Tools of the trade

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Decoding ice flow history from englacial radar stratigraphy

Ice sheets originate from compacted snow layers. Under the force of gravity, the ice sheets move slowly towards the coast. However, the pattern of flow is uneven. In some places, the ice is nearly stationary, but in others, it flows rapidly along narrow conduits called ice streams. Next to melting, the transport of ice via ice streams is one of the primary ways that ice sheets can lose mass. The paths and speeds of present-day ice streams can be clearly mapped from space, but it is unclear how stable they have been over the many thousands of years since the ice sheets of Greenland and Antarctica first formed. Understanding past ice-stream behaviour under the influence of ongoing warming is very important to constrain the implications for sea level rise in the future.

High-resolution radio-echo sounding (RES) data enable visualization of stratigraphic layers deep within the ice, which are used to reconstruct the remnants of defunct ice streams. To map a large area, data are acquired using airborne radar systems. Systems with multiple antennas operating with broadband chips and multiple waveforms, as well as advanced processing methods, are used to achieve high resolution throughout the ice sheet. Focused flow within the ice sheet, such as occurs in an ice stream, is recorded by specific patterns of distortion and folding of the stratigraphy. Three-dimensional reconstruction of these patterns allows us to interpret the deformation history of the ice sheet and link it to the flow activity in and around ice streams.

For example, cylindrical folds can be considered markers of convergent ice flow, which happens as ice converges to form an ice stream. Elsewhere, the shear margins of some ice streams display a unique imprint of very sharp near-vertical folds in the radar stratigraphy. Multiple such observations allow for interpretations of past large-scale ice-flow regime shifts. The insight into how ice streams can appear, shift, and die out will affect our understanding and ability to model the impact of global warming on Earth's ice sheets and their contributions to future sea level rise.

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Competing interests
The author declares no competing interests.

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