Institut de Recherche en Sciences et Technologies pour l'Environnement et l'Agriculture

STAGE 2017

Mapping vegetation properties in heterogeneous canopies using imaging spectroscopy: contribution of radiative transfer modeling for the study of the influence of vertical heterogeneity of foliage on the canopy reflectance of tropical forests.

Structure hosting the internship:

Irstea is a French public research institute focusing on major issues of responsible agriculture and sustainable land use planning, water management and associated risks, drought, floods, flooding, the study of complex ecosystems of biodiversity in their interrelationship with human activities.

Context:

Global monitoring of the state of tropical ecosystems is a priority for decades to come in the context of an accelerated erosion of biodiversity, due to many environmental and climatic factors associated with human activity. Remote sensing allows for the temporal monitoring of these environments characterized by poor accessibility, and represents a high potential tool for monitoring the rainforests from local to global scale.

- From a methodological perspective, studies at the local scale demonstrated the possibility to finely characterize the foliar chemistry and to map biodiversity [1]–[3].
- From an instrumental perspective, the development of new sensors (Sentinel- 2, EnMap ...) requires to study the feasibility of adapting to a wider geographical scale the existing methods already developed and validated only at local scale [4].

Beyond the promising results obtained from experimental data, a clear understanding of the factors influencing the spectral response measured by a top canopy sensor is necessary in order to i) optimize and improve the methods and tools available for the study of these complex environments, and ii) define instrumental and environmental limitations . This step is particularly necessary for the dimensioning and the definition of the specifications of the future satellite sensors developed by the governmental space agencies and industrial partners.

This analysis of the signal and its interpretation in terms of the relative contribution of the various factors (foliar chemistry, 3D structure, acquisition conditions ...) requires the use of a database encompassing a wide variety for each of these factors, which is impossible to acquire experimentally. For this reason, approaches based on three-dimensional radiative transfer modeling are particularly suitable for the study of complex media. 3D models such as the DART model [5] allow simulating remote sensing images from a detailed representation of a scene, in this case a rainforest canopy.

The HyperTropik project, funded by the TOSCA group of the French Space Agency (CNES), aims to continue the development of a modeling platform for testing performance of existing methods for mapping of biodiversity and ecosystem function when applied to data acquired with current and forthcoming sensors, in relation to instrumental and environmental factors. This modeling platform has been partly developed, in particular for the simulation of LiDAR instrument. This project particularly focuses on the hyperspectral sensor project HYPXIM developed by CNES. This internship is funded by the TOSCA as part of this project.

Several field data collection campaigns were done in the frame of the HyperTropik project (field spectroscopy, terrestrial LiDAR, atmospheric properties ...), as well as an airborne acquisition campaign including imaging spectroscopy and LiDAR in 2016. This comprehensive data collection will enable detailed 3D modeling of forest plots documented in French Guyana as well as a validation of the simulations carried out with DART.

The first step is to better understand and quantify the influence of the vertical heterogeneity of vegetation cover on the measured signal. This information is useful in several respects because it provides information on:

- the potential of remote sensing data for the fine monitoring of variations in canopy cover induced by phenology and environmental disturbances
- the definition of the requirements in terms of field information for the 3D representation of complex environments to generate realistic simulations.

This preliminary analysis prepares for a more comprehensive sensitivity analysis focusing on biodiversity mapping using satellite imagery. Following this internship, the student will start a PhD program and join the scientific consortium built during HyperTropik. The goal of the PhD project is to prepare the development of a methodological framework for tropical biodiversity mapping using satellite imagery and to study the possibility of a methodological transfer to the Theia Land Data Center. This work will be based on imagery acquired by the Sentinel constellation of the Copernicus Program (ESA).

Work expected from the intern:

During the first part of the internship, the student will explore different tools integrated in the simulation platform developed in Python, in order to use, develop and adapt them according to the requirements for the simulation of forest canopy. This work will involve handling and integrating various types of data, including structural and radiometric descriptors from field data. The trainee will familiarize with the tools (DART model, simulation platform), as well as the different types of data available (spectroscopy, imaging spectroscopy, LiDAR), under multidisciplinary scientific supervision. The objective of this first part is to prepare for the development of a processing chain simulating vertical gradients of chemical and structural properties of vegetation.

During the second part of the internship, the student will develop the processing chain and perform a sensitivity study to analyze the influence of vertical heterogeneity on the canopy reflectance. The analysis of the results obtained will be carried out in order to conclude on the sensitivity of the signal to the vertical chemical gradients and to the foliar demography, which represent a strong interest for ecologists.

At the end of this internship, the results will help specifying the level of detail to be adopted in order to simulate complex forest environments in a realistic way. This will allow optimizing protocols for field data collection, and will contribute to the improved documentation of the simulation platform. This wok will also prepare the sensitivity studies to be developed for the evaluation of the potential of different sensors for tropical biodiversity mapping and characterization of foliar traits.

Specifically, this will involve:

- **Learning how to use and develop the modeling platform: DART model and development in Python**
- **Developing and documenting a protocol to integrate field data and study the influence of vertical gradients of leaf chemistry on the signal reflected by vegetation across the solar spectral domain.**
- **Applying the protocol to different types of vegetation of varying complexity, from eucalyptus plantation to tropical rainforest, based on data acquired in the field.**
- **Analyzing results from simulations and preparing the next simulations for the development of methods of mapping tropical biodiversity.**
- **Working in close collaboration with specialists in remote sensing, physical modeling, image analysis, and ecology in order to extract relevant information about vegetation properties in complex ecosystems**

The intern will be supervised by a researcher from IRSTEA. A part of working time is left to the student for writing the internship report.

Le ou la stagiaire sera encadré(e) par un chargé de recherche IRSTEA. Regular exchanges will be made with the scientific team of the CESBIO (physical modeling with DART) and the UMR AMAP (development of the simulation platform). A part of the working time will be left to the trainee for the writing of his Master's thesis.

This internship forms part of a project on longer term, and will ideally continue in the frame of a PhD project during 3 years. Funds will be guaranteed during this 3 years period.

Profile:

- Master 2 student or engineer in remote sensing / image processing, with skills and interest for physics and ecology.
- Programing skills (python, R)
- Ability to work in interdisciplinary environment and to organize and perform field data collection.
- Ability to write, read and speak good scientific english (literature review, scientific reports and redaction of international publications)

Duration:

Internship for Master 2 : 6 months between February-March and August-September 2017.

Interest of the internship for the student:

Contribute to the work done within the framework of the preparation of the hyperspectral satellite mission HYPXIM, and for the processing of the Sentinel -2 satellite data. Applied research and development that will require numerous contacts with research partners on the site and at national level (Labex CEBA, Cesbio , CNES , CNRS).

Opportunity to continue the internship with a PhD.

Location:

IRSTEA Montpellier

UMR TETIS, maison de la télédétection

Agropolis, 500, rue JF. Breton, 34093 Montpellier.

Contact & informations:

Jean-Baptiste Féret - IRSTEA (04.67.54.87.49).

email: jb.feret@teledetection.fr

Allowance: ~ 500 €/mois

References:

[1] J.-B. Féret and G. P. Asner, "Mapping tropical forest canopy diversity using high-fidelity imaging spectroscopy," *Ecological Applications*, vol. 24, no. 6, pp. 1289–1296, Sep. 2014.

[2] G. Vaglio Laurin *et al.*, "Biodiversity Mapping in a Tropical West African Forest with Airborne Hyperspectral Data," *PLoS ONE*, vol. 9, no. 6, p. e97910, Jun. 2014.

[3] G. P. Asner, R. E. Martin, C. B. Anderson, and D. E. Knapp, "Quantifying forest canopy traits: Imaging spectroscopy versus field survey," *Remote Sensing of Environment*, vol. 158, pp. 15–27, Mar. 2015.

[4] G. Vaglio Laurin *et al.*, "Discrimination of tropical forest types, dominant species, and mapping of functional guilds by hyperspectral and simulated multispectral Sentinel-2 data," *Remote Sensing of Environment*, vol. 176, pp. 163–176, Apr. 2016.

[5] J.-P. Gastellu-Etchegorry *et al.*, "Discrete anisotropic radiative transfer (DART 5) for modeling airborne and satellite spectroradiometer and LIDAR acquisitions of natural and urban landscapes," *Remote Sensing*, vol. 7, no. 2, pp. 1667–1701, Feb. 2015.