

## Cooinformation and Earth Observation

## Mapping and monitoring tropical plantations by remote sensing

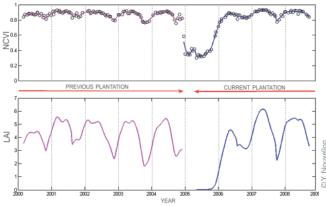
The productivity of planted tropical ecosystems must be increased in the long term, while avoiding negative impacts on the environment, in order to meet growing market needs. Environmental and climatic conditions as well as current and previous cropping practices could, however, have a major lasting impact on the evolution of biophysical and biogeochemical components of planted tropical ecosystems. It is essential to quantify these factors.

The CIRAD internal research unit (UPR) Functioning and Management of Tree-Based Planted Ecosystems focuses research on characterizing and formalizing water, carbon and mineral cycling within tropical plantations. An ecosystem-based approach is implemented to gain insight into the relevant plant-soil-climate interactions.

Satellite imaging is an efficient tool for spatiotemporal monitoring of plantations. Specific sensors with suitable spatial, temporal and spectral properties are required for studying particular ecosystem features. The satellite information collected cannot be used without processing, i.e. different treatments involving geographic information systems (GIS) and complex models are required.

Some structural and physiological characteristics of plantations that can be estimated via satellite imaging are:

- leaf-area index (quantity of leaves on the plantation)
- vegetation biomass
- chlorophyll content
- productivity.



▲ Use of a satellite signal (NDVI, black circles) to estimate leaf-area index (LAI) patterns on a eucalyptus plot in Brazil.

Annual declines correspond to dry season leaf shedding.

These characteristics can then be analysed spatially (differences between plots) and/or temporally (plot changes over time). For instance, information on temporal changes in the leaf-area index in plantation stands can reveal the duration and intensity of water stress (see above graph). Spatial information can highlight differences in fertility or the water storage capacity of the soil during the dry season

All of this information can then be used to fit ecosystem functioning models on a plot scale or for a set of plots. These models can be implemented, for instance, to assess the sustainability of carbon or mineral stocks in plantations.

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## Lidar mapping of vegetation, landscape and surface water



▲ Left: panoramic photograph; Right: 3D point cloud obtained by terrestrial lidar.

Lidar (light detection and ranging) technology involves an active remote sensing sensor based on a laser impulse transmission-reception principle. Lidar, which is conventionally used in topometry and meteorology, shows promise for characterizing continental and oceanic surfaces, especially from aerospace platforms. As lidar is capable of penetrating into environments such as water and vegetation, the information it generates can supplement other information obtained by radar and optical imaging. Signals from lidar sensors are processed on the basis of telemetry principles. This can generate accurate topographical data on natural environments, submerged or slightly submerged areas, along with a 3D description of the vegetation structure. A more complete form of the backscattered signal (a highly sampled waveform) can also be processed using suitable signal processing algorithms. Other target

properties can then be extracted depending on the wavelengths used, e.g. the geometry and nature of the target (water turbidity, local slope, vegetation density, etc.).

Research carried out by UMR TETIS, LISAH and AMAP is focused on three thematic fields: vegetation characterization, hydrology and fine topography. The aim is to develop specific methods for processing lidar waveforms and lidar derived 3D point clouds and to qualify the data. Lidar signal modelling studies are also conducted in collaboration with CNES and commercial stakeholders to determine the specifications of sensors for future space missions. For vegetation studies, biomass is assessed and canopy and understorey structures are characterized since such information is crucial for sustainable management of forest environments (forest fires, biodiversity). In hydrology, altimetric monitoring and bathymetric assessment of continental waters are carried out to improve management of water resources and aquatic environments. Another aim is to make effective use of detailed descriptions of areas imaged by airborne topographical lidar (dams, drainage systems) in order to improve descriptions of surface flows and to predict associated risks such as erosion.