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Editorial

Climate Change and Land – Current Knowledge and Future Challenges

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1. Current Knowledge

The Earth's surface has experienced land cover changes since its beginning. Natural land cover changes include, among other things, weathering, flooding, wildfires as part of the landscape evolution, avalanches and landslides, earthquakes and lava flows from volcanic eruptions, ice-ages and regrowth. Tectonic movements of the continental plates brought natural evolution and changes in land cover. The surface properties (e.g. albedo, emissivity, specific heat capacity, thermal conductivity, roughness, leaf area index, slope) determine the partitioning of incoming net solar radiation into ground/surface heat fluxes, sensible and latent heat fluxes as well as upward- and downward long-wave radiation at the surface-atmosphere interface. Consequently, any surface changes alter the surface energy budget and local climate. In addition, the altered surface may result in different atmospheric uptake of matter like soil, ash, pollen and different release of precursor gases for particulate matter all of which affect the local radiation budget and hence climate.

In Earth's history, huge meteorites have destroyed vast areas leaving craters of various size behind. Depending on their size and depth, the microclimate may differ from that outside as the slopes of the impact crater may provide favourable conditions for inversion formation and local wind circulation systems.

Anthropogenic land cover changes have altered local and regional climate since humankind started settlements and culturing the land for food production. Over time, establishing irrigation systems and water reservoirs added to the land surface changes. The improved life conditions led to an increase in population, urbanization and further deforestation to gain land for agricultural use turning Europe into a mostly cultivated landscape. Various model simulations documented the various regional climate impacts of settling based on today's and the historic landscape of the USA. In the history of the Middle East, unlimited irrigation and grazing turned fertile land into dry deserted areas. On the contrary, in regions with regulated irrigation and limits on grazing, the comparatively cooler, moister land as compared to the surrounding bare land fosters (local recycling of) precipitation.

Well-known and documented local climate impacts of urbanization are the heat-island effect and the increased precipitation in the downwind of large cities. White and green roofs, urban forest as well as green parking lots are measures to diminish the urban warming and establish thermal comfort even in the mid of summer. The vegetation also serves to reduce drainage problems caused by the mostly sealed urban area. In addition, to these hydro-thermodynamic impacts, mega cities affect atmospheric dynamics. Fronts notably decelerate when propagating over mega cities, especially those with a large number of extremely high skyscrapers.

2. Current and Future Land Cover Related Climate Challenges

Many of the world's existing mega cities are close to the ocean to have access to global shipping. Future research on growing mega cities will have to examine the impacts on land- and sea-breezes as well as the interaction between the clean oceanic and polluted urban air. Studies should include how the increased availability of cloud condensation nuclei affects the formation and albedo of marine stratus in the area of mega cities. Such research can be performed via model simulations as well as analysis of satellite data. Another important research question is how to keep the climate in mega cities thermally comfortable. An unanswered question is also how the construction of skyscrapers affects atmospheric boundary layer and wind field behaviour over and in the downwind of mega cities.

To reduce the release of carbon dioxide from fossil fuels growing plants for production of bio-fuel has been subsidized in many countries. However, raps, soy and maize have quite different growth cycles than the traditionally grown plants like, for instance, wheat, rye and barley. Consequently, the water demands of these plants occur at quite different times. Thus, not only the timing of evapotranspiration and hence water supply to the atmosphere changes, but also irrigation may be needed. Besides these hydrothermal effects the different timing of harvest also affects the wind field via surface roughness as well as the surface radiation budget via albedo and emissivity, among other things. Related future research challenges are (1) to examine how changes in agricultural practices and products grown affect local climate and (2) the search for possibilities to minimize the need for irrigation.

Since the 1970s, various studies have shown short-term local weather impacts due to the smoke during and after tropical bio-mass burning. The resulting clearings were found to have lasting impacts on the hydrological cycle and local wind fields. Deforestation in the Tropics was found to influence climate beyond the Tropics due to the role of the Hadley Cell in the atmospheric circulation. The recent growing market for bio-fuel may lead to further deforestation and/or burning of tropical forests at a large scale. Therefore, it is an urgent need to examine whether such large scale, unprecedented land cover changes might cause world-wide teleconnections.

World-wide huge wind farms have been set up to reduce burning of fossil fuel for energy production. Depending on the wind turbine type, the blades reach about 150 m or more into the atmosphere. Consequently, they increase the surface roughness as compared to the formerly usage of the land.

Depending on the blade length, sweep areas are of the order 2×10^5 m^2. Thus, when operating the turbines not only remove kinetic energy from the wind field, but also mix the air in the layer of their downwind wake vortex. This mixing influences atmospheric stability and the fluxes of sensible and latent heat at the surface-atmosphere interface in their immediate downwind. Future research needs to examine and quantify these impacts of the wake vortices on local climate and the long-term impacts of world-wide removal of kinetic energy from the wind field on climate.

Another future challenge of land cover related climate research is to detangle the interaction and contributions of the water-, energy- and trace-gas cycle to the overall change in climate. This kind of research requires teams of remote sensing, modelling and observational experts from atmospheric and environmental sciences as well as engineering of new more sensitive observational devices.

This special issue on *Land Cover and Climate* serves not only as a synthesis and review of current knowledge on land cover impacts on climate, but also to present new angles of addressing the complexity of the land cover and climate interactions at the interface of environmental sciences and engineering.

Author Contributions

Nicole Mölders did all work.

Competing Interests

The author has declared that no competing interests exist.


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