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Boron biogeochemical cycle in forest ecosystem: a question of long term soil-water-plant dynamic

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The boron biogeochemical cycle in forest ecosystem is particularly imprinted by vegetation cycling. This control by plants explains that soil solutions have a boron isotopic composition very close to the that of the litter. However, a review of boron in forest ecosystems highlights large isotopic fractionation, towards ^{11}B enrichment, between plant tissues and soil minerals while no significant isotopic fractionation is observed during boron uptake by tree roots. This isotopic fractionation is particularly marked in young plant tissues. The origins of the boron isotopic fractionation are internal to the plants and have to be found during its transfer from old to young tissues and the boron partitioning between the perennial (wood) and annual (leaves) biomass. Investigations of boron isotopes in different soil-water-plant systems reveal that the magnitude of the boron isotopic fractionation between plant tissues and soil minerals may depend on the boron bioavalaibility in soil and therefore reveal mechanisms of plant acclimatation to environmental conditions.

We developed a numerical box-model of the boron biogeochemical cycle at the soil-water-plant scale intended to to determine the nodes of boron isotopic fractionation and the possible boron isotopic response to changes of the environmental parameters. The model was calibrated to reproduce the B stocks, fluxes and isotope observed in the beech tree plots developped on two different type of soils in Montiers (France): a deep acid soil (Dystric Cambisol) with a large pool of bioavailable B and a shallow calcareous soil (Rendzix Leptosol) with a reduced pool of bioavalaible boron. The model results emphasize that the fractionation of boron isotopes is primarily controlled by two parameters. The first one, internal to the plant, is the partition of absorbed boron between perennial and ephemeral tissues. This partition is the driver of the observed boron isotopic fractionation between plant and soil. The second one, internal to the soil, is the partition of boron between plant recycling and water drainage. This rate controls the long-term boron evolution of the ecosystem.