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Putting the brakes on climate change – it's about more than just CO2.

By Kathleen A. Mar, 14 January 2021

RESEARCH ARTICLE

Climate change mitigation is about more than just CO_2. Mitigating a suite of additional pollutants is important for limiting climate change: in particular, taking action on what are known as "short-lived climate-forcing pollutants" (SLCPs). Although it is common to report the effect of non-CO_2 climate warmers in terms of "CO_2 equivalence" they aren't simply "equivalent" – their effects on climate and ecosystem are distinct. In the case of SLCPs, one important difference is in the time horizon: SLCPs have the largest impact on near-term climate whereas CO_2 has the largest impact on long-term climate. This article explores the reasons for these differences and examines why it is important to consider them when designing effective climate mitigation policies. It argues that clear communication on the different time horizons relevant for CO_2 vs. SLCP mitigation is important for clarifying climate policy discussions and ethical decisions regarding the relative importance of near-term vs. long-term effects. It also argues that using a 100-year time horizon as primary basis for evaluating climate effects undervalues the positive near-term effects that can be achieved via SLCP mitigation –including for health, food security and sustainable development – and thus fails to take full advantage of near-term interests to motivate action.

Climate change mitigation is about more than just CO_2

What can we do in response to the climate crisis? Well, one option is to do nothing at all (or nothing more than what has been done already). But most people agree that a world with unchecked climate change – with sea level rise, unprecedented heatwaves, severe droughts and floods, as well as increased social inequality, migration, and conflict – is not a desirable one to live in. For this reason people across the globe are calling for climate action, one key pillar of which is known as climate mitigation, the term used to describe actions to reduce emissions that worsen climate change. The main focus of climate mitigation: reduction of carbon dioxide (CO_2) emissions. Reducing CO_2 emissions to near zero, which largely needs to be accomplished by transitioning away from fossil fuels, is the most important thing we need to do as a society in order to limit climate change. But CO_2 is not the only climate warmer of importance. A suite of additional pollutants is jointly responsible for climate warming – and reducing their emissions is also a key element of climate mitigation. These additional pollutants include long-lived greenhouse gases treated in the 1997 Kyoto protocol such as nitrous oxide (N_2O), sulfur hexafluoride (SF_6), and halocarbons as well as an important category of non-CO_2 climate warmers known as “short-lived climate-forcing pollutants (SLCPs)”, usually defined to include methane (CH_4), tropospheric ozone (O_3), black carbon (BC, commonly known as soot), and hydrofluorocarbons (HFCs). Reducing SLCPs could avoid approximately 0.5 °C of additional warming by 2050 [UNEP/WMO, 2011], and the IPCC Special Report on Global Warming of 1.5°C emphasizes that all pathways that are consistent with the 1.5° target include deep cuts in SLCPs as well as CO_2 [IPCC, 2018].

To set climate mitigation goals and to measure how much has been achieved in this regard, it is common to group all the warming pollutants together and express their total effect in terms of “CO_2 equivalence”, where the “equivalence” is based on comparing climate effects on a 100-year timescale via the metric “global warming potential” or GWP (here GWP100, considering the 100-year time horizon). While practical in many contexts, this simplification obscures the fact that these other pollutants are distinct from CO_2 in many ways, including their effects on climate, ecosystems, and human health. In the case of SLCPs, one important difference is in the time horizon in which they impact the climate. Mitigation of SLCPs is most effective at slowing near-term climate warming (i.e. between now and 2050), whereas mitigation of CO_2 is the most important thing to do for limiting long-term climate warming (i.e. 2100 and beyond). This article explores the reasons for these temporal differences and examines why it is important to consider them when designing effective climate mitigation policies. I argue that the continued dominance of using 100-year time horizons (via GWP100) as the primary basis for evaluating climate impacts is disadvantageous in two major ways: it obscures potential trade-offs in short- vs. long-term effects when making policy decisions, and it undervalues the positive near-term effects that can be achieved via SLCP mitigation – and the associated political benefits of motivating action based on near-term self-interest.

Caring for climate: near- and long-term considerations

Global average temperature has already risen by 1°C compared to pre-industrial times [IPCC, 2018], but this change plays out very differently from region to region. Depending on where you live, you may or may not have noticed the effects of climate change. Perhaps you live in a region where its effects are felt relatively subtly – for instance, with warmer and drier summers or less snow in the winter. But there are regions of the world already experiencing dramatic impacts of climate change – one example being the Australian bush fires in December 2019-January 2020, which scientists concluded were made at least 30% more likely because of climate change [G.J. van Oldenborgh et al., 2020]. Another example is the Saami community in northern Scandinavia, who see the warmer winters they are experiencing as a threat to their entire culture, because it endangers the reindeer herds around which their life is traditionally centred [Climate Action Network Europe, 2020]. Climate change has long been perceived as a distant threat, but the evidence is clear: climate change is not just a problem for “the future” anymore; we are already experiencing the consequences of climate change today.

How did we get here? The climate change that we experience today is the aggregate effect of cumulative emissions of CO_2 and other long-lived greenhouse gases (GHGs) since humans first began emitting them in earnest during the industrial revolution, plus the effect of more recent emissions of short-lived climate forcers, including SLCPs [M.R. Allen et al., 2018]. Let’s disentangle these effects.

One of the more pernicious qualities of CO_2 is that it accumulates in the atmosphere – once it is emitted into the air, it takes a long time for it to be removed via uptake by the land and oceans. Given a pulse of CO_2 injected into the atmosphere today, approximately 40% of it will be removed from the atmosphere 20 years from now, an additional 20% percent will be removed 100 years from now, and 20-30% will still remain in the atmosphere 1000 years from now [F. Joos et al., 2013]. This is why we are still feeling the effects of CO_2 emitted into the atmosphere at the start of the industrial revolution, and why our emissions today will affect generations to come. What does this mean for CO_2 mitigation? Even if we stopped burning all fossil fuels tomorrow, the stabilization of the climate would be slow, precisely because of the time it takes for CO_2 to be removed from the atmosphere. And yet this is also why the time to act is now: our emissions today are “locking in” the climate change that will be seen by our grandchildren.

SLCPs behave very differently in this regard, as illustrated in table 1. The “short-lived” descriptor in their name refers to the fact that they have short residence times in the atmosphere compared to CO_2. This means that when we stop emitting these pollutants, the atmosphere and climate system react much more quickly: if we completely stopped emitting

SLCPs tomorrow, atmospheric concentrations would drop to natural background concentrations within weeks to decades, and the beneficial climate effects would also be felt in this time frame – that is, in our lifetimes. Studies indicate that rapid reduction in SLCP emissions could also slow the rate of climate change, reducing the risk of triggering dangerous and potentially irreversible climate tipping points (as one example, the possible irreversible retreat of the Greenland ice sheet) and allowing more time for climate adaptation [D. Shindell et al., 2017].

Table 1. Overview of selected climate-warmers.

Pollutant	Atmospheric residence time[a]	GWP20[a,b]	GWP100[a,b]	Notable non-climate impacts
Carbon dioxide (CO2)	Decades to millennia[c]	1	1	
Hydrofluorocarbons (HFCs)	15 years[d]	3700[e]	1300[e]	
Methane (CH4)	12 years	84	32[f]	A precursor to tropospheric ozone, which harms human health and causes crop losses
tropospheric ozone (O3)	Weeks	N/A[g]	N/A[g]	A harmful air pollutant to breathe, which also damages plants and leads to crop losses
black carbon (BC)	Days to weeks	N/A[g]	N/A[g]	A component of fine particulate matter (PM2.5), an air pollutant that is harmful to breathe

a) Unless otherwise indicated, values are taken from IPCC AR5.
b) The metric Global Warming Potential (GWP) is a measure of how much heat a gas traps relative to carbon dioxide. GWP20 makes this comparison using a 20-year time horizon and GWP using a 100-year time horizon.
c) Because of its different atmospheric removal processes, a single atmospheric residence time cannot be assigned to CO2.
d) Weighted by usage; following Xu and Ramanathan 2017. Note that HFCs refer to a category of pollutants, whose individual lifetimes vary.
e) For HFC-134a, a commonly-used HFC.
f) From Etminan et al. 2012; Represents an increase from the value of 28 from IPCC AR5.
g) The atmospheric residence times of tropospheric ozone and black carbon are so short when compared to CO2 that calculating GWP values is not meaningful.

Clear communication on the different time horizons relevant for CO_2 vs. SLCP mitigation is important for clarifying climate policy discussions, and the political decisions that may need to be made regarding the relative importance of near-term vs. long-term effects [J.K. Shoemaker et al., 2013; I.B. Ocko et al., 2017]. This can become relevant, for example, in debates over the benefits of CH_4 as a “bridge” fuel during the transition to renewable energies, promoted because of methane’s more favourable climate balance than other fossil fuels. For instance, since methane’s potency as a greenhouse gas is more pronounced at short timescales (table

1) proponents of natural gas tend to emphasize its GWP100 (of 32), whereas opponents emphasize its GWP20 (of 84). That is, methane appears to be less harmful for climate if its 100-year impact is reported.

SLCPs as "super pollutants"

Some advocates have underscored the importance of mitigating SLCPs by calling them "super pollutants". One reason for this characterization is the fact that, on a kg-per-kg basis, the SLCPs hydrofluorocarbons and methane are much more potent warming agents than CO_2 (table 1). This is true whether a 20-year or 100-year time horizons is considered (table 1). For instance, methane is approximately 80 times more potent a warmer than CO_2 in the first 20 years after it is emitted, and 30 times more potent than CO_2 when a 100-year time horizon is considered. HFCs are thousands of times more potent than CO_2 on a per-kg basis.

Beyond climate impacts, the SLCPs methane, tropospheric ozone and black carbon also contribute to air pollution worldwide, providing even more reasons to reduce their emissions. With impacts such as lung disease, heart disease, and neurological disorders, air pollution contributes to approximately 7 million premature deaths annually, making it the number one environmental health risk faced by humans [WHO, 2020]. Beyond shortening life spans, air pollution negatively impacts our day-to-day lives, causing respiratory illness and leading to days of missed work and school, and a general reduced quality of life. Furthermore, tropospheric ozone damages plants and leads to millions of tonnes of crop losses annually. Improving health and reducing crop losses would be valuable contributions to sustainable development worldwide.

From a political perspective, it is a distinct advantage that arguments for reducing SLCP emissions can be made based on near-term self-interest [D.G. Victor et al., 2015]: slowing near-term climate warming, reducing air pollution and improving crop yields are benefits that citizens could experience today and in the near future. Particularly in many developing country contexts, these near-term benefits often resonate with national political interests – such as reducing local air pollution and advancing sustainable development – opening up political opportunity for acting on SLCPs. Furthermore, measures to reduce SLCP emissions can be implemented with existing technologies and practices, and many are also cost-effective. One simple example of this is the collection of landfill gas, which is primarily composed of methane and can then be used for fuel. Raising awareness on the opportunities of SLCP mitigation with this type of political messaging is one of the key strategies of the Climate and Clean Air Coalition (CCAC), a voluntary partnership of governments, scientific institutions and civil society organizations whose mission is to catalyse fast action to reduce SLCPs [CCAC, 2020]. If clear reporting on and consideration of both short- and long-term effects of climate policy were to become more mainstream within the climate community, it could also serve to strengthen the political motivations for acting on SLCPs.

The way forward: climate mitigation for now and the future

If we want to effectively limit climate change, both in the near-and long-term, we have to reduce both types of emissions: CO_2 and the long-lived GHGs as well as the short-lived climate forcers. The good news is that phasing out fossil fuels will reduce both CO_2 and SLCPs at the same time: the burning of carbon-based fuels generates CO_2 and air pollutants, including SLCPs, which are then emitted together from smokestacks and exhaust pipes. However, not all air pollutants have a warming effect on climate – sulfur dioxide (SO_2) and inorganic aerosols, also co-emitted during fossil fuel combustion, have a cooling effect, “masking” some of the warming we would otherwise feel [Y. Xu and V. Ramanathan, 2017]. Nevertheless, we still have very good reasons to reduce these pollutants – namely their high toxicity and negative impacts on human health – and a recent study shows that even an aggressive transition to a non-fossil energy society provides a net benefit for climate and human health from decadal to centennial time scales, despite concurrent reduction of cooling aerosols [D. Shindell and C.J. Smith, 2019].

To fully address SLCPs, however, we need to go beyond phasing out fossil fuels and address other emitting sectors. Methane and black carbon emissions from the agriculture and waste management sectors, for example, have important climate as well as health impacts. HFCs are primarily used as coolants, where they were introduced to replace the stratospheric-ozone depleting chlorofluorocarbons (CFCs). Phasing out HFCs as coolants while at the same time introducing more energy-efficient cooling technologies is one way to reduce CO_2 and HFC emissions at the same time, with a double benefit for climate. Addressing these and other often-neglected SLCP sectors is another important part of the work of the CCAC [CCAC, 2020].

From a legal perspective, CO_2 and SLCPs are regulated under different national and international policy frameworks. CO_2 and CH_4 are both greenhouse gases covered under the UNFCCC Paris Agreement and its predecessor, the Kyoto Protocol. The phase-down of HFCs is now regulated by the 2016 Kigali Amendment to the Montreal Protocol, a treaty that was originally agreed upon to address stratospheric ozone depletion. Tropospheric ozone and black carbon have traditionally been treated as an air quality (rather than climate) concern, and are regulated primarily under national laws, as well as under a few international (but not global) agreements. One important international agreement in this regard is the Gothenburg Protocol. This protocol, covering many countries in the Northern Hemisphere (including Europe, the USA and Canada, but excluding much of Asia), explicitly targets the reduction of SLCPs BC and O_3 both for their negative impacts on human health and their warming impact on climate [Y. Yamineva and S. Romppanen, 2017].

Several countries, including Norway, Canada, Mexico, Ghana, Nigeria, and others, have prioritized SLCP mitigation, considering it a central element of national climate and air quality strategies [CCAC, 2020]. If this momentum can be translated into actual, on-the-ground emission reductions at a global scale, then it will certainly be a win for climate, air quality and health. Equally important is that SLCP reduction strategies be developed together with strategies for deep cuts in CO_2 emissions and a plan for phasing out fossil fuels – for it is clear that action on both short- and long-lived climate forcers is essential for limiting the most dangerous effects of anthropogenic climate change. And while there is increasing discussion in academic and political spheres about the importance of distinguishing between different time horizons for mitigation of different climate forcers, this has not yet been mainstreamed into the UNFCCC: according to the rules for the Paris Agreement, GWP100 is the metric that should be used in national reporting [UNFCCC, 2018]. I expect that any expansion of the Paris Agreement rules to additionally include metrics for shorter time frames (e.g., GWP20) will only happen if there is significant demand from the countries themselves. With some countries already including SLCPs in their national commitments under the Paris Agreement (the so-called “Nationally Determined Contributions” of Mexico, Chile and Nigeria all include separate sections on SLCPs, for example), perhaps this could indeed come to pass.

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