Author response to Referee #1

We thank Referee #1 for the careful reading of our manuscript and for their constructive, detailed comments. We appreciate the positive assessment of the relevance of the topic and the modeling approach. The following is our response to each of the referee's general and specific comments. All suggested changes have been applied to the revised manuscript.

General comments

Comment:
The Introduction and Discussion are too long, the Materials and Methods section lacks sufficient detail, and the Results and Figures require substantial improvement.

Response:
We thank the referee for this overall assessment. The clarity and structure of the manuscript have been improved. In the revised version, the Introduction has been shortened (it now ends on line 103) to reduce excessively descriptive literature references. We have reorganized the topics to focus on the most relevant studies of SOC modeling using LiDAR.

The Discussion section (lines 288-394) has undergone similar streamlining to highlight the most important findings (SOC approach, LiDAR application, RF evaluation, limitations and further studies).

The referee's suggestions have also been integrated into the improved Materials and Methods and Results sections. We revised the description fo the soil carbon determination and modeling procedures in the Materials and Methods section to ensure full reproducibility. The Results section has been rewritten and the number of tables and figures has been reduced. Supplementary Material has also been edited.

Specific comments

Title

Comment:
"lidar" → "LiDAR"

Response:
This has been corrected.

Abstract

Comment:
Please explain the meaning of "LiDAR" when it first appears. Include key SOC stock results and briefly discuss management practices or climate events affecting SOC.

Response:
These suggestions have been incorporated into the new manuscript: the meaning of "LiDAR" was added in lines 14 and 42 and SOC stock results appear in lines 19-20, along with a brief comment about management practices in line 26.

Introduction

Comment:
The Introduction is relatively long; focus on relevant studies and clearly state scientific hypotheses.

Response:
The introduction was revised and reduced in length to focus on relevant and related topics. Two hypotheses were added in line 97.

Materials and Methods – Soil carbon determination

Comment:
Provide sufficient methodological detail; the techniques used are not the most common.

Response:
A paragraph has been added to the Discussion section (lines 374-389) to clarify this issue.

Materials and Methods – Modeling approach

Comment:
The modeling description lacks clarity and justification for model selection.

Response:
We have re-worked the modeling description by clarifying the models used and adding two new references in line 226 (Odebiri et al., 2021; Beisekenov et al., 2025). The Materials and Methods section has been thoroughly revised and is substantially improved in the new manuscript.

Results

Comment:
Avoid restating what is apparent in tables and figures.

Response:
The Results section has been revised, repetitive information eliminated, and the number of tables and figures reduced to five each.

Discussion

Comment:
The Discussion is overly long and should be condensed.

Response:

The discussion section has been reduced and streamlined to focus on the main topics.

Tables and Figures

Comment:
The number of figures and tables is excessive; improve quality and design.

Response:
The number of figures and tables has been reduced and supplementary material has been revised.

Line-specific comments

L33:
Clarify what soil condition or SOC status is expected to be achieved by 2050.

Response:
The suggestion has been incorporated and appears in Line 34.

L45:
SOC already defined in the Abstract.

Response:
Agreed. The redundant definition has been removed.

L46–47:
“Soil facilitates photosynthesis” is inaccurate.

Response:
We agree. The corresponding paragraph has been removed from the revised Introduction.

L52:
“reducing the effects of climate change” → “reducing the negative effects of climate change”

Response:
We agree. The corresponding paragraph has been removed from the revised Introduction.

L192:
Why 34 plots? When was sampling conducted? Temporal consistency of data?

Response:
The number of plots was determined based on the systematic sampling design and logistical constraints, to ensure representative spatial coverage of the study area. Soil and forest inventory sampling were conducted within a short and consistent window of time. LiDAR data acquisition occurred within a compatible timeframe, to minimize temporal mismatch effects.

L206:
Consider elemental analyzer measurements for total carbon.

Response:
A paragraph has been added to the Discussion section (lines 374-389) to clarify this issue.

L213:
Clarify how “organic C content of the fine soil fraction” was determined.

Response:
The samples were sieved; the term “fine” has been removed to avoid confusion.