

Response to Reviewer #1

Reviewer 1.1: This is excellent piece of work. The text accompanying it should be a first port of call for anyone who wants to seek direction for novel work using ^{14}C radiocarbon.

Answer 1.1: Thank you kindly for taking the time to review our manuscript and the overall positive assessment of it.

R1.2: As a soil scientist I find the delta unit uninformative, a kind of disconnect, now we have a double delta delta ^{14}C per mil. I would be happy to just see somewhere in the text what -100, -500 and -1000 means in terms of years (approxatiely). Also there are no measurements it seems below -1000 so you can stop the scale there I guess.

A1.2: We appreciate the suggestion. We have added additional information to contextualize these values and the use of $\Delta\Delta^{14}\text{C}$ to the manuscript. We use $\Delta\Delta^{14}\text{C}$ (measured $\Delta^{14}\text{C}$ minus atmospheric $\Delta^{14}\text{C}$ at the time of sampling) specifically because it normalizes for temporal changes in atmospheric ^{14}C without requiring any assumptions about carbon age. This is particularly important because during and after the 'bomb' period, the same raw $\Delta^{14}\text{C}$ value can correspond to two distinct ages (one pre-bomb, one post-bomb), making direct age conversion ambiguous without additional model assumptions. Rather than imposing such assumptions on a database spanning decades of sampling, $\Delta\Delta^{14}\text{C}$ provides a consistent, model-independent metric.

We added the following to the manuscript:

L80ff: Throughout the manuscript, we express radiocarbon measurements as $\Delta\Delta^{14}\text{C}$ (measured $\Delta^{14}\text{C}$ minus atmospheric $\Delta^{14}\text{C}$ at the time of sampling) rather than as C ages. This approach normalizes for temporal changes in atmospheric ^{14}C during the period from 1990 to the 2020's, when most samples in the database were taken. During this peridod, the $\Delta^{14}\text{C}$ of atmospheric CO_2 decreased by nearly 200‰. Subtracting this changing atmospheric component allows us to compare measurements made in different years without requiring assumptions about the age distribution of soil C.

The reported $\Delta\Delta^{14}\text{C}$ values can provide insight into C dynamics. For example, fractions with consistently positive $\Delta\Delta^{14}\text{C}$ are respiring C fixed years to decades earlier when atmospheric CO_2 values were higher than atmospheric $\Delta^{14}\text{C}$ values in the year of sampling. Conversely, negative $\Delta\Delta^{14}\text{C}$ values ($< \sim -25\text{‰}$) indicate that the C in the fraction was mostly fixed prior to the onset of bomb testing. While C ages may be easier to interpret, direct conversion of $\Delta\Delta^{14}\text{C}$ to C ages is not straightforward for two reasons. First, during and after the 'bomb' period, a single $\Delta\Delta^{14}\text{C}$ value can correspond to two distinct ages. Second, bulk soil C represents a mixture of C pools with different ages and turnover times, meaning any single age estimate would be an oversimplification of the underlying C dynamics. Quantifying soil C turnover with ^{14}C requires the use of a model, and radiocarbon measurements like those in ISRad provide important constraints or tests of the dynamics built into soil C models.

R1.3: The lack of compound specific ^{14}C dates seems worrying and still only lipids suggest the field is not moving forward or too difficult or complex ? I wonder why there no recorded dates on compound specific PLFAs in the database.

A1.3: The reviewer raises an important point. The scarcity of compound-specific radiocarbon data in ISRaD reflects the current state of the field rather than a limitation of the database structure. Currently, we have 64 entries classified as lipids (see L403f). Compound-specific radiocarbon analysis requires large sample masses, specialized preparation, and access to accelerator mass spectrometry facilities capable of handling very small C samples, making it technically demanding and expensive relative to bulk ^{14}C measurements. For PLFAs specifically, the C masses obtainable from typical soil samples are often at or below the detection limits of most AMS facilities. That said, we agree this represents an important frontier - compound-specific approaches offer unique mechanistic insights into microbial C cycling that bulk measurements cannot provide. We have added a note in the fraction data section acknowledging these technical barriers and highlighting compound-specific radiocarbon as a priority area for future methodological development and data contribution.

L438f: Furthermore, compound-specific approaches offer unique mechanistic insights into microbial C cycling that bulk measurements cannot provide, yet are rarely analyzed for radiocarbon.

Response to Reviewer #2

Reviewer 2.1: This manuscript presents a version 2 of the International Soil Radiocarbon Database (ISRaD), a major expansion of a community-driven, open-access resource compiling global soil radiocarbon data. The updated version substantially increases the number of studies, sites, and observations, while introducing improvements in database structure, metadata standardization, and accessibility tools. The paper also highlights scientific advances enabled by ISRaD v1 and outlines future research directions. The database has clear potential to support large-scale syntheses, model benchmarking, and improved understanding of soil carbon dynamics across spatial and temporal scales. The effort toward standardization and community engagement is particularly commendable.

However, the manuscript is descriptive and would benefit from a more critical and integrative perspective. Several important processes influencing radiocarbon data interpretation are insufficiently discussed and there is a lack of arguments of the choices made by authors:

- the role of radiocarbon-dead carbon (not only geogenic) inputs is insufficiently considered, despite their significance for data interpretation and recent work using the version 1,
- the consideration of parent material, land use change and forestry which may limit the robustness of global-scale interpretations,
- soil classification and the consideration of mangrove and salt marshes as soils,
- some methodologies used in soil sciences are missing and future direction could be refined.
- the absence of formal governance and long-term funding raises concerns regarding database sustainability and maintenance.

In summary, this is a valuable and timely contribution for soil science communities, but the manuscript would benefit from a more critical and comprehensive discussion of limitations and

from clarification of several methodological and conceptual aspects. At this stage I recommend a major revision and these following major comments need to be developed in the new version of the ms.

Answer 2.1: Thank you kindly for taking the time to review our manuscript. Please find below our detailed answers to each of the points listed here.

R2.2: 1. Incomplete consideration of processes on radiocarbon interpretation

The manuscript does not sufficiently address key processes that can strongly influence soil radiocarbon signatures and interpretation. In particular, the role of radiocarbon-dead carbon, that encompass not only geogenic OC, is largely overlooked. Given the growing body of literature on these processes, their omission represents (only a sentence in the text) a significant conceptual gap that may lead to misinterpretation of compiled data. Indeed, recent works clearly show the importance of these dead-C contribution in soils, leading to a clear misunderstanding of soil C dynamics, with apparent aged SOC cause by this dilution of this dead-C. This ancient C contribution should be clearly considered as a new set of variables in this v2. In detail and throughout the ms:

L124: why there is no mention of radiocarbon dead-C contribution is the new version of ISRaD? since this contribution can reach 50% and more in deepsoils and a quarter in subsoils (see Copard et al., 2025)

L153f: again, why there is no mention of radiocarbon dead-C contribution... this contribution can reach 50% and more in deep soils? in fact, as stated recently by these works, not only C from sedimentary rocks but also from surficial deposits (e.g. loess) and C with low energy (Kleber's work). Authors should give more details about these origins that modify the C dynamics and some conclusions made by previous authors cited at the beginning of this section. Additionally, authors should consider the conclusions of these papers.

L181: section 4.1: why there is no mention of the radiocarbon-free SOC there ? it is now relatively easy to calculate the contribution of this SOC component. In the new version of ISRaD, I suggest to give this crucial info when it is possible.

L278f: see also the stock given in Copard et al. 2025 about ancient free¹⁴C stock in sub and deepsoil - suggest to add this important detail.

A.2.2: We agree that radiocarbon-dead C contributions are an important consideration when interpreting soil radiocarbon data. However, ISRaD is a repository of raw measurements, and calculating radiocarbon-dead C contributions requires assumptions and modeling approaches that go beyond the scope of the database itself. Where such contributions have been directly measured, they can be entered as fraction data. We have added a dedicated paragraph in Section 3 discussing the potential significance of radiocarbon-dead C contributions and pointing users to relevant literature:

L153ff: Recent studies also demonstrate that radiocarbon-dead C from multiple sources, including geogenic organic C from sedimentary parent materials (e.g., kerogen, lignite) **and surficial deposits such as loess**, can contribute substantially to ¹⁴C depletion in soils and should be carefully considered when interpreting soil radiocarbon data. **These contributions can potentially exceed 50% of total C in deep soils (Copard et al., 2025), and ISRaD users are particularly**

encouraged to consider such inputs when working with data from deep soils, soils formed in areas with appreciable aeolian inputs, and/or soils derived from C-rich parent materials.

R2.3: L605f: I insist on the fact that ISRaD should focus on parent material and used the previous recent results in this database, notably since these works used profiles from ISRaD database.... - in addition, and in this sentence, this concerns not only climate datasets but also land use change trajectory which could greatly help the understanding of ^{14}C distribution with depth.

A2.3.: We agree that parent material and land-use change can have significant effects on C persistence and ^{14}C -derived C ages. The database already allows users to specify parent material, land cover, whether sites have been burned, and land-use history in a free-format column where applicable (all these variables are reported in the 'profile' table). However, these variables are not mandatory as they are not available for many studies. Given that there is no single universally accepted parent material map, and since the most appropriate land-use dataset depends on the specific research question being asked, we encourage users to supplement ISRaD data with the global data products most relevant to their research. ISRaD Extra (provided through the R package) already extracts several common global products for users, but providing all possible global products goes beyond the scope of the database. We have made the following change to the manuscript:

L605ff: Linking ISRaD with other soil information systems (e.g., parent material and land-use history), aquatic C databases, and climate datasets could unlock powerful cross-disciplinary research on soil C dynamics and fate. The ISRaD database distinguishes between raw data available in publications and extrapolations. One limitation of this approach is that users must research and add information not provided by the original study. This information may include parent material, land use, disturbance history, mineralogy, and other standard soil descriptors that might be available at nearby sites or from global products, some of which are provided through ISRaD extra.

R2.4: 2. Absence of the major factors controlling soil C processes

Although the manuscript acknowledges data gaps (e.g., tropical regions, deep soils), important controlling factors are not fully considered compared to climate. A more comprehensive discussion of biases - including geological, land-use change is necessary.

L147: numerous studies already published state that land use change, and forestry modify SOC persistence, I think authors should give some words there.

L440f: why such a database cannot unlock the question of the best-practice? - also why talking about climate feedback only, why not land use change and/or even impact of the parent material feedbacks?

L535-section 7.2: the nature of parent material and if possible, the OC content of this material should be also a key variable.

A2.4: We agree that geological context, parent material, and land-use history are important factors governing SOC persistence and should be considered alongside climate. Regarding the best-practice fractionation comment, we respectfully maintain that the lack of consensus reflects the current state of the field rather than a gap in our discussion. The most appropriate fractionation method depends on the specific research question being asked, and imposing a single best-

practice standard would be premature given the diversity of scientific objectives in the community. We made the following changes to the manuscript.

L147ff: Studies using ISRaD also supported the existing hypothesis that climate, soil properties, **parent material, and land use history** jointly regulate SOC persistence, albeit with noticeable and important regional differences (e.g., Chai et al., 2023; Huang et al., 2023; von Fromm et al., 2023, 2024; Wang et al., 2023).

L439ff: More broadly, ISRaD's expanded fraction database demonstrates both the power and the limitation of current fractionation approaches: while diverse methods reveal the complexity of soil C age structure, the continued lack of consensus on 'best-practice' fractionation highlights fundamental questions about which soil C characteristics are most relevant to understanding how ecosystem-scale C cycling is attendant to climate, **parent material, and land use feedbacks**. More systematic comparison of different fractionation methods across diverse soil systems are needed (Trumbore and Zheng 1996, Crow et al., 2015, Leuthold et al., 2024)

L603ff: While ISRaD captures the core radiocarbon measurements and basic soil properties, several types of supplementary data can significantly strengthen the interpretive power of radiocarbon studies but are often incompletely reported: i) soil mineralogy and texture, ii) soil chemistry, iii) microbial and biological indicators, iv) management and disturbance history, **and v) parent material**. We recognize that not all studies will have access to comprehensive soil and site characterization data. However, when such data are available, we strongly encourage their inclusion in ISRaD submissions or as supplementary information linked to database entries.

R2.5: 3. Mangroves and salt marshes and soils classification

L445: many researchers belong to the soil and geology communities consider that mangrove and salt marsh are not soils but consist in sediment deposits only, why are the arguments used by authors to consider that as soils?

L175-177, L243, figure 2: what the authors mean? soil classification (group, class)? Why not replace by soil group and why authors use this soil classification rather than an international one (WRB).

L351f: before in the text, it was order, now type, I suggest to use class or group, the soil classification used needs to be added and argued (the best would be to use an international classification, as WRB), nb: usda is only cited in the figure caption;

A2.5: We respectfully disagree with the characterization that mangroves and salt marshes should be excluded from ISRaD. These ecosystems store substantial organic C and are widely studied using radiocarbon methods. Whether their substrates are classified as soils or sediments is partly semantic and varies across disciplines. Within ISRaD, mangroves and salt marshes are categorized as wetlands under land cover, rather than as a separate soil classification, which we believe is an appropriate and inclusive approach. Excluding these ecosystems would represent a significant gap in global soil C coverage and would be inconsistent with a growing body of soil science literature that recognizes organic-rich coastal wetland substrates as soils (see for example Holmquist et al. 2018, <https://www.nature.com/articles/s41598-018-26948-7>).

Regarding soil classification, we use USDA soil taxonomy because it is the most commonly reported classification system in the database. We have added a clarification that soil orders are

reported as given in the individual studies, and users may report alternative classification systems including WRB (which the database already allows for). We have also ensured consistent use of the term 'soil order' throughout the manuscript. We made the following changes:

L253f: Soil order representation (as reported in the original studies) largely mirrors the above-described climate-related patterns, with Aridisols being among the least sampled soils in the database (Figure 2c).

R2.6: 4. Integration of recent methodological advances, methodological recommendation and future direction

The manuscript does not fully incorporate recent approaches relevant to soil carbon characterization as Rock-Eval 6 pyrolysis. Including such approaches would improve the completeness and forward-looking perspective of the database.

L198: authors should also consider the numerous works using Rock-Eval method applied to SOC.

A2.6: ISRaD is a database that focuses on radiocarbon measurements. Within the fraction table, users can specify and enter data from different fractionation methods, including pyrolysis-based approaches. We already have data from ramped thermal oxidation fractionations in the database, where CO₂ collected at different temperature intervals is analyzed for radiocarbon. Rock-Eval pyrolysis operates on a similar thermal fractionation principle and could in theory be coupled with radiocarbon analysis in the same way. However, to our knowledge this coupling has not yet been routinely applied in the soil radiocarbon literature, which explains the current absence of Rock-Eval radiocarbon data in ISRaD.

R2.7: L192: I didn't check on the first version, but and prior isolation fractions, methods (because there are different methods, from acids concentration, fumigation etc) to isolate Corg could be also described and authors could provide recommendation (best-practice) too in order to avoid a loss of light SOC fractions during these treatments.

A2.7: This is a valid and important point. ISRaD assumes that bulk ¹⁴C measurements have been made on organic C, but the database does not systematically track which method was used to remove carbonates prior to analysis (e.g., acid fumigation, HCl treatment). We acknowledge that different carbonate removal methods can influence measured ¹⁴C values, particularly through potential loss of light SOC fractions. However, many published studies do not specify the method used, which limits our ability to capture this information consistently. Where carbonate fractions have been measured separately, users can enter these as fraction data. We recognize this as an important caveat of the database and encourage authors to report carbonate removal methods when publishing soil radiocarbon data. We made the following changes to be more explicit about it:

L267f: Bulk measurements entered in the database always refer to the organic C soil component, assuming that the inorganic C has been removed prior to the radiocarbon analysis.

L553f: Clear identification of the material analyzed (e.g., bulk soil, specific fraction, roots, incubation, interstitial CO₂), including pretreatment methods if applicable (e.g., acid-base-acid for macrofossils, acid fumigation or HCl treatment for carbonate removal).

R2.8: L492: since the understanding of vertical C dynamics is still debated with the C exchanges between atmosphere, biosphere, pedosphere and lithosphere reservoirs - effort and lateral C fluxes within the LOAC are a bit premature - the priority for ISRaD should be to well understand and better consider the vertical ones; especially the recent works about the incorporation of parent material in soils which disturb the SOC age and dynamics.

A2.8: We respectfully disagree that lateral C fluxes are premature to consider. While vertical C dynamics remain an important and debated research topic, lateral C fluxes through the land-ocean aquatic continuum are increasingly recognized as a significant component of the global C cycle and are already the focus of a growing body of radiocarbon research. ISRaD aims to reflect the full scope of soil radiocarbon research as it exists in the community, rather than prescribing which research directions should be prioritized. We agree that parent material plays an important role in controlling both vertical and lateral C dynamics and have already addressed this point in our response to comment R2.4. As a database, ISRaD can only represent the measurements that the community has made and reported. We highlight throughout the manuscript where we see important gaps and future opportunities, including the role of parent material in controlling soil C dynamics.

R2.9: L592f: put e.g.; the authors should refer to the fundamental (precursor) papers dealing with this point (notably Meybeck, Raymond, Bianchi works etc).

A2.9: We have added Raymond et al. (2004) *Marine Chemistry* and Butman et al. (2015) *Nature Geoscience* to address this comment, along with other precursor papers that were the first to report how lateral losses of soil C may be detected in aquatic ecosystems using radiocarbon measurements: Masiello and Druffel (2001) *Global Biogeochemical Cycles* used radiocarbon measurements to demonstrate the impacts of soil erosion on lateral C export, Townsend-Small et al. (2007) *Global Biogeochemical Cycles* reported the first radiocarbon measurements for C exported laterally from tropical soils to headwater streams, and Barnes et al. (2018) *ES&T* made connections between the radiocarbon composition of lateral C exports and soil flow path. We are not aware of any papers by Michel Meybeck or Tom Bianchi that involve radiocarbon measurements of C species exported laterally from soils, although Meybeck (1993) is a fundamental paper on the importance of C export from soils to rivers. To highlight the precursor papers that demonstrate the importance of soil-derived C in aquatic C fluxes and the global C budget (notably Meybeck (1993), Cole et al. (2007), and Hotchkiss et al. (2015)), we added a sentence to Section 7.3. We believe that the other papers currently cited capture the range of global syntheses that have been reported over the years and thus, have kept them cited in this statement.

L591ff: Another emerging research area is understanding the fate of soil-derived C once it leaves terrestrial systems and enters aquatic pathways. **It is well established that the fate of soil-derived C in aquatic ecosystems and emission of soil-derived C to the atmosphere plays a critical role in the global carbon cycle (e.g., Meybeck et al., 1993; Cole et al., 2007, Hotchkiss et al., 2015).** There is a growing body of literature demonstrating that streams, canals, and rivers transport and emit substantial quantities of aged soil C to the atmosphere, **further** highlighting the importance of lateral C fluxes in global C budgets (**e.g., Barnes et al., 2018; Bowen et al., 2024; Butman et al., 2015; Dean et al., 2025; Galy et al., 2015; Marwick et al., 2015; Masiello and Druffel, 2001; Raymond et al., 2004; Townsend-Small et al., 2007).**

R2.10: L595 : as said previously, ISRaD should focus on vertical fluxes first, what happens in river system is by far completely different than soil processes, however, since river system are, most of time, anthropized, soil can develop along these systems (why not give a word on these unknown young soils)? understanding the ^{14}C data in river system is by far different since rivers act as a conduit grouping all the eroded sources coming from the catchments (different soils, rocks, surficial formations, combustion residues, human-derived OM (wasted material), and NPP from river) - other suggestion is to focus on plastics in soils...All in all, there is a lot of to do before an adventure in rivers system.

L611f: focus on river won't help about the ability to predict soil C response face to env. changes.

A2.9: The export of soil-derived C to aquatic systems is a well-established research area with a growing radiocarbon literature, and understanding these fluxes is directly relevant to constraining terrestrial C budgets. We agree that river systems integrate multiple C sources, which is precisely why radiocarbon is a valuable tracer in these systems. We also agree that there are many other important future directions beyond those we highlight, and we do not intend our future directions section to be exhaustive or prescriptive. Rather, it reflects a subset of emerging opportunities identified by the broader soil radiocarbon community. We have added a sentence clarifying this in the manuscript.

L566f: **The following future directions represent a subset of emerging opportunities identified by the soil radiocarbon community and are not intended to be exhaustive or prescriptive.**

R2.11: 5. Sustainability and governance concerns

The manuscript acknowledges that ISRaD operates without formal governance or stable funding. While community-driven approaches are valuable, the long-term sustainability of the database remains uncertain. This issue should be more explicitly discussed, including potential strategies for ensuring continuity and data quality.

A2.11: We appreciate the reviewer's concern about long-term sustainability. We would like to point out that this issue is already explicitly discussed in Section 4.3 of the manuscript, where we acknowledge the challenges of operating without formal governance or stable funding and highlight the need for institutional and financial support. We believe the current discussion strikes an appropriate balance between transparency about these challenges and the positive demonstration that this community-driven approach has proven effective in practice, as evidenced by the substantial growth of ISRaD since v1.

R2.12: Minor comments

L46: precise if organic, inorganic or both.

A2.12: Done.

L46f: **Total** soil carbon (C) is the largest terrestrial C reservoir, serving as an important climate regulator.

R2.13: L50 - 53: need reference(s) at the end of these sentences.

L50: a bit evasive, do the authors meant soil carbon dynamics?

A2.13: Done.

L49ff: With ongoing environmental and climatic change threatening these benefits, there is a need to understand how soil C **dynamics** will respond. Models used to predict how organic matter responds to environmental changes often treat soil C as a homogeneous pool (Todd-Brown et al. 2013). However, observational evidence, including radiocarbon data, suggests that soil C dynamics are better explained by models that treat soil C as separate pools (or fractions) that cycle on different timescales (Schmidt et al. 2011, Stoner et al. 2023, Trumbore 2009, Sierra et al. 2018).

R2.14: L87: acronym no defined (GLOSIS).

A2.14: Done. GLOSIS stands for **G**lobal **S**oil Information **S**ystem

R2.15: L120: see major comment 1 ; not only, but also origin, as geogenic etc, see comments line 155

A2.15: We have added a mention of radiocarbon-dead C inputs from geogenic sources and parent material to this sentence, as suggested. This is also discussed in more detail in Section 3, where we have expanded the existing text on radiocarbon-dead C contributions to soil ¹⁴C signatures.

L120f: **Beyond simple aging, several other** processes **can** influence the age distribution of soil C, **including** vertical transport, pre-aging of litter, **and inputs of radiocarbon-dead C from geogenic sources or parent material.**

R2.16: L124: give 1 or 2 examples about these new concepts.

A2.16: We are not entirely sure which 'new concepts' the reviewer is referring to, as the sentence at L124 already provides explicit examples of emerging approaches (ramped thermal oxidation; Grant et al., 2019; Stoner et al., 2023), and the following sentences provide further examples of experimental manipulations with corresponding references. We believe the current text already adequately illustrates the concepts with concrete examples and have therefore not made any changes to this section.

R2.17: L177 and 184-185: sentences is a bit useless since these ideas were already given many times before.

A2.17: We agree that the first sentence is somewhat repetitive and have removed it. The remaining sentences serve a transitional function and have been retained.

L177f: ~~This growth underscores the increasing importance of radiocarbon as a tool for constraining soil C dynamics.~~

R2.18: L218: what is this information you want to increase?

A2.18: Thanks for catching this. We have removed the sentence entirely, as it was very vague and not adding much information.

L218f: ~~In the future, we aim to increase the amount of soil radiocarbon information to assist those less familiar with the nomenclature and use of soil radiocarbon data.~~

R2.19: L253: not agree, there are azonal soils which escape from this rule.

A2.19: We agree and have added 'largely' to acknowledge that azonal soils do not always follow climate-related patterns.

L253f: Soil order representation (as reported in the original studies) largely mirrors the above-described climate-related patterns, with Aridisols being among the least sampled soils in the database (Figure 2c).

R2.20: Figure 2: this is an interesting figure; however geology is missing at the profile scales, it could be interesting to know if all the parent materials (geology, surficial formations) on which the soils are developing were considered in this database.

A2.20: We agree that geological and surficial formation information would be a valuable addition to Figure 2. However, the majority of studies in ISRaD do not report parent material or geology, making it impossible to include this information in a meaningful way at the database level. Furthermore, existing global geological datasets have important limitations at the profile scale. For example, many areas are mapped as “unconsolidated materials”, which gives no indication of the mineralogical character of the deposits and is therefore not a particularly useful classification. Additionally, soil parent material can vary widely in character over small spatial scales, adding additional uncertainty to the appropriateness of using coarse-scaled geologic maps to extract soil parent material characteristics. We therefore leave it to users to extract and link such information from global products most appropriate for their specific research questions, consistent with our general approach of encouraging users to supplement ISRaD data with relevant external datasets. We encourage users to feedback the independent work they have done into ISRaD as a mechanism for growth of the database. This could include additional data, as well as R code on how to extract global products or perform certain calculations with the existing data.

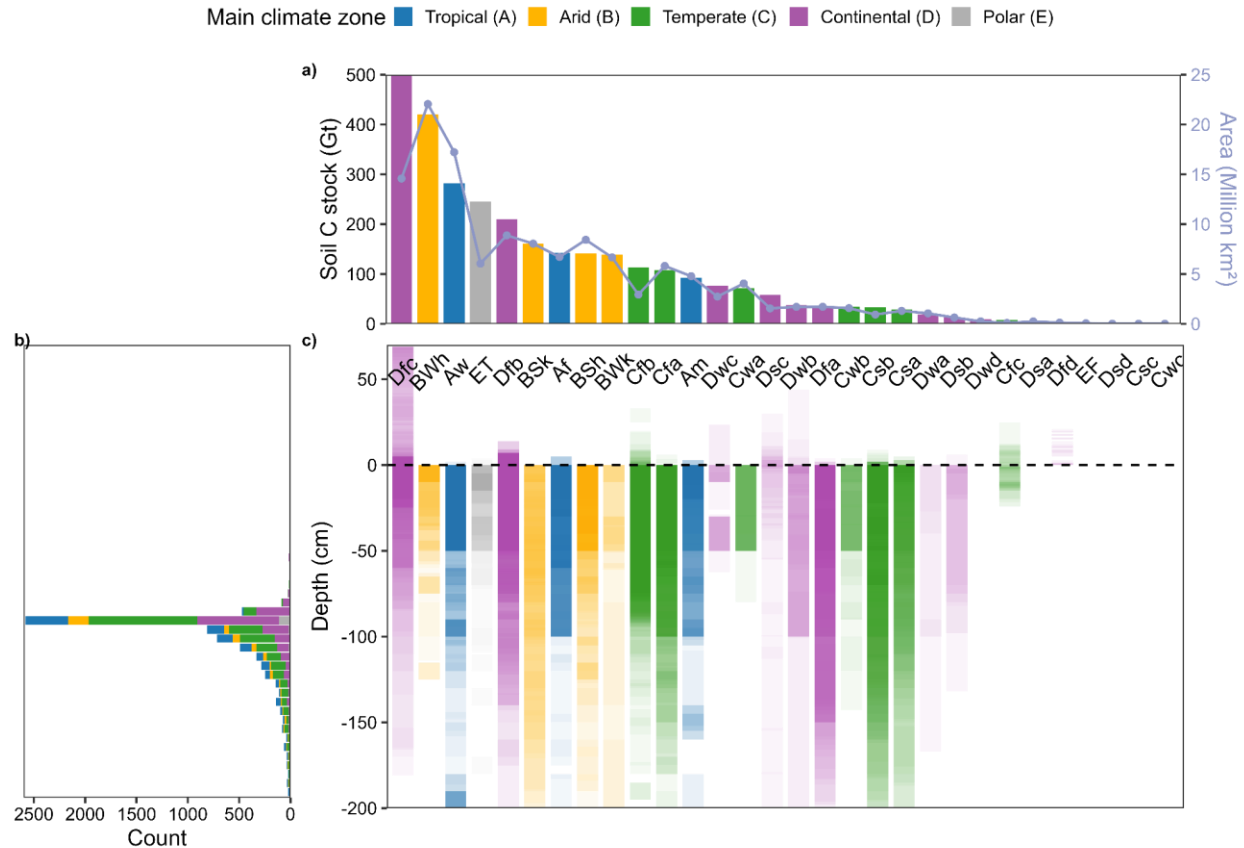
R2.21: L275f: rephrase with topsoil, I don't understand, subsoil concerns 30-100cm, here there is a mix between sub and deepsoils, could you clarify?

A2.21: We made the following changes to be more clear:

L276f: Despite the critical importance of subsoils and deep soils for long-term C storage and contribution to global SOC stocks (Jobbágy & Jackson, 2000), horizons below 30 cm, and particularly deep soil horizons (>100 cm), remain severely undersampled across all climate zones, soil orders, and land-cover types.

R2.22: Figure 3: the koeppen-Geiger zone is hard to follow in 3a and 3c – also I suggest to label b by c and vice versa.

A2.22: Done. We have increased the font of the labels. However, we would like to keep the labeling of the panels as it is currently so they read from left to right.



R2.23: L392: in this subsection 5, there are some statements about future research direction, I suggest to put all these in the appropriate section (7) or delete these sentences if it is also given in this section 7 to avoid redundancy.

A2.23: The future directions mentioned in Section 5 are specific to individual data types and serve to contextualize the limitations of each data type discussed in that section. They are more granular than the broader strategic directions outlined in Section 7, and we believe keeping them in Section 5 improves the readability and completeness of both sections. We do not consider this redundancy but rather a deliberate structural choice that serves the reader.

R2.24: L394f: could you explain better what do you mean there, why this comparison is important for you and what is upland for you? - this sentence is a bit unclear and disconnected from the other...alternatively, suggest to delete.

A2.24: We agree that the second sentence was unclear and disconnected from the rest of the paragraph. We have removed it entirely. The first sentence already adequately captures the key future data needs for flux measurements.

L394f: ~~Finally, future work could also investigate how C fluxes are related to the ratio of particulate organic matter to mineral-associated matter fractions, as well as how the age of upland C fluxes compares to wetland C fluxes.~~

R2.25: L402: what do you mean by macrofossils, come from parent material?, old macrorests? Not clear since it is not defined.

A2.26: We agree that 'macrofossils' was insufficiently defined and have added a brief clarification to the text specifying that these refer to recognizable plant remains commonly isolated in peatland studies.

L401ff: The majority of fraction data are from density separations (n = 3,991), followed by physical separation of distinct particles such as macrofossils (i.e., recognizable plant remains such as seeds, leaves, or wood fragments, commonly separated in peatland studies), charcoal or roots (n = 1,849), chemical separations (n = 1,446), and particle size fractions (n = 850).

R2.27: Figure 5: in this figure, FA and HA quantification is an old soil science concept no longer used actually - I am not sure if these distinctions still remain suitable, the best is to group in HS. Or at least, authors should explain their choice to keep this old terminology.

A2.27: We appreciate the reviewer's comment and agree that humic substance fractionation into fulvic acid, humic acid, and humin fractions is increasingly considered outdated in modern soil science. However, as a database of historical and current radiocarbon measurements, ISRaD documents what has been measured in the published literature rather than prescribing which methods should be used. Excluding or regrouping these data would misrepresent the original measurements. We note that the figure already groups these fractions under the 'chemical - HS' column header, with fulvic acid, humic acid, and humin shown as sub-groups, which we believe strikes an appropriate balance between preserving methodological detail and acknowledging their shared conceptual basis. Users are free to include or exclude certain methods when analysing data from the database.

R2.28: L610: modelling of what?

A2.28: We made the following changes:

L609f: We invite the soil science, soil C modeling, and aquatic C communities to collaborate on defining priorities for these integrations and to contribute technical expertise and resources toward building the necessary linkages and products.