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

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The majority of grounded ice in Antarctica is buttressed by fringing ice shelves, making them a critical mass balance component (Smith et al., 2019). Rapid collapse of Antarctic Peninsula ice shelves demonstrated sensitivity to recent warming, exacerbated by the formation of surface meltwater features (Berthier et al., 2012). Supraglacial lakes (SGLs) and slush have lower albedo than that of surrounding snow, increasing radiation absorption and generating melt (Jakobs et al., 2019). Quantification of the energy balance of supraglacial features is essential for confirming the significance of the melt-albedo feedback. Nivlisen Ice Shelf (70°S, 11°E) is illustrative of the increasingly prevalent surface melt on the EAIS.

Study Aims

1. Calculate lake and slush area of Nivlisen Ice Shelf
2. Develop a Surface Energy Balance (SEB) model in Earth Engine using Landsat 8 and Sentinel-2 imagery as appropriate
3. Quantify extra energy absorbed by different supraglacial features, 2017 – 2020
4. Validate modelled energy absorption at lakes with observed lake volume

Surface Energy Balance Model in Earth Engine

- Equations following Buzzard et al., 2017; Law et al., 2020 to quantify extra energy transferred to Nivlisen at SGL and slush
- Earth Engine provides rapid processing, availability of Landsat 8 and Sentinel-2 imagery, and Global Forecast System Data (6 hourly meteorological data, including shortwave radiation)

Results

- Shortwave flux dominates net SEB – corroborates Law et al., 2020
- No inter-annual trend of average energy absorbed at SGL or slush
- 2017 – high net energy absorption by SGLs (Fig. 3)
- 2019 – high net energy absorption by slush (Fig. 3)
- High slush extent years have similar significance to high SGL extent years for energy absorption

Conclusions

The PCA-histogram method is confirmed to be successful for supraglacial feature extraction used with different satellite sensors and advantages for future research of hydrology evolution. SEB model results confirm and quantify energy contribution of SGLs whilst indicating previously underestimated implications of slush in particular years. Inter-annual modelled extra energy absorbed at lake pixels is validated by comparison to inferred energy transfer derived from total SGL volume ($R^2 = 0.813$).
References


• PCA Schematic image (left hand image) accessed at www.nlpca.org/pca_principal_component_analysis.html on 06/04/2020.