Boundary Detection of Debris-Covered Glaciers Using Fractal Analysis and Normalized Differencing of Thermal and Infrared Bands in Remote-Sensed Landsat Datasets

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The importance of studying glacial melting to understand the impact of climate change is amplified by the number of glaciers in the world, and complicated by the feasibility of monitoring them individually. Remote sensing techniques, such as multiyear satellite imaging, provide a valuable dataset to help monitor glaciers comprehensively. My prior work demonstrates how fractal geometry can be applied to the Landsat images of glaciers to accurately predict glacial melt. However, delineating the boundaries of glaciers is critical to such analysis. Debris-covered glaciers present unique challenges to identifying these boundaries as the underlying glacier is not readily evident from satellite imagery. Understanding and characterizing these boundaries are important for several reasons, including preparing regions for glacial lake outburst floods. Current techniques to detect the boundaries of debris-covered glaciers rely upon machine learning but suffer from localization and segmentation effects. This study combines fractal analysis with thermal and infrared Landsat bands to determine the boundaries of debris-covered glaciers. This research further attempts to delineate these boundaries for Earth's youngest glacier–Crater Glacier in Mt. St. Helens, WA, USA. Linear regression reveals a positive correlation between fractal dimension and moisture ($p < 0.001$, $R^2 = 0.9$). ANOVA reveals that the fractal dimension of the edges and the interior of the glacier are distinct (F/F-crit = 12.5). These results show promise in determining the boundaries of debris-covered glaciers and demonstrate that the fractal dimensions of such images may be indicative of subsurface water and ice. Confirmatory analysis reveals that the predicted boundaries closely approximate the actual boundaries.