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Possible long-term effects of increased CO_2 on vegetation and the Hydrological Cycle

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The continuous increase in atmospheric CO_2 concentrations has the potential to significantly influence hydrological cycles. Besides having an effect on global temperatures and climate, increased CO_2 is now thought to lead to a global decrease in transpiration by reducing stomatal aperture in plants. The effect of CO_2-induced stomatal closure is progressively being incorporated in global climate predictions and has even been attributed to be responsible for the observed increase in global continental runoff during the past century. However, stomatal closure might not be the only means by which vegetation responds to an increase in atmospheric CO_2 concentrations. If, for example, stomatal closure is offset by an increase in vegetation cover in the long term, the effect of increased CO_2 on global transpiration could, in fact, be reversed.

In the present study we use a coupled water balance and vegetation model to investigate the possible long-term response of vegetation to increased levels of atmospheric CO_2. In contrast to conventional models, the model used here not only allows for the adaptation of stomatal conductance, but also for adjustments in biochemical foliage properties, vegetation cover and rooting depth. Short-term responses to increased CO_2 are separated from long-term responses by distinguishing which vegetation properties can adapt in the long term from those capable of adaptation in the short term. The model is applied to a number of catchments in different climates and reveals that, in certain climates, the long-term effect of elevated CO_2 on transpiration can be opposite to the short-term effect. The ramifications for global climate predictions and the dangers in the extrapolation of short-term observations to long-term environmental change are discussed.