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Supplement of

Greenhouse gas emissions and their trends over the last 3 decades across Africa

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Supplementary figures and methods

Table S1. Surface flasks characteristics over the African continent. Data synthetized from NOAA website: https://www.noaa.gov.

Station name, Country	Parameter	First sample date	Status for the three GHG	Frequency	Elevation (in meters above mean sea level)	Cooperating Agencies
Assekrem, Algeria	CO_2 CH_4 N_2O	12/09/1995 12/09/1995 12/09/1995	Terminated since 26/08/2020	Discrete Monthly	2710	Algerian National Office of Meteorology
Gobabeb, Namibia	CO_2 CH_4 N_2O	13/01/1997 13/01/1997 13/01/1997	Ongoing	Discrete Monthly	456	Gobabeb Training and Research Center
Mahe Island, Seychelles	CO_2 CH_4 N_2O	15/01/1980 12/05/1983 13/06/1997	Ongoing	Discrete Monthly	2	Seychelles Bureau of Standards
Cape Point, South Africa	CO_2 CH_4 N_2O	5/01/1980 12/05/1983 13/06/1997	Ongoing	Discrete Monthly	230	South African Weather Service
Mt. Kenya, Kenya	CO_2 CH_4 N_2O	11/02/2010 11/02/2010 11/02/2010	Inactive since 21/06/2011	Discrete Monthly	3644	Kenya Meteorological Department

Table S2. List of African countries per group.

Country name	Group
Algeria	Northern Africa
Chad	
Egypt	
Eritrea	
Libya	
Mali	
Mauritania	
Morocco	
Niger	
Sudan	
Tunisia	
Benin	Subsahelian Western Africa
Burkina Faso	
Cape verde	
Ivory Cote	
Gambia	
Ghana	
Guinea	
Guinea-Bissau	
Liberia	
Nigeria	
Sao Tome and Principe	
Senegal	
Sierra Leone	
Togo	
Cameroon	Central African countries
Central African Republic	
Democratic Republic of the Congo	
Gabon	
Republic of the Congo	
South Sudan	
Burundi	Horn of Africa
Comoros	
Djibouti	
Ethiopia	
Kenya	
Rwanda	
Seychelles	
Somalia	
Uganda	
United Republic of Tanzania	
Angola	Southern countries
Botswana	
Madagascar	
Malawi	
Mauritius	
Mozambique	
Namibia	
Zambia	
Zimbabwe	
Lesotho	Group of South Africa
South Africa	
Swaziland	

Methodological Supplementary S1 - discussion about the rescaling for CO_2 inversions

We operated a rescaling by subtracting back the prescribed fossil fuel fluxes to make sure that the inversions do not differ regarding prior fluxes for better comparability.

Figure S1. Comparison of PRIMAP-hist, GCP versus prescribed fossil fluxes for three CO_2 inversion models at the regional scale.

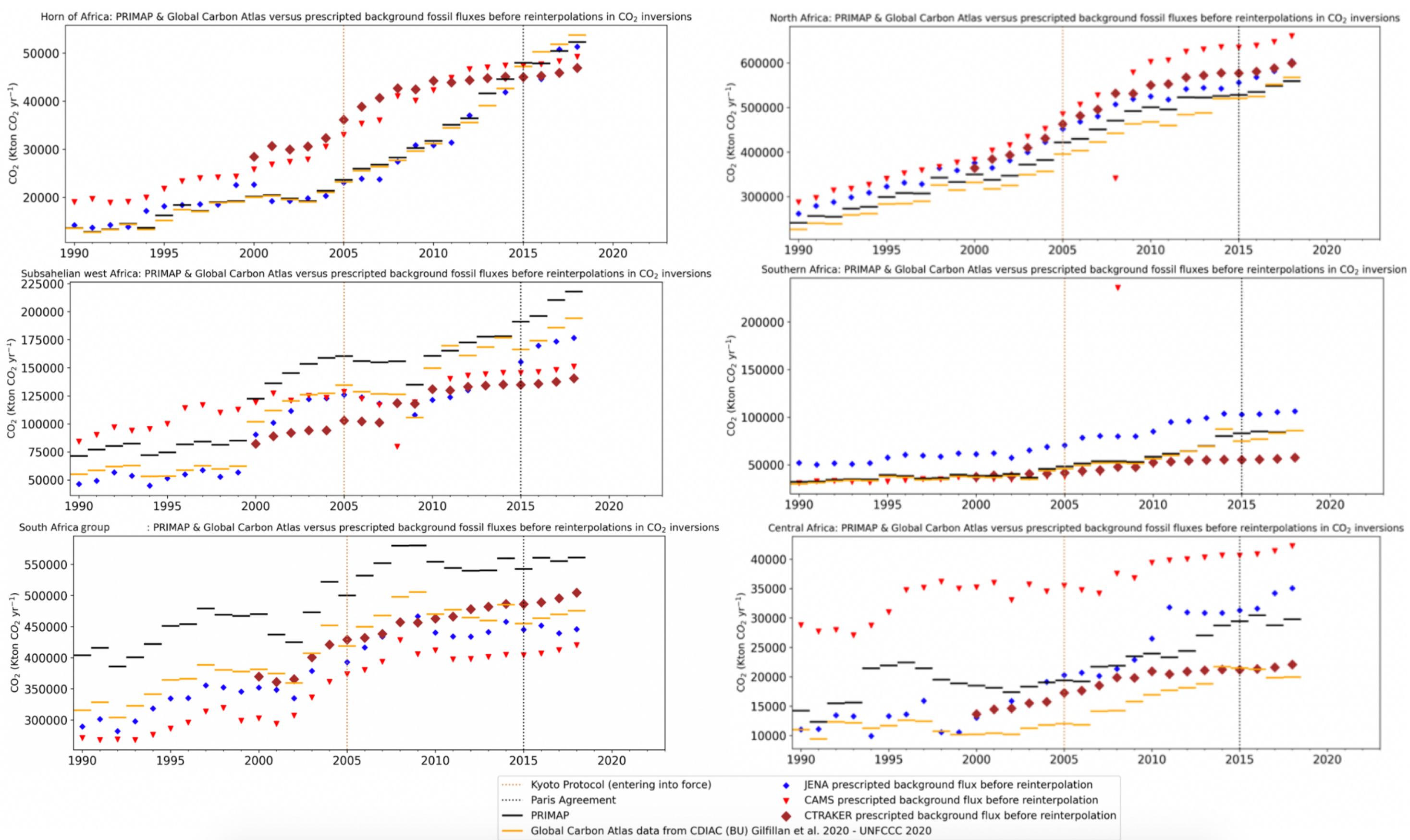


Figure S2. Map of six African groups.

Table S3.Data sources for the anthropogenic fossil CO_2 emissions included in this study.

Method	Product type / file name	Species	Overall period covered	References
BU	GCP/CDIAC	CO_2 fossil country totals with detailed emissions separating different subsectors	1990-2019	-GCP (Le Quéré et al., 2018; Friedlingstein et al., 2019) -CDIAC https://cdiac.ess-dive.lbl.gov/
BU	PRIMAP-hist	CO_2, CH_4 and N_2O fossil country totals (excluding LULUCF) with detailed emissions separating different subsectors	1990-2019	-PRIMAP https://www.pik-potsdam.de/paris-reality-check/primap-hist/

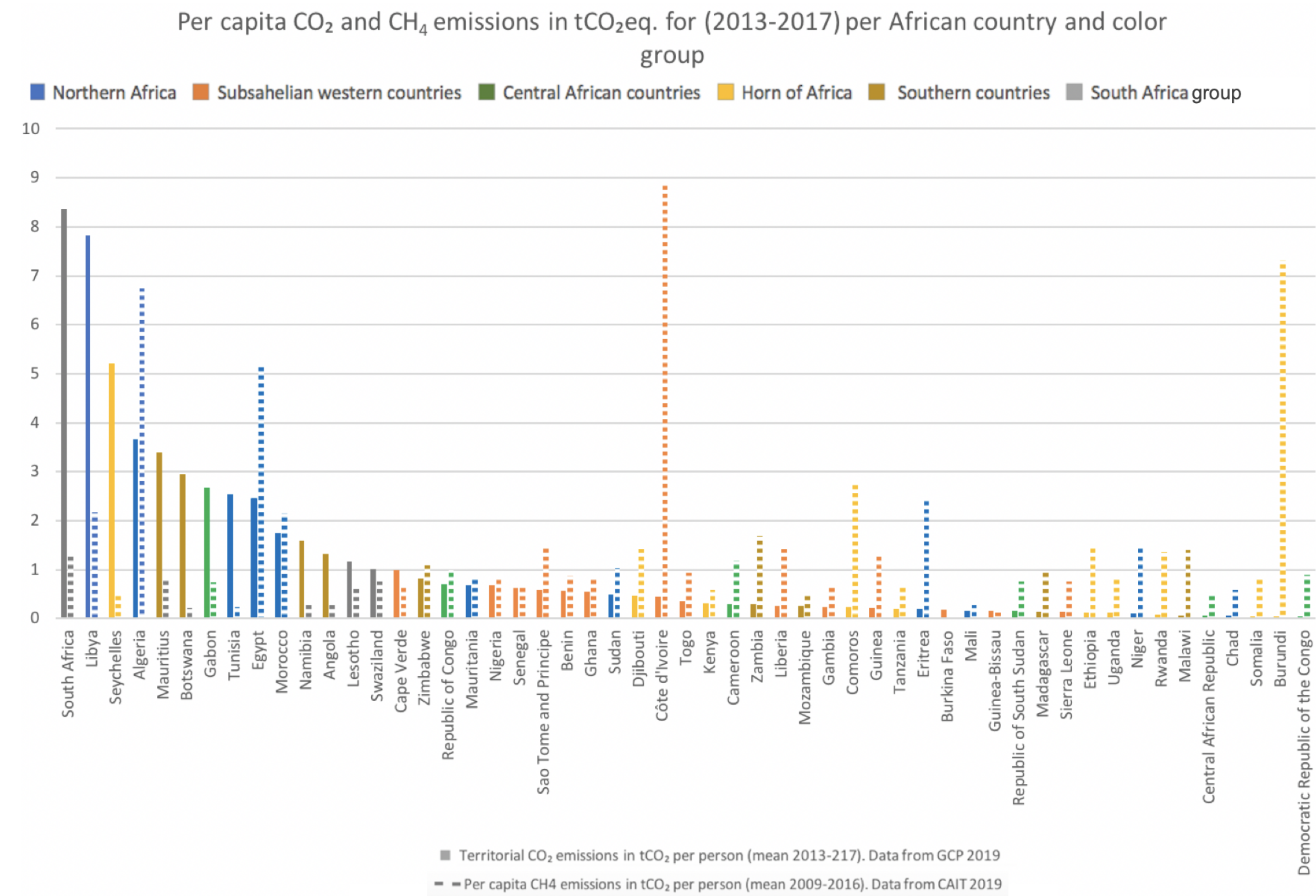


Figure S3. Bar plots of detailed African emissions for the mean values of the recent five years for fossil CO_2 and anthropogenic CH_4 in tCO_2e per capita, and by group color for 2009-2016.

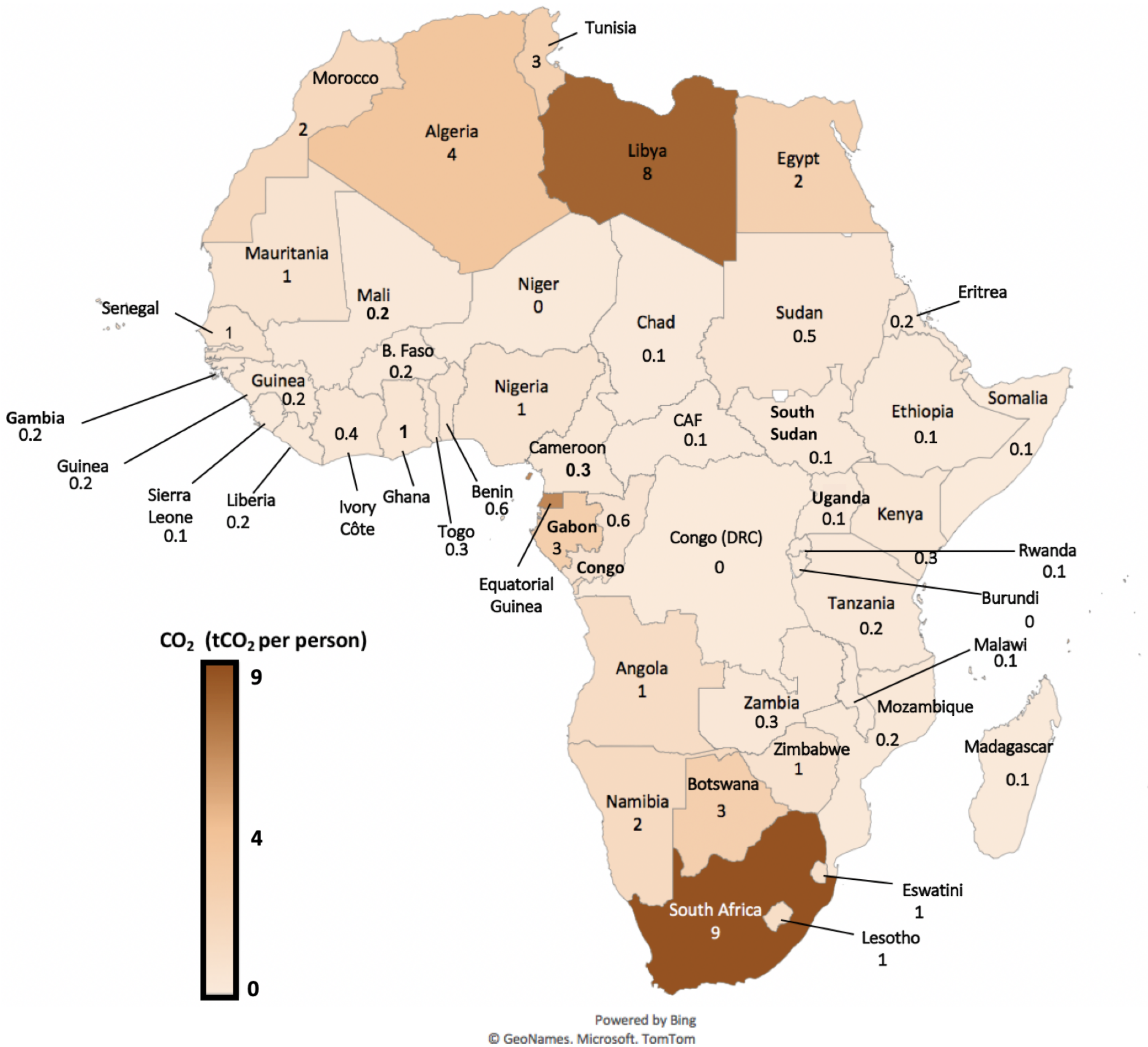


Figure S4. Map of African decennial 2009-2018 GCP CO_2 fossil fuel emissions per capita in tCO_2 per person - CDIAC.

Methodological supplementary S2. Steps for computing the Gini index of African country emissions.

The Gini index is a metric assessing the level of dispersion and therefore the level of inequalities among the values of a given dataset. To show the inequalities of per capita emissions among the African countries, we computed the continent Gini index for each of the last three decades using the Pareto principle for the following fluxes: fossil CO_2 per capita emissions, CH_4 fossil + agriculture per capita emissions, CH_4 from agriculture per capita emissions.

We computed the Gini using the Paretto method also named 20/80 or ABC method, using an excel file for the several countries' data manipulation. We obtained the GINI index (γ) thanks to the formula:

$$Y = \frac{[(\sum_{1}^{n} y_i \times x) - 5000\ ]}{5000}$$

When γ is bigger than 0.6, it means that the area delimited by the curve of the cumulated criterion and the graph diagonal represents more than 60% of the surface of half of the graph, and that the dispersion of the dataset is high. This method was built in the 19^{th} century based on Vilfredo Paretto's observations regarding the inequalities of repartition of the volume of housing taxes among the taxpayers (he realized that 80% of this tax was paid by 20% of the taxpayer.) The different steps that we followed to compute the Gini are detailed below:

1) computation of the territorial emissions per capita in every African country,
2) ranking in a decreasing order (from the highest to the smallest one),
3) computation of the cumulative emissions,
4) creation of a column with the cumulative emissions expressed as a percentage,
5) creation of a column with a rank (integer) for those ordered emissions from the biggest to the smallest,
6) conversion of this rank as a percentage in another column,
7) distinction of the emissions representing less than 25% of emissions, less than 50%, and less than 75% of emissions.
8) computation of the GINI index (γ) thanks to the Paretto's formula given above.

Methodological supplementary M3. Computation of correlation coefficient.

In mathematics, the linear correlation between two variables that we can call X and Y implies that two variables have a linear relationship between each other. If there is a linear relation between two variables, it can be represented by a straight line. To compute this linear correlation coefficient, we use the Pearson formula that is the computation of the covariance among variables (cov(X,Y)), divided by the product of their standard deviation (σ_X and σ_Y). Thus, we can compute the linear correlation ρ_{XY} among two variables by using the following formula: $\rho_{XY} = \frac{\mathrm{cov}(X,Y)}{\sigma_X \sigma_Y}$

The higher the absolute value of a linear correlation coefficient between two variables, the more the variables are linearly correlated.

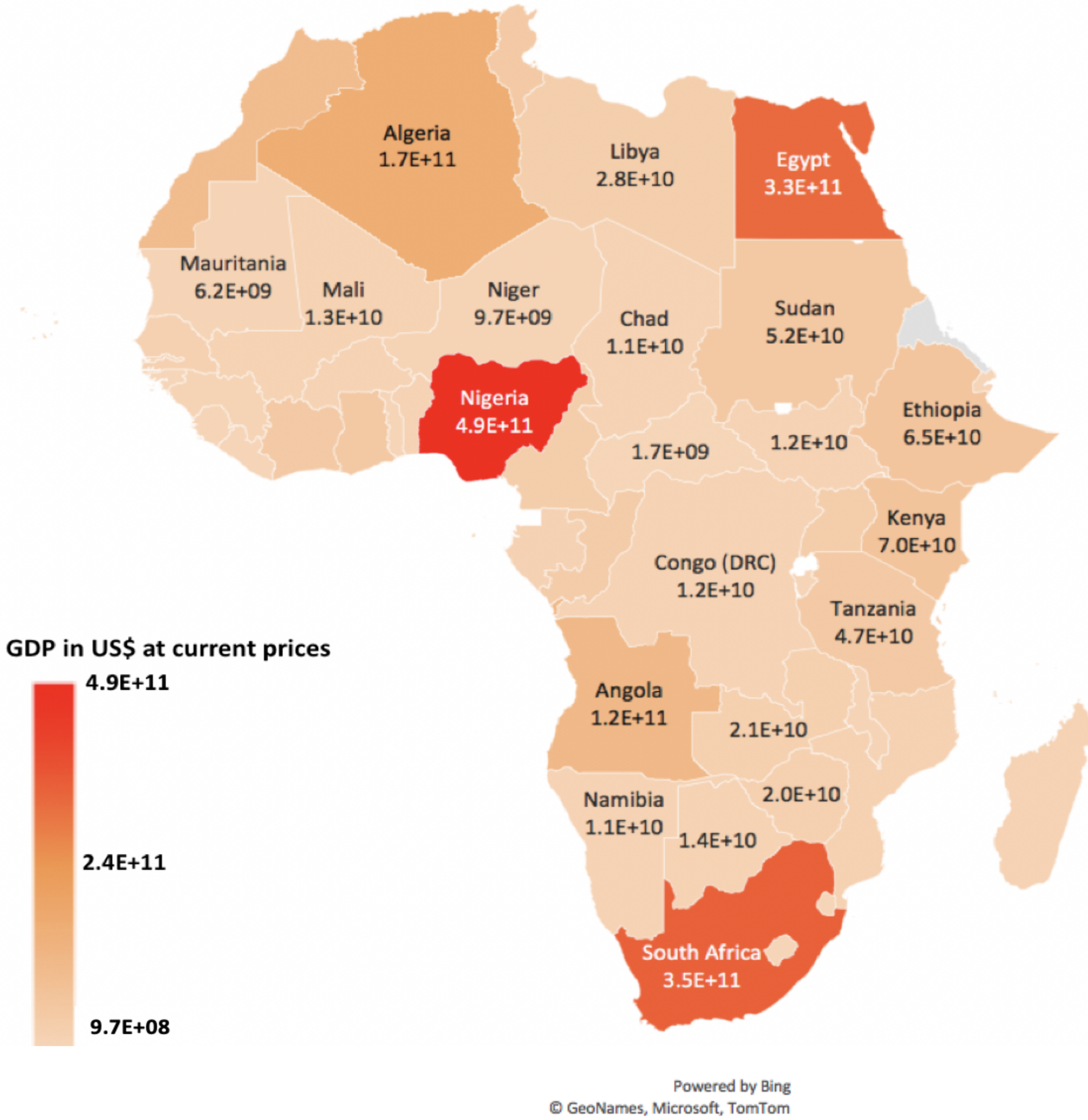


Figure S5. Bar plots and associated map of African GDP in US$ for the year 2015, dataset taken from World Bank national accounts data/OECD (2020).

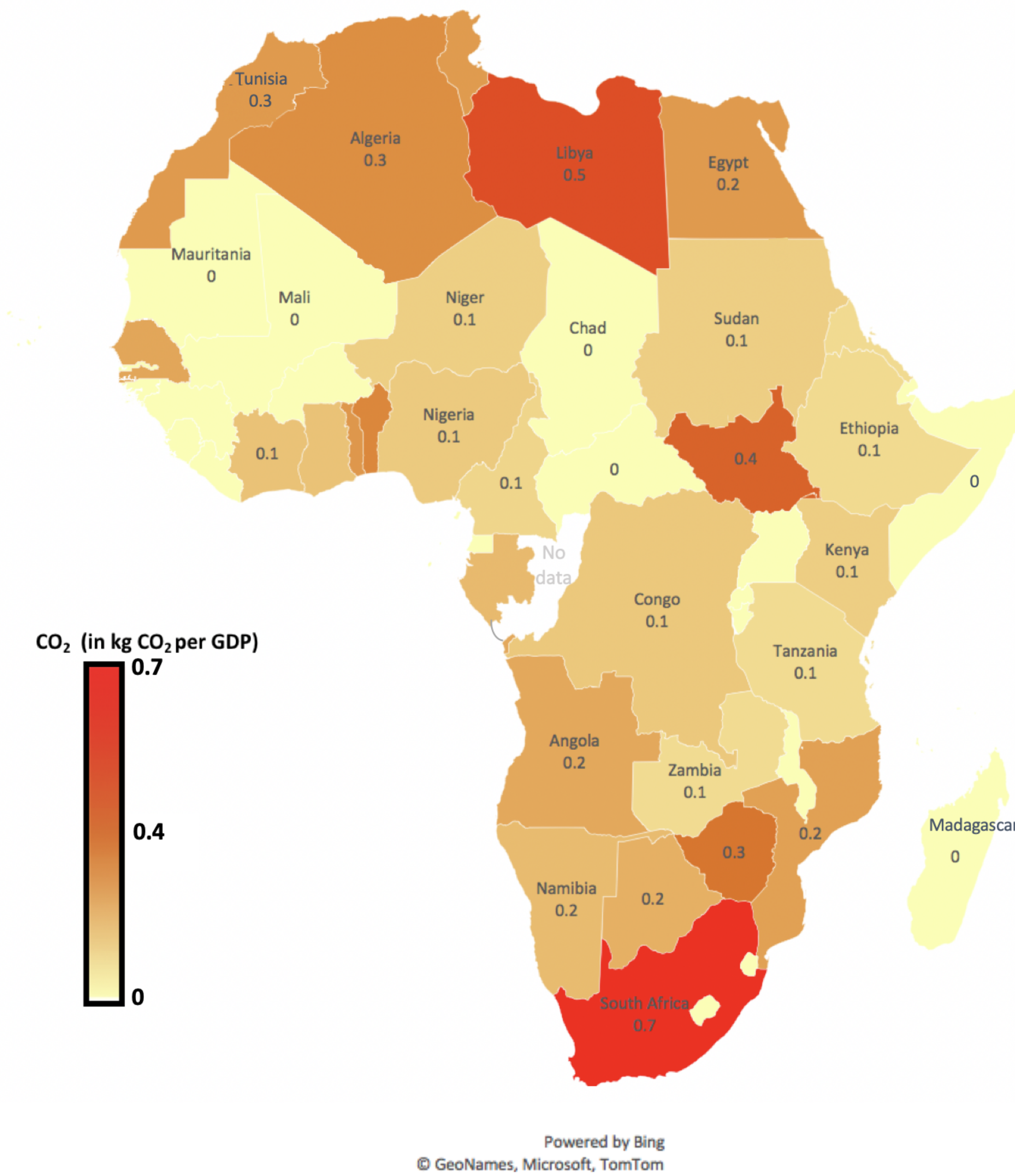


Figure S6. Map of territorial mean 2013-2017 emissions and its associated bar plots in kg CO_2 of GDP, dataset taken from GCP 2019 (CDIAC).

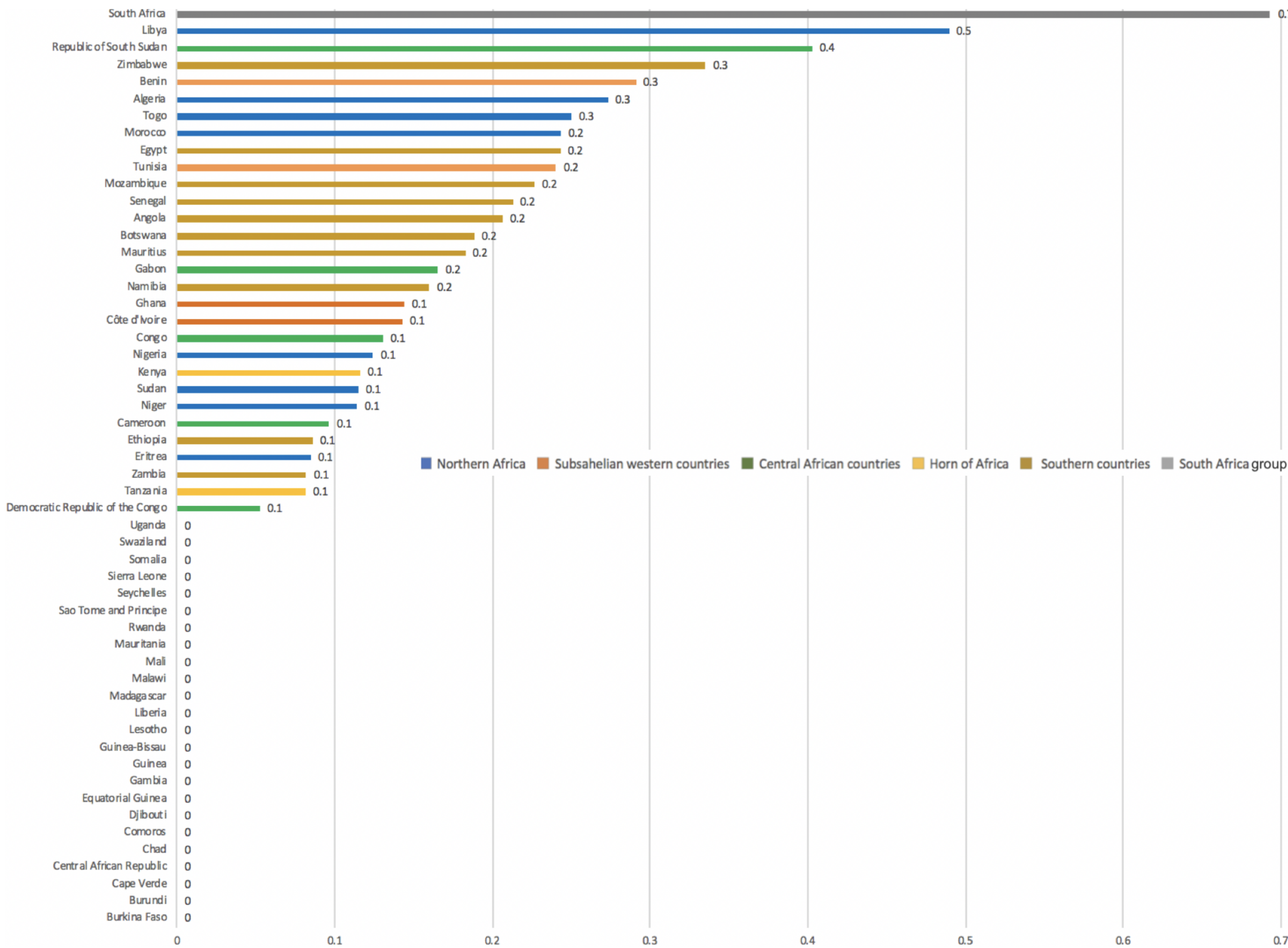


Figure S6 bis. Map of territorial mean 2013-2017 emissions and its associated bar plots in $kgCO_2$ per GDP, dataset taken from GCP 2019 (CDIAC).

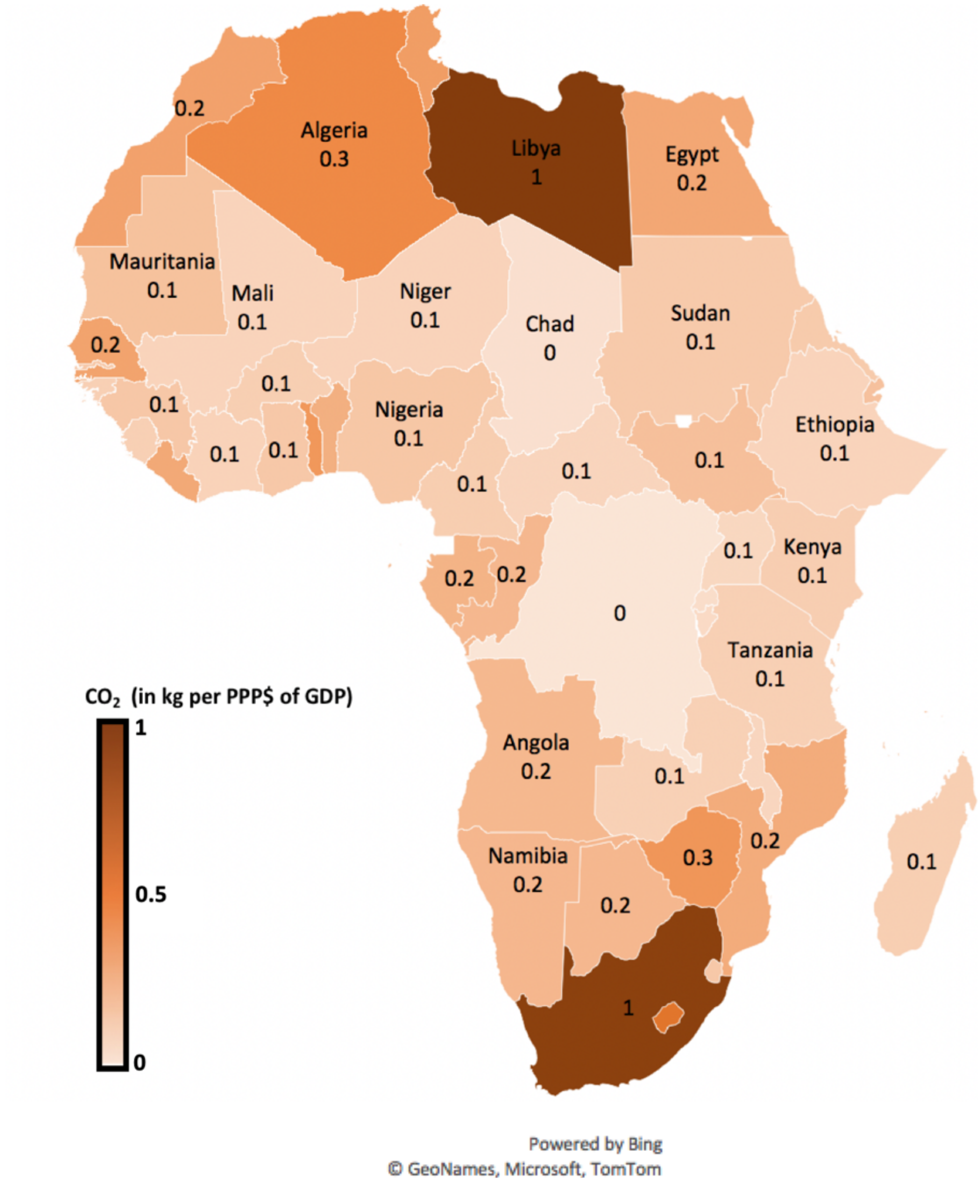


Figure S7. Map of African CO_2 emissions expressed in kg per PPP$ of GDP in 2016 - CDIAC.

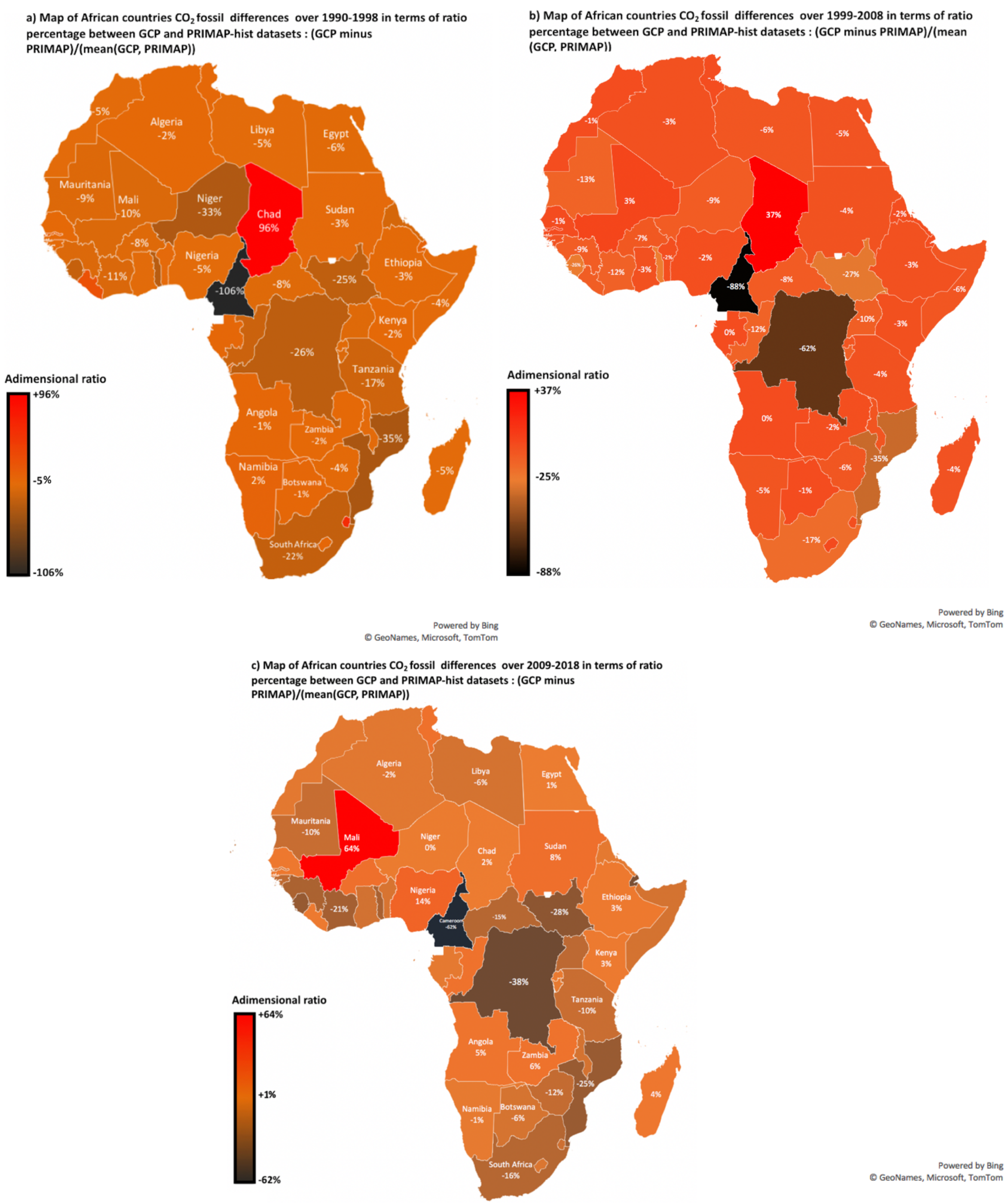


Figure S8. Three maps of African countries fossil CO_2 emissions per decade: ratio percentage showing the discrepancies between GCP and PRIMAP-hist datasets over three decades (1990-2018).

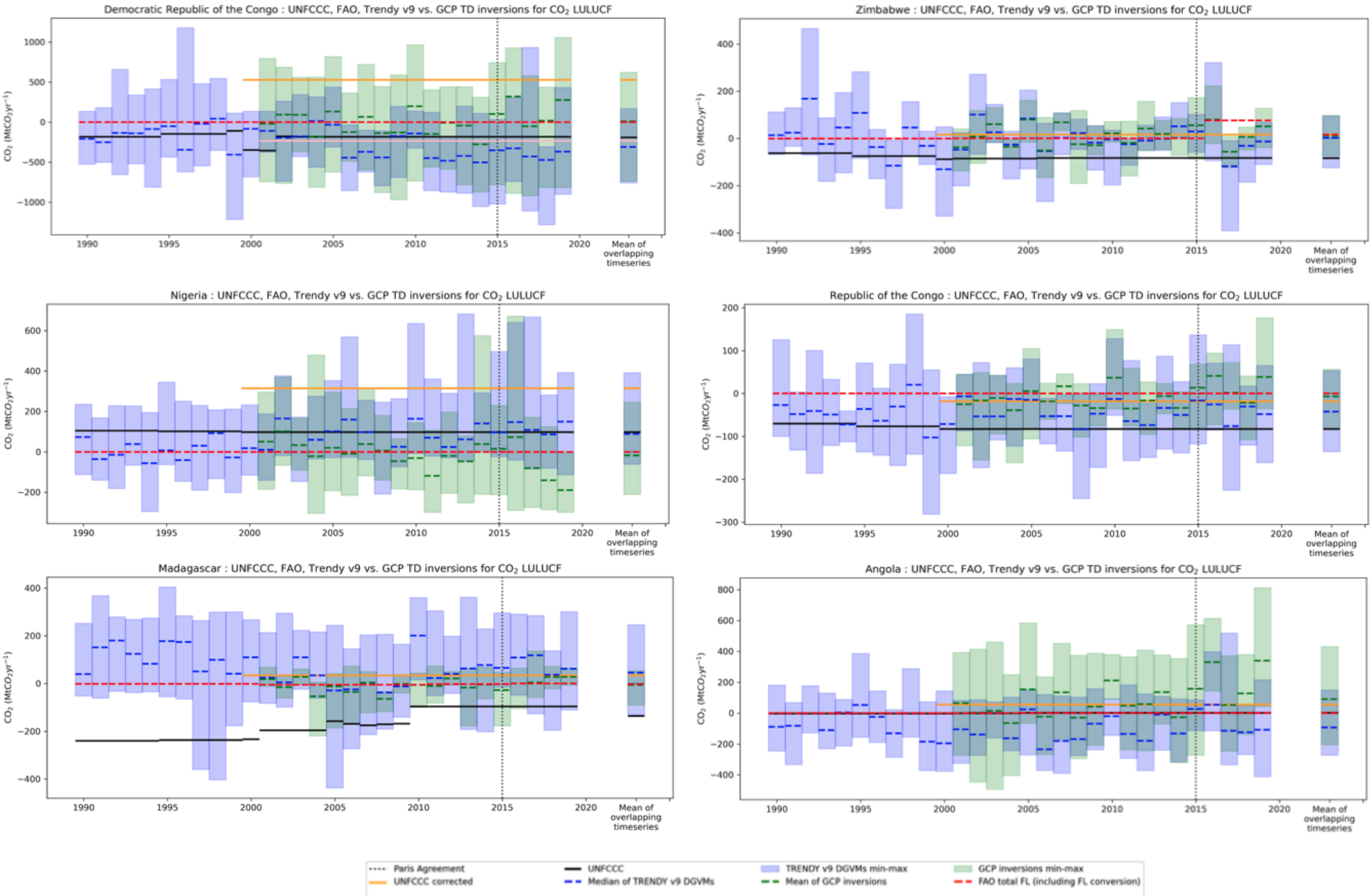
Table S4. List of Least Developed Countries and Small Islands Developing States in Africa.

33 Least Developed Countries (LDCs)	6 Small Islands Developing States (SIDS)
Angola, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, D.R. Congo, Djibouti, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, São Tomé and Príncipe, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Tanzania, Togo, Uganda, Zambia.	Cape Verde, Comores, Guinea-Bissau, Mauritius, Sao Tomé and Principe, Seychelles.

Table S5. List of corrected countries for CO_2 LULUCF (in $MtCO_2$) - corrections in line with Grassi (2022)

Country	Year of most recent outlier report	Outlier value and source	Year corrected data	Corrected data and source	Mean corrected value over 2000-2020	Mean difference over 2000-2020	Comments on the chosen correcting method.
CAF	2010	-1766 (NC2)	2016	-229 (NDC)	-229	1537	NDC 2016 because more recent than NC2 (2015), and sink in most recent NDC 2021 biophysically impossible.
Guinea-Bissau	2001	-11288 (NC1)	2010	-1 (NC2)	-1	-11287	NC1 value reports an unrealistically high sink.
Tanzania	1994	810 (NC2)	2022	77 (NDC 2022[1])	77	566	NDC is more recent and underlines a more realistic order of magnitude.
Guinea	2000	-444 (NC2)	2021	34 (NDC 2021)	34	478	NDC 2021 chosen because more recent than NC2 (2018), and the sink in NC2 is biophysically impossible (-444 $MtCO_2.yr^{-1}$ over only 5 Mha of forest). However, a remaining problem with the corrected value from nc2 is that no forest sink at all is reported.
Namibia	2000	11 (NC3)	2019	-117 (NIR 2019[2])	-106	-117	NIR 2019 chosen because more recent than NC3 (2015) and more complete than NDC 2021 which is more recent.
Mali	2010	-245 (NC3)	Mean 2000 and 2010	-221 (mean of NC2 and NC3)	-155	66	Mean of NC2 and NC3 as more complete than REDD+. The sink in NC3 is high and here considered implausible, but it is however consistently reported in various official UNFCCC documents.
Democratic Republic of the Congo	2015	-235 (NC3)	2021	529 (NDC 2021)	529	761	NDC 2021 chosen because more recent than the NC3 (2015) and broadly consistent with REDD+ (2018). But a weakness of this correction source is that it does not report any carbon sink from forest.
Madagascar	2010	-97 (NC3)	2017	34 (REDD+ 2018)	34	131	REDD+ (2018) chosen because more recent than NC3 (2017), but it covers only deforestation. NC3 reports a biophysically impossible sink over only 9 Mha of forest.
Nigeria	2014	98 (NC2)	2017	315 (BUR2)	287	189	BUR2 (2021) chosen because more recent than NC2 (2014) and more detailed than NDC 2021 which report different numbers.
Zimbabwe	2006	-83 NC3 (2017)	2021	16 (BUR1)	11	95	BUR1 (2021) as more recent than the NC3 (2017) and more complete than NDC 2021.
Congo	Since 2000	-83 (NC2)	2009	-18 (NC2)	-18	65	NDC2021 chosen because more recent than the NC2 (2009).
Angola	2012	0.7 (NC1)	2021	55 (NC2)	55	54	NC2 (2021) chosen because more recent that NC1 (2012).
Mauritius	2013	-490 (NC3)	2016	0 (NIR 2021)	0	490	NIR 2021 more recent than NC3 (with unrealistically high value).

[1]Using Tanzania GHGs Inventory Report and MRV System (2018).
[2]NIR = National Inventory Report (NIR).


Democratic Republic of the Congo : UNFCCC, FAO, Trendy v9 vs. GCP TD inversions for CO_2 LULUCF
Zimbabwe : UNFCCC, FAO, Trendy v9 vs. GCP TD inversions for CO_2 LULUCF
Nigeria : UNFCCC, FAO, Trendy v9 vs. GCP TD inversions for CO_2 LULUCF
Republic of the Congo : UNFCCC, FAO, Trendy v9 vs. GCP TD inversions for CO_2 LULUCF
Madagascar : UNFCCC, FAO, Trendy v9 vs. GCP TD inversions for CO_2 LULUCF
Angola : UNFCCC, FAO, Trendy v9 vs. GCP TD inversions for CO_2 LULUCF
CO_2 ($MtCO_2 yr^{-1}$)
Mean of overlapping timeseries
Paris Agreement
UNFCCC corrected
UNFCCC
Median of TRENDY v9 DGVMs
TRENDY v9 DGVMs min-max
Mean of GCP inversions
GCP inversions min-max
FAO total FL (including FL conversion)

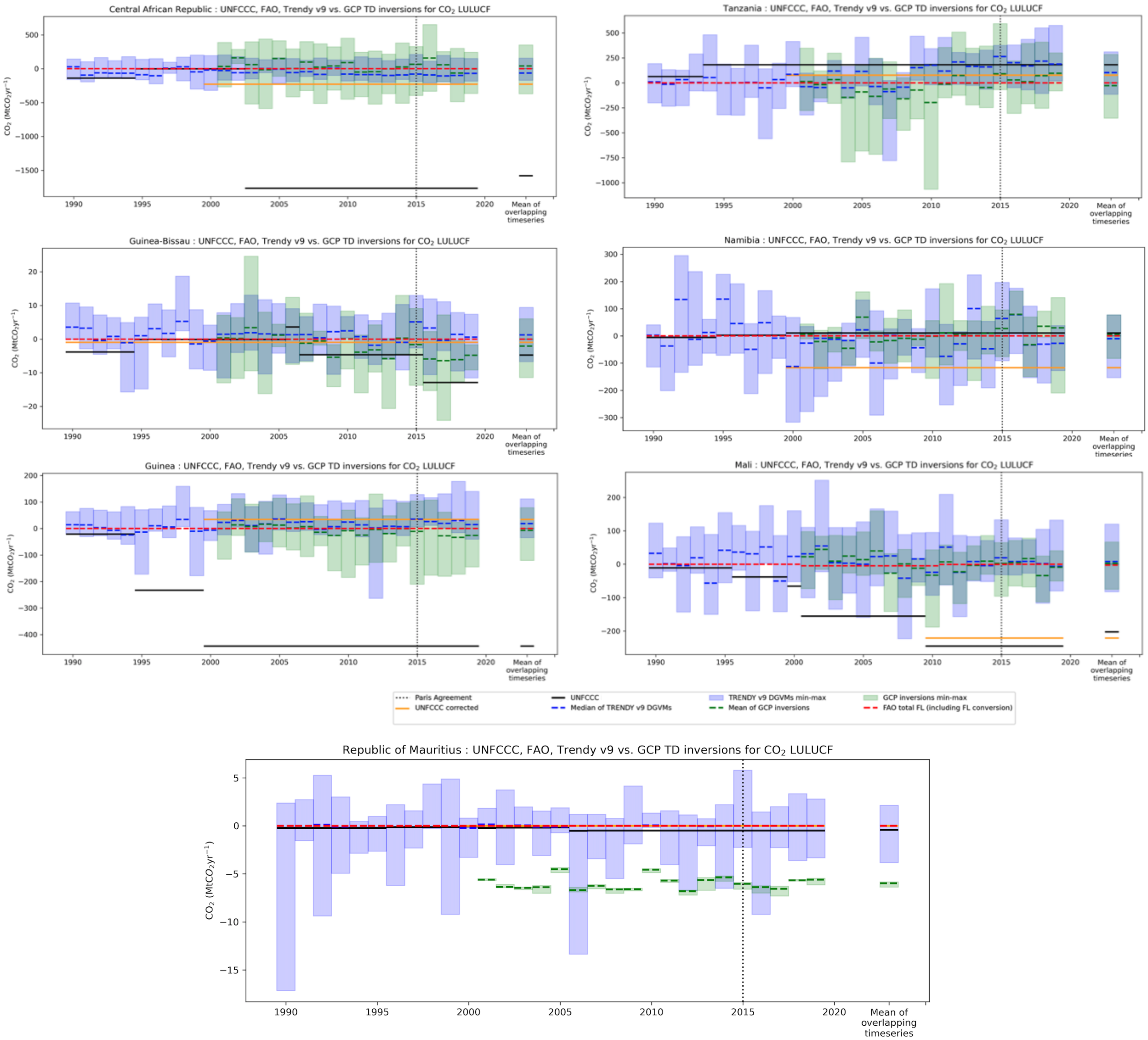


Figure S9. Country details for LULUCF CO_2 emissions and sinks from UNFCCC corrected (strictly consistent with Grassi et al. 2022) for 13 African countries that we identified as outliers vs. UNFCCC uncorrected data, TRENDY v9, DGVMs and GCP (2020) inversions. Unit is in $MtCO_2$. Black lines denote the PRIMAP-hist estimates for total anthropogenic emissions including all IPCC sectors. Shaded green areas represent the minimum and maximum ranges from GCP inversions. Shaded blue areas represent the minimum and maximum ranges for TRENDY v9 DGVMs. Green dashes denote the median of GCP inversions, blue dashes denote the median of TRENDY v9 DGVMs, green dashes the median of GCP inversions. The positive values represent a source while the negative values refer to a sink.

Table S6. Data sources for the land CO_2 emissions in this analysis.

Method	Product type / file name	Species	Overall period covered	References
BU	TRENDY v9 (2019) 14 DGVMs : CABLE, CLASS, CLM5, DLEM, ISAM, JSBACH, JULES, LPJ, LPX, OCN, ORCHIDEE-CNP, ORCHIDEE, SDGVM, SURFEX	Land-related Carbon emissions (Net Biome Productivity)	1900-2019	Met Office UK/ Le Quéré et al. (2018) www.icos-cp.eu/GCP
BU	UNFCCC	LULUCF Net CO_2 emissions / removals	1990-2015	UNFCCC https://unfccc.int/non-annex-I-NCs
TD	GCB 2019	Total CO_2 inverse flux (Net Biome Productivity)	2000-2018	Friedlingstein et al. (2020)
	Carbon Tracker Europe (CTE)		2000-2018	van der Laan-Luijke et al. (2017)
	CAMS (in-situ)		2000-2018	Chevallier et al. (2005) Rödenbeck (2005)
	Jena CarboScopeReg (in situ)		2006-2010	Kountouris et al. (2018)

Table S7. Data sources for total CH_4 emissions in this analysis.

Method/observations	Product type / number of inversions	Overall period covered	References
TD (surface stations)	Carbon Tracker-Europe CH_4 CTE_SURF (FMI)/ 1	2000-2017	Tsuruta et al. (2017)
TD (GOSAT NIES L2 v2.72)	Carbon Tracker-Europe CH_4 CTE_GOSAT (FMI)/ 1	2000-2017	Tsuruta et al. (2017)
TD (surface stations)	GELCA_SURF (NIES)/ 1	2000-2015	Ishizawa et al. (2016)
TD (surface stations)	LMDZ_PYVAR (LSCE)/ 2	2010-2016	Yin et al. (2020)
TD (GOSAT 7.2 Leicester v2)	LMDZ_PYVAR (LSCE)/ 4	2010-2016	Yin et al. (2020)
TD (GOSAT 7.2 Leicester v2)	LMDZ_PYVAR (LSCE)/ 2	2010-2017	Zheng et al. (2018)
TD (surface stations)	MIROC4- ACTM (JAMSTEC)/ 1	2010-2016	Patra et al. (2016)
TD (surface stations)	NICAM-TM (NIES)/ 1	2000-2017	Niwal et al. (2017)
TD (surface stations)	NIES-TM-FLEXPART-VAR (NETFVAR), (NIES)/ 1	2010-2017	Maksyutov et al. (2020); Wang et al. (2019)
TD (GOSAT NIES L2 v2.72)	NIES-TM-FLEXPART-VAR (NETFVAR), (NIES)/ 1	2010-2017	Maksyutov et al. (2020); Wang et al. (2019)
TD (surface stations)	TM5-CAMS (TNO)/1	2000-2017	Segers and Houweling (2018). Bergamaschi et al. (2013, 2018)
TD (GOSAT/CCI v2.3.8 and surface observations)	TM5-CAMS (TNO)/1	2010-2017	Segers and Houweling (2018). Bergamaschi et al. (2013, 2018)
TD (surface stations)	TM5-4DVAR (EC_JRC)/2	2000-2017	Bergamaschi et al. (2013, 2018)
TD (GOSAT/CCI v2.3.8 and surface observations)	TM5-4DVAR(EC_JRC)/2	2010-2017	Bergamaschi et al. (2013, 2018)
TD (surface stations)	TOMCAT (University of Leeds)/	2003-2015	McNorton (2018)

Table S8. Data sources for total N_2O inverse flux over Africa (in situ).

Method	Product type / file name	Period covered	References
TD	PyVAR	1998-2017	Thompson et al. (2014), Tian et al. (2020)
TD	TOMCAT- INVICAT	1998-2015	Wilson et al. (2014), Tian et al. (2020)
TD	MIROC4- ACTM (JAMSTEC)	1998-2016	Patra et al. (2018), Tian et al. (2020)

Table S9. Area of managed land reported in NC/BUR/REDD+ versus FAO forest land (2015) and FAO forest land + other woodlands (2015) for Africa.

Country	Forest area in Mha. Data: FAO (2015)	Inventories forest area in Mha. Data: UNFCCC/REDD+	Forest land area + other woodland area in Mha. Data : FAO (2015)
Mauritius	0.04	0.00	0.05
Rwanda	0.27	0.00	0.53
Cape Verde	0.04	0.04	0.08
Burundi	0.28	0.71	0.28
Togo	1.22	1.00	3.33
Eritrea	1.07	1.59	7.03
Algeria	1.96	2.14	4.53
Guinea-Bissau	2.02	2.46	2.19
Eq. Guinea	2.49	2.50	2.49
Mauritania	0.34	3.00	2.74
Côte d'Ivoire	3.40	3.40	5.96
Benin	3.39	3.59	5.34
Liberia	7.77	4.52	8.07
Guinea	6.39	4.60	12.24
Kenya	3.52	4.75	35.14
Botswana	15.85	5.83	42.34
Morocco	5.68	6.00	6.97
Namibia	6.99	7.00	61.07
Niger	1.14	8.00	4.28
Ghana	7.88	8.97	7.88
Madagascar	12.50	9.00	26.96
Malawi	2.45	9.00	2.45
Nigeria	22.44	14.00	22.44
Senegal	8.27	14.00	13.42
Zimbabwe	17.67	16.00	25.13
Ethiopia	17.43	17.43	39.83
Gabon	23.59	18.27	23.59
Cameroon	20.62	20.00	33.34
South Africa	17.23	23.00	66.91
Congo	22.02	23.52	26.39
Burkina Faso	6.47	27.30	16.45
Mozambique	37.94	34.00	52.36
Tanzania	48.09	48.00	63.38
Zambia	45.76	48.00	58.97
Angola	69.38	53.00	95.31
Sudan	19.21	70.00	39.96
Dem. Rep. Congo	131.66	152.00	143.17

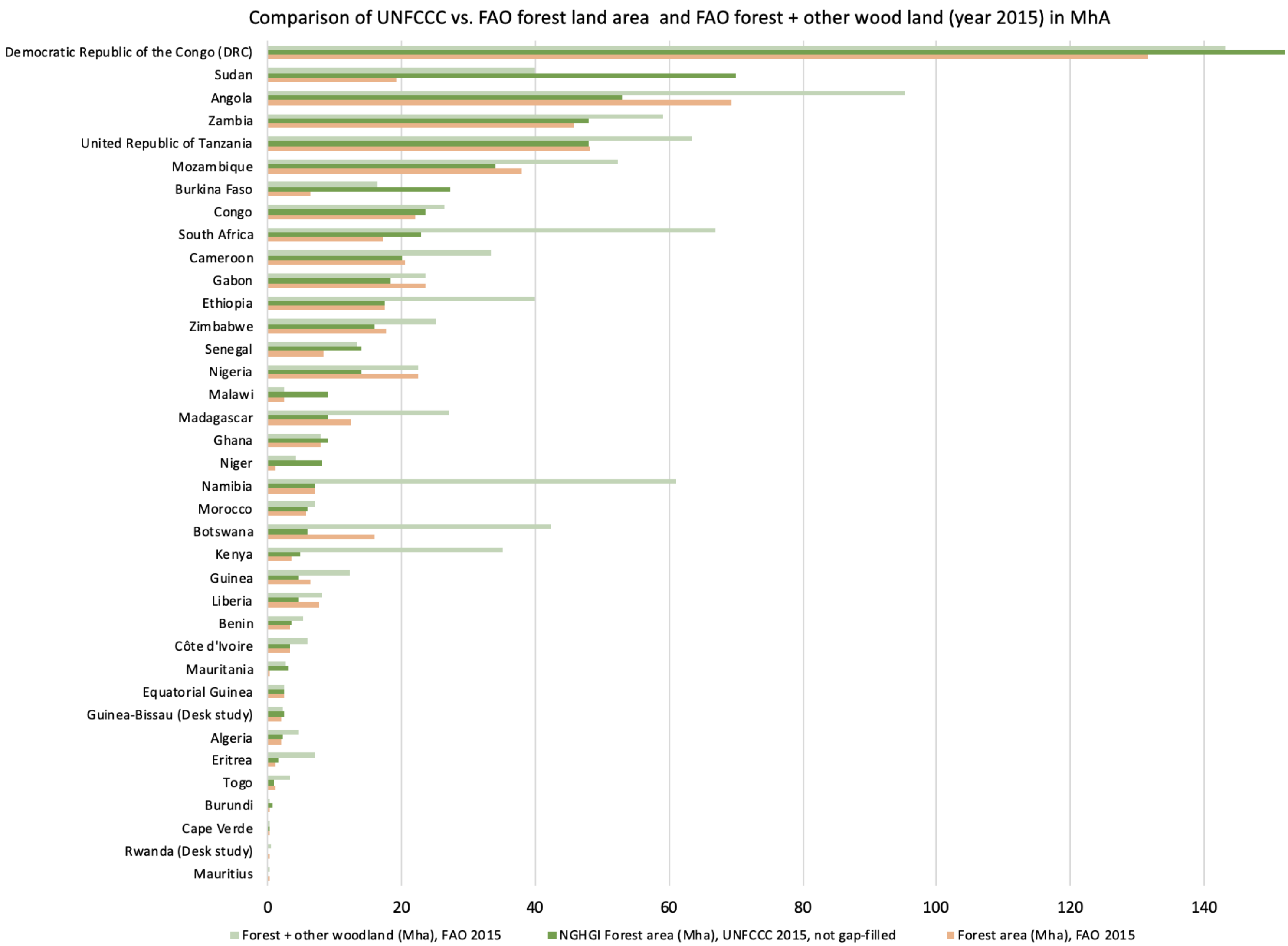


Figure S10. Bar plots comparing areas of managed land reported in Mha for NC/BUR/REDD+ versus FAO forest land (2015) in Mha and FAO forest land + other woodlands areas (2015) for African countries. (Source: Forest Resource Assessment, FAO, 2021). See also Table S7 for detailed values.

Table S10. Synthesis of TD and BU mean CH_4 emissions and removals in $MtCO_2e.yr^{-1}$ for the overlapping time series (2010-2017) for whole Africa and for the six groups using Method 1 (Foss+ AGRIW + BBUR - wildfires).

Region	Rank median PRIMAP	Rank median GOSAT	Rank median surface inversions	Rank wetlands median GMB	Rank wildfires	Rank wetlands median GMB
North Africa	**1**	**1**	**1**	**5**	3	**5**
Subsahelian West Africa	**2**	3	**2**	**4**	5	**4**
Horn of Africa	**3**	2	**3**	**3**	4	**3**
Southern Africa	4	**5**	**5**	**2**	1	**2**
Central Africa	5	**4**	**4**	**1**	2	**1**
South Africa Group	**6**	**6**	**6**	**6**	**6**	**6**

Table S11. Anomalies in ranking for TD and BU mean values on the overlapping time periods (2010-2017) for whole Africa, and for six African groups using Method 1 for anthropogenic CH_4 (FOSS + AGRIW + BBUR - wildfires) in $MtCO_2e.yr^{-1}$.

Region	PRIMAP	Median GOSAT inv.	Max GOSAT inv.	Min GOSAT inv.	Median surface inv.	Max surface inv.	Min surface inv.	Max wetlands GCB	Median wetlands GCB	Min wetlands GCB	Wildfires
Africa Total	1231	1117	1390	903	1094	1330	853	946	827	481	110
North Africa	293	270	330	174	302	396	245	146	69	34	11
Subsahelian West Africa	272	186	329	174	249	396	245	161	77	48	8
Horn of Africa	252	242	551	206	237	302	183	171	86	47	9
Southern Africa	212	114	173	99	114	146	91	214	102	65	41
Central Africa	123	130	170	106	123	142	88	615	428	195	40
South Africa Group	78	91	168	75	88	124	65	21	13	2	1

Table S12. Synthesis of wetlands (GCB) mean CH_4 emissions and removals in $MtCO_2e.yr^{-1}$ for the overlapping time series (2010-2017) for the whole Africa and six African groups.

Region	Max wetlands GCB	Median wetlands GCB	Min wetlands GCB
Africa	946	827	481
North Africa	146	69	34
Subsahelian West Africa	161	77	48
Horn of Africa	171	86	47
Southern Africa	214	102	65
Central Africa	615	428	195
South Africa group	21	13	2

Table S13. Comparison between N_2O PRIMAP-hist mean values and the median of inversions on the overlapping period (2010-2017) for Africa and the six African groups in $MtCO_2e.yr^{-1}$.

Region	PRIMAP-hist	Median global inversions
Africa total	360	1647 (1502 to 1760)
North Africa	106	330 (274 to 419)
Subsahelian West Africa	68	271 (68 to 330)
Horn of Africa	46	240 (217 to 265)
Southern Africa	62	263 (214 to 310)
Central Africa	182	461 (424 to 517)
South Africa group	24	68 (51 to 81)

Table S14. Synthesis for the three main GHGs net African budget: comparative net emissions and removals computation by TD methods for Africa as a whole and for six sub-groups of African countries over the overlapping period (2001-2017), in $MtCO_2e$. Use of Method 1 for CH_4 (FOS+AGRIW+BBUR-wildfires) excluding UNFCCC outliers, and including the range for GCP CO_2 LULUCF.

Region	TD Method 1 and GCP for FCO_2				TD Method 1 and PRIMAP for FCO_2			
	CH_4 median GOSAT inversions + median N_2O inversions	**CH_4 median SURF inversions + median N_2O inversions**	**CH_4 median SURF inversions + PRIMAP N_2O**	**CH_4 median GOSAT inversions + PRIMAP N_2O**	**CH_4 median GOSAT inversions + median N_2O inversions**	**CH_4 median SURF inversions + median N_2O inversions**	**CH_4 median SURF inversions + PRIMAP N_2O**	**CH_4 median GOSAT inversions + PRIMAP N_2O**
Africa total	3889_{1296}^{7257}	3866_{1246}^{7197}	2579_{104}^{5797}	2602_{154}^{5857}	3983_{1390}^{7621}	3960_{1340}^{7291}	2673_{198}^{5890}	2696_{248}^{5950}
North Africa	1014_{553}^{1438}	1046_{624}^{1504}	822_{456}^{1190}	790_{385}^{1124}	1022_{591}^{1446}	1054_{632}^{1511}	830_{464}^{1232}	798_{393}^{1132}
Central Africa	758_{-758}^{2064}	751_{-776}^{2036}	344_{-1145}^{1573}	351_{-1128}^{1602}	766_{-750}^{2072}	759_{-768}^{2043}	352_{-1138}^{1582}	359_{-1120}^{1610}
Subsahelian West Africa	546_{-95}^{1282}	609_{-24}^{1349}	406_{-24}^{1086}	343_{95}^{1019}	542_{-98}^{1278}	605_{-27}^{1345}	403_{-27}^{1083}	340_{98}^{1016}
Southern Africa	616_{-175}^{1726}	616_{-186}^{1699}	415_{-338}^{1451}	415_{-331}^{1478}	618_{-340}^{1728}	618_{-348}^{1701}	416_{-337}^{1452}	416_{-329}^{1479}
South Africa group	458_{103}^{710}	455_{93}^{747}	411_{116}^{689}	414_{126}^{734}	537_{184}^{871}	534_{172}^{927}	490_{196}^{769}	493_{206}^{813}
Horn of Africa	399_{-274}^{1215}	394_{-297}^{966}	201_{-467}^{748}	206_{-444}^{997}	401_{-273}^{1216}	395_{-296}^{967}	202_{-467}^{749}	207_{-444}^{998}

Table S15. Synthesis for the three main GHGs net African budget: comparative net emissions and removals computation by TD methods for Africa as a whole and for six sub-groups of African countries over the overlapping period (2001-2017), in $MtCO_2e$. Use of Method 1 for CH_4 (FOS+AGRIW+BBUR-wildfires) excluding UNFCCC outliers, and excluding the range for GCP CO_2 LULUCF (possible outliers).

Region	TD Method 1 and GCP FCO_2				TD Method 1 and PRIMAP FCO_2			
	CH_4 median GOSAT inversions + median N_2O inversions	CH_4 median SURF inversions + median N_2O inversions	CH_4 median SURF inversions + PRIMAP N_2O	CH_4 median GOSAT inversions + PRIMAP N_2O	CH_4 median GOSAT inversions + median N_2O inversions	CH_4 median SURF inversions + median N_2O inversions	CH_4 median SURF inversions + PRIMAP N_2O	CH_4 median GOSAT inversions + PRIMAP N_2O
Africa total	3889_{3530}^{4276}	3866_{3480}^{4216}	2579_{2338}^{2815}	2602_{2388}^{2875}	3983_{3624}^{4639}	3960_{3574}^{4309}	2673_{2432}^{2909}	2696_{2482}^{2969}
North Africa	1014_{862}^{1164}	$1046_{933.1}^{1230}$	822_{765}^{916}	790_{694}^{850}	1022_{870}^{1171}	1054_{941}^{1237}	830_{773}^{958}	798_{702}^{858}
Central Africa	758_{697}^{853}	751_{679}^{826}	344_{309}^{363}	351_{327}^{391}	766_{705}^{862}	759_{687}^{833}	352_{317}^{371}	359_{335}^{399}
Subsahelian West Africa	546_{331}^{748}	609_{402}^{815}	406_{402}^{553}	343_{331}^{486}	542_{328}^{745}	605_{399}^{812}	403_{399}^{550}	340_{328}^{483}
Southern Africa	616_{552}^{722}	616_{544}^{695}	415_{392}^{447}	415_{400}^{474}	618_{390}^{724}	618_{382}^{697}	416_{393}^{448}	416_{401}^{475}
South Africa group	458_{374}^{467}	455_{364}^{504}	411_{388}^{446}	414_{398}^{491}	537_{453}^{628}	534_{443}^{584}	490_{467}^{526}	493_{477}^{570}
Horn of Africa	399_{340}^{733}	394_{317}^{484}	201_{147}^{266}	206_{179}^{515}	400_{341}^{734}	395_{318}^{485}	202_{148}^{267}	207_{171}^{516}

Table S16. Mean net total Africa and regional groups from mean TD (excluding the range for CO_2 LULUCF due to outliers) and mean best fitted BU Methods excluding outliers. (For TD approaches, N_2O inversions were excluded and replaced by PRIMAP estimates. For DGVMs the range for GCP CO_2 LULUCF was not considered due to probable outliers. UNFCCC outliers are also excluded.) Net emissions and removals are expressed in $MtCO_2e.yr^{-1}$ over the overlapping period (2001-2017).

Region	**Mean of TD methods** excluding N_2O inversions replaced with N_2O PRIMAP and excluding the range for GCP CO_2 LULUCF (with probable outliers)	**Ranking with TD methods**	**Mean net of best fitted BU methods** (excluding uncorrected UNFCCC data)	**Ranking with BU methods**
North Africa	806_{730}^{883} (GCP FCO_2) 814_{737}^{908} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 810_{733}^{895}	1	713_{641}^{807} (GCP FCO_2) 720_{649}^{816} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 717_{645}^{812}	1
South Africa group	412_{393}^{468} (GCP FCO_2) 491_{472}^{547} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 452_{432}^{508}	2	534_{443}^{613} (GCP FCO_2) 613_{522}^{692} PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 574_{483}^{653}	3
Horn of Africa	203_{158}^{390} (GCP FCO_2) 204_{159}^{391}(PRIMAP FCO_2) Mean GCP &PRIMAP (FCO_2): 204_{159}^{391}	6	432_{296}^{524}(GCP FCO_2) 433_{297}^{525}(PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 433_{297}^{525}	4
Subsahelian West Africa	375_{367}^{520}(GCP FCO_2) 371_{363}^{516} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 373_{365}^{518}	4	612_{539}^{776} (GCP FCO_2) 609_{535}^{772} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 610_{537}^{774}	2
Southern Africa	415_{396}^{460}(GCP FCO_2) 416_{397}^{462} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 416_{397}^{461}	3	228_{178}^{529}(GCP FCO_2) 355_{179}^{531}(PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 292_{178}^{530}	5
Central Africa	348_{318}^{377}(GCP FCO_2) 356_{326}^{385} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 352_{322}^{381}	5	-70_{-210}^{168}(GCP FCO_2) -62_{-202}^{176}(PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): -66_{-206}^{172}	6
Africa total	2591_{2363}^{2845}(GCP FCO_2) 2684_{2457}^{2939} (PRIMAP FCO_2) Mean GCP &PRIMAP (FCO_2): 2638_{2410}^{2892}		2576_{2140}^{3228} (GCP FCO_2) 2669_{2233}^{3251} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 2623_{2186}^{3240}	

Table S17. Mean net total Africa and regional groups from best fitted mean TD and mean BU Methods excluding outliers. For TD approaches, N_2O inversions were excluded and replaced by PRIMAP estimates. For DGVMs, the range for GCP CO_2 LULUCF was considered. UNFCCC outliers are also excluded. Net emissions and removals are expressed in $MtCO_2.yr^{-1}$ over the overlapping period (2001-2017).

Region	**Mean net of TD methods** (including range for CO_2 LULUCF from GCP inversions with outliers but excluding N_2O inversions (N_2O PRIMAP)	Ranking with TD methods	**Mean net of best fitted BU methods** (excluding uncorrected UNFCCC data)	Ranking with BU methods
North Africa	806_{129}^{1157}(GCP FCO_2) 814_{428}^{1182} (PRIMAP FCO_2) Mean GCP & PRIMAP: 810_{279}^{1170}	1	713_{641}^{807} (GCP FCO_2) 720_{649}^{816} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 717_{645}^{812}	1
South Africa group	412_{121}^{712} (GCP FCO_2) 491_{201}^{791} (PRIMAP FCO_2) Mean GCP & PRIMAP: 452_{161}^{751}	2	534_{443}^{613} (GCP FCO_2) 613_{522}^{692} PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 574_{483}^{653}	3
Horn of Africa	203_{-456}^{872} (GCP FCO_2) 204_{-455}^{873} (PRIMAP FCO_2) Mean GCP & PRIMAP: 204_{-456}^{873}	6	432_{296}^{524}(GCP FCO_2) 433_{297}^{525}(PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 433_{296}^{525}	4
Subsahelian West Africa	375_{36}^{1053} (GCP FCO_2) 371_{36}^{1050} (PRIMAP FCO_2) Mean GCP & PRIMAP: 373_{356}^{1051}	4	612_{539}^{776} (GCP FCO_2) 609_{535}^{772} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 610_{537}^{774}	2
Southern Africa	415_{-335}^{1464}(GCP FCO_2) 416_{-333}^{1466} (PRIMAP FCO_2) Mean GCP &PRIMAP: 416_{-334}^{1465}	3	228_{178}^{529}(GCP FCO_2) 355_{179}^{531}(PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 292_{178}^{530}	5
Central Africa	348_{-1137}^{1588}(GCP FCO_2) 356_{-1129}^{1596}(PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 352_{-1133}^{1592}	5	-70_{-210}^{168}(GCP FCO_2) -62_{-202}^{176}(PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): -66_{-206}^{172}	6
Africa total	2583_{2251}^{3037} (GCP FCO_2) 2654_{2322}^{3089} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 2638_{1761}^{5873}		2576_{2140}^{3228} (GCP FCO_2) 2669_{2233}^{3251} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 2623_{2186}^{3240}	

Table S18. Mean net total of best fitted mean TD and mean BU methods excluding N_2O inversions (replaced by PRIMAP estimates), using Method 1 for CH_4 (FOS+AGRIW+BBUR-wildfires) excluding UNFCCC outliers, and including the range for GCP CO_2 LULUCF, for Africa total and for regional groups, with associated ranking.

Region	**Mean of best fitted TD and BU methods using both GCP and PRIMAP FCO_2** (excluding UNFCCC outliers and N_2O inversions, but including range for CO_2 LULUCF from GCP inversions)	Ranking with TD methods
North Africa	761_{460}^{988}	1
South Africa group	513_{161}^{702}	2
Horn of Africa	318_{-80}^{699}	5
Subsahelian West Africa	492_{286}^{913}	3
Southern Africa	354_{-78}^{998}	4
Central Africa	143_{-670}^{882}	6
Africa total	2630_{1974}^{4557}	

Table S19. Mean net total Africa and regional groups from TD inversions only including N_2O inversions (and the range for CO_2 LULUCF from GCP inversions). For BU methods, UNFCCC outliers are excluded.

Region	**Mean TD from inversions only** (including range for CO_2 LULUCF from GCP inversions and N_2O inversions)	**Ranking with BU methods**
North Africa	1030_{589}^{1471} (GCP FCO_2) 1038_{512}^{1479} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 1034_{600}^{1475}	1
South Africa group	457_{98}^{729} (GCP FCO_2) 536_{178}^{899} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 496_{138}^{814}	5
Horn of Africa	397_{-286}^{1090} (GCP FCO_2) 398_{-285}^{1091} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 397_{-285}^{1091}	6
Subsahelian West Africa	577_{-60}^{1315} (GCP FCO_2) 574_{-63}^{1312} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 576_{-61}^{1313}	4
Southern Africa	616_{-181}^{1713} (GCP FCO_2) 618_{-344}^{1714} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 617_{-262}^{1713}	3
Central Africa	755_{-767}^{2050} (GCP FCO_2) 763_{-759}^{2058} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 759_{-763}^{2054}	2
Africa total	3787_{1274}^{7226} (GCP FCO_2) 3971_{1365}^{7456} (PRIMAP FCO_2) Mean GCP & PRIMAP (FCO_2): 3879_{1320}^{7341}	

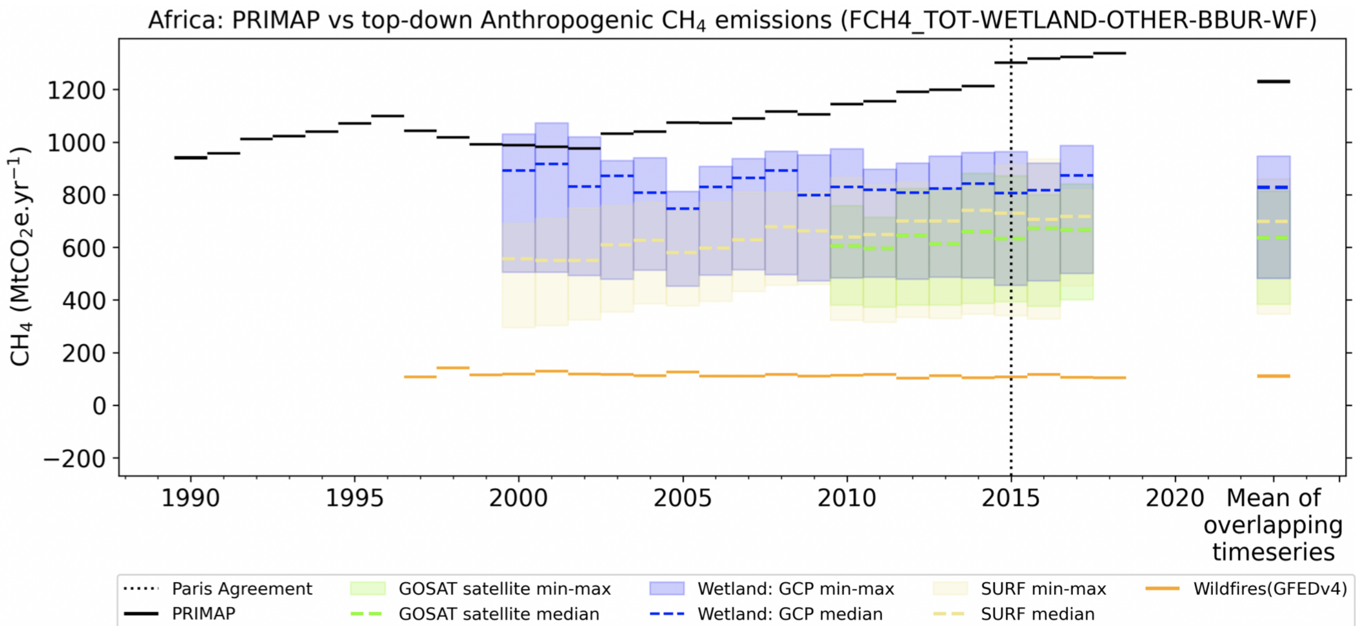


Figure S11. Comparison of the total anthropogenic CH_4 emissions from PRIMAP-hist and 22 top-down global ensembles using Method 2 for total Africa, including wildfire emissions. Anthropogenic CH_4 emissions from TD methods were computed by withdrawing the sum of available data regarding natural emissions from the total flux (wetlands, "other natural" emissions, biomass burning, and wildfires (GFEDv4)). Black lines denote the PRIMAP-hist estimates for total anthropogenic emissions including all IPCC sectors. Shaded green areas represent the minimum and maximum ranges from satellite concentration observations (GOSAT) inversions. Shaded blue areas represent the minimum and maximum ranges for wetlands. Shaded yellow areas represent the minimum and maximum ranges for surface stations (SURF). Green dashes denote the median of 11 global GOSAT satellites, blue dashes denote the median of wetlands, yellow dashes the median of inversions using surface stations (SURF). The orange lines represent wildfire emissions. Following the atmospheric convention, positive numbers represent an emission to the atmosphere.

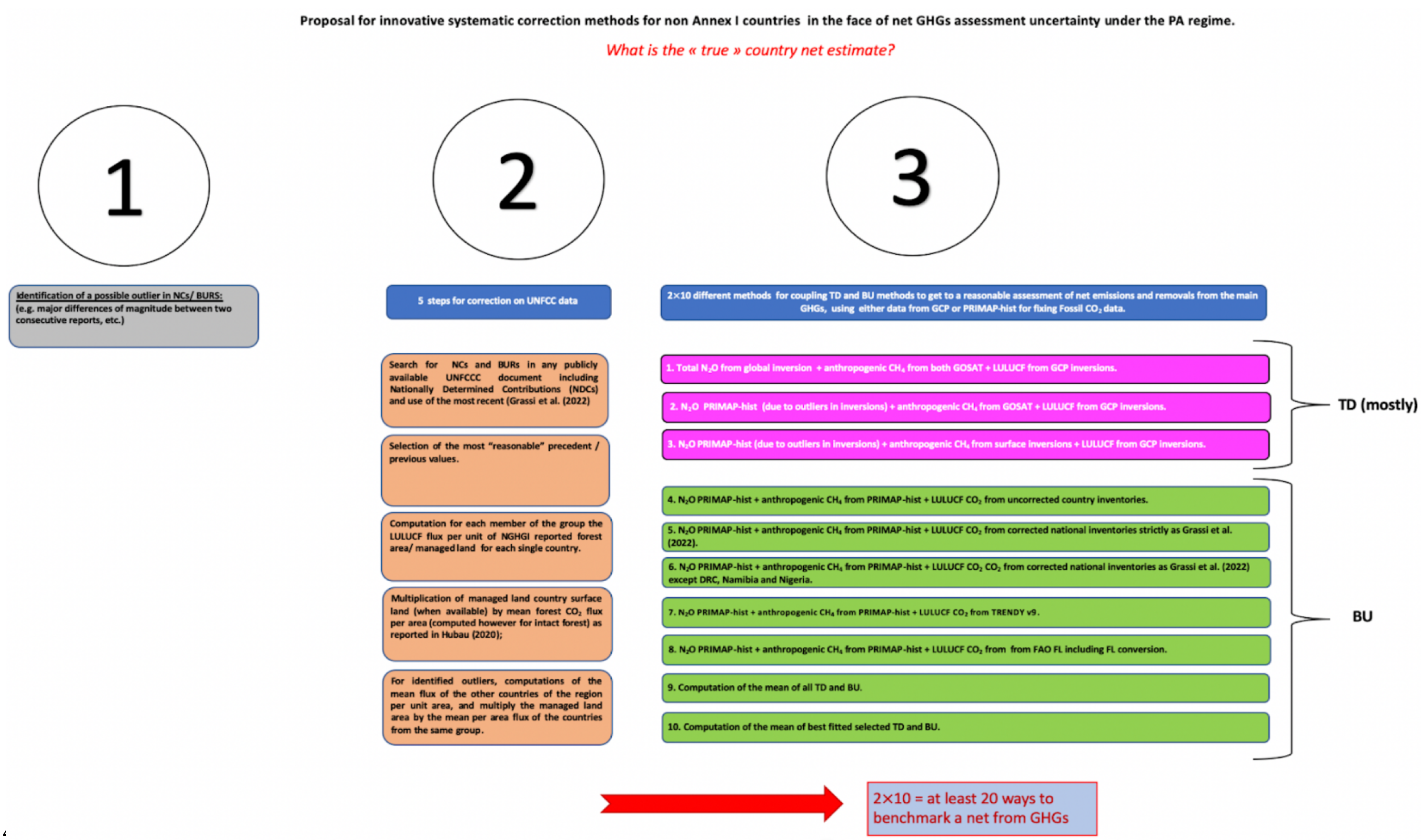


Figure S12. Synthesis of the different methodological steps used in this paper for assessing net African GHG trends.

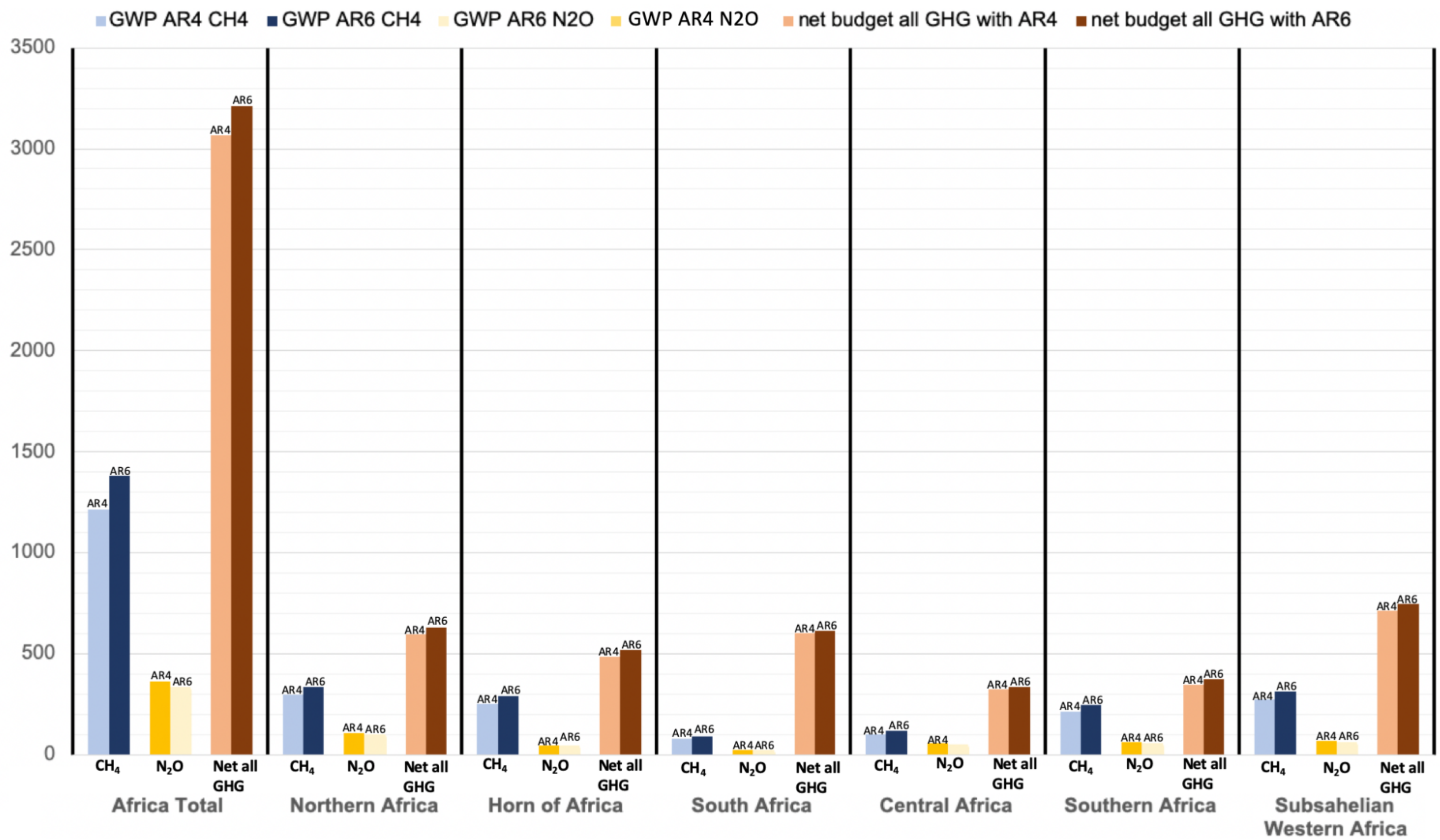


Figure S13. Differences in $MtCO_2e$ in the CH_4 emissions, N_2O emissions and total GHG net budget coming from the use of AR4 and AR6 GWP-100 for CH_4 and N_2O with PRIMAP fossil CO_2 emissions and LULUCF CO_2 for the 6 African regions and Africa total, using PRIMAP-hist for fossil CO_2 and UNFCCC data consistent with Grassi et al. (2022).

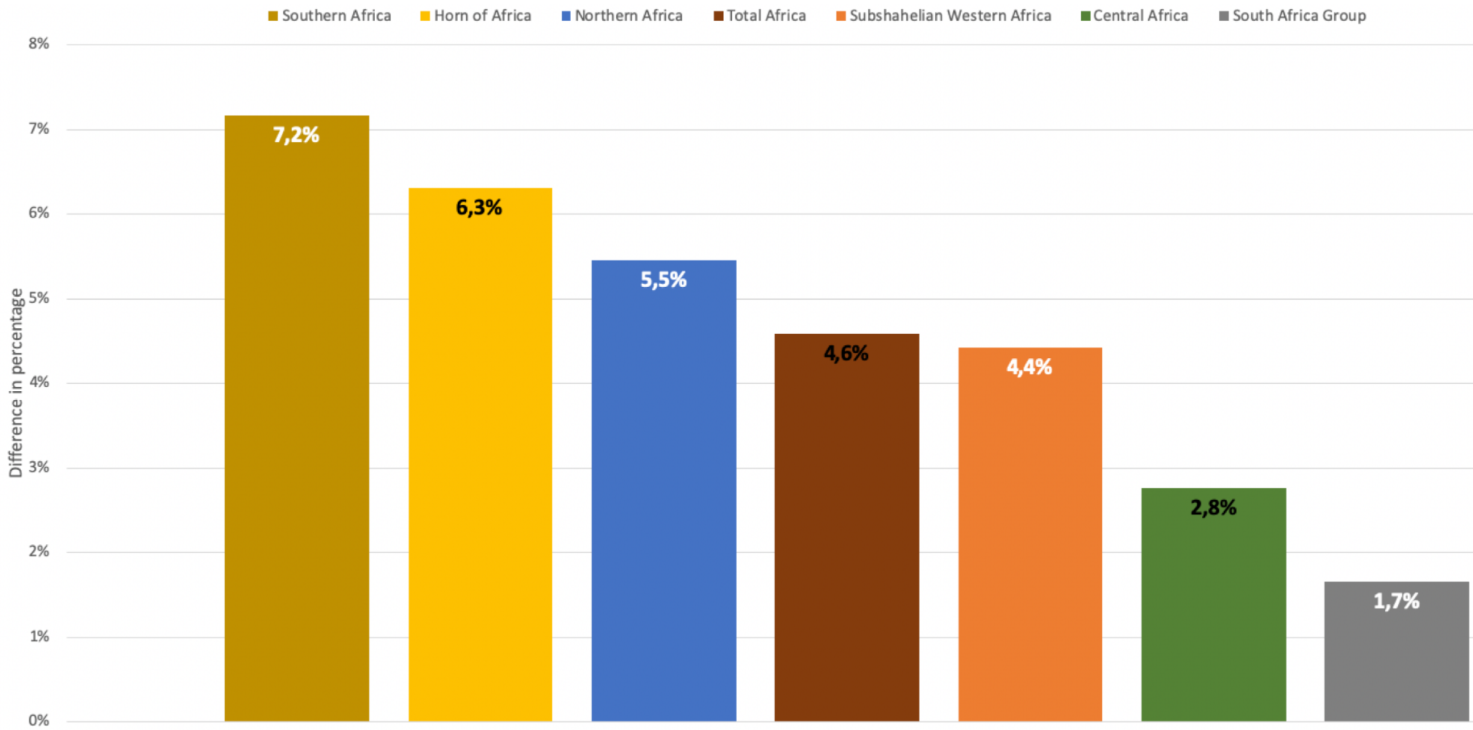


Figure S14. Percentage of difference in the 2001-2018 net budget coming from the difference between the use of AR6 GWP-100 and AR4 GWP-100 for CH_4 and N_2O, with PRIMAP fossil CO_2 emissions and UNFCCC LULUCF CO_2 (Grassi, 2022) for the 6 African regions and Africa total.

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