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Determining key drivers of the annual carbon budget of biocrusts in different climatic zones

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Biocrusts are distributed over all climate zones of the world and they substantially contribute to ecosystem functioning. Their growth, determined by their carbon balance, can be affected by various climatic drivers. The effects of individual drivers are clear from laboratory experiments, but the relative importance of different drivers along climatic gradients and their underlying mechanisms are largely unknown. Moreover, the effects of seasonal acclimation on the annual carbon balance are not fully understood either. Therefore, we aim at determining the level and variation of annual biocrust carbon balances and their connection to climatic drivers along environmental gradients. In addition, we explore the role that acclimation plays in the carbon balance of biocrusts.

Here, we applied a data-driven model at six study sites along climate gradients and performed several sensitivity analyses to investigate the most relevant factors for the annual carbon balance, including impacts of acclimation of traits. The model was developed using a physiology-based photosynthesis model, and the necessary parameters were obtained from field and laboratory measurements.

We found a consistent set of control factors under different climate conditions, namely radiation, relative humidity, surface temperature, and ambient CO_2 concentration, which were of roughly equal relevance. However, the effect of relative humidity on the carbon balance depended on the habitat's microclimate, and a reduction in non-rainfall water sources resulted in more carbon loss in drylands but fostered carbon gain in humid environments. In addition to climate factors, the seasonal acclimation of traits played an essential role in the annual carbon balance at humid sites. Thereby, not accounting for acclimation processes in models of biocrusts may be a potential explanation for estimated negative carbon balances in humid regions.

Our results suggest that global change, which may lead to warmer and drier air in some regions, will likely affect biocrust long-term carbon balances. Moreover, for experimental investigations,

the season and timing of collecting and monitoring the species should be given additional consideration, especially when the traits are used as the basis for quantitative estimates and forecasts.