INDICATORS OF

GLOBAL CLIMATE CHANGE

IGCC

WHY IS IGCC'S ANNUAL UPDATE IMPORTANT?

The IGCC project bridges the gap between Intergovernmental Panel on Climate Change (IPCC) assessment reports, providing decision makers and the public with up-to-date climate science.

- 2021 — IPCC SIXTH ASSESSMENT REPORT (AR6) — WGI: THE PHYSICAL SCIENCE BASIS
- 2022 — IPCC AR6 — WGII, WGIII
- 2023 — IGCC ESTABLISHED
- 2024 — WE'RE HERE, USING DATA TO THE END OF 2023
- 2025
- 2026
- 2027
- 2028 — IPCC SEVENTH ASSESSMENT REPORT (AR7) — WGI: THE PHYSICAL SCIENCE BASIS — *EXPECTED IN 2028

IGCC includes IPCC veterans and early-career scientists. They produce this to keep you informed.

WHAT'S THE LATEST SCIENCE TELLING US?

Humans are heating Earth at a rate of **0.26°C** per decade — the highest rate since records began.

This heating is due to carbon dioxide (CO_2) and other greenhouse gases (GHGs) accumulating in the atmosphere, blocking outgoing infrared radiation. As less heat escapes to space, an energy imbalance is created. Earth heats up.

CH_4: 1923ppb (IPCC AR6, 2019: 1866ppb)

CO_2: 419ppm (IPCC AR6, 2019: 410ppm) — ATMOSPHERIC LEVELS OF CO_2 ARE HIGHER THAN AT ANY TIME IN AT LEAST 2 MILLION YEARS

N_2O: 337ppb (IPCC AR6, 2019: 332ppb)

CH_4: 8.8 BILLION TONNES (CO_2 EQUIVALENT) — MOSTLY FROM FUGITIVE FOSSIL FUEL EMISSIONS, LIVESTOCK + OTHER AGRICULTURAL PRACTICES

35.3 BILLION TONNES / 4.7 BILLION TONNES — MOSTLY FROM BURNING FOSSIL FUELS FOR ENERGY AND INDUSTRY, BUT ALSO FROM LAND USE CHANGE, MAINLY DEFORESTATION

N_2O: 3.0 BILLION TONNES (CO_2 EQUIVALENT) — MOSTLY FROM FOSSIL FUEL EMISSIONS AND THE USE OF SYNTHETIC FERTILISERS + MANURE

GHGs: Over the past decade, on average we emitted 53 billion tonnes of greenhouse gas emissions into the atmosphere every year.

WEIGHT WISE, THAT'S EQUIVALENT TO 5.25 MILLION EIFFEL TOWERS

CO_2: In 2023, almost 41 billion tonnes was CO_2. The rest consisted of methane (CH_4), nitrous oxide (N_2O) and F gasses (HFCs, PFCs, SF_6, NF_3).

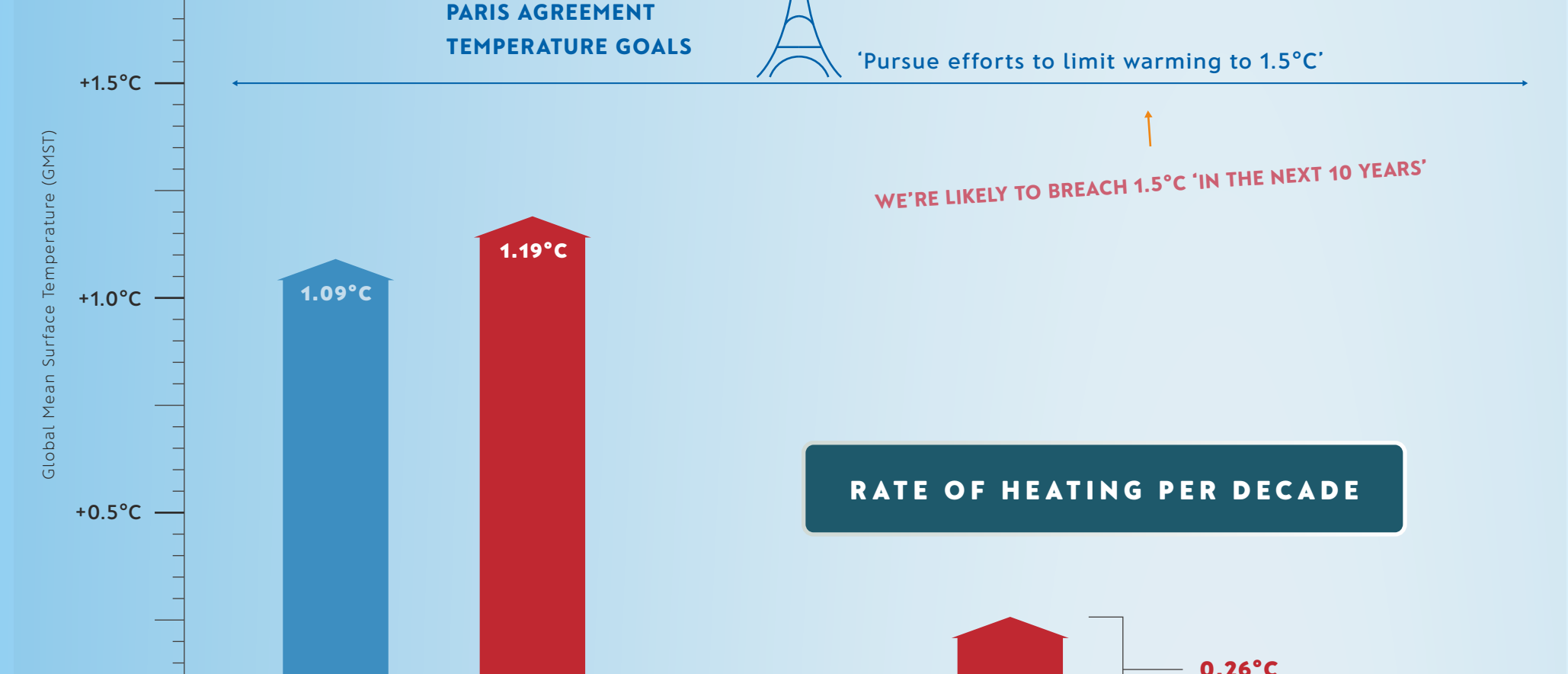
THE LEVEL AND RATE OF HEATING IS UNPRECEDENTED

Human-induced heating has risen to an average of **1.19°C** over the most recent decade (2014 - 2023).

DECADAL AVERAGE

CHANGE IN GLOBAL MEAN SURFACE TEMPERATURE (GMST)

When scientists talk about limiting global heating to 1.5°C or 'well below 2°C', they are referring to the average global temperature increase over decades, rather than any single year's temperature.

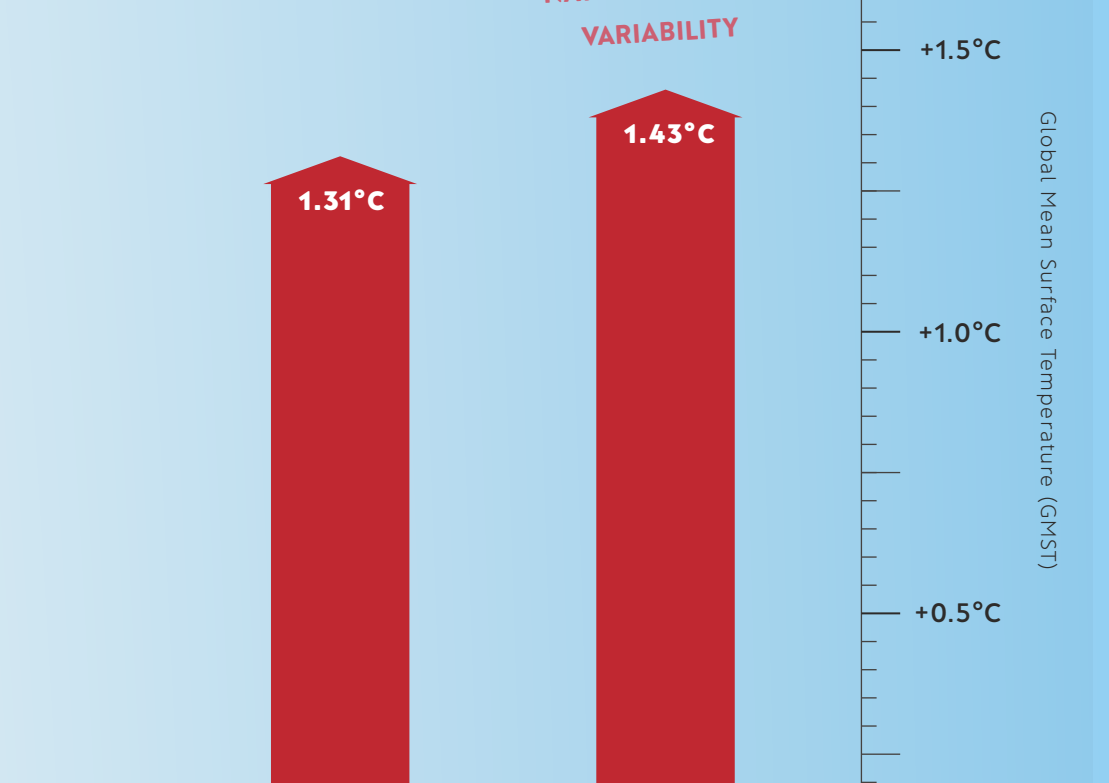


ANNUAL AVERAGE

CHANGE IN GMST, 2023

Heating in 2023 caused by human activity was **1.31°C**.

The total temperature rise in 2023 was **1.43°C**, indicating that natural climate variability, in particular El Niño, played a role in 2023's record temperatures.



An average global temperature rise of **1.19°C** has already caused irreversible changes — unprecedented for thousands, if not hundreds of thousands, of years. As the world nears 1.5°C of heating, extreme temperatures will have the most profound impacts on people and nature.

OUR 'CARBON BUDGET'

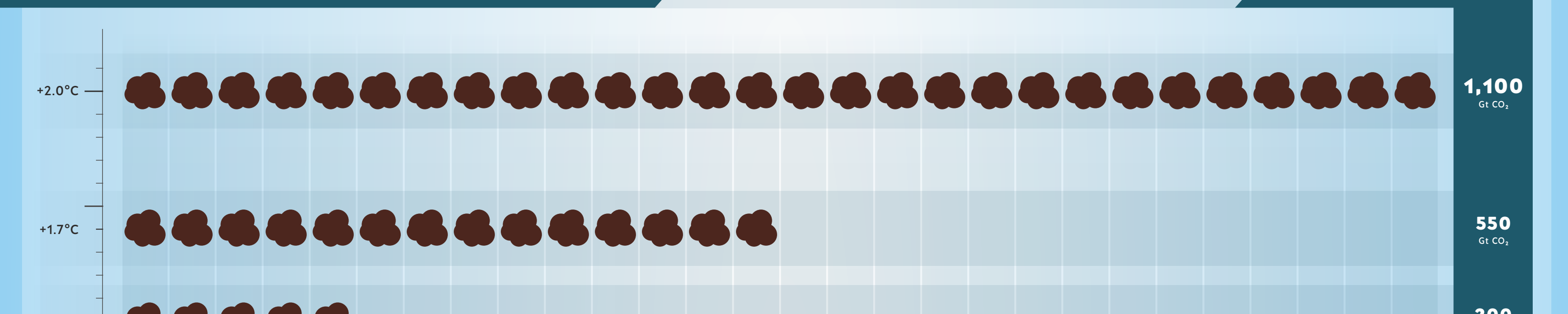
In 2020, the IPCC calculated the remaining carbon budget for 1.5°C at about 500 billion tonnes. At the start of 2024, the remaining carbon budget for 1.5°C stood at around 200 billion tonnes.

THE WINDOW FOR LIMITING HEATING TO 1.5°C WITH NO OVERSHOOT IS CLOSING, BUT RAPID EMISSION REDUCTIONS COULD KEEP 1.5°C ACHIEVABLE LATER THIS CENTURY (VIA INDUSTRIAL-SCALE CARBON REMOVALS)

OUR (SHRINKING) CARBON BUDGET

Annual emissions: **40 BILLION TONNES (Gt) OF CO_2**

WHAT'S LEFT?



If annual emissions reduce, budgets will last longer. Deep, rapid and sustained reductions will limit the maximum heating we experience.

To achieve the Paris Agreement's temperature goals, governments should submit stronger carbon-cutting 'Nationally Determined Contributions' — and deliver them.

WHAT ARE NATIONALLY DETERMINED CONTRIBUTIONS (NDCs)?

In 2025, nations are required to submit their third installments of carbon-cutting climate plans (NDCs 3.0) to the UN, outlining their commitments from 2025 to 2035.

The Paris Agreement requires nations to update their NDCs every five years, with each new round representing a **'PROGRESSION'** from the previous one, and demonstrating the **'HIGHEST POSSIBLE AMBITION'** to achieve its goals.

So, although nations have the freedom to set the ambition of their emission reduction pledges, these commitments are expected to increase over time to collectively meet the temperature goals of the Paris Agreement.

ADVANCE WARNING: THE 'LAND-OCEAN HEATING CONTRAST'

Temperatures over land — where people actually live — have increased roughly twice as much as over the ocean.

About +1.8°C

+1.8°C REFLECTS THE AVERAGE INCREASE IN MAXIMUM TEMPERATURES ON LAND IN THE LAST DECADE WHICH IS AN INDICATOR OF CLIMATE EXTREMES - ONE OF THE MOST VISIBLE EFFECTS OF HUMAN-INDUCED CLIMATE CHANGE

+0.9°C REFLECTS THE INCREASE IN GLOBAL OCEAN TEMPERATURE REGISTERED OVER THE SAME PERIOD

IT TAKES LESS ENERGY AND LESS TIME TO HEAT UP LAND COMPARED WITH OCEAN

About +0.9°C

Many high-latitude regions near the planet's North and South Poles have already heated by more than 2°C.

Climate change has adversely impacted food security and terrestrial ecosystems — as well as contributing to an increased frequency, intensity and duration of heat-related events, including heatwaves in most land regions. It's the temperature extremes that affect people and nature most.

The ocean has absorbed about... **90%** ...of the excess heat caused by humans.

Oceans heat more slowly than land due to their higher heat capacity and the slow mixing of warmer surface water with deeper, colder water.

Over decades, changes in surface temperatures can decouple from 'Earth's Energy Imbalance' due to ocean heat mixing processes. Because of this, tracking Earth's Energy Imbalance is a crucially important indicator of climate change on decadal timescales.

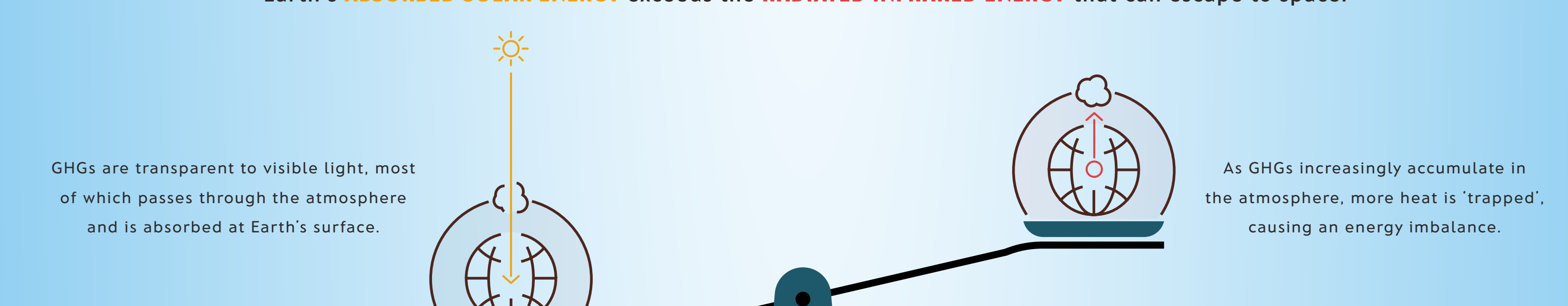
PARTICULARY FOR MONITORING "THE FUTURE EXTENT" OF GLOBAL HEATING

THE EARTH ENERGY IMBALANCE (EEI)

It measures accumulated surplus energy (heat) in the climate system. Due to human-caused GHG emissions, Earth's **ABSORBED SOLAR ENERGY** exceeds the **RADIATED INFRARED ENERGY** that can escape to space.

GHGs are transparent to visible light, most of which passes through the atmosphere and is absorbed at Earth's surface.

As GHGs increasingly accumulate in the atmosphere, more heat is 'trapped', causing an energy imbalance.



IPCC AR6 2006 – 2018

IGCC 2024 2011 – 2023

If GHG emission levels continue increasing, Earth's energy imbalance will become even more lopsided, and average temperatures will continue rising.

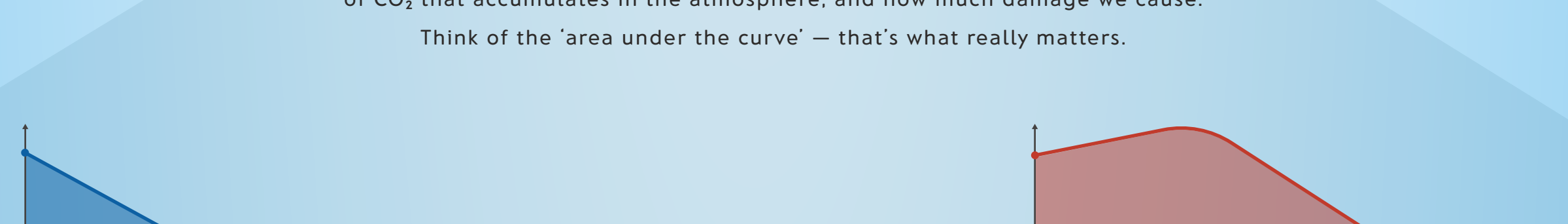
WE KNOW HOW TO FIX IT

Halving CO_2 emissions as quickly as possible, then achieving net zero CO_2 in the early 2050s — along with rapid, deep, and sustained cuts in other GHG emissions — would hold heating close to 1.5°C.

All GHG emissions should reach net zero roughly two decades later.

CO_2: HALVE EMISSIONS BY 2030 + CO_2: NET ZERO BY EARLY 2050s + GHGs: DEEP, STRONG AND SUSTAINED REDUCTIONS

The path to net zero by mid-century will determine the total amount of CO_2 that accumulates in the atmosphere, and how much damage we cause. Think of the 'area under the curve' — that's what really matters.



LESS CUMULATIVE EMISSIONS, LESS GLOBAL HEATING

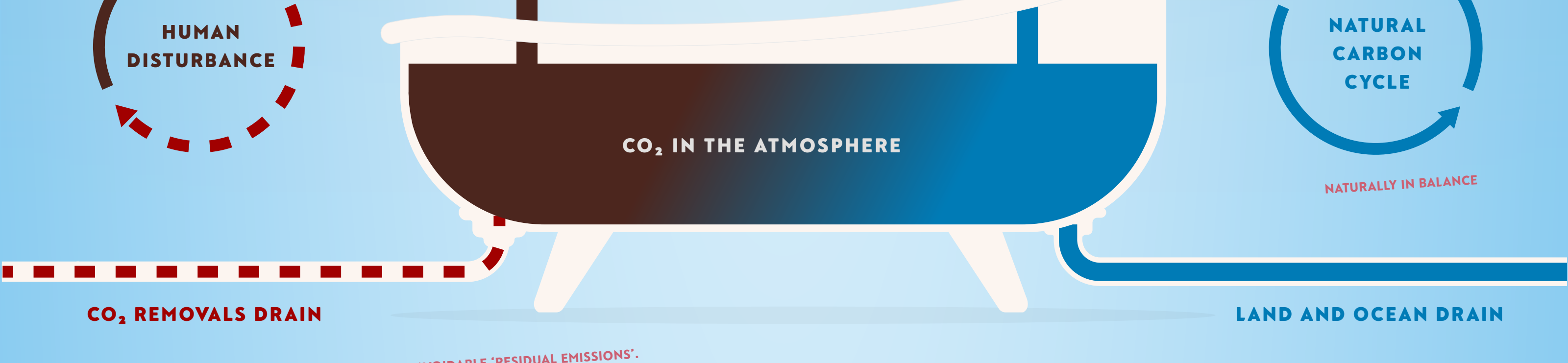
Challenging today but less climate impacts and easier for future generations.

MORE CUMULATIVE EMISSIONS, MORE GLOBAL HEATING

Easier today but more climate impacts and much harder for future generations

WHAT DOES 'ACHIEVING NET ZERO' MEAN?

It's how we stabilise temperature increase. Net zero CO_2 emissions will be achieved when **HUMAN-CAUSED CO_2 EMISSIONS** are slashed to a small enough level where they can be counterbalanced by durable **CO_2 REMOVAL** from the atmosphere.



THE UNTESTED OUTLET FOR COUNTERBALANCING UNAVOIDABLE 'RESIDUAL EMISSIONS'. THERE IS NO GUARANTEE THIS DRAIN WILL WORK AT THE INDUSTRIAL SCALE NECESSARY.

THE BEST FORM OF CO_2 'REMOVAL'?

Turning down the tap through emission reductions. Preventing a tonne of CO_2 emissions today will almost always be easier and cheaper than trying to remove CO_2 from the atmosphere later this century.

01

The number one priority is **slashing CO_2 emissions**. That effectively means turning down the tap of fossil fuel emissions, with a view to turning it off completely.

02

When only residual emissions remain (e.g. 5-10%), we must counterbalance with durable **CO_2 removal** methods to prevent reentry into the atmosphere.

THE MOVE TO CLEAN-ENERGY AND MORE SUSTAINABLE AGRICULTURAL PRACTICES WOULD NEED TO REDUCE EMISSIONS BY ABOUT 90% BEFORE CARBON REMOVAL COULD FEASIBLY PLAY A ROLE IN COUNTERBALANCING RESIDUAL EMISSIONS TO REACH NET ZERO

THE NUMBERS WILL CHANGE, BUT THE TAKEAWAYS WON'T

While the team behind the Indicators of Global Climate Change will update these indicators every year, we already know continued emissions will lead to higher temeratures and more severe impacts on people and natural ecosystems.

Next year the data will be different, but the message will be the same. To prevent the worst impacts of climate change, it's the same formula: deep, strong and sustained reductions in GHG emissions.

EVERY CHOICE MATTERS

EVERY TONNE MATTERS

EVERY YEAR MATTERS

BASED ON THE PAPER

'Indicators of Global Climate Change 2023: annual update of key indicators of the state of the climate system and human influence'

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