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Dynamics of a subglacial meltwater plume revealed by continuous subsurface monitoring directly on the calving front

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Recent literature has highlighted the great importance of subglacial meltwater plumes in a variety of processes including subaqueous ice melting, enhanced fjord-scale circulation, nutrient and heat mixing, foraging ground formation, and the movements of seals that apparently use plumes for returning to the sea surface.

However, direct measurements of plume water properties are scarce due to the difficulty of conducting observations near unstable glacier calving fronts. A few studies have succeeded in obtaining snapshot views of plume structures using bio-logging, remotely operated vessels, or helicopter-borne eXpendable Conductivity Temperature Depth (XCTD) probes, but continuous data time-series remain elusive and technically challenging.

In this study, we overcame these limitations by deploying mooring-based equipment between major calving events from a calving front of Bowdoin Glacier, an ocean-terminating glacier in Northwest Greenland. In July 2017, a first-of-its-kind 10 d dataset of plume dynamics was obtained by attaching instruments to the ice cliff for the logging of conductivity, temperature, and pressure at depths of ~5 m and ~100 m, with a sampling interval of 10 s.

Nonlinear and spectral time-series analysis revealed a chaotic system, an extremely turbulent environment, the presence of coherent structures, tide-modulated signals, and a non-intuitive transition in the dynamics of the plume due to a witnessed glacial lake outburst flood. Our observations should provide an important reference for the glacier-science community, including modellers interested in the evolution of ocean-terminating glaciers, fjord-scale circulation, and glacier fjord ecosystems.