



GEDI Launches a New Era of Biomass Inference from Space

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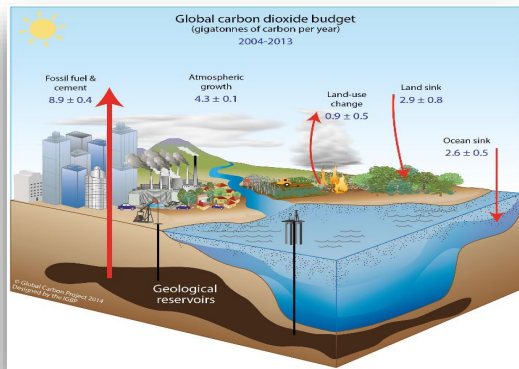


Outline

- GEDI Mission Overview and Data Examples
- GEDI Statistical Framework for Biomass Inference
- Biomass Results and Uncertainty Analyses
- Summary

Science Questions and Objectives

GEDI Goal: Advance our ability to characterize the effects of changing climate and land use on ecosystem structure and dynamics



Carbon Cycle



Biodiversity

Major Obstacle

- Inconsistency among maps

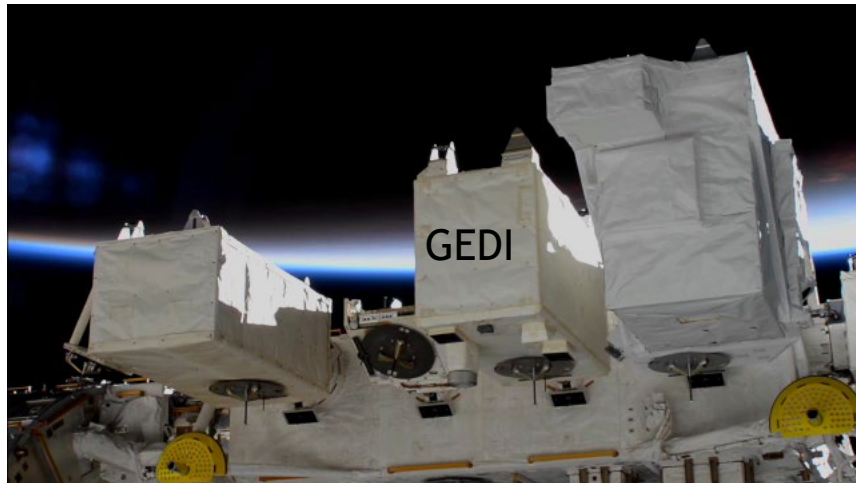
Difficult to resolve inconsistencies

- Uncertainty frameworks may be missing, ad hoc, or lack transparency

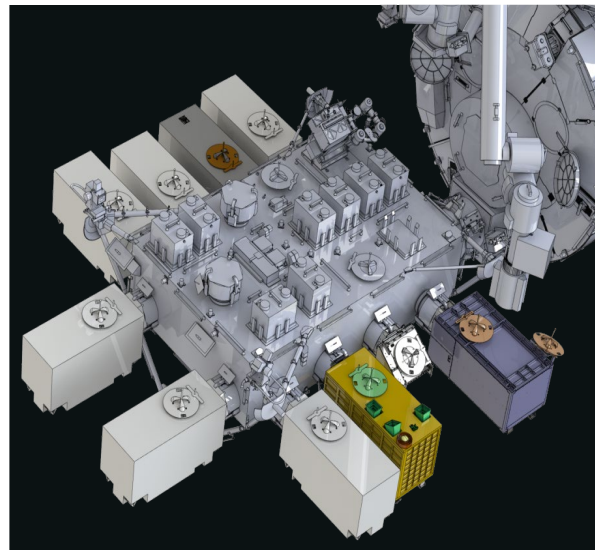
GEDI was formulated specifically to address biomass uncertainty

GEDI: NASA Earth Ventures Instrument (EVI)

High Resolution Laser Ranging of the Earth's Forests and Topography



GEDI is deployed on the JEM-EF



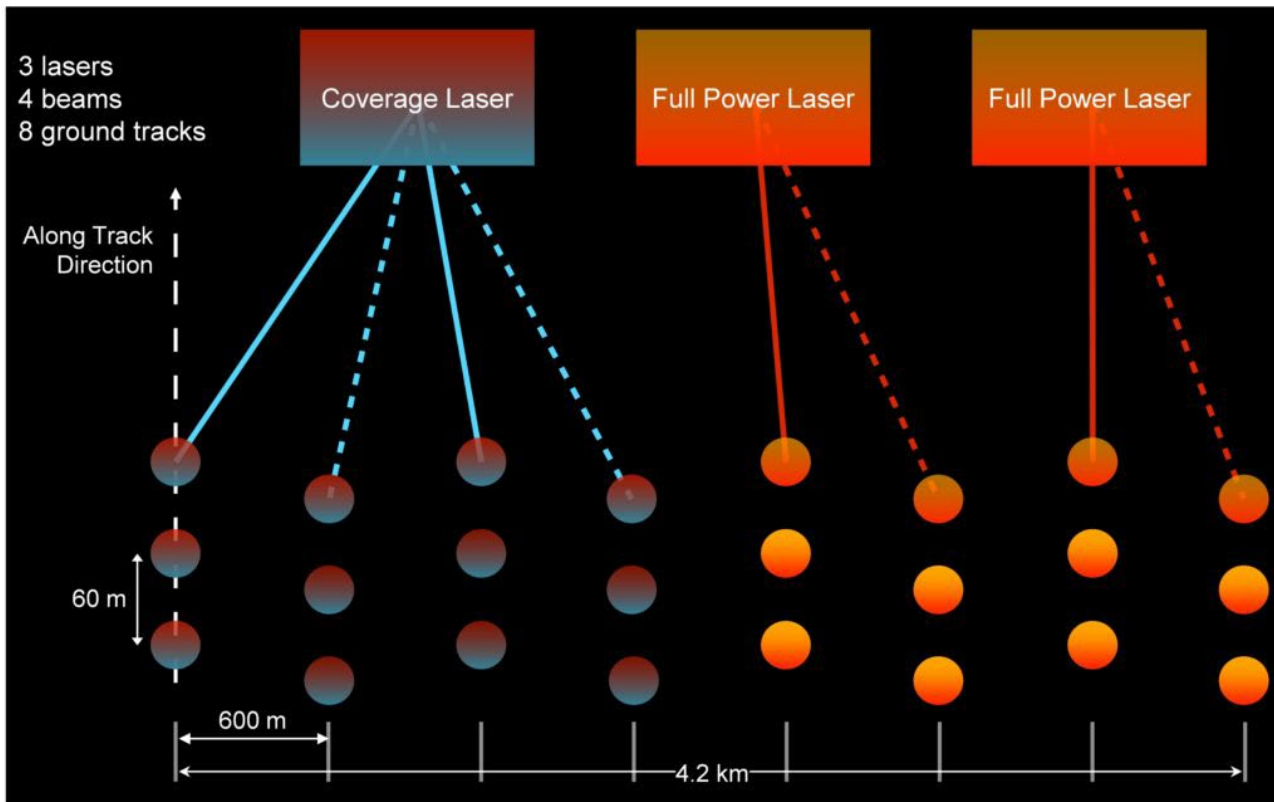
Key Facts

- Selected in 2014 for \$94 M
- Joint project of University of Maryland and NASA GSFC
- Deployed on International Space Station (JEM-EF)
 - Fully commissioned 4/18/2019
- Nominal 2-year mission

Prime Mission ended April 2021

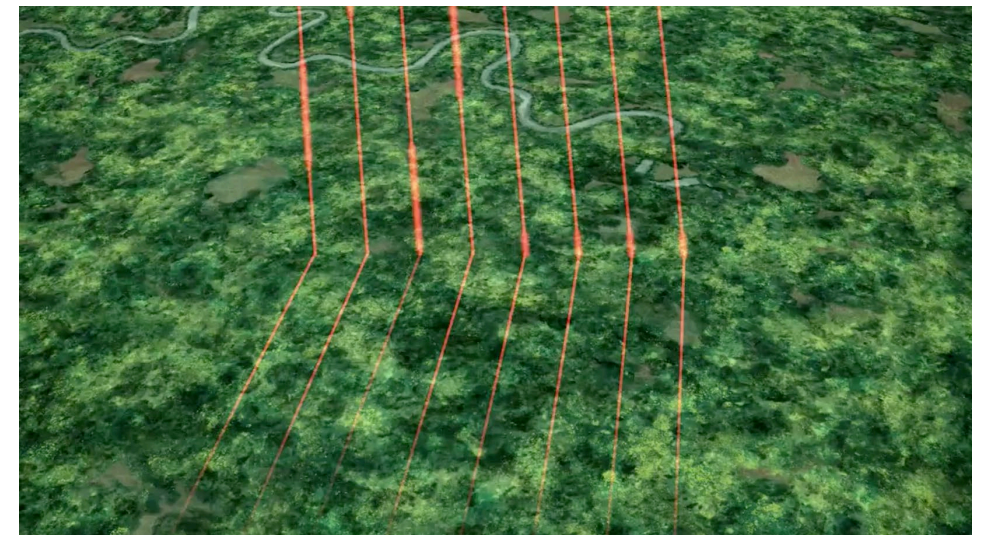
Currently continuing on-orbit operations in Extended Mission

GEDI Observations



GEDI uses 3 lasers to produce 8 transects of lidar waveforms.

Each footprint provides the complete vertical structure of the canopy.



GEDI Canopy Heights



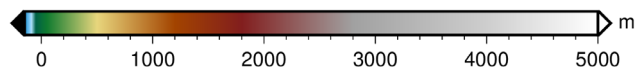
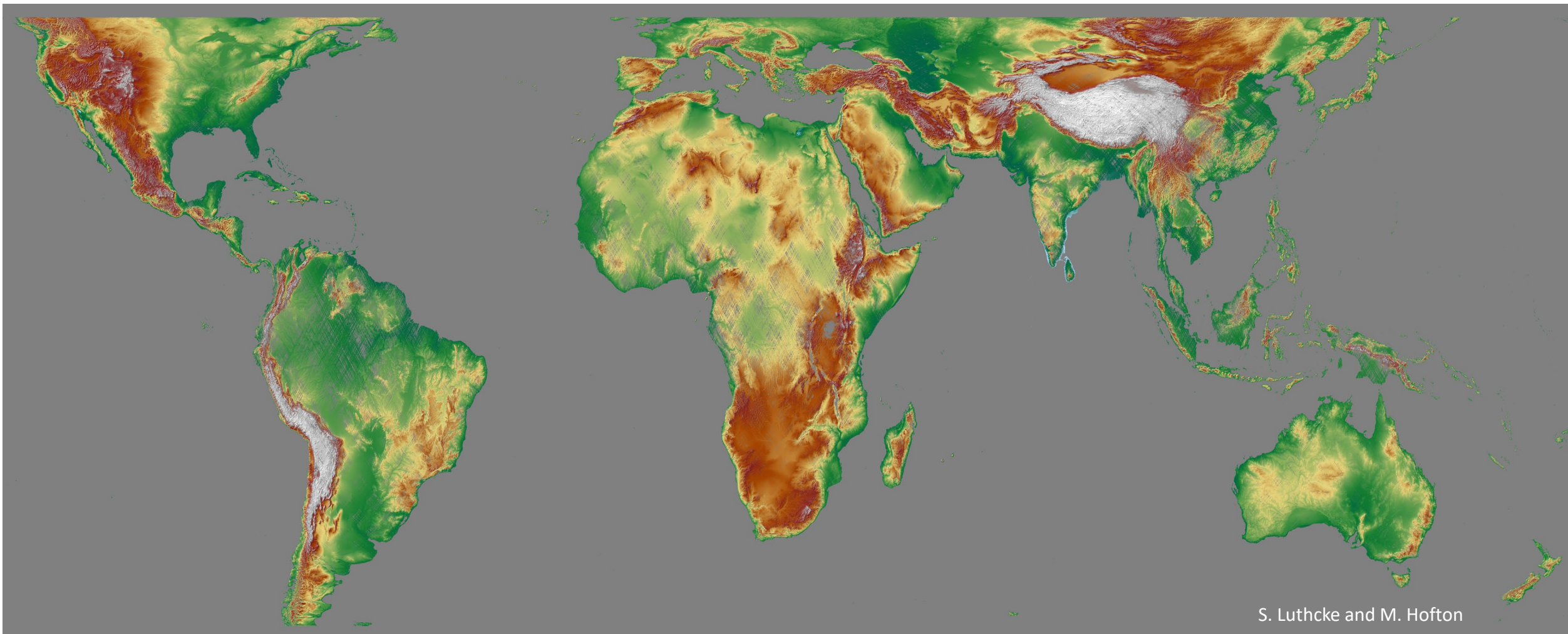
NASA Scientific Visualization Studio



GEDI Biomass Uncertainty
Living Planet Symposium 2022

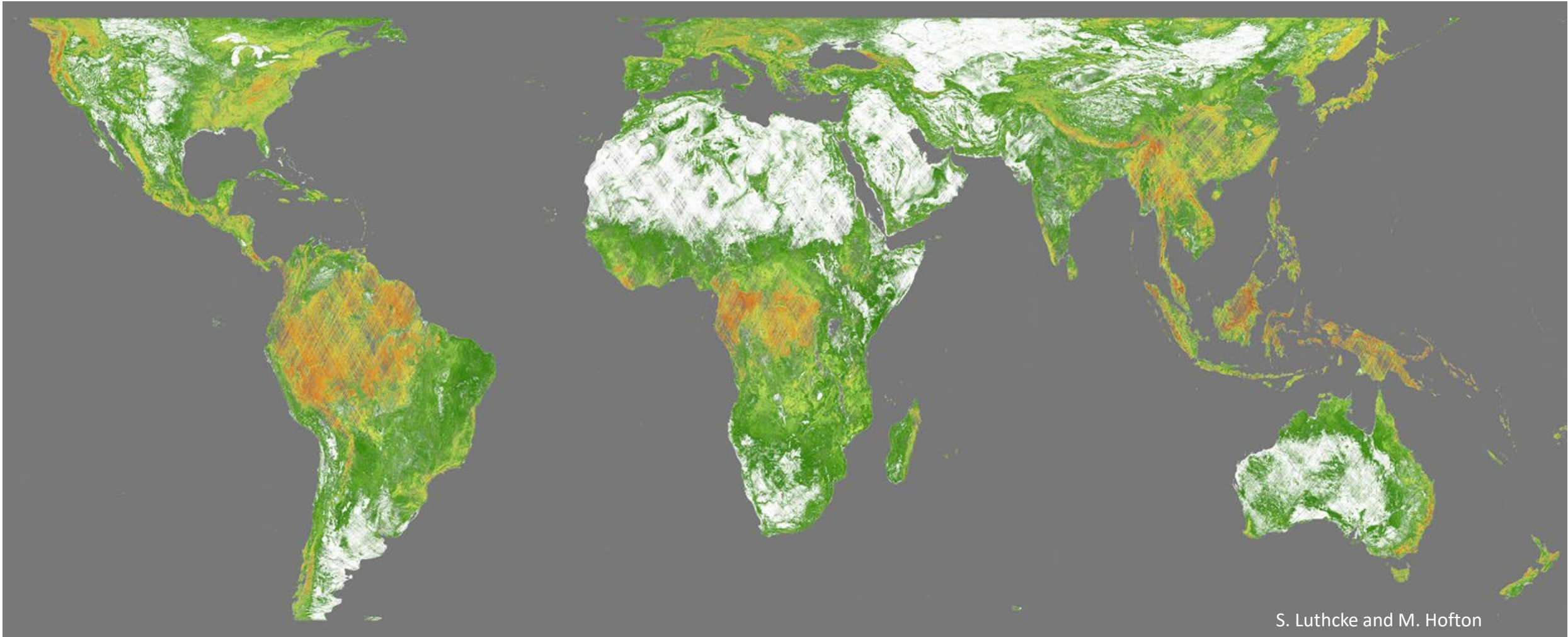


GEDI Topography (2.75 years)



GEDI Biomass Uncertainty
Living Planet Symposium 2022

GEDI Canopy Height



GEDI Biomass Uncertainty
Living Planet Symposium 2022

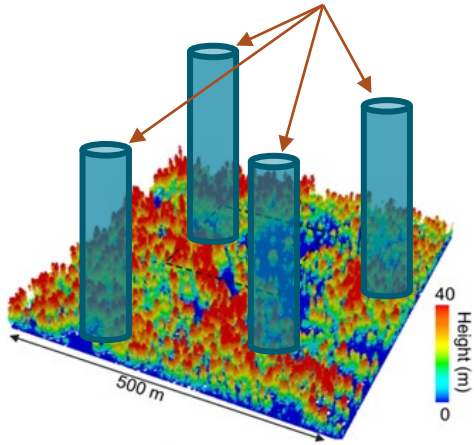
Approach to Biomass Uncertainty

- One of the major challenges to biomass estimation from remote sensing is providing transparent estimates of uncertainty over areas of arbitrary size
- GEDI was designed to provide these uncertainties using hybrid estimation
 - Approach was built into mission, from design to implementation
 - Provides errors from 1 km to sub-national to national levels
 - Propagates errors from sampling and errors from regression models relating biomass to lidar data

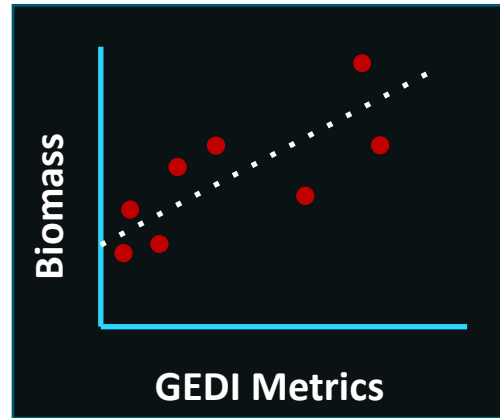
GEDI is the first mission to adopt a formal, inferential approach to uncertainty

L4 Biomass: From Footprints to Grid Cells to Countries

1. Create simulated waveforms

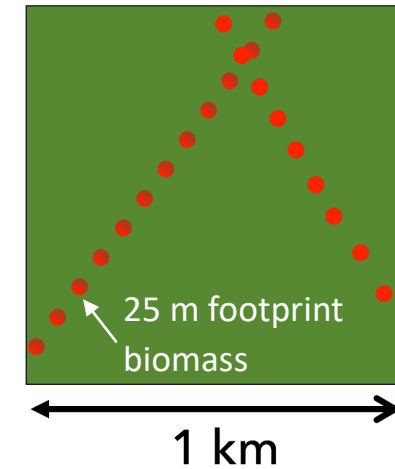


2. Develop relationships among GEDI metrics and biomass

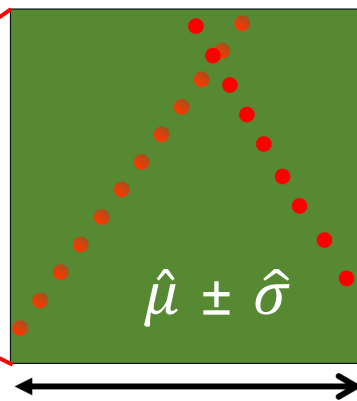
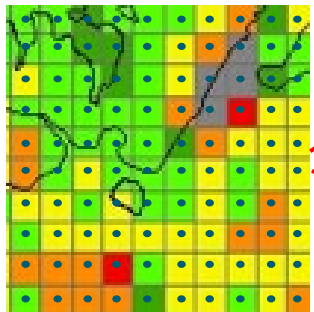


Duncanson et al., (2022) RSE

3. Apply calibration equations to GEDI data on-orbit for footprints

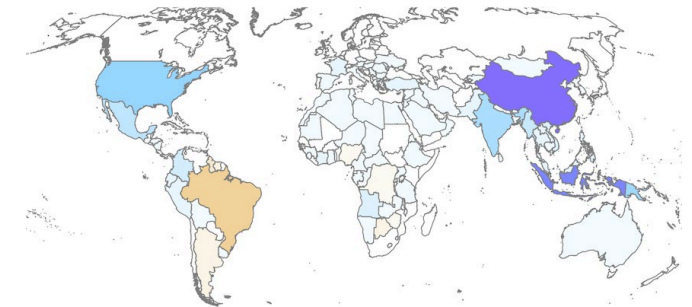


4. Calculate 1 km mean Biomass and uncertainty

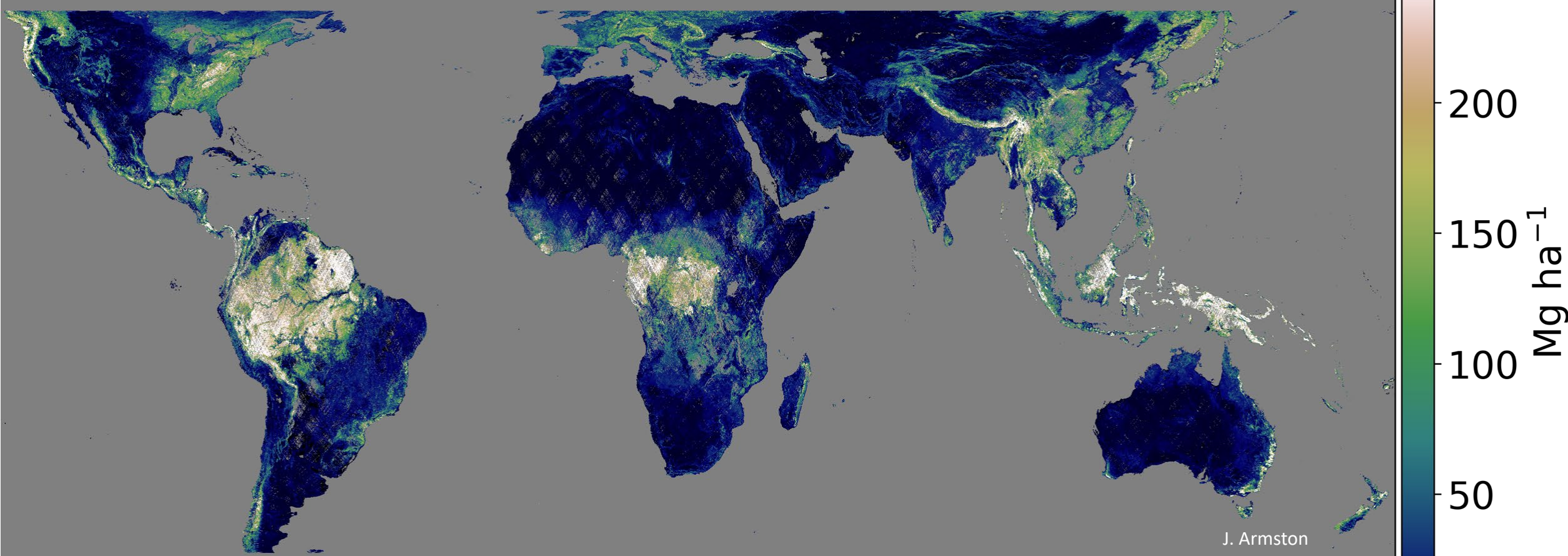


Uncertainty Estimation
Model-based hybrid inference based on cluster sampling

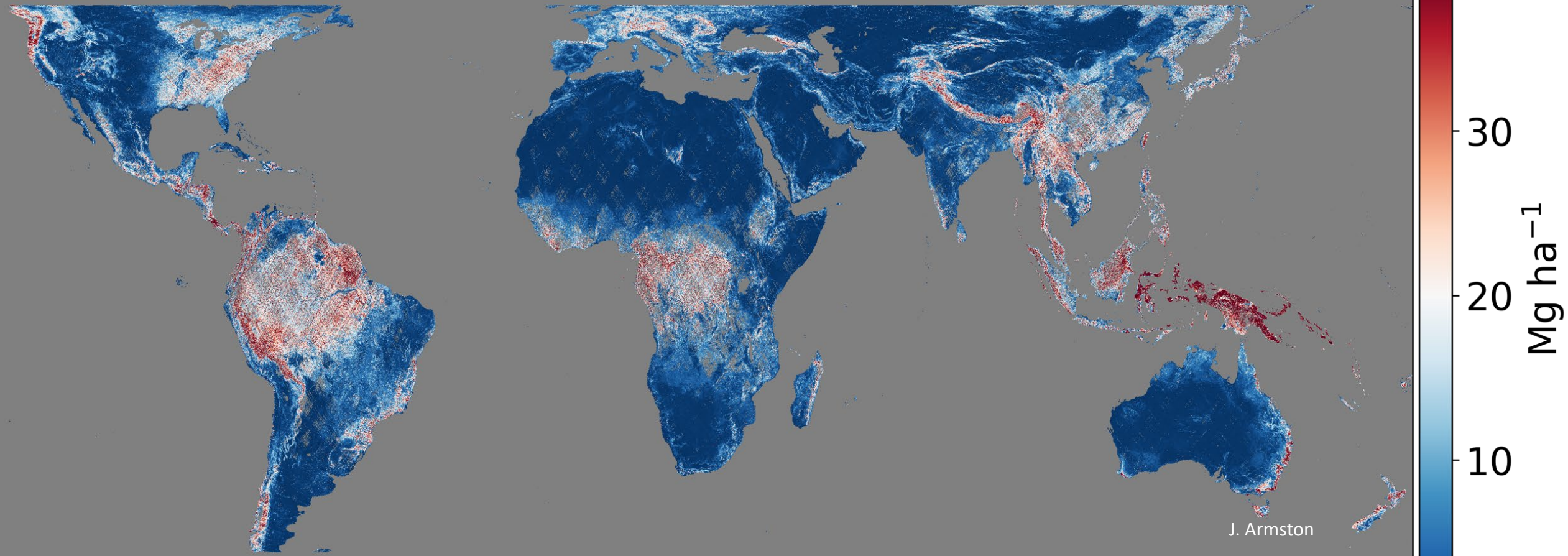
5. Calculate mean biomass and uncertainty for larger areas



GEDI Gridded Biomass (1 km @ 2 years)



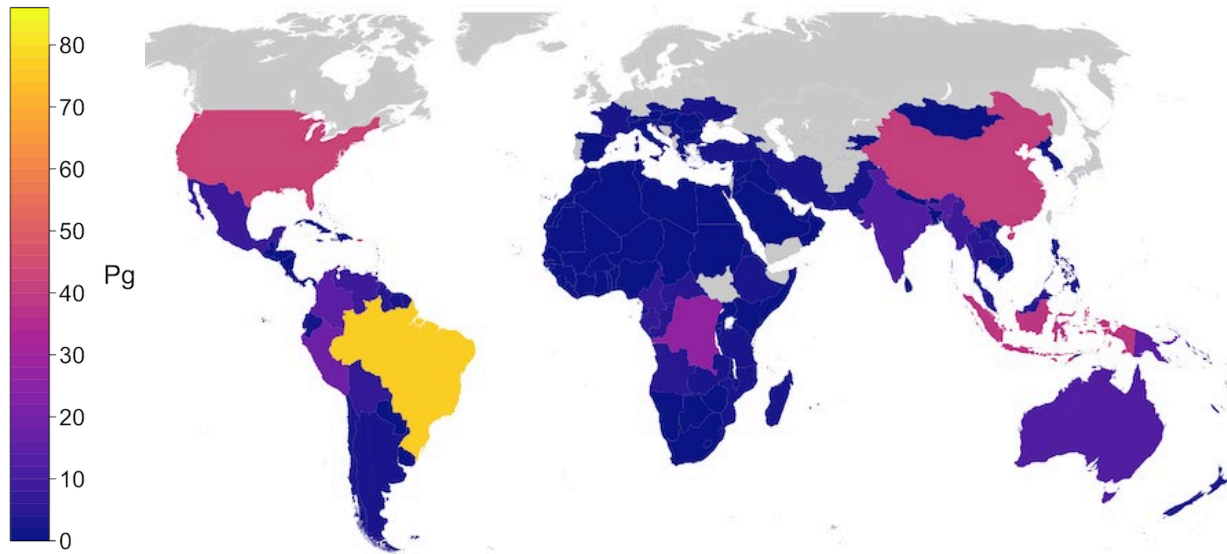
GEDI Gridded Biomass Uncertainty (S.E.)



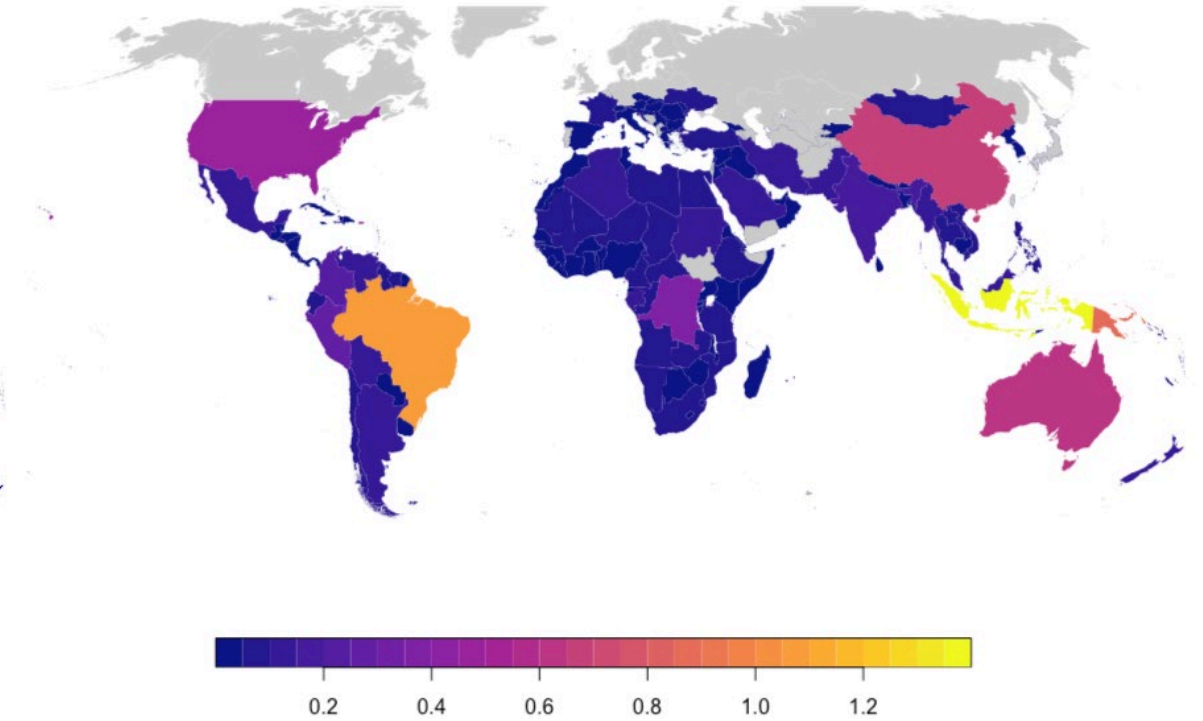
Country-level Biomass Stock Estimates

- GEDI estimates for mean and uncertainty using hybrid inference over every country observed by GEDI

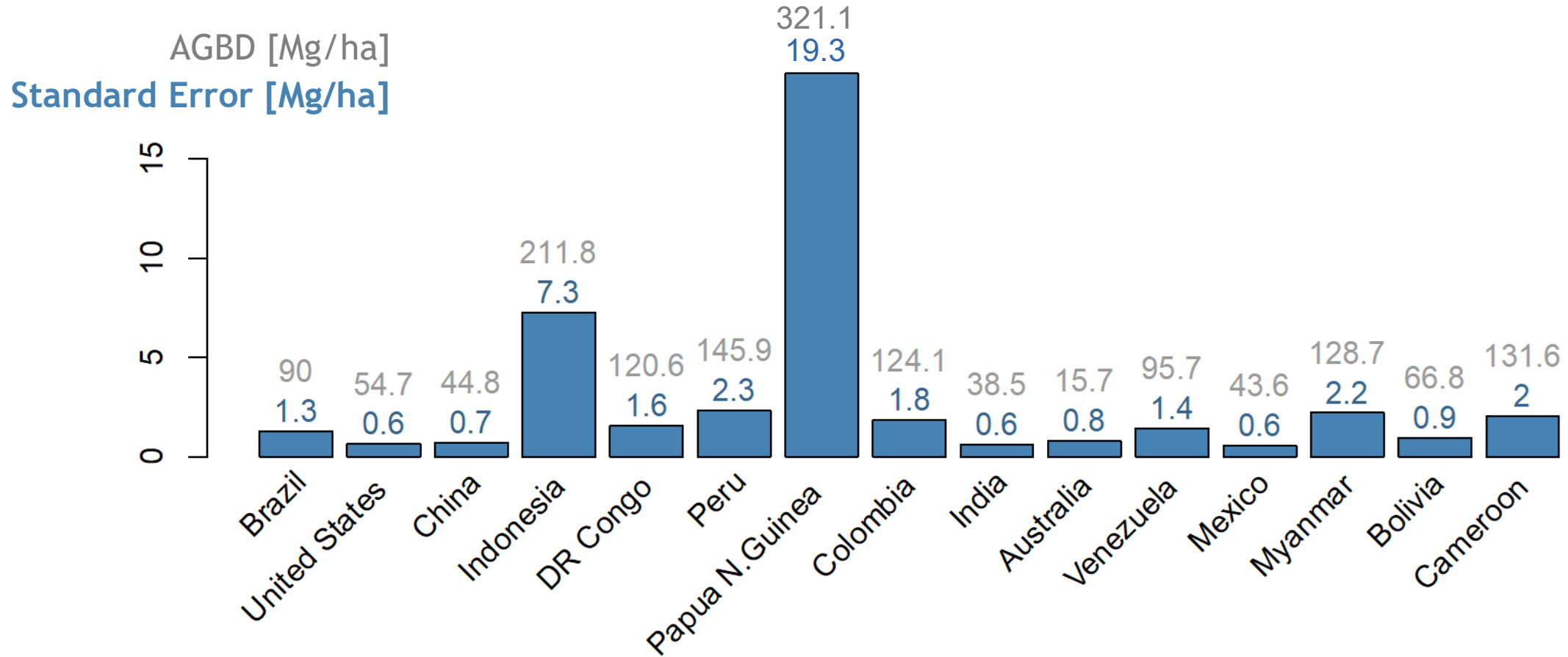
Aboveground Biomass [Pg]



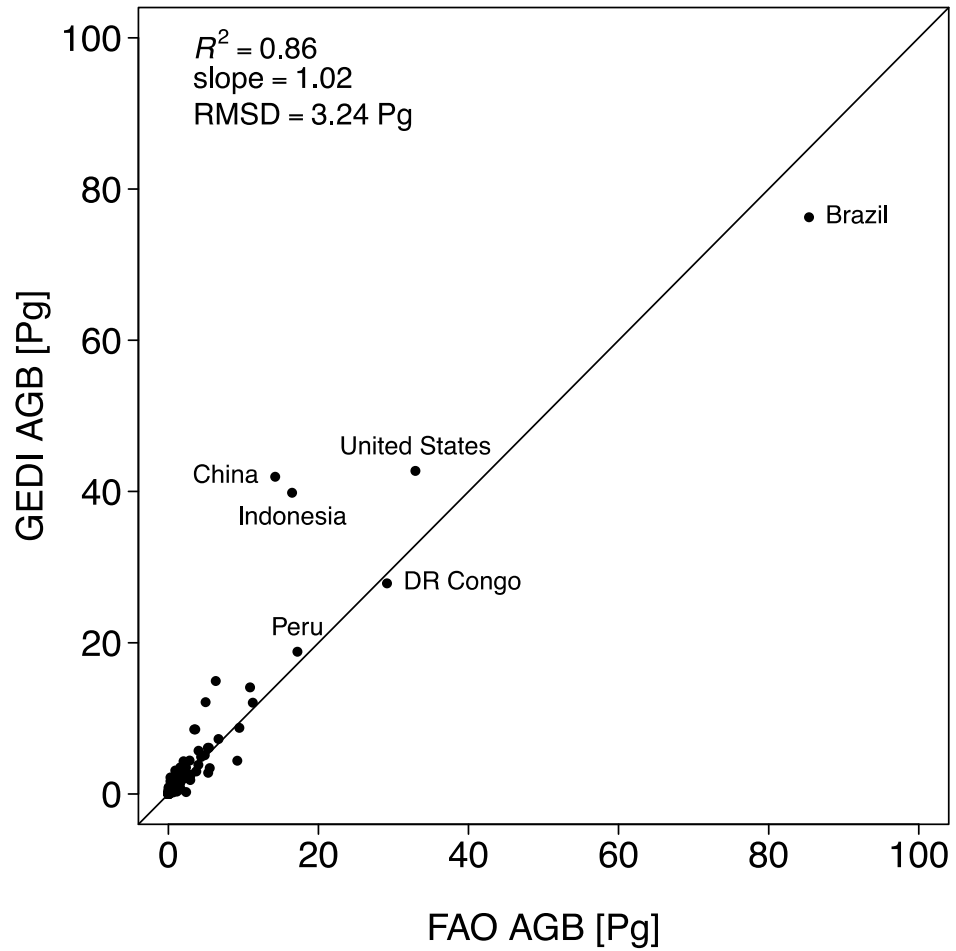
Standard Error [Pg]



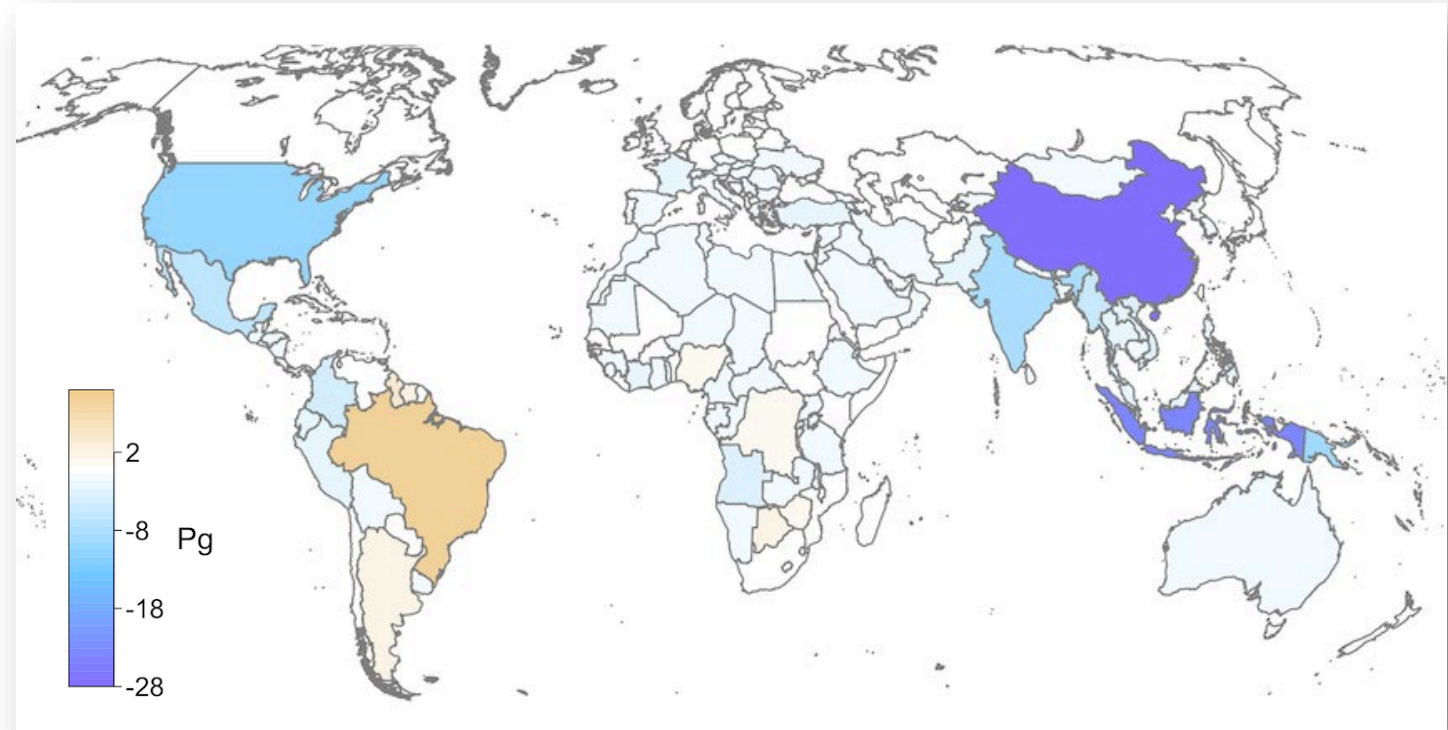
AGBD Standard Errors



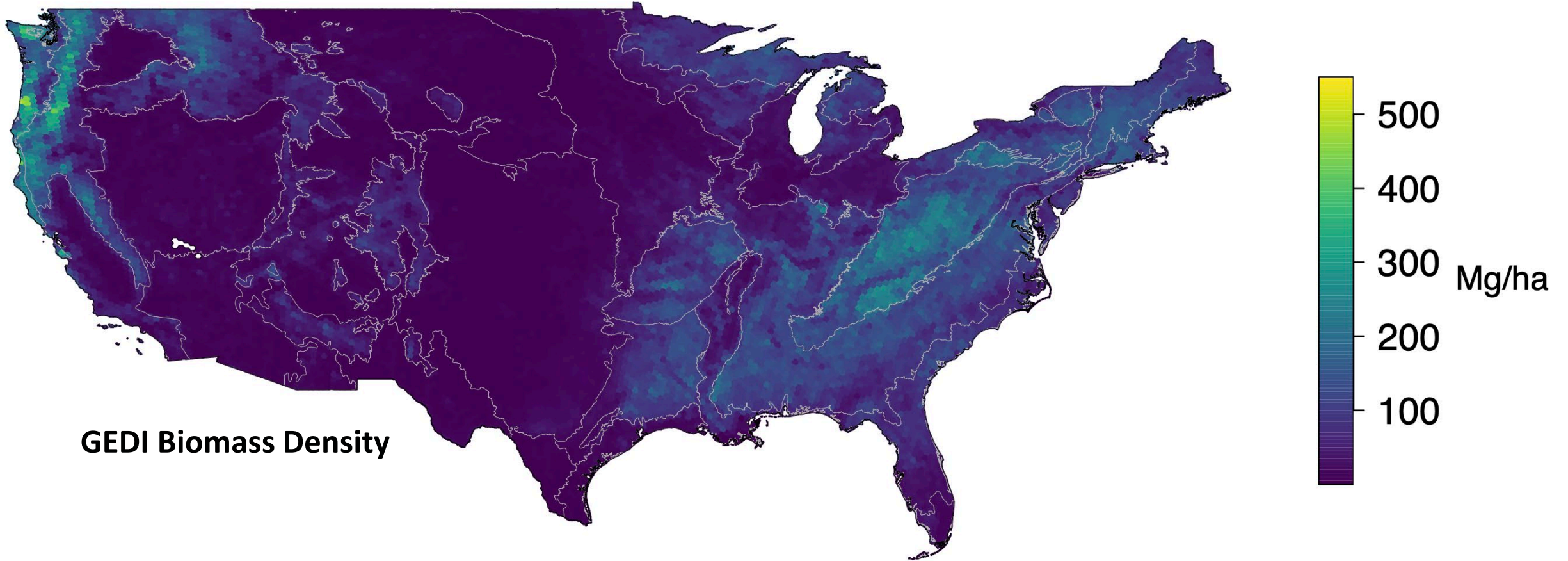
Comparison to FAO



FAO - GEDI

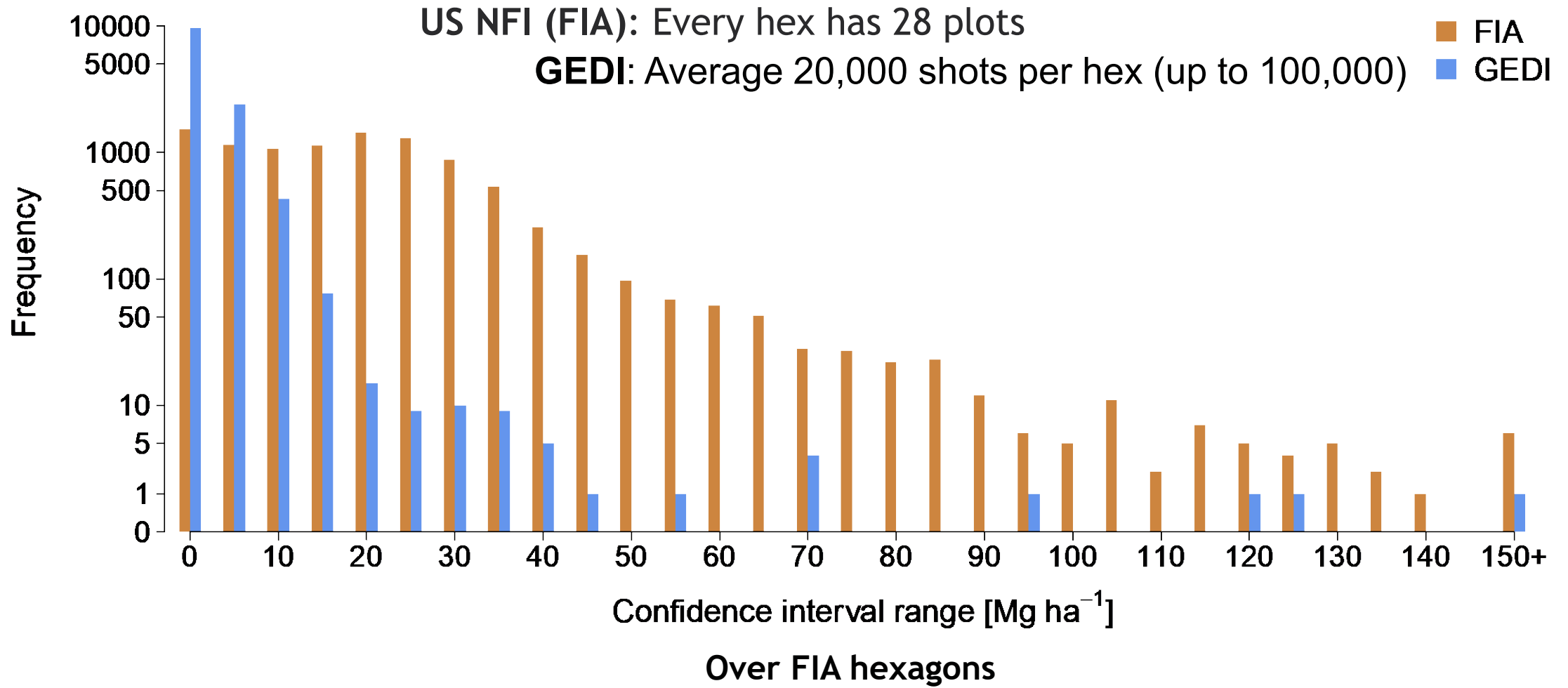


GEDI Biomass for US NFI Hexagons (64,000 ha)

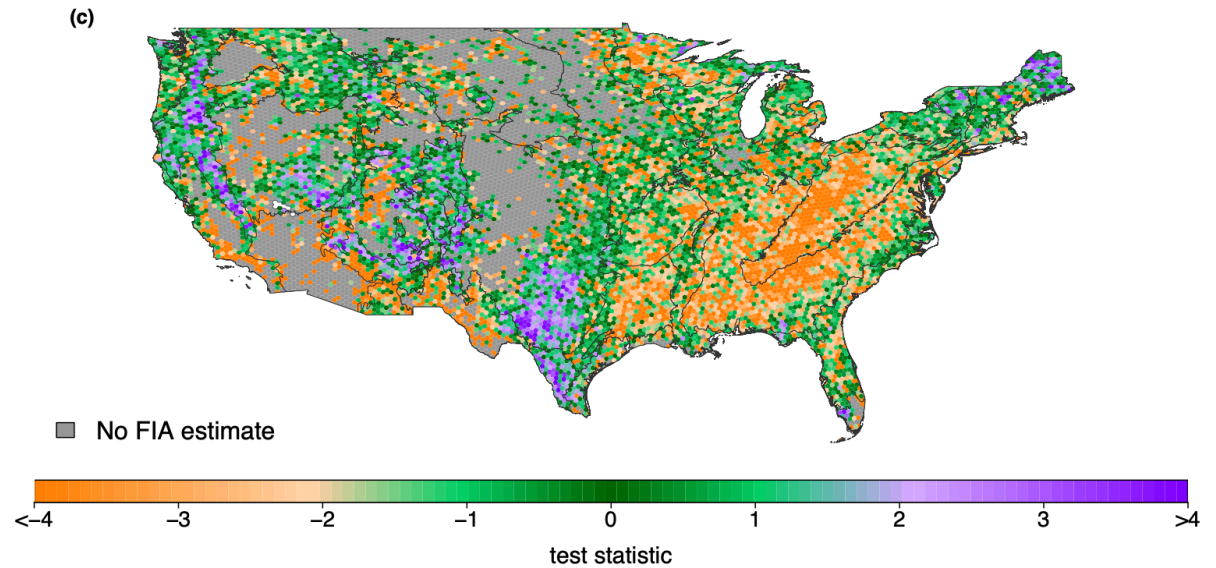
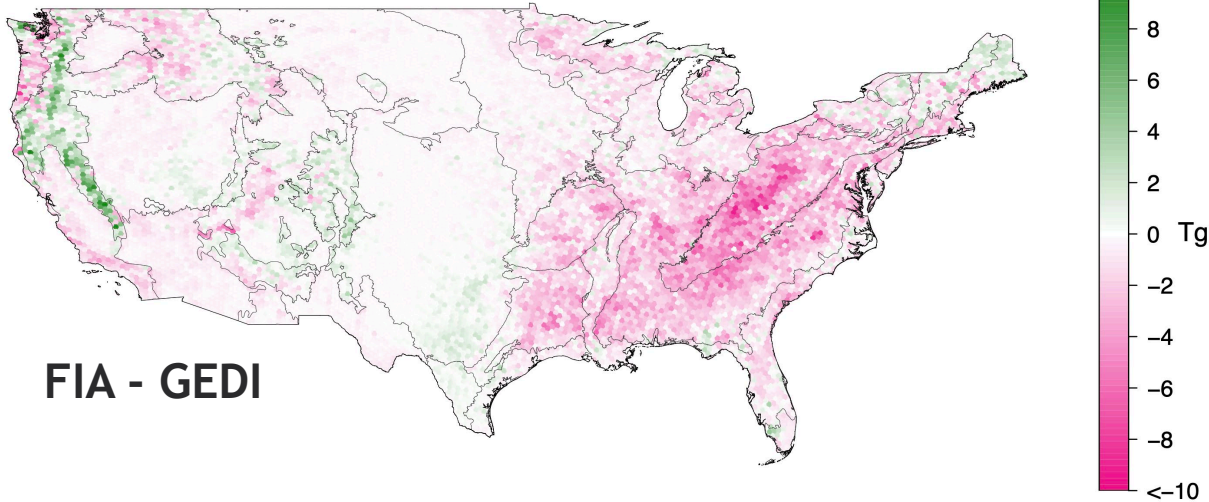
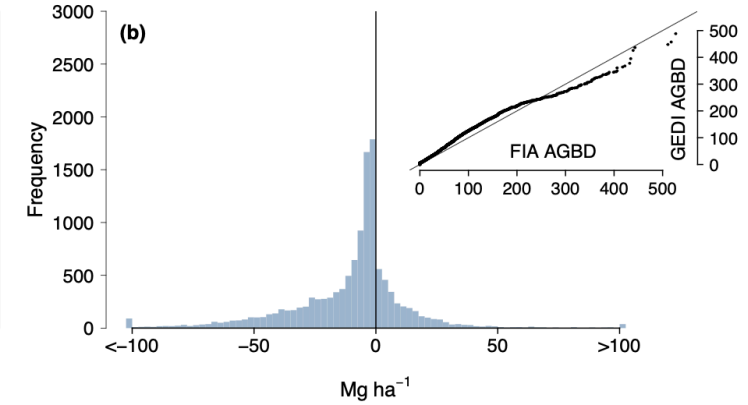
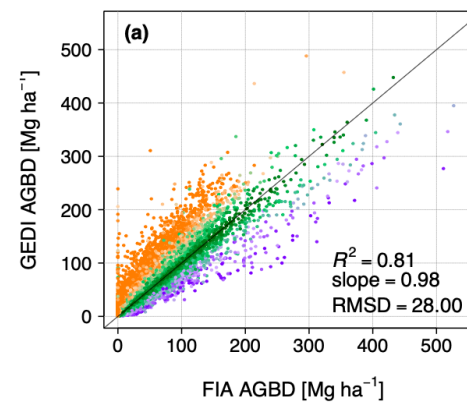
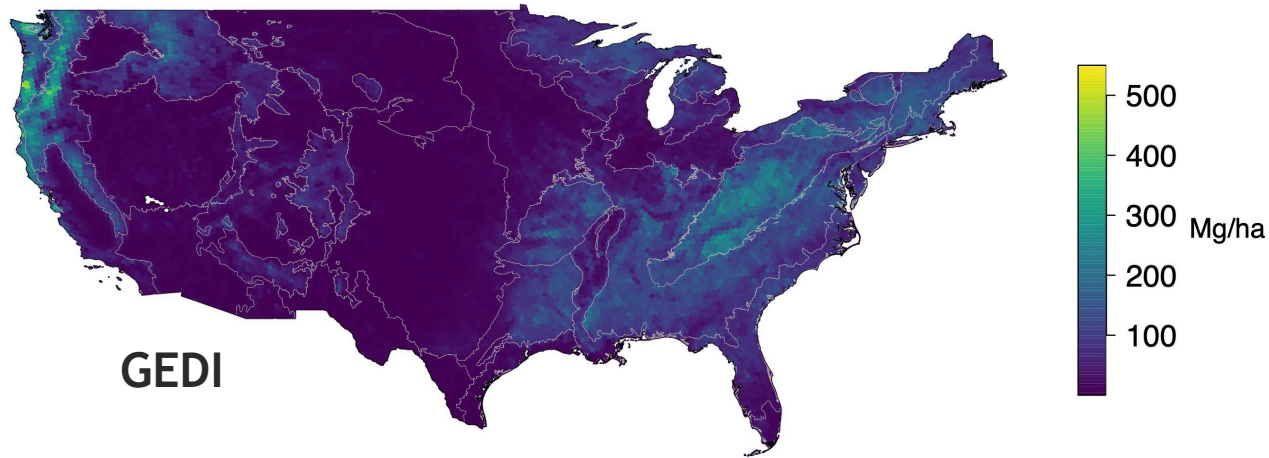


Hexagons correspond to US Forest Service Forest Inventory and Analysis (FIA) areas

GEDI enables confidence interval comparisons



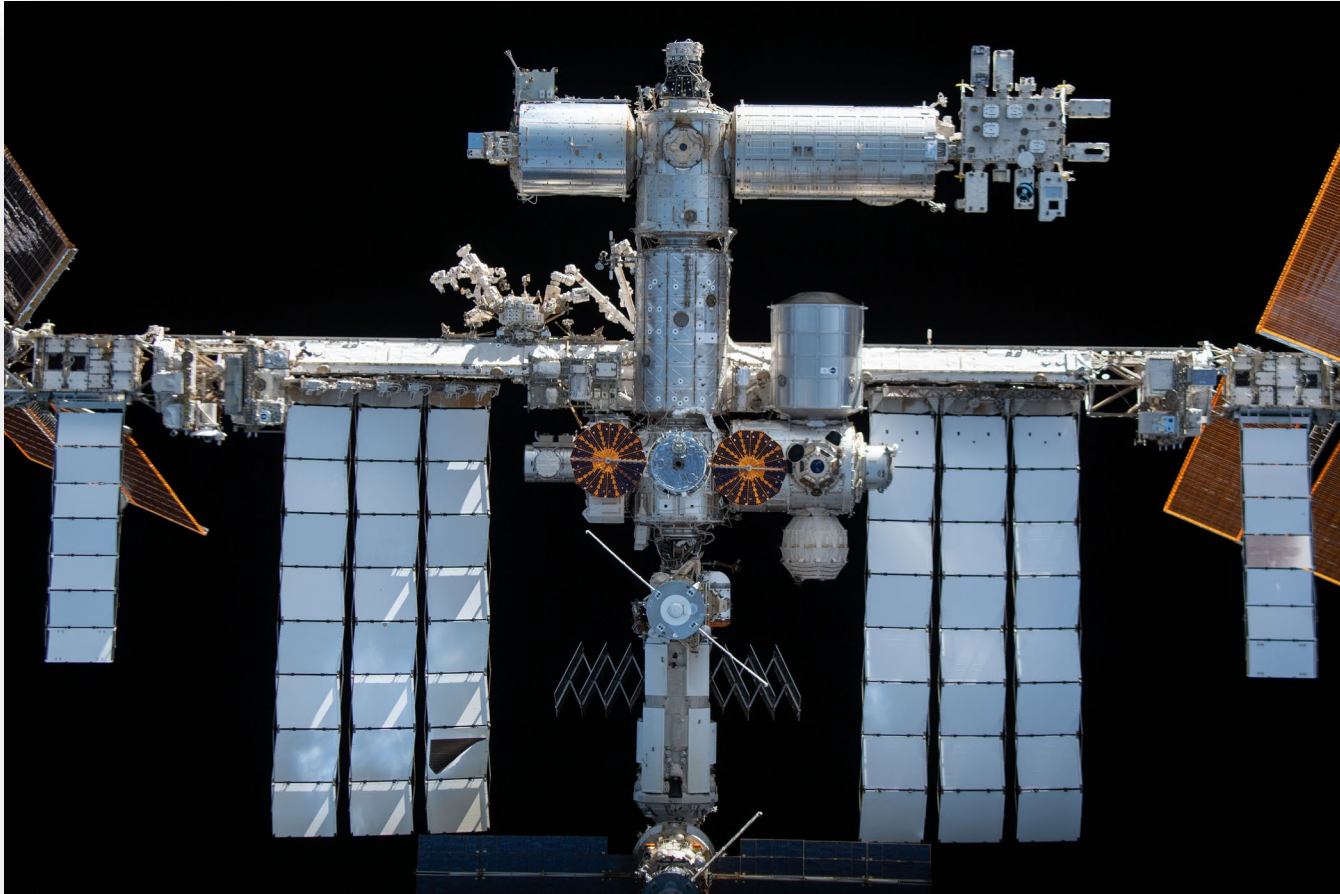
NFI data and uncertainty may help identify biases



Summary

- GEDI continues to perform exceptionally well on-orbit and is providing a spectacular archive of ecosystem structure data
- GEDI's approach integrating formal statistical inference has been ground-breaking
 - Highlights intrinsic value of an approach that explicitly addresses uncertainty as integral part of mission design
- New era of biomass estimation is beginning
 - BIOMASS, NISAR, MOLI
 - Multi-sensor/multi-modal fusion
 - Advanced methods
- Future missions should consider incorporating formal modes of inference for biomass estimation
 - Ongoing research into integration of machine learning, monte carlo, and parametric approaches

Thank You



GEDI is scheduled for de-orbiting in early 2023

**GEDI biomass preprint available at:
eartharxiv.org**

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