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Damage and Dynamic Activity on the Thwaites Glacier Ice Tongue: 2015 to 2021

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The majority of ice mass loss in West Antarctica is due to the ejection of grounded ice into the sea via ice-dynamic processes. Structural changes that impact the flow speed of marine-terminating glaciers can, therefore, impact their contribution to global sea level rise. Thwaites Glacier is among those for which these considerations are particularly important, due to its potential connection to the stability of the West Antarctic ice sheet, and the structural changes that have been observed at its terminus in recent years. However, the interactions between ice structural properties and flow speed are not well established, partly due to the limited availability of coincident observations.

We present weekly ice velocity measurements, derived using Sentinel-1 radar data, showing the recent onset of episodic dynamic variability in the form of two large-magnitude ~30%-45% acceleration/deceleration events between 2017 and 2021, occurring across the majority of the remnant of Thwaites Glacier's floating ice tongue, before a relaxation to the 2015/16 mean speed. Using deep learning methods, we measured a synchronous decrease in the structural integrity of the ice tongue and its eastern shear margin during the study period, and the upstream propagation of these regions of damaged ice. The pattern of change seen in the concurrent damage and ice velocity observations suggests a link between the two, which we explore in the work. The existence of this link is further supported by ice flow modelling, carried out using the BISICLES ice sheet model, in which the spatial pattern and concentration of observed damage are closely reproduced when forced with the observed speed changes.

Our results add to the growing body of evidence that the extent and degree of damaged ice has a significant distributed effect on ice velocity, and further demonstrate that damage processes must be integrated in ice sheet models in order to make accurate predictions of long-term behaviour and sea level contribution.