



Laboratório de Aplicações de Satélites Ambientais da UFRJ

UFRJ



**Departamento de
METEOROLOGIA**
Universidade Federal do Rio de Janeiro

Eventos compostos Secas-Ondas de Calor-Incêndios: estamos preparados?

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ABRIL, 2024



The Nobel Prize in Physics 2021

Syukuro Manabe

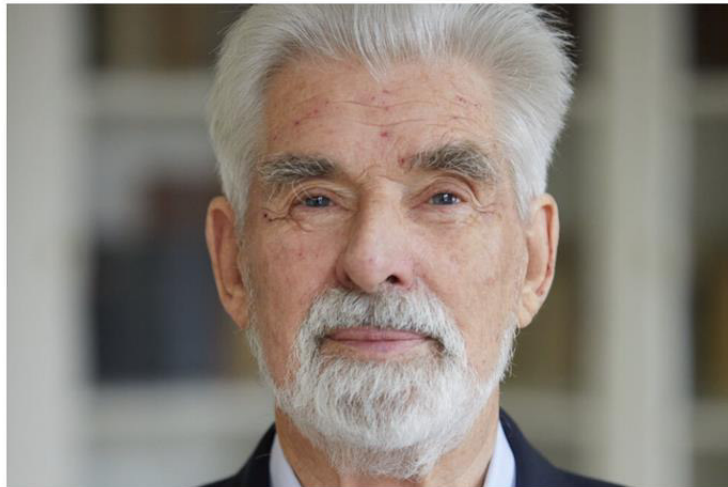
“for the physical modelling of Earth’s climate, quantifying variability and reliably predicting global warming”



© Nobel Prize Outreach. Photo: Risdon Photography

Klaus Hasselmann

“for the physical modelling of Earth’s climate, quantifying variability and reliably predicting global warming”



© Nobel Prize Outreach. Photo: Bernhard Ludewig

Giorgio Parisi

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

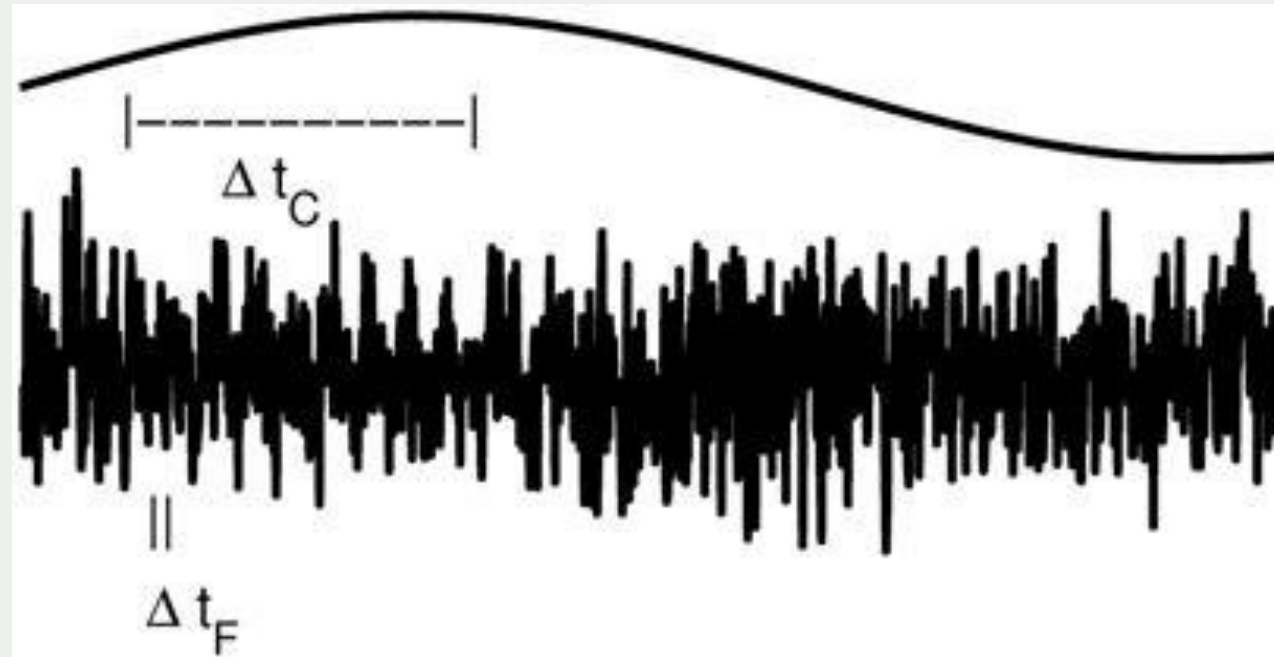


© Nobel Prize Outreach. Photo: Stefan Bladh

STOCHASTIC METHODS TO THE UNDERSTANDING AND MODELLING OF THE CLIMATE SYSTEM

THE UNDERLYING IDEA OF STOCHASTIC CLIMATE MODELING

Stochastic models of climate variability are based on the idea that climate can be decomposed into fast fluctuations, i.e., weather disturbances, and slow variations, i.e., sea-ice or oceanic variations.

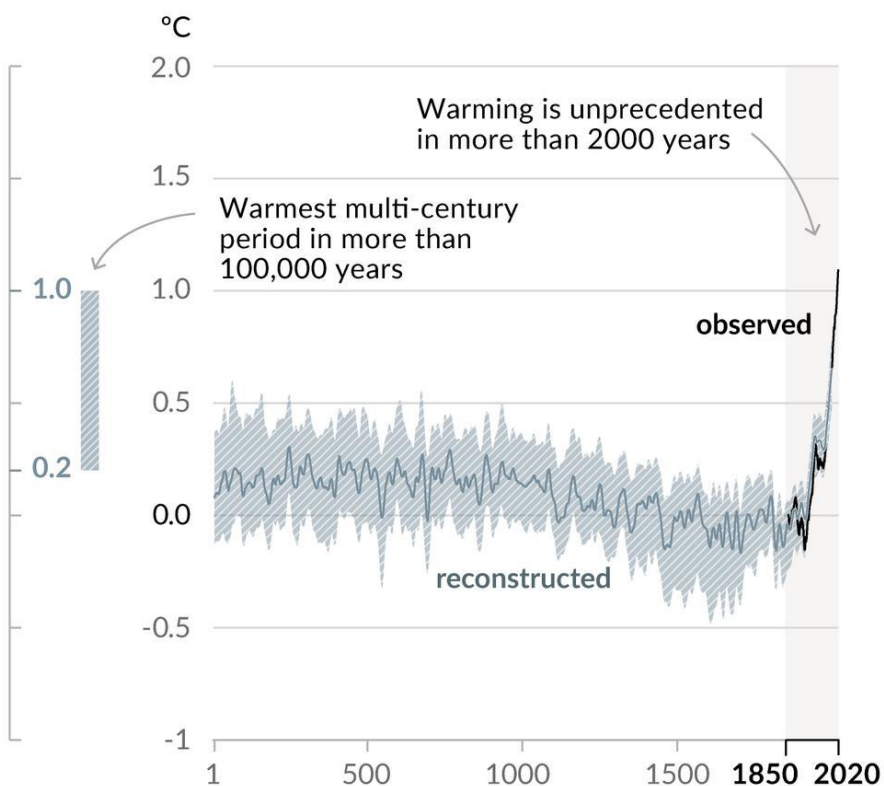


WHILE BOTH PROCESSES ARE DETERMINISTIC, THE FAST PROCESS DECORRELATES ON THE SLOW TIME SCALE Δt_C AND, THUS, CAN BE REPRESENTED BY A STOCHASTIC PROCESS IN AN EFFECTIVE CLIMATE MODEL WHICH ONLY SIMULATES THE SLOW CLIMATE MODE.

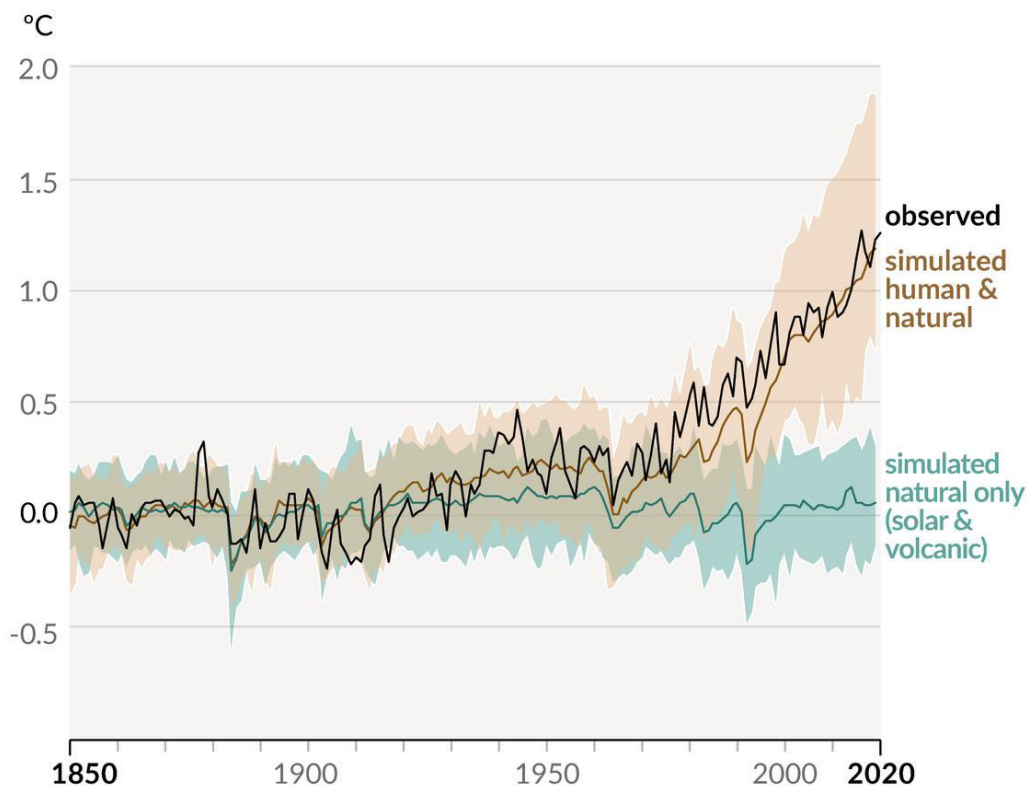
O homem tem aquecido o planeta a uma taxa sem precedentes há pelo menos 2000 anos

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)



b)
Increased concentrations
of GHGs in the atmosphere

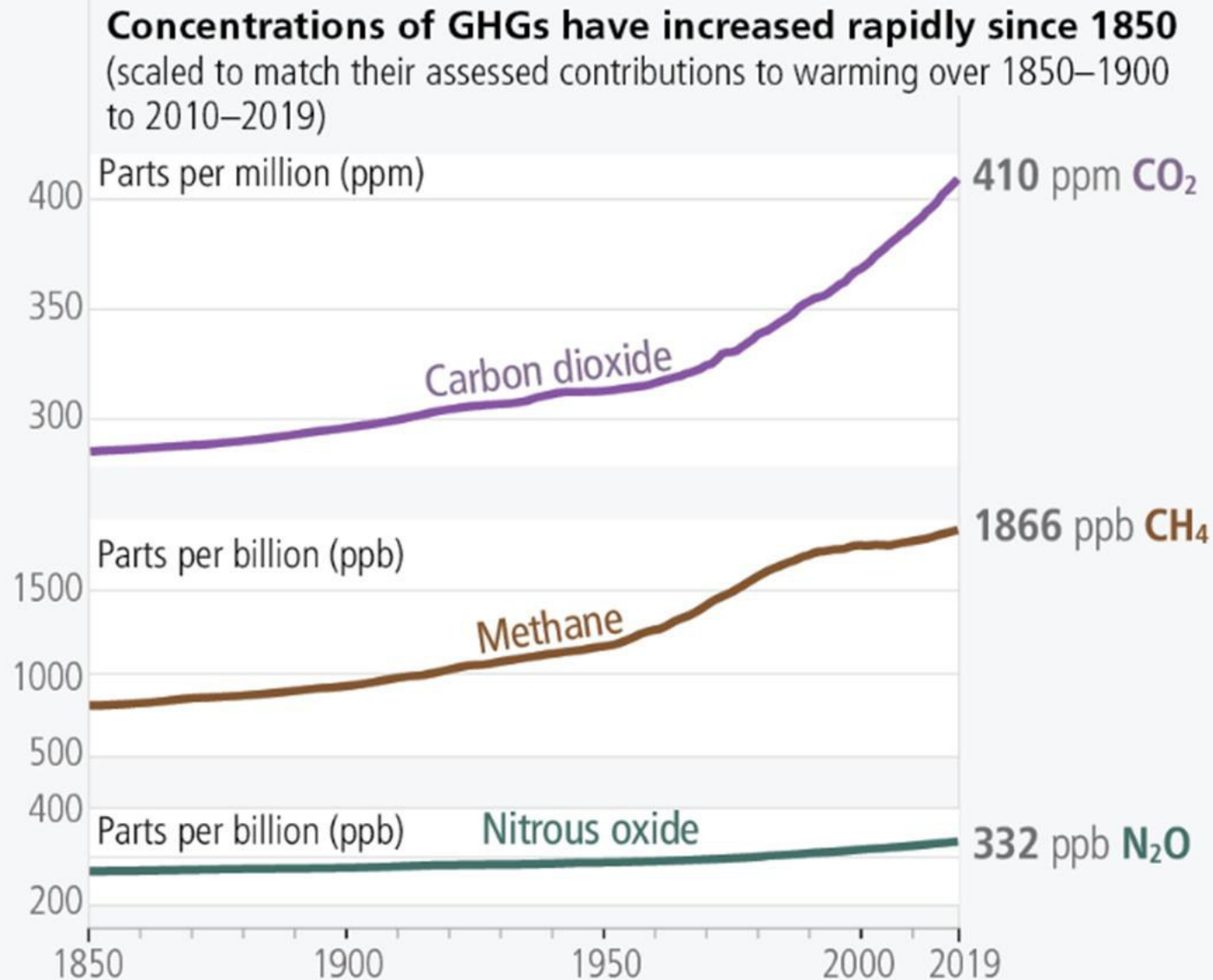


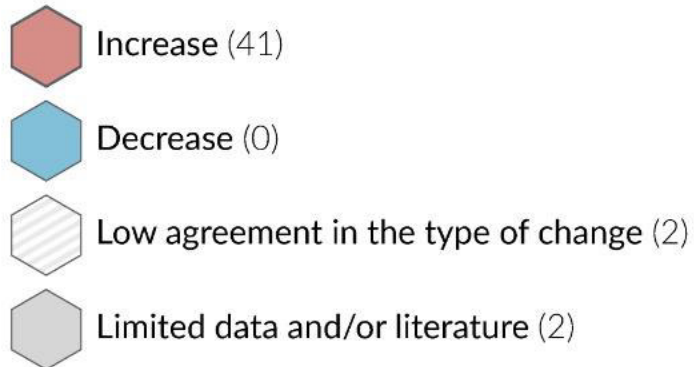
Figura 2.1
IPCC Ar6 - SYR

A mudança climática já afeta cada região habitada no globo, com a influência antropogênica contribuindo para muitas mudanças observadas nos extremos de tempo e clima

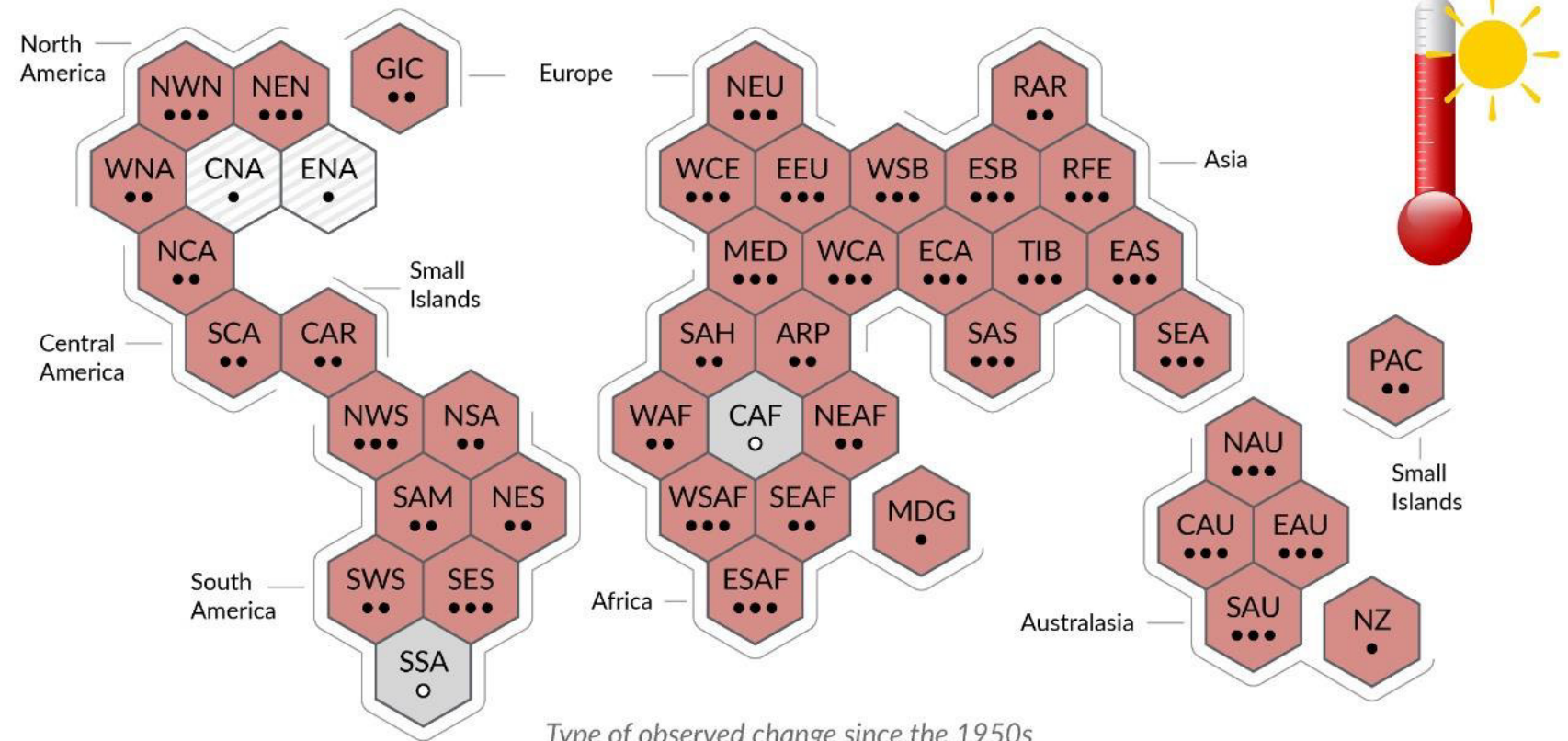
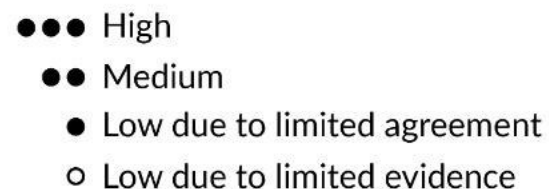
Figura SPM.3

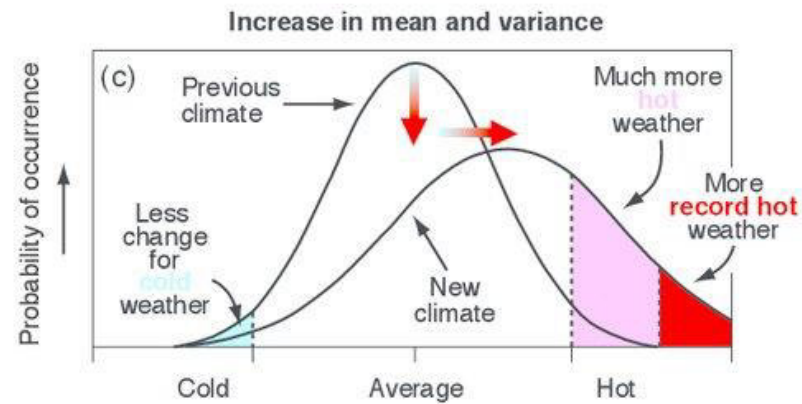
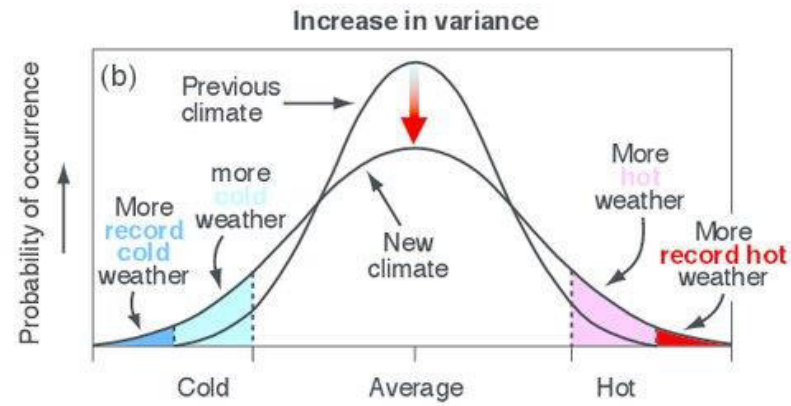
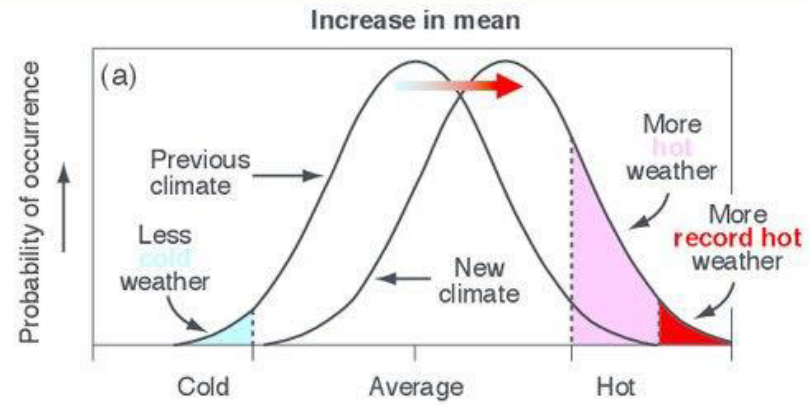
a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

Type of observed change in hot extremes



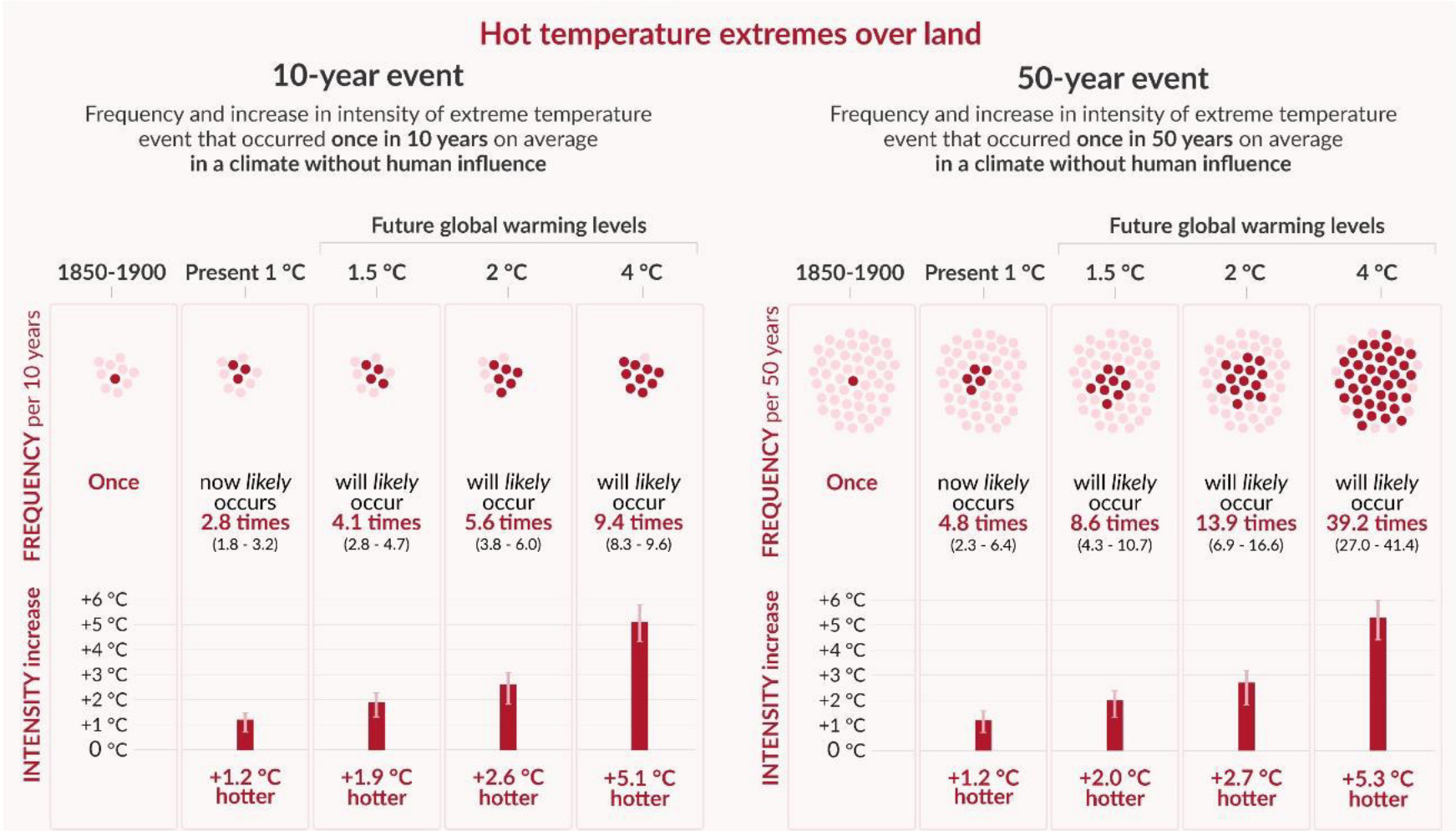
Confidence in human contribution to the observed change





Mudanças projetadas nos extremos aumentam em frequência e intensidade a cada incremento de aquecimento global

Figura SPM.6

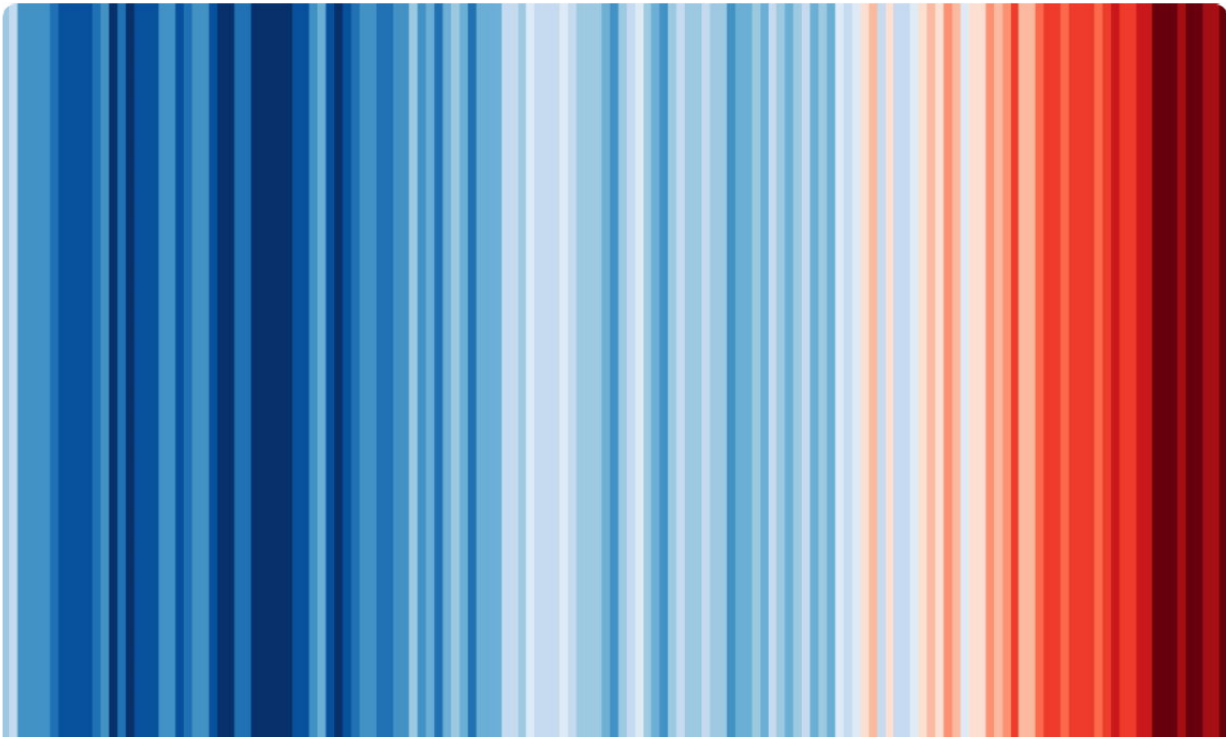


OMM confirma que 2023 bate recorde de temperatura global

● NOTÍCIAS

12 de janeiro de 2024

A Organização Meteorológica Mundial (OMM) confirmou oficialmente que 2023 é o ano mais quente já registrado, por uma margem enorme.



  Serviço de Mudanças Climáticas

Sobre nósO que nós fazemosDados



IMPLEMENTED BY


DESTAQUES DO CLIMA GLOBAL 2023

Copérnico: 2023 é o ano mais quente já registrado, com temperaturas globais próximas do limite de 1,5°C

 Administração Nacional Oceânica e Atmosférica
Departamento de Comércio dos EUA

Pesquisar sites da NOAA

Lar / Notícias e recursos

2023 foi o ano mais quente já registrado no mundo, de longe

Cobertura de gelo marinho na Antártica atingiu mínimo recorde

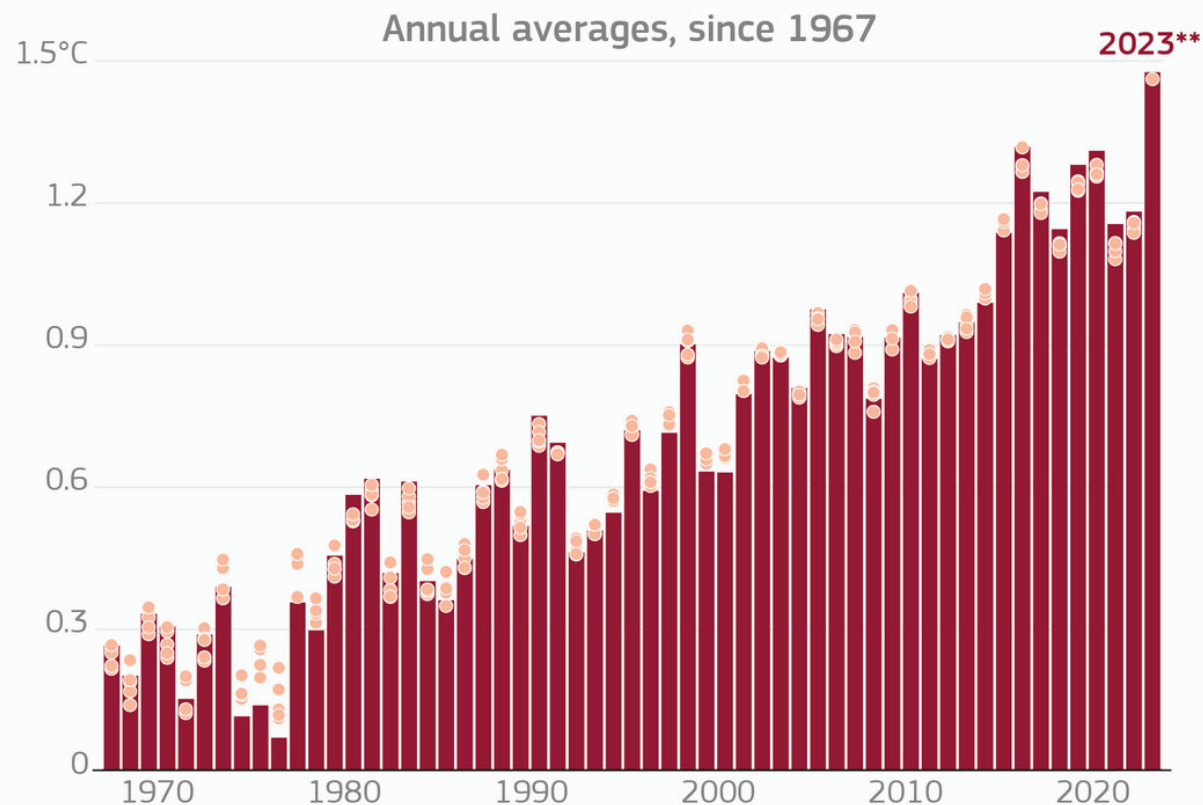
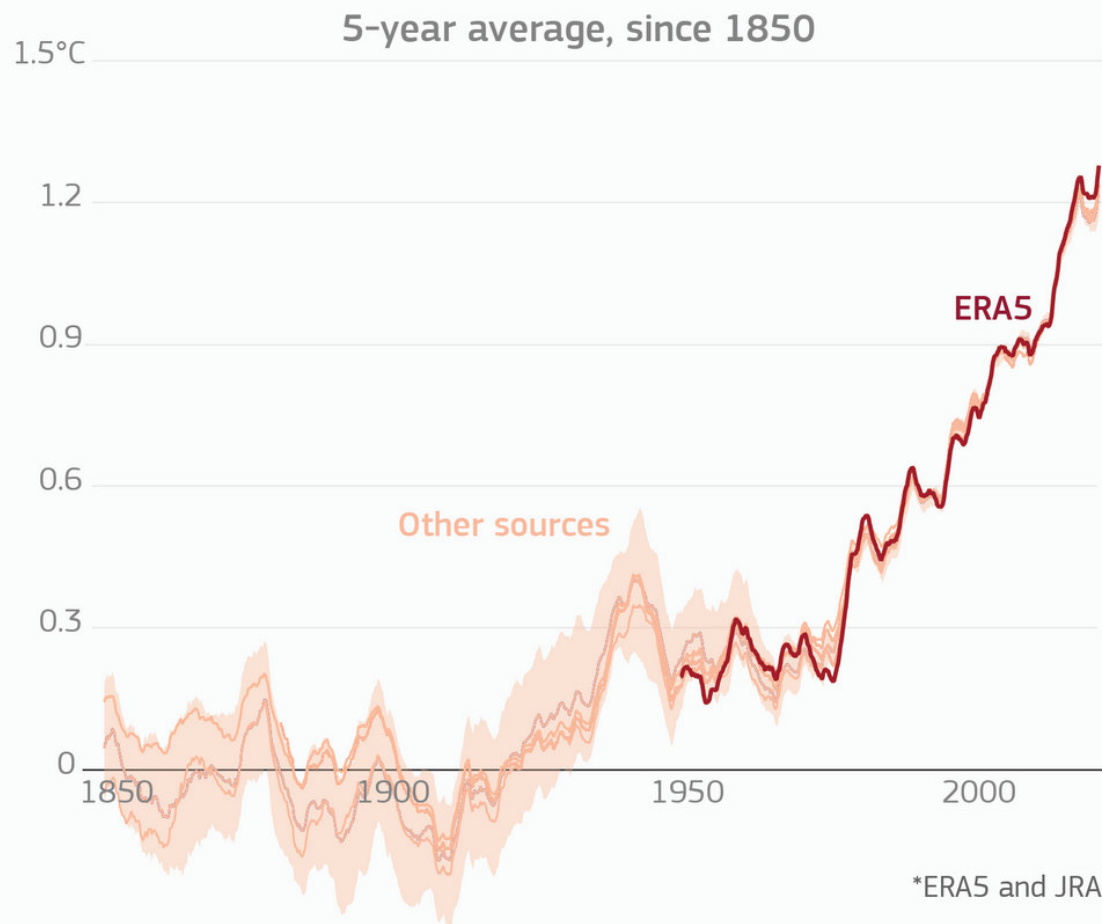
Áreas de foco: Clima, SatélitesTópicos: classificações de temperatura, temperaturas médias globais, Estado do Clima

Compartilhar:    

12 de janeiro de 2024

GLOBAL SURFACE TEMPERATURE: INCREASE ABOVE PRE-INDUSTRIAL LEVEL (1850-1900)

■ ERA5 data ● Other sources* (including JRA-3Q, GISTEMPv4, NOAAGlobalTempv5, Berkeley Earth, HadCRUT5)



*ERA5 and JRA-3Q data are only shown from 1948. Shaded area represents the uncertainty for HadCRUT5 data

**Estimate for 2023 based on ERA5 and JRA-3Q data only

Credit: C3S/ECMWF



PROGRAMME OF THE
EUROPEAN UNION



Climate
Change Service

climate.copernicus.eu

EVENTOS EXTREMOS 2023



GLOBAL AVERAGE TEMPERATURE

The Jan–Dec 2023 average global surface temperature was the highest since global records began in 1850.

CANADA

Wildfires across Canada burned more than 45.7 million acres, shattering a record (2.6 times over) for the most acres burned in Canadian and North American history. These fires caused widespread air quality deterioration across much of Canada and the U.S.

NORTH AMERICA

2023 was North America's warmest year on record.

CALIFORNIA

Nine back-to-back atmospheric rivers pummeled California in Jan 2023, which brought a total of 32 trillion gallons of rain and snow to the state.

EASTERN NORTH PACIFIC HURRICANE SEASON

Above-average activity: 17 storms, including 10 hurricanes

HAWAII

On Aug 8, winds from Hurricane Dora exacerbated a wildfire on the island of Maui in Hawaii that destroyed the historic town of Lahaina and became the deadliest wildfire in the U.S. in over a century.

HURRICANE OTIS

On Oct 25, Hurricane Otis made landfall as a Category 5 hurricane near Acapulco on Mexico's southern Pacific coast after increasing wind speed by 115 mph within 24 hours and bringing catastrophic damage to a city of nearly one million people.

ATLANTIC HURRICANE SEASON

Above-average activity: 20 storms, including seven hurricanes

AFRICA

2023 was Africa's warmest year on record.

SOUTH AMERICA

South America had its warmest year on record.

GLOBAL TROPICAL CYCLONES

Above-average activity: 78 storms, including 45 hurricanes/cyclones/typhoons

GLOBAL OCEAN

For nine consecutive months (Apr–Dec), global ocean surface temperatures were record warm.

ANTARCTIC SEA ICE EXTENT

The Antarctic had record-low annual maximum and minimum sea ice extents during 2023.

ARCTIC SEA ICE EXTENT

The 2023 Arctic maximum and minimum extents were third- and sixth-smallest on record, respectively.

EUROPE

Europe had its second-warmest year on record.

CYCLONE DANIEL

On Sep 10, Storm Daniel brought strong winds and an unprecedented amount of rain to eastern Libya, which caused massive destruction—dams burst across many towns and led to the death of more than 10,000 people, making it the deadliest and costliest tropical cyclone of 2023.

NORTH INDIAN OCEAN CYCLONE SEASON

Above-average activity: eight storms, including four cyclones

SOUTH INDIAN OCEAN CYCLONE SEASON*

Above-average activity: nine storms, including seven cyclones

ASIA

2023 was Asia's second-warmest year on record.

WESTERN NORTH PACIFIC TYPHOON SEASON

Below-average activity: 17 storms, including 12 typhoons

SUPER TYPHOON MAWAR

Super Typhoon Mawar passed within 100 miles of Guam in the Western Pacific on May 24 as a Category 4 storm. Mawar resulted in heavy rainfall and widespread power outages on Guam.

TROPICAL CYCLONE MOCHA

Cyclone Mocha was the North Indian Ocean's first named storm of 2023, and made a devastating landfall as a Category 4 cyclone in Myanmar on May 14.

OCEANIA

Oceania had its 10th-warmest year on record.

AUSTRALIA CYCLONE SEASON*

Above-average activity: nine storms, including five cyclones

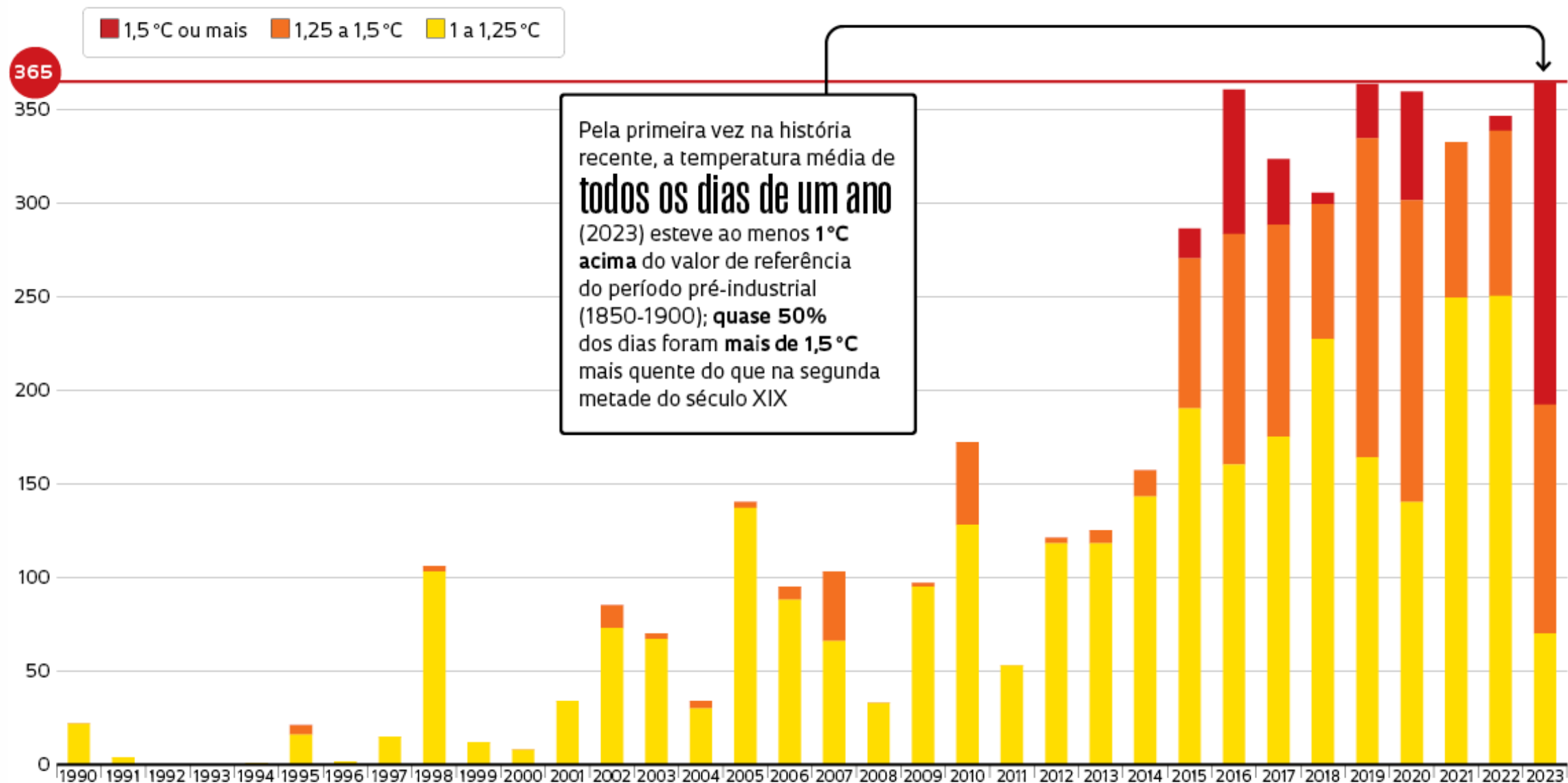
SOUTHWEST PACIFIC CYCLONE SEASON*

Below-average activity: six storms, including three cyclones

*Cyclone season runs from June 2022–July 2023

CALOR RECORDE

Número de dias desde a década de 1990 em que a temperatura média global ultrapassou a do período pré-industrial



Ano de 2023 é o mais quente da série histórica no Brasil

A média das temperaturas do ano no País ficou 0,69°C acima da média histórica

Publicado em 09/01/2024 16h20 . Última modificação 09/01/2024 17h57 .

Compartilhar 9

Postar

O ano de 2023 é o mais quente da história do planeta, segundo dados da Organização Meteorológica Mundial (OMM). No Brasil, a média das temperaturas do ano ficou em 24,92°C, sendo 0,69°C acima da média histórica de 1991/2020, que é de 24,23°C. Em 2022, a média anual foi de 24,07°C, 0,16°C abaixo da média histórica.

O **gráfico 1** mostra os anos mais quentes no País. Confira abaixo! Vale ressaltar que os anos destacados estavam sob influência do fenômeno El Niño, com intensidade de forte a muito forte, assim como em 2023.

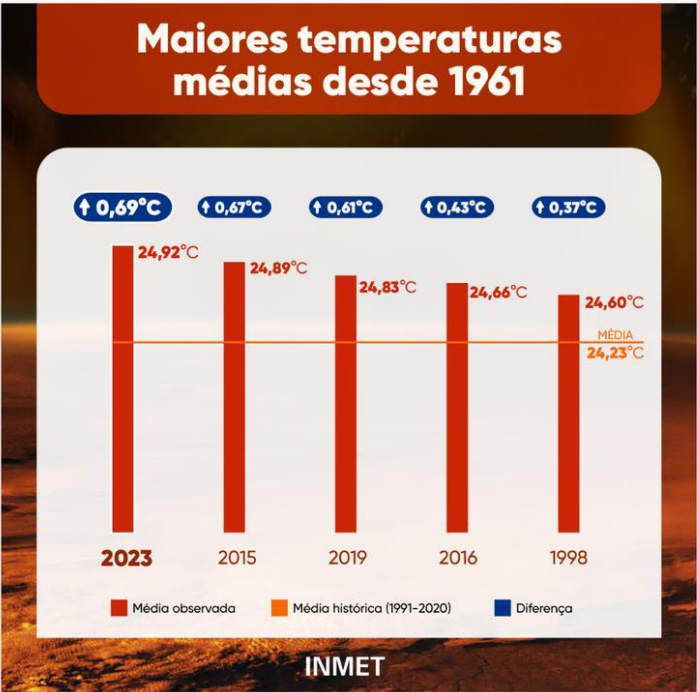


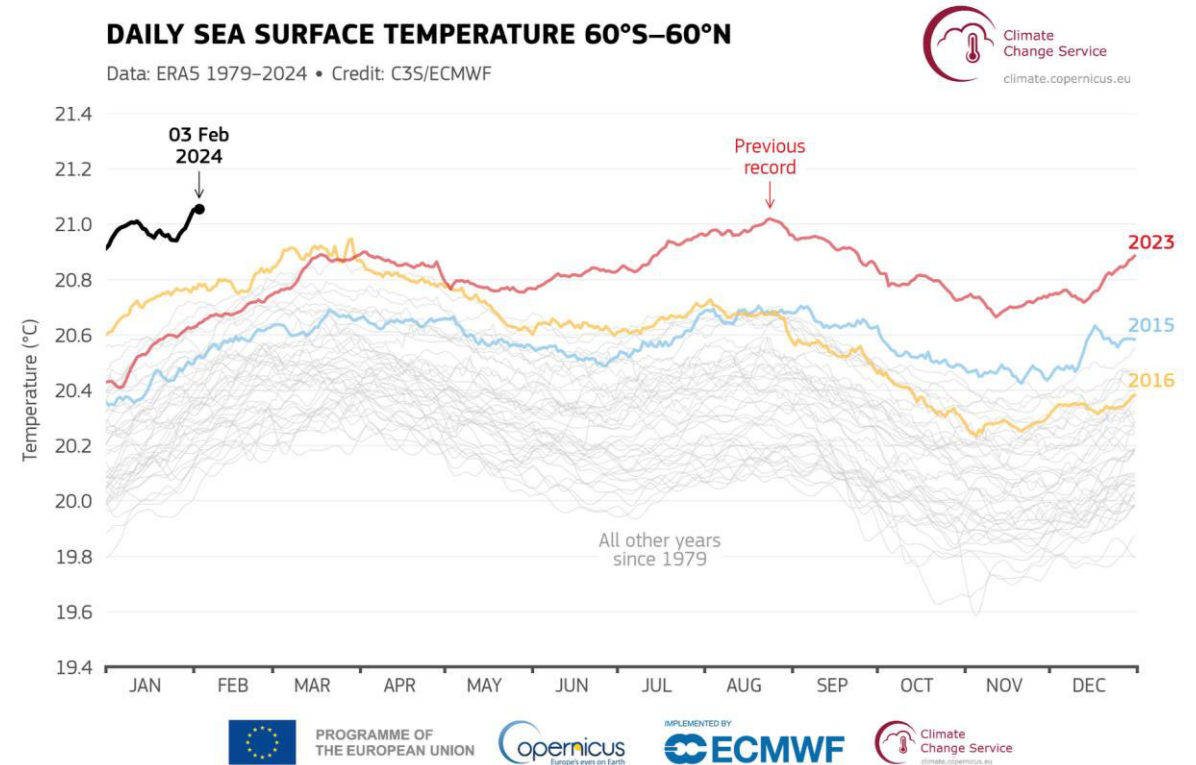
Gráfico 1: Ranking dos cinco anos mais quentes da história do Brasil entre 1961 e 2023.

Mundo teve janeiro mais quente já registrado

● NOTÍCIAS

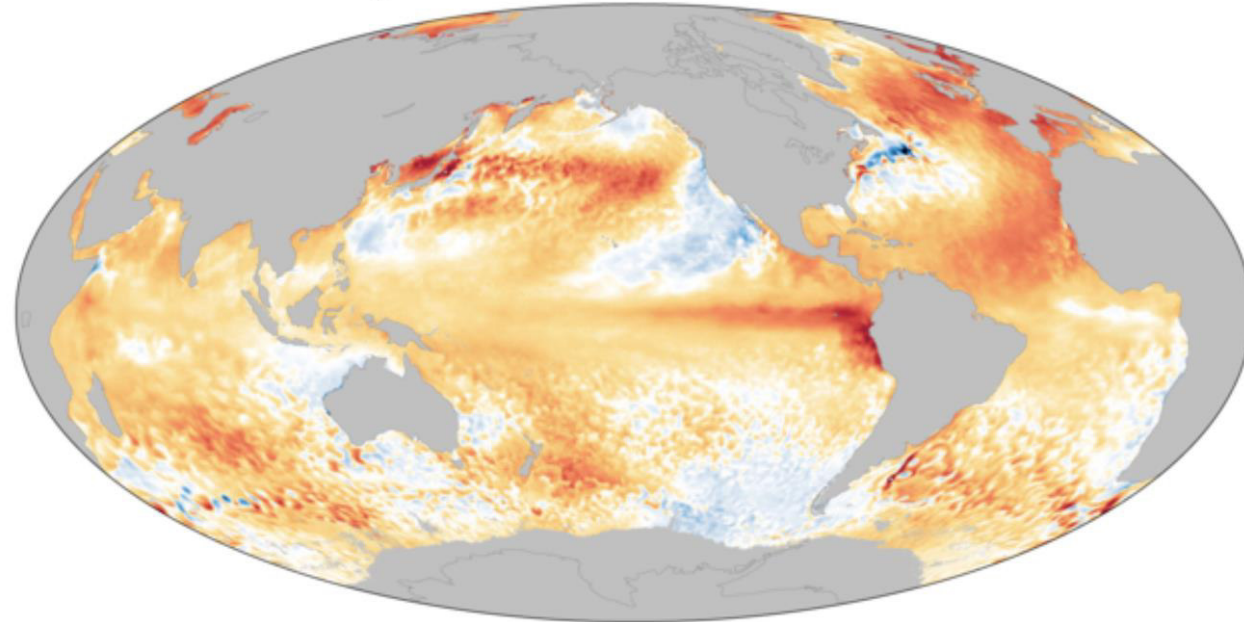
15 de fevereiro de 2024

A tendência recorde observada durante grande parte de 2023 continuou em 2024, sendo Janeiro o mês de Janeiro mais quente já registrado. É o oitavo mês consecutivo mais quente já registrado para a respetiva época do ano. As temperaturas da superfície do mar registaram níveis recorde durante dez meses consecutivos.

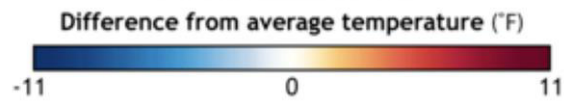


EL NIÑO 2023

June 2023 El Niño with near-global ocean warmth



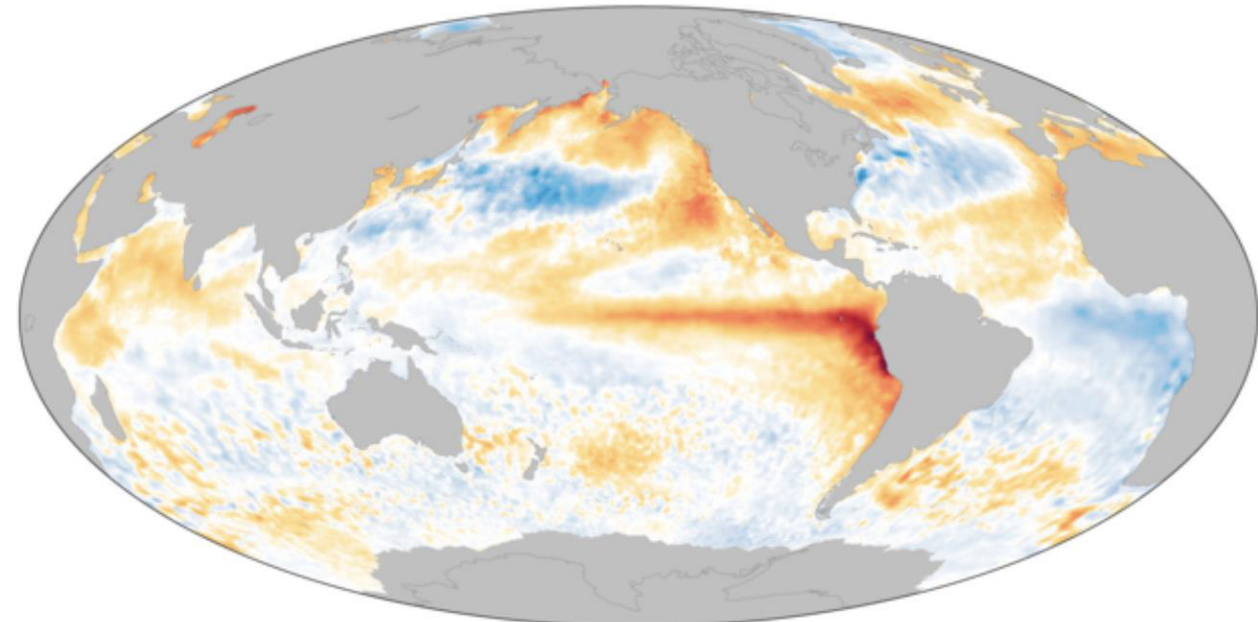
June 2023
Compared to 1985-1993*



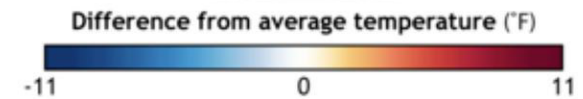
NOAA Climate.gov/NNVL
Data: Coral Reef Watch

EL NIÑO 1997

June 1997 El Niño



June 1997
Compared to 1985-1993*



NOAA Climate.gov/NNVL
Data: Coral Reef Watch

Brasil teve oito ondas de calor em 2023*

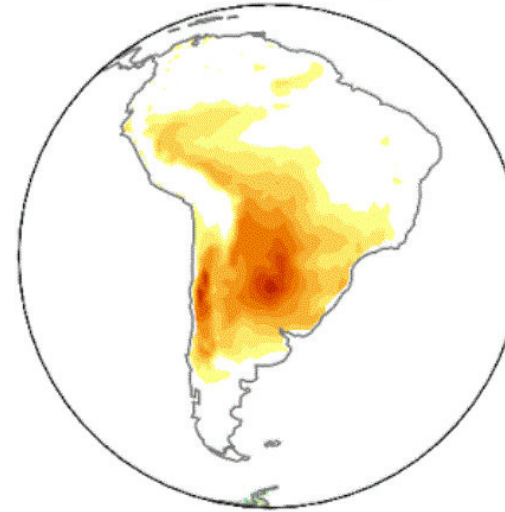
*até 13/11

MÊS	PERÍODO	MÁXIMA NO PERÍODO	LOCAL	DIA
JAN	23 a 28	40,7 °C	Uruguaiana (RS)	24/01
FEV	06 a 13	40,7 °C	Quaraí (RS)	08/02
MAR	09 a 13	39,5 °C	Quaraí (RS)	09/03
AGO	22 a 28	41,8 °C	Cuiabá (MT)	23/08
SET	18 a 29	43,5 °C	São Romão (MG)	26/09
OUT	03 a 06	42,0 °C	Oeiras (PI)	03/10
	17 a 23	44,3 °C	Aragarças (GO)	19/10
NOV	08 até hoje	43,0 °C	Porto Murtinho (MS)	08/11

INMET

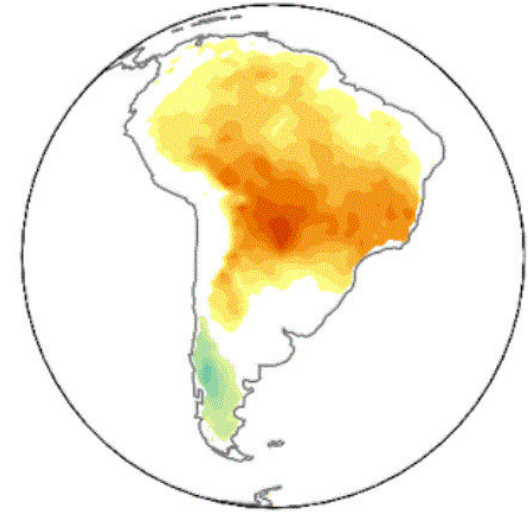
(a)

01 Aug - 07 Aug

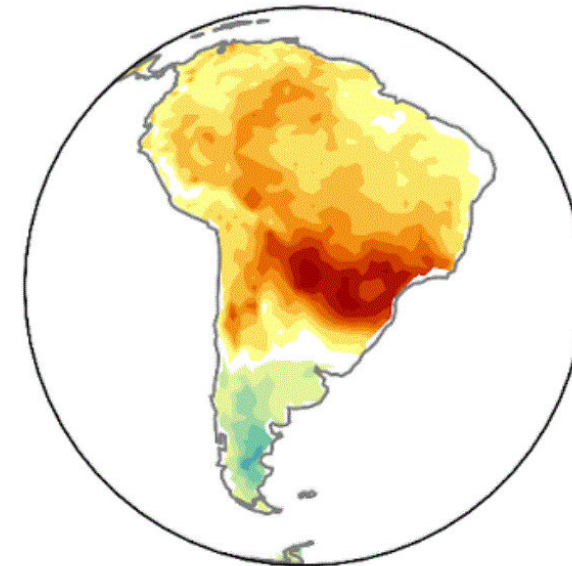


(b)

07 Nov - 19 Nov

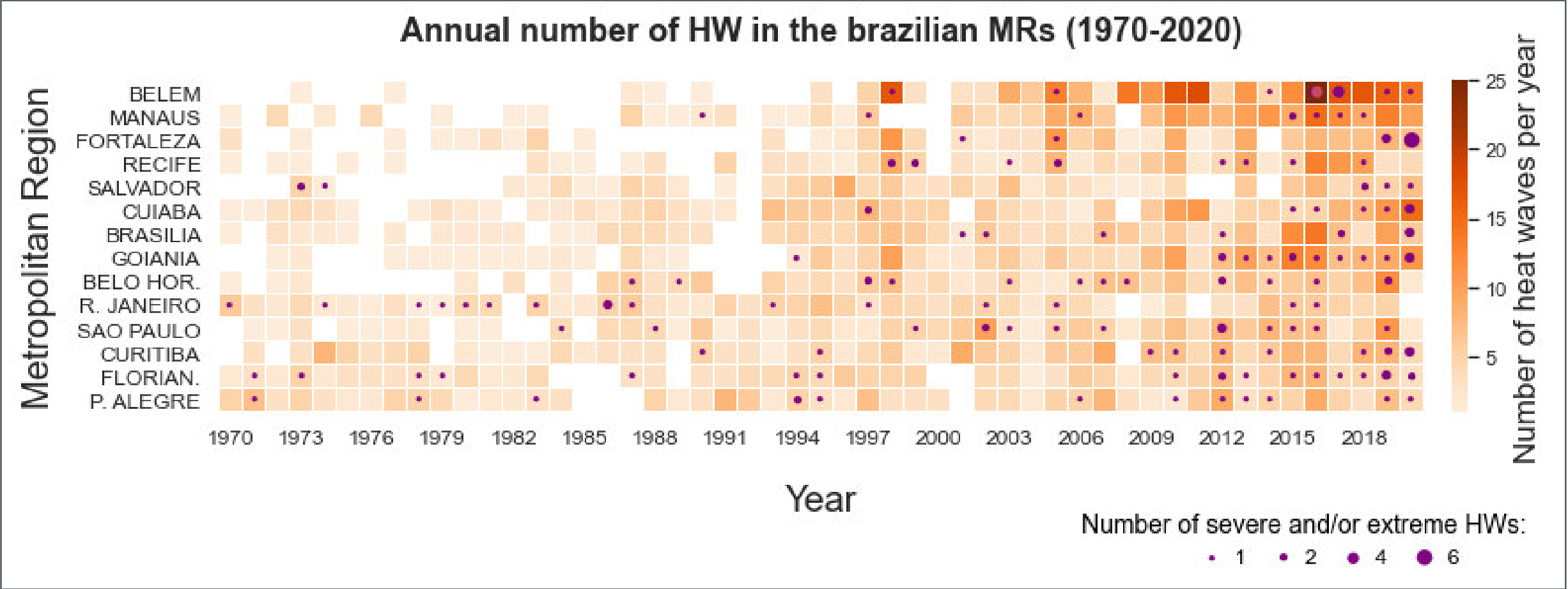


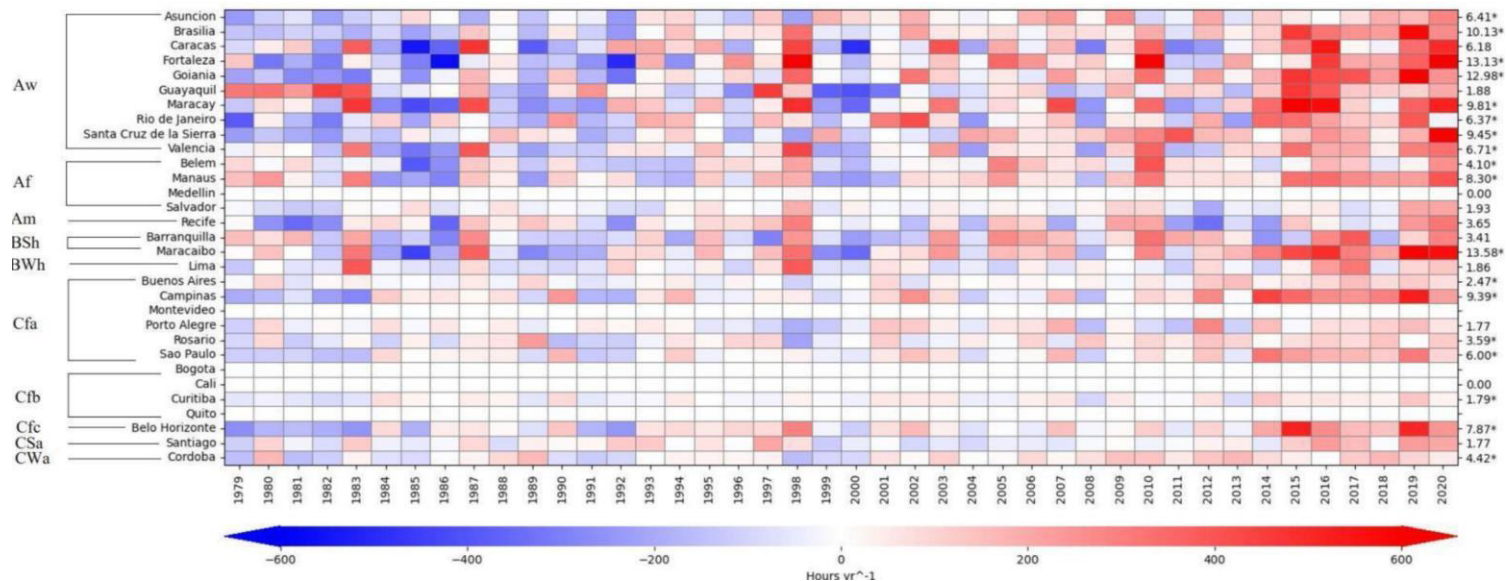
South America
[17 Sep - 26 Sep]



100% MAIS
PROVÁVEL DEVIDO
ÀS MUDANÇAS
CLIMÁTICAS

Twenty-First-Century Demographic and Social Inequalities of Heat-Related Deaths in Brazilian Urban Areas.

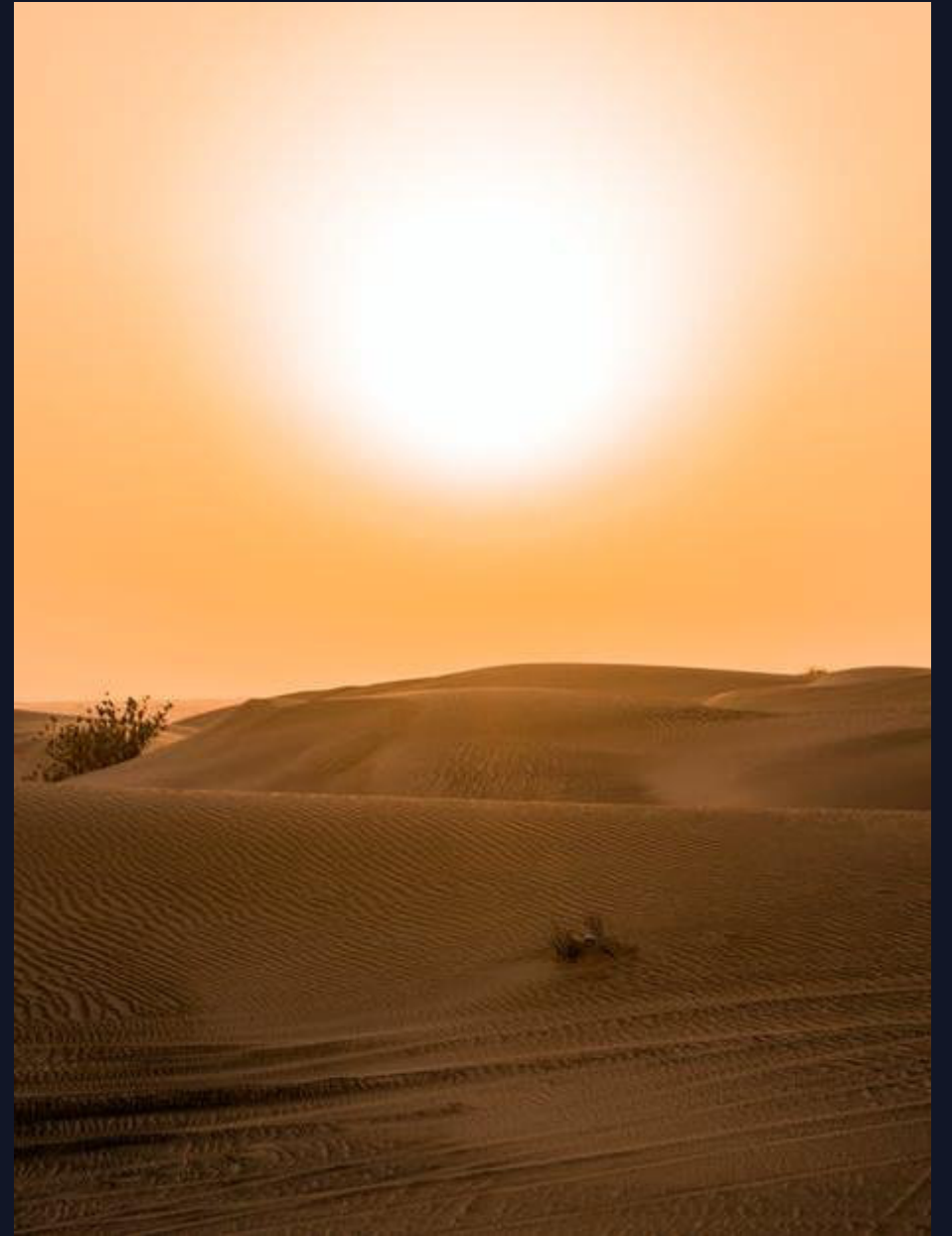




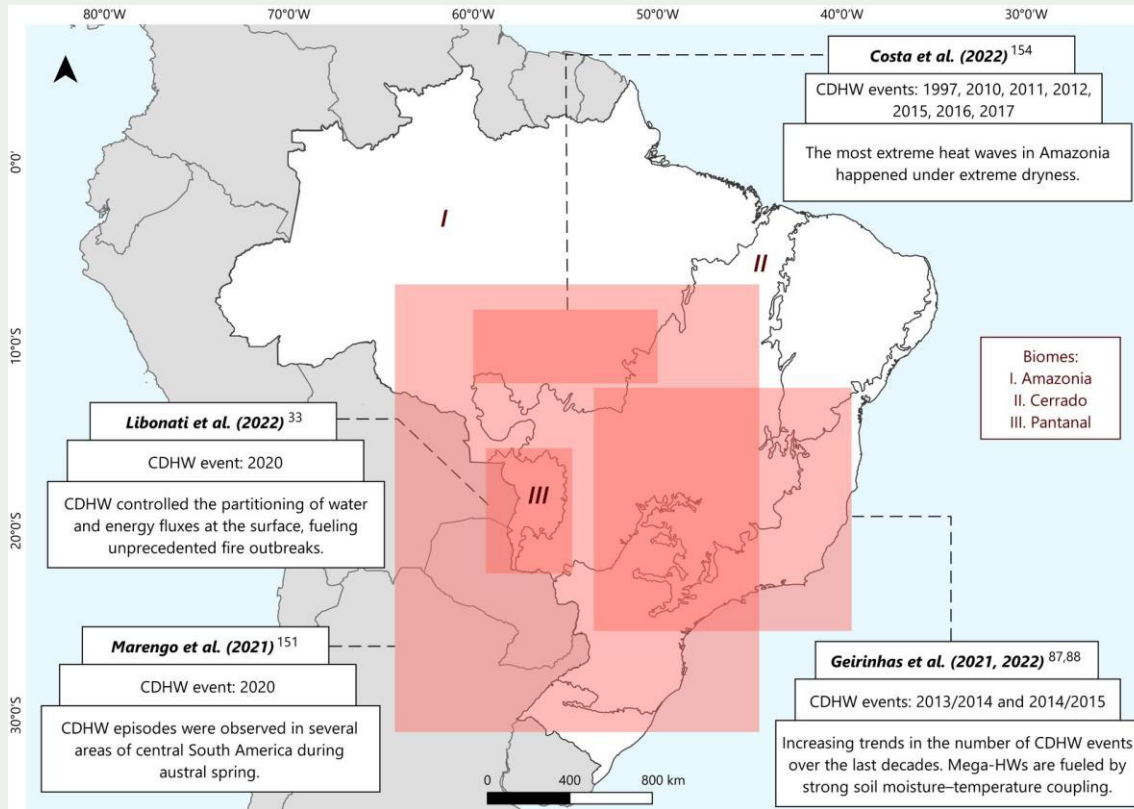
Hours under heat stress (1979-2020)

Eventos acoplados

Type text



LACUNA DE CONHECIMENTO NA AS



DOI: 10.1111/nyas.14887

REVIEW

ANNALS OF THE NEW YORK
ACADEMY OF SCIENCES

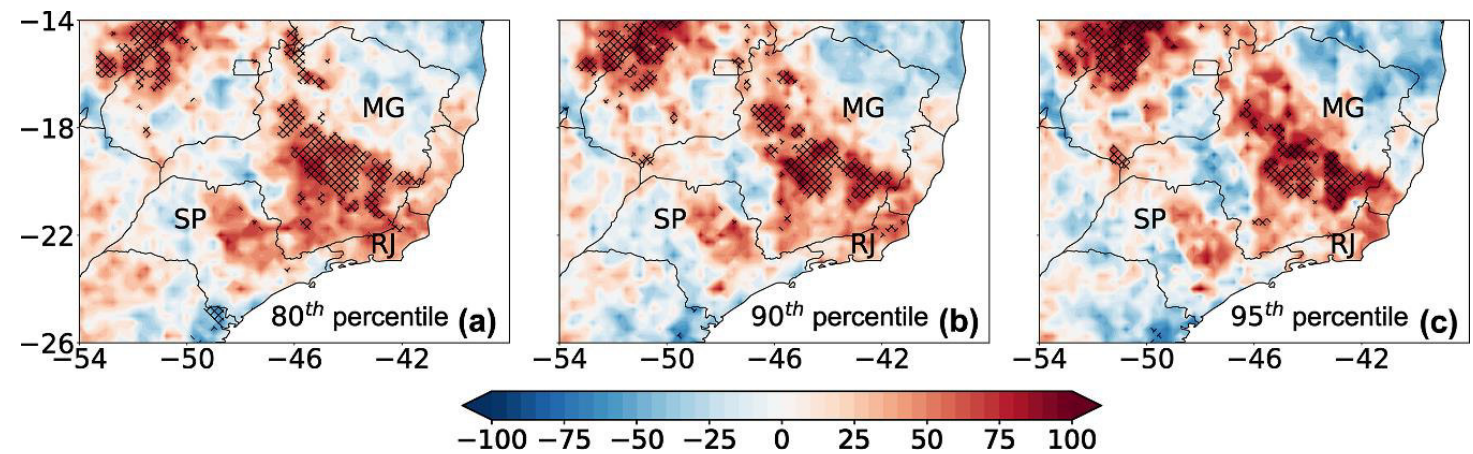
Drought-heatwave nexus in Brazil and related impacts on health and fires: A comprehensive review

Renata Libonati^{1,2,3}  | João L. Geirinhas^{2,#} | Patrícia S. Silva^{2,#} |
Djacintho Monteiro dos Santos^{1,#} | Julia A. Rodrigues¹ | Ana Russo² |
Leonardo F. Peres¹ | Luiza Narcizo¹ | Monique E. R. Gomes¹ | Andreza P. Rodrigues⁴ |
Carlos C. DaCamara² | José Miguel C. Pereira^{3,5} | Ricardo M. Trigo^{1,2}

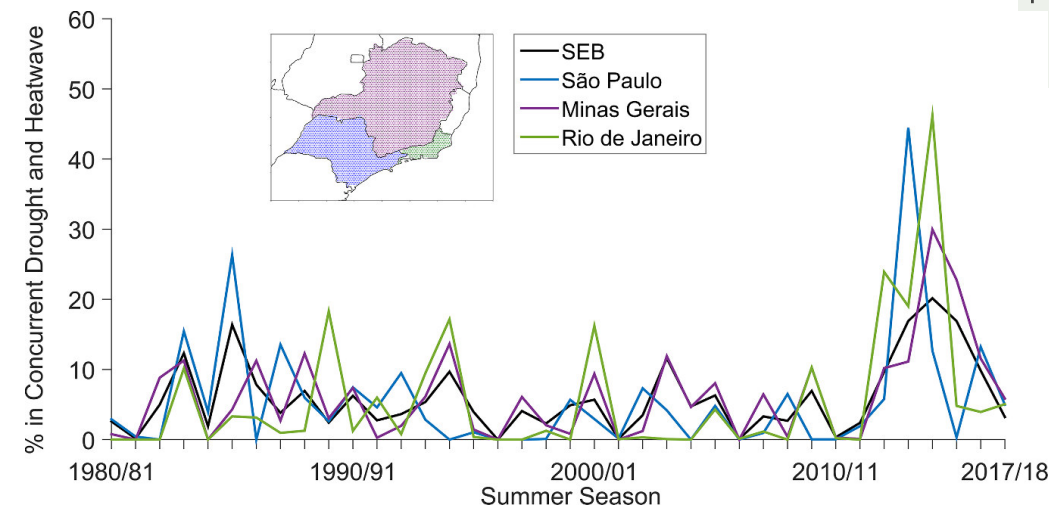
LETTER

Recent increasing frequency of compound summer drought
and heatwaves in Southeast Brazil

João L Geirinhas¹, Ana Russo¹, Renata Libonati^{2,1}, Pedro M Sousa¹, Diego G Miralles¹
and Ricardo M Trigo^{1,2}



Percent change (%) in CDH events during 1999/00–2017/18 summer seasons (DJF) relative to 1980/81–1998/99 summer seasons.



Type header

scientific reports

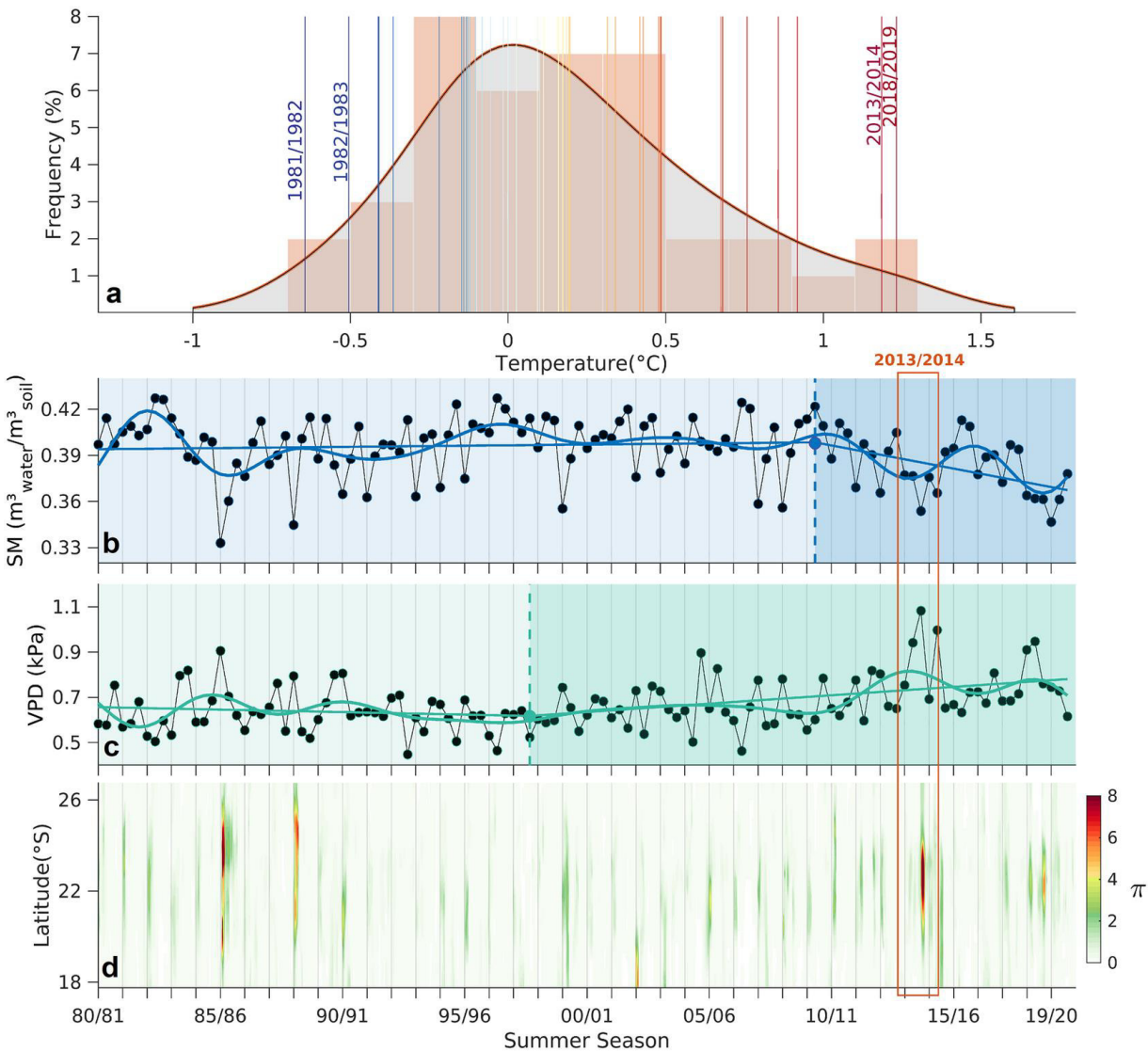
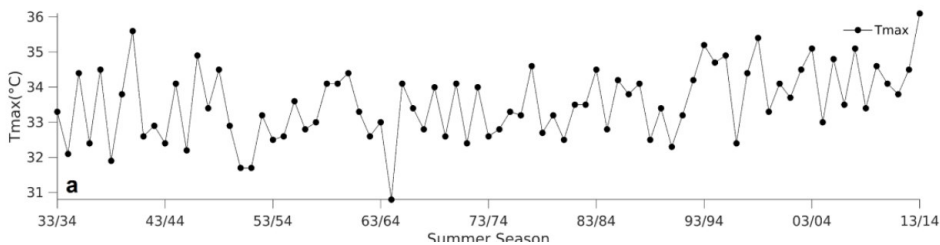


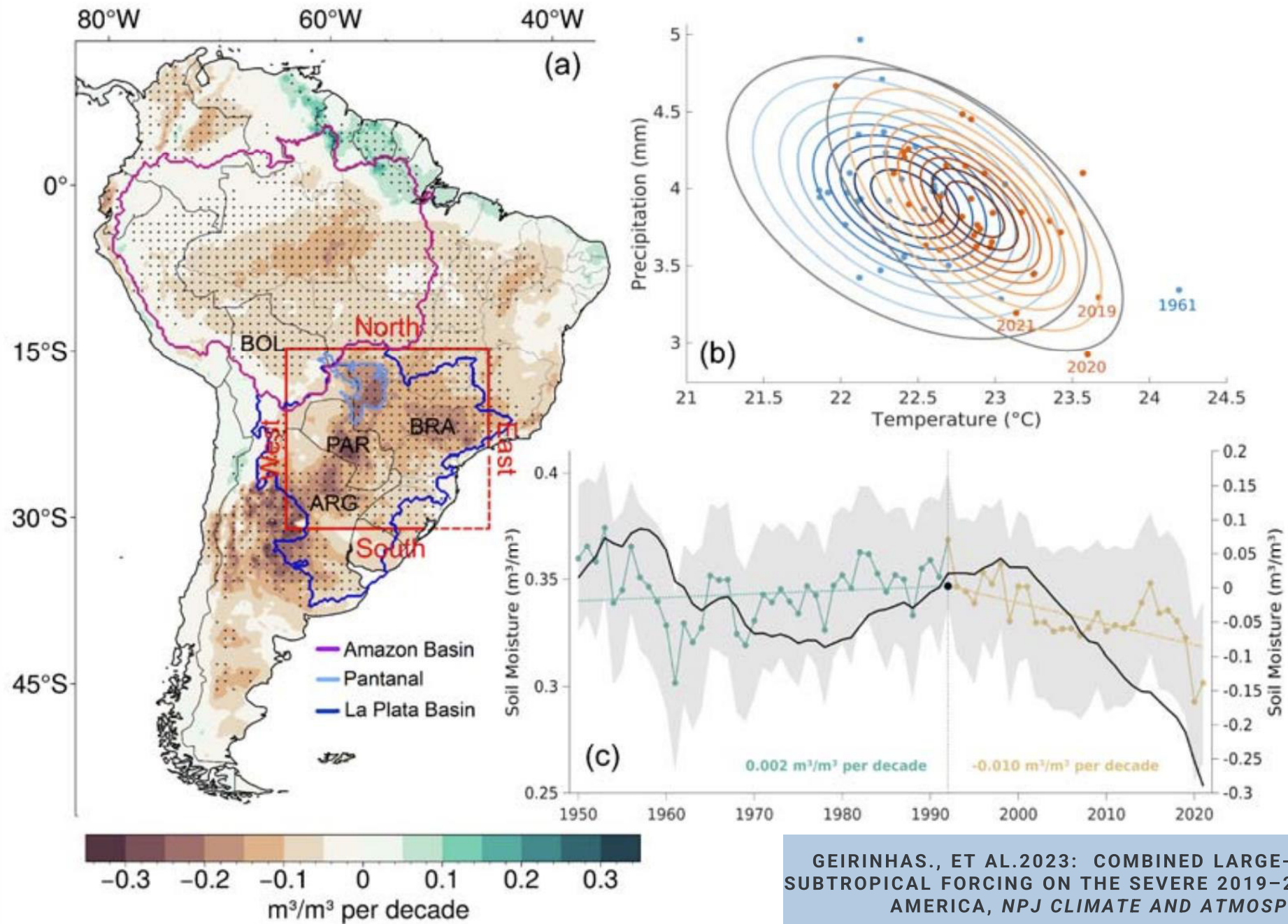
OPEN

The influence of soil dry-out on the record-breaking hot 2013/2014 summer in Southeast Brazil

J. L. Geirinhas^{1,2}, A. C. Russo¹, R. Libonati^{1,2}, D. G. Miralles³, P. M. Sousa^{1,4}, H. Wouters^{3,5} & P. M. Teles^{1,2}

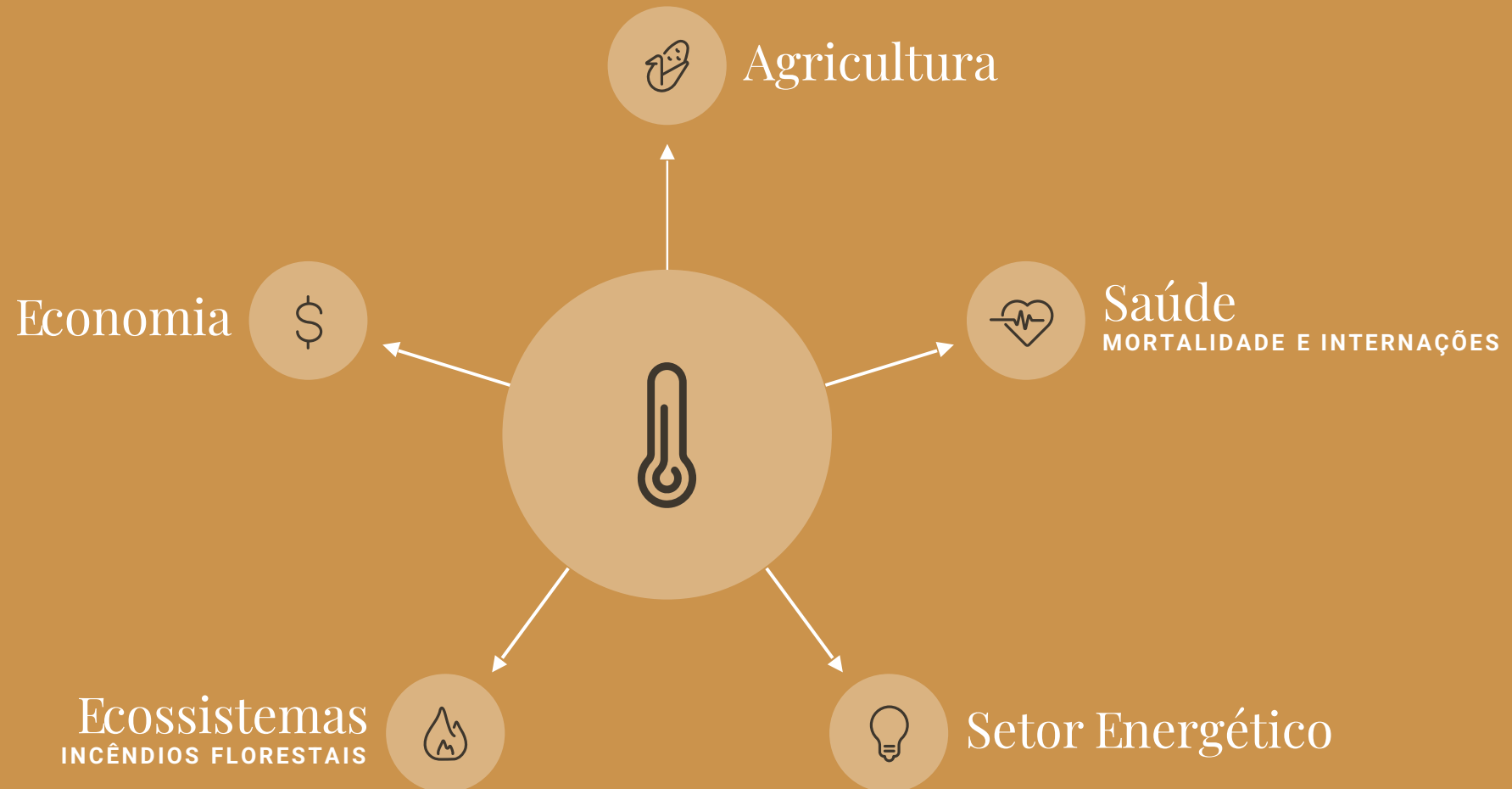
Check for updates





GEIRINHAS., ET AL.2023: COMBINED LARGE-SCALE TROPICAL AND SUBTROPICAL FORCING ON THE SEVERE 2019–2022 DROUGHT IN SOUTH AMERICA, *NPJ CLIMATE AND ATMOSPHERIC SCIENCE*

Impactos



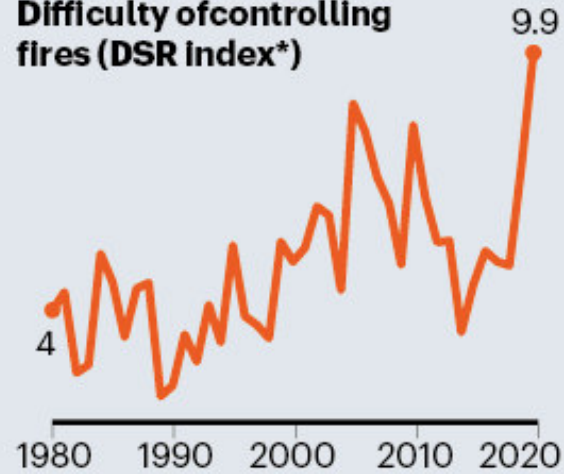
PANTANAL FIRE CRISIS

Almost one-third of this wetland World Heritage Site burnt down in 2020. Drought, climate change, inadequate government response and the pandemic all played a part.

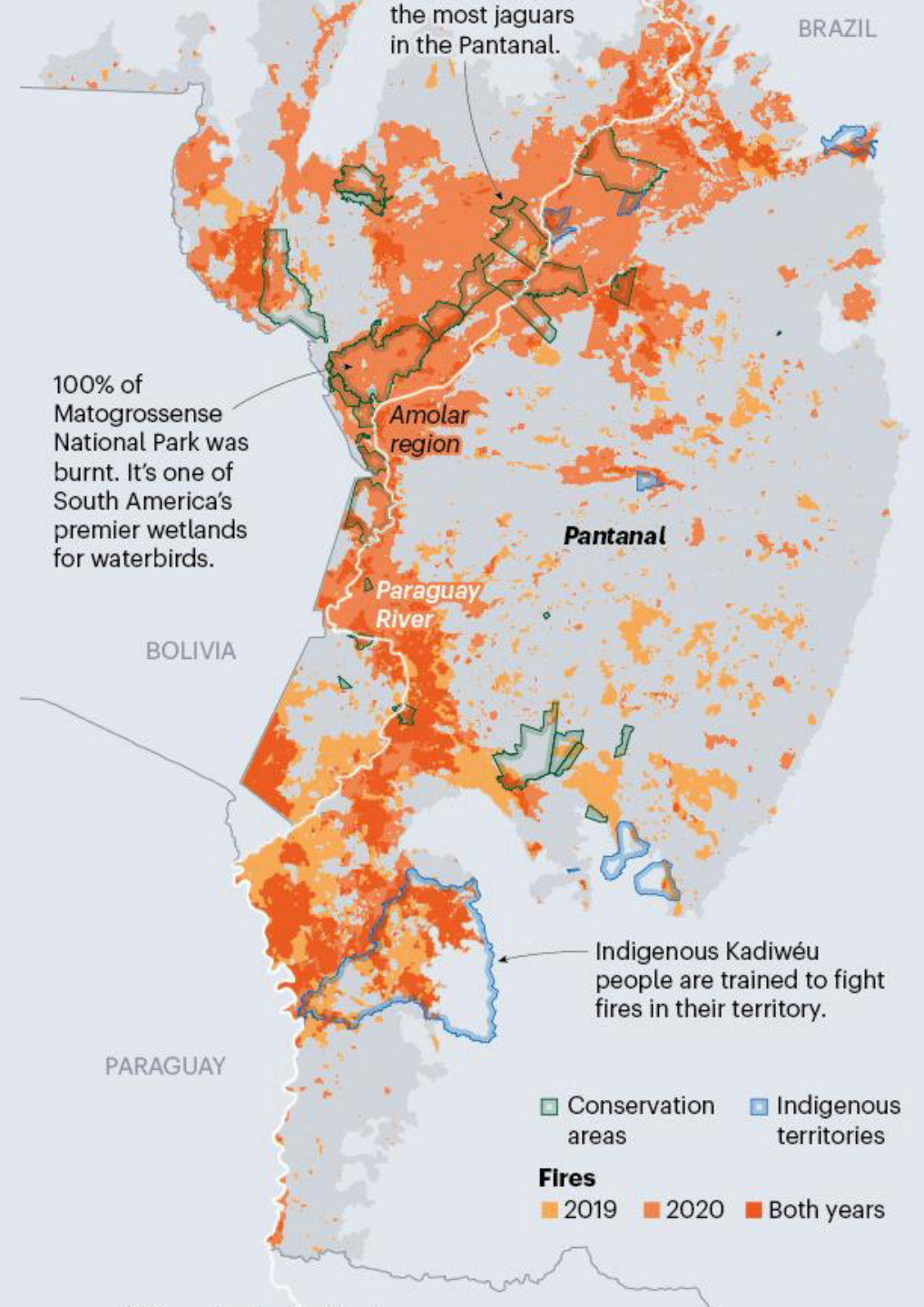


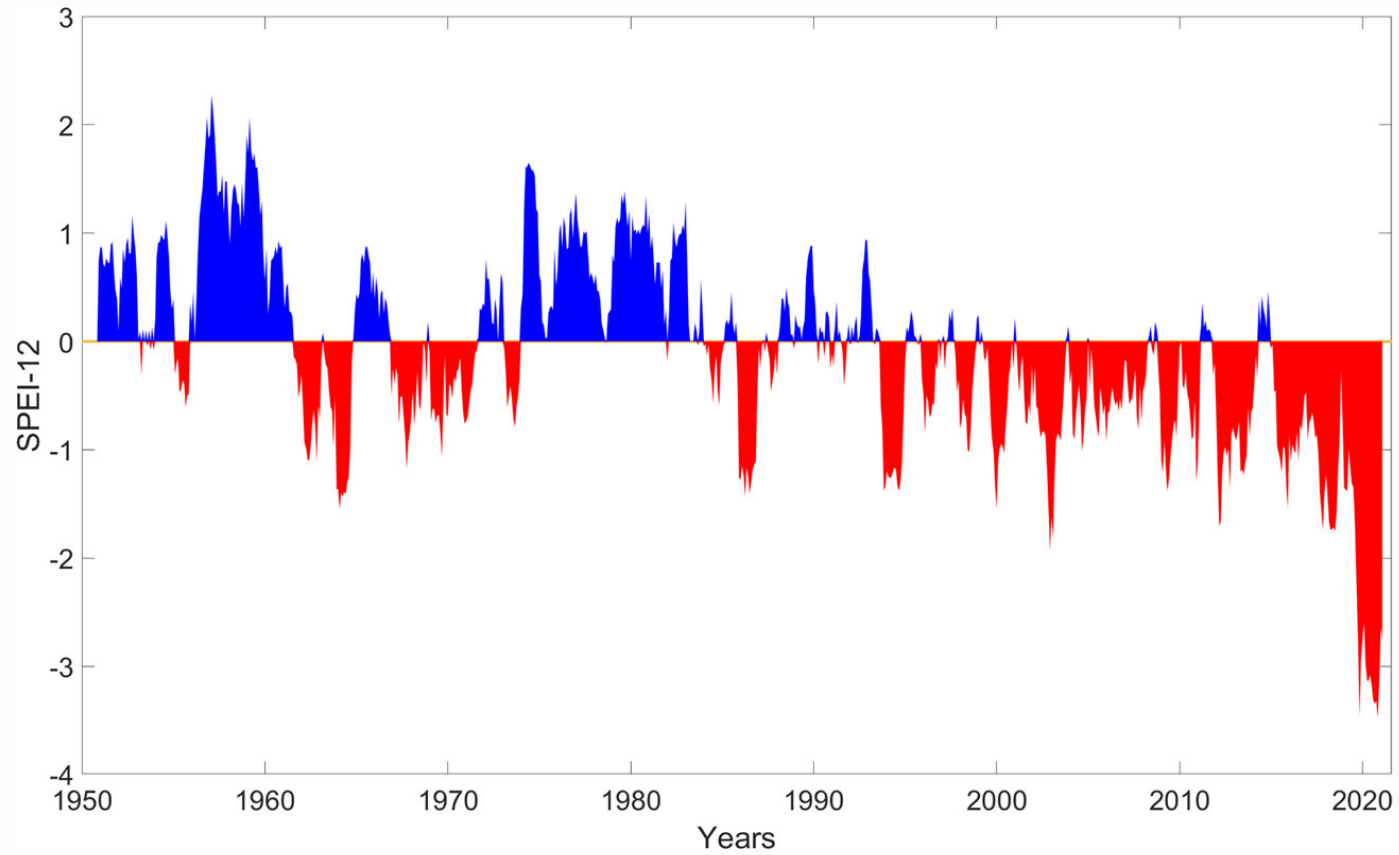
Fire danger ratings are rising as the region warms. 2020 saw the worst conditions in three decades.

Difficulty of controlling fires (DSR index*)



LIBONATI, R., ET AL. "RESCUE BRAZIL'S BURNING PANTANAL WETLANDS." (2020): NATURE

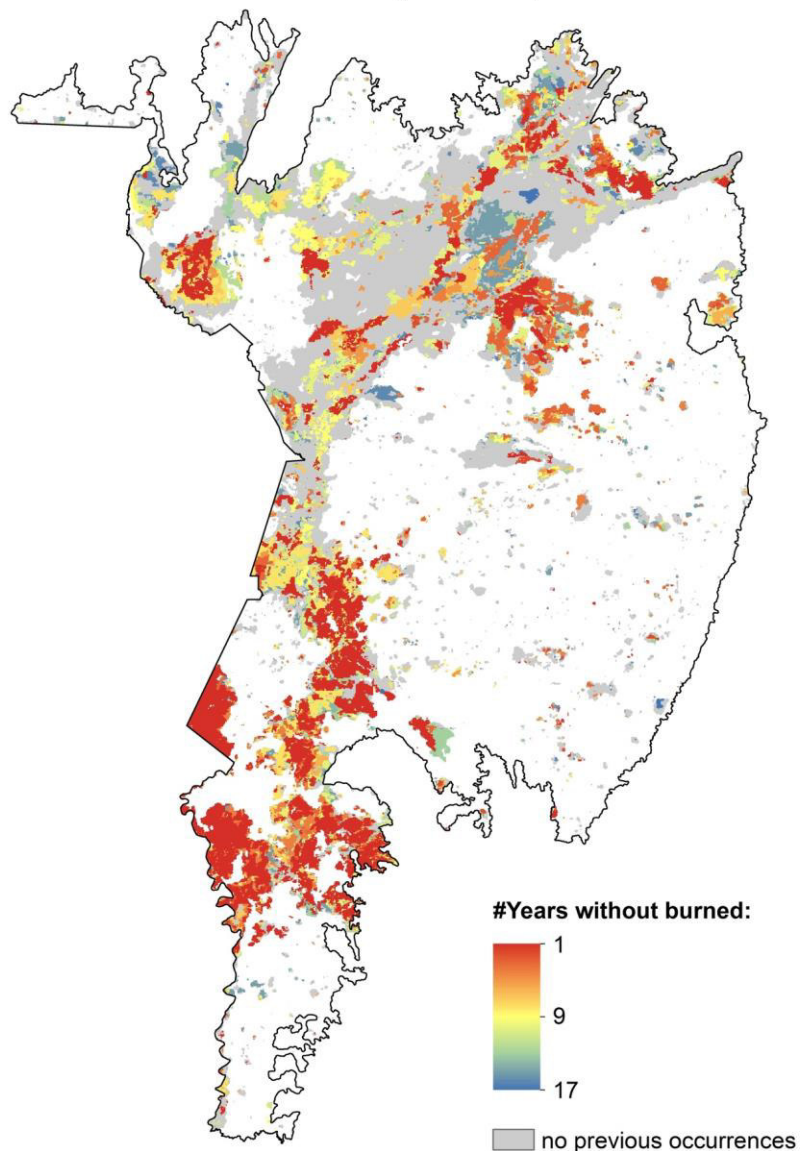




UNPRECEDENT DROUGHT

The worst drought recorded in the Pantanal in 70 years

Burned area 2020 x Occurrences (2003-2019)



ONDAS DE CALOR = FOGO

70%
2020

🔥 🔥 🔥 🔥 🔥 🔥 🔥 🔥 🔥 🔥

44
dias de ondas de calor

📅 📅 📅 📅 📅 📅 📅 📅 📅 📅

Eventos acoplados: ondas de calor e secas

over the last two decades many regions in Europe and the Americas had over 2/3 of their areas under increased susceptibility of HW's during drought episodes

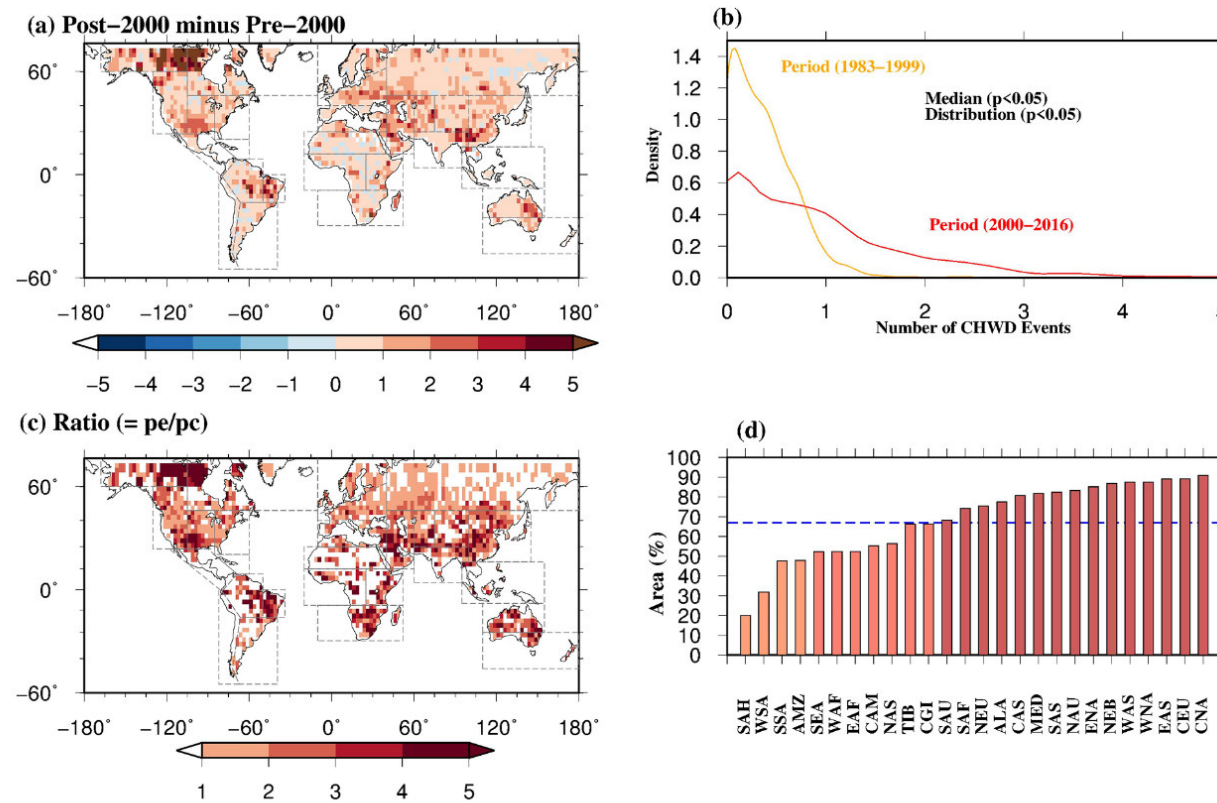
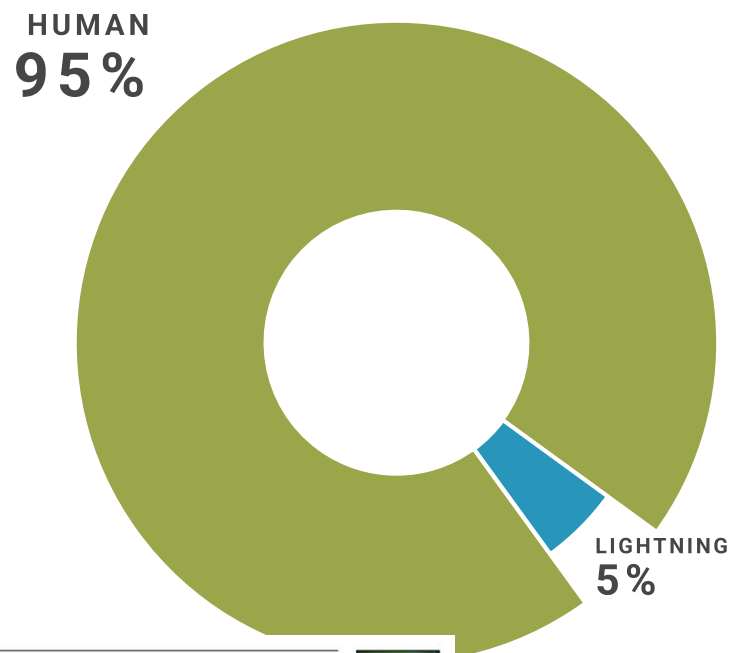


Fig. 1. (a) Difference between the average number of CDHW events during the Pre-2000 period (1983–1999) and Post-2000 period (2000–2016), (b) kernel density plot of the average number of CDHW events during the two periods of the globe, (c) spatial distribution of the ratio of the probabilities where the probability of heat wave day conditioned on drought (pe) is significantly (at 5% significance level) greater than the probability of heat wave day conditioned on no drought (pc), and (d) percentage area of each climate region showing significantly (at 95% confidence level) greater probability of heat wave day conditioned on drought (pe) than that conditioned on no drought (pc).



Pantanal (2012–2017)

scars



burned area

4 mha

TOTAL BURNED AREA



83,4%

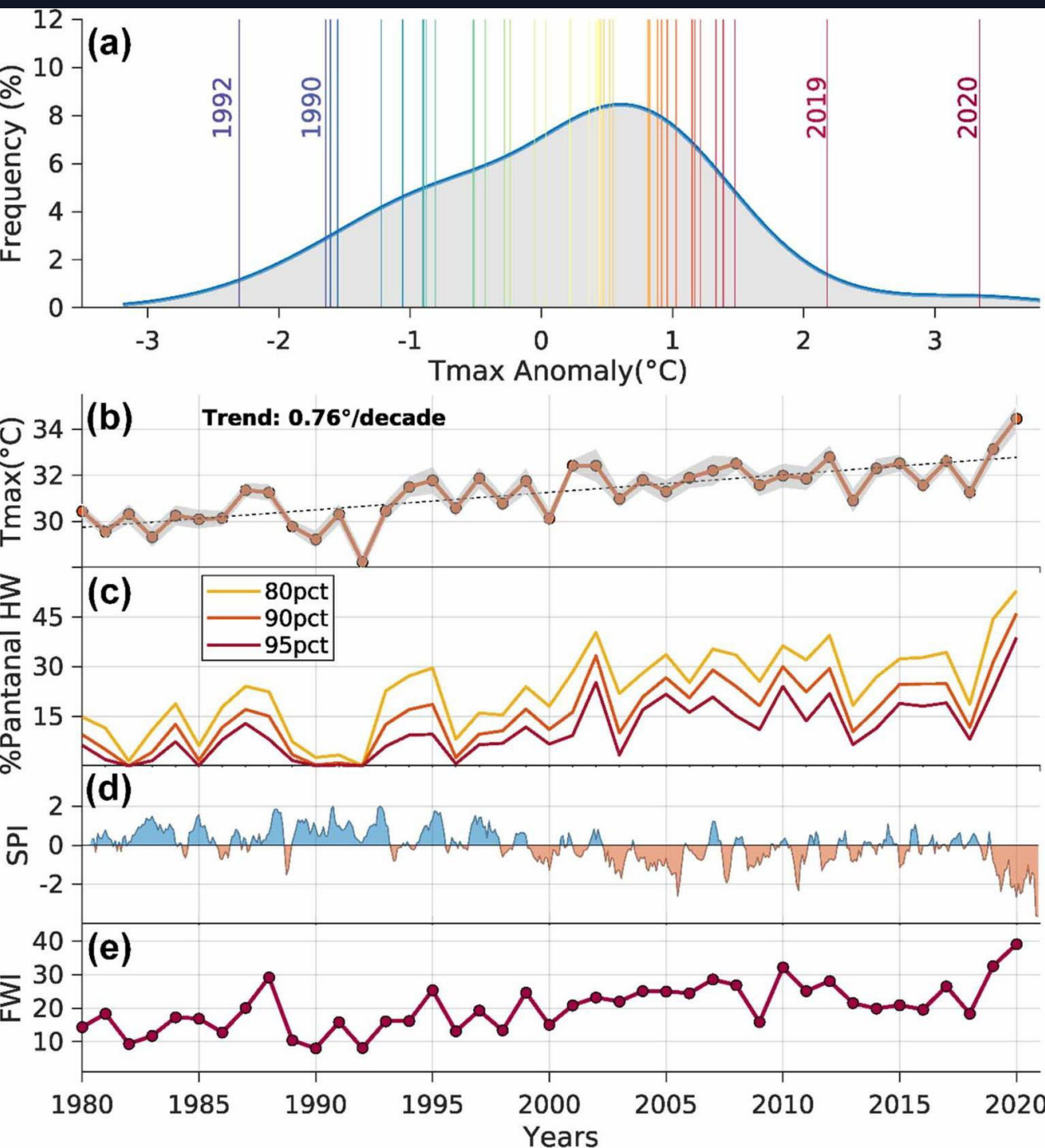
HUMAN-INDUCED



Lightning patterns in the Pantanal: Untangling natural and anthropogenic-induced wildfires



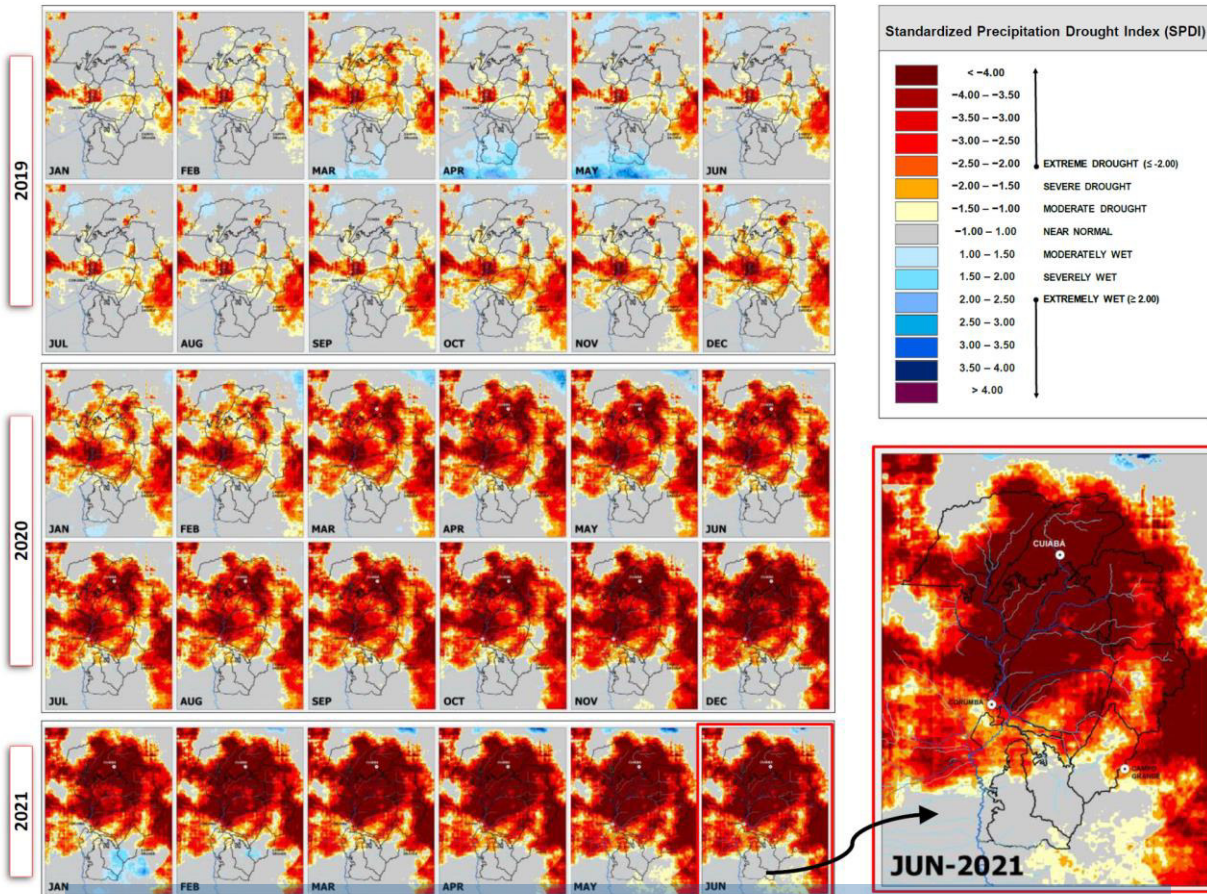
Lucas S. Menezes^a, Aline M. de Oliveira^a, Filipe L.M. Santos^{a,c}, Ana Russo^b, Rodrigo A.F. de Souza^{c,d}, Fabio O. Roque^{e,f}, Renata Libonati^{a,b,g}



AQUECIMENTO ~3-4 °C
ULTIMAS 4 DECADAS

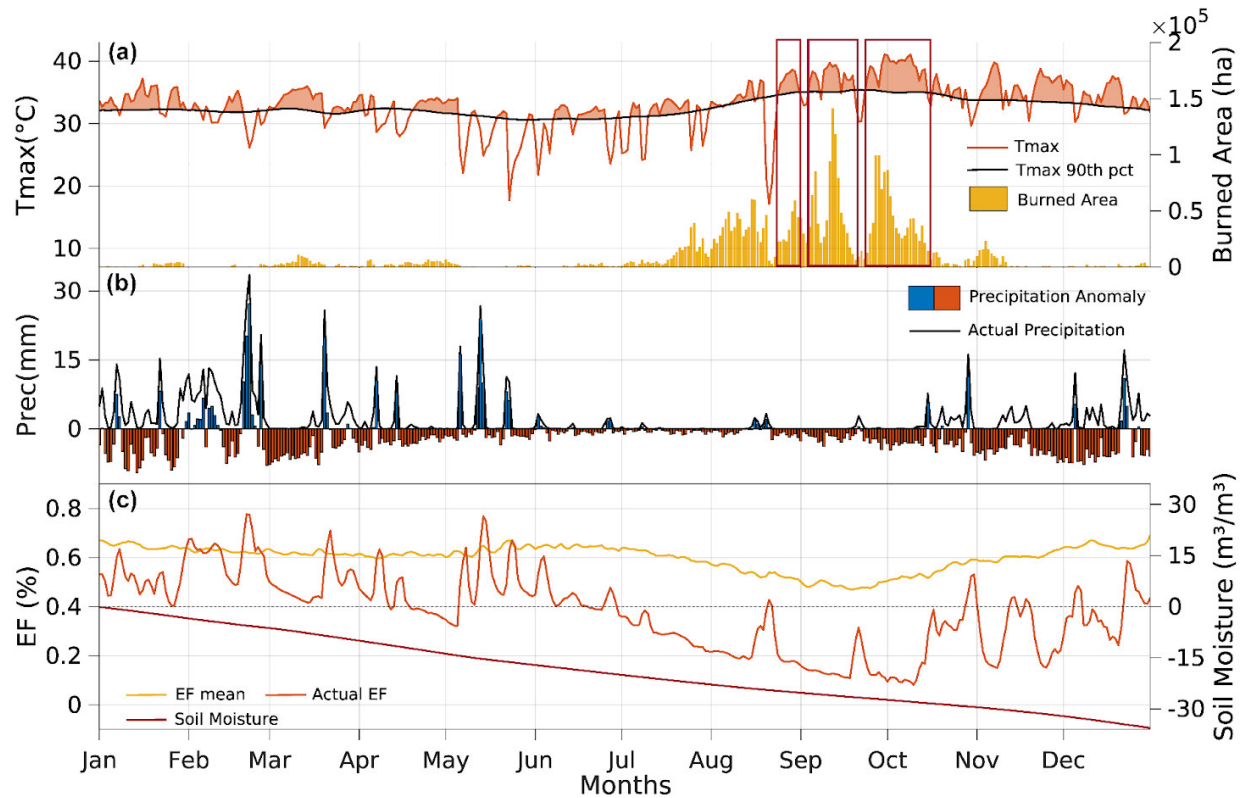
COMBINAÇÃO SECAS E CALOR

LIBONATI, R., ET AL. "ASSESSING THE ROLE OF COMPOUND DROUGHT AND HEATWAVE EVENTS ON UNPRECEDENTED 2020 WILDFIRES IN THE PANTANAL." ENVIRONMENTAL RESEARCH LETTERS 17.1 (2022): 015005.



THIELEN ET AL. THE PANTANAL UNDER SIEGE—ON THE ORIGIN, DYNAMICS AND FORECAST OF THE MEGADROUGHT SEVERELY AFFECTING THE LARGEST WETLAND IN THE WORLD. WATER 2021, 13, 3034. [HTTPS://DOI.ORG/10.3390/W13213034](https://doi.org/10.3390/W13213034)

TYPE TEXT



OCTOBER HEAT WAVES

Throughout 2020, a temporal match between the occurrence of HWs and increasing values of BA was observed.

HIGH HEAT ANOMALIES > 5.8 °C

On average, the Tmax value for the three HWs was 38.5 °C.

55% OF THE BA OCCURED DURING 3 HWS

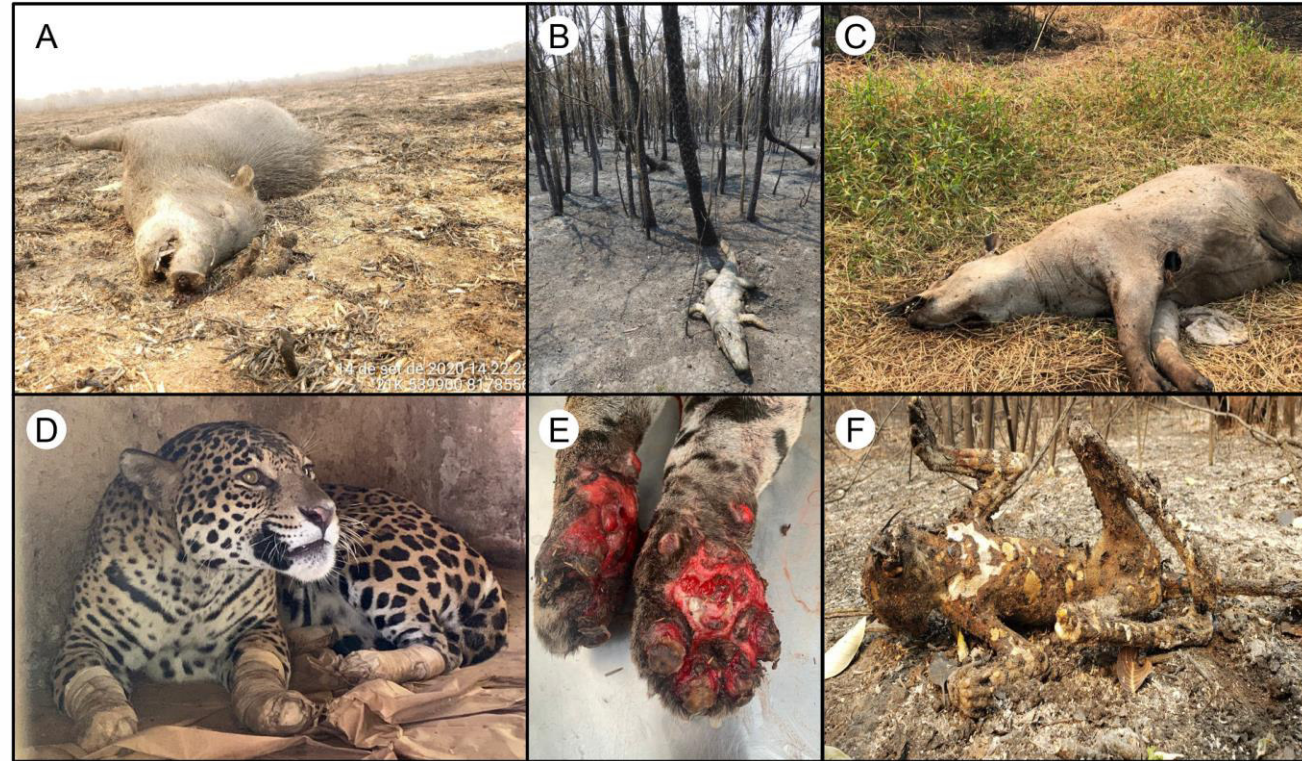
The BA recorded during these three massive HWs accounted for 55% (62%) of the total 2020 (fire season) BA.

ENVIRONMENTAL RESEARCH LETTERS

LETTER • OPEN ACCESS

Assessing the role of compound drought and heatwave events on unprecedented 2020 wildfires in the Pantanal

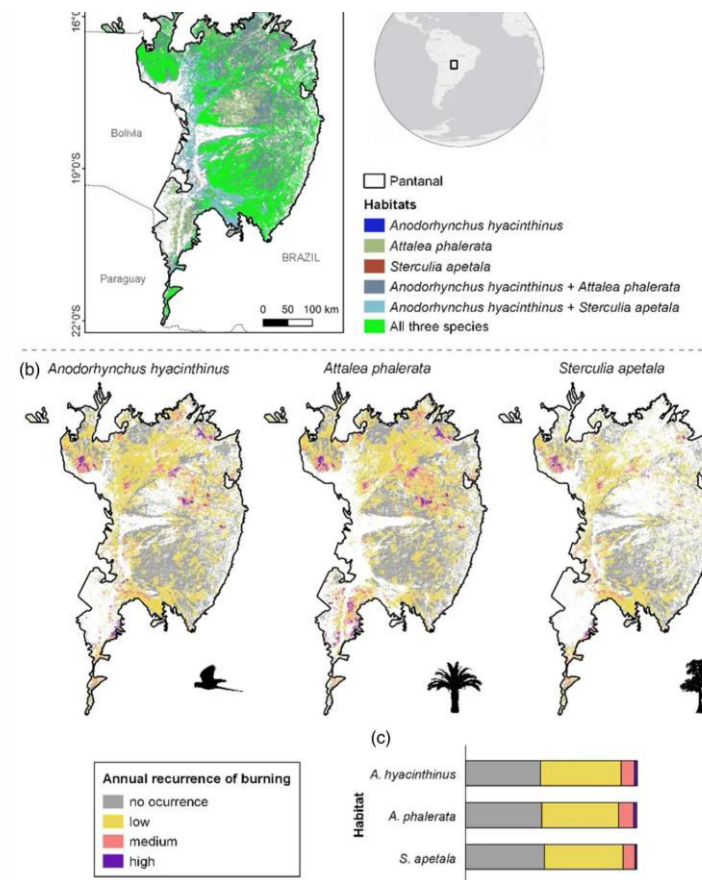
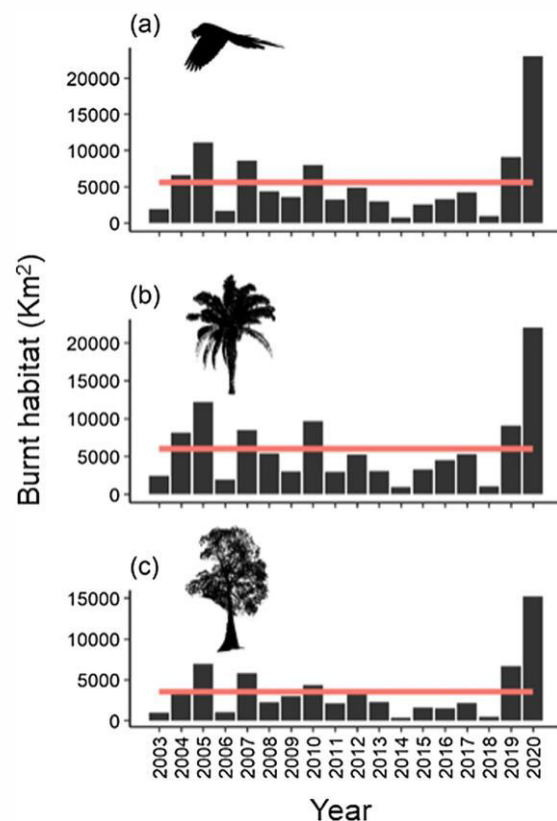
Renata Libonati^{7,8,1,2} , João L Geirinhas^{7,2} , Patrícia S Silva² , Ana Russo² ,
Julia A Rodrigues¹ , Liz B C Belém¹ , Joana Nogueira³, Fabio O Roque^{4,5} ,
Carlos C DaCamara² , Ana M B Nunes¹ + Show full author list



17 MILLION

Vertebrates Directly Killed by the 2020's Wildfires in the Pantanal Wetland, Brazil

TOMAS, W. M., BERLINCK, C. N., CHIARAVALLOTI, R. M., FAGGIONI, G. P., STRÜSSMANN, C., LIBONATI, R., ... & MORATO, R. (2021). DISTANCE SAMPLING SURVEYS REVEAL 17 MILLION VERTEBRATES DIRECTLY KILLED BY THE 2020'S WILDFIRES IN THE PANTANAL, BRAZIL. SCIENTIFIC REPORTS, 11(1), 1-8.



25% DO HABITAT DAS ARARAS AZUIS COMPROMETIDOS EM 2020

26% DAS FONTES DE ALIMENTOS DESTRUÍDAS EM 2020



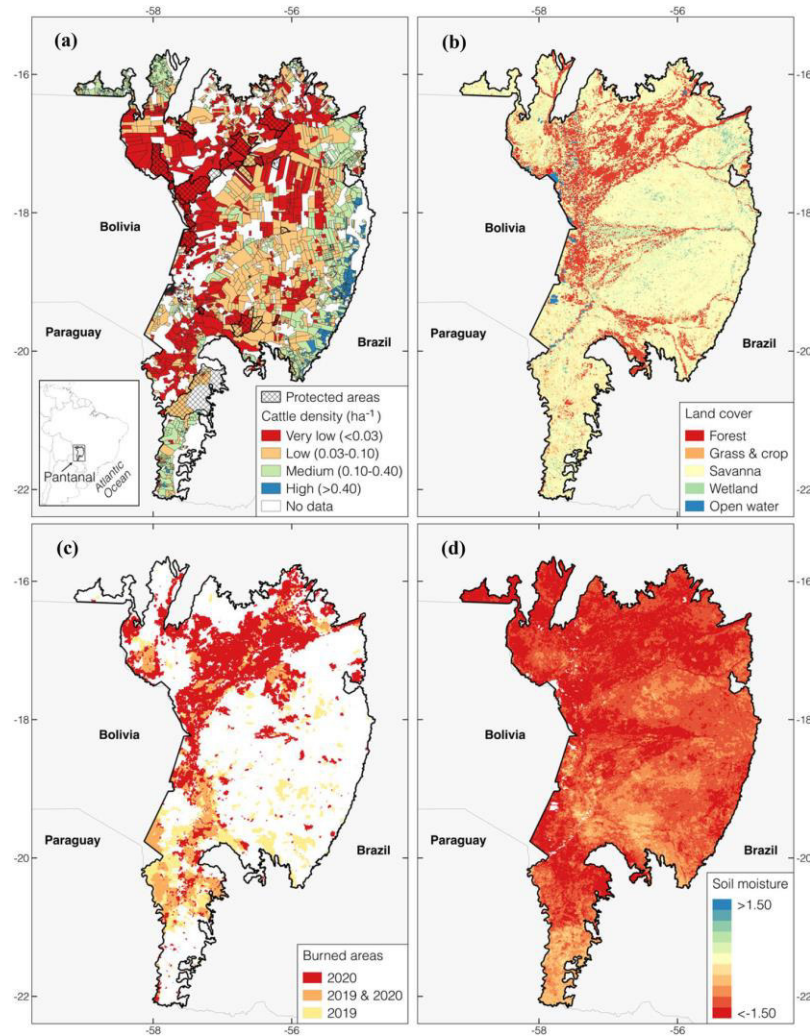
DOS SANTOS FERREIRA, B. H., DA ROSA OLIVEIRA, M., RODRIGUES, J. A., FONTOURA, F. M., GUEDES, N. M., SZABO, J. K., LIBONATI, R... & GARCIA, L. C. (2023). WILDFIRES JEOPARDISE HABITATS OF HYACINTH MACAW (*ANODORHYNCHUS HYACINTHINUS*), A FLAGSHIP SPECIES FOR THE CONSERVATION OF THE BRAZILIAN PANTANAL. *WETLANDS*, 43(5), 47.

OPEN

Changes in land use enhance the sensitivity of tropical ecosystems to fire-climate extremes

Sujay Kumar^{1,2}, Augusto Getirana^{1,2}, Renata Libonati³, Christopher Hain⁴, Sarith Mahanama^{1,2} & Niels Andela⁵

Check for updates

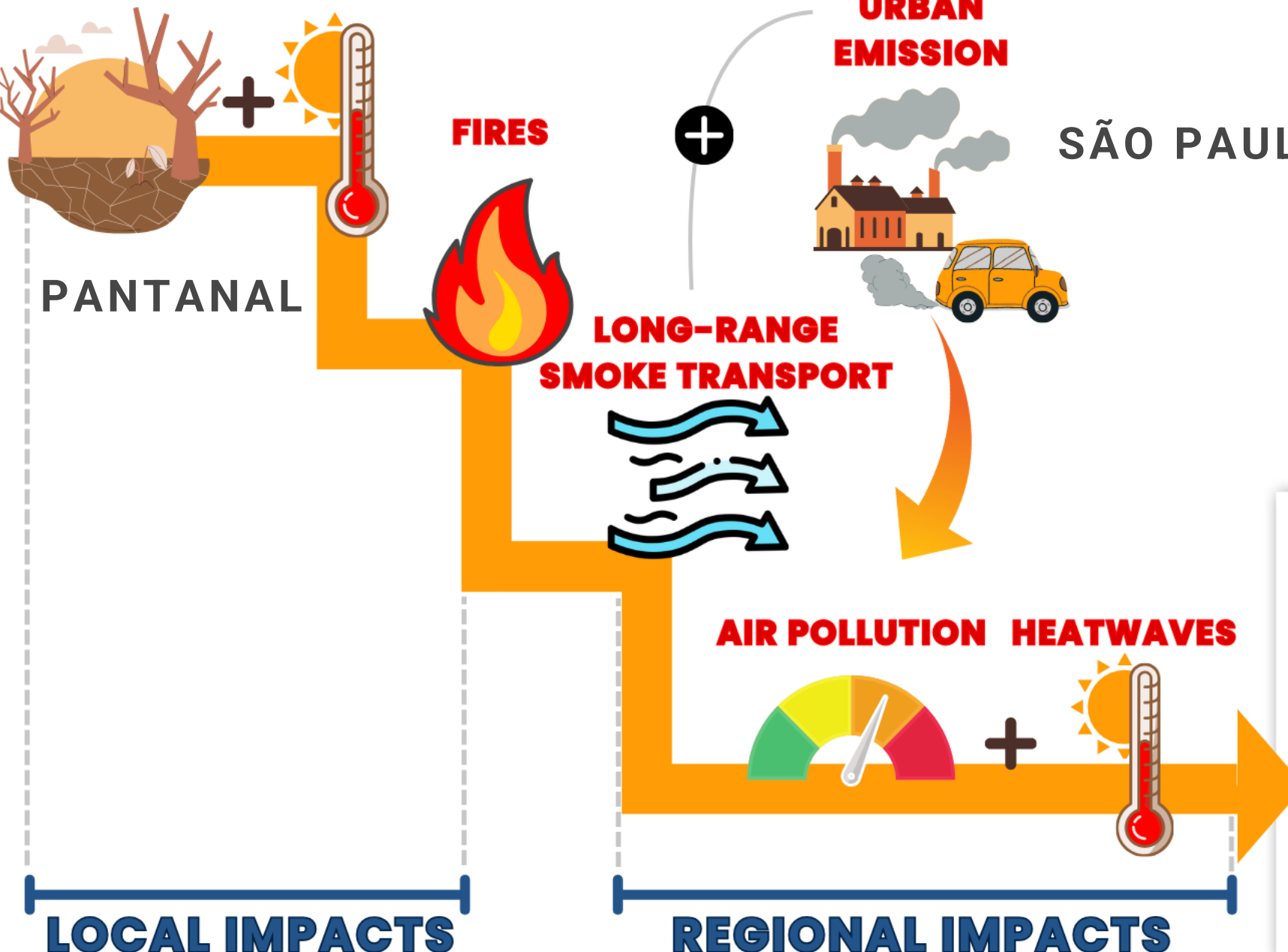


Vegetation

There was a clear decrease in evaporation and an increase in runoff over the natural areas



**COMPOUND DROUGHT
AND HEATWAVES**



HEALTH EFFECTS



2.000

Excess Deaths



JORNAL NACIONAL

Passa de 130 o número de mortos nos incêndios florestais do Chile; é a pior tragédia em 15 anos no país

As zonas mais afetadas pelos incêndios estão nas províncias de Valparaíso e Quillota. O fogo se espalhou por 290 km² - uma área equivalente ao tamanho da cidade de Guarulhos, na Grande São Paulo.

Por Jornal Nacional

06/02/2024 21h11 · Atualizado há uma semana



O GLOBO | Clima e ciência

ASSINE

Buscar

Mundo / Clima e ciência

Calor extremo e moradias pouco resistentes ao fogo: veja o que se sabe sobre os incêndios florestais que assolam o Chile

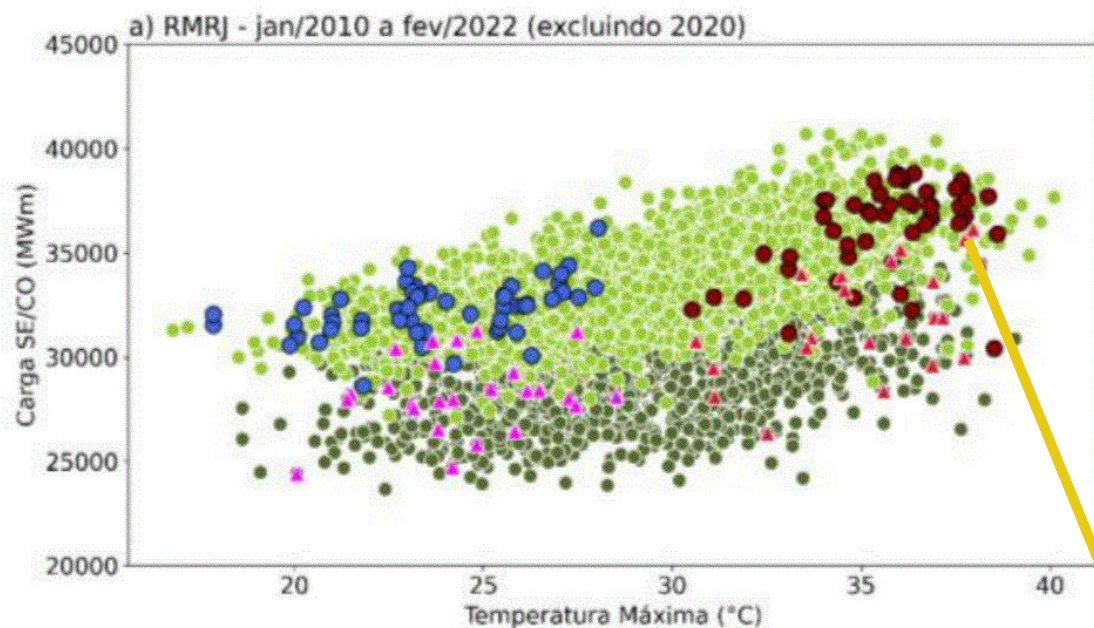
Combinação entre onda de calor e vento ajudou a propagar as chamas, deixando mais de cem mortos até o momento

IMPACTOS SETOR ELÉTRICO

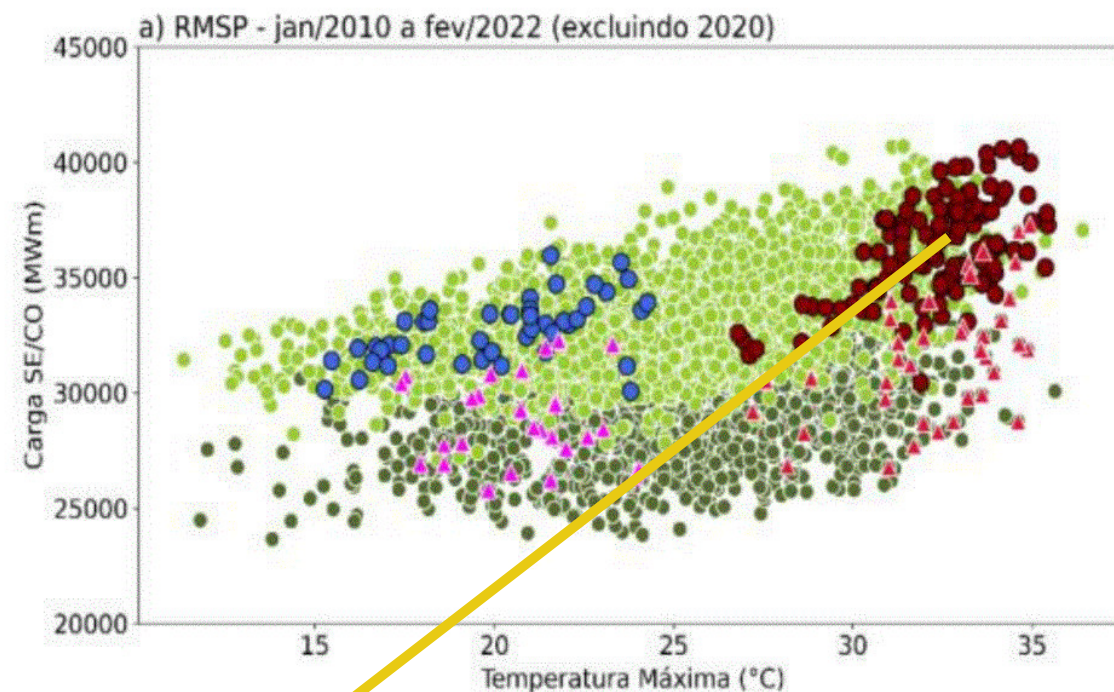


IMPACTO ONDAS DE CALOR X CARGA SETOR ELÉTRICO BRASILEIRO: 2010-2022

RIO DE JANEIRO



SÃO PAULO



ONDAS DE CALOR

Impactos de ondas de calor na **saúde humana**

IMPACTOS DIRETOS



- Desidratação
- Cãibras de Calor
- Insolação



- Doenças Respiratórias Crônicas
- Cardiovasculares



- Doenças Renais
- Saúde Mental

IMPACTOS INDIRETOS



- Sobrecarga nos sistemas de saúde



- Aumento do risco de acidentes de trabalho

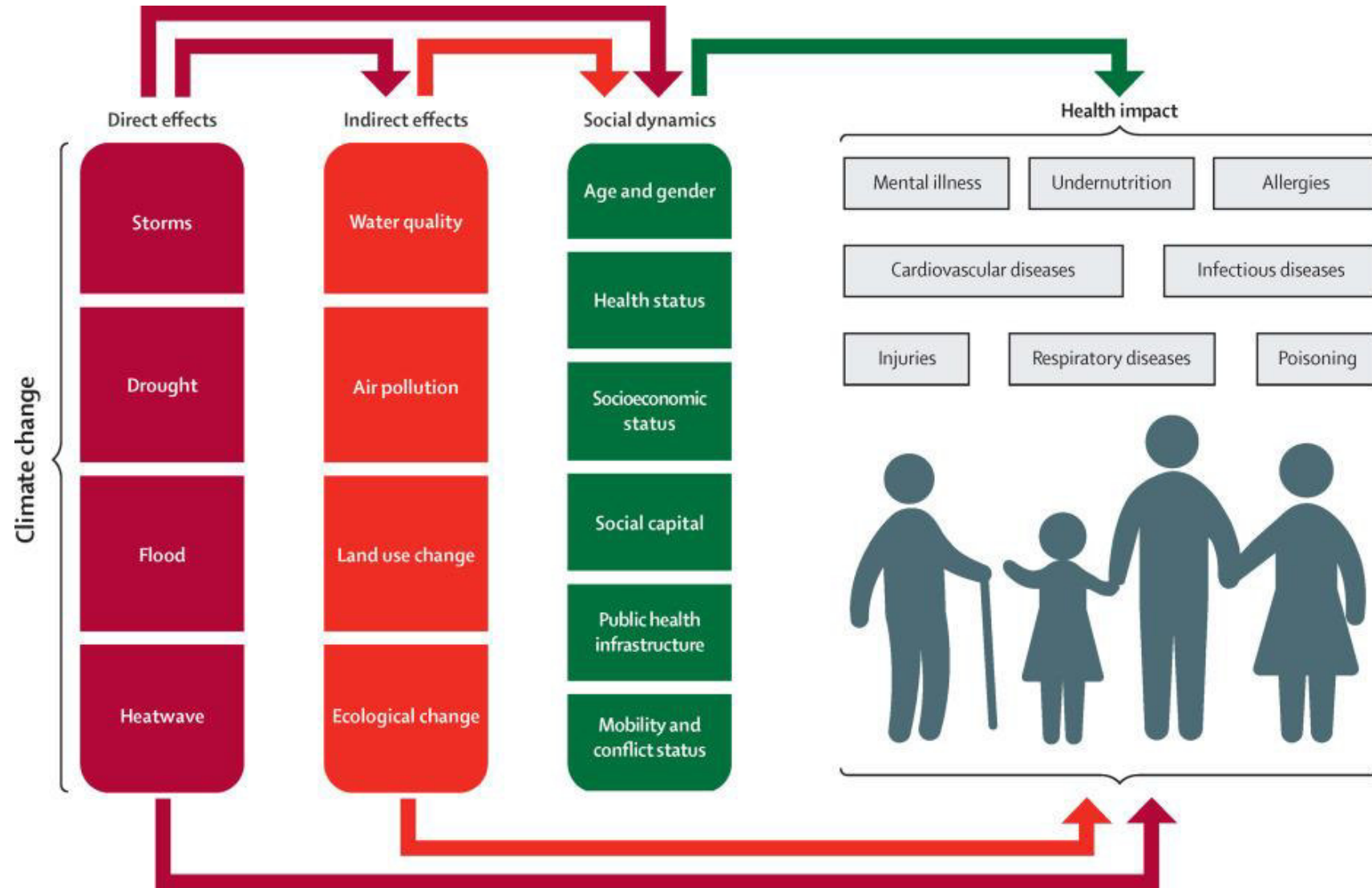


- Transmissão de doenças



- Fornecimento de alimentos, energia, água e transporte

Impactos na saúde: aspectos sociais



Watts, Nick, et al. "Health and climate change: policy responses to protect public health." The lancet (2015)

Calor afeta mais pretos, pardos, idosos e mulheres no Brasil, aponta estudo



GETTY IMAGES

Estudo da UFRJ aponta 48 mil mortes por calor no Brasil em duas décadas; idosos, mulheres, pardos, pretos e população de baixa escolaridade são principais vítimas

Brasil

'A onda de calor é um desastre negligenciado', diz pesquisadora da UFRJ, comparando fenômeno a enchentes e deslizamentos

Em entrevista, Renata Libonati, do Laboratório de Aplicações de Satélites Ambientais, afirma que, entre ações que podem ser adotadas, estão suspensão de aulas em escolas sem ar-condicionado e uso de shoppings como abrigo

Por Ana Lucia Azevedo — Rio de Janeiro

20/09/2023 04h31 · Atualizado há 5 meses



g1

MEIO AMBIENTE

Calor matou mais que deslizamentos de terra no Brasil, aponta estudo

Pesquisa inédita de cientistas brasileiros e portugueses aponta 48 mil mortes em duas décadas, com vítimas principalmente entre idosos, mulheres, negros e a populações de baixa escolaridade.

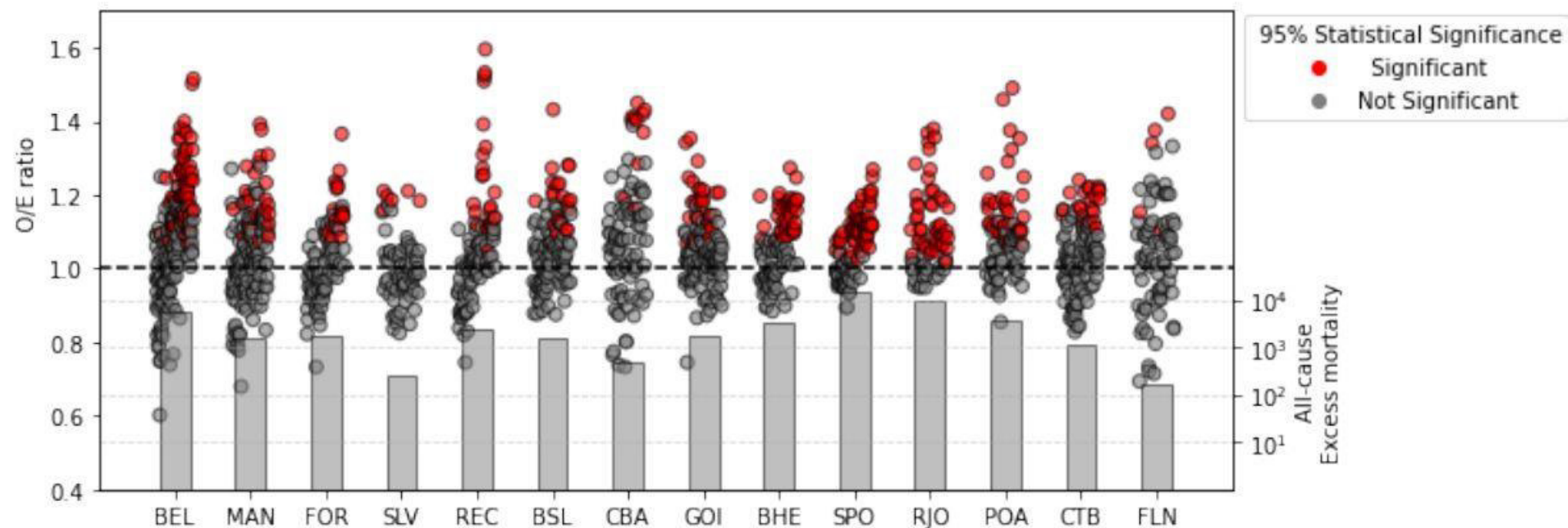
PLOS ONE

RESEARCH ARTICLE

Twenty-first-century demographic and social inequalities of heat-related deaths in Brazilian urban areas

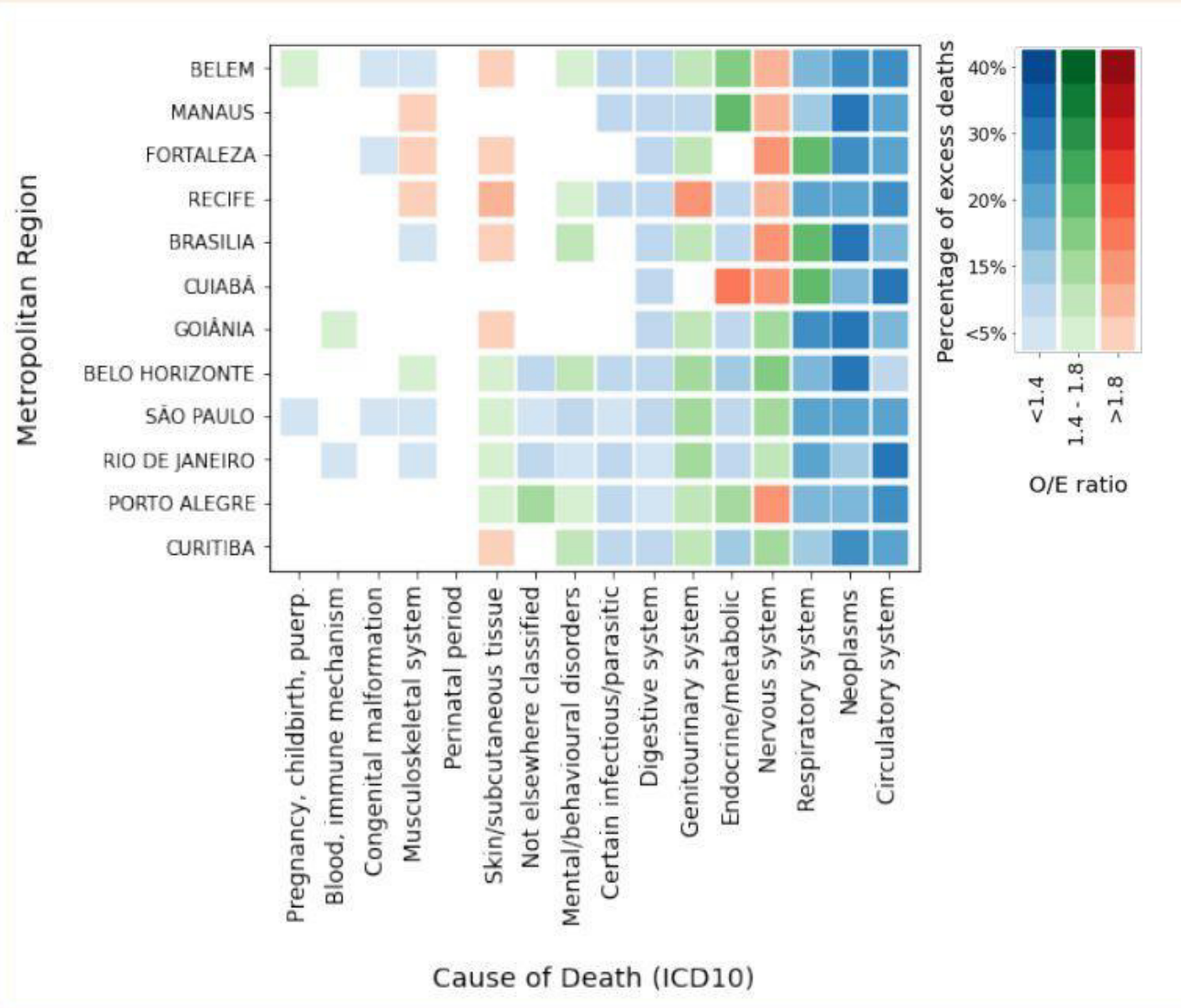
Djacinto Monteiro dos Santos^{1*}, Renata Libonati^{1,2,3*}, Beatriz N. Garcia^{1†}, João L. Geirinhas², Barbara Bresani Salvi⁴, Eliane Lima e Silva^{5,6}, Julia A. Rodrigues¹, Leonardo F. Peres¹, Ana Russo², Renata Gracie⁷, Helen Gurgel^{5,6}, Ricardo M. Trigo^{1,2}

Razão O/E e excesso de mortalidade



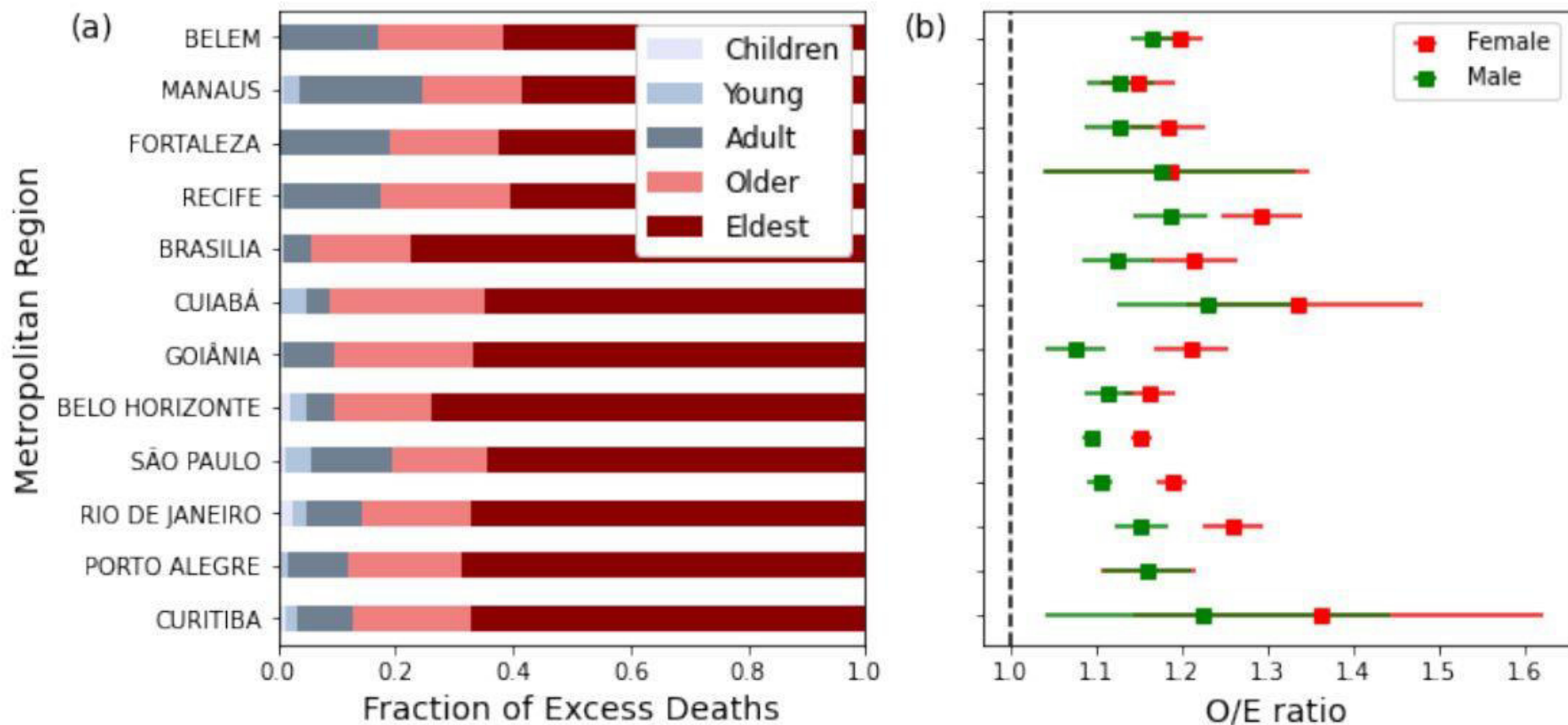
- **48.075 mortes em excesso** relacionadas ao calor nas grandes RM brasileiras (2000-2018).
- Principalmente em São Paulo e Rio de Janeiro, no Sudeste, e na RM de Belém, no Norte.

Causas de mortes relacionadas ao calor

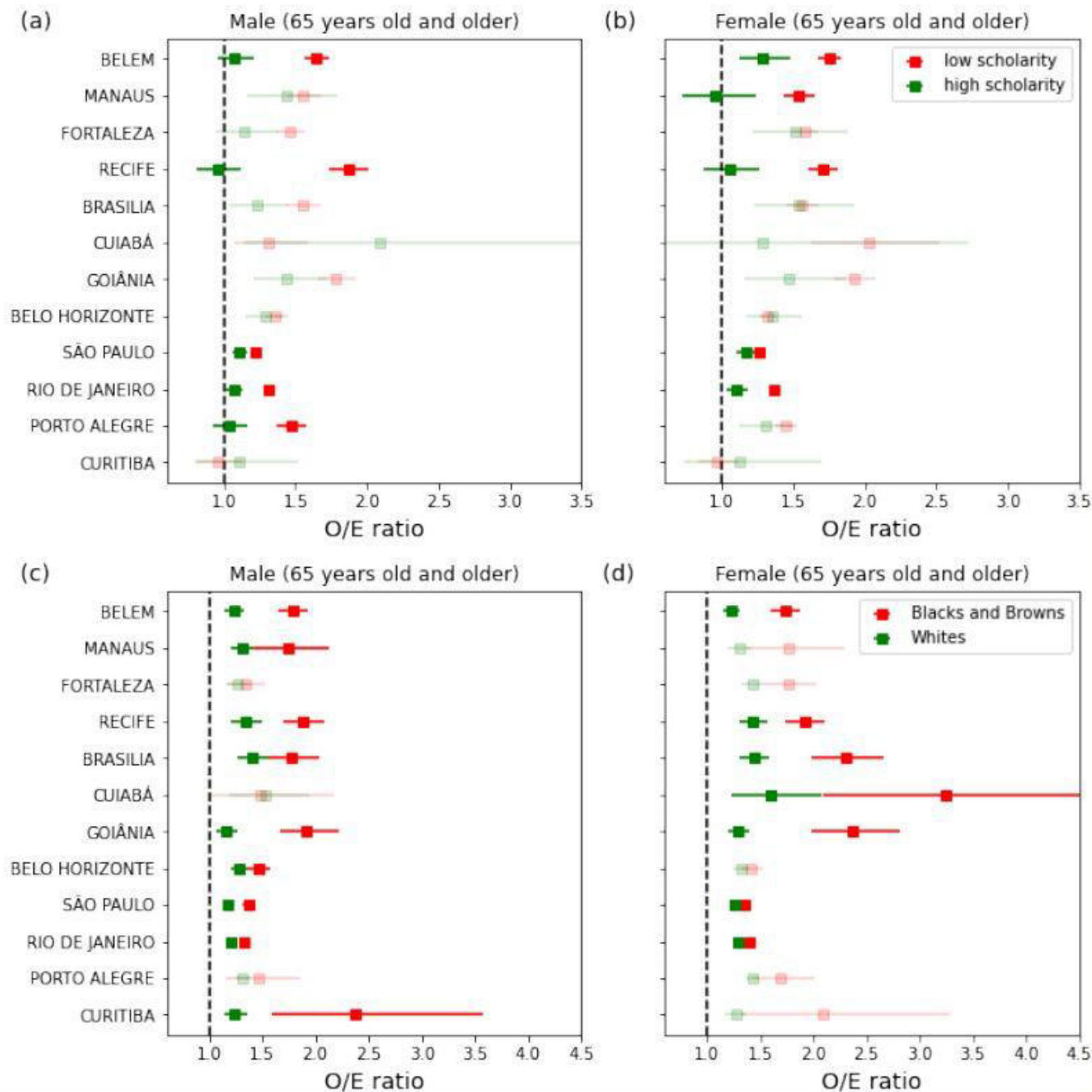


- Doenças do sistema **circulatório, respiratório e neoplasias predominam** (46–70%).
- Aumento de mortes por doenças da **pele e do tecido subcutâneo, sistema nervoso e geniturinário**.

Disparidades entre gênero e grupo etário



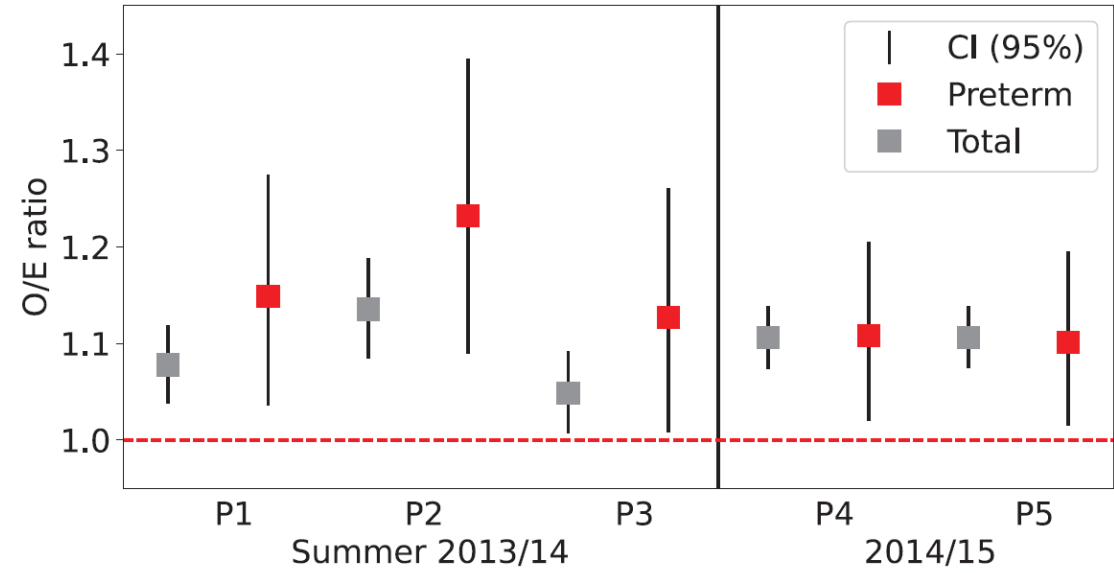
- Os **idosos (>65 anos)** representam 75-94% do excesso de mortes.
- As **mulheres** apresentaram maiores valores de O/E que os homens em todas as regiões.



Interseccionalidade e mudanças climáticas

- Aspectos econômicos e sociais são fatores determinantes para o acesso, utilização e qualidade dos **serviços de saúde**.
- **Vulnerabilidade** e capacidade de **adaptação**.

PREMATURIDADE E ONDAS DE CALOR



DOI: 10.1111/nyas.14887

REVIEW

ANNALS OF THE NEW YORK
ACADEMY OF SCIENCES

Drought-heatwave nexus in Brazil and related impacts on health and fires: A comprehensive review

Renata Libonati^{1,2,3} | João L. Geirinhas^{2,#} | Patrícia S. Silva^{2,#} |
Djacinto Monteiro dos Santos^{1,#} | Julia A. Rodrigues¹ | Ana Russo² |
Leonardo F. Peres¹ | Luiza Narcizo¹ | Monique E. R. Gomes¹ | Andreza P. Rodrigues⁴ |
Carlos C. DaCamara² | José Miguel C. Pereira^{3,5} | Ricardo M. Trigo^{1,2}

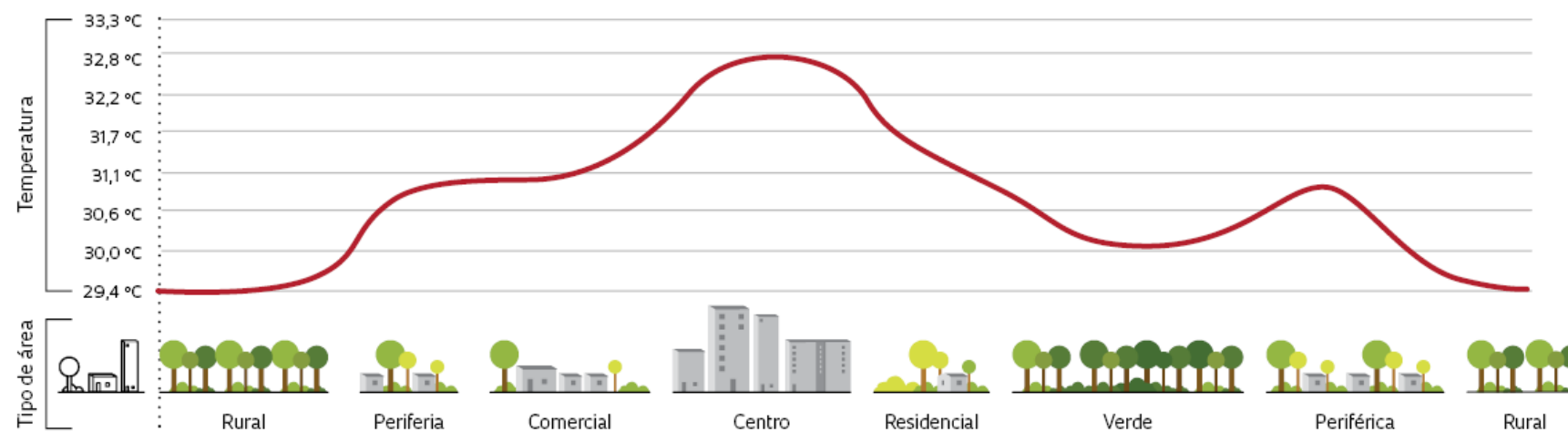
Efeito das ilhas de calor urbano esquenta até cidades de médio e pequeno porte

Diferença de temperatura entre áreas tomadas por concreto e asfalto e bairros com mais vegetação pode chegar a 10 graus Celsius

**55% DA POPULAÇÃO
GLOBAL MORA EM
CENTROS URBANOS,
MAIS QUENTES DO QUE
A ZONA RURAL**

MODELO DE VARIAÇÃO TÉRMICA EM UM MUNICÍPIO

Setores com mais asfalto e concreto são mais quentes do que os trechos arborizados

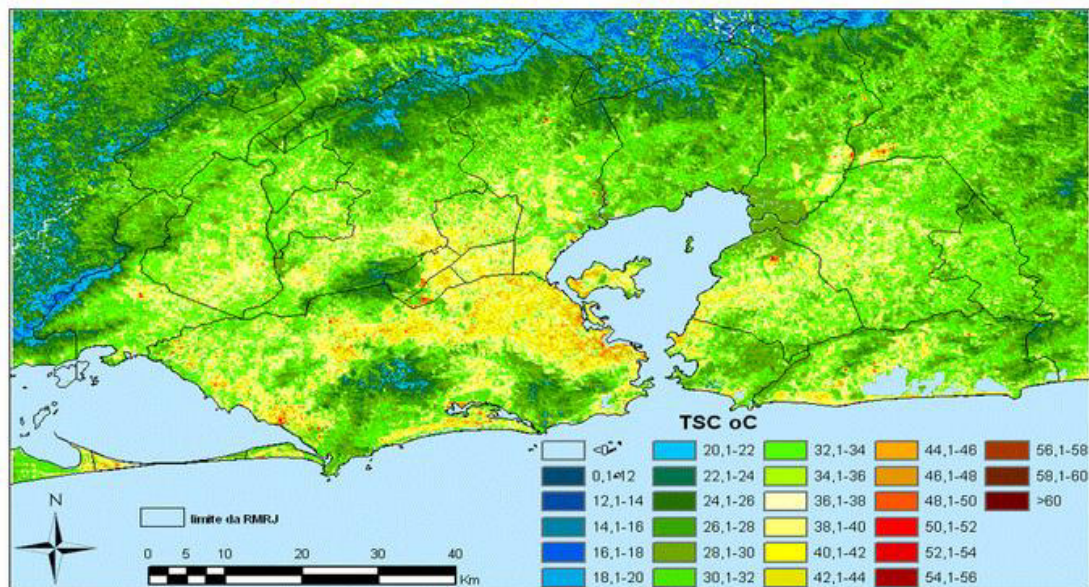




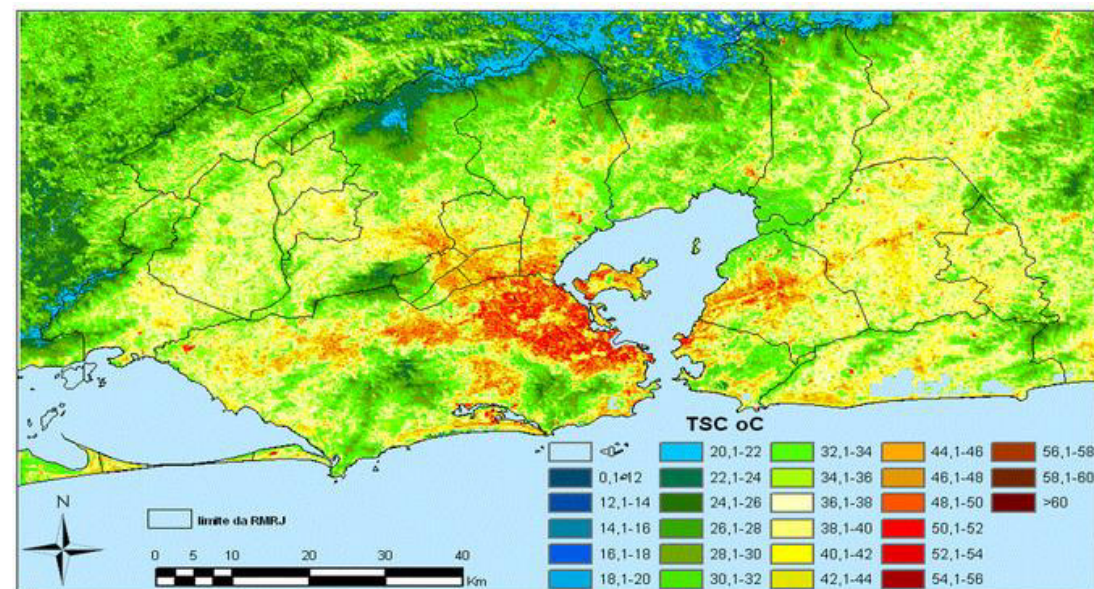
RIO DE JANEIRO - 1974



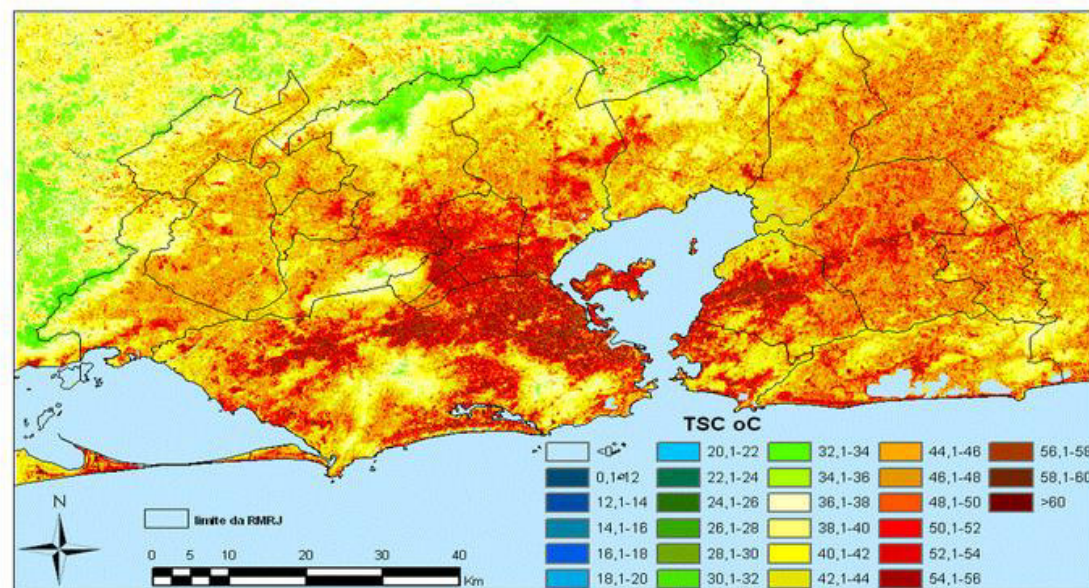
RIO DE JANEIRO - 2014



Década 80



Década 90



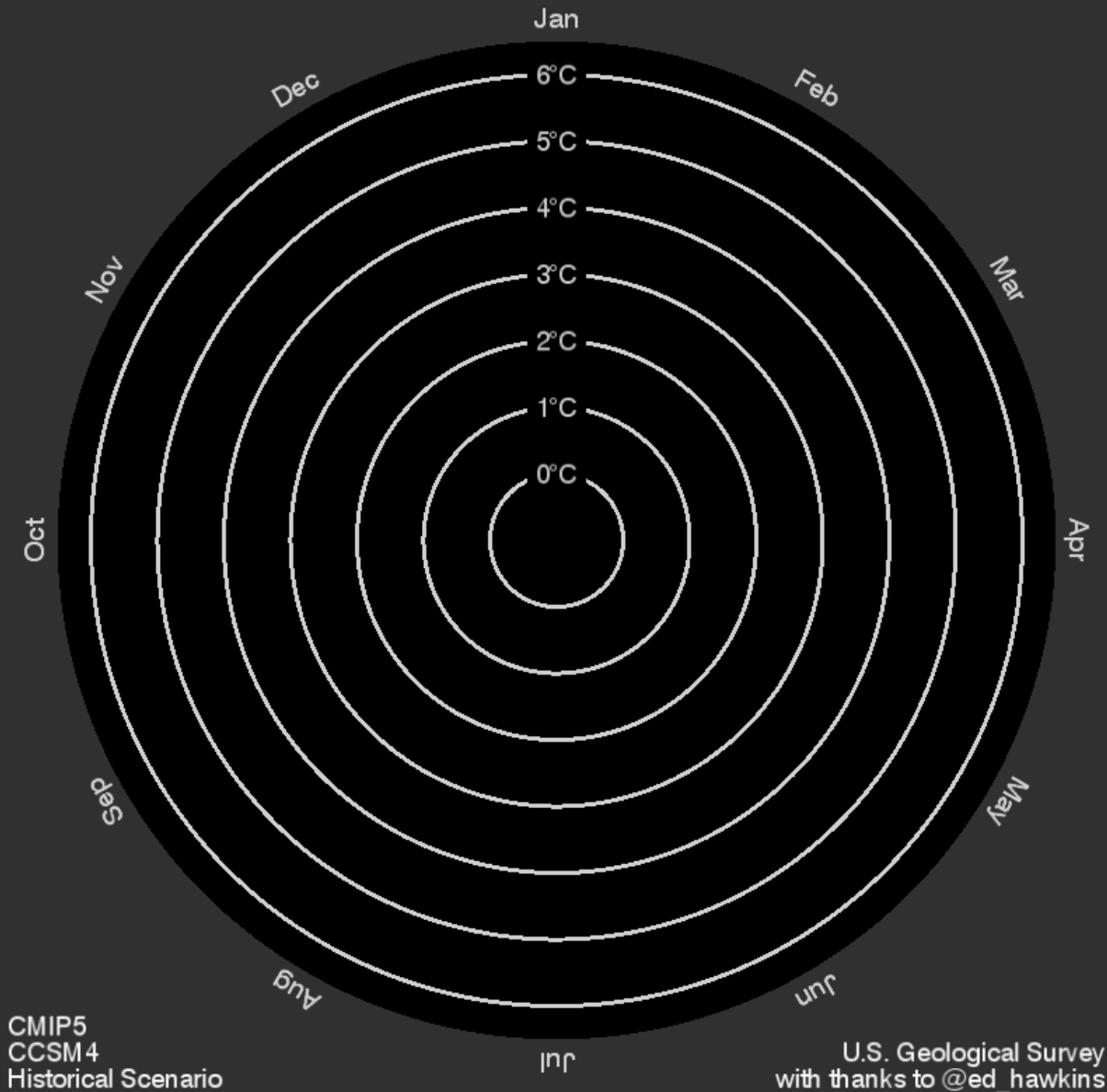
Década 2000

E o futuro?

O que nos espera?

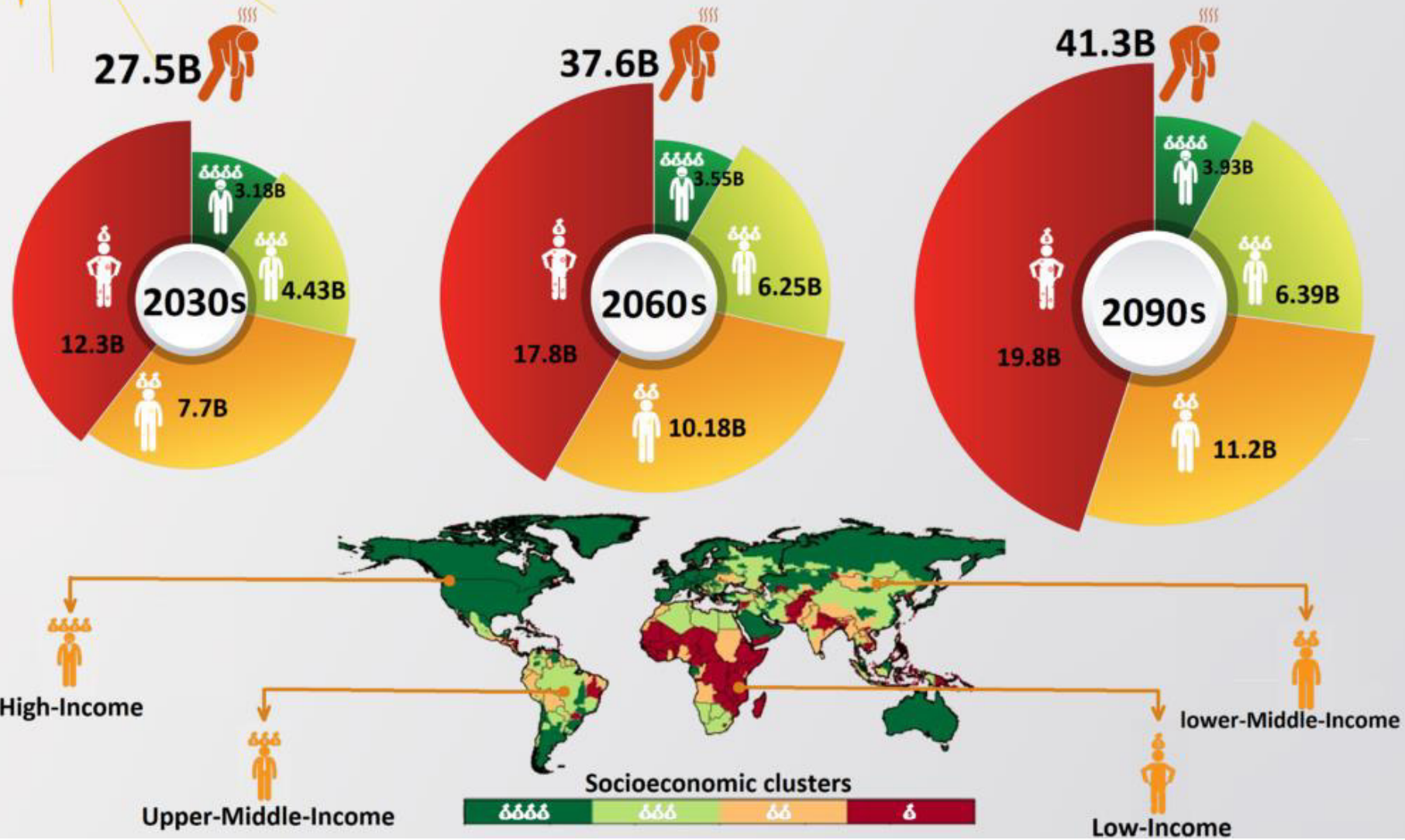


Simulated global temperature change (1850-2100)



Typ

Exposure to heatwaves (Billion person-days per year)



Obrigad@



UFRJ_LASA



[HTTPS://ALARMES.LASA.UFRJ.BR/](https://alarmes.lasa.ufrj.br/)



RENATA.LIBONATI@IGEO.UFRJ.BR



Laboratório de Aplicações de Satélites Ambientais da UFRJ