Offsetting is a dangerous smokescreen for inaction

Offsetting carbon emissions – the approach of trading "credits" that represent a benefit intended to equally compensate for harmful emissions, in exchange for continuing to burn fossil fuels – is receiving increased attention (eg Anderson *et al.* 2017; Laville 2019). Large corporations, including Google, Apple, and Shell, along with airlines, US states, international cricket teams, and even music bands, plan to or already use this strategy, in attempts to reduce the impact of their business choices on the climate.

Most offsetting schemes follow the principle that the buyer is allowed to emit carbon in exchange for paying for emissions that have already been captured or avoided elsewhere. These schemes are controversial due in part to the complexities of ensuring that the carbon remains captured, a lack of oversight on the schemes' comprehensive environmental or social impacts (Cushing *et al.* 2018), and uncertainty over whether the carbon offset is additional to what would have been stored in absence of the offset program (Anderson *et al.* 2017). There is also evidence that offsetting schemes, despite their original intent, may actually discourage reductions in emissions, or even facilitate their unabated increase (Anderson 2012).

This situation is complicated by the dynamic nature of, and the interactions and feedbacks within, the Earth system, which can undermine the effectiveness of offsetting approaches. Once released, carbon dioxide (CO_2) immediately begins to warm the atmosphere. It then takes between 6 months to 1 year for a subset of that atmospheric CO_2 to equilibrate across the ocean's surface (Gattuso *et al.* 2010). Once absorbed by the ocean, this CO_2 will only return to the atmosphere a few hundred years later, due to the slow internal movement of water. This long-term absorption has helped to slow the impact of global warming, but is also driving ocean acidification (Raven *et al.* 2005). Many marine organisms are already being negatively impacted; some are coping, but future resilience is unclear (IPCC 2019).

Consider a single transatlantic flight taken during 2018. One year later, ~44% of the flight's CO_2 emissions are likely still in the atmosphere, ~30% have been absorbed by terrestrial plants, but ~23% have been absorbed and locked away by the ocean (Friedlingstein *et al.* 2019). In the time between the release of emissions and attempts to "re-capture" those emissions, they are already warming the atmosphere, and a portion will have been locked away in the ocean and will already be negatively affecting marine life.

Because the majority of offsetting services pay for carbon already captured (as the credit applies to historical emissions that have already been absorbed or avoided), they do nothing toward capturing the emissions of the person paying for the offset. Therefore, if everyone chooses to offset their emissions, the current rates of ocean acidification and atmospheric warming are likely to continue. The only sources of carbon that will have a net zero impact on the climate are those that are not emitted to the atmosphere and are not made available to the ocean. By overlooking the difference between the timescale of the Earth system's response to emissions and the timescales relevant to offsetting schemes, proponents of offsetting may have inadvertently transformed it into a method of avoiding emissions reductions, which could lead to inaction.

Reputable carbon offsetting schemes that are endorsed by leading pro-environmental groups may provide long-term benefits to the environment and society. Even so, investors in and users of offsetting schemes must realize that no scheme genuinely offers a solution for achieving net zero emissions, or a net zero impact on the climate. To transition to net zero emissions they should instead not only invest in technologies and supply chains that minimize emissions but also use renewable sources of energy. This tactic would support rapid and strong mitigation of CO_2 emissions. Otherwise, investors and users must accept that their decision to solely offset is at the expense of our ocean, the food it provides, and ultimately our climate.

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Changing climate in Brazil's "breadbasket"

Marks *et al.* (2020) critiqued the paper by Costa *et al.* (2019), which warned that Amazonian deforestation would