ANALYSIS OF EROSION IN AGRICULTURAL LAND USING VERY-HIGH RESOLUTION AIRBORNE IMAGES

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Linear erosion in agricultural land?

- Erosion is a major problem worldwide
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- Soil protection policies: **mapping erosion for efficiency**

Our objectives

Linear erosion is mapped by field surveys

⬆ Economic costs + Time + Error

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Can we assess linear erosion in agriculture with very-high resolution images obtained by drones ?

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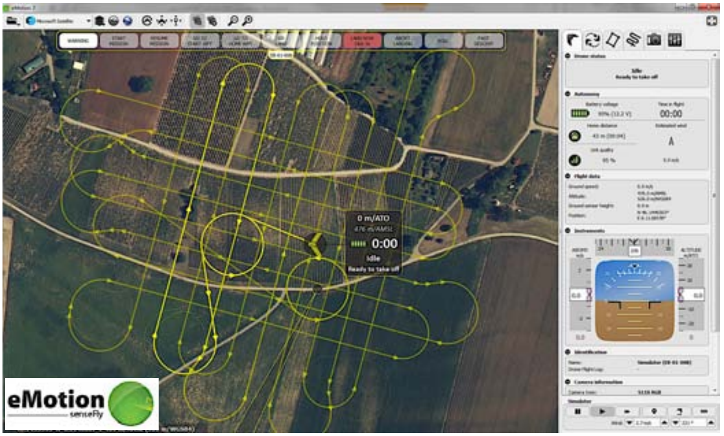
Can we assess linear erosion in agriculture with very-high resolution images obtained by drones ?

- Automatize a methodology for rill detection
- Validation of the modelled rills through field measurements
- Defined limitations of drones in agriculture

⓵ Image acquisition

Creating a flight plan with *eMotion*



Choose the **parameters**

- resolution
- overlap

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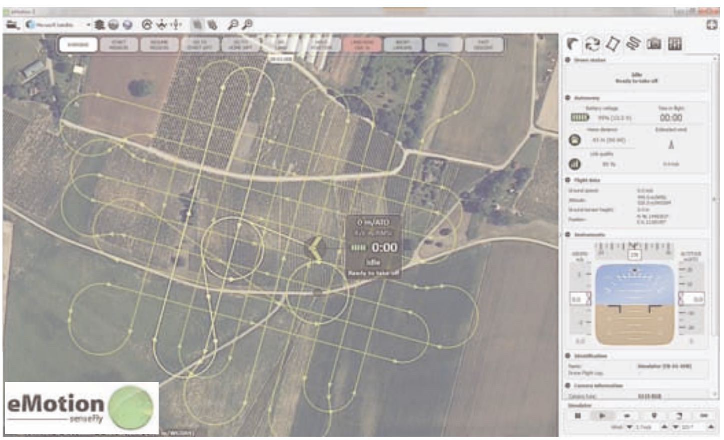
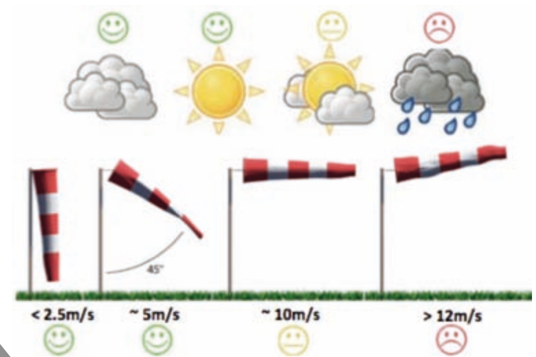


Check weather (wind ≤ 10m/s)



Calibrate white balance for RGB

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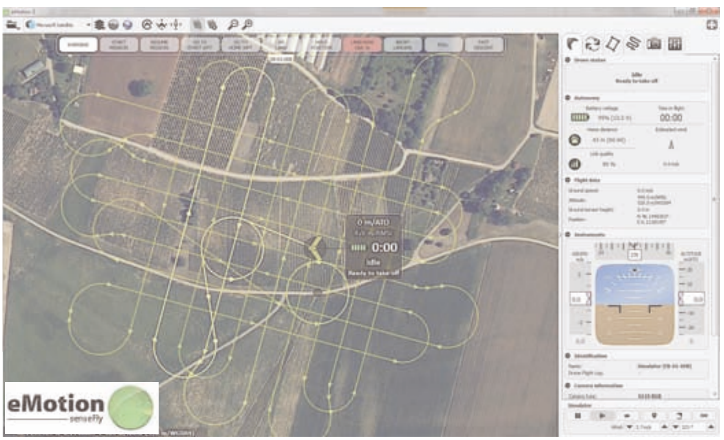

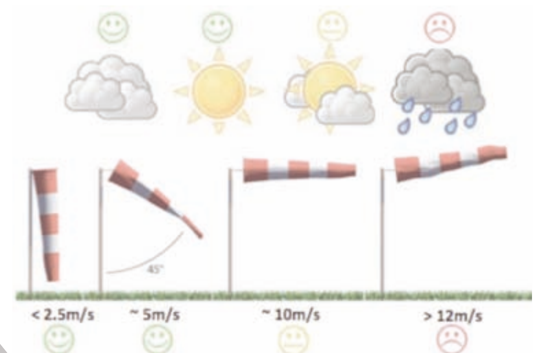

Sensfly ® eBee

Choose the **parameters**

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Calibrate white balance for RGB

① Image acquisition

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Assembly on Pix4D (EPFL, Switzerland)

Georeferenced ortho-mosaic RGB

Generation of a digital surface model (DSM)

Pixel resolution 2.6 – 4 cm

- ☐ Image acquisition
  + Field prospection

Depth measurements at spaced sections

- Image acquisition + Field prospection

② Image pre-processing

Reconstruction of a Pre-erosion DSM

Remove noise

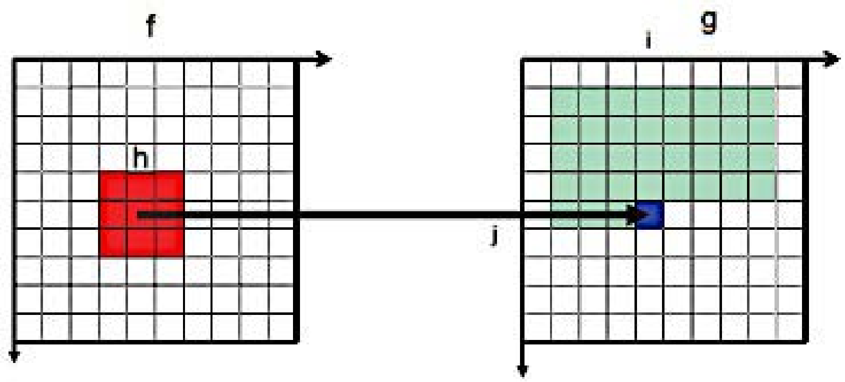
☐ Image acquisition + Field prospection ➔ ② **Image pre-processing**

The basis:

DSM = matrix of altitudes

ortho-photos = matrix of colour intensities in three bands RGB

Spatial filtering with convoluting kernels (with *Scipy libraries in Python*)




```
g(i,j) = f(i-1,j-1)h(0,0) + f(i,j-1)h(1,0) + f(i+1,j-1)h(2,0)
       + f(i-1,j)  h(0,1) + f(i,j)  h(1,1) + f(i+1,j)  h(2,1)
       + f(i-1,j+1)h(0,2) + f(i,j+1)h(1,2) + f(i+1,j+1)h(2,2)
```

□ Image acquisition + Field prospection → □ Image pre-processing → ③ **Detection of rills**

Image segmentation

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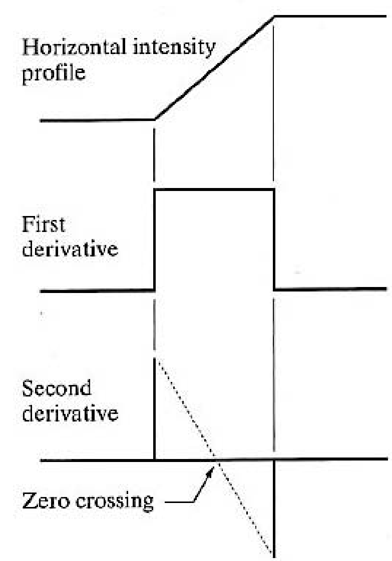
Image segmentation

Edge detection on elevation data or colour intensities

$$\begin{matrix} t_{(1,1)} & .. \; t_{(1,j)} & ... \; t_{(1,n)} \\ t_{(i,1)} & t_{(i,j)} & t_{(1,n)} \\ t_{(m,1)} & .. \; t_{(m,j)} & ... \; t_{(m,n)} \end{matrix} \star \begin{matrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{matrix} \Rightarrow \begin{matrix} g_{(1,1)} & .. \; g_{(1,j)} & .. \; g_{(1,n)} \\ g_{(i,1)} & g_{(i,j)} & g_{(1,n)} \\ t_{(m,1)} & .. \; g_{(m,j)} & .. \; g_{(m,n)} \end{matrix}$$



Perennial culture: the vineyard example

Annual culture: winter crops

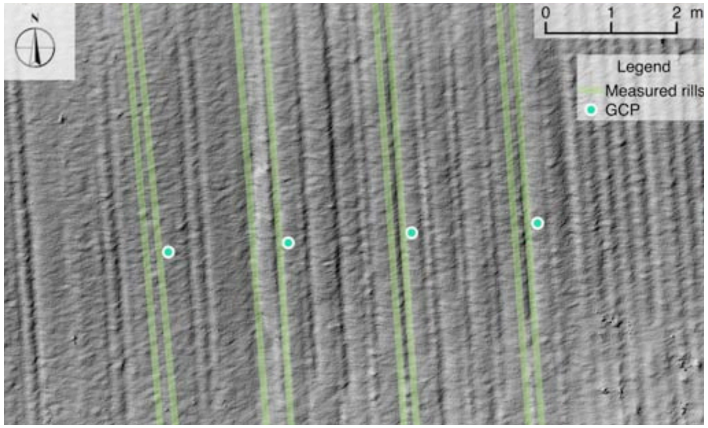
Ortho-photo

Pixel resolution 2.6 cm

Results – The vineyard example

Original DSM on Erosion Zone 1

Hillshade



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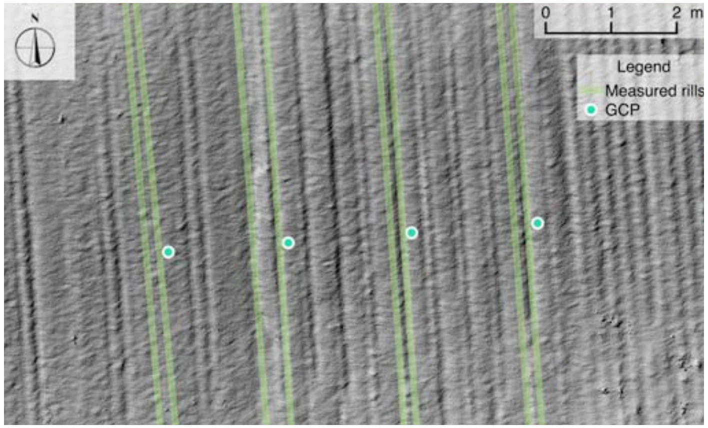
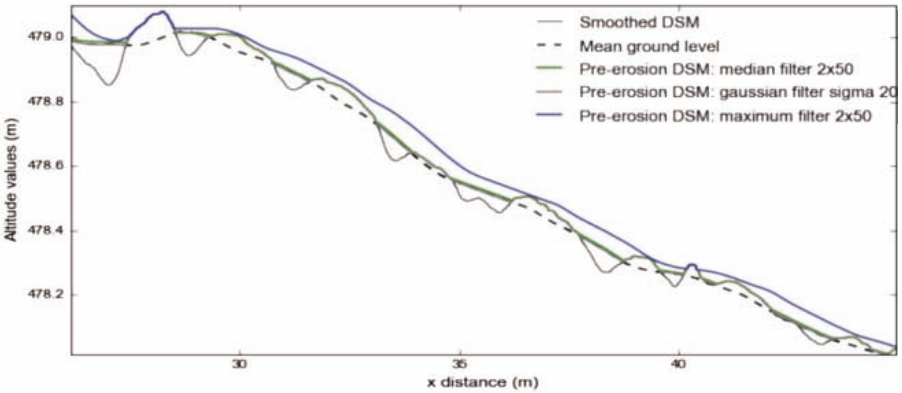


☐ Pre-erosion model

DSM smoothing with average filter of size 100x100



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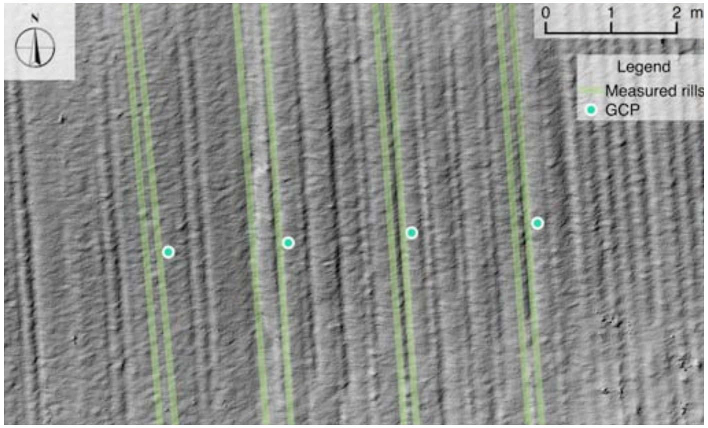

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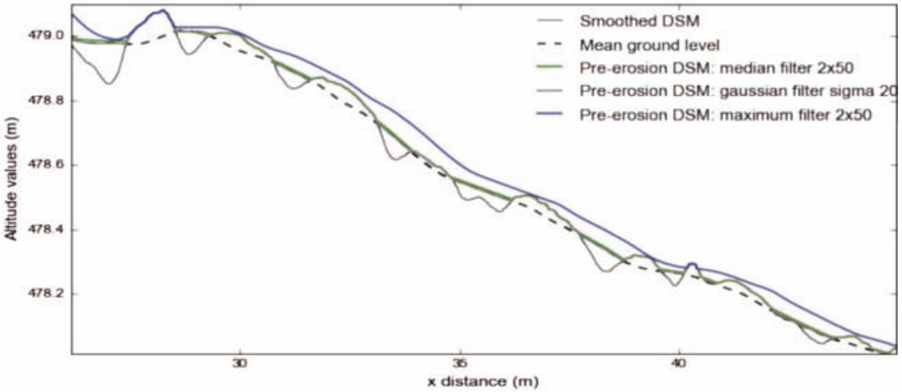
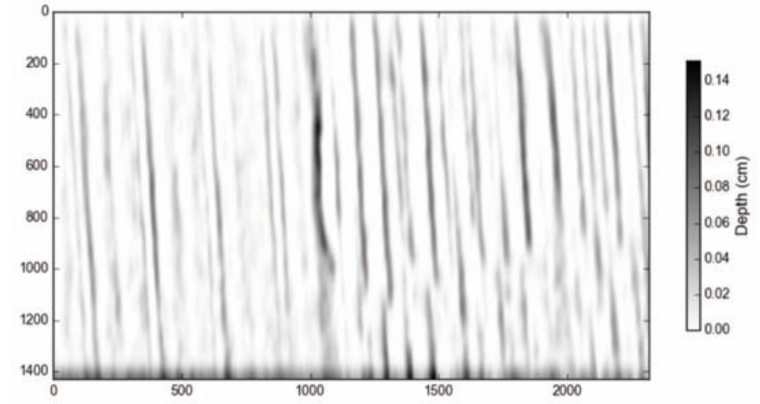


Differential Depth Model

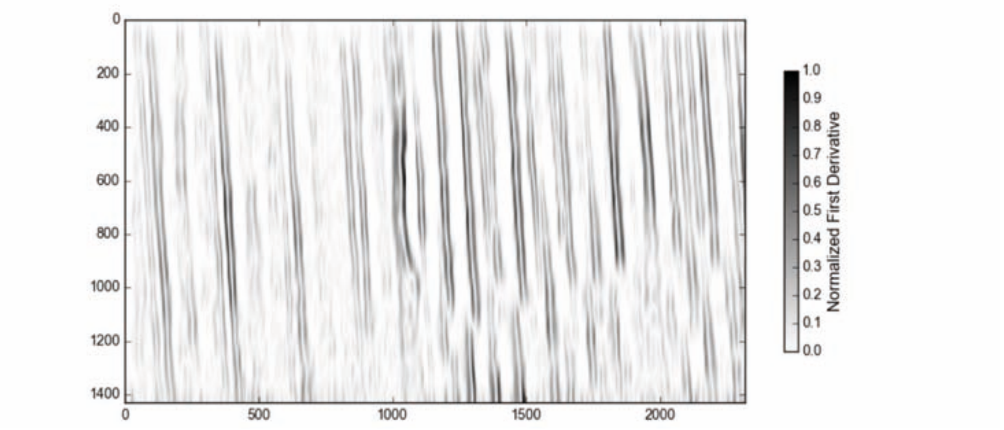
Pre-erosion DSM – actual DSM



Results – The vineyard example

- Gradient model

Derivative on the x-axis



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□ Gradient model

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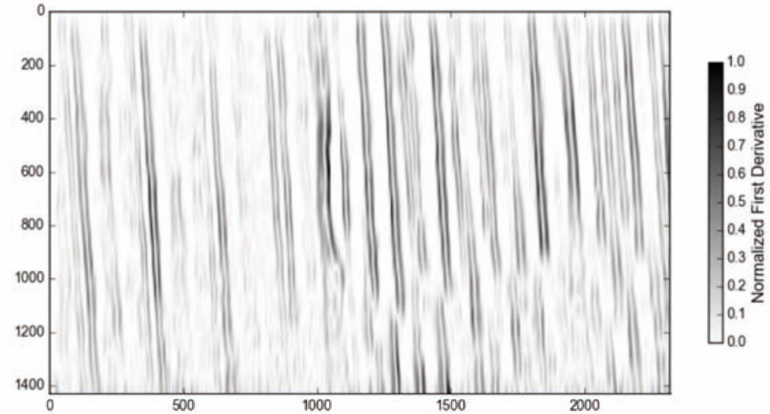
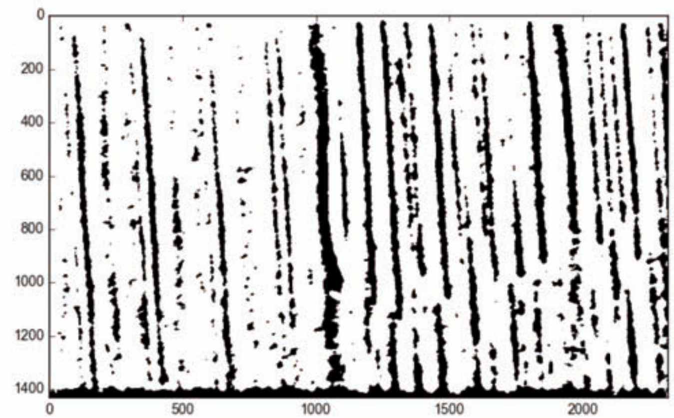


Potential rills detection

Thresholding on gradient and depth



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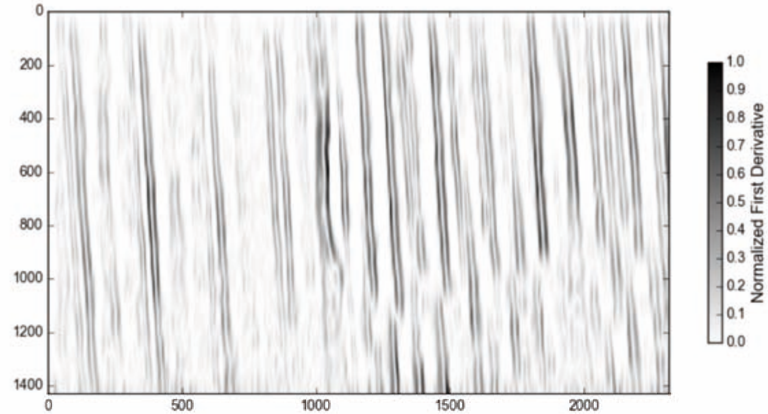

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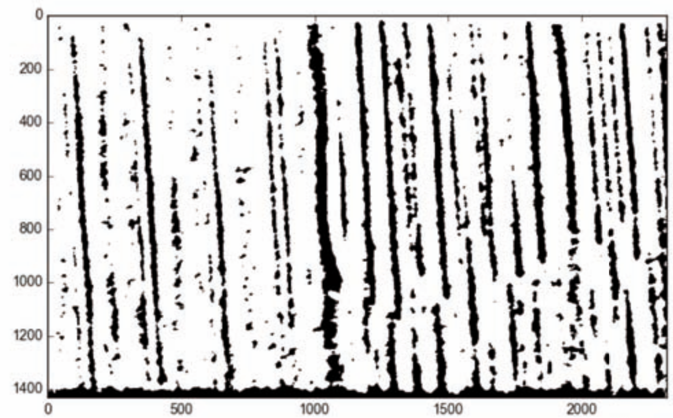
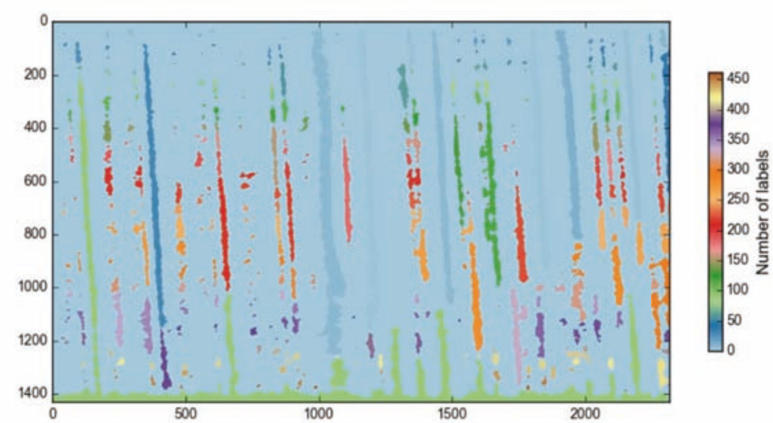


Automatic location of rills

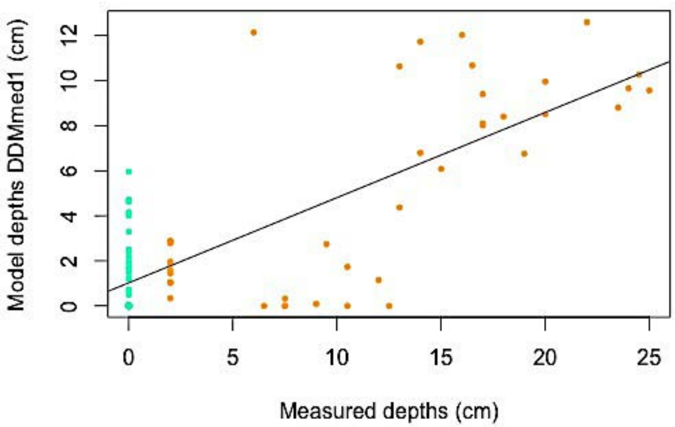
Labelling

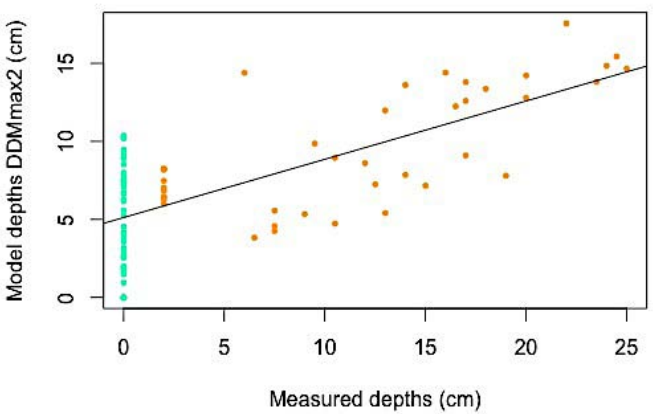


Results – The vineyard example

Validation of the constructed DDM

Manually digitized polygons
Field depths – actual DSM





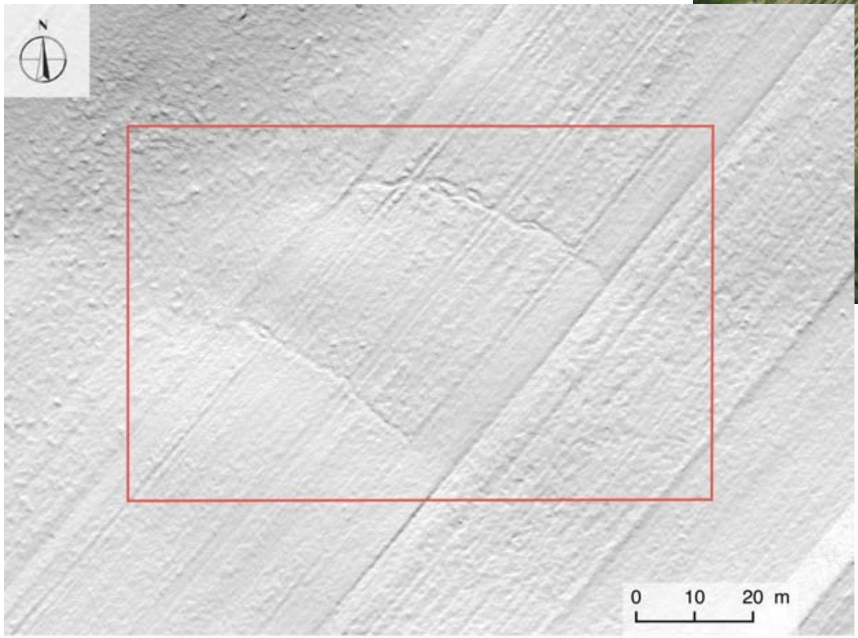
Significant difference depths rill vs. no-rill (p Kruskal-Wallis <0.05)

Validation of the detected rills

Chi-squared test p<0.05

Results – Winter crops with vegetal cover

Ortho-photo of the area



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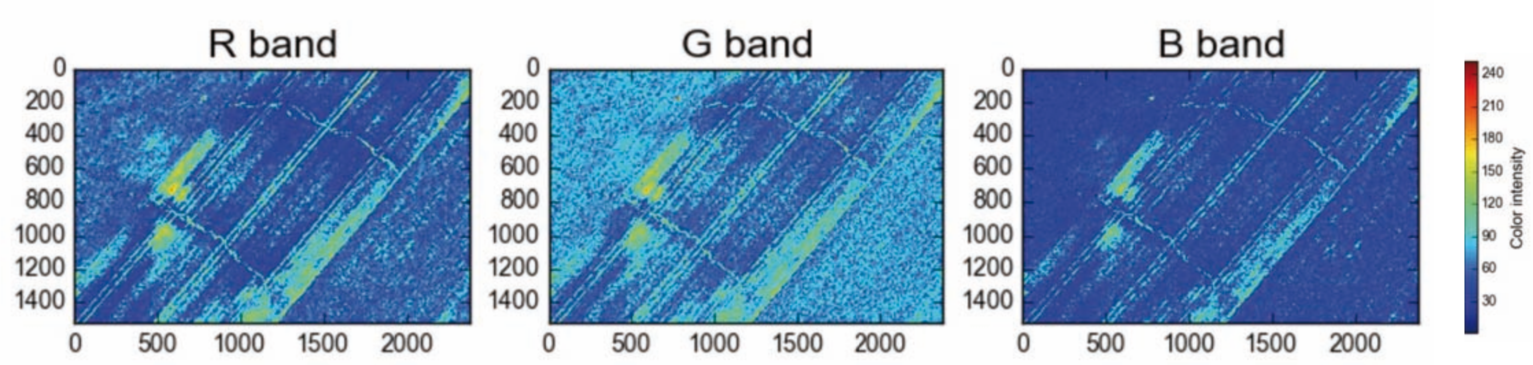
Hillshade

Pixel resolution 4.0 cm

Results – Winter crops with vegetal cover

Colour intensities vegetation – nudity



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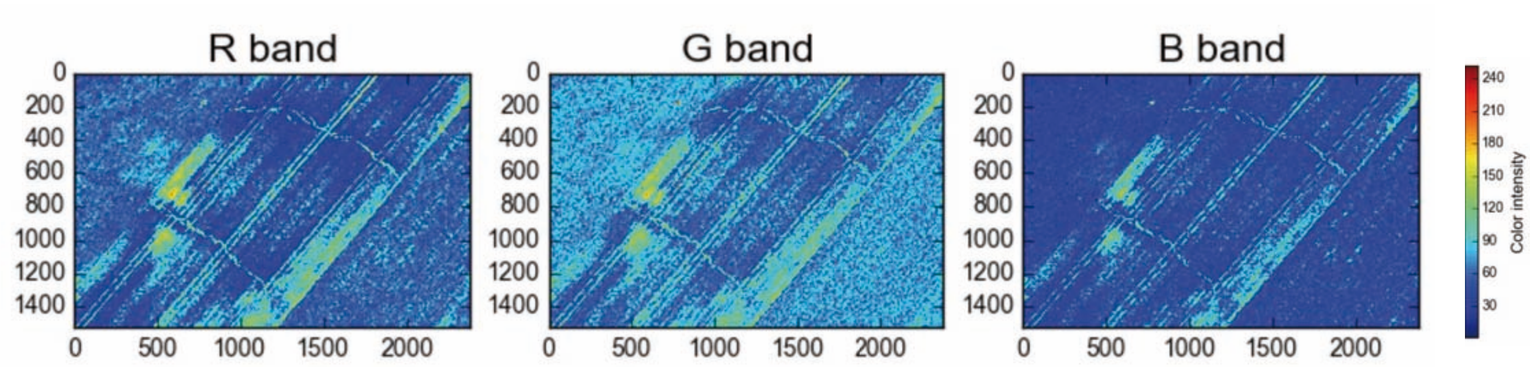
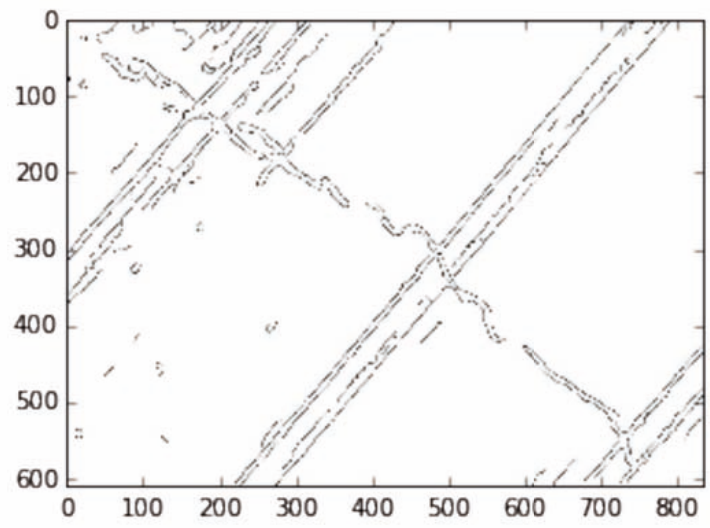


Potential rills

Zero crossing edge detection on 1 band



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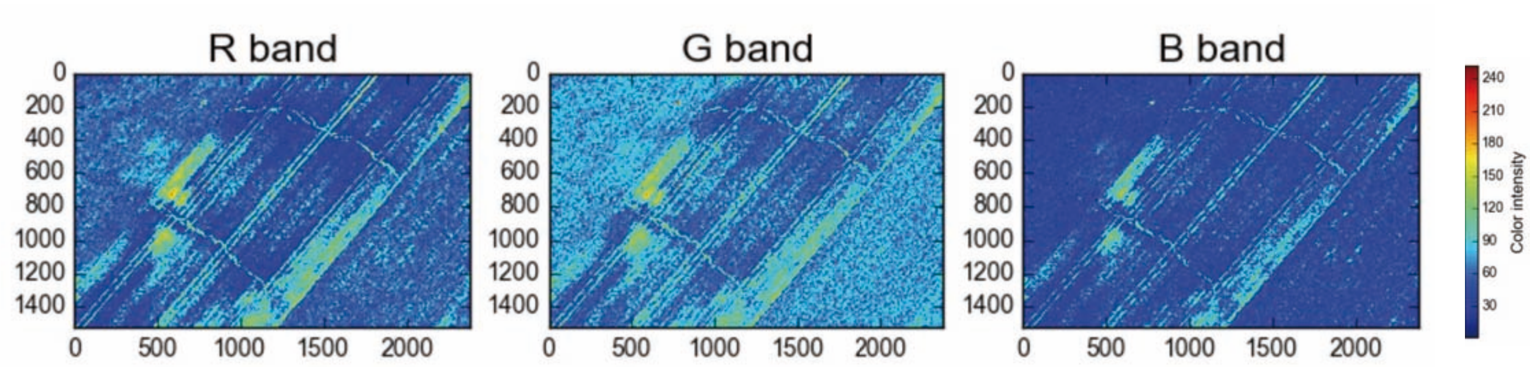

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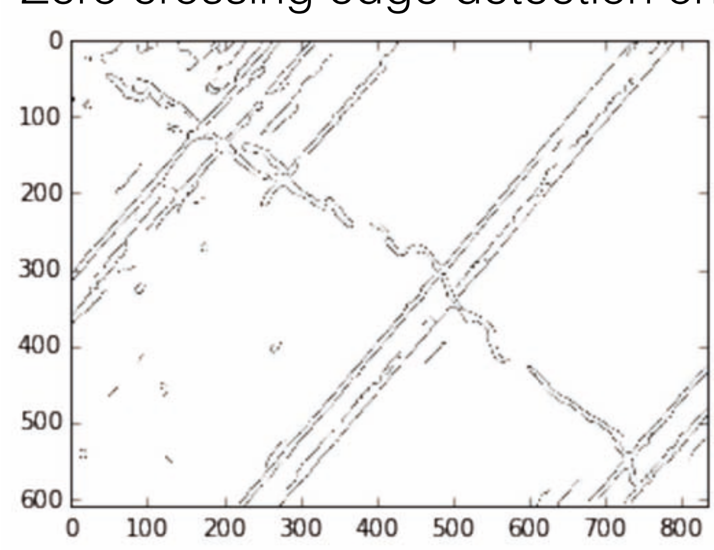
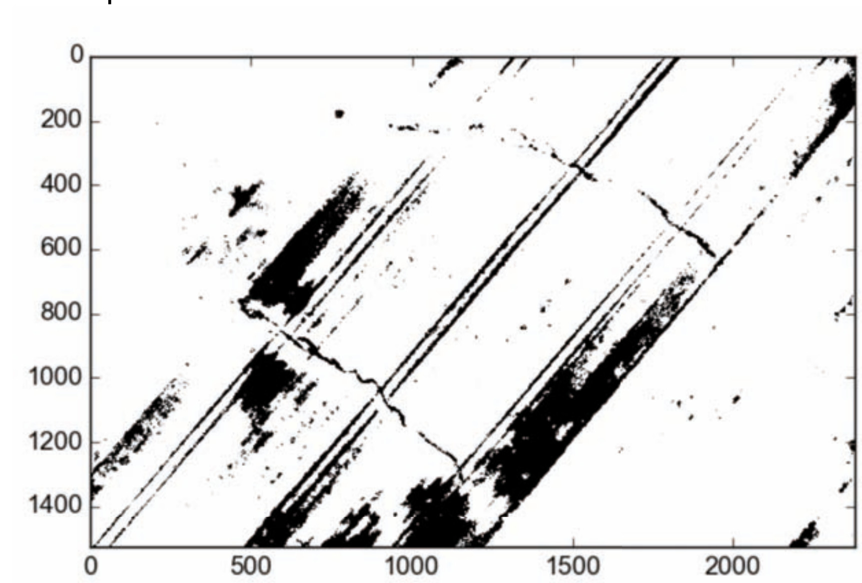


Supervised classification on 3 bands



Conclusions

Very-high resolution material obtained by drones:

- Great flexibility of analysis
- Detect the micro-relief in agricultural context
- Calculate depths correlated with field data
- Automatically detect location of rills

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- Aerial surveys limited by weather
- Need of pre-processing to adjust scale of details
- Large size of files: computing capacities

What comes next?

- Optimize image pre-processing
- Automatize spatial scale filtering: no arbitrary thresholds
- Promote computer learning: adapt to rill variability
- Maximum exploitation of field data for methodological validation
- Calculation of erosion volume
- **Simple erosion assessment for prevention practices**

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Thank you!
Moltes gràcies!

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