Forest Management in the Earth System

The scientists working in the Emmy Noether Group „Forest Management in the Earth System“ at the Max Planck Institute for Meteorology (MPI-M), led by Dr. Julia Pongratz, aim at a better understanding and a better quantification of the overall impact of land use change on climate. A key focus lies on forest management.

The vegetation covering the continents has decisive influence on climate, exchanging heat, moisture, momentum, and a variety of chemical materials with the atmosphere. Humans are substantially interfering with this exchange by altering the vegetation cover: about one third of the natural vegetation on Earth's ice-free land surface has been transformed to agricultural areas ("anthropogenic land cover change"). On an even larger area the original vegetation type is kept, but is now managed to some extent by humans ("land management", for example forest management). Only the rest, a mere quarter of the land surface, remains untouched by direct human influence, although via global climate change also these regions are indirectly altered by human activity (fig. 1).

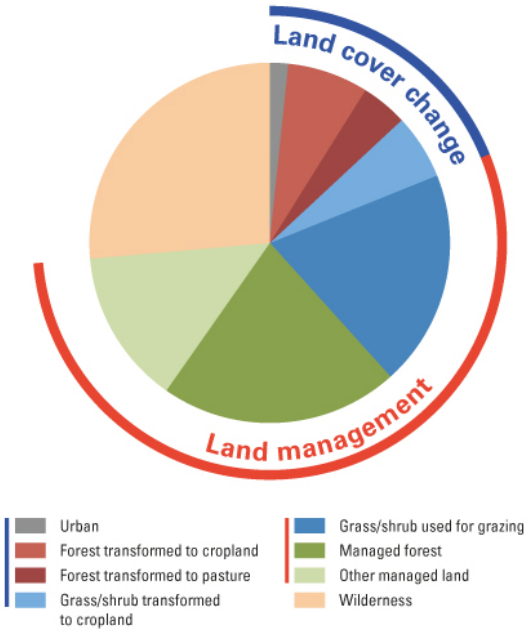

Fig. 1: Three quarters of the ice-free land surface is managed by humans. Land management takes place on an area twice as large as that affected by anthropogenic land cover change, still the latter process is much better studied.

A multitude of observational and modeling studies have revealed substantial influences of land cover change and land management on climate. For example, about one third of the cumulative anthropogenic CO_2 emissions until today have been caused by historical deforestation for agricultural expansion. However, large uncertainties remain with respect to the overall impact on climate: The carbon cycle effects of land cover change and land management are highly uncertain on a large scale. Furthermore, biogeophysical effects such as changes in land surface reflectivity (albedo) and turbulent heat fluxes also contribute to the overall impact on climate.

The group takes various approaches to improve our understanding of how land use and climate interact. The main tool in doing so is the Max Planck Institute´s Earth system model MPI-ESM. One goal is to reduce uncertainties in the modeling of carbon fluxes. Last year, the scientists led by Julia Pongratz showed that the large spread in estimates of land use emissions in the literature is primarily due to different definitions of carbon fluxes in different types of models (see news item). Within a given model, it is especially the fluxes from soils that are difficult to reproduce realistically. The majority of terrestrial carbon is stored in soils and can be affected by land use. By comparing model simulations with a multitude of local observational studies Sylvia Nyawira examines how well a typical global vegetation model can represent such soil carbon fluxes caused by changes in land use.

The ability to absorb carbon from the atmosphere, and thus counteract global warming, is the reason why land use became a much-discussed tool to mitigate climate change. However, focusing exclusively on carbon uptake would not do justice to the complexity of this matter because biogeophysical effects of land use can substantially influence climate, in particular on the local scale. Dark forests, for example, are often several degrees warmer than agricultural areas, which reflect more solar radiation, but forests can also have a cooling effect because their large leaf area evaporates a lot of water. These effects are included in vegetation models, but could not be assigned to specific regions in previous modeling studies. Johannes Winckler develops new methods to solve this problem. Dorothea Mayer´s work also aims at a better understanding of the mitigation potential of land use changes. Her work focuses on the much-discussed biomass plantations.

While the effects of anthropogenic land cover change have been well investigated, there are far fewer studies on the effects of land management. Also the Max Planck Institute´s Earth system model considers primarily only changes in land cover. One aim of Julia Pongratz´s group is to integrate land management in the MPI-ESM. The impact on climate through land management is of the same order of magnitude as that through land cover changes, as an empirical study in *Nature Climate Change* shows (see references), i.e. the effects are not negligible in the models. Analyses of ground measurements and satellite observations have shown that temperature changes due to land cover changes and land management are of similar magnitude at several degrees Celsius. Since land management covers about half of the land surface, it is crucial to include the influence of land management in Earth system models when estimating the complete anthropogenic impact on climate.

Therefore, scientists of the Emmy Noether group, especially Dr. Julia Nabel and Dr. Kim Naudts, are working on integrating forestry – an important part of land management - in the land surface model of the MPI-ESM. Globally, about 60 % of the forests are managed (fig. 2). The scientists improve the representation of forest growth in the model and implement different forest management strategies. This model development is particularly relevant to assess the anthropogenic influence on the Earth system for the future, when the growth of global population and demand for bioenergy is projected to increase the need for land-based resources.

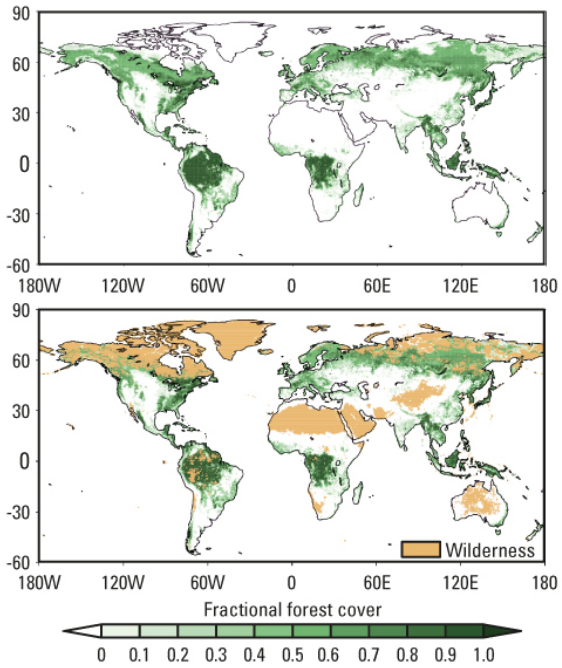

Fig. 2: The upper panel shows the current forest extent, the lower panel depicts the forest extent overlaid with wild areas. About 60 % of the global forests are managed; large areas of pristine forests remain only in less accessible regions. (Forest data stems from Pongratz et al., 2008, wilderness data from Haberl et al., 2007).

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References:

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Further information:

http://www.mpimet.mpg.de/en/science/the-land-in-the-earth-system/working-groups/forest-management-in-the-earth-system.html

http://www.mpimet.mpg.de/nc/en/kommunikation/aktuelles/single-news/article/apples-and-oranges-confusion-about-definition-explains-factor-2-difference-of-land-use-emission-es.html

The Emmy Noether Programme by the German Research Foundation (DFG):

http://www.dfg.de/en/research_funding/programmes/individual/emmy_noether/index.html

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