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Assessing 20th century climate-vegetation feedbacks of land-use change and natural vegetation dynamics in a fully coupled vegetation-climate model

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Climate and vegetation strongly interact: the climate exerts the dominant control on the spatial distribution of the major vegetation types at the global scale, while vegetation cover affects climate via its physical characteristics (biogeophysical mechanisms) and via the gas-exchange with the atmosphere (biogeochemical effects).
Land-use and land-cover change (LULCC) have been the most important drivers of changes in vegetation patterns and, thus, in land surface properties and yield high potential to do so in the future.
It has been shown past and future LULCC have limited impact on average temperature and hydrology at the global level. However, at a more local level, changes in vegetation composition can have significant effects, due to the many positive and negative feedbacks.
We have investigated the full interaction between climate and dynamic vegetation given a prescribed LUC-pattern by coupling the GCM SPEEDY (Simplified Parameterizations primitivE Equation DYnamics model) with the dynamic global vegetation model LPJmL, at a 40 minutes time-step basis.
We show historic LULCC have a strong impact on regional climate, especially in middle to high latitudes. Land-use change has a stronger effect on climate than the natural's vegetation response to climate change, where changes in albedo act as the main driver. In the high latitudes, the boreal greening trend counteracts the land-use change (LUC) signal, which is stronger in the mid latitudes. Although smaller, both historic LUC and shifting natural vegetation patterns have a significant impact on global average climatology.

Implementing dynamic vegetation into climate models adds an additional source of inaccuracy to climate projections, but is essential for climate simulations because the dynamic response of vegetation considerably alters the land-use and greenhouse-gas signal in our simulations, especially on regional scales.