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The significance of land-atmosphere interactions in the Earth system—iLEAPS achievements and perspectives

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ABSTRACT

The integrated land ecosystem-atmosphere processes study (iLEAPS) is an international research project focussing on the fundamental processes that link land-atmosphere exchange, climate, the water cycle, and tropospheric chemistry. The project, iLEAPS, was established 2004 within the International Geosphere-Biosphere Programme (IGBP). During its first decade, iLEAPS has proven to be a vital project, well equipped to build a community to address the challenges involved in understanding the complex Earth system: multidisciplinary, integrative approaches for both observations and modeling. The iLEAPS community has made major advances in process understanding, land-surface modeling, and observation techniques and networks. The modes of iLEAPS operation include elucidating specific iLEAPS scientific questions through networks of process studies, field campaigns, modeling, long-term integrated field studies, international interdisciplinary mega-campaigns, synthesis studies, databases, as well as conferences on specific scientific questions and synthesis meetings. Another essential component of iLEAPS is knowledge transfer and it also encourages community- and policy-related outreach activities associated with the regional integrative projects. As a result of its first decade of work, iLEAPS is now setting the agenda for its next phase (2014–2024) under the new international initiative, future Earth. Human influence has always been an important part of land-atmosphere science but in order to respond to the new challenges of global sustainability, closer ties with social science and economics groups will be necessary to produce realistic estimates of land use and anthropogenic emissions by analysing future population increase, migration patterns, food production allocation, land management practices, energy production, industrial development, and urbanization.

1. Introduction

The land-atmosphere interface is where humans primarily operate. Humans modify the land surface in many ways that influence the fluxes of energy and trace gases between land and atmosphere. Their emissions change the chemical composition of

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the atmosphere and anthropogenic aerosols change the radiative balance of the globe directly by scattering sunlight back to space and indirectly by changing the properties of clouds. Feedback loops among all these processes couple land, the atmosphere, and biogeochemical cycles of nutrients and trace gases extending the human influence even further.

The Earth is a highly complex system formed by mutually interlinked components (land, atmosphere, ocean), its interfaces (land-atmosphere, atmosphere-ocean, land-ocean) and processes operating on a wide range of temporal and spatial scales. Our capacity to understand the whole system is predicated on our capability to understand its various elements and their interactions. The land-atmosphere interface is a prime example of such interlinked elements, particularly crucial for the functioning of the Earth system through interactions via mass, energy and momentum fluxes as well as through biogeochemical cycles. The scientific understanding of the interface therefore contributes to our ability to describe, understand and predict the Earth system and its functioning as a whole. Exploring and quantifying the land-atmosphere interactions is thus extremely important.

The International Geosphere Biosphere (IGBP) program was reorganized in 2000 to emphasize the importance of scientific research at the interface of the major geosphere biosphere disciplines. The new structure included a new cross-disciplinary research program, called the integrated land ecosystem-atmosphere processes study (iLEAPS), aimed at improved understanding of the processes, linkages and feedbacks in the land-atmosphere interface (Fig. 1). This project was designed to build on key findings of previous IGBP projects, especially BAHC (biospheric aspects of the hydrological cycle) and IGAC (International Global Atmospheric Chemistry). The iLEAPS international project office was based at the University of Helsinki. iLEAPS activities, workshops and scientific conferences facilitated the establishment of a community with a common goal to enhance the understanding of how interacting physical, chemical and biological processes transport and transform energy and matter through the interface, particularly emphasizing interactions and feedbacks at all scales, from past to future and from local to global. A science conference highlighting the accomplishments of the first decade of iLEAPS was held in Nanjing, China in 2014 and coincided with the transfer of the international project office to Nanjing. The current iLEAPS scientific steering committee, activities and initiatives are described on the iLEAPS website (www.iLEAPS.org).

The scientific goals of iLEAPS are chosen to reflect issues and regions where previous research has shown that interactions, feedbacks and teleconnections play prominent roles and are essential to our scientific understanding. It is clear that understanding such a complex system is an enormous challenge that requires more integrative approaches and collaboration, crossing the boundaries among spatial and temporal scales as well as among the various science disciplines. iLEAPS meets these requirements with the aim of creating a deep understanding of the current challenging global issues. The research within iLEAPS covers the basic processes that link surface-atmosphere exchange with ecological and physiological processes on the one hand and with atmospheric dynamics, tropospheric chemistry and physical climate on the other. iLEAPS integrates the knowledge and expertise from several fields, such as biology, chemistry, physics, meteorology, hydrology and ecology. Moreover, addressing the complex issues related to global challenges requires bridging the gap between the natural and social sciences. In the current epoch driven by human activities, engagement of social sciences into the framework of iLEAPS research is necessary. Migration patterns, food production allocation, and land management practices are some examples of topics requiring a wide integrative approach facilitated by iLEAPS in its second phase. Here, we outline the development that has occurred in this field in recent years from the perspective of iLEAPS.

iLEAPS is not a specific research organization or project. It is, like other IGBP core projects, rather a research network that through its vast network including leading scientists inspires and supports groups of scientists to merge efforts and to focus on urgent scientific questions in our field. The scientific steering committee is comprised of about 16 diverse scientists, a mixture of

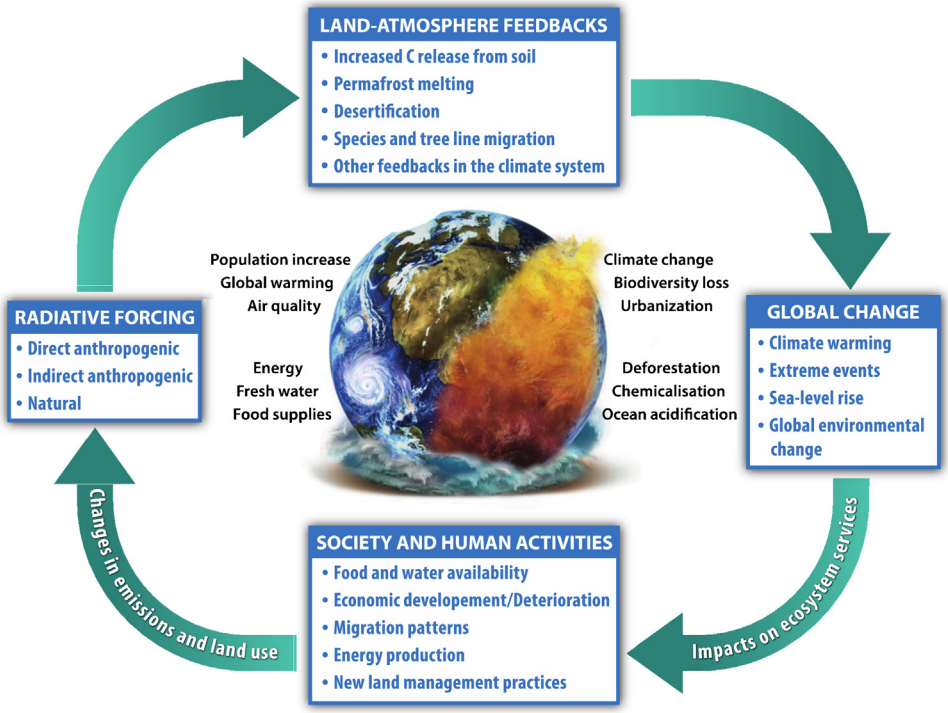

Fig. 1. The land–atmosphere-society processes under global change that are the focus of iLEAPS.