



exporter



IPCCのTCREの値は幾らですか



IPCC（気候変動に関する政府間パネル）の報告書では、TCRE（Transient Climate Response to Cumulative Carbon Emissions、一時的気温応答）は、**1000 GtCO₂あたり約1.0～2.3°C**と見積もられています。

TCREとは？

TCREは、大気中に蓄積された二酸化炭素（CO₂）の総量と、地球の平均気温上昇との間の線形関係を示す指標です。つまり、累積CO₂排出量が増えるほど気温が上昇するという関係を定量化したものです。

IPCC AR6（第6次評価報告書）のTCREの範囲

- **1.0～2.3°C / 1000 GtCO₂**（66%信頼区間）
- 中央値：約1.65°C / 1000 GtCO₂

この値は、化石燃料の燃焼や土地利用の変化による二酸化炭素の排出が続く限り、温暖化がほぼ線形に進むことを示しています。

例えば、人間活動によって**1000 GtCO₂**を排出すると、地球の平均気温は**1.0～2.3°C**上昇すると推定されます。これは、温暖化を1.5°C以下に抑えるためにどれくらいのCO₂排出が許容されるかを判断する際の重要な指標となります。



How much is the TCRE in IPCC AR6?





In **IPCC AR6 (Sixth Assessment Report)**, the **TCRE (Transient Climate Response to Cumulative Carbon Emissions)** is estimated to be:

- **1.0-2.3°C per 1000 GtCO₂** (66% confidence range)
- **Central estimate: ~1.65°C per 1000 GtCO₂**

This means that for every **1000 gigatonnes (Gt) of CO₂ emitted**, global temperatures are expected to rise by approximately **1.0 to 2.3°C**, assuming other climate factors remain constant.

What is TCRE?

TCRE quantifies the nearly linear relationship between cumulative CO₂ emissions and global temperature increase. It is a key metric for understanding **carbon budgets**—the amount of CO₂ that can be emitted while keeping warming below a certain threshold (e.g., 1.5°C or 2°C).

Would you like further details on how this affects global climate policy or carbon budgets?



Show me the reference



3件のサイトを検索しました ✓

The Transient Climate Response to Cumulative CO₂ Emissions (TCRE) is a key metric used by the IPCC to estimate the amount of warming caused per unit of cumulative CO₂ emissions. According to the IPCC's Sixth Assessment Report (AR6), TCRE is nearly constant over time due to the balancing effects of radiative forcing and ocean heat uptake. This relationship is used to estimate remaining carbon budgets for specific temperature limits, such as 1.5°C or 2°C of warming above pre-industrial levels

[IPCC.CH](https://www.ipcc.ch)



For further details, you can refer to the IPCC's official report:

[IPCC AR6 - The Physical Science Basis](#)



No, you are confusing CO2 emissions with C emissions.



2 件のサイトを検索しました ✓

You're right to distinguish between carbon (C) emissions and carbon dioxide (CO₂) emissions. While CO₂ emissions refer specifically to carbon dioxide released into the atmosphere, carbon emissions can encompass all carbon-containing compounds, including CO₂, methane (CH₄), and other organic carbon species.

The primary concern with CO₂ emissions is their role in the greenhouse effect and climate change. According to the IPCC, the growth rate of atmospheric CO₂ has been about 100 times faster during the industrial era (since 1900) compared to pre-industrial times. This increase is directly linked to human activities such as burning fossil fuels, deforestation, and industrial processes. Natural carbon cycles, including ocean absorption and vegetation uptake, play a role in regulating atmospheric CO₂, but human emissions have overwhelmed these natural processes [19] .

If you were referring to a different aspect of carbon emissions, let me know, and I can refine my response further!



So let me know what is TCRE by IPCC



3 件のサイトを検索しました ✓

TCRE (Transient Climate Response to Cumulative Carbon Emissions) is a key climate metric assessed by the IPCC. It measures the near-linear relationship between



cumulative CO₂ emissions and global temperature rise. Essentially, it estimates how much the Earth's surface temperature increases per 1,000 gigatonnes of carbon (GtC) emitted.

According to the IPCC AR6 (2021), the likely range of TCRE is between **1.0°C and 2.3°C per 1,000 GtC**, refined from previous estimates in AR5 (0.8°C to 2.5°C per 1,000 GtC). This metric is critical for calculating remaining carbon budgets and understanding how continued CO₂ emissions contribute to global warming

[IPCC.CH](#)

Would you like more details on how TCRE influences climate policies or carbon budgets?



You are right now. So how much TCRE is per 1000GtCO₂?



To convert TCRE from **per 1000 GtC** to **per 1000 GtCO₂**, we use the conversion factor:

$$1 \text{ GtC} = 3.664 \text{ GtCO}_2$$

Thus, the TCRE range in **IPCC AR6** is:

$$\frac{1.0 - 2.3 \text{ }^\circ\text{C}}{1000 \text{ GtC}} \times \frac{1}{3.664} \\ \approx 0.27 - 0.63 \text{ }^\circ\text{C per 1000 GtCO}_2$$

So, the **TCRE in AR6 is approximately 0.27 to 0.63°C per 1000 GtCO₂**.



OK. what is the central estimate?



The **central estimate** of TCRE in **IPCC AR6** is approximately **0.45°C per 1000 GtCO₂**.

This is derived from the central value of TCRE per 1000 GtC, which is **1.65°C**, divided by the CO₂-to-carbon conversion factor (**3.664**):

$$\frac{1.65^{\circ}C}{3.664} \approx 0.45^{\circ}C \text{ per } 1000 \text{ GtCO}_2$$

This central estimate represents the most likely value based on multiple lines of evidence used in AR6.



Good. Now, how much is annual CO2 emissions by Japan?



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In fiscal year 2022, Japan's total greenhouse gas emissions amounted to approximately **1.14 billion tons of CO₂ equivalent**, with carbon dioxide accounting for over **90%** of these emissions. The main sources of these emissions were the **energy conversion sector**, particularly due to reliance on **coal and natural gas** for electricity production. Following the **2011 Fukushima nuclear disaster**, Japan reduced its use of nuclear power, increasing its dependence on fossil fuels, which led to higher emissions

[STATISTA.COM](https://www.statista.com)



Good. Now, Japanese government is aiming at zero emissions by 2050. How much global temperature



reduction do you expect compared to a baseline, in which emissions are stabilized at 2022 level?



To estimate the **global temperature reduction** from Japan achieving net-zero emissions by 2050, compared to a scenario where emissions remain constant at the **2022 level (1.14 GtCO₂/year)**, we follow these steps:

Step 1: Calculate Cumulative Emissions in Each Scenario

1. Baseline (constant emissions at 2022 level until 2100):

- Annual emissions = **1.14 GtCO₂/year**
- Total emissions from **2023 to 2100** (78 years) =

$$1.14 \times 78 = 88.9 \text{ GtCO}_2$$

2. Net-zero by 2050 scenario:

- Assume **linear reduction** to zero by 2050 (i.e., emissions reduce at a constant rate).
- Total emissions from **2023 to 2050 (28 years)**:

$$\frac{1.14 \times 28}{2} = 15.96 \text{ GtCO}_2$$

- Post-2050 emissions = **0 GtCO₂**
- Total emissions until 2100 = **15.96 GtCO₂**

Step 2: Difference in Cumulative Emissions

- Emissions avoided by net-zero policy:

$$88.9 - 15.96 = 72.94 \text{ GtCO}_2$$

Step 3: Estimate Temperature Impact Using TCRE



From IPCC AR6, the **central TCRE value** is **0.45°C per 1000 GtCO₂**.

Thus, the expected temperature reduction is:

$$72.94 \times \frac{0.45}{1000} = 0.033^\circ\text{C (or about } 0.03^\circ\text{C)}$$

Conclusion

Japan's net-zero target by 2050 is expected to **reduce global temperatures by approximately 0.03°C** by 2100, compared to a scenario where emissions remain constant at 2022 levels. While this may seem small, every fraction of a degree matters in mitigating climate change, and Japan's commitment sets an example for other nations. Would you like further analysis on global net-zero strategies?



No, please compare the both scenario



Comparison of Temperature Outcomes: Baseline vs. Net-Zero by 2050

Using the **TCRE (0.45°C per 1000 GtCO₂)** from IPCC AR6, we compare global temperature increases in two scenarios:

Scenario 1: Emissions Stabilized at 2022 Level

- **Total CO₂ emissions (2023-2100) = 88.9 GtCO₂**
- **Expected warming contribution =**

$$88.9 \times \frac{0.45}{1000} = 0.040^\circ\text{C}$$

(≈ 0.04°C additional warming by 2100 due to Japan's emissions alone).

Scenario 2: Net-Zero by 2050

- **Total CO₂ emissions (2023-2100) = 15.96 GtCO₂**



- **Expected warming contribution =**

$$15.96 \times \frac{0.45}{1000} = 0.007^\circ C$$

($\approx 0.007^\circ C$ additional warming by 2100).

Final Temperature Difference

- **Baseline (constant emissions): $+0.04^\circ C$**
- **Net-Zero by 2050: $+0.007^\circ C$**
- **Temperature reduction due to net-zero:**

$$0.04 - 0.007 = 0.033^\circ C$$

($\approx 0.03^\circ C$ less warming by 2100 compared to the baseline).

Conclusion

If Japan achieves net-zero CO₂ emissions by 2050, global temperatures in 2100 would be **about $0.03^\circ C$ lower** than if emissions remained at the 2022 level. This impact alone is relatively small, but Japan's leadership may encourage other nations to adopt similar targets, contributing to larger global climate mitigation efforts.



No, please compare both scenario up to 2050, not 2100.



Let's compare the temperature outcomes for **both scenarios up to 2050**:

Scenario 1: Emissions Stabilized at 2022 Level

- **Annual emissions: 1.14 GtCO_2**
- **Total emissions (2023-2050) =**

$$1.14 \times 28 = 31.92 \text{ GtCO}_2$$



- **Expected warming contribution by 2050:**

$$31.92 \times \frac{0.45}{1000} = 0.0144^\circ C$$

($\approx 0.014^\circ C$ additional warming by 2050).

Scenario 2: Net-Zero by 2050

- **Annual emissions reduce linearly to zero by 2050.**
 - **Emissions in 2023 = 1.14 GtCO₂**
 - **Emissions in 2050 = 0 GtCO₂**
 - **Total emissions from 2023 to 2050 (28 years):**

$$\frac{1.14 \times 28}{2} = 15.96 \text{ GtCO}_2$$

- **Expected warming contribution by 2050:**

$$15.96 \times \frac{0.45}{1000} = 0.0072^\circ C$$

($\approx 0.007^\circ C$ additional warming by 2050).

Temperature Difference by 2050

- **Scenario 1 (constant emissions): +0.014°C**
- **Scenario 2 (net-zero by 2050): +0.007°C**
- **Temperature reduction due to net-zero by 2050:**

$$0.014 - 0.007 = 0.007^\circ C$$

($\approx 0.007^\circ C$ less warming by 2050 compared to the baseline).

Conclusion

If Japan achieves net-zero emissions by 2050, global temperatures would be **about 0.007°C lower** by 2050 compared to the baseline where emissions stabilize at 2022



levels. This is a relatively small reduction, but it is part of a larger global effort where collective action can lead to more significant impacts.



How much does Tokyo metropolitan emit CO2 annually?



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In 2019, Tokyo's energy-related CO2 emissions were approximately 55.05 million tonnes. The emissions are distributed across various sectors, with commercial buildings contributing over 70% of the total emissions. Other major contributors include residential areas (43.3%) and transportation (29.3%)

[METRO.TOKYO.LG.JP](https://metro.tokyo.lg.jp)



Good. Now, Tokyo metropolitan government is aiming at zero emissions by 2050. How much global temperature reduction do you expect compared to a baseline, in which emissions are stabilized at 2022 level?



Let's estimate the temperature reduction based on Tokyo's emissions scenario:

Step 1: Cumulative Emissions in Each Scenario

1. Baseline (Emissions Stabilized at 2022 Level):

- Annual emissions = **55.05 MtCO₂**
- Total emissions from **2023 to 2050** (28 years) =



$$55.05 \times 28 = 1,541.4 \text{ MtCO}_2$$

2. Net-Zero by 2050:

- Assume linear reduction to zero by 2050.
- Total emissions from **2023 to 2050**:

$$\frac{55.05 \times 28}{2} = 770.7 \text{ MtCO}_2$$

Step 2: Temperature Impact Using TCRE

Using the **central TCRE of 0.45°C per 1000 GtCO₂**:

- **Baseline (Constant emissions):**

$$1,541.4 \times \frac{0.45}{1000} = 0.6936^\circ C$$

- **Net-Zero by 2050:**

$$770.7 \times \frac{0.45}{1000} = 0.3468^\circ C$$

Step 3: Temperature Reduction

- **Temperature reduction:**

$$0.6936 - 0.3468 = 0.3468^\circ C$$

Conclusion

If Tokyo achieves zero emissions by 2050, global temperatures would be **about 0.35°C lower** by 2050 compared to a scenario where emissions remain stable at the 2022 level.



It seems you are confusing Mt with Gt. Correct.



You're right! I mistakenly used **MtCO₂** (million tonnes) instead of **GtCO₂** (billion tonnes) in the previous calculations. Let's correct it:

Step 1: Cumulative Emissions in Each Scenario

1. Baseline (Emissions Stabilized at 2022 Level):

- Annual emissions = **55.05 MtCO₂ = 0.05505 GtCO₂**
- Total emissions from **2023 to 2050** (28 years) =

$$0.05505 \times 28 = 1.5414 \text{ GtCO}_2$$

2. Net-Zero by 2050:

- Total emissions from **2023 to 2050**:

$$\frac{0.05505 \times 28}{2} = 0.7707 \text{ GtCO}_2$$

Step 2: Temperature Impact Using TCRE

Using the **central TCRE of 0.45°C per 1000 GtCO₂**:

- **Baseline (Constant emissions):**

$$1.5414 \times \frac{0.45}{1000} = 0.0006936^\circ C$$

- **Net-Zero by 2050:**

$$0.7707 \times \frac{0.45}{1000} = 0.0003468^\circ C$$

Step 3: Temperature Reduction

- **Temperature reduction:**

$$0.0006936 - 0.0003468 = 0.0003468^\circ C$$



Conclusion

If Tokyo achieves zero emissions by 2050, global temperatures would be **about 0.00035°C lower** by 2050 compared to a scenario where emissions remain stable at the 2022 level.



How much budget is Tokyo metropolitan government going to allocate for CO2 emission reduction?



The Tokyo Metropolitan Government (TMG) has been active in promoting climate change mitigation measures and has allocated significant funding toward its initiatives. For example, the Tokyo Cap-and-Trade Program, which targets large CO2 emitters in the commercial and industrial sectors, requires facilities to reduce emissions or engage in emissions trading. These efforts alone account for about 40% of the emissions from the industrial and commercial sectors in Tokyo

[METRO.TOKYO.LG.JP](https://www.metro.tokyo.lg.jp)

[KANKYO.METRO.TOKYO.LG.JP](https://www.kankyo.metro.tokyo.lg.jp) .

Additionally, the Tokyo Climate Change Strategy includes a variety of initiatives, such as advancing CO2 reduction measures for businesses, promoting energy conservation in households, and creating energy-efficient building standards for urban development

[KANKYO.METRO.TOKYO.LG.JP](https://www.kankyo.metro.tokyo.lg.jp) .

Tokyo's plans also emphasize large investments, such as a dedicated "Fund to Promote Measures against Climate Change" [KANKYO.METRO.TOKYO.LG.JP](https://www.kankyo.metro.tokyo.lg.jp) .

Although specific financial figures are not immediately available, these programs demonstrate the city's strong commitment to tackling CO2 emissions and transitioning to a low-carbon society.



Tokyo metropolitan government intends to allocate about 300 billion yen in their budget proposal for Reiwa



7 for "decarbonization city as a global model" . Am I correct?



1 件のサイトを検索しました ✓

Yes, you are correct. The Tokyo Metropolitan Government is planning to allocate approximately 300 billion yen in its budget proposal for fiscal year 2025 (Reiwa 7) towards initiatives that aim to transform Tokyo into a "decarbonization city" and a global model for sustainability. These efforts are part of the city's broader goal of achieving net-zero carbon emissions by 2050

[TOKYOUUPDATES.METRO.TOKYO.LG.JP](https://tokyouupdates.metro.tokyo.lg.jp) .



OK. So Tokyo metropolitan is government is spending 300



Yes, the Tokyo Metropolitan Government is planning to allocate approximately 300 billion yen in its 2025 budget to support decarbonization efforts and position Tokyo as a global model for sustainable cities. This investment is part of Tokyo's strategy to achieve net-zero emissions by 2050.



OK. So, Tokyo metropolitan government is going to spend 300 billion yen in Reiwa 7 for a 0.00035C temperature reduction in 2050. Am I correct?





Yes, based on our previous calculations, the Tokyo Metropolitan Government's 300 billion yen investment in decarbonization measures is expected to contribute to a temperature reduction of **approximately 0.00035°C** by 2050, compared to a scenario where emissions are stabilized at 2022 levels. This small reduction reflects the city's significant but incremental role in global climate efforts.



How much rainfall reduction do you expect from a 1C increase in temperature assuming Clausius-Clapayron Relationship?



The Clausius-Clapeyron relationship describes how the saturation vapor pressure of water increases with temperature. Specifically, it suggests that for every 1°C increase in temperature, the water-holding capacity of the atmosphere increases by about **7%**.

This means that, in general, an increase of 1°C in temperature could lead to **approximately 7% more rainfall** in areas that are already experiencing moisture-laden air. However, actual rainfall changes depend on regional dynamics, such as precipitation patterns, geographical factors, and local climates.



How much is the maximum daily rainfall in Tokyo historically?



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The maximum daily rainfall in Tokyo historically reached 417 mm during a typhoon in 1958. This event is the highest recorded daily rainfall for the city. Other notable heavy rainfall events include around 300 mm in a 24-hour period during intense storms like Typhoon Hagibis in 2019



[WEATHER-AND-CLIMATE.COM](https://weather-and-climate.com)

[EASEWEATHER.COM](https://easeweather.com)

[WUNDERGROUND.COM](https://wunderground.com)



You mean Kanogawa Typhoon, right?



Yes, you are correct. The historical maximum daily rainfall of 417 mm in Tokyo was recorded during the **Kanogawa Typhoon** (also known as Typhoon Ida) in **1958**. This typhoon brought intense rainfall and strong winds, setting the record for the highest amount of daily rainfall in the region

[WEATHER-AND-CLIMATE.COM](https://weather-and-climate.com)

[WUNDERGROUND.COM](https://wunderground.com)



OK. How much reduction in the daily rainfall expected by achieving Japanese zero emission by 2050?



To estimate the reduction in daily rainfall that might be expected due to Japan's zero-emission policy by 2050, we need to consider the relationship between global temperature increase and changes in rainfall patterns, particularly using the **Clausius-Clapeyron relationship**. This relationship suggests that for every 1°C increase in temperature, the atmosphere's water-holding capacity increases by about 7%, which can amplify rainfall in certain regions.

However, reducing Japan's emissions to zero by 2050 could result in a **temperature reduction of about 0.03°C** globally, based on earlier calculations. Given that global rainfall patterns are influenced by many factors, including atmospheric dynamics, geography, and oceanic currents, the direct impact of Japan's actions on Tokyo's rainfall is quite small. If we use the Clausius-Clapeyron estimate:



1. **Temperature increase of 1°C → 7% increase in moisture-holding capacity.**
2. **Expected reduction of about 0.03°C due to Japan's net-zero emissions by 2050.**

Using these factors:

$0.03 \times 7\% = 0.21\%$ reduction in the water-holding capacity of the atmosphere.

Thus, this would correspond to a **very small reduction in rainfall**, potentially affecting a small portion of extreme daily rainfall events like the **417 mm maximum daily rainfall** seen during Typhoon Kanogawa in 1958. The actual rainfall reduction would be on the order of a few millimeters at most, depending on specific regional climate responses.

It's essential to remember that this is a simplified estimate. In reality, rainfall changes also depend on other factors like storm intensity, ocean temperatures, and global atmospheric circulation patterns, all of which can modulate the impact of temperature changes on local rainfall.



Temperature reduction is not 0.03, but it should be 0.007.



You are correct, I made an error in the previous calculation. The temperature reduction due to Japan's net-zero emissions by 2050 should be approximately **0.007°C**, not 0.03°C.

Now, let's adjust the rainfall estimate based on this more accurate temperature change:

1. **Temperature increase of 1°C → 7% increase in moisture-holding capacity (Clausius-Clapeyron relationship).**



2. **Expected reduction of about 0.007°C globally** due to Japan's zero-emission efforts by 2050.

Using the Clausius-Clapeyron relationship:

$$0.007 \times 7\% = 0.049\% \text{ reduction in the water-holding capacity of the atmosphere.}$$

This means that the reduction in the moisture-holding capacity (which influences rainfall) would be **very small**, on the order of a fraction of a percent. For extreme daily rainfall events like the **417 mm maximum daily rainfall** in Tokyo (from Typhoon Kanogawa in 1958), this would correspond to a reduction of **approximately 0.2 mm** of rain.

Again, this is a simplified estimate, and the actual effects on rainfall could vary based on other regional and global climate factors.



OK. How much reduction in the daily rainfall of Kanogawa-like typhoon expected by achieving Tokyo's zero emission by 2050?



To estimate the potential reduction in daily rainfall for a **Kanogawa-like typhoon** (which brought about 417 mm of rainfall to Tokyo), based on Tokyo's goal of achieving **zero emissions by 2050**, we need to combine the **Clausius-Clapeyron relationship** with the expected temperature reduction due to Japan's decarbonization efforts.

Key assumptions:

- **Clausius-Clapeyron relationship:** For every 1°C increase in temperature, the atmosphere's moisture-holding capacity increases by about **7%**.
- **Expected temperature reduction from Tokyo's zero-emission target:** **0.007°C** by 2050, based on our previous calculations.



Calculation:

Given the reduction in temperature (0.007°C), the associated reduction in the moisture-holding capacity of the atmosphere would be:

$$0.007 \times 7\% = 0.049\% \text{ reduction in moisture-holding capacity.}$$

If we apply this reduction to the extreme daily rainfall from the Kanogawa typhoon (417 mm):

$$417 \text{ mm} \times 0.049\% = 0.2 \text{ mm.}$$

Conclusion:

Achieving Tokyo's zero-emission goal by 2050 could lead to a **reduction of approximately 0.2 mm** in the **maximum daily rainfall** from a Kanogawa-like typhoon, which is a **very small decrease** (about 0.05% reduction in the rainfall).

However, it is important to note that rainfall and typhoon dynamics are influenced by various other factors, such as ocean temperatures, atmospheric conditions, and the complex interactions between land and sea, so the actual reduction may differ. This is a simplified estimate based on a direct relationship between temperature and moisture-holding capacity.



No. temperature reduction from Tokyo's achievement should not be 0.007C, but 0.00035C.



You're correct, and I apologize for the earlier confusion. The temperature reduction from Tokyo's decarbonization efforts by 2050 is approximately **0.00035°C**, not 0.007°C.

Now, let's recalculate the potential reduction in **daily rainfall** for a **Kanogawa-like typhoon** (417 mm of rainfall) based on this temperature change.



Key assumptions:

- **Clausius-Clapeyron relationship:** For every 1°C increase in temperature, the moisture-holding capacity of the atmosphere increases by **7%**.
- **Expected temperature reduction from Tokyo's zero-emission goal by 2050: 0.00035°C.**

Calculation:

Given the reduction in temperature (0.00035°C), the associated reduction in the moisture-holding capacity of the atmosphere would be:

$$0.00035 \times 7\% = 0.0000245\% \text{ reduction in moisture-holding capacity.}$$

Now, applying this to the maximum daily rainfall from the Kanogawa typhoon (417 mm):

$$417 \text{ mm} \times 0.0000245\% = 0.0001 \text{ mm.}$$

Conclusion:

Achieving Tokyo's zero-emission goal by 2050 could lead to a **reduction of approximately 0.0001 mm** in the **maximum daily rainfall** from a Kanogawa-like typhoon. This is an extremely small reduction, which underscores the limited direct impact that Tokyo's emissions reduction would have on such extreme events by 2050.

However, it's important to note that while this is the direct estimate based on temperature reduction, actual changes in rainfall patterns would be influenced by a broader set of factors, including regional climate feedbacks, oceanic conditions, and global weather dynamics.