

Greenhouse gas emissions

Which countries emit the most greenhouse gases each year? How do they compare per person?

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In discussions on climate change, we tend to focus on carbon dioxide (CO₂) – the most dominant greenhouse gas produced by the burning of fossil fuels, industrial production, and land use change.

However, CO₂ is not the only greenhouse gas that is driving

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Here we look at total greenhouse gas (GHG) emissions across the world, plus breakdowns of other major gases including methane and nitrous oxide.

Total greenhouse gas emissions

Global greenhouse gas emissions

How much greenhouse gases does the world emit every year?

This chart shows the change in global greenhouse gas emissions over time. Greenhouse gases are measured in 'carbon dioxide-equivalents' (CO₂e).

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Greenhouse gas emissions

Greenhouse gas emissions include carbon dioxide, methane and nitrous oxide from all sources, including land-use change. They are measured in tonnes of carbon dioxide-equivalents over a 100-year timescale.

Table Map Chart

Show selection only ⓘ

Annual greenhouse gas emissions tonnes of CO₂ equivalents

Country/area ↓	↕ 1900	↕ 2022	↕ Absolute Change	↕ Relative Change
Afghanistan	11,820,230.0 t	36,614,290.0 t	+24,794,060.0 t	+210%
Albania	2,196,375.0 t	8,034,590.5 t	+5,838,215.5 t	+266%
Algeria	2,758,092.5 t	281,968,320.0 t	+279,210,227.5 t	+10,123%
Andorra	28,455.8 t	482,078.7 t	+453,622.8 t	+1,594%
Angola	13,860,202.0 t	182,069,890.0 t	+168,209,688.0 t	+1,214%
Antigua and Barbuda	-835.6 t	683,093.1 t	+683,928.7 t	+81,847%
Argentina	142,965,260.0 t	388,107,140.0 t	+245,141,880.0 t	+171%

▶ 1850

2022

Data source: Jones et al. (2024) – [Learn more about this data](#)

Note: Land-use change emissions can be negative.

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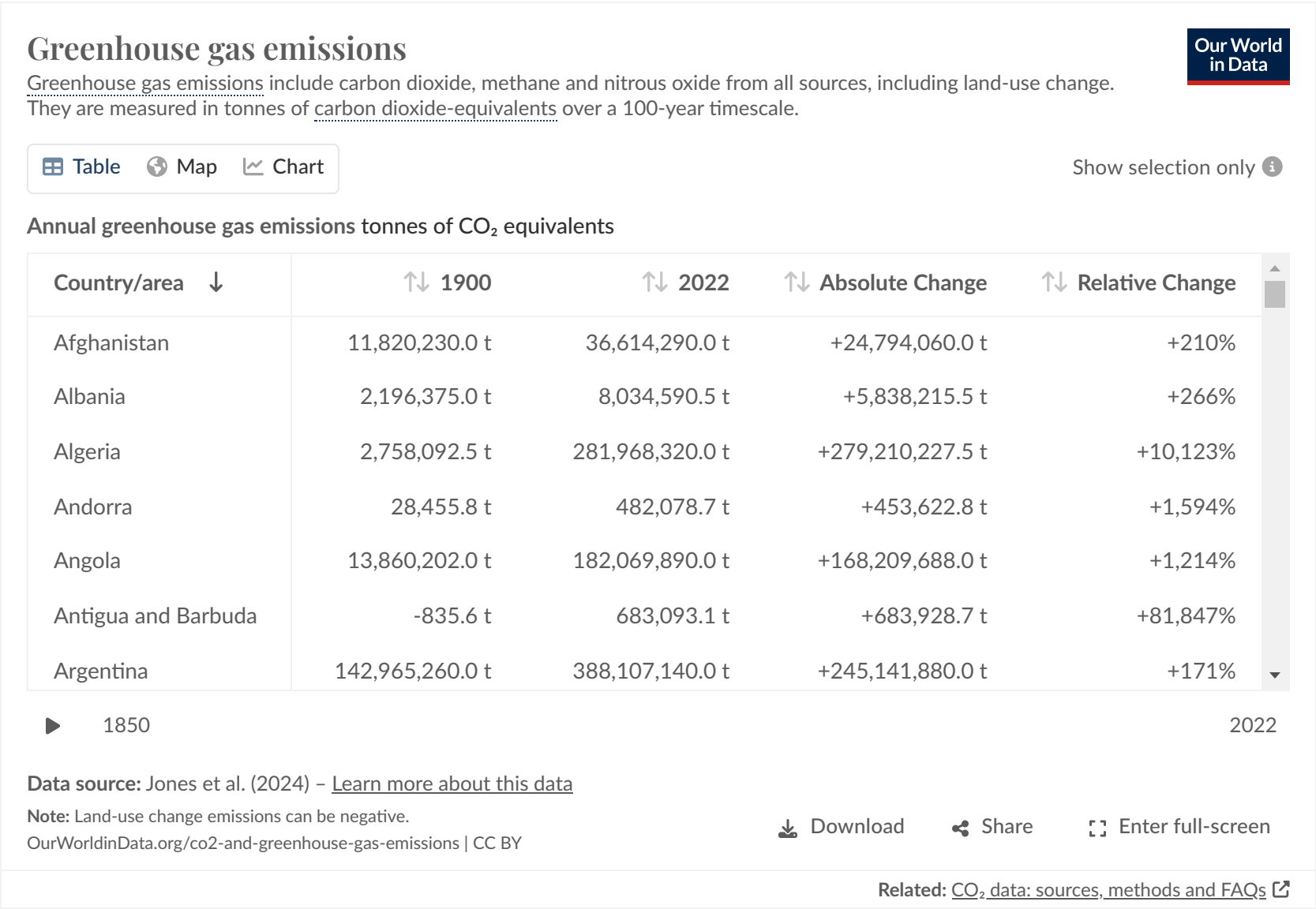
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Greenhouse gas emissions by country

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the world. Again, this is measured in tonnes of carbon dioxide equivalents.



Total annual emissions allow us to see the world's largest emitters in absolute terms. But they tend to tell a story of population — China and India, for example, are in the top three emitters, but are also the two most populous countries in the world.

How do emissions compare when we correct for the population?

This interactive map shows *per capita* greenhouse gas emissions. This is measured in tonnes per person per year.

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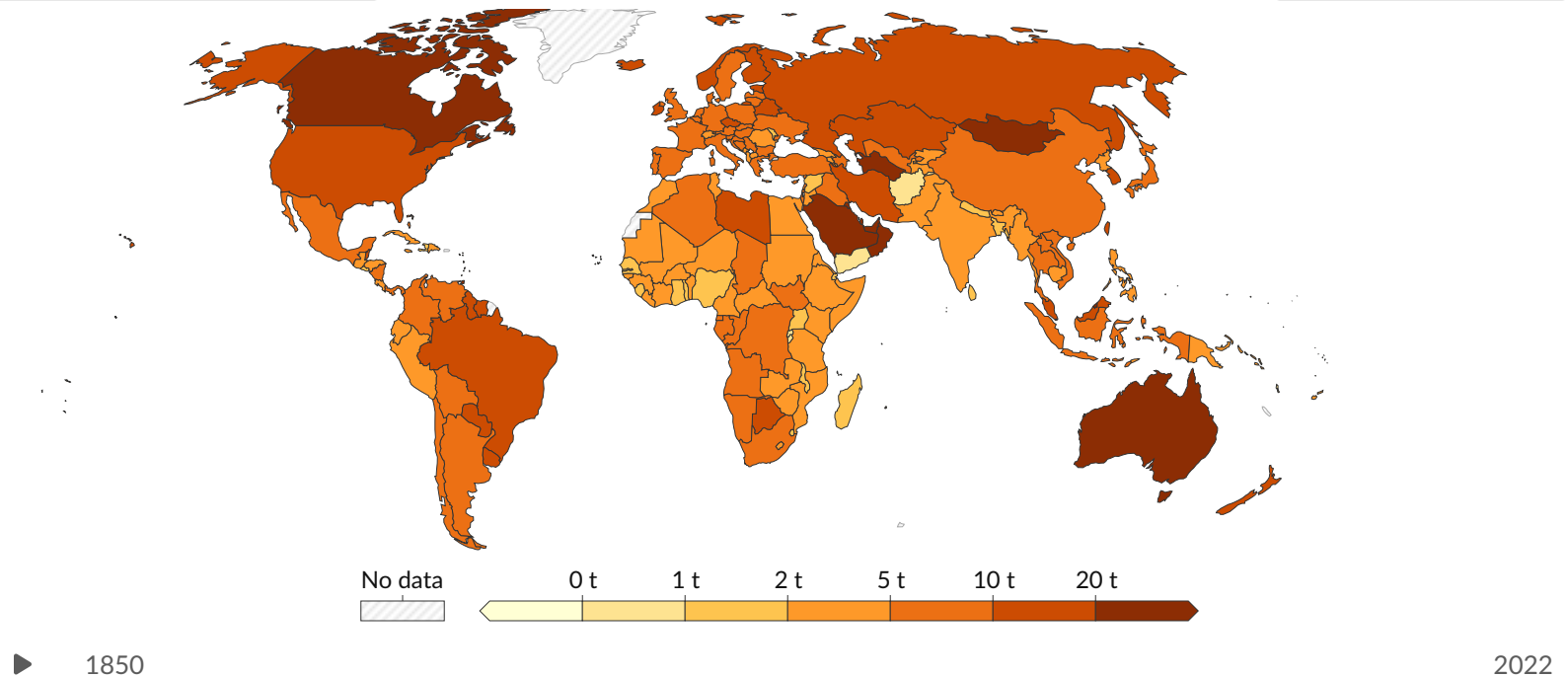
Per capita greenhouse gas emissions, 2022

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Greenhouse gas emissions include carbon dioxide, methane and nitrous oxide from all sources, including land-use change. They are measured in tonnes of carbon dioxide-equivalents over a 100-year timescale.

Table Map Chart

World



Data source: Jones et al. (2024); Population based on various sources (2023) – [Learn more about this data](#)

Note: Land-use change emissions can be negative.

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By gas: how much does each contribute to total greenhouse gas emissions?

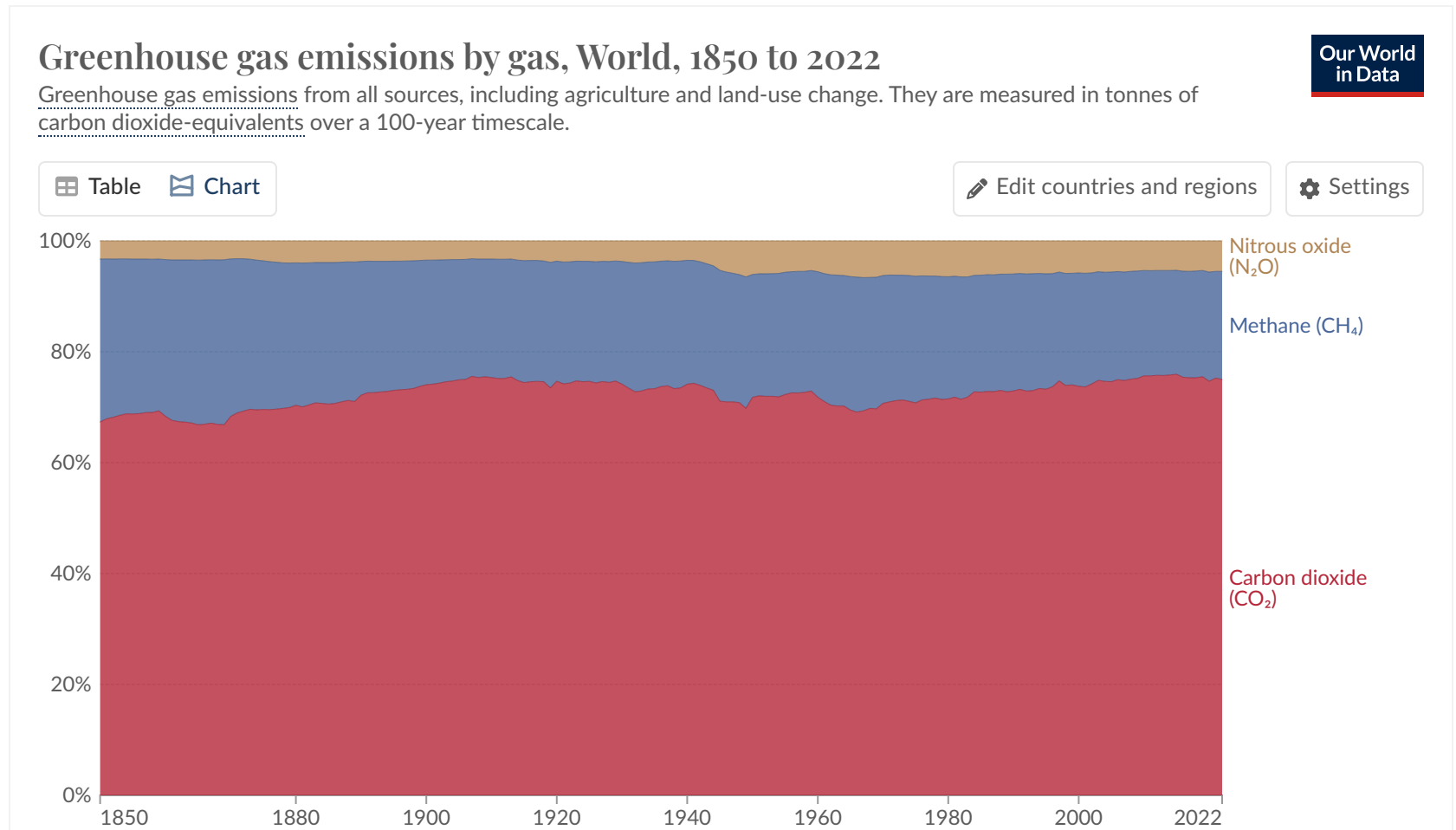
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smaller trace gases such as hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF₆).

How much does each gas contribute to global greenhouse gas emissions?

In the chart, we see the breakdown of global emissions, measured based on carbon dioxide-equivalents (CO₂e).



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Methane (CH₄) emissions

Where does methane come from?

Agriculture, fossil fuel production, and the management of waste are the primary sources of methane emissions:

- **Livestock** (ruminant animals — cattle, goats, and sheep) produce methane through a process called 'enteric fermentation'.
- **Rice cultivation** produces methane — waterlogged paddy fields provide an ideal environment for microbes to produce methane in a process called 'methanogenesis'.
- **Biomass burning**: methane is produced from the incomplete combustion of large-scale burning of woodlands, savanna, and agricultural waste.
- **Waste**: the decomposition of organic waste in landfills produces methane.
- **Fossil fuel production**: methane can be released during oil and gas extraction – a category often termed 'fugitive emissions'.

What is the warming potential of methane compared to CO₂?

Methane is a much stronger greenhouse gas than CO₂ in

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methane would generate **28 times** the amount of warming as one tonne of CO₂.^{1 2 3}

This means that, despite contributing a small amount of greenhouse gas emissions in terms of mass, methane has been responsible for around one-quarter of radiative forcing since 1750.⁴

How long does methane stay in the atmosphere?

Methane is a very 'short-lived' greenhouse gas. This means that after it accumulates in the atmosphere, it is removed relatively quickly — on the timescale of decades in contrast to CO₂ which can persist in the atmosphere for centuries or even thousands of years. The average 'lifetime' of methane in the atmosphere is around **12 years**.³

This means that reductions in methane *emissions* quickly result in reductions in the methane *concentrations* in the atmosphere. This would reduce its warming effects. So, tackling methane emissions could be an effective and rapid way to mitigate some of the impacts of climate change — on the timeframe of decades.⁵

Annual methane emissions: how much do we emit each year?

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Methane emissions are measured in tonnes of carbon dioxide equivalent (CO₂e), so are weighted for their 100-year global warming potential value.



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Total annual emissions allow us to see the world's largest emitters in absolute terms. But they can tell a story of population rather than lifestyle or individual impact.

How do emissions compare when we correct for the population?

This interactive map shows *per capita* methane emissions. This is measured in tonnes of carbon dioxide equivalents per person per year.

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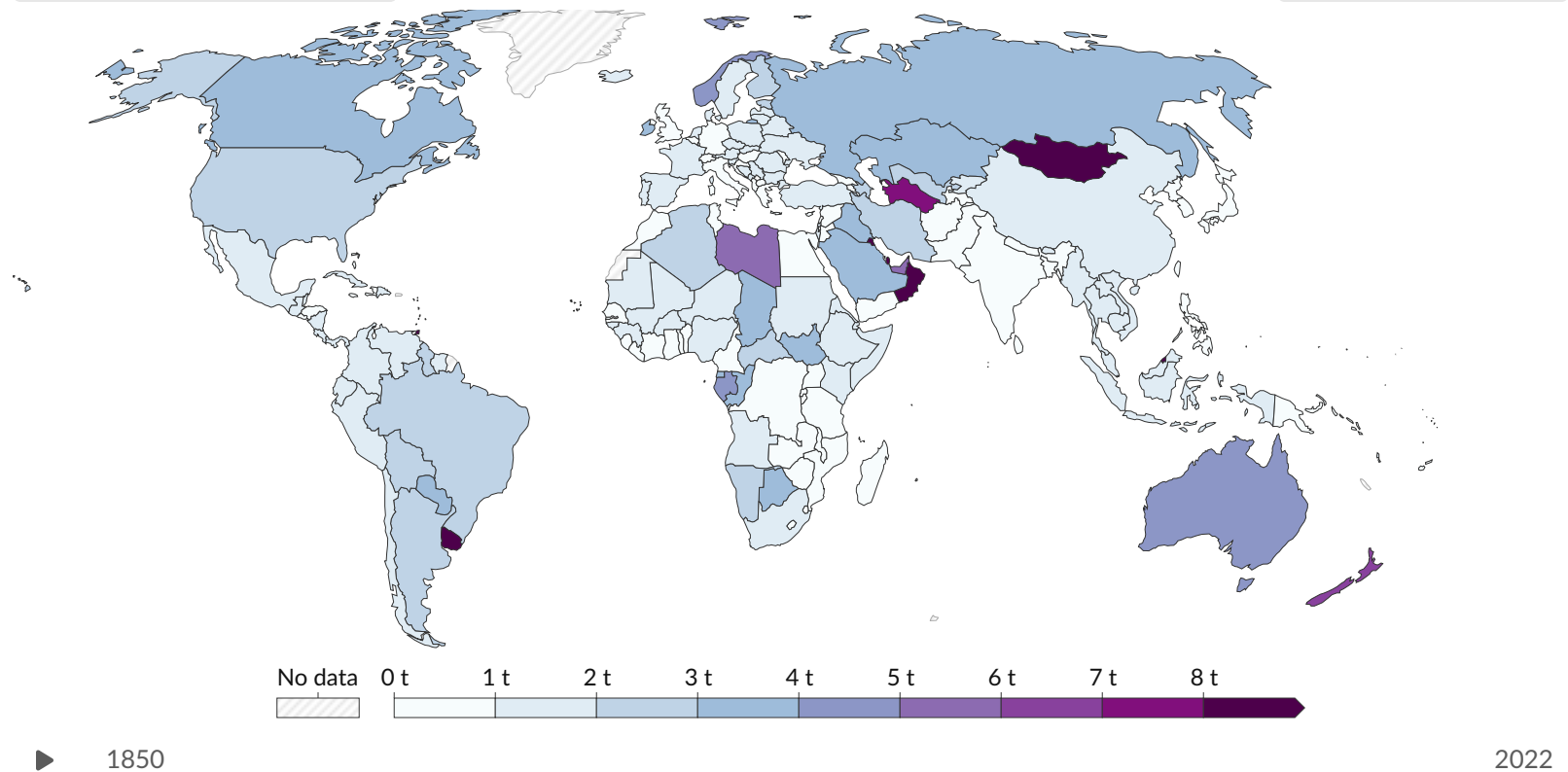
Per capita methane emissions, 2022

Per capita methane emissions are measured in tonnes of carbon dioxide-equivalents per person per year.

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Table Map Chart

World



Data source: Jones et al. (2024); Population based on various sources (2023) – [Learn more about this data](#)

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Nitrous oxide (N₂O) emissions

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Nitrous oxide is produced by microbes in nearly all soils. However, the application of nitrogen fertilizers makes much more nitrogen readily available for microbes to convert to N_2O – this is because not all of the applied nutrients are taken up by crops.

Nitrous oxide is not only produced when synthetic nitrogen fertilizer is applied; the same processes occur when we use organic fertilizers such as animal manure.

What is the warming potential of nitrous oxide compared to CO_2 ?

Nitrous oxide is a much stronger greenhouse gas than CO_2 in terms of its 'warming potential'. Over a 100-year timescale, and without considering climate feedback, one tonne of nitrous oxide would generate **265 times** the amount of warming as one tonne of CO_2 .^{6 3}

How long does nitrous oxide stay in the atmosphere?

The average 'lifetime' of nitrous oxide in the atmosphere is around **121 years**.³

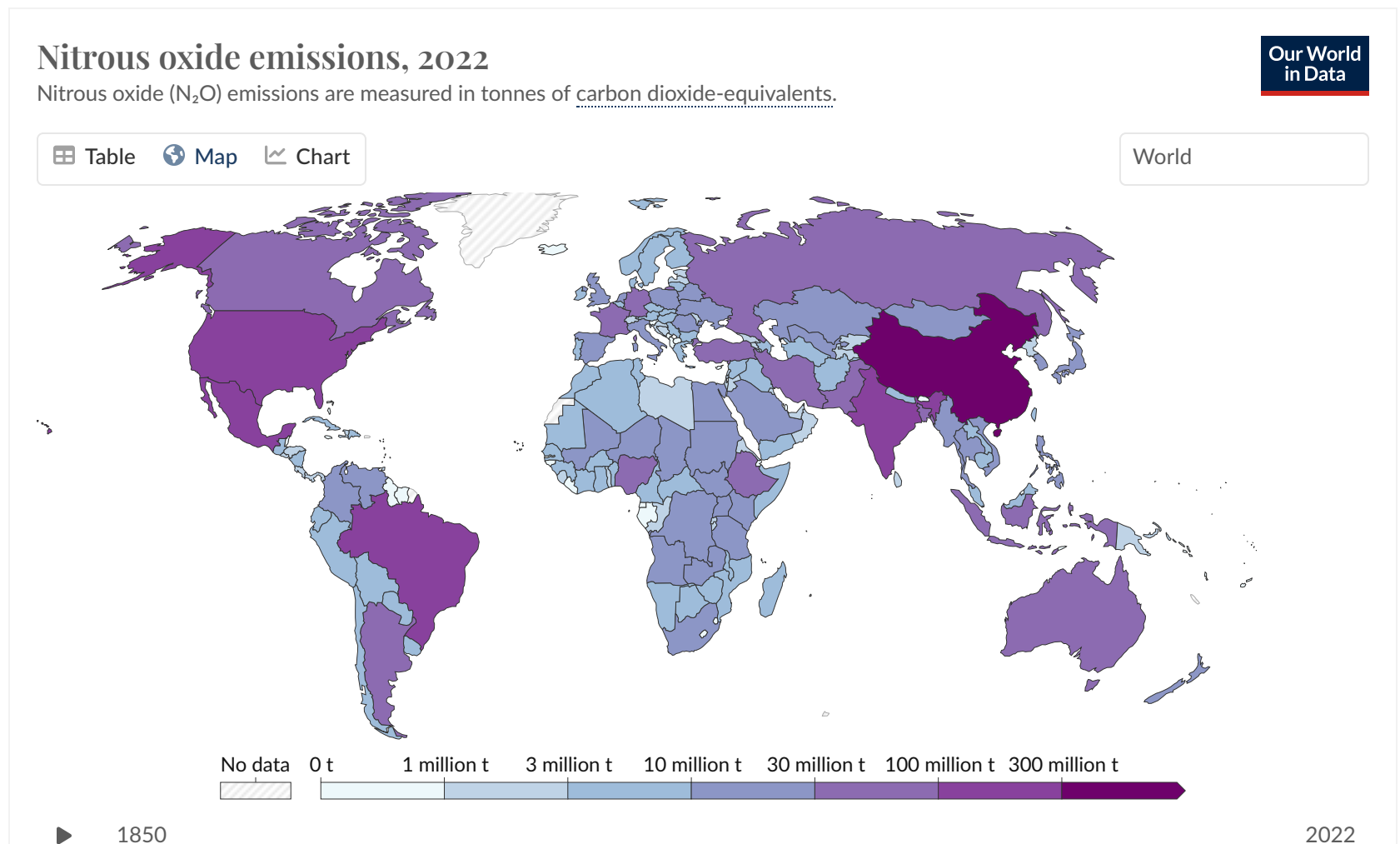
This is typically shorter than CO_2 (which can persist for centuries or even thousands of years), but longer than methane (which has an average lifetime of 12 years).

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This interactive chart shows nitrous oxide (N₂O) emissions across the world.

Nitrous oxide emissions are measured in tonnes of carbon dioxide equivalent (CO₂e), so are weighted for their 100-year global warming potential value.



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Per capita nitrous oxide emissions: how much does the average person emit?

How do emissions compare when we correct for the population?

This interactive map shows *per capita* nitrous oxide emissions. This is measured in tonnes of carbon dioxide equivalents per person per year.

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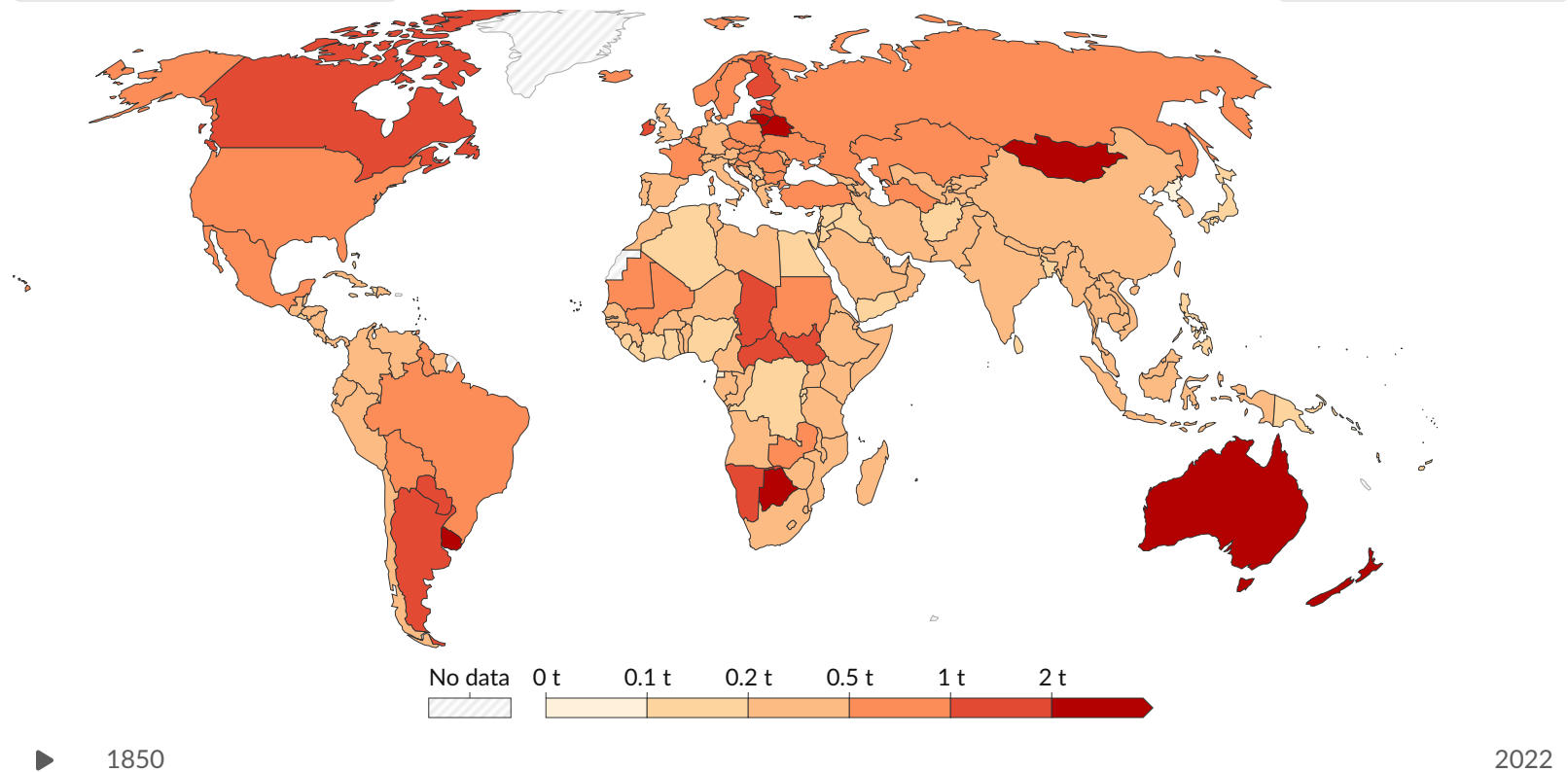
Per capita nitrous oxide emissions, 2022

Per capita nitrous oxide emissions are measured in tonnes of carbon dioxide-equivalents per person per year.

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Table Map Chart

World



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How do we quantify greenhouse gas emissions?

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(UNFCCC); is used in official GHG reporting and target-setting by countries and institutions; and is the most widely adopted metric used within the scientific literature. As some researchers have highlighted, the lack of life-cycle assessment data disaggregated by gas can result in the loss of important information which could help us develop more optimal strategies for climate mitigation.⁷

What are carbon dioxide-equivalents? Carbon dioxide (CO₂) is the most important greenhouse gas, but not the only one — gases such as methane and nitrous oxide are also drivers of global warming. Carbon dioxide-equivalents (CO₂eq) try to sum all the warming impacts of the different greenhouse gases together to give a single measure of total greenhouse gas emissions. Two things make this more complicated: the gases have different ‘strengths’ of warming; and gases persist for different amounts of time in the atmosphere.

To convert non-CO₂ gases into their carbon dioxide-equivalents we multiply their mass (e.g. kilograms of methane emitted) by their ‘global warming potential’ (GWP). GWP measures the warming impacts of a gas compared to CO₂; it measures the ‘strength’ of the greenhouse gas averaged over a chosen time horizon. The standard way to do this is to evaluate the GWP over a 100-year timescale (GWP₁₀₀). GWP₁₀₀ is the accounting metric adopted by the

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Potential (GTP) as examples of different metrics that were useful depending on the question being asked.

The GWP_{100} value for methane from AR5 is 28 (or 34 if climate feedback processes are included).⁸ This means that emitting one kilogram of methane creates 28 times the amount of warming as one kilogram of CO_2 averaged over the next 100 years. But what this doesn't account for is the fact that methane is a short-lived greenhouse gas. It has a very strong warming impact when it is first emitted, but this warming impact diminishes over the following decades. Whereas, if you emitted the same amount of CO_2 , it could persist for centuries.

Using this GWP_{100} metric can therefore misrepresent the impact of short-lived gases such as methane in both directions.⁹ It underestimates short-term warming: the warming impact of methane when it's first emitted and the following years is much higher than the '28' value assigned by GWP_{100} . Some people therefore argue that we should use a value that represents the global warming potential over 20 years (GWP_{20}) since it gives a better indication of short-term warming. The IPCC reports a GWP_{20} value of 84 for methane (86 if feedbacks are included). Others argue that GWP_{100} *overestimates the long-term impacts* of methane; the methane emitted today will not be around a century from now. These differences are reflected by the large changes in GTP over

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This makes it difficult to reconcile these warming impacts into a single metric. Our choice of metric can also impact how we prioritize GHG reduction strategies: do we first target strong but short-lived gases such as methane? This may slow warming in the short term — a reasonable argument if we are concerned about approaching temperature-induced tipping points. Or should we focus instead on the persistent CO₂ emissions, which will be the primary driver of long-term temperature impacts?

Some researchers have developed new methods that aim to provide a closer representation of the actual temperature response to different gases. Myles Allen, Michelle Cain, and colleagues at the University of Oxford's Martin School lead a research program on climate pollutants, which looks directly at this challenge.

They have proposed a new way to represent short-lived greenhouse gas emissions – GWP* — which aims to be more representative of the warming response.^{10 11} Dr Michelle Cain, one of the lead researchers in this area, discusses the challenges of GHG metrics and the role of a new GWP* metric, in an article in the *Carbon Brief* here.

GWP* is used to calculate CO₂-warming-equivalent emissions, which reflects that (a) increasing methane emissions would

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methane. Scenarios (b) and (c) are very different from CO₂, as rapidly or gradually decreasing CO₂ emissions lead to further global temperature increases (only the rate of temperature increase slows).

This is explored further in an Oxford Martin School briefing note, found [here](#), and the recent publication by researchers John Lynch, Michelle Cain, Raymond Pierrehumbert, and Myles Allen (2020).¹²

How do we account for the warming of different gases?

As discussed in previous sections, greenhouse gases vary in their relative contributions to global warming; i.e. one tonne of methane does not have the same impact on warming as one tonne of carbon dioxide.

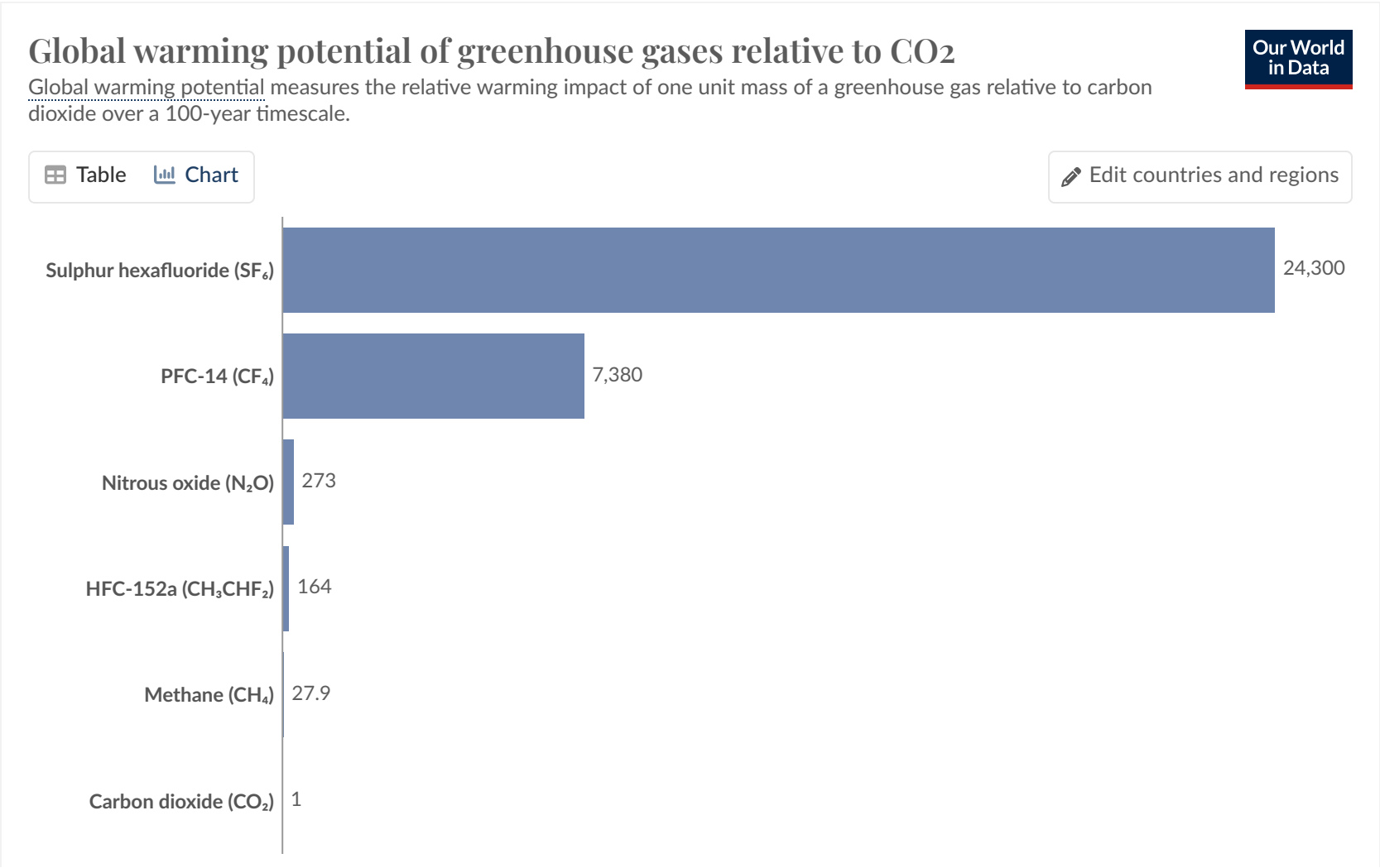
We define these differences using the metric, 'Global Warming Potential' (GWP). GWP can be defined on a range of time periods, however, the most commonly used (and that adopted by the IPCC) is the 100-year timescale (GWP₁₀₀).¹³

In the chart, we see the GWP₁₀₀ value of key greenhouse gases relative to carbon dioxide. The GWP₁₀₀ metric measures the relative warming impact of one molecule or unit mass of a greenhouse gas relative to carbon dioxide over a 100-year

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carbon dioxide equivalents (CO₂e). CO₂e is derived by multiplying the mass of emissions of a specific greenhouse gas by its equivalent GWP₁₀₀ factor. The sum of all gases in their CO₂e form provides a measure of total greenhouse gas emissions.



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ENDNOTES

1. If climate feedback effects are included, this increases to 34 times that of CO₂.
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