

## STUDY USING LiDAR TECHNOLOGY ON TIME MODIFICATIONS OF THE PILCOMAYO HYDROGRAPHIC BASIN IN PARAGUAY DURING 2018-2020

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### Abstract

*The main objective of the project, entitled "STUDY WITH THE HELP OF LIDAR TECHNOLOGY ON CHANGES OVER TIME OF THE PILCOMAYO HYDROGRAPHIC BASIN IN PARAGUAY IN THE PERIOD 2018-2020", is to create, with the help of specialized programs and software, the digital model of the land and the model digital of the surface, for a portion of the Pilcomayo River, located in the central part of South America.*

*The final result must come in support of the people who will draw up flood scenarios and plans, due to the fact that the river is constantly changing, threatening both the flora and fauna of the area, but also the communities of people near its banks.*

*As part of the project, volumetric calculations will also be made, which will result in the quantities of excavation and filling that will be necessary to combat possible floods.*

### INTRODUCTION

The main objective of the project is to create, using specialized programs and software, the digital terrain model and the digital surface model for a portion of the Pilcomayo River located in the central part of South America.

Over time, numerous scientific research studies have been conducted to understand its behaviour, as it is a river constantly changing.

It is famous for its flood period marked by the rainy season, occurring in the months of December and January. The flooding starts in February and reaches its peak level in April. The river's descending period occurs between the months of May and December.

### THE WORKING METHODOLOGY

The equipment used to obtain the data:  
Bell 206 helicopter (ZP-HCH)



Figure 1. The equipment used

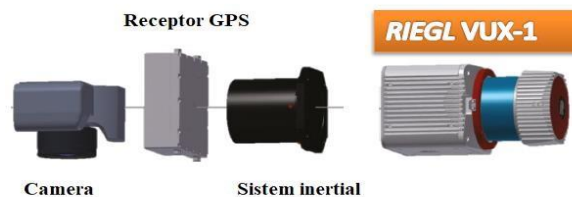


Figure 2. Components

On the digital model, the changes that have occurred over time on the terrain can be observed most effectively. In practice, this serves as the basis for analysis. Volumetric calculations will be performed and the evolution of the river banks will be analyzed.

Based on the resulting digital models, flood scenarios can be created to observe how the terrain would behave in the event of floods. The evolution of the Pilcomayo River is constantly monitored, with periodic scans being conducted on it.

The control points were materialized with hydraulic markings made of concrete with a bronze plate at the central point, similar to the markings of the national geodetic network.

They were geolocated using a GPS K9 device.



Figure 3. Control point

## CREATING THE DIGITAL TERRAIN MODEL

The Digital Terrain Model is a three-dimensional mathematical representation, to scale, in digital format, of the terrain in a specific area.

It accurately describes an extensive land surface, often inaccessible or difficult to access, such as vegetation-covered areas or mountainous regions, where the use of traditional surveying techniques would be nearly impossible to implement in practice

The steps involved in creating the digital terrain model in this work are:

1. Importing the lidar data into the specialized software Envi LiDAR
2. Selecting the processing parameters
3. Processing the data
4. Displaying the results
5. Importing the data into Global Mapper

6. DTM processing
7. Processing the parameters
8. Final DTM result

Specialized programs and software for creating the digital terrain model:

### Envi Lidar

The ENVI software product for satellite image analysis uses mathematically proven analyses to deliver highly accurate results. Private companies, as well as other organizations, use ENVI because it integrates with existing workflows, supports today's most popular sensors, and can be easily customized to meet unique project requirements.

Initially, we imported the data obtained from the scanning process in 2018.

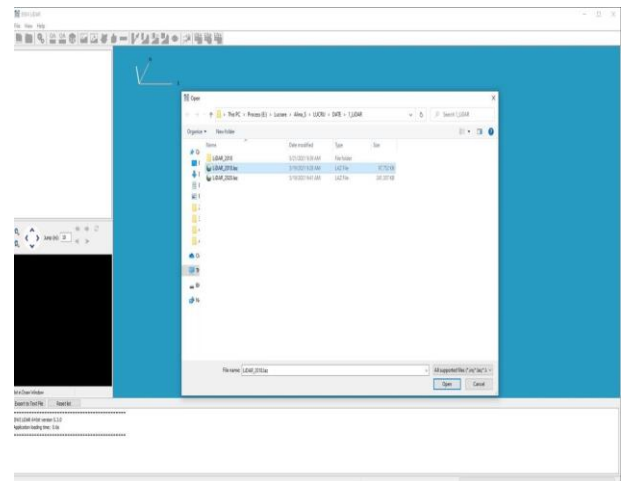


Figure 4. Importing LiDAR data

In the image below, after the import, we can observe the presence of "noise" points, which will be of no use to us.

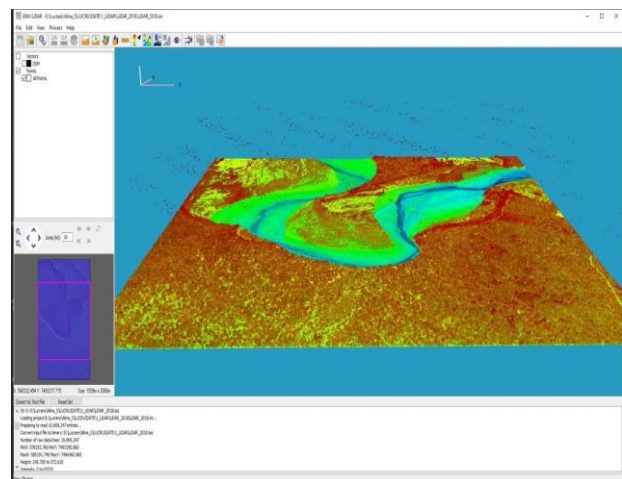


Figure 5. Importing LiDAR data

For parameter processing, we selected the options "Produce DSM, P. DEM, P. Trees, P. Point Cloud." We chose the U.T.M. projection system, WGS84 datum, and Zone 20S. Furthermore, we selected a resolution of 1m/pixel and then waited for the point cloud processing to complete.

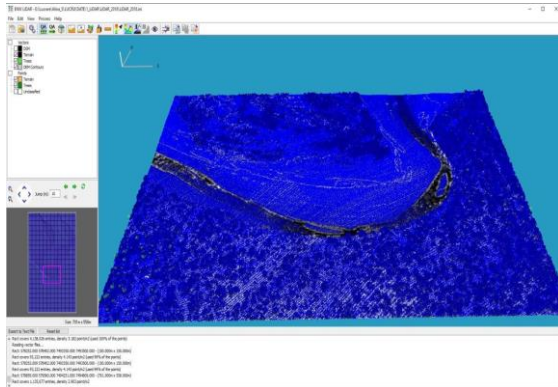


Figure 6. Envi LiDAR result

### Global Mapper

Global Mapper is a Geographic Information System (GIS) software that provides users with the ability to create, edit, analyze, and visualize geospatial information. This software is developed by Blue Marble Geographics and offers a wide range of features, including data import and export, geospatial data analysis, map creation, and visualization tools. It is available for both personal and commercial use. Initially, we started by importing the data into the Global Mapper software.

Once the data import was completed, we proceeded to the stage of processing the digital terrain model. From the "Analysis" window, we selected the option "Create Elevation Grid from 3D Vector/Lidar Data."

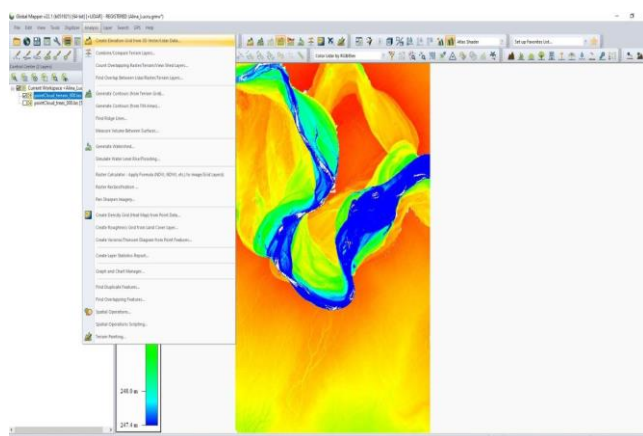


Figure 7. DTM processing

Then we selected the option "pointCloud terrain". In the next window, we filled in the "Layer" field with the desired type of digital model, specifically DTM. We waited for the processing of parameters, and finally, the Digital Terrain Model (DTM) was generated.

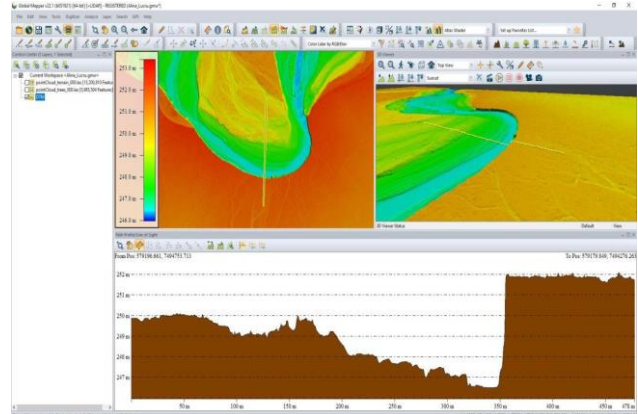


Figure 8. DTM result

Continuing the same process, we proceeded to obtain the Digital Surface Model (DSM), with the only difference being the selection of the option "Layer - DSM."

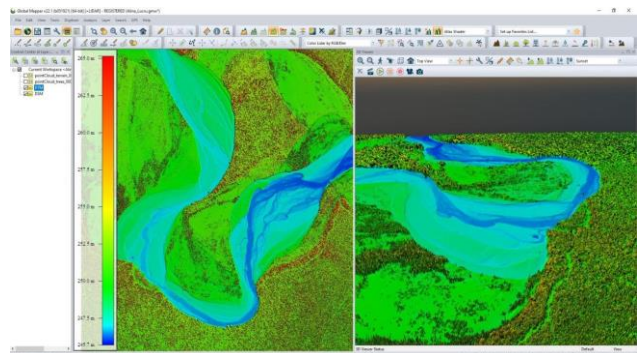


Figure 9. DSM result

In the image below, you can observe the difference between the created DTM and DSM:

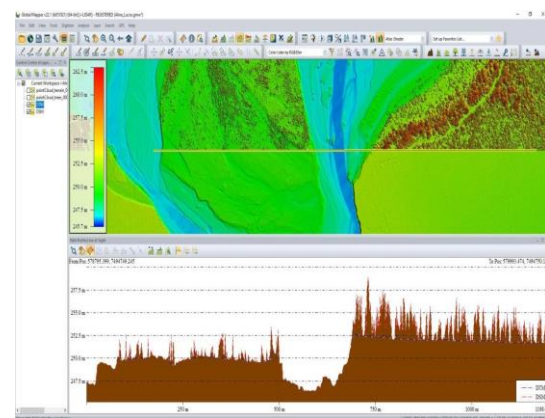


Figure 10. Comparison between DTM – DSM

The differences between the digital terrain model (DTM) and the digital surface model (DSM) are clearly visible at first glance. The DSM provides detailed information about vegetation cover and areas that may appear inaccessible.

In the following images, we will demonstrate how two images can be displayed simultaneously in Global Mapper software:

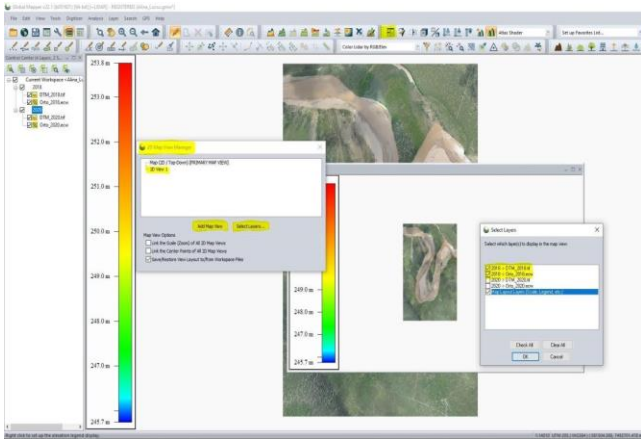


Figure 11. Simultaneous visualization

Here, we have presented a concurrent view of an orthophotoplan from 2018 and another one from 2020. The differences are extremely visible.

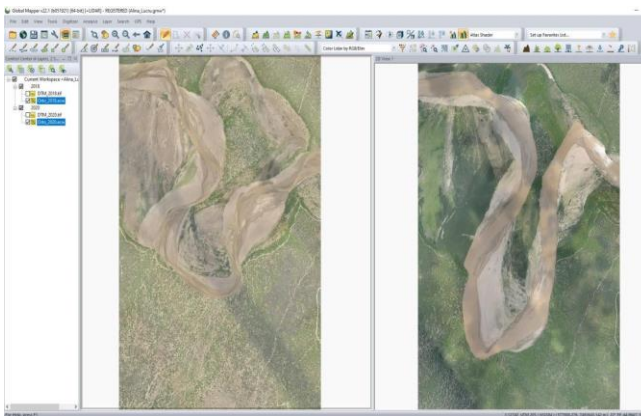


Figure 12. Ortho visualization 2018-2020

We repeated the same steps for the data obtained from the 2020 scanning, and now we will present a series of comparisons and changes over the course of these two years.

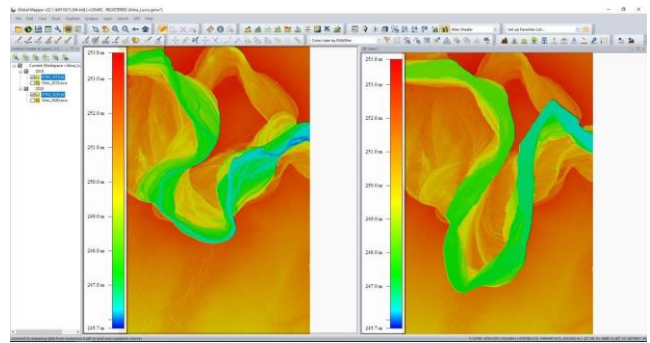


Figure 13. Visualization DTM 2018-2020

In the current image, the two digital terrain models from the two years are displayed. To compare the two digital terrain models, we selected the "Combine/Compare Terrain Layers" command from the "Analysis" window.

In the following images, I wanted to highlight the changes that occurred over the course of two years in our area of interest.

For this, we used a tool in Global Mapper that allows us to perform operations on the analyzed surfaces.

In the initial phase, we wanted to see where and by how much the land elevation has increased due to the river action. To achieve this, we filtered the created raster to highlight positive differences.

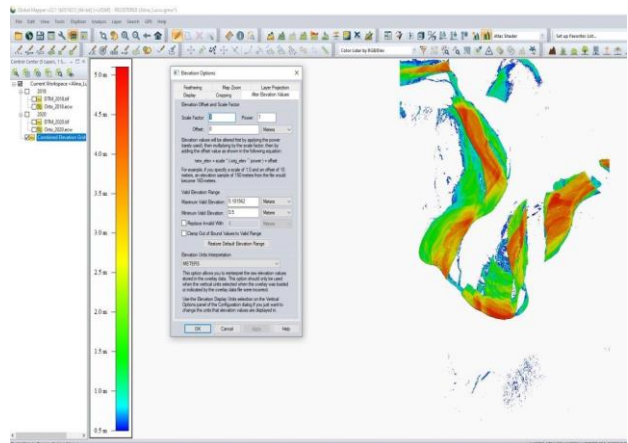


Figure 14. Positive changes: 2018-2020

For the next image, we wanted to visualize the land eroded as a result of the river action. We filtered the data to highlight negative differences.

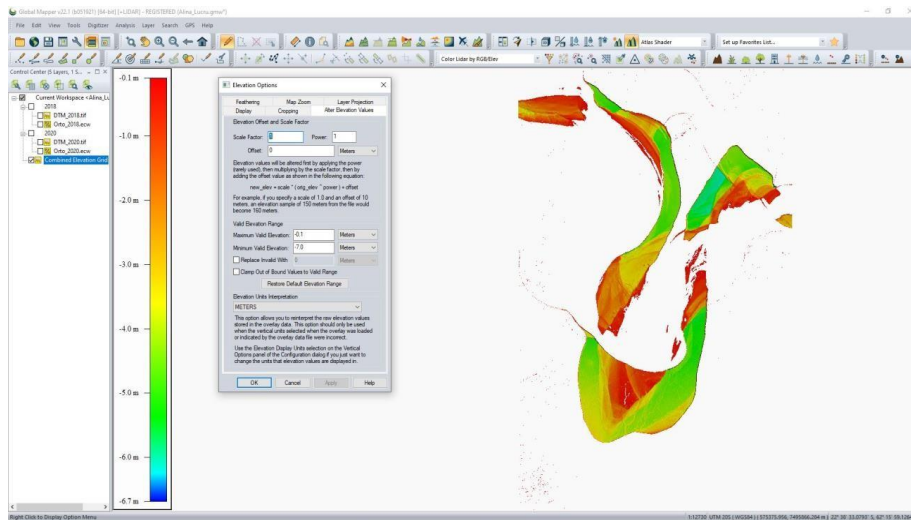


Figure 15. Negative changes 2018-2020

## ANALYSIS AND CONCLUSIONS

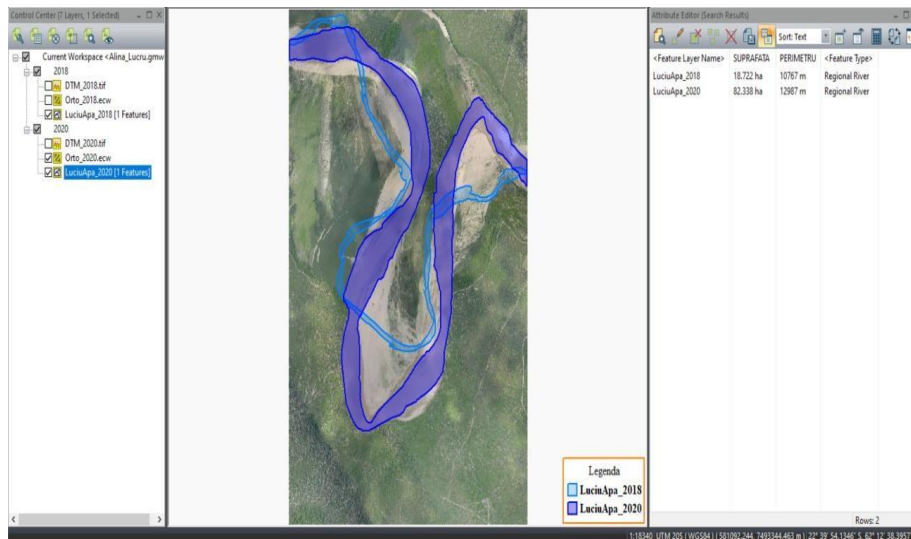


Figure 16. Comparison of the surface

The surface and perimeter changes over the course of the two years are clearly visible. The total calculated volume from the two

surfaces is 6,423,580.2 m<sup>3</sup>. The excavation area was 126.96 hectares, and the fill area was 3,147,228.3 m<sup>3</sup>.

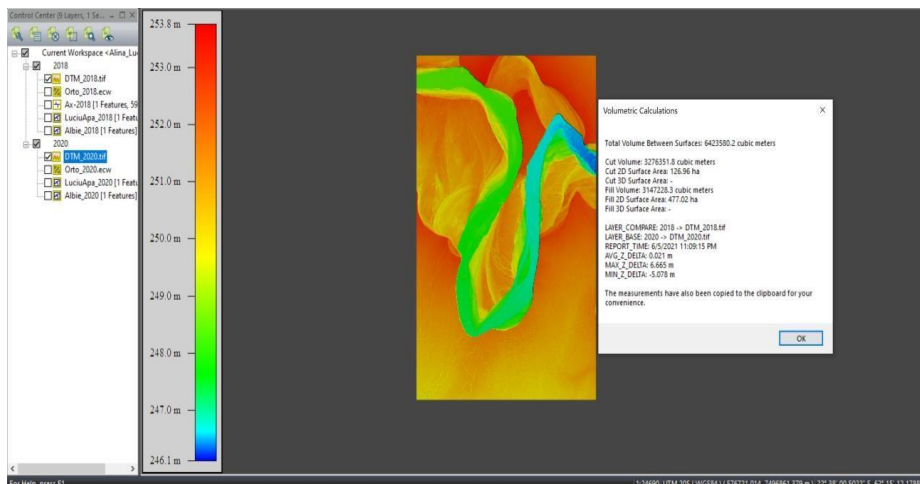


Figure 17. Excavation-Fill Volume

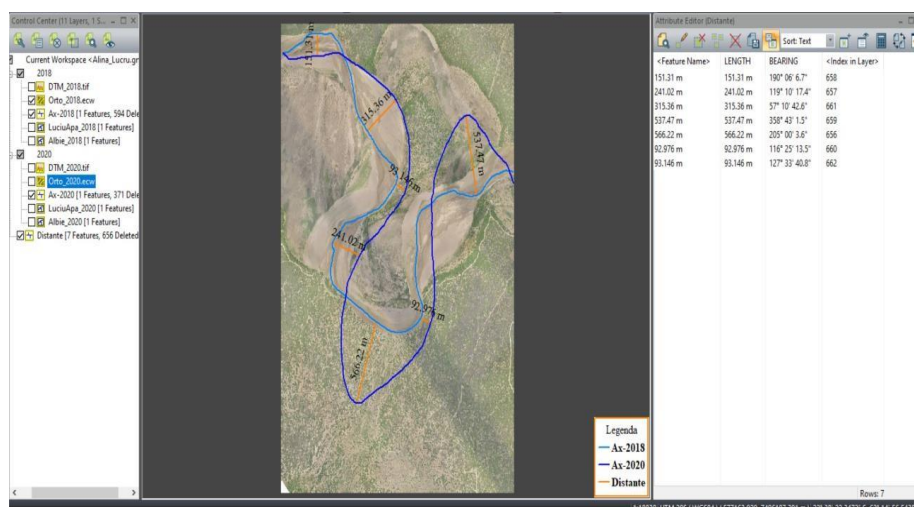


Figure 18. Distances

In the image above, the changes in the river over a period of 2 years are represented by distances.

It can be observed that the movement of the riverbank is very noticeable, highlighting the importance of constant river monitoring.

## CONCLUSIONS

The ability to perform rapid and accurate measurements over large areas at an optimal cost, as well as the capability to simultaneously acquire other data sources such as high-resolution aerial imagery, make airborne laser scanning technology an important tool for numerous applications related to planning and land management.

The measurement of surface areas traversed by water has become essential for evaluating sediment volumes, analyzing changes in water courses, calculating water velocity and level dynamics, and describing the structure and geomorphological changes of territories.

In this study, the Riegl VUX-1 airborne sensor was used. It can be easily mounted on any type of aircraft, such as airplanes or helicopters. The advantage of the equipment used lies in its accuracy and the quality of the final product it produces.

Following the scanning process, the digital terrain model and digital surface model were obtained, aiming to prevent potential natural disasters such as floods, as the river is constantly changing.

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