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Interactive comment on "Technical note: On comparing greenhouse gas emission metrics" *by* Ian Enting and Nathan Clisby

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Conclusions, restructured as suggested by reviewer 2

Our analysis has used the concept of FEI-equivalence to analyse various definitions of greenhouse gas emission equivalence in terms of how closely equivalent emissions at a time t lead to equal radiative forcing at future times. The approach is applied to the consideration of CH_4 emissions in terms of various definitions of their CO_2-equivalent emissions. In the special case of exponentially growing emissions, FEI-equivalence can be achieved when the emissions are scaled by the instantaneous (0 time horizon) GWP, multiplied by the ratio of the asymptotic airborne fractions. This ratio depends on the e-folding growth rate. Various emission metrics can be compared in terms of how

well they match this ratio at the range of relevant timescales. This analysis is equivalent to considering Laplace transforms of the impulse response functions of the respective gases.

GWP treats this ratio as a constant for all timescales, effectively defining GWP_H as the instantaneous GWP multiplied by the ratio of average airborne fractions over the time horizon, H. For CH_4, referenced to CO_2, this means that GWP over-estimates the CH_4 contribution for growth rates less than $1/H$ and under-estimates the CH_4 contribution from shorter timescales.

Metrics relating CO_2-equivalence to rates of change of CH_4 emissions, or emissions of other short-lived gases, are treating the ratio of airborne fractions as proportional to the e-folding rate. This can provide a good representation of long-term behaviour relevant for stabilisation, but over-estimates the role of CH_4 on the shorter timescales relevant for emission trading

A range of metrics that better match FEI over a wide range of timescales from decades to millennia can be constructed. These include the metric proposed by Cain et al. (2019) which compares CH_4 emissions over a 20 year interval, and a reduced model approximation to FEI-equivalence, achieved at the expense of comparisons involving longer time periods.

The political acceptability of metrics other than the GWP will involve various trade-offs between accuracy and practicality. The type of analyses presented here, can help analyse such trade-offs without reference to specific cases of changes in greenhouse gas emissions.

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