Detection of forest canopy gaps with LiDAR: a regeneration perspective

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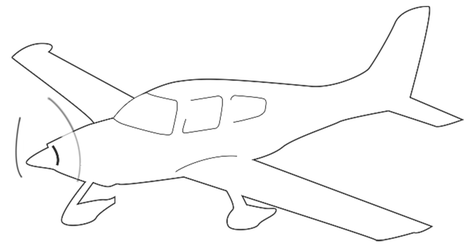
Context & Objectives



Forest canopy gaps are suitable for recruitment of tree species because of light availability. Mapping and charactering canopy gaps is a complex issue. As an active sensor, LiDAR tackles the problems of shadows and penetration into the canopy. We investigate several methods to map canopy gaps from LiDAR data. A validation is done to control the quality of the gap detection and to compare the different map versions.

Material & Methods

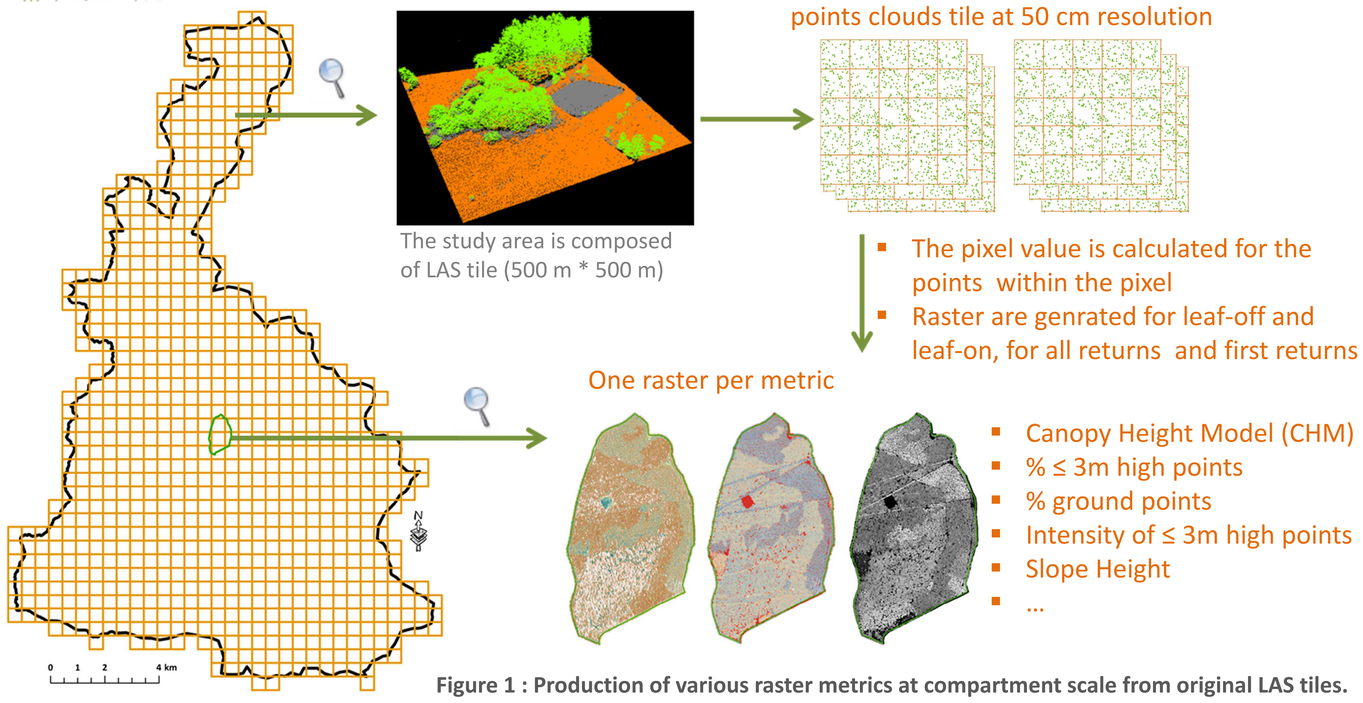


Figure 1 : Production of various raster metrics at compartment scale from original LAS tiles.

- Leaf-off and leaf-on LiDAR high density data are used to detect canopy gaps. We work with height and "canopy porosity" metrics.
- These rasters metrics are generated for all returns and for first return only. In a mapping objective, metrics are produced at the compartment scale by merging the rasters created from the original tiles (Figure 1).
- Thresholding and image segmentation produce several maps of canopy gaps which are analysed and compared with confusion matrix (Figure 2).
- We create a systematic grid (50m*50m) to collect reference data on the field for the mapping validation. For each point, we note whether we were in a gap or not. A gap is defined as an opened cover area with a minimim extent of 200m² and a maximum vegetation height of 3m.

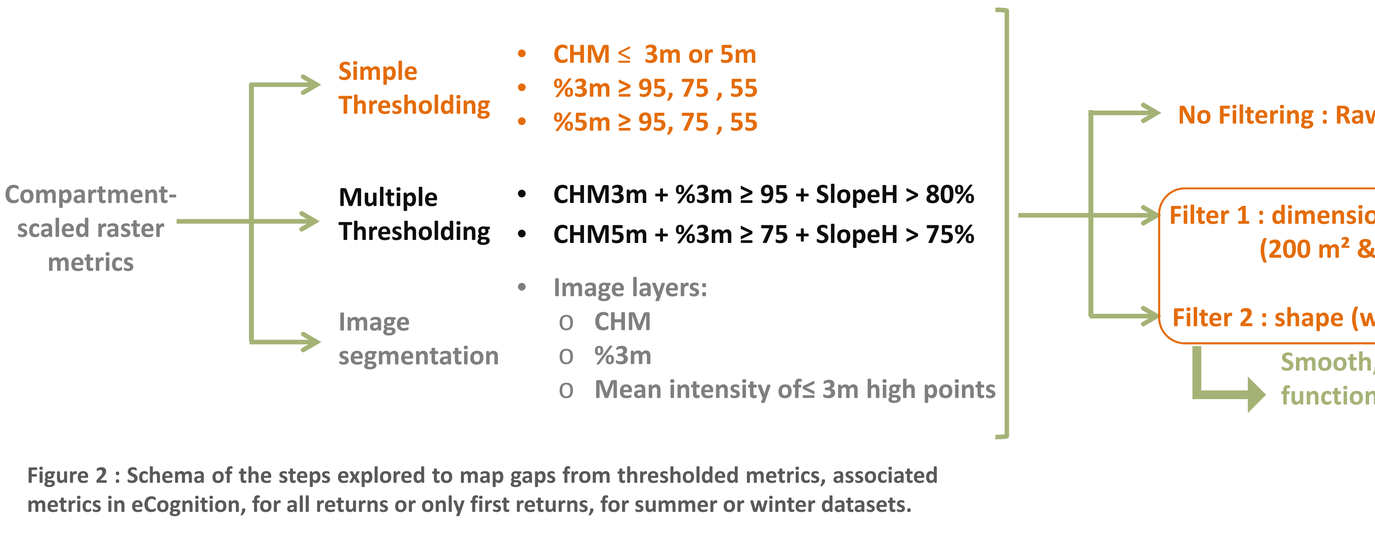


Figure 2 : Schema of the steps explored to map gaps from thresholded metrics, associated metrics in eCognition, for all returns or only first returns, for summer or winter datasets.

Gap detection	% NBP 3m ≥ 75 First returns Filter 2	eCognition All returns Filter 1
Producer accuracy (%)	60.3	85.1
Consumer accuracy (%)	75.7	62.6

Figure 3 : Results precisions of 2 different map versions (eCognition & threshold)

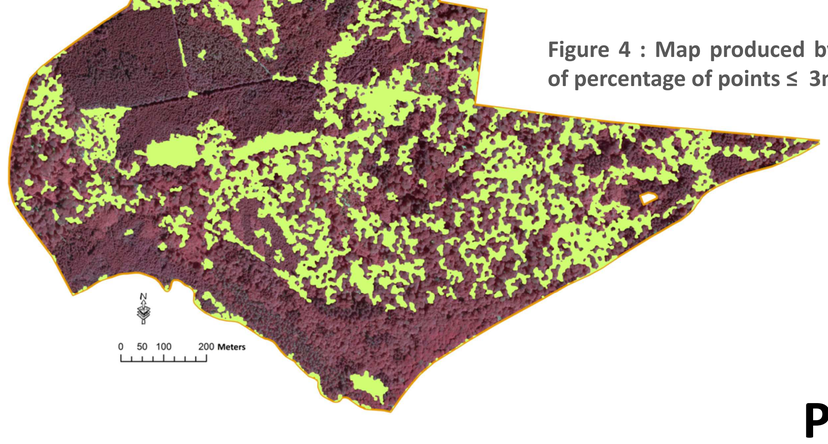


Figure 4 : Map produced by simple thresholding of percentage of points ≤ 3m high ≥ 75%.

Results

- To our knowledge, LiDAR is the best existing remote sensing tool for mapping forest canopy gaps.
- Global precision are good (69% – 86%), significantly higher for leaf-off. However, our good global precisions are due to a majority presence of forest stands (75%), well discriminated, especially by height criteria.
- Leaf-off data produce lower omission error than leaf-on. Same trend is observed but less pronounced for comission error. The lower omission errors are obtained with eCognition process (Figure 3).
- Comission errors, namely areas identified as gaps but which are not, result from confusion with forest roads and meadows.
- Field data collect & LiDAR data have an interval of one growing season.
- Omission errors are important. One explanation is the estimation inaccuracy of the surface and the vegetation height. In addition, the applied filters are perhaps too strong. We see an increasing omission error for raw → filter 2 → filter 1.
- In conclusion, though some improvements are needed our results are very promising (Figure 4).

Perspectives

- The consideration of forest parcels shapefile would be useful to decrease the comission error (elimination of roads).
- A validation of the gap cartography is in progress (with dGPS and electronic compass) for analyzing the quality of the gap's delimitation.
- After the cartography step, we will focus on gap characterization to assess the regeneration quality.
- The canopy gap will be described with dimensions & shape, vegetation cover, the surrounding stand. Ancillary data as altitude, slope, aspect, soil,… could enhance the dataset.
- Especially, hemispherical photographs would be interesting complementary data to link regeneration and light conditions.
- The choice of relevant field data to assess the regeneration quality is a key issue.