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# Mapping glacial sediment plumes in the Antarctic Peninsula using deep learning

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The subglacial discharge of sediment-rich meltwater plumes can be detected in satellite imagery where plumes reach the ocean surface at the terminus of tidewater glaciers. These meltwater plumes can influence glacier melting and ocean properties in important ways. Studying them provides insights into meltwater pathways in glacial hydrological systems.

Sediment-rich meltwater plumes are observed extensively in Greenland, Svalbard and other regions, however in Antarctica observations have been more limited. Recent detections of seasonal speed variations on tidewater glaciers of the Antarctic Peninsula suggest that surface meltwater reaching the glacier bed may be an important factor influencing ice dynamic behaviour on the Antarctic Peninsula Ice Sheet (APIS), however surface-bed hydrological connections have not been directly observed through fieldwork on the mainland APIS. Therefore, studying the presence and distribution of sediment plumes around the Peninsula can provide insights to understand the factors influencing newly observed seasonal ice speed fluctuations.

Here we develop a remote-sensing approach to map the locations and frequency of sediment plumes on the Antarctic Peninsula coastline using high-resolution multi-spectral imaging from Sentinel-2 satellites and a U-Net based convolutional neural network. This methodology allows us to detect small sediment plumes in images with high cloud and sea-ice densities. We apply our approach to the Antarctic Peninsula north of 65°S, including the South Shetland Islands, to produce a time-series of sediment plumes from 2016 to 2023 covering 150,000 km$^2$.

We use these results combined with outputs from regional climate models and reanalysis to assess the link between surface-visible sediment plumes and surface melt and runoff from the Antarctic Peninsula's glaciers. We find that the timings and locations of sediment plumes correspond to modelled runoff, providing evidence for widespread surface-bed hydrological connections in the Antarctic Peninsula.