Chapter 25: Attributing causes of regional climate change

Land cover change

This subchapter discusses land cover change as an external forcing of regional climate change. The influence of land-cover change on global and regional climate change is poorly known at this time. Natural, climate-induced land-cover change (e.g. replacement of tundra vegetation by forest, or the inverse) is part of the climate system and may produce either positive or negative feedbacks on climate, i.e. may either amplify or mitigate the initial change; anthropogenic land-cover change (e.g. deforestation or reforestation) may have similar effects and is, in that case, a climate forcing. A clear attribution of climate change to anthropogenic land-cover change is thus very difficult.

1. Interactions between vegetation and climate

-> Biogeophysical effects are related to the exchange of energy and moisture between the atmosphere and the land surface. There are two possible contrasting biogeophysical effects of a vegetation/land-cover change (climate or human-induced) from grass- to forest-dominated land surface:
- a warming effect due to the lower albedo of forests compared to that of low herb vegetation (high albedo), and
- a cooling effect due to higher evapotranspiration associated with forest expansion.

-> Biogeophysical effects are mainly photosynthesis-mediated and result in terrestrial carbon sinks and sources. For example, in cold regions, warming leads to vegetation growth, increasing photosynthesis and carbon uptake, which then leads to a cooling. All these factors and processes are often operating in parallel and may have opposite effects. Anthropogenic deforestation, for instance, leads to a decrease in carbon uptake, and to a release of carbon via decomposition of dead wood or burning, i.e. has a warming effect. On the other hand, deforestation may also produce a cooling effect due to increased albedo. It is important to understand which of these effects is dominant and whether the net result is a warming or a cooling. The feedback loops shown in Figure 1 may be modified or eliminated by taking anthropogenic land-cover change into account.

2. Past anthropogenic land-cover changes and their effects on climate

Scenarios of past anthropogenic land cover change (ALCC; e.g. Kaplan et al. 2009, Pongratz et al. 2010) show very inconsistent results. Pollen records from lake sediments and peat deposits may resolve some of these inconsistencies (Figure 2). Pollen records for NW Europe reveal i) deforestation from ca. 4,000 BC (Neolithic time), with particularly large deforested areas from ca. 1,000 BC (Bronze Age) up to the 19th century, and ii) reforestation from the mid-19th century. In Europe (and the Baltic Sea region), deforestation was at its maximum around AD 1850-1900 (60-80%, Figure 2).

3. Global and Regional effects

On the regional scale, biogeophysical feedbacks are of particular interest since they exert a direct measurable effect on regional climate. Biogeophysical feedbacks are more relevant in the context of global climate change. However, the Baltic Sea region has extensive forests and wetland areas, therefore the carbon storage in vegetation and soils in the region is significant, although specific regional estimates are lacking. Results from global climate models: Globally, biogeophysical effects from ALCC during the last millennium apparently had a slight cooling influence on mean temperature (~0.03 K in the 20th century), while biogeophysical effects led to a strong warming (0.16–0.18 K) (Pongratz et al. 2010). The climate response to historical ALCC, both globally and in most regions, is dominated by a warming due to the release of CO2.

References


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Authors: Marie-José Gaillard, Thomas Kleinen, Patrick Samuelsson, Anne Birgitta Nielsen, Johan Bergh, Jöd O. Kaplan, Anneli Poska, Camilla Sandström, Gustav Strandberg, Anna-Kari Trondman and Anna Wrammey