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Global changes in climate, CO2 and soil moisture, and their effects on NPP: a fragile balance

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Climate change affects the global water system in many aspects including ecosystem water availability. We explored the impact of atmospheric CO2 enrichment and climate change on soil moisture and related water limitation of global terrestrial net primary production (NPP). The latter is quantified as the ratio of actual over potential canopy conductance of carbon and water. The study was performed using a well-established dynamic global vegetation and water balance model (LPJ) forced by climate change scenarios from five General Circulation Models. The simulations consistently indicate increasing soil wetness in high northern latitudes by the end of the century (2071-2100) compared to recent conditions (1971-2000), due primarily to increased precipitation and CO2 concentration. By contrast, soil moisture tends to decrease in many other regions. However, the detailed regional pattern of change differs substantially among the scenarios, depending on the geographical distribution and magnitude of GCM-specific precipitation changes. Water limitation of NPP changes little or even decreases by the end of this century in many regions, that is, NPP will be less water-limited despite concurrent declines in soil moisture. This hydrologic resilience of the biosphere toward climate change is due to 1) the physiological vegetation response to elevated atmospheric CO2 concentration (which implies a reduction in potential canopy conductance and transpirational water loss irrespective of soil moisture), and 2) continuous acclimation and adaptation of vegetation to the changing environmental conditions. The impact of climate change on NPP water limitation would be much more severe in the absence of the beneficial CO2 effect, with its sign of change being reversed from predominantly positive to predominantly negative. We suggest that analysis of precipitation or soil moisture changes alone is not sufficient when effects of climate change on natural and also agricultural ecosystems are to be evaluated.