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Applying an energy balance model of a debris covered glacier through the Himalayan seasons – insights from the field and sensitivity analysis

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Although some recent studies have attempted to model melt below debris cover in the Himalaya as well as the European Alps, field measurements remain rare and uncertainties of a number of parameters are difficult to constrain. The difficulty of accurately measuring sub-debris melt at one location over a longer period of time with stakes adds to the challenge of calibrating models adequately, as moving debris tends to tilt stakes. Based on measurements of sub-debris melt with stakes as well as air and surface temperature at the same location during three years from 2012 to 2014 at Lirung Glacier in the Nepalese Himalaya, we investigate results with the help of an earlier developed energy balance model. We compare stake readings to cumulative melt as well as observed to modelled surface temperatures.
With timeseries stretching through the pre-Monsoon, Monsoon and post-Monsoon of different years we can show the difference of sensitive parameters during these seasons. Using radiation measurements from the AWS we can use a temporarily variable time series of albedo. A thorough analysis of thermistor data showing the stratigraphy of the temperature through the debris layer allows a detailed discussion of the variability as well as the uncertainty range of thermal conductivity. Distributed wind data as well as results from a distributed surface roughness assessment allows to constrain variability of turbulent fluxes between the different locations of the stakes.
We show that model results are especially sensitive to thermal conductivity, a value that changes substantially between the seasons. Values obtained from the field are compared to earlier studies, which shows large differences within locations in the Himalaya. We also show that wind varies with more than a factor two between depressions and on debris mounds which has a significant influence on turbulent fluxes. Albedo decreases from the dry to the wet season and likely has some spatial variability that is considered in the sensitivity analysis.