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Unresolving the “real age” of fine roots in forest ecosystems

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Estimating the turnover time of tree fine roots is crucial for modelling soil organic matter dynamics, but it is one of the biggest challenges in soil ecology and one of the least understood aspects of the belowground carbon cycle. The methods used - ranging from radiocarbon to ingrowth cores and root cameras (minirhizotrons) - yield very diverse pictures of fine root dynamics in forest ecosystems with turnover rates reaching from less than one year to decades. These have huge implications on estimates of carbon allocation to root growth and maintenance and on the persistence of root carbon in soils before it is decomposed or leached. We will present a new approach, involving techniques to study plant anatomy, which unravels the “real age” of fine roots.

For a range of forests with diverse water and nutrient limitations located at different latitudes, we investigated the annual growth rings in the secondary xylem of thin transversal sections of fine roots belonging to tree species which form distinct growth rings. In temperate forests we find mean root “ring ages” of 1-2 years while in sub-arctic forests living fine roots can also persist for several years. The robustness of these results were tested by counting the maximum yearly growth rings in tree seedlings of known age and by counting the maximum number of growth rings of fine roots grown in ingrowth cores which were kept in temperate forest soils for one and two years. Radiocarbon estimates of mean “carbon ages”, which define the time elapsed since structural carbon was fixed from the atmosphere, instead average around a decade in root systems of temperate forests (mixture of newly produced and older living roots). This dramatic difference may not be related to methodological bias, but to a time lag between C assimilation and production of a portion of fine root tissues due to the storage of older carbon components. The time lag depends very likely on tree species and environmental conditions. We further observed that the root ring age increases with root diameter although it does not appear to be related to the branching order. Our findings suggest that both the physiological and radiocarbon ages must be modelled jointly in forest ecosystems, if we want to correctly account for the inputs of root litter