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Delineating giant Antarctic icebergs with Deep Learning

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Icebergs account for half of all ice loss from Antarctica. Their melting affects the surrounding ocean properties through the intrusion of cold, fresh meltwater and the release of terrigenious nutrients. This in turn influences the local ocean circulation, sea ice formation and biological production. To locate and quantify the fresh water flux from Antarctic icebergs, we need to track them and monitor changes in their area and thickness. While the locations of large icebergs are tracked operationally by manual inspection, delineation of iceberg extent requires detailed analysis – either also manually or through automated segmentation of high resolution satellite imagery.

In this study, we apply three machine learning techniques to 191 Sentinel-1 images between 2014 and 2020 and assess their skill to segment seven giant Antarctic icebergs between 54 and 1052 km^2 in size. Most previous studies to detect icebergs have focused on smaller bergs. In contrast, we aim to segment selected giant icebergs with the goal to automate the calculation of their changing area, volume, and freshwater input. Two of our techniques are standard segmentation techniques (k-means and Otsu thresholding) and the third one is a deep neural network (U-net). It is the first study to apply a deep learning algorithm to iceberg detection.

We analyse the strengths and weaknesses of the different machine learning approaches across a range of challenging environmental conditions: These include scenes where the iceberg is surrounded by deformed sea ice, when other big bergs are present and when berg fragments are close to the main iceberg. We also cover cases when the iceberg drifts close to the coast and summer images with surface thawing conditions, which invert the backscatter contrast between iceberg and ocean.