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Thermal fracturing on a Himalayan debris-covered glacier

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Thermal fracturing is an important erosion process on the icy surfaces of Solar System bodies, including Earth, Mars, and comets. However, the exact timing of this thermal fracturing process is poorly constrained, despite the need for this information to validate models, and its importance in the weathering of glacial ice is largely unknown and often overlooked. Our recent passive seismic observations revealed nocturnal thermal fracturing of a high-altitude Himalayan debris-covered glacier. These observations in Nepal suggested that glacial ice bursted with icequakes as temperature decreased unless ice was protected with a thick debris cover. To support these observations we consider four different numerical approaches to describe material behaviour of ice under thermal stress in order to find out how debris modulates stresses and which method agrees with the experimental evidence. We numerically estimate thermal stress conditions near the surface of a glacier with and with out debris and find that a half-of-a-meter-thick debris is sufficient to protect ice from mechanical damage induced by diurnal variation of temperature. Furthermore, our work suggests that thermal stress and associated cracking deserve further studies, since they can be important factors for weathering of exposed ice. It is possible that new cracks can facilitate ablation, and thus accelerate ice loss in high mountains, which serve as water towers for local populations.