Global Change Biology

Global Change Biology (2010) **16**, 2602–2613, doi: 10.1111/j.1365-2486.2009.02122.x

Infra-red thermometry of alpine landscapes challenges climatic warming projections

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Abstract

Rough mountain terrain offers climatic conditions (niches) to plants and animals poorly represented by conventional climate station data. However, the extent to which actual temperatures deviate from those of the freely circulating atmosphere had never been assessed at a landscape level. Here, we quantify thermal life conditions across topographically rich mountain terrain by using a combination of thermal (IR) imagery of surface temperature with data from a large number of miniature data loggers buried at 3 cm soil depth. The data obtained from six alpine (Alps) and arctic-alpine slopes (Norway, Sweden, Svalbard) evidence persistent root zone temperatures of 2–4 K above air temperature during summer. Surface temperatures show strong positive (2–9 K) and negative (3–8 K) deviations from air temperature on bright days and clear nights, respectively. As to be expected, south oriented slopes are warmer than west and north slopes but microclimatic variation on clear sky days was strong within all slopes, with 8.4 ± 2.5 K (mean ± SD) surface temperature differences persisting over several hours per day along horizontal (i.e., equal elevation) transects. Life conditions of alpine organisms are thus strongly decoupled from conditions in the free atmosphere and cannot reliably be inferred from climate station data in both, temperate and arctic latitudes. Microtopography can mimic temperature differences of large elevational (or latitudinal) gradients over very short horizontal distances. This is important in the context of climate change because it shows that species do not necessarily need to climb several hundred meters in elevation to escape the warmth. Quite often, few meters of horizontal shift will do. For plants unable to, or too slow to adapt to a warmer climate, thermal microhabitat mosaics offer both refuge habitats as well as stepping stones as atmospheric temperatures rise.

Keywords: Alps, Arctic, leaf temperature, microclimate, soil temperature, thermal niche, topography

Received 4 August 2009 and accepted 24 September 2009