

Parameterizing Glacier Thinning and Retreat: A Case Study in High Mountain Asia Pacifica (Kitrea) L. M. Takata-Glushkoff, Class of 2019

As climate change generally increases world-wide glacial melt, it becomes increasingly important to capture the details of glacier dynamics to effectively understand and predict glacier changes. Increased glacial melt can change downstream water regimes, pose local avalanche and flood hazards, and contribute to global sea level rise. In order to mitigate or proactively adapt to these impacts, we must refine our understanding of glacier processes, and thereby incorporate that knowledge into glacier evolution models.

Large-scale glacier evolution models require computationally inexpensive methods of capturing glacier retreat and thinning dynamics. Huss et al. (2010) previously derived mass redistribution curves (thinning curves) which demonstrate *how thinning varies along the elevation profile of a glacier*. The curves show that retreating glaciers typically undergo maximal thinning at the low elevation glacier terminus, and minimal thinning at the high elevation glacier head. Huss et al. focused on Swiss Alps glaciers, finding that thinning curves differ based on total glacier area, with larger area associated with less thinning.

To know the inter-regional transferability of the Swiss Alps thinning curves, it is necessary to understand glacier thinning patterns in other regions. This study assesses glacier thinning patterns in High Mountain Asia, which contains a quarter of world-wide glacier area outside polar latitudes.

Our research objectives were to:

- 1) Determine the typical glacier thinning along the elevational profiles of High Mountain Asia glaciers
- 2) Assess how glacier *area*, *debris cover*, and *slope* impact the relative thinning of glaciers
- 3) Compare High Mountain Asia glacier thinning curves to Swiss Alp glacier thinning curves

We used Python to plot the thinning curves of 4287 High Mountain Asia glacier based on satellite-derived geodetic mass balance data from the years 2000 and 2017. We then grouped and averaged these curves based on their characteristics of interest (Figure 1) and assessed how each characteristic impacts the curves.

First of all, when compared with Swiss Alps glaciers, High Mountain Asia glaciers show a similar general relationship wherein larger glacier undergo less relative thinning. However, this association is less pronounced in High Mountain Asia glaciers, and the curves themselves differ from Swiss Alps curves, suggesting the importance of regional curve derivations. Second of all, the more debris cover, the less the glacier terminus thins (Figure 2). Lastly, the steeper the glacier slope, the less glacier thinning occurs along the full elevational profile of the glacier. Continuing to quantify and investigate these curves will allow for more regionally-accurate, computationally simple thinning and retreat parameterizations for glacier modeling.

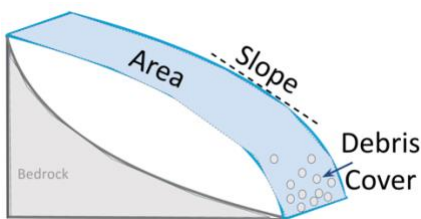


Figure 1. Glacier 3-D cross section highlighting three characteristics of interest for their impacts on the glacier thinning curves.

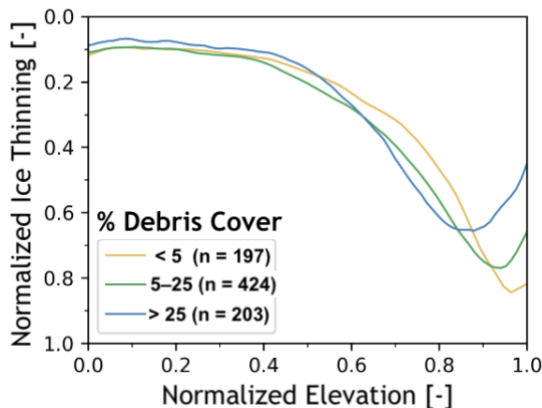


Figure 2. Average thinning curves for glaciers with <5% (yellow), 5-25% (green), and >25% (blue) debris cover. Highest debris cover is associated with less thinning toward the terminus.

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References

Huss, M., Juvet, G., Farinotti, D., and Bauder, A. (2010). Future high-mountain hydrology: a new parameterization of glacier retreat. *Hydrol. Earth Syst. Sci.* 14, 815–829.