Aboveground Carbon Biomass Estimate with Physics-informed Deep Network

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Paper: https://arxiv.org/abs/2210.13752

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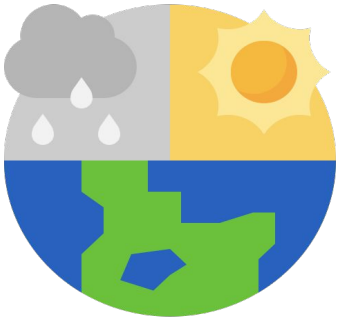
Why Biomass?



Key parameter in many climate processes (eg.carbon flux, sequestration, land productivity)

Monitor ecosystem risks (eg. wildfire, land-use changes)

Helps achieve carbon neutral goals (eg. carbon credit, reforestation)

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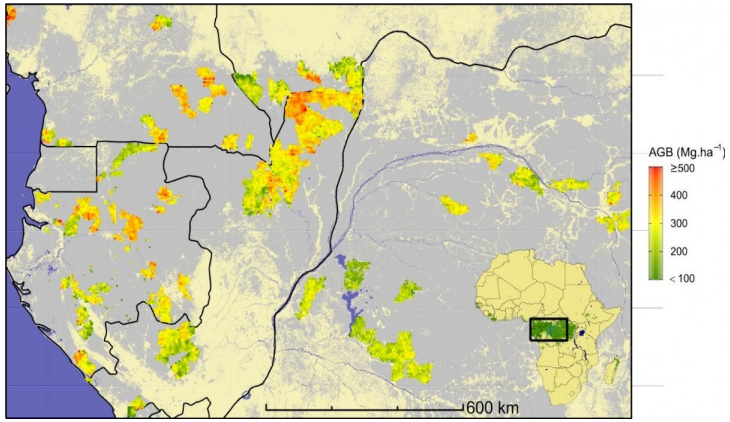
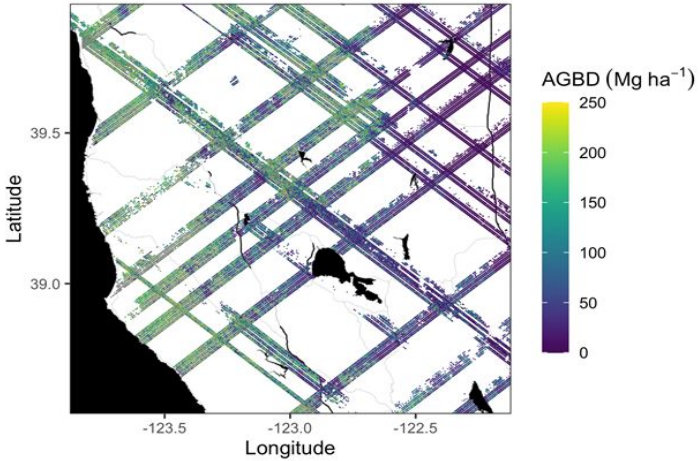
Current Challenges

Dense yet local data



Field plots: *expensive to measure accurate AGB (estimated with allometric equation that relates diameter, tree species, etc)*

Global yet sparse data



GEDI Mission: *state-of-the-art space-borne LiDAR system*

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Can we **interpolate** globally available AGB estimates, **validated** with accurate yet limited field observations, using **Physically-informed model?**

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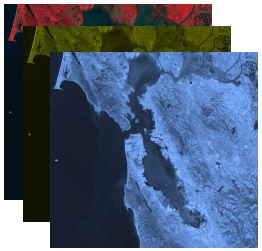
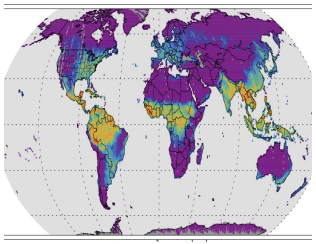
Our Approach



Sentinel-1 and
Sentinel-2 bands



SIF*-based GPP

Dense Inference

GEDI AGB

Prediction

Masking

Evaluation and Training

Deep Network

Validation

Ground-truth

Specifications:

Spatial resolution: CONUS, 30-meter resolution

Temporal resolution: Year 2021

Deep Network: Masked-variation of UNet

Solar-induced fluorescence (SIF) explains photosynthetic activities

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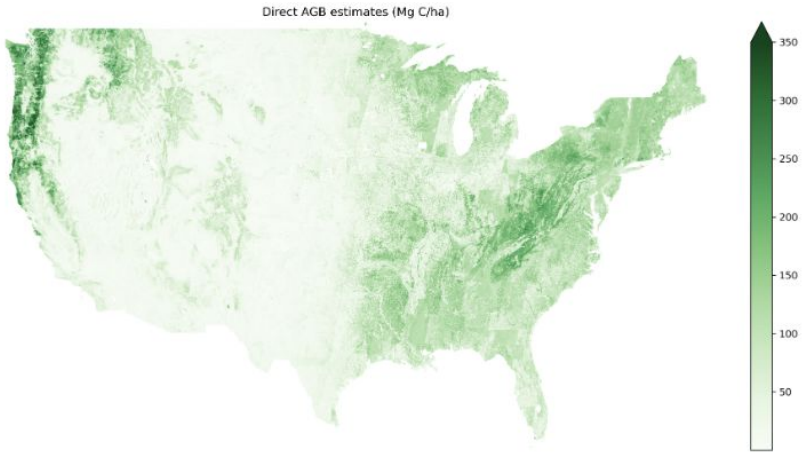
Results

Final Estimate



Model Performance & Ablation Study

Model	Inputs	Testing	Validation
Linear Regressor	SIF/S1/S2	66.07 ± 0.06	81.95 ± 0.01
	S1/S2	66.46 ± 0.10	84.33 ± 0.00
	S2-only	67.10 ± 0.11	90.99 ± 0.03
XGBoost	SIF/S1/S2	56.66 ± 0.06	53.37 ± 0.05
	S1/S2	57.35 ± 0.05	54.74 ± 0.03
	S2-only	57.82 ± 0.02	54.81 ± 0.26
RF	SIF/S1/S2	57.16 ± 0.05	52.30 ± 0.03
	S1/S2	58.05 ± 0.03	54.72 ± 0.06
	S2-only	58.12 ± 0.02	54.88 ± 0.18
UNet	SIF/S1/S2	$\mathbf{48.83 \pm 0.19}$	$\mathbf{37.93 \pm 1.36}$
	S1/S2	49.30 ± 0.18	41.99 ± 3.23
	S2-only	50.35 ± 0.43	45.93 ± 2.25

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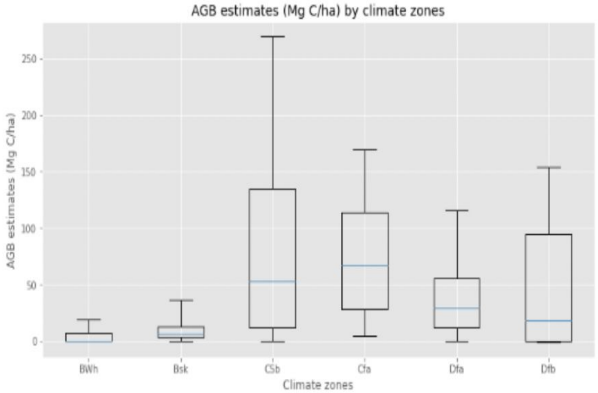
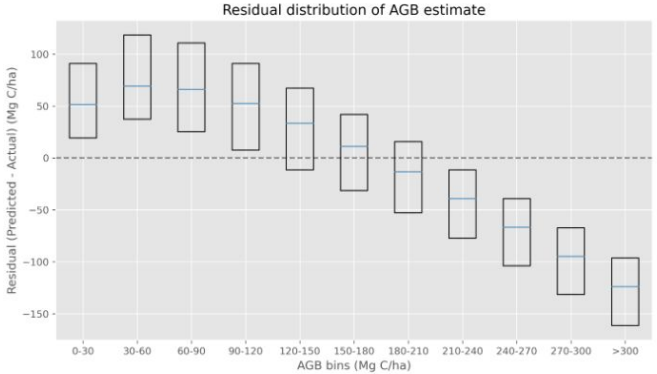
Evaluation

Internal Consistency



Agrees with literature: highest in summer temperate and lowest in (semi)-arid regions

Residuals



Overestimation for low AGB and underestimation for high AGB: difficulty to capture non-vegetation and extremely dense vegetation

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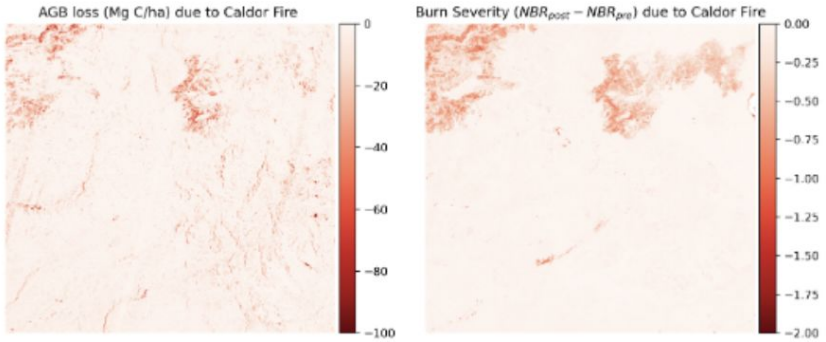
Application - Wildfire Monitoring

Case: Caldor Fire in California 2021

- Estimate AGB after and before the fire event
- Compare with Normalized Burn Ratio (NBR) that measured fire severity
- Close relationship between impact (AGB loss) and intensity (NBR difference)



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