

Introdução às Mudanças Climáticas Globais

Bases físicas, impactos e adaptações, opções de mitigação

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SMA – FCAV/UNESP
Junho 2024

Climate change: Physical basis



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SVANTE ARRHENIUS (1859-1927)

Arrhenius did very little research in the fields of climatology and geophysics, and considered any work in these fields a hobby. His basic approach was to apply knowledge of basic scientific principles to make sense of existing observations, while hypothesizing a theory on the cause of the "Ice Age." Later on, his geophysical work would serve as a catalyst for the work of others.

In 1895, Arrhenius presented a paper to the Stockholm Physical Society titled, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground." This article described an energy budget model that considered the radiative effects of carbon dioxide (carbonic acid) and water vapor on the surface temperature of the Earth, and variations in atmospheric carbon dioxide concentrations. In order to proceed with his experiments, Arrhenius relied heavily on the experiments and observations of other scientists, including Josef Stefan, Arvid

"ARRHENIUS ARGUED THAT VARIATIONS IN TRACE ATMOSPHERIC CONSTITUENTS COULD INFLUENCE THE EARTH'S HEAT BUDGET."

On the Shoulders of Giants

[Svante Arrhenius](#)

Arrhenius' Carbon

Dioxide

Research

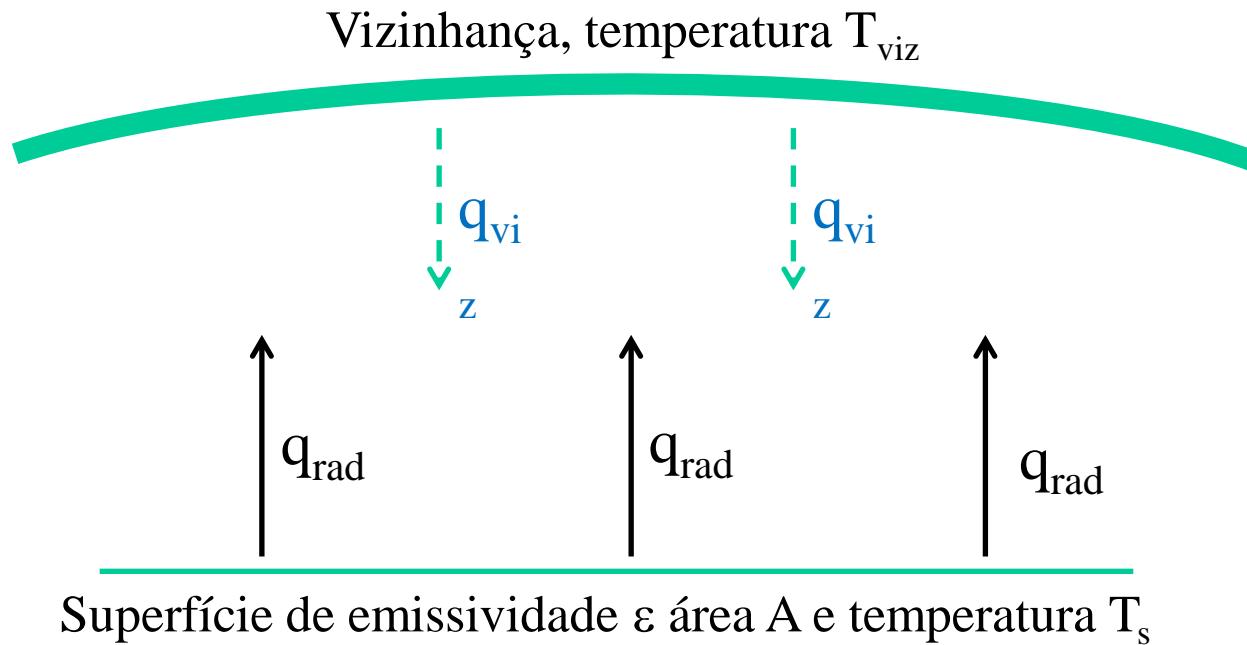
[Hot House Theory](#)

Links and

References

His calculations showed that the "temperature of the Arctic regions would rise about 8 degrees or 9 degrees Celsius, if the carbonic acid increased 2.5 to 3 times its present value. In order to get the temperature of the ice age between the 40th and 50th parallels, the carbonic acid in the air should sink to 0.62 to 0.55 of present value (lowering the temperature 4 degrees to 5 degrees Celsius)."

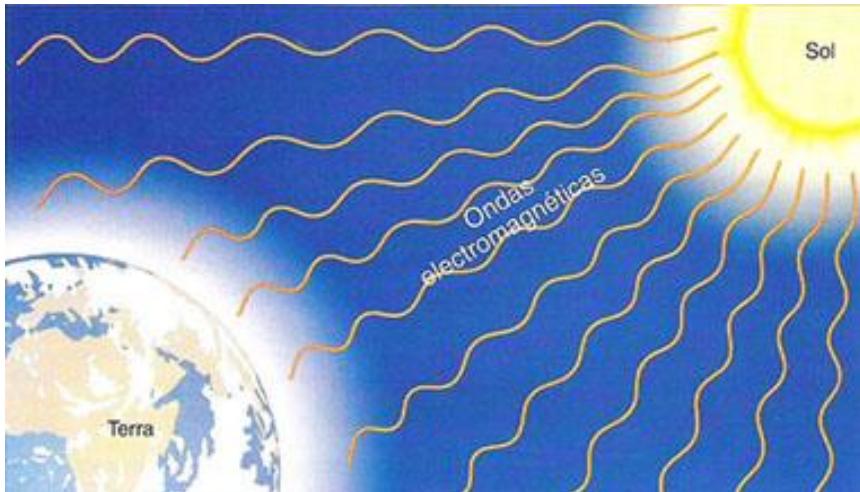
Radiação de Calor: Troca de radiação entre duas superfícies



A radiação é a energia emitida pela matéria que quando numa temperatura $T > 0$ K

A energia é transportada na forma de ondas eletromagnéticas, e não exige a presença de um meio material, a radiação se propaga no vácuo

Termodinâmica (radiação)



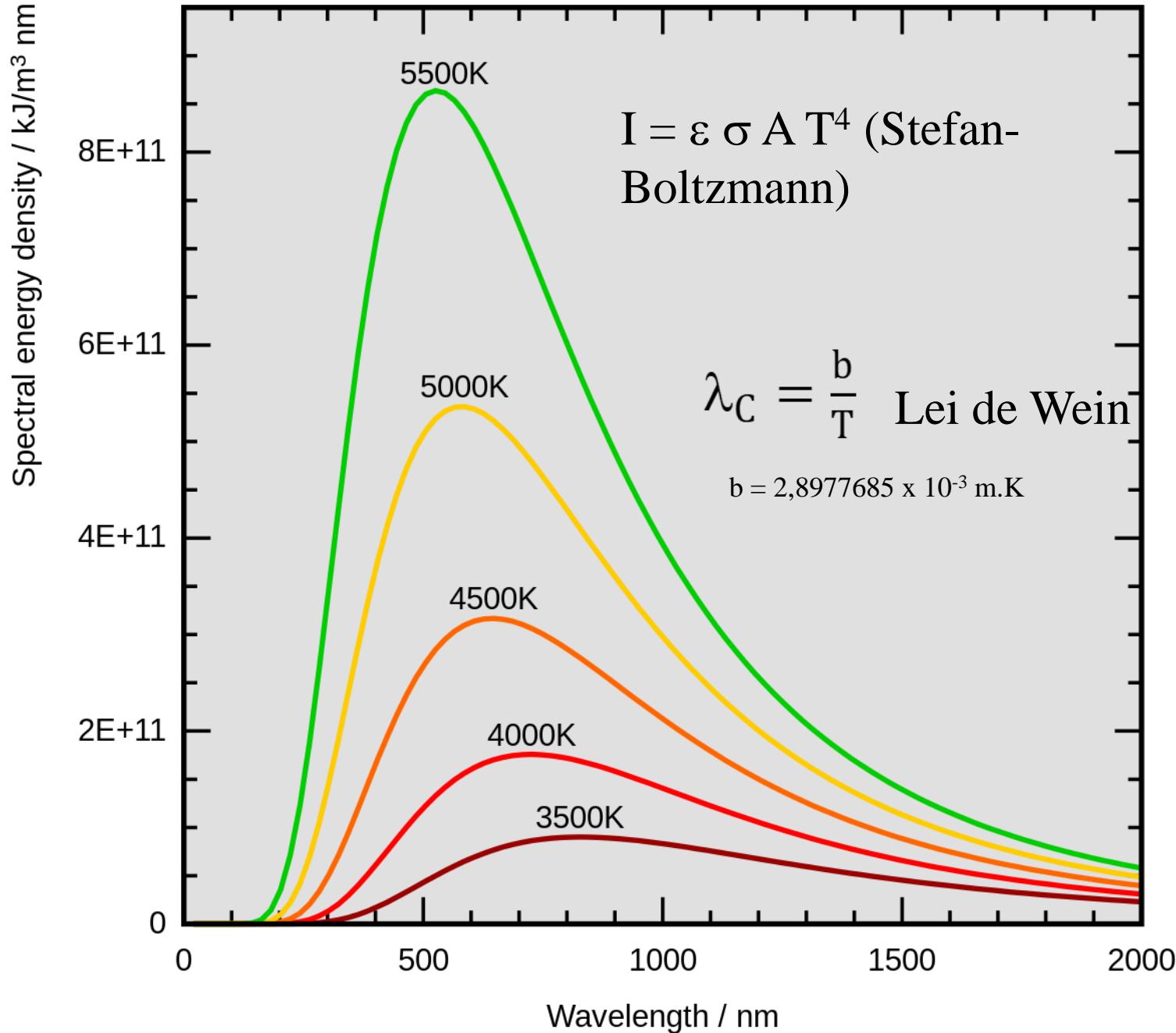
A potencia emitida pelo corpo a é dado pela lei de Stefan-Boltzmann:

$$q_{\text{rad}} = \varepsilon \sigma A (T_s)^4$$

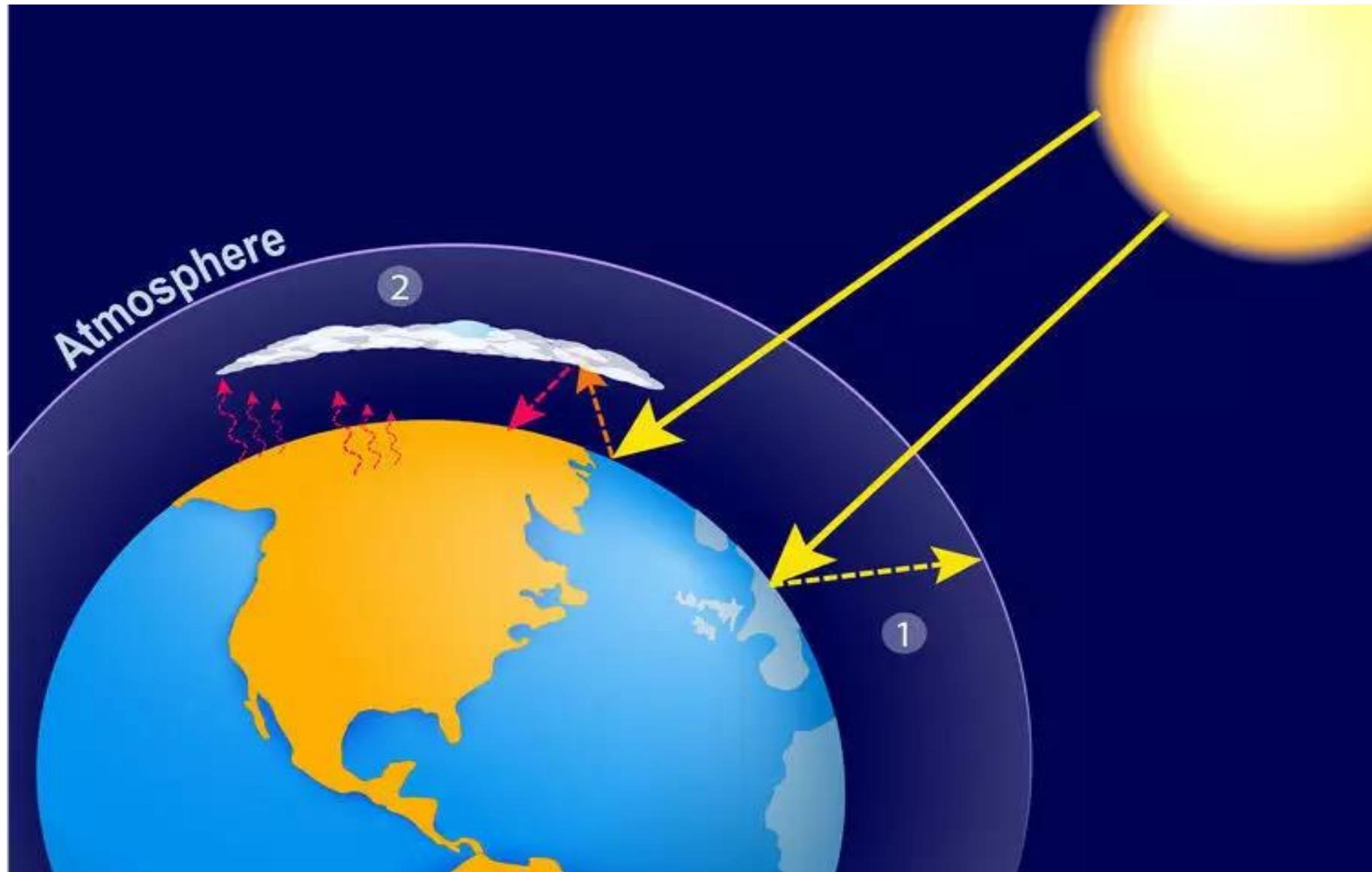
Onde T_s é a temperatura (K) da superfície, σ é a constante de Stefan-Boltzmann ($5,67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$) e ε a emissividade da superfície (entre 0 e 1, adimensional).

Assim, a taxa líquida de troca de radiação térmica entre a superfície e sua vizinhança é dada por:

$$q_{\text{rad}} = \varepsilon \sigma A (T_s^4 - T_{\text{viz}}^4)$$

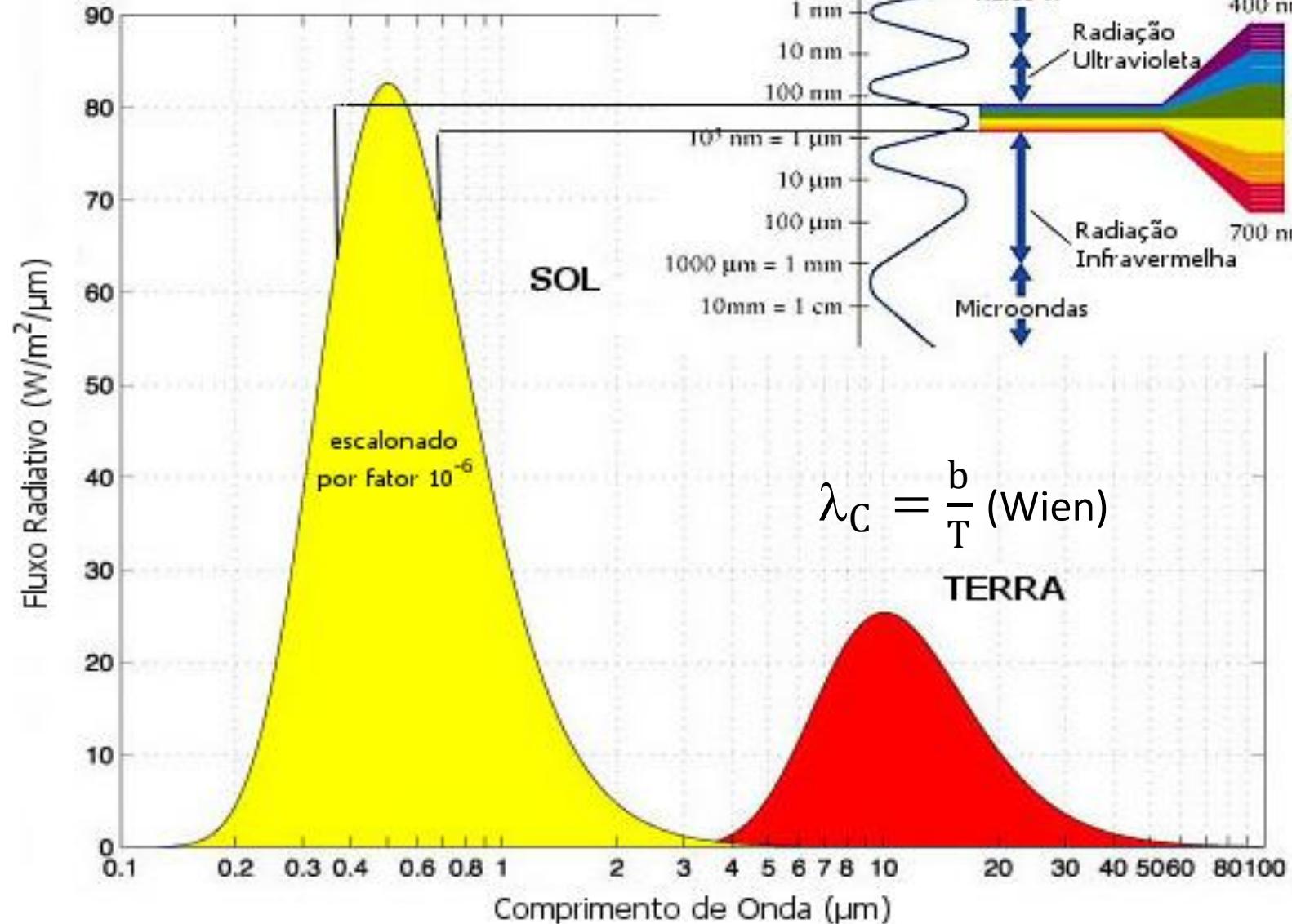


Efeito Estufa

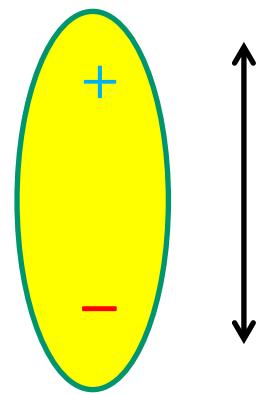
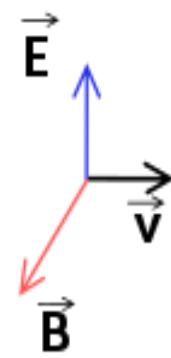
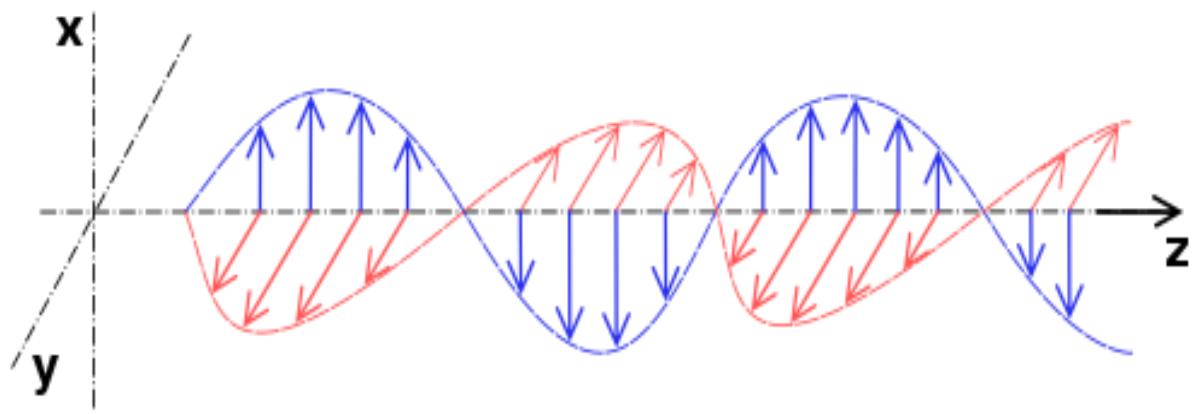


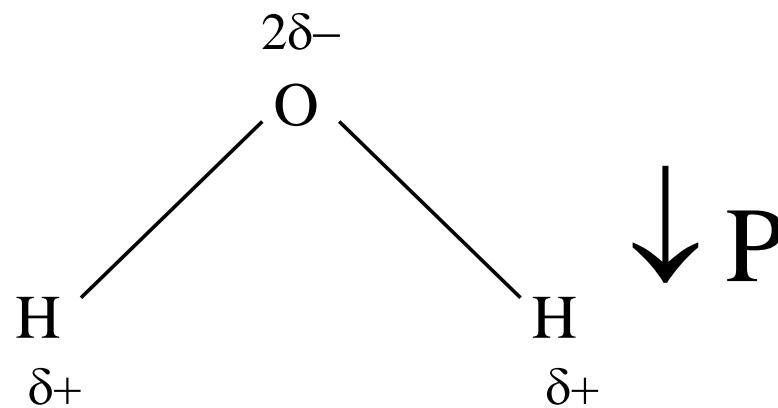
Não houvesse efeito de estufa a temperatura da superfície terrestre seria, em média, cerca de 33 °C mais fria do que é, +15 °C para –18 °C

$$I = \epsilon \sigma A T^4 \text{ (Stefan-Boltzmann)}$$

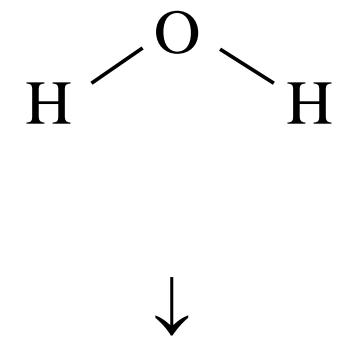
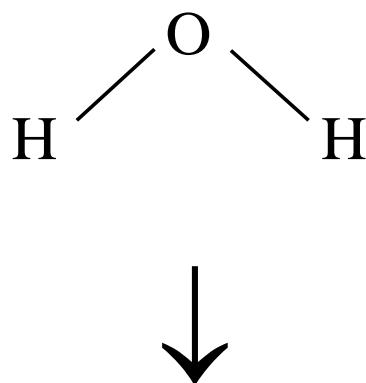
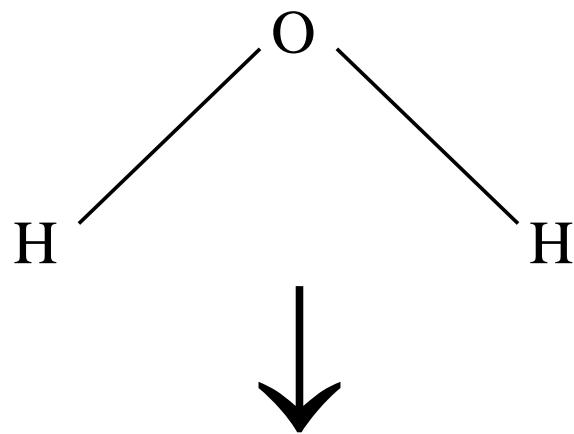


$$\lambda_C = \frac{b}{T} \text{ (Wien)}$$

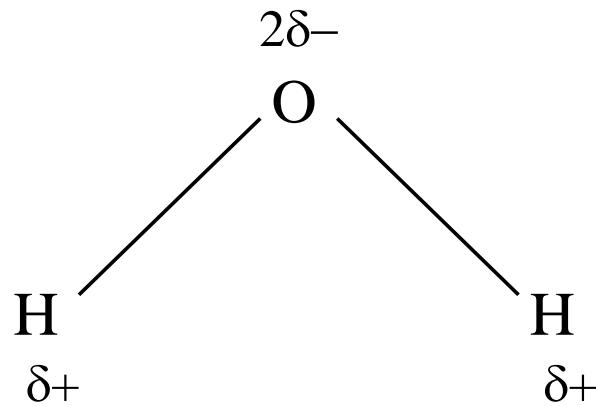




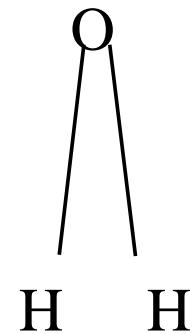
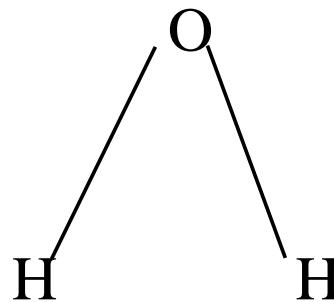
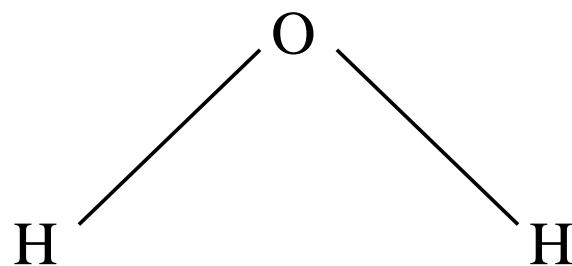
Deformações Axiais Simétricas e Assimétricas



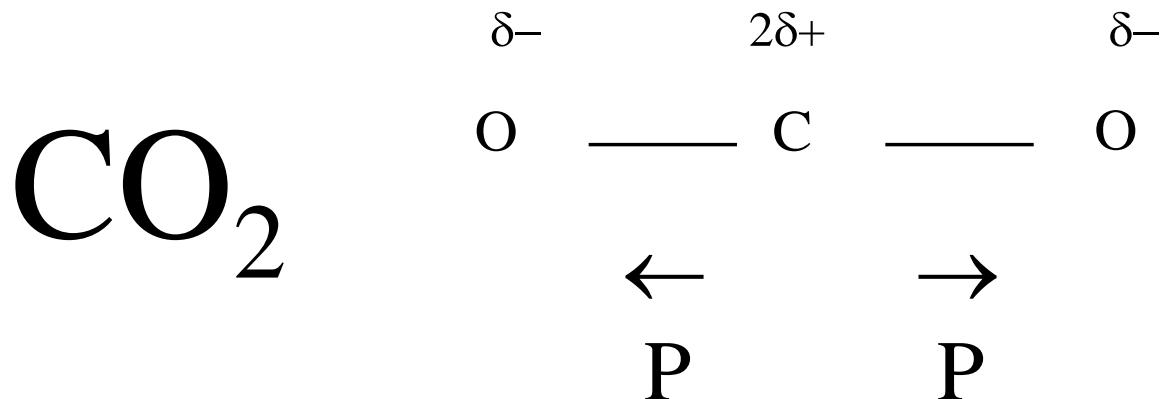
Absorção / emissão na faixa espectral próxima a $2,7 \mu\text{m}$



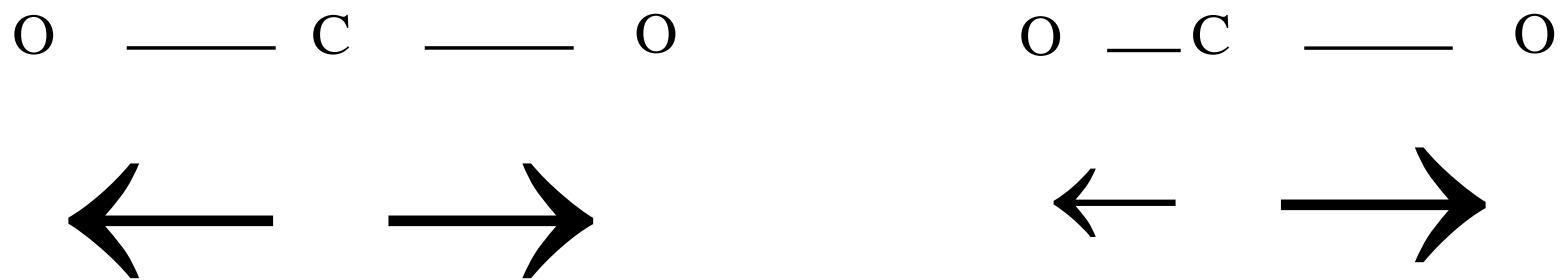
Deformação Angular



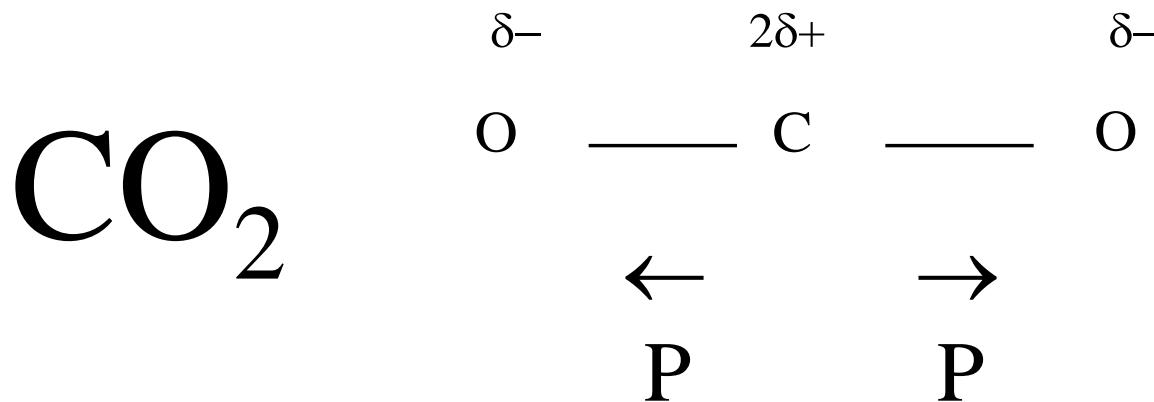
Absorção / emissão na faixa espectral próxima a 6,0 μm



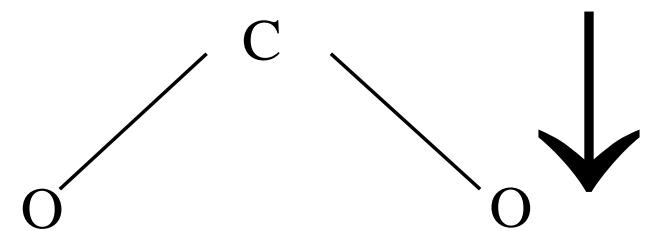
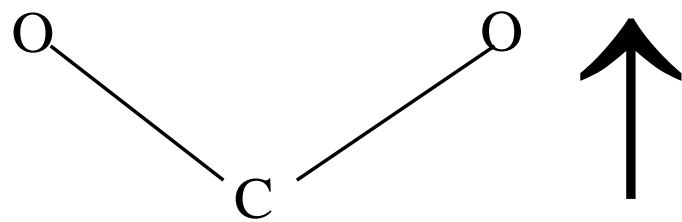
Deformações Axial Assimétrica



Absorção / emissão na faixa espectral próxima a 4,25 μm

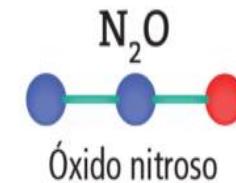
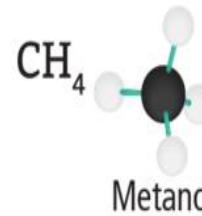
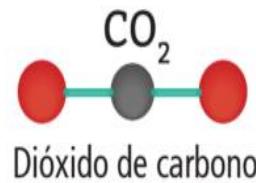
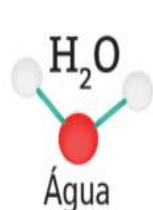


Deformações Angulares Simétricas

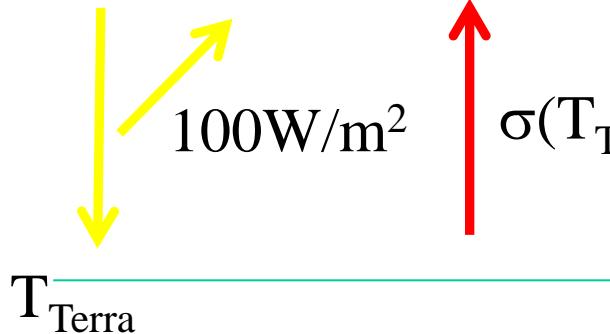


Absorção / emissão na faixa espectral próxima a $15 \mu\text{m}$

Efeito Estufa



$$I_{\text{Sol}} = 340 \text{ W/m}^2 \quad I_{\text{Terra}} = 340 \text{ W/m}^2$$



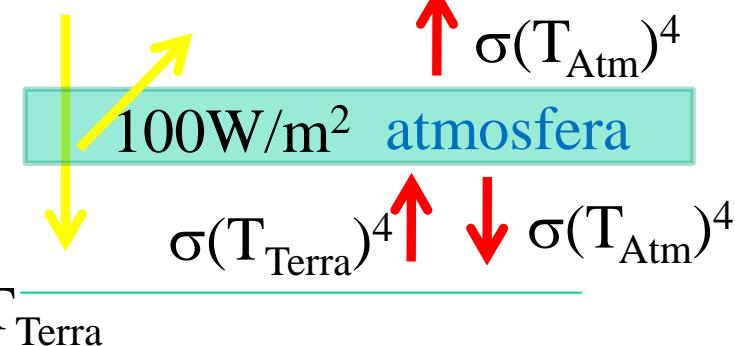
Em 1 m²

$$I_{\text{Terra}} = 240 \text{ W} = \sigma(T_{\text{Terra}})^4$$



$$T_S = 255 \text{ K } (-18^\circ\text{C})$$

$$I_{\text{Sol}} = 340 \text{ W/m}^2 \quad I_{\text{Terra}} = 340 \text{ W/m}^2$$



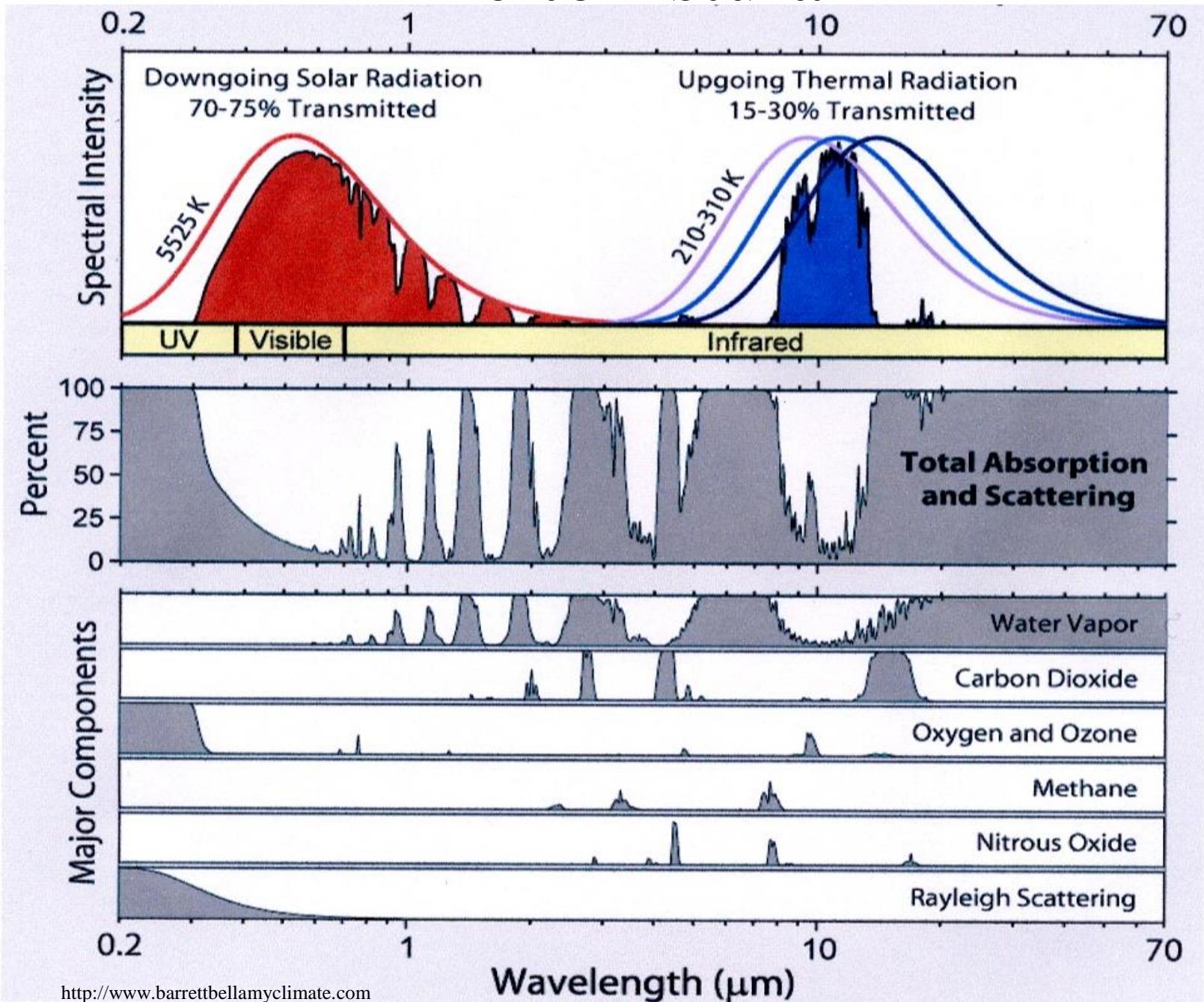
Em 1 m²

$$I_{\text{Terra}} = 395 \text{ W} = \sigma(T_{\text{Terra}})^4$$



$$T_S = 289 \text{ K } (+16^\circ\text{C})$$

Efeito Estufa





SPECIAL AND METHODOLOGY REPORTS

- [Methodology Report on Short-lived Climate Forcers](#)
- [Global Warming of 1.5°C](#)
- [Climate Change and Land](#)
- [2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories](#)
- [The Ocean and Cryosphere in a Changing Climate](#)

SIXTH ASSESSMENT REPORT

- [AR6 Synthesis Report: Climate Change 2023](#)
- [AR6 Climate Change 2022: Impacts, Adaptation and Vulnerability](#)
- [AR6 Climate Change 2022: Mitigation of Climate Change](#)
- [AR6 Climate Change 2021: The Physical Science Basis](#)

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FIFTH ASSESSMENT REPORT

- [AR5 Synthesis Report: Climate Change 2014](#)
- [AR5 Climate Change 2013: The Physical Science Basis](#)
- [AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability](#)
- [AR5 Climate Change 2014: Mitigation of Climate Change](#)

The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change.

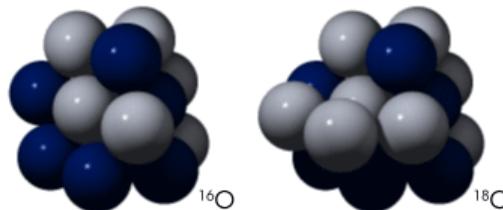


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Paleoclimatology: the Oxygen Balance

by Holli Riebeek • May 6, 2005

Oxygen is one of the most significant keys to deciphering past climates. Oxygen comes in heavy and light varieties, or isotopes, which are useful for paleoclimate research. Like all elements, oxygen is made up of a nucleus of protons and neutrons, surrounded by a cloud of electrons. All oxygen atoms have 8 protons, but the nucleus might contain 8, 9, or 10 neutrons. "Light" oxygen-16, with 8 protons and 8 neutrons, is the most common isotope found in nature, followed by much lesser amounts of "heavy" oxygen-18, with 8 protons and 10 neutrons.



The ratio (relative amount) of these two types of oxygen in water changes with the

Paleoclimatology

[Introduction](#)

[Written in the Earth](#)

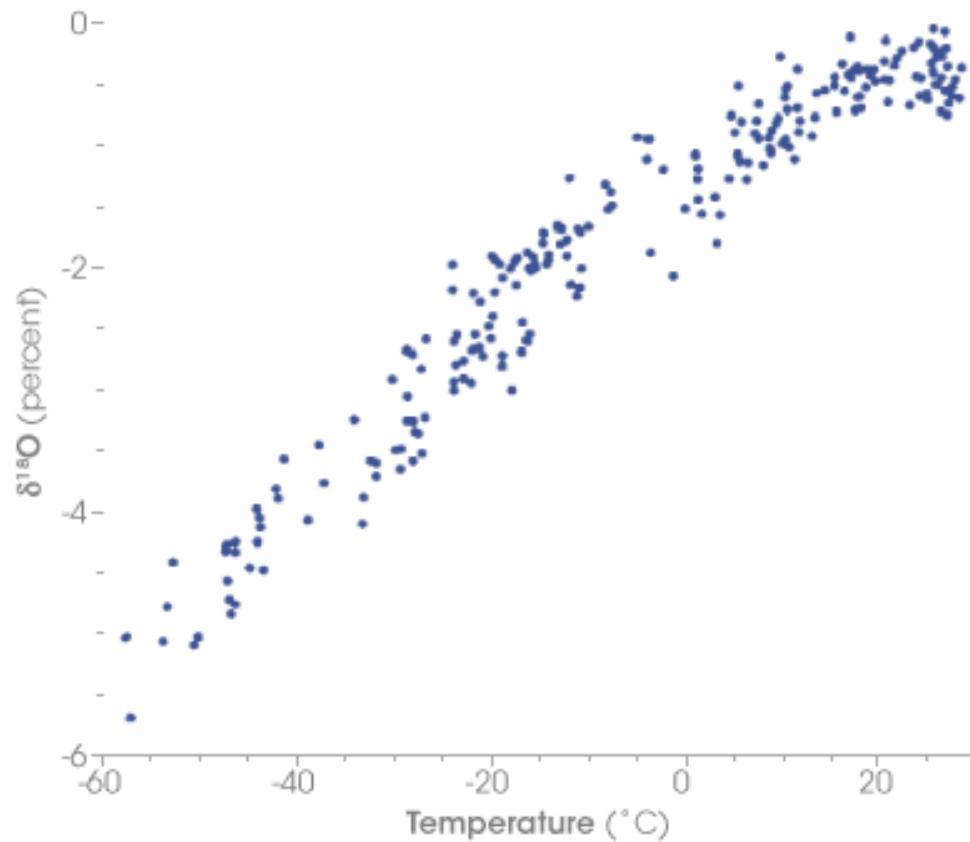
[A Record from the Deep](#)

[The Ice Core Record](#)

[Climate Close-up](#)

[Explaining the Evidence](#)

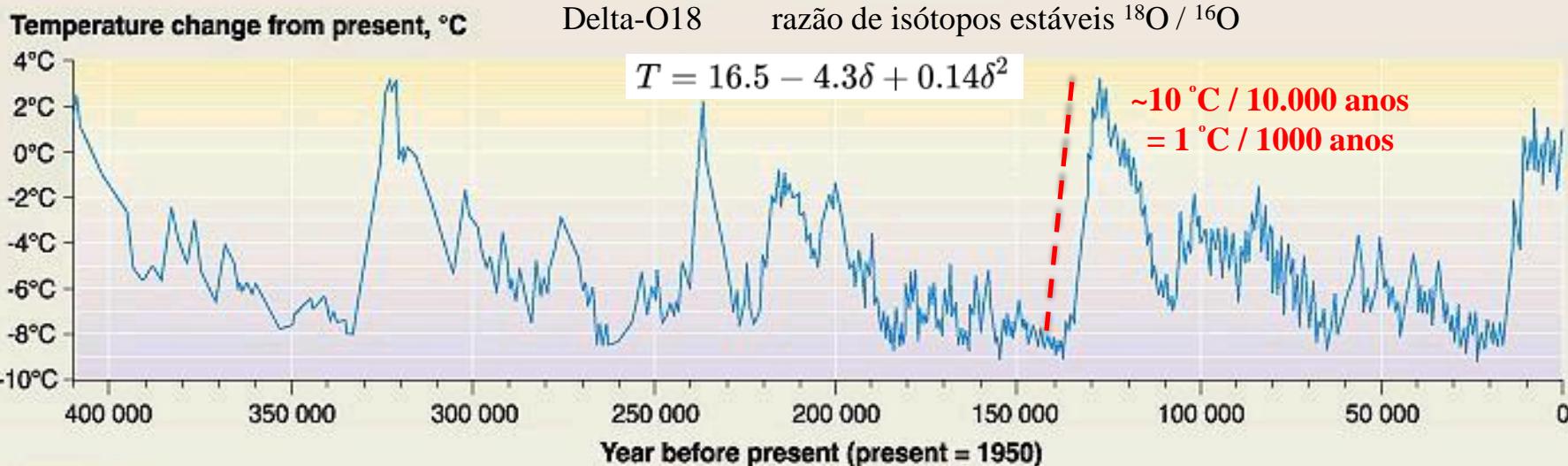
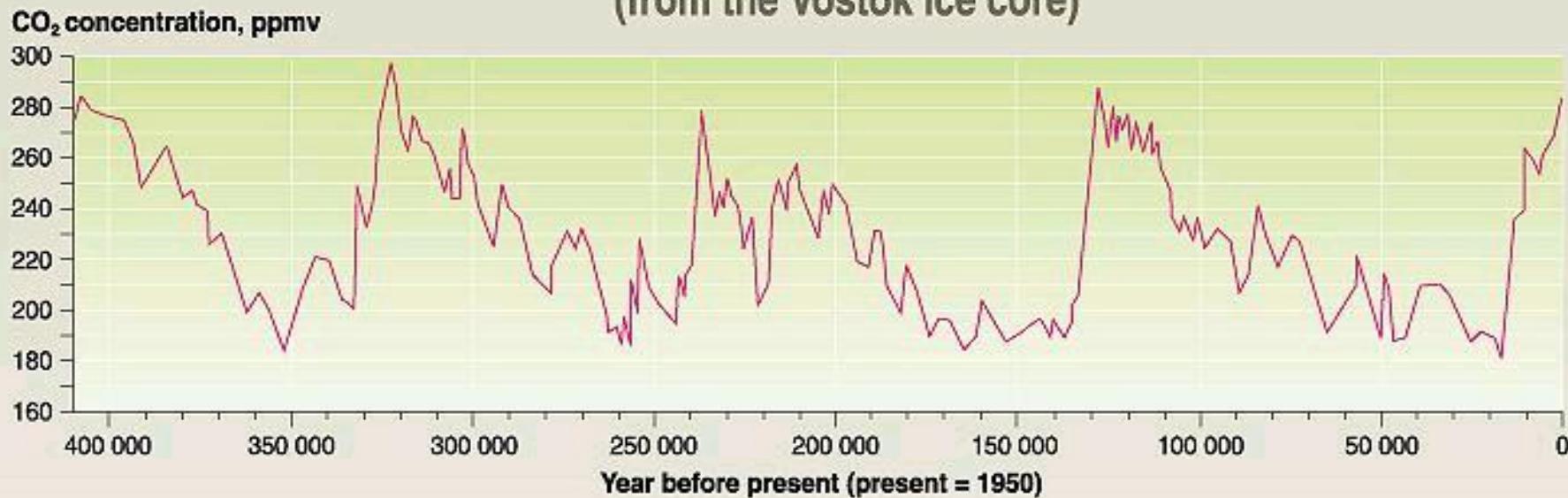
[Understanding the Past to Predict the Future](#)



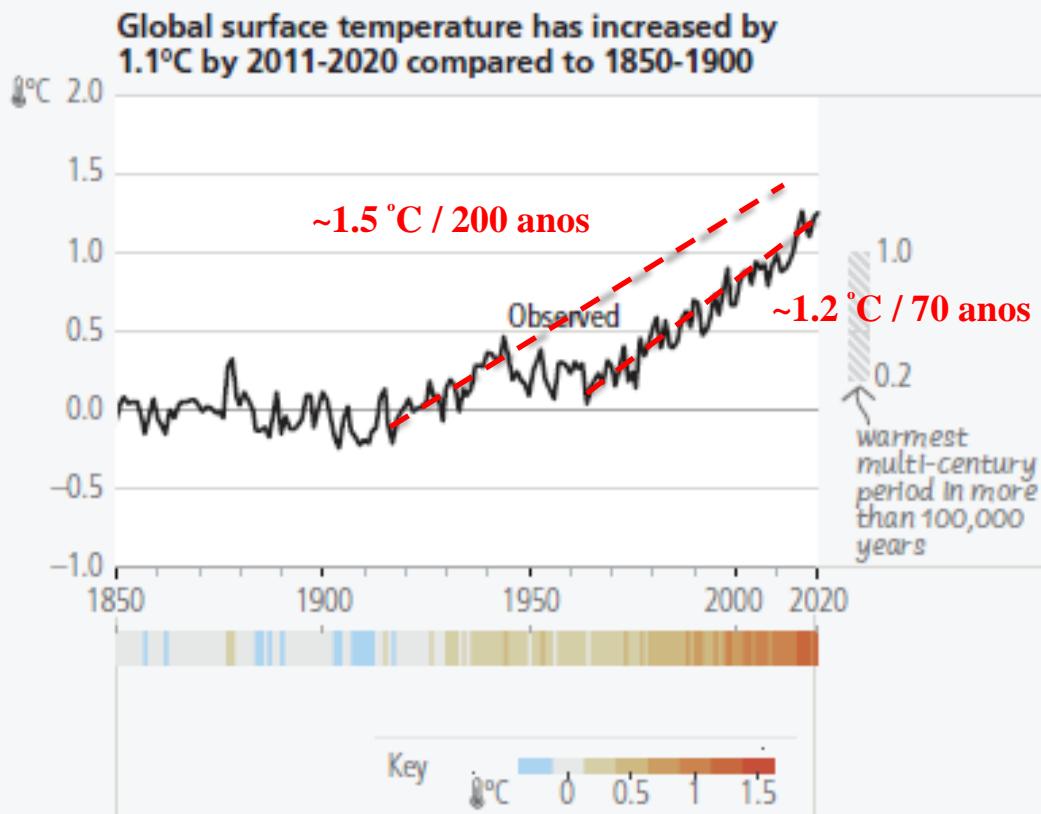
The Oxygen-18 isotope has an extra two neutrons, for a total of 10 neutrons and 8 protons, compared to the 8 neutrons and 8 protons in a normal oxygen atom. The slightly greater mass of

Testemunho de gelo: Dados paleoclimáticos

Temperature and CO₂ concentration in the atmosphere over the past 400 000 years
(from the Vostok ice core)

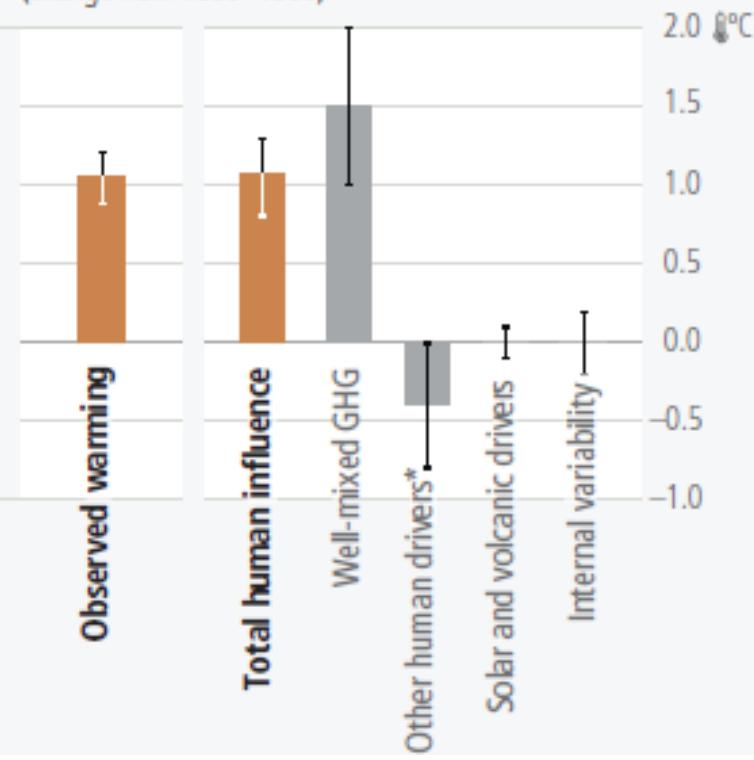


c) Changes in global surface temperature

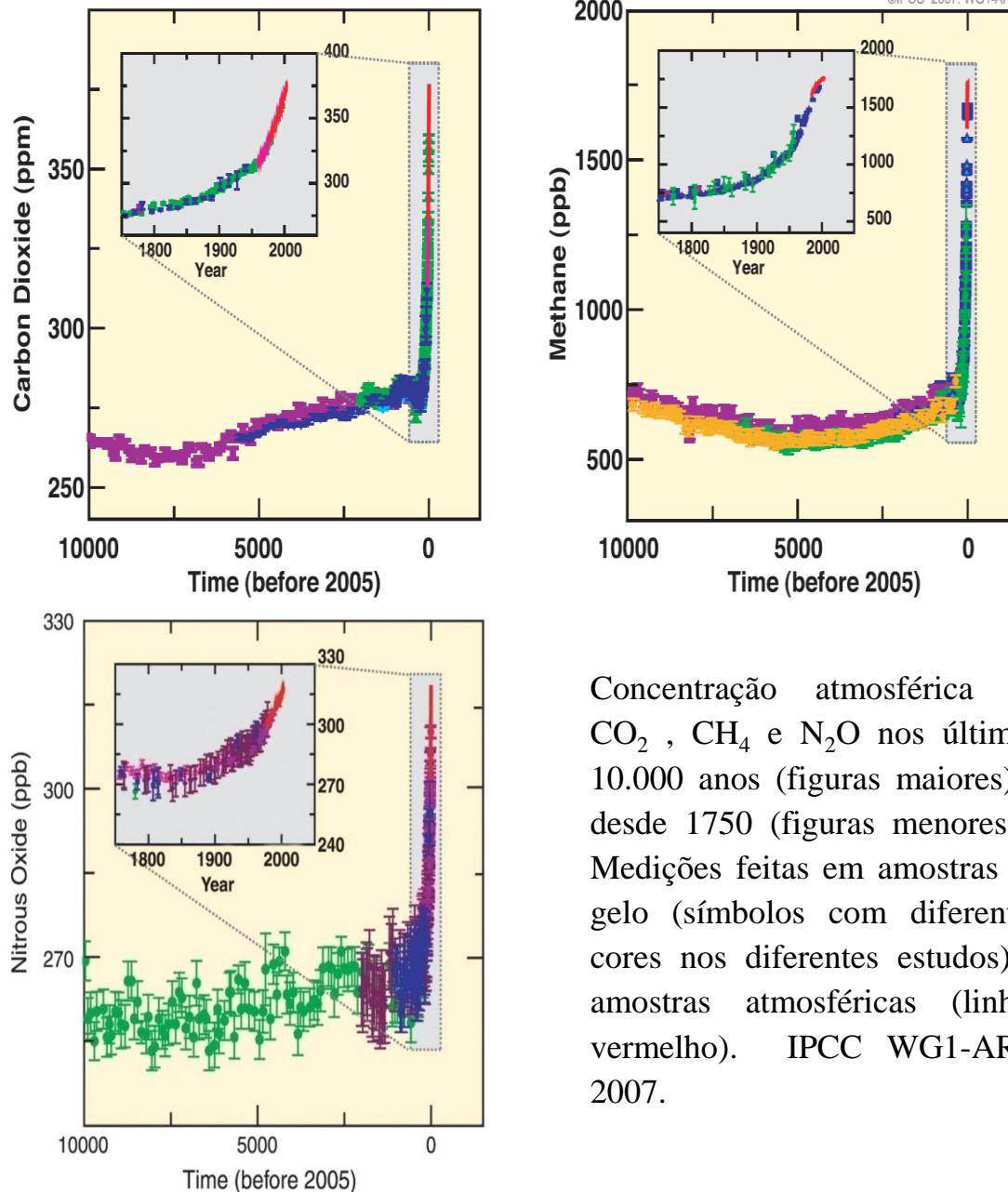


d) Humans are responsible

Observed warming is driven by emissions from human activities with GHG warming partly masked by aerosol cooling 2010–2019 (change from 1850–1900)



EFEITO ESTUFA



Concentração atmosférica de CO₂, CH₄ e N₂O nos últimos 10.000 anos (figuras maiores) e desde 1750 (figuras menores). Medições feitas em amostras de gelo (símbolos com diferentes cores nos diferentes estudos) e amostras atmosféricas (linhas vermelho). IPCC WG1-AR4, 2007.

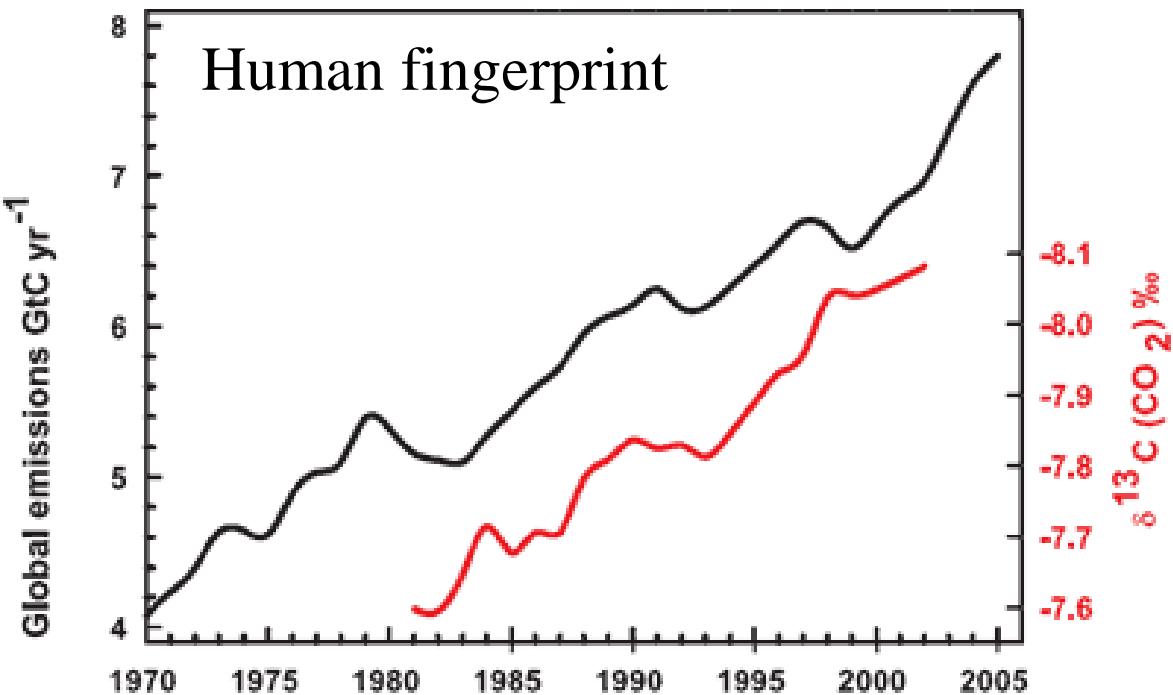


Figure 2: Annual global CO_2 emissions from fossil fuel burning and cement manufacture in GtC yr^{-1} (black), annual averages of the $\delta^{13}\text{C}/12\text{C}$ ratio measured in atmospheric CO_2 at Mauna Loa from 1981 to 2002 (red). The isotope data are expressed as $\delta^{13}\text{C}(\text{CO}_2)$ ‰ (per mil) deviation from a calibration standard. Note that this scale is inverted to improve clarity. (IPCC AR4)

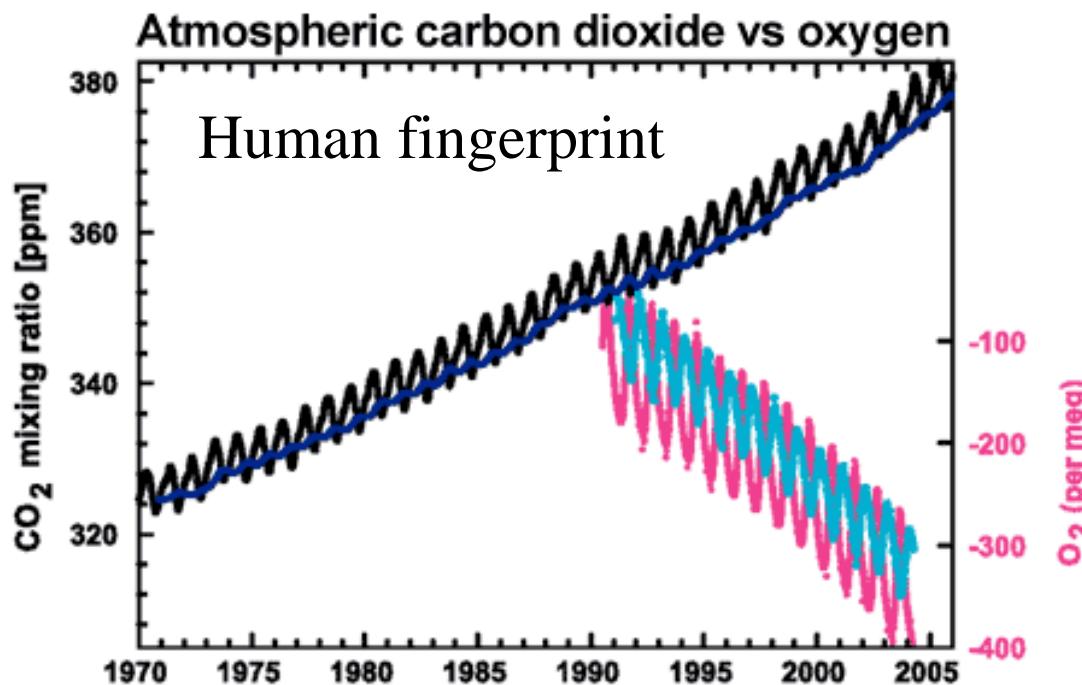


Figure 3: CO_2 concentrations from Mauna Loa, Hawaii (black) and Baring Head, New Zealand (blue). In bottom right corner is atmospheric oxygen (O_2) measurements from Alert, Canada (pink) and Cape Grim, Australia (cyan) (IPCC AR4 2.3.1 adapted from Manning 2006).

The Royal Swedish Academy of Sciences has decided to award
the Nobel Prize in Physics 2021

SYUKURO MANABE KLAUS HASSELMANN

"for the physical modelling of Earth's climate, quantifying variability
and reliably predicting global warming"

GIORGIO PARISI

"for the discovery of the interplay of disorder and fluctuations in
physical systems from atomic to planetary scales"

Syukuro Manabe Facts



Syukuro Manabe
The Nobel Prize in Physics 2021

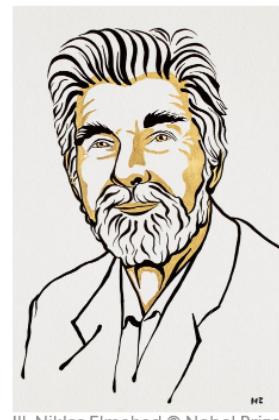
Born: 21 September 1931, Shingu, Ehime Prefecture, Japan

Affiliation at the time of the award: Princeton University,
Princeton, NJ, USA

Prize motivation: "for the physical modelling of Earth's
climate, quantifying variability and reliably predicting global
warming."

Prize share: 1/4

Klaus Hasselmann Facts



Klaus Hasselmann
The Nobel Prize in Physics 2021

Born: 25 October 1931, Hamburg, Germany

Affiliation at the time of the award: Max Planck Institute for
Meteorology, Hamburg, Germany

Prize motivation: "for the physical modelling of Earth's
climate, quantifying variability and reliably predicting global
warming."

Prize share: 1/4

Mudanças Climáticas, evidências, impactos e mitigação: Algumas instituições que podem ser consultadas....

[IPCC Website](#)

[WMO Climate Pages](#)

[Global Framework
For Climate Services
\(GFCs\)](#)

[World Climate
Programme \(WCP\)](#)

[World Bank Climate
Change Knowledge
Portal](#)

[NASA Global
Climate Change](#)

[ESA Climate Change
Initiative](#)

[NCAR Community
Data Portal](#)

[Max Planck: The
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[The Guardian
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Warming](#)

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Climate Change

From the unique vantage point in space, NASA collects critical long-term observations of our changing planet.

VITAL SIGNS

Show All 

Carbon Dioxide

 **427** parts per million

Global Temperature

 **1.4** °C since preindustrial

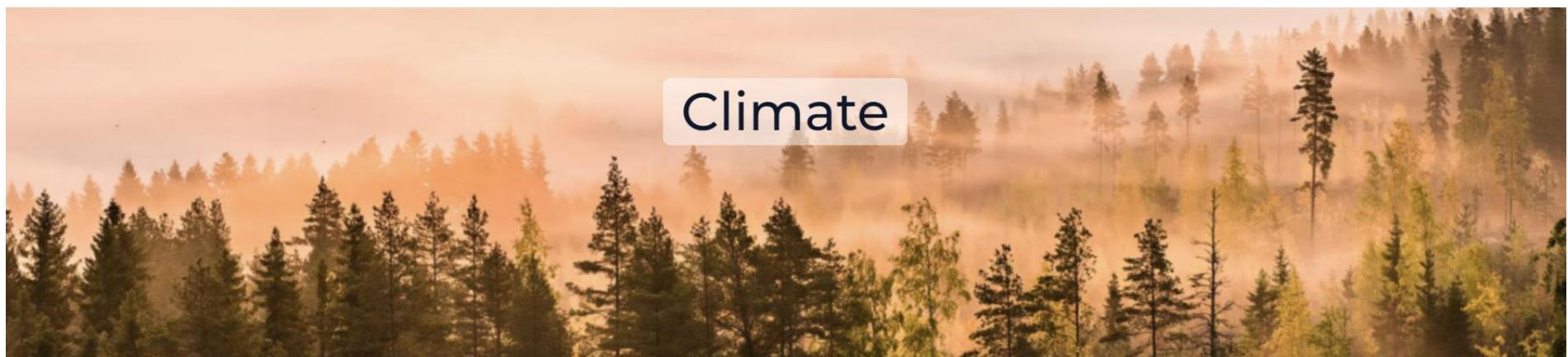
Methane

 **1932** parts per billion

Arctic Sea Ice Minimum Extent

 **12.2** percent per decade since 1979



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Climate

1.45°C

The global mean temperature in 2023 was about 1.45°C above the 1850-1900 average.

2023

The warmest year on record, because of long-term climate change and the effect of 2023/2024 El Niño episode

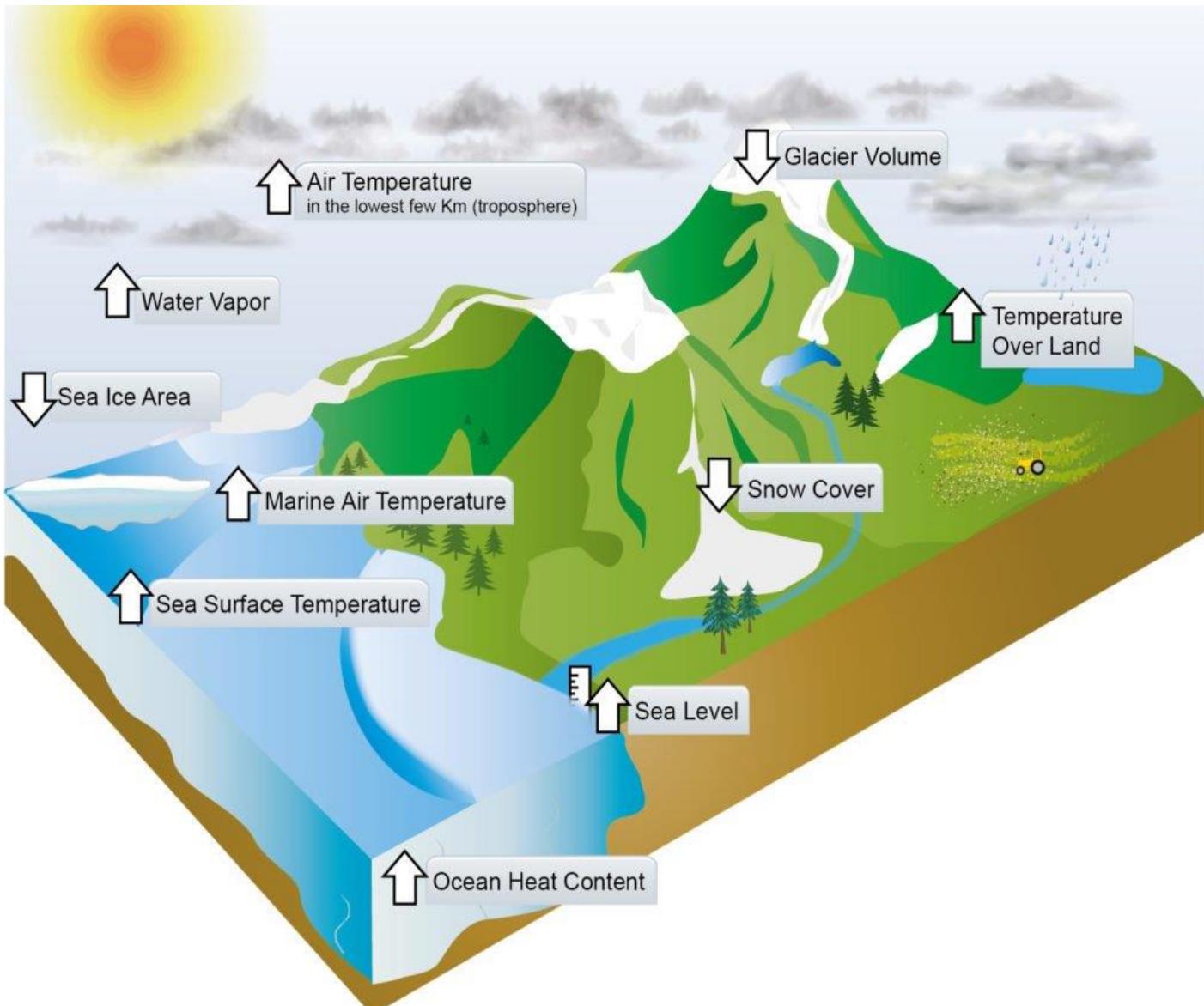
90%

The ocean absorbs approximately 90% of energy in the climate system, warming it to record levels in 2023.

110mm (4.3 in)

Global sea level increased to a new high in 2023, since the beginning of the satellite altimetry measurement in 1993.

EFEITO ESTUFA



Componentes que estão sendo modificadas e que estão de acordo com o esperado para uma aumento da temperatura média do planeta e do aquecimento global. IPCC 2013

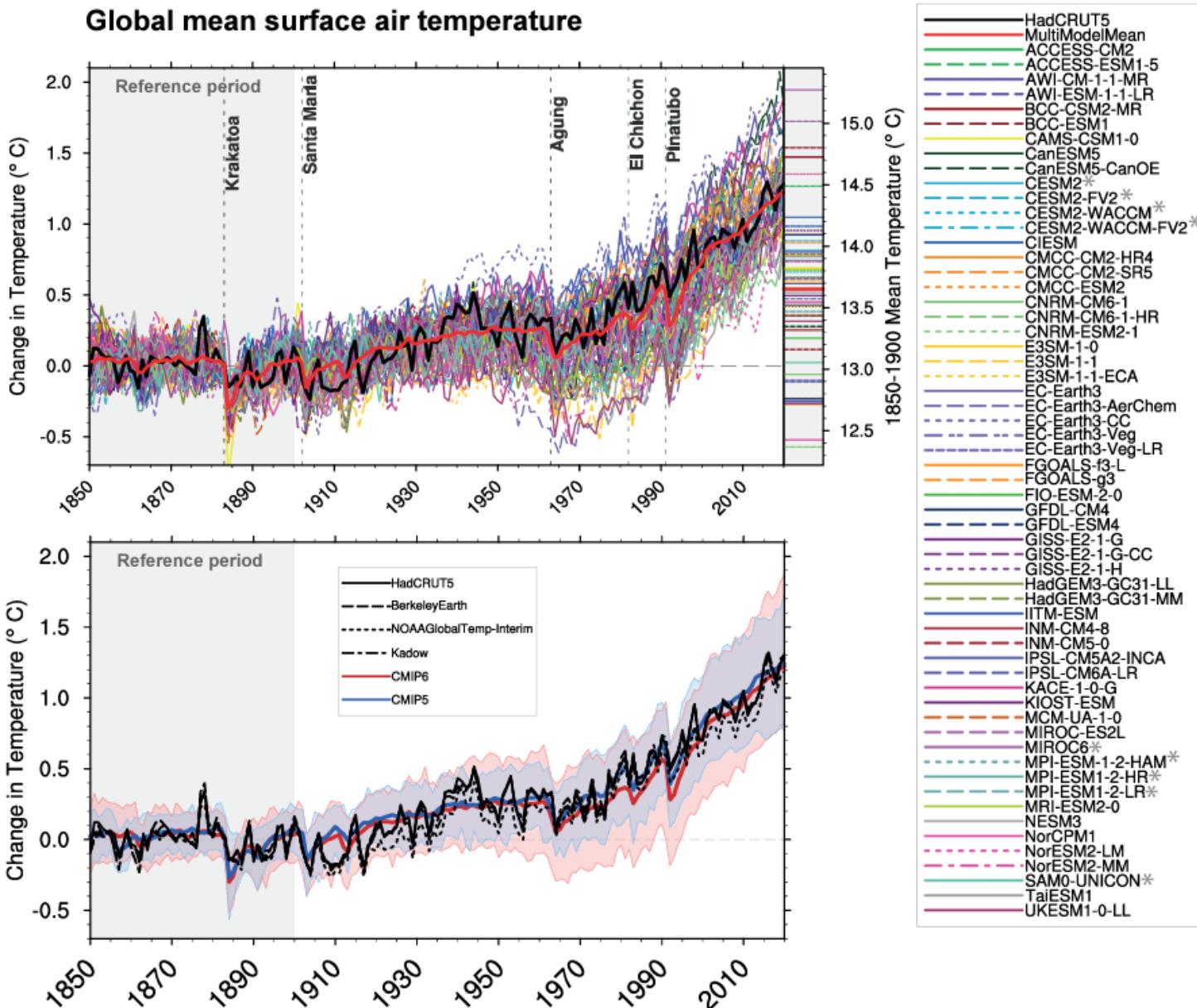
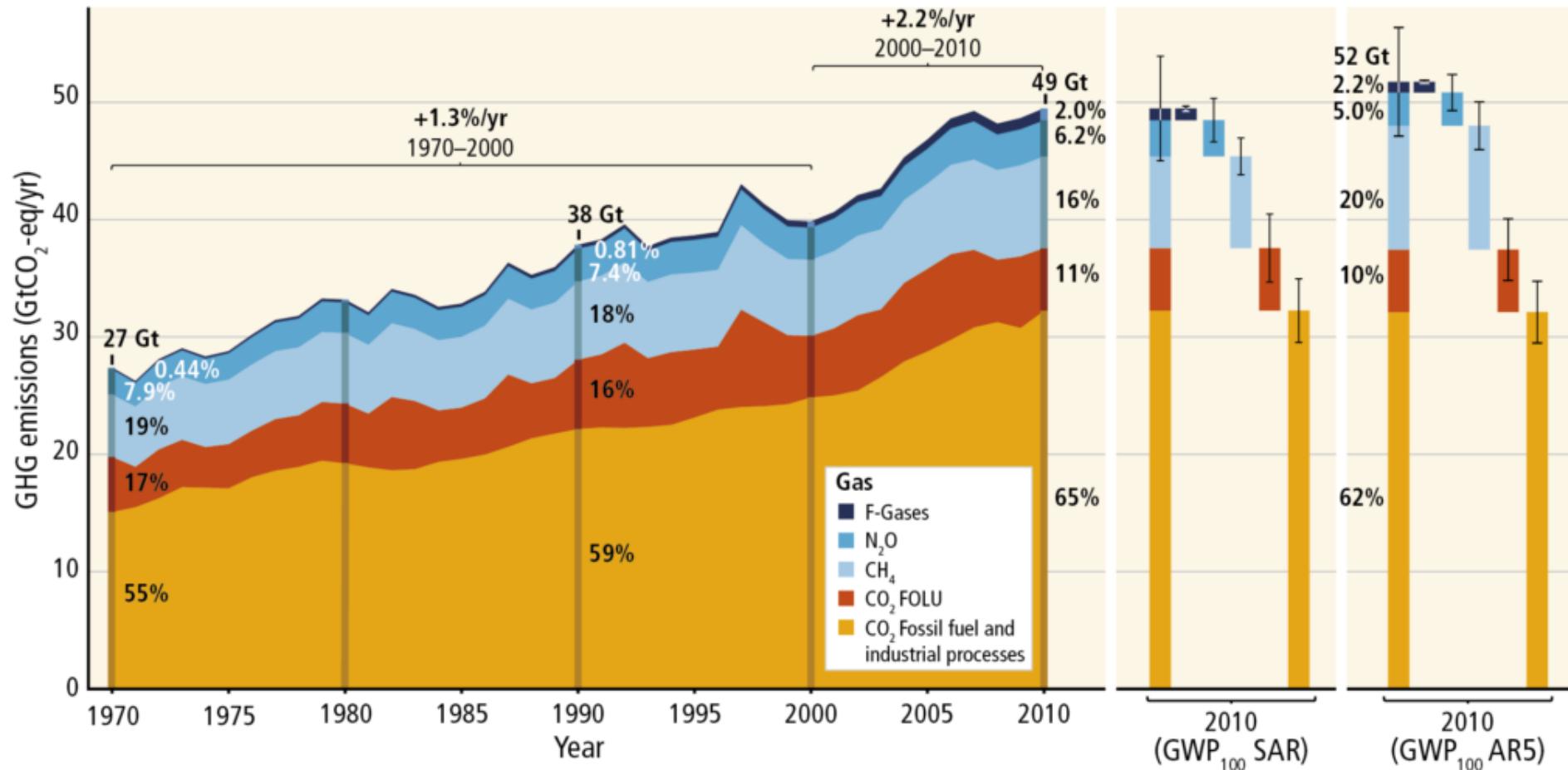


Figure 3.4 | Observed and simulated time series of the anomalies in annual and global mean surface air temperature (GSAT). All anomalies are differences from the 1850–1900 time-mean of each individual time series. The reference period 1850–1900 is indicated by grey shading. (a) Single simulations from CMIP6 models (thin lines) and the multi-model mean (thick red line). Observational data (thick black lines) are from the Met Office Hadley Centre/Climatic Research Unit dataset (HadCRUT5), and are blended surface temperature (2 m air temperature over land and sea surface temperature over the ocean)

Causes of changes: Global Emissions

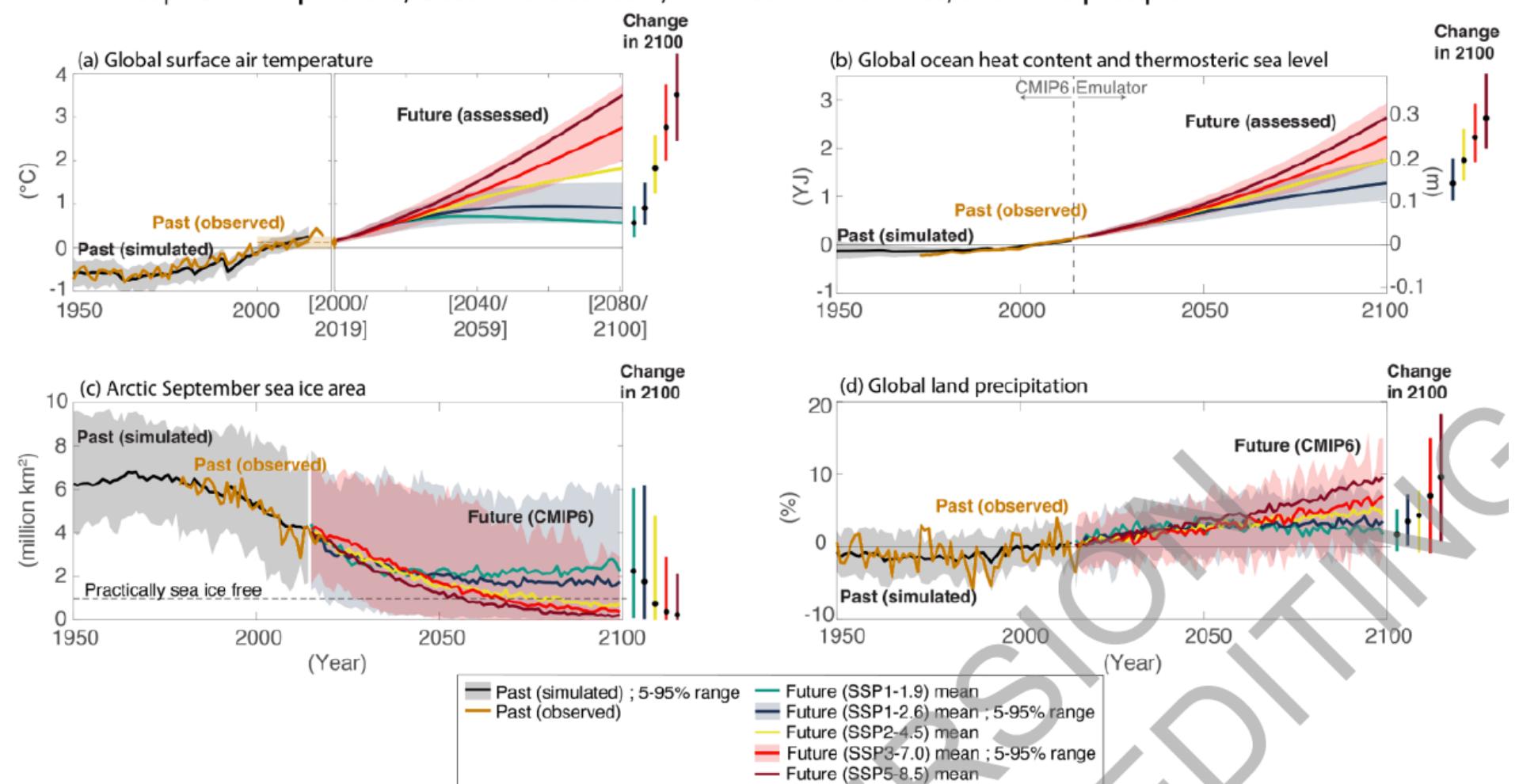
Total annual anthropogenic GHG emissions by gases 1970–2010



Impacts, Adaptation and Vulnerability

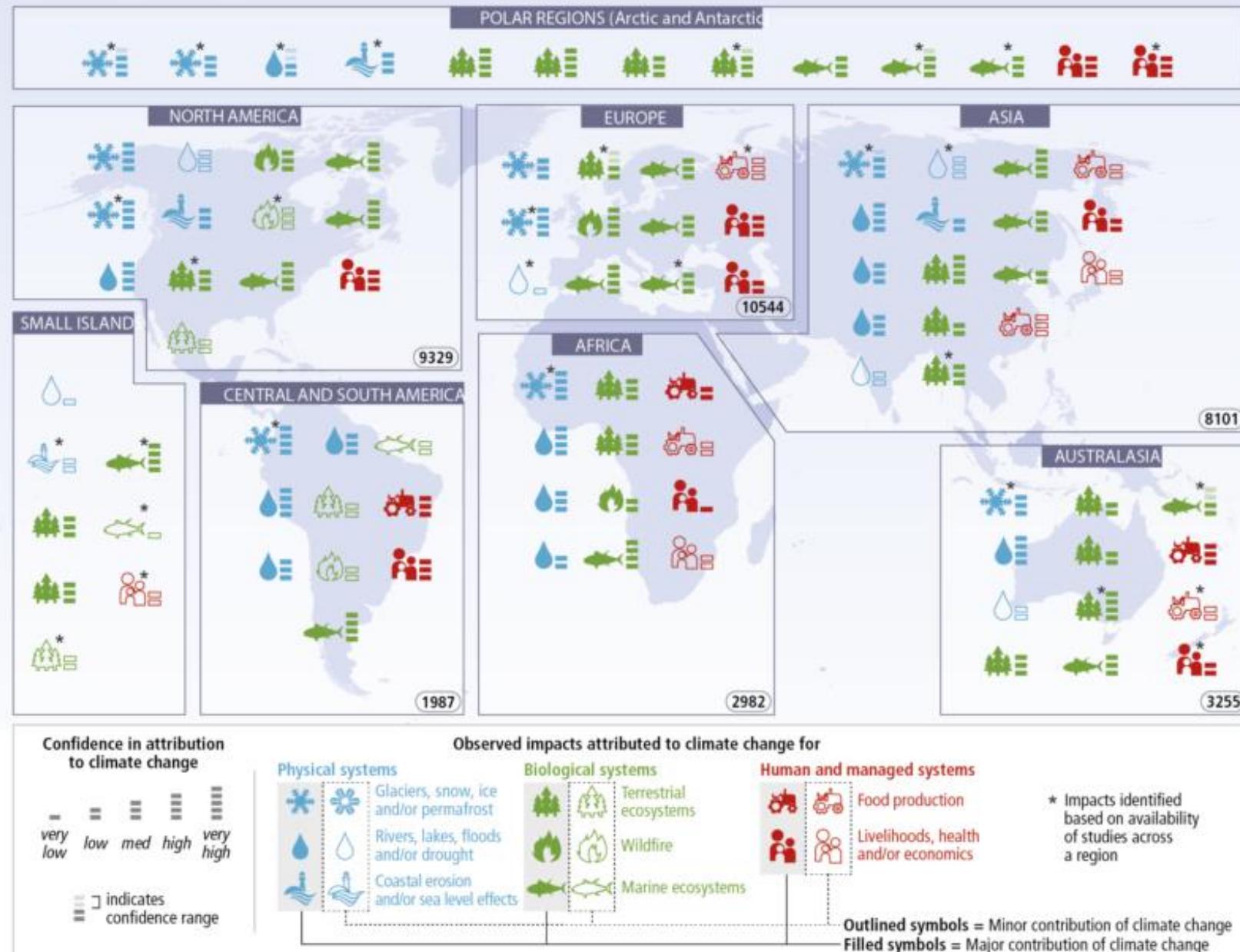
Recent and Future change of 4 key indicators of the climate system

Atmospheric temperature, Ocean heat content, Arctic summer sea-ice, and Land precipitation

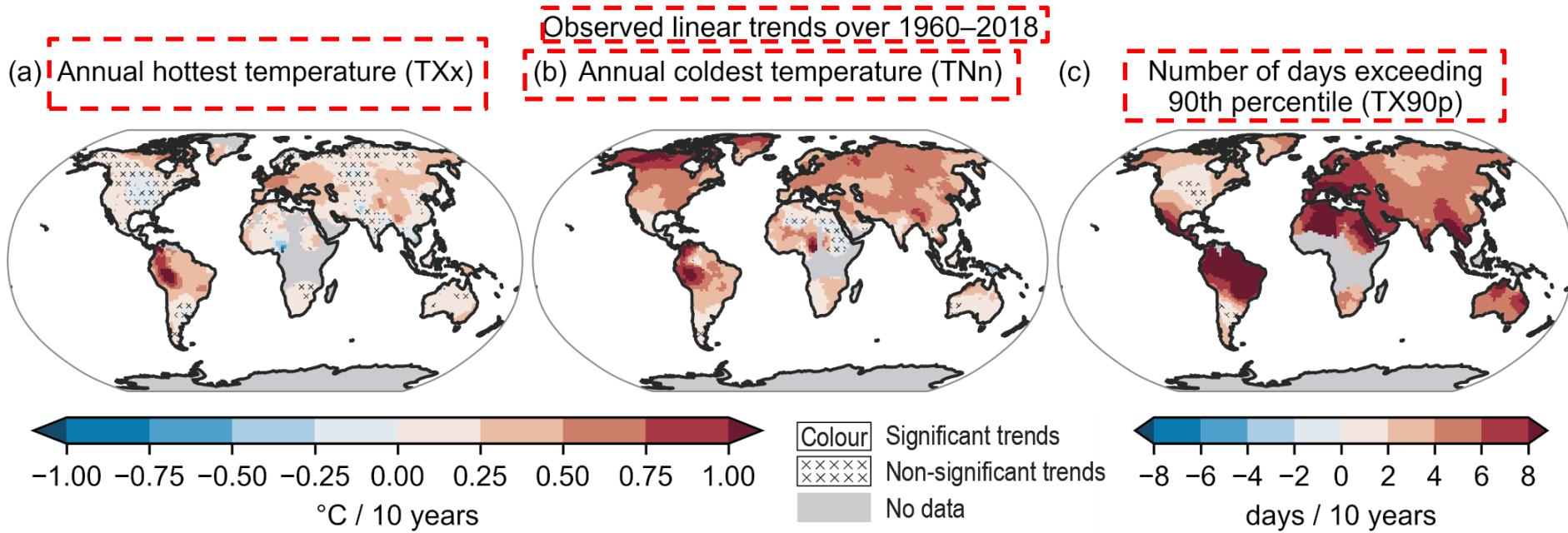


Observed, simulated and projected changes compared to the 1995–3 2014 average in 4 key indicators of the climate system through to 2100 differentiated by SSP scenario pathway. Past simulations are based on the CMIP6 multi-model ensemble. Future projections are based on the assessed ranges based upon multiple lines of evidence for (a) global surface temperature (Cross-Section Box TS.1) and (b) global ocean heat content and the associated thermosteric sea level contribution to Global Mean Sea Level (GMSL) change (right-hand axis) using a climate model emulator (Cross-Chapter Box 7.1), and CMIP6 simulations for (c) Arctic September sea ice and (d) Global land precipitation. SSP1-1.9 and SSP1-2.6 projections show that reduced GHG emissions lead to a stabilization of global surface temperature, Arctic sea ice area and global land precipitation over the 21st century. SSP1-2.6 shows that emissions reductions have the potential to substantially reduce the increase in ocean heat content and thermosteric sea level rise over the 21st century but that some increase is unavoidable

(a) Widespread impacts attributed to climate change based on the available scientific literature since the AR4



EVENTOS EXTREMOS



TXx maior temperatura do ano está aumentando (a cada 10 anos).

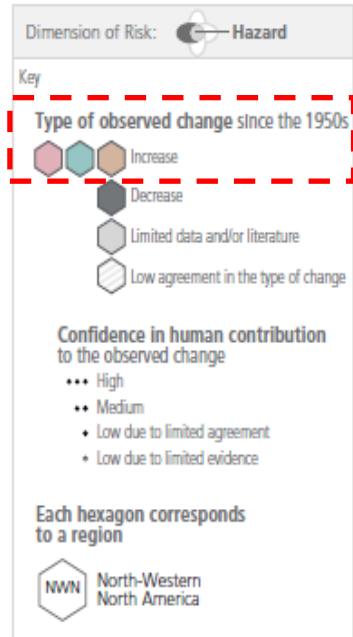
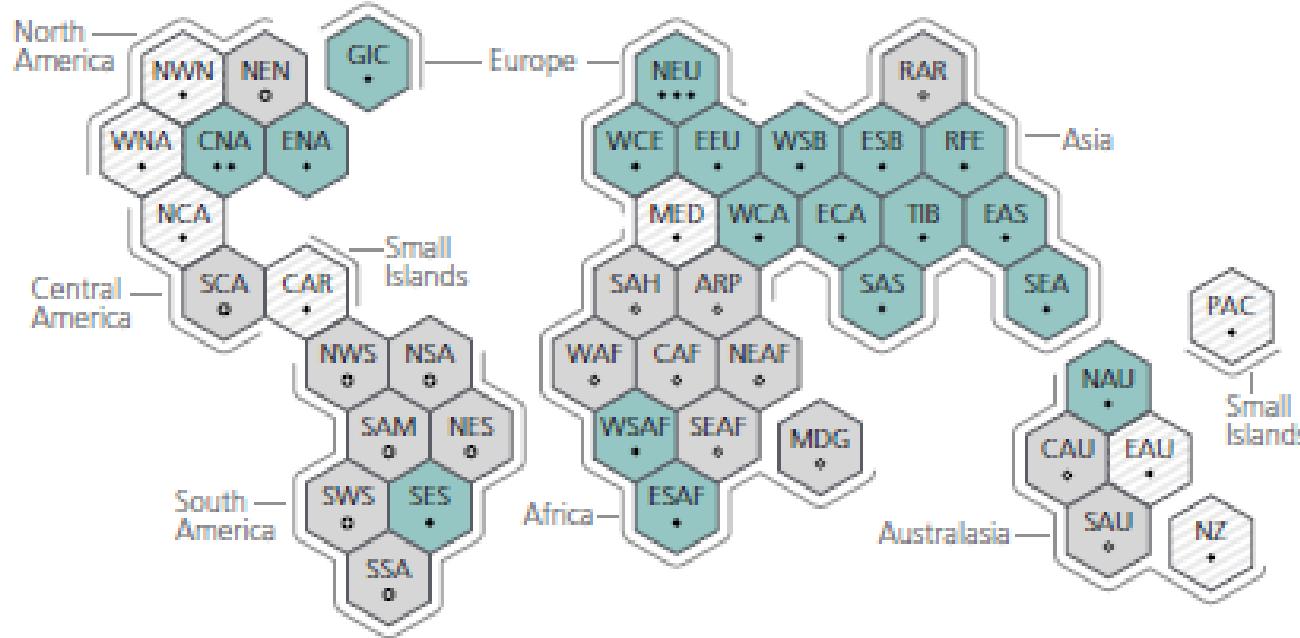
TNn mais fria do ano (geralmente a noite) está aumentando (a cada 10 anos).

Nº de dias que possuem temperaturas maiores do que os 90% da distribuição (a cada 10 anos).

EVENTOS EXTREMOS

Section 2

Heavy precipitation



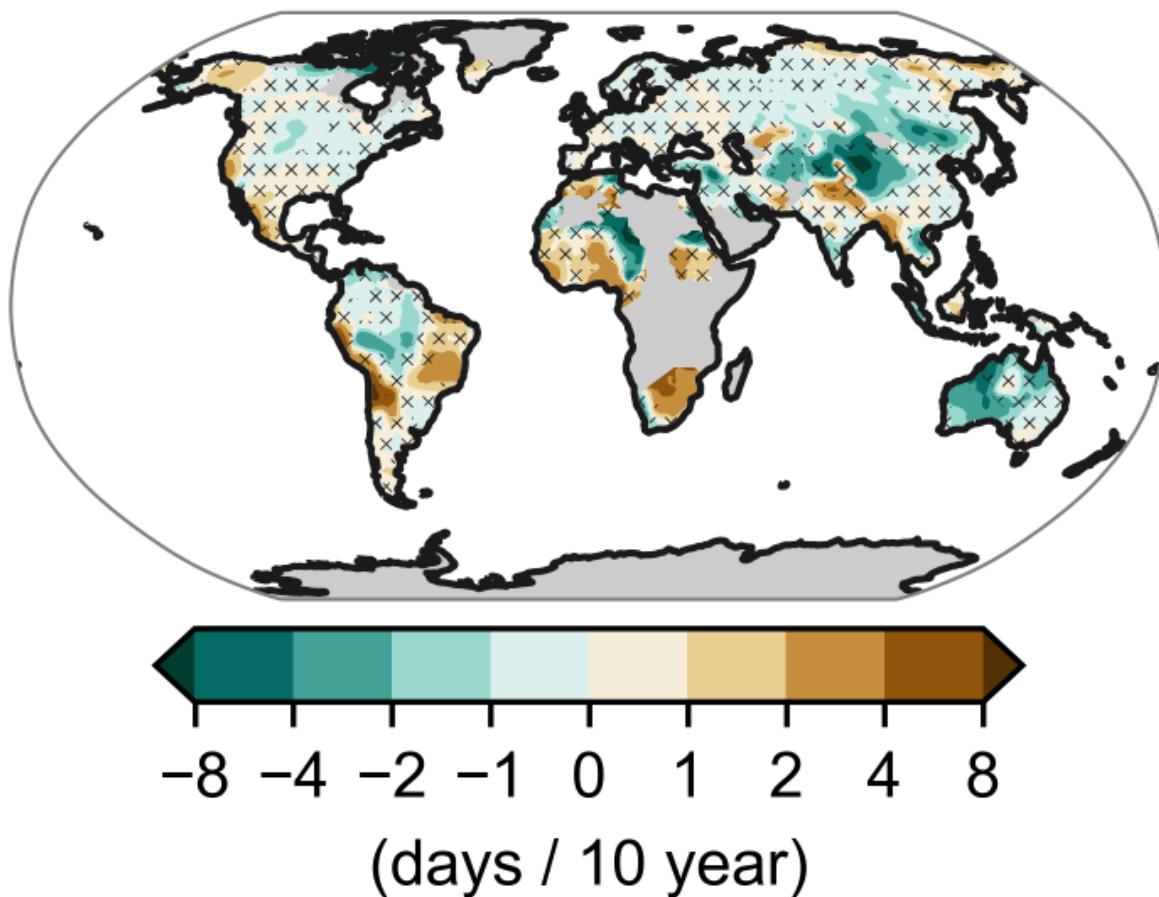
SES (Sudeste da América do Sul)

Aumento: Confiança baixa devido a concordância limitada

EVENTOS EXTREMOS

(a) Consecutive dry days (CDD)

Observed Trends (1960-2018)



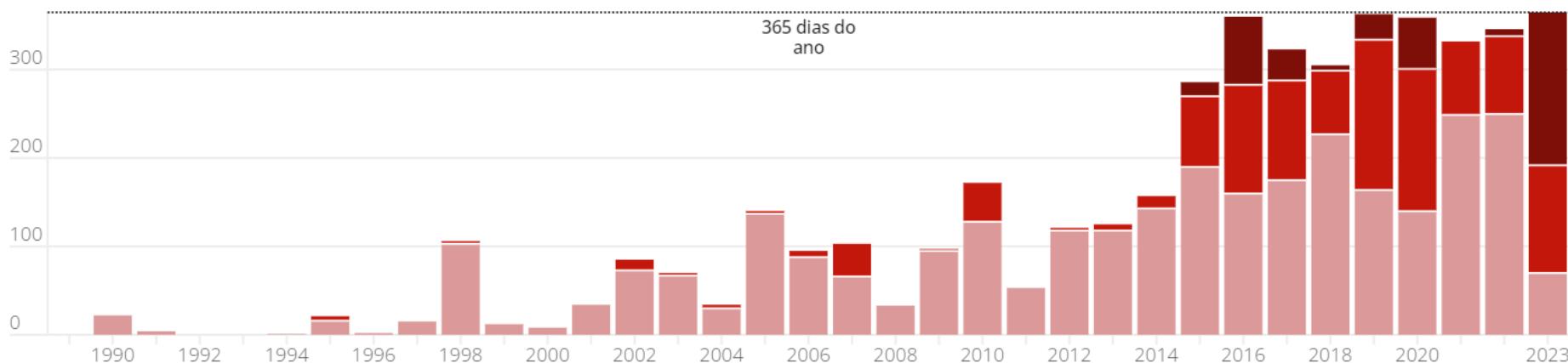
**CDD = Dias Consecutivos de Seca
(Confiança média)
diretamente ação humana
(a cada 10 anos)**

05/06/2024

Dias com temperatura acima da média pré-industrial

Dados são do Copernicus e consideram o número de dias em que a temperatura do planeta ultrapassou (em mais de 1°C) a média de 1850-1900, o período pré-industrial.

■ entre 1°C e 1.25°C ■ entre 1.25°C e 1.5°C ■ acima de 1.5°C



g1

Fonte: ERA5/C3S/ECMWF

<https://g1.globo.com/meio-ambiente/noticia/2024/06/05/mundo-tem-o-12o-mes-consecutivo-de-recorde-de-calor-e-temperatura-global-anual-deve-exceder-limite-de-15c.ghtml>

c) Observed impacts and related losses and damages of climate change

HUMAN SYSTEMS

		Global	Africa	Asia	Australasia	Central & South America	Europe	North America	Small Islands
Water availability and food production	Physical water availability	•	•
	Agriculture/crop production
	Animal and livestock health and productivity	...	•	•	•	•	•	•	..
	Fisheries yields and aquaculture production
Health and wellbeing	Infectious diseases	•
	Heat, malnutrition and harm from wildfire
	Mental health	...	-	/	-
	Displacement	/	..	-
Cities, settlements and infrastructure	Inland flooding and associated damages	•	•
	Flood/storm induced damages in coastal areas	•
	Damages to infrastructure
	Damages to key economic sectors

Dimension of Risk: Impact

Key

Increased climate impacts

HUMAN SYSTEMS

- Adverse impacts
- Adverse and positive impacts

ECOSYSTEMS

- Climate-driven changes observed, no assessment of impact direction

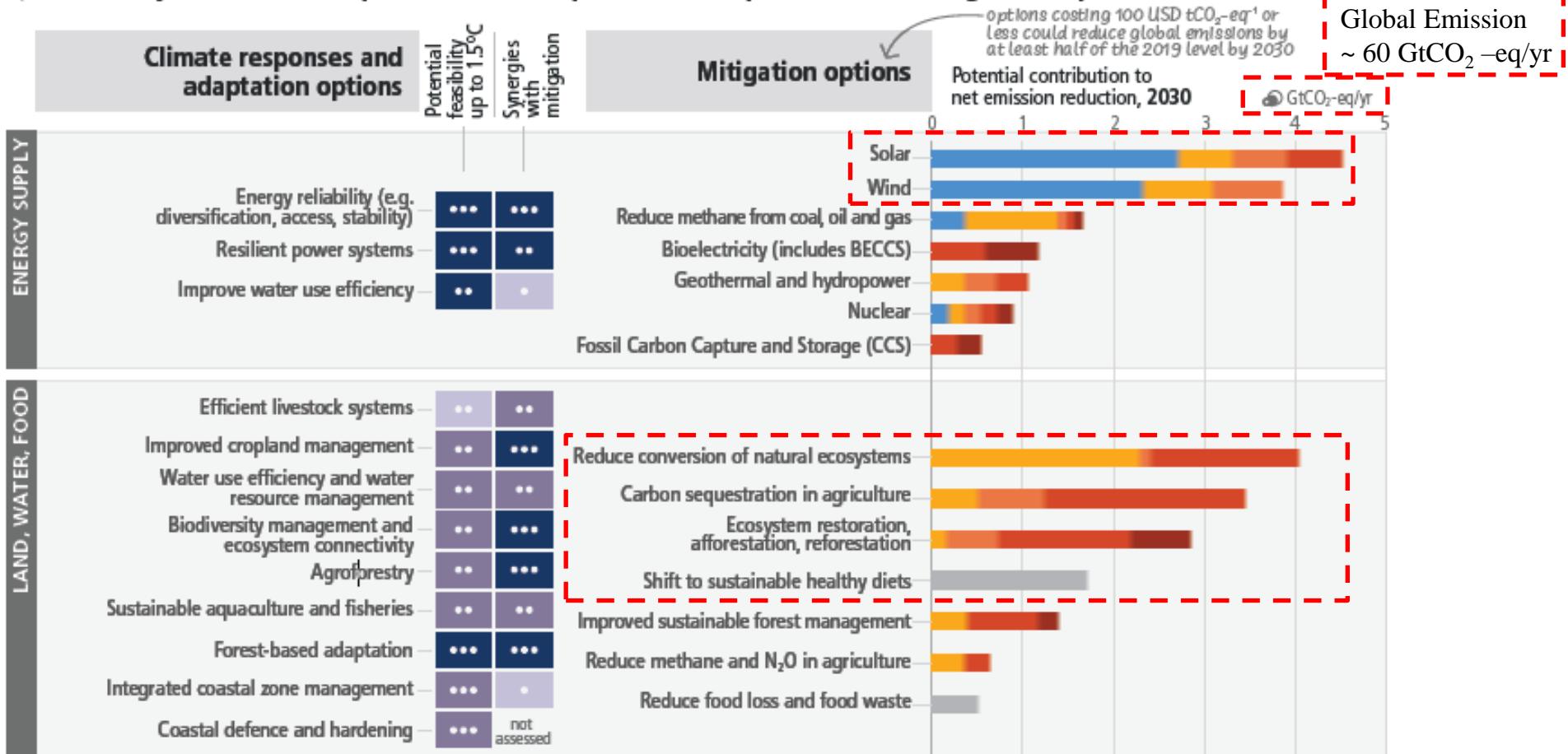
Confidence in attribution to climate change

- High or very high
- Medium
- Low
- Evidence limited, insufficient
- / Not assessed

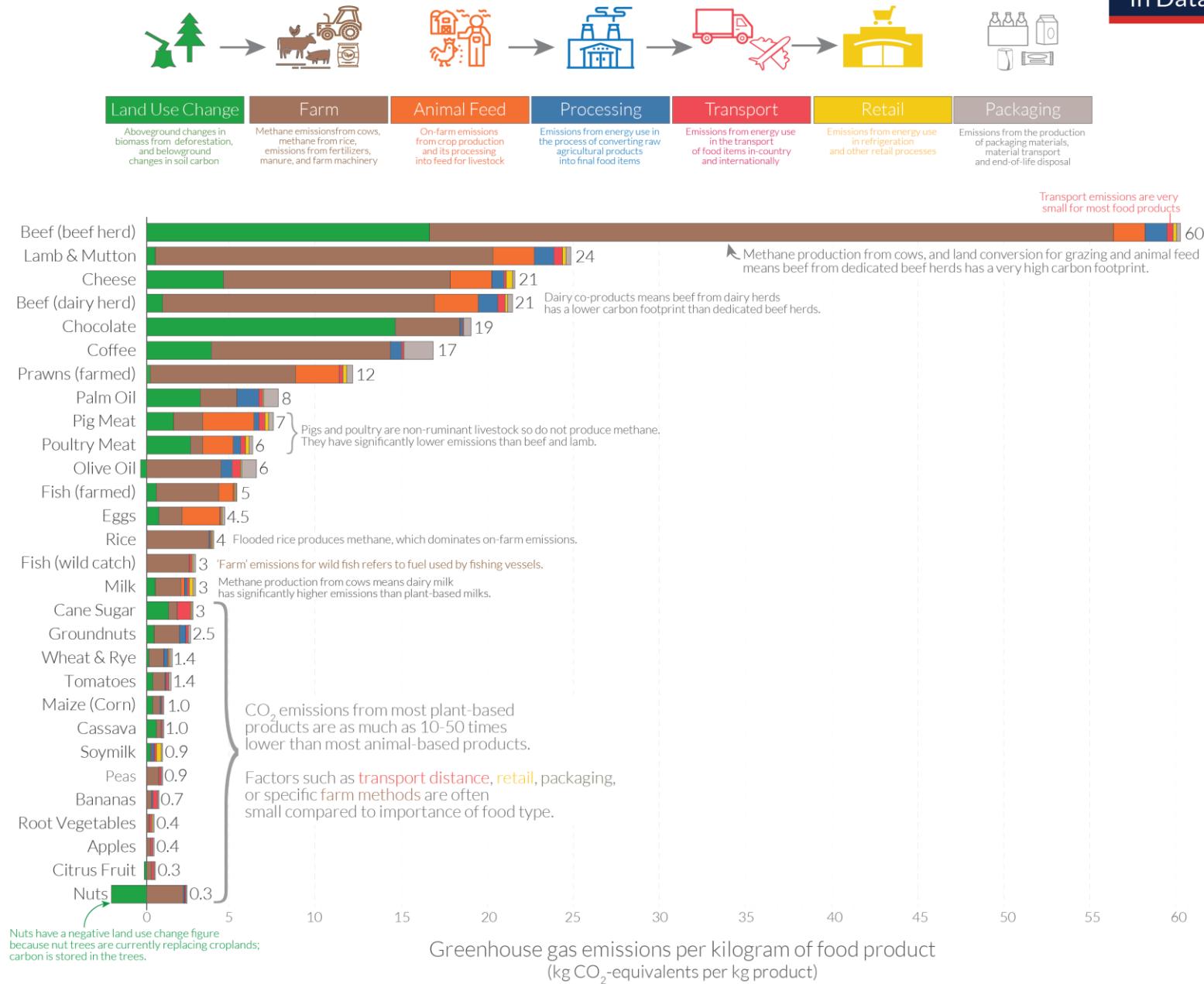
Mitigation of Climate Change

There are multiple opportunities for scaling up climate action

a) Feasibility of climate responses and adaptation, and potential of mitigation options in the near term



Food: greenhouse gas emissions across the supply chain



Note: Greenhouse gas emissions are given as global average values based on data across 38,700 commercially viable farms in 119 countries.

Data source: Poore and Nemecek (2018). Reducing food's environmental impacts through producers and consumers. *Science*. Images sourced from the Noun Project.

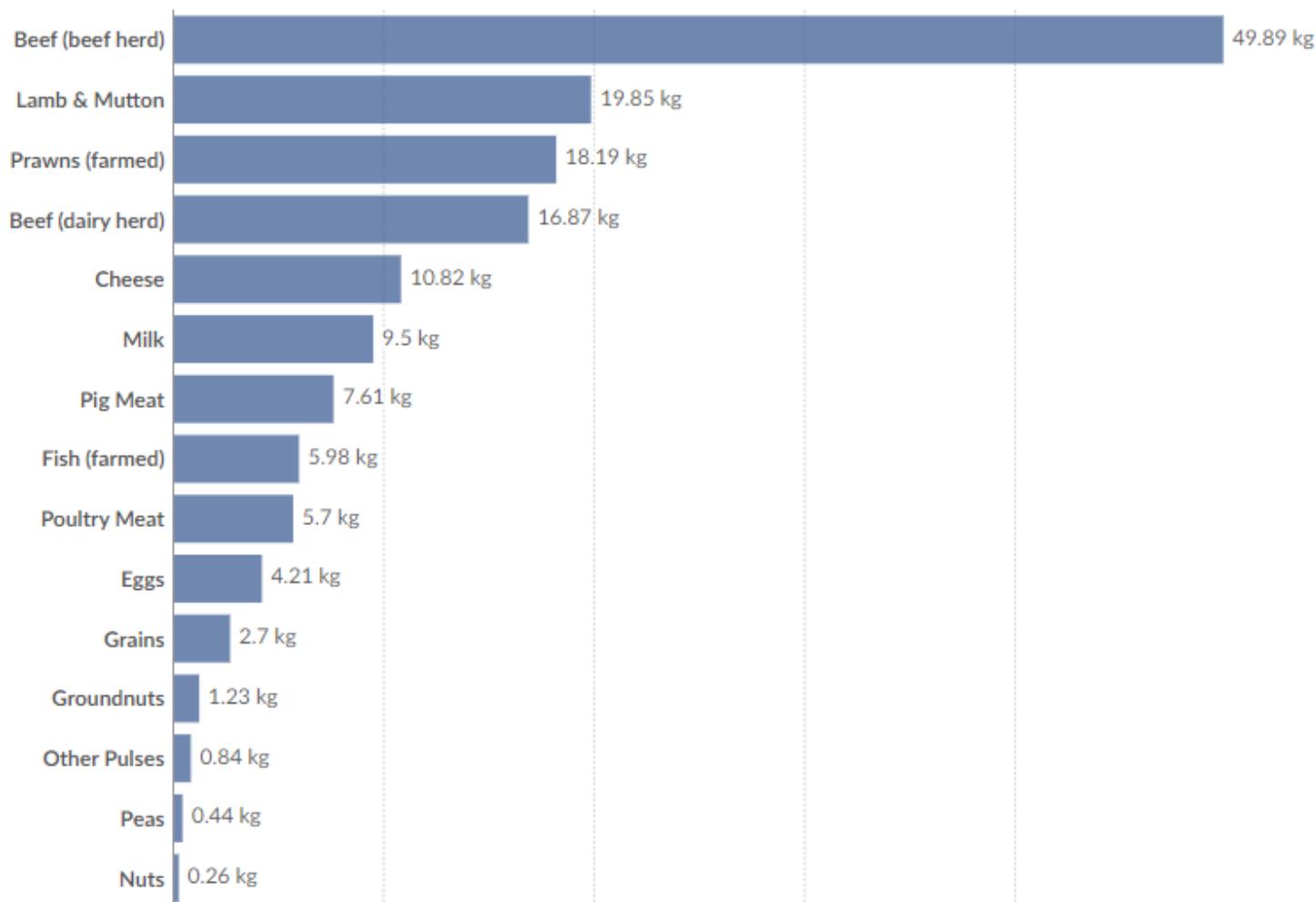
OurWorldInData.org – Research and data to make progress against the world's largest problems.

Licensed under CC-BY by the author Hannah Ritchie.

Greenhouse gas emissions per 100 grams of protein

Greenhouse gas emissions are measured in kilograms of carbon dioxide-equivalents.

Table Chart



Data source: Poore and Nemecek (2018) – [Learn more about this data](#)

OurWorldInData.org/environmental-impacts-of-food | CC BY



Related: [FAQs: Data on the environmental impacts of food](#)

Inventário Emissões

Estimativa de Emissões e Remoções de Gases de Efeito Estufa (CO₂e GWP) no Brasil em 2018*

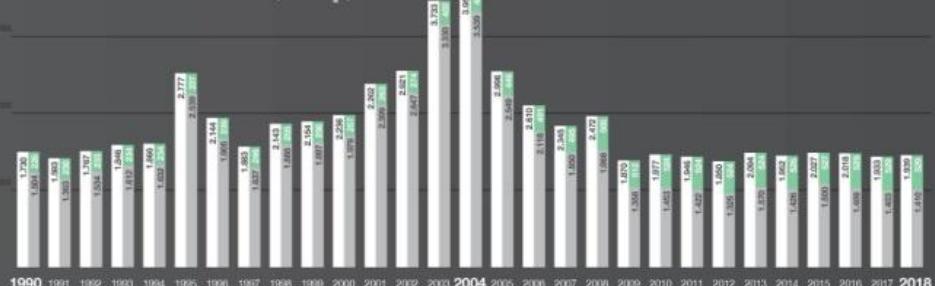
Para obter mais dados e nota metodológica, acesse seeg.eco.br.

GEE BRASIL 2018

EMISSÕES BRUTAS

EMISSÕES LÍQUIDAS

HISTÓRICO DE EMISSÕES
BRUTAS E LIQUIDAS 1990-2018 (Mt CO₂e)*



REMOÇÕES

1.939 Mt CO₂e

529 Mt CO₂e

1.410 Mt CO₂e

EMISSÕES
TOTAIS POR
ESTADO (Mt CO₂e)*

- 201 a 300
- 151 a 200
- 101 a 150
- 51 a 100
- 26 a 50
- 0 a 25

BRASIL: O SÉTIMO MAIOR
EMISSOR DE GASES DE
EFEITO ESTUFA (GEE)

- | Rank | País | Emissões (Mt CO ₂ e) |
|------|----------------------|---------------------------------|
| 1º | China | ~13.000 |
| 2º | EUA | ~12.000 |
| 3º | UE (27) | ~4.000 |
| 4º | Índia | ~3.000 |
| 5º | Indonésia | ~2.000 |
| 6º | Rússia | ~1.800 |
| 7º | BRASIL (3,4%) | ~1.410 |
| 8º | Japão | ~1.200 |
| 9º | Canadá | ~1.000 |
| 10º | Alemanha | ~800 |



ENERGIA

408

Produção de
combustíveis,
Queima de
combustíveis.

AGRO
PECUÁRIA

492

Fermentação entérica,
Manejos de animais.
Cultivo do arroz.
Queima de resíduos.
Solos agrícolas.

RESÍDUOS

92

Fluentes líquidos.
Resíduos sólidos.

INDÚSTRIA

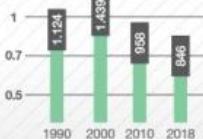
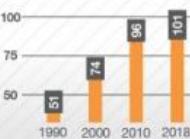
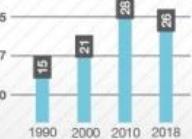
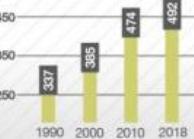
101

Emissões de HFCs.
Indústria química.
Produção de metais.
Produtos minerais.
Outros.

USO DA
TERRA

846

Alterações
de uso do solo.
Resíduos florestais.
Calagem.



<http://seeg.eco.br/infografico>

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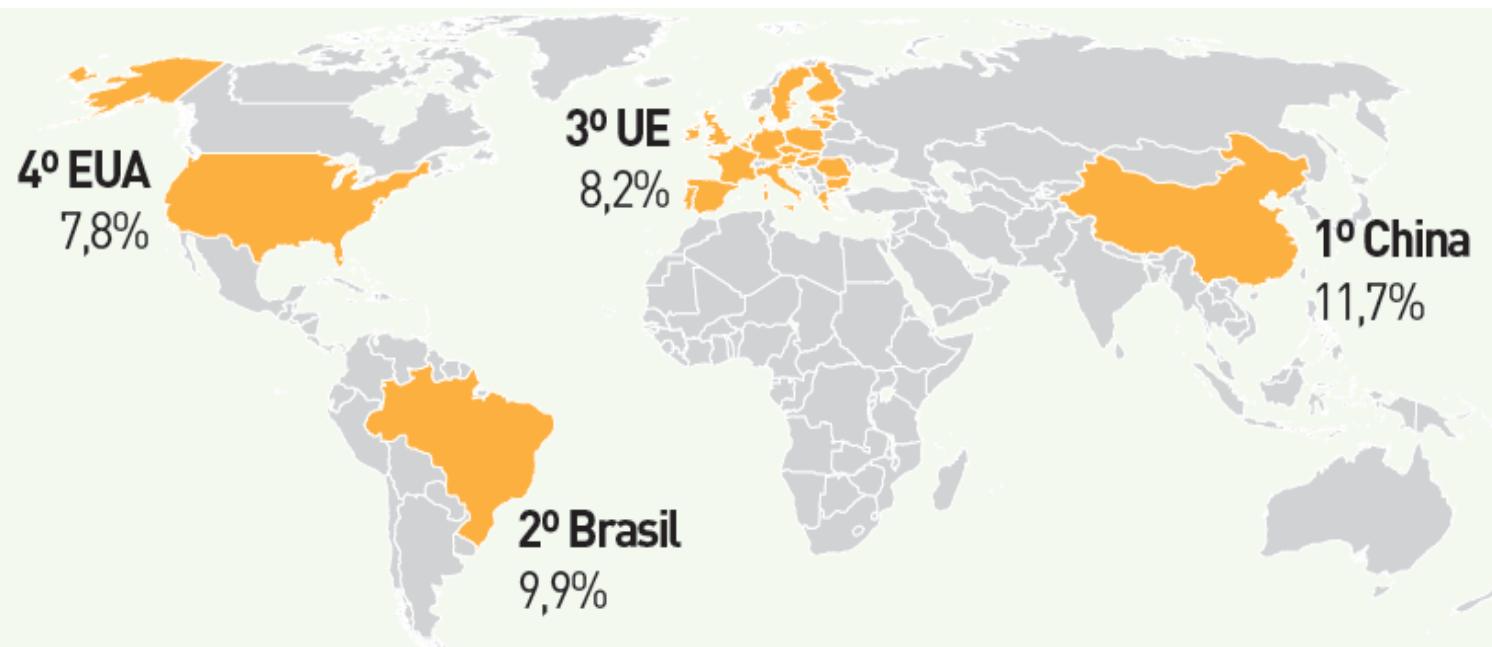
Costa Rica



Côte d'Ivoire

Agricultura + Pecuária

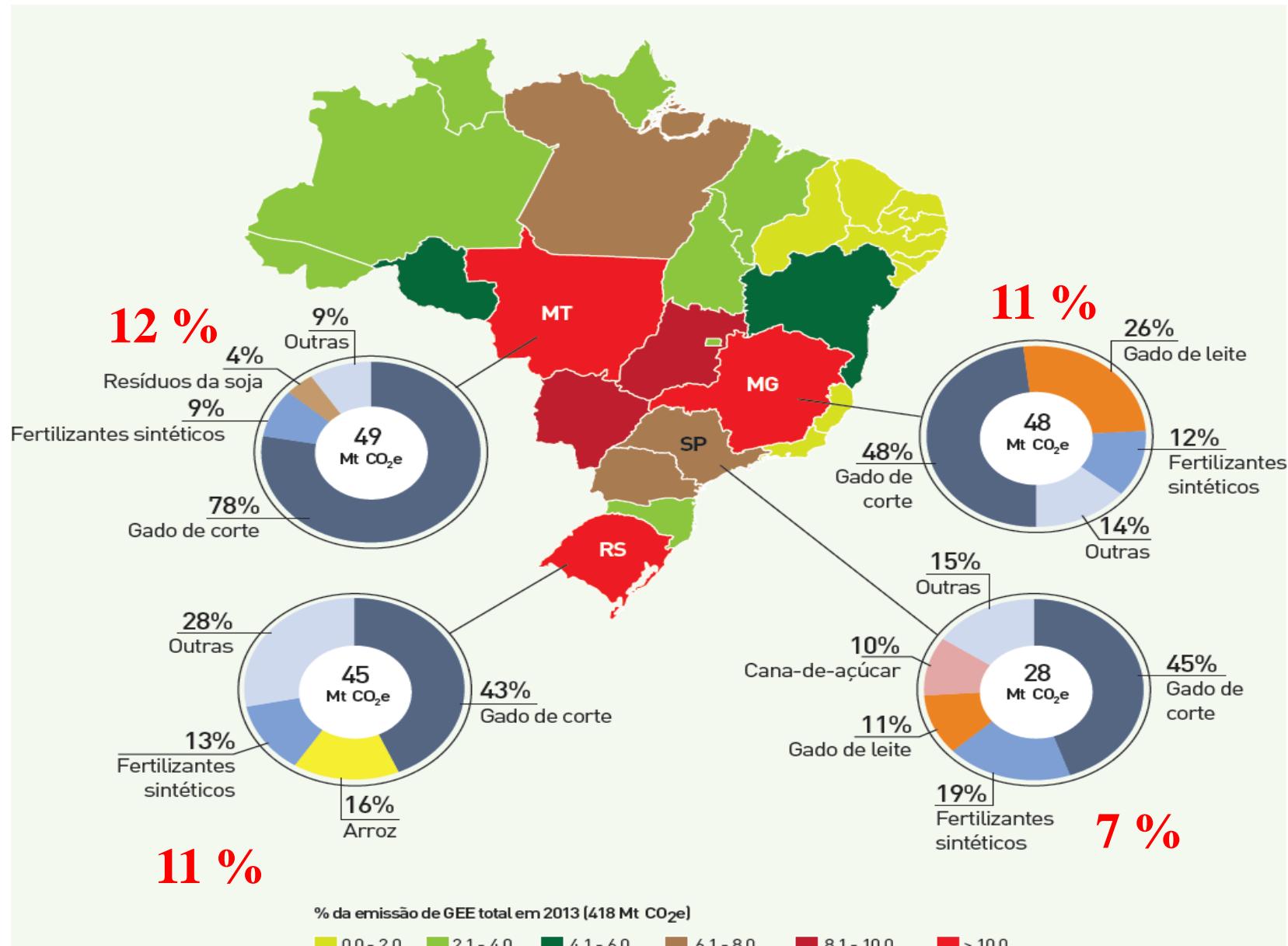
Ranking das emissões de GEE



[Fonte: WRI – <http://cait2.wri.org>)

Figura 6: ranking das emissões de GEE mundiais pela agropecuária em 2011

Brazil – Relative contribution of emission (Agricultural sector)



Source: Observatório do clima, 2015

<http://seeg.eco.br/analise-de-emissoes-brasileiras-de-gee-no-brasil-1970-2013/>

Como reduzir as emissões de GEE agricultura?

SUBPROGRAMA	ÁREA ATUAL 2010	EXPANSÃO ENTRE 2010 E 2020	REDUÇÃO DE EMISSÃO DE GEE 2010/2020
Recuperação de pastagens degradadas Subsídios para manejo e adubação. Base de cálculo foi de 3,79 Mg de CO ₂ e.ha ⁻¹ .ano ⁻¹ .	40 milhões de ha	15 milhões de ha	83 a 104 milhões de t CO ₂ e
Integração Lavoura-Pecuária-Floresta (ILPF) Adoção de sistemas pecuários integrados com agricultura e/ou floresta, incluindo sistemas agroflorestais (SAFs). Base de cálculo foi de 3,79 Mg de CO ₂ e.ha ⁻¹ .ano ⁻¹ .	2 milhões de ha	4 milhões de ha	18 a 22 milhões de t CO ₂ e
Sistema Plantio Direto (SPD) Implementação de SPD. Base de cálculo foi de 1,83 Mg de CO ₂ e.ha ⁻¹ .ano ⁻¹ .	25 milhões de ha	8 milhões de ha	16 a 20 milhões de t CO ₂ e
Fixação Biológica do Nitrogênio (FBN) Adoção de sistemas com plantio de leguminosas. Base de cálculo foi de 1,83 Mg de CO ₂ e.ha ⁻¹ .ano ⁻¹ .	11 milhões de ha	5,5 milhões de ha	10 milhões de t CO ₂ e
Florestas Plantadas Plantio comercial de árvores. Não está computado o compromisso brasileiro relativo ao setor da siderurgia, e não foi contabilizado o potencial de mitigação de emissão de GEE.	6 milhões de ha	3 milhões de ha	10 milhões de t CO ₂ e (potencial de captura)
Tratamento de dejeto animais Produção de biogás e fertilizante orgânico Base de cálculo foi de 1,56 Mg de CO ₂ e.m ⁻³ .		4,4 milhões de m ³ tratados	6,9 milhões de t CO ₂ e
Adaptação às Mudanças Climáticas	Ainda não foram estabelecidas as ações de adaptação		
Total de redução prevista até 2020			144 a 173 milhões de t CO₂e*



ANÁLISE DAS EMISSÕES BRASILEIRAS DE

Gases de Efeito Estufa

E SUAS IMPLICAÇÕES PARA AS METAS
DE CLIMA DO BRASIL
1970-2019

2020

01 PANORAMA GERAL DAS EMISSÕES BRASILEIRAS

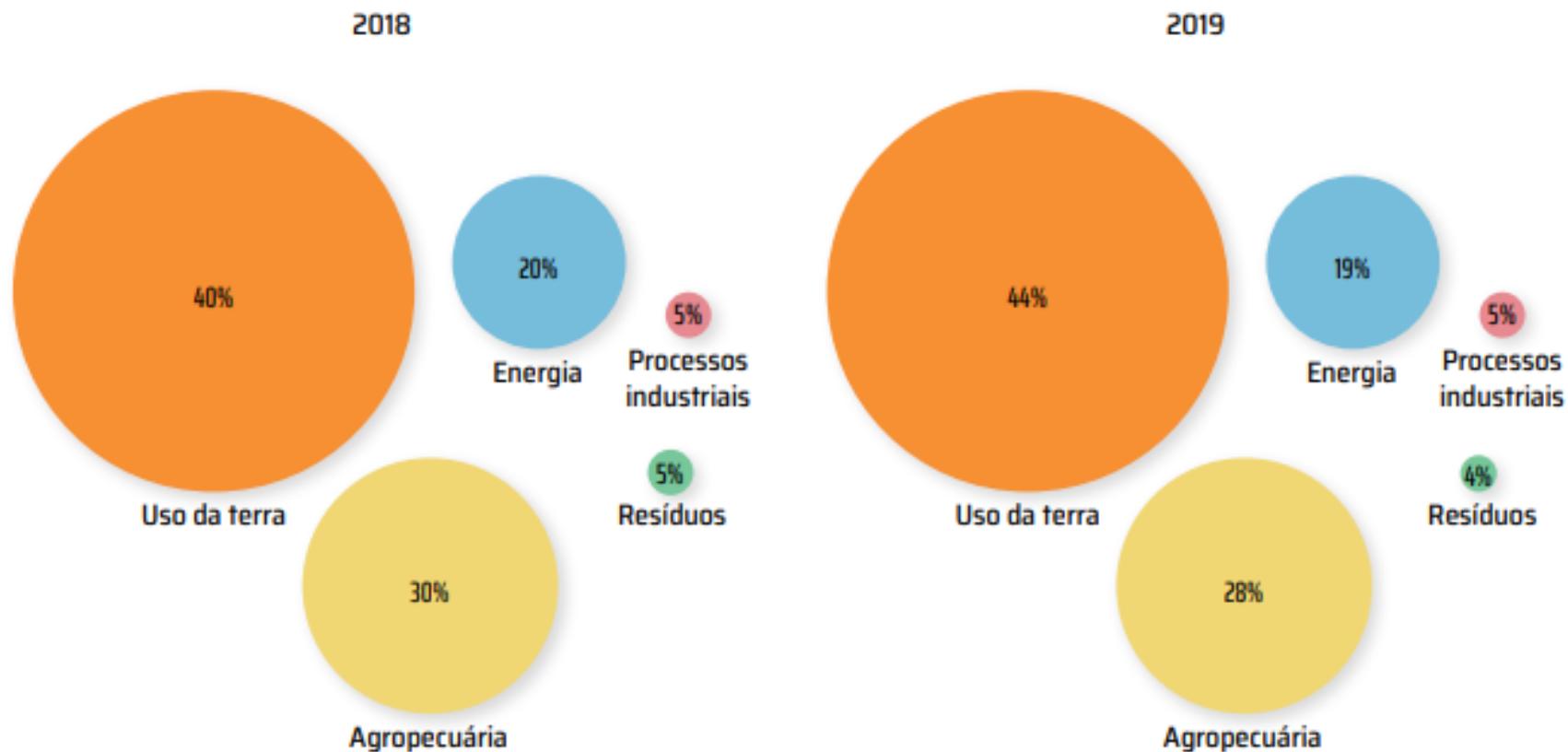


Figura 2 - Participação dos setores no perfil das emissões brasileiras



É PRECISO CONTABILIZAR O CARBONO NO SOLO

As mudanças no Quarto Inventário fizeram as emissões do setor de agropecuária crescer. É uma má notícia por um lado, porque mostra que a lição de casa do setor para que o Brasil cumpra suas metas no Acordo de Paris é maior. Por outro lado, também indica que o setor está fazendo esforços para entender melhor suas emissões - e mitigá-las. Uma peça importantíssima nesse esforço precisa ser a contabilização do balanço de carbono sequestrado no solo.

Desde 2015 o SEEG vem calculando e reportando em separado o carbono emitido principalmente por pastagens degradadas e o carbono sequestrado por pastagens bem manejadas. Essas emissões e remoções não entram na contabilidade do inventário nacional, mas é de interesse do agronegócio que sejam monitoradas e incluídas: à medida que a meta de recuperação de pastagens degradadas (30 milhões de hectares até 2030, somando-se os compromissos da PNMC e da NDC) for cumprida, será fundamental entender como ela pode ajudar a reduzir o sinal de carbono da agropecuária.

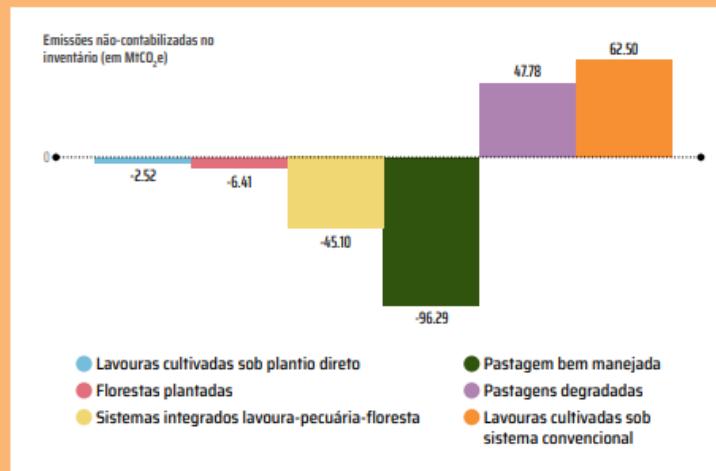
Em 2019, o balanço entre as fontes de remoção de carbono (florestas plantadas, lavouras sob sistema de plan-

tio direto, pastos bem manejados e sistemas integrados Lavoura-Pecuária-Floresta) e as fontes de emissão (lavouras sob sistema de plantio convencional e pastos degradados) resultou em uma remoção líquida de 39,7 MtCO₂e, quase 1% menor do que em 2018 (40,1 MtCO₂e).

Essa queda na remoção de carbono ocorreu devido ao aumento das emissões provenientes de pastos degradados e lavouras sob sistema de plantio convencional, de 0,4% e 3,8%, respectivamente, gerando uma remoção líquida menor em 2019 do que em 2018, mesmo com o aumento da remoção de todas as demais fontes.

Estima-se ainda que no Brasil haja aproximadamente 100 milhões de hectares de pastagens que apresentam algum grau de degradação, segundo dados do MapBiomas, o que representa uma área do tamanho dos territórios da França e da Alemanha juntos. Ao todo, essas pastagens degradadas foram responsáveis pela emissão de 47,8 Mt tCO₂e em 2019. A principal forma de minimizar esses impactos é através da adoção de boas práticas agropecuárias para melhoria de qualidade dos pastos.

Figura 8 – Balanço das fontes de emissão e remoção para o cálculo da quantidade de carbono no solo em 2019.





3.3 Mudança de uso da terra

As mudanças no uso da terra responderam por 363 milhões de toneladas de CO₂e das emissões líquidas nacionais e 968 milhões de toneladas das emissões brutas em 2019. A maior parte das emissões brutas (93%) é causada por alterações de uso do solo, que em sua maioria consistem no desmatamento do bioma Amazônia, que concentra 87% (841 MtCO₂e) das emissões brutas do setor.

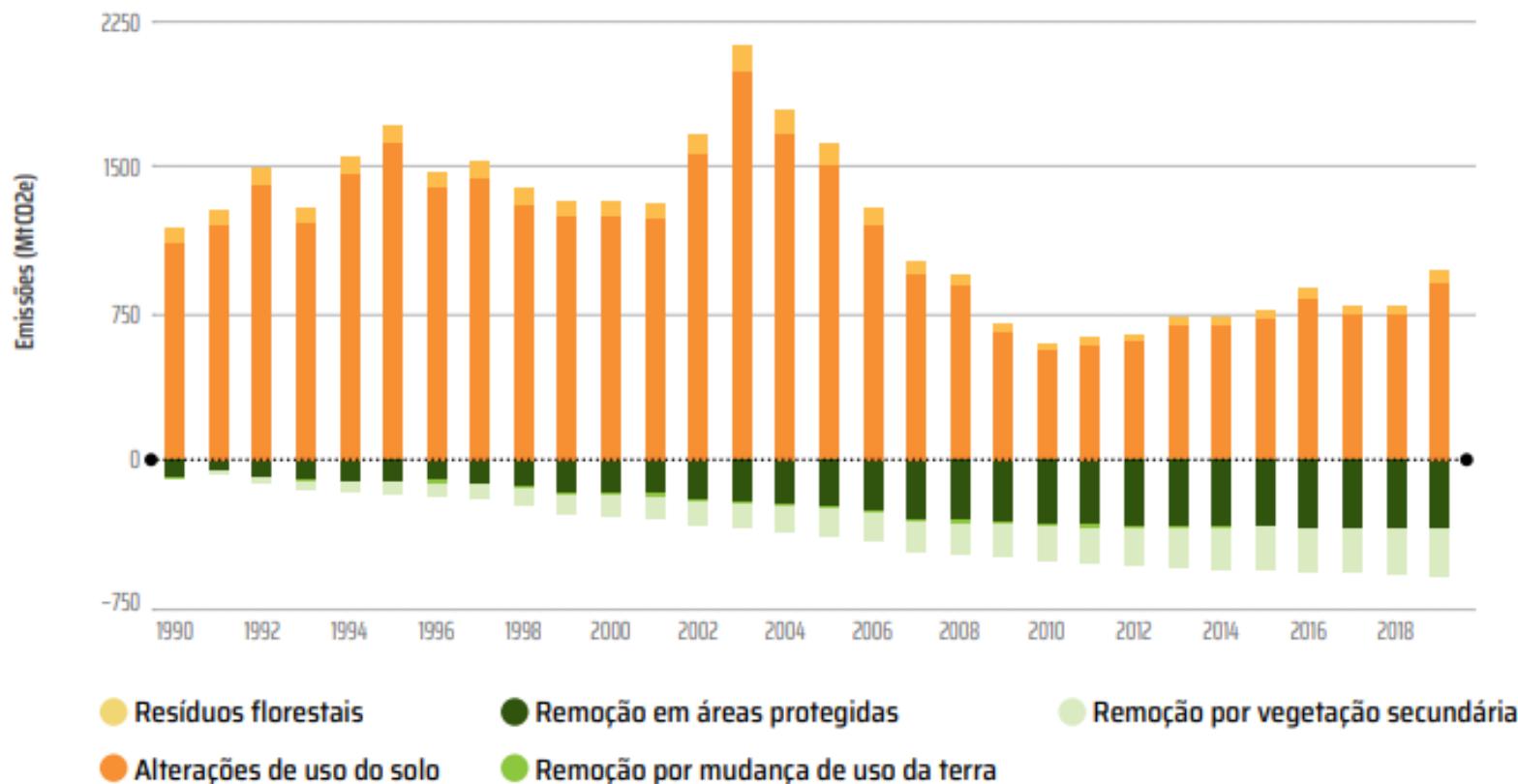


Figura 13 – Emissões e remoções por mudança de uso da terra



OBJETIVOS DE DESENVOLVIMENTO SUSTENTÁVEL

1 ERRADICAÇÃO DA POBREZA



2 FOME ZERO E AGRICULTURA SUSTENTÁVEL



3 SAÚDE E BEM-ESTAR



4 EDUCAÇÃO DE QUALIDADE



5 IGUALDADE DE GÊNERO



6 ÁGUA POTÁVEL E SANEAMENTO



7 ENERGIA LIMPA E ACESSÍVEL



8 TRABALHO DECENTE E CRESCIMENTO ECONÔMICO



9 INDÚSTRIA, INovação E INFRAESTRUTURA



10 REDUÇÃO DAS DESIGUALDADES



11 CIDADES E COMUNIDADES SUSTENTÁVEIS



12 CONSUMO E PRODUÇÃO RESPONSÁVEIS



13 AÇÃO CONTRA A MUDANÇA GLOBAL DO CLIMA



14 VIDA NA ÁGUA



15 VIDA TERRESTRE



16 PAZ, JUSTIÇA E INSTITUIÇÕES EFICAZES

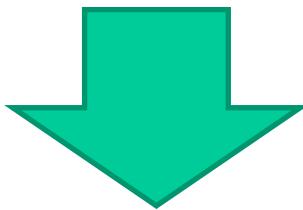


17 PARCERIAS E MEIOS DE IMPLEMENTAÇÃO



OBJETIVOS
DE DESENVOLVIMENTO
SUSTENTÁVEL

Pandemias, Perda Biodiversidade, Desastres Naturais, Mudanças Climáticas.



Devido: Uso não racional, **não sustentável**, dos recursos naturais



Resultam: **Enormes** impactos econômicos e sociais



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