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Causes of Water-Use Efficiency Variability in Europe and Their Representation in the Community Land Model v5

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The water-use efficiency (WUE, carbon assimilation per unit of water-use) describes a major axis of variability of ecosystems and identifies how these are coping with environmental changes. However, the response of WUE to climate change and hydrological extremes between different ecosystems remains poorly understood.

Here we investigated how the WUE of ecosystems in Europe varied from 1995 - 2018, as long-term trends and in response to precipitation (P) and soil moisture (SM) droughts. We aggregated data from remote-sensing and reanalysis to calculate three different WUE indices, conducted Mann-Kendall trend analyses and determined WUE anomalies for different hydro-climates and plant functional types during P and SM deficits. Finally, we applied the Peter & Clark Momentary Conditional Independence (PCMCI) algorithm to identify causative networks of environmental variables and WUE and differences among ecosystems.

We found extensive, negative long-term WUE trends in Eastern Europe, where WUE is predominantly controlled by carbon assimilation (GPP). Further, we identified soil moisture and transpiration control of GPP as drivers for the positive WUE response to droughts in arid ecosystems. In contrast, negative trends in humid ecosystems were driven mostly by temperature, which governed GPP variability.

In addition, outputs from a state-of-the-art land-surface and carbon model (CLM5-BGC) will be used to compare trends, drought response and the causative relationships with the ones from satellite and reanalysis data in order to evaluate the model representation of ecosystem variability.