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Integrated modelling of anthropogenic land-use and land-cover change on the global scale

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In many cases land-use activities go hand in hand with substantial modifications of the physical and biological cover of the Earth's surface, resulting in direct effects on energy and matter fluxes between terrestrial ecosystems and the atmosphere. For instance, the conversion of forest to cropland is changing climate relevant surface parameters (e.g. albedo) as well as evapotranspiration processes and carbon flows. In turn, human land-use decisions are also influenced by environmental processes. Changing temperature and precipitation patterns for example are important determinants for location and intensity of agriculture. Due to these close linkages, processes of land-use and related land-cover change should be considered as important components in the construction of Earth System models.

A major challenge in modelling land-use change on the global scale is the integration of socio-economic aspects and human decision making with environmental processes. One of the few global approaches that integrates functional components to represent both anthropogenic and environmental aspects of land-use change, is the LandSHIFT model. It simulates the spatial and temporal dynamics of the human land-use activities settlement, cultivation of food crops and grazing management, which compete for the available land resources. The rational of the model is to regionalize the demands for area intensive commodities (e.g. crop production) and services (e.g. space for housing) from the country-level to a global grid with the spatial resolution of 5 arc-minutes. The modelled land-use decisions within the agricultural sector are influenced by changing climate and the resulting effects on biomass productivity. Currently, this causal chain is modelled by integrating results from the process-based vegetation model LPJmL model for changing crop yields and net primary productivity of grazing land. Model output of LandSHIFT is a time series of grid maps with land-use/land-cover information that can serve as basis for further impact analysis.

An exemplary simulation study with LandSHIFT is presented, based on scenario assumptions from the UNEP Global Environmental Outlook 4. Time horizon of the analysis is the year 2050. Changes of future food production on country level are computed by the agro-economy model IMPACT as a function of demography, economic development and global trade pattern. Together with scenario assumptions on climatic change and population growth, this data serves as model input to compute the changing land-use und land-cover. The continental and global scale model results are then analysed with respect to changes in the spatial pattern of natural vegetation as well as the resulting effects on evapotranspiration processes and land surface parameters. Furthermore, possible linkages of LandSHIFT to the different components of Earth System models (e.g. climate and natural vegetation) are discussed.