Workshop: Use of space-based biomass maps for policy reporting
20-22 March 2024

Background

Several institutions, organizations and scientists across the globe are producing continental to global-scale biomass maps with Earth Observation (EO) data. To name a few, the map products include the European Space Agency's (ESA) Climate Change Initiative (CCI) Biomass global maps at a scale of 100 m for 2010, 2017, 2018, 2020 and annually thereafter, NASA JPLs (National Aeronautics and Space Administration Jet Propulsion Laboratory) global 100 m map for 2020 (to be publicly released in early 2024), NASA GEDI estimates covering latitudes between about 51.6° N and 51.6° S, the NASA ICESat-2 30 m boreal map for 2020 etc. These existing and upcoming products can potentially assist with estimating carbon stocks and hence aid various (sub)national initiatives and UNFCCC processes.

The 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas (GHG) Inventories mentions the use of biomass maps for estimating emission factors (EF)[1]. This refinement is supported by GFOI guidance (v.3)[2]. However, at the time of developing this guidance, country examples using biomass maps for GHG reporting were scarce or not available. In the last few years, the USGS has organized a series of regional workshops and one-on-one consultations with countries to understand the potential of using these maps for improving their emission factors for international reporting. At the same time, dedicated research on integration methods of biomass maps with forest inventory data has been carried out, which are a product of research/country collaborations. Actions and recommendations from workshops and collaborations need to be undertaken in advance to support countries wishing to utilize a global (or pantropical) biomass map product in current (sub)National Forest Monitoring.

The University of Maryland and the USGS SilvaCarbon program with the support of the GFOI R&D Component held an expert workshop with biomass product developers, GHG reporting experts, statisticians and country representatives from one country (Mexico) to discuss integration methods of space-based biomass maps and national forest inventories for policy-level reporting.

Workshop objectives:

1. Receive an update from map developers on current methods and approaches to estimating biomass and associated uncertainty, and clarify what the current requirements for reporting on the policy side are. This exercise is for map developers to understand policy-level needs for consistency and transparency on various sources of uncertainty.

2. Collaboratively review approaches and codes to integrate NFI data and EO-based AGBD (CCI) or forest height (GEDI) estimates. Data from two countries (Mexico and Mozambique) were used for this exercise, with the aim of creating codes/modules that are practically implementable by in-country technical teams.

3. Collaboratively discuss the steps needed towards operationalizing the use of biomass maps in national estimation and reporting, the existing limitations on country uptake, as well as developing guidance on the use of biomass maps for GHG reporting. Discussions were moderated by the GFOI R&D component lead and coordinator.

Location
The workshop was held in the USGS headquarters in Reston, Virginia. Virtual participation was also possible.

Organizers

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[1] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Generic Methods.pdf
[2] https://www.reddcompass.org/mgd/en-3/s10s03s01s02.html#56885958

Neha Hunka and Laura Duncanson (UMD), Sylvia Wilson (USGS), Daniela Requena Suarez and Martin Herold (GFOI R&D/GFZ)

Detailed Agenda

Wednesday March 20, 2024 (time zone US Eastern Summer Time)

Time	Presentation / Discussion	Name
	Policy needs and Biomass Maps: Can we meet reporting requirements **Moderator**: Laura Duncanson	
09:00 AM	Introductions and Workshop objectives	Sylvia W. /Neha H
09:30 AM	Biomass Harmonization project and Lessons for Space Agencies	Laura D.
10:00 AM	Summary of USGS biomass workshops: Feedback	Sylvia W.
10:30 AM	Reporting for Carbon Markets: Validation and Verification	Catalina B.
11:30 AM	------ Coffee ------	
11:00 AM	Reporting to the UNFCCC. What is the ask, what must EO provide?	Joana M.
11:30 AM	Insights from cross-country model-assisted estimation applications	Natalia M.
12:00 AM	Characterizing and communicating uncertainty: How can we provide more concrete, technical details on uncertainty analysis for cases based on model-assisted and model-based inference	Ron M.
12:30 AM	------ Lunch ------	
Moderator: Robert Kennedy		
14:00 PM	Introduction to Mozambique's NFI and study assumptions	Natalia M.
14:30 PM	Hands-on R demo/scripts: Integration of CCI Biomass map and Mozambique NFI *(followed by discussion/feedback session)*	Natalia M./Daniela R.
15:15 PM	------ Coffee -------	
15:30 PM	The GEDI uncertainty estimation process: Hybrid, GHMB	John A./Sean H.
16:00 PM	The CCI mapping approach and uncertainty estimation	Maurizio S.
17:00 PM	------ End of day -----	

Thursday March 21, 2024 (time zone US Eastern Summer Time)

Time	Presentation / Discussion	Name
	Integrating NFIs and EO data: Approaches, estimators and case studies **Moderator**: Maurizio Santoro	
09:30 AM	Bayesian hierarchical spatial models to generate statistically rigorous estimates of forest carbon using remote sensing data	Chad B./Andy H.
10:30 AM	CONAFOR: Introduction to Mexican NFI and reporting needs	Armando Alanís/ Angeles Soriano Luna
11:15 AM	------ Coffee ------	

Time	Presentation / Discussion	Name
11:30 AM	Hands-on R demo/scripts : Integration of maps and Mexico's NFI *(followed by discussion/feedback session)*	Neha H./Paul M./Chad B.
12:15 AM	------ Lunch ------	
Moderator: Andy Hudak		
14:00 PM	Discussion session: potential applications and communication strategies of GMB outputs	Neha H./Paul M./Chad B.
15:00 PM	Uncertainty in NASA's Carbon Monitoring System: Conceptual framework and applications	Robert K.
17:00 PM	------ End of day -----	

Friday March 22, 2024 (time zone US Eastern Summer Time)

Time	Presentation / Discussion	Name
EO-based estimates can be used to fill gaps in current guidance in the policy **Moderator**: Martin Herold		
09:00 AM	JAXA: CEOS SIT Chair prospectus and JAXA new biomass mapping project	Osamu O.
09:30 AM	EO-based estimates of IPCC Tier 1 defaults: Useful or not?	Neha H./Joana M.
10:00 AM	------ Coffee ------	
10:15 AM	Country feedback on the use of space-based biomass maps for policy reporting	Sylvia W.
10:30 AM	Towards operationalizing the use of global biomass maps in national estimation and reporting	Daniela R. / Marti H.
	Discussion section: how can R&D contribute to the development of further guidance. What next steps are required?	Led by Daniela R. / Martin H.
12:00 PM	Discussion session: Communication on accounted sources of uncertainty for CCI Biomass and GEDI	Maurizio S. / Laura D.
12:30 PM	Meeting summary and actions	ALL
13:00 PM	------ End of day -----	

Participant list

	Participant	Institute	Attendance
1	Neha Hunka	University of Maryland	In-person
2	Sylvia Wilson	USGS (SilvaCarbon)	In-person
3	Daniela Requena Suarez	Helmholtz Center Potsdam GFZ	In-person
4	Martin Herold	Helmholtz Center Potsdam GFZ	In-person
5	Laura Duncanson	University of Maryland	In-person
6	John David Armston	University of Maryland	In-person

7	Maurizio Santoro	Gamma Remote Sensing	In-person
8	Natalia Malaga	Wageningen University	In-person
9	Robert Kennedy	Oregon State University	In-person
10	Chad Babcock	University of Minnesota	In-person
11	Paul May	South Dakota Mines	Online
12	Sean Healey	USFS	Online
13	Andrew Hudak	USFS	In-person
14	Erik Næsset	Norwegian University of Life Sciences	Online
15	Ronald McRoberts	University of Minnesota	Online
16	Joana Melo	EC JRC	Online
17	Osamu Ochiai	JAXA	Online
18	Ake Rosenqvist	JAXA	Online
19	Catalina Becerra	World Bank	In-person
20	Pontus Olofsson	NASA	In-person
21	Armando Alanis (and team)	CONAFOR	Online
22	Angeles Soriano (and team)	CONAFOR	Online

Summary of discussions

Day 1 Summary

1. **Workshop objectives:** Neha H. outlined key objectives for the workshop, focusing on addressing policy needs from biomass maps, improving communication between the biomass mapping community and policymakers, and initiating discussions on the development of country guidance.
2. **Feedback from biomass workshops:** Sylvia W. summarized feedback from USGS biomass workshops, highlighting limitations in biomass map utilization such as accuracy, resolution, and coverage issues. Suggestions were made to enhance communication with countries to identify and address these limitations.
3. **Biomass Harmonization and Lessons for Space Agencies:** Laura D. discussed how this workshop's outcomes can contribute to summarizing lessons for space agencies, including recommendations such as ensuring continuity of biomass maps.
4. **Policy reporting:** Catalina B. from the World Bank discussed reporting requirements for Carbon Markets, emphasizing the need for transparency, replicability, and compliance with standards. Joana M. discussed reporting to the UNFCCC, emphasizing the role of EO data in supporting international policy decisions on climate change.
5. **Cross-country comparison of model-assisted estimation:** Natalia M. presented insights on a cross-country comparison using global biomass maps as a supplementary source to improve the precision of (sub)national forest-related biomass estimates for reporting purposes. Challenges included aligning reference NFI data with map values and ensuring context-specific assessment for different countries.
6. **Characterizing and communicating uncertainty:** Ron M. discussed uncertainty analysis for model-assisted and model-based inference, emphasizing the importance of probability sampling designs in NFIs. Furthermore, technical details were provided on how to use biomass maps when there is a probabilistic sample and when there is a non-probabilistic sample or no reference data. A key recommendation was for countries to henceforth develop NFIs using common, probability sampling designs.
7. **Mozambique's NFI and model-assisted estimation:** Natalia M. introduced Mozambique's NFI and the assumptions used in her analysis based on the NFI design and implementation. This presentation was followed by a hands-on R notebook session in which Natalia M. and Daniela R. explained the model-assisted approach used for the Mozambique NFI step by step through a set of R notebooks. Discussions on ways to improve these notebooks centered on including more explicative text, including map outputs for better visualization of the method, and potentially creating replicable functions for some sections.
8. **GEDI uncertainty estimation process:** John A. discussed GEDI's uncertainty estimation process, highlighting improvements in biomass models with new data and the importance and need for local/regional calibration.
9. **CCI Biomass mapping approach and uncertainty estimation:** Maurizio S. presented the CCI mapping approach and uncertainty estimation, focusing on the integration of C-band and L-band radar data and the challenges of using national or sub-national averages of ground-estimated AGB in model parametrization.

Day 2 Summary

1. **Modeling Approaches (Bayesian vs. Frequentist approaches):** Chad B. presented Bayesian hierarchical spatial models for estimating forest biomass, particularly focusing on spatial autocorrelation and uncertainty propagation. A comparison between frequentist and Bayesian approaches highlighted the advantages of Bayesian methods in handling uncertainty and adapting to complex data structures.
2. **Introduction to Mexican NFI and Reporting Needs:** Armando A. and Angeles S. presented an overview of Mexico's NFI system and reporting requirements for national and international purposes. Current challenges include financial constraints, which have led to incomplete data collection in recent NFI cycles. To estimate aboveground forest biomass for national internal reporting, CONAFOR uses machine learning approaches. Additional challenges highlighted include need for transparency and replicability of methods per year, estimating net biomass change in forests remaining forests (incl. forest degradation), NFI gap filling, and improving land cover change mapping.

3. **Mexico's NFI and geostatistical model-based estimation:** Neha H. led a hands-on demonstration of the methods behind the integration of Mexico's NFI data with GEDI height data and CCI Biomass data using a geostatistical model-based (GMB) approach. The objective of this approach was to fill in gaps within the existing NFI dataset and allow predictions over small areas (typical of the size of anthropogenic disturbances). Large scales were accounted for through the Finite Element Method (FEM). Discussions followed on improving the communication and clarity for sharing this method, as well as defining examples with applications of interest for reporting countries. Explainer notebooks are available online[3].

4. **Mapping AGB and Communicating uncertainties:** Robert K. presented an overview on past biomass estimation efforts, and frameworks to guide effective communication strategies to conveying methods and uncertainty to developers and end-users.

Day 3 Summary

1. **JAXA Biomass Mapping Project:** Osamu O. presented on JAXA's role as CEOS SIT Chair, emphasizing the need to develop a coordinated effort for the upcoming Global Stocktake. Furthermore, plans for JAXA's new biomass mapping project were revealed, including activities such as airborne LiDAR collection and field campaigns in Japan and Cambodia.

2. **EO-based estimates of IPCC Tier 1 biomass stock defaults:** Neha H. presented briefly on a framework to produce biomass estimates from space-based biomass data in a format that aligns with current IPCC Tier 1 biomass stock values[4]. This was followed by discussions led by Joana M. on the usefulness of new map-based Tier 1 values for verification/control purposes and building trust through open-science communications.

3. **Country considerations for the dissemination of biomass data:** Sylvia W. presented a summary of key points highlighted by countries for map developers on the dissemination and use of biomass data. These included data accessibility, privacy and transparency. Ethical considerations in data dissemination to minimize adverse effects on local populations were also mentioned. A final point stressed the importance of country engagement as integration methods are being developed, with a focus on understanding country-specific context, challenges and needs. A key recommendation was the inclusion of these highlights in any forthcoming guidance.

4. **Formulation of a GFOI Biomass map module:** Daniela R. presented background of existing guidance (2019 IPCC Refinement and GFOI MGD) and the need to develop concrete examples – such as those presented in this workshop – to support existing guidance, as well as to answer the request for operational guidance by GFOI MGD, WB and FAO. This is to be done as a joint GFOI effort. Martin H. led a discussion on the current limitations of biomass map uptake, and highlighted the importance of understanding and addressing country needs. Discussions centered on the TACCC principles of the UNFCCC and how they relate to existing biomass products and integration methods. Next steps, such as advocacy for continuity of existing missions and community efforts in developing guidelines were discussed.

Based on the discussions during the three days of workshop, it is clear methods that integrate EO data, EO-derived biomass maps, and NFIs have made significant progress. Research continues to invest in open-science and clear communication for countries to uptake these methods for policy, while addressing ongoing challenges in EO-data integration and modeling. Across the wokrshop's presentations and discussions, there was an emphasis on the need for coordinated efforts, methodological transparency, and policy alignment to ensure the effective dissemination and utilization of biomass data. Moving forward, sustained collaboration, focus on country needs, and a commitment to open communication of methods and results will be essential to formulate guidance on the use of biomass maps for country reporting. A follow-up GFOI workshop in which guidance is consolidated has been tentatively set for October 22-25, 2024 (location TBD).

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[3]https://repo.maap-project.org/lduncanson/biomass_harmonization/-/blob/master/NASA_CMS_2023/Mexico/GMB_Mexico.ipynb

[4] Neha Hunka, Laura Duncanson, John Armston, et al. Intergovernmental Panel on Climate Change (IPCC) Tier 1 forest biomass estimates from Earth Observation. *ESS Open Archive (preprint)* . March 04, 2024. DOI: 10.22541/au.170958900.06861359/v1