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Accounting for the impact of elevated CO_2 on vegetation water use and ecohydrological processes

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Many studies have projected that the land surface will in general become more arid as elevated CO_2 increases. These studies have generally taken the meteorological output from fully coupled climate models and used that to calculate potential evaporation. In general, potential evaporation increases with warming because of increasing vapour pressure deficit and when this trend is put into a drought impact model, the model predicts increasing aridity into the future. This is the basis for the commonly held view that aridity and drought both increase in a high CO_2 world. In contrast, the original (fully-coupled) climate model output projects a global average trend for increased vegetation productivity and slightly more water in rivers, i.e. a less arid future. This difference is known as the aridity paradox.

Here we show that the aridity paradox is resolved when meteorological and biological factors are used jointly to calculate potential evaporation. The biological factor of interest here is the effect of elevated CO_2 on vegetation water use efficiency and we present a new formulation that can account for this important effect. With this new formulation we find that potential evaporation does not increase over vegetated surfaces in a warmer high CO_2 world because the effect of increasing vapour pressure deficit is more or less countered by the increase in atmospheric CO_2. The result is that the projections from off-line drought impact models are now in agreement with those from the fully coupled climate models. This has resolved the aridity paradox.