A BIRD'S EYE VIEW

TO LIVE IN HARMONY WITH NATURE, FARMERS IN BOLIVIA ONCE EMULATED THE ACTIVITIES OF ANIMALS SUCH AS WORMS TO CONDUCT 'RAISED FIELD' AGRICULTURE. TO PRESERVE THESE MOUNDS, UAVS EQUIPPED WITH CAMERAS AND LIDAR ARE BEING USED TO SURVEY THEIR EXTENT. BUT AS BRUNO ROUX REPORTS, BOTH THE MOUNDS AND BOLIVIA ITSELF PRESENT THEIR OWN CHALLENGES FOR FIELD TEAMS

Mound-field landscapes are located in humid continental areas of the intertropical belt. Alluvial plains in those areas can seem homogeneous, but a closer look often reveals the existence of an extremely regular micro-relief. This regular and repeated heterogeneity is the result of either human activities or organisms that are 'Earth engineers', such as worms, social insects or burrowing mammals.

Like most humid zones, these landscapes are threatened by human activities, such as intensive rice growing or excessive drainage. Nevertheless, they also show examples of agriculture benefiting from the humidity rather than trying to overcome it, which enables the coexistence of agricultural production and the preservation of biodiversity and ecosystem services.

By developing adaptations analogous to the biological adaptation of the earth engineers, people have erected earth mounds in alluvial plains, to conduct 'raised field' agriculture. Landscapes marked by this type of agriculture can be found in South America, as archaeological vestiges of abandoned fields following the disruption brought by the European conquest, and in Africa, where raised field agriculture is used in a few alluvial plains.

To preserve such sites, it is essential to identify and characterise them. This is possible by combining exhaustive cartography information with geomatics methods, observations and ecological and anthropological data. While classical airborne LiDAR is difficult to mobilise in the most remote places of Bolivia, it is possible with an ultralight and compact LiDAR system mounted on a UAV, such as YellowScan, which weighs 2kg. Photogrammetry is difficult to apply to the mounds, whereas YellowScan enables the generation of a 3D model with a resolution greater than 100 points/m^2. Its integrated RTK GNSS also means a 3D terrain model with a precision greater than 10cm can be quickly generated without any ground control points.

Operating in difficult conditions

At the request of the CNRS CEFE, French aerial photography company L'Avion Jaune ran a campaign of UAV cartography in the plains of north

In aerial views, the mounds are hidden beneath the trees and are invisible

Bolivia. This included coverage of a dozen sites located a few kilometres from Santa-Rosa de Beni. The dry season from October 16 to 30 2015 was chosen to allow travel from one place to another in motorised vehicles adapted to the rugged terrains.

This campaign, as well as being a fantastic scientific project expanding our knowledge of mound-field landscapes, was also the opportunity to test the YellowScan LiDAR in harsh conditions, evaluating its general resistance to humidity and dust. Transport from one site to another on highly deteriorated roads would also put the equipment under extreme strain due to violent bumps and significant vibration.

Very low flights

L'Avion Jaune's Mikaël Jouanne and I made up the field team. We had to transport all the equipment, including the two multi-rotor Onyxstar UAVs and the GNSS base station, in our luggage. Our first complication was the transport of the UAVs' batteries, which weighed a total of 25kg. These had to be dispatched in our luggage to comply with regulations on battery transport in commercial aircraft.

Each flight consisted of an Onyxstar UAV with eight motors, a LiDAR and an RVB camera. This 2.5kg payload was able to simultaneously collect point cloud and optical images, to merge the data for the analysis of landscapes covered.

For each site, the strategy was to follow flight lines at a 75m height – an altitude permitting a point density sufficient for a good description of the mounds. Each site was an area of about 1km^2, and took two to three flights to cover, so to cover all the sites needed a total of about 30 flights, representing around three hours of flight in total.

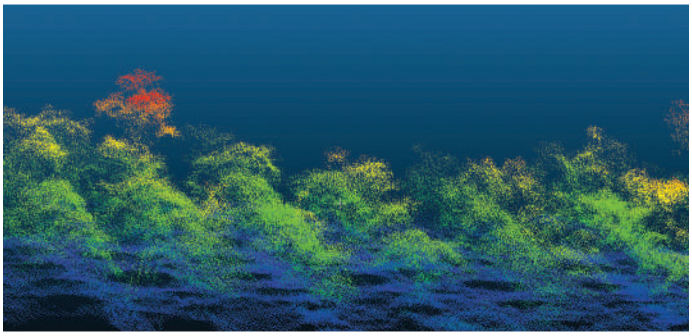
The multirotor UAV proved tailor-made to operate the system, thanks to its trajectory stability, low speed and lack of vibration, which enabled the acquisition of high quality datasets. The entire system worked without fail at high operating temperatures and sometimes in dense dust clouds.

Some promising early results

A first visual evaluation of the data showed the benefits of LiDAR in the understanding of mound-field landscapes. With data analysis software, such as Cloud Compare, we can distinguish heavily worn reliefs that an observer on the ground cannot see. We also noticed on a larger scale that the variation in the micro-topography (z-variations of a few decimetres to a few hundreds of metres) has a strong influence on the water system and therefore on the distribution and maintenance of the mounds.

These points will be dealt with in depth through GIS software by merging the point clouds and optical images and then using ENVI and QGIS. We can then apply Fourier transforms and an object-oriented picture analysis to complete the study.

One of the goals of future treatments will be to remove the herbaceous vegetation covering the mounds that disturbs the exact height measures. This essential information for the understanding of these ecosystems has been occasionally measured from the ground but never before by airborne solutions. The LiDAR should show good results on this.



A point cloud showing some raised-fields under the trees-cover.

A close range mosaic where anthropic mounds are melted with 'surrales' (small mounds created by earthworm)

Mikaël Jouanne (right) and Bruno Roux preparing a flight with YellowScan in very hot weather (40°C)

An undeniable advantage of this technique is the detection of mounds under the trees. With tailor-made flight plans (low height and speed), we get very detailed data on a particular site where each mound is covered by a tree.

The first results will be followed by careful studies by students at the PRODIG laboratories in Paris, the CNRS-CEFE and L'Avion Jaune. This collaboration will make it possible to treat most of the massive datasets acquired. We nevertheless had to choose the three most interesting sites to meet the study deadlines and produce the final report ordered by the project's investors by the beginning of 2016.

These original datasets will contribute to the inventory of these fascinating biotopes, will provide data for thesis work, and will help calibrate high-resolution satellite image analysis methods for the automatic detection of this kind of landscape in the intertropical zone

THIS ESSENTIAL INFORMATION FOR THE UNDERSTANDING OF THESE ECOSYSTEMS HAS BEEN OCCASIONALLY MEASURED FROM THE GROUND BUT NEVER BEFORE BY AIRBORNE SOLUTIONS

Bruno Roux is co-founder of L'Avion Jaune (www.lavionjaune.com)