Comment 1: The current study produces the accurate soil organic carbon density (SOCD) products from 1985 to 2020 with the spatial resolution of 1km with depths of 0-20 cm and 0-100 cm, using 8203 soil samples. I acknowledge that the authors conducted an important work to improve our understanding of SOCD in China at temporal scale. However, I think the current study should be published after addressing the revisions associated with the sample size, data share, data analysis, and information of sample time. If the following concerns were addressed, I think the current manuscript is an important contribution to global carbon cycle community.

Response: We sincerely appreciate your positive evaluation and constructive comments. We fully agree that addressing the concerns regarding sample size, data sharing, analysis methods, and sampling time is critical for ensuring the robustness of this study. Guided by your suggestions, we have conducted a comprehensive revision. Notably, we have significantly expanded the sample size (from 8,203 to 11,743 profiles), clarified the sampling time information, and made both the estimated products and raw point data publicly available. Given the significant increase in sample size, we re-ran all model simulations and redrew all corresponding figures to ensure consistency. We are confident that these substantive improvements have strengthened the manuscript significantly, enhancing its contribution to the global carbon cycle community.

Comment 2: As a data paper, the manuscript must provide the original dataset with details of latitude and longitude, soil depth, sampling year, ecosystem types, elevations, and so on, point by point. However, the current study just provides the data as raster version. At global or national scale, there are several data products, however, the true value of current dataset is the original observations rather than the ".tif" data. Importantly, the value of current manuscript is the temporal dynamics. Therefore, the sampling time of individual samples is critical.

Response: We sincerely thank the reviewer for this important and constructive comment. We fully agree that, for a data paper, providing transparent and traceable point-level metadata (including coordinates, depth, year, and ecosystem attributes) is essential to ensure the reproducibility and long-term value of the dataset.

Thank you for this critical and highly constructive feedback. We wholeheartedly agree with your fundamental point. You have precisely identified the core value of our work and the cornerstone of a data paper suitable for ESSD: the original, point-level observational dataset is the primary scientific contribution. We sincerely apologize for failing to provide this in our initial submission and for placing undue emphasis on the derived raster products. Your comment has prompted us to fundamentally revise our data-sharing strategy to align fully with the mission of ESSD and the needs of the scientific community.

In the revised manuscript and data repository, we have taken the following decisive steps:

1、Full Release of Point-Level Data: We have compiled and shared the complete soil sample dataset in our updated Figshare repository (https://doi.org/10.6084/m9.figshare.27290310.v2). This dataset includes all 11,743 soil profiles (covering both 0–20 cm and 0–100 cm depths) in .csv format. As requested, each record includes the precise metadata:

Sampling year: The specific year of sampling (crucial for temporal analysis).

Longitude (decimal degrees): The geographic longitude.

Latitude (decimal degrees): The geographic latitude.

Depth: Upper and lower boundaries (0–20 cm or 0–100 cm).

SOCD_value (kg C m^{-2}): The calculated Soil Organic Carbon Density for the given depth.

CLCD_Type: The classified ecosystem or land cover type at the time of sampling.

Elevation (m): The elevation of the sampling location.

2、Clarification of Temporal Coverage: We have revised Section 2.2 (Data sources) to clearly describe the temporal distribution of these samples (spanning the 1980s, 2000s, and 2010s), ensuring users can accurately utilize the data for temporal dynamic analysis.

3、Statistical Summaries: To assist users in assessing representativeness, we have provided aggregated statistics on the number of soil profiles by depth, ecosystem, and sampling year in the revised Figures 4, 5 and Table 1.

Table 1. Summary of the number of valid soil profiles stratified by sampling period and standardized depth intervals

Period	Soil observations	0-20cm profiles	0-100cm profiles
1980s	8527	2397	1605
2000s	3979	2304	1675
2010s	24769	7042	4765

4、Raster Products: We continue to provide the high-resolution (1 km) raster products as a derived dataset for users requiring continuous spatial coverage.

We agree with you completely that the true value of our dataset is the original observations. The gridded .tif products should be viewed as one possible application derived from this valuable point dataset, whereas the point data itself represents the foundational asset for the community. Your guidance has been instrumental in helping us present our work in a way that maximizes its value and utility.

Thank you once again for this essential feedback. We are confident that these changes have fundamentally transformed our manuscript into a true data paper that fully serves the scientific community and meets the high standards of *Earth System Science Data.*

Comment 3: In the manuscript, the number of soil profiles and soil depth distribution should be considered. In China, the soil depth for a lot of the regions is shallower than 100 cm, therefore, the current study would overestimate the SOC storage.

Response: We appreciate the reviewer's careful consideration of soil depth and its implications for SOC storage estimates, and we fully agree that soil depth distribution must be explicitly accounted for, especially in a country like China where many regions have soils shallower than 100 cm.

In response, we have clarified both what our 0–20 cm and 0–100 cm SOC density (SOCD) values represent, and how soil depth and profile selection are handled, so that potential overestimation of SOC storage is avoided or at least clearly bounded.

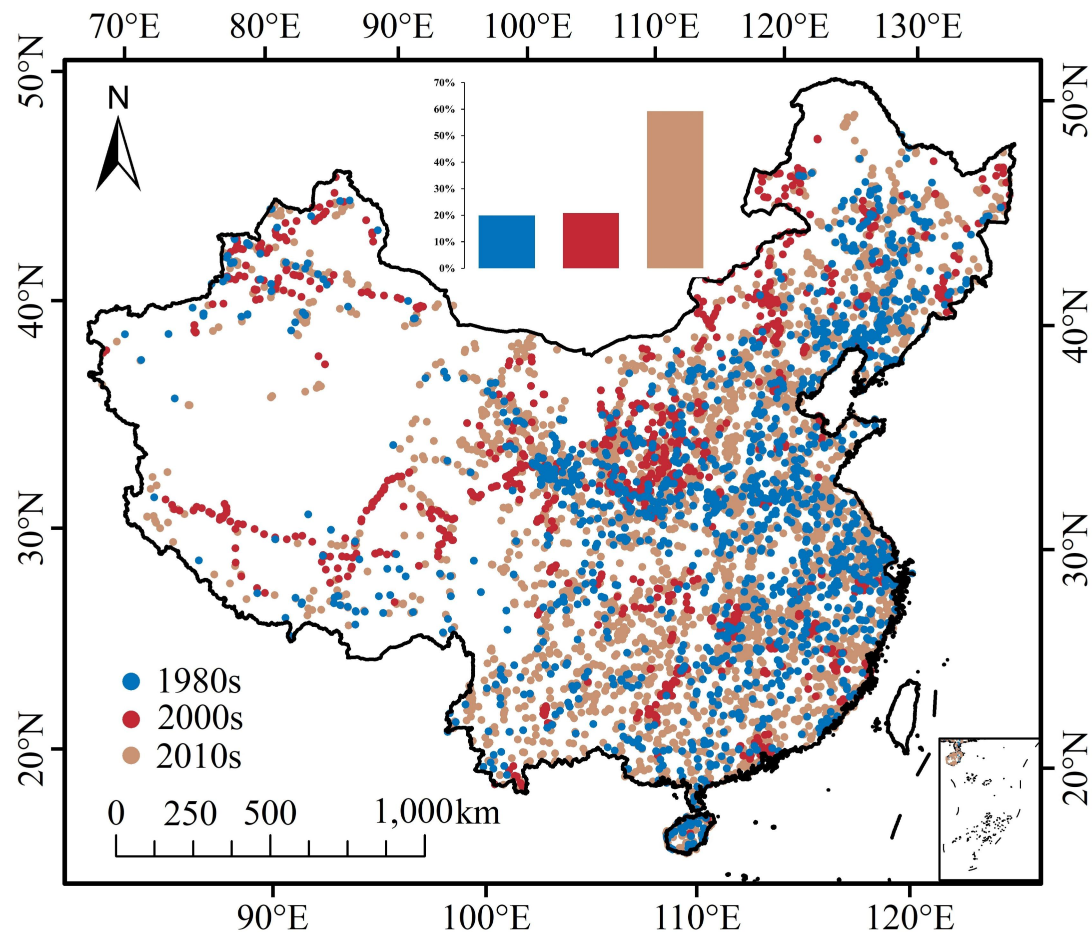

Figure. Spatial distribution of 0-100cm SOC sample points

① Clarifying what our 0–20 cm and 0–100 cm SOCD represent

Our primary product is a profile-based, depth-harmonized SOCD dataset. Using the mpspline2 mass-preserving spline, we estimate SOCD for the 0–20 cm and 0–100 cm layers at the profile locations.

These SOCD values represent the SOC stock within the soil down to 20 cm or 100 cm where soil actually exists at those locations; they do not assume that soil is everywhere ⩾100 cm over the whole of China.

② Soil profile depth distribution and profile selection

We now summarize the observed profile depth distribution in the revised manuscript. We briefly describe their spatial distribution across China.

In the Methods, we explicitly state that: For 0–20 cm SOCD, we use all profiles that reach at least 20 cm; shallow soils are fully included in this layer. For 0–100 cm SOCD, we only use profiles with observed depth ⩾100 cm. We apply mpspline2 within the observed profile and do not extrapolate SOC below the maximum observed depth for shallower profiles.

Profiles shallower than 100 cm are therefore *not* contributing to 0–100 cm SOCD statistics, which prevents us from artificially inflating SOC stocks at locations where the soil actually ends above 100 cm.

As mentioned in Response to Comment 2, we have now released the original point-level dataset (including sampling depth). This allows users interested in shallow soil dynamics to directly analyze the observed depth distribution and filter the data according to their specific research needs.

By restricting 0–100 cm calculations to profiles that truly reach 100 cm, we avoid overestimating local SOC stocks due to unobserved soil layers. Acknowledged as a limitation that our profile network underrepresents very shallow soils in some environments (e.g. rocky mountains, karst areas, thin soils on bedrock), and that neglecting these shallow soils in upscaling may bias national stock estimates if soil depth is not explicitly considered.

We believe these clarifications effectively bound the uncertainties and guide the community to use the dataset correctly without overestimating national SOC storage.

Comment 4: I also found several data sources from recent data papers. Especially, the sample size for Chen et al. 2025 is 23,103 samples from 7,852 soil profiles after 2010, which is greater than current study. I suggest the manuscript should integrate these datasets and delete the replicated ones, and highlight the temporal information, which is important.

Chen Z, Chen L, Lu R, et al. A national soil organic carbon density dataset (2010–2024) in

China[J]. Scientific Data, 2025, 12(1): 1480.

Shi G, Sun W, Shangguan W, et al. A China dataset of soil properties for land surface modeling (version 2)[J]. Earth System Science Data Discussions, 2024, 2024: 1-35.

Response: We are grateful to the reviewer for recommending these two critical and timely datasets (Chen et al., 2025; Shi et al., 2024). We fully agree that integrating these recent data products is essential to ensure our study represents the state-of-the-art in soil carbon research.

Following your suggestion, we have successfully integrated these datasets into our compilation and performed a complete re-analysis of the spatiotemporal modeling. The specific improvements are as follows:

1. Integration and rigorous de-duplication: We obtained the datasets from Chen et al. (2025) and Shi et al. (2024). As the reviewer noted, Chen et al. (2025) contains a large number of samples (23,103). However, our overlap analysis revealed that a significant portion of these profiles share the same primary data sources (legacy data) as our original database. To avoid pseudo-replication and double-counting, we implemented a strict de-duplication protocol (detailed in revised Section 2.2). We matched profiles based on geographic coordinates (lat/lon), sampling year, and soil depth intervals. Only profiles that were distinct from our existing records were retained. The improvement is as Line 91 - Line 101.

"To enhance spatiotemporal coverage, particularly for data-scarce regions, we incorporated additional SOC data from two recent national data products: the national soil organic carbon density dataset for 2010–2024 in China (Chen et al., 2025) and the updated China dataset of soil properties for land surface modelling (Shi et al., 2025). We harmonized the point-level information from these datasets (profile ID, latitude and longitude, upper and lower depth, SOC content, sampling year, and land-use type) to match the structure of our database. Then a detailed overlap analysis between these profiles and our original compilation was done. Because many profiles in Chen et al. (2025) and Shi et al. (2024) originated from the same legacy sources as our database, we applied a strict de-duplication procedure based on geographic coordinates, sampling year, and depth structure to identify duplicated entries. Profiles that matched existing profiles within a small spatial tolerance and with similar temporal and depth characteristics were treated as duplicates and excluded. Only those profiles that could be clearly identified as non-overlapping were retained and merged into our database."

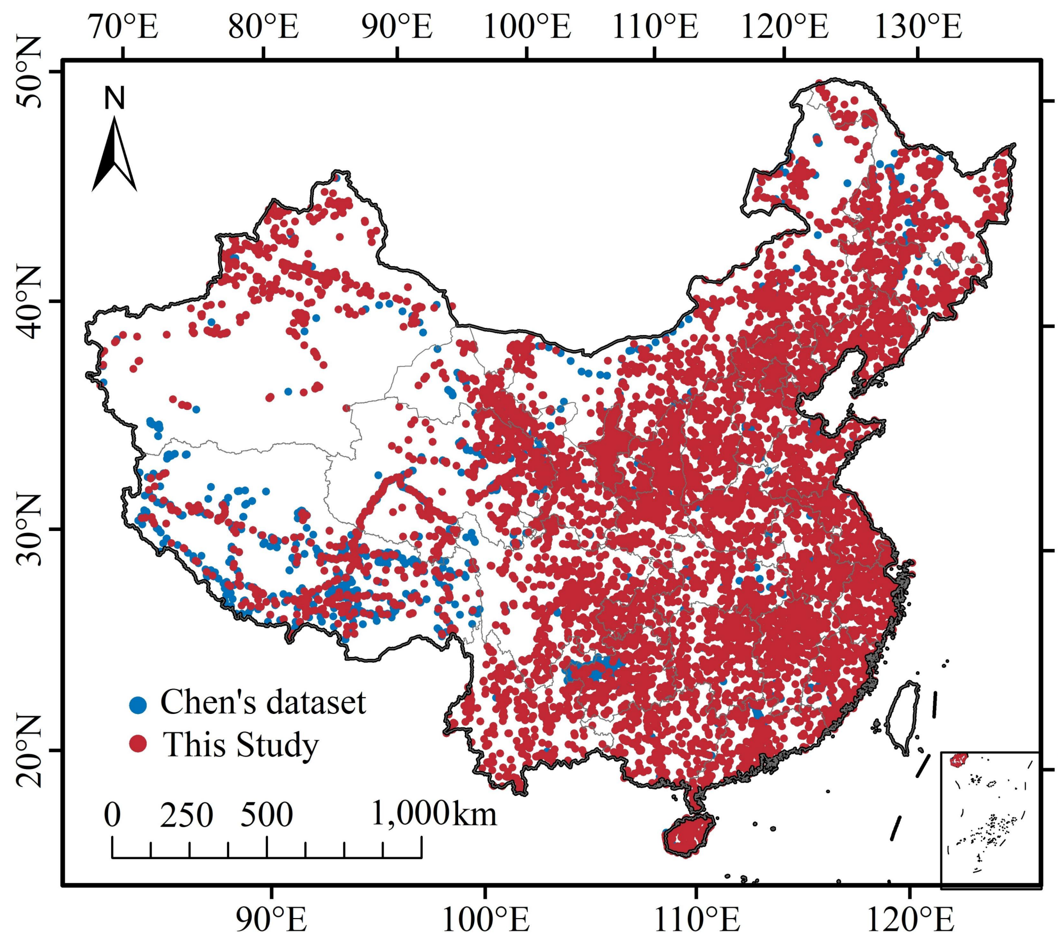

Figure. Spatial distribution of soil sample points with this study and Chen's dataset.

2. Substantial I\increase in sample size: This integration has fundamentally strengthened the foundation of our work. Our final quality-controlled dataset has grown from 8,203 to 11,743 profiles. This expansion is particularly valuable for improving the temporal coverage, as a large proportion of the newly added unique profiles are from the 2010s and 2020s, directly addressing the reviewer's comment on the importance of temporal dynamics.

3. Complete model re-execution: Specifically, the substantial expansion of the dataset (from 8,203 to 11,743 profiles) necessitated a complete re-implementation of our machine learning modeling framework. We re-trained the Random Forest models across all climatic zones, re-validated model accuracy using the new independent datasets, and re-analyzed the spatiotemporal patterns of SOCD. Consequently, all figures (Figs.2, 4–14) and tables in the revised manuscript have been entirely regenerated to reflect these updated and more robust results.

4. Manuscript revisions: We have updated the Abstract, Data Sources (Section 2.2), and Results sections to reflect these changes. We explicitly credit Chen et al. (2025) and Shi et al. (2024) as key data sources that helped elevate the quality of this product.

In summary, your suggestion has been transformative. It has pushed us to elevate our work from an important contribution to what we believe is now a benchmark dataset for soil carbon studies in China. We have turned a potential weakness into a central strength of the paper.

Thank you again for your expert guidance and for pushing us to achieve a higher standard of scientific rigor. We are confident that these extensive revisions have fully addressed your concerns and have made the manuscript substantially more valuable to the community.

Comment 5: Methodology： A lot of the details of the methods are lacking. For example, the number of soil observations and profiles for the studied period of 1980s, 2000s, and 2010s respectively for 0-20 and 20-100 soil layers. How were the soil layers of "20-30" or "20-40" classified? If the soil depth for an observed soil profile is 70 cm, how do calculate the SOCD for 0-100 cm? And so on.

Response: We thank the reviewer for these very helpful and concrete suggestions. We agree that the original version of the manuscript did not provide sufficient detail on several key methodological steps, especially regarding the temporal stratification of observations, the harmonization of soil layers, and the computation of SOCD for standard depth intervals. In the revised version, we have substantially expanded the Methods section to clarify these points, as outlined below.

Below, we address each of the specific points you raised, which are now all clarified in the revised manuscript.

1) On the Distribution of Soil Observations by Period and Depth

Reviewer Comment: "the number of soil observations and profiles for the studied period of 1980s, 2000s, and 2010s respectively for 0-20 and 20-100 soil layers."

Our Response: This is a crucial piece of summary information that was missing. While the distribution and counts of soil profiles were visually presented in Figure 4 and 5, we acknowledge that this information should have been explicitly detailed in the Methodology section to provide a clear overview of the dataset foundation before presenting the results. To provide a clear overview of our data's spatiotemporal distribution, we have created a new summary table (Table 1). This table explicitly details:

Table 1. Number of soil samples stratified by sampling period and standardized depth intervals

Period	Soil observations	0-20cm profiles	0-100cm profiles
1980s	8527	2397	1605
2000s	3979	2304	1675
2010s	24769	7042	4765

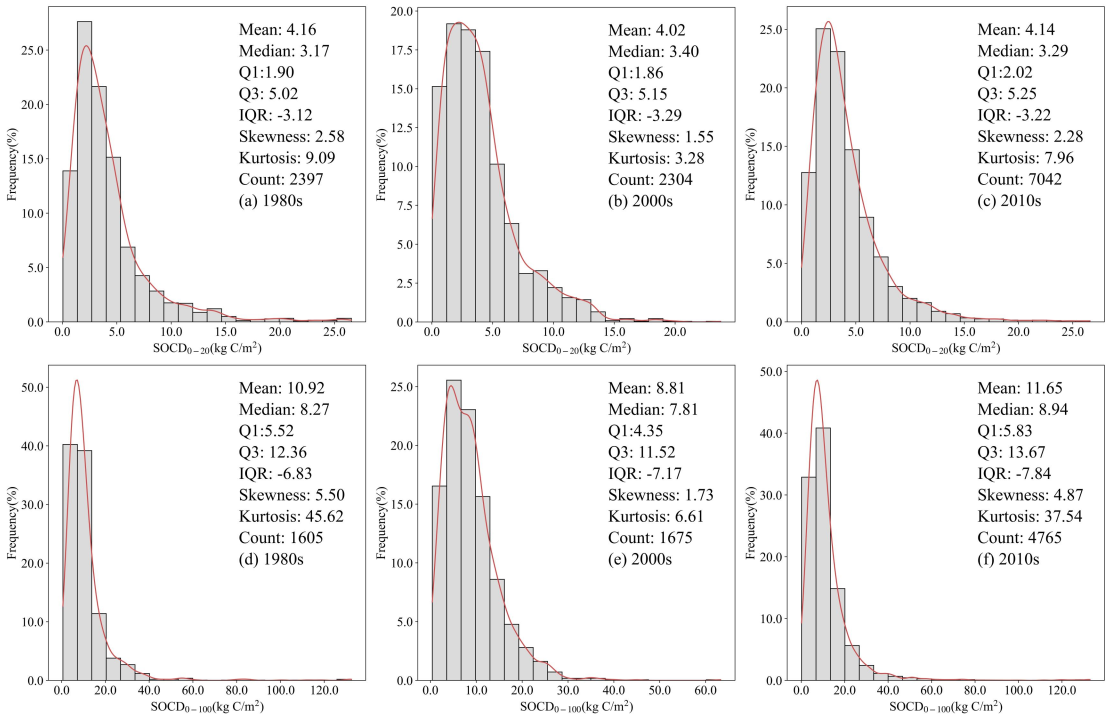

Figure 4. Statistical characteristics of soil sample points in different periods. Frequency distribution of SOCD data with the soil depth of 0-20 cm (a-c) and 0-100 cm (d-f) during the 1980s, 2000s, and 2010s.

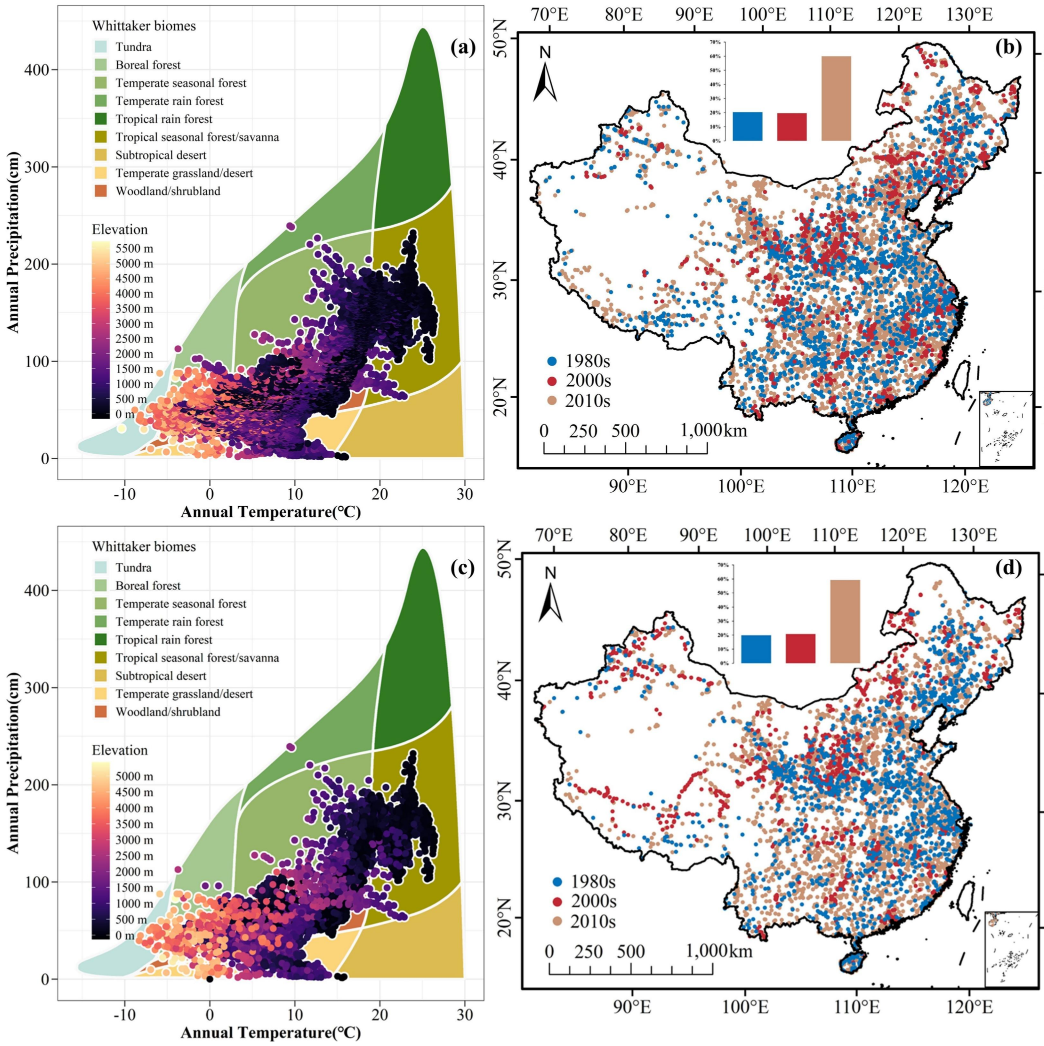

Figure 5. Spatial distribution of soil sample points with depth of 0-20 cm (b) and 0-100 cm (d). And the Whittaker biomes of soil sample points with depth of 0-20 cm and 0-100 cm are shown in (a) and (c).

2) On the Harmonization of Non-Standard Soil Layers

Reviewer Comment: "How were the soil layers of "20-30" or "20-40" classified?"

Our Response: In the original manuscript we only briefly mentioned depth harmonization. We now clarify that we use the mpspline2 function (mass-preserving spline) to harmonize all horizon-level observations to the standard depth intervals 0–20 cm and 0–100 cm:

For each profile, we input the observed horizons defined by their upper and lower depths, together with the measured SOC, into mpspline2.

We specify target depth intervals of 0–20 cm and 0–100 cm; mpspline2 fits a mass-preserving spline to the vertical SOC profile and then integrates this spline over the requested depth intervals.

As a result, horizons such as 20–30 cm or 20–40 cm are not classified manually into "layers";

instead, their information is used by the spline to reconstruct a continuous SOC profile with depth, and the contribution of each horizon to the 0–20 and 0–100 cm intervals is handled automatically through spline integration.

3) Regarding the reviewer's specific question about profiles that do not reach 100 cm (e.g. a profile with a maximum depth of 70 cm), we have clarified in the Methods that:

Our Response: We do not extrapolate beyond the observed soil depth. Profiles shallower than 100 cm are used to compute SOCD only for the depth intervals that are fully covered by observations (e.g. 0–20 cm).

When we report and analyze SOCD for the full 0–100 cm interval, we restrict the calculations to profiles that reach at least 100 cm depth after quality control. Shallow profiles (e.g. 0–70 cm) are therefore not used for 0–100 cm SOCD statistics, but they are retained in analyses of shallower layers (such as 0–20 cm).

We now explicitly state this criterion in Section 3.1 and indicate the number of profiles that meet the ≥100 cm requirement, so that readers understand the sample base for the 0–100 cm SOCD estimates. The improvement is as Line 174 - Line 180.

"*The observed horizons, defined by their upper and lower depths, were input to `mpspline2`, which fits a mass-preserving spline to the vertical SOC profile and integrates this spline over the target depth intervals. We used the default value of 0.1 for the spline smoothing parameter lambda. We do not extrapolate beyond the observed soil depth when calculating SOCD. Profiles shallower than 100 cm are used to compute SOCD only for depth intervals that are fully covered by observations, but they are excluded from 0–100 cm SOCD statistics. When we report and analyze SOCD for the full 0–100 cm interval, we therefore restrict the calculations to profiles with an observed depth of at least 100 cm after quality control.*"

We believe that these additions and clarifications substantially strengthen the transparency and reproducibility of our methodology and directly address the reviewer's concerns. We are grateful for the reviewer's detailed comments, which helped us to improve the methodological description.

Comment 6: The coarse fractions percentage was from global dataset of SoilGrids 2.0, if there are any dataset from China?

***Response**:* Thank you for this exceptionally insightful and important piece of feedback. Your point about using a national dataset for coarse fractions in China is absolutely correct and represents a critical step toward improving the accuracy of our SOCD estimates. We deeply appreciate your expert knowledge and sharp eye for detail. We completely agree with your assessment that utilizing a localized, higher-precision national dataset is the best scientific practice. Guided by your invaluable suggestion, we undertook a renewed and more intensive search for such data. We are pleased to report that we successfully located and obtained a high-quality national dataset for soil coarse fraction content for China [Basic soil property dataset of high-resolution China Soil Information Grids (2010-2018) (Liu et al., 2022)]. The improvement is as Line 180- Line 182.

We immediately took action to integrate this superior national dataset into our workflow, replacing the global SoilGrids product. This involved re-running our entire data processing and analysis pipeline. This update has led to significant and tangible improvements:

① Methodological Update: We have revised our Methods section (now Section 3.1) to clearly describe this new data source. We provide details on the origin of the national coarse fraction dataset, its spatial resolution, the methodology used in its creation, and its advantages over the global product (its foundation on a much denser set of local soil profile observations, better capturing the specific parent material and geomorphological characteristics of China).

② Improved and Recalculated Results: Using this new national dataset, we have recalculated all SOCD estimates.

In conclusion, your suggestion has been one of the most transformative pieces of feedback we have received. It has directly led to a substantial and critical improvement in the quality of our dataset. We are extremely grateful for your expert guidance, which has enabled us to elevate the accuracy of our work to a much higher standard. Thank you once again for your invaluable contribution.

Liu F, Wu H, Zhao Y, et al. Mapping high resolution national soil information grids of China[J]. Science Bulletin, 2021, 67(3): 328-340.

Comment 7: The long-term dynamics of SOC are influenced by land use cover; however, the current study did not consider this critical factor.

Response: We appreciate the reviewer highlighting the critical role of Land Use and Land Cover (LULC) in driving long-term SOC dynamics. We completely agree that any robust SOC model must account for these effects.

To address this point and enhance clarity, we have made the following revisions:

1. We have added a clear statement that LULC was incorporated as an essential covariate in our Random Forest models. We utilized the annual China Land Cover Dataset (CLCD) to match the specific year of each soil observation, allowing the model to capture the relationship between land cover types and SOC levels dynamically over time. We have now revised the Data sources section to explicitly list the CLCD dataset. The improvement is as Line 128 - Line 129.

"The land cover dataset newly released by Wuhan University (Yang and Huang, 2021) is used in

this study"

2. Following the reviewer's suggestion to better reflect this factor, we have updated our released point-level dataset. The dataset now explicitly includes a 'Land Use' column for each profile (standardized to a common classification scheme), along with the original latitude, longitude, and depth information. This allows future users to directly analyze the land-use-specific characteristics of the soil samples.

We hope these revisions clarify that LULC was integral to our analysis and that the data is now more accessible for land-use-related inquiries.