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Exploratory Research on the Implementation of Segment Anything Model (SAM) 2 for Glacier Calving Front Detection using SAR Imagery

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1. INTRODUCTION

Accurate delineation of glacier calving fronts is essential for quantifying marine-terminating glacier retreat and understanding ice-ocean interactions. These fronts mark the dynamic boundary between glacial ice and body of water and are critical for estimating ice discharge and tracking the response of outlet glaciers to climate forcing. Synthetic Aperture Radar (SAR) amplitude imagery offers unique advantages for high-latitude glacier monitoring due to its ability to penetrate clouds and operate independently of solar illumination. However, automatic segmentation of calving fronts in SAR data remains challenging due to the presence of speckle noise, variable radar backscatter, and low contrast between surface of the glacier tongue, glacier ice mélange, and concentration of winter sea ice floes (Zhao and Ban 2025).

2. RESEARCH METHODOLOGY

In this study, we explore the feasibility of applying Segment Anything Model 2 (SAM 2), a prompt-driven, general-purpose segmentation foundation model developed by Meta AI (Geetha and Hussain 2024), to calving front delineation problem. Unlike traditional segmentation models that are trained for specific use cases, SAM 2 is designed for zero-shot and prompt-based generalization across diverse visual domains (Ma et al. 2023; Zhang et al. 2023). Its flexible architecture allows users to guide segmentation using sparse spatial prompts such as points, boxes, or masks, making it potentially valuable for scientific applications with limited training data.

We focus our investigation on major tidewater glaciers in the Svalbard archipelago, including those in Kongsfjorden, Hornsund, and Hinlopenstretet, where calving dynamics have been previously observed to vary across spatial and seasonal scales. Sentinel-1 SAR amplitude imagery is used as the primary data source. To adapt optical-model-based segmentation to radar data, we apply preprocessing techniques tailored to SAR, including multi-look speckle filtering,

logarithmic scaling for dynamic range normalization, and edge-enhancing transformations. Prompts are derived from semi-automated edge detection (e.g., Sobel and Canny operators) and, in some cases, manually defined bounding boxes based on glacier outlines.

This preliminary investigation aims to assess the generalizability of SAM 2 in a new geophysical domain—cryospheric SAR analysis—and to develop a flexible workflow that can later be fine-tuned with expert annotations or paired with radar-specific models. Although model performance is not quantitatively reported here, the framework is built to support future evaluation using calving front reference datasets and metrics such as Intersection over Union (IoU), Dice similarity coefficient (also known as F1-score), and geometric accuracy.

By demonstrating the integration of a vision foundation model with SAR-specific preprocessing, this work lays the foundation for advancing automated, scalable glacier monitoring. It also contributes to the broader effort of repurposing powerful generalist models for domain-specific scientific challenges, particularly in Earth observation contexts where annotated training data are scarce.

References

Geetha, A.S., and M. Hussain (2024), From SAM to SAM 2: Exploring improvements in Meta's Segment Anything Model, arXiv:2408.06305, DOI: 10.48550/arXiv.2408.06305.

Ma, Z., X. He, S. Sun, B. Yan, H. Kwak, and J. Gao (2023), Zero-shot digital rock image segmentation with a fine-tuned Segment Anything Model, arXiv:2311.10865, DOI: 10.48550/arXiv.2311.10865.

Zhang, C., L. Liu, Y. Cui, G. Huang, W. Lin, Y. Yang, and Y. Hu (2023), A comprehensive survey on Segment Anything Model for vision and beyond, arXiv:2305.08196, DOI: 10.48550/arXiv.2305.08196.

Zhao, Y., and Y. Ban (2025), Assessment of L-band and C-band SAR on burned area mapping of multiseverity forest fires using deep learning, *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens*. **18**, 14148–14159, DOI: 10.1109/JSTARS.2025.3560287.

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