



UNIVERSIDADE DE SÃO PAULO
Campus USP “Luiz de Queiroz”
Centro de Energia Nuclear na Agricultura



EFEITOS DA POLUIÇÃO NO CLIMA: MUDANÇAS GLOBAIS E LOCAIS

Wanderlei Bieluczyk

Piracicaba, 14 de setembro de 2023





1. TEMPO *vs* CLIMA

2. AQUECIMENTO GLOBAL

3. MUDANÇAS GLOBAIS DO CLIMA

4. EFEITOS MICROCLIMÁTICOS: CENTROS URBANOS

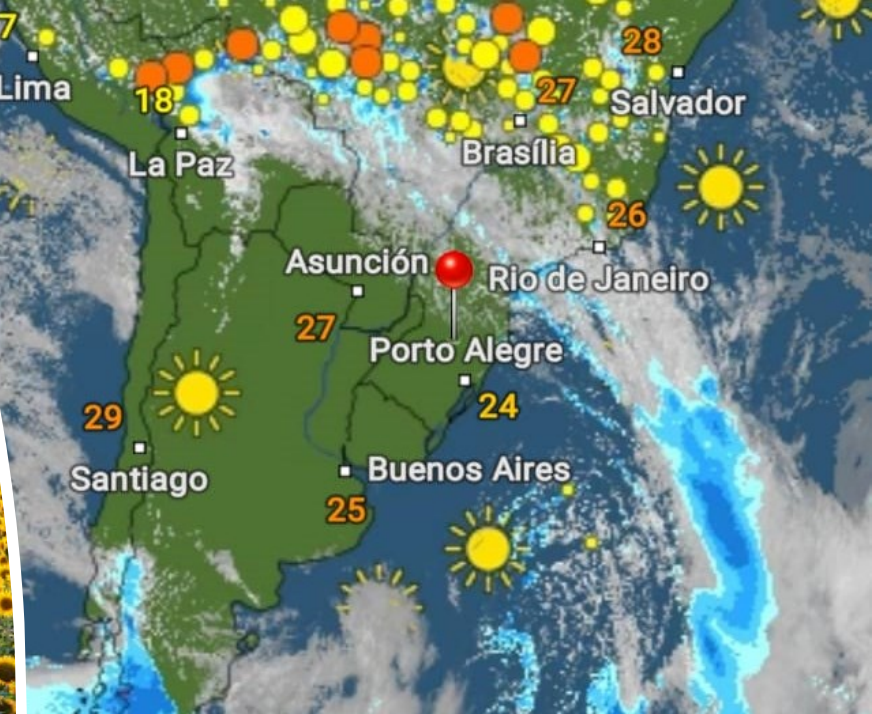
TEMPO

Elementos meteorológicos:

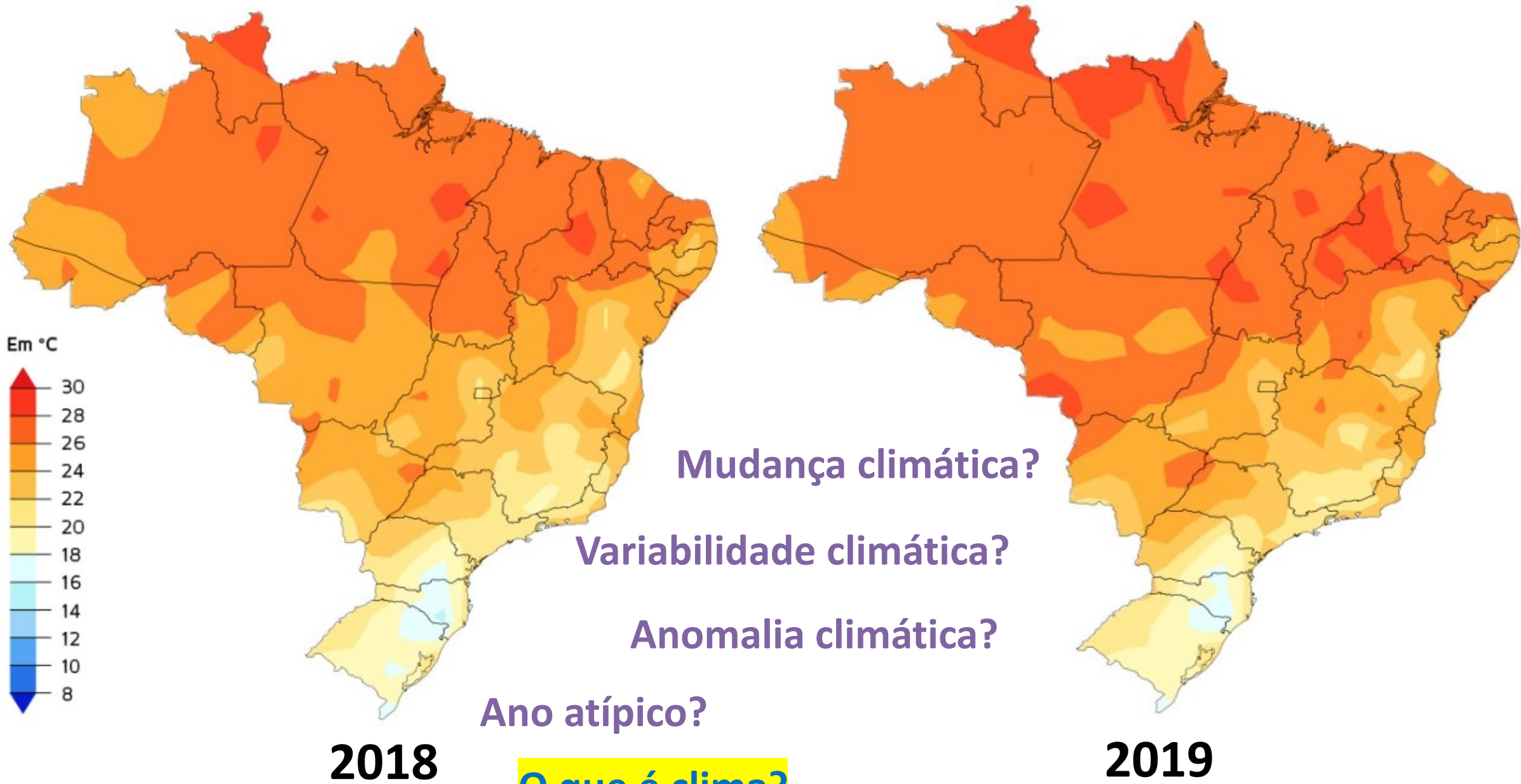
- *Temperatura e umidade relativa do ar.*
- *Velocidade e direção do vento.*
- *Precipitação.*
- *Nebulosidade.*
- *Pressão atmosférica.*
- *Radiação solar.*

Condição atual:

- *Termos instantâneos.*
- *Extremamente dinâmica.*

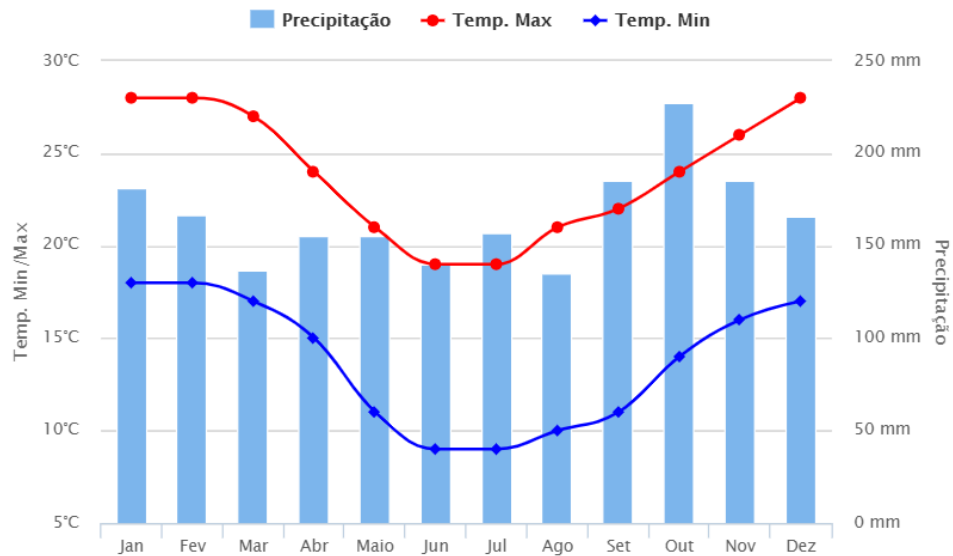


TEMPERATURAS MÉDIAS ANUAIS OBSERVADAS PARA O BRASIL EM 2018 e 2019.



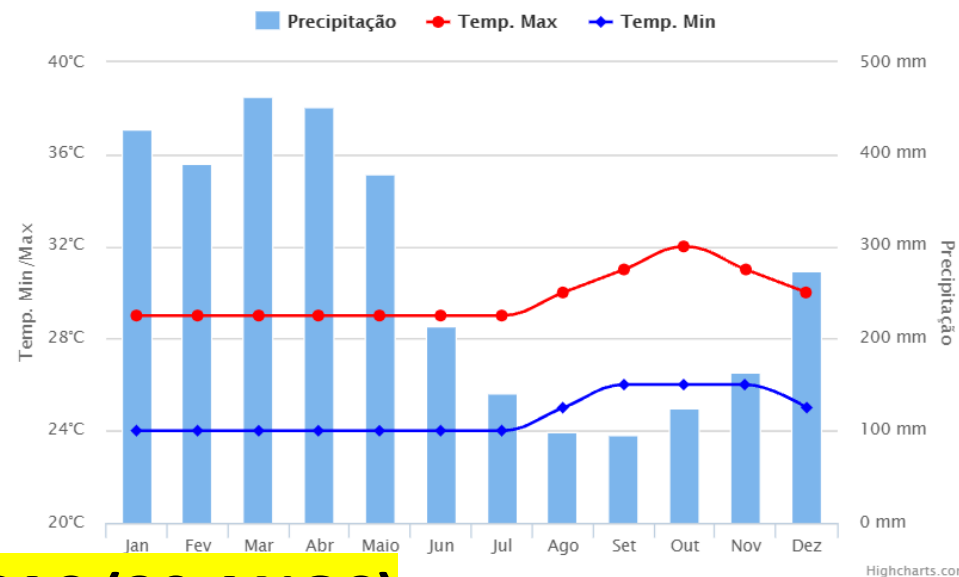
Centenário - BR

compartilhar



Santarém - BR

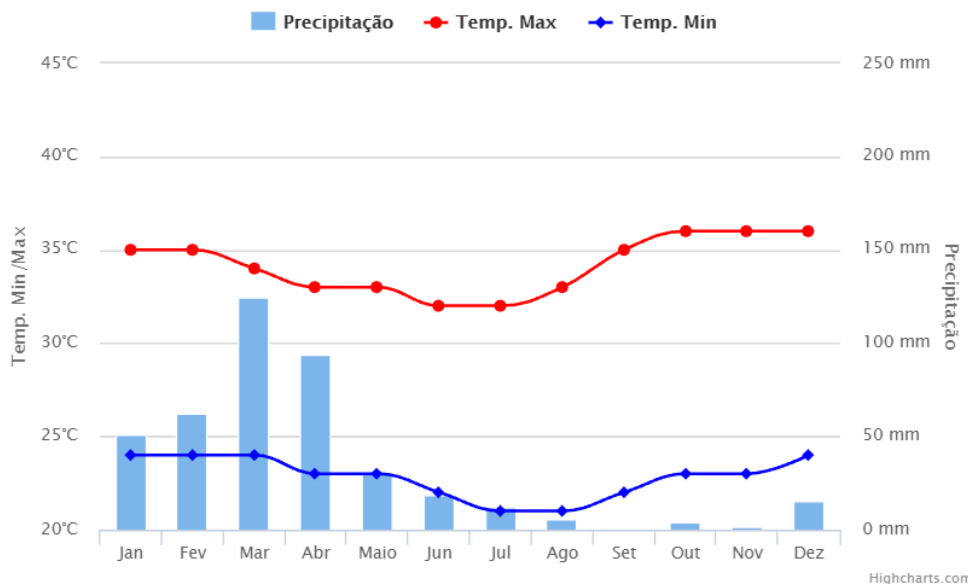
compartilhar



NORMAIS CLIMATOLÓGICAS (30 ANOS)

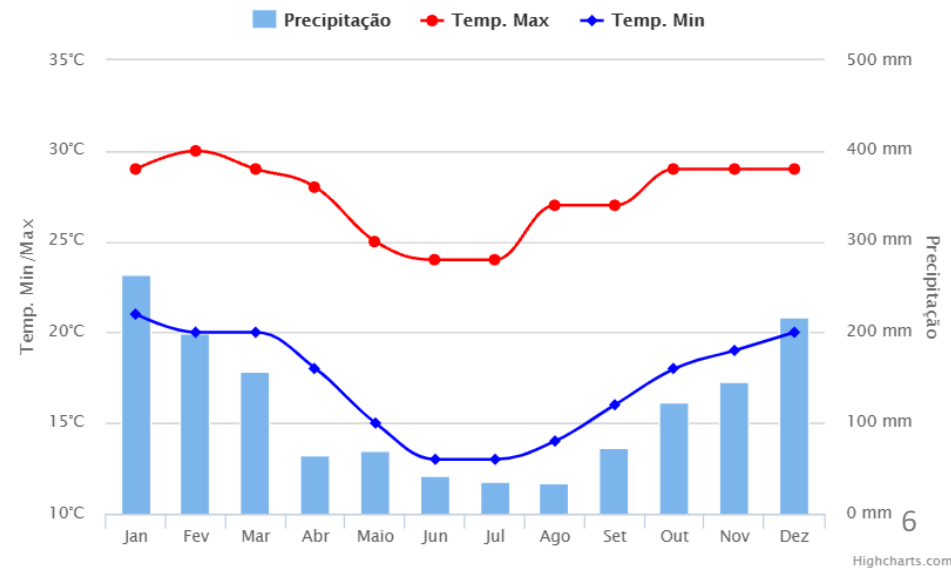
Caicó - BR

compartilhar



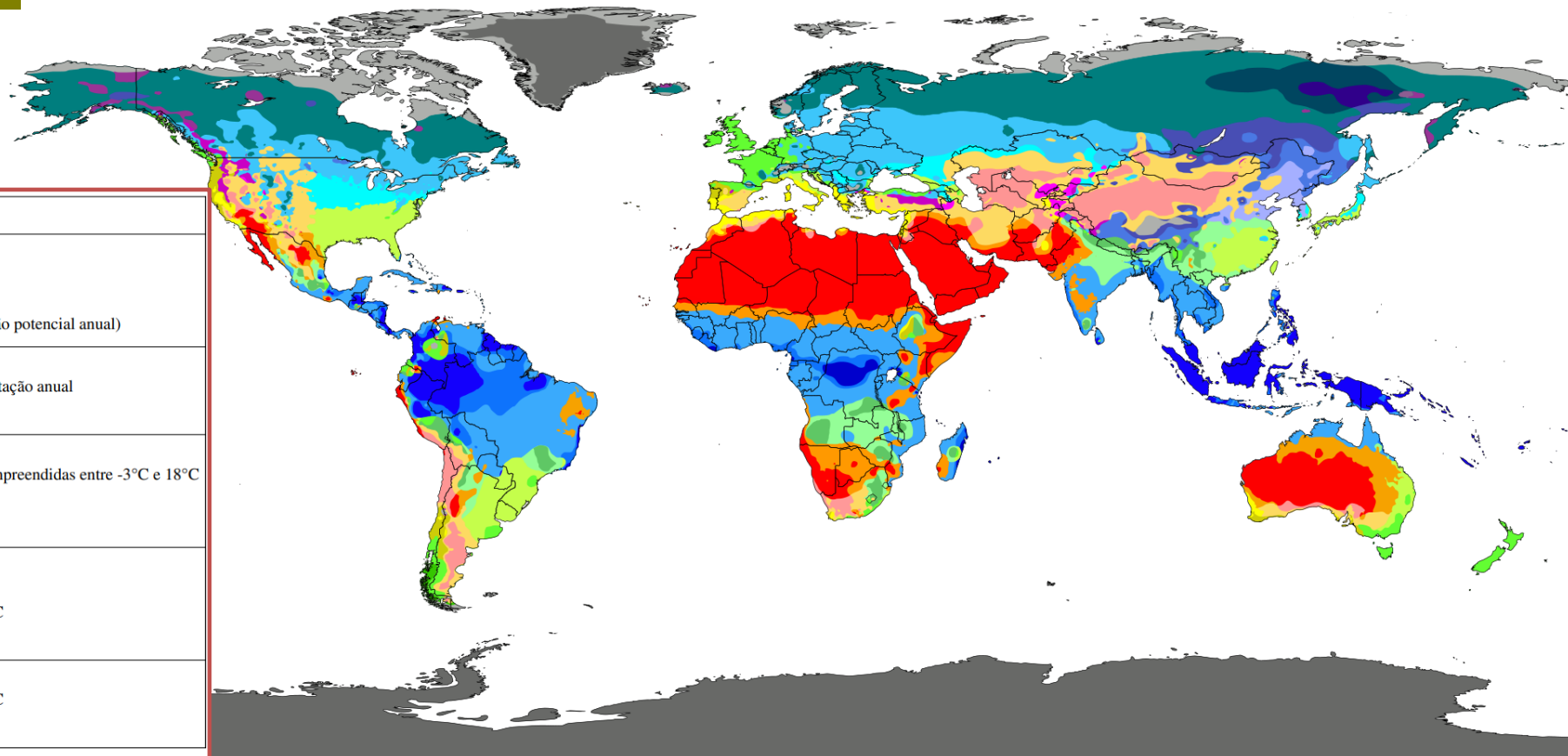
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O CLIMA É VARIÁVEL NO GLOBO

World map of Köppen-Geiger climate classification



Código	Tipo	Descrição
A	Clima tropical	<ul style="list-style-type: none"> Climas megatérmicos Temperatura média do mês mais frio do ano > 18°C Estação invernal ausente Forte precipitação anual (superior à evapotranspiração potencial anual)
B	Clima árido	<ul style="list-style-type: none"> Climas secos (precipitação anual inferior a 500 mm) Evapotranspiração potencial anual superior à precipitação anual Não existem cursos de água permanentes
C	Clima temperado ou Clima temperado quente	<ul style="list-style-type: none"> Climas mesotérmicos Temperatura média do ar dos 3 meses mais frios compreendidas entre -3°C e 18°C Temperatura média do mês mais quente > 10°C Estações de Verão e Inverno bem definidas
D	Clima continental ou Clima temperado frio	<ul style="list-style-type: none"> Climas microtérmicos Temperatura média do ar no mês mais frios < -3°C Temperatura média do ar no mês mais quente > 10°C Estações de Verão e Inverno bem definidas
E	Clima glacial	<ul style="list-style-type: none"> Climas polares e de alta montanha Temperatura média do ar no mês mais quente < 10°C Estação do Verão pouco definida ou inexistente.

Distribuição actualizada dos tipos de clima segundo a classificação Köppen-Geiger.^[1]

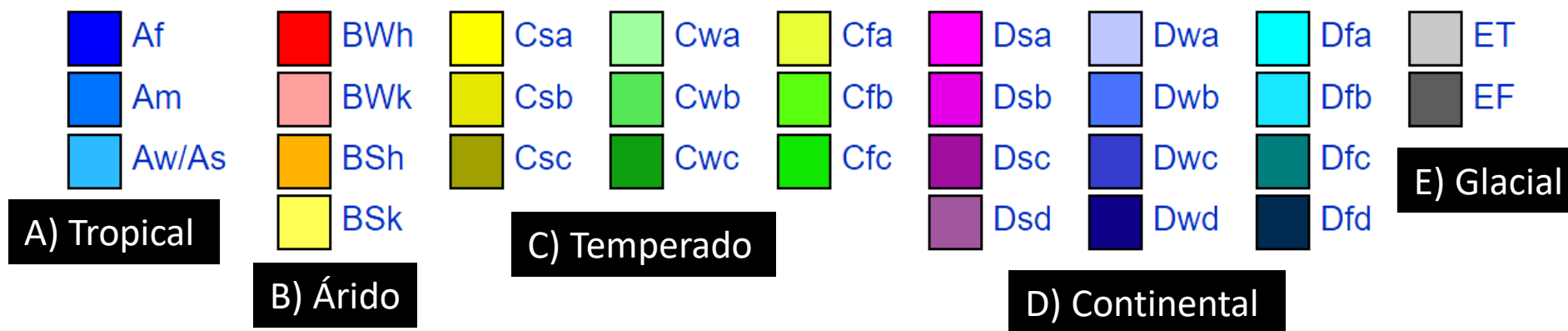


Table 1: Temperature and rainfall criteria for the complete Köppen's climate classification.

Temperature			Rainfall		Climate		Symbol	
T _{COLD}	T _{HOT}	T _{ANN}	R _M	R _{ANN}				
≥ 18 °C			R _{DRY} ≥ 60 mm		(A) Tropical	(f) without dry season	Af	
			R _{DRY} < 60 mm	≥ 25 (100 - R _{DRY})		(m) monsoon	Am	
				< 25 (100 - R _{SDRY})		(s) with dry summer	As	
				< 25 (100 - R _{WDY})		(w) with dry winter	Aw	
				≥ 5 * R _{THRESHOLD}	(B) Dry	(S) Semi-arid	(h) low latitude and altitude	BSh
				< 10 * R _{THRESHOLD}			(k) mid-latitude and high altitude	BSk
				< 5 * R _{THRESHOLD}		(W) Arid	(h) low latitude and altitude	BWh
							(k) mid-latitude and high altitude	BWk
							(a) with hot summer	Cfa
							(b) with temperate summer	Cfb
≥ -3 °C < & < 18 °C	≥ 22		R _{DRY} > 40 mm	(C) Humid subtropical	(f) Oceanic climate, without dry season	(a) with hot summer	Cfa	
	< 22 °C & T _{M10} ≥ 4					(b) with temperate summer	Cfb	
≥ -38 °C & < 18 °C	< 22 °C & 1 ≤ T _{M10} < 4					(c) with short and cool summer	Cfc	
≥ -3 °C & < 18 °C	≥ 22 °C		R _{DRY} < 40 mm		(w) With dry winter	(a) and hot summer	Cwa	
	< 22 °C & T _{M10} ≥ 4		R _{SWET} ≥ 10 * R _{WDY}			(b) and temperate summer	Cwb	
≥ -38 °C & < 18 °C	< 22 °C & 1 ≤ T _{M10} < 4					(c) and short and cool summer	Cwc	
≥ -3 °C & < 18 °C	≥ 22 °C		R _{DRY} < 40 mm		(s) With dry summer	(a) and hot	Csa	
	< 22 °C & T _{M10} ≥ 4		R _{WWET} ≥ 3 * R _{SDRY}			(b) and temperate	Csb	
≥ -38 °C & < 18 °C	< 22 °C & 1 ≤ T _{M10} < 4		R _{SWET} < 10 * R _{WDY}			(c) and short and cool summer	Csc	
≥ -38 °C & < -3 °C	≥ 22 °C		R _{DRY} > 40 mm	(D) Temperate continental	(f) Without dry season	(a) with hot summer	Dfa	
	< 22 °C & T _{M10} ≥ 4					(b) with temperate summer	Dfb	
	< 22 °C & 1 ≤ T _{M10} < 4					(c) with short and cool summer	Dfc	
< -38 °C & < -3 °C						(d) with very cold winter	Dfd	
≥ -38 °C & < -3 °C	≥ 22 °C		R _{DRY} < 40 mm		(w) With dry winter	(a) with hot summer	Dwa	
	< 22 °C & T _{M10} ≥ 4		R _{SWET} ≥ 10 * R _{WDY}			(b) and temperate summer	Dwb	
	< 22 °C & 1 ≤ T _{M10} < 4					(c) and short and cool summer	Dwc	
< -38 °C & < -3 °C						(d) and very cold winter	Dwd	
≥ -38 °C & < -3 °C	≥ 22 °C		R _{DRY} < 40 mm		(s) With dry summer	(a) and hot	Dsa	
	< 22 °C & T _{M10} ≥ 4		R _{WWET} ≥ 3 * R _{SDRY}			(b) and temperate	Dsb	
	< 22 °C & 1 ≤ T _{M10} < 4		R _{SWET} < 10 * R _{WDY}			(c) and short and cool summer	Dsc	
< -38 °C & < -3 °C						(d) and very cold winter	Dsd	
	< 10 & ≥ 0 °C			(E) Polar	(T) Tundra		ET	
	< 0 °C				(F) Frost		EF	

T_{COLD} = Temperature of the coldest month; T_{HOT} = Temperature of the hottest month; T_{ANN} = Annual mean temperature; R_M = Monthly Rainfall; R_{ANN} = Annual Rainfall; R_{DRY} = Rainfall of the driest month; R_{SDRY} = Rainfall of the driest month in summer; R_{WDY} = Rainfall in the driest month in winter; R_{SWET} = Rainfall of the wettest month in summer; R_{WWET} = Rainfall in the wettest month in winter; T_{M10} = number of months where the temperature is above 10 °C; R_{THRESHOLD} = varies according to equation 1; For the southern hemisphere summer is defined as the warmer six month period (ONDJFM) and winter is defined as the cooler six month period (AMJJAS). For the northern hemisphere summer is defined as the warmest six month period (AMJJAS) and winter is defined as the coolest six month period (ONDJFM).

CLASSIFICAÇÃO CLIMÁTICA NO BRASIL

75°W 70°W 65°W 60°W 55°W 50°W 45°W 40°W 35°W

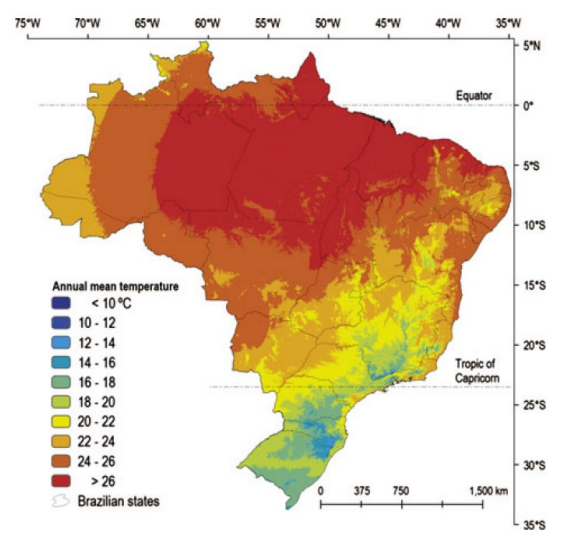
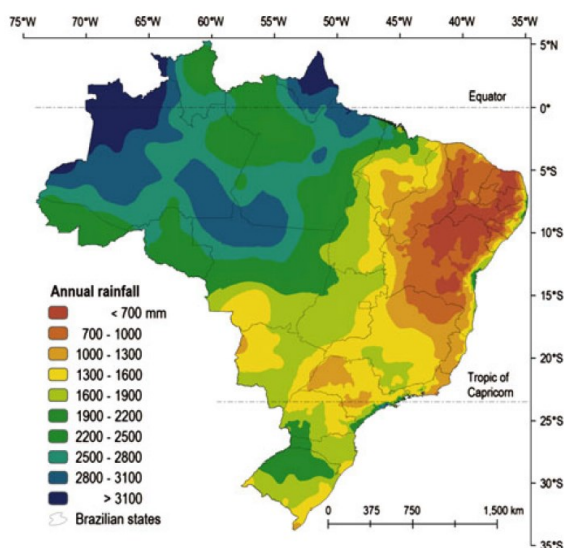
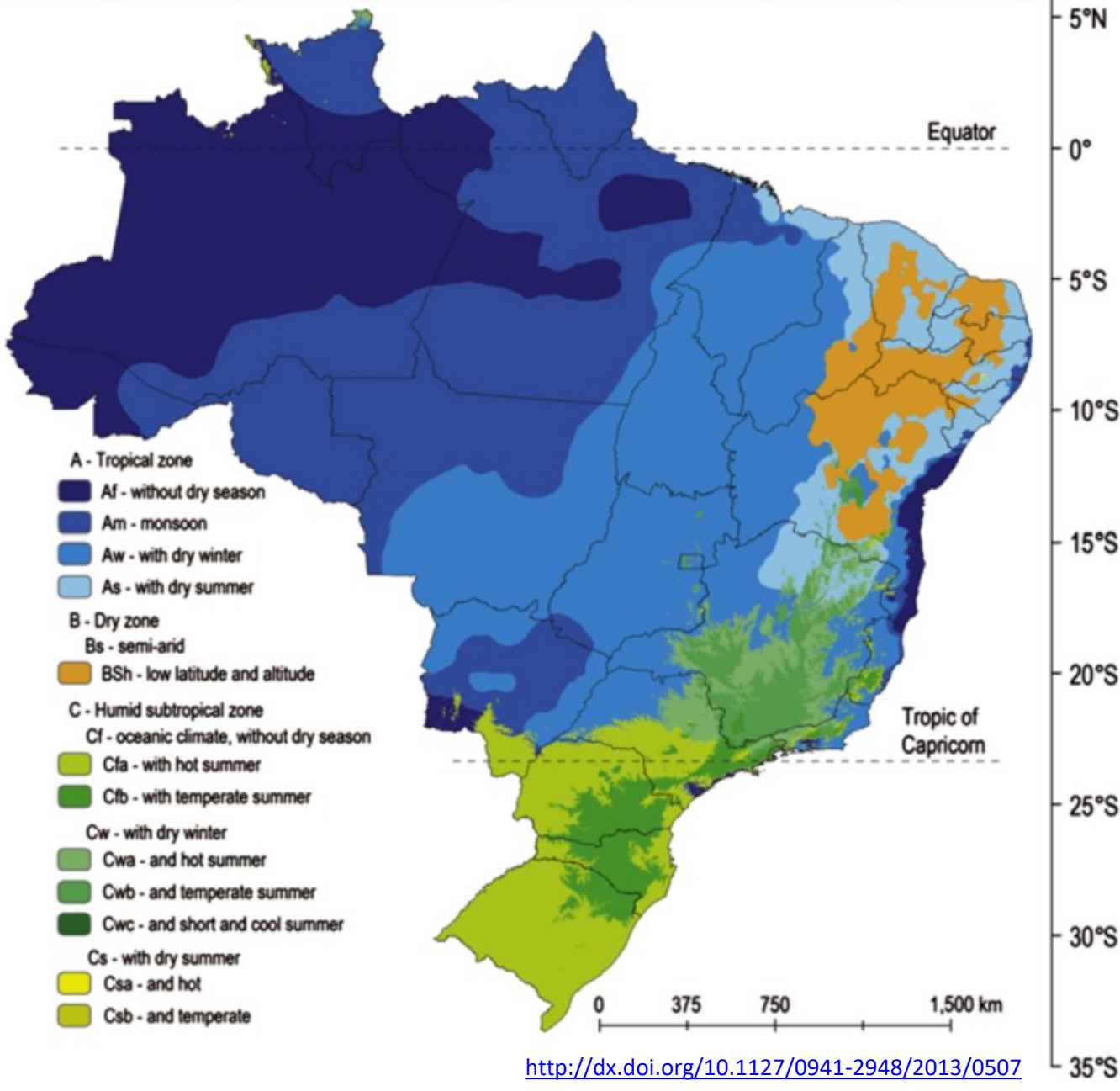


Figure 4: Annual mean air temperature map for Brazil (modified from ALVARES et al., 2013).



<http://dx.doi.org/10.1127/0941-2948/2013/0507>

Figure 6: Climate classification for Brazil, according to the KÖPPEN (1936) criteria.

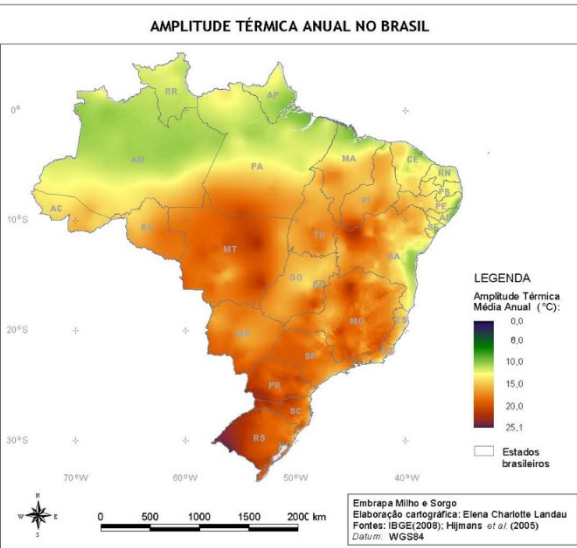
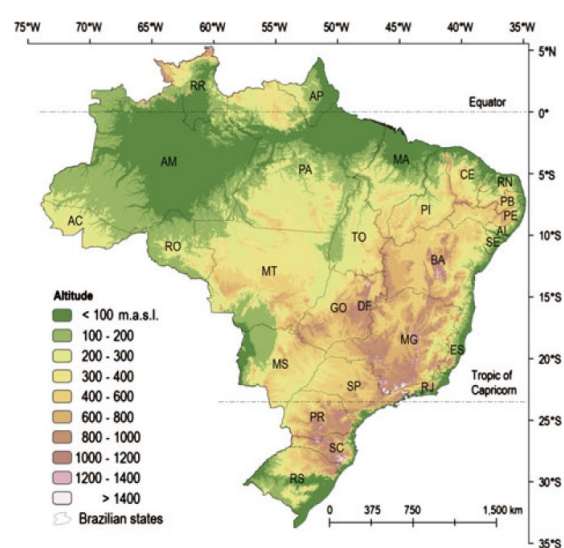
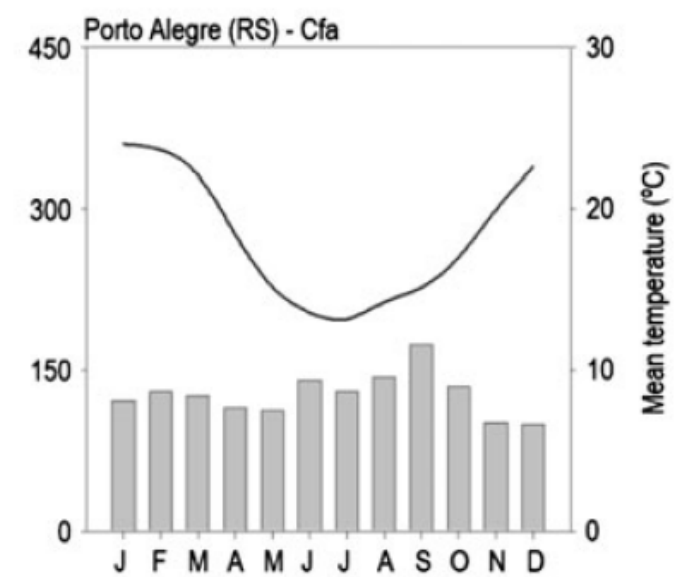
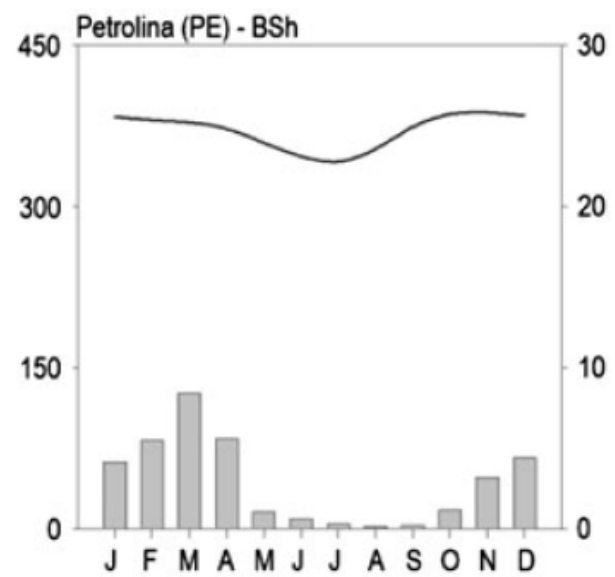
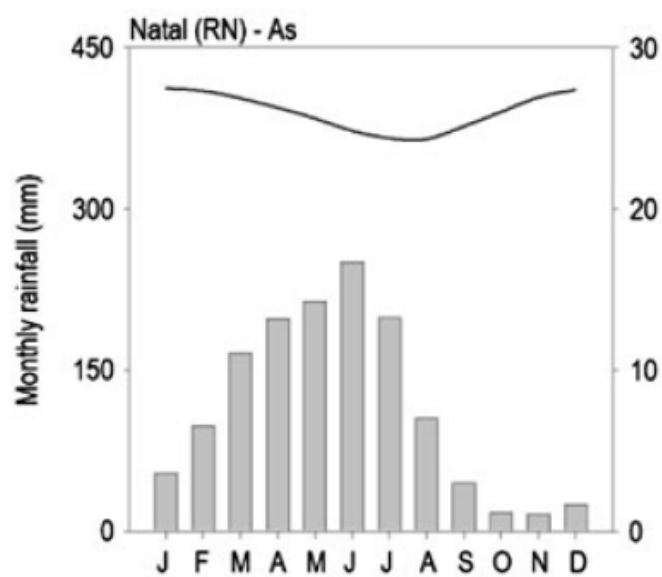
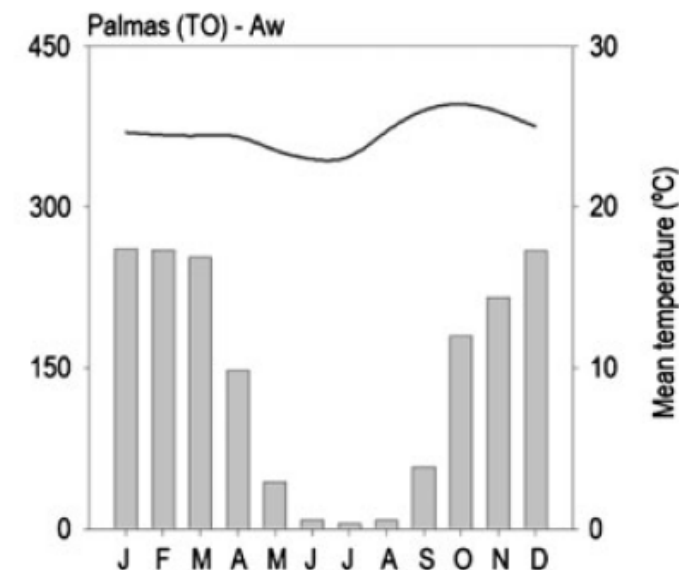
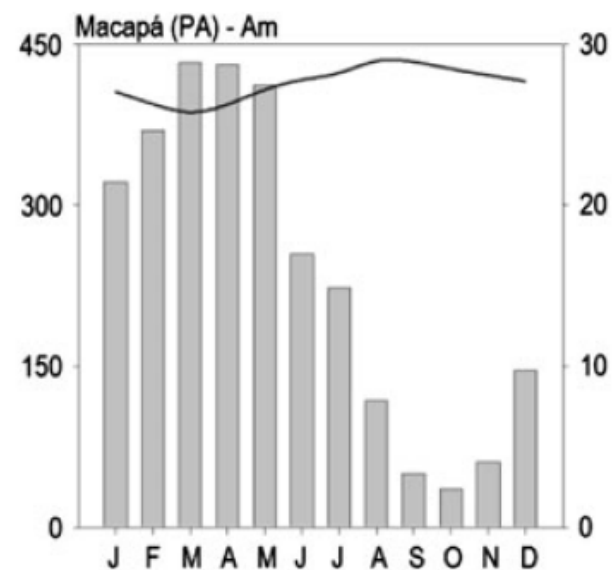
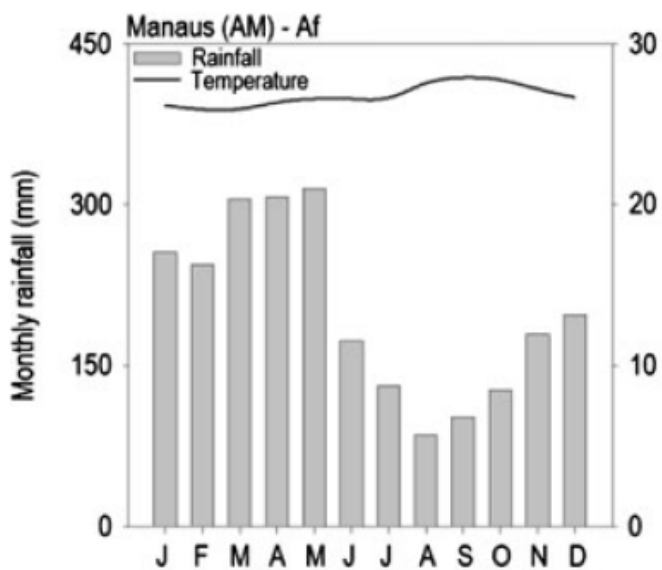


Figure 3: Digital elevation model of Brazil.

CLASSIFICAÇÃO CLIMÁTICA NO BRASIL

- Af - Clima tropical úmido ou Clima Equatorial
- Am - Clima de monção
- Aw - Clima Tropical com Estação seca no inverno
- BSh - Clima das estepes quentes de baixa latitude e altitude
- BWh - Clima das regiões desérticas quentes de baixa latitude e altitude

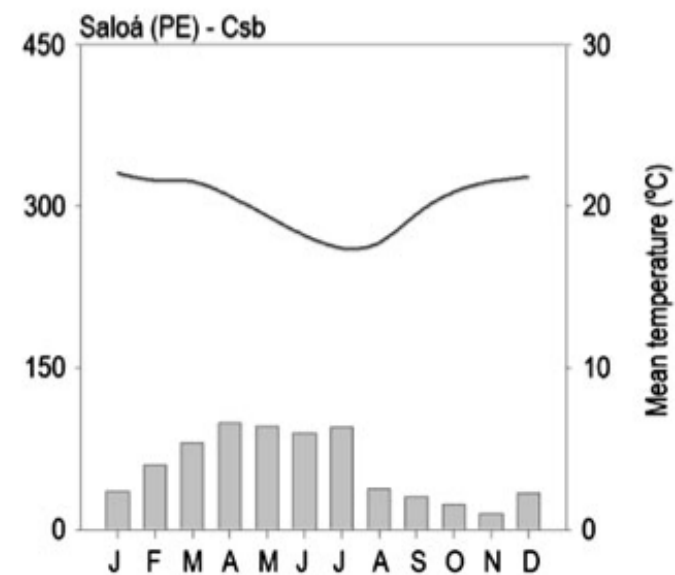
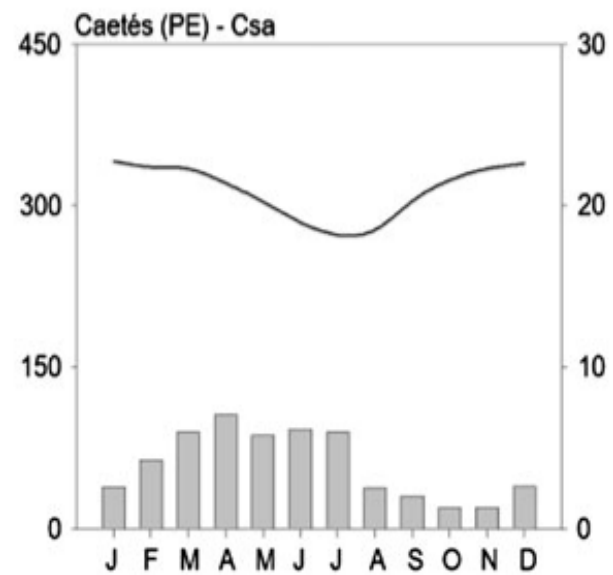
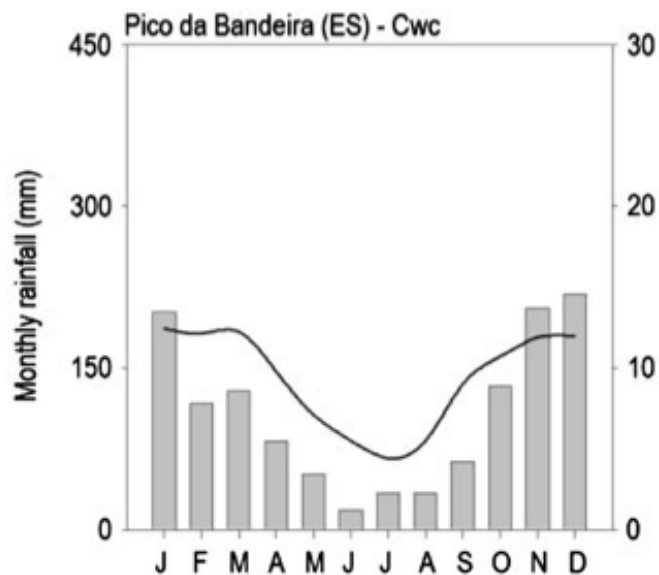
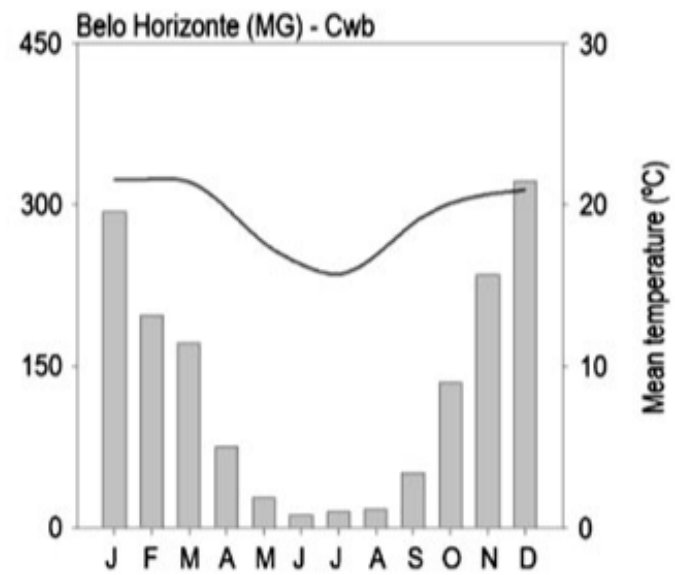
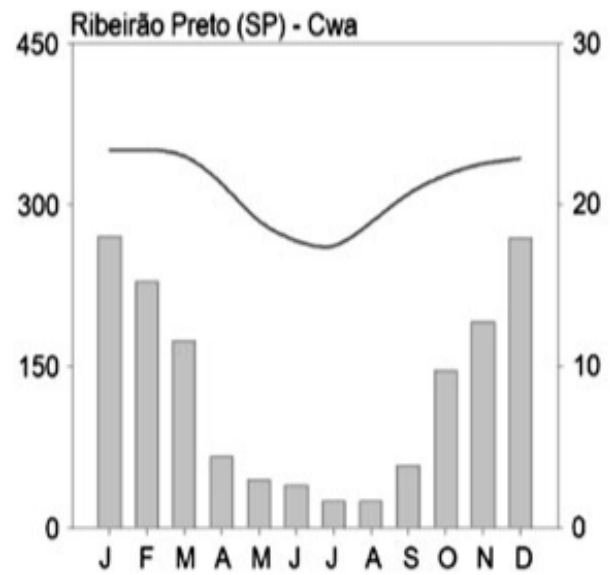
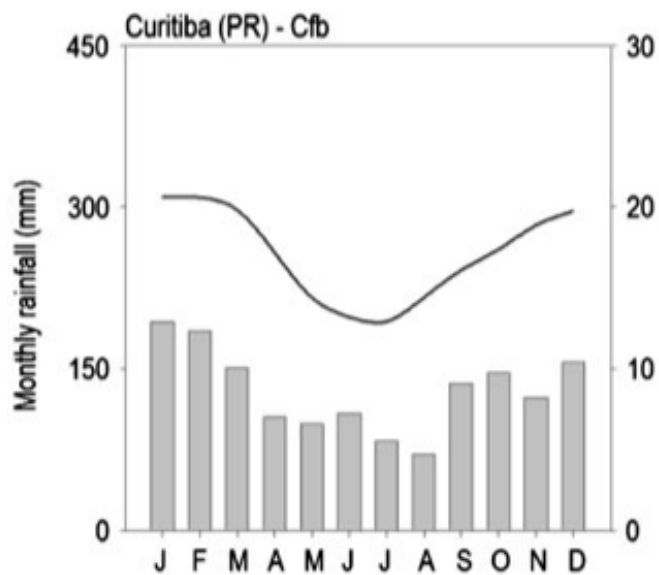
- Cfa - Clima temperado úmido com Verão quente
- Cfb - Clima temperado úmido com Verão temperado
- Cwa - Clima temperado úmido com Inverno seco e Verão quente
- Cwb - Clima temperado úmido com Inverno seco e Verão temperado



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- Cwb - Clima temperado úmido com Inverno seco e Verão temperado



ENTÃO VAMOS SIMPLIFICAR E FIRMAR OS CONCEITOS!

TEMPO: condição instantânea dos elementos meteorológicos da atmosfera.

CLIMA: condição média dos elementos meteorológicos da atmosfera, em série temporal de longo prazo (≥ 30 anos), definida em termos estatísticos.

VARIABILIDADE CLIMÁTICA: flutuações das condições meteorológicas, no espaço e no tempo, em torno das normais climatológicas.

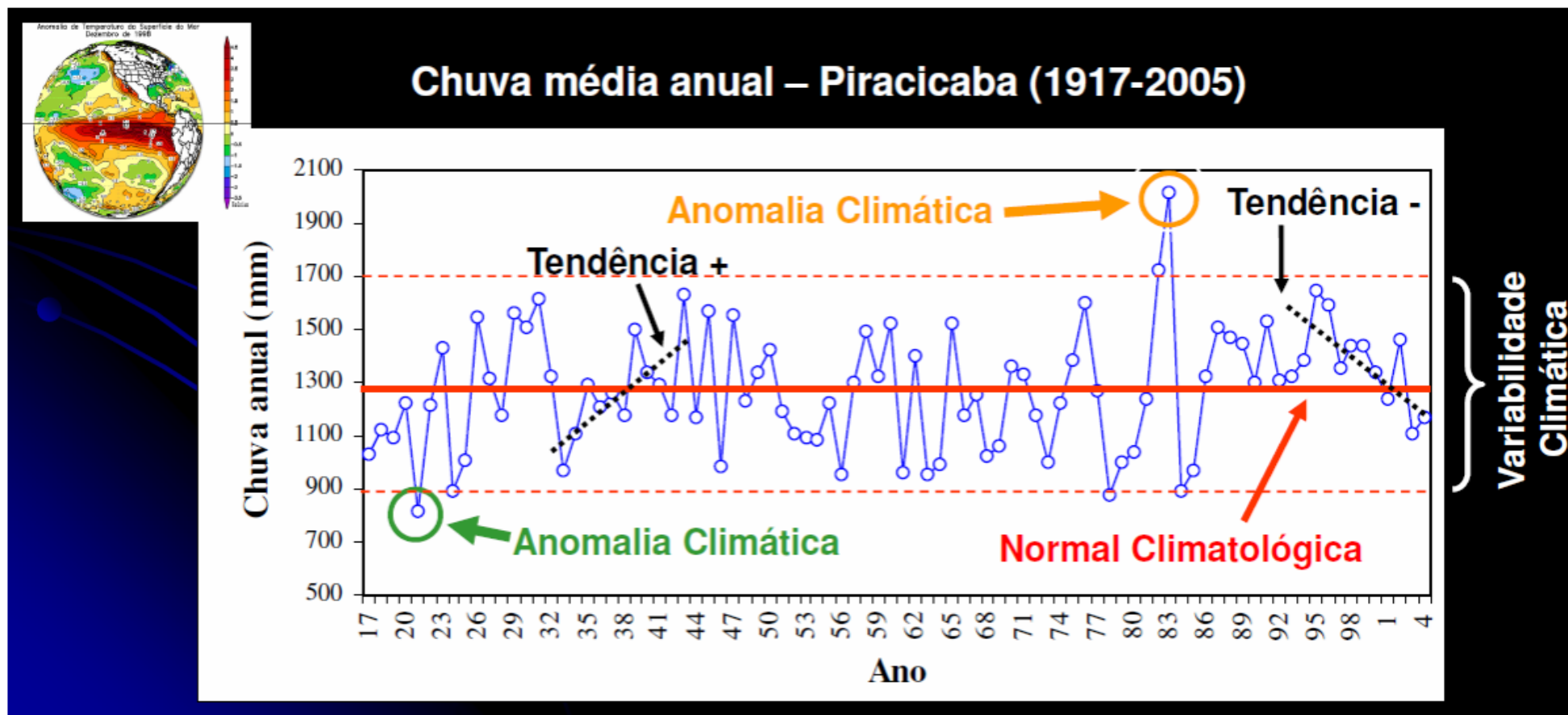


Figura 1. Variação da precipitação anual em Piracicaba, SP, a partir de 1917.

ENTÃO VAMOS SIMPLIFICAR E FIRMAR OS CONCEITOS!

TENDÊNCIA CLIMÁTICA: ocorre em curto período de tempo e não deve ser confundida com mudança climática.

ANOMALIA CLIMÁTICA: desvio acentuado além do padrão da variabilidade climática. Pode também ser influenciado por eventos como o El Niño e La Niña.

MUDANÇA CLIMÁTICA: tendência de alteração estatística significativa da média de um elemento climatológico ou de sua variabilidade em períodos de tempo mais extensos, como décadas ou séculos.

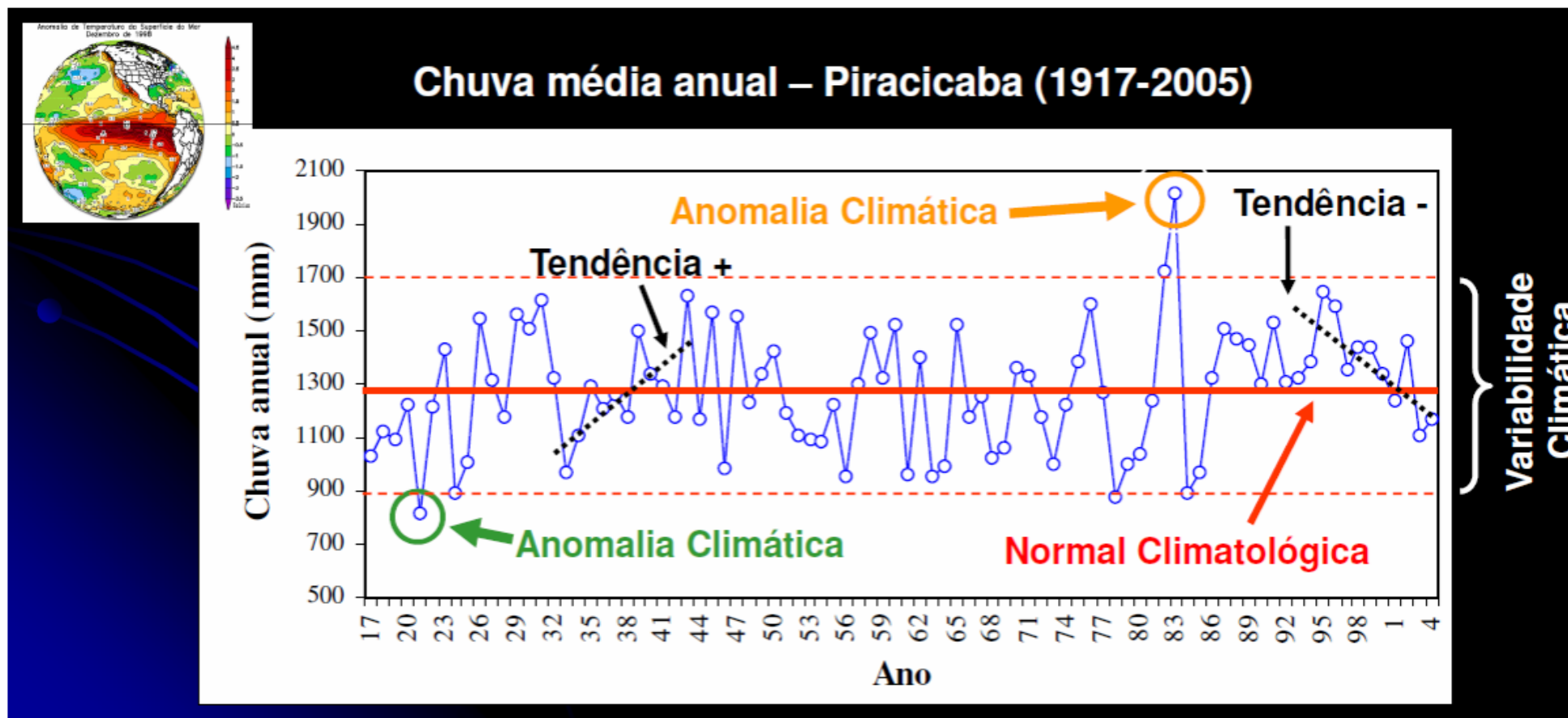


Figura 1. Variação da precipitação anual em Piracicaba, SP, a partir de 1917.

1. TEMPO *vs* CLIMA

2. AQUECIMENTO GLOBAL

3. MUDANÇAS GLOBAIS DO CLIMA

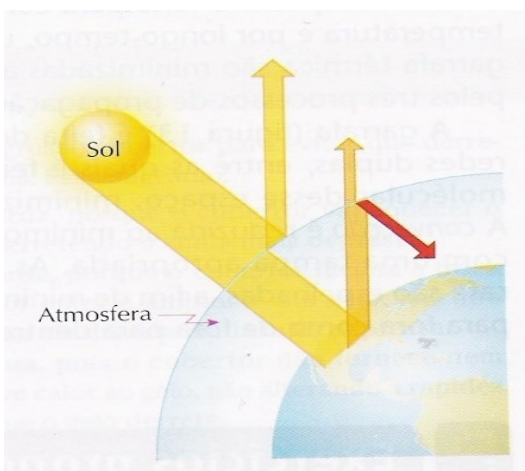
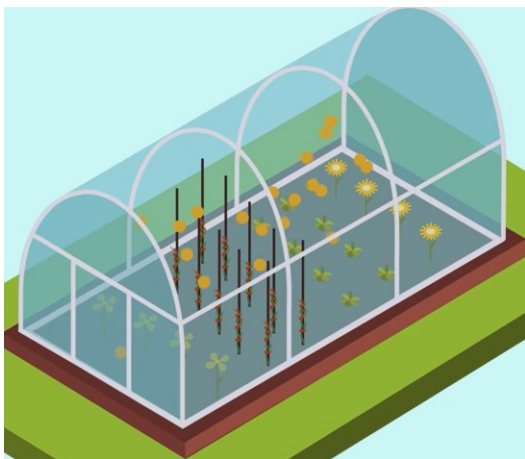
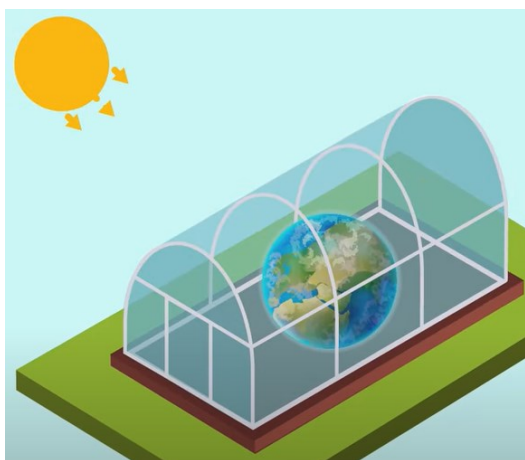
4. EFEITOS CLIMÁTICOS NOS CENTROS URBANOS

MUDANÇAS
CLIMÁTICAS

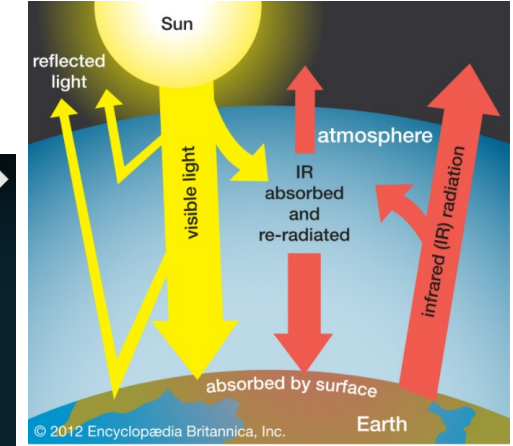
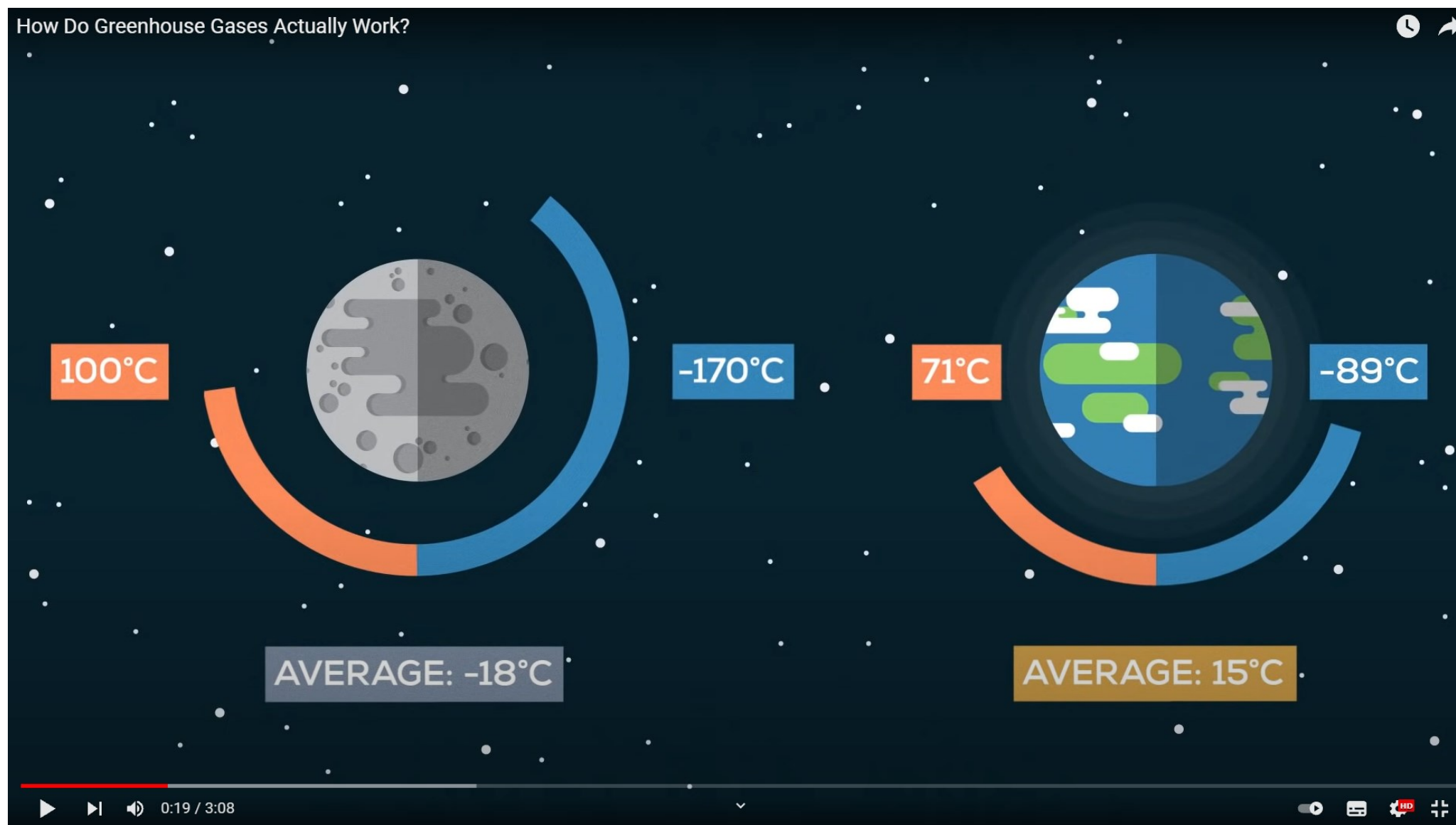
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AQUECIMENTO
GLOBAL

GASES DE EFEITO ESTUFA



<https://www.youtube.com/watch?v=sTvqlijqvTg>



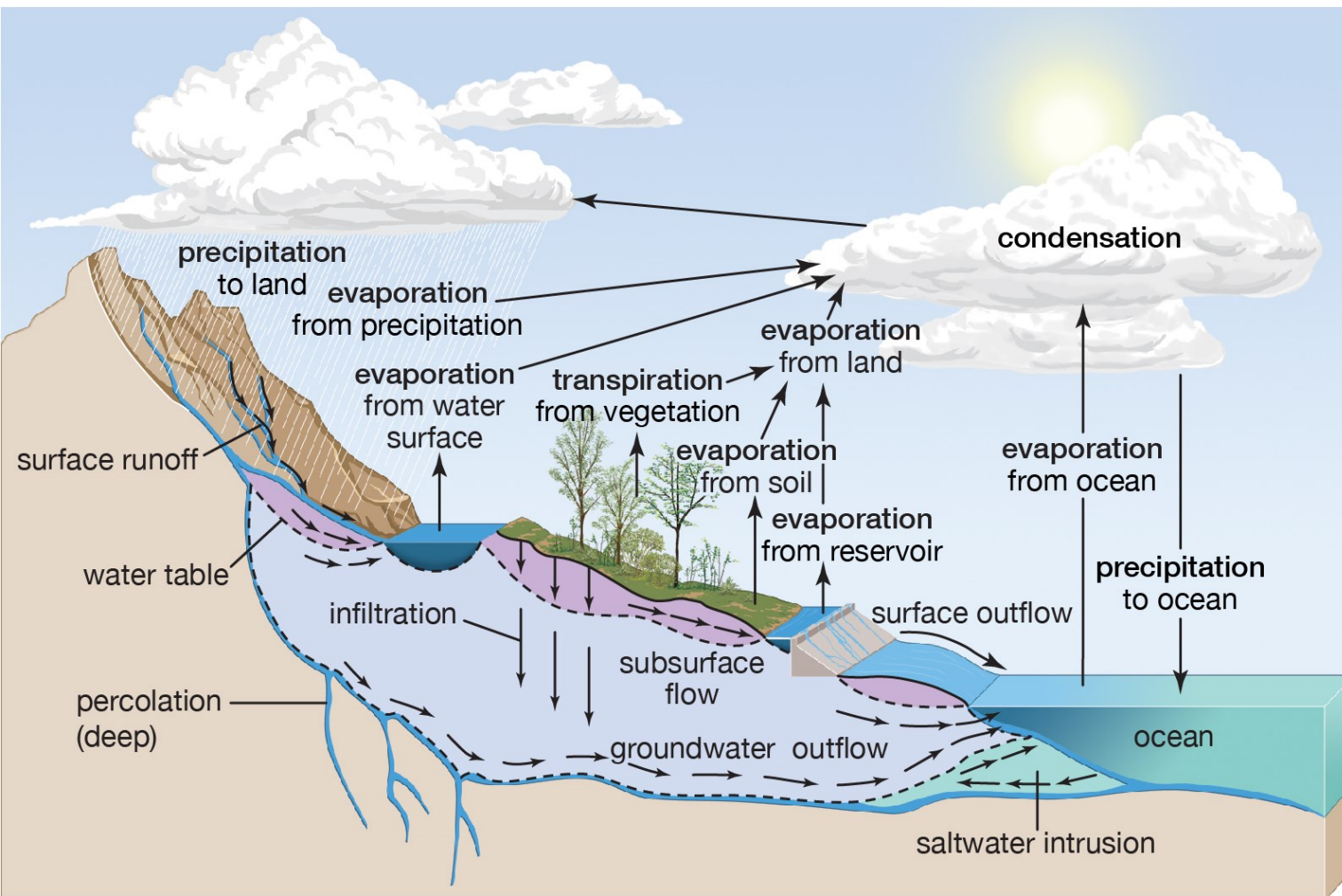
- Amplitude térmica
- “Escudo”
- Colisão/Vibração
- Absorção I.V.

Para brincar



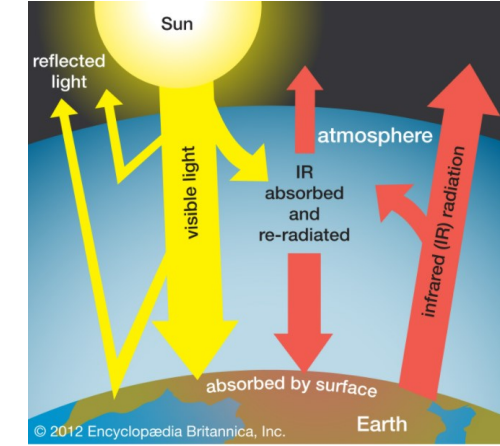
https://phet.colorado.edu/sims/html/molecules-and-light/latest/molecules-and-light_all.html

Vapor de água



soil moisture groundwater

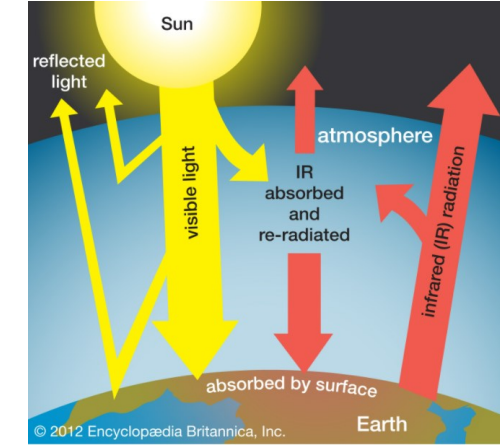
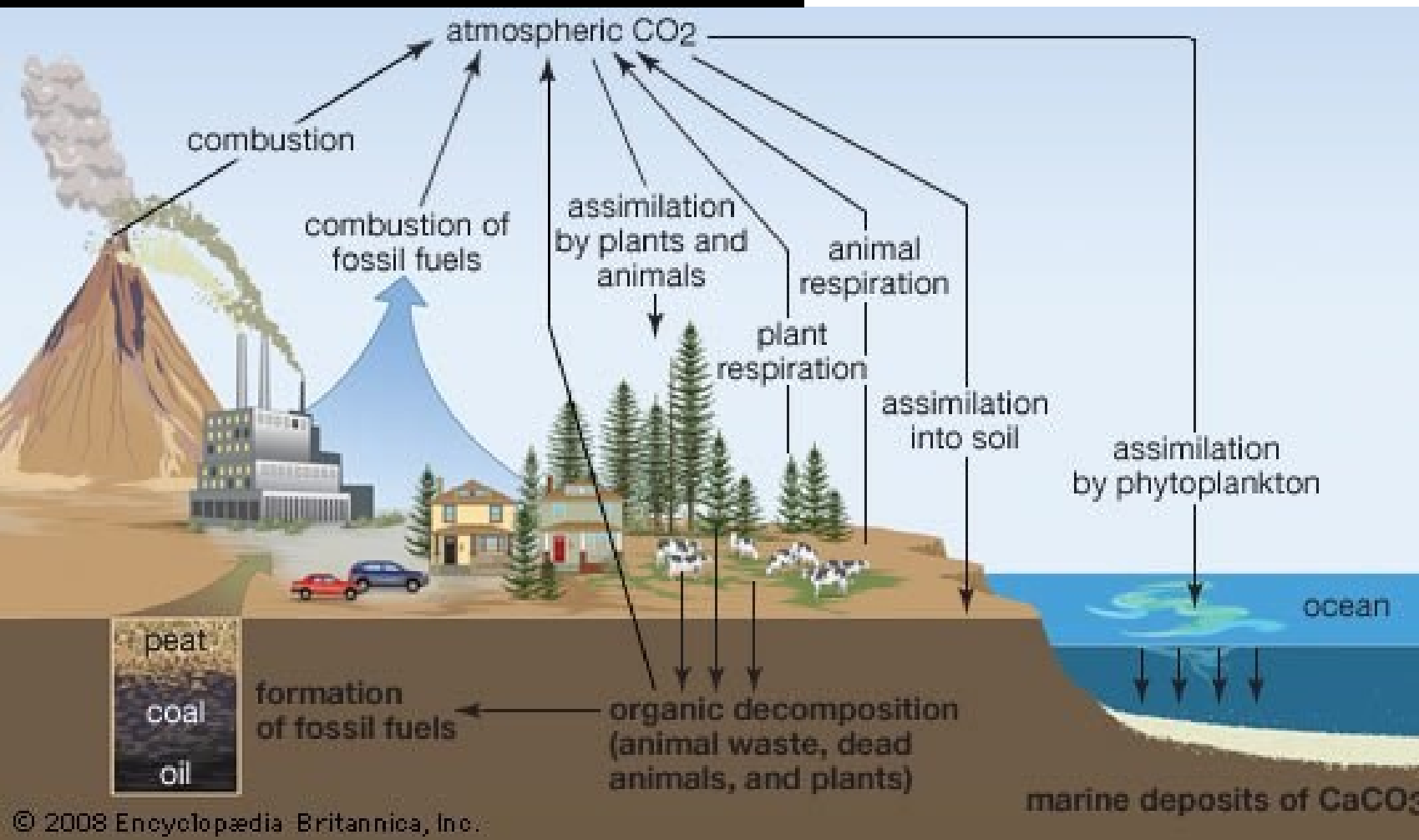
ocean covers 71 percent of Earth's surface
196,950,000 sq mi (510,000,000 sq km)



- Efeito estufa mais dominante.
 - *Feedback* positivo com o CO₂.
 - A Temp. do Ar controla o vapor de água.
- +CO₂ + Temperatura + vapor de água ++CO₂...

PRINCIPAIS CAUSADORES DO EFEITO ESTUFA

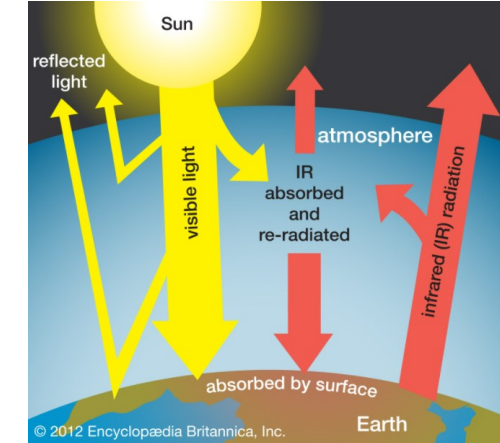
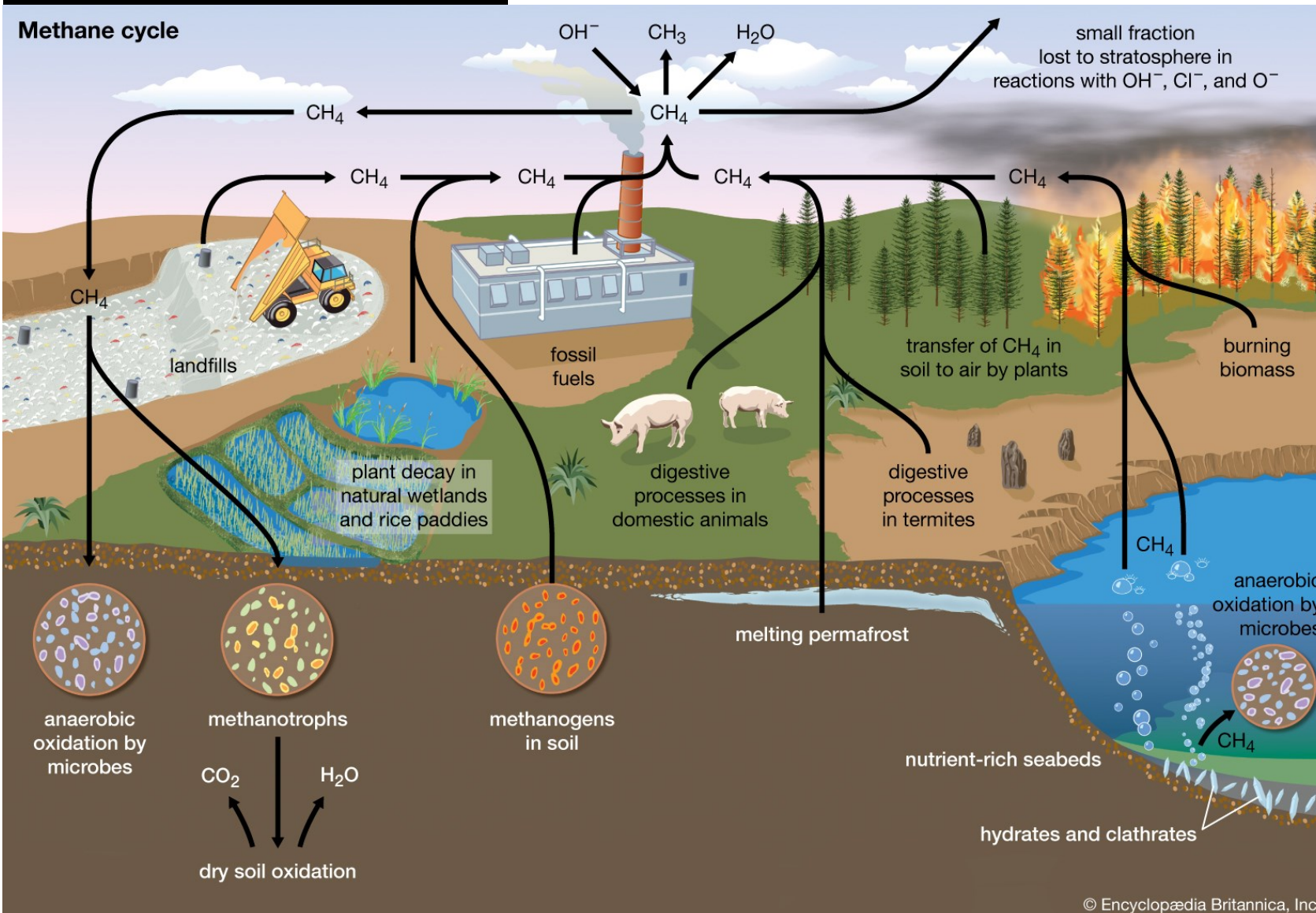
Dióxido de carbono (CO₂) – 1 GWP



- Mudança do uso da terra.
- Agropecuária.
- Energia: transporte.
- Energia: construção civil.
- Energia: industrial.
- Resíduos e rejeitos “lixo”.
- Outros.

PRINCIPAIS CAUSADORES DO EFEITO ESTUFA

Metano (CH₄) – 27 GWP



- Pecuária: principalmente bovinos.
- Agricultura: principalmente arroz.
- Lagos naturais.
- Queimadas de biomassa.
- Combustíveis fósseis.
- Lixo: chorume.
- Derretimento do permafrost.
- Outros.

PRINCIPAIS CAUSADORES DO EFEITO ESTUFA

Óxido Nitroso (N₂O) – 273 GWP

<https://www.nature.com/articles/s41586-020-2780-0>

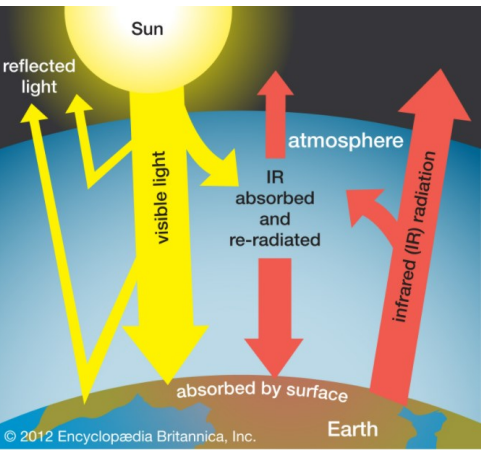
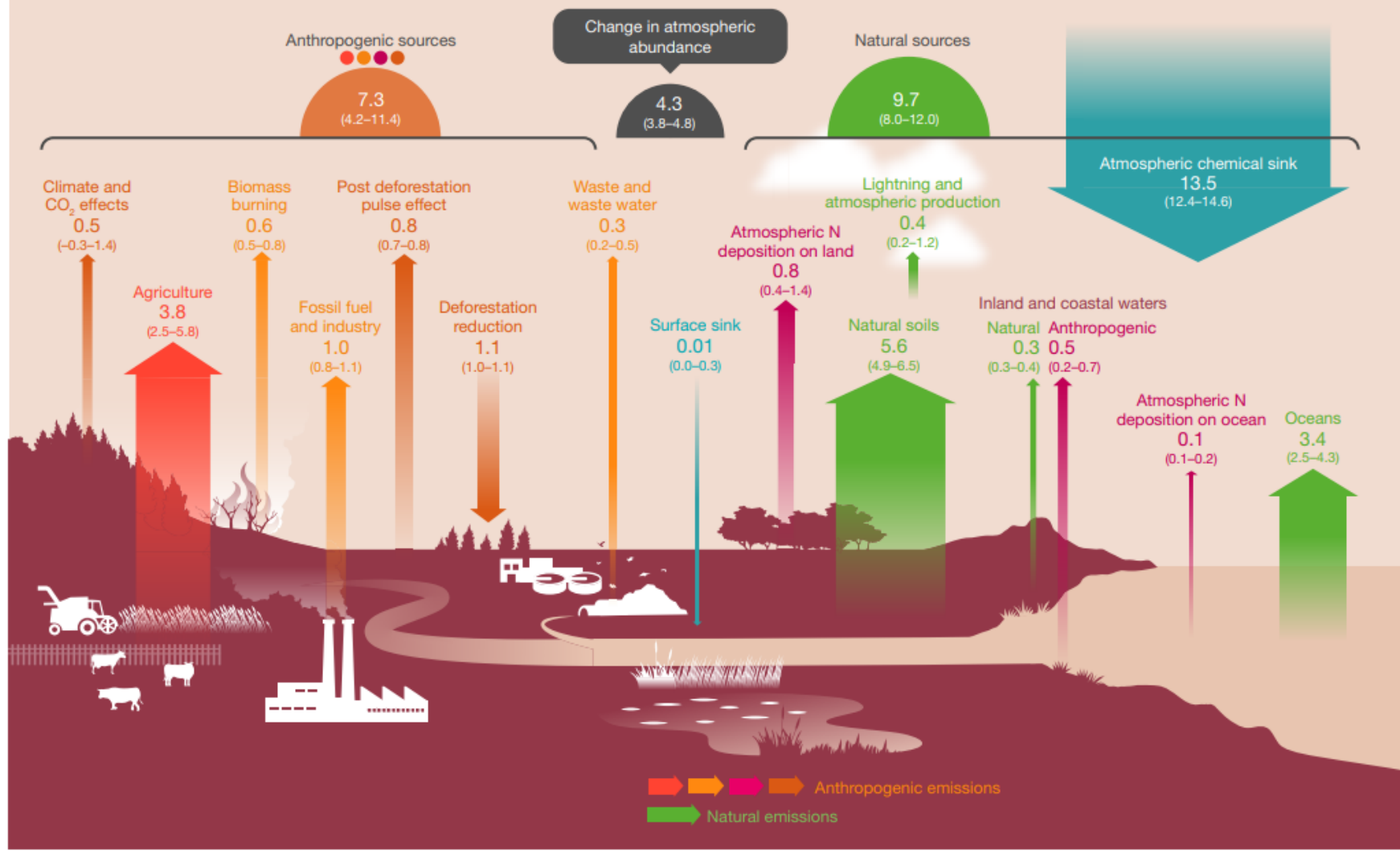


Fig. 1 | Global N₂O budget for 2007–2016. The coloured arrows represent N₂O fluxes (in Tg N yr⁻¹ for 2007–2016) as follows: red, direct emissions from nitrogen additions in the agricultural sector (agriculture); orange, emissions from other direct anthropogenic sources; maroon, indirect emissions from anthropogenic nitrogen additions; brown, perturbed fluxes from changes in climate, CO₂ or land cover; green, emissions from natural sources. The anthropogenic and natural N₂O sources are derived from bottom-up estimates. The blue arrows represent the surface sink and the observed atmospheric

chemical sink, of which about 1% occurs in the troposphere. The total budget (sources + sinks) does not exactly match the observed atmospheric accumulation, because each of the terms has been derived independently and we do not force top-down agreement by rescaling the terms. This imbalance readily falls within the overall uncertainty in closing the N₂O budget, as reflected in each of the terms. The N₂O sources and sinks are given in Tg N yr⁻¹. Copyright the Global Carbon Project.

GASES DE EFEITO ESTUFA

Potencial de aquecimento global (GWP-100)

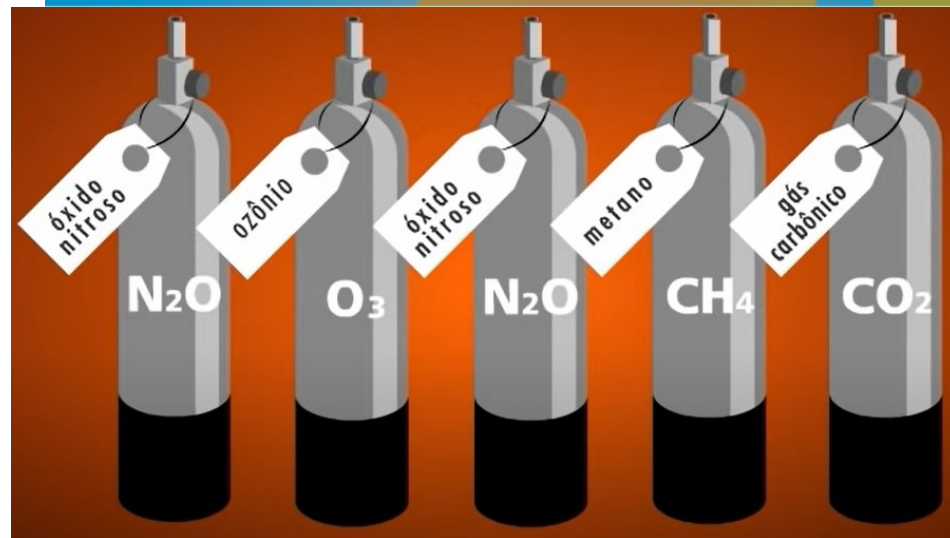
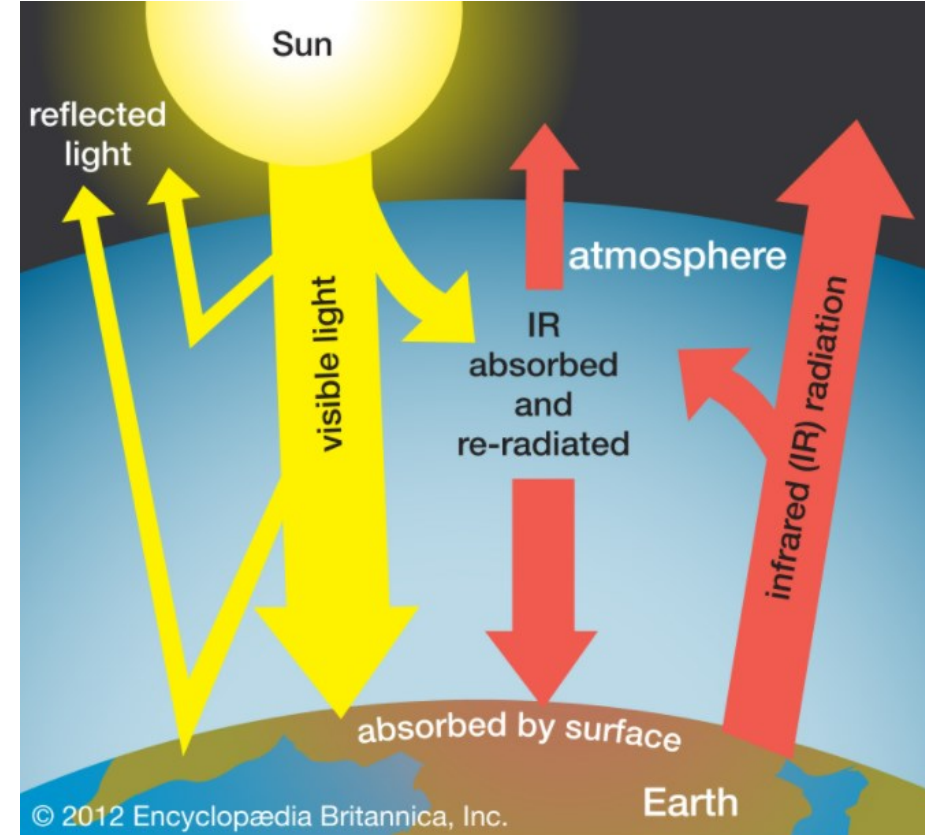
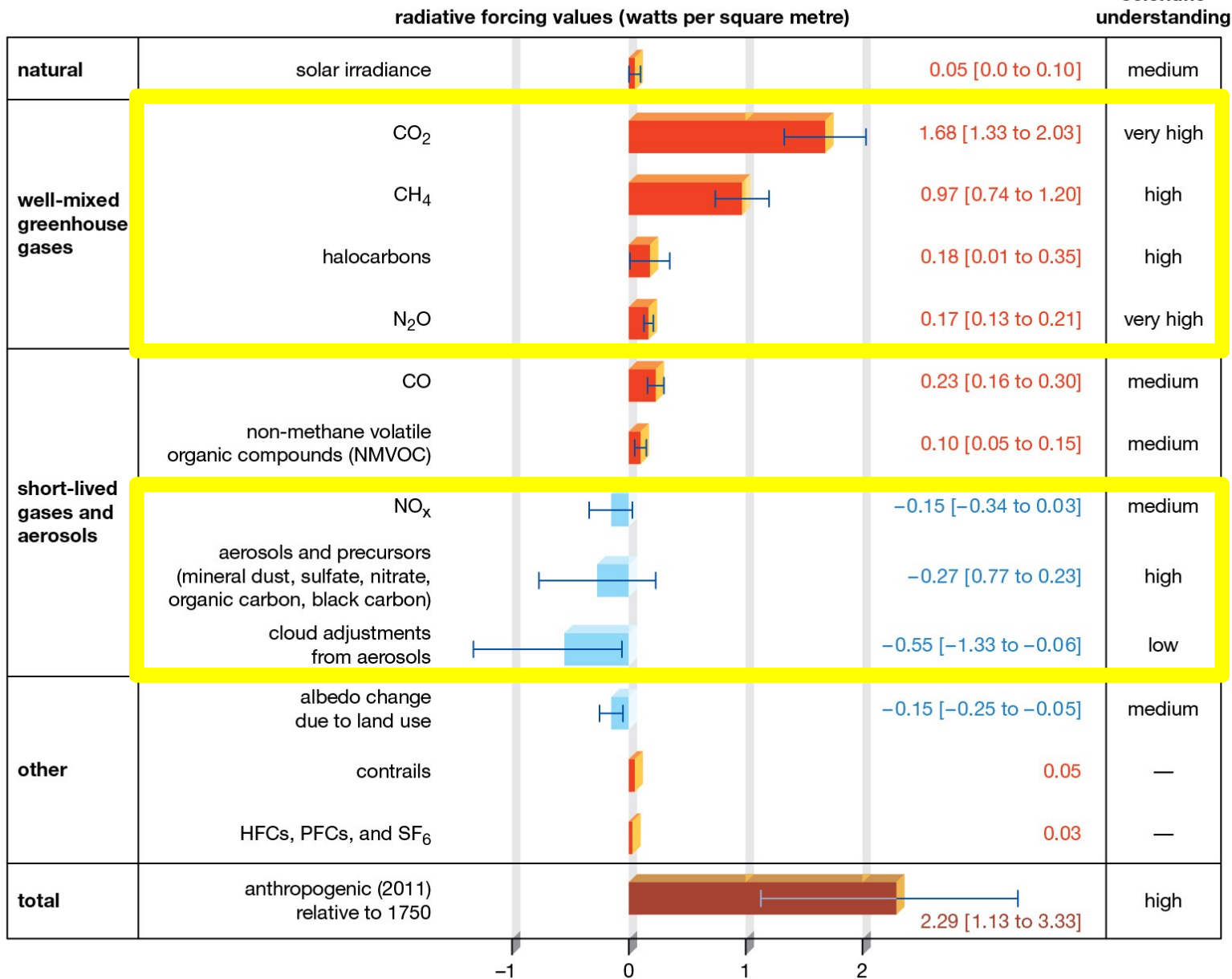
Período de Vida (Lifetime)

Table 7.15 | Emissions metrics for selected species: global warming potential (GWP), global temperature-change potential (GTP). All values include carbon cycle responses as described in Section 7.6.1.3. Combined GTPs (CGTPs) are shown only for species with a lifetime less than 20 years (Section 7.6.1.4). Note CGTP has units of years and is applied to a change in emissions rate rather than a change in emissions amount. The radiative efficiencies are as described in Section 7.3.2 and include tropospheric adjustments where assessed to be non-zero in Section 7.6.1.1. The climate response function is from Supplementary Material 7.SM.5.2. Uncertainty calculations are presented in Supplementary Tables 7.SM.8 to 7.SM.13. Chemical effects of CH₄ and N₂O are included (Section 7.6.1.3). Contributions from stratospheric ozone depletion to halogenated species metrics are not included. Supplementary Table 7.SM.7 presents the full table.

Species	Lifetime (Years)	Radiative Efficiency (W m ⁻² ppb ⁻¹)	GWP-20	GWP-100	GWP-500	GTP-50	GTP-100	CGTP-50 (years)	CGTP-100 (years)
CO ₂	Multiple	1.33 ± 0.16 × 10 ⁻⁵	1.	1.000	1.000	1.000	1.000		
CH ₄ -fossil	11.8 ± 1.8	5.7 ± 1.4 × 10 ⁻⁴	82.5 ± 25.8	29.8 ± 11	10.0 ± 3.8	13.2 ± 6.1	7.5 ± 2.9	2823 ± 1060	3531 ± 1385
CH ₄ -non fossil	11.8 ± 1.8	5.7 ± 1.4 × 10 ⁻⁴	79.7 ± 25.8	27.0 ± 11	7.2 ± 3.8	10.4 ± 6.1	4.7 ± 2.9	2675 ± 1057	3228 ± 1364
N ₂ O	109 ± 10	2.8 ± 1.1 × 10 ⁻³	273 ± 118	273 ± 130	130 ± 64	290 ± 140	233 ± 110		
HFC-32	5.4 ± 1.1	1.1 ± 0.2 × 10 ⁻¹	2693 ± 842	771 ± 292	220 ± 87	181 ± 83	142 ± 51	78,175 ± 29,402	92,888 ± 36,534
HFC-134a	14.0 ± 2.8	1.67 ± 0.32 × 10 ⁻¹	4144 ± 1160	1526 ± 577	436 ± 173	733 ± 410	306 ± 119	146,670 ± 53,318	181,408 ± 71,365
CFC-11	52.0 ± 10.4	2.91 ± 0.65 × 10 ⁻¹	8321 ± 2419	6226 ± 2297	2093 ± 865	6351 ± 2342	3536 ± 1511		
PFC-14	50,000	9.89 ± 0.19 × 10 ⁻²	5301 ± 1395	7380 ± 2430	10,587 ± 3692	7660 ± 2464	9055 ± 3128		

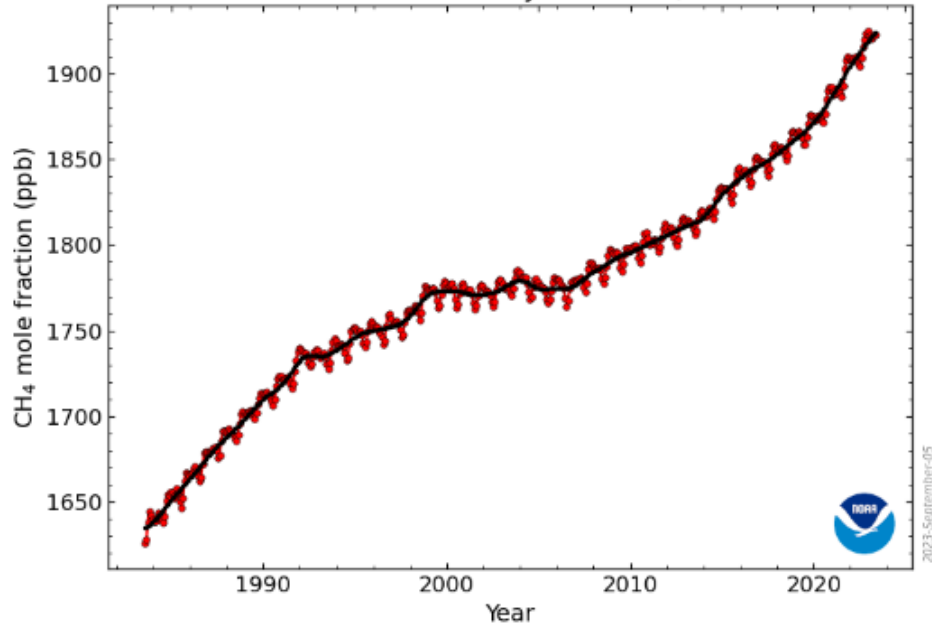
PRINCIPAIS CAUSADORES DO EFEITO ESTUFA

Global mean radiative forcings since 1750

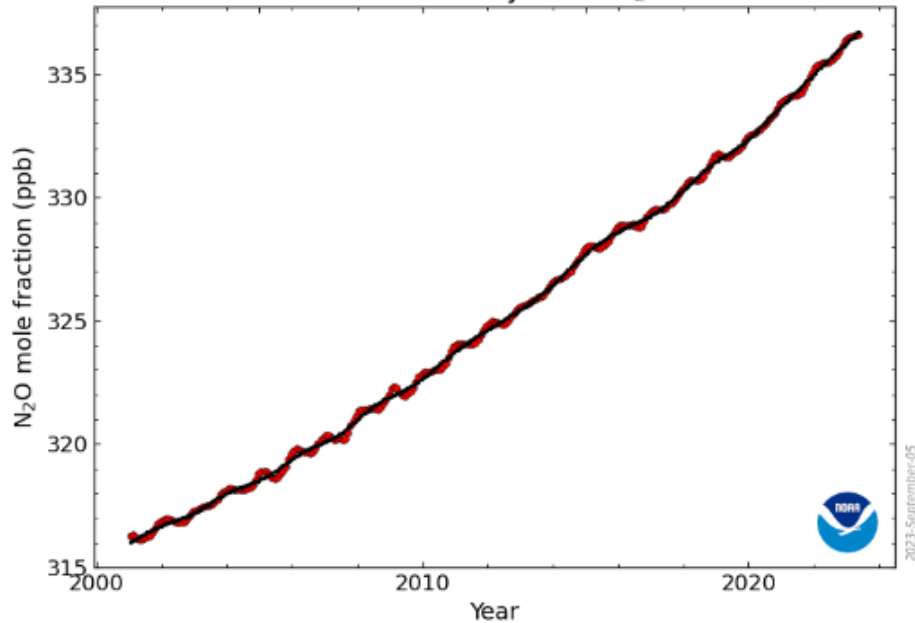


VISITE O SITE DO NOAA!!!

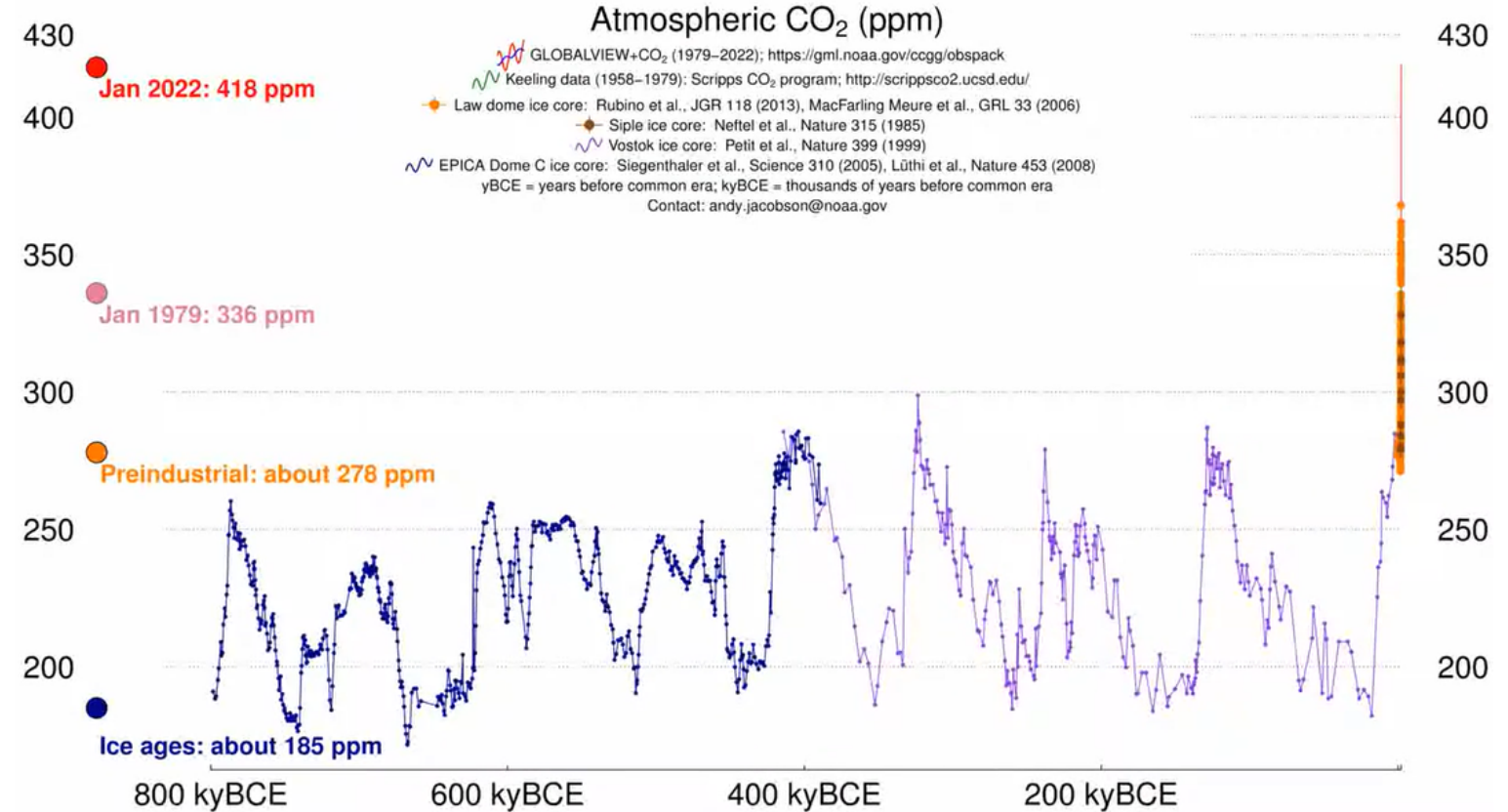
Global Monthly Mean CH₄



Global Monthly Mean N₂O



History of atmospheric carbon dioxide from 800,000 years ago until the end of the most recent GLOBALVIEW+ CO₂ collection



<https://gml.noaa.gov/ccgg/trends/history.html>

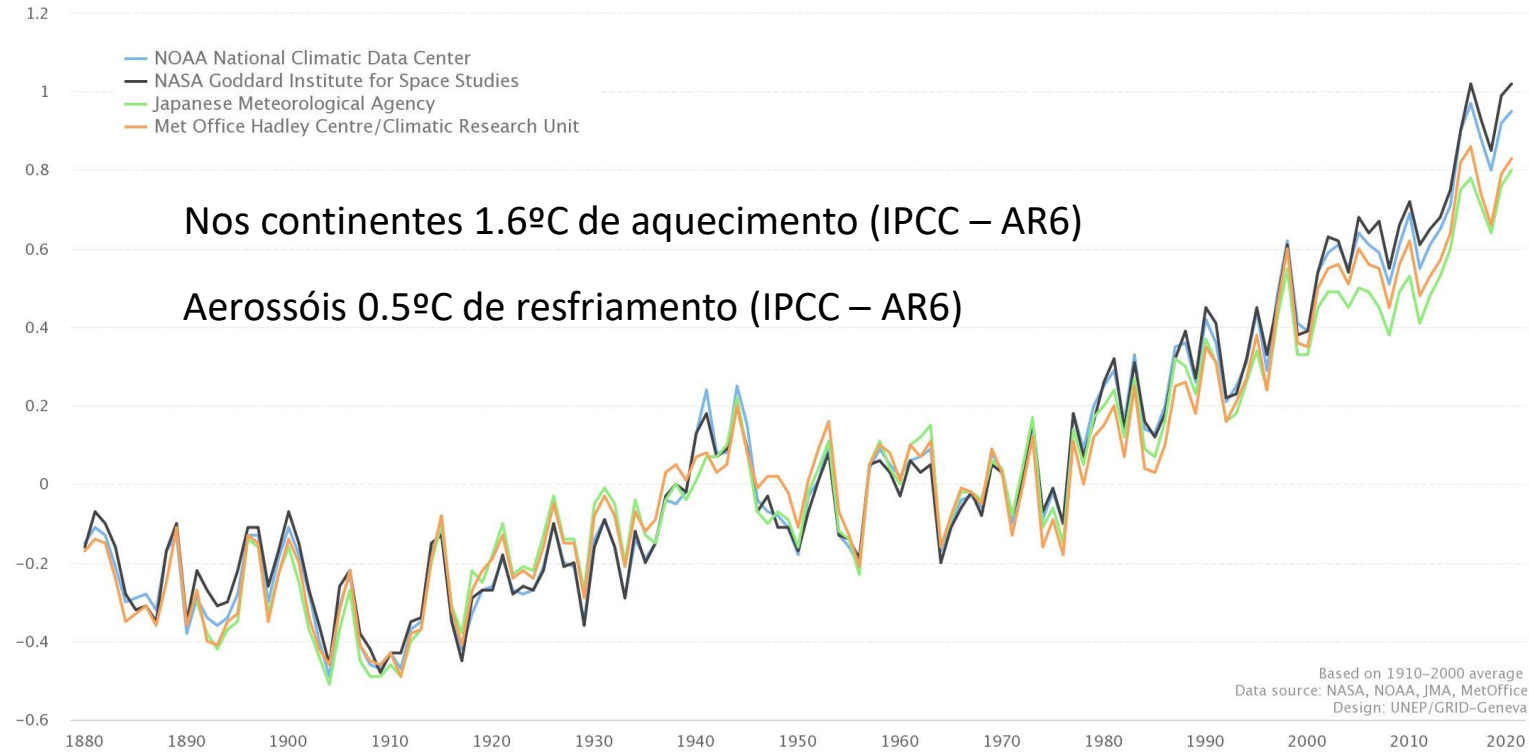
A temperatura do globo também aumentou?



Global Surface Temperature

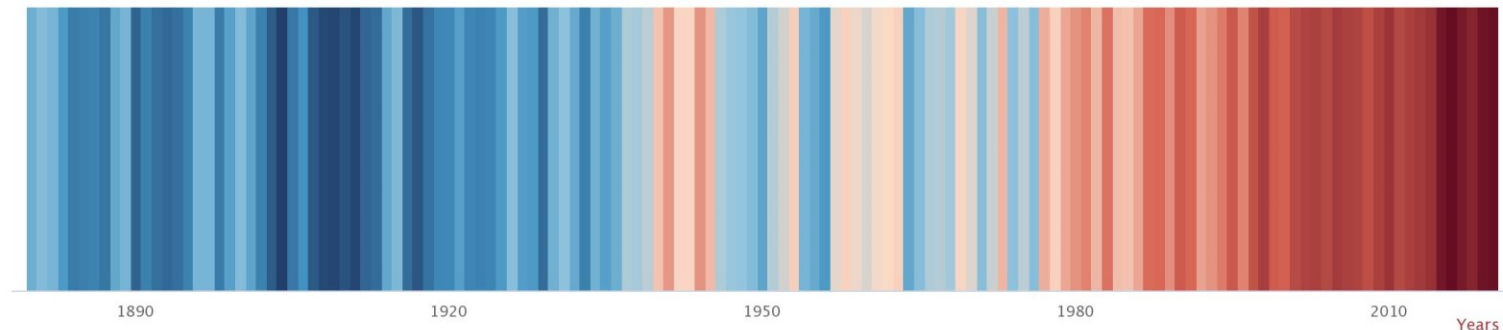
Temperature Anomaly (°C)

Four independent data sources show nearly identical long-term warming trends

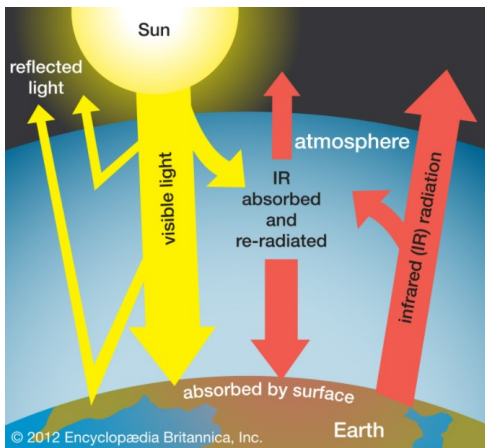


Global Annual Temperature Deviation

based on 1981–2010 average



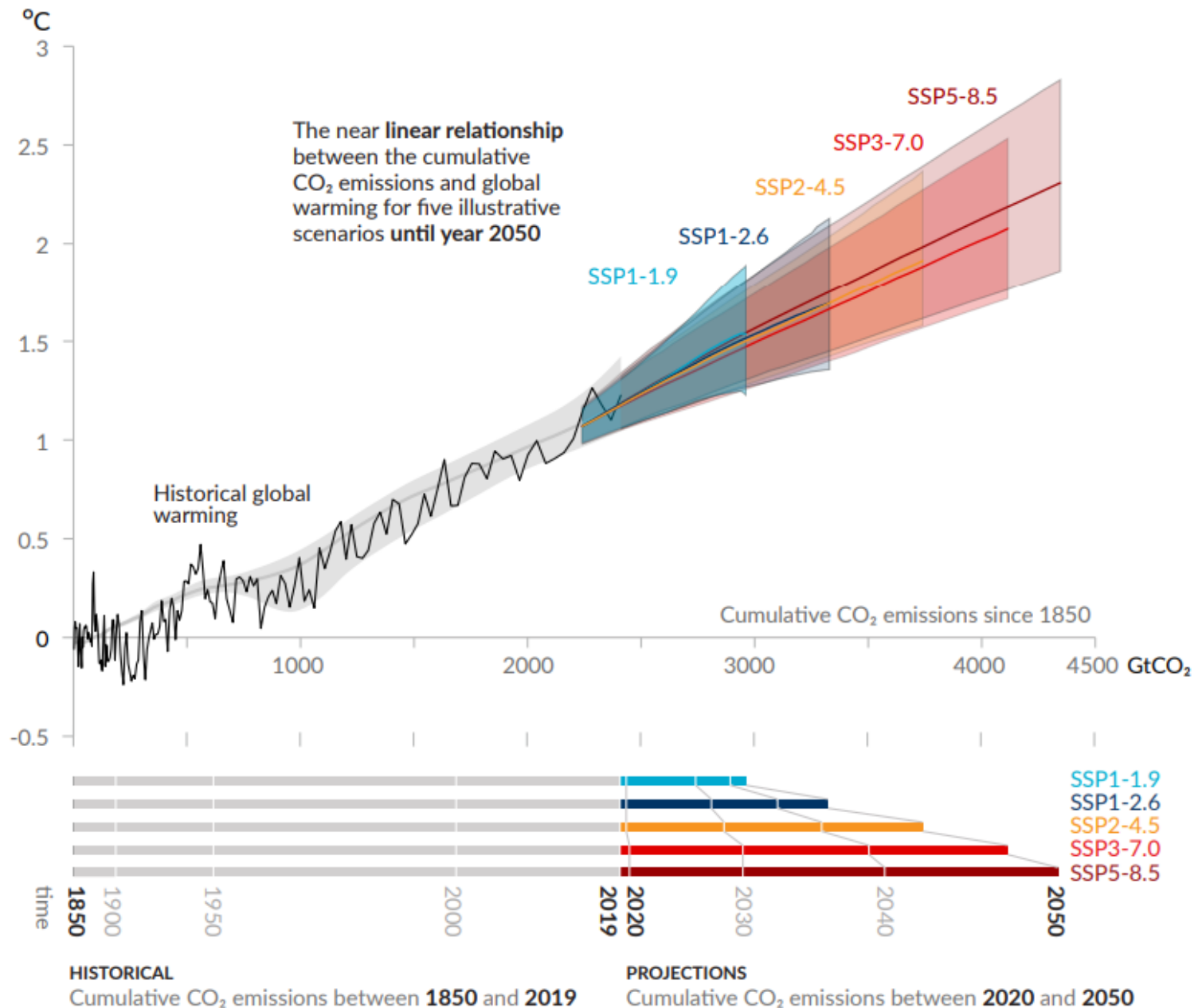
Data source: NOAA
Design: UNEP/GRID–Geneva



<https://www.unep.org/pt-br/noticias-e-reportagens/reportagem/o-aumento-alarmante-da-temperatura-global>

Every tonne of CO₂ emissions adds to global warming

Global surface temperature increase since 1850-1900 (°C) as a function of cumulative CO₂ emissions (GtCO₂)



Há relação da temperatura do globo com as emissões de CO₂?



IPCC AR6

(universo científico)

- Mais de 14 mil trabalhos científicos revisados no último relatório do IPCC.
- 234 autores de 66 países.
- 36 editores revisores.
- 517 co-autores contribuintes.

<https://www.ipcc.ch/report/ar6/wg1/>

https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

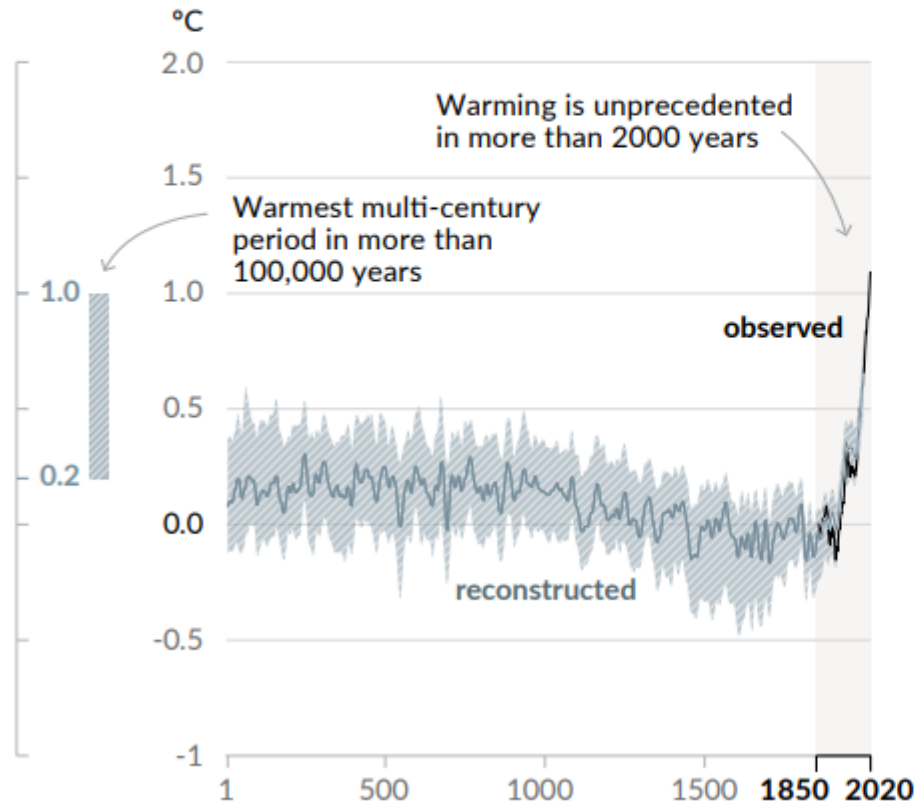
Mas foram será que foram poucos anos avaliados?



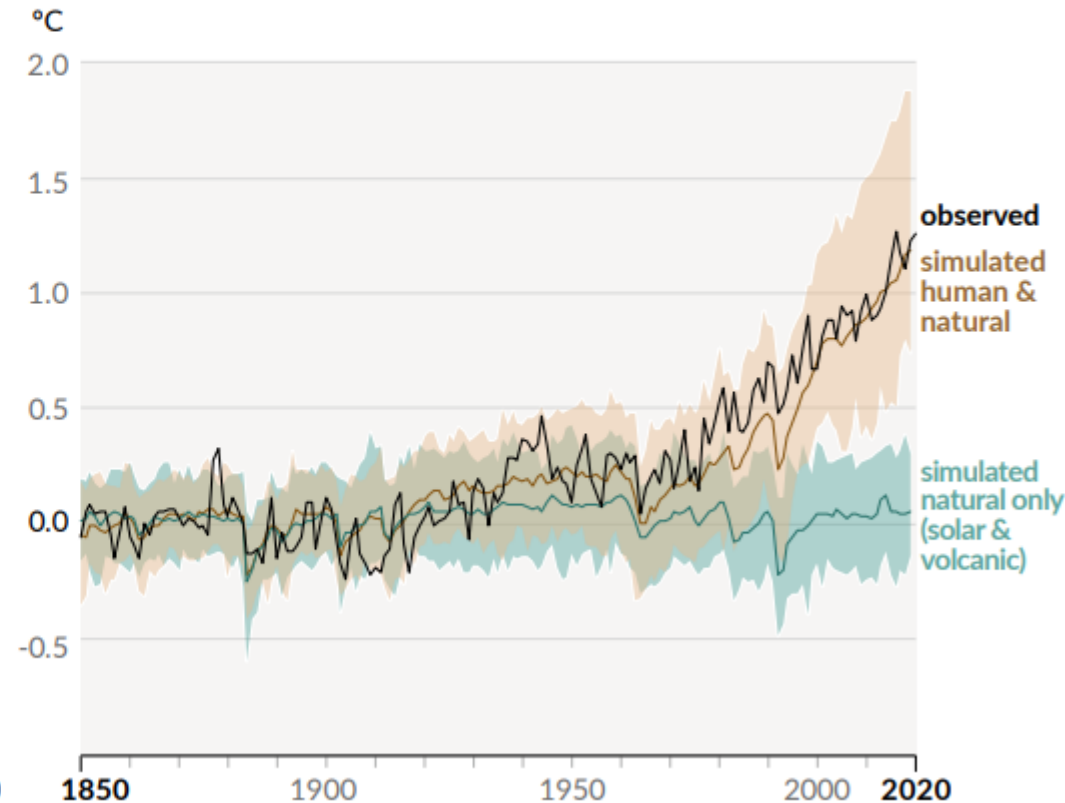
MUDANÇAS NA TEMPERATURA MÉDIA DO PLANETA
2 mil anos

Changes in global surface temperature relative to 1850-1900

a) Change in global surface temperature (decadal average) as reconstructed (1-2000) and observed (1850-2020)



b) Change in global surface temperature (annual average) as observed and simulated using human & natural and only natural factors (both 1850-2020)



IPCC AR6

(universo científico)

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- 234 autores de 66 países.
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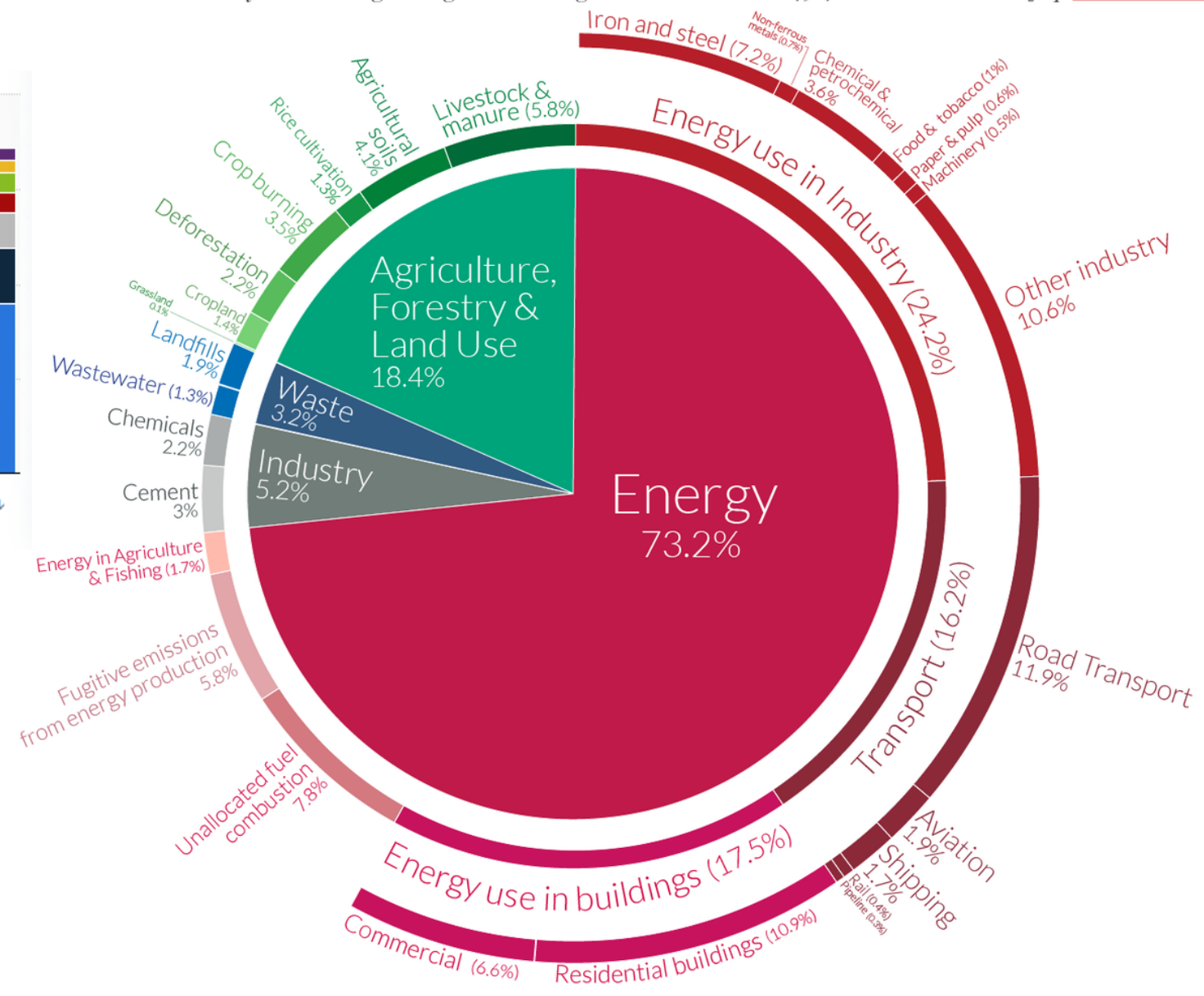
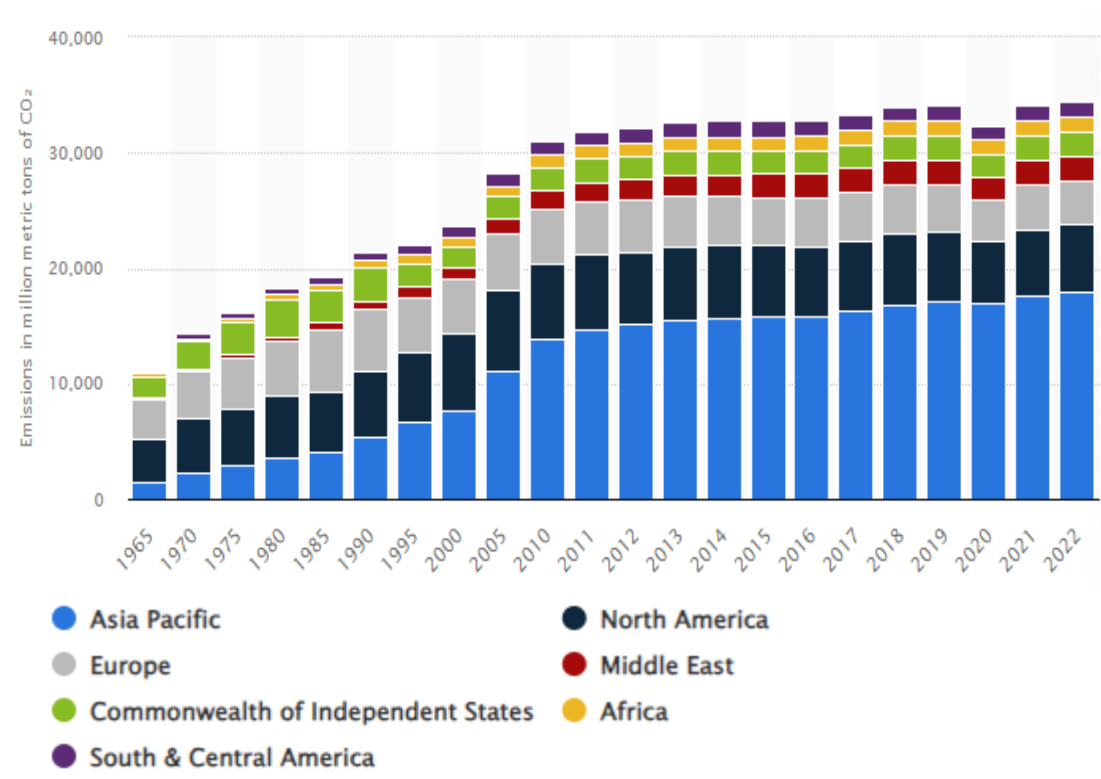
<https://www.ipcc.ch/report/ar6/wg1/>

https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

EMISSORES NO MUNDO

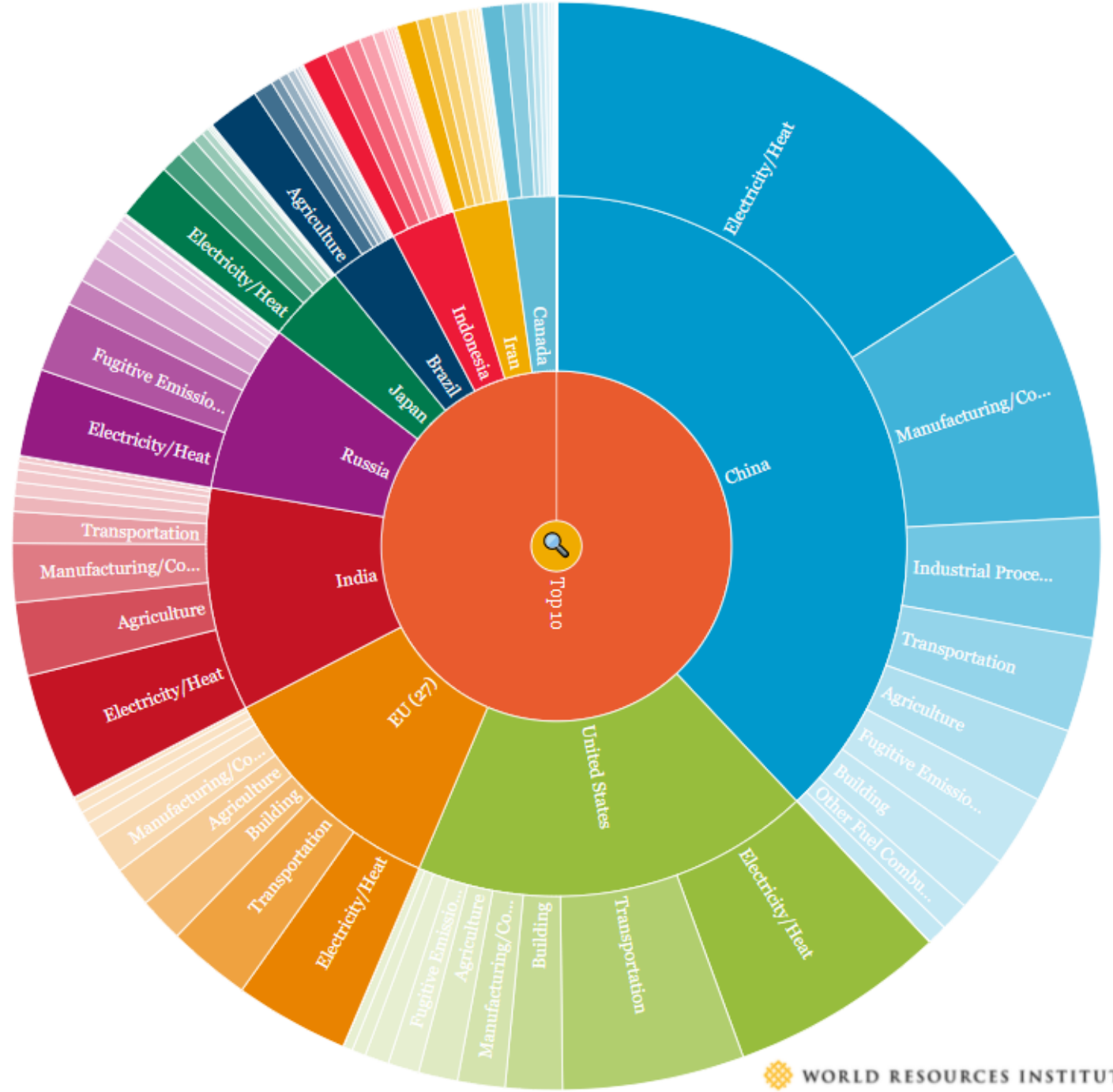
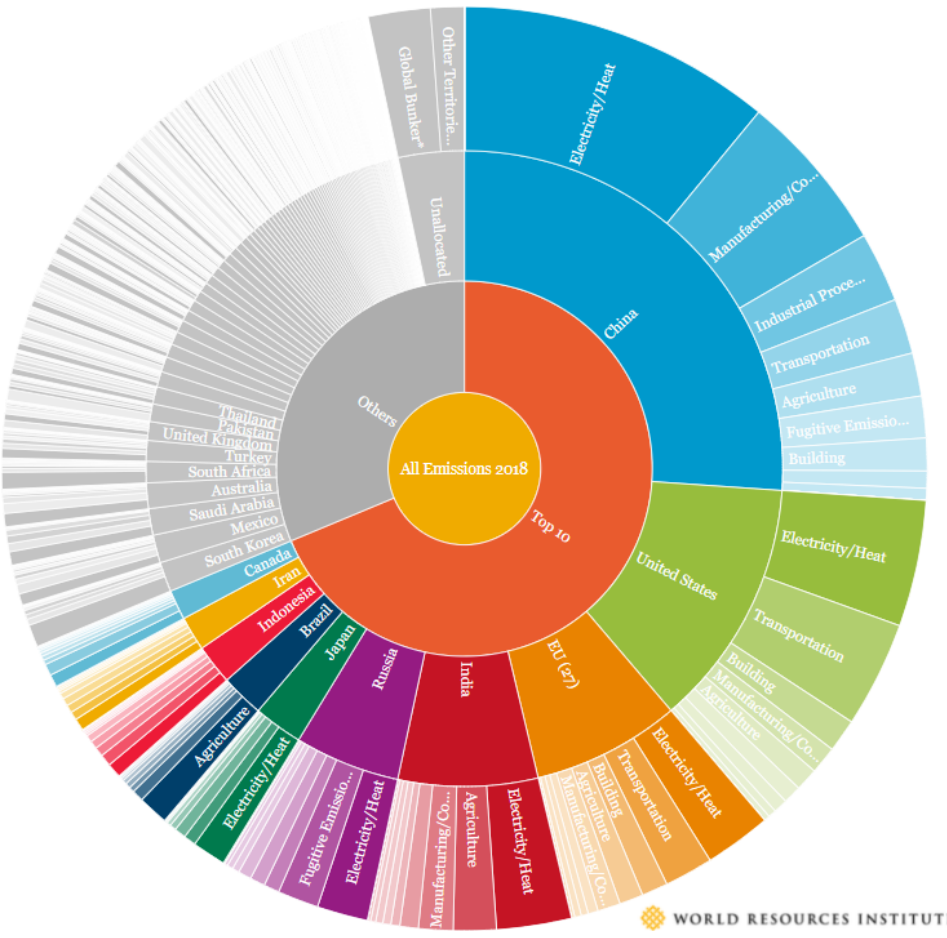
Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.



EMISSORES NO MUNDO

<https://www.wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters>



Confira quais são os países que mais emitem carbono

Brasil está em 6º lugar.

(Clique no gráfico para ver os números)

● China ● Estados Unidos ● Índia ● Rússia ● Indonésia
● BRASIL ● Japão ● Irã ● Alemanha ● Canadá

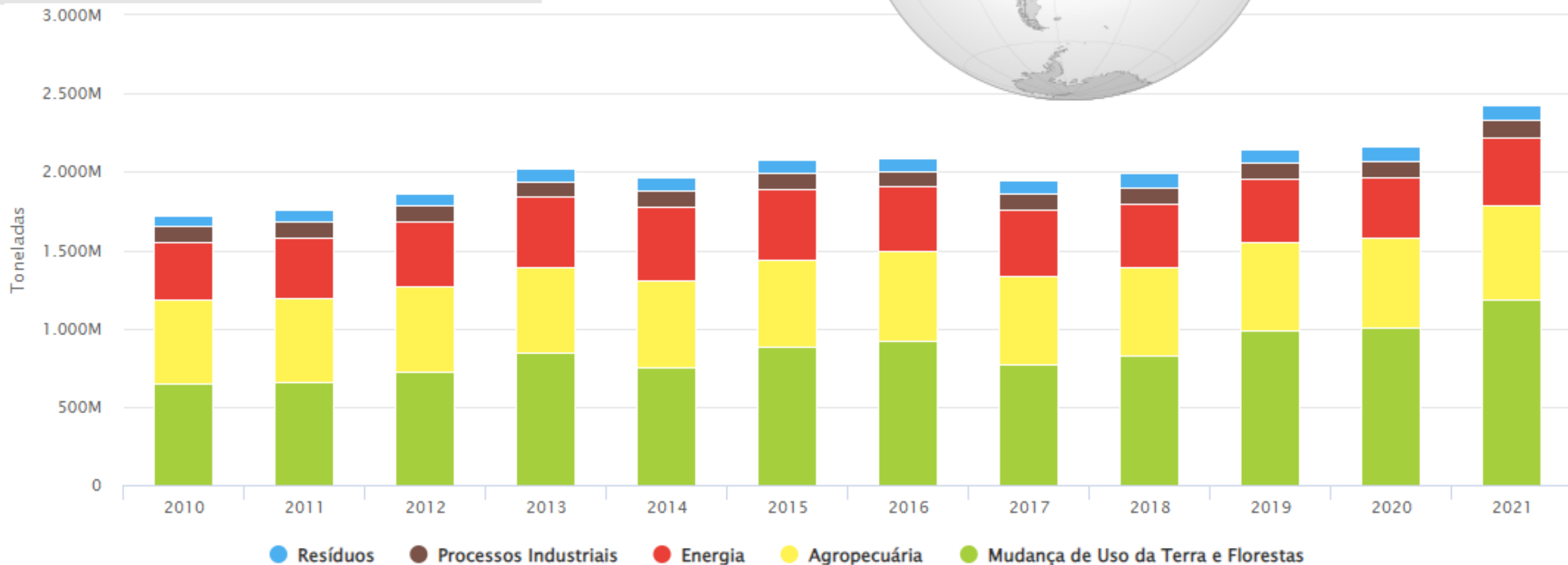
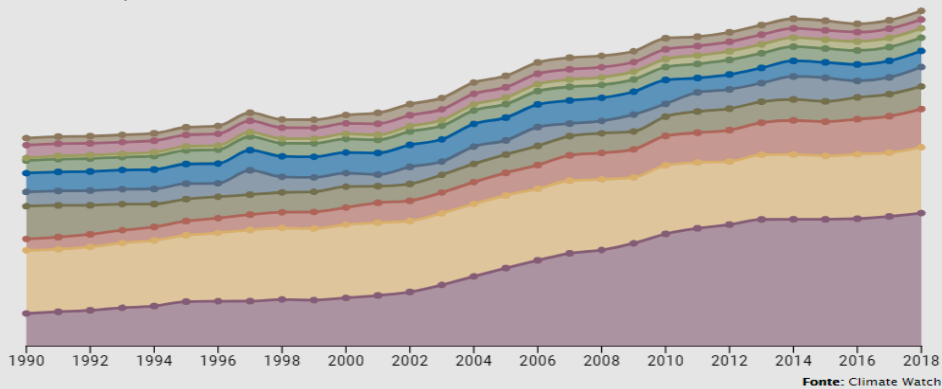
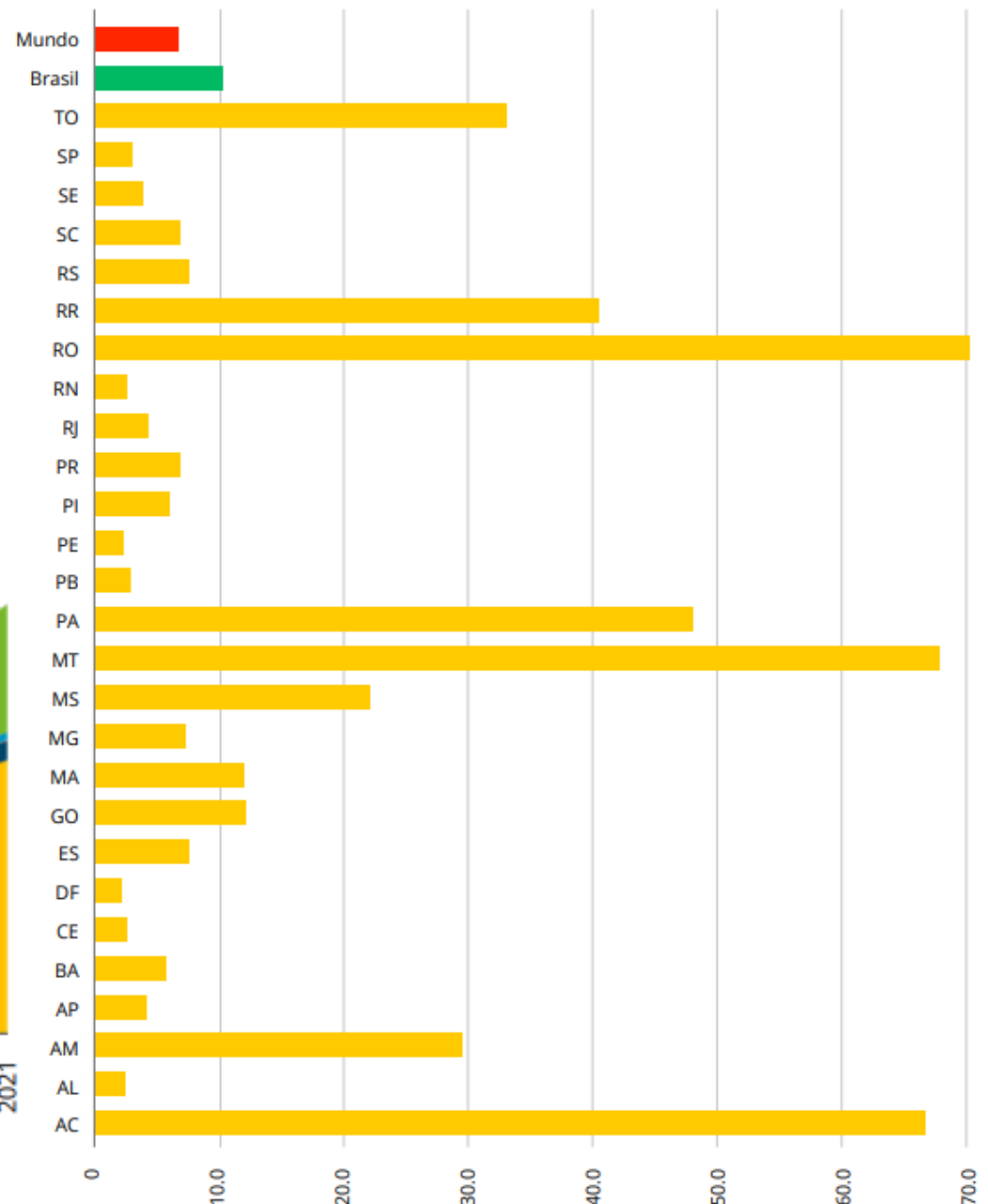
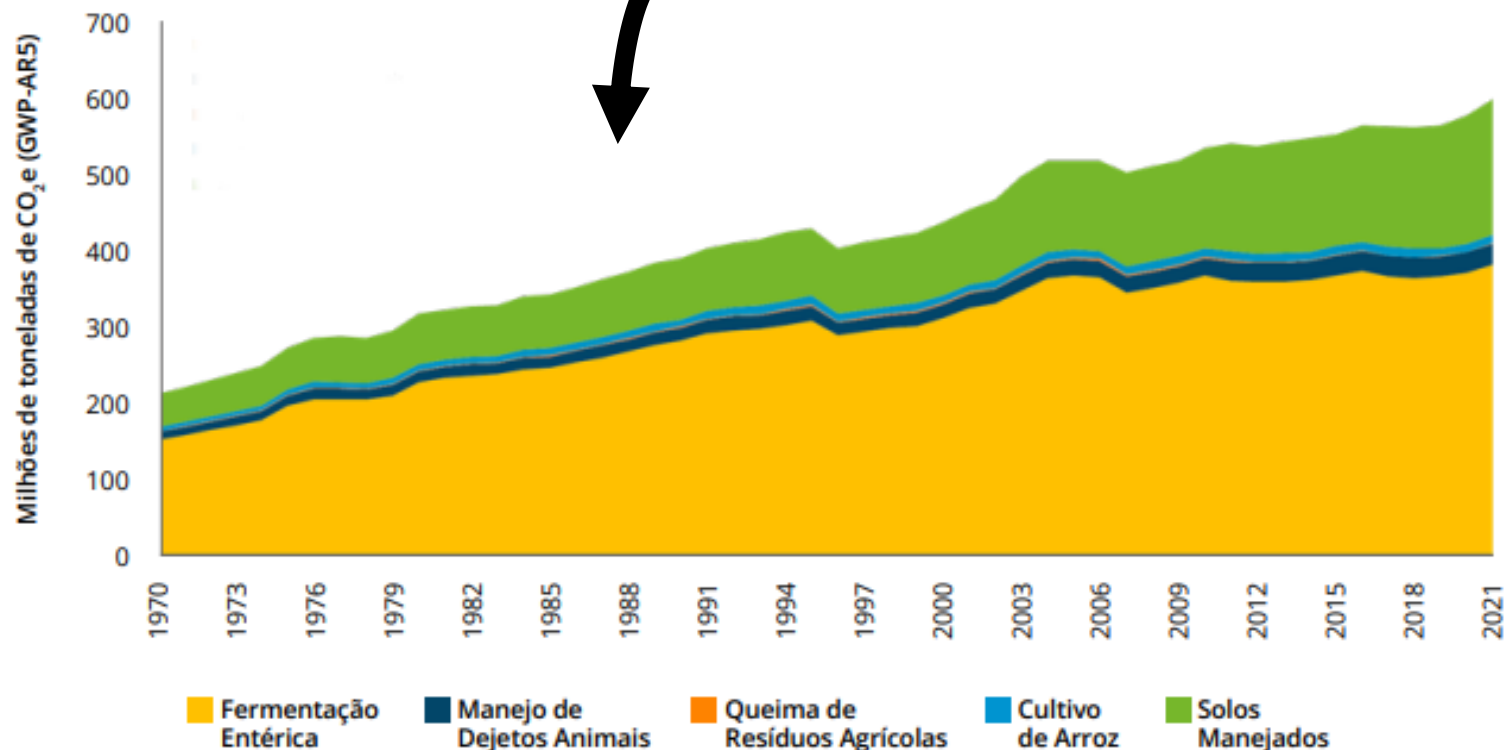
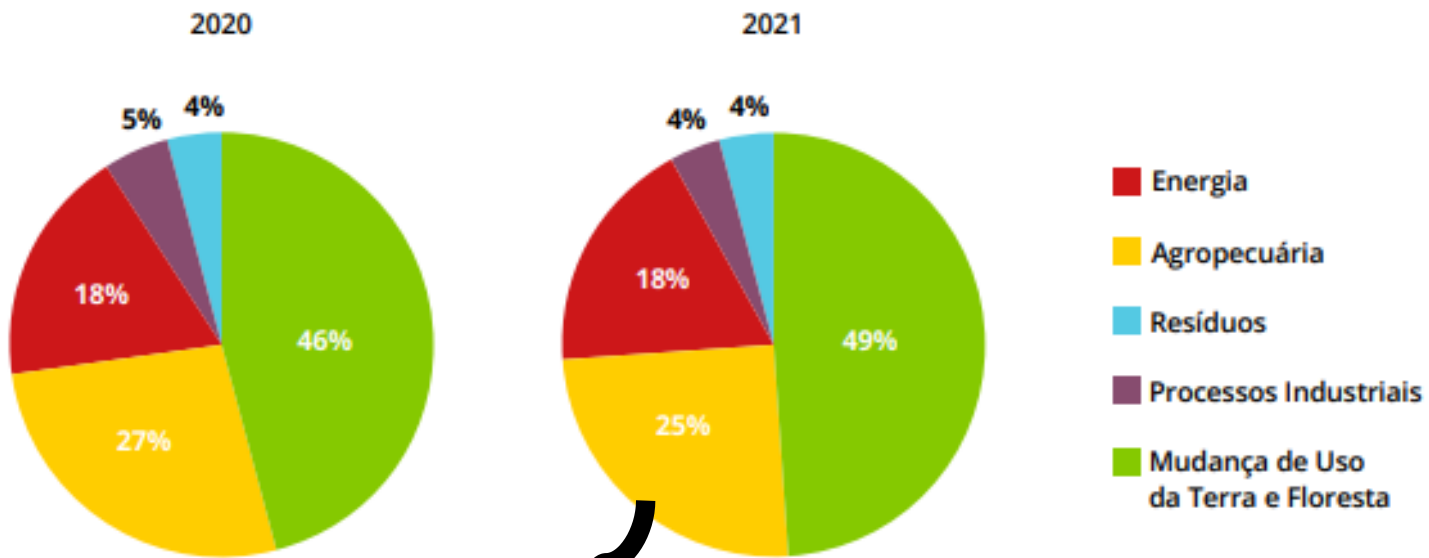


Figura 25 - Emissões per capita por Estado, 2021 (tCO₂e/habitante)



**EMISSÃO É DIFERENTE
DE BALANÇO!**

Low-carbon agriculture in South America to mitigate global climate change and advance food security

João Carlos de Moraes Sá^{a,*}, Rattan Lal^b, Carlos Clemente Cerri^c, Klaus Lorenz^b, Mariangela Hungria^d, Paulo Cesar de Faccio Carvalho^e

<http://dx.doi.org/10.1016/j.envint.2016.10.020>

Highlights

- The potential of South America as a terrestrial C sink by Low-Carbon Agriculture is 8.24 Pg C
- The C-offset by No-till through 2016 to 2050 period is limited to 24.3%
- The pay-back time by Low-Carbon Agriculture for historical C losses was 56 to 188 years
- Low-Carbon Agriculture adoption can increase 17.6 Mton year⁻¹ of food and 1.6 Mton year⁻¹ of meat

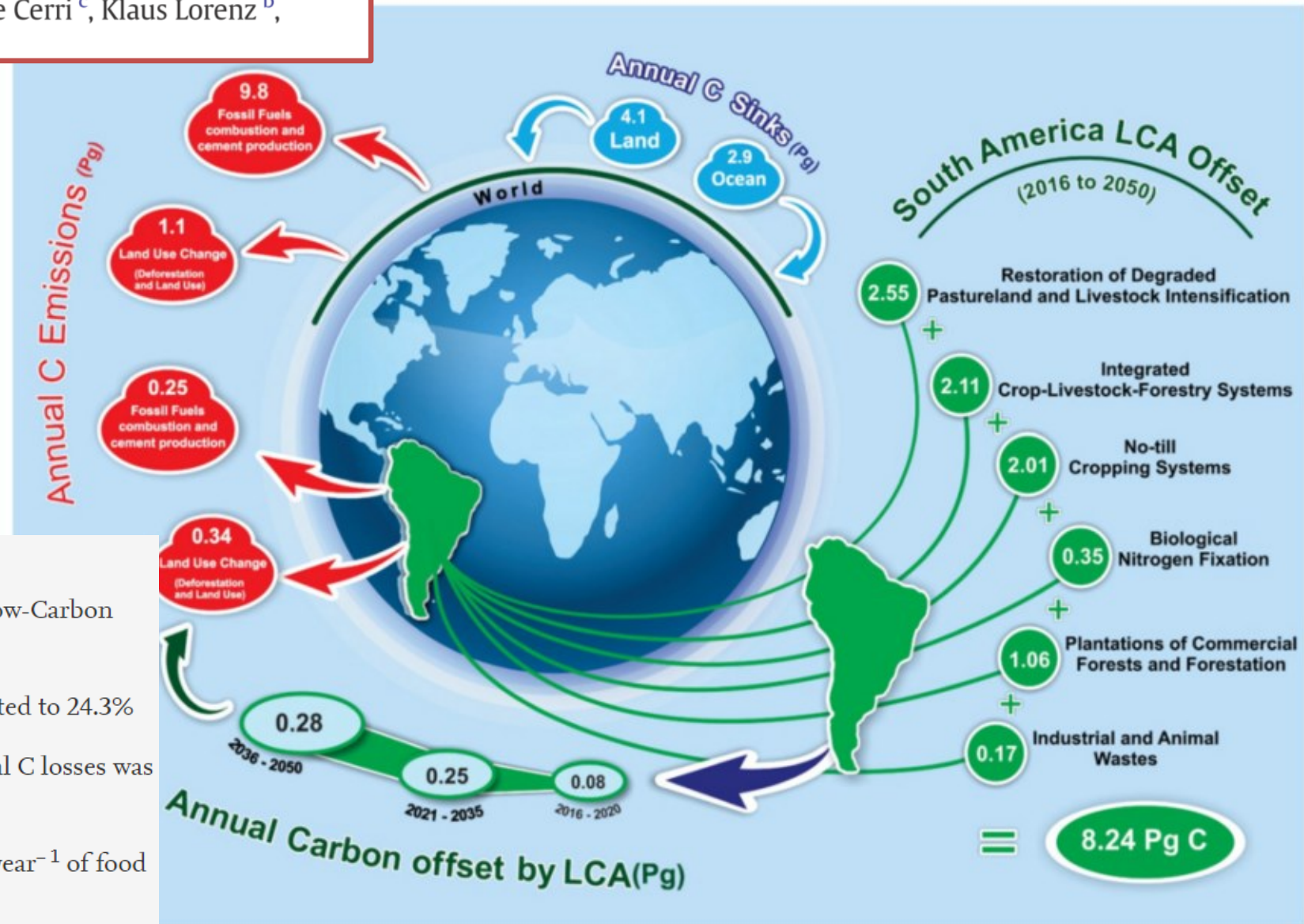












Fig. 1. Global carbon emissions and sinks, and South America C-offset by Low Carbon Agriculture (1 Pg C = 1 billion ton of C).

METAS ABC+ e Mitigação 2021 a 2030

TECNOLOGIAS 		META milhões ha ⁽¹⁾ /m ³⁽²⁾ /animais ⁽³⁾	META MITIGAÇÃO milhões Mg CO ₂ eq
Práticas para Recuperação de Pastagens Degradadas (PRPD) 		30,0 ⁽¹⁾	113,7
Sistema Plantio Direto (SPD)	Sistema Plantio Direto de Grãos (SPDG) 	12,5 ⁽¹⁾	12,1
	Sistema Plantio Direto Hortaliças (SPDH) 	0,08 ⁽¹⁾	0,88
Sistemas de Integração (SIN)	Integração Lavoura- Pecuária- Floresta (ILPF) 	10,0 ⁽¹⁾	34,1
	Sistemas Agroflorestais (SAF) 	0,1 ⁽¹⁾	37,9
Florestas Plantadas (FP) 		4,0 ⁽¹⁾	510,0
Bioinsumos (BI) 		13,0 ⁽¹⁾	23,4
Sistemas Irrigados (SI) 		3,0 ⁽¹⁾	50,0
Manejo de Resíduos da Produção Animal (MRPA) 		208,4 ⁽²⁾	277,8
Terminação Intensiva (TI) 		5,0 ⁽³⁾	16,24
TOTAL ABC+	72,68 milhões ha + 208,40 milhões m³ + 5 milhões de animais		1.076,14 milhões de Mg CO₂eq



Balanco de carbono ao invés de emissão de CO₂e...

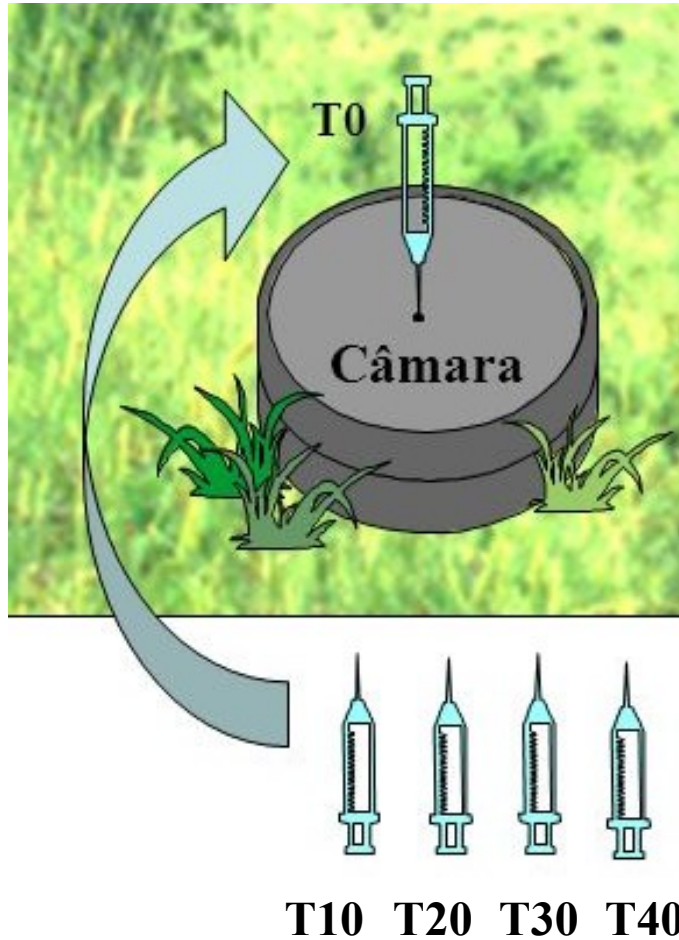


State of art about methods of measuring soil carbon stocks: agriculture in general and coffee production

Author: Carlos Eduardo Cerri

https://www.youtube.com/watch?v=3aA-L_lzzHo

Métodos tradicionais



Método de Fluxo Contínuo – LOS GATOS



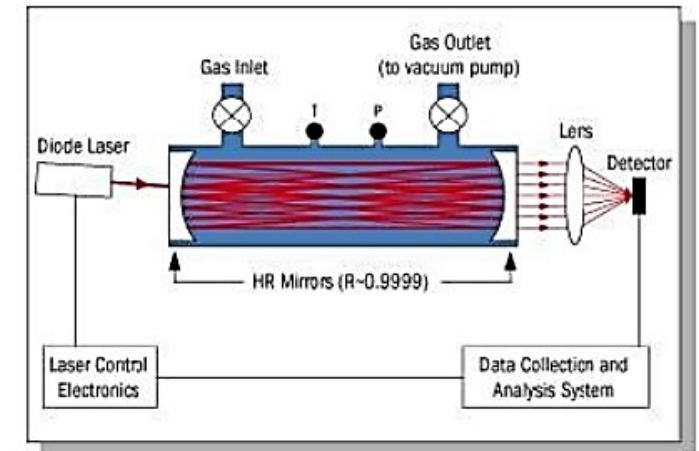
ULTRA PORTÁTIL – análises NO CAMPO!

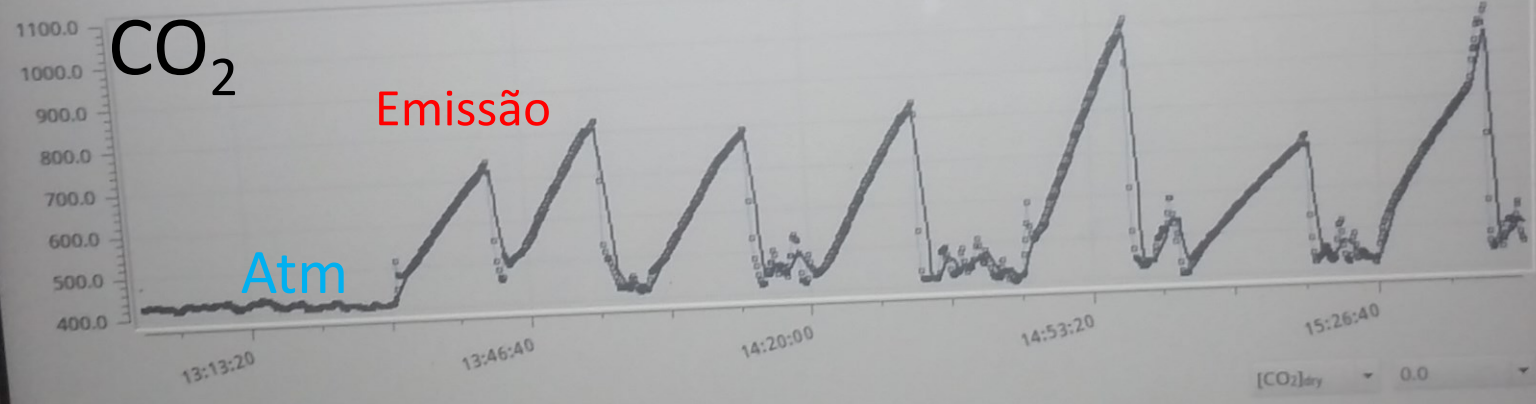
Tempo de medição reduzido (10 min);

Leituras a cada 10 segundos (ajustável);

Robustez e precisão em diversas condições de temperatura, radiação solar e umidade;

Coleta de amostra de gás após medição de fluxo;

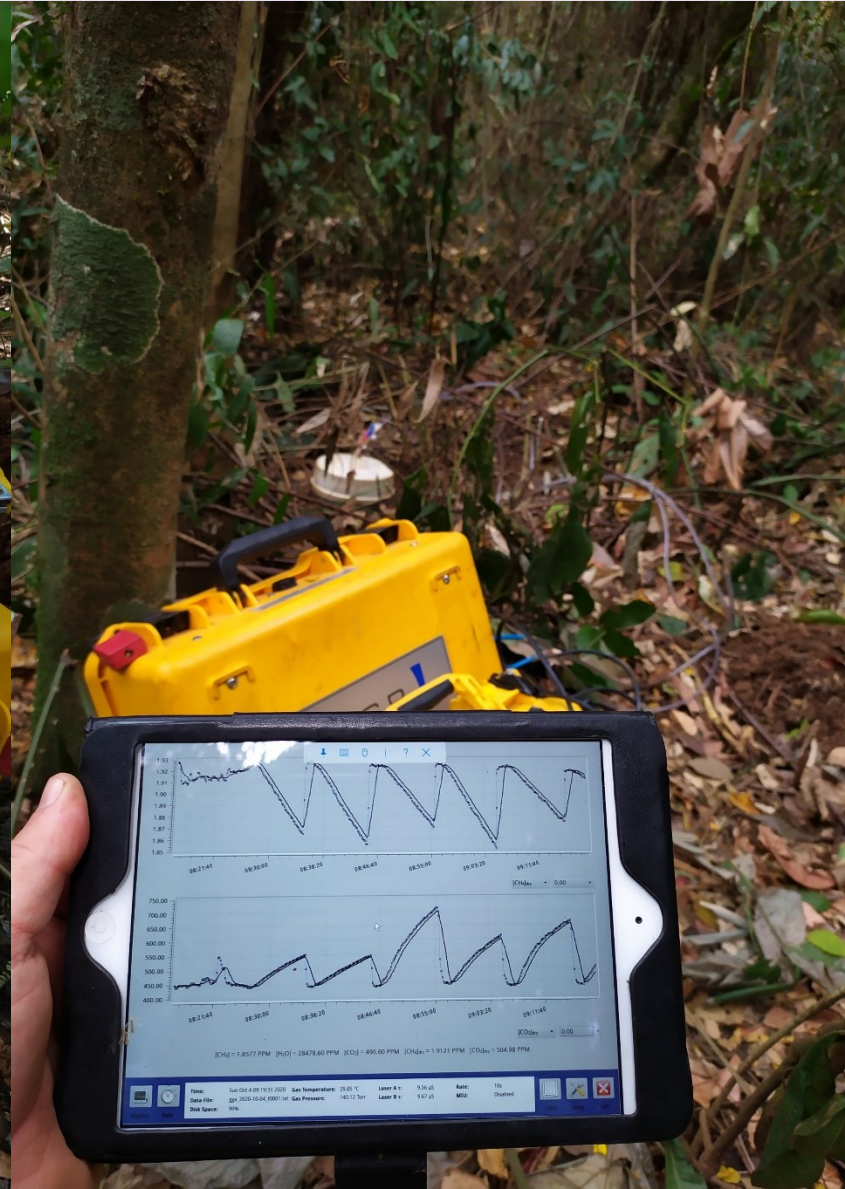




[CH₄] = 1.8099 PPM [H₂O] = 35809.56 PPM [CO₂] = 440.03 PPM [CH₄]_{av} = 1.8771 PPM [CO₂]_{av} = 456.37 PPM

Time: Tue Oct 24 15:43:14 2017 Gas Temperature: 36.37 °C Laser A τ: 9.85 μs Rate: 10s
 Data File: Ega_2017-10-24_f0001.txt Gas Pressure: 140.39 Torr Laser B τ: 10.13 μs MIU: Disabled

Expedições de 2020, 2021 e 2022 para coletas em florestas, pastagens, cana e restauração florestal na Mata Atlântica



Expedições de 2020, 2021 e 2022 para coletas em florestas, pastagens, cana e restauração florestal na Mata Atlântica



Expedições de 2022 para coletas em turfeira na Mata Atlântica



VÍDEOS

1. TEMPO *vs* CLIMA

2. AQUECIMENTO GLOBAL

3. MUDANÇAS GLOBAIS DO CLIMA

4. EFEITOS CLIMÁTICOS NOS CENTROS URBANOS

FRASES MARCANTES DO RELATÓRIO DO IPCC – 2021 (IPCC – AR6)

“Mudanças recentes no clima são generalizadas, rápidas, intensificadas e sem precedentes em pelo menos 6500 anos.”

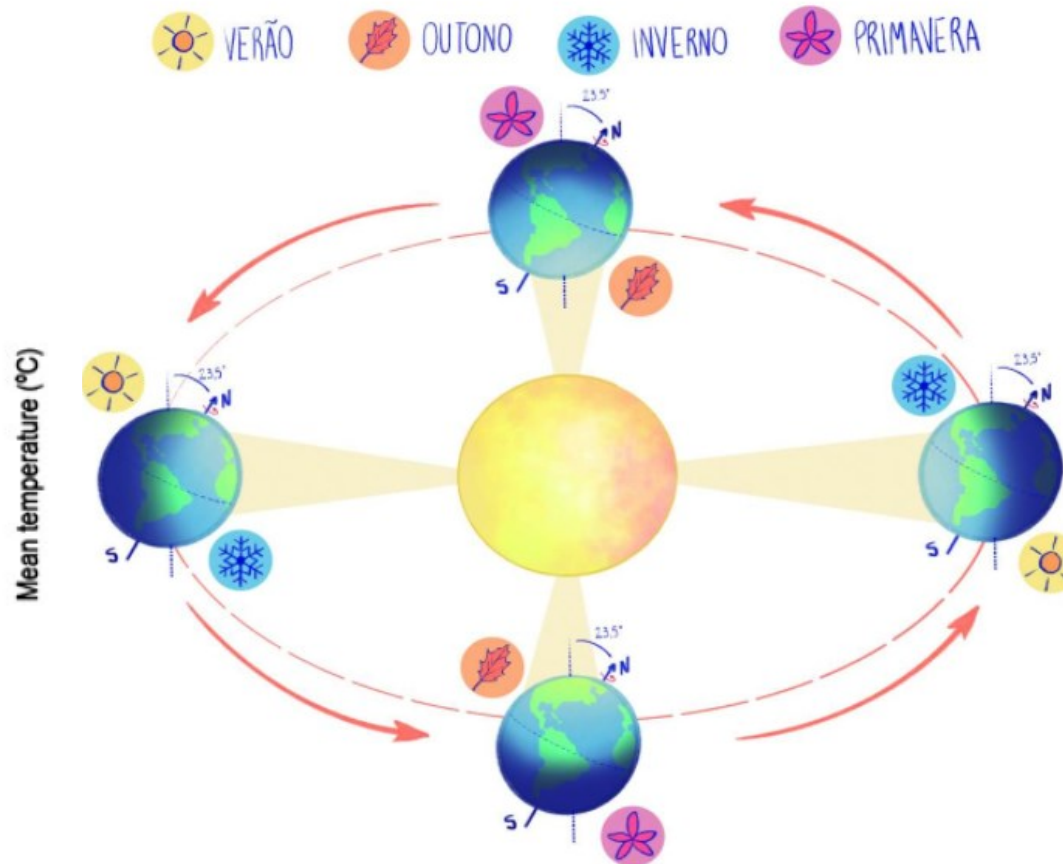
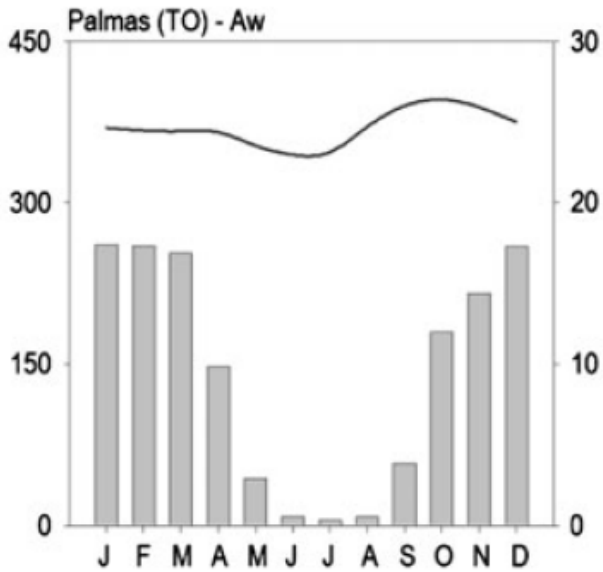
“A menos que haja reduções imediatas, rápidas e em grande escala nas emissões de gases de efeito estufa, limitar o aquecimento a 1,5 °C pode ser impossível.”

“É indiscutível que as atividades estão causando mudanças climáticas, tornando eventos climáticos extremos, incluindo ondas de calor, chuvas fortes e secas, mais frequentes e severas.

“A mudança climática já está afetando todas as regiões da terra, de muitas maneiras. As mudanças que experimentamos aumentarão com o aquecimento global.

“Algumas das mudanças climáticas são irreversíveis. No entanto algumas mudanças podem ser retardadas e outras podem ser interrompidas se limitarmos as emissões”.

“Para limitar o aquecimento global são necessárias reduções fortes, rápidas e sustentadas de CO₂, metano e outros gases de efeito estufa. Isso não só reduziria as consequências das mudanças climáticas, mas também melhoraria a poluição do ar nas cidades”.



SOLSTÍCIO		
ESTACÃO DO ANO QUE SE INICIA	Verão austral (HS) inverno boreal (HN)	Inverno austral (HS) verão boreal (HN)
DATA DO EVENTO	21 ou 22 de dezembro	20 ou 21 de junho
INCIDÊNCIA DA RADIAÇÃO	Sol incidindo perpendicularmente sobre o Trópico de Capricórnio no HS (23,5°S)	Sol incidindo perpendicularmente sobre o Trópico de Câncer no HN (23,5°N)

EQUINÓCIO		
ESTACÃO DO ANO QUE SE INICIA	Outono austral (HS) primavera boreal (HN)	Primavera austral (HS) outono boreal (HN)
DATA DO EVENTO	19 ou 20 de março	22 ou 23 de setembro
INCIDÊNCIA DA RADIAÇÃO	Sol incidindo perpendicularmente sobre a linha do equador; mesma intensidade de luz em ambos os hemisférios	

Mudanças climáticas significam alterações por longo prazo nos elementos meteorológicos e/ou climáticos. Alguns indicadores tem sido recorrentes no tempo:

- Eventos extremos: aumento na ocorrência de enchentes e secas prolongadas.
- Acidificação dos oceanos com o aumento da concentração de CO₂ da atmosfera.
- Derretimento de geleiras e aumento do nível do mar.
- Aumento da temperatura média do globo terrestre.
- Aumento da temperatura média da água do mar.
- Aumento da ocorrência de tempestades (e.g. ciclones).
- Ondas de calor.

Climate change is already affecting every inhabited region across the globe with human influence contributing to many observed changes in weather and climate extremes

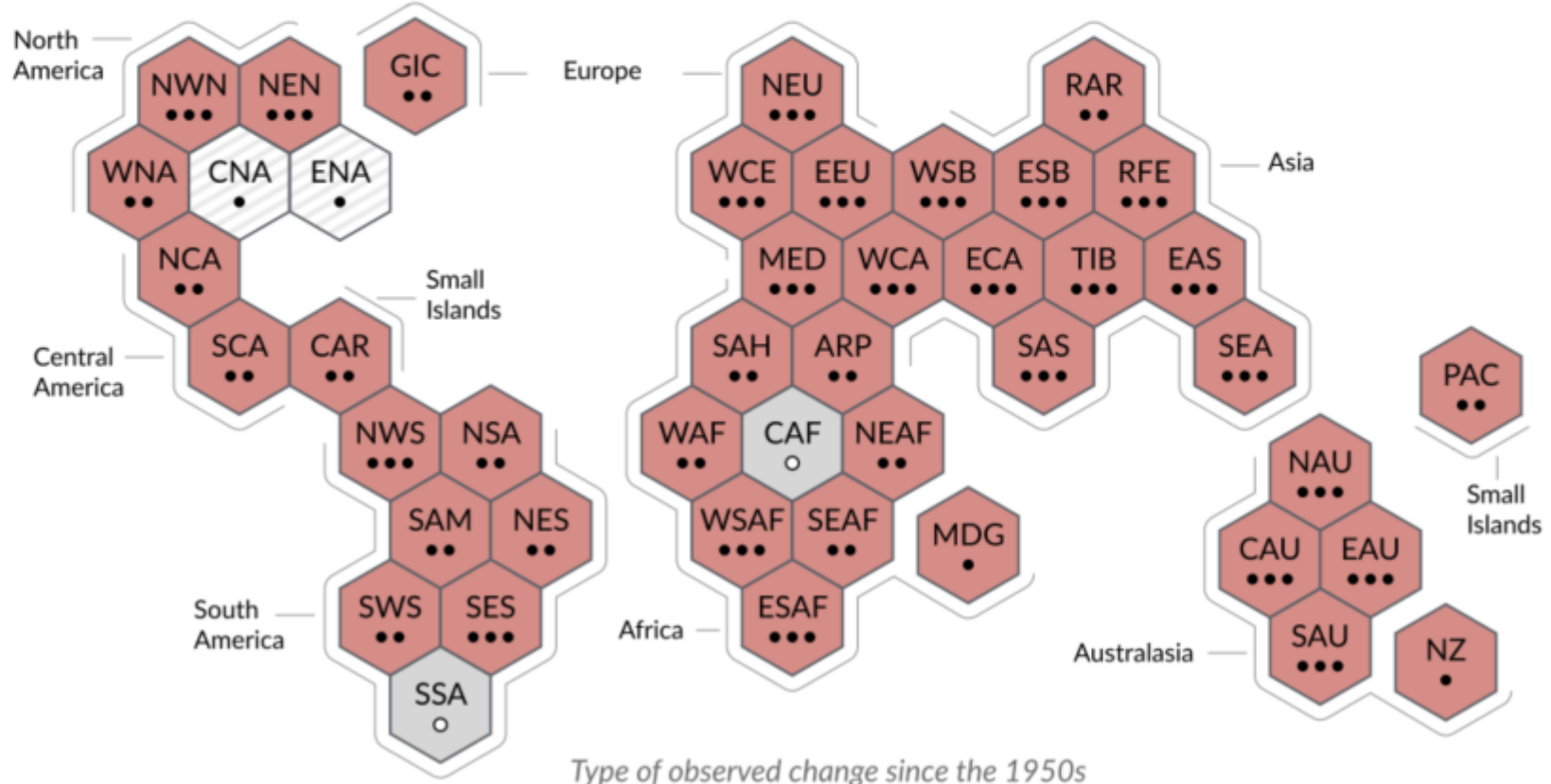
a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

Type of observed change in hot extremes

- Increase (41)
- Decrease (0)
- Low agreement in the type of change (2)
- Limited data and/or literature (2)

Confidence in human contribution to the observed change

- High
- Medium
- Low due to limited agreement
- Low due to limited evidence



Type of observed change since the 1950s

Climate change is already affecting every inhabited region across the globe with human influence contributing to many observed changes in weather and climate extremes

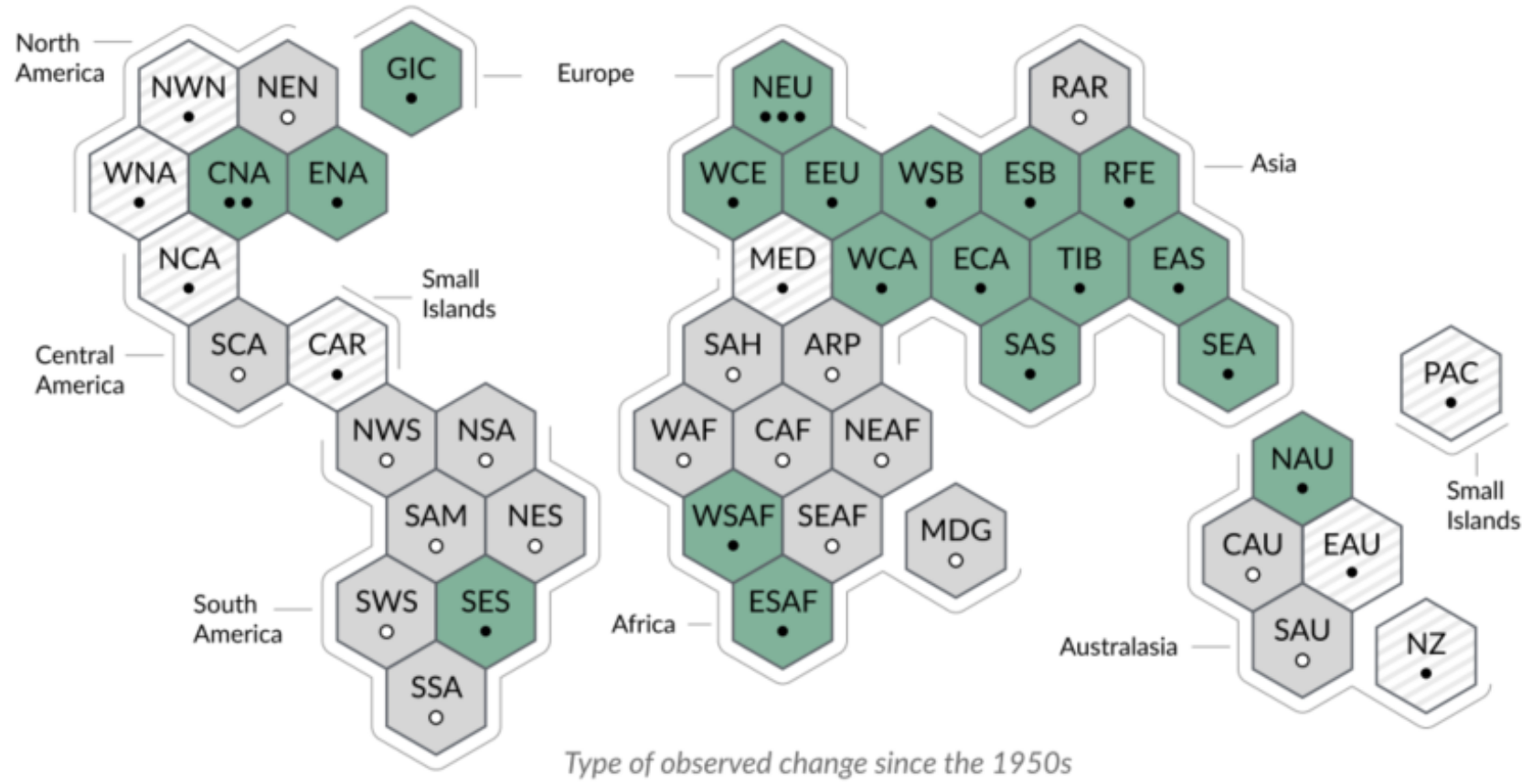
b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

Type of observed change in heavy precipitation

- Increase (19)
- Decrease (0)
- Low agreement in the type of change (8)
- Limited data and/or literature (18)

Confidence in human contribution to the observed change

- High
- Medium
- Low due to limited agreement
- Low due to limited evidence

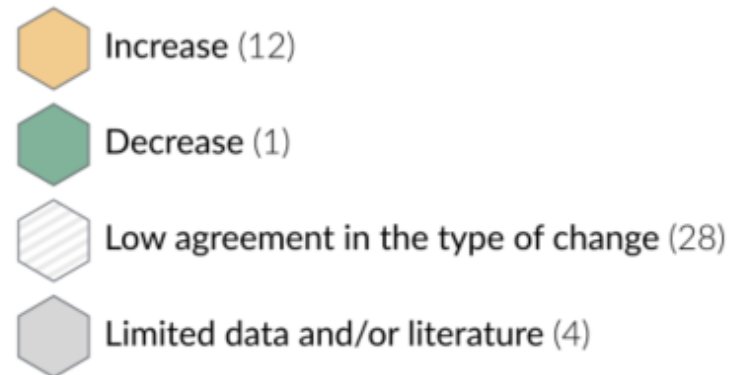


Type of observed change since the 1950s

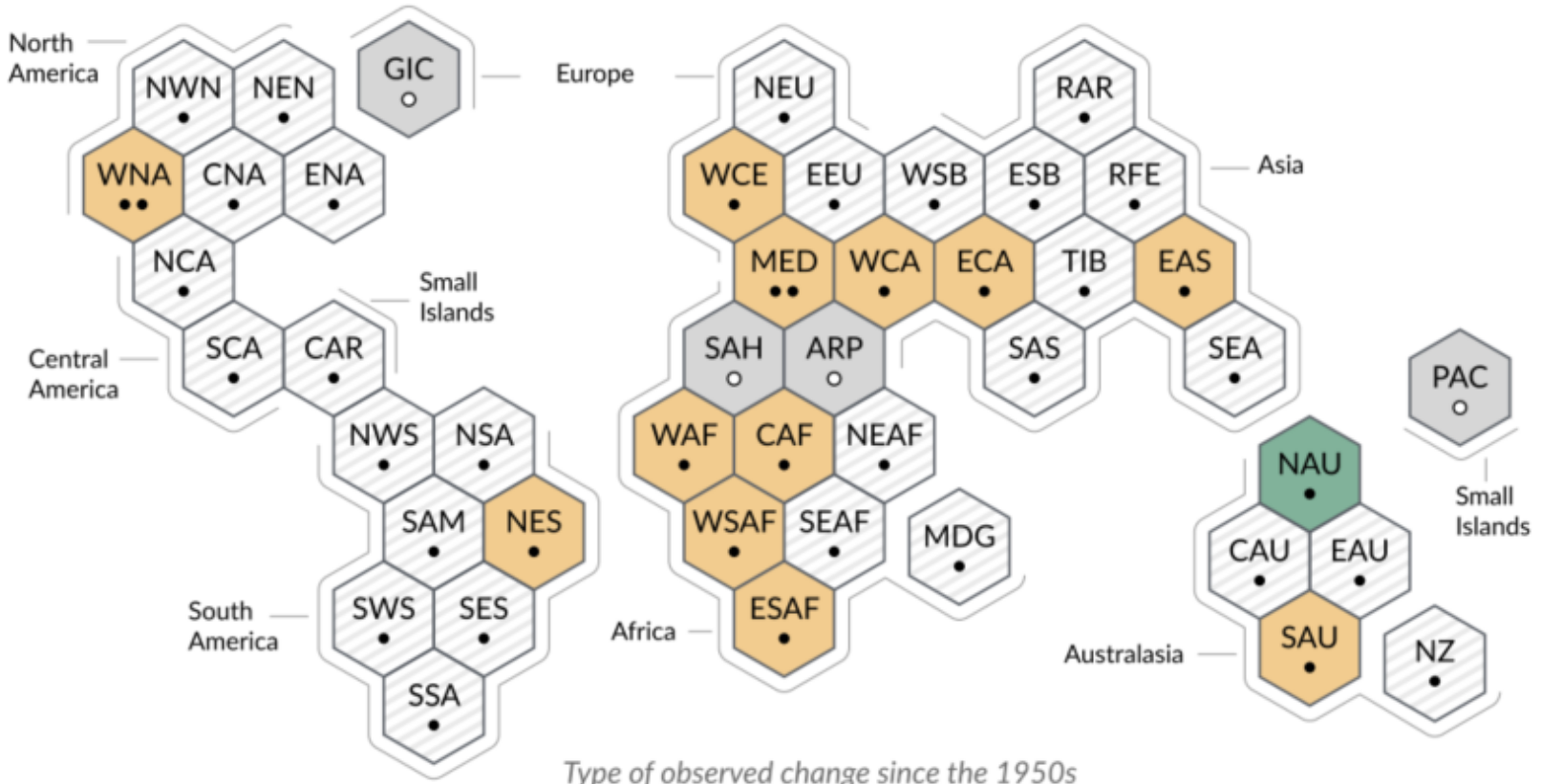
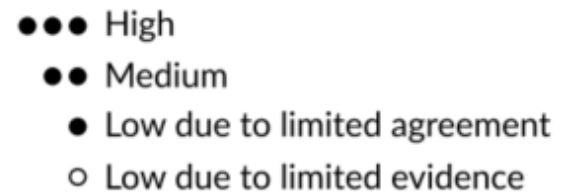
Climate change is already affecting every inhabited region across the globe with human influence contributing to many observed changes in weather and climate extremes

c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions

Type of observed change in agricultural and ecological drought



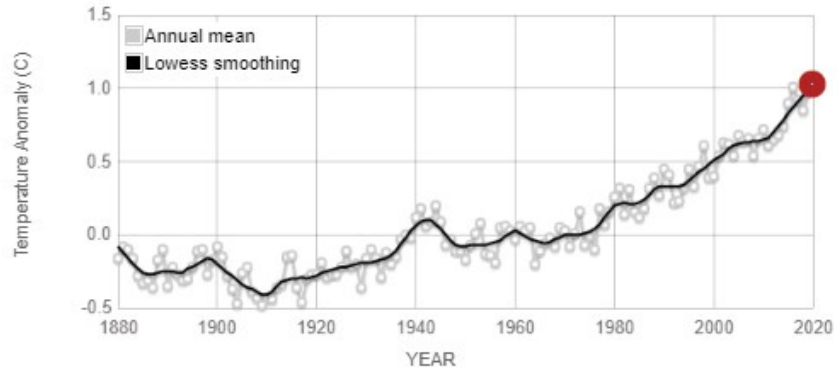
Confidence in human contribution to the observed change



Type of observed change since the 1950s

GLOBAL LAND-OCEAN TEMPERATURE INDEX

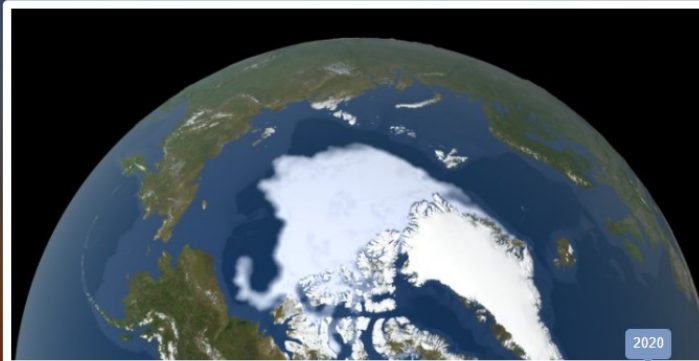
Data source: NASA's Goddard Institute for Space Studies (GISS).
Credit: NASA/GISS



Click+drag to zoom

Get Data: [HTTP](#) | Snapshot: [PNG](#)

Sea Ice

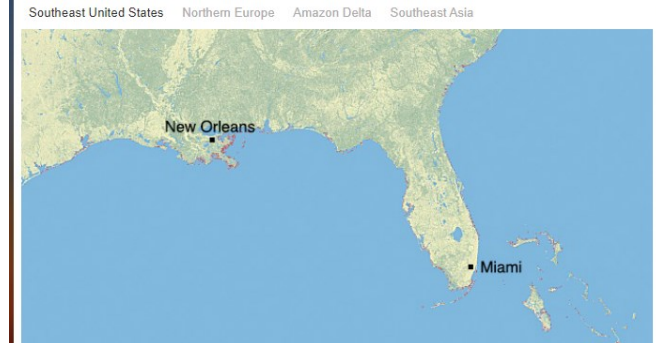


1979 2020

This visualization shows the annual Arctic sea ice minimum since 1979. At the end of each summer, the sea ice cover reaches its minimum extent, leaving what is called the perennial ice cover. The area of the perennial ice has been steadily decreasing since the satellite record began in 1979.

Data source: Satellite observations.
Credit: NASA Scientific Visualization Studio

Sea Level



0m 6m

Recent satellite observations have detected a thinning of parts of the Greenland ice sheet at lower elevations. A partial melting of this ice sheet would cause a 1-meter (3-foot) rise. If melted completely, the Greenland ice sheet contains enough water to raise sea level by 5-7 meters (16-23 feet).

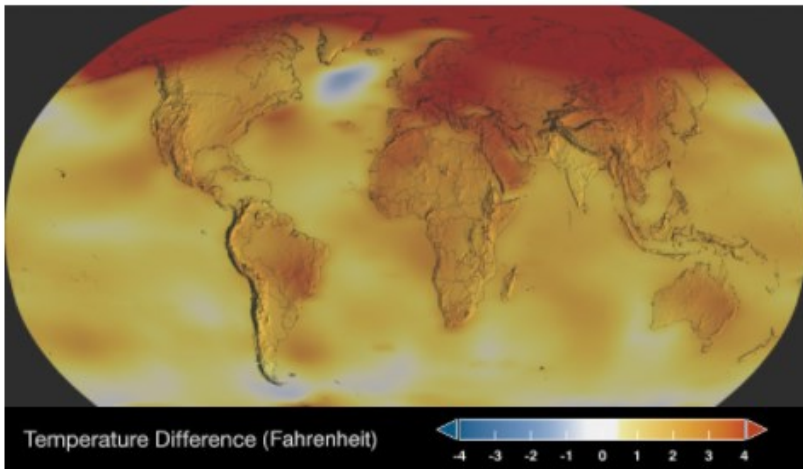
This visualization shows the effect on coastal regions for each meter of sea level rise, up to 6 meters (19.7 feet). Land that would be covered in water is shaded red.

Credit: Center for Remote Sensing of Ice Sheets

TIME SERIES: 1884 TO 2020

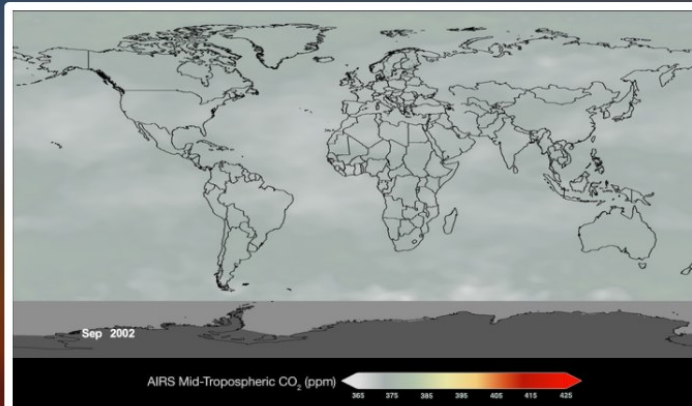
Data source: NASA/GISS
Credit: NASA Scientific Visualization Studio

2020



1884 2020

Carbon Dioxide

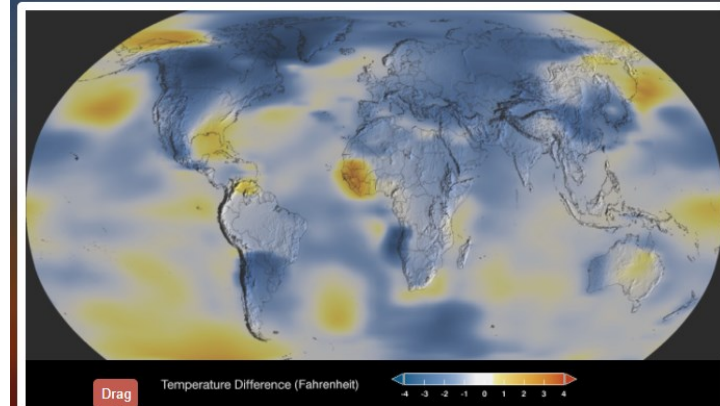


2002 2016

This time series shows global changes in the concentration and distribution of carbon dioxide since 2002 at an altitude range of 1.9 to 8 miles. The yellow-to-red regions indicate higher concentrations of CO₂, while blue-to-green areas indicate lower concentrations, measured in parts per million.

Data source: Atmospheric Infrared Sounder (AIRS).
Credit: NASA

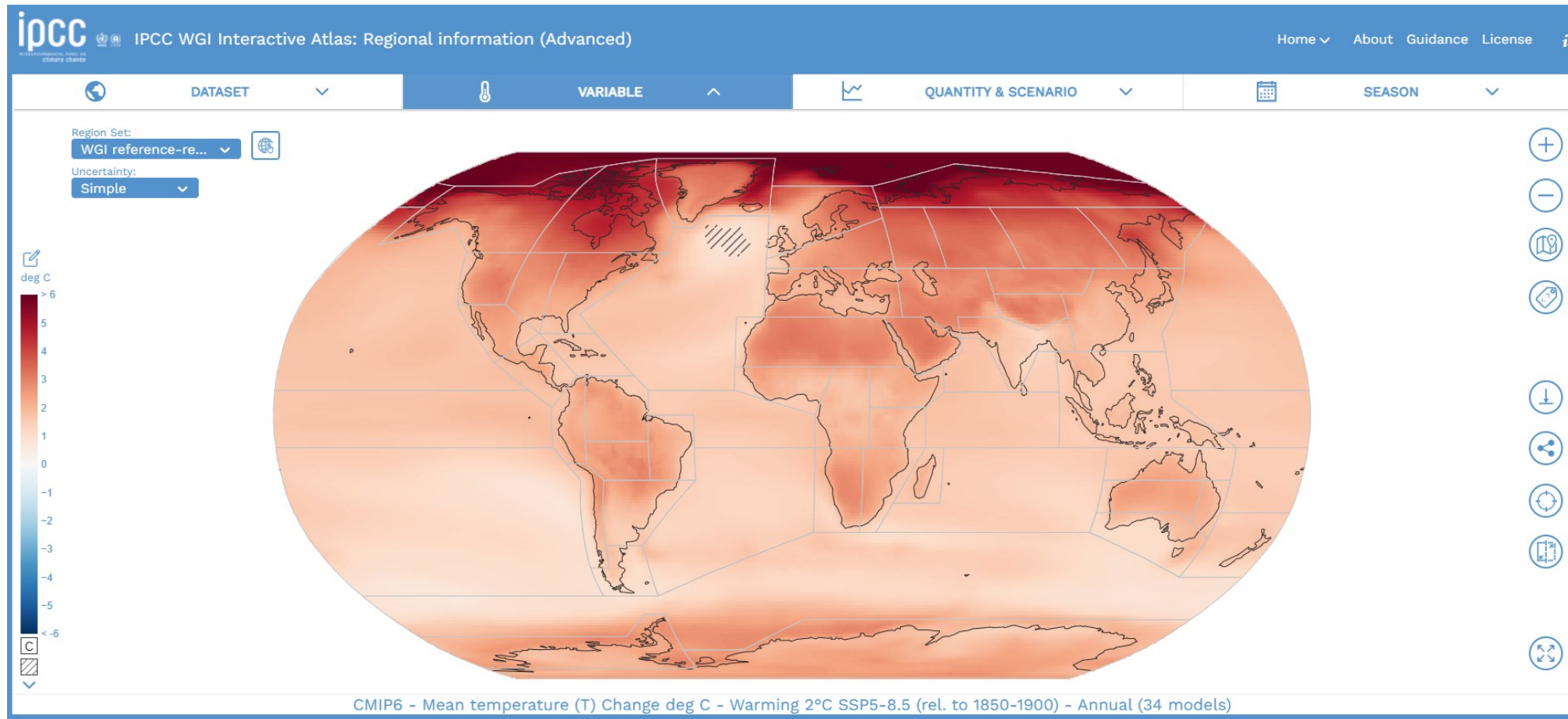
Global Temperature



1884 2020

This color-coded map shows a progression of changing global surface temperatures since 1884. Dark blue indicates areas cooler than average. Dark red indicates areas warmer than average.

Data source: NASA/GISS
Credit: NASA Scientific Visualization Studio

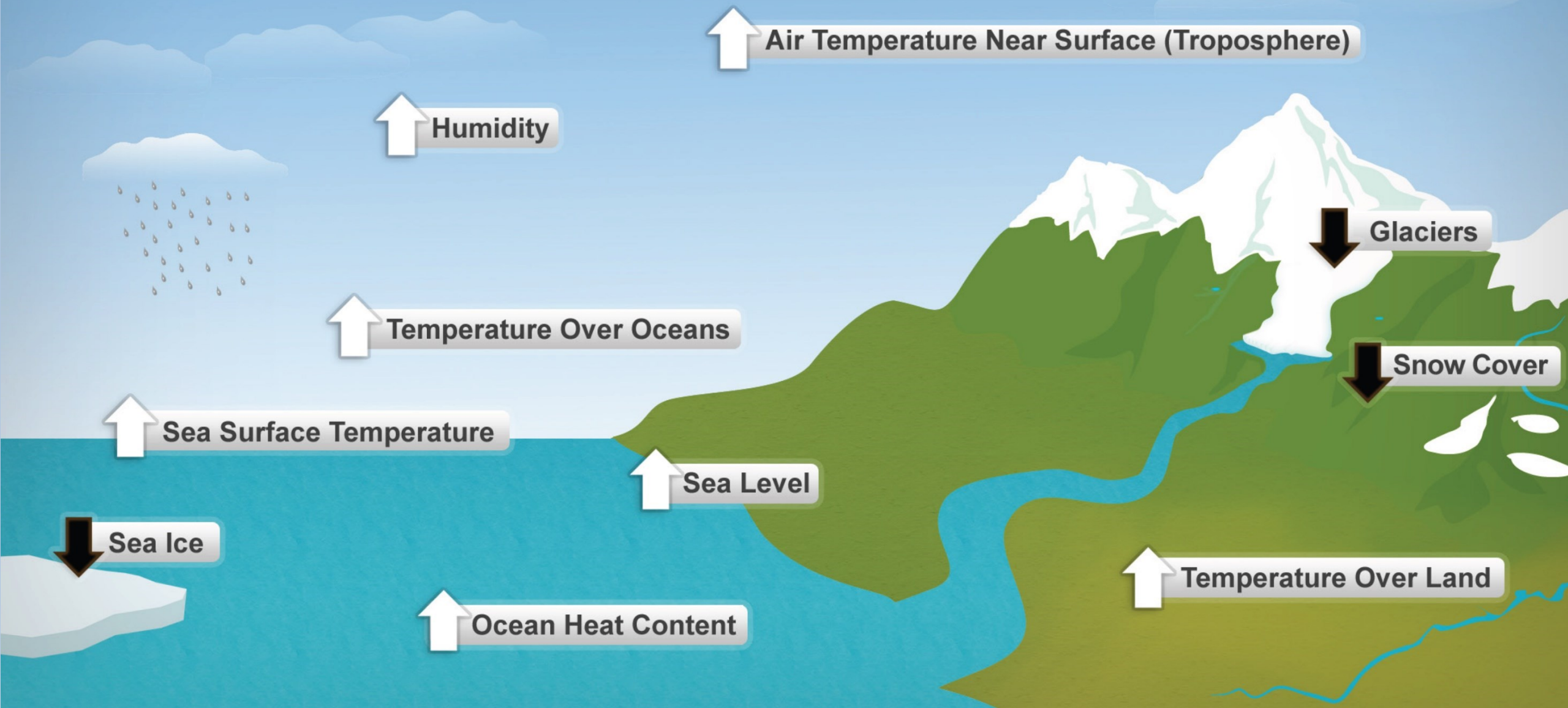


Projeções de impactos na sociedade e impactos na agricultura.

- Mudanças também na distribuição das chuvas.
- Mudanças na umidade do solo.
- Ondas de calor.
 - Mar perde potencial de funções: resfriamento e sequestro de CO₂.
 - Ponto de inflexão da Amazônia.
 - Altas intensidades de precipitação.



Ten Indicators of a Warming World



EFEITOS SOCIOECONÔMICOS DA MUDANÇA CLIMÁTICA



1. TEMPO *vs* CLIMA

2. AQUECIMENTO GLOBAL

3. MUDANÇAS GLOBAIS DO CLIMA

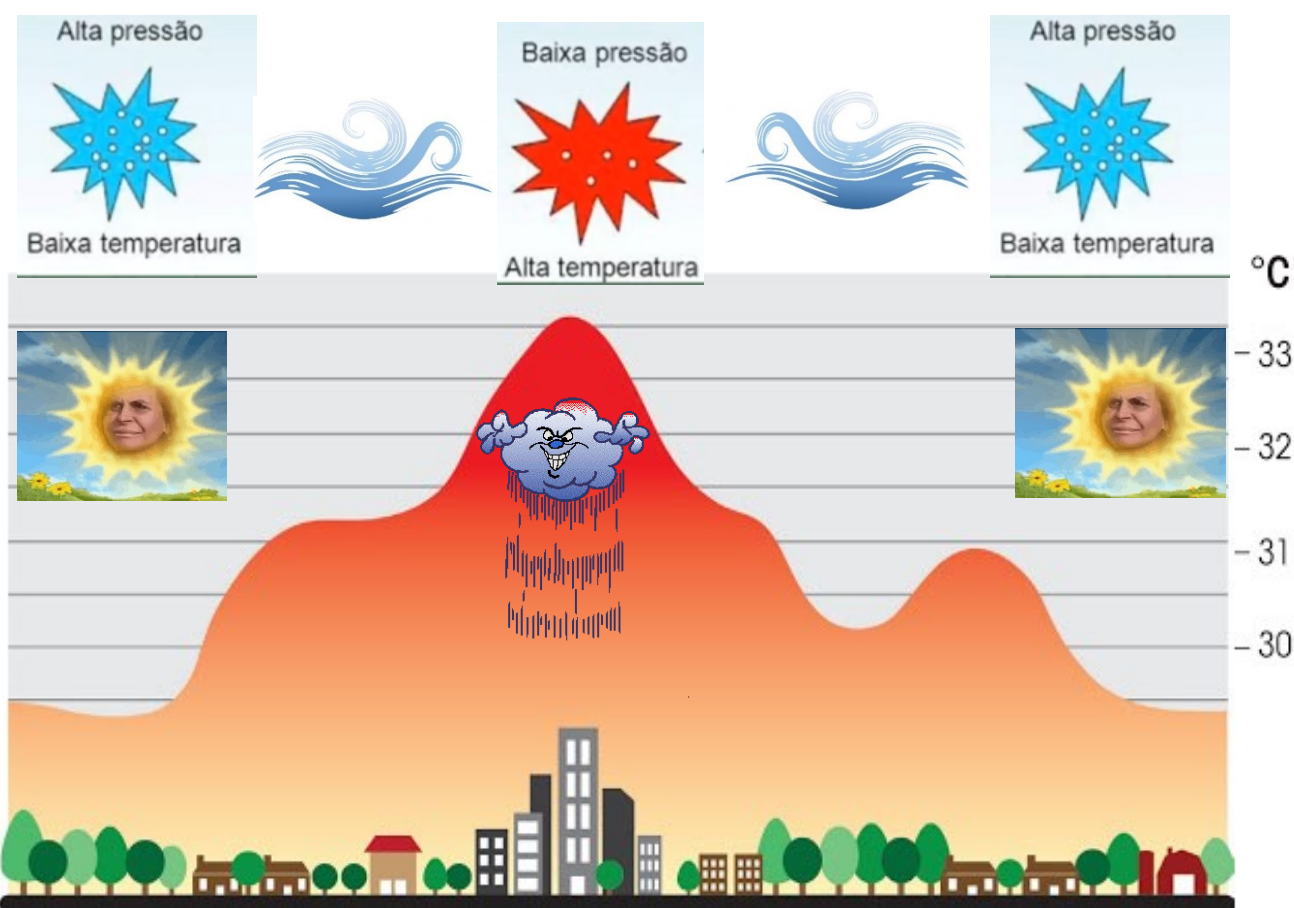
4. EFEITOS CLIMÁTICOS NOS CENTROS URBANOS

ILHAS DE CALOR



- Reflexão da radiação entre as construções. Absorção pelo concreto e asfalto.
- Redução na circulação do ar (barreira física).
- Por vezes aumenta a temperatura do ar no centro da cidade em até 8 °C.

- Concentrações de poluentes do ar no centro da cidade.
- Chuvas intensas no centro da cidade.
- Enchentes em função da baixa permeabilidade.

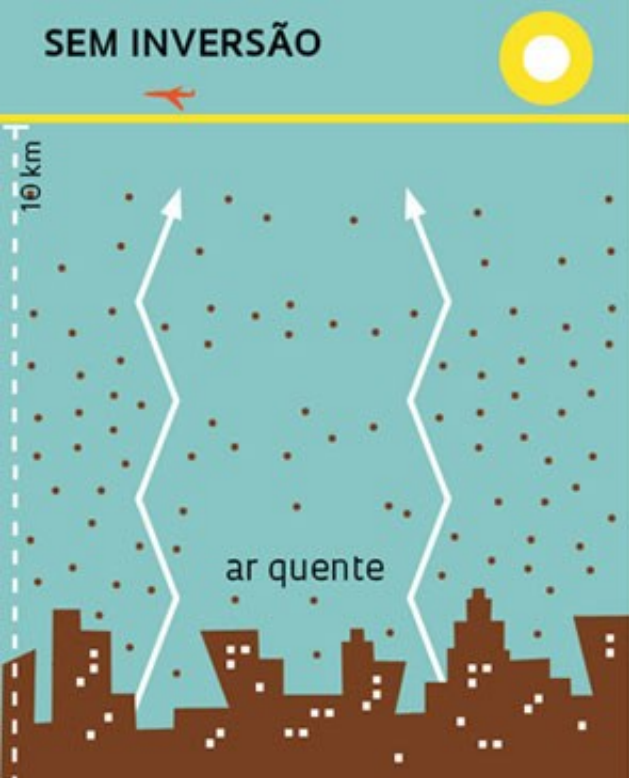


ILHAS DE CALOR





SEM INVERSÃO



INVERSÃO TÉRMICA



INVERSÃO TÉRMICA

A inversão térmica ocorre naturalmente.

DIAS FRIOS: Normalmente, a Inversão Térmica ocorre entre a madrugada e o início da manhã.

NO VERÃO: “Efeito tampão” → massas de ar quente, oriundas do oceano, formam tampões sobre as grandes cidades

O problema são os poluentes.

Concentração de toneladas de poluentes e a dispersão é dificultada pelos baixos níveis pluviométricos

Montanhas são barreiras para a dispersão dos poluentes.

Dia com inversão térmica:
Ar frio desce e aprisiona poluentes

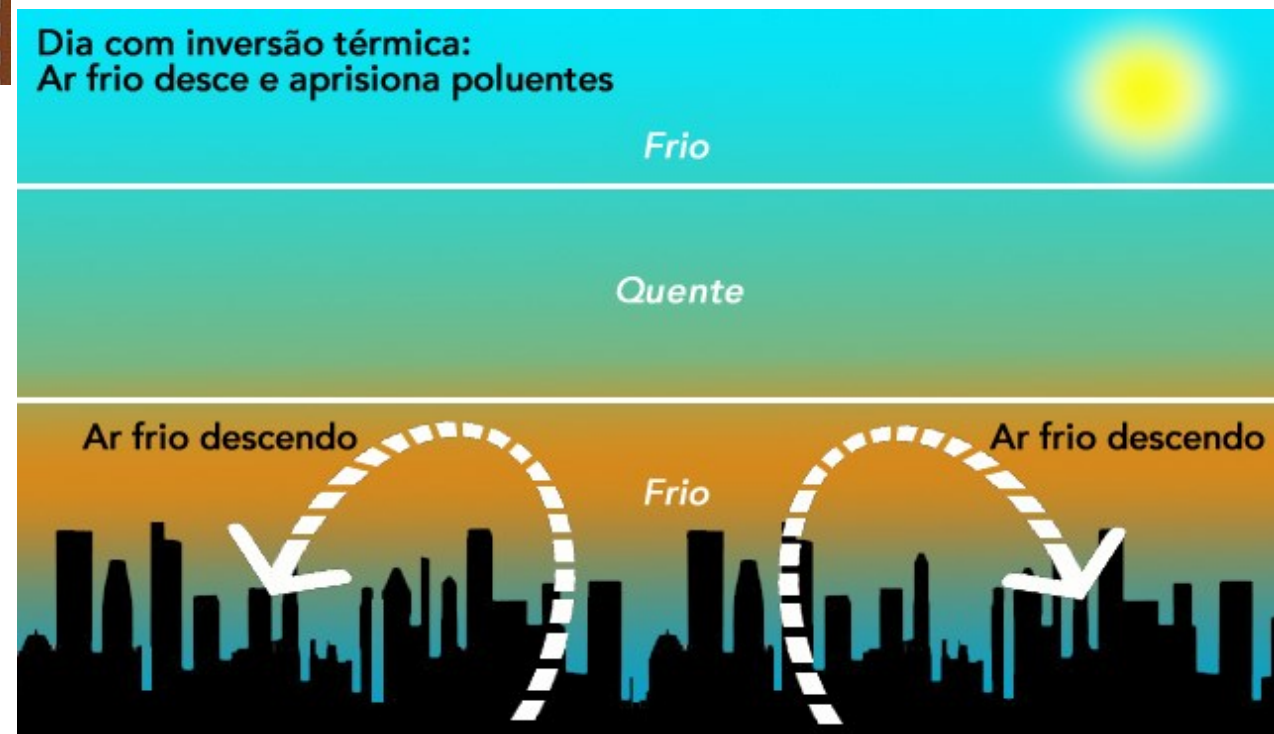
Frio

Quente

Ar frio descendo

Frio

Ar frio descendo



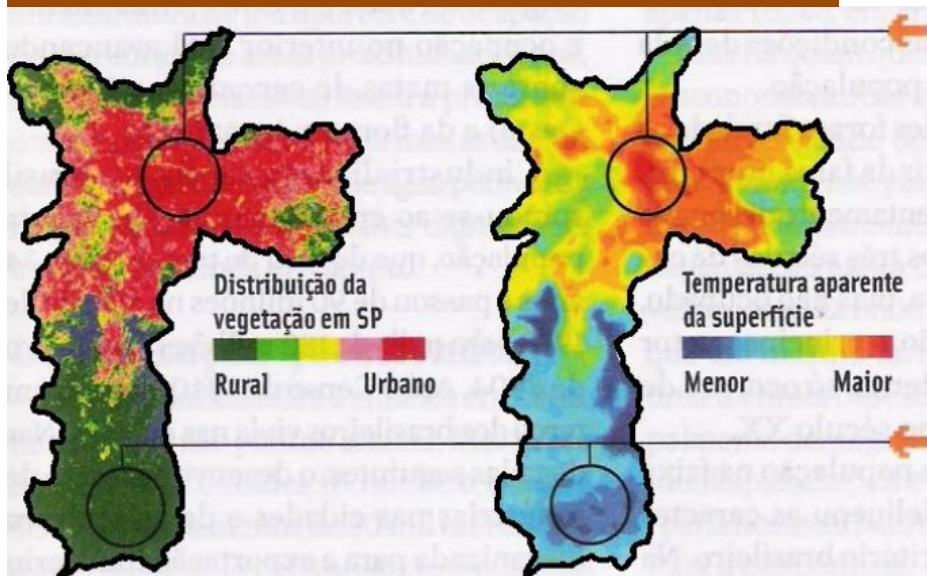


INVERSÃO TÉRMICA



PRINCIPAIS VULNERABILIDADES DAS CIDADES FRENTE ÀS MUDANÇAS CLIMÁTICAS GLOBAIS

ILHAS DE CALOR: + INTENSO



Fonte: Atlas Ambiental do Município de São Paulo

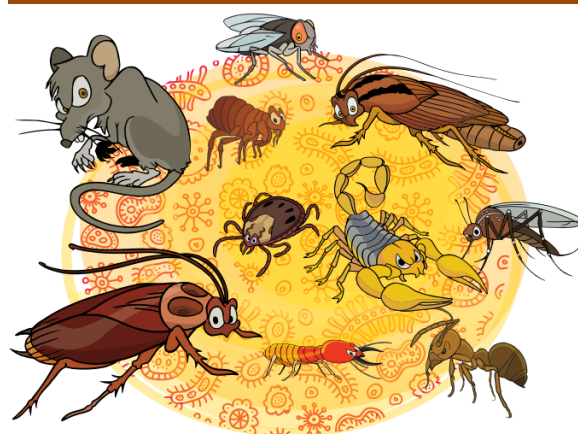
ENCHENTES E INUNDAÇÕES: MAIOR OCORRÊNCIA



+CHUVAS INTENSAS +DESLIZAMENTOS



EPIDEMIAS



Coronavírus
COVID-19



Alguns exemplos...



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act now before it's too late