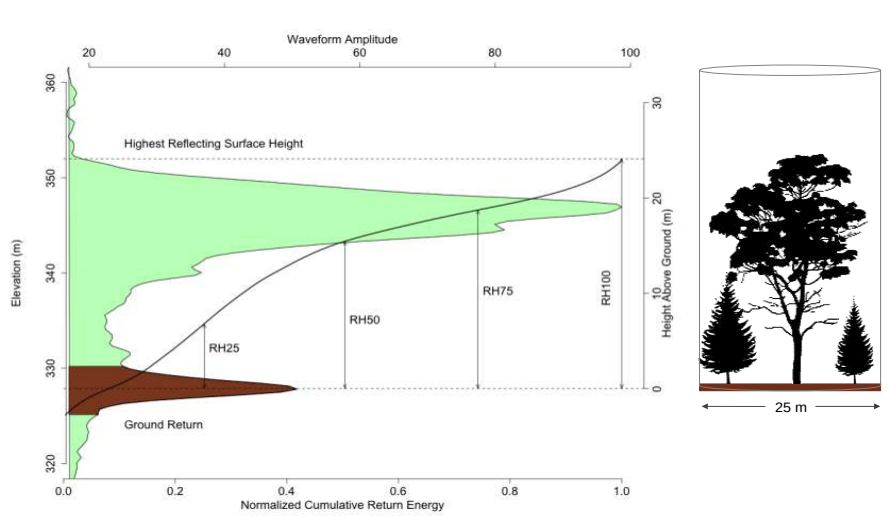


Comparison of Empirical Modeling Approaches for Modeling Forest Biomass with NASA's GEDI Mission

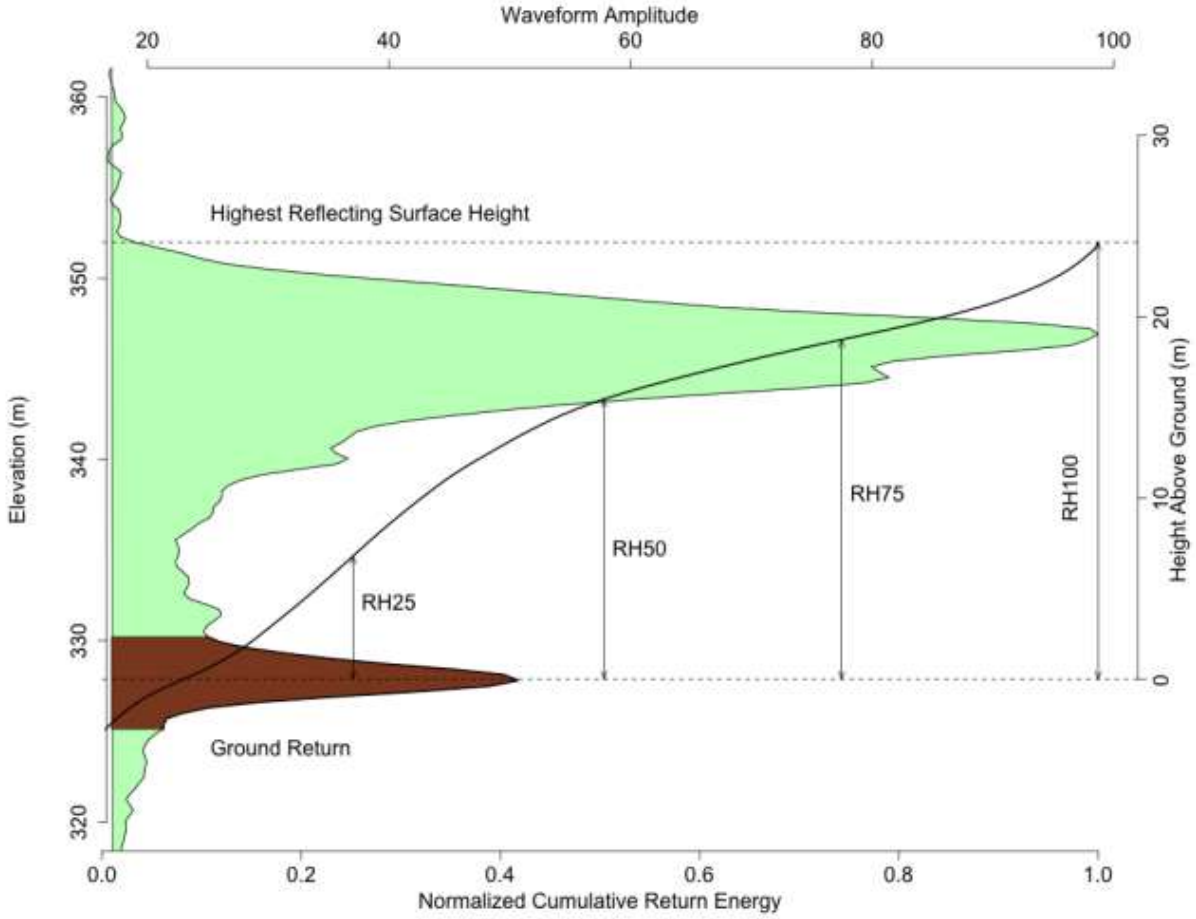
Laura Duncanson[1,2], John Armston[2], Jim Kellner[3], Steve Hancock[2], Suzanne Marselis[2], Ralph Dubayah[2] & the GEDI Science Team

1. NASA Goddard Space Flight Center 2. University of Maryland, College Park 3. Brown University

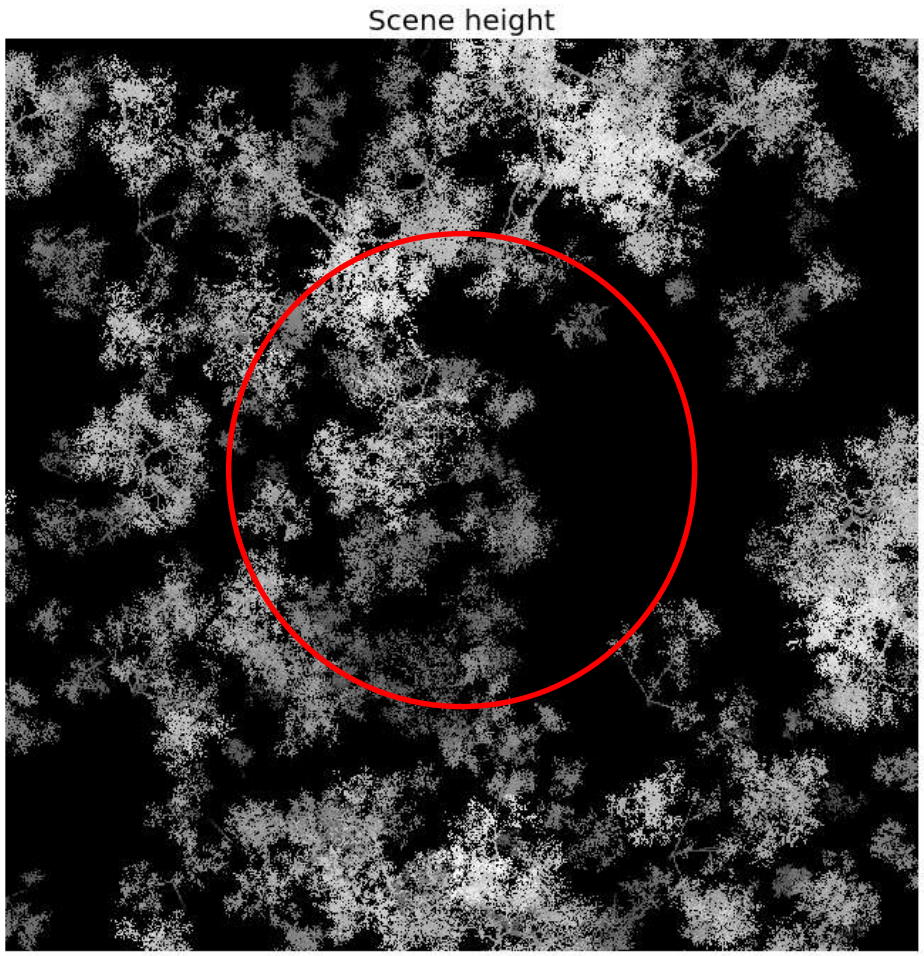
GEDI is the first spaceborne LiDAR designed specifically to study forests

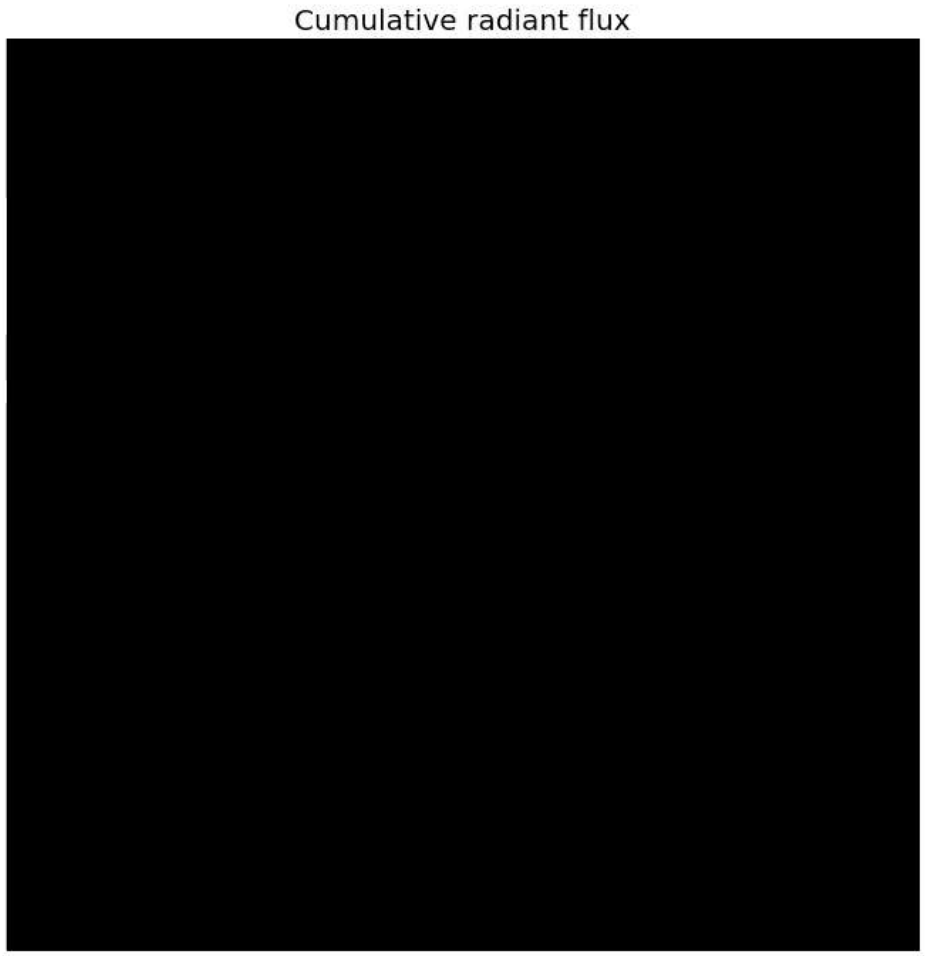
- Full waveform near infrared LiDAR system
- Launching to ISS in December, 2018
- Data products coming online in 2019
- ~12 billion cloud-free waveform observations of Earth's land surface are expected

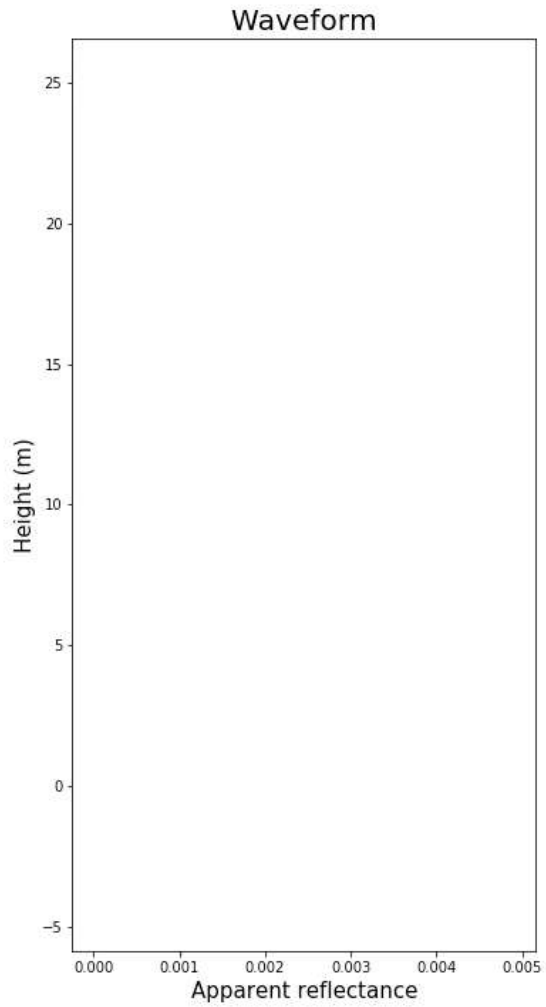
The only GEDI measurement is a lidar waveform



What is Waveform Lidar?





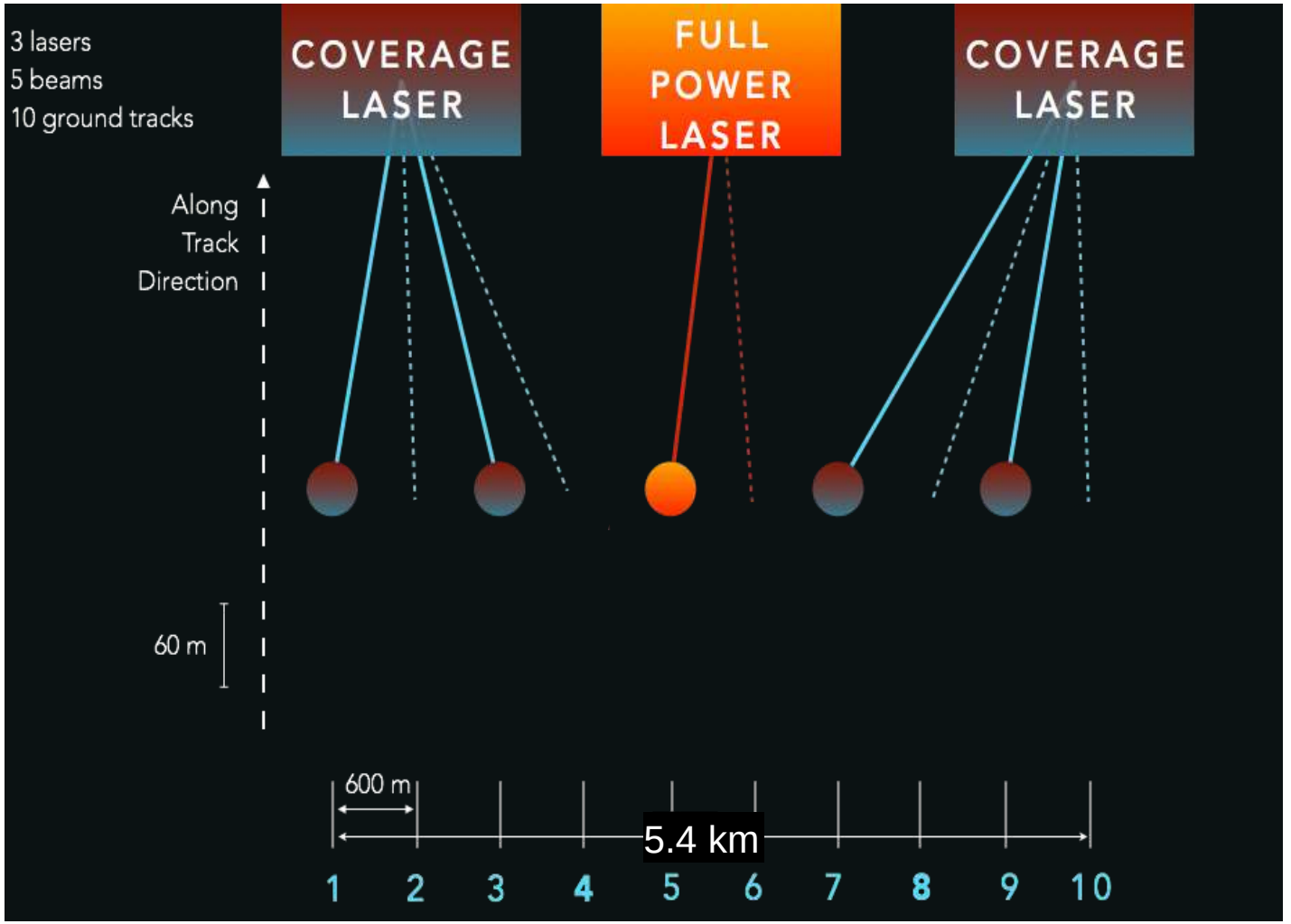


International Space Station

SPACE-X
DRAGON
CAPSULE

GEDI Sampling Design

- 3 Lasers, 5 Beams
  - 1 power
  - 4 coverage
- 10 Ground Tracks
- Will sample +/- ~51.5° N/S for 2 year period



How Do We Translate Waveforms to Biomass?

GEDI will likely sample for ~ two years

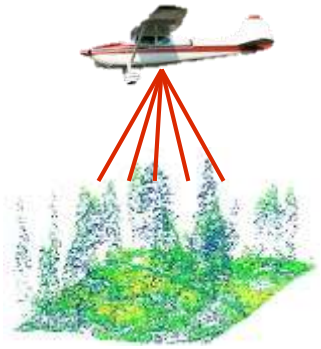
Each waveform will have ~7m geolocation accuracy (at one sigma)

Therefore:

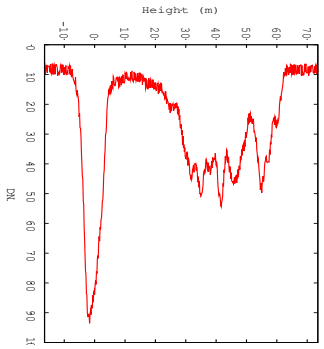
To develop algorithms relating lidar to biomass we rely on collaborations with an international network of scientists to collect existing field data co-located with airborne lidar data

How Do We Translate Waveforms to Biomass?

1. Use existing field plot a nd lidar data



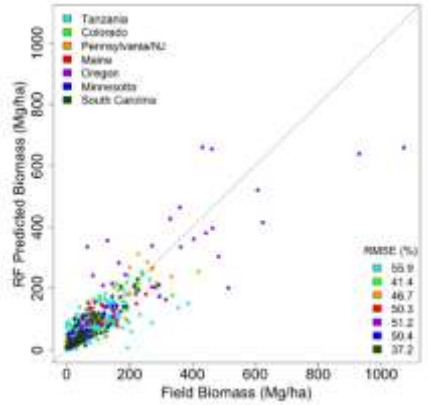
2. Simulate GEDI waveforms



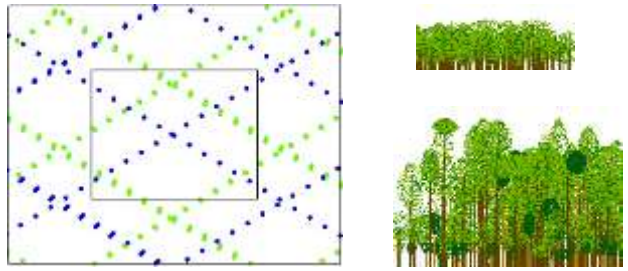
3. Extract GEDI Metrics

- RH Metrics
- Canopy cover
- Waveform shape
- Leading/trailing edge

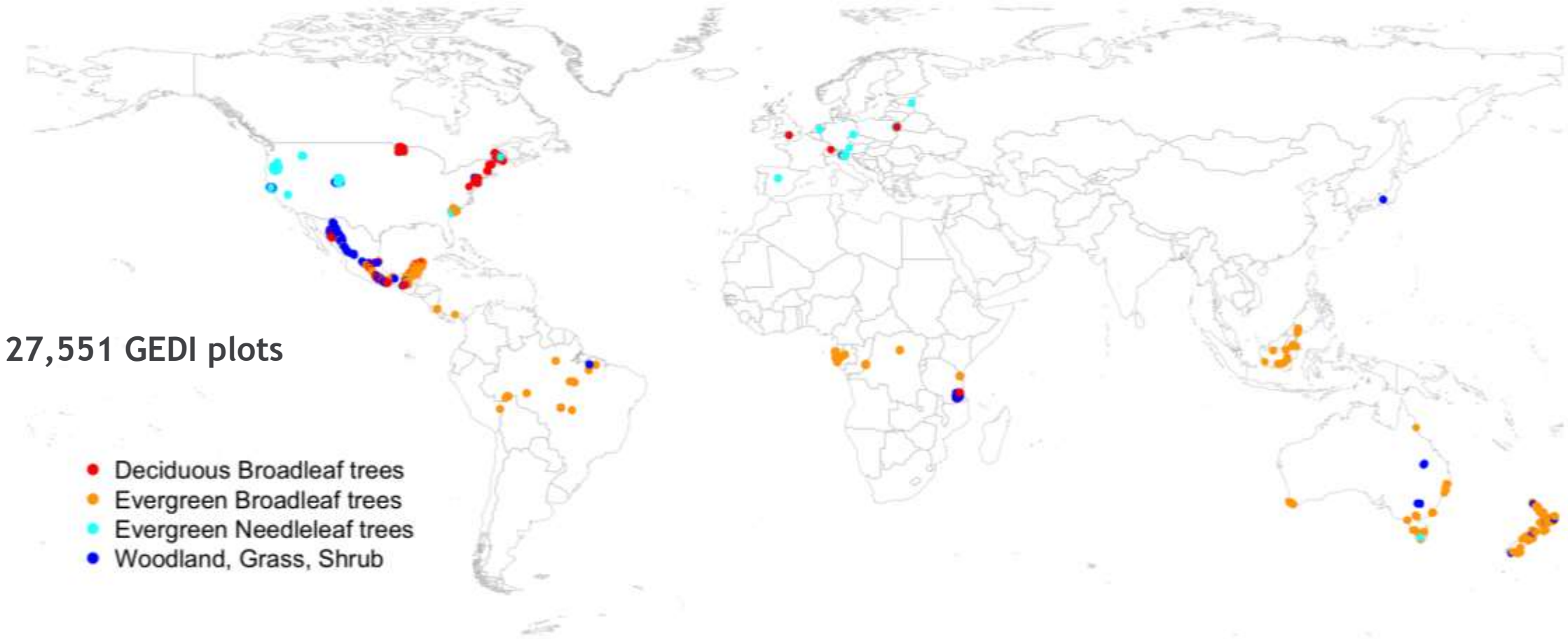
4. Build Calibration Models



5. Simulate Measurement and Sampling Uncertainties



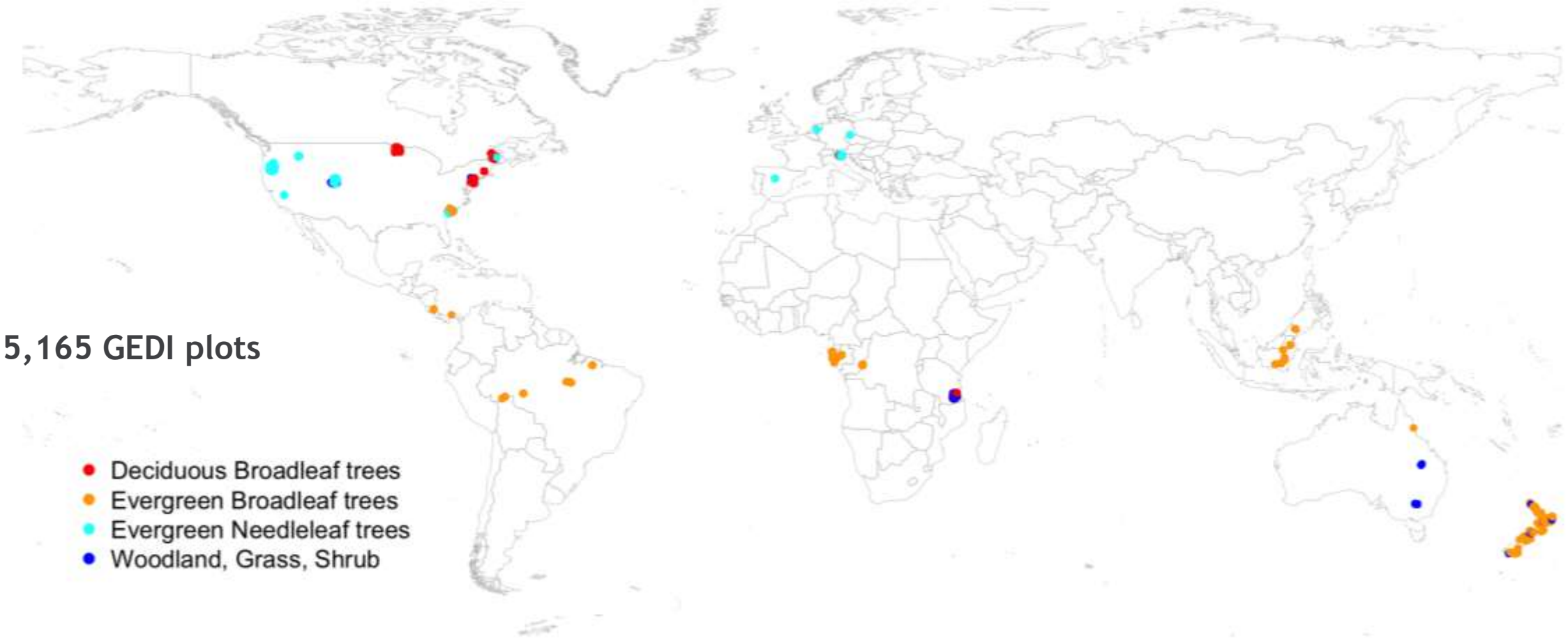
GEDI's Field and Lidar Calibration Database



Data are crowd-sourced from international collaborators

We require field data with spatially and temporally coincident airborne (or terrestrial) lidar

Data Subset Deemed ‘Analysis Ready’



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Biomass Calibration Strategy

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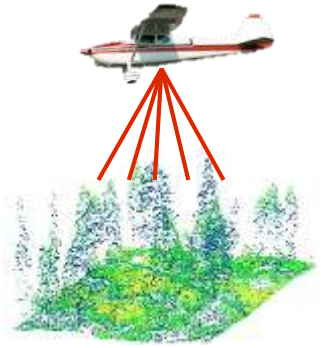

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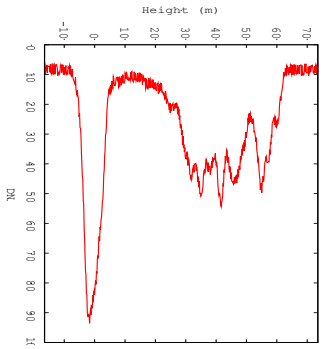

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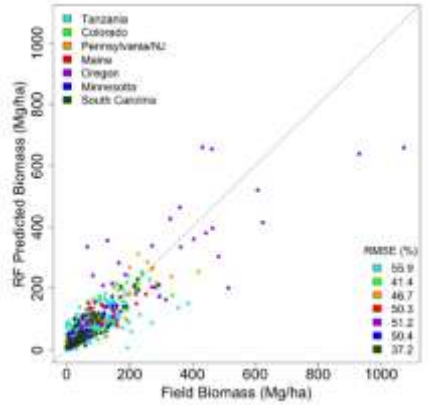

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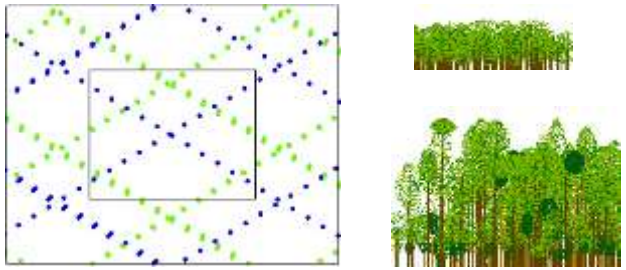
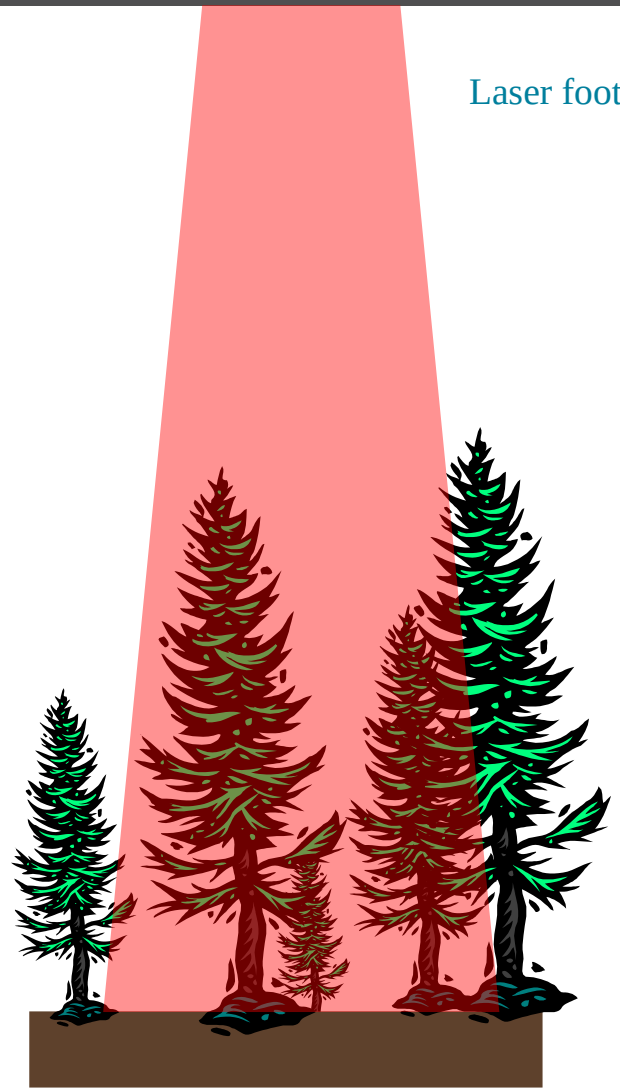
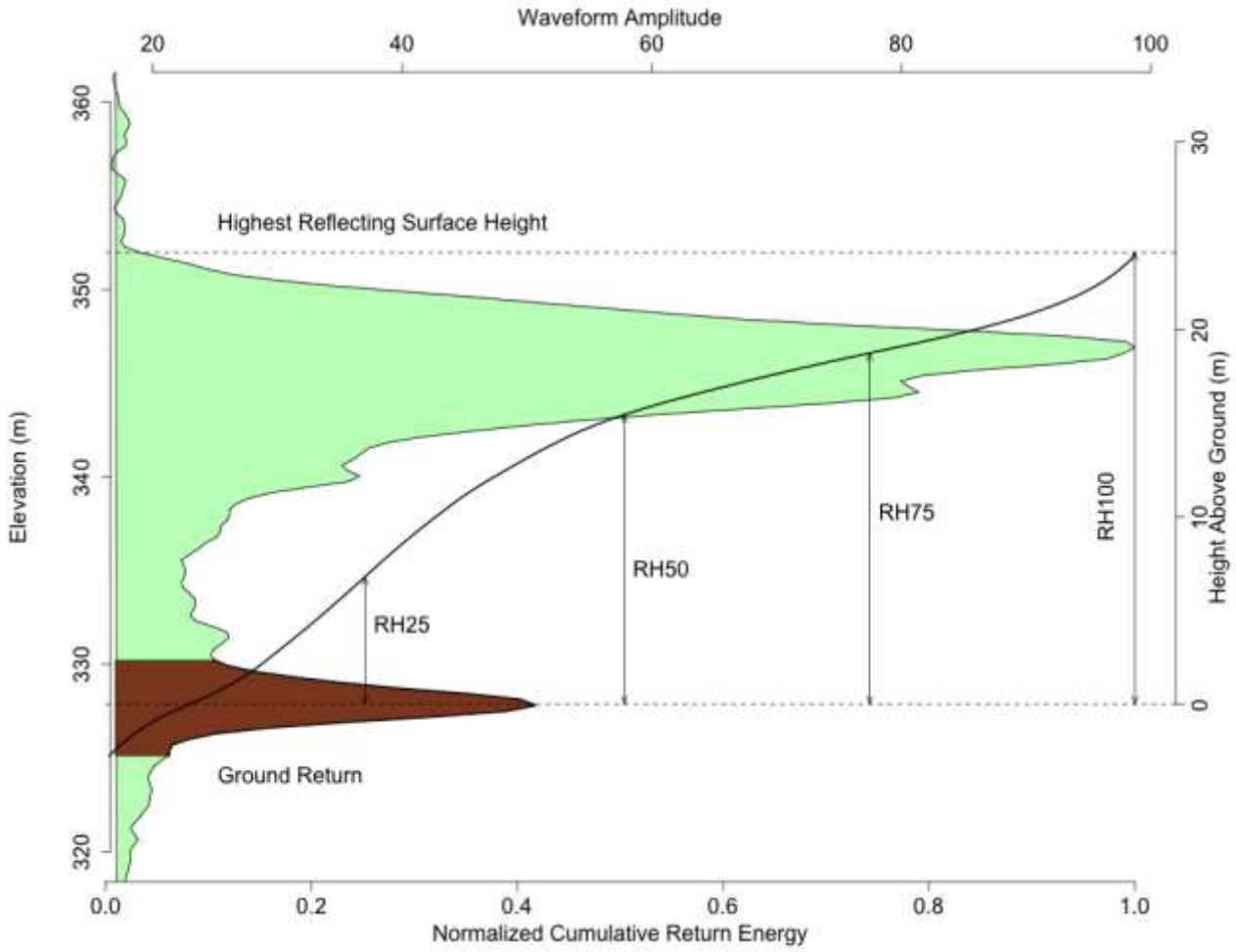


Simulating GEDI with Airborne Lidar





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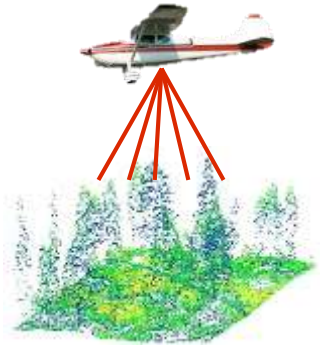

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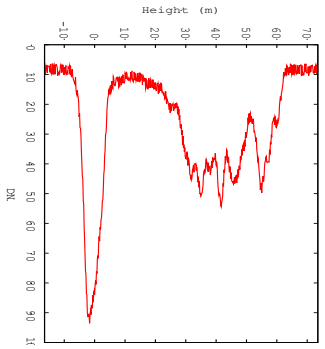

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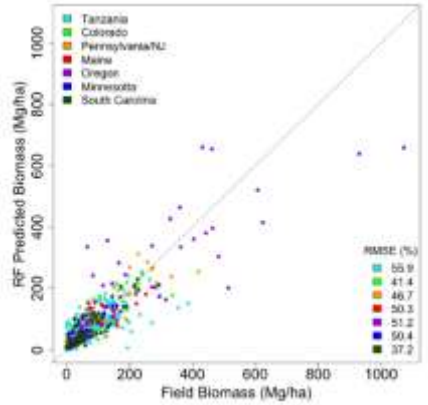

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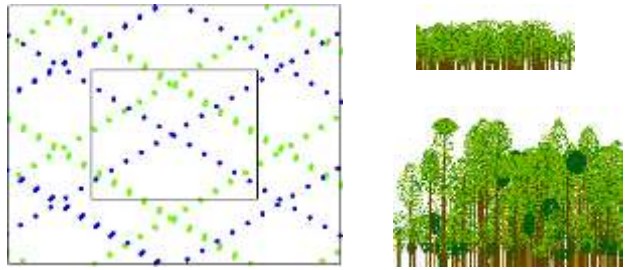

Biomass Calibration Strategy

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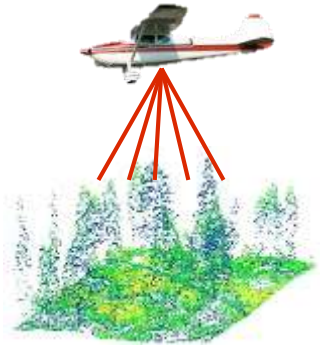

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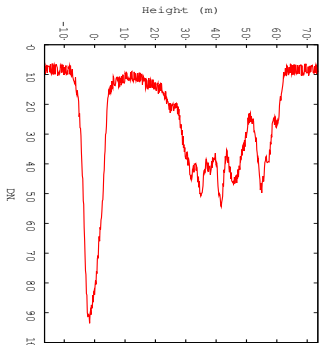

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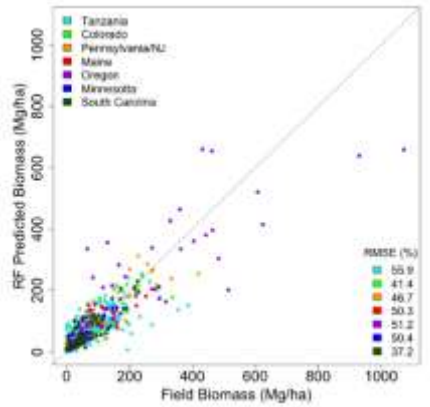

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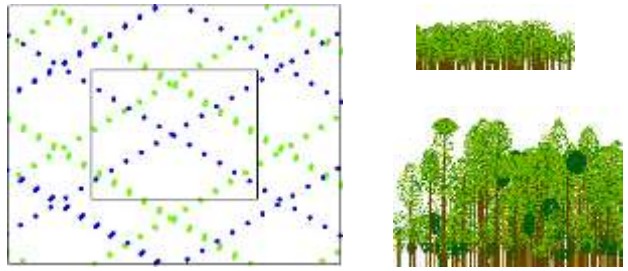
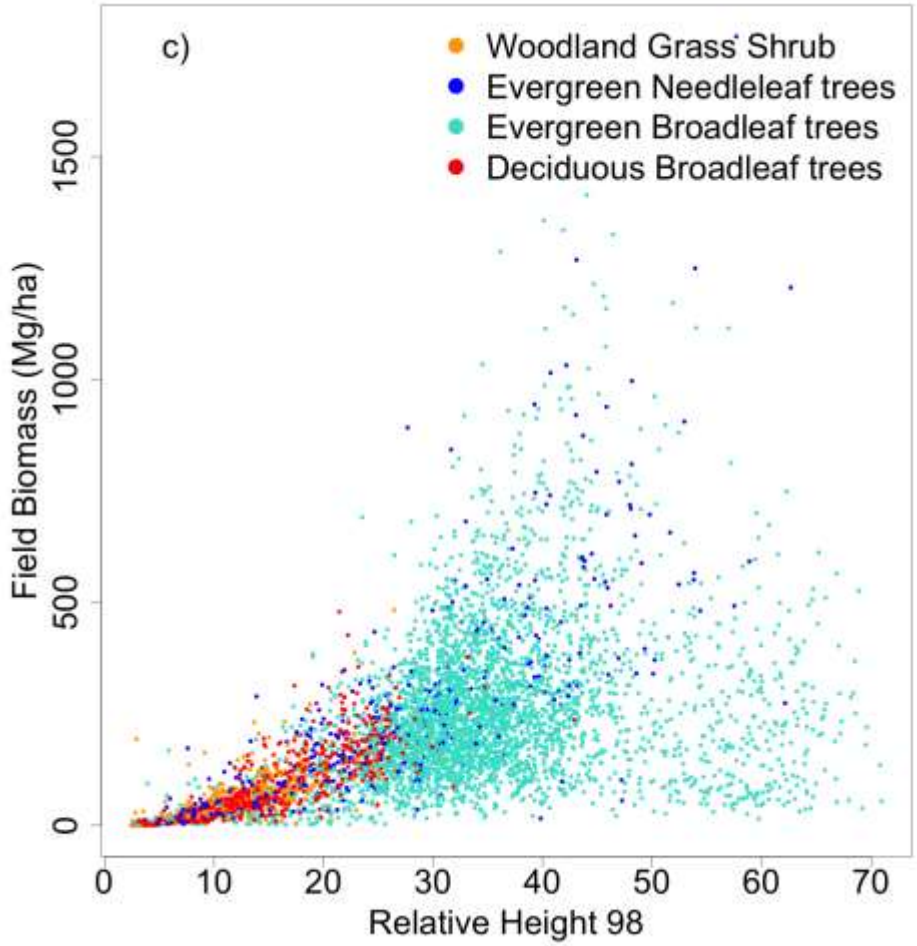
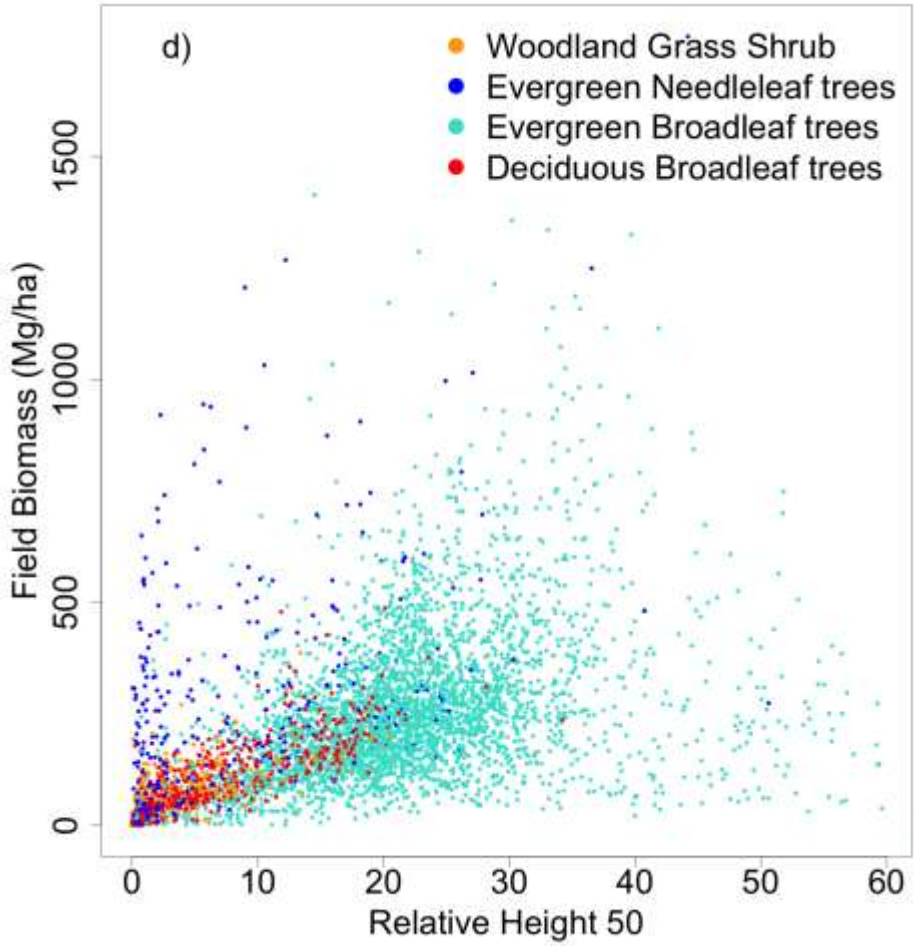


How universal are relationships between height and biomass?



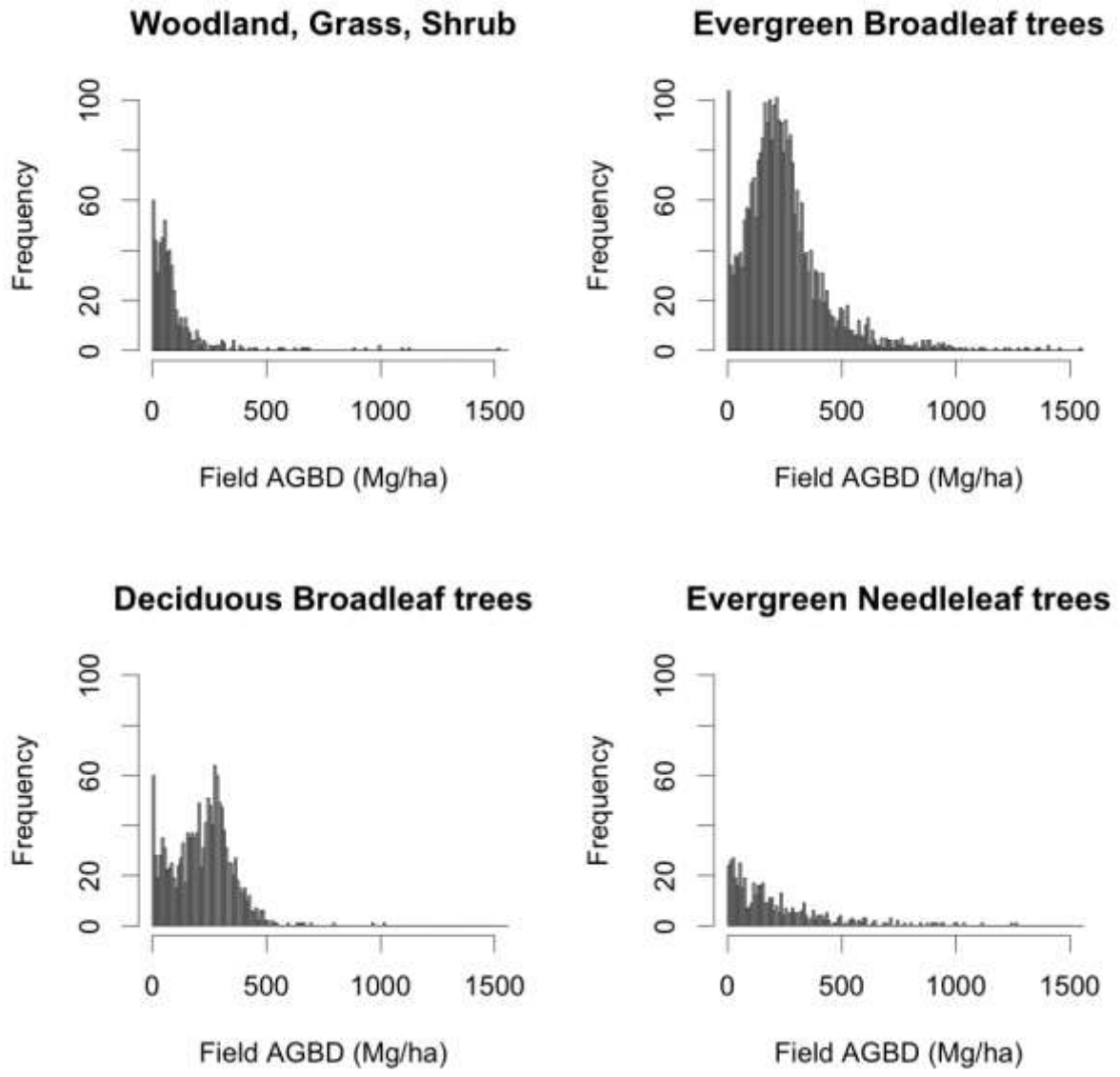


Empirical Models fit to Plant Functional Types

We fit models for each of 4 PFTs from MODIS

We test four statistical models:

1. Ordinary Least Squares (OLS) Regression
2. Partial Least Squares (PLS) Regression
3. Random Forest Regression
4. Theoretical Model: Biomass=f(Max height, Basal Area, Wood Specific Gravity)



GEDI ECOSYSTEM LIDAR

Theoretical Model

$$\text{Biomass} = a(\textbf{max\_height}^{b}) * c(\textbf{basal\_area}^{d}) * e(\textbf{wsg\_ba}^{f})$$

Where **max_height** is RH98 (max waveform height);

basal_area is predicted from a cross validated sub model as a function of a suite of waveform metrics; and

wsg_ba is basal area weighted wood specific gravity, which can either be fit using field estimates or from a regional look up table

Empirical Models fit to Plant Functional Types

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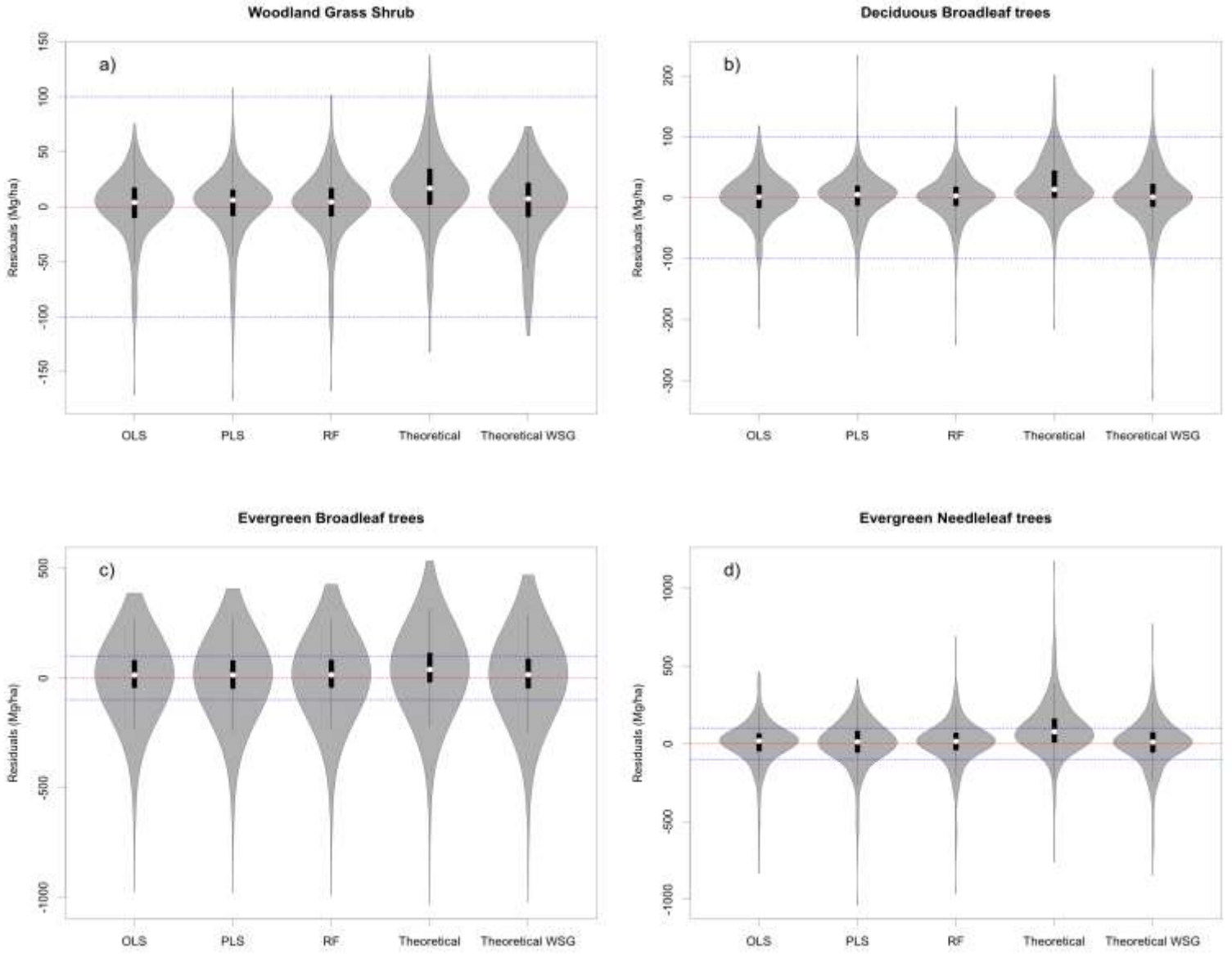
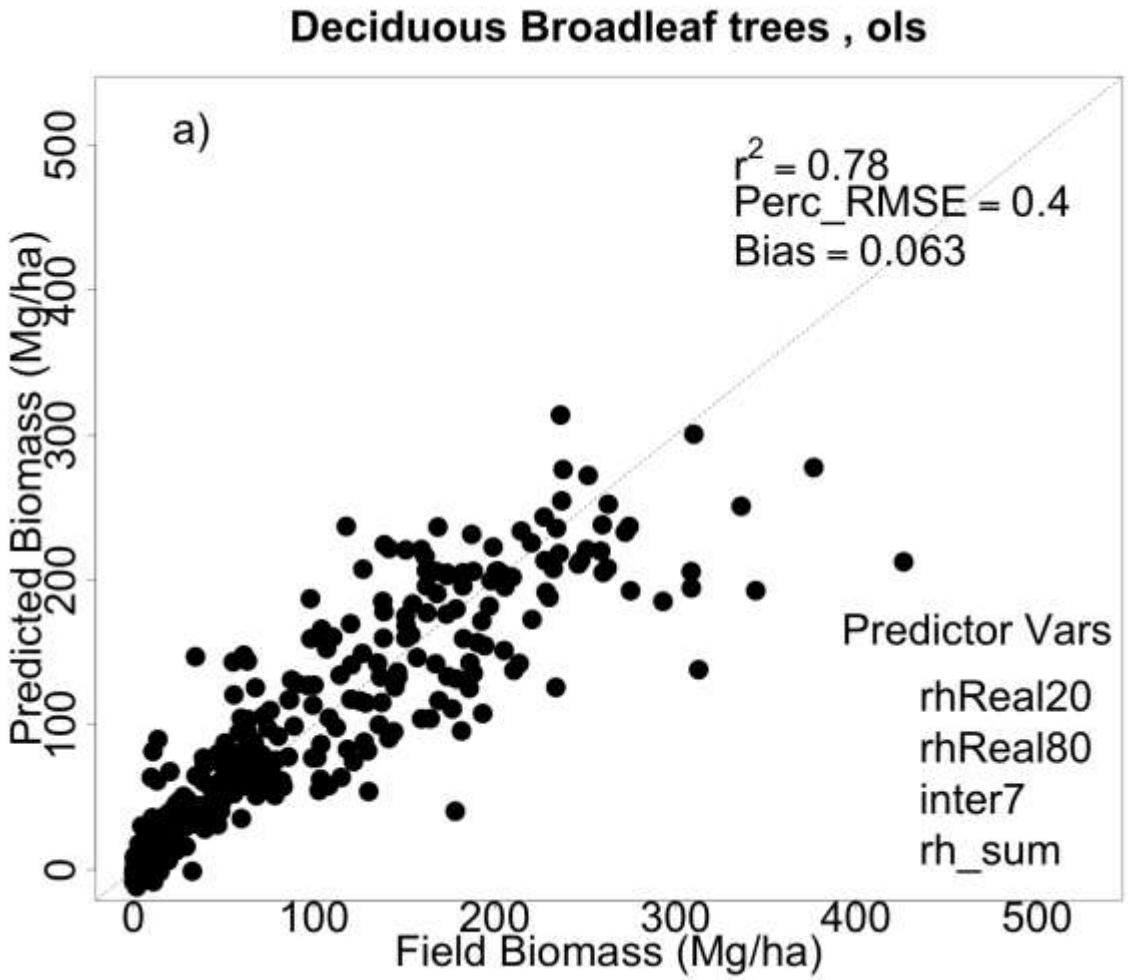
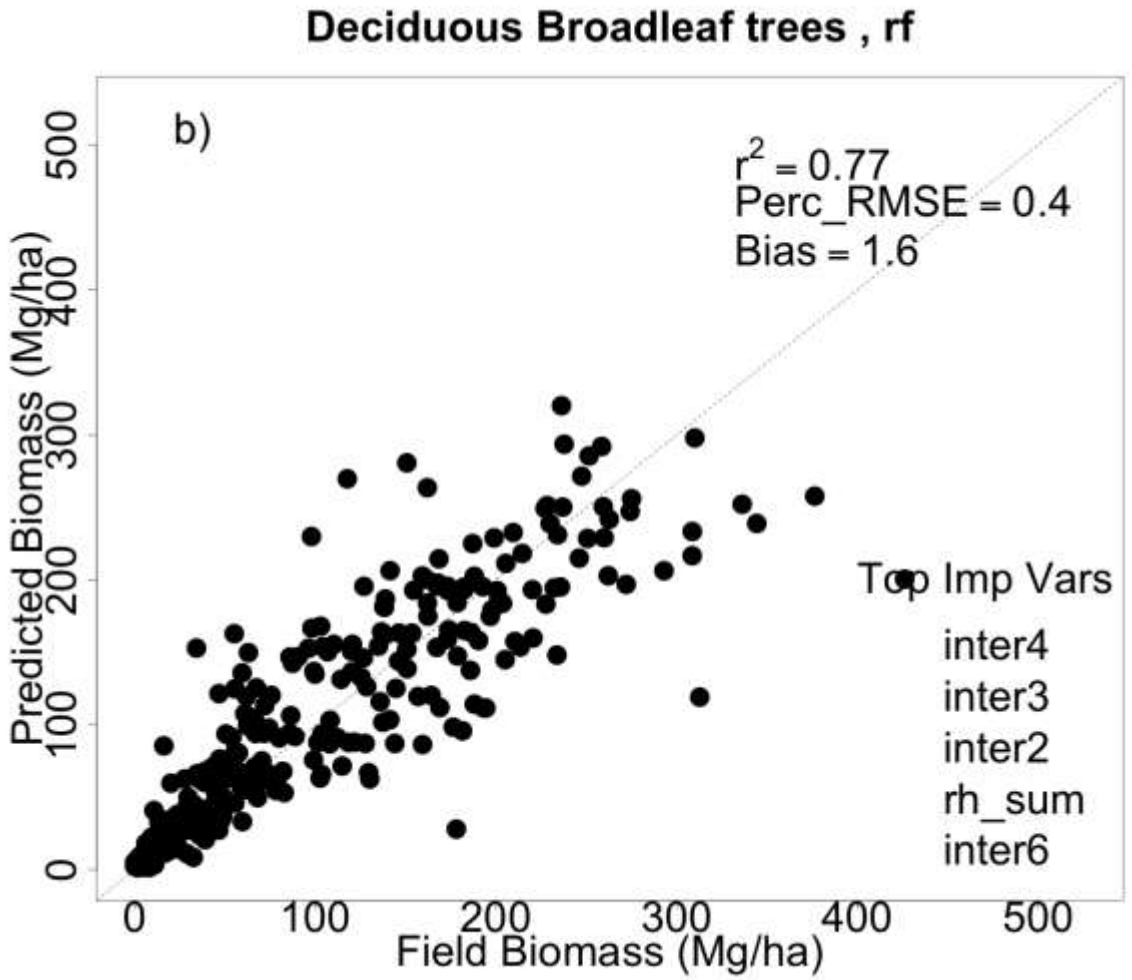


GEDI ECOSYSTEM LIDAR

Models perform similarly, but *are* different





GEDI ECOSYSTEM LIDAR

Models perform comparably, but select different predictors

NASA

UNIVERSITY OF MARYLAND

Conclusions

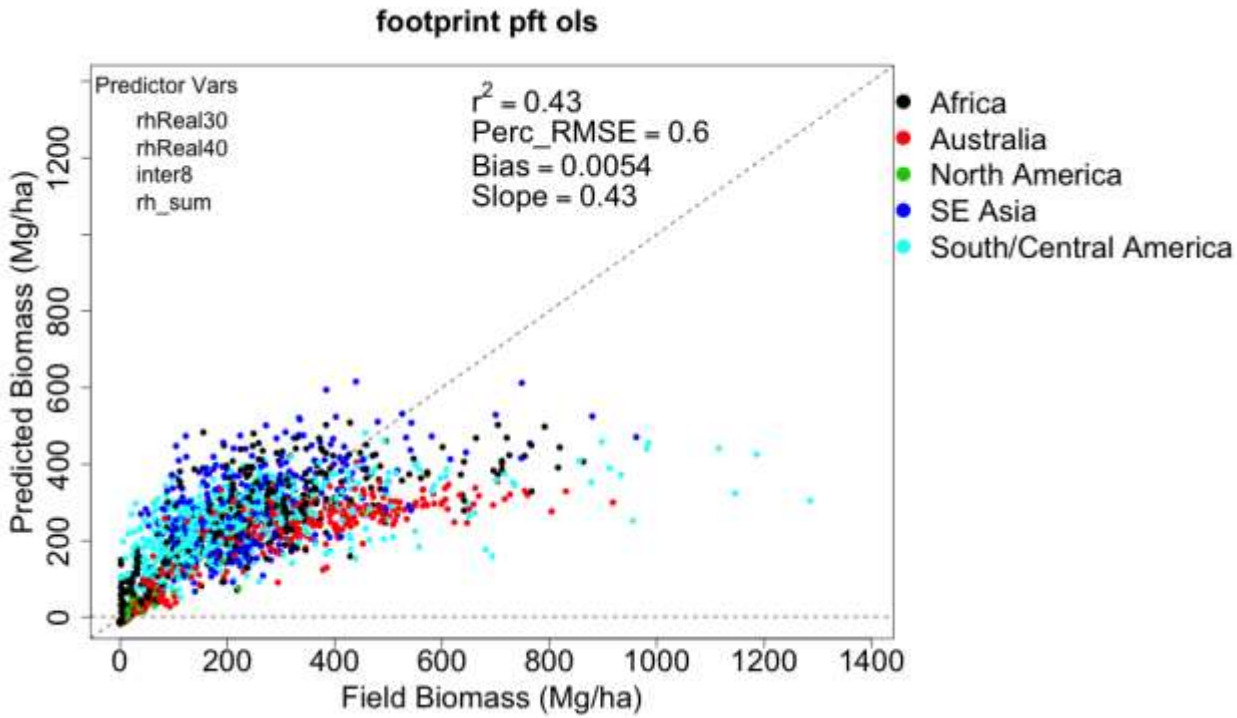
In terms of mean absolute cross validated residuals, empirical model selection does not appear to matter

We recommend choosing a model that can be easily interpreted (e.g. OLS, theoretical) as these models can help inform scientific progress

Next Steps

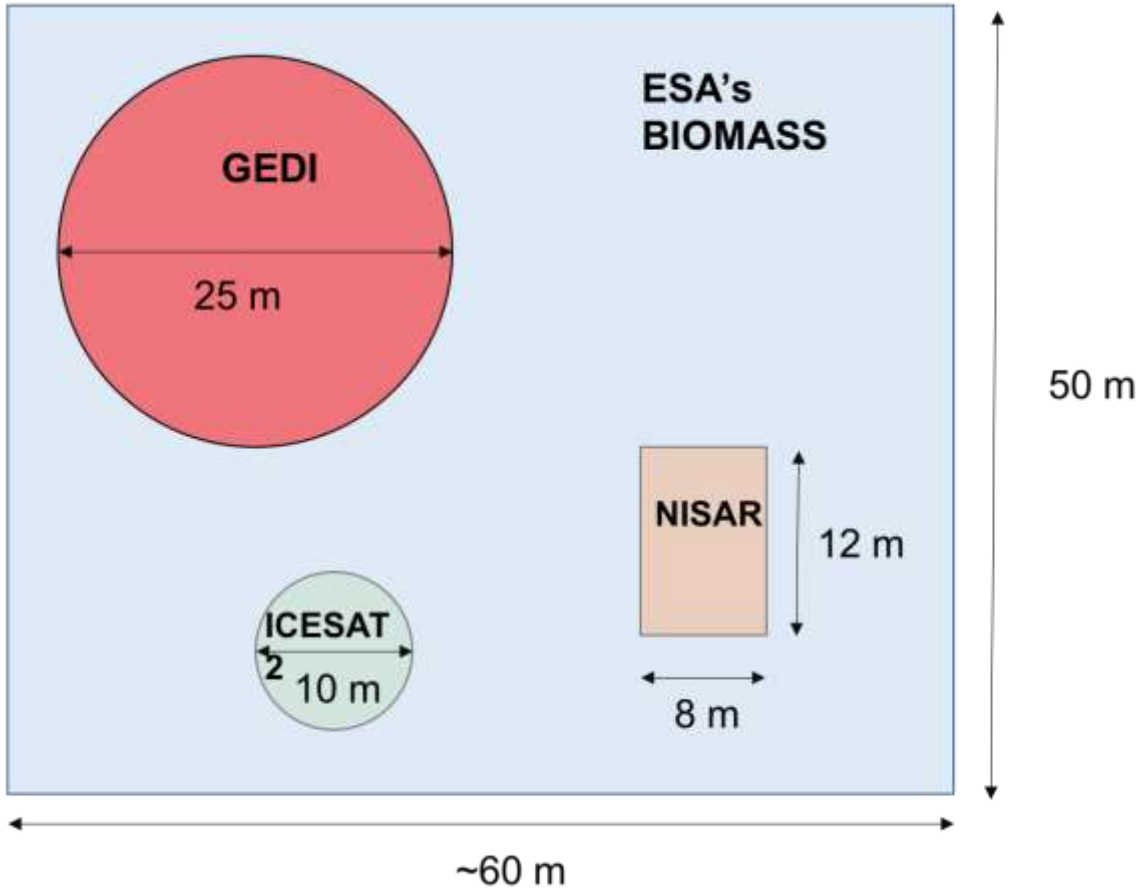
- Stratify the Evergreen Broadleaf PFT based on the observation that these tropical forests vary in structure by continent
- Include more data in model calibrations
- Determine global representativeness of current sample (and propose new airborne flights over existing field plots that may fill data gaps)

Broadleaf Evergreen OLS Model



The Potential of GFBI Data to the EO Community

- From several upcoming missions we expect dozens of global biomass products in the next decade
- Validating these future products is absolutely critical for science and policy communities
- Airborne lidar over field plots is the recommended path forward to enable validation of different remote sensing products a a single site



Thank You to our GEDI Data Collaborators!

Hans Anderson, Warren Cohen, Erik Næsset, Terje Gobakken, Andy Hudak, Mike Falkowski, Felix Morsdorf, David Coomes, Tomasso Jucker, Sassaan Saatchi, Marc Simard, Lola Fatoyinbo, Victoria Meyer, Antonio Ferraz, Elizabeth Kearsley, Hans Verbeeck, Simon Lewis, Paul Montesano, TERN Network, NEON, NASA CMS, David Clark, Deborah Clark, Jean-Francois Bastin, Mat Disney, Natascha Kljun, Wayne Walker, Embrapa (Michael Keller, Marcos Longo et al.), AfriSAR team, Ruben Valbuena, Jerome Chave, Ross Hill, Tim Baker, Jonathan Dash, Oliver Phillips, Doreen Boyd, Krzysztof Sterenczak, Yadvindar Malhi, Andreas Huth, Rico Fischer, Michele Dalponte, Juan Suarez, Tom Crowther