Submitted Abstract

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Abstract

Debris-covered glaciers have been investigated in detail from a glaciological perspective, however their role in catchment hydrology is less clear. Nearly 5% of all global mountain glacier ice is covered in debris, reaching up to 30% for some catchments in the Andes and the Himalaya. Debris thicker than a few centimeters generally inhibits melt, while thin debris can increase melt rates. As energy needs time to travel through the debris pack before reaching the ice surface the timing of melt is delayed. Additionally, melt water cannot drain as fast as over a clean ice and is retained and possibly refrozen in the debris layer, which is similar to unconsolidated soil. Based on multiple years of melt measurements on a debris-covered glacier in the Central Himalaya and concurrent monitoring of local climate and discharge, we show how debris cover influences the catchment's hydrology. In the catchment, where 30% of the total glacier ice is covered in debris. During the monsoon 60% of the total ice melt originates from clean ice glaciers. This is reversed in spring, where the lower lying debris-covered ice provides nearly 80% of all glacier melt. Moreover, melt water from clean ice glaciers peaks around noon while melt from debris-covered ice peaks consistently 3 hours later. This potentially explains some of the very late and bimodal peak of discharge in the catchment. Discharge from glacier ice in the catchment exceeds 50% of the total discharge for 15% of the year. There are even periods when the glacier melt is larger than the observed river discharge. This suggests that a significant amount of melt water is routed through the debris layer and the subsurface before it leaves the catchment more than 24h after the melt occurred. As debris cover is expected to increase upwards, this delay in discharge is likely to become more pronounced in future.