Geophysical Research Abstracts
Vol. 15, EGU2013-8426, 2013
EGU General Assembly 2013

Terminology as a key uncertainty in net land use flux estimates

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The net flux of carbon from land use and land cover change has contributed about one third to anthropogenic CO_2 emissions over the entire industrial era and about 10% in recent years. The net land use flux includes not only emissions of CO_2 to the atmosphere when natural vegetation is cleared for human activity, e.g., when a forest is burnt for agricultural land or harvested for wood products; it also comprises substantial carbon sinks, e.g., from regrowth of forest recovering from past anthropogenic disturbance. Published estimates for the land use flux are highly uncertain ranging from a net source of 0.6 to 1.6 PgC/year for recent decades. Accurately quantifying the net land use flux is crucial for our understanding of the global carbon budget. The observed exchange flux between atmosphere and land indicates the land as whole is a net sink for CO_2. The difference between this observed net land sink and the net source due to land use change indicates a residual land sink (partly due to fertilizing effects of rising CO_2) and the former terms are used to define the size of the latter. Good understanding and quantification of all flux terms today and in the future are necessary to estimate the required strength of mitigation efforts.

A recent study comparing thirteen estimates of the net land use flux (Houghton et al, Biogeosciences, 2012) has identified key reasons for differences: uncertainties in the rates of deforestation, different assumptions on carbon densities of the vegetation cleared, the type of model used, and the inclusiveness of management activities and flux components accounted for. Here we show that an important reason for the differences in estimates is the way authors define the net land use flux. We analyze the definitions used in recent publications and show that estimates may differ by up to a factor of 2 due to disagreement on which components the net land use flux should include. Key issues are in the accounting of legacy fluxes, e.g., delayed emissions from soil or slow regrowth, and in the accounting of feedbacks. For example, some estimates include in the net land use flux the substantial terrestrial sink that is induced by the increase of the atmospheric CO_2 concentration caused by land use emissions.

Based on our analysis of published estimates and additional simulations using the Earth system model MPI-ESM, we illustrate the importance of an explicit definition of the various component fluxes that form part of the net land use flux. This allows us to separate the direct anthropogenic effects from biospheric feedbacks, which is needed to understand the effects of land use and land cover change on the global carbon budget and thus on the evolution of the Earth system. As a wealth of new estimates of the net land use flux are being compiled in the framework of the IPCC's 5th Assessment Report, it is particularly important at this point in time to eliminate confusion in terminology so that we can identify and address the real uncertainties in carbon flux estimates.