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# Geochemical monitoring for detection of $CO_2$ leakage from subsea storage sites

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Carbon Capture and Storage (CCS) in subsea geological formations is a promising large-scale technology for mitigating the increases of carbon dioxide ($CO_2$) in the atmosphere. However, detection and quantification of potential leakage of the stored $CO_2$ remains as one of the main challenges of this technology. Geochemical monitoring of the water column is specially demanding because the leakage $CO_2$ once in the seawater may be rapidly dispersed by dissolution, dilution and currents. In situ sensors capture $CO_2$ leakage signal if they are deployed very close to the leakage point. For regions with vigorous mixing and/or deep water column, and for areas far away from the leakage point, a highly sensitive carbon tracer ($C_{seep}$ tracer) was developed based on the back-calculation techniques used to estimate anthropogenic $CO_2$ in the water column. Originally, the $C_{seep}$ tracer was computed using accurate discrete measurements of total dissolved inorganic carbon (DIC) and total alkalinity ($A_T$) in the Norwegian Sea to isolate the effect of natural submarine vents in the water column. In this work we assess the effect of measurement variables on the performance of the method by computing the $C_{seep}$ tracer twice: first using DIC and $A_T$, and second using partial pressure of $CO_2$ ($pCO_2$) and pH. The assessment was performed through the calculation of the signal to noise ratios (STNR). We found that the use of the $C_{seep}$ tracer increases the STNR ten times compared to the raw measurement data, regardless of the variables used. Thus, while traditionally the pH-$pCO_2$ pair generates the greatest uncertainties in the oceanic $CO_2$ system, it seems that the $C_{seep}$ technique is insensitive to that issue. On the contrary, the use of the $pCO_2$-pH pair has the highest $CO_2$ leakage detection and localization potential due to the fact that both $pCO_2$ and pH can currently be measured at high frequency and in an autonomous mode.