**Titel:**

Towards Delineating Channel Meltwater Extent Using Sentinel-1 on Greenland: An Assessment of Challenges and Limitations

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**Abstract**

Global warming is accelerating the melting of glaciers and ice sheets, leading to the formation of supraglacial meltwater, which accumulates in supraglacial lakes and significantly impacts glacier stability. Supraglacial channels can redistribute meltwater and improve glacier stability and are currently monitored using optical data from Sentinel-2. Using Sentinel-1 synthetic aperture radar data omits issues related to cloud cover and darkness, which is the primary focus of this study. The study focuses on three glacier site subsections: Nioghalvfjerdsbrae Glacier, Humboldt Glacier, and Russell Glacier. Sentinel-1 data is compared to the well-established optical data from Sentinel-2, which serves as the reference for channel delineation. The methodology encompasses both thresholding techniques and a GLCM-assisted random forest regression for co- and cross-polarized Sentinel-1 data, while Sentinel-2 data utilizes a thresholding technique based on Glen et al. (2024) and a path-opening algorithm developed by Yang et al. (2015) to delineate narrow channels from enhanced NDWI images. Google Earth Engine is employed for data access and preprocessing, whereas Python is leveraged to conduct the subsequent analysis. Preliminary studies have shown that individual Sentinel-1 scenes may only partially capture supraglacial channels. Therefore, individual scenes are aggregated by taking the backscatter minimum (assumed to be indicative of water due to specular reflection) and standard deviation (representative of change) over a melt season. Composite images offer a more comprehensive view of the supraglacial drainage network during the melt season and form the basis for GLCM texture feature calculations. A 3-by-3 kernel is used around pixels to generate an additional 64 input features by calculating the contrast, correlation, heterogeneity, and dissimilarity over 4 discrete angles for the HH and HV minima and variance. The backscatter features are fed through a random forest regressor with the per-pixel water fraction (i.e. the fraction of which each pixel is classified as water over all images) as the target variable derived from the Sentinel-2 reference classification, providing a more flexible regressor than a binary distinction. Results indicate that channels with sufficient cross-sectional area are detectable in Sentinel-1 data for both polarizations, albeit with varying success. Challenges such as speckle noise, channel size, the heterogeneity of pixel elements, and the movement of glaciers complicate the analysis. The study finds that while thresholding outperforms GLCM-assisted regression, both methods struggle with speckle noise inherent in Sentinel-1 data and alignment issues between the model input and reference classification. Despite these challenges, GLCM-assisted regression shows promising results by leveraging textural information and outweighing backscatter minima and variances in terms of feature importance. To conclude, Sentinel-1 data can be incorporated to delineate channels of sufficient size. Channels approaching the pixel resolution are captured partially at best and require image compositing. The variability in terrain and channel features, alongside persistent noise, limits the accuracy and reliability of this approach. GLCM texture feature analysis and random forest regression show promising results despite the multitude of problems. Other machine-learning techniques should be explored prior to continuing with this approach.