UNIVERSITY OF BAYREUTH

Department of Micrometeorology

Proceedings of the International Conference of "Atmospheric Transport and Chemistry in Forest Ecosystems" Castle of Thurnau, Germany Oct 5 to Oct 8, 2009

**Johannes Lüers and Thomas Foken
(Editors)**

International Conference of

"Atmospheric Transport and Chemistry in Forest Ecosystems"

Castle of Thurnau, Germany, Oct 5 - 8, 2009

Intention •

Intensive field experiments were performed in 2007 and 2008 within the joint effort of the EGER research group to study the diurnal cycles of energy, water, and reactive and non-reactive trace substances in the soil-vegetation-boundary-layer interaction of a mountainous forest ecosystem. The intention of this meeting is to provide a venue for micrometeorological and biogeochemical scientists to meet and discuss especially the ideas and results of the EGER-group and ongoing matters focused on forest ecosystems. The conference will be of interest to those who work on refined methodological approaches regarding the problem of scale interactions and who work to gain additional knowledge regarding the spatial patterns of the biological, chemical, and physical parameters driving the energy and matter fluxes in a forest ecosystem. This includes homogeneous and heterogeneous chemistry of reactive nitrogen and biogenic trace gases in laboratory systems and ecosystems. We invite the entire bio- and geosciences community to present and examine all aspects of atmospheric transport and biogeochemistry in Forest Ecosystems.

Conference Board •

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Monday, Oct 5 ☰

Welcome and Opening session

13:15 - 13:30 ✳ Opening address by the University of Bayreuth Administration Office

13:30 - 14:00 ✳ Thomas Foken, Franz X. Meixner, Eva Falge, Cornelius Zetzsch (Univ. of Bayreuth, MPI for Chemistry Mainz)
ExchanGE processes in mountainous Regions (EGER) – An overview

Session 1 ✳ Heterogeneous Photochemical Processes and Aerosols (Chair: C. Zetzsch)

14:00 - 14:40 ✳ (Key Note) Christian George, Barbara D'Anna (Université de Lyon)
Photo enhanced deposition of trace gases at the interface of organic surfaces

14:40 - 15:05 ✳ Matthias Sörgel, A. Serafimovich, A. Moravek, I. Trebs, F. X. Meixner, C. Zetzsch (Univ. of Bayreuth, MPI for Chemistry Mainz)
Effects of coupling regimes and humidity on HONO concentrations in and above a spruce forest

15:05 - 15:30 ✳ Jörg Kleffmann, T. Gavriloaiei, A. Hofzumahaus, F. Holland, R. Koppmann, L. Rupp, E. Schlosser, M. Siese, A. Wahner (Univ. of Wuppertal)
Gradient measurements of HONO in a forest

15:30 - 16:00 ✳ Coffee break

16:00 - 16:25 ✳ Eiko Nemitz, A. Huffman, J. Jimenez, B. Baker, J.T. Walker, A. Delia, D. Toohey, T. Karl, C. Stroud, A. Guenther (Centre for Ecology & Hydrology, Penicuik)
Size and composition resolved aerosol fluxes above a pine forest and their response to biogenic chemistry

16:25 - 16:50 ✳ Andreas Held, A. Guenther, E. Patton, J. Smith, A. Turnipseed (Leibniz Institute for Tropospheric Research, Leipzig)
Aerosol fluxes in a walnut orchard during CHATS

16:50 - 17:15 ✳ Veronika Wolff, I. Trebs, F.X. Meixner (MPI for Chemistry Mainz)
Concentrations and exchange processes of the ammonia-nitric acid-ammonium nitrate triad above a forest canopy

17:15 - 17:40 ✳ Ana Alebic-Juretic (Univ. of Rijeka)
Deposition of Sulphur and Nitrogen in the forest area (Highland District) of Croatia

18:30 ✳ Dinner

20:00 - 22:00 ✳ Time for small discussion groups and welcome meetings

1 Heterogeneous Photochemical Processes and Aerosols

Key Note

Photoenhanced deposition of trace gases at the interface of organic surfaces

Christian George[1], Barbara D'Anna[1]
[1] IRCELYON, CNRS-University of Lyon

Atmospheric aerosol particles have been found to contain moderate to high fractions by mass of organic compounds. These may be biogenic or anthropogenic in origin, depending on the location and history of the individual particle. The recent and growing awareness of this has spurred a significant effort in understanding how organic compounds on particle surfaces influence water condensation there; how this changes as the particle becomes "processed" (i.e. oxidized) in the atmosphere, and how these processes influence the gas phase composition in volumes containing such particles. Most of these studies evaluated the uptakes or the deposition of some trace gases at the organic interface under dark conditions. However, very few investigations focus on the effect of solar irradiation on atmospheric heterogeneous chemistry, although recent findings confirm the presence of UV-A/Visible light absorbing material in airborne particles and environmental surfaces which can allow photo-induced (or photosensitized) processes. The present work demonstrates the photo-enhanced uptake of NO_2 and O_3 on various organic surfaces as various aromatic compounds used as proxy of biogenic and anthropogenic emissions (PAHs, phenolic compounds) and humic acid coatings and submicron particles. The results suggest that photo-induced uptake can be important under atmospheric conditions with respect irradiance, humidity, temperature and gas trace mixing ratio.

Effects of coupling regimes and humidity on HONO concentrations in and above a spruce forest

Matthias Sörgel[1], Andrei Serafimovich[2], Alexander Moravek[3], Ivonne Trebs[3], Franz X. Meixner[3], Cornelius Zetzsch[1]

[1] Atmospheric Chemistry Research Laboratory, University Bayreuth
[2] Department Micrometeorology, University Bayreuth
[3] Max-Planck-Institute for Chemistry, Mainz

Nitrous acid (HONO) has been measured in the atmosphere for about 30 years now. But formation pathways are still controversial especially for daytime formation. Night time formation is believed to occur via heterogeneous hydrolysis of NO_2 forming HONO and HNO_3. Thus wetted ground surfaces should contribute a lot to HONO formation, but also act as sinks at high relative humidity when liquid films are formed. We have performed simultaneous HNO_2 measurements in and above a tall spruce forest canopy using two long path absorption photometers (LOPAPs) at a field site located in the Fichtelgebirge mountains in north-eastern Bavaria, Germany (50°09'N, 11°52'E, 775 m above sea level) during intensive operating periods of the EGER- Project. Coupling regimes according to Thomas and Foken [1] were calculated from measurements of sonic anemometers. Diurnal cycles of HONO and concentration differences from above canopy (24.5 m) and close to the forest floor (0.5 m) are discussed in view of coupling (of the forest to the atmosphere) and the interdependency of HONO and humidity.

[1] C. Thomas and T. Foken; Flux contribution of coherent structures and its implications for the exchange of energy and matter in a tall spruce canopy; Boundary-Layer Meteorology;123; 2007; 317-337.

Gradient measurements of HONO in a forest

Jörg Kleffmann[1], Traian Gavriloaiei[1], Andreas Hofzumahaus[2], Frank Holland[2], Ralf Koppmann[2], Lutz Rupp[2], Eric Schlosser[2], Manfred Siese[2], Andreas Wahner[2]
[1] Physikalische Chemie / FB C, Bergische Universität Wuppertal
[2] ICG II / Forschungszentrum Jülich

Nitrous Acid (HONO) is an important source of the OH radical in the atmosphere. Recent studies demonstrate that the photolysis of HONO is not only important in the morning but also later during daytime and different photolytic HONO sources have been postulated based on lab and field studies. In the present study, gradient measurements of HONO will be presented, which have been performed during the ECHO field campaign in a forest at the Forschungszentrum Jülich. HONO, NO_x and other trace gases were measured in the altitude range 1 - 38 m. The study demonstrates the existence of a strong daytime source of HONO, which correlates with the light intensity. Different potential sources will be discussed based on the measurement results.

Size and composition resolved aerosol fluxes above a pine forest and their response to biogenic chemistry

Eiko Nemitz[1], Alex Huffman[2], Jose Jimenez[2], Brad Baker[3], John T Walker[4], Alice Delia[5], Darin Toohey[5], Thomas Karl[6], Craig Stroud[7], Alex Guenther[6]

[1] Biogeochemistry Programme, Centre for Ecology and Hydrology (CEH), Edinburgh, UK
[2] University of Colorado / CIRES, Boulder, CO, USA
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[6] Atmospheric Chemistry Division, NCAR, CO, USA
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Fluxes of aerosols were measured above a loblolly pine plantation at Duke Forest, North Carolina, during the CELTIC campaign (Chemical Emission, Loss, Transformation, and Interactions with Canopies). Measurements were made by eddy covariance for total number fluxes (using two condensation particle counters with different cut-offs), size-segregated particle fluxes (using an optical particle spectrometer) and for individual sub-micron aerosol components by aerosol mass spectrometry (AMS). The fluxes of particle numbers, sulphate and organic components show bi-directional behaviour with consistent diurnal patterns, while nitrate was always deposited. The reasons for the bi-directional behaviour are discussed, and the measurements are used to estimate particle growth rates due to vapour uptake that would be consistent with the observations. Aerosol measurements are integrated with measurements of biogenic volatile organic compounds (BVOCs) at different scales (branch emissions, in-canopy gradients and canopy scale fluxes). The measurements demonstrate that organic emissions during midday are linked to the peak in plant emissions and photo-chemistry, and point to a yet unidentified source of reactive sulphur compounds in the forest canopy.

Aerosol fluxes in a walnut orchard during CHATS

Andreas Held[1], Alex Guenther[2], Edward Patton[2], Jim Smith[2], Andrew Turnipseed[2]
[1] Institut für Troposphärenforschung
[2] National Center for Atmospheric Research

Quantifying biosphere-atmosphere exchange of aerosol particles is a great challenge in ecosystem research. This is due to the fact that aerosol number concentrations and size distributions change rapidly through physical and chemical processes such as particle production and consumption by chemical reactions, condensational growth, and phase transitions. In addition, technical limitations of current aerosol instrumentation, e.g. with respect to time resolution, complicate the adaptation of direct micrometeorological techniques for particle flux measurements. Therefore, indirect techniques such as relaxed eddy accumulation or spectral methods have been applied to estimate aerosol fluxes. The Canopy Horizontal Array Turbulence Study (CHATS) 2007 provides a unique observational dataset for an improved understanding, simulation and modeling of coupled forest atmosphere-land surface interactions. Within this framework, aerosol number fluxes were measured directly by eddy covariance. These eddy covariance flux estimates have been compared with relaxed eddy accumulation simulations using different proxy scalars and different updraft/downdraft definitions. In addition, wind and aerosol time series have been analyzed to evaluate the assumption of spectral similarity of turbulent scalars and to assess the applicability of spectral estimation methods. A comparison and evaluation of different methods based on micrometeorological measurements to estimate biosphere atmosphere aerosol fluxes will be presented. This will contribute to a better understanding and representation of the turbulent transport of aerosol particles in and above forest canopies.

Oral - Nr. 5 in 1 Heterogeneous Photochemical Processes and Aerosols

Concentrations and exchange processes of the ammonia-nitric acid-ammonium nitrate triad above a forest canopy

Veronika Wolff[1], Ivonne Trebs[1], Franz X. Meixner[1]
[1] Biogeochemistry, Max Planck Institute for Chemistry

The inter-conversion between the gas and particle phase in the ammonia-nitric acid-ammonium nitrate (NH_3-HNO_3-NH_4NO_3) system complicates the detection of these compounds in the atmosphere. The measurement of vertical profiles and the application of the aerodynamic gradient method to derive fluxes is often hampered by fast chemical inter-conversion processes violating the constant flux layer assumption. Thus, for the determination of NH_3, HNO_3 and particulate NH_4NO_3 fluxes using the aerodynamic gradient method chemical interactions have to be taken into account. In summer 2007 we measured vertical profiles of NH_3, HNO_3, and related aerosol species NH_4^+ and NO_3^- as well as SO_2, and aerosol SO_4^{2-} above a spruce canopy in south-east Germany. Measurements were performed as part of an intensive observation period within the framework of the EGER (**ExchanGE** processes in mountainous **R**egions) project. Gaseous NH_3, HNO_3, and SO_2, particulate NH_4^+, NO_3^-, and SO_4^{2-} were measured using the *Gradient Analyzer for Aerosols and Gases (GRAEGOR)*, mounted on a tower. The gases and particles were collected selectively and simultaneously at two different heights by two rotating wet-annular denuders and two Steam-Jet Aerosol Collectors, respectively. Liquid samples were analysed on-line via ion chromatography and flow injection analysis. For the first time vertical profiles of these gas and aerosol species were measured selectively, simultaneously and with high time resolution (30 min) above a forest canopy. Data accuracy and precision analyses are provided by a rigorous data screening, including the use of an internal standard, careful error estimation, in-field blanks and side-by-side sampling. The available data set provides additional information on aerosol size distribution, surface wetness, and wind, temperature and humidity vertical profiles through the forest canopy. The data are used to investigate exchange processes of NH_3 and HNO_3 as well as particulate NH_4^+ and NO_3^-, gas-particle-phase partitioning, the effect of temperature and humidity on the thermodynamic equilibrium assumption and the validity of the application of the aerodynamic gradient method. Mixing ratios of the gaseous species showed their maxima during daytime with 2-3 ppb for NH_3 and above 1 ppb for HNO_3, while particulate species showed their maxima during night with around 4 ppb for NH_4^+ and around 2 ppb for NO_3^-. NH_3 gradients indicate bidirectional exchange whereas HNO_3 and particle gradients indicate net deposition. Flux estimates from the measured gradients will be investigated taking into account the restrictions mentioned above.

Deposition of Sulphur and Nitrogen in the forest area (Highland District) of Croatia

Ana Alebic-Juretic[1]
[1] Air Polltion Division, Teaching Institute of Public Health/School of Medicine, University of Rijeka, Croatia

Highland District (Gorski kotar) is a forested part of Croatia situated north of Rijeka, a Northern Adriatic port. In spite being next to Mediterranean Sea, due to the high mountains rising from the coast (up to 1500 m) the penetration of maritime air masses deeper into the mainland is prevented. Therefore, this area is characterized with continental climate, with cold winter and mild summer, both accompanied with high precipitation amounts. Although acid rains were claimed to be responsible for forest decline observed during the eighties, the first analyses of precipitation in this area started only in 1995, at two locations: a settlement (Site 1) approx 40 km east, and a hunting resort (Site 2), approx 25 km north-east from Rijeka. As this latter location is inaccessible during the winter time due to high snow level, the precipitation analyses were extended in 2004 to another Site 3, 8 km away and downhill from the Site 2. The results of the 14-years long survey led to several conclusions:

- Precipitation weighted average (PWA) concentrations of sulphates and nitrogen species (nitrate and ammonium) at the remote island Site 4, at the entrance of the Kvarner Bay, and the mountainous Site 1 are practically equal, meaning there is hardly any influence of the Rijeka acid gases emissions to the rainwater acidity in this mountainous area;

- Similar depositions of S-SO_4^{2-} and tot-N (NO_3^-+NH_4^+) in the city of Rijeka (Site 5) and Site 1 are due to different reasons: higher PWA concentrations of sulphates and nitrogen species in the urban site due to the local washout of the atmosphere, and higher precipitation depth in the mountainous site;

- Deposition of sulphur and nitrogen in the forest Sites is similar and within the respective critical loads. In conclusion, acid deposition is not likely to be the principal cause for the forest decline in the Highland District area. Further studies are required to identify the main cause/es.

Tuesday, Oct 6 ≡

Session 2 ∗ Turbulence structure in and above forests (Chair: Th. Foken)

09:00 - 09:40 ∗ (Key note) Monique Leclerc (Univ. of Georgia)
Unexpected Teleconnection between Vegetation Canopies and the Free Atmosphere

09:40 - 10:05 ∗ Roger Shaw, J. Finnigan, N. Patton (Univ. of California)
Canopy/roughness sublayer turbulence

10:05 - 10:30 ∗ John Finnigan, R. Shaw, N. Patton (Marine and Atmospheric Research, Canberra)
The Origins of Coherent Eddy Structure in and Above Plant canopies

10:30 - 10:50 ∗ Coffee break

10:50 - 11:15 ∗ Andrei Serafimovich, L. Siebicke, T. Biermann, Th. Foken (Univ. of Bayreuth)
Vertical and horizontal transport of energy and matter by coherent motions in a tall spruce canopy

11:15 - 11:40 ∗ Pavel Sedlak, K. Potuznikova, R. Czerny, D. Janous (Institute of Atmospheric Physics, Prague)
Canopy airflow and turbulence near the top of a forested ridge

11:40 - 12:05 ∗ Peter Werle (IMK-IFU, Garmisch-Partenkirchen)
Quality assurance aspects for laser based eddy covariance measurements of atmospheric trace gases

12:05 - 12:30 ∗ Vanessa Haverd, R. Leuning, E. van Gorsel, D. Griffith, M. Cuntz (Marine and Atmospheric Res., Canberra)
The turbulent Lagrangian time scale in forest canopies constrained by fluxes, concentrations and source distributions

12:30 - 14:00 ∗ Lunch

2 Turbulence structure in and above forests

Key Note

Unexpected Teleconnection between Vegetation Canopies and the Free Atmosphere

Monique Leclerc[1]
[1] The University of Georgia, Atmospheric Biogeosciences

This paper reports on spatial observations of canopy-atmosphere exchange in the presence of a strong coupling between the upper regions of the boundary layer and above with surface information. Furthermore, this paper reports on the mechanisms giving rise to that teleconnection observed between vegetation canopies and the atmosphere in nocturnal conditions. It draws examples from the latest high-precision concentrated measurements obtained at the recently established Carbon Flux Super Site near Aiken, SC, USA and from other sites throughout the world. These findings are then linked to the specifics of mass and energy transport modulation. The need for a re-examination of the interpretation of the in-canopy turbulent transfer data is highlighted. This paper also points out the need for awareness of the presence of such linkages in achieving confidence and robustness of scientifically credible net carbon uptake figures for any particular location. The paper closes with a discussion of re-evaluation of our current *modus operandi* in the analysis of flux measurements.

Canopy/roughness sublayer turbulence

Roger Shaw[1], John Finnigan[2], Ned Patton[3]
[1] Land, Air and Water Resources, University of California
[2] Marine and Atmospheric Research, CSIRO
[3] National Center for Atmospheric Research

We compare the turbulence statistics of the canopy/roughness sublayer (RSL) and the inertial sublayer (ISL) above, where the turbulence is more coherent, more efficient at transporting momentum and scalars, and more closely resembles a turbulent mixing layer than a boundary layer. To understand these differences, we analyse a Large Eddy Simulation of the flow above and within a vegetation canopy. The 3D velocity and scalar structure of a characteristic eddy is educed by compositing, using local maxima of static pressure at canopy top as a trigger. The characteristic eddy consists of an upstream Head-down, sweep-generating hairpin vortex superimposed on a downstream Head-up, ejection-generating hairpin. The conjunction of the sweep and ejection produces the pressure maximum between the hairpins, and this is also the location of a coherent scalar microfront. In the vicinity of the canopy, the sweep between the legs of the Head-down hairpin makes a substantially larger contribution to momentum flux than does the ejection between the legs of the Head-up hairpin. When a similar analysis is performed using a static pressure trigger at three times canopy height, hairpins appear centred at this level but they are much less distinct, and the ejection becomes the major contributor to momentum transfer.

The Origins of Coherent Eddy Structure in and Above Plant canopies

John Finnigan[1], Roger Shaw[2], Ned Patton[3]
[1] Marine and Atmospheric Research, CSIRO
[2] UC Davis
[3] NCAR

In plant and some urban canopies, turbulent statistics are significantly different from those in the inertial sublayer or log layer above. In many ways the turbulence is more 'efficient' at transporting momentum and scalars. The differences extend above the canopy top into a Roughness Sub Layer (RSL) with particular consequences for flux measurements over forests as most such measurements are taken in the RSL. As described in Shaw et al (2009; this conference) we have educed this eddy structure by conditional sampling data from a large eddy simulation of a canopy flow. The characteristic eddy consists of an upstream Head-down, sweep-generating hairpin vortex superimposed on a downstream Head-up, ejection-generating hairpin. The conjunction of the sweep and ejection produces a pressure maximum between the hairpins and this is also the location of a coherent scalar microfront. This eddy structure matches that observed in simulations of homogeneous shear flows and channel flows by several workers and also fits with earlier field and wind tunnel measurements in canopy flows. It is significantly different from the eddy structure educed over smooth walls by conditional sampling based only on ejections as a trigger. We have developed a phenomenological model to explain both the structure of the characteristic eddy and the key differences between turbulence in the canopy/RSL and the ISL above. This model assumes that the inflected mean velocity profile at canopy top is inviscidly unstable and that this instability is ultimately responsible for the coherence of the resulting canopy eddies (the mixing layer hypothesis). However, we have extended this analysis by numerically simulating the evolution of the inviscid instability and show that the Head-up Head-down vortex pairs are generated spontaneously as the instability develops from its linear into its non-linear phase. This phenomenological model suggests a new scaling length that has been used to collapse turbulence moments over a range of vegetation canopies and diabatic stabilities.

Vertical and horizontal transport of energy and matter by coherent motions in a tall spruce canopy

Andrei Serafimovich[1], Lukas Siebicke[1], Tobias Biermann[1], Thomas Foken[1]
[1] Department of Micrometeorology, University of Bayreuth

In the frame of the EGER project the contribution of coherent structures to the transfer of energy and matter in a tall spruce canopy was investigated. Two measuring campaigns were carried out at the Waldstein site in the Fichtelgebirge mountains. Observations of coherent structures were obtained by a vertical profile of sonic anemometers equipped with fast gas analyzers.

Duration of coherent events detected in the trunk space of the forest was two times longer than duration of coherent events in the canopy. The analysis shows dominant momentum and sensible heat transport by coherent structures in the canopy space. Carbon dioxide and latent heat transport by coherent structures increases with height within the canopy and reaches a maximum at the upper canopy level. The flux contribution of the ejection phase decreases with increasing height within the canopy and becomes dominant above the canopy level. The flux fraction transported during the downward directed sweep phase increases with height within the canopy and becomes the dominating exchange process at the upper canopy level. Close to the ground surface in the subcanopy space, ejection and sweep phase contribute equally to the flux transport.

The determined exchange regimes indicate consistent decoupling between trunk space, canopy, air above the canopy during evening, night and morning hours. Entire coupling between all canopy levels and trunk space of the forest was observed around noon.

Canopy airflow and turbulence near the top of a forested ridge

Pavel Sedlak[1], Katerina Potuznikova[1], Radek Czerny[2], Dalibor Janous[2]
[1] Institute of Atmospheric Physics AS CR, Praha, Czech Republic
[2] Institute of Systems Biology and Ecology AS CR, Brno, Czech Republic

Forest sites situated on a mountain ridge differ from the flat terrain sites in the structure of the canopy airflow and turbulence. This is important for assessing the contribution of advection to the trace gas budget and for analysis of the eddy flux footprint at such sites. The Experimental Ecological Study Site Bily Kriz in the Czech Republic is located near the top of a mountain ridge forested by a young Norway spruce plantation. Flow directions across the ridge (i.e. upslope or downslope) strongly prevail at the site. In addition to the standard single-point eddy covariance measurements above the canopy, vertical profiles of the flow velocity in the canopy were measured by sonic anemometers during an experimental campaign. Differences in the canopy flow characteristics as recorded when the site was on the upwind vs. downwind side of the ridge are described here.

In the "upwind" cases, vertical profiles of the studied characteristics (wind speed, skewness and kurtosis of the velocity components, u-w correlation coefficient) are similar to the profiles in flat terrain but they indicate somewhat enhanced efficiency of turbulence at transferring momentum deeper into the canopy. The "downwind" cases are characterized by much larger variability of the analyzed quantities, by intermittency of the flow direction and by lower efficiency of the momentum transfer down the canopy. Wavelet analysis was used for detection of characteristic temporal scale of coherent structures, their persistence and transfer effectiveness. First results for the typical cases of airflow over the ridge will be presented.

Quality assurance aspects for laser based eddy covariance measurements of atmospheric trace gases

Peter Werle[1]
[1] Institute of Meteorology and Climate Research IMK-IFU, Research Center Karlsruhe

In performing and using measurements of atmospheric turbulence to determine ensemble parameters and second-order moments we must assume that the ensemble possesses certain properties in order to be able to statistically estimate this moment. Since frozen turbulence is assumed, spatial properties are translated into temporal properties. Almost all measurements are performed by averaging over time and we must assume that the atmosphere is stationary and ergodic over some limited time and vertical dimension. Today ecosystem researchers increasingly use laser based gas monitors to measure fluxes of greenhouse gases in and above forests. As these complex measurement devices under field conditions cannot be considered as stable, drift characterisation is an important issue to distinguish between atmospheric data and sensor drift. Therefore, in this contribution a concept based on the two sample variance is discussed to characterize the stationarity of spectroscopic and micrometeorological data in the time domain and will be applied to assess the optimum high-pass filter time constant for detrending of time series data. The method to be described provides information similar to existing characterizations as the ogive analysis, the normalized error variance of the second order moment as well as information about the spectral characteristics of turbulence in the inertial sub range. The approach is straight forward, easy to implement and, therefore, well suited to assist as a useful tool for a routine data quality check for both, new practitioners and experts using today's laser gas analyzers to measure trace gas fluxes in the field.

The turbulent Lagrangian time scale in forest canopies constrained by fluxes, concentrations and source distributions

Vanessa Haverd[1], Ray Leuning[1], Eva van Gorsel[1], David Griffith[2], Matthias Cuntz[3]
[1] Marine and Atmospheric Research, CSIRO
[2] University of Wollongong
[3] Helmholtz-Zentrum fur Umweltforschung

One-dimensional Lagrangian dispersion models, frequently used to relate in-canopy source/sink distributions of energy, water and trace gases to vertical concentration profiles, require estimates of the standard deviation of the vertical windspeed, which can be measured, and the Lagrangian time scale, T_L, which cannot. In this work we use non-linear parameter estimation to determine the vertical profile of the Lagrangian time scale that simultaneously optimises agreement between modelled and measured vertical profiles of temperature, water vapour, HDO and carbon dioxide concentrations within a 40-m tall temperate Eucalyptus forest in south-eastern Australia. Modelled temperature and concentration profiles are generated using a Lagrangian dispersion theory combined with source/sink distributions of sensible heat, H_2O, HDO and CO_2. These distributions are derived from a multilayer Soil Vegetation Atmospheric Transfer model subject to multiple constraints: (1) day-time eddy flux measurements of sensible heat, latent heat, and CO_2 above the canopy, (2) in-canopy laser measurements of leaf area density distribution, (3) chamber measurements of CO_2 ground fluxes and (4) deuterium isotopic content of soil and plant water and evaporative fluxes. The resulting estimate of Lagrangian time scale within the canopy under near-neutral conditions is about 1.7 times higher than previous estimates and decreases towards zero at the ground. It represents an advance over previous estimates of T_L, which are largely unconstrained by measurements.

Tuesday, Oct 6 ≡

Session 3 ∗ Horizontal and vertical trace gas advection (Chair: F.X. Meixner)

14:00 - 14:40 ∗ (Key Note) Marc Aubinet, C. Feigenwinter, C. Bernhofer, A. Lindroth, L. Montagnani, C. Rebmann (Gembloux Agricultural University)
Direct advection measurements do not help to solve the nighttime CO_2 closure problem – evidence from three inherently different forests

14:40 - 15:05 ∗ Lukas Siebicke, M. Hunner, A. Serafimovich, J. Schröter, J. Ruppert, Th. Foken (Univ. of Bayreuth)
Advection experiments at the Waldstein/Weidenbrunnen FLUXNET site

15:05 - 15:30 ∗ Ronald Queck, A. Bienert, S. Harmansa (TU-Dresden)
Calculating advective fluxes in tall canopies – Towards better wind speed distribution using 3D vegetation scans in high resolution

15:30 - 16:00 ∗ Coffee break

16:00 - 16:25 ∗ Uta Moderow, C. Bernhofer, C. Feigenwinter (TU Dresden)
The true mean vertical wind velocity - a miracle?

16:25 - 16:50 ∗ Ian Harman, J. Finnigan, E. van Gorsel, S. Belcher (Marine and Atmospheric Research, Canberra)
Limits to accuracy and optimal instrument deployment for eddy flux measurement in complex terrain

16:50 - 17:15 ∗ Ralph Dlugi, G. Kramm, M. Berger, M. Zelger (Arbeitsgruppe Atmosphärische Prozesse, München)
Segregation Effects and their Impact on Chemical Transformation Rates and Vertical Eddy Fluxes of Atmospheric Trace Constituents

18:30 ∗ Dinner

Discussion forum ∗ Energy talk (Chair: Foken)

20:00 - 22:00 ∗ The effect of the energy balance closure problem on trace gas fluxes

3 Horizontal and vertical trace gas advection

Key Note

Direct advection measurements do not help to solve the night time CO_2 closure problem – evidence from three inherently different forests.

Marc Aubinet[1], Christian Feigenwinter[1], Christian Bernhofer[2], Anders Lindroth[3], Leonardo Montagnani[4], Corinna Rebmann[5]
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The ADVEX campaigns aimed at performing extensive advection measurements at three sites characterized by different topographies. One goal of the campaign, which we address in this paper, was to establish the CO_2 balance in night conditions in order to improve NEE estimates. A set-up made of four towers forming a 100 m side square and equipped notably with sixteen sonic anemometers and $[CO_2]$ sampling points was installed. It was used to obtain storage, vertical and horizontal advection while turbulent fluxes were measured by an eddy covariance system placed at the top of the main tower placed at the centre of the square. Results showed that horizontal advection varied greatly from site to site and from one synoptic condition to another, the highest values being reached at large friction velocities and intermediate stability conditions. Vertical advection varied lesser and was found maximal at low u* and stable conditions. Night NEE estimates deduced from an advection completed CO_2 balance were found not compatible with biotic fluxes because (i) they varied strongly from one synoptic condition to another, which cannot solely be explained by a response to climatic variability (ii) their order of magnitude was different from those of biotic fluxes and (iii) they still presented a trend vs. u*. A critical analysis of the measurement and data treatment procedures led us to the conclusion that the causes of the problem should rather be related with the measurement representativity (control volume size, sampling resolution) or with the hypotheses underlying the CO_2 balance equation (neglecting of horizontal turbulent flux divergence). In view of these problems, improvement of eddy flux measurements by developing an advection completed CO_2 balance at night appears hardly practicable.

Advection experiments at the Waldstein/Weidenbrunnen FLUXNET site

Lukas Siebicke[1], Martina Hunner[1], Andrei Serafimovich[1], Joel Schröter[2], Johannes Ruppert[3], Thomas Foken[3]
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Advection measurements at the Waldstein/Weidenbrunnen FLUXNET site were conducted during three experiments: Waldatem 2003, EGER IOP1 2007 and EGER IOP2 2008. Techniques applied to measure horizontal gradients of CO_2 are presented ranging from the well known single analyzer approach using a switching valve system (applied in 2003 and 2007) to a multi-instrument setup (applied in 2008). Advection estimates from the different setups are presented as well as an overview over the statistical approach developed to make use of the multi-analyzer measurements. Finally, the effect of advection on estimates of NEE will be shown.

Calculating advective fluxes in tall canopies – Towards better wind speed distribution using 3D vegetation scans in high resolution

Ronald Queck[1], Anne Bienert[2], Stefan Harmansa[1]
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The wind speed distribution in forests is dominated by inhomogeneities like step changes in stand height and forest clearings. Thus a major limitation in the attempts to describe and model the wind field in destined tall canopies is the parameterization of plant architecture. The relationship between wind speed, drag coefficient and plant area distribution was experimentally investigated in a mixed conifer forests in the lower ranges of the Osterzgebirge. The results of this study will be applied to different kinds of flow models to investigate the influence of advective fluxes of energy and matter. From May 2008 to May 2009 intensive turbulence measurements took place on a transect over the forest clearing „Wildacker" (Tharandter Wald, N 50°57'49", E 13°34'01"). In total 25 measurement points, at 4 towers (heights: 40 m, 40 m, 40 m, 30 m) including five at ground level position (2 m), are used to record the turbulent flow simultaneously. Terrestrial laser scanning is a fast developing tool and appears to be an efficient method to record 3D models of the vegetation. The forest stands around the clearing (500 m x 60 m) were scanned applying a Riegl LMS-Z 420i and a Faro LSHE880. Thereby scans from different ground positions and from the top of the main tower (height: 40 m) were done. The scans were filtered and combined to a single 3D representation of the stands. The detection of trees was done automatically and mean tree distances were calculated. The 3D point cloud of trees in a 60m x 310m x 50m model domain was transformed into a 3D voxel space. The normalized point density of each voxel represents the plant area density PAD. A scaling of the laser derived totals per floor space was done by measurements with the LAI2000 (LICOR). The so calculated PAD and the spatial arrangement of points inside the voxel can be used to derive a parameterization for the drag coefficients. Simultaneously, the drag coefficients are calculated from turbulence measurements at the positions of anemometers. Finally the dependency between drag coefficients and PAD can be investigated with respect to stability and wind speed. Using measured wind profiles this study aims further to validate and develop estimates of parameters like mixing length, displacement height and roughness length from the plant area density profile.

The true mean vertical wind velocity – a miracle?

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Estimation of advective fluxes is a challenging task. It requires a high amount of information as well as a careful data treatment and selection of the most suitable methods depending on site characteristics and in turn on available data. One crucial point in estimation of advective fluxes is the assessment of the mean vertical velocity (e.g. Heinesch et al. 2007; Vickers and Mahrt 2006) that is needed for the calculation of the vertical advection. Data of the advection experiments ADVEX (Feigenwinter et al. 2007) are used to calculate vertical velocities on the basis of different tilt correction methods or rotation algorithms (e.g. Lee 1998, Paw U et al. 2000, Wilczak et al. 2001). The ADVEX data give the possibility not only to compare different sites but also to compare measurements of four different towers at the same site. A comparison of these different methods clearly showed that the agreement between these methods at the same tower is satisfying but not between the towers. First results suggest a poor agreement between the tilt correction methods and an alternative method using the divergence of horizontal wind speed. Different vertical advection estimates are computed on the basis of the different calculated vertical velocities. They are compared to each other and are investigated with regard to plausibility.

Limits to accuracy and optimal instrument deployment for eddy flux measurement in complex terrain

Ian Harman[1], *John Finnigan[1]*, Eva van Gorsel[1], Steven Belcher[2]
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[2] University of Reading

The influence of topography on the flow and turbulence remains a substantial challenge when interpreting micrometeorological observations of ecosystem-scale exchanges of energy, water and trace gases. Topographically induced perturbations to the flow and turbulence can lead to large localised perturbations in the observed vertical eddy fluxes and/or divergence in the horizontal advective fluxes which, even with substantial instrumentation, may not easily be diagnosed or corrected. For simple scalar source distributions, analytic and numerical flow and transport models can be combined to provide information on the spatial pattern of the scalar concentration and flux fields in complex terrain and hence guide the positioning of towers and instrumentation. However, information about the 'reverse' problem is of more use to experimentalists. That is, what information about the scalar sources, such as magnitude and uncertainties, can we obtain from observations of fluxes and concentrations at a limited number of locations? Here we show that by inverting the flow models we can obtain information on the underlying limits of accuracy we can expect for observations of ecosystem exchange for a given set of instrument locations, instrumental accuracy and uncertainties in the models. We will also consider what are the optimal locations of instruments to reduce the uncertainty in ecosystem exchange estimates and, for a range of hill shapes, whether sufficiently accurate estimates of ecosystem exchange can be obtained using only one tower.

Segregation Effects and their Impact on Chemical Transformation Rates and Vertical Eddy Fluxes of Atmospheric Trace Constituents

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Segregation effects play a prominent role in turbulent plumes of reacting species (e.g., Lenschow, 1982; Georgopoulos and Seinfeld, 1986) and in turbulent diffusion flames (e.g., Moss, 1995). Since the dispersion of highly reactive trace species in the atmospheric boundary layer can strongly be affected by chemical reactions (e.g., Kramm and Meixner, 2000), the corresponding segregation effects have to be considered. Results of such segregation effects determined during various field campaigns for the chemical triad of ozone with NO and NO_2 and reactions of OH with some biogenic VOCs are to be presented. In addition, the importance of higher order moments up to the fourth order is shown for homogeneous and inhomogeneous mixed conditions. Their impact on the corresponding reaction rates and the vertical fluxes of these trace species are to be pointed out. These results underline that, at least, second-order closure principles are indispensable for computing such segregation effects in turbulent flows.

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The energy balance closure problem – Introduction to a panel discussion

Thomas Foken
Department of Micrometeorology, University of Bayreuth

Former assumptions that measuring errors or storage terms are the reason for the unclosed energy balance do not stand up because even turbulent fluxes derived from documented methods and calibrated sensors, net radiation, and ground heat fluxes cannot close the energy balance. Instead, exchange processes on larger scales of the heterogeneous landscape have a significant influence. By including these fluxes, the energy balance can be approximately closed. Therefore, the problem is a scale problem and has important consequences for the measurement and modelling of turbulent fluxes – not only the energy fluxes. The aim of the panel discussion is to address the consequences for trace gas fluxes and even reactive trace gas fluxes and to find a solution with which to handle this problem for quantitative flux studies.

Participants on the discussion:

Thomas Foken[1] (Chair), Marc Aubinet[2], John Finnigan[3], Monique Leclerc[4], and Matthias Mauder[5]

[1] Department of Micrometeorology, University of Bayreuth
[2] Unit of Physics, Faculté Universitaire des Sciences Agronomiques de Gembloux
[3] Marine and Atmospheric Research, CSIRO
[4] The University of Georgia, Atmospheric Biogeosciences
[5] Institute of Meteorology and Climate Research IMK-IFU, Research Center Karlsruhe

Wednesday, Oct 7 ☰

Session 4 ∗ Forest biogeochemistry of reactive trace gases (Chair: E. Falge)

09:00 - 09:40 ∗ (Key note) Jose D Fuentes (Pennsylvania State University)
Forest biogeochemistry of reactive trace gases

09:40 - 10:05 ∗ James Ryder, B. Langford, D. Oram, P. Misztal, C. Helfter, G. Phillips, M. Coyle, J. Whitehead, D. Lowe, G. McFiggans, E. Nemitz (Centre for Ecology & Hydrology, Penicuik)
Sources, sinks and chemical processing of volatile organic compounds within a South-East Asian rainforest canopy

10:05 - 10:30 ∗ Thomas Pugh, R. MacKenzie, N. Hewitt, B. Langford (Lancaster University)
Simulating atmospheric composition over a South-East Asian tropical rainforest

10:30 - 10:50 ∗ Coffee break

10:50 - 11:15 ∗ Zhilin Zhu, A. Tsokankunku, D. Plake, E. Falge, Th. Foken, F.X. Meixner (Chinese Academy of Science, MPI for Chemistry Mainz)
Multi-level eddy covariance measurements for ozone fluxes above, within and below spruce forest canopy

11:15 - 11:40 ∗ Anywhere Tsokankunku, Z. Zhu, F.X. Meixner, I. Trebs, Th. Foken, M. Welling, D. Plake, M.O. Andreae (MPI for Chemistry Mainz)
Eddy covariance fluxes of the NO-NO_2-O_3 triad above a spruce forest canopy in south-eastern Germany

11:40 - 12:05 ∗ Christof Ammann, M. Kortner, A. Thielmann, U. Rummel, F.X. Meixner (Agroscope Reckenholz-Tänikon Res. Stat.)
What controls the discrepancy between biogenic emission/uptake and above-canopy fluxes of NO and NO_2?

12:05 - 12:30 ∗ Claudia Breuninger, F.X. Meixner, J. Kesselmeier (MPI for Chemistry Mainz)
Exchange of NO_2 between spruces and the atmosphere is dominated by deposition

12:30 - 14:00 ∗ Lunch

4   Forest biogeochemistry of reactive trace gases

Key Note

Forest biogeochemistry of reactive trace gases

Jose D Fuentes[1]
[1] Department of Meteorology, The Pennsylvania State University

Trees and flowers release a variety of volatile and fragrant gases. These compounds play crucial ecological roles such as attracting insects to visit and pollinate flowers. Because of the large source of emissions in the presence of nitrogen oxides, volatile compounds can exacerbate air quality and indirectly impact regional climate. This presentation will provide an overview on the chemical processing of these gases within plant canopies. In addition, the presentation will explain how much plant-emitted volatiles contribute to regional pollution and indirectly influence climate. The speaker will additionally propose that, once reacted and converted to particulates, plant-emitted volatiles can indirectly reduce the levels of atmospheric warming.

Oral - Nr. 1 in 4 Forest biogeochemistry of reactive trace gases

Sources, sinks and chemical processing of volatile organic compounds within a South-East Asian rainforest canopy

James Ryder[1], Langford Ben[2], Oram David[3], Misztal Pawel[1], Helfter Carole[1], Phillips Gavin[1], Coyle Mhairi[1], Whitehead Jamie[4], Lowe Douglas[4], McFiggans Gordon[4], Nemitz Eiko[1]

[1] Centre for Ecology & Hydrology
[2] Lancaster University
[3] University of East Anglia
[4] University of Manchester

We report the physical measurements and modelling findings from comprehensive in-canopy measurements conducted during July 2008 as part of the ACES/OP3 campaign at Danum Valley (Sabah, Borneo, Malaysia). Time-series profile data of biogenic Volatile Organic Compounds (VOCs) concentration, photo-active radiation (PAR), NOx, O3, temperature, aerosol size distributions, leaf area index and turbulence statistics have been collected in order to provide a comprehensive description of chemistry and transport within the rainforest canopy.   Significant concentrations of isoprene and monoterpene are observed during daylight hours. However, across the eight days of measurements, there is considerable day-to-day variation in the concentration and dispersion of compounds. These differences are partly explained by variations of in-canopy turbulence and measured PAR. Measured in-canopy turbulence is low (the friction velocity, as measured at the top tree platform is generally less than ~ 0.4m/s), and PAR is influenced by fast changing cloud cover.   An Inverse Lagrangian Transport source/sink analysis demonstrates that the bulk of the isoprene and monoterpene is emitted from the uppermost levels of the trees. The measurements also show that the longer-lived degradation products of these VOCs are transported further down into the canopy. In addition, larger concentrations of methanol observed close to the ground suggest that this compound is partly emitted from leaf litter and other debris.

The ultimate intent is to use the collected data in a 1D size segregated aerosol chemistry and transport model. Whilst the in-canopy measurements will help to constrain and validate the chemical interactions and transport of matter inside the canopy the model will make predictions of the escape efficiency and upward flux into the lower troposphere. These predictions can be compared with above canopy measurements that were also taken as part of the OP3 campaign. Preliminary output from this model will also be presented.

Simulating atmospheric composition over a South-East Asian tropical rainforest

Thomas Pugh[1], Robert MacKenzie[1], Nicholas Hewitt[1], Ben Langford[1]
[1] Lancaster Environment Centre, Lancaster University

Atmospheric composition above tropical rainforests is currently quite poorly defined, particularly for south-east Asia. A box model of atmospheric boundary layer chemistry is compared to measurements made in and over the rainforest at Danum Valley, Malaysian Borneo. Multi-variate optimisation against ambient concentration measurements was used to estimate 24-hour average canopy-scale emissions for isoprene, total monoterpenes and nitric oxide. The excellent agreement between estimated values and measured fluxes of isoprene and total monoterpenes provides confidence in validity of this method, and indicates that it may be applied where measured fluxes are not available. The model performs robustly in representing NO_x and O_3 concentrations. However several problems affect the modelled VOC chemistry. In particular concentrations of methacrolein (MACR) and methyl-vinyl ketone (MVK) are greatly overestimated and the hydroxyl radical [OH] is substantially underestimated. It is shown that dry deposition is able to account for the MACR/MVK overestimation. However, increasing [OH] production is not found to be a satisfactory solution to [OH] underestimation, due to negative effects on the model fit for volatile organic compounds (VOCs). Given the constraints on isoprene flux provided by measurements, a substantial decrease in the rate constant for the reaction of VOCs with OH is the only remaining option to explain the measurement/model discrepancy for OH. A reduction in the isoprene + OH rate constant of 50% is able to produce both isoprene and OH concentrations within error of those measured. It is also demonstrated that night time isoprene loss cannot be fully explained by the chemistry, leading to the suggestion that inadequate representation of mixing processes within the PBL may explain the discrepancy. This study demonstrates that the inadequacies apparent in box and global model studies of tropical VOC chemistry may be much more strongly influenced by representation of detailed micrometeorological effects than errors in the chemical scheme.

Multi-level eddy covariance measurements for ozone fluxes above, within and below spruce forest canopy

Zhilin Zhu[1], Anywhere Tsokankunku[2], Daniel Plake[2], Eva Falge[2], Thomas Foken[3], Franz X. Meixner[2]

[1] Institute of Geographic Sciences and Natural Resources Research, CAS
[2] Max Planck Institute for Chemistry, Mainz, Germany
[3] University of Bayreuth, Bayreuth, Germany

Tropospheric ozone is known to have negative effect on vegetation, affecting plant tissue, photosynthesis and other physiological functions. To investigate the vertical distribution of ozone depositions at different levels above, within and below spruce forest, ozone eddy covariance fluxes at 4 levels (1, 17, 25 and 32 m) were measured. Meanwhile, some meteorological components (temperature, humidity, wind speed etc.), reactive and non-reactive gases (O_3, NO, NO_2, CO_2 and H_2O) concentration profiles at 11 heights were also measured in Fichtelgebirge Mountains, Germany. The raw ozone fluxes at different levels were corrected by a serial of steps, e.g. the errors caused by lag time, insufficient frequency response and instruments separation, instruments tilt, air temperature and humidity fluctuation, etc. Particularly, in the experiments, 3 kinds of fast response ozone sonde were employed. Via side-by-side comparison, large differences in the final results were found. To eliminate systematic error induced by different sondes, one sonde was determined as the 'relative standard' by using spectral analysis method. Corrected ozone deposition velocities, mixing ratios and fluxes at different levels were compared and analyzed. The results show that (1) the mean deposition velocities were 0.57 cm s^{-1} (above canopy, 32 m), 0.41 cm s^{-1} (within canopy, 17 m) and 0.05 cm s^{-1} (below canopy, 1 m) in daytime, and the corresponding values were 0.28 cm s^{-1}, 0.19 cm s^{-1} and 0.04 cm s^{-1} in night time, respectively.
(2) The fluxes at 3 levels above, within and below canopy were -527 ng $m^{-2} s^{-1}$, -334 ng $m^{-2} s^{-1}$ and -36 ng $m^{-2} s^{-1}$ in daytime and -248 ng $m^{-2} s^{-1}$, -144 ng $m^{-2} s^{-1}$ and -24 ng $m^{-2} s^{-1}$ in night time, respectively. (3) Ozone storage changes can also influence ozone fluxes in different layers. The mean storage change rates for entire canopy are 12.1 ng $m^{-2} s^{-1}$ in daytime and -17.8 ng $m^{-2} s^{-1}$ in night time. (4) Mean daily ozone deposition from upper atmosphere above forest is -35.48 mg $m^{-2} d^{-1}$, the mean daily deposition amount in different layers were -2.68 mg $m^{-2} d^{-1}$ (0 m to 1 m), -19.34 mg $m^{-2} d^{-1}$ (1 m to 17 m) and -13.46 mg $m^{-2} d^{-1}$ (17 m to 32 m) and the corresponding ratios to the total deposition were 7.6%, 54.5% and 37.9%.

Eddy covariance fluxes of the NO-NO2-O3 triad above a spruce forest canopy in south-eastern Germany

Anywhere Tsokankunku[1], Z Zhu[2], F.X. Meixner[1], I Trebs[1], Th Foken[3], M Welling[1], D Plake[1], M.O Andreae[1]

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[2] Chinese Academy of Science
[3] Micrometeorology Department, University of Bayreuth, Bayreuth, Germany

We investigated the diel variability of measured eddy covariance fluxes of the NO-NO_2-O_3 triad above a spruce forest canopy at the "Weidenbrunnen" research site (Fichtelgebirge, Germany). Measurements were part of the EGER project (ExchanGE processes in mountainous Regions), which focuses on the role of process interactions among the different scales of soil, in-canopy and atmospheric exchange processes of reactive and non-reactive trace gases and energy. The eddy covariance platform was at the top of a 32 m high tower (50˚ 08'31" N, 11˚ 52'1"E, elevation 755 m.a.s.l). The eddy covariance system consisted of a CSAT3 sonic anemometer and a high speed, high resolution NO-NO_2 two channel chemiluminescence analyzer (Ecophysics CLD 790 SR2). Two solid-state blue-light photolytic converters in series were connected to the NO_2 channel of the analyzer just behind the sample inlet for specific conversion of NO_2 to NO. Ambient air was sampled via 52 m long tubes with the instrument located in a temperature-controlled container at the ground. The NO-NO_2 analyzer was operated at 5 Hz. A fast solid-phase chemiluminescence ozone analyzer (GFAS) was deployed to measure O_3 eddy covariance fluxes. All trace gas inlets were situated at 32.5 m, 20 cm below the path of the sonic anemometer. The mixing ratio measured at 32m by an independent NO, NO_2, and O_3 profile system was used as reference for the fast ozone analyzer and the two channel NO-NO_2 chemiluminescence analyzer. Preliminary results showed that NO and NO_2 advection played a substantial role in the magnitude and direction of the fluxes at the site. The main source of the advection was a busy country road situated about 2 km west of the site. Extended periods of fluxes unaffected by advection of anthropogenic NO_x usually occurred on Sundays when the amount of traffic was significantly lower. During the "golden days period" (29 June – 3 July 2008), NO and O_3 fluxes were mainly downward (within the margin of error), and net emission of NO_2 from the spruce forest canopy was observed. This is in contrast to what is typically found under ideal micrometeorological conditions such as short grassland. Due to decreased turbulence within the taller forest canopy O_3 reacted with NO to form NO_2, depleting NO in the canopy to such extent that the canopy became a sink for NO above the canopy. In this respect, the ratio of chemical reaction timescales to turbulent transport timescales plays an important role in determining whether the forest canopy is a source or sink of reactive gases. The critical Damköhler number was used to determine periods when the contribution of chemical production and loss to the net eddy covariance flux was high. It was found to be largest during night time and periods of stationarity. NO and NO_2 fluxes ranged between +1.5 and -1.5 nmol m^{-2} s^{-1} and maximal O_3 deposition fluxes were up to -25 nmol m^{-2} s^{-1} during daytime.

What controls the discrepancy between biogenic emission/uptake and above-canopy fluxes of NO and NO2?

Christof Ammann[1], Michael Kortner[2], Axel Thielmann[2], Udo Rummel[2], Meixner Franz X.[2]

[1] Research Station ART

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It is commonly acknowledged that the main source and sink processes for NOx (= $NO+NO_2$) in vegetated ecosystems are (a) the soil emission of NO originating from nitrification and denitrification and (b) the deposition of NO_2 via plant stomates and, to a minor degree, to outer plant and soil surfaces. Consequently, these processes are usually included in atmospheric chemistry models as simple surface parameterizations. However, the exchange of reactive trace gases at the atmosphere-biosphere interface is often influenced by several interacting processes with similar time scales including (photo) chemical reactions. This is especially the case in forest canopies where transport mechanisms control to what extent emitted and deposited species are affected by these processes during transfer to or from the atmosphere. In order to investigate this problem, we performed surface exchange measurements on the $NO-NO_2-O_3$ triad in two contrasting forest ecosystems, a primary rainforest in Rondônia/Brazil (LBA-EUSTACH) and a mixed temperate forest in Jülich/Germany (AFO2000-ECHO). At both sites, the measurements addressed processes on various scales: (a) dynamic chambers for soil emission and deposition, (b) vertical concentration profiles throughout the canopy, and (c) net turbulent fluxes above (and within) the canopy. In addition, profiles of radiation, thermal stratification, and turbulence intensity were observed. In both canopies, soil emitted NO was rapidly oxidized by O_3 to NO_2. Consequently, only a fraction of NO emitted from soils reached the atmospheric boundary layer as either NO or NO_2. During daytime over the temperate forest, a deposition flux of NO was observed despite the strong soil emission. And in contrast to the detected NO_2 uptake by the foliage, a net NO_2 emission was found above the canopy. This effect may be explained by the lack of NO_2 photolysis within the dark canopy. With the experimental datasets, it was tested, to what extent the interacting canopy processes for NO and NO_2 could be described by simple model approaches (that may be suitable for atmospheric chemistry models). Furthermore, the influence of various controlling parameters, especially the canopy residence time, on the discrepancy between biogenic sources/sinks and net canopy fluxes was analyzed.

Exchange of NO_2 between spruces and the atmosphere is dominated by deposition

Claudia Breuninger[1], Franz X. Meixner[1], Jürgen Kesselmeier[1]
[1] Max Planck Institute for Chemistry, Mainz

The chemical budget of tropospheric ozone is largely determined by the concentration of NO_x (NO and NO_2), which is in remote areas related to biological activities of soils and vegetation. The atmospheric concentration of NO_2 is strongly influenced by the bi-directional exchange between the atmosphere and plants. The exchange depends on stomatal compensations points in close relation to the NO_2 concentrations in ambient air. It is accepted that NO_2 uptake by plants represents a large NO_2 sink, but the magnitude is still unidentified. A better knowledge of compensation point values for the bi-directional NO_2 exchange is a matter of recent discussions, as accurate estimates would help to reliably classify vegetation types. In close relation to our previous studies of *Betula pendula, Fagus sylvatica, Quercus ilex und Pinus sylvestris* we investigated a further representative of conifers, *Picea abies*, under field and laboratory conditions**.** The measurements were part of the DFG joined project EGER (ExchanGE processes in mountainous Regions). We used dynamic chambers and a sensitive and highly specific NO-NO_2-Analysator. CO_2 and H_2O exchange were measured simultaneously to assess physiological comparative parameters such as photosynthesis, transpiration and stomatal conductance. Additionally O_3 concentrations were recorded, to detect and estimate chemical reactions within the chamber. During the measurements the NO_2 exchange was obviously dominated by deposition and depended on stomatal conductance.

Wednesday, Oct 7 ≡

Session 5 ∗ Poster presentations (Chair: J. Lüers)

14:00 - 16:00 ∗ Poster presentations (alphabetical order): Quick shots 2 min each

15:30 - 16:00 ∗ Coffee break

16:00 - 18:00 ∗ Social EVENT ∗ Guided tour ∗ "Töpfermuseum Thurnau"

18:30 ∗ Dinner

5   Poster presentations

Boreal Scots pine (Pinus sylvestris) forest floor BVOC emissions peak in early summer and autumn

Hermanni Aaltonen[1], Jaana Bäck[1], Jukka Pumpanen[1], Mari Pihlatie[2], Hannele Hakola[3], Heidi Hellén[3]
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[3] Finnish Meteorological Institute

Biogenic volatile organic compounds (BVOCs) constitute the largest part of volatile chemicals produced and emitted by the biosphere (Guenther et al. 2006). In troposphere BVOC compounds take part in chemical reactions which affect the formation and growth of aerosols (Kulmala et al. 2000). Aerosols themselves are important in the formation of clouds which increase the albedo of the atmosphere and thus slow down the warming of troposphere. Although the boreal zone is the largest forested region in the world, understanding on the dynamics of soil processes and the roles of different soil components such as roots, rhizosphere and decomposing organisms to BVOC formation and deposition is limited. In boreal forest soil, BVOC emissions have been observed to be the highest in spring and autumn (Hellén et al. 2006), but the processes behind seasonal fluctuation are still uncertain. Soil temperature and humidity conditions have a direct connection to many physical and biological processes of soil BVOC formation (Asensio et al. 2007). Thus climate change and soil BVOC emissions may have a close interaction via feedback reactions, which raise an urgent need of soil process based studies of BVOCs. We have conducted BVOC emission measurements in Scots pine (*Pinus sylvestris*) forest at SMEAR II station in Hyytiälä, in southern Finland, between April and November 2008. Forest floor BVOC fluxes were measured with manual chambers from five collars permanently installed at the site. Air samples are taken from the flow-through chambers into Tenax-adsorbent tubes and analysed by GC-MS (Gas Chromatography-Mass Spectrometer). Results show, that BVOC emissions fluctuated greatly during the snow-free time between April and November when soil is unfrozen and microbial population is in the active stage. We measured fluxes of 37 VOC compounds, and 19 of them were identified to be from natural sources. Most prevalent BVOC group was monoterpenes, also hemiterpenoids and sesquiterpenes were detected, but their emissions were low. Monoterpene emissions peaked in June and in October, the autumn peak being the highest. The single most emitted compound was α-pinene, its emissions reached 6.7 and 5.8 µg m^{-2} h^{-1} in October and in June, respectively. Two first samplings in April and in May showed decreasing trend in emissions, which can be a sign of higher emissions in the spring prior the start of the measurement period. Scots pine is dropping the oldest needle age class in autumn, and the high input of needle litterfall, measured at the SMEAR II station, correlated clearly with the BVOC emission peak in October. Thus the litter decomposition seems to have strong influence to forest floor BVOC emissions. The onset of the photosynthesis of the ground vegetation might have a connection to the BVOC emission peak in June. However, an identical profile in monoterpene emissions with the peak in October suggests that the emission peak in June is also due to the decomposition of litter. Chamber measurements in forest floor do not distinguish emissions coming from soil and from ground vegetation. Thus measurements from different soil layers are needed to find out how strongly different soil layers are involved to the BVOC production. The results of this study will be used in the future to build up a model of the BVOC emissions from boreal forest soil and forest floor, and the results provide also quantitative information for climate modelling.

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Seasonal canopy uptake of dry deposited 15N-NH3 under different N loads and the interaction with leaf physical properties

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Semi-natural ecosystems such as forests are exposed to higher anthropogenic inputs of atmospheric nitrogen (N) compared to open-field circumstances because of their surface roughness, higher leaf area index and physiological leaf characteristics (Erisman *et al*., 2003). This increased input is manifested largely by the dry deposition of ammonia gases (NH_3), originating from intensive agriculture, and reactive nitrogen oxides (NO_y), originating from combustion processes. Since this deposited N compounds are partially assimilated by the foliage, they are a direct addition of N to plant metabolism, and could therefore potentially more readily influence plant growth compared to soil deposited N (Nadelhoffer, 1999). Previous studies revealed that the NH_3 fluxes to the canopy greatly exceed those of NO_2 and that stomatal conductance and cuticular adsorption play an important role in these fluxes (Gessler *et al*, 2002). Therefore, this study focused on the assessment of seasonal changes in foliar uptake of $N-NH_3$ between different tree species and the impact of leaf characteristics on this observed uptake. To quantify this N uptake accurately, we applied a ^{15}N-labelled source to young trees of three deciduous species, i.e. European beech (*Fagus sylvatica* L.), pedunculate oak (*Quercus robur* L.) and common birch (*Betula pendula* L.), and one coniferous species, i.e. Scots pine (*Pinus sylvestris* L.). Living twigs in plastic bags were exposed to $^{15}N-NH_3$ and $^{13}C-CO_2$ for examining gaseous N uptake, corrected for varying light conditions. Four different levels of N load were used, representing 1, 4, 10 and 20 times the average ambient NH_3 concentration in Flanders. To assess the effect of leaf phenology, the application was conducted in April, August and October of 2008. Leaf anatomy, stomatal characteristics and maximal stomatal conductance were determined simultaneously to explain differences between tree species and phenological stadia. The results reveal a significant effect of leaf phenology, tree species and N load on the observed $^{15}N-NH_3$ uptake. The highest ^{15}N-uptake during spring was observed at a concentration level of 4 times the ambient level, while during summer this was at a concentration level of 10 times the ambient level. Also, the uptake of NH_3 differed significantly between seasons for all deciduous species, except for Scots pine. A similar interaction between tree species and leaf phenology was observed for ^{13}C uptake, indicating a higher photosynthetic gas exchange of the deciduous species in summer compared to spring, which could be confirmed by leaf characteristics in both seasons.

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Wavelets and high frequency meteorological data to estimate mass and energy fluxes

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Wavelet Transform analysis is applied to estimate mass (CO_2 and H_2O) and energy fluxes above forest canopy in order to provide a tool for turbulent moments estimation to be compared with canonical Reynolds averaging procedure. Past studies indicated the differences between the methods and the theoretical flexibility of multiresolution analysis that could be an added value for measurements of turbulent fluxes in non stationary conditions, but to our knowledge few experimental tests have been done. The use of this mathematical tool, combined with meteorological standard measurements collected at frequency higher than usual, could help in better understanding and describing exchange process in critical conditions such during cases of stable stratification and nonstationarity.

Biogenic NO emission from a spruce forest soil in the Fichtelgebirge under influence of different understory types

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Within the framework of the EGER project (ExchanGE processes in mountainous Regions) soil samples have been taken from the spruce forest site "Weidenbrunnen" (Fichtelgebirge, Germany) in September 2008 to determine the NO exchange in the laboratory and for a series of soil analyses. The soil was sampled below four different understory types: moss/litter, grass, young spruce and blueberries. We investigated the net NO release rate from corresponding organic layers of respective soils. Additionally we measured pH, C/N ratio, ammonium, nitrate, and organic C content, bulk density, the thickness of the organic layer and the quality index of the organic matter. Net NO release rates (as well as the NO production and NO consumption rates) from the soil samples were determined by a fully automated laboratory incubation system. Purified dry air passed five dynamic incubation chambers, four containing water saturated soil samples and one reference chamber. By this procedure, the soil samples dried out slowly (within 2-6 days), covering the full range of soil moisture (0-100% water filled pore space (WFPS)). To quantify NO production and NO consumption rates separately, soil samples were fumigated with zero-air (approx. 0 ppb NO) and air of 133 ppb NO. The chambers were placed in a thermo controlled cabinet for incubation at 10 and 20°C. NO and H_2O concentrations at the outlet of the five dynamic chambers were measured sequentially by chemiluminescence and IR-absorption based analyzers, switching corresponding valves every two minutes. Net NO release rates were determined from the NO concentration difference between sample and reference chambers. Corresponding measurements of H_2O mixing ratio yielded the evaporation loss of the soil samples, which (referenced to the gravimetric soil water content before and after the incubation experiment) provided the individual soil moisture content of each soil sample during the incubation experiment. With the aid of the particle and bulk density we calculated the WFPS for every soil sample. Our contribution focuses on NO fluxes from the O horizon of a spruce forest soil sampled under different understory types. Soils sampled below "moos/litter" showed the lowest NO fluxes while organic soil below blueberry patches showed the highest NO fluxes. Also we will present a small scale upscaling for the Weidenbrunnen site as a function of WFPS and temperature. The understory seems to be influencing the NO exchange significantly. However, we could not detect a significant influence of soil nutrients on the soil NO exchange at the Weidenbrunnen site.

Turbulence parameter inside and above a tall spruce site

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For most flux measurements it is crucial that the turbulent flow field is well developed. Integral turbulence characteristics, the normalized standard deviation of a turbulent quantity, can be used to describe the structure of turbulence therefore a comparison between measured and predicted values is used in quality assessment. Since there is no uniform theory for the parameterizations of integral turbulence characteristics inside a forest different approaches were tested. Observations of turbulence structure were obtained by a vertical profile of sonic anemometers covering all parts of the forest up to the lower part of the roughness sub layer during the EGER (ExchanGE processes in mountainous Regions) project in fall 2007 at the BayCEER research site Weidenbrunnen, a 23 m tall spruce site located in the Fichtelgebirge Mountains in North-Eastern Bavaria. Field observations are complemented by simulations of ACASA model (Advanced Canopy-Atmosphere-Soil Algorithm). Profiles of the integral turbulence characteristics show a strong dependency on stratification and inside a forest on the structure of the stand. The comparison of different approaches showed that the wind components should be parameterized with a dimensionless height $z* = hc\ L^{-1}$ instead of $z = z\ L^{-1}$, which is used above short vegetation. The comparison also showed a great dependency on the stand structure, the parameterizations therefore also need to be adjusted to the different measurement levels inside the stand. Selecting the profiles of the integral turbulence characteristics by coupling situations between the atmosphere above and inside the stand did not reveal a significant different behavior than a selection according to stratification above the canopy. A comparison between the measured values and model results from the ACASA model showed a fairly good agreement for the normalized wind speed but the integral turbulence characteristics of the wind components were not well represented. For the quality control of flux data inside and above a forest a combined parameterization which accounts for stability and stand structure dependency is recommended an can not be replaced by a model.

The next generation field experiment technology: WINDSCANNER.DK

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In the Wind Energy Division at Risø-DTU, a new research infrastructure facility for wind and turbulence measurements is developed. It is called a wind-scanner, since it will be able to scan an extensive plane or a large volume of the air at a rate of several hundred points per second. The wind scanner is comprised of three ground-based remote sensing wind LIDARs (LIght Detection And Ranging), with modified double-prism control which makes it possible to focus the three laser beams in one point, thereby enabling the measurement of all three wind components. Compared to a single LIDAR, this represents a great improvement since the requirement of flow homogeneity for precise wind measurements is no longer necessary. The LIDARs employed for the wind scanner have a higher acquisition rate (500 Hz) than what currently is commercially available (0.1 Hz). We believe that the wind scanner will enable a leap in the scientific understanding of turbulent atmospheric flow, by providing detailed and fully-resolved 3D wind measurements that are not affected by flow distortion from the instruments and masts themselves. During 2010, the first Risø wind-scanner with the updated technology will be tested at the Risø-DTU test site Høvsøre in Western Jutland. The primary focus is to measure, quantify and understand the detailed structures of a wind turbine wake. We have, however, also started the discussion regarding the first field experiments of the wind scanner facility for classical micro-meteorological challenges; for example in complex terrain, near roughness changes and over forest canopies. At the conference, we would like to discuss possible applications of the wind scanner with the international community of micro-meteorological researchers. Measurements from an experiment using a simpler version of the wind scanner at Høvsøre, as well as single-lidar measurements from a forest experiment, will be shown on demand at the poster.

Flow angles measured at a fetch-limited beech forest with clearings

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Flow angles were measured with a Gill Solent R2 and a Metek USA-1 sonic anemometer. The Solent sonic was mounted at 43m height and the USA-1 at 31m height above a 26-27m high beech forest. The beech forest is characterized by inhomogeneous surface cover with clearings and several plantations of around 15m tall Noway Spruce. Further, in the direction where the forest is most homogeneous, the distance to the upwind forest edge from the mast corresponds to only 18 canopy heights. The measured flow angles were analyzed in relation to the terrain. It was possible to relate local minima and maxima to influence from the clearings or the limited fetch. During summer time, flow angles taken with the two different anemometers agreed well especially after flow distortion corrections were applied. The flow angles were also analyzed as a function of atmospheric stability. Both the stable and unstable data showed similar dependence on wind direction as the near-neutral data. The difference between the near-neutral and the stable flow angles depended on what sonic anemometer was analyzed and what flow distortion correction was applied. Since the distribution of attack angles on the sonic anemometer depended on atmospheric stability, the difference between near-neutral and stable data could be significantly biased by imperfect flow distortion corrections. The difference between flow angles measured during near-neutral, unstable and stable stratification should be a reflection of the fact that the flow reacts to the combined effect of surface inhomogeneities and atmospheric stability. It is argued that the vertical advection caused by the heterogeneous surface cover should not be included in the net ecosystem exchange since this term can only be considered representative for a relatively small area close to the mast and not for the forest as a whole.

On the Recognition of Fundamental Physical Principles in Recent Atmospheric-Environmental Studies

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In this paper, so-called alternative mass balance equations for atmospheric constituents published recently are assessed in comparison with the true local mass balance equations deduced from exact integral formulations. It is shown that these "alternative" expressions appreciably violate the physical law of the conservation of mass as expressed by the equation of continuity. It is also shown that terms of these "alternative" mass balance equations have different physical units, a clear indication that these "alternative" expressions are incorrect. Furthermore, it is argued that in the case of "alternative" mass balance equations a real basis for Monin-Obukhov similarity laws does not exist. These similarity laws are customarily used to determine the turbulent fluxes of momentum, sensible heat and matter in the so-called atmospheric surface layer over even terrain. Moreover, based on exact integral formulations a globally averaged mass balance equation for trace species is derived. It is applied to discuss the budget of carbon dioxide on the basis of the globally averaged natural and anthropogenic emissions and the globally averaged uptake caused by the terrestrial biosphere and the oceans.

Free convection events on a spruce forest clearing

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Experimental data of a modified Bowen ratio mast installed during the EGER (ExchanGE processes in mountainous Regions) project on a clearing in a spruce forest (*Picea abies*) at the Waldstein site in the Fichtelgebirge Mountains are used to investigate the initiation and occurrences of free convection events. Free convection events are found to be triggered on the heated ground of the clearing if buoyant forces dominate over shear forces within turbulence production. These situations are detected by the stability parameter (ratio of the measurement height to the Obukhov length) calculated from turbulent flux data of the modified Bowen ratio system. Single free convection events are selected and compared to measurement data of a nearby installed turbulence tower above the spruce forest and a Sodar measurement system. The latter is situated on the clearing and provides wind velocity information of the boundary layer and thus of the local circulation system, which possibly influences the initiation of the observed free convection events.

Local wind phenomena at the Waldstein/Weidenbrunnen FLUXNET site

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Two Intensive Observation Periods (IOP) of the EGER project (ExchanGE processes in mountainous Regions) were performed at the Waldstein/Weidenbrunnen FLUXNET site (DE-Bay) in the Fichtelgebirge/Germany. IOP1 was conducted in September and October 2007, IOP2 in June and July 2008. The project is focused on the detailed quantification of relevant processes within the soil-vegetation-atmosphere system by observing diurnal and annual cycles of energy, water and trace gases. The atmospheric boundary layer was profiled with an acoustic and radar remote sensing system (SODAR-RASS). The SODAR provided 10 minute mean profiles up to 500 m a.g.l. In contrast to IOP1 a second SODAR (referred to as miniSODAR) without a RASS-extension was used during IOP2 and provided 5 minute mean profiles up to 200 m a.g.l. The aims of this study included the observation of local wind phenomena at the site, the determination of their frequency and their relation to surrounding meteorological circumstances.

During both IOPs some nocturnal low-level jets (LLJ) with a duration time of several hours were observed. Maximum horizontal wind speed (v_{h_max}) was in the range from 8.2 to 11.0 m s^{-1} for IOP1 and in the range from 8.6 to 13.0 m s^{-1} for IOP2. The height of v_{h_max} varied between 100 and 400 m a.g.l. Most of the LLJ events were characterised by an approaching flow from south-westerly or south-easterly directions. Another phenomenon was observed in the profile of the wind vector. It showed a strong turn of the wind direction with increasing height. At night times and during the morning hours flows above the canopy came from the east while the geostrophic wind approached from the south-westerly directions. The topography and resulting canalising effects seem to be the reason for the generation of LLJ as well as for the turn of the wind direction.

Evaluation of gradient measurements of ammonia with direct flux measurements above a coniferous forest in the Netherlands

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A field campaign has been conducted to compare direct flux measurement with gradient measurements of ammonia above a coniferous forest in the Netherlands for 4 weeks in june 2009. Due to chemical conversions between heights for the NH3-HNO3-NH4NO3 triad flux derivation from gradient measurements is not straight forward. Gradient measurements of gases and aerosols at two heights were conducted with the MARGA and at three heights for ammonia with the GRAHAM. Direct flux measurements of ammonia were executed with the CIMS and for aerosols with an AMS. Preliminary results of the campaign will be presented.

Multilevel Investigation of Subcanopy Respiration Flux by Relaxed Eddy Accumulation Conditional Sampling above and within a Spruce Forest

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This work investigates the subcanopy respiration flux (R_e), which reflects mainly CO_2 soil efflux, at the coniferous Weidenbrunnen FLUXNET site, located in the Fichtelgebirge Mountains (Northern Bavaria) and is applying a recently developed Relaxed Eddy Accumulation (REA) conditional sampling approach to high frequency eddy covariance data. Data was collected within the framework of the EGER (ExchanGE processes in mountainous Regions) project and during the first Intensive Observation Period (IOP1). The project is focused on the detailed quantification of relevant processes within the soil-vegetation-atmosphere system by observing diurnal and annual cycles of energy, water and trace gases. Five days were selected from IOP1 (20.09.2007 to 24.09.2007) and high frequency times series of wind vector , water vapor and CO_2 were recorded at five sampling heights below, within and above the forest canopy. Eddies transporting respiration flux information from the ground to the air above the canopy are considered to possess a unique and detectable CO_2 and water vapor signature. The method used combines REA with hyperbolic dead bands and quadrant analysis, extracting the respiration events from the overall dataset. The overall REA formulation and its statistics were checked. The REA method is likely to overestimate fluxes due to overestimation of the β- coefficient. R_e- events were identified and extracted from the data with hyperbolic thresholds of H = 0.25 and 0.5. For daytime conditions and above canopy systems the results were in the same order of magnitude to expected respiration fluxes, with H = 0.5 yielding best results. The estimates at the below canopy systems and during nighttime conditions were too large. The time fraction of daytime respiration events was < 10% and correlation coefficients ($r_{c,q}$) approached -1, resulting in periods with no respiration signal extractable (22% of daytime data). The R_e- signal above the canopy was correlated to net fluxes near ground, but the explained variance was small (~5%). Canopy storage of CO_2 seemed negligible, but partial reassimilation by understory vegetation might occur, leading to underestimation of respiration. R_e- events seemed rather dependent on turbulence (u_*) than on canopy exchange regime, but sample size was too small for sound statistical testing. Most events are very short, but longer events contribute significantly to overall flux. Encountered event durations are within the timescales of coherent structure ejection phase. For future applications the REA formulation (β ; H) should be improved and a longer data set is needed for final evaluation of the model's performance with subcanopy eddy covariance data and direct respiration measurements.

Source Apportionment of Total Suspended Particulate in Coarse and Fine Size Ranges over Delhi

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Source apportionment of total suspended particulate matter (TSPM) and associated heavy metals has been carried out for the city of Delhi using the Chemical Mass Balance Model, Version 8 (CMB8), as well as principle component analysis (PCA) of SPSS (Varimax Rotated Factor Matrix method) in coarse- and fine-size mode. Urban particles were collected using a five-stage impactor at six sites in the winter of 2005-06. The impactor segregates the TSPM into five different size ranges (viz. > 10.9, 10.9–5.4, 5.4–1.6, 1.6–0.7 and < 0.7 μm). Four samples were collected from six different sites every 24 hours. Samples were analyzed in five size ranges gravimetrically and chemically for the estimation of SPM and metals. The five different size ranges were divided into two broad categories: coarse (1.6 to > 10.9 μm) and fine (< 1.6 μm). The CMB8 and PCA were executed separately for both coarse and fine size ranges. Results obtained by CMB8 indicate the dominance of vehicular pollutants (62%), followed by crustal dust (35%) in the fine size range; while in the coarse size range crustal dust dominated (64%) over vehicular pollution (29%). Little contribution from paved-road dust and industrial sources was observed. Results of PCA (or factor analysis) reveal two major sources (vehicular and crustal re-suspension) in both coarse and fine size ranges. The correlations of factors (sources) with the metals show that in the coarse size range the dominant source is crustal re-suspension (68%) followed by vehicular pollution (23%). However, this is reversed in the case of the fine size range factor analysis where vehicular pollution (86%) dominated over crustal re-suspension (10%). **Keywords:** Source apportionment; Chemical mass balance; Principle component analysis; Coarse particles; Fine particles; Delhi.

The effects of transport systems on natural park ecosystems in Tehran

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The city of Tehran is one of populous city in the world and the biggest city in Iran. One of the main effective factor on air pollution in that city is individual transport system as common car. The Municipality of Tehran is using a new strategy about controlling of all private common transport system since 2004. The data analyzing are collected from 12 air measurement stations which are distributed in whole city, showed that following to that strategy not only reduced the amounts of air pollution, but had a very positive effective on natural parks in Tehran. This paper will discuss the results of air pollution and its effects on natural park ecosystems in details during last 5 years in Tehran.
Keywords: Transport, Air pollution, Natural park and Ecosystem.

Peroxy radical concentration in the tropical troposphere over the South East rainforest in April and July 2008 (0P3-Danum-08)

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Continuous measurement of peroxy radicals (HO_2+RO_2),the photolysis rate coefficient J(NO_2), J($O1D$), metrological measurement and number of other trace gases including NO_2,NO_3,O_3 and VOCS were carried out at the Bukit Atur Global Atmospheric Watch station in the Danum Valley forest conservation area in Sabah Malaysia in April and July 2008.A mean concentration of 25 +/− 3.3 parts per trillion by volume (pptv) was calculated from continuous measurement of the sum of inorganic and organic peroxy radicals using the Chemical amplification technology. Significant night time radical level of peroxy radical were measured up to 40 pptv. A rate of production and destruction analysis showed that radicals were generated during the night time mainly by the reaction of Ozone with Alkenes. There are two different peaks peroxy radical those come from Ozone photolysis which is dominate in mid day and secondary reached its peak about 3 hours later than that of solar radiation by dominate isoprene.

Carbon dioxide and water vapor fluxes above a subtropical mountain cloud forest: The influence of fog

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The turbulent vertical fluxes of CO_2 and water vapor were measured above a cypress tree (Chamaecyparis species) plantation within the subtropical mountain cloud forest range of NE Taiwan. The study site is characterized by a high frequency of fog. CO_2 and water vapor fluxes were measured on two instrumented micrometeorological towers aligned along the main wind direction. Fog occurs frequently at that site. Despite the large reduction of solar radiation during foggy conditions by 64% as compared to clear situations, the reduction of the CO_2 uptake is rather small at tower 1, for which Chamaecyparis is the dominating species within the footprint area. The Chamaecyparis species perform well under these extreme conditions of reduced light. A large section of the footprint area of tower 2 is vegetated with Cryptomeria japonica. CO_2 flux comparison at both towers during foggy and non-foggy conditions, and direct tower-totower comparisons showed a significant difference statistically in the CO_2 fluxes. While the photosynthesis rate of Chamaecyparis was hardly reduced during fog that of Cryptomeria japonica decreased strongly during foggy conditions. Cryptomeria japonica is less well adapted to the low light conditions. The net water vapor flux was dominated by evaporation of intercepted fog. Transpiration contributed only little to the water vapor flux during the experimental field study.

Examination of CO2 transport processes in a mountainous cool temperate deciduous forest in central Japan using atmospheric 222Rn measurement

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In order to examine CO_2 transport processes over a complex terrain, measurements of atmospheric ^{222}Rn, a natural radioactive noble gas emitted from soil with a half life of 3.82 days, were made at Takayama, a deciduous forest site (TKY; 36.15°N, 137.42°E, 1420 m a.s.l.) in central Japan; this is one of the longest flux monitoring sites in the world. Continuous measurements of vertical CO_2 profiles, as well as of CO_2 fluxes and meteorological parameters, were made at two towers, one on the ridge and another one on the slope; the distance between the two towers was about 100 m. ^{222}Rn measurements were made at the towers using an electrostatic collection method.

In the growing season, prominent CO_2 diurnal cycles with a maximum during the nighttime and a minimum in the early afternoon were observed, consistent with the biological activities, while ^{222}Rn showed a complicated diurnal variation. However, the following relationships between ^{222}Rn and topographical winds were found:

(1) With upslope wind, ^{222}Rn at the ridge tower tended to increase due likely to an accumulation of ^{222}Rn emitted from the soil in the airmass flowing upward along the slope.

(2) With downslope wind, ^{222}Rn at the slope tower tended to increase due likely to an accumulation of ^{222}Rn emitted from the soil in the airmass flowing downward along the slope. This increase in ^{222}Rn occurred only near the ground surface. During the periods when higher ^{222}Rn values were observed at the slope tower, the CO_2 concentrations were also observed to be higher at the slope tower than at the ridge tower, indicating a downslope transport of respiratory CO_2 emitted near the surface.

Using the observed ^{222}Rn and wind data and the ^{222}Rn flux from soil estimated from an empirical equation at TKY, each component of the ^{222}Rn budget (i.e., the eddy vertical transport, the advective transport and the storage) in the canopy layer was estimated for the nights when the downslope winds were observed, followed by a calculation of the effective eddy diffusivity (K). Using the CO_2 concentration, wind data and the obtained K, each component of the CO_2 budget in the layer was also estimated. For the 3 nights during the intensive campaign in October 2008, ^{222}Rn transported vertically upward and downward parallel to the slope were estimated to be, on average, about two thirds and one third of the ^{222}Rn emitted from the soil, respectively. With the assumption that the CO_2 emitted from the soil is transported vertically and in parallel to the slope in the same ratio as the observed ^{222}Rn emitted from the soil, and combined with the soil respiration estimated using an empirical equation for TKY, we calculated the vertical and ground-parallel transport components of the respiratory CO_2 emitted above ground. As a result, we found that about one third and two thirds of CO_2 emitted above ground were transported vertically and in parallel to the slope, respectively.

Turbulence, heat and trace gas fluxes above a South-East Asian rainforest

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Two major intensive field campaigns were conducted in Malaysian Borneo during the first half of 2008 by a NERC-funded consortium of eight UK institutions, aiming at investigating Oxidant and Particle Photochemical Processes (OP3). As part of this study, flux measurements were made from the Global Atmospheric Watch (GAW) tower located in the Danum Valley conservation area; this tower stands 100 m tall on a small hill. The forest surrounding the GAW tower can be described as selectively logged diptocarp forest. Here we present the micrometeorological characteristics of the GAW site and examine its diurnal turbulence as observed between April and July 2008. We also present fluxes of trace gases (CO_2, O_3) and heat atop the GAW tower by eddy-covariance and modified Bowen ratio technique and investigate their controls.

HUmic-Like Secondary Organic Aerosol from catechol and guaiacol as model substances for heterogeneous atmospheric chemistry

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So-called HUmic Like Substances (HULIS) attracted attention in atmospheric aerosol only recently, initiating a discourse about their aromaticity and other properties, such as reactivity and hygroscopicity. A major portion of HULIS originates from volatile organic compounds, which form secondary organic aerosol (SOA) by abiotic oxidizing reactions. Thus aerosol smog-chamber studies with appropriate precursors are needed to generate SOA with HULIS qualities *in situ* inside the smog-chamber. Catechol and guaiacol were chosen as aromatic precursors for synthetic HULIS production.

The SOA was produced in a 700 L aerosol smog chamber, made of Duran glass and using FEP film as window material. The smog chamber is equipped with a solar simulator (HMI lamp 4.000 W, Osram, and cut-off filter at 300 nm). For each precursor, formation of SOA in the dark with O_3 , formation of SOA with simulated sunlight and O_3 and formation of SOA and simulated sunlight with O_3 and 25% relative humidity was studied using the methods of CNC-DMA, longpath-FTIR and ATR-FTIR absorption spectroscopy. UV/VIS spectroscopy and temperature-programmed-desorption/mass-spectrometry (TPD-MS) will be performed to study certain properties of the so produced HULIS.

Those investigations show that aromatic precursors are able to form synthetic HULIS for laboratory-scale measurements. However, sunlight and relative humidity play a major role in particle production and composition of functional groups, which are the anchor points for heterogeneous atmospheric chemistry.

Fast detection of ozone: Improving a solid-phase chemiluminescence ozone sensor

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One major goal of the EGER project (ExchanGE processes in mountainous Regions, 2008) was the investigation of the vertical profile of ozone fluxes in and above a spruce forest canopy (Fichtelgebirge/Germany) using the eddy covariance method. Fast measurements of ozone concentrations are made by solid-phase ozone sensors based on the chemiluminescence reaction of ozone with an organic dye adsorbed on a silica gel plate. A photomultiplier converts the emitted light in an electronic signal, which is directly proportional to the ozone concentration. Important advantages of such ozone sensors are the light weight, low costs and the high temporal resolution (10 – 20 Hz), making them suitable for eddy covariance measurements. However, commercially available detection plates show some disadvantages, e.g. the signal decreases with duty time and water vapor has a significant influence on the reactive surface, and hence the measured signal. In this study, we present experimental results about improving the ozone sensor by varying the composition of the detection plates. The main goals were to prolong the duty times up to four days while maintaining the sensitivity and to decrease the humidity effect. Several mixtures of organic dyes with impregnating substances and energy transfer reagents were tested. Additionally, different solvents, substrates and drying conditions were used. The tests showed that not only the combination and concentration of organic dyes had a large influence on the duty time of the detection plates, but also the substrate plays an important role. Volatile solvents and strong drying conditions slightly improved the sensitivity of the detecting plates. Neither impregnating substances nor reverse phase silica gel could completely diminish the humidity effect. Further tests are planned investigating substrates consisting of silica gel with different functional end groups and new combinations of organic dyes with energy transfer reagents.

A mechanistic model to predict aerosol dry deposition with a special attention to forests

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The estimation of the dry deposition flux of particles depends on the combined properties of the vegetation cover, the turbulence and the depositing aerosols. A mechanistic model has been recently developed and accounts for the main mechanisms dominating the deposition of particles. Applications of this model to different forest configurations (both coniferous and broadleaf) are presented and its results are compared with existing particle flux measurements.

Vertical Profiles of Reactive Trace Gases (NO, NO2, O3) in a Forest Ecosystem

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Within the framework of EGER (ExchanGE processes in mountainous Regions), tower-based vertical profiles of both reactive (NO, NO_2, O_3) and non-reactive (CO_2, H_2O) trace gas mixing ratios were measured during the two Intensive Observation Periods (IOP I from 6th of September to 3rd of October 2007 and IOP II from 05th of June to 11th of July 2008). Measurements were made at several heights (IOP I: 9 heights and IOP II: 11 heights) between 0.005 m and 31.5 m in a spruce forest ecosystem (mean canopy height: 23 m) using two identical, but independently operating analyzing units. Special emphasis was given on resolving vertical gradients at the soil–trunk space and canopy–roughness sublayer interfaces. Accompanying measurements comprise vertical profiles of wind speed, air temperature, relative humidity, global and photosynthetic active radiation, as well as the NO_2 photolysis rate. Additionally, fluxes of momentum, sensible and latent heat, NO, NO_2 and O_3 were measured above the forest (32.5m) using the eddy covariance technique (EC).

Vertical profiles are a useful tool for the interpretation of the measured EC fluxes of reactive compounds. Due to reduced turbulence within the forest canopy the residence time of the in-canopy air mass increases. Additionally, radiation and, thus, the NO_2 photolysis frequency is attenuated non-uniformly throughout the forest canopy. Biogenic soil emissions of NO and subsequent conversion to NO_2 by the reaction with O_3 are investigated using the vertical profiles as well as the influence of advection of NO_x from nearby anthropogenic sources during the morning hours. Both chemical interconversion and advection have a significant impact on the direction and magnitude of the reactive trace gas fluxes.

Fluxes of reactive and non-reactive trace gases close to the forest floor

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This work investigates fluxes and concentrations of reactive as well as non-reactive trace gases in the ground level layers of the atmosphere in an ecosystem with high vegetation. In the course of the EGER IOP2 experiment at the coniferous Weidenbrunnen investigation site in the Fichtelgebirge Mountains (Northern Bavaria, Germany), data was collected from June 29th to July 2nd. Besides meteorological parameters, collected by an automatic weather station, concentration measurements of the trace gases CO_2, H_2O, O_3, NO and NO_2 at five, as well as ^{220}Rn and ^{222}Rn at four sampling heights inside the lowest meter above the forest floor were conducted. Afterwards, miscellaneous modelling approaches, based on, e.g., common profile equations or hydrodynamical research, are used for trace gas flux determination. A hydrodynamical multilayer model, which accounts for the existence of three different layers within the lowest meter of the atmospheric boundary layer, where the transition of molecular to turbulent exchange takes place, provides the most feasible results. These are compared with fluxes measured by eddy covariance technique and static soil chambers. Oftentimes, the spatial heterogeneity of the forest ecosystem originates considerable differences of the fluxes, despite relatively small displacement of the measurement locations. The varying understorey vegetation impeded satisfactory comparisons in case of the sensible and latent heat flux. If these are intended for future experiments, the spatial arrangement of the measurement setup is to be reconsidered. However, this was not a problem for the comparison between eddy covariance determined and modelled O_3 fluxes, which fit quite well most of the time and validate the hydrodynamical multilayer modelling approach. The fact that the static soil chamber delivers much lower CO_2 and ^{222}Rn surface fluxes, compared to the model, requires a discerning consideration of the applied soil chamber system. This is essential, because the surface flux is a basic parameter of the turbulent eddy diffusion coefficient (K) determination. With an unconventional approach, based on Fick's first law, K-profiles are provided, as groundwork for further concentration profile modelling, especially of reactive trace gases, which are strongly affected by transportation velocity and residence time. Choosing, e.g., the modelled ^{222}Rn surface flux for the calculations, results, on average, in $1.2 \cdot 10^{-4}$ to $6.5 \cdot 10^{-3}$ m^2 s^{-1} higher turbulent eddy diffusion coefficients than using the originally designated soil chamber flux. A modern soil chamber system, with an improved exponential fit of the concentration rise in the chamber, is suggested. In the course of this work , observed differences between modelled and measured fluxes initiated causal research, especially in terms of soil close decoupling events. For the detection of those, a two step surface concentration modelling approach was developed. Compared to empirical surface concentrations, conclusions about separation of coupled and decoupled conditions become possible. The usage of two different non-reactive trace gases ^{222}Rn and water vapour, results in more than 80% consistence.

Trace gas exchange at the forest floor

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In our contribution we focus surface fluxes of the reactive trace gases NO, NO_2, and O_3 at the forest floor, using a flux gradient approach which specifically takes transportation times of the reactants into account. While in the first meter above the forest soil, vertical concentration gradients can be measured quite easily, the determination of vtr (the bulk (turbulent) transfer velocity; a measure for transport efficiency) requires unconventional approaches. We estimate vtr from measurements of a chemically inert tracer, namely the radioactive noble gas radon (Rn). The vertical distribution and the decay constant (0.0125 s^{-1}) of the short-lived isotope ^{220}Rn ($t_{1/2}$= 55.6 s) are employed to calculate transportation times and corresponding bulk transfer velocities. Combined measurements of vertical concentration differences and soil surface fluxes by static chambers of the long-lived isotope ^{222}Rn ($t_{1/2}$= 3.81 d) result in bulk (turbulent) diffusion coefficients. Once the bulk turbulent diffusion coefficient (directly related to the bulk transfer velocity) for the near-surface gas transport at hand, it is applied to vertical concentration differences of NO, NO_2, and O_3 in order to infer corresponding surface fluxes. Results from these approaches obtained during field experiments in a Bavarian spruce forest at the Weidenbrunnen/Fichtelgebirge (50.142°N 11.867°E, 780 m a.s.l.) in September 2007 and July 2008 are presented. Mean bulk transfer velocities in the first 30 centimeters of the trunk space ranged between 0.003 m s^{-1} and 0.016 m s^{-1}, equivalent to bulk turbulent diffusion coefficients of 0.9×10^{-4} m^2 s^{-1} up to 4.5×10^{-3} m^2 s^{-1}. We developed a numerical algorithm to consider fast (photo)-chemical reactions of the NO-NO_2-O_3 triad during the turbulent transport within the first meter about the forest floor. By this we corrected surface fluxes of NO, NO_2 and O_3 for the vertical flux divergence caused by chemical reactions. Finally, surface fluxes of NO, NO_2 and O_3 are compared to simultaneously performed direct surface flux measurements by dynamic soil chambers and eddy covariance techniques. Even under very stable meteorological conditions, when turbulence is so small ($u_* < 0.08$ m s^{-1}), that direct common methods (e.g. eddy covariance) are no longer applicable; the presented approaches can be used to characterize near-surface exchange of non-reactive and reactive trace gases.

Significant contribution of largely neglected semi-arid forests to the climate system

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Forests both take up atmospheric CO_2, and enhance absorption of solar radiation, with contrasting effects on global temperature. Quantifying these effects has mostly neglected the large dry transition climate zone (precipitation 250-600 mm) that covers ~17.7% of land surface area. Based on a nine year study in a semi-arid forest at the forests' dry timberline, we show: (1), that significant carbon sequestration potential (cooling effect) is maintained in this region by shifts in peak photosynthetic activities from summer to early spring; and (2), this is counteracted by a newly identified longwave radiation (L) suppression (warming effect), doubling the better known shortwave (S) albedo effect of forestation. Owing to the two-fold S+L surface energy effect, several decades of carbon accumulation are required before any forestation in this region achieves a net negative radiative forcing. Desertification over the past several decades, however, contributed negative forcing at the earth's surface as large as ~20% of the anthropogenic CO_2 effect over the same period, moderating warming trends.

A statistical approach applied to trace gas gradients with low signal to noise ratios

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Estimates of horizontal CO_2 advection require the measurement of gradients which are small in relation to their uncertainty. To keep instrument related uncertainty to a minimum, many studies used a single gas analyzer to sample multiple points in space one after the other. The drawback is limited spatial and temporal resolution. For the benefit of an excellent temporal resolution of 1 Hz this study employed a multi-analyzer setup. This contribution aims to show how uncertainties related to the multi-analyzer setup can be minimized by statistical postprocessing methods. Analysis of the similarity of concentration time series sampled at different locations can be used to define criteria for conditional signal shifting according to time dependent sample distributions.

Influence of coordinate rotation on calculation of vertical advection

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Different physical, chemical and biological processes in the soil-vegetation-boundary-layer system were investigated during the EGER (ExchanGE processes in mountainous Regions) project at the FLUXNET station Waldstein Weidenbrunnen in Germany. Turbulence structure, advection and flux gradients of meteorological and chemical quantities were observed within the first intensive observation period, in September and October 2007 (IOP 1). Measurements of a sonic anemometer including vertical velocity are available for a longer period, from September 2007 to February 2008. Vertical advection is determined by CO2 concentration gradient and mean vertical velocity. The small values of the later cause a high source of uncertainty to vertical advection calculation. To correct influences of sensor misalignment, obstacles or local topography, the planar fit coordinate rotation is carried out. The influence of time span and classification in wind sectors as well as the effect of data quality on the correction of vertical velocity and therefore on the calculation of vertical advection were tested. On the one hand vertical velocity was corrected with a planar fit correction using all data and on the other hand with a planar fit for separate sectors of wind direction. The later was furthermore distinguished into data selected according to neutral stratification and data filtered according to quality assessment using friction velocity. Best values are obtained using the last method, showing a distribution of mean vertical velocity close to zero and no dependence on wind direction, which the method using all data still shows. However, no big difference can be observed in the resulting vertical advection comparing the three alternatives of correcting vertical wind velocity. Regarding mean diurnal courses of vertical velocity for the dataset of September 2007 to February 2008, it is negative at night and positive during the day. However for the shorter period of IOP 1 mean daily values of vertical velocity are displaced by about + 4 cm s-1 when calculated with planar fit correction coefficients obtained by the half year period. Thus it is important to find an appropriate time span for the coordinate rotation to avoid an over- or underestimation of vertical velocity and consequently vertical advection, which in this case leads to high negative mean values throughout the day. For a shorter planar fit period mean vertical advection is closer to zero, with mainly positive values at night and slightly positive and negative values by day.

CFD modelling of airflow and flux footprint over complex hilly terrain

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Eddy covariance measurements of turbulent fluxes provide a piece of the trace gases balance puzzle (Baldocchi et al., 2001). The flux footprint defines the field of view of the flux sensor and reflects the influence of the surface on the measured turbulent flux; therefore the footprint is important for the correct interpretation of experimental data (Schuepp et al., 1990; Vesala et al., 2008). To estimate the influence of different landscapes on flux footprint the knowledge of airflow structure over investigated landscape is needed. During last years the ABL model SCADIS (scalar distribution model (Sogachev et al., 2002)) have been successfully applied for both airflow and footprint modelling over complex terrain, providing a better understanding of canopy flows and improving the quality of experimental data measured in non-ideal conditions. The model provides adequate descriptions of flows over ecosystems with wide range of vegetation architectures and species composition without any additional place- or canopy-specific modifications. It is capable to take into account complex vertical variations in foliage density and in intensities of CO_2 sources and sinks (Sogachev and Panferov, 2006). This study presents the recent achievements of SCADIS in airflow and footprint modelling over complex hilly terrain. We demonstrate the model's ability to simulate reasonably the air flow over the Askervain hill. This flow, because of its well documented field campaign (Taylor and Teunissen, 1985), provides the ideal framework for development and appraisal of computer models. Also we explore how wind field formed by orographic irregularities effects flux footprint in the case of sources located on a floor of spatially homogeneous forest. Our numerical results clearly indicate that caution should be exercised when analytical footprint models are used for the interpretation of flux measurements not only over sites with complex topography but also for measurements over smooth terrain when ground source of forest ecosystems growing there is very strong.

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Statistical analysis of HONO and relative humidity time series measured in the EGER-Project

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The HONO concentrations measured with two LOPAPs (LOng Path Absorbtion Photometer) at the Waldstein-Weidenbrunnen site in north eastern Bavaria, Germany (50°09'N, 11°52'E, 775m above sea level) during field campaigns of the EGER-Project (Exchange processes in a mountainous region) are related to humidity. On timescales of about one week this is due to low and high pressure areas causing dry or rainy weather. During dry periods HONO concentrations rise continuously aside the diurnal cycle to maximum values of about 500ppt at night, whereas rain events cause an (almost complete) washout, down to 15-20 ppt. But also on a 10min scale (~ time resolution of the LOPAP instruments) the HONO concentration and humidity signals show a good congruence. In order to gain more detailed insights into often discussed relative humidity dependence of HONO formation process, we have applied Singular Spectrum Analysis (SSA) (Kondrashov and Ghil 2006) to HONO and humidity time series measured during intensive operating periods of the EGER-Project. The SSA was used as a gap filling method to obtain continuous time series for applying cross correlation function. The analytical step of the SSA gains information about the main frequencies of the time series like weekly or diurnal variations. For comparison the same analysis was done for NO_2 and HONO. Spatio-temporal filling of missing points in geophysical data sets; D. Kondrashov and M. Ghil; Nonlinear Processes in Geophysics;2006; 13; 151-159

Species effect on the water use efficiency of a mixed forest of beech (Fagus sylvatica L.), Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) and silver fir (Abies alba Mill.) in Belgian Ardennes

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Carbon and water vapour fluxes of a mixed forest (deciduous and coniferous) were performed for over ten years by the eddy covariance method at the Vielsalm site (Belgian Ardennes) as a part of the CarboEurope project (Aubinet et al, 2001, 2002). Whereas carbon fluxes have been analyzed in detailed and good estimations of the Gross Primary Production (GPP) were obtained at different scale a thorough analysis of water vapour fluxes remains to be done. Especially, an analysis of the water use efficiency (ratio of gross primary productivity and evapotranspiration) at both the species and stand scale is relevant in the case of temperate forests. The WUE well characterizes the vegetation productivity and ecosystem response to environmental factors. It's an important parameter that allows evaluating the sensitivity of temperate woody species to drought. Improving analysis of the eddy covariance vapour fluxes measurements and monitoring species transpiration will contribute to the estimation of the WUE at the Vielsalm site, at the species and the stand scale. First, we will monitor and analyze each species water use by measuring sap flow with the thermal dissipation method (Granier, 1985, 1987). The studied species are beech (*Fagus sylvatica* L.), Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and silver fir (*Abies alba* Mill.). Results at the species level will then be upscaled and compared to measurements of water vapour fluxes obtained by the eddy covariance methodology since 1996. Transpiration of each species will be analyzed in relation with their own phenological and ecophysiological attributes and ecosystem soil and atmospherics conditions, to clarify among others their behaviour in case of water deficit. The presented results will concern the 2009 growing season. Aubinet, M., Chermanne, B., Vandenhaute, M., Longdoz, B., Yernaux, M., Laitat, E. (2001) Long term carbon dioxide exchange above a mixed forest in the Belgian Ardennes. *Agricultural and Forest Meteorology*, **108**, 293-315. Aubinet, M., Heinesch, B., Longdoz, B. (2002) Estimation of the carbon sequestration by a heterogeneous forest: night flux corrections, heterogeneity of the site and inter-annual variability. *Global Change Biology*, **8**, 1053-1071. Granier, A. (1985) Une nouvelle méthode pour la mesure du flux de sève brute dans le tronc des arbres. *Ann. Sci. for.*, **42** (2), 193-200. Granier, A. (1987) Mesure du flux de sève brute dans le tronc du Douglas par une nouvelle méthode thermique. *Ann. Sci. for.*, **44** (1), 1-14.

Determination of scalar fluxes using Surface Renewal

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The surface renewal (SR) method for estimating fluxes from canopies involves high frequency measurements of scalar parameters. The high frequency data are analyzed for ramp-like characteristics and the amplitude and inverse ramp frequency are used in basic energy or mass conservation equations to estimate fluxes. In early research, good results were reported for estimating SR scalar flux density over a variety of vegetated surfaces, but the method required calibration against eddy covariance (EC) measured fluxes. In more recent research, methods to determine SR fluxes without the need for calibration against EC data have emerged. In this paper, we report on a method to estimate the fluxes using uncalibrated SR measurements. Data were collected over Mediterranean shrub vegetation near the west coast of Sardinia, Italy. Three-dimensional, high frequency (10 Hz) wind speed, temperature, humidity, and carbon dioxide fluctuations were recorded using a CSAT3 sonic anemometer and Licor 7500 infrared gas analyzer. The same high frequency data were used to determine H, LE, and Fc using both the EC and SR methods. The uncalibrated SR provided scalar fluxes that were comparable to the EC measurements, and the method gave a better energy balance closure. The methodology and results of our experiments will be presented.

Sensitivity and predictive uncertainty of the ACASA model at a spruce forest site

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The Advanced Canopy-Atmosphere-Soil Algorithm (ACASA), developed at the University of California, Davis, was used to model the turbulent fluxes of heat, water vapor and momentum as well as the CO_2 exchange within and above a spruce canopy at the FLUXNET-station Waldstein-Weidenbrunnen in the Fichtelgebirge mountains in northern Bavaria, Germany. This multilayer canopy-surface-layer model incorporates a diabatic, third-order closure method to calculate turbulent transfer within and above the canopy.
The present work focusses on the evaluation of the sensitivity and uncertainty of the ACASA model by employing the Generalized Likelihood Uncertainty Estimation (GLUE) method. Flux data above the canopy for five days from each of the intensive observation periods carried out within the EGER (ExchanGE processes in mountainous Regions) project in autumn 2007 and summer 2008 were considered. This sensitivity analysis allowed the identification of the most influential parameters of the ACASA model. However, the sensitivity analysis also revealed the equifinality of many parameters in the ACASA model, similarly to other complex process-based models. The analysis of two time periods, each representing different meteorological conditions (relatively wet and cool in autumn 2007, hot and dry in summer 2008), provides an insight into the seasonal variation of parameter sensitivity. Furthermore, weaknesses of the representation of some processes within the model were detected.

Stomatal, soil and cuticular ozone deposition over a mature pine forest and an agricultural field

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Tropospheric ozone (O_3) is known to damage vegetation, materials and human health. Moreover, as other greenhouse gases, the atmospheric concentration of O_3 increases progressively and could reach concentrations of 100 ppb in 2100. Since the last decades, some studies have been performed over forest, crops and grasslands for a better understanding of ozone deposition. However, these studies consider the total ozone deposition and only a few are interested in the different pathways of deposition, i.e. stomatal, cuticular and soil deposition as well as chemical destruction of ozone. For a better understanding of how terrestrial ecosystems could be a sink for ozone, it is necessary to better understand the different pathways of deposition. To address this question, continuous measurements of ozone deposition and climatic conditions (RH, T°…) have been performed over an agricultural field with maize crop near Paris and a mature pine forest in South-West France during the year 2008. We present here results of total canopy conductance for ozone and the partitioning in stomatal and non stomatal components. This study focuses on the influence of climatic factors on ozone deposition and the role played by the structure of the canopy as well as on the role of NO reaction on non stomatal deposition.

Methane exchange of a boreal forest

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Factors controlling the exchange of methane in a forest ecosystem need to be further studied. Methane is oxidized in forest soils that are well drained but it is not clear how large this uptake is and which factors that control the uptake. Anaerobic environments like wetlands were thought to be the one important source of methane in forest ecosystems, but in 2006, Keppler et al, reported that plants could emit methane also under aerobic conditions. At Norunda forest site in central Sweden, a new project started in 2007 aiming at studying the methane exchange of a mixed pine and spruce forest in detail. The whole ecosystem CH_4 exchange will be calculated based on measurements of CH_4 gradients above the canopy and the turbulent diffusivity. A gas chromatograph was used to measure the CH_4 concentration at three levels above the canopy: 32, 58 and 100 m. The turbulent diffusivity is calculated based on measurements from an eddy covariance system. To see how the variation of CH_4 concentration over time depends on the origin of the air, the position of the air masses five days before entering the measuring area will be tracked. The whole ecosystem CH_4 exchange will also be compared with data of soil CH_4 fluxes. Fluxes at soil level have been measured manually and can, due to a strong correlation with soil respiration, be calculated for the periods when data is missing. Results will be presented in October.

Upscaling of shoot scale volatile organic compound emissions to the ecosystem scale and beyond

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Volatile organic compound (VOC) emission inventories have usually been based on shoot or plant scale emission measurements, recently also on direct ecosystem scale flux measurements. Emission inventory models offer information for regional air quality models, which normally operate in the landscape scale. Upscaling from smaller scales to the model scale introduces a source of uncertainty in modelling results. We explore the validity of upscaling procedures using shoot and ecosystem scale emission measurements and concentration profile measurements conducted at a boreal forest ecosystem in southern Finland. Proton transfer reaction mass spectrometry and the dynamic chamber and disjunct eddy covariance methods were employed in these integrated measurements, which are now used together with a one-dimensional turbulent transport and atmospheric chemistry model. According to the preliminary analysis, our present upscaling procedures yield ecosystem scale VOC emissions comparable to the measurements.

Effect of plant height on microclimate, evapotranspiration and water use efficiency of a banana plantation in a screenhouse

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The area of agricultural cultivation of vegetable crops and orchards in screenhouses and under screens is constantly increasing in Israel and other countries. The porous screens provide protection from unfavorable climatic conditions (e.g. hail, wind and supra-optimal radiation), reduce insect invasion and fruit sunburn, and allow savings of irrigation water. The aim of the present study was to investigate microclimate and crop water use during the initial growth stages of crops cultivated in screenhouses. This information will assist farmers in improving irrigation management of young plantations. Measurements were conducted in a screenhouse in northern Israel which covered a banana plantation. Screenhouse dimensions were 300 m x 190 m and 6 m high. Energy and CO_2 flux measurements were made in the middle of the screenhouse using an eddy covariance system consisting of a three-axis ultra-sonic anemometer and an open path infra-red gas analyzer, positioned 4.25 m high. During the measurement period, plant height increased from 2.7 m to 3.9 m. Additional instruments were installed to measure net radiation, air temperature and humidity and soil heat flux. Outside climatic conditions were measured by an external meteorological station. Energy balance closure analysis of half hourly covariances resulted in the following relation between available (*X*) and dissipated (*Y*) energy: $Y = 0.71\,X - 2.09$ ($R^2 = 0.79$), generally supporting the validity of measured energy fluxes. Daily evapotranspiration rose during the measurement period from about 2.2 mm d^{-1} for the smaller plants, up to about 3.4 mm d^{-1} for the taller plants. A Penman-Monteith evapotranspiration model, modified for the screenhouse conditions, was in general agreement with the measurements, especially for the taller plants. The increase in net CO_2 consumption was 2-fold during the same period, from about 10.7 g m^{-2} d^{-1} to about 21.5 g m^{-2} d^{-1}. Thus water use efficiency, defined as the ratio between net vertical fluxes of CO_2 and water vapor, was higher for taller than for smaller plants. Diurnal courses of CO_2 concentration above the plants showed significantly lower concentration for the taller plants as compared with the smaller plants. This corresponds well with the increase in CO_2 flux with plant height. Diurnal courses of the difference in air absolute humidity between inside and outside showed a significantly larger humidity difference for the taller than the smaller plants. Ventilation rate was estimated using the mass balance approach; it is demonstrated that the taller plants reduce the air exchange rate of the screenhouse as compared with the smaller plants, presumably due to their higher resistance to air flow.

Observations of Subcanopy Flow and the Carbon Budget in two Amazon Rain Forest: Santarém and Manaus Sites

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Under LBA-ECO NASA project, measurements of horizontal and vertical fluxes and gradients of CO_2 and wind, were made in two Amazon tropical rain forest sites, the Tapajós National Forest Reserve (FLONA-Tapajós - 54°58'W, 2°51'S) and Cueiras Reserve (Manaus - 60°12'W, 2°36'S). Two observational campaigns in 2003 and 2004 were conducted in Santarem Site to describe subcanopy flows, clarify their relationship to winds above the forest, and estimate how they may transport CO_2 horizontally. Also in Manaus Site were made observations during October 2005 to September 2006, with same instrumentations system. It is now recognized that subcanopy transport of respired CO_2 is missed by budgets that rely only on single point Eddy Covariance measurements, with the error being most important under nocturnal calm conditions. We tested the hypothesis that horizontal mean transport, not previously measured in tropical forests, may account for the missing CO_2 in such conditions. A subcanopy network of wind and CO_2 sensors was installed. Significant horizontal transport of CO_2 was observed in the lowest 10 m of the canopy. Results indicate that CO2 advection accounted for 73% and 71%, respectively of the carbon budget for all calm nights evaluated during dry and wet periods. We found that horizontal advection is likely important to the canopy CO_2 budget even for conditions with the above-canopy friction velocity higher than commonly used thresholds. On the Manaus LBA-SITE very different pattern have been found, with reversal wind flow in the lee side of hill observed up sloping during nighttime and inverted during daytime. The subcanopy flow and CO_2 horizontal and vertical gradients over slope in complex terrain it was very different than Santarem Site. The diurnal cycles of the subcanopy flow and CO_2 gradients were associated with a "gully Flow" or channel flow over the micro basin at Manaus Site. This channel flow just above the canopy has important role in the subcanopy flow and CO_2 gradient strength in small ecosystem scale.

Effects of storms on soil CO_2 efflux in boreal forests

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Regional carbon budgets are to some extent determined by disturbances of the ecosystems. Disturbances are believed to be partly responsible for the large inter-annual variability of the terrestrial carbon balance. When neglecting anthropogenic disturbances, forest fires have been considered the most important kind of disturbance. However, also insect outbreaks and wind-throw may be major factors in regional carbon budgets. The effects of wind-throw on CO_2 fluxes in boreal forests are not well known due to lack of data. Principally, the reduced carbon sequestration capacity and severe soil perturbation following wind-throw are expected to result in increased CO_2 fluxes from the forest to the atmosphere. In January 2005, the storm Gudrun hit Sweden, which resulted in approx. $66*10^6$ m³ storm-felled stem wood distributed over an area of approx. 272 000 ha. Eddy covariance flux measurements on a storm-felled area started in July 2005 and data from the first months suggests increased CO_2 fluxes by a factor of ca. 2.5, as compared to normal silviculture (i.e. clear-cutting and soil scarification). An important question is how long such enhanced CO_2 fluxes persist. Data from 2005-2009 will be analyzed and presented at the workshop.

Conditional flux analysis and stable isotopes

Matthias J. Zeeman[1], Alexander Knohl[1], Nina Buchmann[1], Patrick Sturm[1], Christoph Thomas[2]
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We propose to investigate to what extend conditional flux analysis can benefit from the addition of stable isotope information. Stable isotopes have been recognized for their potential as process tracer, and could add an extra dimension to the conditional flux concept, which aims at directly quantifying component fluxes and identifying their sources. Differences in ^{13}C abundance in carbon dioxide can be used to distinguish assimilation or respiration sources, whereas the ^{18}O abundance expresses differences in water exchange, for instance between canopy and soil. Lending to recent advances in measurement technology, stable isotopes can now be measured at high temporal resolutions (10Hz) required for commonly applied micrometeorological methods such as the eddy-covariance technique, or related conditional flux methods. We will present current ideas on how the conditional flux method, as recently proposed by Thomas et al. (2008) to perform daytime flux partitioning at the ecosystem level, can be refined by stable isotope analysis (^{13}C and ^{18}O) of carbon dioxide as additional dimension for identification of fluxes.

Thursday, Oct 8 ≡

Session 6 ∗ SVAT-Modeling and scale interactions (Chair: F.X. Meixner)

09:00 - 09:40 ∗ (**Key Note**) **Kyaw Tha Paw U, R.D. Pyles, L. Xu (Univ. of California)**
SVAT-Modeling and scale interactions

09:40 - 10:05 ∗ **Serena Marras, D. Spano, C. Sirca, P. Duce, R.L. Snyder, R.D. Pyles, K.T. Paw U (Univ. of Sassari)**
ACASA simulations and comparison with measured fluxes over Mediterranean maquis

10:05 - 10:30 ∗ **Katharina Staudt, E. Falge, A. Serafimovich, R.D. Pyles, Th. Foken (Univ. of Bayreuth)**
Modeling the exchange of energy and matter within and above a spruce forest site with ACASA

10:30 - 10:50 ∗ Coffee break

10:50 - 11:15 ∗ **Eva Falge, K. Staudt, F.X. Meixner (MPI for Chemistry Mainz)**
Validation of gas exchange models for a Picea abies canopy in the Fichtelgebirge, Germany

11:15 - 11:40 ∗ **Laurens Ganzeveld (Wageningen University and Research Centre)**
Local- to global scale canopy interactions relevant to the exchange of reactive compounds and aerosols

11:40 - 12:05 ∗ **Catherine Van den Hoof, M. Aubinet, B. Heinesch, C. Vincke (Belgian Nuclear Research Centre)**
Evaluation of the suitability of the land surface model JULES for climate impact studies in Belgian ecosystems

12:05 - 12:30 ∗ **Ulrike Falk, C. Conrad, J. Hendrickx (Univ. of Bonn)**
Cross-scale intercomparison of different approaches for measuring and modeling heat energy fluxes in West-Africa

12:30 - 12:45 ∗ **Closing statement (F.X. Meixner)**

13:00 - 14:00 ∗ Lunch

Optional program point

Excursion to the BayCEER Research fields (FLUXNET-Station Waldstein-Weidenbrunnen) located in the mountain region "Fichtelgebirge".
Shuttle-bus transfer (app. 1 h distance)

Departure time: 14:30

Back passage from the research field at 17:00
Arrival at the Castle or Bayreuth train station app. 18:00

6   SVAT-Modeling and scale interactions

Key Note

SVAT-Modeling and scale interactions

Kyaw Tha Paw U[1], R. David Pyles[1], Liyi Xu[1]
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The soil-vegetation-atmosphere transport (SVAT) model ACASA (Advanced Canopy Atmosphere Soil Algorithm) has been linked to regional scale models (MM5 and WRF). These linked models allow scaling from the leaf level to continental levels, and allows identification of dominant processes and controlling parameters.

Feedback between the microscale canopy interactions and the regional scale models are important, and must be adequately described by detailed turbulent transport parameterizations between layers in the canopy. Results indicate that simplified surface models, such as those using single layers, two-layers, and flux-gradient (K-theory) yield substantially different results than more detailed higher-order closure turbulent transport models.

Preliminary comparison with observations shows improvements by using ACASA in MM5 and WRF over the more traditional Land Surface Models, including those imbedded in MM5 and WRF. Advantages and disadvantages of the different models in describing scaling from the leaf to the canopy to the region are discussed.

ACASA simulations and comparison with measured fluxes over Mediterranean maquis

Serena Marras[1], Donatella Spano[1], Costantino Sirca[1], Pierpaolo Duce[2], Snyder Richard L.[3], Pyles R. Dave[3], Paw U Kyaw Tha[3]
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[3] University of California, Davis, CA, USA

Energy and mass fluxes between terrestrial ecosystems and atmosphere are widely simulated using land surface models. The "Advanced Canopy Atmosphere Soil Algorithm" (ACASA) model was used to estimate fluxes over a maquis ecosystem. The model accurately simulated wind speed and direction, air turbulence, energy fluxes, and mean scalar profiles within and above ecosystems (20 atmospheric layers). ACASA consists of an advanced scaling model from the leaf and soil level to the canopy level. The model employs a process-based interactive set of modules that include radiative transfer within the ecosystem, ecophysiological response of the vegetation to soil and atmospheric conditions, column water, snow and ice hydrology, and sophisticated interlayer turbulent transfer physics. Parameters were added to account for soil moisture stress, which is simulated with a soil water transport model. These linked models automatically yield carbon dioxide exchange and transpiration by accounting for stomatal control of evapotranspiration. Turbulent exchange between the layers and the atmosphere is described by a higher-order closure model, which allows counter-gradient transport that simpler models are unable to describe. ACASA requires (1) plant and soil characteristics, (2) 30-minute meteorological data, and (3) initial soil water content conditions. Input data came from in situ measurements or were selected from the literature when observations were unavailable. The aim of this research was to parameterize and validate the model over a sparse maquis canopy. ACASA flux outputs were compared with three years of field measurements over Mediterranean maquis near Alghero, Italy (Northwestern Sardinia). Different measurement periods were used to parameterize and validate the model. Net radiation and energy balance fluxes compared well with measured values. Differences between modeled and observed sensible (H) and latent (LE) heat fluxes were small. Both positive and negative CO_2 flux simulations were well predicted by the model. ACASA captured the seasonal variation in Net Ecosystem Exchange (NEE) flux, including the summer decrease due to drought induced water stress. Therefore, ACASA showed good performances at predicting energy and mass fluxes between the atmosphere and the sparse maquis covered surface.

Modeling the exchange of energy and matter within and above a spruce forest site with ACASA

Katharina Staudt[1], Eva Falge[2], Andrei Serafimovich[1], R. David Pyles[3], Thomas Foken[1]

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Within the EGER project, the exchange of energy and matter between the soil, the vegetation and the atmosphere at the spruce forest site Waldstein-Weidenbrunnen in the Fichtelgebirge mountains in northern Bavaria, Germany, was modeled with the Advanced Canopy-Atmosphere-Soil Algorithm (ACASA). ACASA is a multilayer canopy-surface-layer model that incorporates a third-order closure method to calculate turbulent transfer within and above the canopy and was developed at the University of California, Davis.

Comprehensive micrometeorological and plant physiological measurements were performed during the two intensive observation periods of the EGER project in autumn 2007 and summer 2008, such as measurements of in- and above canopy profiles of standard meteorological parameters and eddy covariance measurements at six heights on a 36 m high tower observing the turbulence structure within and above the forest. This data base allowed us to extensively test the ability of the ACASA model to simulate the exchange of energy and matter at our site.

In a first step, a sensitivity analysis of the ACASA model using the generalized likelihood uncertainty estimation (GLUE) methodology was performed, considering fluxes above the canopy. It appeared that the model was only strongly sensitive to a few of the input parameters, whereas for many parameters equifinality was observed, a common problem of complex SVAT models. However, the calculation of uncertainty bounds demonstrated that the ACASA model was able to reproduce all above-canopy fluxes well.

For two fair weather periods not only fluxes above the canopy but also profiles of water vapor fluxes within the canopy were compared to eddy-covariance measurements. Thereby, the contribution of coherent structures to the fluxes was accounted for and the ability of the ACASA model to cover these contributions investigated. ACASA was capable of reproducing the shape of the profiles of water vapor fluxes within the canopy well. In general, the profiles were in good agreement for coupled and partly coupled exchange regimes, whereas during decoupled situations modeled and measured values were less consistent.

Validation of gas exchange models for a Picea abies canopy in the Fichtelgebirge, Germany

Eva Falge[1], Katharina Staudt[2], Franz Meixner[1]
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Canopy exchange of water and carbon dioxide in a mountain Norway spruce stand of Central Germany was analyzed with two micrometeorology and gas exchange models, the three dimensional STANDFLUX, and the one dimensional ACASA. The models describe canopy water vapor and carbon dioxide exchange based on rates calculated for individual needles and as affected by local gradients in photon flux density, atmospheric humidity, atmospheric carbon dioxide concentration, and air temperature. The models were used to calculate forest radiation absorption, net photosynthesis and transpiration of the tree canopy. Model parameterization was derived for the Weidenbrunnen site, a 54-year-old *Picea abies* stand. Parameterization included information on vertical and horizontal leaf area distribution (STANDFLUX and ACASA), tree positions and tree sizes (STANDFLUX). Needle gas exchange in STANDFLUX was modeled using specific sets of physiological parameters for top, middle, and bottom of the canopy measured during two intensive field campaigns (IOP-1&2). For ACASA build-in leaf physiological parameters were adapted to accommodate these measurements. Comparisons of the vertical distribution of modeled branch transpiration with water use estimates from xylem sapflow measurements in the canopy profile provided a test of the models. The validation of the models is an important step toward effective use of IOP-1&2 data from the entire EGER project. While the one dimensional model is best suited for assessing vegetation/atmosphere exchanges of landscapes or regions, STANDFLUX provides a starting point for developing efficient tools for three dimensional simulations of plot-scale vegetation/atmosphere exchange of both, not reactive and reactive chemicals. Model development in the area of in-canopy turbulent transport is viewed as critical over the long-term in order to provide an efficient linkage between studies at the measurement sites and generalization via remote sensing/mesoscale modeling. The results are a contribution to the EGER project (Exchange Processes in Mountainous Regions, Deutsche Forschungsgemeinschaft), which investigates the role of process interactions among different scales of soil, in-canopy and atmospheric processes for mass and energy budgets of vegetated surfaces.

Local- to global scale canopy interactions relevant to the exchange of reactive compounds and aerosols

Laurens Ganzeveld[1]
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Atmosphere-biosphere exchange of reactive nitrogen (N_r) and reactive carbon (C_r) plays a key role in the Earth system through the regulation of atmospheric- and biogeo-chemistry. It is also relevant to climate through its role in the regulation of the oxidizing capacity, production of Secondary Organic Aerosols (SOA) and affecting ecosystem functioning through nutrient and ozone (O_3) deposition. The global biosphere emits about 1.3 PgC yr^{-1} of reactive carbon in the form of Volatile Organic Compounds (VOCs), exceeding anthropogenic emissions by a factor of 10. Soils are a large source of nitric oxide (NO), a N_r compound which controls the NO_x ($NO+NO_2$, nitrogen dioxide) budget in remote and rural areas while emissions from fossil fuel combustion dominate the NO_x budget in industrialized areas.

One of the uncertainties in the global biogenic emission inventories is the role of the canopy interactions between emissions, dry deposition, turbulence and chemistry. These interactions result for example in an about 50% decrease in the biogenic source of NO_x as simulated explicitly with an implementation of a multi-layer canopy exchange model in a chemistry-climate model. This model is now also applied to study the role of canopy interactions for VOC and SOA exchange through consistent simulation of in-canopy N_r and C_r sources and sinks at the site- (using a single column version of the chemistry-climate model) and global scale. I will discuss the ongoing research on local- to global scale chemical canopy interactions by showing the results of detailed evaluation of the multi-layer model for a number of sites and global scale implications. In addition, I will address the main uncertainties in these simulations of canopy interactions with a particular focus on the role nocturnal and daytime turbulent mixing conditions and leaf- to canopy scale interactions between emissions and dry deposition.

Evaluation of the suitability of the land surface model JULES for climate impact studies in Belgian ecosystems

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The increasing demand for land and water resources, in conjunction with climate change, are expected to significantly alter the terrestrial ecosystems and, by consequence, the energy, water, and carbon fluxes between land and atmosphere. These changes will vary substantially from region to region and within regions, from ecosystem to ecosystem. In order to evaluate the sustainability issues that we will face in the near future in Belgium, we need to understand the relationships between the land-surface characteristics and the energy, water and carbon cycles for the different ecosystem types found in Belgium. Furthermore, we need to quantify how these relationships might change with changes in environmental conditions, such as land cover and climate. Land surface models are important tools for understanding and predicting these relationships.

The purpose of this study is to evaluate the suitability of the land surface model JULES (Cox *et al.*, 1998) to simulate carbon, water vapour and energy fluxes in Belgian ecosystems, and to analyse the response of the different ecosystems to climatic factors. JULES, the UK Land Environment Simulator, was originally designed to represent the land surface in meteorological and climate models. Its scheme includes the full hydrological cycle and vegetation effects on energy, water, and carbon fluxes. JULES has been shown to improve the simulation of global surface climate when included in a climate model, but has also been tested at field site and hydrological catchment's scales (Harding et *al.*, 2000; Harris *et al.,* 2004).

In this study, the evaluation of the land surface model JULES consists of a thorough sensitivity analysis to the environmental conditions, i.e. soil, vegetation and climate, found in the major Belgian ecosystems. Next, the model is tested against the surface flux data collected for several consecutive years at the different FLUXNET and CarboEurope projects sites in Belgium. For this purpose, JULES is parameterised according to the site-specific vegetation and soil characteristics. To evaluate the seasonal and inter-annual climate variability the model is forced with the meteorological data measured at the field sites. So far this study has been restricted to two sites, Lonzée (Moureaux *et al.*, 2006) and Vielsalm (Laitat *et al.*, 2000), both located in the Southern part of Belgium (the Walloon region). Lonzée is an agricultural site and, a mixed forest covers the Vielsalm site. The preliminary results of this study will be presented.

Cross-scale intercomparison of different approaches for measuring and modeling heat energy fluxes in West-Africa

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Evapotranspiration (ET) mapping from remotely sensed satellite images is critical for water management since the estimation of spatial and temporal ET distributions over large areas is impossible using only ground measurements. A major difficulty for the calibration and validation of operational ET remote sensing algorithms is the ground measurement of ET at a scale similar to the spatial resolution of the remote sensing image. While the spatial length scale of remote sensing images covers a range from 30 m (LandSat) to 1000 m (MODIS), direct methods to measure the latent heat flux (W/m^2) – i.e. the evapotranspiration rate (mm/day) multiplied by the latent heat for vaporization– such as eddy covariance (EC) only provide measurements at a scale that may be considerably smaller than the estimate obtained from a remote sensing method. The Large Aperture Scintillometer (LAS) flux footprint area is larger (here about 1 km²) and its spatial extent better constraint than that of EC systems. Nevertheless, it is only an indirect method for estimation of ET. Two years of continuous data from LAS as well as EC systems are analyzed and compared to modeled estimates of ET using remote sensing. Major difficulties here are the different areas probed by either ground measurements or remote sensing, but also the heterogeneity of small-scale agricultural landscape found in Burkina Faso. A method to estimate the LAS footprint is presented as well as application of existing footprint methods for the EC measurements. The objective of this contribution is to present our experiences with time series of ET mapping using ground observations and the Surface Energy Balance Algorithms for Land (SEBAL). This research is part of the BIOTA West and GLOWA Volta projects, funded by the BMBF.

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