

Glacial Lake Bathymetry Derived from ICESat-2 and Multispectral Satellite Images: A Case Study on Tso Lhamo Lake, Sikkim Himalaya

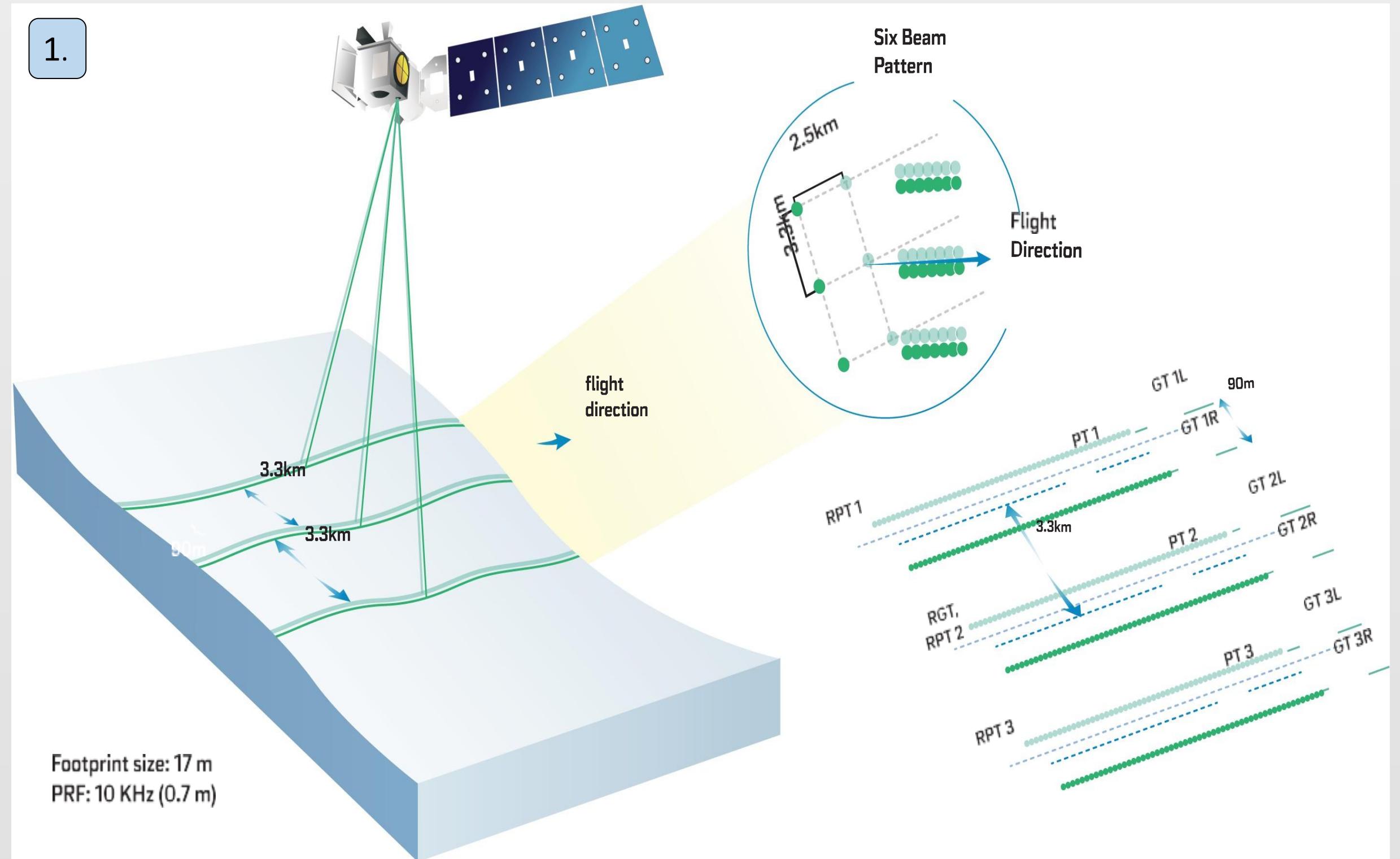
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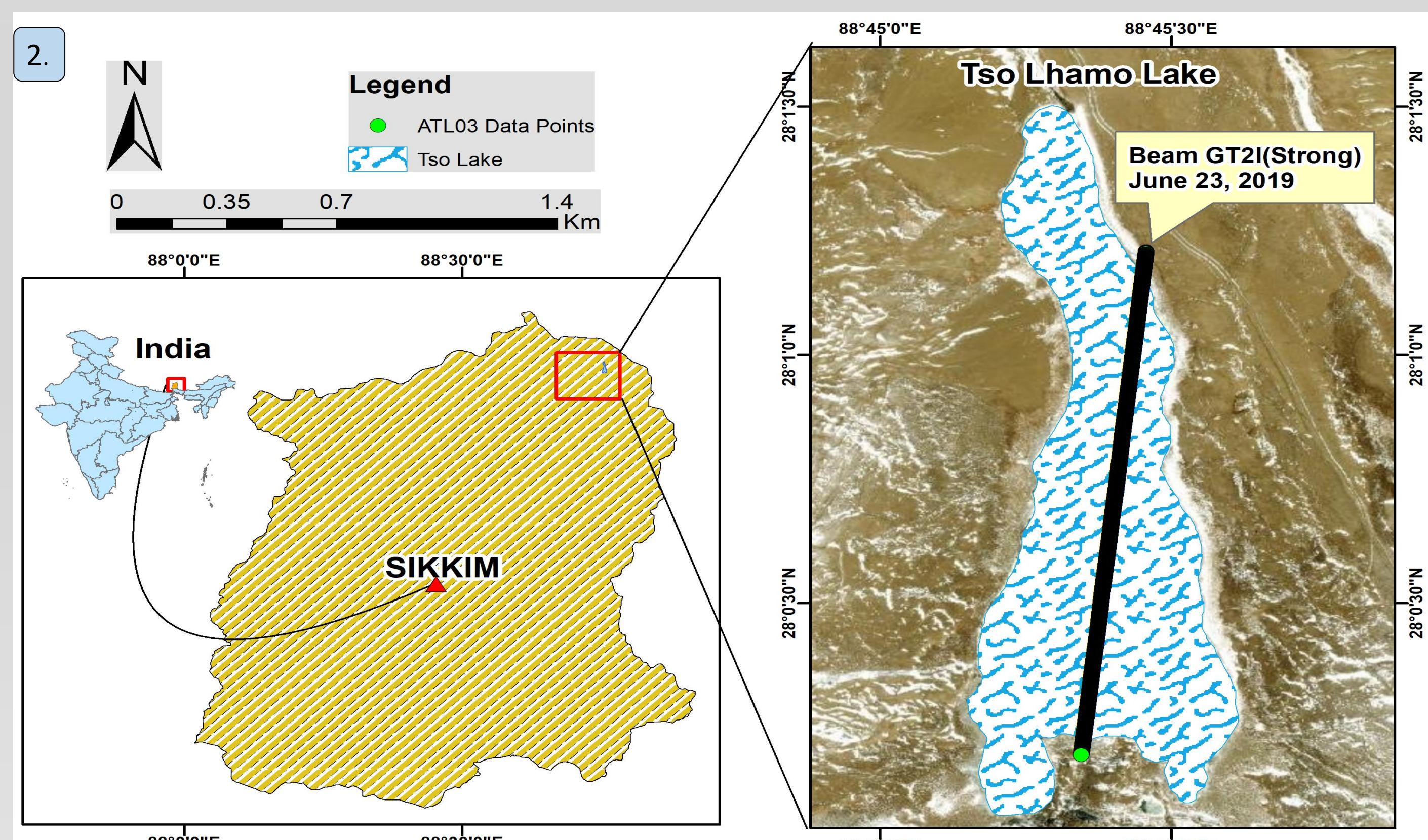
INTRODUCTION

- Himalayan glaciers lakes are increasing in both size and numbers due to climate change.
- In-situ bathymetry in the Himalayas are limited due to harsh weather conditions, remote locations, and lack of trained manpower.
- Green photons of the ICESat-2 mission can penetrate into water bodies up to several meters and provides high-resolution lake/reservoir bathymetry.



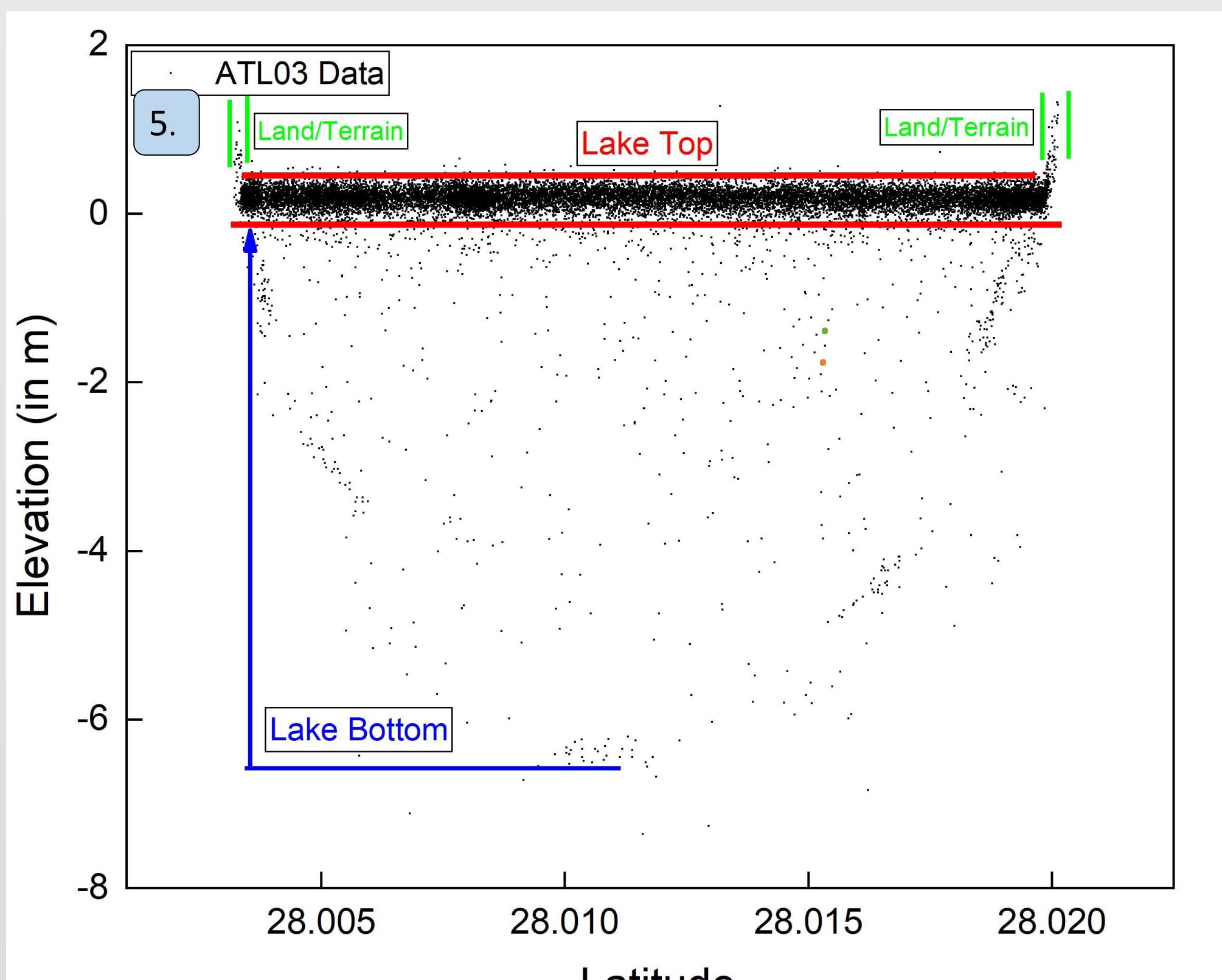
STUDY AREA AND DATASETS

- Tso Lhamo lake is the highest lake in India, at an elevation of about 5100 m above mean sea level (amsl), located in Northern Sikkim (28.0°N 88.7°E).
- The Advanced Topographic Laser Altimeter (ATLAS) system is a photon-counting 532 nm laser altimeter aboard ICESat-2 split into 6 beams which are divided into 3 pairs (separated by 3.3 km), where beams within each pair are separated by 90m.
- The ICESat-2, ATL03 product (Strong beam,gt2I, 23/06/19) were used to estimate the lake surface and bottom.



METHODOLOGY

- ALT03 photons were processed and clipped over the lake region using geospatial analysis toolbox, Pho_REAL_v2.34.
- Based on historical records (Panigrahy, et. al., (2012)), photons that fall outside the lake surface and the bottom were discarded.
- Lake surface detection carried out by taking the mean of all geolocated photon lies at an ellipsoid height of between 5067.5 to 5066.5 meter.
- The lake bottom were estimated using second kernel density calculation of 0.5 m bin width around the remaining bottom photons.



FUTURE STEPS

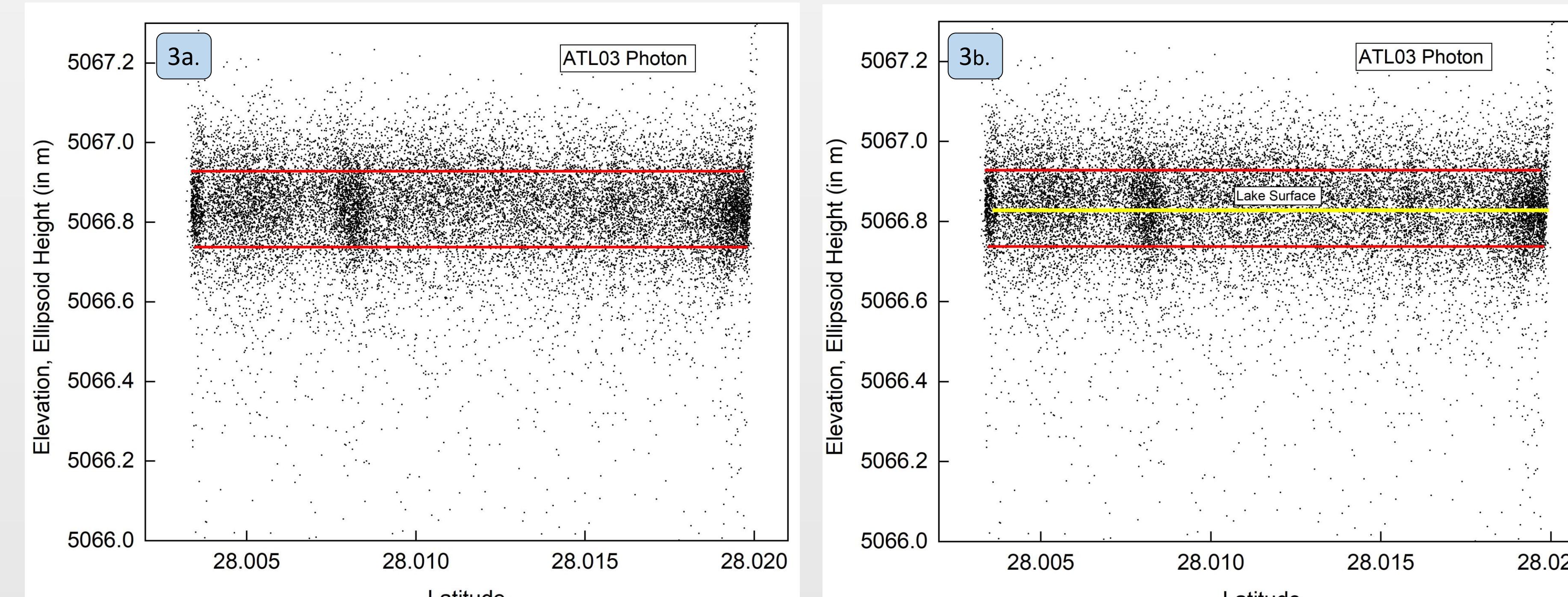
Establish a relationship between the reflectance in green band of multi-spectral images and ATL03 based lake depth estimation to spatially resolve lake depths

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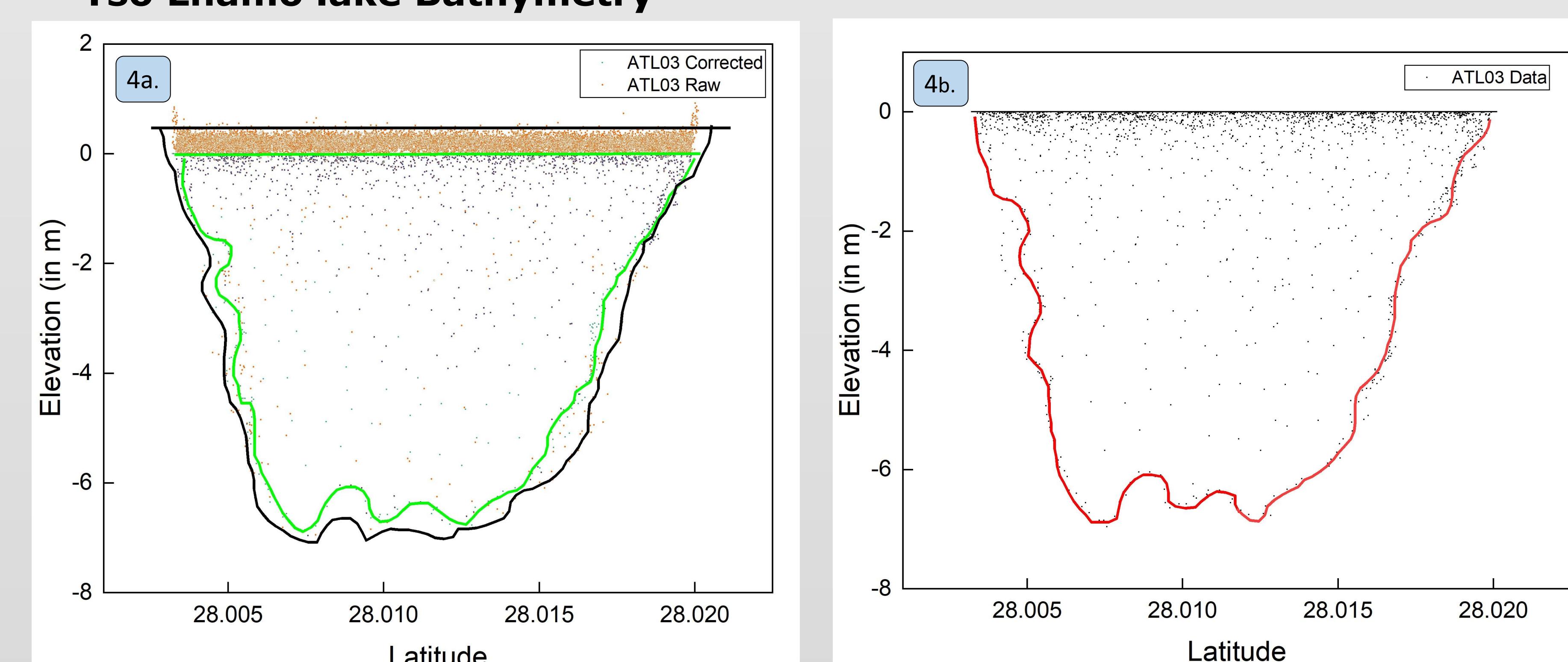
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RESULTS

Tso Lhamo lake Surface Detection



Tso Lhamo lake Bathymetry



OUTCOMES AND CONCLUSION

- Demonstrated the potential of ICESat-2 ATL03 data product for detection of glacial lake surface and bottom.
- Results indicated that the top surface of Tso Lhamo lake is located at an elevation of 5095.4 m above mean sea level.
- The attenuation in signal near the lake surface indicates the presence of land/rock or terrain.
- The maximum lake depth inverted from the method comes out to be 7m.

LIMITATIONS

- Very few ATL03 data points over the various lakes in Himalayan region.
- Limited resources to Visualize and process the ICESat-2 ATL03 data sets.
- The method might not be useful for depth greater than 10m.

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