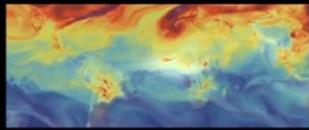

Accurate quantification of carbon stocks at the individual tree level in semi-arid regions in Africa.

Martí Perpinyà Vallès

26 September 2023

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Context: The scientific gap

Satellite technologies have allowed large-scale mapping at coarse to medium resolution (~10km – 10m), but still lacks the capability to accurately map semi-arid areas.

High resolution imagery (~1m) allows to observe individual trees. However, most methods rely on tree crown area alone or do not have the validation data at tree level.

Additionally, the Sahel region has been under-monitored and in-situ data is generally missing for these ecosystems.

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Context: The JeSAC Project.

AGROFORESTRY

Promotion of agroforestry and climate resilient agriculture

INNOVATION

Development of a pilot system of Payments for Environmental Services (PES) based on agroforestry initiatives.

MOBILIZATION

Strengthen leadership and empowerement among young generations in governance and climate solutions.

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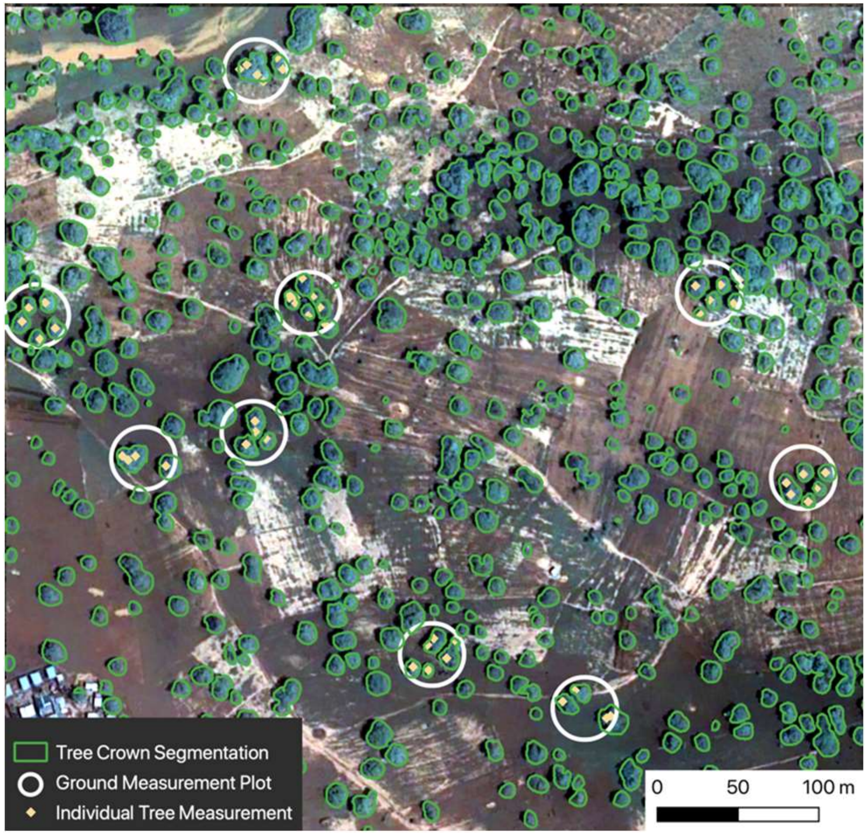
Objective

Development of a validated and scalable monitoring system of carbon stocks for restoration and agroforestry activities in semi-arid areas.

Involvement of communities

In-situ measurement campaign training in Niamey, Niger, in collaboration with the Great Green Wall Initiative and Oxfam Intermon within the JeSAC project.

Use of AI and VHR satellite imagery



Segmentations calculated using DL model from Brandt et al. 2020.

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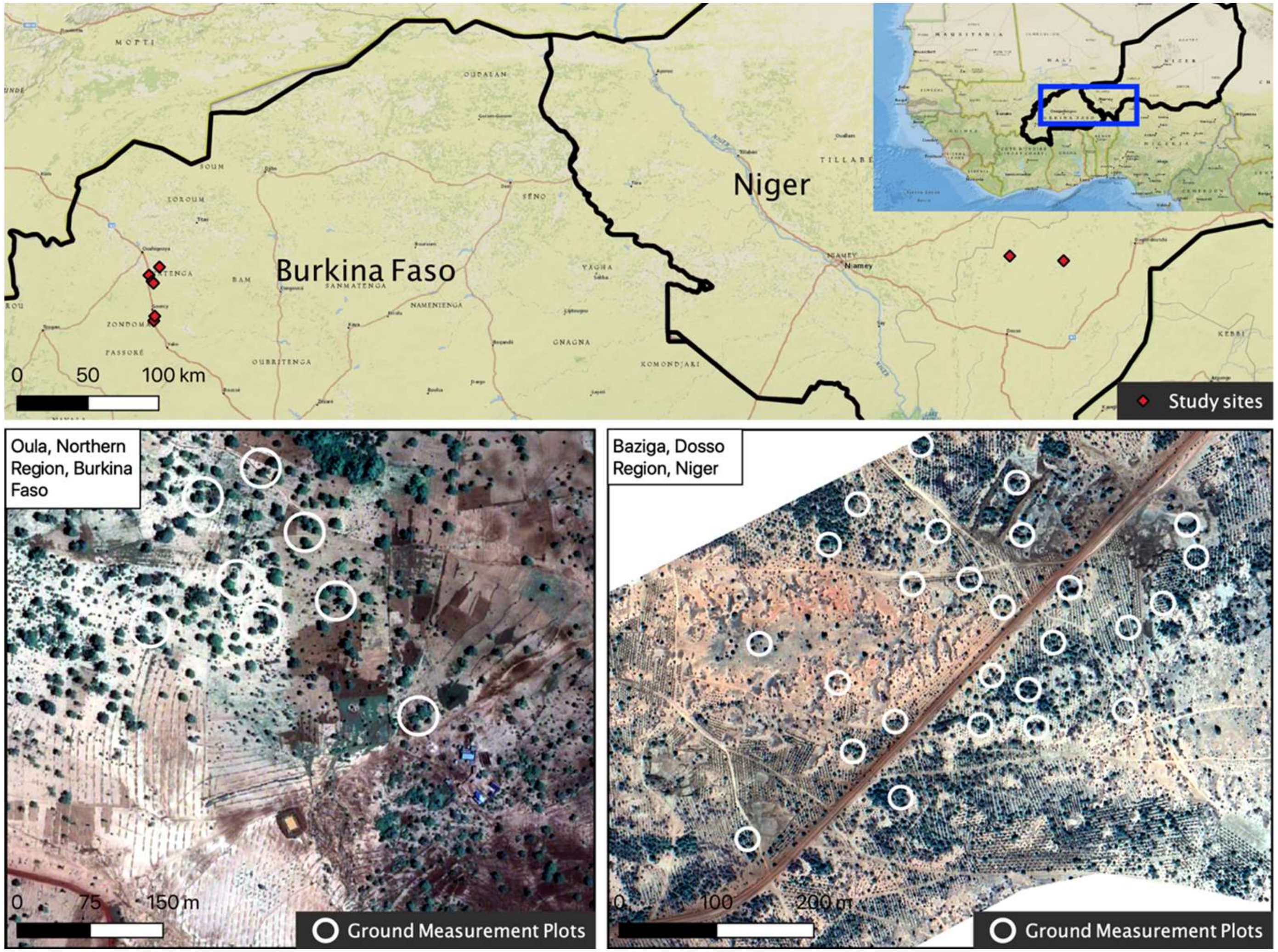
Materials & Methods

- 8 study sites in the Sahel region, selected and measured by the Great Green Wall Initiative experts.
- One Pléiades image per site.



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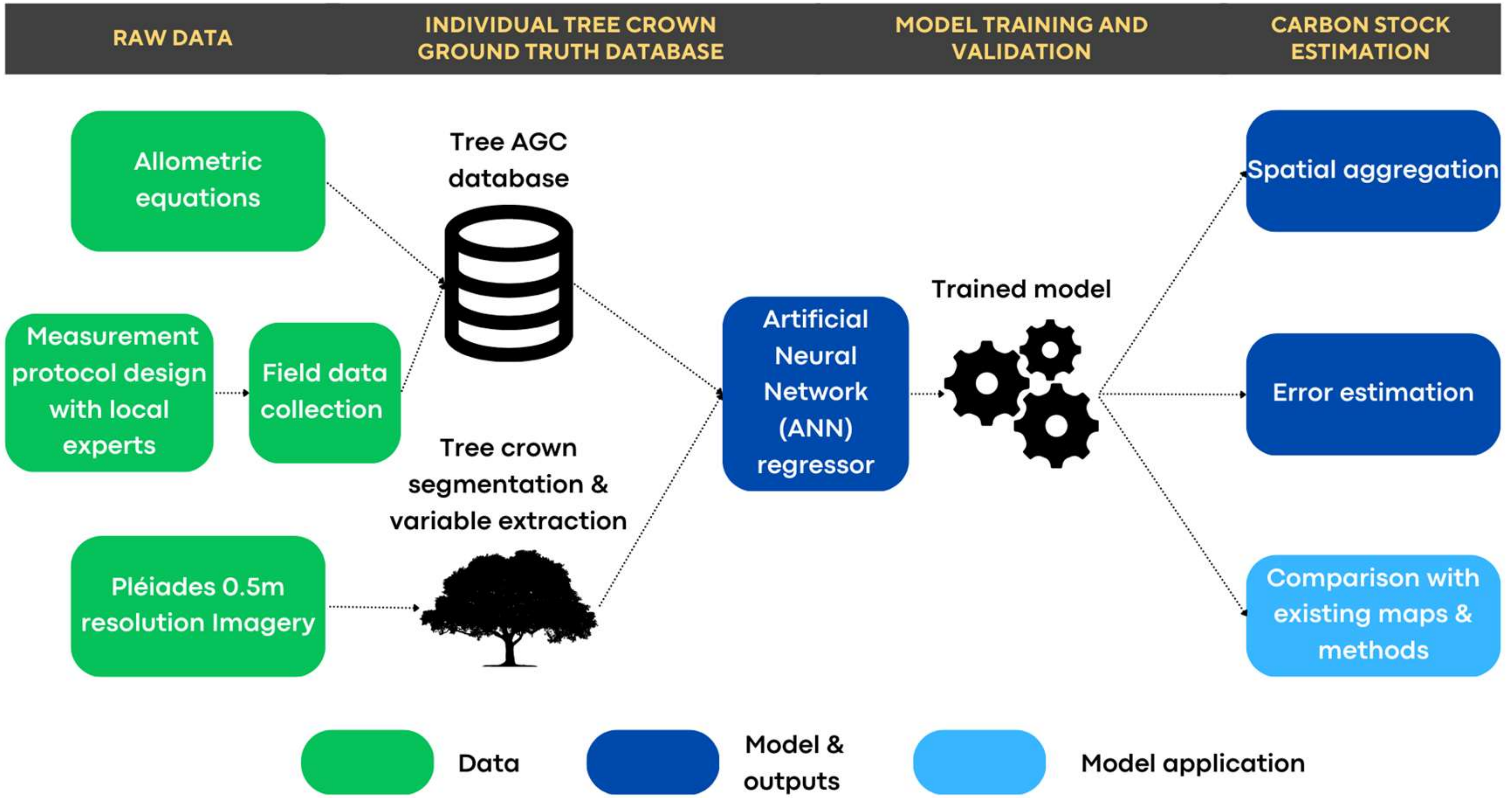
Materials & Methods



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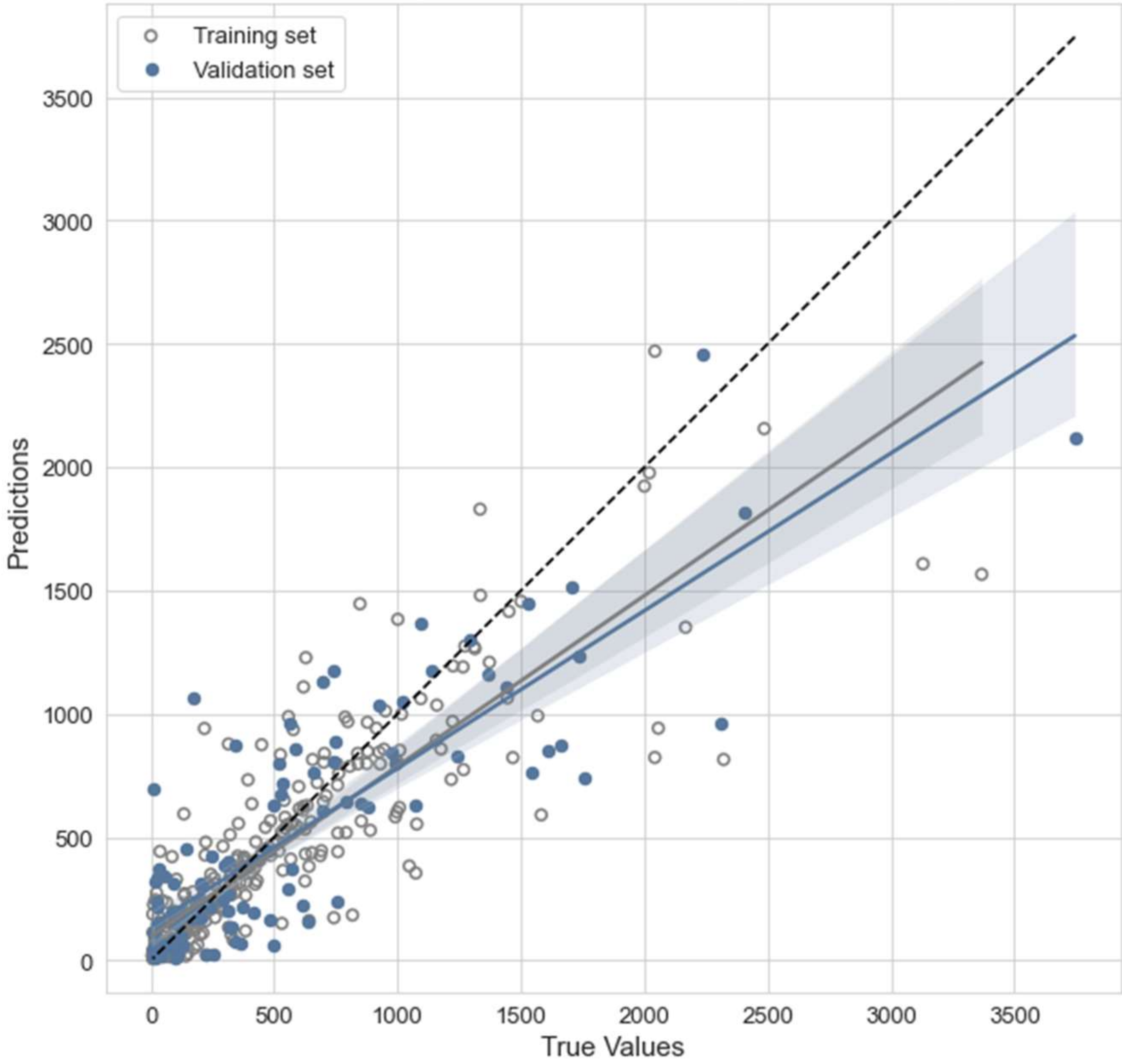
Results

ANN model results at the individual tree level.

Metric	Validation	Full dataset
Pearson R	0.84	0.85
R^2	0.69	0.71
RMSE	355 kg	293 kg
rRMSE	51%	49%
Bias	-58 kg	-46 kg



Scatter plot showing ANN model results on the training and validation dataset.

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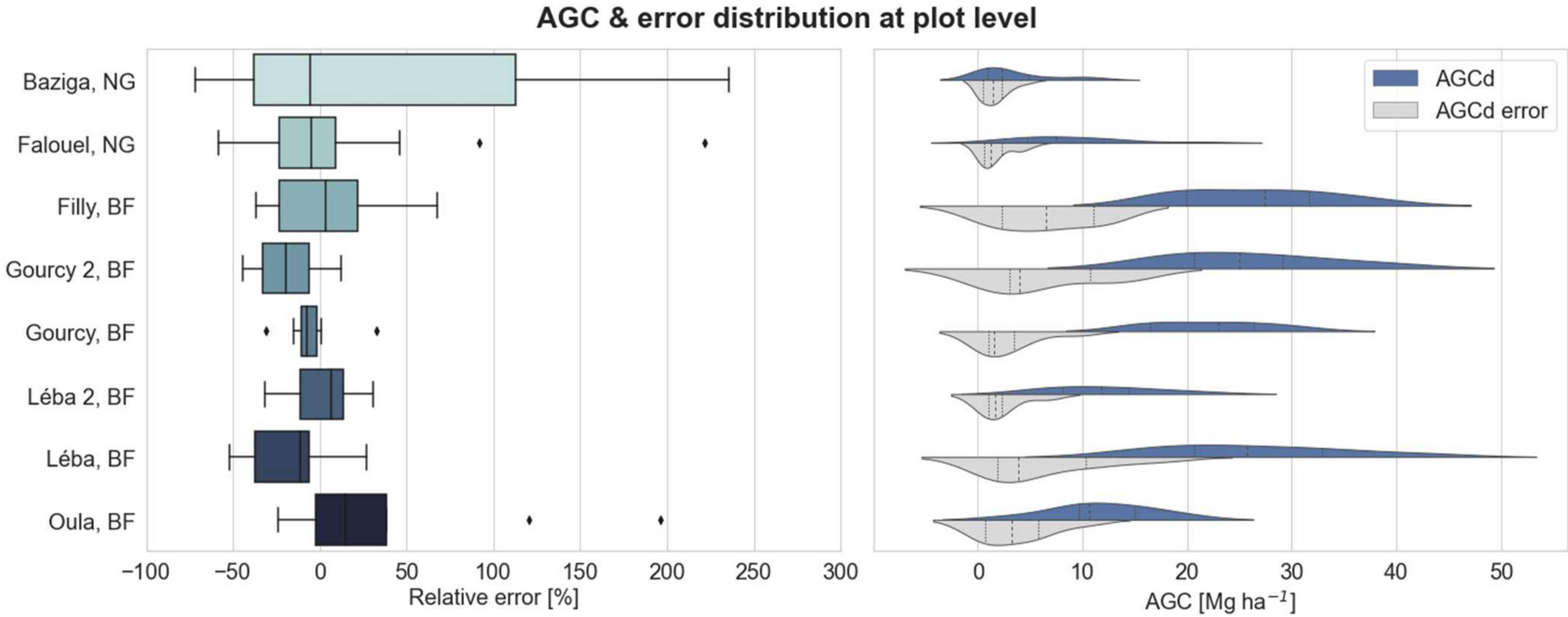
Results

When aggregating results at coarser resolutions, overall errors decrease.



(Left) Relative errors aggregated at measurement plot level. (Right) Absolute errors and AGC distributions aggregated at plot level.

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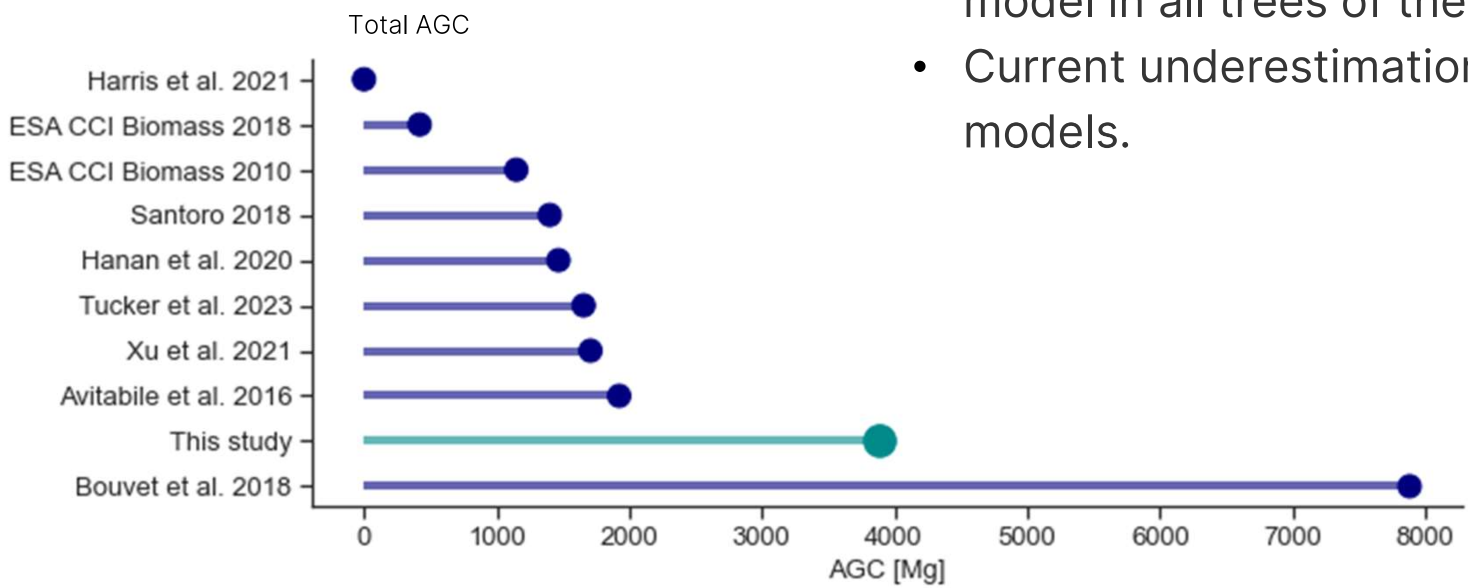
Discussion

Comparison with state-of-the-art AGB / AGC maps and datasets.

- Total AGC obtained using the validated model in all trees of the study sites.
- Current underestimation trend of most models.



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Discussion

	Ground truth	This study	Hiernaux et al. 2023 AGC	Hiernaux et al. 2023 AGC+BGC
Q0.25	93.13	136.65	111.22	140.10
Q0.75	651.34	798.82	349.38	447.12
RMSE		355.62	462.02	404.27
Bias		**-57.28**	-216.21	-143.59

Comparison with crown area based allometries from Hiernaux et al. 2023 used in Tucker et al. 2023.

- Underestimation trend in larger tree crowns. Overall larger bias for this study's ground truth dataset.

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Conclusions

Ground-based methods and global approaches to carbon stock estimation in semi-arid areas usually lead to underestimation and uninformed decision-making

Accurately measuring and geolocating individual trees in VHR imagery allows us to provide better estimates of tree cover and AGC.

Further validation of this methodology in similar areas along the Sahel region has a large potential for fine-tuning the models and scaling this technology at regional and country levels.

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Conclusions: Results from the JeSAC project

On-line platform created with individual tree carbon data for all the areas of interest of the project.

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Conclusions: The NoR program

- This Project was supported by **the ESA Network of Resources (NoR) Initiative**, with ID: **240610**.
- The NoR program provided access to **commercial Very High Resolution imagery** which, in research projects, can be otherwise too expensive to use at the needed scale for the research objectives.
- The NoR program provided access to the **Sentinel-Hub platform, which simplified** the purchase, processing and downloading of the data and allowed for **fast exploration** of the areas of interest.
- The NoR program allowed to **test the methodology in different areas** via accessing small portions of the historical VHR imagery over the areas of interest.

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References

General allometric equation:
J. Chave et al. (2005), Tree allometry and improved estimation of carbon stocks and balance in tropical forests, *Oecologia* **145**, 87–99 (2005). https://doi.org/10.1007/s00442-005-0100-x

Segmentation model:
M. Brandt et al. (2020), An unexpectedly large count of trees in the West African Sahara and Sahel. *Nature* **587**, 78–82 (2020). https://doi.org/10.1038/s41586-020-2824-5

Crown area allometries:
Allometric equations to estimate the dry mass of Sahel woody plants mapped with very-high resolution satellite imagery, *Forest Ecology and Management*, Volume **529**, 120653, ISSN 0378-1127, https://doi.org/10.1016/j.foreco.2022.120653.

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References

Comparison maps and datasets:

- Harris, N.L., Gibbs, D.A., Baccini, A. et al. Global maps of twenty-first century forest carbon fluxes. *Nat. Clim. Chang*. **11**, 234–240 (2021). https://doi.org/10.1038/s41558-020-00976-6
- ESA Biomass Climate Change Initiative (Biomass CCI): Global datasets of forest above-ground biomass for the years 2010, 2017 and 2018, v3. https://doi.org/10.5285/5F331C418E9F4935B8EB1B836F8A91B8
- Globbiomass - global datasets of forest biomass. https://doi.pangaea.de/10.1594/PANGAEA.894711
- Hanan et al. (2020), Gridded estimates of woody cover and biomass across sub-saharan697
- africa, 2000-2004, https://doi.org/10.3334/ORNLDAAC/1777
- Tucker et al. (2023), Sub-continental-scale carbon stocks of individual trees in african drylands. *Nature*, **615** (7950), 80–86. https://doi.org/10.1038/s41586-022-05653-6
- Liang Xu et al. (2021), Changes in global terrestrial live biomass over the 21st century. *Sci. Adv.7*, eabe9829. DOI:10.1126/sciadv.abe9829
- Avitabile et al. (2016), An integrated pan-tropical biomass map using multiple reference datasets. *Global Change Biology*, **22** (4), 1406–1420. https://doi.org/10.1111/gcb.13139
- Bouvet et al. (2018), An above-ground biomass map of african savannahs and woodlands at 25 m resolution derived from ALOS PALSAR. *Remote Sensing of Environment*, **206**, 156–17. https://doi.org/10.1016/j.rse.2017.12.030

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Thanks.

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Links of interest

Conference abstract (oral presentation). EGU 23.

JESAC project website: https://www.jesac-project.com

"Quantification of carbon stocks at the individual tree level in semi-arid regions in Africa." Paper submitted, under review.