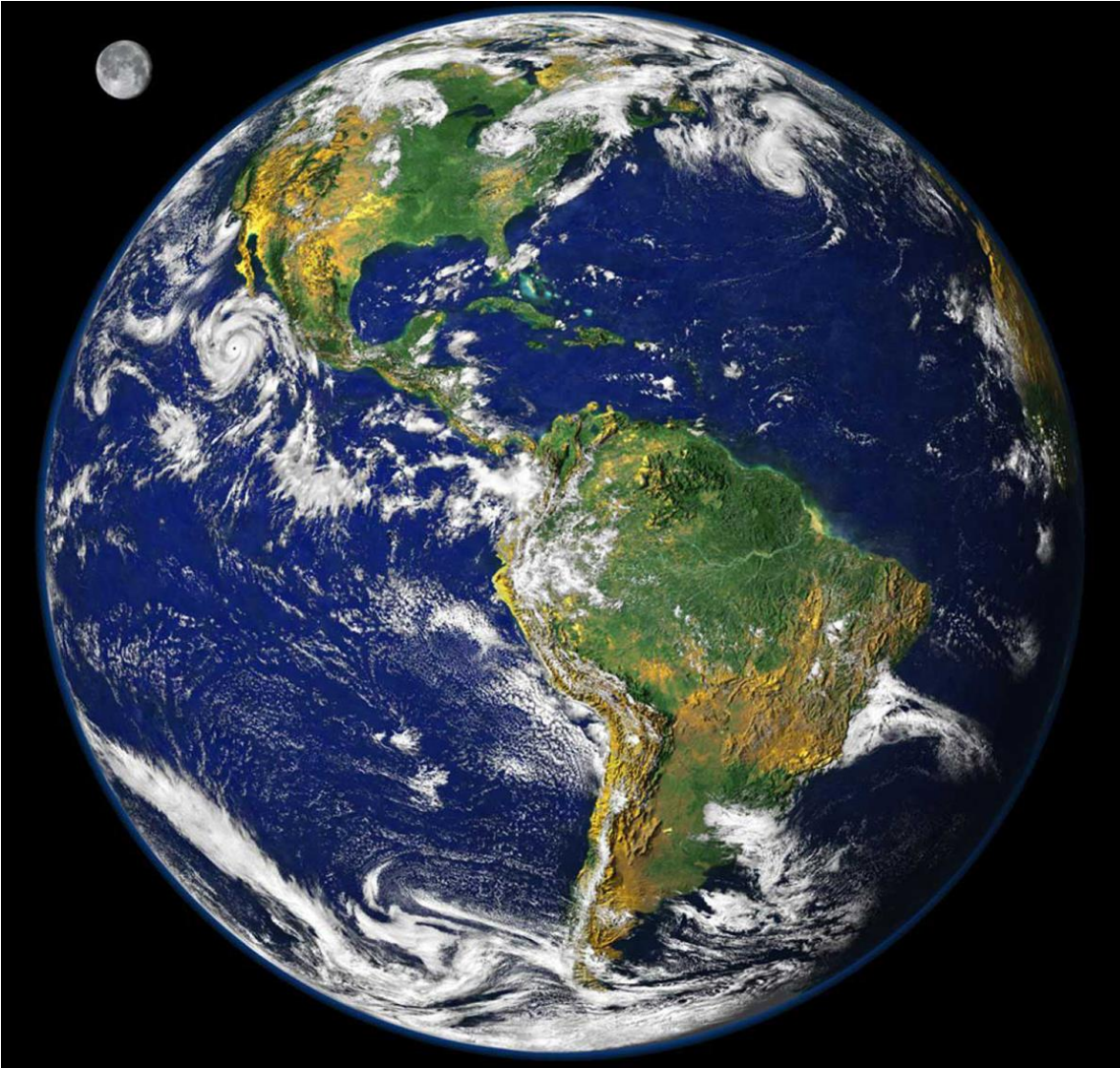


Ciência das Alterações Climáticas



Luís Fazendeiro
<https://climaximo.wordpress.com/>

SPN, Porto, 27/10/2018

Índice

I – Efeito de estufa e emissões de GEE

II – Alterações climáticas

III – Acordo de Paris

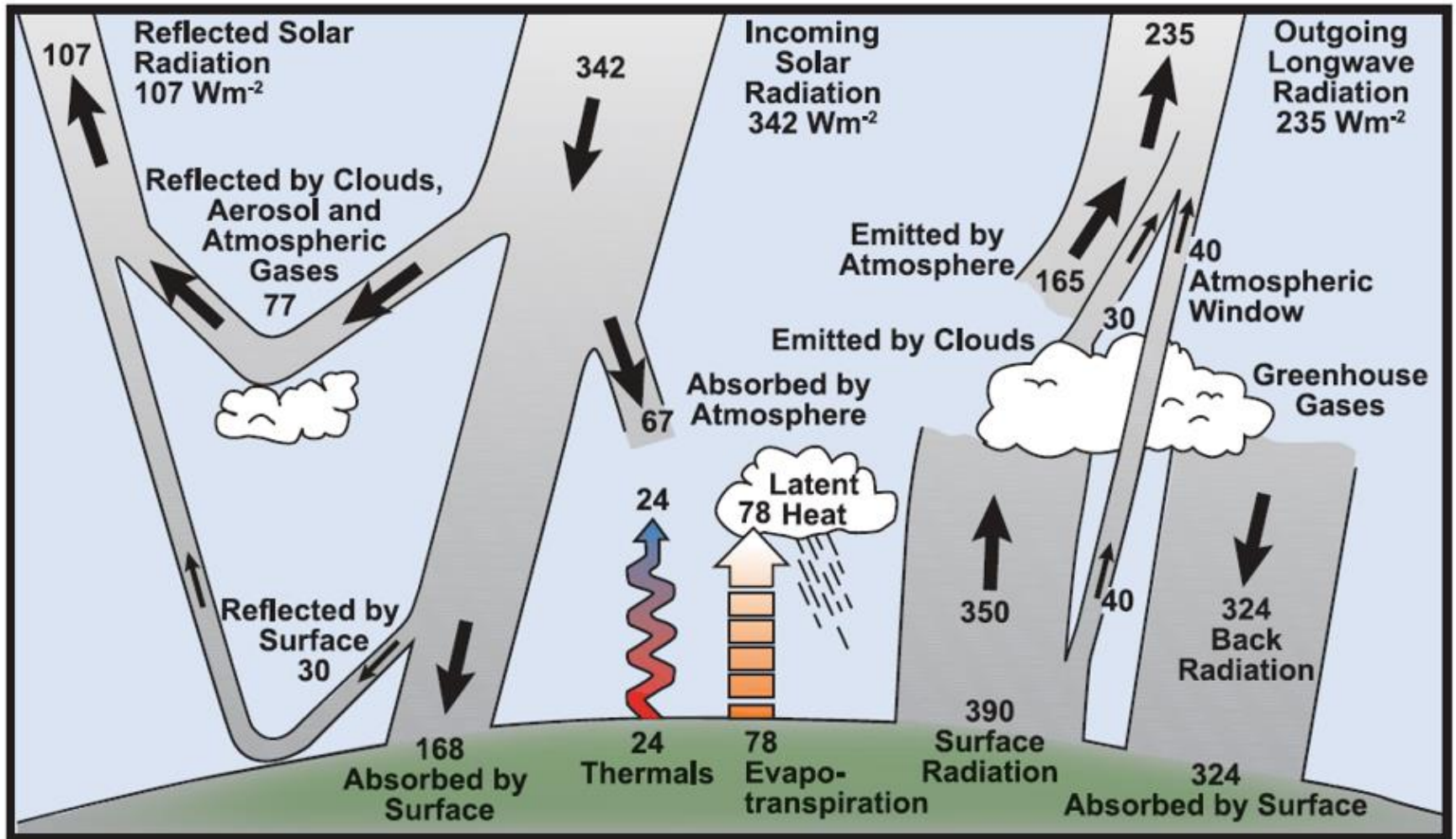
IV – Justiça climática

V – Portugal

I – Efeito de estufa - cronologia

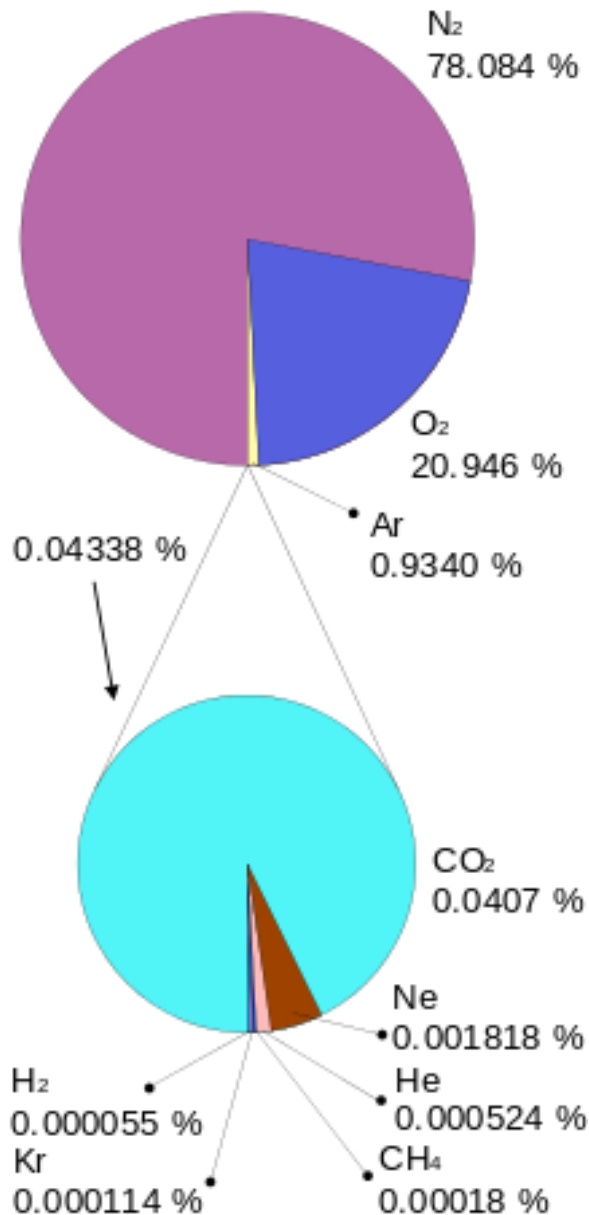
- Joseph Fourier, 1824: atmosfera deixa passar radiação vinda do espaço, mas **aprisiona parte da que é reflectida**;
- John Tyndall, 1859: mediu as **propriedades radiativas de certos gases** e relacionou as suas concentrações com **idades do gelo**;
- Svante Arrhenius, 1896; estudos quantitativos, calculou que **duplicação de CO₂ na atmosfera (i.e., 280 -> 560 ppm) levaria a $\Delta T > 6^{\circ}\text{C}$** ;
- Charles Keeling, 1957: começam medições em **Mauna Loa no Hawai** de concentração de CO₂ (famosa curva de Keeling);
- James Lovelock e Lynn Margulis, 1974: elaboram pela primeira vez a hipótese da **biosfera como um sistema dinâmico capaz de auto-regulação** (hipótese de Gaia);
- James Hansen, 1988: testemunho perante o Senado norte-americano de que **aquecimento global é uma realidade e com origens claramente antropogénicas**; (formação do IPCC - 1988)

Balanço radiativo da Terra



FAQ 1.1, Figure 1. Estimate of the Earth's annual and global mean energy balance. Over the long term, the amount of incoming solar radiation absorbed by the Earth and atmosphere is balanced by the Earth and atmosphere releasing the same amount of outgoing longwave radiation. About half of the incoming solar radiation is absorbed by the Earth's surface. This energy is transferred to the atmosphere by warming the air in contact with the surface (thermals), by evapotranspiration and by longwave radiation that is absorbed by clouds and greenhouse gases. The atmosphere in turn radiates longwave energy back to Earth as well as out to space. Source: Kiehl and Trenberth (1997).

Atmosfera terrestre



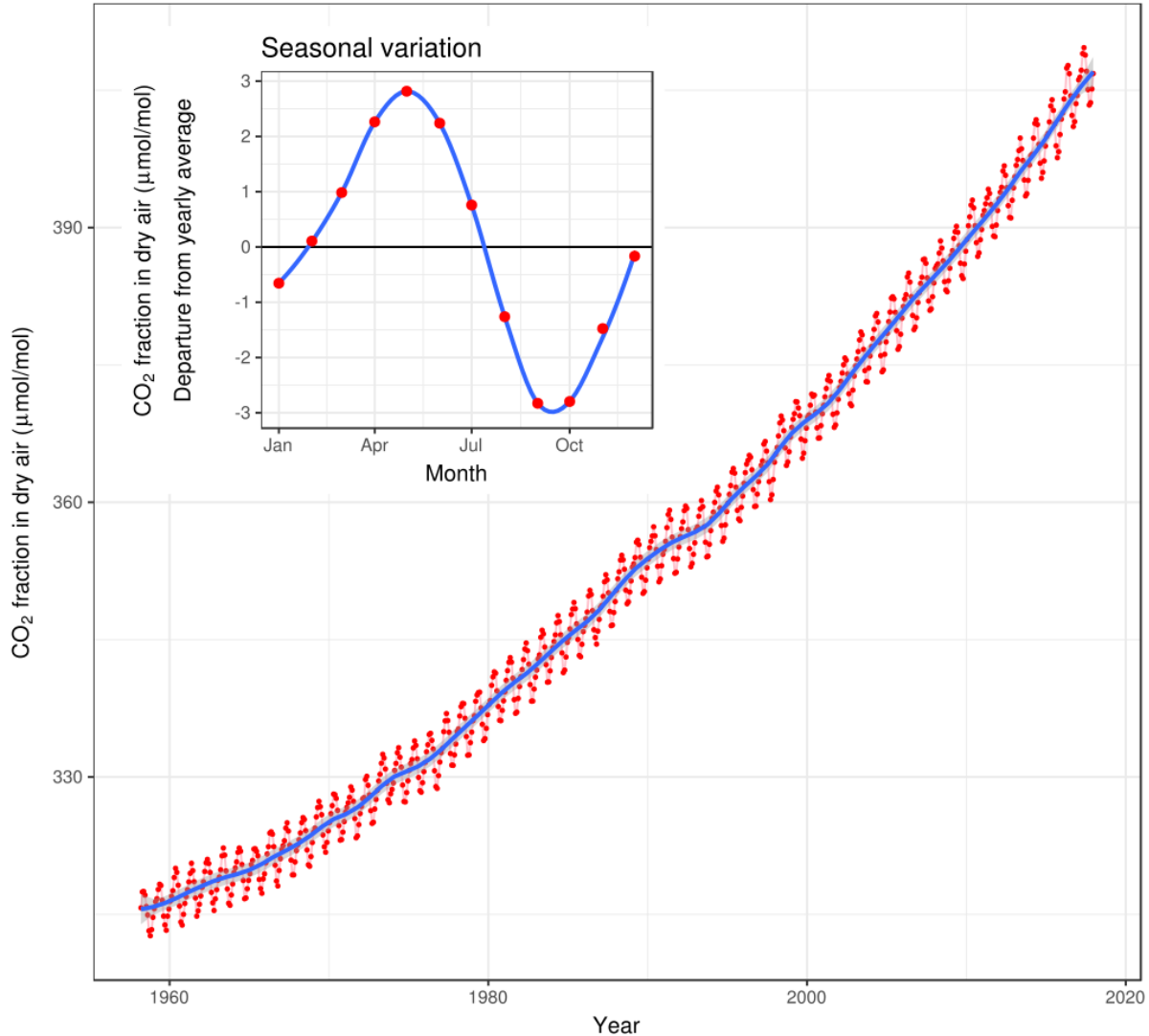
E se não houvesse efeito de estufa?

| | Vénus | Terra | Marte |
|---------------------|-------|-------|-------|
| T média (°C) | 477 | 15 | -47 |
| T sem EE (°C) | -46 | -18 | -57 |
| ΔT devido a EE (°C) | +523 | +33 | +10 |

Curva de Keeling – CO₂

Monthly mean CO₂ concentration

Mauna Loa 1958 - 2017

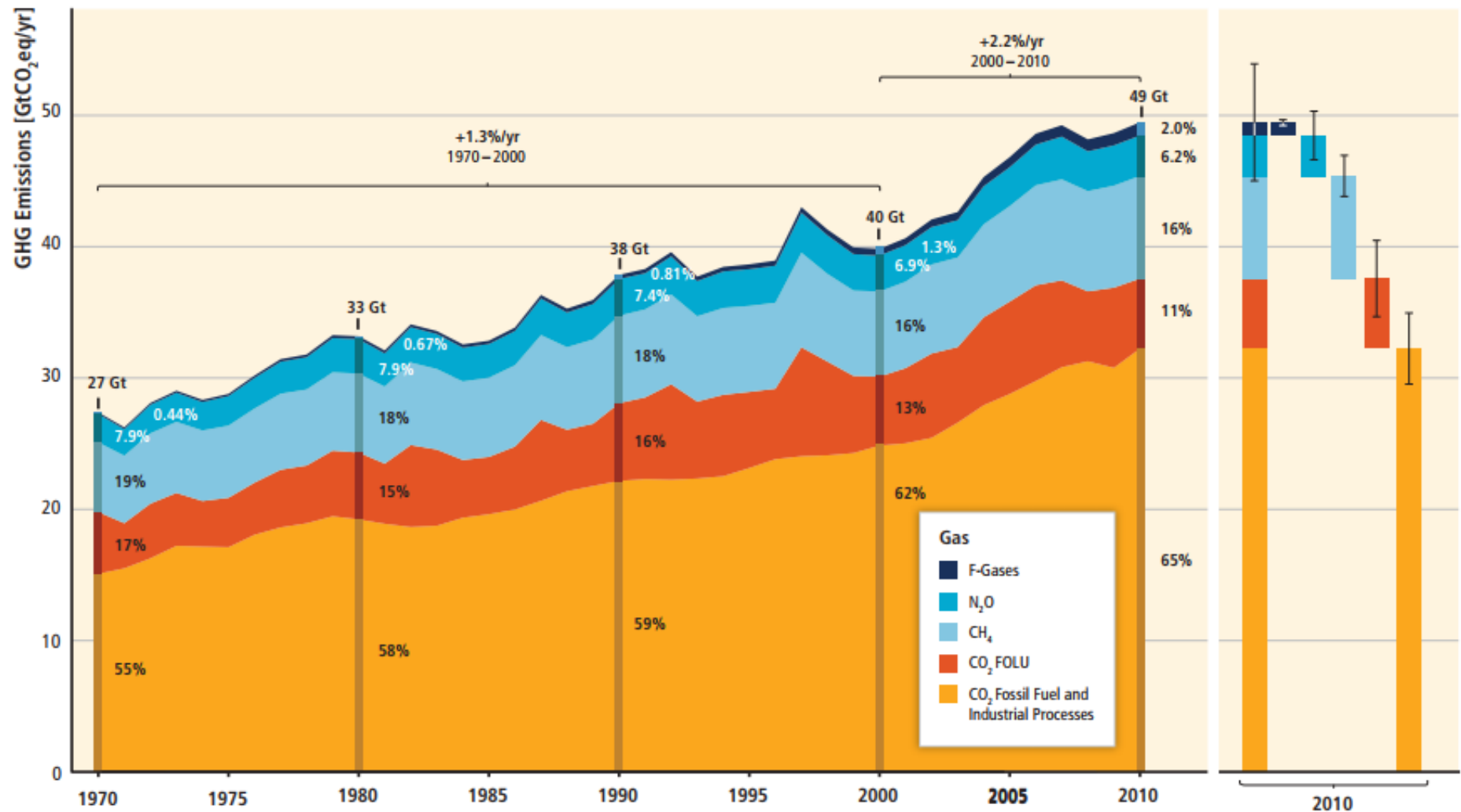


Data : NOAA/P. Tans

**Em 26 de Maio de 2018:
411.89 ppm**

Emissões de GEE

Total Annual Anthropogenic GHG Emissions by Groups of Gases 1970–2010



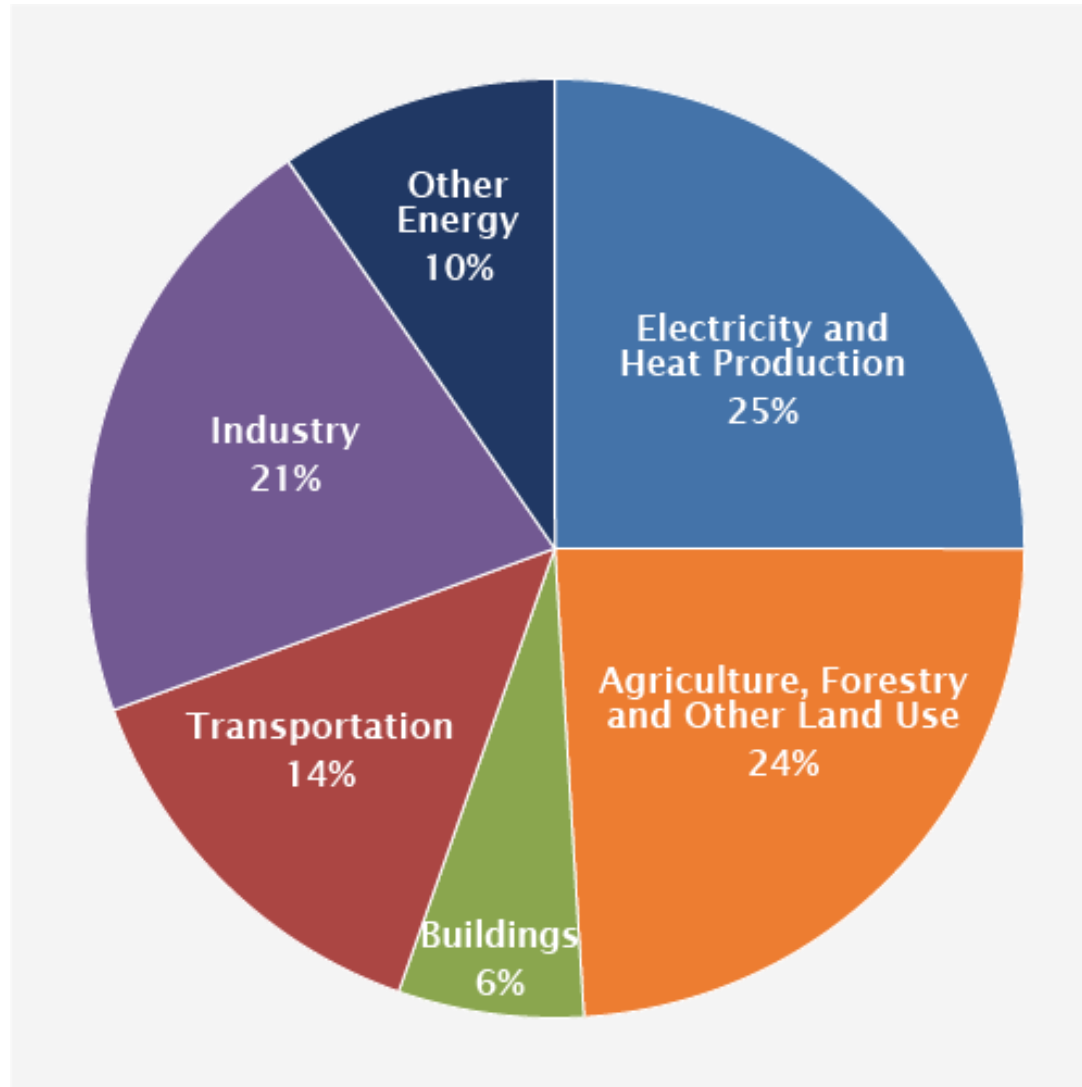
Global Warming Potential

| GWP values and lifetimes from 2007 IPCC AR4 p212 ^[9] (2001 IPCC TAR ^[10] in parentheses) | Lifetime in years | | GWP | | | | | |
|---|-------------------|---------|----------|----------|-----------|----------|-----------|----------|
| | | | 20 years | | 100 years | | 500 years | |
| Methane | 12 | (12) | 72 | (62) | 25 | (23) | 7.6 | (7) |
| Nitrous oxide | 114 | (114) | 289 | (275) | 298 | (296) | 153 | (156) |
| HFC-23 (hydrofluorocarbon) | 270 | (260) | 12,000 | (9400) | 14,800 | (12,000) | 12,200 | (10,000) |
| HFC-134a (hydrofluorocarbon) | 14 | (13.8) | 3,830 | (3,300) | 1,430 | (1,300) | 435 | (400) |
| Sulfur hexafluoride | 3200 | (3,200) | 16,300 | (15,100) | 22,800 | (22,200) | 32,600 | (32,400) |

| GWP values and lifetimes from 2013 IPCC AR5 p714 (with climate-carbon feedbacks) ^[8] | Lifetime (years) | GWP | |
|--|------------------|----------|-----------|
| | | 20 years | 100 years |
| Methane | 12.4 | 86 | 34 |
| HFC-134a (hydrofluorocarbon) | 13.4 | 3790 | 1550 |
| CFC-11 (chlorofluorocarbon) | 45.0 | 7020 | 5350 |
| Nitrous oxide (N ₂ O) | 121.0 | 268 | 298 |
| Carbon tetrafluoride (CF ₄) | 50000 | 4950 | 7350 |

Incertezas: “The precautionary principle says that the **lack of full scientific certainty should not be used as an excuse to postpone action when there is a threat of serious or irreversible damage.**” - UNFCCC

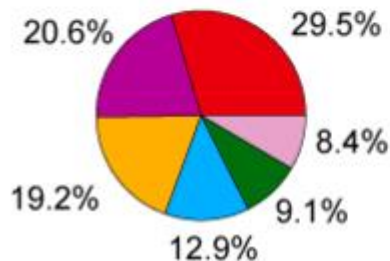
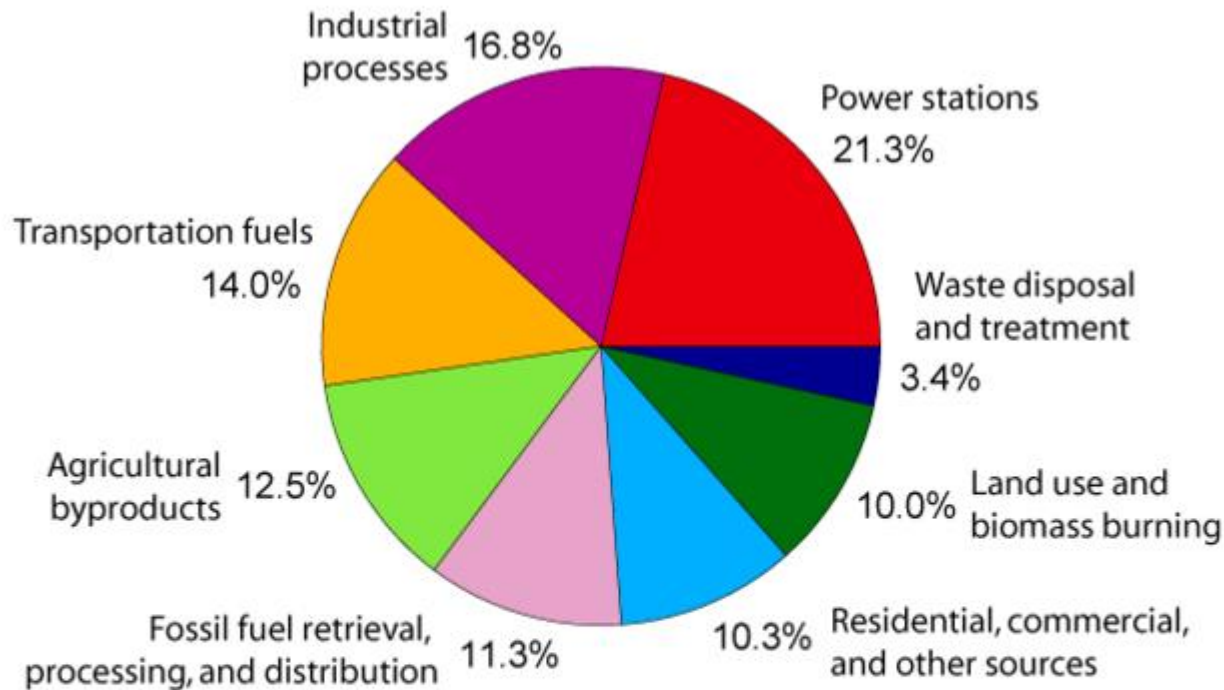
Fontes principais de GEE



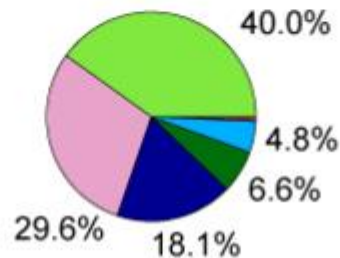
Fonte: AR5, IPCC, 2014.

Emissões de GEE por sector

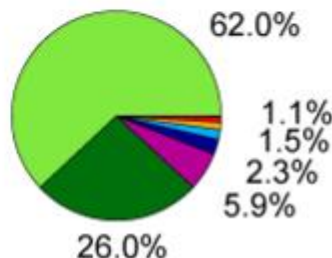
Annual Greenhouse Gas Emissions by Sector



Carbon Dioxide
(72% of total)



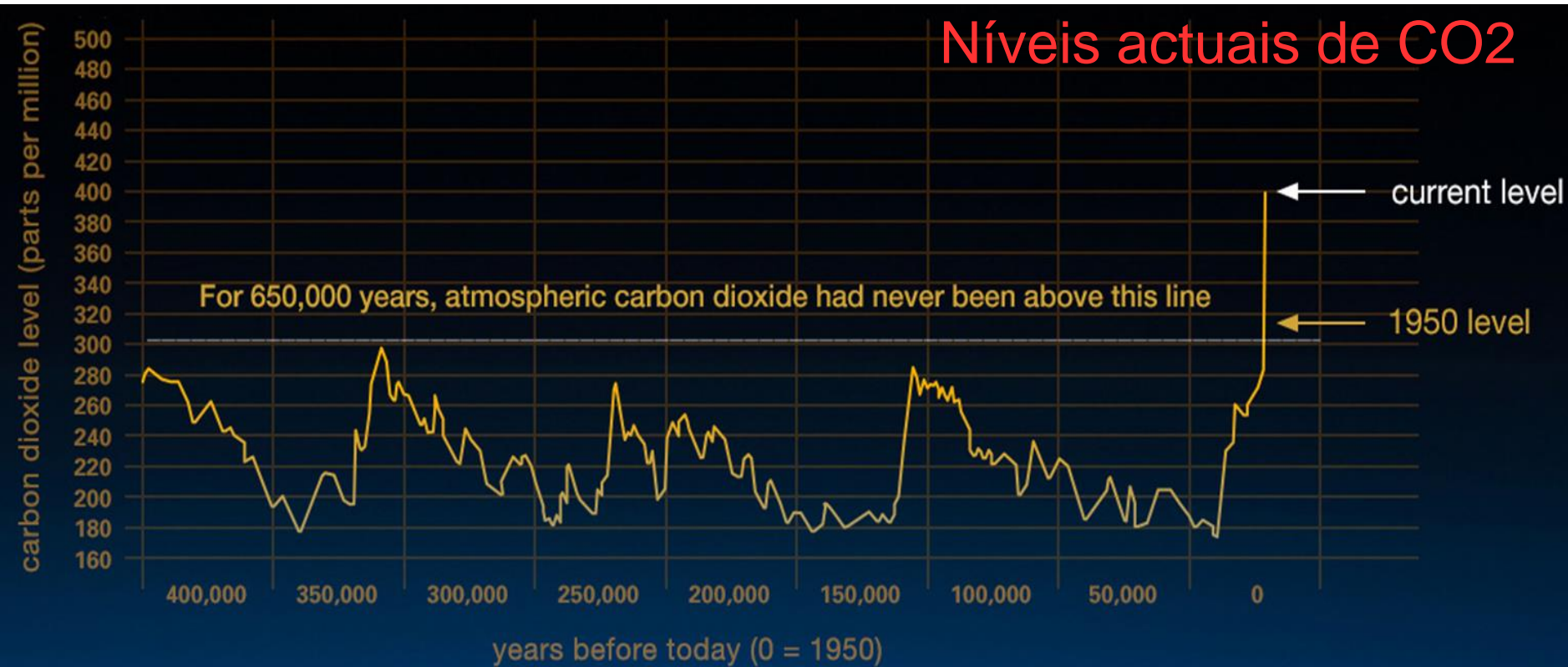
Methane
(18% of total)



Nitrous Oxide
(9% of total)

Emissões em 2000

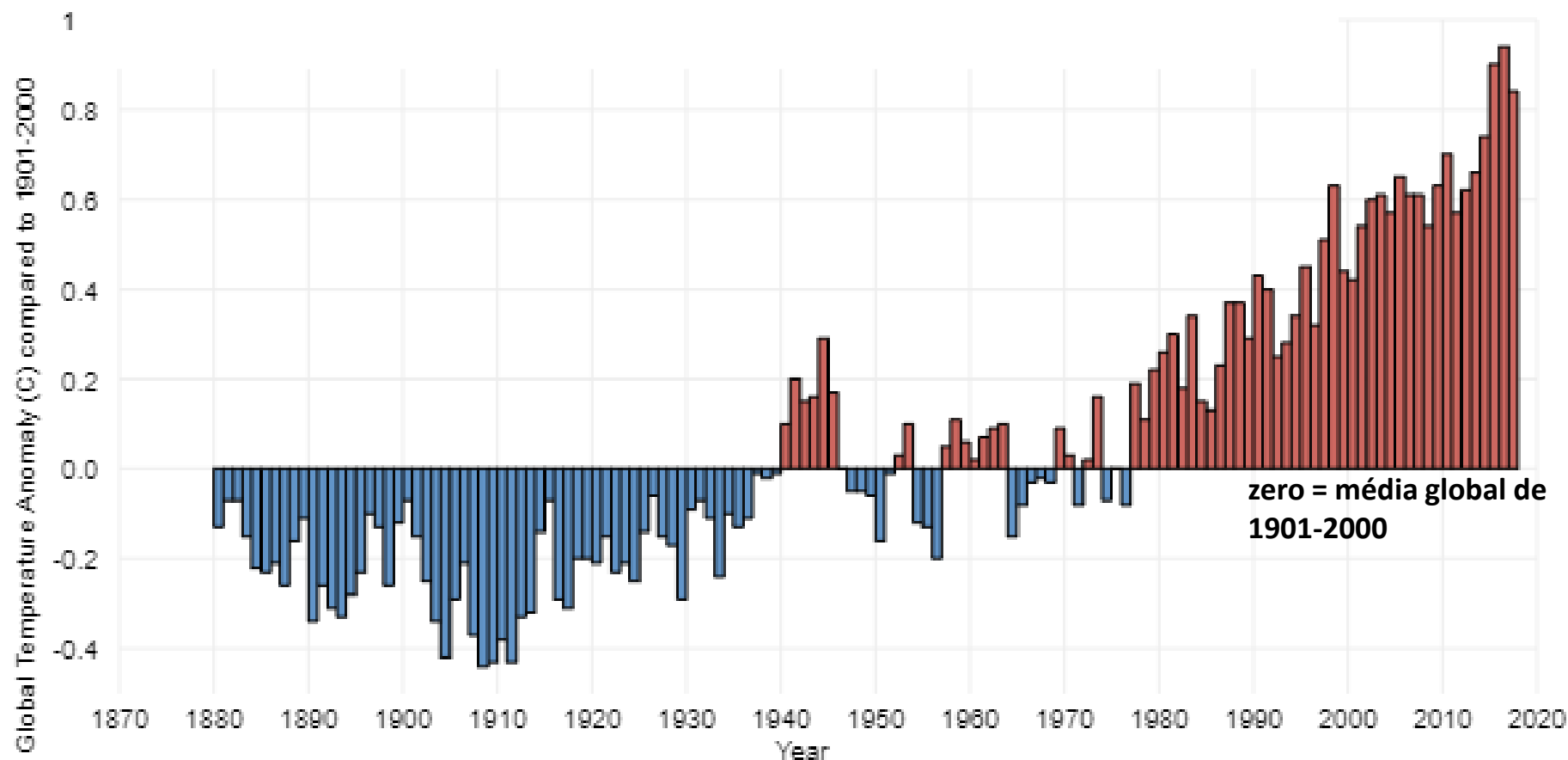
II – Alterações climáticas



- Nível **pré-industrial** é **280ppm de CO₂** na atmosfera, última Idade do Gelo = 200ppm, **valor actual = 400ppm**, aumento anual = 2-3ppm)
- Limite de segurança para um **clima estável** ~ **350ppm** (James Hansen da NASA)

Aumento médio da temperatura global

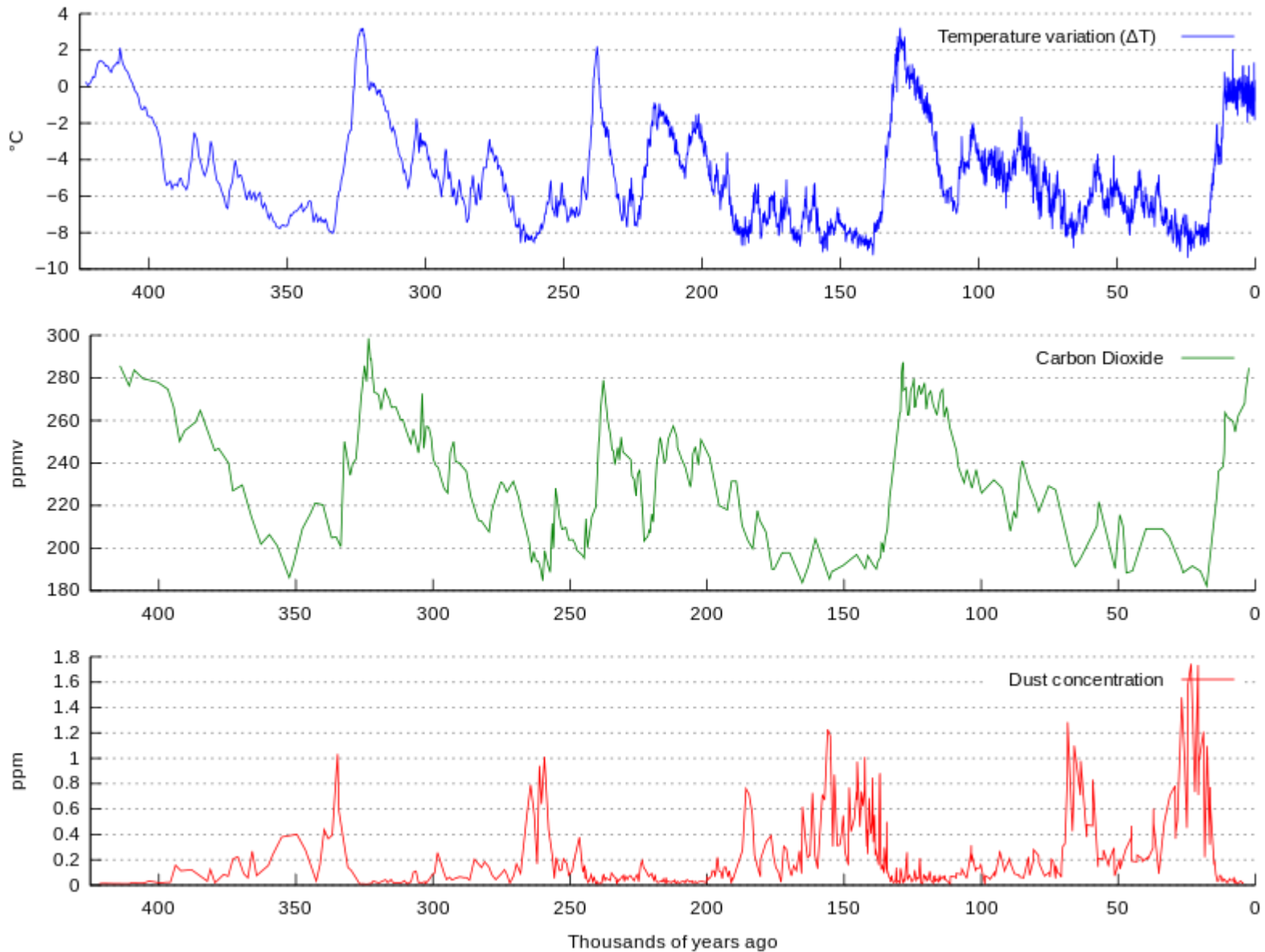
2015, 16, 17



- Nos últimos 45 anos (1970-2015) as **temperaturas globais** à superfície aumentaram a uma média de **0.17°C por década**— mais do dobro dos 0.07°C por década verificados para 1880-2015.

<https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature>

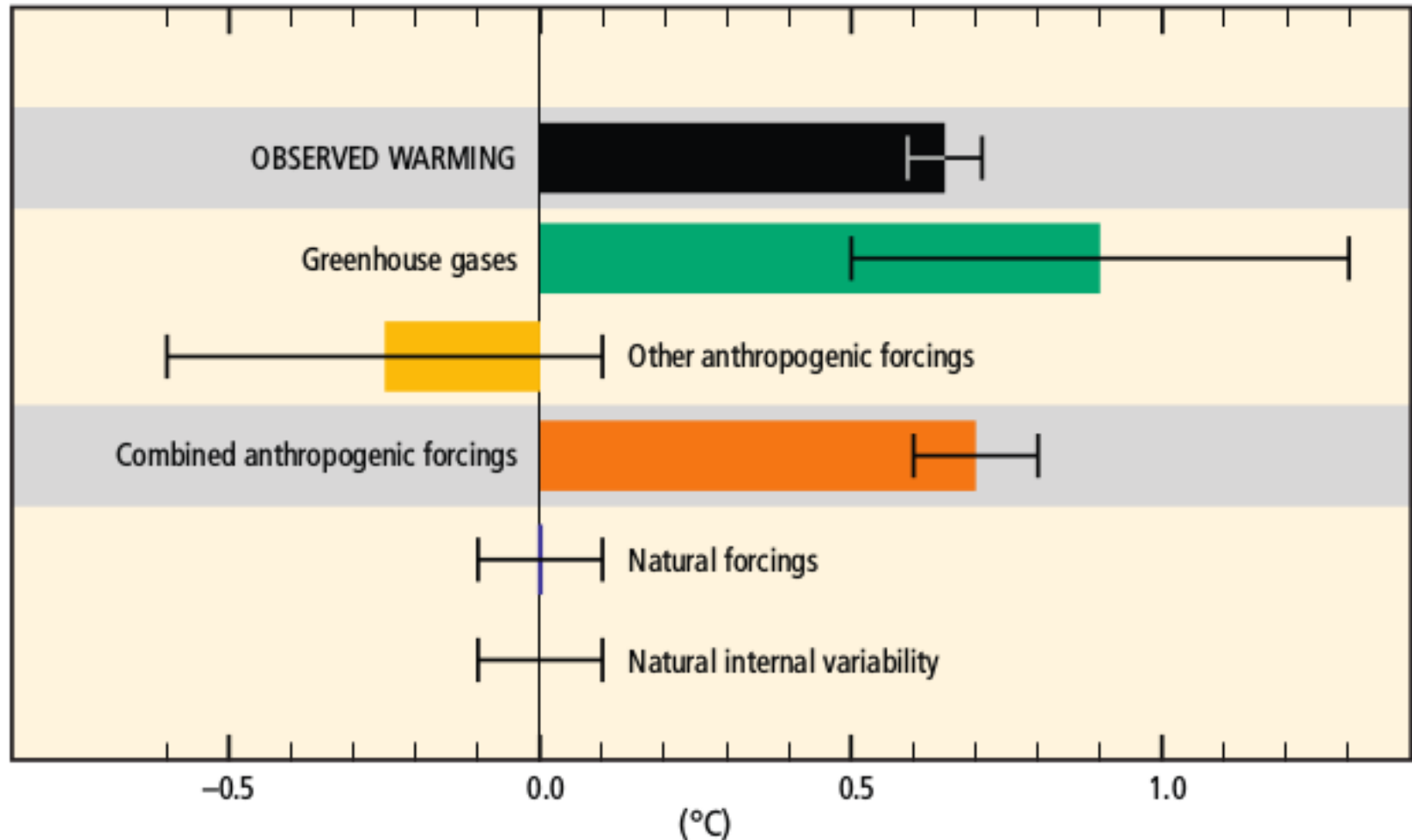
GEE e temperatura



Vostok ice core measurements, last 450K years

Influência humana no clima

Contributions to observed surface temperature change over the period 1951–2010



Efeitos separados em termos de aquecimento (watts por metro quadrado), incluindo GEE, outros **efeitos antropogénicos e causas naturais**, durante o período 1950–2010. SYR5, IPCC, Fig. SPM3.

Positive feedbacks



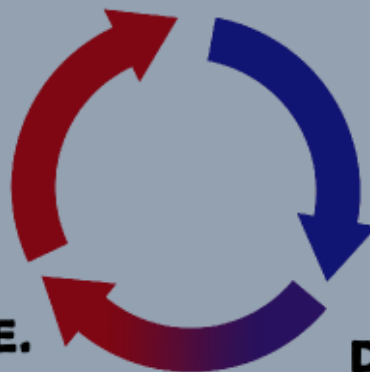
<https://climaximo.wordpress.com/acoes/tempo-de-vida-6-graus/>

Positive feedbacks II

DESAPARECIMENTO DO GELO

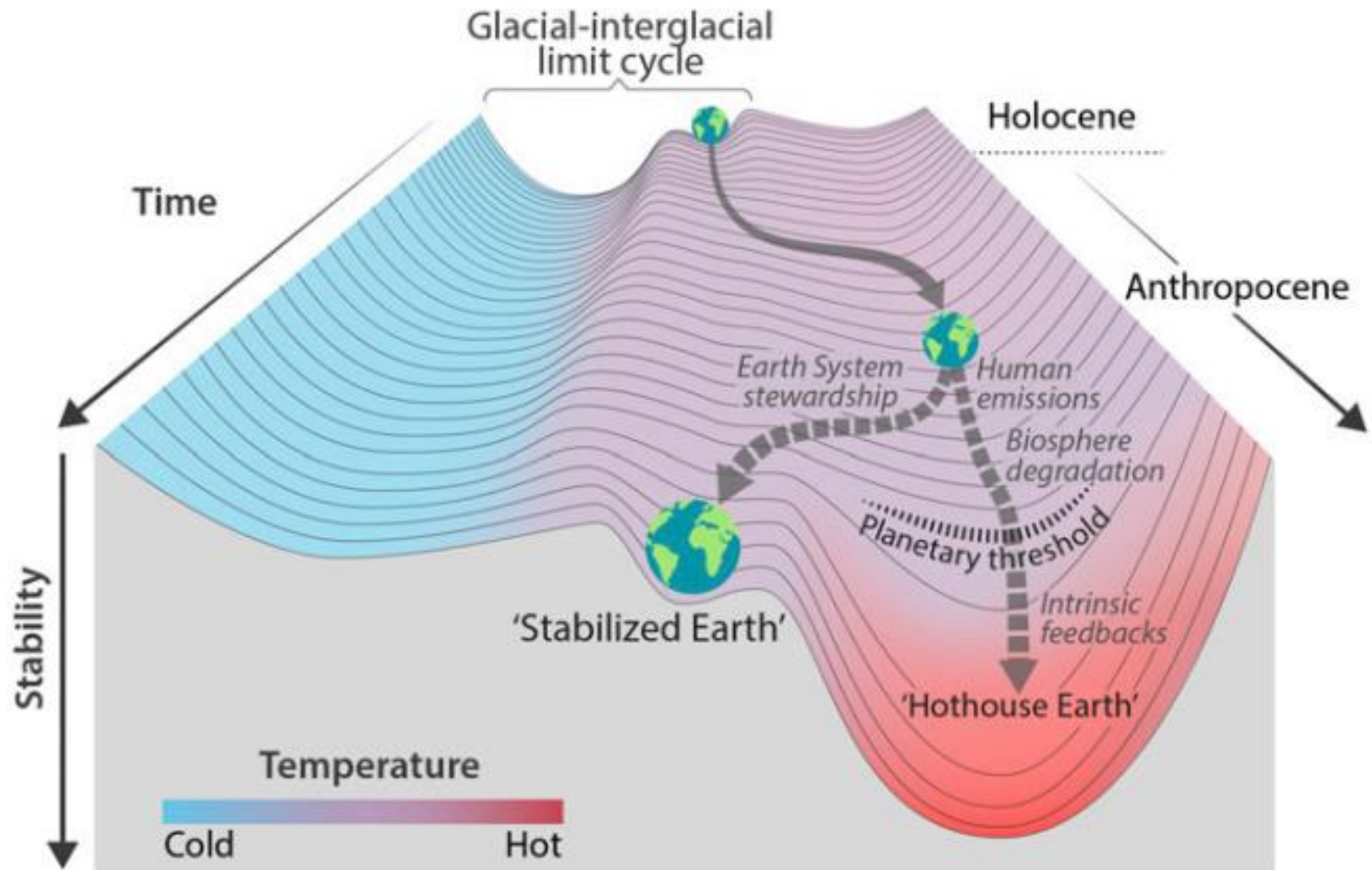
**80% DO GELO DO ÁRTICO DESAPARECE
DEVIDO AO AQUECIMENTO.**

**OS OCEANOS
AQUECEM.
MAIS GELO DERRETE.**



**O OCEANO
ABSORVE
MAIS CALOR
DO QUE O GELO.**

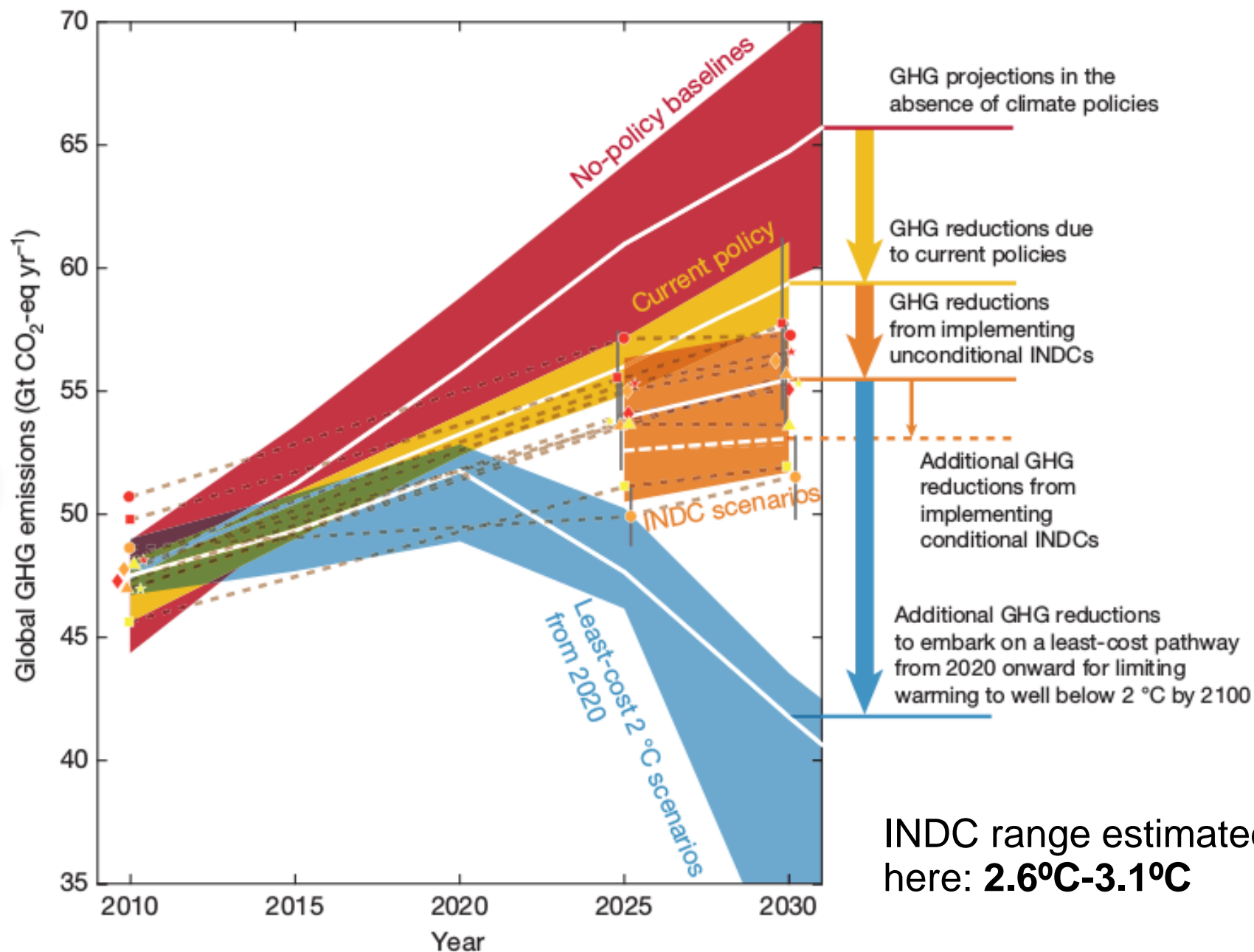
Positive feedbacks III



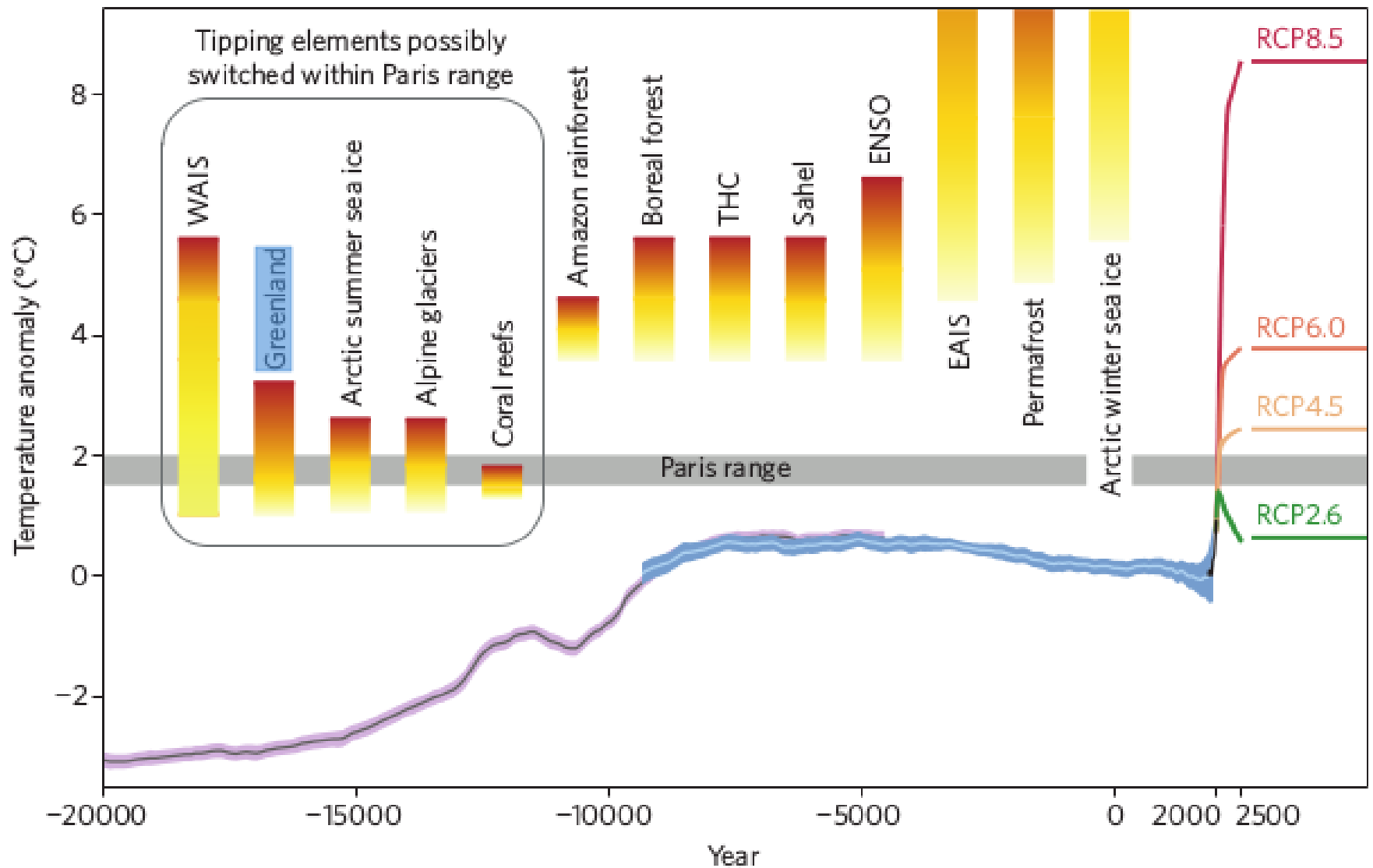
Steffen, Rockstrom et al., Trajectories of the Earth System in the Anthropocene, PNAS, 2018. Fig. 2

III – Acordo de Paris – COP21

- **"You have been negotiating all my life!"** estudante Canadiana, parte da delegação juvenil, durante a COP17 em Durban, na África do Sul, 2011 (COP1 in 1995, Berlin).
- Acordo negociado por representantes de **196 países** (maior reunião de chefes de estado de sempre!);
- “Holding the increase in the global average temperature to **well below 2°C** above pre-industrial levels and **to pursue efforts** to limit the temperature increase to **1.5°C above pre-industrial levels**, recognizing that this would **significantly reduce the risks and impacts** of climate change;”
 - Artigo 2, alínea a);
- Ratificado por **180 países** (à data); entrou em vigor a 4 de Novembro de 2016; http://unfccc.int/paris_agreement/items/9444.php
- MAS: soma das **contribuições voluntárias nacionais** (INDC) levam a aumento de pelo menos **2.6°C-3.1°C** (em vez dos 1.5°C-2°C acordados)!!!!

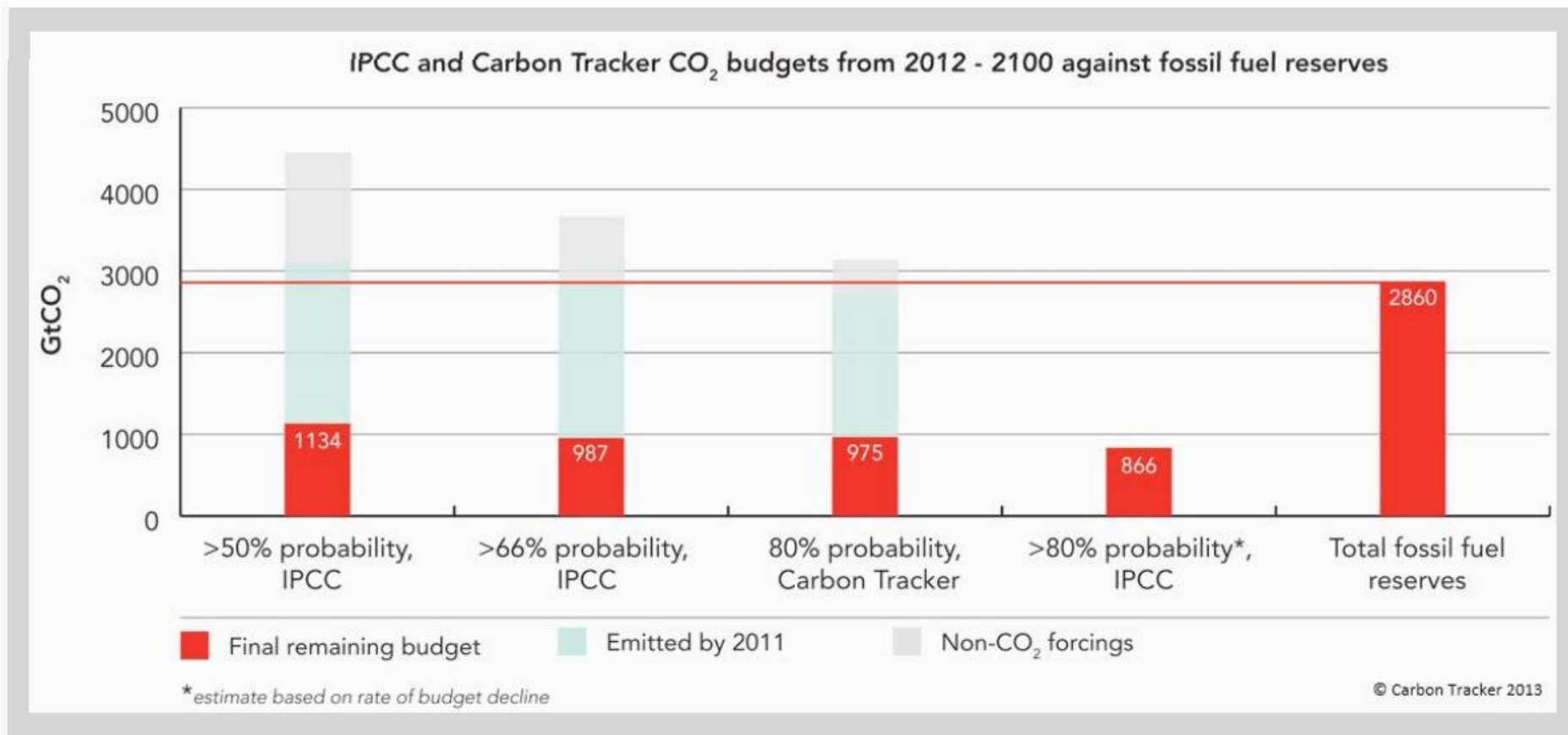


INDC range estimated here: **2.6°C-3.1°C**



Schellnhuber et al., Nature Climate Change, 2016.

Carbon budget



Apesar das reservas conhecidas serem **3-4X superiores ao orçamento de carbono disponível ($\Delta T \leq 2^\circ\text{C}$)**, as petrolíferas gastam **~\$500-600 mil milhões/ano** para encontrar **novas reservas**

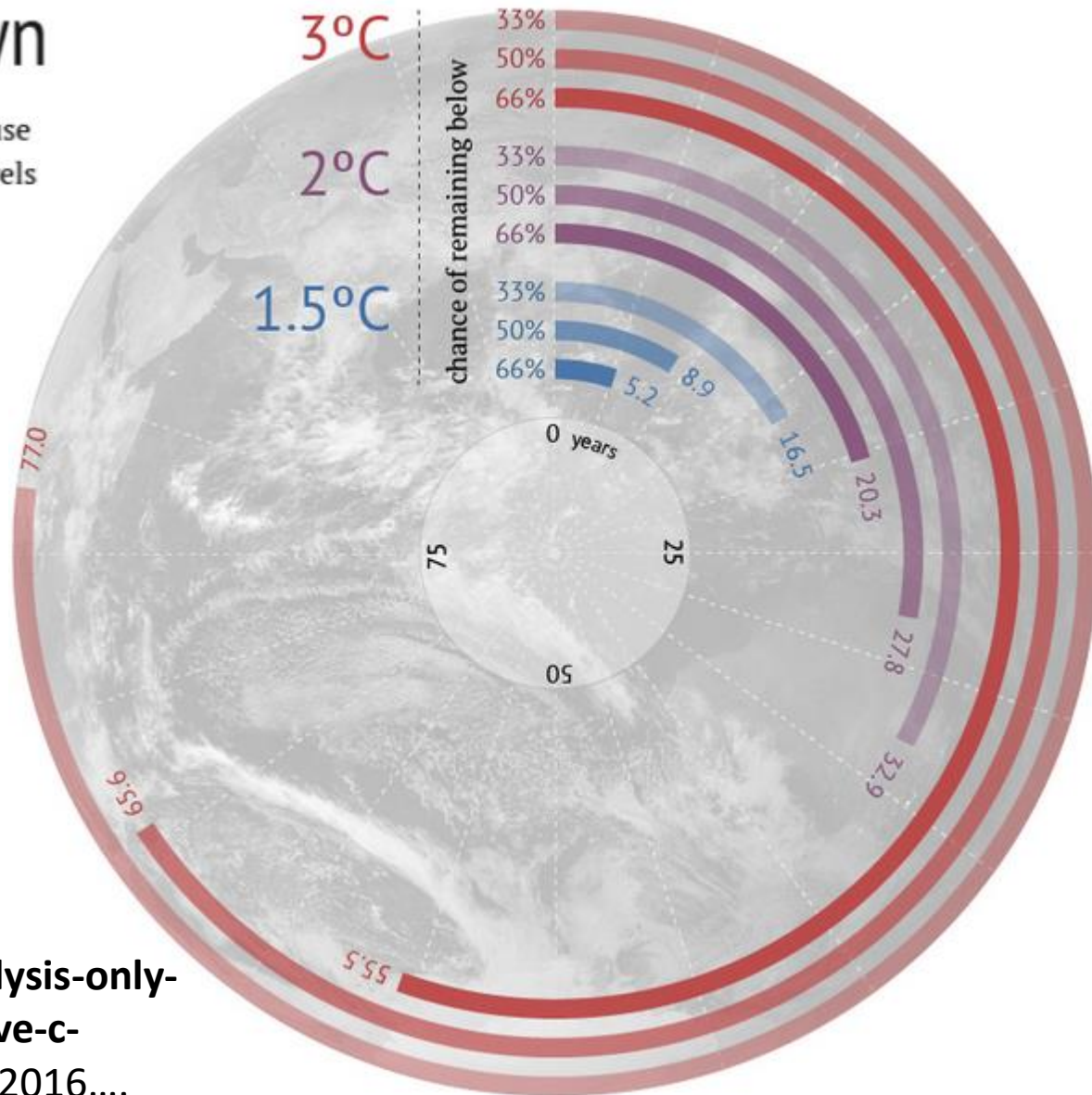
<https://climatenexus.org/climate-issues/the-carbon-budget/>

Carbon budget II



Carbon Countdown

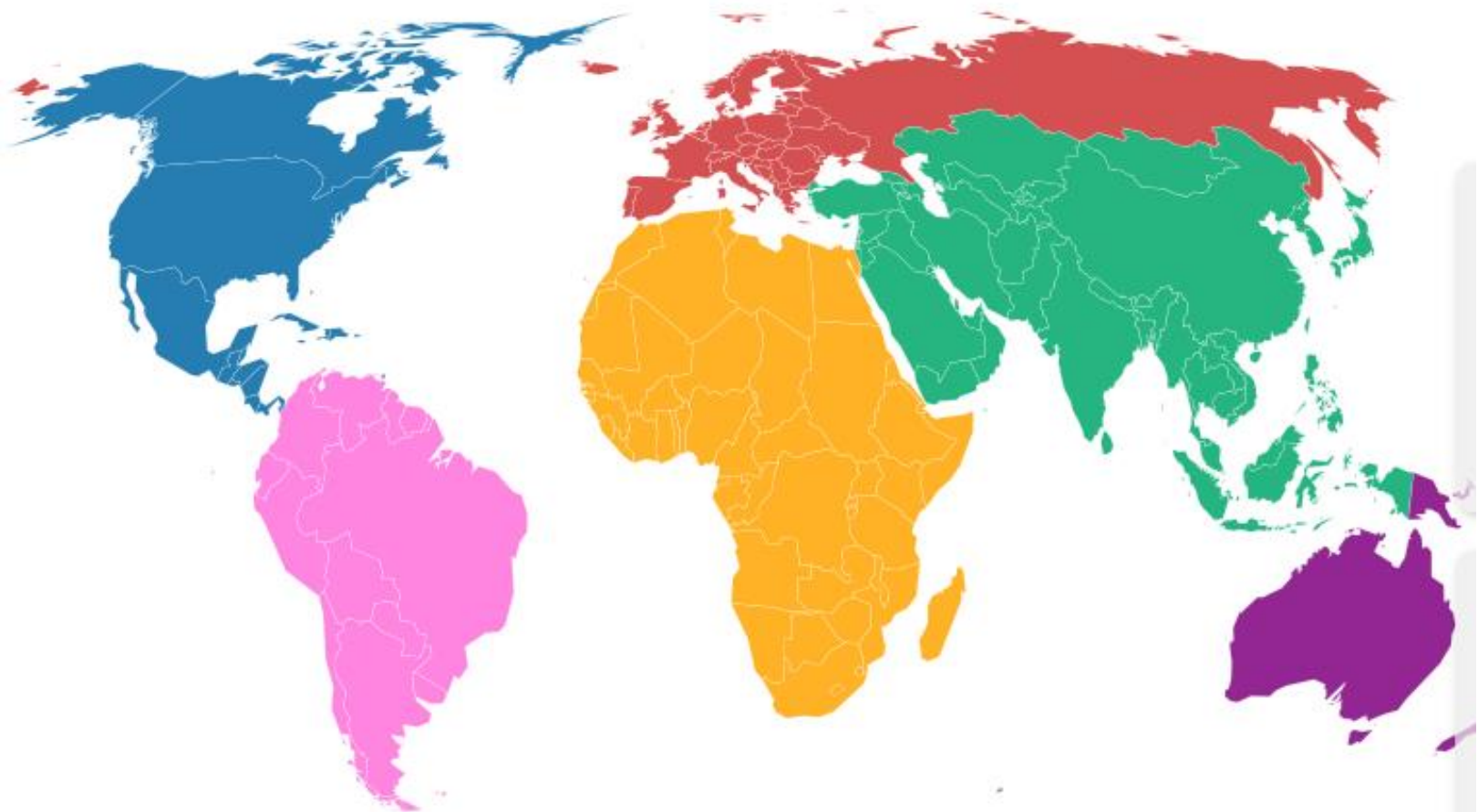
How many years of current emissions would use up the IPCC's carbon budgets for different levels of warming?



<https://www.carbonbrief.org/analysis-only-five-years-left-before-one-point-five-c-budget-is-blown> - análise de Maio 2016....

IV – Justiça climática

| BACKGROUND | | RESPONSIBILITY | | | | VULNERABILITY | | | | | |
|------------|------|----------------|--------|------------|-----------|---------------|------------|----------|----------------|-----------|---------|
| ↺ | Area | Population | Wealth | Extraction | Emissions | Consumption | Historical | Reserves | People at risk | Sea level | Poverty |



<http://www.theguardian.com/environment/ng-interactive/2014/sep/23/carbon-map-which-countries-are-responsible-for-climate-change>

BACKGROUND



Area Population

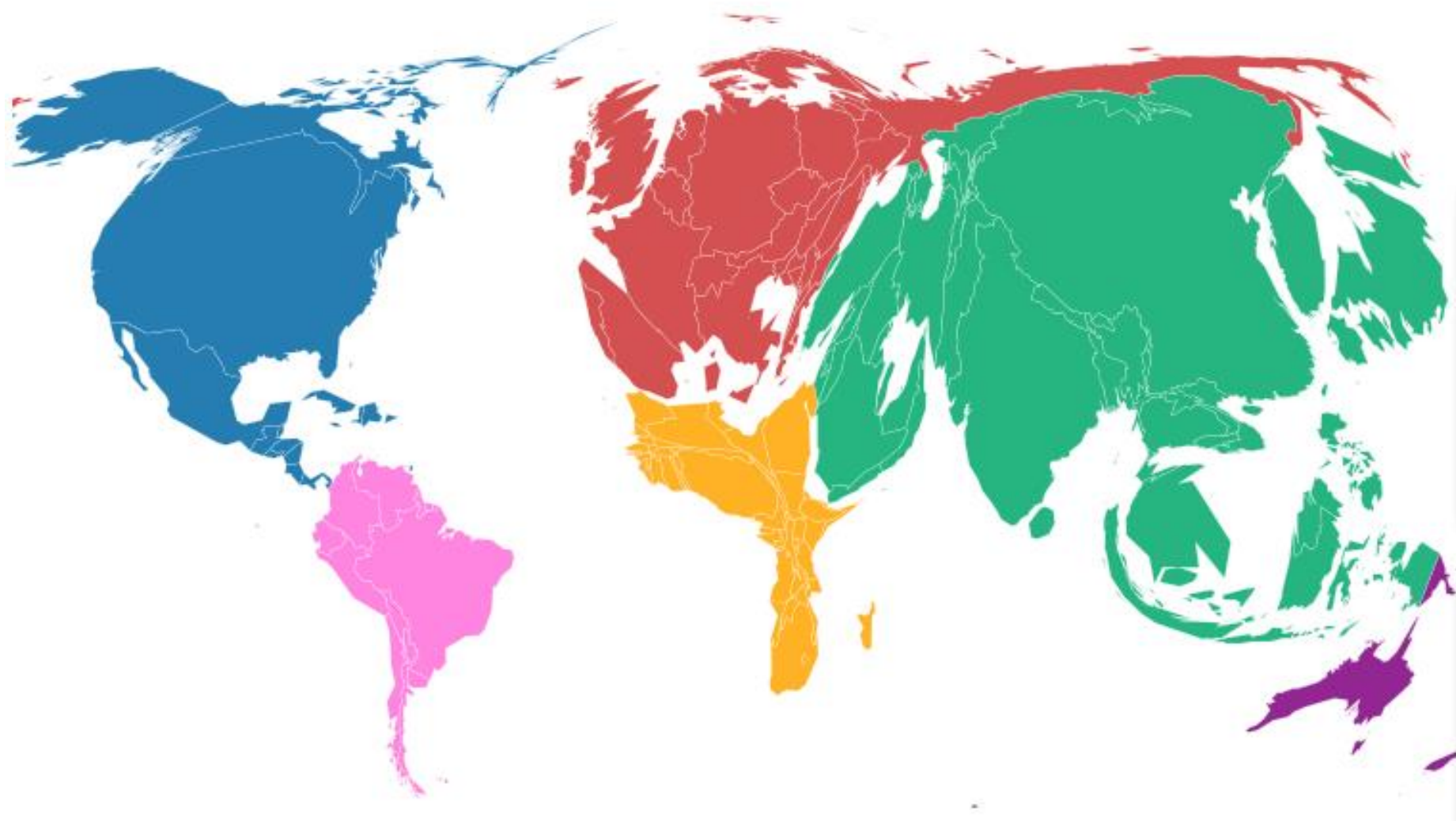
Wealth

RESPONSIBILITY

Extraction Emissions Consumption Historical Reserves

VULNERABILITY

People at risk Sea level Poverty



BACKGROUND



Area Population Wealth

RESPONSIBILITY

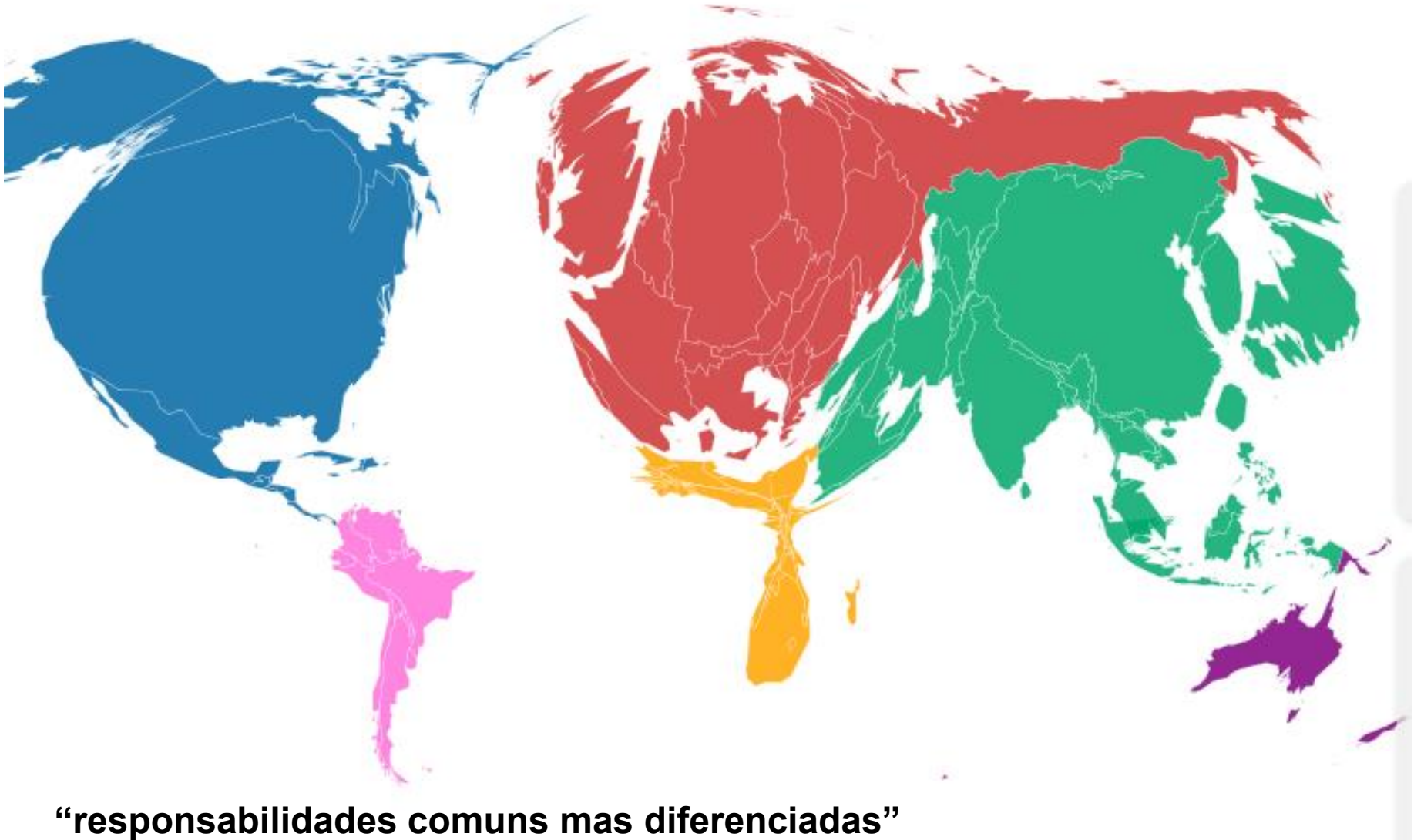
Extraction Emissions Consumption

Historical

Reserves

VULNERABILITY

People at risk Sea level Poverty



“responsabilidades comuns mas diferenciadas”

“responsabilidades comuns mas diferenciadas”

BACKGROUND



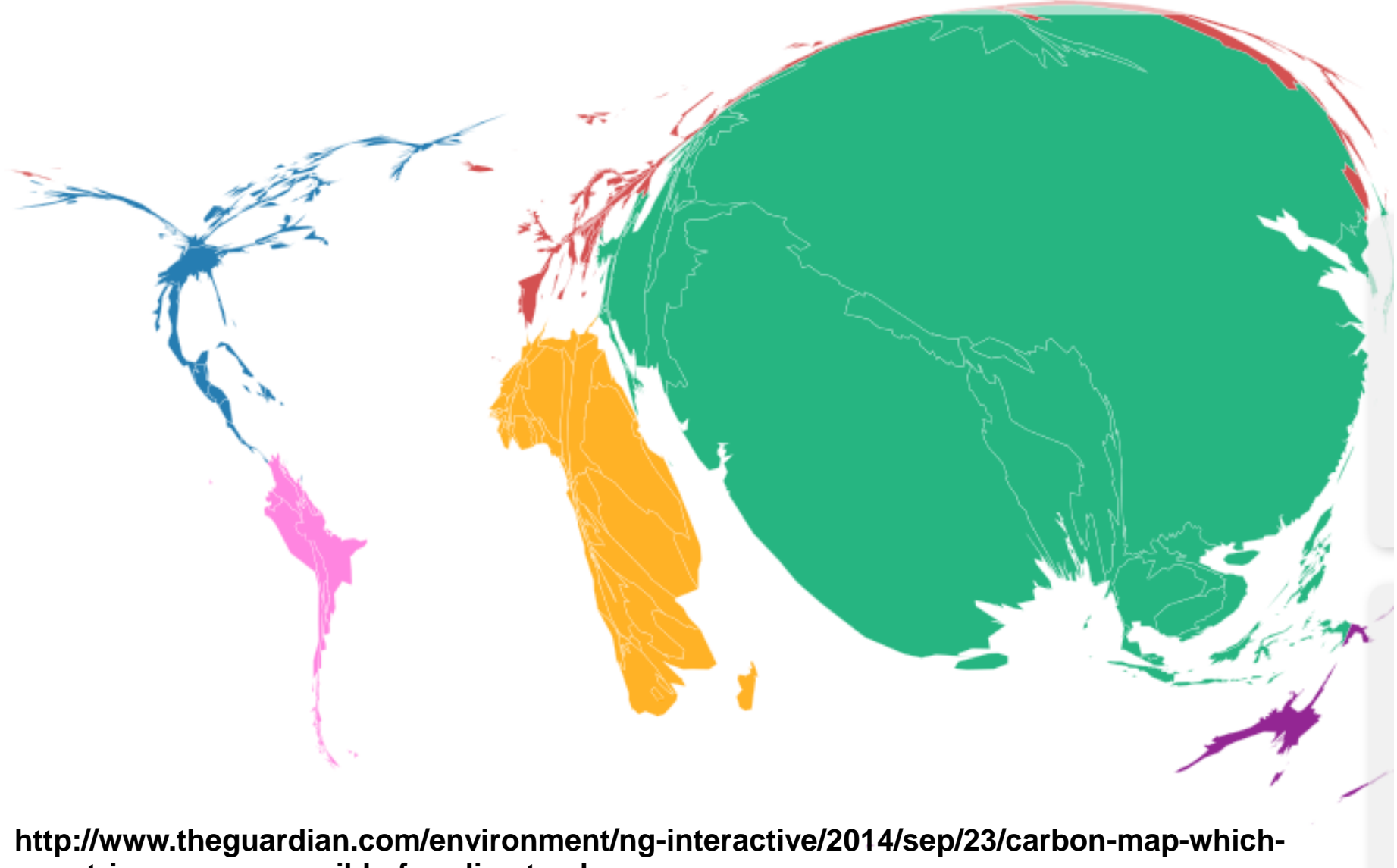
Area Population Wealth

RESPONSIBILITY

Extraction Emissions Consumption Historical Reserves

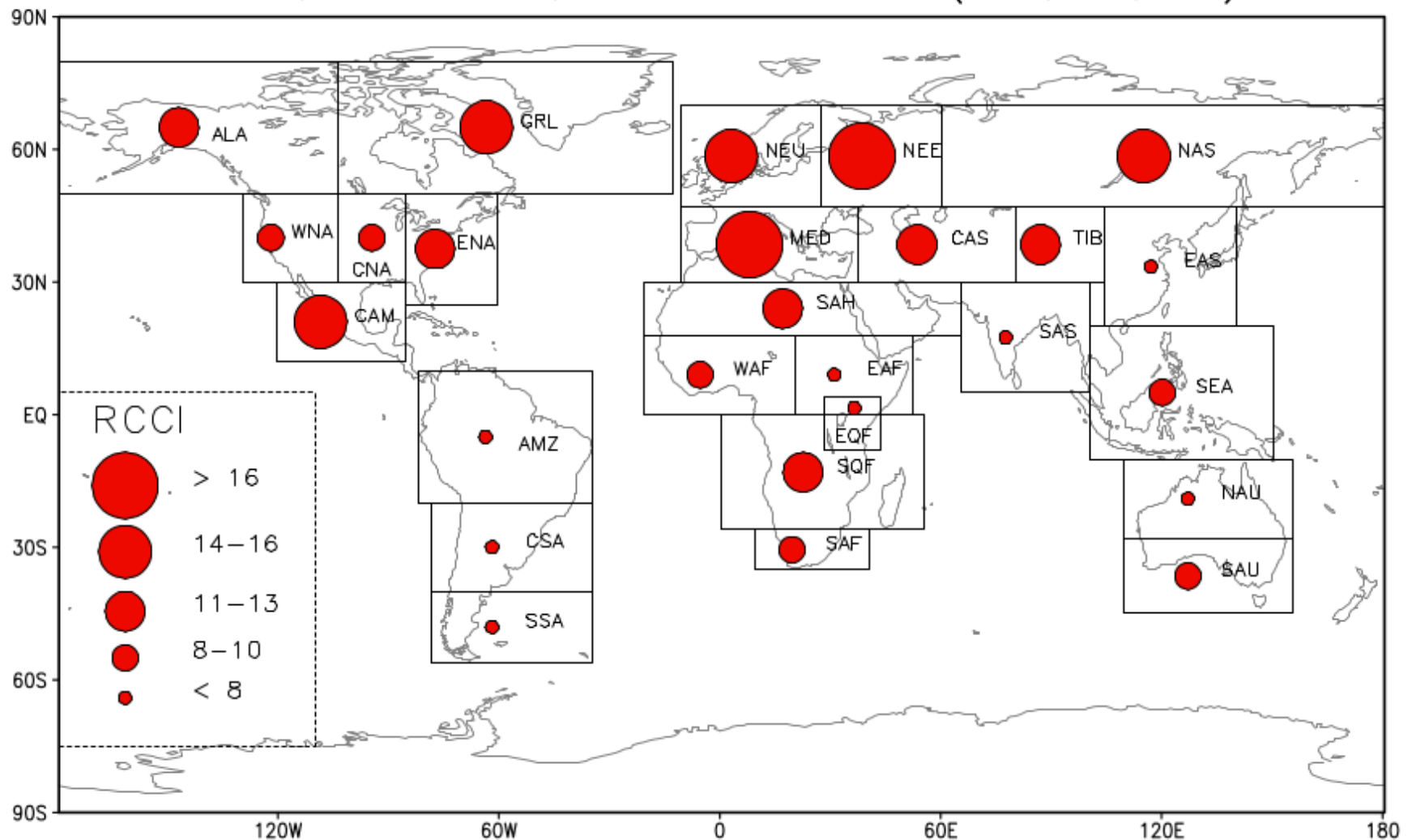
VULNERABILITY

People at risk Sea level Poverty



<http://www.theguardian.com/environment/ng-interactive/2014/sep/23/carbon-map-which-countries-are-responsible-for-climate-change>

RCCI, 20 Models, Three Scenarios (A1B, A2, B1)



RCCI = Regional Climate Change Index; tem em conta mudanças na:
precipitação média, temp. média, variabilidade inter-anual;

Giorgi, *Geophys. Res. Lett.*, vol. **33**, L08707, 2006.

V – Portugal

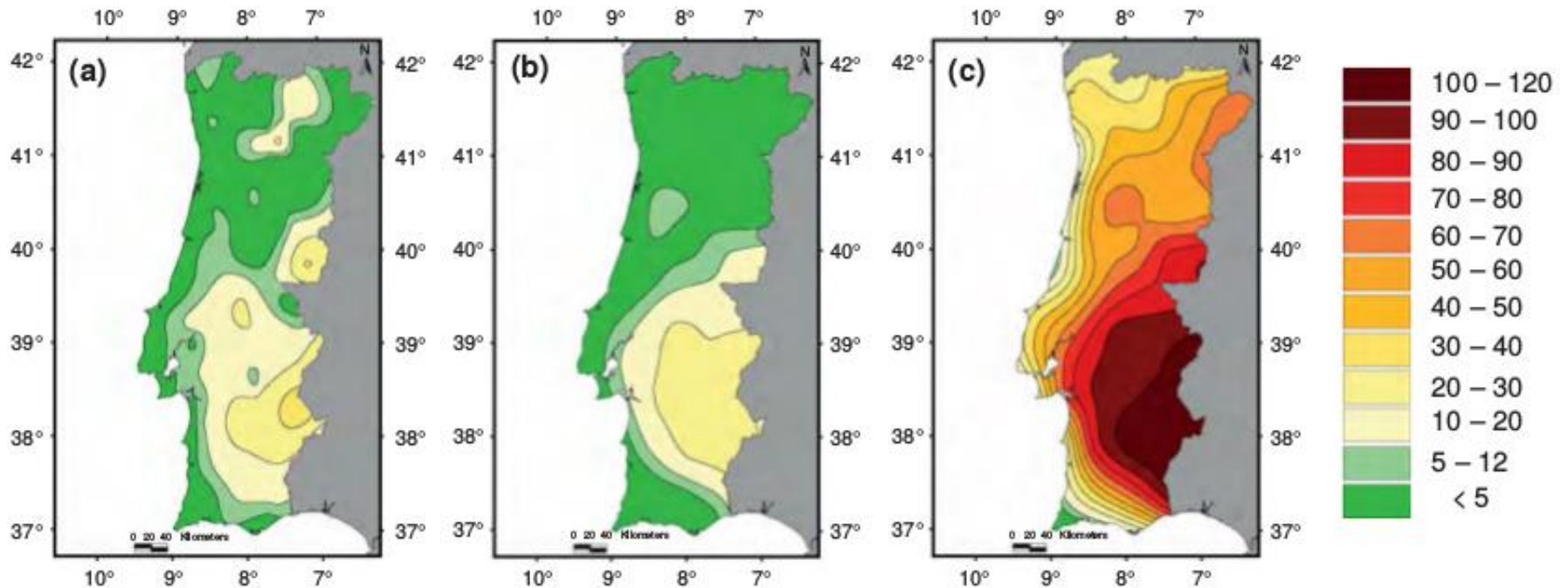
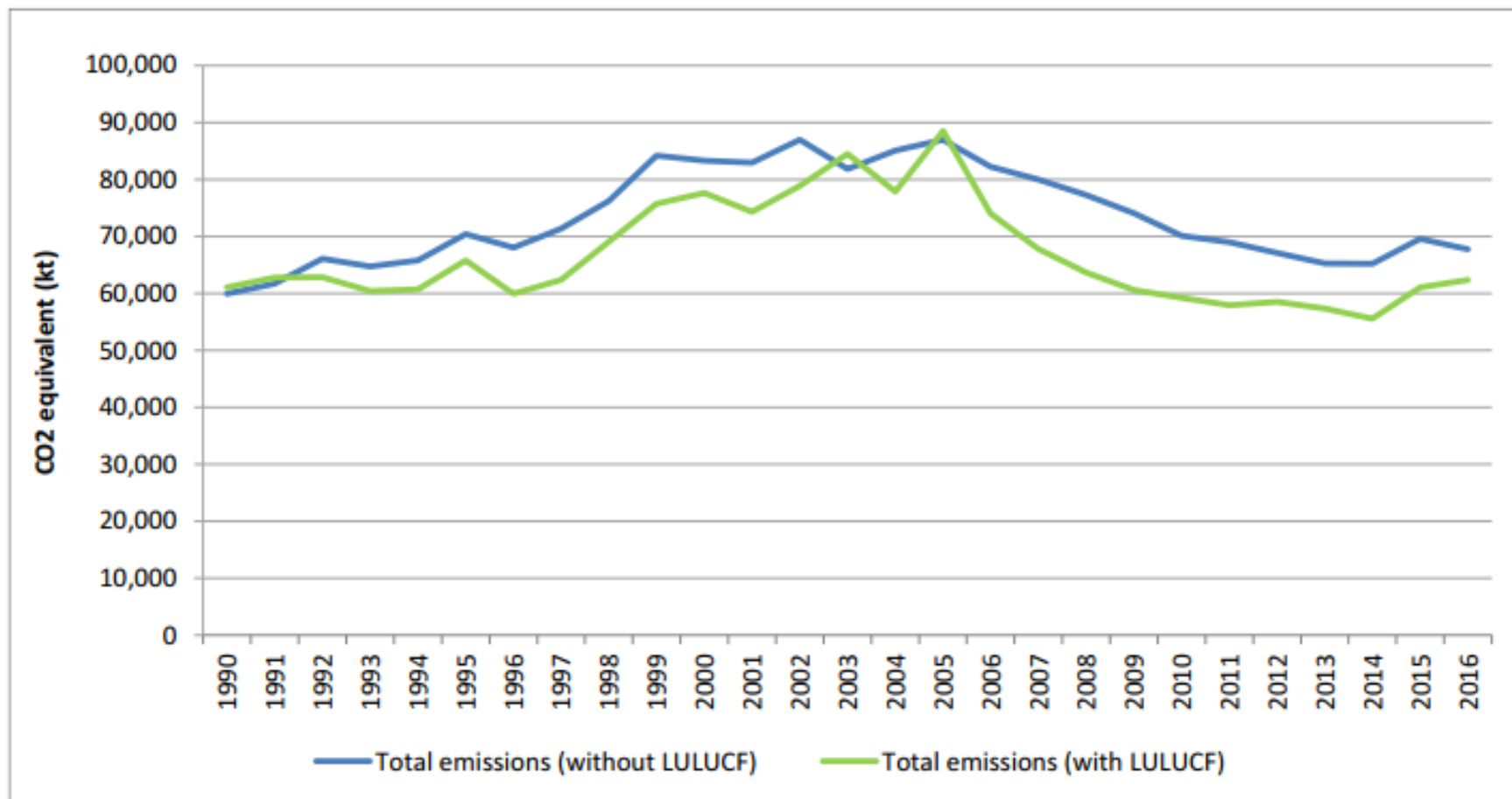


FIGURE 1 | Number of hot days per year with maximum temperature above 35° (summer days) for the (a) 1961–1990 climatology; (b) HadRM2 control simulation; (c) IS92a HadRM2 simulation (2081–2100). Source: Ref 28, Figure 2.66, p. 90.

FD Santos, P. Miranda (eds.) Alterações Climáticas em Portugal, Projecto SIAMII, Cap. 2, pag. 90, 2006.
<http://www.siam.fc.ul.pt/>

Emissões GEE em Portugal



APA- National Inventory Report of GHG, 28/5/2018 (Fig. 2.1)

Energia Renovável

Portugal runs for four days straight on renewable energy alone

Zero emission milestone reached as country is powered by just wind, solar and hydro-generated electricity for 107 hours



▲ As recently as 2013, renewables provided only about 23% of Portugal's electricity. By 2015 that figure had risen to 48%. Photograph: Pete Titmuss/Alamy Stock Photo

Guardian, 18/5/2016

Renewable energy generated 104% of Portugal's electricity consumption in March

Most of the energy came from wind and hydroelectric power

Lydia Smith | Thursday 5 April 2018 13:52 | 1 comment

[f](#) [t](#) [v](#) [L](#) Click to follow The Independent

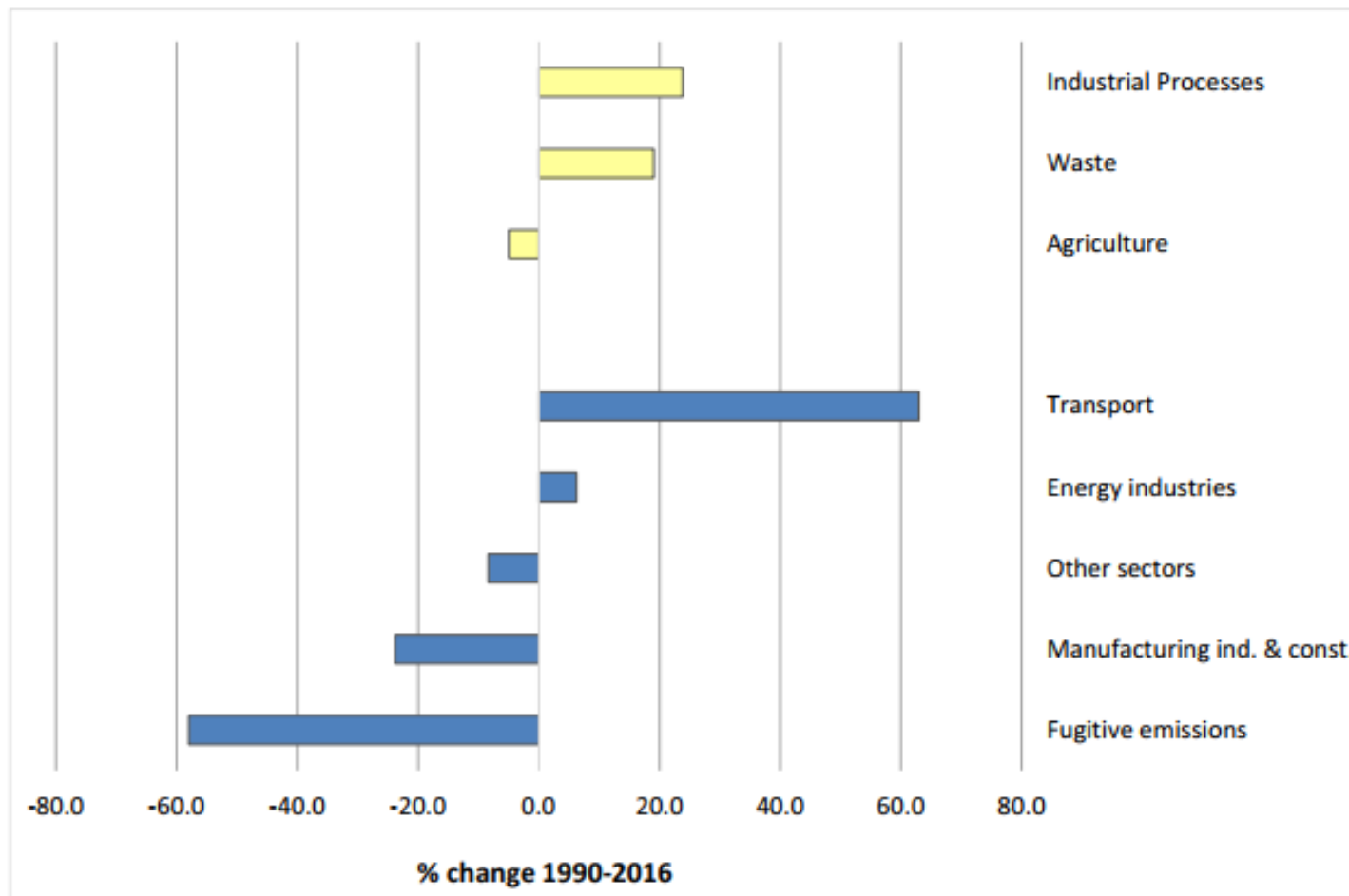


A floating wind turbine is pictured off the coast of Agucadoura, near Porto, in Portugal (AFP/Getty Images)

Independent, 5/4/2018

Emissões em Portugal II

Figure 2.10 – GHGs emissions percentage change (1990-2016) by IPCC category (LULUCF excluded).

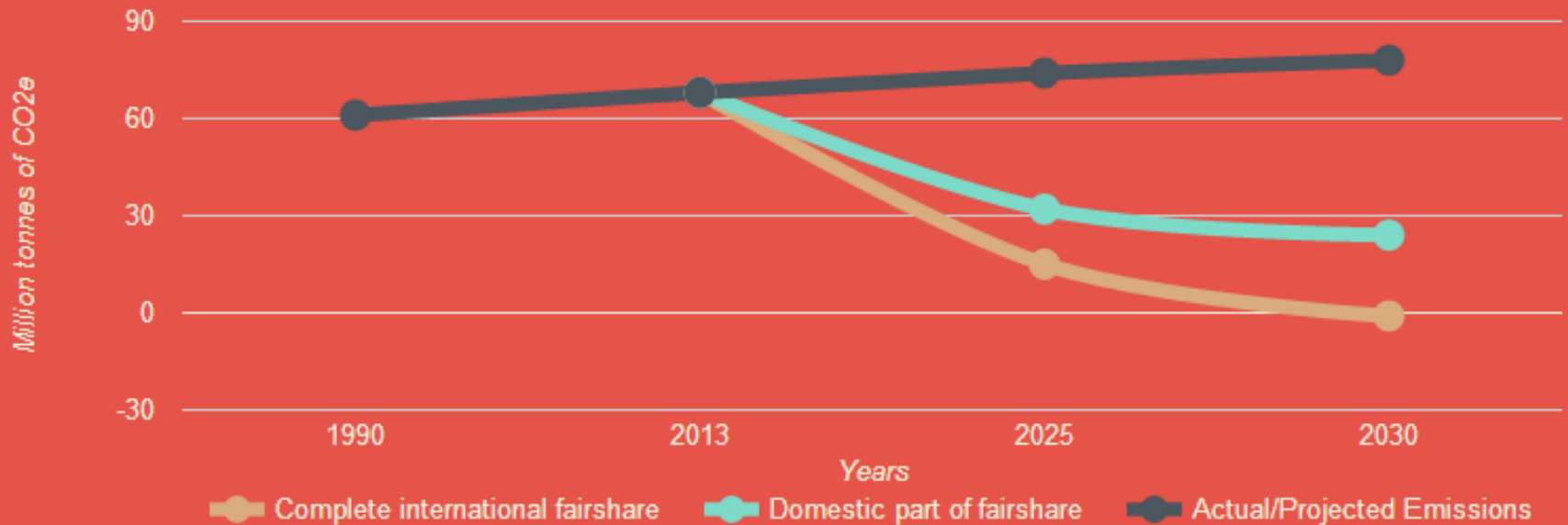


APA- National Inventory Report of GHG, 28/5/2018 (Fig. 2.10)

Cortes justos e necessários

Portugal

Emissions pathways



<http://www.climatefairshares.org/>

- Cortes de 61-71% em 2030 (relativo a 1990), tendo em conta justiça climática

Efeito de ação individual vs. ação colectiva

- Média de **emissões per capita** em Portugal: **~6-7 toneladas CO₂eq/ano**

- **1000 pessoas**, vivendo uma média de **80 anos** emitem uma média de **480 mil toneladas CO₂eq** em toda a sua vida;

- estilo de vida “espartano”: eventualmente **1-2 toneladas CO₂eq/ano**, poderiam poupar-se **400 mil toneladas CO₂eq** (1000 pessoas, ao longo de 80 anos...); Como? Nunca (!) voar; dieta vegana; não ter carro; andar a pé ou de bicicleta; consumir pouco ou nada....

- **MAS: central termoeléctrica de Sines emite ~6M toneladas CO₂eq num só ano!!!!**

- <https://climaximo.wordpress.com/2016/10/06/a-central-termoelectrica-de-sines-tapar-o-sol-com-o-carvao/>

- <https://climaximo.wordpress.com/2016/05/24/activism-its-better-than-dying-sinan-edem/>



Algarve (e Portugal) livres de gás e petróleo!

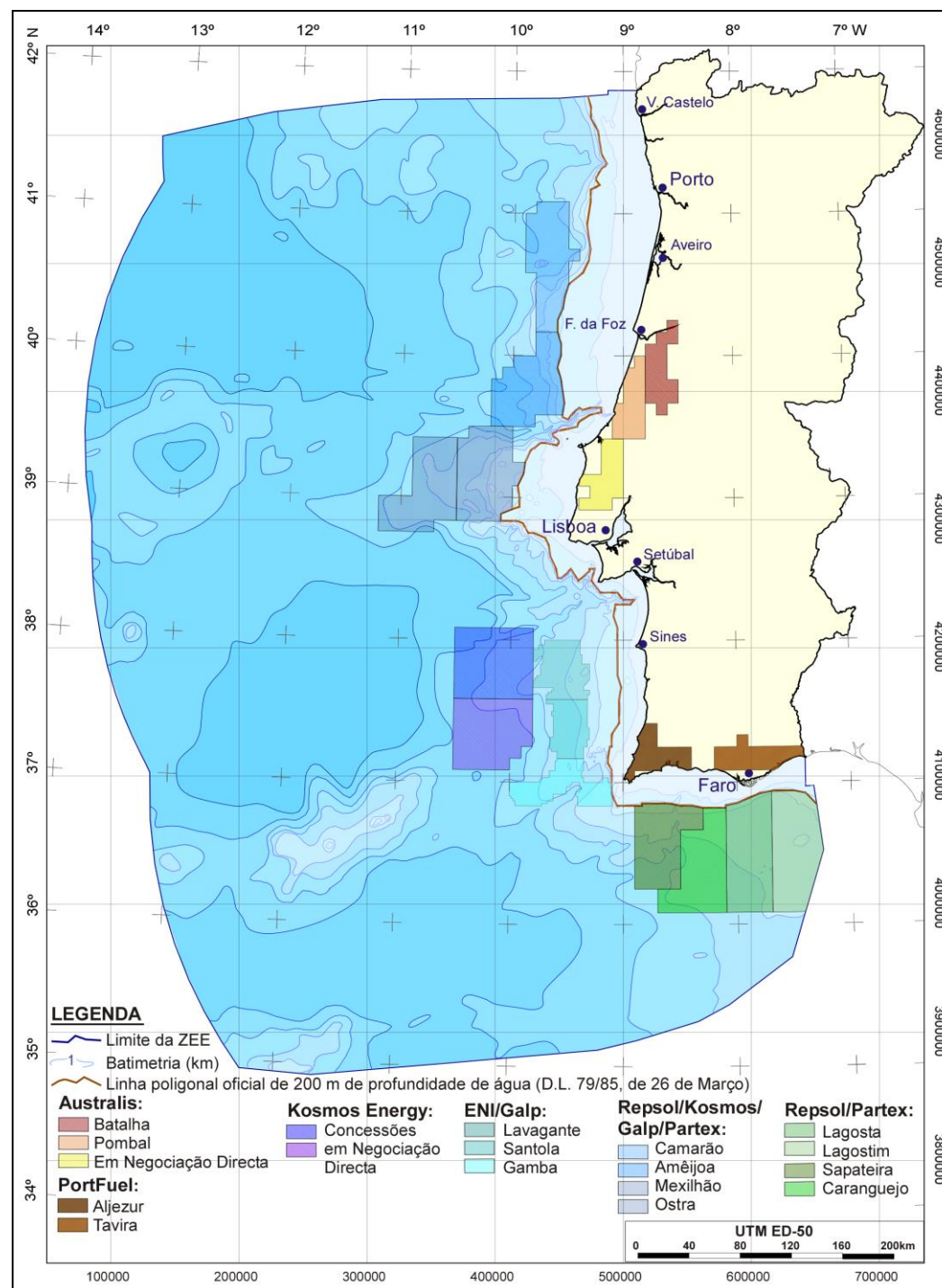


- 1 de Julho 2016: Ação “Toxic Tour reloaded”, pelo **Climáximo** e **colectivo Bicicletada**.

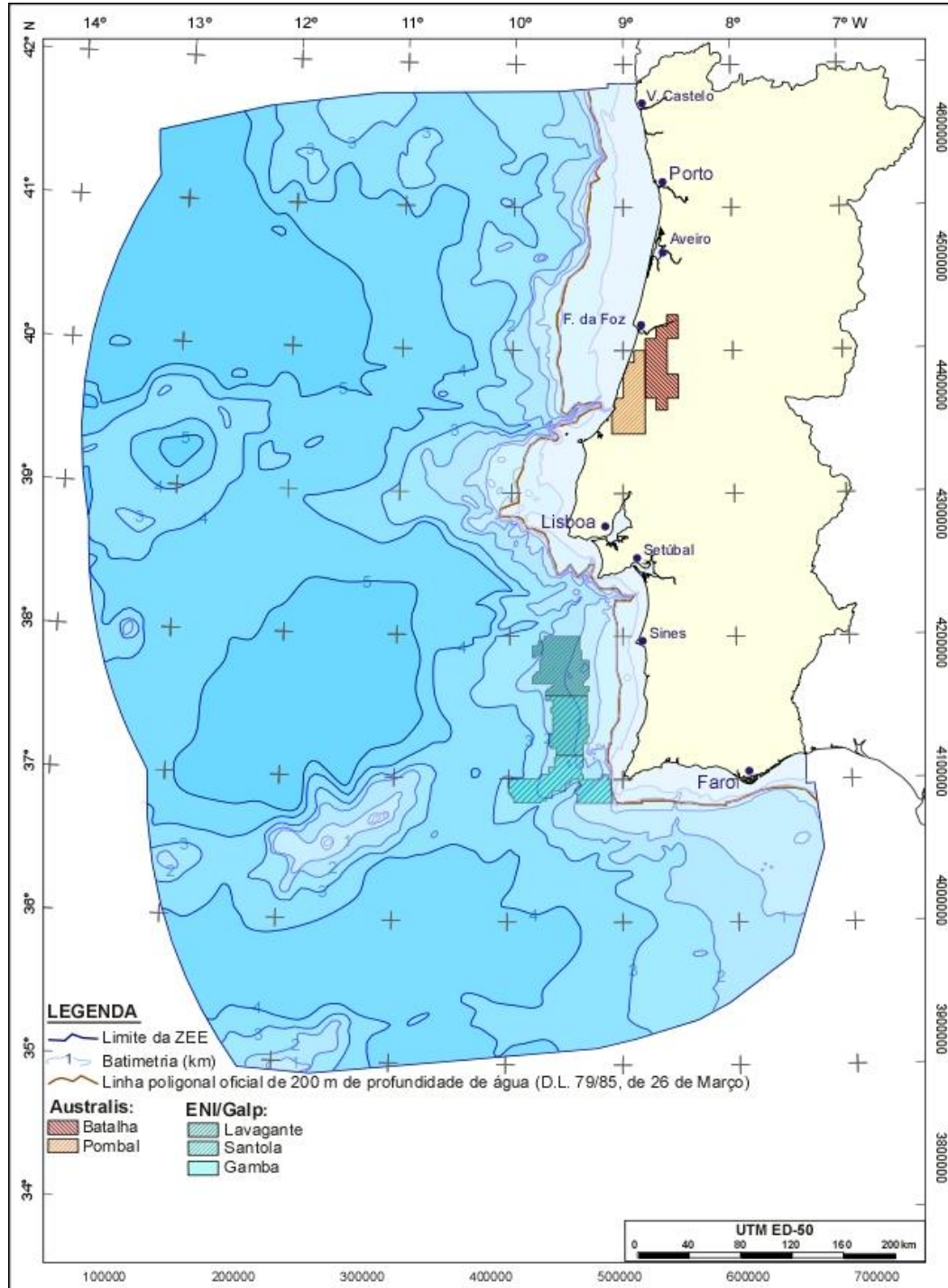
- 23 de Julho 2016: Cordão humano na ilha de Tavira (“**Acampamento Anti-Fóssil**”, 21-24 de Julho)

- 30 de Julho 2016: GALP anuncia **adiamento do primeiro furo de exploração offshore** na costa do Algarve para 2017.

Situação em 2015:
15 concessões,
 11 no mar e 4 em terra;
 Mais 3 em negociação
 direta.



Situação em **2018**:
5 concessões,
3 no mar e 2
em terra



Não haverá furo de petróleo em 2018

13.10.2018 às 8h00



Prospecção ao largo de Aljezur: ENI diz que “adiamento é inevitável”. Contrato termina em janeiro de 2019



CARLA TOMÁS

Expresso, 13/10/2018

“Os trabalhos de prospeção (previstos para setembro) foram suspensos com base na providência cautelar interposta pela **Plataforma Algarve Livre de Petróleo (PALP)**”

Em carta enviada à Entidade Nacional do Mercado de Combustíveis, com conhecimento para o Ministério do Mar, Direção-Geral de Recursos Marítimos (DGRM) e Direção-Geral de Energia, o consórcio Eni/Galp assume que não tem condições para avançar com o furo de pesquisa de petróleo ao largo de Aljezur este ano. No documento datado de agosto, lê-se que a suspensão dos trabalhos decretada pelo Tribunal Administrativo de Loulé “tem como consequência imediata a impossibilidade fáctica e legal de realização da sondagem” e que, “por motivos não imputáveis às concessionárias (...) o adiamento é, uma vez mais, inevitável”. O contrato em vigor termina em janeiro de 2019 e fonte do Ministério da Economia lembra que “não pode voltar a ser prorrogado, mas a decisão judicial suspende os prazos alguns meses”.

<https://climaximo.wordpress.com/2018/08/07/relatorio-lutar-para-vencer-report-fight-to-win/>

- Julho 2015: “kayaktivists” em Seattle, a tentar travar partida de plataforma da Shell, rumo ao Ártico



- Setembro 2015: Shell anuncia cancelamento de prospeção de petróleo no Ártico

Recursos e sugestões de leitura

- IPCC, AR5 Synthesis Report, 2014, <http://www.ipcc.ch/report/ar5/syr/>
- www.guardian.com/environment
- www.democracynow.org

- Rachel Carson, **Silent Spring** (1962).
- Donella H. Meadows, Dennis L. Meadows, et al.
 - **The Limits to Growth** (1972)
 - **Beyond the limits: global collapse or a sustainable future** (1992)
- James Lovelock, **Gaia: A new look at life on Earth** (1979)
- Bill McKibben, **The End of Nature** (1989)
- Jared Diamond, **Collapse: How Societies choose to fail or succeed** (2005)
- Tim Jackson, **Prosperity Without Growth** (2009)
- Naomi Oreskes and Erik M. Conway, **Merchants of Doubt** (2010)
- Daniel Tanuro, **O Impossível Capitalismo Verde** (2012)
- Naomi Klein, **This Changes Everything: Capitalism vs. the Climate** (2014)
- Elizabeth Kolbert, **The Sixth Extinction** (2014)
- João Camargo, **Manual de Combate às Alterações Climáticas** (2018)

VI - SUPLEMENTAR

1 - “Dutch government **ordered to cut carbon emissions in landmark ruling** - Dutch court orders state to reduce emissions by 25% within five years to **protect its citizens from climate change** in world’s first climate liability suit”

<https://www.theguardian.com/environment>, 24 Junho 2015.

2 - “Landmark Climate Lawsuit: Meet the **Youth Activists Suing the U.S. Government & Fossil Fuel Industry**”

<http://www.democracynow.org>, 14 Abril 2016

3 - “**Exxon knew of climate change in 1981**, email says – but it funded deniers for 27 more years”

<https://www.theguardian.com/environment/>, 8 Julho 2015

Exxon Mobil a ser investigada pelo estado de NYC por ter mentido ao público e espalhado desinformação – em analogia com indústria do tabaco (N. Oreskes e E. M. Conway, “Merchants of Doubt”, 2010.)



Jair Bolsonaro

Brazil's frontrunner for president would rather his son die than be gay

 Josh Jackman

 7th September 2018, 2:36 PM

Guardian, 21/9/2018



Jair Bolsonaro, presidential candidate for the Social Liberal Party (EVARISTO)

'Stop this disaster': Brazilian women mobilise against 'misogynist' far-right Bolsonaro

Jair Bolsonaro, who has called women idiots and issued taunts about rape, could be the next president. For the 2.5m women who joined a new Facebook group, something had to be done



Pink News, 7/9/2018

Jair Bolsonaro II

Brazil: Bolsonaro threatens to quit Paris climate deal

Published on 14/08/2018, 6:09pm

De facto presidential frontrunner says he would follow Donald Trump out of the international pact, drawing criticism from the UN's environment chief



Jair Bolsonaro says he would withdraw Brazil from the Paris Agreement if elected president (Photo: Commons)

<http://www.climatechangenews.com> (14/8/2018)

Companhias com mais lucros - 2016

The following is the list of top 10 companies, as published on July 20, 2016. It is based on the companies' [fiscal year](#) ended on or before March 31, 2016.^[4]

| Rank | Company | Country | Industry | Revenue in USD |
|------|--------------------------|--|-------------|------------------|
| 1 | Walmart |  United States | Retail | \$482.1 billion |
| 2 | State Grid |  China | Power | \$329.6 billion |
| 3 | China National Petroleum |  China | Petroleum | \$299.3 billion |
| 4 | Sinopec Group |  China | Petroleum | \$294.3 billion |
| 5 | Royal Dutch Shell |  Netherlands  United Kingdom [†] | Petroleum | \$272.2 billion |
| 6 | Exxon Mobil |  United States | Petroleum | \$246.2 billion |
| 7 | Volkswagen |  Germany | Automobiles | \$236.6 billion |
| 8 | Toyota Motor |  Japan | Automobiles | \$236.59 billion |
| 9 | Apple |  United States | Technology | \$233.7 billion |
| 10 | BP |  United Kingdom | Petroleum | \$225.98 billion |

https://en.wikipedia.org/wiki/Fortune_Global_500

Companhias com mais lucros - 2018

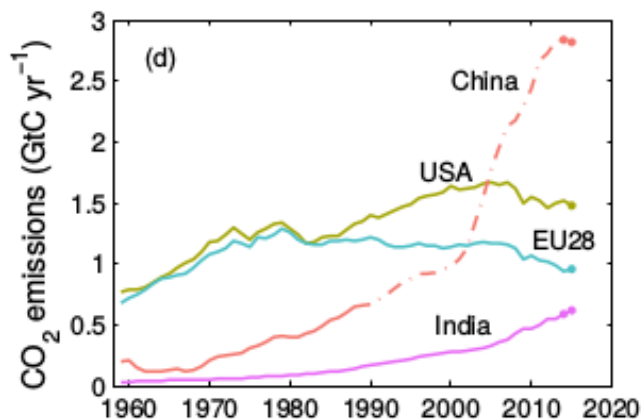
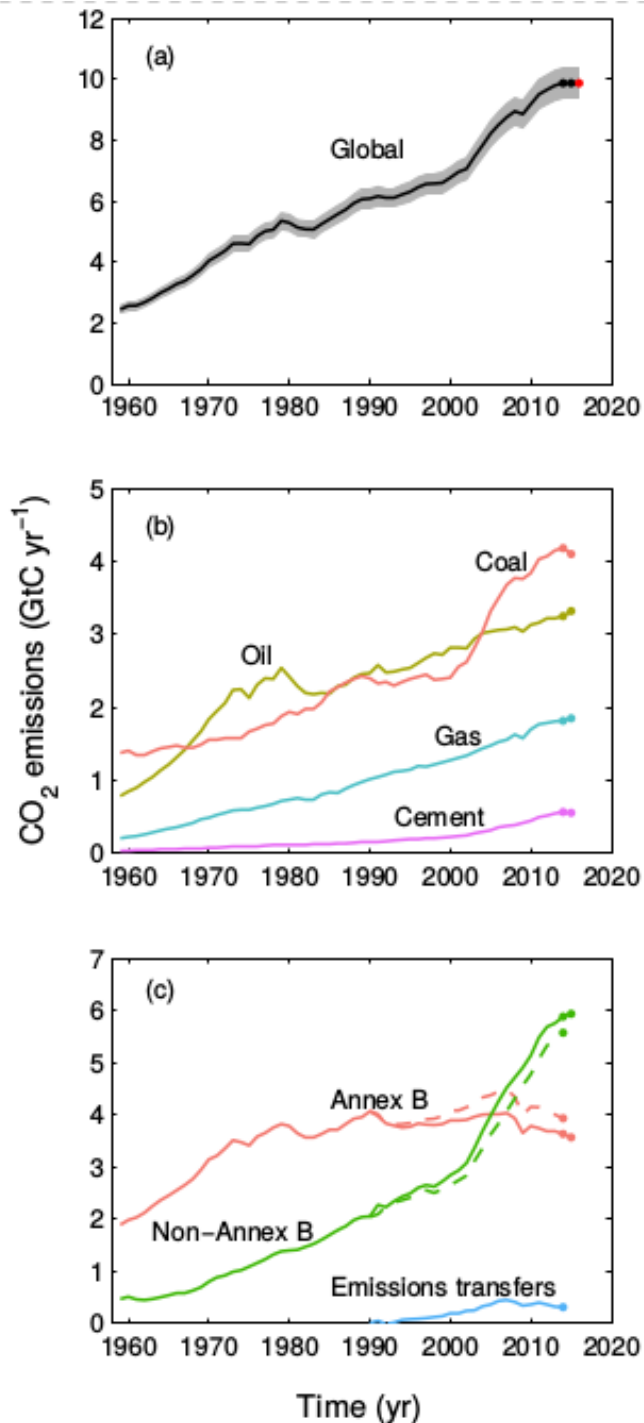
Fortune Global 500 list of year 2018 [\[edit \]](#)

The following is the list of top 10 companies.^[5]

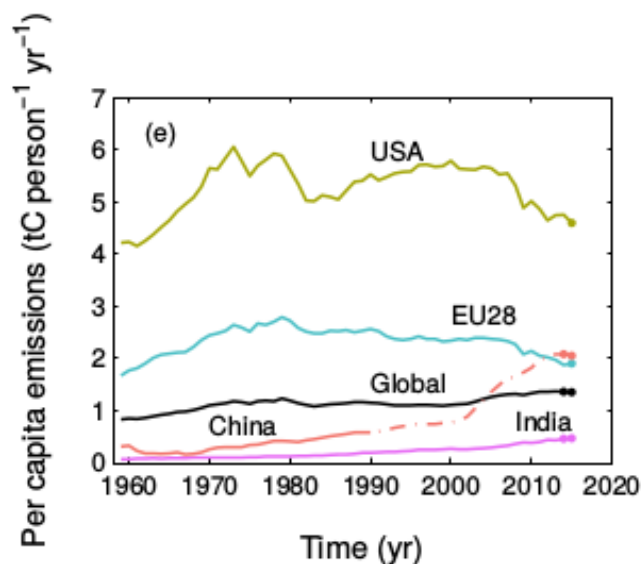
| Rank ↕ | Company ↕ | Country ↕ | Industry ↕ | Revenue in USD ↕ |
|--------|--------------------------|--|-------------|------------------|
| 1 | Walmart |  United States | Retail | \$500 billion |
| 2 | State Grid |  China | Power | \$349 billion |
| 3 | Sinopec Group |  China | Petroleum | \$327 billion |
| 4 | China National Petroleum |  China | Petroleum | \$326 billion |
| 5 | Royal Dutch Shell |  Netherlands | Petroleum | \$312 billion |
| 6 | Toyota Motor |  Japan | Automobiles | \$265 billion |
| 7 | Volkswagen |  Germany | Automobiles | \$260 billion |
| 8 | BP |  United Kingdom | Petroleum | \$245 billion |
| 9 | Exxon Mobil |  United States | Petroleum | \$244 billion |
| 10 | Berkshire Hathaway |  United States | Products | \$242 billion |

https://en.wikipedia.org/wiki/Fortune_Global_500

Emissões de CO2 em 2014-16



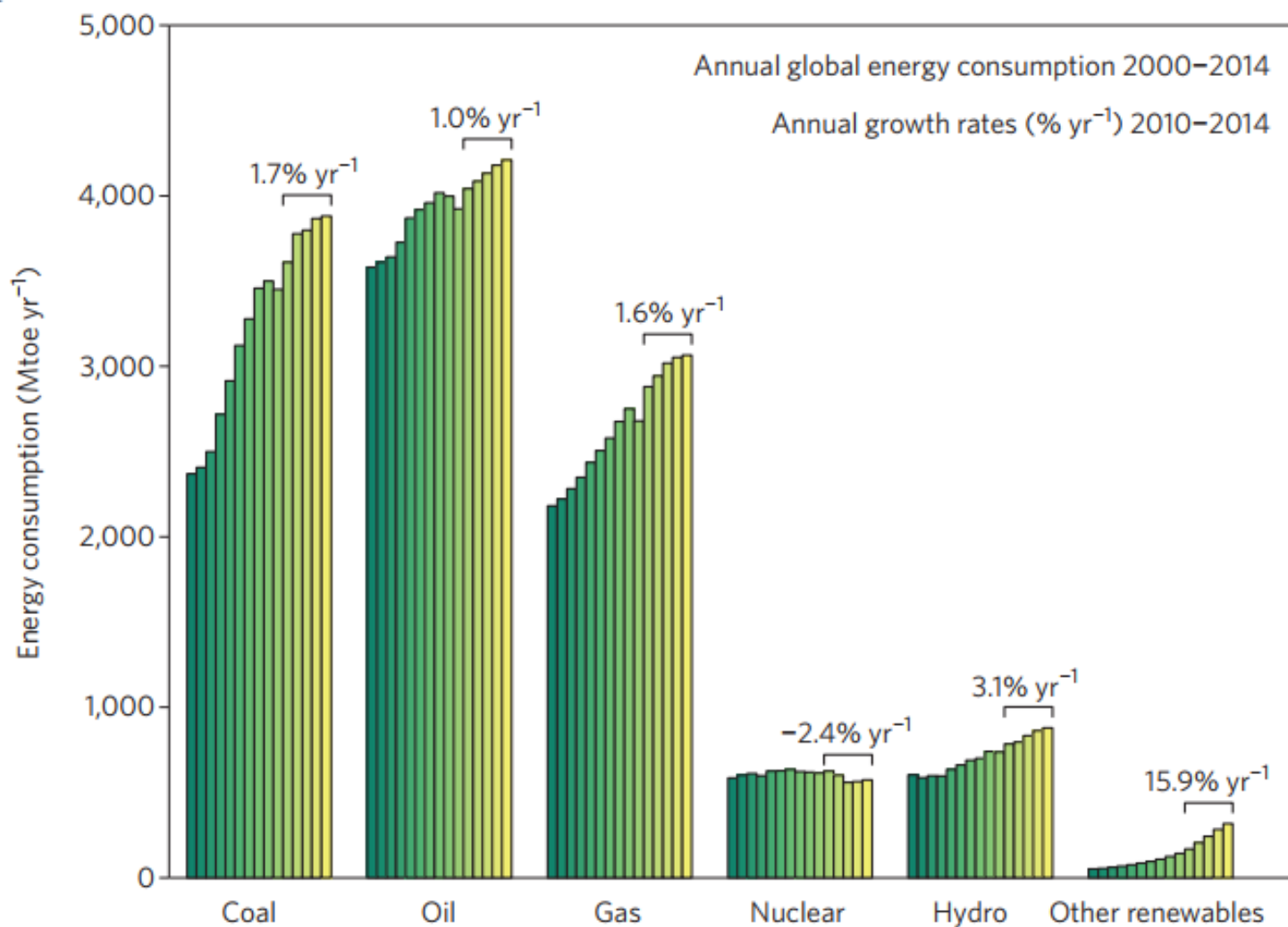
← total



← per capita

Le Quéré et al., "Global Carbon Budget 2016", 2016.

Energia Renovável



Consumo de energia entre 2000-14, com taxas de crescimento para 2010-14
(Jackson, Canadell, et al., Reaching Peak Emissions, Nature Clim. Change, 2016.)