Airborne laser scanning applications in river courses studies

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LIDAR- LIGHT DETECTION AND RANGING

What is LiDAR?

- ❖ A technology that is changing the world…
- ❖ What is known as **LiDAR** is sometimes simply called **laser scanning** or **3D scanning**
- ❖ An evolved radar technology that uses light waves instead of microwaves
- ❖ The science of using a laser to measure distances between specific points
- ❖ An active remote sensing technique, through which highly accurate data and information can be obtained about the topography of terrain, vegetation, buildings, etc.

ADVANTAGES

- ❖ LiDAR sensors can be used in all types of weather, unaffected by sunlight and can even be used at night
- ❖ A useful tool for obtaining Digital Terrain Models with high accuracy in complex areas such as flood valleys and watersheds
- ❖ Provides high-resolution topographic data capable of covering large areas with high accuracy both horizontally and vertically in a short period of time
- ❖ The ability to obtain high resolution (1 m) Digital Terrain Models (DTM) directly from the point cloud.
- ❖ Can generate both accurate DSMs and DTMs from the same data acquisition, by using multiple returns from a single emitted pulse

LIDAR- LIGHT DETECTION AND RANGING

The LiDAR measurement system scans surfaces by taking measurements stored as points. The result of the flight is a multitude of points (in the order of millions), commonly known as a **point cloud**, positioned in a global reference system.

The three-dimensional coordinates (x, y, z or latitude, longitude and altitude) of the points corresponding to the measured objects are calculated using three main elements, namely:

(1) the time difference between the emission and return of the laser pulse;

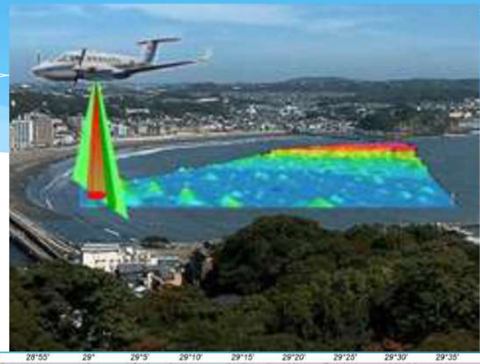
(2) the angle at which the laser pulse was emitted;

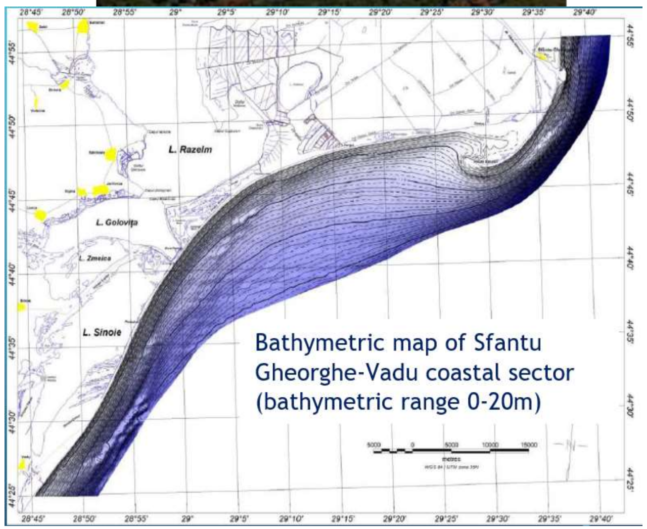
(3) the exact location of the sensor on or above the Earth's surface.

Classification of laser scanning systems

1. Airborne Laser Scanning (ALS)

Bathymetric airborne laser scanning





Bathymetric map of Sfantu Gheorghe-Vadu coastal sector (bathymetric range 0-20m)

2. Terrestrial laser scanning

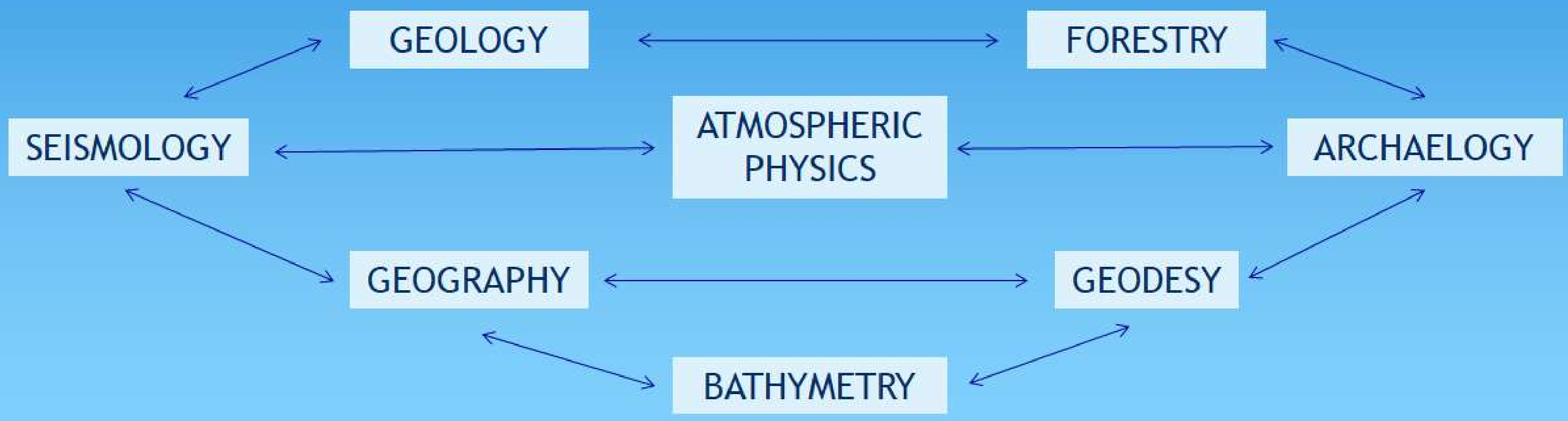
Mobile terrestrial LiDAR

Static terrestrial LiDAR

LIDAR

Light Detection and Ranging

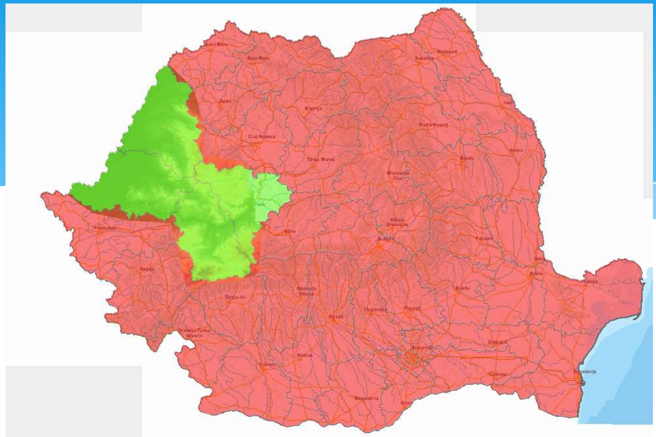
- LiDAR technology is used to make the high-resolution maps with applications in:



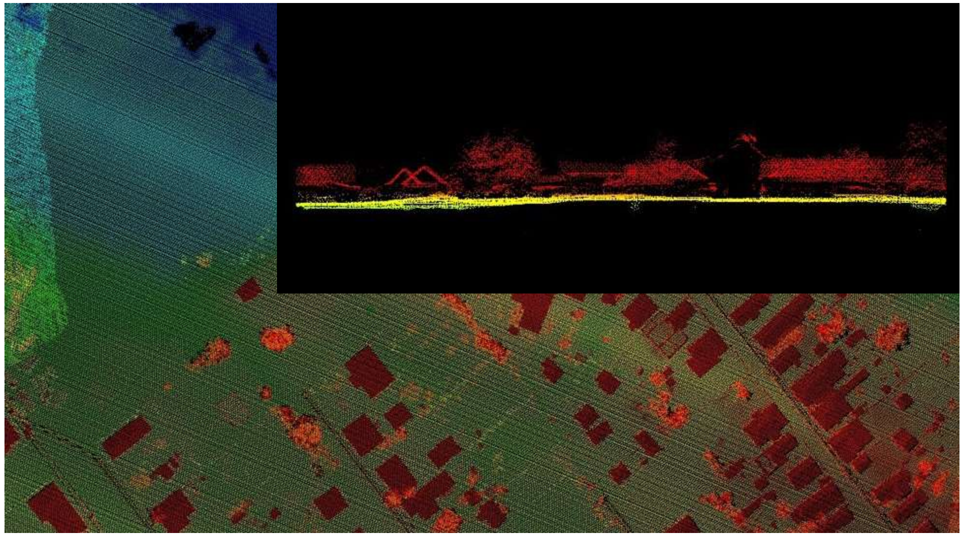
LAKI – LAND ADMINISTRATION KNOWLEDGE IMPROVEMENT

- Project name: Geographic Information for Environment, Climate Change and EU Integration.
- The overall objective: to provide geographic information for monitoring the environment, climate change and the implementation of the EU Directive on the harmonization and exchange of geographic information at European level.
- The specific objectives: obtaining DTM and DSM by aerial laser scanning with LiDAR system, obtaining ortophotoplans with a spatial resolution of 20 cm and making the digital map and related database.

LAKI II



- ❖ Project duration: 2017-2021
- ❖ DTM and DSM for four counties in Romania: Bihor, Arad, Hunedoara and Alba
- ❖ The LiDAR flight was performed in March-May and October-November 2017 using 2 photogrammetric cameras produced by Vexcel (UltraCam Eagle Mark 2, UltraCam Lp), mounted on a Twin Commander 690A airplane



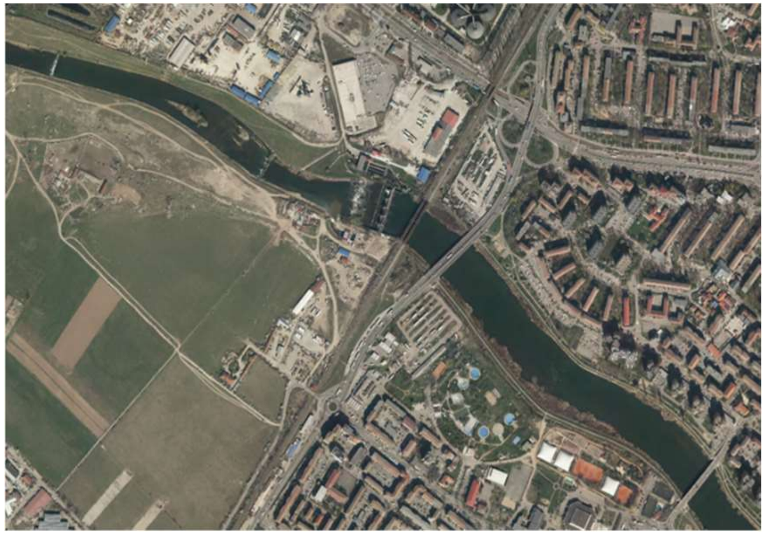
Classified point cloud and cross-sectional profile

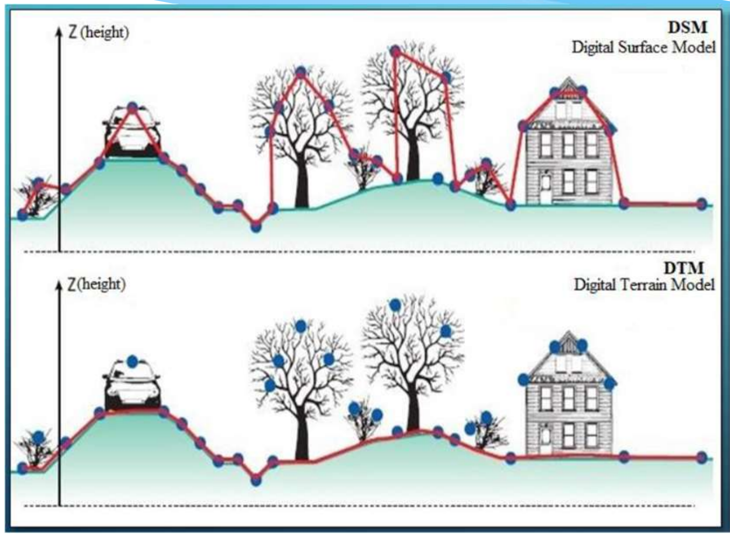
The point cloud:

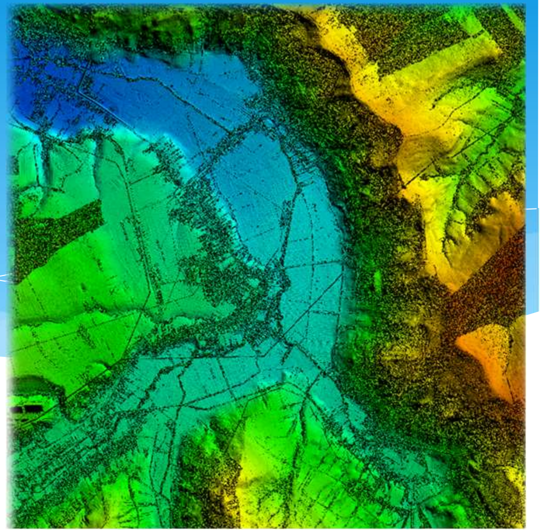
- has a density of 8 points/m2 for high flood risk areas and 2 points/m2 for other areas
- has been classified into four classes: noise, soil, non-soil and bridge points

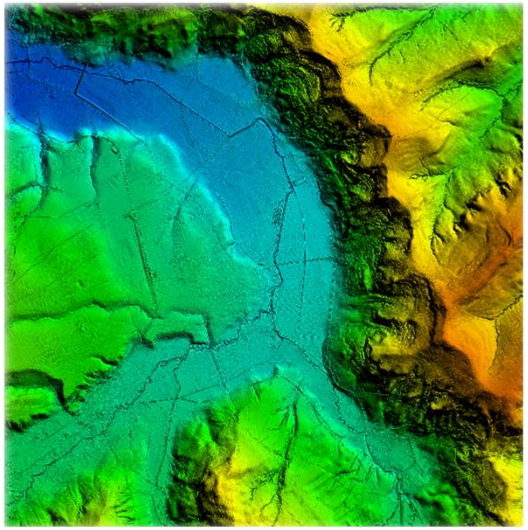
FINAL PRODUCTS OF LAKI II

DTM and DSM with a spatial resolution of 1 meter and an elevation accuracy of 20 cm for area with high risk of flooding and 30 cm for the other areas.





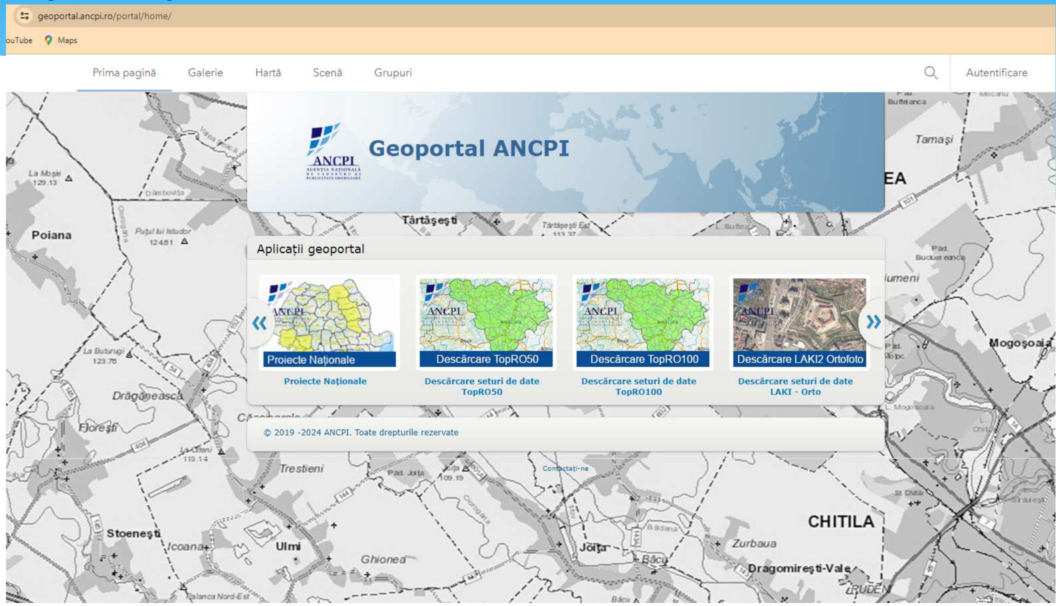




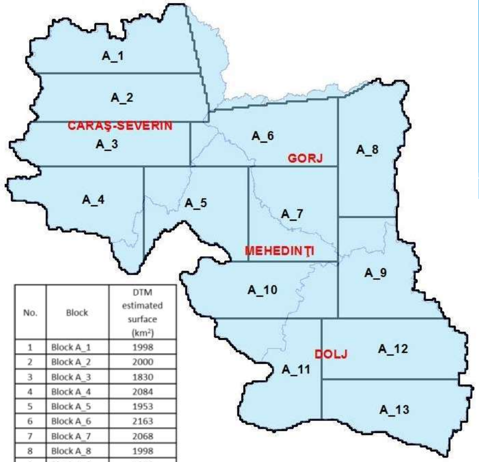
Ortophotoplans with 20 cm spatial resolution, 20 cm planimetric accuracy and 3-band spatial resolution -RGB

DISTRIBUTION OF PROJECT DATA

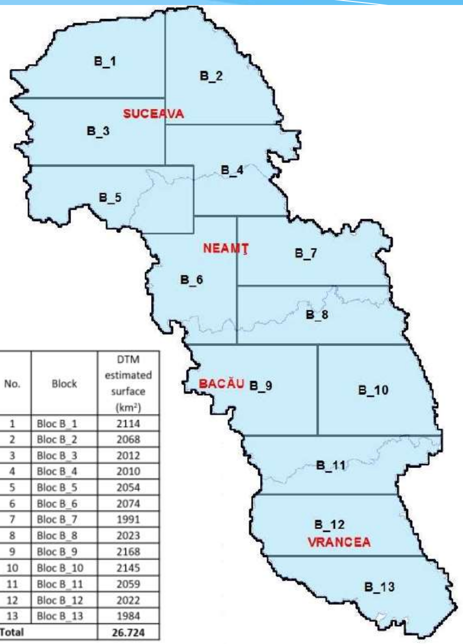
The final products of LAKI II can be downloaded for free from the ANCPI geoportal: https://geoportal.ancpi.ro/portal/home/



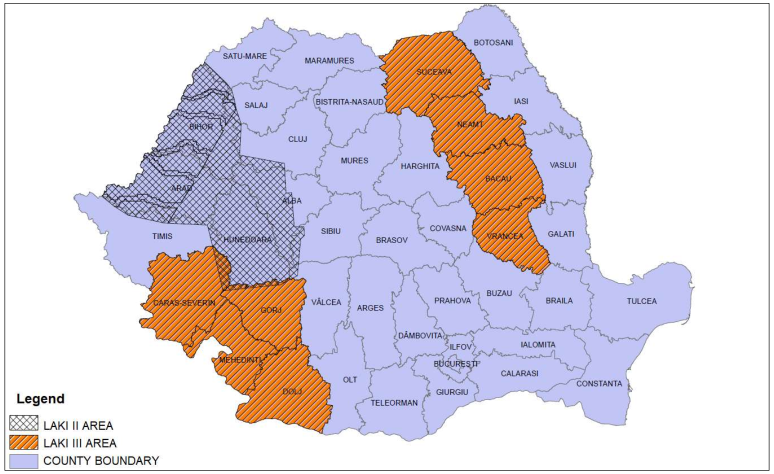
LAKI III



No.	Block	DTM estimated surface (km²)
1	Block A_1	1998
2	Block A_2	2000
3	Block A_3	1830
4	Block A_4	2084
5	Block A_5	1953
6	Block A_6	2163
7	Block A_7	2068
8	Block A_8	1998
9	Block A_9	1948
10	Block A_10	2052
11	Block A_11	2092
12	Block A_12	2088
13	Block A_13	1995
Total		**26.269**



No.	Block	DTM estimated surface (km²)
1	Bloc B_1	2114
2	Bloc B_2	2068
3	Bloc B_3	2012
4	Bloc B_4	2010
5	Bloc B_5	2054
6	Bloc B_6	2074
7	Bloc B_7	1991
8	Bloc B_8	2023
9	Bloc B_9	2168
10	Bloc B_10	2145
11	Bloc B_11	2059
12	Bloc B_12	2022
13	Bloc B_13	1984
Total		**26.724**

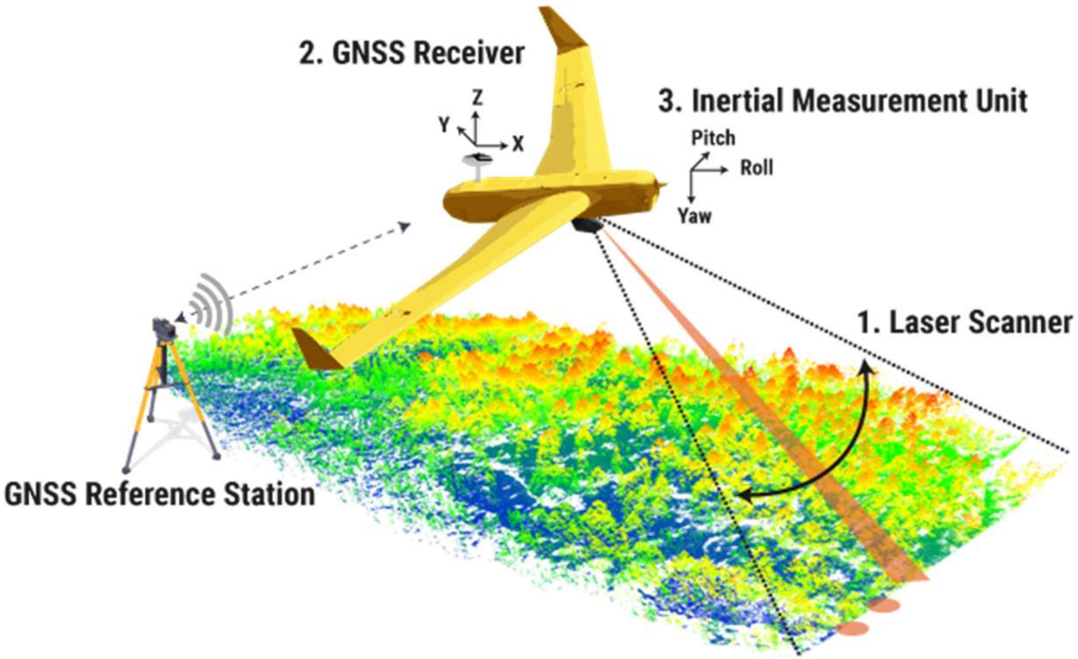


- Project duration: 2023-2025
- The project area: 50000 Km²
- Zone A: Caras-Severin, Gorj, Mehedinti and Dolj counties divided into 13 blocks of 2000² km each
- Zone B: Suceava, Neamt, Bacau and Vrancea counties divided into 13 blocks of 2000² km each
- The specific objective: aerial laser scanning to produce DTM and DSM

TECHNICAL SPECIFICATION

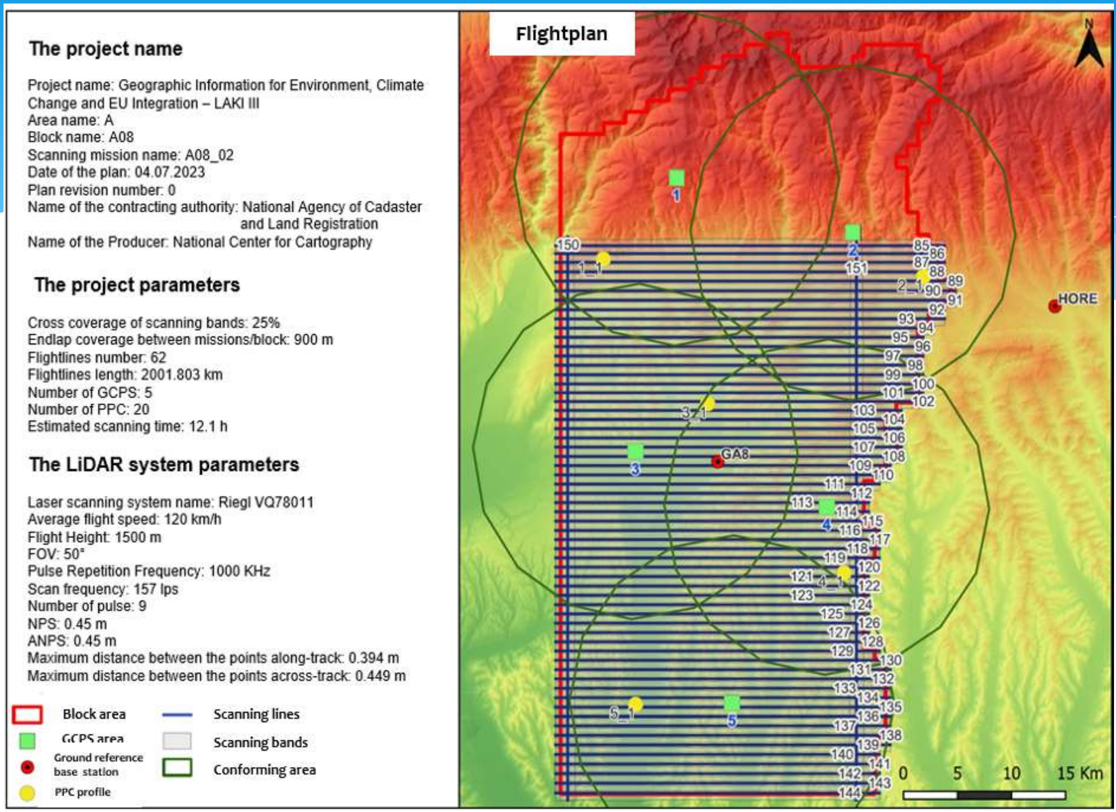
Accuracy and point cloud density

Point cloud density (point/m2)	ETRS 89		Romanian National Coordinate Reference System (Stereographic 1970)	
	Standard horizontal deviation (m)	Standard vertical deviation (m)	Horizontal root mean square error (m)	Vertical root mean square error (m)
5	± 0.30	± 0.15	± 0.40	± 0.30

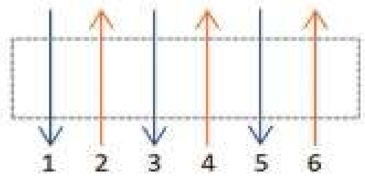


- ❖Scanning equipment: RIEGL Q780 scanner și RIEGL VQ-1460
- ❖The basic components of the airborne LiDAR System: a laser scanner unit, a GNSS receiver and an Inertial Measurement Unit (IMU)
- ❖The auxiliary components of the airborne LiDAR System: gyrostabilizing platform, digital camera, computer with storage units

TECHNICAL SPECIFICATION

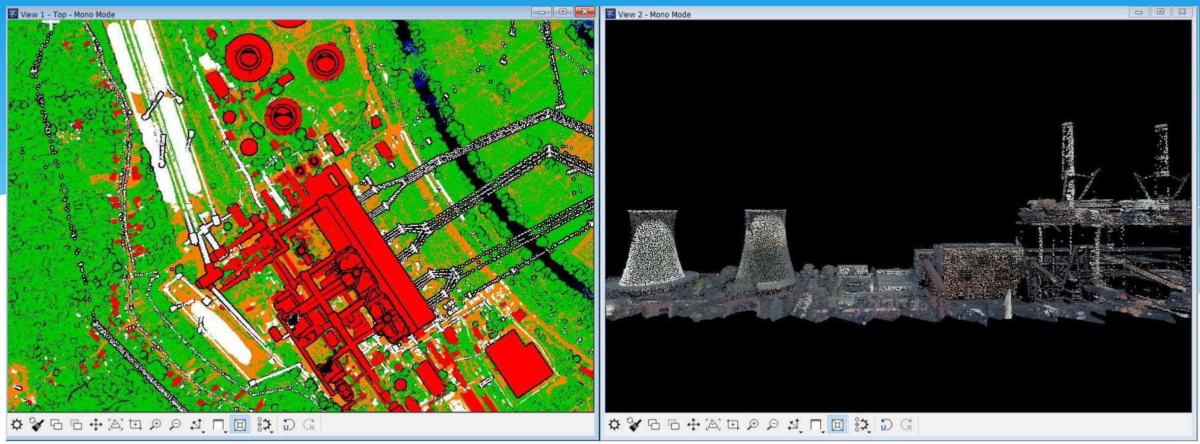


- optimal conditions for Data Acquisition: the surface should be free from snow or flooded areas and the minimum meteorological conditions for the flight (without fog and clouds between instrument and ground);
- opposite flight directions for alternative routes, the data collection should be performed, preferably, in the East-West direction



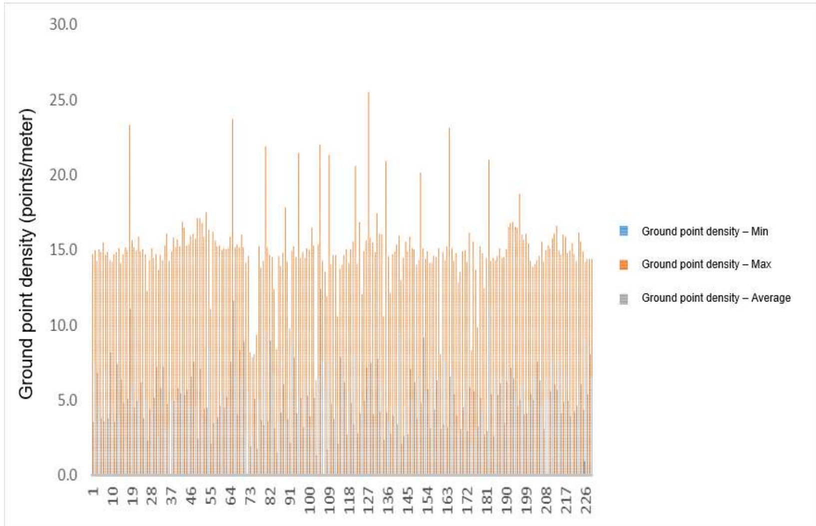
- the minimum overlaps between flightlines must be no less than 25%
- an overlap of at least 400 m with the adjacent performed mission / block (endlap)
- the maximum flightline length must not be more than 90 km
- it should be at least 5 GCP(Ground Control Points) clusters uniform and homogeneus distributed in each block

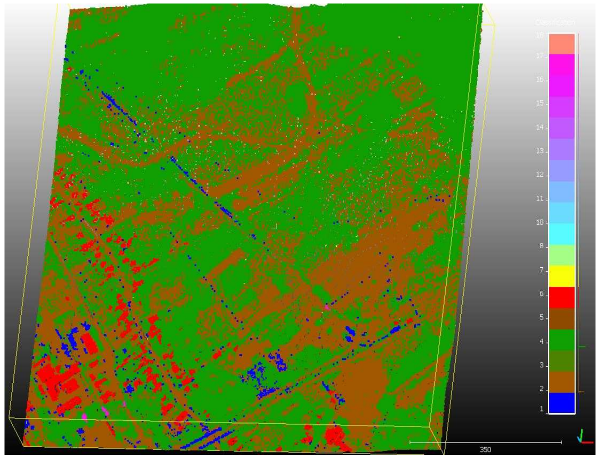
POINT CLOUDS



Classified point cloud and the RGB-encoded point cloud

Density analysis of point cloud





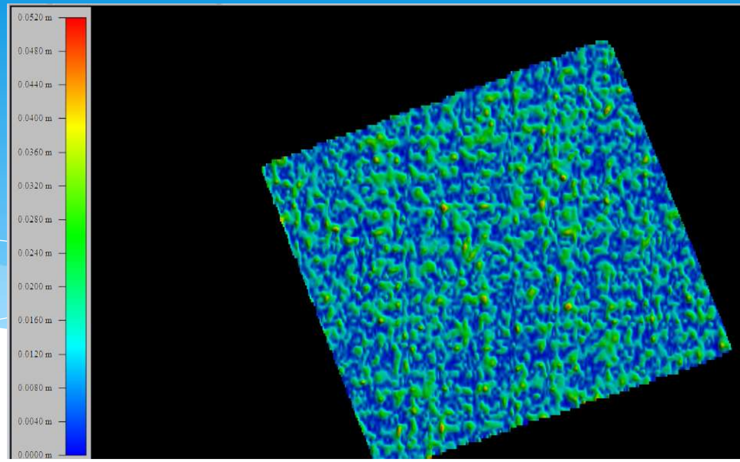
Classes for LiDAR points:

- ❖ Unclassified points (class 1);
- ❖ Bare earth (class 2);
- ❖ Vegetation (class 4);
- ❖ Buildings (class 6);
- ❖ Low noise (class 7 and 18);
- ❖ Water (class 9);
- ❖ Bridge deck (class 17).

POINT CLOUDS

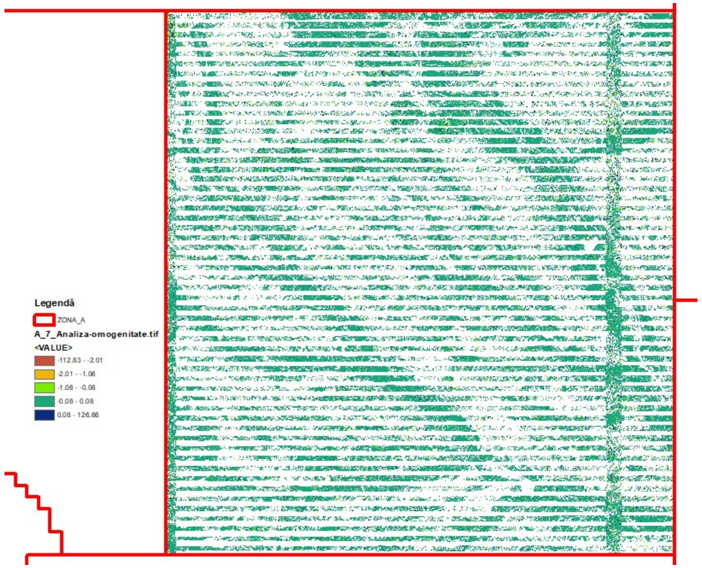
Relative and absolute accuracies in the National Reference Coordinate System

Relative vertical accuracy		Absolute vertical accuracy (RMSE)	Absolute horizontal accuracy (RMSE)
Intraswath Precision	Interswath (Overlap) Consistency		
≤0.06 m	≤0.08 m	≤0.30 m	≤0.40 m



raster example with elevation difference

Control profiles examples



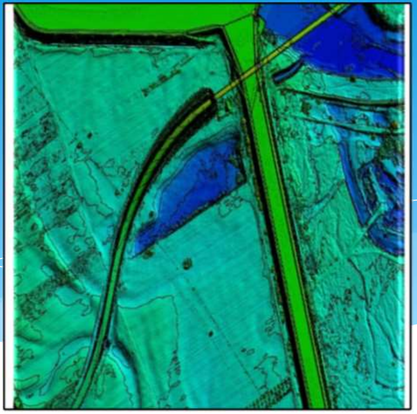
Homogenity analysis

FINAL PRODUCTS OF LAKI III

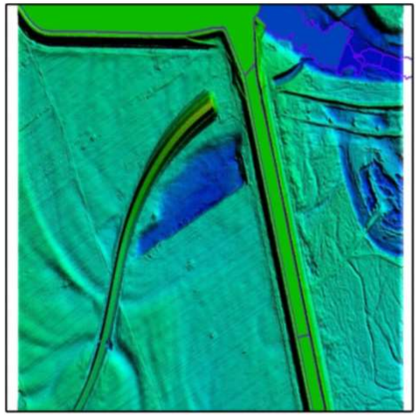
❖Technical specification for DTM and DSM generation:

- must be hydro-flattened using the break lines;
- it must not contain bridges;
- water canals must be included;
- the area without data, from the tiles on the contour of the project surface that are not completely covered with DTM, must be coded using the value “NODATA” equal to -9999;
- the artefacts (ex: dust, reflections, shadows, people, etc.) must be removed from DTM tiles, including the built-up areas;
- there must be no large differences in height between the tiles on the connection area;
- must be generated in the Romanian National Reference System (Krasovski 1940 ellipsoid, Stereographic 1970 projection and Black Sea 1975 Normal Height System.

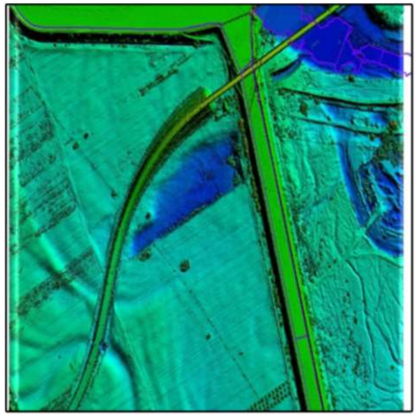
DSM and contour line



DTM



DSM



Area	Resolution DTM/DSM (m)	Root mean square error DTM/DSM (m)
Area A/Area B	0.50	±0.40

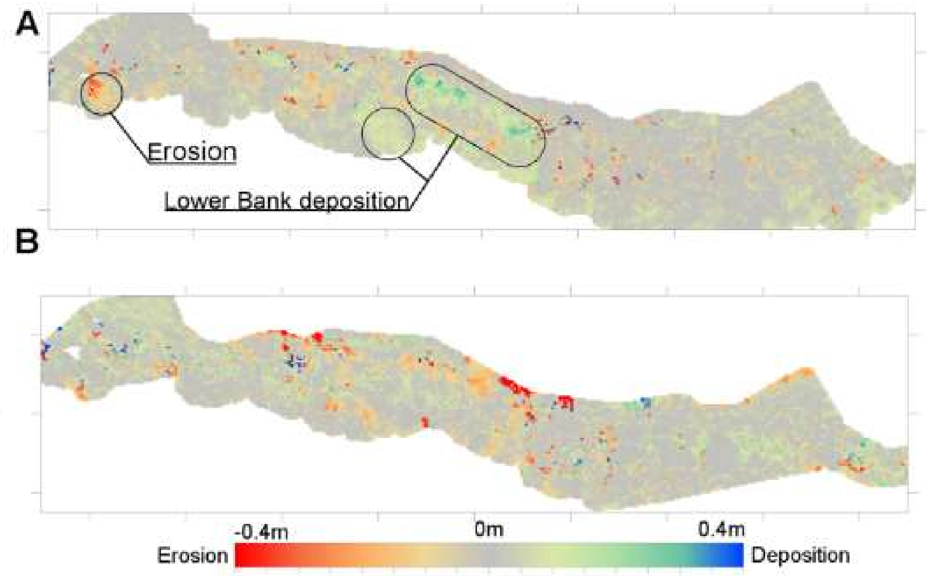
APLICATIONS OF LASER SCANNING DATA ON WATER COURSES

- ❖ Hydraulic and hydrological modelling
- ❖ Hazard and flood risk mapping
- ❖ Bathymetric mapping
- ❖ Monitoring and analysis of morphological changes in riverbeds
- ❖ Automated water surface classification
- ❖ Long-term morphological evolution of the watercourse
- ❖ Bank erosion analysis
- ❖ Characterization of the seabed morphology

APLICATIONS OF LASER SCANNING DATA ON WATER COURSES

Airborne Laser Scanning- is applied for mapping elevations in riparian areas, for good flood management and for assessing erosion and sediment deposition

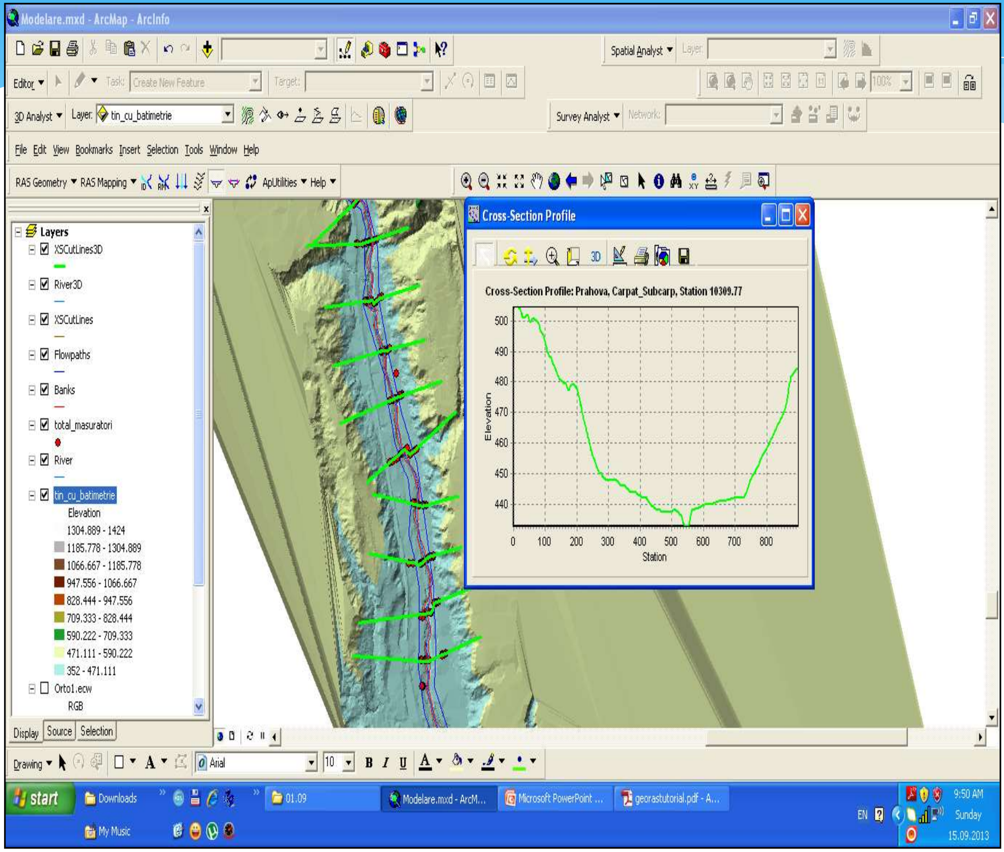
Terrestrial laser scanning - is used for the quantitative determination of eroded material, but also for the identification of spatial and temporal transformations over an entire river course. These data are also used for the study of river morpho dynamics and for the identification of riverbank changes.



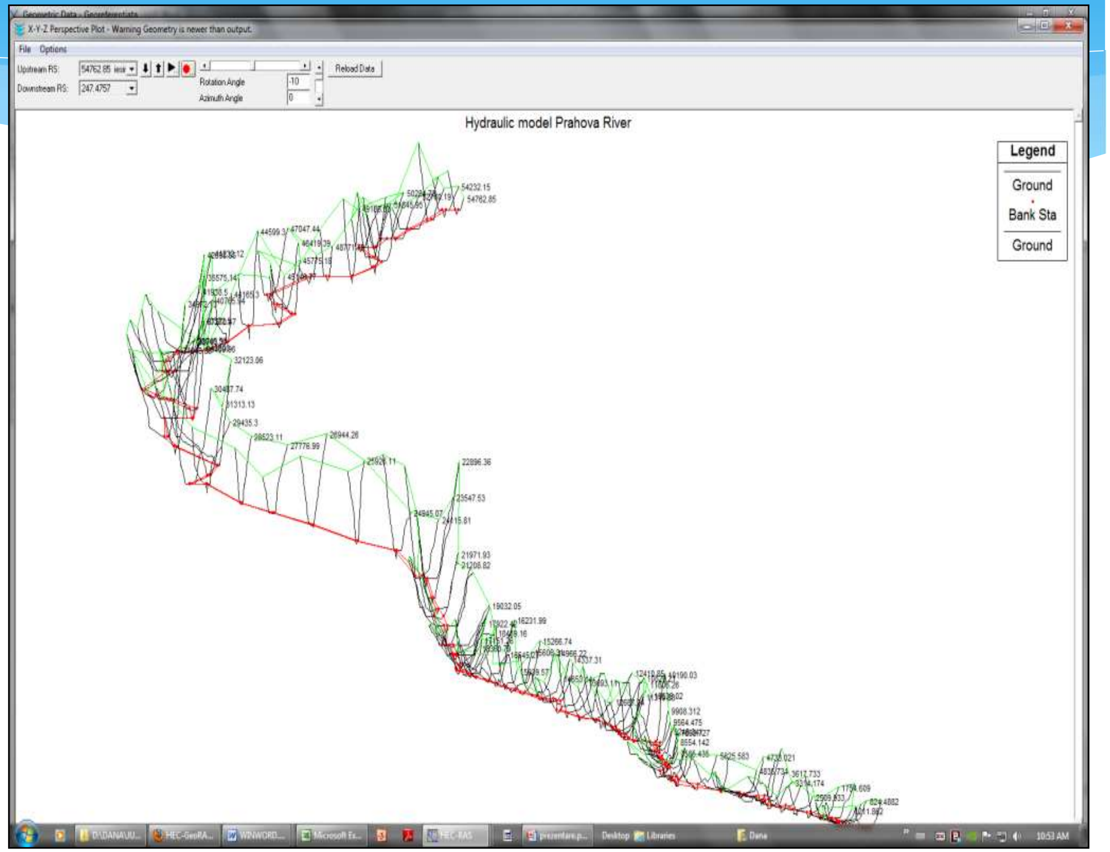
Identification of erosion and deposition zones for the Tartano Alpine river in the northerm Italy

CASE STUDY – PRAHOVA RIVER, ROMANIA

- Use of LiDAR data to create the geometry of the hydraulic model



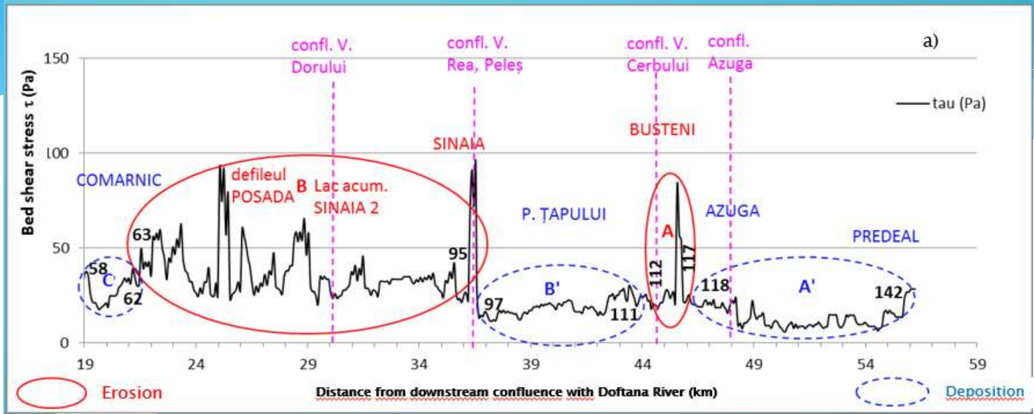
A cross section profile from study area

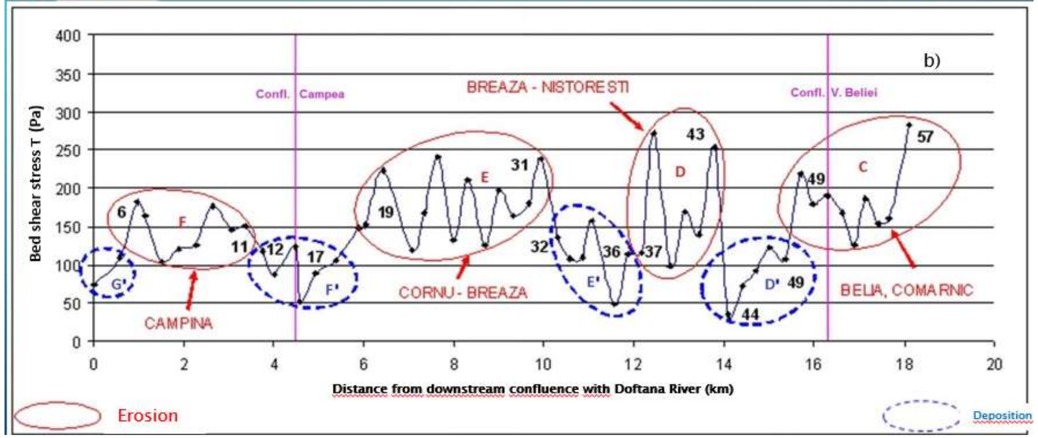


The hydraulic model Prahova River
(3D view in HEC-RAS soft)

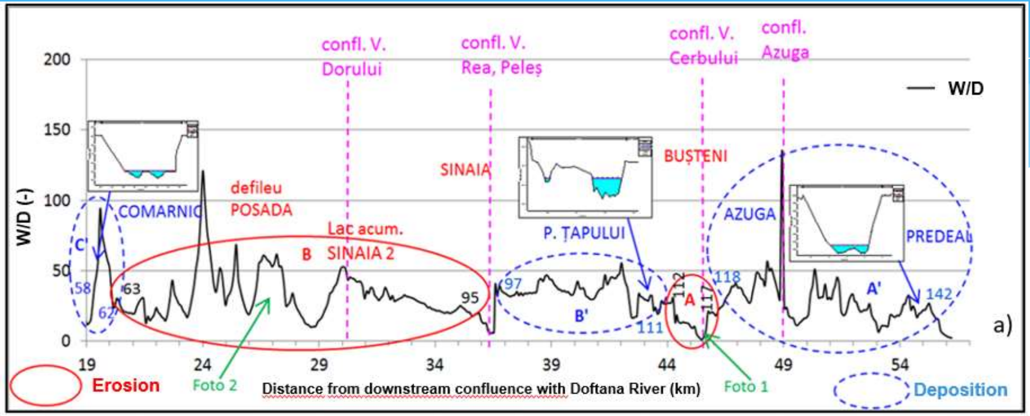
ANALYSIS OF EROSION AND DEPOSITION POTENTIAL OF RIVER CHANNELS BY HYDRAULIC MODELLING

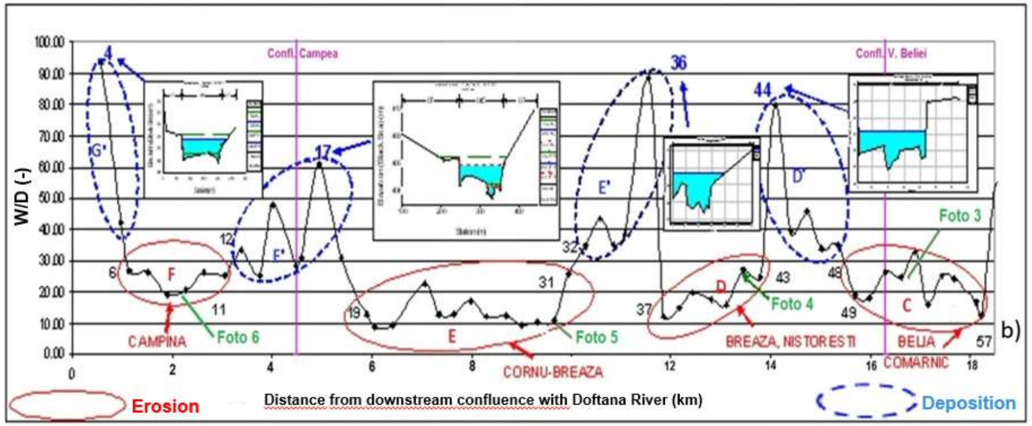
Prahova River, Romania





Shear stress values from: a) the Carpathian reach of Prahova River, 19-56 km distance from downstream confluence with Doftana River (Comarnic-Predeal); b) the Subcarpathian reach of Prahova River, 0-19 km distance from downstream confluence with Doftana River (Comarnic-Predeal); areas of potential erosion (A-F, with names) and deposition (A'-G') are emphasized.





W/D (W— top width; D — hydraulic depth) from: a) the Carpathian reach of Prahova River, 19-56 km distance from downstream confluence with Doftana River (Comarnic-Predeal); b) the Subcarpathian reach of Prahova River, 0-19 km distance from downstream confluence with Doftana River (Comarnic-Predeal); areas of potential erosion (A-F, with names) and deposition (A'-G') are emphasized.

ANALYSIS OF EROSION AND DEPOSITION POTENTIAL OF RIVER CHANNELS

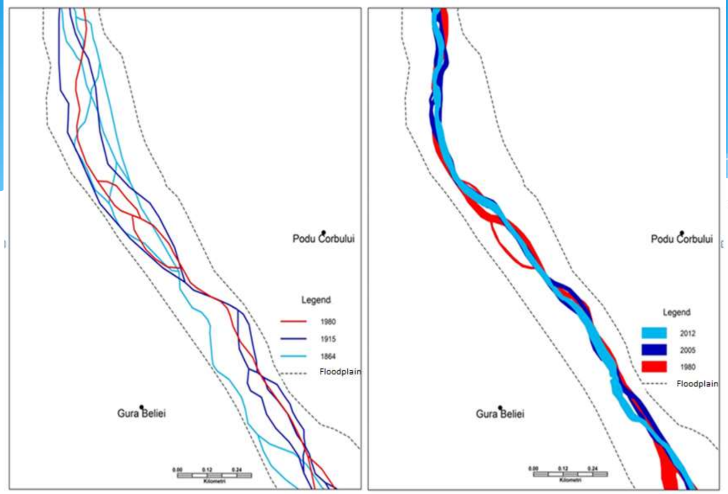
Prahova River, Romania

The C-erosion area upstream Belia confluence on the lefthandside riverbank is an outcrop of red 'Gura Beliei' marls.

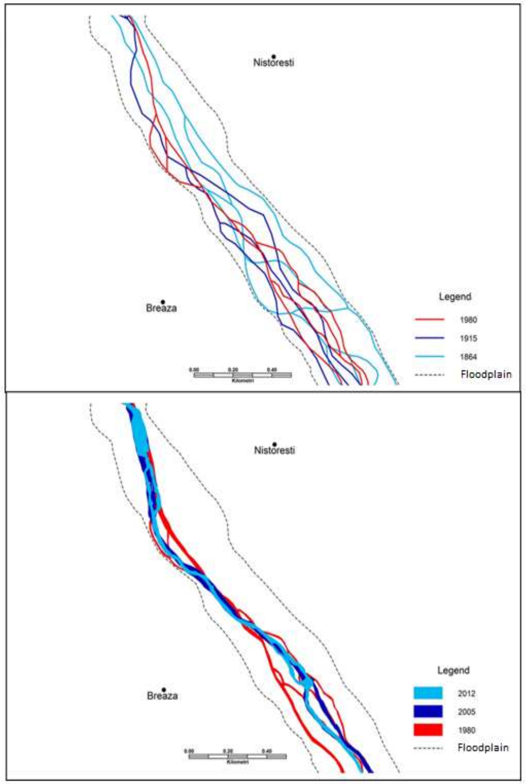
The D-erosion area- water pipes laying under the gravel bed may currently be seen at the water surface.

The E-erosion area- near Breaza town- Sărăcilă Valley. In August, 2006, the road was damaged by lateral erosion.

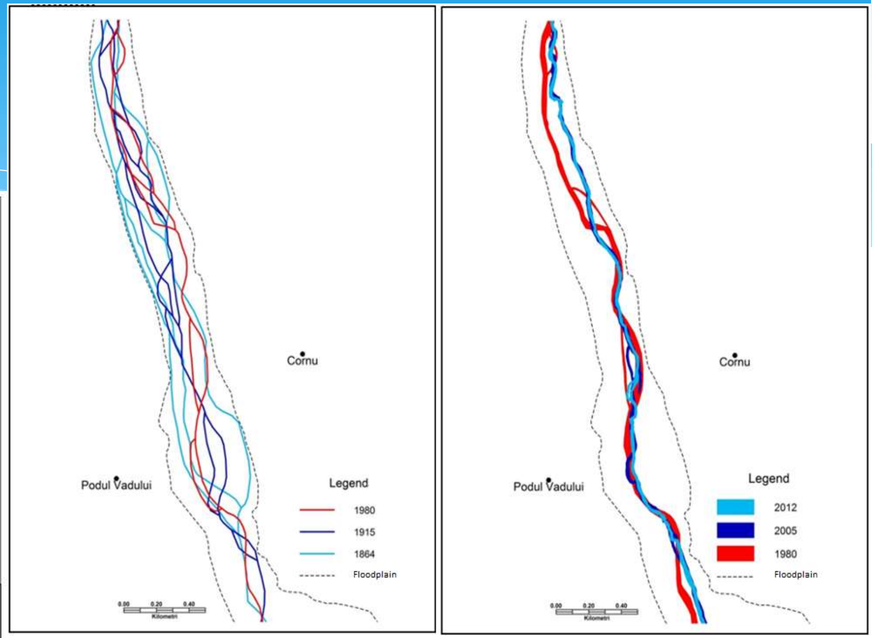
MORPHOLOGICAL PLANFORM CHANGES OF PRAHOVA RIVER CHANNEL



Morphological planform changes of Prahova river channel in the C erosion area



Morphological planform changes of Prahova river channel in the D erosion area



Morphological planform changes of Prahova river in the E erosion area

CONCLUSIONS

Digital Terrain Models obtained by airborne laser scanning are the highest quality information layer for many applications including river geomorphology. They allow the development of new analysis methodologies and a detailed morphological and hydrological characterization of areas traversed by water, thus improving the understanding of hydrological and sediment transport processes. Thus, Digital Terrain Models resulting from the processing of data acquired at different time intervals are used both for the analysis of river relief in areas crossed by watercourses and for monitoring its evolution over time.

This presentation reviewed a number of research results on the evolution and morphology of the Prahova riverbed (Romania), an analysis that was also made possible by the use of DTM (resulted by airborne laser scanning) in hydraulic modelling. The evolution model of the Prahova river bed, resulting from the research methods addressed, shows the following styles of bed adjustment: continuous narrowing of the minor bed, lowering of the talweg line through erosion processes in depth and morphology change from a braided bed type to a sinuous, unitary bed. These mechanisms of fluvial response and regulation occurred in the context of anthropogenically imposed disconnections, against the background of a neotectonic trend specific to the Carpathian Curvature.

CNC

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Thank you !

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