Listening to glaciers

To the Editor — There are indications that the Greenland ice sheet may respond more rapidly to global warming than anticipated even a few years ago. The rise in sea level appears to have accelerated since 1993 and is now near the upper end of the range projected in recent estimates. Fast ice flow and discharge into the ocean have been observed in Greenland and elsewhere. Assuming that ice–ocean interactions within Greenland fjords are a key element of ice-sheet activity, we propose that acoustic detection and monitoring of glacier calving in fjords is feasible and can contribute substantially to our understanding of ice-sheet behaviour in Greenland.

Linear extrapolation of sea-level rise over the past several decades yields a rise in sea level of around 30 cm by the end of the twenty-first century. However, the geologic record of sea level rises in the past half million years suggests that ice sheets can deteriorate sufficiently rapidly to yield rates of more than 1 m per century, including in situations when sea level was close to the present position. Such rates exceed by far expectations from state-of-the-art ice-sheet models and therefore suggest that there are gaps in our understanding of the processes relevant to ice-sheet decay, as noted in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. As a consequence, the uncertainties around sea-level projections for the twenty-first century are large.

Observations show increasing rates of rapid retreat and thinning at major outlet glaciers draining the Greenland ice sheet, especially in southern Greenland. These outlet glaciers terminate within large fjords and exhibit highly nonlinear dynamics where both flow and iceberg calving rates can undergo rapid and substantial changes. Current work suggests that the dynamics may be intimately related to changes in oceanographic parameters, in particular, to ocean temperature.

To understand the response of outlet glaciers to changes in the surrounding ocean, hydrographic conditions in 'glacier fjords' need to be recorded over a suitable time span of several years in combination with measurements of related changes in the activity of the associated glaciers. In this context, the import of heat from the open sea into the fjord would seem to be of central importance. However, the environment of fjords with glacier termini is logistically challenging and not well suited for making series of routine measurements.

We therefore suggest using novel approaches of quantitative observations, including the long-term deployment of hydro-acoustic instruments and pressure gauges in selected portions of a glacier fjord, in addition to traditional instruments for recording temperature and salinity. Hydro-acoustics could be used for passive listening — for example, to calving, iceberg collision, tidal flow, sediment transport and wind action — as well as active echo-sounding (for example, Doppler detection of water and ice motions).

Presumably, with proper calibration, ice-generated sounds can be related to changing rates of calving events. Integration of simultaneously acquired hydroacoustic and land-based observations with ice-flow modelling efforts will reduce the uncertainties associated with the future behaviour of outlet glaciers and the Greenland ice sheet.

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