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Causes of variations in observed and modelled historical trends in water use efficiency of plants and ecosystems

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Water-use efficiency (WUE, the carbon gained through photosynthesis per unit of water lost through transpiration) is an indicator of relative rate of exchange of CO_2 and water between the vegetation and the atmosphere. Changes in atmospheric CO_2 concentrations and climate variations both affect the stomatal regulation of leaf gas exchange, thereby modulating WUE. However, the magnitude of recent changes in WUE remains highly uncertain, owing to the large variability in WUE trends between scales of investigation (leaf versus ecosystem). Predictions from vegetation and land surface models (LSMs) also continue to differ greatly in their representations of land carbon uptake and water loss, resulting in major unresolved discrepancies in predictions of past and future CO_2 uptake, vegetation cover and WUE. In this presentation, we will compare different methods applied for quantifying interannual changes in WUE from the leaf to the ecosystem scale, and present a synthesis and interpretation of the discrepancies observed within and across scales. The types of data that will be considered are stable carbon isotopes in tree-rings and eddy covariance flux measurements. We will then test the performance of a simple vegetation model based on optimality theory to simulate long-term changes in WUE. Finally, we will provide recommendations for improving observation-based estimates of WUE with the aim of better informing the representation of WUE in LSMs.