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Biogeographical Patterns of Light Use efficiency?

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The emergent spatial organization of ecosystems in elevational gradients suggest that some ecosystem processes, important enough to shape morphological traits, must show similar patterns.

The most important of these processes, gross primary production (GPP), usually (albeit with some exceptions) decreases with elevation. This was previously thought to be a direct consequence either of the decrease in temperature, or the decrease of incident light due to cloud cover. However, some recent developments in photosynthetic theory, plus the unprecedented availability of ecophysiological data, support the hypothesis that plants acclimate (optimize) their photosynthetic traits to the environment. In this new theoretical context, the temperature is no longer considered as a major constraining factor, except when either freezing or excessively high temperatures inhibit plant function generally.

Two of the most important photosynthetic traits, the maximum rate of carboxylation (V_{CMAX}) and the intrinsic quantum efficiency (φ_o), vary in opposite directions with increasing elevation. Plants tend to increase V_{CMAX} to compensate for a decrease in the ratio leaf-internal to ambient partial pressures of CO_2, while φ_o increases with temperature up to a plateau. To explore how these different responses, documented at leaf level, converge in emergent spatial patterns at ecosystem scale we considered how elevation shape light use efficiency (defined as the ratio of CO_2 assimilated over light absorbed) over mountain regions worldwide. We used data from eddy-covariance flux towers, from different networks, located in mountain regions around the world, adding up to 618 station-years of record. To complement our analysis, we included theoretical predictions using an optimality model (P-model) and evaluated changes in the spatial pattern with simulation experiments.

Empirically we found an asymptotic response of LUE to the average daytime temperature during the growing season with increasing elevation, and a small, but globally consistent effect of elevation on LUE. We propose a theoretical explanation for the observation that temperature differences have little impact on the biogeographical pattern of LUE, but we also find that different assumptions on the acclimation of the maximum rate of electron transport (J_{MAX}) and φ_o change this pattern.