**Simple formula for the calculation of the non-CO2 contribution to remaining carbon budgets**

A simple way of accounting for non-CO2 forcing in carbon budgets is to convert everything to CO2 forcing-equivalent (CO2-fe) emissions, or the time-history of CO2 emissions that would give a particular radiative forcing path . This provides the most accurate definition of an ‘all-pollutants CO2 budget’ and is defined in Jenkins *et al.*, 2018. This requires an invertible carbon cycle model, but on decade-to-century timescales CO2-fe emissions may be approximated with a simple formula. If non-CO2 forcing is defined using effective radiative forcing, then human-induced warming ΔT over a multi-decade time-interval is

(1)

where the TCRE is the transient climate response to emissions11,12, represents cumulative CO2 emissions, the average and the change in non-CO2 radiative forcing over that time-interval. This expression does not capture sub-decadal adjustments, so must be defined between periods each of at least a decade in duration. is the Absolute Global Warming Potential of CO2, or the forcing integrated over time-horizon resulting from a one-tonne pulse emission of CO2, and is a constant.

The value of depends on the fractional rate at which forcing is expected to decline over the decades after CO2 emissions are set to zero. This depends on the past forcing history, but an indication is given by noting that zero CO2 emissions is consistent with stable temperatures, and forcing would need to decline at a rate to maintain stable temperatures in the decades immediately following forcing stabilisation after a 70-year linear increase; where ECS is the Equilibrium Climate Sensitivity, TCR the Transient Climate Response and the longer of the two adjustment timescales7,8 of the physical climate system. This implies per year and with years.8–10

For example, using years, years, and converting forcing to emissions using the approximate relationship we find the an equation for the temperature change over a 20 year period in terms of – the average LLCP annual emission rate over that 20 year period (in CO2e using GWP100), – the annual average SLCP emission rate over that 20 year period (in CO2e using GWP100), and – the change in the average SLCP emission rate over the 20 year period (, where / are average annual SLCP emissions in CO2e using GWP100 over the 20 years prior to the start/end year). This is exactly the formula employed in Cain *et al.*, 2019 for CH4, but applied more widely to the SCLPs and LLCPs. For agents with significantly shorter lifetimes than that of CH4 (e.g. aerosols) is best fit to smaller values (e.g. for aerosol RFs ).

Figure 1 shows the application of equation 1 to a set of radiative forcing timeseries to estimate the temperature response to each component. The right panel shows the the contributions to the total temperature response using CO2-forcing-equivalent emissions (solid), while dotted lines show the application of equation 1 to the emissions timeseries (for LLCPs) and radiative forcing timeseries (for SLCPs).

Figure 1: Panel a plots the median radiative forcing timeseries from all 1.5-compatible scenarios available in the IAMC SR15 database[!!]. Panel b plots the temperature response relative to 2018 to those radiative forcing profiles (solid lines) and as calculated using equation 1 (dotted). Parameters used in the production of figure 1 are detailed to the right of panel b.

Also the stuff about comparing it to other metrics!!

**References**