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Can mapping and modelling erosion figures in endangered ecosystems be done using affordable UAVs ?

I. ROUET (1), E. SCHNEITER (2), T. HOIBIAN (3), M. ALLENBACH (3) , O. COHEN (3) ,W. TAGAR (3)

1 – Rouetis R&D, New-Caledonia (rouetis@gmail.com)
2 – Emmanuel Schneiter (chamanea@gmail.com)
3 – University of New Caledonia
(thierry.hoibian@univ-nc.nc, michel.allenbach@univ-nc.nc)

UNIVERSITÉ de la NOUVELLE-CALÉDONIE

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Can mapping and modelling erosion features in endangered ecosystems be done using affordable UAVs ?

Plan

1. Why ? (context, needs & constraints)
2. Methods and software
3. Equipment
4. First test in the Southern Massif, New Caledonia
5. Conclusion

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Why ?

CONTEXT : ***Erosion*** *in our countries*

- Cyclonic climate
  (heavy rains events, strong winds, cyclonic swell)
- Sensitive materials
  (thick weathered mantles, thin & non cohesive particles - laterites, hydroxides particles)
- High islands / Slope erosion
  (forest fires, human activities)
- Sea level rise / Coastal erosion

NEEDS

- The need of knowledge
  (where are the sensitive areas ? What kinds of current phenomena ?)
- *The need of understanding & hazard mitigation*
  (why is this happening ? How ? What can we do ?
- *The need to save endangered endemic species*
  (high level of biodiversity)

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CONSTRAINTS

- Areas & access
  - *Reccurent access difficulties*
  - *Difficulties for 3D reconstruction*
  - *(deep & narrow, irregular shapes to map (field), complex landscape)*
- Usual field mapping
  - *Mapping methods are time consuming,*
  - *Use expensive devices, (topography, DGPS...)*
  - *Human resources consuming & sometimes dangerous,*
- Professionnal UAV field mapping
  - *Fast & safe*
  - *Use expensive devices each time,*
  - *Strong aerial constraints (flying licence, flying allowance, time consuming administrative regulation rules...)*

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The test area

- 1 active gully erosion system (~1ha watershed)
  - *3 head gullies (5-20m wide x 100m long x 5-10m depth)*
  - *1 main gully channel*
- Well known (> 4 years of surveys & monitoring)
- Ground control points available

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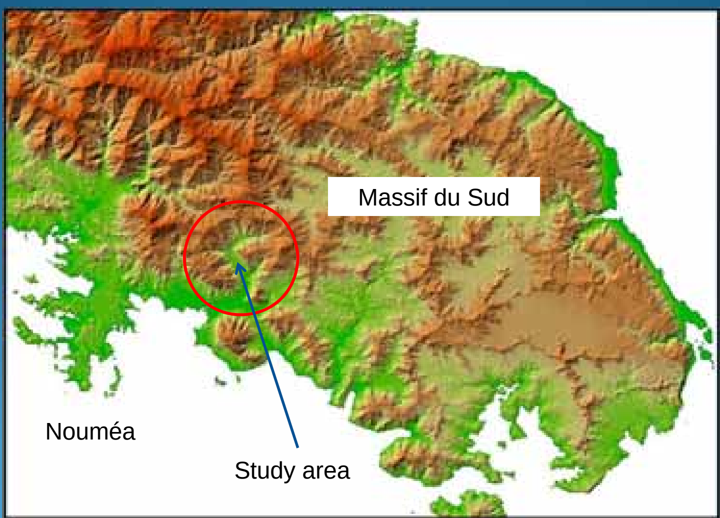

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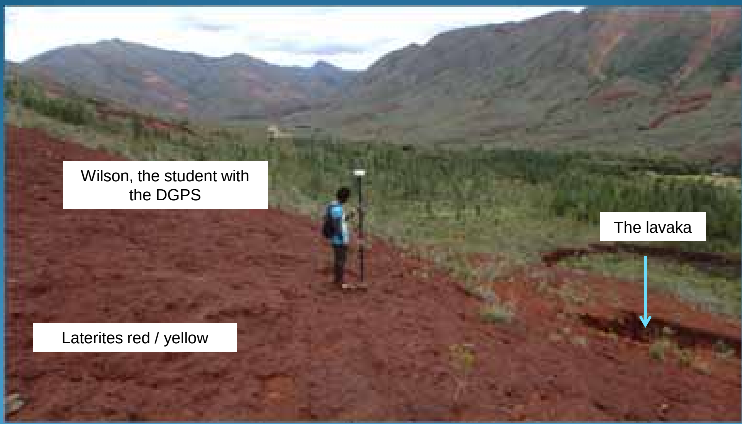

The valley seen from the top of the site lavaka

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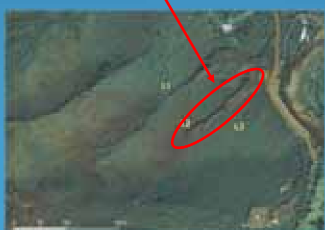
The aerial picture of the site

Classical aerial imagery a 1/20 000 or 1/80 000 is not enough accurate to see details



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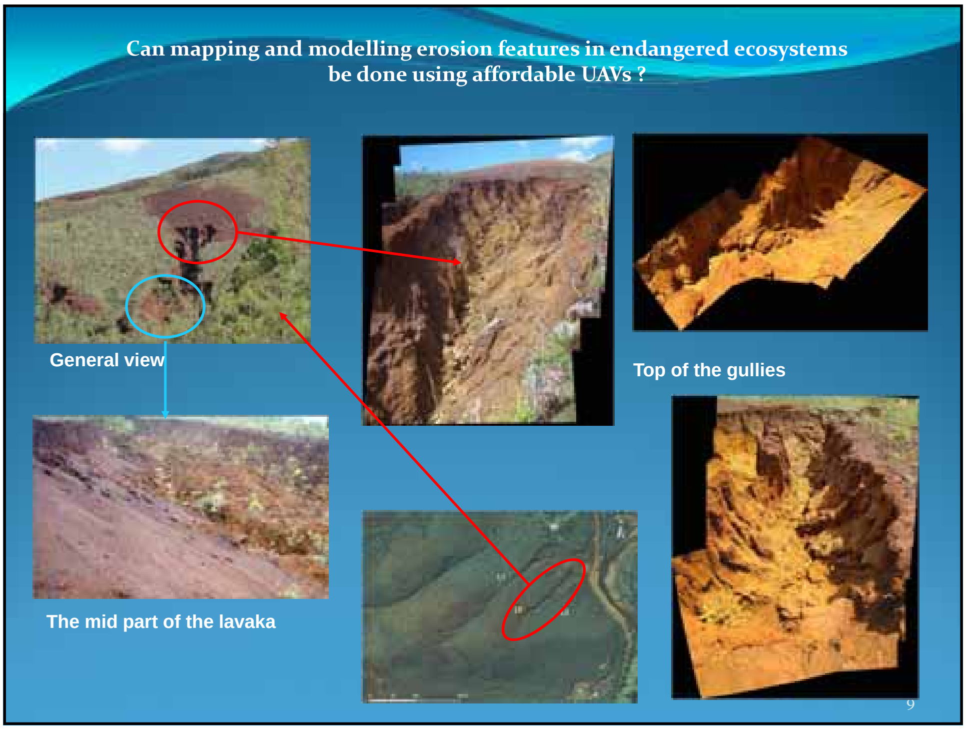
Can mapping and modelling erosion features in endangered ecosystems
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General view
Top of the gullies
The mid part of the lavaka
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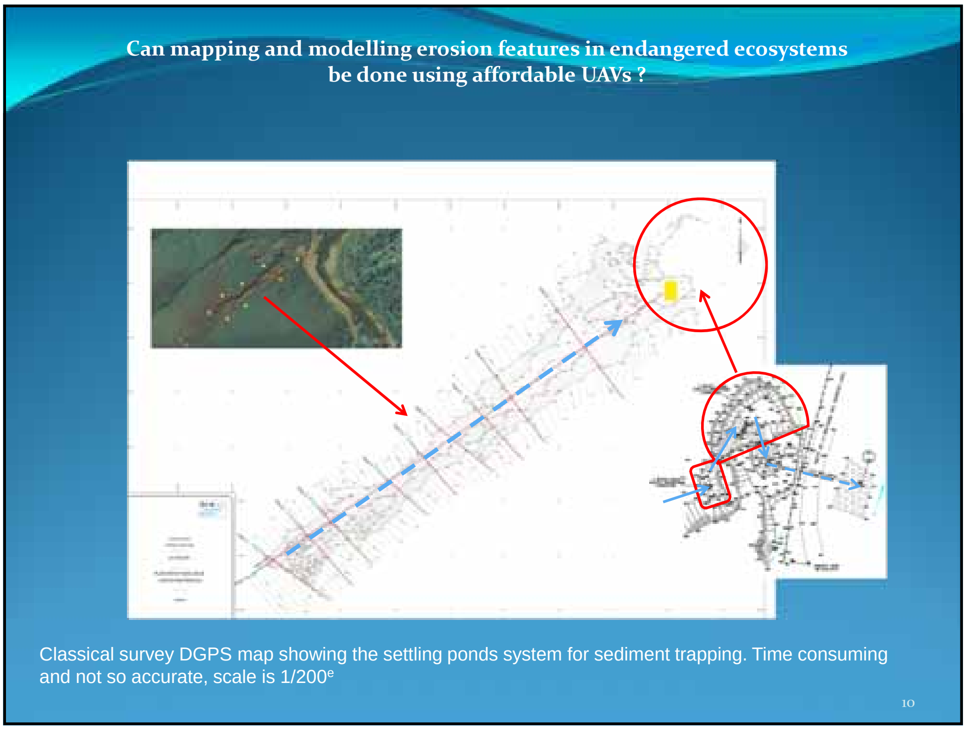
Can mapping and modelling erosion features in endangered ecosystems
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Classical survey DGPS map showing the settling ponds system for sediment trapping. Time consuming and not so accurate, scale is 1/200e
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Method - Photogrammetry

Photogrammetry was invented by Aimé Laussedat in 1849, at the beginning of the photography

It was used for the measurement of monuments, from 2 pictures taken at a known distance from each other in the same direction.The distance between two corresponding points on each image is an indication on their real geometry.

Nowadays digital camera with 20 mpix & image processing methods such as crosscorrelation allows to assemble the matching images throughout a photography session.

Computer method is sparse and dense cloud reconstruction, softwares are Bundler, PMVS, Micmac, Agisoft Photoscan, …

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Photogrammetry Software

- Agisoft PhotoScan Software
  - *Performs 3D reconstruction of a scene from aerial/ground pictures*
  - *Allows to use calibration ground targets, control points, scale bars*
  - *Use camera positionning data with the GPS exif*
- Simple workflow
  - *Load images & selection*
  - *Image aligment & sparse point cloud computing*
  - *Dense point cloud computing*
  - *Mesh computing*
  - *3D model texturing*
- Possible georeferenced outputs
  - *3D models*
  - *Digital surface model (or DTM if no vegetation)*
  - *Orthophoto*
  - *Surface and volume measurements*
  - *Reports*

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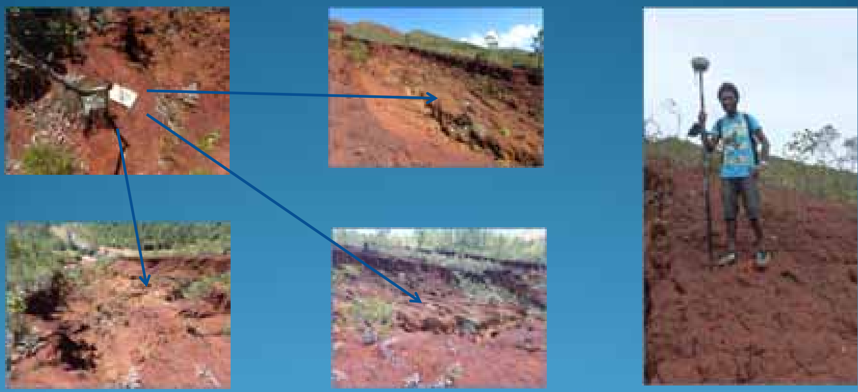
Calibration targets for the UAV tests



Before the flights calibration targets were positioned horizontally to be scanned by the UAV. If unknown, the points coordinates were surveyed with a DGPS. Unfortunately too few calibration targets were available at this time, and the points were quite sparse and not equally distributed

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Equipment - The flying kit

- 1 UAV : DJI F550
  - *Hexacopter*
  - *Gimbal for vertical imaging*
- 1 GoPro Hero 3+ Black Edition camera
  - *Wide angle (F = 2.8 mm / 20 mm eq. 35 mm)*
  - *3000 x 2250 pixels*
  - *Fisheye effect*
- Positionning system for the UAV : GPS, barometer, and iosd
- Option: remove fish eye effect

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Photogrammetry technique can also be applied to UAV remote sensing pictures

The Uav used is a DJI 550 hexacopter with telemetry service IOSD and a Gopro camera with gimbal. Flight time is quite short, 5 to 8 minutes. Altitude reached was 70 m.

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The Tests

- *Few ground target positionned (<10)*
- *1 picture taken every 2 seconds approx*

- 1st test was made with a traditional camera Canon without a gimbal
  - *This gave blurry pictures, because of the copter vibrations, and were not usable.*
- 2d test with the GoPro with the gimbal
  - *Pictures and videos Ok*
  - *No fisheye effect management*
- 3d test with the GoPro the gimbal and a removing of the fisheye effect
  - *Pictures and videos Ok*
  - *The results were correct*

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2nd test

For the second test, the pictures of the Gopro camera had a highest resolution (1920 x 1080) and were uncorrected from the fisheye effect .

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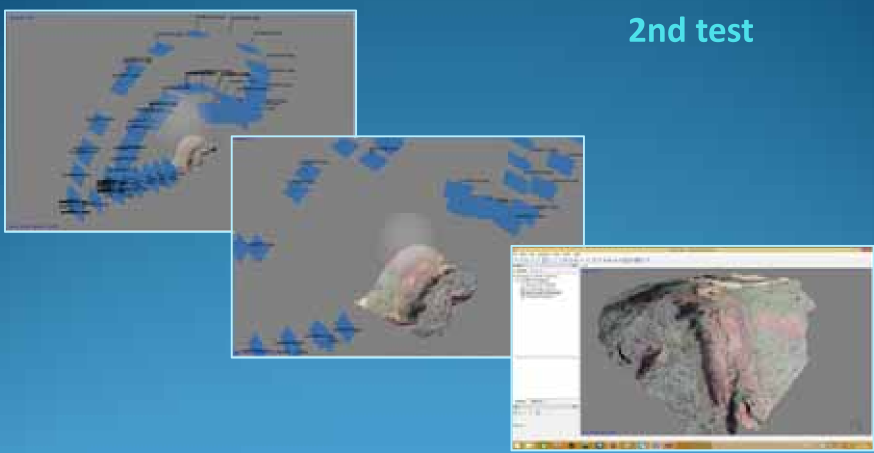
2nd test



The result of uncorrected fisheye effect pictures : images and DEM are very distorted. DEM is rolled over itself like are the pictures.

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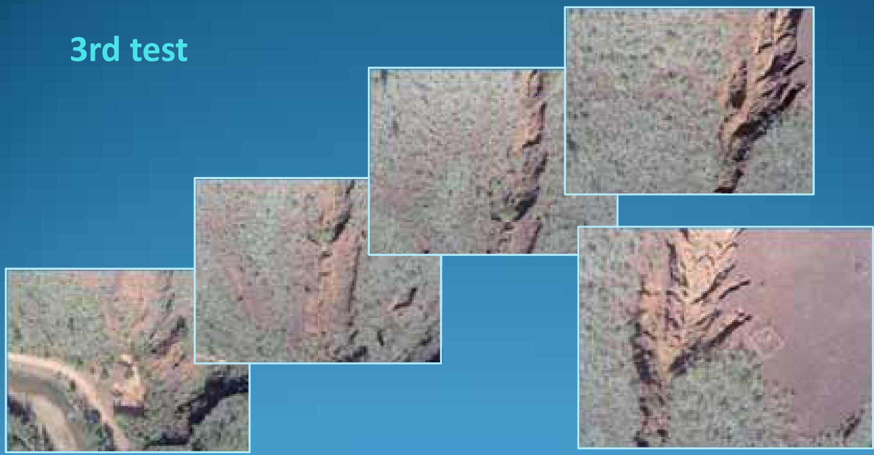
3rd test



For the third test, the pictures of the Gopro camera were corrected from the fisheye effect with a lower resolution (720p). The distorsion is less important and the resolution stay good. Two flights were made this day.

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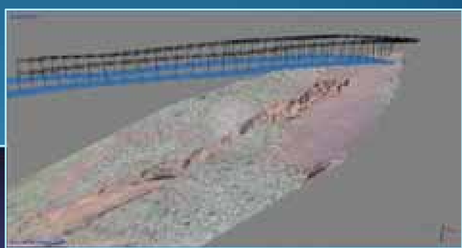
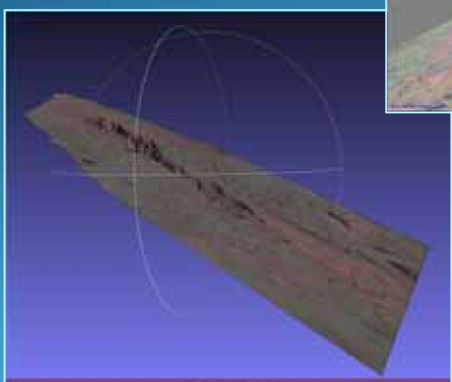
First flight

The first flight was made perpendicularly to the contour lines at an altitude of 70 m.





The consequence of a flight perpendicular to contour lines is a distorsion of the DTM due to the strong variation of scale of the images along the flight path.

If the top of the relief is restituted correctly, the bottom is totally flat with no relief

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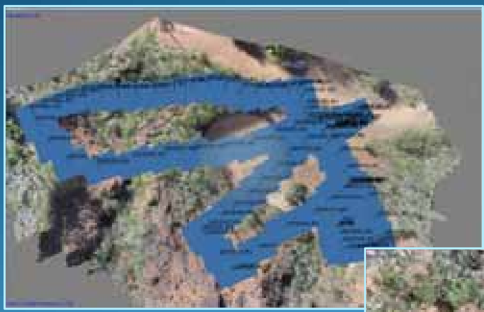

Second flight

The second flight was made at a lesser altitude of 20 to 40 m on the lower part of the gully and the settling ponds.

The DEM doesn't present any distorsion due to a flight path partially parallel to contour lines and due to the variations occurring in the altitudes.

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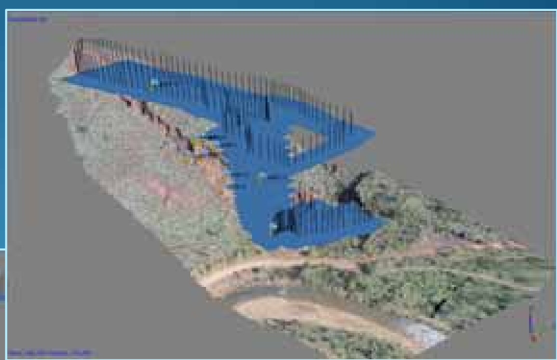
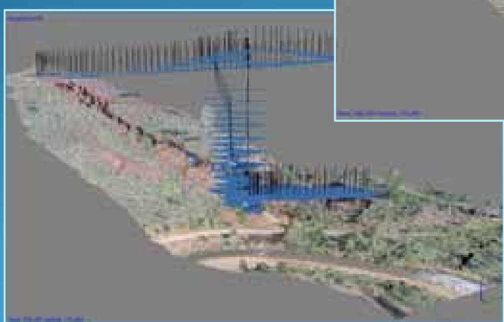
Finally the images of the both flights were mixed to compute the final DEM with Agisoft Photoscan





the morphology was reconstituted normally and the scale variation occuring for the first set of pictures was corrected.

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GCP integration

After building the DEM, coordinates of calibration points obtained by a RTK DGPS survey were integrated in the model to geo-reference the DEM. Then comparisons and morphological analysis became possible due to the high accuracy of the result. (ongoing work …).

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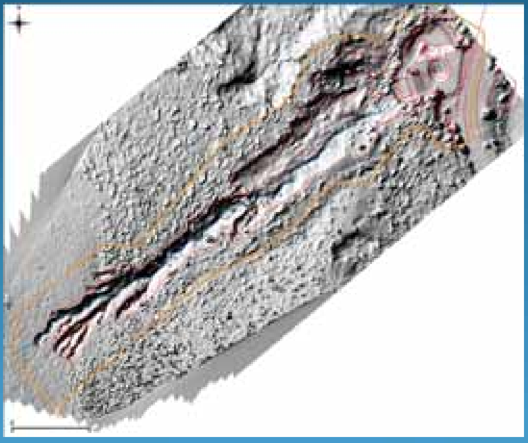

Result DEM was imported in a GIS and compared to previous mapping : for ex: the shadowed digital surface model with a 8 cm mesh. The superposition with previous mapping indicates a good accuracy of the model.

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The orthophoto computed by the software is compared to the previous mapping and indicates also a good accuracy of the result.

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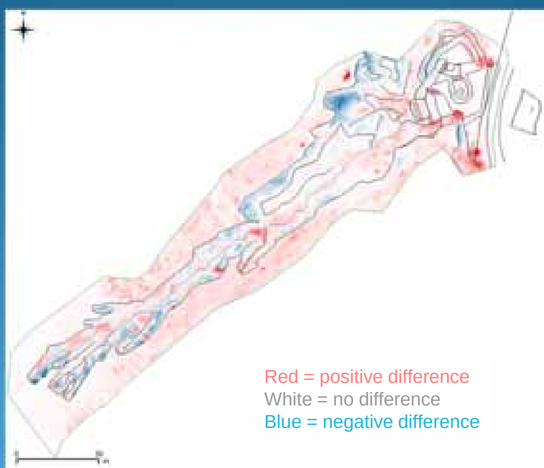
Elevation difference

2015 UAV data
MINUS
2012 DGPS data



A map of the difference in altitude between previous model (2012) and the model made using UAV picture (2015). This suggests a growth of the vegetation off the canyon and an erosion in the gullies and along the cliffs.

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Conclusion – Perspectives – Next step

- These first **results are very convincing** & give us few ideas to improve the acquisition process (shadows, ground targeting)
- This 3D model is only at a middle resolution : a high resolution calculation should improve the quality of the results.
- A low cost uav can produce high resolution remote sensing data on erosion area at **less cost and work**.
- Due to the high resolution imagery this technique present a **serious potential** to allow accurate morphological analysis for erosion figure, fissure patterns, tectonic analysis.
- The accuracy of the results let us expect to estimate the loss of laterite by erosion along time and eventuallity of a displacement of the laterite coverage (slumping, landslide).

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Thank you for your attention


UAV orthophoto

Vinaka – Thank you – Merci – Graccie – Danke

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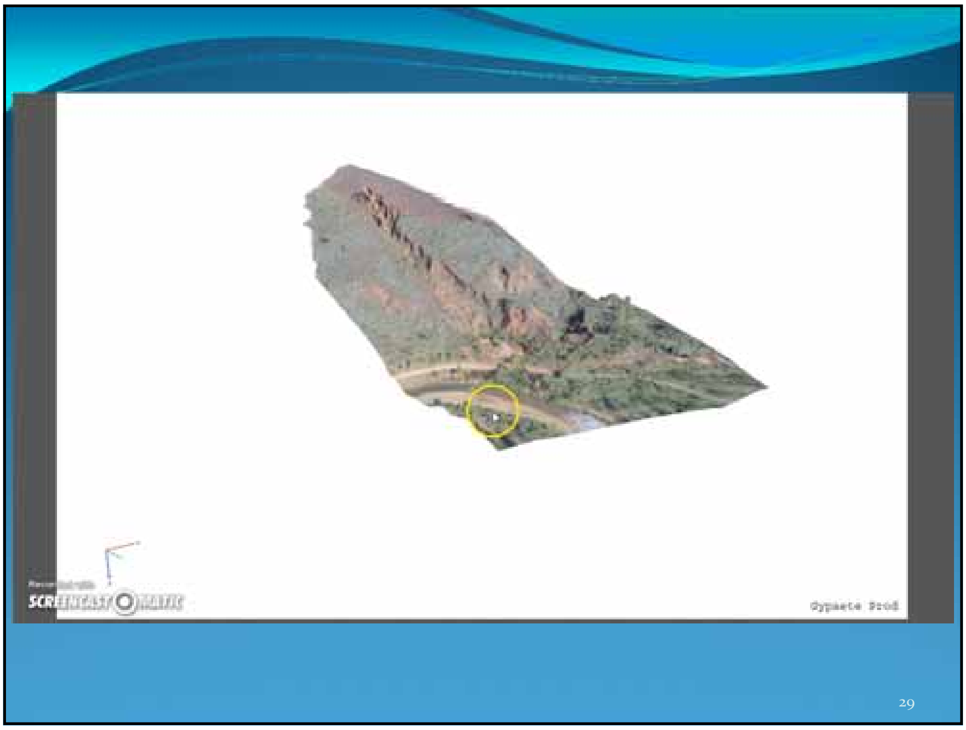
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