Offsetting Ongoing Methane Emissions — An Alternative to Emission Metrics

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Summary

- Propose methane offset approach to avoid widely recognised difficulties with Global Warming Potential (GWP).
- Offset on-going emissions of 0.9 to 1.05 kg of methane per year and one-off emissions of 1 tonne of carbon.
- Close equivalence in terms of resultant radiative forcing for time scales from decades to centuries.
- Our approach represents an approximate solution to the Forcing Equivalence Index (FEI).
- Proposed approach may provide an attractive mechanism for offsetting methane emissions from rangeland systems.
- Accepted for publication in *The International Journal of Greenhouse Gas Control*.

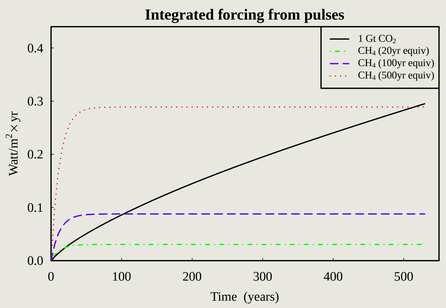
GWP and methane

- Equivalence between greenhouse gases is usually expressed in terms of radiative forcing, often referenced to CO_2.
- Concentration-equivalence is defined in terms of instantaneous radiative forcing
- Emission-equivalence is defined in terms of time-integrated radiative forcing:
  - A choice of 'time-horizon' for integral is required;
  - Ratios relative to CO_2 define Global Warming Potentials (GWPs);
  - GWPs define 'Emission-equivalence' in the Kyoto Protocol.

The 'perturbation lifetime' for methane in the atmosphere is approximately 12 years, whereas CO_2 has an unbounded lifetime. The consequence of this is starkly illustrated in the figure to the right: equivalence in time-integrated radiative forcing between pulse emissions of CO_2 and methane at one time-scale results in large discrepancies at other time-scales. For example, the integrated radiative forcing due to a GWP-100 equivalent emission of methane is much higher than that of CO_2 for times of less than 100 years, and is equally bad in the opposite direction for longer times.

Many studies have criticised the use of GWPs as an 'emission-equivalence' metric due to this lack of robustness over a range of time-scales.

- e.g. large differences in outcomes of 'CO_2-equivalent' scenarios [4].
- This sort of problem is a generic issue for metrics which attempt to define equivalent pulse emissions of CO_2 and methane.
- In particular, 'emission-equivalance' is *not* appropriate for stabilisation of radiative forcing: CO_2 requires a cap on cumulative emissions while methane requires a cap on the rate of on-going emissions [5].



Other approaches

- Analysis of stabilisation of radiative forcing in terms of capping cumulative CO_2 emissions [1, 3].
- Broader analysis in terms of caps on cumulative emissions of CO_2 and N_2O, and caps on ongoing emissions of methane in the context of stabilisation [5].
- Enting et al. (report for Garnaut review of climate change, 2008) proposed the use of 500-year GWPs as a compromise between 100 years (planning horizon) and the infinite time scale of stabilisation.

The most important antecedent is the 'Forcing Equivalent Index' (FEI) noted by Wigley [6]

- The FEI is defined via the following inverse problem: Given a pulse emission of gas A, what time profile of emissions of gas B would result in the same forcing? (at all times)
- The FEI of the CO_2–methane case is closely examined in Manning and Reisinger [2].

Our proposal

Equivalence between a pulse CO_2 release Δ_{CO2} and on-going methane emissions is

$$E_{\mathrm{CH4:ongoing}} = \frac{a_{\mathrm{CO2}}}{a_{\mathrm{CH4}}} \frac{R_{\mathrm{eff}}}{\tau_{\mathrm{CH4}}} \Delta_{\mathrm{CO2}}$$

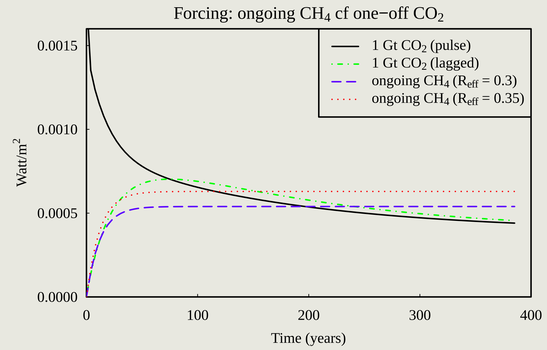
or the converse:

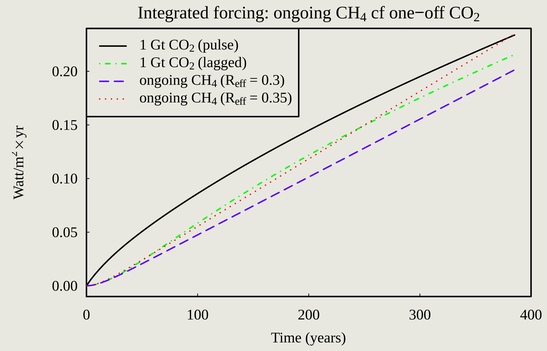
$$\Delta_{\mathrm{CO2}} = \frac{a_{\mathrm{CH4}}}{a_{\mathrm{CO2}}} \frac{\tau_{\mathrm{CH4}}}{R_{\mathrm{eff}}} E_{\mathrm{CH4:ongoing}}$$

where

- τ_{CH4} is perturbation lifetime of methane;
- a_X is forcing per kg of gas X;
- R_{eff} is long-term mean CO_2 impulse response.
- As can be seen in the figures to the right, this new notion of equivalence defined by the single parameter R_{eff} allows for close equivalence for both radiative forcing and integrated radiative forcing of methane and CO_2 emissions. The choice of R_{eff} to be either 0.30 or 0.35 would depend on how conservative one wishes to be in offsetting methane emissions.
- We introduce an additional parameter, τ, as the e-folding time of carbon sequestration, as the example we have in mind is the sequestration of carbon via tree planting to offset ongoing methane emissions.
- The choice $\tau = 40$ is sensible in this context, and allows for even closer equivalence. This case is the 'lagged' CO_2 emission shown in the graphs.
- This approach was previously proposed as the 'Lauder calculator', but is here refined by the introduction of R_{eff}.

Our new approach provides an approximate solution to the FEI problem for methane and CO_2 which is convenient and accurate.





Rangeland systems

Key idea: offset ongoing methane emissions of rangeland cattle by sequestering carbon through tree planting. Why is this desirable?

- Very sparse grazing, low quality feed – little management of herd and little scope for management changes.
- Methane is how ruminants get rid of hydrogen – little scope for major change in biochemistry.
- Thus, offsets are more practical than abatement.
- Applying offsets within a single agricultural unit increases transparency.

Applicability of this approach depends on contexts:

- Agents (farmers through to nations) seeking to be climate-neutral.
- Agents acting within a GWP-based regulatory system.
- Global community seeking to mitigate human influence on climate.

Details for typical rangeland:

- 10 hectares/animal (10 animals per km^2).
- 5.5kg methane per hectare per year must be offset by 6.1 tonnes carbon storage.
- $\Rightarrow$ Offsetting ongoing methane emissions requires (re-)planting 20% of grazing area.

Rangeland habitats at Swan's Lagoon, near Townsville, Qld, Australia. Images due to Meat and Livestock Australia.

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