Characterizing vegetation structure is essential for studying light distribution and air flow regime within agroforestry plots. Canopy heights and foliage density notably stand as key variables and should be described at both the internal and at the landscape scale.

The recent development of unmanned aerial vehicles (UAVs) and the miniaturization of devices for the acquisition of georeferenced images have open new possibilities for remote sensing applications that we intend to test here.

A generic methodology is proposed for describing vegetation structure of agroforestry plots using very high resolution stereoscopic visible and near-infrared images acquired through UAV flights.

### Material

Three agroforestry vineyards were selected in Southern France in order to sample diverse contexts of vegetation structure. At each site, flights were performed in July and August 2016 using a polypropylene flying wing – elbee® from Sensel. Two sensors were successively used: a RGB (Red-Green-Blue) digital camera and a four bands multispectral sensor. Flight trajectories and altitudes were set in order to generate at least 5 overlapping images.

### Methods

#### Step 1: Land cover mapping

1. Computation of the difference index (DGI) and the green percentage index (GPI) according to Poblete-Echiverri et al. (2017);
2. Supervised classification by training a Random Forest (Breiman 2001);
3. Post-processing:
   (i) masking of the limits of plots for re-attributing grapevine /tree classes;
   (ii) and majority filtering applied specifically to the vine class so that only grapevine pixels being connected to other grapevine-pixels are retained.

Tools: Python script calling the Orfeo Toolbox (OTB) (ENES 2018) and Geospatial Data Abstraction Library (GDAL) (GDAL/OGR contributors 2018).

#### Step 2: Vegetation height mapping

Vegetation height is mapped by subtracting a Digital Terrain Model (DTM) to the Digital Surface Model (DSM). Two methods are compared:
- the filtered DSM method from Zarco-Tejada et al. (2014): only requires a high resolution DSM; $H_{\text{vegetation}} = \text{DSM}_m - \text{DSM}_b$;
- vs. a DTM-DSM method: requires a high resolution DSM and the corresponding land occupation map. $H_{\text{vegetation}} = \text{DSM}_m - \text{DTM}_m$.

Implementation of the filtered DSM method adapted from Zarco-Tejada et al. (2014) and of the DTM-DSM method for mapping vegetation height is shown in the flowchart.

### Conclusions and perspectives

The overall approach opens many potential applications for computing vegetation metric such as vegetation 3D density. In addition, the newly proposed ‘DSM- DTM’ method is highly recommended for pixel-by-pixel applications. The land cover mapping method could gain both accuracy and reproducibility considering only the images from the RGB sensor: indeed, testing a two-step classification with RGB bands then DTM-DSM shows promising results for mapping foliage gaps more accurately.