To Reviewer #1

General Comments

[Comment 1] *Authors have improved the manuscript according to comments from reviewers. I basically satisfy most of the modifications, especially the updated vegetation classification scheme. However, such classification still has some shortfalls, such as the study couldn't separate evergreen and deciduous forests from broadleaved and coniferous forests, and couldn't separate alpine shrubland and desert from alpine meadow and steppe. The reviewer understands that from the global remote sensing datasets and also from pollen data, such separations are very hard. So, the authors should discussion how such shortfalls of this vegetation scheme could affect the interpolation of the detailed vegetation change on the TP.*

[Response] Thank you for your constructive comment and understanding. As the reviewer noted, the updated vegetation classification scheme represents a compromise between broader applicability and accuacy, constrained by the limitations of both modern global remote-sensing datasets and pollen datasets. In the revised manuscript, we have explicitly discussed these limitations and their implications for the application of our dataset. Specifically, we added the following text: "The accuracy of both pollen- and remote-sensing–based vegetation classifications imposes constraints on the vegetation classification scheme of our reconstruction. Pollen identification, relying primarily on exine morphology, is typically limited to the genus or family level, making it difficult to distinguish functional ecological traits such as evergreen versus deciduous. For example, evergreen and deciduous species of *Quercus* display only minor morphological differences in their pollen and are therefore generally grouped as "*Quercus*-type pollen" (Peñuelas et al., 2009), with finer distinctions requiring additional evidence such as macrofossils (Liu et al., 2007). This limitation is compounded by the relatively coarse spatial resolution of MODIS data, while suitable for regions with simple land cover types, often yields low classification accuracy in areas with more complex vegetation (Zeng et al., 2016). As a result, we did not separate evergreen and deciduous forests from broadleaved and coniferous forests. Additionally, all existing global land cover datasets consistently indicate that shrub cover on the Tibetan Plateau is minimal, generally less than 2% (Yang et al., 2017). Accordingly, shrubs were not treated as a separate class but instead merged with trees under the broader category of woody vegetation. The inability to separate evergreen and deciduous forests constrains applications in climate, carbon, and biodiversity studies, as well as paleoecological reconstructions of vegetation responses to environmental disturbances." (Lines 324-336 on Pages 15-16)

Furthermore, we emphasized that coupling data-driven and process-based approaches provides a promising direction for future improvement. For instance, process-based models such as REVEALS can generate taxon-specific cover estimates by accounting for pollen productivity and dispersal, whereas data-driven approaches provide actual vegetation cover to calibrate and refine these reconstructions. Such integration not only enhances the robustness and reliability of the dataset through cross-validation of independent methods, but also allows taxon-level reconstructions that enable tracing of species' migrations, expansions, and contractions in response to climatic transitions. We consider this integration an important avenue for our future work. All of this information has been clarified in the revised manuscript.

Specific Comments

[Comment 2] *Another suggestion: woody plants can be changed to woody vegetation, and herb plants to herb vegetation. These new terms match with the terms of other forest and grassland vegetation.*

[Response] Thank you for your helpful suggestion. In the revised manuscript, we have adopted the terms “woody vegetation” and “herb vegetation” in place of “woody plants” and “herb plants,” respectively.

To Reviewer #2

General Comments

[Comment 1] *I concur with the previous reviewers' observations. While the dataset provides valuable information, there remains substantial uncertainty associated with the original sample data, the reconstruction procedures, and the interpolation, as well as the temporal and spatial extrapolations. A more comprehensive discussion of the data sources and methodologies is warranted, together with explicit cautionary notes on the appropriate use and interpretation of these data.*

[Response] Thank you for your thoughtful suggestion. Following your advice, we have added a new subsection in the revised manuscript to systematically address the uncertainties in paleovegetation reconstructions, including those arising from pollen datasets, remote-sensing-derived vegetation cover, land-cover products, and methodological limitations, as the following text: "Although data-driven machine learning methods provide a less parameter-intensive approach to reconstructing paleo-vegetation, they still rely on the assumption that the relationship between pollen records and vegetation cover, extracted from modern observations, has remained consistent over time. Consequently, the robustness of our reconstruction ultimately depends on the quality of the input datasets, including pollen percentage data and vegetation cover derived from remote sensing observations.

Pollen datasets, compiled from diverse studies with varying objectives and methods, inevitably contain inconsistencies in sampling, taxonomic identification, and age control. We implemented rigorous quality-control procedures, including duplicate removal, correction of inaccurate coordinates, taxonomic standardization, and filtering for higher temporal resolution and reliable chronologies. Nonetheless, unavoidable uncertainties remain due to environmental contamination and the absence of standardized pollen processing and identification protocols. Furthermore, pollen samples could potentially be corrupted by anthropogenic disturbances, such as land use, agricultural practices, and the introduction of exotic plants (Cronin et al., 2017; Sobol et al., 2019a; Zhang et al., 2025).

To link modern pollen assemblages with vegetation cover, we employed the MCD12Q1 land cover product in conjunction with the GLASS vegetation cover dataset to estimate the cover of different plant functional types. While these satellite-based reanalysis datasets are robust at the global scale and are widely applied, they generally introduce larger uncertainties than field observations or region-specific vegetation maps. Such acceptable but non-negligible errors inevitably affect the precision of paleovegetation reconstructions. In addition, although the majority of modern pollen samples used in this study were collected after the 2000s, some were obtained in the 1980s and 1990s. The vegetation represented by these earlier samples may have shifted under contemporary climate change, particularly given the rapid warming observed in recent decades.

The accuracy of both pollen- and remote-sensing–based vegetation classifications imposes constraints on the vegetation classification scheme of our reconstruction. Pollen identification, relying primarily on exine morphology, is typically limited to the genus or family level, making it difficult to distinguish functional ecological traits such as evergreen versus deciduous. For example, evergreen and deciduous species of Quercus display only minor morphological differences in their pollen and are therefore generally grouped as “Quercus-type pollen” (Peñuelas et al., 2009), with finer distinctions requiring additional evidence such as macrofossils (Liu et al., 2007). This limitation is compounded by the relatively coarse spatial resolution of MODIS data, while suitable for regions with simple land cover types, often yields low classification accuracy in areas with more complex vegetation (Zeng et al., 2016). As a result, we did not separate evergreen and deciduous forests from broadleaved and coniferous forests. Additionally, all existing global land cover datasets consistently indicate that shrub cover on the Tibetan Plateau is minimal, generally less than 2% (Yang et al., 2017). Accordingly, shrubs were not treated as a separate class but instead merged with trees under the broader category of woody vegetation. The absence of a more detailed vegetation classification scheme constrains the applications of this paleovegetation dataset in climate, carbon cycle, and biodiversity studies, particularly when differences among vegetation types are of primary interest.” (Lines 304-336 on Pages 15-16)

In addition, in light of the uncertainties discussed above, we have summarized explicit cautionary notes on the appropriate use and interpretation of the dataset. The following text has been added to the revised manuscript: “The construction methods and spatiotemporal resolution of this dataset necessitate several considerations in its application: (1) The magnitude of modern vegetation cover datasets directly influences the magnitude of reconstructed vegetation cover, while their spatial heterogeneity shapes the temporal variability of reconstructed sequences. However, substantial discrepancies exist among vegetation cover datasets owing to differences in data sources, processing methods, and classification systems (Liu et al., 2024b; Xu et al., 2024). Therefore, when comparing paleovegetation reconstructions derived from different modern vegetation cover datasets, these intrinsic differences must be carefully taken into account. (2) The spatiotemporal resolutions of 0.5° × 0.5° and 400 years are appropriate for regional- to continental-scale analyses and for examining long-term trends, but they are insufficient to resolve fine-scale ecological heterogeneity or capture decadal climatic fluctuations. (3) The classification of vegetation into seven types, while facilitating comparability with Earth System Models, does not fully capture the complexity of plant functional diversity or ensure direct equivalence with model-specific plant functional types." (Lines 479-389 on Page 17).