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Quantification of the Impact of Supraglacial Lakes and Slush on Surface Energy Balance of Ice Shelves

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Despite the well-researched implications of SGL development and drainage for changes in mass balance and dynamics on Greenland, little is known about the role of energy absorption by lakes on Antarctica. Supraglacial lakes (SGLs) are prevalent features of Antarctic surface hydrology forming mainly on ice shelves (<100 m a.s.l) and efficiently conveying atmospheric energy to the ice interior (Lenaerts et al., 2017; Bell et al., 2018). SGLs on Antarctic Ice Shelves are significant for mass balance given lower surface albedo and drainage-induced collapse of fringing ice shelves and consequent increased discharge from tributary outlet glaciers (Stokes et al., 2019).

There have been few efforts to quantify the energy exchanges between SGLs, atmosphere and ice to calculate their effects on glacier ablation (Law et al., 2018), although Miles et al. (2016) find that ponds on a debris-covered mountain glacier input large amounts of energy to underlying ice. Therefore, it is proposed that ice-sheet ponds also act as a significant energy exchange surface inputting large amounts of energy to the ice.

This study aims to code a computationally efficient surface energy balance model (SEB) in Google Earth Engine Editor to quantify how much extra energy is absorbed by SGLs at the during 2019 melt season. The most prolific surface melt is associated with the Antarctic Peninsula, but several East Antarctic ice shelves experience upwards of 60 days/yr of melting (Bell et al., 2018). Near-grounding line negative mass balance of the Nivlisen Ice Shelf (70 S, 12 E) in central Dronning Maud Land, East Antarctica, is sufficient to form SGLs and will be used to test SEB accuracy.

The one-dimensional numerical energy-balance SGL model GlacierLake, developed by Law et al. (2018), will be implemented in Google Earth Engine to code for surface energy exchanges. GlacierLake is most sensitive to the proportion of shortwave radiation absorbed at the surface which indicates that it is responsive to surface energy fluxes and is useful for the purposes of this study. A variety of methods, including NDWI and Principle Components Analysis, will be evaluated for use to classify lake and slush extents.

Given that it takes 3.4 x 10^5 J/kg of latent heat to melt ice at 0 °C, the volume of liquid water on the Nivlisen ice shelf implies how much atmospheric energy has been transferred to the ice shelf. The modelled quantification of extra energy absorbed by lakes will be compared to the observed water volume on the Nivlisen Ice Shelf to test model accuracy.

Whilst this study will focus on the Nivlisen Ice Shelf, the SEB model may be applied at pan-Antarctic scales to calculate the ice-sheet wide extra energy absorbed by surface meltwater pooling. A precise quantification of the present impact of energy absorption by lakes on mass balance and dynamics provides a baseline to gauge how meltwater contribution could evolve under atmospheric warming.