Políticas Públicas em Meio Ambiente e Sustentabilidade

Felipe Buchbinder


O que é “clima”?

Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.[1]

(IPCC, 2001)

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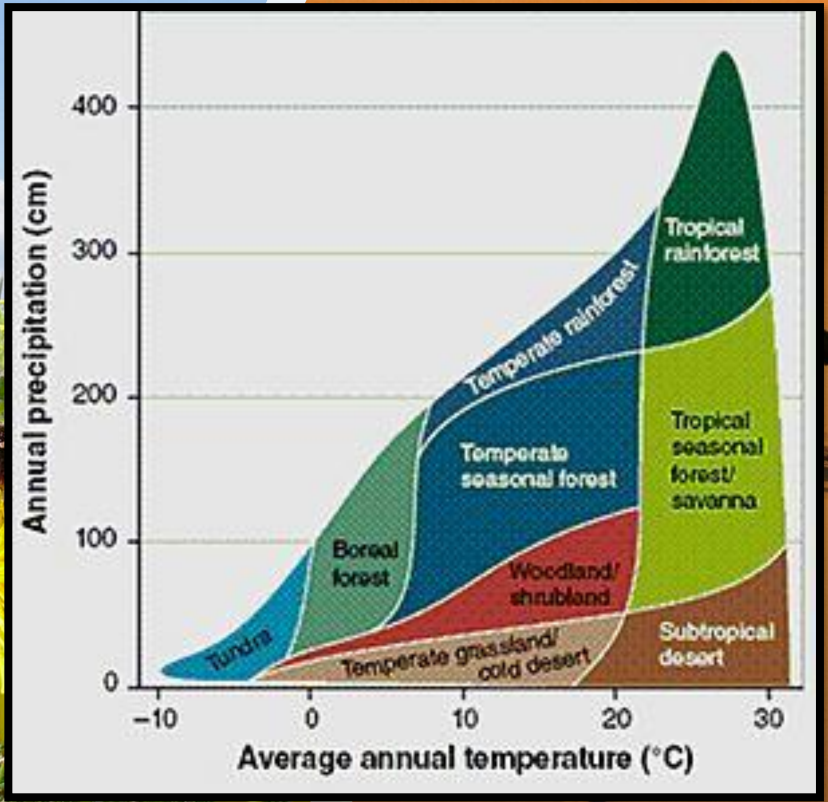
(IPCC, 2001)

O clima determina quais formas de vida conseguem sobreviver em determinada região



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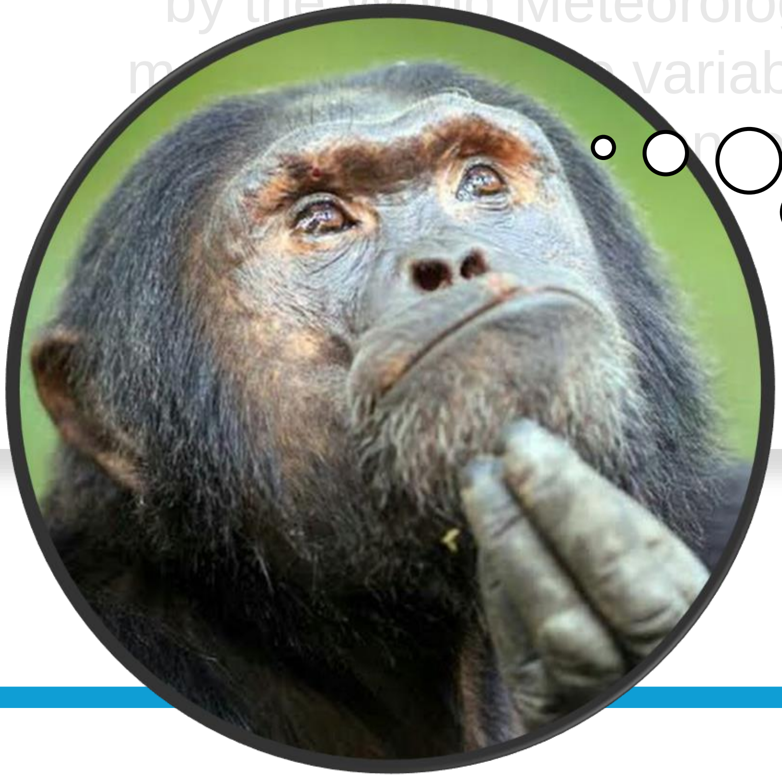
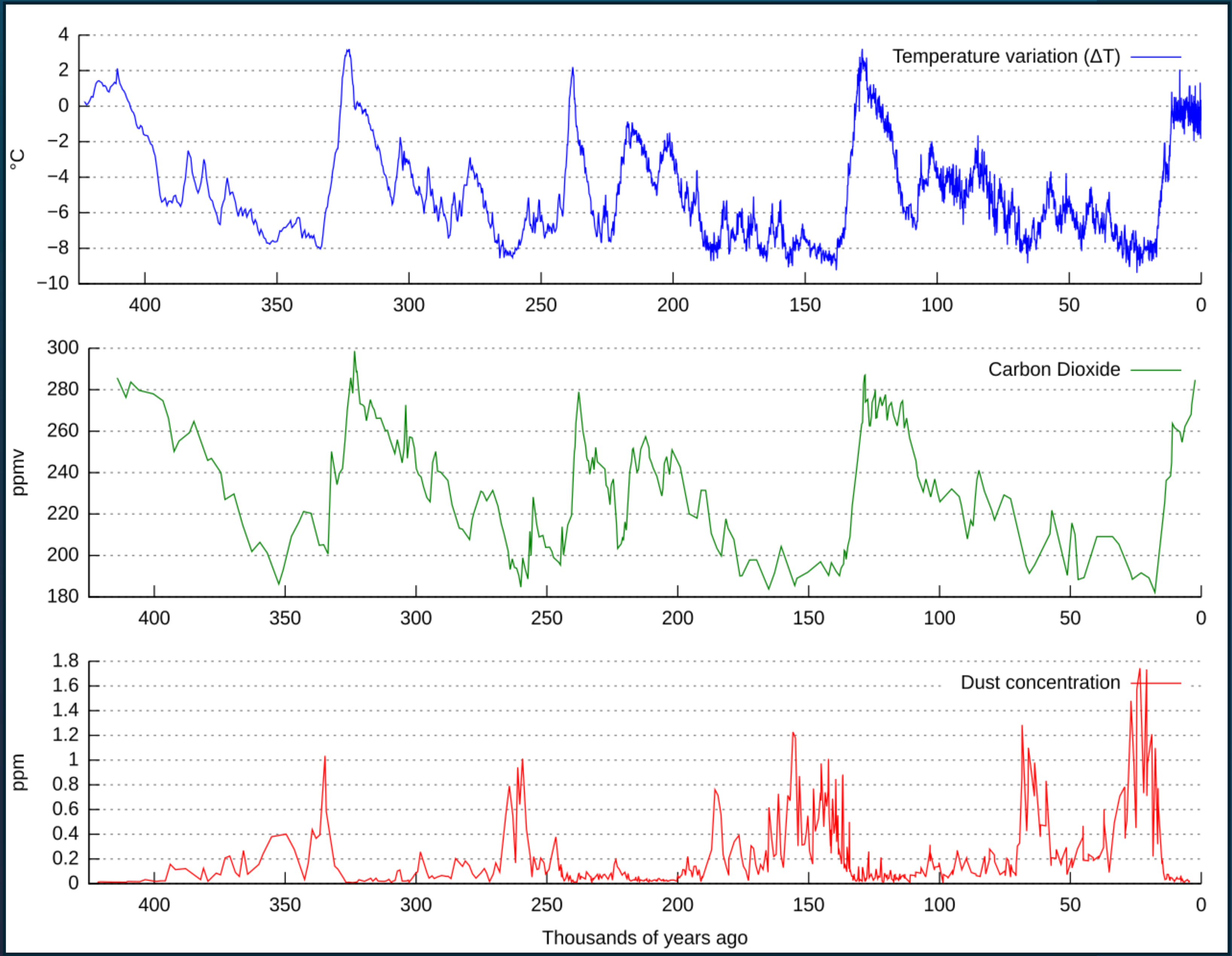


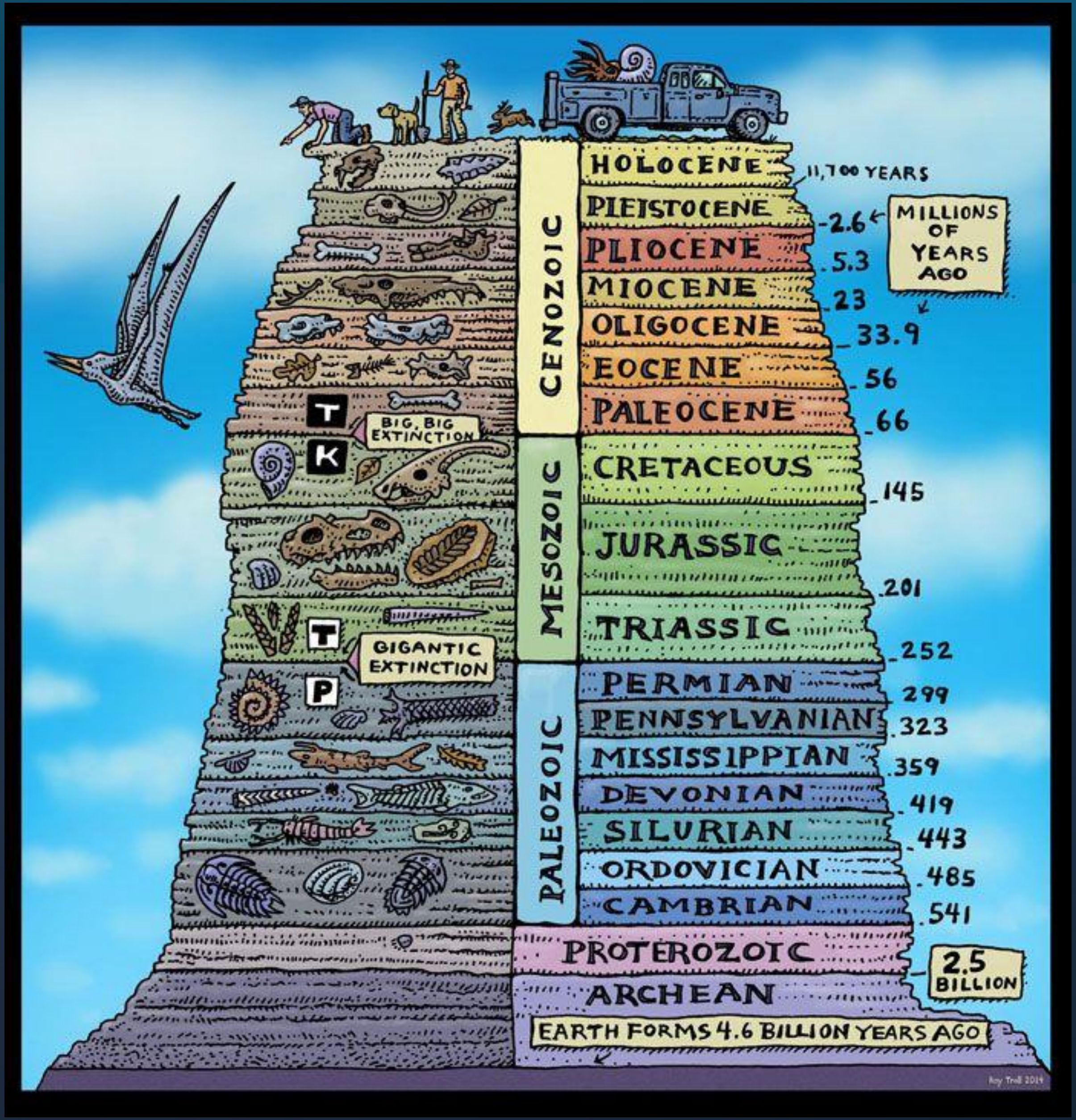
Por que um período tão longo?

Por que não simplesmente usar a média desde sempre?

(IPCC, 2001)

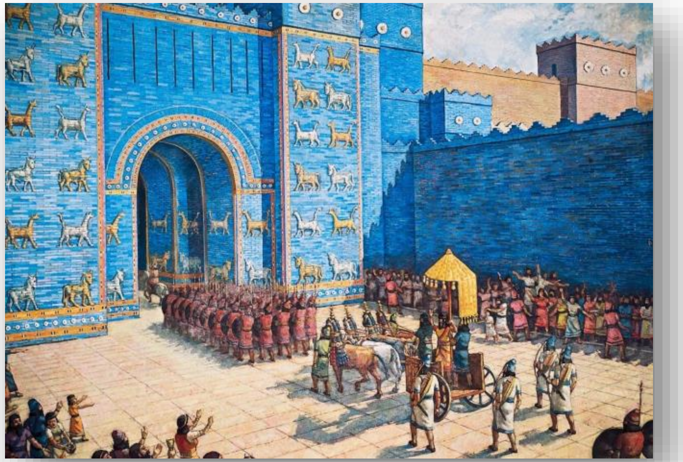


Fonte: Royer, Dana (2014). Dana Royer comment at RealClimate. *RealClimate*



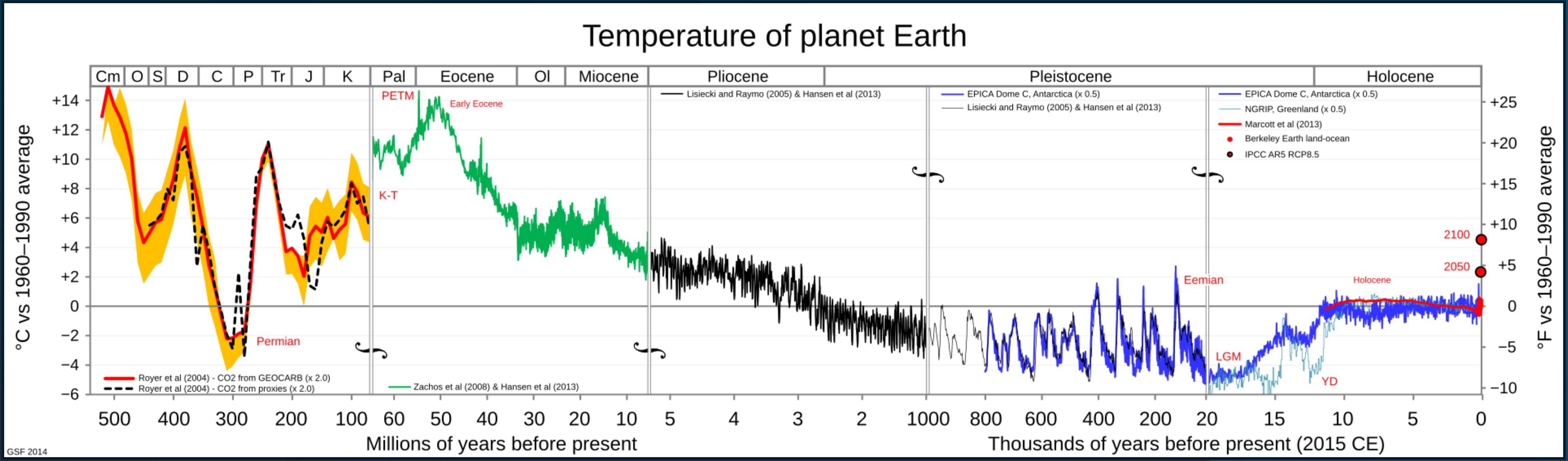
HOLOCENE
11,700 YEARS
PLEISTOCENE
2.6
MILLIONS OF YEARS AGO
PLIOCENE
5.3
MIOCENE
23
OLIGOCENE
33.9
EOCENE
56
PALEOCENE
66
CENOZOIC
T
BIG, BIG EXTINCTION
K
CRETACEOUS
145
JURASSIC
201
TRIASSIC
MESOZOIC
T
GIGANTIC EXTINCTION
P
252
PERMIAN
299
PENNSYLVANIAN
323
MISSISSIPPIAN
359
DEVONIAN
419
SILURIAN
443
ORDOVICIAN
485
CAMBRIAN
541
PALEOZOIC
PROTEROZOIC
2.5 BILLION
ARCHEAN
EARTH FORMS 4.6 BILLION YEARS AGO

Pleistoceno
(ca 2.5My – 11.7ky)

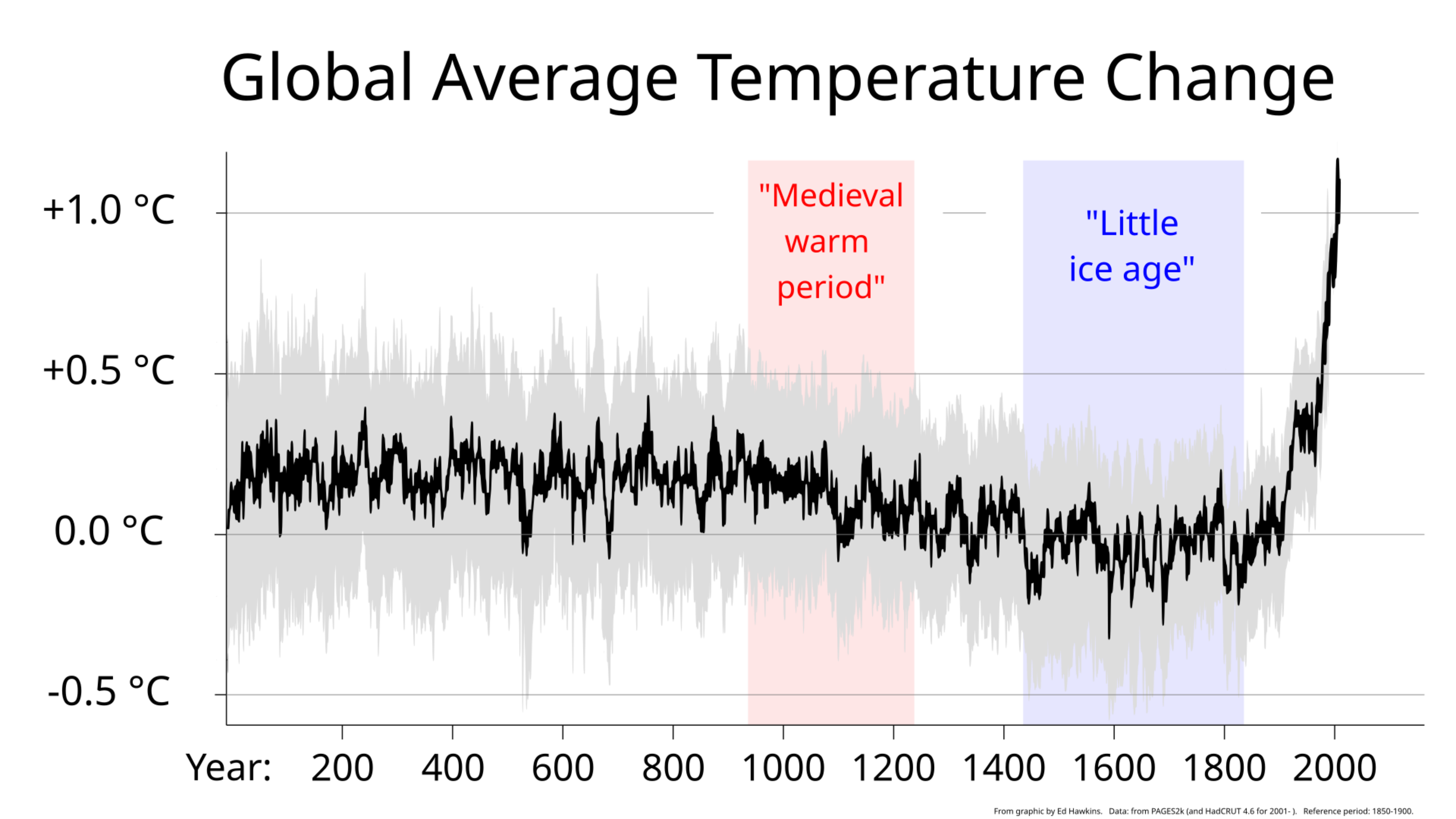


Holoceno
(11.7ky – ?)

Antropoceno
(1800? 1950? – ?)



Fonte: Royer, Dana (2014). Dana Royer comment at RealClimate. *RealClimate*



Fonte: Royer, Dana (2014). Dana Royer comment at RealClimate. *RealClimate*


O grande
experimento
do
antropoceno

FOOTE, Eunice (1865) On the heat in the sun's rays. *American Journal of Science and Arts*, vol. XXII, p.382

Thirdly. The highest effect of the sun's rays I have found to be in carbonic acid gas.

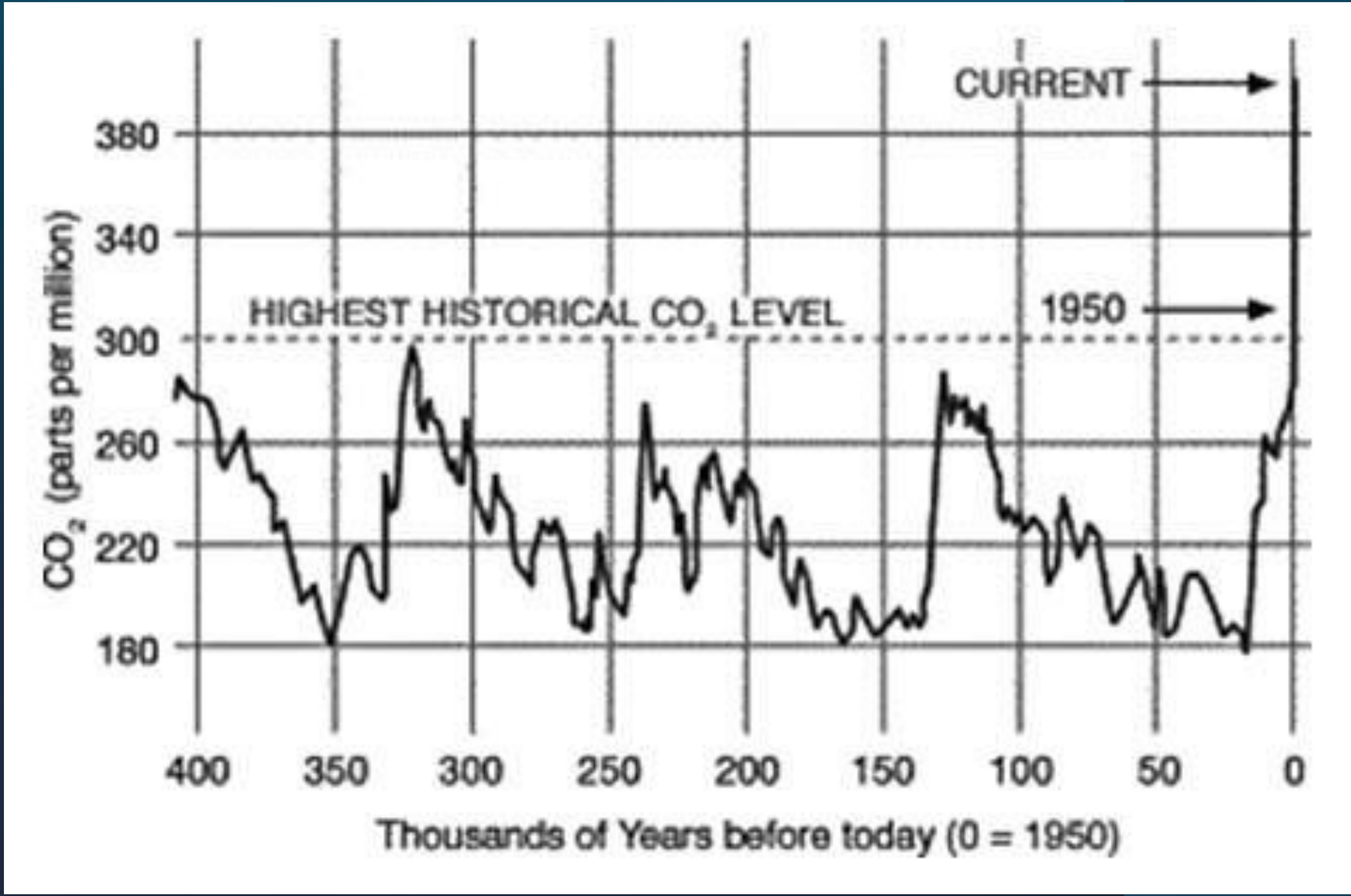
One of the receivers was filled with it, the other with common air, and the result was as follows:

In Common Air.		In Carbonic Acid Gas.	
In shade.	In sun.	In shade.	In sun.
80	90	80	90
81	94	84	100
80	99	84	110
81	100	85	120

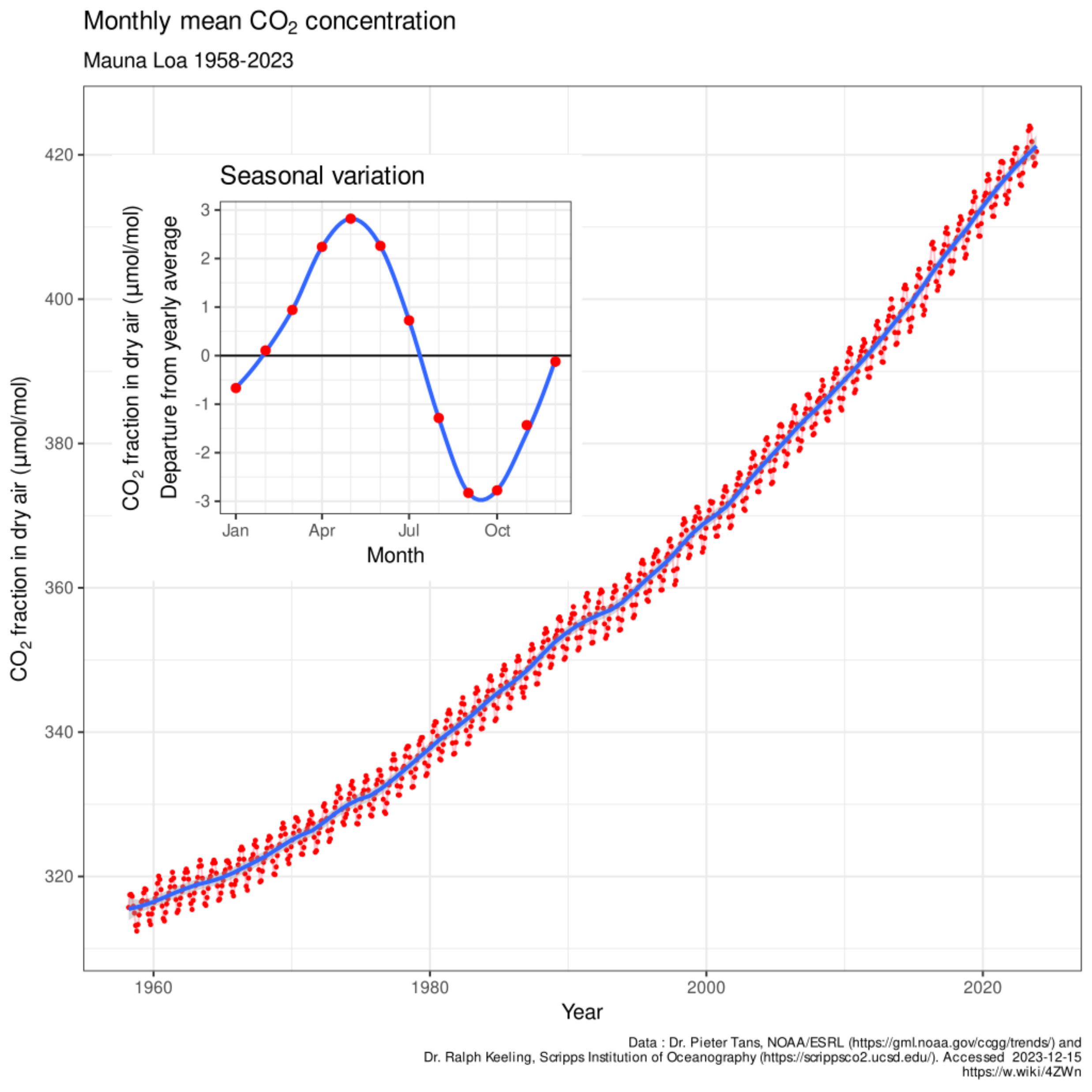
The receiver containing the gas became itself much heated—very sensibly more so than the other—and on being removed, it was many times as long in cooling.

An atmosphere of that gas would give to our earth a high temperature; and if as some suppose, at one period of its history the air had mixed with it a larger proportion than at present, an increased temperature from its own action as well as from increased weight must have necessarily resulted.

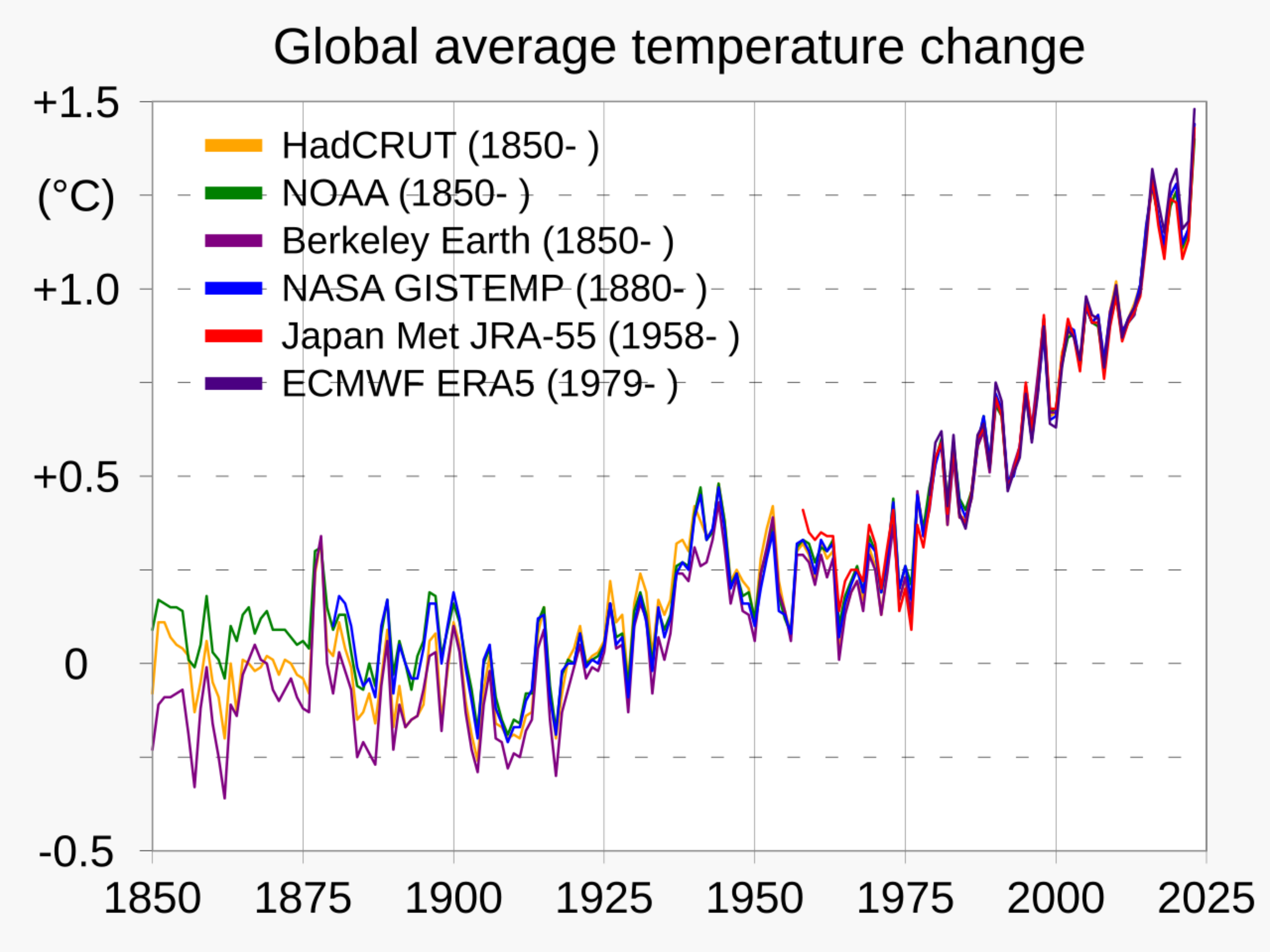
On comparing the sun's heat in different gases, I found it to be in hydrogen gas, 104°; in common air, 106°; in oxygen gas, 108°; and in carbonic acid gas, 125°.



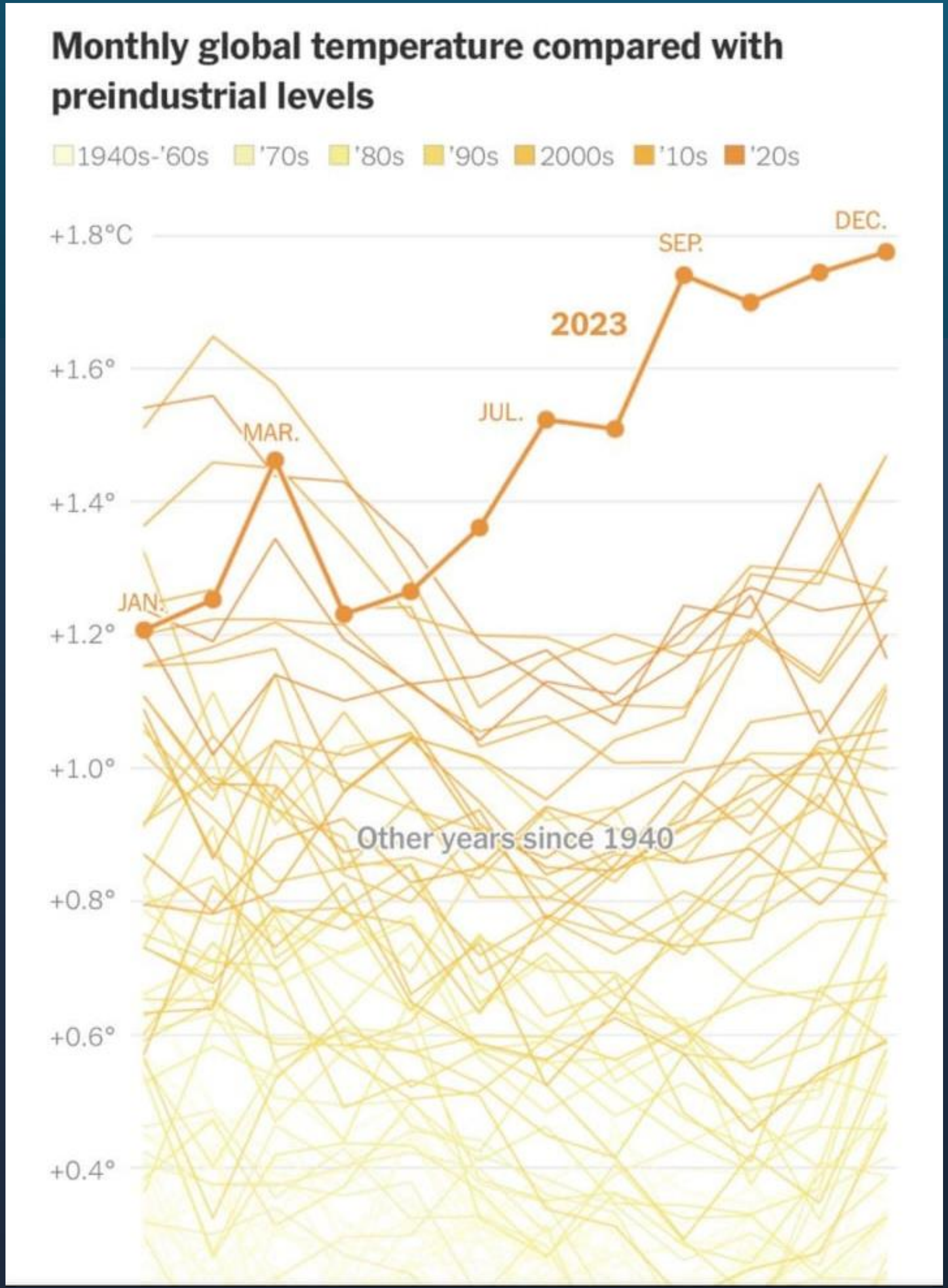
Fonte: Callery, Jackson and Shaftel, Carbon Dioxide 07



Monthly mean CO_2 concentration
Mauna Loa 1958-2023
Seasonal variation
CO_2 fraction in dry air (µmol/mol)
Departure from yearly average
Month
Jan
Apr
Jul
Oct
Year
1960
1980
2000
2020
320
340
360
380
400
420
Data : Dr. Pieter Tans, NOAA/ESRL (https://gml.noaa.gov/ccgg/trends/) and
Dr. Ralph Keeling, Scripps Institution of Oceanography (https://scrippsco2.ucsd.edu/). Accessed 2023-12-15
https://w.wiki/4ZWn

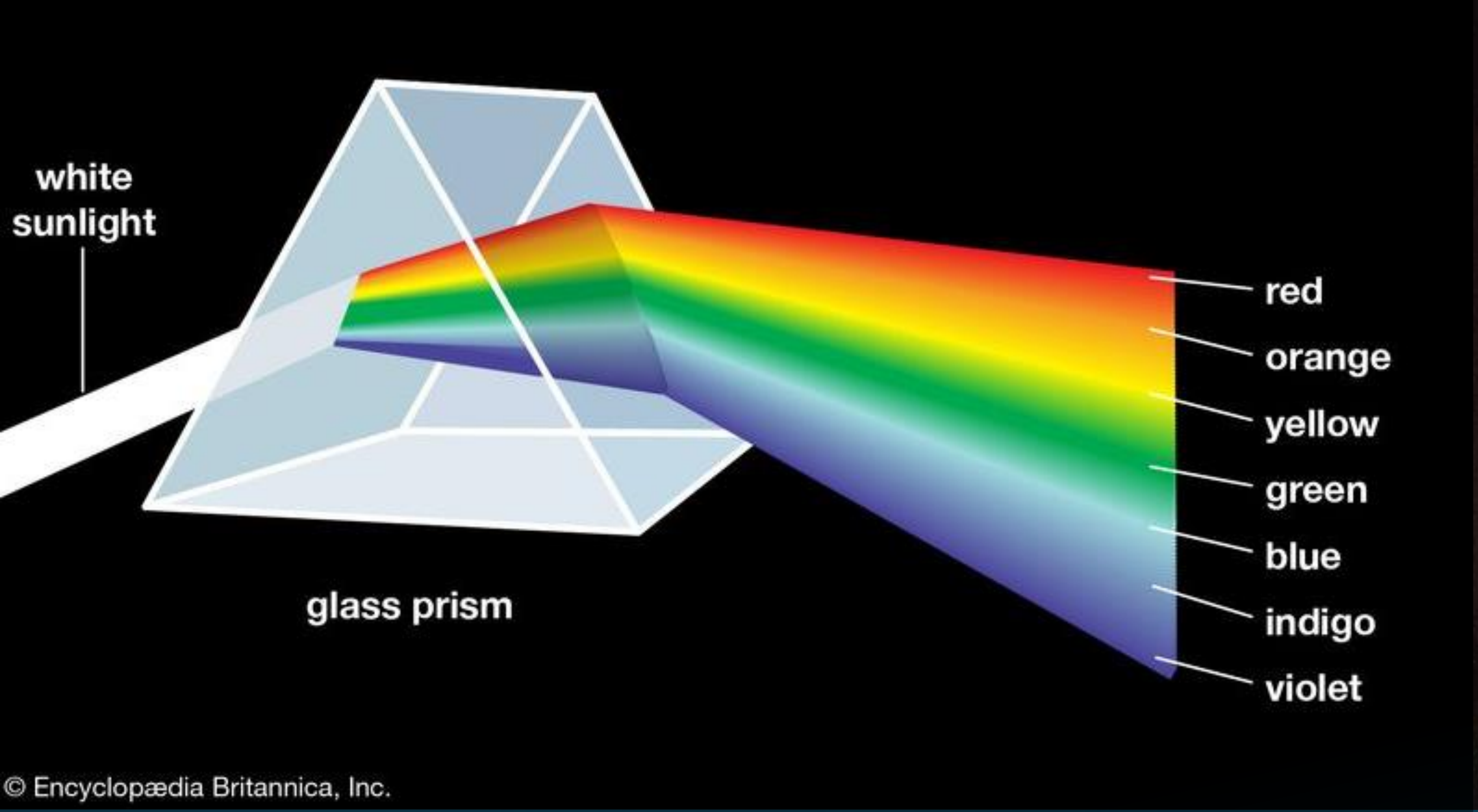


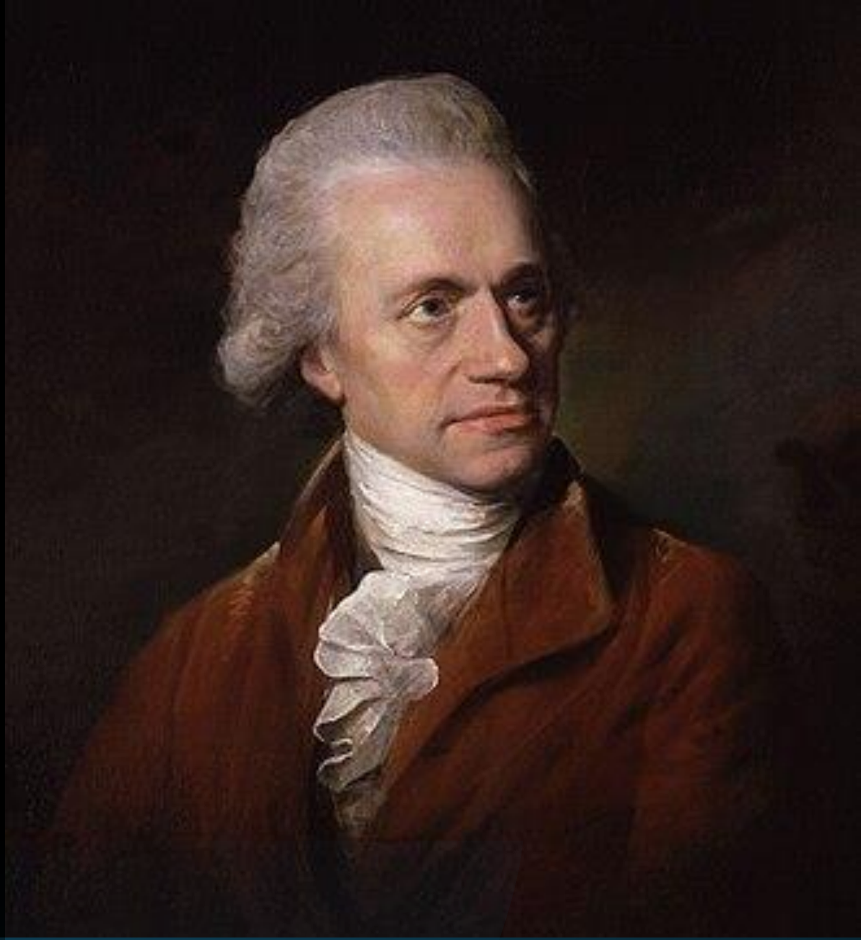
Global average temperature change
+1.5
(°C)
+1.0
+0.5
0
-0.5
HadCRUT (1850-)
NOAA (1850-)
Berkeley Earth (1850-)
NASA GISTEMP (1880-)
Japan Met JRA-55 (1958-)
ECMWF ERA5 (1979-)
1850
1875
1900
1925
1950
1975
2000
2025


Monthly global temperature compared with preindustrial levels
1940s-'60s
'70s
'80s
'90s
2000s
'10s
'20s
+1.8°C
+1.6°
+1.4°
+1.2°
+1.0°
+0.8°
+0.6°
+0.4°
JAN.
MAR.
JUL.
SEP.
DEC.
2023
Other years since 1940

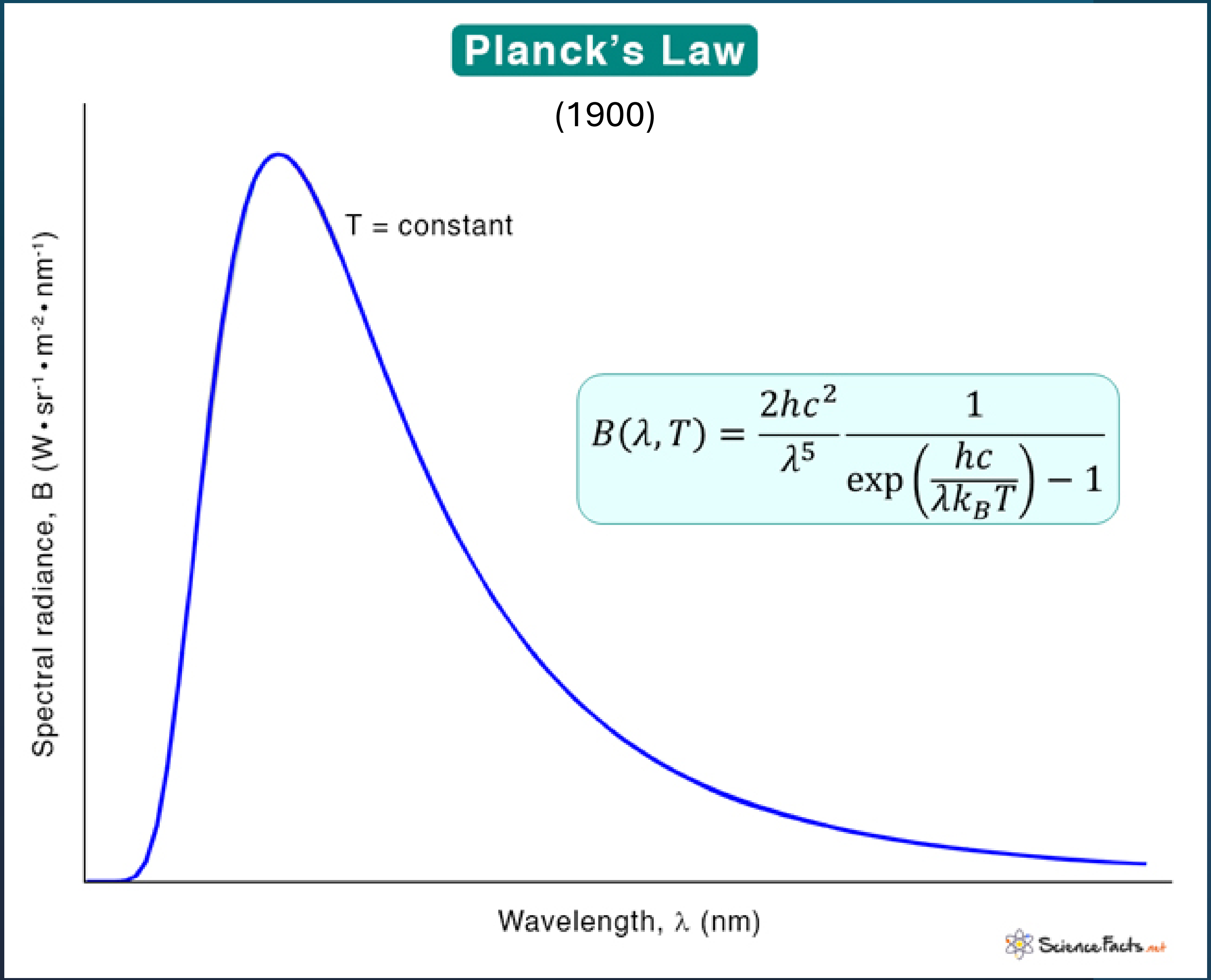
Como isso acontece?

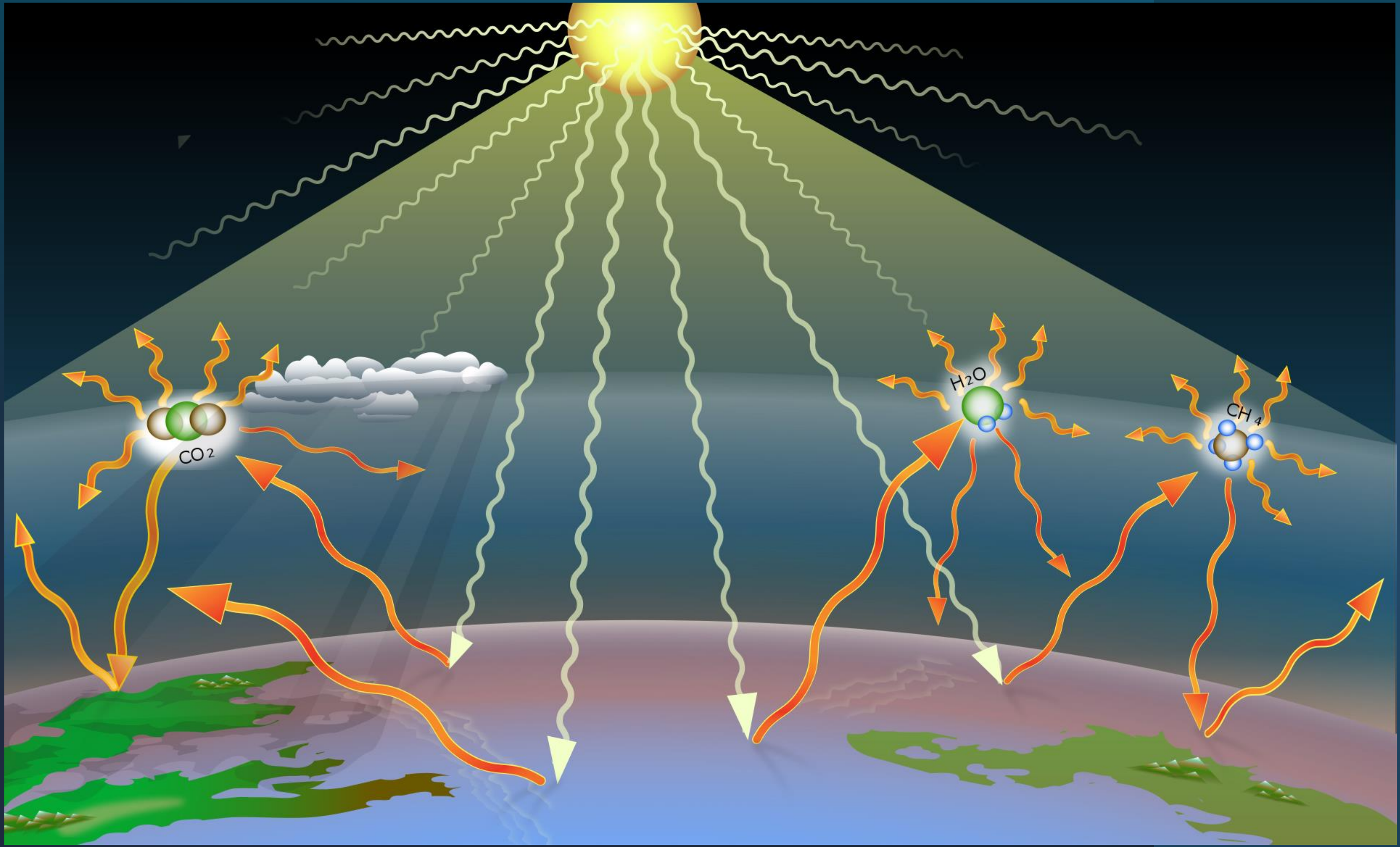
Noções de climatologia



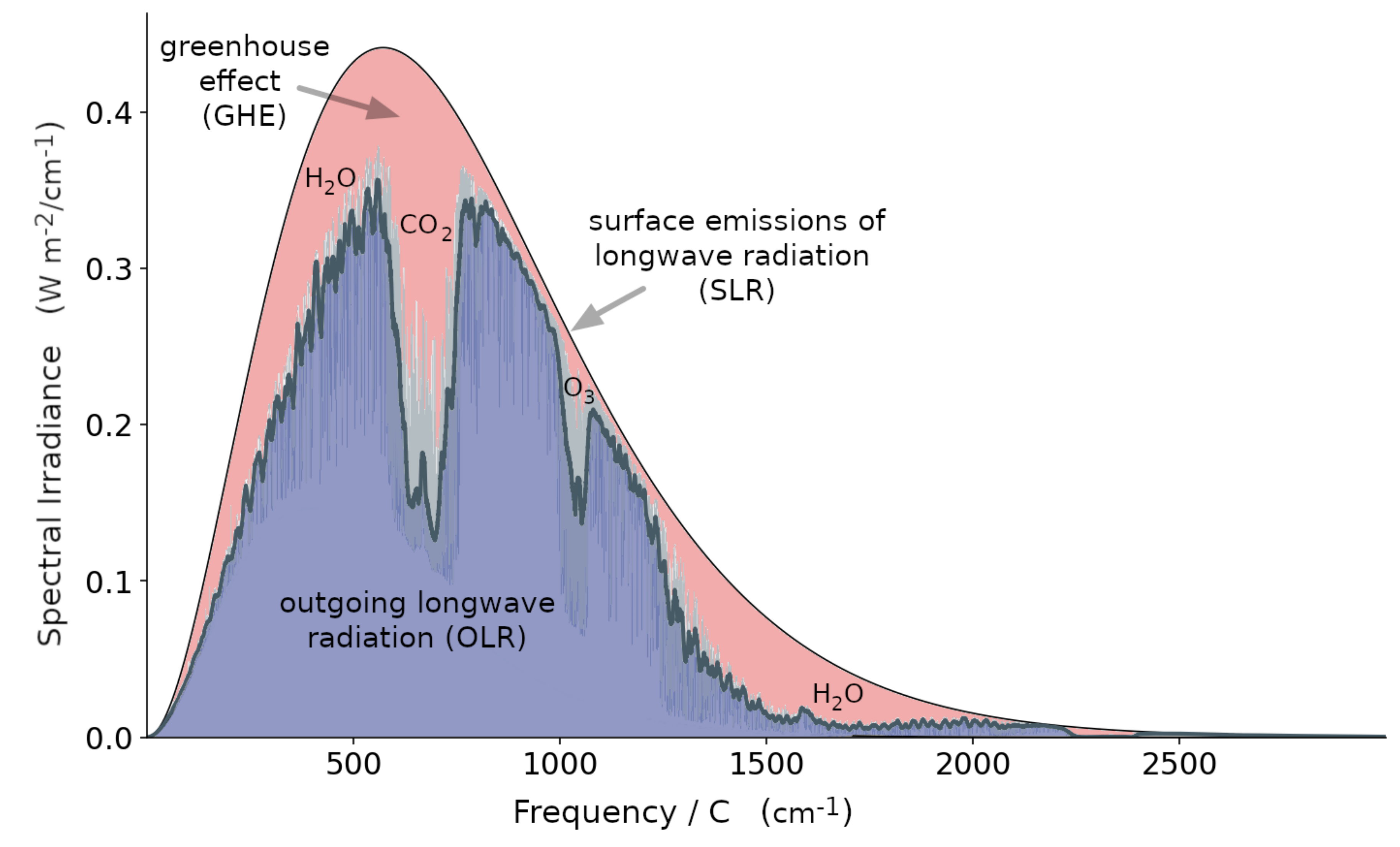


A experiência de Herschel (1800)

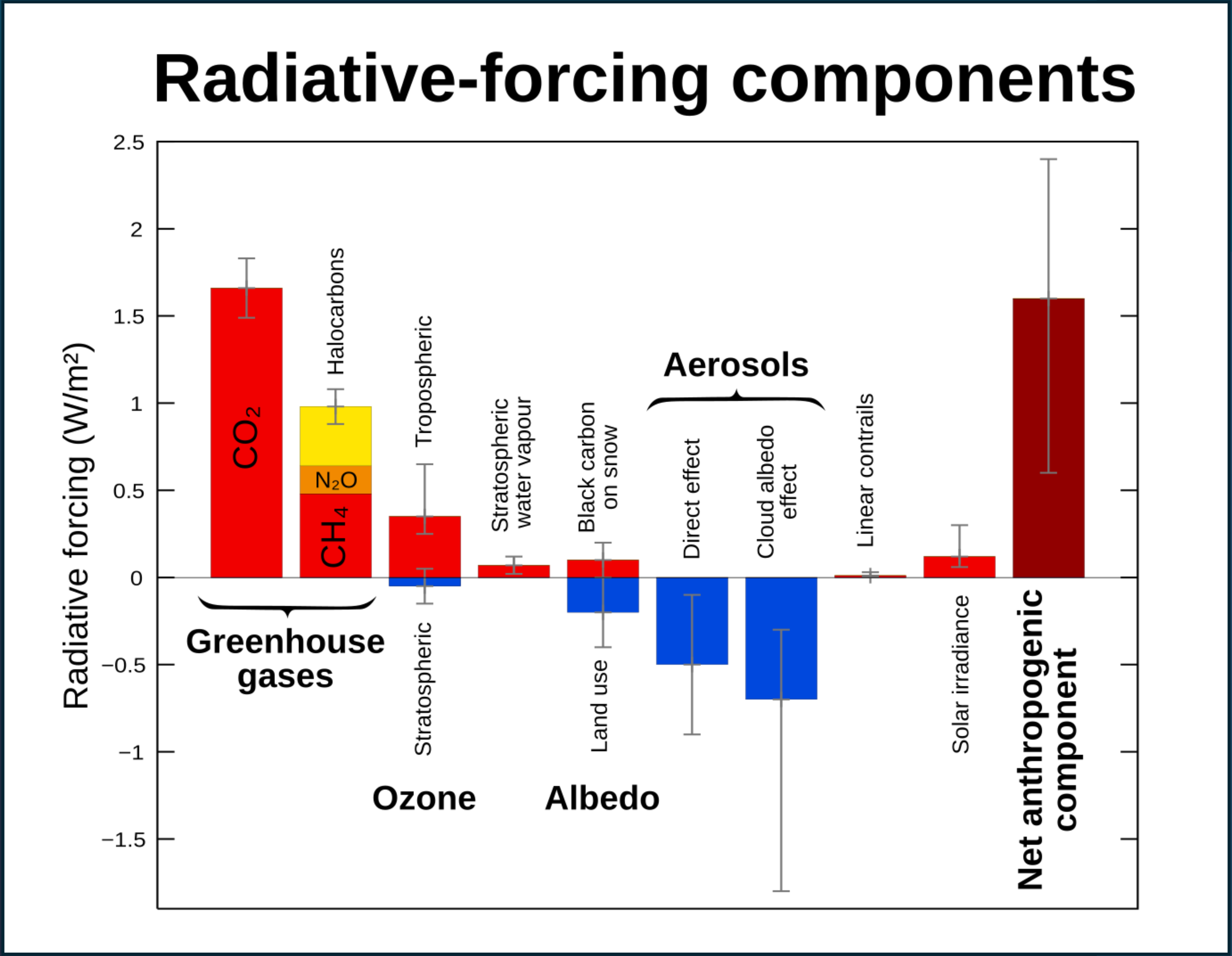

Planck's Law
(1900)
T = constant
$B(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{\exp\left(\frac{hc}{\lambda k_B T}\right) - 1}$
Spectral radiance, B (W•sr⁻¹•m⁻²•nm⁻¹)
Wavelength, λ (nm)
ScienceFacts.net



CO2
H2O
CH4



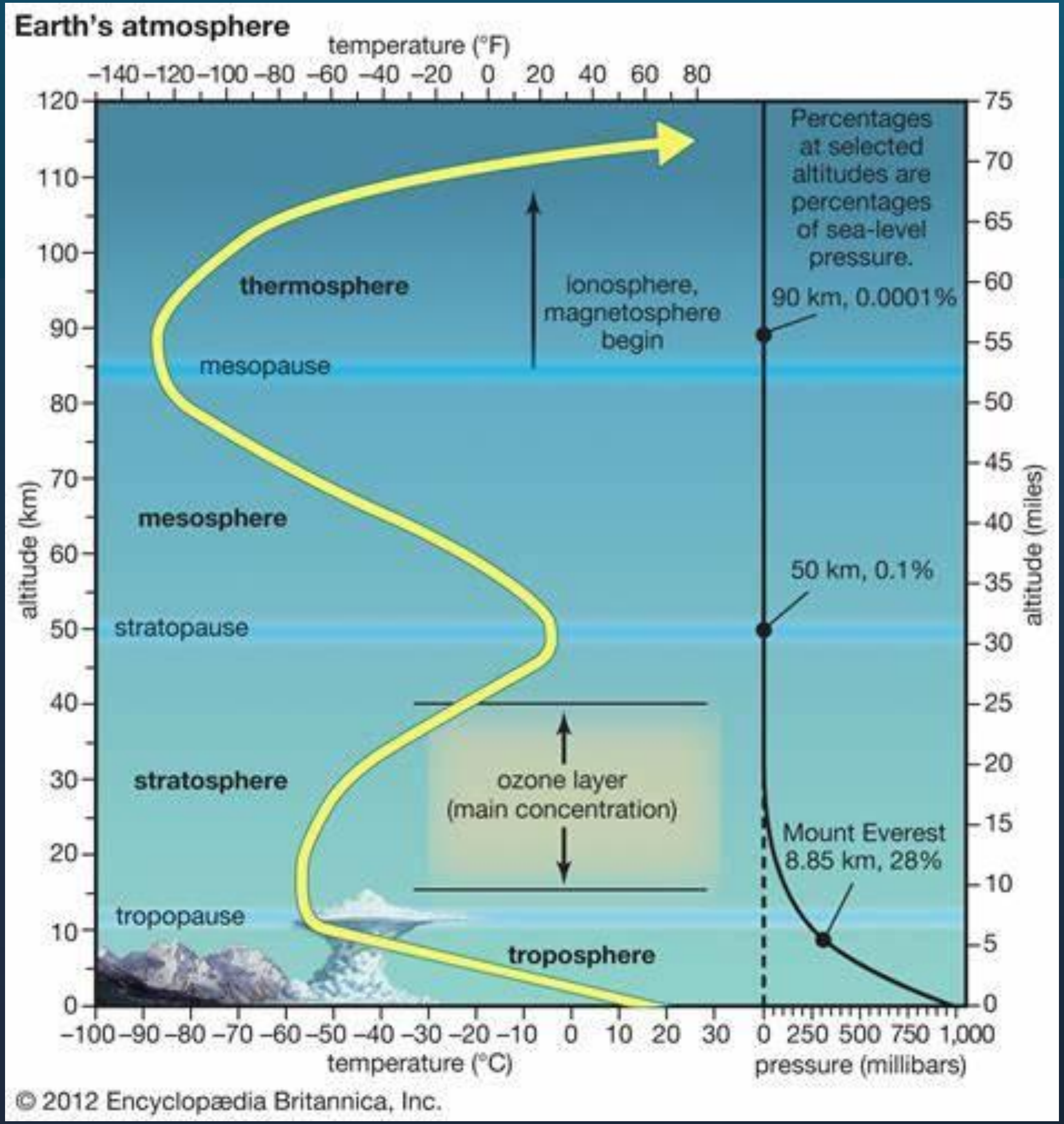
greenhouse effect (GHE)
surface emissions of longwave radiation (SLR)
outgoing longwave radiation (OLR)
H2O
CO2
O3
H2O
Spectral Irradiance (W m-2/cm-1)
Frequency / C (cm-1)
0.0
0.1
0.2
0.3
0.4
500
1000
1500
2000
2500



Radiative-forcing components
Radiative forcing (W/m²)
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
CO2
CH4
N2O
Halocarbons
Greenhouse gases
Tropospheric
Stratospheric
Ozone
Stratospheric water vapour
Black carbon on snow
Land use
Albedo
Aerosols
Direct effect
Cloud albedo effect
Linear contrails
Solar irradiance
Net anthropogenic component

CO2 equivalente (1CO2e = 1GWP)

Greenhouse Gas		Global Warming Potential (GWP)
1.	Carbon dioxide (CO_2)	1
2.	Methane (CH_4)	25
3.	Nitrous oxide(N_2O)	298
4.	Hydrofluorocarbons (HFCs)	124 – 14,800
5.	Perfluorocarbons (PFCs)	7,390 – 12,200
6.	Sulfur hexafluoride (SF_6)	22,800
7.	Nitrogen trifluoride (NF_3)[3]	17,200


Earth's atmosphere
temperature (°F)
−140 −120 −100 −80 −60 −40 −20 0 20 40 60 80
120
110
100
90
80
70
60
50
40
30
20
10
0
altitude (km)
thermosphere
mesopause
mesosphere
stratopause
stratosphere
tropopause
troposphere
Ionosphere, magnetosphere begin
ozone layer (main concentration)
Percentages at selected altitudes are percentages of sea-level pressure.
90 km, 0.0001%
50 km, 0.1%
Mount Everest 8.85 km, 28%
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
altitude (miles)
−100 −90 −80 −70 −60 −50 −40 −30 −20 −10 0 10 20 30
temperature (°C)
0 250 500 750 1,000
pressure (millibars)
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Prêmio Nobel de Física em 2021

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Thermal Equilibrium of the Atmosphere with a Given Distribution of Relative Humidity

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Geophysical Fluid Dynamics Laboratory, ESSA, Washington, D. C.

(Manuscript received 2 November 1966)

ABSTRACT

Radiative convective equilibrium of the atmosphere with a given distribution of relative humidity is computed as the asymptotic state of an initial value problem.

The results show that it takes almost twice as long to reach the state of radiative convective equilibrinm for the atmosphere with a given distribution of relative humidity than for the atmosphere with a given distribution of absolute humidity.

Also, the surface equilibrium temperature of the former is almost twice as sensitive to change of various factors such as solar constant, CO_2 content, O_3 content, and cloudiness, than that of the latter, due to the adjustment of water vapor content to the temperature variation of the atmosphere.

According to our estimate, a doubling of the CO_2 content in the atmosphere has the effect of raising the temperature of the atmosphere (whose relative humidity is fixed) by about 2C. Our model does not have the extreme sensitivity of atmospheric temperature to changes of CO_2 content which was adduced by Möller.

1. Introduction

This study is a continuation of the previous study of the thermal equilibrium of the atmosphere with a convective adjustment which was published in the JOURNAL OF THE ATMOSPHERIC SCIENCES (Manabe and Strickler, 1964). Hereafter, we shall identify this study by M.S. In M.S. the vertical distribution of absolute humidity was given for the computation of equilibrium temperature, and its dependence upon atmospheric temperature was not taken into consideration. However, the absolute humidity in the actual atmosphere strongly depends upon temperature. Fig. 1 shows the distribution of relative humidity as a function of latitude and height for summer and winter. According to this figure, the zonal mean distributions of relative humidity of two seasons closely resemble one another, whereas those of absolute humidity do not. These data suggest that, given sufficient time, the atmosphere tends to restore a certain climatological distribution of relative humidity responding to the change of temperature. If the moisture content of the atmosphere depends upon atmospheric temperature, the effective height of the source of outgoing long-wave radiation also depends upon atmospheric temperature. Given a vertical distribution of relative humidity, the warmer the atmospheric temperature, the higher the effective source of outgoing radiation. Accordingly, the dependence of the outgoing long-wave radiation is less than that to be expected from the fourth-power law of Stefan-Boltzman. Therefore, the equilibrium temperature of the atmosphere with a fixed relative humidity depends more upon the solar constant or upon absorbers such as CO_2 and O_3, than does that with a fixed absolute humidity, in order to satisfy the condition of radiative convective equilibrium. In this study, we will repeat the computation of radiative convective equilibrium of the atmosphere, this time for an atmosphere with a given distribution of relative humidity instead of that for an atmosphere with a given distribution of absolute humidity as was carried out in M.S.

As we stated in M.S., and in the study by Manabe and Möller (1961), the primary objective of our study of radiative convective equilibrium is the incorporation of radiative transfer into the general circulation model

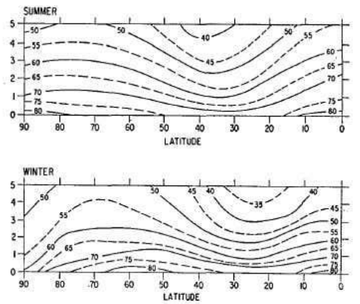
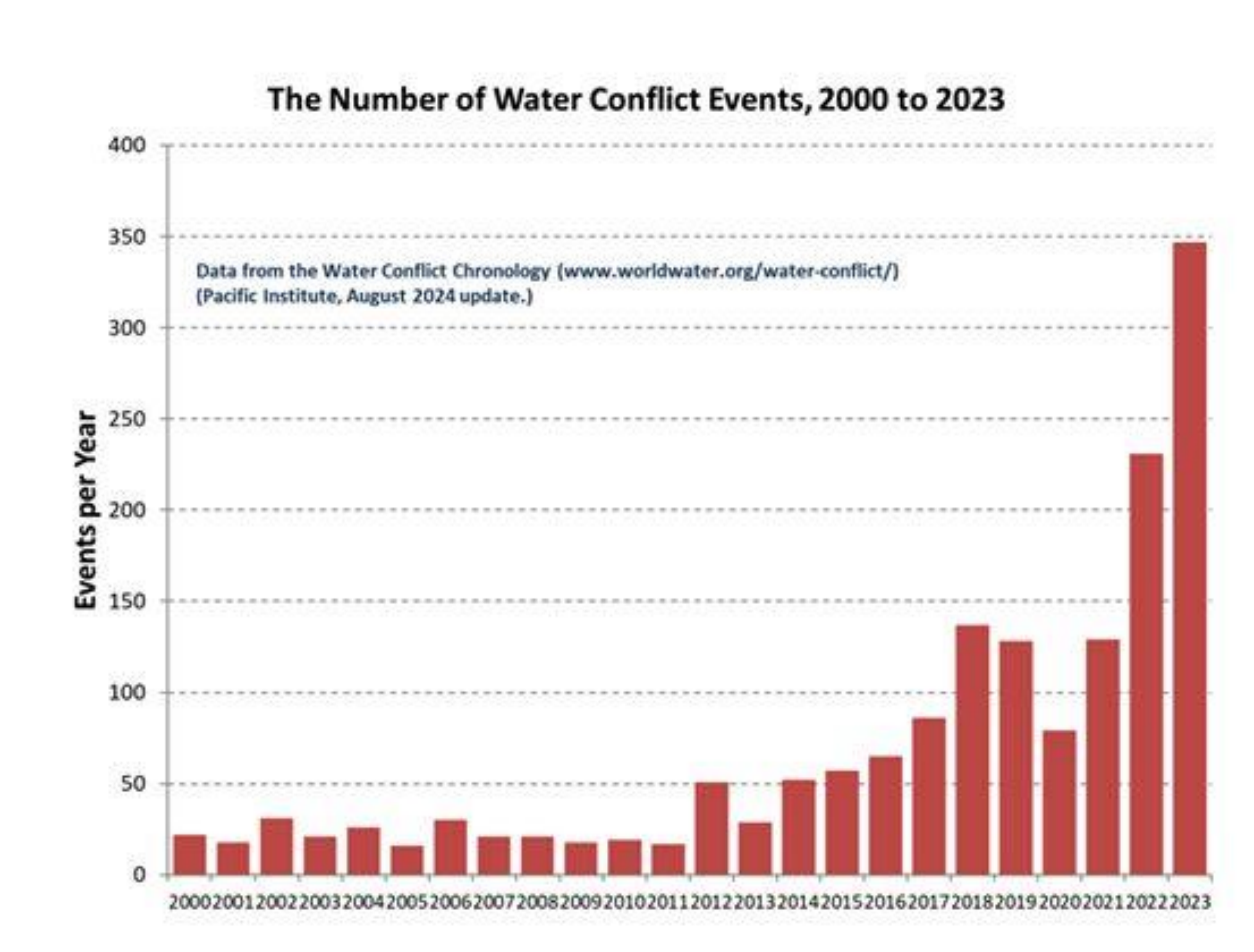


FIG. 1. Latitude-height distribution of relative humidity for both summer and winter (Telegadas and London, 1954).

96% da atmosfera de Vênus é CO_2.
Sua temperatura é 464ºC,
de dia e de noite,
nos pólos ou no equador.

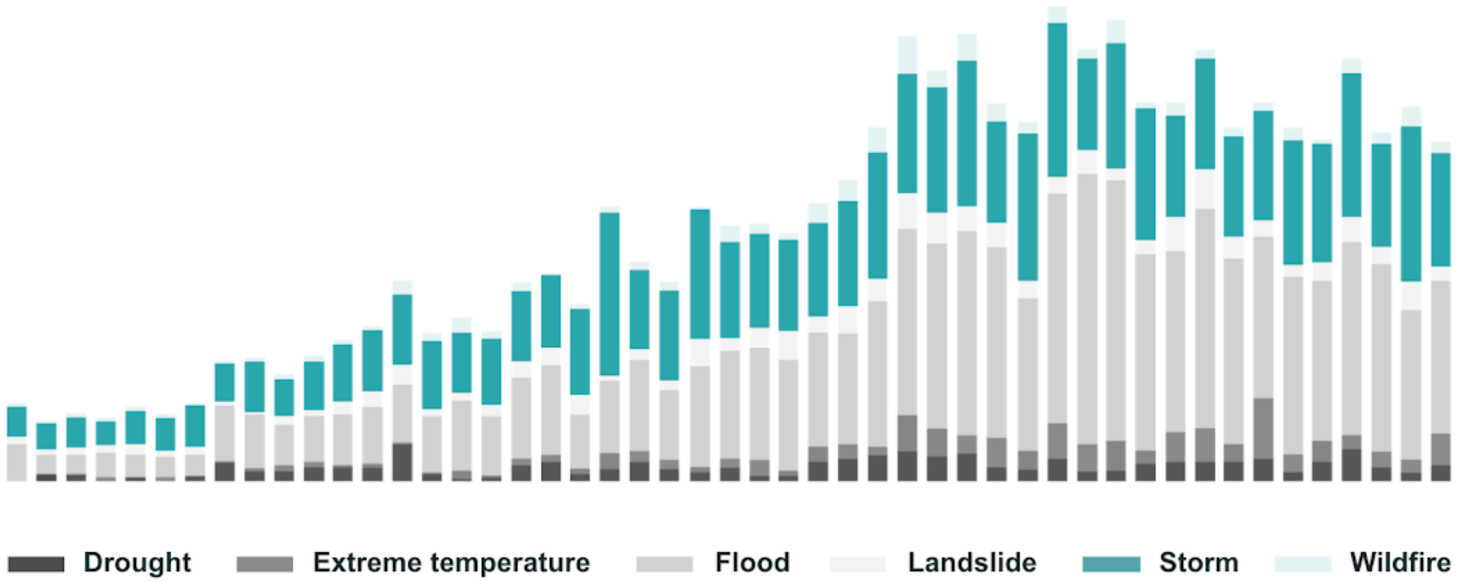
Vênus é 300ºC mais quente do que Mercúrio, mesmo recebendo apenas ¼ da incidência solar.


E daí? Não é meu planeta!



The Number of Water Conflict Events, 2000 to 2023
Data from the Water Conflict Chronology (www.worldwater.org/water-conflict/)
(Pacific Institute, August 2024 update.)
Events per Year
400
350
300
250
200
150
100
50
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

EXTREME WEATHER EVENTS ARE BECOMING MORE FREQUENT



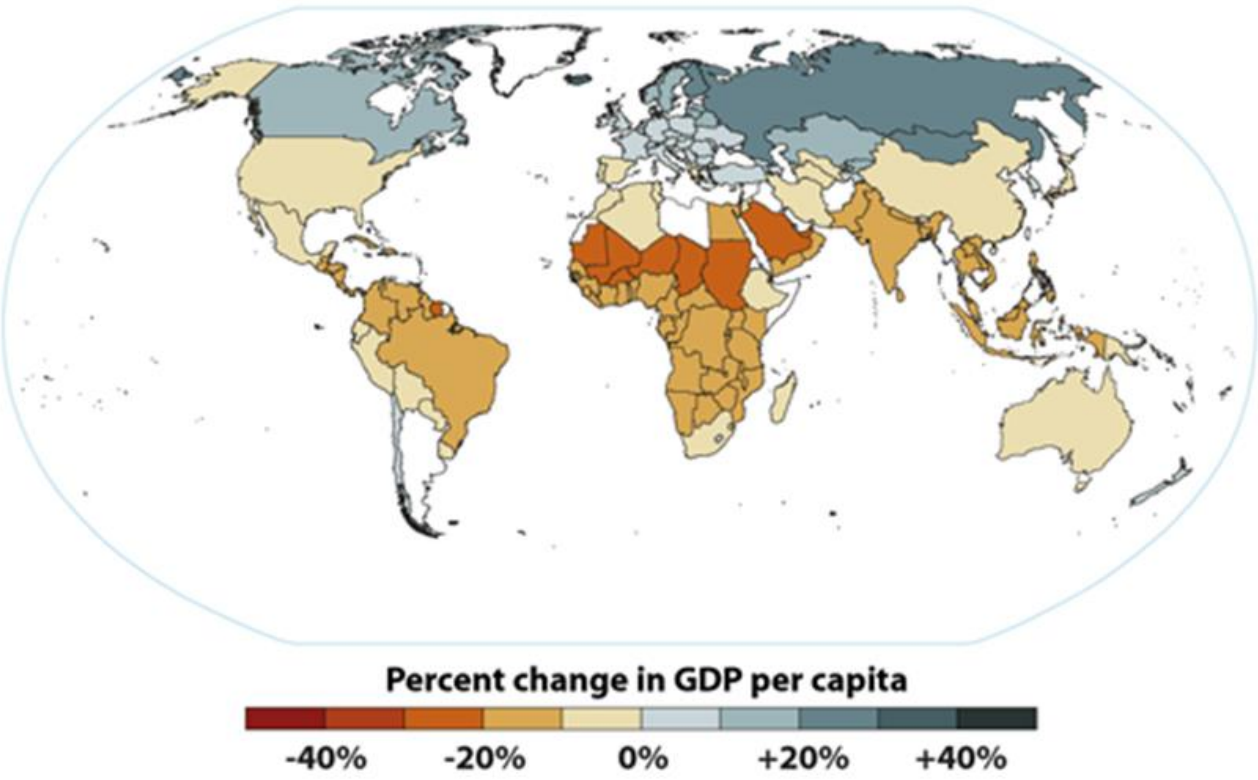
Incidence of extreme weather events since 1950 - Source : EM-DAR The CRED/OFDA International disaster database

Impact of Climate Change on GDP

Most countries would have been better off economically without climate change in recent decades, new research suggests. The researchers used climate models to estimate the loss or gain caused by rising global temperatures.

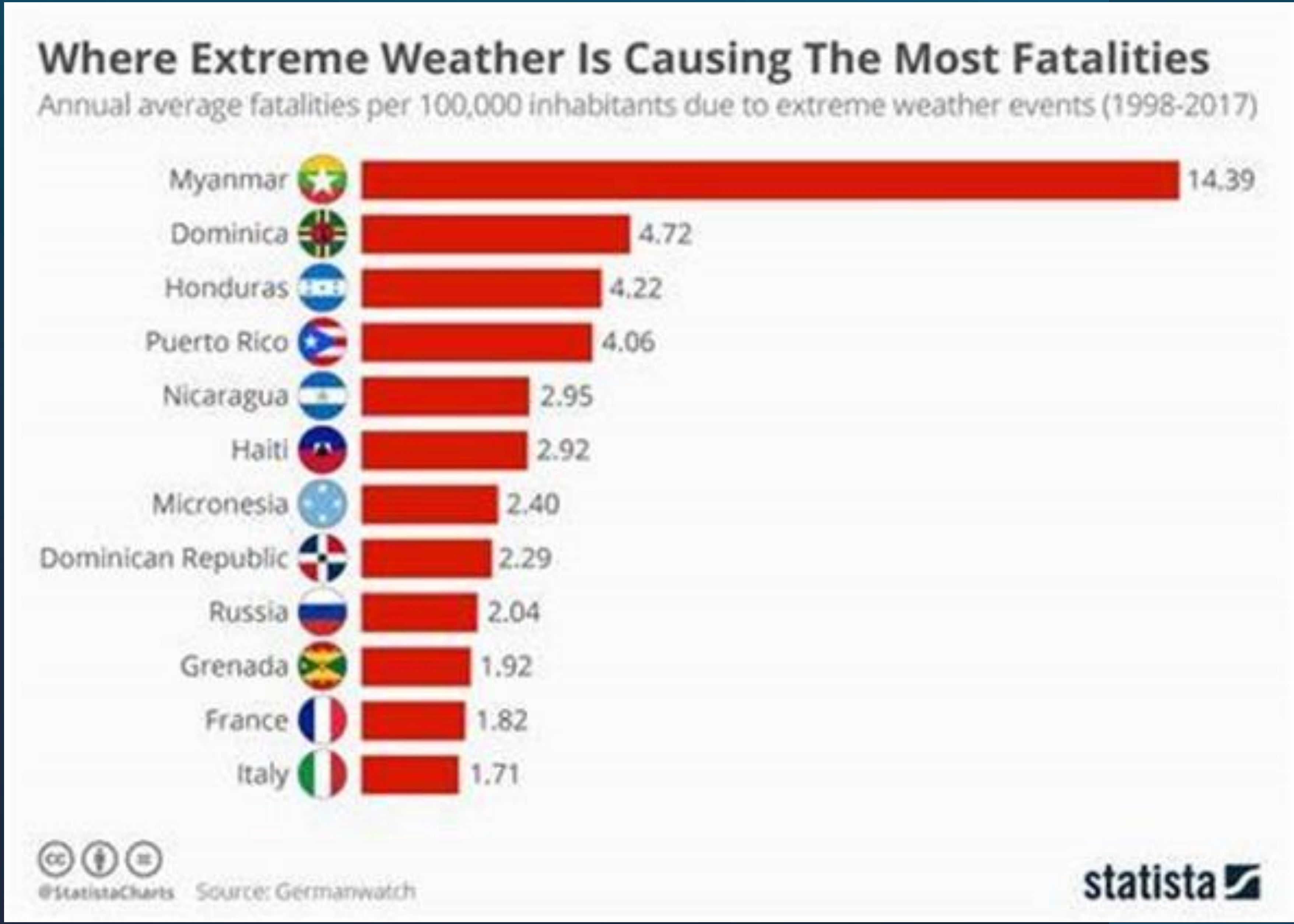
ESTIMATED ECONOMIC IMPACT OF GLOBAL WARMING

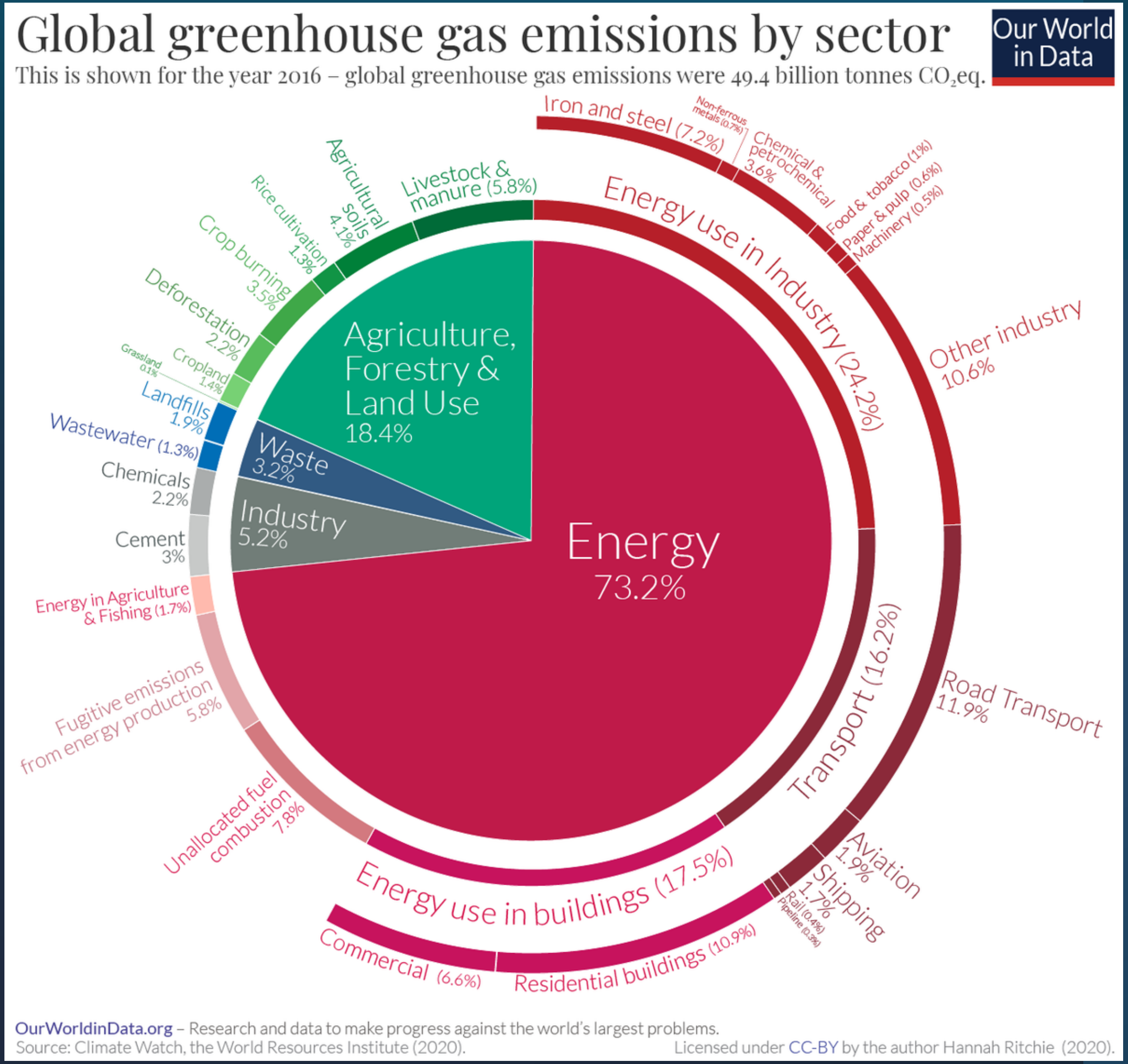
Percent change in GDP per capita, 1991-2010

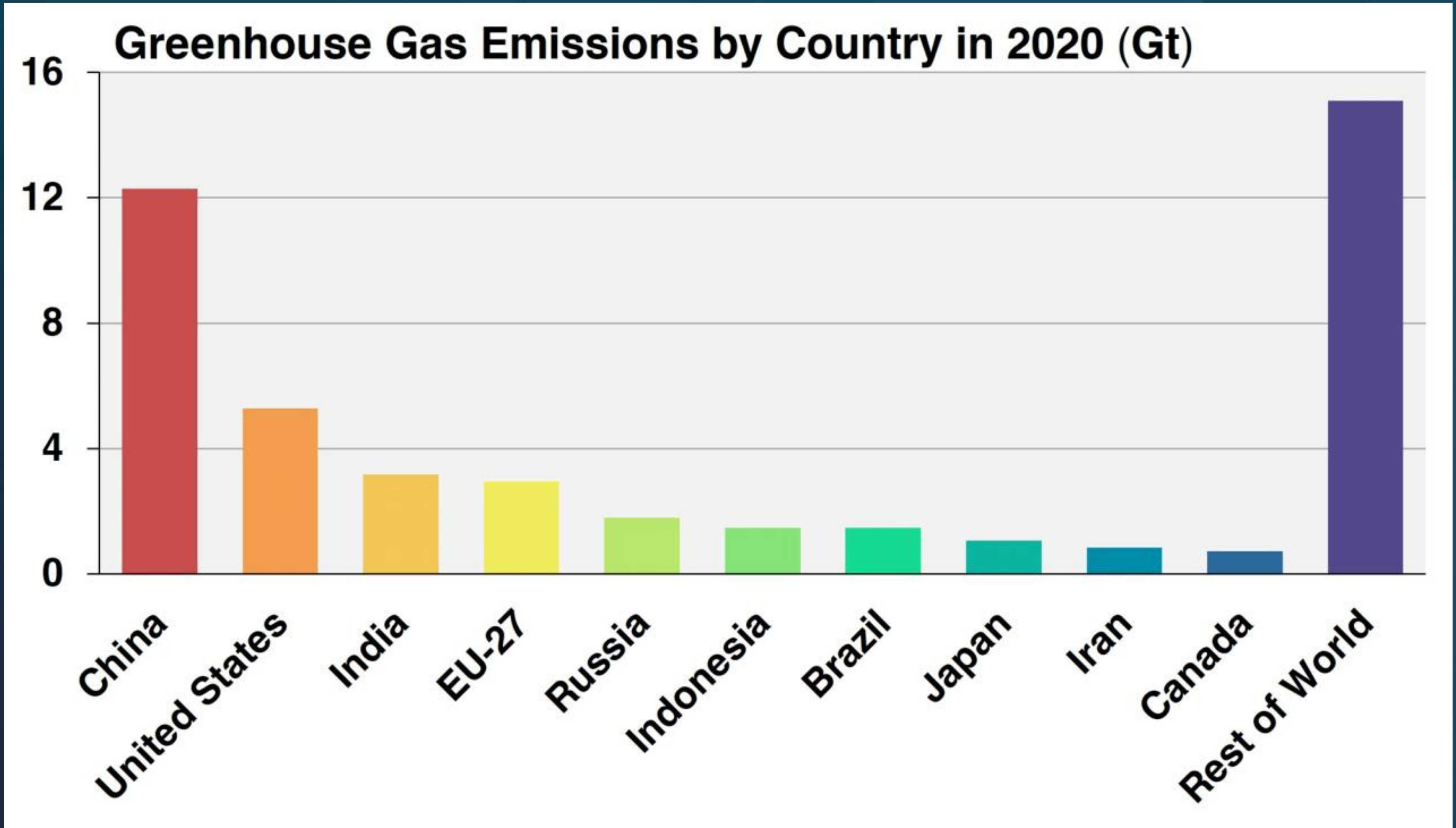


SOURCE: Noah S. Diffenbaugh and Marshall Burke, 2019

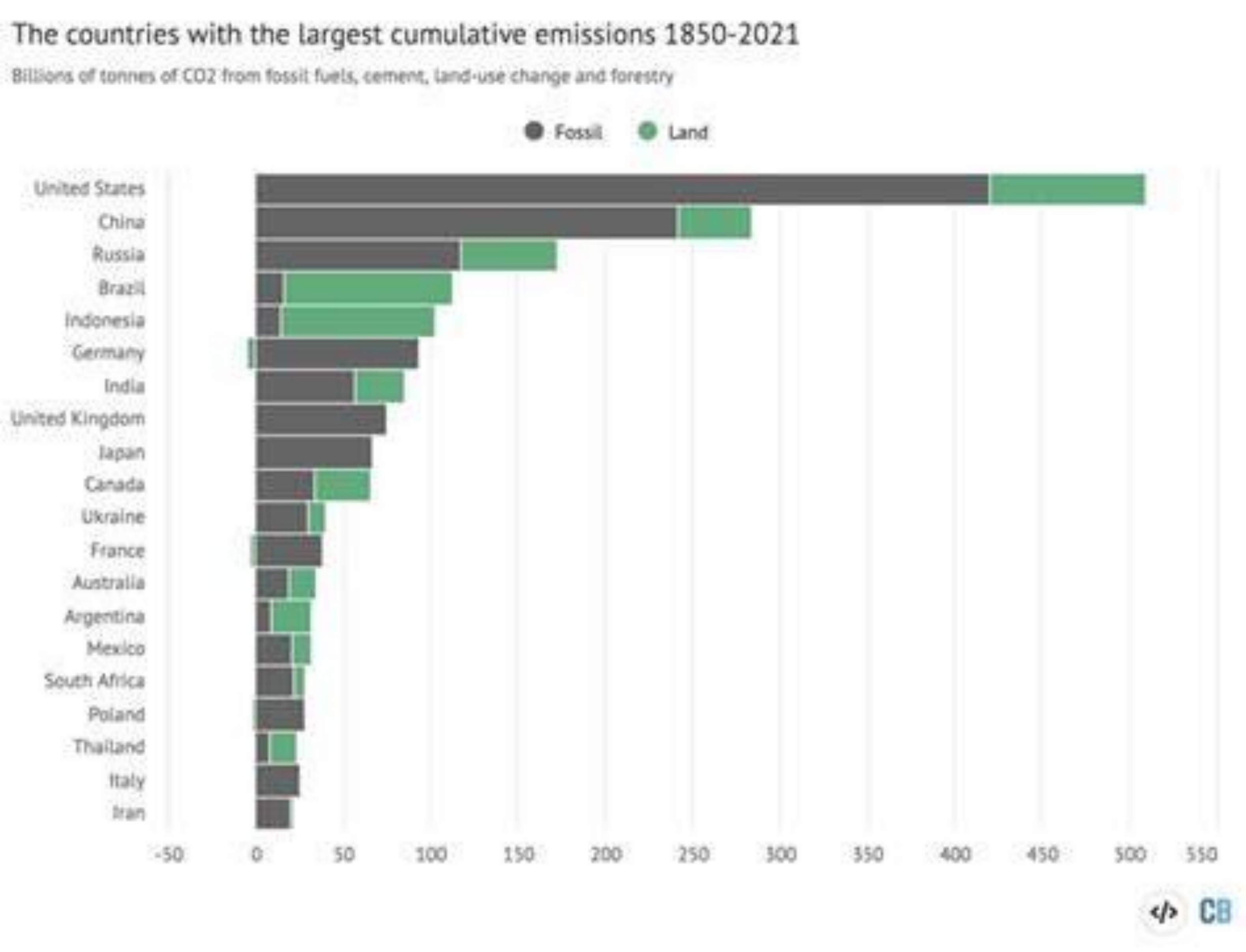
InsideClimate News

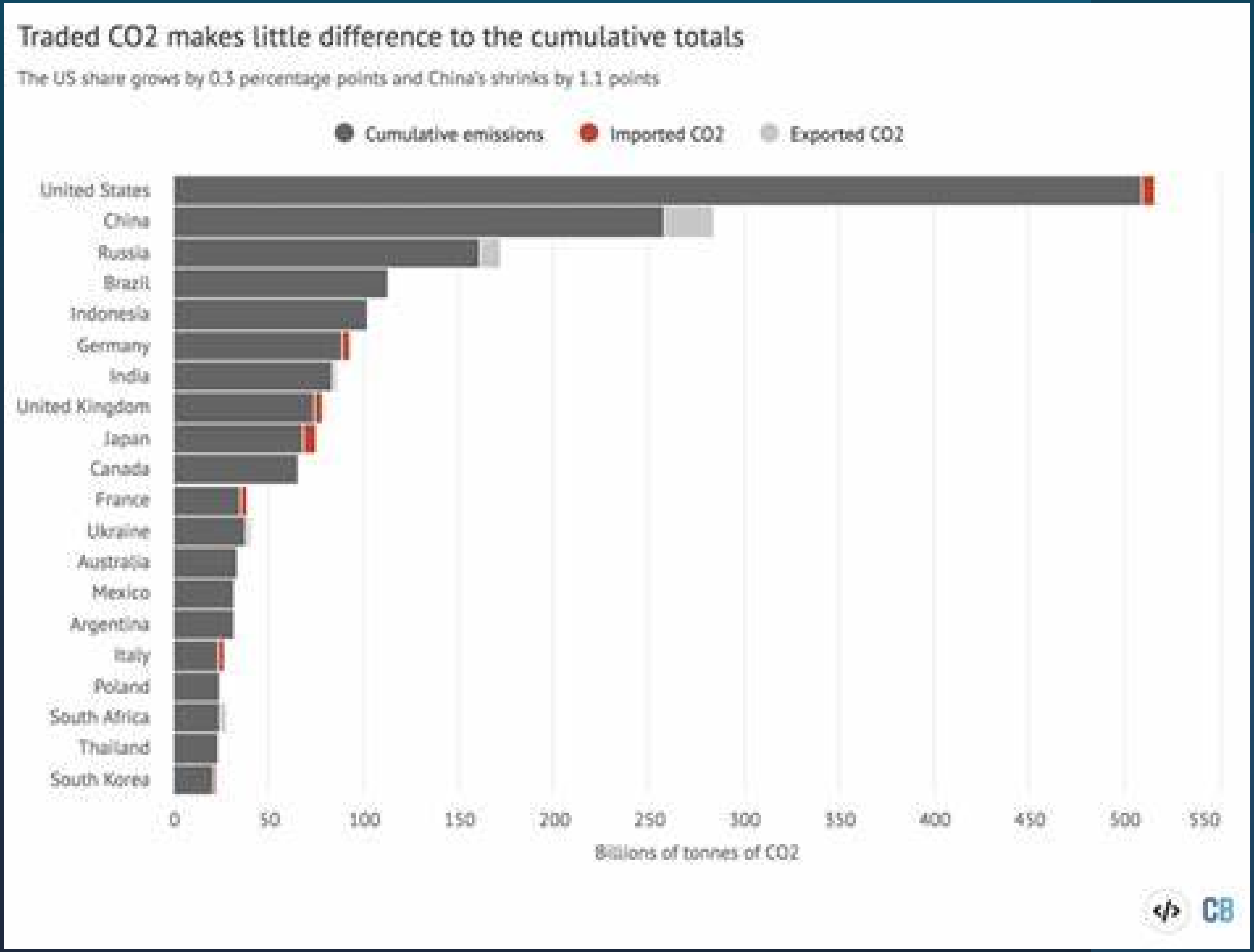

Where Extreme Weather Is Causing The Most Fatalities
Annual average fatalities per 100,000 inhabitants due to extreme weather events (1998-2017)
Myanmar 14.39
Dominica 4.72
Honduras 4.22
Puerto Rico 4.06
Nicaragua 2.95
Haiti 2.92
Micronesia 2.40
Dominican Republic 2.29
Russia 2.04
Grenada 1.92
France 1.82
Italy 1.71
@StatistaCharts
Source: Germanwatch
statista


Global greenhouse gas emissions by sector
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.
Our World in Data
Energy 73.2%
Agriculture, Forestry & Land Use 18.4%
Waste 3.2%
Industry 5.2%
Energy use in Industry (24.2%)
Iron and steel (7.2%)
Non-ferrous metals (0.7%)
Chemical & petrochemical 3.6%
Food & tobacco (1%)
Paper & pulp (0.6%)
Machinery (0.5%)
Other industry 10.6%
Transport (16.2%)
Road Transport 11.9%
Aviation 1.9%
Shipping 1.7%
Rail (0.4%)
Pipeline (0.3%)
Energy use in buildings (17.5%)
Residential buildings (10.9%)
Commercial (6.6%)
Unallocated fuel combustion 7.8%
Fugitive emissions from energy production 5.8%
Energy in Agriculture & Fishing (1.7%)
Cement 3%
Chemicals 2.2%
Wastewater (1.3%)
Landfills 1.9%
Grassland 0.1%
Cropland 1.4%
Deforestation 2.2%
Crop burning 3.5%
Rice cultivation 1.3%
Agricultural soils 4.1%
Livestock & manure (5.8%)
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020).
Licensed under CC-BY by the author Hannah Ritchie (2020).



Fonte: Data from Climate Watch; Climate Watch Historical GHG Emissions (1990-2020). 2023. Washington, DC: World Resources Institute.
Available online at: https://www.climatewatchdata.org/ghg-emissions


The countries with the largest cumulative emissions 1850-2021
Billions of tonnes of CO2 from fossil fuels, cement, land-use change and forestry
Fossil
Land
United States
China
Russia
Brazil
Indonesia
Germany
India
United Kingdom
Japan
Canada
Ukraine
France
Australia
Argentina
Mexico
South Africa
Poland
Thailand
Italy
Iran
-50
0
50
100
150
200
250
300
350
400
450
500
550
CB


Traded CO2 makes little difference to the cumulative totals
The US share grows by 0.3 percentage points and China's shrinks by 1.1 points
Cumulative emissions
Imported CO2
Exported CO2
United States
China
Russia
Brazil
Indonesia
Germany
India
United Kingdom
Japan
Canada
France
Ukraine
Australia
Mexico
Argentina
Italy
Poland
South Africa
Thailand
South Korea
0
50
100
150
200
250
300
350
400
450
500
550
Billions of tonnes of CO2
CB

Emissões por setor no Brasil

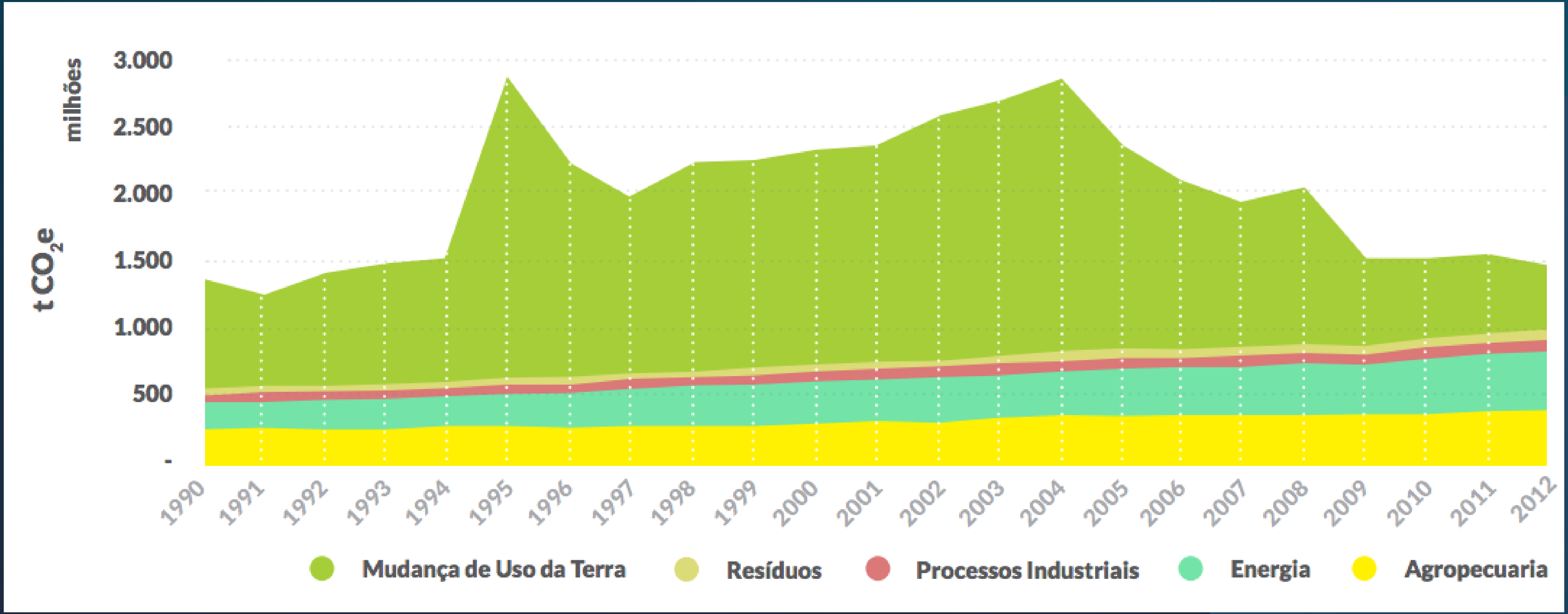
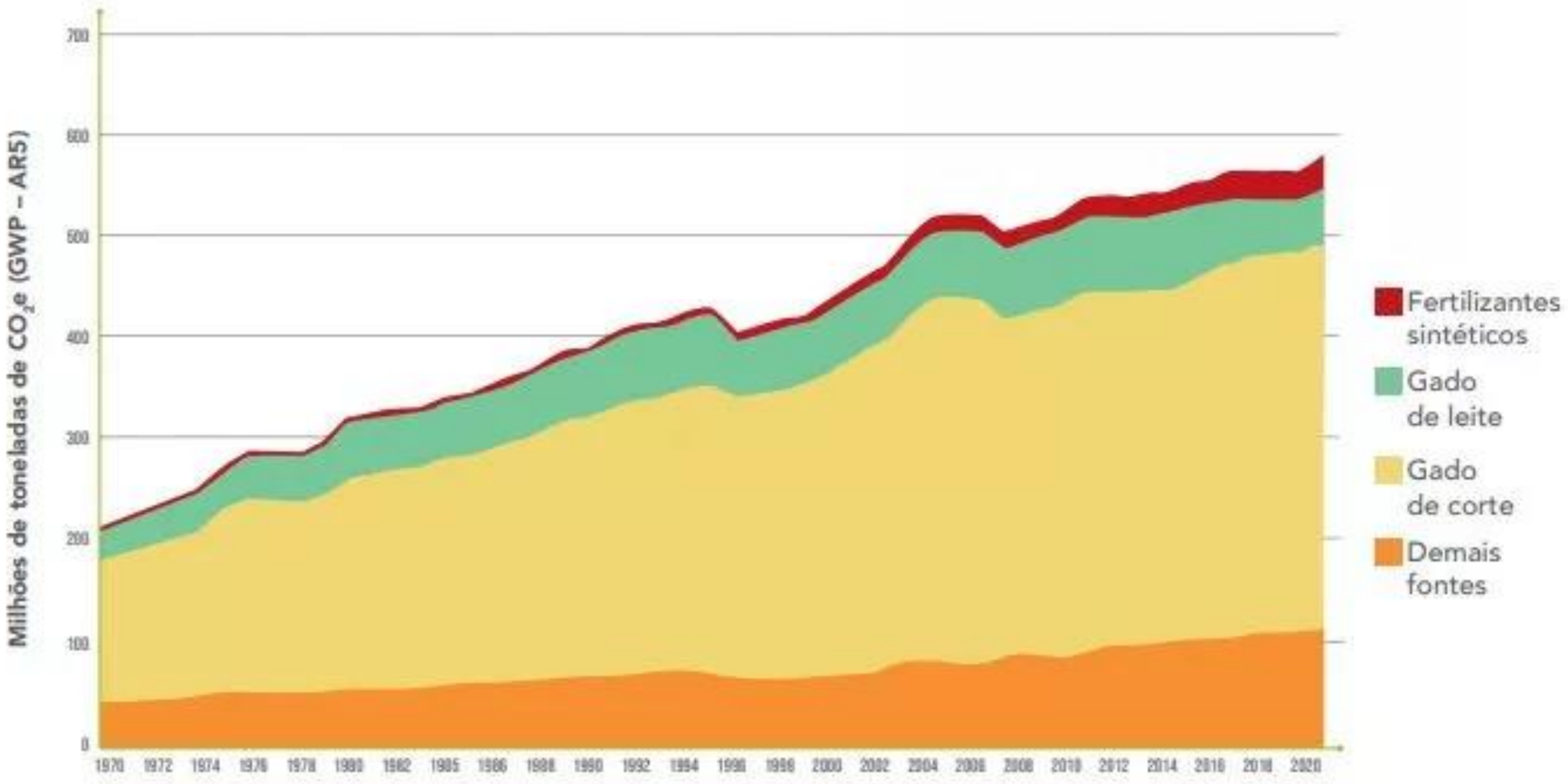
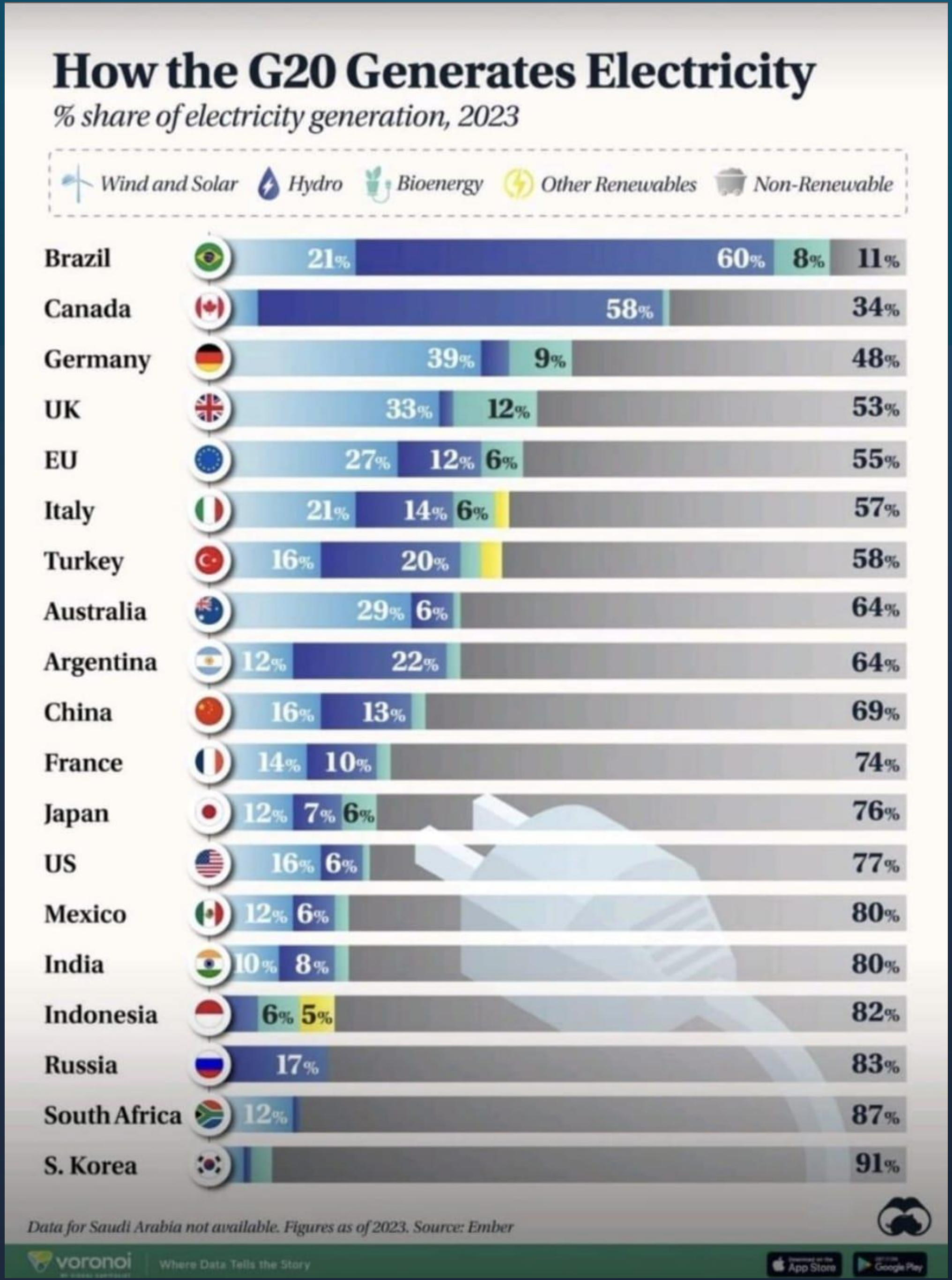


Figura 5. **Emissões de GEE do setor agropecuário pelas principais fontes no período de 1990 até 2020**

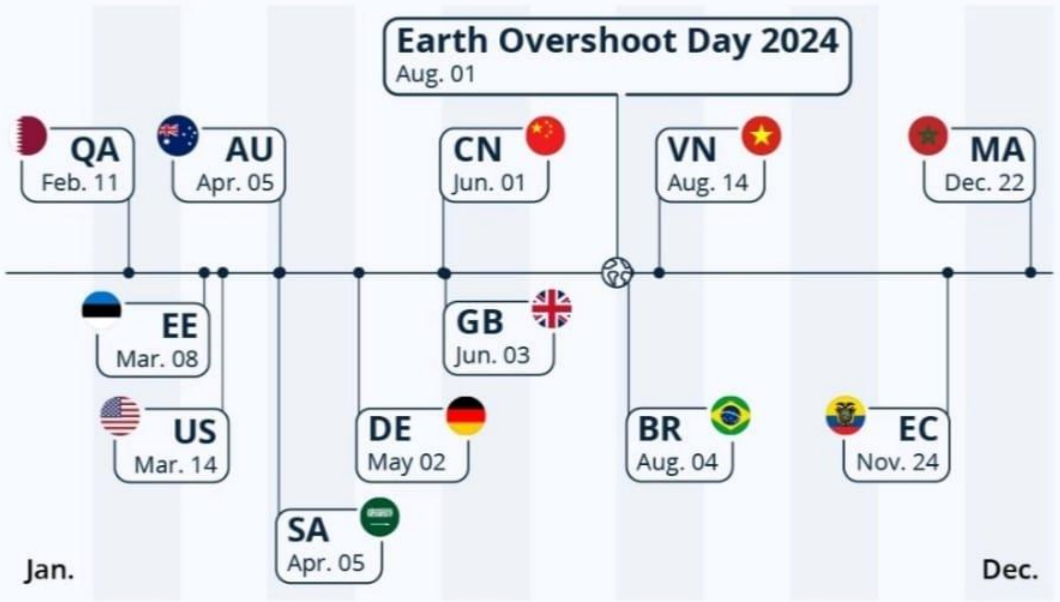




How the G20 Generates Electricity
% share of electricity generation, 2023
Wind and Solar
Hydro
Bioenergy
Other Renewables
Non-Renewable
Brazil 21% 60% 8% 11%
Canada 58% 34%
Germany 39% 9% 48%
UK 33% 12% 53%
EU 27% 12% 6% 55%
Italy 21% 14% 6% 57%
Turkey 16% 20% 58%
Australia 29% 6% 64%
Argentina 12% 22% 64%
China 16% 13% 69%
France 14% 10% 74%
Japan 12% 7% 6% 76%
US 16% 6% 77%
Mexico 12% 6% 80%
India 10% 8% 80%
Indonesia 6% 5% 82%
Russia 17% 83%
South Africa 12% 87%
S. Korea 91%
Data for Saudi Arabia not available. Figures as of 2023. Source: Ember
voronoi
Where Data Tells the Story
App Store
Google Play

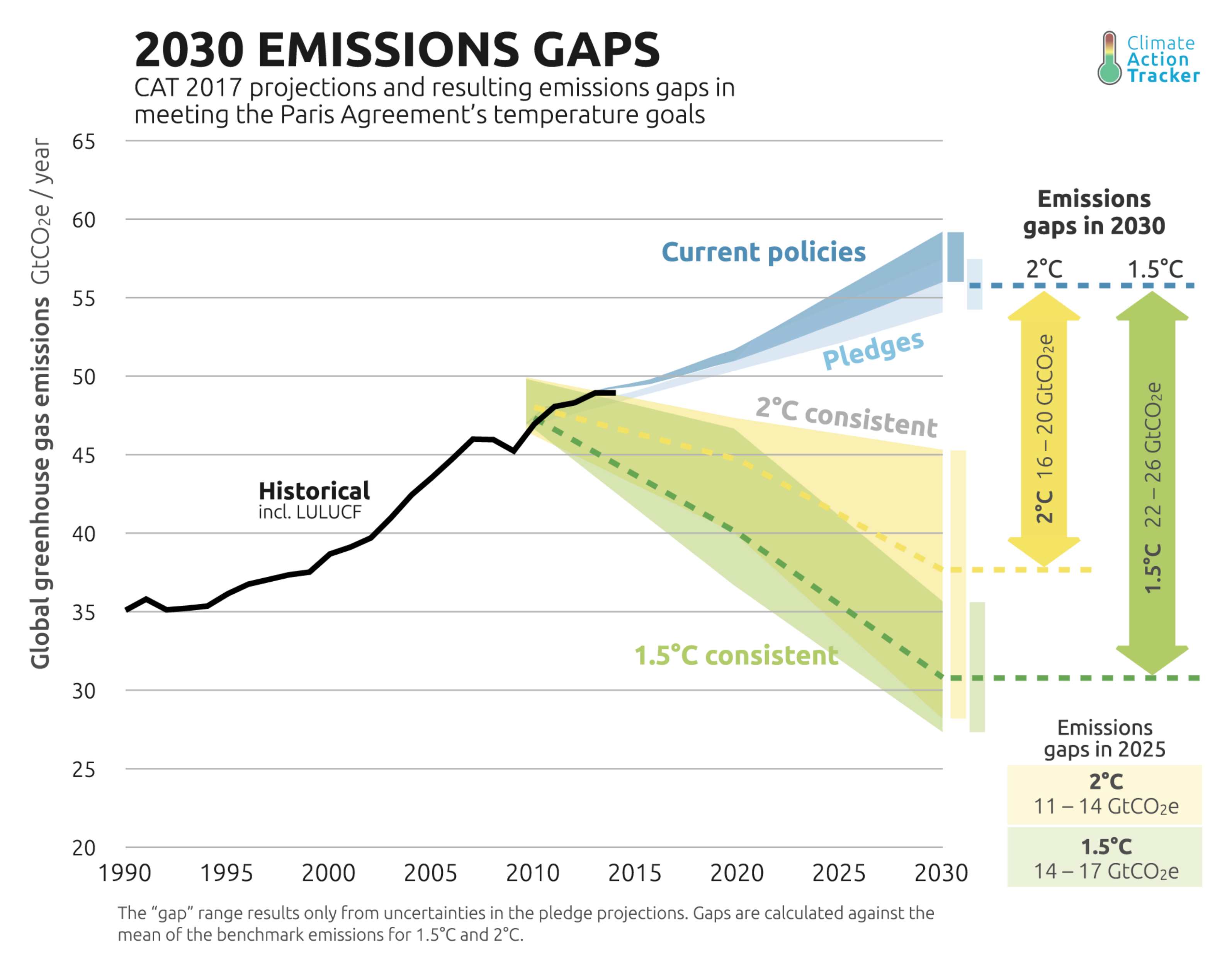
How Fast Are Countries Burning Through Natural Resources?

Date of Earth Overshoot Day if the world's population lived like the following selected countries



56 countries do not overextend their natural resources.

Source: Earth Overshoot Day


2030 EMISSIONS GAPS
CAT 2017 projections and resulting emissions gaps in meeting the Paris Agreement's temperature goals
Climate Action Tracker
Global greenhouse gas emissions GtCO2e / year
65
60
55
50
45
40
35
30
25
20
1990
1995
2000
2005
2010
2015
2020
2025
2030
Historical
incl. LULUCF
Current policies
Pledges
2°C consistent
1.5°C consistent
Emissions gaps in 2030
2°C
1.5°C
2°C 16 – 20 GtCO2e
1.5°C 22 – 26 GtCO2e
Emissions gaps in 2025
2°C
11 – 14 GtCO2e
1.5°C
14 – 17 GtCO2e
The "gap" range results only from uncertainties in the pledge projections. Gaps are calculated against the mean of the benchmark emissions for 1.5°C and 2°C.

"(...) the net-zero transition between 2021 and 2050 would amount to about $275 trillion, (...) an annual increase of as much as $3.5 trillion from today.

To put this increase in comparative terms, the $3.5 trillion is approximately equivalent, in 2020, to half of global corporate profits" (p.8)

Exhibit 1: Global sustainable, social and green bond issuance

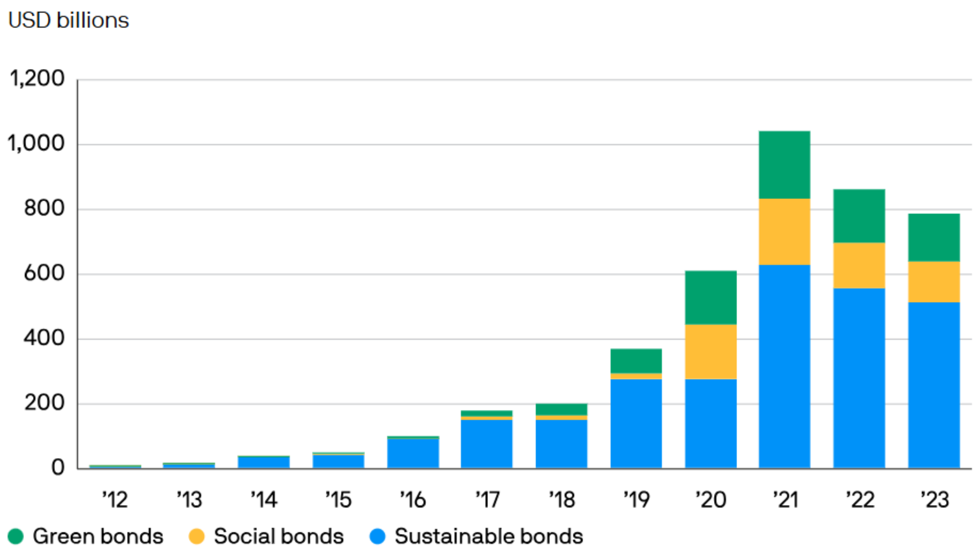
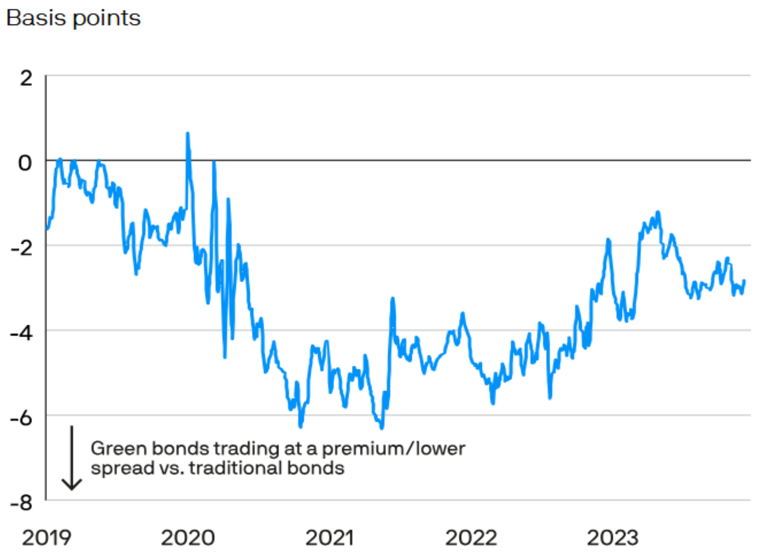


Exhibit 2: Spread between green and traditional corporate bonds



FINANCIAL TIMES

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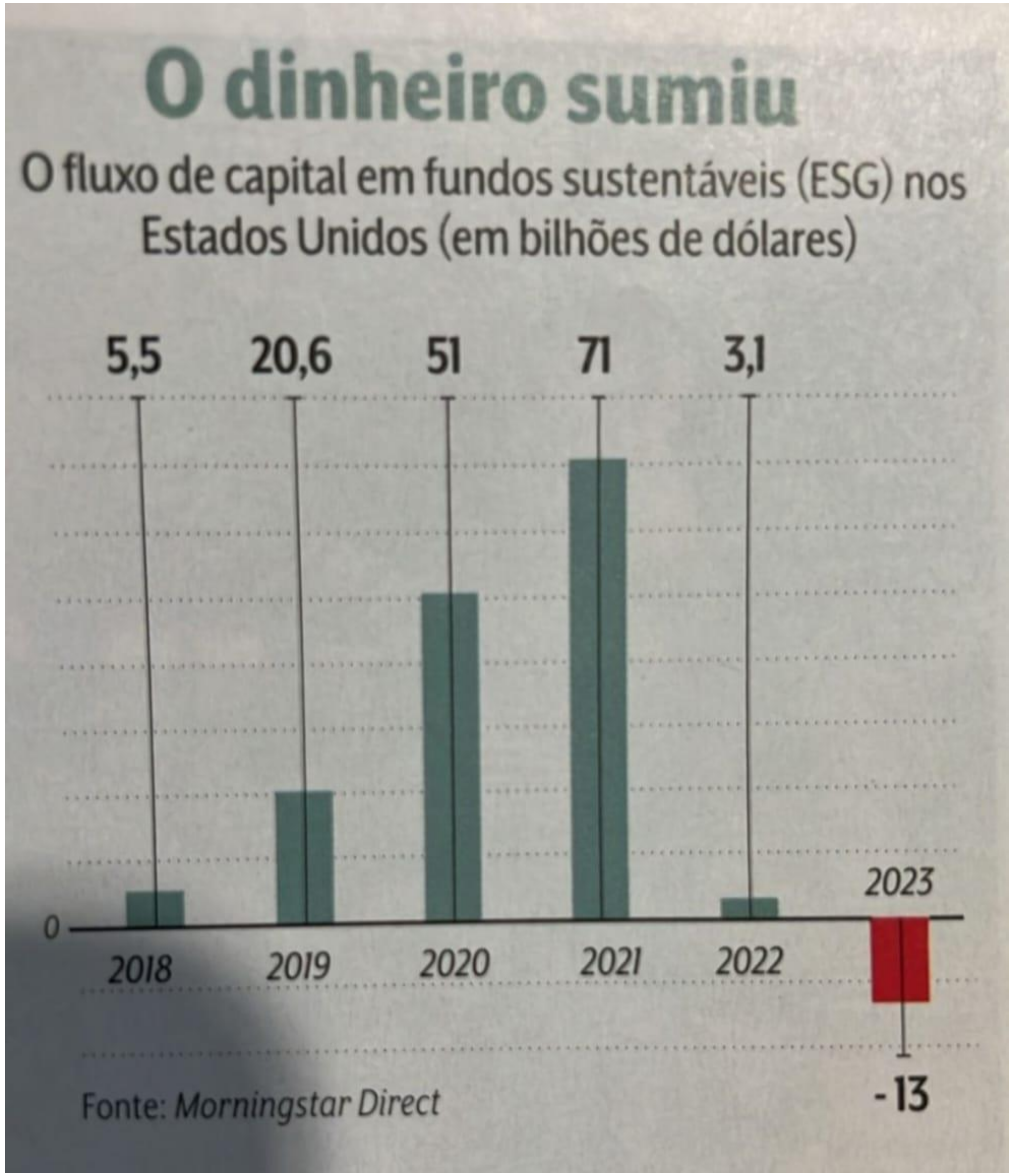
BlackRock Inc + Add to myFT

BlackRock pulls back support for climate and social resolutions

Proposals that 'dictate the pace' of energy transition receive fewer votes from $8.5tn money manager

Save

BlackRock's support for environmental and social proposals dropped from 43% in last year's meeting season to 24% this year © Brendan McDermid/Reuters



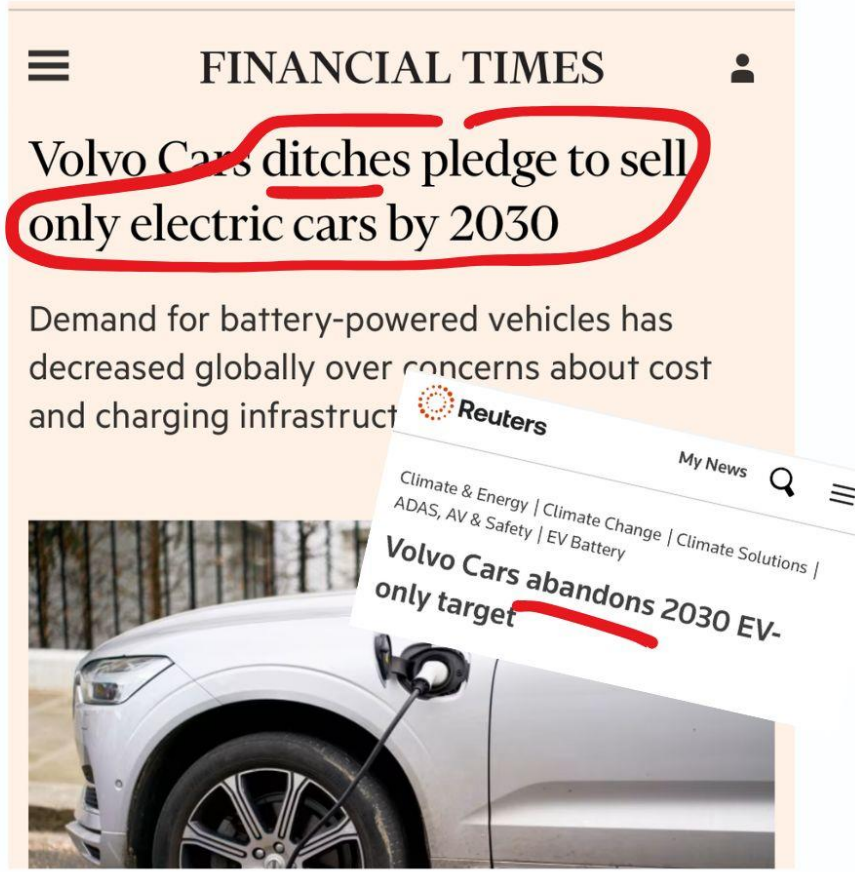
Volvo **THEN**
(2021)


The New York Times

Volvo Plans to Sell Only Electric Cars by 2030

The Swedish company would phase out internal combustion engine vehicles faster than other automakers.

Volvo **NOW**
(Sep. 2024)


FINANCIAL TIMES

Volvo Cars ditches pledge to sell only electric cars by 2030

Demand for battery-powered vehicles has decreased globally over concerns about cost and charging infrastruct

Reuters

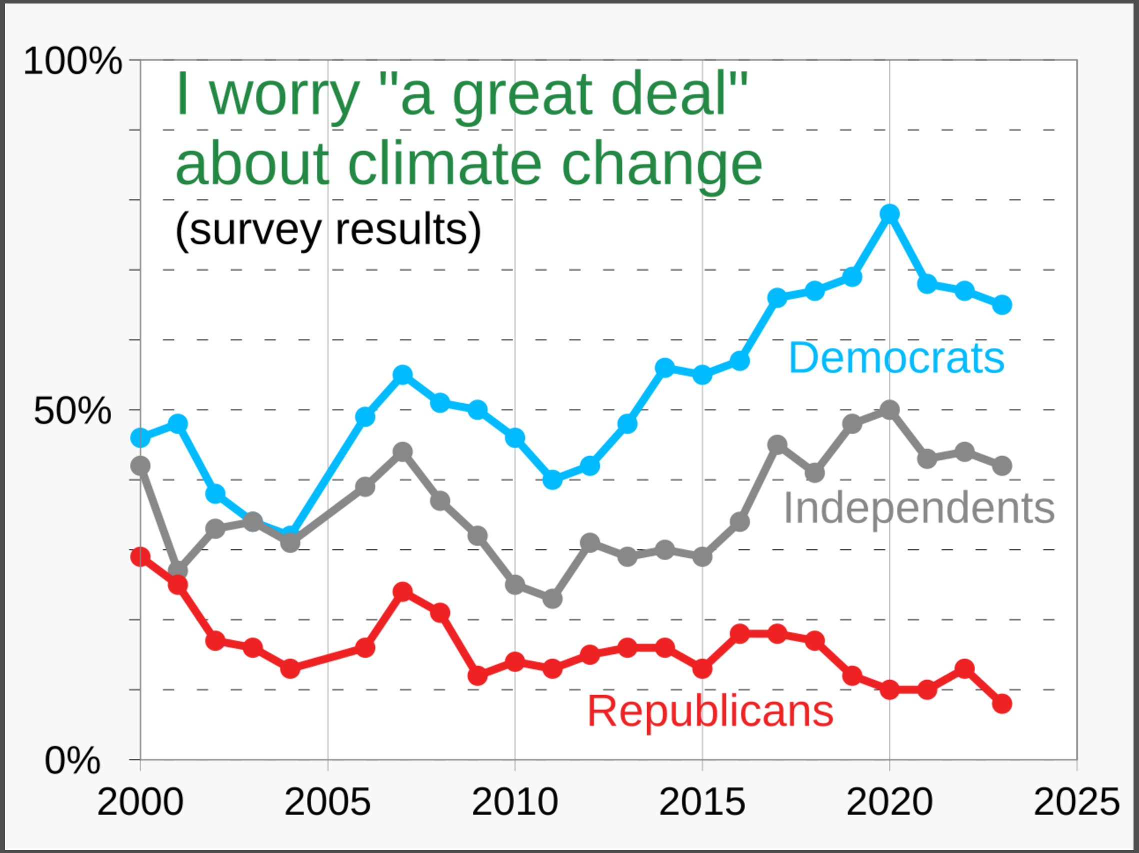
My News

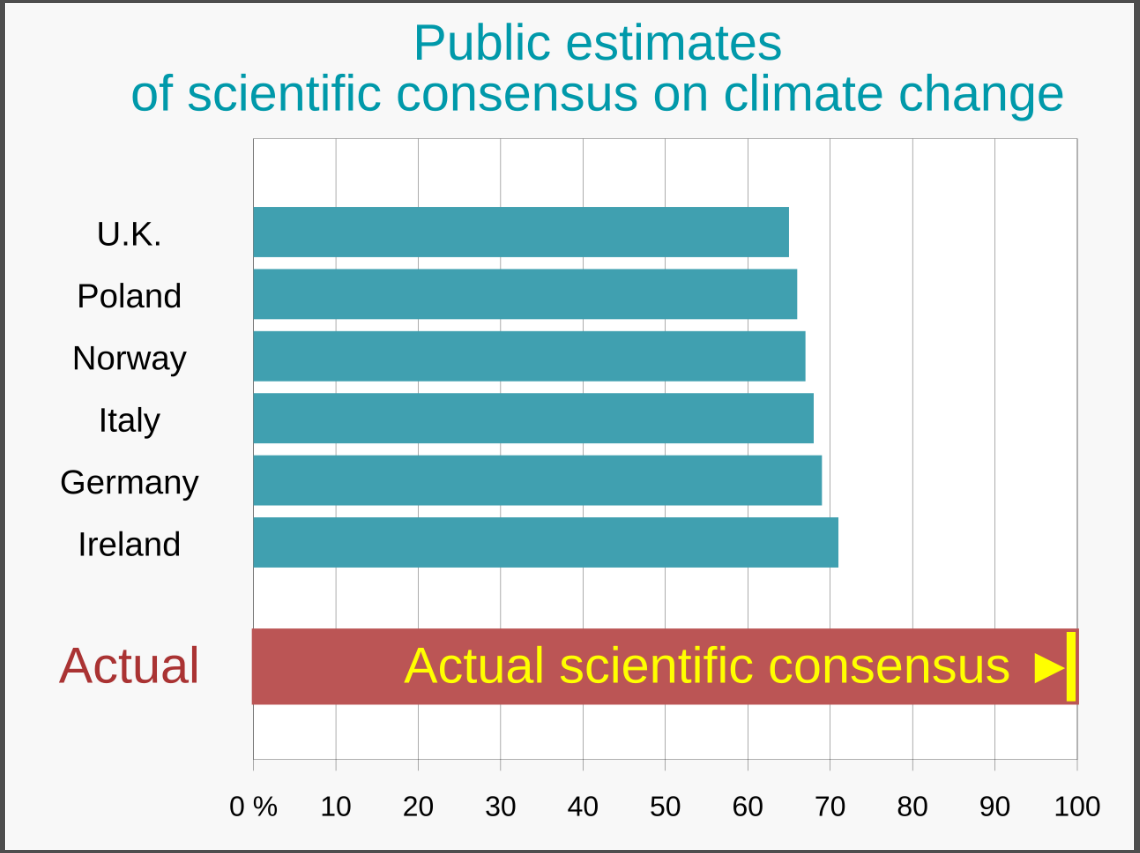
Climate & Energy | Climate Change | Climate Solutions | ADAS, AV & Safety | EV Battery

Volvo Cars abandons 2030 EV-only target

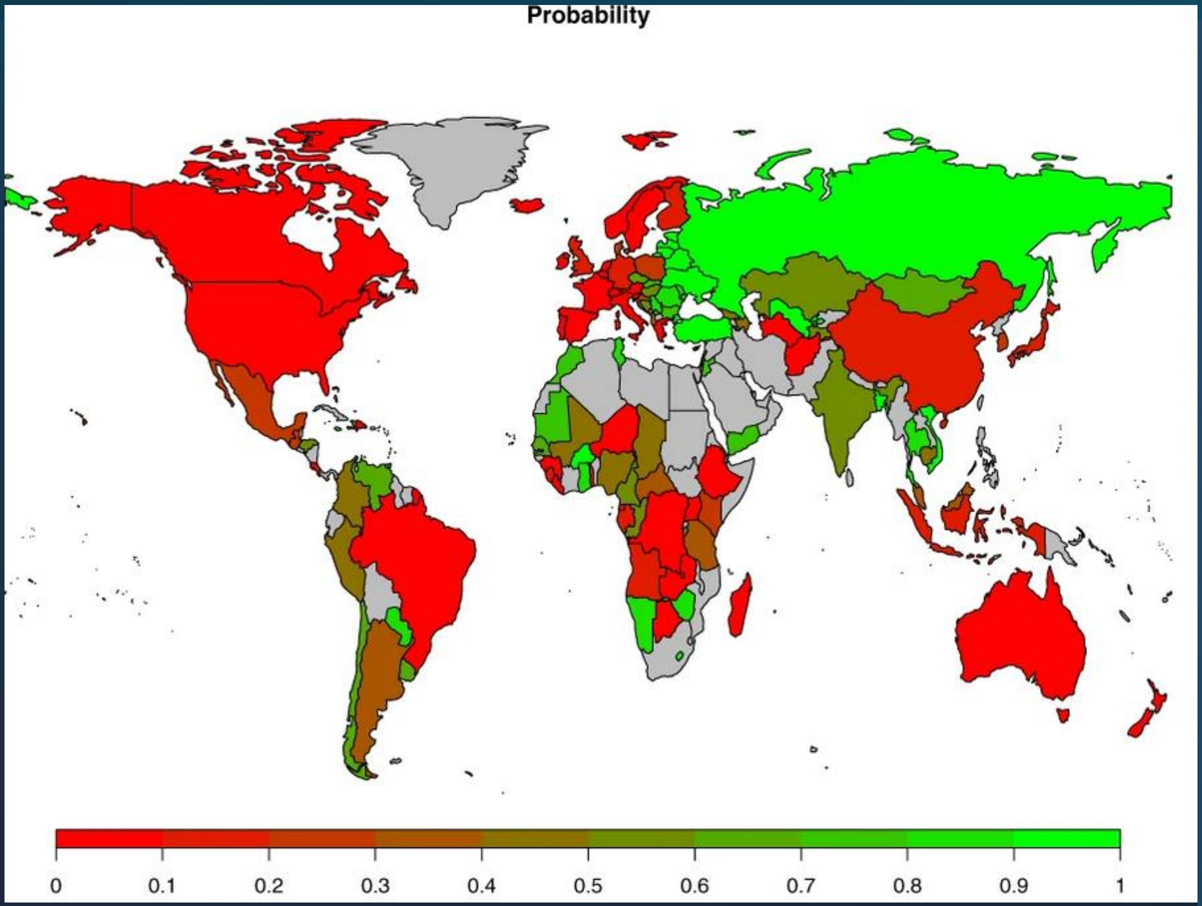
NANCIAL TIMES

npresas com boa nota ESG poluem nto quanto as mal avaliadas


I worry "a great deal"
about climate change
(survey results)
100%
50%
0%
2000
2005
2010
2015
2020
2025
Democrats
Independents
Republicans


Public estimates
of scientific consensus on climate change
U.K.
Poland
Norway
Italy
Germany
Ireland
Actual
Actual scientific consensus ▶
0 %
10
20
30
40
50
60
70
80
90
100

Probability that countries achieve their Paris Agreement Goals according to their nationally determined contributions as of 2021 (NDCs)



Estrutura do Curso

Parte I: Introdução

- Mudanças climáticas. Noções de ciência do clima.
- Impactos socioeconômicos da mudança climática
- Estratégias de adaptação e de mitigação.
- Transição energética.

Parte II: Soluções possíveis

- Soluções de Mercado
  - Mercados de carbono
  - Taxação do carbono
  - Clubes climáticos
  - CBAM
- Soluções baseadas na Natureza
  - Reflorestamento
  - Preservação florestal
- Soluções de Tecnológicas
  - Energia solar, eólica, nuclear e geotermal
  - Hidrogênio verde e hidrogênio azul
  - Biocombustíveis
  - Baterias
  - Captura de Carbono.
- Soluções para o problema do financiamento
  - Finanças Verdes (*Green Finance*)

Parte III: Geopolítica do clima

- O caso do Brasil
- Comércio internacional e mudanças climáticas
- Posicionamento climática de EUA, China e Europa

Avaliação

Participação em aula: 20%

Apresentação em sala: 10%

Primeiro trabalho: 30%

Segundo trabalho: 40%

Dinâmica

Leitura prévia (ver plano de aula)

Um grupo apresenta

Discussão guiada

Resumo e fechamento