Session 2: Climate Change and Biodiversity

Unexpected Feedbacks between Land Biota and Climate

Pavel Kabat
Chair and Director, the Royal Dutch Academy of Sciences Institute
for Integrated Research on Wadden Sea Region, The Netherlands

The notion that global climate operates as a systems in which the biosphere plays an important role is not new. The fact that the vegetation co-regulates the hydrological cycle has been known for over the century. However, the fact that the biosphere and climate are closely interlinked, and the suggestion that living land biota itself may be an active and necessary player in planetary dynamics are much more recent (e.g. the Gaia hypothesis).

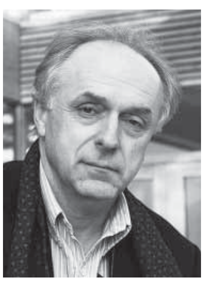
The Earth Climate is a complex system, characterized by intricately linked processes, feedbacks and tele-connections. An example is the tight coupling between global climate and biogenic trace gases (CO_2, CH_4,) in the atmosphere which was recorded in the Antarctic ice over more than 600,000 years. A close covariance between atmospheric trace gas concentrations and the inferred temperature found in these records poses the question of cause and effect: Are fluctuations in the biogenic greenhouse gases driving the climatic variability, or are externally forced climate variations responsible for changes that result in varying emissions of these gases? Current consensus suggests that there is no simple either/or answer to this question, but that the biota and their geophysical and geochemical environments have co-evolved, resulting in a multitude of complex feedbacks.

The Earth's climate system, including the hydrological cycle, encompasses both the a-biotic and the <u>*living*</u> world. The land surface – atmosphere interface is particularly crucial for the functioning of the Earth Climate System through interactions via energy and momentum fluxes, as well as through the biogeochemical cycles. A key lesson from the IGBP programme Biospheric Aspects of the Hydrological Cycle (BAHC) and from the WCRP Global Energy and Water Experiment (GEWEX) was that <u>*land-cover and land-use (vegetation)*</u> strongly affect the exchange of water, CO_2, and energy between the land surface and the atmosphere, which makes them important and <u>*integral components of the climate system.*</u> At the same time, climate variability and atmospheric processes such as transport and deposition of chemicals, are major constraints on biogeochemical cycles, 'natural' as well as anthropogenic ones. For example, inter-annual variability of carbon uptake at all spatial and temporal scales is strongly influenced by variations in climate through the related feedbacks to physiology and productivity. Gases and aerosols deposited from the atmosphere can also strongly influence ecosystem functioning, sometimes acting as fertilizers, sometimes as toxic substances. Consequently, <u>*human-driven change*</u> in land cover, and <u>*thus in the composition and the functioning of the land biota and land biodiversity, is likely to result in significant regional and global climate change.*</u> In turn, climate change affects terrestrial ecosystems and land biota in general at all spatial and temporal scales, maybe even to the extent of destabilizing large regions like the Amazon forest or the Taiga forest.

One example for such a set if interactions is the massive perturbation of the tropical atmosphere by the combination of land use change (deforestation) and the emission of atmospheric pollutants, especially aerosols from industrial combustion and biomass burning. Both anthropogenic and biogenic emissions of aerosols and their precursors, occurring mainly on the land surface, affect the properties of clouds and thereby the intensity and location of rainfall, as well as the vertical redistribution of pollutants in the atmosphere. These effects feed back on the land surface by affecting the terrestrial water cycle, which in turn has consequences for water availability, agricultural productivity and the emission of trace gases from land ecosystems. Since the tropics are the “heat engine” that drives the large-scale atmospheric circulation, the perturbation of tropical cloud and rainfall processes is expected to affect climate dynamics worldwide. In addition, in the tropical regions a major and rather abrupt perturbation of the global carbon balance may be triggered, as a result of huge releases of the soil carbon to the atmosphere due to global warming.

Another example are the arctic and boreal regions, where perhaps the most dramatic climate change is presently occurring. Temperatures and precipitation have risen rapidly in much of the region over past decades, river flows are increasing, and snow and ice cover decreasing. As a result, vegetation zones are expected to shift, fires are increasing in frequency and extent, and significant impacts on society are likely. In addition, and comparably to tropical regions, global warming in the northern latitudes may result in an unprecedented release of the methane and soil carbon to the atmosphere, which in turn may significantly accelerate the climatic change.

Tropical, arctic and boreal regions are intensively studied under the auspices of the IGBP core project Integrated Land Ecosystem - Atmosphere Process Study (ILEAPS).



Pavel Kabat

Chair and Director, the Royal Dutch Academy of Sciences Institute
for Integrated Research on Wadden Sea Region, The Netherlands

Academic Degrees

M.Sc., Prague Technical University (hydrology and Wate Resources), Czech Republic
Charles Unversity of Prague (applied mathematics), Czech Republic
Ph.D., Prague Technical Unversity, Czech Republic
Wageningen University, The Netherlands

Field of Study
Hydrology and Water Resources