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An improved method to compute supra glacial debris thickness using thermal satellite images together with an Energy Balance Model in the Nepal Himalayas

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A significant proportion of Himalayan glaciers is debris covered. Knowing the thickness of the debris cover is essential to obtain accurate estimates of melt rates. Due to the remoteness of these glaciers, collecting field measurements of debris thickness for a large number of glaciers is not realistic.
For this reason, previous studies have proposed an approach based on computing the energy balance at the debris surface using surface temperature from satellite imagery together with meteorological data and solving the energy balance for debris thickness. These studies differ only in the way they account for the nonlinearity of debris temperature profiles and the heat stored in the debris layer.
In our study we aim to 1) assess the performance of three existing models, and 2) develop a new methodology for calculating the conductive heat flux within the debris, which accounts for the history of debris temperature profiles by solving the advection-diffusion equation of heat numerically. Additionally, we found that in the previous studies several input variables are considered as uniform and we improved this by using distributed representations.
As a study case we use Lirung glacier in Langtang valley, Nepal, and we work with Landsat satellite thermal images. Results are validated using measurements of debris thickness on the glacier from October 2012 and 2015.
In some cases the existing models yield realistic results. But there is very little consistency between results for different satellite images. In general, computed debris thickness is frequently too thin compared to reality. Two of the existing models were able to accurately reproduce the extent of thin debris cover on the upper part of Lirung glacier. The mean debris thickness on Lirung obtained with the existing models lies between 0.1 m and 0.3 m depending on the model used, whereby the upper value of 0.3 m corresponds best to the field measurements.
Preliminary results from our new model show a larger spatial variability of debris thickness on the glacier as compared to existing models. Mean debris thickness on Lirung glacier computed with the new model is 0.4 m and is therefore closer to the field measurements than with the existing models. All models are most sensitive to effective thermal conductivity, shortwave radiation and albedo. We conclude that there is a large potential for improvement in debris thickness modelling.