

## Seasonal variations in the thermal structures of proglacial lakes in the Southern Patagonia Icefield

MINOWA, Masahiro<sup>1\*</sup> ; SUGIYAMA, Shin<sup>1</sup> ; SAKAKIBARA, Daiki<sup>1</sup> ; SKVARCA, Pedro<sup>2</sup>

<sup>1</sup>Institute of Low Temperature Science, <sup>2</sup>Museo del Hielo Patagonic

Patagonia Icefields are losing ice mass at one of the greatest rates in the world. The icefields are characterized by a number of outlet glaciers calving into lakes and the ocean. Many of these calving glaciers are retreating, but rates of the retreats are significantly different in each glacier. For example, Glaciar Upsala retreated by 2.9 km over the period of 2008 — 2011. Mass loss from the glacier accounts for about 15% of the total mass loss from the Southern Patagonia Icefield in 2000 — 2012. On the other hand, Glaciar Perito Moreno has shown no significant change in the terminus position over the past century. Recent studies in Greenland and Alaska suggest the importance of melting of calving face below the sea surface for recent mass loss of calving glaciers. Despite the increasing numbers of data from fjord of tidewater glaciers, little is known even in the thermal structure in lake, seasonal variation and how various water masses mix. To investigate the thermal structure of proglacial lake, we measured temperature and turbidity of lake water in front of calving glaciers in the Southern Patagonia Icefield. Lake measurements were carried out at Glaciar Upsala, which covers an area of 840 km<sup>2</sup> and flows into a ~600 m deep lake, and Glaciar Perito Moreno, which covers an area of 259 km<sup>2</sup> and flows into a shallower lake (~200 m deep). We repeated measurements in summer (December, 2013) and spring (October, 2014) to investigate seasonal variations in the lake water properties.

Our results in spring showed relatively uniform water temperature and turbidity from the lake surface to the bottom, whereas temperature and turbidity showed steeper vertical gradients in summer. These results are consistent in the two lakes. In summer, water temperature in front of Glaciar Upsala (2 — 4°C) was colder than in spring, because of large amounts of subglacial discharge from the glacier. Turbid and cold water (<1°C) was found at the deepest part of the lake (>500 m below the lake surface), which is a strong indication of subglacial meltwater discharge. Contrasting to Glaciar Upsala, cold deep water was missing in the lake of Glaciar Perito Moreno both in summer and spring. In summer, water temperature (6°C) was warmer than in spring by ~3°C within whole lake, and in particular, warm water layer (~8°C) observed at the lake surface (<5 m below the lake surface).

These data indicate different thermal structures in front of the two freshwater calving glaciers in Patagonia. The structure is probably dependent on the bathymetry and subglacial discharge. Warmer lake is formed by relatively small amount of subglacial discharge and shallow lake, which should play crucial roles in the melting of calving face below the lake surface.

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