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Does plasticity in plant physiological traits explain the rapid increase in water use efficiency? An ecohydrological modeling approach

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The rise of atmospheric CO_2 concentration is expected to stimulate plant productivity by enhancing photosynthesis and reducing stomatal conductance and thus increasing plant water use efficiency (WUE) worldwide. An analysis of eddy covariance flux tower data from 21 forested ecosystems across the north hemisphere detected an unexpectedly large increase in WUE (Keenan et al, 2013), which was six times larger than the increase found by most previous studies based on controlled experiments (e.g., FACE), leaf-scale analyses, and numerical modelling. This increase could be solely attributed to the increase in atmospheric CO_2 since other confounding factors were ruled out. Here, we investigate the potential contribution of plant plasticity, reflected in the temporal adjustment of major plant physiological traits, on changes in WUE using the ecohydrological model Tethys and Chloris (T&C). We hypothesize that the increase in WUE can be attributed to small variations in plant physiological traits, undetectable through observations, eventually triggered by the atmospheric CO_2 increase. Data from the 21 sites in the above mentioned study are used to force the model. Simulation results with and without plasticity in the physiological traits (i.e., model parameters in our numerical experiments) are compared with the observed trends in WUE. We test several plant adaptation strategies in being effective in explaining the observed increase in WUE using a multifactorial numerical experiment in which we perturb in a systematic way selected plant parameters.

Keenan, T. F., Hollinger, D. Y., Bohrer, G., Dragoni, D., Munger, J. W., Schmid, H. P., and Richardson, A. D. (2013). Increase in forest water-use efficiency as atmospheric carbon dioxide concentrations rise. *Nature*, 499(7458), 324–7.