Assessment of ice mélange impacts on tidewater glacier dynamics using high resolution ICEYE imagery

William D. Harcourt[1], Leigh A. Stearns[2], Michael G. Shahin[2], and Siddharth Shankar[2]

[1]School of Geosciences, University of Aberdeen, Aberdeen, United Kingdom (william.harcourt@abdn.ac.uk)
[2]Department of Geology, University of Kansas, Lawrence, KS, United States
(stearns@ku.edu,shahinmg@ku.edu,s.shankar@ku.edu)

There is growing evidence that ice mélange, the granular mixture of sea ice and icebergs at the termini of tidewater glaciers, impacts ice sheet discharge through physical buttressing forces and alterations to fjord circulation via iceberg melting. However, ice mélange is a highly dynamic, fragmented and mobile phenomenon which varies over a range of timescales (e.g. hours, days, weeks) and hence is difficult to monitor using traditional ground-based and spaceborne sensors. In this contribution, we utilise high spatio-temporal satellite imagery acquired from the ICEYE small satellite constellation to assess correlations between ice mélange characteristics and tidewater glacier dynamics. ICEYE is a growing constellation of 20+ small satellites each equipped with an X-band Synthetic Aperture Radar (SAR) and capable of mapping the entire globe at least once a day with fine spatial resolution (1-3 m). We utilised the ICEYE SAR imagery to study the perennial mélange matrix at the terminus of Helheim Glacier in southeast Greenland. ICEYE SAR imagery was acquired during summer and winter to assess how seasonal ice mélange conditions impact tidewater glacier dynamics. Sentinel-1 SAR imagery and ground-based TLS 3D data from two autonomous terrestrial laser scanners (ATLAS) were used to validate remote sensing analysis and provide additional data sources for interpretation of the glaciological processes. We will report on the following: (1) a spatial texture analysis (e.g. Grey Level Co-occurrence Matrix (GLCM), Gabor Transforms) of ice mélange at the terminus of Helheim Glacier using high resolution ICEYE SAR imagery; (2) results of hierarchical and random forest classifiers to map icebergs, sea ice and open water within the ice mélange matrix; (3) quantification of glacier and mélange flow variability at daily to weekly timescales; and (4) the development of observational models correlating ice mélange texture, iceberg distributions, mélange/glacier flow rates, and tidewater glacier stability. Our case study at Helheim Glacier aims to demonstrate a new approach to rapidly monitor ice mélange conditions and tidewater glacier stability using high resolution SAR imagery. In particular, this study pushes forward our Earth Observation capabilities and will help us better understand the complex processes operating at the ice-ocean interface which is critical for improved predictions of how the Greenland Ice Sheet will evolve under a warming climate.