How accurately can minimum temperatures at the cold limits of treespecies be extrapolated from weather station data?

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Author(s) Kollas, Chris; Randin, Christophe F.; Vitasse, Yann; Koerner, Christian
Author(s) at UniBasel Körner, Christian ; Randin, Christophe ; Vitasse, Yann ; Kollas, Chris ;
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Most plant physiological processes act on micro-geographic scales within meters or less and on temporal scales of minutes or less. Yet, most studies relating species distribution to climate used typical resolutions of kilometers and months at best. Commonly available climate records from weather stations or freely available coarse-resolution geographic climatic layers thus, do not reflect local climatic conditions. In this study we selected sites where eight temperate deciduous tree species are growing at their cold upper elevational and latitudinal limits in the Swiss Alps (from 1165 m a.s.l. to 1804 m a.s.l.) and in Sweden (from 58 degrees 18'N to 59 degrees 27' N). At each site, temperature was recorded for 1-2 years in different conditions: at understorey height (50 cm), 2-m above ground, in the top of tree canopies and at 10 cm depth in the soil. We compared these biologically meaningful temperatures with the closest weather station data after correction for elevation. The data evidence that in mountain terrain, scaling from weather station data to on-site forest conditions requires month-specific lapse rates of temperatures, separated for means and extremes (e.g. minima). Besides best elevation-correction procedures, monthly absolute minimum temperatures predicted from near weather stations remained 1.4 +/- 0.2 K (mean +/- se, 12 sites) cooler than in situ conditions during growing season (2.0 +/- 0.2 K cooler during the non-growing season). At the time when 2-m air temperature reached its absolute monthly minimum, the top of the tree canopy was found 0.4 +/- 0.1 K cooler (mean +/- se, 12 sites) during growing season and 0.9 +/- 0.1 K during the non-growing season. These systematic deviations of low temperature extremes from those predicted from weather stations close the gap between geographical range limits of species, their physiological limits (e.g. freezing resistance) and meteorological information. The "thermal niche" concept of species range limits needs to account for such deviations of life conditions from meteorological data, should the niche boundaries have a functional meaning rooted in plant biology.

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