Agriculture's impact on climate: the science, not the headlines

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https://www.oxfordmartin.ox.ac.uk/pollutants

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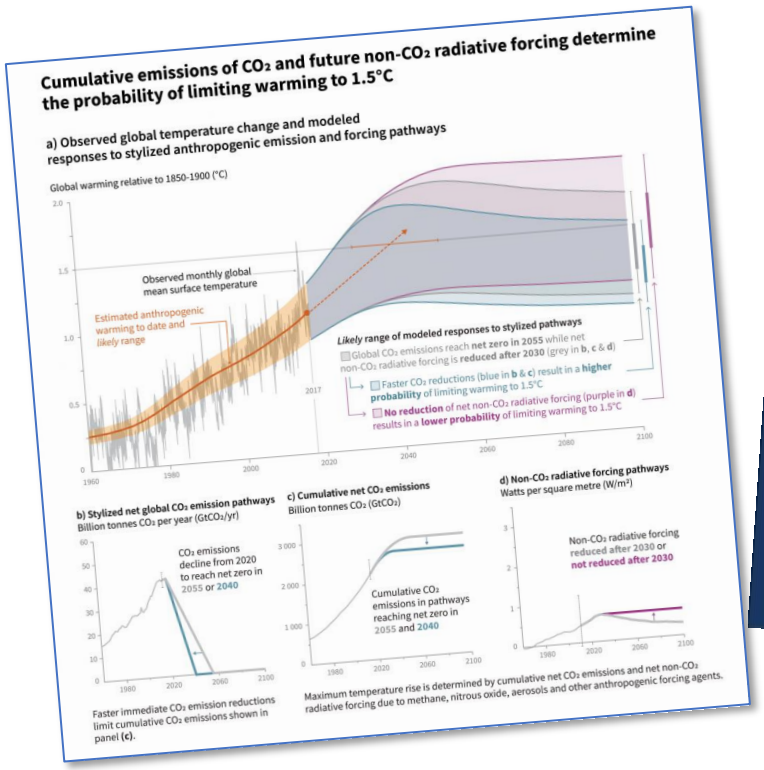
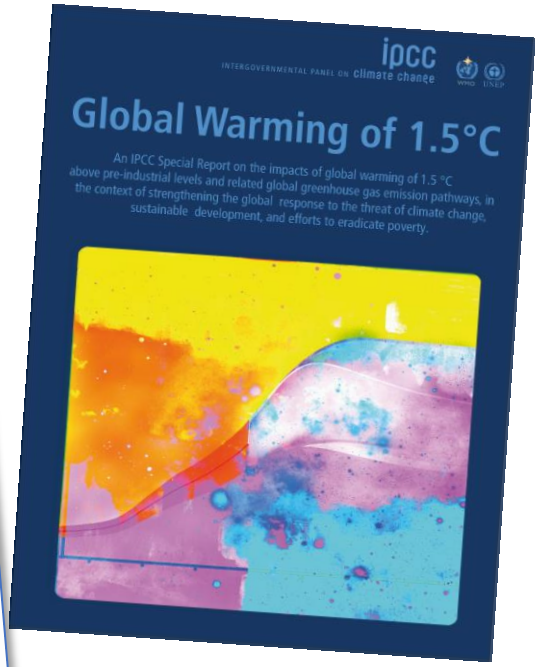
Achieving Net Zero – The role of land

What it takes to stop global warming

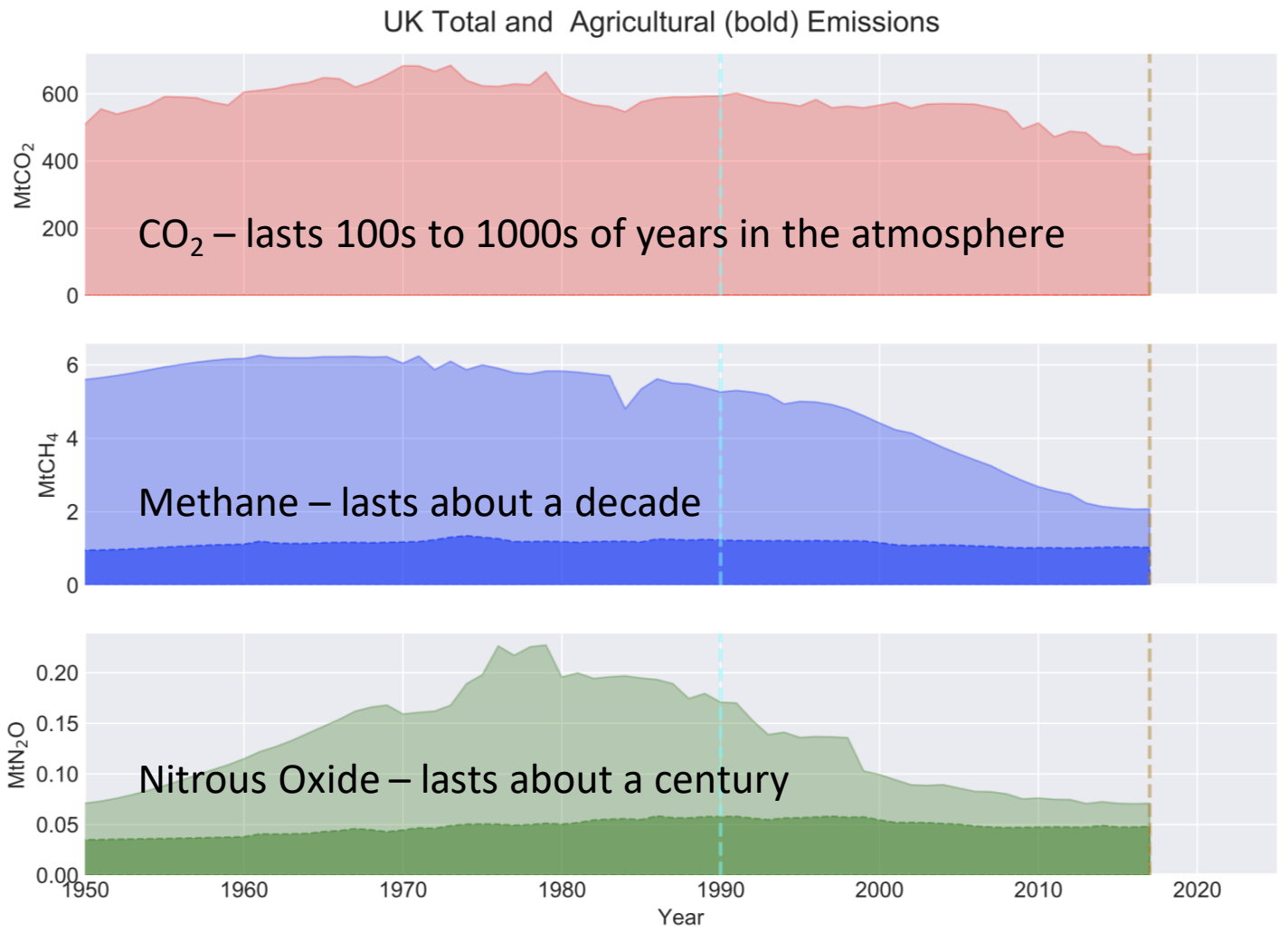
- Net Zero emissions of carbon dioxide
- Net Zero ***additional warming*** due to other emissions
  - this is not the same as Net Zero emissions of all greenhouse gases





Conclusions of the 2018 IPCC Special Report on 1.5°C

Methane and nitrous oxide dominate agricultural emissions

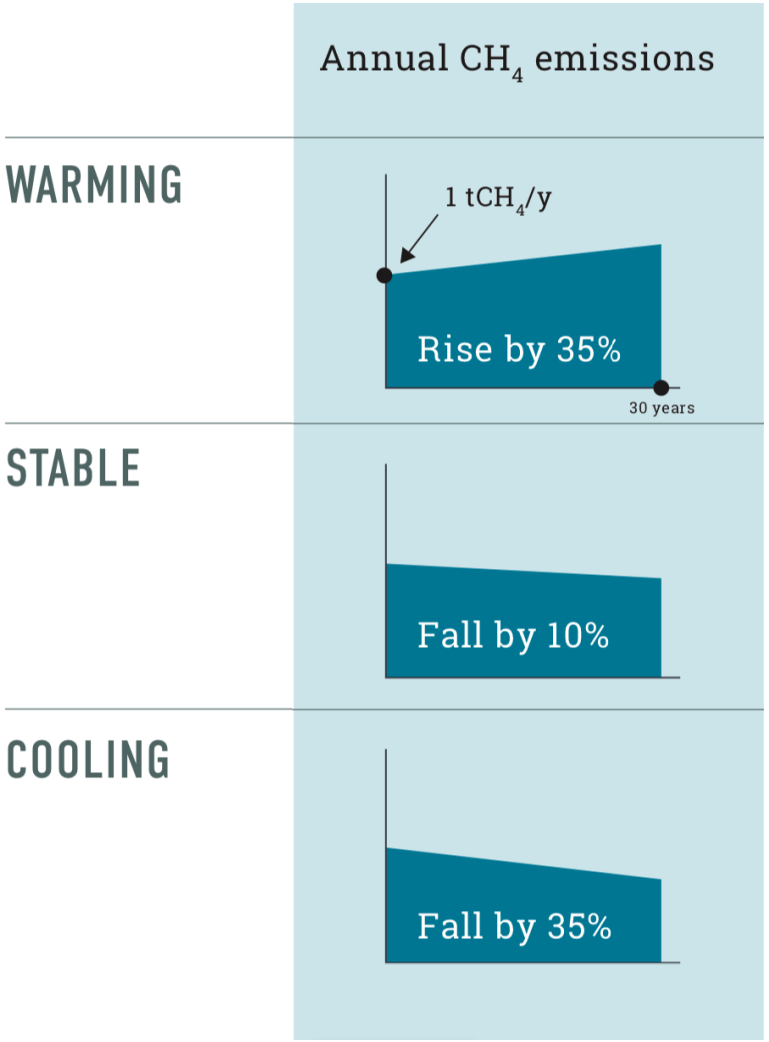


Total UK annual emissions (light)

Agricultural annual emissions (dark)

Figure: Edward Hornsby

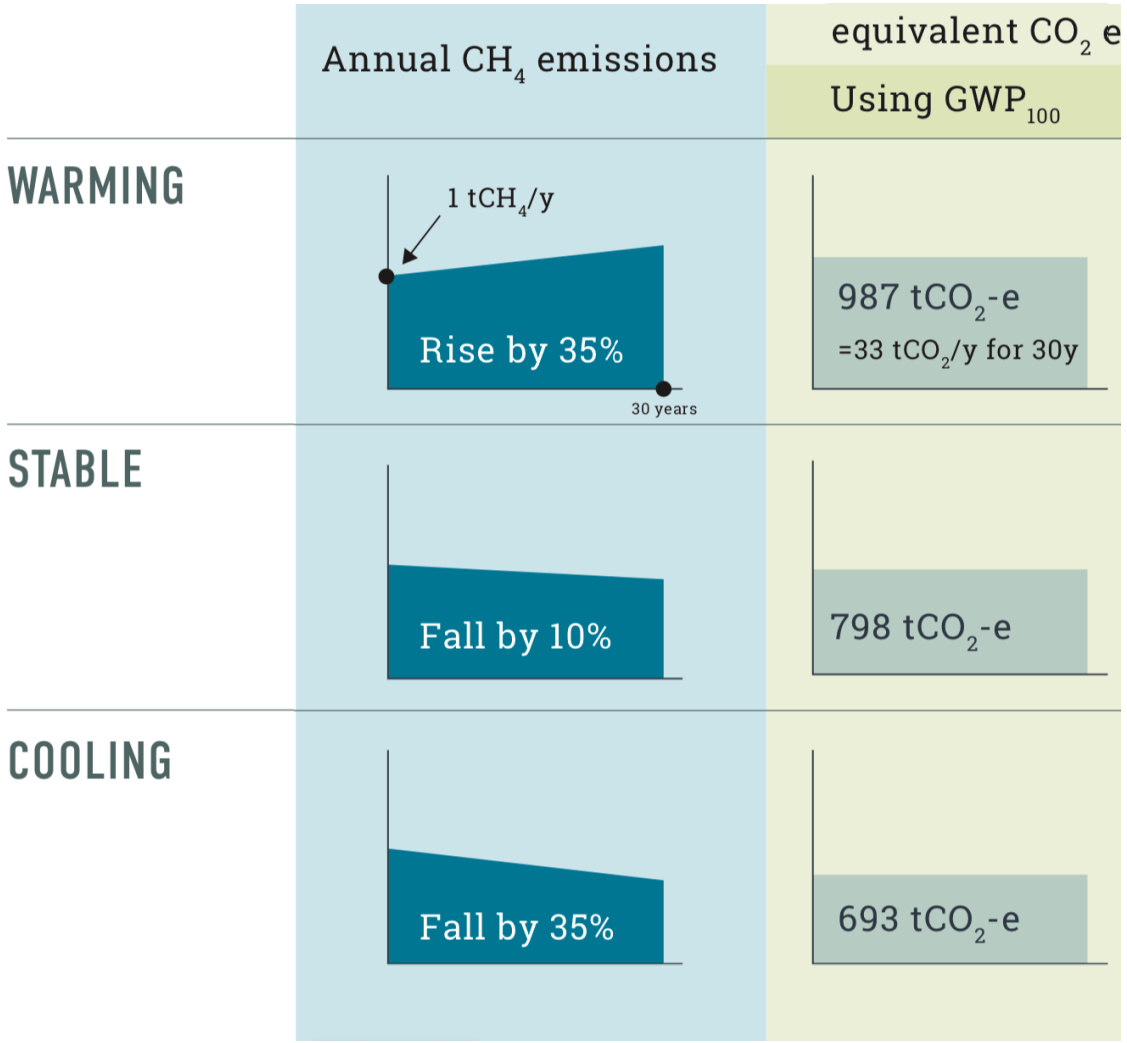
How does methane affect temperature?



- Rising methane emissions cause warming: lots of warming.
- Gently falling methane emissions cause no further warming.
- Rapidly falling methane emissions cause cooling.

https://www.oxfordmartin.ox.ac.uk/publications/net-zero-for-agriculture/

A problem with current accounting metrics

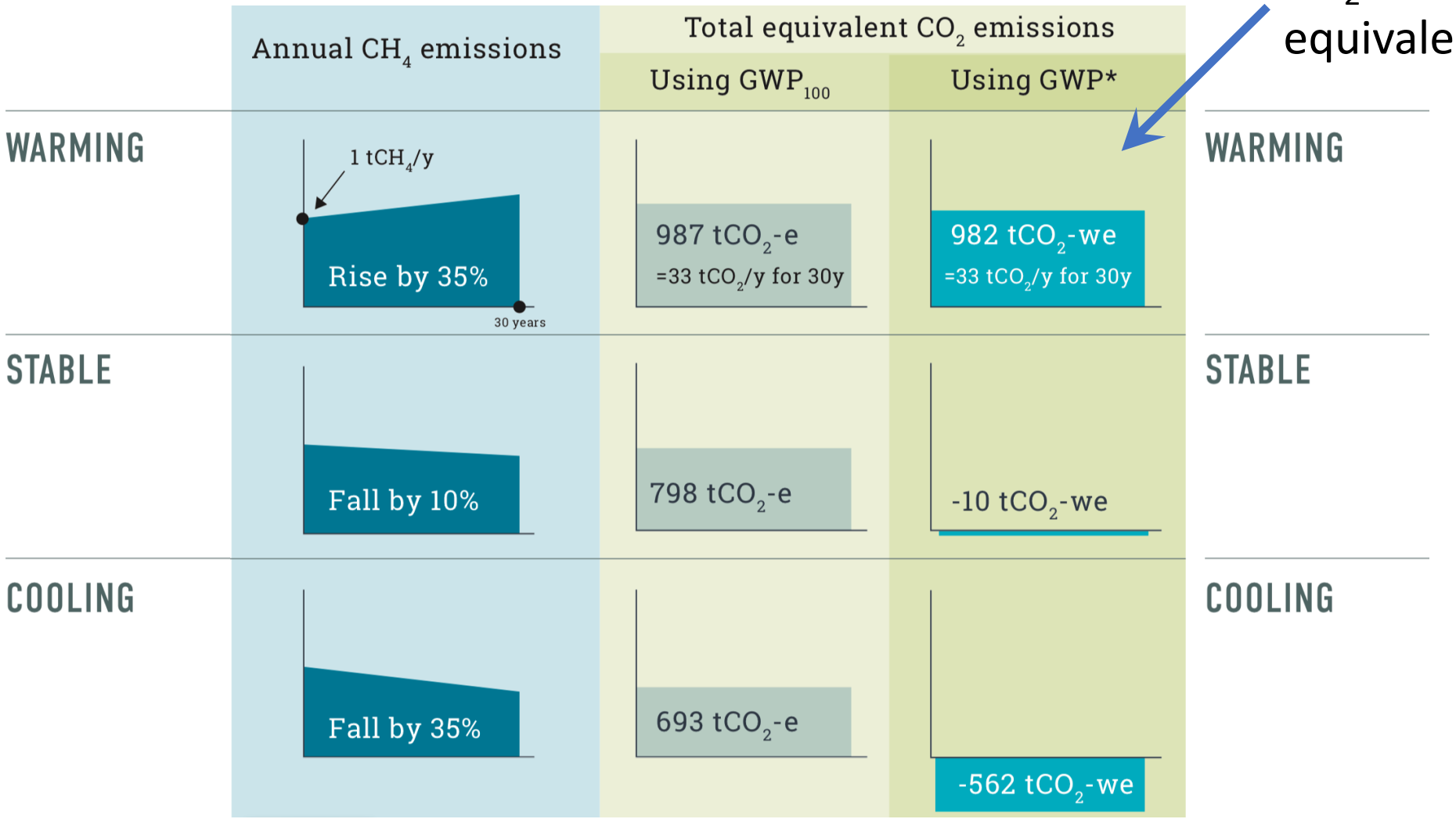


- Standard calculation of "CO_2-equivalent" emissions: multiply methane by 28.
- All three profiles are equated with ongoing CO_2 emissions, all of which cause warming.

https://www.oxfordmartin.ox.ac.uk/publications/net-zero-for-agriculture/

Can we do better?

CO_2-warming-equivalence



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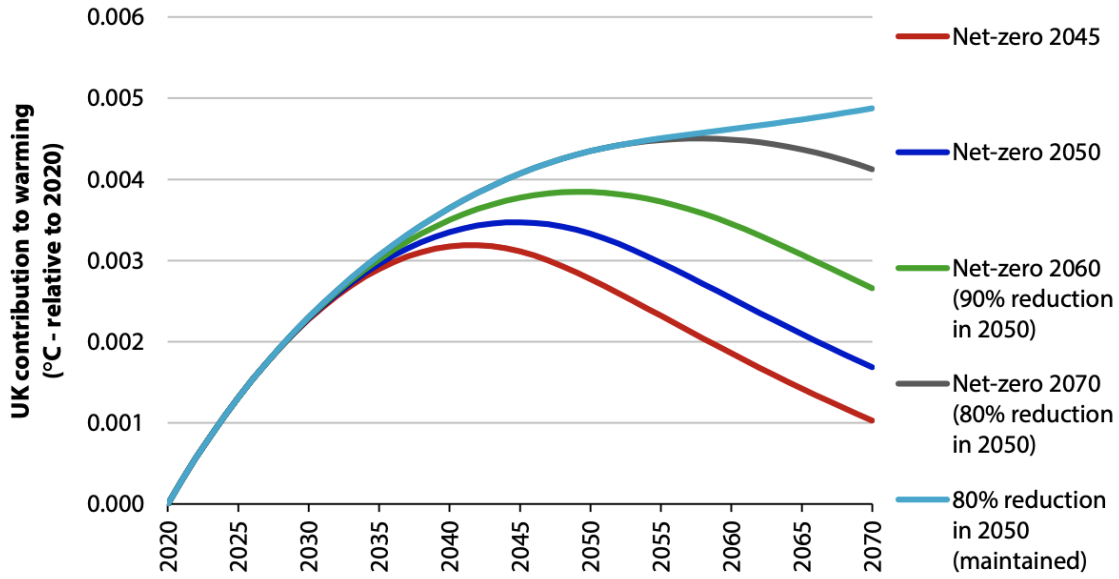
The CCC recommendation for Net Zero

- Target of net zero emissions for all GHGs by 2050
- Defined using existing guidelines for CO_2-equivalence (GWP_{100})
- Report notes that this would lead to the UK contributing towards **cooling** because ongoing methane emissions are 'offset' by removals defined with CO_2-e

Figure 2.3. UK impact on global temperature under hypothetical future emissions pathways



Source: The CCC Net Zero Report https://www.theccc.org.uk

What does this mean for UK agriculture?

- **Traditional "CO_2-equivalent" emissions:**
  - Undervalue new or increasing methane sources (good for Irish farmers and fracking operators)
  - Overvalue long-established or declining methane sources (bad for most UK livestock farmers)
- **"CO_2-warming-equivalent" emissions:**
  - Can be used to estimate warming accurately
  - Helpful for estimating temperature outcome from applying a policy

- **Thought experiment:**
  What if the UK reduces its agricultural methane emissions to zero by 2050?

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- It would have the same impact on global temperatures as:
  - the removal of about 2 billion tonnes of CO2,
  - which is about 5 years of current UK CO2 emissions from all sources,
  - which is £50 billion at an ETS price of £25/tCO2.

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- Reducing emissions from livestock is needed; there is a genuine debate about:
  - how much by
  - how to do it (reduced herd, efficiencies, farm management, technologies…)
  - what replaces the livestock (environmental impact of the replacements, offshoring of emissions)
  - consequences for land use, biodiversity, water, food supply…

Extra slides

In summary

- CO_2 emissions must get to at least net zero to stop global warming
- The more other gases can be reduced, the lower the peak temperature will be
- Short-lived gases like methane should be reduced, but do not need to reach zero emissions
- Reducing emissions from livestock is needed; there is a genuine debate about:
  - how much by
  - how to do it (reduced herd, efficiencies, farm management, technologies…)
  - what replaces the livestock (offshoring of emissions, environmental impact of the replacements)
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In summary

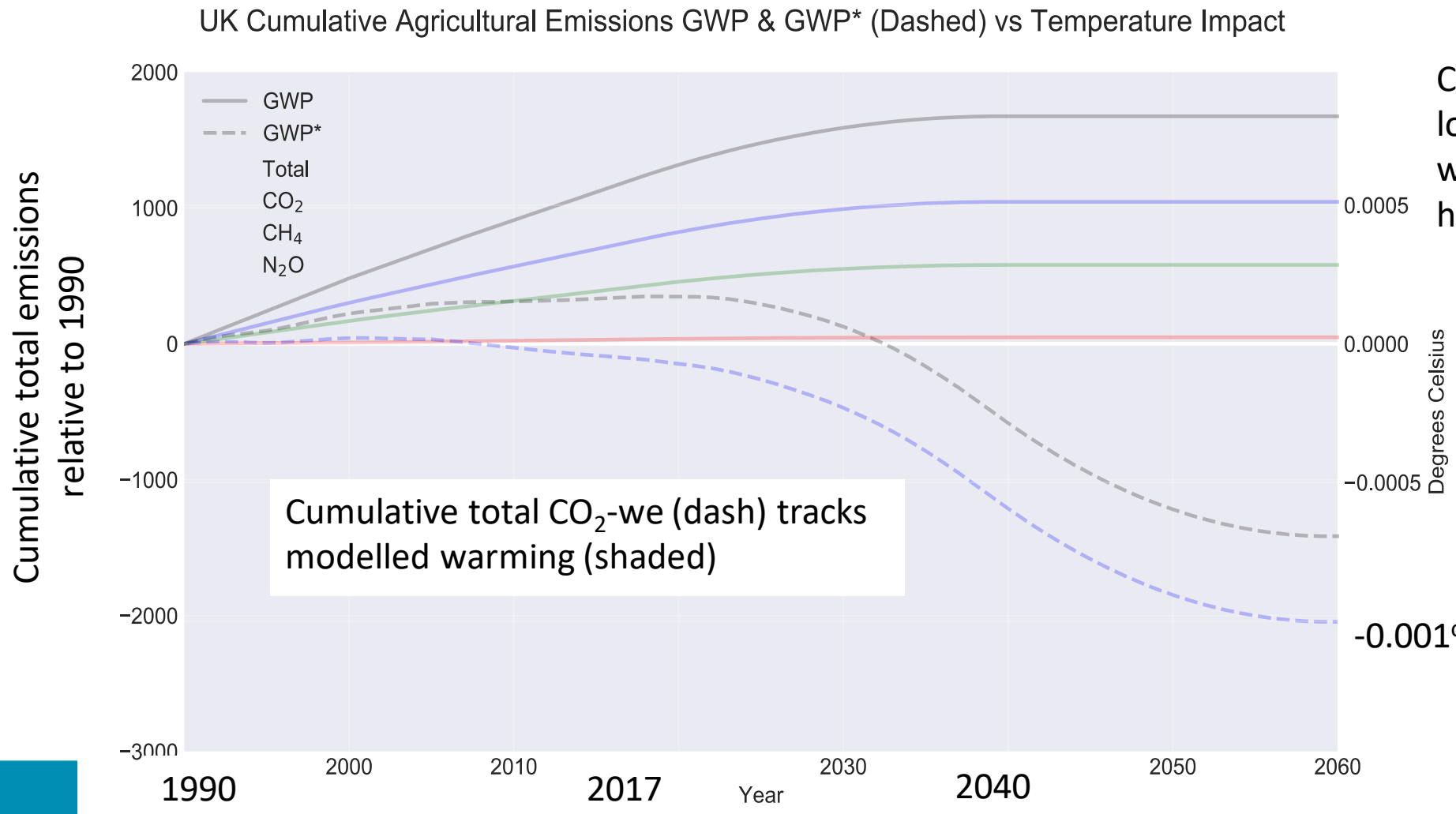
- If limiting global warming is the goal, mitigation options should be evaluated in terms of **reductions in temperature**
  - this would make the evaluation measure consistent with the Paris Agreement temperature target
  - conventional CO_2-equivalent (CO2-e) emissions do not align with temperature
  - CO_2-warming-equivalent (CO2-we) emissions do

Can we do better?

- GWP_{100} : **28 times** your methane emissions **this year** gives your "CO_2-equivalent" emissions.

- GWP* : **112 times** your methane emissions **this year minus 105 times** your methane emissions **20 years ago** gives your "CO_2-warming-equivalent" emissions.

Thought experiment:
What if UK agriculture goes to zero emissions by 2040?



Cumulative total CO_2-e (solid) looks nothing like modelled warming (shaded) because of the high fraction of methane

UNPUBLISHED FIGURE

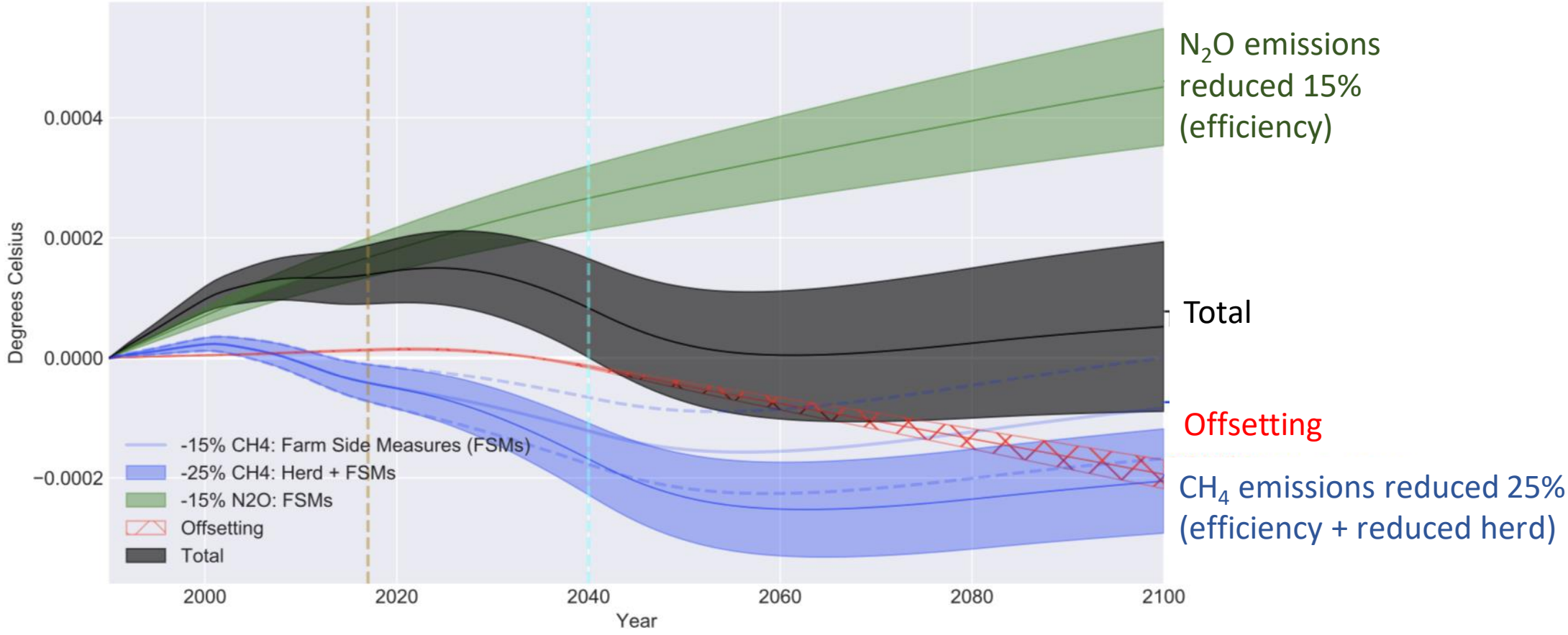
Figure by Edward Hornsby

Thought experiment:
What if UK agriculture goes to zero emissions by 2040?

- Agriculture's contribution to global warming would be reversed to **below 1990 levels** even before zero is reached
- because the methane-induced cooling is greater than the nitrous oxide and CO_2-induced warming

A (slightly) more realistic scenario for UK agriculture

UK agriculture's contribution to global warming reversed back to 1990 levels by mid-century

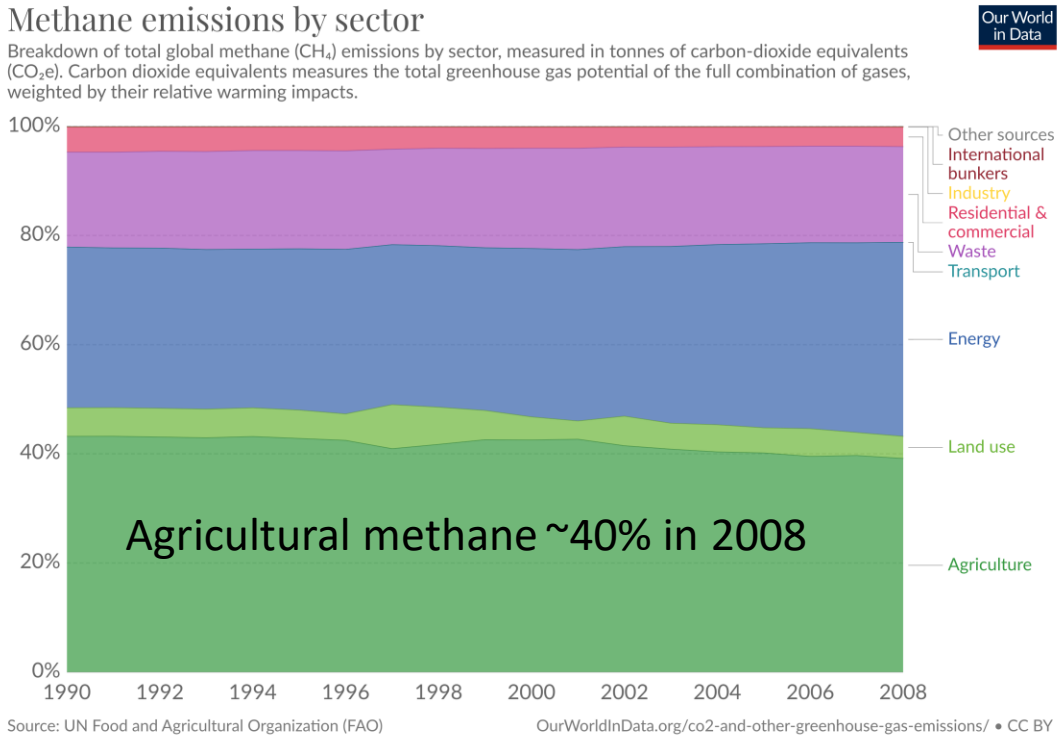


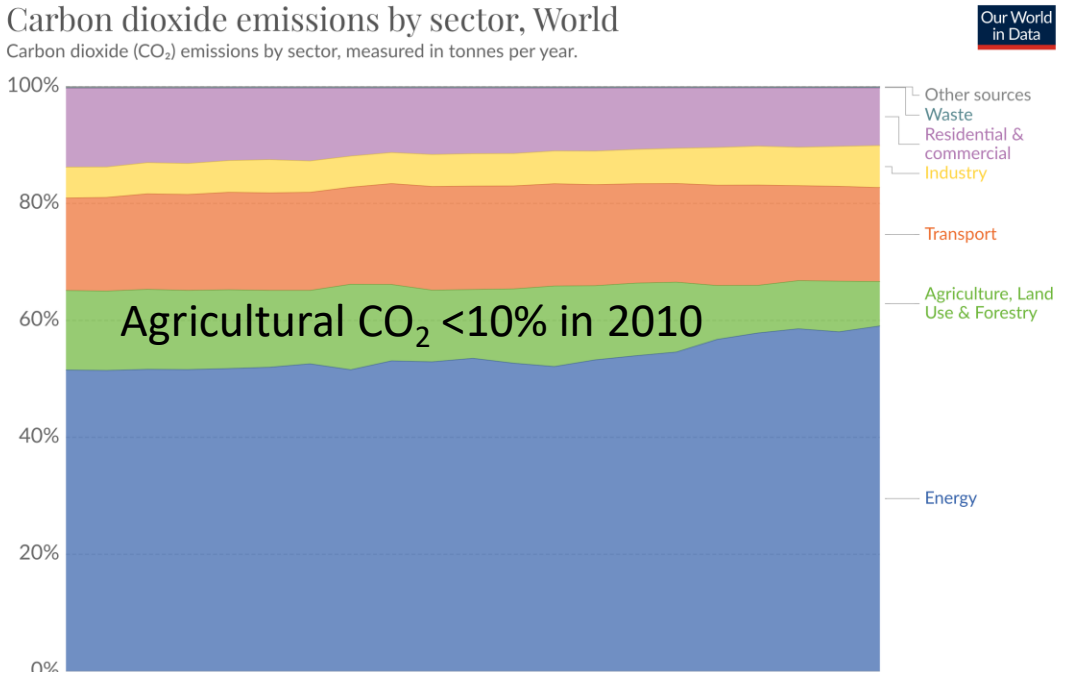
UNPUBLISHED FIGURE

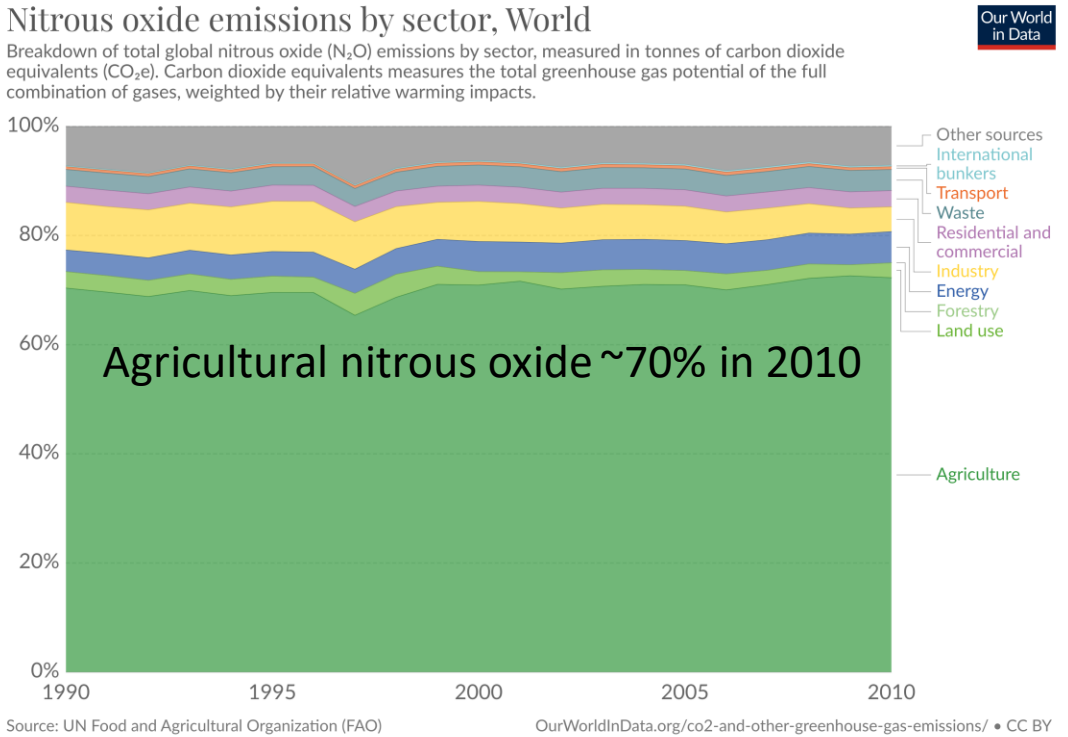
Figure by Edward Hornsby

Agricultural greenhouse gas emissions are dominated by: **methane** (CH_4) and **nitrous oxide** (N_2O)

Figures from OurWorldInData.org, data from FAO







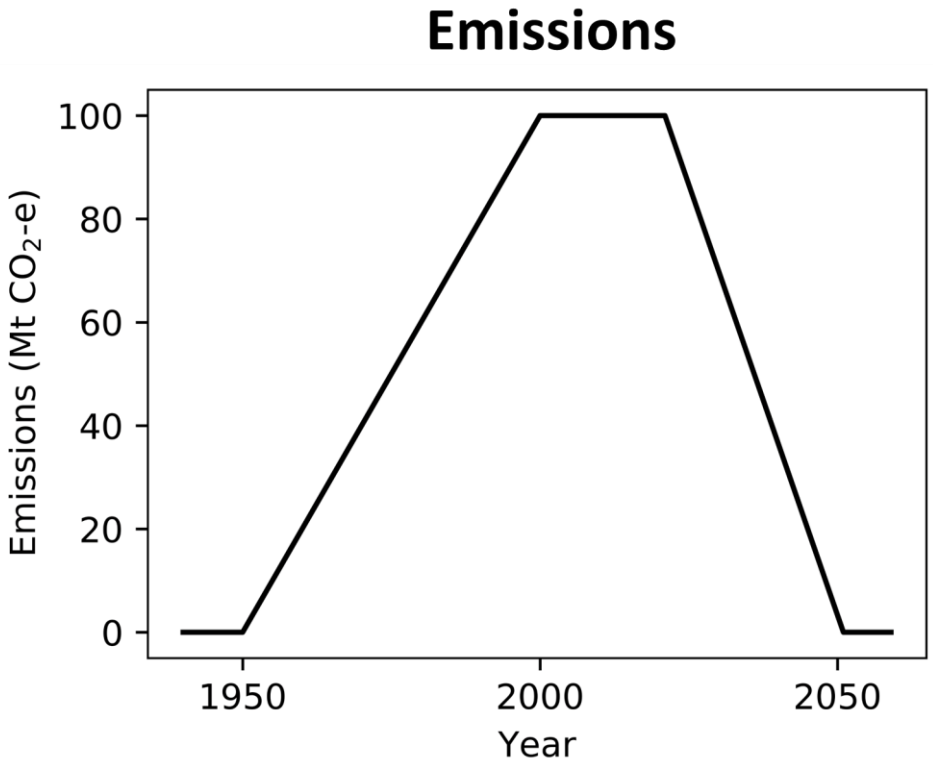
Equivalent drivers of climate change

A closed power station

A gently declining (10% over 30 years) herd of cattle

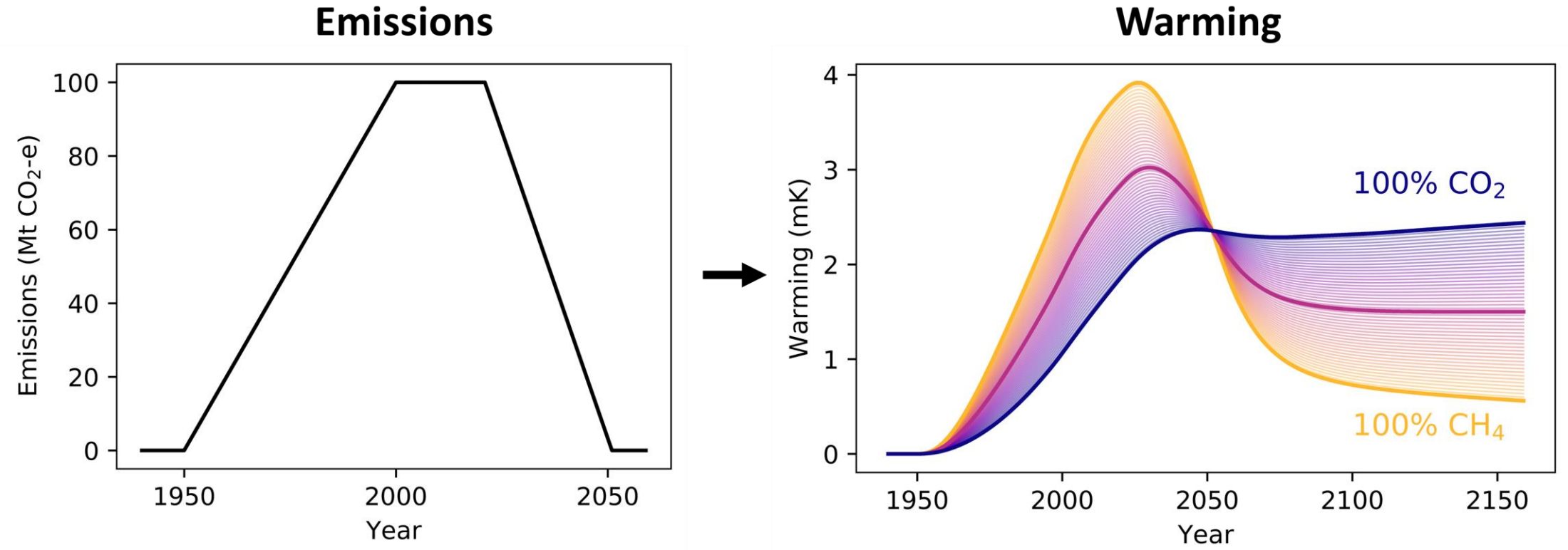
Motivation

- A country (or a sector) has a target of reducing CO_2e to zero by 2050, from a 2020 level of 100 $MtCO_2e$
- What would the effect on global mean surface temperature be if:
  - all their emissions were CO_2 ?
  - all their emissions were CH_4 ?



CO_2e = CO_2 equivalent emissions, calculated using standard GWP_{100} methodology

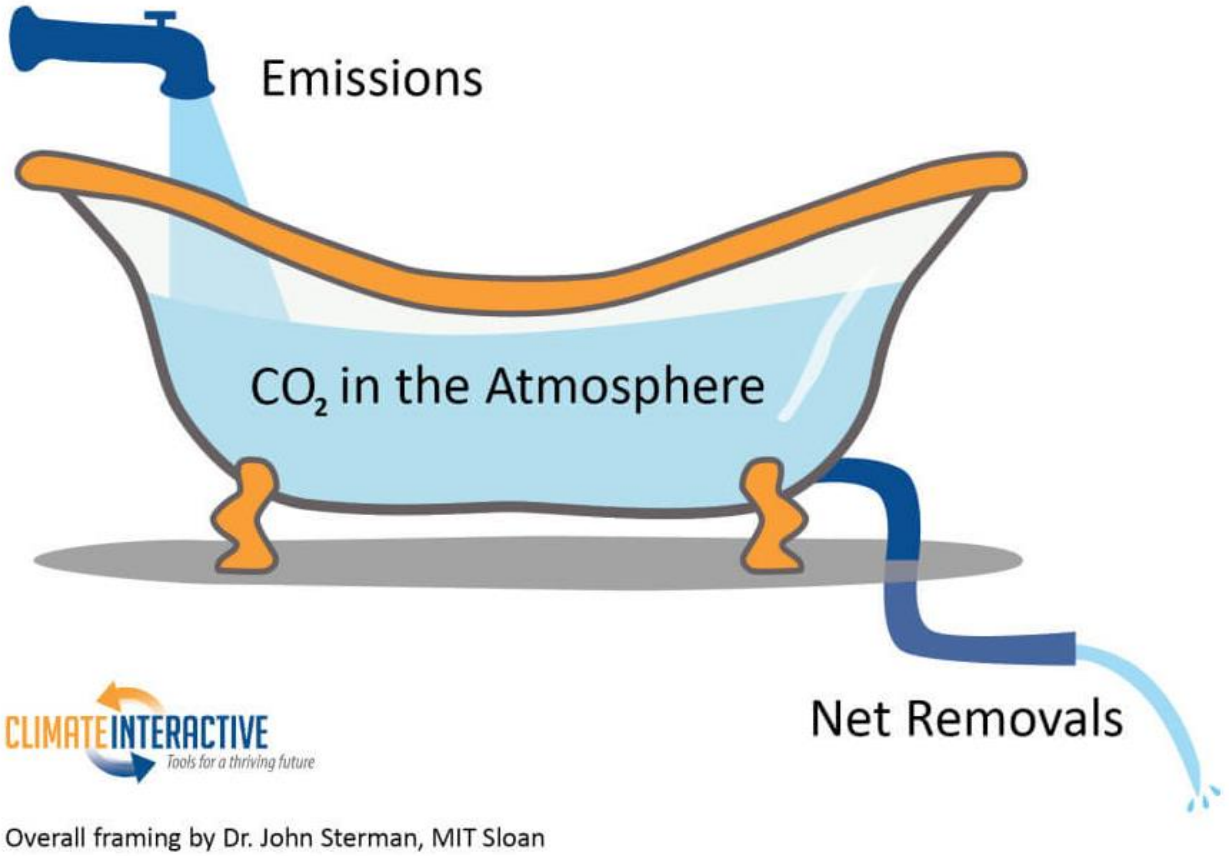
Different impacts from CO_2 and CH_4 emissions



Why do the same CO_2e emissions give such different outcomes?

Figure: Lynch et al, Agriculture's contribution to climate change and role in mitigation is distinct from predominantly fossil CO2-emitting sectors (in press)

How methane differs from CO_2



In the atmosphere:

CO_2 lasts 100s to 1000s of years

Nitrous oxide lasts about a century

Methane lasts about a decade

i.e. For ***methane***, removals are large already

Compared to CO_2, relatively small emissions reductions needed to stabilise methane levels