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Relevance of Preindustrial Land Cover Change for Attribution of Excess Atmospheric Carbon Dioxide

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There has been considerable discussion about how to partition the historical contribution of each country to today's observed atmospheric CO2 increase and temperature change. These discussions have had particular relevance to the distribution of obligations under UNFCCC negotiations aimed at avoiding dangerous climate change. Much attention has been paid to emissions from fossil-fuel burning, but less to emissions from anthropogenic land cover change (ALCC). In particular, the role of emissions from preindustrial ALCC (about 50 to 120 Gt C) in the attribution of current increases in atmospheric CO2 content and temperature has not been assessed. Here, we use simulation results from the comprehensive climate-carbon cycle model ECHAM5-JSBACH/MPIOM-HAMOCC5 and a response function approach to give improved estimates of countries' contributions to atmospheric CO2 increase, based on a spatially explicit reconstruction of ALCC that reaches back until AD 800.

We find that considering emissions from ALCC in addition to fossil-fuel burning substantially shifts the attribution of the present-day CO2 increase towards tropical regions, consistent with previous studies. So far unrecognized, however, has been the role of the large-scale preindustrial deforestation in India and China. Together, these countries contributed more than 20% to the global atmospheric CO2 increase well into the 20th century. As a consequence, the relative contribution to the CO2 increase of Europe, the Former Soviet Union, and North America combined is about 100% in 1850 and 70% today when only fossil-fuel emissions are considered, but only about 30% in 1850 and 50% today when ALCC emissions are also considered.

We investigate specifically the role of emissions from ALCC in the preindustrial era for today's climate. We find that they account for 12% of today's cumulative global CO2 emissions, for 5% of today's global atmospheric CO2 increase, and for 7% of today's temperature increase. Considering emissions from preindustrial ALCC in addition to the emissions during the industrial era that have been considered in previous studies alters the relative contribution to global temperature increase of the world regions by up to 2%. Changes of few percent are important politically if the regional contributions are used as basis for sharing the burden of climate change mitigation. When emissions from preindustrial ALCC are considered, the relative contribution of India, China, and Southeast Asia is higher than estimated by previous approaches, and lower for the developed countries.

Much discussion has been devoted to the starting date of the accounting period. The Brazilian Proposal suggested that it should be 1840 to account for the history of emissions, in contrast to the year 1990 used in the Kyoto protocol. Here we show that emissions prior to 1840 would need to be included to give the scientifically most defensible attribution. A starting date in the preindustrial era is also advantageous because it accounts for legacy effects such as delayed emissions from soils and wood products. These effects lead to delayed emissions from preindustrial land use activity in the industrial era, in our study 10 of the 62 Gt C caused by preindustrial ALCC are released after 1850. Similarly, including the preindustrial history of ALCC is needed to correctly quantify carbon sinks in the terrestrial biosphere that are caused by regrowth of natural vegetation on abandoned agricultural land. Through this effect the Middle East counteracts the atmospheric CO2 increase since late medieval times. Similar carbon sinks have been created in Europe and the eastern USA, where croplands have been abandoned since the 1850s. High spatial resolution and a sufficiently long history of ALCC need to be applied to capture such sources and sinks and their consequences for the attribution of today's climate change to world regions.