Analogue modeling of water flow under ice; what can we learn?

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Analogue models have been used extensively in the Earth sciences to improve understanding of natural processes. We report on preliminary experiments to understand the nature of, and impacts from, water flow under ice. To simulate ice flow we use polydimethyl-siloxane (PDMS) – a liquid polymer used extensively in the tectonics community. PDMS is a transparent, non-toxic material with a specific weight similar to that of ice. Additionally, the viscosity of PDMS is well-suited to ice flow studies as it is strain-rate dependent. The polymer is loaded into a 4'x6' plastic box which is coated with a water-based lubricant across much of the width of the box to reduce friction between the polymer and the plexiglas base. Water is injected at the interface between the polymer and the plastic box through a set of tubes that distribute the water supply across the upstream end at a constant discharge.

We measure horizontal surface displacements by tracking several bright stickers placed on the surface of the polymer through a sequence of images that make up each experimental run. Coincident water discharge and channel pattern measurements are made to correlate changes in discharge to changes in channel geometry and surface motion. The channelized area is observed by injecting dark blue dye into the water.
Of particular interest is the response of the channel system to discharge pulses. To observe this we change discharge into the flume from ~70 cm3/s to 550 cm3/s which reflects a ~8-fold increase in discharge and represents the typical diurnal fluctuation in discharge observed for alpine glaciers due to increased surface melt.

Future experiments to be conducted include experimenting with larger discharge pulses representing extreme events such as supraglacial lake drainage, changes to the shape of the bed to represent water flow around obstacles and into depressions. We also wish to understand how ice sheet surface elevation changes correspond with ponding and subsequent release of subglacial water. Finally, we will repeat experiments with a sediment layer to understand the differences in channel patterns for hard-bedded versus soft-bedded glaciers.