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Variability in circulation in Cumberland Bay, South Georgia, and implications for glacier retreat

Joanna Zanker[1], Emma Young[1], Ivan Haigh[2], Paul Holland[1], and Paul Brickle[3]
[1]British Antarctic Survey, Polar Oceans, United Kingdom of Great Britain – England, Scotland, Wales (joazan@bas.ac.uk)
[2]University of Southampton, University Rd, Southampton, U.K.
[3]South Atlantic Environmental Research Institute, Stanley, Falkland Islands

Mass loss from marine-terminating glaciers in high-latitude fjords is increasing globally, contributing to sea-level rise. It is widely cited that oceanic melting of these glaciers is enhanced by turbulent plumes rising in contact with the submarine face. Increasing evidence suggests fjord-wide horizontal circulation also enhances melting outside of plumes. The influence of buoyancy-driven outflow arising from submarine plumes on fjord-wide circulation is complex and subject to fjord geometry. There are many studies of fjord systems in Greenland and Antarctica, but relatively little is known about fjords on sub-Antarctic islands such as South Georgia. This study uses observations and a new high-resolution model of Cumberland Bay, South Georgia, to study the interactions between fjord geometry and buoyancy-driven outflow on the circulation regime. We examine how this varies seasonally and the implications for glacier retreat. Cumberland Bay is a fjord system with two arms, each with a large marine-terminating glacier at the head. These glaciers have shown contrasting retreat rates over the past century. In the shallower fjord arm (~70 m) the plume reaches the surface year-round, whereas in the deeper fjord arm (~160 m) the plume terminates sub-surface for ~3 months of the year. The addition of a shallow submarine sill in the deeper fjord arm leads to warmer and fresher water properties in the inner basin by blocking colder, higher salinity waters at depth. This change in water properties results in the plume reaching the surface year-round and the strength of the circulation outside of the plume is increased by recirculation of the buoyancy-driven outflow bouncing off the sill. The increase in temperature and energetic fjord-wide circulation both increases the plume-driven melt by as much as 2 m per day, and the potential for melt outside of the plume. Our results give the first detailed description of the oceanography of Cumberland Bay and highlight the importance of the interaction between fjord geometry and buoyancy-driven outflow influencing the rate of glacier retreat.