

Land-atmosphere-society processes in the boreal and Arctic regions – collaboration opportunities within iLEAPS and PEEX

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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 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, land, the atmosphere, and biogeochemical cycles of nutrients and trace gases extend the human influence even further.

iLEAPS (Integrated Land Ecosystem – Atmosphere Processes Study, a core project of the ICSU-sponsored IGBP (International Geosphere-Biosphere Programme), is an international cross-disciplinary research program aimed at improved understanding of processes, linkages and feedbacks in the land-atmosphere interface affecting the Earth System. iLEAPS facilitates scientific collaboration as well as synthesis and distribution of results to scientific, political and public audiences. The main activities in iLEAPS include 1) highlighting and advertising important scientific results (newsletters, bulletins, website, synthesis reports and articles); 2) organising science conferences, workshops and trainings around LEAP science; 3) organising and co-sponsoring sessions at conferences; 4) organising the iLEAPS Science Conference that gathers together the latest findings and breakthroughs of the iLEAPS science community all over the world, and most importantly 5) developing LEAP science by starting off new initiatives and projects that focus on land-atmosphere-society interactions and take steps towards global sustainability. One of the foci of iLEAPS research in the next 3-4 years is Arctic research, and the international initiative Pan-Eurasian Experiment (PEEX).

Over the last decade, the importance of land-atmosphere processes and feedbacks in the Earth System has been shown on many levels and with multiple approaches, and a number of publications have shown *the crucial role of the terrestrial ecosystems as regulators of climate*. Modellers have clearly shown the effect of missing land cover changes and other feedback processes and regional characteristics in current climate models and recommended actions to improve them. Unprecedented insights of the long-term net impacts of aerosols on clouds and precipitation have also been provided. Land-cover change has been emphasized with model intercomparison projects that showed that realistic land-use representation was essential in land surface modelling. Crucially important tools in this research have been the networks of long-term flux stations and large-scale land-atmosphere observation platforms that are also beginning to combine remote sensing techniques with ground observations.

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. Emphasis should be placed on, for instance, new observation networks incorporating remote sensing techniques with ground-based observations; the role of land-cover changes in modulating carbon, nitrogen, and hydrological cycles and, consequently, atmospheric chemistry, aerosol dynamics, and climate; regional (high-latitude) processes and their influence on global simulations; and interactions among anthropogenic and biogenic aerosols, clouds, and climate.

One of the major research themes of iLEAPS is the Arctic and its near regions. Boreal forests are a substantial source of greenhouse gases, biogenic volatile organic compounds (BVOCs) and natural aerosols, the critical atmospheric components related to climate change processes. A large fraction of boreal forests of the world is situated in the Siberian region. Representative measurements of carbon dioxide (CO₂) and methane (CH₄) concentrations, BVOC emissions and aerosols production from Siberia are of special importance when

estimating global budgets of climate change relevant factors. The scope of the new iLEAPS-endorsed research programme, Pan Eurasian Experiment (PEEX), is to set up a process for planning of a large-scale, long-term, coordinated observations and modelling experiment in the Pan Eurasian region, especially to cover ground base, airborne and satellite observations together with global and regional models to find out different forcing and feedback mechanisms in the changing climate. The work will integrate natural sciences and socioeconomical sciences to address the complex dynamics among human and natural systems and the interactions among managed ecosystems, climate, and societies in the boreal and Arctic regions of Eurasia.

PEEX, organised by the University of Helsinki and the Finnish Meteorological institute, aims to gather all the European and Russian key players in the field of climate and Earth system science to plan future research activities in the Pan-Eurasian region. In the European scale, PEEX is part of the JPI Climate Fast Track Activity 1.3. "Changing cryosphere in the climate system – from observations to climate modeling". PEEX research topics are closely related the NordForsk's Top Research Initiative CRAICC – Cryosphere – atmosphere interaction in the changing Arctic climate. PEEX is also a central part of the ongoing the Finnish Cultural Foundation – Earth System modeling Working Group activity (2012-2013).

PEEX scientific aims and future actions to develop Pan Eurasian research infrastructure can be linked to several EC and ESA funded activities aiming to develop next generation research infrastructures and data products: EU-FP7-ACTRIS-I3-project (Aerosols, Clouds, and Trace gases Research InfraStructure Network-project 2011-2015); ICOS a research infrastructure to decipher the greenhouse gas balance of Europe and adjacent regions; EU-FP-7 e-infra ENVRI "Common Operations of Environmental Research Infrastructures" project. New Siberian research infrastructure and data products should be developed in line with the ACTRIS, ICOS and ENVRI approaches. Furthermore, that PEEX is supported by iLEAPS brings the PEEX under the umbrella of the International Geosphere-Biosphere Programme (IGBP) and the developing global sustainability research programme Future Earth, led by ICSU, UNEP, UNESCO, UNU, WMO, and the Belmont forum.

The permafrost regions and boreal forests of the Pan Eurasian area can be identified as a hot spot of climate change research in a global scale. PEEX can be considered as a crucial part of the strategic aims of several international and national roadmaps for climate change research and the development of next-generation research infrastructures.