Responses to the comments from the 2nd Reviewer

Wu and coauthors present a robust and geographically extensive dataset of more than 20 soil elements derived from 1,314 samples across 30 mountain regions in China. This dataset covers diverse bioclimatic zones and three soil development horizons, which offers a valuable vertical and horizontal resolution for understanding the large-scale biogeochemical patterns. This comprehensive, spatially-explicit dataset from mountainous regions is timely and necessary considering the sampling difficulty and terrain complexity. The methodology alongside the rigorous quality control, open-access availability, and comprehensive metadata can significantly increase the reusability and scientific value of this dataset. In general, the manuscript is well-organized and written in fluent academic English, and scientifically rigorous. There are some concerns on the current manuscript that may help further clarify and improve the dataset's accessibility and documentation. Please find my specific comments and suggestions below.

Responses: We appreciate very much for your positive comments on our manuscript, and we also thank you for the valuable and professional suggestions to improve the manuscript. According to your comments and suggestions, we have made careful corrections and improvements of our manuscript. The detailed revisions are listed below.

Please specify the sampling time in this work, which will help well use the dataset.

Responses: Thank you for your valuable comment. The soil sampling was conducted between July 2012 and March 2013. This information has now been explicitly added to the main text to enhance clarity.

The sampling strategies need to be described more specific, considering such a large spatial scale and soil stratification. Were the samples composited from multiple subsamples or taken as single cores? How many replicates were collected per horizon at each site? Were replicate samples analyzed separately or composited before analysis? This information will help to assess the spatial resolution and statistical robustness of the dataset.

Responses: Thank you very much for the thoughtful and constructive comments regarding the sampling strategies. At each site or altitude of a mountain, three soil profiles were excavated by hand, and then each soil horizon was carefully divided. Each soil sample collected was mixed by subsamples taken from a horizon. During laboratory analysis, these replicate samples were analyzed separately rather than composited, ensuring the reliability of the data and enabling robust statistical estimation, including standard error calculation. We now add and clarify this information in the section of Soil sampling. The revised content is as follows:

Sampling campaigns were conducted at 166 sites spanning 30 mountains between July 2012 and March 2013. In each mountain, sites were selected based on the altitude and dominant vegetation types. At each site, the geographic coordinate was recorded using a GPS device (eTrex Venture, USA). Three replicate plots (10 m × 10 m) were randomly established per site, spaced approximately 50 m apart to account for spatial heterogeneity. In each plot, soil profiles were manually excavated down to the parent material horizon. Soil horizons were delineated in the field based on morphological characteristics following the Chinese Soil Taxonomy (Chinese Soil Taxonomy Research Group, 2001; Yang et al., 2023). Horizon boundaries were determined through visual and tactile assessments (e.g., color, texture, consistency, moisture, and root distribution). Horizons were typically classified as O (organic), A (surface mineral), and C (parent material) horizons. For each profile, the name, code, depth range, and diagnostic features were recorded. Soil samples were collected sequentially from bottom to up within each profile to avoid cross-pollution, with composite samples formed by homogenizing subsamples from each horizon.

The authors have emphasized lithogenic and biogenic controls on soil elemental patterns in this study, and relevant lithology data have been used in their prior publications (e.g., Wu et al., 2025; Yang et al., 2022). However, such information is not included in the dataset. I strongly encourage the authors to incorporate this information as an additional column in the main dataset or in the supplementary materials. This will substantially enhance the dataset's applicability in Earth system modeling.

Responses: We appreciate your insightful feedback regarding the dataset. We fully agree that incorporating lithological information will significantly enhance the applicability of the dataset for Earth system modeling. In response to the comment, we have added parent material (lithology) data for each sampling site to the dataset. Specifically, parent material data for the SOTER geological reservoir at a scale of 1:1000000 in Chinese provinces (1990) were obtained from the National Earth System Science Data Center (http://www.geodata.cn). The revised dataset is available at the following link: https://doi.org/10.11888/Terre.tpdc.302620 or https://cstr.cn/18406.11.Terre.tpdc.302620

In Figures 5 and 6, the abbreviation "AI" (aridity index) is not defined. Please ensure that all variables and indices (e.g., AI, CIA, NDVI) are spelled out at first mention, including in figure captions and abstract, to support clarity for multidisciplinary readers.

Responses: Thank you for pointing out this important issue. We have carefully checked the entire manuscript, including the abstract, figure captions, and main text, to ensure that all abbreviations are fully spelled out at their first mention. The figure captions for Figures 5 and 6 have also been updated accordingly to improve clarity for readers.

Carefully check all the figures to ensure that axis labels, units, and legends are present, standardized, and clearly legible. Some figures appear to lack axis units or use inconsistent font sizes. Improving figure formatting will significantly enhance the readability and usability of the manuscript.

Responses: Thank you for your feedback on Figures. We have carefully reviewed and standardized all figures to ensure that axis labels, units, and legends are complete, consistent, and clearly legible. Font sizes and formatting have been adjusted uniformly across all figures to improve readability and overall presentation quality.

Although the DOI is cited, the manuscript would benefit from explicitly stating the name of the data hosting platform (i.e., "National Tibetan Plateau Data Center") and providing a summary of available file formats (e.g., .CSV, .XLSX) and data structure.

Responses: Thank you very much for your valuable feedback. In response, we have revised the Data Availability section to explicitly specify the name of the data hosting platform and to provide a summary of the available file formats and data structure. The revised text is as follows:

The database is freely accessible via the National Tibetan Plateau/Third Pole Environment Data Center at https://doi.org/10.11888/Terre.tpdc.302620 or https://cstr.cn/18406.11.Terre.tpdc.302620 (Wu et al., 2025b). The dataset provides comprehensive information for each sample, including mountain affiliation, geographical coordinates, climatic characteristics, vegetation type, soil type, parent rock type, normalized difference vegetation index, atmospheric nitrogen deposition rates, soil physicochemical properties, chemical weathering indices, and concentrations of 24 soil elements. The data are stored in Excel spreadsheet format, accompanied by a separate data documentation file that describes variable names, units, and definitions.

In the dataset files, columns such as “Vegetation” and “Horizons” use abbreviated codes. Please ensure these codes are clearly documented in the metadata or in a separate codebook/readme file.

Responses: Thank you for your helpful suggestion. We have updated the dataset documentation to include detailed explanations of all abbreviated codes used in the dataset files. Full definitions are now provided in the revised metadata file and the accompanying dataset description to enhance clarity and ensure ease of use for data users. The revised dataset file is available at the following link: https://doi.org/10.11888/Terre.tpdc.302620 or https://cstr.cn/18406.11.Terre.tpdc.302620

In addition to its clear value for biogeochemical modeling and soil quality assessment, the dataset also offers considerable potential for applications in soil development and weathering modeling. The inclusion of vertically stratified soil horizons, chemical weathering indices, and a range of environmental covariates, combined with the recommended addition of lithological data, provide a strong basis to simulate pedogenesis and mineral nutrient weathering and release across climate gradients. These potential applications are needed by highlighting them in the discussion to better reflect the broader relevance of the dataset.

Responses: We sincerely appreciate your insightful comments regarding the broader applicability of our dataset. We fully agree that beyond its demonstrated value for biogeochemical modeling and soil quality assessment, the dataset also holds significant potential for applications in soil development and weathering modeling. Following your suggestion, we have added a dedicated discussion of these potential applications in the revised manuscript, highlighting how the inclusion of vertically stratified horizons, chemical weathering indices, and lithological data can support process-based models of pedogenesis and nutrient release. This addition aims to clarify the dataset's broader relevance and enhance its value to researchers working on long-term soil development, especially in mountainous regions where such data are scarce. We thank the reviewer again for helping us improve the manuscript in this important aspect. The added content is as follows:

In addition, the inclusion of horizon-specific data (O, A, and C horizons), weathering indices, and lithological information provides valuable input for soil formation and rock weathering models. Process-based models like SoilGen or conceptual frameworks such as CLORPT (climate, organisms, relief, parent material, and time) can benefit from the dataset's vertical resolution and environmental coverage to simulate pedogenesis, profile evolution, and mineral nutrient release across climate gradients. Accordingly, the dataset can serve as a regional benchmark for calibrating and validating long-term soil development models, particularly in mountainous regions where such data are scarce yet critically needed.