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Determining the transit time of carbon in soils

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The large organic carbon (OC) reservoir in soils makes them an important source or potential sink for the greenhouse gas CO_2. Knowledge on the timescale that carbon resides in soils is necessary to model how much of the total soil carbon stock is labile and respired back to the atmosphere. While radiocarbon (14C) contents of bulk soil samples inform about the average time that carbon in that sample stayed in the soil, 14C of respired CO_2 informs rather about carbon transit times. Therefore, we determined both for samples from tree depth profiles of three German beech forest sites on different parent material. We hypothesized that 14C contents of respired OC would be younger than bulk OC and that the age of respired carbon would get older with incubation time if increasingly more stable carbon is respired.
Confirming our first hypothesis, 14C contents of bulk soils samples ranged between 100 and 102 pMC in 0-10 soil depth, while those of respired CO_2 ranged between 104 and 107 pMC in the first month of incubation, suggesting a larger contribution of bomb-derived carbon to respired CO_2. With increasing incubation time, the bomb content of respired CO_2 increased further to values between 105 and 112 pMC after five months. While 14C contents of respired CO_2 declined similarly with soil depths than bulk soil carbon, the decline was less pronounced and values of respired CO_2 always exceeded those of bulk soils. These results were independent if samples incubated in undisturbed soil cores or after sieving and removal of roots. 14C contents of respired CO_2 are therefore a more suitable indicator for the transit time of carbon in soils than bulk samples and can be used to model respective differences between sites and soil depths.