Climate-effective terrestrial carbon dioxide removal could induce biogeochemical state shifts

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One of the discussed climate engineering methods is the extraction of carbon dioxide (CO_2) from the atmosphere, by increasing the terrestrial carbon sink (tCDR). Large-scale biomass plantations could theoretically act as a measure to reduce atmospheric CO_2 concentrations (sequestration plus substitution effect) in case mitigation efforts fail to substantially reduce greenhouse gas emissions within this century.
To provide a quantitative assessment of the biospheric impacts of such biomass plantations (if cultivated over an area as large as current cropland), we assess its consequences for major biogeochemical and hydrological state variables of the Earth system (net primary production, soil respiration , harvest flux, soil and vegetation carbon stocks, evapotranspiration, runoff). The changes are compared against both the current state under agricultural land-use and a state of potential natural vegetation. Respective simulations for these three ‚worlds' were conducted with LPJmL, an intermediately complex dynamic global vegetation model. The confidence in the model results is underpinned by an evaluation of the modeled biomass harvest against available observations from literature.
Simulation results indicate a remarkable increase in net primary production in the bioenergy world compared to potential natural vegetation; nevertheless, owing to the regular harvests on such plantations, vegetation carbon stocks are significantly lower. The water cycle is impacted by decreasing river discharge and increasing transpiration. We also developed a metric (covering the joint effect of the different process changes) to assess the degree and likelihood of state shifts in Earth system functioning. We find that commitment to tCDR via biomass plantations potentially alters major determinants of ecosystem functioning even more than current agricultural practices do. Hence, the biogeochemical state of the global biosphere could be shifted considerably in a world with tCDR.