Dear Reviewer,

Thank you very much for your comments and professional advice. Your insights have significantly contributed to enhancing the academic rigor of our article. We appreciate the time and effort you devoted to reviewing our work. Based on your valuable suggestions and requests, we have implemented corrections and modifications to the revised manuscript. We believe these enhancements will further strengthen the quality of our work. We would like to provide a detailed account of the changes made:

Note: The modifications are shown in bold font. The comments are blue colored.

GENERAL COMMENTS:

Soil point data:

Comment #1: Key information is missing about the soil point data (Sect. 2.1.2). Are these observations (you use the term in-situ values) laboratory measurements or pedological field estimates (or perhaps both depending on the dataset and soil property)? If they are laboratory measurements, what methods were used to measure them? Are they data only from soil profiles or also from boreholes / augerings? At what depth was sampled (by fixed/predefined soil layer in cm or by pedological soil horizon)? What is the sampling design of the different datasets?

Response: Thank you for your detailed comments, and I apologize for the confusion caused by the term "in-situ." The majority of the soil profile data used in this study are based on laboratory measurements rather than direct field observations ("in-situ"). We have revised the manuscript to replace "**in-situ**" with "**laboratory measurements**" to avoid any misunderstanding.

Regarding measurement methods, Shangguan et al. (2013) provide detailed descriptions for soil profiles from the Second National Soil Survey of China (SNSSC), while Batjes et al. (2020) document the measurement methods for soil profiles in the World Soil Information Service (WoSIS) database.

In response to your question on data sources, all observations are derived solely from soil profiles, with no data from boreholes or augerings. The regional database contains only surface data, and both the SNSSC and WoSIS datasets consist of soil profile data.

Concerning the sampling design, data collection was primarily soil type-based, with each soil type represented by one characteristic soil profile. Although the original soil surveys contained multiple profiles, only one representative profile was retained for each typical soil type in the final dataset. Since SNSSC soil profile data were extracted from soil survey books, there was no formal sampling design. However, if a sampling approach must be specified, it could be considered as a soil type-based stratified sampling design.

Modification:

"The laboratory methods for soil profile data from the SNSSC and WoSIS databases are detailed in Shangguan et al. (2013) and Batjes et al. (2020), respectively. All data are exclusively from soil profiles, with no inclusion of boreholes or augerings. The regional database includes only surface data, while the SNSSC and WoSIS datasets contain full soil profiles. Sampling was primarily soil type-based, with each type represented by one characteristic profile. Although no formal sampling design was used for SNSSC data extracted from soil survey books, this approach may be considered soil type-based stratified sampling."

Shangguan, W., Dai, Y., Liu, B., Zhu, A., Duan, Q., Wu, L., Ji, D., Ye, A., Yuan, H., Zhang, Q., Chen, D., Chen, M., Chu, J., Dou, Y., Guo, J., Li, H., Li, J., Liang, L., Liang, X., Liu, H., Liu, S., Miao, C., and Zhang, Y.: A China data set of soil properties for land surface modeling, J. Adv. Model. Earth Syst., 5, 212–224, https://doi.org/10.1002/jame.20026, 2013.

Batjes, N. H., Ribeiro, E., and van Oostrum, A.: Standardised soil profile data to support global mapping and modelling (WoSIS snapshot 2019), Earth System Science Data, 12, 299－320, https://doi.org/10.5194/essd-12-299-2020, 2020.

Data-splitting and model evaluation:

Comment #2: It seems that the authors did not group the data-splitting procedures by location / soil profile. If observations from the same profile but at different depths are used in both training and testing (calibration and validation, or in case of CV, it’s also called hold-in vs. hold-out), then accuracy statistics are overly optimistic. This seems problematic in several steps of the modelling framework: RFE using OOB, 10-fold CV during hyperparameter tuning and most importantly, during model evaluation used for reporting the accuracy metrics. Please adjust methods so that, in all steps, all observations from the same location / profile are either in the hold-in or hold-out.

Response:

Thank you for your insightful comment. In our study, we developed separate models for each soil depth layer individually, meaning that there is no overlap of observations from the same profile across training and testing datasets. This setup ensures that no observations from the same profile at different depths are used simultaneously in both the training and testing stages. Depth was not treated as a covariate, and each depth layer was modeled independently. We have clarified this approach in the manuscript and added notes in relevant sections and figures to specify that models were developed separately for each layer, avoiding the issue described.

Modification:

"**Separate models were developed independently for each soil depth layer, ensuring no overlap of observations from the same profile across training and testing datasets, with depth not used as a covariate.**"

Discussion on use at various spatial scales:

Comment #3: I miss a discussion and recommendations of when and when not to use these maps. You have generated national maps for China of 20 soil properties, which you can expect will be widely used for science, policy and society. Therefore, it is in your interest to make sure they are not used the wrong way. Resolution is not the same thing as accuracy. While it’s great that the authors have created high-resolution products, this does not mean that they are accurate or should be recommended to use at the local level, e.g. farm or field scale. For local-scale policy and land use decisions, local models with more detailed soil surveys would most likely need to be made. However, surely on a national scale and perhaps also on a large regional scale (provincial level), these maps can be used (given that users also consider the uncertainty that you report, i.e. accuracy metrics and uncertainty maps). Please add a section on this topic in the discussion supported by relevant literature.

Response: Thank you for your suggestion. We have added a discussion to clarify the recommended spatial scales for using these maps. The new section highlights that, while these maps are high-resolution, they are best suited for national or regional applications, with additional caution advised for local-scale use.

Modification:

"These maps are suitable for broad-scale applications, such as national and provincial-level analyses. Although generated at a high resolution (90 m), they may not provide sufficient accuracy for farm- or field-scale applications, where locally calibrated models and detailed surveys are recommended. Users should consider the provided uncertainty metrics to assess suitability for specific applications (Helfenstein et al., 2024)."

Helfenstein, A., Mulder, V. L., Teuling, K., Walvoort, D. J. J., Heuvelink, G. B. M., Wageningen, A., and Wageningen, R.: BIS-4D: mapping soil properties and their uncertainties at 25 m resolution in the Netherlands, 2024.

Comment #4: Please proofread for English spelling and grammar carefully. Currently there are numerous spelling and grammatical errors, some of which (not all) I have listed in the “technical corrections” below. Figures should be improved and legends and axes labels are often not readable.

Response: Thank you for your careful review and helpful comments. We have thoroughly proofread the manuscript to address spelling and grammatical issues, making corrections throughout the text. Additionally, we have enlarged the font size of legends and axis labels in the figures to improve readability.

Assets (data and code):

Comment #5: I was not able to access or download the data (90m resolution prediction maps). I recommend changing the data repository site and choosing one recommended by ESSD (https://www.earth-system-science-data.net/submission.html#assets). The model code is not provided and so the manuscript and modelling results are not reproducible (repository only contains 2 small scripts). I was not able to open the IGSN link when clicking on it but it did work when I pasted it into the browser (https://doi.org/10.11888/Terre.tpdc.301235). The “data sets” and “IGSN” assets are the same so one can be deleted. The “interactive computing environment” asset is merely a link to the python website and can be removed.

Response: Thank you for your feedback. We have made the dataset available on an additional data platform, "scienceDB" (**https://www.scidb.cn/s/ZZJzAz**), which should facilitate smooth access to the 90 m resolution prediction maps. The repository now includes the model code for reproducibility. Currently, as the manuscript is in submission with ESSD, we are unable to remove the “IGSN” and “Interactive computing environment” links. However, if granted the permission to make changes later, we will remove these redundant assets.

Modification:

"The soil maps in this study for six depth layers (0-5, 5-15, 15-30, 30-60, 60-100, and 100-200 cm) at 90 m spatial resolution across China are openly accessible https://www.scidb.cn/s/ZZJzAz or https://doi.org/10.11888/Terre.tpdc.301235"

Specific comments:

Comment #6: L42-46: A more recent national product very similar to your own that is worth listing here is https://doi.org/10.5194/essd-16-2941-2024

Response: Thank you for your suggestion. We have now included the recent national product by Helfenstein et al. (2024) on the Netherlands in the manuscript.

Comment #7: L105-106: I would suggest to remove the first aspect: you already mentioned several times that new datasets were incorporated and more data were used than in other DSM studies in China. In addition, given the size of the country, the number of soil profiles is still not very high.

Response: Thank you for your suggestion. We have removed the first aspect as recommended. We also acknowledge that, given the size of the country, the number of soil profiles remains limited.

Modification:

"Additionally, compared to existing datasets, this second edition offers a major innovation: over 20 comprehensive soil property variables were developed, while most current research focuses on mapping only a few basic soil properties."

Comment #8: L109-115: Thank you for including Fig. 2, which is very useful (see also my technical recommendations regarding this figure below). However, I think the list 1-4 here in the text does not summarize all the relevant steps completely. What about soil point data and covariate harmonization and preparation (which generally takes the longest!), model evaluation not only using data-splitting but also uncertainty maps?.

Response: Thank you for your helpful comments. Based on your suggestion, we have revised the workflow to include the steps related to soil point data and covariate harmonization and preparation, as well as model evaluation using both data-splitting and uncertainty maps. These steps are now explicitly addressed in the updated workflow description.

Modification:

"The workflow of this study is shown in Fig. 1. Five main processes are involved in this framework:

1. **Harmonizing and preparing soil point data and environmental covariates.**
2. **Incorporating laboratory measurements of multiple soil profiles and overlaying them with covariates to generate a regression matrix for modeling.**
3. **Using cross-validation to obtain optimal modeling parameters.**
4. **Fitting prediction models based on the regression matrix.**
5. **Applying spatial prediction models using high-resolution covariates and evaluating the models using data-splitting and independent sample validation, as well as uncertainty maps."**

Comment #9: L263-265: How did you obtain the mean prediction using QRF? Or did you use RF for obtaining the mean prediction? This issue is discussed also in https://doi.org/10.1016/j.geoderma.2021.115659IF: 5.6 Q1 , https://doi.org/10.5194/essd-16-2941-2024IF: 11.2 Q1 or https://doi.org/10.5194/soil-7-217-2021

Response: Thank you for your insightful comment, and I apologize for the lack of clarity in the manuscript. In this study, we used the Random Forest (RF) model to obtain mean predictions. Quantile Regression Forests (QRF) were used specifically for generating prediction maps at different quantiles. We have clarified this distinction in the revised manuscript.

Modification:

"The RF model was used to generate mean predictions, while QRF were applied to produce prediction maps at different quantiles, providing a more comprehensive representation of uncertainty."

Comment #10: L261-265: Did you compare median and mean predictions? You could do so quantitatively by comparing accuracy metrics and qualitatively by

comparing the quality of the maps visually. Perhaps for some of the many soil properties that you predicted, median predictions are more accurate or are to be preferred over mean predictions. Median and mean predictions of DSM products using QRF and RF are e.g. compared in https://doi.org/10.5194/essd-16-2941-2024.

Response: Thank you for your valuable suggestion. We will conduct a comparison between the median and mean predictions to determine the most accurate approach for each soil property. This analysis may take some time, as certain properties may indeed perform better with median predictions, while others may be better represented by mean predictions. *Once this comparison is complete, we will update the final dataset based on the results as soon as possible.*

Comment #11: L274: Why did the authors choose the WoSIS dataset as the independent dataset for statistical validation (second method)? Looking at Fig. 1 of the soil point data on the map, it's quite clear to me and it's a good choice, but it should still be shortly explained as this is an important detail. The choice of dataset used for statistical validation strongly influences accuracy metrics (e.g. https://doi.org/10.1111/j.1365-2389.2011.01364.x).

Response: Thank you for your comment. As shown in the soil profiles spatial distribution map (Fig. 2), the WoSIS dataset has a more uniform spatial distribution across the study area, making it well-suited as an independent dataset for statistical validation.

Comment #12: L276-281 and Eq. 2-4: Consider changing the order to ME followed by RMSE and then MEC since mathematically this makes much more sense (ME is a part of RMSE equation). This would also make more sense for explaining the terms in the text directly afterwards (L282-286).

Response: Thank you for your suggestion. We have revised the order of ME, RMSE, and MEC as recommended,

Comment #13: L303: I don't think Yan et al., 2020 is the most appropriate citation here. Better choose a manuscript that is specifically about prediction uncertainty and its error sources in DSM or statistical modelling. Some examples include: https://doi.org/10.1007/978-3-319-63439-5_14 or https://doi.org/10.1016/j.geoderma.2024.117052.

Response: Thank you for your suggestion. We have updated the citation to refer to studies specifically addressing prediction uncertainty and error sources in DSM and statistical modeling, as recommended.

Comment #14: L333-334: I suggest referencing the extensive review study of Chen et al. 2022 (https://doi.org/10.1016/j.geoderma.2021.115567) and also comparing with other studies (e.g. https://doi.org/10.5194/essd-16-2941-2024) not only in China to support the statement that pH is usually easiest to predict.

Response: Thank you for your suggestion. We have updated the manuscript to include the recommended references, which provide further support for the statement that pH is usually the easiest soil property to predict, not only in China but also in other regions.

Comment #15: L401: Careful! Confidence intervals are not the same as prediction intervals. Here you should be referring to prediction intervals, just as you do in the methods section.
Response: Thank you for pointing this out, and I apologize for the oversight. We have revised the manuscript to replace "**confidence interval**" with "**prediction interval**" as suggested.

Comment #16: L555-556: A more recent approach has also used covariates dynamic not only in two dimensional space but also over depth (and time), see https://doi.org/10.1038/s43247-024-01293-y.
Response: Thank you for your suggestion. We have now included the recommended reference in the manuscript.

Technical corrections:

Comment #17: L75: remove parentheses around Zhou et al., 2019a.
Response: The parentheses around Zhou et al., 2019a have been removed as suggested.

Comment #18: L104: "without explicit uncertainty"
Response: Thank you for your comment. In response to your feedback and the suggestions from the first anonymous reviewer, we have made the following revisions: The key advancements of this second edition dataset, compared to the first edition, are as follows:

1. **Integration of multi-source soil profile samples, including data from the Second National Soil Survey of China (Shangguan et al., 2013), the World Soil Information Service (Batjes et al., 2020), the First National Soil Survey of China (National Soil Survey Office, 1964), and regional databases (Shangguan et al., 2012), enhancing the spatial representation of soil profiles, rather than relying solely on data from the Second National Soil Survey as in CSDLv1.**
2. **Application of advanced machine learning methods, replacing the conventional soil polygon linkage method used in CSDLv1.**
3. **Consideration of high-resolution environmental covariates as predictors for the machine learning models, allowing the model to capture more detailed spatial relationships between soil properties and environmental factors.**
4. **As a result of the improvements in points 1-3, the spatial resolution has been enhanced from the original 1 km to 90 m, providing more detailed and accurate spatial predictions of soil properties.**

Comment #19: L109: Fig. 1 is the map of soil profiles. Here I assume you refer to Fig 2. Check this and make sure all tables and figures are in the correct chronological order in which they appear in the text.

Response: Thank you for pointing this out. We have adjusted the order of the figures to ensure they appear in the correct sequence as referenced in the text.

Comment #20: L131: If I am not mistaken 11,209 should be written as 11 209 and 8,979 as 8979. Also, there should be spaces between units (also percentages) and the number. Please carefully read through https://www.earth-system-science-data.net/submission.html. There is a very detailed and useful section about "mathematical notation and terminology". Please check this and apply to entire manuscript.

Response: Thank you for your suggestion. We have revised "**11,209**" to "**11 209**" and "**8,979**" to "**8 979**" as recommended. Additionally, we have reviewed the entire manuscript and made the necessary formatting adjustments for all numerical values and units according to the guidelines.

Comment #21: L146-147: include reference to GSM standard depths to make it clear which international standards you are referring to:

Arrouays et al., 2014. GlobalSoilMap: Basis of the global spatial soil information system)

Arrouays et al., 2015. The GlobalSoilMap project specifications, in: Proceedings of the 1st GlobalSoilMap Conference.

Response: Thank you for your suggestion. We have added the recommended references (**Arrouays et al., 2014; Arrouays et al., 2015**) to clarify the international standards for soil depth used in this study.

Comment #22: L160: Perhaps adjust to "Covariates related to the soil-forming factor 'organism'".

Response: Thank you for your suggestion. We have revised the text to "**Organism-related covariates were primarily sourced from six datasets…**" as recommended.

Tables and Figures:

Comment #23: Figures in the manuscript and supplements are often too small, axis and legend labels are non-readable. It is key that these figures are improved for publication, as maps are key to this study. Some colors scales in the figures are not color-blind friendly (red and green colors), e.g. Fig. S26.

Response: Thank you for your valuable feedback. We have made improvements to the figures in both the main manuscript and the supplements to enhance readability and ensure they are suitable for publication. The axis and legend labels have been enlarged, and we have adjusted the color schemes to be more color-blind friendly, avoiding red and green combinations as suggested.

Comment #24: In general, I would recommend re-assessing where and how information is presented in figures, which I realize is challenging with so many predicted soil properties at different depths and maps of uncertainty etc. Perhaps see https://doi.org/10.5194/essd-16-2941-2024IF: 11.2 Q1 and the supplements of that manuscript for ideas (https://doi.org/10.5194/essd-16-2941-2024-supplement) – there they organized the supplements by soil property.

Response: Thank you for your suggestion. Following your recommendation, we have reorganized the figures and supplemental materials by soil property, referencing the structure provided in the ESSD manuscript (https://doi.org/10.5194/essd-16-2941-2024) and its supplements. We hope this improves the clarity and accessibility of the presented information.

Comment #25: Figure 2: remove "altitude", shown in parentheses below depth. Altitude usually refers to elevation, whereas here you are referring to depth. According to Meinshausen 2006, QRF should be "quantile regression forest", not "quantile random forest". You also refer to it as quantile regression forest elsewhere. Check entire manuscript to make sure it's the same. "Variables" is misspelled ("varibles maps"). Finally, the caption is grammatically incorrect: either "for national-scale soil properties mapping" or "for developing national-scale soil property maps". Please check.

Response: Thank you for your detailed feedback. We have removed "altitude" as suggested and corrected "QRF" to consistently refer to "**quantile regression forest**" throughout the manuscript. We have also fixed the spelling of "**Variables maps**" and revised the figure caption to "f**or developing national-scale soil property maps**" for grammatical accuracy.

Comment #26: Figure 5: Maps are too small. Legends and axis labels cannot be read. Maps need to be enlarged. Consider restructuring figures (see comment above).

Response: Thank you for your comment. We have enlarged the maps and increased the font size of legends and axis labels in Figure 5 to improve readability and suitability for publication.