Offsetting Ongoing Methane Emissions — An Alternative to Emission Metrics


1Carbon Grazing, Queensland, 2MASCOS, The University of Melbourne (corresponding author: ian.g.venting@gmail.com), 3Department of Science, Information Technology, Innovation and the Arts, Queensland, 4Rural Climate Solutions, University of New England/NW Department of Primary Industries, 5IFE, Queensland University of Technology, 6CSIRO Marine and Atmospheric Research, ACT

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.

GWPs and methane

- Equivalence between greenhouse gases is usually expressed in terms of radiative forcing, often referenced to CO2.
- 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 CO2 define Global Warming Potentials (GWP). GWPw defines ‘Emission-equivalence’ in the Kyoto Protocol.

The ‘perturbation lifetime’ for methane in the atmosphere is approximately 12 years, whereas CO2 has an unbounded lifetime. The consequence of this is starkly illustrated in the figure to the right: the equivalence in time-integrated radiative forcing between pulse emissions of CO2 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 CO2 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 CO2-equivalent scenarios [4].
- This sort of problem is a generic issue for metrics which attempt to define equivalent pulse emissions of CO2 and methane.
- In particular, ‘emission-equivalence’ is not appropriate for stabilisation of radiative forcing: CO2 requires a cap on cumulative emissions while methane requires a cap on the rate of on-going emissions [5].

Our proposal

- Equivalence between a pulse CO2 release $\Delta CO2$ and on-going methane emissions is
  
  $$E_{CH4\,\text{ongoing}} = \frac{R_{CH4}}{R_{CO2}} E_{CO2}$$

  or the converse:

  $$\Delta CO2 = \frac{R_{CO2}}{R_{CH4} E_{CH4\,\text{ongoing}}}$$

  where

  - $\frac{R_{CO2}}{R_{CH4}}$ is perturbation lifetime of methane;
  - $\frac{R_{CH4}}{R_{CO2}}$ is forcing per kg of gas X;
  - $E_{CH4\,\text{ongoing}}$ is long-term mean CO2 impulse response.

- As can be seen in the figures to the right, this new notion of equivalence defined by the single parameter $R_{eq}$ allows for close equivalence for both radiative forcing and integrated radiative forcing of methane and CO2 emissions. The choice of $R_{eq}$ 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, $\tau$, 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 CO2 emission shown in the graphs.

  - This approach was previously proposed as the ‘Lauder calculator’, but is here refined by the introduction of $R_{eq}$.

- Our new approach provides an approximate solution to the FEI problem for methane and CO2, 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 km2)
  - 5.9kg methane per hectare per year must be offset by 6.1 tonnes carbon storage.
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References