Biomass Estimation with GEDI and OBI-WAN

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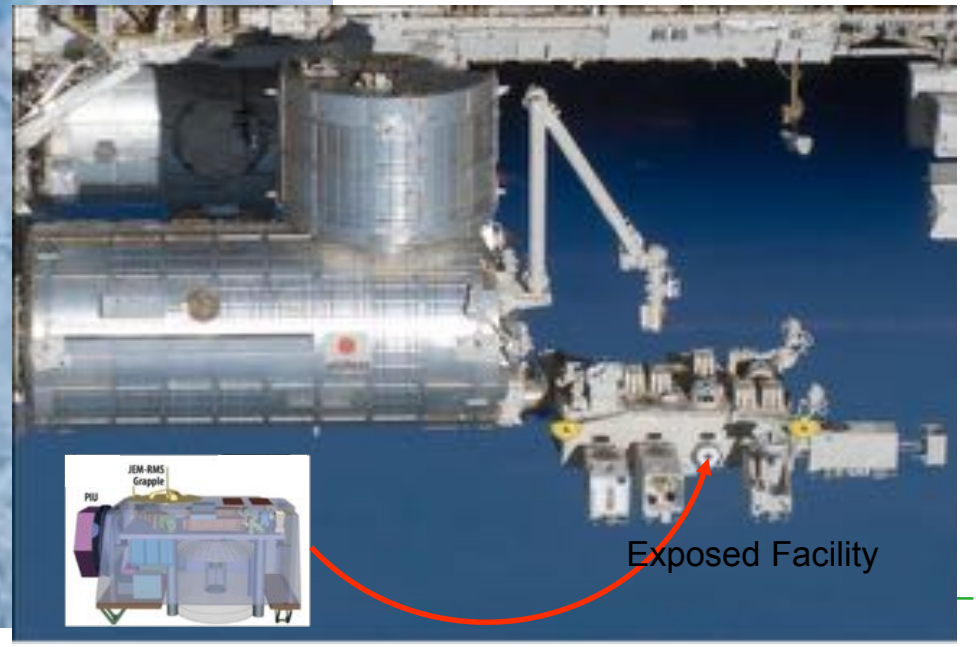
GEDI (Global Ecosystem Dynamics Investigation)

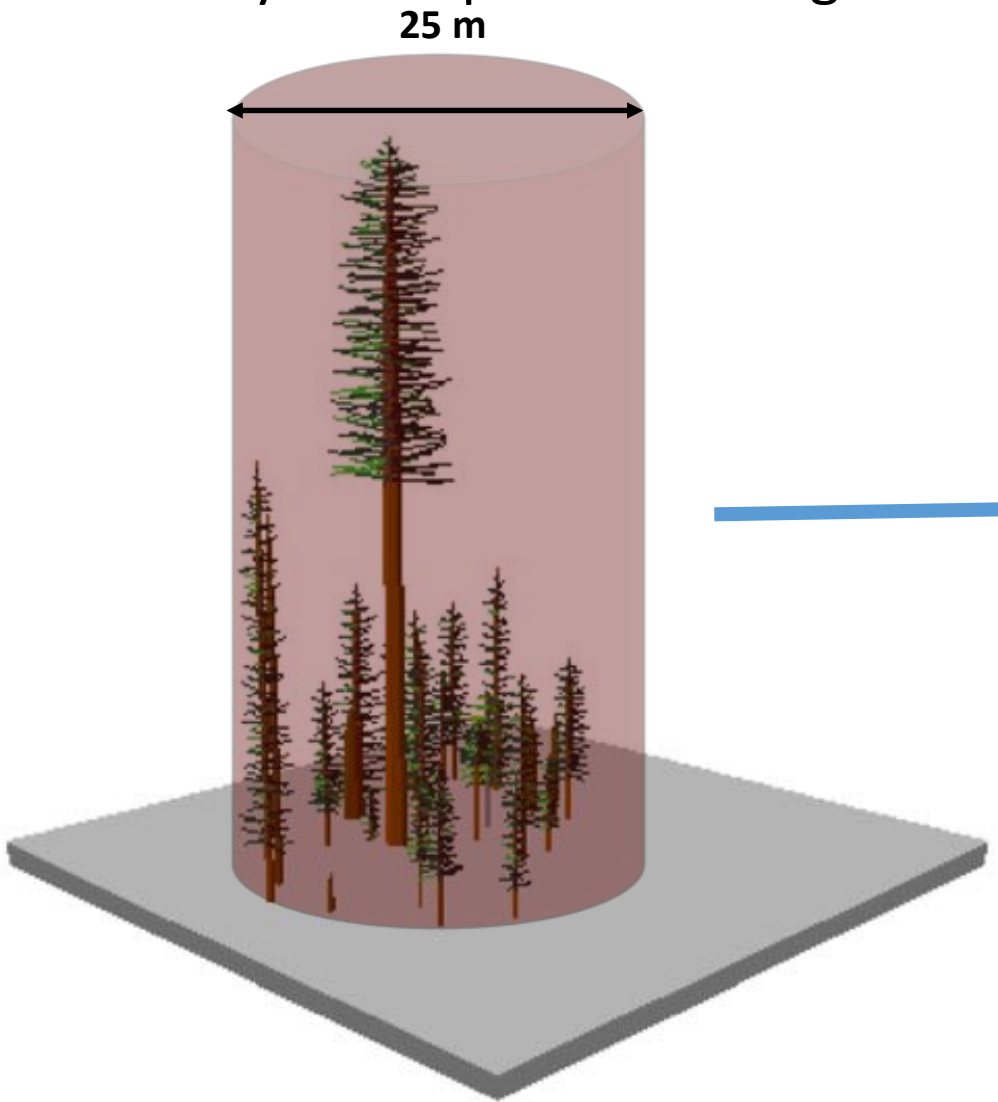
Investigator-led Venture-Class mission, launching 2018/19
(PI: Dubayah)

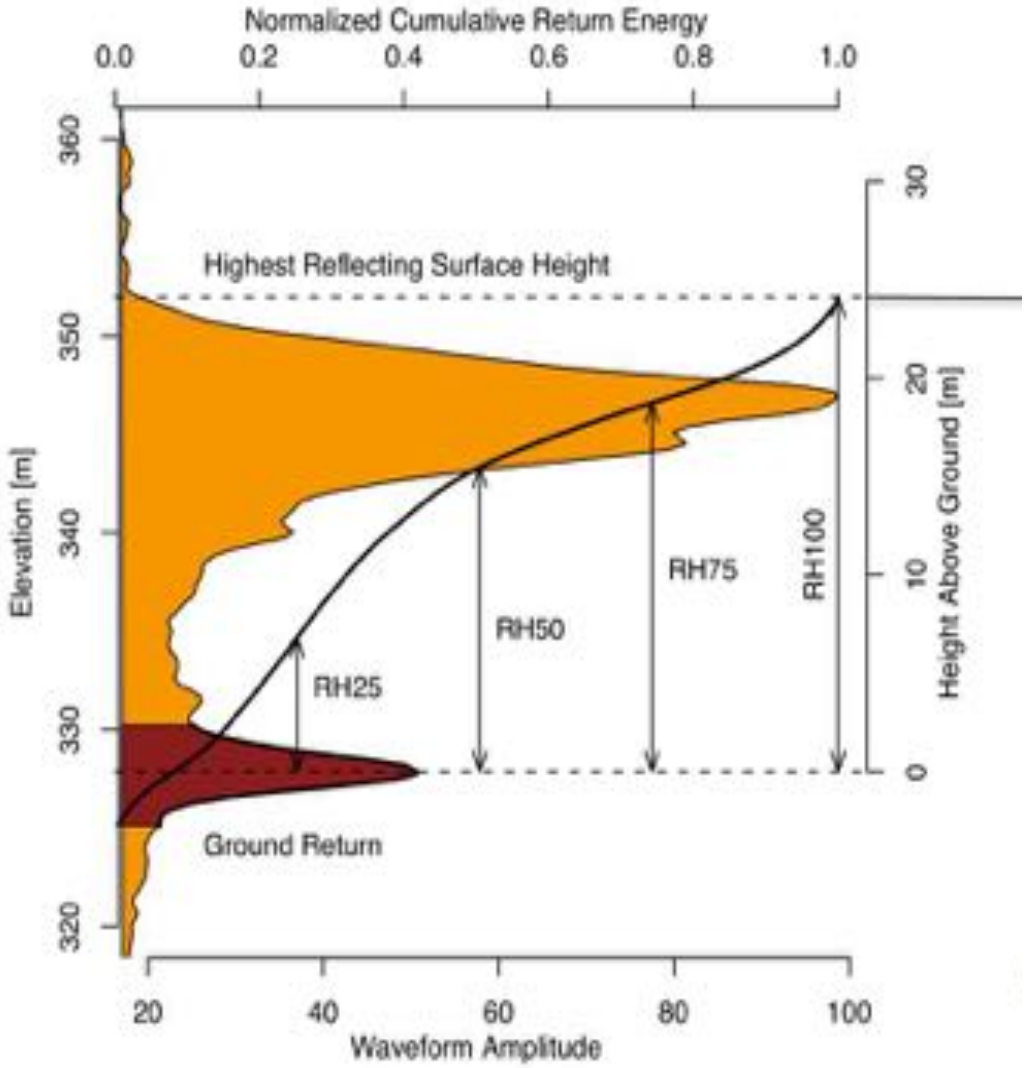
SPACE-X DRAGON CAPSULE

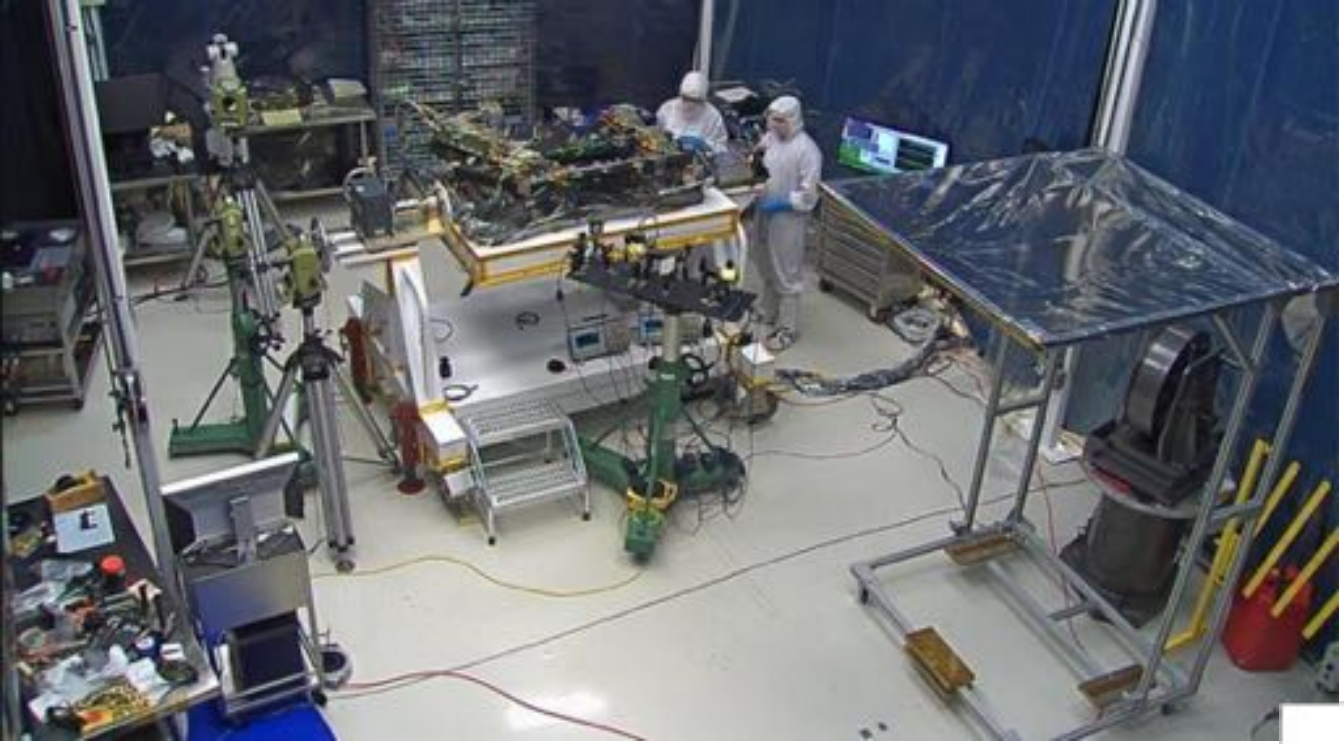


GEDI observes canopy structure by collecting “waveform” data over 25-m footprints

- Waveforms describe how dense the canopy is at different heights above the ground
- 20 years experience using similar measurements from LVIS

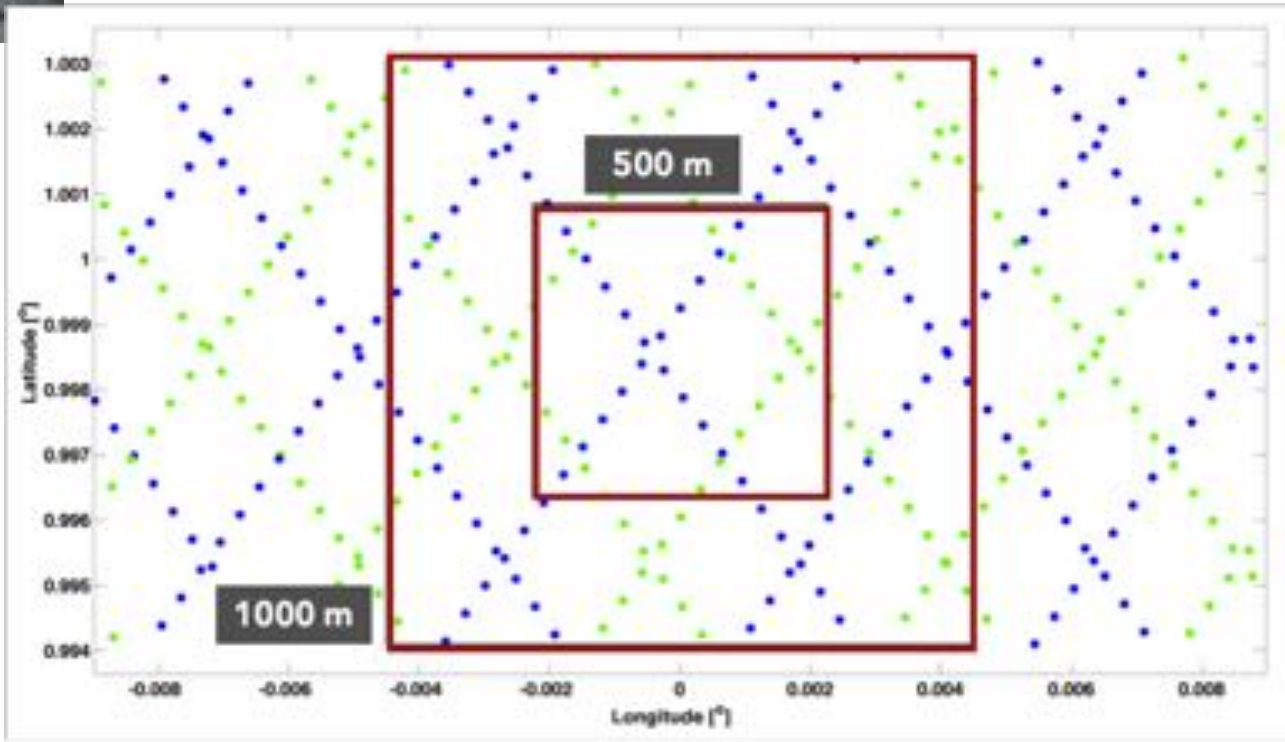






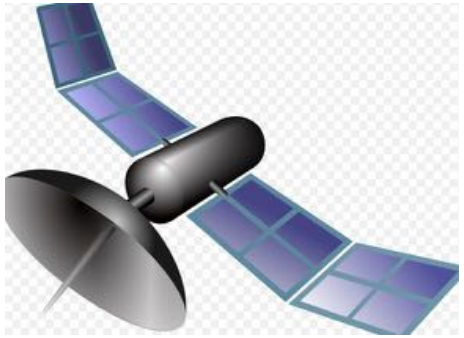
GEDI Launch Readiness Date:
27 November, 2018
Range: 51˚S to 51°N

Footprints will be acquired roughly in a lattice pattern (500-m cross track, 60-m along-track spacing), although the forest in many cases will be obscured by clouds



Challenge: Turn multiple 22m-footprint waveforms in a given spatial domain (including each 1km grid cell) into an estimate of mean biomass (with uncertainty)

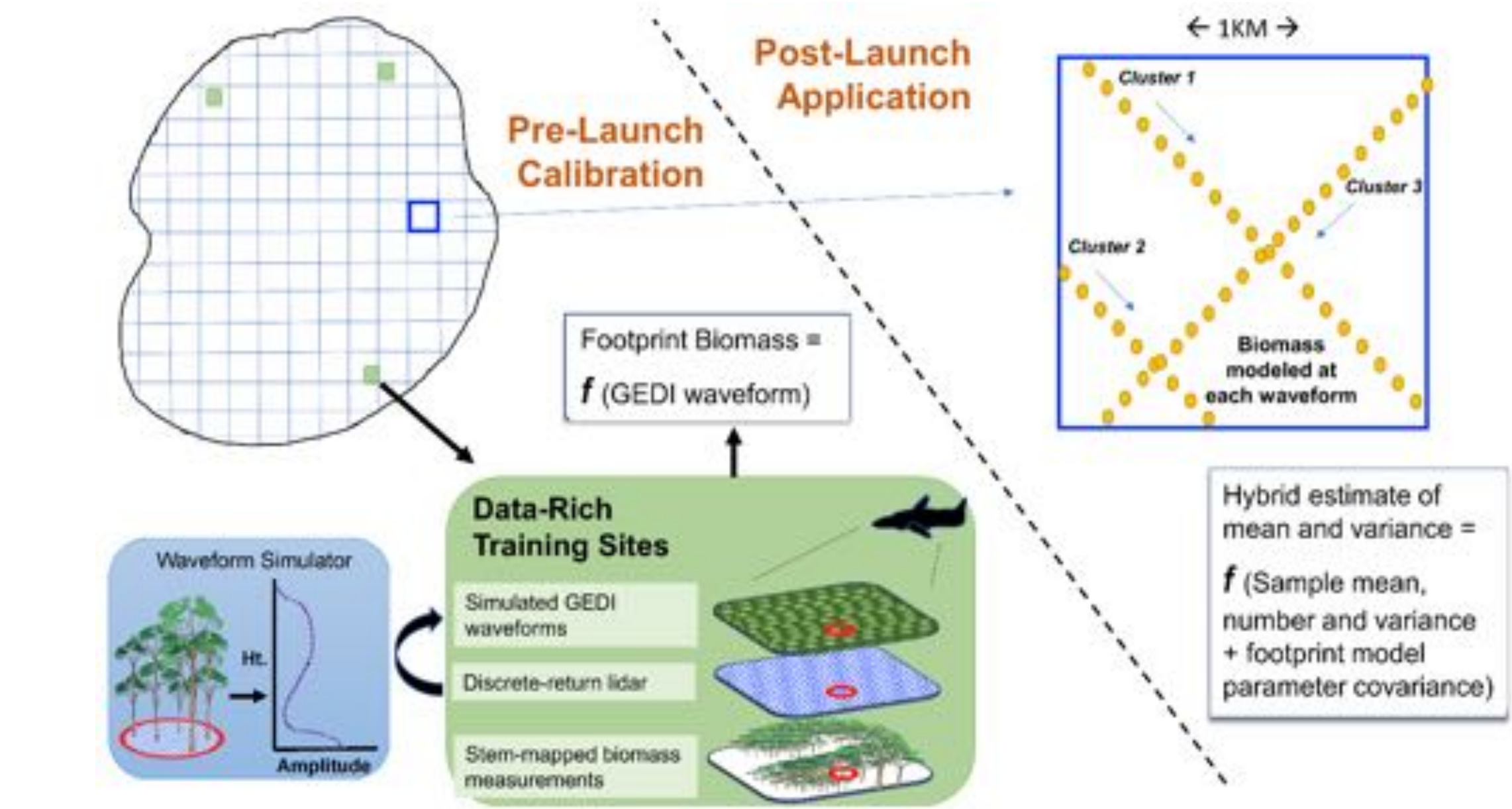
How do we think about inference?



	Remote Sensing	Inventory
Basis for estimate	Add up the pixels	Sample theory
Basis for uncertainty	Predicted vs. observed	Sample theory (sample variance and number)
Measure of uncertainty	RMSE, r^2	Standard Error

This dichotomy is changing

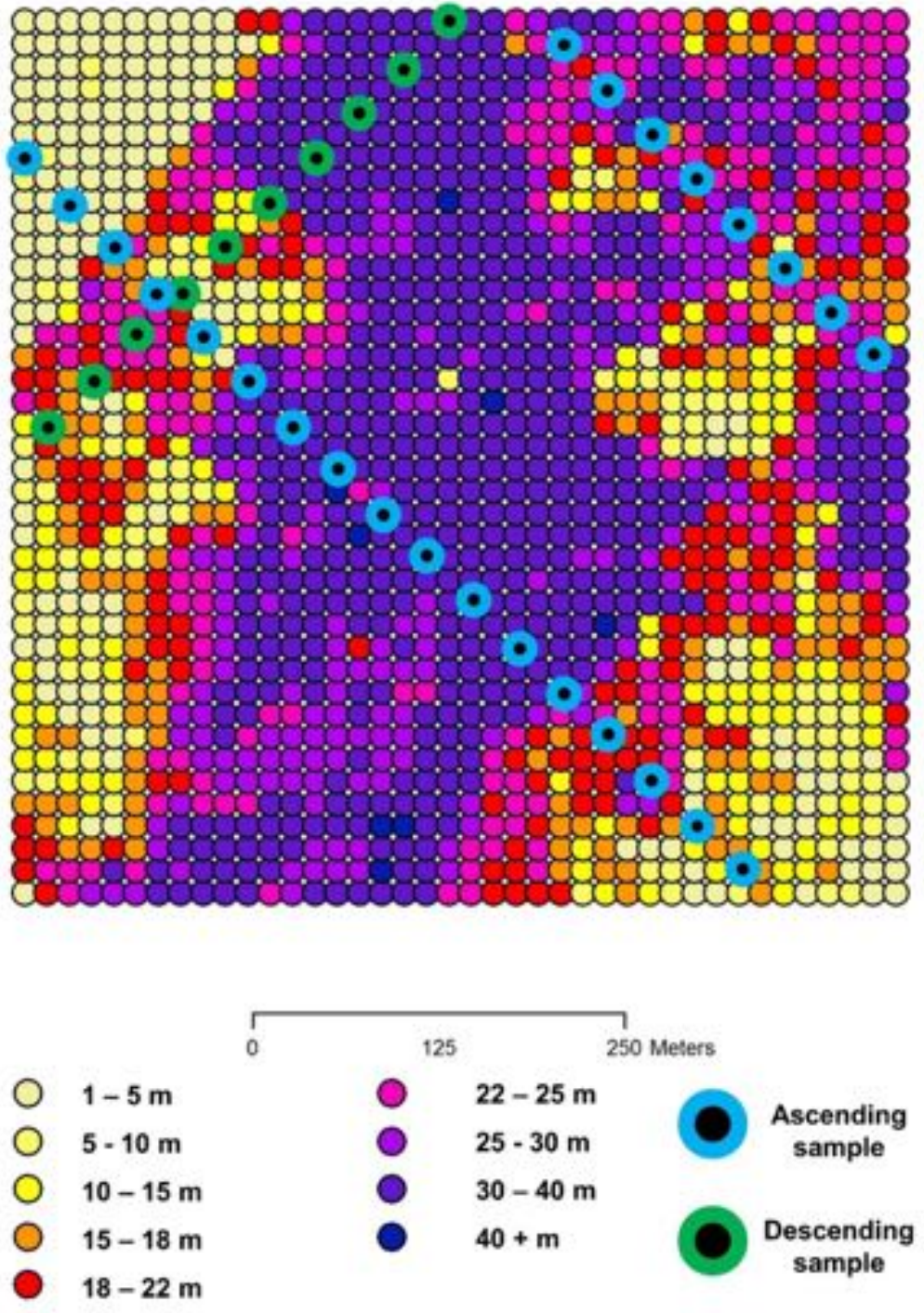
We are using a pre-launch calibration approach with hybrid inference



We see the 1-km grid cell as a finite population that is being sampled using a clustered design

Variance estimators at the 1-km scale (or for larger and/or irregularly shaped domains) consider both sample design and model covariance

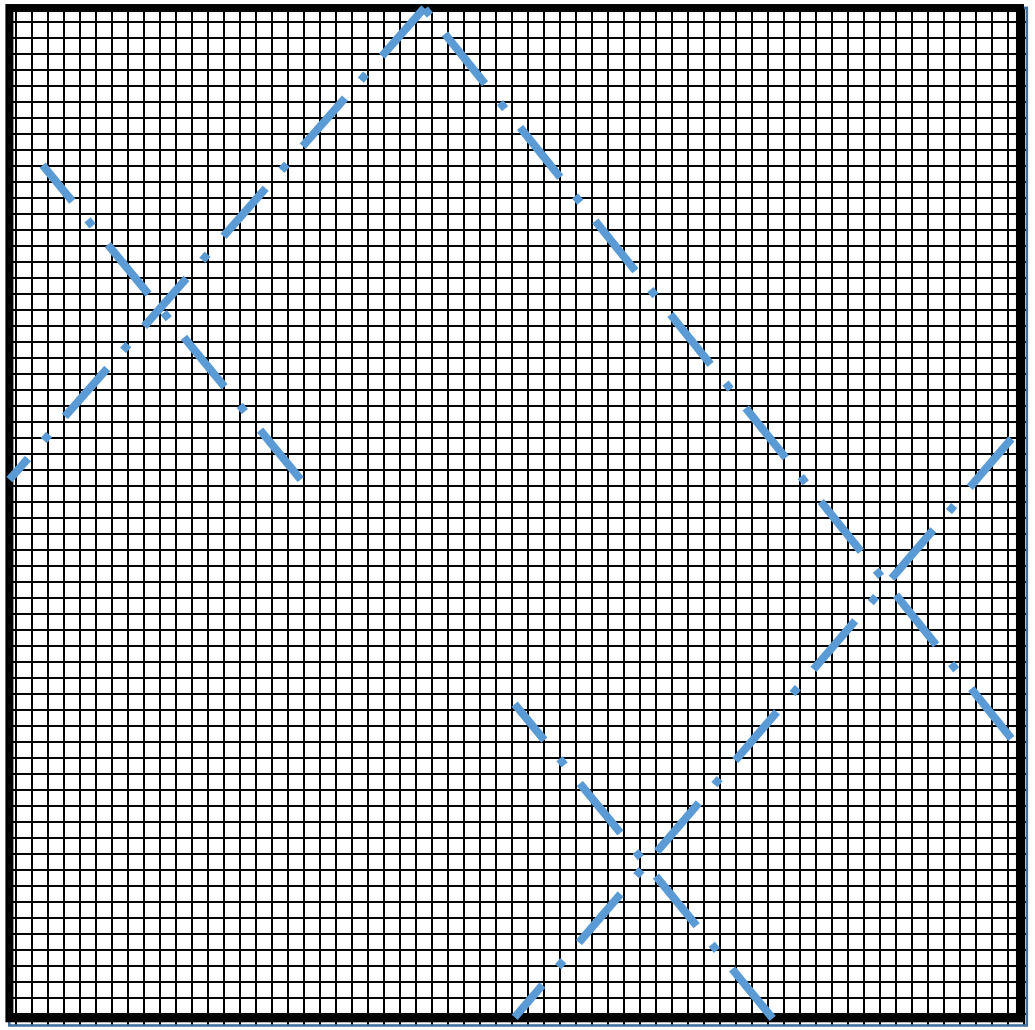
Patterson et al., In review, *Environmental Research Letters*



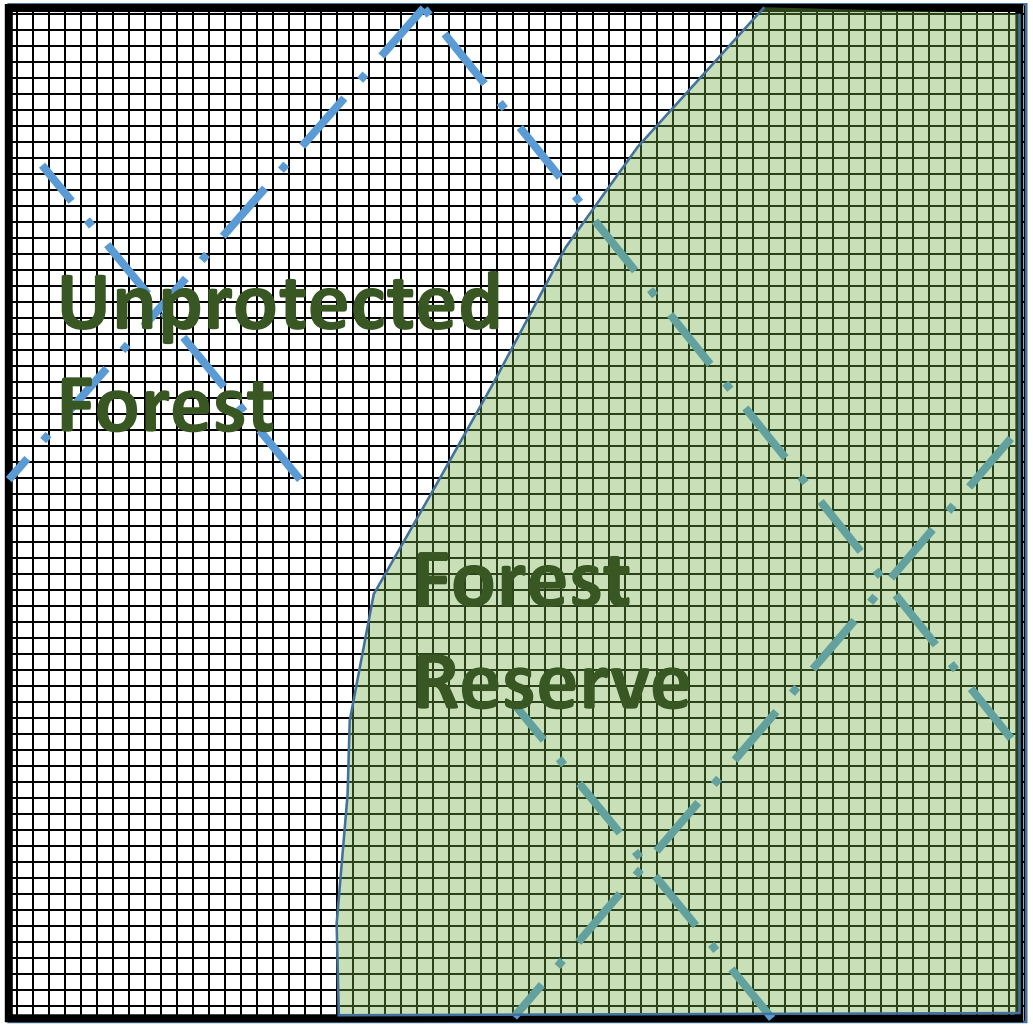
Supplementing GEDI with wall-to-wall imagery will allow us to make estimates for areas obscured by clouds and may reduce our standard errors

Hierarchical Model-Based Inference

- **Model biomass: ground → GEDI → Local Landsat (or NISAR or Tandem-X)**
- **Account for multiple levels of model uncertainty**
- **Add up the Landsat-scale predictions**



Saarela et al. (2016) *Annals of Forest Science*
Saarela et al. (In review) *Remote Sensing*



There is no reason hierarchical model-based inference should be limited to grid cells

OBI-WAN

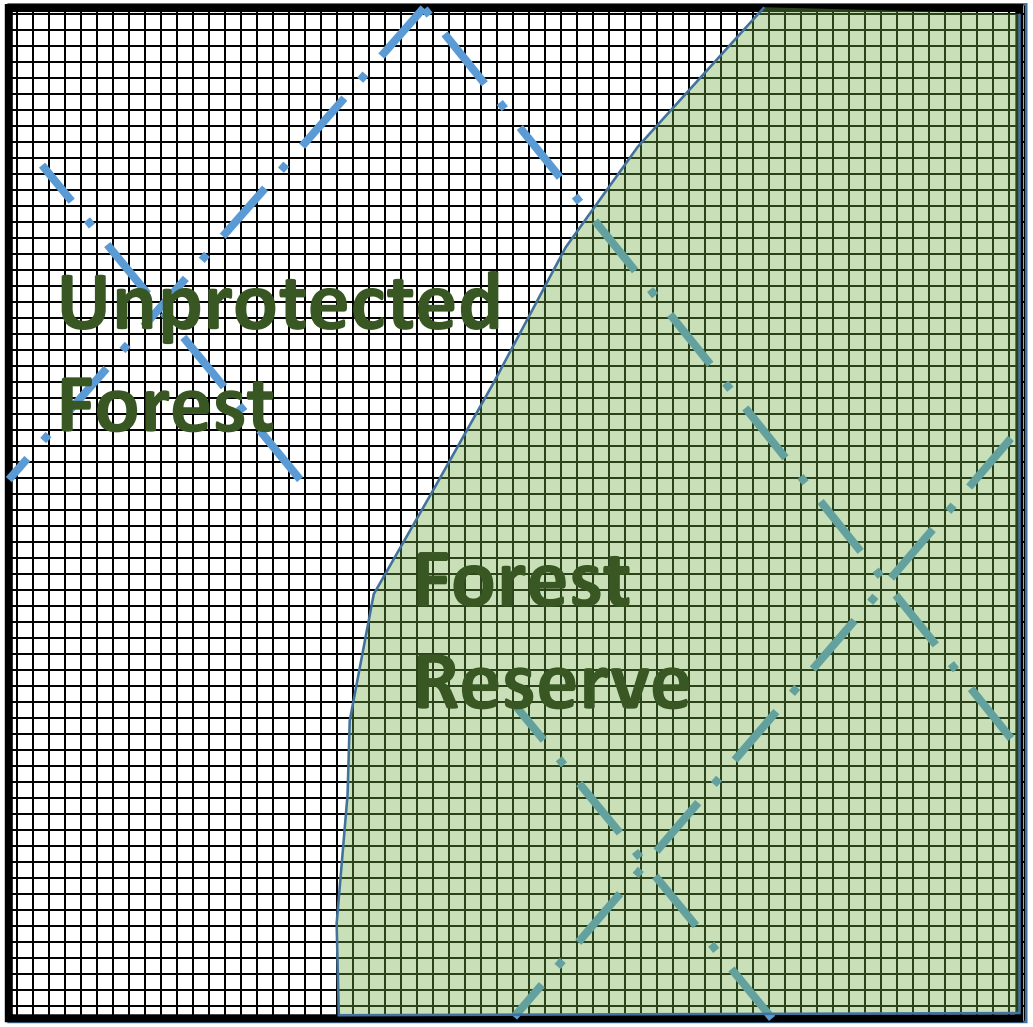
Online Biomass Inference using Waveforms And iNventory

GEDI ECOSYSTEM LIDAR

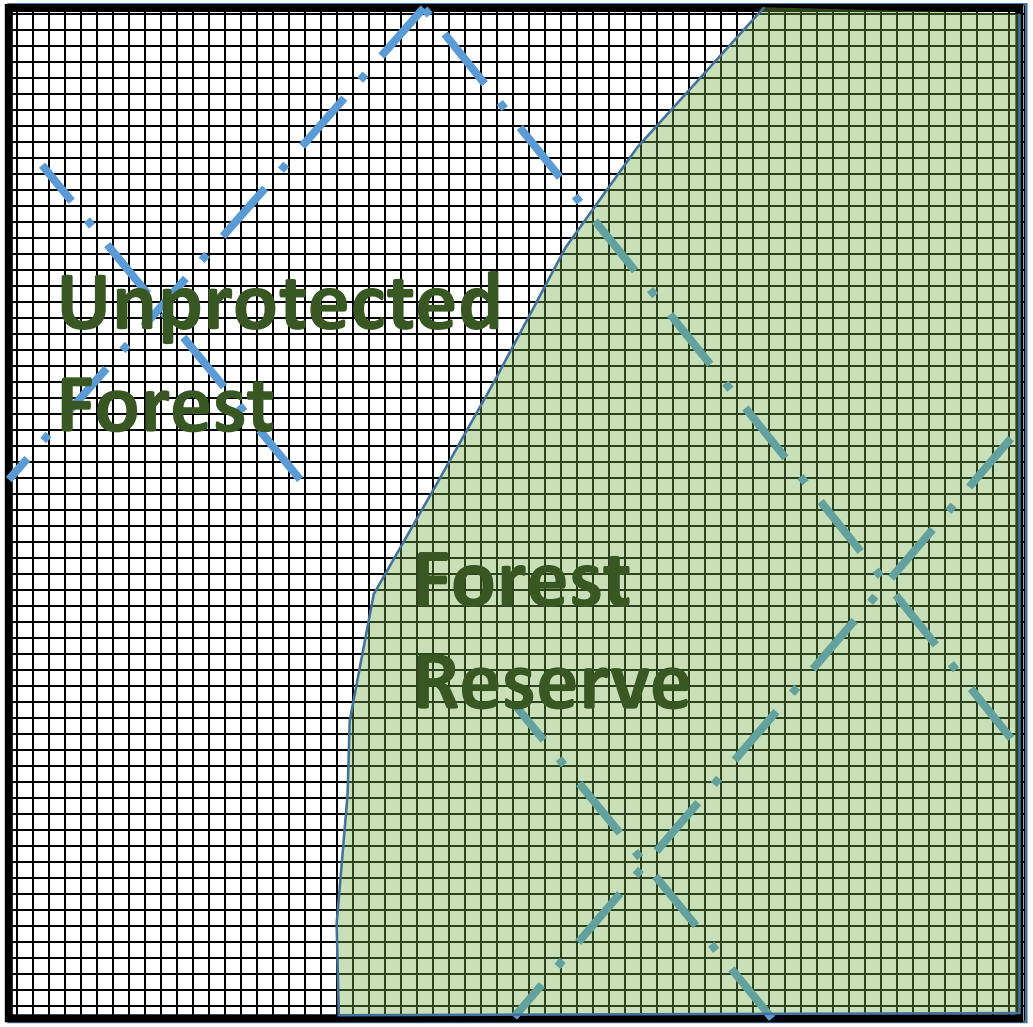
NASA

FIA The Nation's Forest Census

OBI-WAN



1. User inputs shapefile to a Google Earth Engine app (200-hectare minimum)
2. OBI-WAN accesses GEDI's plot/model/lidar database, supplemented with Landsat archive stored on Google Earth Engine
3. Uncertainty is tracked through hierarchical model-based inference
4. Customized forest biomass report is generated, including estimates of mean biomass, standard error of the mean, and thorough documentation



Potential applications of OBI-WAN include reporting carbon stocks for:

- Forest reserves
- Individual companies
- Municipalities from villages to countries

Estimates of forest carbon will be available through OBI-WAN starting in mid-2020

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