IPCC TFI Expert Meeting on Use of Atmospheric Observation Data in Emission Inventories – 5 – 7 September 2022

Airborne Amazon Carbon budget and CH4 emissions

Luciana V. Gatti

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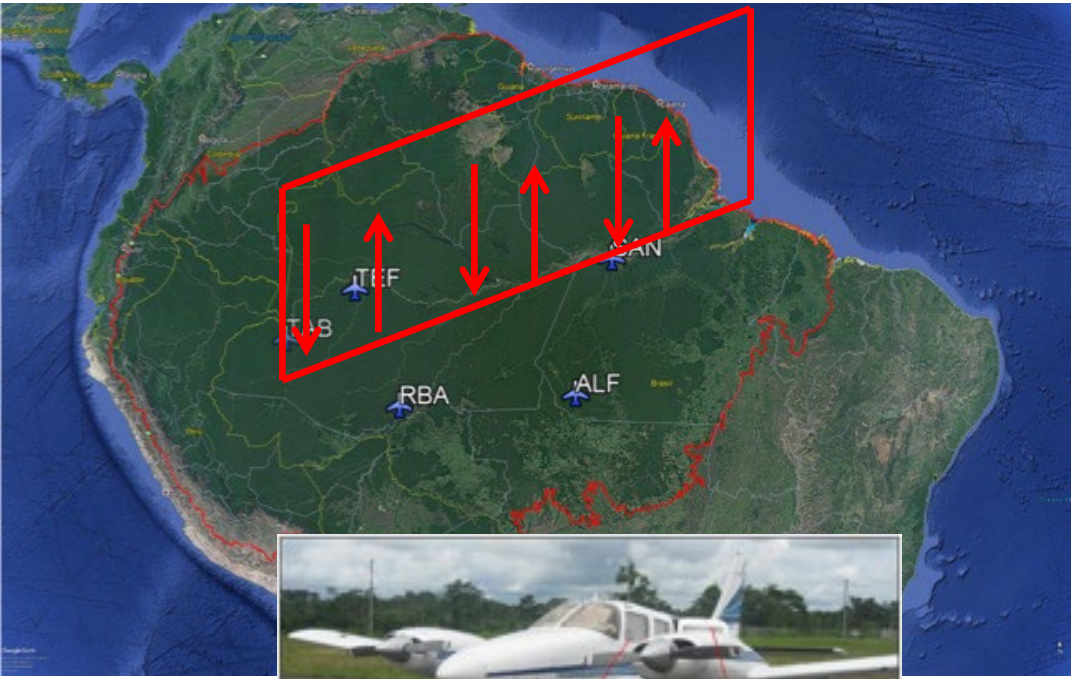
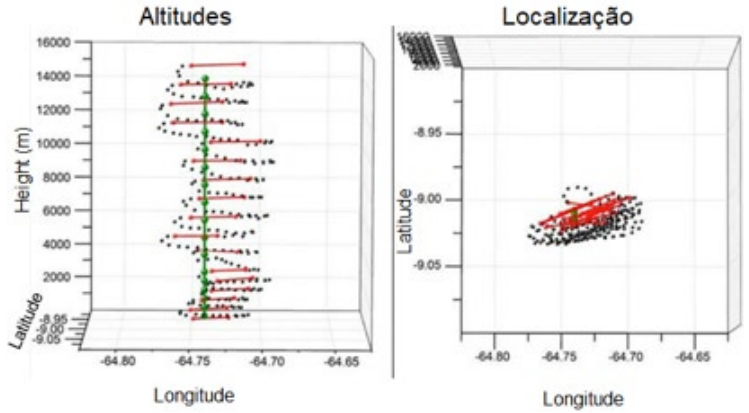
General Coordination of Earth Science
INPE – National Institute of Space Research

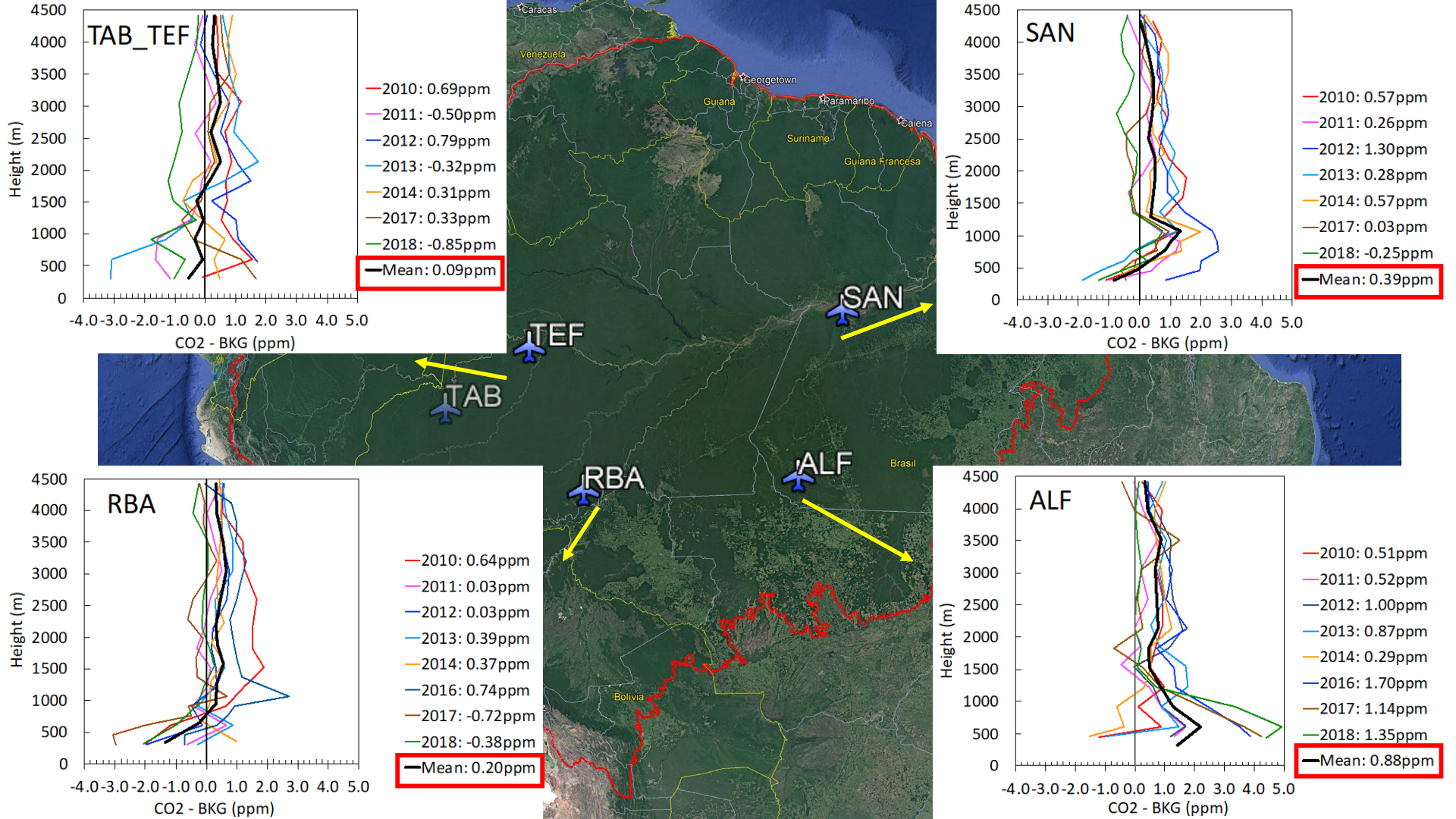

50% Global Tropical Forest
~ 120Pg above ground biomass
Amazon river discharge ~20% of
Global fresh water input to ocean
~20% Global biodiversity
Panamá
Trinidad e Tobago
Venezuela
Colômbia
Equador
Fortaleza
Brasil
Salvador
Bolívia
São Paulo
Rio de Janeiro

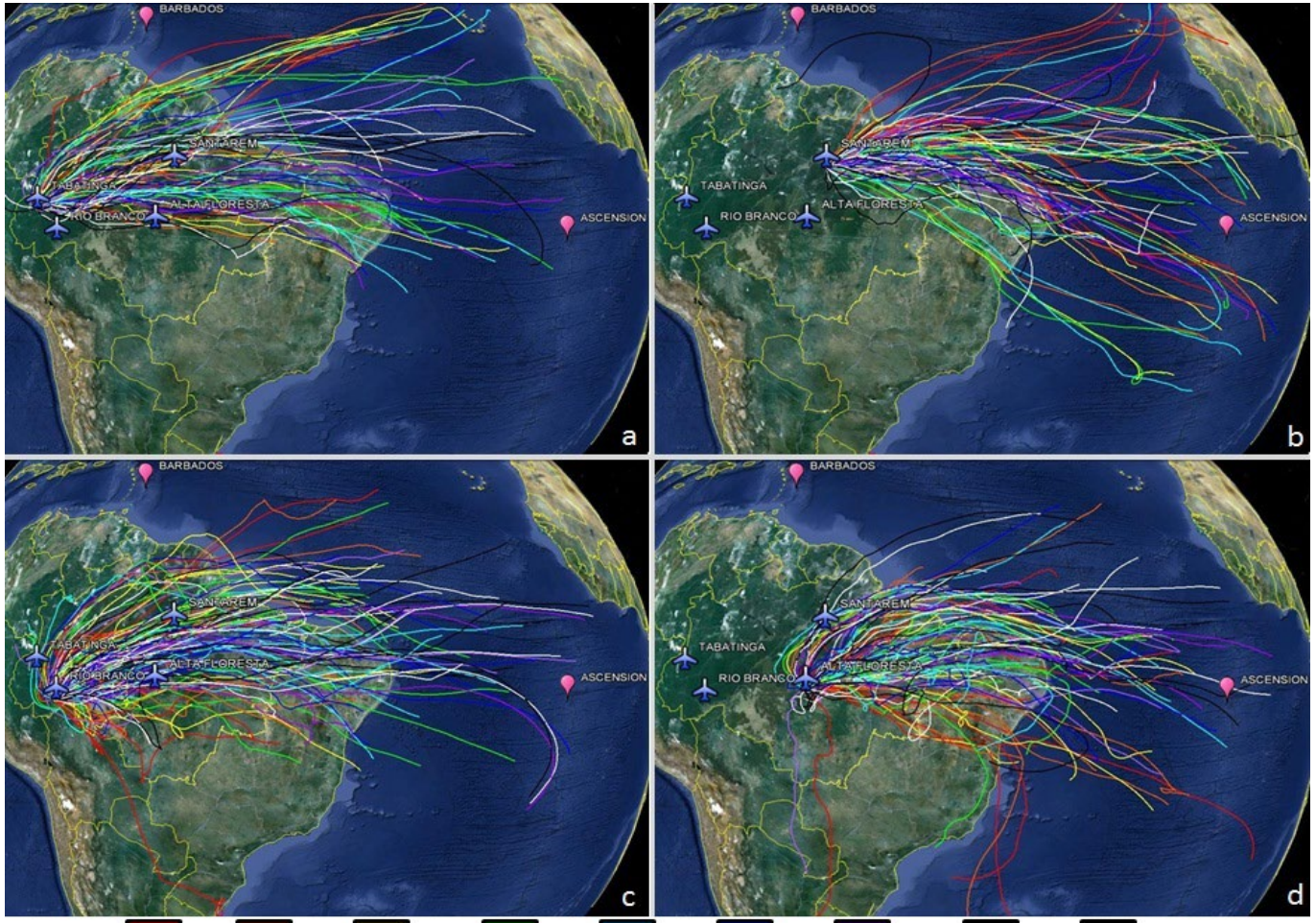
7.25 x 10^6 km^2

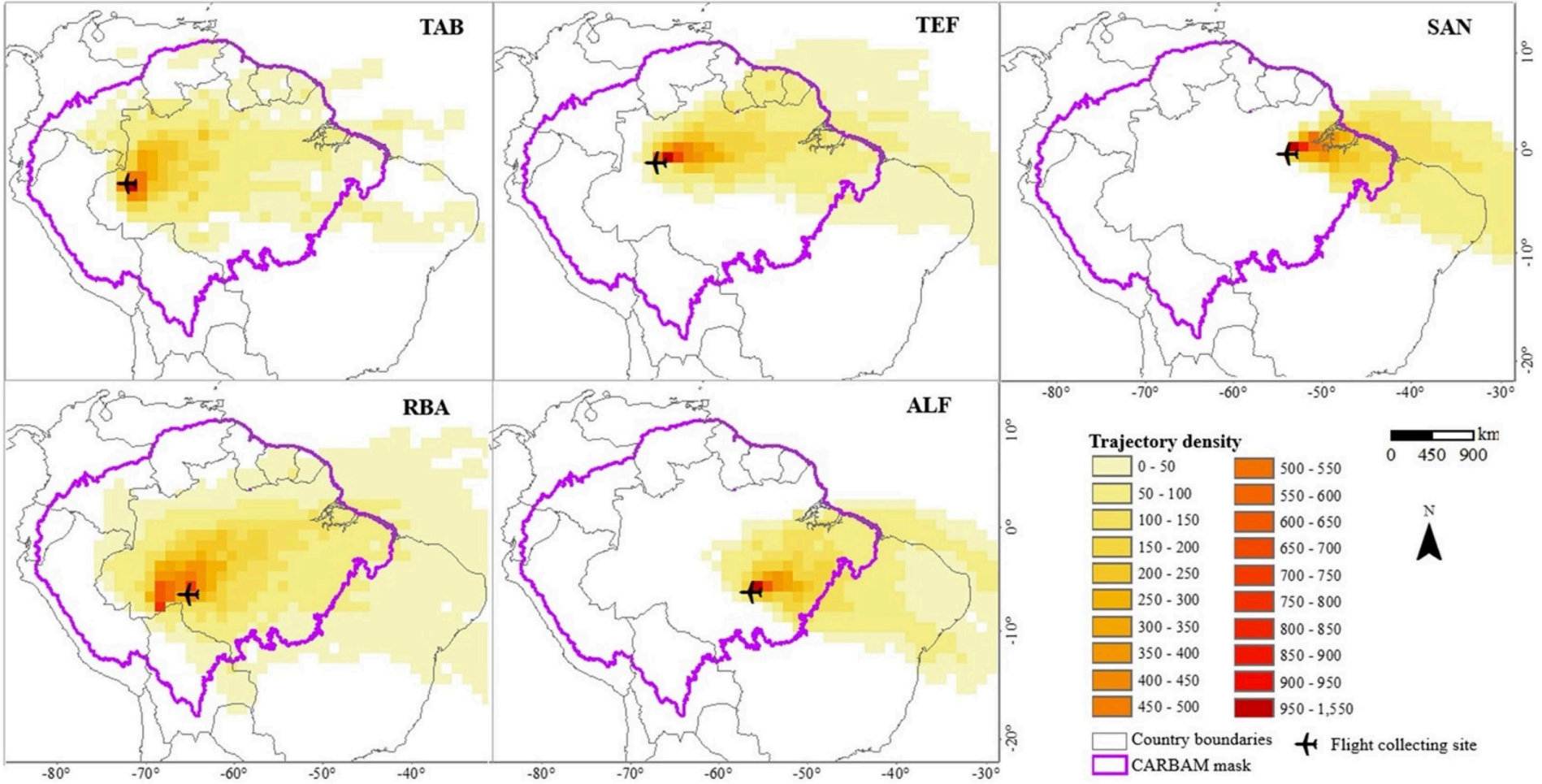


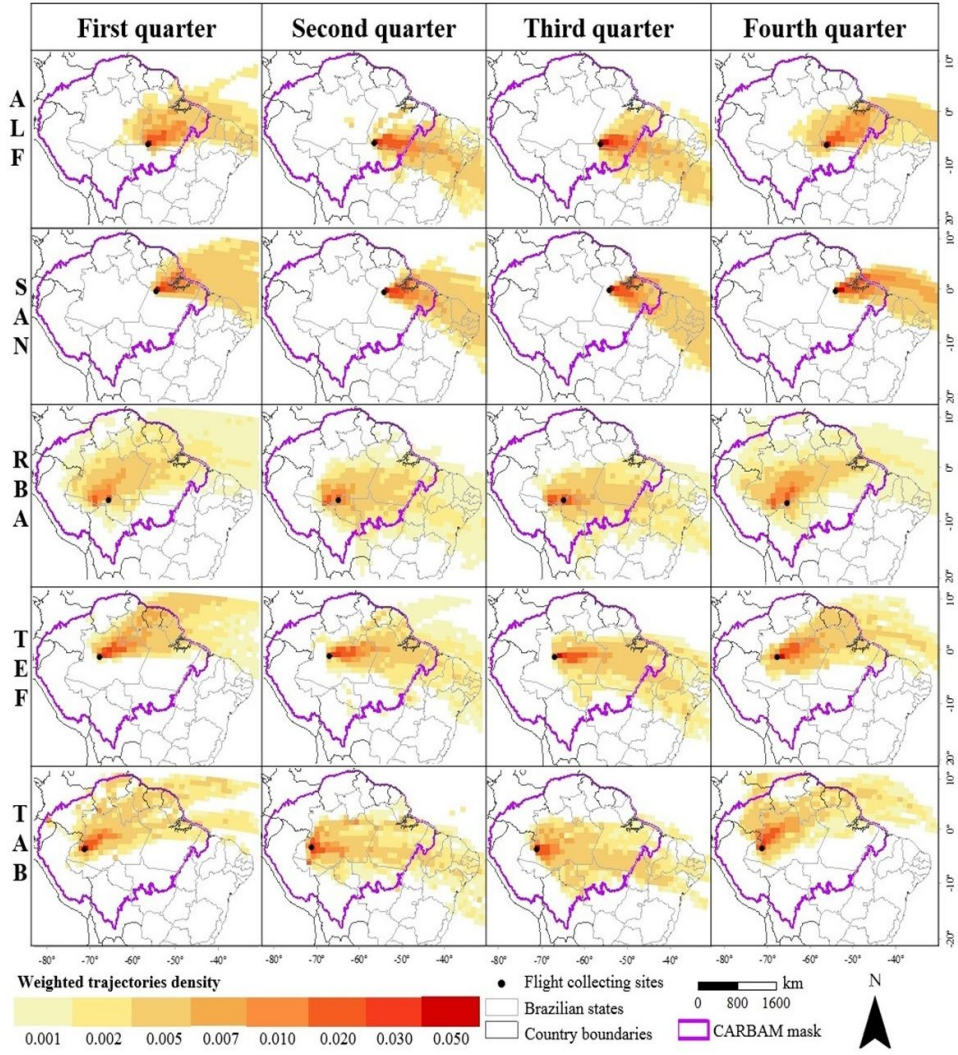


CO_2, CH_4, N_2O and CO

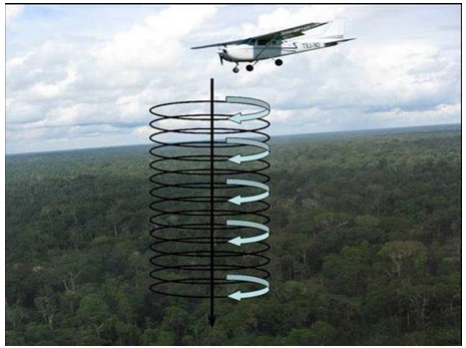

TAB_TEF
Height (m)
CO2 - BKG (ppm)
2010: 0.69ppm
2011: -0.50ppm
2012: 0.79ppm
2013: -0.32ppm
2014: 0.31ppm
2017: 0.33ppm
2018: -0.85ppm
Mean: 0.09ppm
SAN
2010: 0.57ppm
2011: 0.26ppm
2012: 1.30ppm
2013: 0.28ppm
2014: 0.57ppm
2017: 0.03ppm
2018: -0.25ppm
Mean: 0.39ppm
RBA
2010: 0.64ppm
2011: 0.03ppm
2012: 0.03ppm
2013: 0.39ppm
2014: 0.37ppm
2016: 0.74ppm
2017: -0.72ppm
2018: -0.38ppm
Mean: 0.20ppm
ALF
2010: 0.51ppm
2011: 0.52ppm
2012: 1.00ppm
2013: 0.87ppm
2014: 0.29ppm
2016: 1.70ppm
2017: 1.14ppm
2018: 1.35ppm
Mean: 0.88ppm
TEF
TAB
SAN
RBA
ALF
Caracas
Venezuela
Georgetown
Guiana
Paramaribo
Caiena
Suriname
Guiana Francesa
Brasil
Bolivia

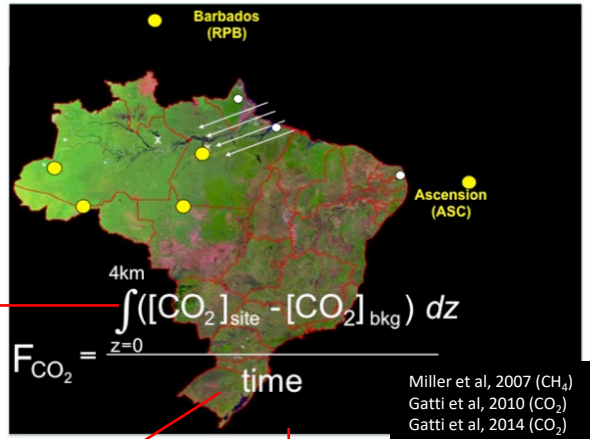

BARBADOS
SANTAREM
TABATINGA
ALTA FLORESTA
RIO BRANCO
ASCENSION
a
b
c
d
500m
1000m
1500m
2000m
2500m
3000m
3500m
4000m
4500m


TAB
TEF
SAN
RBA
ALF
10°
0°
-10°
-20°
-80°
-70°
-60°
-50°
-40°
-30°
Trajectory density
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350
350 - 400
400 - 450
450 - 500
500 - 550
550 - 600
600 - 650
650 - 700
700 - 750
750 - 800
800 - 850
850 - 900
900 - 950
950 - 1,550
km
0 450 900
N
Country boundaries
CARBAM mask
Flight collecting site

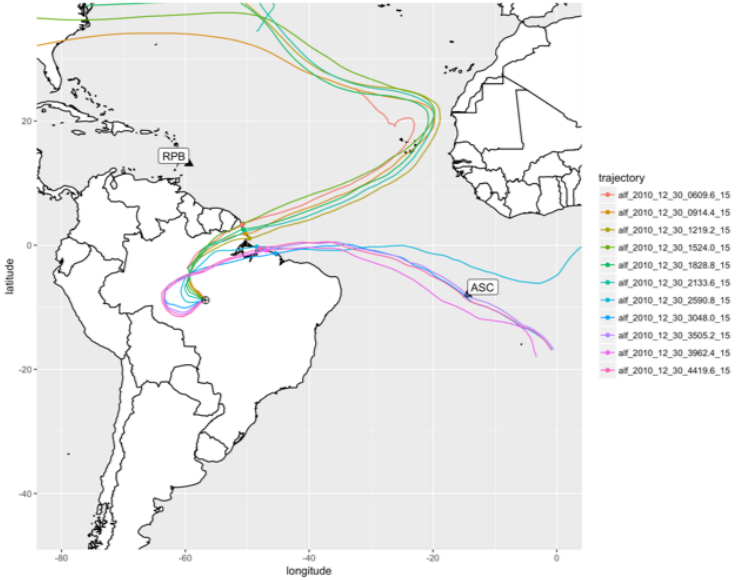

First quarter
Second quarter
Third quarter
Fourth quarter
ALF
SAN
RBA
TEF
TAB
Weighted trajectories density
0.001
0.002
0.005
0.007
0.010
0.020
0.030
0.050
Flight collecting sites
Brazilian states
Country boundaries
CARBAM mask
km
0 800 1600
N

Flux from Column Budget Technique

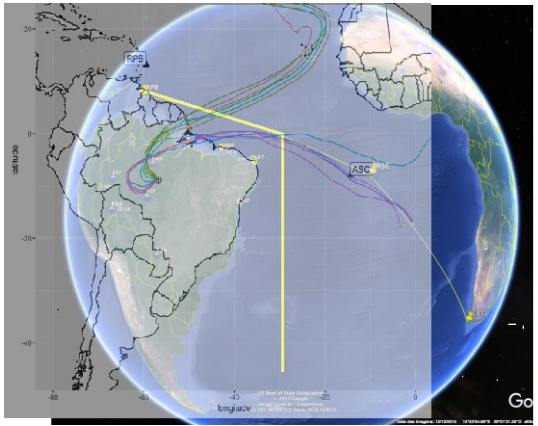


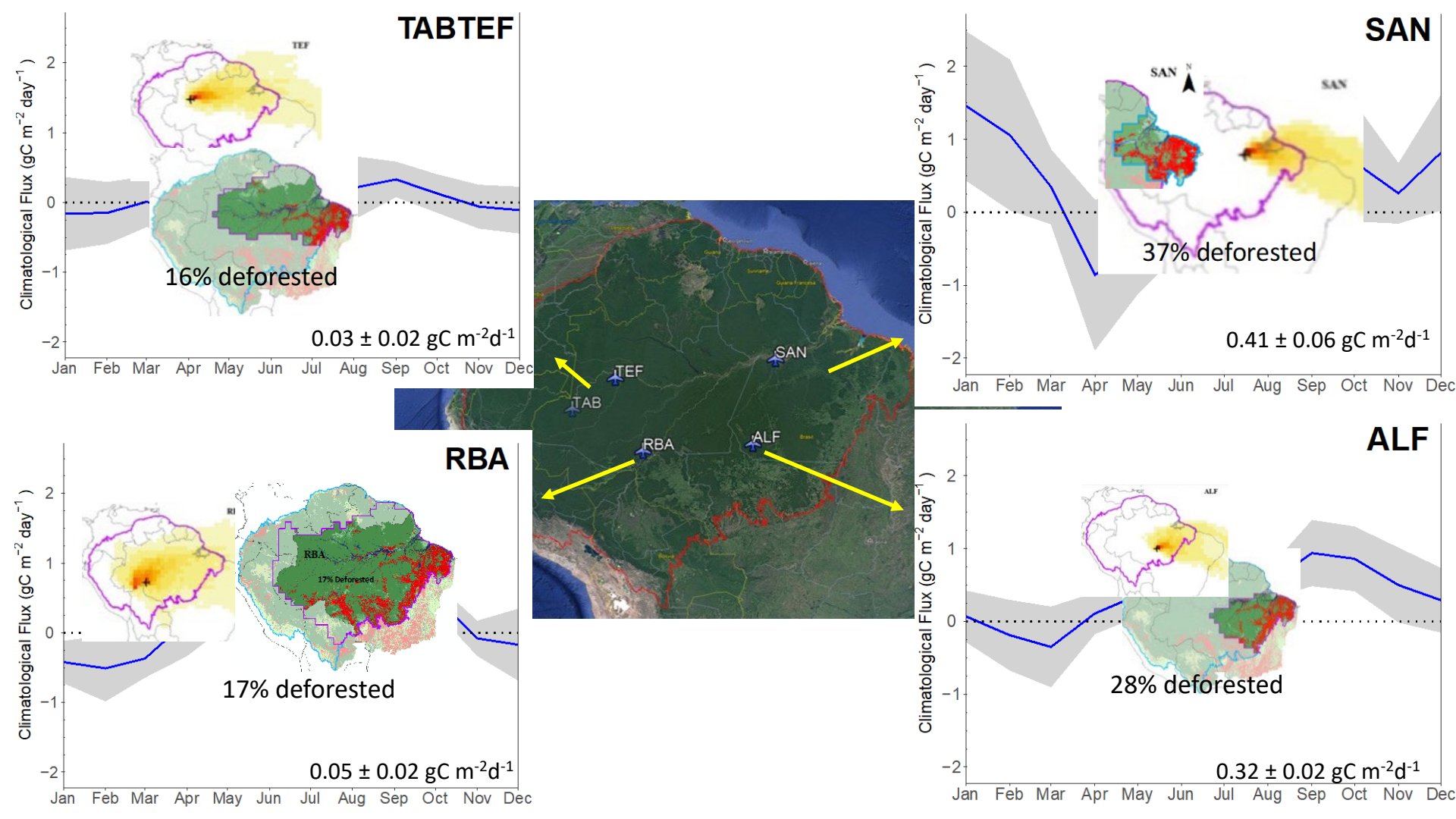


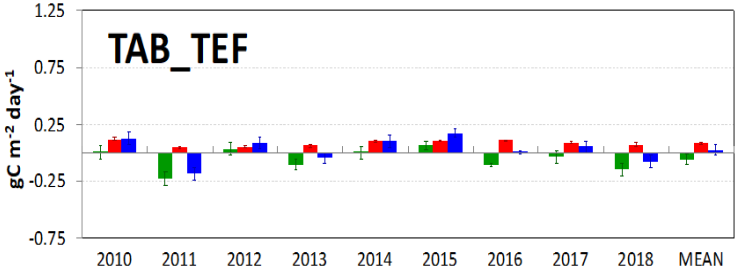
Miller et al, 2007 (CH_4)
Gatti et al, 2010 (CO_2)
Gatti et al, 2014 (CO_2)
Basso et al, 2016 (CH_4)
Gatti et al, 2021 (CO_2)
Basso et al, 2021 (CH_4)
Gatti et al, 2022 ($CO_{2\ submitted}$)



Background

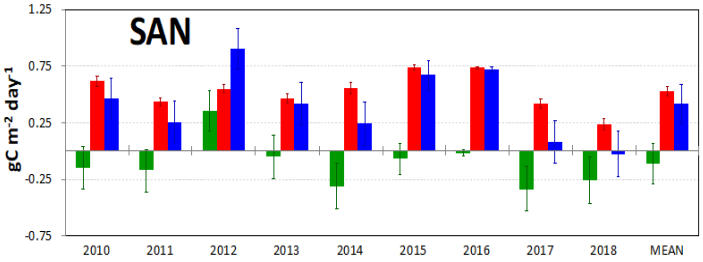



TABTEF
Climatological Flux (gC m^{-2} day^{-1})
TEF
16% deforested
0.03 ± 0.02 gC m^{-2}d^{-1}
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
SAN
SAN
37% deforested
0.41 ± 0.06 gC m^{-2}d^{-1}
TEF
TAB
SAN
RBA
ALF
RBA
RBA
17% Deforested
17% deforested
0.05 ± 0.02 gC m^{-2}d^{-1}
ALF
ALF
28% deforested
0.32 ± 0.02 gC m^{-2}d^{-1}



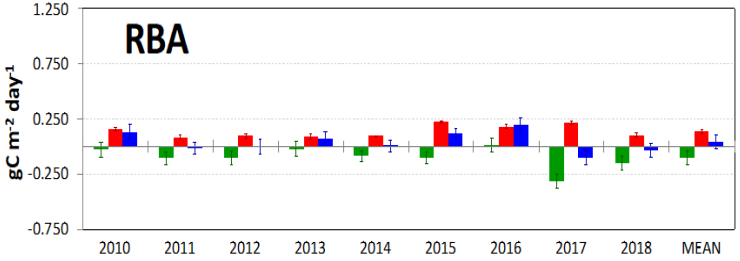
TAB_TEF **Total C Flux: 0.03 ± 0.02 gC.m^{-2}.day^{-1}**
Fire C Flux: 0.08 ± 0.004 gC.m^{-2}.day^{-1}
NBE C Flux: -0.06 ± 0.02 gC.m^{-2}.day^{-1}

16% deforested



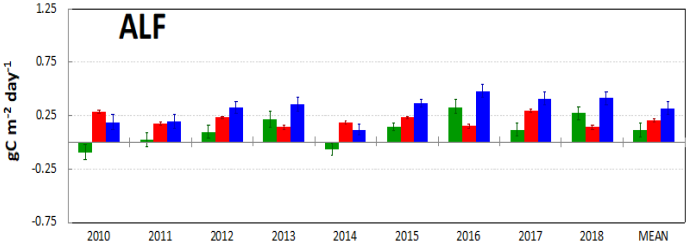
SAN **Total C Flux: 0.41 ± 0.06 gC.m^{-2}.day^{-1}**
Fire C Flux: 0.53 ± 0.01 gC.m^{-2}.day^{-1}
NBE C Flux: -0.13 ± 0.06 gC.m^{-2}.day^{-1}

37% deforested



RBA **Total C Flux: 0.05 ± 0.02 gC.m^{-2}.day^{-1}**
Fire C Flux: 0.14 ± 0.01 gC.m^{-2}.day^{-1}
NBE C Flux: -0.10 ± 0.02 gC.m^{-2}.day^{-1}

17% deforested



ALF **Total C Flux: 0.32 ± 0.02 gC.m^{-2}.day^{-1}**
Fire C Flux: 0.20 ± 0.01 gC.m^{-2}.day^{-1}
NBE C Flux: +0.11 ± 0.02 gC.m^{-2}.day^{-1}

29% deforested

www.dpi.inpe.br/proarco/bdqueimadas/

Ciência e Tecnologia e Meio Ambiente
Ministério da Ciência e Tecnologia e Inovação e Ministério do Meio Ambiente

BRASIL

Queimadas
Monitoramento de Focos

CPTEC

Português
English
Español

Recompor | Meteorologia | Imagens Satélite | Cartografia | Mapas Temáticos | Tamanho da Tela

OBT DPI

Parâmetros Básicos

Data Inicial (aaaa-mm-dd): 2010-08-01 00:00:00 GMT
Data Final (aaaa-mm-dd): 2010-10-01 23:59:59 GMT
País: BRASIL
Estado/Regiao (um ou mais): MA, MG, MS, MT
Município (opcional):
Satélite (um ou mais): TODOS, Satelite Referencia, NOAA 15 Noite, NOAA 15 Manha
Bioma Brasileiro: Todos
Região (opcional): Norte 55.0, Oeste -120.0, Leste 65.0, Sul -55.0
Coordenada Específica (opcional): Latitude, Longitude
Consultar

Gráficos

Tipo: Politico
Histograma

Focos nas Unidades de Conservação...

Acessórios

Coordenadas dos focos na projeção UTM, Policônica, Mercator, Albers...
Focos NOAA Antigos: 1992 A 1998...
Ajuda...
Veja Relatorio enviado ontem as 23:30...
Relatórios-Resumo Diários de Focos
Receba um relatório resumido dos focos nas UCs em seu email. Inscreva-se...
Perguntas Frequentes...
Calculadora Geográfica...
Banco de fotos de campo

HOME QUEIMADAS

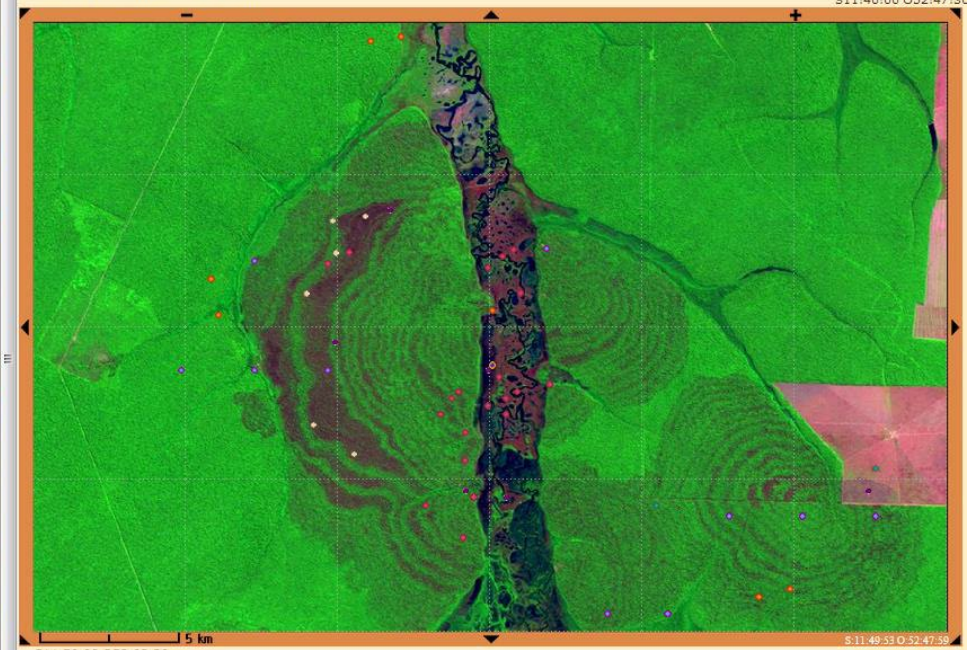
Dúvidas, comentários e sugestões:
queimadas@inpe.br

Atualizações Diárias:
04:30, 10:30, 13:30, 16:30, 19:30, 21:30 e 23:30 horário de Brasília/DF

41368 1
Visitas desde 31/08/2002

Mosaico LandSat 2011 (AMZ)/Grade LandSat TM/

S11:40:00 O52:47:30

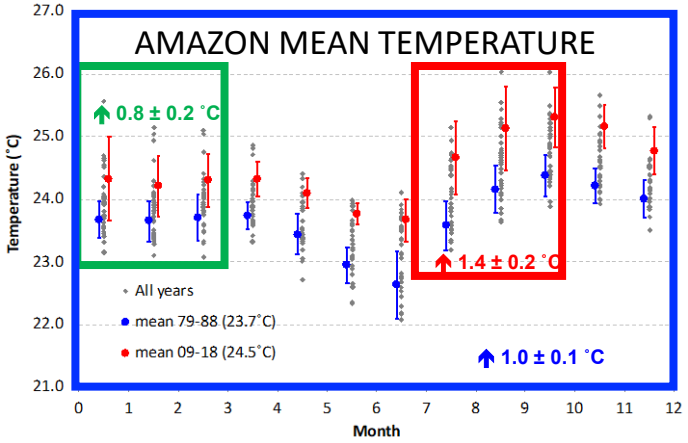


S11:50:00 O53:02:30

52 de 203228 Focos, nesta tela, entre 2010-08-01 00:00:00 - 2010-10-01 23:59:59 GMT
Obs: na tela só estão sendo mostrados 20000 focos
Em 22/agosto/2011, O CPTEC/INPE mudou o satélite de referencia para contabilização das queimadas para o AQUA-UMD - Tarde, veja detalhes

= NOAA-15; = NOAA-15D; = NOAA-12; = NOAA-12D; = NOAA-14;
= NOAA-16; = NOAA-16N; = NOAA-17; = NOAA-18D; = NOAA-18;
= NOAA-19D; = NOAA-19; = GOES-08; = GOES-10; = GOES-12;
= GOES-13; = AQUA-T; = AQUA-M; = TERRA-T; = TERRA-M;
= METEOSAT-02; = AQUA_M-M; = AQUA_M-T; = TERRA_M-M; = TERRA_M-T;
= AQUA-MEX; = TERRA-MEX; = ATSR; = TRMM;

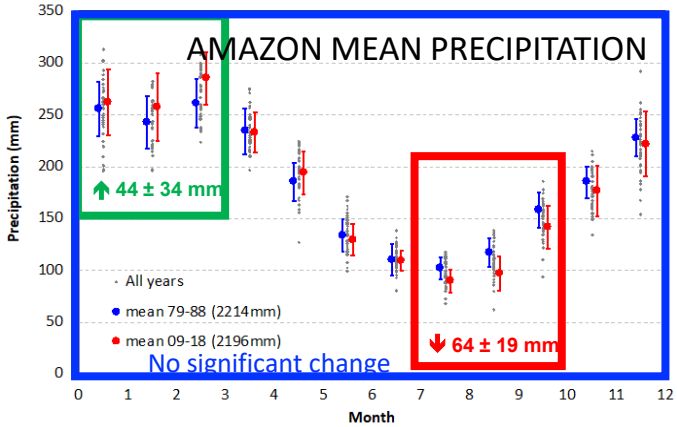
Exportar Focos: Tela/Screen/Pantalla (Html) Ok



https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels-monthly-means?tab=form

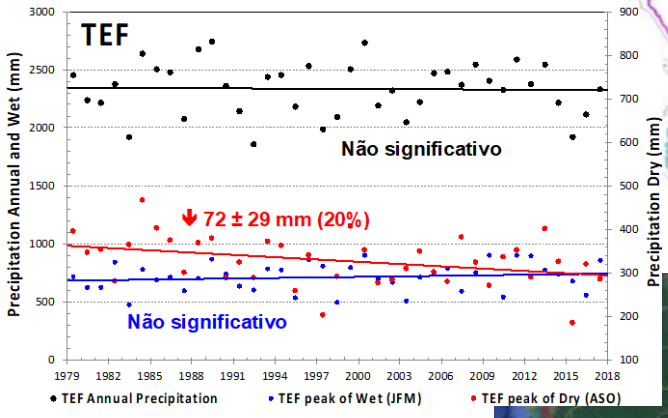
Amazon 7.25 x 10^6 km^2

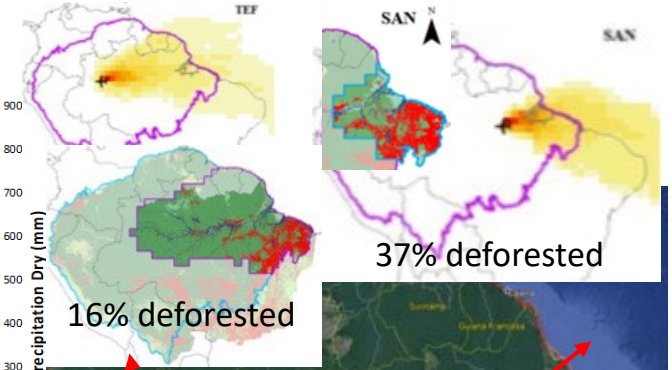
17% deforest until dez 2018

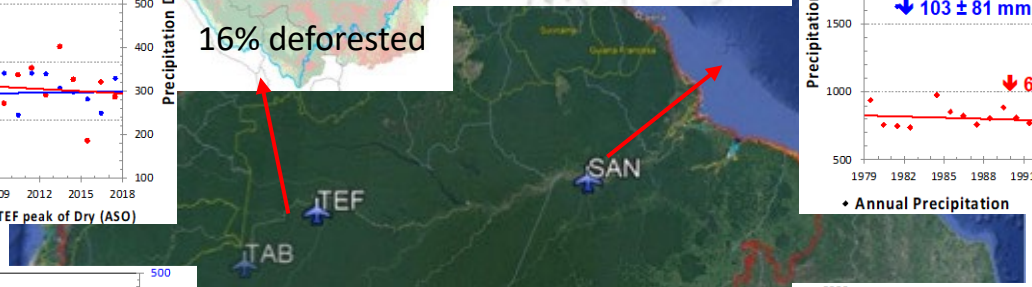


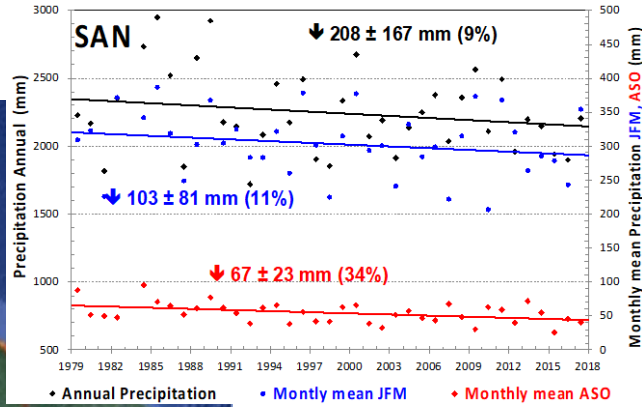
https://climatedataguide.ucar.edu/climate-data/gpcp-monthly-global-precipitation-climatology-project

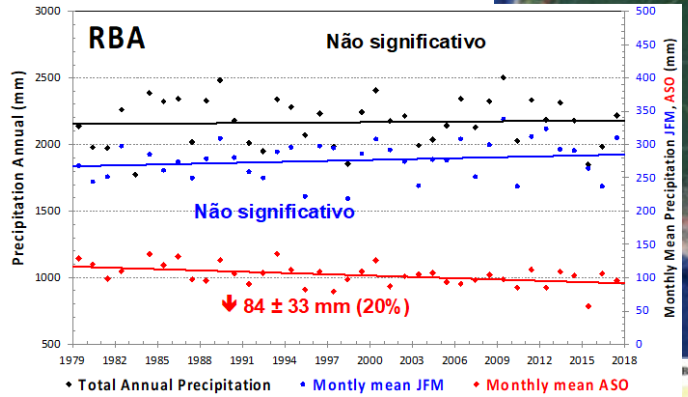
↓ Precipitation ASO

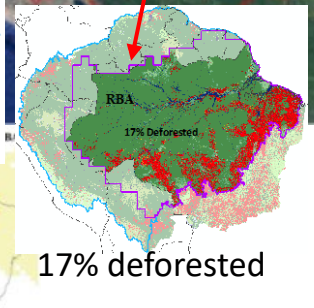


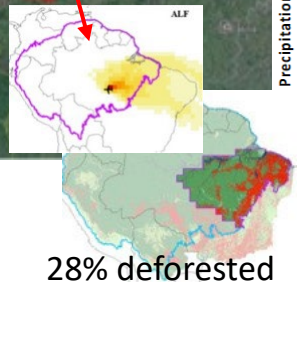


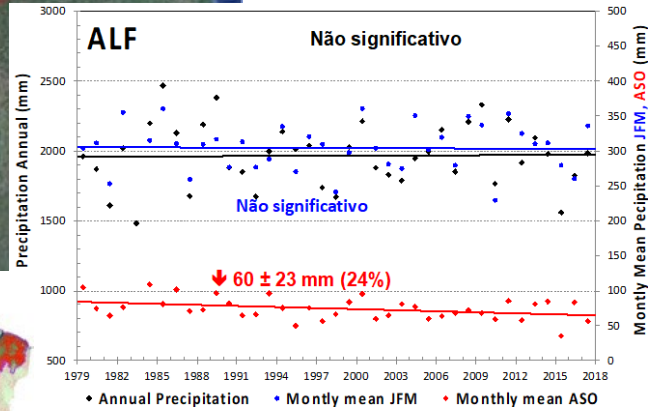


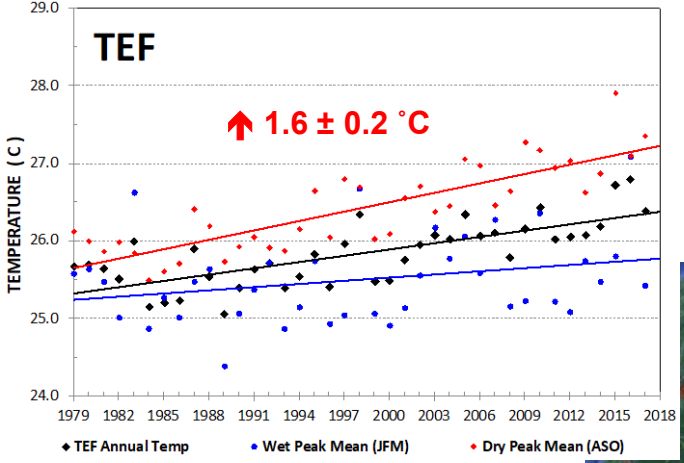




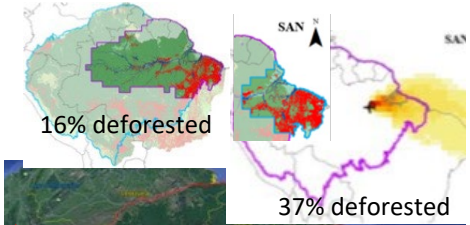


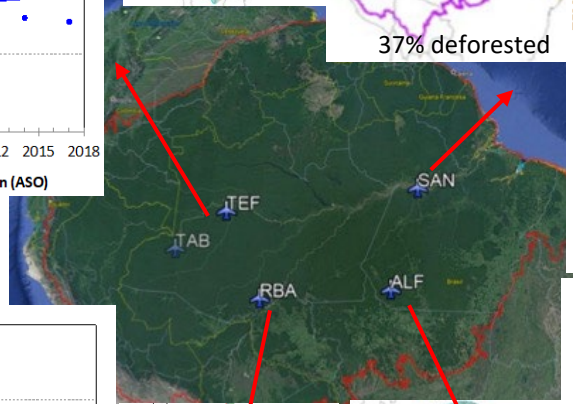


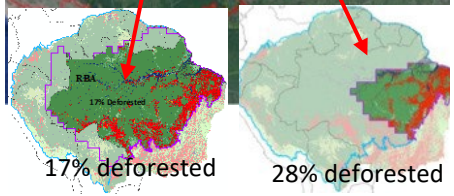


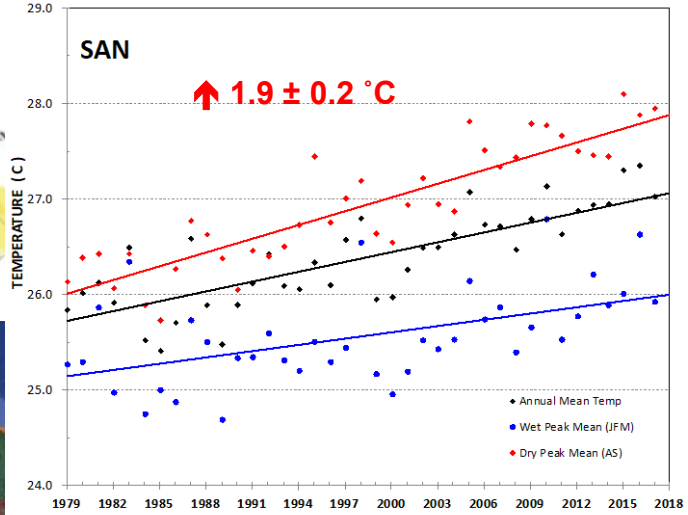


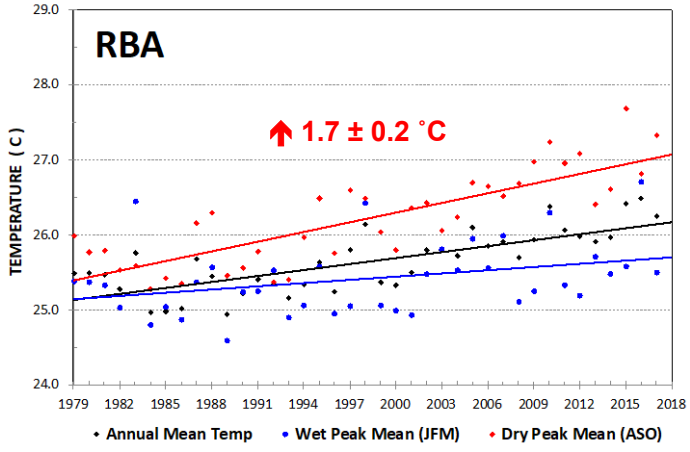
Temperature ASO

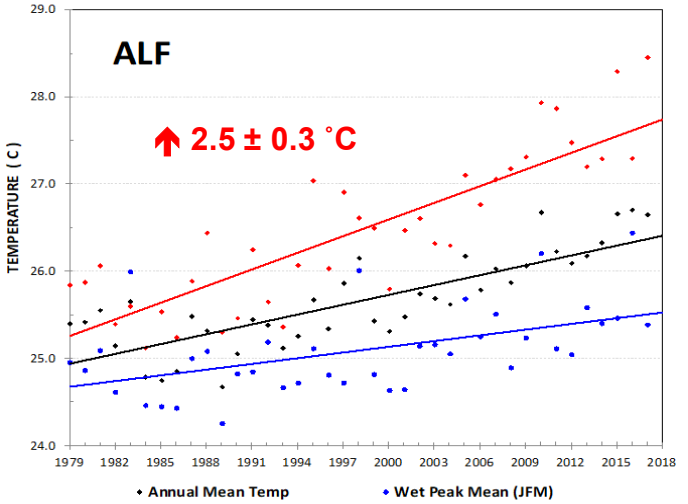


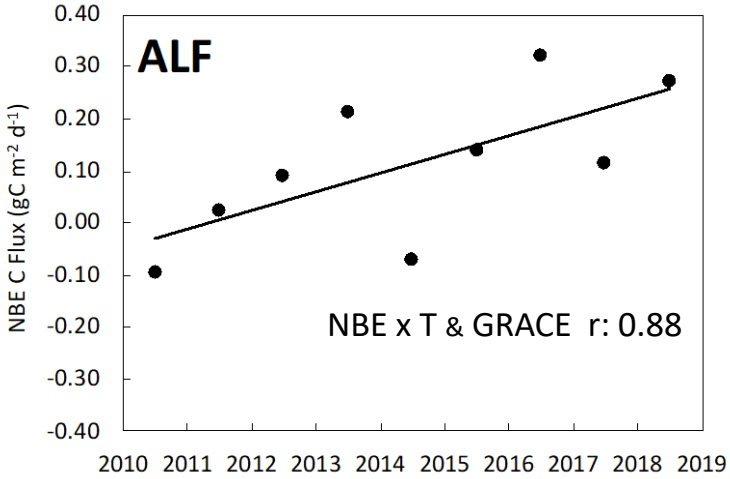


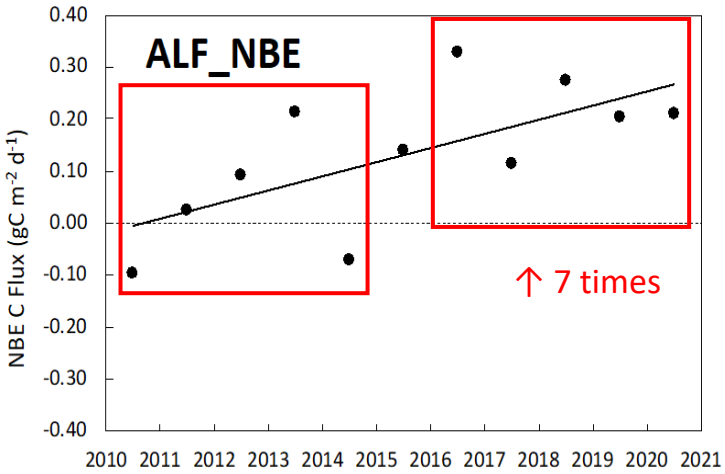






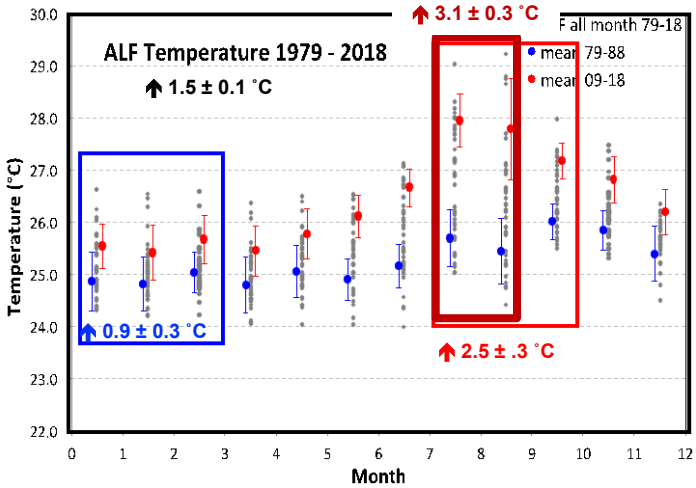




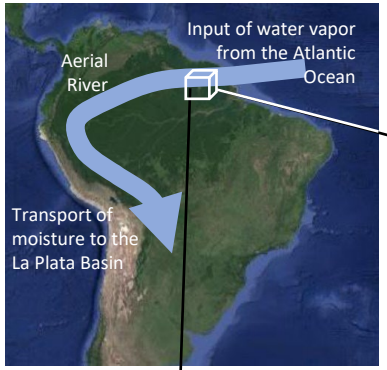


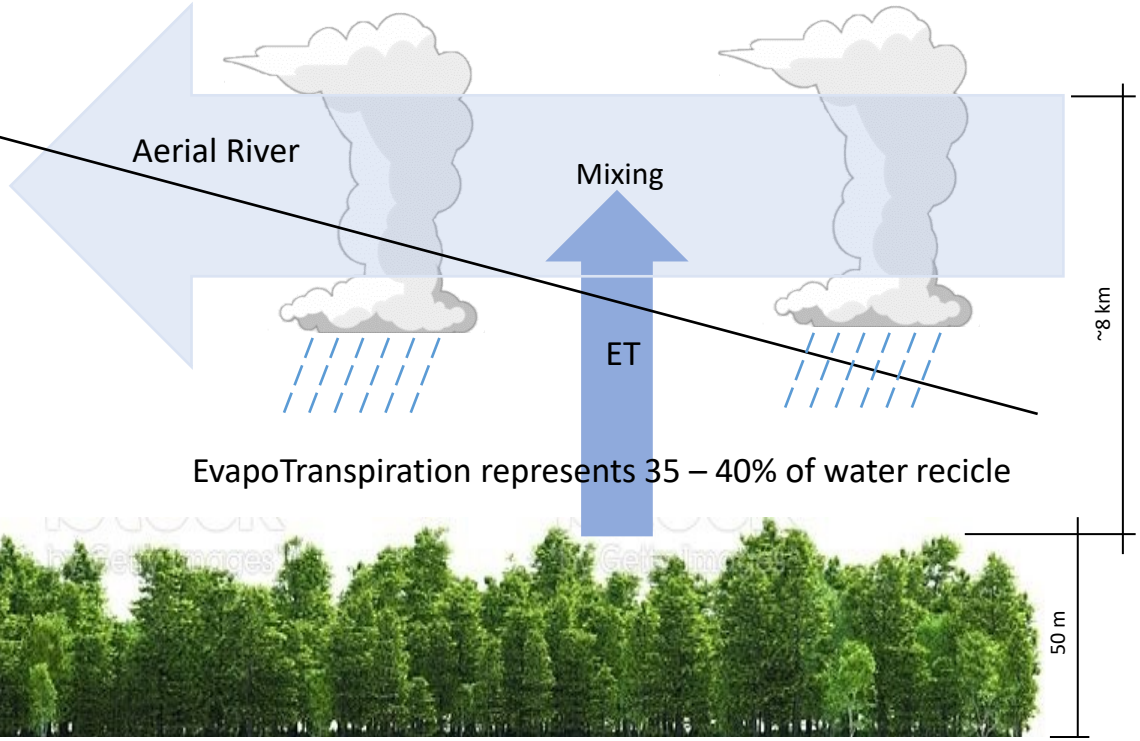
New results

Temperature and water in the soil have a significant impact



	NBE	C FIRE	Total C Flux
2010-2014	0.03	0.20	0.24
2016-2020	0.23	0.21	0.44





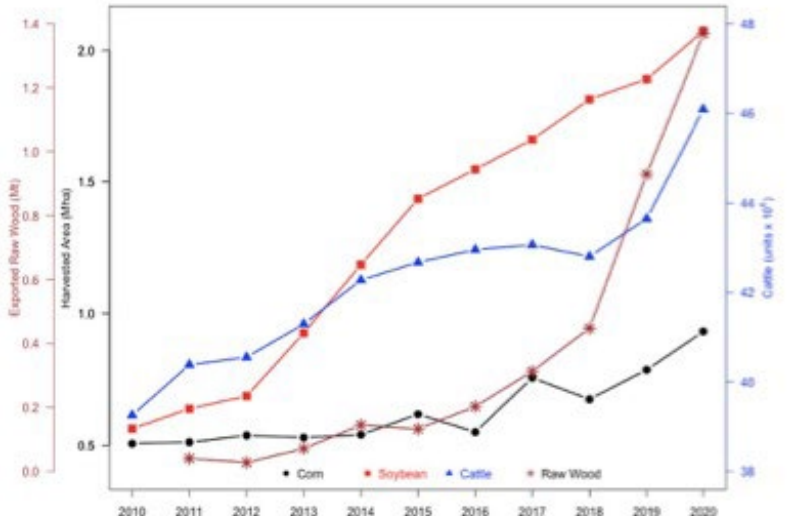
Science Panel for the Amazon (SPA) WG3 / CHAPTER 7 - Biosphere-Atmosphere Interactions

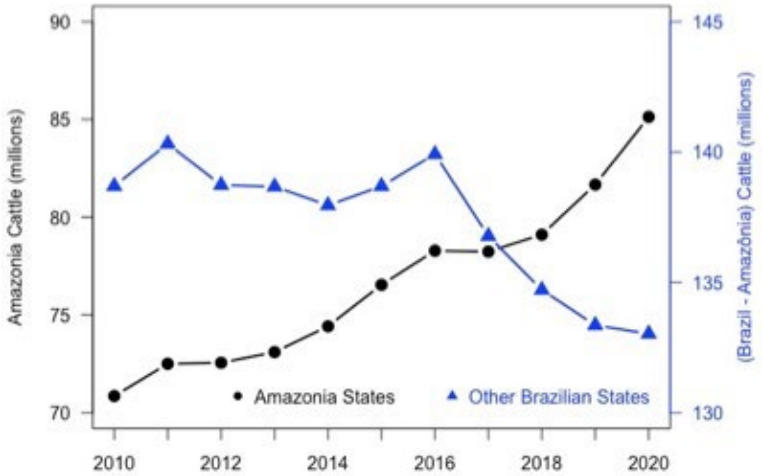
Lead Authors: Marcos H. Costa & Luciana V. Gatti

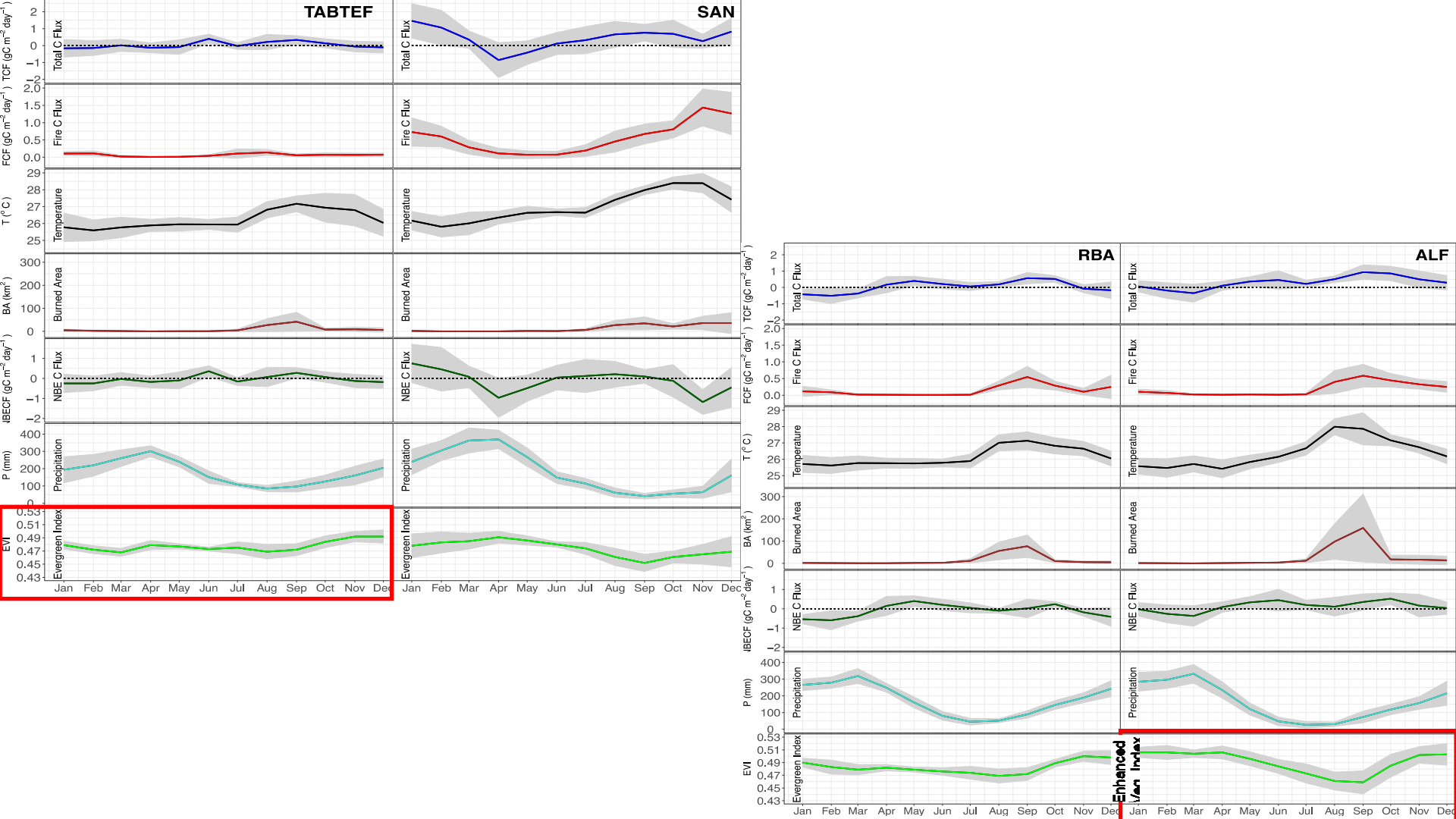
36% of Brazil total cattle

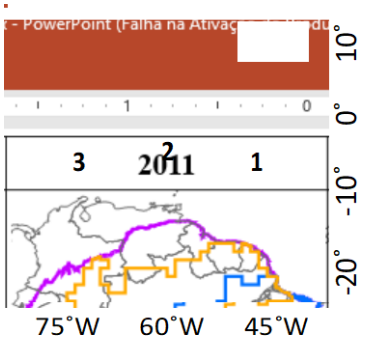
.944
Pará

29.858.399
Mato Grosso



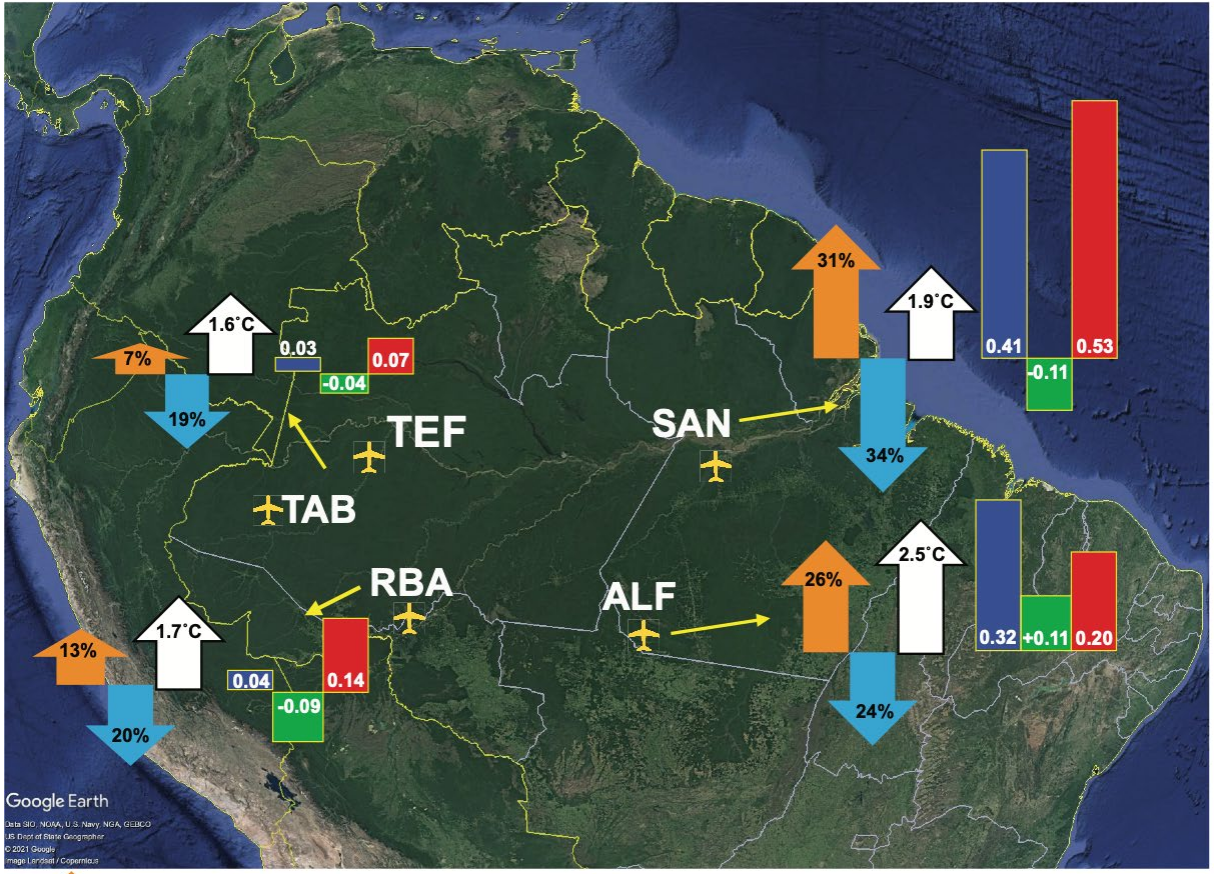



TABTEF
SAN
RBA
ALF
TCF (gC m-2 day-1)
FCF (gC m-2 day-1)
T (°C)
BA (km2)
NBE (gC m-2 day-1)
P (mm)
EVI
Total C Flux
Fire C Flux
Temperature
Burned Area
NBE C Flux
Precipitation
Evergreen Index
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



gC/m²/dia	Amazon Total Region	West side Amazon (2,3)	East side Amazon (1)
		11% deforested	27% deforested
Total	0.11±0.16	0.04±0.12	0.35±0.22
NBE	-0.04±0.15	-0.07±0.12	0.04±0.21
Fire	0.15±0.07	0.11±0.05	0.31±0.10

Amazon Carbon Balance (7,256,362 km^2)	**Amazon Forest total Area**
Total C Balance (PgC y^{-1})	0.29 ± 0.08
Fire C Balance (PgC y^{-1})	0.41 ± 0.02
NBE C Balance (PgC y^{-1})	-0.13 ± 0.08



Deforestation

Precipitation ASO

Temperature ASO

Total C Flux (gC m^{-2} d^{-1})

NBE C Flux (gC m^{-2} d^{-1})

FIRE C Flux (gC m^{-2} d^{-1})

Phillips and Brienen *Carbon Balance Manage* (2017) 12:1
DOI 10.1186/s13021-016-0069-2

Carbon Balance and Management

RESEARCH Open Access

Carbon uptake by mature Amazon forests has mitigated Amazon nations' carbon emissions

Oliver L. Phillips*†, Roel J. W. Brienen† and the RAINFOR collaboration

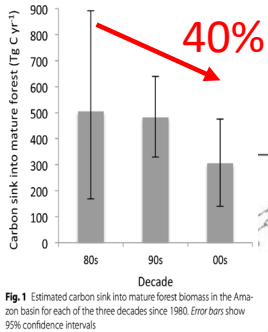
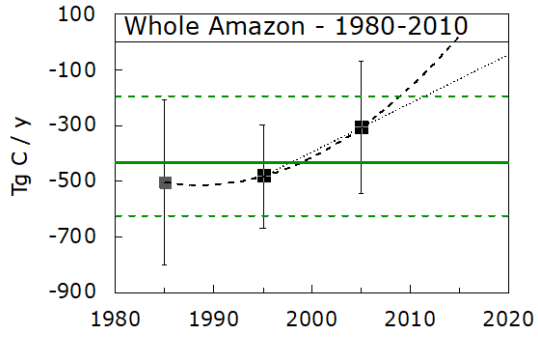
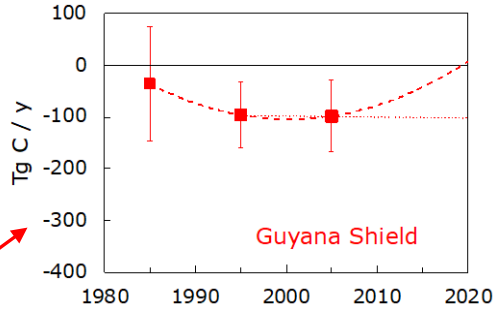
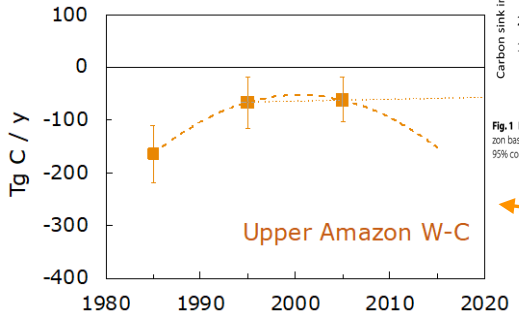


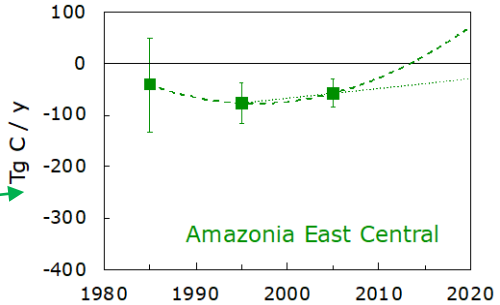
Fig. 1 Estimated carbon sink into mature forest biomass in the Amazon basin for each of the three decades since 1980. *Error bars* show 95% confidence intervals

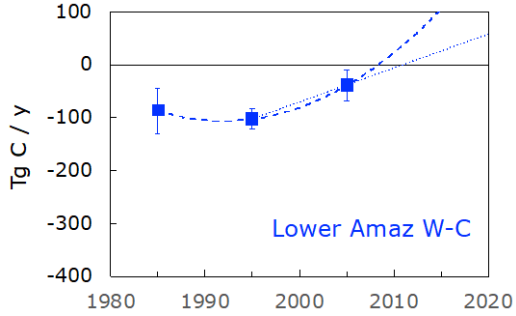
40%

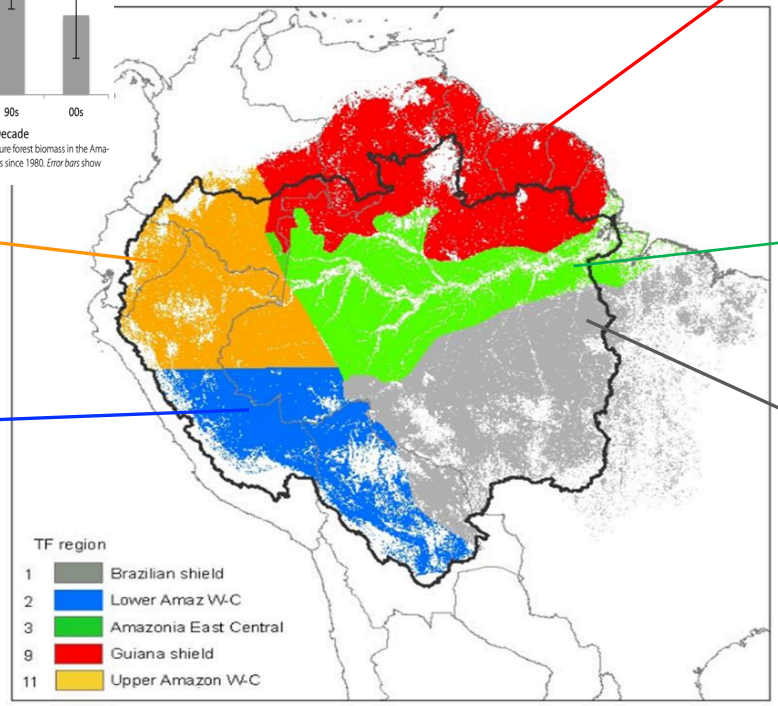


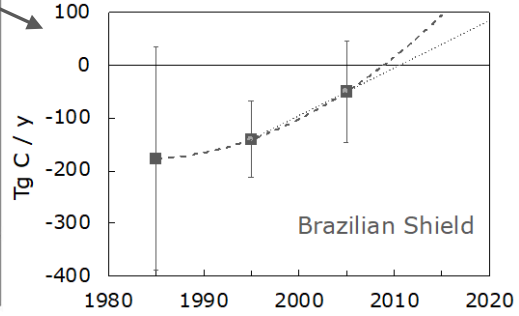












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ARTICLE

https://doi.org/10.1038/s41467-020-18996-3 OPEN

Tree mode of death and mortality risk factors across Amazon forests

Adriane Esquivel-Muelbert et al.#

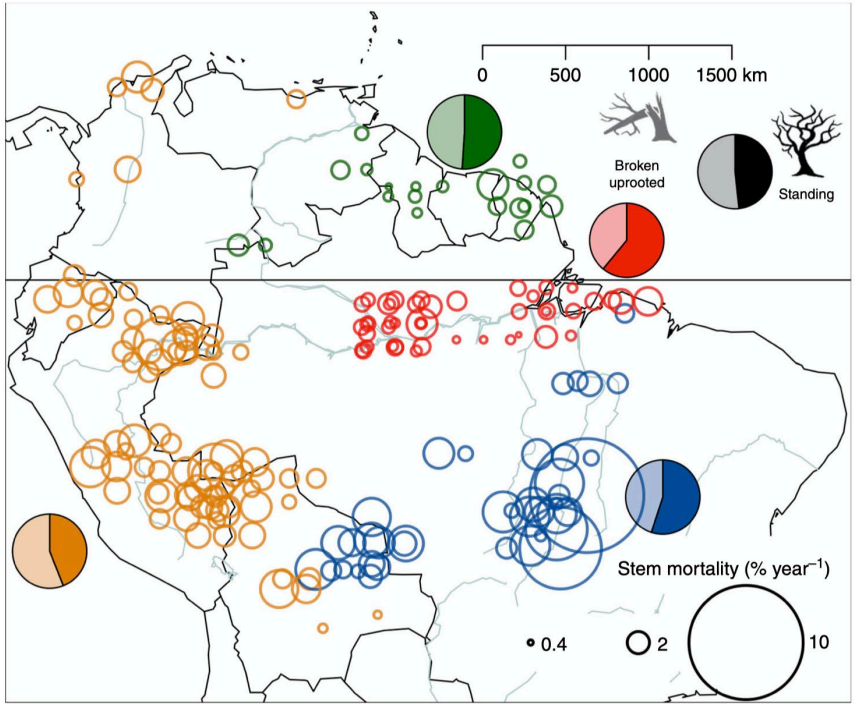
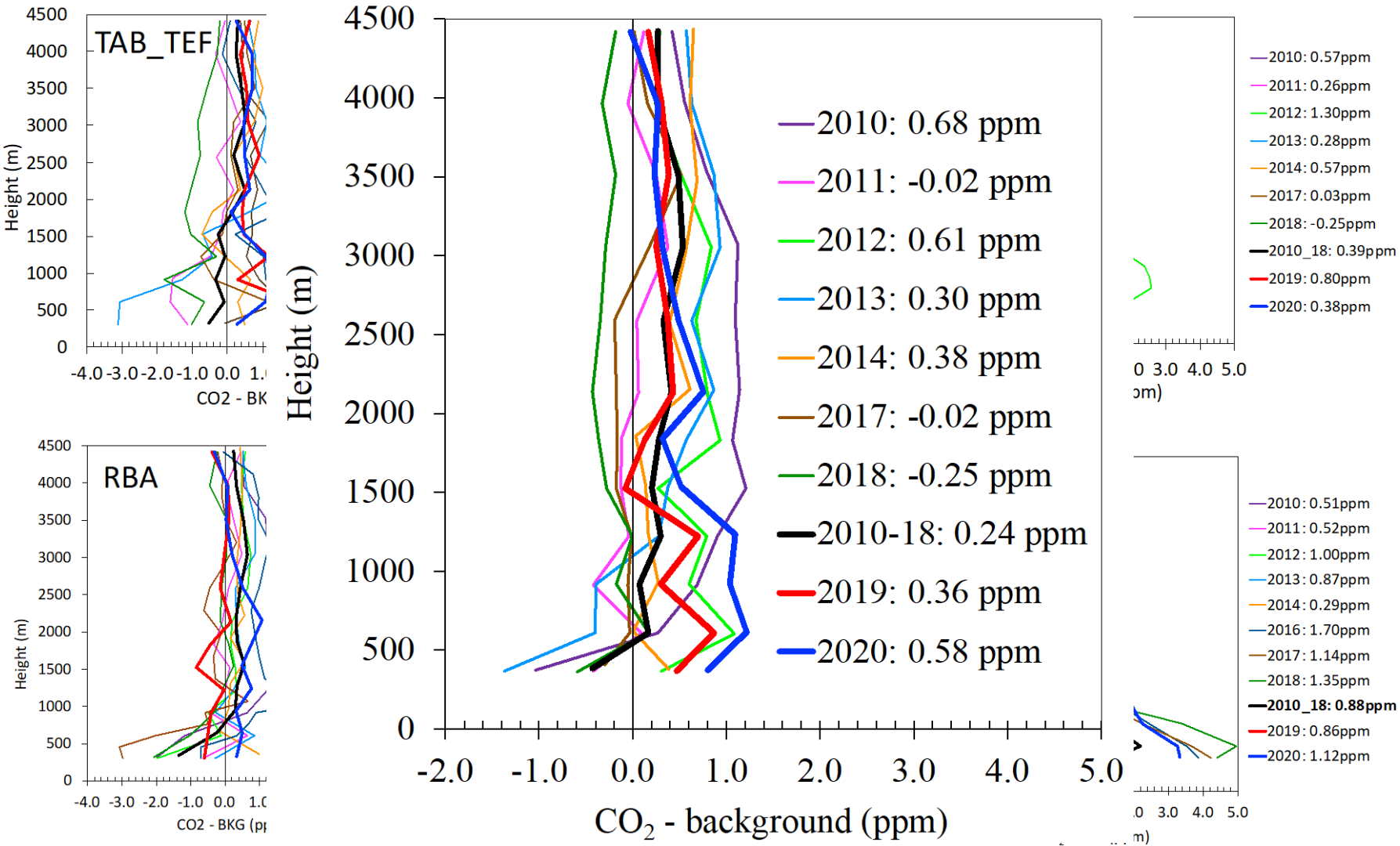
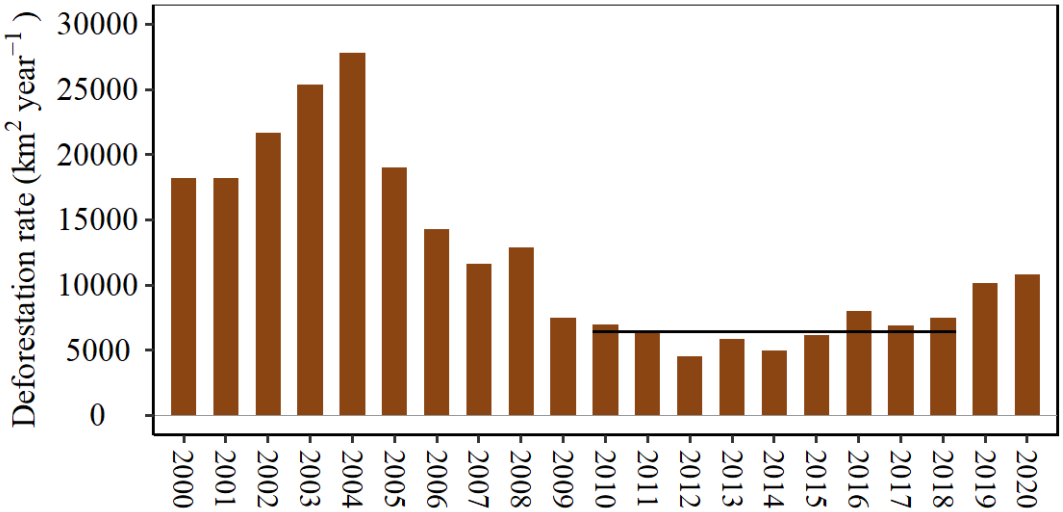


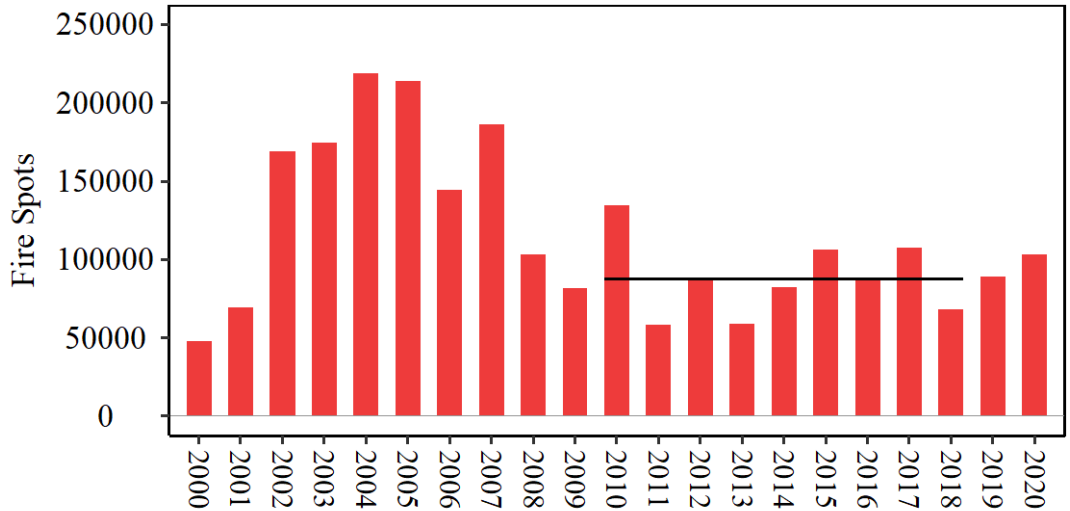
Fig. 1 Tree mortality rates and mode of death across Amazonia and adjacent lowland forests. Circles show the mean mortality rate across the entire time series available for each plot (% year^{-1}). Pie charts show the proportion of dead trees found standing (darker shading) and broken/uprooted (paler shading). Different colours represent the four geological regions: Northern (green), East-Central (red), Western (yellow) and Southern (blue). Mortality rates per plot were calculated as the mean value across all censuses weighted by the census-interval length.


TAB_TEF
Height (m)
CO2 - BK
RBA
Height (m)
CO2 - BKG (pp
Height (m)
CO_2 - background (ppm)
2010: 0.68 ppm
2011: -0.02 ppm
2012: 0.61 ppm
2013: 0.30 ppm
2014: 0.38 ppm
2017: -0.02 ppm
2018: -0.25 ppm
2010-18: 0.24 ppm
2019: 0.36 ppm
2020: 0.58 ppm
2010: 0.57ppm
2011: 0.26ppm
2012: 1.30ppm
2013: 0.28ppm
2014: 0.57ppm
2017: 0.03ppm
2018: -0.25ppm
2010_18: 0.39ppm
2019: 0.80ppm
2020: 0.38ppm
2010: 0.51ppm
2011: 0.52ppm
2012: 1.00ppm
2013: 0.87ppm
2014: 0.29ppm
2016: 1.70ppm
2017: 1.14ppm
2018: 1.35ppm
2010_18: 0.88ppm
2019: 0.86ppm
2020: 1.12ppm



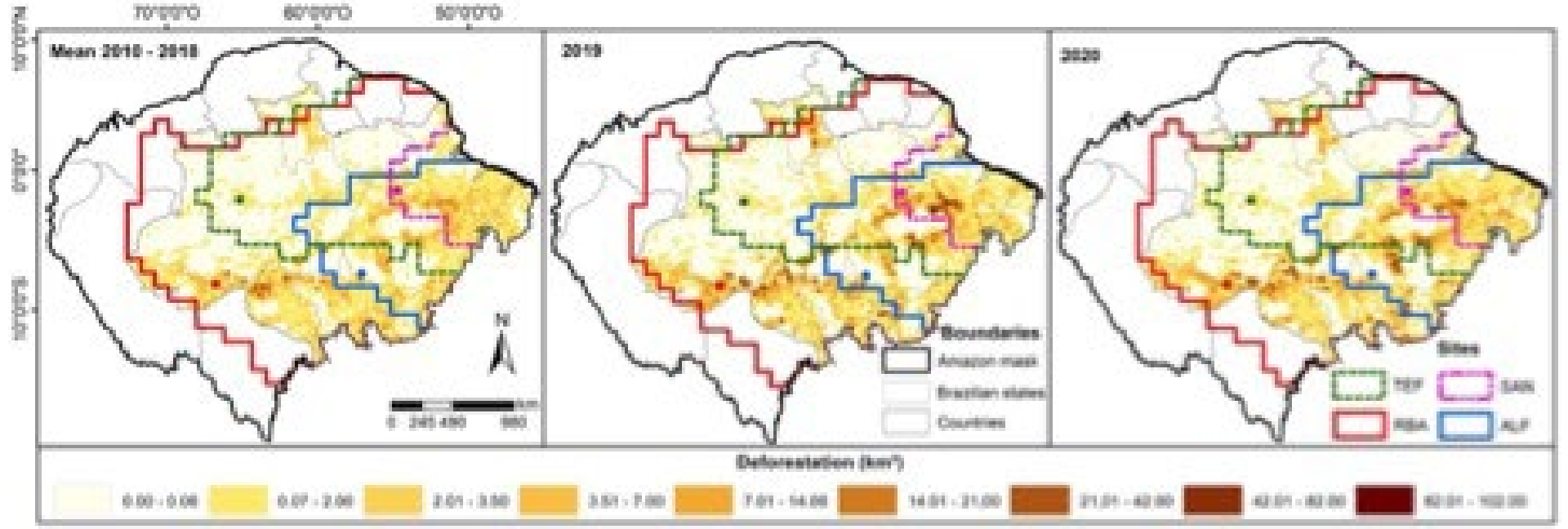
2019 ↑ 58%

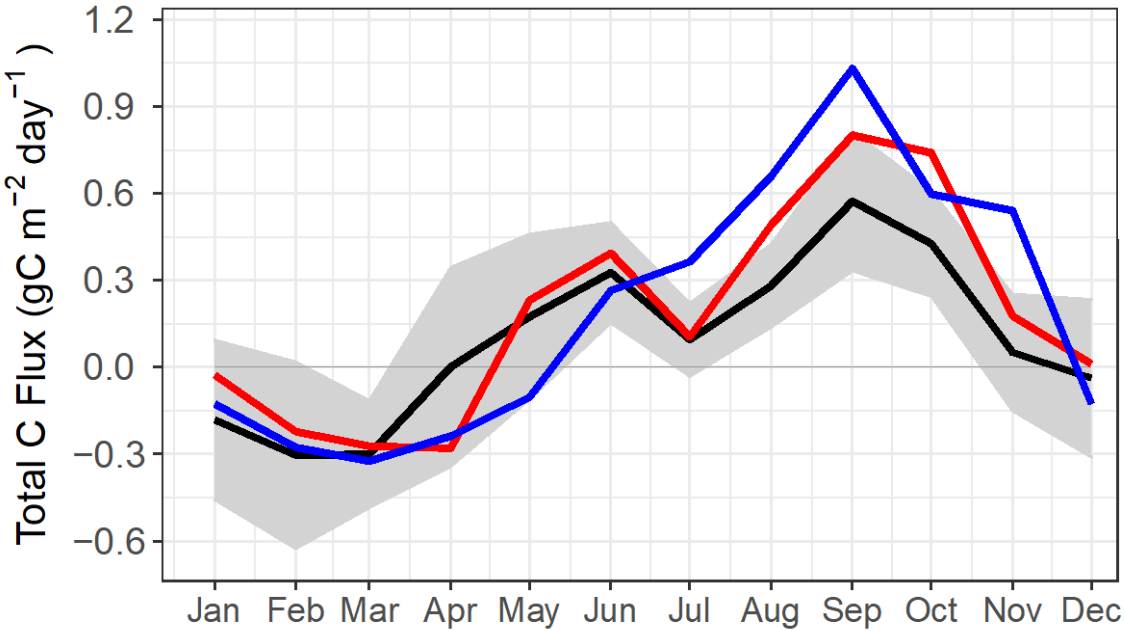
2020 ↑ 69%

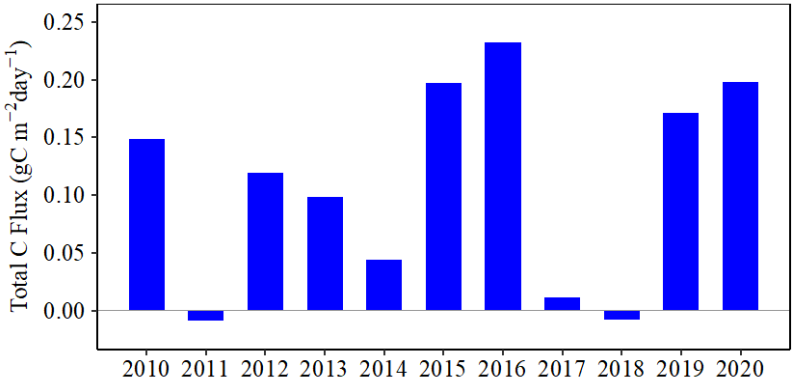


2019 - %

2020 ↑ 17%


70°0'0"O
60°0'0"O
50°0'0"O
10°0'0"S
0°0'0"
10°0'0"N
Mean 2018 - 2019
2019
2020
N
0 245 490 980
Boundaries
Amazon mask
Brazilian states
Countries
Sites
TEF
SAN
RBA
ALP
Deforestation (km²)
0.00 - 0.06
0.07 - 2.00
2.01 - 3.50
3.51 - 7.00
7.01 - 14.00
14.01 - 21.00
21.01 - 42.00
42.01 - 82.00
82.01 - 102.00





2010-18

gC/m²/dia	Amazonia	2019	2020
Total	0.09	0.17 (84%)	0.20 (120%)
NBE	-0.06	+ 0.01	+ 0.05
Fire	0.15	0.16	0.16

Pg C / y	Amazonia	2019	2020
Total	0.25	0.44	0.52
NBE	-0.15	0.02	0.12
Fire	0.40	0.41	0.40

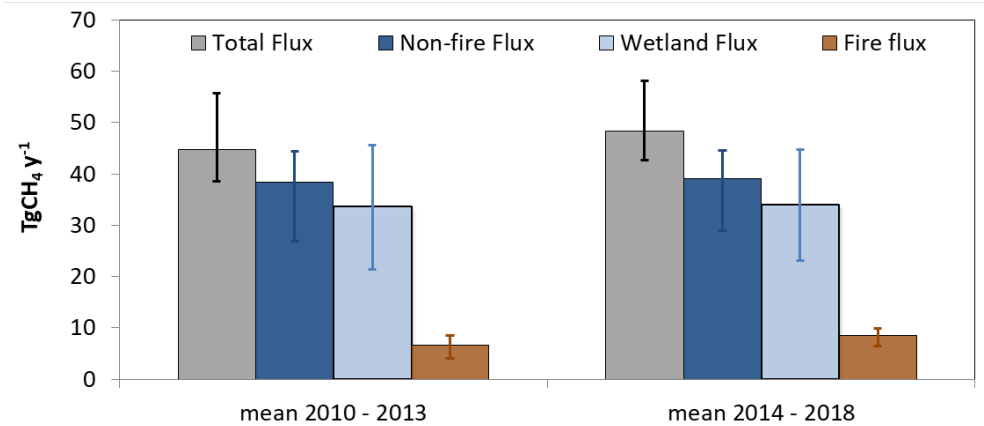
Amazon annual mean emission 2010-2018 ($TgCH_4\ y^{-1}$)

8% of global total emissions → F_{CH4}: 46,2 ± 10,3

$F_{NON\text{-}FIRE\_CH4}$: 38,8 ± 10,7

23% of global wetland emissions → F_{WET_CH4}: 33,8 ± 7,6

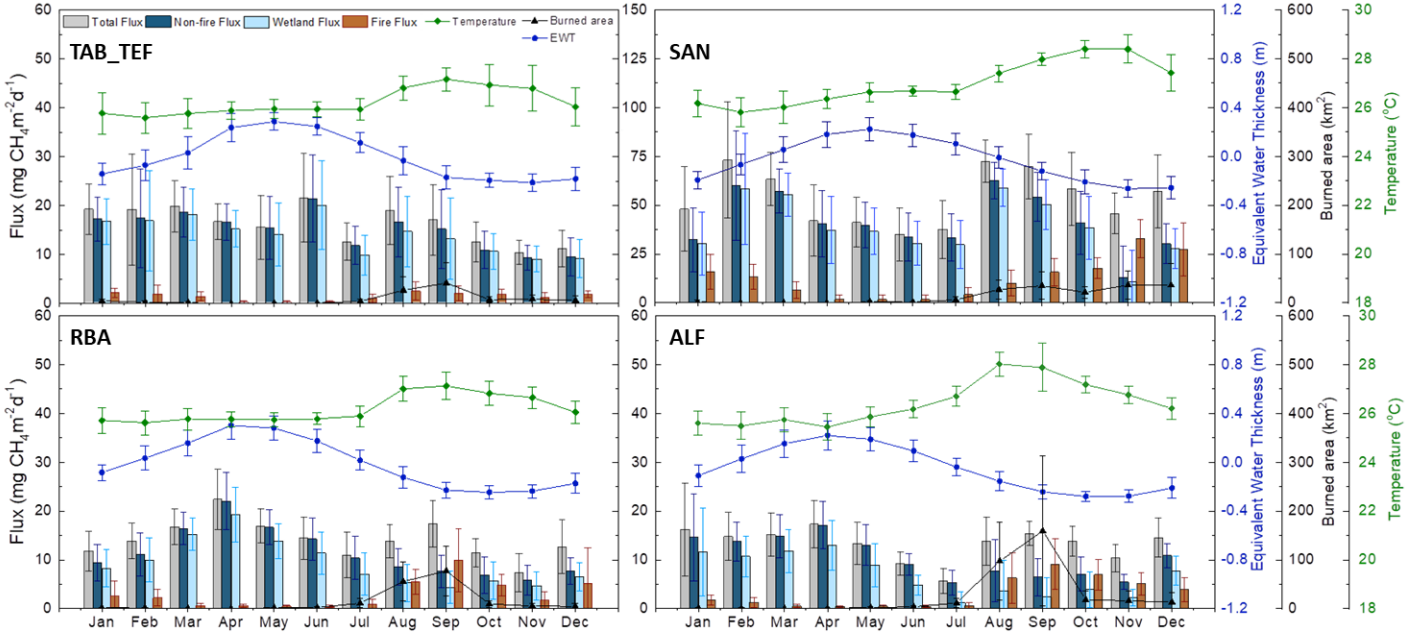
45% of biomass burning global emissions → F_{FIRE_CH4}: 7,7 ± 1,6



- Non-fire sources – mainly wetlands - dominate emissions (biomass burning contribution ~17%)

- No significant emission trend over the period from 2010-2018 based on vertical profile data (Basso et al. 2021)

Comparison of magnitude and seasonality of fluxes



- northwest-central region: nearly a-seasonal consistent with weak precipitation seasonality
- southern regions: strongly seasonal synchronously with equivalent water thickness
- northeast region: double-peak emissions - causes unclear
- Distinct east-west contrast with an emission peak in the northeast
    - cause not fully understood

(Basso et al. 2021)

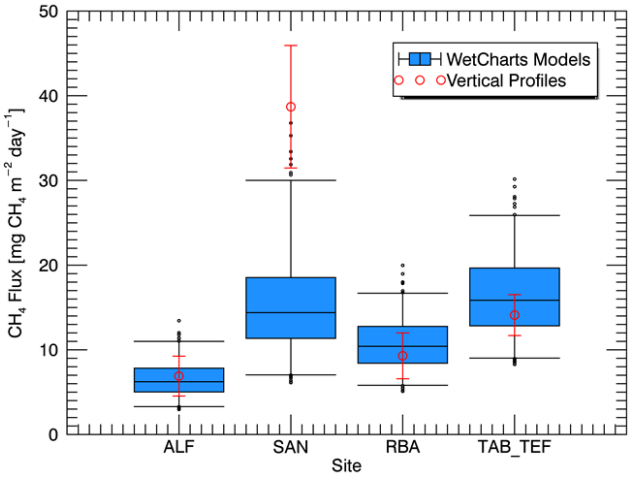
Comparison with wetland model predictions

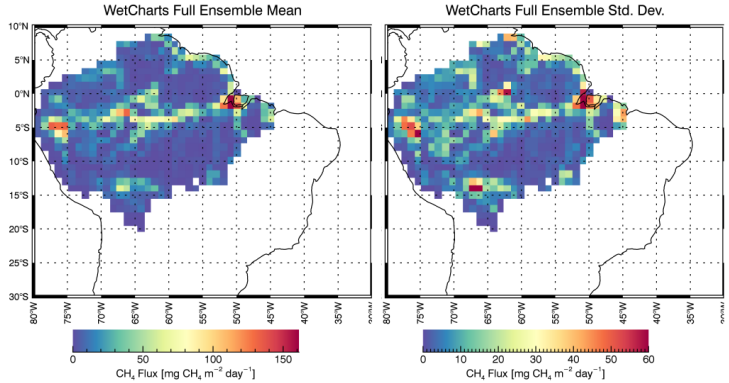
A global wetland methane emissions and uncertainty dataset for atmospheric chemical transport models (WetCHARTs version 1.0)

A. Anthony Bloom[1], Kevin W. Bowman[1], Meemong Lee[1], Alexander J. Turner[2], Ronny Schroeder[3], John R. Worden[1], Richard Weidner[1], Kyle C. McDonald[1,3], and Daniel J. Jacob[2]

For Amazon area (7.2 millions km^2)

- annual WetCharts wetland emissions: 39.4±10.3 TgCH$_4$ y^{-1}
- our data-based approach 33.8±12.7 TgCH$_4$ y^{-1}



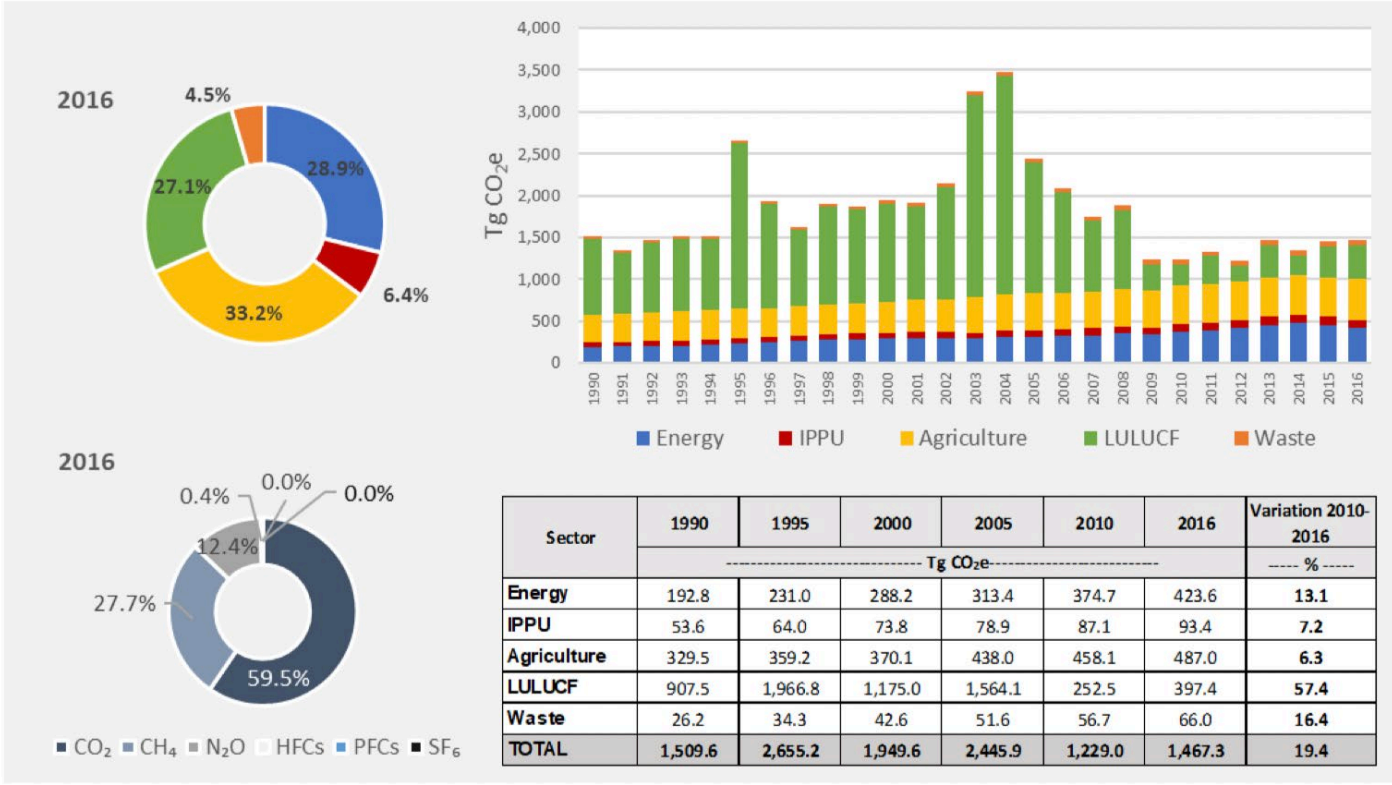


- Our wetland estimates were similar to fluxes from the WetCharts wetland model ensemble:
  - except for the SAN region:
    - WetCharts does show substantial emissions , but still just 40% of our estimates;

(Basso et al. 2021)

N_2O emissions in $TgN_2O\ year^{-1}$

	EPA, 2010 (Global)	Davidson & Kanter, 2014 (Global)	INPE(Amazon) Average	%
Total	18,8	18,9	2,43	13%
Natural	12,1	10,1	1,95 (BIO)	16 a 30%
Anthropic	6,7	8,8	0,47 (FIRE)	7 a 15%

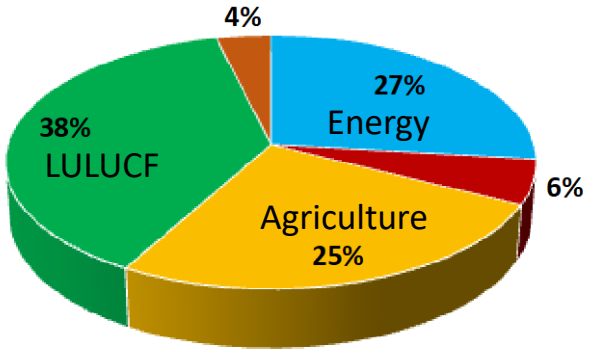


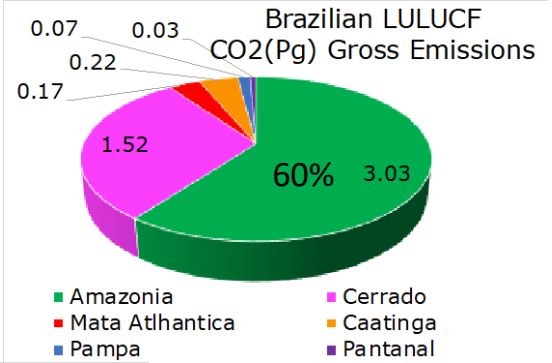
Sector	1990	1995	2000	2005	2010	2016	Variation 2010-2016
	Tg CO_2e						----- % -----
Energy	192.8	231.0	288.2	313.4	374.7	423.6	13.1
IPPU	53.6	64.0	73.8	78.9	87.1	93.4	7.2
Agriculture	329.5	359.2	370.1	438.0	458.1	487.0	6.3
LULUCF	907.5	1,966.8	1,175.0	1,564.1	252.5	397.4	57.4
Waste	26.2	34.3	42.6	51.6	56.7	66.0	16.4
TOTAL	1,509.6	2,655.2	1,949.6	2,445.9	1,229.0	1,467.3	19.4

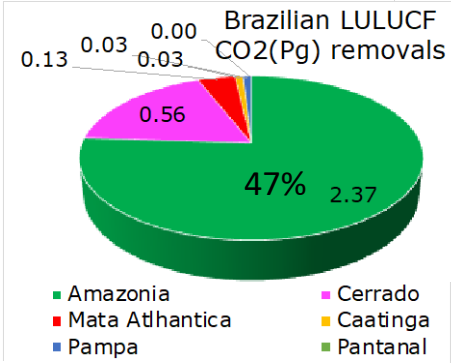
Figure 2.4. Total GHG emissions from 1990 to 2016 in Tg of CO_2e

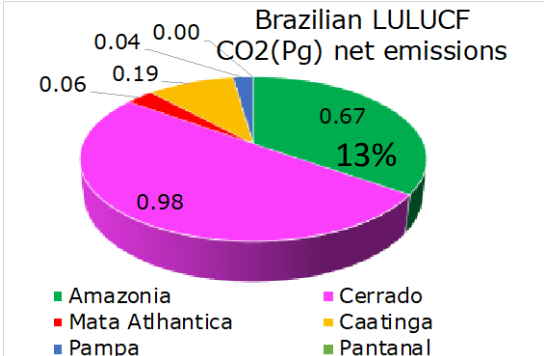
In 2016, Brazilian emissions were 873,272 Gg CO2; 19,333.2 Gg CH4, and 586.09 Gg N2O, which represented 59.5%, 27.7%, and 12.4% of the total Inventory in CO2e. Between 2010 and 2016, total CO2, CH4, and N2O emissions increased by 30.3%, 3.8%, and 10.7%, respectively.

IV National Communication from Brazil - Inventory (2010-2016)

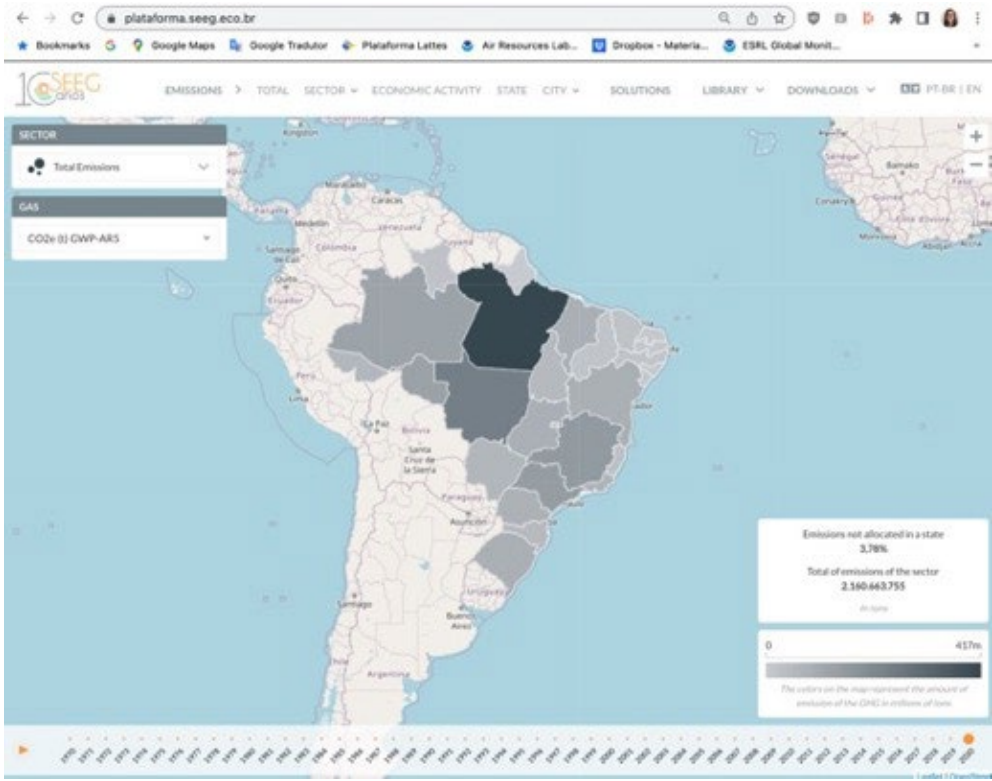








Pg CO2/y	IV Braz. Inv.	LaGEE/INPE	SEEG (Pg CO2 eq)
2010-2016	0.674	0.915	0.508
2016-2020		0.926	0.646
2010		0.964	0.407
2011		0.132	0.417
2012		1.082	0.414
2013		0.876	0.510
2014		0.335	0.502
2015		1.481	0.598
2016		1.535	0.705
2017		0.327	0.526
2018		0.219	0.570
2019		1.164	0.647
2020		1.387	0.783



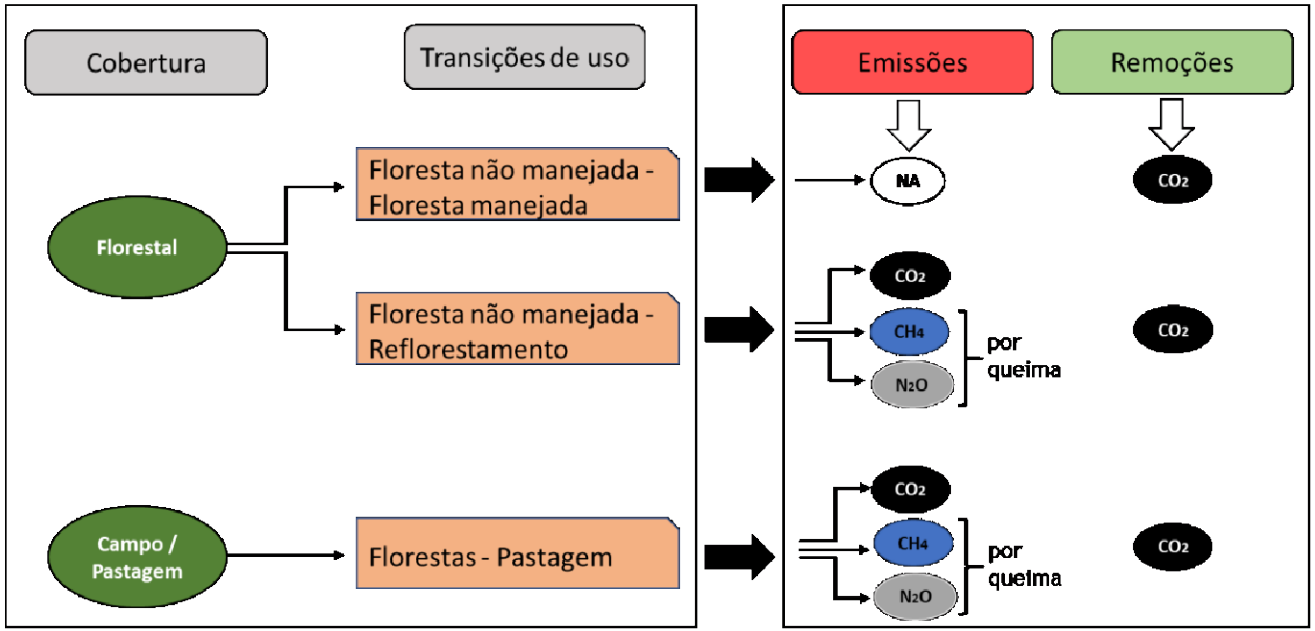


Figura 7. Exemplos de categorias, subcategorias e gases de GEE emitidos no setor LULUCF.

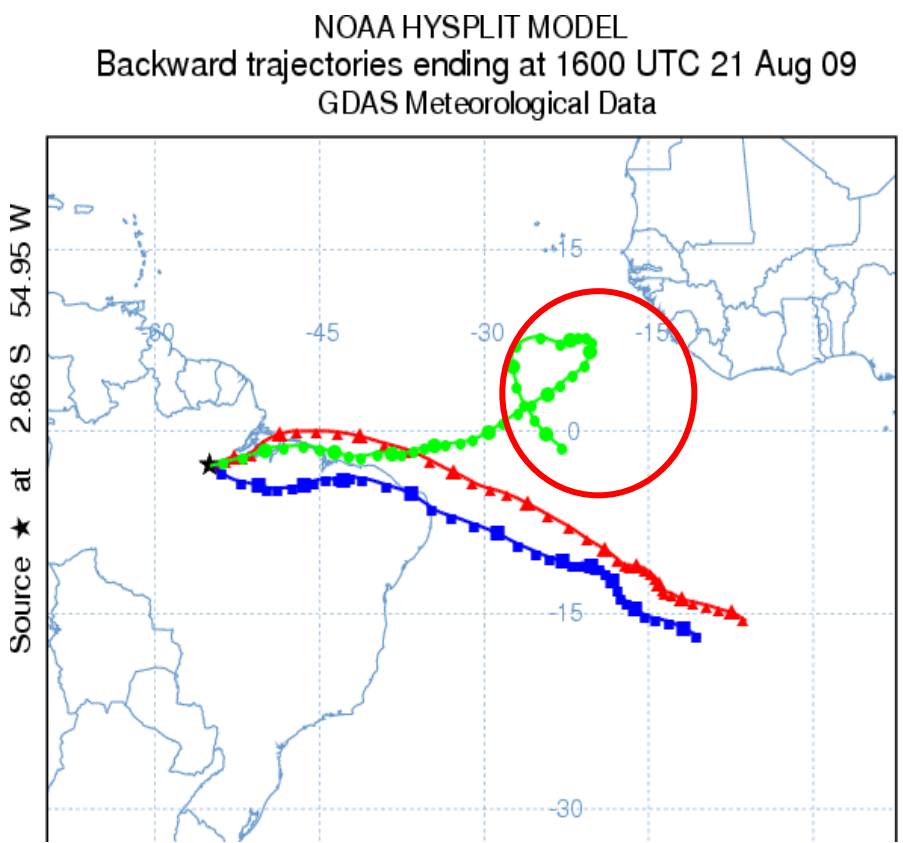
Conclusions

- The Amazon was and could continue to be our Climate Protection
    - Carbon Sink
    - Produce precipitation
        - Reduce temperature

- Deforesting the Amazon it becomes an acceleration of climate change
    - Carbon Source
    - Reduce dry season precipitation and and makes it longer
        - Increase temperature

Thank you

http://www.ccst.inpe.br/lagee/



ACKNOWLEDGEMENTS

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES
BRASIL GOVERNO FEDERAL
CAPES
FAPESP
CNPq
NASA
HORIZON 2020
NATURAL ENVIRONMENT RESEARCH COUNCIL
SEVENTH FRAMEWORK PROGRAMME
ipen
NOAA
UNIVERSITY OF LEEDS
INPE
university of groningen