Training course/workshop on

EddyUH: a software for eddy covariance flux calculation

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ABSTRACTS

Greenhouse Gas Emissions from Energy Forest Plantations

Anna Hedenrud[1], Per Weslien[1], Anders Lindroth[2], Pär Aronsson[3], Leif Klemedtsson[1]
[1]Department of Plant and Environmental Sciences, University of Gothenburg;
[2]Department of Earth and Ecosystem Sciences, Lund University;
[3]Department of Crop Production Ecology, Swedish University of Agricultural Sciences

Background

Willow plantations are used as an alternative energy source in Sweden and elsewhere. In Sweden it is common to use sewage sludge after harvest as fertilization. The applicationof sewage sludge ought to give high emissions of N2O compared to commercial fertilization, based on the knowledge on emissions after manure fertilization. However, no data exist. Data regarding this matter are needed for the negotiations within EU on thegreenhouse gas (GHG)impact from the Swedish willow plantations.

Project description

The project aims to investigate a willow plantation in a holistic manner. Different academic disciplines and methods, andcollaborators, will meet to provide a rich picture of a willow plantation ecosystem's biogeochemical processes and its role from a societal point of view. The objectives of the project are

-to measure GHG fluxes for N2O, NO, H2O and CO2with eddy covariance technique. The emissions will be related tothe C and nitrogen (N) storage in the biomass and soil ecosystem.

-to evaluate eddy covariance footprints for the willow forest plantation.

-to use an ecosystem model to estimate the emissions of GHGs from Swedish energy forest plantations.

-to evaluate energy forest plantations from an ecological economics perspective.

Site description

The site is located in south-western Sweden with a plantation size of 6 ha (App.Fig.1). It is a typical Swedish willow plantation that uses sewage sludge as fertilizer after harvest.

Field set-up

The site was initiated this year and build-up of the site is still on-going. It will be a complete climate station with measurements of e.g. global radiation, air temperature and precipitation. Also, soil temperature, soil water content, and ground water levels will be measured. Optical instruments will measureGHG fluxes from a 10 m tower (Fig.2), an enclosed path IR analyser, LI-7200 (LI-COR Inc., Lincoln, Nebraska, USA) (Fig.3) and a Quantum Cascade Laser (Aerodyne Inc., USA) (Fig.4).(An identical, but mobile system will be usedin the future workto measure the control treatment, but then with a low mast, 2m).

Future work

In 2012 part of the plantation will be harvested, and sludge willbe applied on half of the harvested area (Fig.1). 6 automatic chambers (Fig.5 and 6) will measure the N2O emissions on areas with and without sewage sludge.On the remaining part of the plantation commercial fertilizer will be applied during 2012, where the EC-measurements will continue to run.

Carbon storage and fluxes: scaling from leaf-level to ecosystems

Alisa Krasnova, Lea Hallik, Ülo Niinemets, Steffen M. Noe

Department of Plant Physiology, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Tartu, Estonia

Carbon storages are distributed within the ecosystem on several organisational levels ranging from leaf tissues to the whole stand. Freshly taken up carbon is stored into sugars and starch and further distributed over the tree organs (leaves, stem, roots). Partly, the use of stored carbon lead to time lags between the uptake from photosynthesis and the release by respiration. Furthermore, the annual cycle of tree phenology lead to movements of stored compounds inside leaf tissues to leaf litter and by that contributing to soil respiration.

Ecosystem scale flux measurements such as Eddy covariance integrate the sources and sinks of carbon within the ecosystem.

A new site to monitor land-atmosphere exchanges of carbon dioxide and methane: Adventalen 78°N.

Arnaud Héroult[1], Mikhail Mastepanov[1] and Torben R. Christensen[1].

[1] *Department of Department of Earth and Ecosystem analysis, Division of Physical Geography and Ecosystem Analysis, Lund University, Sölvegatan 12, 223 62 Lund, Sweden*
Corresponding author (Arnaud.Heroult@nateko.lu.se)

The Arctic region has received considerable attention in the last decade. A major concern being its role in the carbon cycle and how this might be affected by the current climate situation given that global warming is occurring much faster in the Arctic than in the rest of the world. Potentially this region is extremely susceptible to warmer conditions given the massive amounts of carbon stored into high-latitude soils. It has been estimated that terrestrial ecosystems of the northern high latitudes contain approximately 50% of the global terrestrial estimated global belowground organic carbon pool and 88% of the carbon stocked in this region is found in frozen soils and deposits. While permafrost is thawing at alarming rate because of raising atmospheric temperatures, theses large stocks of fossil carbon are turning into available organic material for any biological activity. Eventually, this carbon may end up being loss and released to the atmosphere through heterotrophic respiration in the form of carbon dioxide and methane. Therefore it is especially important to monitor carbon fluxes at high-latitudes.

Despite the recent intensification of scientific research in the Arctic, data on the carbon exchanges remain scarce in this region. Therefore a new study site will be established in Svalbard in the summer 2011, at 78°N in an Arctic valley named 'Adventalen'. In this report, the establishment of this site equipped with a gradient tower and automatic chamber and its associated challenges are being presented as well as some potential preliminary results of summertime carbon fluxes of this High-Arctic tundra.

Keywords: Arctic, carbon, carbon dioxide, methane, permafrost, tundra gradient tower, automatic chambers.

Energy fluxes in a high Arctic environment subjected to strong climate warming

Magnus Lund[1], Michele Citterio[2], Birger U. Hansen[3], Ken Hill[4], Signe H. Larsen[2], Stine H. Pedersen[3], Mikkel P. Tamstorf[1]

[1] Department of Bioscience, Aarhus University, Denmark

[2] Marine Geology and Glaciology, Geological Survey of Greenland and Denmark (GEUS), Denmark

[3] Department of Geography and Geology, University of Copenhagen, Denmark

[4] ASIAQ – Greenland Survey, Greenland

During recent decades the observed warming in the Arctic has been almost twice as large as the global average. The implications of such strong warming on the surface energy balance, regulating permafrost thaw, hydrology, soil stability and carbon mineralization, needs to be assessed. In Zackenberg, NE Greenland, measurements of energy balance components in various environments have been performed since the late 90's, coordinated by Zackenberg Ecological Research Operations. This study aims to describe the current energy balance in a number of habitats and landscape types in Zackenberg, including tundra heaths, fen and glacier. Eddy covariance flux measurements have been performed in a heath site and a fen site, allowing for detailed investigations of the relationships between heat and water vapour fluxes and meteorological and soil physical characteristics. Models of evapotranspiration will be evaluated using eddy covariance data. As the available data set spans more than a decade, possible trends in energy flux components resulting from warming related changes such as earlier snow melt, increased active layer depth and higher temperatures will be investigated. Preliminary results from this study will be presented at the workshop.

HIGHLY SIZE RESOLVED PARTICLE FLUXES OVER AN URBAN AREA

M. J. Deventer[1], F. Griessbaum[1,2] and O. Klemm[1]
[1] Climatology Working Group, University of Münster, 48148 Münster, Germany
[2] now at LI-COR Biosciences GmbH, Bad Homburg Germany

From April 11th through May 27th, 2011, turbulent exchange of sub-micron particles between the urban surface and the urban boundary-layer was measured above the city area of Münster (NW Germany). The aim of the study is to investigate and quantify how particles of different size classes contribute to urban particle fluxes.
Up to the present day publications on size-resolved particle fluxes in urban environments are very rare, which is mainly accountable to a lack of suitable measurement devices. Cities are both sources and sinks for atmospheric aerosol particles. The input of particulate material from the regional background is mostly established through aged accumulation range particles. The emissions originate from combustion processes, yielding large numbers of nano-sized particles, and from re-suspension of coarse particles from the urban surfaces.
For this study, we employed the Ultra-High Sensitivity Aerosol Spectrometer (UHSAS, manufactured by Droplet Measurement Technologies, Boulder, Colorado, USA) covering the size range between 55 nm and 1 µm diameters by sizing the sampled particles in up to 99 bins. The eddy-covariance setup was installed on a 62 m above ground level (a.g.l.) high radio tower located in a military base, southeast to the city center. For a more detailed site description see SCHMIDT and KLEMM (2008), GRIESSBAUM AND SCHMIDT (2009) and DAHLKOTTER et al. (2010).
The results suggest that the city of Münster acts as a distinct source for particles with a mean daily emission of 2.49 108 particles/(m2 d). However, this is just a result of simultaneous but opposing fluxes of two different particle regimes. Emission is mostly driven by Ultrafine particles, whereas bigger particles in the accumulation mode (168 – 1000 nm) are main drivers for deposition leading to a negative mass flux of 1.39 µg/(m2 d) on weekdays and 0.34 µg /(m2 d) on Sundays.
The observation of bi-directional fluxes as a function of particle sizes is in good agreement to results of the preliminary study of SCHMIDT and KLEMM (2008). The highly size-resolved approach of this study allowed the quantification of the tipping point (167.7 nm) between these regimes with an accuracy of 19.6 nm. Furthermore, our results are in conformity with particle source apportionment studies at urban street level sites (GIETL and KLEMM, 2009). It is found that a portion of the particles in the urban environment originates from distant sources while another portion is produced within the city environment itself. Our concept of bi-directional fluxes in the urban canopy layer perfectly matches this image.

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Eddy covariance flux measurements of volatile organic compounds using PTR-ToF-MS

P. Rantala, S. Schallhart, T.M. Ruuskanen, M.K. Kajos, J. Patokoski, R. Taipale and J. Rinne
University of Helsinki, Department of Physics, Finland

Volatile organic compounds (VOCs) are mostly emitted into atmosphere from natural sources (Guenther et al., 1995). Some of the compounds, such as monoterpenes, are highly reactive and seem to have major contributions to aerosol particle formation and growth, thus these compounds are also connected to the global climate change (Kulmala et al., 2004).
The PTR is a highly sensitive technique for online measurements of VOCs (Lindinger et al., 1998). PTR uses hydronium ions (H_3O^+) to ionize target compounds via proton transfer reaction and quadrupole (PTR-MS) or time-of-light (PTR-ToF-MS) technique as a mass analyzer.
PTR-ToF-MS gives a unique opportunity to measure VOC fluxes using eddy covariance (EC) method (e.g. Müller et al., 2010). However, data processing of ToF-MS is quite heavy and difficult, therefore, it is not maybe possible to use PTR-ToF-MS for continuous and long term EC-measurements.

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N_2O fluxes using TDLAS/eddy covariance technique - The new and only Swedish ICOS agricultural site.

Per Weslien & Leif Klemedtsson

Department of Plant- and Environmental Sciences, University of Gothenburg

ICOS - Integrated Carbon Observation System - is a new European research infrastructure for quantifying and understanding the greenhouse gas balance of the European continent and of adjacent regions.

The new ICOS site will use state of the art eddy covariance system for measuring N_2O (Quantum cascade laser), CO_2 and H_2O (IRGA) fluxes.

The results from the ICOS site, with one conventional crop rotation, will be compared to the results of the other agricultural stations within ICOS. Furthermore, we are currently measuring N_2O fluxes from six 1-hectare plots using a N_2O concentration profile detection system (Campbell Sci. TGA100A) which is operated in the field immediately adjacent to the ICOS setup. This will allows us to compare the Swedish ICOS results with alternative crop rotations.

Flux measurements at SMEAR Estonia

Steffen M. Noe[1], Alisa Krasnova[1], Lucian Copolovici[1], Ülle Püttsepp[2], Georg Wohlfahrt[3]

[1] Department of Plant Physiology, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Estonia

[2] Department of Environmental Protection, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Estonia

[3] Institute of Ecology, University of Innsbruck, Austria

Flux measurements have been conducted in a hemiboreal forest ecosystem at the SMEAR Estonia station in Järvselja since 2008. The station is not yet fully equipped over all time of the year. In 2008 and 2009, Eddy flux measurements on two height levels were conducted, 2 m within the canopy and at 20 m height above the canopy. Since 2010, the Eddy covariance measurement system at 20 m height is installed permanently and at 2 m works from June until November.

During measurement campaigns, additional leaf and branch level fluxes of the main tree species, Norway spruce, Silver and Downy Birch, in the vicinity of the flux tower were measured. Further studies on soil fluxes are conducted at the site since 2008 ongoing in campaigns.

Main fluxes of carbon dioxide and water vapour are assessed on all levels. On the leaf and branch level as well on soil level including leaf litter, fluxes of volatile organic compounds are measured using offline techniques. On the level of soil fluxes a small set of methane fluxes were measured in 2008 and 2009 with soil chamber systems.

A comparison of sonic anemometer performance under foggy conditions at a mountain cloud forest site

Tarek S. El-Madany*[a], G. Fratini[b], F. Griessbaum[a], J.-J. Yuang[c], S.-C. Chang[d], O. Klemm[a]
a) University of Münster Institute for Landscape Ecology Department of Klimatology
b) Licor Bioscience, Lincoln, Nebrasca, USA
c) National Taiwan University, Department of Geography, Taiwan
d) National Dong Hwa University, Institute of Natural Resources, Taiwan

At a mountain cloud forest site in Taiwan the performance of 4 sonic anemometer types (Campbell CSAT3, Gill R3-50, METEK USA-1 Scientific and Young 81000VRE) was tested under foggy conditions. 16 consecutive days with 86 hours of fog (visibility < 1000 meter) were used for the analysis. The following three levels of analysis were performed:
(i) spike detection during different visibilities was compared between the sonic anemometers to get a general picture of the performance.

(ii) correlation analysis for meteorological parameters as well as variances and fluxes was done to evaluate how good the measurements coincide.

(iii) Spectra were used to determine the frequencies, which are affected by fog.

The spike detection showed that nearly 3 of 4 sonics have a clear trend to increase the number of spikes with the reduction of visibility. Only the CSAT3 shows a slight decrease in the average number of spikes for the lowest visibility class (<500 m). A second aspect of the spike statistics is the distribution upon u,v,w, and T. The 81000VRE has 50 % of its spikes in the u component and 35 % in the v component. The CSAT shows 43 % of the spikes in w and 45 % in T. The USA-1 and the R3-50 come up with 62 and 71 %, respectively in the w component.
The correlation analysis shows in general a good agreement between the sonics. Under non foggy conditions (Visibility > 2500 m) all the correlation coefficients (Spearmann Rho) have values larger than 0.96 and most of the slopes have less than 10 % differences to each other. Under foggy conditions the correlations show more scatter and larger differences in the slopes. The sonic temperature of the R3-50 shows larger scatter and stronger differences in the slopes compared to the other sonic anemometers.
The spectral analysis reveals that particularly the high frequencies are affected during foggy conditions. Usually a damping of the signal can be observed that changes to white noise if the fog continues for longer periods. In general, the spectra of the sonic temperature are most sensitive to fog. Here the damping and the noise can be seen earlier than in other spectra. The w spectra seem to be the most robust. The spectra of the R3-50 show usually the smallest effects in the high frequency range.