Meta-analysis of biophysical impacts of land use – land cover change

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Key findings from *Meta-analysis of biophysical impacts of land use - land cover change*:

- LULCC may alter the energy budget modifying the local/regional seasonal/annual surface temperatures and precipitations (biophysical effects)
- Mitigation and adaptation strategies should take into account the overall effect of LULCC on climate, including the biophysical effects, focusing not only on greenhouse gas balances
- The meta analysis highlights the need to further explore the size dependency of the LULCC biophysical effect on climate

***L*and-*u*se *c*hange: assessing the net climate *for*cing, and options *for c*limate change mitigation and adaptation**

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What is the challenge?

Land Use and Land Cover Changes (LULCC) have a recognized effect on climate, both in terms of changes in the carbon cycle due to changes in vegetation and soil carbon (biogeochemical effects), and through variations in the surface energy budget mediated by reflected sunlight, evapotranspiration, canopy structure etc. (known collectively as biophysical effects). **Biophysical effects result in changes** in seasonal and/or annual surface temperatures with **prevalently local to regional effects,** which depend greatly - in sign and magnitude - on the latitude and ecosystems where they occur. Although biophysical impacts on climate can be relevant at the regional scale, the international UNFCCC process focuses only on the biogeochemical effects. Nonetheless, since the effects of climate mitigation are felt not only globally, but also locally, an emerging question is: *How to provide a simple climate metric that summarizes the changes in temperature and precipitation due to biophysical impacts following large scale LULCC?*

How did LUC4C address this challenge?

With the objective of providing a simple climate metric, data were summarized from model experiments of LULCC for the main ecological zones (tropical, temperate, boreal) into a **meta-analysis of the existing scientific literature**, to support the assessment of land-based mitigation/adaptation policies. Of **the ca. 80 papers analyzed, 16 papers fulfilled the identified eligibility criteria**. Data were analyzed by calculating the general statistics of change in the climate variable (temperature, precipitation) for each specific LULCC (i.e. assessing average changes, standard deviation and the range).

What are the main findings?

Results suggest that deforestation has a predominantly warming effect in the tropics ($\Delta T = +1.05 \pm 0.71$°C) due to reduced evapotranspiration, but a cooling effect in the boreal regions in winter due to increased reflection of sunlight ($\Delta T = -2.03 \pm 1.16$°C). Temperate ecosystems are influenced by both evapotranspiration and light-reflection; the warming/cooling effect of LULCC is highly uncertain and may be affected strongly by local climate (e.g. snow seasonality, dry season, etc). On average, deforestation in this area resulted in a slight cooling effect ($\Delta T = -0.53 \pm 0.42$ °C).

Regardless of the ecological zone, deforestation at regional level always leads to a reduction in annual precipitation, although the quantity of data are extremely scarce and affected by high uncertainties. The most dramatic effects are likely to occur in tropical zones, with a change of -485± 105 mm y^{-1}, followed by the temperate zone with -121 ± 81 mm y^{-1} and the boreal with -97.09 ±22.14 mm y^{-1}. These values

refer to model simulation studies where a complete removal of tree vegetation is assumed for the whole study area. This area can either be the whole ecological zone, or a wide sub-continental portion (e.g. the Amazon region or European continent).

What issues are still open?

The main limitation encountered in the meta-analysis is the difficulty in assessing the dependency of the effects on the size of the LULCC. Current studies on the biophysical impact of LULCC deals only with idealized global/regional-scale deforestation or reforestation experiments using global climate or earth system models and thus do not take account of the size dependency of biophysical effects. Still, the output of the meta-analysis can provide a useful indication of the direction and magnitude of the biophysical impact of LULCC on climate at regional and global scale levels. Further experiments within LUC4C and the international community (e.g., through the LUMIP model inter-comparison planned for the IPCC 6th Assessment Report) will shed further light on these issues.