POTSDAM
GHG FLUX WORKSHOP

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From Natural to Urban Systems
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Abstracts

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Keynote Presentations

Keynote: Soil Flux

Jens-Arne Subke (1)

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Measurements of soil CO_2 flux have become a core component of ecosystem research. Our understanding of belowground processes underlying the production and transport of CO_2 has increased significantly in recent decades, and the application of soil CO_2 flux system now goes well beyond a "simple" quantification of soil CO_2 efflux. Measurements of methane provide new challenges, owing to the lower concentration in the atmosphere, and greater analytical challenges in detecting it. However, fast analysers have been available for some years now and are increasingly used to collect time series of soil methane exchange, enabling new methods of investigating methanogenesis and methanotrophy. In this talk, I will outline the main methods used to measure soil CO_2 flux, and some of the key developments in soil C research where soil flux measurements have been instrumental in understanding specific processes and dynamics. There are by now a wide range of methods to partition soil CO_2 flux in order to distinguish different sources and their respective dependencies on biotic and abiotic drivers. The aim of this talk is to give an introduction and overview of some methods with particular attention to recent techniques and new developments.

References (PDF)

Keynote: Introduction to eddy-covariance

Thomas Foken (1)

(1) University of Bayreuth, Bayreuth Center of Ecology and Environmental Research

More than 60 years ago, the basics of the eddy-covariance method were proposed by Montgomery, Swinbank and Obukhov, with the first widely applicable sonic anemometers becoming available more than a decade later. For a long time, the method was only used by specialists like Dyer, Businger, and Kaimal, who developed the devices and correction methods, etc. During the last 20 years, the ecological community has had access to many commercial devices and has used the method to determine the carbon exchange within the FLUXNET programme. During this time, the focus was on the development of tools and instructions to enable even non-specialists to apply this not entirely simple method. Three problems are still under discussion: the energy balance closure problem, the handling of non-turbulent situations, and the determination of the accuracy. The development of sensors has become more and more a task carried out by engineers rather than scientists, but this has not always been to the benefit of the method as it is used by scientists. For the future, we should use the method to directly determine energy and matter fluxes in a turbulent atmosphere, while other methods must be used for non-turbulent conditions.

References (PDF)

Keynote: Eddy-covariance quality - General problems - Eddy-covariance and soil chamber fluxes

Thomas Foken (1)

(1) University of Bayreuth, Bayreuth Center of Ecology and Environmental Research

An important part of the successful application of the eddy-covariance method is quality assurance and quality control. There are different steps of the control for electronic, meteorological and statistical problems. The fulfilment of the theoretical assumptions of the measuring method and the non-steady-state test and the integral turbulence test are extensively discussed as well as an overall flagging for data quality and a site-specific quality analysis using footprint models. Finally, problems are discussed which are not yet included yet in the control program and which are mainly connected with the complicated turbulence structure above high vegetation or in heterogeneous areas. Ecologists often compare eddy-covariance and soil chamber results, but both methods have different spatial scales and they are often used without the same resolution in time. Only under specific turbulent conditions of the atmosphere and longwave net radiation do both methods agree very well.

References (PDF)

Keynote: Eddy-covariance - Footprint

Thomas Foken (1)

(1) University of Bayreuth, Bayreuth Center of Ecology and Environmental Research

The interpretation of meteorological measurements made at a given level over a surface having characteristic properties in roughness, albedo, and fluxes of heat, moisture, carbon dioxide, and other gases is an old question which goes back to the very beginnings of modern micrometeorology. The extension of these measurements to inhomogeneous experimental sites requires a quantitative knowledge of influences of the surface characteristics. The 'footprint' concept – which came about 25 years ago – when modelled using atmospheric transport models similar to air pollution models, provides us with information on whether or not the condition of upwind site homogeneity has been fulfilled. Since these first models, there has been significant progress made in the development of more scientifically-based models, validation experiments, and applications. The keynote provides an overview of these developments, to analyze present deficits, and to describe applications for ecological and eddy-covariance measurements.

Keynote: Filtering, gap-filling, partitioning and uncertainty in eddy covariance measurements

Dario Papale (1)

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Eddy covariance data, after the raw data processing and fluxes calculation, must follow additional quality filtering steps in particular in order to remove measurements potentially affected by advection. These filtering activities introduce gaps in the time-series that are added to the one due to problems occurred at the site (power and instruments failures) that need to be filled in order to calculate daily to annual budgets. The gap-free time-series can be then further processed in particular to estimate the two main components of the NEE (Gross Primary Production and Ecosystem Respiration) helping the ecological interpretation of the measurements. All these steps (filtering, gap-filling, partitioning) introduce uncertainty in the measurements that must be quantified and considered when the data are used. In this presentation the data life cycle from the calculated fluxes (e.g. the output from EddyPro) to the final version available for the scientific interpretation is presented, with particular attention to the uncertainty introduced in each step and the overall evaluation of the site based on the consistency across the different processing options available. Finally, an overview of the international networks and standardization/harmonization activities ongoing will be discussed as option to better integrate single sites in the global framework.

Keynote: Added value-products from eddy-covariance flux network data: ecosystem functioning and up-scaling

Markus Reichstein (1), Martin Jung (1), Mirco Migliavacca (1), Miguel Mahecha (1)

(1) Max-Planck-Institute for Biogeochemistry, Jena, Germany

The flux and meteorological observations, once they have undergone rigorous quality control and processing (cf. antecedent Papale et al. talk) can be used to estimate budgets, variability or trends. This is one important goal of long-term observation networks such as ICOS or NEON. I will argue here that the rich information contained in the continuous high-resolution data can further be leveraged by the derivation of added value products and integration of additional information sources. This includes three different mathematical "mapping" exercises.

- Estimation of flux and biogeochemical model parameters using the flux data with model-data fusion approaches (cf. Reichstein et al. 2003; Williams et et al. 2009)
- Mapping the flux observations (which contain gaps in space and time dimensions) into a spatio-temporal "wall-to-wall" data cubes, such that global scale questions can be addressed (e.g. Jung et al. 2011)
- Derivation of ecosystem functional properties both at local and global scales (Reichstein et al. 2014)

Principles and examples of these three fundamental avenues (and their combinations) are elaborated in this contribution to the workshop.

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Keynote: Linking phenology and ecosystem processes using digital repeat photography

Mirco Migliavacca (1), Edoardo Cremonese (2), Gianluca Filippa (2), Marta Galvagno (2), Andrew D. Richardson (3)

(1) Max Planck Institute for Biogeochemistry, Jena, Germany (2) Regional agency for environmental protection (ARPA), Aosta, Italy (3) Harvard University, Cambridge, USA

Phenology is the study of the timing of recurring biological events and the causes of their temporal change regarding biotic and abiotic forces. The timing of the main plant phenological events and their year-to-year variability is controlled by meteorological and environmental forcing. Therefore, phenology has been shown to be an important indicator for the biological impacts of climate change. The use of repeated digital images collected by conventional cameras has been shown to be promising for phenological research in various ecosystems and a number of network are now growing (e.g. PHENOCAM network: phenocam.sr.unh.edu/). Several studies are now directly linking color indices derived by digital cameras and measurements of ecosystem functions (e.g. collected with eddy covariance technique). To derive data comparable across sites and camera types, a standardized treatment of imagery archive is needed. The lesson will be articulated in the following points:

- General introduction about the link between phenology and ecosystem processes, and the theory behind the use of digital repeat photography to derive phenological indicators.
- Hands-on session using a new software (phenopix) available as R package and developed with the collaboration between ARPA Valle d'Aosta, Max Planck Institute for Biogeochemistry, and Harvard University.

In the hands-on session we will work on 2 datasets from the experimental site of Majadas (managed by the MPI) and Torgnon site (managed by ARPA Valle d'Aosta) and the main steps of the analysis of imagery archives will be discussed. Specifically, the practical exercises will be focused on: 1) draw a region of interest (ROI) on an image; 2) extraction of red, green, and blue digital numbers (DN) from a seasonal series of images, 3) data filtering and extraction of phenological phases for the 2 experimental sites, and 4) analysis of the spatial variability of the different phenophases.

Keynote: Urban Flux Model Integration

Philippe Ciais (1)

(1) IPSL—Laboratoire des Sciences du Climat et de l'Environnement CEA-CNRS-UVSQ

Atmospheric concentration measurements are 2 emissions of the Paris urban area, using as a first guess a spatially explicit emission inventory established by the Airparif local air quality agency. We use 5 atmospheric monitoring sites, all near the ground except one at the top of the Eiffel tower. The atmospheric inversion is based on a Bayesian approach, and relies on an atmospheric transport model with a spatial resolution of 2 km with boundary conditions from a global coarse grid transport model. The inversion adjusts the CO_2 fluxes (anthropogenic and biogenic) with a temporal resolution of 6 hours, assuming temporal correlation of emissions uncertainties within the daily cycle, and from day to day, while keeping the a priori spatial distribution from the Airparif emission inventory. The inversion significantly improves the agreement between measured and modelled concentrations.

Keynote: Mobile Methane Measurements with Fast Open-Path Technology: Experiences, Opportunities & Perspectives

G. Burba (1), J. von Fischer (2), J. Ham, M. Zondlo, B. Gioli (3), R. Zulueta, P. Levy, T. Anderson (1), J. Hupp (1), E. Price (1) and K. Ediger (1)

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Methane plays a critical role in the radiation balance and chemistry of the atmosphere. The major sources of CH_4 include agricultural and natural production, landfill emissions, oil and gas development sites, and natural gas distribution networks in rural and urban environments. The majority of agricultural and natural CH_4 production occurs in areas with little infrastructure or easily available grid power (e.g., rice fields, arctic and boreal wetlands, tropical mangroves, etc.) Past approaches for direct measurements of CH_4 fluxes relied on fast closed-path analyzers, which typically require powerful pumps and grid power. Power and labor demands may be among the key reasons why such CH_4 fluxes were often measured at locations with good infrastructure and grid power, and not necessarily with high CH_4 production. Landfill CH_4 emissions were traditionally assessed via point-in-time measurements taken at monthly or longer time intervals using techniques such as the trace plume method, the mass balance method, etc. These are subject to large uncertainties because of the snapshot nature of the measurements, while the changes in emission rates are continuous due to ongoing landfill development, changes in management practices, and the barometric pumping phenomenon. Installing a continuously operating flux station in the middle of an active landfill requires a low-power approach with no cables stretching across the landfill. The majority of oil and gas and urban CH_4 emission happens via variable-rate point sources or diffused spots in topographically challenging terrains, such as street tunnels, elevated locations at water treatment plants, vents, etc. Locating and measuring CH_4 emissions from such sources is challenging when using traditional micrometeorological techniques, and requires development of novel approaches. In 2010, a new lightweight high-speed high-resolution open-path technology was developed with the goal of allowing eddy covariance measurements of CH_4 flux with power consumption 30-150 times below other available technologies. The instrumentation was designed to run on solar panels or a small generator, and could be placed in the middle of the methane-producing ecosystem without a need for grid power. This significantly expanded the CH_4 flux measurement coverage in permafrost regions, wetlands, rice fields and landfills. In the past few years, this instrumentation has been utilized increasingly more frequently outside of the traditional use at stationary flux towers. The novel approaches included measurements from various moving platforms, such as cars, aircraft, and ships. Projects included mapping of concentrations and vertical profiles, leak detection and quantification, mobile emission detection from natural gas cars, soil CH_4 flux surveys, etc. This presentation will describe key developmental steps in the lightweight low-power high-resolution open-path technology, the instrument principles and key elements of the design, and will highlight several novel approaches where such instrumentation was used in mobile deployments in urban and natural environments.

Keynote: CADFEM Urban Simulation - Numerical simulations master urban challenges

Stefan Trometer (1)

(1) CADFEM GmbH, München, Germany

Based on the close cooperation between CADFEM and virtualcitySYSTEMS digital 3D city models were used to develop new simulation applications for the urban space. They contribute to master the challenges from the ongoing urbanization, but also to master the consequences from global climate change. The development of applications is based on semantic 3D city models, which represent the urban complexity of cities and allow for automated processes because manual model creation isn't possible anymore. But also the ongoing changes in cities are taken into account by regular updates. So, there is always a realistic and up-to-date 3D simulation model available. In addition the need for realistic numerical simulations just arises by the urban complexity, if you want to analyze turbulent air flows in cities, for example. But this is just one field of application for 3D simulations. By modeling the thermal stratification, the solar energy input and by additional information about the general weather conditions urban climate scenarios can be evaluated. By adding realistic pollution sources their distribution and concentration in the urban space can be assessed. Compared to experiments or measurements the major advantage of simulations is that the total model with all parameters is determined and individual layouts can be investigated. The workshop focuses on the latest developments in the field of urban simulation shown by different realistic applications. The close relation between 3D city models and numerical simulations is presented and the arising advantages are pointed out. Additionally the manifold challenges during the R&D process are discussed.

Keynote: UrbENO - An urban observatory in the context of larger holistic research strategies

Stefan Emeis (1)

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Urban areas become increasingly important as living places for larger parts of mankind. This is why cities have been put into the focus of several research programs in recent times. A sustainable planning and development of cities (including a cautious re-shaping of existing cities) requires a deep understanding of the system "city". Investigating this complex system needs a large amount of data. The idea of an urban observatory – called "UrbENO (Urban Environmental Observatory)" – has been brought forward in the last application for the Helmholtz research program ATMO a few years ago. The name and the principal idea have been chosen in analogy to the existing "TERENO (TERrestrial Environmental Observatory)" run by several institutes of the Helmholtz Association since about eight years. TERENO is focussing on energy and matter fluxes and budgets in river catchment areas. The idea of UrbENO is to capture the matter and energy fluxes between the different compartments forming the system "city" and the respective budgets. The relations with the surrounding rural areas will have to be taken into account as well. This requires well-designed measurement strategies and monitoring techniques due to the large complexity and the dynamic development of cities. This presentation will try to describe the complexity of such an urban observatory and how this idea is embedded in further, currently developed research strategies. UrbENO fits into a new Helmholtz research initiative on cities as well as into the national German research and innovation initiative "City of the Future" (Nationale Plattform Zukunftstadt) which was launched earlier this year. Similar research initiatives with various aims have been developed in other parts of the world. Just one example is the US program LTER which includes to urban stations as well.

Keynote: Urban CO_2 Exchanges: Variability and Key Drivers

CSB Grimmond (1), HC Ward (1), (3), S Kotthaus (1), A Björkegren (2), A Font Font (2), M Wilkinson (4), JG Evans (3), JIL Morison (4), M Iamarino (5) and WTJ Morrison (1)

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Exploration of anthropogenic and biogenic controls on surface-atmosphere exchange of CO_2 are examined. In summer, suburban and forested areas are similar, as photosynthesis and respiration control the diurnal CO_2 flux pattern. In winter, emissions from human activities dominate urban and suburban fluxes; building emissions increase during cold weather, while traffic is a major component of CO_2 emissions all year round. Observed CO_2 fluxes reflect diurnal traffic patterns (busy throughout the day (urban); rush-hour peaks (suburban)) and vary between working days and non-working days. Suburban vegetation offsets some anthropogenic emissions, but 24-h CO_2 fluxes are usually positive even during summer. Observations are compared to estimated emissions from simple models and inventories. Annual CO_2 exchanges are significantly different between areas, demonstrating the impacts of increasing urban density (and decreasing vegetation fraction) on the CO_2 flux to the atmosphere.

Keynote: Monitoring CO_2 in cities and its link to climate Finance

Denis Jorisch (1)

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Workshop purpose: The aim of this workshop is to provide the attendants a better understanding of the role cities have when tackling climate change, the importance of an accurate monitoring of CO_2 emissions on city level and how this is linked to the implementation of innovative climate finance instruments. Workshop description: In this workshop the Climate-KIC flagship programme "Low Carbon City Lab" (LoCaL) will be introduced, addressing the role of cities tackling climate change. After an overview of the different fields in which LoCaL is active, an in-depth assessment of monitoring CO_2 emissions from transport will be given. This will encompass the whole bandwidth of monitoring approaches, with a particular focus on Clean Development Mechanism (CDM) methodologies for the transport sector. After discussing current challenges with these methodologies, ongoing innovation projects under LoCaL that aim to address these challenges will be showcased. Last but not least, the importance of new monitoring approaches to unlock the potential of innovative climate finance instruments (such as carbon credits or green bonds for example) will be highlighted.

Posters

P2015-1 Poster download (PDF)

Heat flux comparison between eddy covariance measurements and simulations based on thermal UAV data.

Helene Hoffmann (1), Hector Nieto (2), Rasmus Jensen (1) and Thomas Friborg (1)

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Advantages of data collection conducted with UAVs (Unmanned Aerial Vehicles) compared to more traditional data collections are numerous and already well-discussed in environmental sciences (Berni et al., 2009; Laliberte et al., 2011). However, studies investigating the quality and applications of UAV data are vital if advantages are to be beneficial for e.g. water management and precision agriculture. In this study, thermal UAV data are collected over a barley field in Denmark during the spring and summer 2014. The collected data are mosaicked into a single thermal orthorectified image covering a 400x400 m area and used to estimate heat fluxes through the two source energy balance modelling schemes. More specific the original TSEB (Norman et al., 1995) and the DTD approach (Norman et al., 2000) are used. Simulated sensible and latent heat fluxes are compared between models and validated against measurements from an eddy covariance tower situated at same field over which the UAV flights were conducted. This study shows that thermal data collected with a UAV are of sufficient quality to serve as input to the two source energy balance modelling scheme. Simulated heat fluxes are in good agreement with eddy covariance measurements, with the DTD model as the superior algorithm.

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P2015-2 Poster download (PDF)

Combining Eddy-Covariance and Chamber Measurements to Determine the Methane Budget from a Small, Urban Wetland Park

Timothy Morin (1), Kay C. Stefanik (1), Gil Bohrer (1), Andres C. Rey-Sanchez (1) and William J Mitsch (2)

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Greenhouse gas (GHG) fluxes from wetlands are a key component in the global GHG budget. Wetlands uptake and store large amounts of CO_2 but also emit methane. There is a very large uncertainty in our understanding of the GHG budget of wetlands. Most wetlands, and particularly small urban ones are composed of a heterogeneous landscape with intermittent flooded, partially flooded and dry areas and patches of different vegetation types and open water. This ecosystem heterogeneity is accompanied by great spatial and temporal heterogeneity of flux rates.

The most common approaches to measure GHG fluxes from wetland are the eddy-covariance method (EC) and chamber-based measurements. Each approach has advantages and disadvantages. Manual chamber measurements are intermittent and include a small sample of point-sources. Automated chambers provide continuous observations but are restricted by the number of sample points and their spatial spread. EC measurements provide a continuous time series of fluxes from an integrated source-footprint area. However, the footprint area, which represents a mixture of sub-patches with different emission rates, varies in time as the wind and turbulent mixing change. EC measurements, therefore, cannot provide the flux budget for a fixed and ecologically defined area, such as the permanently flooded component of a wetland.

We present an approach to combine the patch-level emission data from intermittent manual chamber measurements of representative locations in specific patch types, with continuous EC measurements. We used data from a 3-years measurement campaign at the Wilma Schiermeier Olentangy River Wetland Research Park in Columbus, OH, USA, a created urban wetland park. We use a 2-D footprint model and a remote-sensing map of the patch-type distribution around the flux tower to upscale the chamber measurements to the equivalent integrated EC footprint-area source fluxes. By combining information about the relative emission rates of each patch type from the chambers with the temporal dynamics of the footprint-area flux-rate we can solve for the flux contribution of each patch type, and of a prescribed fixed area within the wetland park. We show that in our measurement site, which is a young wetland with relatively high carbon uptake rates and low methane emission rates, the GHG emissions from the permanently flooded area of the park are offset by carbon uptake at the park's forested areas.

P2015-3 Poster download (PDF)

A new silicon photovoltaic pyranometer for measuring solar irradiance in meteorological and solar resource applications

Taylor Thomas (1), Dave Johnson (1), Patrick Morgan (1), Dave Heinicke (1), Dayle McDermitt (1), George Burba (1), Rex Peterson (1), John Wurm (1) and Bill Biggs (1)

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Silicon photovoltaic pyranometers are commonly used instruments for quantifying global solar irradiance in Wm^{-2}. For nearly forty years, LI-COR has been manufacturing these types of pyranometers for use at thousands of locations around the world to monitor solar radiation for meteorological, agricultural, and solar resource assessment studies. Building off the standard, LI-COR is introducing a new version of the pyranometer that features an improved physical design while offering the same proven measurement performance with increased durability and function. The cosine response is within 2% out to 82° from vertical resulting in accurate radiation measurements. An overview of the design features and preliminary test data demonstrating daily irradiance values, sensor responsivity, cosine response, and azimuth response are presented.

P2015-4 Poster download (PDF)

Silicone Tubes –Tools for Methane Gas Extraction and Monitoring in the Course of Hydrate Formation and Dissociation

Bettina Strauch (1), Judith M. Schicks (1) and Martin Zimmer (1)

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This study assesses the capability and limits of silicone tubes as tools to monitor the methane gas flux and its distribution in the course of hydrate formation and dissociation. Also, their ability to serve as a suitable *in situ* gas extraction tool for methane released during hydrate decomposition has been examined. In the framework of the SUGAR Project, we simulate different methods (depressurization, thermal stimulation and distortion of the chemical equilibrium by CO_2) for methane gas production from gas hydrates deposits in a LArge scale Reservoir Simulator LARS. Within this setup, thin-walled (0.8 mm) silicon tubes are utilized for *in situ* gas capture. They function as membranes for the extraction of methane gas, leaving sediment and brine behind. First tests show that, driven by the transmembrane pressure difference, the methane flux through these membranes is about 1 mL per minute per cm² membrane surface at a reservoir pressure of about 20 MPa. The operation of the membranes as a simple capture tool for the released methane from a hydrate deposit is therefore considered as feasible and, due to their robust nature, reliably applicable in remote and rough areas. Furthermore, the silicone tubes have been utilized for the monitoring of spatial and temporal gas distributions. For that, LARS has been equipped with silicone membranes at various locations to quantify free and dissolved gas volumes in the progress of hydrate formation and decomposition. The results show that inhomogeneous gas distributions within the reservoir are detectable and terminable.

P2015-5 Poster download (PDF)

Carbon Dioxide Exchange in Pyrenean Grasslands: Relative Influence of Vegetation and Climate

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Mountain semi-natural grasslands host a high biodiversity and provide fundamental ecosystem services, including their potential role in climate change mitigation. In these systems, Net Ecosystem CO_2 Exchange (NEE) is usually near to the equilibrium and grasslands can act as sources or sinks depending on local conditions. We carried out a survey of CO_2 exchange rates in two Eastern Pyrenees grasslands. The objectives of our study were: 1) to describe CO_2 dynamics (daily and seasonally) during growing season and 2) to assess the influence of environmental variables (temperature, photosynthetic active radiation (PAR) and soil water content and) and vegetation structure on CO_2 dynamics. The study sites were: La Bertolina (42°05'56"N, 1°39'40"E, 1275 m.a.s.l) and Castellar (42°18'18"N, 2°02'01"E 2000 m.a.s.l). At each sampling point, CO_2 exchange was measured with soil chambers connected to an infrared gas analyser and two types of variables registered: NEE (translucent chamber) and Reco (ecosystem respiration; opaque chamber). Afterwards, vegetation was cut and sorted into plant functional types (PFT): legumes, non-fixing forbs and grasses and aboveground biomass was determined. Daytime NEE was mostly dominated by assimilation, with maximums of 10.51 ± 2.35 and 20.23 ± 2.64 µmol m-2 s1 in La Bertolina and Castellar respectively, values in the range of other European semi-natural grasslands. Seasonal CO_2 exchange variations showed a strong relation with temperature and green biomass evolution. Daily NEE variations were related with PAR following a rectangular hyperbolic model, which improved the fit when it was calculated specifically for each PFT.

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Soil gas flux calculation from chamber measurements: the influence of faba bean (*Vicia faba* L. var. *minor*) volume on headspace volume

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The chamber technique is widely used to measure soil gas fluxes. This technique allows to test the effects of different crop managements on soil gas emissions in agricultural soils. Soil flux is calculated from the slope of the increment of the gas concentration during the chamber deployment time. Collar and chamber volumes are both part of the headspace volume and must be included in the gas flux calculation. In order to follow crop growth and left the plants uncut stackable extensions placed on the collar can be used. Extensions volume must be taken into account in the headspace volume calculation. The use of the extensions with big size crops right inside addresses to an issue: does plants volume affects the headspace volume? The aim of this work is to understand whether plant volume needs to be measured or not in order to accurately calculate soil gas fluxes. Nitrous oxide (N_2O) was monitored on a faba bean (*Vicia faba* L. var. *minor*) cultivation that was part of the LIFE+IPNOA project field trials in Pisa (central Italy). N_2O was measured from February to October 2014 with the chamber technique and the laser absorption technology (OA-ICOS, LGR). The treatment was tillage intensity with two levels, ploughing (30 cm deep) and minimum tillage (10 cm deep). Plants volume was measured monthly with water displacement method using a graduated cylinder. The volume increment during the growing season was calculated with linear interpolation between two measured values. At the end of the flux monitoring campaign two N_2O fluxes datasets were compared, one including plants volume in headspace volume calculation and the other not including it. Statistical analysis highlighted no differences between the two datasets. Although plants height was about 1.3 meters at the harvest, crop volume during the crop cycle was only in the range from 0.7 to 3.4 % of the headspace volume. The maximum volume for faba bean plants inside the collar was about 600 cm^3, founded on March in the ploughed field. On the other hand, tillage intensity was identified as a key factor affecting N_2O emissions. The increasing depth of the tillage was the major driver for the N_2O emissions.

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End members of Arctic soil CH_4 oxidation – importance of the "odd spots"

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Recent findings in Arctic ecosystems point toward a higher than expected atmospheric CH_4 sink in the drier soils of the landscape exceeding the emissions from adjacent wetlands [1], [2]. However, the dry, upland tundra ecosystems, although constituting the dominating part of the Arctic land areas, have mostly been overlooked in studies of CH_4 dynamics. Consequently, very little is known about the extent of this CH_4 sink. We studied CH_4 oxidation rates in the soil during May – August 2015 in the Disko Bay area, Western Greenland covering three different geological settings; basalt, sandstone and gneiss. The paradigm of the campaign was to go outside of the vegetated areas where most data on Arctic CH_4 fluxes otherwise originate from. We hypothesized that CH_4 oxidation rates in non-vegetated areas were similar to or exceeded the rates observed in vegetated upland tundra. We covered the "odd spots" of the landscape: erosion gullies, escarpments, mountain ridges, mudboils, river beds and wind abrasion plateaus. To estimate CH_4 oxidation rates we used two fast-deployable non-steady-state flow-through (0.4 L min^{-1}) chambers made of steel with a height of 0.12 m and areal coverages of 0.26 and 0.07 m^2, respectively. The enclosure time was 8 minutes with a theoretic flux detection limit of ±0.37 µg CH_4 m^{-2} h^{-1}. The chambers were connected to the Ultraportable Greenhouse Gas Analyzer (Los Gatos Research Inc., USA) (precision: 0.6 ppb). The analyzer, control unit and datalogger was mounted on a backpack for mobility. At deployment the chamber was pushed 1 to 2 cm in to the top soil. Pressure induced disturbance was avoided by leaving an open hole in the chamber top to allow instant equilibration between with the atmosphere. No disturbance of headspace CH_4 concentrations could be observed. In total we logged 267 flux measurements. In most geomorphological classes CH_4 oxidation was observed, but not emission. The CH_4 oxidation fluxes displayed rates between -285 to 0 µg CH_4 m^{-2} h^{-1} and comparable to recent findings from *Salix* and *Betula* type tundra landscapes in Greenland [1], [2] and Canada [3] as well as for temperate forests [4], but exceeded regional estimates for vegetated tundras (avg. -17 µg CH_4 m^{-2} h^{-1}) [4]. It is well known that CH_4 oxidation is ubiquitous in upland soils, however our findings using a mobile, highly precise chamber system point to that the magnitude of the sink is higher than previously anticipated.

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Setting up an eddy covariance system to measure N_2O fluxes exchanged by a production crop

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Nitrous oxide (N_2O) is a greenhouse gas responsible for 8% of anthropogenic radiative forcing. It is also a major contributor to stratospheric ozone depletion. Agricultural soils represent its main source. N_2O is produced by microorganisms through nitrification and denitrification processes. Both depend on oxygenation conditions and nitrogen and labile carbon availability, which are driven by soil and climate conditions and by farming practices. Yet there remain science gaps concerning the understanding of emission mechanisms and dynamics. The eddy covariance technique allows studying a whole ecosystem with a half-hourly temporal resolution, opening up for long-term monitoring. However, this technique requires a specific expertise. In order to study N_2O exchanges by a Belgian production crop, we installed an eddy covariance system at the Terrestrial Observatory of Lonzée (Belgium), using a H_2O and N_2O quantum cascade laser analyzer and a sonic anemometer. At present, despite the shortness of the data series, data preprocessing and flux calculation were initiated. We observed a drifting time-lag between the analyzer and the anemometer time series, presumably caused by an internal clock drift. Time-lag determination (using the covariance function maximum method) was more difficult for N_2O than H_2O, suggesting that this routine should be adapted to gas characterized by low fluxes. We investigated high frequency loss and comparison of water vapor and sensible heat cospectra provided a 0.5 Hz system cut-off frequency. This could not be estimated for N_2O because of low fluxes during turbulent conditions.

Due to a very short dataset, many questions were left pending:

- Which method is best suited to N_2O time-lag determination?
- How should Vickers and Mahrt (1997) quality tests be adapted to N_2O?
- If a drift is observed in concentration data, which detrending method should be recommended?
- Are cospectra more suitable than spectra for total high frequency loss evaluation?
- Further work and many more data will be needed in order to bring answers to these questions.

P2015-9 Poster download (PDF)

Biased winter net ecosystem CO_2 exchange of a boreal forest partly explained by decoupling

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An apparent "carbon uptake" observed during winter time eddy covariance (EC) measurements of above-canopy carbon fluxes led us to investigate whether decoupling of below- and above-canopy air mass flow and consequently potential below-canopy lateral flow might contribute to this observation. The measurements were conducted at a ~ 90-year-old Scots pine stand (*Pinus sylvestris* L.) near Vindeln in northern Sweden (64°10′ N, 19°45′ E; 155-160 m above sea level) and consisted in EC measurements below and above the canopy. Despite a relatively open stand structure with a leaf area index of ~ 3 m^2 m^{-2} we observed decoupling of above- and below-canopy air mass flow in 45 % of all cases using the correlation of σ_w – the standard deviation of vertical wind – as mixing parameter. Air masses are coupled if the correlation between σ_w above and below canopy is linear. We identified 0.33 m s^{-1} and 0.06 m s^{-1} as site-specific σ_w thresholds to reach this linear range. The decoupling of 45 % amounted to 0.57 tons carbon per hectare potential below-canopy carbon loss for the shown winter period. Despite the site being rather flat up to a distance of ~ 200 m to the tower with a maximum elevation difference of ~ 2 m, below- and above-canopy flow investigations indicated a strong topographical influence. This yielded to a predominant wind direction below canopy and consequently wind shear between below- and above-canopy air masses. To underline the global importance of tower surrounding topography – beyond the nearest tower vicinity – we investigated the elevation in a radius of 300 m and 1000 m around a number (110) of forest ecosystem FLUXNET towers worldwide. Medians of height differences in a circle around these towers with 300 m radius and 1000 m radius, respectively, were 24 m and 66 m, respectively. The corresponding numbers for our study site were 23.9 m and 114 m. Two major conclusions shall be stressed: i) forest canopies can cause decoupling and below canopy drainage flow, even when they are rather open and even when the site is rather flat in the nearest vicinity of the tower; ii) the majority of EC sites worldwide is measuring in heterogeneous terrain with distinct elevations around the towers which may bias the above-canopy results. Both conclusions lead to the recommendation that additional below-canopy EC measurements should get a standard procedure worldwide.

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Trace gases exchange at ecosystem level in a urban forest in Naples

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Urban forests are living systems integrated in highly anthropic areas, where they establish close interactions with all the other systems around. Thanks to those interactions, urban forests provide to people and to all the urban environment many ecosystem services, the most important of which is probably the absorption of chemically and radiatively-active trace gases and thus the effect on the local air quality. Among the trace gases, beyond the main GHG gases (CO_2, H_2O and CH_4) in urban areas a relevant role is played by the photochemical pollution mainly constituted by O_3 and particulate matters. Despite their importance, experimental sites monitoring trace gases fluxes in urban forest ecosystems are still scarce. Here we show the preliminary results of an innovative experimental site located in the Royal Park of Capodimonte within the urban area of Naples (coordinates 40°51'N-14°15'E, 130 m above sea level). The site is mainly composed by Quercus ilex with some patches of Pinus pinea and equipped with an eddy-covariance tower measuring the exchange of CO_2, H_2O, CH_4, O_3, PM, VOCs and NOx; it is running since the end of 2014 and it is part of the I-AMICA project.

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Comparison of the diurnal and seasonal variability of turbulent fluxes of greenhouse gases (water vapor, carbon dioxide and methane) in the center of Lodz, Poland

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Precise measurements of the greenhouse gases exchange between the ground and the atmosphere are crucial for understanding their role in the climate system. The result of such measurements is, firstly, fairly well described variability of water vapor and carbon dioxide fluxes at different time scales and, secondly, description of the relation between the land use and intensity and direction of the exchange. These results, however, mainly relate to areas covered by vegetation, used by human in various ways. Such research in urban areas was only performed in several cities around the world which allowed to obtain preliminary information on the impact of urbanization on the temporal variability of exchange of greenhouse gases. Turbulent methane exchange between the ground and the atmosphere is a process that is just beginning to be studied. Measurements of methane fluxes focus on areas that are the largest natural sources of this gas to the atmosphere (wetlands and rice paddies). In urban areas only a few measurement campaigns has been carried out, while the cities can be a significant source of methane to the atmosphere (the burning of fossil fuels, sewer, leaks from pipelines, etc.). The aim of this study is to compare the results of measurements of turbulent exchange of water vapor, carbon dioxide and methane in the Lodz center. Continuous eddy covariance measurements of fluxes of these gases are conducted in Lodz since 2000 (water vapor), 2006 (carbon dioxide) and 2013 (methane). The study focuses on the period of July 2013 - August 2015, when the fluxes were measured simultaneously. Results of measurements show that both similarities and differences of temporal variability of fluxes. First of all, most of the fluxes are positive which means that the center of Lodz is a source of H_2O, CO_2 and CH_4 to the atmosphere. In addition, variabilities of all three fluxes are characterized by a distinct annual and diurnal course. But on the other hand, annual variations of fluxes are not always compatible with the rhythm of the temperature. Only a water vapor flux, determined mainly by natural processes, demonstrate such coincidence. The differences can be seen also in the average diurnal variability - on average water vapor flux reaches a one maximum during a day, whereas in the case of carbon dioxide and methane fluxes two peaks are observed. Because the carbon dioxide and methane in urban areas comes mainly from anthropogenic emissions, FCO_2 and FCH_4 fluxes also have a weekly rhythm – weekend fluxes are, especially in the case of FCO_2 significantly lower. This variability hasn't been observed in the case of FH_2O. Funding for this research was provided by National Centre of Science under projects 2011/01/D/ST10/07419 in the years 2011-2016.

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A comparison of atmospheric carbon exchange at two contrasting UK forest sites

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Alice Holt and Harwood Forest are two forest flux sites managed by Forest Research, which typify the forested areas of the UK. Alice Holt in Hampshire (south east England) is a typical oak woodland, which across GB, contain 30% of broadleaved woodland C stocks. The overall aim of this research site is to quantify the inter-annual variation in carbon uptake and examine the effects of forest management on the partitioning of the carbon balance. In contrast, Harwood Forest in Northumberland (north England), is an upland Sitka spruce plantation which is the major timber production forest type in the UK and contains some 50% of conifer forest C stocks. The primary aim of this research site is focused on understanding the effect of forest management on the whole ecosystem GHG balance of productive conifer plantations, such as Sitka spruce often planted on organo-mineral soils. The study summarizes and compares the tower based eddy covariance, meteorological and associated measurements at these two contrasting forest sites. Carbon uptake during the summer months was at similar levels for both sites. With similar levels of global radiation our hypothesis is that generally the cooler and wetter climate at Harwood was the limiting factor for carbon uptake. Daily photosynthesis for spruce varied between winter and summer months, reaching maximum after mid-day for January and before mid-day for August. Oak on the other hand, showed a consistent pick in photosynthesis at mid-day. Comparison with historic flux data will confirm if temperature is the limiting factor for carbon fixation in upland conifers.

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Carbon Fluxes in Drained Fens – a Comparison of Static Chamber and Eddy Covariance Methods

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Lowland peat soils represent a significant store of carbon in the UK, but they have historically not received the same attention from the research community as upland blanket bogs. The Lowland Peatland Project (funded by DEFRA) aims to provide a comprehensive assessment of the greenhouse gas (GHG) balance of these systems, and to find emission factors for lowland peats in England and Wales as a factor of land typology and management. The work presented here is from a drained section of the Cambridgeshire fens which is now subject to intensive agricultural production. A combination of static chambers and an eddy covariance (EC) flux tower have been used to study land-atmosphere GHG fluxes from an area of shallow/wasted peat, which has been planted with wheat (2013), two lettuce crops (2014) and maize (2015). Static chambers and a Los Gatos Ultraportable GHG analyser have been used to take approximately monthly measurements of CO_2 and CH_4 fluxes, and the EC flux tower has collected three years of CO_2 flux data. Although both measurement methods capture the same seasonal patterns in net ecosystem CO_2 exchange (NEE), fluxes captured by static chambers frequently show a net emission of CO_2, where half-hourly fluxes measured for the same time period by the EC method suggest net drawdown of CO_2. Partitioning of the EC NEE term results in estimates of gross primary productivity (GPP) and ecosystem respiration (R_{eco}). These agree well with R_{eco} and GPP estimates from the static chamber measurements; however, this agreement breaks down in the late summer and autumn, generally after crops have matured or the ground is bare. Finally, chamber methods captured a temporal hot spot in R_{eco} immediately after sub-soiling and aeration of the field which isn't present in EC flux measurements. It is possible that standard methods of quality assessment and data de-spiking may have led to rejection of valid data.

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Integrative measurements focusing on carbon, energy and water fluxes at the forest site 'Hohes Holz'

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The reduction of greenhouse gas (GHG) emissions and the optimization of carbon sequestration by ecosystems have become priority objectives for current climate change policies. In this context, the long term research project TERENO and the international research infrastructure ICOS were created. Within these projects different ecosystems are investigated with respect to their energy and matter fluxes under the influence of environmental changes. The eddy covariance technique allows obtaining an integrative estimation of the ecosystem carbon and water balance within the footprint of the tower. Furthermore, the assessment of accompanying parameters in response to environmental variables needs to be accounted with increased resolution to determine the specific heterogeneity of the stand. The investigations of these multiple controlling and interacting mechanisms will help to improve the understanding of the complex processes relevant to the energy, hydrologic and carbon cycles. Different ecosystems within the same climatic region are under investigation: (I) a forest (Hohes Holz), (II) a grassland (Großes Bruch) and (III) an agricultural site. At the 1500 ha large forest site a comprehensive system of instrumentation provides continuous data for the evaluation of energy, water and carbon exchange of the complex ecosystem including a 50 m high eddy covariance (EC) tower for micrometeorological investigation in different heights above and below canopy, throughfall and stemflow sensors, a soil moisture/temperature sensor network, a soil respiration chamber system, sap flow sensors, and ancillary analysis of trees and understorey vegetation. Eddy covariance measurements will allow the assessment of the carbon (Net Ecosystem Exchange, NEE) and water balance at the ecosystem scale. In order to achieve higher accuracy in the partitioning between net primary productivity (NPP) and heterotrophic respiration, NEE estimated by eddy covariance needs to be validated with ancillary field measurements. The design and evaluation of global-scale carbon models requires field estimates of NPP and their response to global change and perturbations. Tower-based data of NEE will be therefore complemented and validated with field measurements of C stocks and allocation in biomass and soil, leaf area index estimations, soil respiration measurements (both with continuous measurements and manual survey campaigns) and with the determination of the C emissions from litter and coarse woody debris decomposition. Water flux assessment includes forest floor interception and soil moisture measured in high spatial and temporal resolution using a wireless sensor network.

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A gap-filling method of CO_2 flux based on image inpainting

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Traditional EC gap filling approaches take a linear perspective on data, either using data derived statistically from a moving window, or using a complex function based on a best-guess understanding of the processes driving exchange. The former approach is limited in its ability to capture non-linear trends, and the latter is limited in situations where the flux response to driving variables is poorly understood or unknown (e.g. the response of gas exchange to, for example, water table depth in wetlands). The fact that we can rearrange a time-averaged half-hourly CO_2 flux into a 48*N matrix, where the 48 rows represent the time of a day and the N columns represent the days of a year, provides us a different view of the original time series. One major advantage of doing this is, a better view of the data on a 2-D plane with a clear contour structure, which means that we get centres of high or low values and clear boundaries. As a result, it's possible to apply image processing techniques when we treat the gaps of flux data as holes in a figure. Here we introduce a state of the art technique commonly known as image inpainting to fill gaps in a two dimensional representation of the data, i.e. the flux fingerprint. This has the advantage that any temporal structure is better incorporated into gaps in the flux signal without implying any particular functional response to driving environmental variables. In other words, data gaps are filled solely using information contained in data that are robust. Errors introduced by inpainting depend on the relative duration of the data gap, but compare favorably to errors using standard methods, especially where gaps were small.

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Daily and seasonal evaporation variability for a wetland meadow in the Biebrza River valley

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This study shows the results of evaporation measurements taken in the Biebrza valley (North-East Poland). Biebrza valley is one of the most prominent European wetland preserved in almost untouched condition. The valley is protected as a National Park, EU Natura 2000 site and is listed in the Ramsar Convention. Natural state of the valley highly depends on hydrology. Hence, maintaining the proper hydrological in this area is one of the most important management measures. For this reason, it is necessary to study evaporation in the Biebrza valley with eddy-covariance method. Evaporation is measured in the scope of a project "INterception-TRanspiration-EVaporation; interdependencies of hydrological processes in WETland ECOsystems". Eddy-covariance tower is located in the upper Biebrza basin – this area is typical soligenous peat bogs, slightly drained, with preserved mostly groundwater supplying which maintain appropriate humidity. Vegetation cover is homogeneous and meadows are used extensively. Eddy-covariance tower is equipped with ultrasonic anemometer WindMaster Pro (GILL Instruments) and fast gas analyzer Li-7200 (LI-COR). This allows measuring 3 components of wind speed and water vapor concentration with 10 Hz frequency. Additionally to that some other observations are logged, including: air humidity at 4 height levels, net radiation, soli heat flux, spectral reflectance and infra-red vegetation cover temperature. Eddy covariance tower allows to calculate 15-mintues values of latent heat fluxes using EddyPro software. Based on that, the daily and seasonal variability of evaporation is computed.

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Comparison of CO_2 fluxes measured in dried and un-dried air

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Global oceans are an important sink of carbon dioxide (CO_2). Therefore, understanding the air-sea flux of CO_2, is a vital part in understanding climate change. Eddy covariance (EC) measurements are often used to study CO_2 fluxes from both land and ocean. When using the EC method high frequency instrumentation measuring the three different wind components and the CO_2 concentration are needed. The fluctuations of CO_2 are often measured with infrared absorption sensors that at the same time measure fluctuations of water vapor. Previous studies have shown that measuring CO_2 concentrations when water vapor is present in the sampling air can give erroneous CO_2 measurements due to cross-sensitivity. According to earlier studies the two most likely explanations to this cross-sensitivity problem are pressure broadening effect and the effect of presence of liquid water in the optical path. Studies showing high cross-sensitivity errors in the CO_2 fluxes are all ocean studies. A second concern in the flux community is that, when using open-path sensors, surface heating from the instrument could lead to errors in the CO_2 fluxes. In this study we measure CO_2 fluxes with two LI-COR 7200 sensors and one open-path LI-COR 7500A from both one land site and one ocean site. The sampling gas in one of the LI-COR 7200 instruments has been dried so that the water vapor fluxes are zero. With this setup we want to study the effect of sensible heat flux and the effect of cross-sensitivity on the CO_2 fluxes. The first results from the land site do not show a significant difference in the CO_2 fluxes measured from the dried and the un-dried air samples or a clear effect from sensible heat flux. Because CO_2 fluxes are much higher from land compared to the ocean, we will do further measurements at an ocean based site.

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Bias of EC-fluxes due to transducer shadowing

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The potential bias of EC-fluxes based on ultra-sonic anemometry is a long standing topic of discussion and concern in the micro meteorological community. We performed a simple simulation, which suggests that flow distortion correction is mandatory for all types of sensor arrays except for the vertical wind component measured by orthogonal arrays under conditions of low to medium turbulence intensity. For the simulation, which is based on the transducer shadow parametrization of Wyngaard and Zhang (1985), the angle of attack Θ was varied stochastically according to a Gaussian distribution with σ(Θ) ranging from 5 to 30°. The standard deviation σ(w) of the vertical wind component was calculated for three tilt angles of the sound path (0°, 30°, 45°). The tilt angles were simulated by choosing corresponding mean values of Θ. The underestimation of σ(w) is only negligible for a vertical path in case of low to medium turbulence intensity (σ(Θ) < 10°). At higher turbulence intensity the bias converges for all path inclinations to a common value (in the order of 5 – 10%), depending on the slenderness of the sound path (= ratio of transducer diameter to path length). We suggest to generate calibration look-up tables based on wind tunnel measurements. In contrast to simple parametrizations these can accommodate more complex flow distortion patterns including the influence of supporting structures of the sensor array.

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P2015-19

Monitoring the soil CO_2 flux during CO_2 storage at the Ketzin pilot site, Germany

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The GFZ German Research Centre for Geosciences operates Europe's first on-shore CO_2 storage pilot site at Ketzin, a small town near Berlin. From June 2008 to August 2013 about 67 kt of CO_2 were injected into Upper Triassic sandstones in 630 to 650 m depth via an injection well. Furthermore, the site comprises four observation wells. The sealing of the storage formation is ensured by more than 165 m thick impermeable shaley cap rocks. Additionally, the position of the site at the southern flank of an anticlinal structure restricts the spreading of the CO_2 [Förster et al., 2006]. The monitoring of the soil CO_2 flux started already in 2005, more than three years in advance of the injection procedure using a survey chamber from LI-COR Biosciences. Twenty sampling locations in a grid shape layout around the injection site were selected covering an area of about 3 x 3 km. The region is mainly used for farming with many agricultural roads. As the sampling locations are mostly located next to roads and fields, fertilization and harvesting may have an influence on the soil structure. In order to obtain information on seasonal trends, measurements were performed once a month during the whole year. In addition to the soil CO_2 flux soil temperature and moisture were recorded. Also soil samples were taken at each location down to 70 cm depth in order to get information on soil composition and structure. This background data set serves as a basis for comparison with all further measurements during injection and storage [Zimmer et al., 2010]. To refine the monitoring at the pilot site, eight permanent soil CO_2 flux stations were additionally installed in the direct vicinity of the bore holes. Using this system, installed in 2011, the CO_2 soil efflux is measured continuously every hour. Both, diurnal and seasonal variations can be detected and hence, provide a basis for interpreting the measured data.

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P2015-20 Poster download (PDF)

Measuring peatland carbon sequestration and emission by remote sensing.

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Over 50% of UK carbon stocks are held within peatlands; however some areas have been degraded by land management techniques such as drainage and are consequently losing carbon. Restoration of 21,000 ha per year of Scottish peatlands is one of the key interventions planned to achieve the 2050 target of 80% emissions reduction within the Climate Change Act (Scotland) 2009. One of the main aims of this project is to improve estimates of carbon uptake and emission at a landscape scale across pristine, restored and degraded peatlands under current climatic conditions. This will allow more accurate predictions of how effective restoration schemes will be under future climate scenarios. Earth observation data, like MODIS, have the potential to provide robust information about peatland condition and climatic sensitivity across large areas. However, current algorithms used to estimate carbon fluxes are relatively untested in peatlands and may need to be adjusted because of key ecosystem properties like soil water saturation and unique vegetation species present. This project aims to test and refine remote sensing methods of measuring peatland carbon sequestration and emission by combining field measurements of carbon fluxes with spectral data from field, airborne and satellite platforms. Factors such as vegetation composition and drought susceptibility will be taken into account. Research will focus on the UK's most extensive area of blanket peatland in northern Scotland, building on the established network of platform field monitoring sites used by the RSPB led Forest-to-Bog restoration programme.

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Instrumental approaches to source partitioning of greenhouse gas (CO_2 and H_2O) fluxes

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How does the biosphere react on global change and local land use management? The land surface currently acts as a sink for anthropogenic emissions from fossil fuels, but an additional CO_2 release is caused by land use change. The sensitivities of photosynthetic CO_2 uptake and respiratory CO_2 release to environmental parameters remain uncertain. One possible way to disentangle the flux of greenhouse gases is source partitioning, e.g. into photosynthesis and respiration (CO_2) or into evaporation and transpiration (H_2O). The BMBF-funded project IDAS-GHG (Instrumental and Data-driven Approaches to Source-Partitioning of Greenhouse Gas Fluxes: Comparison, Combination, Advancement) aims at comparing and improving existing methods for partitioning of CO_2 and H_2O fluxes into their respective raw components. Data-driven approaches use existing (raw or processed) data of typical eddy-covariance stations. Instrumental approaches of source partitioning require additional measurements at different parts of ecosystems and different methods, e.g. soil-flux chamber measurements, profile measurements or tracer measurements (isotopes). We present preliminary results of a profile measurement system involving a small elevator continuously moving up and down. It measures changes in the concentration of CO_2 and H_2O at a high vertical and temporal resolution between the soil surface, the plant canopy and the atmosphere. Tests were carried out at the TERENO research site of Selhausen (Lower Rhine Embayment in the river Rur catchment (50°52'09''N, 06°27'01''E, 104.5 m MSL, Germany) on a winter wheat field for a growing season from seeding to harvest (April - August 2015).The half hourly mean profiles of CO_2 and H_2O show the effects of soil respiration and photosynthetic carbon assimilation very clearly, varying both during the daily cycle and during the growing season. An additional way to partition CO_2 and H_2O fluxes is through measurements of concentration profiles of their stable isotopologues ($^{13}CO_2$, $^{12}C^{18}O^{16}O$, $^{1}H^{2}H^{16}O$, and $^{1}H_2{}^{18}O$). Following controlled-conditions experiments in the laboratory on soil columns in autumn and winter 2015, a quantum-cascade dual isotope laser will be deployed at the Selhausen test site in a low-flow (i.e., soil atmosphere and chamber measurements) and high flow (i.e., Eddy-Covariance measurements) configurations for comparison with the above-mentioned profile measurement system.

P2015-22 Poster download (PDF)

Eddy covariance measurements within complex terrain at a high arctic site

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The eddy covariance method had become one of the most relevant measurement methods for quantifying the turbulent fluxes in the surface layer. This trend is not only driven by development of robust commercial instruments by several manufactures but also by the enhancement of a manifold of comparable software packages which simplify and standardise the flux calculations. Therefore eddy covariance system installations are not restricted to areas within easy reach or ideal terrains but may also utilized at exposed sites like Ny-Ålesund (Spitzbergen). This site is characterized by a very complex terrain and strongly deviating climatological conditions (compared to mid-latitudes) introducing a variety of micrometeorological effects like near surface external gravity waves (Jocher et al 2012), flux dependency on prevailing synoptical regime (Jocher et al 2014), disturbed temperature profiles (Lüers & Barreis 2012), occurrence of very low surface based inversions and strongly varying boundary layer height (Schulz 2012) and high temporal variability of the horizontal wind-field (Burgemeister 2013). These local features are not only complicating the local ABL research but also violate frequently the underlying fundamentals of the eddy covariance method resulting in fluxes of poor quality or low availability. Apart from a manifold of other physical processes effects like intermittence, long-living stable conditions and/or short periods of wind-driven turbulence bursts during polar night inducing non-stationary conditions within the well-established time intervals (e.g. 30min). This shall be illustrated by data series acquired by two different eddy covariance measurement systems installed in the vicinity of Ny-Ålesund. In contrast the continuous incoming solar irradiation during polar day results in excellent conditions for accurate flux measurements which will also be shown for both mentioned sites.

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$^{13}CO_2$ in urban atmosphere

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Stable carbon isotopes (^{13}C and ^{12}C) are a useful tool to study carbon cycling on various spatial and temporal scales [e.g. 1,2]. Sources of carbon dioxide can be distinguished because isotopic fractionation differs for specific processes. Recently developed methods for fast and precise measurements of concentration and isotopic composition of greenhouse gases provides an excellent tool to study carbon dynamics in evolving urban atmosphere (e.g. isotopic mass balance introduced by C.D. Keeling has been widely used for CO_2 partitioning [3; 4; 5]. The presented study is focusing on a city of Krakow, located in Southern Poland. There are several categories of anthropogenic CO_2 sources there, including fossil fuel burning by domestic heating, traffic and industry. Since 2011, continuous measurements of CO_2 concentration and its ^{13}C isotopic signature are being performed. Fossil fuel burning introduces carbon dioxide to the urban atmosphere which is depleted in ^{13}C. Thus measurements of concentration and ^{13}C signature of CO_2 in atmosphere can provide information on contribution of specific sources to the total CO_2 burden of this gas in the urban air.

Acknowledgements:

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Eddy covariance measurements along a forest disturbance chronosequence in the Austrian Alps

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Eddy covariance (EC) measurements along disturbance chronosequences have demonstrated the important role natural disturbances play in regulating forest-atmosphere fluxes of sensible heat (*H*), water vapor (i.e. latent heat, *LE*) and carbon dioxide (*NEE*). Although such studies have covered a number of ecoregions, EC measurements at disturbed forest sites in the European Alps have been slow to emerge. While the mountainous setting can pose additional methodological challenges to EC (e.g. non-stationarity, advection), the lack of flux data is nonetheless a concern as natural forest disturbance regimes in the Alps have been intensifying. As part of the Interreg projects, SicAlp and StratAlp, we conducted an EC flux measurement campaign over three growing seasons (second to fourth seasons post-disturbance) at a site in the Austrian Alps, which had recently been disturbed in 2009 by windthrow and bark beetle events. In May 2015, as part of the C-Alp project, we followed up the initial investigation, by transferring the measurement setup to an adjacent, older windthrow site which was opened up in 2007 by the Kyrill storm. Combining the data from the two sites, and thus direct time-series and chronosequence approaches, enabled us to investigate growing season flux dynamics over the first eight years post-disturbance. Despite the complex and sloping terrain, over 50% of the individual 30 min fluxes satisfied quality control criteria and were retained for subsequent analysis. Furthermore, the energy balance closure observed at both sites compares well with closure reported by EC studies in flat terrain. Increasing vegetation cover coincided with decreasing seasonal net carbon dioxide (CO_2) emissions over the observation period. However, eight years after disturbance, the 2007 windthrow site likely remains a net CO_2 source: From 1st May to 22nd Sept 2015, the site registered a small net loss of 5.6 g C m^{-2} to the atmosphere. As partitioning between *H* and *LE* fluctuated strongly with varying weather conditions, no clear trend in Bowen ratios (*H/LE*) was apparent. Mean daytime average Bowen ratios (calculated from the mean diurnal trends in *H* and *LE* for July and August) of 0.82, 0.59, 0.75, and 0.54 were recorded for the second, third, fourth, and eighth years post-disturbance, respectively. However, inversion of the Penman-Monteith equation revealed that dry surface conductance of water vapor increased each season over the initial campaign at the 2009 windthrow site, indicating increasing vegetation influence on energy partitioning between *H* and *LE*.

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Measurements of respiratory losses from disturbed woody debris in a forest ecosystem

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The scientific evidence for accelerated climate change caused by the emissions of greenhouse gases (GHG) into the earth's atmosphere is indisputable. Atmospheric concentrations of GHG, and their increases, are determined by the balance between sources and sinks. Forests are a key component of the global carbon (C) cycle and have a role to play in mitigating climate change. A significant proportion of forest C is stored in the form of coarse woody debris (CWD), which may include stumps and coarse roots, dead branches, fragments of wood, rotting logs, and standing dead trees (snags). To faciliate reforestation after clearfelling, surface debris are removed from the harvested area and assembled into long regular windrows and are compsed of stumps, branches, forest floor, and soil, which are usually left in place to decompose. The windrows therefore are an important, long-term GHG source that needs quantification. It is intended to quantify the contribution of windrowed material to forest ecosystem respiration rates and to compare the decomposition rate of windrowed and non-windrowed woody debris. This information will be used to identify the effect of the management induced disturbance on forest carbon capital and mitigation potential. The seasonal variability of CO_2 efflux (F_s) from windrowed woody debris was measured at three different aged Sitka spruce (*Picea sitchensis* (Bong.) Carr.) forest stands in Co. Wicklow (Ireland). A portable infrared gas analyser (LICOR 6400XT) was used to measure changes in F_s rates from closed-chambers which enclosed *in situ* samples of windrowed material. Additional measurements of CO_2 efflux from locations between windrows were carried out to quantify the respiration differences between the windrowed and non-windrowed sampling points. The scientific principle of the respiration rate measurement is based on the increase in CO_2 concentration within the chamber over a short, fixed period of time, assessed using a linear regression method. Such measurements are not straightforward because the semi-structured, non-solid nature of the heaped debris makes the assessment of within-chamber head-space volume difficult. Fans were employed to mix the chamber volume air. For representative sampling of the windrows, it was necessary to include the full vertical profile, necessitating a large chamber volume and a minimisation of any effects on the environmental conditions of the sampling location. The large size of windrows (typically c. 2 m wide and 1 m high) are sufficient to significantly alter temperature and moisture conditions within them, so measured respiration rates will be correlated with measurements of these parameters inside the windrows to scale to forest stand level.

P2015-26

Turbulent sensible heat flux derived by XLAS and eddy Covariance in Enschede during summertime

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During the end of June and early July in 2015, an early summer heat wave scorched the Netherlands. The maximum temperature in Enschede reached 36.1℃ which set a new record ever since 1951 for this city. This poster examined the turbulent sensible heat flux (H) over the urban area of Enschede using data collected by an extra-large aperture scintillometer (XLAS) and an eddy covariance system (EC) during June 30-July 13. The path of XLAS (4.9 km) crosses the city from southeast to northwest while EC is located in the center of the city, about 1.1km away from the path. The diurnal pattern and footprint of sensible heat flux were determined to compare XLAS and EC measurements and investigate the temporal evolution of H during and after the heat wave.

P2015-27

Measurement of CO_2 fluxes over a High Arctic fjord in Greenland

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High latitude seas (Takahashi et al., 2009)) and shelf waters (Chen et al., 2013) are important areas for ocean CO_2 uptake. The uptake rates of atmospheric CO_2 in the Nordic Seas and particularly the shelf waters around Greenland are among the highest in the world's oceans (Nordic Sea ~2.5 mol m^{-2} y^{-1} (Takahashi et al., 2009) and Greenland shelf ~6 mol m^{-2} y^{-1} (Chen et al., 2013)). The driving factors behind air-sea exchange of CO_2 is the difference between the partial pressure of CO_2 (pCO_2) of the atmosphere and surface waters, leading to an uptake in areas where the pCO_2 of surface waters is lower relative to atmospheric levels. It is critical that we are able to accurately estimate CO_2 uptake by the Greenlandic coastal area because this marine region is sensitive to climate change and because it takes up relative more CO_2 than other marine areas. In order to estimate the uptake, the uptake rates have to be well estimated. They can be assessed from measurements of pCO_2 in surface waters and the air and air - water CO_2 fluxes. These assessments are associated to large uncertainties due to the difficulties in measuring the very small air - water fluxes over a moving surface in an atmosphere of sea spray and high humidity. Furthermore the coastal area is highly heterogeneous in terms of biogeochemical parameters. Here we present air – water CO_2 fluxes measured over a high Arctic estuary (Young Sound) at Daneborg in Greenland (Sejr et al., 2011). Based on water measurements of pCO_2 the estuary appears as a CO_2 sinks, but data from one month of monitoring the CO_2 flux using eddy covariance suggests an upward flux during some conditions. Potential conditions and processes responsible for this are discussed.

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P2015-28 Poster download (PDF)

Effect of chamber enclosure time on soil respiration flux: A comparison of linear and non-linear methods of flux calculation

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One of the major shortcomings of closed chamber methods in soil respiration (SR) measurements is the decreased CO_2 diffusion from soil to chamber headspace that may occur due to increased chamber CO_2 concentrations. This feedback on diffusion may lead to underestimation of fluxes by linear regression techniques. Thus, usually an exponential curvature is formed due to the decreased diffusion gradient. Non-linear models based on biophysical theory usually fit to such curvatures and may eliminate the error. In this study, we examined the effect of increasing chamber enclosure time on SR flux rates calculated using a linear and two non-linear methods, namely an exponential model (Kutzbach et al., 2007) and the HMR approach (Pedersen et al., 2010). Soil respiration rates were measured with a Li-Cor 8100-102 closed chamber (LiCor Inc., Lincoln, USA) in combination with an infrared gas analyzer (LI-8100). During SR flux measurements the chamber was gently placed on the collars (10 cm diameter), and data of CO_2 concentration in the chamber headspace were recorded at 1 Hz frequency for 45 minutes. Fluxes were measured in different soil types (sandy, sandy loam and organic soils), and for various manipulations (tillage, flooding and drought) and soil conditions (temperature and moisture) to obtain large range of fluxes with different shapes of curves. Results showed that non-linear models can correct most of the underestimation caused by prolonged enclosure times, but the linear method provided more stable flux results during short enclosure times. For prolonged enclosure times, both non-linear methods fitted better than the linear method, but the HMR approach was more robust as the method showed no or only small enclosure time effects.

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P2015-29 Poster download (PDF)

Improving performances of closed-path eddy covariance systems by sampling line heating

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Eddy covariance measurements performed with closed-path systems are affected by high-frequency flux losses due to the passage of sampled air through a gas sampling system (GSS). This problem is more relevant for gases that undergo strong sorption processes, such as H_2O. Recent "enclosed" analyzer designs (e.g. LI-7200, LI-COR Biosciences Inc.) mitigate the problem by allowing a short length of the intake tube (<1 m). Further improvements can come from carefully designed filtering and heating systems that reduce GSS contamination and H_2O adsorption on its surfaces. Water vapor sorption processes become increasingly more efficient with increasing relative humidity (RH). Thus, a strategy to reduce high-frequency attenuations is that of maintaining RH sufficiently high inside the GSS by increasing sampled air temperature via heating. In this work, we propose an optimized heating design that improves the performances of the LI-7200 while limiting the implied increase in power consumption.

From field tests we found that placing a 2 µm particulate filter (FW-series, Swagelok) ≈20 cm downstream of the inlet rain cap of a 700 mm stainless steel intake tube, and concentrating 2/3 of the supplied heat in this first 20 cm and 1/3 in the remainder of the tube, provides optimal performances. In the tested conditions, we found that 6 W was enough to gain a >1 Hz improvement in system's frequency response, while further heating gave negligible improvements. Using model co-spectra and a range of realistic measurement and environmental conditions, we estimated H_2O spectral corrections to reduce as much as ≈85% with respect to the same sampling line left unheated, and to get very close to those of CO_2 in most conditions of interest, i.e. of the order of 1-3%.

P2015-30 Poster download (PDF)

Laughing gas from our freshwaters – what importance do they have for the nitrogen budget and the greenhouse effect?

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Reactive nitrogen in surface waters and sediment of aquatic systems is being microbially reduced to molekular nitrogen. During the process of denitrification, the intermediary product nitrous oxide (laughing gas, N_2O) can be emitted to the atmosphere in measureable quantities. With a global warming potential of about 300 (compared to CO_2) and rising atmopsheric levels, it bears significance for the global climate change. Denitrification is primarily controlled by the available amount of nitrate in an ecosystem. Since nitrogen loads in the atmosphere, streams and standing water bodies remain high, it is assumed that denitrification in freshwaters poses an important contribution of nitrous oxide.

In this subproject of NITROLIMIT II, the importance of nitrate-rich streams and lakes for the emission of N_2O from selected German freshwaters is examined. For the identification of adequate sampling sites, lakes and streams with nitrate loads higher than 5 mg L^{-1} were chosen, for which the NITROLIMIT waterbodies database provided the data. Different lakes in the federal state of Mecklenburg-Vorpommern and streams in Thuringia were probed in February and April 2015, whereas the streams carried loads as high as 15 mg L^{-1} and more. To determine N_2O flux rates, floatable flux chamber time series measurements were applied, together with readings of relevant parameters like temperature, oxygen saturation, pH and redox potential. Sediment core samples were taken to determine organic matter content and nitrous oxide saturation in the pore water.

So far, no relevant emissions of nitroux oxide from these waters could be found. In fact, several lakes acted as a sink for N_2O at that given time. The net emissions are so low that N_2O is not considered to be important for the nitrogen budget as well.

P2015-31 Poster download (PDF)

Estimating surface fluxes using eddy covariance and numerical Ogive optimization

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Estimating representative surface-fluxes using eddy covariance leads invariably to questions concerning inclusion or exclusion of low frequency flux contributions. For studies where fluxes are linked to local physical parameters and up-scaled through numerical modelling efforts, low frequency contributions interfere with our ability to isolate local biogeochemical processes of interest, as represented by turbulent fluxes. No method currently exists to disentangle low frequency contributions on flux estimates. Here, we present a novel comprehensive numerical scheme called *Ogive optimization*, which identifies and separates out low frequency contributions to vertical turbulent surface fluxes. The method makes no assumptions concerning appropriate averaging time or the presence of a spectral gap, does not require the application of any transfer functions and allows for very high temporal resolution of flux evolution. In addition it improves flux estimates by extrapolating spectral contributions into the very high/low frequency ranges which cannot be observed directly. For high flux-rates ($|H|>40 Wm^{-2}$, $|L|>20 Wm^{-2}$ and $|F_{CO2}|>100 mmol m^{-2} d^{-1}$) we found that the average relative difference between fluxes estimated by Ogive optimization and the conventional method was low (5-20%) suggesting modest low frequency influence and that both methods capture the turbulent fluxes equally well. For flux-rates below these thresholds, however, the average relative difference between flux estimates was found to be very high (23-98%) suggesting significant influence of low frequency flux contributions and that the conventional method fails in separating low-frequency influences from the turbulent fluxes. Hence, the Ogive optimization method is an appropriate method of flux analysis, particularly in low-flux environments and environments characterized by a challenging topography. Additional information available in the published article [1].

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P2015-32 Poster download (PDF)

FluxSuite: a new scientific tool for advanced network management and cross-sharing of next-generation flux stations

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Significant increases in data generation and computing power in recent years have greatly improved spatial and temporal flux data coverage on multiple scales, from a single station to continental flux networks. At the same time, operating budgets for flux teams and stations infrastructure are getting ever more difficult to acquire and sustain. With more stations and networks, larger data flows from each station, and smaller operating budgets, modern tools are needed to effectively and efficiently handle the entire process. This would help maximize time dedicated to answering research questions, and minimize time and expenses spent on data processing, quality control and station management. Cross-sharing the stations with external institutions may also help leverage available funding, increase scientific collaboration, and promote data analyses and publications. FluxSuite, a new advanced tool combining hardware, software and web-service, was developed to address these specific demands. It automates key stages of flux workflow, minimizes day-to-day site management, and modernizes the handling of data flows:

- Each next-generation station measures all parameters needed for flux computations
- Field microcomputer calculates final fully-corrected flux rates in real time, including computation-intensive Fourier transforms, spectra, co-spectra, multiple rotations, stationarity, footprint, etc.
- Final fluxes, radiation, weather and soil data are merged into a single quality-control file
- Multiple flux stations are linked into an automated time-synchronized network
- Flux network manager, or PI, can see all stations in real time, including fluxes, supporting data, automated reports, and email alerts
- PI can assign rights, allow or restrict access to stations and data: selected stations can be shared via rights-managed access internally or with external institutions
- Researchers without stations could form “virtual networks” for specific projects by collaborating with PIs from different actual networks

This presentation provides detailed examples of FluxSuite currently utilized to manage two large flux networks in China (National Academy of Sciences and Agricultural Academy of Sciences), and smaller networks with stations in the USA, Germany, Ireland, Malaysia and other locations around the globe.

P2015-33 Poster download (PDF)

Assessing the spatial and temporal dynamics of carbon and water cycling in a mountain catchment using field, laboratory, and remote sensing techniques

Jeff Atkins (1), Howard Epstein (1) and Daniel Welsch (2)

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In complex terrain, the heterogeneity of biogeochemical cycles is affected by landscape position and vegetation heterogeneity through the lateral and vertical redistribution of soil water across a catchment. Preferential flow paths result in convergent and divergent areas of soil moisture that exert controls on the spatial and temporal dynamics of carbon cycling. The magnitude of these effects is further mediated by climatic forcings and inter-annual climatic variability. To investigate the controls on carbon and water cycling within a mountainous, humid watershed, we conducted field measurements in the Weimer Run watershed, a 373 ha, mountainous (1150 m ABSL) watershed in West Virginia from 2010 through 2012.Our experiment employed a factorial approach whereby plots were placed in one of three vegetation classes (OPEN, SHRUB, CANOPY) located within three elevation classes (LOW, MID, HIGH) along an elevational gradient. Our research consisted of three main parts: 1) intensive and extensive fieldwork measuring soil CO_2 efflux, soil moisture, soil temperature, below-ground soil CO_2 concentrations, and soil chemical and physical properties; 2) a two year paired litterbag study to quantify rates of and controls on decomposition; and 3) spatial and temporal evaluation of vegetation change using Landsat TM derived vegetation indices. Vegetation cover was found to have a strong effect on soil CO_2 efflux, with plots located beneath evergreen shrubs (e.g. *Rhododendron maximum*) exhibiting the highest flux rates. However, fluxes were constrained during periods of high soil moisture, and amplified at below-average soil water availability. The interaction of precipitation and topography also exerted strong controls on the temporality and magnitude of fluxes. Results from our litterbag study show that winter snowfall and elevation affect decomposition rates. Analysis of remote sensing data shows that evergreen shrub cover in the watershed has been expanding steadily between 1986 and 2011—an important consideration given the effects of evergreen shrubs on carbon cycling and soil properties. This study highlights the importance of considering the interactions of spatial heterogeneities—including topography and vegetation structure—with moisture and climate to impact biogeochemical cycles.

P2015-34 Poster download (PDF)

Significance of high-speed air temperature measurements in the sampling cell of a closed-path gas analyzer with a short tube

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Eddy covariance gas analyzers measure gas content in a known volume, thus essentially measuring gas density. The fundamental flux equation, however, is based on the dry mole fraction. The relationship between dry mole fraction and density is regulated by the ideal gas law describing the processes of temperature- and pressure-related expansions and contractions, and by the law of partial pressures, describing the process of dilution. As a result, this relationship depends on water vapor content, temperature and pressure of the air sample. If the instrument is able to output precise high-speed dry mole fraction, the flux processing is significantly simplified and WPL density terms accounting for the air density fluctuations are no longer required. This should also lead to the reduction in uncertainties associated with the density terms resulting from the eddy covariance measurements of sensible and latent heat fluxes used in these terms. In this framework, three main measurement approaches may be considered:

Open-path approach

Outputting correct high-speed dry mole fraction from the open-path instrument is difficult because of complexities with maintaining reliable fast temperature measurements integrated over the entire measuring path, and also because of extraordinary challenges with accurate measurements of fast pressure in the open air flow.

Classical long-tube closed-path approach

For instruments utilizing traditional long-tube closed-path design, with tube length 1000 or more times the tube diameter, the fast dry mole fraction can be used successfully when instantaneous fluctuations in the air temperature of the sampled air are effectively dampened to negligible levels, instantaneous pressure fluctuations are regulated or negligible, and water vapor is measured simultaneously with gas or the air sample is dried.

Short-tube closed-path approach, the enclosed design

For instruments with a short-tube enclosed design, most - but not all - of the temperature fluctuations are attenuated, so calculating unbiased fluxes using fast dry mole fraction requires high-speed, precise temperature measurements of the air stream inside the cell. Fast pressure and water vapor content of the sampled air should also be measured in the sampling cell, and carefully aligned in time with gas and temperature measurements.

This presentation examines data from the three different sites equipped with enclosed short-tube analyzers in order to evaluate the significance of high-speed, precise air temperature measurements in the sampling cell of the analyzer. Short-term and long-term effects are examined using half hourly fluxes of carbon dioxide and water vapor, as well as long-term carbon and water budgets.

P2015-35

Greenhouse gas emissions from paddy rice fields in Ebro Delta (Spain)

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The project Life+ Ebro-ADMICLIM puts forwards pilot actions for adaptation to and mitigation of climate change in the Ebro Delta (Catalonia, Spain), an area vulnerable to sea level rise and subsidence. We propose an integrated approach for managing water, sediment and habitats (rice fields and wetlands), with the multiple aim of optimizing ground elevation (through inputs of inorganic sediment and organic matter), reducing coastal erosion, increasing the accumulation (sequestration) of carbon in the soil, reducing emissions of greenhouse gases (GHG), and improving water quality. Pilot actions are proposed for the rice fields and wetlands, to optimize carbon and nutrient sequestration and GHG emissions. Rice cultivated under flooded conditions is one of the main contributors to anthropogenic emissions of greenhouse gases (GHG), in particular methane (CH_4). A line of research is being carried out within Life Ebro-ADMICLIM project aiming at measuring GHG emissions from rice crop Ebro Delta and assessing their relationship with agronomic practices and physicochemical characteristics of the field. For this purpose, GHG sampling are being conducted in 15 commercial rice fields distributed all over Ebro Delta, covering geographical and physicochemical variability, while agronomic practices (sowing date, crop phenology, cultivar, fertilization, yield, straw management), water management and physicochemical parameters (redox, temperature, conductivity, pH) of soil and water are periodically being monitored. Measurements are being done monthly, from May to December, so that the effect of water and straw management during winter rice crop season is also studied. In addition, the diurnal variation of GHG fluxes was measured once, during reproductive stage in 2015 growing season, at 2-hour intervals. Gas sampling is being done using the manual closed chamber method while gas analyses by gas chromatography (Gc Trace 2000). Preliminary results on daily fluxes pattern show an increasing trend of CH_4 emission over afternoon and evening (17:00 to 23:00 h) whereas seasonal pattern will be discussed after the completion of the current seasonal measurements. The results will serve to establish guidelines for a program of adaptation and mitigation measures (with emphasis on the rice sector) in which it will be essential to design a strategy for voluntary reduction of GHG emissions commanding the support of the rice sector. Improved rates of GHG emissions and carbon sequestration through a change in management practices (for example, a more efficient water management system) would represent a significant improvement that could be applied in other coastal wetlands and rice fields in the European Union.

P2015-36 Poster download (PDF) *2nd Place Student Poster Award Winner*

The consequences of the diurnal variation of soil respiration for soil budgets from up-scaled daytime measurements

Andreas Brændholt (1), Klaus Steenberg Larsen (1, 2), Kim Pilegaard (1) and Andreas Ibrom (1)

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Precise measurement and modelling of soil respiration (R_s) is important in order to correctly estimate annual ecosystem carbon budgets. Here R_s is particularly important to partition autotrophic respiration into below and aboveground parts (Wu et al. 2013, Agric. For. Meteorol., 181, 95-107). Like in this study, R_s is often estimated with manual chamber measurements performed at regular intervals in a number of different plots. While such measurement schemes may capture the variation in R_s on a spatial and seasonal scale, it does not fully catch the diurnal variation, as manual measurements normally are performed during daytime working hours. Up-scaling to daily R_s values from daytime data requires that they are representative; otherwise the daily estimates are systematically biased. To study the consequences of using up-scaled daytime measurements for estimating the annual soil carbon budget, we used a data set of manual measurements of daytime R_s on a high spatial scale and compared this with automated, hourly R_s measurements in a temperate beech forest throughout one year. The hourly automated measurements showed that daytime R_s values were consistently lower than at nighttime. This was particularly surprising as night time soil temperatures are lower than at daytime. Consequently the up-scaled R_s based on daily values underestimated the annual R_s value, compared to using continuous hourly data. The respective systematic errors depended on season and varied on a monthly mean from 5 % to as much as 22 %, with the largest underestimation in summer and the lowest in winter. When correcting the carbon budget from manual daytime measurements, the annual budget increased from 708 to 810 g C m^{-2} yr^{-1}, which corresponded well with the 824 g C m^{-2} yr^{-1} calculated from the automated measurements. This is an increase of 14%. The same approach was used to correct daytime measured R_s of a previously published synthesis of C fluxes in the investigated beech forest (Wu et al. 2013), where the R_s was used to separate below and aboveground autotrophic respiration. This correction changed the ratio of aboveground to belowground autotrophic respiration from 2.9 to 1.6, which is a much more plausible value. We advocate carefully investigating the diurnal pattern of soil respiration across all seasons when up-scaling daytime flux data, since neglecting the diurnal cycle may considerably bias the up-scaled annual budget.

P2015-37 Poster download (PDF)

Indirect effects of wildfire (severity) on carbon fluxes and budgets

Jacob Keizer (1), Casimiro Pio (1), Ana Bastos (2), Frank Verheijen (1), Glória Pinto (2), João Nunes (1), Luísa Pereira (3), Maria Varela (1), Mário Cerqueira (1), Maruxa Malvar (1), Nelson Abrantes (1), Sergio Prats (1), Valdemar Esteves (4), Penelope Serrano Ortiz (5) and Thomas Foken (6)

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In many Mediterranean regions, wildfire regimes have intensified over the past decades, strongly reflecting human activities directly or indirectly. In Portugal, wildfires have been affecting, on average, 100.000 ha per year and over 300.000 ha in extreme years. A key societal concern regarding wildfires is its impacts on forest ecosystem services and, in particular, carbon sequestration. Forest policy and management have increasingly targeted the carbon sink potential of forest to offset greenhouse gas emissions. Wildfire affects forest carbon pools both directly, through combustion/heating processes, and indirectly, by changing abiotic (e.g. soil temperature) and biotic (e.g. leaf area index) conditions. These indirect impacts appear to be important, as model results have suggested that post-fire carbon losses are roughly equivalent to emissions during the fire. Furthermore, forest stands haven been found to act as carbon sink for 10 and more years after wildfire. Wildfire effects on forest carbon dynamics have mainly been addressed through biometric surveys of (annual changes in) carbon stocks. Studies measuring soil respiration effluxes have been less frequent and studies measuring eddy covariance fluxes even less. The combination of the 3 methodologies has been advocated for refining process-based models used to assess larger scale effects on the carbon cycle. The FIRE-C-BUDs project, which was recently recommended for funding by the Portuguese Foundation for Science and Technology (FCT), aims to address the current knowledge gap on forest carbon fluxes and budgets immediately after wildfire and, more specifically, to assess: (i) direct and indirect effects of two contrasting fire severities (low vs. high) on vegetation, ash, litter and soil carbon pools; (ii) indirect effects of fire severity on carbon exports by overland flow and instantaneous rates of soil respiration and photosynthesis, and their evolution with time-since-fire; (iii) evolution, at the high-severity burnt site (worst-case scenario), of net ecosystem exchange and total ecosystem respiration with time-since-fire, using the eddy-covariance technique, and their link with the temporal patterns in point-scale soil effluxes and net carbon assimilation rates. The project foresees to do so for maritime pine plantations in the Caramulo mountain range, as they are one of the two prevalent forest types in north-central Portugal, highly fire-prone and recover less quickly in height than the other predominant and no less fire-prone forest type of eucalypt plantations.

P2015-38 Poster download (PDF)

Preliminary results of two years CO_2 and CH_4 eddy-covariance flux measurements at Biebrza wetlands

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The turbulent fluxes of two major GHG, methane and carbon dioxide, were continuously measured at the mire of Biebrza National Park (BPN) in years 2013–2014. The Biebrza valley wetlands belong to the biggest in central Europe. The measurement site (53°35'30.8"N, 22°53'32.4"E, 110 m a.s.l.) was located in the central basin of Biebrza valley on the large, flat surface near to the village Kopytkowo. The surroundings are characterized by a relatively homogenous mixture of reeds, sedges and rushes characteristic for the Biebrza wetlands. A small river Kopytkówka, completely overgrown with reeds, flows in the nearest neighborhood of the site. The turbulent fluxes of CH_4 and CO_2 were measured with the aid of open-path eddy-covariance system. The fast respond sensors (Li7500 for CO_2/H_2O and Li7700 for CH_4) operating with 10 Hz frequency were mounted at the height of 3.7 m. The outputs from sensors, governed by CR5000 datalogger (Campbell Sci.), were organized in 15 min files and stored on the PC connected to the logger. The eddy-covariance system was complemented by slow-respond sensors: net radiometer (CNR1) and two PAR sensor (faced up and down) mounted on the horizontal arm at the height 2.7 m in a distance more than 3 m from the box, ground heat flux plates, sensor of volumetric water content, rain gauge, two temperature and humidity probes (HMP60) at height 0.5 and 2 m, atmospheric pressure sensor, cup anemometer and wind wane. To achieve comparability, the fluxes were calculated with the EddyPro software, but 3 additional stationarity test were used to get a high quality data. The mean CH_4 flux ranges from about 10 nmol m^{-2} s^{-1} in winter to about 100 nmol m^{-2} s^{-1} (night) and 170 nmol m^{-2} s^{-1} (day) in summer (June–July). The summer CH_4 efflux were characterized by a clear diurnal pattern with maximum in the afternoon and minimum at night. The comparison between two measurement years shows a clear influence of hydrological conditions on monthly and annual totals of CH_4 emission. Depending on the year of the observations and the gap filling procedure the annual totals of CH_4 flux ranges from 18 to 35 g m^{-2} $year^{-1}$. In the summer (June and July) the mean CO_2 flux showed a typical diurnal course with maximal uptake at noon at the level of –(12–13) µmol m^{-2} s^{-1} and nighttime respiration at the level of (2–5) µmol m^{-2} s^{-1}. The winter CO_2 flux was close to zero. The preliminary estimations of the annual uptake of CO_2 at investigated Biebrza mire equaled 500–1000 g m^{-2} $year^{-1}$ (depending on the year and method).

Acknowledgements:

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P2015-39

Influence of *Phragmites* on CH_4 and CO_2 fluxes from a fen in South-West Germany

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About one third of all the soil carbon is stored in peatlands, even though they cover only 3% of earth's land surface. Therefore, peatland conservation or restoration as a climate mitigation option has gained much attention. Apart from the positive effect of carbon storage in peatlands, there is also the effect of the natural production of CH_4, which is a 28 times stronger greenhouse gas than CO_2 over a 100 year time period. Therefore the question is how much peatlands can contribute to climate change mitigation. To gain more knowledge about this subject, a measurement campaign was set up in the reed (Phragmites australis) area of the minerotrophic peatland ´Federseemoor´ (3500 ha). It was suspected that this reed area could release high quantities of CH_4 due to the anoxic conditions in general and the capacity of reed vegetation to transport gas actively between soil and atmosphere in particular. Against this background, CO_2 and CH_4 fluxes have been measured by means of the eddy covariance method since March 2013. From these data it became clear that a strong diurnal pattern of CO_2 and CH_4 fluxes starts when reed vegetation starts to grow. The pattern disappears after the growth season. The highest emissions of $CH_4$are measured during the day, around noon. This seems to be linked to humidity-induced pressure flow, caused by the ability of reed plants to exchange gases between the soil and atmosphere during the day. Therefore, our findings suggest that the fluctuation in CH_4 fluxes during the growth season largely depend on the reed vegetation. In our poster presentation, we will show the eddy covariance results from the first 2 years and evaluate the main environmental factors influencing the CO_2 and CH_4fluxes.

P2015-40 Poster download (PDF)

Relation of heat fluxes with the vegetation in urban areas: the case study of a Nantes district during FluxSAP 2012

Pascal Kéravec (1,2), Fabrice Rodriguez (1,3), Jean-Michel Rosant (1,2), Romain Biron (4), Jean-Martial Cohard (4), Jérome Colin (5), Didier Hébert (6), Nathalie Long (7), Denis Maro (6), Patrice Mestayer (1), Marjorie Musy (1), Georges Najjar (5), Thibaud Piquet (1,2) and Yves Tétard (8).

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FluxSAP 2012 urban hydrometeorology measurement campaign was performed within the VegDUD ANR program on the role of vegetation in the climatology of urban areas. The objective of this campaign was to investigate the vegetation contribution to sensible and latent heat fluxes over an heterogeneous urban area located within the ONEVU long-term observatory in a district of Nantes, over a one-month period in June 2012. The experimental set up includes measurements of air, surface and soil temperature, air and soil water content, wind profiles, and heat fluxes. Fluxes measurements were performed using three different techniques: Eddy Covariance (EC), Large Aperture Scintillometer (LAS), and evaporation chamber. The present study will focus on EC measurements results , in order to potentially make out the contributions from the bare and the vegetated areas. The sites chosen to install the masts were selected to cover the land-use variability of the district using a combination of topographic data and very high resolution satellite image. The measurements heights were adapted according to the site close environment from 3 to 35 meters. An EC systems comparison pre-campaign was carried over a flat grassland to reduce uncertainties from the heterogeneity of the instruments used (three different ultrasonic anemometers and two infrared gas analyzers). The heat fluxes are then calculated following standard recommendations. In this study, the heat fluxes variability is first analyzed using the vegetation fraction in the close neighborhood of the measurement sites. This variability is then investigated using a simple analytical footprint model to take into account the contribution of the source area.

P2015-41

Phenological analysis of a Mediterranean maquis vegetation based on data processing routines of digital images

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Near-surface remote sensing techniques are used to quantify, at high temporal resolution, and with a certain degree of spatial integration, the seasonal variations of the surface optical and radiometric properties. These data provide information on vegetation phenological and ecophysiological responses (Richardson et al 2009; Sonnentag 2011). The ECO-SCALE (Integrated High Resolution Monitoring of Mediterranean vegetation) project is aimed to the development and validation of new technologies and methodologies for the identification of functional responses of natural vegetation in a Mediterranean area to environmental and climatic changes. In particular, the project aims to develop an integrated system for environmental monitoring based on digital photography, hyperspectral radiometry, and micrometeorological techniques. The analyses of integrated data obtained from different methods and techniques would improve our knowledge of the mechanisms underlying the development processes of Mediterranean species. In this paper results of the specific work package of the project aimed to implement a methodology based on digital images for the automated phenological vegetation monitoring are presented, with particular regards to those related to the analysis of a phenological behavior based on digital image. To the end of retrieve phenological information from digital images, a routine of commands to process the digital image file using the program MATLAB (R2014b, The MathWorks, Natick, Mass.) was specifically created. The color channel information was extracted and the RGB value was correlated with the pattern of phenological development. Results showed that the use of digital images is well-suited to identify phenological pattern of shrubland Mediterranean species.

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P2015-42 Poster download (PDF)

Greenhouse gas emissions from urban area of Naples

Daniela Piscitelli (1), Daniela Famulari (1), Andrea Esposito (1), Paul Di Tommasi (1), Giuseppe Agrillo (1), Maurizio Tosca (1), Adriano Mazzarella (3), Raffaele Viola (3), Nicola Scafetta (3), Beniamino Gioli (2), Enzo Magliulo (1), Angelo Riccio (4), Alessandro Zaldei (2) and Piero Toscano (2)

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Urban areas are among the main causes of greenhouse gases emissions on the planet, despite covering relatively small areas of the land. Recently, a number of projects aim at monitoring the dynamics of city emissions using micro meteorological measurements by applying the technique of eddy correlation for measuring the fluxes of carbon dioxide, water, methane and energy. In this perspective, a super-site for the measurement of atmospheric pollutants from urban sources has been established in Naples (Campania, Southern Italy), where the complex layout of the coast and surrounding mountains favours the development of combined sea breeze upslope winds and the evolution of return flows with several layers of pollutants and subsidence. At the super-site, an eddy covariance tower has been installed on the rooftop of the Meteorological Observatory of Largo San Marcellino, situated in the historical city centre: a fast response ultrasonic anemometer (Gill WindMaster) has been mounted on a 10-m mast, alongside three insulated inlet lines through which the air is sampled for gaseous pollutants and particulate matter. The height of the terrace is on average 35 m above the irregular street level, resulting in an overall measuring height of 45 m. Mixing ratios of CO_2, CH_4 and H_2O are measured by an infrared spectrometer (10 Hz, Los Gatos Research). The results shown that the mean urban levels of CO_2 are between 420-520 ppm; the mean levels of CH_4 span between 1.85-2.48 ppm. These fluxes are representative of varying footprint source areas, covering the historical centre of Naples, the harbour, and some main traffic arteries of the city. The analysis of these measurements on long-term will allow to establish relationships between the fluxes of greenhouse gases and the other pollutant species measured.

P2015-43 Poster download (PDF)

Impact of changes in barometric pressure on landfill methane emission

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Landfill methane emissions were measured continuously using the eddy covariance method from June to December 2010. The study site was located at the Bluff Road Landfill in Lincoln, Nebraska, USA. Our results show that landfill methane emissions strongly depended on changes in barometric pressure; rising barometric pressure suppressed the emission, while falling barometric pressure enhanced the emission, a phenomenon called barometric pumping. There was up to a 35-fold variation in day-to-day methane emissions due to changes in barometric pressure.Wavelet coherence analysis revealed a strong spectral coherency between variations of barometric pressure and methane emission at periodicities ranging from 1 day to 8 days. Power spectrum and ogive analysis showed that at least 10 days of continuous measurements was needed in order to capture 90% of the total variance in themethane emission time series at our landfill site. From our results, it is clear that point-in-time measurements taken at monthly or longer time intervals using techniques such as the trace plume method, the mass balance method, or the closed-chamber method will be subject to large variations in measured emission rates because of the barometric pumping phenomenon. Estimates of long-term integrated methane emissions from landfills based on such measurements could yield uncertainties, ranging from 28.8% underestimation to 32.3% overestimation. Our results demonstrate a need for continuous measurements to quantify annual total landfill emissions. This conclusion may apply to the study of methane emissions from wetlands, peatlands, lakes, and other environmental contexts where emissions are from porous media or ebullition. Other implications from the present study for hazard gas monitoring programs are also discussed.

P2015-44 Poster download (PNG) *3rd Place Student Poster Award Winner*

CO_2 flux measurements at SMEAR Estonia

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The Station for Measuring Ecosystem-Atmosphere Relations (SMEAR Estonia) was established in Estonia to measure the concentrations and fluxes of energy and matter on different temporal and spatial scales. It is located in a mixed hemiboreal forest stand (at 58.2714 N, 27.2703 E at 36 m a.s.l.) and represents the southernmost point in SMEAR network long distance transect over northern Europe. Eddy covariance CO_2 fluxes have been continuously measured with 2 systems (LI-7200 gas analysers + Metek uSonic-3 Class A anemometers) at 30m and 70m heights (130m high tower) starting spring-summer 2014. 30m height system footprint includes typical for the area pine/spruce mixed forest stands and clear-cut areas left after the building of infrastructure. 70m height footprint additionally covers birch forest stands. Being closer to the canopy 30m system fluxes are less homogeneous and more exposed to the local influences, while 70m system receives naturally integrated signal. We present the first results of continuous eddy-covariance measurements of CO_2 fluxes over a hemiboreal mixed forest at SMEAR Estonia (http://smear.emu.ee).

P2015-45 Poster download (PDF)

Capturing and Processing Surface GHG Fluxes

Rod Madsen (1), Dayle McDermitt (1), Jason Hupp (1), Mark Johnson (1) and Liukang Xu (1)

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The LI-COR LI-8100A Automated Soil CO_2 Flux System is designed to measure soil CO_2 efflux using automated chambers and a non-steady state measurement protocol. While CO_2 is an important gas in many contexts, it is not the only gas of interest for many research applications. With some simple plumbing modifications, many third party analyzers capable of measuring other trace gases, e.g. N_2O, CH_4, or $^{13}CO_2$ etc., can be interfaced with the LI-8100A System, and LI-COR's data processing software (SoilFluxPro™) can be used to compute fluxes for these additional gases. In this paper we describe considerations for selecting an appropriate third party analyzer to interface with the system, how to integrate data into the system, and the procedure used to compute fluxes of additional gases in SoilFluxPro™. A case study is presented to demonstrate methane flux measurements using an Ultra-Portable Greenhouse Gas Analyzer (Ultra-Portable GGA, model 915-0011), manufactured by Los Gatos Research and integrated into the LI-8100A System. Laboratory and field test results show that the soil CO_2 efflux based on the time series of CO_2 data measured either with the LI-8100A System or with the Ultra-Portable GGA are essentially the same. This suggests that soil GHG fluxes measured with both systems are reliable.

P2015-46

Spatial variability of soil properties in hemiboreal forest (SMEAR Estonia)

Dmitrii Krasnov (1), Alisa Krasnova (1), Ülo Niinemets (1) Steffen M. Noe (1)

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Soil is an essential component of terrestrial ecosystems, impacting on ecosystem processes in multiple ways. It is a non-homogeneous body with specific patterns in both spatial and temporal variability. While temporal variation mostly depends on climatic conditions, spatial variability is a result of complex inter-related factors and therefore a challenge for investigation. Soil respiration is an indispensable part of the ecosystem carbon cycle and can be considered as an indicator of soil activity. Higher rates of soil CO_2 flux reflect quite often more intensive processes taking place inside the soil. Soil respiration is a combination of related processes: root respiration, organic matter decomposition. The main factors affecting autotrophic respiration are the vegetation period, plant photosynthetic activity, nutrient availability and root mycorrhiza. Heterotrophic respiration is mainly influenced by soil moisture, temperature and available substrate. A non-homogeneous distribution of these factors leads to different spatial patterns of soil CO_2 flux. To avoid over- or under-estimation of carbon balance when upscaling spot measured data to the whole ecosystem level such unequal spatial distributions of parameters and processes need to be taken into account. In this research, we studied the forest microtopography and spatial distribution of several soil properties (soil respiration, moisture and temperature, thickness of organic horizons) in a mixed hemiboreal forest stand at SMEAR Estonia (http://smear.emu.ee).

P2015-47 Poster download (PDF)

Deposition flux of surface ozone to forest vegetation

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Surface ozone (O_3) still poses a serious threat to forest ecosystems across Europe and represents a priority for the UNECE Convention on Long-range Transboundary Air Pollution (Schaub et al., 2015). Deposition flux of O_3, especially the fractions of the *flux* absorbed by *stomata* acts as a phytotoxin that produces an oxidative stress in plants. Current research is focused on climate change, air pollution and atmospheric deposition interactions and their synergetic effects on forest ecosystems. Forests in mountain areas are sensitive to secondary pollutants including O_3 and its precursors from long-range transport. Cumulative exposure index AOT40 for forest protection indicates that rural highland sites of Europe are more vulnerable to environmental risk associated with perpetual O_3 exposure than urban lowland areas (Bičárová et al. 2013). Phytotoxic effect of O_3 on forest vegetation is hardly distinguishable by direct methods. Deposition models such as DO_3SE that simulate the total and stomatal O_3 fluxes are enable to estimate the risk of O_3 damage to European vegetation. In Slovakia, ongoing project „Mapping of phytotoxic ozone doses in the forest area of High Tatra Mts.“ (MapPOD) includes DO_3SE model as an appropriate tool for the assessment of critical O_3 level exceedance and risk of secondary air pollution for mountain forest ecosystems. Interfaced version of the model (DO3SE_INTv2.0, http://www.sei-international.org/do3se) is provided for user to estimate phytotoxic ozone dose (PODy) on a site-specific basis according to local meteorological and O_3 concentration data. The first results of MapPOD for growing season 2014 indicate phytotoxic effect of O_3 on spruce forest at five research plots with altitudes from 810 to 1778 m a.s.l. along vertical and spatial profile in High Tatra Mts. Accumulated stomatal O_3 flux above a threshold value of 1.0 nmol/m^2PLA/s (POD1) exeeded critical level of 8 mmol/m^2PLA at all considering sites during July, around at mid-growing season. Application of eddy covariance method in study of flux processing could be beneficial to further research work in the High Tatras. This work was supported by the Slovak Research and Development Agency under the contract No. APVV–0429–12 and by the Grant Agency of the Slovak Republic under the project VEGA No. 2/0053/14.

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Rewetted fens are not mandatorily CO_2 sinks

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In recent years, rewetting of drained and degraded fens became a popular method tending to revitalize their function as carbon (C) sinks in the long term. However, it remains unclear whether this effect will be achieved in any case and as to when. Methane (CH_4) emissions increase immediately after raising the water table and are expected to decrease in the following years. In contrast, most often a fast shift towards continuous carbon dioxide (CO_2) uptake is reported. Based on eddy covariance measurements we show that rewetted fens can also be strong sources of CO_2, even after nine years of rewetting. Our study site is a temperate rewetted fen in NE Germany with a cumulative net ecosystem exchange (NEE) of 525 g CO_2 m^{-2} and cumulative CH_4 emissions of 41 g CH_4 m^{-2} during the one-year observation period. CO_2 contributed 83 % and 32 % to the annual C loss (173 g C m^{-2}) and global warming potential (GWP_{100}; 1659 g CO_2-Eq. m^{-2} a^{-1}), respectively. The positive CO_2 budget was the result of high ecosystem respiration (R_{eco}) rates, which exceeded gross primary production (GPP) during most of the year. In order to identify the source of the high CO_2 release rates, we assigned GPP and R_{eco} to the main surface classes (open water and emergent vegetation dominated by *Typha latifolia*) by a combination of footprint analysis and NEE partitioning. Both, open water and emergent vegetation were net CO_2 sources with 162 and 777 g CO_2 m^{-2} a^{-1}, respectively. The surface class emergent vegetation shifted to an almost continuous CO_2 source already in early summer. R_{eco} and GPP rates were around 4-fold higher than for open water. We assume the unusual warm and dry summer to be the reason for the high Reco rates. The associated water table lowering exposed organic mud especially at former very shallowly inundated parts, which are most often covered by emergent vegetation. This organic mud was deposited at the bottom of the water bodies and decomposed quickly and intensely during the exposure. CH_4 emissions of open water (53 g CH_4 m^{-2} a^{-1}) are around 4-fold higher than from the emergent vegetation stands and the result of anaerobic decomposition of the organic mud. Our results indicate that inundation is unfavourable for the water management during rewetting, as the organic mud deposited at the bottom of water bodies seems to be crucial for both high CH_4 emissions during inundation and high CO_2 emissions especially in case of exposure during non-inundated conditions. We show that contrary to the current assumption, rewetted peatlands potentially act as substantial net CO_2 sources in addition to high CH_4 emissions, resulting in a large GWP.

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Cost effective solution for sub-ppm Methane sensing

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Methane (CH4) is considered as one of the most powerful agent maintaining the Greenhouse effect. The GWP (Global Warming Potential) index for Methane is 28-32 whereas GWP CO_2 =1. Respectively developing of the low cost solution for sensing Methane on sub-ppm level becomes one of the most important aims for improving quality of tools for researches devoted to evaluation of Methane's impact in Greenhouse effect. SenseAir AB (Sweden) is an innovation-based sensor company and a world-leading manufacturer of NDIR (non-distractive infrared) sensors. SenseAir AB has introduced the HPP (high precision platform) for measurement of gas concentration on sub-ppm level. Methane sensing now is one of the most prospective applications for HPP technique. The newest Methane sensor from SenseAir:

- Sub-ppm resolution in 10 sec integration time
- Low-cost highly stable plastic optics
- One meter optical path in eight centimeters cavity
- Integrated thermal stabilization system
- Advanced I/O set for managing external instruments such as valves, pumps, heaters etc.

Poster contains:

- Sensor's photo and 3D image of its internal structure.
- Photo of the full system- sensor + dehumidifier + zero gas generator
- Optic system presenting working principle based on White cell approach
- Diagrams presenting Non-distractive infrared (NDIR) approach for sensing gas concentration
- Test results (drifts, different gas concentrations tests)