An application of plume theory to asses impacts of subglacial discharge on glacier subaqueous melting

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Surface meltwater in Greenland ice sheets percolates down to the bed rock through moulins and enters the ocean from the bottom of glaciers, forming upwelling plumes in front of the glacier calving face. A common assumption in sub-ice cavity is that the only source of buoyancy that acts to stratify the water column and maintains overturning circulation is the generation of meltwater at the ice-ocean interface. Most insights into the processes of ocean circulation and melting beneath ice shelves have been provided by applications of plume theory in inclined coordinate systems. In contrast, the dynamics at the ice front in fjords are significantly influenced by the relative strength of buoyancy to inertia of freshwater discharge at the bottom of the glacier.

Here, we apply theory of forced plumes to investigate the sensitivity of melt rate to discharge flux and thermal forcing. We compare the analytical results to numerical simulations. We employ a finite-element, fully-unstructured-mesh ocean model, Fluidity-ICOM in an idealized domain. The geometric flexibility of employing the fully-unstructured-mesh offers several advantages over previous approaches. The model can allocate fine resolution near the ice front and decrease the resolution in all three directions toward the open boundary and represent melting or freezing on ice-ocean interfaces oriented in any direction. We will discuss the scalings of melt rate found in the application of theory and simulations.