

# ***Interactive comment on “Geospatial Analysis and Simulation of Glacial Lake Outburst Flood Hazard in Hunza and Shyok Basins of Upper Indus Basin”***

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**Anonymous Referee #2**

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The manuscript presents glacial lake hazard assessment in two river basins in the Upper Indus Basin. GLOFs have been a serious concern in the mountainous regions over the last two decades. Especially in the Himalaya, the climate-driven glacier retreat is contributing to the growth of the high altitude lakes. These lakes may present a great threat to the downstream regions. Ascertaining the GLOF hazard in the Himalaya is extremely important and relevant in the current scenario of climate change. This paper has potential in this regard, however, the present study does not succeed comprehensively addressing the issue. There are many important issues that need to be addressed and suggestions which need to be incorporated. The detailed general and section-wise remarks on the manuscript have been outlined below. This study

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mostly concentrates on GLOF assessment using remote sensing and modeling approaches (HEC RAS). I am not sure if the study fits well in the scope of the journal "The Cryosphere", however, such studies are more suitable in NHESS or Natural Hazards.

General comments:

1. The abstract is too long and general. It lacks in representing the importance of the given study. 2. The methods are not clearly outlined in the manuscript. It is poorly organized and contents of different sections overlap. 3. The results produced in the study are not sufficient to support the interpretations and conclusions. The discussion section lacks a comparative analysis, the results do not show any quantitative comparison with other studies in the region. 4. The English needs improvement in the entire manuscript.

Section-wise Comments:

Introduction:

The introduction lacks the latest literature on GLOF modeling studies in the Himalaya. (see the references below). I would suggest to summarise the structure of the paper in a few lines towards the end of the section.

Materials and methods

1. The sections (2.1, 2.2, 2.3) can be combined together into a common section as "Study regions and climate". 2. Sections ( 2.4 and 2.5) can be combined as "Data and Methods" 3. The details of the remote sensing datasets used in the study are missing. I do not understand why is ASTER DEM interpolated to 15 m as it has an actual resolution of 30m. 4. Area-based scaling has been used to calculate the volume of the lakes. However, it is not clear which empirical relation has been adopted for the calculations. ( Refer to Huggel et al., 2004; Cook and Quincey,2015; Fujita et al., 2013). As this is the most crucial factor in GLOF hazard evaluation, it should be discussed. 5. The

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flow chart and the methodology doesn't explain about the breach hydrograph. How is it obtained? What are the breach parameters? Mechanism of failure?. The methodology sections need to be revised and rewritten giving more emphasis on the GLOF parameters and flood hydrographs. There is a lot of overlap between the methods and results in the presented manuscript.

#### Results and Discussion:

This section is too short and vaguely written. It does not provide all the required details of the results obtained. This section should be thoroughly rewritten. 1. In section 3.1 – It is more of a methodology than results. The number of lakes and hazard evaluation criteria for selecting the specific lakes for this study remains unclear. 2. In Section 3.2 the text mostly explains about the classification of the lakes and does not fit well in the section as the section reads as “GLOF analysis of HUza basin” 3. The hazard criteria adopted in the study does not explain the thresholds used for dam geometry, freeboard, and potential lake impacts.

Section 3.3 1. The results and methods are not well separated here. The input parameters of the hydrodynamic model fits well in the method section than the results. 2. Section 3.3.1 is not clear how flood volumes were considered for the different GLOF scenarios. 3. The potential flood hydrographs produced in scenario modeling is not shown. The initial breach hydrograph is most crucial in any GLOF analysis as it determines the flood hydraulics downstream as the GLOF propagates along the flow channel. This section needs to be rewritten showing results of the breach parameters and flood hydrographs. 4. In section 3.3.2 and 3.3.3, the routing parameters are not clear, there has been no mention of the surface roughness along the flow channel. 5. The boundary condition (upstream and downstream) for routing the potential GLOF event remains unclear. 6. Are the flow depths/ velocities representing the mean value along the crosssection or just at a specific point? 7. There has been no mention of the flood wave arrival timings at specific sites along the flow channel. 8. The above comments apply for sections 3.4 to 3.6

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## Figures:

All figures lack in proper resolution. I recommend exporting the figures with a minimum resolution of 300 dpi for more clarity. Figures 2 and 3 can be combined. The drainage of the basin and the location of the potentially inundated settlements are not shown in the figures. Figure 5 can be removed. Figure 6-The figure lacks locational information. The legends remain unclear. The figure can be better represented using other GIS platforms instead of RAS MAPPER. Figure 5-The figure lacks locational information and legends. Figure 9-see comments for figure 6.

Overall, the presented GLOF hazard assessment requires significant reworking. I hope incorporating the above-mentioned comments can be helpful to improve the presented study. I, therefore, recommend a major revision.

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