

## **Reviewer #2:**

Thank you very much for the reviewers' suggestions. We have made the following modifications to the questions raised by the reviewers:

This manuscript investigates the altitudinal patterns of soil organic carbon (SOC) and inorganic carbon (SIC) in an arid alpine grassland ecosystem in the northern Qinghai-Tibetan Plateau. The study addresses a relevant and underexplored topic and contributes to our understanding of carbon pool dynamics in fragile, water- and temperature-constrained ecosystems. The finding that SOC increases with altitude while SIC shows a non-linear pattern is interesting and provides valuable contrast to previous studies in humid alpine zones. However, several issues related to English expression, logical structure, data analysis (particularly SEM), and the discussion of SIC need to be addressed before publication.

Specific comments:

1. The manuscript requires moderate editing for grammar and clarity. Some sentences are overly long or awkward (e.g., lines 233–235). Consider professional language polishing.

Response: According to the reviewers' comments, we made modifications to the long sentences in the article. For example, “In contrast to the findings from prior studies with alpine meadow or moist grasslands (Chen et al., 2017; Chen et al., 2022), our results show the predominance of soil inorganic C in the dry alpine rangeland.” was changed to “Contrary to the previous research results that the soil carbon pool of alpine meadows or moist grasslands was mainly composed of organic carbon (Chen et al., 2017; Chen et al., 2022). Our research results show that inorganic carbon in the soil of arid and alpine plateaus dominates.” in line 241-245.

2. The current version does not adequately explain the broader research background or the regional climate-vegetation features of the study area. Suggest briefly stating why arid alpine grasslands are important.

Response: Thanks very much to the suggestions of the reviewers, we have added the sentence about the importance of alpine grassland in arid areas in line 68-71. “Alpine

meadows in arid areas are also an important part of the alpine meadow ecosystem on the Qinghai-Tibet Plateau and are the foundation of agriculture and animal husbandry in the northern part of the Qinghai-Tibet Plateau (Zhang et al., 2021). ”

3.The description of climatic and vegetation features of the study area is insufficient in the introduction. Add 1–2 sentences summarizing key traits of arid alpine grasslands.

Response: Thanks very much to the suggestions of the reviewers, we have added the sentence about climatic and vegetation features in line 77-80. “ The alpine grassland in the northern part of the Qinghai-Tibet Plateau is located in the arid climate area, with a relatively low vegetation coverage. The surface is severely eroded by wind and water, and the community type is mainly desert grassland”.

4.Hypotheses lack specificity – In the introduction, the hypothesis should be expanded to state expected relationships between environmental, vegetation, and soil variables and SOC/SIC.

Response: Based on the reviewers' comments and the introduction in the preface, we will modify the hypothesis to (1) With the increase of altitude, the decrease of temperature and the increase of vegetation, the content of soil organic carbon increases; (2) With the increase of altitude, the drought limitation is alleviated and the inorganic carbon content in the soil decreases; (3) With the increase of altitude, the proportion of organic carbon in the soil carbon pool increases, while the proportion of inorganic carbon decreases.

5.line 94-95, 91°18'E, 36°N - 37°49'N, Punctuation error.

Response: Thanks very much to the suggestions of the reviewers, we have revised the sentence.

6.Line 105 – Figure S1 is cited but not provided.

Response: Change "Fig. S1" to "Fig. 1".

7.The description of the initial SEM model is missing. Please add information on model structure, variable selection rationale, and key fit indices (e.g.,  $\chi^2$ , RMSEA).

Response: In this paper, the F-value test used in the SEM model calculation is used,

and the significance and fitting degree of the model are represented by Fisher's,  $p$ , AIC and BIC.

8.Line 259 – It is stated that MAT and SWC significantly increased SOCD and SICD, but no mechanistic interpretation is provided for SICD.

Response: Since this part of the content only explains the changes and influencing factors of SOCD, SICD is not mentioned. Therefore, we deleted “SICD”.

9.Discussion on SIC / SIC:

The discussion of SIC is relatively fragmented. Recommend reorganizing it into two parts: (a) Abiotic controls (e.g., parent material, soil water, slope effects); (b) Potential biotic influences (e.g., root respiration, vegetation cover).

Response: According to the reviewers' comments, we analyzed the influencing factors of SICD changes at different altitude gradients into abiotic factors and biological factors. In line 298-314, we analyzed the influences of abiotic factors such as precipitation, topography, and soil parent material. In line 314-319, we analyzed the influence of biological factors such as plant communities. Finally, the main influencing factors and causes of this area were comprehensively analyzed through the SEM model analysis.

10.Line 303 – “SEM-composite” is unclear. Possibly rephrase as “composite SEM model” or “final SEM structure.”

Response: Thanks very much to the suggestions of the reviewers, we changed “SEM-composite” to “composite SEM”.