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Mitigating near-term climate change

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1. Introduction

Rapid reduction of greenhouse gas (GHG) emissions is critical to constrain climate warming to socially acceptable levels. This urgency is reflected in the timeline of corporate emission reductions targets: 89% of corporate emissions targets are set for the year 2030 or sooner (figure 1(a)). Immediate cuts of emissions of long-lived climate pollutants (LLCPs), like carbon dioxide (CO_2), will not mitigate the effects of climate change that society is beginning to experience. This is because LLCP emissions remain in the atmosphere over the long term. Mitigating the near-term climate change that society has begun to experience requires removing LLCPs from the atmosphere (Keller *et al* 2018) and cutting emissions of short-lived climate pollutants (SLCPs), like methane (CH_4) (Nisbet *et al* 2020), that have strong warming effects in the first few years after their emission. Despite the need to mitigate near-term climate change, common emissions accounting methods prioritize the impact of interventions over the long term (e.g. 100 years). We synthesize three key criteria for a rigorous framework to measure near-term climate impacts, including both reduced emissions of SLCPs and the removal of CO_2. These criteria are: separate accounting for SLCPs, quantify removal durability rather than assume permanence, and adopt dynamic baseline accounting methods.

2. Criterion 1. Account for SLCPs separately in target setting and monitoring

The standard practice for establishing climate targets is to aggregate all GHGs into a global warming potential (GWP) metric, with a time horizon of 100 years being most common (GWP-100). This approach is well-suited for quantifying the long-term *magnitude* of an emissions reduction or quantifying the impact of a carbon (C) removal that lasts for 100 years. The 100 year norm is based on an outdated justification: multiple time horizons were originally used for GWP comparisons (Fearnside 2002) under the Kyoto Protocol in 1997; 100 years was selected because it was deemed most relevant to societal needs. At that time, the use of a 100 year time horizon for accounting metrics was deemed justifiable because the impacts of climate change were primarily viewed as a future concern. Thirty years later, climate change is no longer only a long-term concern; it has already begun to impact life on this planet (IPCC 2021). To reduce the near-term effects of climate change it is urgent to also limit the *rate* of warming, not just the long-term magnitude, to keep warming in line with the 2 °C target of the Paris Agreement.

Most GHG accounting frameworks and assessments of climate change mitigation potential focus on the magnitude of warming (e.g. cumulative 100 year impact) not the rate of warming. For example, evaluation of natural climate solutions' mitigation opportunity (as captured in IPCC AR6) shows that pathways focusing on reducing CH_4, such as agricultural interventions and wetland conservation or restoration, possess lower technical potential compared to approaches that decrease CO_2, such as reforestation (Roe *et al* 2021). This assessment is not wrong, but the story is incomplete. Reliance on GWP-100—or its emissions equivalent CO_2e—to compare pathways inherently de-emphasizes interventions that reduce emissions of SLCPs and, in turn, contribute to mitigating the effects of near-term climate change. Other metrics exist. GWP-20 uses the same approach as GWP-100, but with a shorter time horizon. Another metric, GWP* (Allen *et al* 2018, Lynch *et al* 2020, Smith *et al* 2021), quantifies the impact of a rate of change in the emission of SLCPs compared to a pulse of an LLCP (Lynch *et al* 2020). Application of GWP* shows that reducing CH_4 emissions by

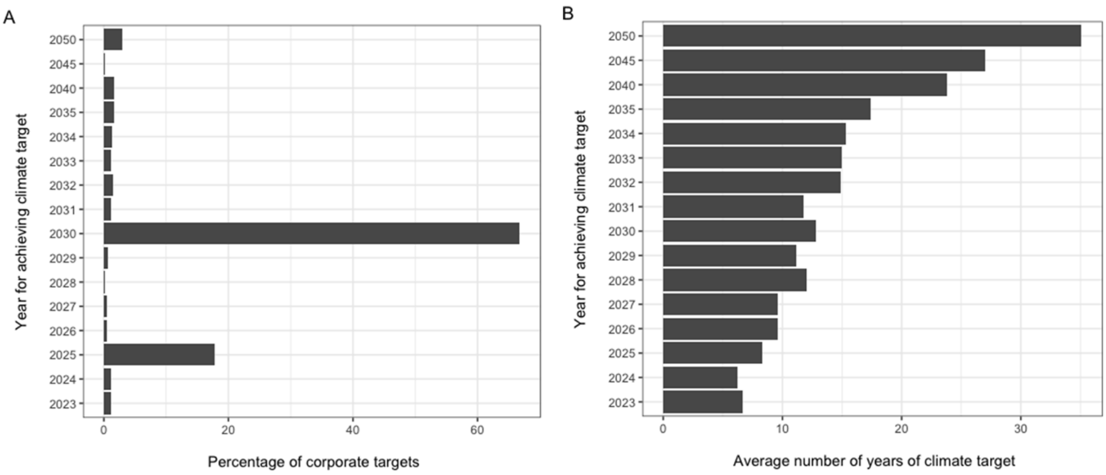

Figure 1. All corporate climate targets are set for the near-term, with the majority set for 2030. Data come from 936 corporate emissions targets reported by the Science-based Targets Initiative Target Dashboard (Science Based Targets Initiative 2023). The vertical axis shows the final year of the climate target. All targets fall between 2023 and 2050. The horizontal axis shows the percentage of all targets established for a given year (A) or the average number of years between the baseline and the target for a given final target year (B).

5% per year between 2020 and 2040 would neutralize the warming impact of agricultural CH_4 emissions since 1981. By contrast, GWP-100 estimates that the same annual 5% decrease would reduce emissions by 2.6 Gt CO_2-e, but would leave a net annual contribution to emissions of 1.3 Gt CO_2-e (Costa C *et al* n.d.). All corporate emissions targets under the Science-based Targets Initiative, one platform for companies to established climate targets, are set for less than 35 years (figure 1(b)), yet the emissions inventory methods used for tracking progress towards targets rely on GWP-100. Although targeting and reporting mechanisms, such as the Carbon Disclosure Project, allow for separate targets for SLCPs, this is not required and not common.

The science is clear that GWP-100 should be retired from accounting frameworks that seek to mitigate near-term warming. To replace GWP-100, separate targets should be required for each SLCP to reflect their differential warming impacts. Both GWP-20 and GWP* should be used for SLCPs because they represent complementary information about warming effects. Not all SLCPs should have required targets; some, such as black carbon, are poorly understood and classified by the IPCC as 'low confidence' (Szopa *et al* 2021). Targets should also consider the life-cycle warming impacts of SLCPs: CH_4 is a precursor to the formation of stratospheric H_2O and ozone (O_3), both of which influence warming, in the presence of NO_x. It is also critical to distinguish between SLCPs that recycle existing GHGs and those that add new C to the system. Biogenic CH_4 (e.g. rice paddies, enteric fermentation, biomass burning, etc) begins as CO_2 removal before being emitted through methanogenesis, while natural gas and CH_4 leakages add new C to the atmosphere and therefore increase the stock of CO_2 in the atmosphere in addition to the near-term warming effect of the CH_4 as an SLCP.

3. Criterion 2. Account for near-term and long-term impacts separately by quantifying removal durability instead of assuming long-term permanence

Carbon removals, in combination with emissions reductions, are essential to mitigate climate change by reducing the stock of GHGs in the atmosphere. The dominant approach to removals accounting is to treat durability as binary: a removal is either permanent or it is not (Weiss 2022). A permanent removal is one that is *ex ante* assumed to remain in the biosphere for a pre-established period, most often 100 years so that a removal can cancel out an emission over a 100 year accounting horizon (Paul *et al* 2023). Yet a growing body of evidence demonstrates that, because of both human land use change and increasing extreme weather events, it is unlikely that all removals will remain in the biosphere for 100 years (Anderegg *et al* 2020). In addition, because of the urgency of addressing near-term climate impacts, a long-term time horizon may not be the most appropriate for mitigating near-term climate change.

Rather than ignoring short-term removals, or assuming that all removals will achieve permanence, we advocate for incorporating short-term removals into climate targets by quantifying the duration of a removal and its resulting impact on radiative forcing (Leifeld and Keel 2022, Leifeld 2023, Matthews *et al* 2023). For example, a soil C removal with a duration of 20 years represents 44% of the net negative radiative forcing of a 100 year removal (Leifeld and Keel 2022).

Short-term removals accounting (also sometimes called tonne-year accounting) has been criticized based on its rigor—either through economic discounts or subjective time horizons—in discounting a removal compared to the impact of a continued emission (Chay *et al* 2022). We advocate for a slightly different use of short-term removals as a separate indicator, specifically with the aim of quantifying the impact of actions on mitigating near-term warming. To operationalize this, we recommend setting separate targets for near-term and long-term climate impacts. For companies, separate targets are already being established based on when actions will be taken (e.g. 2030 targets); we recommend aligning targets on when action will be taken with when impacts will occur (e.g. near-term or long-term). A generalized approach to short-term removals accounting would first quantify the negative net radiative forcing of a removal over some pre-determined reference period(s) using parameters extracted from Earth System Models to represent how C pools adjust to small perturbations in atmospheric CO_2 concentrations (Joos *et al* 2013). We recommend using short- and long-term reference periods (e.g. 20 years and 100 years, or other) to match with separate short- and long-term impact targets. Then, the difference in negative net radiative forcing of the actual removal relative to the removal during the reference period represents the impact of the shorter-term removal (Leifeld and Keel 2022).

Short-term removal accounting methods come with limitations. The cumulative climate impact of a short-term removal critically depends on the oxidation end product of the removal (e.g. whether it is oxidized as CO_2 or as CH_4). A removal of CO_2 that is later emitted as CH_4 would be worse than if the removal were emitted as CO_2 and, depending on the hold time of the removal, may be worse than if the removal had not occurred at all. This could occur, for example, if a reforested area later burnt and smoldered for some time, increasing proportional emissions of CH_4 and higher hydrocarbons compared to the CO_2 that would result from a high intensity burn. Additionally, if the reversal of removals pushes forward emissions to a period where emissions have not yet plateaued, then this could exacerbate climate impacts. It is critical therefore to consider these factors in determining how short-term removals fit into a portfolio of efforts to mitigated either near- or long-term effects of climate change.

4. Criterion 3. Use dynamic baselines to combine durability and additionality into a consolidated approach

In addition to quantifying removal durability, it is also critical to understand whether a removal could be credibly claimed to be caused by an intervention (i.e. additionality). Questions about removal additionality have underpinned recent critiques of natural climate solutions (West *et al* 2020, Guizar-Coutiño *et al* 2022). Additionality is challenging to establish universal yes/no criteria for. Commonly, baseline conditions and scenarios are used to determine if the result of an intervention is different than what would have occurred in the absence of the intervention. Yet the conditions that determine whether a removal would have occurred in the absence of an intervention can change as policies, economics, norms, and biophysical conditions shift.

Dynamic baseline methods offer an alternative by allowing counterfactual estimates to vary as conditions change in the real world and adjust mitigation claims accordingly. For instance, Verra's VM0045 methodology uses a dynamic matched baseline approach where baseline plots are established outside of the project area, paired to a project unit, and monitored through time as a dynamic performance benchmark. This approach simultaneously improves the rigor of claims for additionality (by 'checking' to see if additional climate benefits do indeed accrue over time) and permanence (by building in reversal monitoring to the accounting system). Whether a given removal or avoided emission is additional can be dynamically updated as a function of changing conditions in baseline comparison areas. If a removal is held for 10 years, then the criteria for additionality should be relevant to that 10 year period, not a 100 year crediting period. There is a large body of scientific work on causality and impact evaluation being drawn on for dynamic baseline accounting, such as difference in differences, synthetic controls, matching, and regression adjustments (Athey and Imbens 2017, Abadie 2021).

5. Conclusions

Since the Kyoto Protocol in 1997, a 100 year time horizon has been used to compare the warming effects of different GHGs. Looking only at long-term comparisons fails to account for the near-term climate benefits of SLCP emission reductions and C removals. Most of the emissions targets set by companies revolve around aggressive, near-term targets and immediate actions. Quantifying the near-term climate mitigation benefits of these targets and interventions is critical and requires a different approach to accounting.

We propose three criteria that take large steps toward quantifying—and incentivizing—actions that have both immediate and long-term climate benefits. First, rather than establishing single targets based on long-term warming metrics, separate targets should be established for SLCPs. Second, carbon removals should not be assumed to be permanent and fully fungible with an emission; instead, the warming impact of a removal should be quantified specifically as a function of how long that removal remains out of the atmosphere. Third, dynamic baseline accounting methods should be adopted to more realistically represent the probability that climate actions are additional.

The benefits of adding extra steps to climate accounting frameworks outweigh the shortcomings of continuing to rely on fixed time horizons and binary measures that misrepresent the impact of actions on near-term climate. Accounting for these impacts allocation of resources to climate solutions this decade will positively impact human and natural systems by reducing near-term warming and hence the magnitude of climate impacts over this decade and beyond.

Data availability statement

No new data were created or analyzed in this study.

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