Supplementary material

S1. Incubation characteristics

The isotopic characteristics of the labeling experiment are summarized in the table S1.

Table S1 : Incubation characteristics and the initial isotopic compositions of the labeling experiments. $^{13}A_m$, A_m and A_w are respectively the ^{13}C and ^2H abundance of the added labeled source (molecule or water) and $^{13}A_{tot\_i}$, A_{tot_i} are respectively the ^{13}C and ^2H abundance of the total soil at the initial conditions (time 0).

				$^{13}A_m$ %			$^{13}A_{tot\_i}$ % ± 0.02			A_m or A_w %			A_{tot_i} % ± 0.005		
Experience	Added molecule	mg	^2H_2O	Cambisol	Podzol	Leptosol	Cambisol	Podzol	Leptosol	Cambisol	Podzol	Leptosol	Cambisol	Podzol	Leptosol
	phenylalanine	22.9	-	6.08	11.08	13.08	1.28	1.29	1.22	2.015	2.015	3.015	0.041	0.052	0.026
	glucose	37.5	-	6.08	11.08	16.08	1.28	1.29	1.25	2.015	2.015	3.015	0.057	0.076	0.033
Experiment 1	glucose	12.5	-	-	11.08	-	-	1.15	-	-	3.015	-	-	0.046	-
$^{13}C^2H + ^1H_2O$	glucose	25	-	-	6.08	-	-	1.15	-	-	2.015	-	-	0.056	-
	isoleucine	27.3	-	6.08	11.08	16.08	1.28	1.29	1.25	2.015	2.015	3.015	0.060	0.080	0.035
	palmitic acid	20	-	6.08	11.08	16.08	1.28	1.29	1.25	2.015	2.015	3.015	0.057	0.076	0.033
	phenylalanine	22.9	yes	6.08	11.08	16.08	1.28	1.29	1.22	0.28	0.46	0.27	0.284	0.470	0.275
	glucose	37.5	yes	6.08	11.08	16.08	1.28	1.29	1.25	0.28	0.46	0.27	0.015	0.015	0.015
Experiment 2	glucose	12.5	yes	-	11.08	-	-	1.15	-	-	0.46	-	-	0.015	-
$^{13}C^1H + ^2H_2O$	glucose	25	yes	-	6.08	-	-	1.15	-	-	0.46	-	-	0.015	-
	isoleucine	27.3	yes	6.08	11.08	16.08	1.28	1.29	1.25	0.28	0.46	0.27	0.015	0.015	0.015
	palmitic acid	20	yes	6.08	11.08	16.08	1.28	1.29	1.25	0.28	0.46	0.27	0.015	0.015	0.015
Experiment 3	-	-	yes	-	-	-	1.08	1.08	1.08	0.28	0.46	0.27	0.015	0.015	0.015
Control	-	-	-	-	-	-	1.08	1.08	1.08	-	-	-	0.015	0.015	0.015

S2. Mass balance calculations

All the variables are summarized in the table S2.

Carbon:

$$C_{tot} = C_{dfm} + C_{dfs} \quad \text{(SI1)}$$

$$^{13}A_{tot}*C_{tot} = {}^{13}A_m*C_{dfm} + {}^{13}A_{tot\_0}*C_{dfs} \quad \text{(SI2.a)}$$

$$^{13}A_{tot}*C_{tot} = {}^{13}A_m*C_{dfm} + {}^{13}A_{tot\_0}*(C_{tot} - C_{dfm}) \quad \text{(SI2.b)}$$

from SI1 and SI2 we derive:

$$C_{dfm} = ({}^{13}A_{tot} - {}^{13}A_{tot\_0})/ ({}^{13}A_m - {}^{13}A_{tot\_0})* C_{tot} \quad (1)$$

Hydrogen:

After freeze-drying, hydrogen is considered in three compartments: (i) NEH derived from labeled molecule atoms, (ii) NEH from unlabeled sources, and (iii) exchangeable hydrogen, which is by definition equilibrated with the atmosphere with a given fractionation ε_1

$$H_{tot} = H_{dfm} + H_{dfs} + H_e \quad \text{(SI3)}$$

$$A_{tot}*H_{tot} = A_m*H_{dfm} + A_{dfs}*H_{dfs} + (A_{atm} + \varepsilon_1)*H_e \quad \text{(SI4)}$$

from SI3 and SI4 we derive:

$$A_{tot}*H_{tot} = A_m*H_{dfm} + [A_{dfs}*H_{dfs} + (A_{atm} + \varepsilon_1)*H_e]/(H_{dfs} + H_e)*(H_{tot} - H_{dfm}) \quad \text{(SI5)}$$

The term $[A_{dfs}*H_{dfs} + (A_{atm} + \varepsilon_1)*H_e]/ (H_{dfs} + H_e)$ is the average composition of unlabeled hydrogen. It is derived from the analysis of the unlabeled sample:

$$H_{tot\_0} = H_{dfs} + H_e \quad \text{(SI6)}$$

$$A_{tot\_0} = [A_{dfs}*H_{dfs} + (A_{atm} + \varepsilon_1)*H_e]/(H_{dfs} + H_e) \quad \text{(SI7)}$$

from SI5 and SI7 we derive:

$$A_{tot}*H_{tot} = A_m*H_{dfm} + A_{tot\_0}*(H_{tot} - H_{dfm}) \quad \text{(SI8)}$$

$$H_{dfm} = [(A_{tot} - A_{tot\_0})/(A_m - A_{tot\_0})]*H_{tot} \quad (2)$$

By similarity, for Experiment 2 (labeled water), we write:

$$H_{dfw}= (A_{tot} - A_{tot\_0})/(A_w - A_{tot\_0}]*H_{tot} \quad (3)$$

These equations are based on approximations: the isotope fractionation term between atmosphere and exchangeable H is supposed to be equal in labeled and unlabeled samples: this is supported by the fact that the amount of exchangeable hydrogen is considered unaffected by the (small) amount of introduced labeled material. The amount of unlabeled HNE (H_{dfs}) and its abundance (A_{dfs}) are considered equal in the labeled and unlabeled samples. Inequality would affect the denominator in equations (2) and (3). Equality is a numerical approximation without consequence, owing to the very high enrichment of labeled material (A_m, $A_{w,}$ see table S1).

Table S2: Definition of the variables used for mass balance calculation

Variables		Definition
Quantity (mg g^{-1} dry soil)	C_{tot}	Total amount of carbon in the soil
	H_{tot}	Total amount of hydrogen in the dry soil
	C_m	Initial amount of carbon in the added molecule
	H_m	Initial amount of non-exchangeable hydrogen in the added molecule
	H_w	Total amount of water hydrogen in the soil
	H_e	Amount of exchangeable hydrogen in the dry soil
	C_{dfs}	Amount of unlabeled carbon already present in the soil
	C_{dfm}	Amount of carbon derived from molecule
	H_{dfs}	Amount of unlabeled non-exchangeable hydrogen present in the soil
	H_{dfw}	Amount of non-exchangeable hydrogen derived from water
	H_{dfm}	Amount of non-exchangeable hydrogen derived from molecule
Abundance	$^{13}A_{tot}$	^{13}C abundance of the total bulk soil
	A_{tot}	^{2}H abundance of the total bulk soil
	$^{13}A_{tot\_0}$	^{13}C abundance of the unlabeled experiment (control)
	A_{tot_0}	^{2}H abundance of the unlabeled experiment (control)
	$^{13}A_m$	Initial ^{13}C abundance of the labeled molecule
	A_m	Initial ^{2}H abundance of the labeled molecule
	A_w	Initial ^{2}H abundance of the labeled water
	A_{atm}	^{2}H abundance of the atmosphere

S3. Propagation error calculation

Uncertainties on the element and isotope ratio measurements affect the estimate of the amount of labeled-source derived carbon or hydrogen atoms. To assess the uncertainty σ_{Cdfm} (err7), σ_{Hdfm} (err8), σ^2_{Hdfw} (err9) or on the calculated values C_{dfm} (Eq. 6), H_{dfm} (Eq. 7), and H_{dfw} (Eq.8) we calculated the statistical error propagation of the uncertainties on measured isotopic compositions and element content of replicated samples presenting in supporting information.

$$\sigma^2_{Cdfm} = (\sigma^2_{13Atot} + \sigma^2_{13Atot\_0})*[C_{tot}/(^{13}A_m - {}^{13}A_{tot\_0})]^2 + (\sigma^2_{13Am} - \sigma^2_{13Atot\_0})*(^{13}A_{tot} - {}^{13}A_{tot\_0})^2*C_{tot}^2/(^{13}A_m - {}^{13}A_{tot\_0})^2 + \sigma^2_{Ctot}*[(^{13}A_{tot} - {}^{13}A_{tot\_0})/(^{13}A_m - {}^{13}A_{tot\_0})]^2 \qquad \text{(err6)}$$

$$\sigma^2_{Hdfm} = (\sigma^2_{Atot} + \sigma^2_{Atot\_0})*[H_{tot}/(A_m - A_{tot\_0})]^2 + (\sigma^2_{Am} - \sigma^2_{Atot\_0})*(A_{tot} - A_{tot\_0})^2 * H_{tot}^2/(A_m - A_{tot\_0})^2 + \sigma^2_{Htot}*[(A_{tot} - A_{tot\_0})/(A_m - A_{tot\_0})]^2 \qquad \text{(err7)}$$

$$\sigma^2_{Hdfw} = (\sigma^2_{Atot} + \sigma^2_{Atot\_0})*[H_{tot}/(A_w - A_{w\_0})]^2 + (\sigma^2_{Aw} - \sigma^2_{Aw\_0})*(A_{tot} - A_{tot\_0})^2 * H_{tot}^2/(A_w - A_{w\_0})^2 + \sigma^2_{Htot}*[(A_{tot} - A_{tot\_0})/(A_w - A_{w\_0})]^2 \qquad \text{(err8)}$$

where the indices of the terms σ_X stand for the standard deviation of the respective variable. In this calculation, the uncertainties σ^2_{Am}, σ^2_{Aw} and σ^2_{13Am} were considered as negligible.