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Using infrared thermography to assess micro-climatic variations at alpine rockwalls

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Frost cracking and, to a lesser degree, above-zero thermal fluctuations are held responsible for weathering and rock decay at alpine rockwalls. The required temperature ranges and temperature fluctuations have been a matter of ongoing debate. For example, a great deal of attention is currently being given to the duration spent within the so-called frost cracking window (FCW) between approx. -3 and -8°C. This duration is commonly modelled from large-scale meteorological data or extrapolated from sensor data. However, small-scale variability (at a scale of some tens or hundreds of meters) deriving from micro-topography, joints, snow fields, water seepage etc. is generally not considered.
Infrared thermography can potentially close this scale gap and contribute to a better understanding of rockwall microclimate. However, several possible disturbance factors need to be considered: (1) The emissivity of rocks varies between different rock types and depends on surface structures, roughness etc.; (2) emissivity and reflectivity (e.g. from cold sky light) depend on the angle between the direction of the camera and the surface normal of the rock; (3) reflectivity may be altered by moisture or water films at the rock surface and water drops in the beam path of the camera can distort the results.
We investigated the impact of these factors in a natural setting at small sections (ca. 3 x 3 to 8 x 8 m) of calcareous rockwalls in the Gesäuse area (Austria) by means of 24-hour IR monitoring using a high-resolution InfraTec IR camera. The rockwalls were first scanned by TLS and targets were used to obtain the exact micro-topography of each pixel of the IR images, thus allowing a GIS-based analysis of the influence of orientation on temperatures. Miniature sensors (iButtons) were placed in shallow boreholes and covered by a thin mortar layer in the colour of the limestone to verify the IR readings. Additionally, after a dry 24-hr cycle water was sprayed on the rockwalls and in the ray path of the camera.
First results show that under natural conditions, sensible heat and radiation temperature are in good agreement. The emissivity of the investigated limestone is close to 0.9 which is in accordance to textbook values. Angles between camera and surface normal of up to 60° did not significantly affect the results and the disturbance from wetting the surface was less than 0.5 K. This means that even irregular rockwalls can be monitored by IR thermography if extreme micro-topography is avoided and critical areas are masked. First attempts at larger rock faces (some tens of m) show surprisingly diverse micro-climatic patterns which may cause very different frost weathering climates at the same rockwall.