EGU23-14207, updated on 21 Apr 2024
https://doi.org/10.5194/egusphere-egu23-14207
EGU General Assembly 2023

Mapping Antarctic Crevasses at High Spatiotemporal Resolution with Deep Learning applied to Synthetic Apertur Radar Data

Trystan Surawy-Stepney[1], Anna E. Hogg[1], Stephen L. Cornford[2], and David Hogg[3]
[1]School of Earth and Environment, University of Leeds, Leeds, United Kingdom
[2]School of Geographical Sciences, University of Bristol, Bristol, United Kingdom
[3]School of Computing, University of Leeds, Leeds, United Kingdom

Understanding how the presence of fractured ice alters the dynamics, hydrology and energy balance of glaciers and ice shelves is important in determining the future evolution of the Antarctic Ice Sheet (AIS). However, these processes are not all well understood, and large-scale quantitative observations of fractures are sparse. Fortunately, the large amount of satellite data covering Antarctica gives us the opportunity to change this.

The Sentinel-1 satellite cluster, from the European Space Agency's Copernicus programme, has acquired synthetic aperture radar (SAR) data over the AIS with a repeat period of 6-12 days for the last 8 years. A broad range of crevasse types are visible in this imagery: rifts, surface crevasses and some basal crevasses on ice shelves, and fine surface crevasses on grounded ice streams - even those bridged by snow or pixel-scale in width.

In this study, we use machine learning to automatically map crevasses in this imagery; producing monthly composite maps over the AIS at 50m resolution. We developed algorithms to partition crevasses into those on grounded and floating ice, and extract these features in parallel using a mixture of convolutional neural networks, trained in a weakly supervised way, and more traditional computer vision techniques.

Having developed parallelisable routines for the large-scale batch processing of SAR data, we have processed every Sentinel-1 acquisition over the Antarctic Ice Sheet. The resulting dense timeseries of fracture maps allows us to assess the evolution of crevasses during the Sentinel-1 acquisition period. By measuring the density of fractures we develop a method to quantify structural change on ice shelves, and investigate those of the Amundsen Sea Embayment. We show an increase in crevassing in buttressing regions of the Pine Island and Thwaites ice shelves over the last 8 years, with observed changes elsewhere in the Amundsen Sea dominated by the advection of existing crevasses.

Finally, we develop methods demonstrating how our fracture data can be assimilated into numerical modelling experiments aiming to quantify the impact of ice shelf fracture on glacier dynamics.