Reviewer 1

Comments:

Line 148-149: The role of the second oven is not sufficiently explained here.

Re: We thank the reviewer for this constructive comment. We agree that the function of the second oven was not clearly described in the original text. The revised sentence reads:

"...while the second oven is maintained at constant temperature and contains catalytic material to ensure complete oxidation and removal of non-carbon species."

Line 159-160: Strictly speaking, comparability across temperature windows requires that all experimental conditions are consistent, including carrier gas flow, heating rate, oxygen availability, and other operational parameters. If these differ between the applied techniques, then the same nominal temperature intervals may not correspond to equivalent processes or OM fractions. I therefore suggest that the authors explicitly clarify a bit here.

Re: We thank the reviewer for this important comment and agree that direct comparability across temperature windows requires consistent experimental conditions, which is not the case for the applied techniques. We have revised the sentence to clarify that the predefined temperature windows serve as a conceptual framework for comparison rather than representing directly equivalent OM fractions across methods. The revised sentence reads:

"...selected to provide a consistent temperature framework for comparison with the SoliTOC decomposition scheme. While this alignment facilitates cross-method interpretation, it does not imply direct equivalence of organic matter fractions, given the differing analytical conditions and reaction pathways involved."

Line 187-190: Similar to Comment 2, the applied techniques rely on fundamentally different processes. Ts-Py-GCMS is a pyrolysis-based method, whereas ORO-AMS and SoliTOC are based on combustion.

Therefore, signals within the same temperature range may not represent comparable OM fractions, which should be clarified.

Re: We agree with the reviewer and thank them for this comment. The step-wise temperature approach is used intentionally to provide a consistent first-order framework that allows comparison of thermal trends across methods. We have revised the text to clarify that:

"…While the underlying processes differ (pyrolytic decomposition for Ts-Py-GCMS versus oxidative combustion for ORO–AMS and SoliTOC), the use of a common temperature framework provides a reference for comparison of thermal trends across methods, not direct equivalence of OM fractions."

Line 256-257: I saw higher ROC/TOC by ORO.

Re: We thank the reviewer for pointing this out. Upon revisiting the data, we confirm that ORO–AMS yields systematically higher ROC/TOC values compared to SoliTOC (Fig. S2). The original wording was incorrect and has been revised accordingly. The revised text now reads:

"SoliTOC- and ORO–AMS–derived ROC/TOC ratios show consistent patterns across sample types, with higher values in PF, DB, and RU (ROC/TOC ≈ 0.25–0.45) and substantially lower values in AL (typically <0.15). However, ORO–AMS systematically yields higher absolute ROC/TOC values compared to SoliTOC (Fig. S2)."

Line 286-287: HO2 also shows a rebound in carbon age.

Re: We thank the reviewer for highlighting this point. While the rebound in the HO2 profile is described in the text, we agree that it was not sufficiently reflected in the overall summary. The revised sentence reads:

"…Together, these patterns show that $F^{14}C$ generally decreases with increasing thermal resistance across most features, with the exception of the AL and a partial rebound observed in the HO2 profile.

Figure 4: The rationale for comparing 14C results from ORO with pyrolysis-based molecular fingerprints is not entirely clear.

Re: We thank the reviewer for this constructive comment. We agree that the rationale for combining ORO–AMS radiocarbon data with Ts-Py-GCMS molecular fingerprints was not sufficiently explained in the original manuscript.

We have revised both the figure caption and the main text to clarify that the combined presentation is intended to relate molecular composition to thermal stability and radiocarbon age, rather than to imply direct equivalence between fractions derived from pyrolysis and combustion-based methods. The revised text now reads:

Caption Figure 4 Line 311 "The combined presentation is intended to relate molecular composition to thermal stability and radiocarbon age, rather than to imply direct equivalence between fractions obtained by pyrolysis and combustion-based methods."

And main text line 321 "To facilitate interpretation across methods, molecular compound-class distributions are presented alongside $F^{14}C$ values derived from ORO–AMS for corresponding temperature intervals, providing a combined view of organic matter composition, thermal stability, and radiocarbon age."

Supplementary Material - Line 58: "green triangles"

Re: We thank the reviewer for pointing this out. The figure description has been corrected to ensure consistency between the text and the plotted symbols. The revised sentence now reads:

"...samples from FM2 (green triangles) and FM3 (red circles)."

Supplementary Material - Line 59: "with ORO–AMS reporting slightly higher ROC/TOC values"

Re: We thank the reviewer for pointing this out. The figure description has been corrected accordingly. The revised sentence now reads:

"...with ORO–AMS reporting systematically higher ROC/TOC values (slope = 0.71, R^2 = 0.76, bias ≈ 0.12),..."

Supplementary Figure S2 Line 67-74 – "…Differences in absolute ROC/TOC ratios between SoliTOC and ORO–AMS are largely methodological. The continuous ramping approach of ORO–AMS and the discrete temperature steps of SoliTOC partition intermediate thermal fractions differently, leading to systematic offsets in ROC/TOC values. In particular, intermediate-temperature carbon fractions may be assigned differently between methods, resulting in higher apparent ROC/TOC values in ORO–AMS compared to SoliTOC. This offset (~0.2 on average in our dataset) is consistent with inter-method differences reported in similar comparative studies. These method-inherent biases highlight the value of using multiple thermal approaches to constrain OM reactivity and underscore the complementarity of SoliTOC and ORO–AMS."

Supplementary Material - Line 82: "yield lower TIC/TC values than SoliTOC"

Re: We thank the reviewer for pointing this out. The figure description has been corrected accordingly. The revised sentence now reads:

"…with a systematic tendency for ORO to yield lower TIC/TC values than SoliTOC."

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