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Atmospheric constraints on Plant Water Use Efficiency drivers and patterns of changes since 1900

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Water Use Efficiency (WUE) controls the relationship between the ecosystem water and carbon balance. Because WUE responds to environmental changes it can be used as a metric to quantify the effect of climate change on ecosystems. The actual WUE_{eco} is defined as a ratio of gross primary production and transpiration fluxes. On the leaf scale this is equal to the atmospheric WUE_{atm}, which is a function of the ambient and internal CO_2 concentration, the saturated specific humidity and relative humidity. Using observations and the JULES and HadCM3 models we explore on which temporal and spatial scales WUE_{eco} and WUE_{atm} are equal, and how they respond to climate change.

Leaf level definitions are valid at site level, where annual WUE_{eco} and WUE_{atm} simulated with JULES are equal and linearly increasing with atmospheric CO_2 concentration for a range of sites. For drier sites lower values of both were simulated. The simulated values are within the same range as values derived from eddy covariance observations.

Having shown the near equivalence between WUE_{eco} and WUE_{atm} for specific sites, we can use the formula for WUE_{atm} to estimate the change in plant WUE over the 20th century, using observed climatological data and CO_2 concentrations. In general WUE is found to increase strongly with the CO_2 concentration, but this is offset by warming and drying that increases evaporative demand and therefore reduces WUE.

As a result we find complex spatio-temporal patterns of changes in WUE, resulting from the differing drivers of climate change and variation. For example, warming due to the reduction in atmospheric aerosol pollution since the late 1980s reduced WUE in some previously heavily-polluted regions despite the ongoing increase in atmospheric CO_2. We will describe the methods used to reconstruct WUE from observations, and discuss the spatial and temporal variation of WUE since 1900.