

# **Concept for a coordinated activity to provide refined global biomass and biomass change estimates in support of the UNFCCC Global Stocktake**

## **Background**

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The biomass multi-mission calibration and validation group, with representatives from NASA GEDI, ICESat-2, NISAR, ESA BIOMASS, JAXA ALOS-1/2/4, field networks, and the MAAP platform, meets monthly to discuss biomass product cal/val and related mission activities. At present, there are ongoing projects producing ALOS/ALOS-2 based global biomass maps (i.e. CCI-Biomass, 100m global for 2010, 2017, 2018; global 100 m JPL product for 2015, and time series of biomass at 10-km from 2000-2020) and additional global-scale biomass products are forthcoming in the first half of 2021. The GEDI 1-km gridded biomass product, with associated 25m lidar sample estimates, and uncertainty will be the first official mission product in the pipeline to be released ~February, 2021. Next, complementing GEDI by filling in the spatial domain north of the ISS coverage, is a NASA funded boreal biomass product that will cover 50N and above using ICESat-2 data. This product is anticipated for release in mid 2021. CCI Biomass and Sassan Saatchi's group are also working toward products that include GEDI and ICESat-2 data, and thus will be representative of 2020+ conditions. There are also a series of biomass change/flux products becoming available (i.e. recent NCC paper lead by Nancy Harris/WRI).

These biomass products will represent the next generation of maps for improved global and regional estimations. There are currently no formal plans for product intercomparison, coordinated validation and harmonization. These would however be key steps toward a dedicated contribution to policy processes like the UNFCCC Global Stocktake. Each product's accuracy is being assessed individually, and thus these accuracies may not be directly comparable to allow for suitable integration of various estimates towards a common objective. This is a gap that could be filled during 2021 through a CEOS-supported and coordinated international effort. This effort should build upon the new CEOS biomass cal/val protocol and reference data and tools available and used by CEOS partners now. Key global biomass production and validation expert teams should be engaged for such a coordinated effort.

To make a dedicated contribution to the UNFCCC Global Stocktake, the aim is to come up with a "best available" biomass stock product at a jurisdictional level globally. The reason for providing estimation at a jurisdictional level is to allow for integration of data sources at different resolutions, to include an aggregation to avoid large random errors at the pixel level, to reduce variations of spatial patterns and potential systematic errors that are inherent features of available biomass map products, and finally to provide harmonized and relatively unbiased estimates at sub-national level and for large-area (i.e. country) aggregates that are

verified by ground observations to the extent possible. A coordinated harmonization, comparative validation and integration of products is at the core of this exercise. All estimations will be accompanied by uncertainty assessment and potential systematic limitations (i.e. lack of sensitivity in high biomass areas).

One idea discussed was to make use of the evolving ESA/NASA MAAP platform (once available, ~April 2021). This platform may be an ideal tool for conducting parts of this activity as a coordinated open-science activity, but discussions need to be had regarding what data and compute power can be made available for this activity. The associated product teams would need to adhere to the open source terms of service for biomass map products and methods. This presents an opportunity to lead the biomass community toward open science.

The multi-mission group will continue discussions toward the potential biomass product inter-comparison / harmonization activity. The ideal scope and scale of this activity for integration with the Global Stocktake should be presented as a coordinated community best effort that aims to provide biomass data both at national and global levels, and helping to harmonize between existing global estimations (i.e. models using in IPCC AR6) and country GHG inventories.

Resources and support will be required for participation of various product teams as this activity would fall outside the scope of funded activities, and therefore relevant CEOS member agencies should be engaged in a discussion of their interest to support this work.

## **CEOS Biomass Harmonization Implementation Plan**

### **Key Personnel:**

1. Laura Duncanson (CEOS, GEDI, ICESat-2, MAAP)
2. Martin Herold (GFOI R&D, CCI)
3. Sassan Saatchi (NISAR)
4. Shaun Quegan (BIOMASS)
5. Joana Melo (NDCs)
6. Richard Lucas (CCI Biomass)
7. Heather Kay (CCI Biomass)
8. John Armston (GEDI, NISAR)
9. Ralph Dubayah (GEDI, NISAR)
10. Sylvia Wilson (GFOI SilvaCarbon)
11. Sean Healey (GEDI, SilvaCarbon, statistics, OBIWAN)
12. Ron McRoberts (statistics)
13. Erik Naesset (statistics)
14. Osamu Ochai (JAXA)
15. Takeo Tadono (JAXA)
16. Ake Rosenqvist (JAXA, ALOS)
17. Klaus Scipal (ESA, BIOMASS)
18. Clement Albinet (MAAP, ESA, BIOMASS)

We are not starting from scratch. Validation efforts will follow the recommendations from the CEOS WGCV LPV biomass protocol and will be the basis for the implementation plan:

- All validation will be done using open code
- All validation will be done using open data (to the degree practicable).

- Where possible, locally calibrated airborne lidar maps will be used to assess pixel-level uncertainties. Note that (as mentioned above) these often include random error and therefore should be conducted using a large sample of geographically distributed products, as available.
- For regions where LIDAR-based reference data are unavailable, other data sources can be used as on a best-efforts basis to allow for larger geographic coverage, and integration and comparisons at jurisdictional levels. In particular the use of plot data from National Forest Inventories (NFIs) are important for the linking to national forest monitoring and GHG inventories.
- Biomass reference data have uncertainties as well and they would need to be included in reference data and map comparisons. All reference data will be screened for spatial and temporal coincidence with remote sensing products. Typically no more than 5 years discrepancies between field/airborne data and satellite data is acceptable, assuming no visible disturbance from an optical time series (Landsat, Sentinel 1/2, Planet).

## **Candidate Products and reference datasets**

We aim to be inclusive of any publicly available continental to global scale aboveground woody biomass product. However considering the tight time frame, filtering candidates using the following criteria for this first ‘pilot’ harmonization activity is advantageous. Candidate biomass products should:

- Cover a large spatial domain (ideally global scale, minimum ~continental scale,)
- Be representative of 2020 conditions (2015 onwards considered)
- Adopt a robust uncertainty framework following recommendations from the CEOS biomass protocol
- Be publicly available by mid 2021 (end of July?), including source code as far as possible
- Have a product representative willing and able to participate in the harmonization activity

In addition to the space-based, large-area biomass, the integration and harmonization relies upon quality reference data coming from LIDAR and relevant plot data sources. Several reference datasets have been compiled by the various biomass mapping efforts/teams (i.e. GEDI, CCI-Biomass) and they should be assessed and combined for this purpose. Particular efforts are needed to compile NFI datasets from the majority of the Annex-I countries with established NFI systems and targeted tropical countries where national or sub-national data may be available for the verification of the jurisdictional estimations.

## **Product Inter-comparison / Validation**

The details and methods employed for inter-comparison and validation will be jointly developed by the biomass harmonization team in collaboration with a few pilot countries in the USGS SilvaCarbon program. While the final methods will be developed, the tentative plan is as follows:

### **Pixel and Ecoregion-level inter-comparison**

- Compile available reference data (following acceptable standards in CEOS biomass protocol) for Terrestrial Ecoregions separated continentally using the best available ecoregion delineation.
- Compare pixel-level reference AGBD to pixel-level biomass product AGBD (e.g. using plot2map).
- Report and analyze uncertainties for each biome at the pixel level (bias, %RMSE)
- Aggregate ecoregion-wide biomass estimates, compare all products at the ecoregion-level
- Spatially map discrepancies, analyze strength and weaknesses of each of the products
- Develop the final product by selecting or combining the estimates, perform jurisdictional scale bias correction and report mean and variance of biomass values

### **Jurisdictional Inter-comparison**

- Put together a global jurisdictional (sub-national) level GIS layer from ESRI or DVIA-GIS or comparable information with the most recent boundaries of jurisdictions globally.
- Derive biomass estimates (mean and variance) at a jurisdictional level globally and/or in the partner countries for each candidate biomass product; considering country definitions of forest and biomass and consistency of forest cover within jurisdictions.
- Estimate jurisdictional-level biomass from available reference data in the candidate countries (e.g. from NFIs).
- Report uncertainties at a jurisdictional-level where reference data are available (bias, %RMSE)
- Compare all products globally at a jurisdictional level
- Spatially map discrepancies

The results from this two-level product validation and inter-comparison exercise will give a quantitative assessment of the usefulness of each biomass product across scales and ecoregions. The examples from the jurisdictional level analysis will provide a pathway toward product uptake by countries, while allowing an assessment of the degree to which pixel-level discrepancies reduce when analysis is conducted at an aggregate scale.

The results from the pixel-level analysis will almost certainly show higher %RMSE values for individual products, and higher discrepancies between products. However these are useful

results, as many biomass product users do analysis at the pixel-scale. A comparison between these results and the aggregated biome and jurisdictional-level results will help facilitate trust in products.

The biome-level results will help facilitate harmonization, as it is anticipated that some products are more or less accurate in different ecosystems.

## **Product Harmonization and Biomass Estimation**

The details of the product harmonization will be discussed by the team, but notionally harmonization will aim to produce a single product at a meaningful spatial resolution for the Global Stocktake. This product will use the best available product(s) estimates for each ecoregion, summarized to a jurisdictional level. For the final “best” biomass estimation there are two options: (1) the top performing product will be selected for each region, for example if there is more than a 20% reduction in uncertainty or a statistically significant reduction in regional bias compared to other products or (2) multiple biomass estimates (and an understanding of their uncertainties) from various products will be combined for an “improved estimate” (reduced bias and uncertainties) in case there is no statistically significant difference in ecoregion-level accuracy statistics (bias, %RMSE). This approach prevents inclusion of products that do not perform well in a specific ecoregion while being flexible to include all candidate products that fulfill the candidacy requirement list above.

Ideally this activity will be conducted on the ESA-NASA Multi-Mission Algorithm and Analysis Platform (MAAP), and open science tool designed for wide area biomass mapping with active remote sensing missions.

## **Product Publication and Dissemination**

The harmonization product, and available source code and reference data will be made publicly available as much as possible (aggregated where data privacy issues exist). An application should be developed that will allow policy makers to easily access and visualize the harmonization product, as well as the contributing biomass product layers and associated uncertainties. This may follow the COVID-19 Dashboard concept.

The effort will be summarized in a joint scientific publication.

## **Required Support**

This activity will require funding and logistical support from associated CEOS membership agencies, including technical support (e.g. of the ESA-NASA MAAP) and salary for key participating groups. Likely one full time FTE will be needed for each candidate biomass model, for generation of the jurisdictional reference dataset, for generation of the biome-level reference dataset, and for an activity coordinator/coder. Ideally the framework will be mature

by July, 2021, with a harmonized and validated product available in advance of COP-26 in November, 2021. This is an ambitious plan on a tight timeline, and to achieve success funding scientists and technicians to begin on this activity will be imminently required.

Time	Activity	Meeting	Milestone
March 2021	Solicit feedback and secure support from CEOS agencies	CEOS SIT	CEOS agencies confirm support for the effort
April 2021	Discuss technical details of the implementation	GFOI R&D workshop / dedicated GST day	Refined concept (incl. list of products, reference data, methods, countries) for the implementation (meeting report)
May/June 2021	<ul style="list-style-type: none"> <li>● Data collection/refinement</li> <li>● Methods selection/implementation</li> <li>● MAAP trials</li> <li>● Candidate country engagement</li> </ul>	Regular team teleconferences	
July 2021	Finalize technical framework and compilation of all data sources	Regular team teleconferences 1 day expert workshop	All data and algorithms selected, documented and ready to be used
Aug/Sept/Oct 2021	Implement validation, harmonization and estimation by various teams	Regular team teleconferences	
Nov 2021	Derive prototype biomass estimates and solicit feedback from key partners and countries	UNFCCC COP 26	Present prototype at UNFCCC COP 26 side event
Dec'21- Feb '22	Finalized biomass estimations and document in scientific paper	Regular team teleconferences	Final dataset and scientific paper available online