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Simulating spectral heterogeneity in tropical forest canopy reflectance with 3D radiative transfer modeling

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Introduction

- Biodiversity monitoring needed to mitigate the erosion of biodiversity → Remote sensing can provide information for such task
- Spectral Variation Hypothesis (Palmer et al. 2002): potential for biodiversity mapping in tropical forests using spectral info (Féret & Asner 2014)
- Operational applications need validation of experimental results and identification of potential and limitations of existing and future satellite missions
- Physical modeling allows better understanding of how to link remote sensing data with vegetation properties

How to represent complex concept such as biodiversity with 3D physical modeling?

Objective

- Test two representations aiming at simulating spectral heterogeneity by taking into account horizontal variability in leaf optical properties (LOPs):
  - ITC approach: LOPs identical for all pixels within an Individual Tree Crown (ITC)
  - Pixel approach: LOPs vary among pixels within ITC, based on estimates of pigments

Study area & Experimental data

- Experimental site (200 x 200 m) located in the North of French Guiana (Paracou)
- Airborne imaging spectroscopy: measured spectral heterogeneity
- LiDAR data (TLS and ALS): accurate definition of 3D structure, including wood and leaves
- ITCs delineation, species inventories and LOPs measured from field spectrometer

Methods

- Reconstruction of 3D forest structure from ALS and TLS using AMAPVox
- ITC approach: LOPs measured from an identified ITC with field spectroscopy applied to all pixels of this ITC
- Pixel approach: Estimation of leaf pigments (Chlorophylls – Cab, Carotenoids – Cxc, Anthocyanins) using spectral indices (Gitelson et al. 2006)
  - Adjustment of a statistical model between spectral indices and leaf pigment content using DART simulation
  - Application of the statistical model on each pixel of experimental airborne imaging spectroscopy
- Compare spectral dissimilarity among and within a selection of species for each approach, using spectral angle

Theoretical relation between leaf chemistry and spectral indices

Methodological workflow

Assessment of spectral dissimilarity

- Two ways of integrating variability in LOPs in 3D RTM have been tested for the simulation of spectral heterogeneity
- Pixel approach outperforms ITC approach: need of many samples (ITCs delineation) for validation
- Need to test other metrics for spectral dissimilarity

Conclusion & perspectives

References