MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

A importância de realizarmos medidas diretas de Gases de Efeito Estufa

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LaGEE

WEATHER CLIMATE WATER

WORLD METEOROLOGICAL ORGANIZATION | GLOBAL ATMOSPHERE WATCH

WMO GREENHOUSE GAS BULLETIN

The State of Greenhouse Gases in the Atmosphere
Based on Global Observations through 2022

Table. Global annual surface mean abundances (2023) and trends of key greenhouse gases from the GAW in situ observational network for GHG. Units are concentrations in dry-air, and uncertainties are 68% confidence limits. The averaging method is described in GAW Report No. 184 [2].

	CO_2	CH_4	N_2O
2023 global mean abundance	420.0±0.1 ppm	1934±2 ppb	336.9±0.1 ppb
2023 abundance relative to 1750[a]	151%	265%	125%
2022–2023 absolute increase	2.3 ppm	11 ppb	1.1 ppb
2022–2023 relative increase	0.55%	0.57%	0.33%
Mean annual absolute increase over the past 10 years	2.4 ppm yr^{-1}	10.7 ppb yr^{-1}	1.07 ppb yr^{-1}

[a] Assuming a pre-industrial concentration of 278.3 ppm for CO_2, 729.2 ppb for CH_4 and 270.1 ppb for N_2O. The number of stations used for the analyses was 146 for CO_2, 153 for CH_4 and 112 for N_2O.

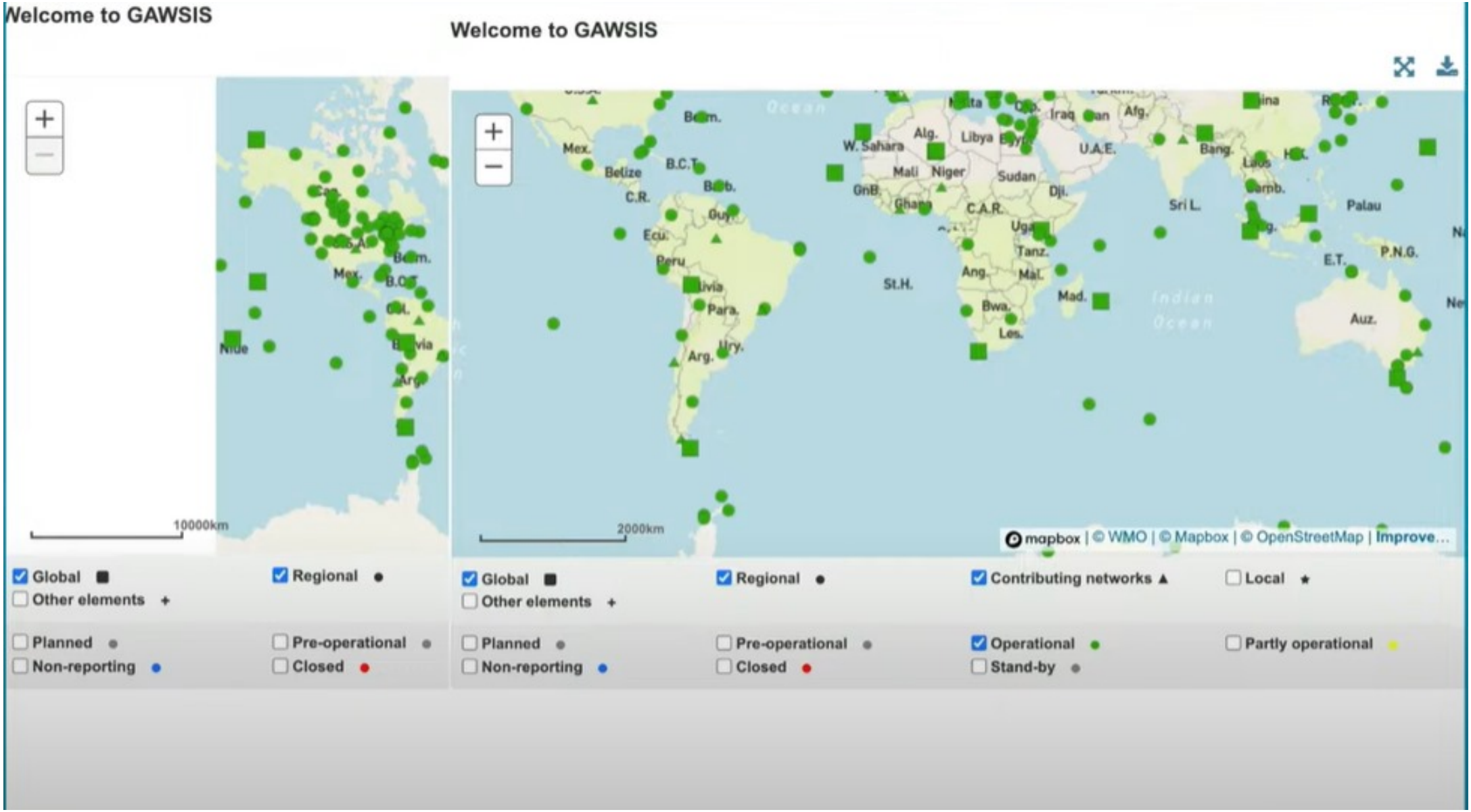
30 GAW Global stations

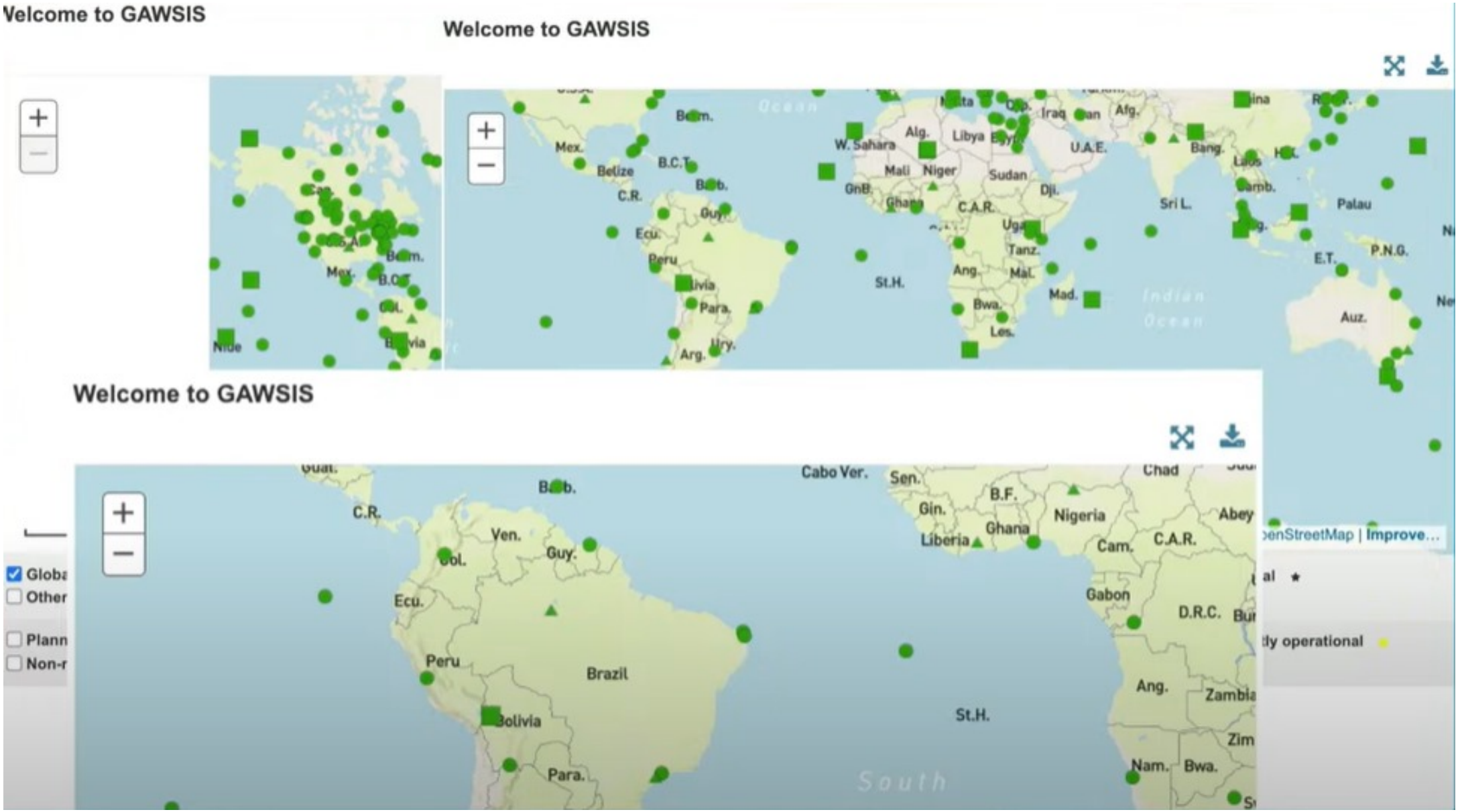
+ 400 Contributing Stations

Welcome to GAWSIS

- [x] Global ■
- [x] Regional ●
- [x] Contributing networks ▲
- [ ] Local ★
- [ ] Other elements +

- [ ] Planned ●
- [ ] Pre-operational ●
- [x] Operational ●
- [ ] Partly operationa
- [ ] Non-reporting ●
- [ ] Closed ●
- [ ] Stand-by ●


Welcome to GAWSIS
Welcome to GAWSIS
10000km
2000km
mapbox | © WMO | © Mapbox | © OpenStreetMap | Improve...
Global
Regional
Other elements
Planned
Pre-operational
Non-reporting
Closed
Global
Regional
Contributing networks
Local
Other elements
Planned
Pre-operational
Operational
Partly operational
Non-reporting
Closed
Stand-by


Welcome to GAWSIS
Welcome to GAWSIS
Welcome to GAWSIS
Mex.
Belize
C.R.
Ecu.
Peru
Para.
Arg.
W. Sahara
Alg.
Libya
Mali
Niger
Sudan
GnB.
Ghana
C.A.R.
U.A.E.
Afg.
Iraq
Bang.
Sri L.
Palau
P.N.G.
E.T.
Tanz.
Ang.
Mal.
Mad.
St.H.
Bwa.
Les.
Auz.
Indian Ocean
Cabo Ver.
Sen.
B.F.
Gin.
Liberia
Nigeria
Chad
Cam.
Gabon
D.R.C.
Ang.
Zambia
Zim
Nam.
Bwa.
St.H.
Ven.
Guy.
Col.
Brazil
Bolivia
Para.
South
Peru
Ecu.
C.R.
Abey
C.A.R.
penStreetMap | Improve...
operational

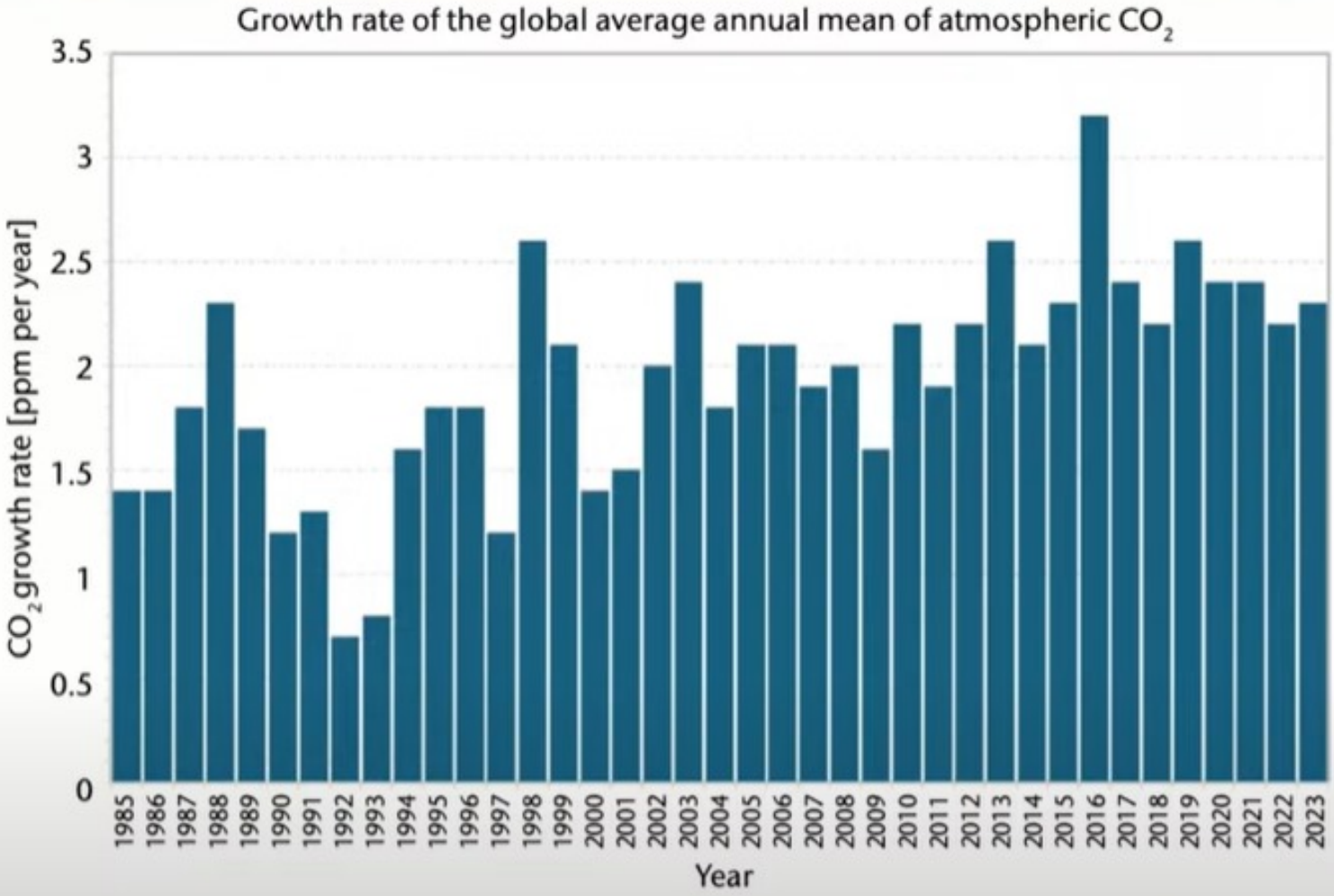


Figure 1. Growth rate of the annual global mean atmospheric CO_2, calculated from WMO GAW network observations for the period 1985–2023 following the method described in [2].

What is the uncertainty of the Southern Hemisphere average for CO2, CH4 and other GHGs?

How much Brazil could reduce this uncertainty?

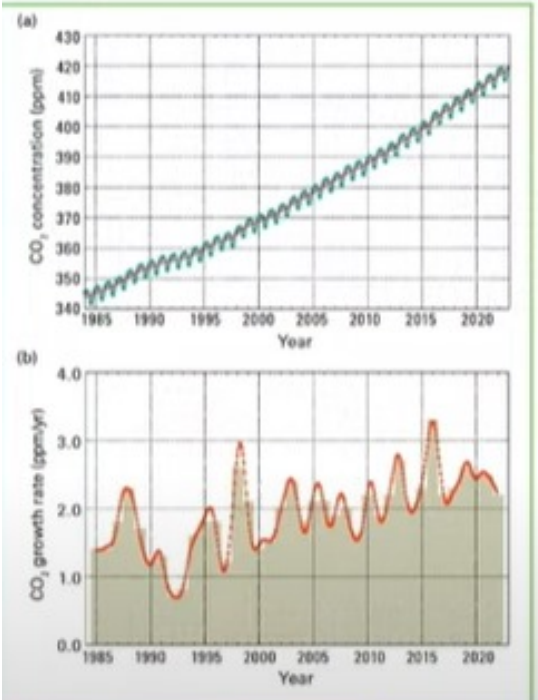


Figure 5. Globally averaged CO_2 concentration[1] (a) and its growth rate (b) from 1984 to 2022. Increases in successive annual means are shown as the shaded columns in (b). The red line in (a) is the monthly mean with the seasonal variation removed; the blue dots and blue line in (a) depict the monthly averages. Observations from 146 stations were used for this analysis.

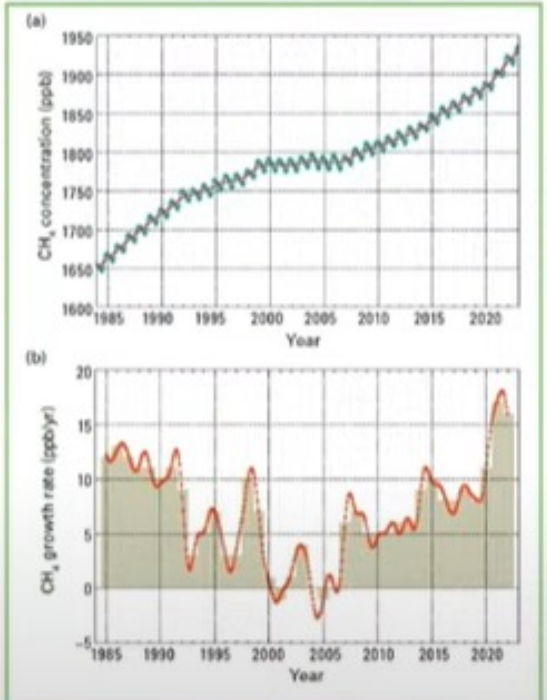


Figure 6. Globally averaged CH_4 concentration (a) and its growth rate (b) from 1984 to 2022. Increases in successive annual means are shown as the shaded columns in (b). The red line in (a) is the monthly mean with the seasonal variation removed; the blue dots and blue line in (a) depict the monthly averages. Observations from 151 stations were used for this analysis.

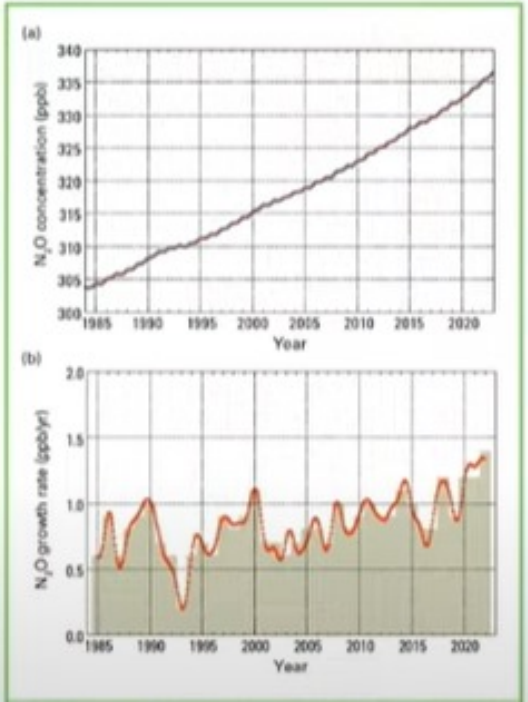


Figure 7. Globally averaged N_2O concentration (a) and its growth rate (b) from 1984 to 2022. Increases in successive annual means are shown as the shaded columns in (b). The red line in (a) is the monthly mean with the seasonal variation removed; in this plot, the red line overlaps the blue dots and blue line that depict the monthly averages. Observations from 109 stations were used for this analysis.

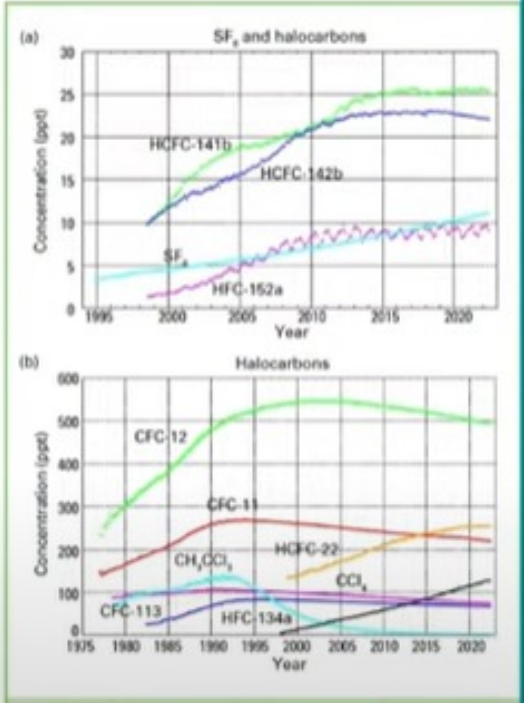


Figure 8. Monthly mean concentration of sulfur hexafluoride (SF_6) and the most important halocarbons: (a) SF_6 and lower halocarbon concentrations and (b) higher halocarbon concentrations. For each gas, the number of stations used for the analysis was as follows: SF_6 (88), CFC-11 (24), CFC-12 (26), CFC-113 (22), CCl_4 (23), CH_3CCl_3 (25), HCFC-141b (11), HCFC-142b (15), HCFC-22 (15), HFC-134a (12), HFC-152a (11).

21st WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases and Related Measurement Techniques (GGMT-2022)

Wageningen, The Netherlands 19-21 September 2022

Edited by Andrew Crotwell, Lin Huang, Peter Sperlich, and Felix Vogel

WORLD METEOROLOGICAL ORGANIZATION

GLOBAL ATMOSPHERE WATCH

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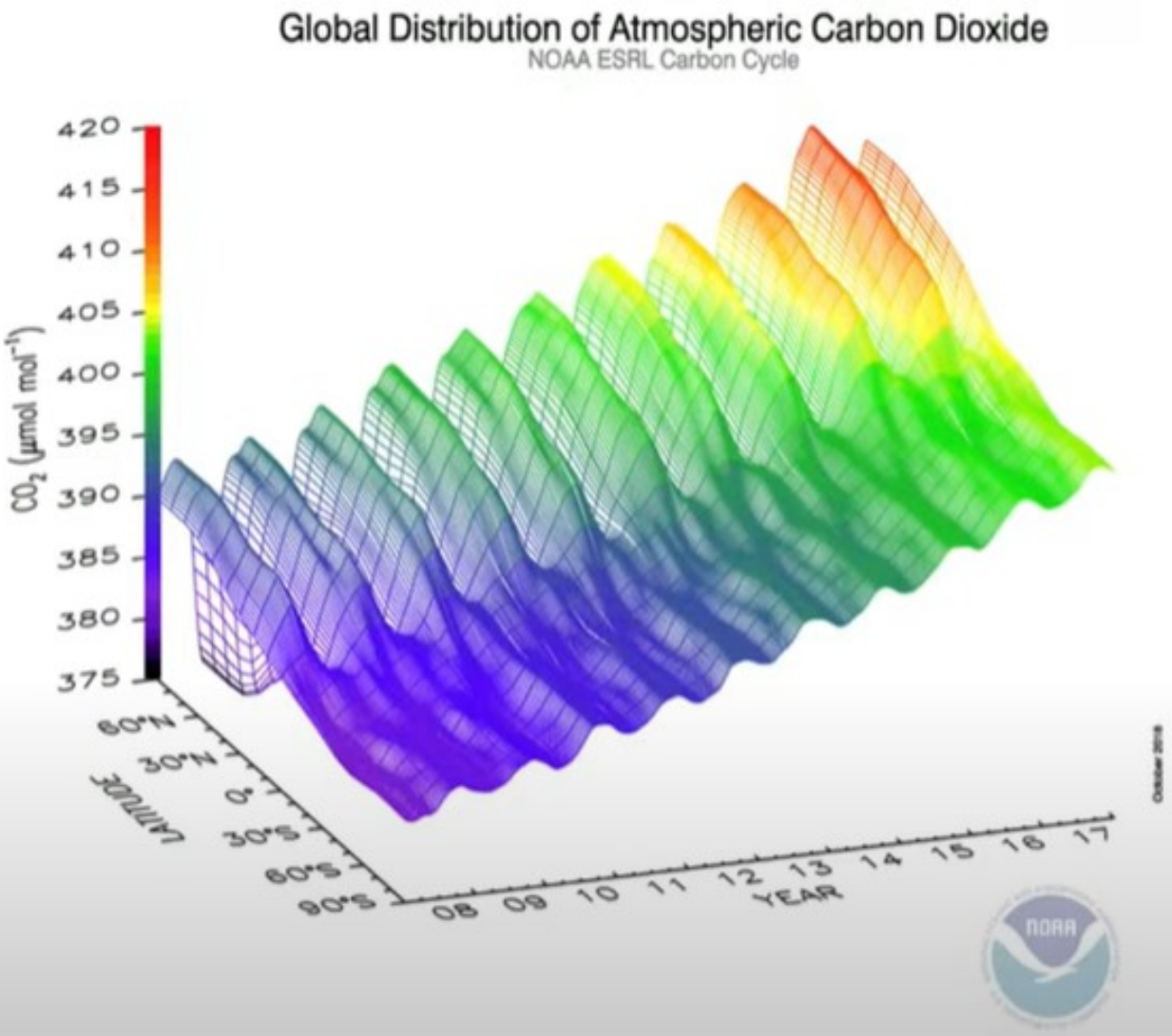
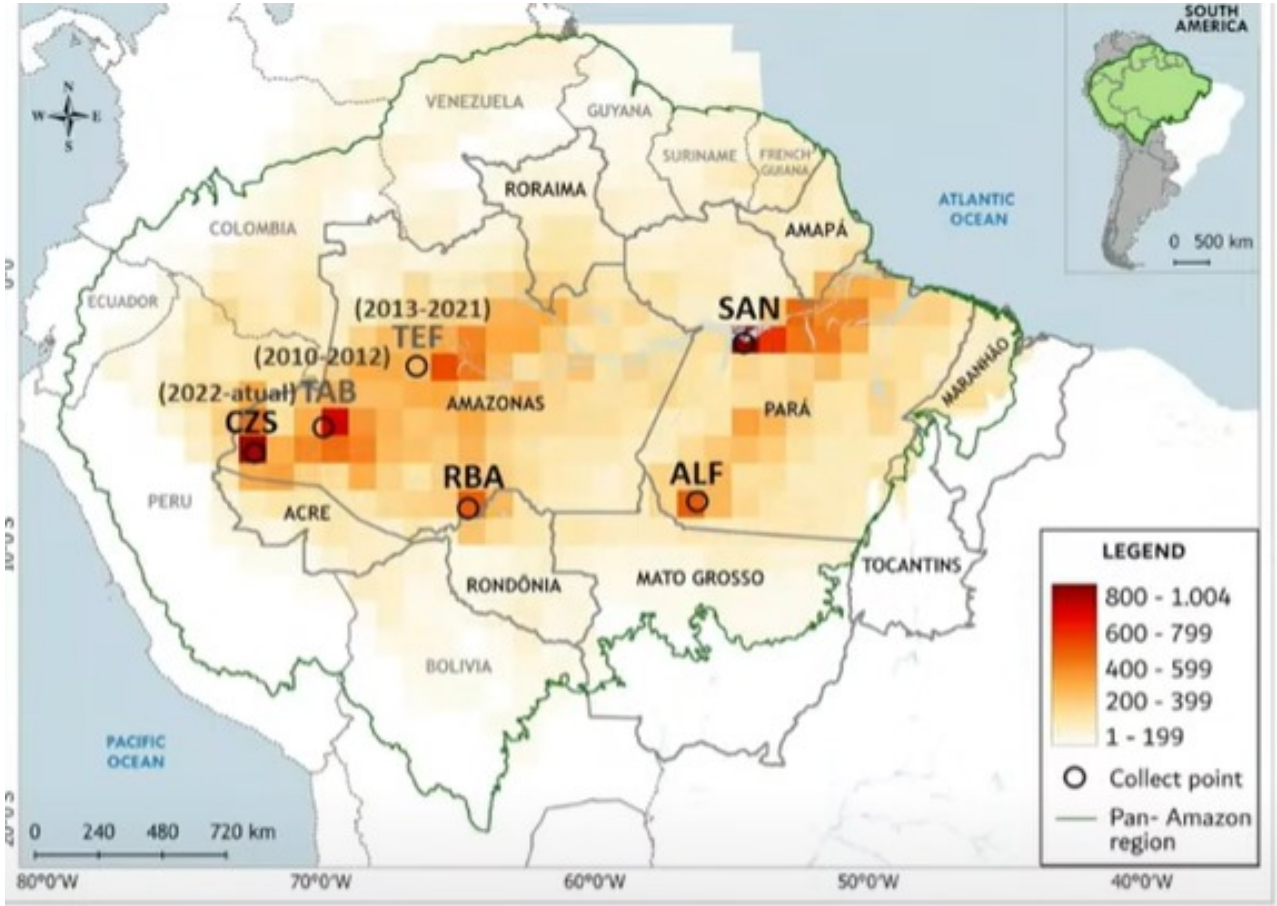
Table 1. Recommended network compatibility of measurements within the scope of WMO/GAW

Component	*Network compatibility goal*[1]	*Extended network compatibility goal*[2]	*Range in unpolluted troposphere (approx. range for 2022)*	*Range covered by the WMO scale*	*Global mean abundance 2022*[3]	*Abundance rel to 1750*[3]	*2022-2021 absolute increase*[3]
CO2	0.1 ppm (NH) 0.05 ppm (SH)	0.2 ppm	380 – 450 ppm	250 – 800 ppm	417.9 ppm	150%	2.2 ppm
CH4	2 ppb	5 ppb	1750 – 2100 ppb	300 – 5900 ppb	1923 ppb	264%	16 ppb
CO	2 ppb	5 ppb	30 – 300 ppb	30 – 500 ppb			
N2O	0.1 ppb	0.3 ppb	325 – 335 ppb	260 – 370 ppb	335.8 ppb	124%	1.4 ppb
SF6	0.02 ppt	0.05 ppt	9 – 11 ppt	2.0 – 20 ppt			
H2	2 ppb	5 ppb	400 – 600 ppb	140 –1200 ppb			
δ^{13}C-CO2	0.01‰	0.1‰	–9.5 to –7.5‰ (VPDB)				
δ^{18}O-CO2	0.05‰	0.1‰	–2 to +2‰ (VPDB-CO2)				
δ^{13}C-CH4	0.02‰	0.2‰	–51 to –46‰ (VPDB)				
δ^{2}H-CH4	1‰	5‰	–120 to –63‰ (VSMOW)				
Δ^{14}C-CO2	0.5‰	3‰	–80 to 20‰				
Δ^{14}C-CH4	0.5‰		50-350‰				
Δ^{14}C-CO	2 molecules cm^{-3}		0-25 molecules cm^{-3}				
O2/N2	2 per meg	10 per meg	–900 to –400 per meg (vs. SIO scale)				

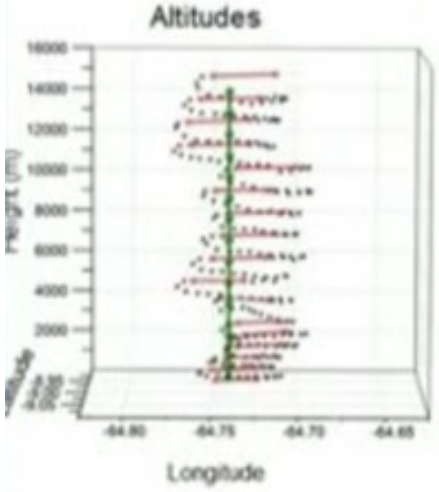

Global Distribution of Atmospheric Carbon Dioxide
NOAA ESRL Carbon Cycle
420
415
410
405
400
395
390
385
380
375
CO_2 (μmol mol^{-1})
LATITUDE
90°N
60°N
30°N
0
30°S
60°S
90°S
08
09
10
11
12
13
14
15
16
17
YEAR
NOAA

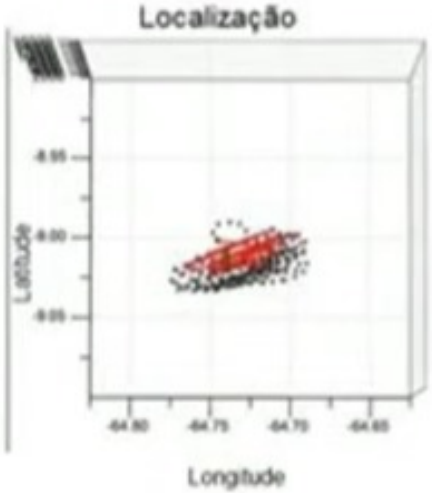
CARBAM Amazon Carbom measurements



CO_2, CH_4, N_2O, CO Vertical Profile

1 – Continuação do monitoramento com perfil de avião na Amazonia, iniciado em 2010 em 4 regiões (Sudeste, sudoeste e noroeste da Amazonia e desde 2004 na região nordeste da Amazônia

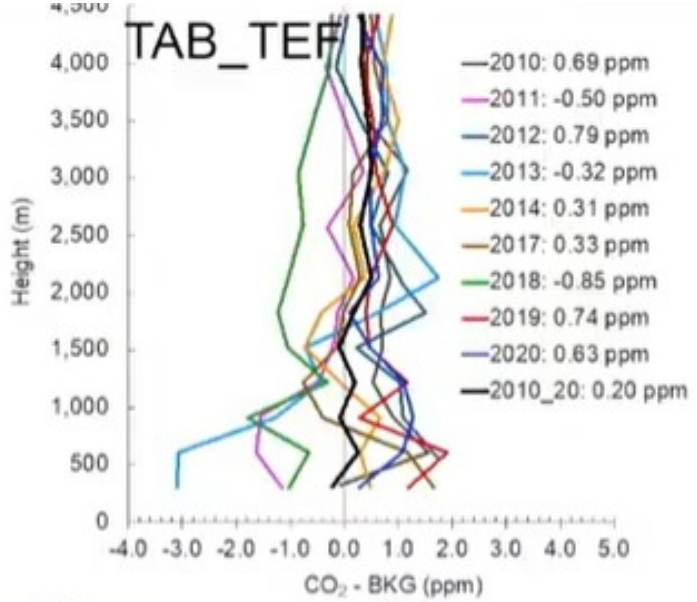


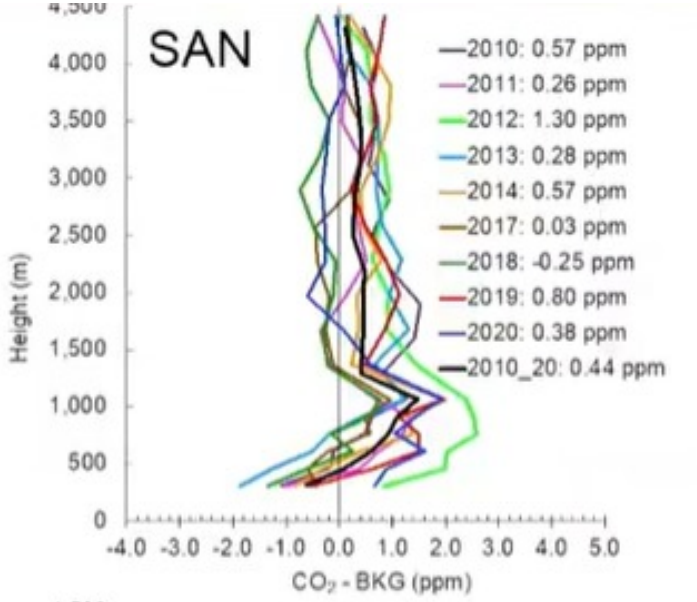


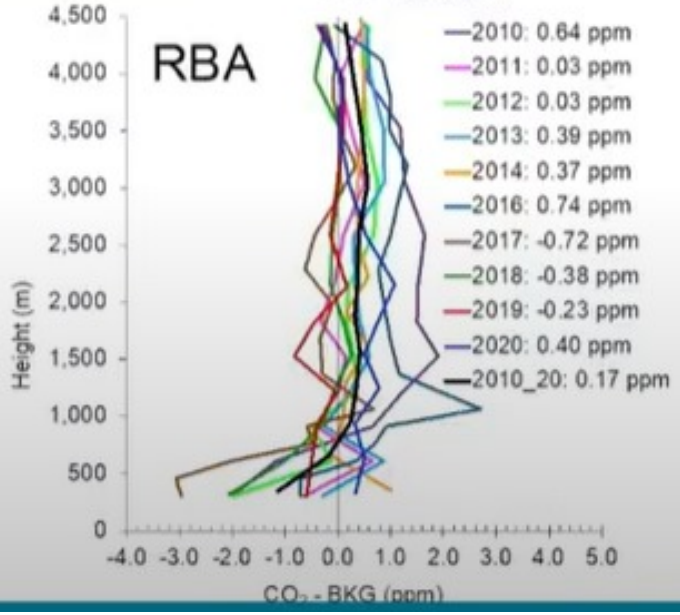
	NOAA	LaGEE - IPEN						LaGEE - INPE									
	2000/03	2004/09	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total LaGEE
SAN	22	86	19	23	24	23	16	6		17	21	18	17	20	16	13	319
ALF			20	19	24	22	19	5	20	24	23	23	21	21	21	14	276
RBA		1	20	18	22	19	15	12	21	24	20	23	17	18	23	16	269
TAB/TEF			20	14	9	15	16	4		14	13	17	9	9	1		141
CZS															18	11	29
FOR	11																0
PAN										11	8	8					27
SAH						8	11	2									21
MAN		35								9	2	15	10				71
Total	33	122	79	74	79	87	77	29	41	99	87	104	74	68	79	54	1153

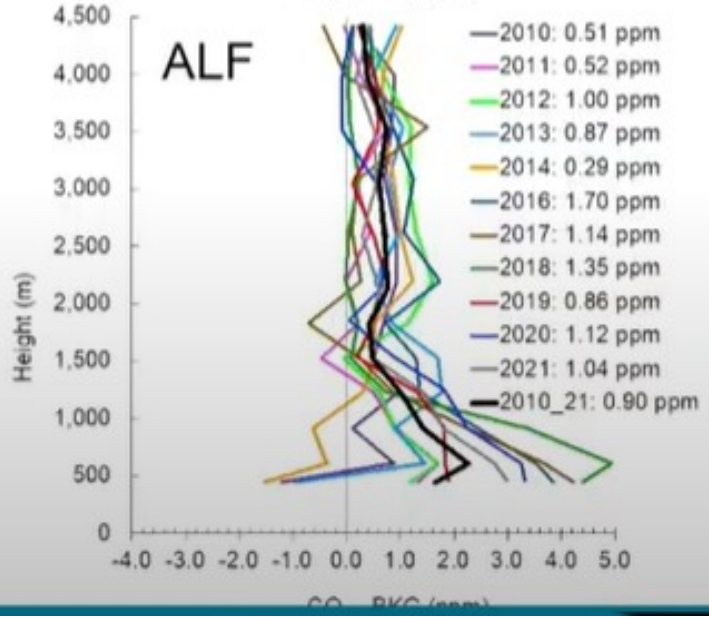
CO_2, CH_4, N_2O and CO

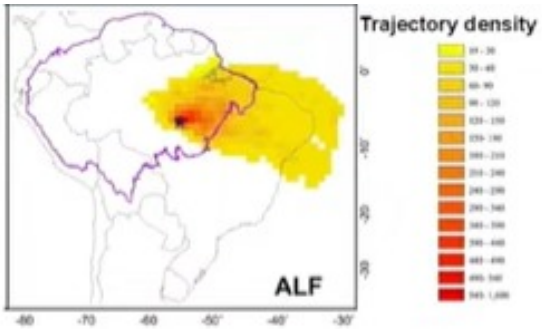
Why is it important to continue measures in the Amazon?


TAB_TEF
Height (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0
CO2 - BKG (ppm)
2010: 0.69 ppm
2011: -0.50 ppm
2012: 0.79 ppm
2013: -0.32 ppm
2014: 0.31 ppm
2017: 0.33 ppm
2018: -0.85 ppm
2019: 0.74 ppm
2020: 0.63 ppm
2010_20: 0.20 ppm

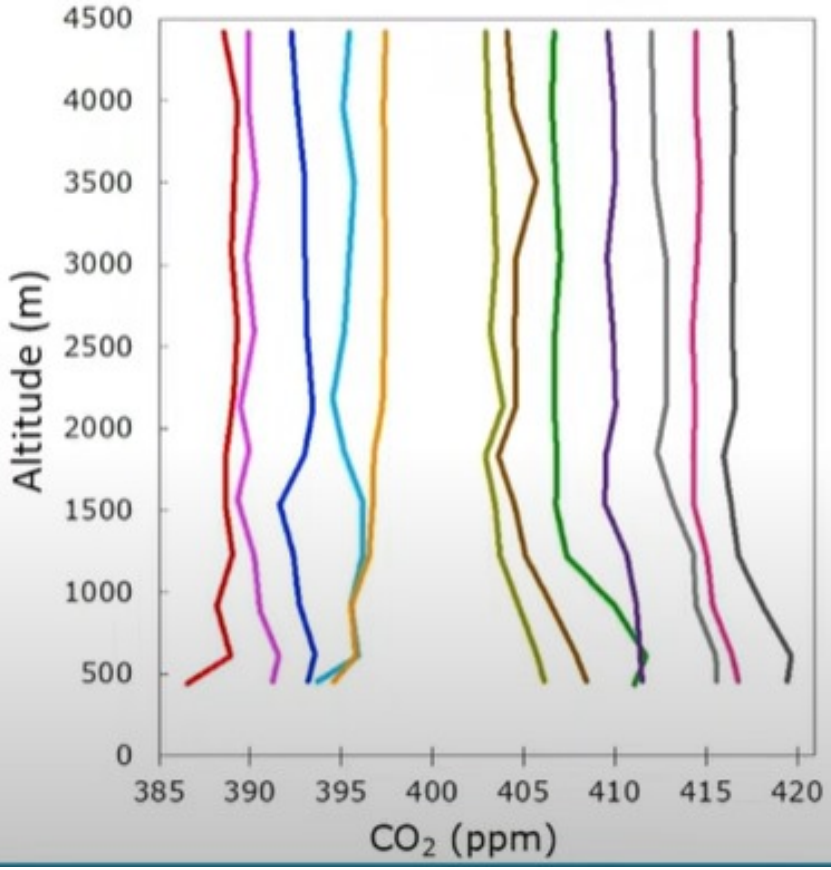

SAN
Height (m)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0
CO2 - BKG (ppm)
2010: 0.57 ppm
2011: 0.26 ppm
2012: 1.30 ppm
2013: 0.28 ppm
2014: 0.57 ppm
2017: 0.03 ppm
2018: -0.25 ppm
2019: 0.80 ppm
2020: 0.38 ppm
2010_20: 0.44 ppm

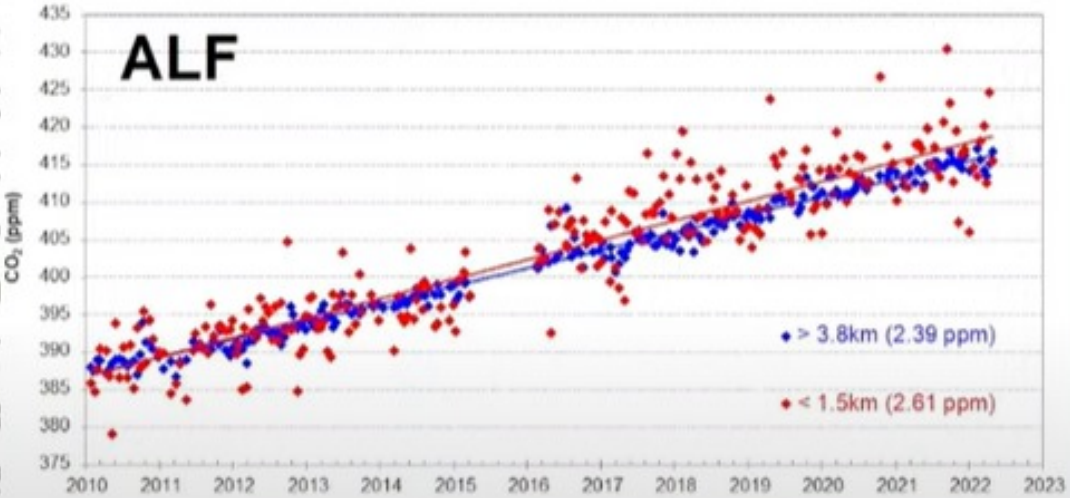

RBA
Height (m)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0
2010: 0.64 ppm
2011: 0.03 ppm
2012: 0.03 ppm
2013: 0.39 ppm
2014: 0.37 ppm
2016: 0.74 ppm
2017: -0.72 ppm
2018: -0.38 ppm
2019: -0.23 ppm
2020: 0.40 ppm
2010_20: 0.17 ppm

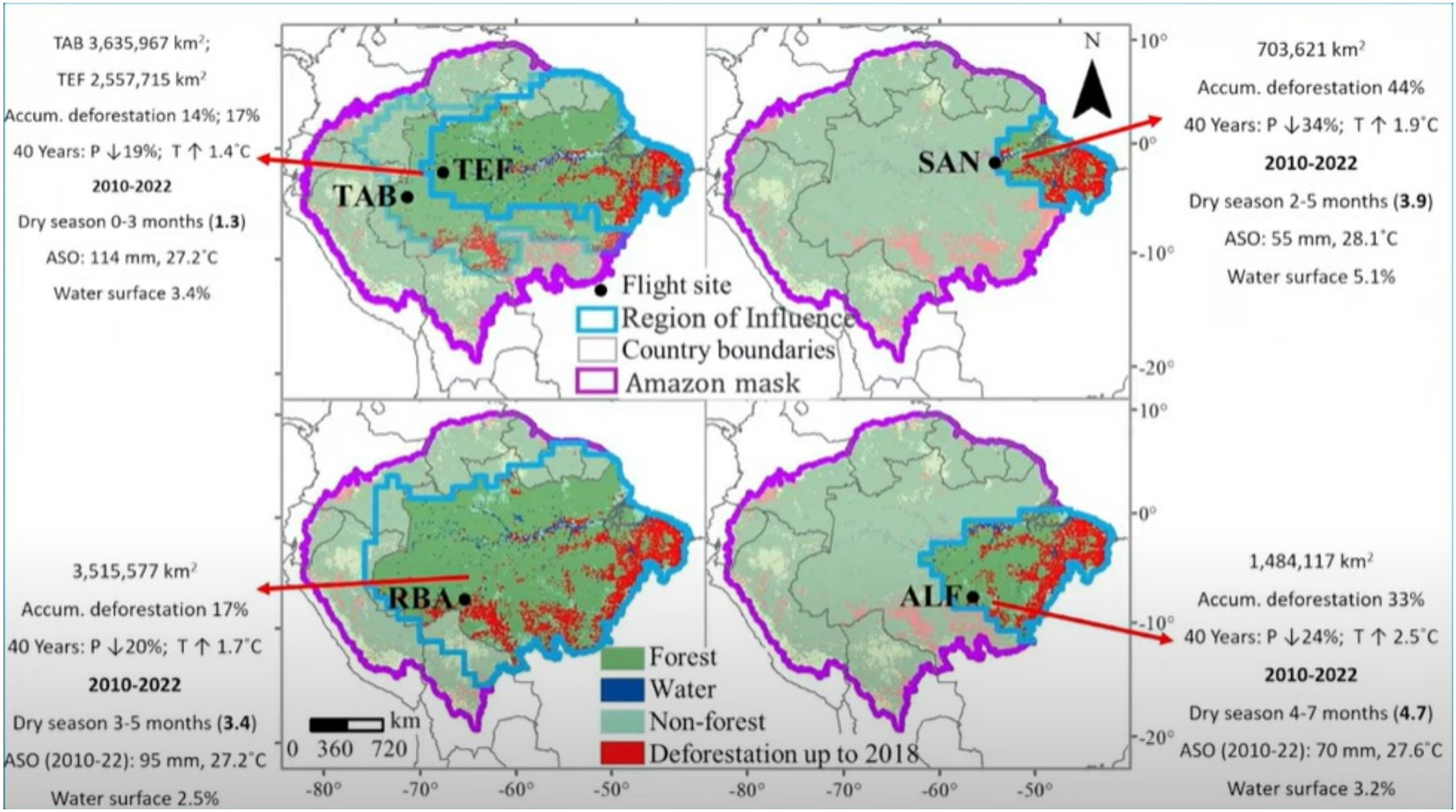

ALF
Height (m)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0
2010: 0.51 ppm
2011: 0.52 ppm
2012: 1.00 ppm
2013: 0.87 ppm
2014: 0.29 ppm
2016: 1.70 ppm
2017: 1.14 ppm
2018: 1.35 ppm
2019: 0.86 ppm
2020: 1.12 ppm
2021: 1.04 ppm
2010_21: 0.90 ppm

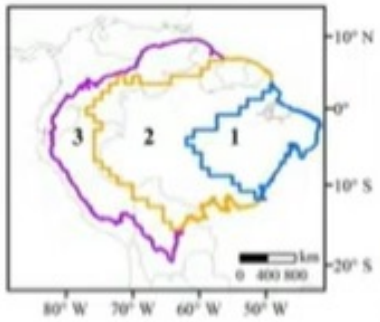


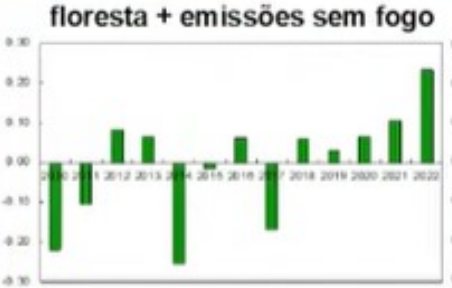
Accumulated deforestation 33%

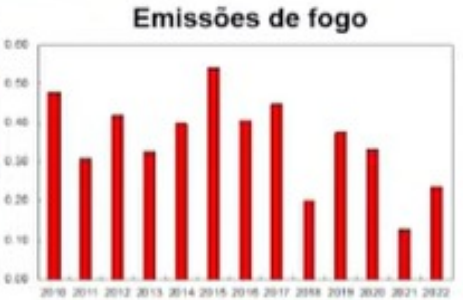


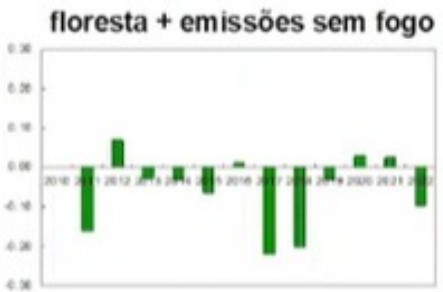


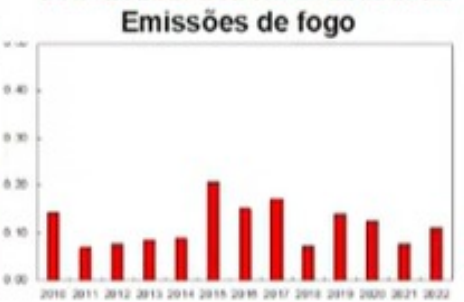

TAB 3,635,967 km²;
TEF 2,557,715 km²
Accum. deforestation 14%; 17%
40 Years: P ↓19%; T ↑ 1.4˚C
2010-2022
Dry season 0-3 months (1.3)
ASO: 114 mm, 27.2˚C
Water surface 3.4%
703,621 km²
Accum. deforestation 44%
40 Years: P ↓34%; T ↑ 1.9˚C
2010-2022
Dry season 2-5 months (3.9)
ASO: 55 mm, 28.1˚C
Water surface 5.1%
3,515,577 km²
Accum. deforestation 17%
40 Years: P ↓20%; T ↑ 1.7˚C
2010-2022
Dry season 3-5 months (3.4)
ASO (2010-22): 95 mm, 27.2˚C
Water surface 2.5%
1,484,117 km²
Accum. deforestation 33%
40 Years: P ↓24%; T ↑ 2.5˚C
2010-2022
Dry season 4-7 months (4.7)
ASO (2010-22): 70 mm, 27.6˚C
Water surface 3.2%
TAB
TEF
SAN
RBA
ALF
N
Flight site
Region of Influence
Country boundaries
Amazon mask
Forest
Water
Non-forest
Deforestation up to 2018
km
0 360 720
10°
0°
-10°
-20°
-80°
-70°
-60°
-50°











gC/ m2.day	mean 2010-2022	media 2010-18	media 2019-22
Region 1 Total CF	0.350	0.337	0.378
Region 1 NBE	-0.004	-0.054	0.109
Region 1 Fire CF	0.354	0.392	0.268
Region 2 Total CF	0.065	0.050	0.098
Region 2 NBE	-0.053	-0.069	-0.017
Region 2 Fire CF	0.118	0.119	0.114
Times lower	5.4	6.8	3.9

floresta + emissões sem fogo