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**

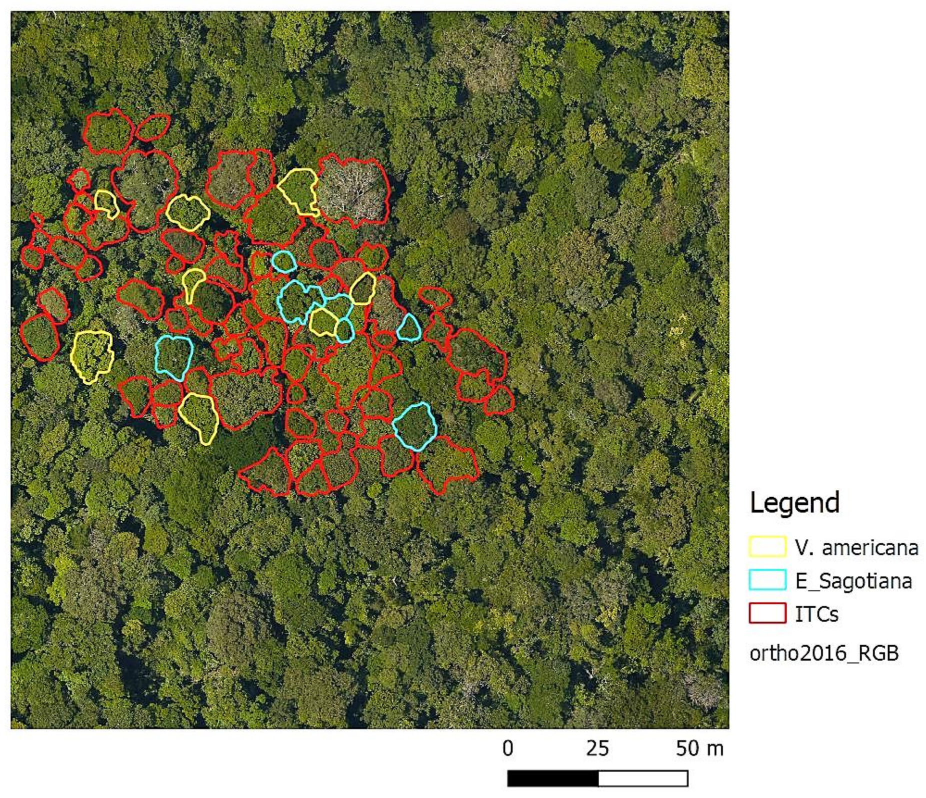
How to represent complex concept such as biodiversity with 3D physical modeling?

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

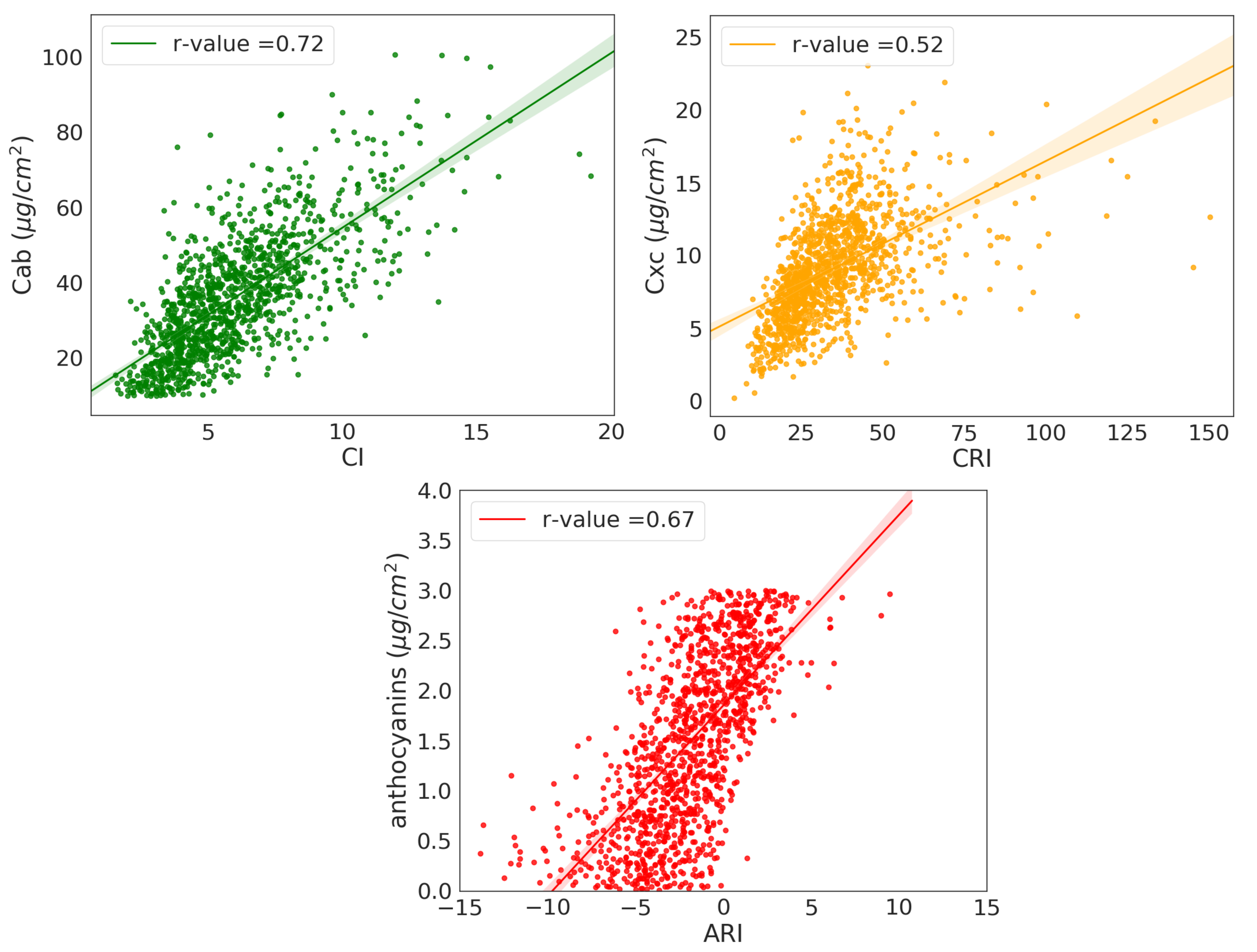
- Experimental site (200 x 200 m) located in the North of French Guiana (Paracou)
- Airborne imaging spectroscopy: measured spectral heterogeneity
- LiDAR data (TLS and ALS): accurate definition of 3D structure, including wood and leaves
- ITCs delineation, species inventories and LOPs measured from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



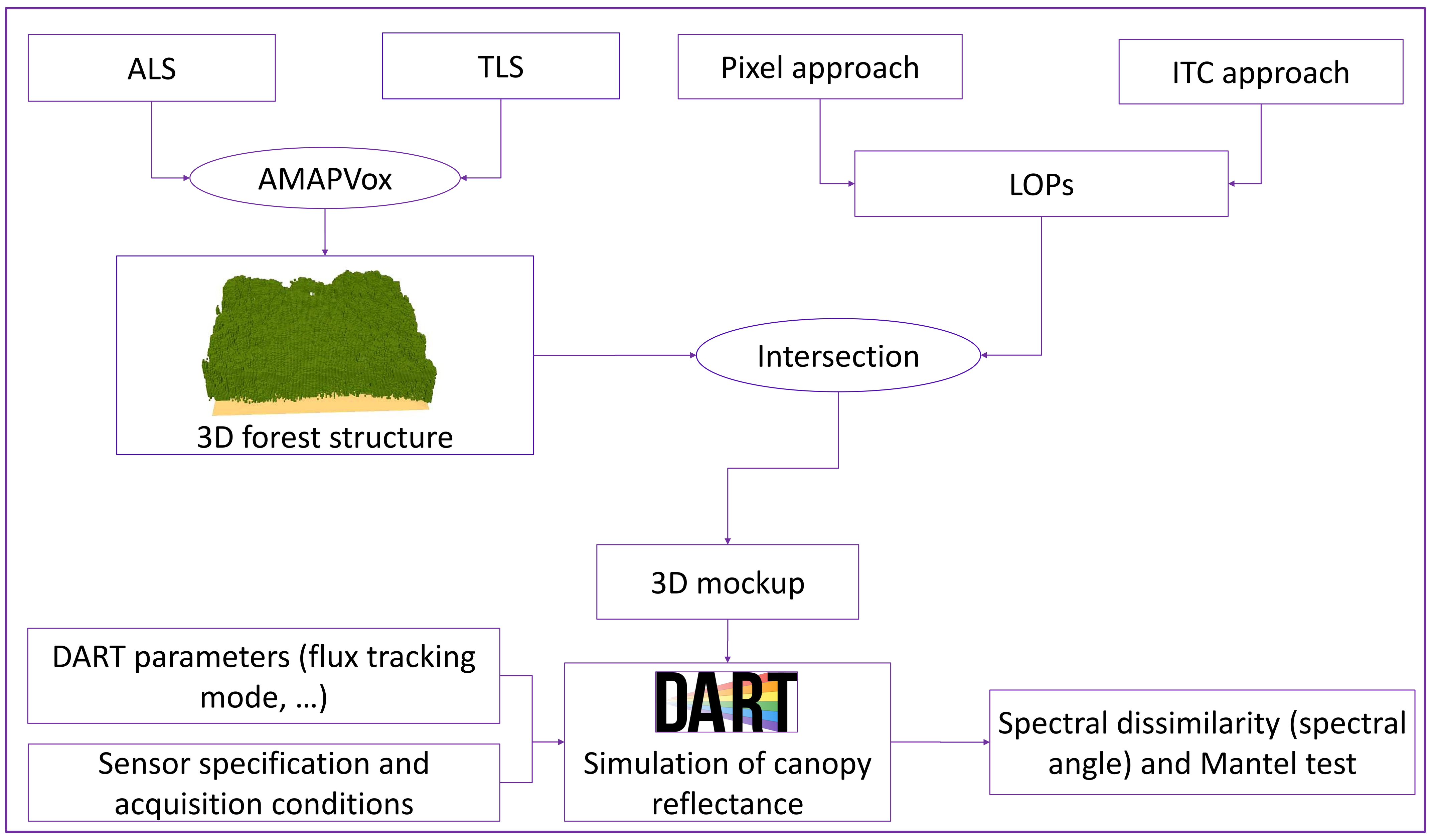
Methods

- 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

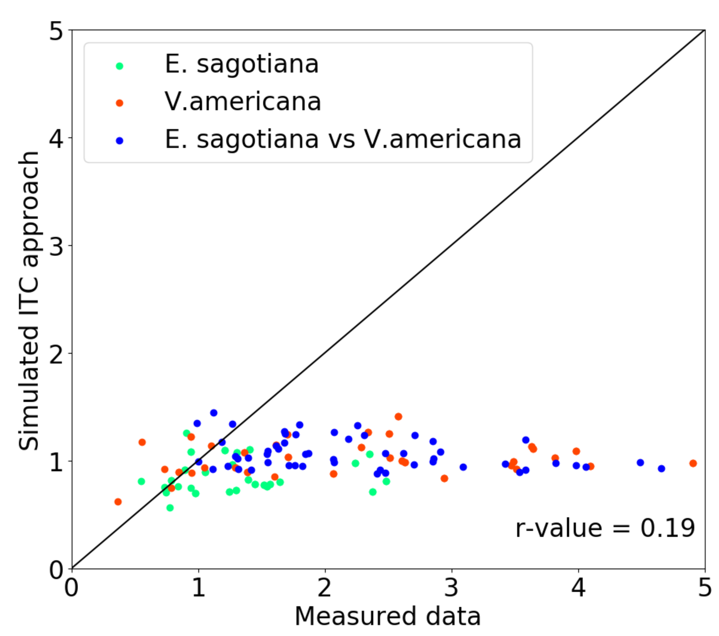


Methodological workflow

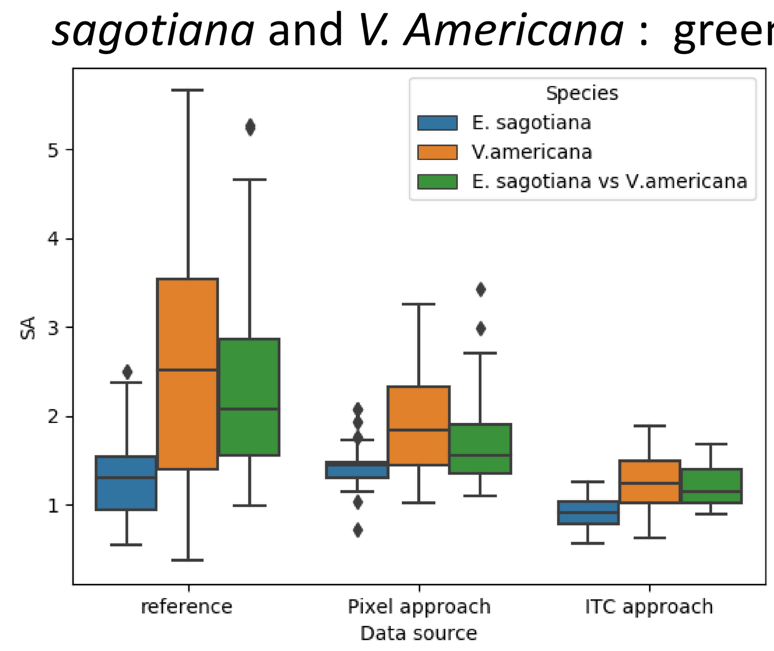


Assessment of spectral dissimilarity

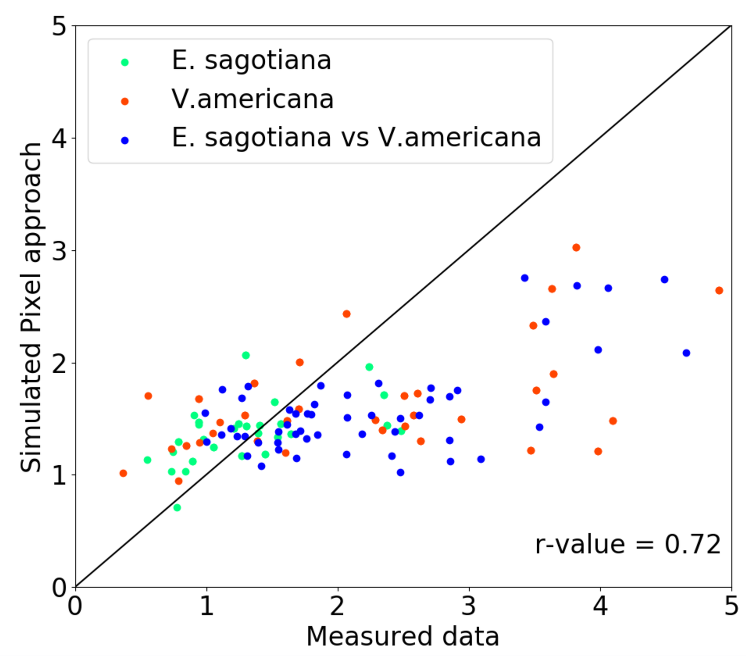
- Relation of spectral dissimilarity between measured data and ITC approach



- **Spectral dissimilarity within** : *E. sagotiana*: blue, *V. Americana*: orange and **among** *E. sagotiana* and *V. Americana* : green



- Relation of spectral dissimilarity between measured data and pixel approach



Degradation of spectral heterogeneity with ITC approach

Conclusion & perspectives

- 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

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