

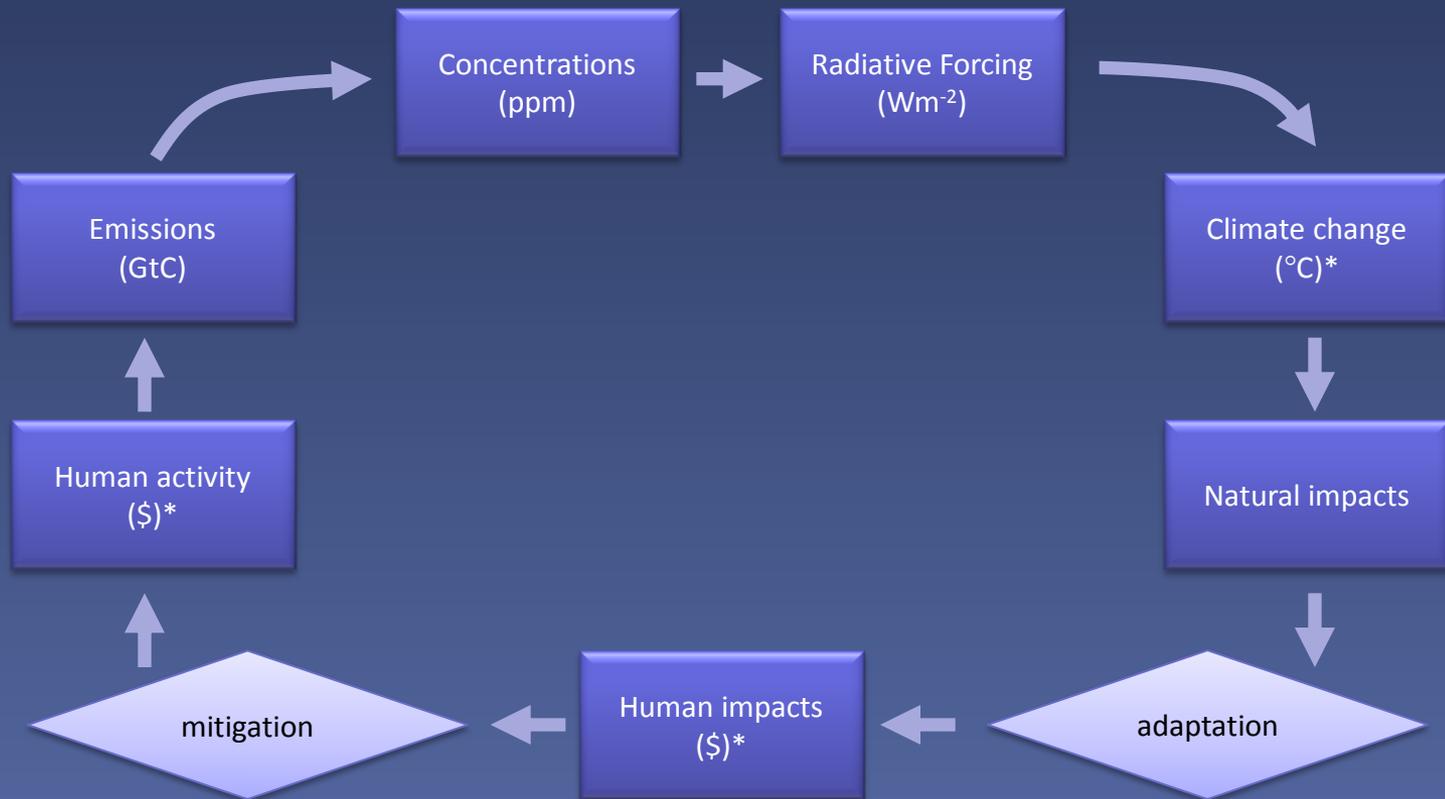
Metrics: a guide for the perplexed

Dave Frame

Climate Change Research institute

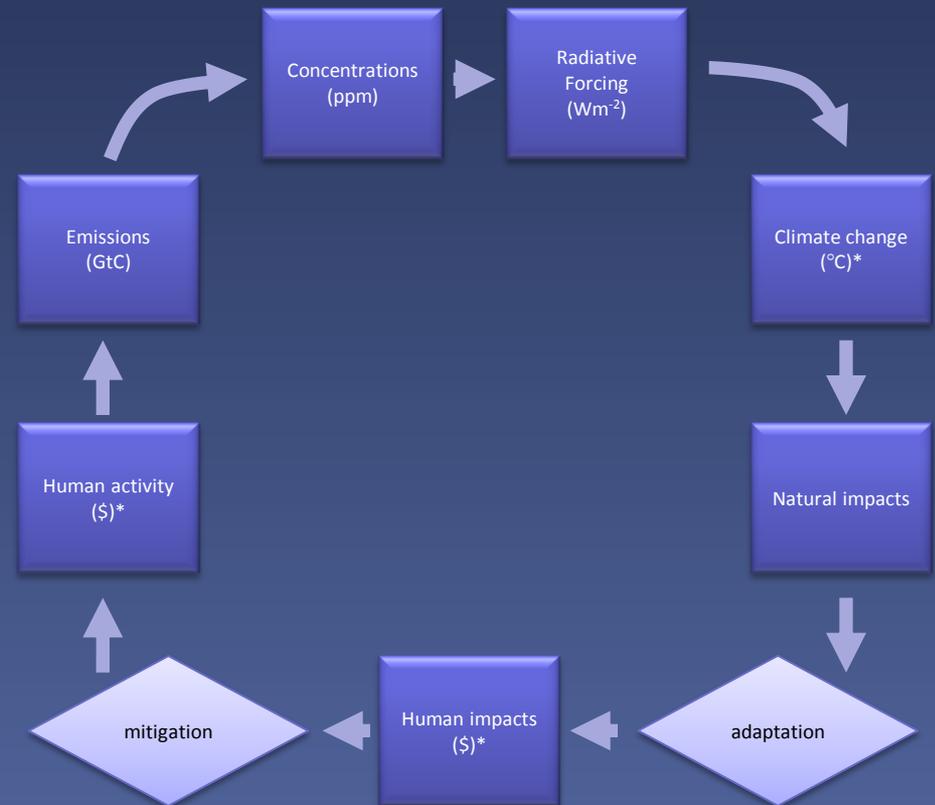
Victoria University of Wellington

Climate change processes



Introduction to metrics

- Metrics compare the effects of different gases
- In theory, that comparison could be made at any two points in the process cycle
- But the different temporal properties of the gases means decisions have to be made about “time”
- The choices have distributional implications

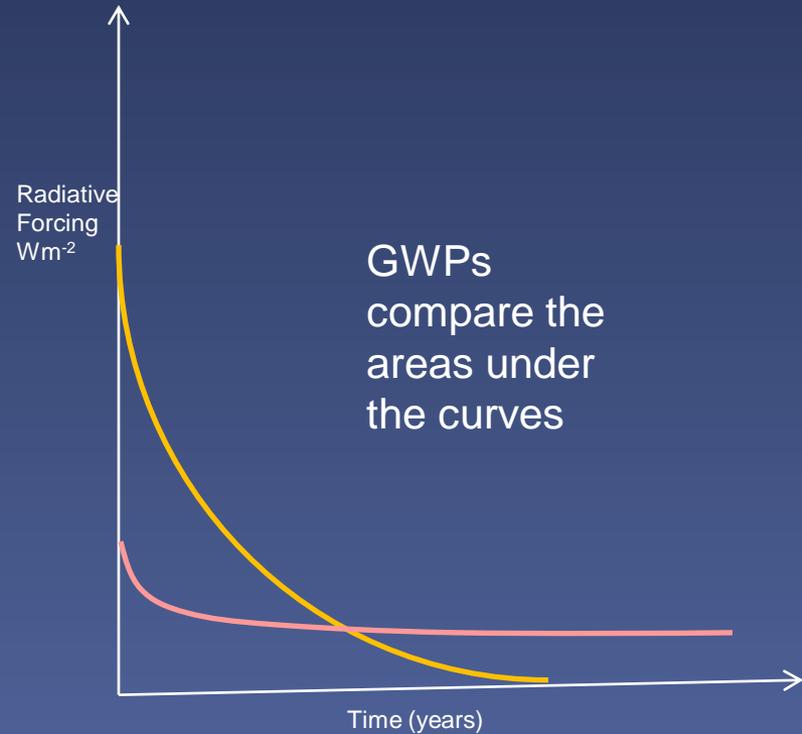


The role of metrics

- Metrics are a comparison between the *effects* of different gases
- In an ideal policy world this would involve evaluation of the abatement costs of a unit of a gas, set against the damages arising from that unit of gas.
- And then we'd compare these costs across the basket of gases
- In the second-best world we actually inhabit, we use physically-based comparisons

Global warming potentials

- Global Warming Potentials compare the integrated radiative forcing over a specified period (e.g., 100 years) from a unit mass pulse emission and are a way of comparing the potential climate change associated with emissions of different greenhouse gases.
- IPCC AR4, TS.2.5



A brief history

- “The GWP was originally presented as a climate analogue to the ozone depletion potential, to help assess the climate impacts of switching from chlorofluorocarbons to hydrofluorocarbons (and related molecules).
- I believe that we had many of the necessary caveats in place but I was particularly struck by one statement:
- *“It must be stressed that there is no universally accepted methodology for combining all the relevant factors into a single [metric] . . . A simple approach [i.e. the GWP] has been adopted here to illustrate the difficulties inherent in the concept.”*
- But it seems that the die was cast. The IPCC retained the GWP as a metric of choice.”
- *Shine, K. P. 2009 The global warming potential: the need for an interdisciplinary retrieval. Climatic Change 96, 467–472.*

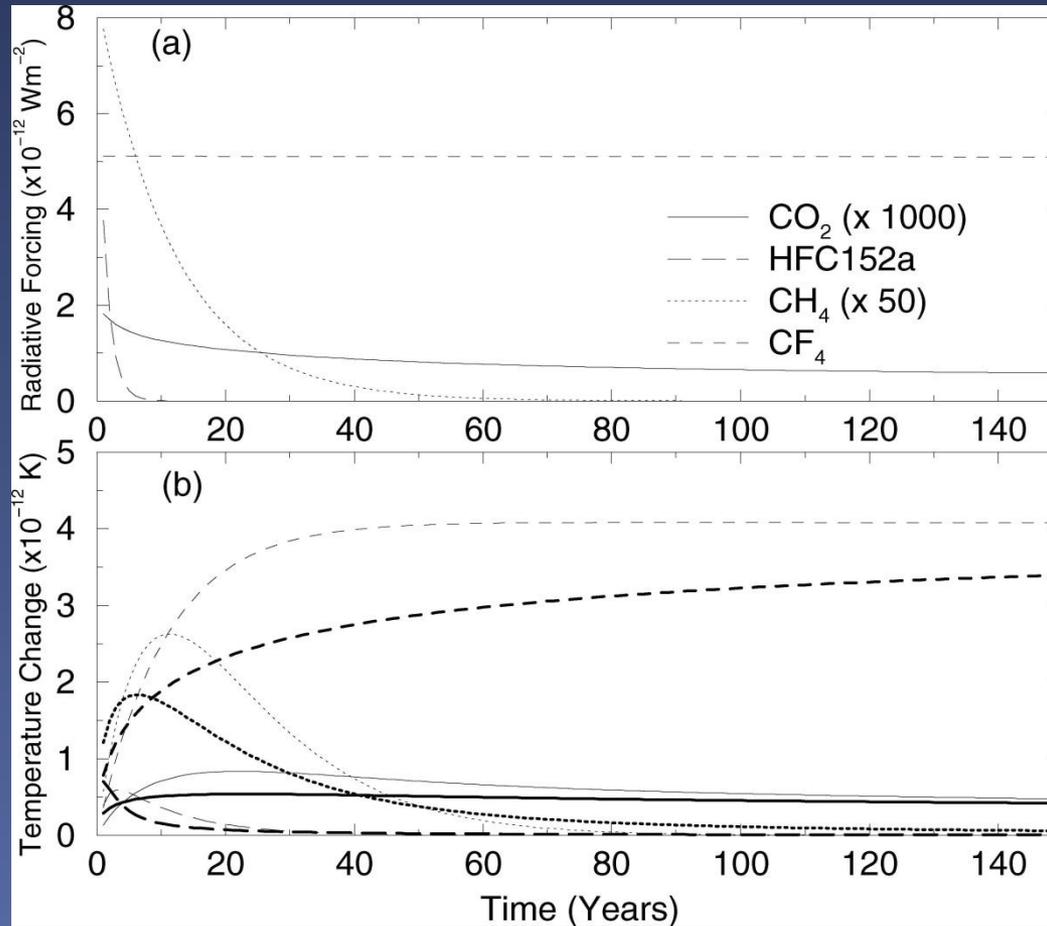
Path dependence at work

- “Earlier, we noted two problems with GWPs: the failure to incorporate damages and abatement costs, and the arbitrary choice of time horizon for calculating cumulative radiative forcing.
- Here we highlight two additional problems. GWPs assume that the trade-off ratios remain constant over time and are independent of the ultimate goal. Clearly, neither of these assumptions makes economic sense.”
- *Manne, A.S., and R.G. Richels 2001 An alternative approach to establishing trade-offs among greenhouse gases. Nature, 410, 675-677*
- “Did something go wrong here? How did “a simple approach” which was “adopted . . . to illustrate . . . difficulties” become established in a major piece of environmental legislation, where it had the potential to influence big investment and policy decisions?”
- *Shine, 2009.*

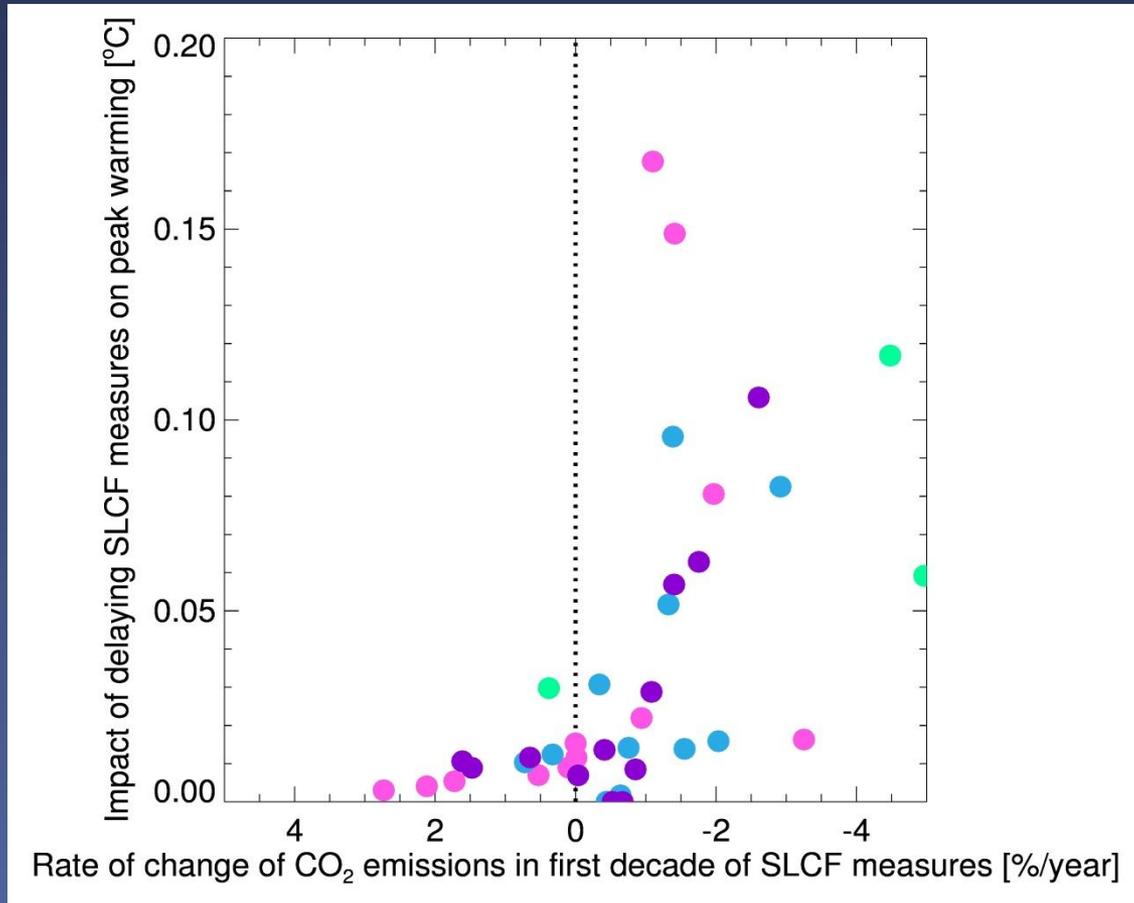
Innovation

- The climate research community has never satisfied with GWPs, and alternative approaches have been considered
 - Wigley 1998 focussed on a trajectory-based alternative that took account of Manne & Richels' second point
 - Shine et al 2005 developed “global temperature potentials” (GTP) as an alternative physically-based metric, which considers a variable closer to damages**
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- **Pretty much all integrated assessment models rely on temperature as the closest physical variable they can get to damages

Response to pulse emissions (eg 1kg of X emitted now)

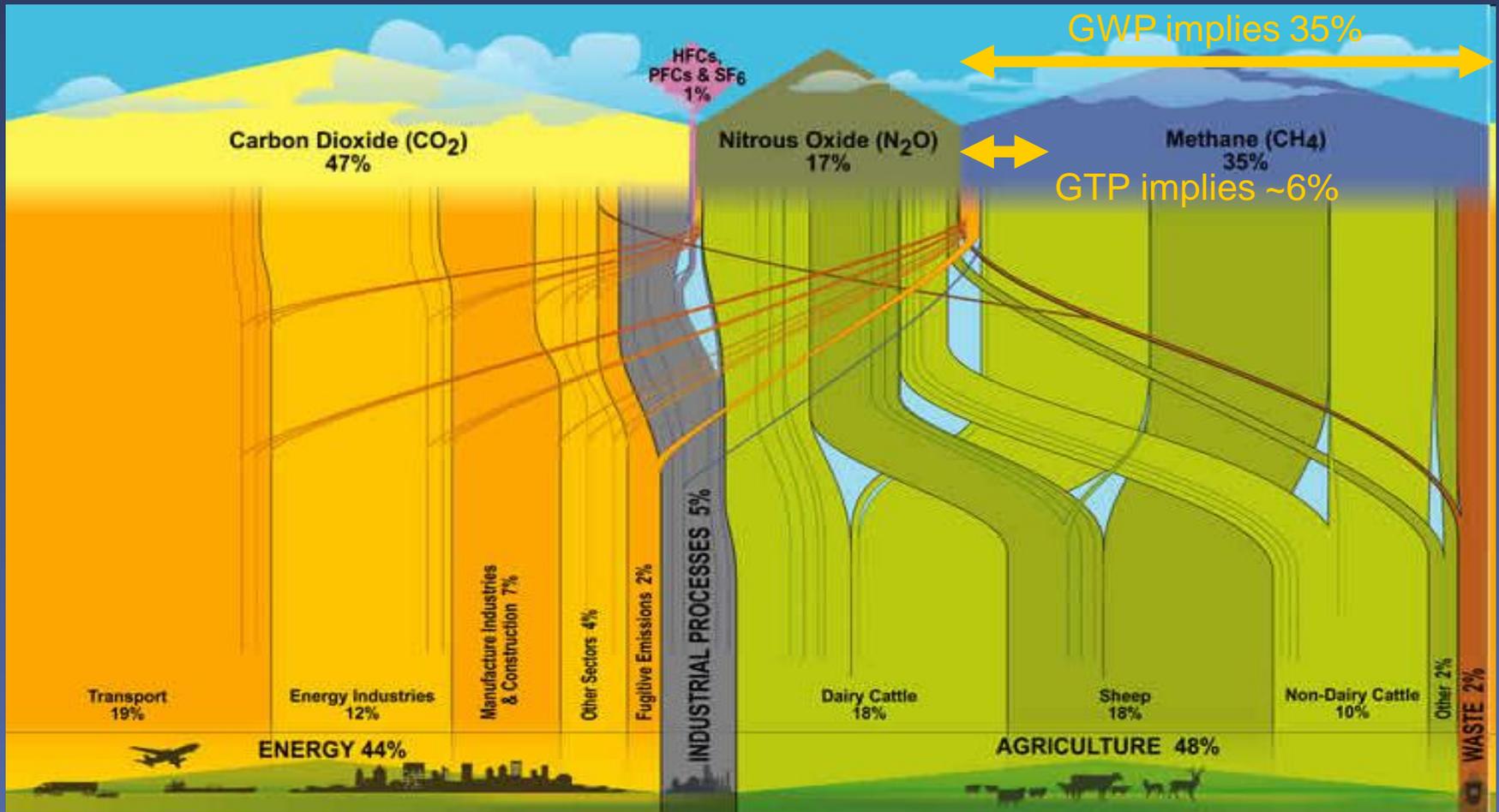


Short-lived vs Long-lived forcings

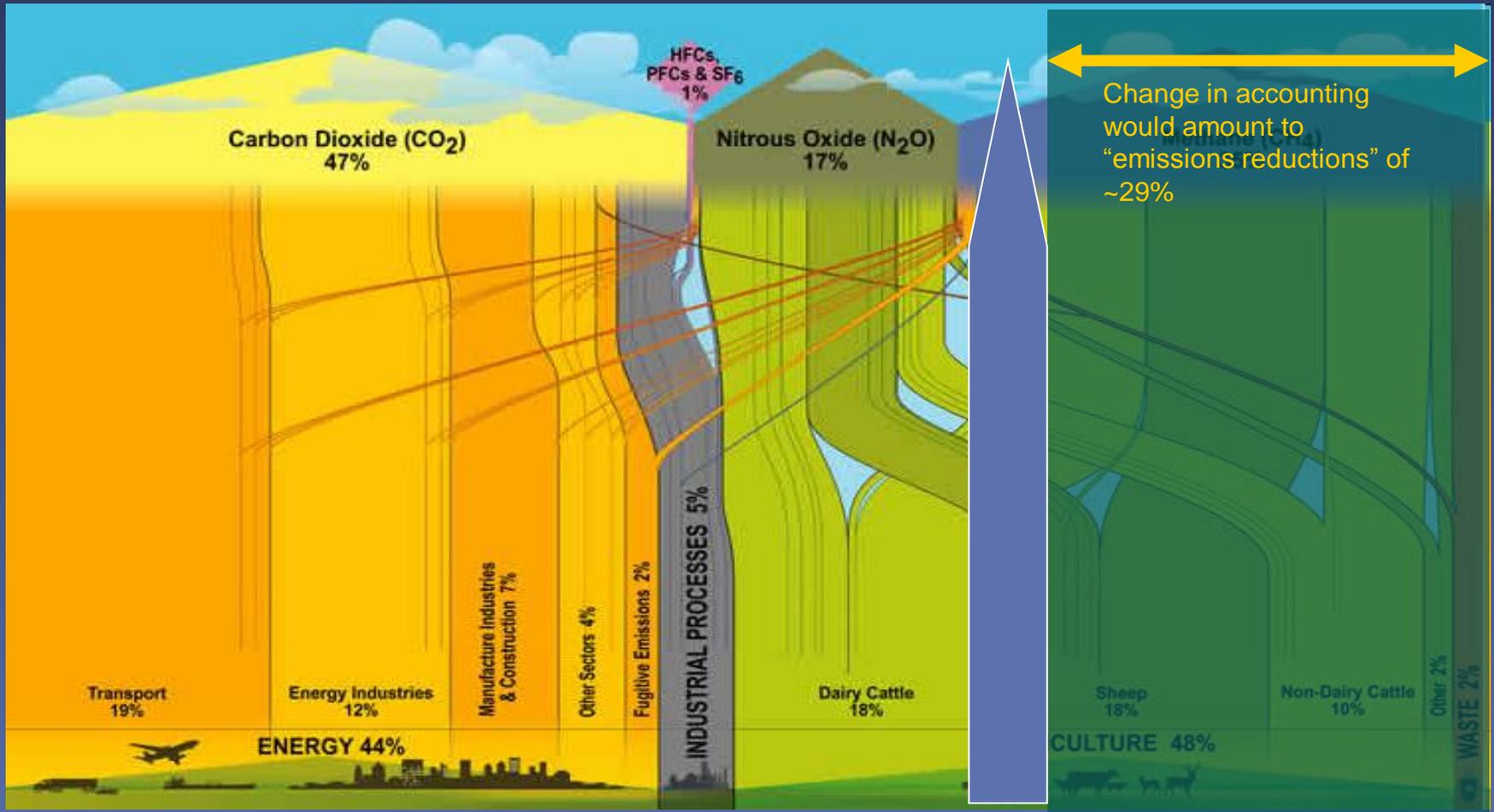


Impact on peak warming of early implementation of SLCF measures versus simultaneous rate of reduction of CO₂ emissions. Vertical axis shows the most likely increase in peak warming resulting from delaying SLCF measures by two decades.

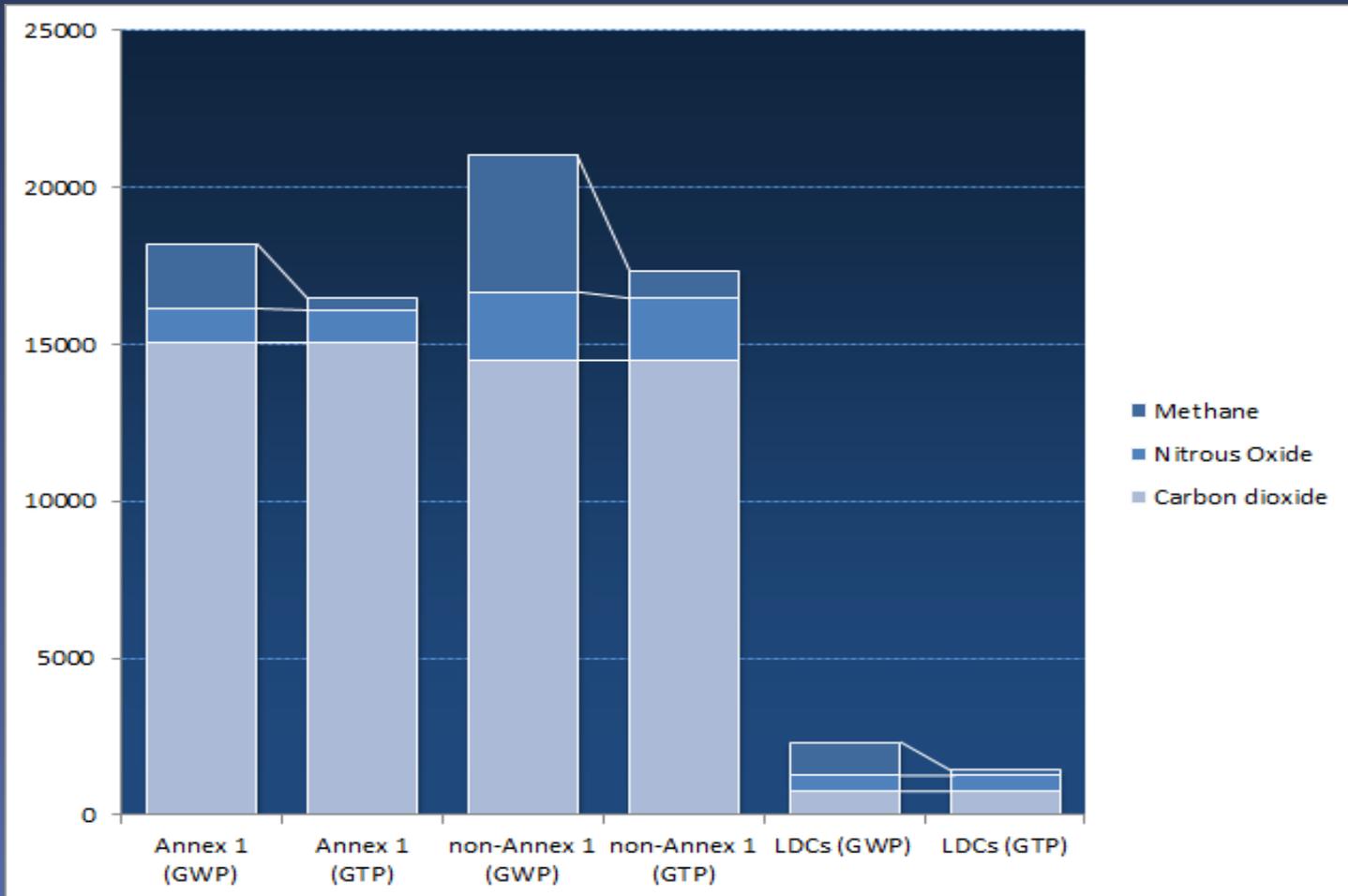
Emissions Accounting



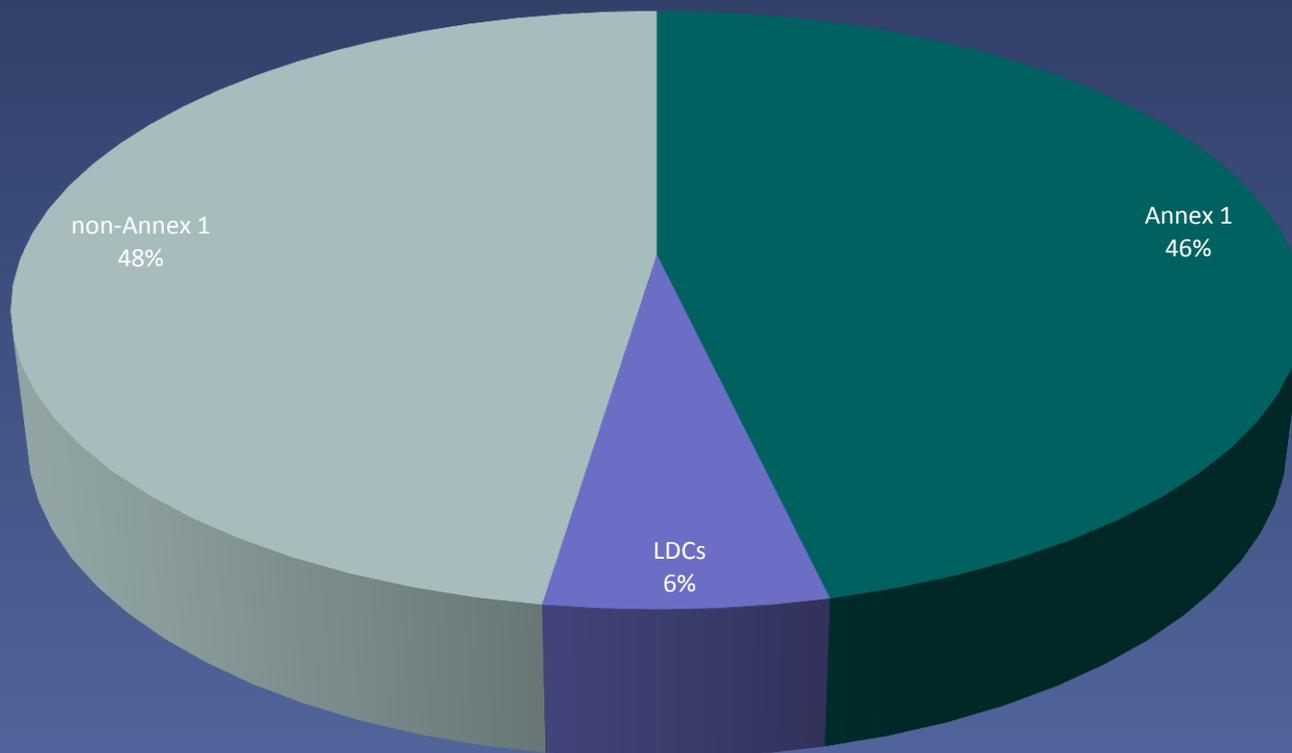
Emissions Accounting



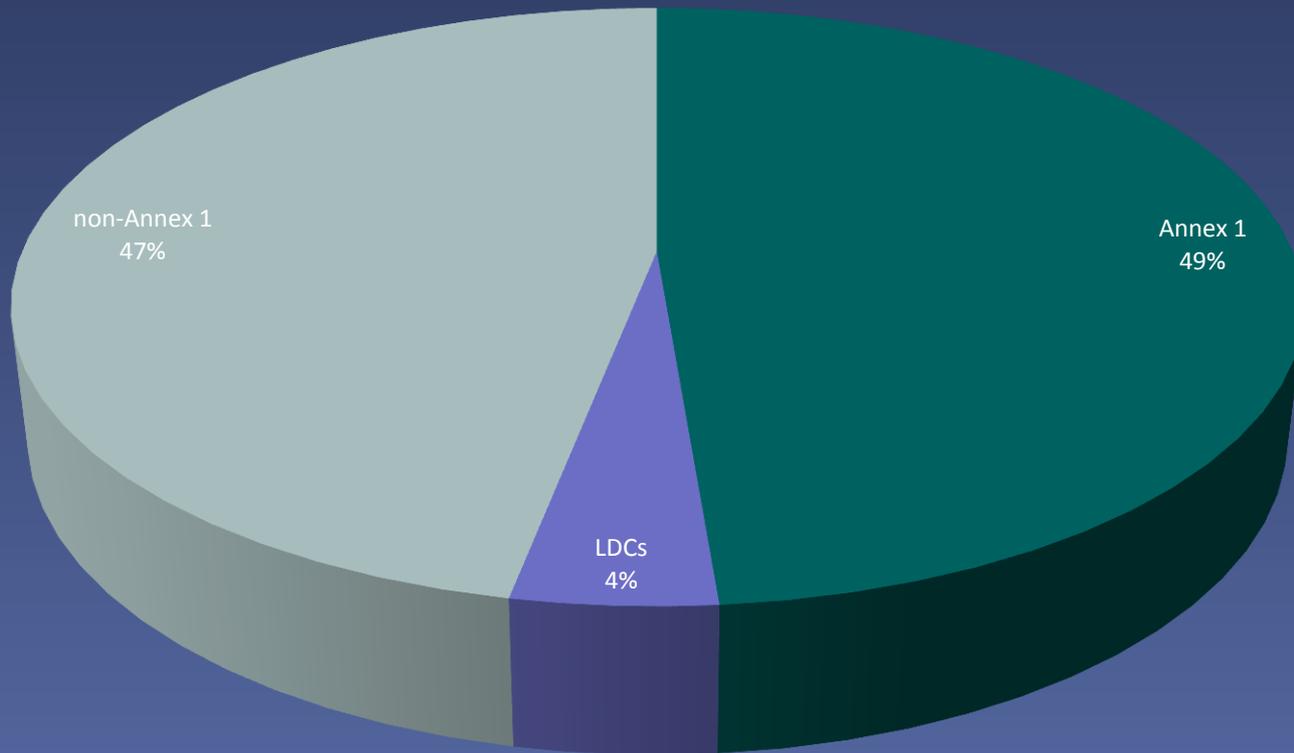
Distribution of emissions under GWP & GTP



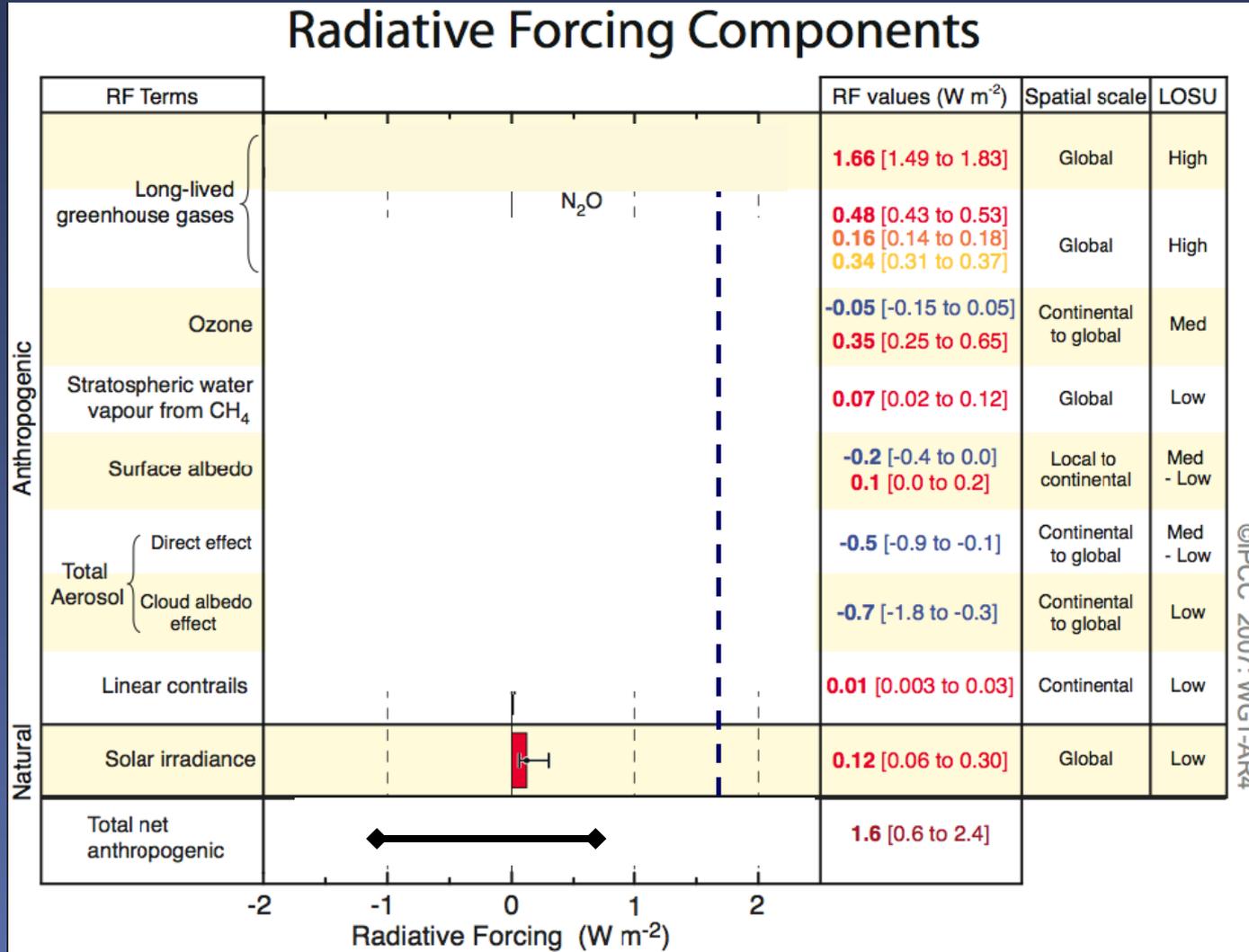
Distribution of emissions: GWP(100)



Distribution of emissions: GTP(100)



Some thoughts on other gases



Elements of metrics

Climate impact	Unit	Examples
○ Radiative forcing	Wm^{-2}	GWP
○ Temperature change	$^{\circ}\text{C}$	GTP
○ Rate of temperature change	$^{\circ}\text{C}/\text{decade}$	
○ Sea-level rise	metres	
○ Damages	\$	Manne & Richels 1990
Function of time	Relationship	Examples
○ Proportional to signal <ul style="list-style-type: none"> • Instantaneous • Trajectory-based 	$m = f(t)$	GTP FEI
○ Rates of change	$m = \frac{df}{dt}$	
○ Integrated over time	$m = \int_{t_1}^{t_2} f(t) dt$	GWP
○ Integrated and discounted	$m = e^{-rt} \int_{t_1}^{t_2} f(t) dt$	Manne & Richels 1990
Principle	Policy justification	Examples
○ Physical proxy	Pros: simple; Cons: lacks policy relevance	GWP
○ Cost-effectiveness	Pros: fairly simple; Cons still second best	
○ Cost-benefit comparison	Pros: first-best; Cons hard	Manne & Richels 1990

Thoughts on the recent developments

- Temperature is almost certainly a better proxy for damages than is time-integrated radiative forcing, given the treatment of the problem in IAMs
- Arbitrary time-horizons are probably less aligned with policy-relevance than are trajectory based approaches
- But trajectory-based approaches can lead to problems, too, especially around credibility & over-prescription
- Near-term pushes on short-lived forcings don't make much physical sense
- Distributional issues are inevitable, but winners & losers depend on the decisions of others

Summary

- Calculation of physically-based metrics is a complicated scientific issue
- Calculation of damage-based metrics is a complex economic issue
- Adoption of any metric is political, since metrics necessarily involve framing choices
- The main policy issue associated with metrics is normative, not scientific: which choices are we to make?
- This has inevitable distributional implications

Implications for NZ

- As a very broad summary, whether switching from GWPs to GTPs is of benefit to New Zealand strongly depends on other climate policy assumptions. In scenarios where agriculture is exposed globally to the full costs of its non-CO2 emissions, New Zealand stands to receive net economic gains due to increasing commodity prices and associated increased export earnings; switching from GWPs to GTPs would reduce those gains. In scenarios where New Zealand is the only country to expose its agriculture sector to the full costs of non-CO2 emissions, it would experience net costs due to its reduced competitive advantage; in that case, switching from GWPs to GTPs would reduce those costs.
- *Andy Reisinger & Adolf Stroombergen, (2011), Implications of alternative metrics to account for non-CO2 GHG emissions*

Concise reading list

- IPCC 1990 Climate Change: The Intergovernmental Panel on Climate Change Scientific Assessment, Cambridge University Press, Cambridge UK
- Shackley S, Wynne B (1997) Global warming potentials: ambiguity or precision as an aid to policy. *Climate Research* 8:89–106
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- Reisinger, A. & A. Stroombergen (2011), Implications of alternative metrics to account for non-CO2 GHG emissions, Report prepared for the Ministry of Agriculture and Forestry