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Research Article

A toolbox for studying thermal heterogeneity across spatial scales: from unmanned aerial vehicle imagery to landscape metrics

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Summary

1. A major barrier for the scientific community of climate change biologists is the spatial mismatch between the size of organisms and the resolution at which global climate data are collected and modelled. Thus, the development of integrative and quantitative tools for the monitoring and spatial characterization of microclimates across spatial scales is a key issue for climate change ecologists.

2. We proposed an integrative toolbox for quantifying the spatial heterogeneity in surface temperatures by bringing together procedures of unmanned aerial vehicles, thermal imagery, orthomosaic, GIS classification and spatial metrics. This toolbox permits to yield high-resolution visual and infrared orthoimages that are processed into a GIS for selecting surfaces of interest in the landscape (e.g. soil, vegetation). Then, the thermal matrices of selected surfaces (i.e. temperature values of the pixels belonging to the selected surfaces only) are processed within R to generate a variety of thermal landscape metrics (e.g. thermal patch richness and density, thermal aggregation and cohesion index).

3. We applied this toolbox to the thermal characterization of mountainous agricultural landscapes in Ecuador with implications for ectothermic pest dynamics. UAV flights at a height of 60 m above-ground level allowed us to acquired high-resolution visual and thermal images (1 and 5 cm/pixel, respectively) for 12 potato fields with a mean surface of 1017 ± 117 m^2. Landscape metrics on plant and soil surfaces showed that crop phenology drives the spatial patterns of surface temperatures and strongly modifies the overall thermal ecology of crop fields, with potential implications for ectothermic pest occurrence and

dynamics.

4. Overall, our toolbox affords a timely and innovative methodological framework to better assess the thermal heterogeneity of natural landscapes across a wide range of spatial scales. In particular, this toolbox would be of topical interest for ecologists trying to bridge the gap between the resolution of their climatic data and the body size of their study organisms.

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