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Adapting afforestation patterns considering their local biogeophysical induced cooling and warming

Michael Windisch, Florian Humpenöder, and Alexander Popp
Potsdam Institute for Climate Impact Research, Transformation Pathways, Germany (michael.g.windisch@gmail.com)

Afforestation is expected to take on a key role in the fight against climate change. A quarter of the emission reductions pledged by countries under the Paris Agreement are to be provided by newly established forests. Low emission scenarios equally rely heavily on land-based mitigation options to remove hundreds of gigatons of carbon dioxide from the atmosphere within this century. This proposed extensive change of the terrestrial land-cover will exert a biogeophysical (BGP) impact on climate by altering the surface albedo as well as the evapotranspiration capacity. These BGP processes are mostly absent in the land-use components of Integrated Assessment Models which currently only focus on carbon sequestration. Hence, their afforestation prospect does not take into account the local BGP induced cooling or warming that either enhances or counteracts the mitigation effort. Neglecting BGP processes can lead to under- or overestimating the benefits of afforestation depending on the location of the forest. In the worst case it even risks proposing afforestation in regions where new forests would warm the climate. We incorporate observation-based estimates of the BGP effect of afforestation into the land-use model MAgPIE (Model of Agricultural Production and its Impact on the Environment). MAgPIE is a land-use optimization model driven by the cost of agricultural production. It produces cost optimal land-use patterns for a set of climatic (Representative Concentration Pathways) and societal (Shared Socioeconomic Pathways) developments and has already been used to investigate afforestation and forest protection as mitigation options. We translate the BGP induced local cooling or warming to a carbon equivalent metric by using the local climate sensitivity and add it to the mitigation benefit of carbon sequestration. The mitigation incentive for afforestation will be enhanced or reduced by considering the local cooling or warming. Hence, the model will be able to endogenously judge afforestation decisions regarding both their carbon sequestration potential and BGP impact. We will report the changes in afforestation patterns imposed by considering their combined BGP and biogeochemical effects.