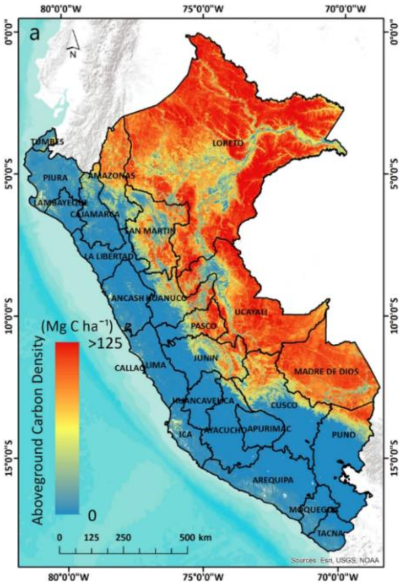
EO-FIN

Estimation of Above-Ground Carbon Stocks in Forests



High-resolution ACD map of Peru at 1-ha resolution expressed in Mg C ha−1 using Planet Dove satellite imagery and LIDAR data (Source: Csillik, O., Kumar, P., Mascaro, J., O'Shea, T. and Asner, G.P., 2019. Monitoring tropical forest carbon stocks and emissions using Planet satellite data. Scientific reports, 9(1), p.17831.).

Product Category

☐ Land Use ☐ Natural Disaster ☐ Coast Management ☐ Earth's Surface Motion
☐ Land Cover ■ Climate Change ☐ Marine

Financial Domain(s)

☐ **Investment management** ☐ **Risk analysis** ☐ **Insurance management** ■ **Green finance**

User requirements

UN30: Need for monitoring with accurate measurements the growth and health of trees
UN32: Need to periodically estimate the growth of above-ground carbon stocks (in forests).

Description

Calculating aboveground carbon stock on forests is crucial as they store a significant portion of Earth's carbon. Accurate measurement of gains and losses of carbon associated with forest growth, loss, and degradation. aids in designing effective conservation strategies, sustainable land-use planning, and informed policy decisions. Calculation of Aboveground Carbon Density (ACD) starts by measuring the Above Ground Biomass (AGB) due to the strong correlation between both. AGB is calculated based on the height and structure of trees in forests. While field data collection is possible, it encounters geographical constraints within forests. Conversely, LiDAR data, providing valuable information on canopy heights and forest structure, emerges as a more viable option for encompassing broader geographical extents. Although LiDAR enables the expansion of analysis to more extensive regions, its geographic scope is constrained by the financial implications and logistical challenges linked to aircraft deployment. To address this challenge, LiDAR or even field tree inventory data are frequently coupled with remote sensing data possessing diverse spectral and spatial characteristics, facilitating the transition to comprehensive coverage using satellite-based platforms.

Spatial Coverage Target

Forests

Data Throughput

Rapid tasking	☐ High	■ Low
Data availability	☐ High	■ Low

Product specifications	
Main processing steps	Information about the height and structure of the forest should be gathered through fieldwork or LIDAR. In the fieldwork method, measurements of tree

Product specifications	
	height and diameter at breast height (DBH) are collected from select trees, forming inputs for allometric equations. These equations are then utilized to compute Above-Ground Biomass (AGB), which would be multiplied by a factor (based on the type of the forest) to calculate ACD. In the case of using LIDAR, the top of the canopy height is used as an indicator of the height and structure of the trees. This value serves as the basis for AGB estimation through calibrated equations derived from the earlier allometric model. These data serve as ground truth for training machine learning models using satellite-based data. These datasets comprise optical information from sensors like Sentinel-2 or VHR sensors, along with SAR data from sensors like Sentinel-1 or VHR sources. Predictors for the machine learning models encompass spectral reflectance, vegetation indices, and biophysical variables from optical sensors, as well as SAR backscatter data, image textures computed via techniques like the grey-level co-occurrence matrix, and DEM data. Before training the machine learning model for AGB or top-of-canopy height prediction, applying feature selection algorithms is vital to identify impactful input features. The chosen features are then employed to train the model. Following training and validation, the model is deployed to estimate AGB or top-of-canopy height across the study area, which is subsequently input into the allometric or calibrated equations for ACD computation.
Input data sources	Optical: Sentinel-2, VHR based on the availability like Pleiades 1A/1B & NEO, WorldView2&3, and SPOT6/7 Radar: Sentinel-1, VHR images from different sources like ICEYE, Capella space, Umbra, and TerraSAR-X Supporting data: Ground truth data for tree inventory like LIDAR
Accessibility	Sentinel-1&2: freely and publicly available from ESA. SAR and optical VHR imagery: commercially available on demand from EO service providers.
Spatial resolution	Sentinel-2: 10m Optical VHR: < 0.5m Sentinel1: 20m SAR VHR: < 3m
Frequency (Temporal resolution)	Sentinel-2: 6 days Optical VHR: daily Sentinel1: 6 days SAR VHR: daily
Latency	≤ 1 day
Geographical scale coverage	Globally
Delivery/ output format	Data type: Raster File format: GeoTIFF
Accuracies	Thematic accuracy: 70-80% (based on input data) Spatial accuracy: 1.5-2 pixels of input data
Constraints and limitations	■ Lack of ground truth data about trees height and structures obtained from filed work or LIDAR. ■ Cloud presence ■ Satellite data might not provide direct measurements of biomass, requiring the use of models and assumptions that can introduce uncertainties.
User's level of knowledge and skills to extract information and perform further analysis on the EO products.	Skills: Ample Knowledge: Essential