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Effects of diffuse and direct light on the carbon and water ecosystem cycles

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The importance of diffuse radiation for terrestrial net carbon exchanges is widely recognized. However, effects on terrestrial water cycling are still largely unknown. In this study, we investigate the influence that light quality has on ecosystem-atmosphere carbon and water exchanges using an inductive approach. This purely empirical approach is based on artificial neural networks and has been developed to explore large, fragmented, noisy, and multidimensional datasets. The functional relationships between meteorology and ecosystem fluxes are identified directly from the observations. To check the generality of the obtained relationships, the approach is applied here to a wide variety of ecosystems covered by the FLUXNET data set.

We find that a higher fraction of diffuse light typically enhances light use efficiency of photosynthesis, which shows less tendency to saturate in more diffuse light. However, whether this leads to enhanced net ecosystem carbon exchange also depends on the prevailing light levels. While under cloudy conditions, high diffuse light fractions occur only at low light levels, increased concentrations of atmospheric aerosols and scattering may lead to a high diffuse fraction at higher light levels. Hence, it makes a difference whether diffuse light increases through increased cloudiness or aerosols. Furthermore, we find that via the increase in light use efficiency, the water use efficiency may also be affected by diffuse radiation. We discuss potential mechanisms of this findings and their implications for ecosystem carbon and water fluxes.