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Dynamic fracture development in response to extreme summer temperatures: 27/7/2014, Långören Island, Finland

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Long periods of exceptionally high temperatures in Finland and California during the summer of 2014 were associated with the formation of large 'exfoliation' or 'sheeting' fractures in bedrock surfaces. Videos taken at both locations show sharp fractures forming along the edge of thin (<1 m) bedrock sheets several meters across, before the rock surface appears to jump and buckle in the hot summer sun. Long striations visible on the surface of the rock at Långören Island are the result of boulders being dragged over the landscape during the last glacial period (>15,000 years ago), hinting at the rarity of the recent events on the otherwise undamaged surface. In order to uncover the mechanisms driving this remarkable event, we installed a unique low-cost monitoring system to track the behavior of the new Långören Island fracture through the summer of 2016. This included a local meteorological station, Arduino-based rock temperature profiles, acoustic emission measurements, and a 3G-enabled all-in-one PC for live data communication. Coupled with GPR data, field mapping, and a local DEM derived from a 'Go-Pro on a stick' structure from motion capture, we generate a unique insight into the conditions at the time of the 2014 event, and potential active micro-fracturing during a hot period in 2016. Our models suggest rock surface temperatures approached 40°C during 2014, almost ten degrees above the peak air temperature. The mid- to late-afternoon timing of fracturing was associated with peak thermal stress in the upper 1 m of bedrock, consistent with 2016 observations, where measured surface temperatures of around 35°C generate a thermal front that coincides with a series of acoustic emission events on a sensor installed in a borehole near the crest of the fracture.