Earth Syst. Sci. Data Discuss., referee comment RC2
https://doi.org/10.5194/essd-2021-354-RC2, 2022

Comment on essd-2021-354

Anonymous Referee #2

Referee comment on "Spatio-temporal evolution of glacial lakes in the Tibetan Plateau over the past 30 years" by Xiangyang Dou et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2021-354-RC2, 2022

Dear editors,

dear authors,

Thank you for giving me the opportunity to review the manuscript essd-2021-354 "Spatio-temporal evolution of glacial lakes in the Tibetan Plateau over the past 30 years" by Dou and co-authors. In this study, Dou et al. mapped glacial lakes on the Tibetan Plateau at three time steps between 1990 and 2019. The authors accessed Landsat time series via the Google Earth Engine, which they fed into a processing chain that included thresholds for band indices and manual post-processing. The authors found the largest number and area of glacial lakes reported to date for the Tibetan Plateau. In the discussion, they offer reasons that might explain these differences between previous studies and suggest possible areas of application of this data set.

I was interested in reading this manuscript, especially given the large number of glacial lake inventories at the regional scale that appeared in the last decade (Zheng et al., 2021; Nie, 2017; Wang et al., 2020; Zhang et al., 2015; Chen et al., 2021; Shugar et al., 2020; Gardelle et al., 2011). My motivation was to obtain a consistent, high-resolution (both spatially and temporally) pattern of glacial lakes in this region and to see a thorough comparison of HOW and, more importantly, WHY this study performs in comparison to previous mapping efforts. Given the known challenges of mapping glacial lakes in a region where clouds, shadows, snow, and ice often obscure the view of glacial lakes, I also expected a major methodological advance.

Indeed, the authors have done a tremendous job in mapping glacial lakes in this region, which I greatly acknowledge. The largest number and size of glacial lakes is also a newsworthy result, and the figures can largely be used to illustrate the regional pattern of glacial lakes. However, to make an original and novel contribution, this study needs more justification and discussion of why it is different from all previous studies. From the current structure, it remains unclear why this study represents a major advance in either the technical processing of satellite imagery or the physical understanding of glacial lakes on the Tibetan Plateau. The authors do cite some previous studies dealing with lake mapping. However, given the differences in temporal and spatial extent, minimum mapping units, distance to different glacier inventories, mapping uncertainties, time periods studied, aggregated time intervals, etc., it remains difficult for the reader to say why this inventory is a "must read" or a "must have" for future studies. I will take the liberty of explaining some of these points in more detail. For example, regarding

- The minimum mapping unit: This is a known issue particularly for lakes at the lower size-distribution. Mixed spectral signatures can cause a lake that persists throughout the study period to fall either within or outside the threshold chosen in this study (81,000 m²). Nie et al. (2017, p.10) used the same threshold, and report that *"other research selected 0.0001 km2 (Salerno et al.,2012), 0.0027 km2 (Zhang et al., 2015), 0.0036 km2 (Gardelle et al., 2011) or 0.0045 km2 (Li and Sheng, 2012) as the minimum mapping unit. Our result indicates that 8.1% of glacial lakes belonged to the size class 0.0081–0.01 km2, which only took up 0.79% of the total area. It is obvious that the minimum mapping unit has a significant effect on the total number of glacial lakes, however it affects the total area only slightly."* I thus wonder how large this effect is, even when comparing this study with that of Chen et al (2021) and Wang et al. (2020) who used similar mapping units. Figure 12 is interesting in this regard, as it suggests that this study on average reports more lake area of a given size than Wang et al. and Chen et al. However, dots above the diagonal line suggest those studies also report a number of cases that have more lake area than this study, and I wonder why? A more detailed assessment of the reasons behind these differences could add a convincing point to readers why to choose the presented dataset from now on.
- Aggregation: what is the effect of digitizing lakes only from one image in a given year against an aggregate of images over an entire decade? What is the effect of consistently using images from one month against aggregating over a range of month in a given year? In this regard, the authors note that *"During this period [July to November], the coverage of snow and ice is minimal, while the area of the glacial lake usually reaches its maximum, which does not change much due to factors such as glacier supply and precipitation"*. Others, however, do find that seasonality matters for the case of supraglacial lakes (Miles et al., 2017).
- Methods: The processing chain for using NDWI thresholds in optical imagery is well established but has its known drawbacks, e.g., potential confusion of water with mountain or cloud shadows. Other studies have recently experimented with satellite missions with higher temporal repeat rates (Wu et al., 2020), radar data (Wangchuk et al., 2022), and image segmentation (Qayyum et al., 2020). I am aware that many resources such as Sentinel-1 data are not available for older time periods in the record. However, is there possibly potential for using the current high-resolution, high-repetition-rate data to improve our lake abundance models for earlier decades for which we only have Landsat imagery?
- Classification of lake types: Apart from the supraglacial lake class, I find it difficult to assess the value of classes such as proglacial, ice-marginal, or unconnected lakes. What do we learn when a glacier is "unconnected" to its parent glacier in terms of its vulnerability or its use as a freshwater resource? Many researchers using this dataset would probably be more interested in a robust assessment of dam type. That is, whether a lake is impounded by a moraine or a glacier, or whether it is located in a rocky depression, cirque, or on a glacier. The study by Lesi et al. (2022), which is currently under review at ESSD, goes an important step forward and classifies lake types according to the formation mechanism of glacier lakes and dam material

properties. This could be a strong contribution from this study, if this is accomplished for the entire study region.

In summary, I think it would probably be more useful to compare this study to previous studies rather than just presenting another lake inventory for the Tibetan Plateau and adjacent mountain ranges, as nice as it is. Instead, the authors might consider summarizing the lake outlines from all the previous studies in some sort of review paper. Such a paper could help show how consistent the frequency, size, and changes in glacial lakes are in light of this new dataset, and point out regions where our knowledge is still uncertain. Given these criticisms and opportunities for improvement, I am concerned whether Earth System Science Data is the most appropriate journal for this study.

In the following, I list more detailed line-by-line comments:

L8: “As the Third Pole of the Earth and the Water Tower of Asia”: please stay objective in highlighting the relevance of this region in the abstract. Physically speaking, there is now “Third Pole” on Earth, and the role of a “Water Tower” might not equivalently strong in all regions of the Tibetan Plateau.

L8: I am unsure whether “Tibetan Plateau” is the most suitable term for this region, as the glacier lakes that are investigated in this study are largely located in the mountain ranges fringing the TP, if I am not mistaken.

L12-14: This sentence needs to state how many time slices have been created in this study.

L15: “different regions of TP exhibited varying change rates in glacial lake size”: ambiguous, please be more precise.

L16: “because of reduced rainfall rates”: do the authors show this in this study?

L20: “Third Pole” instead of “third pole”, yet suggest to remove this term entirely from this manuscript.

L22: “the most significant number and area of glaciers outside polar regions”: please be more precise. Also, it depends which regions are classified as 'polar'. Alaska has more ice the High Mountain Asia.

L26-27: “glacier landmass”: unclear, please revise.

L31: “hidden dangers”: please stay objective.

L33: “extremely important”: please avoid subjective qualifiers and quantify instead, why the role is so important.

L67: The minimum mapping unit is an important consideration, but also a weak motivation for another study, assuming that those previous studies remained consistent in their use of a minimum mapping unit. This introduction, and this section in particular, call for a much stronger motivation for this analysis.

L74-79: Instead of describing the workflow of this study, the introduction could rather end with a key research question.

L77-78: “This study mapped the glacial lakes in TP to the maximum”: unclear.

L81: “Roof of the World”: please stay objective. Suggest deleting.

L90: “many countries”: how many?

L93: “~1900s”: given the rest of the sentence, it’s rather the 1930? Furthermore, climate data are not assessed in the rest of the manuscript. Suggest tone down the effects of atmospheric warming / precipitation changes in this manuscript?

L96: Is this “wetting trend” consistent in the entire study region?

L100: Figure 1: Suggest moving the inset to the main map.

L116-117: “which does not change much”: contradicts previous part of the sentence?

L126-127: What is the effect of this thresholds on lakes adjacent to glaciers with steep tongues that melted since the generation of ALOS DEM?

L166-167: Why the reference to Alaska, and why talking about the distribution in the TP in the methods section?

L168-170: “maybe not”: unclear.

L182: “topography and location”: ambiguous, please be more precise.

L184: “applied” instead of “applicable.

L188: Where is the uncertainty in the parameters that were estimated from data that the authors have mentioned before?

L211: style: report the mean first, then the min and max.

L213: yes, that's what the formula implies, given that the uncertainty is inversely proportional to the size of the lake. What does this tell relative measure of error tell us?

L216: Figure 4: What is the purpose of the normal curve? It is not mentioned in the text. In left plot (suggest using labels a and b), dots overlap and don’t allow for a meaningful representation of mapping uncertainty.

L225: how “slow”?

L226-227: “The increase of glacial lake number at higher elevations”: I can’t see this in this manuscript. “ultra-small”: which size class is this?

L230: “a relatively consistent trend with the increase of altitude”: not sure what this means. Please rephrase.

L232: “are” instead of “account”.

L235: Figure 5: suggest avoiding a second y-axis, given that the scale of the two axis differ. Why are plots b and c in 3D? They partly overlap, especially in the tails that could be important to highlight changes in glacier lake elevation. Also, please list all abbreviations in the caption (PGL, UGL, etc.). This critique applies to all plot in the following.

L247: How “significantly”?

L252: “and selected typical glacial lakes expanded or contracted as examples”. Unclear, please rephrase.

L253: “variation trend”: unclear, please rephrase.

L255: “did not provide an in-depth analysis”: so, do the authors provide a more detailed analysis? I fear no.

L257: “various”: four?

L259-260: Content of this sentence is largely subjective and speculative. Suggest deleting.

L261: “is” instead of “was”.

L274: Legend of Figure 10: “Area change rate”: is it %? Meters? Temporal reference period? Also, the color stretch is wrong, as it suggests that the value range from -1 to 0 is the same as for 0 to 7.8

L277-283: Suggest deleting the chapter on lake volumes, given that the volumes are a simple conversion of area and are not at the heart of this paper. This chapter also adds hardly any novel insights compared to the previous estimates on lake areas.

L281: “which confirmed a frequency increase of GLOFs in the Himalayan region”: NO, this is exactly opposite to what some of these studies have found.

L305: so, this study is a lumped sum over a longer period. Could this explain the higher abundance / area compared to previous studies?

L316: “Considering the difference in time coverage of the three datasets”: Not sure how useful this comparison is then?

L319: Not the 1° x 1° grids anymore? Why this resolution?

L326: Figure 12: Add years of publication to y-axis. Why not add a 1:1 line to the plot? It is important to mention that the trend is smaller than 1, hence the authors observe more lake area on average than previous studies. Figure caption needs to mention that the data have been aggregated on a grid.

As a non-native speaker, I can't fully judge the quality of the language, but I think this manuscript also deserved to be improved by a native speaker.

References

Chen, F., Zhang, M., Guo, H., Allen, S., Kargel, J. S., Haritashya, U. K., and Watson, C. S.: Annual 30\,m dataset for glacial lakes in High Mountain Asia from 2008 to 2017, 13, 741–766, https://doi.org/10.5194/essd-13-741-2021, 2021.

Gardelle, J., Arnaud, Y., and Berthier, E.: Contrasted evolution of glacial lakes along the Hindu Kush Himalaya mountain range between 1990 and 2009, Global and Planetary Change, 75, 47–55, https://doi.org/10.1016/j.gloplacha.2010.10.003, 2011.

Lesi, M., Nie, Y., Shugar, D. H., Wang, J., Deng, Q., and Chen, H.: Landsat and Sentinel-derived glacial lake dataset in the China-Pakistan Economic Corridor from 1990 to 2020, Cryosphere – Glaciology, https://doi.org/10.5194/essd-2021-468, 2022.

Miles, E. S., Willis, I. C., Arnold, N. S., Steiner, J., and Pellicciotti, F.: Spatial, seasonal and interannual variability of supraglacial ponds in the Langtang Valley of Nepal, 1999–2013, J. Glaciol., 63, 88–105, https://doi.org/10.1017/jog.2016.120, 2017.

Nie, Y.: A regional-scale assessment of Himalayan glacial lake changes using satellite observations from 1990 to 2015, 13, 2017.

Qayyum, N., Ghuffar, S., Ahmad, H., Yousaf, A., and Shahid, I.: Glacial Lakes Mapping Using Multi Satellite PlanetScope Imagery and Deep Learning, IJGI, 9, 560, https://doi.org/10.3390/ijgi9100560, 2020.

Shugar, D. H., Burr, A., Haritashya, U. K., Kargel, J. S., Watson, C. S., Kennedy, M. C., Bevington, A. R., Betts, R. A., Harrison, S., and Strattman, K.: Rapid worldwide growth of glacial lakes since 1990, Nature Climate Change, 10, 939–945, https://doi.org/10.1038/s41558-020-0855-4, 2020.

Wang, X., Guo, X., Yang, C., Liu, Q., Wei, J., Zhang, Y., Liu, S., Zhang, Y., Jiang, Z., and Tang, Z.: Glacial lake inventory of high-mountain Asia in 1990 and 2018 derived from Landsat images, Earth Syst. Sci. Data, 12, 2169–2182, https://doi.org/10.5194/essd-12-2169-2020, 2020.

Wangchuk, S., Bolch, T., and Robson, B. A.: Monitoring glacial lake outburst flood susceptibility using Sentinel-1 SAR data, Google Earth Engine, and persistent scatterer interferometry, Remote Sensing of Environment, 271, 112910, https://doi.org/10.1016/j.rse.2022.112910, 2022.

Wu, R., Liu, G., Zhang, R., Wang, X., Li, Y., Zhang, B., Cai, J., and Xiang, W.: A Deep Learning Method for Mapping Glacial Lakes from the Combined Use of Synthetic-Aperture Radar and Optical Satellite Images, Remote Sensing, 12, 4020, https://doi.org/10.3390/rs12244020, 2020.

Zhang, G., Yao, T., Xie, H., Wang, W., and Yang, W.: An inventory of glacial lakes in the Third Pole region and their changes in response to global warming, Global and Planetary Change, 131, 148–157, https://doi.org/10.1016/j.gloplacha.2015.05.013, 2015.

Zheng, G., Allen, S. K., Bao, A., Ballesteros-Cánovas, J. A., Huss, M., Zhang, G., Li, J., Yuan, Y., Jiang, L., Yu, T., Chen, W., and Stoffel, M.: Increasing risk of glacial lake outburst floods from future Third Pole deglaciation, Nat. Clim. Chang., 11, 411–417, https://doi.org/10.1038/s41558-021-01028-3, 2021.