Are mangrove carbon exports old or modern? A multiple radio- and stable isotope analysis

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Around half of the carbon fixed by mangroves globally is unaccounted for in current carbon budgets. Much of the "missing" carbon may be associated with the underground respiration of organic matter which is exported via groundwater flow. In mangrove systems, crabs burrows and macropores created by dead roots may expose buried carbon to changes in redox conditions, and potentially lead to the remineralisation and export of old carbon (100's to 1000's of years old). This has important implications for the global "blue carbon" stocks in mangroves. To assess whether old or modern carbon is exported, we measured Δ^{14}C-DIC concentrations in a mangrove creek hourly over a tidal cycle. In addition we measured groundwater radiogenic geochemical tracers (^{223}Ra, ^{224}Ra, ^{226}Ra and ^{222}Rn), along with continuous measurements of δ^{13}C-CO_2 using a cavity ring down spectrometer. There was significant export of DIC from the mangrove system that had a δ^{13}C value matching mangrove organic matter. The export was driven by underground carbon respiration and subsequent export via groundwater as determined via radiogenic tracers. Interestingly, the age of the exported DIC as determined by a mixing and mass balance model of measured Δ^{14}C-DIC values, was 100's of years old, suggesting that the timescale used to estimate long term carbon burial in mangroves should be longer than what is currently used (typically buried carbon > 30 years old is considered "permanent"). The results also suggest that there might be at least two distinct pathways for carbon export from mangroves – 1) Remineralisation of "young" shallow surface organic matter which is lost directly to the atmosphere as CO_2 within the mangrove forest, and 2) Remineralisation of "old" buried carbon which is exported via lateral groundwater export to the coastal ocean. Measuring these pathways in conjunction will help to adequately constrain carbon budgets and determine the long term burial capacity of mangroves.