ICG2022-325, updated on 06 Jun 2023
https://doi.org/10.5194/icg2022-325
10th International Conference on Geomorphology

Characterizing the role of supraglacial debris thickness variability on underlying ice ablation

Calvin Beck[1,2], Lindsey Nicholson[2], Anna Wirbel[2,3], and Thorsten Simon[2,4]
[1]Université de Caen Normandie (UNICAEN), CNRS, M2C, 14000 Caen, France
[2]Department of Atmospheric and Cryospheric Sciences, Universität Innsbruck, Austria
[3]Austrian Research Centre for Forests (BFW), Department of Natural Hazards, Division Snow and Avalanche, Innsbruck, Austria
[4]Faculty of Economics and Statistics, Universität Innsbruck, Austria

Projections of future climate implicate the thickening of debris-covered glaciers. Thus it becomes increasingly important to consider the influences of the debris layer on glacier melt especially because of the strong non-linear relationship between debris thickness and ablation rate. This relationship is known as the Østrem curve. For very thin debris layers ablation is increased due to a higher albedo where as thicker debris layers reduce ablation due to insulation. Some local scale models based on satellite images already partly account for this effect. They take the average debris thickness per decametre large grid cells and scale the ablation based on a representative Østrem curve. Unfortunately, supraglacial debris thickness has been shown to vary substantially over short length scales on a glacier surface. The debris thickness frequency distribution is also non-linear, with varying skew and kurtosis. Therefore sub-debris ice ablation is a result of the combined non-linearities of the particular Østrem curve with the particular frequency distribution of the debris thickness.
In this study, we investigate the error of the ablation rate introduced by neglecting debris frequency distribution. We obtained the Østrem curves from field measurements and different numerical models. A gamma distribution with different rate and shape parameters was used to represent likely debris thickness frequency distribution. The analysis shows that the debris frequency distribution has a strong effect on calculated glacier melt. For some cases, this can result in a doubling or tripling of ablation values in comparison to that calculated using the mean debris thickness. Therefore neglecting this effect in numerical models has the potential to drastically underestimate glacier melt.
Within the framework of this study, an interactive application was developed that allows one to investigate the error on ice ablation if not considering the debris layer's thickness frequency distribution.