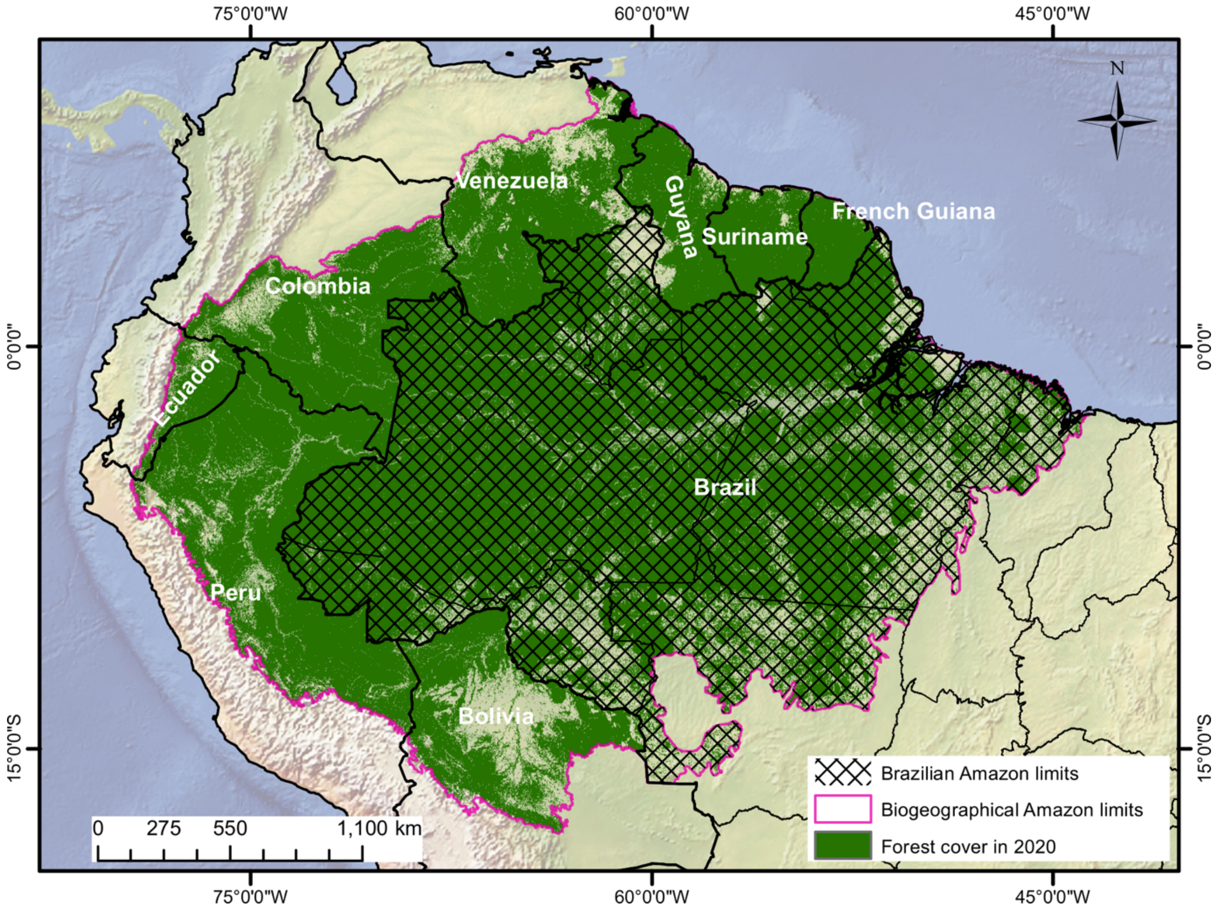
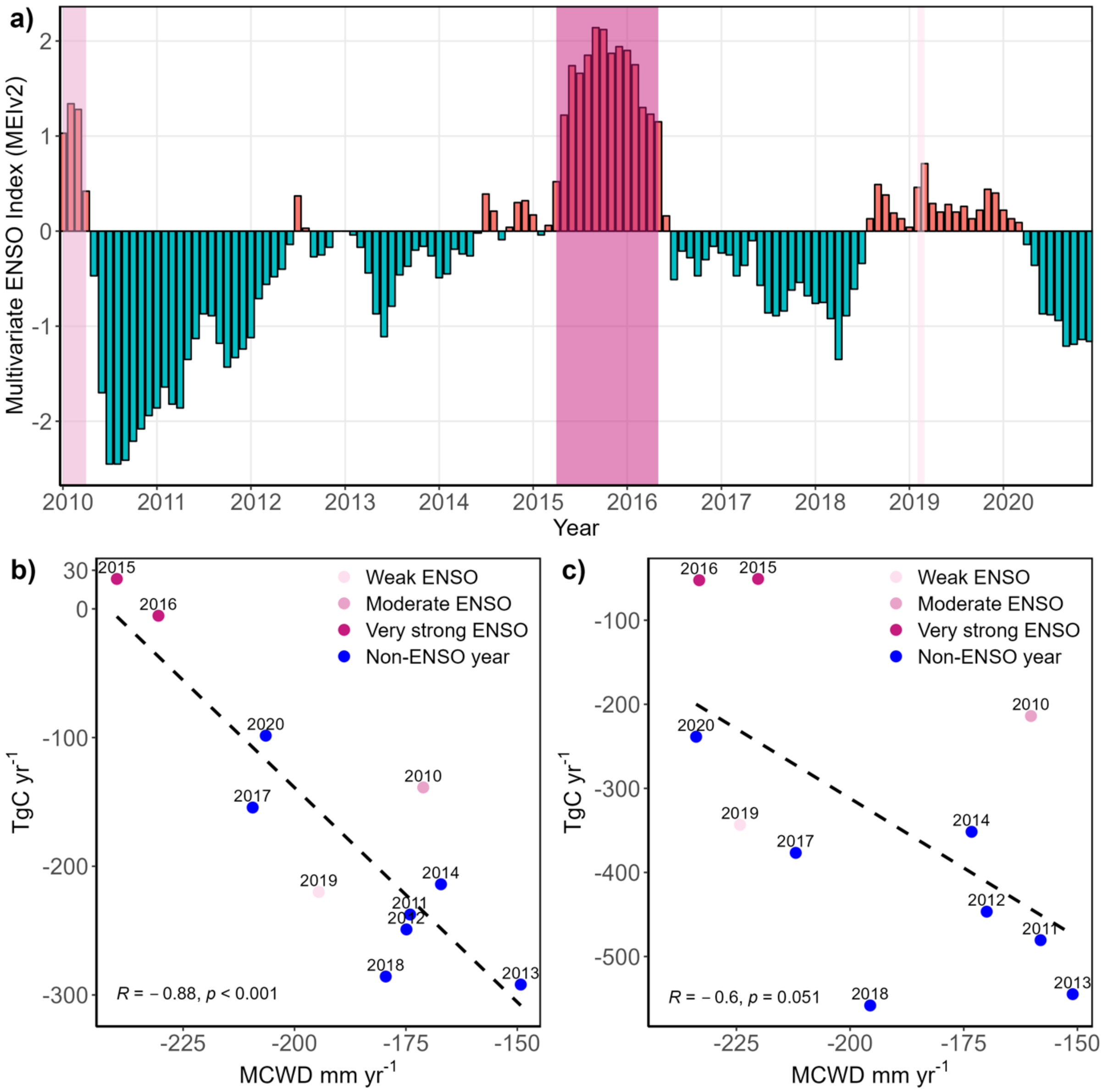
Supporting Information

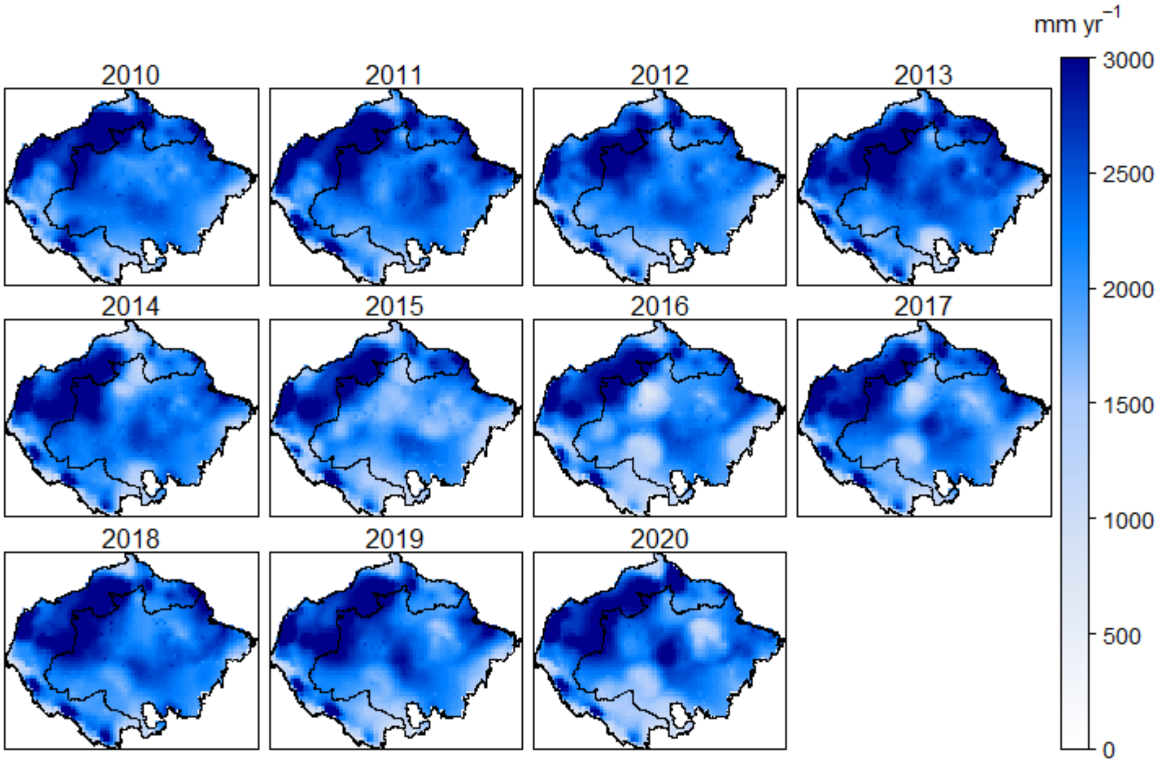
Supporting figures and tables of "Synthesis of the land carbon fluxes of the Amazon region between 2010 and 2020" by Rosan et al.



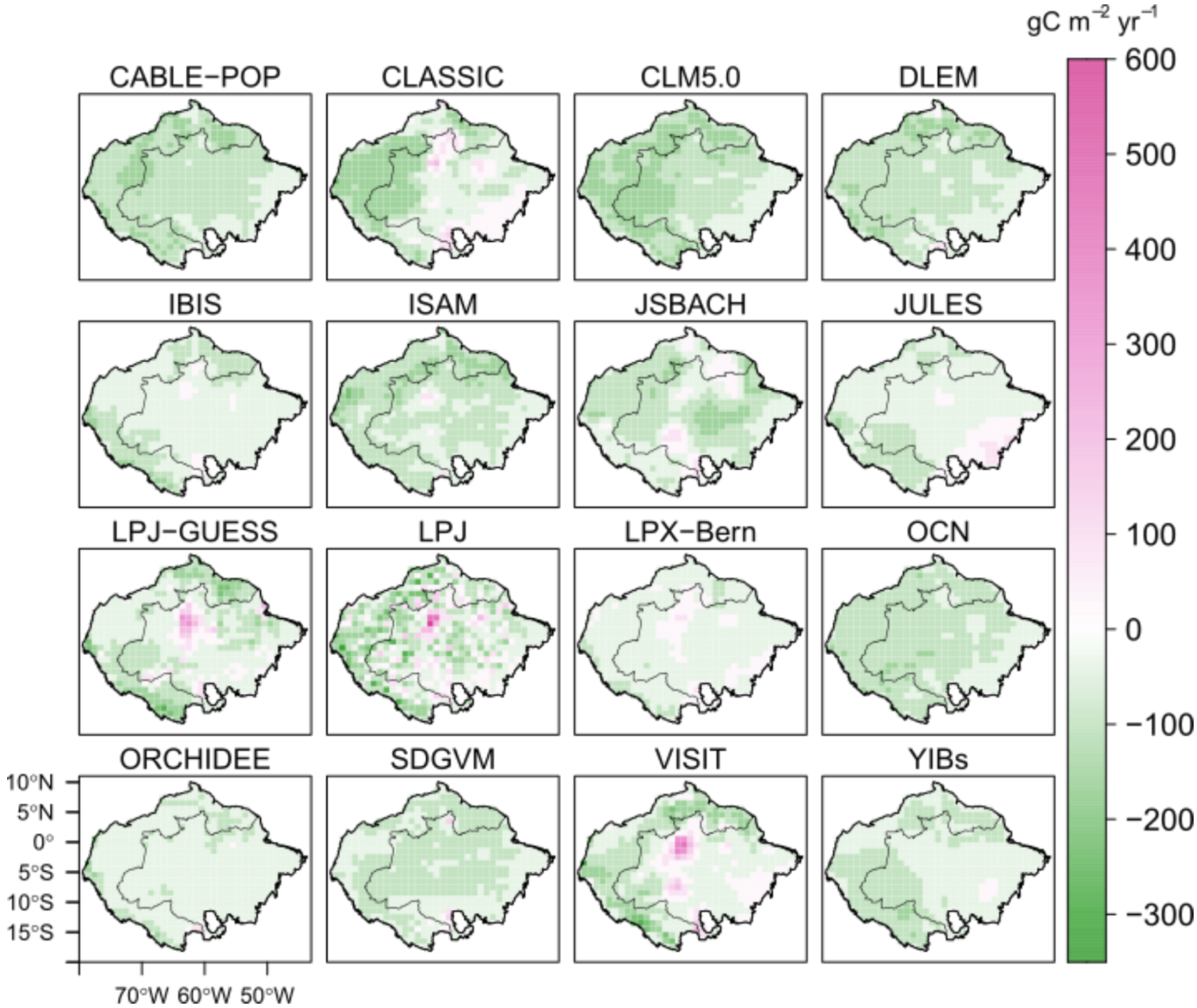
Supplementary Figure 1 Amazon Forest cover in 2020 with the limits of Brazilian Amazon (hatched area) and the whole Biogeographical Amazon (pink area). Source of the Amazon Forest cover is MapBiomas Amazonia collection v4.0.



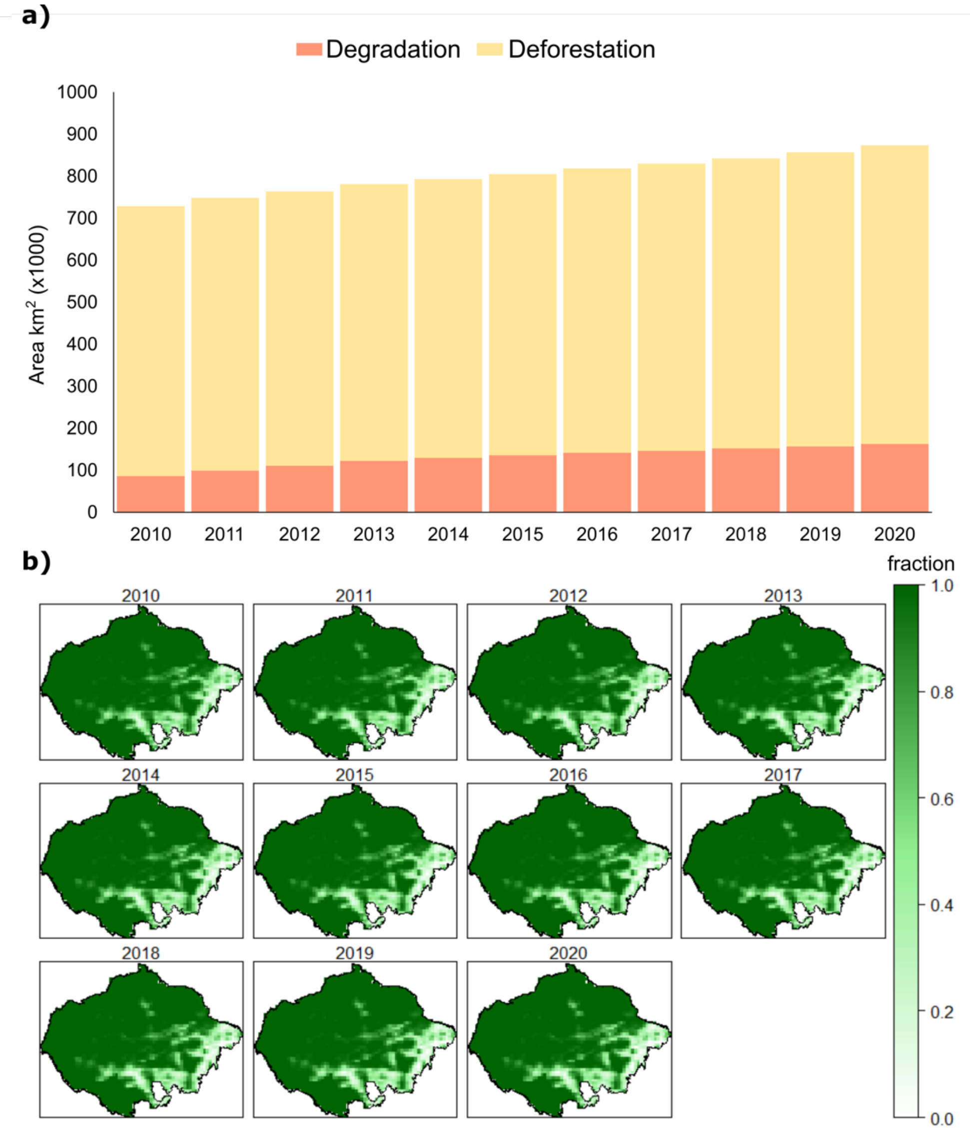
Supplementary Figure 2 El Niño–Southern Oscillation (ENSO) events between 2010 and 2020. a) Bimonthly Multivariate ENSO index (MEIv2) from the National Oceanic and Atmospheric Administration (NOAA); shaded pink areas highlight the ENSO occurrence between 2010 and 2020. b) Correlation between old-growth forest sink simulated by the TRENDY-v11 DGVMs (Tg C yr^{-1}) and the Annual Maximum Cumulative Water Deficit (MCWD mm yr^{-1}) for the Brazilian Amazon. c) Correlation between old-growth forest sink simulated by the TRENDY-v11 DGVMs (Tg C yr^{-1}) and the Annual Maximum Cumulative Water Deficit (MCWD mm yr^{-1}) for the whole Biogeographical Amazon. Dashed line represents the correlation between the old-growth forest sink and the MCWD and the Pearson's correlation, the Pearson correlation coefficient (R) and p-value at 95% confidence level are in the bottom-right of plots b and c, respectively.



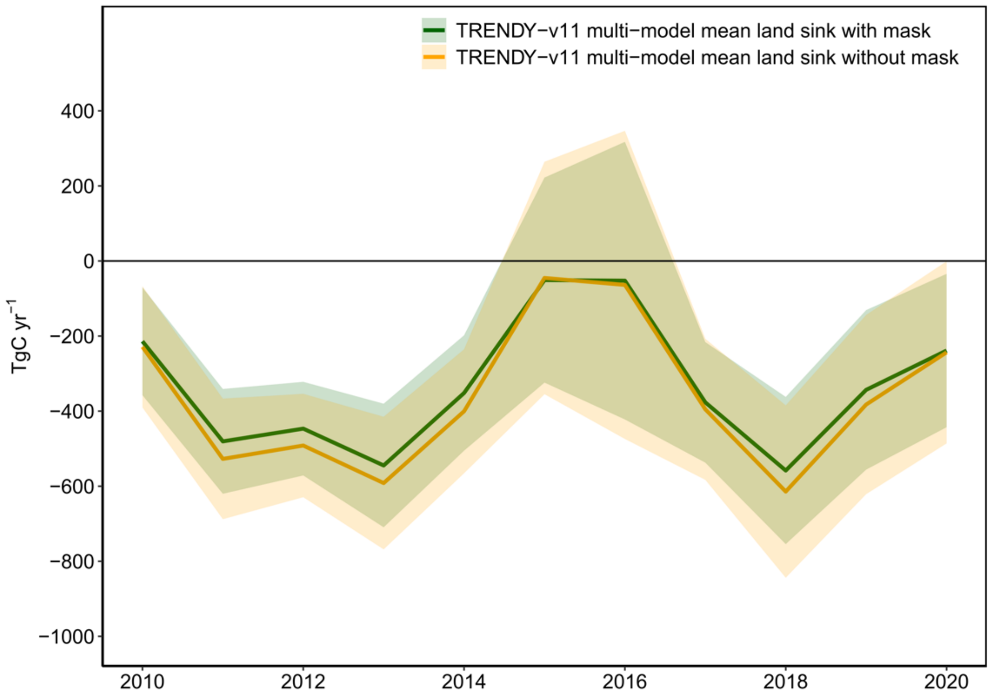
Supplementary Figure 3 Amazon annual total precipitation (mm yr^{-1}) between 2010 and 2020 from CRUJRA2.4 used as input for the DGVMs in TRENDY-v11.



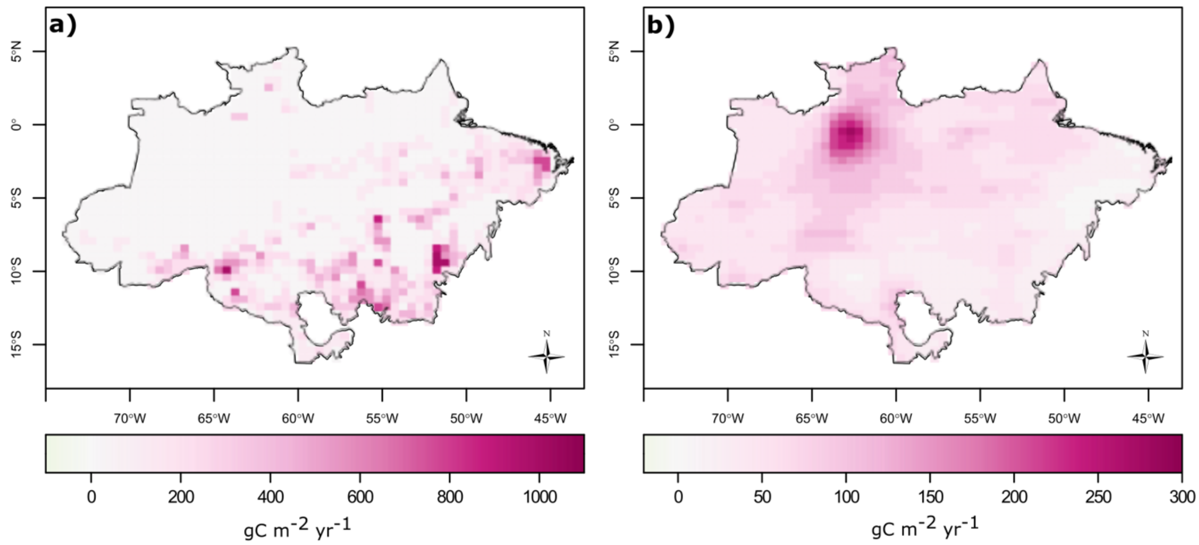
Supplementary Figure 4 Mean Amazon old-growth forest sink (gC m^{-2} yr^{-1}) between 2010 and 2020 from each DGVMs used in TRENDY-v11.



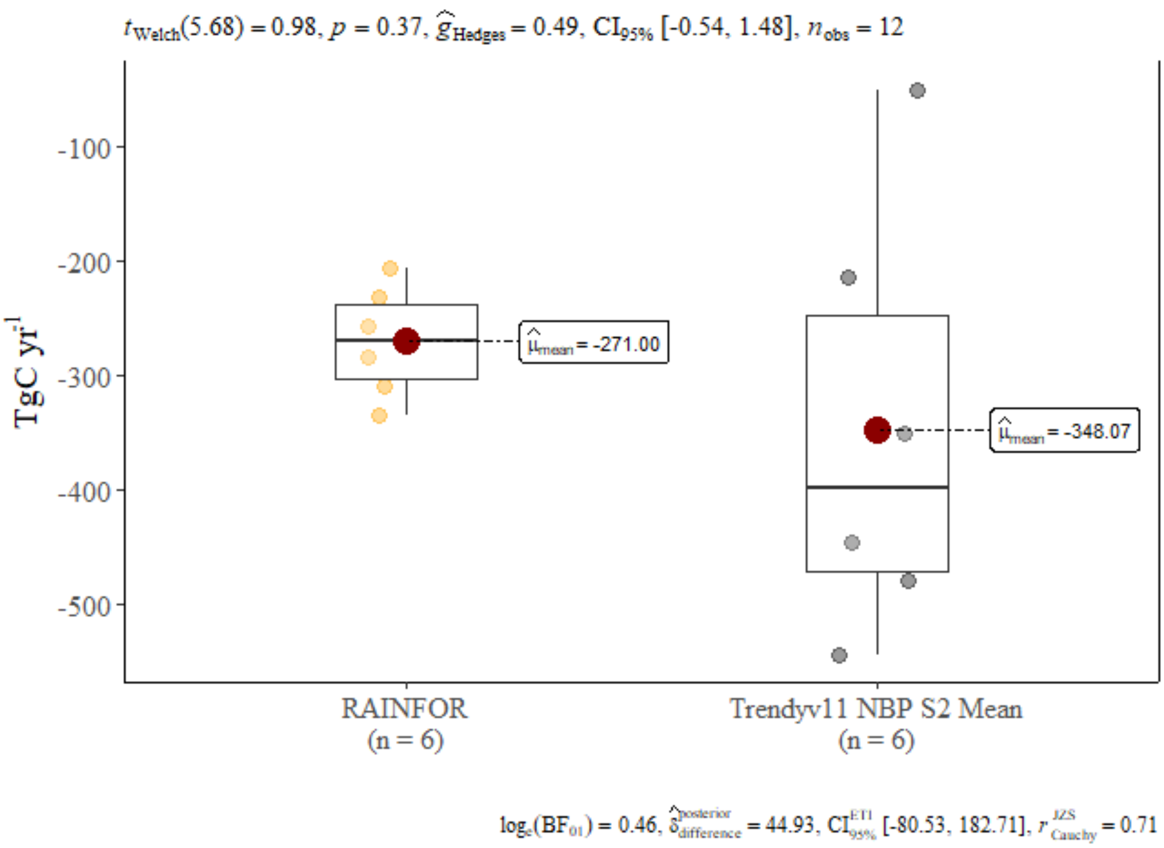
Supplementary Figure 5 Correction of TRENDY-v11 sink estimates using an old-growth areas mask. a) Accumulated deforestation and degradation area in the Brazilian Amazon (km^2 x1000); b) Whole biogeographical Amazon old-growth forest fraction mask based on the annual accumulated disturbance area of deforestation and degradation from INPE.



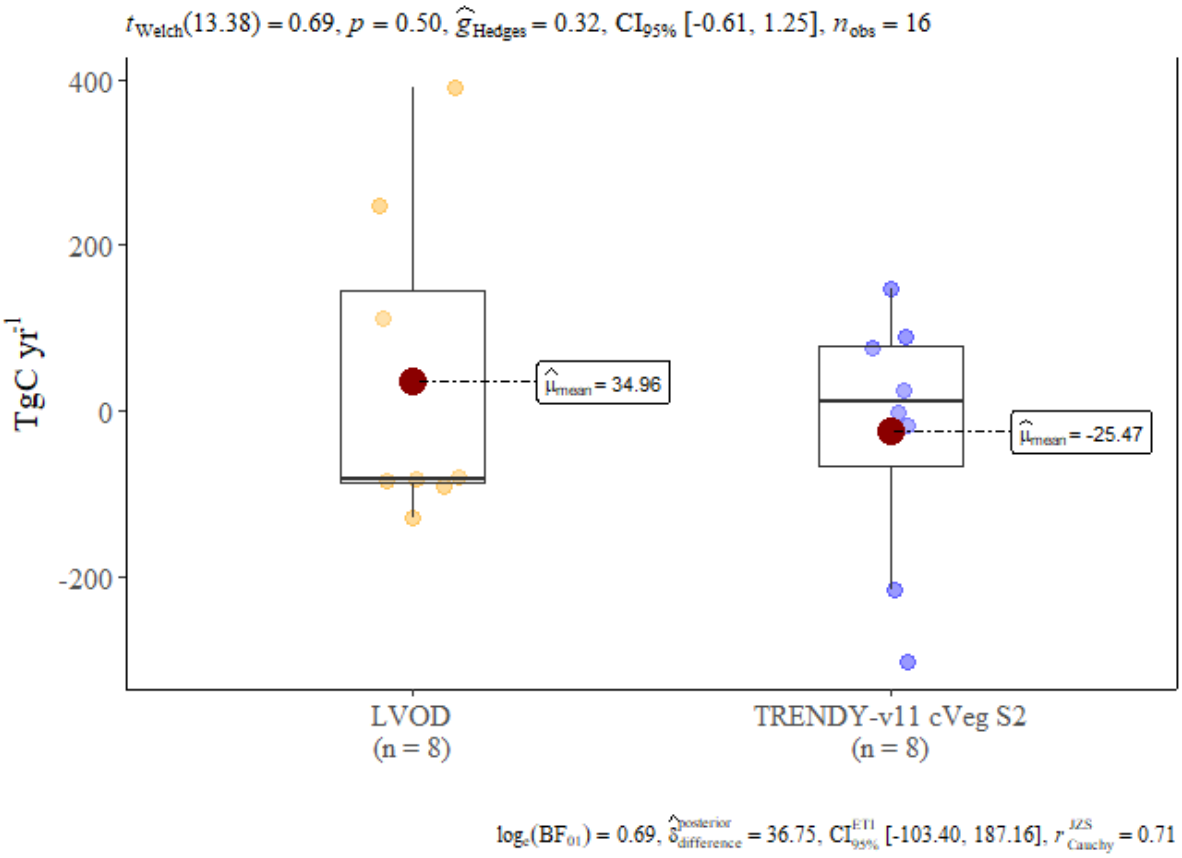
Supplementary Figure 6 Annual intact sink over the whole Biogeographical Amazon simulated by TRENDY-v11 DGVMs with and without the accumulated disturbance mask (Supplementary Figure 2) applied.



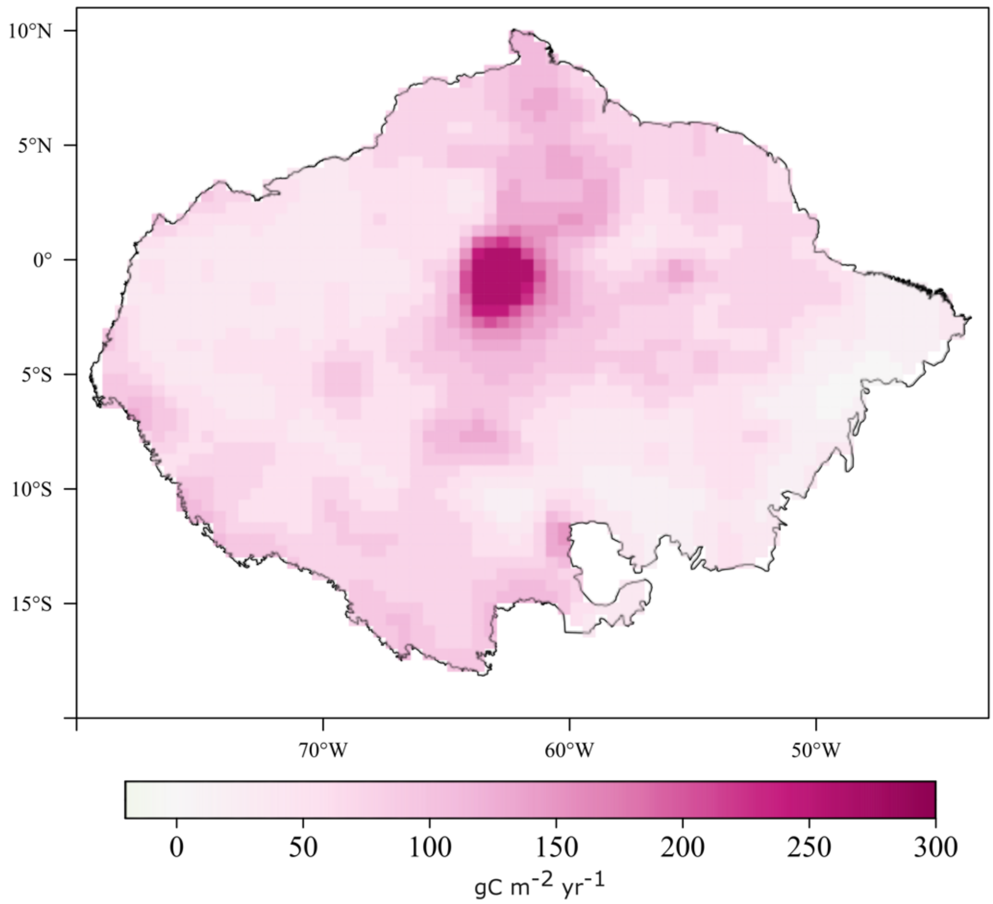
Supplementary Figure 7 Spatial uncertainty of main Figure 1. a) Average spatial uncertainty (2010-2020) of the disturbance fluxes in the Brazilian Amazon; **b)** Spatial average uncertainty (2010-2020) of the intact sink from TRENDY-v11 DGVMs in the Brazilian Amazon. Data in gC m^{-2} yr^{-1}.



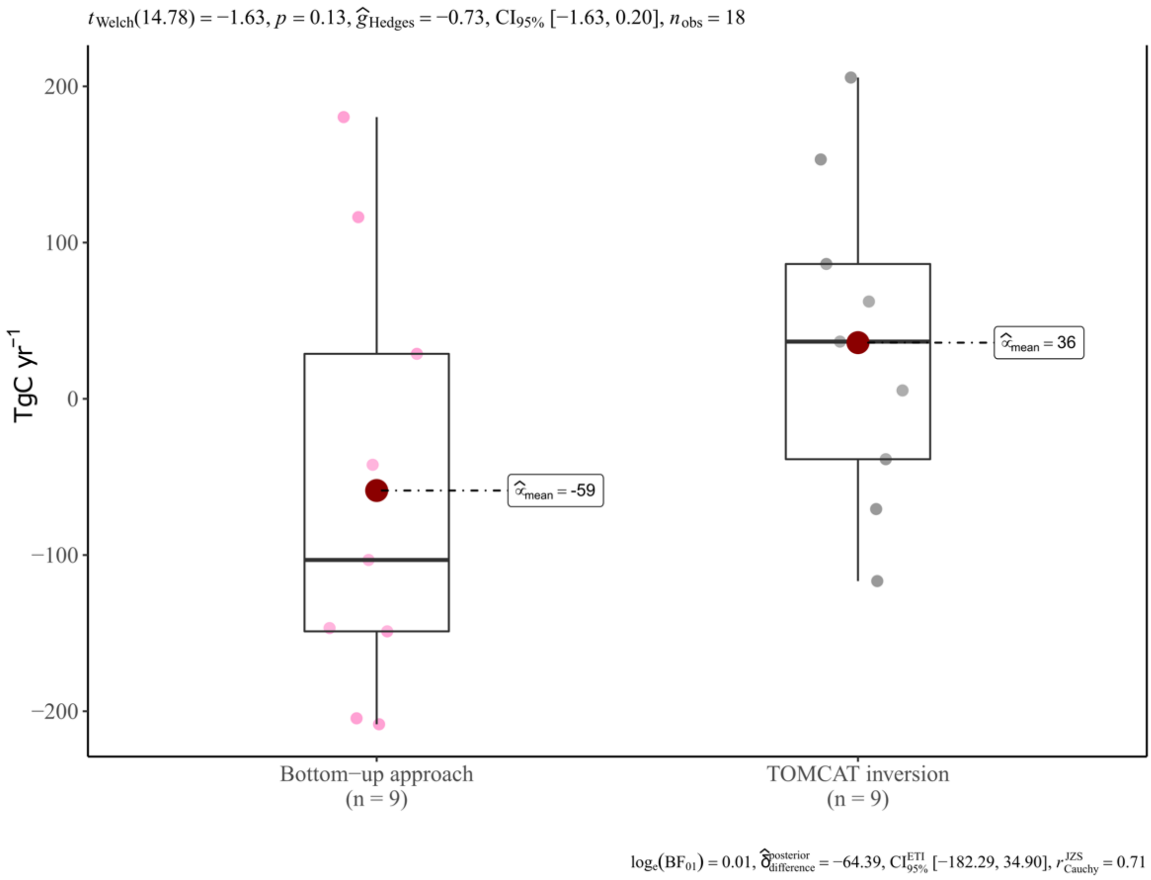
Supplementary Figure 8 Welch's t-test of the comparison between the mean intact sink from RAINFOR and TRENDY-v11 over 2010-2015; n is equal the number of years available for the analysis of each estimate (2010-2015).



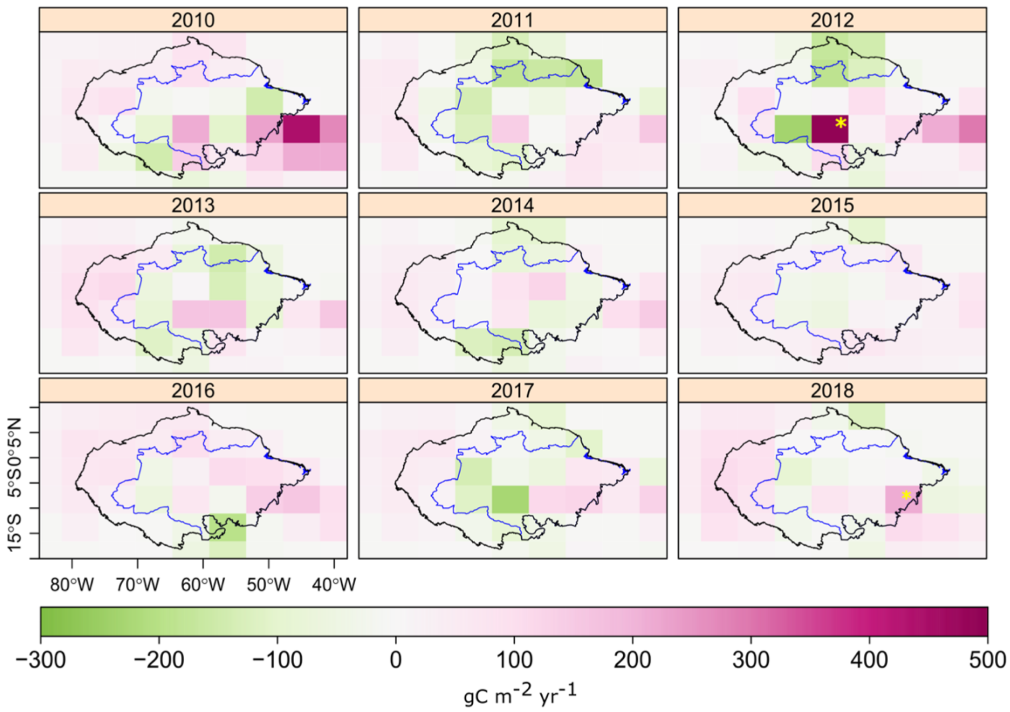
Supplementary Figure 9 Welch's t-test of the comparison between the intact aboveground carbon changes from L-VOD[8] and TRENDY-v11 multi-model mean 2011-2019, n is equal the number of years available for the analysis of each estimate.



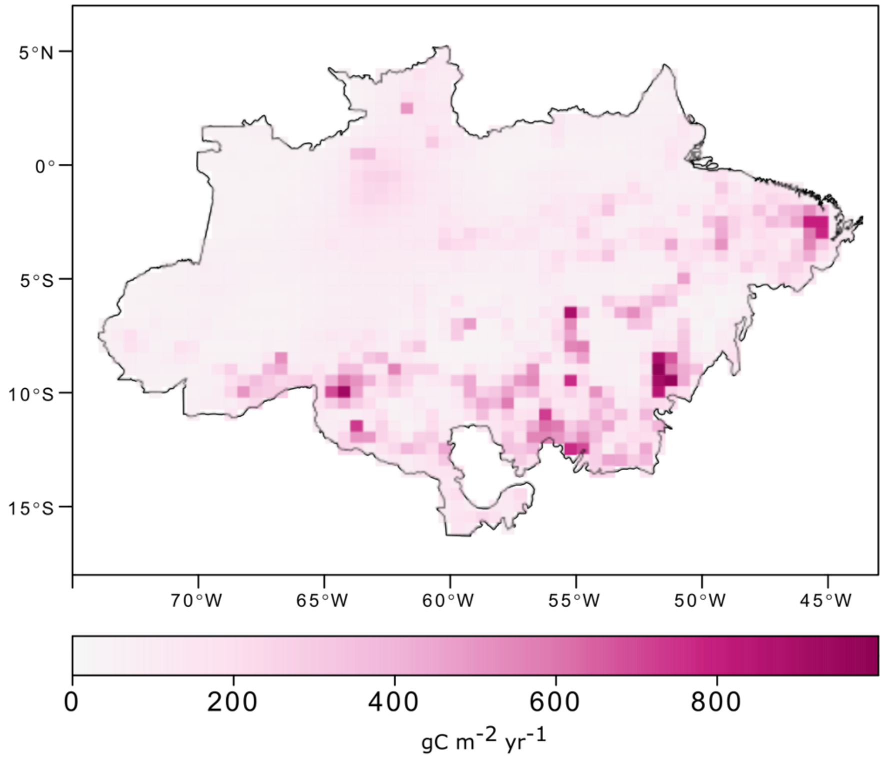
Supplementary Figure 10 Average intact sink uncertainty from TRENDY-v11 DGVMs over the whole biogeographical Amazon (gC m^{-2} yr^{-1}).



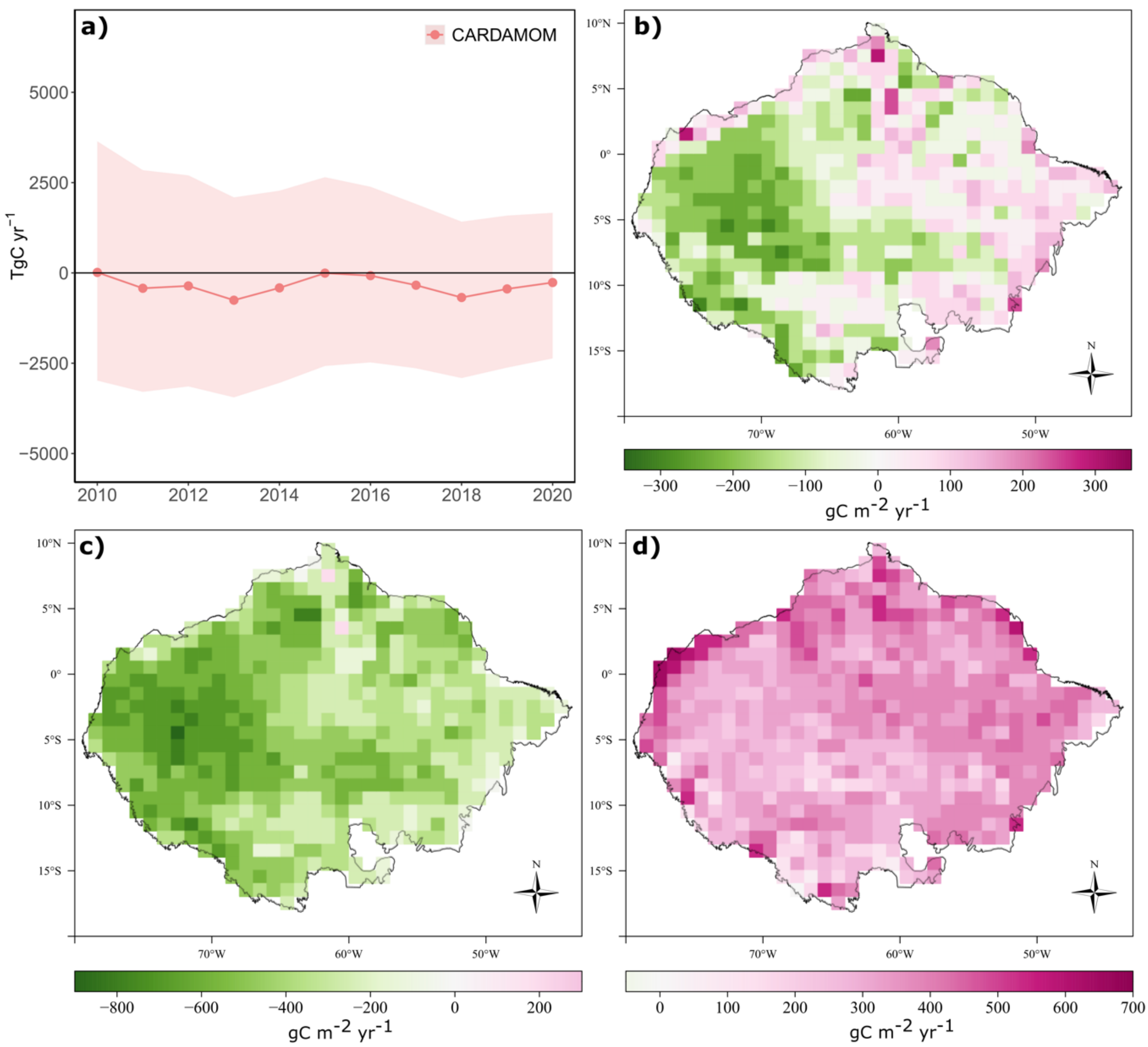
Supplementary Figure 11 Welch's t-test to compare the net land carbon fluxes from bottom-up approach and top-down inversion over 2010-2018 for the Brazilian Amazon.



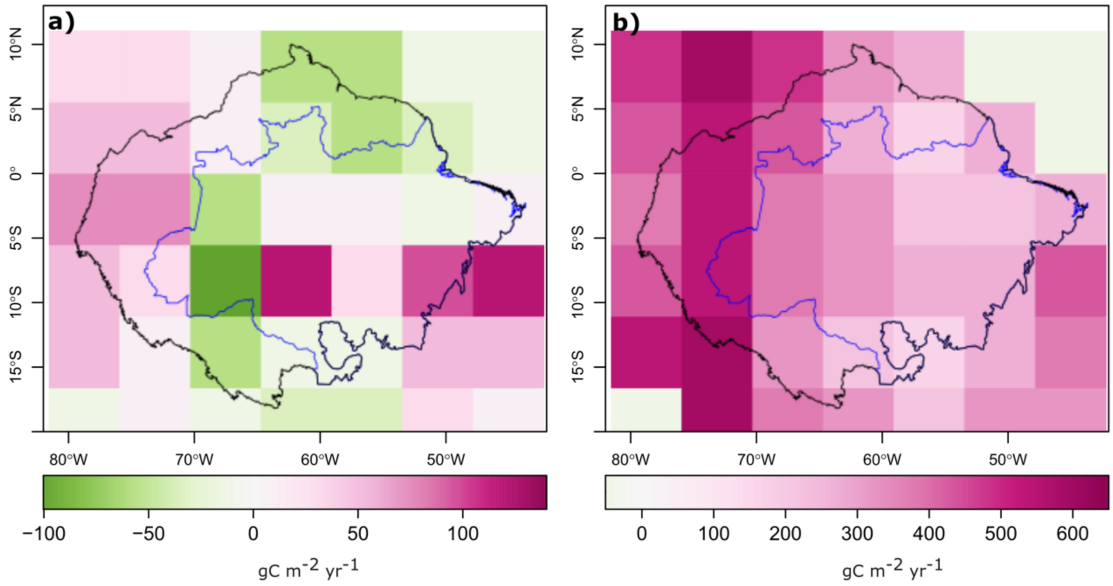
Supplementary Figure 12 Annual spatial net land carbon flux from TOMCAT atmospheric inversion (gC m^{-2} yr^{-1}). The black line is the biogeographical Amazon limits, and the blue line is the Brazilian Amazon limits. Grid-cell with yellow star have the highest fluxes in 2012 and 2018 maps.



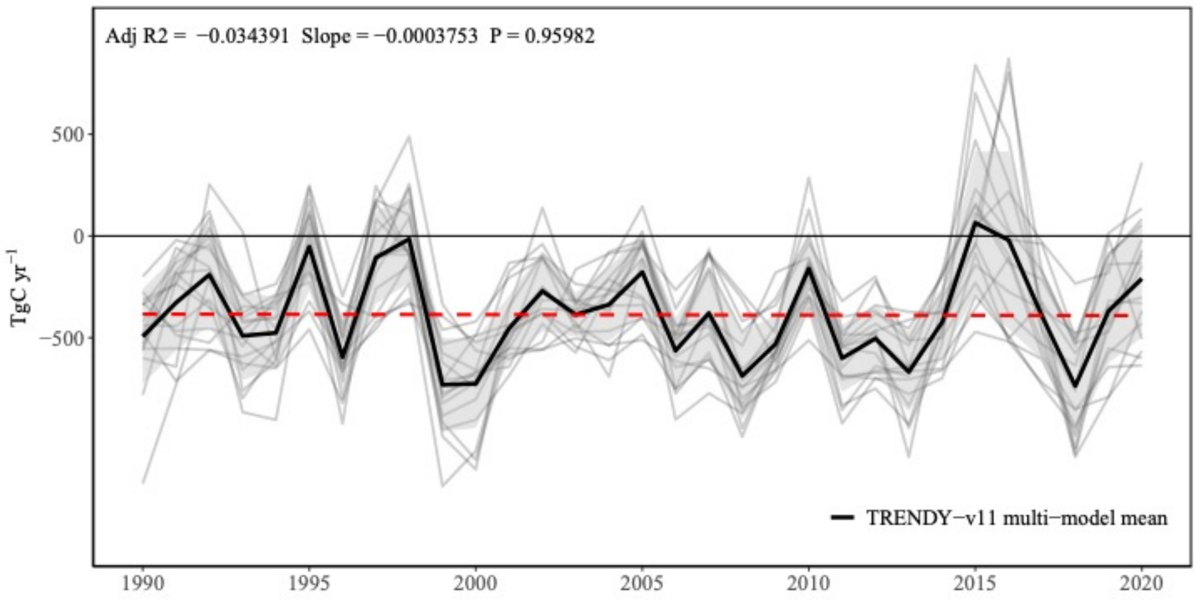
Supplementary Figure 13 Spatial Brazilian Amazon net land carbon flux uncertainty from the bottom-up approach over 2010-2020 (gC m^{-2} yr^{-1}).



Supplementary Figure 14 Net land carbon fluxes from CARDAMOM. a) Annual net land carbon fluxes for the whole biogeographical Amazonia; b) Spatial average net land carbon fluxes (gC m^{-2} yr^{-1}) of from CARDAMOM between 2010 and 2020; c) Spatial average uncertainty (gC m^{-2} yr^{-1}) of CARDAMOM between 2010 and 2020 (CI 97.5%); d) Spatial average uncertainty (gC m^{-2} yr^{-1}) of CARDAMOM between 2010 and 2020 (CI 2.5%).



Supplementary Figure 15 Spatial fluxes from the top-down atmospheric inversion. a) TOMCAT atmospheric inversion net land carbon fluxes over 2010-2018 (gC m^{-2} yr^{-1}); b) average uncertainty estimate over 2010-2018 from TOMCAT atmospheric inversion (gC m^{-2} yr^{-1}). The blue line is the Brazilian Amazon limits and the black line the biogeographical Amazon limits.



Supplementary Figure 16 Multi-model mean of TRENDY-v11 old-growth forest sink between 1990 and 2020 (TgC yr^{-1}) over the whole biogeographical Amazon. The red dotted line is the linear trend line.

Supplementary Table 1 INPE-EM parameters to quantify the E_{LUC} and degradation fluxes. Source: INPE-EM website and Aguiar et al., 2012.

Description	Value	Source
Deforestation		
Accumulated deforestation area up to the initial year of the model	Spatial	PRODES INPE
Yearly deforestation rate	Spatial	PRODES INPE
Forest area in the initial year of the model	Spatial	PRODES INPE
Biomass		
Forest aboveground live biomass	Spatial	
Percentage of belowground biomass in relation to the aboveground biomass	20%	MCTI 2016
Percentage of litter in relation to the aboveground biomass	4%	MCTI 2016
Percentage of dead wood in relation to the aboveground biomass	7%	MCTI 2016
Vegetation removal		
Percentage of the remain AGB	0%	n.a. (clear-cut)
Percentage of AGB that goes to wood products	15%	Aguiar et al. 2012
Percentage of AGB that will release carbon via fire	42,5%	Aguiar et al. 2012
Percentage of AGB that will release carbon via decomposition	42,5%	Aguiar et al. 2012
Percentage of remain BGB	0%	n.a. (clear-cut)
Percentage of BGB that will be burned	0%	Aguiar et al. 2012
Percentage of BGB that will release carbon via decomposition aboveground	0,0%	Aguiar et al. 2012
Percentage of BGB that will release carbon via decomposition belowground	100,0%	Aguiar et al. 2012
Percentage of litter that will release carbon via fire	50%	Aguiar et al. 2012
Percentage of litter that will release carbon via decomposition	50%	Aguiar et al. 2012
Percentage of dead wood that will release carbon via fire	50%	Aguiar et al. 2012
Percentage of dead wood that will release carbon via decomposition	50%	Aguiar et al. 2012
Number of years to burn the residues	3 years	Aguiar et al. 2012
Percentage of carbon non released by combustion and will slowly decompose as elemental carbon	2%	Houghton et al. 2000, Aguiar et al. 2012
Decay rate of wood products	0,1	Houghton et al. 2000, Aguiar et al. 2012

Decay rate of AGB	0,4	Houghton et al. 2000, Aguiar et al. 2012
Decay rate of BGB by decomposition belowground	0,7	Aguiar et al. 2012
Decay rate of BGB by decomposition aboveground	0,4	Aguiar et al. 2012
Decay rate of remain AGB and will slowly decompose as elemental carbon	0,001	Houghton et al. 2000, Aguiar et al. 2012
Emission factors		
Conversion factor of biomass to carbon	0,47	Longo et al. 2009
Conversion factor of biomass to CO2 by decay	1,72249	Longo et al. 2009
Conversion factor of biomass to CO2 by fire	1,601	Longo et al. 2009
Conversion factor of biomass to CH4 by fire	0,00625	Longo et al. 2009
Conversion factor of biomass to N20 by fire	0,0002	Longo et al. 2009
Conversion factor of biomass to NOx by fire	0,00017	Longo et al. 2009
Conversion factor of biomass to CO by fire	0,1078	Longo et al. 2009
Global warming potential		
Global warming potential CO2	1	IPCC 2013
Global warming potential CH4	28	IPCC 2013
Global warming potential N20	265	IPCC 2013
Global warming potential NOx	0	IPCC 2013
Global warming potential CO	0	IPCC 2013
Secondary vegetation		
Percentage of secondary vegetation area	0.21*	TerraClass
Time that the area will be abandoned after deforestation	2 anos	Aguiar et al. 2012
Percentage of the original biomass to be recovered in the period 1	70%	Houghton et al. 2000, Aguiar et al. 2012
Time of regrowth period 1	25 anos	Houghton et al. 2000, Aguiar et al. 2012
Percentage of the original biomass to be recovered in the period 2	30%	Houghton et al. 2000, Aguiar et al. 2012
Time of regrowth period 2	50 anos	Houghton et al. 2000, Aguiar et al. 2012
Number of years that 50% of the secondary vegetation will be cut again	5**	Almeida 2009, Aguiar et al 2012
Complementary parameter of half life: number of abandonment years needed to satellite images detect secondary vegetation	3	Almeida 2009, Aguiar et al, 2012
Degradation		
Average biomass in a cell unit	spatial	Brazilian Third National GHG Inventory (MCTIC, 2017)

Percentage of cell unit identified as degraded that year by fire/logging events	spatial	DEGRAD/INPE
Percentage of AGB lost as result of the event	54,2%	Rappaport et al., 2018
Percentage of BGB lost as result of the event	0	
Percentage of dead wood lost as result of the event	46.90%	Withey et al., 2018
Percentage of litter lost as result of the event	46.90%	Withey et al., 2019
Rates of regeneration of the AGB along the years		Based on Rappaport et al., 2018 relationship between: a) intact and 1x burned forest; b) intact and 2x burned forest

Supplementary Table 2 Tropical vegetation parameters of BLUE to estimate E_{LUC}. Values in Tg/ha. Source: adapted from GCB (2022).

	Carbon stocks							
Primary Vegetation Type	Primary - Veg C	Secondary - Veg C	Pasture - Veg C	Crop - Veg C	Primary - Soil C	Secondary - Soil C	Pasture - Soil C	Crop - Soil C
Tropical evergreen forest	200	150	18	5	117	88	87.75	58
Tropical deciduous forest	160	120	18	5	117	88	87.75	58
Raingreen shrubs	27	27	18	5	69	69	69	34
C4 natural grasses	18	18	18	5	42	42	42	21
	Harvest							
	Fraction of roundwood assigned to decay pools after harvest, 1yr	Fraction of roundwood assigned to decay pools after harvest, 10yr	Fraction of roundwood assigned to decay pools after harvest, 100yr	Fraction of vegetation carbon transferred dead to soil at clearing for primary forest	Fraction of vegetation carbon transferred dead to soil at clearing for secondary forest	Minimum soil C following harvest	Time of soil carbon to reach minimum (as found following harvest)	
Tropical evergreen forest	0.9	0.04	0.06	0.785	0.71	76	5	
Tropical deciduous forest	0.9	0.04	0.06	0.86	0.81	76	5	
Raingreen shrubs	1	0	0	0.86	0.81	44.8	5	
C4 natural grasses	1	0	0	0.86	0.81	27.3	5	
	Clearing							
	Fraction of vegetation carbon assigned to decay pools	Fraction of vegetation carbon assigned to decay pools	Fraction of vegetation carbon assigned to decay pools	Fraction of vegetation carbon transferred dead to soil at	Soil carbon after initial, rapid loss after clearing	Time of rapid soil carbon loss	Time of soil carbon to reach minimum (as found under cultivation)	

	after clearing, 1yr	after clearing, 10yr	after clearing, 100yr	clearing (1-SUM(product pools))				
Tropical evergreen forest	0.4	0.27	0	0.33	70	3	15	
Tropical deciduous forest	0.4	0.27	0	0.33	70	3	15	
Raingreen shrubs	0.4	0.1	0	0.5	41	3	15	
C4 natural grasses	0.5	0	0	0.5	25	3	15	
	Recovery from harvest/clearing							
	Time required for biomass carbon to recover (to secondary land) after abandoned	Time required for soil carbon to recover (to secondary land) after abandoned						
Tropical evergreen forest	50	15						
Tropical deciduous forest	50	15						
Raingreen shrubs	25	15						
C4 natural grasses	5	15						

Supplementary Table 3 Processes relevant for S_{LAND} in addition to CO_2 fertilization and climate included in the DGVMs from GCB. Source: adapted from GCB 2022.

	DGVMs															
	CABLE-POP	CLASSIC	CLM5.0	DLEM	IBIS	ISAM	JSBACH	JULES-ES	LPJ-GUESS	LPJ	LPX-Bern	OCNv2	ORCHIDEEv3	SDGVM	VISIT	YIBs
Fire simulation and/or suppression	no	yes	yes	no	yes	no	yes	yes	yes	yes	yes	no	no	yes	yes	no
Carbon-nitrogen interactions, including N deposition	yes	no	yes	yes	no	yes	yes	yes	yes	no	yes	yes	yes	yes	no	no

References

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