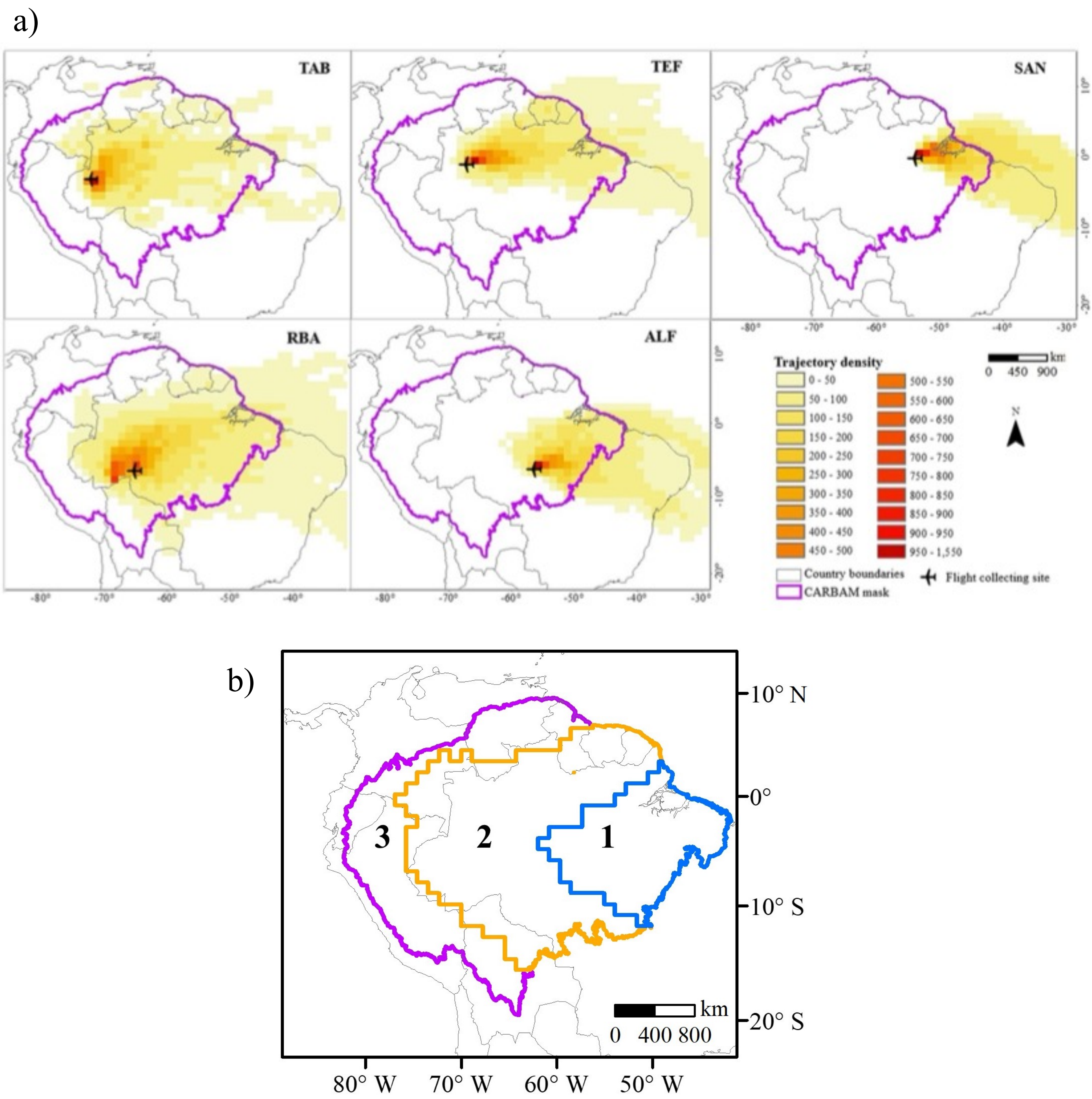
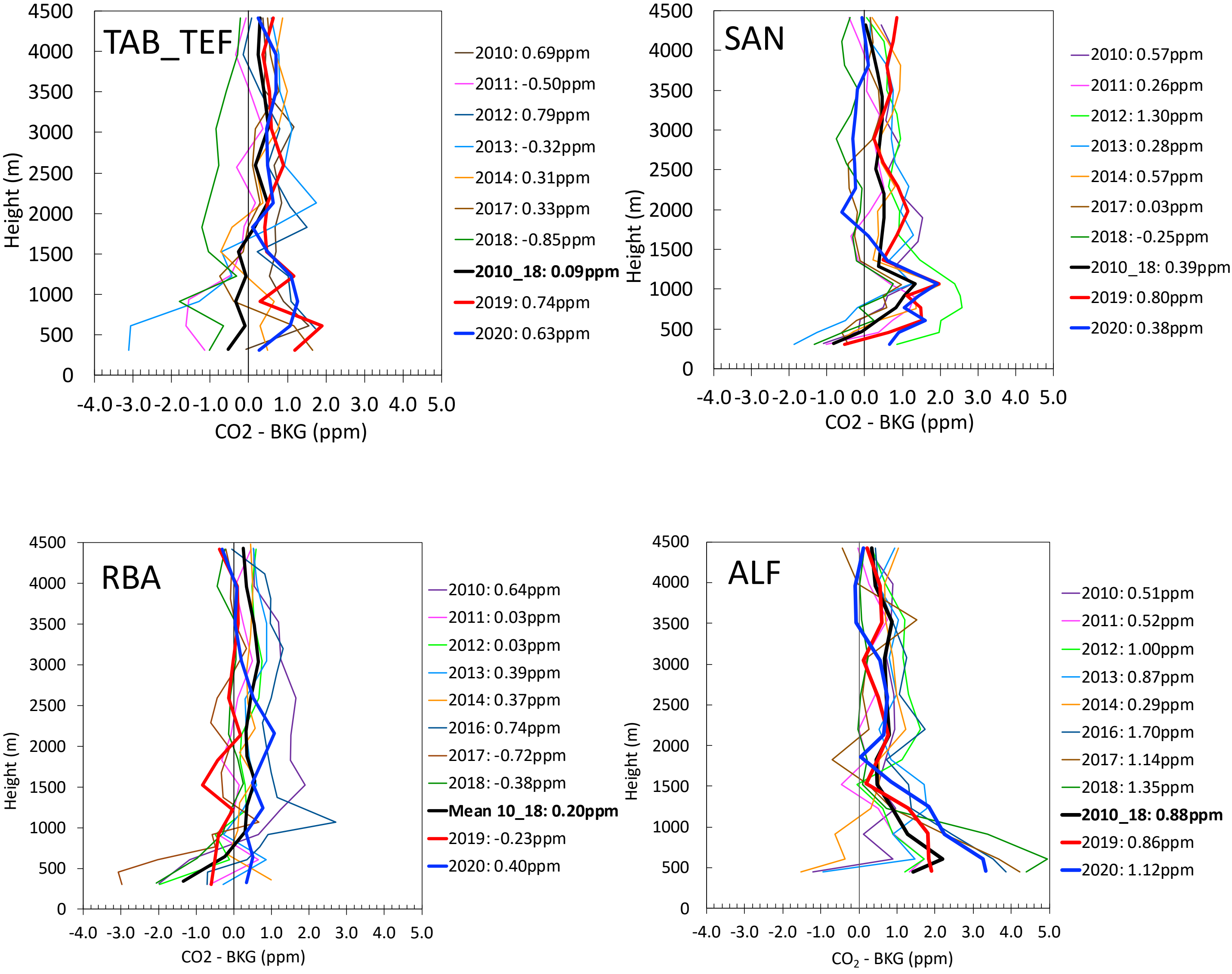
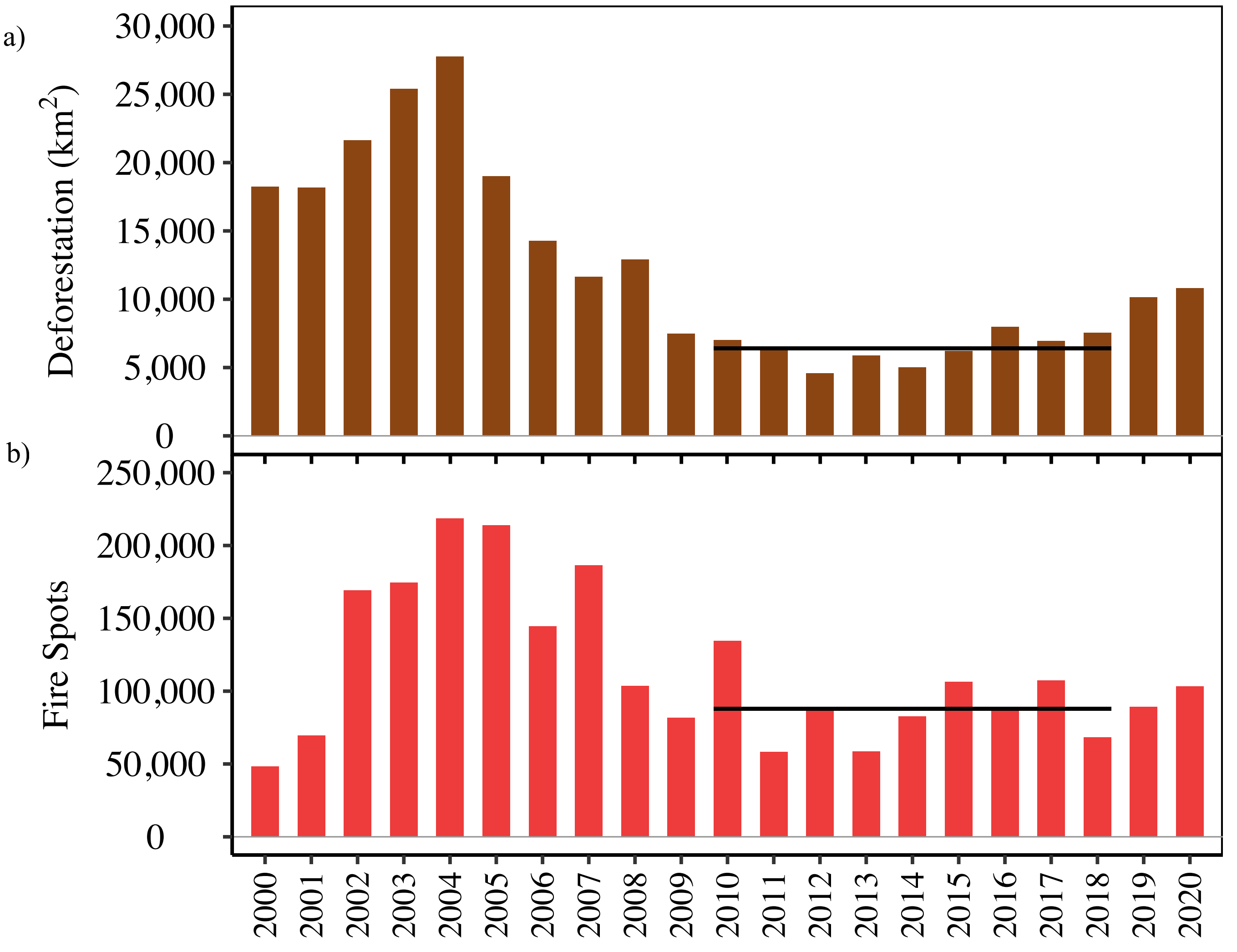


Extended Data Fig. 1 | Regions of Influence. a)Annual mean regions of influence (trajectory densities) averaged between 2010 and 2020, calculated using the density of back-trajectories (see Methods). b) Separation of three different areas inside the Amazon Mask (7,256,362 km^2, purple line) using mean annual influence regions of all years (2010 to 2018). Region 1: Combined ALF and SAN regions of Influence, Region 2: Combined RBA and TAB (2010-12) and TEF (2013-18) to compose regions of Influence 2 and excluding Region 1 for the quantification and composing Amazonia ΔVP; Region 3: the remaining area outside regions 1 and 2 and inside the purple line.



Extended Data Fig. 2 – Annual mean ΔVPs per site. Annual mean ΔVPs for each site ALF, RBA, SAN and TAB_TEF for the time series (2010–2020), constructed from the VP year mean, where the background was subtracted from each height, each flask (see methods). The black thick line represent the 2010-2018 Amazonia mean vertical profiles, the red thick line 2019 mean and blue thick line 2020 mean.

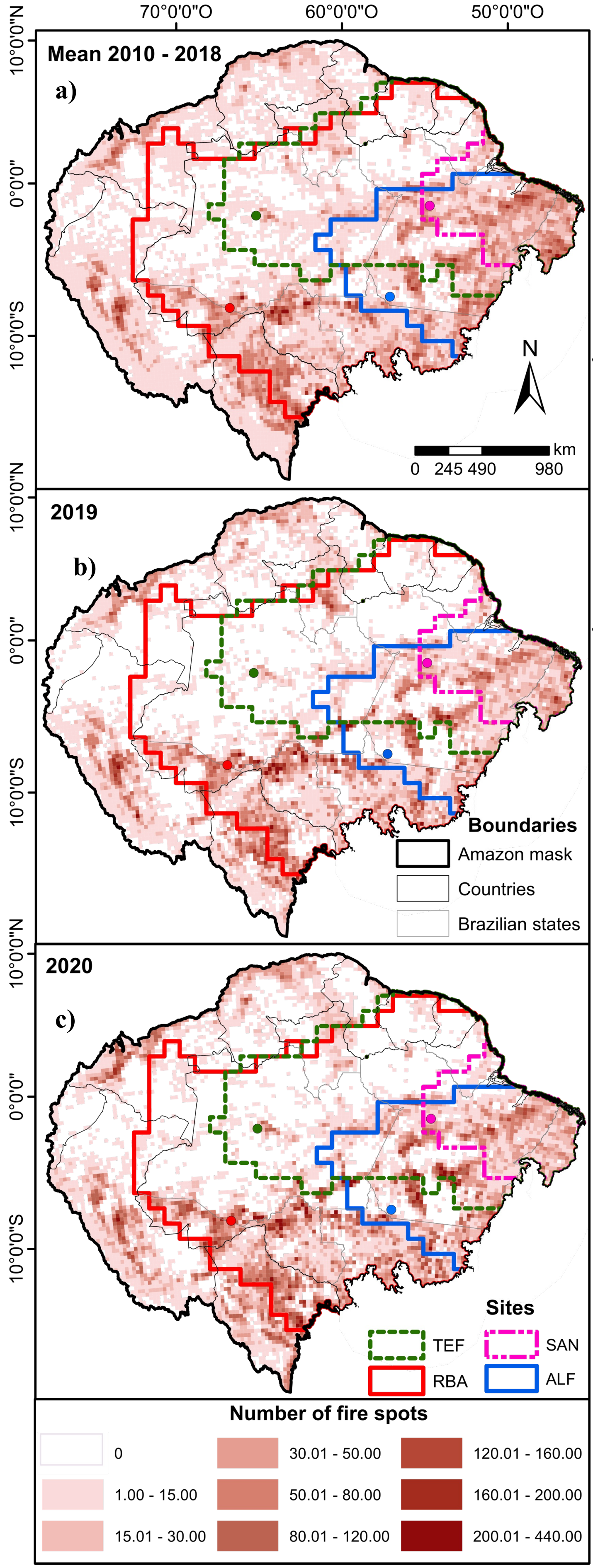


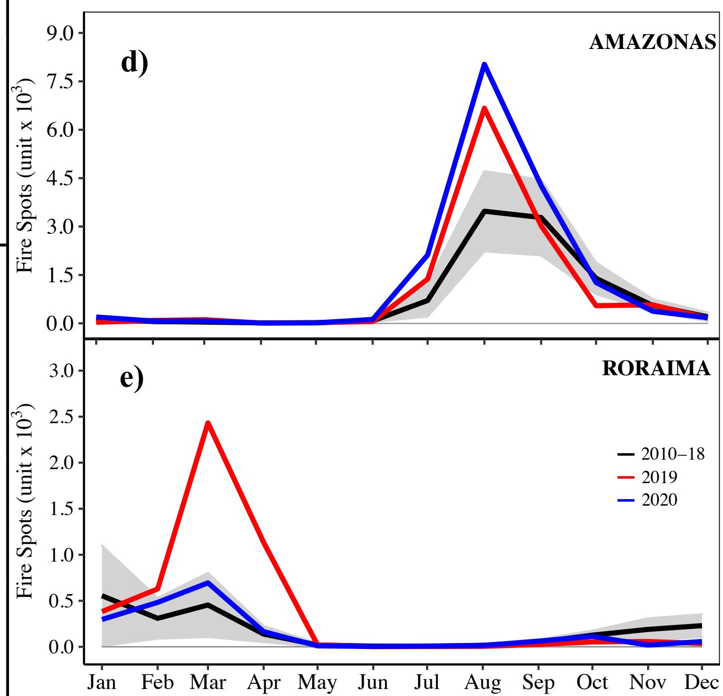
c)

	Deforestation* PRODES (km^2)	burned area (km^2)	Fire spots
2010	6,366.27	580,023	221,587
2011	5,769.02	280,764	102,941
2012	4,495.20	371,955	130,983
2013	5,476.63	230,687	92,923
2014	5,184.18	280,149	117,450
2015	6,210.79	324,819	145,057
2016	7,368.89	319,684	142,177
2017	7,089.57	392,675	148,224
2018	7,182.54	173,029	109,458
2019	10,980.50	375,292	138,365
2020	10,673.07	466,470	164,365

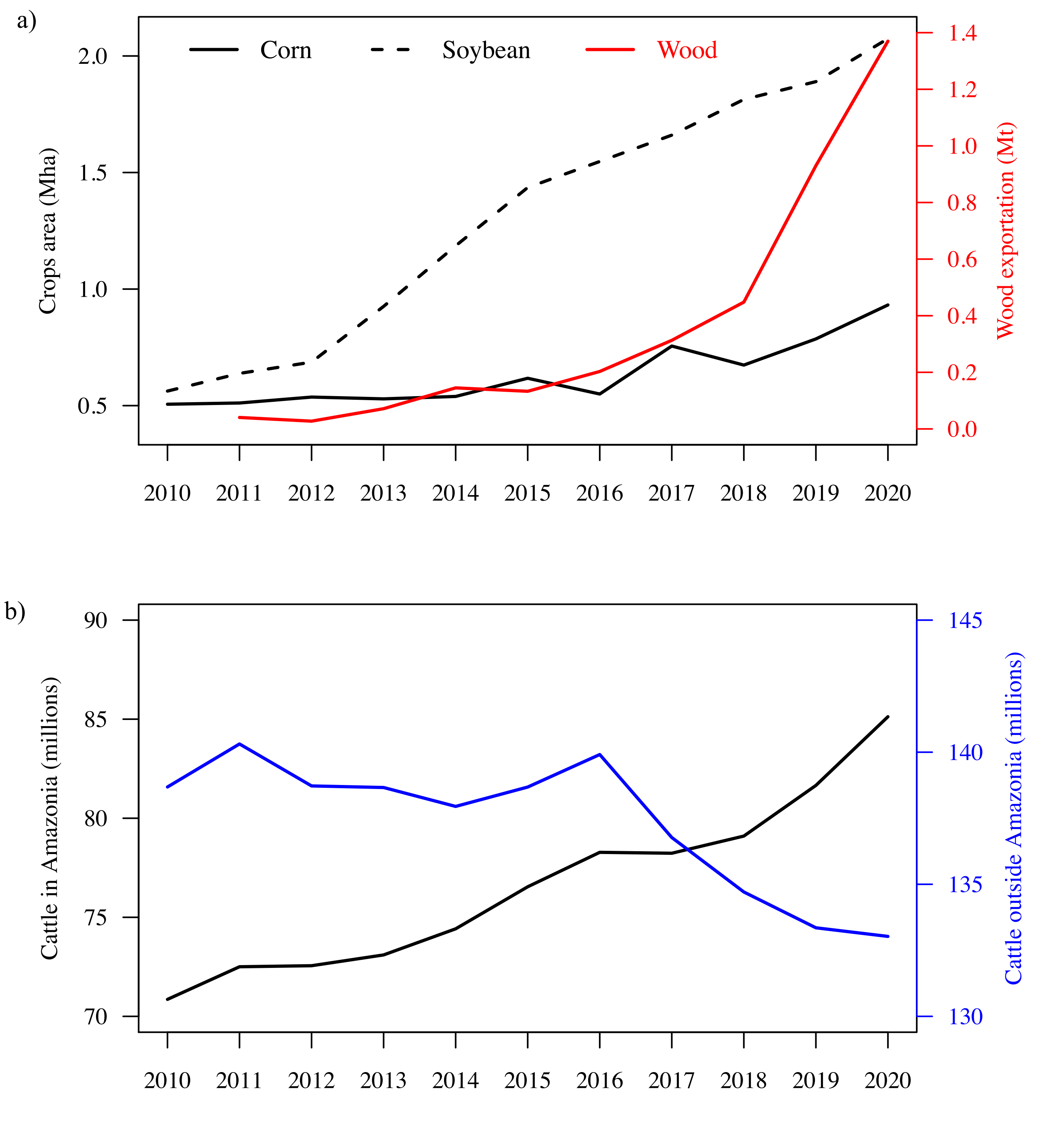
*limited to the Brazilian Amazon

Extended Data Fig. 3 | Amazonia's Deforestation and fire spots time series. a) Deforestation limited to the Brazilian Amazonia classified as Legal Amazon (km^2) by PRODES / INPE[27] since 2000 to 2020, b) Fire spots limited to the Brazilian Amazonia classified as Biome Amazonia by BD Queimadas/ INPE[16] since 2000 to 2020, c) Deforestation calculated for the Amazonia mask used in Fig. 2 and limited to the Brazilian Amazonia from 2010 to 2020, burned area derived from MODIS (collection 6) and Fire spots calculated for the whole Amazonia mask used in Fig. 2 and Extended data Fig 4a, for the whole Amazonia from 2010 to 2020.





Extended Data Fig. 4 | Spatial fire spot distribution. Fire spots in Pan-Amazonia are given in grid cells 0.25˚x0.25˚, were retrieved from INPES´s "Queimadas" wildfire monitoring program[15]. a) . The mean fire spot per grid between 2010-18; b) Absolute deforested area in 2019; c) Absolute deforested area in 2020. d) Fire spot detected at Amazonas state from 2010-20. Black line mean 2010-18, grey band denote the standard deviation of the monthly mean, red line the 2019 monthly mean, blue line the 2020 monthly mean. e) Fire spot detected at Roraima state from 2010-20. Black line mean 2010-18, grey band denote the standard deviation of the monthly mean, red line the 2019 monthly mean, blue line the 2020 monthly mean.

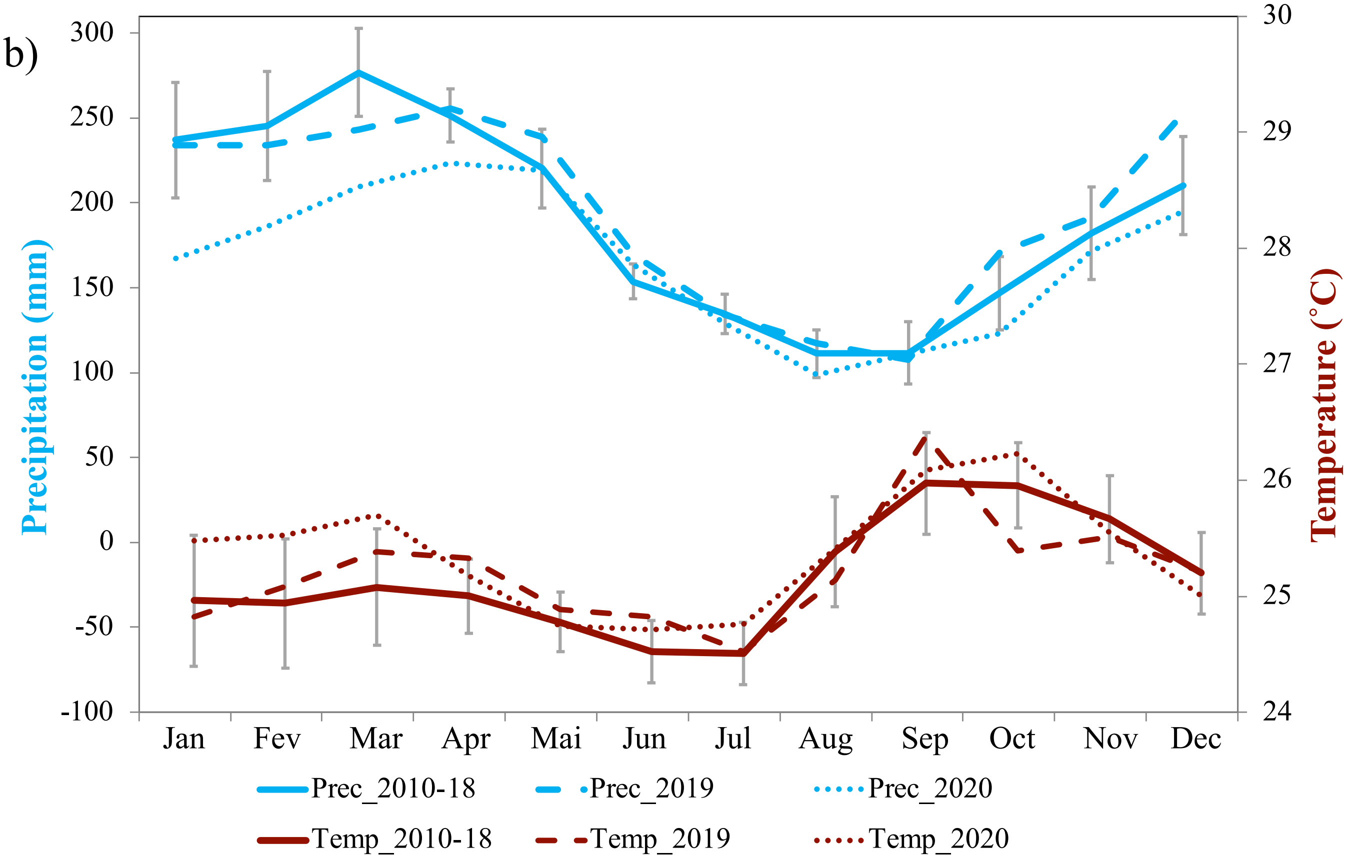


Extended Data Fig. 5 | Amazonia crops area, cattle and wood exportation. Increase replacement of the forest by soybean, corn, beef, wood commerce as a consequence of deforestation. a) Evolution of harvested area of soybean (black line), corn (dashed line)[23], and wood exportation (blue line)[24]. b) Cattle production evolution inside (black line) and outside Amazonia, i.e. in others Brazilian states (blue line)[25].

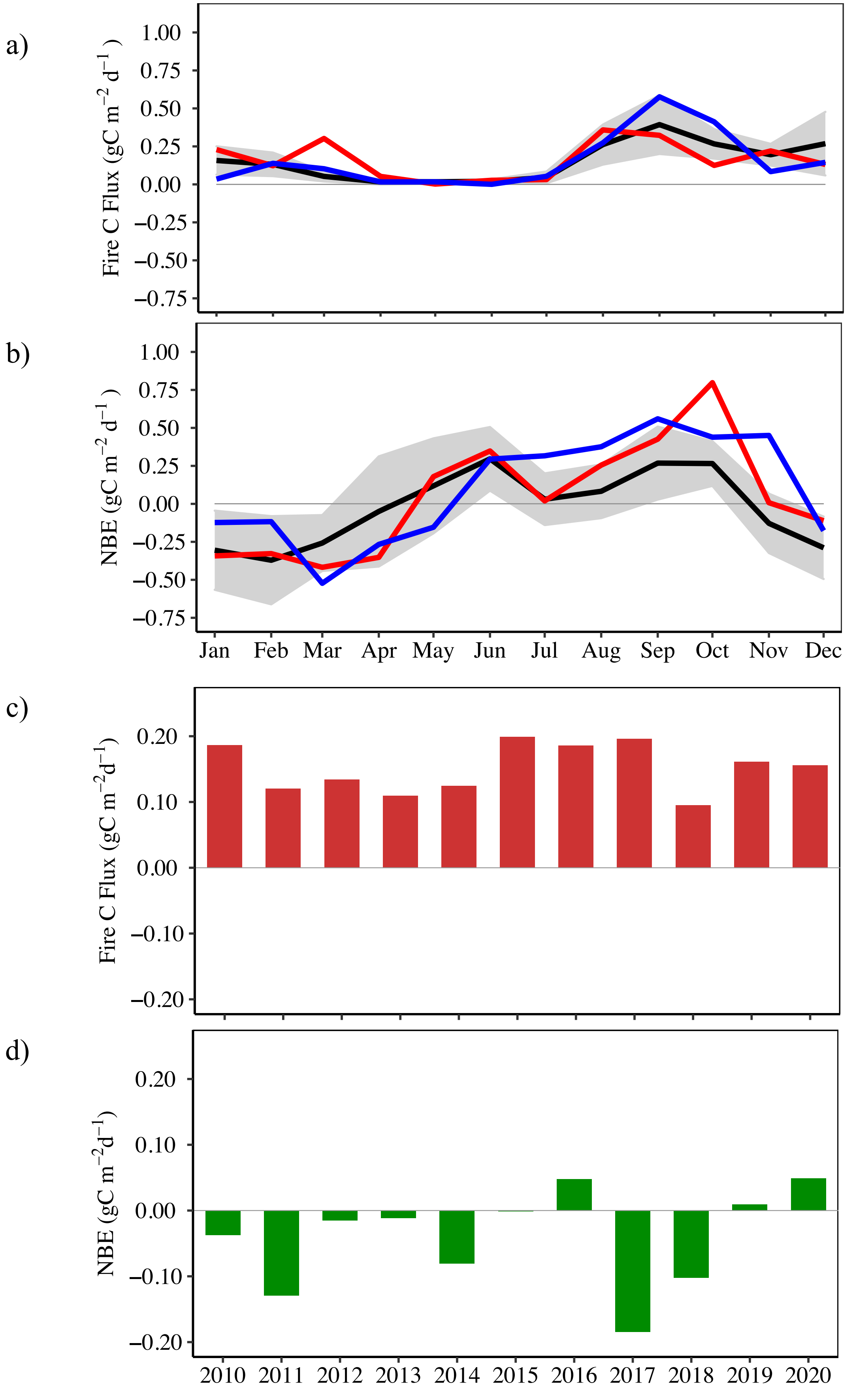
a)

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2010	**1.5**	**1.2**	**0.8**	0.4	-0.2	**-0.7**	**-1.0**	**-1.3**	**-1.6**	**-1.6**	**-1.6**	**-1.6**
2011	**-1.4**	**-1.2**	**-0.9**	**-0.7**	**-0.6**	-0.4	**-0.5**	**-0.6**	**-0.8**	**-1.0**	**-1.1**	**-1.0**
2012	**-0.9**	**-0.7**	**-0.6**	**-0.5**	-0.3	0.0	0.2	0.4	0.4	0.3	0.1	-0.2
2013	-0.4	-0.4	-0.3	-0.3	-0.4	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.3
2014	-0.4	-0.5	-0.3	0.0	0.2	0.2	0.0	0.1	0.2	**0.5**	**0.6**	**0.7**
2015	**0.5**	**0.5**	**0.5**	**0.7**	**0.9**	**1.2**	**1.5**	**1.9**	**2.2**	**2.4**	**2.6**	**2.6**
2016	**2.5**	**2.1**	**1.6**	**0.9**	0.4	-0.1	-0.4	**-0.5**	**-0.6**	**-0.7**	**-0.7**	**-0.6**
2017	-0.3	-0.2	0.1	0.2	0.3	0.3	0.1	-0.1	-0.4	**-0.7**	**-0.8**	**-1.0**
2018	**-0.9**	**-0.9**	**-0.7**	**-0.5**	-0.2	0.0	0.1	0.2	**0.5**	**0.8**	**0.9**	**0.8**
2019	**0.7**	**0.7**	**0.7**	**0.7**	**0.5**	**0.5**	0.3	0.1	0.2	0.3	0.5	0.5
2020	0.5	0.5	0.4	0.2	-0.1	-0.3	-0.4	**-0.6**	**-0.9**	**-1.2**	**-1.3**	**-1.2**
2021	**-1.0**	**-0.9**	**-0.8**	**-0.7**	**-0.5**	-0.4	-0.4	**-0.5**	**-0.7**	**-0.8**	**-1.0**	**-1.0**

b)



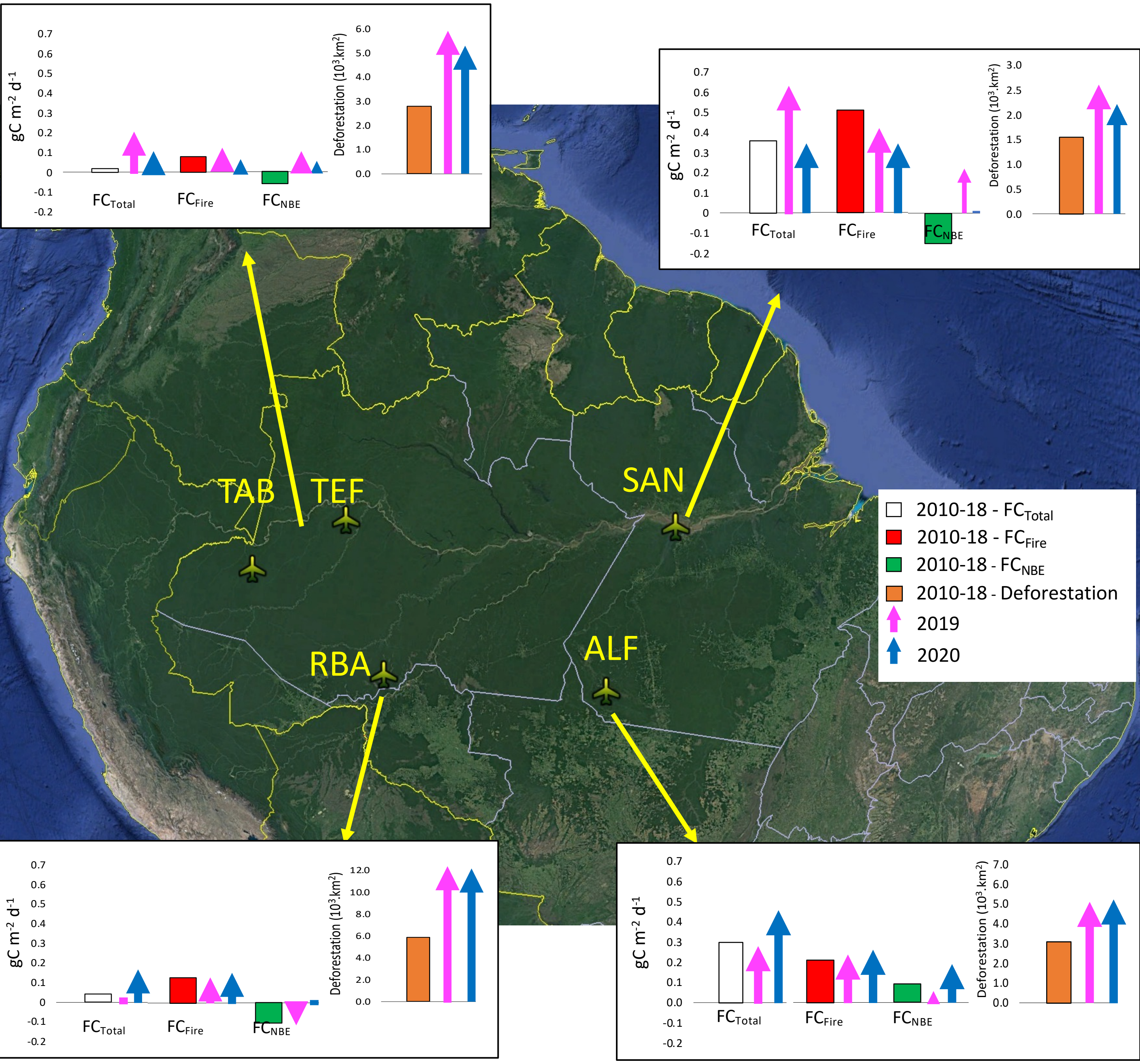
Extended Data Fig. 6 | El Nino / La Nina episodies (ONI) and seasonal precipitation and temperature. a) Warm (red) and cold (blue) periods based on a threshold of +/- 0.5oC for the Oceanic Niño Index (ONI) [3 month running mean of ERSST.v5 SST anomalies in the Niño 3.4 region (5˚N-5˚S, 120˚-170˚W)], based on centered 30-years base periods updated every 5 years[33]. b) Seasonal monthly Amazon mean precipitation mean 2010-18 (solid light blue line), temperature (solid brown line). Grey bar is the standard deviation for the monthly means 2010-18 and dashed line for P and T 2019 and dotted line for P and T 2020.



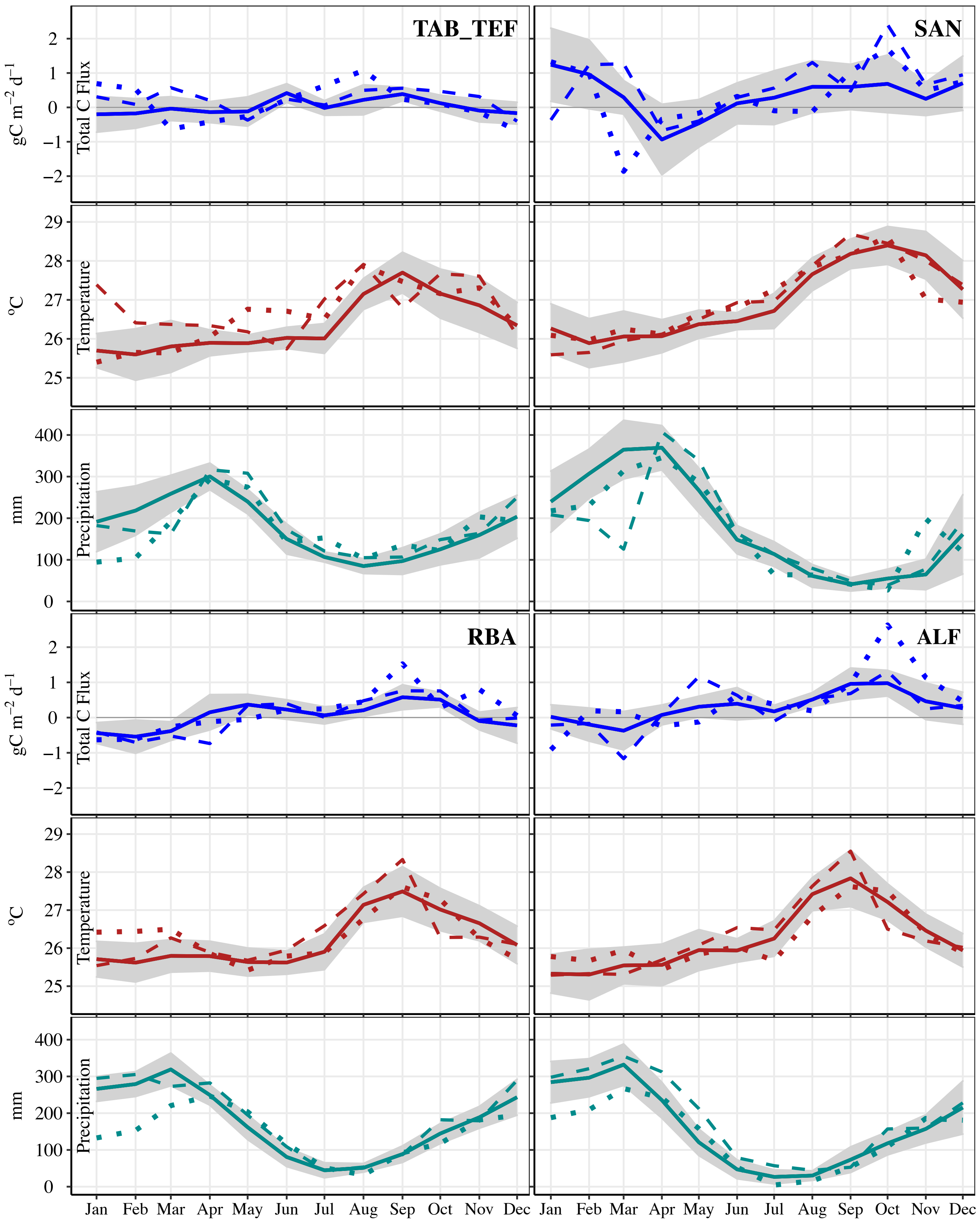
Extended Data Fig 7 | Amazonia carbon Fire and NBE flux 2010-20. a) Monthly means for Amazonia Fire carbon flux (FC_{Fire}). Black line for 2010-18 mean, where grey bands denote the standard deviation of the monthly mean. Red line 2019 and blue line 2020. b) Annual mean Amazonia total carbon flux (see methods).

Extended Data Table 1 | Summary results for all sites. Summary for the 4 sites and for the whole Amazonia presenting the results for total carbon flux (FC_{Total}), fire carbon flux (FC_{Fire}), net biome exchange (FC_{NBE}), deforestation (*only for Brazilian Amazon), Fire spots, Burned area, annual accumulated precipitation, wet season peak mean precipitation (months January, February and March: JFM), dry season peak mean precipitation (months August, September, October: ASO), annual temperature, wet season peak mean temperature (JFM) and dry season peak mean temperature (ASO). For each site and parameters are presented the mean for the years 2010-2018, the mean for 2019 and 2020. Considering the 11 years time series, it were also presented the results for the first 5 years mean (2010-2014) and the last 5 years mean (2016-2020) to observe the trends in changes for carbon flux, on the climatological parameters, deforestation, burned area and fire spots.

		FC_{NBE} $gC.m^{-2}.d^{-1}$	FC_{FIRE} $gC.m^{-2}.d^{-1}$	FC_{Total} $gC.m^{-2}.d^{-1}$	Defor.* km^2	Fire spots	Burned area km^2	Annual Prec. mm	M.M.P. JFM mm	M.M.P. ASO mm	Annual Temp. ˚C	M.M.T. JFM ˚C	M.M.T. ASO ˚C
ALF	Mean 2010-18	0.09±0.05	0.21±0.01	0.30±0.04	3,087	51,076	325.3	1,937	304	74	26.2	25.4	27.5
	2019	0.05±0.05 (↓44%)	0.23±0.01 (↑10%)	0.28±0.05 (↓7%)	5,566 (↑80%)	33,533 (↓34%)	278.0 (↓15%)	2,277 (↑18%)	325 (↑7%)	85 (↑15%)	26.3 (↑0.1)	25.3 (↓0.1)	27.6 (↑0.1)
	2020	0.19±0.05 (↑111%)	0.26±0.01 (↑24%)	0.46±0.05 (↑53%)	5,757 (↑87%)	51,439 (↑0%)	416.5 (↑28%)	1,665 (↓14%)	221 (↓27%)	59 (↓20%)	26.2 -	25.9 (↑0.5)	27.3 (↓0.2)
	Mean 2010-14	0.02±0.05	0.20±0.01	0.22±0.05	2,936	49,195	286.8	2,020	320	78	26.1	24.7	27.3
	Mean 2016-20	0.17±0.05	0.21±0.01	0.39±0.04	4,291	50,115	349.2	1,943	281	76	26.3	25.6	27.5
SAN	Mean 2010-18	-0.15±0.14	0.51±0.03	0.36±0.13	1,553	29,784	168.1	2,194	304	52	27.0	26.1	28.1
	2019	0.23±0.18 (↑253%)	0.42±0.04 (↓18%)	0.64±0.17 (↑78%)	2,591 (↑67%)	9,478 (↓68%)	48.8 (↓71%)	1,992 (↓9%)	176 (↓42%)	56 (↑8%)	27.0 -	25.7 (↓0.4)	28.3 (↑0.2)
	2020	0.00±0.16 (↓100%)	0.34±0.04 (↓33%)	0.34±0.15 (↓6%)	2,245 (↑45%)	9,948 (↓67%)	53.3 (↓68%)	2,074 (↓5%)	254 (↓16%)	44 (↓15%)	27.0 -	26.1 -	28.2 (↑0.1)
	Mean 2010-14	-0.10±0.15	0.52±0.04	0.42±0.14	1,559	32,305	137.2	2,259	307	61	26.8	26.0	27.9
	Mean 2016-20	-0.13±0.13	0.42±0.03	0.29±0.12	1,922	19,097	112.8	2,118	271	49	27.0	26.1	28.3
RBA	Mean 2010-18	-0.10±0.04	0.13±0.01	0.04±0.04	5,871	94,566	172.3	2,117	288	95	26.2	25.7	27.2
	2019	-0.11±0.04 (↓10%)	0.13±0.01 -	0.02±0.03 (↓50%)	10,632 (↑81%)	59,902 (↓37%)	181.5 (↑5%)	2,294 (↑8%)	291 (↑1%)	108 (↑13%)	26.3 (↑0.1)	25.9 (↑0.2)	27.4 (↑0.2)
	2020	0.01±0.05 (↑110%)	0.15±0.01 (↑15%)	0.16±0.05 (↑300%)	10,354 (↑76%)	79,239 (↓16%)	177.6 (↑3%)	1,743 (↓18%)	169 (↓41%)	81 (↓15%)	26.3 (↑0.1)	26.5 (↑0.8)	27.2 -
	Mean 2010-14	-0.08±0.04	0.11±0.01	0.03±0.04	5,175	81,092	156.9	2,166	294	101	26.1	25.6	27.1
	Mean 2016-20	-0.10±0.04	0.15±0.01	0.04±0.04	8,390	89,147	183.5	2,069	257	95	26.3	26	27.2
TAB_TEF	Mean 2010-18	-0.06±0.05	0.08±0.01	0.02±0.05	2,785	52,465	108.2	2,136	223	102	25.9	25.2	26.3
	2019	0.10±0.06 (↑267%)	0.12±0.01 (↑50%)	0.21±0.06 (↑950%)	5,443 (↑95%)	31,106 (↓41%)	87.0 (↓20%)	2,207 (↑3%)	171 (↓23%)	120 (↑17%)	26.1 (↑0.2)	25.7 (↑0.5)	26.6 (↑0.3)
	2020	0.05±0.06 (↑183%)	0.06±0.01 (↓25%)	0.11±0.06 (↑450%)	4,806 (↑73%)	18,351 (↓65%)	32.7 (↓70%)	2,012 (↓6%)	130 (↓42%)	120 (↑17%)	26.4 (↑0.5)	25.6 (↑0.4)	26.6 (↑0.3)
	Mean 2010-14	-0.06±0.05	0.07±0.01	0.02±0.05	2,650	54,707	106.7	2,256	246	113	25.8	25.3	25.9
	Mean 2016-20	-0.04±0.04	0.09±0.01	0.06±0.04	3,914	41,558	89.7	2,065	174	108	26.2	25.4	26.7
Amazonia	Mean 2010-18	-0.06±0.07	0.15±0.02	0.09±0.07	2,785	134,533	328,198	2,280	253	123	25.2	25.0	25.8
	2019	0.01±0.08 (↑117%)	0.16±0.02 (↑7%)	0.17±0.08 (↑89%)	5,443 (↑79%)	138,365 (↑3%)	375,292 (↑14%)	2,349 (↑3%)	237 (↓6%)	132 (↑7%)	25.2 -	25.1 (↑0.1)	25.6 (↓0.2)
	2020	0.05±0.08 (↑183%)	0.16±0.02 (↑7%)	0.20±0.08 (↑122%)	4,806 (↑74%)	164,365 (↑22%)	466,470 (↑42%)	1,998 (↓12%)	188 (↓26%)	111 (↓10%)	25.4 (↑0.2)	25.6 (↑0.6)	25.9 (↑0.1)
	Mean 2010-14	-0.06±0.07	0.13±0.02	0.08±0.07	5,458	133,177	348,716	2,335	261	128	25.1	24.9	25.6
	Mean 2016-20	-0.03±0.07	0.16±0.02	0.12±0.07	8,659	140,518	345,430	2,229	231	125	25.3	25.3	25.8

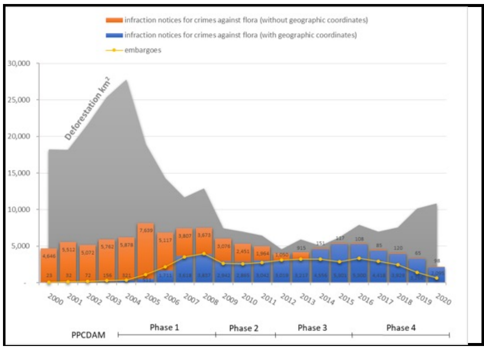


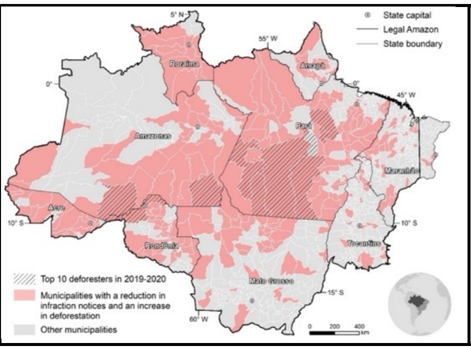
Extended Data Fig. 8 | Amazonia results overview. Summary of Total carbon flux (white box), Fire carbon flux (red box), Net Biome Exchange (green box) and deforestation per site (orange box). The boxes are all related to the mean 2010-18 and 2019 pink arrow and 2020 blue arrow for all fluxes (gC m^{-2} d^{-1}) and deforestation (km^2).



Extended Data Fig 9 | Seasonal total carbon Flux, precipitation and temperature. TAB_TEF, SAN, RBA and ALF 2010-2018 seasonal monthly total flux mean (solid blue line), temperature (solid brown line) and precipitation (solid cyan line). Grey banding is the standard deviation for the monthly means 2010-18 and dashed line for 2019 and dotted line for 2020 for all variables.

Supplementary Information 1 | Environmental law enforcement over time in the Amazon. Brazil's past success in curbing illegal deforestation in the Amazon has been credited to a combination of policies carried out by the government, civil society, and the private sector. Chief among them were the expansion of protected areas (Soares-Filho et al., 2010) and strengthening of law enforcement under the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (Brasil, 2004). The PPCDAM plan evolved in four phases — PPCDAm-I (2004–2008), II (2009–2011), III (2012–2015), and IV (2016–2020). A celebrated decline of 84% in deforestation rates took place from 2004 to 2012 (below). However, the more stringent enforcement of the law, largely ignored hitherto, produced a backlash. Rural lobbies pressed to relax the law, resulting into the revision of the Forest Code in 2012, which granted an amnesty to 58% of all illegal deforestation before 2008 (Soares-Filho et al. 2014) and suspended the collection of environmental fines, in addition to providing 20 years for landowners to attain compliance with the Forest Code requirements. The ensued sense of impunity, in addition to attempts to roll back conservation gains, has increasingly influenced the rise of deforestation since then. In 2019, annual deforestation rate achieved a ten-year peak of over 10 thousand km^2 (fig. S1), raising again international concerns, further fueled by the public stance of the Brazilian government against forest law enforcement and the environmental agencies themselves, which the Presidency called an "industry of fines" (Reuters, 2022).





(left) Deforestation rates (Prodes) and annual field notifications issued by IBAMA for crimes against flora in the states of Legal Amazon (Amazonas, Acre, Amapá, Rondônia, Roraima, Pará, Mato Grosso, Maranhão and Tocantins). (right) Municipalities with both a reduction in infraction notices and an increase in deforestation rates in the Legal Amazon.

Despite statistical difficulties in disentangling individual measures from the policy mix that contributed to the past decline in deforestation rates in the Amazon (Thales and Fearnside, 2021), law enforcement has indeed contributed to this reduction, especially during the first phases of the PPCDAm (Hargrave, Kis-Katos, 2013; Sousa, 2016; Borner et al 2015; Tacconi et al., 2019). During PPCDAm-I, the average annual number of infraction notices for crimes against the flora (basically deforestation but also other forms of native vegetation suppression) increased by 26%, whereas the average annual deforestation rate fell by 18% in relation to that of the previous period (2000-2003). In the following years, several improvements to detect offenders and characterize environmental injuries – both crucial to accountability – were implemented mainly through geotechnologies developed by the Brazilian Space Agency (INPE). While in 2004, only 5% of infraction notifications had at least one geographic coordinate, in 2011, 61% of notifications were properly geolocated (see above left side). Yet, during the second phase of PPCDAm (2009-2011), there was a 25% reduction in the annual number of infraction notices. In both phases, over 52 thousand fines were issued alongside sanctions directed to decapitalize offenders such as embargoes (see above left side). After 2012, deforestation rates began to rise over the PPCDAm-III (2012-2015) even as the environmental agencies attempted to counteract the growing deforestation pressure. Between 2012 and 2018, 32.3 thousand fines were issued (see above left side). In its last phase, PPCDAm-IV (2016-2020) changed its focus to "economic and normative Instruments" as the main strategy to combat deforestation, including a potential market for trading forests (Soares-Filho et al., 2016) along with programs for payment for ecosystem services (PES), but these instruments were not implemented (MMA, 2020). As a result, deforestation rates in 2019-2020 got much worse detaching from the growing trend that began in the previous decade, largely reflecting the dismantling of federal inspection bodies and hence decreased field law enforcement. The precipitous fall in infraction notices against the flora in 2019 and 2020 stands out, whose numbers are the lowest on record over the last decade despite rising deforestation rates. The drop in fines took place within the ten municipalities with the highest deforestation rates between 2018 and 2019, evidencing the federal government's pullback from fighting deforestation (see above right side).

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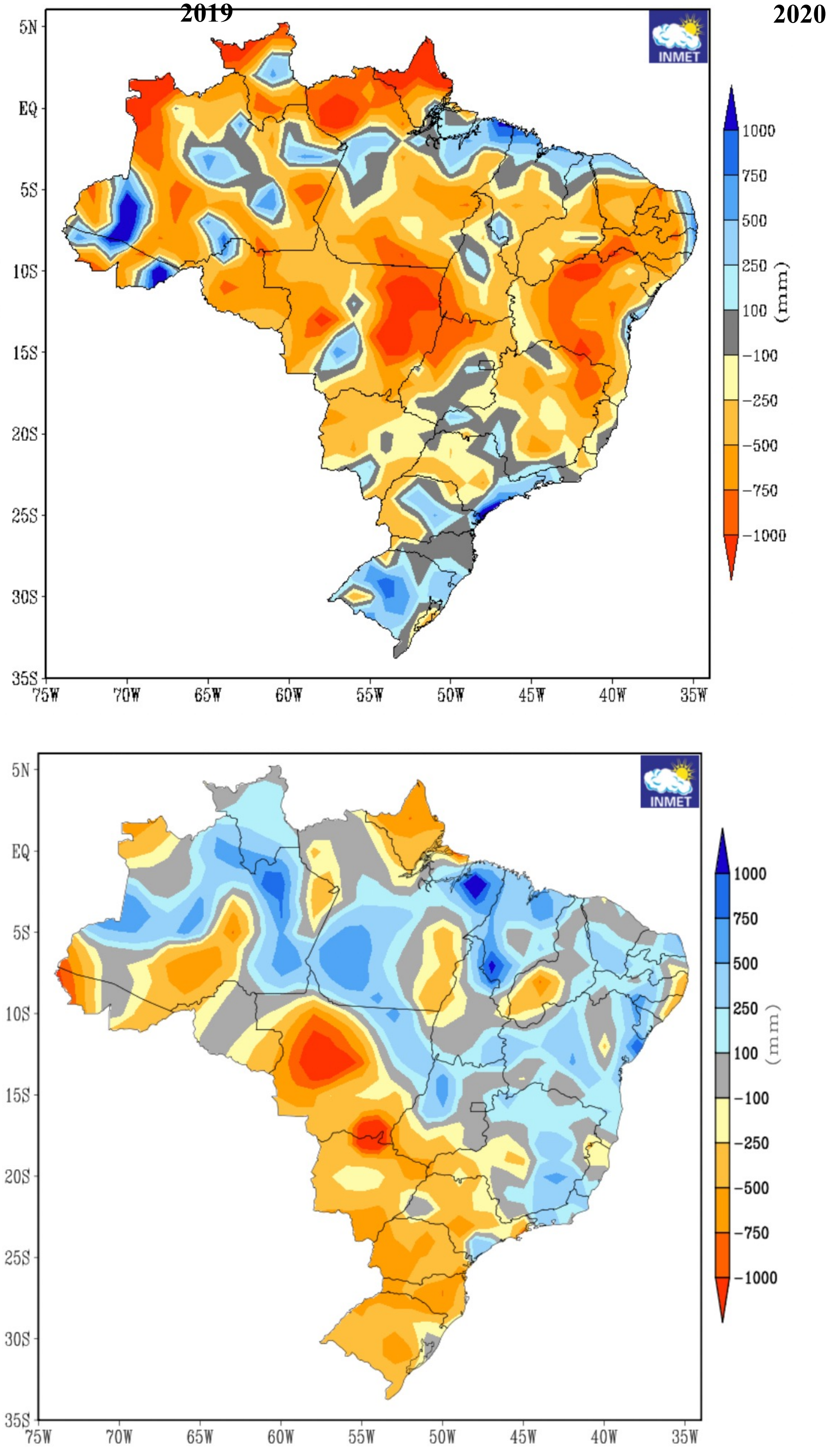
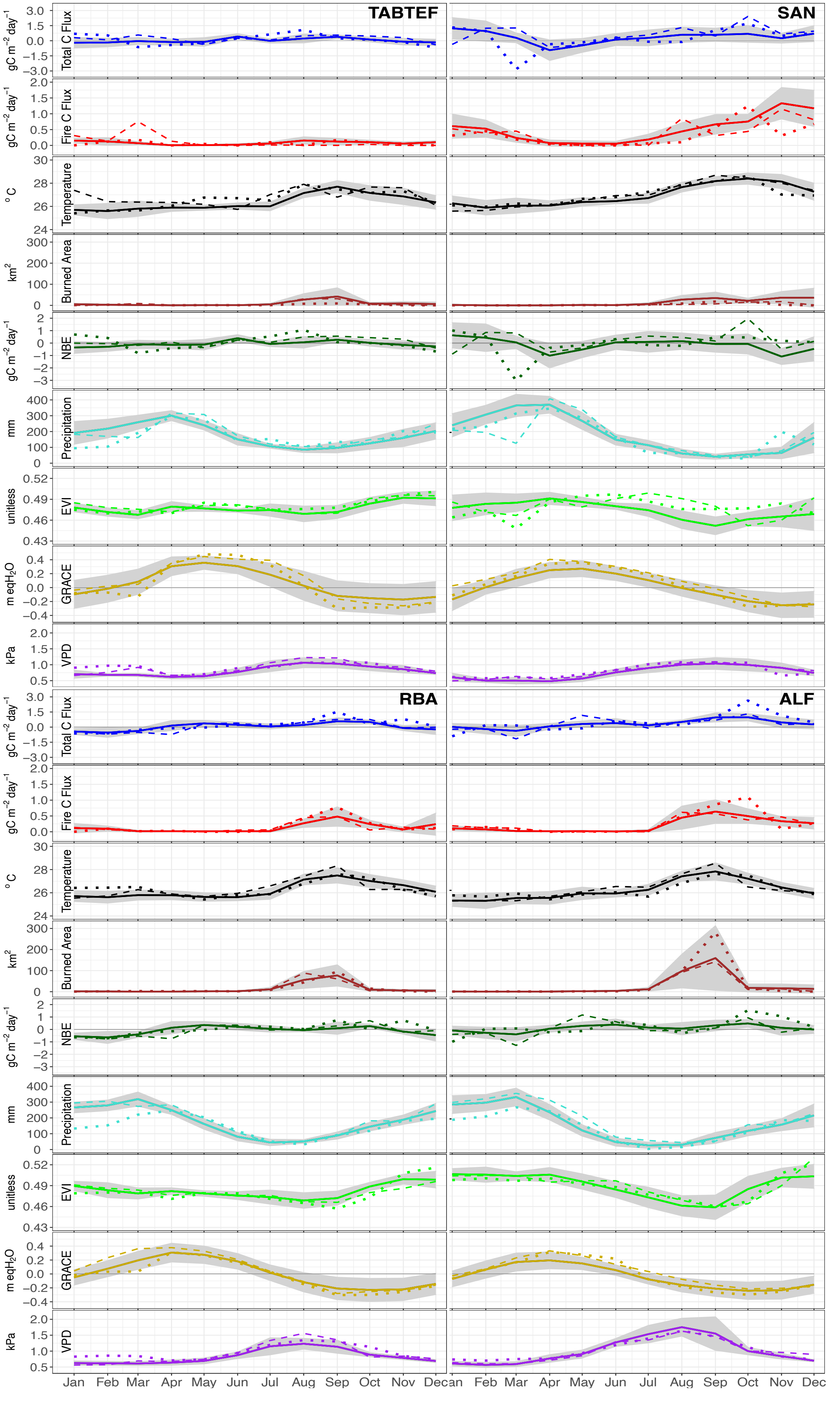
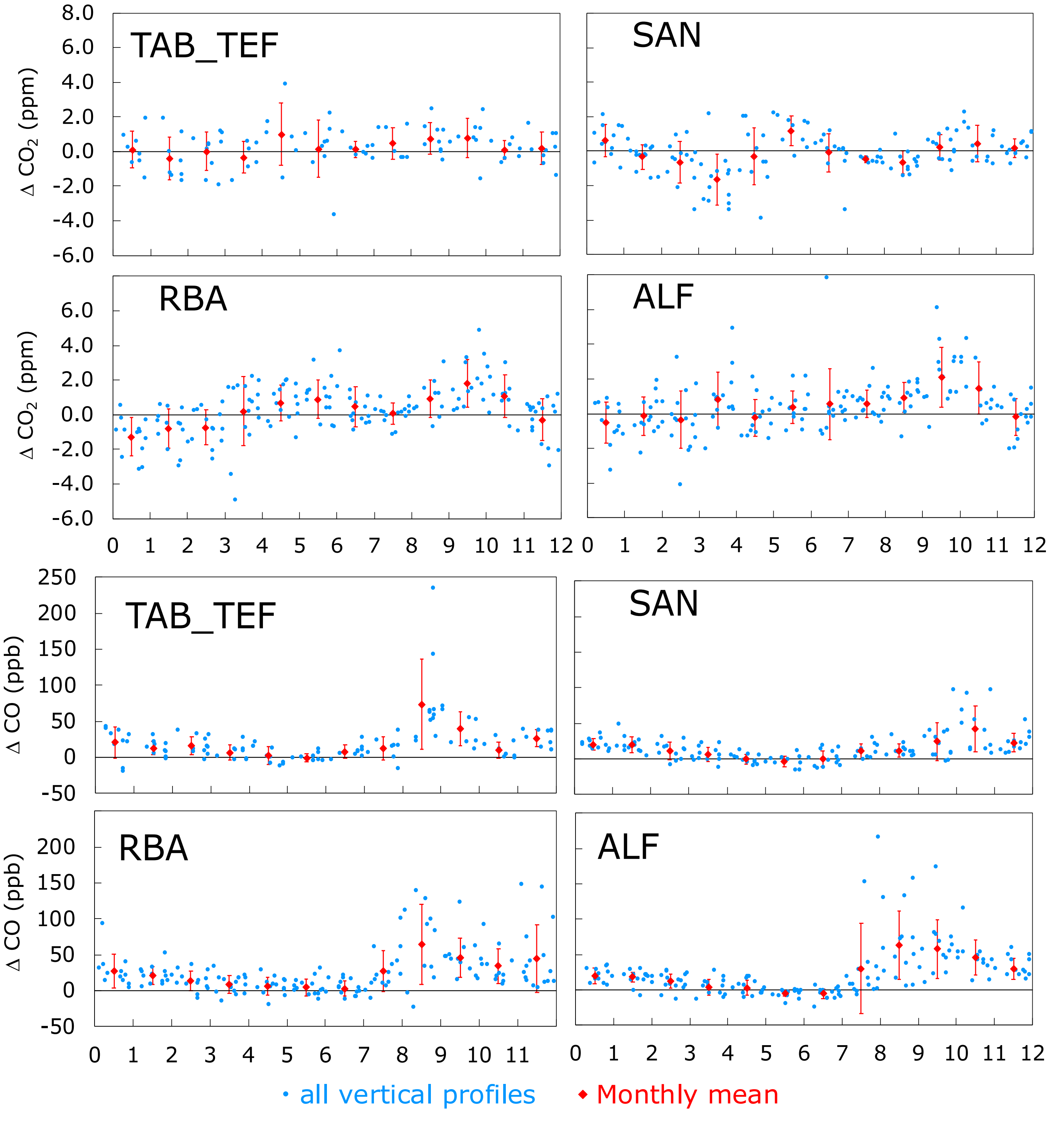


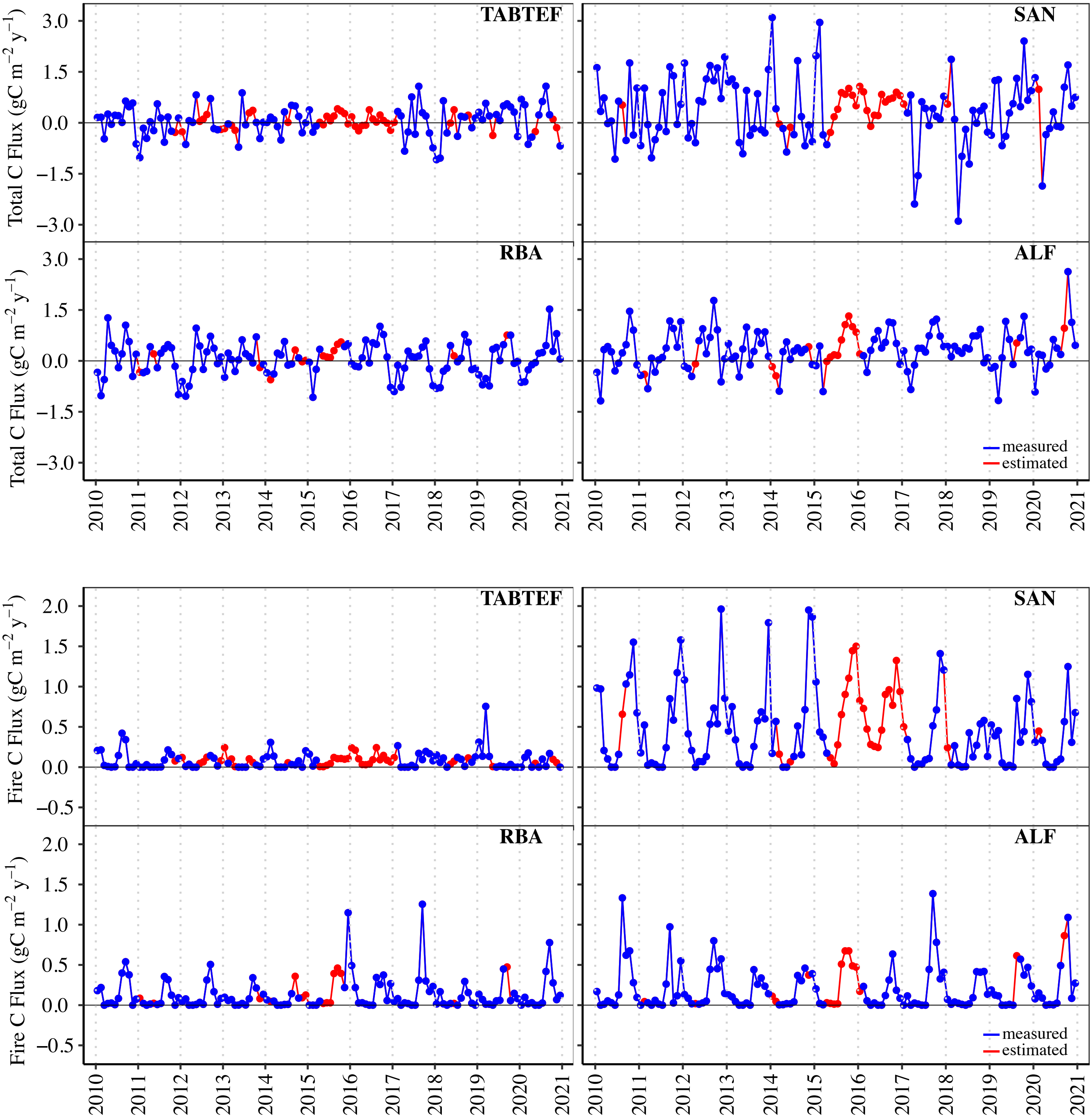
Supplementary Figure 2 | Quarterly Precipitation Anomaly in dry season peak. Quarterly precipitation anomaly from INMET (National Institute of Meteorology), related to the mean 1981 to 2010, for the months August, September and October, the dry season peak, when occurs the burning season for the years 2019 (above) and 2020 (below).
https://clima.inmet.gov.br/prec



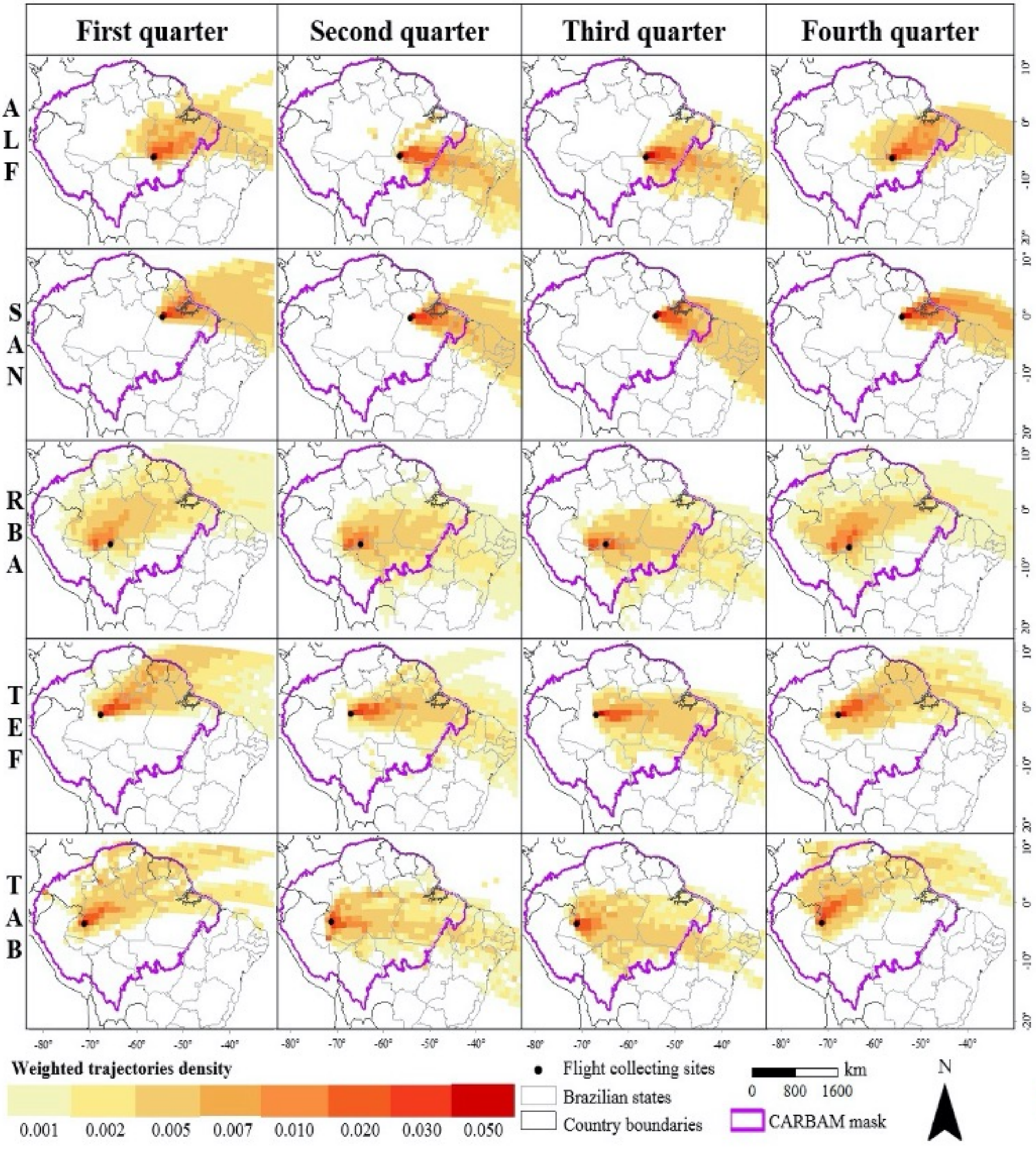
Supplementary Figure 3 | Seasonal Carbon Flux and driver variables. TAB_TEF, SAN, RBA and ALF 2010-2018 seasonal monthly flux means and potential flux driver variables. Grey banding for each variable is the standard deviation for the monthly means.



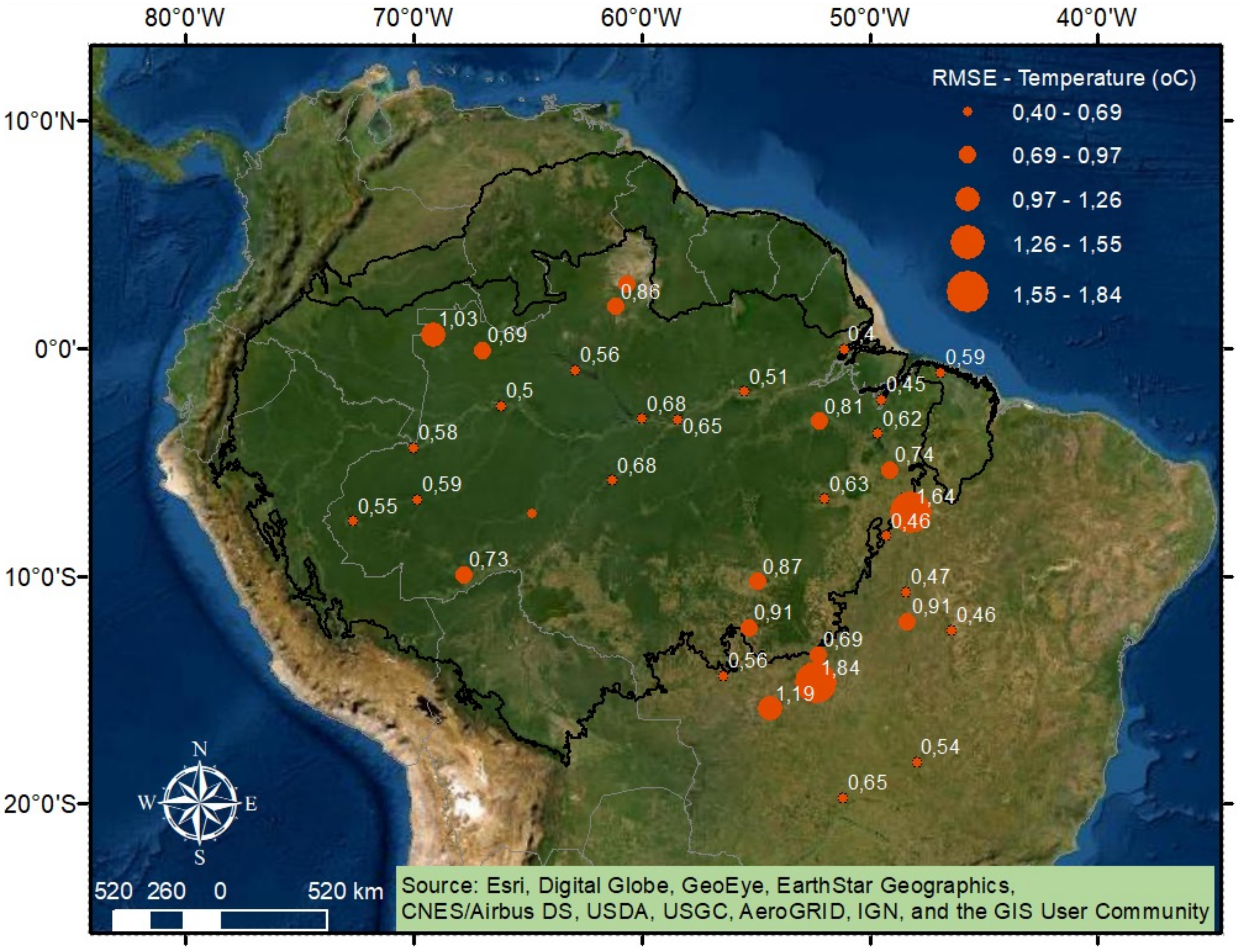
Supplementary Figure 4 | Difference between the top (>3.8km) of VP and BKG. a) Differences from mean concentration above 3.8 km height at vertical profiles (VP) and the background concentrations for the correspondents heights for TAB_TEF, SAN, RBA, ALF. Dispersion per month along the year for the CO_2 differences from mean concentration above 3.8 km height and the background concentrations for these same heights (above). And dispersion per month along the year for the CO differences from mean concentration above 3.8 km height and the background concentrations for these same heights (below).



Supplementary Figure 5 | Carbon fluxes measured and estimated. Time series of carbon total flux (FC_{Total}) calculated according to eq. M1 and carbon fire flux (FC_{Fire}) obtained from eq. M2, for the sites TAB_TEF, SAN, RBA and ALF (blue filled circles) and the filled gaps (red filled circles) using "Miss Forest" methodology (see methods).



Supplementary Figure 6 | Regions of Influence. Quarterly mean regions of influence for the ALF, SAN, RBA, TEF and TAB sites, averaged between 2010 and 2020, calculated using the density of back-trajectories per grid 1˚ x 1˚ (see Methods).



Supplementary Figure 7 | Validation for temperature. Validation sites of ERA5 products, showing the root-mean-square error (RMSE) for each gauge station from the INMET (National Institute of Meteorology, Brazil). The symbol's size in the maps represents the magnitude of the RMSE for each gauge station.