Multi-Source LiDAR Approaches for Direct Retrieval of Canopy Structure Parameters in Mediterranean Forests

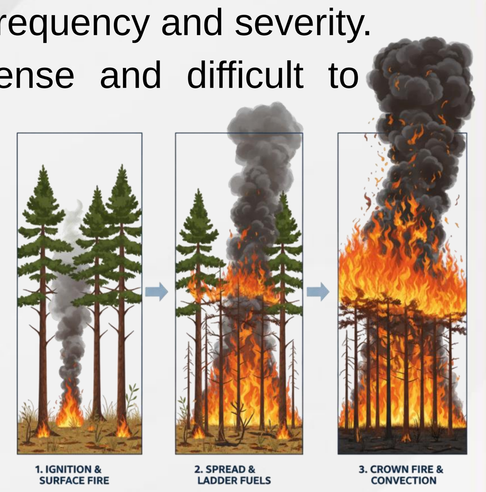
Pegah Mohammadpour [1,2], Domingos Xavier Viegas [1], Alcides Pereira [3], Emilio Chuvieco [2]

pegah@adai.pt

[1] Univ of Coimbra, ADAI, Department of Mechanical Engineering, Rua Luís Reis Santos, Pólo II, 3030-788 Coimbra, Portugal
[2] Universidad de Alcala, Environmental Remote Sensing Research Group, Department of Geology, Geography and Environment, Colegios 2, 28801 Alcalá de Henares, Spain
[3] Univ Coimbra, Centre for Earth and Space Research of the University of Coimbra, Department of Earth Sciences, Portugal

Introduction

- Wildfires pose a growing threat across the Iberian Peninsula, with increasing frequency and severity.
- Crown fires are more intense and difficult to manage than surface fires.
- Accurate description of fuel types and their parameters is key to wildfire behavior and prevention.

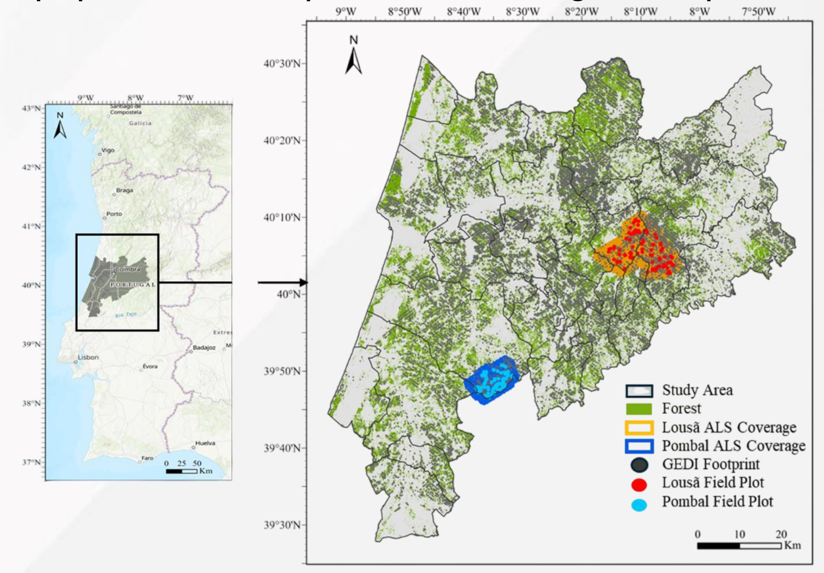


Objectives

- Estimating and mapping four key canopy fuel attributes directly from LiDAR data.
- Enhance estimation by using an innovative stratification approach based on Gaussian decomposition and components.

Study Area

- Located in Central Portugal, Pilot site 3 of FirEUrisk
- The landscape is characterized by diverse vegetation covers and complex topography
- The region is considered one of the most wildfire-prone areas in the country, largely due to widespread eucalyptus cultivation, exacerbated by rural depopulation, and poor land management practices



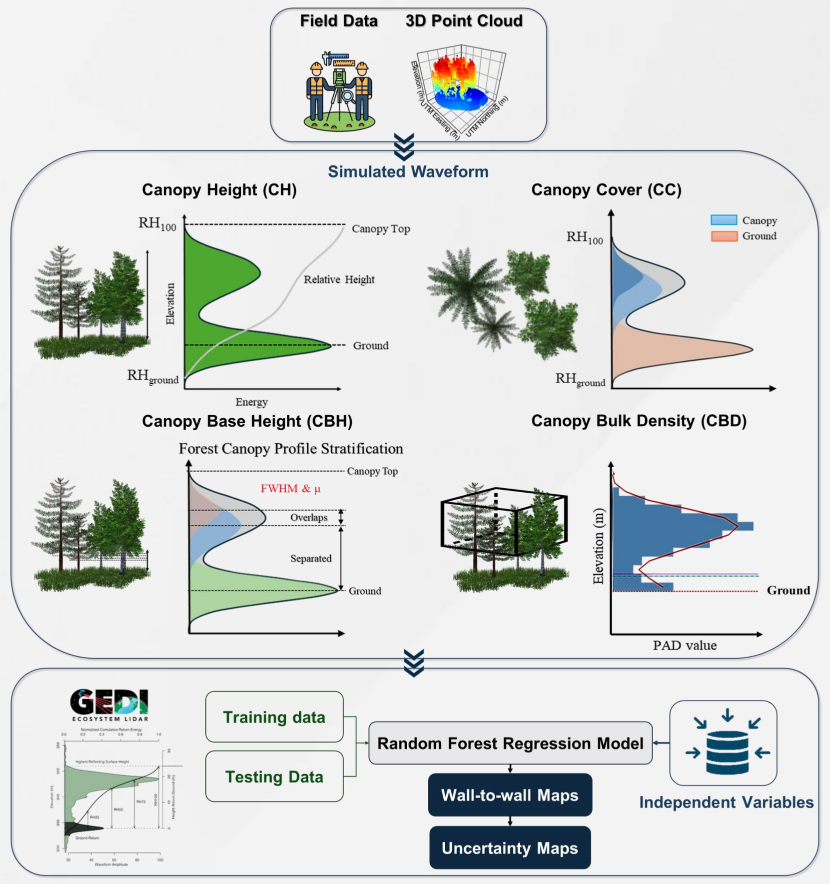
Geographic location of the study area within mainland Portugal, with an illustration of the spatial distribution of the datasets.

Acknowledgments

The authors thank the project partner, the University of Coimbra, the University of Alcala, the Portuguese Foundation for Science and Technology (FCT- grant agreement No. 2021.05971. BD attributed to the 1st author), and the Horizon 2020 research and innovation programme (FirEUrisk- grant agreement No. 101003890) for supporting this work.

Method

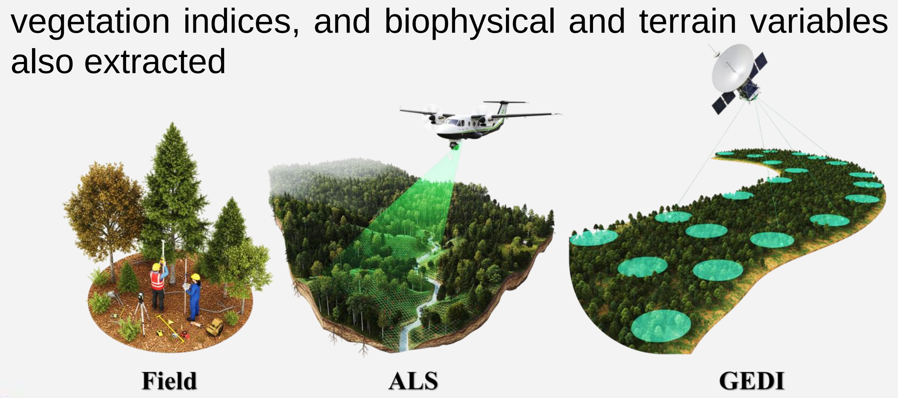
ALS point clouds served as ground truth for estimating CH and CC, while field measurements provided ground truth for CBH and CBD. Simulated GEDI waveforms, derived from the ALS point clouds, were used to estimate the parameters. Gaussian decomposition and forest canopy profile stratification were applied, and GEDI footprints were utilized in a regression model to produce wall-to-wall maps.



Overview of the methodology for mapping four key fuel parameters using a direct approach based on multisource LiDAR data.

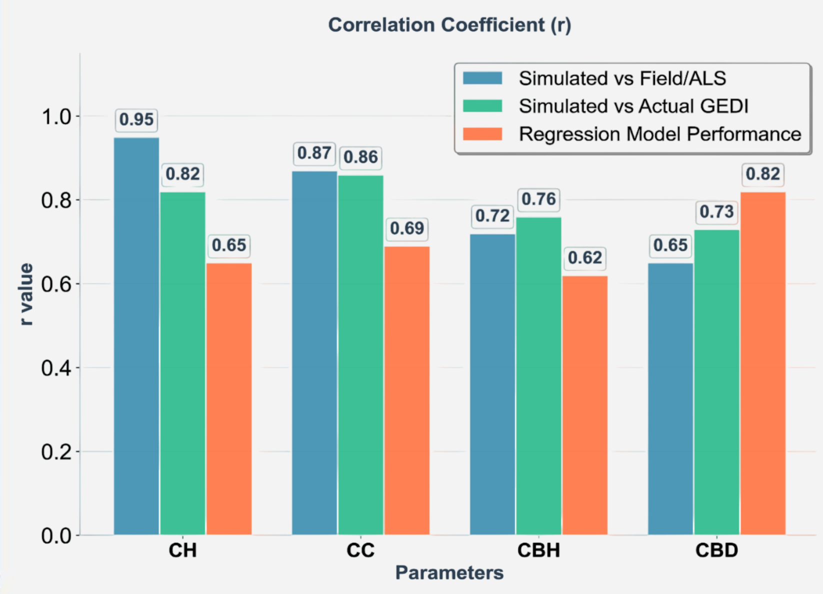
Data

- Field measurement data collected between April 2020 and June 2021 by ForestWISE within the LiDAR coverage under the coordination of ICNF
- ALS LiDAR point cloud data provided by ICNF from 19 June 2020 (Pombal) and 21 June 2020 (Serra de Lousã)
- GEDI L1B, L2B, and L2A Version 2 for 1st May to 30th September of 2019 to 2021 obtained from Earthdata (NASA)
- Auxiliary data such as Sentinel-1/2, ALOS PALSAR-2, vegetation indices, and biophysical and terrain variables were also extracted

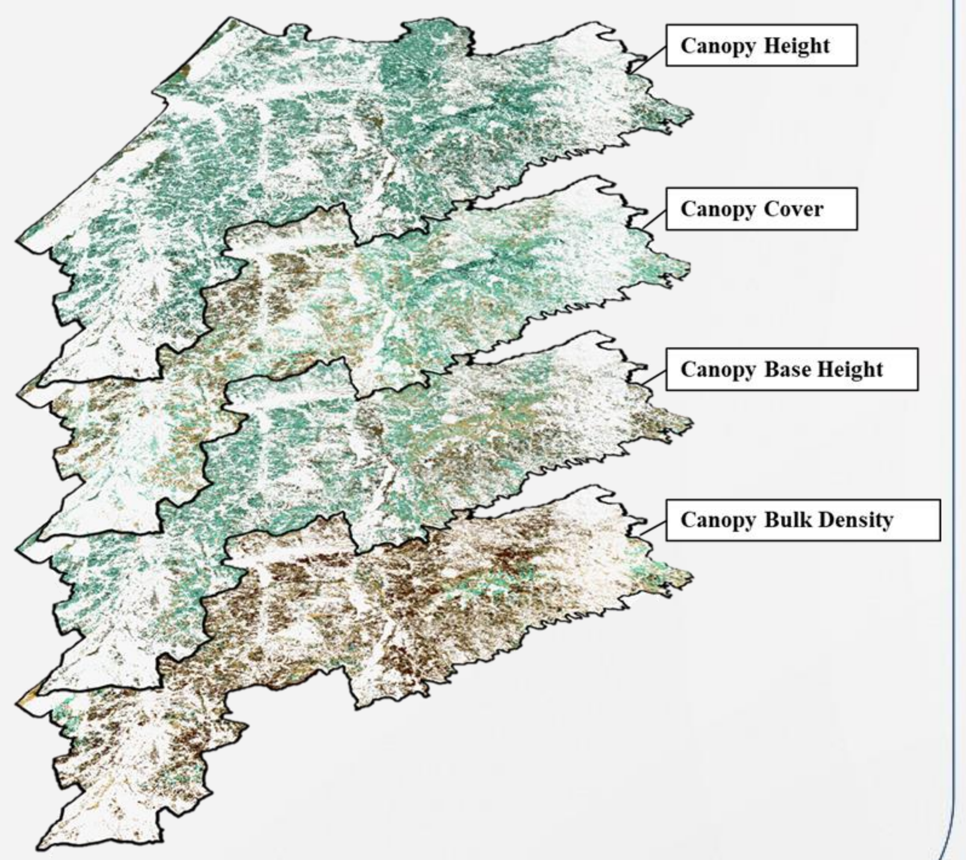


Results

- The proposed methodology demonstrated good to high correlations between parameters estimated from simulated GEDI pseudo-waveforms and those derived from field measurements or ALS-based metrics, with r values ranging from 0.65 to 0.95.
- Comparative analysis using actual GEDI footprints within ALS coverage confirmed the reliability of simulated GEDI-based estimates, with r values between 0.73 and 0.86, highlighting the potential of spaceborne LiDAR for direct fuel parameterization in areas lacking ALS data.
- The approach also showed the effectiveness of the hybrid Gaussian decomposition combined with a novel forest vertical profile classification for the direct estimation of CBH and CBD. This method achieved higher correlations and lower RMSE across fuel parameters compared to existing European maps, demonstrating its transferability and scalability.
- The generated high-resolution wall-to-wall maps, integrating multisource datasets, achieved satisfactory validation results against independent data (r = 0.65–0.82) and provide valuable inputs for wildfire behavior simulation.



Performance evaluation of fuel parameters metrics across three assessment stages.



Wall-to-wall map of four forest fuel parameters, CH, CC, CBH, and CBD.

Conclusion

This study introduces a direct approach for estimating four essential canopy fuel parameters (CH, CC, CBH, and CBD) using multisource LiDAR data. Simulated GEDI pseudo-waveforms, derived from ALS point clouds, were employed to establish a robust connection between airborne and spaceborne LiDAR datasets, facilitating fuel parameter estimation in regions lacking direct overlap between GEDI footprints and field plots. Wall-to-wall maps of fuel parameters were produced using Random Forest regression, integrating multisource input data with GEDI footprints for model training and validation. The proposed methodology delivers reliable spatial datasets that support wildfire risk assessment and ecological modeling in Mediterranean fire-prone environments.

Universidad de Alcalá
Universidade de Coimbra
FCT Fundação para a Ciência e a Tecnologia
fireurisk

VII Symposium of Doctoral Students of the UAH in Research with Geographic Information Technologies (SITIG-UAH)