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Specialty grand challenge: renaming our section to "Carbon Dioxide Removal"

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While the concept of removing carbon dioxide (CO_2) from the atmosphere to help prevent climate change has been around for decades, it is only relatively recently that its importance within climate policy has moved into mainstream discussions. As such, conventions for nomenclature are widely debated (for examples, see Table 1). The proposed methods of removing CO_2 from the atmosphere to restore a level that ensures a stable climate, are diverse and often share little in their form and function beyond their impact on atmospheric CO_2. However, for this reason alone, it is useful to refer to these within an umbrella term. In this editorial, we outline why the editorial board has decided to rename this section of Frontiers in Climate to "Carbon Dioxide Removal".

The original title for the section "Negative Emission Technologies" (NETs) was first used in a paper title by Lemoine et al. (2012), although "negative emissions" seems to have been used perfunctorily in the climate modeling community (e.g., Harvey, 2004) as a useful driver to a desired atmospheric CO_2 concentration, and the "technologies" for achieving this were implicit (Azar et al., 2006), and finally explicitly referred to as NETs (Azar et al., 2010) specifically for biomass energy carbon capture and storage. It similarly has been used within life-cycle analysis (LCA) to describe emissions reduction approaches that result in a net negative value on LCA emissions balance sheets (e.g., Brinck et al., 2011). McLaren (2012), responding to the use of "negative emissions" terminology by the UK Climate Change

TABLE 1 The use of terminology to describe the removal of CO_2 from the atmosphere from IPCC 1.5 degree report and the 6th Assessment Report.

Carbon Dioxide Removal	"Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but excludes natural CO_2 uptake not directly caused by human activities."
Negative Emissions	"Removal of greenhouse gases (GHGs) from the atmosphere by deliberate human activities, i.e., in addition to the removal that would occur via natural carbon cycle processes."
Net negative emissions (IPCC 1.5 degree) Net negative greenhouse gas emissions (AR6)	"A situation of net negative [greenhouse gas] emissions is achieved when, as result of human activities, more greenhouse gases are removed from the atmosphere than are emitted into it. [when metric weighted anthropogenic greenhouse gas (GHG) removals exceed metric-weighted anthropogenic GHG emissions]. Where multiple greenhouse gases are involved, the quantification of negative emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon)."
Greenhouse gas removal	"Withdrawal of a GHG and/or a precursor from the atmosphere by a sink."

Committee, was the first to connect negative emissions with the broader set of technologies that perform the function (although with a preference for "techniques") and encompassing non-CO_2 greenhouse gasses. NETs has subsequently been used in high level reports by the Committee on Developing a Research Agenda for Carbon Dioxide Removal Reliable Sequestration (2019) and the European Academies' Science Advisory Council, EASAC (Courvoisier and European Academies Science Advisory Council, 2018), and it was within this context that the name was chosen for this section (Renforth and Wilcox, 2020).

"Carbon Dioxide Removal" (CDR) has been used extensively (e.g., an early example specifically referring to removal from the atmosphere is Spector and Dodge, 1946). CDR was also the preferred sub categorization within the emerging discussion on "Geoengineering" (Keith, 2000; The Royal Society Shepherd, 2009; NASEM, 2015). The term appears to be favored within the IPCC's 6th Assessment Report (AR6), referenced in both Chapter 3, 4, 7 and 12 of working group III to specifically refer to the approaches that remove CO_2 from the atmosphere (Babiker et al., 2022; Lecocq et al., 2022; Nabuurs, 2022; Riahi et al., 2022). "Negative emissions" is used by AR6 to refer to outcome of applying CDR at a systems level, rather than the removal approach. The "technologies" within NET is almost entirely omitted from use within AR6, and follows concerns about the drawing of arbitrary lines between "natural" and "technological" CDR (Bellamy and Osaka, 2020). Likewise, within international, European and US governance policy landscapes, the terms "carbon removal" and "CDR" are now consistently used (see for example negotiations around Article 6.4 of the Paris Agreement (UNFCCC Secretariat, 2015), the EU legislative process on the certification of carbon removals (European Commission, 2022), the proposed US Federal Carbon Dioxide Removal Leadership Act (US Congress, 2022) and other policy spheres (Schenuit et al., 2021; Schenuit and Geden, 2023). Finally, the term has been the preferred choice in the influential Carbon Dioxide Removal Primer (Wilcox et al., 2021).

An initial reason for the choice of NETs for the section was that CDR can easily be confused with processes that remove CO_2 from other gases, especially carbon capture and storage (CCS) which was first suggested in 1977 (under the moniker "geoengineering" Marchetti, 1977), and developed throughout the 1990s and 2000s—therefore long before CDR came into policy debates. More recently, there have been advances in using the captured carbon (carbon capture and utilization CCU). The confusion between CCS and CDR is highly problematic given their similar names but different climate policy purposes (the former helping to reduce emissions, the latter compensating for residual emissions or contributing to net negative emission pathways). Careful consideration of locating CDR within the landscape of climate change responses is well established academically (Heyward, 2013), and the differentiation for policy has also been well articulated (Schenuit et al., 2023). While the risk of confusion remains, the possible impact is less than in 2018 and CDR has since become a well-established term.

The use of "Greenhouse Gas Removal" (GGR) followed early use of CDR in a categorization review by Boucher et al. (2014), and has been used almost exclusively in Europe, and especially in the UK (Royal Society, 2018). It was included in the glossary of the IPCC's Special Report on Global Warming of 1.5°C (Masson-Delmotte et al., 2022), but omitted from the glossary of AR6 and considered only as a previously used term. Research considering the removal of other, short-lived, greenhouse gases (e.g., methane) from the atmosphere is still at a relatively early stage, with the direct comparison with CO_2 removal not being particularly helpful given that the removal of short-lived gases has a similar impact on climate as reducing their emissions. It is of equal relevance that CDR approaches do not only differ in the processes that captures the CO_2 from air or bodies of water, but also in the fate of the CO_2 and how long it remains removed from the environment.

Academic journals play a vital role in disseminating scientific knowledge and fostering scholarly communication. They serve as platforms for researchers to share their findings, exchange ideas, and catalyze scientific progress. CDR is a field of interdisciplinary research, and it is essential for our section in Frontiers in Climate to embrace the broadest appeal to accommodate the needs of the scientific community. Furthermore, the use of "Negative Emission Technologies" can impose an unnecessary restriction to the potential authorship and readership of the journal as non-technical aspects such as policy, legal, and social implications are not limited to individual technologies. On the contrary, "Carbon Dioxide Removal" has a greater potential of engaging audience from a broader field of Social Sciences and Humanities. We believe that renaming the section to Carbon Dioxide Removal uses the most widely used terminology for what the section publishes.

Author contributions

PR: Conceptualization, Writing—original draft, Writing—review and editing. RB: Writing—original draft, Writing—review

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The authors declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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