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Ice Stream Dynamics during Deglaciation of the Laurentide Ice Sheet

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Ice streams rapidly drain large sectors of ice sheet interiors. At present, they account for approximately 50% and 90% of the mass loss from Greenland and Antarctica, respectively, but there are concerns over recent increases in ice discharge. This has been linked to atmospheric and oceanic warming, but the longer-term implications for ice sheet deglaciation are less clear. A key question is whether the activity of ice streams is predictably linked to climate-driven ice sheet mass balance, or whether their activity might accelerate deglaciation. To explore this, we analyse ice streaming during deglaciation of the Laurentide Ice Sheet (LIS) from ∼18 to ∼7 ka. Following a recent mapping inventory, we bracket the timing of >100 ice streams using existing ice margin chronologies. At the Last Glacial Maximum (LGM), ice streams formed a drainage network similar to modern ice sheets. Numerous ice streams were located in topographic troughs and likely operated for thousands of years from the LGM. These drained the marine-based sectors of the northern and eastern margins of the ice sheet until ∼11 ka and show a degree of spatial self-organisation. Other ice streams operated over much shorter time-scales and switched on and off, perhaps active for as little as a few hundred years. These include large ice streams that switched positions over sedimentary bedrock at the western and southern terrestrial margins. As the LIS retreated onto its low-relief and predominantly crystalline bedrock interior (after ∼11 ka), a smaller number of large ice streams operated that were very wide (50-100 km), and have no modern analogue. Overall, the number of ice streams decreased during deglaciation and they represented a small proportion of the ice sheet circumference. We use simple scaling relationships, based on a data-set of modern Antarctic and Greenland ice stream dimensions and velocities, to estimate the mass loss delivered by ice streams. Our estimated total flux from ice streams is relatively stable until 13 ka and drops rapidly thereafter. We therefore find no evidence for major ice sheet instabilities linked to ice stream activity and conclude that deglaciation was largely driven by surface melt.