Response to Huw Horgan (Public justification, 2)

Thank you for the submission of your revised manuscript. I have reviewed your submission and appreciate the time you have spent implementing the reviewer's recommendations.

It is my opinion that your manuscript still requires some changes prior to acceptance. You have included the relevant content but there are now some structural issues as much of the requested information has been placed in the discussion section while it is more suited to methods and results. Specifically I am referring to the method used to select the number of clusters used in your K-means cluster determination. You have done a good amount of work demonstrating your reasoning and the impact of your selection.

> **Reply:** Thanks a lot for your detailed comments, feedback, and suggestions! We appreciate your indications and the solutions to the structural issues, which improve our manuscript. We have moved some contents to the Methods and Result sections and remerged several paragraphs. Hope these changes can address your concerns. Thank you again for your invaluable suggestions!

Specific changes I think should be implemented include:

-Include the details on the number of clusters selection (currently paragraph 2 of your discussion) in your Data and Methods section.

> **Reply:** We have moved part of paragraph 2 of the Discussion section to the Data and Methods section 'Clustering Analysis in Latent Space' (Line 169-173).

- Include details on changing number of subset reflectors in cluster analysis in Data and Methods.

> **Reply:** We have moved the details on changing K number of subset reflectors (Figure S2 and S3) to the Data and Methods section 'Clustering Analysis in Latent Space' (Line 173).

-Shift the figures that show the sensitivity to number of clusters from discussion to results.

> **Reply:** We have added a new subsection '3.3 Detection Sensitivity with Number of Clusters' and shifted the figure and descriptions about sensitivity to number of clusters to this subsection (Line 313-338). We also separated the paragraph and remerged to suit the Results section.

-Include the K-means elbow analysis in the main body of the manuscript (Data and Methods).

> **Reply:** We have included the Elbow curves in the Data and Methods section.

-The presentation of the spatial distribution of latent space distance also seems better suited to Results.

> **Reply:** We agree with you. We have moved the sentences about the latent space distance to the Results section (Line 329-338). We also retained the second half of the part about latent space distance in the Discussion section to discuss the potential application (Line 345-350, as well as the limitation of the existing subjective elements).

Smaller technical changes:

1. L3 'in the' > 'from the'

> **Reply:** Done. Thanks for your advice.

2. L6 'are used' > 'are then used'

> **Reply:** Done. Thanks.

3. L7 (and elsewhere) 'known lakes inventory' > 'known-lakes inventory'

> **Reply:** Done. Thank your for your indication.

4. L23 Paden and Arnold references are not the correct references here.

> **Reply:** Thanks a lot for your indication. We have amended these incorrect references with "(Peters et al., 2008; Horgan et al., 2012)"(Line 23-24), we are sorry for the mistake.

5. L37-L46 consider combining these short paragraphs with sentence linking existing basal picks to deep learning suitability.

> **Reply:** Good suggestion. We have merged these two paragraphs, removed some inessential citations, and appended a sentence linking the deep learning to the large dataset (Line 37-45). Thanks.

6. L50 'Using this' > 'Using these'

> **Reply:** Done. Thanks for you indication.

7. L62 'We will introduce' > 'we introduce'

> **Reply:** Done. Thanks.

8. Figure 1. Should include the spatial and power filtering applied

> **Reply:** Thanks for your suggestion, we have updated both Figure 1 and its caption according to your suggestion.

9. L69 'lake inventory' > 'lake inventories' Correctly bracket references.

> **Reply:** Done. Thanks for your helpful indication.

10. L84 'which maintain' > 'which maintains'

Reply: Done. Thanks.

11. L85 'length of 128' > 'length of 128 samples'

Reply: We have added 'samples' following your indication. Thanks.

12. L97 Include a short definition of 'latent space' so as not to lose the non-experts

Reply: We have appended a sentence about a brief definition to 'latent space': *"Between the encoder and decoder, the latent space characters as the 'bottleneck' of the VAE, in which the input feature is depressed into the smallest size."*(Line 97-98).Thanks for your helpful suggestion.

13. L106 'easier presenting' meaning unclear, please clarify

Reply: We have modified this sentence with '*The 2-D latent space also facilitates the visualization of spatial distributions among the latent vectors in 2-D plots.*' (Line 105-106). Thanks for your feedback.

14. L120 'VAE' > to 'the VAE' (twice)

Reply: Done. Thanks for the indication.

15. L127 'low dimensional bottleneck' briefly define

Reply: We have replaced the 'bottleneck' with 'latent space' to match the preceding description (Line 127). Thanks.

16. L138 '2-length' > 2*1

Reply: Done. Thanks for the suggestion.

17. L144 'intact dataset' meaning unclear, clarify

Reply: We have modified 'intact dataset' with 'entire dataset' (Line 144). Thanks for your indication.

18. L154 '...amount of data used.' citation needed.

Reply: Thanks for your indication. This was the conclusion we drew according to the experience. We noticed that this expression was indeed too subjective here. Thus, we have modified this sentence with "*In clustering, a redundant dataset can slow down the clustering calculation. Conversely, over-reduced datasets may lack essential features and lower the accuracy.*" (Line 154-144)

19. L158 'which based' > 'which is based'

Reply: Done. Thanks.

20. L166 '(Figure S2)' present in main body.

Reply: We have moved Figure S2 (Elbow Curves) to the main body (as Figure 4 in the revised version).

21. L168 'ultimately selected K = 15' justify.

Reply: Thanks for your indication, we noticed that 'ultimately' is not a precise expression here, and have amended that with 'finally' (Line 173).

22. L186 'continuously distributed' > 'spatially continuous'

Reply: Thanks a lot for your helpful advice that improves our manuscript. We have updated this sentence (Line 188-189).

23. Section 2.4 include subheadings 'Spatial continuity' 'Interpolation' 'Depth-dependent echo power filtering' or similar.

Reply: Thanks for your indication. We agree it lacked subheadings in this section and have appended the subheadings for these two paragraphs in this section (Line 193: 2.4.1 Spatial threshold and discontinuity interpolation and Line 203: 2.4.2 Depth-dependent echo power filtering).

24. L190 'In further applications of observational data' Meaning unclear, probably not needed. > 'It has been...'

Reply: Thanks for your suggestion, we have removed the redundant sentence here (Line 194).

25. L191 'radar signals.' citation needed.

Reply: We have added the missing citation (Hills et al., 2020, Line195). Thanks.

26. L209 'Considering....' Hard to parse this sentence. Please clarify.

Reply: Thanks for your feedback. We have updated this sentence with "*Considering the VAE-clustering has analyzed reflector features, and the simplified ice thickness is applied, a lower linear threshold in average echo power ...*"(Line 213).

27. L224 '...similar in the ...' > '...similar at the length-scales covered by the radar image.' Or similar.

Reply: Thanks for your great suggestion. We have modified this sentence following your suggestion.

28. L254 '...than the established thresholds.' > '...than the thresholds used here.'

Reply: We have modified this sentence according to your suggestion. Thanks!

29. L244 'long-distance' > 'spatially extensive'

Reply: Thanks. We have modified this phrases.

30. Figure 9 caption 'subglacial lakes or lakes' and 'regional subglacial lakes' meaning unclear, please clarify.

Reply: Thanks for your indication. We are sorry for the typo of 'subglacial lakes or lakes', which has been amended. 'regional subglacial lakes' means 'subglacial lakes with smaller sizes', which we noticed was a repeated explain here. We have removed the additional 'regional' in this sentence.

31. L291 'distinct phases' meaning unclear. Clarify.

Reply: Thanks for your indication, 'distinct phases' should be 'different phases' (Line 296). Thanks for you indication. We have amended this wrong description.

32. L297 'Besides, ' > 'Also, '

Reply: Thank you for you suggestion, we have modified this sentence following your suggestion.

33. L302 'submerged' > 'obscured'

Reply: Done. Thank you.

34. L303 'Besides, the' > 'The.....can also provide'

Reply: Done. Thanks.

35. L304 'are essential' > 'will help'

Reply: Thanks for you advice. We have replaced that.

36. L305 'miss-detection' > 'false positives'

Reply: Thank you for your suggestion. We agree that 'false positives' are better and have updated according to your suggestion.

37. Discussion. Much of this first paragraph belongs in Methods and Results.

Reply: We have moved the paragraphs to the Methods and Results sections. Thanks a lot for these helpful suggestions that improve our manuscript.

38. L353 'Compared with' > 'Compared to'

Reply: Done. Thanks for the suggestion that improves our manuscript.

39. L372 'automated' > 'mostly automated'

Reply: Done. Thanks.

40. L381-382 odd tangent to end on

Reply: Thanks for your feedback and indication. We agree that the tangent in the end indeed was quite odd here. Thus, we have removed the sentences about the potential Martian applications in this part.

41. Conclusions. These are very brief.

Reply: Thanks for your feedback. We have modified conclusion by adding an additional sentence for conclude the entire workflow (Line 385-386), and have appended more details for connecting reflection feature to latent space (Line 387-389).