ESTIMATION OF BIOPHYSICAL TRAITS OF EUCALYPTUS FORESTS USING EMPIRICAL, PHYSICAL AND HYBRID METHODS

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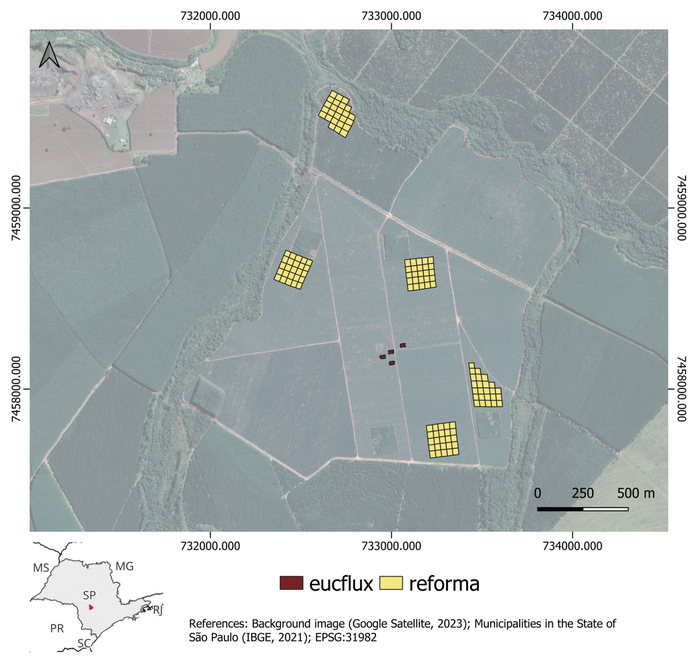
1. INTRODUCTION

Brazil is a major wood producer with extensive eucalyptus plantations. Understanding how these systems respond to severe environmental changes is critical to precision agriculture. Biophysical traits, such as leaf area index (LAI), chlorophyll (CHL), water thickness (EWT), leaf mass per area (LMA) play an essential role in assessing crop growth. However, they are highly variable in space, within the same stand, between stands and over time. This PhD thesis aims to estimate the biophysical characteristics of Eucalyptus plantations in Sao Paulo, Brazil, using a combination of empirical, physical and hybrid methods [1], as well as hyperspectral and multispectral satellite data.

2.DATA AND STUDY AREA

The field data consist of destructive measurements **of LAI, CHL, EWT, LMA, average canopy angle** between April 2019 and October 2021 on reforma blocks, each containing 25 eucalyptus genotypes and main genotype (eucflux) plots situated in Itatinga (Brazil). The remote sensing data consists of Sentinel-2 surface reflectance data (2019 - 2022) and EnMAP data (2023). The **EnMAP** data was acquired between mid-April 2023 and mid-June 2023, during an extensive data acquisition campaign. A total of 4 images were acquired during this period, with nadir off ranging from -5.08 to 19.44.



3. METHODOLOGY

3.1 Data collection and pre-processing

- **EnMAP (2023 - 2025)**
- Sentinel-2 (2019- 2025)
- Field data (2019- 2025)

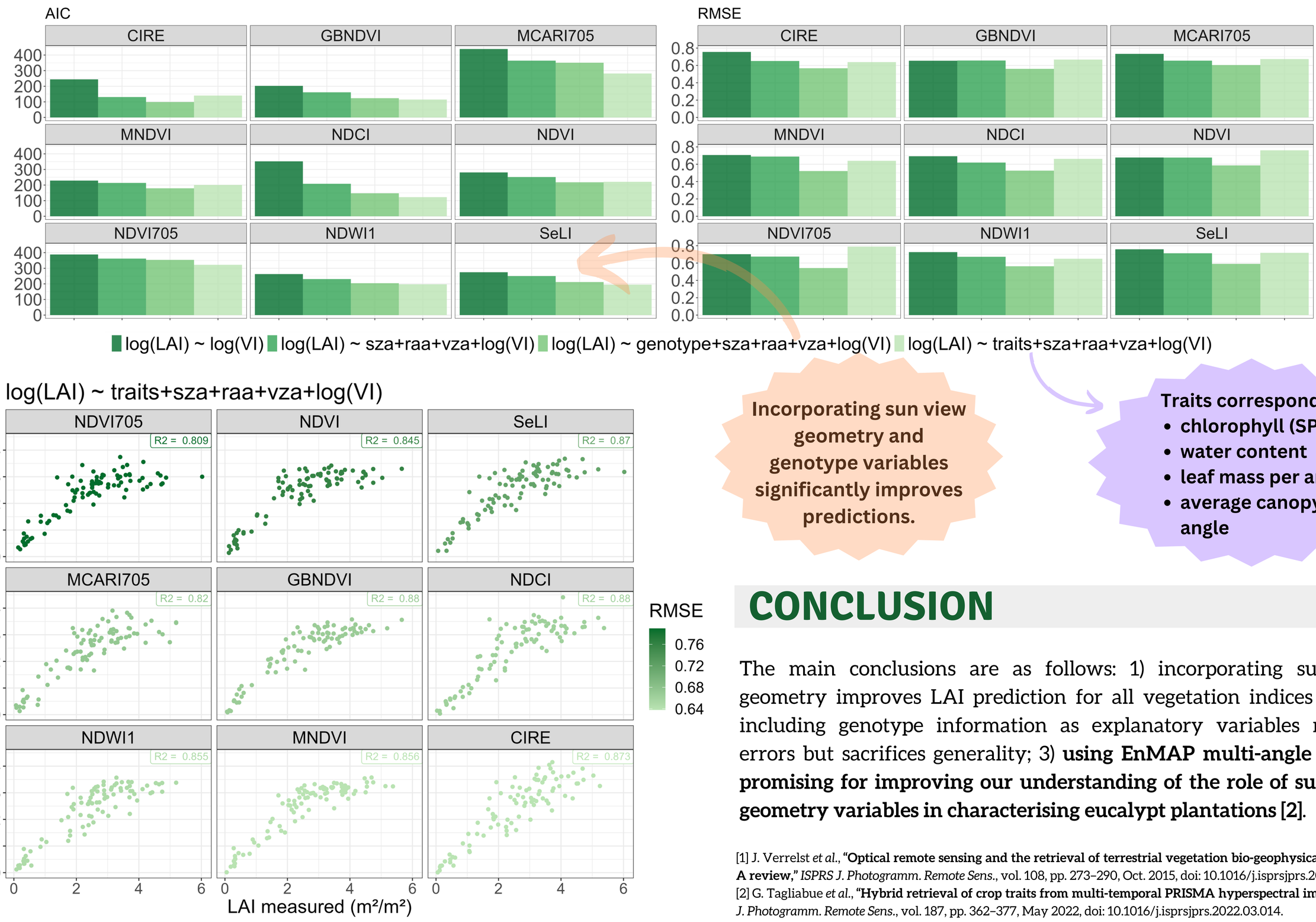
3.2 Modelling

- **Empirical models**
- Physical models (PROSAIL and INFORM)
- Physical + Machine Learning (Joint Gaussian Process (JGP))

3.3 Anomaly detection

- Water stress
- Biotic stress

4.PRELIMINARY RESULTS : SENTINEL -2



Incorporating sun view geometry and genotype variables significantly improves predictions.

Traits correspond to:

- **chlorophyll (SPAD)**
- **water content**
- **leaf mass per area**
- **average canopy leaf angle**

CONCLUSION

The main conclusions are as follows: 1) incorporating sun-view geometry improves LAI prediction for all vegetation indices (VI); 2) including genotype information as explanatory variables reduces errors but sacrifices generality; 3) **using EnMAP multi-angle data is promising for improving our understanding of the role of sun-view geometry variables in characterising eucalypt plantations [2].**

[1] J. Verrelst *et al.*, **"Optical remote sensing and the retrieval of terrestrial vegetation bio-geophysical properties – A review,"** *ISPRS J. Photogramm. Remote Sens.*, vol. 108, pp. 273–290, Oct. 2015, doi: 10.1016/j.isprsjprs.2015.05.005.
[2] G. Tagliabue *et al.*, **"Hybrid retrieval of crop traits from multi-temporal PRISMA hyperspectral imagery,"** *ISPRS J. Photogramm. Remote Sens.*, vol. 187, pp. 362–377, May 2022, doi: 10.1016/j.isprsjprs.2022.03.014.