AICarbonHub: An Earth Observation based Carbon Marketplace for Continuous Monitoring and Verification

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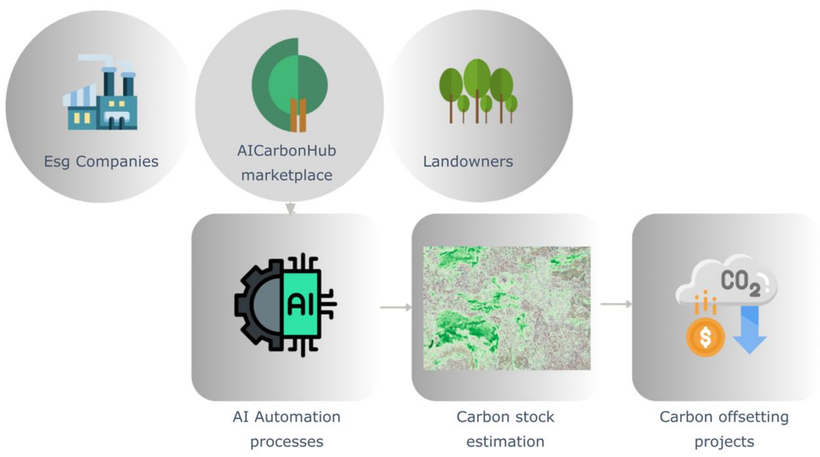
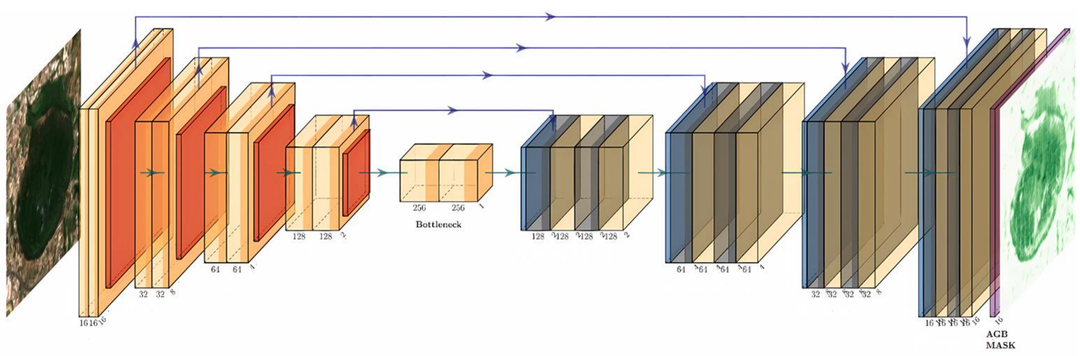
Introduction

The emergence of carbon markets as a crucial tool to promote the reduction of greenhouse gas emissions has necessitated the establishment of reliable and transparent carbon sequestration monitoring mechanisms. This work highlights the potential of employing Earth Observation data for monitoring, reporting, and verifying carbon offset projects through a voluntary carbon marketplace. Two effective methodologies have been proposed to estimate carbon stocks of plants, initially evaluated as above-ground biomass (AGB) and then converted into carbon stocks using empirical rules.



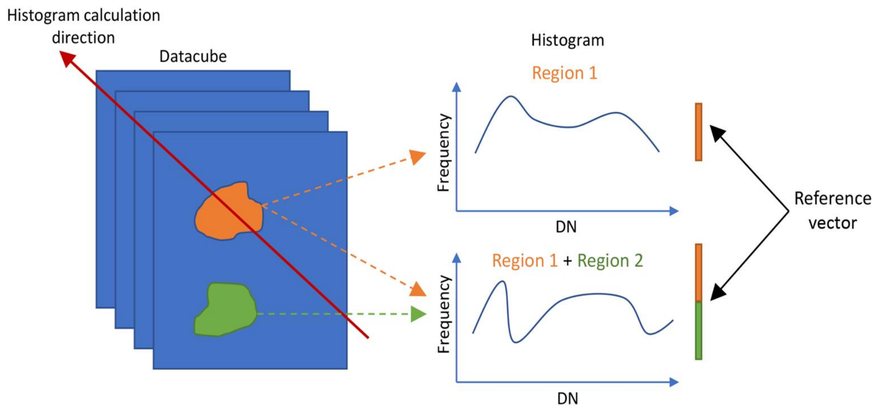
Carbon Monitoring using public data and deep learning

The first method[1] employs deep learning to estimate global carbon sequestered by greenery. Utilizing publicly available AGB data from the European Space Agency's Climate Change Initiative Biomass project, a time series of Sentinel-2 images and a pixel-wise regressive U-Net are employed to estimate the carbon sequestration capacity of any area. This tool offers quick estimates even in challenging conditions, such as after fires or hard-to-reach areas and could be used to create alerts if deforestation is recognized.



Active learning to reduce field sampling

The second method[2] uses active learning and satellite imagery to highlight the more informative areas to sample. Based on Shannon's entropy for sample selection, techniques significantly reduce field sampling while providing carbon stock estimates, preserving the accuracy of conventional methods.



Results

Tab.1 and Tab.2 show, respectively, the results of experiments for global carbon monitoring using public data with deep learning and active learning to promote the reduction of in-situ sampling.

Area	Model	MAE	RMSE	R^2
Vietnam	ReUse with raw bands	**42.0 ± 6.6**	**57.7 ± 7.3**	**0.4 ± 0.2**
	ReUse with feature extraction	44.4 ± 6.0	59.5 ± 4.7	**0.4 ± 0.2**
	Competitor 1 [10]	60.1 ± 8.3	73.0 ± 9.4	0.2 ± 0.2
	Competitor 2 [14]	58.9 ± 8.6	72.0 ± 9.7	0.2 ± 0.2
Myanmar	ReUse with raw bands	10.8 ± 2.0	15.0 ± 2.4	**0.7 ± 0.1**
	ReUse with feature extraction	**10.7 ± 2.2**	**14.9 ± 2.6**	**0.7 ± 0.1**
	Competitor 1 [10]	15.7 ± 1.9	20.2 ± 2.3	0.4 ± 0.1
	Competitor 2 [14]	15.5 ± 1.5	20.1 ± 1.8	0.4 ± 0.1
Europe	ReUse with raw bands	24.5 ± 3.3	**46.6 ± 5.2**	**0.6 ± 0.1**
	ReUse with feature extraction	**24.1 ± 3.4**	46.9 ± 4.2	**0.6 ± 0.1**
	Competitor 1 [10]	32.5 ± 3.1	48.0 ± 4.4	0.5 ± 0.5
	Competitor 2 [14]	34.8 ± 3.1	51.1 ± 3.9	0.5 ± 0.5

Table 1. Results for carbon monitoring using public data and deep learning.

	Proposed						Benchmark		
	PLSR		GB		Ensemble		Bootstrap		NN
Samples	RMSE		RMSE		RMSE		RMSE*	$\overline{RMSE}$	
	Area	Inc	Area	Inc	Area	Inc			
All	28.8	31.3	33.7	36.3	28.8	30.6	26.2	46.8	
k = 10	30.7	32.1	34.2	36.7	30.0	31.5	27.7	47.7	30.4
k = 5	31.6	32.2	34.0	37.9	30.7	32.3	28.5	49.7	

Table 2. Results using active learning.

Carbon Marketplace

AI Carbon Hub is an innovative platform that leverages the benefits of the two above discussed AGB estimation methods. It provides an integrated management cycle for carbon credit trading on a voluntary basis. The platform through the analysis and quantification of CO2 sequestered by forest areas will facilitate the exchange between landowners and private companies aiming to improve their environmental impact.

Conclusions

The two methods provide complementary approaches to carbon stock estimation: a global method that reliably releases alerts related to deforestation events and a localized one with minimized field sampling.

References

[1]Pascarella, Antonio Elia, et al. "ReUse: REgressive Unet for Carbon Storage and Above-Ground Biomass Estimation." Journal of Imaging 9.3 (2023): 61.

[2]Amitrano, Donato, et al. "Forest Carbon Stock Estimation Using Machine Learning Ensembles: Active Sampling Strategies for Model Transfer" (under-review).