The role of the Amazon in the regional climate in times of global ebullition (boiling)

Foster Brown

Woodwell Climate Research Center – Federal University of Acre

“Artificial Intelligence and Geospatial revolution to Avoid a Boiling Amazon" of AmazonTEC2023

15 November 2023

Image: CHAT GPT 4

Indigenous peoples have occupied this part of Amazonia continuously for 8,000 years, during times of natural climate change.

These geoglyphs near Rio Branco, Acre are an indication of this indigenous occupation, which is important for us to remember and appreciate.

https://www.livescience.com/57770-mysterious-amazon-geoglyphs-photos.html

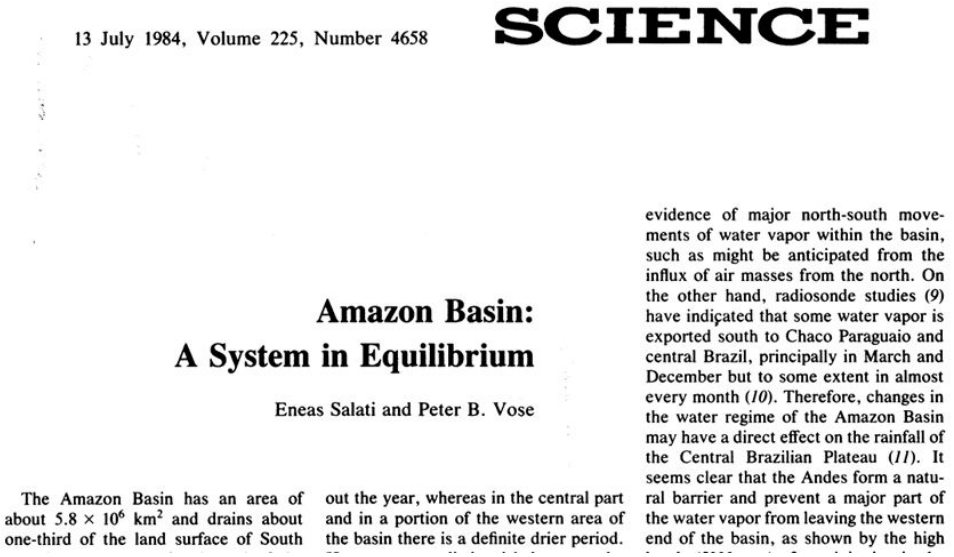
Climate in the Amazon – a mix of global and regional processes.

- A brief chronology
- Current situation
- Some considerations for the future.

Image: CHATGPT 4

1984 – 39 years ago. Eneas Salati and Peter Vose predicted the impact of Amazonian deforestation on climate.

(…) The Andes form a barrier at the western end of the basin and, coupled with the prevailing easterly winds, ensure an almost unique precipitation and water-recycling regime. On average **50 percent of the precipitation is recycled**, and in some areas even more. (…) Continued **large-scale deforestation** is likely to lead to (…) **reduced evapotranspiration and ultimately reduced precipitation**. Reduced precipitation in the Amazon could (…) **adversely affect climate and the present agriculture in south-central Brazil**.



13 July 1984, Volume 225, Number 4658 **SCIENCE**

Amazon Basin: A System in Equilibrium

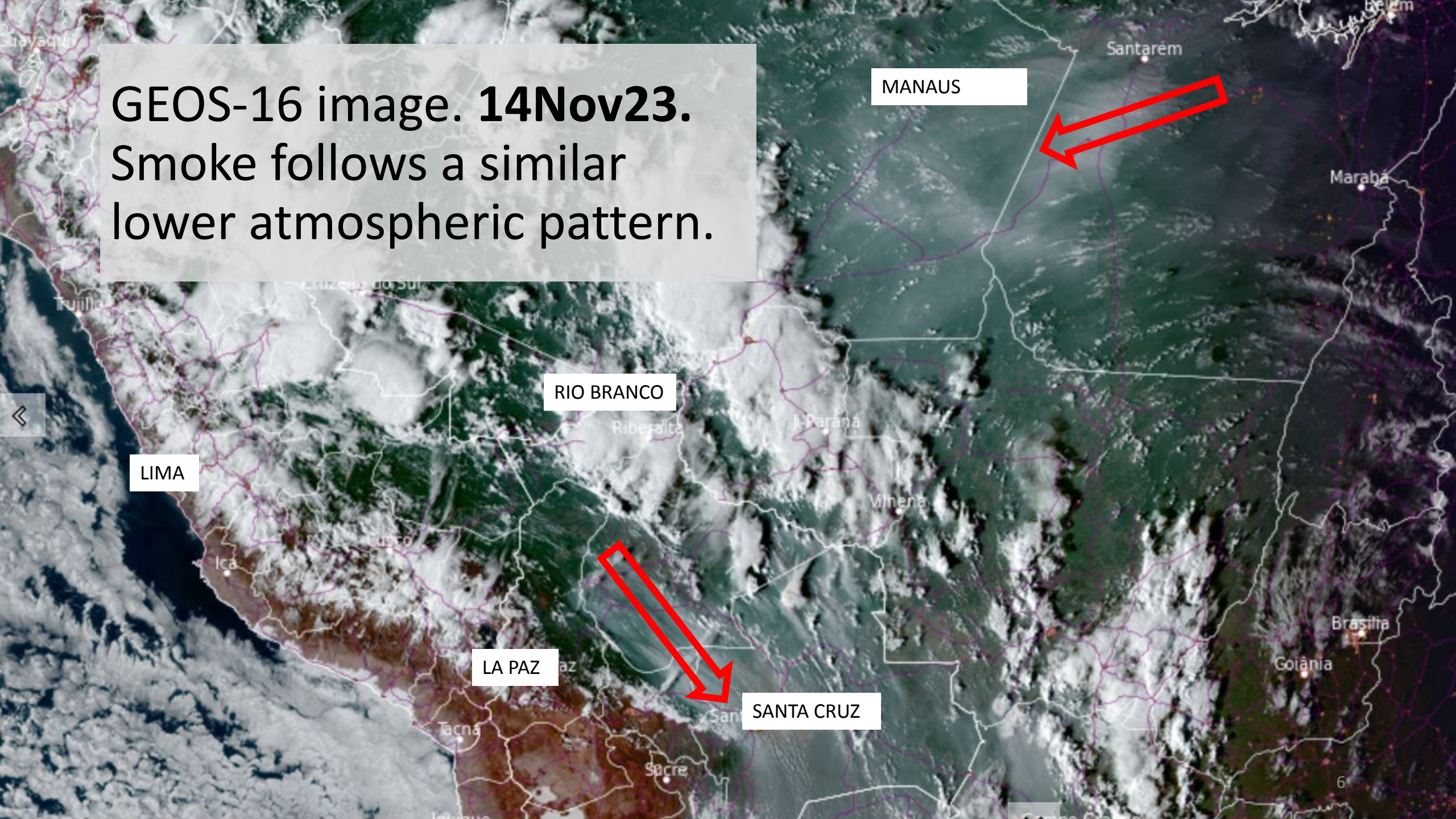
Eneas Salati and Peter B. Vose

The Amazon Basin has an area of about 5.8×10^6 km^2 and drains about one-third of the land surface of South

out the year, whereas in the central part and in a portion of the western area of the basin there is a definite drier period.

evidence of major north-south movements of water vapor within the basin, such as might be anticipated from the influx of air masses from the north. On the other hand, radiosonde studies (*9*) have indiçated that some water vapor is exported south to Chaco Paraguaio and central Brazil, principally in March and December but to some extent in almost every month (*10*). Therefore, changes in the water regime of the Amazon Basin may have a direct effect on the rainfall of the Central Brazilian Plateau (*11*). It seems clear that the Andes form a natural barrier and prevent a major part of the water vapor from leaving the western end of the basin, as shown by the high

Idealized water cycle in the Amazon with “atmospheric rivers”

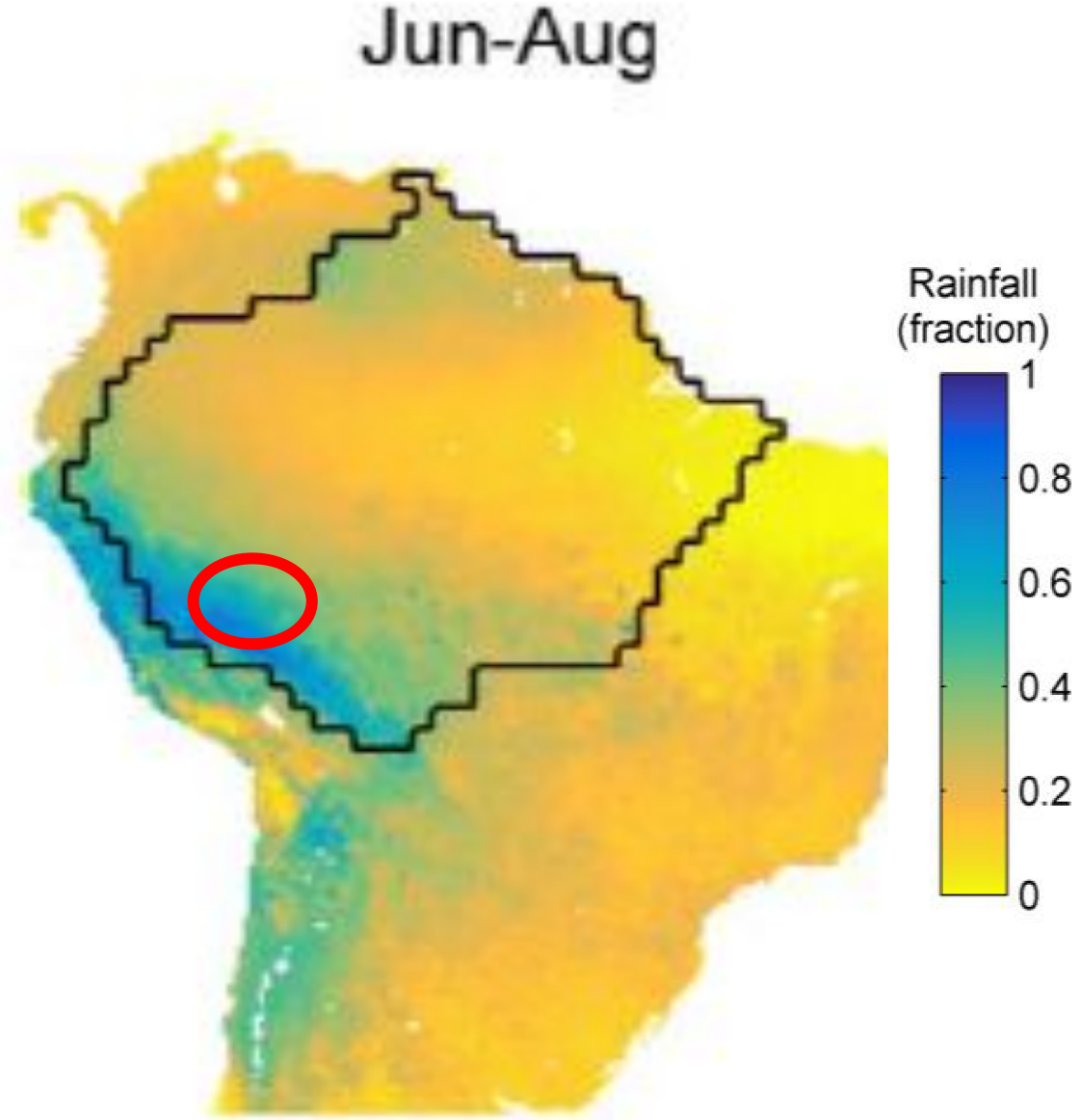

GEOS-16 image. **14Nov23.**
Smoke follows a similar
lower atmospheric pattern.
MANAUS
RIO BRANCO
LIMA
LA PAZ
SANTA CRUZ
Santarém
Marabá
Ribeirão Preto
Uberlândia
Brasília
Goiânia
Ica
Tacna
Sucre

Hydrologists confirmed in articles published in 2003 and 2011 that deforestation changes river discharges and reduces evapotranspiration in the Tocantins and Araguaia Rivers, supporting the hypothesis of Salati and Vose.

•Costa, Marcos Heil, Aurélie Botta, and Jeffrey A Cardille. "**Effects of Large-Scale Changes in Land Cover on the Discharge of the Tocantins River, Southeastern Amazonia**." *Journal of Hydrology* 283, no. 1 (December 10, 2003): 206–17. https://doi.org/10.1016/S0022-1694(03)00267-1;

•Coe, M. T., E. M. Latrubesse, M. E. Ferreira, and M. L. Amsler. "**The Effects of Deforestation and Climate Variability on the Streamflow of the Araguaia River, Brazil.**" *Biogeochemistry* 105, no. 1 (September 1, 2011): 119–31. https://doi.org/10.1007/s10533-011-9582-2

Arie Staal and others in 2018 confirmed the critical role of Amazon forest water recycling. The role is particularly important in the dry season for SW Amazonia and the Peruvian/ Bolivian Andes.



Staal, Arie, Obbe A. Tuinenburg, Joyce H. C. Bosmans, Milena Holmgren, Egbert H. van Nes, Marten Scheffer, Delphine Clara Zemp, e Stefan C. Dekker. **"Forest-rainfall cascades buffer against drought across the Amazon".** *Nature Climate Change* 8, nº 6 (1º de junho de 2018): 539–43. https://doi.org/10.1038/s41558-018-0177-y.

Forest and climate are inter-linked in the Amazon

While the Amazon forest is a major carbon reservoir, it also serves as a major factor affecting climate in South America.

Forest evapotranspiration is not only a water flux, it is also a heat transfer mechanism that cools the forest several degrees C below deforested lands (Coe et al. 2017. Silverio et al. 2015, Butt et al. 2023).

Reforestation is one way of reducing the rate of temperature rise in the region. (Haghtalab et al. 2022).

1991 – 32 years ago. Carlos Nobre forecast a colapse of the southern Amazon Forest

Amazonian Deforestation and Regional Climate Change

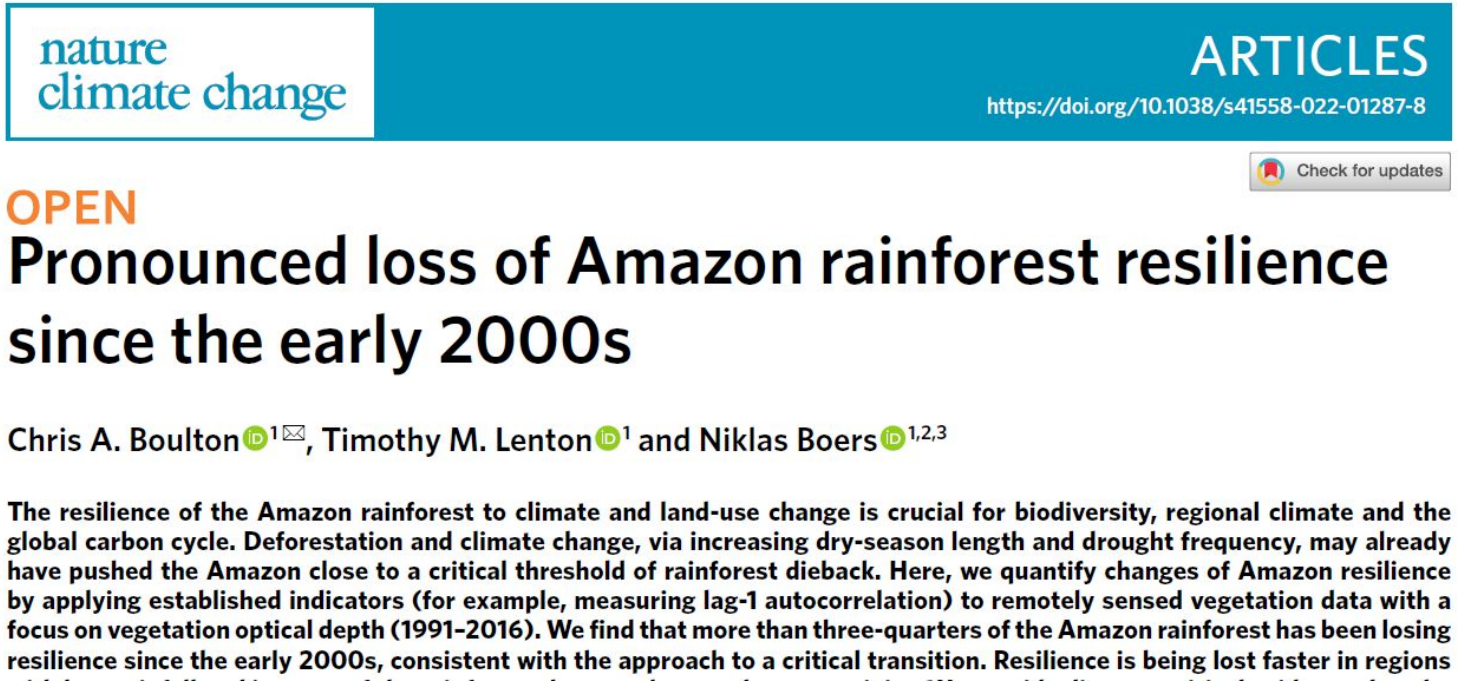
CARLOS A. NOBRE,* PIERS J. SELLERS AND JAGADISH SHUKLA

These results suggest that a complete and rapid destruction of the Amazon tropical forest could be effectively irreversible in the southern part of Amazonia. Changes in the region's hydrological cycle and the disruption of complex plant–animal relations could be so profound that once the tropical forests were destroyed, they might not be able to reestablish themselves.

VOLUME 4 JOURNAL OF CLIMATE OCTOBER 1991

The effect on forests, hypothesized by Nobre et al., has been occurring since early 2000s.

- We find that more than **three-quarters of the Amazon rainforest has been losing resilience since the early 2000s**, consistent with the approach to a critical transition. **Resilience is being lost faster in regions with less rainfall and in parts of the rainforest that are closer to human activity.** We provide **direct empirical evidence that the Amazon rainforest is losing resilience, risking dieback** with profound implications for biodiversity, carbon storage and climate change at a global scale.



nature climate change

ARTICLES

https://doi.org/10.1038/s41558-022-01287-8

Check for updates

OPEN

Pronounced loss of Amazon rainforest resilience since the early 2000s

Chris A. Boulton[1]✉, Timothy M. Lenton[1] and Niklas Boers[1,2,3]

The resilience of the Amazon rainforest to climate and land-use change is crucial for biodiversity, regional climate and the global carbon cycle. Deforestation and climate change, via increasing dry-season length and drought frequency, may already have pushed the Amazon close to a critical threshold of rainforest dieback. Here, we quantify changes of Amazon resilience by applying established indicators (for example, measuring lag-1 autocorrelation) to remotely sensed vegetation data with a focus on vegetation optical depth (1991–2016). We find that more than three-quarters of the Amazon rainforest has been losing resilience since the early 2000s, consistent with the approach to a critical transition. Resilience is being lost faster in regions

The dry season in the southern Amazon has been expanding.

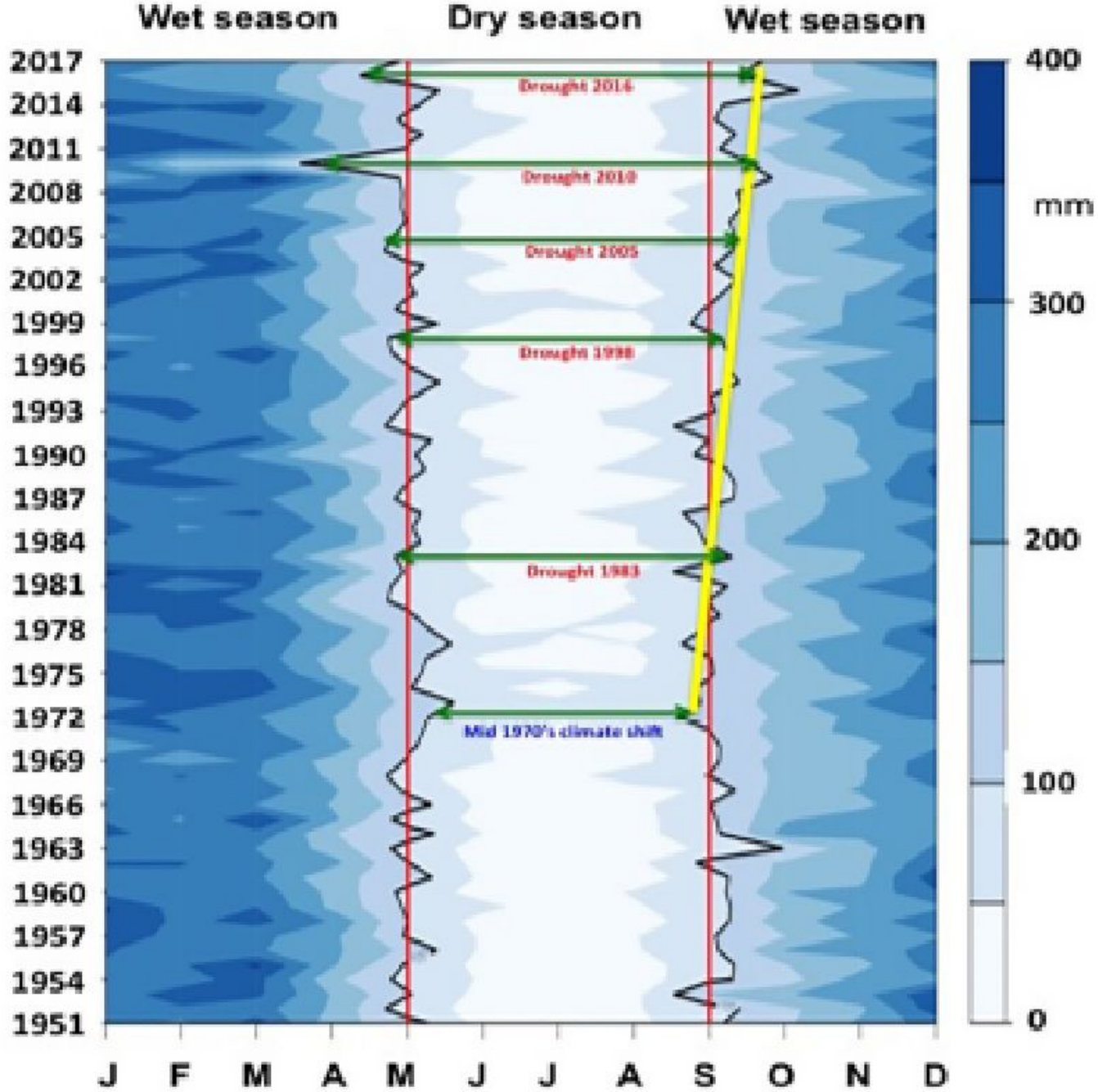
Espinoza, J.C., Ronchail, J., Marengo, J.A. *et al.* Contrasting North–South changes in Amazon wet-day and dry-day frequency and related atmospheric features (1981–2017). *Clim Dyn* **52**, 5413–5430 (2019). https://doi.org/10.1007/s00382-018-4462-2

frontiers in Earth Science
REVIEW
Received: 21 December 2018
doi: 10.3389/feart.2018.00228

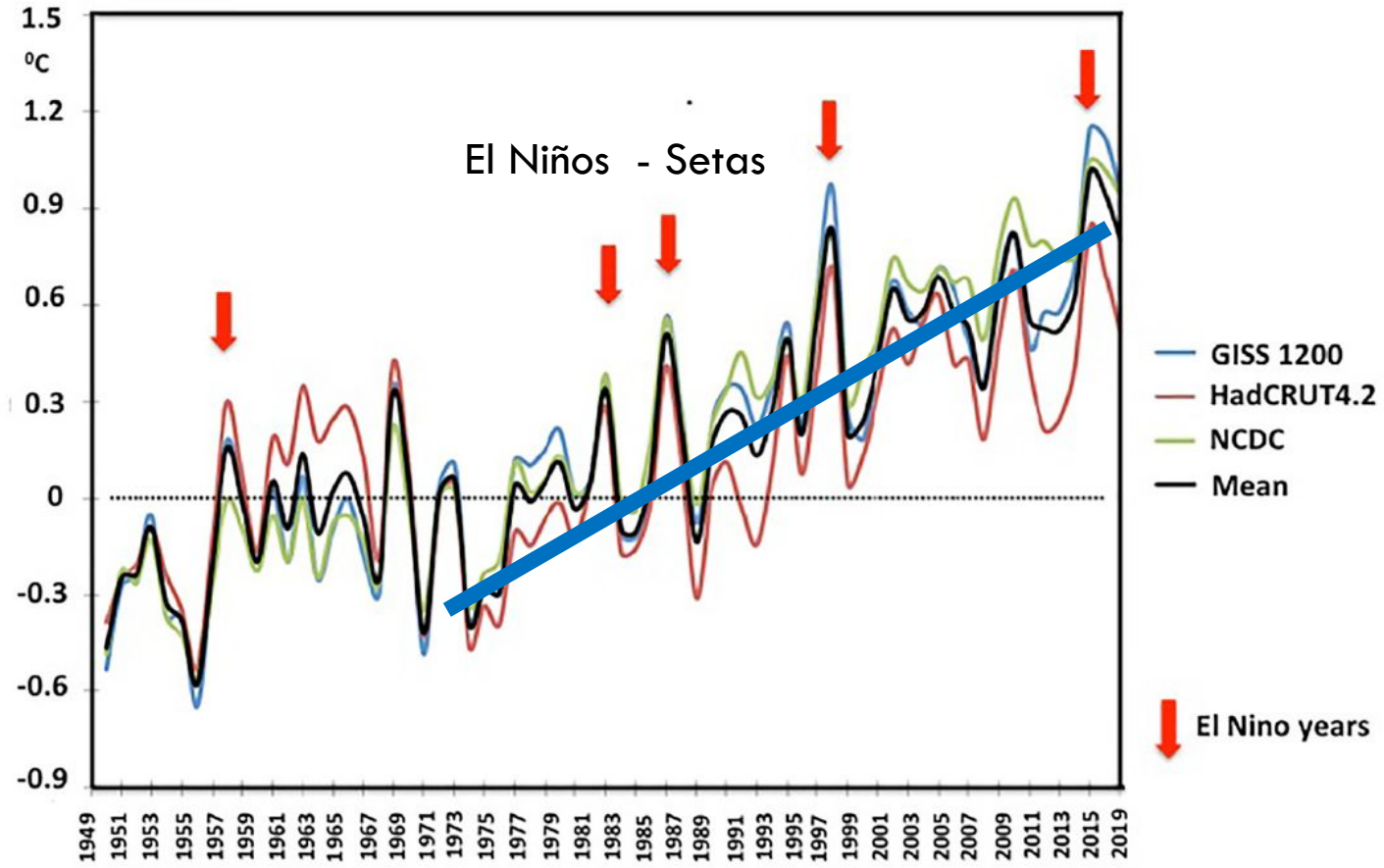
201
8

Changes in Climate and Land Use Over the Amazon Region: Current and Future Variability and Trends

Jose A. Marengo[1], Carlos M. Souza Jr.[2], Kirsten Thonicke[3], Chantelle Burton[4], Kate Halladay[4], Richard A. Betts[5], Lincoln M. Alves[4,6] and Wagner R. Soares[7]*

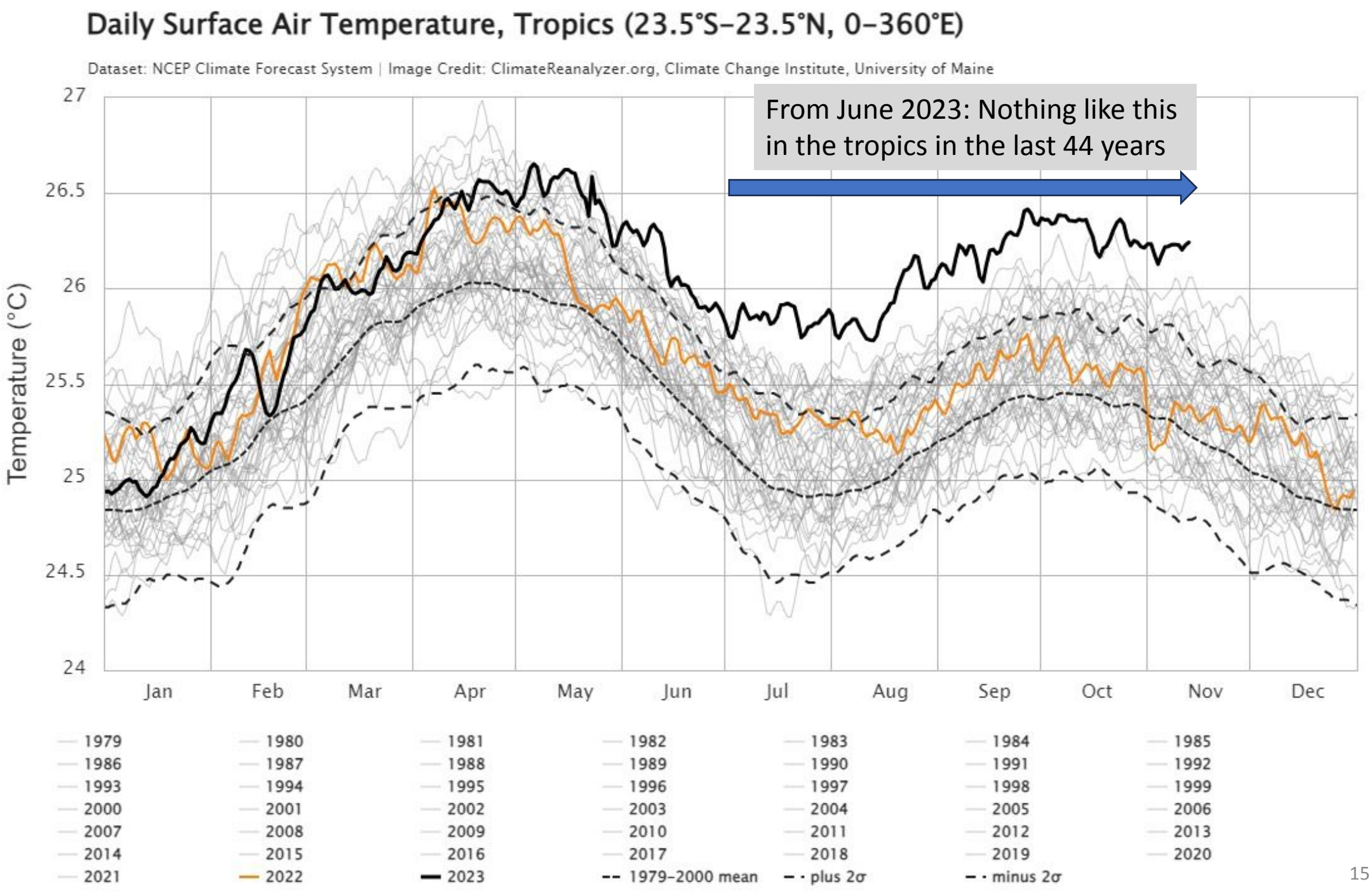


Temperatures have also been rising, with the help of El Niños.



Marengo, Jose A., Carlos M. Souza, Kirsten Thonicke, Chantelle Burton, Kate Halladay, Richard A. Betts, Lincoln M. Alves, and Wagner R. Soares. 2018. "Changes in Climate and Land Use Over the Amazon Region: Current and Future Variability and Trends." *Frontiers in Earth Science* 6: 228. https://doi.org/10.3389/feart.2018.00228.

Current Situation



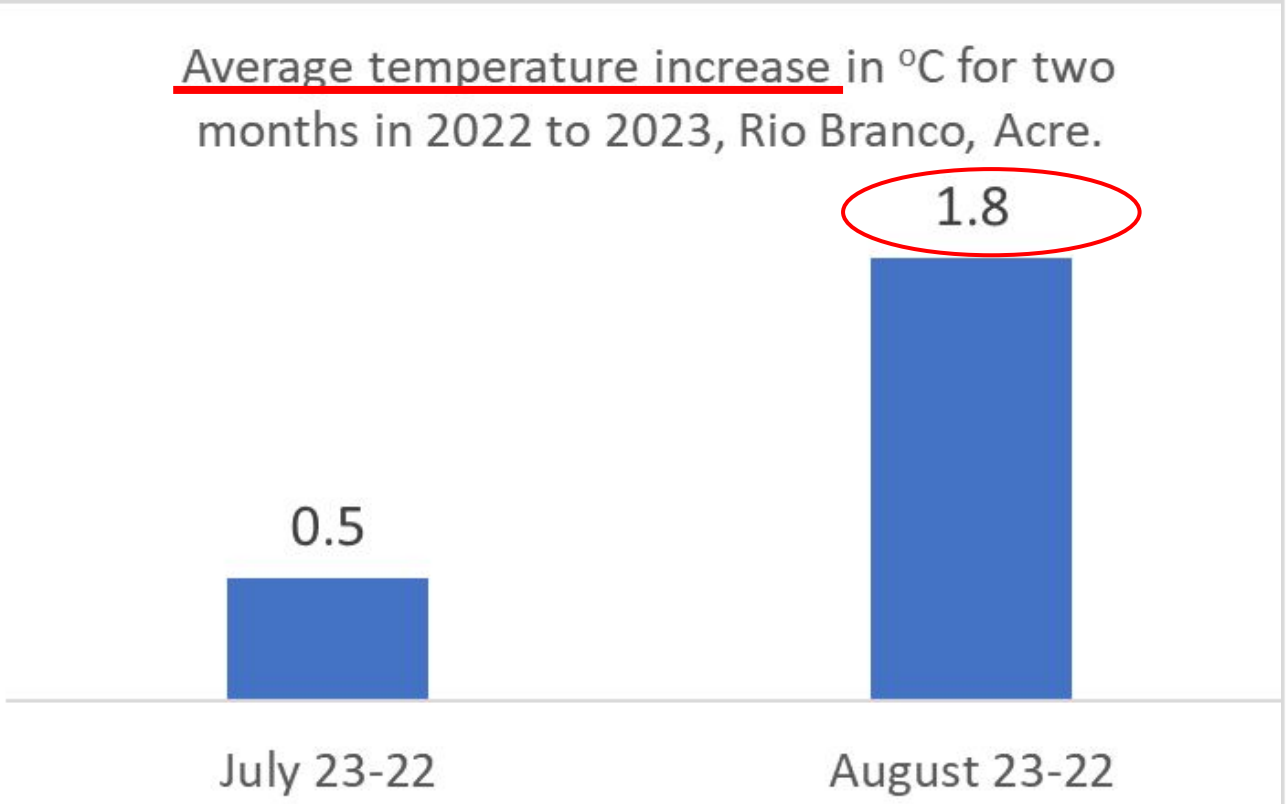
https://climatereanalyzer.org/clim/t2_daily/?dm_id=tropics

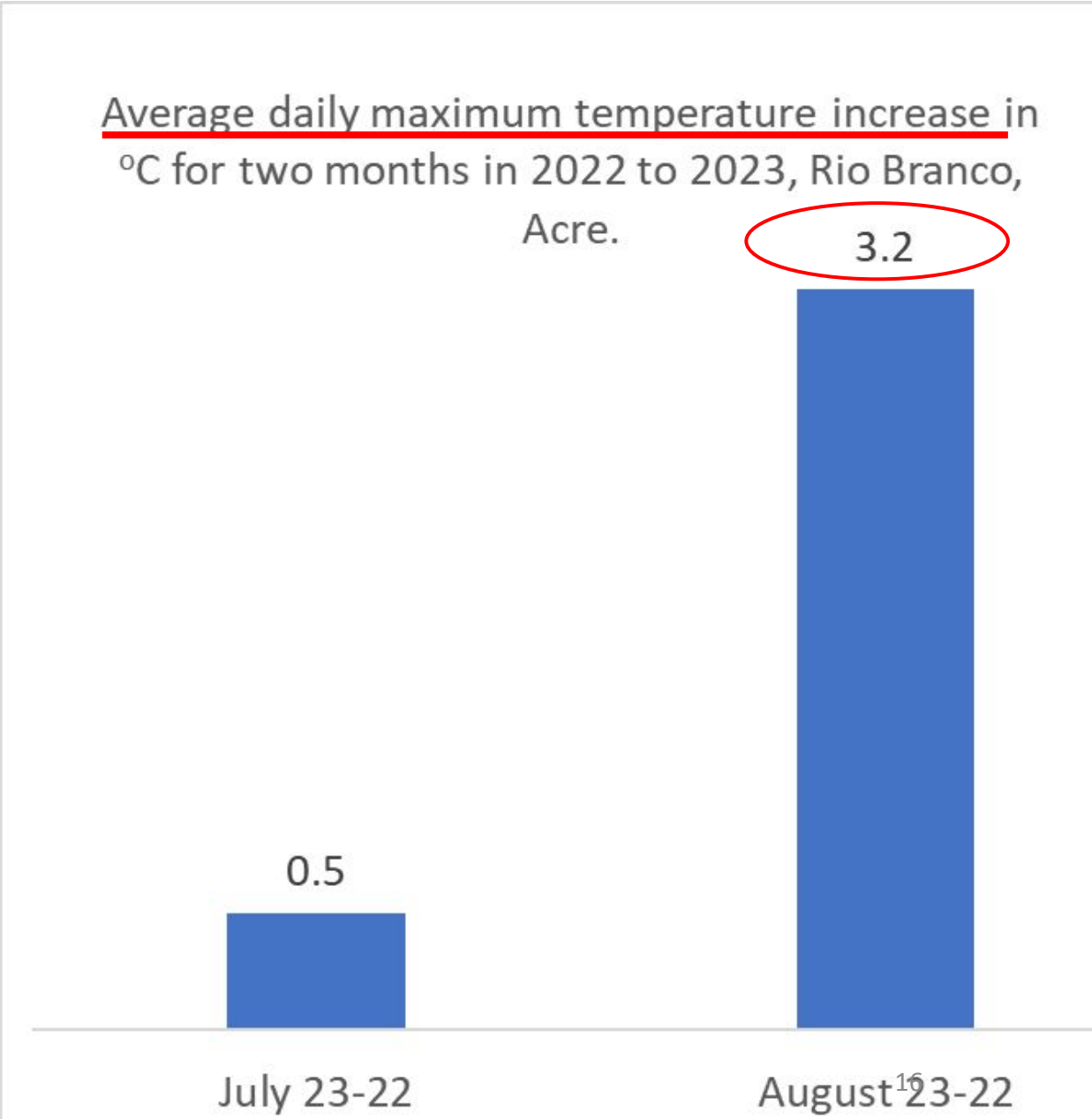
‘Mais quente do que o ano passado? Sim! Quanto? Depende da medida’; pesquisadores explicam aumento do calor no Acre e alertam sobre o futuro

'Se não adaptarmos a estas mudanças em marcha e mitigarmos os fatores causadores, o futuro vai se esquentar e vamos ter saudade das temperaturas de agosto de 2023, em Rio Branco', alertam pesquisadores da Ufac. Entenda.

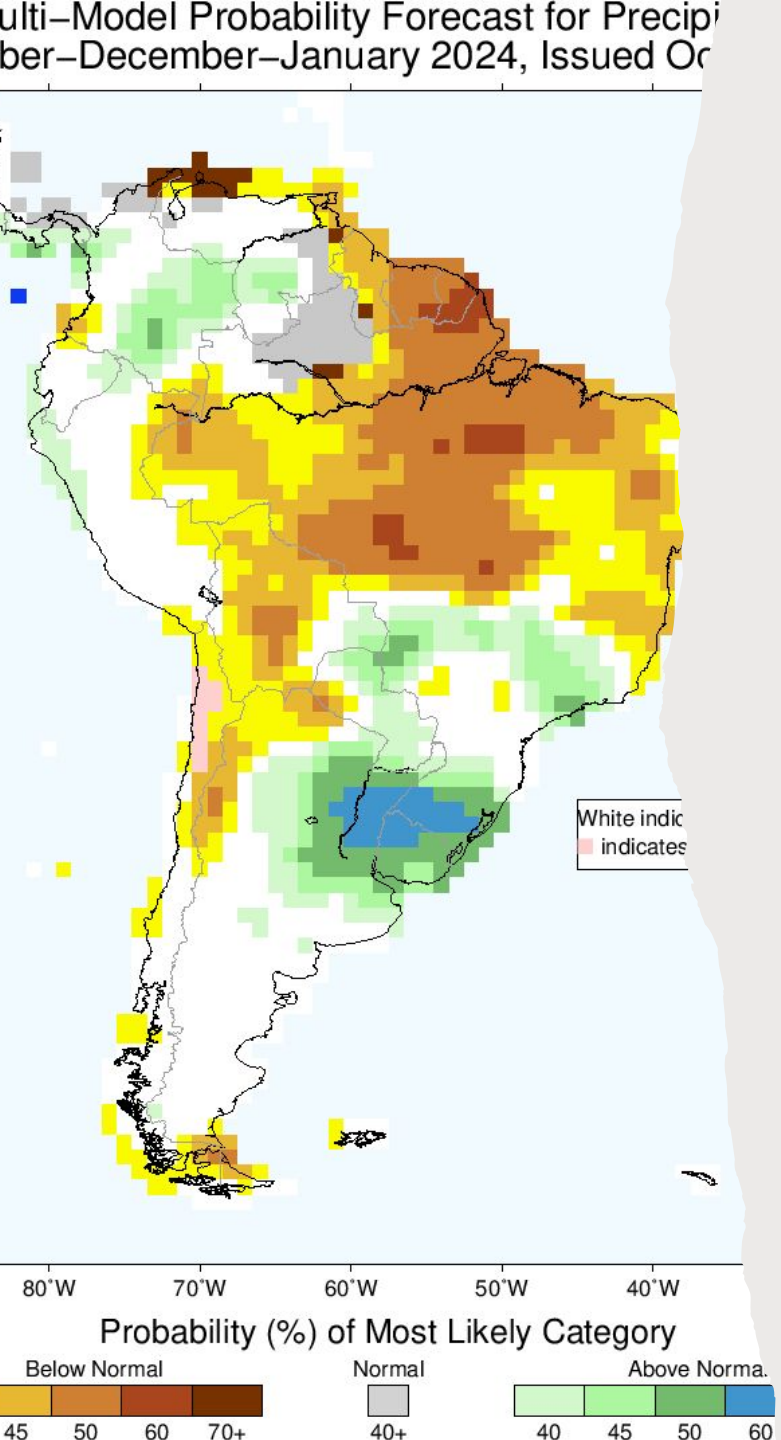
por A Gazeta do Acre – 21/09/2023 AA

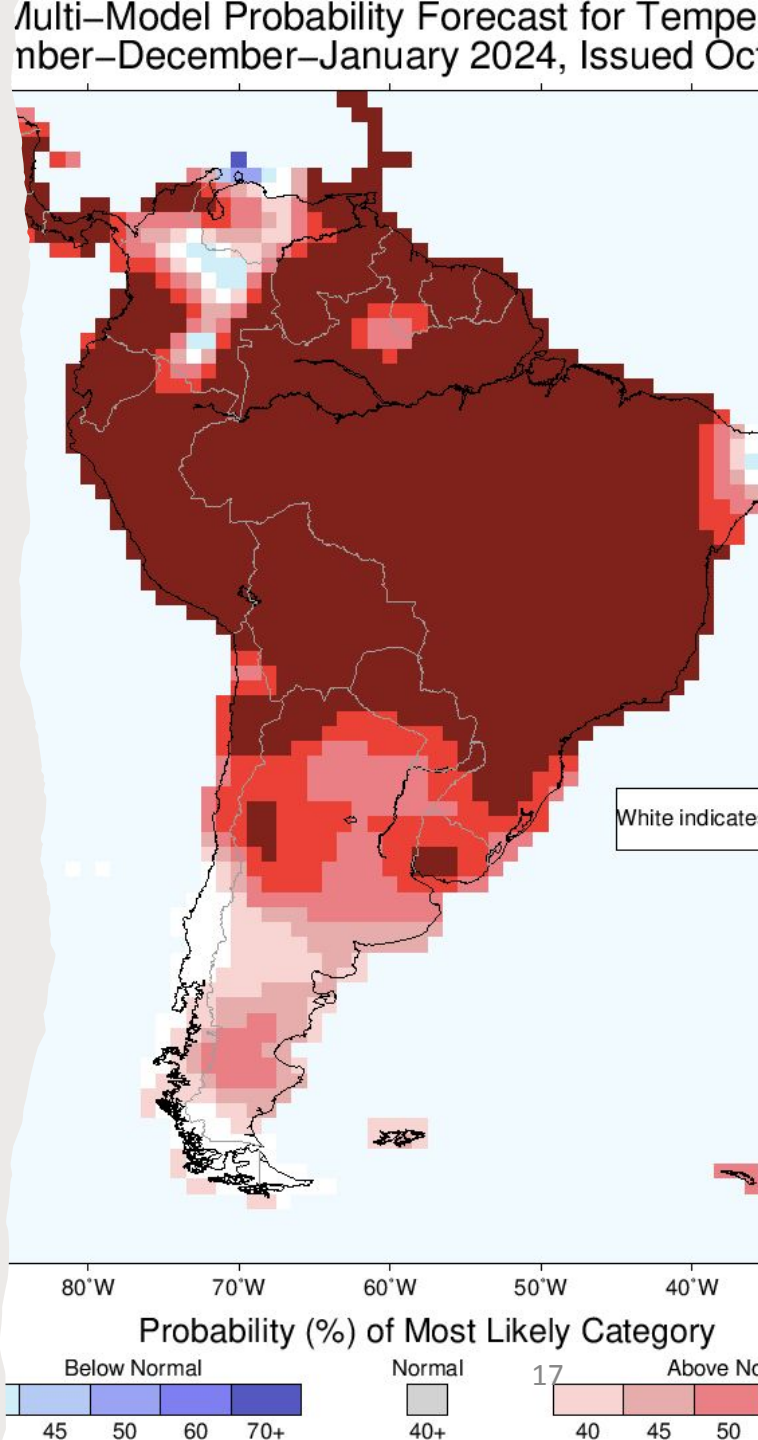
https://agazetadoacre.com/2023/09





Rainfall below and temperatures above normal in the Amazon. Nov-Dec-Jan





- https://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/

Temperature records and low water levels are record breaking in 2023 in the Amazon.

THE BRAZILIAN REPORT
Brazilian politics, economics and social issues.
By Brazilians, in English.

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INSIDER

Heat wave turns Amazon states into "smoke belt"

saneamento ambiental

NOTÍCIAS REVIST

MUDANÇAS CLIMÁTICAS

Rio Amazonas atinge o nível mais baixo dos últimos 120 anos

27/10/2023

Com um nível inferior a 13 metros em Manaus, o rio mais rico em água do mundo caiu para seu nível mais baixo

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NEWS | 14 November 2023

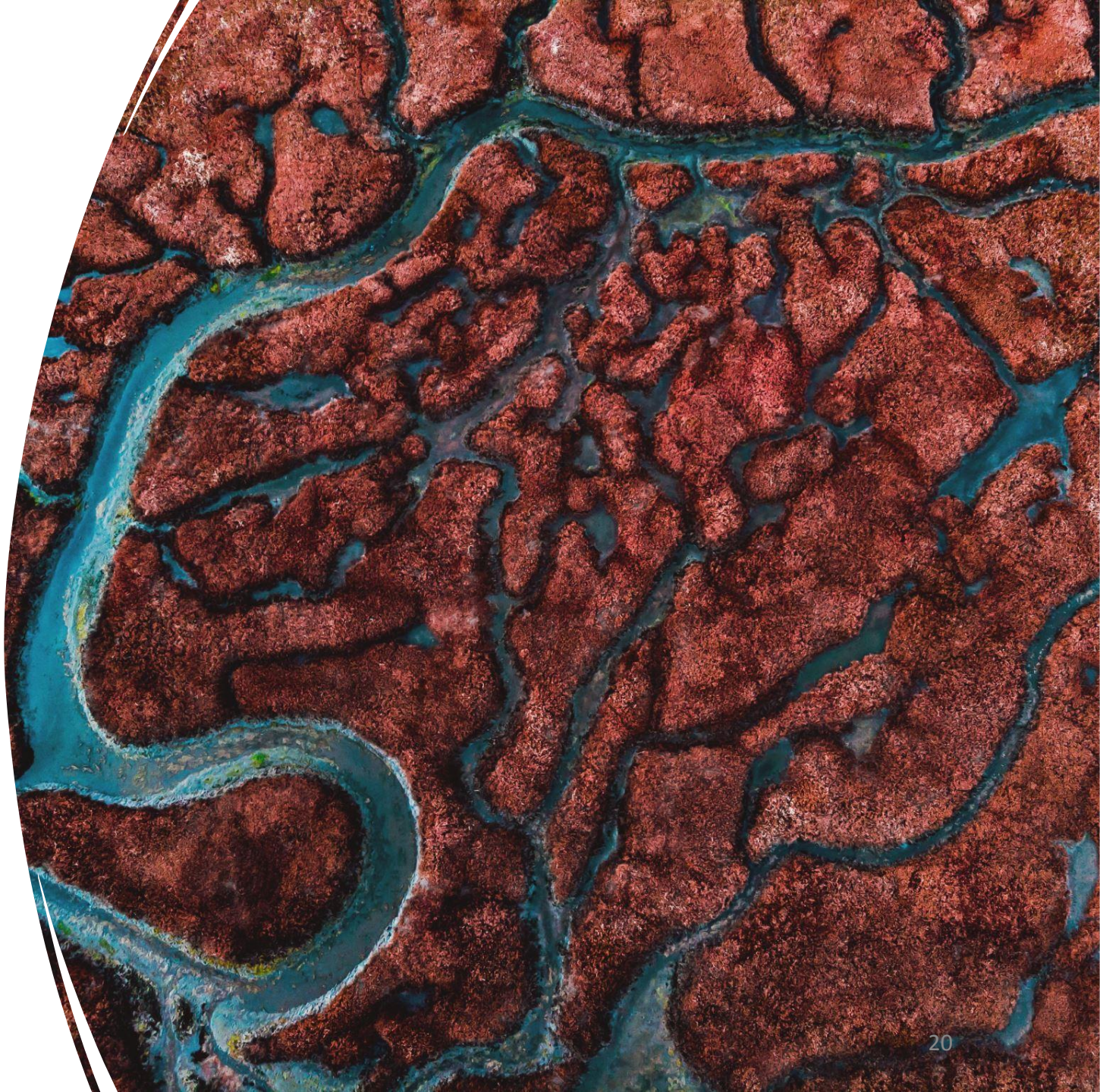
The Amazon's record-setting drought: how bad will it be?

Scientists tell *Nature* why the rainforest has dried out, and what to expect in the coming months.

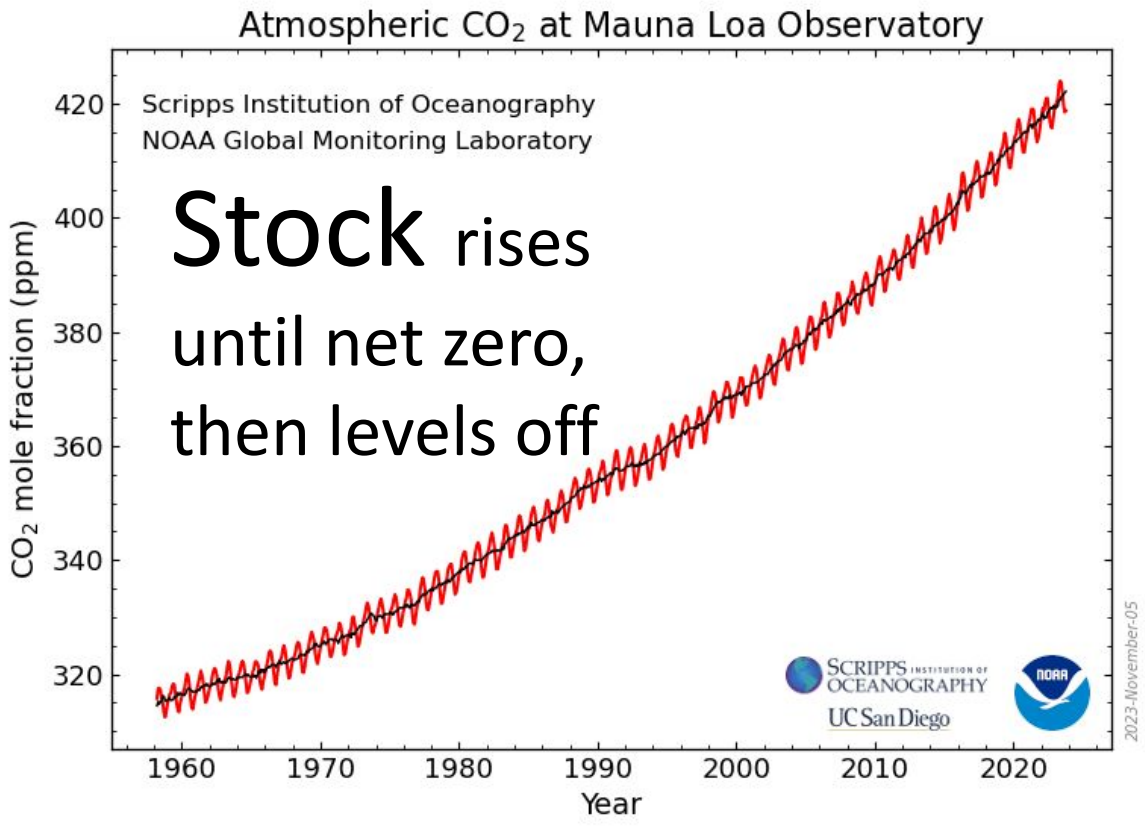
Considerations for the Future

Beware Natural Climate Extremes, like Mega El Niños

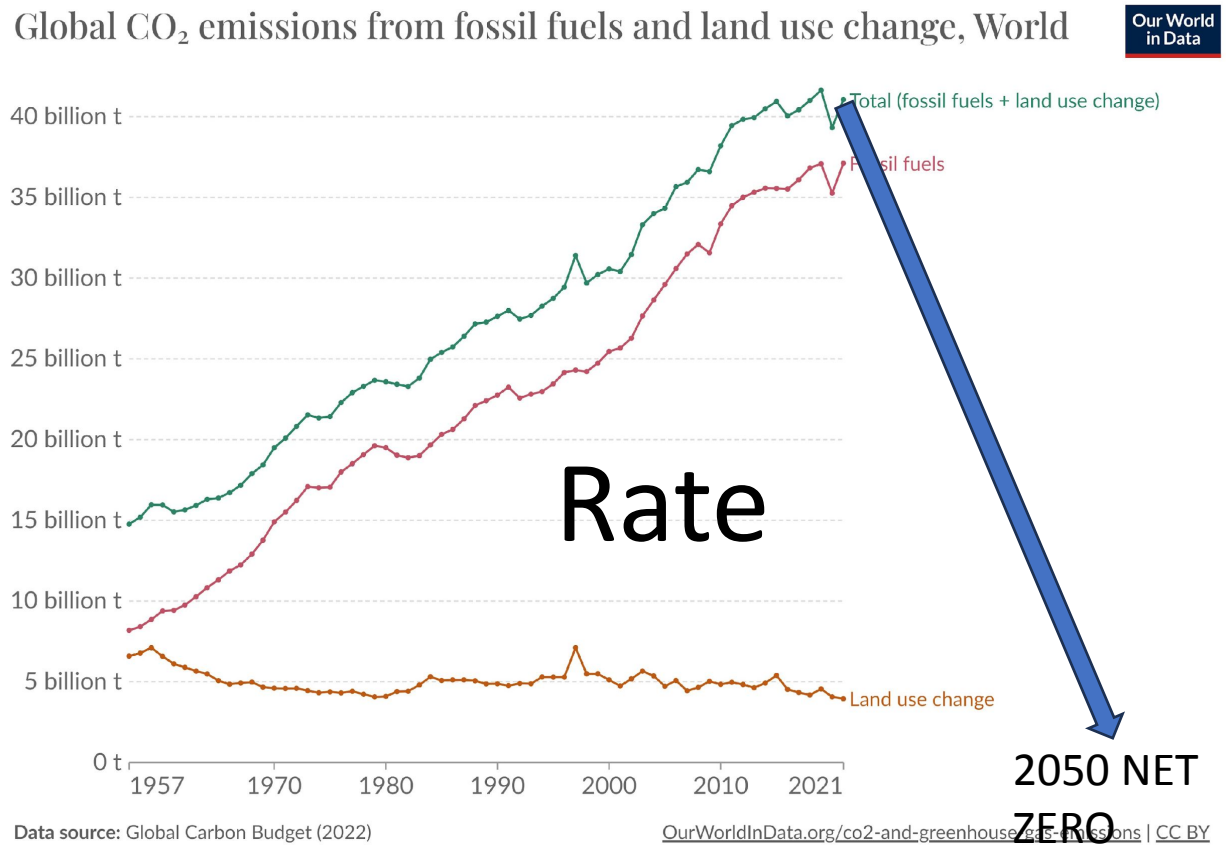
- Impacted Indigenous civilizations in the Amazon in the last several hundred years (Meggers 1994).
- Affected countries around the world in 1789-1793 (Grove 2007).
- Caused fires in the Amazon in 1925-26 (Williams et al. 2005).
- **These extremes will also occur in the future**, just to make things more complicated.



One major climate driver, CO_2, now being emitted at **~40 gigatons per year** and about half is accumulating in the atmosphere.



https://gml.noaa.gov/webdata/ccgg/trends/co2_data_mlo.png



https://ourworldindata.org/co2-emissions

We are on the path for greater and more frequent extreme climate events in the Amazon for the coming decades.

If things weren´t bad enough, a controversial article of James Hansen et al. argues that global climate change will come more quickly. Consequently, the Amazon will be also affected more quickly.

- Decline in aerosols increases global temperature rate to ≥0.27 degrees C per decade.
- Anomaly of 1.5 degrees C reached before 2030
- Anomaly of 2.0 degrees C reached before 2050.

JOURNAL ARTICLE

Global warming in the pipeline

James E Hansen ✉, Makiko Sato, Leon Simons, Larissa S Nazarenko, Isabelle Sangha, Pushker Kharecha, James C Zachos, Karina von Schuckmann, Norman G Loeb, Matthew B Osman ... Show more

Oxford Open Climate Change, Volume 3, Issue 1, 2023, kgad008, https://doi.org/10.1093/oxfclm/kgad008

Published: 02 November 2023 **Article history** ▾

Using a jigsaw puzzle as a metaphor for finding solutions.

The most important pieces are the ones that are missing or are not linked to others.

Image: ChatGPT 4

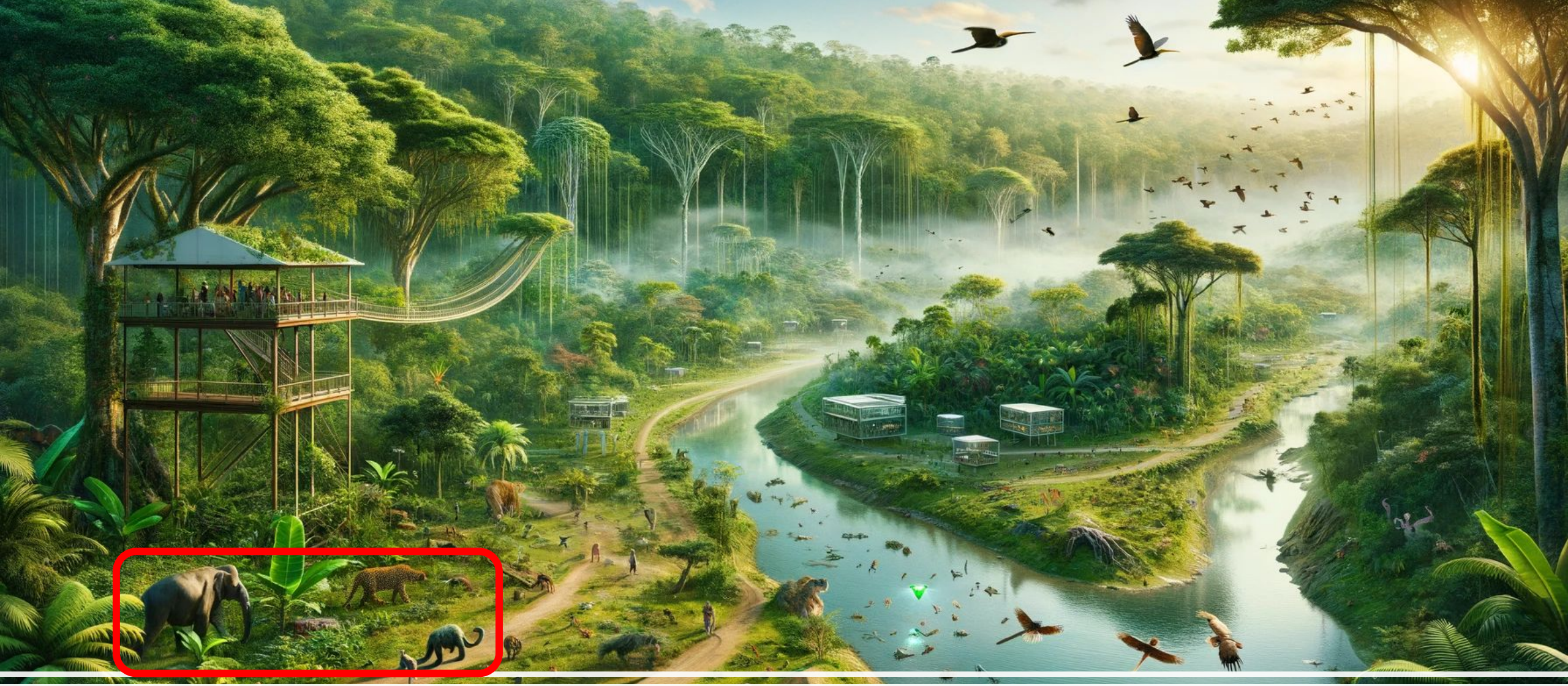
Missing or disconnected pieces of the solution puzzle

The list is relatively simple.

- Stop deforestation.
- Restore forests in degraded lands.
- Control wild fires.
- Reduce greenhouse gas buildup in the atmosphere.

The ways of implementing them is not.

- Change in societal values.
- Change in economic systems.
- Change in political actions.



A cautionary tale about Artificial Intelligence. It also needs human intelligence. ChatGPT 4: Image for the future of the Amazon Forest

Just verify that Artificial Intelligence doesn´t put elephants and dinosaurs in solutions for reducing the climate impact on Amazon forests.

We are together in this trip.
Thank you.

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Feijo, Acre
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