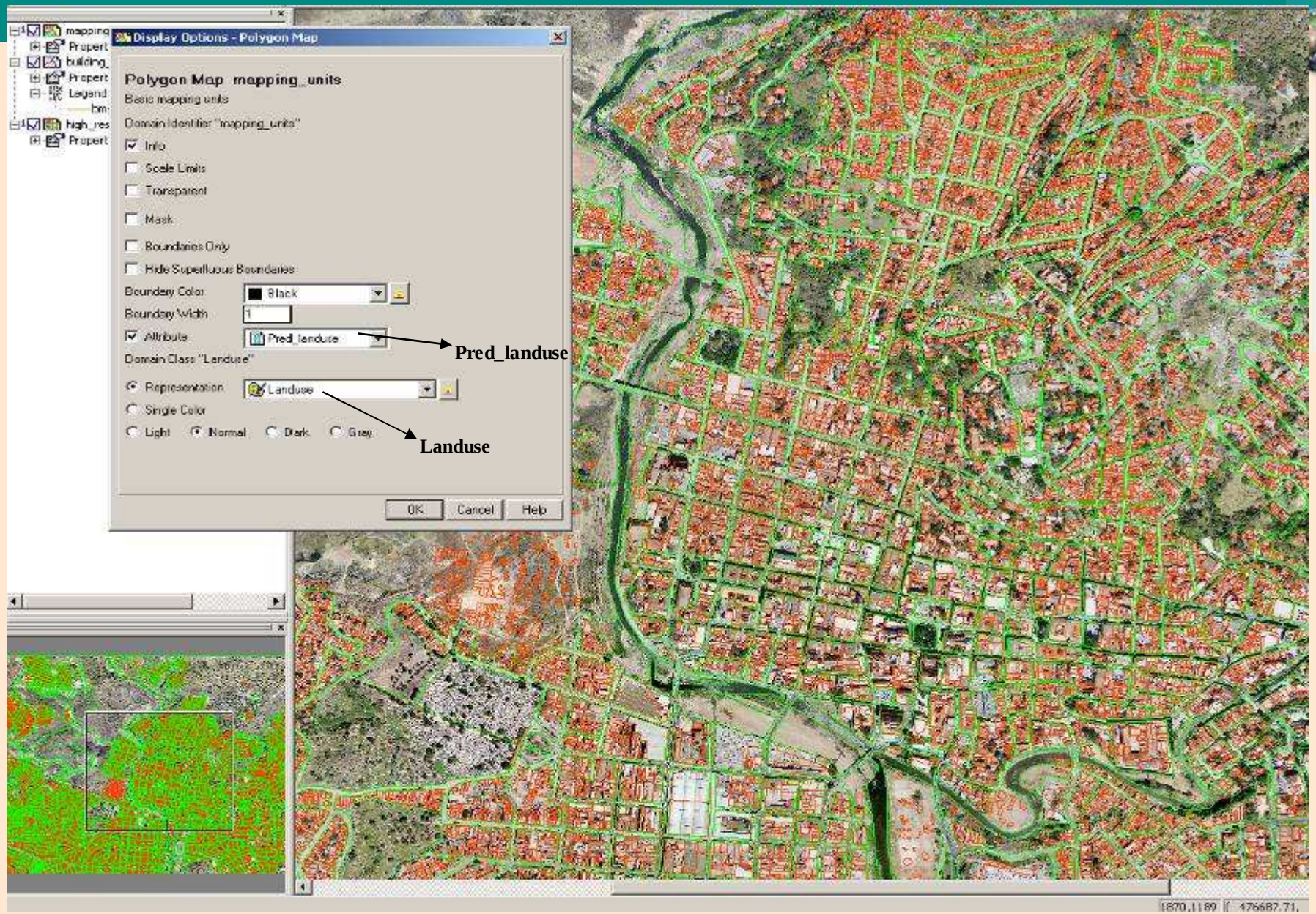
mapping units

building footprints

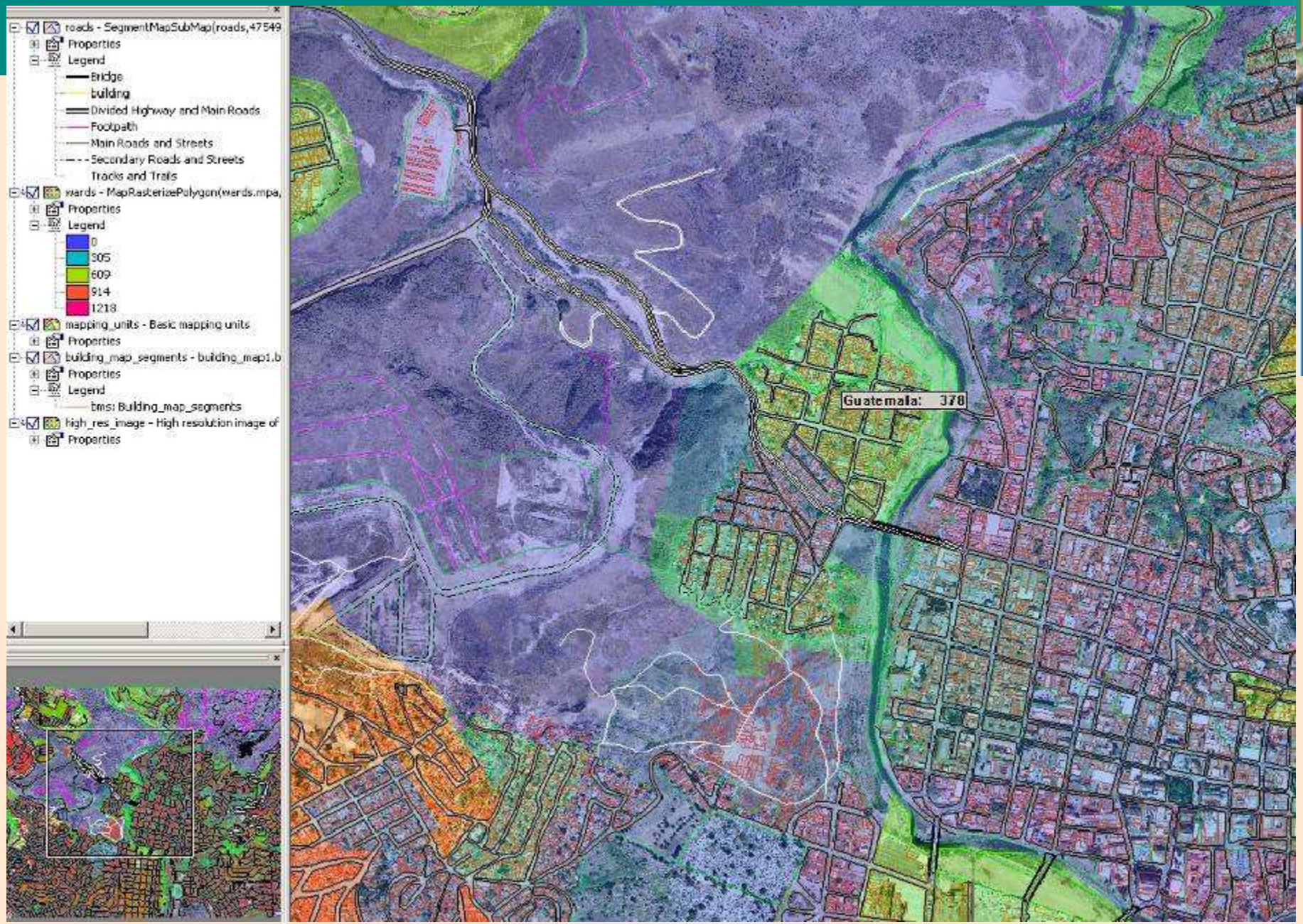
roads



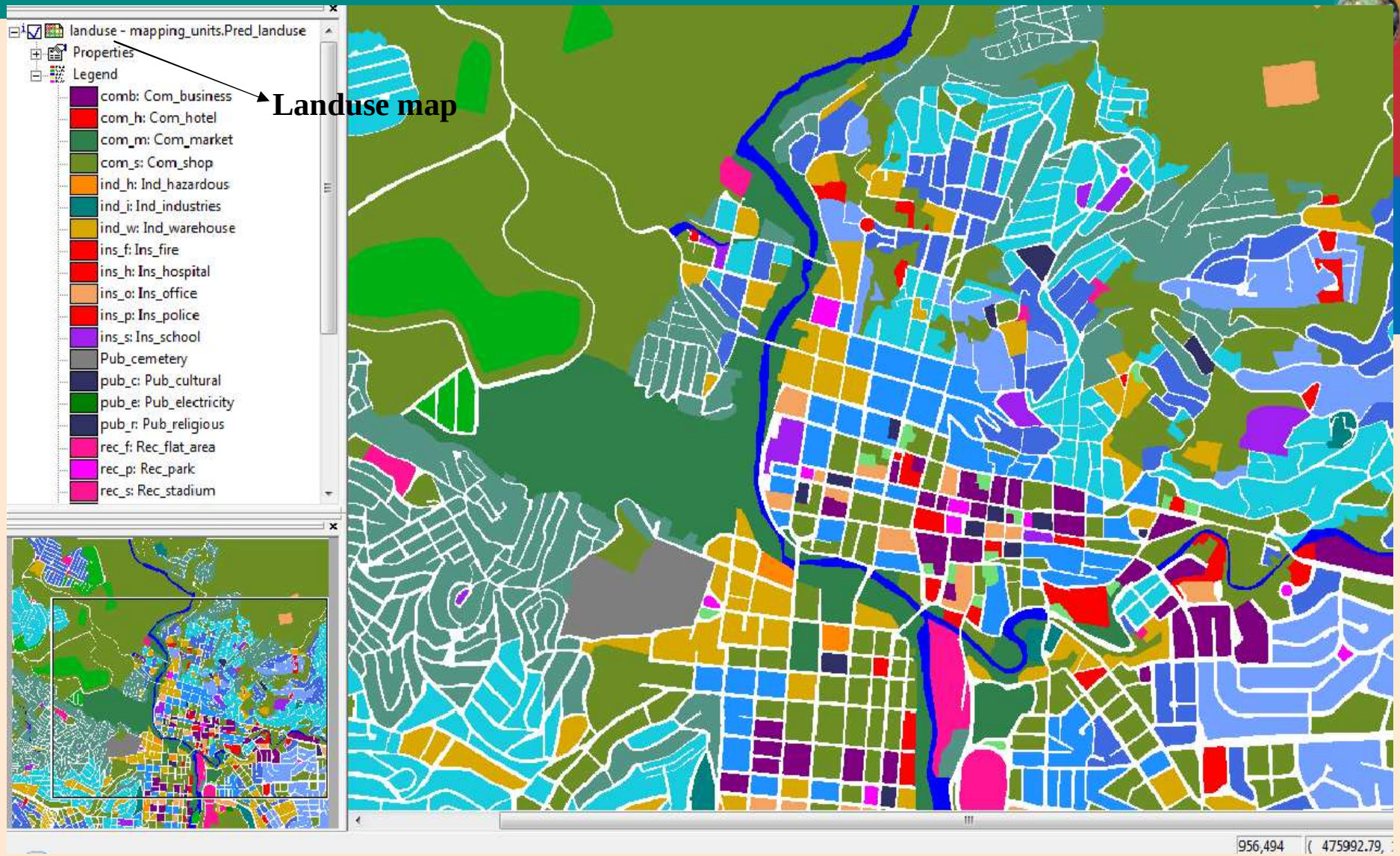
Display the Urban Landuse as an attribute



Final Display with overlay of Ward and road map on High resolution Image



Calculating the number of destroyed buildings



Cross table after the cross operation with the raster maps Landuse and building map

Dependent Table "Landuse_buildings" - TableCross(landuse.mpr,building_map.mpr,IgnoreUndefs) - ILWIS

File Edit Columns Records View Help

	landuse	building_map	NPix	Area	Vac_damaged
ind_w * B_27344	Ind_warehouse	B_27344	70	70	29594
ind_w * B_27368	Ind_warehouse	B_27368	53	53	29594
ind_w * B_27389	Ind_warehouse	B_27389	67	67	29594
ind_w * B_27401	Ind_warehouse	B_27401	58	58	29594
ind_w * B_27427	Ind_warehouse	B_27427	2	2	29594
ind_w * B_28484	Ind_warehouse	B_28484	1352	1352	29594
ind_w * B_28630	Ind_warehouse	B_28630	296	296	29594
ind_w * B_28694	Ind_warehouse	B_28694	1469	1469	29594
ind_w * B_28695	Ind_warehouse	B_28695	134	134	29594
ind_w * B_28792	Ind_warehouse	B_28792	140	140	29594
ind_w * B_28836	Ind_warehouse	B_28836	126	126	29594
ind_w * B_28924	Ind_warehouse	B_28924	444	444	29594
ind_w * B_28938	Ind_warehouse	B_28938	121	121	29594
ind_w * B_28940	Ind_warehouse	B_28940	84	84	29594
ind_w * B_28955	Ind_warehouse	B_28955	172	172	29594
ind_w * B_28975	Ind_warehouse	B_28975	165	165	29594
ind_w * B_28984	Ind_warehouse	B_28984	233	233	29594
ind_w * B_29091	Ind_warehouse	B_29091	109	109	29594
ind_w * B_29154	Ind_warehouse	B_29154	200	200	29594
ind_w * B_29166	Ind_warehouse	B_29166	117	117	29594
com_h * B_00072	Com_hotel	B_00072	582	582	29594
com_h * B_01108	Com_hotel	B_01108	281	281	29594
com_h * B_01358	Com_hotel	B_01358	8	8	29594
com_h * B_01369	Com_hotel	B_01369	106	106	29594
com_h * B_01410	Com_hotel	B_01410	237	237	29594
com_h * B_01541	Com_hotel	B_01541	279	279	29594
com_h * B_01920	Com_hotel	B_01920	5	5	29594
com_h * B_01950	Com_hotel	B_01950	4	4	29594
com_h * B_02123	Com_hotel	B_02123	445	445	29594
com_h * B_02217	Com_hotel	B_02217	34	34	29594
com_h * B_02557	Com_hotel	B_02557	1	1	29594
com_h * B_02738	Com_hotel	B_02738	1577	1577	29594
com_h * B_02880	Com_hotel	B_02880	9	9	29594
Min			1	1	29594
Max			28578	28578	29594
Avg			108	108	29594
StD			231	231	0
Sum			3207970	3207970	875804836

Lidar

Position of the aircraft

+

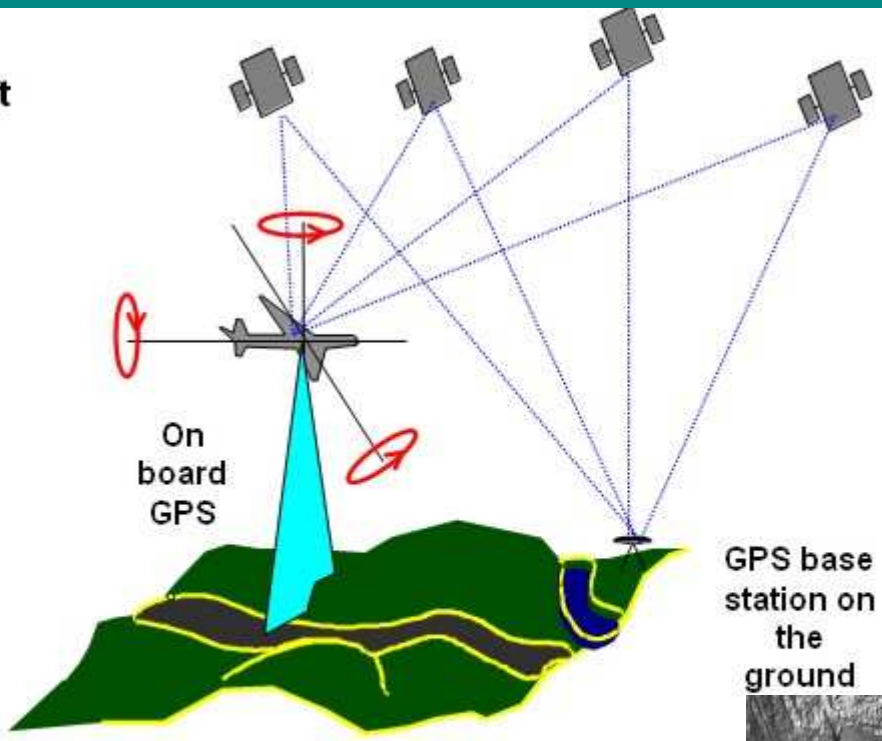
Attitude of the aircraft

+

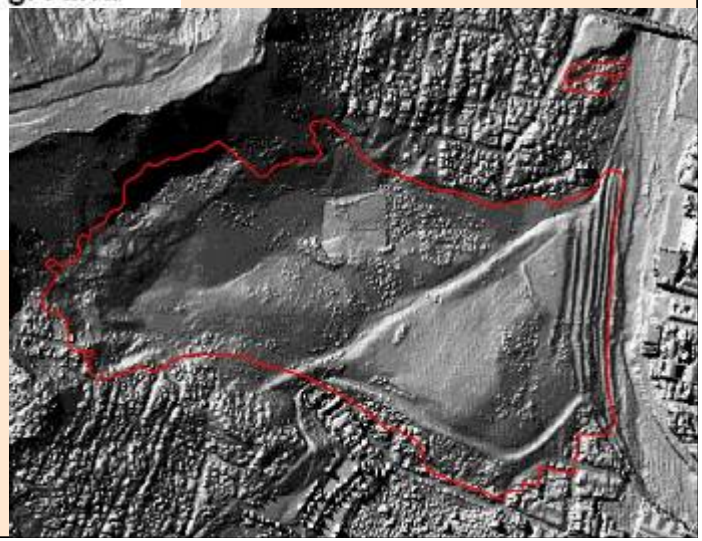
Distance between the aircraft and the 'ground'

+

Angle under which the distance has been measured

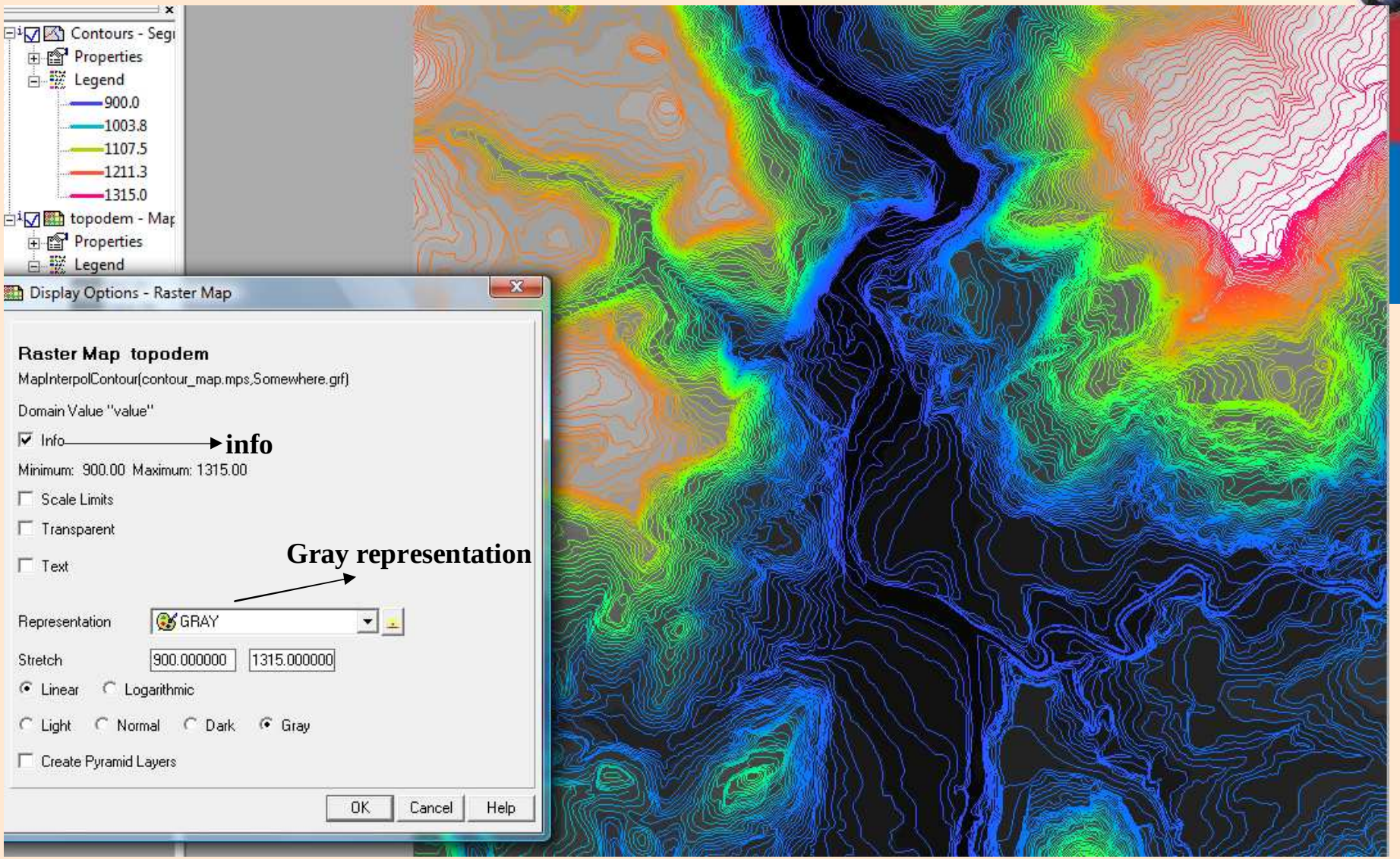


All information is required to determine the co-ordinates of the measured points and calculate the terrain elevation

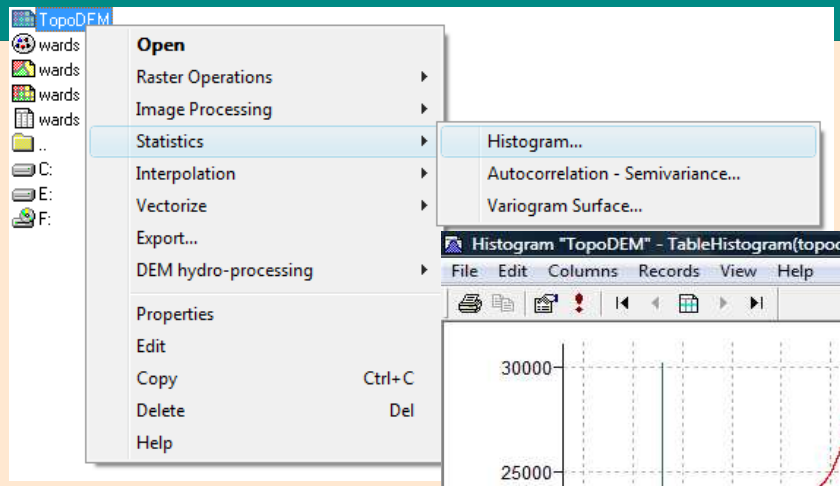


Altitude Data & Digital Elevation Model

After the overlay the topodem map over the contour map with gray representation

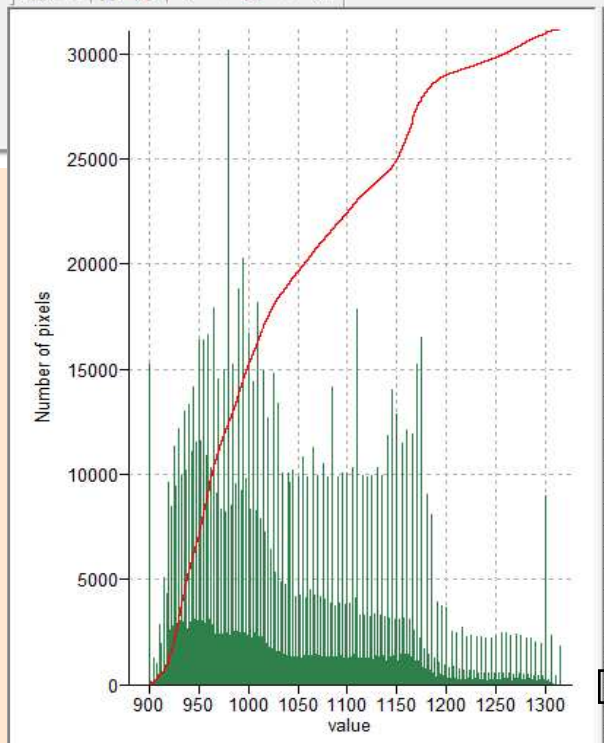


Statistics/Histogram of Topo_DEM :



Histogram "TopoDEM" - TableHistogram(topodem.mpr) - ILWIS

File Edit Columns Records View Help



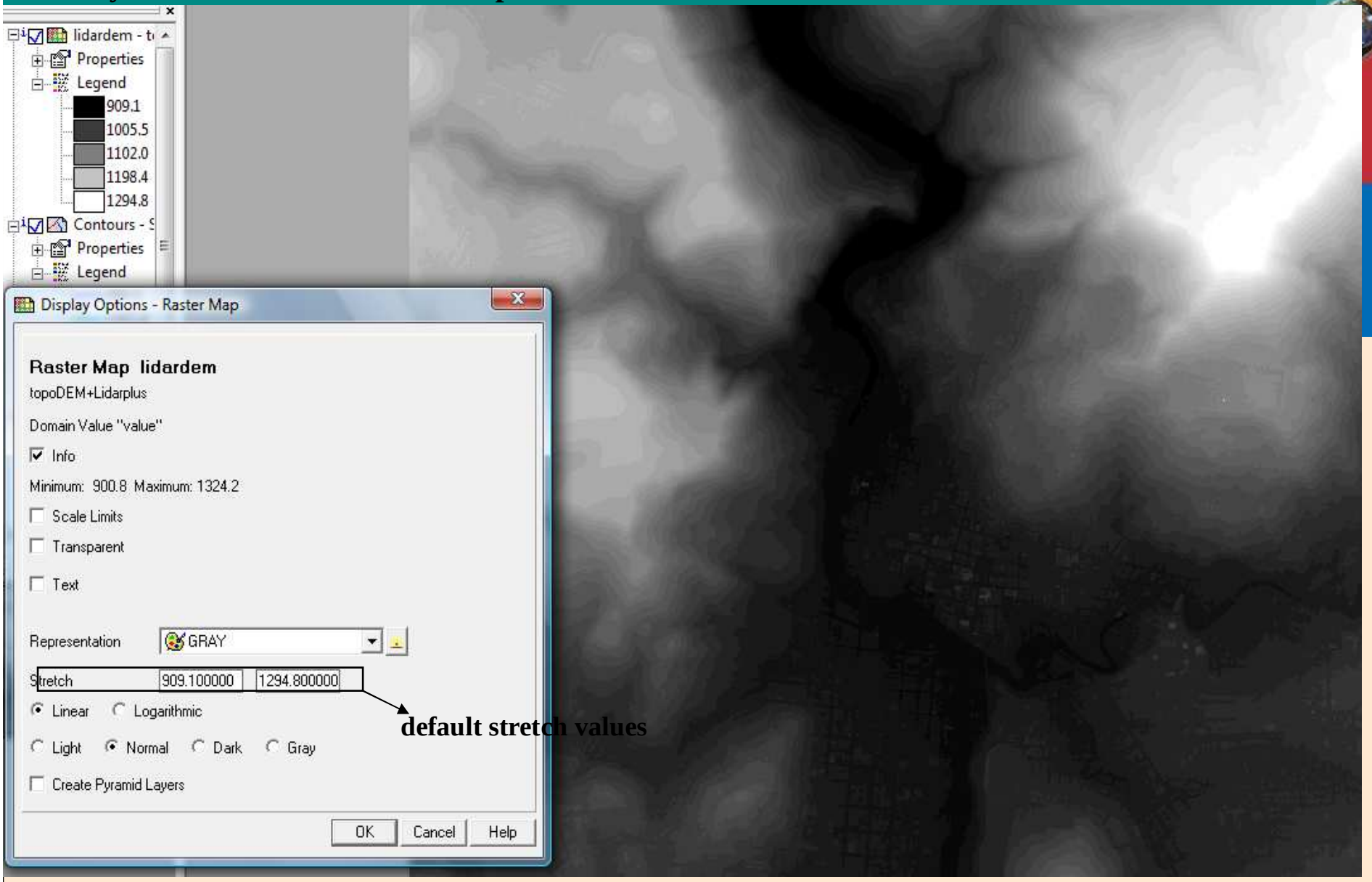
	value	npix	npixpct	npixcum	npcumpct	Area
1	900.00	15327	0.11	15327	0.11	15327
2	900.04	1	0.00	15328	0.11	1
3	900.05	232	0.00	15560	0.11	232
4	900.06	37	0.00	15597	0.11	37
5	900.07	81	0.00	15678	0.11	81
6	900.08	59	0.00	15737	0.11	59
7	900.09	90	0.00	15827	0.11	90
8	900.10	100	0.00	15927	0.11	100
9	900.11	63	0.00	15990	0.11	63
10	900.12	67	0.00	16057	0.11	67
11	900.13	60	0.00	16117	0.12	60
12	900.14	107	0.00	16224	0.12	107
13	900.15	51	0.00	16275	0.12	51
14	900.16	59	0.00	16334	0.12	59
15	900.17	48	0.00	16382	0.12	48
16	900.18	80	0.00	16462	0.12	80
17	900.19	93	0.00	16555	0.12	93
18	900.20	86	0.00	16641	0.12	86
19	900.21	62	0.00	16703	0.12	62
20	900.22	39	0.00	16742	0.12	39
21	900.23	95	0.00	16837	0.12	95
22	900.24	81	0.00	16918	0.12	81
23	900.25	53	0.00	16971	0.12	53
24	900.26	74	0.00	17045	0.12	74
25	900.27	57	0.00	17102	0.12	57
26	900.28	89	0.00	17191	0.12	89
27	900.29	85	0.00	17276	0.12	85
28	900.30	64	0.00	17340	0.12	64
Min	900.00	1	0.00	15327	0.11	1
Max	1315.00	30265	0.22	14000000	100.00	30265
Avg	1106.59	343	0.00	9357027	66.84	343
StD	119.94	635	0.01	4107119	29.34	635
Sum	45116699.26	14000000	58.93	**********	********	14000000

```
Mean=1036.68          Std.Dev=101.42
Median=1003.40        Pred=980.00 (30265)
0.0% int=  900.00:1315.00    0.5% int=  905.44:1300.31
1.0% int=  908.90:1293.06    2.0% int=  914.81:1278.98
5.0% int=  922.00:1236.82   10.0% int=  930.06:1176.91
```

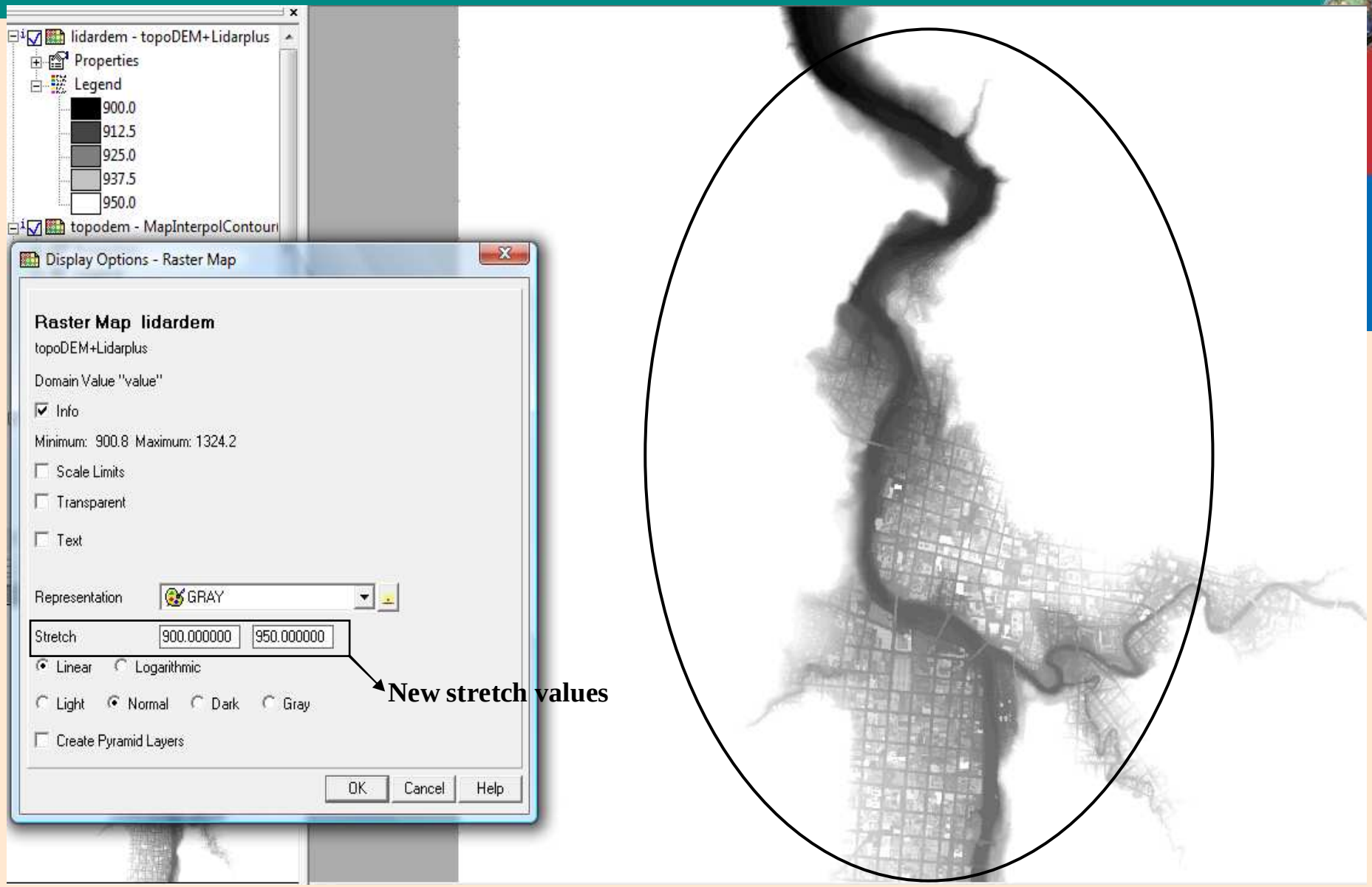
Average altitude

Image Stretching

Overlay the Lidar DEM over the TopoDEM with default stretch values:

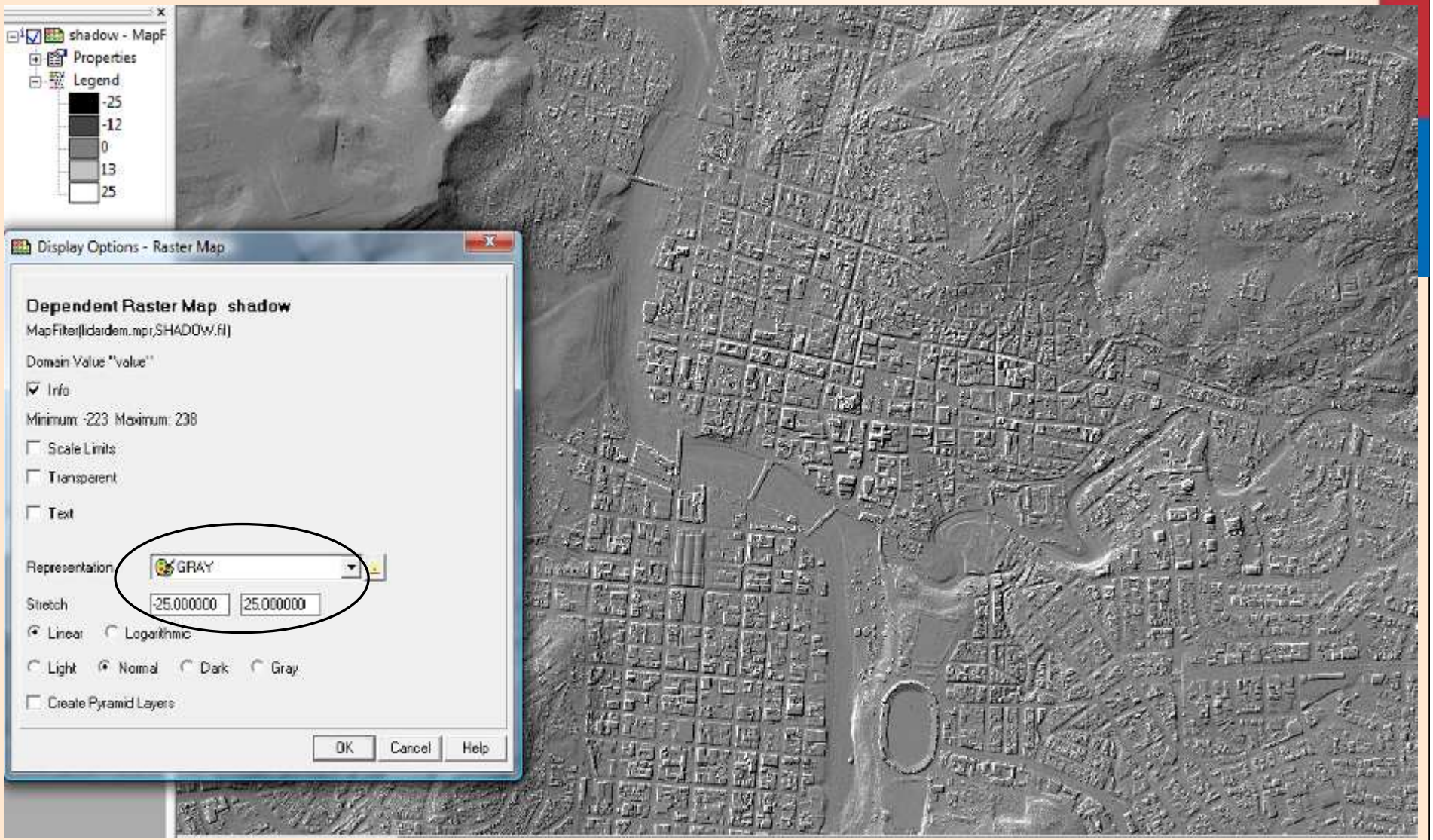


Changes seen below after using different stretch options:



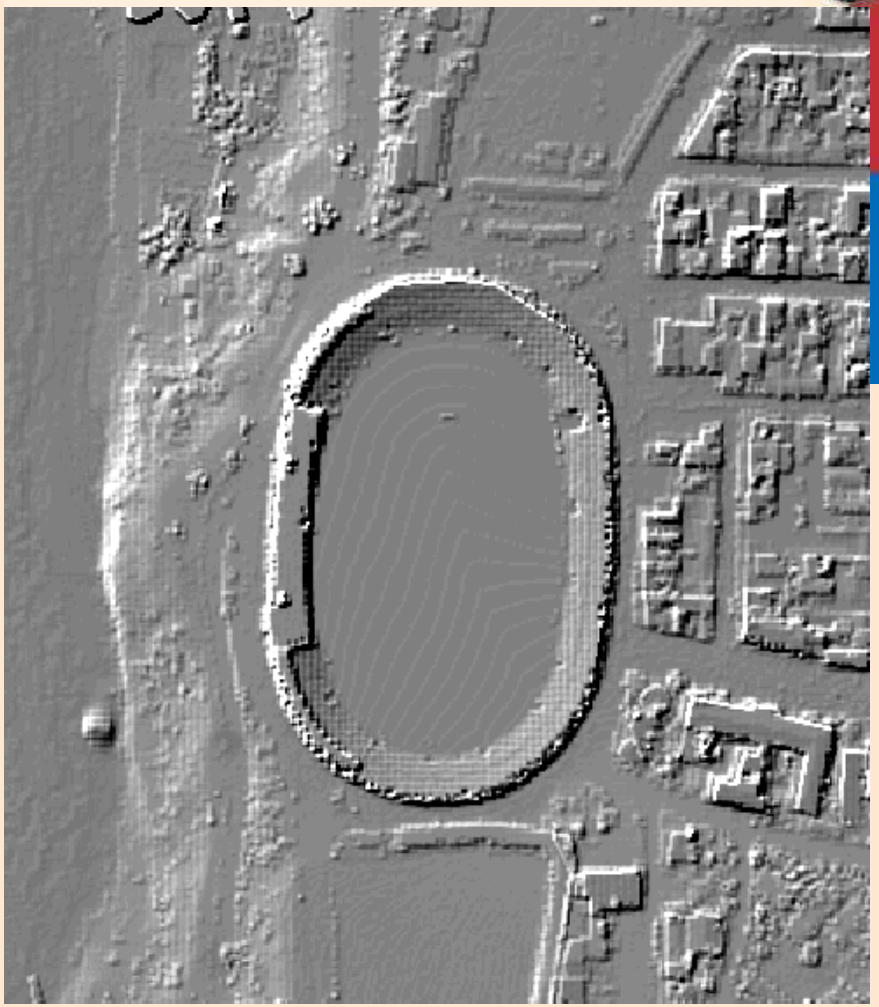
Filtering

Generation of a hillshading image from Lidar map using shadow filter and different stretch values:



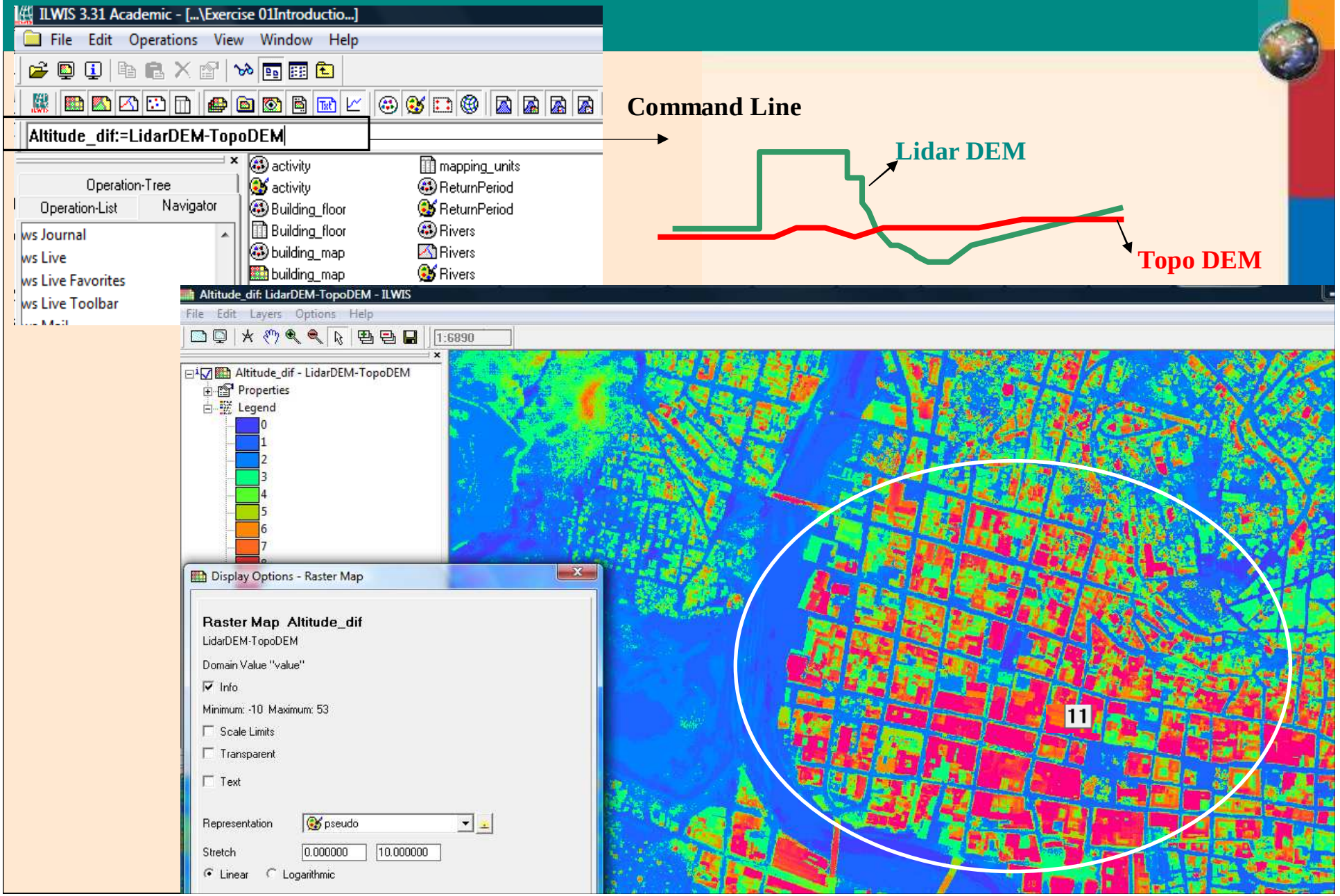
Comparison between High Resolution Image and Hillshading Image:

High Resolution Image



Hillshading Image

Map Calculation



Pixel Information