

An Updated Inventory of Glacial Lakes in the Upper Indus Basin (UIB), Pakistan

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Introduction

- Glacial lakes are an important water resource, but they also cause devastating glacial lake outburst floods (GLOFs).
- GLOFs originate due to the breach of a natural dam and result in life losses, and destruction of property, infrastructure (roads, bridges, hydropower plants) and agricultural land [1] (Figure 1).
- Increased number and volume of glacial lakes leading to frequent GLOFs [2, 3] (Figure 2)

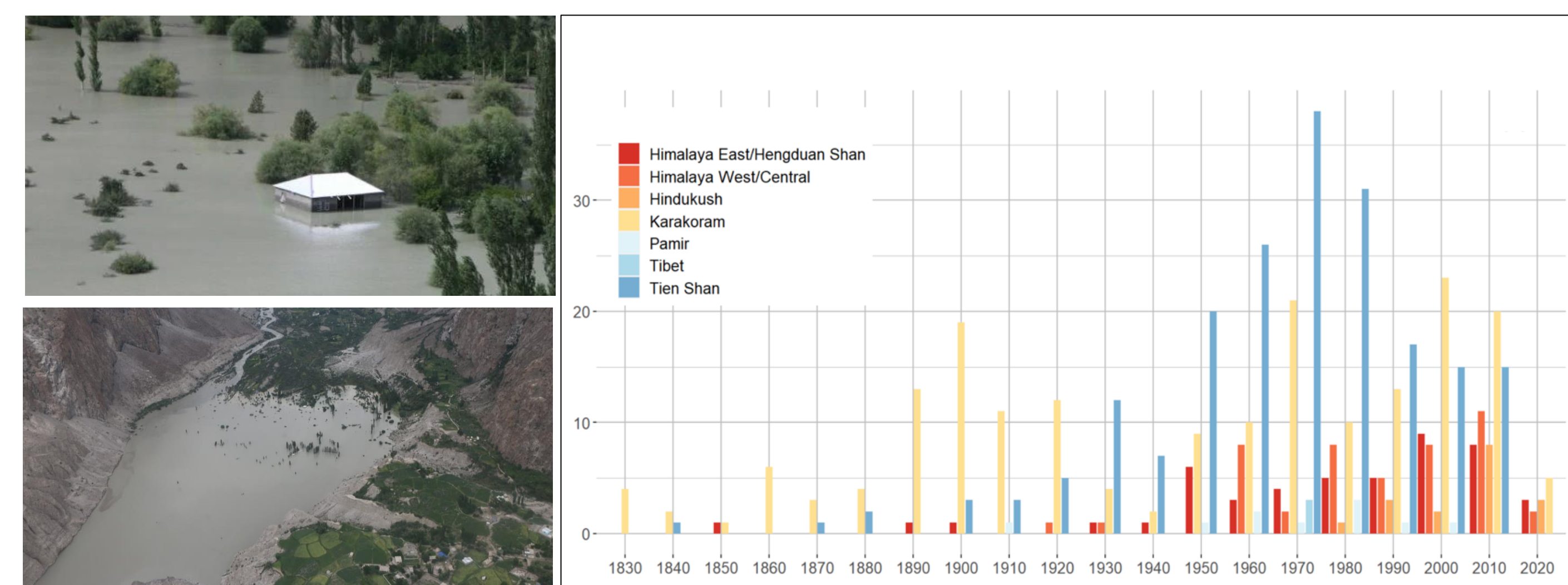


Figure 1. Badswat GLOF in the Hindu Kush, 2018 (Photos: AKDN)

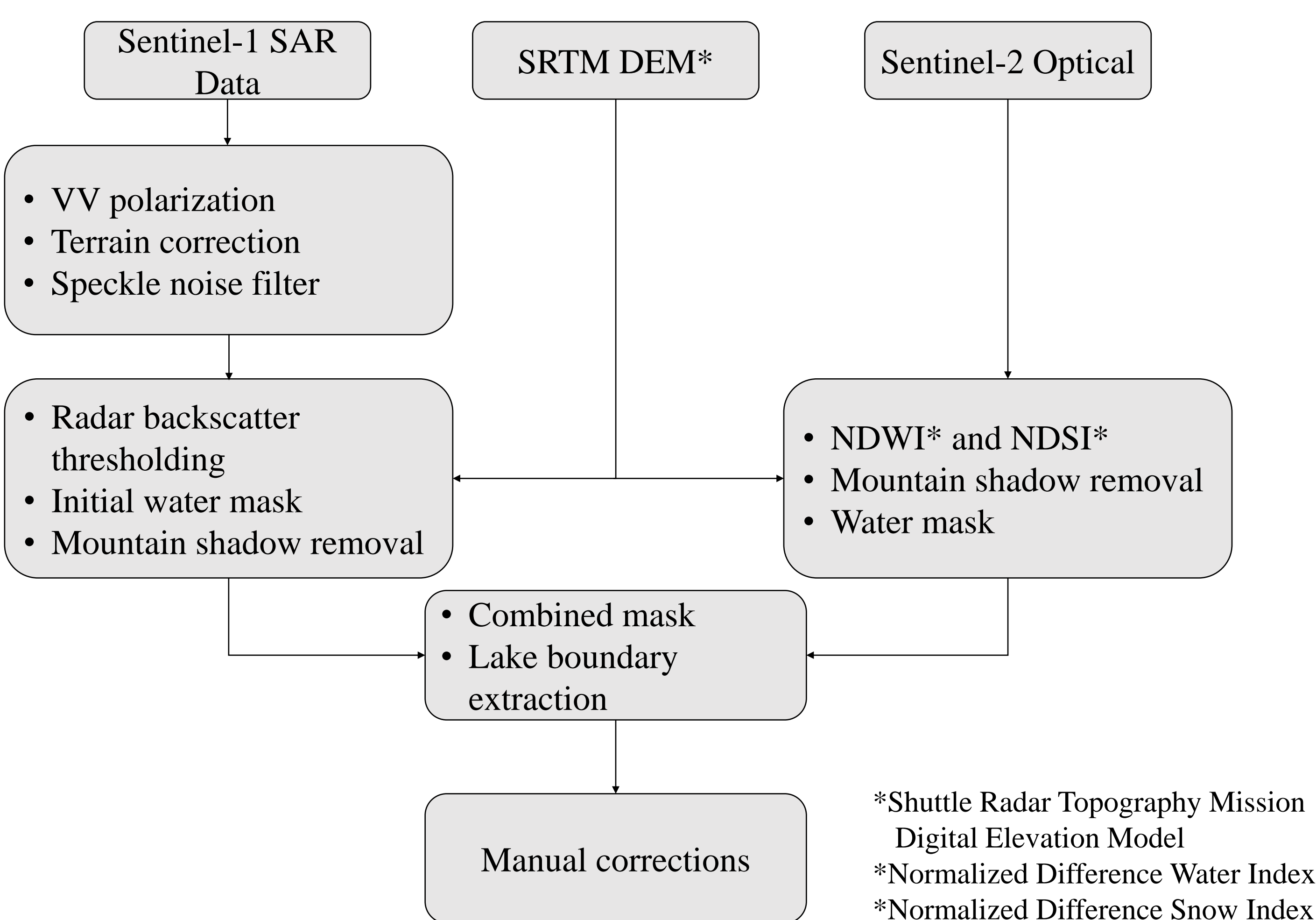
Figure 2. Glacial lake outburst flood (GLOF) occurrence in High Mountain Asia [2]

- 2 million people in Pakistan are exposed to potential GLOFs [1]
- Timely information on glacial lakes and an improved understanding of GLOF risks is critical for building community resilience.

Objective

- Create an updated inventory of glacial lakes in the UIB, Pakistan using Sentinel-1 synthetic aperture radar (SAR) and Sentinel-2 optical imagery.

Data and Methods



*Shuttle Radar Topography Mission Digital Elevation Model
*Normalized Difference Water Index
*Normalized Difference Snow Index

Upper Indus Basin

- Located in the mountain ranges of the Hindu Kush, Karakoram, and the Himalayas (Figure 3)
- Covers an area of 121,724 km² and home to thousands of glaciers and glacial lakes
- Provides freshwater to millions of people.

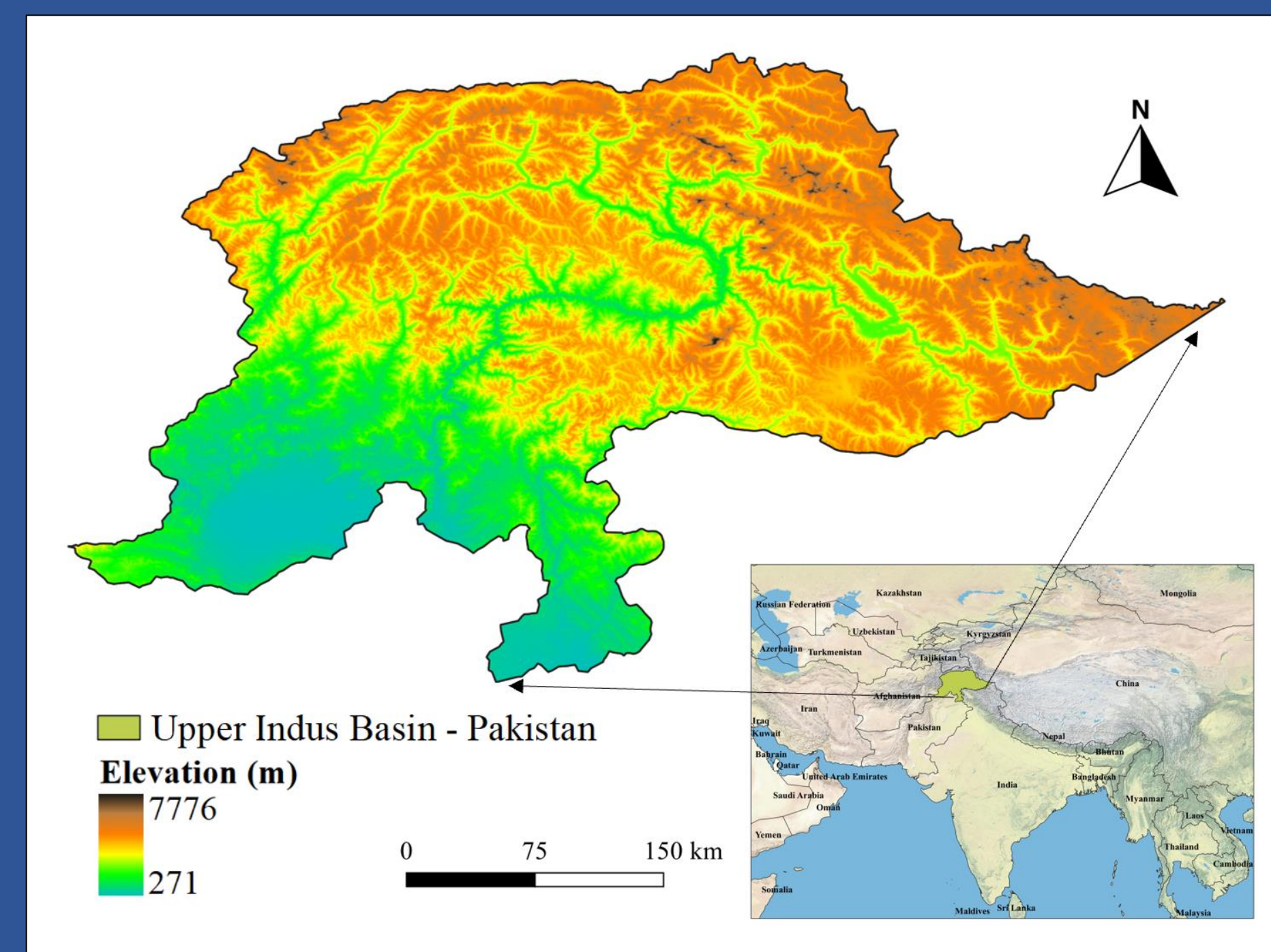


Figure 3. Map of Upper Indus Basin

Result 1: 8639 lakes identified, covering a total area of 100.72 km²

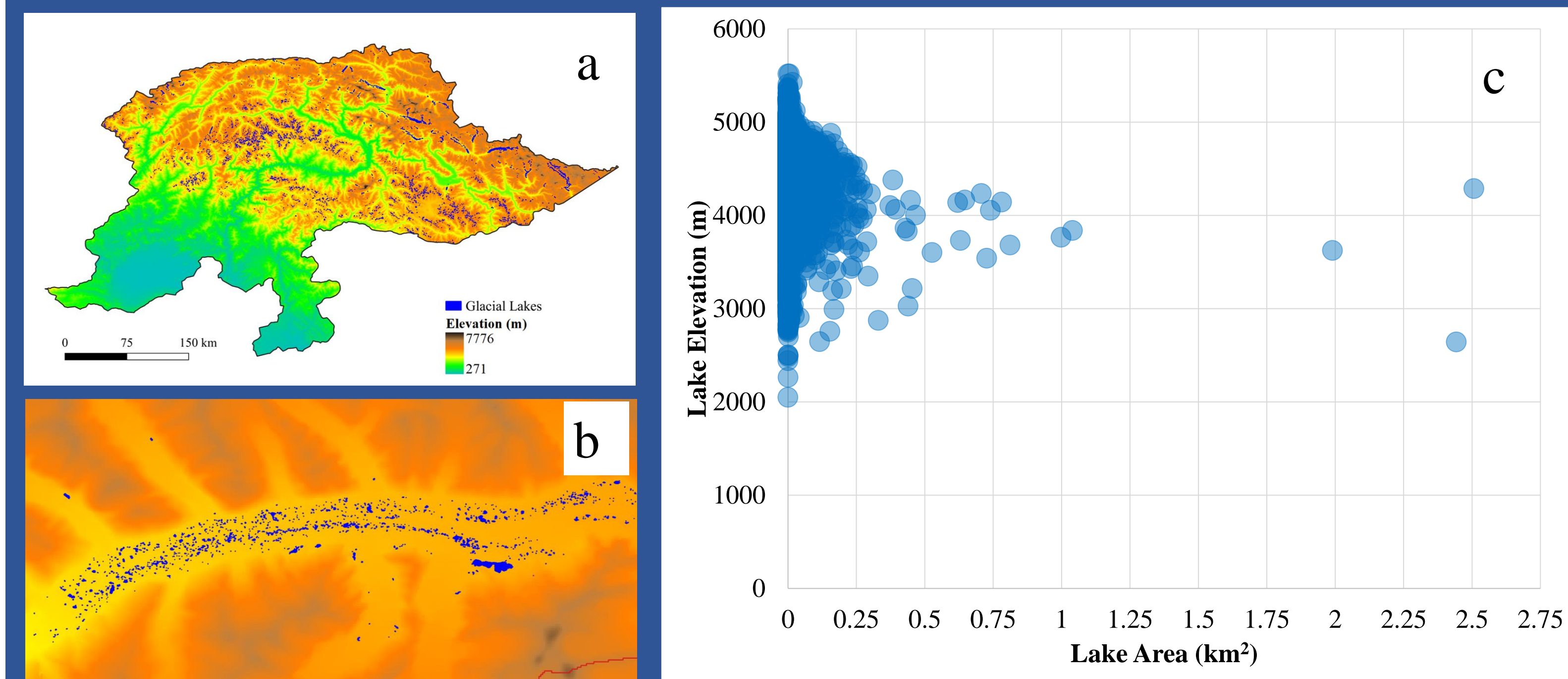


Figure 4. Glacial lakes identified in the UIB (a), supraglacial lakes on Baltoro Glacier in the Karakoram (b), and lake elevation and area distribution (c)

Result 2: Lake elevation distribution by sub-basins

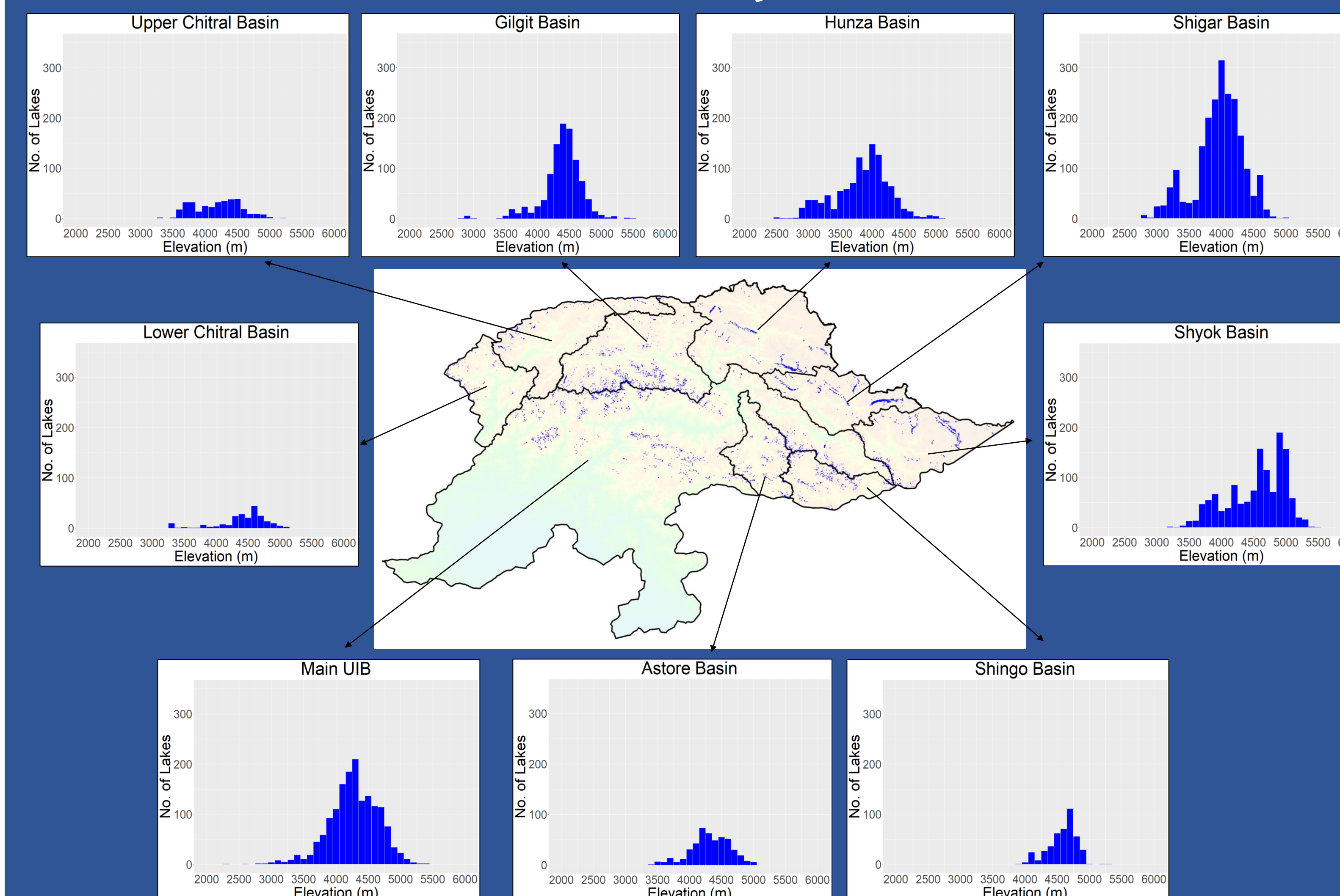


Figure 5. Glacial lake elevation by sub-basin

Result 3: Supraglacial lakes are more common in the Karakoram Sub-basins (Figure 6)

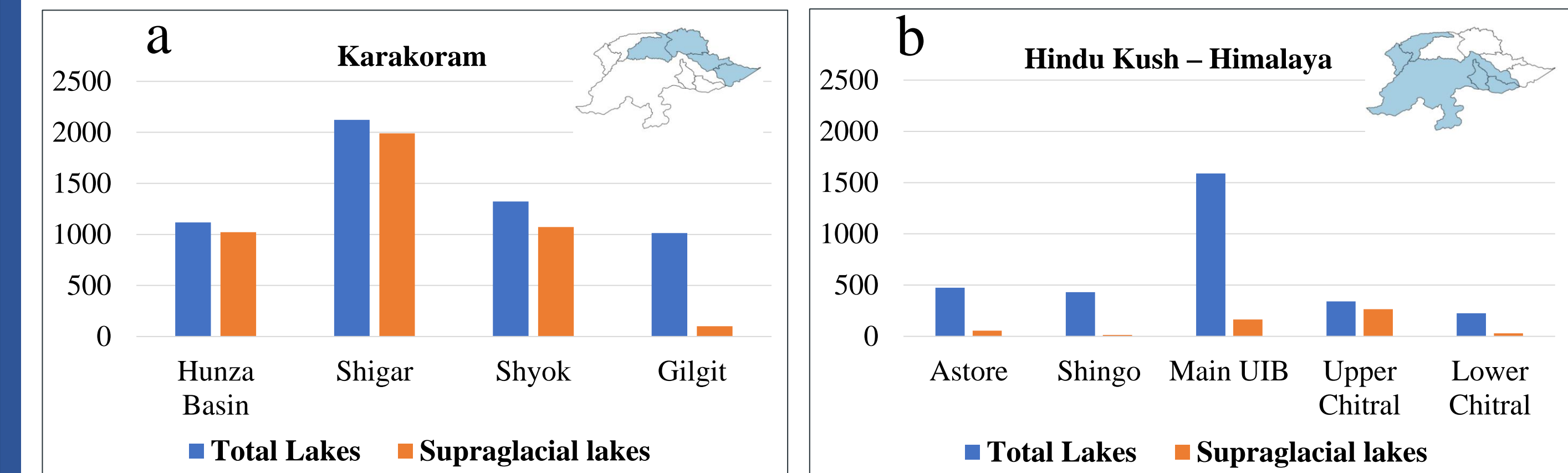


Figure 6: No. of supraglacial lakes compared to total no. of lakes in the Karakoram (a), and the Hindu Kush-Himalayas (b)

Result 4: Ice-dammed and supraglacial lakes show higher seasonal variation in size

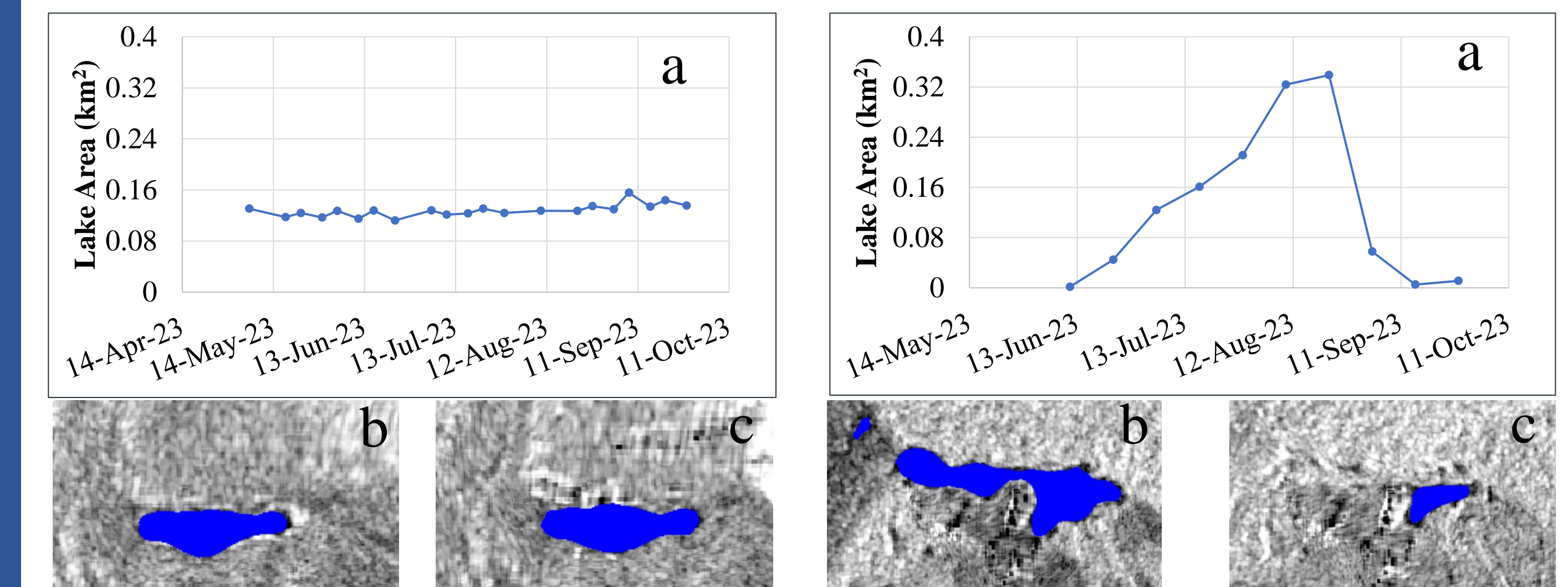


Figure 7. Surface area of moraine-dammed Borit Lake in the Karakoram (a), lake area on 8/10/2023 (b) and 9/20/2023 (c)

Figure 8. Surface area of an ice-dammed lake in the Karakoram (a), lake area on 8/22/2023 (b) and 9/03/2023 (c)

Conclusion and Future Steps

- Currently, there are thousands of glacial lakes in the UIB; an important water resource but could also be a source of disasters.
- There is a higher seasonal variation in the surface area of ice-dammed and supraglacial lakes – greater GLOF potential.
- Sentinel-1 SAR is capable of monitoring glacial lakes at a high temporal frequency – critical for effective GLOF management.
- GLOF mathematical modelling using GeoClaw and HEC-RAS

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