The impact of mitigating agricultural methane emissions on climate change

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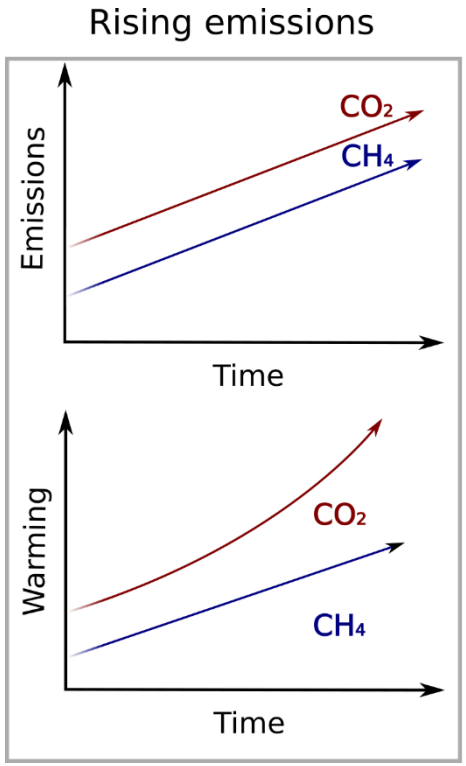
Structure of the Presentation

1. How do methane (CH_4) emissions contribute to global warming?
2. Linking Greenhouse Gas (GHG) emission metrics and global temperature
3. Assessing how methane mitigation can affect global warming

1. How do methane emissions contribute to global warming?

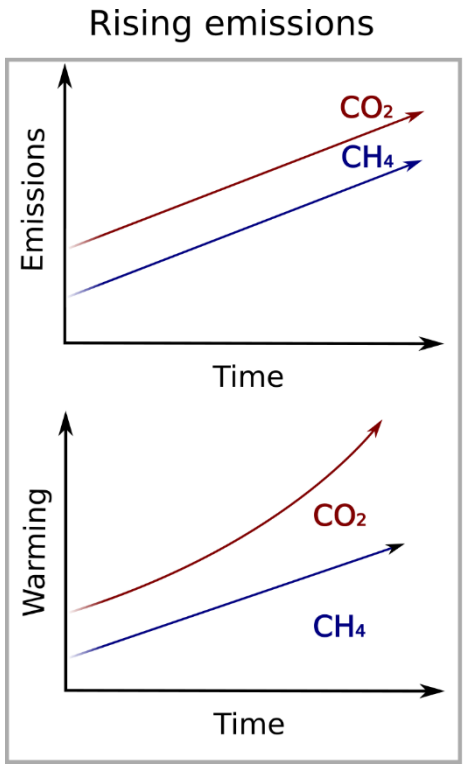


Emissions scenarios

Approximate impact on global mean surface temperature if you put these emissions in a climate model

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

1. How do methane emissions contribute to global warming?

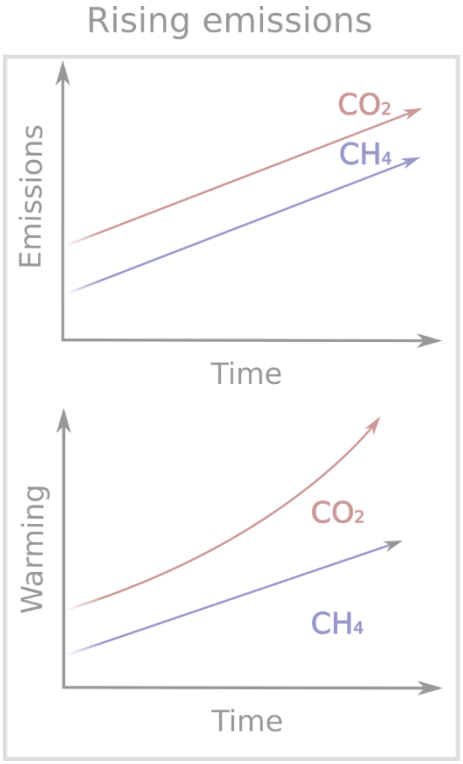


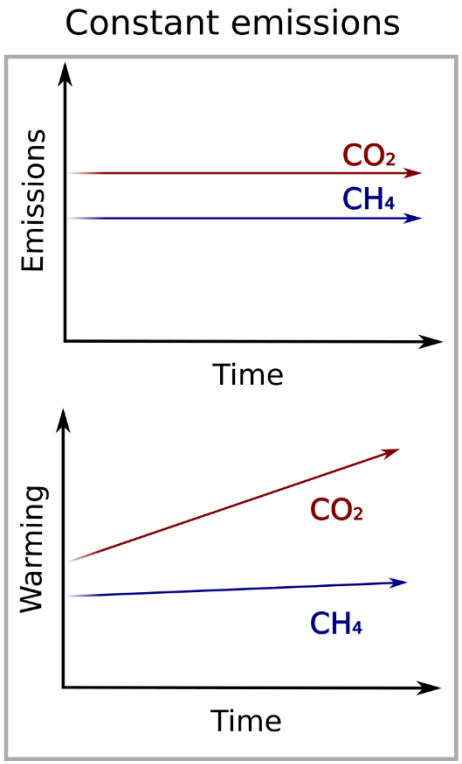
Similar to the global agricultural CH_4 trend

CH_4 emissions rise → temperature rises

CO_2 emissions rise → temperature rises

1. How do methane emissions contribute to global warming?



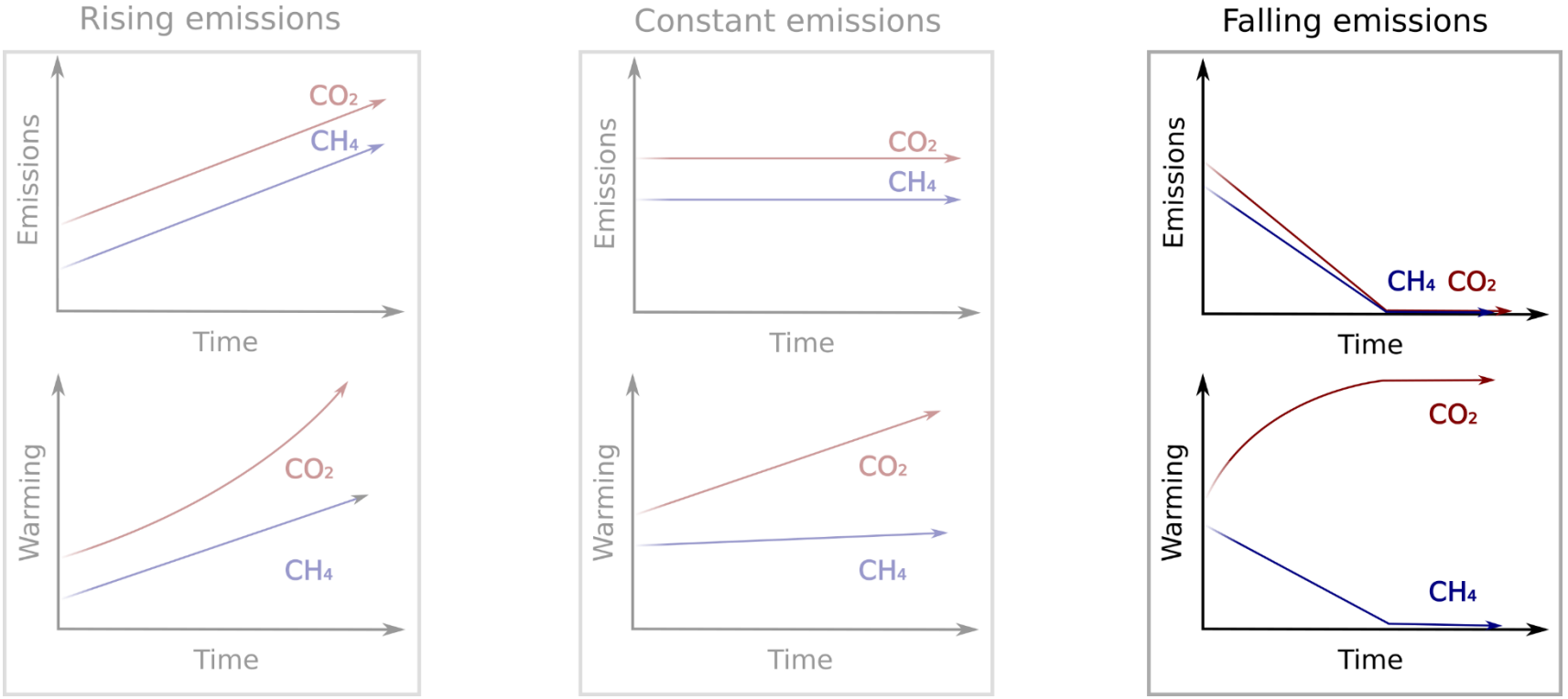


Similar to the USA's agricultural CH_4 trend

CH_4 emissions stable → temperature rises slowly until reaches equilibrium

CO_2 emissions stable → temperature rises

1. How do methane emissions contribute to global warming?



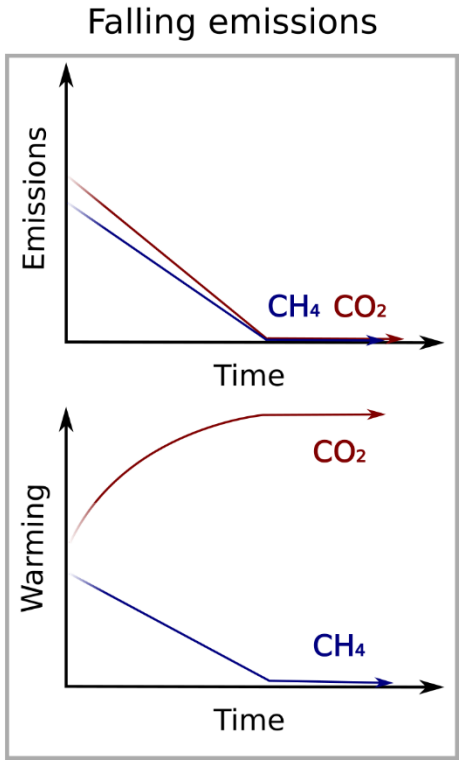
Declining CH_4 is similar to the EU agricultural CH_4 trend (although it is not getting near to zero emissions)

CH_4 emissions falling → temperature declines

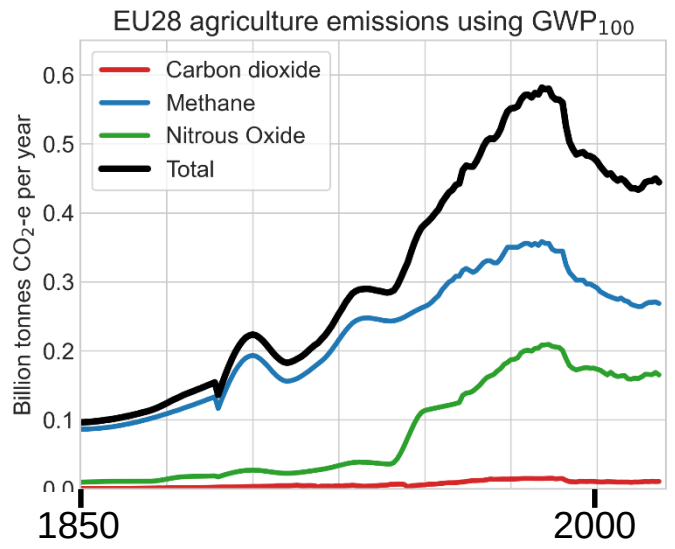
CO_2 emissions falling → temperature rises (until emissions are zero)

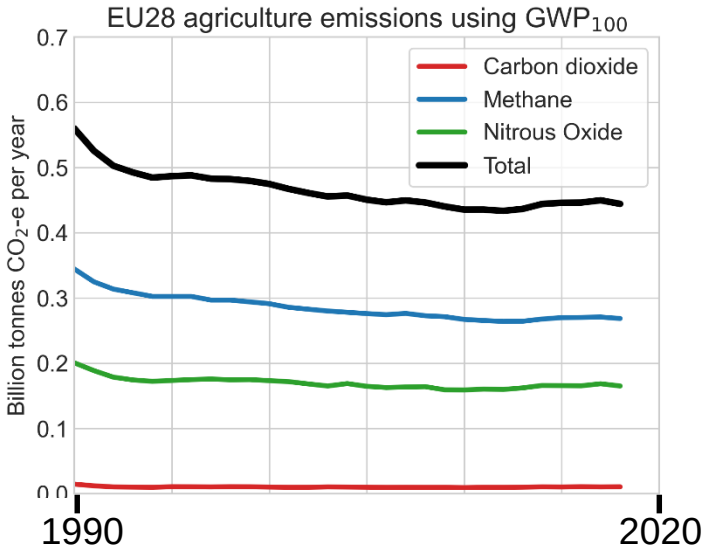
2. Linking GHG emission metrics and global temperature

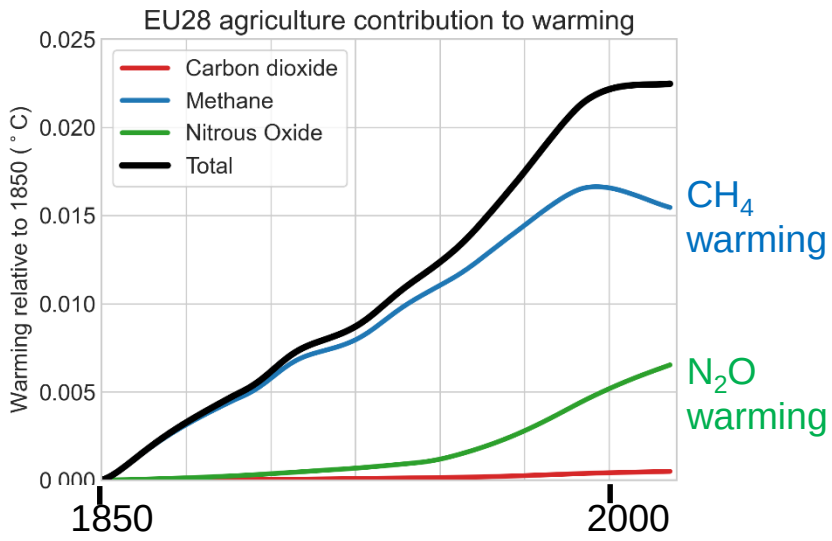
- Cutting methane emissions means temperature decreases – as past emissions are not 'replaced'
- CO_2-e defined using GWP100 doesn't capture this reduction in temperature
- To capture it, we use warming-equivalent methods[1], allowing to compare warming from different gases

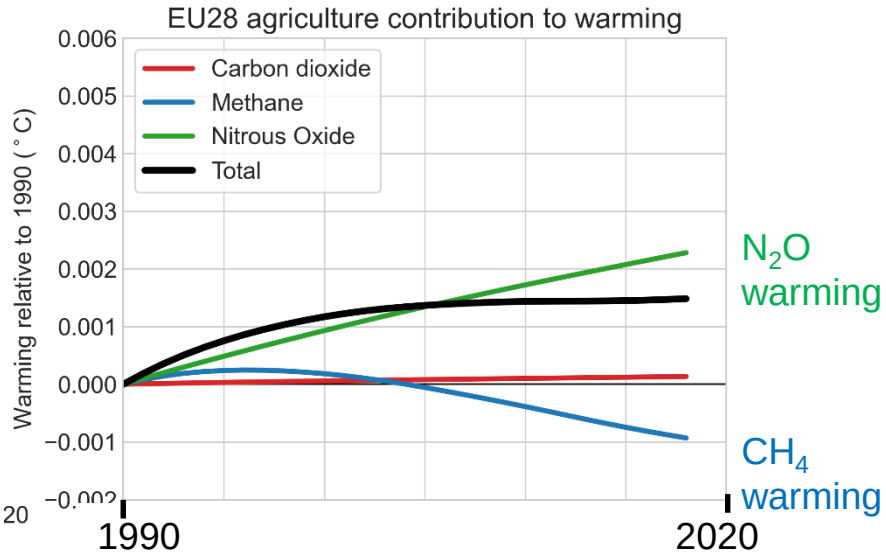


[1]e.g. step-pulse metrics like GWP* in IPCC AR6 WGI Ch7, or climate models.
GWP = Global Warming Potential
GWP* = a modified usage of GWP CO_2-e = CO_2-equivalent









Graphs courtesy of Myles Allen, U. of Oxford

2. Linking GHG emission metrics and global temperature

- **Key points from FAO (2023) report on methane:**
- Each metric captures a specific climate impact at a specific time, or over a specific period
- The equivalence based on one metric does not imply equivalence based on other metrics
- Choice of metric depends on the policy question being investigated

FAO. 2023. *Methane emissions in livestock and rice systems – Sources, quantification, mitigation and metrics*. Rome. https://doi.org/10.4060/cc7607en

2. Linking GHG emission metrics and global temperature

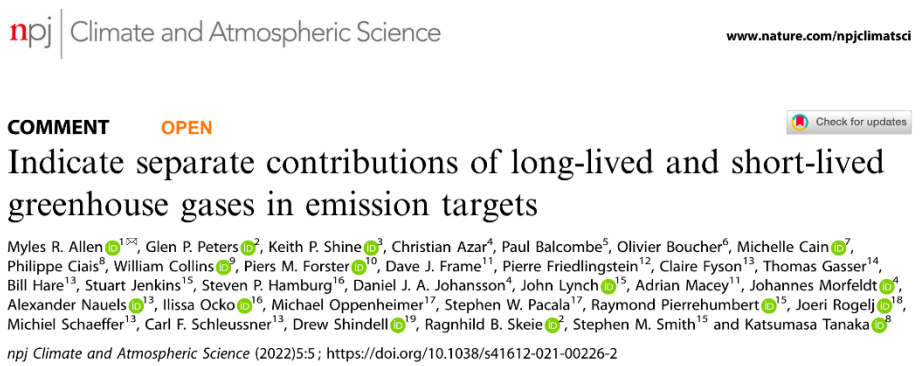
- **You cannot accurately assess temperature impacts of GWP100-aggregated emissions:**
- Sustained net-zero CO_2-e emissions using GWP100 can cause a cooling trend *or* a warming trend[1]
- Sustained net-zero CO_2-e emissions using a warming-equivalent method (e.g. GWP*) gives temperature stabilization[2]
- Awareness of this is needed for metrics to be used appropriately and intentionally towards a policy objective

[1]e.g. Fuglestvedt et al. (2018), Tanaka and O'Neill (2018), Allen et al. (2021)
[2]e.g. IPCC AR6 WGI Technical Summary TS.3.3.3 p101 (includes a summary of emissions metrics)

2. Linking GHG emission metrics and global temperature

- **How to do this for methane:**
- Use a warming-equivalent method e.g. GWP*, climate model
- At minimum, need to report short-lived (e.g. methane) and long-lived (e.g. CO_2, N_2O) gases separately[1]

[1]Allen et al. (2022). Indicate separate contributions of long-lived and short-loved greenhouse gases in emissions targets. Paper includes 33 authors.



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Check for updates

Indicate separate contributions of long-lived and short-lived greenhouse gases in emission targets

Myles R. Allen[1✉], Glen P. Peters[2], Keith P. Shine[3], Christian Azar[4], Paul Balcombe[5], Olivier Boucher[6], Michelle Cain[7], Philippe Ciais[8], William Collins[9], Piers M. Forster[10], Dave J. Frame[11], Pierre Friedlingstein[12], Claire Fyson[13], Thomas Gasser[14], Bill Hare[13], Stuart Jenkins[15], Steven P. Hamburg[16], Daniel J. A. Johansson[4], John Lynch[15], Adrian Macey[11], Johannes Morfeldt[4], Alexander Nauels[13], Ilissa Ocko[16], Michael Oppenheimer[17], Stephen W. Pacala[17], Raymond Pierrehumbert[15], Joeri Rogelj[18], Michiel Schaeffer[13], Carl F. Schleussner[13], Drew Shindell[19], Ragnhild B. Skeie[2], Stephen M. Smith[15] and Katsumasa Tanaka[8]

npj Climate and Atmospheric Science (2022)5:5 ; https://doi.org/10.1038/s41612-021-00226-2

3. Assessing how methane mitigation can affect temperature

- Cutting methane globally will lower methane's contribution to global warming
  - 30% cut between 2020 and 2030, and a slower decline after that, gives approx 0.1C lowering of temperature by 2050[1]
  - If global methane emissions decline slower at 3% per decade, methane's contribution to global warming remains roughly constant[2]
- Currently, global methane emissions are rising and causing additional warming – pushing us closer to 1.5C

[1]Compared to 2020 temperature. See Figure 1 median scenario in Cain et al., (2021)
[2]e.g. Cain et al., (2019), IPCC AR6 WGI Ch7 p1015

Take home points

- Emissions of CO_2, CH_4 and N_2O aggregated using GWP100 do not show global warming impacts
- To know global warming impacts, you must:
  - separate CH_4 from CO_2 and N_2O, or
  - use a warming-equivalent metric
- The EU could report its CO_2-e emissions (using GWP100) AND their impact on global warming (e.g. using GWP*)

[1]Allen et al., 2022
Full reference list included in summary document.

Take home points

- To pursue and evaluate progress towards a temperature goal, we need to know how activities contribute to global warming
- Short- and long-lived pollutants should be reported/targeted separately so temperature implications are clear and intended[1]
  - e.g. New Zealand has a separate biogenic methane target
- Transparency about every sector's contribution towards both climate change and its mitigation will help us work together towards limiting global warming effectively.

[1]Allen et al., 2022
Full reference list included in summary document.

Supporting information for the presentation

1. How do methane emissions contribute to global warming?

Myles Allen, John Lynch, Michelle Cain and David Frame. **Climate metrics for ruminant livestock.**

Oxford Martin Programme on Climate Pollutants briefing paper (updated 2022)

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

2. Linking GHG emission metrics and global temperature

Allen, M., Tanaka, K., Macey, A., Cain, M., Jenkins, S., Lynch, J., Smith, M., 2021. **Ensuring that offsets and other internationally transferred mitigation outcomes contribute effectively to limiting global warming.** Environmental Research Letters 16, 074009. https://doi.org/10.1088/1748-9326/abfcf9

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., Macey, A., Morfeldt, J., Nauels, A., Ocko, I., Oppenheimer,M., Pacala, S.W., Pierrehumbert, R., Rogelj, J., Schaeffer, M., Schleussner, C.F., Shindell, D., Skeie, R.B.,Smith, S.M., Tanaka, K., 2022. **Indicate separate contributions of long-lived and short-lived**

greenhouse gases in emission targets. npj Climate and Atmospheric Science 5, 18–21.https://doi.org/10.1038/s41612-021-00226-2

Arias, P.A., et al., 2021: **Technical Summary. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change** [Masson-Delmotte, V., P. et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 33−144. doi:10.1017/9781009157896.002.

Forster, P., T. et al., 2021: **The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change** [Masson-Delmotte, V., et al., (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York,NY, USA, pp. 923–1054, doi:10.1017/9781009157896.009

FAO. 2023**. Methane emissions in livestock and rice systems – Sources, quantification,mitigation and metrics.** Rome. https://doi.org/10.4060/cc7607en

Fuglestvedt, J., Rogelj, J., Millar, R.J., Allen, M., Boucher, O., Cain, M., Forster, P.M., Kriegler,E., Shindell, D., 2018. **Implications of possible interpretations of 'greenhouse gas balance' in the Paris Agreement.** Philosophical Transactions of the Royal Society A: Mathematical, Physical andEngineering Sciences 376, 20160445. https://doi.org/10.1098/rsta.2016.0445

Tanaka, K., O'Neill, B.C., 2018. **The Paris Agreement zero-emissions goal is not always consistent with the 1.5 °C and 2 °C temperature targets.** Nature Clim Change 8, 319–324.

https://doi.org/10.1038/s41558-018-0097-x

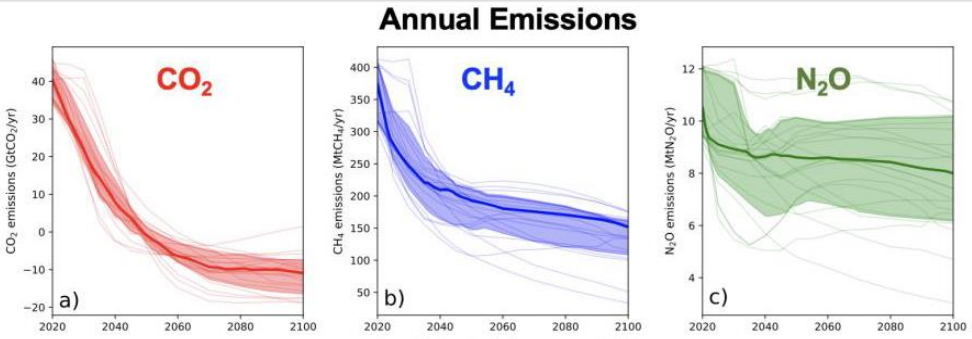
3. Assessing how methane mitigation can affect temperature

Cain, M., Lynch, J., Allen, M.R., Fuglestvedt, J.S., Frame, D.J., Macey, A.H., 2019. **Improved calculation of warming-equivalent emissions for short-lived climate pollutants.** npj Climate and Atmospheric Science 2, 29. https://doi.org/10.1038/s41612-019-0086-4

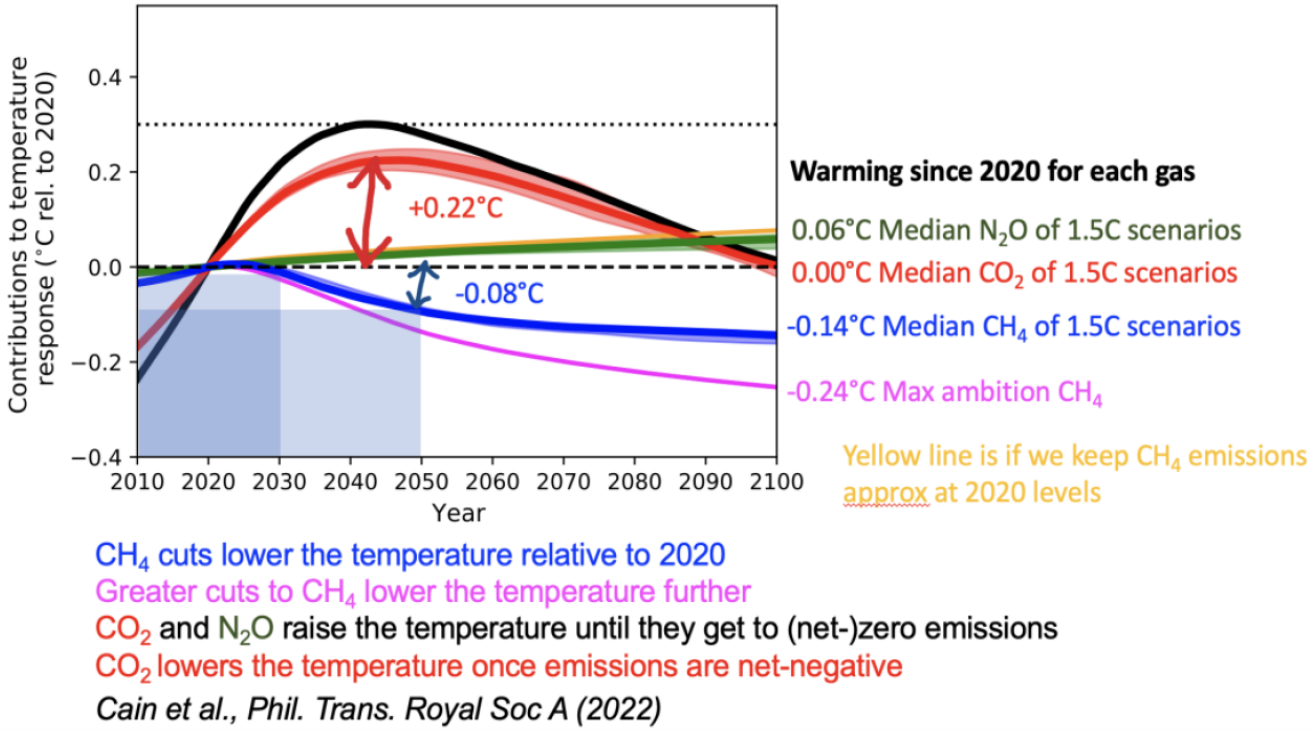
Cain, M., Jenkins, S., Allen, M.R., Lynch, J., Frame, D.J., Macey, A.H., Peters, G.P., 2022. **Methane and the Paris Agreement temperature goals.** Philosophical Transactions of the RoyalSociety A: Mathematical, Physical and Engineering Sciences 380. https://doi.org/10.1098/rsta.2020.0456

Cutting methane emissions globally will lower methane's contribution to global warming. However, methane cuts must be in addition to CO2 cuts, given that without getting CO2 emissions to net-zero, we cannot achieve the Paris Agreement.

Several studies have investigated the impact of the Global Methane Pledge. In Cain et al., (2022) greenhouse gases from future scenarios that limit warming to 1.5C were modelled in a simple climate model. Their results show that methane cuts of around 30% between 2020 and 2030, followed by more gradual cuts after that, lead to levels of warming from methane going down by around 0.1C by 2050 relative to 2020 (Figure on next slide). If methane emissions decline at approximately 3% per decade, the warming from methane would be roughly stable. However, currently atmospheric methane is rising, thus pushing temperatures upwards.



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



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
Cain et al., Phil. Trans. Royal Soc A (2022)

Figure 1: Graphs based on Cain et al., (2022) as evidence for statements made in slide 12 of the presentation.