How to think about short-lived gases

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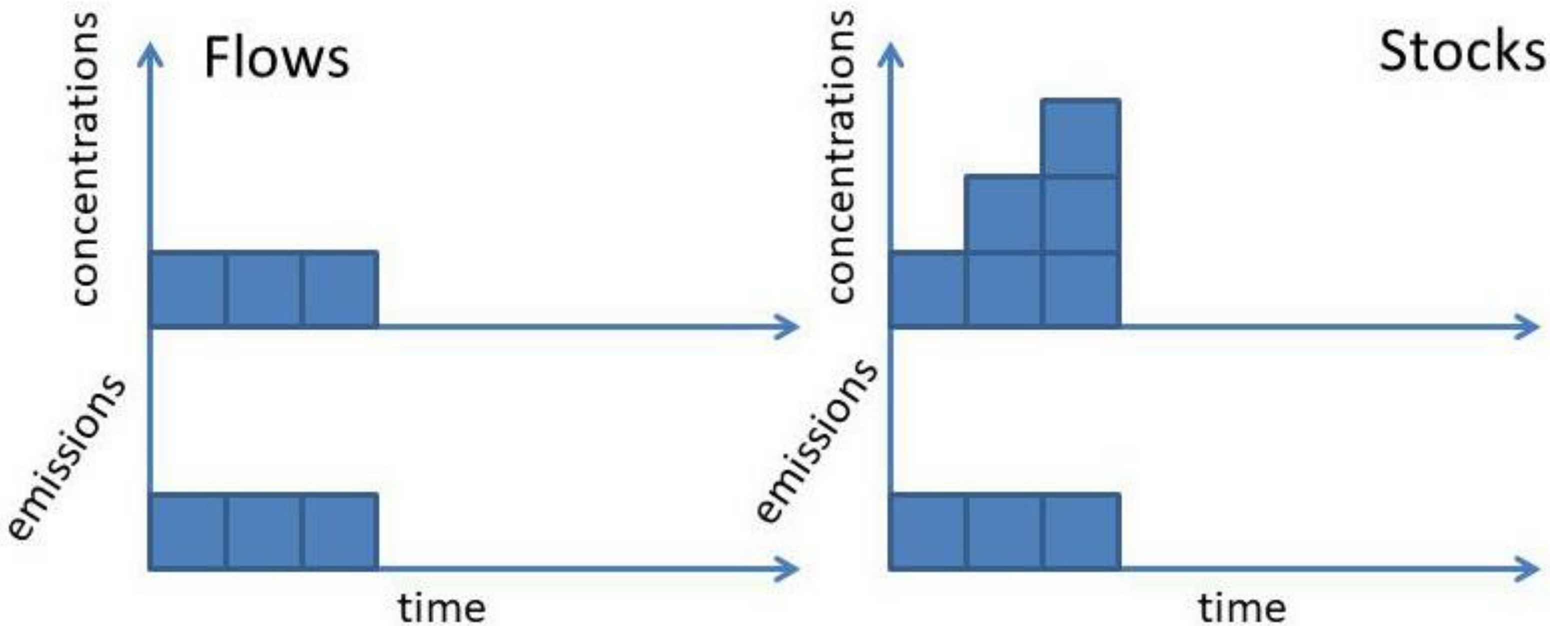
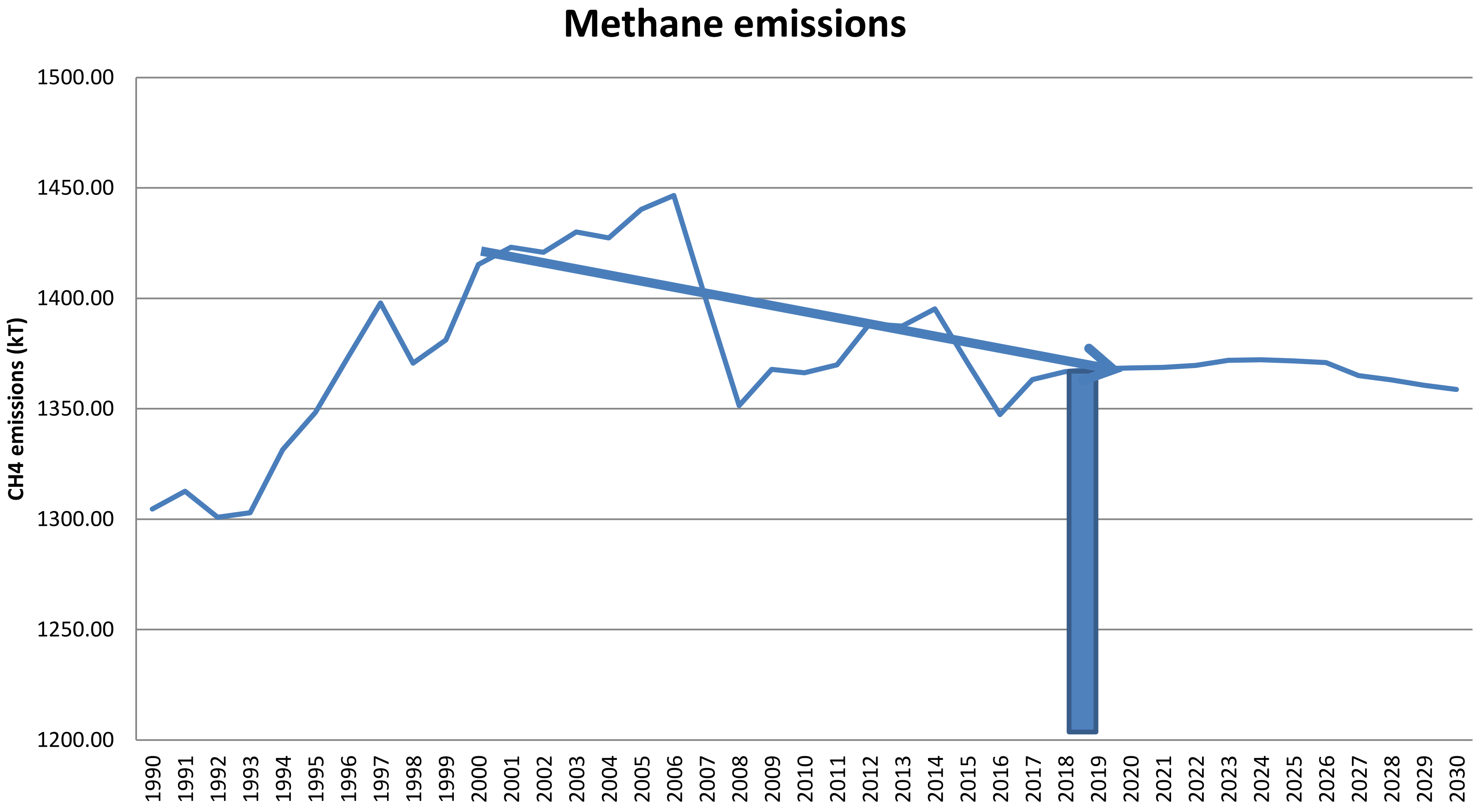
Methane ~ flow and CO2 ~ stock

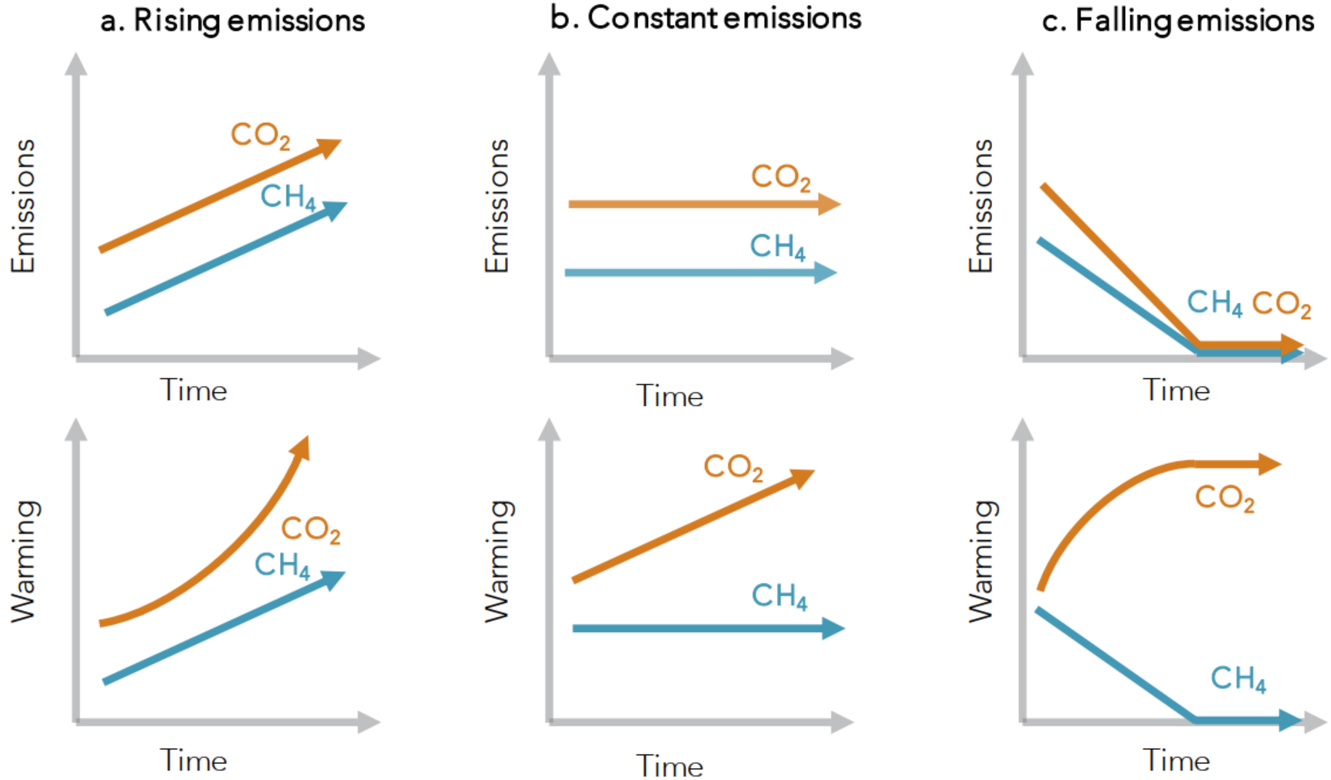


The temperature effects of methane



Near equilibrium

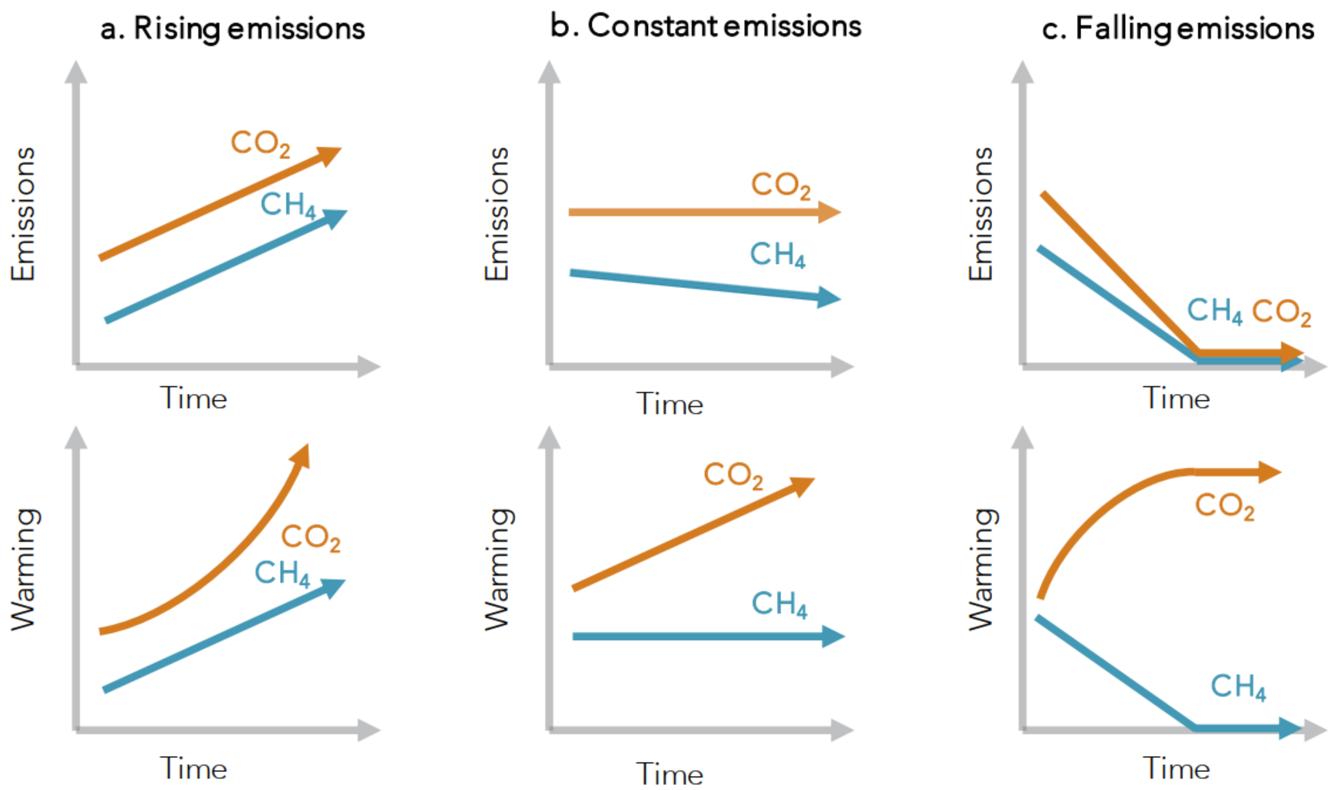
Figure 9-2 Relationship between emissions and warming for short- and long-lived gases



Source: Allen et al. (2017).

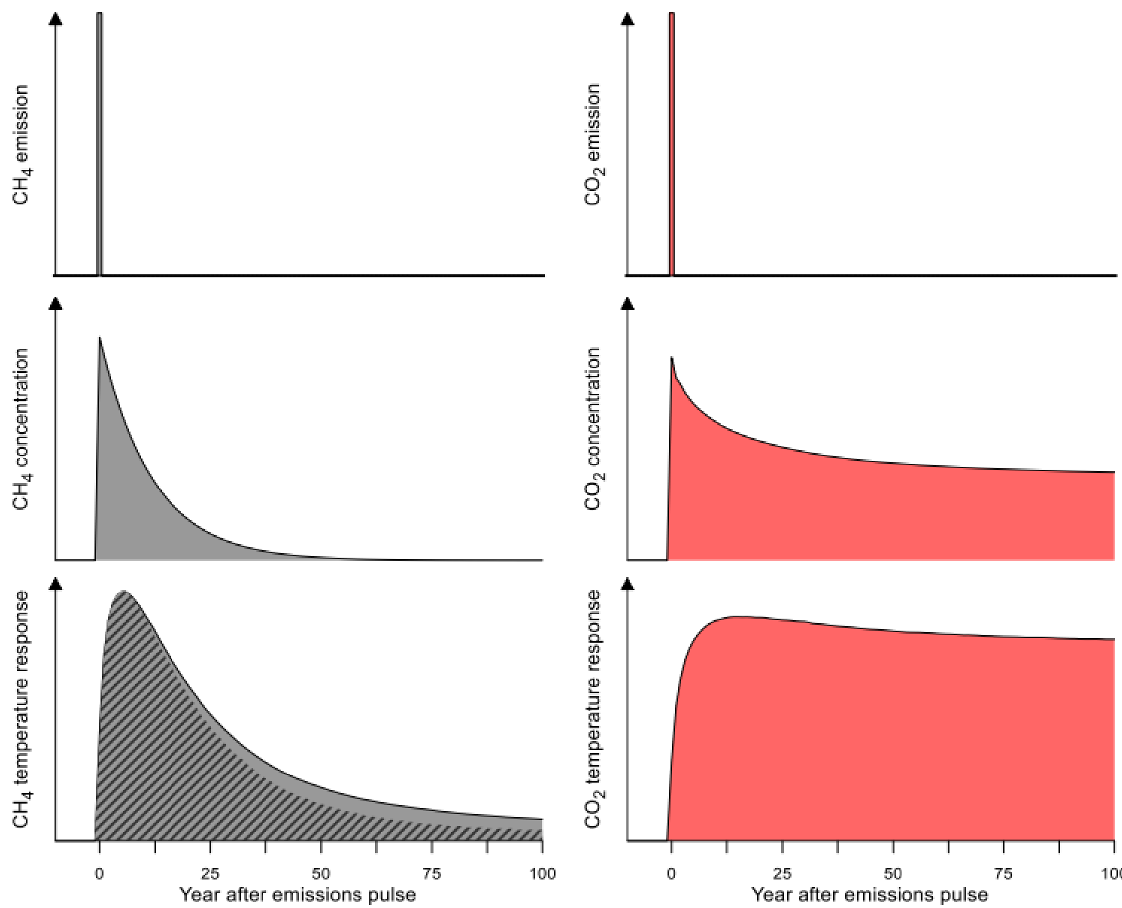
Further from equilibrium

Figure 9-2 Relationship between emissions and warming for short- and long-lived gases

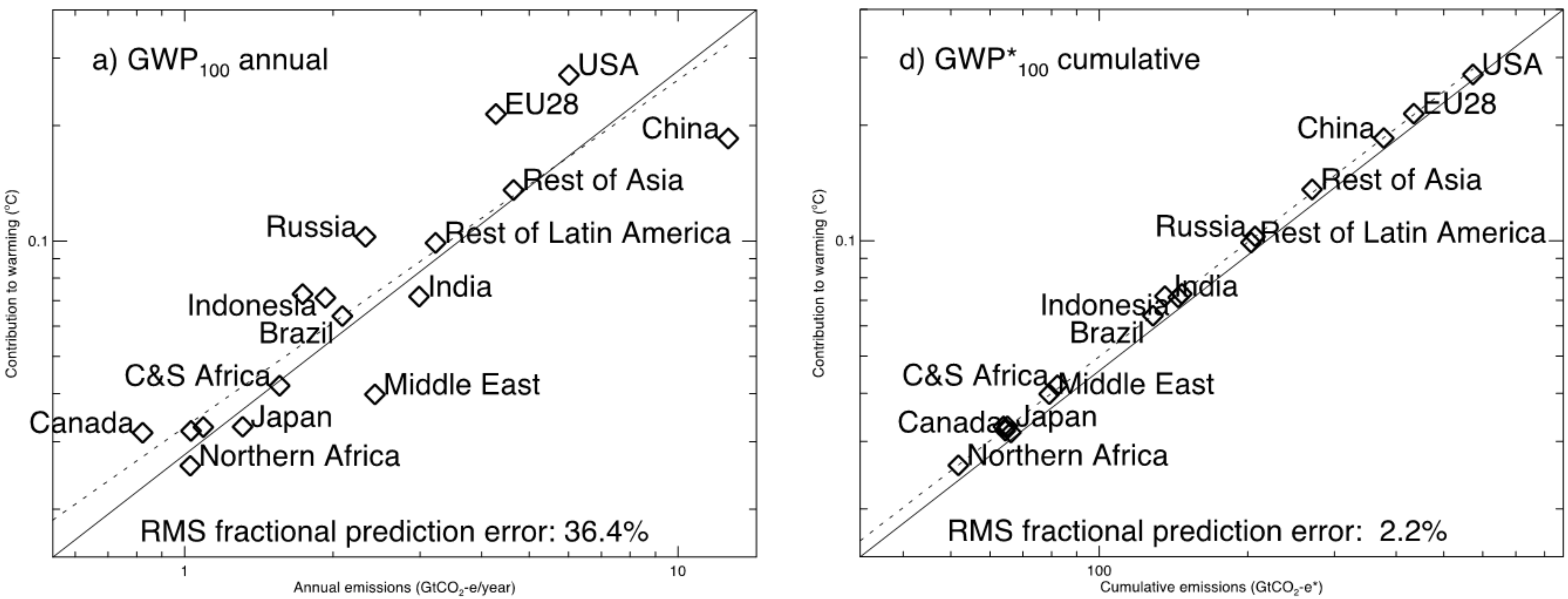


Source: Allen et al. (2017).

CH4 ~ flow and CO2 ~ stock



GWP* reflects the warming and GWP_{100} doesn't



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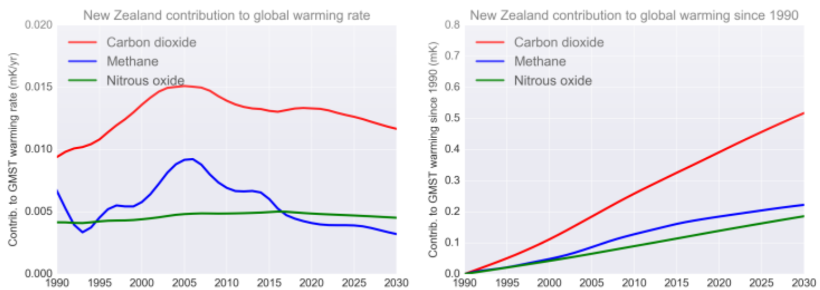


Figure 1: Warming
How NZ greenhouse gas emissions contribute to global warming rate (left) and total warming since 1990 (right)

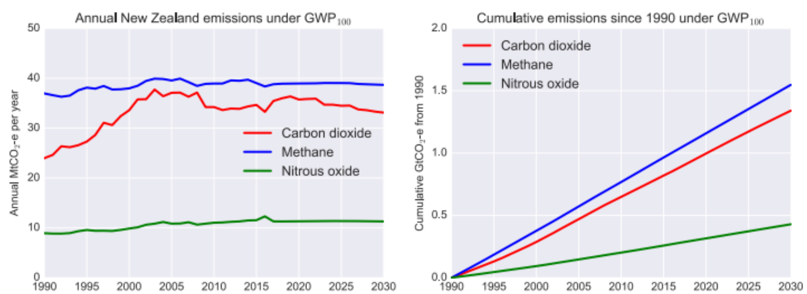


Figure 2: GWP_{100}
Annual (left) and cumulative NZ greenhouse gas emissions since 1990 (right) expressed in CO_2-e using GWP_{100}.

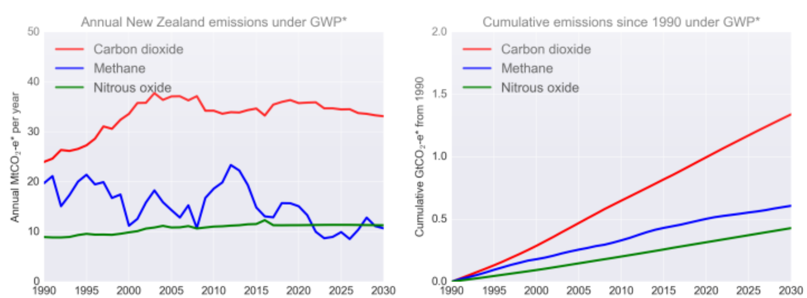


Figure 3: GWP*
Annual (left) and cumulative NZ greenhouse gas emissions since 1990 (right) expressed in CO_2-e using GWP*).

Summary

- GWP_{100} is not fit for purpose as a metric of the impact of greenhouse gas emissions on global mean surface temperature.

- Using GWP_{100} gives more CO_2-e emissions from methane than CO_2 (fig 2), despite the fact that the warming (fig 1) is dominated by CO_2 because GWP_{100} overestimates the cumulative effects of methane.

- Declining methane emissions cause cooling.

NZ Future warming

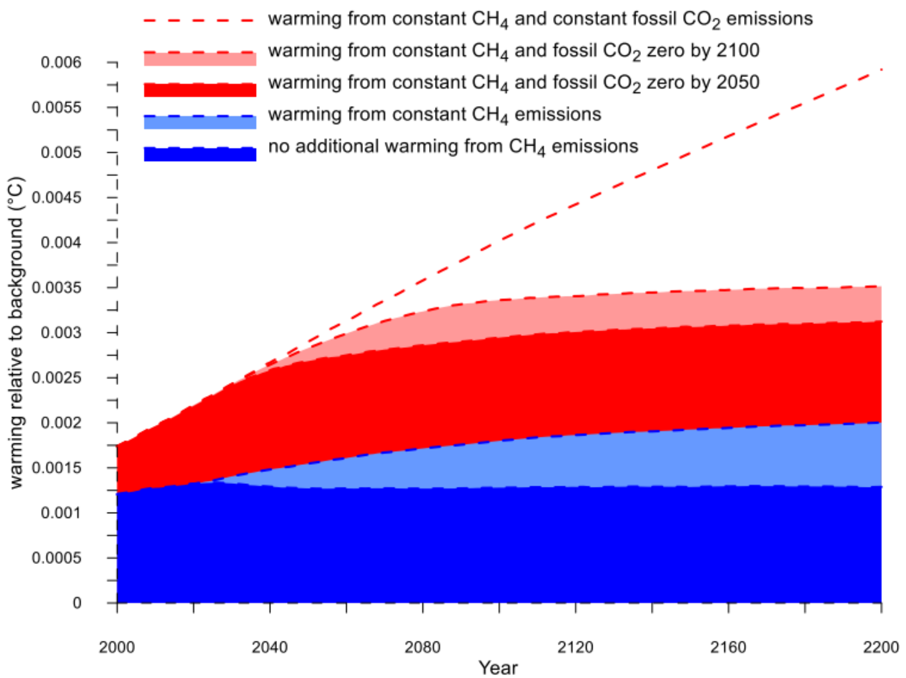


Figure 21. Total warming from New Zealand livestock methane and fossil carbon dioxide emissions from 2000 to 2200. The dark blue shaded area indicates the total warming if methane emissions are reduced such that no additional warming results after 2016; the light blue shaded area indicates the additional warming that would result if methane emissions were held constant from 2016 onwards. The dark red area indicates the total warming from fossil carbon dioxide emissions, added to the total warming from methane emissions, if fossil carbon dioxide emissions were reduced to zero by 2050, and the light red shaded area indicates the warming that would result if fossil carbon dioxide emissions were reduced to zero by 2100. The red dashed line indicates the total warming that would result if both livestock methane and fossil carbon dioxide emissions were held constant at year 2016 levels. Levels of warming represent the best estimate (median) result of probabilistic MAGICC simulations (see Appendix I).

Asking the same question of all gases

- What level of emissions reductions are required to prevent any further warming from the 3 main gases?
  - CO_2: negative emissions immediately
  - N_2O: zero or negative emissions immediately
  - CH_4: you can maintain 99.7%, per annum, of the previous year's emissions.

Time flexibility

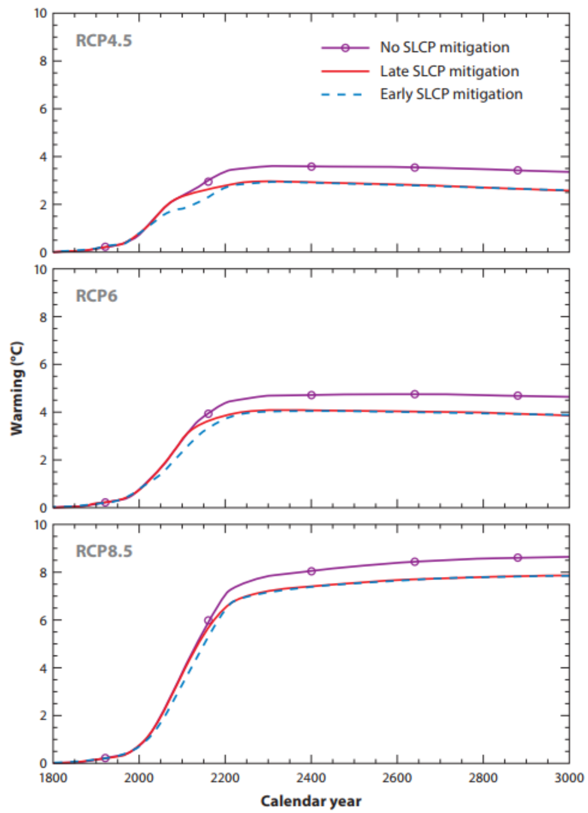


Figure 12

Comparison of warming from early, late, and no short-lived climate pollution (SLCP) abatement scenarios applied on top of a baseline consisting of RCP4.5, RCP6, and RCP8.5 CO_2 emissions plus the baseline SLCP and sulfate aerosol shown in **Figure 10**.

"Eventual mitigation of SLCP can make a useful contribution to climate protection, but there is little to be gained by implementing SLCP mitigation before stringent carbon dioxide controls are in place and have caused annual emissions to approach zero. Any earlier implementation of SLCP mitigation that substitutes to any significant extent for carbon dioxide mitigation will lead to a climate irreversibly warmer than will a strategy with delayed SLCP mitigation. SLCP mitigation does not buy time for implementation of stringent controls on CO_2 emissions."

Time flexibility, cont'd

Substituting SLCP for CO_2

- It is seen that any amount of substitution of SLCP abatement for CO_2 abatement results in a situation in which a temporary and modest reduction in near-term temperature is bought at the expense of a permanent increase in the long-term temperature. The greater the substitution, the less the short-term climate benefits and the greater the irreversible harm.

SLCPs and peak temperatures

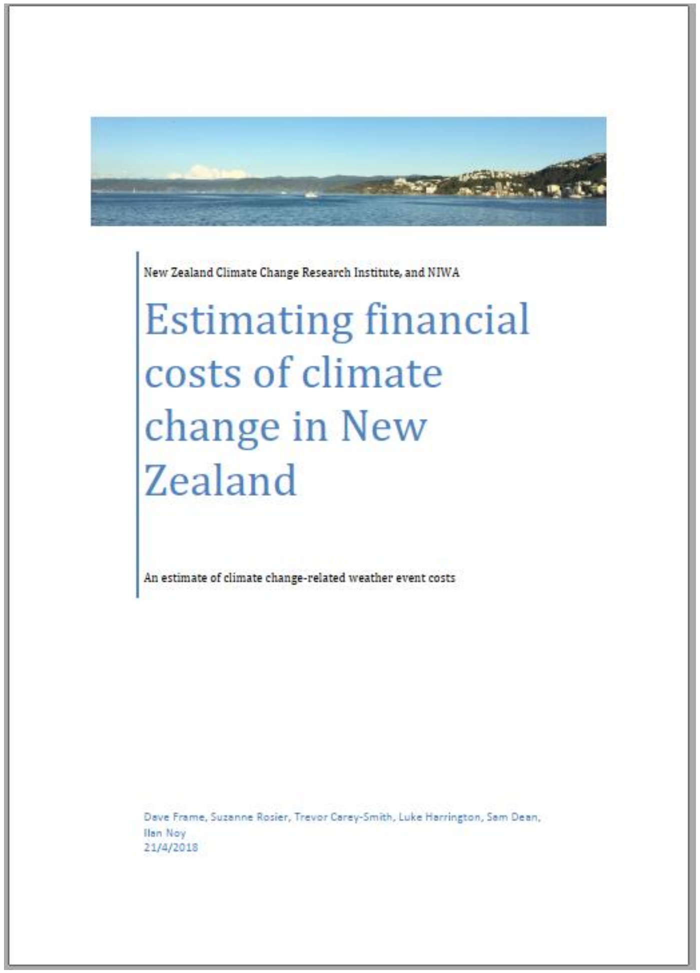
- if the prime climate protection goal is to limit peak warming, then early SLCP mitigation is pointless, because in no case does early SLCP mitigation significantly reduce the peak warming. The calculation does show, however, that eventual SLCP mitigation helps trim the magnitude of the peak warming.
- Bowerman et al. (2013), using a somewhat different set of assumptions, also arrived at the conclusion that doing SLCP mitigation early rather than late has no effect on peak warming. They conclude further that under most circumstances of interest, accelerating SLCP mitigation does not reduce even the maximum rate of warming.

Summary

- Methane emissions reductions that come at the expense of CO_2 reductions leave behind a warmer world

- If methane emissions reductions can be made without substituting for CO_2 reductions, then they're a good idea

Linking climate science to social concerns: attributing costs to climate change


New Zealand Climate Change Research Institute, and NIWA

Estimating financial costs of climate change in New Zealand

An estimate of climate change-related weather event costs

Dave Frame, Suzanne Rosier, Trevor Carey-Smith, Luke Harrington, Sam Dean, Ilan Noy
21/4/2018

Year	Date	Event	FAR	Cost ($M)	Attributable Cost ($M)
2007	10 -12-Jul	North North Island	0.30	68.65	20.595
2017	3-7 April	North Island	0.35	66.4	23.24
2013	19-22 April	Nelson, BoP	0.30	46.2	13.86
2017	7-12 March	Upper North Island	0.40	41.7	16.68
2015	18-21 June	Lower North Island	0.10	41.5	4.15
2016	23-24 March	West Coast-Nelson	0.40	30.2	12.08
2015	2-4 June	Otago	0.05	21.5	1.075
2015	13-15 May	Lower North Island	0.30	21.9	6.57
2011	29-Jan	Northland to BoP	0.30	19.8	5.94
2014	8-10 July	Northland	0.30	18.8	5.64
2017	13-16 April	Mostly North Island	0.35	18.	6.3
2007	29-Mar	Far North	0.30	12.	3.6
	Total attributable extreme rainfall insurance costs				$119.73

Cool, *verb*

- **1.** *intransitive*. To become less hot or warm; to become cool. Frequently with *down*, *off*.

GWP* reflects the warming and GWP_{100} doesn't

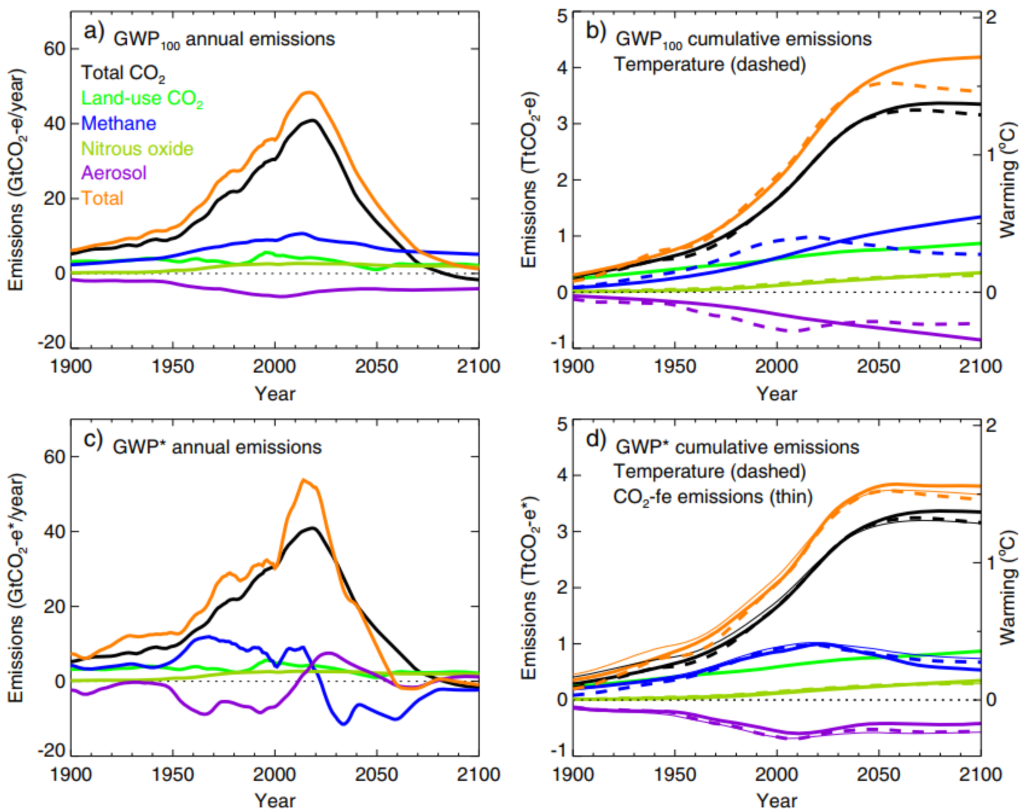
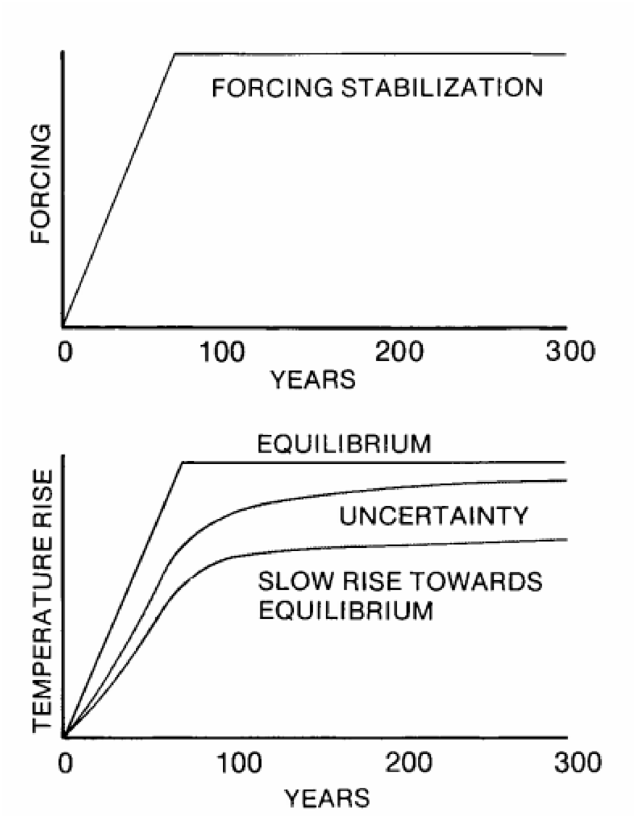


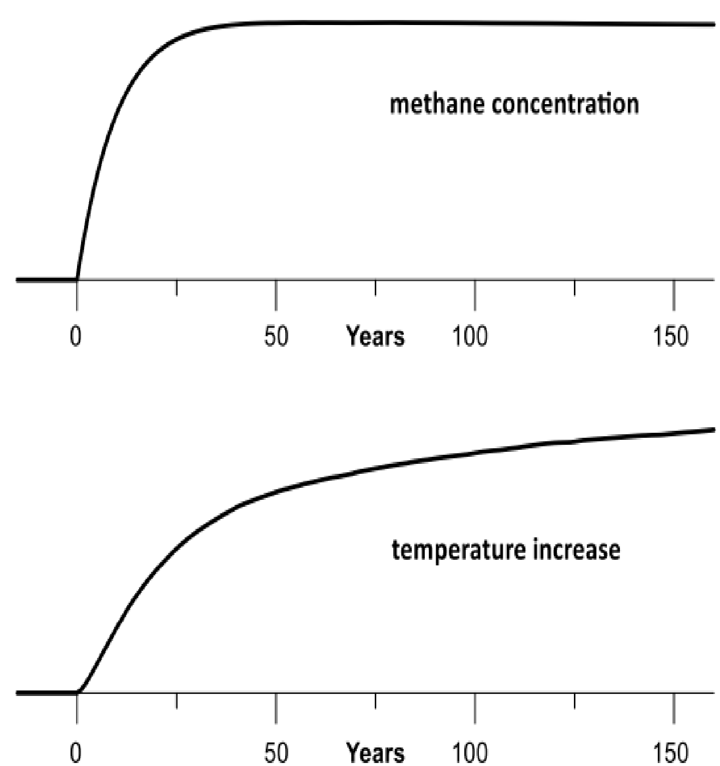
Fig. 2 Annual **a**, **c** and cumulative **b**, **d** CO_2-e and CO_2-e* emissions under the GWP_{100} **a**, **b** and GWP* **c**, **d** metrics using historical emissions to 2015 extended with the RCP2.6 scenario. Dashed lines show global mean surface temperature (GMST) response to radiative forcings associated with these emissions (not available separately for land-use CO_2). Colors indicate gases following the legend in **a**, with "Aerosol" also including ozone and other minor constituents. Thin solid lines in **d** show cumulative CO_2-forcing-equivalent emissions closely tracking GMST response

Generic response to RF

IPCC 1990



PCE



Residual warming

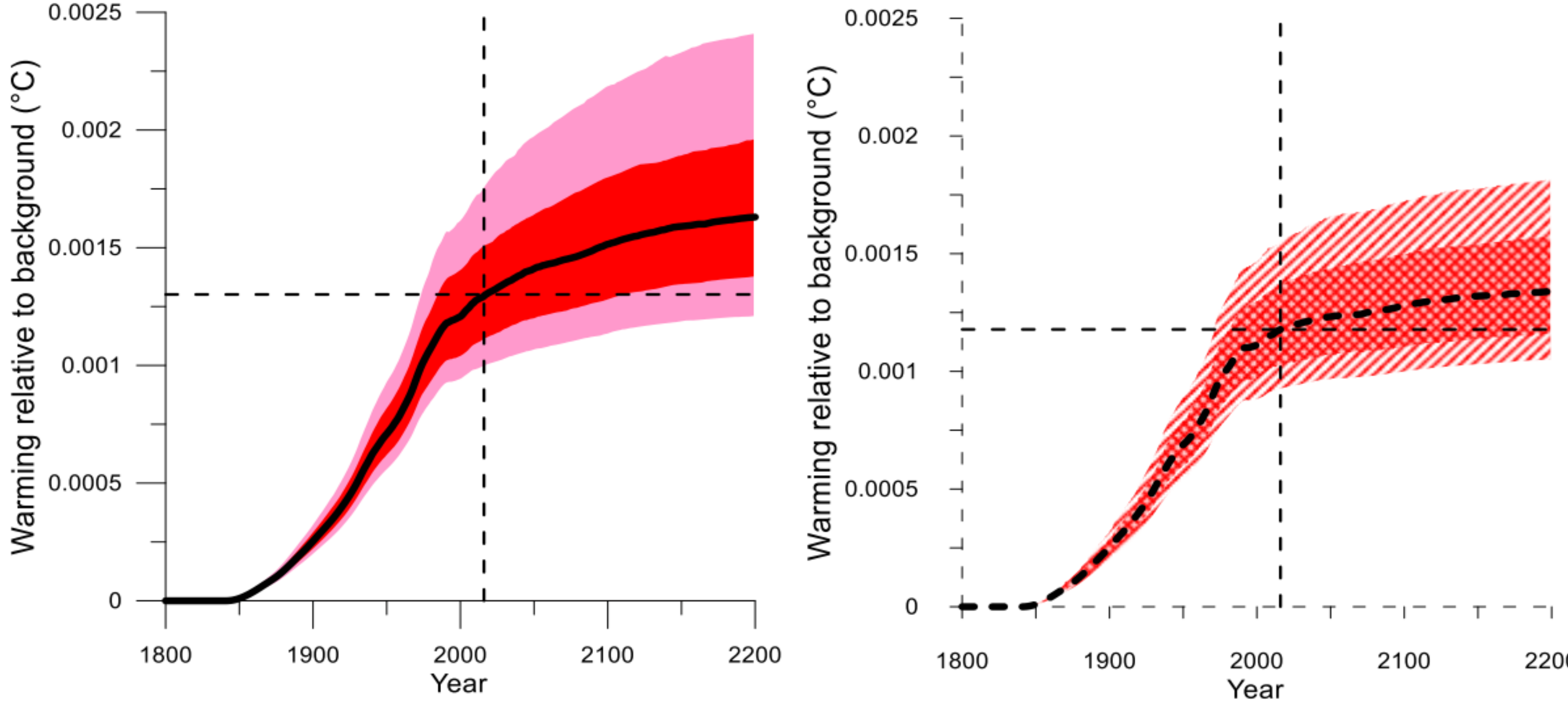
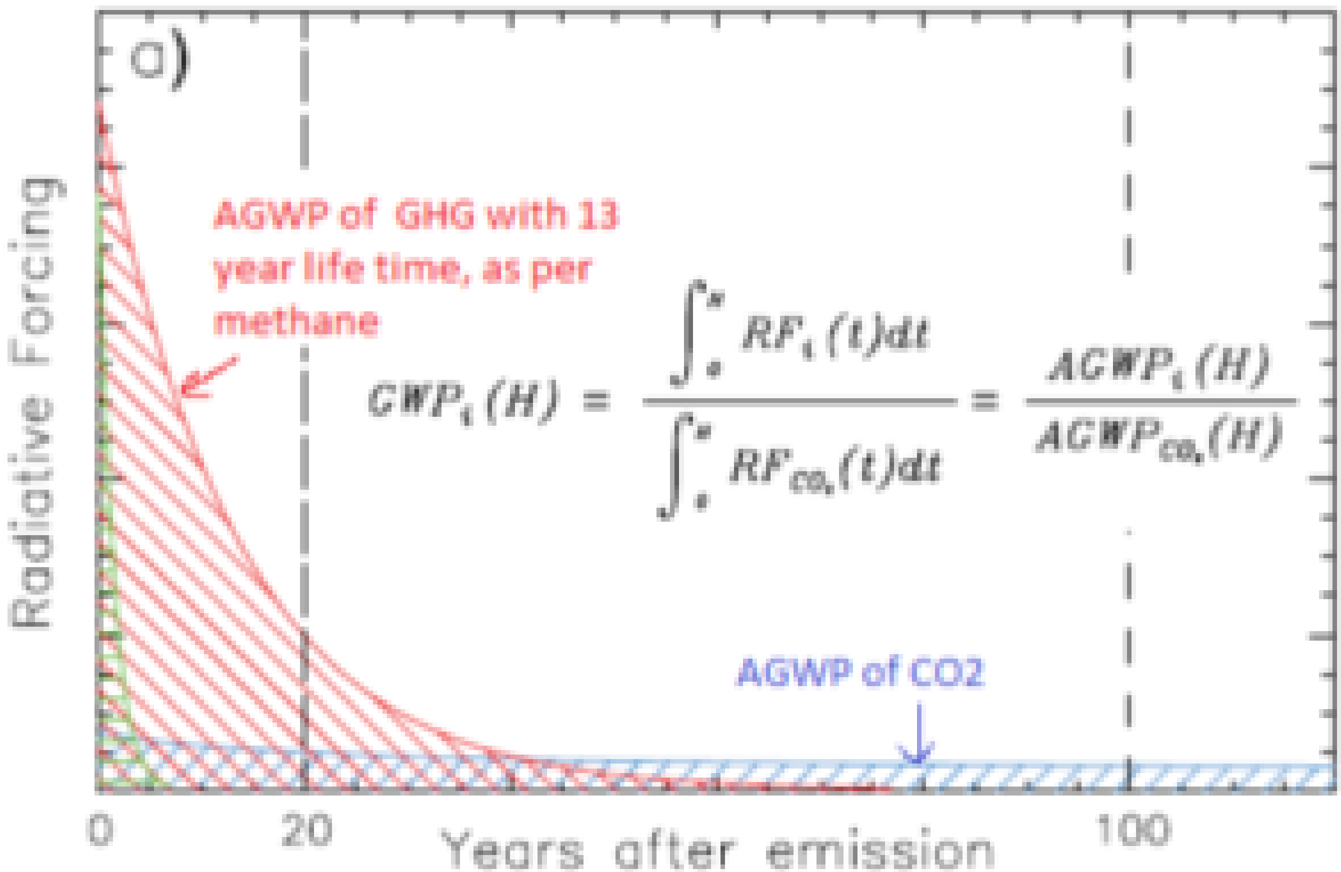
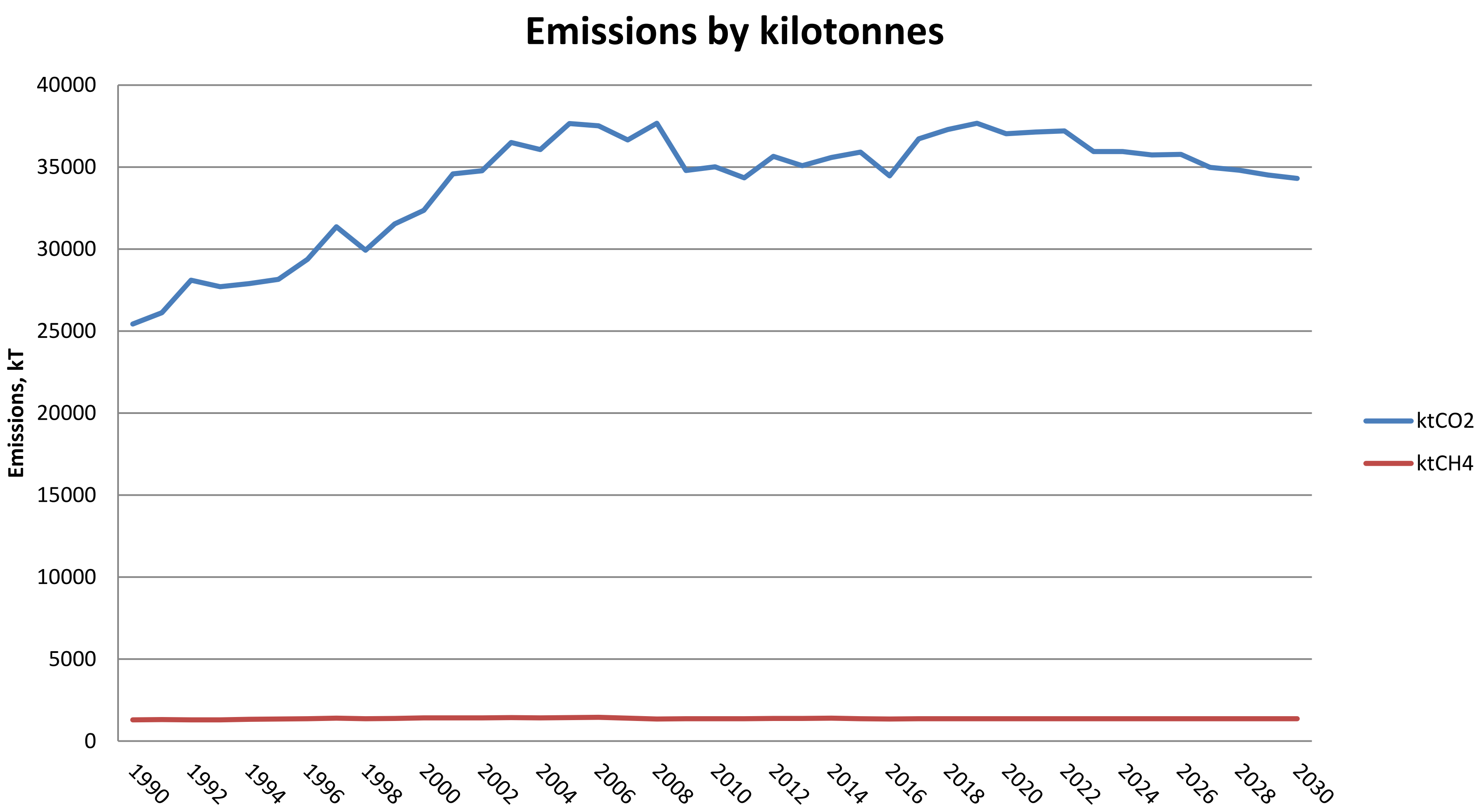


Figure 15. Modelled warming from New Zealand livestock methane emissions, with the effect of climate-carbon cycle feedbacks included (left panel, solid shading) and excluded (right panel, hashed shading). Global background concentrations were assumed to be constant from 2011 onwards. Dashed lines indicate the warming estimated to have occurred due to New Zealand's methane emissions by the year 2016.

Per tonne, Methane vs CO2

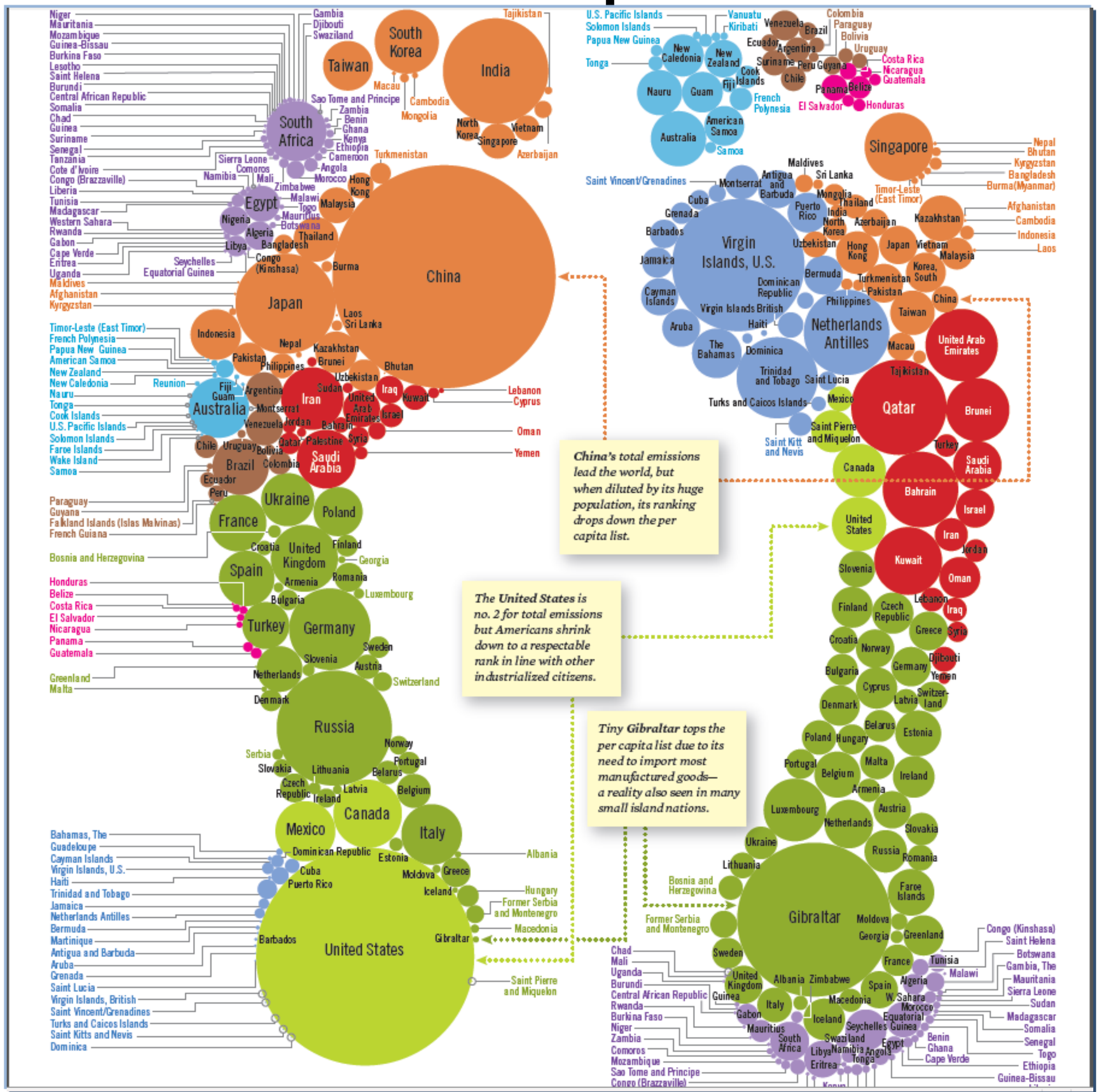


But gulf in quantity, too.



Analogy with the per capita vs total carbon footprint issue

Total



Per capita