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BIOMASS

CLIMATE RESEARCH DATA PACKAGE

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Symbols and Acronyms

AGB	Above-ground biomass
ALOS PALSAR	Advanced Land Observing Satellite -2 Phased-Array L-band type Synthetic Aperture Radar
ASAR	Advanced Synthetic Aperture Radar
CCI	Climate Change Initiative
CRDP	Climate Research Data Package
ECV	Essential Climate Variable
Envisat	Environmental Satellite
ESA	European Space Agency
FAO	Food and Agriculture Organization
SAR	Synthetic Aperture Radar

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1. Introduction

1.1. Purpose of the document

This document is a cover for the Climate Research Data Package (CRDP) for the Biomass project produced as part of ESA's Climate Change Initiative (CCI+).

1.2. Document Status of the document



This is the seventh issue of the CRDP document, reflecting Version 7.0 of the Climate Research Data Package (CRDPv7).

1.3. Preface

Above-ground biomass (AGB) is an Essential Climate Variable (ECV) within the Global Climate Observing System (GCOS). Here, AGB represents the density of above-ground biomass (unit: Mg/ha or tons/ha). It is defined as the mass, expressed as oven-dry weight of the woody parts (stem, bark, branches and twigs), of all living trees excluding stump and roots per unit area. An approximate value for the corresponding carbon density (unit: MgC/ha) can be obtained by scaling with a factor of 0.5.

For climate science communities, AGB is a pivotal variable of the Earth System, as it impacts the surface energy budget, the land surface water balance, the atmospheric concentration of greenhouse gases and a range of ecosystem services. The requirement is for AGB to be provided wall-to-wall over the entire globe for all major woody biomes, with a spatial resolution between 500 m and 1 km (based on satellite observations of 100-200 m) spatial resolution, with a relative error of less than 20% where AGB exceeds 50 Mg/ha and a fixed error of 10 Mg/ha where the AGB is below that limit.

One of the objectives of the CCI Biomass project is to generate global maps of AGB using a variety of Earth Observation (EO) datasets and state-of-the-art models for several epochs spanning several decades and assess biomass changes between consecutive years and over a decade. Synthetic aperture radar (SAR) observations of the backscatter are pre-processed to a common spatial grid. Before 2015, ALOS PALSAR and Envisat ASAR observations are used. Starting with 2015, ALOS-2 PALSAR-2 and Sentinel-1 observations are used. AGB is estimated with a parametric model that relates the SAR backscattered intensity to AGB. Individual estimates of AGB are obtained for individual observations of the SAR backscatter. For each year, the estimates are synthesized to a single value with a weighted average. The retrieval is aided by auxiliary data layers acting as a constraint to the inversion (allometric functions and maximum AGB based on spaceborne LiDAR observations, land cover, tree canopy density etc.). The precision of the map is represented by a layer of per pixel standard deviation of the AGB obtained

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by propagating individual standard deviation values of the remote sensing observations and the retrieval model parameters.

AGB change is defined as the difference of AGB estimates between two epochs. Positive values represent a gain of AGB, negative values represent a loss of AGB. The precision of the AGB change estimates is defined as the square root of the sum of the variances of the two individual maps. As a consequence of the different type of data available, a quality flag is provided. The quality flag expresses the level of overlap of the AGB histograms associated with a pixel at the two epochs.

Assuming that AGB1 and AGB2 are two estimates at Epoch 1 and Epoch 2, with Epoch 1 prior to Epoch 2. The follow scenarios can occur

- Significant difference ($AGB_2 \ll AGB_1$), i.e., disjoint 1-SD intervals, corresponding to an AGB loss
- Potential loss ($AGB_2 < AGB_1$) i.e., partially overlapping histograms
- Insignificant difference, i.e., overlapping histograms, corresponding to no change
- Potential gain ($AGB_2 > AGB_1$) i.e., partially overlapping histograms
- Significant difference ($AGB_2 \gg AGB_1$), i.e., 1-SD intervals, corresponding to an AGB gain



The CRDP of year 7 consists of the following layers.

Full resolution, corresponding to a pixel size of 1 ha (100 m x 100 m).

- AGB maps for each year between 2005 and 2012 and between 2015 and 2024.
- AGB standard deviation for each year between 2005 and 2012 and between 2015 and 2024.
- An example of a decadal AGB change dataset (2020 vs. 2010) and an annual AGB change dataset (2020 vs. 2019). The change dataset consists of the AGB change, AGB change standard deviation and the quality flag.
- Code to compute the AGB change, the AGB change standard deviation and the quality flag for any pair of AGB maps included in this CRDP.

Coarse resolution

- Spatially averaged AGB maps at pixel sizes of 1 km, 10 km, 25 km and 50 km of AGB
- Standard deviation of the AGB averages.
- Change maps of the average AGBs, standard error of the average change and the quality factor of the change magnitude.
- Code to compute the AGB change, the AGB change standard deviation and the quality flag for any pair of aggregated AGB maps included in this CRDP.

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NOTE: It is strongly advised to use the quality flag map of the AGB change product when evaluating the AGB change data products!

1.4. Temporal Coverage

CRDPv7 covers the years 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023 and 2024.

1.5. Spatial Coverage

CRDPv7 at full resolution covers all land masses between 80°N and 60°S latitude.

The projection is geographic. The vertical and horizontal pixel spacing is 0.000888888°, corresponding to 100 m at the Equator.

The aggregated datasets are filled in to cover all latitudes between 90°N and 90°S. The vertical and horizontal pixel spacing is as follows:

- 0.01° corresponding to roughly 1 km at the Equator,
- 0.10° corresponding to roughly 10 km at the Equator,
- 0.25° corresponding to roughly 25 km at the Equator,
- 0.50° corresponding to roughly 50 km at the Equator.



1.6. Data availability and release

CRDPv7 is made available through the CCI Data Portal (<https://climate.esa.int/de/data/>).

At the full resolution of 100 m x 100 m, the data are provided in the form of a single NetCDF file per year, e.g., in the case of the AGB map for 2020 and for the AGB change between 2019 and 2020:

Variable	File name
AGB and AGB SD	ESACCI-BIOMASS-L4-AGB-MERGED-100m-2020-fv7.0.nc
AGB change, quality flag and SD	ESACCI-BIOMASS-L4-AGB-CHANGE-100m-2020-2019-fv7.0.nc

Note: AGB change maps can be computed from the AGB maps by taking their plain difference.



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AGB per epoch and their standard deviations, AGB changes, their standard deviation and the quality flag of the AGB changes are also available in the form of 10° x 10° wide tiles, in GeoTiff format.

For the spatial averages, the CRDP provides a single file for a given pixel size, including all years for the (i) AGB and (ii) AGB SD maps and all combinations for the (iii) AGB change, (iv) AGB change SD and (v) quality flag. The structure differs depending on whether the data are stored in NetCDF or in GeoTiff format. The tables below provide an example for the case of the 10 km averages:

NetCDF	
Variable	File name
AGB and AGB SD	ESACCI-BIOMASS-L4-AGB-MERGED-10000m-fv7.0.nc <i>Includes years 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023 and 2024</i>
AGB change, quality flag and SD	ESACCI-BIOMASS-L4-AGB-CHANGE-10000m-fv7.0.nc <i>Includes</i> - <i>annual changes: 2020-2019</i> - <i>decadal changes: 2020-2010</i>

GeoTiff	
Variable	File name
AGB	ESACCI-BIOMASS-L4-AGB-MERGED-10000m-fv7.0.tif <i>Includes years 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023 and 2024</i>
AGB SD	ESACCI-BIOMASS-L4-AGB_SD-MERGED-10000m-fv7.0.tif <i>Includes years 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023 and 2024</i>

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AGB change	<p>ESACCI-BIOMASS-L4-AGB-DIFF-10000m-fv7.0.tif</p> <p><i>Includes</i></p> <ul style="list-style-type: none"> - <i>annual changes: 2020-2019</i> - <i>decadal changes: 2020-2010</i>
AGB change quality flag	<p>ESACCI-BIOMASS-L4-AGB-DIFF_QF-10000m-fv7.0.tif</p> <p><i>Includes</i></p> <ul style="list-style-type: none"> - <i>annual changes: 2020-2019</i> - <i>decadal changes: 2020-2010</i>
AGB change SD	<p>ESACCI-BIOMASS-L4-AGB-DIFF_SD-10000m-fv7.0.tif</p> <p><i>Includes</i></p> <ul style="list-style-type: none"> - <i>annual changes: 2020-2019</i> - <i>decadal changes: 2020-2010</i>

1.7.Examples

Figure 1 and Figure 2 show the CCI BIOMASS dataset of the year 2020 (AGB and AGB standard deviation, respectively) as part of CRDP v7. The AGB datasets for the other years present the same overall distribution of AGB, albeit with local differences due to the different set of predictors used to generate the pre-2015 and post-2015 datasets.

Figure 1-3 and Figure 1-4 show a full resolution example of the AGB and AGB standard deviation products, respectively. The example refers to a standard 10° x 10° tile as distributed by the CCI Biomass project, covering the region of Manaus, Brazil (extent of tile: Lat: 0°N, 10°S; Lon: 60°W, 50°W). An example of annual AGB change products relative to the years 2019 and 2020 are displayed in Figure 1-5 (AGB change), Figure 1-6 (standard deviation of AGB change) and Figure 1-7 (quality flag). An example of decadal AGB change products relative to the years 2010 and 2020 are displayed in Figure 1-8 (AGB change), Figure 1-9 (standard deviation of AGB change) and Figure 1-10 (quality flag).

The aggregated map for the year 2020 at the 0.1°-pixel size and its standard deviation are displayed in Figure 1-11. The change products for the years 2010 and 2020 at 0.1° are displayed in Figure 1-12.

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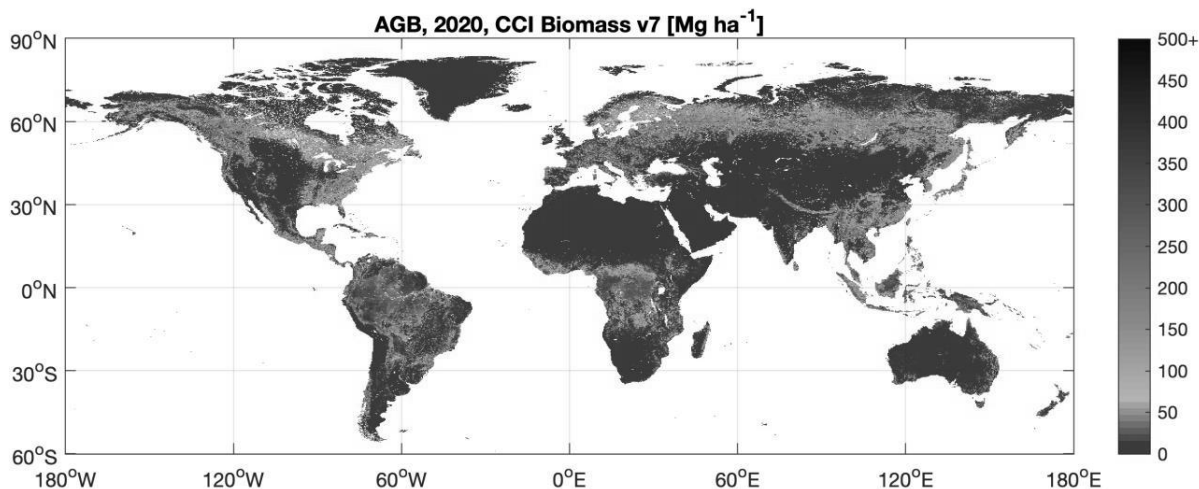


Figure 1-1: Global AGB estimates for the year 2020. Spatial resolution: 100 m. AGB has been constrained between 0 and 500 Mg/ha to enhance the color contrast.

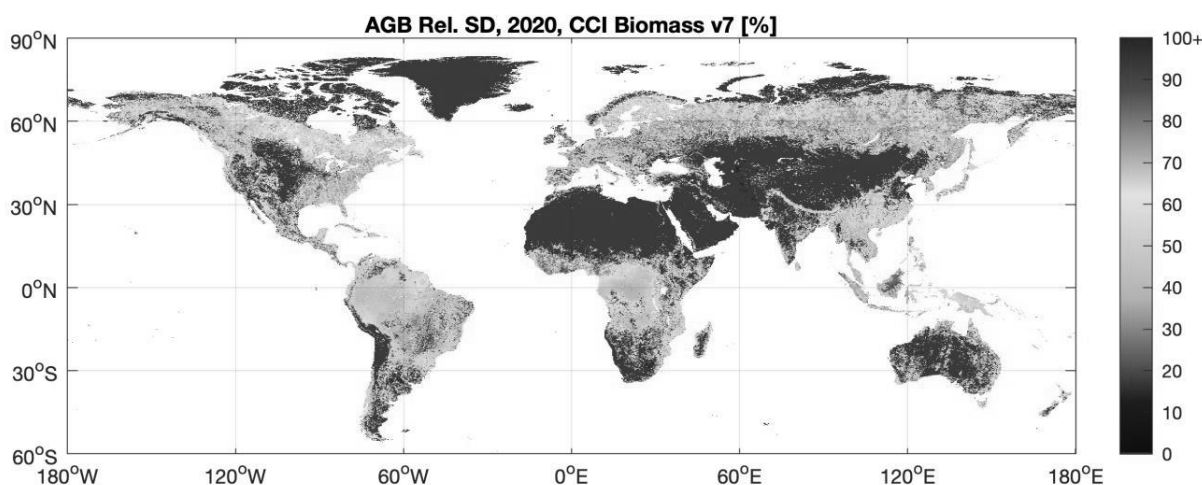




Figure 1-2: Global estimates of the AGB standard deviation for the year 2020. The standard deviation is reported relative to the AGB estimate, in percent values. Spatial resolution: 100 m. The display has been constrained between 0 and 100% of the estimated AGB value to enhance the color contrast.

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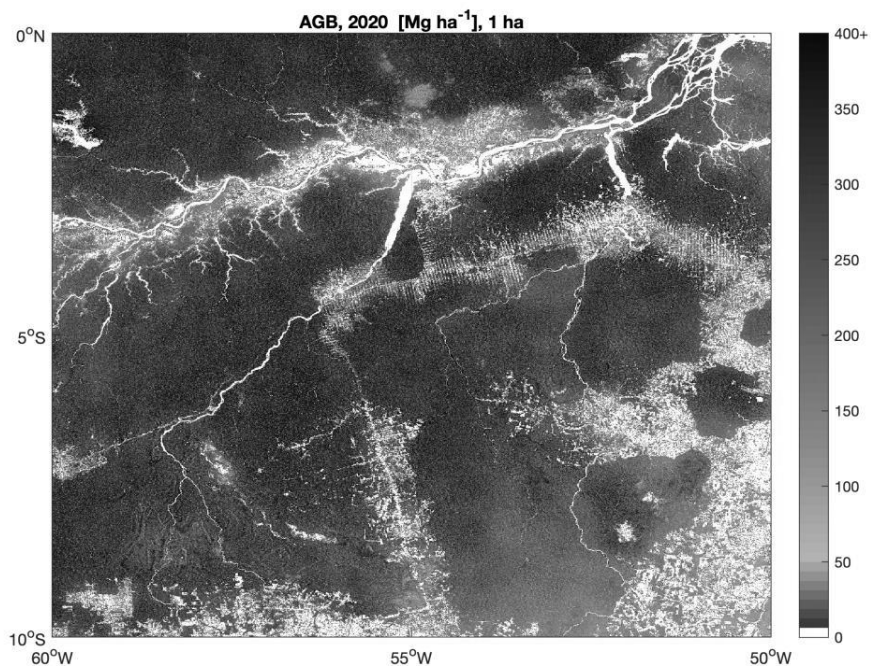


Figure 1-3: AGB of 2020. The color ramp is constrained between 0 and 400 Mg ha⁻¹ to increase color contrast.

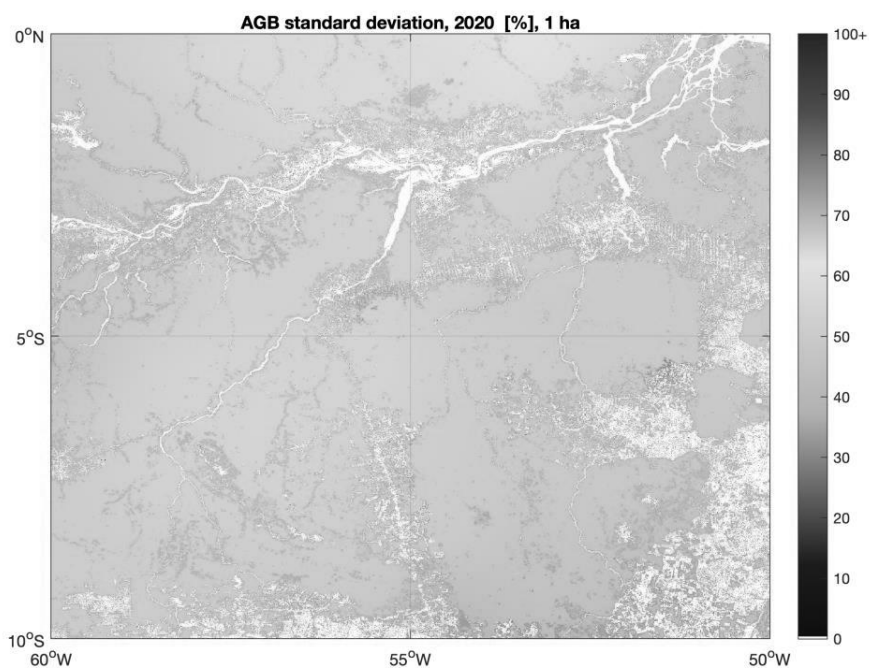




Figure 1-4: Standard deviation of AGB of 2020. The color ramp is constrained between 0 and 100% relative to the AGB to increase color contrast.

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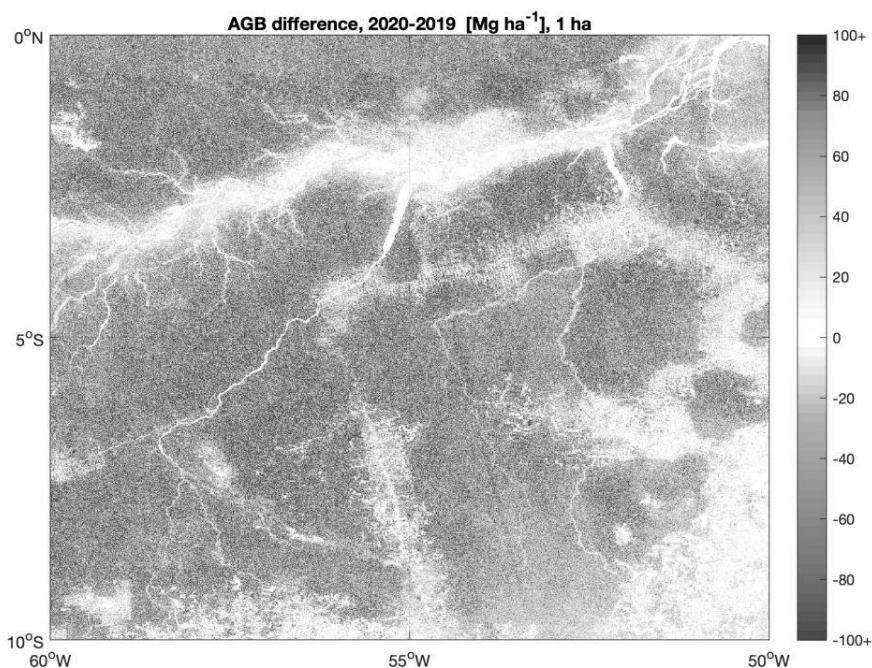


Figure 1-5: AGB change between 2019 and 2020, defined as difference between AGB maps of 2020 and 2019. The color ramp is constrained between $-/+100 \text{ Mg ha}^{-1}$ to increase color contrast.

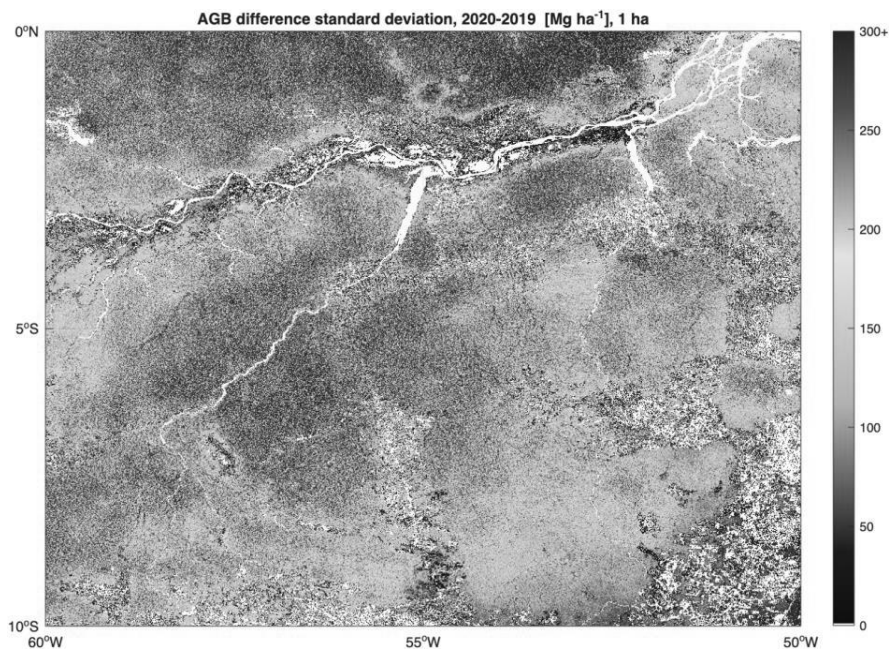




Figure 1-6: Standard deviation of AGB change between 2019 and 2020. The color ramp is constrained between 0 and 300 Mg ha^{-1} to increase color contrast.

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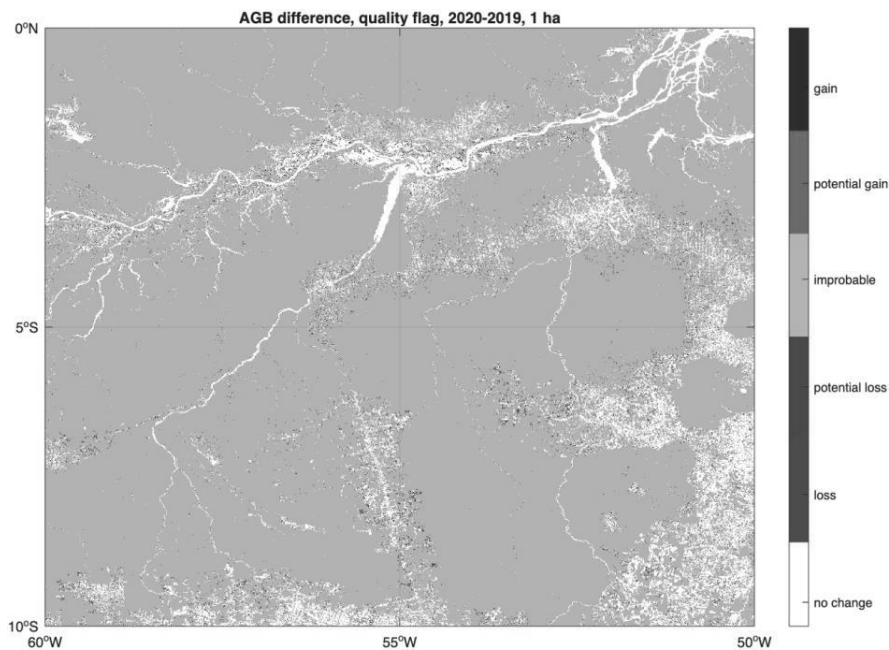




Figure 1-7: Quality flag of AGB change between 2019 and 2020.

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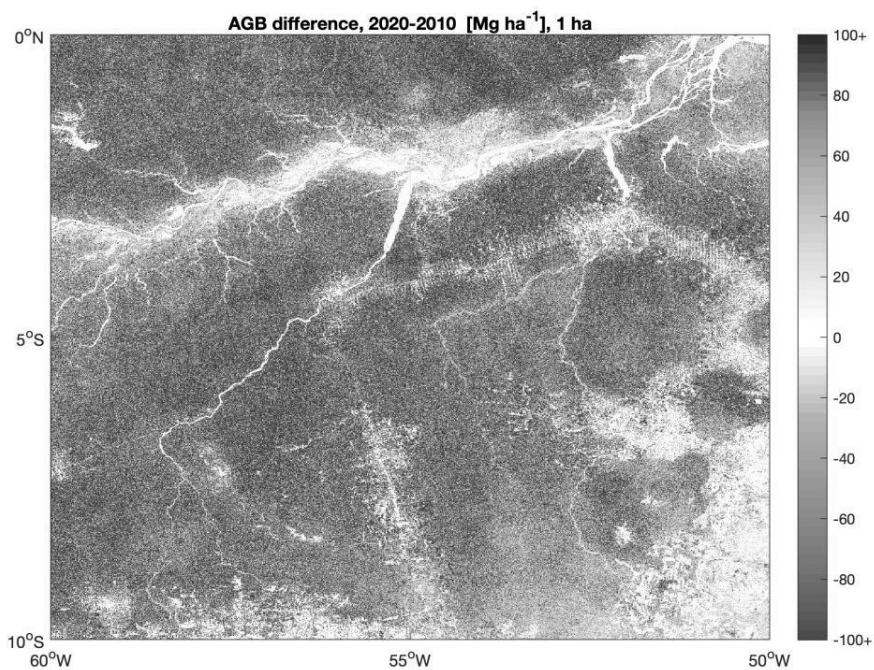


Figure 1-8: AGB change between 2010 and 2020, defined as difference between AGB maps of 2020 and 2010. The color ramp is constrained between $\pm 100 \text{ Mg ha}^{-1}$ to increase color contrast.

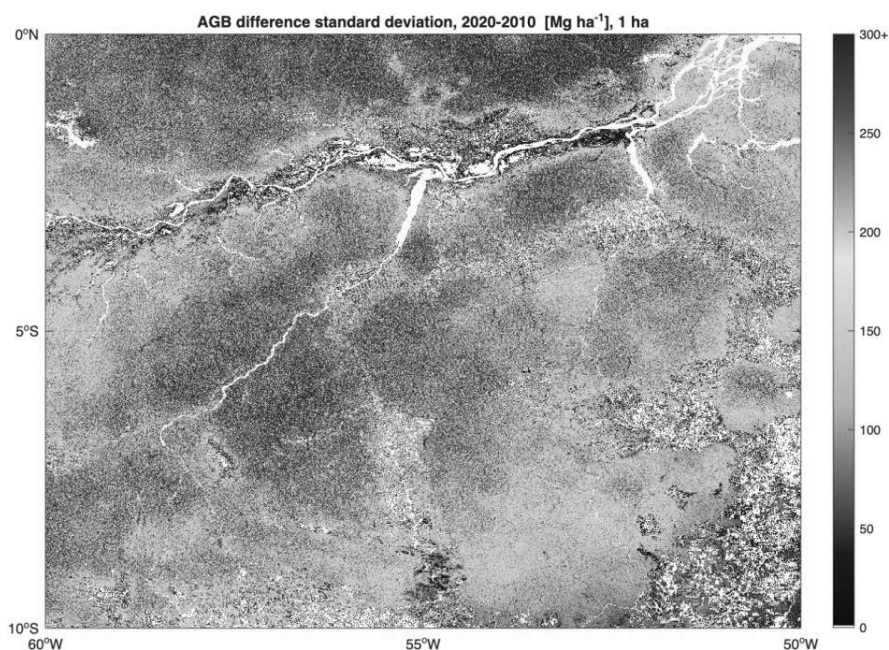




Figure 1-9: Standard deviation of AGB change between 2010 and 2020. The color ramp is constrained between 0% and 100% relative to the AGB difference to increase color contrast.

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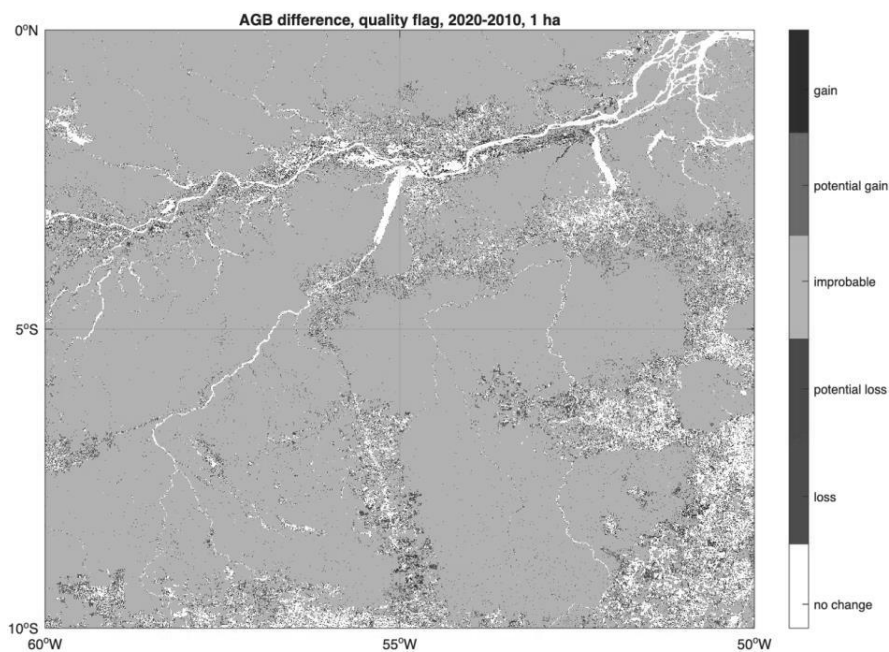




Figure 1-10: Quality flag of AGB change between 2010 and 2020.

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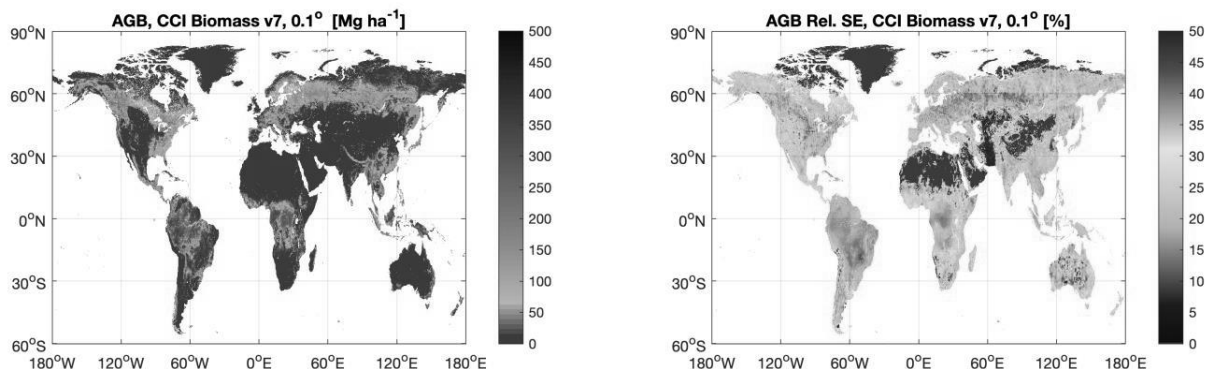


Figure 1-11: Maps of AGB (left) and AGB standard error relative to the AGB value (right) at 0.1° (top) and 0.5° (bottom) obtained by spatial averaging the CCI BIOMASS maps of 2020.

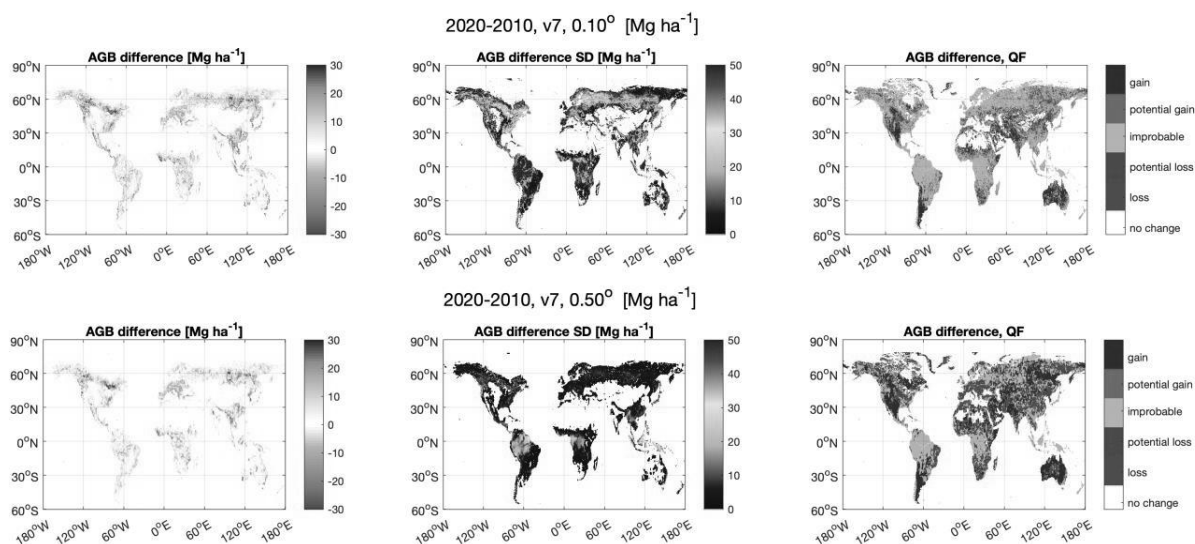


Figure 1-12: Maps of AGB change (left), corresponding standard deviation (middle) and quality flag (right) at 0.1° (top) and 0.5° (bottom) obtained by spatial averaging the CCI BIOMASS AGB maps of 2020 and 2010 and taking their difference.