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Interactive comment on "Carbon transfer, partitioning and residence time in the plant-soil system: a comparison of two $^{13}CO_2$ labelling techniques" *by* M. S. Studer et al.

Anonymous Referee #1

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This manuscript provides a useful comparison of two common isotopic labelling methods. As well as elaborating on assumptions regarding the contrasting approaches based on their own experiments, it provides a useful theoretical background on how turnover of C in different pols in plants and soil are calculated. It is well written (I have only minor suggestions – see below), and I find the figures and tables all informative. A number of specific issues should be addressed before final acceptance, but overall I find this an interesting study worth publishing.

The difference in calculated turnover times between the two methods is large – in fact worryingly large. Some suggestions are made regarding the steady-state assumption on which exponential and inflection point based calculations are based, as biological

systems are never at a complete steady state during the growing season. Still, a very large correction based on changes in pool size over the tracer period would be required to achieve even approximate agreement between the pulse and continuous labelling approaches. Is there more to it than the pool change that is overlooked in the theory of using decay and inflection points that should be highlighted?

Regarding the growth vs steady state assumption, I think the dotted lines in Fig. 1 may be drawn on the wrong side of the steady state trace. For a pulse chase experiment, a growing system would surely show a sharper peak where the pulse-derived C is diluted more quickly in tissue and stores by un-labelled post-pulse assimilates. For the continuous figure, the pulse derived C should represent a larger proportion of pool C in a growing system as more labelled C is found as a proportion of the total than would be expected in a steady state system?

3 replicates are a low number for isotopic labelling studies, give the inherent variability in assimilation and allocation observed. For a lab study this may seem less of a problem, but also here I think that more replicates would have enabled a more robust analysis. It's worth acknowledging this and including it as a recommendation for future studies.

As well as discussing the differences between the turnover calculations, I think that the discussion should also include approaches of modelling tracer C in systems that makes more specific reference to recent and existing C in pools. This partly addresses the growth issues by incorporating GPP and NPP information and hence actual turnover in labile and structural biomass pools. I understand that the approach here is to look at conventional bulk 13C turnover for the two methods, but use of even quite simple models can help resolve the actual movement and hence turnover of C in different pools. See Street et al (Oecologia 167:325-337) for an example of using C turnover models in a pulse chase experiment. Another issue for many pulse or continuous labelling studies is that often the amount of assimilated label is not measured or calculated, even though many set-ups would allow this to be done. This would allow return fluxes and

BGD

10, C6392–C6396, 2013

tracer pools to be expressed as a fraction of assimilated C, rather than of all pols for a given point in time.

Specific comments

16238, 5: delete “the” before “pulse” and “continuous”

16238, 15: The term “cuttings” appears throughout the text, and I was at first confused. I suggest explaining at least once that these are stem sections from which plants were grown by sprouting. It’s a fairly special case as far as comparison to natural systems are concerned, but reasonable to include for tracer pools here.

16238, 25: State which approach this over-and under estimation refers to.

16239, 7: “of” rather than “on”

16240, 10: comma after “labelling”

16240, 11: FACE originally meant “Free Air CO2 Enrichment”. To include other tracers, it has been used as “Free Air Concentration Enrichment”. I’m not aware of it meaning “Carbon Exposure”, as this is not really a good description of what it is. . .

16240, 17: I’m not sure about the use of the word “approved”, as it implies some authorisation – maybe better to say “accepted”?

16240, 21-22: “Hardly possible” is not right. Do you mean “complex” or simply “difficult”?

16241, 6: “time” rather than “moment”.

16241, 14: Delete “we”

16241, 19: I’m not sure what you mean by “fresh biomass”. It’s plant biomass, or not?

16242, 4; “Facility”, rather than “device” (?)

16243, 3-6: Please specify the concentration of CO2 in addition to the isotopic values

BGD

10, C6392–C6396, 2013

for the duration of the pulse.

16244, 20: “where” rather than whereas”

16246, 14: “latter”, rather than “later”

16247, 5: I don’t see that much modelling in this section What you describe are regression fits that are used to calculate turnover, and measuring lag times. Without C flux information and dynamic calculation of net fluxes and pool sizes, I don’t see how this section deals with modelling.

16247, 9-10: Make it clear that you refer to net import and net export of 13C. This is close to the issue of accounting for turnover, as the assumption of both approaches work on fairly simple phases of lag, import and export. In reality, 13C export starts almost as soon as there is import, as e.g. roots will start respiring pulse-derived 13C as soon as it becomes available n the labile C pool in roots. What happens post peak or inflection is that export processes proceed at a faster rate than import processes. This should be clarified here and in figures and also very clearly in the discussion of turnover. (See my point on modelling pools in this context.)

16247, 19-16248, 8: This section is not correctly placed. Please work this into the discussion, as it is based on your interpretation of results.

16248, 18: “compartment in plant-soil system” or “plant or soil compartment”, rather than plant-soil compartment”. I’m not sure what it is supposed to mean. . .

16248, 24-25: “analogously”, and no comma to follow it; no “the” before “roots”, “microbial” and “cumulative”

16249, 16: “latter”, not “later”

16251, 4: “within” rather than “already”

16251, 9-11: This is not correct. The same amount of label yields the same strength in signal. I think what you mean to say is that the same amount of assimilation results in

BGD
10, C6392–C6396, 2013

a stronger signal under higher enrichment than it does under low enrichment as in the CL. Please make this distinction between “assimilated C” and “label” more clearly.

16251, 21: “By contrast” rather than “On the opposite”

16252, 11: no comma after “reveal”

16253, 14/15: “very” rather than strongly”, and “early” rather than “first” (?)

16254, 25: no comma after “compartments”

16256, 7: “strongly”

Table 2 caption: Also here I struggle to see how these are modelling results. Maybe call it “Calculated 13C distributions” instead? The caption is quite long, and most of the parameter explanation is actually provided in the column headers – consider shortening.

Table 3: I suggest “plant and soil compartments” (2nd row in caption). To improve legibility, maybe increase spacing after every second row in the table (below rows with error terms). You need to specify what the errors (I assume that’s what’s in brackets) indicate. The last two points also apply to Table 4

Figure 1: I think the first short sentence of the caption is redundant. Make it clear that you refer to net import and export in the figure!

Figure 2: delete “the” after “Dynamics in”. Make it clear that you refer to 13C in excess of natural abundance here.

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