Supplementary information for

Design and performance of the Climate Change Initiative Biomass global retrieval algorithm

by Santoro, M., Cartus, O., Quegan, Q., Kay, H., Lucas, R.M., Araza, A., Herold, M., Labrière, N., Chave, J., Rosenqvist, Å., Tadono, T., Kobayashi, K., Kellndorfer, J., Avitabile, V., Brown, H., Carreiras, J., Campbell, M.J., Cavlovic, J., da Conceição Bispo, P., Gilani, H., Khan, M.L., Kumar, A., Lewis, S.L., Liang, J., Mitchard, E.T.A., Pacheco Pascagaza, A.M., Phillips, O., Ryan, C.M., Salkia, P., Schepaschenko, D., Sukhdeo, H., Verbeeck, H., Vieilledent, G., Wijaya, A., Willcock, S., Seifert, F.M.

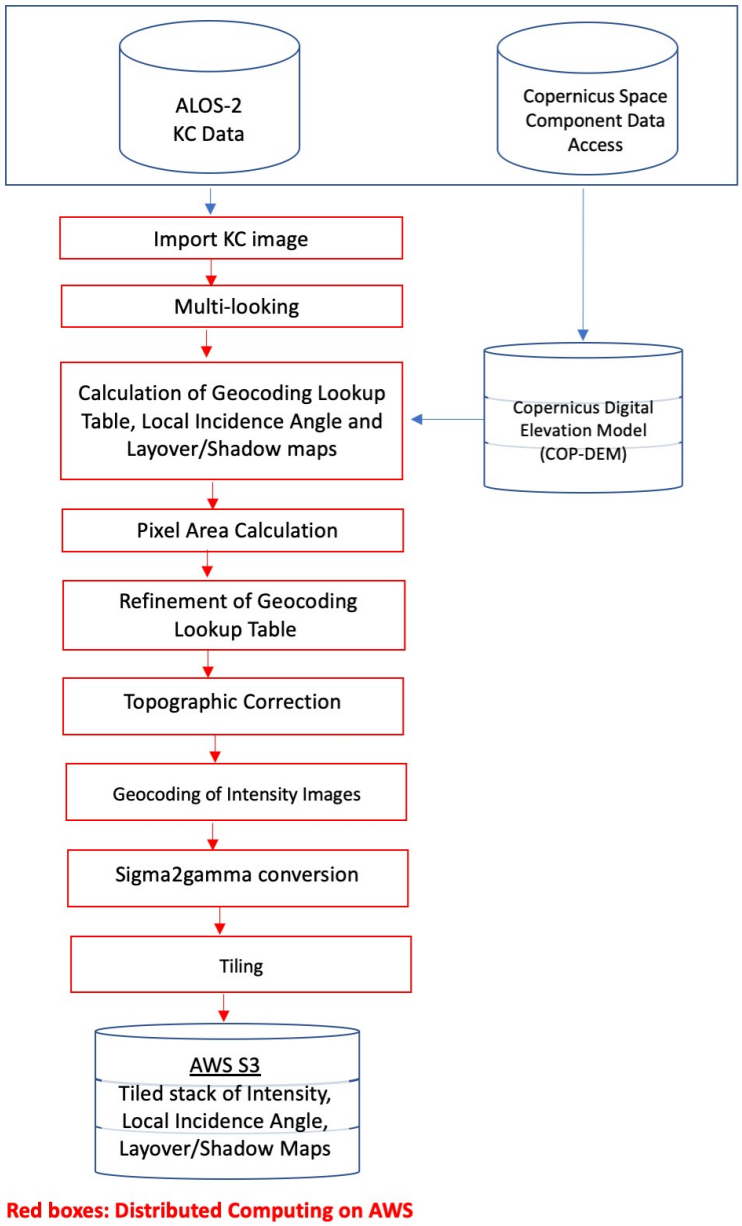

Figure S1. Processing workflow for the ALOS-2 PALSAR-2 FB mode image dataset. The processing was implemented on the Amazon Web Services (AWS).

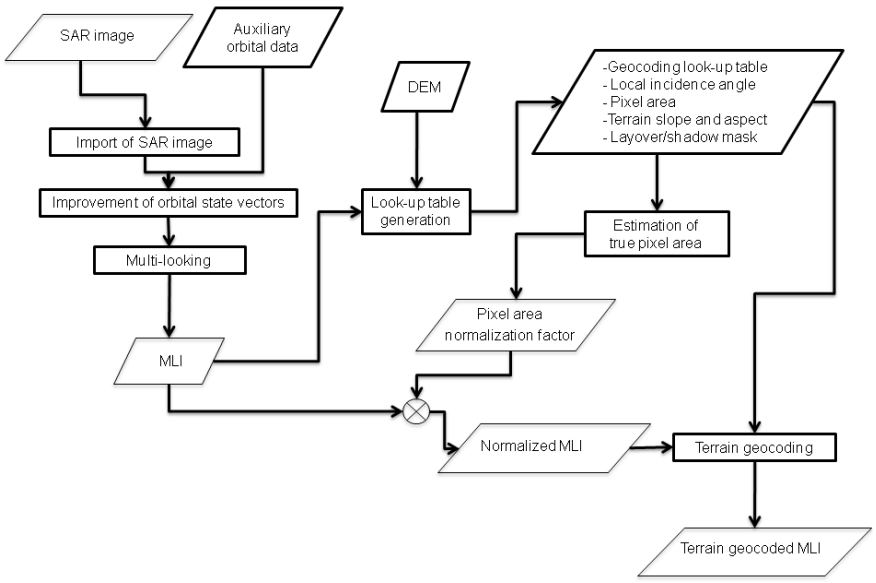

Figure S2. Flowchart of the Sentinel-1 data pre-processing

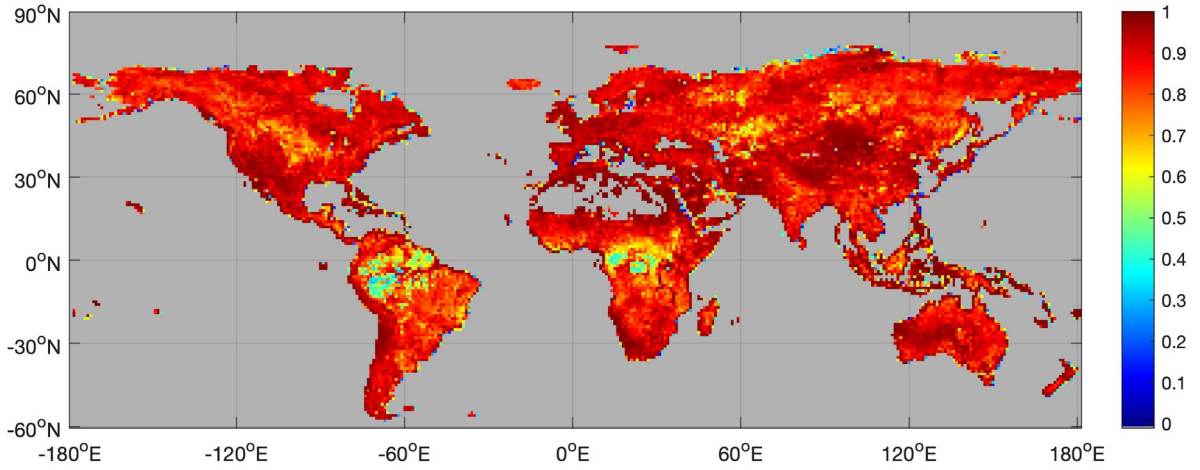

Figure S3. Map of the average correlation coefficient for Sentinel-1 backscatter observations (year 2020, VH-polarization) acquired in the same month.

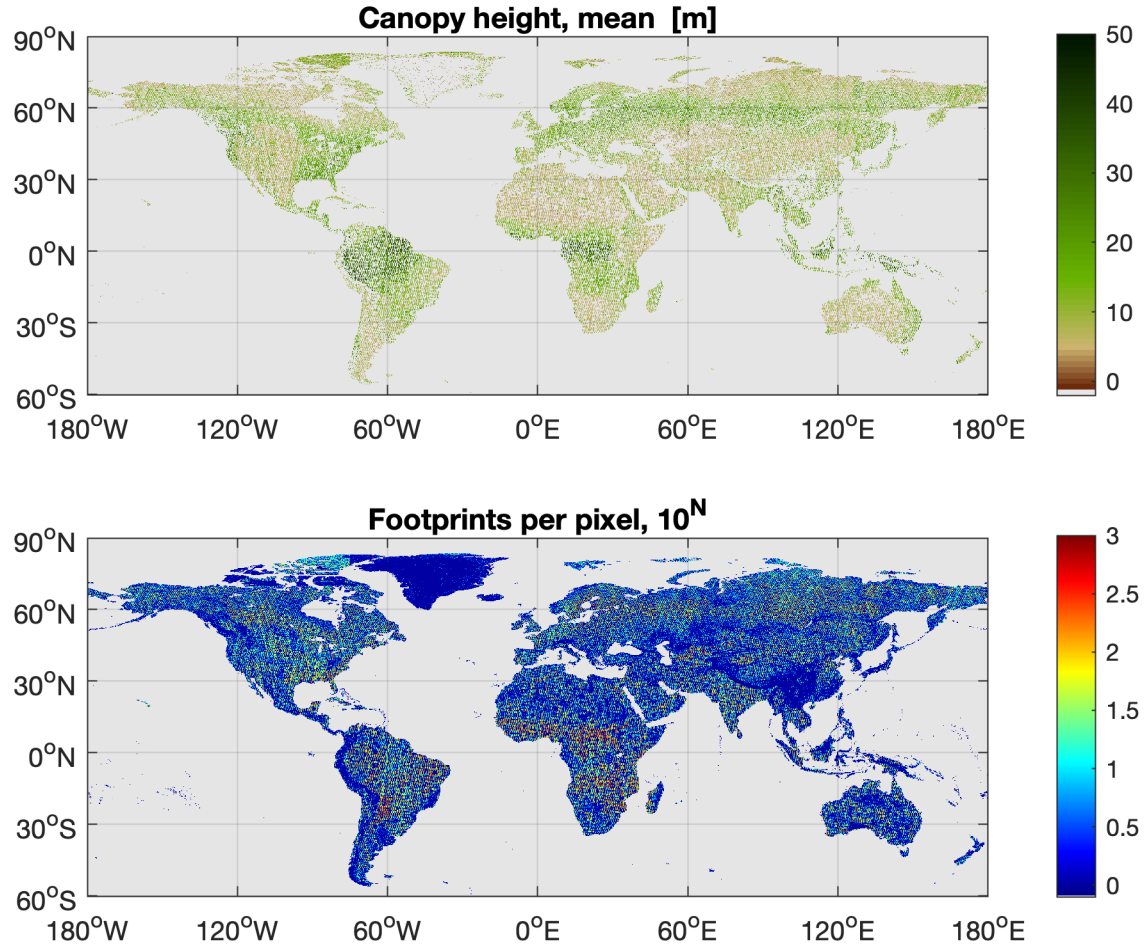

Figure S4. Maps of average canopy height and corresponding number of ICESat GLAS LiDAR footprints for a grid cell spacing of 0.1°.

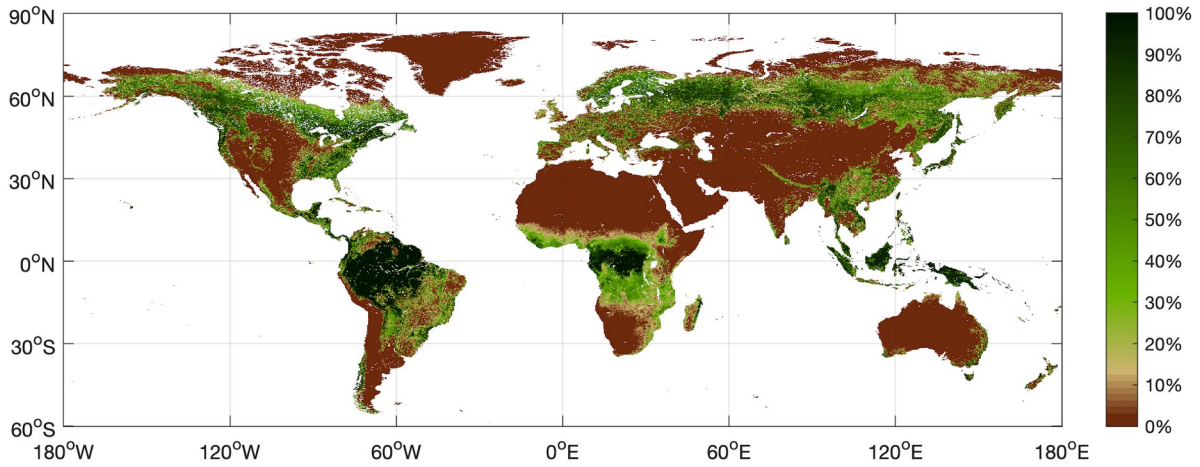

Figure S5. Tree cover for the year 2010 (Hansen et al., 2013).

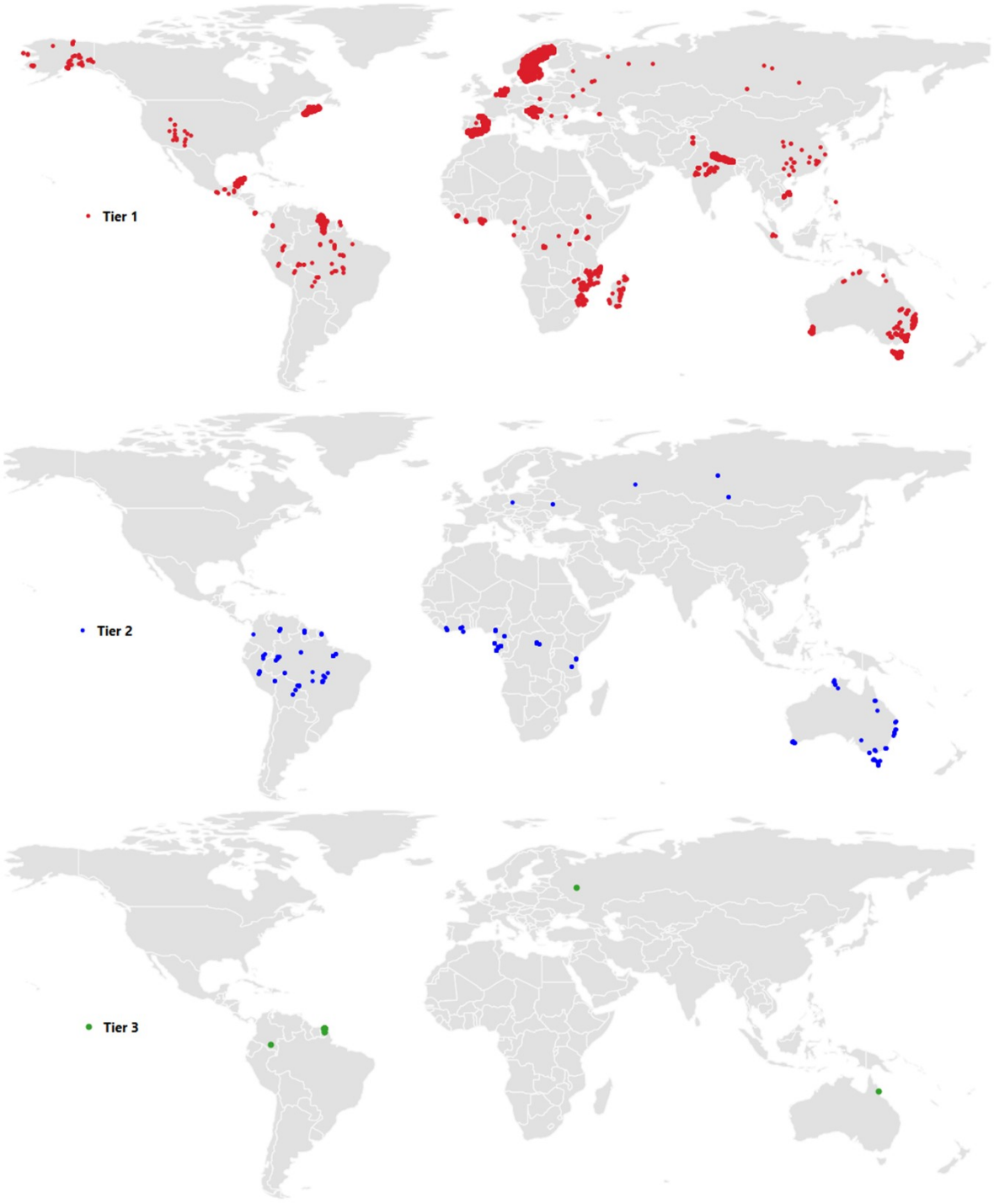

Figure S6. Locations of forest inventory plots stratified by Tier. Tier 1 consists of plots 0.6

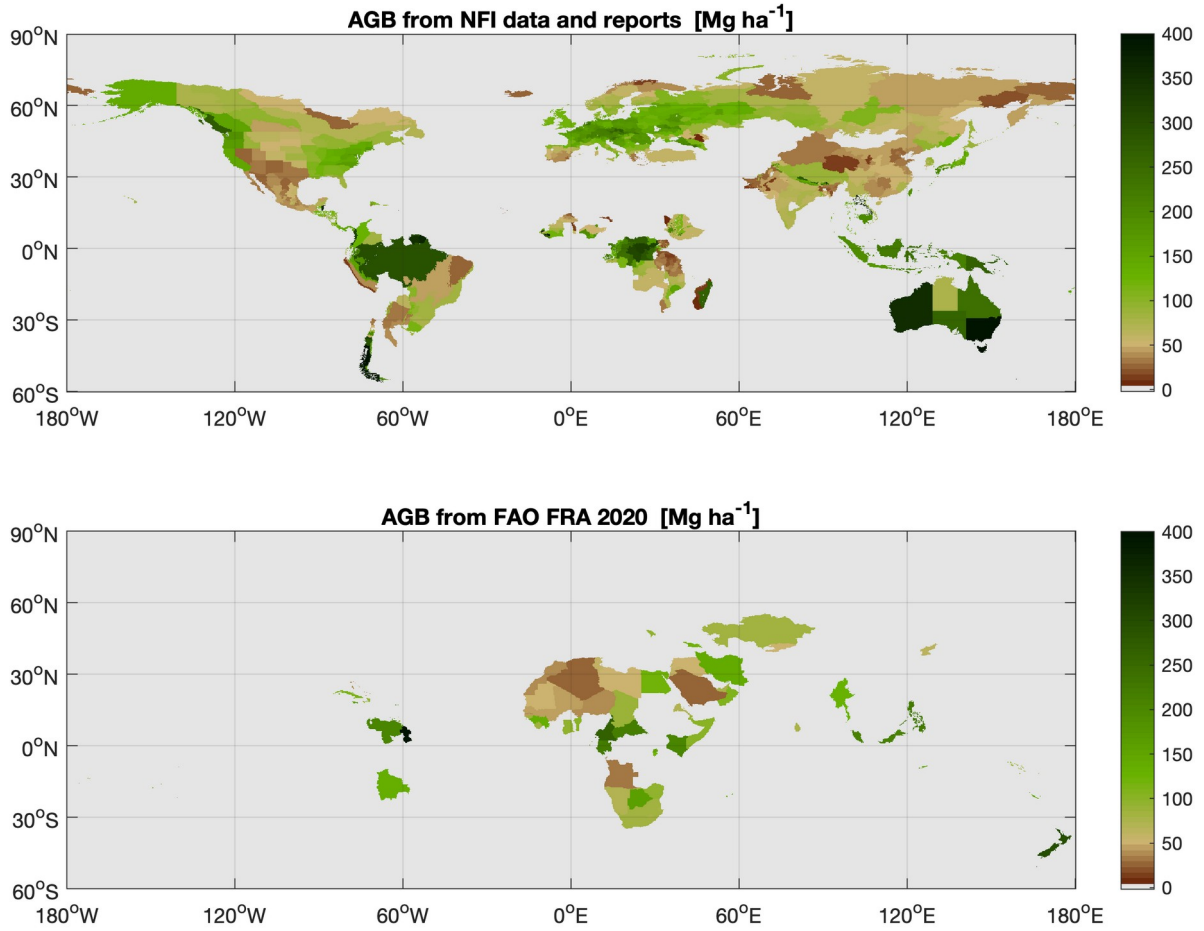

Figure S7. Map illustrating the coverage of AGB values at sub-national or national level based on NFI measurements and reports.

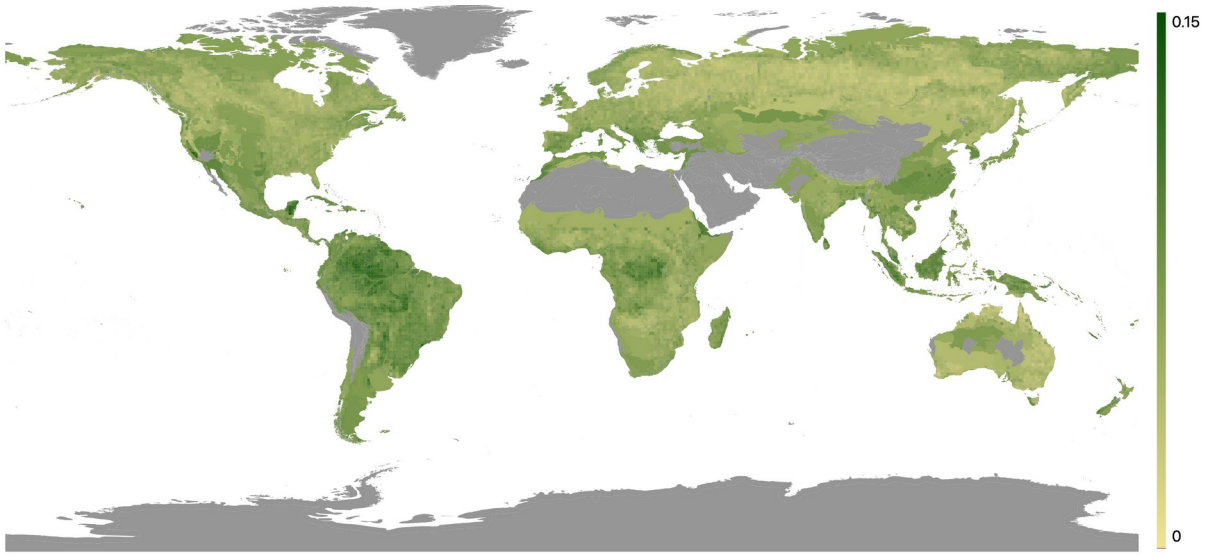

Figure S8. Map of the coefficient q in Eq. (3) per combination of Terrestrial Ecoregions of the World dataset and 1° × 1° grid cells, obtained through least squares regression of ICESat GLAS metrics of canopy height and canopy density within each ecoregion after filtering (Kay et al., 2021). Ecoregions in white had no footprints.

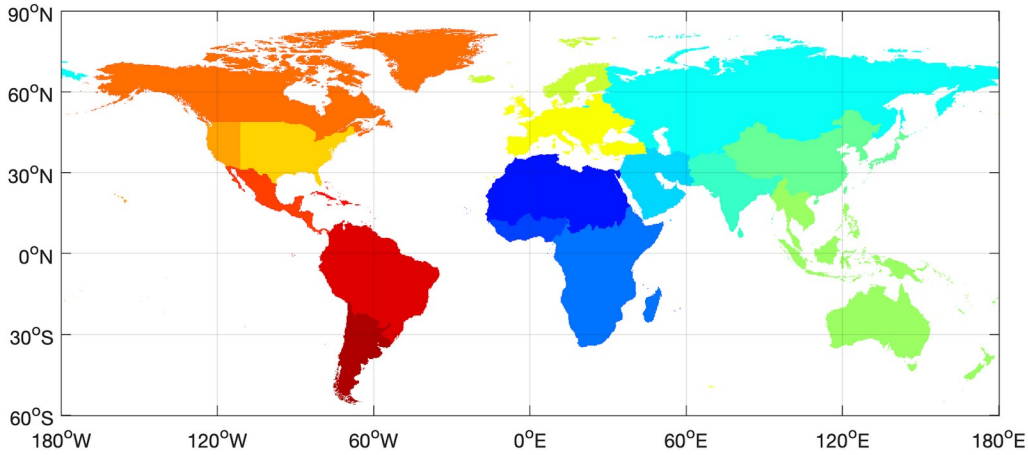

Figure S9. Strata used to split the database of AGB and LiDAR canopy height statistics.

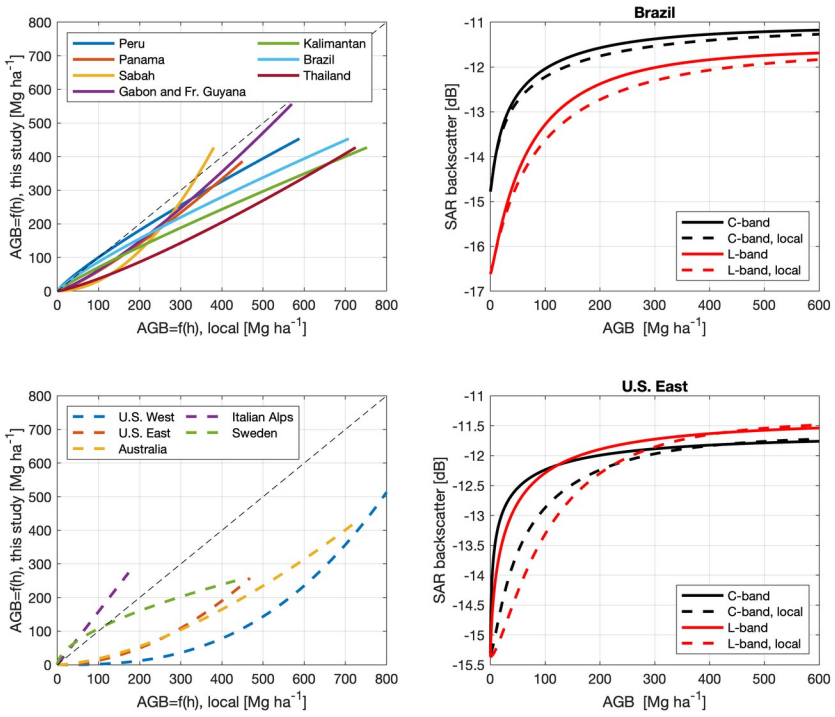

Figure S10. Comparison of AGB estimated from Eq. (4) using published functions and functions developed in this study for tropical regions (top left panel) and extra-tropical regions (bottom left panel) (Asner and Mascaro, 2014; Coomes et al., 2017; Labriere et al., 2018; Labriere, unpublished; Jha et al., 2020; Dalponte et al., 2019; Santoro et al., 2021). The panels on the right hand-side shows predicted AGB for sites in Brazil (top right panel) and U.S. East (bottom right panel) using the AGB = f(h) functions derived in this study (solid curves) and published in literature (dashed curves) at C- and L-band.

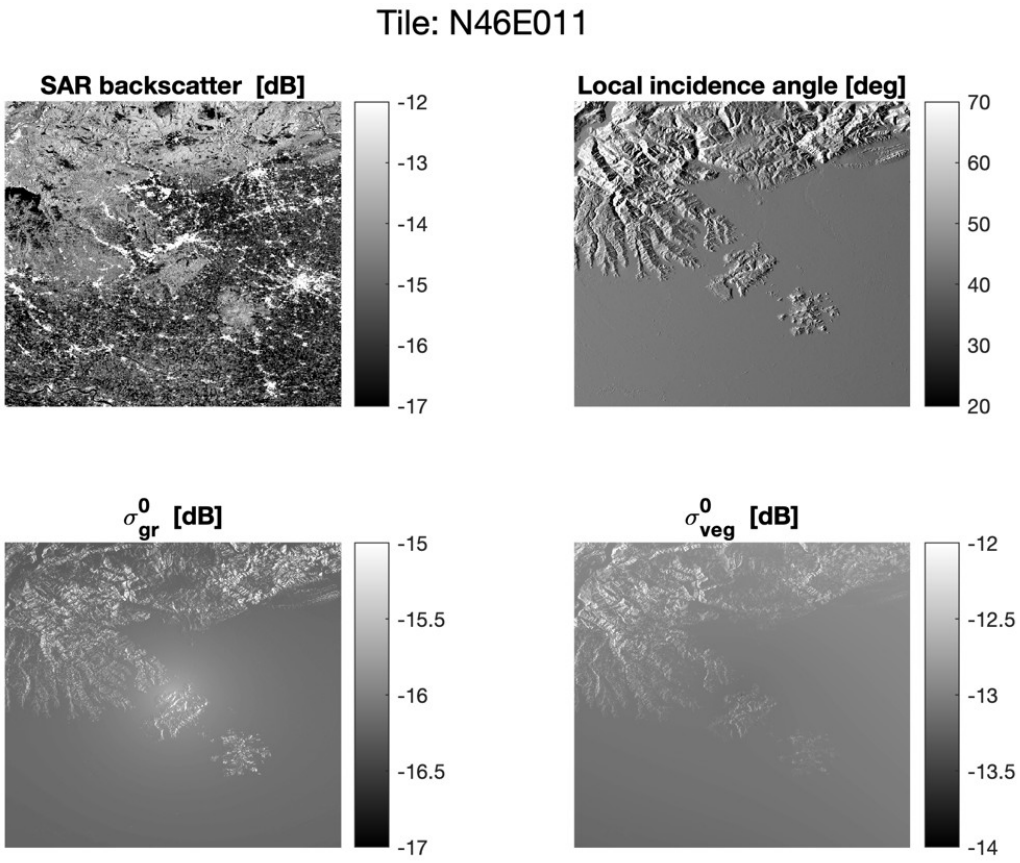

Figure S11. Example of raster images of the estimates of σ^0_{gr} and σ^0_{veg} (bottom row) for the Sentinel-1 tiled image used in Fig. 9. The top row shows the image of the SAR backscatter and the image of the local incidence angle. The raster images of σ^0_{gr} and σ^0_{veg} show a slight decrease of the backscatter coefficients for increasing incidence angle following the quadratic function fitted to the five estimates of σ^0_{gr} and σ^0_{veg} for local incidence angle in Fig. 9.

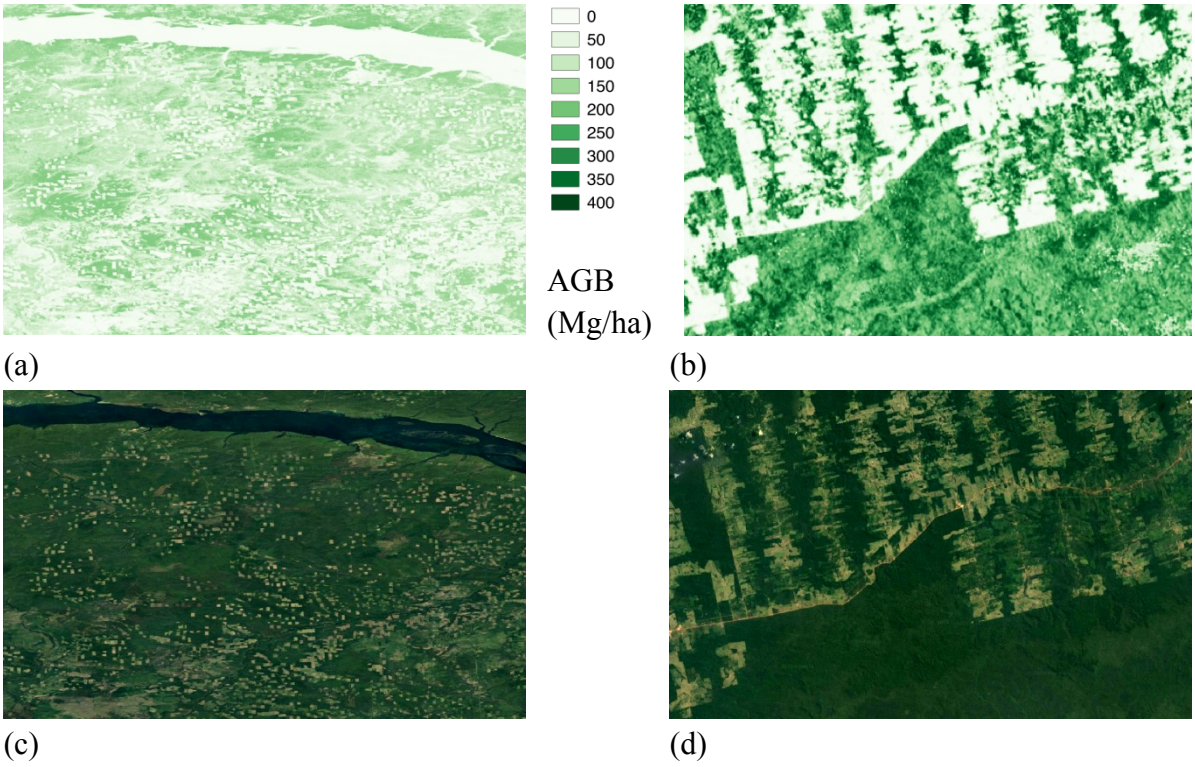

Figure S12. Detailed views of the AGB map for the region of Bratsk, Central Siberia, (a) and along the Trans-Amazonian Highway, between the cities of Uruará and Altamira, Brazil (b). Panels (c) and (d) are optical imagery from Google Earth and serve as reference for each of the AGB maps. The region displayed in panels (a) and (c) consists of forests dominated by boreal coniferous species with AGB up to 200 Mg ha^{-1}. Clear-cuts due to intensive logging, visible in the Google Earth image in the form of yellow rectangles, appear in the AGB map as white, i.e., with a value close to 0 Mg ha^{-1}. The region displayed in panels (b) and (d) show a detail of the forest along the Trans-Amazonian Highway.

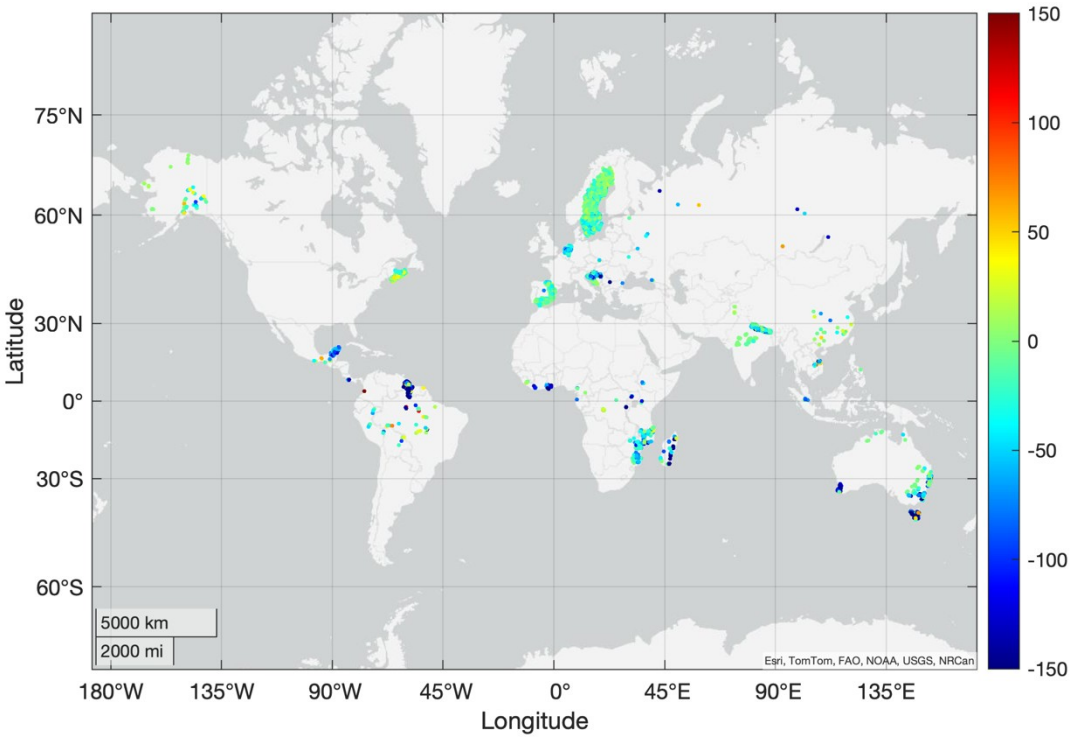

Fig. S13. Map of the spatial distribution of estimation errors at grid cell level. Errors are defined as the difference between map-based and plot-based average AGB per grid cell. The color bar is constrained between ± 150 Mg ha^{-1} to enhance the contrast.

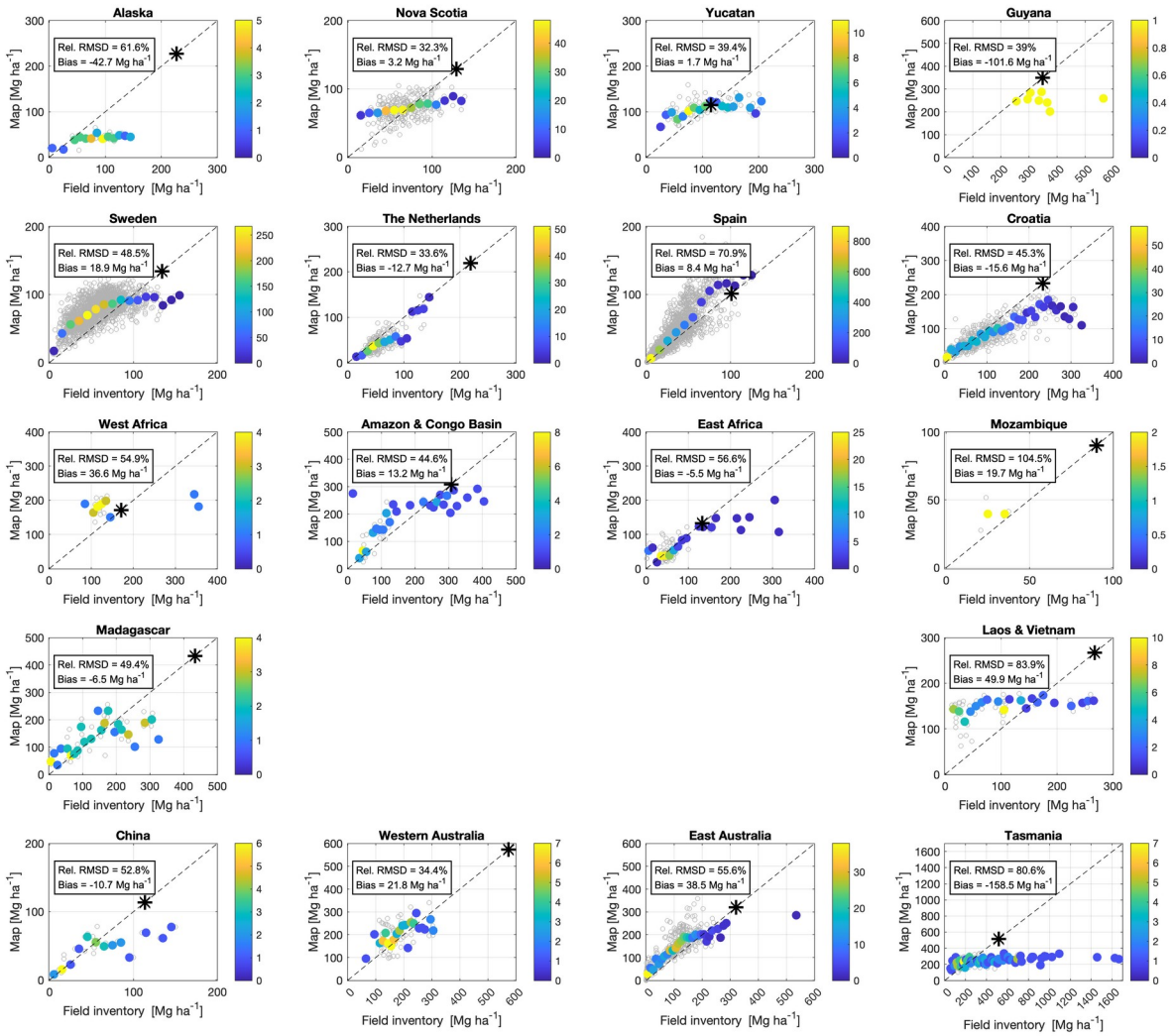

Fig. S14. Comparisons between the map-based and the plot-based AGB values spatially averaged to 0.1° (grey circles) used in Santoro et al. (2021). The data are grouped for the same regions as in Fig. 18. In each panel, the map-based AGBs were also binned over 10 Mg ha^{-1} wide ranges with filled circles representing the median mapped AGB per bin. The color bars represent the number of grid cells within a given AGB interval. Each panel includes the root mean square difference (RMSD) between map and field inventory AGB relative to the mean value of the reference AGB and the bias, i.e. the difference between mean values of the map AGB and the reference AGB. The asterisks on the identity line represent the maximum AGB in each region.

Table S1. Metadata of the Tier 1 field inventory dataset of AGB.

ID	Average year	Average size ha	Biome	Reference / source
AFR_FOS	2013	0.25	Tropical rainforest	(Schepaschenko et al., 2019)
AFR_GHA	2010	0.1	Tropical rainforest	(Brown et al., 2020)
AFR_KEN	2011	0.09	Tropical and subtropical grasslands, savannas and shrublands	n/a (private sharing)
AFR1	2010	0.5	Tropical rainforest	(Hirsh et al., 2013)
AFR12	2010	0.16	Tropical rainforest	(Avitabile et al., 2012)
AFR15	2013	0.25	Tropical dry and mosit forest	(Vieilledent et al., 2016)
AFR4	2012	0.13	Tropical mountain system	(DeVries et al., 2012)
AFR5	2012	0.08	Tropical rainforest	(Vaglio Laurin et al., 2016)
AFR9	2016	0.13	Tropical dry forest	(Carreiras et al., 2012)
ASI_IND	2018	0.5	Tropical and subtropical dry broadleaf forest	n/a (private sharing)
ASI_NEP1	2022	0.1	Temperate broadleaf and mixed forests	(Khanal et al., 2023)
ASI_NEP2	2022	0.1	Temperate broadleaf and mixed forests	n/a (private sharing)
ASI_PAK	2022	0.1	Temperate broadleaf and mixed forests	n/a (private sharing)
ASI1	2010	0.05	Tropical mountain system and rainforest	(Avitabile et al., 2016)
ASI2	2011	0.11	Tropical dry forest	(WWF and ÖBf, 2013)
ASI4	2010	0.02	Tropical dry forest	(Wijaya et al., 2015)
ASI9	2012	0.13	Tropical rainforest	(Avitabile, 2014)
AUS1	2012	0.1	Subtropical steppe	(Paul et al., 2016)
EU_FOS	2015	0.28	Boreal forests	(Schepaschenko et al., 2019)
EU_FOS	2016	0.2	Different biomes	(Schepaschenko et al., 2019)
EU1	2011	0.01	Temperate broadleaf and mixed forests and Boreal forests	https://www.slu.se/en/Collaborative-Centres-and-Projects/the-swedish-national-forest-inventory/listor/sample-plot-data/
EU2	2010	0.2	Mediterranean forests	https://www.miteco.gob.es/es/biodiversidad/servicios/banco-datos-naturaleza/informacion-disponible/ifn3.html
EU3	2013	0.06	Temperate oceanic forest	(Schelhaas et al., 2014)
EU4	2010	0.06	Temperate broadleaf and mixed forests and Mediterranean forests	(Cienciala et al., 2008)
NAM_JUNI	2022	0.1	Temperate woodlands	(Campbell et al., 2024)
NAM_TUND	2012	0.3	Tundra	n/a (private sharing)
NAM1	2010	0.04	Boreal coniferous forest	(Liang et al., 2015)

NAM3	2010	0.03	Temperate continental forest	n/a (private sharing)
NAM4	2010	0.04	Temperate mountain system	n/a (private sharing)
SAM_BAJ	2017	0.25	Tropical rainforest	(Pacheco-Pascagaza et al., 2018)
SAM_FOS	2011	0.25	Tropical rainforest	(Schepaschenko et al., 2019)
SAM_GUY	2019	0.1	Tropical rainforest	n/a (private sharing)
SAM_TAPA	2010	0.5	Tropical rainforest	(Bispo et al., 2014)
SAM2	2013	0.23	Tropical rainforest	https:// www.paisagenslidar.cnptia.embrapa.br
SAM3	2011	0.13	Tropical rainforest	(Brown et al., 2014)
SAM4	2014	0.15	Tropical rainforest	(Goodman et al., 2014)
SAM5	2014	0.6	Tropical rainforest	n/a (private sharing)

Table S2. Metadata of the Tier 2 field inventory dataset of AGB.

ID	Average year	Average size ha	Biome	Reference / source
AFR_FOS	2014	1	Tropical rainforest	(Schepaschenko et al., 2019)
AUS1	2010	1	Subtropical steppe	(Paul et al., 2016)
AFR7	2012	1	Tropical rainforest	(Lewis et al., 2013)
AFR6	2010	1	Tropical dry forest	(Willcock et al., 2014)
EU_FOS	2016	2	Different biomes	(Schepaschenko et al., 2019)
SAM_FOS	2010	1	Tropical rainforest	(Schepaschenko et al., 2019)
SAM_RF	2010	1	Tropical rainforest	(Lopez□Gonzalez et al., 2011)
SAM_BAJ	2017	1	Tropical rainforest	(Pacheco-Pascagaza et al., 2018)
SAM2	2013	1	Tropical rainforest	https:// www.paisagenslidar.cnptia.embrapa.br

Table S3. Metadata of the Tier 3 field inventory dataset of AGB.

ID	Average year	Average size ha	Biome	Reference / source
AUS1	2010	25	Subtropical steppe	(Paul et al., 2016)
EU_FOS	2014	16.25	Boreal forests	(Schepaschenko et al., 2019)
SAM_FOS	2010	7.8	Tropical rainforest	(Schepaschenko et al., 2019)
SAM_RF	2010	6	Tropical rainforest	(Lopez□Gonzalez et al., 2011)

Table S4. Metadata of the sub-national averages of AGB.

Country	No. units	Type of unit	Variable	Year	Reference / URL
Albania	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
American Samoa	1	Country	AGB	2012	https://apps.fs.usda.gov/fiadb-api/evalidator
Argentina	6	Ecoregion	AGB	2017	https://www.argentina.gob.ar/ambiente/bosques/segundo-inventario-nacional-bosques-nativos
Australia	8	Territory	AGB	2016	https://www.agriculture.gov.au/abares/forestsaustralia/sofr/sofr-2018/
Bangladesh	5	Socioeconomic zone	AGB	2016-2019	(Henry et al., 2021)
Belarus	6	Province	GSV	2010	http://www.metla.fi/julkaisut/workingpapers/2010/mwp170.pdf
Belize	1	Country	AGB	2018	https://openknowledge.fao.org/server/api/core/bitstreams/bf057fe4-5bbb-49f1-a82d-2051716ec388/content
Bhutan	20	Province	GSV	2012-2015	http://www.bhutantrustfund.bt/wp-content/uploads/2018/11/National-Forest-Inventory-Report-Vol.-I-DoFPS.pdf
Bosnia	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Brazil	6	Ecoregion	AGB	2018	https://snif.florestal.gov.br/images/pdf/publicacoes/Brazilian_Forests_2019_Ingles.pdf
Bulgaria	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Burkina Faso	13	Province	AGC	2014	http://cns.bf/IMG/pdf/rapport_second_inventaire_forestier_national2.pdf
Cabo Verde	9	Island	AGB	2012	http://www.caboverdeifn.ifer.cz/?page_id=79
Cambodia	3	Ecoregion	AGB	2014	https://cambodia-redd.org/wp-content/uploads/2016/01/Forest-biomass-in-Cambodia-from-field-plots-to-national-estimates.pdf
Canada	12	Ecozone	AGB	2006-2017	https://nfi.nfis.org/en/standardreports
Chile	11	Region	GSV	2020	https://ifn.infor.cl/index.php/descargas-recursos/descargas/category/2-documentos-inventario-forestal
China	31	Province	AGB	2014-2018	http://www.china-ceecforestry.org/wp-content/uploads/2019/08/Forest-Resources-in-China——The-9th-National-Forest-Inventory.pdf

Colombia	5	Biogeografic region	AGB	2015-2019	https://openknowledge.fao.org/server/api/core/bitstreams/bf057fe4-5bbb-49f1-a82d-2051716ec388/content
Comores	3	Island	AGB	2010	https://www.fao.org/forest-resources-assessment/fra-2020/country-reports/en/
Congo	5	Ecoregion	CO2 equivalent	2014	https://www.fao.org/3/cb2941fr/cb2941fr.pdf
Costa Rica	11	Life zone	CO2 equivalent	2014-2015	https://www.sirefor.go.cr/Sirefor/publicaciones_tabla?nombre=INF
Croatia	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Cyprus	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Democratic Republic of the Congo	26	Province	AGB	2011-2016	https://medd.gouv.cd/wp-content/uploads/2020/10/NERF-de-la-RDC.pdf
Dominican Republic	4	Ecoregion	AGB	2018	https://fdocuments.ec/document/informe-final-inventario-nacional-forestal-de-repblica-ndice-elaboracin.html
Ecuador	9	Ecoregion	AGC	2009-2013	http://enf.ambiente.gob.ec/web_enf/?page_id=1239
El Salvador	4	Ecoregion	AGB	2018	https://cidoc.marn.gob.sv/documentos/inventario-nacional-de-bosques-de-el-salvador/
Estonia	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Ethiopia	4	Ecoregion	AGB	2010	https://redd.unfccc.int/files/ethiopia_frel_3.2_final_modified_submission.pdf
Fiji	1	Country	AGB	2006	http://fijireddplus.org/resources/publications/NFI2006DraftReport.pdf
Finland	19	NFI unit	AGB	2016-2020	https://statdb.luke.fi/PxWeb/pxweb/en/LUKE/LUKE__04%20Metsa__06%20Metsavarat/1.29_Puuston_biomassa_metsa_ja_kitumaalla.px/
French Guiana	1	Country	AGB	2015	https://openknowledge.fao.org/server/api/core/bitstreams/bf057fe4-5bbb-49f1-a82d-2051716ec388/content
Guam	1	Country	AGB	2013	https://apps.fs.usda.gov/fiadb-api/evalidator
Guatemala	3	Forest type	AGB	2002-2003	https://openknowledge.fao.org/server/api/core/bitstreams/bf057fe4-5bbb-49f1-a82d-2051716ec388/content
Honduras	4	Forest type	AGC	2020	https://icf.gob.hn/wp-content/uploads/2021/08/Anuario_Estadistico_Forestal_de_Honduras_2021.pdf
Iceland	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)

India	41	State	AGC	2016	https://fsi.nic.in/isfr-2021/chapter-9.pdf
Indonesia	7	Island	AGB	2014	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf
Ivory Coast	3	Ecoregion	AGB	2014	https://www.fao.org/3/i8019f/i8019f.pdf
Japan	47	Prefecture	GSV	2013-2017	https://www.rinya.maff.go.jp/j/keikaku/genkyou/h29/attach/pdf/3-13.pdf
Kosovo	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Laos	4	Forest type	AGB	2019	https://nfms.maf.gov.la
Latvia	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Liberia	15	Province	Total biomass	2018	https://www.forestcarbonpartnership.org/system/files/documents/Liberia%20National%20Forest%20Inventory.pdf
Liechtenstein	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Luxembourg	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Madagascar	4	Ecoregion	AGB	2017	https://redd.unfccc.int/files/2017_frel_mdg_modified_submission.pdf
Malawi	2	Region	Total biomass	2018	https://cepa.rmportal.net/Library/inbox/national-forest-inventory-2018-report
Marshall Islands	1	Country	AGB	2018	https://apps.fs.usda.gov/fiadb-api/evalidator
Mexico	32	State	AGB	2005-2009	(de Jong et al., 2010)
Micronesia	1	Country	AGB	2016	https://www.fs.usda.gov/pnw/projects/pnw-fia-pacific-islands-inventory
Mongolia	4	Ecoregion	AGB	2017	http://forest-atlas.gov.mn/DataSetResults.aspx
Montenegro	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Mozambique	10	Province	AGB	2018	https://www.biofund.org.mz/wp-content/uploads/2019/01/1548412245-Relatório%20do%20%20IV%20Inventário%20Florestal%20Nacional.pdf
Nepal	3	Physiographic region	AGB	2017	https://nepalindata.com/resource/STATE-OF-NEPAL%27S-FORESTS/
Nicaragua	4	Forest type	AGB	2007-2008	https://cambioclimatico.ineter.gob.ni/bibliografia/Mitigacion%20del%20cambio%20climatico/Informe%20Final%20inventario%20forestal.pdf

Nigeria	6	Ecozone	AGB	2019	https://www.fao.org/3/cb0037en/cb0037en.pdf
North Macedonia	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Northern Mariana Islands	1	Country	AGB	2015	https://www.fs.usda.gov/pnw/projects/pnw-fia-pacific-islands-inventory
Pakistan	12	Forest type	AGC	2008-2012	https://redd.unfccc.int/files/1._unfccc_frel_pakistan__final_with_proofread_-final.pdf
Palau	1	Country	AGB	2014	https://apps.fs.usda.gov/fiadb-api/evalidator
Panama	1	Country	AGB	2013-2015	https://chm.cbd.int/api/v2013/documents/05B386D2-5BCD-A52D-6097-F853803CC619/attachments/205145/Inventario%20Nacional%20Forestal%20-%20Resultados%20Fase%20Piloto%202013-2015.pdf
Papua New Guinea	1	Country	AGB	> 2010	https://pngfa.gov.pg/images/articledocs/National_Forest_Inventory/Proceedings_of_the_second_NFI_Research_Conference_compressed.pdf
Paraguay	6	Ecoregion	AGC	2014	http://www.infona.gov.py/index.php?cID=296
Peru	6	Ecozone	AGB	2013-2018	https://openknowledge.fao.org/server/api/core/bitstreams/bf057fe4-5bbb-49f1-a82d-2051716ec388/content
Puerto Rico	1	Country	AGB	2019	https://openknowledge.fao.org/server/api/core/bitstreams/bf057fe4-5bbb-49f1-a82d-2051716ec388/content
Republic of Korea	10	Province	GSV	2014	https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjRkbvRtZn6AhWYh_0HHeG5C7kQFnoECAUQAQ&url=https%3A%2F%2Fwww.forest.go.kr%2Fkfsweb%2Fcmm%2Ffms%2FFileDown.do%3Bjsessionid%3DNLnLiHubhFNUOX5DhDrmaHEZurg8MExsUujmYxegMKFeFV2IJg2pXlg5gjiYe8wd.frswas01_servlet_engine5%3FatchFileId%3DFILE_00000000000664384%26fileSn%3D1%26dwldHistYn%3DN%26bbsId%3DBBSMSTR_1064&usg=AOvVaw0iCa_PPyQe6pgoOnvJOsjc
Russia	83	Province	GSV	2011-2020	Private data sharing, courtesy of D. Schepaschenko (IIASA)
Sudan	3	State	GSV	2017	https://redd.unfccc.int/files/sudan_frl_submission_to_unfccc_january_2020.pdf
Suriname	2	Ecozone	AGC	2017	https://sbbsur.com/wp-content/uploads/2017/04/

					TechnischrapportEmissieFactors_CarbonStocks.pdf
Taiwan	8	Province	GSV	2021	https://www.forest.gov.tw/EN/0001465
Tanzania	25	Province	GSV	2015	https://www.tfs.go.tz/uploads/NAFORMA_REPORT.pdf
Thailand	3	Forest type	AGB	2013-2018	https://redd.unfccc.int/files/thailand_frel_frl_report.pdf
Togo	4	Ecoregion	AGB	2015-2016	https://redd.unfccc.int/files/nrf_togo_06_1_20_rev_18_08_20_finale.pdf
Turkey	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
Uganda	80	Province (district)	AGB	2005	https://www.nfa.go.ug/images/reports/biomasstechnicalreport2009.pdf
Ukraine	25	Province	GSV	2010	Private data sharing, courtesy of D. Schepaschenko (IIASA)
United Kingdom	1	Country	AGB	~ 2015	(Avitabile and Camia, 2018)
United States	50	State	AGB	2010-2021	https://apps.fs.usda.gov/fiadb-api/evalidator
United States Virgin Islands	1	Country	AGB	2014	https://openknowledge.fao.org/server/api/core/bitstreams/bf057fe4-5bbb-49f1-a82d-2051716ec388/content
Uruguay	1	Country	AGB	2009-2016	https://openknowledge.fao.org/server/api/core/bitstreams/bf057fe4-5bbb-49f1-a82d-2051716ec388/content
Vietnam	5	Forest type	Total carbon	2016	https://redd.unfccc.int/files/2016_submission_frel_viet_nam.pdf
Zambia	1	Country	AGB	2009-2016	https://redd.unfccc.int/files/zambia_frel-2020-technical_assessment.pdf

References

Asner, G.P., Mascaro, J., 2014. Mapping tropical forest carbon: Calibrating plot estimates to a simple LiDAR metric. Remote Sensing of Environment 140, 614–624. https://doi.org/10.1016/j.rse.2013.09.023

Avitabile, V., Baccini, A., Friedl, M.A., Schmullius, C., 2012. Capabilities and limitations of Landsat and land cover data for aboveground woody biomass estimation of Uganda. Remote Sensing of Environment 117, 366–380. https://doi.org/10.1016/j.rse.2011.10.012

Avitabile, V., 2014. Carbon stocks of vegetation in the Vu Gia Thu Bon river basin, central Vietnam (Technical Report), Land Use and Climate Change Interactions in Central Vietnam (LUCCi) project. Jena.

Avitabile, V., Camia, A., 2018. An assessment of forest biomass maps in Europe using harmonized national statistics and inventory plots. Forest Ecol Manag 409, 489–498. https://doi.org/10.1016/j.foreco.2017.11.047

Bispo, P.C., Santos, J.R., Valeriano, M.M., Touzi, R., Seifert, F.M., 2014. Integration of polarimetric PALSAR attributes and local geomorphometric variables derived from SRTM for forest biomass modeling in central Amazonia. Canadian Journal of Remote Sensing 40, 26–42. https://doi.org/10.1080/07038992.2014.913477

Brown, H.C.A., Berninger, F.A., Larjavaara, M., Appiah, M., 2020. Above-ground carbon stocks and timber value of old timber plantations, secondary and primary forests in southern Ghana. Forest Ecology and Management 472, 118236. https://doi.org/10.1016/j.foreco.2020.118236

Brown, S., Goslee, K., Casarim, F., Harris, N.L., Petrova, S., 2014. Sampling Design and Implementation Plan for Guyana's REDD+ Forest Carbon Monitoring System (FCMS): Version 2. Submitted by Winrock International to the Guyana Forestry Commission, GFC 02/08/2010 Addendum. Guyana Forestry Commission.

Carreiras, J.M.B., Melo, J.B., Vasconcelos, M.J., 2013. Estimating the above-ground biomass in miombo savanna woodlands (Mozambique, East Africa) using L-band synthetic aperture radar data. Remote Sensing 5, 1524–1548. https://doi.org/10.3390/rs5041524

Cienciala, E., Apltauer, J., Exnerová, Z., Tatarinov, F., 2008. Biomass functions applicable to oak trees grown in Central-European forestry. J. For. Sci. 54, 109–120. https://doi.org/10.17221/2906-JFS

Coomes, D.A., Dalponte, M., Jucker, T., Asner, G.P., Banin, L.F., Burslem, D.F.R.P., Lewis, S.L., Nilus, R., Phillips, O.L., Phua, M.-H., Qie, L., 2017. Area-based vs tree-centric approaches to mapping forest carbon in Southeast Asian forests from airborne laser scanning data. Remote Sensing of Environment 194, 77–88. https://doi.org/10.1016/j.rse.2017.03.017

Dalponte, M., Jucker, T., Liu, S., Frizzera, L., Gianelle, D., 2019. Characterizing forest carbon dynamics using multi-temporal lidar data. Remote Sensing of Environment 224, 412–420. https://doi.org/10.1016/j.rse.2019.02.018

de Jong, B., Anaya, C., Masera, O., Olguín, M., Paz, F., Etchevers, J., Martínez, R.D., Guerrero, G., Balbontín, C., 2010. Greenhouse gas emissions between 1993 and 2002 from land-use change and forestry in Mexico. Forest Ecology and Management 260, 1689–1701. https://doi.org/10.1016/j.foreco.2010.08.011

DeVries, B., Avitabile, V., Kooistra, L., Herold, M., 2012. Monitoring the impact of REDD+ implementation in the Unesco Kafa biosphere reserve.

Goodman, R.C., Phillips, O.L., Baker, T.R., 2014. The importance of crown dimensions to improve tropical tree biomass estimates. Ecological Applications 24, 680–698. https://doi.org/10.1890/13-0070.1

Hirsh, F., Jourget, J.-G., Feintrenie, L., Bayol, N., Atyi, R.E., 2013. Projet pilote REDD+ de la Lukénie. (No. Document de Travaille 111). CIFOR, Bogor, Indonesia.

Jha, N., Tripathi, N.K., Chanthorn, W., Brockelman, W., Nathalang, A., Pélissier, R., Pimmasarn, S., Ploton, P., Sasaki, N., Virdis, S.G.P., Réjou-Méchain, M., 2020. Forest aboveground biomass stock and resilience in a tropical landscape of Thailand. Biogeosciences 17, 121–134. https://doi.org/10.5194/bg-17-121-2020

Labriere, N., Tao, S., Chave, J., Scipal, K., Toan, T.L., Abernethy, K., Alonso, A., Barbier, N., Bissiengou, P., Casal, T., Davies, S.J., Ferraz, A., Herault, B., Jaouen, G., Jeffery, K.J., Kenfack, D., Korte, L., Lewis, S.L., Malhi, Y., Memiaghe, H.R., Poulsen, J.R., Rejou-Mechain, M., Villard, L., Vincent, G., White, L.J.T., Saatchi, S., 2018. In Situ Reference Datasets From the TropiSAR and AfriSAR Campaigns in Support of Upcoming Spaceborne Biomass Missions. IEEE J. Sel. Top. Appl. Earth Observations Remote Sensing 11, 3617–3627. https://doi.org/10.1109/JSTARS.2018.2851606

Lewis, S.L., Sonké, B., Sunderland, T., Begne, S.K., Lopez-Gonzalez, G., Van Der Heijden, G.M.F., Phillips, O.L., Affum-Baffoe, K., Baker, T.R., Banin, L., Bastin, J.-F., Beeckman, H., Boeckx, P., Bogaert, J., De Cannière, C., Chezeaux, E., Clark, C.J., Collins, M., Djagbletey, G., Djuikouo, M.N.K., Droissart, V., Doucet, J.-L., Ewango, C.E.N., Fauset, S., Feldpausch, T.R., Foli, E.G., Gillet, J.-F., Hamilton, A.C., Harris, D.J., Hart, T.B., De Haulleville, T., Hladik, A., Hufkens, K., Huygens, D., Jeanmart, P., Jeffery, K.J., Kearsley, E., Leal, M.E., Lloyd, J., Lovett, J.C., Makana, J.-R., Malhi, Y., Marshall, A.R., Ojo, L., Peh, K.S.-H., Pickavance, G., Poulsen, J.R., Reitsma, J.M., Sheil, D., Simo, M., Steppe, K., Taedoumg, H.E., Talbot, J., Taplin, J.R.D., Taylor, D., Thomas, S.C., Toirambe, B., Verbeeck, H., Vleminckx, J., White, L.J.T., Willcock, S., Woell, H., Zemagho, L., 2013. Above-ground biomass and structure of 260 African tropical forests. Phil. Trans. R. Soc. B 368, 20120295. https://doi.org/10.1098/rstb.2012.0295

Henry, M., Iqbal, Z., Johnson, K., Akhter, M., Costello, L., Scott, C., Jalal, R., Hossain, Md.A., Chakma, N., Kuegler, O., Mahmood, H., Mahamud, R., Siddique, M.R.H., Misbahuzzaman, K., Uddin, M.M., Al Amin, M., Ahmed, F.U., Sola, G., Siddiqui, Md.B., Birigazzi, L., Rahman, M., Animon, I., Ritu, S., Rahman, L.M., Islam, A., Hayden, H., Sidik, F., Kumar, M.F., Mukul, R.H., Nishad, H., Belal, A.H., Anik, A.R., Khaleque, A., Shaheduzzaman, Md., Hossain, S.S., Aziz, T., Rahaman, Md.T., Mohaiman, R., Meyer, P., Chakma, P., Rashid, A.Z.M.M., Das, S., Hira, S., Jashimuddin, M., Rahman, M.M., Wurster, K., Uddin, S.N., Azad, A.K., Islam, S.M.Z., Saint-André, L., 2021. A multi-purpose National Forest Inventory in Bangladesh: design, operationalisation and key results. For. Ecosyst. 8, 12. https://doi.org/10.1186/s40663-021-00284-1

Liang, J., Zhou, M., Tobin, P.C., McGuire, A.D., Reich, P.B., 2015. Biodiversity influences plant productivity through niche–efficiency. Proc Natl Acad Sci USA 112, 5738–5743. https://doi.org/10.1073/pnas.1409853112

Lopez□Gonzalez, G., Lewis, S.L., Burkitt, M., Phillips, O.L., 2011. ForestPlots.net: a web application and research tool to manage and analyse tropical forest plot data. J Vegetation Science 22, 610–613. https://doi.org/10.1111/j.1654-1103.2011.01312.x

Pacheco-Pascagaza, A.M., Garcia, M., Rodriguez-Veiga, P., Balzter, H., 2018. The Use of Multifrequency SAR Data for Assessing Levels of Forest Disturbance in Bajo Calima Colombia, in: IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium. Presented at the IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium, IEEE, Valencia, pp. 7015–7018. https://doi.org/10.1109/IGARSS.2018.8518871

Paul, K.I., Roxburgh, S.H., Chave, J., England, J.R., Zerihun, A., Specht, A., Lewis, T., Bennett, L.T., Baker, T.G., Adams, M.A., Huxtable, D., Montagu, K.D., Falster, D.S., Feller, M., Sochacki, S., Ritson, P., Bastin, G., Bartle, J., Wildy, D., Hobbs, T., Larmour, J., Waterworth, R., Stewart, H.T.L., Jonson, J., Forrester, D.I., Applegate, G., Mendham, D., Bradford, M., O'Grady, A., Green, D., Sudmeyer, R., Rance, S.J., Turner, J., Barton, C., Wenk, E.H., Grove, T., Attiwill, P.M., Pinkard, E., Butler, D., Brooksbank, K., Spencer, B., Snowdon, P., O'Brien, N., Battaglia, M., Cameron, D.M., Hamilton, S., Mcauthur, G., Sinclair, J., 2016. Testing the generality of above-ground biomass allometry across plant functional types at the continent scale. Global Change Biology 22, 2106–2124. https://doi.org/10.1111/gcb.13201

Santoro, M., Cartus, O., Fransson, J.E.S., 2021. Integration of allometric equations in the water cloud model towards an improved retrieval of forest stem volume with L-band SAR data in Sweden. Remote Sensing of Environment 253, 112235. https://doi.org/10.1016/j.rse.2020.112235

Schelhaas, M.J., Clerkx, A.P.P.M., Daamen, W.P., Oldenburger, J.F., Velema, G., Schnitger, P., Schoonderwoerd, H., Kramer, H., 2014. Zesde Nederlandse Bosinventarisatie; Methoden en basisresultaten (No. Alterra rapport 2545). Wageningen, Alterra Wageningen UR (University & Research Centre).

Schepaschenko, D., Chave, J., Phillips, O.L., Lewis, S.L., Davies, S.J., Réjou-Méchain, M., Sist, P., Scipal, K., Perger, C., Herault, B., Labrière, N., Hofhansl, F., Affum-Baffoe, K., Aleinikov, A., Alonso, A., Amani, C., Araujo-Murakami, A., Armston, J., Arroyo, L., Ascarrunz, N., Azevedo, C., Baker, T., Bałazy, R., Bedeau, C., Berry, N., Bilous, A.M., Bilous, S.Yu., Bissiengou, P., Blanc, L., Bobkova, K.S., Braslavskaya, T., Brienen, R., Burslem, D.F.R.P., Condit, R., Cuni-Sanchez, A., Danilina, D., del Castillo Torres, D., Derroire, G., Descroix, L., Sotta, E.D., d'Oliveira, M.V.N., Dresel, C., Erwin, T., Evdokimenko, M.D., Falck, J., Feldpausch, T.R., Foli, E.G., Foster, R., Fritz, S., Garcia-Abril, A.D., Gornov, A., Gornova, M., Gothard-Bassébé, E., Gourlet-Fleury, S., Guedes, M., Hamer, K.C., Susanty, F.H., Higuchi, N., Coronado, E.N.H., Hubau, W., Hubbell, S., Ilstedt, U., Ivanov, V.V., Kanashiro, M., Karlsson, A., Karminov, V.N., Killeen, T., Koffi, J.-C.K., Konovalova, M., Kraxner, F., Krejza, J., Krisnawati, H., Krivobokov, L.V., Kuznetsov, M.A., Lakyda, I., Lakyda, P.I., Licona, J.C., Lucas, R.M., Lukina, N., Lussetti, D., Malhi, Y., Manzanera, J.A., Marimon, B., Junior, B.H.M., Martinez, R.V., Martynenko, O.V., Matsala, M., Matyashuk, R.K., Mazzei, L., Memiaghe, H., Mendoza, C., Mendoza, A.M., Moroziuk, O.V., Mukhortova, L., Musa, S., Nazimova, D.I., Okuda, T., Oliveira, L.C., Ontikov, P.V., Osipov, A.F., Pietsch, S., Playfair, M., Poulsen, J., Radchenko, V.G., Rodney, K., Rozak, A.H., Ruschel, A., Rutishauser, E., See, L., Shchepashchenko, M., Shevchenko, N., Shvidenko, A., Silveira, M., Singh, J., Sonké, B., Souza, C., Stereńczak, K., Stonozhenko, L., Sullivan, M.J.P., Szatniewska, J., Taedoumg, H., ter Steege, H., Tikhonova, E., Toledo, M., Trefilova, O.V., Valbuena, R., Gamarra, L.V., Vasiliev, S., Vedrova, E.F., Verhovets, S.V., Vidal, E., Vladimirova, N.A., Vleminckx, J., Vos, V.A., Vozmitel, F.K., Wanek, W., West, T.A.P., Woell, H., Woods, J.T., Wortel, V., Yamada, T., Nur Hajar, Z.S., Zo-Bi, I.C., 2019. The Forest Observation System, building a global reference dataset for remote sensing of forest biomass. Sci Data 6, 198. https://doi.org/10.1038/s41597-019-0196-1

Vaglio Laurin, G., Hawthorne, W., Chiti, T., Di Paola, A., Cazzolla Gatti, R., Marconi, S., Noce, S., Grieco, E., Pirotti, F., Valentini, R., 2016. Does degradation from selective logging and illegal activities differently impact forest resources? A case study in Ghana. iForest 9, 354–362. https://doi.org/10.3832/ifor1779-008

Vieilledent, G., Gardi, O., Grinand, C., Burren, C., Andriamanjato, M., Camara, C., Gardner, C.J., Glass, L., Rasolohery, A., Rakoto Ratsimba, H., Gond, V., Rakotoarijaona, J.-R., 2016. Bioclimatic envelope models predict a decrease in tropical forest carbon stocks with climate change in Madagascar. J Ecol 104, 703–715. https://doi.org/10.1111/1365-2745.12548

Wijaya, A., Liesenberg, V., Susanti, A., Karyanto, O., Verchot, L.V., 2015. Estimation of Biomass Carbon Stocks over Peat Swamp Forests using Multi-Temporal and Multi-Polratizations SAR Data. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XL-7/W3, 551–556. https://doi.org/10.5194/isprsarchives-XL-7-W3-551-2015

Willcock, S., Phillips, O.L., Platts, P.J., Balmford, A., Burgess, N.D., Lovett, J.C., Ahrends, A., Bayliss, J., Doggart, N., Doody, K., Fanning, E., Green, J.M., Hall, J., Howell, K.L., Marchant, R., Marshall, A.R., Mbilinyi, B., Munishi, P.K., Owen, N., Swetnam, R.D., Topp-Jorgensen, E.J., Lewis, S.L., 2014. Quantifying and understanding carbon storage and sequestration within the Eastern Arc Mountains of Tanzania, a tropical biodiversity hotspot. Carbon Balance Manage 9, 2. https://doi.org/10.1186/1750-0680-9-2

WWF and ÖBf, 2013. Xe Pian REDD+ project document. Gland, Switzerland.