



GlacierHack 2025

YP Activity of IEEE InGARSS 2025

Phase II Problem Statement

October 11, 2025

Problem Statement

Image semantic segmentation is the process of partitioning an image into meaningful regions or objects, typically at the pixel level. In the context of IEEE GRSS (Geoscience and Remote Sensing Society), it is applied to areas such as land cover classification, urban mapping, vegetation delineation, and disaster monitoring using satellite or aerial imagery.

A specialized application of image semantic segmentation is **glacier semantic segmentation**, where the objective is to extract and analyze glacial regions from satellite images. It plays a vital role in understanding and responding to the effects of climate change. It enables precise mapping of glacier extents, which is essential for:

- Monitoring glacial retreat
- Estimating freshwater reserves
- Predicting glacial lake outburst floods (GLOFs)

Accurate semantic segmentation supports policy-making, disaster risk reduction, and long-term environmental monitoring in high-altitude regions.

Mathematical Problem Formulation

Let $X \in \mathbb{R}^{n_1 \times n_2 \times c}$ be a multispectral input image with spatial dimensions $n_1 \times n_2$ and $c = 5$ spectral channels: B2 (Blue), B3 (Green), B4 (Red), B6 (Short-Wave Infrared - SWIR), and B10 (Thermal Infrared - TIR1).

Let the ground truth mask be represented as:

$$Y \in \{0, 85, 170, 255\}^{n_1 \times n_2}$$

where:

$$Y_{i,j} = \begin{cases} 255 & \text{if pixel } (i, j) \text{ is a lake pixel} \\ 170 & \text{if pixel } (i, j) \text{ is a debris pixel} \\ 85 & \text{if pixel } (i, j) \text{ is a glacier pixel} \\ 0 & \text{if pixel } (i, j) \text{ is a non-glacier pixel or undefined} \end{cases}$$

The task is to learn a mapping function:

$$f : \mathbb{R}^{n_1 \times n_2 \times c} \rightarrow \{0, 1, 2, 3\}^{n_1 \times n_2}$$

such that:

$$f(X) \approx Y$$

and individual pixels are assigned to corresponding categories accurately .

Evaluation Metric: Matthews Correlation Coefficient (MCC)

The MCC is defined as:

$$\text{MCC} = \frac{TP \cdot TN - FP \cdot FN}{\sqrt{(TP + FP)(TP + FN)(TN + FP)(TN + FN)}}$$

where:

- TP : True Positives
- TN : True Negatives
- FP : False Positives
- FN : False Negatives

Validation Strategy

After training on one Himalayan region, the model will be validated on an **unseen region** to evaluate generalization performance. This approach ensures the transferability of the semantic segmentation method across diverse terrains and supports its application to large-scale glaciological studies.