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Measurement and verification of carbon dioxide removal on land and in the ocean

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Meeting the Paris Agreement goal of limiting the increase in global temperature to less than 2 °C above pre-industrial levels not only requires significant and rapid reductions in greenhouse gas emissions but also active removal of carbon dioxide (CO_2) from the atmosphere. Various technological and nature-based solutions for achieving both permanent emission reductions and carbon removal are being explored but key to accelerating their scale-up for effective climate action is the need to establish robust carbon accounting methodologies.

The first part of this presentation focuses on detection and quantification of potential leakage from sub-seafloor CO_2 storage sites. I summarise results of a recent CO_2 release experiment conducted in the North Sea that injected CO_2 mixed with inert tracers into the sub-seabed sediments and tracked the CO_2 as it was transported through the sediments and across the seabed into the water column [1]. CO_2 leakage was effectively quantified in both dissolved and gas phases and it was found that the proportion of CO_2 that was transferred into the water column increased as a function of the CO_2 injection rate. The presence of injected CO_2 in the water column was rapidly verified by shipboard analysis of tracers.

The second part of the presentation focuses on measurement and verification of atmospheric carbon dioxide removal via enhanced rock weathering (ERW) [e.g., 2]. Application of freshly pulverised rock material to agricultural land speeds up natural weathering processes that convert atmospheric CO_2 into hydrogen carbonate ions (alkalinity) or carbonate minerals (carbon mineralisation). I summarise results from a series of large-scale field experiments that have revealed the intricacies of quantifying CO_2 removal via ERW, including the need to determine the alkalinity source (silicate vs carbonate weathering) and the need to account for intra-annual variability in soil carbonate content. The presentation concludes by setting out a road map for establishing protocols for effective and accurate carbon accounting.

[1] Flohr A. et al., (2021) *Int. J. Greenhouse Gas Control* 106, 103237.

[2] Beerling D.J. et al., (2020) *Nature* 583, 242-248.