Short-term variations in the dynamics of Bowdoin Glacier in northwestern Greenland

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Tidewater glaciers in Greenland ice sheet are rapidly retreating by under the influence of changes in ice dynamics (e.g. Nick et al., 2009). For example, Bowdoin Glacier began rapid retreat in 2008, which was accompanied by significant acceleration near the glacier front (Sugiyama et al., 2015). Submarine melting and ice-mélange weakening are suspected as triggering mechanisms of the rapid retreat of tidewater glaciers in the Greenland ice sheet (e.g. Straneo et al., 2013), but details of processes at the ice-ocean interface are poorly understood. To better understand these processes, we measured ice-front position of Bowdoin Glacier in northwestern Greenland and glacier/ice-mélange movement in front of the glacier. The glacier/ice-mélange measurement was performed by processing 3-hourly photographs taken by a time-lapse camera operated over two years since July 2013. We also operated a dual-frequency GPS at 3 km from the calving front to measure ice speed from May to July in 2014 and 2015.

The image analysis revealed clear seasonal variations in the ice-front position with an amplitude of ~200 m. Seasonal changes were also observed in ice speed along the center of the glacier (amplitude ~50%). During summer, the ice-front position was relatively stable, but retreated occasionally by large calving events. These events occurred near upwelling of subglacial discharge, where a large submarine melt rate is expected. The glacier began to advance in September approximately when daily mean air temperature dropped below 0°C. The glacier advanced the most in winter when the fjord was covered by ice-mélange. After winter, extended portion of the glacier rapidly disintegrated by a few calving events. Such event coincided with onset of ice-mélange movement in front of the glacier. This movement occurs when air temperature above 0°C and high wind speed were observed, suggesting the calving event was due to decrease in the mechanical support from the ice-mélange.

These results indicate both ice-mélange and submarine melting play roles in seasonal advance and retreat of Bowdoin Glacier. Moreover, the onset of glacier advance (retreat) coincided with the changes from positive to negative (negative to positive) temperatures, implying that air temperature is an indirect indicator of the ice-front position change.

References

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