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CO and H2 uptake and emissions by soil: variability of fluxes and their isotopic signatures

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In order to study the uptake and release of H2 and CO by soil, we performed long term, high frequency measurements with an automatic soil chamber at two sites in the Netherlands (Cabauw – grassland, and Speuld – forest). The measurements were performed over different seasons and cover in total a cumulated interval of about one year. These measurements allow determining separately, for each species, the two distinct fluxes i.e. uptake and release, and investigating their temporal variability and dependencies on environmental variables.
Additional experiments were performed for determining the isotopic signatures of the H2 and CO uptake and release by soil. Flask samples were filled from the soil chamber, and then analyzed in the laboratory for the stable isotopic composition of H2 (δD) and CO (δ13C and δ18O).

We find that both uptake and release are present at all times, regardless of the direction of the net flux. The emissions are significant for both species and at Cabauw, there are times and places where emissions outweigh the soil uptake. For each species, the two fluxes have different behavior and dependence on external variables, which indicates that they have different origins.

The isotope results also support that, for both H2 and CO, uptake and emission occur simultaneously. We were able to determine separately the isotopic effects of the two fluxes. For both H2 and CO, soil uptake is associated with a small positive fractionation (the lighter molecule is taken up faster). The soil uptake fractionation (α = kheavy/klight) was 0.945 $\pm$ 0.004 for H2; for CO, the fractionation was 0.992 for 13C and 0.985 for 18O. The isotopic composition of the H2 emitted from the grassland was -530 $\pm$ 40 ‰ less depleted that what is expected from the isotopic equilibrium of H2 with water. For CO, the isotopic composition of the soil emission is depleted in 13C compared to atmospheric CO, and lower than the average isotopic composition of plant or soil organic matter.