12th ATF Seminar
17 November 2022

A European Public-Private Partnership

Taking another look at methane

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What does the IPCC say about methane?

Sixth Assessment report (AR6) Working Group 1 Summary for Policy Makers (SPM) says:

- In 2019, atmospheric CO_2 concentrations were higher than at any time in at least 2 million years (*high confidence*),

  and concentrations of **CH_4 and N_2O were higher than at any time in at least 800,000 years** (*very high confidence*).

  Since 1750, increases in CO_2 (47%) and **CH_4 (156%)** concentrations far **exceed** – and increases in N_2O (23%) are similar to – **the natural multi-millennial changes** between glacial and interglacial periods **over at least the past 800,000 years** (*very high confidence*).

What does the IPCC say about methane?

Sixth Assessment report (AR6) Working Group 1 Summary for Policy Makers (SPM) says:

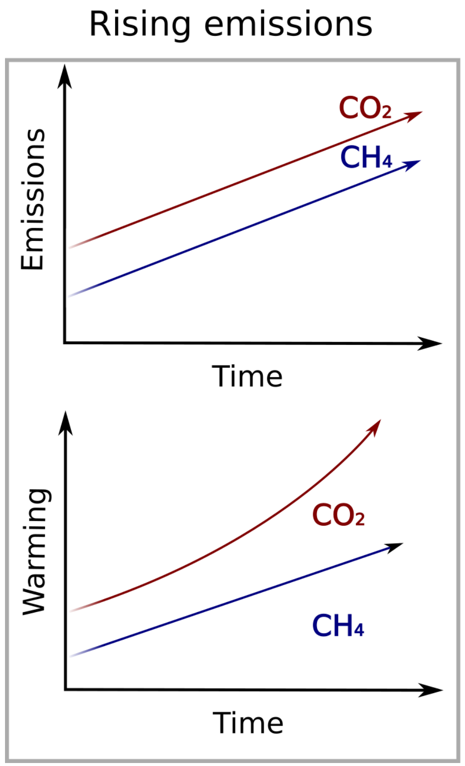
D.1 From a physical science perspective, limiting human-induced global warming to a specific level requires limiting cumulative CO_2 emissions, reaching at least net zero CO_2 emissions, along with strong reductions in other greenhouse gas emissions. Strong, rapid and sustained reductions in CH_4 emissions would also limit the warming effect resulting from declining aerosol pollution and would improve air quality. {3.3, 4.6, 5.1, 5.2, 5.4, 5.5, 5.6, Box 5.2, Cross-Chapter Box 5.1, 6.7, 7.6, 9.6} (Figure SPM.10, Table SPM.2)

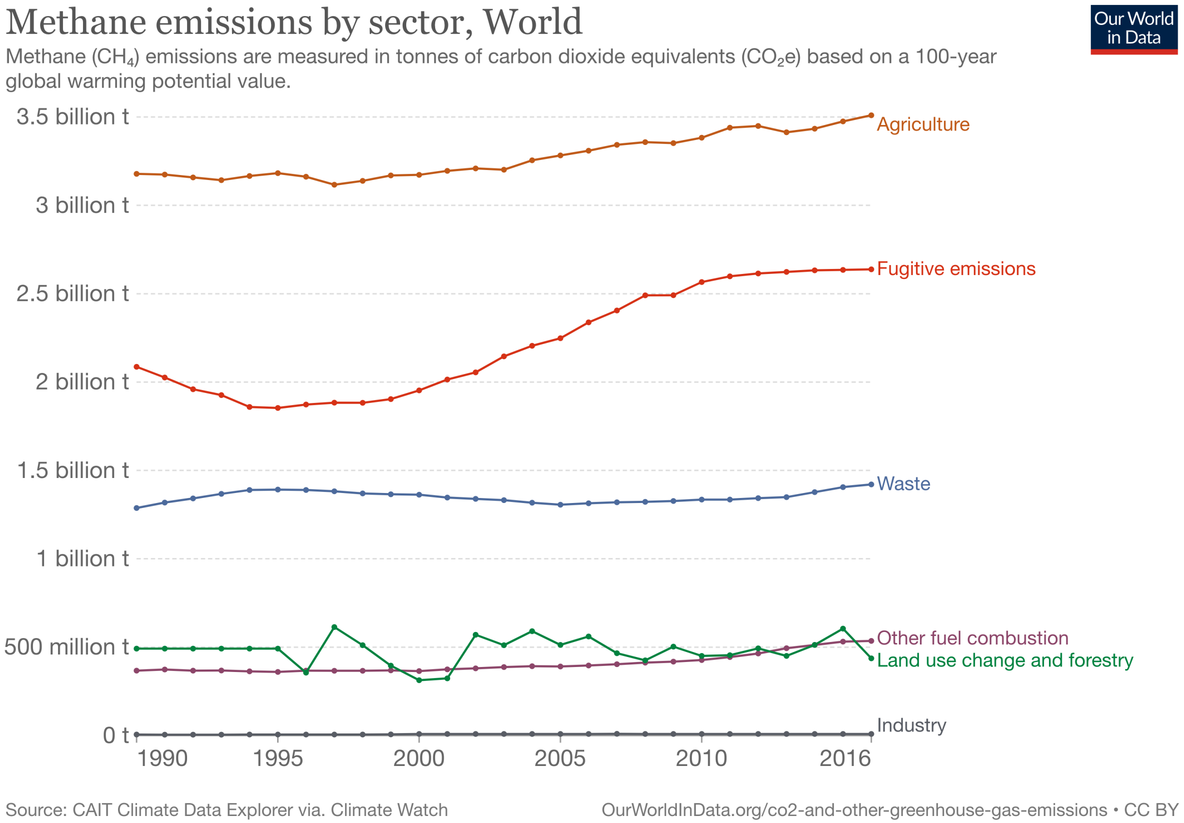
Aerosol pollution reduces → temperature goes up

Methane emissions reduce → temperature goes down

Both short lived pollutants.
Methane has a ~10 year lifetime.
Effect of changing methane emissions becomes apparent after about 10 years (depends on the size of the change).

How changes to methane emissions affect temperature



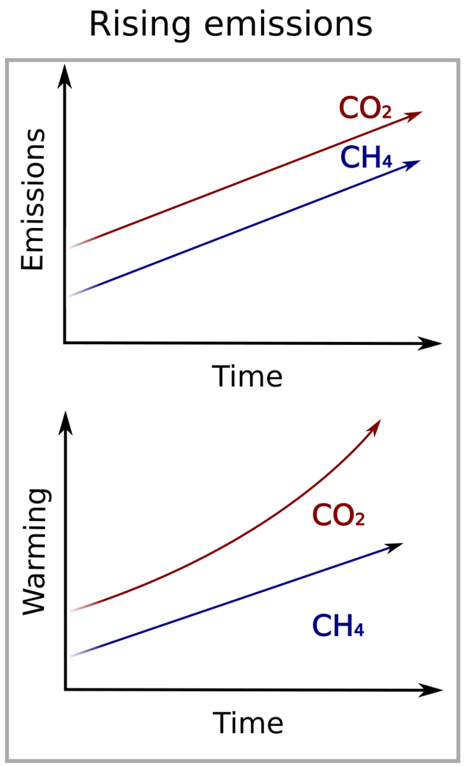


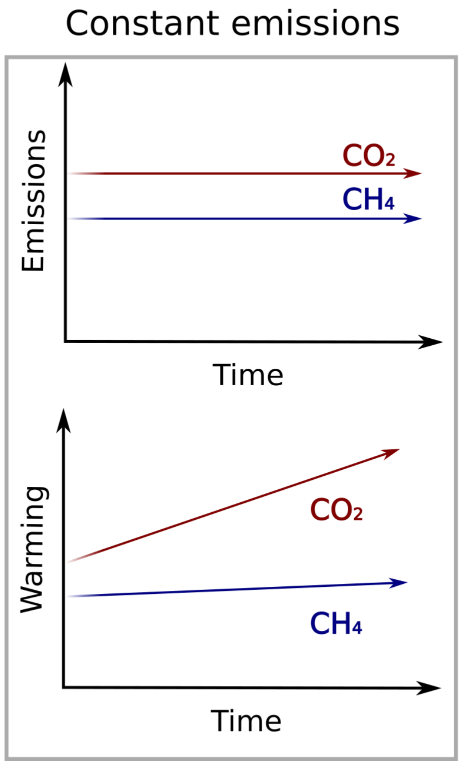
CH_4 emissions rise → temperature rises

CO_2 emissions rise → temperature rises

Figure: https://www.oxfordmartin.ox.ac.uk/publications/climate-metrics-for-ruminant-livestock

How changes to methane emissions affect temperature





CH_4 emissions rise → temperature rises

CO_2 emissions rise → temperature rises

CH_4 emissions stable → temperature rises slowly until reaches equilibrium

CO_2 emissions stable → temperature rises

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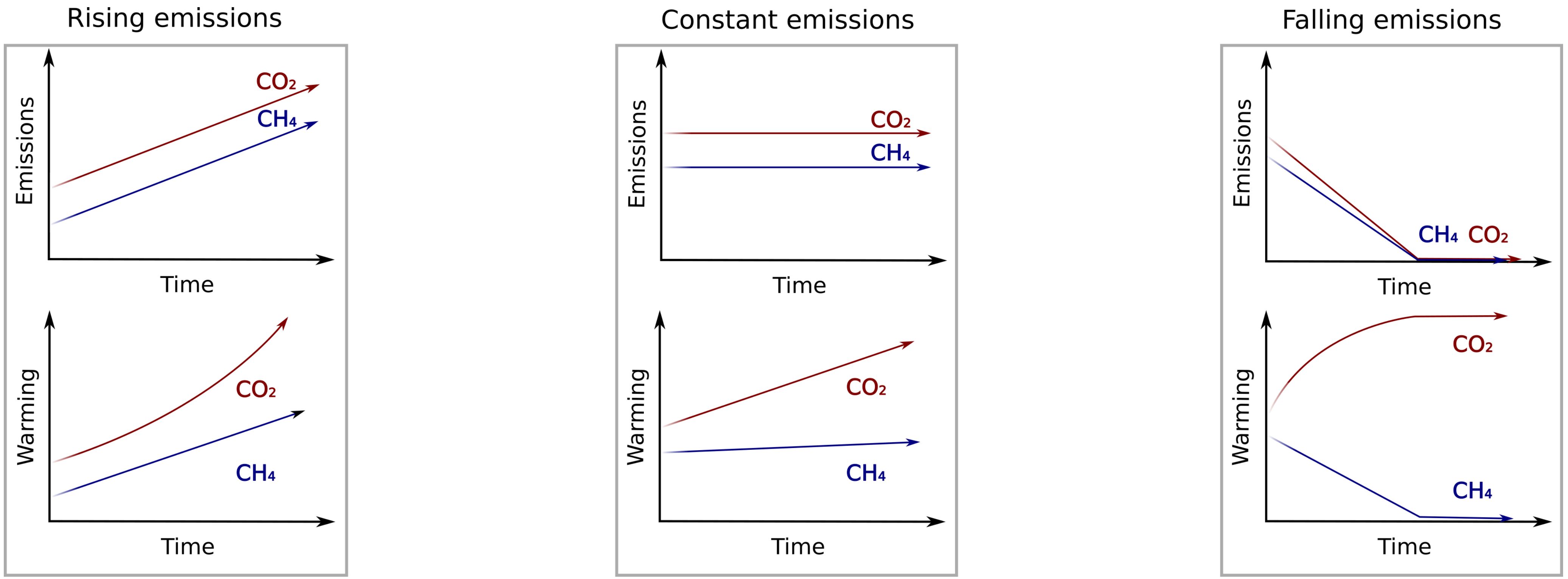
How changes to methane emissions affect temperature



CH_4 emissions rise → temperature rises

CO_2 emissions rise → temperature rises

CH_4 emissions stable → temperature rises slowly until reaches equilibrium

CO_2 emissions stable → temperature rises

CH_4 emissions falling → temperature declines

CO_2 emissions falling → temperature rises (until emissions are zero)

Figure: *https://www.oxfordmartin.ox.ac.uk/publications/climate-metrics-for-ruminant-livestock*

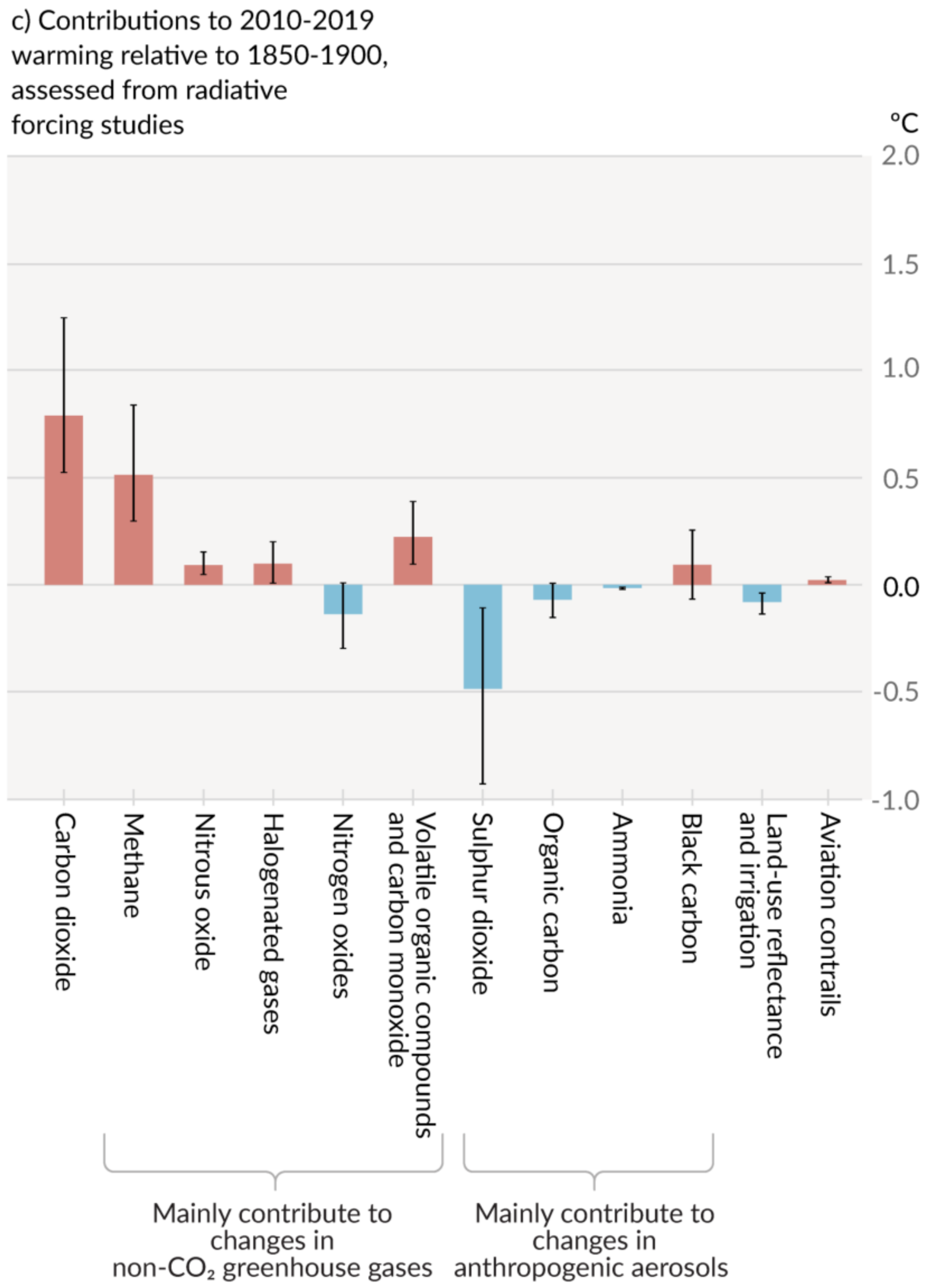
Present day contributions to global warming

Contribution to global warming from different forcings

CO_2 is the first bar

Methane is the second bar

What if we stopped all emissions today?



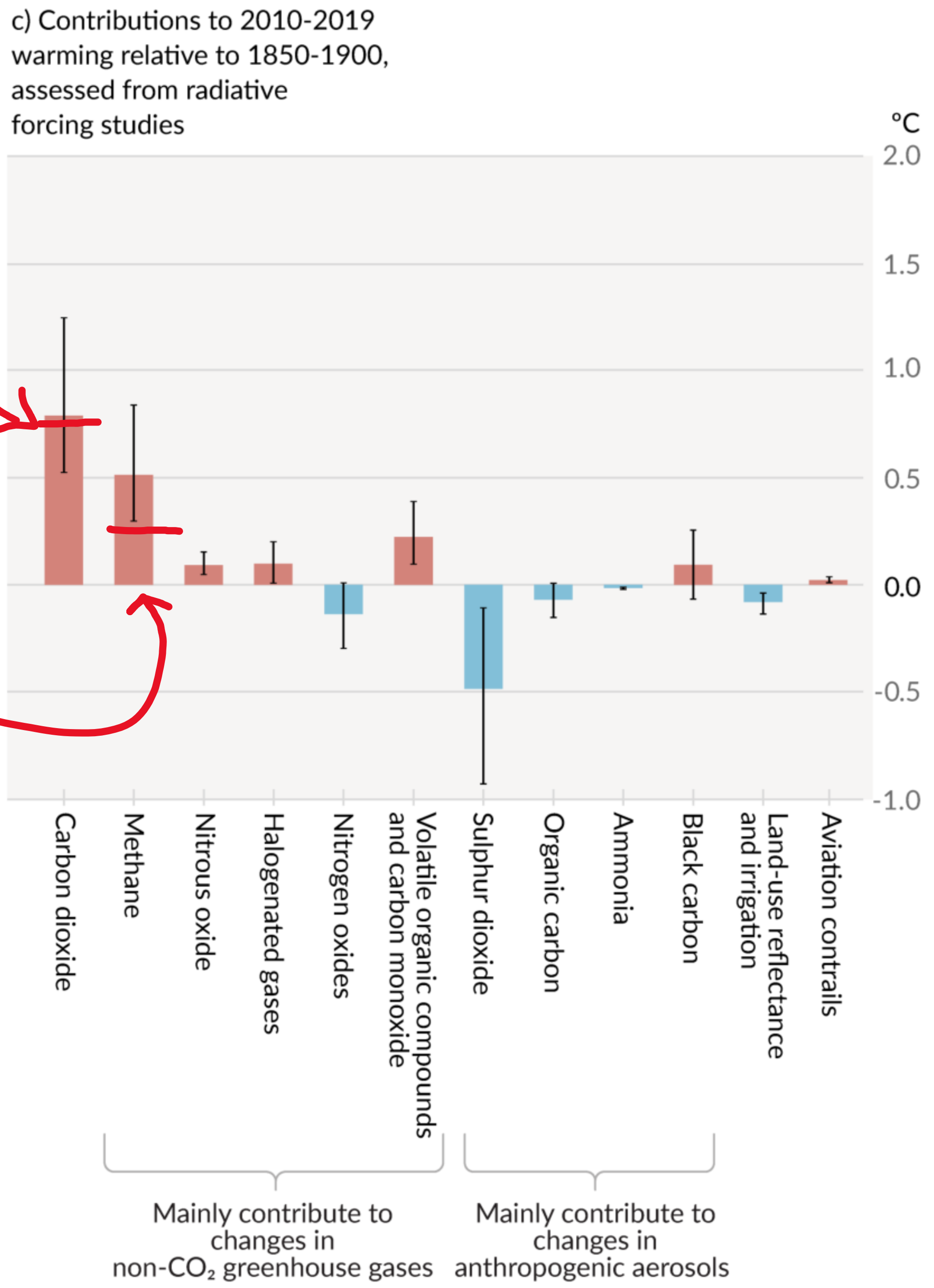
AR6 WGI SPM (2021).
Download the report from ipcc.ch

Present day contributions to global warming

If you stop all emissions:

CO_2 bar stays the same

Methane bar halves in 20-30 years



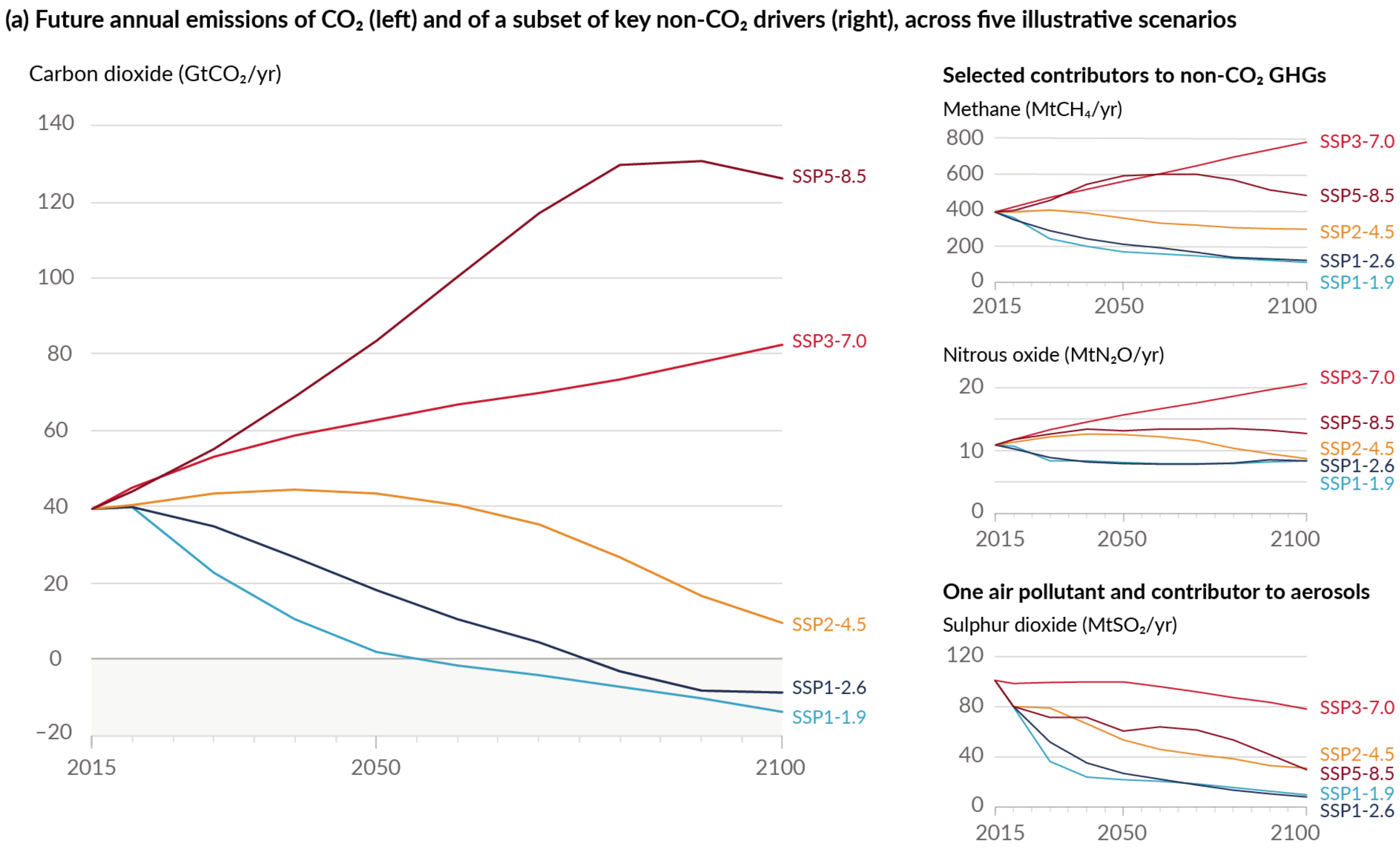
CO_2 emissions must be at or below **net-zero** to stop further warming. To achieve Paris goals, this condition **must** be satisfied

CH_4 emissions do not have to reach net-zero[1] to stop further warming and are therefore **not a pre-requisite** to achieve Paris goals.
NB although not essential to be net-zero, the lower CH_4 goes, the closer we get to achieving the Paris goals.

AR6 WGI SPM (2021).
Download the report from ipcc.ch

[1]Using GWP100 to define net-zero

Illustrative emissions scenarios of key gases to 2100: Paris compliant examples in blue



Methane falls by roughly a third by 2030 in the blue scenarios

These scenarios achieve Paris goals using the available mitigation in the models

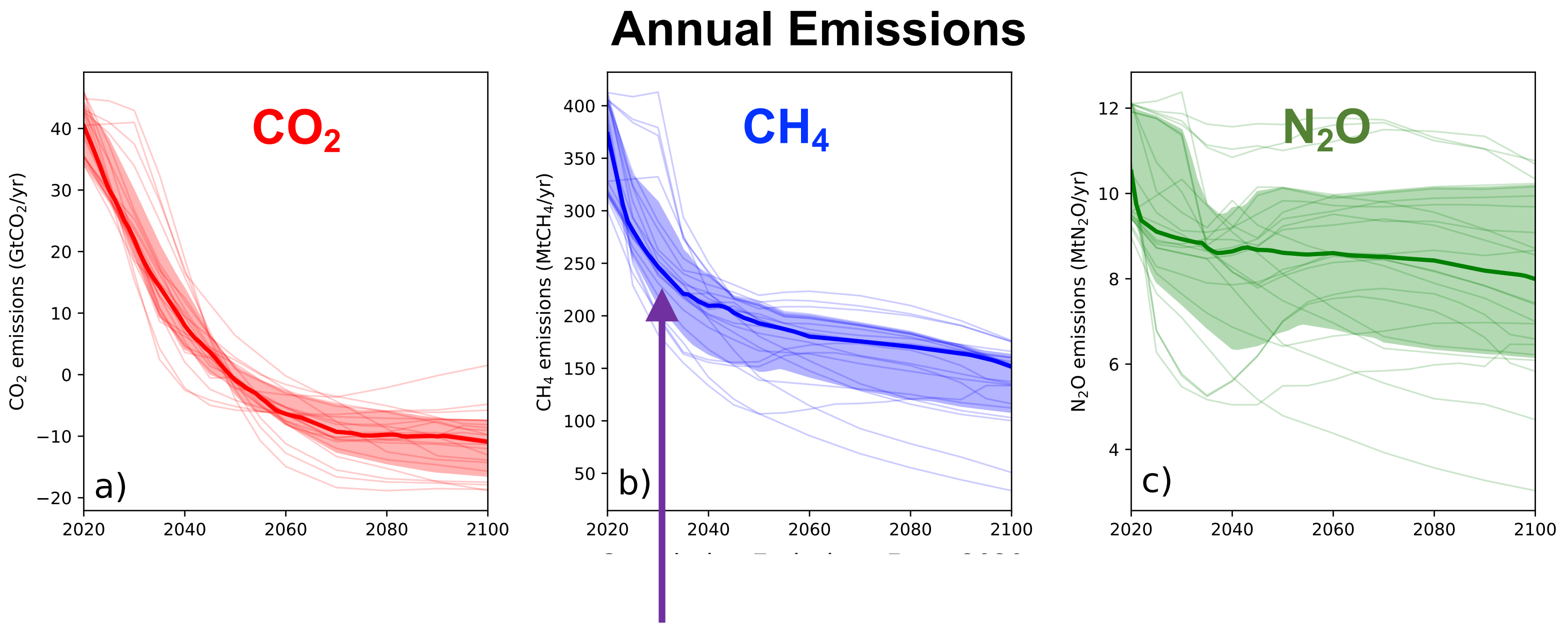
If methane doesn't decline as fast, something else has to take its place to achieve Paris goals (same goes for CO_2, N_2O)

These scenarios aren't the only pathways to a Paris compliant future – however we aren't established on a credible Paris compliant pathway at present

AR6 WGI SPM.4 (2021).

Impact of the Global Methane Pledge?

We can take a look based on the database of scenarios used in the IPCC's Special Report on 1.5C

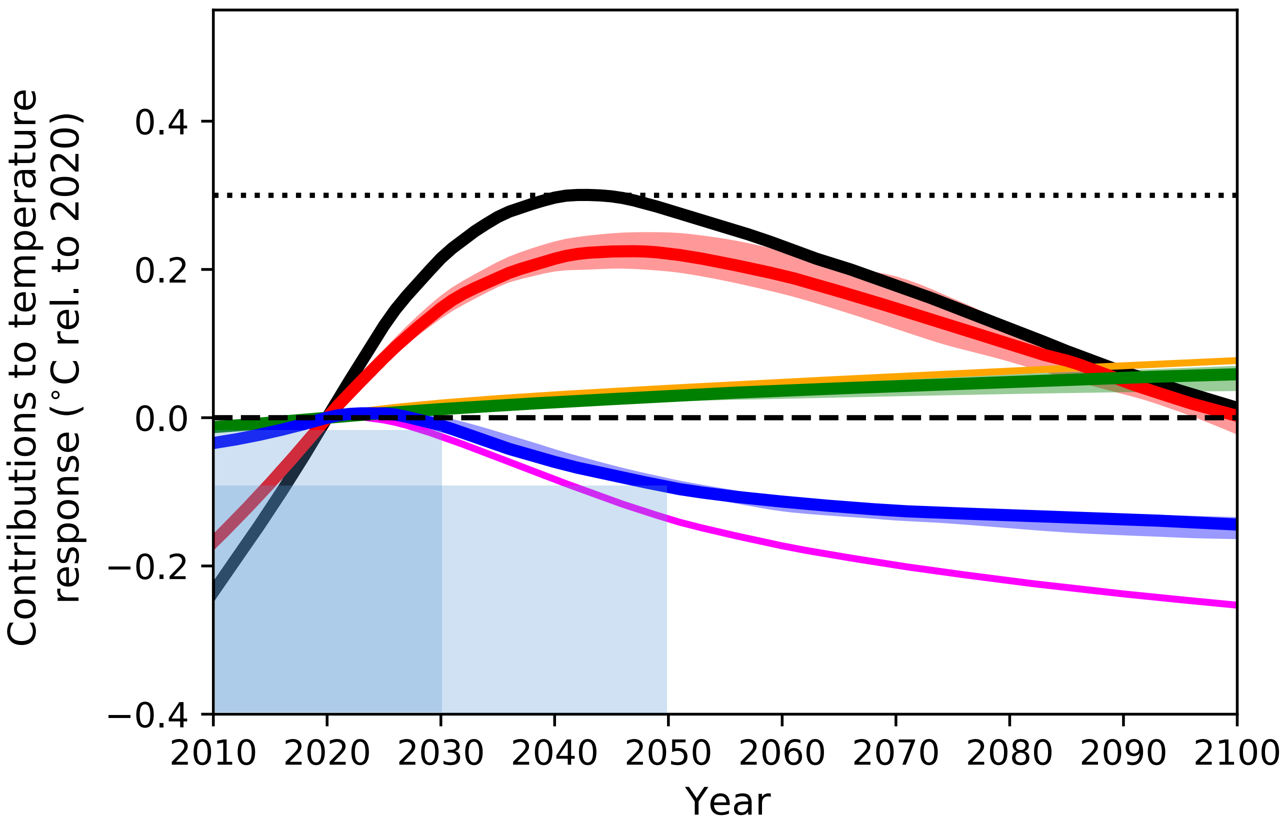


Median scenario (heavy line) cuts methane emissions by approx. 30% by 2030. There are less rapid cuts thereafter.

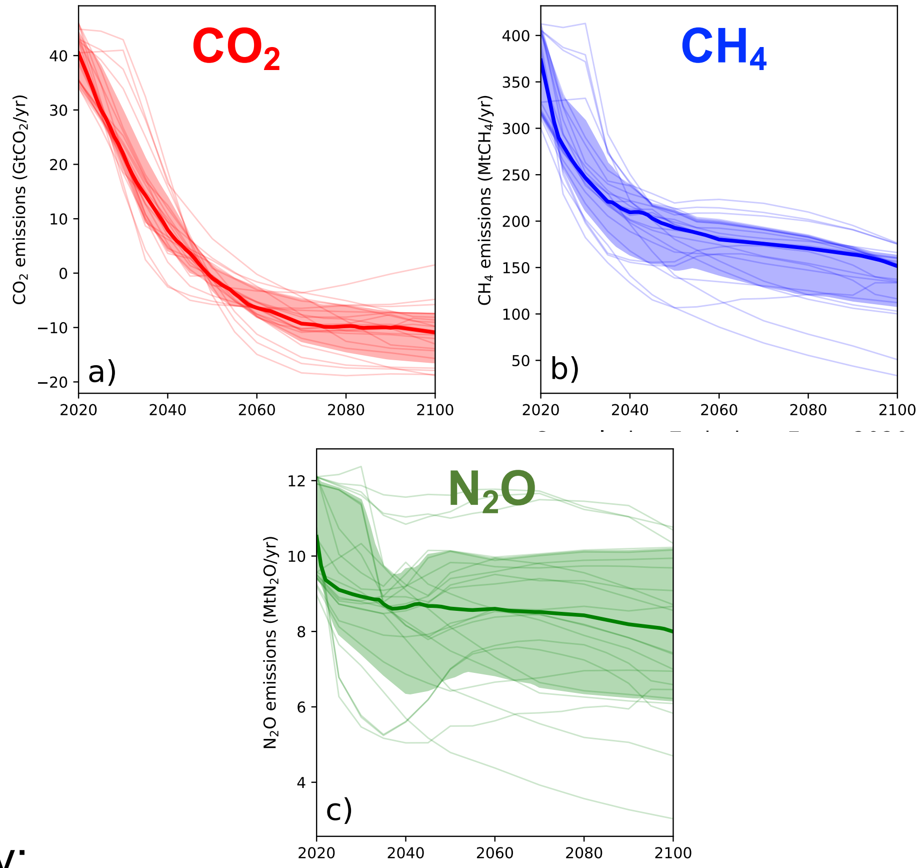
Use this as an estimate of impact of enacting Global Methane Pledge

Figure from Cain et al., Phil. Trans. Royal Soc A (2021)

Impact of the Global Methane Pledge?



Annual Emissions



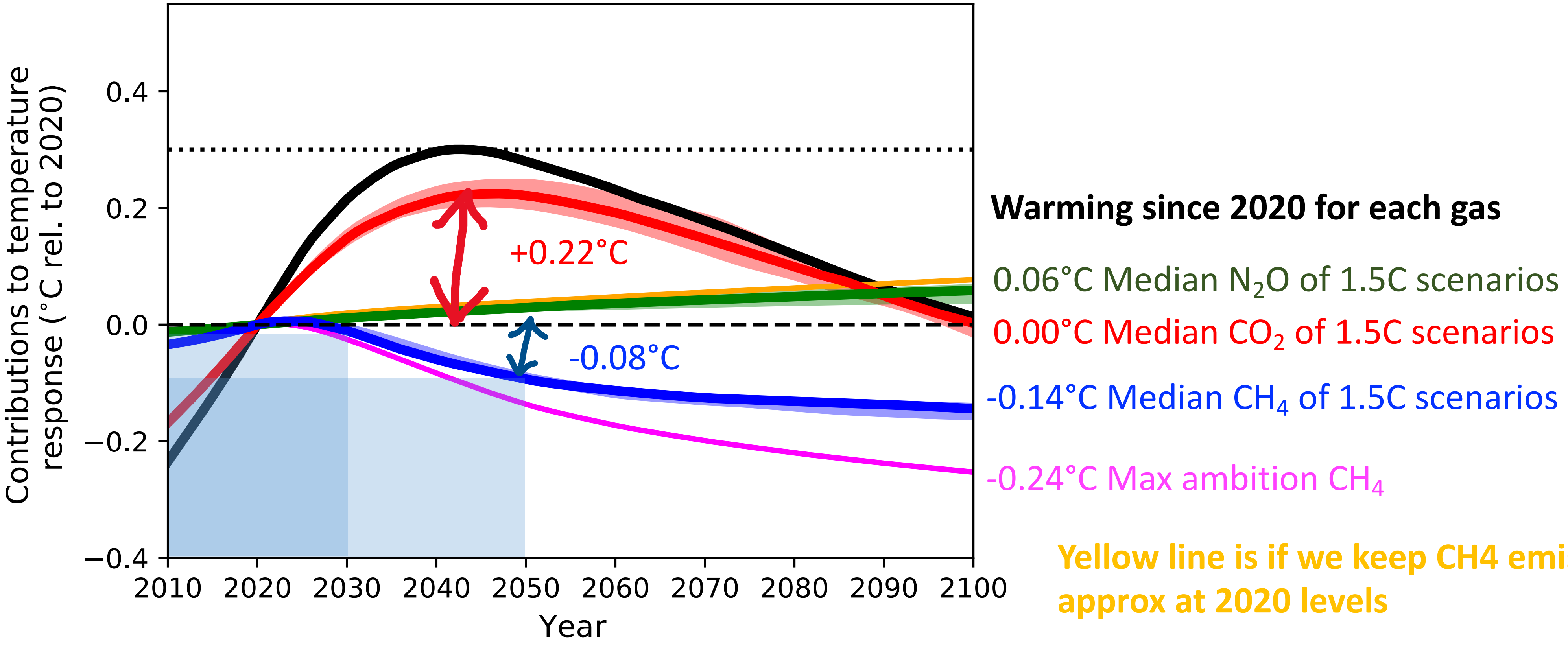
Modelled impact of CH_4 cuts is to lower temperature **relative to 2020** by:

- a barely noticeable amount in 2030
- nearly 0.1C by 2050 (assuming further cuts beyond 2030)

Compare to impact of cuts to CO_2 and N_2O

Figures from Cain et al., Phil. Trans. Royal Soc A (2021)

Impact of the Global Methane Pledge?



Yellow line is if we keep CH4 emissions approx at 2020 levels

CH_4 cuts lower the temperature relative to 2020

Greater cuts to CH_4 lower the temperature further

CO_2 and N_2O raise the temperature until they get to (net-)zero emissions

CO_2 lowers the temperature once emissions are net-negative

Figures from Cain et al., Phil. Trans. Royal Soc A (2021)

Metrics

- A greenhouse gas emission metric can be used to compare different gases by using CO_2-equivalent units

- Standard metric used is 100-year Global Warming Potential (**GWP100**)

  - Is the additional energy in the system over a 100 year period after emitting 1kg of gas (e.g. methane), relative to the same thing from 1kg of CO_2.

  - This can be a useful way to compare different gases – it depends on your question!

  - It doesn't directly compare impact on temperature for short lived gases

  - Hence other metrics developed to do so e.g. Global Temperature-change Potential, GWP*

Metrics

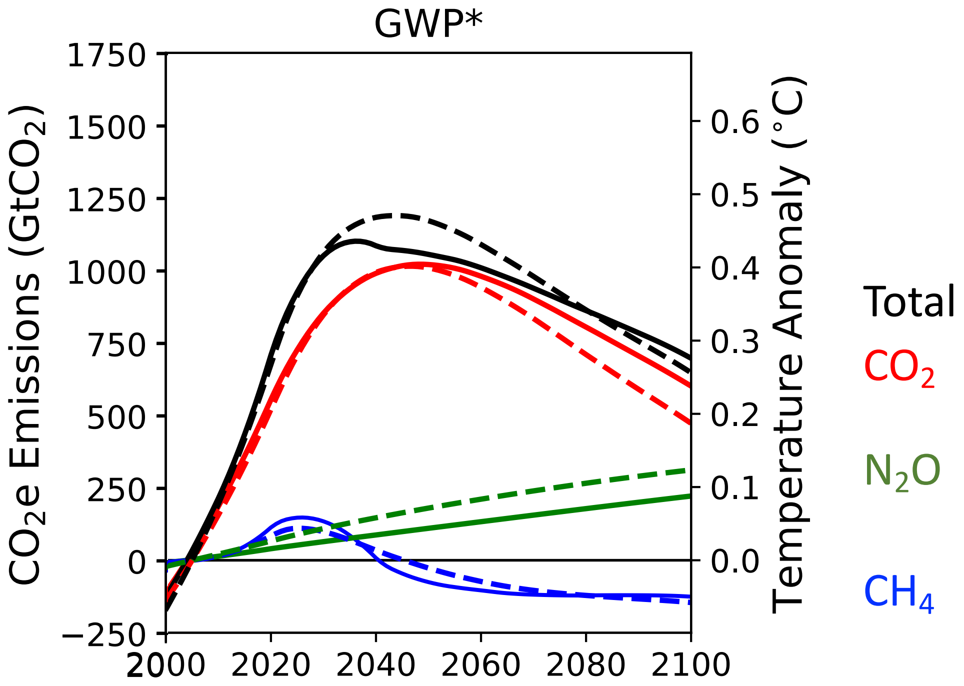
- Bottom line: if you want to measure an apple and an orange and a banana, you may use a ruler (height), tape measure (circumference), scales (weight).

- Each metric is accurate, but different. Which you use depends on what you are trying to do:
  - *Seeing which fruit fits in a particular lunch box?*
  - *Seeing which fruit takes up most surface area on the shelf?*
  - *Seeing which fruit is heaviest to carry?*
  - *Perhaps the tape measure to find circumference is a bit nonsensical for the banana, it only really works for spherical fruit?*
  - *Should we use some hybrid of all of these? Or all at once?*

CO_2-warming-equivalence: using GWP* as an approximation of temperature change

- Showing cumulative emissions of CO_2-warming-equivalent (CO_2-we) calculated using GWP* can be used as an **approximation** of temperature outcome

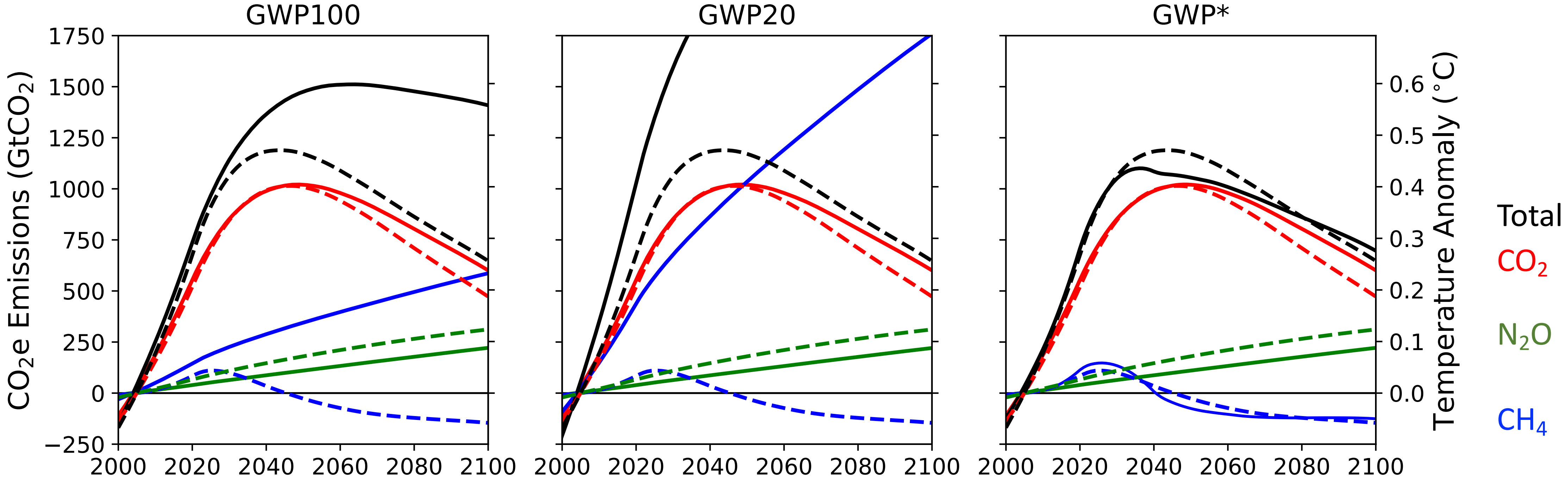
- Could evaluate which of two different mitigation options has the preferred temperature limiting effect
  - eg compare CH_4 and N_2O



Dashed: modelled temperature
Solid: Cumulative CO_2-we

Cain et al (2021)

Standard CO_2-equivalence using GWP100 or GWP20 does not give warming equivalence for mitigation scenarios



Metric-based cumulative global CO_2e emissions since 2000 (solid lines)
Temperature from each gas using a simple model, FaIR2.0, (dashed lines)

GWP100 and GWP20 indicates temperature change for long lived gases like N_2O but not short lived like CH_4

Cain et al (2021)

Metrics in the most recent IPCC report

- IPCC 6th Assessment Report (AR6) chapter 7

- Cumulative CO_2e emissions of methane using **GWP* (green)** provides best approximation of modelled temperature (black line)

- **CGTP** also shows warming-equivalence

- **GWP100 (blue)** doesn't approximate temperature, it represents radiative forcing over 100 years (apples vs bananas)

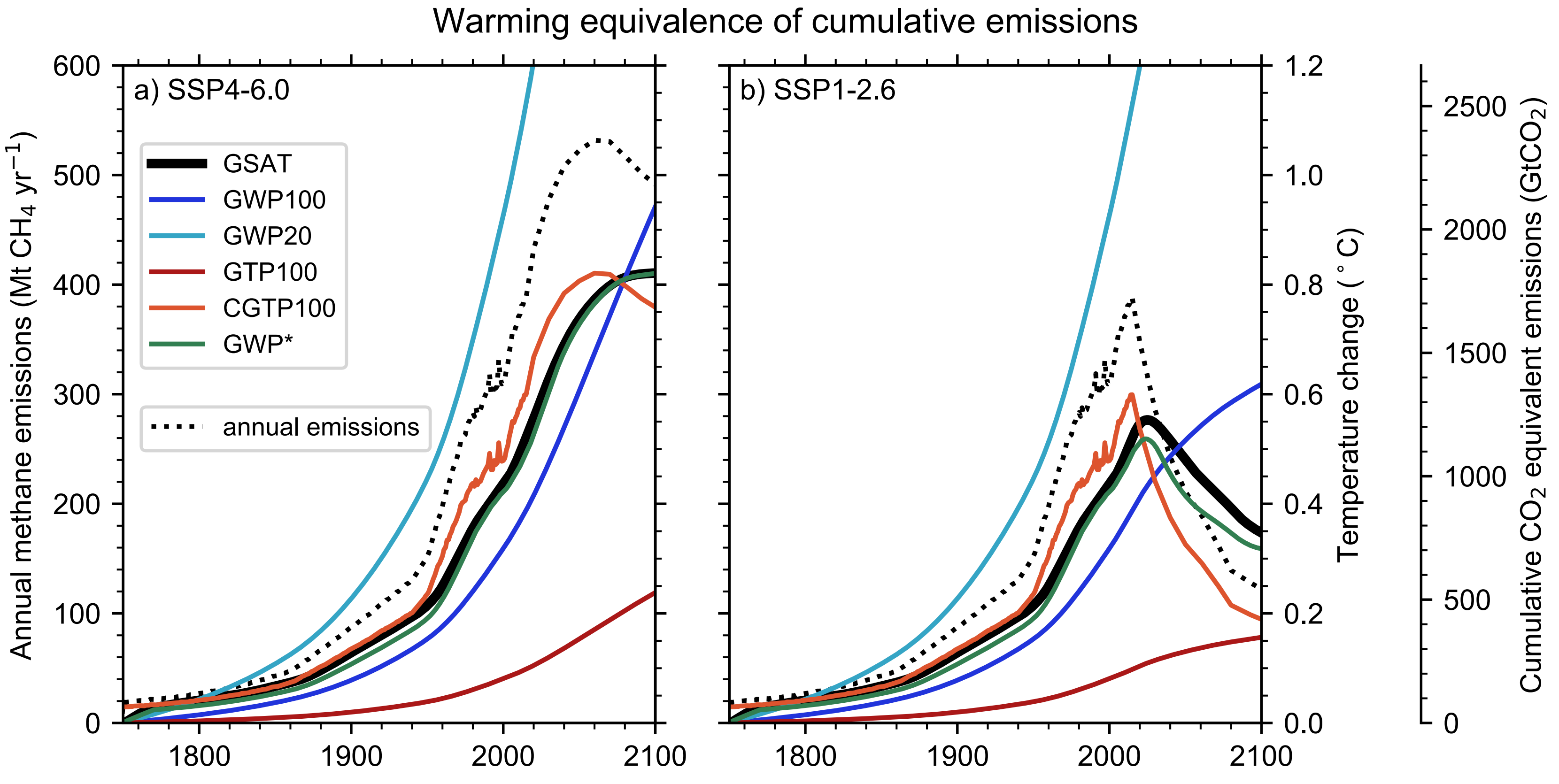


Fig 7.22 Ch7 Working Group 1 AR6 (Forster et al.)

CO_2-warming-equivalence (e.g. GWP* or CGTP)

- Asks the question: if we change our methane emissions, how does this affect the temperature?
- If you want to assess how much temperature has gone up from past (or planned future) emissions from any particular source, you can use GWP*
- Choice of metric doesn't change the fact that the lower the methane emissions, the lower the temperature
- It does allow you to compare trade-offs between different gases (e.g. methane and nitrous oxide) with their relative impact on the temperature
    - the metric you use for equivalence between short- and long-lived pollutants will affect how a trade-off is valued
- There is a strong case for specifying short- and long-lived targets separately (Allen et al., 2022)

Summary

Methane mitigation impacts

- Cutting methane globally will lower methane's contribution to global warming
  - 30% cut by 2030 on 2020 levels, and a slower decline after that, gives approx 0.1C lowering of temperature by 2050

- Methane emissions do not need to reach 'net-zero' (defined using GWP100) to stop adding to global warming in the same way long-lived gases do
  - If global methane emissions decline at 3% per decade, methane's contribution to global warming remains roughly constant
  - Currently, global methane emissions are rising and causing additional warming – pushing us closer to 1.5C
  - Cutting global methane emissions now will slow our path towards higher temperatures in the next few decades

- IPCC says 'every action counts' and methane cuts provide tangible near-term (co-)benefits

Summary

Metrics

- Each metric captures a different physical (or socio-economic) effect
- Different metrics vary in magnitude for methane as methane is short-lived, so metric choice can make a large difference
- CO_2-warming-equivalent emissions capture the impact on temperature of a change to methane emissions accurately
- If this is a quantity that you wish to evaluate (e.g. to incentivize limiting warming), then GWP* can be used (other metrics are available)
- Responsible usage is recommended, as with any metric use!

Take home messages

- To pursue and evaluate progress towards a temperature goal, we need to know how activities contribute to global temperature change
- Cumulative CO_2-warming-equivalent emissions does this for short- and long-lived emissions
- Standard CO_2-equivalence only does this for long-lived emissions
- At minimum, short- and long-lived pollutants should be reported/targeted separately so temperature implications are clear (Allen et al., 2022)
- It's important to be honest about every sector's contribution towards both climate change and its mitigation so we can work together towards limiting global warming

References

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- Allen, M. R., Peters, G. P., Shine, K. P., Azar, C., Balcombe, P., Boucher, O., Cain, M., Ciais, P., Collins, W., Forster, P. M., Frame, D. J., Friedlingstein, P., Fyson, C., Gasser, T., Hare, B., Jenkins, S., Hamburg, S. P., Johansson, D. J. A., Lynch, J., … Tanaka, K. (2022). Indicate separate contributions of long-lived and short-lived greenhouse gases in emission targets. *Npj Climate and Atmospheric Science*, *5*(1), 5. https://doi.org/10.1038/s41612-021-00226-2
- *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. (2021). https://www.ipcc.ch/report/ar6/wg1/
- Allen, M et al., Climate metrics for ruminant livestock, https://www.oxfordmartin.ox.ac.uk/publications/climate-metrics-for-ruminant-livestock/