**Response to Reviewer 1 comment**

**Comments and Suggestions for Authors**

The manuscript entitled “Determination of Mehlich 3 extractable elements with visible and near infrared spectroscopy in a mountainous agricultural land, the Caucasus Mountains” aims to evaluate the potential of VIS-NIR spectroscopy and PLSR modeling to predict M3 extractable elements (Ca, Mg, Cd, Cu, Fe, K, P, Pb, Mn, and Zn) in a representative test area of Caucasus Mountains. A lot of work has been done. However, there are some issues that need to be resolved before this manuscript can be considered for publication.

**My major concerns:**

This manuscript attempts to integrate different preprocessing methods (8 kinds), sample grouping designs (88/26, 75%/25%), and soil spectral data to predict 15 soil properties by building PLSR models. Although this manuscript is about the application of proximal remote sensing technology to the prediction of soil properties in mountainous areas, the research focus of this manuscript is not prominent, and the conclusions drawn are not very clear. In other words, the manuscript feels like a lot of work has been done, but it doesn't specify what the important conclusions and innovations are.  The abstract and conclusion parts lack conciseness and prominence. Especially in the results and discussion section, most of the content is to state the experimental results (correlation of data), while the discussion (eg. prediction mechanism, prediction accuracy, etc.) is not in-depth, and the analysis of model accuracy is rarely involved in the discussion.

Response: We would like to thank you for your valuable comments and directions. We have carefully considered all issues and have revised the manuscript completely (e.g. separation of sections and subheadings, revising all the text, adding paragraphs & references, adding/changing Tables & Figures):

1) Abstract was revised.

2) Introduction was revised, and 2 new paragraphs were added. Such modification leaded to the clear description of the objectives.

3) Material and Method section was revised. Revised version contains 5 subheading.

4) The results and discussion sections were separated, and their subheadings were reorganized. In the revised manuscript the Results contain 5 subheading and Discussion contain 3subheading.

5) Presentation of the results are improved with consideration of reviewers’ comments.

1. Original Manuscript contained 3 Tables and 3 Figures. Revised manuscript contains 4 Tables and 5 Figures and 1 supplementary table and 1 supplementary figure.
2. New subheading (3.2. Land use effect on soil properties) was added. It contains new Table 2, Supplementary Table 1 and Supplementary Figure 1.
3. New Table 4 and Figure 4 were added. Table 4 is related to partial correlation analysis with consideration of spkoil properties, and Figure 4 is related to the principal component analysis.
4. Clarification: Table 1 and Table 3 were not changed. Old Table 2 is new Figure 2. Old Figure 2 is new Figure 3. Old Figure 3 is new Figure 5.

6) Discussion with new 3 subheading was significantly expanded and linked to the references, and the novelty was highlighted.

7) Conclusions was modified to show its practical outcomes for the local and international readers.

8) New 12 references were added to update the manuscript to address reviewers’ comments.

Due to the separating the Results and Discussion section, overlapping of some comments made by reviewers and associated changes, all the text of the manuscript was modified. Thus, to avoid possible confusion we provided the location (subheading or line) for any change introduced. Our point-to-point response to the comments of the reviewers is detailed below. Subheading or line numbers refer to the line numbers in the revised manuscript.

Two version of the manuscript was uploaded: edited main manuscript (with track change), and edited main manuscript (clear).

**Specific comments:**

When the samples are grouped, it is generally carried out according to 7:3 or 3:1 or a certain ratio. There are 114 soil samples in this study, what is the basis for grouping by 88/26 (77.2%/22.8%)?

Response: Thanks. Sorry for the technical error. The sample set was divided into two subsets (75% and 25%) for calibration (86 samples) and validation (28 samples).

Should the writing of the results and discussion sections be separated? Please think carefully.

Response: Thanks. The sections were separated as recommended.

During the discussion, the reasons behind the experimental results should be analyzed, not only from the correlation between the sample data but also cannot be explained by relying too much on the VIP score curve.  In addition, partial correlation analysis (e.g., Cheng et al., 2019) could be helpful and bring more insights given the fact that soil spectra are simultaneously influenced by several soil properties (e.g., SOM and Iron oxide).  This may help to analyze the underlying mechanism.

Response: Thanks. The comment was fully considered: the PCA and partial correlation analysis was adopted form the recommended study (e.g., Cheng et al., 2019). Correspondingly, separate subheadings (with new Table 4 and Figure 4) were added. Generally it was considered in Introduction and Materials & Methods, Results and Discussion sections. Such approach helped to analyze the underlying mechanisms.

Line 104, 195, 223, 544: Is it “modelling” or “modeling”? The whole text should be unified.

Response: Thanks. It was corrected to “modeling”.

Lines 145-146: “, soil reaction (pH) in 1:1 soil to KCl solution” is not clearly expressed.

Response: Thanks. It was corrected. pH was measured in water solution. (Line: 206-207)

Lines 163-164: “…were conducted under a controlled laboratory environment.” Can you explain this sentence? Generally, soil spectral measurement is carried out in a dark room to avoid interference from external light sources.  What does the controlled laboratory environment you describe look like?

Response: Thanks. It was revised as recommended. (Line: 244-249)

Line 174: “…resulting in 12 spectra”. It is not clear how the 12 spectra were obtained here.

Response: Thanks. The text was revised. Each single measurement was based on internally averaged of 50 spectra (3 times). Each sample was measured from four positions (90°rotating the Petri dish each time). Consequently, 4 rotation x 3 time = 12 spectra were obtained. It is one of the commonly used method and several references are available. Line;252-259

Line 176: “…resulted 50 spectra…”. It is also not clear how 50 spectra were obtained.

Response: Thanks. It was revised. See previous comment.

Line 190: “…moving window sizes (mainly 7, 9 and 11)”. Need to use 3 different moving window sizes? It undoubtedly increases your experimental workload, and you do not explain it later. As far as I know, most articles use only one moving window size.

Response: Thanks. The whole paragraph was revised. Line: 262-269.

We would like to note that in practice a large variety of pre-processing techniques are used with different gap and moving window size to improve prediction quality (Luce et al. 2017, Mammadov at al. 2020). Yet, the quality of prediction still depends on several factors (measurement method, used device etc.).

Line 191, 365: “…with different gaps and segment sizes.” “…with gap segment size of…”. Do these two places mean the same thing?

Response: Thanks. The text was revised, see previous comment.

Line 194: “was” should be “were”. Please pay attention to the singular and plural in the sentence.

Response: Thanks. Corrected.

Line 233: It’s usually written as “Results and discussion”.

Response: Thanks. Corrected.

Line 243: “(pH, temperature, precipitation)” should not be placed after the word elevation.

Response: Thanks. It was revised as “change in pH, temperature, precipitation by elevation”. Line:334-337.

Line 264: “…CaCO3 and Fe),” Where is the left parenthesis?

Response: Thanks. It was edited.

Line 264: “…, and hence parent material.” It’s not clear here.

Response: Thanks. Corrected to “soil type”.

Lines 281, 249: Why did you use Spearman's Rho correlation coefficients earlier and Pearson correlation coefficients here?

Response: Thanks. Both methods are used to characterize relations between soil properties and spectra. Based on our experience, for current study (or similar studies) relations among soil properties, and between PC1 and soil properties are well characterized by Spearman, and Pearson is more relevant to the relations between spectra and soil properties.

Lines 325-328: “Regardless of… spectra.” Is there a necessary connection between these two sentences? The spectral absorption characteristics near 1400, 1900, and 2200 nm have their corresponding influencing factors.

Response: Thanks. It was revised. Line:515-518.

Line 347: “different pattern” should be “different patterns”. Note the singular and plural in the sentence.

Response: Thanks. It was edited.

Lines 353-354, 374: “Savitzky-Golay 1st derivative…” “Savitzky-Golay 2nd derivatives” This is a very confusing way to write it.

Response: Thanks. It was revised. Line:43, 440

Line 354-355: “…, in our case 11 bands…” “…in our case 10 wavebands…” It's confusing here. And all in Table 3 are “10-bands”.

Response: Thanks. It was modified. Line: 438-441

Lines 356-357: Can the first derivative preprocessing method be used to remove illumination differences?

Response: Thanks. It was revised. Line: 696-699

Lines 360-362: “… due to overtones and combination of fundamental vibrations of soil organic matter occurring in the VIS and NIR region.” The meaning of this sentence is not expressed clearly.

Response: Thanks. It was edited. Line:702-705

Line 409: Note the singular and plural in the sentence.

Response: Thanks. It was edited.

Line 449, 479: “CO3”?

Response: Thanks. Corrected to “CaCO3”. Line: 750-752

Line 455: “soil mineralogy”?

Response: Thanks. It was replaced with “clay mineralogy”.

Lines 456-457: What does this sentence do here?

Response: Thanks. It was revised. Line 736-740

Line 471, 480, 520: “(r = 0.4\*)” “(r =-0.52\*)” “(r = 0.40\*)”, etc. It is recommended that the number of digits after the decimal point for the value of the correlation coefficient throughout the text be consistent.

Response: Thanks. It was corrected.

Lines 490-491: “Unlikely, a weakly represented VIP peak centered at ~850 nm was a significant predictor for the Cd content.” The meaning of this sentence is not clear, and it is a little strange.

Response: Thanks. It was revised. Line:759-762

Lines 516-518: You call attention to the spectral signature at 2326 nm, and then what?  Readers may be more interested in your analysis and interpretation.

Response: Thanks. It was revised. It was related to the contribution of the basic soil properties (e.g. controlling factor CaCO3, Fe, clay) to the prediction of M3 extractable elements Line:780-786.

Line 520: The correlation between K content and P content is not very high (r = 0.40\*), but their corresponding VIP patterns are “identical”, how do you explain it?

Response: Thanks. Corrected or revised. Line:786-789

Line 523: “correspond absorption” should be “correspond to absorption”.

Response: Thanks. It was edited. Line:790-791

Lines 522-525: Is there a necessary connection between the first half of the sentence and the second half of the sentence? Is VIP peak related to Fe or SOC content?

Response: Thanks. Revised. Partial correlation analysis showed that the contribution of Fe was more important than that of SOC though the moderate correlation existed between them. Line: 786-791

Lines 541-543: Is this sentence appropriate here?

Response: Thanks. Edited.