

Response to editor's comments.

A very convincing study which was presented to-the-point. Great to see this formal proof that also thermal fractions remain heterogeneous mixtures of fast and slow cycling SOM. The idea to indeed in future also a priori subdivide SOM into mineral and free OM before engaging in a similar RPO/Py-GC/MS analysis seems very appropriate to me. In doing so we might further discover several less composite thermal fractions.

RESPONSE: Thank you for the kind words.

Just two more points where I see room for improvement.

1° As pointed out by referee 1 conditions for pyrolysis were quite different between the 'Py-GC-MS' and off-line pyrolysis for 'Ramped pyrolysis oxidation'. It should be recognized in the discussion that one cannot just assume that the sequential Py-GC-MS was really able to 'mimic' oxidation at various temperatures during ramped pyrolysis oxidation. Of course sources of pyrolysis products (CO₂ for RPO and volatilized compounds for Py-GC) will display quite some correspondence but a 'perfect match' seems impossible.

RESPONSE: We have added a short but full paragraph (L254-259) recognizing this limitation and suggest new research to better understand how matched or mismatched the two data sources are.

2° No interpretation is given on the distinct $\delta^{13}\text{C}$ of the various thermal fractions. Without this it would in fact be best to omit these data. For instance: why are F1 and F2 that similar in their $\Delta^{14}\text{C}$ but different in their $\delta^{13}\text{C}$? Could this be related to the shift in relative proportions of lipids/lignin/phenols?

RESPONSE: Reconciling the ^{13}C and ^{14}C could make for an interesting discussion as there are intriguing trends that might lead to the differential response. In an earlier draft we attempted such a paragraph but in the end felt it was too speculative without further data so decided to remove it. In the end, we have decided that the focus of this paper is on the ^{14}C and py-GC/MS data so we have removed the ^{13}C data from the manuscript. Measurement of ^{13}C is still in the methods section and the ^{13}C data are still reported in the appendix because these data are necessary for correcting the ^{14}C data.

Minor comments:

I can certainly follow that the authors refrained from trying to really explain the time series of OM composition. But perhaps you might still want to comment on the following two points: Fig.1 How could you match the lower thermal stability of the >1963 soils with their lower OC%? Seems contradictory. + in in 1973: $\Delta^{14}\text{C}$ was -27.3 ‰ → reason?

RESPONSE: Good points for us to clarify in the paper.

Without replication in the RPO measurements it is difficult to know if the shift in the 1963 thermogram compared to the 1973-1993 thermograms is significant or not. We could not explain the low ^{14}C value for the fraction of the 1973 sample and treated it as an outlier in the turnover modeling. Unfortunately, we did not have the financial resources to rerun this sample.

L117 superscript for -1

RESPONSE: Corrected.

L217 studies'

RESPONSE: Corrected.

L220 dominant?

RESPONSE: Yes, dominant not 'dominate'

L238 something wrong with this sentence here

RESPONSE: Yes, this sentence as written did not make sense. We have revised to: "Secondary chemical reactions in soil (de Assis et al., 2012) and wildfire (González-Pérez et al., 2004) as well as the pyrolysis process itself (Hatcher et al., 2001) are potential sources of heterocyclic N, but direct plant and microbial inputs also make a key contribution to this pool (Leinweber et al. 2014; Paul, 2016)."

352 'soil comes from'

RESPONSE: We're not sure what line is being referenced here. L352 is in the references.

L252 'site'

RESPONSE: Corrected.

Fig. 1 Difficult to discern thermograms for the different years: use colour perhaps instead of shades of grey. °C instead of C

RESPONSE: Because color is already used in the background to differentiate the 5 fractions, we cannot use color for the plots but we have revised the figure to use different dot-dash patterns for the 4 thermograms. 1973-1993 are nearly identical so regardless of color or line pattern these would be hard to differentiate, but now 1963 plot should be much easier to pick out from the others.

Table 2 -> units for τ_{fast} and τ_{slow} + perhaps in the caption repeat meaning of τ

RESPONSE: Units were added. τ was defined below the table

Table b2 two different notations are used for the fraction of modern C: 'F modern' and 'Fm' -> keep one.

RESPONSE: Corrected to F modern in both column headers.