Committee on Earth Observation Satellites

WGCV LPV Biomass Validation Protocol and Activities

Laura Duncanson, University of Maryland, College Park, WGCV LPV Biomass

CEOS SIT-35

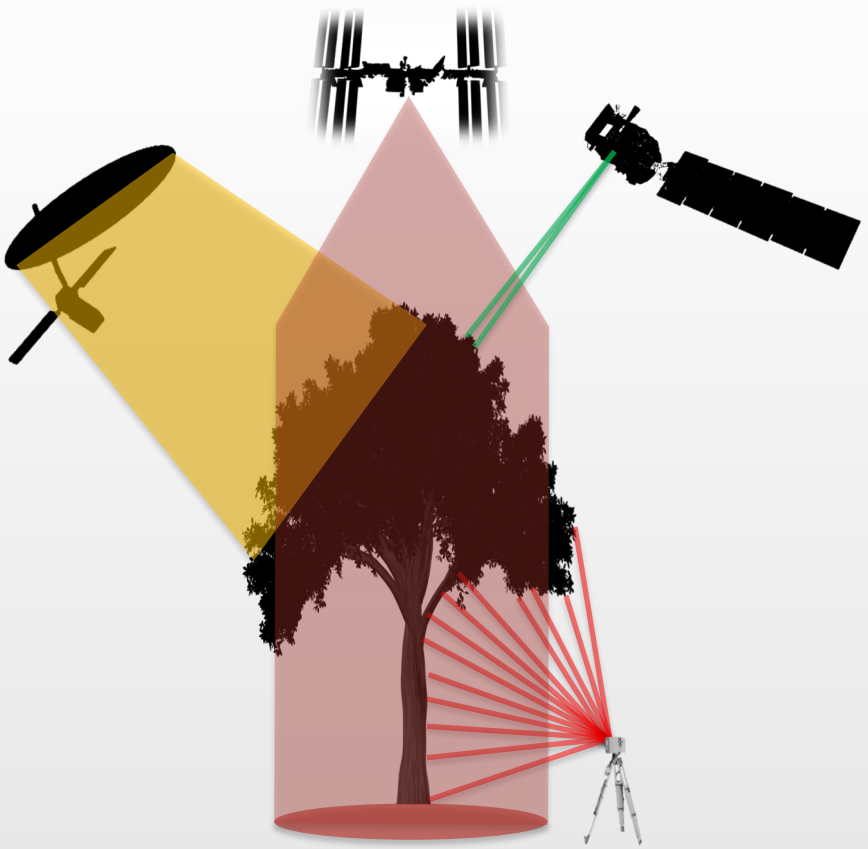
Virtual Meeting

25 – 26 March 2020

CEOS WGCV LPV Biomass Validation Protocol and Activities

Laura Duncanson, John Armston, Mat Disney

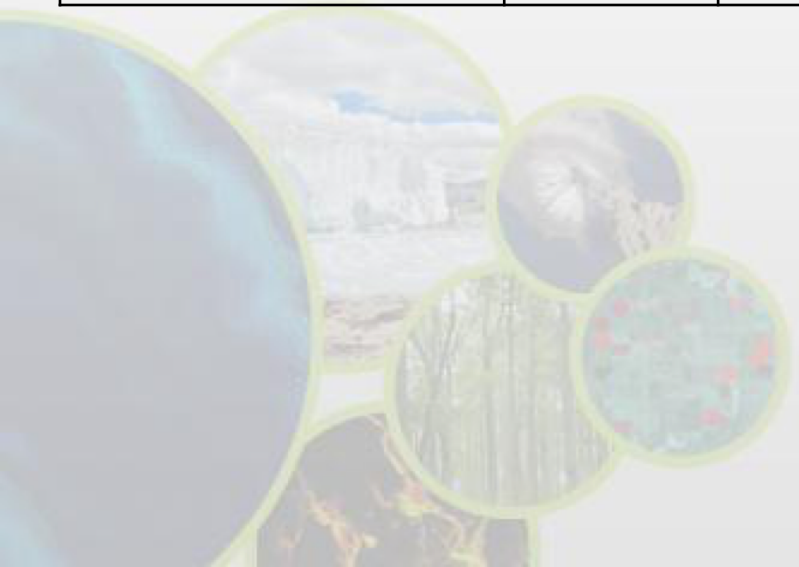
Clement Albinet, Valerio Avitabile, Tim Baker, Harm Bartholomeus, Jean François Bastin, Nicolas Barbier, Kim Calders, Sarah Carter, Bruce Chapman, Jerome Chave, Tom Crowther, Stuart Davies, Styze de Bruin, Martin de Kauwe, Grant Domke, Ralph Dubayah, Lola Fatoyinbo, Mike Falkowski, Martin Herold, Patrick Jantz, Inge Jonckeere, Tomasso Jucker, Mirko Karan, Jim Kellner, Nicolas Labrière, Richard Lucas, Natasha MacBean, Felix Morsdorf, Amy Neuenschwander, Jaime Nickeson, Ron McRoberts, Keryn Paul, Oliver Phillips, Shaun Quegan, Maxime Réjou-Méchain, Miguel Roman, Paul Rosen, Ake Rosenqvist, Stephen Roxburgh, Sassan Saatchi,Crystal Schaaf, Dmitry Schepaschenko, Klaus Scipal, Paul Siqueira, Atticus Stovall, Christian Thiel, Mat Williams, Mike Wulder, Hank Margolis



Formation in Response to a CEOS Carbon Action

3.2 Progress implementation of the CEOS Strategy for Carbon Observations from Space

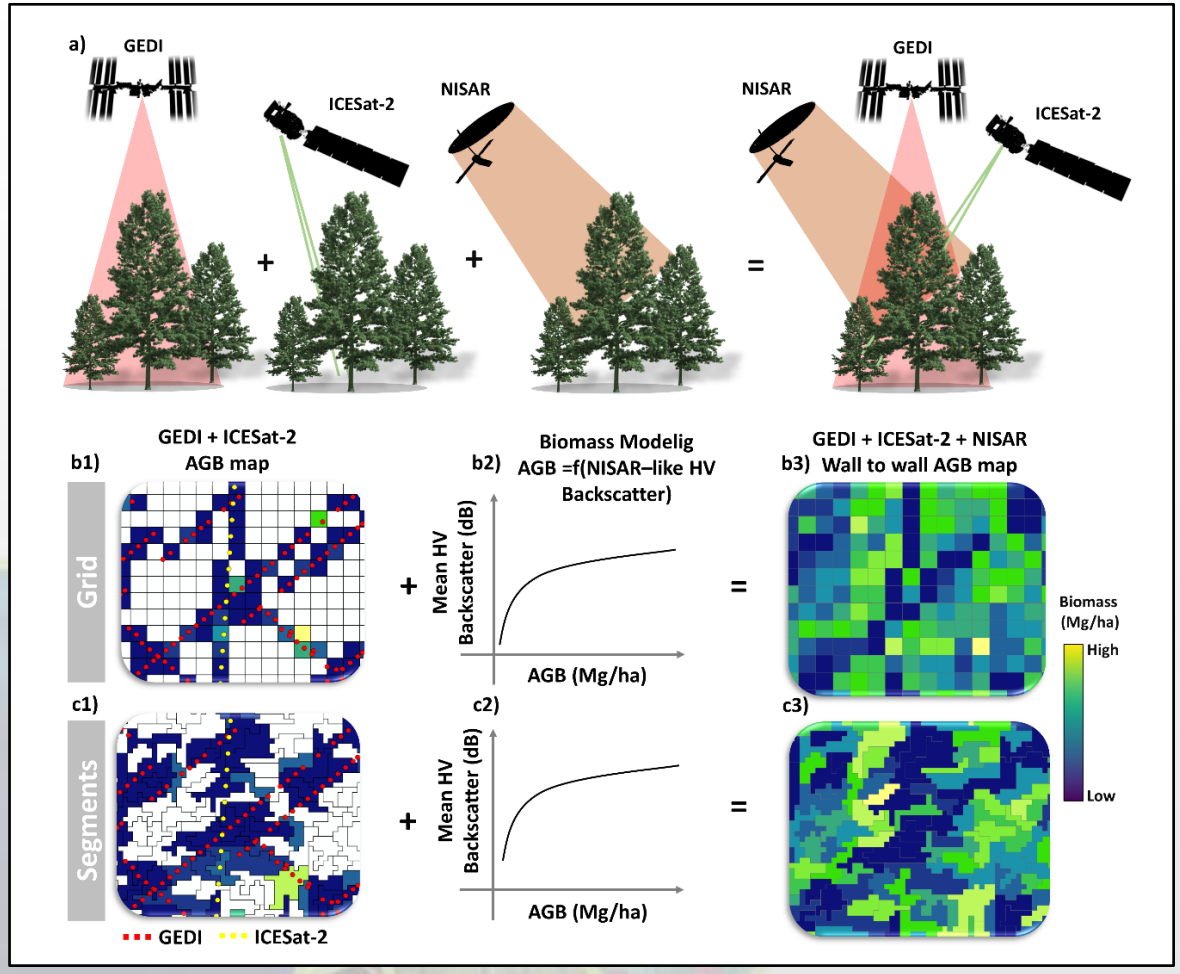
CARB-16: Cal/val and production of biomass products from CEOS missions	Q4 2019	Development of a coordinated cal/val strategy across NASA and ESA biomass missions that rationalizes protocols, data sharing, and the establishment of ground-based carbon super-sites.	NASA and ESA



Many Upcoming Missions will Provide Data Used to Map Biomass

Mission	Funding Agency	Expected Launch Date	Data Type	Biomass Product Resolution	Geographic Domain	Accuracy Requirement
NISAR	NASA/ISRO	2022	L-band SAR	1 ha (<100 Mg/ha)	Global	<20% RMS accuracy for <100 Mg/ha
GEDI	NASA	Dec 5, 2018	1064 nm waveform lidar	1 km	ISS (+/- ~51.6°)	<20% SE for 80% of forested 1 km cells
BIOMASS	ESA	2022	P-band SAR	4 ha	Global (minus defense issues)	Accuracy of 20%; 10 Mg/ha for <50 Mg/ha
MOLI	JAXA	2023?	1064 nm waveform lidar	500 m	ISS (+/- ~51.6°)	NA
SAOCOM 1A	CONAE	October 8, 2018	L-band SAR	NA	Global	NA
ICESat-2	NASA	Sept 15, 2018	532 nm photon counting lidar	NA	Global	Global
TanDEM-L	DLR	2022-2023?	L-band SAR	1 ha	Global	20% accuracy or 20 Mg/ha
ALOS-4	JAXA	2022	L-band SAR	NA	Global	NA

Many Biomass Mapping Approaches Through Fusion



Silva et al., in prep

Combining Multiple Data Streams (e.g. GEDI, ICESat-2, NISAR, BIOMASS, ALOS4) allows:

- Reduced errors
- Higher resolution maps

Open source tools enable production of many global maps (e.g. Google Earth Engine)

How will users make sense of all the new biomass products?

If data are not turned into useful, actionable information in a timely fashion, then our field is recording history rather than changing it.

Mission	Funding Agency	Expected Launch Date	Data Type	Biomass Product Resolution	Geographic Domain	Accuracy Requirement
NISAR	NASA/ISRO	2022	L-band SAR	1 ha (<100 Mg/ha)	Global	<20% RMS accuracy for <100 Mg/ha
GEDI	NASA	Dec 5, 2018	1064 nm waveform lidar	1 km	ISS (+/- ~51.6°)	<20% SE for 80% of forested 1 km cells
BIOMASS	ESA	2022	P-band SAR	4 ha	Global (minus defense issues)	Accuracy of 20%; 10 Mg/ha for <50 Mg/ha
MOLI	JAXA	2023?	1064 nm waveform lidar	500 m	ISS (+/- ~51.6°)	NA
SAOCOM 1A	CONAE	October 8, 2018	L-band SAR	NA	Global	NA
ICESat-2	NASA	Sept 15, 2018	532 nm photon counting lidar	NA	Global	Global
TanDEM-L	DLR	2022-2023?	L-band SAR	1 ha	Global	20% accuracy or 20 Mg/ha
ALOS-4	JAXA	2022	L-band SAR	NA	Global	NA

WGCV LPV Biomass Protocol

The protocol is a good practices guide to biomass model calibration and product validation at a global (or near global) scale

Good Practices for Biomass Estimation in the Field (K. Paul, J. Chave, K. Calders)

- Allometric Error
- Field Measurement Error
- Terrestrial Laser Scanning

Linking Remote Sensing Observations to Field Estimates (M. Réjou-Méchain, N. Barbier, J. Armston, L. Duncanson)

- Geolocation & Spatial Scale
- Using airborne data to scale from field to spaceborne data

Error Propagation (S. Roxburgh, R. McRoberts)

- Sources of Uncertainty
- Extrapolating models to global maps

Recommendations for User-led validation (Valerio Avitabile)

- Harmonization of definitions
- Screening of Data
- Considerations of Scale

Utility of Protocol for Other Communities

- Modeling community (M. Williams)
- Policy communities (M. Herold, S. Carter)
- Non-forest communities (N. MacBean)

Knowledge Gaps

- Experiments that will advance the field
- Airborne / Field data gaps
- Cross mission cal/val plans
- Improvement of allometric models
- Development of tools for validation and intercomparison

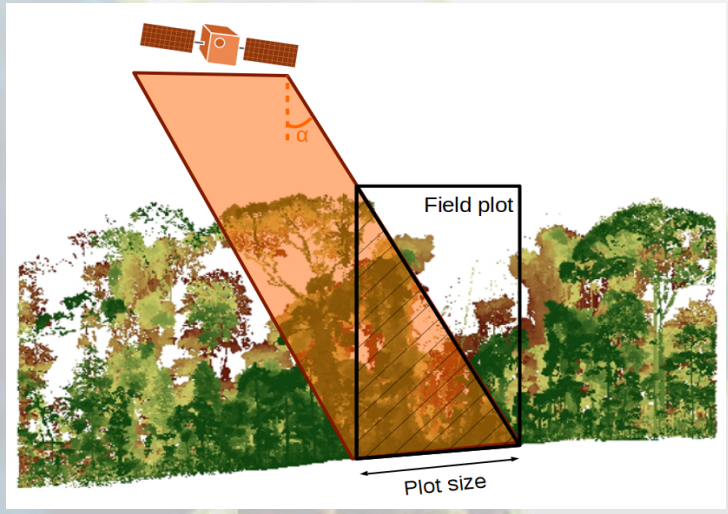
Recommendations for Field Measurements

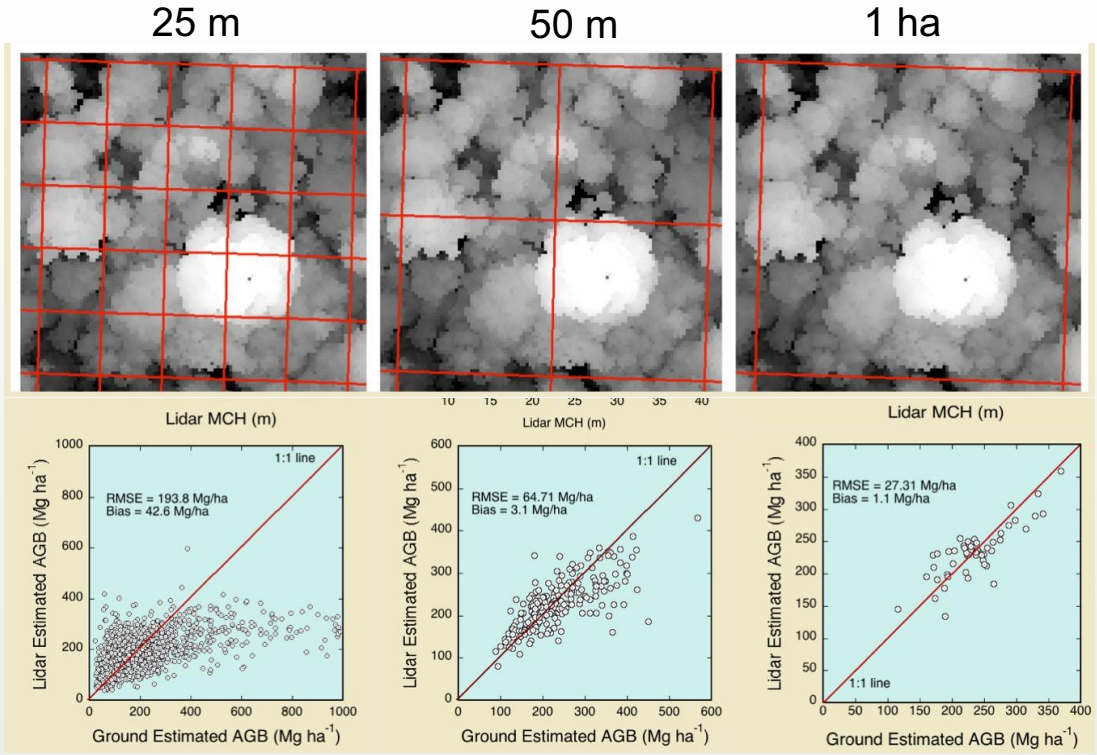
Field Estimates are Estimates, not truth - there are large errors.

- **Need transparent handling and reporting of errors, consistent definitions**
- **Provision of individual tree measurements to facilitate error checking**
- **Terrestrial Laser Scanning (TLS) where possible**
- **New TLS-driven allometric models**

We recommend large plots in tropical forests

- Small plots with poor geolocation are not useful for validation at the pixel-level
- Large plots reduce errors, particularly from large crowns/edge effects and geolocation

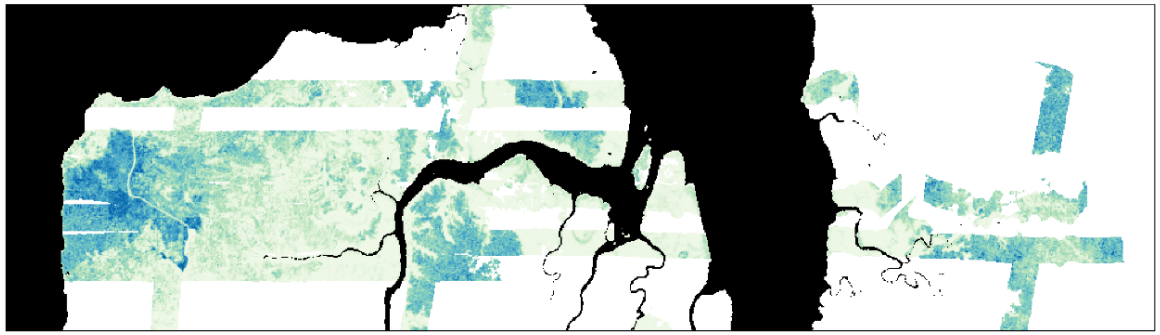


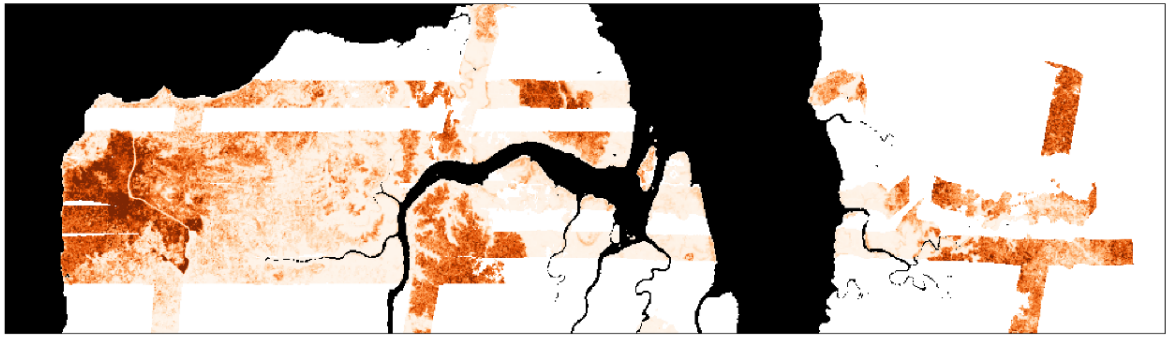


- 0.25 ha – 1 ha in tropics; smaller (~25 m) sufficient in temperate/boreal assuming good geolocation

Airborne Lidar is Critical for Multi-mission Validation & Fusion

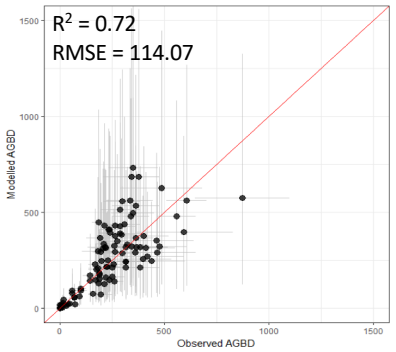
Airborne lidar biomass maps can do multi-resolution validation (provided they are calibrated with local high-quality field plots over the range of environmental conditions covered by the lidar)



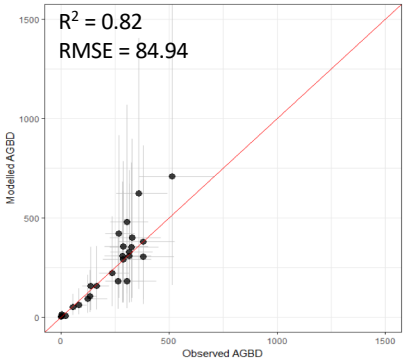


Armston et al., in prep

0.25 ha



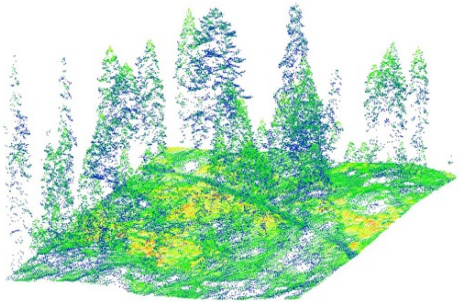
1 ha



General Biomass Validation Concept

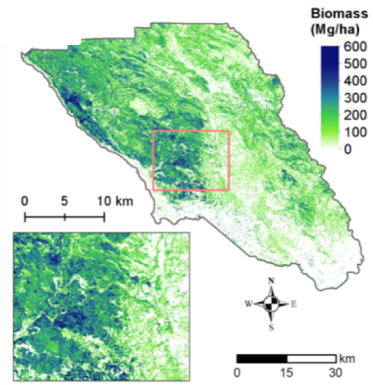
Error Propagation

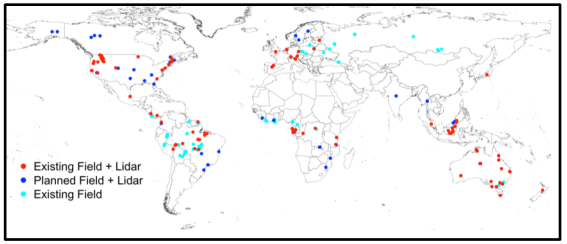
1. Collect field data for plot biomass estimates (+TLS where possible)



2. Collect airborne lidar to scale between plots and satellite data

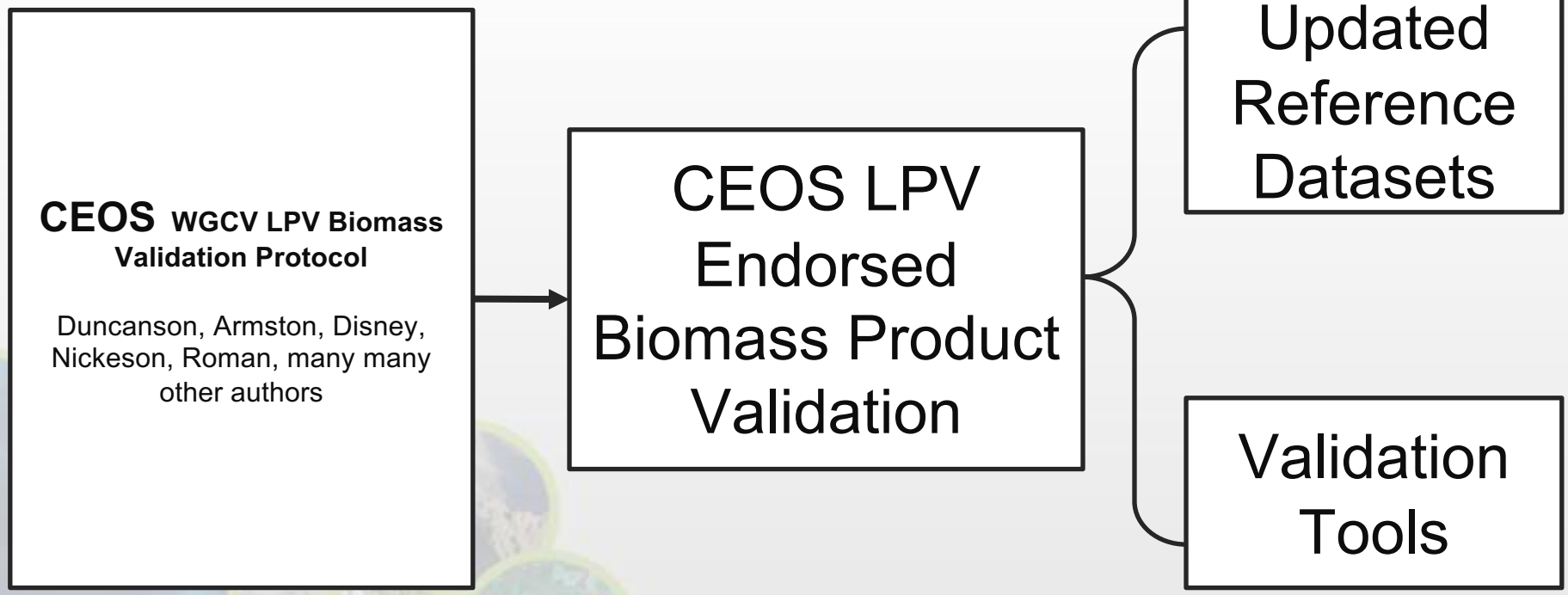
3. Train lidar biomass maps with local field data





4. Use suite of biomass maps from global biomass 'supersite' network for product validation

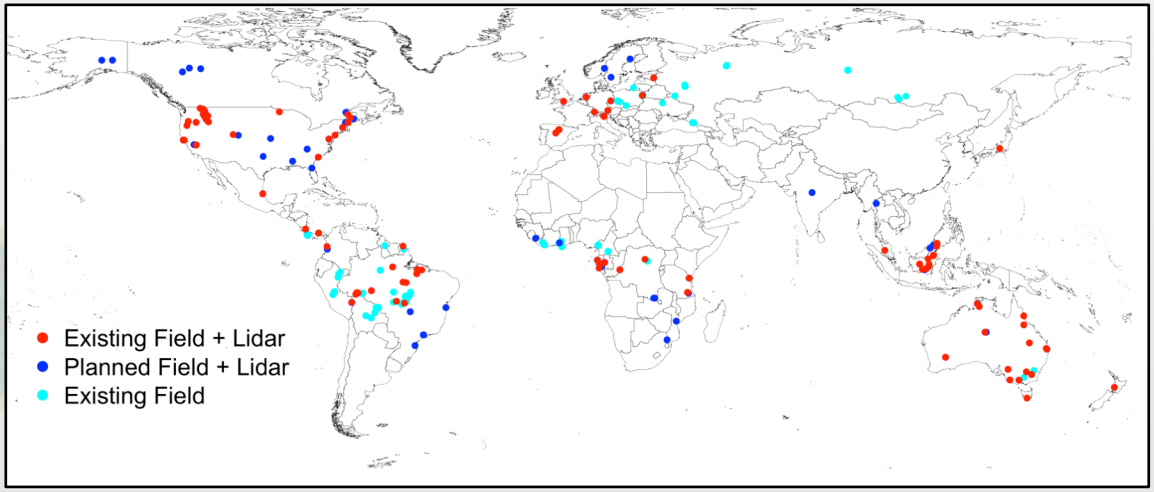
Protocol Implementation Considerations



Multi-Mission Biomass Cal/Val Group Meets Monthly

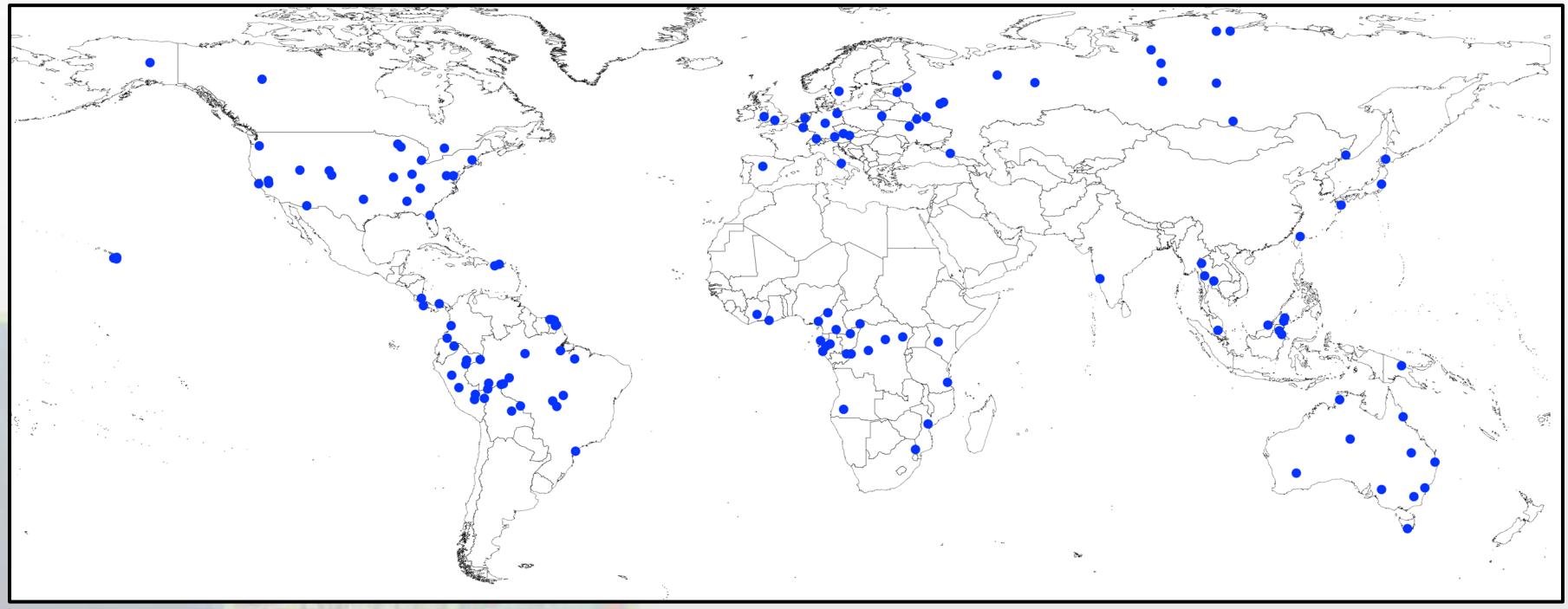
- **NISAR:**
  - Bruce Chapman
  - Paul Siquiera
  - Sassan Saatchi
  - Paul Rosen
- **GEDI:**
  - Ralph Dubayah
  - Laura Duncanson
  - Michelle Hofton
  - Lola Fatoyinbo
  - John Armston
  - David Minor
  - Jim Kellner
- **BIOMASS:**
  - Klaus Scipal
  - Shaun Quegan
  - Jerome Chave
  - Nicolas Labriere
  - Clement Albinet
- **Plot Networks:**
  - Stuart Davies (ForestGEO)
  - Oliver Phillips (ForestPlots)
  - Jerome Chave (FOS)
  - Tim Baker (ForestPlots)
  - Dmitry Schepaschenko (FOS)
- **MAAP:**
  - Marco Lavalle
  - Clement Albinet
  - Amanda Whitehurst
  - Laura Duncanson
- **Other:**
  - Mike Falkowski (NASA HQ)
  - Richard Lucas (CCI Biomass)
  - Amy Neuenschwander (ICESat-2)
  - Mat Disney (UCL, CEOS LPV)
  - Ake Rosenqvist (JAXA missions)

Group coordinates on field and airborne data consolidation and sharing, campaign planning, mission updates, protocol development. Current activities are focused on recommendations for global reference sites and determining spatial data gaps



Proposed Biomass Reference Sites Require Funds for Upkeep

These sites are *potential* reference sites, but often need augmentation (+lidar, +TLS), and will be outdated by the 2022 missions. They require significant funding for coordinated re-measurement to meet protocol standards for validation of forthcoming biomass products.



Costs are higher in the biomass-rich tropics (remote sites, challenging species ID, limited long term support of plot networks).

Opportunities and Challenges for Implementation of Biomass Protocol

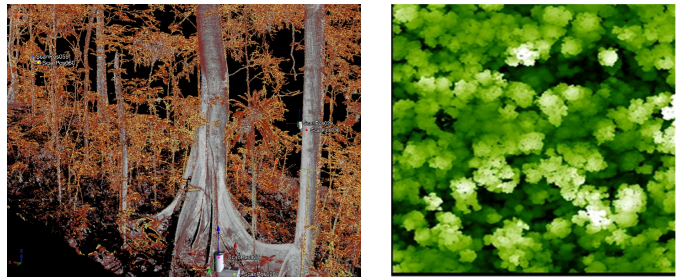
Group: ESA

Opportunities: Mid-2020 for 2 years, ESA-funded initiative led by UCL (TLS), with Wageningen (UAV), Leeds (census), Edinburgh (UAV), Cambridge (ALS), AMAP (UAV), CIRAD (logistics)

- Super-site (SS1): Paracou, French Guiana 10+ ha w TLS, census, UAV, ALS, all within a single campaign / time window
- SS2: Lopé, Gabon, 4+ ha w TLS, census, UAV, but with time differences of eg 1-2 years
- SS3: Sepilok, Malaysia, 4+ ha w TLS, 20+ ha census, ALS (2020) but with time differences of eg 1+ year for TLS and census

Challenges: Temporal gaps between new field measurements and airborne campaigns.

New technology for characterising forest structure and biomass at 'Super Sites' for EO cal/val across the tropics

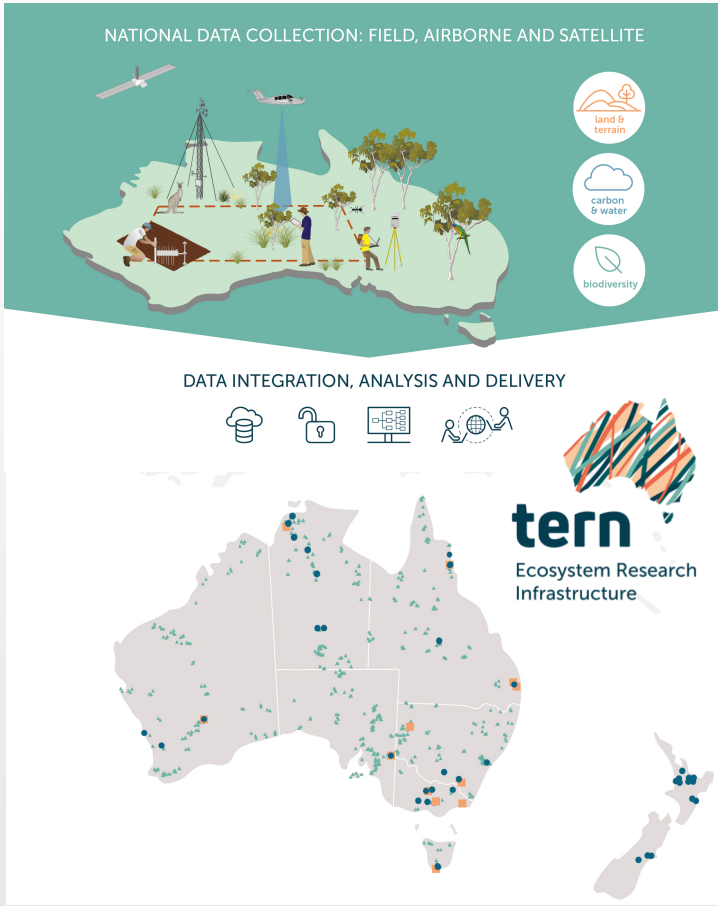


UCL · WAGENINGEN UNIVERSITY & RESEARCH · UNIVERSITY OF LEEDS · THE UNIVERSITY of EDINBURGH · UNIVERSITY OF CAMBRIDGE · esa

Opportunities and Challenges for Implementation of Biomass Protocol

Group: TERN Australian Terrestrial Ecosystem Research Network

- 10 yrs of national collaborative partnerships between research and government
- 12 high intensity monitoring sites and a national flux tower network
- 600+ 1 ha ecological survey plots



Opportunities: New collaborations with TERN and its partner institutions including protocol compliant collection of new high quality field data (Stem measures, UAV/Airborne LIDAR, TLS) including uncertainty assessments

Challenges: This will require extra funding to acquire field stem maps over a suitable spatial extent with coinciding airborne/UAV LIDAR and TLS acquisition

What is needed to overcome challenges?
Additional funding will allow biomass data collection at our existing field sites, suitable for training LIDAR models, in a timely manner.

Opportunities and Challenges for Implementation of Biomass Protocol

Opportunities:

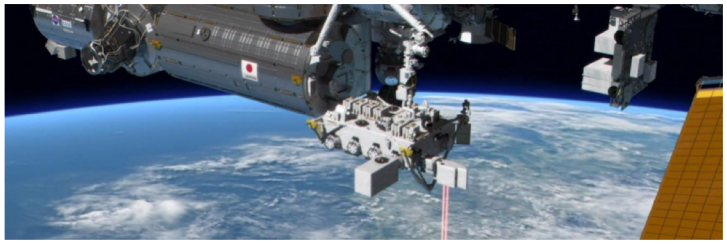
- Well established long-term forest ground measurement networks in Japan (e.g. JSS500, JAUF, JaLTER, JapanFlux)
  - In situ measurements of biomass-related parameters and C flux
  - Limited airborne LIDAR
- Relevant JAXA missions
  - Historical L-band SAR baseline: JERS-1, ALOS, ALOS-2
  - Near-future key missions: MOLI, ALOS-4
- Emerging close collaboration: JAXA & forest research institutions

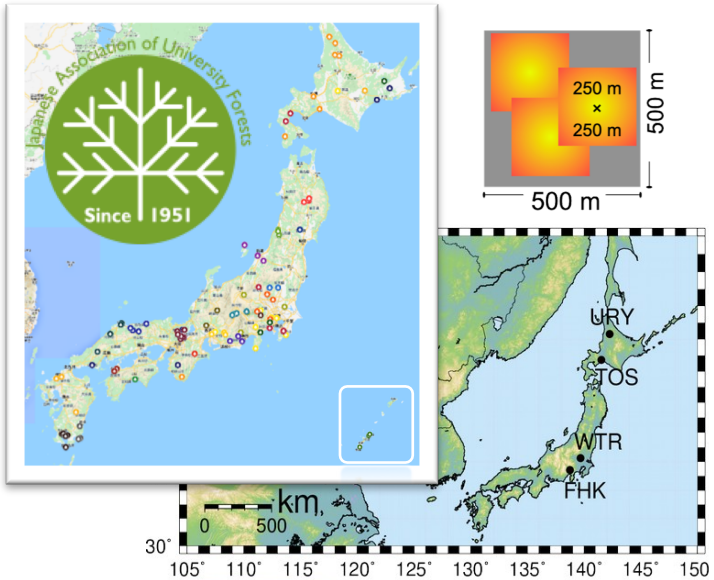
Challenges:

- Adaptation of ground sites for spaceborne measurements
- Lack of contemporary airborne & spaceborne LIDAR observations
- Limited long-term availability of spaceborne LIDAR

Requirements:

- Resources for contemporary airborne & spaceborne LIDAR over key sites
- CEOS coordination
  - MOLI continuation following GEDI
  - Joint observation strategy planning for optimal ALOS-4/NISAR/BIOMASS synergy





FFPRI

筑波大学
University of Tsukuba

JAXA
Japan Aerospace Exploration Agency

Conclusions and Recommendations from Biomass Community

1. The magnitude of new biomass data and products could reduce product uptake by user community unless validation activities are user-friendly, transparent, and well-coordinated.

2. **Significant funding for new and updated reference datasets is required**: new field plot, terrestrial laser scanning and airborne lidar measurements over global biomass reference sites. These measurements must follow consistent protocols.

3. **Biomass reference data should be free and open** to enable transparency in product validation.

Conclusions and Recommendations from Biomass Community

No Space Agency alone can fund the required work to establish a global network of biomass reference sites but each Agency can make a contribution by e.g. funding national supersites or by adopting a supersite (i.e. by making a binding commitment to finance the collection and delivery of ground data over a certain period).

Space Agencies are encouraged to collaborate with established networks (e.g. ForestGEO, Rainfor, NEON, TERN, Afritron, AusCover, TMFO, IIASA, etc) and their local collaborators.

Thank you to the many data collaborators and protocol co-authors – this is a community driven activity!