

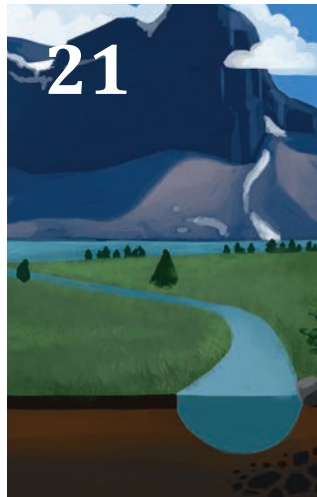
Newsletter

Integrated Land Ecosystem - Atmosphere Process Study

Issue No. 12- September 2012

Future
land-atmosphere
observation platforms

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ILEAPS Newsletter

ISSN Printed version 1796-0363

ISSN On-line version 1796-0401

For submissions and subscriptions, please contact ipo@ileaps.org

Publisher

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Hardcopy circulation

3500

The iLEAPS IPO is sponsored by the University of Helsinki, the Finnish Meteorological Institute, and the Ministry of Education, Finland.

Future Earth - research for global sustainability

Future Earth will be a global platform for international research coordination and engagement of stakeholders in support of global sustainability. The initiative will transform the way of doing research. It will mobilize thousands of scientists while bringing together natural science and social science communities.

Future Earth is expected to be operational in 2014. Funding will be available from mont forum annual calls (IOF).



New projects under iLEAPS endorsement programme

iLEAPS continues to search for more scientific research partners to sign up new projects under the iLEAPS endorsement umbrella. Recently, iLEAPS has welcomed two new projects based in Africa:

Welgegund Observation

Platform project – The scientific objective of this project is to provide integrated air quality and climate change -relevant parameters over a long period in the important and under-sampled source region of South Africa.

Taita Research Station in Kenya – This project utilises a multidisciplinary approach to study the impacts of climate change on sensitive and unique African ecosystems. It also focuses on ecosystem services in these regions, especially with regard to agriculture and food security.

Break down boundaries in climate research

Paulo Artaxo, Nature 481, 239 (2012) –

Scientists wanting to implement change must collaborate between disciplines in natural sciences and in social sciences as well. The ambitious Amazon study LBA (Large Scale Biosphere-Atmosphere Experiment in Amazonia) has been a prime example of this approach for the past two decades. The project encouraged cooperation between physicists, chemists, meteorologists and biologists, as well as economists and social scientists. This was necessary in order to fully understand all the factors influencing a system as complex as the Amazon basin.

iLEAPS research priorities

In 2011, the iLEAPS SSC reviewed the iLEAPS Science Plan and came up with ten most urgent research topics for the land-atmosphere community

1. Ground-based Earth System observation systems and networks
2. Boundary-layer dynamics
3. Land-use and land-cover changes (LULCC)
4. Regional emphasis (such as high latitudes and tropics)
5. Integrative model evaluation
6. Evaluation of climate models
7. Extreme events vs. gradual change and adaptation
8. Interactions between managed ecosystems and atmosphere
9. Human-induced change in land-atmosphere interactions
10. Aerosols and climate.

iLEAPS is happy to offer coordination and other assistance to projects focusing on these priorities. More information: ipo@ileaps.org.

20 million EUR for integrative research on global sustainability

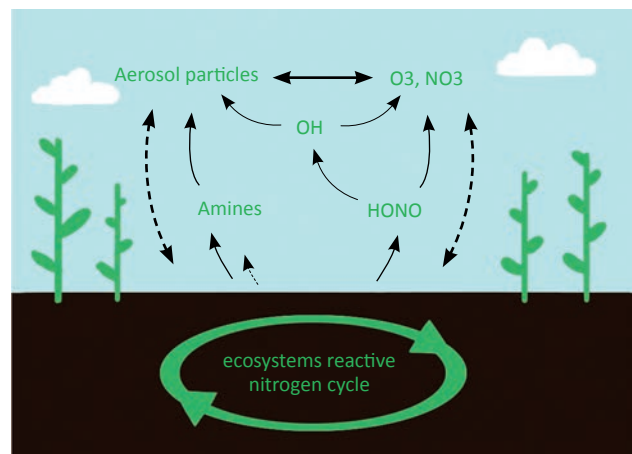
An international group of funding agencies has announced an "International Opportunities Fund" (IOF) worth 20 million EUR for international research projects focusing on coastal vulnerability and freshwater security. The deadline for this call was 20th of July 2012. The second cycle of the IOF is currently in discussion and may include research areas associated with the Arctic, food security, and e-science coordination.

The IOF is a joint funding call between the Belmont Forum and G8 Heads of Research Councils. The Belmont forum is interested in hearing the research community's feedback for these research themes and for other possible future calls of the IOF. You can send your feedback to ipo@ileaps.org.

New connections between soil and atmosphere

Kulmala M and Petäjä T, Soil nitrites influence atmospheric chemistry, *Science*, 333, 1586-1587 (2011)

Climate change has been linked to greenhouse gases, aerosol particles, and human actions, but the global nitrogen cycle plays a crucial role as well. Emissions of reactive nitrogen (such as HONO) from the soil link the nitrogen and sulphur cycles with the water and carbon cycles. Documenting all the ecosystem-atmosphere cycles including the soil, atmospheric oxidation, and aerosol particles and their links and feedback loops is essential to fully understand how the biosphere affects the atmosphere and the global climate.



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Future land-atmosphere observation platforms

As the complexity of our Earth-System science understanding increases, so does our capability to model the functioning and evolution of the Earth System (or regions thereof) in a progressively integrated way and over an ever-widening span of spatial and temporal scales. As this trend continues into the future, modelling systems become more and more skilled at coupling physical, chemical, biological, and ecological processes and interactions across all relevant Earth System compartments, and are beginning to include socio-economical processes as well. Along with this growing understanding and modelling capability rises the demand for observational data to examine model predictions, or train parameterisations. To satisfy this demand, the Earth System observation platforms of the future need to match or exceed the integrated nature of the models, their spatial resolution, and temporal range.

The iLEAPS Post-Conference Workshop on Challenges and Opportunities of Integrated Long-Term Land Ecosystem-Atmosphere Process (LEAP) Observations (September 25-26, 2011, Garmisch-Partenkirchen, Germany) was motivated by developments of ecological/environmental observatory networks in recent years. Examples are the regional Long Term Ecological Research (LTER) networks that are organized internationally in ILTER, the National Ecological Observatory Net-

work (NEON) in the United States, the Integrated Carbon Observation System (ICOS) in Europe, the global FLUXNET, Critical Zone Observatories and a number of others.

These observational networks have their own objectives, history and methodical foci, but all of them strive to increase knowledge on processes in the layer from vegetation canopy to the soil and groundwater that sustains human life, and their interaction with the atmosphere and climate. As we strive to design future land-atmosphere observation platforms, we can learn from the experience gained by long-term observatories, the challenges faced and opportunities offered by integrated long-term land ecosystem-atmosphere process observations.

This issue of the iLEAPS Newsletter contains five contributions that illustrate the history and motivation for the development of long-term integrated observation sites and networks (by J.W. Munger, T. Vesala, and J. Völkel) and highlight their added-value potential for data-model integration (by G. Bonan) and cross-disciplinary collaboration and research training (by N. Saigusa *et al.*).

Collectively, the sites of such networks constitute a potentially invaluable source of data for the detection of temporal and spatial trends in key environmental variables, and for the development and evaluation of models. However, this potential can only be ful-

ly exploited, if data and methods are transferable not only within networks, but between networks. Whether the full potential of such long-term observations can ever be brought to fruition depends on their sustained operation at a consistently high quality, and, in turn, on sustained institutional commitment for them and their financial support.

Ecosystem-atmosphere interactions take place over a broad range of time-scales, from seconds to the lifetime of plants (in many cases several decades) or much longer, if the adaptation/development of ecosystems to different climates or the formation of soils and weathering processes is considered (see Völkel, this issue). Because ecosystem-atmosphere interactions involve transformations and exchange between different compartments in the soil-vegetation-atmosphere system, a cross-disciplinary measurement approach in multi-compartmental long-term observatories is thought to be particularly suited to shed light on the time-scales and feedbacks involved (see Vesala, this issue). Observatories that are organized in concerted network fashion can additionally address questions of spatial scales, geographic or climatic gradients, or can quasi-extend the observed time span through the concept of chrono-sequences. Concerted work in such networks requires a highly developed level of cross-disciplinary research collaboration and ex-

change (see Saigusa *et al.*, this issue). The ability of ecosystems to emit (for instance) greenhouse gases (GHG), or to remove them from the atmosphere, depends on the type of ecosystem (vegetation, soil type, microbial community), its maturity or successional state, climatic conditions, pool sizes and pool quality of carbon and nutrients, and the internal exchange between various compartments. The overall balance is highly variable in space and time and characterized by an interlinked set of feedback mechanisms between biogeochemical and biophysical control parameters (see Munger; Vesala, this issue).

The time scales in the bio-physical controls (such as temperature, light, humidity, water availability) are dominated by daily and seasonal courses, but are strongly modified by weather, inter-annual variability and multi-annual quasi-climatic oscillations related to slow atmospheric and oceanic circulation modes (such as North Atlantic Oscillation, Atlantic Multidecadal Oscillation, El-Niño/La-Niña), by regional expressions of global climate variability and by climate change.

Vice versa, ecosystems function within a wide range of time scales. Some of the strongest short-term variations represent responses to bio-physical forcings and are well understood and quantitatively described by process-level models. At longer time scales, maturity states, succession and response

to disturbance interact with bio-physical variations and extreme events, to affect a permanent but variable state of imbalance between pool sizes (for instance carbon, nutrients, water, biomass), climate and GHG exchange (see Bonan, this issue). The ability of process models to capture such complex long-term interactions is notoriously poor, in particular regarding the effects of land use and land management and their interactions with ecosystem vulnerability and resilience, and thus, their prognostic applicability in climate models is severely compromised, despite some recent efforts at synthesis and data-model fusion.

Fragmentary evidence from long-term data records at individual sites suggests that this lack of a concerted and comprehensive database of long-term ecosystem-atmosphere exchange across climatic/regional and land-use gradients is likely the most important limitation for a better understanding of long-term Earth System dynamics. The long-term approach of continuous ecosystem-atmosphere observatories, with continuous data quality control, analysis, interpretation and modelling, goes far beyond mere fishing for serendipity. Emerging long-term observation programs (such as EU-ICOS or US-

NEON) promise to be invaluable tools to detect the scales of environmental variability and long-term trends; they form the basis for the identification of anomalies and their underlying processes; they are the most important data source for the independent evaluation of Earth System - climate models and GHG balance projections (see Bonan, this issue). ■



Gordon B. Bonan, Samuel Levis, and William R. Wieder
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A modeller's perspective of long-term integrated data series of ecosystem-atmosphere processes



Gordon Bonan is a senior scientist and Head of the Terrestrial Sciences Section in the Climate and Global Dynamics Division at the National Center for Atmospheric Research (NCAR). Trained as an ecologist (PhD in environmental sciences, University of Virginia), he specialises in the development of and experimentation with terrestrial biosphere models for climate simulation. He leads the development of NCAR's Community Land Model, with a current emphasis on biogeochemistry. Gordon Bonan is also a member of the iLEAPS Scientific Steering Committee.

The evolution of climate models to Earth System Models (ESM) is marked by recognition of the central role of the terrestrial biosphere in regulating climate through physical, chemical, and biological processes. Terrestrial ecosystems influence climate through exchanges of energy, water, carbon, reactive nitrogen, and aerosols [1, 2, 3, 4]. ESMs have expanded beyond their hydrometeorological heritage (with emphasis on energy fluxes) to include biogeochemical cycles (such as carbon and nitrogen), land use, and vegetation dynamics. These models are important research tools to study land-atmosphere interactions, climate feedback from ecological processes, and ecosystem management practices to mitigate climate change.

Human activities have influenced planetary functioning since pre-industrial times by elevating concentrations of atmospheric carbon dioxide (CO₂) and tropospheric ozone; by increasing emissions and subsequent deposition of reactive nitrogen; by changing climate; and through introduction of invasive species and land-use practices such as agriculture, deforestation, afforestation, and reforestation. ESMs are used to understand the consequences of these and future changes. For example, Fig. 1 shows drivers of change for the period 1981-2010 for a region of central Massachusetts, USA, used in simulations with the Community Land Model (CLM), which is the land com-

“*Long-term monitoring is necessary to discern if ecological changes simulated by Earth System Models are real; to distinguish short-term variability from long-term trends; and to attribute these changes to particular forcings.*”

ponent of the Community Earth System Model at the National Center for Atmospheric Research (NCAR) [5]. The model uses these forcings to simulate surface energy fluxes, the hydrologic cycle, biogeochemical cycles, and their feedbacks with climate (Fig. 2).

With emphasis on fluxes of energy, water, and momentum resolved at high temporal resolution (30 minutes or less), model development and evaluation have long utilised eddy covariance tower measurements. Such analyses typically involve model calibration and evaluation at one or more flux tower sites. Initially, such observations extended for only short (three weeks or less) field campaigns. For example, flux data collected in the Boreal Ecosystem Atmosphere Study (BOREAS) during the 1990s were used to evaluate NCAR models [6].

The short duration of the data collection limited the model-data comparison to the mean diurnal cycle of the field campaigns. Initialisation of mod-

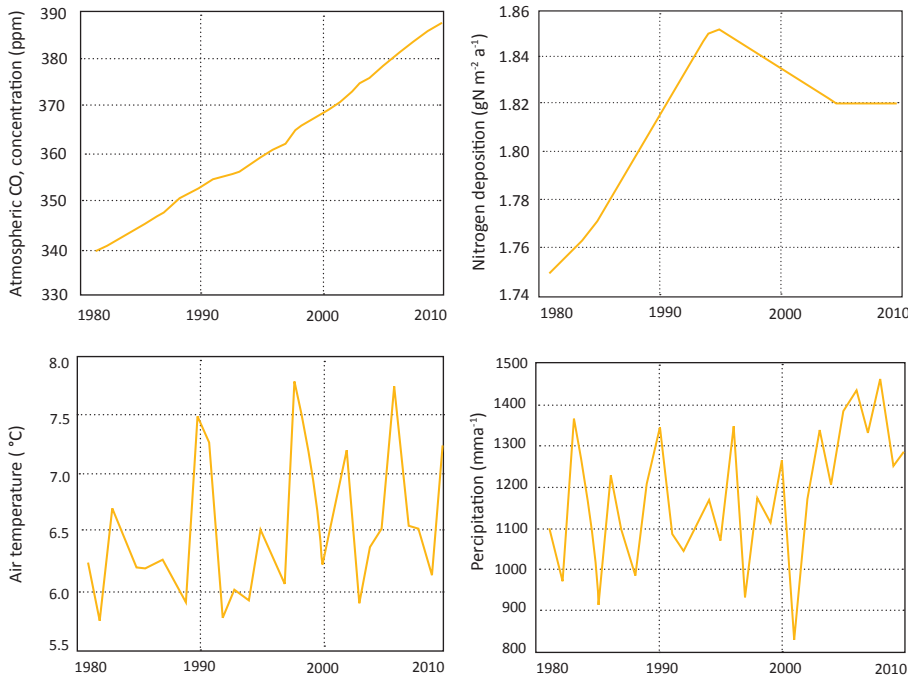


Figure 1. Observations of atmospheric CO₂ concentration, nitrogen deposition, air temperature, and precipitation for a region of central Massachusetts, USA, used in simulations with the National Center for Atmospheric Research Community Land Model version 4 (CLM4). Shown are annual averages for the period 1981-2010.

el state variables (such as soil moisture) for these periods was challenging. Furthermore, the model analysis utilised flux data from three separate science teams each running a particular tower site. Standardisation of flux data, screening for extreme values, and gap filling of missing data had to be addressed for each site. Missing data was particularly problematic in assembling the meteorological data (air temperature, humidity, wind speed, solar radiation, longwave radiation, and precipitation) needed for the simulations.

A decade later, flux-tower measurements were more routine-like, with multi-year observations at many sites organised in networks such as AmeriFlux (<http://public.ornl.gov/ameriflux/>) in the USA and FLUXNET (<http://www.fluxdata.org>) internationally. These long-term observations collected in a variety of biomes critically guided the evaluation and development of the CLM [7]. Model development utilised data for 15 FLUXNET tower sites from temperate, Mediterranean, tropical, boreal and subalpine climate zones. Each site had three or more years of continuous flux and meteorological data. Still, data preparation required removal of outliers, gap filling, and standardization of flux data. Analyses examined hourly fluxes over the multi-year record and the annual cycle as rep-

resented by monthly mean fluxes. Additional ancillary data, particularly soil moisture, allowed informed diagnosis of model errors in latent heat flux.

With the advent of global flux datasets derived from individual tower sites, the models can now be confronted with data of biosphere functioning at the global scale. The global flux fields are empirically upscaled using FLUXNET towers, satellite, and meteorological data and provide multi-year datasets [8]. These data critically informed and improved the most recent version of the CLM [9]. The model-data analyses utilised transient model simulations for the period 1982-2004 forced with meteorological data for that same period and compared with contemporary flux data.

The progression of model evaluation – from individual tower sites over short-term field campaigns to networks extending over several years to global datasets spanning many years – illustrates two important points. Observational datasets for model evaluation should be long-term, extending over multiple years, and should be geographically extensive, rather than for a particular site. Coordinated flux tower networks such as AmeriFlux and FLUXNET meet these requirements. Eddy covariance measurements of sensible heat flux, latent heat flux, and CO₂

flux are now routinely used to evaluate models [5, 10].

The ecosystem-atmosphere coupling represented in ESMs is routinely evaluated in terms of the present-day mean state, such as fluxes or carbon stocks averaged over some multi-year period [5, 10]. However, the models are applied to study biosphere responses to environmental change. A frequent application of the models is to attribute carbon cycle trends over the twentieth century to particular forcings such as elevated CO₂, nitrogen deposition, and climate change [11].

A key issue is whether observational records are sufficient to test these model attributions. For example, vegetation simulated for the central Massachusetts site shown in Fig. 2 gained 700 g (C) m⁻² over the 20-year period 1981-2000. Can such a trend be observed given measurement uncertainty? Moreover, the terrestrial biosphere models used in Earth System simulations are generalisations of complex ecological systems and may not adequately represent site-specific features such as soil characteristics, phenotypic variability, and disturbance history. The current generation of models generally perform better at simulating regional- to continental-scale vegetation patterns rather than individual sites.

Insight to the causes and consequences of environmental change ne-

“*Ecosystem responses to extreme events such as droughts and heatwaves provide a strong test of models, but require a long-term, spatially extensive network of sites to sample these sporadic events.*”

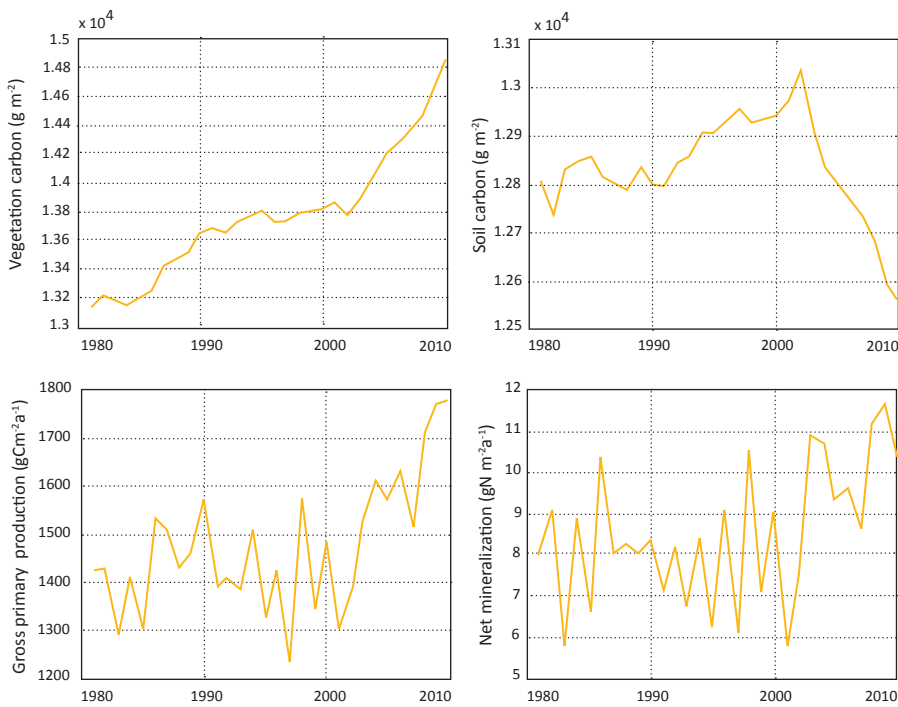


Figure 2. Simulated vegetation carbon, soil carbon, gross primary production, and net nitrogen mineralisation based on the observed drivers in Fig. 1.

cessitates distinguishing ecological response to long-term forcing (such as increasing atmospheric CO_2 concentration or nitrogen deposition) from seasonal-to-interannual climatic variability (such as droughts and heatwaves). Seasonal-to-interannual climate variability creates variation around decadal-scale changes. For instance, droughts and heatwaves may mask the expected increase in plant production in response to rising atmospheric CO_2 concentration. Short-term fluctuations can be misinterpreted as trends. Site land-use history and endogenous ecosystem processes may also mask responses to exogenous forcings. According to CLM simulations based on the measured drivers in Fig. 1, the ecosystem depicted in Fig. 2 rapidly stores carbon in plants in the period following 2002. At the same time, the ecosystem has increased heterotrophic respiration, soil carbon loss, increased nitrogen mineralisation, and enhanced productivity. Long-term monitoring is necessary to discern if these simulated ecological changes are actually occurring, to distinguish short-term variability from long-term trends, and to attribute the

change to particular forcings.

Much of the model development and evaluation is focused on monitoring networks. There has been comparatively little use of ecosystem experimental manipulations, which provide powerful tests of modelled response to a perturbation. For example, watershed deforestation studies give insights to biotic regulation of the hydrologic cycle [12]. Other experiments illustrate response to CO_2 enrichment [13] and soil warming [14]. Models can be evaluated on their simulated response to CO_2 enrichment and soil warming [11].

Long-term and geographically comprehensive monitoring networks, when used in carefully crafted analysis, can give insight to ecosystem responses to perturbations. Drought, for example, can bring to light the different hydrological functioning of forest and herbaceous ecosystems and climatic feedbacks with land cover change [15]. Ecosystem responses to extreme events such as droughts and heatwaves provide a strong test of models, but require a long-term, spatially extensive network of sites to sample these sporadic events.

While model development and evaluation routinely uses long-term flux tower networks, there has not been broad use of long-term ecological research networks. In part, this is related to the particular science questions that

“*Only multidisciplinary, long-term monitoring in combination with modelling can help us understand how we can manage the biosphere for a sustainable Earth system.*”

drive the individual science teams and research sites within the networks. The flux tower networks provide coordinated and standardised data with common measurements across sites. The observations are post-processed and saved in the same format for all sites. Such data are directly amenable to cross-site synthesis and model evaluation.

A different network philosophy is illustrated in the USA with the Long-term Ecological Research Network (LTER, lternet.edu). Though there are common themes across sites (for instance, net primary production), research at each site in the LTER network is driven by the particular science questions of the principal investigators and the uniqueness of the site. Less emphasis is placed on coordination across sites and standardisation of measurements to allow cross-site comparison or modelling. However, when such coordinated measurements are made, they provide great insights to ecosystem functioning, as illustrated with the Long-Term Intersite Decomposition Experiment [16]. Coordinated ecological networks such as the National Ecological Observatory Network (NEON, <http://www.neoninc.org>) in the USA can bridge the gap between the flux tower and ecological communities.

The terrestrial biosphere is under pressure from complex interactions among atmospheric CO_2 , nitrogen deposition, ozone damage, climate change, land-use history, and ecosystem dynamics. Long-term observations provide the basis to assess how the biosphere is responding to these pressures and to formulate hypotheses to explain the observed changes. ESMs provide one means to test these hypotheses, and also the means to study feedbacks and management policies that accentuate or mitigate these pressures. The two research methodologies proceed

in tandem, and indeed the geophysical and ecological datasets with which to evaluate ESMs have advanced together with model capability. Only multi-disciplinary, long-term monitoring in combination with modelling can provide the knowledge with which to understand how the Earth system functions and how we can manage the biosphere for a sustainable Earth system. ■

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Earth System Dynamics - Special Issue

Impacts of Land-Uses and Land-Cover Changes (LULCC) on the functioning of the Earth System

Editors: Nathalie de Noblet-Ducoudré, Mark Rounsevell, Laurens Ganzeveld, Ian Harman and George Hurtt

Land use and land cover change (LULCC) is a central topic in global change research. Improving the fundamental understanding of LULCC interactions with human, bio-geochemical, and bio-geophysical dynamics is of crucial importance. Similarly, the influence of LULCC on the regional and planetary climate system, as well as on the functioning of our socio-economic system are globally significant topics that are not understood sufficiently. This special issue aims to synthesize existing research, new findings, and to provide a roadmap for future research.

Example topics for submitted papers:

- What are the relationships between land-use activities and land cover changes, past, present, and expected for the future?
- How do rates of land-use change depend on land cover and climate?
- Which types of LULCC feedbacks within the climate and socioeconomic system are important?
- What are the plausible options to manage the future LULCC to mitigate and adapt to climate variability (including extremes) and to more long-term change?
- What is the role of LULCC in air quality and atmospheric chemistry, e.g., through affecting boundary layer exchanges of reactive compounds and aerosols?

How can we improve models of the global land system by representing human behavioural and decisional processes?

http://www.earth-syst-dynam-discuss.net/special_issue6.html

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Benefits of long-term CO₂ flux observations – lessons from Harvard Forest



J. William Munger is a Senior Research Fellow in the School of Engineering and Applied Sciences and Department of Earth and Planetary Sciences at Harvard University. His MSc thesis at the University of Minnesota examined acid precipitation. After moving to California he worked on cloud and fog chemistry, earning a PhD in Environmental Engineering Science from Caltech. In 1988 he came to Harvard where he has focused on biosphere atmosphere exchange of carbon, water and other trace gases and regional air quality, with particular interest in nitrogen deposition and forest carbon budgets. Besides observations at the Harvard Forest he has worked at field sites on the Greenland ice sheet, in the Brazilian Amazon, and in China.

In 1989, eddy covariance was a relatively new tool for observing trace gas exchange above plant canopies [1]. Improvements in instrumentation, such as 3-dimensional sonic anemometers, CO₂/H₂O infra-red gas analysers, and data acquisition/data processing hardware were enabling longer sampling periods and reduced operator attention. Eddy-flux measurements had been part of First ISLSCP Field Experiment (FIFE), Red Lake Peatlands study, and campaigns in the Amazon among others [2-6].

Our group at Harvard, consisting of Prof. Steve Wofsy and two graduate students Peter Bakwin and Song-Miao Fan, along with Dave Fitzjarrald and colleagues from the Atmospheric Science Research Center at State University of New York (SUNY) -Albany had just successfully completed a 6-week Arctic Boundary Layer Expedition (ABLE-3A) in the Alaskan Tundra that included continuous CO₂ eddy flux measurements [7] when I joined the group as a new post-doc. A new Long-Term Ecological Research (LTER) site was being established at the Harvard Forest and we took this opportunity to start a continuous, year-round eddy covariance site there to better understand ecosystem carbon budget at seasonal to annual scales and its dependence on climate and air pollution stress. Over 20 years later the measurements are still going, providing new insights into the controls on

decadal-scale variation in ecosystem function.

WHY MAKE LONG-TERM MEASUREMENTS?

Short measurement periods ranging from intensive campaigns during critical seasons to full annual cycles are valuable for understanding ecosystem-scale physiology and functional dependencies on environmental parameters, but the time scale of climate change is decades and longer. Furthermore, in large-stature vegetation the pace of ecosystem change is slow (absent catastrophic disturbance) and the turnover times of the major carbon pools range from decades to century. Equally long observational records are necessary to observe response to these environmental changes and capture infrequent, high-impact events.

OVERVIEW OF THE HARVARD FOREST SITE

The Harvard Forest Environmental Measurements Site (HFEMS) is a component of the Harvard LTER site in north central Massachusetts (Fig. 1). The tower site lies 1.6 km east of the nearest paved road and buildings. Nearby vegetation is dominated by red oak (*Quercus rubra*) (44% by basal area) and red maple (*Acer rubrum*), with scattered stands of eastern hemlock (*Tsuga canadensis*), white pine (*Pinus strobus*), and white oak (*Quercus alba*).

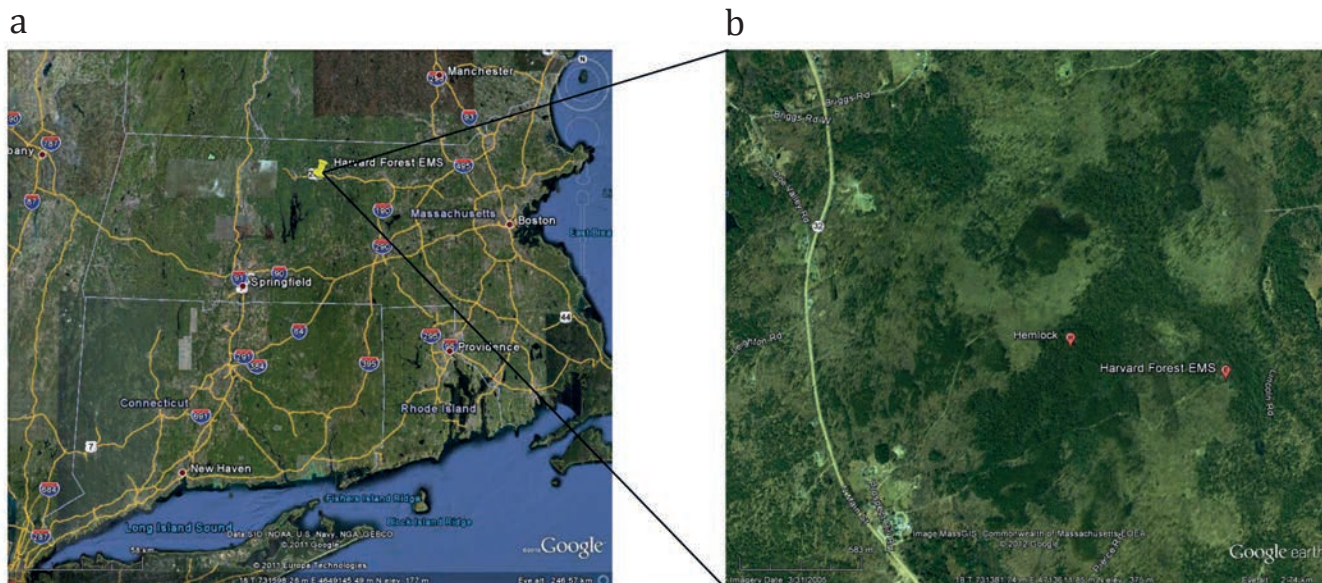


Figure 1. The location of Harvard Forest flux towers is indicated on satellite imagery of the northeastern US. First panel (a) shows the location of Harvard Forest relative to major roads and urban areas. In the second panel (b), a close-up view from March 2005 shows several km² adjacent to the tower. Conifer-dominated stands are dark green and deciduous-dominated stands are pale green. The region surrounding Harvard Forest is largely forested and sparsely populated, with extensive areas of protected watershed and conservation lands. The third panel (c) shows a view from the tower in the upwind direction. (Photo: courtesy of J. W Budney).

of the HFEMS tower. Individuals in this stand range in age up to 230 years. Together, the HFEMS and Hemlock tower capture the range of typical vegetation in this region. In addition, the hemlock-site observations will serve as a baseline for the anticipated decline in this stand as it is infested by hemlock wooly adelgids, an exotic pest that kills hemlocks over a span of 5-15 years. The species has been expanding its range northward and is now present at Harvard Forest.

MAJOR FINDINGS

Whether eddy-covariance data could be reliably aggregated to provide annual carbon balances was unclear at the outset. Continuous long-term measurements required a different strategy than intensive campaigns. Intense operator attention that is practical for

nus strobus) and red pine (*P. resinosa*). Above-ground biomass in trees larger than 10 cm in diameter at breast height (dbh) was 127 Mg (C) ha⁻¹ at the end of 2011.

Topography and variations in land-use at the scale of individual farm plots in 17th-18th century have generated a heterogeneous vegetation pattern, with gradients in species composition and a range of past land use including cultivation, pasture, and uncleared woodlots. Based on tree-ring analysis, the oldest oaks were growing prior to 1895. The rest were present by 1930 or in 1938 after a major hurricane. The flux measurements are made from a 30-m triangular cross section tower that extends

above a 24-m average canopy.

The flux tower measurements are complemented by biomass observations on an array of 34 plots extending out to 500 m aligned with the predominant NW to SW wind direction. Each plot is 10 m in diameter and all trees thicker than 10 cm are identified and fitted with dendrometer bands that monitor their growth. Additional measurements include annual litter inputs, sorted by species, and leaf-area index (LAI; the area of leaf surface per square metre of ground) measured frequently over the course of the growing season.

In 2000, led by Julian Hadley, a second flux tower was established in a hemlock-dominated stand 600 m WNW

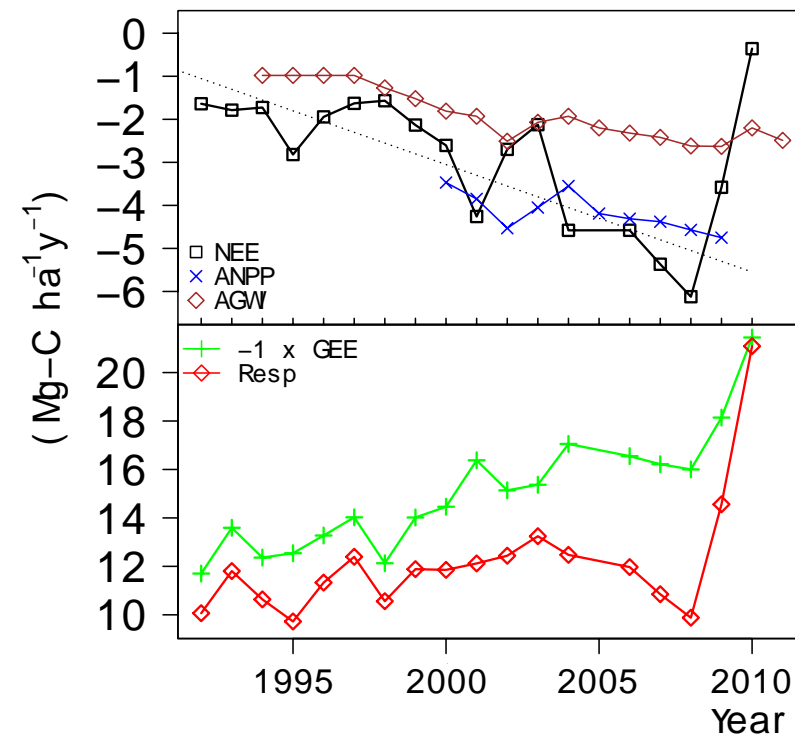


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In large-stature vegetation the pace of ecosystem change is slow and the turnover times of the major carbon pools range from decades to century. Equally long observational records are necessary to observe response to these environmental changes.

a few days or weeks in a focused field campaign could never be kept up for round-the-clock operation throughout the year. Automation of the instrument calibration, data collection and initial data processing was essential [8]. Calibrations of everything from CO₂ analysers to the basic temperature and light sensors had to be part of standard operation protocols to ensure data comparability over time.

Over the first 5 years, we demonstrated that hourly data could be aggregated to determine defensible sums on seasonal to annual intervals. Annual net ecosystem exchange of CO₂ between the forest and the atmosphere (NEE) ranged from 1.4 to 2.8 Mg (C) ha⁻¹y⁻¹. This calculation required accounting for periods of low turbulence at night (when the eddy-covariance method does not work) and for other missing data periods (aka ‘gap filling’). Importantly, the integrated fluxes were consistent with biometric carbon budgets [9-10].

After 13 years, we were able to say that the forest exhibited a clear, significant overall trend toward increasing annual net carbon uptake [11] (Fig. 2), which was somewhat surprising given that the forest was already nearly 100 years old and ought to be approaching a steady state carbon balance with annual average NEE=0. The overall trend toward increasing carbon uptake continued beyond 2004 and reached annual carbon uptake approaching 6 Mg (C) ha⁻¹y⁻¹ in 2008. More importantly, continuous long-term eddy covariance measurements allowed us to quantify changes in ecosystem-scale physiological parameters such as photosynthetic efficiency resulting from



disturbance events and recovery phases that stretched over several years. We saw a reduction in LAI and mean CO₂ uptake at high light in 1998 that did not fully recover until 2001 (not shown). The cause of the LAI reduction in 1998 was subtle: a combination of unfavourable growing conditions during spring leaf out rather than any one discrete event. On another occasion in December 2008, an ice storm affected the region. We measured 0.57 and 0.46 Mg (C) ha⁻¹ inputs as coarse and fine woody debris from storm damage to the canopy and an average reduction of 0.86 m² m⁻² in LAI the following summer in 2009. Heterotrophic respiration of the debris likely contributed to the increased CO₂ emission in 2009 and 2010 (Fig. 2). However, increased respiration alone cannot account for the dramatic decrease in annual NEE from the peak 6 Mg (C) ha⁻¹y⁻¹ in 2008 to near zero by 2010 (Fig. 2).

Nature does not give up its secrets easily, but some factors that contribute to the accelerating carbon uptake observed at Harvard forest have emerged. Carbon gain was dominated by accumulation of biomass in red oaks. Oaks have higher light-use efficiency than maples and, as their relative contribution to the canopy increased, the overall light-use efficiency increased as well, which we observed in the data as

Figure 2. Time series of carbon exchanges at the Harvard Forest EMS tower. Top panel shows net ecosystem exchange (NEE) measured by eddy covariance (negative values indicate a net downward CO₂ flux from atmosphere to forest) together with annual biomass increment in trees with dbh > 10 cm (above-ground wood increment, AGWI) and estimated above-ground net primary production (ANPP) that combines wood and litter production. Bottom panel shows the estimated partitioning of NEE into ecosystem respiration and gross ecosystem exchange (GEE) (inverted to plot on the same scale as respiration (R)).

increasing magnitude of mid-summer CO₂ uptake at optimum light from 22 to 30 mmole m⁻²s⁻¹ between 1992 and 2004 [11].

However, the oak light-use efficiency alone cannot account for the trend, and indeed we observed two other contributing factors: firstly, an extension of the active growing season by 60 days because climate has warmed (0.3 °C decade⁻¹ increase in annual temperature from 1964 to 2010); and secondly, an increase in the relative biomass of conifers especially in the subcanopy layer over the past 20 years that has led to significant CO₂ uptake in the early spring before the broad-leaf canopy has emerged. The rate of the conifer CO₂ uptake is about half that of the nearby hemlock stand during the same month. These last two points demon-

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Ancillary biological measurements (biomass, litter production, LAI, soil carbon pools) turn out to be critical constraints on the slowly evolving processes controlling interannual variability and decadal trends.

strate the power of long-term observations in detecting ecosystem responses to climate and in witnessing the influence of natural forest succession.

Interpretation of continuous observations within a modelling framework provides key insights into the long-term response of forest ecosystems. Variations in carbon exchange from one hour to the next are well understood; ecosystem process models or even statistical fits to temperature and light response functions capture up to 80% of the variance at the hourly time step using fixed parameters derived from a period of data and observed meteorology, but this cannot be aggregated to accurately predict interannual variability and decadal patterns [11-13]. The clear message is, firstly, that environmental variability is not directly responsible for long-term variability ecosystem carbon exchange; ecosystem functional attributes are not constant over time. Secondly, developing improved understanding at this scale requires more than flux data alone; the measurements that are considered ancillary biological data (biomass, litter production, LAI, soil carbon pools) turn out to be critical constraints on the slowly evolving processes controlling interannual variability and decadal trends [14].

CONCLUSIONS

Though we have gained some understanding of how the Harvard Forest ecosystem functions, the trend of increasing carbon uptake is still not fully explained. Biomass observations show that annual above-ground net primary production (NPP = photosynthesis – plant’s own maintenance respiration)

is comparable to the annual NEE (NEE = NPP – soil respiration by microbes), but not all of the carbon has shown up in the wood (Fig. 2), hence some of the accumulated carbon may be vulnerable to eventual loss if it is stored in reservoirs with shorter turnover times. As we enter a new decade, we see from the sharply reduced NEE in 2010 that the forest may be ready tell us something new yet again leaving us to figure out why a decade-long pulse of high carbon uptake might come to an end. ■

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Long-term integrated ecosystem-atmosphere observations – the Hyttiälä philosophy



Timo Vesala is Professor of Meteorology (Department of Physics, University of Helsinki). He currently directs the Micrometeorology and Atmosphere-Biosphere Interactions research group of about 15 persons. He is the advisory board member in ICOS – Integrated Carbon Observation System and he directs ICOS-Finland. His research interests cover many aspects of ecophysiology and micrometeorology with new interdisciplinary approaches, such as combining flux measurements over different ecosystems (forest, wetland, lake, urban surface) with underlying process understanding and developing physico-biological modeling of tree hydrology and peatland methane emissions. The flux measurements do not include only greenhouse gases and energy but also ozone and aerosol particle deposition.

The biosphere interacts with the atmosphere via the exchange of mass, heat and momentum. Central for these processes is the tight coupling of transport phenomena, phase transitions, and plant metabolism. The metabolic processes create sources and sinks which act as driving forces for transport, either molecular (diffusion) or convective (bulk flow). The main idea of the SMEAR II (Station for Measuring Ecosystem Atmosphere Relations) infrastructure in Hyttiälä (southern Finland) is to accommodate continuous, comprehensive measurements of fluxes, storage, and concentrations of material and energy in the land ecosystem-atmosphere continuum [1-4]. The aim is to clarify how different ecosystem processes influence and interact with atmospheric processes.

Simultaneous measurements of several phenomena in a forest ecosystem and the atmosphere at different temporal and spatial scales enable not only the analysis of carbon, nitrogen and water circulation, but also an analysis of how substances emitted by the ecosystem contribute to biogenic aerosol formation, cloud formation, and atmospheric chemistry. The Earth system behaves in a complex, non-linear manner. The understanding of complex processes from molecular to larger scale (up to global by field-site networks, satellites, and models) requires multi-variable, multi-compartment and multi-disciplinary observations.

“*Comprehensive, long-term observations enable confirming unexpected results by other, independent measurements.*”

Based on this thinking and in order to answer some challenging questions, Prof *emeritus* Pertti Hari (Department of Forest Sciences (DoFS), University of Helsinki (UHEL)) and Academy Professor Markku Kulmala (Department of Physics (DoP), UHEL) started to plan the SMEAR II station more than 15 years ago. The first SMEAR station (SMEAR I) in remote eastern Lapland had started to operate already in 1991 with much smaller measurement capacities. For SMEAR II, Hari and Kulmala planned that the material and energy fluxes and the metabolic and physical processes generating atmospheric fluxes should be in the focus of the measurements.

Naturally, the planning and construction of the SMEAR II station was a team effort. Eero Nikinmaa (DoFS, UHEL) took care of tree measurements, Hannu Ilvesniemi (now in Finnish Forest Research Institute) of soil measurements and Timo Vesala of micrometeorological measurements. The technical designers and builders were Toivo Pohja (hardware; Hyttiälä Forestry Research Station), Erkki Siivola (electricity; DoP, UHEL) and Tapani

Lahti (programming; Finnish Museum of Natural History). At SMEAR II, we have always been blessed with skilful, committed and laborious technical staff that have actively developed the measuring setup and its maintenance. Their contribution has been crucial and should not be forgotten.

Test measurements at SMEAR II started in August 1995 and by winter 1996, the station was operational. However, as instrumentation develops rapidly, we have expanded the measuring system continuously. Currently, electric failures after storm events are the main reason for measurement gaps; otherwise the system is always running and measuring also in winter when the

temperature may be low, even $-30\text{ }^{\circ}\text{C}$.

At the core of the SMEAR II station ($61^{\circ}51'\text{N}$, $24^{\circ}17'\text{E}$, 181 m above sea level) is a Scots pine (*Pinus sylvestris* L.)-dominated stand that was established in 1962 by sowing after the area had first been treated with prescribed burning and light soil preparation. The forest floor vegetation is dominated by lingonberry, blueberry, and mosses; it is an important and integral part of the ecosystem [5]. The annual mean temperature in Hyytiälä is 3°C and precipitation 700 mm (1960–2000). The station represents boreal coniferous forests, which cover 8% of the Earth's surface and store about 10% of the total carbon in terrestrial ecosystems.

The main components at SMEAR II are

- A 127-m-high instrumented tower (extended in 2010 from the original 73 m in order to reach above the surface layer; Fig. 1) with basic meteorological measurements and gas profiles (7 levels)
- Aerosol and air chemistry monitoring
- Monitoring of tree and soil functioning and radiation
- Two small, instrumented water catchment areas
- Two above-canopy and one sub-canopy eddy covariance (EC) measurement set-ups
- Further EC measurements for O_3 , BVOC (biogenic volatile organic compounds) and aerosol number fluxes
- Automatic chamber measurements for CO_2 , H_2O , NO_x , O_3 , N_2O , CH_4 , and BVOC fluxes.



The long-term carbon and water balance components are presented in [6] and in [7], respectively. Additional flux measurements are carried out at a nearby wetland, Siikaneva fen [8] and at Lake Kuivajärvi. A third SMEAR station (SMEAR III) is in operation in the city of Helsinki and consists of two flux towers (in Kumpula campus and in city centre) and of comprehensive aerosol and air chemistry measurements (campus) [9].

To illustrate the added value achievable from versatile measurements carried out at a single site, we give three concrete examples from SMEAR II observations:

- 1 Kulmala *et al.* [10] studied the connection of carbon exchange with aerosol dynamics. The analysis was based on simultaneous measurements of aerosol formation and growth rates, carbon dioxide fluxes, and monoterpene concentrations and revealed a potentially important feedback among forest ecosystem functioning, aerosols and climate (Fig. 2).

Figure 1. A comprehensive measurement station needs proper facilities. a) The 127-m-tall measuring tower (photo: J. Aalto) and b) (next page) a cottage where measured values are stored and monitored (photo: P. Hari).



2 Vesala *et al.* [11] studied the effect of commercial thinning performed in the Hyytiälä pine stand. The analysis was based on simultaneous measurements of CO₂, water vapour, ozone, and aerosol particle fluxes. The somewhat controversial result was that the thinning decreased the deposition velocities of fine particles but did not affect (within detection limits) the carbon sink, evapo-transpiration and ozone deposition.

Although aerosol deposition is still not well understood and includes very difficult open questions [12], the effect of thinning to particle deposition was clearly very straightforward: less foli-

age led to less deposition since depositing particles do not enter into stomata and do not directly interact with biological processes. That the carbon sink, evapotranspiration, and ozone deposition remained seemingly unaffected by a significant thinning was surprising indeed. The result was attributed to redistribution of biological sources/sinks and changes in stomatal conductance resulting from increased light penetration and decreased among-tree competition that compensated the effects of the thinning. Without multi-year, multi-component surface flux records this finding could not have been obtained.

3 The eddy-covariance method of measuring gas fluxes between the atmosphere and a forest requires very accurate information of all local air mass transport mechanisms: vertical and horizontal advection (steady bulk motion of air, typically downhill) and turbulent transport of air parcels. An ideal measuring site would be so flat and uniform in all directions that advection would be absent altogether and only turbulent transport would remain.

Typically, however, advection exists and is dominant at night time. Mammarella *et al.* [13] made the surprising observation that instead of horizontal advection (transport of air mass along the ground, usually down a slope, decoupled from any vertical transport), CO₂ exchange in Hyytiälä is actually dominated by vertical advection (the downhill-flowing air replaced by more air coming down from above the forest). This is a rare result but plausible, given that the measuring tower at the SMEAR II station is located at the top of a small hill where air can flow down at all sides and replaced by air coming down from above the measuring tower.

However, this observation is not common and to ensure the validity of our result, we utilised the possibilities of our comprehensive measuring site and repeated the analysis using long ozone (O₃) flux and concentration profile records [14]. O₃ and CO₂ behave very differently at night: O₃ is mainly removed from the atmosphere by depositing down on the foliage (downward flux), whereas CO₂ is released up from the soil (upward flux). Our O₃ analysis showed similar dominance of vertical advection and thus confirmed our earlier result for CO₂.

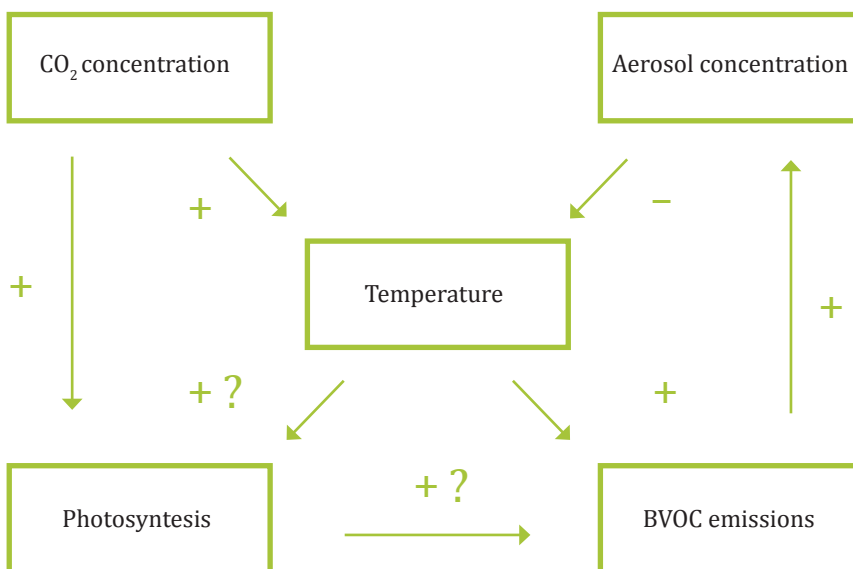


Figure 2. Schematic picture of the coupling of atmospheric CO₂ concentration, photosynthesis, emissions of biogenic volatile organic compounds (BVOC) and aerosol concentration with atmospheric temperature (adapted from [10]). CO₂ fertilisation increases (+) photosynthesis and globally increasing temperature is likely to lead (+?) to increased photosynthesis. An increase in forest biomass would likely increase BVOC emissions and thereby enhance organic aerosol production. Enhanced aerosol and cloud condensation nuclei concentrations will decrease temperature, thus creating a feedback mechanism among CO₂, aerosols, and temperature.

The research conducted at SMEAR II is the result of very close co-operation between physicists and forest ecologists. SMEAR II may in fact be the only measuring station that is planned and constructed to measure all relevant aspects of a forest ecosystem that cover both ecological phenomena and atmospheric physics. Over the years, the measurements at SMEAR II station have contributed to over 20 Nature and Science papers. The versatile infrastructure also acts as an ideal site for testing of new instruments and prototypes and educating students. These are important future aspects in ICOS (Integrated Carbon Observation System; <http://www.icos-infrastructure.fi/>) in addition to its main aim of providing long-term data on atmospheric greenhouse gas concentrations and their fluxes.

To be able to cover regional and global spatial and temporal variations, Hari *et al.* [4] suggested that a hierarchy of stations from basic level to flux and to flag-ship level is necessary. The number of flag-ship stations (such as SMEAR II) with very demanding scientific and technical requirements cannot be high, but approximately 20 stations in different ecosystems should be constructed. However, lower level flux and atmospheric stations (like those in FLUXNET and ICOS) should preferably go beyond mere greenhouse gas measurements as well and accommodate some other trace gas and aerosol measurements. An efficient multi-compartment measurement philosophy includes also the establishment of other smaller sites nearby the main flagship site, as we have done in Hyytiälä, accompanying it with observation platforms at the Siikaneva fen/bog and at the nearby Lake Kuivajärvi. Long-term, multi-disciplinary monitoring of terrestrial water bodies is a very important, emerging field [15]. It requires a measurement philosophy of its own [16].

Nevertheless, one must remember that field observations alone will not answer all our open questions. Comprehensive biogeochemical and atmospheric research requires theoretical frameworks, long-term field observations at different spatial and temporal scales together with remote sensing,

intensive measurement campaigns, laboratory experiments, process models and Earth system models. ■

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Cross-disciplinary research collaboration and training during integrated long-term environmental observations



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To predict global climate change and its influence on ecosystems and human societies, reliable understanding of land surface - atmosphere interactions is essential. Developing monitoring systems for the early detection of biological feedbacks to climatic change has thus become an urgent issue for monitoring the spatial distribution and temporal variation of energy, water, and greenhouse gas (GHG) fluxes.

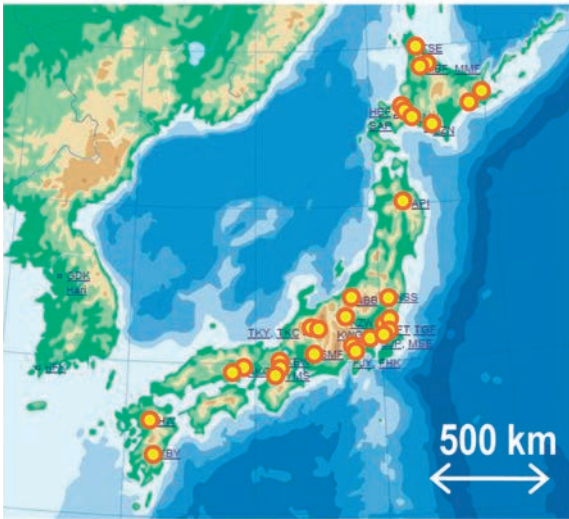
Biological feedbacks to climate change, especially global warming, include positive and negative feedbacks. Examples of positive feedbacks include higher temperatures bringing higher emissions of GHGs (CO₂ and CH₄) from permafrost in Arctic regions and irreversible changes that may occur in vulnerable ecosystems, such as peatlands, leading to enormous amounts of CO₂ emission. Examples of negative feedbacks include, for instance, higher temperatures expanding the growth area of plants in higher latitudes and altitudes and the rising atmospheric CO₂ concentration enhancing the growth rate of plants by a fertilisation effect if the soil nutrient availability is sufficient.

Cross-disciplinary research collaboration helps scientists develop integrated long-term observation networks to study such feedbacks. Recent studies [1,2] have proposed developing a hierarchical network of observatories for future land ecosystem-atmosphere process studies, such as (i) basic level sites for monitoring temperature

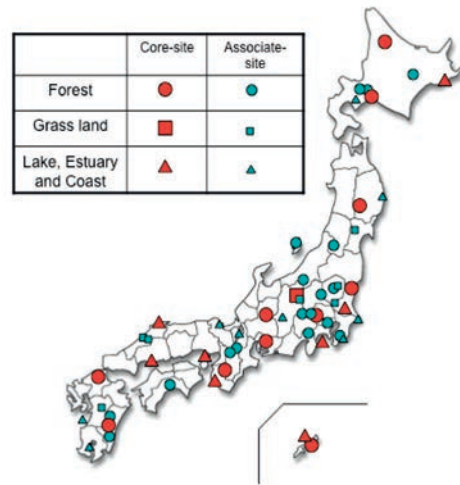
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All life is constantly changing. The best we can do is to monitor these changes and create integrated, multidisciplinary datasets for the future.

and water environments and trace gas concentrations, (ii) flux level sites including GHG fluxes, and (iii) flagship level sites covering additional reactive gas fluxes and environmental variables in higher spatial resolutions. Here, we would like to emphasise focusing more on monitoring biological processes directly and detecting changes in the processes, as they are the key drivers of energy and gas exchange. It is crucial to observe the roles of plants, animals, and microorganisms in relation to production, decomposition, nutrient cycling, species composition (biodiversity), vulnerability and resilience, invasion, and succession, among other processes.

Living things are always changing. They move (migrate), adapt their structure and physiological responses to environmental changes, and evolve. Since we do not have enough understanding to predict future changes in the biosphere, the best we can do at present is to start monitoring at appropriate platforms in the world as soon as possible and create integrated datasets for the future.



Sites in JapanFlux



Sites in JaLTER

Full-scale collaboration among different disciplines is not easy, but sharing terrestrial monitoring platforms is one of the upfront strategies to overcome this difficulty. The US National Ecological Observatory Network (NEON; <http://www.neoninc.org/>) and the European Integrated Carbon Observation System (ICOS; <http://www.icos-infrastructure.eu/>) are leading the scientific world in the direction of “new harmonised networks for Earth System observations” [2]. In Asia, on the other hand, more attention should be paid to monitoring ecosystem degradation and biodiversity, particularly in tropical regions, where climate change mitigation is in conflict with biodiversity conservation. Malaysia has become one of the major palm oil -producing countries, and the influence of the resulting large-scale deforestation and loss of natural biodiversity on carbon management and mitigation of climate change is unknown [3].

Furthermore, large areas of tropical peatland in Indonesia are undergoing degradation, namely, climatic or artificial influence that shifts the ecosystem’s carbon balance from a net sink to a source [4]. Developing reliable monitoring systems that include sustainability and resilience of the local ecosystem and society is a critical issue, as is establishing and operating the REDD (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) and MRV (Meas-

uring/Reporting/Verification) systems successfully.

In the mid-latitudes, the rapid industrialisation of Asian countries, such as China and India, has led to increasing emissions of GHGs and atmospheric pollutants. Nitrogen deposition is increasing in downwind countries, such as Korea and Japan [5], as confirmed by a chemical transport model validated by the data of Acid Deposition Monitoring Network in East Asia (EANET; <http://www.eanet.cc/>), but the effect on the ecosystems is still unknown. Global warming may alter Asian monsoon circulation as well as the length and strength of the summer rainy season and storms (typhoons), which directly affect the spatial distribution of productivity and regime of disturbance in Asia [6,7].

Under these circumstances, the JapanFlux (one of sub-networks of AsiaFlux and FLUXNET) and Japan Long Term Ecological Research network (JaLTER; <http://www.jalter.org>) have started working together by sharing sites, data, and observational skills toward maintaining long-term comprehensive observation networks (Fig. 1). The “Monitoring Sites 1000” was founded in 2003 by the Ministry of the Environment of Japan, aiming at biodiversity monitoring for the long term (~100 years) at approximately 1,000 locations in various ecosystems, including forests, grasslands, lakes, and coastal areas. JaLTER and Monitoring

Figure 1. Spatial distribution of JapanFlux sites and JaLTER sites. Images are modified from original maps in the AsiaFlux web page (<http://asiaflux.net/>) and JaLTER brochure with permission.

Site 1000 are trying to establish a nationwide system for monitoring the structure, function, and diversity of ecosystems [8].

The Japan Aerospace Exploration Agency (JAXA) is developing collaborations with sites of JapanFlux and JaLTER under the Global Change Observation Mission (GCOM) to gain long-term validation datasets. The Phenological Eyes Network (PEN; http://pen.agbi.tsukuba.ac.jp/index_e.html) is expanding the ground observation of vegetation dynamics (phenology) and their optical properties using spectral radiometers and camera images. In addition to ecosystem-atmosphere exchange of GHGs, the present challenge

“ *Cross-disciplinary observation platforms may help us detect long-term changes in ecosystem functions as well as biological feedbacks to climate change that have not yet been found.* ”

is to evaluate ecosystem functioning, biodiversity and ecosystem services under changing climate. This initiative is led by GEO BON (Biodiversity Observation Network), in which a tight linkage between atmospheric science and ecological science is crucial.

Cross-disciplinary research collaboration and training efforts at integrated environmental observatories will take a long time to develop; however, their effects will be far-reaching, as follows:

1) Datasets acquired using different methods in different disciplines will be used for inter-comparison, verification, and better understanding of each process (see Fig. 2).

2) Comprehensive datasets will enable the development and testing of various process-based ecosystem models, which include processes such as energy/water/carbon cycles, emissions of GHGs and reactive gases, leaf phenology, nutrient cycle, plant growth, soil development, and change in species composition.

3) Additional studies, such as manipulation experiments for ecosystems, can be effectively added to those platforms, since the basic components are already being monitored.

4) Long-term and continuous ground-truth datasets with appropriate spatial resolution will have high value for direct comparison with airborne and satellite remote sensing data.

5) The research communities growing at integrated observation platforms will contribute to the education of young scientists by bridging different disciplines.

Cross-disciplinary research collaboration regarding integrated observa-

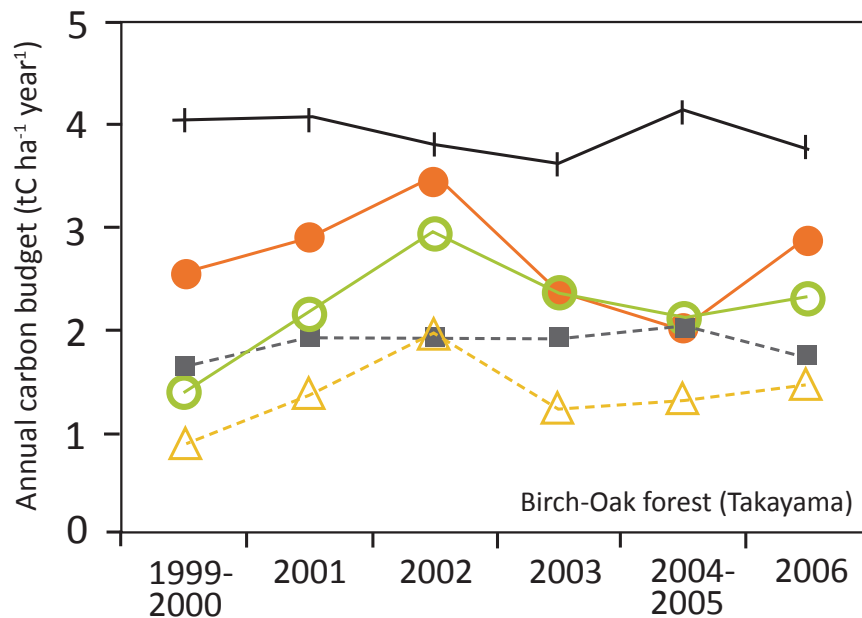


Figure 2. Year-to-year changes in annual carbon budget components observed at one of the comprehensive monitoring sites (Takayama deciduous broad-leaved forest site) where essential observations are maintained by Gifu University and the National Institute of Advanced Industrial Science and Technology (AIST). Each symbol represents the net carbon uptake (NEP) estimated by the eddy covariance method (red circles), NEP by the biometric-based method (green triangles),

annual woody tissue Net Primary Production (NPP) (blue triangles), foliage NPP (black squares), and heterotrophic respiration (open circles). This figure indicates the level of error in the estimation of NEP (difference between eddy covariance-based and biometric-based data) as well as the inter-annual variability inherent in each carbon budget component. Figure adopted from [9].

tions helps us develop important indices expressing various biological processes. The data acquired in such observations may have the potential to enable detection of long-term changes in ecosystem functions and structure as well as biological feedbacks to climate change that have not yet been found. ■

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Critical Zone Exploration Networks and integrated long-term ecosystem-atmosphere observatories



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The **Critical Zone** (CZ) is the heterogeneous, near-surface environment in which complex interactions involving rock, soil, water, air, and living organisms regulate the natural habitat and determine the availability of life-sustaining resources [1]. It is defined as the external terrestrial layer encompassing all fluid, mineral, gaseous, and biotic components extending from the planetary boundary layer and outer limits of vegetation through soils, sediments and any lithosphere's weathering products (such as regolith and saprolite) down to and including the zone of groundwater within bedrock (see, for instance, [2]). Therefore, CZ describes an important reactor in any landscape. In a more pithy kind, it could also be called the Earth's weathering engine [3], and, last but not least, it is the zone that hosts the terrestrial life on Earth [4]. To understand the CZ, crossing disciplines and scales is crucial.

Any understanding of landscape heterogeneity and ecosystem functioning is based on a sphere model that describes the interactions and back and forth coupling among the terrestrial spheres - atmosphere, pedosphere, lithosphere, hydrosphere, and biosphere. To develop a conceptual framework identifying the critical problems has been part of the ecological research for more than 70 years. In Germany, Carl Troll 1939 [5] and Josef Schmithüsen 1942 [6] outlined concepts and

identified the challenges in differentiating ecosystem processes occurring at multiple temporal and spatial scales.

C. Troll, a physical geographer and botanist, was the first scholar to identify the great possibilities which aerial photographs could offer ecological research. J. Schmithüsen wrote a book on vegetation research and site ecology and their implications for research on cultural landscapes. From early on, the potential of interdisciplinary approach and sphere models have been recognised as important constituents of landscape analysis. The concept of the Critical Zone (CZ) is a strategy to overcome the lack of theories concerning spatially explicit ecosystem functions. The approach is not new but is, nevertheless, necessary for formulating an operational approach to the sphere model within the interdisciplinary work on both ecosystem and landscape ecology.

For more than five decades, integrated long-term ecosystem-atmosphere observatories have existed over the whole globe, established by the UNESCO International Biological Program (IBP) and mainly operated by nations of the western world. In Germany, for example, the Solling-Project (1966-1973) was established by Ellenberg [7], while at the same time a more geoecologically orientated theme called the Schönbuch-Project was headed by Eisele [8]. Within the US, the Long-Term

Ecological Research Program (LTER) was established by the National Science Foundation (NSF) in 1980 to support research on long-term ecological phenomena in the United States. Today, it includes 26 LTER sites representing diverse ecosystems and research emphases. It is understood as a collaborative effort investigating ecological processes over long temporal and broad spatial scales, promoting synthesis and comparative research across sites and ecosystems and among other related national and international research programs. The eldest LTER site is Niwot Ridge on the Colorado Front Range (<http://culter.colorado.edu/NWT/>).

LTER Niwot Ridge is also involved in the newly launched US National Ecological Observatory Network (NEON), a continental-scale ecological observation platform designed to both detect ecological change and enable forecasting of its impacts (also NSF-funded). NEON will gather and synthesise data over 30 years on the impacts of climate change, land-use change and invasive species on natural resources and biodiversity. Obtaining integrated data on these relationships over a long-term

period is crucial for improving forecast models and resource management for environmental change (<http://NEON-inc.org>).

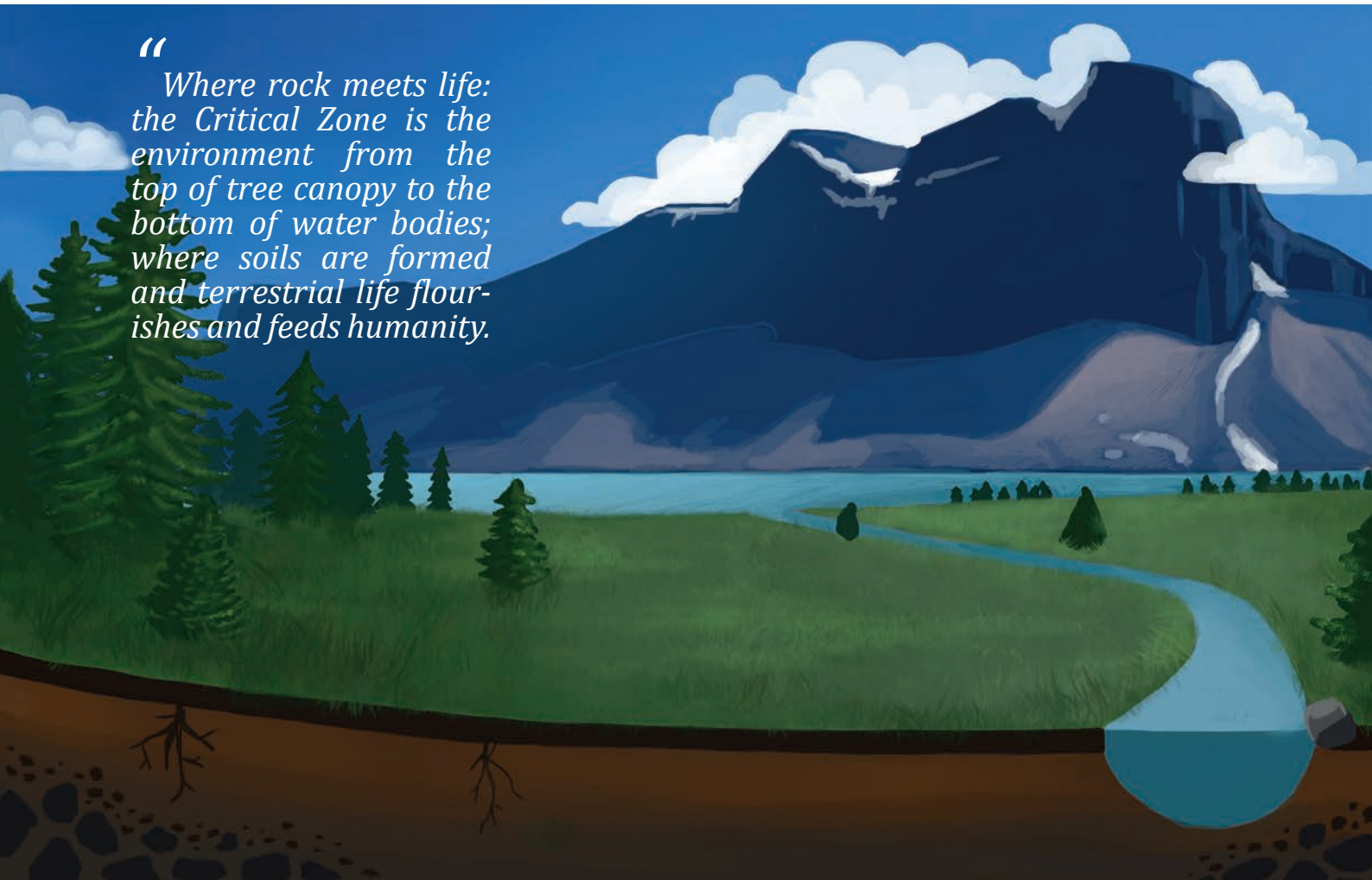
Discussing CZ Exploration Networks and integrated long-term ecosystem-atmosphere observatories, we come back to the LTER site Niwot Ridge at Colorado. LTER sites are not thought to be Critical Zone Observatories (CZO) because any LTER site is operating on questions of ecosystems ecology encompassing atmospheric processes as well; a CZO is orientated towards landscape ecology. CZOs “operate at the watershed scale and will significantly advance our understanding of the integration and coupling of Earth surface processes as mediated by the presence and flux of fresh water. Successful proposals will be motivated and implemented by both field and theoretical approaches, each providing the impetus for advances in the other, and they will include substantial and novel plans for education, outreach and broader impacts” (NSF 2006 <http://nsf.gov/pubs/2006/nsf06588/nsf06588.htm>).

Six CZOs have been established and funded by NSF since 2007. One of the

main topics is the shallow subsurface and its interaction with all terrestrial spheres combined in and highlighted by the CZ-concept. One of these CZOs is Boulder Creek Critical Zone Observatory (Bc-CZO). Even though the investigation area of Bc-CZO is not congruent with Niwot Ridge, it is situated nearby and involves parts of the alpine Niwot Ridge LTER. Therefore, it is necessarily partly a NEON site as well and interwoven with the above-named NSF-programs.

To develop a unifying theoretical framework, every CZO is working toward a holistic conceptual model of CZ evolution that integrates new knowledge of coupled hydrological, geochemical, geomorphic, and biological processes. This model includes both positive and negative feedbacks and their distribution in time and space. To develop coupled systems and models to explore how critical zone services respond to anthropogenic, climatic, and tectonic forcings, CZO is building systems models that quantitatively combine multiple processes, often spanning a whole watershed. These models typically track fluxes and storage of en-

“*Where rock meets life: the Critical Zone is the environment from the top of tree canopy to the bottom of water bodies; where soils are formed and terrestrial life flourishes and feeds humanity.*”





ergy, water, carbon, sediments, and/or other materials [4, 9, <http://CZO.org>].

The concept of CZ services expands on that of “ecosystem services” that was introduced in part as a framework for considering the many benefits or services provided by both near-natural and highly-managed ecosystems [10] by explicitly including the coupled hydrologic, geochemical, and geomorphic processes that underpin ecosystem processes (<http://CZO.org>).

Arising out of the CZO program, a Critical Zone Exploration Network (CZEN) has been established. CZEN is a set of observatories chosen along gradients in environmental variables. This network acts as a community of people and a network of field sites investigating processes within the CZ. CZEN members are a diverse group of researchers and educators who study the physical, chemical and biological processes shaping and transforming Earth’s Critical Zone. This research spans a wide range of disciplines including geosciences, hydrology, microbiology, ecology, soil science, and engineering.

CZEN encourages all researchers working in the Critical Zone to join the effort by registering on this site and contributing content. CZEN’s primary goal is to create a network of observatories for investigating Critical Zone processes such as weathering and soil formation. Through this network, researchers can access and integrate data in a way that allows isolation of environmental variables and comparison of environmental effects across gradients of time, lithology, human disturbance,

biological activity and topography [2].

The EU-project SoilTrEC (Soil Transformation in European Catchments) is a form of CZO-project establishing four CZO sites within the EU. “The crucial challenge for the SoilTrEC project is to understand the rates of processes that dictate soil mass stocks and their function within Earth’s Critical Zone (CZ). The CZ is the environment that extends from the top of the tree canopy to the bottom of our drinking water aquifers; where terrestrial life flourishes and feeds most of humanity. The heart of the CZ is where soils are formed, degrade and provide their essential eco-services. Whilst our understanding of the CZ has increased over the last 100 years, further advance requires scientists to cross disciplines and scales to integrate understanding of processes in the CZ, ranging from the nano to the global scale.” (<http://soil-trec.eu>)

In Germany, the Helmholtz Gemeinschaft Deutscher Forschungszentren (HGF) has financed the TERENO network to carry out terrestrial environmental observations. TERENO is an Earth observation network across Germany extending from the North German lowlands to the Bavarian Alps (for instance, one of the four sites is TERENO South [Bavarian Alps / Prealpine]). This unique large-scale project aims to catalogue the long-term ecological, social and economic impact of global change at regional level. Scientists and researchers will use their findings to show how humankind can best respond to these changes (<http://teodoor.icg.kfa-juelich.de/>).

Another newly launched research initiative is the TUM-Critical Zone Observatory (TUM-CZO), launched in cooperation with TERENO South, at the watershed scale within the Ammer Rv. catchment. TUM-CZO is carefully following the CZO-concepts in defining specific research aims as well as outlining ecosystem functions and services in the context of climatic variations and land-use change. At this research site, different science communities have complementary needs and ideas, but they collaborate with a shared infrastructure (<http://geomorphologie.wzw.tum.de>). Because of its hypsometric gradient, accentuated differentiations in altitudinal belts, climatic and meteorological phenomena, landscape change and changes in land use over more than 8000 years, TUM-CZO has the potential to become a “super site” within the CZ exploration network and integrated long-term ecosystem-atmosphere observation. ■

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Welgegund - long-term land-atmosphere measurement platform in South Africa

Apart from its regional economic prominence, South Africa (SA) is an important source of various atmospheric pollutants generated by, for instance, biomass burning and the NO₂ hotspot over the SA Mpumalanga Highveld [1]. SA is also globally regarded as the 9th largest sulphur emitting country [2].

Historically (prior to 2005), air quality (AQ) measurements in SA were mainly performed by industries for compliance monitoring whereas atmospheric research studies were limited to short-term intensive campaigns (such as SAFARI-92 and 2000) or less comprehensive long-term measurements. The Cape Point Global Atmospheric Watch (GAW) station is the most comprehensive long-term station in SA. However, it is not representative of the

continental interior, since it is mostly influenced by marine background. It is also removed from the industrial hub of SA and is not influenced by meteorological conditions dominating the interior.

To partially address the need for longer-term comprehensive data sets that are regionally representative, the University of Helsinki (Finland), the North-West University (NWU SA) and the Finnish Meteorological Institute initiated various measurement campaigns [3-8]. In mid-2010, the instruments used in these measurements were consolidated into a permanent long-term land-atmosphere measurement station at Welgegund (26°34'10"S, 26°56'21"E, 1480 m.asl) that can be regarded as the best equipped in southern Africa

(<http://www.welgegund.org/>).

The location was chosen because there are no major pollution sources nearby and the entire sector from north to south-east is representative of the regional background of the SA interior. However, the site is frequently influenced by plumes from four industrialised source regions (all within 100-300 km from the site) in the industrial hub of SA:

- In the north to north-eastern sector lies the western limb of the Bushveld Igneous Complex (BIC), containing eleven pyrometallurgical smelters occurring within an approximately 55-km radius. The BIC produces most of the world's chromium and platinum group metals (PGMs). PGMs are primarily used in automotive catalytic converters; hence the international importance of this region. AQ standards in the western BIC are frequently exceeded [6].
- In the north-eastern to eastern sector lies the Johannesburg-Pretoria megacity (>10 million people). This area is relatively heavily polluted and, because of the large population affected by the pollution, deserves more research attention [1]. Megacities also influence regional and global atmospheric chemistry [9].



Figure 1. South African post-graduate students working at the Welgegund station.

- In the eastern to south-eastern sector lies the Vaal Triangle, where most of the SA petrochemical and related chemical industries are concentrated, together with other large point sources. This area, together with the southern Gauteng province was proclaimed as a national air pollution hotspot. This indicates that the government recognises that AQ standards are regularly exceeded and that improvement is required.

- To the east of the megacity and the Vaal Triangle lies the Mpumalanga Highveld, containing eleven coal-fired power stations (without de-SO_x and de-NO_x technology), several pyrometallurgical smelters and numerous other point source, all within an approximately 50-km radius. This region (eastern Gauteng and western Mpumalanga) was also proclaimed as a national air pollution hotspot.

Geographically, Welgegund is also located within an elevated plateau known as the SA Highveld. The meteorological conditions over the Highveld are quite unique, dominated by anticyclonic recirculation patterns and frequent formation of multiple inversion layers.

The vegetation type at Welgegund is known as the Vaal-Vet Sandy Grassland (~22750km²). Only 0.3% of it is currently conserved, while the rest is mostly used for farming. To be regionally representative, the station was located on a commercial farm, with the immediate area being grazed. The Vaal-Vet Sandy Grassland forms part of the Dry Highveld Grassland Bioregion, which covers a third of the surface of SA. Most of SA's staple food is cultivated in this bioregion. Long-term measurements could therefore be used to better quantify the influence of AQ (such as elevated ozone) on crops and the effects of climate change on food security, as well as ecosystem sustainability in southern Africa.

In addition to the afore-mentioned strategic positioning, the location of the Welgegund station close to the NWU dramatically improves its sustainability because of the logistical ease of access and the availability of support services.

Continuously operating equipment at Welgegund include basic meteorology (temperature, pressure, relative humidity, wind speed and direction, precipitation intensity, vertical temperature difference), aerosol number size distribution (12 – 840 nm), ion number size distribution (0.4 – 40 nm), mass of aerosol particles smaller than 10 μm (PM10), aerosol light absorption, aerosol light scattering, trace gas concentrations (SO₂, NO_x/NO, O₃, CO), various direct and reflected radiation wavelength ranges, flux measurements (H₂O, CO₂ and sensible heat) and soil measurements (T, moisture and heat flux).

Interdisciplinary botany and entomology studies have also been initiated, with surveys being conducted four times per year on several transects. Complementing soil chemical analyses have also been performed.

To date, several measurement campaigns have also been undertaken: PM10 Aerosol Chemical Speciation Monitor (ACSM) in collaboration with Aerodyne, vertical column measurements in collaboration with Penn State University (USA), volatile organic compound (VOC) measurements and GCXGC-TOFMS analysis of organic components.

From the first fifteen months of operation (6/10-8/11), several papers are already in preparation, including articles on plume characterisation of the various source regions; the characterisation of biomass burning plumes, PM10 chemical speciation, a comprehensive temporal VOC study and a flux measurements paper.

What does the future hold for the Welgegund station? The focus will be on the collection of high-quality data with the core set of instruments operating over the long term, adding instrumentation over time and conducting campaigns to complement the data set. Although the core partners are likely to remain SA/Finnish, other international cooperation is welcome. Long-term finance of the operational costs and limited availability of technical support personnel are likely the main future challenges.

From a socio-economic perspective, knowledge gained will aid in miti-

gating AQ, climate change and food security challenges that southern Africa is facing. The post-graduate students trained at this facility will also be well equipped to improve in situ measurement platforms throughout southern Africa, which will enhance the overall level of scientific understanding of the region and improve the quality of life for the inhabitants. ■

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Development of the European ICOS Research Infrastructure

Climate change is one the most challenging problems that humanity will have to cope with in the coming decades. Long-term coordinated and standardised observations of greenhouse gas concentrations provided by ICOS (Integrated Carbon Observation System) help to reduce the uncertainties of future projections and predict the future behaviour of the global carbon cycle and greenhouse gas emissions. ICOS data will enable us to determine the carbon balance of Europe for the first time, as well as the extent to which emissions of greenhouse gases are being absorbed by the land surface. As a result, researchers will be able to better inform policy-makers, providing annual updates of the carbon balance of Europe. They will also be able to evaluate the effect of extreme events such as drought and to estimate the contribution and reaction of terrestrial ecosystems to the changing climate.

ICOS is a pan-European distributed research infrastructure aimed to function for the next 20+ years. The back-

bone of ICOS consists of the coordinated operative ICOS observing networks for harmonised atmospheric, ecosystem and ocean greenhouse gas measurements. The European central facilities constructed largely in France (Atmospheric Thematic Centre), Italy (Ecosystem Thematic Centre), and Germany (Central Analysis Laboratory) support their activities in data management, sample analysis and quality assurance.

The location of the Ocean Thematic Centre and the Carbon Portal will be confirmed by the end of 2012. The Carbon Portal will provide central access, data services and end products for the user community, including researchers and decision makers. The headquarters will have a central role in strategic scientific and technical planning and coordination, managing the ICOS legal entity and community building and outreach.

11 countries willing to participate in establishment of ICOS ERIC (European Research Infrastructure Con-

sortium) have signed a Letter of Intent (LOI) giving Finland a mandate to lead the negotiations among the potential ICOS member countries and to set up the legal entity for operative phase. During the preparatory and construction period the highest decision-making body in ICOS is the ICOS Stakeholder Interim Council, ISIC, established in April 2010 as a high-level council for country representatives to discuss and approve strategic issues such as legal, governance and financial implementation, site selection, and facility location. ISIC made a decision in February 2012 to locate the ICOS headquarters in Finland. The European Community legal framework for ERIC is a specific legal form designed to facilitate the joint establishment and operation of research infrastructures of European interest.

The preparatory phase project (<http://www.icos-infrastructure.eu>), with 17 countries participating, is funded by the European Commission (2008-2013) and coordinated by France. After the preparatory phase the construction phase of the research infrastructure continues and at the same the networks are being progressively extended, instrumented and upgraded in the countries. ICOS will be fully operative in 2014 with near-real-time data available on line. ■

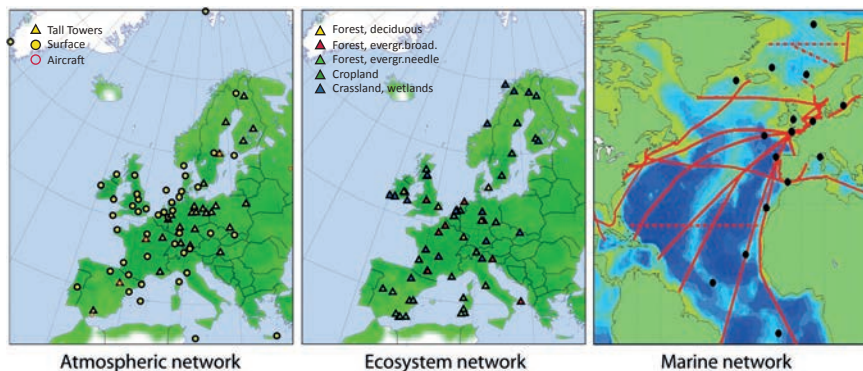


Figure 1. Planned ICOS station networks for atmosphere, ecosystem and marine measurements.



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Networking among young scientists

Young scientists devote substantial time to academic training by learning sophisticated measurement, modeling, and data analysis techniques. This is challenging and leaves little time for activities such as additional training in transferable skills (such as scientific writing, project and time management, presentation techniques) and networking among colleagues. However, these skills and networking activities are indispensable for a successful career in science and require venturing beyond the confines of the university or research group.

The main source for connecting to a network of scientific colleagues is one's academic advisor. This source for networking largely depends on the advisor's willingness and active efforts to share their scientific network. An additional and independent source can be networks established among young scientists themselves that provide access to the international community of scientists in an early career stage. Today's young scientists may become future leaders in their field and active networking among these colleagues provides the foundation for future collabo-

rations and projects.

This article provides an overview of networking activities in two international young scientist networks. At first, the objectives of the networking activities are described, followed by discussing the tools used for connecting young scientists, membership statistics, and concluding with considerations for improvements.

The FLUXNET Young Scientist Network (YSN) and the GHG-Europe YSN are two examples from the iLEAPS community that connect young scientists internationally. Their overall objectives are to establish a network among colleagues at an early career stage, and to provide an informal exchange platform for questions regarding research, career and funding opportunities. Both networks consider young scientists to be students (from undergraduate to PhD level) or postdocs, who do not lead their own research groups and who are not main supervisors of PhD students. 'Young' in this case refers to the career stage, and not the actual age of the members ('academic age' concept).

The main tools used for networking among the young scientists are a mailing list, an interactive website, and more recently an online networking platform called ResearchGate (RG, www.researchgate.net). These internet-based

Topic	Last Comment	Threads	Posts	Subscribe
Grants & Fellowships	With Abba http://www.abba.ethz.ch/... 1 day ago by Enrico Tomelleri	3	6	🔔
Meetings	Dear GHG-EU young scientists, I ho... 23 days ago by Enrico Tomelleri	9	9	🔔
Summer Schools	5th EUFAR FP7-EUROSPEC Training Cou... Mar 13, 2012 by Enrico Tomelleri	10	10	🔔
Job Offers	Research Fellowship to support a Ph... Jan 18, 2012 by Enrico Tomelleri	9	9	🔔
General discussion	http://www.hukseflux.com/products/p... Jul 28, 2011 by Enrico Tomelleri	2	2	🔔
Specific issues	A collections of useful information... May 2, 2011 by Sebastian Wolf	1	1	🔔

Figure 1. GHG-europe workgroup at ResearchGate

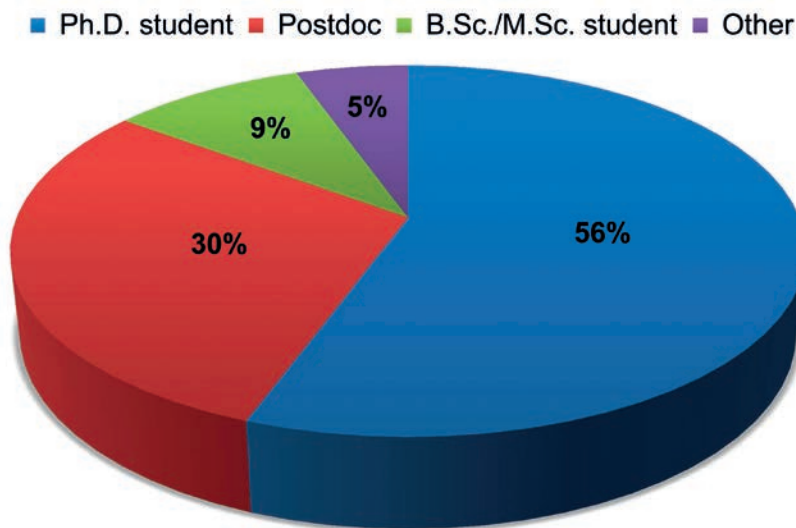


Figure 2. FLUXNET YSN member composition

networking activities are complemented by informal social meetings at conferences that provide the opportunity for direct interactions with colleagues. Such events are traditionally organized at big conferences (such as EGU General Assembly, AGU Fall Meeting, iLEAPS Science Conference) with attendance typically ranging from 20 to 40 people.

The mailing lists are currently the most actively used component of the YSNs, and are used to distribute job offers and announcements for workshops, summer schools and social meetings. To archive announcements, for scientific discussions, file exchange and to present oneself, the FLUXNET YSN has been using an interactive website (MS SharePoint -based). This setup is, however, limited to one particular network and cannot be linked to other platforms easily (*nota bene*: many members are part of several networks), or retained when not being ‘academically young’ anymore. Therefore, and with the increasing popularity of social networking media, both YSNs have recently implemented the platform RG to complement the networking activities.

RG is a social networking platform that can be seen as the ‘Facebook for Scientists’, but which extends Facebook’s capabilities into a professional context and provides specific tools for the scientific community. While Facebook is mainly used for private networking, RG is intended for professional networking among scientific

colleagues. Among these tools are discussion, file sharing and poll functionalities as well as the sharing of publications including citation and impact statistics. RG also provides a personal profile to present oneself with scientific interests and expertise, a key feature that is largely underestimated by young scientists so far.

Once an RG profile is created, it can be easily linked to other workgroups at RG, such as the recently emerging FLUXNET group with experienced scientists. The workgroups within RG are closed (on invitation only) and used within the YSNs to compile information on job offers, conferences, workshops and summer schools, to discuss emerging research topics, and to assemble helpful information on scientific writing, reviewing and young scientist life (Fig. 1). First experiences with this new and powerful tool have shown the potential for improved networking among young and experienced scientists across the globe, and also for bridging the gap between them.

The number of members in these two YSNs has been increasing since establishment (FLUXNET YSN in 2004, re-launch in 2009; GHG-Europe YSN in 2011) and regular status renewals are performed to keep the member lists updated. In April 2012, the FLUXNET YSN had about 300 members from 38 countries with the majority being PhD students (56%) and post docs (30%, Fig. 2). Because of project-related ge-

ographical confinement, the GHG-Europe YSN is much smaller (25 members) but with similar composition (mainly PhD students) and some crossover; with 20% of the members also being members of the FLUXNET YSN.

Much potential still remains for young scientists to benefit more from their membership in these networks, where most of the contributions are currently made by the organisers. The increasing popularity of social networking media provide great potential for young scientists to participate more actively in networking activities using state-of-the-art communication technology.

Further information about both YSNs can be found on their websites: FLUXNET YSN (fluxnet.ornl.gov/young-scientists-network), GHG-Europe YSN (www.ghg-europe.eu/index.php?id=165). A good overview on RG is given by an article published by the New York Times in January 2012 (www.nytimes.com/2012/01/17/science/open-science-challenges-journal-tradition-with-web-collaboration.html). ■

Acknowledgements

We are grateful for support by Deb Agarwal (Lawrence Berkeley National Laboratory, LBL), Robert Cook (Oak Ridge National Laboratory, ORNL) and Barbara Michel (Thuenen-Institute of Agricultural Climate Research, vTI). Anna Görner (MPI-BGC) provided helpful insights to get started with ResearchGate. S.W. acknowledges funding by the Swiss National Science Foundation (Fellowship for Prospective Researchers), L.K. by the US National Science Foundation (project FLUXNET) and E.T. by the European Union (FP7 project GHG-Europe).

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FLUXNET Young Scientist Network (YSN)



The FLUXNET YSN aims to connect early career scientists working within the FLUXNET community and the regional networks.

Young scientists are considered to be students (undergraduate to PhD) and Postdocs, who do not lead their own research groups and who are not the main supervisor of PhD students.

The YSN consists of a mailing list, interactive website and a ResearchGate workgroup. Together, these resources constitute an informal exchange platform for questions regarding research, career and funding opportunities. Social meetings at conference complement these online tools.

Further information and details about how to register can be found on the FLUXNET Website (fluxnet.ornl.gov/young-scientists-network).

Welcome to the FLUXNET Young Scientist Network

This interactive website provides an informal exchange platform for questions regarding research, career and funding opportunities for young scientists. Furthermore, young scientists can present themselves and meet other fellows.

The website contains a blog, a wiki, a calendar of events, and a discussion forum. Links to each of these can be found in the menu to the left.

For questions regarding the website please see the [Young Scientist FAQ](#).

ResearchGate

FLUXNET YSN

Common interest: Meteorology, Climatology, Biogeography, Ecology and Environmental Science

Share with this workgroup

Thread title *

Comment *

Meetings & Workshops

RECENT DISCUSSIONS

AGU Fall Meeting 2012, 3-7 December, San Francisco (USA)

Monday 3 December - Friday 7 December 2012

Session Proposal deadline: 30 April 2012

Abstract Submission deadline: 8 August 2012

Visit the Fall Meeting Web site for more. [more]

Jan 16, 2012 | Comment | Add to discussion

Write a comment...

Tanja Suni
Executive Officer
tanja.suni@helsinki.fi

Tanja Suni worked as an Interim Science Officer at the iLEAPS International Project Office (IPO) already in 2003–2004.

She then received her PhD in environmental physics at the University of Helsinki in September 2004 and left for Australia to work as a post-doc in the Marine and Atmospheric Research group of the Commonwealth Scientific and Industrial Organisation (CSIRO) in Canberra. In her PhD, she studied the exchange of trace gases and aerosols between the atmosphere and the boreal forest. In Canberra, she studied biogenic aerosol formation in several Australian ecosystems including coastal areas, subalpine eucalypt forests, and the tropical rain forests in the North.

Tanja returned to Finland in 2007 and started as a Science Officer at the iLEAPS IPO in November 2008. Tanja is working as iLEAPS Executive Officer and is responsible for running the International Project Office as well as for planning and implementing iLEAPS-related activities. She provides input to the scientific development of the project, and communicates the research results to the broader scientific community as well as the policy community and general public.

Tanja is the Executive Editor of the iLEAPS Newsletter.



Alla Borisova
Project Manager
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Alla started to work for the iLEAPS IPO already in 2008 and is now acting as iLEAPS Project Manager.

She has a background in Applied Mathematics and obtained her degree at the Moscow State University. Alla is involved in planning and implementation of research activities and actively promotes communication within the iLEAPS scientific community across the globe. She acts as the general iLEAPS contact point, liaises with the iLEAPS Scientific Steering Committee, organises and facilitates the SSC meetings, and oversees the arrangements for iLEAPS Science Conferences.

She is responsible for website content management and assembles information about the training courses and summer schools around LEAP science. She is also responsible for disseminating this information to the iLEAPS community through various channels such as email bulletins and alerts. Last but not least, Alla is responsible for the planning and reporting of iLEAPS finances.



Magdalena Brus
Project Secretary
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Magdalena works as a Project Secretary in the Division of Atmospheric Sciences at the University of Helsinki and has assisted the iLEAPS IPO since 2011. She has Master's Degree in History and Social Sciences. Within iLEAPS, Magdalena provides administrative and management support to the Executive Officer and Project Manager, helping especially with text editing and writing reports. She also ensures the dissemination of information and awareness of iLEAPS activities through graphic communications by creating various presentations, brochures, flyers, and other graphic material.



The 3rd iLEAPS Science Conference

18 - 23 September, 2011, Garmisch-Partenkirchen, Germany

The conference consisted of oral sessions with wide-perspective plenary lectures, innovative invited speeches given by prominent scientists and highlighted poster sessions as well as an early-career scientist programme. During Opening day, a discussion session on "Borderless Science" took place with a distinguished Panel consisting of members of the Conference International Overseeing Committee.

An Early-Career Scientist Workshop (ECSW) was organised immediately before the conference, and satellite events such as the iLEAPS Scientific Steering Committee meeting, ALANIS-Aerosol progress meeting, IMECC Final Assembly and the LULCC Kick-Off Meeting took place along the week. Directly after the conference, on 25-26 September, a Post-Conference Workshop (PCW) was organised with the objective to synthesise and discuss the experience gained by long-term observatories, the challenges faced and opportunities offered by integrated long-term LEAP observations.

Outcomes of the conference and satellite events:

- **Newsletter issue 12.** This issue was initiated with the PCW theme "Future land-atmosphere observation platforms".
- **Workshop on Earth System Modelling** - iLEAPS and three Nordic Centres of Excellence (NCoE: SVALI, CRAICC, and DEFROST) are organising a joint workshop in autumn 2012 on Earth System Modelling (ESM) that aims to report the progress and plans of ESM activities in each NCoE, assess how observation and process based studies are involved into the ESM activities and vice versa, as well as to plan actions of collaboration between NCoEs in the themes of ESM. The workshop is the first in a series of four that form a 2-year project called "New approach on Earth System modelling".

Planet under Pressure

26 - 29 March, 2012, London, UK

This international conference brought together 3000 world-leading scientists, decision makers, business representatives, and journalists. Over 400 articles have been published worldwide in 15 languages and the conference still reverberates in the media, online discussions and policy circles. The conference highlighted the urgent need to focus on solutions to global challenges. Part of the solution is to bring natural and social scientists even closer together. In this respect, Planet under Pressure may mark a turning point in international Earth-system research.

Planet under Pressure included five iLEAPS-related sessions and side events:

- **Biosphere-climate interactions:** Quantifying the current state of land-atmosphere interactions
- **Land-Use / Land-Cover Changes and Climate:** what plausible options to manage future land-uses?
- **Life in extreme environments:** from knowledge to sustainable exploitation of new resources under growing pressures
- **Which Land-Use/Land-cover changes induce important feedbacks and effects in the climate system?**
- **Convergent global megatrends:** Interdependent processes and policy responses

iLEAPS-related sessions at EGU 2012

22 - 27 April, Vienna, Austria

The EGU General Assembly 2012 brought together geoscientists from all over the world into one meeting covering all disciplines of the Earth, Planetary and Space Sciences. EGU hosted ten iLEAPS-related sessions. Five sessions were co-sponsored or co-organised by iLEAPS:

1. Remote Sensing and data assimilation in the Biogeosciences (Convener: F. Veroustraete)
2. Seasons and phenology: Evidence

from observations, reconstructions, measurements and models (Convener: T. Rutishauser)

3. Air-Land Interactions (Convener: A. Ibrom)
4. Earth Observation for Land-Atmosphere Interaction Science (Convener: M. Marconcini)
5. Climate extremes, ecosystems and biogeochemical cycles (Convener: M. Reichstein)

ALANIS (Atmosphere-LANd Interaction Study) Final Workshop

14th February, 2012, Postdam, Germany

The ALANIS project, a collaboration between European Space Agency (ESA) and iLEAPS, aimed at enhancing the coordination and collaboration between Earth observation researchers and Earth system scientists and modellers. During the meeting, the results of ALANIS were summarised and evaluated with critical feedback and recommendations. Both ESA and iLEAPS felt that the project had been a success and useful for both communities. As a result, ESA is launching new similar efforts with other core projects and is planning ALANIS Phase II with iLEAPS. For more information about ALANIS, see the Key Projects on www.ileaps.org.

ILEAPS SCIENTIFIC STEERING COMMITTEE 2012

Alex Guenther (Co–Chair), Atmospheric Chemistry Division, National Center for Atmospheric Research (NCAR), Boulder, Colorado, USA

Markku Kulmala (Co–Chair), Dept. Physics, University of Helsinki, Helsinki, Finland

Eleanor Blyth, Centre for Ecology and Hydrology, UK

Gordon Bonan, Climate and Global Dynamics Division, National Center for Atmospheric Research (NCAR), Boulder, Colorado, USA

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Dan Yakir, Weizmann Institute of Science, Israel

Sergey Afanasievich Zimov, North–East Scientific Station of Pacific Institute of Geography, Chersky, Yakutia, Russia

Honorary members

Meinrat O. Andreae, Biogeochemistry Department, Max Planck Institute for Chemistry, Mainz, Germany

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Nathalie de Noblet–Ducoudré, Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif–sur–Yvette cedex, France

Daniel Rosenfeld, The Institute of Earth Sciences, The Hebrew University, Israel

ILEAPS-RECOGNISED PROJECTS

ABBA

Advancing the Integrated Monitoring of Trace Gas Exchange between Biosphere and Atmosphere

ACPC

Aerosols, Clouds, Precipitation and Climate Research Program

Sat-ACPC

Remote Sensing Aerosols, Clouds, Precipitation and Climate Interactions

LULCC

Land Use and Land Cover Change

AMMA

African Monsoon Multidisciplinary Analyses

FLUXNET

International Network Measuring Terrestrial Carbon, Water and Energy Fluxes

FIRE Task

HENVI Forests and Climate Change

GEIA

Global Emissions Initiative

LUCID

Land-Use and Climate, Identification of robust impacts

NEESPI

Northern Eurasia Earth Science Partnership Initiative

TAITA

Multidisciplinary Research Station in Kenya

WELGEGUND

Observation Platform in South Africa

ALANIS

Atmosphere–LAND Integrated Study in the boreal zone